CO-OPS SPECIFICATIONS AND DELIVERABLES FOR INSTALLATION, OPERATION, AND REMOVAL OF WATER LEVEL STATIONS

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Engineering Division
Center for Operational Oceanographic Products and Services National Ocean Service
National Oceanic and Atmospheric Administration

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1.0 Introduction

1.1 Purpose

The Center for Operational Oceanographic Products and Services (CO-OPS) is a line office of the National Ocean Service (NOS). This purpose of this document is to provide guidance and list specifications for the installation, maintenance and removal of the water level stations, and list requirements for the water level data and metadata documentation submission. This document is applicable when stations are installed by CO-OPS' Indefinite Delivery Indefinite Quantity (IDIQ) contractors, NOAA contractors, CO-OPS' partners and their contractors. These specifications are also applicable for stations supporting the NOS Vertical Datum Transformation (VDatum) program, partner stations such as those installed by United States Geological Survey (USGS), the United States Army Corps of Engineers' (USACE) Comprehensive Evaluation of Project Datums (CEPD) Program, and the NOS National Estuarine Research and Reserves (NERRS). Guidance and specification documents for the water level stations supporting the Office of Coast Survey (OCS) hydrographic surveys (NOS Hydrographic Surveys Specifications), and the National Geodetic Survey (NGS) Shoreline Mapping Surveys, are available in the CO-OPS Field Library.

1.2 Data Quality Control and Monitoring

Data from all CO-OPS stations (including short-term stations for hydro, photo, and partner support) are quality controlled 24 hours per day, 7 days a week by CORMS (Continuous Operational Real-Time Monitoring System). However, this does not relieve contractors of the responsibility to perform their own QC to ensure proper station operation. For non-real-time (i.e., internal recording only) hydrographic or photogrammetric contract surveys, or NOS Vertical Datum Transformation (VDatum) projects, the contractor is fully responsible for all data monitoring, repairs, and proper functioning of the water level measurement station.

1.3 General Data and Reference Datum Requirements

All water level data shall be collected on station datum; all other vertical datums are determined from the station datum. The present NOAA Nautical Chart Reference Datum for tidal waters is 'Mean Lower Low Water' (MLLW) which is based on the latest NOAA National Tidal Datum Epoch (NTDE) of 1983-2001. The present NOAA shoreline reference datums are MLLW and Mean High Water (MHW).

In non-tidal areas, including the Great Lakes, special low water datums are defined for specific areas, and are used as chart datum in these locations. In some cases where historical sites are re-occupied, site datum shall be selected to a pre-established MLLW/MHW datum held on a bench mark. In that case, acquire data relative to MLLW/MHW for immediate application during the shoreline mapping surveys.

For the Great Lakes, a unique Low Water Datum (LWD) for each lake relative to International Great Lakes Datum of 1985 (IGLD 85) is the reference datum. In other non-tidal coastal areas, LWD is determined by subtracting 0.5 ft. from Mean Water Level (MWL) (equivalent to Mean Sea Level (MSL)) observed at the water level stations. In some cases where historical sites are re-occupied, every effort shall be made to collect the new data series on the historical Station Datum (SD).

2.0 Water Level Station Requirements

2.1 Data Collection and Field Work

The field party shall ensure the collection of continuous, high quality, valid data. The computation of accurate tidal datums requires a month of data with no continuous gaps exceeding three days. Some data gaps that are significantly less than three days cannot be filled-in or interpolated during certain meteorological conditions, or in weak or non-tidal regions. At sites where data transmission is not possible, an independent backup sensor or a complete redundant water level collection system should be utilized.

2.2 Water Level Sensor and Data Collection Platform (DCP)

The primary water level sensor shall be selected from one of CO-OPS approved sensors:

- Aquatrak® self-calibrating air acoustic sensor
- ParoScientific® pressure sensor(s), connected to a single (or dual) orifice gas purged bubbler system
- BEI® Motion Systems absolute shaft angle encoder (SAE)
- Xylem/YSI (Design Analysis Associates, Inc.) WaterLOG® Microwave Water level (MWWL) radar sensor
- Xylem/YSI (Design Analysis Associates, Inc.) NILE® MWWL radar sensor

All installations and sensor types shall be approved by CO-OPS, based on the submitted site reconnaissance and design documents. A detailed reconnaissance report shall be submitted within 90 calendar days prior to the planned installation. The reconnaissance for water level stations shall be performed in accordance with the references 'Desktop Reconnaissance Procedure for Observing System Installation Planning', and the 'Field Reconnaissance Procedures for Observing System Installation Planning'.

The sensor measurement range shall be greater than the expected range of water level at the measurement site, and the installation shall be designed to measure the full range of extreme water levels, such as highest observed and lowest observed water level data (100 years, if available). The highest observed may have an additional wave allowance value added as determined by CO-OPS' Engineering Division (ED). Sensor resolution is also important. For a tidal range less than or equal to 5m, the sensor resolution shall be 1mm or less. For a tidal range between 5m and 10m, the sensor resolution shall be 3mm or less, and for a tidal range greater than 10m, the sensor resolution shall be 5mm or less.

Calibration of sensor systems prior to deployment is required. The calibration standard's accuracy must be traceable to National Institute of Standards and Technology (NIST), manufacturer, or an independent reputable laboratory. The calibrations records shall be submitted with the station documentation.

The primary water level sensor configured at the majority of CO-OPS water level stations is the Aquatrak® acoustic sensor with a protective well and parallel plate assembly. At stations where freezing of the water surface or the lack of a suitable support structures prohibits installation of the acoustic sensor, a single or dual ParoScientific® intelligent pressure sensor(s) is satisfactory. A MWWL radar sensor, or a well/float with absolute shaft angle encoder are other options for water level measurement stations. For short-term subordinate stations, the MWWL sensor is preferred over the pressure sensor.

For pressure sensor installations, the orifice shall be mounted on a vertical surface such as a pier or wharf piling, so that the precise elevation of the orifice below a staff stop can be measured with a steel tape. The elevation of the staff stop can be measured via differential leveling to the nearest bench mark, and with the primary bench mark (PBM). If the orifice is mounted vertically and its elevation can be determined precisely with reference to the primary bench mark, staff-to-gauge readings may not be necessary. This requirement for staff-to-gauge readings may also be waived in saltwater environments as described in Sections 2.5.1 and 2.5.2, provided that weekly density measurements are taken and submitted to CO-OPS. If the orifice cannot be mounted to a vertical surface for direct leveling to the PBM, then staff-to-gauge readings are required to relate the water level datums to the bench marks.

If a ParoScientific® sensor is planned, the reconnaissance shall include a conductivity/temperature/depth (CTD) cast performed in accordance with the reference 'Conductivity/Temperature/Depth (CTD) Observation Analysis'. The CTD data must be submitted with the reconnaissance report and station documentation.

