PART TWO

Final Data Processing
6. VERIFICATION AND SMOOTH PLOTTING

6.1. DEFINITION AND PURPOSE

Each registered hydrographic survey shall be verified to ensure that the survey data to be smooth plotted and stored in the hydrographic data bank are as accurate as possible and provide a true representation of the surveyed area. Although modern verification procedures rely heavily on high-speed automated techniques for batch processing the voluminous survey data, human judgment and intercession are still required during the verification process. Verifiers must be continually alert for lost or erroneous data that could compromise the quality of a survey. They must make frequent value judgments when assessing various data, and must be prepared to make final comprehensive statements as to whether or not surveys meet basic hydrographic standards and specifications.

Field survey data are processed through a sequence of both computer and automatic plotter operations and manual verification checks; the types and applications of these checks depend on the control system, method of sounding, and other equipment used to acquire the data. The timing of each verification check is important. All errors and omissions in field survey data must be systematically found and corrected to avoid unproductive repetitive work by the verifier and to not waste time on automation equipment.

A verifier’s primary duty is to carefully check every phase of a survey for accuracy and for conformance to established specifications, conventions, and guidelines. His task extends beyond correcting obvious errors and providing a complete record of a survey; he must also detect and correct errors of a less evident nature that may affect the accuracy of a smooth sheet and the corresponding final data listings. Specific areas of discrepancy are frequently not revealed until the final verification stages. Because the factors affecting the plotted data are so complex, verifiers often find it necessary to review analog depth records, velocity correction data, echo sounder calibration data, tidal information, calibration of electronic control systems, and computer input data—then make other adjustments as necessary to eliminate discrepancies and provide a true cartographic representation of the survey area.

Utilization of sophisticated data acquisition and processing systems does not lessen the inherent responsibilities of a verifier. The high standards described in chapter 7 for the completeness and clarity of the cartographic presentation of hydrographic data must be adhered to rigorously. A slight knowledge of equipment and survey methods now in general use and a casual awareness of the contents of this and other pertinent manuals are not sufficient. A verifier must be thoroughly knowledgeable about all phases of hydrography and automated data processing and must be capable of applying correctly the principles involved.

6.2 VERIFICATION WORK SCHEDULES

Because of the difficulties encountered when scheduling the large number of plotting and verification phases through which each survey must progress, it may not be possible for one verifier to complete all stages. Assignments of the various phases therefore must be made giving consideration to the degrees of difficulty of the work and to the relative capability, experience, and judgment of an individual verifier. As each step of the verification process is completed, each unresolved problem or unusual situation must be documented to provide information and guidance to those assigned to the later stages of the work. A summary of significant changes to the raw survey data shall be prepared to accompany the completed smooth sheet.

Close working relationships must be maintained between survey verifiers and those responsible for automated data processing (Electronic Data Processing Branches). Such relationships help to ensure an efficient application of the many corrections and changes to preliminary data found during each phase of verification. All corrections and changes made by the verifier must either be clearly indicated in the Sounding Volumes, on the data listings or printouts, or be tabulated in a neat orderly manner that is easy to follow. Such notes made by verifiers become the basis for detailed instructions that list remedial actions and reprocessing requirements. Such lists of instructions must be inspected and approved by the
HYDROGRAPHIC MANUAL

M) are useful in shallow waters and where mechanical cable handling equipment is not available. Longer tow cables (200 m to 10,000 m) are steel armored, high-density cables designed to achieve maximum tow depth and minimum noise interference at given tow speeds.

Depth of the transducer towfish is controlled by the length of cable deployed, vessel towing speed, and vessel course. Tow depths can be increased by the use of a depressor or suitable weights.

The graphic recorder contains most of the electronics for the system as well as the graphic mechanism. Most recorders are designed to operate from 24 V d.c. or 110 to 220 V a.c. power supply. (See figure AI-1.)

AI.3. Side Scan Sonar

The following discussion is limited to a description of the side scan sonar system currently used by the National Ocean Survey for hydrographic and bathymetric surveying. The technical manual published by the manufacturer is a necessity for satisfactory operation and maintenance of the system.

AI.3.1. KLEIN ASSOCIATES, INC; SIDE SCAN SONAR SYSTEM. The Klein side scan sonar system consists of the following components:

1. Dual Channel Hydroscan Recorder
2. 50-kHz Dual Channel Towfish.
3. 100-kHz Dual Channel Towfish.
4. Lightweight Tow Cable - 300 feet.
5. Lightweight Tow Cable - 600 feet.
6. Armored Tow Cable - 2,000 feet.
7. Towfish Stablizer Depressor.

The Klein side scan system can be operated from both small and large ships. The system is imperious to marine environments including temperatures of 0°C to 50°C. The equipment will operate from both 24 V d.c. ±10% and 120 V a.c. 60 Hz ± 10%. The service manual (Klein Associates, Inc.-1977) includes all necessary instructions, schematics, parts lists, troubleshooting, and general maintenance instructions. This manual is available as Klein Part No. 521-01 from Klein Associates, Inc., Route 111, RFD 2, Salem, New Hampshire 03079.

FIGURE AI-1.— Klein Hydroscan Dual Channel Side Scan Sonar Recorder (courtesy of Klein Associates, Inc., Salem, New Hampshire)

AI.3.1.1. Side Scan Recorder. The Klein recorder contains the patented Hands-Off-Tuning feature which provides automatic adjustment, making uniform results across the sonar chart. Switches are provided for each channel to additionally permit manual selective tuning. Three event mark features are included: an internally generated 2-minute mark, a pushbutton on the recorder control panel, and a remote event mark pushbutton.

Both recording channels print simultaneously, reading outward from the center of the record in true left/right perspective. The range of the system using the 100-kHz towfish is at least 1,500 feet port and starboard at speeds up to 6 knots. At a 5-knot tow speed the 50-kHz towfish range is at least 2,000 feet. The range of the side scan system is also dependent on the operational environment, target, and the tow speed.

AI.3.1.2. Side Scan Transducers. The towfish consists of individual modular port and starboard transducers whose vertical beam may be varied in 10° ± 2° increments from 0° to 20° by means of minor external mechanical adjustments to the transducer modules. (See figure AI-2.) The tail fin assembly consists of two individual breakaway tail fins, separating when they strike a submerged object. The towfish parts are capable of operation in water depths to 7,500 feet. Separate identical left and right channel plug-in circuit boards are housed in the nose of the towfish.
Al.3.1.3 Tow Cable Assemblies. Lightweight tow cable assemblies consisting of a polyurethane jacket and a Kevlar strength member are provided. The minimum breaking strength is 6,000 pounds. The core consists of four conductors, two of which are individually shielded and used for the right and left channel signal returns, while the other two are for power and trigger pulses. The entire core is additionally shielded. A 300-foot and a 600-foot lightweight cable are provided. The 2,000-foot cable has the same core as the lightweight cable and uses a dual-armored steel jacket providing a breaking strength in excess of 15,000 pounds.

Al.3.1.4. Operations Considerations. Although automatic tuning is available in the control circuitry manual tuning is superior when employed by a trained operator. Experience has shown that properly adjusted, manual controls strongly print a known target which might have been entirely overlooked among other returns on automatic tuning. Herein lies a problem, for if the manual tuning is not properly adjusted, it is worse than the automatic tuning for search. Manual tuning requires constant attention, and some skill to know, or feel, when proper tuning has been achieved. It is important to develop skill in hand tuning by working near a known target for a short period of time. This known target may be attached to an implanted buoy anchor line.

Environmental conditions limit the use of the sonar. The pulse repetition frequency is limited by the time required for the acoustic signal to reach the limit of the search band and return to the towfish. This physical limitation is in direct conflict with the desire to gain resolution on a target by getting as many separate pulses as possible to bounce off the target. There are two solutions to this problem: First, limit search path width; second, move at very slow speed. Both of these decrease the area which can be searched in a given period of time. It should be pointed out that speed over the ground is very important in side scan operations. Slow, constant speed can often be maintained by moving into the current.

Another environmental factor limiting use of side scan is sea state. This factor is most influential in water under 40 feet, but decreases with depth. Sea surface return is so strong with waves of only 2 and 3 feet in less than 40 feet, that it cannot be completely tuned out. As a result, targets on the bottom may be lost. One recourse is to lower the towfish below the interference. This would, of course, endanger the towfish in shallow water. Another means is by use of a recently developed towfish with a variable vertical beam (20º or 40º). The 20º setting is useful to minimize sea clutter.

![Figure AI-2. Klein Side Scan Sonar Towfish (courtesy of Klein Associates, Inc., Salem, New Hampshire)](image-url)
speed—or when a position deviates from the dead-reckoned track without a recorded corresponding change of course. Other errors in positioning may be caused by incorrect visual angles, theodolite directions, or undetected electronic system lane jumps or other anomalies that may not become apparent until depth discrepancies are noted on sounding overlays. (See 6.3.4.)

'Weak' positions are likely to occur on electronically controlled surveys (4.4.3) if the control was inadvertently used beyond the limits of strong intersections or where the signal parallels, crosses, reflects, or otherwise attenuates from landmasses. Under these conditions, sextant or theodolite fixes may have been observed as a check on the electronic control. Where visual fixes are available or where junctions are made with visually controlled hydrography and conflicts in depths occur, positions located by visual methods are generally accepted and appropriate adjustments should be made to those controlled by electronic methods. In such cases, the survey Descriptive Report is consulted for the hydrographer's recommendations.

Estimated positions are frequently needed where it is not feasible to obtain geometric fixes (e.g., in narrow winding creeks or sloughs, arms, high-banked channels, and in other restricted areas where similar conditions prevail). Estimations based on dead reckoning are also used occasionally when positioning ends of sounding lines and when surveying in docking areas or along waterfront structures where it is impractical to control hydrographic lines conventionally. These positions are pricked on the field sheet and subsequently recorded as geographic positions by latitude and longitude. Except for positions in docks and around piers, which generally are smooth plotted as subplans (7.2.4) at enlarged scales, pseudo fixes (forced positions) must be scaled by the verifier for automated plotting, if not already done by the hydrographer.

Each detached position used to locate structures and objects (such as beacons, buoys, rocks) and to position other hydrographic data (such as submerged rocks, obstructions, least depths over shoals) must be checked by the verifier. When a hydrographer has observed so many detached positions that congestion occurs delineating limits for shoals or reefs, the size and shape of piers, or other features, the verifier should retain only the most critical data—the remainder are rejected and excised from the data file.

Survey vessels equipped with fully automated HYDROPLOT systems usually record electronic positional data for each sounding. Vessels not equipped with a HYDROPLOT system or that are conducting visually controlled hydrography furnish position control data only for numbered positions; interval soundings between fixes are plotted by time and course. Positional data from either system may be adversely affected by electronic interference to electronic control. Such interference in phase-comparison measurements is manifested by sporadic "lane jumps" and "dial roll" when electronic receivers attempt to lock onto a spurious signal from outside the system. Super high frequency systems are subject to a number of distance-measuring errors. Signal reflection (multipath measurements), phase interference bands, line-of-sight interference, and improper voltage are among the causes that affect distance readout. Powerful radar transmissions in the vicinity of super high frequency operations frequently cause significant signal blockage.

Lane jumps and dial roll are usually detectable on the analog position record or sawtooth recording. (See 4.8.6.) Otherwise, the verifier must be alert for pronounced irregularities in dead-reckoned positions, poor agreement of depths at sounding line crossings, or depth contour anomalies. Positions in error usually are replotted to agree with time and course of the vessel; such reploting must be noted on the appropriate data lists so the correct data will be input for updated machine plots of the position overlays. Judgment is often required; however, corrections to positions must not be applied capriciously just to force agreement with dead reckonings. When spacings between soundings and positions are relatively constant and the course of a vessel is erratic, irregularity may be attributed to poor steering or to the effects of sea conditions. When such conditions exist, the soundings should generally be assumed to be positioned correctly.

Inshore preliminary position overlays are compared with the field sheets for changes made by the hydrographer and with photogrammetrically compiled shoreline manuscripts to detect and resolve discrepancies in the shoreline, datum line (1.6.1), electronic control correctors, and other hydrographic and topographic details. (See 6.3.5.)

Verifiers must exercise precaution and use every resource available to detect and list for correction every erroneous position prior to ordering sounding overlays. When this phase of verification is
Verification and Smooth Plotting

done thoroughly and efficiently, expensive electronic data processing time is not wasted; and potential problems that could surface at later stages of verification are often eliminated. All major positional errors, deficiencies, or unusual methods that have been discovered must be thoroughly documented for the information and guidance of those involved in the succeeding stages of verification and quality control.

Smooth position overlays are the final plots of positions that accompany each smooth sheet. Normally, a smooth overlay is not plotted until after completion of the sounding verification phase (6.3.4); previously undetected errors are often discovered during sounding verification making necessary further adjustment of positional data.

6.3.3.1. Checking Machine-Plotted Positions. A sufficient number of machine-plotted positions on each smooth sheet shall be checked to ensure overall plotting accuracy. Each position need not be checked — the number of positions to be checked is a judgment matter. Checking methods depend on the positioning system used for the survey.

Visual sextant fixes are checked by plotting positions with three-arm protractors. (See A.9.1.1.) Plastic protractors cannot be adjusted and should be checked for error at least daily when in use. Index and other scale errors can be determined and applied to observed angles for accurate plotting or checking of positions. Plastic protractors have a tendency to warp, particularly near the ends of the arms; the usable portion must be determined and marked or the fiducial line rescribed. Plastic protractors may be used to the full limit of the arm length, but no protractor with an index error greater than 3 min either arm shall be used for verification or position plotting. To plot a three-point fix lying very near one of the three stations, one lays the three lines out on a piece of drafting film that can then be used as the protractor.

When electronic positioning systems are used in the range-range mode, positions are plotted or checked manually by using an Odessey protractor. (See A.9.1.2.) The concentric circles inscribed on the transparent plastic base permit placing the center over the position by measuring the proper increments from each of the nearest distance circles. Before using an Odessey protractor, the circular scales must be checked carefully with a beam compass and meter bar, taking into account the system operating frequency and resultant lane width.

