TIDE METHODOLOGIES

There are three primary tide study methods; Height Difference, Range Ratio and Amplitude Ratio. Each of these methods have unique characteristics that make them suitable for specific circumstances.

HEIGHT DIFFERENCE METHOD

It is important to note that the National Ocean service (NOS) height difference methodology is more than a very short-term tide study. It is doubtful that it would be required for typical mean high water (MHW) line survey procedures in Florida. The NOS height difference methodology requires water level observations for 30 high tides. It is used in lieu of a tertiary tide study where the surveyor and mapper cannot measure the low tides due to obstructions to the tidal wave.

A modification of this method is one of the very short-term tide studies. It is called the alternate height difference method. In this document, the "alternate height difference method will be called the "Height Difference Method". Only three high tides are measured. This method can be used in lieu of leveling, in the following situations.

Example #1 – The project site subordinate tide station(s) (S1,S2, etc.) are located offshore or across the water body where no geodetic bench marks are available and the site is less then one mile from a tide station.

Example #2 – The shoreline is soft wet soil or dense vegetation making differential leveling impractical.

Example #3 – The project consists of thousands of feet of tidal boundary along meandering bayous, island, coves, creeks, and/or open shoreline where leveling is not practical.

The installation requires the setting of a height difference typical tide staff installation at the control tide station (selected by DEP) and an alternate height difference typical tide staff installation at the subordinate tide station(s) at the project site. In using this method, it is essential that the range of tide at the subordinate and control stations be within 10% of each other.

NOTICE TO USERS

The quality of a MHW high water datum using the height difference method may be poor or even unacceptable if less then 30 days of data is collected. This is due to uncertainties in dealing with very short-term water observation periods during days of large or small tides or days of extreme range disparity. For observation periods of less than 30 days, the Bureau of Survey and Mapping (BSM) only recommends using the height difference method to locate MHW points on the shoreline in the vicinity of an NOS Tide Station or a subordinate tide station previously determined by using either the amplitude ratio or range ratio method. In effect, the height difference method should be used only to locate MHW points near existing tide stations in lieu of running differential levels from the existing tide stations. Other uses of this method are discouraged.

RANGE RATIO METHOD

The National Ocean Service (NOS) "Standard Method" for computing mean high water (MHW) at a subordinate tide station is the range ratio method (Marner 1951). MHW computations using the range ratio methods are usually superior to results of other very short term tide studies.

The range ratio method requires simultaneous staff observations of the high and low water at the subordinate and control tide stations for three (3) tide cycles. Use of this process may be limited if only the upper portion of the tide cycle is available at the subordinate tide station. The amplitude ratio method was designed for that situation.

Tide staffs must be located in water deep enough so that the bottom of the staff is 12-18 inches below anticipated low water (LW). Data collection and MHW computations using the range ratio method are simpler than the amplitude ratio methodology. For example, to compute MHW at the subordinate tide station using the range ratio method, the only observations necessary are high and low water on the staff. No curve plots are required. Therefore, long periods of observations are unnecessary, but must be timed to capture high water and low water readings.

AMPLITUDE RATIO METHOD

The amplitude ratio method is one of the very short-term tide studies. In many tidal areas of Florida, only the high water portion of the tide cycle can be observed at the project site. Use of the amplitude ratio method is encouraged in this situation. An amplitude ratio tide study can be undertaken whether or not the peak high water reaches mean high water (MHW). If a full range of tide can be observed at both the control and subordinate stations, use of the range ratio methodology is suggested.

The amplitude ratio method requires simultaneous water level observations of high water at the control and subordinate tide stations. Record water levels at 6-minute intervals during a rising and falling tide on each side of the peak high water at both the control and subordinate station(s). This method only requires a low water reading at the control station. This reading can be immediatly preceding or following the high water. Record the water levels at 6-minute intervals during a falling and rising tide on each side of low water. The observer may terminate observations once assured that the low event for the session has been recorded.

FORMULAS

HEIGHT DIFFERENCE

FORMULA

MHWs = HWs – (HWc – MHWc)

c = Subscript used to denote control tide station.
s = Subscript used to denote subordinate tide station at the project site.

Where:

MHWs = Mean High Water on staff at subordinate tide station

HW = High water observed on staff

MHWc = Mean High Water on staff at control tide station (see NOS published sheets)

RANGE RATIO METHOD

1. MRs = Rs (MRc / Rc)

c = Subscript used to denote control tide station.
s = Subscript used to denote subordinate tide station at the project site.

Where:

R = Range of tide; the observed difference in height between consecutive high and low water observations.