When using a vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle is required at the start, at frequent intervals during deployment, and at the end of a deployment. Frequent gauge/staff comparisons (Refer to Section 2.5.2) during deployment shall be completed to assure measurement stability, and minimize processing errors. The staff-to-gauge observations shall be at least three hours long at the beginning and end of deployment, and periodic observations during deployment shall be at least one hour long. Along with the averaging procedure described above, which works as a digital filter, NOS uses a combination protective well/parallel plate assembly on the acoustic sensor, and a parallel plate assembly (with 2" orifice chamber) on the bubbler orifice sensor to minimize systematic measurement errors from wave and current effects, as shown in Figure 1.
For detailed information, see the *Next Generation Water level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual*, NOAA/NOS, January 1991, available on the CO-OPS publications web page. This document is also available in the CO-OPS Field Library.

In the Great Lakes, a sump with a float-driven absolute shaft angle encoder is used most often. CO-OPS has also approved the MWWL radar sensor for selected NWLON and PORTS® projects.

The Data Collection Platform (DCP) shall acquire and store water level measurements every 6 minutes. The water level measurements shall consist of an average of at least three minutes of discrete water level samples with the period of the average centered about the six-minute mark (i.e., :00, :06, :12, etc.). Compute and store the standard deviation of the discrete water level

samples that comprise the six-minute measurement. The clock accuracy of all satellite radio systems shall be maintained within one-second, to avoid cross-channel interference (i.e., "channel stepping"). Non-satellite radio systems shall maintain clock accuracy to within 30 seconds per month. Handle known error sources for each sensor appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, and high frequency wave action and high velocity currents for all sensor types.

For further information, refer to the *Portable Tide Gauge Setup, Configuration, and Data Export Procedure* which is available on the CO-OPS Field Library.

2.3 Data Transmissions

The following data transmission requirements are applicable only for stations installed by CO-OPS or its contracted installations. This section is not applicable to OCS contract hydrographic surveys, or to NGS contract shoreline mapping surveys.

The ability to monitor water level measurement system performance in near real-time is essential, therefore, all station installations must be equipped with a GOES transmitter (where ready access is available). Hourly data transmissions must use a message format identical to the format currently implemented in NOS CO-OPS' *"NGWLMS GOES MESSAGE FORMATTING"*. If data are not transmitted via GOES, or has been transmitted in an incompatible GOES format, or submitted via digital media, the data must be reformatted as specified in the above document or as documented in section 5.2.

Close coordination is required between the field party and the CO-OPS ED for all water level installations with satellite transmission capability. ED will assist in acquiring assigned platform ID's, time slots, etc., for approved installations, as appropriate. At least ten business days prior to the initiation of GOES data transmission in the field, information about the station number, station name, latitude, longitude, platform-ID, transmit time, channel, and serial numbers of sensors, and DCP shall be emailed to the CO-OPS ED Configuration and Operational Engineering Team (COET), at nos.coops.oetteam@noaa.gov. Configuration of the station and DCP information is required before data can begin to ingest into CO-OPS databases. In addition, all required metadata shall be documented in the eSite Report, NGWLMS Site Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 5.1 Timeline Requirements).

2.4 Station Installation, Operation, Maintenance, and Removal

Contractors shall obtain all required permits and permissions for installation of the water level sensor(s), DCP(s), bench marks, and utilities, as required. The contractor shall be responsible for security and/or protective measures, as required, for protecting the equipment and facility while installing, maintaining or removing a water level station.

The water level station and its various components (tide house, DCP, all sensors, meteorological tower, bench marks, and pertinent access facilities such as railings, steps, etc., as appropriate), when designed and/or installed by contractors, shall be installed and maintained as prescribed by manufacturers, installation manuals, appropriate local building codes, or as specified by the Contracting Officer's Representative (COR), if applicable. The water level station and all installed components shall be structurally sound, secure, and safe. The field party shall provide CO-OPS the geographic position of all tide gauges installed before data collection begins, including those not specified in the Statement of Work or Project Instructions, but added to the scope, as appropriate.

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

2.4.1 Station Installation

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

A. The installation of the water level measurement system (water level sensor, DCP, and satellite transmitter), its supporting structure, and a tide staff, if required.
B. The recovery and /or installation of a minimum number of bench marks and a level connection between all bench marks and the water level sensor(s), and the tide staff, as appropriate. For all installations, a minimum of five bench marks with stability code A or B are required.
C. The horizontal geographic positions of the sensors, station, DCP, and bench marks installed or recovered shall be obtained using a hand-held GPS receiver as latitudes and longitudes and reported in degrees, minutes, seconds, and tenth of a second (e.g. bench mark position as latitude 37 degrees 45 minutes 34.1 seconds and longitude as 75 degrees 25 minutes 32.5 seconds).
D. Perform GPS observations at one or more bench marks as stated in Section 4.2.
E. The preparation and submission of the station installation documentation.

2.4.2 Station Operation and Maintenance

The field party shall monitor the near-real-time water level data on a daily basis for indications of sensor malfunction or failure, and for other causes of degraded or invalid data, such as marine fouling. When GOES telemetry and NOS satellite message format are used, and when CO-OPS is monitoring the gauges for NOS in-house projects, this monitoring can be performed by accessing the CO-OPS Diagnostic Tool (DiagTool). The raw data are typically available within 18 to 30 minutes after collection, depending upon the frequency of transmissions. For NOS contract projects, contractors are responsible for monitoring the gauges and for taking the proper corrective actions, as necessary.

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in eSite report or appropriate maintenance forms as identified in contract documents (see section 5.3 on water level station documentation) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date/time of start and completion of the maintenance activity, date/time of adjustments in sensor/DCP, datum offset/sensor offset/orifice offset changes and date/time of the change, personnel conducting the work, parts/components replaced, component serial numbers before and after the maintenance, tests performed, purpose of the trip, and recommended actions that could not be completed and the reason for the incompletion, etc.

2.4.3 Station Removal

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

A. Closing levels - a level connection between all bench marks and the water level sensor(s) and tide staff as appropriate.
B. Removal of the water level measurement system and restoration of the premises, reasonable wear and tear accepted.
C. Disposal of expendable or unusable components in an environmentally friendly manner.
D. Termination of any utilities.
E. Close-out or terminate license agreement.
F. The preparation and submission of the station removal documentation.

2.5 Tide Staff and Staff Observations

2.5.1 Tide Staff

The field party shall install a tide staff at a station if the reference measurement point of a sensor (zero of a gauge) cannot be directly connected via levels to the local bench marks (e.g., the orifice is laid on the sea floor). Directly leveled pressure gauges also require periodic staff readings for assessment of variations in gauge performance from density variations in the water column. The tide staff shall be mounted on a separate piling from that which the water level sensor is installed, so that independent stability of the staff and sensor is maintained. The staff shall be plumb when installed; when joining two or more staff scales to form a long staff, extra care should be taken to ensure the accuracy of the staff throughout its length. The distance between staff zero and the staff stop shall be measured before the staff is installed, and after removal, and the staff stop above staff zero height shall be reported on the documentation forms.

