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

Updated March 2008

Requirements and Development Division
Center for Operational Oceanographic Products and Services
National Ocean Service

TABLE OF CONTENTS

1.0. Introduction

1.1. NOS National Water Level Observation Network

The Center for Operational Oceanographic Products and Services (CO-OPS), a part of the National Ocean Service (NOS) manages the National Water Level Observation Network (NWLON) of approximately 200 (as of October 2007) continuously operating water level observation stations in the U.S. coastal zone, including the Great Lakes. As most of these stations are equipped with satellite radios, near real-time (within about 30 minutes of collection) raw data are made available to all users through the CO-OPS Web homepage at www.tidesandcurrents.noaa.gov. Verified products, such as edited 6-minute data, hourly heights, high and low waters, and monthly means are made available over the Web within one to four weeks after data collection. NWLON data and accepted tidal datums are used in hydrographic and photogrammetry surveys either to provide tide reducers directly or for control for datum determination at subordinate (short-term) stations. Preliminary and verified data are made available over the Web relative to MLLW datum, station datum, or special water level datum (such as Columbia River datum) as a user option in the interface.

1.2. Data Quality Monitoring

CO-OPS has the Continuous Operational Real-Time Monitoring System (CORMS) that provides quality control and system monitoring functions on a 24 hours/day, 7 days/week for CO-OPS monitored gauges. CORMS will monitor the status and performance of all in-house water level gauges equipped with satellite radios using the NOS satellite message format and that are installed by CO-OPS, NOAA Ships, Navigational Response Teams (NRT), or CO-OPS IDIQ contractors for CO-OPS all of in-house projects including NWLON and NOAA in-house hydrographic or photogrammetry survey projects. Once these gauges are listed on the hydro hot list or COASTAL hot list by CO-OPS, CORMS starts monitoring. CORMS is a NOS provided support function to the operational field parties and does not relieve the contractor of responsibility for performing QC and ensuring proper gauge operation. For NOAA hydrographic or photogrammetry contract surveys, the contractor is responsible for all data monitoring, repairs, and proper functioning of the subordinate gauges.

1.3. General Data and Reference Datum Requirements

All of the water level data is collected on station datums and various datums are determined on the station datum.

For hydrographic surveys, the present NOAA Nautical Chart Reference Datum for tidal waters is Mean Lower Low Water (MLLW) based on the NOAA National Tidal Datum Epoch (NTDE) of 1983-2001 as defined in the *Tide and Current Glossary*. All tidal datum computations and water level reductions for hydrographic surveys shall be referenced to this datum. For photogrammetry surveys, generally Mean Higher Water (MHW) and MLLW datums are needed for shoreline and mapping applications.

In non-tidal areas, including the Great Lakes, special low water datums have been defined for specific areas and are used as chart datum in these locations for hydrographic surveys.

In some cases where historical sites are re-occupied, site datum shall be zeroed to a pre-established station datum held on a bench mark. CO-OPS will generally provide this information if it is available. At present, in Great Lakes areas, a special Low Water Datum relative to IGLD 85 is the reference datum.

2.0. Water Level Station Requirements

2.1. Data Collection and Field Work

The contractor shall collect continuous, high quality and valid data series. Accurate datums cannot be computed for a month of data with a break in the water level measurement series in excess of three days. Even breaks of significantly less than three days duration will not allow for interpolation during times when strong meteorological conditions are present and in areas with little periodic tidal influence. Any break in the water level measurement series affects the accuracy of datum computations. At a critical measurement site where the water level measurement data cannot be transmitted or monitored during project operations, an independent backup sensor or a complete redundant water level collection system should be installed and operated during the project.

2.2. Water Level Sensor and Data Collection Platform

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

The Data Collection Platform (DCP) shall acquire and store water level measurements every 6-minutes. The water level measurements shall consist of an average of at least three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples which comprise the 6-minute measurements shall be computed and stored. The 6-minute centered average water level data is required for compatibility with the NWLON stations, and the standard deviation provides valuable data quality information regarding each measurement. The clock accuracy of a satellite radio system shall be within 5 seconds per month for 3-hourly transmissions, or within 1 second for hourly or 6 minute transmissions, so that channel "stepping" does not occur. Non-satellite radio systems shall have

a clock accuracy of within one minute per month. Known error sources for each sensor shall be handled appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, and high frequency wave action and high velocity currents for all sensor types.

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

In each and any case, the water leveling sampling/averaging scheme shall be as described above. For short term subordinate stations which are installed to support NOS hydrographic surveys, the use of air acoustic sensor is preferred over pressure sensor whenever possible. Where the air acoustic sensor can not be installed, NOS uses a vented strain gauge pressure sensor in a bubbler configuration (Refer to *User's Guide for 8200 Bubbler Gauges*, NOAA/NOS, updated February 1998). When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start, (2) at frequent intervals during deployment, and (3) at the end of a deployment. Frequent gauge/staff comparisons (Refer to Section 2.5.2 for details) during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations shall be at least three hours long at the beginning and end of deployment and the periodic observations during deployment shall be at least 1 hour long. Along with the averaging procedure described above which works as a digital filter, NOS uses a combination protective well/parallel plate assembly on the acoustic sensor and a parallel plate assembly (with 2" orifice chamber) on the bubbler orifice sensor to minimize systematic measurement errors due to wave effects and current effects, as shown in figure 1.

When pressure sensors are used to collect the water level data, the orifice should be mounted on a vertical surface such as the piling of a wharf so that the precise elevation of the orifice below a staff stop could be measured with a steel tape, and the elevation of the staff stop can be measured via differential leveling to the nearest benchmark and with the primary bench mark. If the orifice is mounted vertically and its elevation can be determined precisely with reference to the primary bench mark, then staff to gauge readings may not be necessary, and the requirement for staff-to-gauge readings may be waived in sea water environment as described in Sections 2.5.1 and 2.5.2, provided periodic (every week or 2 weeks during the project duration) density measurements are taken and submitted to CO-OPS . If the orifice can not be mounted to a vertical surface i.e. if the elevation of the orifice can not be determined precisely with the primary bench mark, then staff-to-gauge readings are required to relate the water level datums to the bench marks.

2.3. Data Transmissions

The data transmissions requirements are applicable where CO-OPS is monitoring the gauges. The ability to monitor water level measurement system performance for near real-time quality assurance is essential for operations. Therefore, it is required that, where access to the satellite is available, the measurement system shall be equipped with a GOES transmitter to telemeter the data to CO-OPS, the frequency of data transmissions could be every six minutes, hourly, or three hours. The data transmissions must use a message format identical to the format as currently implemented in NOS CO-OPS' *"NGWLMS GOES MESSAGE FORMATTING"*. This is required to assure direct compatibility with the NOS Data Management System (DMS). This data format is detailed in the reference document *"NGWLMS GOES MESSAGE FORMATTING"*. Once station and gauge information are configured in DMS and the station is listed on the Hydro Hot List (HHL), CORMS will monitor all water level measurement system GOES transmissions to assure the station is operating properly, provided that the GOES data transmitted is compatible with CO-OPS format and CO-OPS is monitoring the data. Data that is not transmitted by GOES, or data transmitted but not in CO-OPS compatible GOES format, or is submitted to CO-OPS via diskette, CD-ROM, or such other digital media, must also conform to the format specified in the above document and as specified in Section 5 under "Water Level Data" so that data can be loaded properly into DMS software. Refer to Section 5 for further details about the water level data format specifications.

