Classification of a Water Level Station as Non-tidal

Procedure Number: SOP # 7.3.A.1
Created: January 18, 2012
Revised: March 10, 2016
Created By: Stephen Gill, Michael Michalski
Approved By: Jerry Hovis, Chief, Products and Services Branch (March 10, 2016)

1. **Title:** Classification of a Water Level Station as Non-tidal.

2. **Purpose:** CO-OPS installs and operates permanent (primary) and temporary (subordinate) water level stations in support of critical mission mandates, and a wide – variety of national needs and user applications. To support these applications, CO-OPS computes and maintains standard land-sea interface references, or water level datums. For most coastal areas subject to measurable tidal influences, CO-OPS provides a standard tidal datum suite through the tabulation of hourly heights and daily high and low tides and their reduction to monthly mean values, and ultimately 19-year Epoch Datums. The primary tidal datums in that suite used for coastal applications are Mean Lower Low Water (MLLW) and Mean High Water (MHW). For example, the plane of reference for depth measurements on NOAA Navigational Charts is Mean Lower Low Water (MLLW), and for elevations of features and overhead obstructions, MHW.

   In some sounds, embayments, rivers, and upper estuary reaches, however, the periodic tide is negligible, with a mean range of tide of only a few tenths of a foot or less, or is irregularly prominent, and is frequently masked by various non-tidal water level forces. It is difficult to identify and tabulate regular daily high and low tides at such stations, and the value of the low energy, often masked, high and low tide observations become statistically negligible for determination of tidal datums. Such areas are classified by CO-OPS as “non-tidal” for datum determination purposes and alternate datum references are determined to support user applications. The plane of reference for depth measurements in “non-tidal” areas is a specific, local Low Water Datum (LWD). LWD is determined by the standard practice of subtracting one half foot from the observed Mean Water Level (MWL) in the area. MWL is determined from the average of the observed hourly heights adjusted to a common 19-year period. This 19-year period corresponds to the same 19-year period for which tidal datums, including MLLW, is based and is referred to as the National Tidal Datum Epoch (NTDE).

   For NOAA shoreline surveys, the shoreline (coastline) is the intersection of the land with the water surface. The shoreline shown on charts represents the line of contact between the land and a selected water elevation. In areas affected by tidal fluctuations, this line of contact is the mean high water (MHW) line. In confined coastal waters of diminished tidal influence which are classified as non-tidal, the mean water level (MWL) line may be used.

The purpose of this SOP is to detail the steps necessary to classify a station as “non-tidal” for datum determination purposes, produce a bench mark publication, and provide the appropriate reference datum to the Office of Coast Survey (OCS) and National Geodetic Survey (NGS) for hydrography, chart compilation and shoreline mapping, as well as to specific partners and general public users.

3. **Background/History:** None of the federal statutes administered by NOAA and none of the NOAA regulations provides a legal definition of the terms "tidal waters" and "non-tidal waters”. CO-OPS does not have an official definition for non-tidal in the Tide and Current Glossary. The NOS General Counsel has explained that, as with many legal terms, the definitions may depend on the context. What is considered "tidal waters" under one law may not constitute "tidal waters" under another statute. Looking for a "legal definition" of these terms that would be applicable in all factual situations is undoubtedly an impossible task. It all depends on how those terms are being used.

It appears that most definitions of the term "tidal waters" emphasize the regular "ebb and flow" of waters, and conversely non-tidal waters would have no such regular ebb and flow, or would have a low energy ebb and flow which results in a negligible range of tide. The starting point for many navigable water issues is the old Supreme Court Case, The Daniel Ball, 77 U.S. 577 (1870) which refers to "ebb and flow" of tidal waters. For a more recent and more complete definition, see 33 CFR 328.3(f) which provides:

"(*f) The term tidal waters means those waters that rise and fall in a predictable and measurable rhythm or cycle due to the gravitational pulls of the moon and the sun. Tidal waters end where the rise and fall of the water surface can no longer be practically measured in a predictable rhythm due to the masking by hydrologic, wind or other effects*."

Other cases include U.S. v. Banks, 115 F3d 916 (1997), Leslie Salt Co. v. Froehlke, 578 F2d 742 (1978), and U.S. v. Stoeco Homes, Inc., 498 F2d 597 (1974).

Here is the definitions language used by the USACE Regulatory program, PART 330 – Nationwide Permit program:

Non-tidal wetland: *A non-tidal wetland is a wetland (i.e., a water of the United States) that is not subject to the ebb and flow of tidal waters. The definition of a wetland can be found at 33 CFR 328.3(b). Non-tidal wetlands contiguous to tidal waters are located landward of the high tide line (i.e., the spring high tide line).*

Tidal wetland: *A tidal wetland is a wetland (i.e., a water of the United States) that is inundated by tidal waters. The definitions of a wetland and tidal waters can be found at 33 CFR 328.3(b) and 33 CFR 328.3(f), respectively. Tidal waters rise and fall in a predictable and measurable rhythm or cycle due to the gravitational pulls of the moon and sun. Tidal waters end where the rise and fall of the water surface can no longer be*

practically measured in a predictable rhythm due to masking by other waters, wind, or other effects. Tidal wetlands are located channelward of the high tide line (i.e., spring high tide line) and are inundated by tidal waters two times per lunar month, during spring high tides.