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

2.5.2 Tide Staff Observations

When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle (minimum 3 hours) shall be conducted (1) at the start of water level data collection, (2) at frequent intervals during deployment, and (3) at the end of a deployment before removing the gauge. Frequent gauge/staff comparisons during the deployment shall be completed to assist in assuring measurement stability and minimizing processing errors. The staff-to-gauge observations at the start and end of deployment shall be at least each three hours long, and the periodic observations during the deployment shall be at least an hour long. The staff-to-gauge observations shall be performed three times per week, during each week of the project, with at least one hour of observations at an interval of every six-minute. The observations shall be recorded at the same time the gauge is collecting data at the six-minute interval (starting with 0 minutes, e.g. 0, 6, 12, 18, 24, 30, 36, 42, 48, and 54 minutes after the hour). Where staff-to-gauge observations cannot be performed three times a week as required, then an explanation is required, and CO-OPS ED may grant a waiver, or an alternate staff-to-gauge observation method may be performed:

a) at a minimum of eight times spread out over each month (e.g., two times per week) at each time at least one hour of observations six-minute intervals, or
b) at a minimum of four times spread out over each month (e.g., one time per week) and at each time at least two hours of observations at six-minute intervals, whichever is most expedient.

The staff-to-gauge differences shall remain constant throughout the set of observations and shall show no increasing or decreasing trends. After the water level data have been collected, the mean value of the staff-to-gauge shall be applied to water level measurements to relate the water level data to SD. A higher number of independent staff readings decrease the uncertainty in transferring the measurements to SD. Figure 2 is an example of a pressure tide gauge record.

If the old staff is found destroyed during the deployment, then a new staff shall be installed for the remainder of the deployment period, and a new staff-to-gauge constant shall be derived by new sets of staff-to-gauge observations. In addition, when a staff or an orifice is replaced or re-established, new check levels shall be run to a minimum of three bench marks, including the PBM. Refer to section 3 for leveling frequency and other leveling requirements.

When reoccupying historic water level stations, CO-OPS will provide the SD information. Generally, this information is the PBM elevation above the historic SD. In this case, for pressure sensors that require staff-to-gauge observations, all the water level data shall be placed on the SD using the following equation:

Water level data on SD = (Preliminary pressure water level data on arbitrary datum) + (PBM above SD) - (Staff Zero below PBM) - (weighted staff-to-gauge constant)

Staff Zero below PBM = (Staff Stop below PBM) + (Staff Zero below Staff Stop)

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

Bubbler Orifice and Parallel Plate Assembly

This bottom assembly is made of red brass, and its chemical properties prevent biofouling by the slow release of copper oxide on its surface. A Swagelok® hose fitting is screwed into the top end cap. and is used to discharge the Nitrogen gas. The Nitrogen gas flows through the bottom of the orifice at a rate sufficient to overcome the rate of tidal change and wave height. This opening establishes the reference point for tidal measurements. The parallel plates produce a laminar flow across the orifice to prevent the Venturi effect. A 2”x8” pipe provides the correct volume of gas for the widest range of surf conditions encountered in most coastal regions. A bubbler orifice with parallel plates is generally required and shall be used for CO-OPS installations.

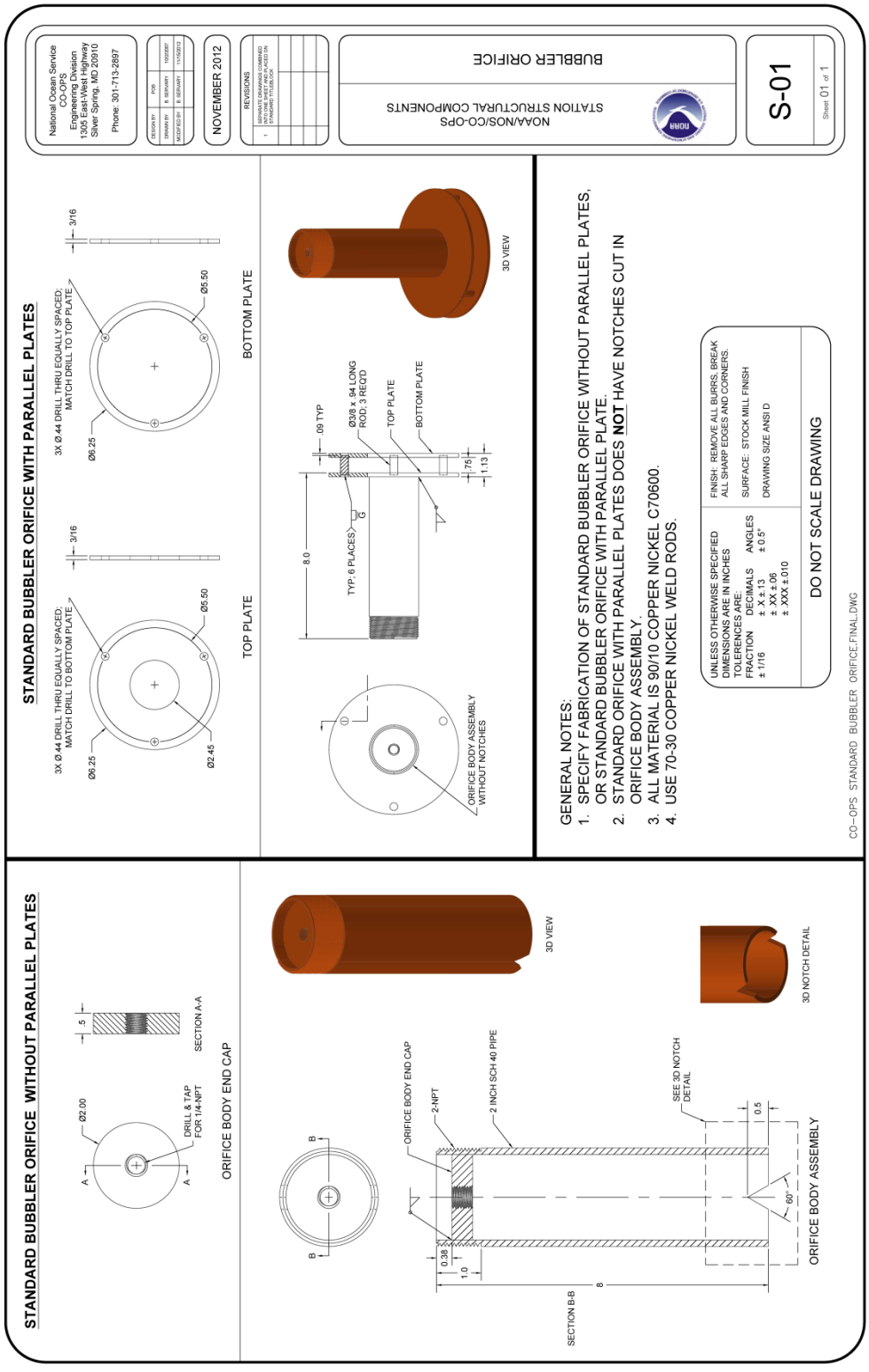

Figure 1. Bubbler Orifice Bottom Plate Assembly

PRESSURE TIDE GAUGE RECORD

Station Name:_____ Station No. (Seven-digit #) _____

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

Figure 2. Example – Pressure Tide Gauge Record

2.6 Bottom-Mounted Pressure Gauges

Requirement

This configuration is required for hydrographic survey locations where traditional shore-based tide stations with water level gauges mounted on near shore infrastructure are not possible during the summer months (non-ice deployments). This includes areas where the low tide line is far offshore, and measuring the full range of tide with typical acoustic, MWWL, or bubbler gauges is not feasible. This most often occurs in Alaska.

