Calculating Tidal Datums

Stephen C. Blaskey, RPLS, LSLS
Types of Tide Gauges

A look at the different types of portable tide gauges, how they work, and how to use them effectively.
There are 3 major types of portable tide gauges

- Manual
- Float Gauges
- Pressure Gauges
Type 1:
Manual Tide Gauges
Example of a Manual Tide Gauge:

Advantages:

Easy to Set up

No Batteries or Calibration Necessary

Very Cheap

Disadvantages:

Complete lack of Automated Data Capture

Has to be manned for entire deployment
Type 2: Float Tide Gauges
Example of Float Tide Gauge

Advantages:

Requires no external calibration
Automated Data Capture

Disadvantages:

Main Electronics Housing must be kept out of water
Requires use of Tide Staff to correlate Data to the Site Control
Type 3: Pressure Tide Gauges
Example of Vented Pressure Gauge

Advantages:

Relative Ease to deploy over Float and Manual Gauges

Easy to calibrate on site for a given condition

Disadvantages:

Main Electronics Housing must be kept out of water

Price
Example of a Non-Vented Pressure Gauge

Advantages:

- Easy to Deploy
- Automated
- All Waterproof Design
- Price

Disadvantages:

- Requires External Air Pressure Measurements
- Requires Measurement of Density of the Water
There are 3 major methods to calculating tidal datums

• Direct Benchmark Transfer to project site
• Standard Method
• Amplitude Ratio Method
Method 1:
Direct Benchmark Transfer
Direct Benchmark Transfer

• Requires that an on-site benchmark be directly related to a benchmark that has a published relationship to the tidal datum you wish to use.
Direct Benchmark Transfer

• In this instance I set a rod with a cap near the location where I plan to work.
• Then, using RTK GPS, I tied the site benchmark to monument “1450 A 1989”.
Direct Benchmark Transfer

Here is the published relationship:

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<th>MHHW</th>
<th>MHW</th>
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<th>MSL</th>
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Source: [http://lighthouse.tamucc.edu/datum/022](http://lighthouse.tamucc.edu/datum/022)
### Raw GPS Data:

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<th>GPS Time</th>
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**Averages:**

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</table>

### Published MHW Relationship of 1450A to MHW:

- 4.54 feet above MHW

### Elevation of MHW based on observations of 1450A

- **Measured Elevation of 1450A:** 5.55
- **Amount above MHW:** 4.54
- **Elevation of MHW:** 1.01

### The Relationship of SP-CST to MHW:

- 1.93 feet above MHW
Method 2: Standard Method
Standard Method

This method involves:

• Establishment of a project gauge and observing a full tide cycle (low tide through high tide).

• Relating the mean range of the control gauge to the project site gauge.

• Relating the average tide level of the observation period to the datum you wish to use.
What we need to perform this calculation:

- $\text{MR}_c = \text{mean range of control gauge}$
- $\text{R}_c = \text{range of control gauge for observation period}$
- $\text{R}_s = \text{range of project site gauge for observation period}$
- $\text{MR}_s = \text{mean range of project site gauge}$
- $\text{TL}_s = \text{average of high tides at project site for observed period}$
- $\text{TL}_c = \text{average of high tides at control gauge for observed period}$
- $\text{MTL}_c = \text{mean tide level of control gauge}$
- $\text{MTL}_s = \text{mean tide level of project site gauge}$
- $\text{MHW}_s = \text{mean high water at project site gauge}$
Standard Method

To obtain the value of $\text{MR}_c$:

**Pier 21, TX**  
**Station ID:** 8771450

*Latitude:* 29° 18.6' N  
*Mean Range:* 1.02 ft.

*Longitude:* 94° 47.6' W  
*Diurnal Range:* 1.41 ft.

*Established:* Jan 1 1908

*Present Installation:* Apr 16 1991

*NOAA Chart #:* 11323

*Time :* 90 W

Source: [http://tidesandcurrents.noaa.gov/station_info.shtml?stn=8771450 Galveston Pier 21, TX](http://tidesandcurrents.noaa.gov/station_info.shtml?stn=8771450)
Standard Method

• To obtain the values for $R_c$ and $R_s$ we will have to look to the raw data for each of these gauges.
Due to the conditions at the time of data collection, we will only be using one tide cycle to perform this calculation.
Standard Method

\( R_c = \text{High Tide Elevation} - \text{Low Tide Elevation} \)
\[ = 1.14 - (-0.46) \]
\[ = 1.60 \]