Plotting and checking a position determined by a hyperbolic positioning system is best accomplished by scaling each line of position separately using a dependable variable scale device. Variable scales are available commercially. When only a few positions need to be plotted or checked, an engineer's scale can be used by skewing the scale between the plotted position arcs to match the scale values with the difference in arc values.

6.3.3.2. Resolving Erroneous Visual Positions. Erroneous sextant positions will normally be resolved by the hydrographer in the field and the data corrected accordingly. Resolution of undetected errors becomes the verifier's responsibility.

When a "split fix" (two angles without a common center object) is observed in the field, a pseudo three-point fix must be created to provide suitable input for a machine plot. An observed position is plotted by constructing the intersection of the loci of the angles. Then the values for a legitimate three-point fix are scaled from the sheet for use on the next plot.

When only one angle was recorded or accepted, the position of the vessel must be plotted on the locus of the angle at a point that coincides with the speed and course made good. The quality of a position of this nature depends on the vessel maintaining a steady speed and course and on the geometric strength and accuracy of the single line of position. It may be necessary to defer the determination of final positioning values until the sounding overlays have been constructed (6.3.4) so as to adjust the soundings to be in agreement with other surrounding hydrography. If a series of positions cannot be resolved, it may be necessary to reject that portion of the sounding line. "Swingers" and other geometrically weak fixes (4.4.2) that are detected and noted during the machine-plotting phase receive similar treatment as positions for which only one angle was observed.

Estimated positions are used when the hydrographer could not observe a strong three-point fix — such positions must be verified with a suspicious and critical eye. Estimated positions are often used close inshore where normal fixes are not available. The distance from a beach, structure, or station should have been estimated and entered in the re-...
cords. Positions of line ends and beginnings can be plotted by dead reckoning on the extended line, provided that a speed change affecting the positioning interval did not occur during the period over which the last three reliable fixes were taken.

Structures and objects such as beacons, buoys, rocks, and piers are often referenced in the sounding records (by distance and direction) when the survey vessel passes the feature. These notes, to provide a check on the survey, must state positively on which side of the object the launch passed and the time of occurrence. See figure 4–24 (4.8.3.1) for an example of a proper entry where "can buoy 7" was 20 m abeam of the survey vessel at 20h 31m 50s GMT. Skillful evaluation of the data is required to resolve the occasional discrepancies that can result from such estimates. Survey vessels often cannot safely get close to rocks and reefs when locating them. In such cases, the vessel stands off the feature, several positions of the vessel are taken, and a distance and direction to the feature are estimated from each position. When possible, sextant cuts or bearings to the feature should have been observed. When estimated positions disagree, a verifier must evaluate whether an incorrect estimate was entered or other "standoff" positions were determined and plotted, yet inadvertently not recorded.

Estimated positions are often used to plot soundings observed after a vessel makes a sharp turn then continues to record soundings. The forward momentum of a vessel varies with its size, hull shape, and speed; such variations should be reflected on field plots and by information provided by the hydrographer.

Occasionally, good fixes are not available, especially when sounding in narrow winding waterways. A hydrographer in such cases should have estimated the vessel position on the field sheet, using the adjacent features of the shoreline as a reference—in such cases, the note "See field sheet" (SFS) will have been entered in the sounding records. To machine plot an estimated position, a verifier must scale a pseudo fix if not already determined by the hydrographer.

Human blunders contribute heavily to the occurrence of sextant position errors. In most cases, erroneous positions can be salvaged if the contributory cause can be recognized. Original data shown in the field records must never be erased or otherwise obliterated; a single line is used to cross out erroneous data, and the revised or corrected data are entered above or alongside in a clear and concise manner. Typical errors that repeatedly occur in recorded positional data include:

1. Entry of an incorrect station number for an observed object because:
   a. A change in observed objects was not reported or recorded;
   b. A recorder misunderstood the station number; or
   c. A wrong object was observed or a signal misidentified.

2. Minutes and degrees of an observed angle were reversed (e.g., an observed angle of 30°50' was recorded as 50°30').

3. Transposition of numbers (e.g., an observed angle of 54°30' was recorded as 45°30').

4. A sextant angle was read incorrectly. Angular errors commonly result from misreading an adjacent vernier division by 20 or 30 min, depending on the type of sextant. Other misreading errors include: 10' on the drum of a Navy-type sextant; 1° on any sextant; 2°, 4°, or 6° when a 1°, 2°, or 3° increment is erroneously applied on the wrong side of the longer 5° or 10° division; 5° and 10° for the same reason as for 10', 20', 30', and 1°. Although errors of this nature occur repeatedly in field observations, recorded angles must not be corrected or adjusted unless the substituted value is confirmed by other factors.

5. A recorder may have misunderstood the reported value of an observed angle and recorded a 15 for a 50, a 7 for an 11, a 5 for a 9, or vice versa.

6. A station position may be in error. Occasionally, a more careful evaluation of a control station location by hydrographic methods may disclose previously undetected errors.

6.3.3.3. RESOLVING ERRONEOUS ELECTRONIC POSITIONS. These positions stem from a multiplicity of causes, many of which admittedly remain unknown. Weak positions occur on electronically controlled surveys when the hydrographer pushes the control system beyond the limits of geometrically strong intersections and acceptable lane widths. When discrepancies between visually controlled and electronically controlled hydrography occur in junctional areas, visual observations are usually more reliable and are generally accepted. See section 4.4.3 for a discussion of potential sources of
VERIFICATION AND SMOOTH PLOTTING

errors in electronic positioning systems.

When discrepancies in electronic positions occur, one or more of the following actions usually will identify the source of error:

1. Check carefully both digital and analog (sawtooth) position records for indications of lane jump, dial roll, erroneous recording of values at positions, and evidence of external interference.

2. Check for line-of-sight obstructions that may have been present between shore stations and the vessel, for indications of landmass-induced signal attenuation, and for evidence of electronic signal reflection.

3. Review and check each calibration observation and computation.

4. Determine whether the position is geometrically strong based on the angle of intersection of the lines of position and the lane divergence factor.

5. Check shore station elevations to determine if significant slant range corrections to the observed electronic values are needed.

Every effort must be expended to resolve questionable electronic positioning data; however, changes to correction values applied by the field party should be made only with sound justification, and must be thoroughly documented and supported in the verifier's report.

6.3.4. Verification of Soundings

This verification to be plotted on smooth sheets is one of the most detailed and arduous phases of final data processing. As is the case in position verification, successive sounding overlays are machine plotted, each new needed overlay being a corrected and refined version of its predecessor. In areas where intensive investigations result in a density of soundings that would cause confusion and congestion if all were shown at the smooth sheet scale, excess sounding overlays are used as necessary. In addition, other plotted soundings that cause congestion and do not reveal important information for the delineation of bottom features should be considered excess and deleted from the plot. Although the information shown on sounding overlays must be displayed in a neat manner, the emphasis should be toward accuracy and completeness. Preliminary sounding overlays are work sheets and do not demand the more exacting drafting standards required for smooth sheets. These overlays provide verifiers with a graphic means of viewing the final results of his checks and his applications of depth corrections, junctional soundings, shoreline and datum line comparisons, depth contours, topographic detail, and for determination of the existence of previously undetected deficiencies or errors.

6.3.4.1. SOUNDING OVERLAYS.

6.3.4.1.1. Preliminary sounding overlay. In contrast to a field sheet, which is plotted during survey operations (using preliminary and possibly uncorrected data), a preliminary sounding overlay is plotted using corrected data. Before the initial preliminary sounding overlay is plotted, the verifier shall make every effort to eliminate errors and shall take the actions necessary to ensure that the plot will conform with hydrographic standards and specifications. Preliminary sounding overlays and their accompanying excess sounding overlays are used to detect and correct errors in the observed hydrographic data and any other errors that may have occurred. Original data must not be adjusted or altered unless the changes are justifiable and can be supported by other evidence. When completed, sounding overlays should have all discrepancies resolved insofar as practical. Except for the degree of neatness and totality of detail, sounding overlays should closely resemble a completed smooth sheet.

Specific actions to be taken prior to producing a sounding overlay include:

1. Tidal or water level reducers entered in the computer listings for application to soundings must be checked against verified tidal hourly heights or verified water levels. Whether time and range corrections are to be applied to hourly heights must be decided. Final determination and application of correct tidal or water level reductions to soundings is the responsibility of the Marine Center.

2. Velocity and transducer (TRA) corrections (4.9) and the Abstract of Corrections to Echo Soundings [5.3.5.(D)] compiled by the field unit and included in the survey Descriptive Report must be carefully checked. Some of the errors more frequently encountered include algebraic sign reversals, faulty interpretation and abstraction of correction data, and corrections entered in an improper format or applied to the wrong vessel.

3. Analog depth records and digital depth listings shall be reviewed for the accuracy and adequacy of the soundings selected to portray the bottom. Particular attention must be given to the
HYDROGRAPHIC MANUAL

time, placement, and scaling of least depths, compensation for wave action, and the interpretation of questionable traces, side echoes, or strays. All corrections to soundings are entered in the data file and applied before the sounding overlay is plotted.

4. On inshore surveys, preliminary position overlays and accompanying field sheets are used as guidance for the placement of needed insets and subplans to the best advantage. Areas where intensive development of the bottom was conducted are examined to determine how many excess sounding overlays will be needed to show all soundings clearly. On offshore surveys where the depth unit is fathoms, the overlays are used as guidance when selecting the proper depth unit and to determine whether sounding numerals need be rotated to avoid deleting (as excess) too many soundings. At this stage, revisions are made to the projection parameters to center the hydrography within the edges of the final smooth plot.

5. Verifiers shall review each Descriptive Report and other related reports to become completely familiar with all field records connected with a survey. As the verification progresses, revisions and appropriate explanatory notes that affect the completed survey are penciled lightly in the Descriptive Report. Following approval of the survey by the appropriate Marine Center review board and prior to final administrative approval, the penciled notes and changes are inked.

6.3.4.1.2. Excess sounding overlays. These are assembled for the following basic purposes:

1. To avoid confusion and congestion of soundings in areas of intensive hydrographic development.

2. To show all soundings that are in the records but are not plotted on the regular sounding overlay or smooth sheet.

3. To show soundings that influence the delineation of depth contours.

Soundings are generally excessed by computer subroutines for preliminary plots, but the verifier should not hesitate to reinsert excessed soundings where he believes a better choice could have been made. The most critical soundings must be shown on the regular sounding overlay and on the smooth sheet; the less critical are shown on the excess sounding overlay to clarify certain bottom features, reveal discrepancies, and (if necessary) justify the placement of depth contours. Final listings or printouts of sounding data shall indicate which soundings have been exceeded.

6.3.4.2. DATA LISTINGS AND PRINTOUTS. When checking and correcting hydrographic data listings and computer printouts, each verifier uses a code to identify his work; when more than one work phase is completed on a single listing or printout by one verifier, each phase is to be marked in a different color. Raw field data listings, final data listings, and new verification data-processing printouts must accompany each survey. Required listings include:

1. All raw data listings, including those with revisions to original entries—such listings or sounding volumes (if used) become official survey records and are archived accordingly.

2. Final computer printouts corresponding with the final position overlay, smooth sheet, and excess sounding overlays.

3. A finalized listing of all horizontal control stations.

4. Velocity and TRA corrections and final verified data listings of tide or water level reductions.

5. Additional listings and printouts, as needed, to clarify the resolution of unusual conditions or problems encountered during verification.

Other preliminary intermediate listings and printouts may be destroyed with the approval of the appropriate Marine Center review board following final inspection. (See chapter 8.)

6.3.4.3. CROSSLINES. Regular systems of sounding lines are usually supplemented by a series of crosslines to check positional accuracy and validate soundings. (See 1.4.2 and 4.3.6.) Systematic crossing discrepancies usually indicate a fault with the sounding equipment, which requires study to determine the most probable cause and proper corrective actions. Sounding discrepancies caused by horizontal displacement may be attributed to questionable control. Otherwise, discrepancies may be caused by one or a combination of factors involving the observation or compilation of control, echo-sounding corrections, or faulty reductions to the datum of reference.

Allowable differences in depths at crossings are based on the amount of horizontal displacement corresponding to the difference in depth, rather than a set percentage of the depth. Generally, in area of flat or gently sloping bottom and in depths of less
than 20 fm, discrepancies of one unit in feet or 0.2 units in fathoms can be expected occasionally; and, except where the natural delineation of depth curves is affected, such differences do not justify extensive investigation. Where considerable areas of hydrography are in disagreement, the verifier must carefully review each phase of the survey to resolve the problem satisfactorily; his report shall point out all unresolved discrepancies and include cross references as needed.

6.3.4.4. DEPTH CURVES. With the excess sounding overlays in proper registry with the preliminary sounding overlay and with their soundings taken into consideration, depth curves are first penciled lightly on the preliminary sounding overlay by the verifier. No single requirement for the spacing of these study curves can be prescribed for all areas and water depths, but they must be spaced closely enough to delineate the bottom configuration completely and accurately. Depth curves are indispensable for interpreting and examining a hydrographic survey; drafting closely spaced depth curves carefully and accurately requires inspection and consideration of each sounding. Merely delineating the standard curves specified in tables 4–5 and 4–6 is generally inadequate for study purposes. When drawing depth curves, incorrect soundings are easily detected; anomalous or improbable configurations are strong evidence that a further investigation of the plotted soundings is required.

The ability to represent submarine relief by means of depth curves is acquired only by training and experience. The shoalest depth curves should be drafted first, then continued in sequence to the maximum depths. To avoid confusion, a verifier should always bear in mind that he is separating shoal water from the deeper water; depth curves generally are drawn to include soundings of equal depth or less. When completed, depth curves should be continuous and extend to the limits of hydrography or approach the shoreline. Depth curves must never overlap, touch, or be drawn through a numeral or symbol. Lines are broken at soundings as necessary to avoid unnatural bottom configurations. Verifiers should not overlook a hydrographer's interpretation of depth curves, particularly those he drew using his local knowledge and direct observations.