4. **Scope/Applicability:** CO-OPS has identified U. S. coastal geographical areas where non-tidal conditions are known to occur based on historical observations. These are listed in attachment 1. Attachment 1 also lists the NOAA Charts containing non-tidal areas in which special notes need to be provided for as well as for the NOAA Coast Pilot and Tide Tables. The significant areas needing analysis described in this SOP are generally the transition zones where the tide transitions from tidal to non-tidal and identifying the cut-off between the two classifications. There are areas along coastal Alaska in the Bering and Chukchi Seas that are suspected of being non-tidal but there are not enough observations to make the determination. Regarding the applications for hydrographic surveying, navigational charting and shoreline mapping, this effort needs to be coordinated with OCS and NGS, appropriately, for full implementation. Determinations of areas as non-tidal and establishment of a LWD in lieu of MLLW for Chart Datum and a MWL datum in lieu of MHW for shoreline shall be made following execution of water level data acquisition requirements identified in the hydrographic and shoreline mapping survey project instructions and CO-OPS' analysis of the acquired data. These water level data acquisition requirements specify the adequate coverage of subordinate water level gauge installations which will provide the base data needed for making this determination across the survey area.

5. **Main Processes:** As a practical definition for standard operating procedures, CO-OPS performs some tests on the observed data to determine if either a tidal (MLLW) or a non-tidal (LWD) is applicable for this station, for charting applications or for publishing tidal datums on bench marks for multiple applications. These tests essentially provide information similar to the USACE definition above: "Tidal waters end where the rise and fall of the water surface can no longer be practically measured in a predictable rhythm due to masking by other waters, wind, or other effects." Likewise, these tests provide information for the cases where a periodic tide is present and consistent, however, the mean range of tide (MN) negligible, that is below CO-OPS' established tidal/non-tidal threshold of 0.09m (0.30ft.).

    1) Using SOP's and standard algorithms for tabulating the tide, we determine if a regularly recurring tide can be tabulated, and determine if the expected astronomical tides occur each tidal day. Further, NOS enforces a tabulation rule such that each high/low pair must be 0.10 ft. or greater apart in elevation and 2.0 hours or greater in time apart to be tabulated as a tidal pair of highs and lows. If the tide cannot be routinely tabulated, then derived tidal datums cannot be computed, and LWD is used. Monthly means of tidal datums are useless; for instance, if they are based on only a few tabulated high and low tides during the month.

Computation of reliable monthly means requires a regularly tabulate tide in response to the known tidal forcing.

2) If the time series is long enough (one-year minimum), then the reduction of variance derived from the least-squares harmonic analysis is examined to determine if the tidal constituents make a meaningful contribution to the total variability of the observations. If the reduction of variance statistics show the non-tidal harmonic constituents to be dominant with very little contribution from the tidal constituents, then that also supports the results of the tabulation process described above. Excluding the seasonal Sa and Ssa constituents and the monthly Mm, Mf, Msf constituents, if the remaining tidal constituents account for less than 30% of the total reduction of variance, the station may be a candidate for a non-tidal classification.

3) If only a shorter time series is available, then a comparison of harmonic constants is made to determine stability of the amplitudes and phases of the harmonic constituents over time. Amplitudes of the major semidiurnal and diurnal constituents should be within 0.20m from month to months and the Phases should be within 10 degrees of each other.

4) If available, a power spectral analysis using MatLab should be performed to verify low energy at the tidal frequency bands. If the energy in the spectral peaks at the semidiurnal and diurnal frequencies is not discernible from, or just above, the frequency "continuum" and the spectra are dominated by energy at the non-tidal frequencies, then the station may be a candidate of classification as non-tidal.

5) Information obtained from the above analysis should be utilized in consultation with DPT, DT, UST, and HPT Leads in order to determine if a location should be classified as non-tidal. Upon finalizing this classification the Products and Services Branch Chief should submit an email to OET, DPT, DT, HPT, DMAT and the Project Lead as specified in SOP # 7.1.0 CO-OPS Guide to Declaring a Newly Installed Water Level Station Operational. This email should specify the station name and number and direct that only hourly heights and monthly mean sea level (MSL) continue to be processed for computation of a MSL (MWL) tidal datum reference. Additionally, Harmonic constituents, if accepted, should be unaccepted and predictions removed. A copy of this information should be inserted into the stations' 490, data processing, and datums packages.