MR = Mean range of tide; the difference in height between MHW and MLW taken from the published NOS Tide Station Report, bench mark data sheet for a given control tide station. This information can be obtained from DEP/BSM.

2. MTLs = MTLc + (TLs – TLc)

Where:

TL = Half tide level; the point half way between HW observed on staff, and LW observed, on staff. NOTE: TL can be checked by simply adding LW observed on staff, and HW observed on staff and dividing by 2 for each tide station.

MTL = Mean tide level; a tidal datum midway between MHW on staff and MLW on staff. See the published NOS Tide Station Report benchmark data sheet for the control tide station. This information can be obtained from DEP/BSM.

3. MHWs = MTLs + (MRs / 2)

Where:

MHWs = MHW on staff; a computed tidal datum at the subordinate tide station.

Note: The Mean Low Water (MLW) at the subordinate station can be determined by subtracting MRs from MHWs. This is the only very-short term tide study that can be used to compute MLWs.

AMPLITUDE RATIO METHOD

To compute the Mean High Water at the subordinate station (MHWs) using the amplitude ratio method, you must solve four formulas in the following sequence.

1. Rs = Rc $*$ As/Ac

Where:

R = Range of tide; the observed difference in height between consecutive high and low water observations.

A = Amplitude; the distance in height between high water and the time interval line.

c = Subscript used to denote control tide station.
s = Subscript used to denote subordinate tide station.

2. MRs = MRc $*$ As/Ac

Where:

MRc = Mean range of tide at the control station the published difference in height between MHW and Mean Low Water (MLW). Subtract the elevation of MLW from the elevation of MHW as found on the NOS Tide Station Report tidal bench mark data sheet.

MRs = Mean range of tide (computed) at subordinate tide station. This is a pseudo range. Although it is used to compute MHW at the subordinate station, it should never be used to compute MLW at the subordinate station.

3. $TLc = HWc – Rc/2$

Where:

TLc = Half tide level, the point halfway between the observed high water, on the staff and the observed low water on the staff at the control station.

NOTE: You can check TLc by simply adding the observed LWc observed on staff and the observed HWc on staff, and dividing by 2.

HWc = High water observed on staff at control tide station.

(4) $MHWs = Hws – Rs/2 – TLC + MTLc + MRs/2$

Where:

MHWs = MHW on staff; a computed tidal datum at the subordinate tide station.

HWs = High water observed (on staff) at the subordinate tide station.

Rs = Range of tide, observed difference in height between consecutive high and low water observations at subordinate tide station.

MTLc = Mean tide level; a published tidal datum midway between MHW and MLW (see NOS Tide Station Report tidal bench mark data sheet) at control tide station.

(5) additional terms:

MHWc = Mean High Water, at the control station a published tidal datum (see NOS tidal bench mark data sheet). It is used to compute MRc.

t = An arbitrary time interval (selected by the surveyor and mapper) to intersect the observed tide curve plots of the control and subordinate tide stations. The same time interval must be used on both curve plots. This time interval can also be seen as a distance. For best computational results, make “t” the greatest length possible so that “A” will be greater than 0.2 feet.

FIELD PROCEDURES

Do not begin water level observations until you receive approval to perform a MHW survey from DEP/BSM. To initiate this approval see the forms section at the beginning of this document and print the "MHW Survey Procedural Approval" form or download it from the MHW interactive map at LABINS.org. Fill out the top portion of the form and FAX it to DEP/BSM at (850/245-2645). This document will then be FAXed back to you with the appropriate approved procedure. Keep this document for your files.

1. **Request from DEP/BSM a copy of the NOS Tide Station Report, tidal bench mark sheets for the control tide station to be used. These reports are also available on the MHW interactive map on LABINS.**

2. **At the project site:**

    a. Determine the location for the subordinate tide stations(s).

    b. Set three on-site bench marks for each subordinate station.

    c. Prepare field notes and sketches describing bench mark locations, materials, and designations.

    d. Geodetic level ties are preferred (but are not required) at either the control or subordinate tide station.

    e. Fabricate and install a tide staff. The Height Difference method requires only high water observations at both the Control and Subordinate sites. The Range Ratio method requires high and low water observations at both the control and subordinate site. The Amplitude Ratio method requires the high and low water observations at the control station and the upper portion of the tide at the subordinate station. If the method used requires observation of the high and low water for each tide cycle, be sure to set the bottom of the staff 12-18 inches below the expected MLW.