Depth curves should eventually delineate natural bottom configurations. From a cartographic viewpoint, minor irregularities in soundings should not be overemphasized. Significant bottom features, however, should not be masked by injudicious smoothing of the curves. When more than one interpretation of depth curves can be deduced from the available sounding data, the depth curves shall be the most prudent representation from a safe navigational standpoint.

Preliminary study depth curves, which are drawn in pencil, must rigorously follow the soundings so as to graphically depict potential deficiencies. Because sounding overlays are used as guidance when constructing smooth sheets, the colors and conventions prescribed for standard depth curves are to be followed. (See 7.3.9.)

Plotting halves of sounding units on the sounding overlay is occasionally desirable in flat or gently sloping bottom areas to eliminate unnatural depth curves.

6.3.4.5. LEAST DEPTHS. Variations in newly determined least depths from previously surveyed values must be investigated in detail. Analog depth records and position data must be closely scanned and checked for errors or omissions. The Descriptive Report must be reviewed to see if the hydrographer made specific mention and recommendations concerning the feature. Occasionally, shoalest soundings are overlooked and not included in the digital data, or erroneous corrections were applied to the observed depths. A verifier must also evaluate whether or not an adequate search was made to determine a least depth. Significant differences with prior survey least depths not mentioned in the hydrographer's portion of a Descriptive Report shall be included in the verification report.

6.3.4.6. PHOTOBATHYMETRY. Water depths and bottom curves are often obtained by photogrammetric methods where the water is shallow and clear. (See 3.2.1.) Photobathymetric surveys are particularly advantageous in areas where coral pinnaclcs or other formations prevent running systematic patterns of sounding lines or prove dangerous to shallow-draft sounding launches. In most instances, photobathymetry will junction with or overlap conventional hydrography; but when two sounding methods are used, occasional conflicts are expected and must be resolved during the verification process. Merging these data together can best be done on the sounding overlay after the hydrographic data have been verified. When discrepancies between hydro-
graphic and photobathymetric data arise and cannot be resolved by a combined review of the work by the verifier and the photogrammetrist, the hydrographic data are generally accepted.

Soundings and other details on the transparent photobathymetric overlay are transferred to the sounding overlay only when necessary for adequate verification. Photobathymetric data, however, are shown on the smooth sheet in accordance with section 7.3.8.3. Where junctional discrepancies cannot be resolved, the most reliable soundings shall be retained and a butt junction made. Photobathymetric information generally is compiled on the topographic or shoreline survey of the area. A copy of the report that describes the compilation shall be attached to the Descriptive Report of the hydrographic survey.

6.3.4.7. COMPARISON WITH ADJOINING SURVEYS. After a preliminary sounding overlay has been plotted, the verifier shall make a comparison with adjoining contemporary surveys to determine the completeness and relative agreement of the hydrographic findings. Descriptive Reports for adjoining surveys should be inspected to guard against gross errors in velocity of sound corrections. A hydrographer's interpretation of the comparisons stated in the Descriptive Report must be reviewed. It must be borne in mind that a hydrographer's evaluation may have been based on preliminary uncorrected data. Consistent differences in soundings, corresponding displacements of depth curves, and gaps in coverage must be described in the verifier's report. If a survey is incomplete, deficiencies shall be noted for investigation when field work on the project is resumed.

In a satisfactorily completed junction, depth curves must be in coincidence, soundings necessary to further define depth curves must be accurately transferred, and depths must be in good agreement. If depth curves and depths do not agree because of bottom changes or other causes, a butt junction is generally made. In this case, a dashed line is drawn in color to show the butt junction, and a note in the same color is entered to indicate the superseded soundings.

6.3.5. Verification of Shoreline, Hydrographic, and Topographic Features

On inshore surveys, preliminary position overlays and preliminary sounding overlays shall be compared in detail with the appropriate shoreline manuscripts to detect and resolve discrepancies in the shoreline, reference datum line (MLW, MLLW, LWD), and other hydrographic and topographic features shown thereon. Class I (final) shoreline manuscripts must be used for this purpose. Shoreline manuscript data need not be transferred to the overlays. Satisfactory comparisons can be made merely by placing one transparent sheet in registry over the other. Depending on the complexity of the survey, on the amount of shoreline and topographic details, and on the revisions recommended by the hydrographer as shown on the field sheet and in the Descriptive Report, one may find it desirable or necessary to transfer data from the shoreline manuscript to the sounding overlay for satisfactory comparison and evaluation. In this case, the cartographic standards and symbolization specified in chapter 7 for smooth sheets should be followed, although minor departures may be made for expediency.

Although all discrepancies between photogrammetric surveys and hydrographic surveys should have been resolved in the field, some occasionally escape detection or are not resolved clearly and concisely. Resolution of these discrepancies rests with the verifier if the hydrographic field unit has left the area. There are no set rules—only generalities can be stated as guidance toward a satisfactory solution.

Photogrammetric locations of shoreline, reference datum lines (MLW and MLLW when determined by tide-coordinated aerial photography), and objects awash or that uncover at the charting datum are usually more accurate and are accepted over hydrographic locations—unless there is unmistakable evidence of error in the shoreline manuscript. Errors in rock positions are among the most common. A verifier must examine carefully all available records to ascertain whether there are actually two rocks or whether the same rock is being shown at two locations. When a feature is clearly visible on aerial photographs and its position on the shoreline map has been verified, the photogrammetric location generally holds; however, if a hydrographer detected and investigated a discrepancy in the field and resolved it satisfactorily, the hydrographic determination takes precedence. In cases where a feature was located in different positions by two different methods (each appearing reliable), the feature must be shown at both positions in the interest of safe navigation. Additional field investigations shall be recommended by the verifier to resolve such discrepancies.

Positions of submerged features or breakers and the notes relating thereto generally should be
accepted from the hydrographic data if it has been determined that the identical feature is involved. Exceptions to this policy may be exercised when a submerged feature was determined during the course of a photobathymetric survey. Elevations of bare rocks or rocks awash are accepted from the most credible source. Proximity to the feature, if known, and availability of accurate tidal or water level data at the time of observation will help determine credibility. Verifiers must be sure that the elevation shown for each rock has been accurately corrected for tidal or water level stage. Supervisors should check a sampling of rock elevations on applicable sheets to ensure accuracy.

6.3.6. Wire-Drag Comparisons

If wire-drag surveys have been made in the area, the results of the two surveys shall be compared and correlated. Except where a hydrographic survey has revealed shoaler soundings, items such as verified soundings, groundings, bottom characteristics, and wreck or obstruction notations are transferred from wire-drag surveys. Such data are entered in green ink; the grounding circle is omitted. Wire drag clearance depths are not transferred. Each discrepancy between hydrographic survey soundings and wire-drag effective depths must be resolved. Notation of features transferred to the smooth sheet shall be made as described in section 6.3.7.3. (See figure 7-7.)

6.3.7. Prior Survey Data

6.3.7.1. COMPARISON WITH PRIOR SURVEY DATA. The most recent prior hydrographic surveys of the area used for charting most of the soundings shall be carefully compared with the present survey. This comparison serves two important purposes. Primarily, it is necessary to determine whether the present survey is adequate to supersede prior surveys, and the comparison is used to transfer important data needed to supplement the new survey. Secondly, the comparison serves to reveal whether the character of the bottom is stable or transient; it provides a record of bottom changes that may be useful when scheduling future revision surveys.

6.3.7.2. EVALUATING PRIOR DATA. When comparing a prior survey with a new survey, differences in least depths, individual depths, general hydrography, and in other details are often revealed. Some differences are caused by natural changes, cultural changes, or by errors in plotted data. Since each significant difference must be evaluated, the survey verifier must carefully judge each case before accepting or rejecting data. Each verifier must be thoroughly familiar with procedures and techniques used in hydrographic surveying and expected accuracies since NOS began hydrographic surveying in 1834.

Unless there is sufficient evidence to show otherwise, the most recent basic survey findings will supersede prior survey data. When a discrepancy is discovered that cannot be resolved logically, extensive research into the prior survey records to prove or disprove data will not be undertaken. When doubts arise as to which information will be shown on a smooth sheet, the safest and most conservative course, from a marine navigational viewpoint, shall be taken.

6.3.7.3. RETENTION OF PRIOR DATA. Important soundings or features on prior surveys that were neither verified nor disproved by a new survey shall be brought forward and shown on the new smooth sheet. (See figure 7-7.) The notation "from H——— (year)" shall be placed near such items with a leader and arrow pointing to the sounding or feature. Where transferred items are scattered over large areas of the smooth sheet, a group notation "Detached Soundings in (color) (east/west of longitude X) from H——— (year)" shall be placed in a marginal area, preferably near the title block. Slanted lettering is to be used for all such notes. Red ink is preferred if not already used for photobathymetry, but most other colors may be used as necessary. The color selected should uniquely identify the intended source. The repetitive use of a particular color to identify data carried forward from several sources may cause confusion in determining the actual source of retained prior survey information. If all available colors have already been utilized, then the group notation should be appropriately formatted so as to eliminate confusion. One suggested format is: "Detached soundings in (color) (east/west of longitude X) from H-xxxx (19xx)."

It is emphasized that the note should clearly and uniquely state the source of the retained prior data. Green ink is reserved for wire drag survey data brought forward. Notations for wire-drag surveys are indicated by the initials "WD" entered after the year.

Locations of important shoals, rocks, and other obstructions and their least depths shall be compared. When differences in position are found for the same feature, the reliability of the present method of location must be evaluated with respect to earlier methods; the most probable position should be accepted. If the least depth on a permanent feature is neither verified nor disapproved by a survey, the prior or least depth must be transferred. Wherever possible,
shoalest depths from both surveys are shown; but if there is insufficient space on the smooth sheet, the deeper of the two should be treated as an excess sounding and not shown. If a retained sounding is from a prior survey, the note "Least depth—(units) from present survey" is to be added to the present survey in black ink with a leader indicating the feature.

Occasionally, a group of soundings must be transferred from a prior survey to complete hydrography in a gap or small unsurveyed area of a new survey. Similarly, a new survey may have to be supplemented by transferring ledge, reef, or rock delineations if both the new hydrographic and photogrammetric surveys are deficient.

When rocks shown on a prior hydrographic or topographic survey have not been verified by the new survey, have been located in a slightly different position, or are somewhat different in character, all available information should be consulted and the following rules applied for disposition of the feature:

1. If the position of what is presumably the same rock differs between a present and a prior survey, the newer position is generally accepted as correct provided the positioning method is considered to be more accurate and conclusive.

2. When an adequate examination made during the present hydrographic survey in the vicinity of a rock or rocks shown on the prior survey fails to disclose or verify existence of the rock, the disposition recommendation made by the hydrographer should be followed.

When general statements in a Descriptive Report indicate that certain rocks shown on old surveys could not be found, these rocks should not be deleted but should be transferred either as rocks awash or as submerged rocks, depending on the circumstances in each case. Without proof of an adequate examination, general statements of this nature can be accepted only as evidence that such rocks were not visible at the time of a cursory examination.

3. Bare rocks on a prior topographic or hydrographic survey that are not shown or are not disproved on the new hydrographic or topographic survey should be carried forward as rocks awash unless more specific information is available.

4. Rocks shown as being awash on a prior survey but shown as being submerged on a new survey, should be considered to be rocks awash (the safest course) unless the new survey shows clearly that the rock was not visible at the low water datum or unless it is known that submergence has occurred since the last survey. When revising a new survey, the rock awash symbol is shown in black ink and a note made in the sounding record.

5. Submerged rocks shown on prior surveys, when not disproved by the new survey, should be carried forward with caution. On some prior surveys, submerged rock symbols may have been used to indicate rocky bottom areas rather than individual submerged rocks that are dangerous to navigation.

6. Generally, the delineation inshore of the reference datum line on the new survey should be accepted as correct — except that significant rocks shown awash on prior topographic or hydrographic surveys which were neither located nor disproved on the new survey should be brought forward in an appropriate color.

6.3.8. Geographic Datums

Verifiers shall identify the geographic datum to which a prior survey was referenced and make adjustments as necessary to permit comparison at the datum used for the most recent survey.

During the early years of survey operations, many detached triangulation networks were established in the United States — each referenced to a datum based on independent astronomic observations within the network. Hydrographic and topographic surveys conducted within such areas consequently were based on these independent local datums. Upon completion of the first transcontinental arc of triangulation, the various detached networks were connected, then a coordinated network based on a single geographic datum was established for the whole country. Station MEADES RANCH in central Kansas was selected as the reference point for this single geodetic datum. In 1901, the adopted datum was officially named the "United States Standard Datum." When Canada and Mexico adopted this datum, it was renamed the "North American Datum."

In 1927, a unified adjustment of all first-order triangulation in the United States was initiated, and the "North American Datum of 1927" was adopted. Use of this datum has been extended into Alaska where several independent datums previously had been used. Modern hydrographic surveys in waters bordering the continental United States are now made on this geographic datum. Surveys in the Caribbean Sea areas, the Hawaiian Is-
VERIFICATION AND SMOOTH PLOTTING

lands, and other South Pacific islands may be based on independent datums; these are specified in the project instructions.

Many older hydrographic surveys list the geographic position of a triangulation station that lies within the surveyed area. Positions of these stations were shown in the lower margin of the sheet; however, the reference datum was not always indicated. On later surveys, both the geographic position of the reference triangulation station and the geographic datum were listed.

6.3.9. Datum Ticks

Before comparing surveys made in various years, the geographic datums must be correlated. Never assume that an unlabeled projection on an older survey was referenced to any specific datum—differences in datums must always be determined before comparing surveys or transferring data. The U.S. Standard or North American Datum was shown by a complete projection (in color) on many of the older surveys. Others (figure 6-1) show only one or two marked projection intersections (ticks) on the U.S. Standard Datum or the NA Datum of 1927.