These determinations are described in detail in "Tidal Characteristics and Datums of Laguna Madre, Texas. NOAA Technical Memorandum NOS OES 008" of July 1995. These procedures were described to the Court in pre-trial evidence proceedings in a Laguna Madre marine boundary dispute case.

6. Detailed Sub-Processes/Checklists

Operationally, the steps for determination of LWD (except for Great Lakes) are :

a) Tabulate the hourly heights and monthly mean sea levels form the period of record
b) Perform a simultaneous comparison with the appropriate nearby NWLON control station to determine a NTDE MSL datum.
c) Subtract 0.5 foot from the NTDE MSL to get the Low Water Datum (LWD).

Here is a typical statement (this one for Pamlico Sound, NC) that we have provided on the "Tide Note" accompanying the water level correctors provided OCS' Hydrographic Surveys Division for final compilation of hydrographic surveys. It shall also be copied to OCS' Marine Chart Division for the inclusion of such hydrographic surveys during the compilation specific nautical charts which cover non-tidal areas.

"The plane of reference for depth measurements in the Atlantic Ocean is Mean Lower Low Water (MLLW), a tidal datum. In the sounds and rivers shown on this chart, except near the ocean inlets, a periodic tide is negligible or has a mean range of less than one half foot. In these areas, the plane of reference for depth measurements is Low Water Datum (LWD). LWD is determined by subtracting one half foot from the observed Mean Water Level (MWL) in the area. MWL is determined from the average of the observed hourly heights adjusted to a common 19-year period. This 19-year period corresponds to the same 19-year period for which tidal datums, including MLLW, is based and is referred to as the National Tidal Datum Epoch (NTDE)". In cases of short-term water level stations with less than 19 years of observations, standard datum computation procedures for providing a "19-year equivalent" datum are followed.

See SOP: SOP 7.3.A.4.2 Tidal Datum Computation for Subordinate Stations.

For shoreline surveys, the following statement should be provided on documentation accompanying the water level solution provided NGS' Remote Sensing Division for final compilation of shoreline mapping surveys. It shall also be copied to OCS' Marine Chart Division for the inclusion of such shoreline mapping surveys during the compilation specific nautical charts which cover non-tidal areas.

"The plane of reference for NOAA Shoreline is Mean High Water (MHW), a tidal datum. In the sounds and rivers shown on this chart, except near the ocean inlets, a periodic tide is negligible or has a mean range of less than one half foot. In these areas, the plane of reference for shoreline is Mean Water Level (MWL). MWL is determined from the average of the observed hourly heights adjusted to a common 19-year period. This 19-year period corresponds to the same 19-year period for which tidal datums, including MLLW, is based and is referred to as the National Tidal Datum Epoch (NTDE)". In

cases of short-term water level stations with less than 19 years of observations, standard datum computation procedures for providing a "19-year equivalent" datum are followed.

See SOP: SOP 7.3.A.4.2 Tidal Datum Computation for Subordinate Stations.

The language above should be used on published bench mark sheets, accepted datums, and appropriate web pages for stations classified as non-tidal. The specific procedures for the handling of non-tidal datum references on published bench mark sheets are outlined in the SOP: SOP 7.3.A.4.6 Generating and Publishing a Bench Mark Sheet

Note: Many federal, state, and local governments have laws and engineering regulations which set horizontal and vertical references based on tidal datums such as MHW and/or MLLW, as property boundaries and for building/permitting, land use limits, and etc. NOAA's declaration of any areas as non-tidal are primarily for providing a repeatable, standardized, and conservative datum for navigational products.

Note: The U.S. Army Corps of Engineers uses tidal datums computed by NOAA for controlling dredging depths for federal channel maintenance below the chart datum MLLW and for controlling building heights relative to MHW. CO-OPS shall provide the appropriate USACE District with a notification of the non-tidal assessments and LWD and MWL references for those areas for appropriate usage. Notice of these procedures will be provided to USACE and other Federal State and local agencies with the release of a Federal Register Notice.

7. **Quality Assurance/Control** QA protocols are followed associated with verification of metadata and verification of the analysis and datum compilation work by senior oceanographers and must follow the "Acceptance" process oversight by someone in a Senior OD oceanographer or Chief Scientist senior/oversight position.

8. **Management/Responsibility** This SOP procedure is carried out by analysts in the Oceanographic Division Data Processing Team and Datums Team. The Hydrographic Planning team must be aware of these areas to incorporate appropriate language in the OCS project instructions. The Datums Team must communicate with and follow-up with the OCS Marine Chart Division for correct language and notification on NOAA Nautical Chart products and publications. Coordination must also occur with NGS RSD for shoreline surveys in non-tidal areas. Management responsibility/accountability also includes FOD for the installation quality and ED for metadata validation. OD Branch Chiefs and Division Chiefs having the overall accountability/responsibility for the quality of the work and for its appropriate dissemination as applicable.