Close coordination is required between the contractor and the Requirements and Development Division (RDD) of CO-OPS for all water level installations with satellite transmission capability. NOS will assist in acquiring assigned platform ID's, time slots, etc. 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 faxed, phoned, or e-mailed to the Operational Engineering Team (OET) of RDD. The e-mail address for OET is nos.coops.oetteam@noaa.gov. Test transmissions conducted on site are outside this requirement. This station and DCP information must be configured in DMS before data transmissions begin so that the data will be accepted in DMS. The documentation required prior to transmission in field is defined in the NGWLMS Site Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 5 Data Submission 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), Data Collection Platforms (DCP), 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.

Water level station and its various components (tide house, Data Collection Platform, all sensors, meteorological tower, bench marks, and pertinent access facilities such as railings, steps, etc., as appropriate), when designed or installed by contractors, shall be installed and maintained as prescribed by manufacturers, installation manuals, appropriate local building codes, or as specified by the Contracting Officer's Technical Representative (COTR), if applicable. Water level

station and all installed components shall be structurally sound, secure, and safe to use for NOS, local partners, and general public, as appropriate.

The contractor shall provide CO-OPS the position of all tide gauges installed before data collection begins, including those that were not specified in the Statement of Work or Project Instructions, as appropriate. The positions of bench marks and stations installed or recovered shall be obtained as latitudes and longitudes (degrees, minutes, and tenth of seconds).

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:

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

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

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

C. The preparation of all documentation and forms.

2.4.2. Station Operation and Maintenance

Contractor shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure, and for other causes of degraded or invalid data, such as marine fouling. 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 COOPS web page (http://www.TidesandCurrents.noaa.gov). The data over this system are typically available for review within 30 minutes to four hours 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 writing using appropriate maintenance forms (see section on water level station documentation below) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date and time of start and completion of the maintenance activity; date and time of adjustments in sensor/DCP, datum offset, or time; personnel conducting the work; parts or components replaced; component serial numbers; tests performed; etc.

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 the minimum number bench marks and the water level sensor(s) and tide staff as appropriate.

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

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

2.5. Tide Staffs and Staff Observations

2.5.1. Staff

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

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

2.5.2. Staff Observations

When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start of water level data collection, (2) at frequent intervals during deployment, and (3) at the end of a deployment before gauge has been removed. Frequent gauge/staff comparisons during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations at the start and end of deployment shall be at least each three hours long and the periodic observations during the deployment shall be at least 1 hour long. The staff to gauge

observations shall be performed three times per week, during each week of the project, with at least an hour long observations of 6 minute interval for each time. Where staff to gauge observations can not be performed three times a week as required then an explanation is required for the deficiency of number of observations, and staff to gauge observations shall be performed at least (a) minimum eight times spread out over each month (e.g. two times per week) and at each time at least 1 hour of observations at 6 minute interval, or (b) minimum of four times spread out over each month (e.g. one time per week) and at each time at least 2 hours of observations at 6 minute interval, whichever is convenient.

The staff-to-gauge differences should remain constant throughout the set of observations and show no increasing or decreasing trends. After the water level data has been collected, the averaged staff-to-gauge shall be applied to water level measurements to relate the data to staff zero. A higher number of independent staff readings decrease the uncertainty in transferring the measurements to station datum and the bench marks. Refer to Figure 2 for an example pressure tide gauge record.

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

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

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

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

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

The orifice elevation above station datum is also defined as accepted orifice offset in CO-OPS Data Management System (DMS).