Configuration

Bottom-mounted pressure gauge (BMPG) station consist of a water level sensor, batteries, bottom-mount moorings and recovery lines, water density sensors (conductivity sensor or hydrometer), barometric pressure sensor, tide staff (fixed scale, or leveling-to-water's edge rod equipped with wave stilling tube (staff shots)), five tidal bench marks, GPS survey equipment, and a data collection platform (DCP). The BMPG requires the configuration of two systems for redundancy.

Specifications:

Water Level:

The water level pressure sensor shall be a ParoScientific® or equivalent (with respect to accuracy and performance). The sensor shall have a documented calibration and certification by the manufacturer or an independent lab such as NIST. The calibration and certification records shall be submitted with the station documentation.

The field party or instrument lab shall perform a documented acceptance check regarding sensor operation prior to deployment. The sensor shall be calibrated immediately if a drift of 0.5 cm or more is noticed in one month of data; otherwise, the sensor shall be calibrated every 10 years.

The system shall have internal recording capability with a sampling scheme of producing an average pressure reading every six-minutes, in which 36 five-second water level samples centered on each tenth of an hour are averaged. A three-standard deviation outlier rejection test is applied and the recalculation of the mean and standard deviation along with the number of outliers is recorded internally in the DCP

The system shall keep accurate internal time with no noticeable drift over a 3-month deployment period, e.g. less than five seconds drift over a three-month period. The system shall be deployable for a minimum of 30-days without having to retrieve for maintenance or data collection. Real-time data telemetry is desirable so that system performance and data quality monitoring.

Water level is generally derived from BMPGs by applying corrections for barometric pressure and for water density to the pressure measurements using standard manufacturer software and the hydrostatic equation relationships. Barometric pressure shall be measured at a location within five miles from the BMPG deployment site and at a minimum sample rate of hourly observations.

Moorings:
The hydrographic survey contractors shall design their own mooring systems.

Typical installations require self-contained sensors each mounted to a 300-1000 pounds anchor with a 45' -120' buoy line (depending on water depth) and an 80'-150' drag line attached to a 150-pound anchor. The objective is to have a mooring that will not drag or move horizontally or vertically during deployment, and be capable of being deployed using relatively small boats and the sensors are deployed offshore far enough (200 -1500m) to ensure measurement of the lowest expected water level.

Water Density:
Water density shall be obtained at least hourly but preferably, every six-minutes by using a bottom mounted conductivity and temperature (CT) sensor, or daily hydrometer measurements during the deployment period. Surface measurements using a hydrometer may be inaccurate in areas of high freshwater runoff. Conductivity and temperature sensors shall undergo documented manufacturer recommended calibrations and field party acceptance tests prior to each deployment. The calibration records shall be submitted with the station documentation.

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

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

Some locations requiring BMPG deployments may require a "virtual tide staff" procedure. This procedure requires repeat geodetic leveling from a bench mark or temporary bench mark (backsight) to a level rod held at the water's edge (foresight staff shots). The water level shall be read off the level rod scale, taking into account wave action (a small stilling tube attached to the rod helps with this reading). Foresight water level readings shall be made every six-minutes for a three hour period after initial deployment of the pressure sensors and just prior to retrieval of the sensors. Backsight closures to the bench mark shall be made at the beginning and end of the three hour periods with the leveling instrument set-up remaining undisturbed.
Interim tide staff readings during the deployment period shall be taken periodically and spread over the month as specified. Interim tide staff readings shall be taken a minimum of (a) eight

times a month spread out over each month (e.g. two times a week) and at each time 1 hour of observations at six-minute intervals, or (b) minimum of four observations spread out over each month (e.g. one time per week) and at each time at least two hours of observations at six-minute intervals. The interim, installation, and removal staff readings should remain constant throughout the set of observations and show no increasing or decreasing trends. A higher number of independent staff readings decreases the uncertainty in transferring the measurements to SD.

Final Water Levels:
Pressure gauge readings are converted to water level via application of documented barometric pressure and water density corrections prior to performing the staff-to-gauge comparisons. Staff-to-gauge constants are determined for each separate deployment. Often, the systems are recovered, checked out, batteries refreshed, etc., and then re-deployed during a survey period. Staff-to-gauge differences are analyzed for outliers and consistency prior to determination of the final constant(s) to be applied to the data. The water level data, level abstracts, and metadata shall be submitted in CO-OPS specified format as per section 5 Deliverables.

3.0 Bench Marks and Leveling

3.1 Bench Marks

A bench mark is a fixed physical object or marker (monument) set for stability and used as a reference to the vertical and/or horizontal datums. Bench marks near a water level measurement station are used as the reference for the local tidal datums derived from the water level data. The vertical relationship between the bench marks and the water level sensor or tide staff shall be established by differential leveling. Please note that if a direct measurement between the water level sensor and the bench marks cannot be made, then staff-to-gauge measurements and comparison as described in *Section 2.5 Tide Staff and Staff Observations* above is required.

3.2 Number and Type of Bench Marks

The number and type of bench marks required depends on the duration of the water level measurements. The *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations* specifies the installation and documentation requirements for the bench marks. Generally, for Partner, USACE CEPD, USGS, NERRS, VDatum, and hydrographic and remote sensing surveys, a minimum five bench marks are required at each station. Each station will have one bench mark designated as the PBM, which shall be connected via leveling during each level run. The PBM is typically the most stable mark in close proximity to the water level measurement station. The field party shall select a PBM at sites where the PBM has not been designated. For historic NOS station reoccupations, CO-OPS will furnish the name of the historic PBM and PBM elevation above station datum, if available.

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

3.3 Leveling

Second-Order Class I geodetic levels are preferred, but at least Third-Order geodetic levels shall be run at short-term stations operated for less than one year. Requirements for higher order levels will be specified in individual project instructions, or contract documents, as appropriate. Additional field requirements and procedures used by NOS for leveling at water level stations can be found in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations*. Electronic digital/barcode level systems are preferred. Specifications and standards for digital levels can be found in *Standards and Specifications for Geodetic Control Networks* and additional field requirements and procedures used by NOS for electronic leveling at water level stations can be found in the *User's Guide for Electronic Levels with Translev and WinDesc.*

The leveling connection to an acoustic sensor shall be made to the Aquatrak® leveling point (AQLP), defined as the top shoulder of the mounting plate collar on the calibration tube.