3. **At the control tide station:**

    a. Using the NOS Tide Station Report tidal bench mark sheets obtained from DEP/BSM, locate as many tidal bench marks as possible.

    b. Establish differential levels between at least two, preferably three, tidal bench marks. This will assure that the mark has not settled or been misidentified.

    c. Select a tidal bench mark and determine its elevation above Mean High Water.

d. Fabricate and install a tide staff. If the method used requires observation of the high and low water for each tide cycle, be sure to set the bottom of the staff 12-18 inches below the expected MLW.

MEAN HIGH WATER DATA COLLECTION

The Bureau of Survey and Mapping has prepared a Mean High Water Data Collection package that should be used for your tide calculations. It is available on LABINS and is in an Excel spreadsheet format to assist you in the calculations.

Tide studies require the recovery of tidal benchmarks to be used when placing your control staff near the location of the original tide station. BSM will supply you with a copy of the control station report and they are also available on the Water Boundary Interactive Map on LABINS. It is essential to understand how to utilize these control station reports. These reports are generally four to seven pages and describe the location of the control station and benchmarks. The last page includes the mathematical data required to fill out the Mean High Water Data Collection Package. (See example on page 8)

EXAMPLE

FLORIDA 872 7989

AUCILLA RIVER

TIDAL DATUMS AT AUCILLA RIVER ARE
BASED ON THE FOLLOWING

LENGTH OF THE SERIES	= 12 MONTHS
TIME PERIOD	= APRIL 1975 – APRIL 1976
TIDAL EPOCH	= 1960 – 1978
CONTROL TIDE STATION	= CEDAR KEY (872 7520)

Elevations of tidal datums referred to mean lower low water (MLLW) are as follows:

HIGHEST OBSERVED WATER LEVEL (09/23/75)	=	5.11
MEAN HIGHER HIGH WATER (MHHW)	=	2.51
MEAN HIGH WATER (MHW)	=	2.29
MEAN TIDE LEVEL (MTL)	=	1.31
*NATIONAL GEODETIC VERTICAL DATUM - 1929 (NGVD)	=	0.11
MEAN LOW WATER (MLW)	=	0.34
MEAN LOWER LOW WATER (MLLW)		0.00
LOWEST OBSERVED WATER LEVEL (12/21/75)	=	-1.12

*NGVD reference based on adjustment of 1967 and NOS levels of 1985.

Bench mark elevation information:

BENCH MARK STAMPING	ELEVATION IN FEET ABOVE MLLW	MHW
“1 1975”	5.66	3.37
“2 1975”	3.81	1.52
“3 1975”	4.84	2.55
“4 1975”	5.19	2.90
“5 1975”	3.22	0.93

The data shown for the Highest Observed Water Level (5.11') through Lowest Observed Water Level (-1.12') are a relative datum related to Mean Lower Low water of 0.00. Typically, though not always, there is an NGVD Geodetic Vertical Datum correction. In this case it is 0.11'. Since this is a positive number, it should be subtracted from the Mean High Water (MHW), the Mean Tide Level (MTL), and the Mean Low Water (MLW) to determine their NGVD 1929 values of 2.18', 1.20', and 0.23' respectively. If the NGVD Geodetic Vertical Datum correction is negative, then it should be added to the values. The Mean Range (MR) is a relative distance, the difference between MHW and MLW regardless of datum.