Bubbler Orifice and Parallel Plate Assembly

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

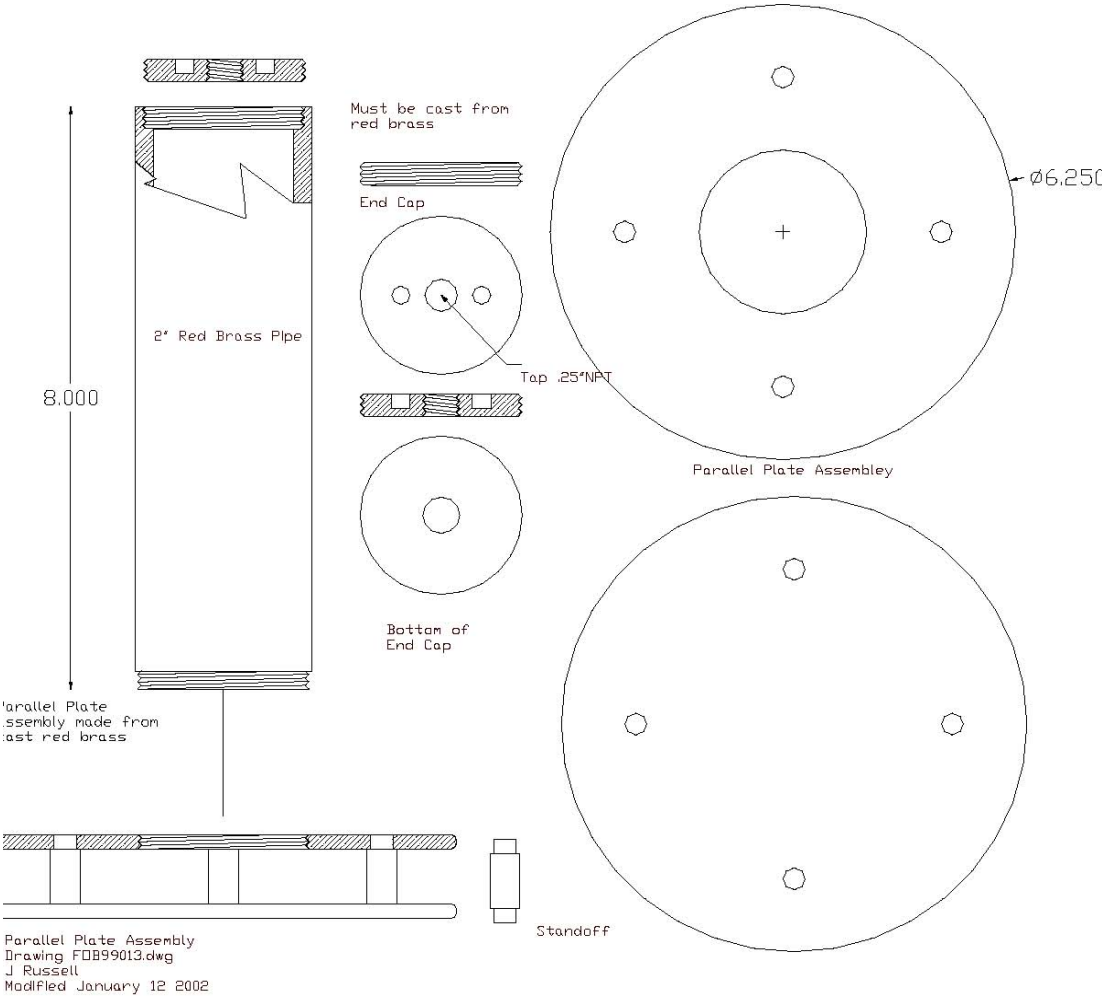


Figure1: Bubbler Orifice Bottom Assembly

PRESSURE TIDE GAUGE RECORD

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

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

Figure2: Example – Pressure Tide Gauge Record

3.0. Bench Marks and Leveling

3.1. Bench Marks

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

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, dated October 1987,* specifies the installation and documentation requirements for the bench marks. Each station will have one bench mark designated as the primary bench mark (PBM), which shall be leveled to on every run. The PBM is typically the most stable mark in close proximity to the water level measurement station. The contractor shall select a PBM at sites where the PBM has not already been designated. For historic NOS station reoccupations, CO-OPS will furnish the name of the PBM and PBM elevation above station datum, as appropriate and if available.

The most desirable bench mark for GPS observations will have 360 degrees of horizontal clearance around the mark at 10 degrees and greater above the horizon and stability code of A or B. Refer to Section 4.2 GPS Observations, and *User's Guide for GPS Observations, Updated March 2007,* for further information.

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

3.3 Leveling

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

3.4 Leveling Frequency

Levels shall be run between the water level sensor(s) or tide staff and the required number of bench marks when the water level measurement station is installed, modified (e.g., water level sensor serviced, staff, or orifice replaced), for time series bracketing purposes, or prior to removal. In any case, levels are required at a maximum interval of six (6) months during the station's operation, and are recommended after severe storms, hurricanes, 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 are required 30 days or more prior to the planned removal of a applicable gauge(s) (for hydrographic/photogrammetry survey projects, or (b) after 6 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 contractor shall document the movement. In some special cases, CO-OPS may require the contractor 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 diskettes whether the gauge data are sent via satellite or not.

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

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

4.0. Geodetic Connections and Datums Relationship

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

Existing geodetic marks in the vicinity of a subordinate tidal station shall be searched for and recovered. A search routine is available at http://www.ngs.noaa.gov. An orthometric level connection and ellipsoidal GPS tie is required at a subordinate tide station which has geodetic bench marks located nearby as stated below for NAVD 88 Level Tie and NAD 83 GPS Tie requirements. NAVD 88 heights for published bench marks are given in Helmert orthometric height units by NGS. The GPS ellipsoid network height accuracies are classified as conforming to 2 cm or 5 cm standards accuracies (Refer to *NOAA Technical Memorandum NOS NGS-58*). At the present time, GPS ellipsoid heights conforming to the 2 cm accuracy standards are required for all projects. Refer to Section 4.2. GPS Observations, and *User's Guide for GPS Observations, NOAA/NOS, Updated March 2007*.

A connection to the geodetic datums at a water level station enhances the value of the tidal data, allowing comparison with other data sets. The geodetic network essentially serves as a global reference datum to which all tidal datums can be referenced. The connection to geodetic datums involves the following three ties:

1. NAVD 88 Level Tie
2. NAD 83 GPS Tie
3. NAVD 88 GPS Tie

4.1. 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 marks are available within 1.6 KM (1 mi) leveling distance of the station location. A GBM is defined as a bench mark that exists, is useable, is available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet.

At stations supporting hydro or other special projects, the tie shall be consistent with the accuracy of the levels required for the project. Information on performing a valid level tie is provided in the 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.

Also, Section 3.4 of *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations* provides 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. Since a level connection to GBMs with dynamic heights defines the IGLD 85 datum offset at each station in the Great Lakes, a valid connection to at least two GBMs is required at each site in the Great Lakes.

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

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 level tie requirement is waived.

4.2. GPS Observations

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

4.2.1 References and standards

Static GPS observations shall be performed at water level stations in accordance with Reference *"User's Guide for GPS Observations"*, Updated March 2007. Reference *"NOS NGS 58"* provides further details. These guidelines are written for establishing GPS derived ellipsoid height accuracy standards of 2 cm as outlined in NGS-58 document, for all survey projects, and special project applications.

Static GPS surveys shall be conducted on a minimum of one bench mark at each subordinate water level station installed/occupied for hydrographic or photogrammetric surveys.

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

4.2.2. Equipment and accuracies

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

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

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

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

The manufacturer, model, and complete serial numbers of all receivers and antennas must be noted for each occupation on each station/bench mark observation log sheet as shown in Figure 6.

4.2.3. Criteria for bench mark selection for GPS observations

The GPS Water Level Station Bench Mark (GPSBM) shall be selected based on the following criteria: (1) permanence or stability; (2) historic GPS use; (3) satellite visibility; and (4) safety and convenience.

(1) Permanence or stability of bench marks

NGS has defined the following monumentation quality codes, also called the stability codes, for various bench mark settings.

Stability code A – monuments of the most reliable nature which may be expected to hold their elevations very well; e.g. Class A rod marks, or marks installed on large boulders/rock outcrop.

Stability code B – monuments which probably hold their elevations well; e.g. Class B rod marks, or marks installed on large concrete footings/foundations.

Stability code C – monuments which may hold their elevations but which are commonly subject to surface ground movements; e.g. pavement or concrete monuments.

Stability code D – movements of questionable or unknown reliability.

The station bench mark selected for GPS observations shall be of stability code A or B. GPS observations on the primary bench mark (PBM) are preferred if the PBM is either stability code A or B, and is suitable for satellite observations. Stability code C and D bench marks shall not be used for GPS observations, unless NGS has previously made GPS observations on those marks. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark.

(2) Historic GPS use

In many states, CO-OPS has provided NGS with lists of selected marks suitable for GPS observations at water level stations, and NGS has completed observations on these marks. Some tidal marks designated as Federal Base Network (FBN) or Cooperative Base Network (CBN) marks may be of stability code C. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. If leveling reveals instability of the mark over time, select another mark.

Priority shall be given to a GBM for GPS observations because the GBM already has a NSRS height (NAVD 88). The GBM considered here is one of the 10 tidal or water level bench marks at a water level station.

(3) Satellite visibility

The most desirable bench mark for GPS observations should have 360 degrees clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have these clearances, if at all possible. If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new mark (stability A or B) shall be established. This new mark shall be connected to the station bench mark network through conventional geodetic leveling, and then GPS observations shall be made.

All existing station bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. If electronic leveling equipment is used, then a note shall be made, either in the APP field of the electronic leveling HA file or on a copy of the published bench mark sheet, stating the suitability of GPS observations for each mark. The GPS visibility obstruction diagram shall also be completed for each mark observed.

GPS visibility obstruction diagram shall also be completed for each mark observed, as shown in Figure 8.