If a prior survey does not show the NA 1927 Datum, this datum shall be established before transferring data to the new survey. To establish the NA 1927 Datum, select at least three widely separated triangulation stations within the sheet limits for which geographic positions are available on the NA 1927 Datum. Two methods can then be used to determine the datum differences:

1. Geographic position data used for plotting an original survey are best determined from old registers, records, or publications. The mean of the differences between positions on the NA 1927 Datum and the datum used for an older survey is the correction to be applied. Position differences for each of the three stations should be nearly equal. If a significant variance is found, an investigation should be made for possible errors in computations or for failure to identify common stations on the two datums. The position of the NA 1927 Datum relative to the original projection can be determined by back plotting NA 1927 values for one of the triangulation stations or by following the rule that, if the latitude (N) and longitude (W) on the old datum are greater than the corresponding values on the new datum, the new projection will be north and west, respectively, of the old projection. If the old values are smaller, the datum shift is to the south and east.

2. This method is applicable where geographic position data used for plotting the selected triangulation stations on the prior survey are not available. A graphic method of determining the datum differences is used. Arcs based on the NA 1927 values of latitude and longitude are swung from the selected triangulation stations shown on the survey, and tangents to the arcs are drawn parallel to the projection. Datum differences between the tangents to the arcs and the original projection can then be scaled. An average of the differences is used to plot the datum tick.

Extreme care shall be exercised when determining the proper relation of the NA 1927 Datum to the original projection. Distortion in the original projection must be measured and applied carefully to all distances plotted. Plotting of the datum tick (in colored ink) is to be verified by another person. Each person enters initials and the date beside the tick. Each tick shall be identified by latitude and longitude and be labeled "NA 1927 Datum." If only approximate datum differences can be determined, the datum tick note includes the abbreviation "approx."

6.3.10. Chart Comparison

The verifier shall carefully check the hydrographer's comparison of the survey with the chart for errors or omissions. Comparison of the survey sheet with the chart by the verifiers shall be with the edition of the chart as listed in the project instructions. (See 5.3.4. (L.).) Charted items that were disposed of satisfactorily during the compari-

FIGURE 6-1.— Change of datum shown on a hydrographic sheet

6-13
(JUNE 1, 1981)
son with prior surveys need not be repeated here. Extensive research to resolve apparent discrepancies is not usually required of the verifier, particularly if an item was charted by approximate position or depth based on reported information. Marine chart compilers have more complete information on such items and are better equipped to make appropriate charting judgments. Such items, however, shall be individually identified and reported by the verifier.

Errors, omissions, and additional recommendations are to be tabulated and entered in the verification reports (6.6); references to these data must be entered in paragraph L of the Descriptive Report text. (See 5.3.4.) To avoid confusion, a chart section identifying the items may be submitted with the list. If the comparison reveals an uncharted danger or condition important to navigation not previously reported, the feature must be reported immediately by radio telephone or telegraph to the nearest Commander, U.S. Coast Guard District with a copy to the Chart Information Branch, OA/C322, for possible inclusion in the next Notice to Mariners. (See 5.9.)

6.4. QUALITY CONTROL

Procedures for quality control shall be developed by each Marine Center or other processing area to ensure that the procedures established for verifying surveys are sound and are so designed to assure that the final product meets the specifications prescribed for smooth sheets. (See chapter 7.) It must be emphasized that the quality of survey verification extends beyond specifications and depends primarily on the methods and thoroughness of the verification processes. Final approval of a verified survey by a Marine Center indicates that adequate verification and inspection have been performed. Hydrographic surveys that fail to meet the requirements of this manual and of the project instructions shall not be submitted to NOS Headquarters without specific recommendations for additional field work.

6.5. COMMON DEFICIENCIES OF VERIFIED SURVEYS

These can be grouped into three general categories: (1) inadequate or inaccurate field data with which a verifier has to work, (2) unrecognized or unresolved discrepancies in the field data, and (3) substandard verification practices and procedures.

Some faults lie in lack of training or careless supervision—others reflect the aptitude of the verifier and his attitude and approach toward the work. To produce a verified survey and smooth sheet that will conform to National Ocean Survey standards, a competent verifier should have had field experience and must be thoroughly familiar with all parts of this manual.

The following is a partial list of the most common deficiencies on both manual and automated surveys:

1. Positions were plotted incorrectly because of improper editing of logged positional data or because of failure to calibrate or register the automated plotter.
2. Errors in recorded observations of any kind were not detected and corrected.
3. Signal location errors or misidentifications were not detected.
4. Positions of signals were entered or plotted incorrectly.
5. Sounding line positions plotted from weak fixes were not properly adjusted to conform to supplemental information.
6. Soundings are spaced incorrectly (e.g., at the inshore end of a line or where a line began from a standing start, where a line began or ended on an uneven position or sounding interval, and where the spacing does not agree with recorded speed or course values).
7. Soundings were selected poorly or improperly to portray a complex feature.
8. Soundings have been spaced at excessively wide or unnecessarily close intervals.
9. The shoreline has been transferred inaccurately, and various symbols (particularly rock symbols) have been drafted carelessly.
10. Depths appearing erroneous or excessive differences at crossings were not checked.
11. Analog depth records were misinterpreted; erroneous digital depth values in kelp or grass were not corrected; soundings were not adjusted for the effects of strays or sea conditions.
12. The shoreline has been transferred to a smooth sheet from other than class-I shoreline manuscripts.
13. A feature is shown at two locations.

(JUNE 1, 1981)
14. Sounding corrections were determined or applied incorrectly.
15. Erroneous elevations were determined for rocks or were incorrectly reduced to the chart datum.
16. Depth contours have not been shown in accordance with standard NOS conventions.
17. Bottom characteristics have been overly condensed and significant information omitted.
18. Inshore sounding lines parallel to the shoreline do not follow the actual path of the vessel.
19. Erroneous tidal or water level reducers were applied.
20. Soundings were not corrected for instrument errors.

6.6. VERIFICATION REPORTS

When a hydrographic survey verification has been completed, a verification report shall be prepared and appended to the Descriptive Report. The verification report is a summary of pertinent facts about a survey and an evaluation of the detailed comparisons made with prior surveys and the charts. The report shall include a description of unusual processing procedures, major changes or adjustments to data, and a list of complete work statistics. Specific statements must be included that evaluate the adequacy of the survey to supersede prior survey data and charted information. The verification report serves as a guide to the chart compiler and identifies areas where additional field work is needed to satisfactorily complete a survey. Subject matter pertinent to the report should consist of the following:

1. NOAA Form 77-27, "Hydrographic Survey Statistics." (See figure 6-2.)
2. A narrative account of the verification procedures and findings.
3. Documentation of all problems encountered and nonstandard procedures used during verification of the survey. Justify any procedure that may have compromised the quality of the data.
4. Statement(s) as to whether any of the following data entered in the Descriptive Report by the hydrographer were revised during verification: (a) projection parameters, (b) electronic position control parameters, (c) list of stations, (d) tide or water level reduction values, and (e) corrections to soundings. If the revisions were not entered on the Descriptive Report listings by the verifier, include them here.
5. Copy of the Headquarters-approved tide or water level note, as appropriate.
6. Reports or notes needed to understand the survey or to clarify procedures or results.
7. Control and shoreline. When the origin of the horizontal control is described adequately in the Descriptive Report, reference the pertinent section. If necessary, add supplementary information determined during verification.
8. Hydrography. Make a summary evaluation of the hydrography. Include specific statements regarding agreement of soundings at crossings and completeness and confidence with which depth contours could be drawn. List any discrepancies with respect to photogrammetric surveys. A statement is to be made evaluating the adequacy of development of the bottom configuration and the determination of least depths. Each significant deficiency shall be described.
9. Condition of survey. Comments in this submission are directed toward deficiencies in fieldwork procedures, in the survey records, and in the Descriptive Report. Mention specifically each case where a procedure was erroneously used or failed to comply with the requirements of this manual or other pertinent documents. Include constructive criticism that should be brought to the attention of the hydrographer. If the condition of the survey is found to be satisfactory, state only that the smooth sheet and accompanying overlays, hydrographic records, and reports are adequate and conform to the requirements stated in this manual.
10. Junctions. Adjoining surveys are referenced by registry number, year, and their position relative to the present survey. Junctions shall be evaluated and their adequacy discussed. Important irreconcilable discrepancies must be described and probable causes stated. Where butt junctions were necessary because of disagreements in depths, the condition shall be specifically described.
11. Comparison with prior surveys. In hydrographic surveys, the results of comparisons between the most recent prior survey and the present survey shall be summarized in a brief introductory
# Hydrographic Survey Statistics

**Hydrographic Survey No. H-9050**

(742 - 20 - 2 - 69)

**Records Accompanying Survey:** To be completed when survey is registered.

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<td>Descriptive Report</td>
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<td>Overlays (POS 1, Control 1)</td>
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**Office Processing Activities**

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**Pre Verification by:**

W. H. Guy, R. R. Hill, B. J. Stephenson

**Verification by:**

B. J. Stephenson

**Evaluated by:**

B. J. Stephenson

**Beginning Date**

- Pre-Verification: 4-30-70
- Verification: 5-19-75
- Evaluated: 6-20-75

**Ending Date**

- Pre-Verification: 4-24-75
- Verification: 6-20-75
- Evaluated: 7-7-75

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**Figure 6-2.** NOAA Form 77-27, "Hydrographic Survey Statistics"
A. All revisions and additions made on the smooth sheet during verification have been entered in the magnetic tape records for this survey. A new final position printout has/has not been made. A new final sounding printout has/has not been made.

Date: __________________

Signed: __________________

Title: Chief, Verification Branch

B. The verified smooth sheet has been inspected, is complete, and meets the requirements of the Hydrographic Manual. Exceptions are listed in the verifier's report.

Date: __________________

Signed: __________________

Title: Chief, Processing Division
paragraph. Changes in shoreline, bottom configuration, and general depths should be described. State whether such changes are attributable to natural, artificial, or less-detailed or less-accurate methods used during prior surveys. The magnitude of significant shoreline changes and bottom changes shall be indicated. Other items discussed individually that have been charted from the preceding survey or earlier surveys must be disposed satisfactorily.

In each discussion, there shall be a statement made that the prior survey is superseded — however, such a statement must be qualified when it is necessary to carry forward and retain specified details from a prior survey.

In wire-drag surveys, discuss separately the comparison made with wire-drag surveys. Comparisons shall be made with both contemporary wire-drag surveys that have been reviewed and prior wire-drag surveys in the area. Where there are no conflicts between present survey depths and effective depths of the wire-drag surveys, only a simple statement need be made to that effect. Discrepancies arising as a result of bottom changes should be identified as such. Wire-drag surveys, however, are not generally superseded by ordinary hydrographic surveys; thus statements to that effect need not be made.

12. Comparison with chart. The chart number and edition shall be entered beside this heading for ready reference. Discussion of the comparison is to be subdivided as follows:

a. Listing of the unresolved discrepancies between the new survey and the charted data. (See 6.3.10.) Do not include items discussed previously in the comparison with prior surveys or items that have been disposed satisfactorily by an adequate hydrographic investigation. Where charted data from sources other than NOS surveys have not been disproved by the present survey, a specific recommendation to retain the data on the chart should be made. The discussion should be concluded with a statement as to the adequacy of the present survey to supersede the charted hydrography. This statement may require qualification because of the verifier’s recommendation to retain certain charted features.

b. Controlling depths. Notes of controlling depths are usually based on data furnished by the U.S. Army Corps of Engineers. Discuss the comparison of the survey with these notes.

c. Aids to navigation. The adequacy with which the charted positions of aids to navigation mark the features or serve the purposes intended should be stated. Definite recommendations should be made when new unmarked dangers are noted or when shoals and channels have been shifted in position and are not properly marked by the charted buoys and fixed aids. Also, differences between the charted positions and present survey positions of nonfloating aids to navigation should be noted.

13. Compliance with instructions. Make a brief statement as to whether the survey adequately complies with the project instructions; note any significant exceptions.

14. Additional field work. Each survey is evaluated as an inadequate, an adequate, a good, or an excellent basic survey. Recommendations shall be made as to whether or not additional field work is needed. If additional field work is recommended, each item or area is to be clearly described or referenced to another specific discussion in the report. Further work, when needed, usually consists of examinations of shoal indications or of questionable charted information, disposal or clarification of discrepancies, and further development of outstanding features or inadequately developed areas.

15. An "Approval Sheet." This shall be included to attest that the verified and smooth-plotted survey, the Descriptive Report, and the verifier’s report have been inspected by a designated verification supervisor, and meets the requirements and specifications stated in this manual, except as noted. (See figure 6-3.)
A. All revisions and additions made on the smooth sheet during verification have been entered in the magnetic tape records for this survey. A new final position printout has/has not been made. A new final sounding printout has/has not been made.

Date: ________________

Signed: ____________________

Title: Chief, Verification Branch

B. The verified smooth sheet has been inspected, is complete, and meets the requirements of the Hydrographic Manual. Exceptions are listed in the verifier's report.

Date: ________________

Signed: ____________________

Title: Chief, Processing Division

FIGURE 6–5.— Verification approval sheet
paragraph. Changes in shoreline, bottom configuration, and general depths should be described. State whether such changes are attributable to natural, artificial, or less-detailed or less-accurate methods used during prior surveys. The magnitude of significant shoreline changes and bottom changes shall be indicated. Other items discussed individually that have been charted from the preceding survey or earlier surveys must be disposed satisfactorily.

In each discussion, there shall be a statement made that the prior survey is superseded — however, such a statement must be qualified when it is necessary to carry forward and retain specified details from a prior survey.

In wire-drag surveys, discuss separately the comparison made with wire-drag surveys. Comparisons shall be made with both contemporary wire-drag surveys that have been reviewed and prior wire-drag surveys in the area. Where there are no conflicts between present survey depths and effective depths of the wire-drag surveys, only a simple statement need be made to that effect. Discrepancies arising as a result of bottom changes should be identified as such. Wire-drag surveys, however, are not generally superseded by ordinary hydrographic surveys; thus statements to that effect need not be made.