The leveling connection to a MWWL sensor shall be made to the MWWL Leveling Point, located on the top of the flange (Figure 3).

The leveling connection to a ParoScientific® sensor shall be made to the orifice LP, with a tape down measurement between the Orifice LP and the Orifice Zero. The Orifice Zero is the bottom of the upper-most parallel plate, or the apex of the of v-notch of the Orifice where bubbles are released.

The leveling connection to a Great Lakes station shall be made to the ETG (Electric Tape Gauge zero) leveling point.

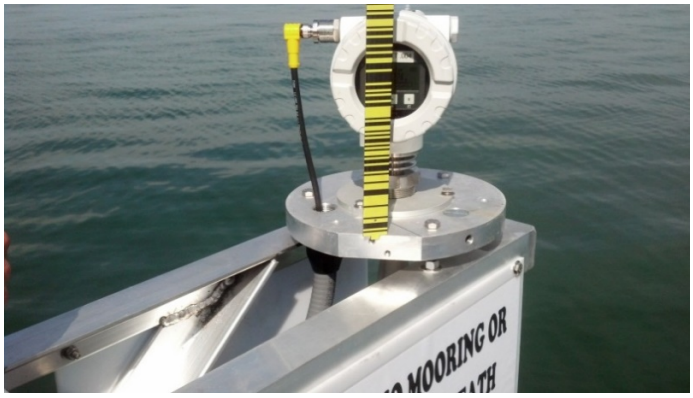

Figure 3. MWWL Leveling Point

To facilitate rod holding, a prefabricated leveling fixture may be slipped over the acoustic sounding tube to rest on the leveling point. The height of the leveling fixture, as inscribed on the fixture, shall be compensated for in the leveling record (abstract). The level abstract shall show the elevation of the leveling point only. A barcoded rule or stainless-steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used in lieu of the leveling fixture by holding the rule directly on the leveling point. In cases where the leveling point is too high for a rod shot, the leveling fixture designed for a down shot shall be utilized and the readings recorded to reflect the down shot. ED must approve use of other leveling fixtures and leveling techniques in advance.

For information on leveling to the bubbler orifice, see sections 2.2 Water Level Sensor and Data Collection Platform and 2.5 Tide Staffs and Staff Observations.

3.4 Leveling Frequency

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

Bracketing levels to appropriate number of marks (five for subordinate stations) are required (a) if smooth tides (water level data reducers) are required 30 days or more prior to the planned

removal of a applicable gauge(s) (for hydrographic/remote sensing survey projects), or (b) every six months for stations collecting data for long term projects.

3.5 Stability

If there is an unresolved movement of the water level sensor or tide staff zero relative to the PBM, from one leveling to the next, of greater than 0.006 m, the field party shall document the movement. In some special cases, CO-OPS may require the field party to verify the apparent movement by re-running the levels between the sensor(s) zero or tide staff to the PBM. This threshold of 0.006 m should not be confused with the closure tolerances used for the order and class of leveling.

3.6 Additional Field Requirements

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

B. All water level data from a gauge shall be downloaded and backed up at least weekly on a digital media (e.g. diskettes, CD-ROM, DVD, ftp site) whether the gauge data are sent via satellite or not.

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

D. At each water level station, GPS observations on one tidal or water level bench mark shall be performed according to the most recent copy of the CO-OPS' "*User's Guide for GPS Observations at Tide and Water Level Station Bench Marks"*.

4.0 Geodetic Connections and Ties

The water level datums are local vertical datums, which may vary at different stations within a geographical area. A geodetic datum is a fixed plane of reference for vertical control of land elevations. The North American Vertical Datum of 1988 (NAVD 88) and the International Great Lakes Datum of 1985 (IGLD 85) datums are accepted geodetic reference datums of the National Geodetic Spatial Reference System (NSRS) for the conterminous United States and Alaska, and are officially supported by NGS. The relationships of tidal datums to geodetic datums such as NAVD 88 and to ellipsoid heights (above GRS 80 ellipsoid) support many hydrographic, coastal mapping, and engineering applications including monitoring of sea level changes, the deployment of GPS Electronic Chart Display and Information Systems (ECDIS), and the NOS VDatum transformation tool, etc.

4.1 NAVD 88 Level Tie

There are two parts for this requirement as described below in A and B.

(A) NAVD 88 Level Tie: At all water level stations, a valid level tie to at least two Geodetic Bench Marks (GBM) is required on each set of levels, where appropriate GBM marks are available within a 1.6 km (1 mi) leveling distance of the station location, and when the GBMs are at least 500 m apart. A GBM is defined as a bench mark that:

- is useable,
- is available in the NGS database,
- has a Permanent ID (PID),
- and has a NAVD 88 elevation published on the datasheet.

Information on performing a valid level tie is provided in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks, listed at the following website:
http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm#3.5

Section 3.4 of "User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations" provides the same information regarding how to perform a valid level tie.

The Second-Order, Class I tie is a requirement for digital levels to be accepted into the NGS database. Short level runs to the sensor, PBM, and two marks are excluded from this requirement since they are usually meant to verify sensor stability only. Since a level connection to GBMs with dynamic heights defines the International Great Lakes Datum of 1985 (IGLD 85) datum offset at each station in the Great Lakes, a valid connection to at least two GBMs (within 1.6 km (1 mile) of station location) is required at each site.

A note shall be made in the remarks of the leveling section of the site report that a valid tie was achieved or not achieved. If not achieved, an explanation shall be provided and/or recommendations made for making a valid tie in the future.

If a successful NAVD 88 level tie is performed then NAVD 88 elevations for all the bench marks in the local leveling network can be determined for the VDatum program.

If the water level station does not have two or more GBMs within 1.6 km (1 mi) leveling distance of the station location, then the NAVD 88 level tie requirement is waived.

(B) NAVD 88 Level connection: An orthometric level connection is required on each set of levels at each water level station which has at least one GBM located within 1.6 km (1 mi) leveling distance of a water level station. If the water level station has two or more GBM within 1.6 km (1 mi) of radial distance of the station location, then perform the NAVD 88 Level Tie (as described above in A) which fulfills the requirement for NAVD 88 level connection.

A successful NAVD 88 level connection to a GBM will help determine the approximate NAVD 88 elevations for the all the bench marks in the local leveling network for the NOS VDatum program.

If there are no GBM within 1.6 km (1 mi) leveling distance of the station location, then the requirement for NAVD 88 level connection requirement is waived.

4.2 GPS Observations

GPS connections involve the following two ties

(1) NAD 83 GPS Tie
(2) NAVD88 GPS Tie

The required "NAD 83 GPS Tie" and "NAVD GPS Tie" are described in the *User's Guide for GPS Observations at Tide and Water Level Station Bench Marks*.

5.0 Deliverables – Timelines, Water Level Data, Documentation, and Points of Contacts

Data submission requirements for water level measurement stations are comprised of two parts: (a) formatted digital water level data collected by the water level measurement system, and (b) supporting documentation (i.e., metadata) for the installation, maintenance, and removal of the station.