(4) Safety and convenience

The location of the GPS bench mark should be safe, secure, and convenient. Bench mark locations which allow unattended GPS data collection are desirable as the field crew can multi-task at the same time as collecting the GPS data. The safety of the GPS equipment (vandalism proof) should be considered in the mark selection process.

The bench mark selected for GPS observations should be located on public property rather than on private property, as permissions from private owners may be required in the future to access the bench mark and for collecting the GPS data. The distance from the station DCP should also be convenient.

4.2.4. Recording of data

Set the epoch update or recording interval (REC INT) for 15-seconds, which should agree with the recording interval of the reference stations (IGS or CORS) used to post-process the data. For GPS sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. The elevation mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to four. For static surveying, setting the minimum number of satellites (MIN SV) is not as critical as for kinematic surveying. However, if the number of satellites tracked drops below four, it could be an indication of other problems, such as an antenna or antenna cable connection problem, RF interference, or an obstruction from traffic (vehicle or vessel). The GPS signal from the satellite is not very strong when entering the receiver, so anything that produces further attenuation of the signal can cause the receiver to stop tracking satellites.

4.2.5. Position and photograph of the GPS bench mark

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

Digital photographs shall be taken of all station bench mark disks in accordance with Reference - *Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005*". A minimum of three photos shall be taken: close-up of the disk face; chest or waist level view of the disk and setting; and horizontal view of location and direction of view. The digital file for a bench mark photo shall have the bench mark designation in its file name, followed by the view, with a jpg extension, i.e. CONTAINER setting.jpg, or CONTAINER location NE.jpg.

A digital photo of the stamping of the bench mark occupied must be made as shown in Figure 10. If a digital photo is not available, then a rubbing of the bench mark must be done as shown in Figure 9. A digital photo of the stamping is preferred over rubbing of the mark.

Photos shall also be taken of station components such as protective wells, staffs, tide house, DCPs, sensors, etc. One general location photo shall be taken showing the water level station in relationship to its supporting structure and the local body of water. All digital station photo files should be named such that the name of the file will indicate the station number and the type of photo taken. For example, the pressure sensor photo for DCP1 at San Francisco shall be named as 94142901 sensor N1.jpg.

4.3. North American Datum 1983 (NAD 83) GPS Tie

The NGS Online Positioning User Service (OPUS) is now used extensively for quick and convenient processing of the GPS raw data for a variety of applications. The position solution provided by OPUS is considered preliminary data and is not retained by NGS. Further information regarding using OPUS is provided in the next section.

The expected ellipsoid height accuracy for a 4 hour OPUS solution is 1.8 cm (at the 67% confidence level), and that is desirable, practical, and achievable with the requirements as specified in Reference, NOAA Technical Memorandum "*NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3"*.

The length of GPS observation sessions depends upon the length of time the field crew has available for GPS observations, security of the equipment, number of satellites available at a site, number of GPS receivers available for GPS observations, etc.

For water level stations, collect a minimum of 4 hours of GPS data on the GPSBM. Extra care shall be taken to ensure that the antenna height is precisely recorded, and that the antenna setup is stable. A continuous long session (at least 4 hours long but less than 24 hours) repeated annually is preferred to two or more shorter sessions (of less than 4 hours each) repeated on the same visit, providing better data for OPUS and more independent observations.

After the data collection session is complete, two independent downloads are required from the GPS receiver to the laptop computer. If one downloaded file gets corrupted, the other file may have good data. Do not make a copy of the downloaded file, as both the files will have the same problem, if there is a problem. Follow the NGS guidelines for naming these files. Submit both copies of the digital GPS data along with the necessary documentation as specified in the *"User's Guide for GPS Observations, Updated March 2007"*.

4.4. GPS Data Processing Using OPUS

Field parties shall use OPUS for processing the raw GPS observations. OPUS provides an easily accessible, rapid method for submitting GPS data and receiving an almost instantaneous solution response from NGS via email.

The NGS OPUS web page can be obtained at http://www.ngs.noaa.gov/OPUS/. The following information is found on the OPUS web page but is also presented here for convenience of the reader.

OPUS allows users to submit their GPS data files to NGS, where the data will be processed to determine a position using NGS computers and software. Each data file that is submitted will be processed with respect to three CORS sites. The sites selected may not be the nearest to your site but are selected by distance, number of observations, site stability, etc. The position for your data will be reported back to you via email in both ITRF and NAD 83 coordinates as well as Universal Transverse Mercator (UTM), U. S. National Grid (USNG) and State Plane Coordinates (SPC) northing and easting.

OPUS is completely automatic and requires only a minimal amount of information from the user:

1. The email address where you want the results sent.

2. The data file that you want to process (which you may select using the browse feature; raw or RINEX accepted).

3. The antenna type used to collect this data file (selected from a list of calibrated GPS antennas).

4. The height of the Antenna Reference Point (ARP) above the monument or mark that you are positioning.

Once this information is complete, you then click the Upload button to send your data to NGS. Your results will be emailed to you, usually within a few minutes. You may upload multiple data files in a zip archive if you wish. However, be careful, the options that you choose will be applied to all of the data files in that archive (i.e. the same antenna type, ARP height will be used for all of the files in the zip file).

The following are some simple guidelines for analyzing the OPUS solutions.

1. Make sure the antenna type and the ARP height are correct.

2. Review the solution statistics:

    a. A good quality OPUS run should typically use 90% or more of your observations.

    b. OPUS should have fixed at least 80% of the ambiguities.

    c. The overall RMS should seldom exceed 3 cm.

    d. The maximum peak to peak errors should be less than 2 cm for horizontal and 4 cm for vertical (This depends, of course, on the accuracy you are trying to achieve).

NGS needs to receive orbit data from IGS in order to obtain a solution. If the data is submitted too quickly, the submitter may need to re-submit the data at a later time. For best results, submit the GPS data to OPUS at least 17 hours after the first midnight (in Greenwich Mean Time) following the time when the observations were recorded. Compare the resultant solution to the last previous solution made at the station, if available, to ensure that you do not have a blunder in the antenna setup. This will be revealed by a noticeable discrepancy in the ellipsoid height. Include a copy of the solution in the station inspection documentation package submitted to CO-OPS RDD/OET, as well as the GPS data sets.

4.5. OPUS DB Preliminary Information

Pending NGS support, OPUS DB will be released by NGS. This advanced version of OPUS will submit OPUS solutions directly to the NGS database if all required documentation is provided by the submitter. Further guidance will be provided once OPUS DB is released and these specifications will be updated as appropriate. Any data sets submitted to OPUS and the results will be subsequently re-submitted by CO-OPS' RDD/OET to OPUS DB to ensure the data is published by NGS.