12. Comparison with chart. The chart number and edition shall be entered beside this heading for ready reference. Discussion of the comparison is to be subdivided as follows:

a. Listing of the unresolved discrepancies between the new survey and the charted data. (See 6.3.10.) Do not include items discussed previously in the comparison with prior surveys or items that have been disposed satisfactorily by an adequate hydrographic investigation. Where charted data from sources other than NOS surveys have not been disproved by the present survey, a specific recommendation to retain the data on the chart should be made. The discussion should be concluded with a statement as to the adequacy of the present survey to supersede the charted hydrography. This statement may require qualification because of the verifier’s recommendation to retain certain charted features.

b. Controlling depths. Notes of controlling depths are usually based on data furnished by the U.S. Army Corps of Engineers. Discuss the comparison of the survey with these notes.

c. Aids to navigation. The adequacy with which the charted positions of aids to navigation mark the features or serve the purposes intended should be stated. Definite recommendations should be made when new unmarked dangers are noted or when shoals and channels have been shifted in position and are not properly marked by the charted buoys and fixed aids. Also, differences between the charted positions and present survey positions of nonfloating aids to navigation should be noted.

13. Compliance with instructions. Make a brief statement as to whether the survey adequately complies with the project instructions; note any significant exceptions.

14. Additional field work. Each survey is evaluated as an inadequate, an adequate, a good, or an excellent basic survey. Recommendations shall be made as to whether or not additional field work is needed. If additional field work is recommended, each item or area is to be clearly described or referenced to another specific discussion in the report. Further work, when needed, usually consists of examinations of shoal indications or of questionable charted information, disposal or clarification of discrepancies, and further development of outstanding features or inadequately developed areas.

15. An "Approval Sheet." This shall be included to attest that the verified and smoothly plotted survey, the Descriptive Report, and the verifier’s report have been inspected by a designated verification supervisor, and meets the requirements and specifications stated in this manual, except as noted. (See figure 6-5.)
7. SMOOTH SHEET

7.1. Definitions and Purpose

A smooth sheet is the final, neatly drafted, accurate plot of a hydrographic survey. In contrast to the field sheet plotted during field operations from preliminary field data, the smooth sheet is plotted from verified or corrected data. The smooth sheet and survey information shown thereon shall conform to the cartographic standards and conventions described in this chapter. Unless specified otherwise in the project instructions, verified hydrographic surveys are smooth plotted by the Marine Center Processing Divisions.

Each smooth sheet shall be accompanied by a smooth position overlay (6.3.3) drawn at the same scale. Smooth position overlays show each horizontal control station within the sheet limits that was used during the survey and all hydrographic positions that portray the sounding line system. Electronic position lattices are also shown provided the lines can be drawn without obscuring position dots and numbers. Otherwise, control stations and lattices must be drafted on separate horizontal control overlays. (See figures 7-6 and 7-7.)

Supplemental overlays are used for developments, insets, and excess soundings that cannot be shown on a basic smooth sheet in a clear and uncongested manner.

Following inspection and administrative approval, a smooth sheet becomes the official permanent graphic record of a survey and is the principal authority for hydrographic data to be charted. Smooth sheets are referred to frequently during chart compilation; photographic copies are often furnished to surveyors, engineers, geologists, lawyers (for use in the courts), and others with interests in marine surveys. Field sheets are usually discarded after final administrative approval of smooth sheets and Descriptive Reports.

7.2. General Specifications

7.2.1. Sheet Material

Smooth sheets shall be plotted only on stable polyester drafting films specifically authorized by the Director, NOS, for this purpose. Arkwrite Drafting Film No. 2102W (manufactured by the Diazo Specialty Company, Fiskeville, R.I.) or equivalent is approved. The film is 0.0075 in thick, semitransparent, and matte finished on both sides.

Overlays are constructed on 0.003-in-thick stable polyester drafting film that is semitransparent and matte finished on one side. Ageproof Polyfilm (manufactured by the Dietzgen Corporation, Des Plaines, Ill.) or equivalent is authorized for overlays.

Sheets must be protected at all times from creasing, defacing, or smudging. A protective cover should be kept over the entire sheet exposing only the small area where work is actually being done. Avoid getting fingerprints on plotting surfaces because ink does not adhere well to oily areas.

7.2.2. Sheet Size and Layout

Smooth sheet sizes shall conform to the specifications contained in section 1.2.4. Overlays should generally be the same size as the smooth sheets they accompany. Smooth sheet limits should conform closely to those shown on the approved sheet layout (2.4) with respect to area coverage, orientation, and size. Field sheet limits usually are compatible with smooth sheet limits. Small limit shifts shall be made as necessary to ensure sufficient margins (7.2.3) and space for title blocks. Occasionally, original sheet layouts must be modified when unforeseen factors are introduced during field operations. Most of these factors and considerations thereof are discussed in 7.2.3 and 7.2.4. Skewed projections should be considered to avoid using "dog ears" to show control stations beyond the sheet limits, and at other times when necessary for marginal requirements.

Smooth sheet scales are generally identical to those of the corresponding field sheets. In some cases, however, it may be desirable to smooth plot at a smaller scale to avoid an oversize smooth sheet or to combine two adjacent surveys. Authorization to plot surveys at reduced scales must be obtained from the Director, NOS. Such reductions may be authorized where:

1. A smaller scale will not significantly reduce the value of a survey.

(JULY 4, 1976)
2. Publication of a chart at a scale larger than the survey scale is not anticipated.

3. Hydrography has not revealed shoals or submarine features that cannot be shown adequately at reduced scales, on subplans, or on overlays.

Smooth plotting at scales larger than those planned is generally confined to subplans as described in section 7.2.4.

7.2.3. Sheet Margins and Extensions

When determining final smooth sheet sizes and limits of hydrography to be shown on each sheet, remember that soundings and other hydrographic information are not to be plotted closer than 7.5 cm (3 in) to the final cut edge of the sheet. Data plotted near the edges may become obscured or destroyed because of repeated handling. Marginal areas may also be needed for labeling projection line or electronic control lattice values. Space for the sheet title, about 15 by 20 cm (6 by 8 in), must be reserved. The exact placement of a tide block on a sheet is not critical and is selected where most convenient and attractive.

Although automated computation and machine drafting has largely reduced the need to plot each horizontal control station used to position a vessel, extensions of smooth sheets to show control stations beyond sheet limits must occasionally be used for manual position plotting and verification. (See 2.4.4.) When possible, oversize sheets should be used to include such control stations, then trimmed to a standard size following final inspection.

If an oversize sheet is impractical, control station may be plotted on "dog ears" that should not extend more than about 15 cm (6 in) from the edge of the sheet. They are attached securely to a smooth sheet or a smooth position overlay by applying strips of masking tape to the underside of the sheet.

When control stations necessary to manually plot hydrographic positions lie beyond the sheet limits, three fine-inked lines to each station are drawn on the sheet. These lines should intersect at the stations at geometrically strong angles and lengths so each station can be replotted accurately after final trimming of a sheet or removing the dog ear. Such leader lines shall be hand drafted to avoid effacing soundings and other hydrographic details. (See figure 7-1.) Each line must be annotated with the station symbol, number, and name.

FIGURE 7-1.— Smooth sheet, dog ear or temporary extension
shall show, in figures, the principal dimensions of the pier.

7.2.5. Drafting Standards

Approved smooth sheets are official government documents retained permanently in the National Ocean Survey archives. Standards of accuracy for smooth plotting and detailing, along with clarity and neatness of drafting, must reflect the high standards of accuracy of the collected data. Manual drafting should not be artistic, but shall be neat, clearly legible, and in accordance with the standards adopted for hydrographic smooth sheets as specified in this chapter. Characters drafted mechanically must be placed to avoid clutter and congestion insofar as possible.

7.2.5.1. Character of Lettering. When constructing smooth sheets and supporting overlays by automation methods, mechanical plotting capabilities shall be fully utilized to accomplish as much of the lettering and symbol drafting as possible. Otherwise, on manually processed or automated smooth sheets, mechanical lettering sets or guides shall be used for lettering all signal names and numerals, but not position numbers, soundings, bottom characteristics, buoy designations, and rock elevations. Generally, descriptive notes and penciled geographic names should be in freehand lettering. Geographic names are entered on smooth sheets in ink using lettering templates following approval of the list of names by the NOS Chief Geographer. (See 5.3.5(C) and 5.7.) See appendix B and the figures in this chapter for lettering character examples. Information originating from the present hydrographic and topographic surveys is generally shown in black ink—exceptions are discussed in the following sections.

7.2.5.2. Lettering Orientation. Symbols and lettering shall be aligned with parallels of latitude so they can be read from the south to the extent practical. Where geographic names cannot be lettered in an east-west direction, they shall be aligned at an angle or along a curve so they can be read from the south. (See 7.3.12.3.)

Regardless of the direction of the sounding line, sounding numerals are consistently oriented normal to an east-west projection line — except in deep-water areas where it may be necessary to plot three- or four-digit soundings at an angle. On east-west lines where soundings are spaced very closely, two-digit soundings may be shown at an angle to the line to avoid congestion. In such cases, orientation of these soundings shall be as consistent as possible and easily readable from the south. (See figure 7-3.)

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

1. Names and descriptions of topographic features that in general include all features above the high water line (or above low water datum in the Great Lakes).
2. Position numbers and soundings.
3. Control station and signal names and numbers.
4. Projection line labels.
5. Title block in formation.
Slant-style characters shall be used for:

1. Names of hydrographic features; in general, all features below mean high water (or below low water datum in the Great Lakes); and related descriptive notes.

2. Elevations of bare rocks, rocks awash, piling, and other similar objects.

3. Official names and designations of all aids to navigation.

4. Bottom characteristics.

7.2.5.3 PLACEMENT OF LETTERING. For annotations, lettering shall be placed on smooth sheets in such a manner that there can be no doubt as to the item or feature it describes. Control station names, dates of establishment, identification numbers, and most other descriptive annotations are placed in the land areas if possible to ensure optimal clarity of hydrographic detail. (See also 4.2.5.) Where practical, annotations should be separated from feature symbols by the space of one letter, and be either on line with the symbol or placed as a subscript. Where an identification or annotation must be placed so that doubt could arise as to its reference, a fine inked arrow or leader, in the same color as the name, must be drawn to the symbol. Extensive usage of offset names, descriptions, and designations is undesirable and should be avoided.

As a rule, station designations should not be placed in water areas, particularly along rugged coast lines; but if such location cannot be avoided, relatively unimportant soundings in generally flat areas may be omitted to allow space. Where room exists for only a hydrographic signal number, the number may be placed there provided the complete station designation is shown on a nearby unused portion of the sheet.

Where hydrographic detail is too congested to permit normal station identification, a capital letter (A, B, C, . . . AA, BA, CA, . . .— omit I and O.) may be used to reference the full station name or number with a reference placed in an unused part of the sheet. Arrows can be used to offset numbers and descriptions provided they are not too long and do not cross congested hydrography. Arrows and leader lines should be broken when crossing a sounding.

7.2.6. DRAFTING MATERIALS
7.2.6.1. SELECTION AND USE OF INK. Selecting and applying proper inks during smooth sheet drafting are important and require judgment and experience. Ink quality is critical because improper inks result in faint, nonphotographic, or watery detail that usually becomes illegible with age. Bottles of coagulated or otherwise aged inks should be discarded. Waterproof drawing inks are most often used on paper drafting surfaces; pigmented inks, when used, must be stirred or shaken to homogeneous consistency. When color intensity becomes weak, use new ink. Green ink is especially perishable and deteriorates rapidly.

Special inks are needed for modern plastic drafting films; ordinary waterproof drawing inks will not bond. Most commercial inks are unsatisfactory
because of their tendency to "bleed" after an ink fixative has been applied; but Pelikan Drawing Ink, "Special Shades, 50 Series" (manufactured by Gunther Wagner, Germany, and distributed by Koh-i-noor Rapidograph, Inc., Bloomsbury, N.J.) has proven satisfactory and should be used.

Special pressurized ball-point pens are approved for machine-drafted detail on overlays provided the information is sufficiently dense and dark for easy sheet reproduction.

Standard characters for inked lettering are specified in appendix B. Freehand and mechanical pens shall be carefully selected and used to conform with these standards as far as possible. Experienced draftsmen are familiar with the various types of pens available and acquire proficiency with a selected few. Less-experienced draftsmen should experiment with different types of pens and practice lettering until able to produce acceptable work. Quality of ink work may be improved by testing a variety of pens, selecting the best, then gently smoothing, rounding, or sharpening the nibs with fine crocus cloth or oilstone as necessary. A set of pens for each of the various colors should be used to avoid blending of colors.

Erasures on drafting film may be accomplished by careful use of plain water or a liquid detergent into which a cotton swab, soft rubber eraser (small areas), or an abrasive tissue (large areas) has been immersed. Hard abrasive erasers must never be used on any drafting surface.

When a sheet has been completed, a fixative must be applied to the inked surface to assure a permanent bond of the ink to the drafting film and prevent loss of hydrographic data. Krylon Workable Fixative Spray Coating, No. 1306 (manufactured by the Borden Company, Columbus, Ohio) or equivalent is approved for this purpose. The room must be well ventilated while spraying the fixative and a protective mask worn over both mouth and nose. Filter mask number 3500 (manufactured by the 3M Company, St Paul, Minn.) or equivalent is recommended.

If an erasure must be made after spraying, a small amount of water or additional fixative applied lightly with an eraser, then wiped off before drying, usually removes the original coat of fixative to permit corrections. Ink applied to a fixative-coated surface must be protected by additional spraying.

7.2.6.2. SELECTION AND USE OF PENCILS.
Proper drawing pencils are essential for good drafting. Pencils that are too hard can mar the drafting surface, and lines from such pencils are often too dim to allow sharp clear reproduction. Soft pencil points become blunt quickly and often result in smearing the plotting surface with a layer of graphite that inhibits proper penetration of ink. Inked soundings deteriorate rapidly on graphite-coated sheets.