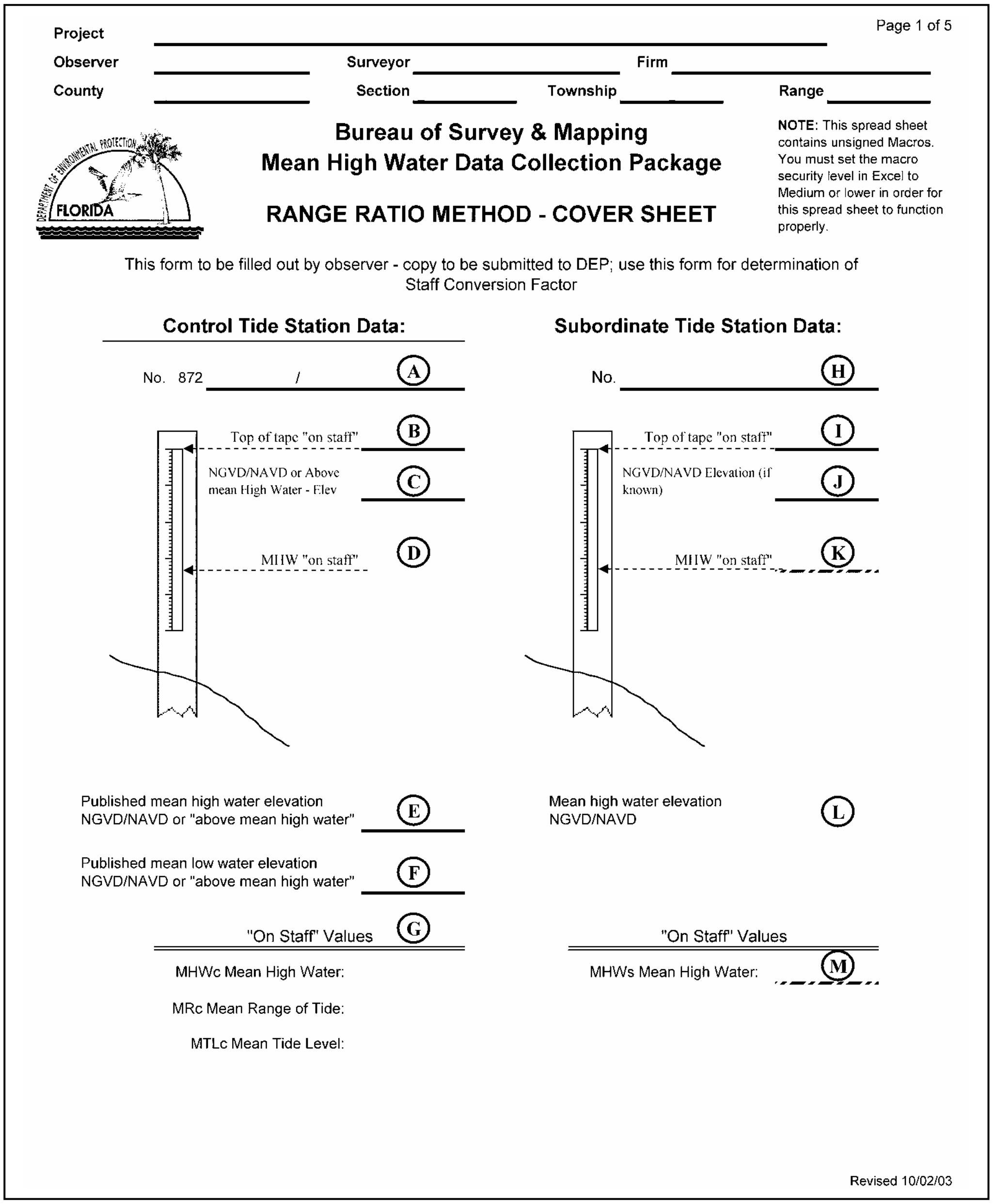
The Benchmarks, shown near the bottom of the page, are provided in feet above Mean High & Mean Lower Low Water. If an NGVD correction is provided above, then it is easy to determine the NGVD values of the Benchmarks by adding the NGVD value of MHW to the Elevation in feet above MHW, which gives you NGVD 1929 elevation on the Benchmarks. For example, BM #2 1975 which is 1.52 above MHW, would have a NGVD value of 3.70 feet (1.52 +2.18).

In the event that an NGVD elevation is not available, you should use the Benchmarks Height Above MHW to tie in the new staff you have set for your control station.

The Data Collection package is fully automated, allowing the user to enter data one time and have it carry through the entire document. The Spreadsheet contains macros. Excel has three levels of security for macros. These spreadsheets contain unsigned macros, therefore it is necessary to set Excel's macro security to Medium or lower. In Excel 2002, this setting can be found in the **Tools** menu under **Macro**.

Most of the calculations are automated once the data has been entered. The data collection package will be discussed for each of the three tide methods.

The following is a replica of the cover sheet for the Range Ratio Method. This sheet is nearly identical to the Amplitude Ratio Method cover sheet and similar to the Height Difference Method sheets and is being shown for discussion and definition purposes.



Project

Page 1 of 5

Observer ________ Surveyor ________ Firm ________

County ________ Section ________ Township ________ Range ________

Bureau of Survey & Mapping
Mean High Water Data Collection Package

RANGE RATIO METHOD - COVER SHEET

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

NOTE: This spread sheet contains unsigned Macros. You must set the macro security level in Excel to Medium or lower in order for this spread sheet to function properly.

This form to be filled out by observer - copy to be submitted to DEP; use this form for determination of Staff Conversion Factor

Control Tide Station Data:

No. 872 ________ / ________ (A)

Top of tape "on staff" (B)

NGVD/NAVD or Above mean High Water - Elev (C)

MHW "on staff" (D)

Published mean high water elevation NGVD/NAVD or "above mean high water" (E)

Published mean low water elevation NGVD/NAVD or "above mean high water" (F)

"On Staff" Values (G)

MHWc Mean High Water:

MRc Mean Range of Tide:

MTLc Mean Tide Level:

Subordinate Tide Station Data:

No. ________ (H)

Top of tape "on staff" (I)

NGVD/NAVD Elevation (if known) (J)

MHW "on staff" (K)

Mean high water elevation NGVD/NAVD (L)

"On Staff" Values

MHWs Mean High Water: (M)

Revised 10/02/03

The top of the page is project related information and should be filled out to assist in the naming and the filing of the project. The following are identification letters for discussion and to define various areas of the sheet.