Height modernization guidelines are here: http://www.ngs.noaa.gov/heightmod/guidelines.shtml

The Opus DB datasheet concept is fully listed at the following NGS web site: http://www.ngs.noaa.gov/PROJECTS/draft/OPUS/OPUS-DB-concept.htm

The following tables identify the required data elements and optional data elements for OPUS DB Respectively:

REQUIRED DATA ELEMENTS (15 each):

ELEMENT	RATIONALE
e-mail	For identification & correspondence.
Filename	Necessary to compute position.
Antenna	Necessary to compute position.
antenna height	Necessary to compute position.
name of submitting agency	Identifies the observer.
permanent identifier (PID)	Identifies the station.
Designation	Identifies the station.
descriptive text	Aids in station recovery.
Rod/pipe depth & units	Describes monumentation quality.
sleeve depth & units	Describes monumentation quality.
setting code & specific setting text	Describes monumentation quality.
photograph (of marker)	Aids in station recovery.

OPTIONAL DATA ELEMENTS (11 each):

ELEMENT	RATIONALE
photographs (of equipment, horizon)	Equipment photos describe antenna height and equipment used. Horizon photos aid in station recovery and could explain visibility or multipath problems.
vertical stability code	Useful for stability assessment.
magnetic property code	Aids in station recovery.
antenna s/n	Useful in identifying equipment-specific problems.
receiver	Useful in identifying equipment-specific problems.
receiver s/n	Useful in identifying equipment-specific problems.
receiver firmware	Useful in identifying firmware-specific problems.
stamping	Aids in station identification.
condition code	Useful for stability assessment.
special application codes	Identifies the station type (tidal station, Public Land Survey corner, etc.)
remarks	Allows user to record observation comments.

This information regarding the Required Data Elements and Optional Data Elements is for reference only and not required at the present time. These requirements will be active once OPUS DB is designated operational by NGS. Out of the 15 Required Data Elements, 13 are applicable to all the marks and the remaining two - rod/pipe depth & units and sleeve depth & units – are applicable only to rod marks.

4.6. NAVD 88 GPS Tie

The NAVD 88 GPS tie involves simultaneous GPS observations at the GPSBM and one or more GBMs located up to 10 KM (6.26 mi) from the GPSBM. This “Height Mod” tie is deferred until such time as NGS enables user-friendly bluebooking of campaign data (OPUS projects).

5.0 Data Submission Requirements

Data submission requirements for water level measurement stations are comprised of both supporting documents for the installation, maintenance, and removal of stations, and the formatted digital water level data collected by the water level measurement system required for NOS quality control and ingestion into the NOS data base management system.

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

5.1 Station Documentation

When a water level station is installed, contractor shall forward draft E-site report (Xpert Site Report or Tide Station Report), raw levels and level abstract within one business day after completion of levels to sensor and required number of bench marks. All other water level documentation shall be forwarded as described below in the next paragraph.

The documentation package shall be forwarded to CO-OPS within 10 business days of: a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, or d) removal of the station. Refer to Section 5.4 for general documentation and timelines requirements, and Figure 3, Water Level Station Documentation Checkoff List, shall be used to check and verify the documentation that is required for submission. The station documentation generally includes, but is not limited to the following:

(1) Transmittal letter (PDF format).

(2) Field Tide Note (PDF format), if applicable (for hydro projects only).

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

(4) E-Site Report, Water Level Station Xpert Site Report, or Tide Station Report (NOAA Form 77-12), or equivalent. (E-Site report application is in web based electronic format, Water Level Station Xpert Site Report or Tide Station report in Microsoft Excel format). Contractor created Site Reports are acceptable as long as the reports provide same required information.

(5) Google Chartlet, or NOAA Chartlet with chart number or map name and scale shown including standard NOS title block (JPEG and PDF format).

(6) U.S. Geological Survey quadrangle map (15 seconds map) indicating the exact location of the station, with map name and scale shown (JPEG and PDF format).

(7) Sensor test worksheet (JPEG and PDF format) (applicable for acoustic gauges).

(8) Sensor elevation drawing (JPEG and PDF format) showing sea floor, pier elevation, and sensor elevation if sensor is mounted vertically.

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

(10) 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 sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (derived from handheld GPS) of the gauge (JPEG and PDF format).

(11) New or updated description of how to reach the station from a major geographical landmark (in Microsoft Word and PDF format). (Refer to User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003).

(12) Bench mark descriptions with handheld GPS coordinates (in Microsoft Word and JPEG format) (Refer to User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003).

(13) Digital photographs of bench mark disk faces, setting, bench mark locations from two different (perpendicular) cardinal directions, station, DCP, equipment, underwater components, and vicinity (JPEG and PDF format) . As a minimum, photographs shall show a view of the water level measurement system as installed, including sensors and DCP; a front view of the staff (if any); multiple views of the surroundings and other views necessary to document the location; and photographs of each bench mark, including a location view and a close-up view showing the bench mark disk (face) stamping. Bench mark photo file names start with mark designation followed by either "face" or "location" and direction of view, with jpg extension (e.g. 8661070 B location south.jpg). All other station component photo file names start with station number and view name (e.g. 8661070 tide station view south).

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

(15) Level abstract (electronic file for optical and barcode levels)

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

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

(18) Staff to gauge observations, if applicable (in Microsoft Excel and PDF format)

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

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

(21) Water level data download

(22) GPS Project report, GPS observations in raw and RINEX format, GPS observations log sheets, antenna height measurements, visibility diagrams, OPUS results, as required GPS documentation, if applicable, (all in various electronic format). The GPS documentation requirements are described in detail in the next Section 5.2.

5.2 GPS Project Documentation

The following information in addition to the results obtained from OPUS shall be submitted to CO-OPS at the end of the project (see the time frames for submission of GPS data later in the Section 5.4) so that proper information can be forwarded to NGS for blue-booking purposes.

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

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

GPS forms in PDF format can be found at the following NGS Federal Base Network web site: http://www.ngs.noaa.gov/PROJECTS/FBN/index.htm

Refer to Figures 4 through 10 for GPS projects submission checklist and sample package contents.

(A) Project report (Refer to Figure 4.):
One project report per GPS project is required.

(B) Station (bench mark) description or recovery notes (Refer to Figure 5)
One per bench mark, for which GPS observations are submitted, is required.

(C) Observation log sheets (Refer to Figure 6 and 7)
One per each GPS observation session is required.

(D) Station/bench mark visibility diagrams (Refer to Figure 8)
One per each bench mark, for which GPS observations are submitted, is required.

(E) Photographs or rubbings of station (bench) marks (Refer to Figure 10 and 9)
One per each bench mark, for which GPS observations are submitted, is required.

(F) Raw GPS data

(G) Rinex GPS data

(H) OPUS results

I. **For Each Water Level Station:**

PROJECT DOCUMENTATION AND DATA CHECKOFF LIST

Project Number: _____ **Locality:** _____

Station Number: _____ **Station Name:** _____

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

	1. Verify station latitude and longitude with handheld GPS.
	2. Verify work dates.

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

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

C. Chart Section

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

D. Bench Mark/Station Location Sketch

	1. Ensure Gage/staff and bench marks are shown, and local body of water is labeled.
	2. Ensure Standard Title block includes: station number and station name, field unit, date of revision
	3. Ensure North arrow depicted.
	4. Include hard copy sketch and GIS digital format on diskette.
	5. Ensure All active (recovered and not recovered) bench marks are identified by designations

	6. Ensure bench marks that are confirmed as destroyed are removed from the sketch.
	7. Provide a digital copy of the sketch saved in jpg format.