Types of pencils used on mylar smooth sheets for geographic names, junction notations, unverified high water lines, and similar details vary with the individual. Those with a heavy hand should use a 3H or 4H pencil as lightly as possible — those with a light hand can use up to a 6H. Care should be taken to keep pencil points sharp to maintain fine narrow lines applying as little graphite as possible. Pencil lines should never be drawn so firmly that permanent indentations are made on the paper or drafting film; such indentations may result in damage to the grained drafting surface and in tears or ruptures of the sheet.

7.2.7. Drafting Instruments and Plotters

All instruments used to plot, verify, and review positions of hydrographic data shall be checked periodically for accuracy; such instruments must be kept clean and in excellent repair and calibration. Poorly maintained or unadjusted instruments can result in serious inaccuracies of the smooth plot. Particular care must be given when using and checking plastic protractors since they have a tendency to warp. (See A.9.1.)

7.3. CARTOGRAPHIC SPECIFICATIONS AND CONVENTIONS

The following sections contain specifications and conventions for the cartographic representation of data on smooth sheets. See also appendix B, "Hydrographic Sheet Cartographic Codes and Symbols," for additional details.

7.3.1. Projection

The polyconic projection shall be used for all smooth sheets unless a different projection is authorized by the project instructions for special surveys. Projections are machine drafted at the Marine Centers as an integral part of the verification and smooth plotting process. Projections shall be shown by (1) black tick marks connected by fine blue lines or (2) continuous lines fine enough so that soundings will not be obscured. See sections 1.2.2 and 4.2.6 for additional details and projection line spac-
PROBLEMS

The problems described in this chapter are intended to provide a variety of exercises for students to practice the concepts and techniques introduced in the text. The problems are divided into sections based on the chapters they correspond to. Each section contains a series of problems, ranging from straightforward calculations to more complex applications. Students are encouraged to work through the problems to reinforce their understanding of the material.

Chapter 1: Introduction to Hydrography

1.1. Introduction to Hydrography

1.1.1. Basic Concepts

1.1.2. Surveying Techniques

1.1.3. Stream Flow Measurements

Chapter 2: Surveying Methods

2.1. Surveying Basics

2.1.1. Traverse Surveying

2.1.2. Leveling

2.1.3. Total Station Surveying

Chapter 3: Topographic Mapping

3.1. Topographic Mapping Fundamentals

3.1.1. Contouring

3.1.2.符号符号

3.1.3. Symbol Placement

Chapter 4: Hydrographic Surveying

4.1. Hydrographic Surveying Basics

4.1.1. Hydrographic Contouring

4.1.2. Hydrographic Surveying Techniques

Chapter 5: Data Analysis and Interpretation

5.1. Data Analysis Techniques

5.1.1. Statistical Analysis

5.1.2. Graphical Analysis

5.1.3. Interpretation of Results

Chapter 6: Environmental Impact Assessment

6.1. Environmental Impact Assessment Basics

6.1.1. Environmental Hazards

6.1.2. Mitigation Measures

6.1.3. Environmental Monitoring

Chapter 7: Case Studies

7.1. Case Study 1: A River Valley

7.1.1. Hydrographic Survey

7.1.2. Topographic Mapping

7.1.3. Environmental Analysis

Chapter 8: Final Project

8.1. Project Requirements

8.1.1. Project Design

8.1.2. Field Work

8.1.3. Data Analysis

8.1.4. Report Preparation

Appendix A: Glossary

Appendix B: References

Appendix C: Sample Data Sets

Appendix D: Answers to Selected Problems
SMOOTH SHEET

the transfer of shoreline from a photogrammetric manuscript to a smooth sheet must be done accurately.

The shoreline, as defined for the project area (1.6.1) shall be shown with a solid black inked line about 0.4 mm wide. Apparent shoreline in marsh, swamp, or mangrove areas is shown by black inked lines 0.2 mm wide. Sections of shoreline shown as dashed or broken lines on class-I shoreline maps shall be left in pencil until the survey has been verified in its entirety. When verification has been completed, such shorelines are shown in ink by the appropriate symbol.

The shoreline is never generalized or smoothed on hydrographic sheets. Topographic detail shall never obscure a control station point. (See figure 7–4.) Minor details usually can be omitted within the station symbol; when necessary, use an extremely fine line to delineate important features within symbols. Shapes of islets must be shown accurately except in areas where slight distortions are permitted to prevent misinterpretation as zero soundings.

When a section of the shoreline is revised during hydrographic operations and supersedes a prior survey for reasons of natural change or error, that section is shown in red ink. (See 3.2.5 and 4.5.8.) Revised shoreline is shown by a continuous line 0.4 mm wide if located by acceptable field methods. [See National Ocean Survey (1974) "Provisional photogrammetry Instructions for Field Edit Surveys."] Otherwise, shoreline is shown by a dashed line.

Generally, shoreline is not shown beyond the limits of a survey. Although extended or flanking shorelines are sometimes shown for reference, excessive work on a large amount of unrelated shoreline is unwarranted; under no circumstances shall features be drafted that are offshore from the shoreline beyond the limits of the survey.

7.3.5. Low Water Lines

The low water line is the intersection of the land with the water surface when the water is at the elevation of the datum of reference prescribed for the area. (See 1.6.1.) Low water lines may also be considered as contours of zero depth. In ocean areas, these lines are often determined photogrammetrically from tide-coordinated infrared aerial photography. Low water lines located by this method are inked in black as dotted lines on smooth sheets.

A low water line delineated hydrographi-

![Figure 7-4](JANUARY 1, 1979)
HYDROGRAPHIC MANUAL

cally from sounding values is shown by a continuous orange inked line. When located by estimated distances from a launch or by other approximate methods, it is shown by a dashed orange line. Low water lines around steep rocky features such as around ledge outcrops are usually represented by the ledge or reef symbol. In some areas, however, an outer ledge limit may be far enough inshore of the actual low water line that the low water line should also be shown. (See figure B-3 in appendix B.)

Low water datum lines are shown only when feasible on hydrographic surveys of the Great Lakes.

7.3.6. Limit Lines

Dashed lines on photogrammetric manuscripts that delineate approximate limits of features such as channels, shoals, kelp, or foul areas are intended to serve as guides to the hydrographer and usually are superseded by hydrographic information. (See 4.2.7.) After the survey has been smooth plotted, such limit lines not superseded by hydrographic information are added in black ink as accepted during office verification. These dashed lines shall be accompanied by an appropriate notation such as "shoal," "foul," "breakers," or "kelp."

Similarly, limits of other danger areas discovered during the hydrographic survey shall be defined by dashed lines and identifying notes; these are to be inked in black. Such areas usually cannot be sounded because of high-risk factors. (See 4.3.3.)

7.3.7. Hydrographic Features

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

7.3.7.1. LEDGES AND REEFS. Rock and coral formations that uncover during some stage of the water level or tidal range are classified as ledges and reefs. A ledge is a rock formation connecting and fringing the shore of an island or larger landmass; it is generally characterized by a steep shear in the submarine topography. A reef is a rocky or coral formation dangerous to surface navigation. Reefs may be above or below the datum of reference. Rocky reefs are always detached from the shore; coral reefs may or may not be connected with the shore.

Symbols for ledges and reefs transferred from shoreline manuscripts are not inked until the hydrographic survey has been smooth plotted and all delineation discrepancies resolved. When transferring very small isolated reef patches, substitute the rock awash symbol for the reef symbol; but where a cluster of closely grouped rock awash symbols extend over an appreciable area, use the reef symbol. Low water detail is not shown on smooth sheets in areas beyond the limits of hydrography.

Along continuous stretches of ledge or reef, the ledge symbol shall be substituted for the zero depth contour. Care should be taken not to extend such symbolization through intervening beaches where the symbol is not applicable and the zero depth contour should be shown.

Do not show zero soundings inside ledge or reef symbols where they may be mistaken for bare rocks or islets. Such soundings should be deleted and removed from the records.

7.3.7.2. CORAL. This feature is found as a reef fringing the shore, as an atoll, or as a detached coral "head" or a pinnacle (usually submerged). A coral reef awash or uncovering at the sounding datum is represented by the reef symbol with the legend "coral." Where all ledges and reefs are composed of coral, only a general note to that effect need be entered on the sheet. Pinnacles and small patches of coral are represented by rock symbols with the abbreviation "Co" or the legend "coral."

7.3.7.3. BARE ROCKS. These extend above the datum of mean high water in tidal areas and may extend above low water datum in the Great Lakes where the shoreline is determined by the water level at the time of the topographic survey. Rocks with elevations of 1.6 ft or more above mean high water on the Atlantic Ocean or Gulf of Mexico Coasts, 2.6 ft or more above mean high water on the Pacific Ocean Coast, or 4.3 ft or more above low water datum in the Great Lakes shall be shown as bare rocks. Actual sizes and shapes of rocks should be shown, if possible, at the scale of the survey. If not, small single rocks are exaggerated in size and shown on the smooth sheet with an open center. Where clusters of bare rocks are shown by dots on photogrammetric manuscripts, use one or more open center symbols as necessary. The bare rock symbol is never overlapped by rock awash or submerged rock symbols. Bare rock elevations in tidal areas are referenced to the datum of mean high water; in the Great Lakes, such elevations are referenced to low water datum. (See figures B-1 through B-3 in appendix B.)
7.3.7.4. ROCKS AWASH. In tidal areas, the rock awash symbol (*) is used to portray rocks that become exposed, or nearly so, between the datum of reference (1.6 ft) and mean high water. In the Great Lakes, the rock awash symbol is used for rocks that are awash, or nearly so, at low water datum. The rock awash symbol shall be applied in accordance with appendix B and the following:

Atlantic Ocean Coast. When rock summits are in the zone from less than 1.6 ft below mean low water to less than 1.6 ft above mean high water.

Gulf of Mexico Coast. When rock summits are in the zone from less than 1.6 ft below Gulf Coast Low Water Datum to less than 1.6 ft above mean high water.

Pacific Ocean Coast. When rock summits are in the zone from less than 2.6 ft below mean lower low water to less than 2.6 ft above mean high water.

Great Lakes. When rock summits are in the zone from 2.7 ft below to less than 4.3 ft above low water datum.

Rock elevations are placed within parentheses beside the symbols as shown in figures B–1 through B–3 in appendix B. Rock awash symbols are drawn with bold, neat pen strokes and must not be substantially reduced in size even where there is a congestion of other rocks or soundings. A symbol need not be shown for each rock in a closely grouped cluster of rocks. The number of symbols should be reduced to avoid overlapping. When appropriate, use the reef or ledge symbol.

7.3.7.5. ROCK ELEVATIONS. Heights of rocks, coral heads, reefs, and ledges are referenced to low water or high water datums as specified in sections 7.3.7.3 and 7.3.7.4. Elevations above any datum are shown to the nearest whole foot; 0.5-ft values are rounded down to the lower value (i.e., a 2.5-ft elevation is shown as 2 ft). Elevations are always shown close to the feature in slanting figures enclosed in parentheses. Elevations referenced to a low water datum are underlined as shown in appendix B. Elevations of bare rocks transferred from topographic surveys or shoreline manuscripts are shown by red inked numerals about 2 mm high; elevations of similarly transferred rocks awash are shown in black ink. All elevations determined by hydrographic methods shall be shown in black ink.

An elevation on a rock covered or exposed ≤ 0.5 ft at the sounding datum is shown as an underscored zero (0)—the notation "awash at (appropriate datum, MLW, MLLW, GCLWD, or LWD)" may be substituted to emphasize the existence of a dangerous isolated rock. The notation "covered 1 ft MLW (2 ft MLLW on the Pacific Ocean Coast)" should be used in inland waters where such covered rocks are seldom exposed by rough water or during low tide. On outer coasts or in areas where a rock is frequently exposed at low tide, the zero value or awash notation shall be used.

Where rocks are grouped closely, the elevations of lesser importance should be omitted. The important values are at the outermost edges of the group and on the highest rocks.

7.3.7.6. SUBMERGED ROCKS. These are covered at the sounding datum and considered to be potentially dangerous to navigation. Rocks with summits below the lower limit of the zone specified for rocks awash (7.3.7.4) are represented on the smooth sheet by symbol only (+) or by soundings accompanied by the legend "Rk," depending on the information available. (See 4.7.) Where several least depths were obtained over a submerged reef and the type of bottom was recorded, the proper notation is the abbreviation "rky" (indicating a rocky bottom). When a depth was not determined and the standard symbol used, the notation "breakers" is shown if so noted in the records.

7.3.7.7. SUBMERGED OBSTRUCTIONS. All submerged obstructions found during a hydrographic survey shall be shown on the smooth sheet using the appropriate symbol listed in appendix B. If least depths could not be determined over unnatural features such as stubs or piles, ruins of piers and other structures, and wreckage of various kinds, the feature is shown by a 1-mm circle or by a dashed outline with appropriate annotation. If the nature of an obstruction was not determined, the note "obstr" shall be used. Dashed lines are used to indicate an extension below the high water datum of marine railways, groins, breakwaters, sewer outfalls, or other unnatural features rising above the bottom. All annotations shall be in slanted lettering.

7.3.7.8. VISIBLE OBSTRUCTIONS. In water areas, visible obstructions such as wrecks, piles, breakwaters, groins, fences, duck blinds, and fish houses are generally located on photogrammetric manuscripts—then transferred to smooth sheets if field confirmation has been made. Such obstructions are depicted by the distinctive symbols shown in appendix B or, if necessary, by outlining the obstruct-
HYDROGRAPHIC MANUAL

ing area with dashed lines. Annotations are to be in vertical lettering for features rising above the shoreline datum for the area (1.6.1); otherwise, use slanted lettering.