A. This is the control station identifier. Using the previous example it would be 872-7989. Once this is filled out, it carries through to the other pages. All control stations in Florida begin with the 872 prefix.

B. Top of tape “on staff”. This is the actual number that shows up on the top of the staff of the control station or piece of tape you are using for your study.

C. This is a datum for the top of tape. It is established by running a closed level loop from the tidal Benchmarks through the staff. This datum can be shown as

Ft. above MHW, NGVD29 or NAVD88. If the tape does not extend to the top of the rod, be sure the individual holding the level rod gets their shot on top of the tape.

D. MHW “On Staff”. This is the computed value of mean high water, related to “on staff” datum. It is computed for you in the Excel Workbook.

E. Published Mean High Water elevation NGVD or elevation “above mean high water”. This is the published value of MHW from the control sheet. If you look at the previous example, it would be 2.18 Ft. NGVD. If it was not related to NGVD, or NAVD88, you would have to use the bench marks shown to tie in your staff related to “above mean high water”. If this occurs, the published MHW Elevation will always be 0!

F. Published Mean Low Water elevation NGVD or “above mean high water”. This is the published value of MLW from the control sheet. If you look at the previous example, it would be 0.23 Ft. NGVD. If it is not related to NGVD, you would determine it by subtracting the MR from the Mean High Water datum being used.

G. The ”on staff” values for Mean High Water, MR and, MTL are computed for you and transferred to the second sheet of the spreadsheet for your calculations.

H. The subordinate tide station name is the name given to the subordinate tide station, usually selected by the surveyor. Once this is filled out, it carries over to the other sheets.

I. Top of Tape “on staff” – This is the actual number that shows up on the top of the subordinate staff or piece of tape you are using for your study.

J. This is a datum for the top of tape. It is established by running a closed level loop from benchmarks with NGVD29 or NAVD88 values.

K. MHW “on staff”. This is the computed value of mean high water, related to “on staff” datum. It is computed for you in the Excel Workbook.

L. MHW elevation NGVD/NAVD. This is the MHW, related to NGVD or NAVD vertical datum. It is computed for you.

M. On Staff Value MHW – The ”on staff” value for Mean High Water is computed for you and transferred to the second page for your calculations.

RANGE RATIO PACKAGE

Pg 2 This is the calculation sheet and all necessary data comes in from page 1, and 3-5.

Pg 3, 4,5 Data should be filled out for the weather conditions. The boxes for the high and low waters have “drop down” time clocks for the hours and minutes. Once the time and staff elevations have been inserted, the program will automatically pick out the highs and lows and transfer them to Page 2. (Repeat these steps for Pages 4 & 5).

AMPLITUDE RATIO PACKAGE

Pg 2 This is the calculation sheet and all necessary data comes in from pages 1, 3 -5.

Pg 3, 4, 5 Data needs to be filled out for the weather conditions. The boxes for the high and low waters have “drop down” time clocks for the hours and minutes. The Amplitude Ratio method requires the plotting of the top of the tide curve for both the control and subordinate sites. It is essential that you collect enough data to get an amplitude of at least .2’ above the time interval line, so it is desirable that all of the data cells be filled out. The high water time and elevation should be placed near the center of the box thereby allowing sufficient space for the curve on either side. This spreadsheet will automatically compute the longest amplitude possible for these events, based upon the data input. (Repeat these steps for Pages 4 & 5).

HEIGHT DIFFERENCE PACKAGE

The cover sheet is similar to the cover sheets for the other two methods, however, the Height Difference Method must accommodate an aspect that the others don’t. Specifically, a Height Difference Subordinate tide station might also be controlled by a Range Ratio/Amplitude Ratio control station. If that occurs, the only calculation data that needs to be inserted for the control tide station is the Top of Tape “on staff” and the Range Ratio/Amplitude Ratio Mean High Water (RR/AR MHW) elevation that has been previously determined.

Pg 2 This sheet requires only the Date, HWs, and the HWc. The MHWs is automatically calculated. As least 3 days of data should be collected and the average will be calculated at the bottom of the page.

STANDARD DEVIATION

The standard deviation for the Mean High Water calculations should be less than or equal to .05. It is a measure of how spread out a distribution is. It is computed as the average squared deviation of each number from its mean.