E. Digital Photographs

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

F. Bench Mark Descriptions/Recovery Notes

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

G. Levels

	1. Ensure all information written in ink.
	2. Cover information complete; station name, number, instrument and rod type, serial numbers, date, personnel.
	3. Note type of levels: installation, bracketing and closing.
	4. Staff information complete (if applicable).
	5. Collimation check shown.
	6. Note that bench mark descriptions are submitted on separate sheets.
	7. Headers on all applicable pages complete.
	8. For multi year projects, or for NWLON, all marks must be connected every two years
	9. Levels include marks specially noted in station specific requirements of the project instructions
	10. Explanation provided for any marks not leveled during this level run.
	11. Provide sectional and overall closure tolerances and ascertain they are within allowable limits.

	12. Compute level abstract starting with PBM accepted elevation and ending with primary sensor elevation
	13. Check for valid tie to NAVD 88, as applicable.
	14. For electronic levels, provide original IN file in separate folder if modified IN file is provided.
	15. For electronic levels, all file dates must be chronologically consistent, i.e. the HA and INX files can not have dates more recent than the ABS file
	16. For electronic levels, provide Invar rod calibration certificates for the first time digital leveling
	17. For electronic levels, error flags are not allowed on sectional distances of the ABS file

H. Datum Offset Computation Worksheet

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

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

	1. Label diskettes with contractor name and list of files on each diskettes.
	2. Data files should be named in the following format: xxxxxxx1.w1.daz, where xxxxxxx = seven digit station number and 1 is the DCP designation. For multiple files from the same station, change the extension, i.e., xxxxxxx1.w1.da1, da2, etc.
	3. Check the begin and end dates of data submitted with dates of hydrographic surveying operations, or project duration for special projects.
	4. Check data continuity.

J. Transmittal Letter

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

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

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

Figure 3. Project Documentation and Data Checkoff List

PROJECT SUBMISSION CHECKLIST

GPS PROJECTS

Project Title: _____

Submitting Agency: _____

Observing Agency: _____

Receiver Type: _____

Antenna Type: _____

PACKAGE CONTENTS

( ) Project Report

( ) Station Description or Recovery notes

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

( ) Station Visibility Diagrams

( ) Photographs or Rubbings of Station Marks

( ) Raw GPS data

( ) Rinex GPS Data - See below

( ) OPUS results

( ) Other

DATA REFORMATTING

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

The NGS-standard data filenames are as follows:

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

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

For example, RINEX2 filenames from station BALD 2 on session A of 12/31/98 are ALD365A.98o and BALD365A.98n

Copy the raw GPS data files and the converted RINEX2 data files onto separate 3.5-inch diskettes or CD ROM.

Figure 4. Project Submission Checklist

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

NATIONAL GEODETIC SURVEY
STATION DESCRIPTION / RECOVERY FORM

PID: QE2736 Designation & Alias: BALD 2 RESET

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

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

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

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

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

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

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

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

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

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

See Back of Form to add Text Description

Figure 5. Station Description/Recovery Form

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

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

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

(name, address, phone of landowner)

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

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

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

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

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

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

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

GPS STATION OBSERVATION LOG (01-Nov-2000)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Note: Entries are Required in all Unshaded areas.

Data File Name(s): BALD365A.dat (Standard NGS Format = aaaaddds.xxx) where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension	Updated Station Description:	✔ Attached ☐ Submitted earlier	LOG CHECKED BY: JGE
	Visibility Obstruction Form:	✔ Attached ☐ Submitted earlier	
	Photographs of Station:	✔ Attached ☐ Submitted earlier	
	Pencil Rubbing of Mark:	✔ Attached	

Figure 6. GPS Station Observation Log

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:

I. Instructions for Fixed-Height Tripods:

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

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

II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

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

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

S = _____ cm

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

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

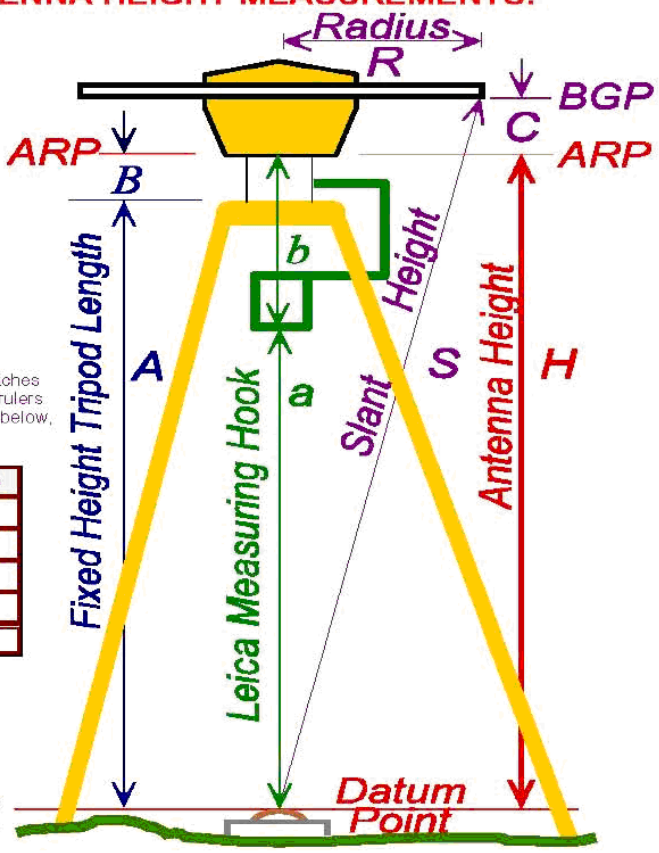
R = 19.05 cm

C = 3.50 cm

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

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



III. Instructions for using the Leica Brand Measuring Hook:

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

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

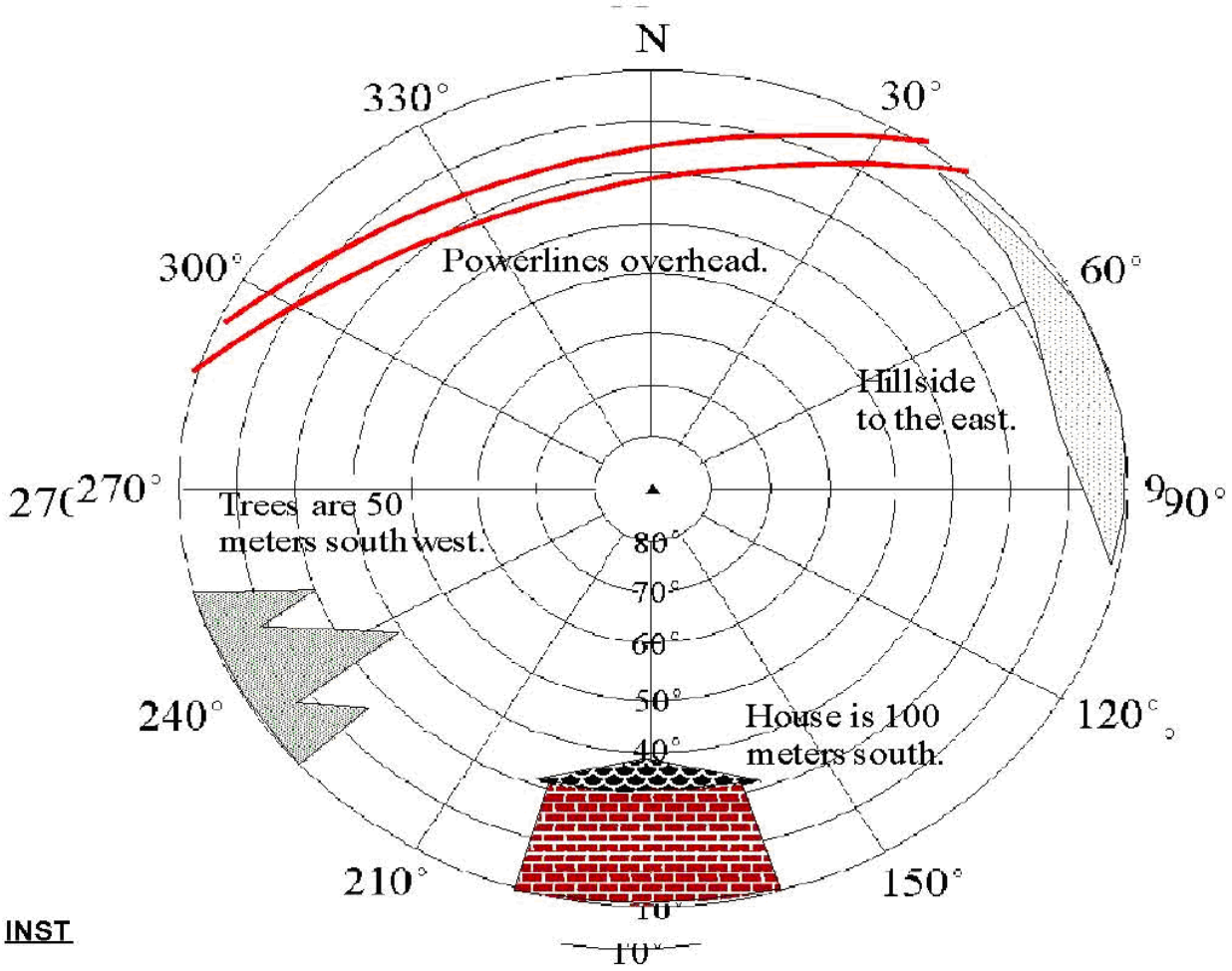
Table of Weather Codes -- for entry into Weather Data Table on front of form:

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

Figure 7. GPS Antenna Height Measurements

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

NATIONAL GEODETIC SURVEY
VISIBILITY OBSTRUCTION DIAGRAM



INST

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

Designation: BALD 2 RESET PID: QE2736

Location: Boiler Bay Wayside County: LINCOLN

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

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

Figure 8. Visibility Obstruction Diagram

Station Pencil Rubbing Form

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

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

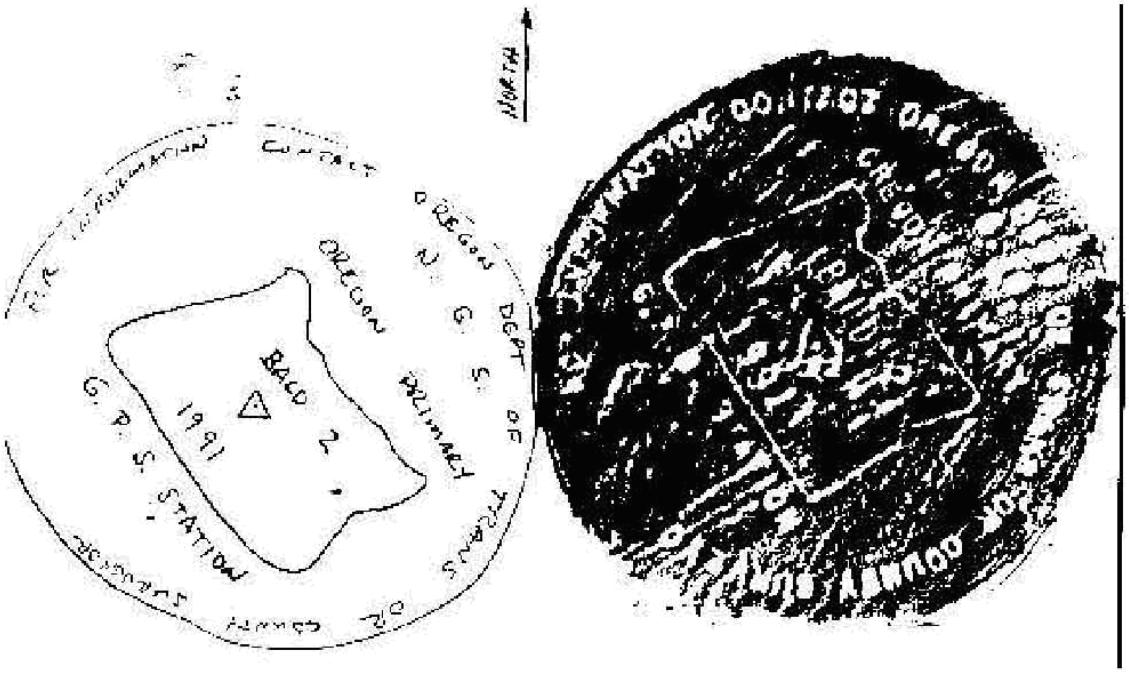
Station Designation: BALD 2 RESET PID: QE2736 Date: 1998-12-31

Circle all applicable: PACS SACS ~~PAM~~ FBN ~~CBN~~ OTHER_____

Observer & Organization: John Q. Surveyor, ORDOT

Station Pencil Rubbing

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



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

Monument Type: Brass Disk

Inscribed Agency: Oregon DOT

Stamping: BALD 2 1991

Figure 9. Station Pencil Rubbing Form

Figure 10. Digital Photo of Stamping of Bench Mark

5.3 Water Level Data

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

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

All digital water level and ancillary data shall be transmitted to CO-OPS in a format dependent on the DCP configuration. If GOES satellite is used, the data shall be transmitted and received using the NOS compressed pseudo binary format (see NGWLMS GOES Message Formatting, Libraro, 1/2003). These satellite messages are then decoded by NOS DMS upon receipt from NESDIS before further processing and review by CORMS can be completed.

If satellite transmission configurations cannot be installed, the data shall be manually downloaded from the DCP and submitted to NOS, as shown in the format below, in a digital format, on CD-ROM, or by email as an ASCII data attachment. It may be prudent to submit data at more frequent intervals under specific circumstances.