7.3.7.9. WRECKS. Stranded wrecks, where part of the hull uncovers at the sounding datum, are generally transferred to smooth sheets from shoreline manuscripts, particularly when a wreck is prominent and close to the shoreline. The small circle of the wreck symbol shown in appendix B is the actual position of the wreck. Wrecks occurring after aerial photography was obtained are normally located by detached positions or by reference to a sounding line; they may be spotted approximately on field sheets. Large hulls should be outlined and labeled accordingly if the scale of the survey permits.

Sunken wrecks are covered at low water, but the masts may uncover. In such cases, the notation "masts" accompanies the sunken wreck symbol. When a least depth over a sunken wreck has been accurately determined, the depth with the notation "wreck" is shown instead of using the wreck symbol. Offshore sunken wrecks are normally located by wire-drag surveys—least depths, groundings, and hangs are transferred to the smooth sheet in green ink with appropriate notation after verification of both surveys.

7.3.7.10. MARINE GROWTH. Limits of kelp beds and other forms of marine growth shown on shoreline manuscripts are frequently revised by hydrographic survey data prior to being smooth plotted. If discrepancies between the two sources arise, the hydrographic determination shall take precedence. Areas of marine growth are shown in pencil on the smooth sheet until the survey has been verified and the final limits accepted. Extensive areas of growth inshore of the sounding lines are finally delineated by dashed lines in black ink and annotated accordingly (e.g., "kelp"). When soundings are included in the growth area, the delineation line is not shown; the kelp legend alone is used. Small detached areas of kelp, whether inshore or offshore, are shown by symbol only. Grassy areas are identified by the abbreviation "Grs" or by the note "grass."

Masses of free unattached kelp or other floating marine growth noted during the survey are not shown. Marine growth recorded on the analog depth record is not shown by symbol or legend unless reported by the hydrographer to be visible at the sounding datum.

7.3.7.11. BREAKERS, TIDE RIPS, AND EDDIES. Breakers, whether offshore or alongshore, should be delineated by a dashed line in black ink with the notation "breakers." The intersection of directional cuts taken to breakers over submerged rocks should be indicated by the appropriate rock symbol.

Tide rips, which occur in conjunction with strong currents, are usually encountered near shoals or uneven bottom. Small areas of tide rips may be shown by legend. Approximate limits of extensive features should be outlined with dashed lines and an appropriate descriptive note added. Tide rips may be qualified as heavy, moderate, or light. Current eddies are shown by legend.

7.3.7.12. WIRE-DRAG HANGS, GROUNDINGS, AND CLEARANCES. Least depths over shoals or obstructions determined by wire-drag examinations conducted as a part of a hydrographic survey are shown on smooth sheets in green ink—provided that the least depth determined by wire drag was less than the depth determined hydrographically. Additional descriptive notes are entered on sheets in green ink as necessary with leaders and arrows used to indicate the proper area. Areas cleared, hangs, groundings, clearance depths, and other wire-drag data are shown on a separate overlay to accompany the smooth sheet, or are included in the Descriptive Report.

When contemporary wire-drag surveys have been conducted by another survey party, all drag hangs and groundings, but not clearances, are transferred to the smooth sheet in green ink following verification of both surveys. In such cases, a note must be entered on the sheet that identifies the wire-drag survey(s).

7.3.8. Soundings

These and related hydrographic detail needed to compile marine charts are the most important observations of a hydrographic survey. It is essential that the final corrected soundings plotted on the smooth sheet be accurately and graphically displayed in a uniform conventional manner. (See figures 7–6 and 7–7.)

Soundings shall be between 2.0 and 2.5 mm high. At this size, legible photographic reproductions can be made at reduced scales. The cen-
When conversions between fathoms and feet are necessary, use table 4–15. (See 4.9.9.)

Soundings are shown to the nearest 0.5 ft on smooth sheets for which the soundings are in whole feet in the following areas:

3. Over both sides of the low water line.

Over smooth bottom, soundings can be plotted without congestion at the following intervals.

East-west lines:

North-south lines:

Soundings with decimals generally are spaced at slightly greater intervals on east-west lines. See table 4–15 for a method used to round-off soundings.

When rounding soundings to 0.5-ft increments, reduced decimal values from 0.3 to 0.7 ft are shown as 0–ft both positive and negative soundings. When rounding positive soundings to integral feet, decimals less than 0.8 ft are disregarded; decimals of 0.8 to 0.9 ft are increased to the next whole unit. When rounding minus soundings, decimals less than –0.3 ft are disregarded and decimals from –0.8 to –0.9 ft are treated as –1.0 ft. See table 4–15 for a method used to round-off soundings.

When the smooth sheet unit is the fathom, negative soundings and soundings in depths less than 20 fm are shown in fathoms and tenths. In depths greater than 20 fm, soundings are generally rounded to integral fathoms; but where depths are charted in feet over smooth bottom and gentle slopes, soundings shall be shown in fathoms and tenths to depths of 31 fm. In such areas, depths between 31 and 101 fm are shown to the nearest 0.5 fm.

The same ranges are applicable when plotting soundings in overlap areas between surveys plotted in fathoms that join surveys plotted in feet. In addition, fathoms and decimals are used in other areas as necessary to define depth contours more accurately. When soundings are shown in 0.5-fm intervals, decimals from 0.3 to 0.7 fm shall be plotted as 0–fm. When soundings are entered in integral fathoms, decimals less than 0.8 fm shall be disregarded; 0.8 and 0.9 decimal values increase the sounding to the next whole number.

When conversions between fathoms and feet are necessary, use table 4–15. (See 4.9.9.)

7.3.8.2. SPACING OF PLOTTED SOUNDINGS. The spacing and density of soundings on smooth sheets shall be such that each depth contour is delineated adequately and the configuration of the bottom is fully revealed. Soundings should have been observed and recorded at intervals appropriate to the scale of the survey, the configuration of the bottom, the speed of the sounding vessel, and the depth of water. (See 1.4.6 and 4.5.6.) Soundings in addition to those taken at regular intervals must often be scaled from the analog depth records to portray all hydrographic features adequately. Smooth sheet soundings are generally spaced uniformly, except as noted in section 7.3.8.3.

Over smooth bottom, soundings can be plotted without congestion at the following intervals.

East-west lines:

North-south lines:

Soundings with decimals generally are spaced at slightly greater intervals on east-west lines.

Where the bottom is irregular, the spacing of soundings will also be irregular. Soundings must be shown at abrupt changes in the bottom slope and over peaks and deeps that characterize the bottom as irregular, undulating, ridged, or channeled.

Multiple-digit soundings should be shown at an angle to sounding lines when necessary to portray the bottom configuration adequately. In many cases, angled soundings provide an attractive alternative to plotting a smooth sheet at a scale larger than planned or to "excessing" an inordinate number of soundings because of overlapping numerals.

7.3.8.3. SELECTION OF SOUNDINGS AND EXCESSING. Soundings must be selected from the hydrographic records to plot on smooth sheets. It can-
FIGURE 7–5.—(A) Use of 0.5ft soundings to smooth otherwise unnatural depth contours and to better delineate a natural continuous channel and (B) use of dashed contour lines (20 fm) over a flat bottom.
not be overemphasized that the proper selection of soundings is essential for a complete and accurate portrayal of the bottom configuration. Analog depth records must be referred to frequently to provide the verifier with a proper conception of the bottom profile that must be reflected by the plotted soundings.

Realistically, every irregularity cannot be represented at the scale of the smooth sheet—minor relief and insignificant features in very irregular bottom generally must be disregarded. That significant peaks and deeps be shown is, however, essential. Soundings to be inserted at uneven intervals must not be shown in small distorted numerals or those that run together and fail to identify individual soundings. Under such conditions, slope soundings may be omitted if another sounding can be scaled from the analog depth records.

Because smooth sheets should reflect the relative density of hydrography, shoal and channel developments, investigations, and crossline soundings should be evident on an initial cursory inspection of the completed sheet.

Noncritical soundings from high-density developments and examinations and soundings that would obscure others (as in the case of line crossings) are nonessential and are shown on supplemental overlays for excess soundings. (See section 6.3.4.1.2 and figure 7–6.) Least depths and others needed to properly delineate depth curves and the bottom configuration must be shown on the smooth sheet.

When routine sounding lines overlap or cross, the shoaler soundings are plotted; however, consideration must be given to retaining the identity of a sounding line when selecting soundings. There should be no hesitation about erasing previously plotted soundings as necessary—such deletions should not mar the smooth sheet surface or impair the legibility of adjacent soundings.

When photobathymetry is used to support a hydrographic survey, soundings and other details shall be transferred from photobathymetric overlays to smooth sheets in red ink—except for depth curves that shall retain their prescribed colors. Identify the source of this data on the smooth sheet with the note "Soundings in red from photobathymetry of ____ (month and year) from T- ____ (sheet number)." In areas of overlap, useful and significant soundings shall be transferred; soundings that do not contribute to the development of the area shall be omitted.

7.3.9. Depth Curves

7.3.9.1. STANDARD DEPTH CURVES. Those listed in table 4–5 shall be drawn on each smooth sheet. Depth curves (isobaths or lines of equal depth) are comparable to topographic contours on land. Principles governing the delineation of topographic contours are equally applicable when drawing depth curves. They generally shall be drawn to include soundings equal to and less than the curve value, but should be broken at soundings as necessary to avoid an unnatural bottom configuration. Depth curves are usually transferred to smooth sheets from preliminary sounding overlays (6.3.4) compiled during the verification phase. See section 6.3.4.4 for a discussion of the conventions for drawing depth curves and see section 7.2.6.1 for the selection and use of inks for line work.

Depth curves are shown on smooth sheets by inked lines approximately 0.4 mm wide in the colors specified in table 4–5. Curves in congested areas and on steep slopes should be about half this width. Curve lines must not be drawn vertically above and below the numeral 1 or on a 45° alignment with the left part of the numeral 4. They should never overlap or cross a letter, numeral, or other symbol. Depth curves are broken into long dashes where not adequately defined by the soundings (e.g., extremely flat monotonous bottoms where the plotted soundings defy the drawing of a meaningful curve). See figure 7–5.

In some inshore areas, only short sections of depth curves can be drawn because of insufficient soundings. Where inshore curves can be extended with reasonable certainty of position, they should be completed to the extent determined by the hydrography. In comparatively shoal depths dangerous to navigation, the cartographer normally will bias the curves on the side of safety.

Drafting aids such as French curves shall not be used to "smooth" the drawn lines; the depth curves should delineate a natural bottom configuration. From a cartographic viewpoint, minor irregularities in soundings should not be overemphasized when drawing the depth curves. The two main reasons for overlooking minor irregularities are (1) when soundings are rounded to integral values, a tenth of a unit change from 0.7 to 0.8 causes a full unit change in the plotted sounding value and (2)
HYDROGRAPHIC MANUAL

continuous minor undulations and irregularities along depth curves detract from the desired emphasis on more significant irregularities. These criteria are difficult to describe and are best cited by illustration. (See figure 7–5.) On the other hand, generalization is desired to a point, but significant configurations of the bottom should not be masked by injudicious smoothing.

7.3.9.2. SELECTION OF DEPTH CURVES. Supplemental depth curves listed in table 4–6 should be added as necessary in shallow waters where (1) there is a considerable horizontal distance between standard depth curves or (2) where supplemental depth curves provide better definition of submarine features such as least depths, tops of shoals, and otherwise undefined channels and depressions. Deeper supplemental curves are added only when significant irregular configurations of the bottom warrant their use. Such applications are a matter of judgment. To emphasize an important shoal sounding or other feature that otherwise would not be delineated by the standard or supplemental depth curves listed in tables 4–5 and 4–6, draw additional depth curves as necessary using short dashes. Such additional depth curves are shown in the same color specified for the next shoaler curves provided that the additional line is only one unit deeper (e.g., (1) if a shoal rises abruptly to a least depth of 19 ft, a 19-ft curve is drawn with a dashed line in the color specified for the 18-ft depth curve or (2) a 10 fm depth curve may be drawn with a dashed line using the 10 fm curve color). Otherwise, additional necessary depth curves are inked as a solid brown line.

When depth curves become congested on steep slopes, only the shoalest and deepest curves need be shown; intermediate depth curves are omitted. The shoalest curves that emphasize hazards to navigation and the deepest curves that define limits of channels or passages are the most important. Where pinnacles, rocks, or steep shoals rise abruptly from much greater depths, one or more of the deeper curves should be omitted for clarity. Where islands, shoals, or reefs rise abruptly from much greater depths and several of the shoaler depth curves are very close to shorelines of the islands or edges of the reefs, the shoaler curves are omitted. To preclude redundancy, never draw depth curves around rock or reef symbols unless the curves can be justified by adjacent soundings that lie on both sides of the curves. The low water line or zero depth curve is an important foreshore feature; in many areas, this line is a legal seaward boundary. Particular care must be taken when delineating this line.

7.3.10. Bottom Characteristics

All recorded bottom characteristics shall be shown on smooth sheets except when an excessive number have been recorded on pole or lead line surveys. (See 4.7.) In the latter case, a selection should be made and all isolated rocky or hard bottom characteristics plotted. In important waters such as harbors and anchorages, the plotted characteristics should be adequate to define the approximate limits of various types of bottom in the area. On those surveys where bottom sampling density requirements have been reduced, bottom characteristics may be transferred (in color) from a prior survey following verification provided the general depths in those areas have not changed.

Standard abbreviations for bottom characteristics have been adopted and are used on smooth sheets. Such abbreviations are entered in black ink using slanted uppercase and lowercase letters as shown in appendix B. The capital letters should not exceed 2 mm in height. Bottom characteristics should be placed reasonably close to and slightly below and to the right of the pertinent soundings, provided there is space. Otherwise, characteristics can be placed in a convenient place nearby. When displacing a bottom characteristic, do not place the lettering where it does not represent the nature of the bottom unless the displacement is indicated by a leader and arrow. The descriptive note "Rk" should always adjoin least depths on submerged rocks when so identified in the sounding records.