5.1 Timeline Requirements

CO-OPS maintains a web-based electronic site report (eSite Report) that interacts with the Data Management System (DMS).As stated in the contract, when appropriate, the field party shall follow the guidance in the reference *SOP 5.5.3.1 A User's Guide for the eSite Report Application* for more information, available in the CO-OPS Field Library.

Within 24 hours after (a) installation of a water level station, or (b) completion of regular scheduled maintenance, or (c) completion of emergency maintenance, or (d) completion of check level, or (e) the removal of a water level station, the one-day eSite Report (Xpert Site Report or Tide Station Report) along with level abstract shall be forwarded to the COET and COR.

The purpose of the one-day (24-hr) eSite Report is so that COET can provide feedback to the field party while at or near the site, and can enter updated datum and sensor offsets in the database as quickly as possible, to maintain real-time data dissemination. This requirement applies to all water level stations and every type of maintenance - installation, regularly scheduled routine maintenance, and unscheduled maintenance or removal of a water level station.

The field party is required to submit the required water level data as described below in Section 5.2, and the documentation as described in Section 5.3, to COET or the COR within 30 calendar days of the completion of the water level station installation, maintenance, repair, removal, or as specified in the contract documents. The station documentation shall be submitted in digital format only.

The installer shall retain all data, metadata, and documentation submitted to CO-OPS for a minimum of three years or as stipulated in the contract.

5.2 Water Level Data

The final observed water level measurements shall be reported as heights in meters to three decimal places (i.e. 0.001 m). All heights shall be referenced to station datum, and times referenced to UTC. The field party shall provide the water level data in the format specified below from all water level gauges.

The original raw water level data and the correctors used to convert the data to station datum shall be retained until notified in writing, or at least three years after the project completion. All algorithms and conversions used to provide correctors shall be fully supported by the

calibrations, maintenance documentation, leveling records, and sound engineering and oceanographic practices. Sensor measurements used to convert data (e.g., pressure to heights) shall be calibrated and maintained for the entire water level collection period.

All digital water level and ancillary data shall be transmitted to CO-OPS in a format dictated by the DCP configuration. If GOES satellite is used, the data shall be transmitted and received using the NOS compressed pseudo-binary format. Refer to the *NGWLMS GOES Message Formatting* for more information.

If satellite transmission configurations cannot be installed, the data shall be manually downloaded from the DCP and submitted to CO-OPS, as shown in the format below, in a digital format, (diskettes, CD-ROM, DVD or ftp site)

Data download files shall be named in the following format: xxxxxxxy.w1.DAZ, where xxxxxxx is the seven-digit station number, y is the DCP number (usually 1), w1 is the product code for 6 minute water level data, and DAZ is the extension (where Z = 1,2,3...if more than one file from the same station and DCP is submitted). Within the data file, each input record (including the final record) must end with a carriage return and exclude any extraneous characters such as trailing blank spaces for both types of water level data.

Acoustic Sensor Data (XXX.ACO format)

```
Column  1- 7 Station ID (7 digits, assigned in the project instructions)
Column  8- 8 1 (DCP number, use 2, 3, etc., for additional DCPs)
Column  9-19 Date (MMM DD YYYY format, e.g. JAN 01 2009)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01, ...., 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00,06,12, ..., 54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 Temperature 1 (tenth of degrees C in integer format)
Column 51-56 Temperature 2 (tenth of degrees C in integer format)
Column 57-58 Sensor type (Ax for acoustic type, “x” is a number 1-9)
Column 59-60 blank
Column 61-61 Data Source (S for Satellite, D for Diskette)
```

Sample data:

```
85169901AUG 17 2008 05:00 1138 23 0 308 297A1 D
85169901AUG 17 2008 05:06 1126 26 0 308 298A1 D
85169901AUG 17 2008 05:12 1107 26 1 309 298A1 D
```

Pressure Sensor or Generic Data (XXX.BWL format)

```
Column  1- 7 Station ID (7 digits, assigned in the project instructions)
Column  8- 8 1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column  9-19 Date (MMM DD YYYY format, e.g. JAN 01 2009)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01, ..., 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00-54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 DCP temperature (tenth of degrees C in integer format)
Column 51-52 Sensor type (Z1 for generic or pressure)
Column 53-53 blank
Column 54-54 Data Source (S for Satellite, D for Diskette)
```

Sample data:

```
85169901AUG 17 2007 05:00 1138 23 0 308Z1 D
85169901AUG 17 2007 05:06 1126 26 0 308Z1 D
85169901AUG 17 2007 05:12 1107 26 1 309Z1 D
```

Note: pressure data must be accompanied by documented staff observations as listed in Section 2.5.2, if applicable.

Microwave Water Level Sensor Data (XXX.QC format)

```
Column 1- 7 Station ID (7 character)
Column 8- 8 1 (DCP number, use 2, 3, etc., for additional DCPs)
Column 9- 10 Blank
Column 11- 27 Date and Time (MMM DD YYYY HH:MM format, e.g.  Jun 01 2013
14:48)
Column 28- 28 Blank
Column 29- 30 Sensor Id (2 characters, e.g. Y1 for MWWL)
Column 31- 31 Blank
Column 32- 32 Source (1 character, e.g. Satellite [S], PORTS [Z], Tsunami
[T], Storm surge [X], Diskette [D])
Column 33- 33 Blank
Column 34- 34 Type (1 character, e.g. Primary [P], Redundant [R])
Column 35- 35 Blank
Column 36- 41 Pressure value (integer divide by 1000 – field length 6)
Column 42- 42 Blank
Column 43- 48 Primary water level value   (integer divide by 1000) -
(Acoustic [A1], Pressure [N1], Storm surge [S1], Tsunami [U1], Air gap [Q1,
MWWL[Y1])
Column 49- 49 Blank
Column 50- 55 Primary water level sigma (integer divide by 1000 – field
length 6)
Column 56- 56 Blank
Column 57– 62 Primary water level outliers (integer)
Column 63- 63 Blank
Column 64- 69 Backup water level value (integer divide by 1000 - field length
6) Backup [B1], Second Pressure [T1])
```

```
Column 70- 70 Blank
Column 71- 76 Backup water level sigma (integer divide by 1000 – field length
6)
Column 77- 77 Blank
Column 78– 83 Backup water level outliers (integer)
Column 84- 84 Blank
Column 85- 90 Backup water level water temp (integer divide by 10)
Column 91- 91 Blank
Column 92- 97 First air temperature (integer divide by 10)
Column 98- 98 Blank
Column 99- 104 Second air temperature (integer divide by 10)
Column 105- 105 Blank
Column 106- 111 Datum offset (integer divide by 1000)
Column 112- 112 Blank
Column 113- 118 Sensor offset (integer divide by 1000)
Column 119- 119 Blank
Column 120- 125 Backup water level gain (integer divide by 1000)
Column 126- 126 Blank
Column 127- 132 Backup water level offset (integer divide by 1000)
```

Sample data:

86310442 MAY 01 2013 15:24 Y1 D P 999999 3269 3 1 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999

86310442 MAY 01 2013 15:30 Y1 D P 999999 3246 3 0 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999

86310442 MAY 01 2013 15:36 Y1 D P 999999 3228 3 0 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999

86310442 MAY 01 2013 15:42 Y1 D P 999999 3205 3 0 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999

5.3 Station Documentation

1) Transmittal letter (PDF format)
2) eSite Report (eSite report in web based electronic format)
3) Sensor Well Drawing (PDF format) (required for newly installed stations or any modification to sensor well – PDF format)
4) Sensor elevation drawing (PDF format) showing sea floor, pier (deck) elevation, and each sensors' elevation above the appropriate datum (required for newly installed sensor(s), any sensor elevation change – PDF format)
5) Water level transfer form (for Great Lakes stations only - PDF format)
6) Bench mark Diagram (PDF format) – Large-scale bench mark location sketch of the station site showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The bench mark diagram shall include an arrow indicating north direction, a title block that includes: the station name and number, NOAA chart number, USGS Quad name (from a 15" x 15" map), field unit, date created, drawn by, and latitude and longitude (obtained from hand-held GPS receiver) of the gauge, and label of the body of water
7) Bench mark descriptions with handheld GPS coordinates (dd/mm/ss.x format) (electronic file - WinDesc)
8) "Station to Reach" statement in Microsoft Word format when eSite Report application is not used.
9) Digital photographs of each bench mark disk (four views: face, setting, and 2 cardinal directions), station, DCP, equipment, underwater components, and the location to include the body of water being observed (JPEG format)
10) Levels (electronic files) including leveling equipment information and field notes of precise leveling, if applicable
11) Abstract of precise leveling (electronic format)
12) Datum offset computation worksheet or Staff/Gauge difference worksheet as appropriate showing how sensor "zero" measurement point is referenced to the bench marks
13) Staff to gauge observations, if applicable (Microsoft Excel format)
14) Calibration certificates for Invar leveling rods, if applicable (PDF format)
15) Calibration records for sensors, if applicable (PDF format)
16) Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (PDF format)
17) Environmental Compliance documentation (Microsoft Word or PDF format)
18) Water level data download in specified format, if applicable
19) DCP configuration files
20) GPS Deliverables - visibility diagram, GPS solution (email), OPUS published datasheet and four photos of the GPSBM in electronic format for each observation session as described in the User's Guide for *GPS Observations at Tide and Water Level Bench Marks*
21) Scheduled Maintenance Checklist
22) Diving Documents (DAMP, Dive Plan, etc.)
23) Confined Space Permit
24) As-Built Engineering Drawings and Design Documents (PDF format)
25) Other information as appropriate, or as specified in the contract (PDF format)

The station documentation shall be submitted in digital format only. All GPS data and documentation shall be published and shared via NGS OPUS. All applicable documentation listed above is required for the installation of a new water level station. After the completion of a scheduled maintenance or removal site visit, only the documents that have changed require submission.

The "Station to Reach" statement, the bench mark diagram, the sensor elevation drawing, and the sensor well drawing need only be submitted if these items have been revised during the station maintenance, upgrade, relocation, or removal.

When using the electronic/barcode system, all digital files created using the WinDesc and Translev programs shall be submitted. At stations where the automated or manual levels are used, Precise Leveling sheets of actual runs (NOAA Form 75-29) and the Abstract of Precise Levels (NOAA Form 76-183) shall be completed and submitted along with the WinDesc description file.

All digital photographs shall be submitted in JPEG format. All digital station photo files shall be named such that the name of the file will indicate the station number and the type of photo taken. For example, the acoustic sensor photo for DCP1 at Los Angeles shall be named as 94106601 A1 sensor.jpg.

All station bench mark photos shall be named such that the name of the file will indicate the station number, PID number (if available), stamping or designation, photo type, and date. For new marks, the PID is not applicable as it is unavailable.

The required photos are as follows:

(1) Close-up photo taken vertically is photo type 1,
(2) Eye level photo taken vertically to show mark and surrounding area is photo type 2, and
(3) Horizontal photo view taken with the mark in the foreground and features in the background is photo type 3. For the horizontal view photo(s), include the cardinal direction (N, NE, S, SE, etc.) that the camera is pointing. If additional photographs are taken, ideally move around the mark to locations, which are 90 degrees apart. Name these photographs number 3XX, where the “XX” is the cardinal direction the camera is pointing, for example, 3N or 3NE, etc.

If more than one type of photo is taken, name the photos as 1A, 1B, 2A, 2B, 3A, 3B, etc.

If a PID is available, then use the designation instead of the stamping for the naming of the file. Use a maximum of 30 alphanumeric characters in the prefix of the filename. If the filename exceeds 30 alphanumeric characters, simply truncate the stamping or designation to produce a 30-character filename. For example, the bench mark E close-up photo for Seattle water level station should be named as 9447130-7130E1990-1- 20090101.jpg.

Sample file names for photo files

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

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

5.4 Station Documentation Submission

The station documentation shall be organized by various subfolders under the main station number folder. Then pertinent information shall be placed in the various folders and submitted on a digital media. The level files, photographs, GPS data, and dive documents shall be submitted in subfolders under the main station folder. All other files are saved under the main station folder.

Below is an example of a submission of the electronic folders for San Francisco water level station. The abbreviations in parenthesis should be used to name the electronic files and subfolders. Empty folders or folders with no deliverable documents do not need to be included.

9414290 San Francisco 2017 Annual Inspection

- Transmittal letter via email for CO-OPS FOD (Transmittal)
- eSite Report (eSite)
- Sensor Well Drawing (Sen Well DWG)
- Sensor elevation drawing (Sen Elev DWG)
- Water level transfer form (WLT Form)
- Bench mark Diagram (BM DWG)
- Bench mark descriptions (WinDesc) (BM Desc)
- “Station To Reach” Statement (STR Stmt)
- Photographs of bench marks, DCP, equipment, and vicinity in digital format (Photos)
- Levels (raw electronic files) and field notes of precise leveling (Levels)
- Abstract of precise leveling (ABS)
- Datum offset computation worksheet or Staff/Gauge difference worksheet (elevation of sensor zero measurement point ref. to bench marks) (DAT WKS)
- Staff to gauge observations, if applicable (STG Obs)
- Calibration certificates for Invar leveling rods, if applicable (Rod Cal Certs)
- Calibration records for sensors, if applicable (Sen Cal Certs)
- Agreements, MOU, contract documents, utilities agreements, if applicable (Docs)
- Environmental Compliance documentation (Enviro Comp)
- Water level data (six-minute, hourly heights, high/low, monthly means, station datum) (WL Data)
- DCP configuration files (DCP Config)
- GPS deliverables (GPS)

- Scheduled Maintenance Checklist (SM Checklist)
- Diving Documents (Dive Docs)
- Confined Space Permit (CS Prmts)
- As Built Drawing (As Built)
- Other information as appropriate, or as specified in the contract (Other)

5.5 Points of Contact for Deliverables

All required deliverables listed in Section 5.3 shall be submitted to the proper point of contact as listed in the project instructions, contract documents, or to NGS or CO-OPS within 30 calendar days of the GPS observations, station installation, maintenance, or a removal of a water level station, or as specified in the Statement of Work or contract, whichever is earlier. All GPS data and documentation shall be published to NGS OPUS.