Data download files shall be named in the following format: xxxxxxxy.w1.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 is from the same station and DCP). This is the format needed when the data is loaded into DMS. Also each water level data file (XXX.BWL or XXX.ACO) shall have only 3 months of data. If the water level station was operational for more than three months, please submit multiple xxxxxxxy.DAZ files, each file with only three months of data.

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

Each input record (including the final record) ends with a carriage return and excludes 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 1998)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01, ...., 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00,06,12, ..., 54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 Temperature 1 (tenth of degrees C in integer format)
Column 51-56 Temperature 2 (tenth of degrees C in integer format)
Column 57-58 Sensor type (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 2007 05:00 1138 23 0 308 297A1 D
85169901AUG 17 2007 05:06 1126 26 0 308 298A1 D
85169901AUG 17 2007 05:12 1107 26 1 309 298A1 D
```

Pressure Sensor or Generic Data (XXX.BWL format)

```
Column  1- 7 Station ID (7 digits, assigned in the project instructions)
Column  8- 8 1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column  9-19 Date (MMM DD YYYY format, e.g. JAN 01 1998)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01, ..., 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00-54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 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.

5.4. Deliverables - Documents and Timelines

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

The purpose of one-day draft E-Site Report submission requirement is to standardize the requirements for all of CO-OPS' field efforts, provide feedback by OET to Installer while at site, so that critical information is verified, appropriate timely and corrective actions and required maintenance actions as described in the station specific Project Instructions are accomplished by Installer while at site. This requirement applies to all types of water level stations and all types of sensors for every type of maintenance - installation, regular scheduled maintenance, emergency maintenance, and removal of a water level station, where CO-OPS is expected to receive and/or process the data.

CO-OPS has developed a web-based electronic site report (E-Site Report) that interacts with DMS. Refer to Reference 25 and 26 for Users Guide and SOP for use of E-Site report. Installer shall follow the SOP for using the E-Site report as described in reference 26.

The installer is required to submit the required documentation as described in Section 5.1 to CO-OPS RDD within 15 business days of completion of water level station installation, maintenance, repair, removal, or as specified in the contract documents. The station documentation shall be submitted in digital format only.

All data and documentation submitted to CO-OPS shall be retained by the installer for a period of not less than three years or as stipulated in the contract, whichever is longer.

Refer to Section 5.1 for details about the documentation.

All data and documentation submitted to CO-OPS shall be retained by the contractor for a period of not less than three years or as stipulated in the contract, whichever is longer.

Standard station documentation package includes the following:

(1) Transmittal letter
(2) Field Tide note, if applicable
(3) Calibration records for sensors, if applicable
(4) E-Site Report, Xpert Site Report, or Tide station report
(5) Chartlet
(6) USGS Quad map (7.5 seconds interval)
(7) Sensor test worksheet
(8) Sensor elevation drawing
(9) Water level transfer form (Great Lakes stations only)
(10) Bench mark sketch
(11) “Station To Reach” statement
(12) Bench mark descriptions
(13) Photographs of bench marks, station, DCP, equipment, and vicinity in digital and paper format
(14) Levels (raw) (electronic files) and field notes of precise leveling
(15) Abstract of precise leveling
(16) Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor “zero” measurement point is referenced to the bench marks.
(17) Calibration certificates for Invar leveling rods, if applicable
(18) Staff to gauge observations, if applicable
(19) Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable
(20) Other information as appropriate, or as specified in the contract
(21) Water level data download
(22) GPS data and documentation, as applicable

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

When using the electronic/barcode system, the data disk and hard copies of the abstract and bench mark description or recovery notes shall be submitted. At stations where the automated or manual levels are used, Precise Leveling sheets of actual runs (NOAA Form 75-29) and Abstract of Precise Levels (NOAA Form 76-183) shall be completed and submitted.

For submission in electronic format, the station documentation shall be organized by various folders under the main station number folder, and then pertinent information shall be placed in the various folders and submitted on a digital media such as DVD/CD-ROM etc.

Here is an example of submission of the electronic folders for San Francisco tide station:

9414290 San Francisco FY 08 Installation
/Transmittal letter
    /Field Tide Note
/Calibration records for sensors, if applicable
/Site Report or tide station report
/Chartlet and USGS Quad maps
/Sensor test worksheet
/Sensor elevation drawing
/Bench mark sketch
/Bench mark descriptions and "Station To Reach" statement
/Photographs of bench marks, station, DCP, equipment, and vicinity in digital and paper format
/Levels (raw) (electronic files) and field notes of precise leveling
/Abstract of precise leveling
/Staff to gauge observations, if applicable
/Datum offset computation worksheet or Staff/Gauge difference work sheet (elevation of sensor zero measurement point referenced to bench marks)
/Calibration certificates for Invar leveling rods, if applicable
/Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable
/Other information as appropriate, or as specified in the contract
/Water level data (6-minute, hourly heights, high/low, monthly means, station datum)
/GPS data and documentation, as applicable

Submit only required GPS deliverables (data and documentation) on a separate DVD/CD-ROM, so that CO-OPS can forward that information to NGS. for example, GPS submission for San Francisco tide station will be as follows:

9414290 San Francisco
/GPS data and documentation, as applicable

Submit one copy of all the documentation, water level data, including GPS data and documentation in digital format. Submit one copy in digital format of the required GPS deliverable (GPS data and documentation including OPUS results) on a separate DVD for transfer to NGS.

Submit the completed station package to

Chief, Requirements and Development Division
NOAA/NOS/CO-OPS/RDD
SSMC 4, Station # 6531
1305 East-West Highway

Silver Spring, MD 20910-3281
Tel # 301-713- 2897 X 145

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.

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

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

2 Xpert Operations and Maintenance Manual, October 2006.

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

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

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

6 User's Guide for GPS Observations, NOAA/NOS, updated March 2007.

7 CO-OPS GPS Observations Implementation Plan, January 2003.

8 CO-OPS Water Levels and Meteorological Site Reconnaissance Procedures, Updated March 2007.

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

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

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

12 NGWLMS GOES MESSAGE FORMATTING, Phil Libraro, 1/2003.

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

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

15 Spatial Data Modifications and Enhancements, FY 05 Functional Requirements Document, August 2005.

16 Revised NGS 3-Dimensional (3-D) Rod Mark, National Geodetic Survey, July 1996.

17 NWLON/DMS Quality Control Software (QC) Functional Requirements Document, Revised November 2004.

18 Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005.

19 SOP-06-001 for Upgrading an Existing Water Level Station or Installing a New Water Level Station, Updated August 22, 2007.

20 Water Level Records Evaluation Criteria, May 2006.

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

22 Standing Project Instructions for Coastal and Great Lakes Water Level Stations, Updated March 2008.

23 Tide and Current Glossary, U.S. Department of Commerce, NOAA, NOS, October 1989.

24. Guidelines for Meteorological Sensors Siting and Meteorological Sensors Measurements, January 2008.

25 "E-Site Report Application User's Guide", Draft Date January 2008.

26 SOP for E-Site Report User Access to Build, Submit, Reject, Advance, and Approve Steps, March 2008.