7.3.11. Aids to Navigation

7.3.11.1. LANDMARKS AND NONFLOATING AIDS TO NAVIGATION. Most landmarks that have been recommended by hydrographers and are approved for charting (See 5.5) are plotted on smooth sheets using the symbols listed in appendix B. Source position data may be the shoreline manuscript, published geodetic position listings, or inclusions in the hydrographic records. Landmarks used to control hydrography or located by geodetic methods are shown on smooth sheets by the control station symbol, not the landmark symbol. To show that a control station is a landmark, enter the proper landmark name in black ink in parentheses after the station identifier. The word "landmark" is entered in parentheses below the station name—
FIGURE 7–6. — Example one of a completed hydrographic smooth sheet. See also figure 7–7.
FIGURE 7–7. — Example two of a completed hydrographic smooth sheet. See also figure 7–6.
known, the height of the landmark above ground and above high water is also shown in black ink in these parentheses.

Objects recommended as landmarks but not used as signals, if not plotted on a shoreline manuscript, shall be plotted on the smooth sheet. Such landmarks are symbolized by a black circle 2 mm in diameter. Names of these landmarks and required annotations are entered in black ink.

All nonfloating aids to navigation found within the survey limits are shown on the smooth sheet. Most of these aids, which include both lights and daybeacons, will have been located previously by photogrammetric methods or by conventional ground surveys of third-order accuracy or better, and may have been used as control stations for the hydrographic survey. (See 1.6.5.) Because positions of new or relocated aids are often established during hydrographic operations, copies of Form 76-40 filed by the hydrographer or field editor must be consulted. (See 5.5.) Each fixed aid in the survey area at the time of the survey shall be shown by the appropriate control station symbol or by the approved cartographic symbol (appendix B) when not located by geodetic methods. If the name or designation of an aid as it appears in the U.S. Coast Guard Light List is not included in the control station name, enter the Light List name in slanting red characters.

Permanent aids established by individuals or nongovernment organizations that were not used to control hydrography are shown by a 1 mm diameter circle and described as "Priv marker," whether or not maintained. Private semipermanent aids such as stakes, with or without baskets or kegs, along shallow channels are plotted as a 1-mm circle and described as "stake."

7.3.11.2. FLOATING AIDS TO NAVIGATION. All of these located by the hydrographer shall be shown on the smooth sheet. Floating aids shall be indicated by the appropriate aid symbol in the proper color. (See appendix B.)

The buoy symbol circle is the position of the buoy. When plotting a mooring buoy, the lower circle indicates its position. Soundings taken at these aids, if important, are shown slightly lower and out of true position so not to overlap the symbol; such soundings may be excessed if they are unnecessary for bottom delineation. Each aid shall be identified by classification and number (e.g., N "7" or Bell "4" as shown in the examples in appendix B). Any discrepancy between charted or U.S. Coast Guard Light List information, designation, description, or characteristic noted during the survey must be mentioned in the Descriptive Report.

7.3.12. Miscellaneous Detail

7.3.12.1. CABLES AND BRIDGES. Locations and paths of overhead and submerged cables are not transferred to smooth sheets from photogrammetric manuscripts; however, terminal points such as towers or signs that were used as signals must be plotted, identified, and described by suitable notes. (See figures 7–6 and 7–7.) Cable and bridge clearances are shown on the smooth sheet only when measured in accordance with section 4.5.14. When positions for towers or signs are unavailable, the approximate inshore ends of cables are shown by black dashed lines with appropriate notes entered in land areas.

7.3.12.2. TIDE AND CURRENT STATIONS. Locations of tide, water level, and current stations shall be shown on smooth sheets by blue circles 4 mm in diameter, without a center dot, and labeled accordingly. (See figure 7–6 and appendix B.) Locations of oceanographic stations or plots of current observations are not shown.

7.3.12.3. GEOGRAPHIC NAMES. These are entered on smooth sheets lightly in pencil after the soundings and other hydrographic data have been verified and plotted. Each name must be placed so as to indicate clearly the feature designated. Geographic names shall not obscure or otherwise confuse plotted soundings and related hydrographic data. Generally, all names are placed landward of the shoreline on inshore survey sheets. Where names must be lettered in water areas, particularly in congested areas, judicious placement and spacing of letters are necessary. Final selection, placement, and inking of geographic names are done after review and approval of the names list by the NOS Chief Geographer. (See 5.3.5(C) and 5.5.)

Since smooth sheets are the authority for the charted names of all features seaward from the shoreline, extreme care must be used when spelling and placing geographic names. Instructions for lettering names are contained in section 7.2.5. Published charts serve as excellent guides for placement of names and relative size of lettering for various features.

7.3.12.4. DESCRIPTIVE NOTES. A variety of descriptive notes is required on each smooth sheet to fully identify, reference, and complete the survey data. (See figure 7-6.) Notes are shown in parentheses when preceded by a station name or other similar designation. Notes shall be as brief as possible, sometimes
HYDROGRAPHIC MANUAL

preceded by a station name or other similar designation. Notes shall be as brief as possible, sometimes abbreviated, but always clear and specific. Lettering may be in neat freehand and not larger than 1.8 mm for most notes, except at landmarks where primary descriptions are entered in capital letters 2.2 mm high. Differentiation between elevated and submerged features and the corresponding placement of lettering are discussed in section 7.2.5. Control stations in water areas must be described. (See 4.2.5.) To avoid misinterpretation between bare rocks and positions, do not place dots over the letter “i” or use them as punctuation in water areas.

7.3.12.5. JUNCTIONS AND ADJOINING SURVEYS. A comparison shall be made with adjoining surveys to determine the completeness and relative agreement of hydrography. When necessary, statements are entered by the verifier in the appropriate Descriptive Report concerning consistent disagreements between soundings, significant displacements of depth contours, and inadequate survey coverage. Soundings and other hydrographic information generally should not be transferred from adjoining surveys to smooth sheets except when needed to reveal least depths, to delineate depth contours, or to better show significant bottom configurations. If an adjoining survey has not been completed or verified, pencil notes are used to indicate junctional surveys until such time as they can be inked.

Critical or significant soundings are transferred from adjoining surveys—even if less important soundings plotted on the smooth sheet must be deleted. Where there are unresolvable differences in general depths in the junctional areas, the less-reliable soundings are disregarded and a butt junction effected. The superseded area should be outlined with a dashed colored line and a label SUPERSEDED BY H-____(19______) should be added. The label on the superseding survey should be the normal junctional designation.

If verification of the survey shows good agreement, the notation “JOINS H-____(19______)” is placed in the junctional areas beyond the limits of hydrography for that smooth sheet.

Lettering for junctional notes shall be mechanically drafted, approximately 2.5 mm high, slanted, and in colored ink. (See figure 7–6.) Different colors should be used to show junctional notes and critical soundings transferred from each consecutive adjoining survey. Preferred ink colors are carmine red, red violet, orange, and brown—in that order. Blue and green should be avoided because they photograph poorly. In wire-drag areas, the color green is reserved for transferring wire-drag soundings. Depth curves shall be drawn so there is a definite continuity and agreement in overlap areas. Supplemental depth curves shown on adjoining surveys, however, should not be transferred unless needed to delineate the bottom configuration adequately.

Junctions should be made with contemporary surveys which comprise surveys of the same year, the preceding year, or the following year. If no contemporary surveys are available in stable bottom areas or areas where no noticeable changes have occurred, adequate junctions usually can be completed with recent noncontemporary surveys. These comprise surveys more than 1 year older than the survey being processed.

Prior surveys are those listed in the Verifier’s Report for comparison with the survey being processed. Usually overlapping surveys need be considered under only one section of the Verifier’s Report, either under JUNCTIONS or COMPARISON WITH PRIOR SURVEYS.

7.3.12.6. SMOOTH SHEET IDENTIFICATION BLOCK. Stamp No. 1A (figure 7–8) shall be applied on the lower right-hand corner of each non-automated smooth sheet. Appropriate entries are made for the field number, registry number, scale, horizontal datum of the sheet, and reference station and its latitude and longitude. In the event geodetic control does not exist for the survey area and control is established by alternate methods, e.g., astronomically, the established control (reference control station and geographic position) will be so noted in the non-automated title block. It will also be indicated as to whether values are adjusted or unadjusted, and if unadjusted, to what geodetic datum. An identification block is not required on smooth sheets produced by automation.

![FIGURE 7–8. — Rubber stamp 1A, smooth sheet identification block](image-url)
NATIONAL OCEAN SURVEY
A. L. POWELL, Director
HYDROGRAPHIC SURVEY No. 9316

ALASKA

GLACIER BAY

TARR INLET

Date of Survey. . . July-August 1972
Scale . . . . . . . . . . . 1 : 20,000
Chief of Party. . . George M. Poor
Surveyed by . . . Ship's Officers

SOUNDINGS IN FATHOMS AND TENTHS
at Mean Lower Low Water

* FIGURE 7–9. — Title block of a non-automated hydrographic smooth sheet *
HYDROGRAPHIC MANUAL

7.3.12.7. TITLE BLOCK. The information to be entered in the title of a hydrographic smooth sheet is extracted from the Title Sheet in the Descriptive Report. (See 5.3.2.) Approximate dimensions for the title block are a height of 6 in and a width of 8 in. Survey data or notes shall not, under any circumstances, be shown inside the block. On most inshore surveys, there is adequate title space in land areas or in unsounded water areas. Offshore sheets must be laid out so there is sufficient space for the title. No particular portion of a sheet is favored over another for the title block.

All titles manually drafted shall be in black ink—letter sizes and line widths are illustrated in figure 7–9. Title lettering for automated smooth sheets shall be as illustrated in figure 7–10. Titles shall be oriented with the bases parallel to the latitudinal projection lines. The proper entry for the Director is the name of the individual holding office at the time field work was completed. Each Chief of Party involved in the sounding operations shall be listed. Enter only months and years for the date of the survey. Use the general term "Ship's Officers" rather than names of the individual hydrographers.

Titles for wire-drag surveys are similar, except that the words "WIRE DRAG" replace the word "HYDROGRAPHIC" in the third line of the title. (See figure 7–9.)

7.4. SPECIAL PROJECTS AND FIELD EXAMINATIONS

The primary purpose of special projects and field examinations is to effect specific investigations of reported shoals, wrecks, or obstructions which constitute a potential danger to navigation. Special projects may also include equipment evaluation, or other special investigations unrelated to the charting program. Requirements for processing special project data will be spelled out in the project instructions. Field examinations are conducted using the same field procedures and office processing required for conventional hydrographic or wire drag surveys. A brief Descriptive Report or Descriptive Letter that provides the necessary details for the survey must be prepared to accompany the sheet. Survey sheets of field examinations shall be cut or folded to 8½ X 11 in. size and inserted into the Descriptive Report.
8. FINAL INSPECTION AND APPROVAL

8.1. FINAL INSPECTION

Each Marine Center Director shall select and maintain a hydrographic survey inspection team (HIT) to conduct a critical inspection of each completed verified survey with regard to survey coverage, delineation of depth contours, development of critical depths, cartographic symbolization, and verification or disproval of charted data. The Verification Report is examined to ensure that all facts have been accurately and properly presented, that significant actions taken and procedures used during the survey verification were appropriate, and that recommendations made by the verifier are logical and justifiable. Survey records must be inspected for completeness and compliance with NOS requirements. An Inspection Report shall be prepared that expresses the team’s concurrence or disagreement with the verifier’s findings, actions, and recommendations. In addition, discrepancies and deficiencies in the survey or survey data that were previously undetected must be included in the report. Adverse findings of the inspection team concerning verification procedures are sufficient justification to require additional processing before submitting a survey for final administrative approval.

Although the members of a hydrographic survey inspection team may vary from time to time depending on local circumstances, each team could typically include the chief of the processing unit, a seasoned verifier, and a person experienced in the operational phases of hydrography. The team should neither be involved with the actual processing of a survey nor be expected to do any further processing. Each member of an inspection team must sign the final Inspection Report.

8.2. ADMINISTRATIVE APPROVAL

Following satisfactory final inspection, each smooth sheet and its accompanying overlays and reports shall be submitted to the appropriate Marine Center Director for final approval of the survey. The final approval statement and Marine Center Director’s signature are placed on a separate sheet and inserted as the last page of the Descriptive Report. The Marine Center Director’s signature is also required on the title block as shown in figure 7–10.

Copies of the approved Verification Report and Inspection Report will be furnished to the field survey unit, the Chief of Party, and other key personnel who participated in the survey.

Additional field work needed on a survey stated as deficient shall be scheduled by the Hydrographic Surveys Division in NOS Headquarters at the earliest opportunity — preferably before the project has been completed and the field unit leaves the area.

8.3. SHIPMENT OF RECORDS

Following final approval of a survey at the Marine Center, all survey records, the smooth sheet, and the accompanying overlays and reports shall be sent by registered mail to the Hydrographic Surveys Division, OA/C353. Certified mail should not be used when forwarding survey records. Original records must be packaged and mailed on a staggered schedule as a safeguard against losing an entire survey. Mailing procedures should be established that will provide a capacity for survey reconstruction if a shipment is lost in the mails. Computations and processed data listings should not be packaged with original field records.

The following records shall be transmitted with each approved survey:

1. The smooth sheet, smooth position overlay, and other overlays as necessary — these are to be sent only in the special containers provided for this purpose.

2. Preliminary overlays used during verification of the survey.


4. The field sheet(s) and accompanying overlays.

5. Smooth position and sounding listings.

6. Raw hydrographic field data listings.

7. Data listings corrected in the field.

8. Sounding Volumes or equivalent documents used to record field observations.

9. Analog position and depth records (to be filed and identified by day in accordion type folders).
HYDROGRAPHIC MANUAL

10. A stable base copy of the shoreline manuscript used to locate hydrographic signals and delineate shoreline and the reference datum line.

11. Magnetic tapes containing the survey data in prescribed transmittal digital formats

12. Other information or documents needed for a thorough understanding of the survey, such as the contemporary nautical chart that was used for chart comparison.