For all work performed by NOAA entities (FOD, NOAA ships, NRT, etc.) submit one copy of all documentation including GPS deliverable in digital media, such as DVD/CD- ROM, ftp sites, etc., to:

Chief, Engineering and Development Branch
CO-OPS, N/OPS1, SSMC 4, Station 6507
1305 East-West Highway
Silver Spring, MD 20910-3821

(B) For all work deliverables performed under CO-OPS IDIQ contract, submit one copy of all documentation including the GPS submission in digital media, via Task Order Management Information System (TOMIS) to the Contracting Officer's Representative (COR) and the Technical Representative (contact information is listed below).

Contracting Officer's Representative
NOAA, NOS, CO-OPS Field Operations Division
672 Independence Parkway
Chesapeake, VA 23320

Submit another copy of the completed station package to the Technical Representative at the appropriate supporting FOD field office, as listed below:

For East Coast IDIQ Contract stations, submit to:
Technical Representative (Task XXX)
NOAA, NOS, CO-OPS, Field Operations Division-Atlantic Operations Branch
672 Independence Parkway
Chesapeake, VA 23320

For West Coast IDIQ Contract stations, submit to:
Technical Representative (Task XXX)
NOAA, NOS, CO-OPS, Field Operations Division-Pacific Operations Branch
7600 Sand Point Way, NE
Bin C15700
Seattle, WA 98115

(C) For OCS contract hydrographic survey projects, submit one copy of all deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, ftp sites, etc., to:

Chief, Engineering and Development Branch
CO-OPS, N/OPS1, SSMC 4, Station 6507
1305 East-West Highway
Silver Spring, MD 20910-3821

(D) For NGS contract shoreline mapping survey projects, submit one copy of all deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, ftp sites, etc., to:

Contracting Officers Representative
NOAA/NOS/National Geodetic Survey
SSMC 3, Station # 8609
1315 East-West Highway
Silver Spring, MD 20910-3281

6.0 Guidelines and References

Various references for the water level measurement and leveling requirements issued by the NOS Center for Operational Oceanographic Products and Services (CO-OPS) and the National Geodetic Survey (NGS) are listed below. The latest versions of most of these documents can be found on the CO-OPS publication page (http://tidesandcurrents.noaa.gov/pub.html) and/or the CO-OPS Field Library (http://tidesandcurrents.noaa.gov/fieldlibrary).

6.1 DCP References

- Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual
- Sutron® Xpert Data Logger Operations and Maintenance Manual
- Sutron® Xpert2 Data Logger Operations and Maintenance Manual
- Sutron® 9210 XLite Operations and Maintenance Manual
- Sutron® 9210B XLite Operations and Maintenance Manual
- Sutron® Satlink 2 Logger & Transmitter Operations and Maintenance Manual
- Portable Tide Gauge Setup, Configuration, and Data Export Procedure
- Xpert and Xpert Dark Internal Battery Replacement
- Procedures for Requesting GOES Platform ID Allocations
- NWLON GOES MESSAGE FORMAT
- NGWLMS GOES Message Formatting for Hourly Transmissions
- Attachment of Conduits to Enclosures
- Engineering Bulletin 10-002 Standardize Battery Type for CO-OPS Water Level and Meteorological Stations with Photovoltaic Charging Systems
- Engineering Bulletin 07-007 Downloading (Exporting) Data from the Xpert Log Files using Xterm
- Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP

6.2 Sensor References

- User's Guide for Model 4100/4110 Series Aquatrak®
- Aquatrak® Calibration Procedure
- BEI® Series MT40 Multi-Turn Absolute Position Encoder
- Waterlog® H-334 Shaft Angle Encoder Manual
- ParoScientific® Digiquartz Pressure Instrumentation
- KPSI® Level and Pressure Transducer User's Manual
- Water Level Sensor Using the Sutron® Data Collection Platform, Ver 1.0
- WaterLog® H-3551 Gas Purge Bubbler Owner's Manual
- WaterLog® H3661 SDI-12 Radar Water Level Sensor
- Sutron® Accubar Barometric Pressure Multiple Interface Sensor Operations & Maintenance Manual
- SOP 3.2.3.6.F3 RBR-CTD Setup and Data Retrieval
- Castaway® CTD User's Manual
- Sutron® Barometer Calibration Procedure
- CO-OPS Sensor Specifications and Measurement Algorithms

6.3 Geodetic References

- User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations
- User's Guide for Writing Bench Mark Descriptions
- User's Guide for Electronic Levels with Translev and WinDesc
- User's Guide for GPS Observations at Tide and Water Level Station Bench Marks
- CO-OPS GPS Observations Implementation Plan
- Standards and Specifications for Geodetic Control Networks
- NGS Attachment R, Requirements for Digital Photographs of Survey Control
- NGS Attachment T, Setting a Concrete Mark
- NGS Attachment U, Setting a Survey Disk in Bedrock
- NGS Attachment V, Setting a NGS 3-D Monument
- NGS Attachment X, Performing Bench Mark Ties
- Preliminary Step by Step Leveling Instrument Procedures
- Leveling Frequency Requirements for Water Level Stations
- Creating a Bench Mark Diagram in PDF Format
- Procedure to Establish a Meteorological Sensor Reference Mark and to Measure Meteorological Sensor Heights
- Level Rod Re-Calibration

6.4 Installation and Maintenance Specifications and References

- Desktop Reconnaissance Procedure for Observing System Installation Planning
- Field Reconnaissance Procedures for Observing System Installation Planning
- CO-OPS Water Level and Meteorological Site Reconnaissance Procedures
- Latest Project Instructions for Coastal and Great Lakes Water Level Stations
- CO-OPS Evaluation Criteria for Water Level Station Documentation
- SOP 7.0.1 Updating Database Information after Annual Inspection or Emergency Maintenance
- Inside/Outside Water Level Check for the Great Lakes Gauging Station SOP
- Field Installation Procedures for Design Analysis WaterLog® H3611i Microwave Radar
- SOP 5.4.1.4A Barometer Calibration Procedure
- SOP 6.3.2.1.12 Battery Load Testing Procedures for CO-OPS Water Level Observation Systems
- CO-OPS Guide to Declaring a Newly Installed Water Level Station Operational
- SOP 3.1.1.5 Conductivity, Temperature, and Density (CTD) Observations Analysis
- SOP 3.2.3.9.132 Engineering Bulletin 17-003 Standardize the Number of Digits for Transmitting Conductivity Data
- Requirements and Guidelines for Equipment Shipping
- CO-OPS eSite User's Guide
- CO-OPS Equipment Return Form
- Engineering Bulletin 09-003 *Update to Xpert Log File Sizes*