\( R_s = \text{High Tide Elevation} - \text{Low Tide Elevation} \)
\[ = 10.35 - 9.55 \]
\[ = 0.80 \]
To calculate $\text{MR}_s$ we will use the following formula:

$$\frac{\text{MR}_s}{R_s} = \frac{\text{MR}_c}{R_c}$$

$$\text{MR}_s = \frac{(\text{MR}_c)(R_s)}{R_c}$$

$$\text{MR}_s = \frac{(1.02)(0.80)}{1.60}$$

$$\text{MR}_s = 0.51$$
Standard Method

To obtain the value of $MTL_c = 0.81$:

Elevation Information

- PID: AW0436
- WM: 040
- Station ID: 8771450
- Date: Thu Dec 2 20:57:34 EST 2010

- MHHW = 1.41 feet (0.429 meters)
- MHW = 1.32 feet (0.403 meters)
- MSL = 0.83 feet (0.252 meters)
- MTL = 0.81 feet (0.245 meters)
- MLW = 0.39 feet (0.119 meters)
- NGVD29 = 0.14 feet (0.043 meters)
- NAVD88 = 0.10 feet (0.031 meters)
- MLLW = 0.00 feet (0.000 meters)

Standard Method

• To obtain $T_{L_c}$ we average all tide readings on the control gauge for the observation period $= 0.24$

• To obtain $T_{L_s}$ we average all tide readings on the project site gauge for the observation period $= 9.94$
To calculate $\text{MTL}_s$ we will use the following formula:

$$
\text{MTL}_s = \text{TL}_s + \text{MTL}_c - \text{TL}_c
$$

$$
\text{MTL}_s = 9.94 + 0.81 - 0.24
$$

$$
\text{MTL}_s = 10.51
$$
To calculate $MHW_s$ we will use the following formula:

$$MHW_s = MTL_s + \frac{MR_s}{2}$$

$$MHW_s = 10.51 + \frac{0.51}{2}$$

$$MHW_s = 10.77$$
• Now we must relate our point on the ground to our project site gauge datum.
• This is done by differential leveling from the tide staff to the rod on the ground.
• SP-CST is at 12.73 on the station datum and, therefore, 1.96 feet above MHW based on this method.
Method 3: Amplitude Ratio Method
Amplitude Ratio Method

• This method requires the establishment of a project tide gauge and observing a full peak of high tide at the control tide station and project site station.

• This method works best when low tides are obscured by weather or geography.
Amplitude Ratio Method

• This method requires most of the same variables as the standard method; it simply provides a different way to calculate $R_s$, $MR_s$, $TL_c$, and $TL_s$.
• This is done by looking at the amplitude of the tide curve at equivalent intervals before and after high tide at the project site station and the control station.
• For this example we will use an interval of 2 hours.
Amplitude Ratio Method

Control Station:
• Tide level at high tide = 1.14
• Tide level 2 hours before high tide = 0.77
• Tide level 2 hours after high tide = 0.78

\[
A_c = \text{High Tide} - \left(\frac{\text{2 hrs before} + \text{2 hrs after}}{2}\right)
\]

\[
A_c = 1.14 - \left(\frac{0.77 + 0.78}{2}\right)
\]

\[
A_c = 0.37
\]
Amplitude Ratio Method

Project Site:
• Tide level at high tide = 10.35
• Tide level 2 hours before high tide = 10.16
• Tide level 2 hours after high tide = 10.20

\[ A_s = \text{High Tide} - \left( \frac{(2 \text{ hrs before} + 2 \text{ hrs after})}{2} \right) \]

\[ A_s = 10.35 - \left( \frac{(10.16 + 10.20)}{2} \right) \]

\[ A_s = 0.17 \]
• We can now calculate $R_s$ using the values of $A_c$, $A_s$, and the value of $R_c$ (which is obtained the same as it was in the Standard Method) with the following formula:

$$R_s = \frac{(R_c \times A_s)}{A_c}$$

$$R_s = \frac{(1.60 \times 0.17)}{0.37}$$

$$R_s = 0.74$$
• Now to calculate $MR_s$ we will use the values of $A_s$, $A_c$, and $MR_c$ (a published value, used in Standard Method) with the following formula:

$$MR_s = \frac{MR_c \times A_s}{A_c}$$

$$MR_s = \frac{1.02 \times 0.17}{0.37}$$

$$MR_s = 0.47$$
Next we must calculate values for \( TL_c \) and \( TL_s \) using the following formulas:

\[
\begin{align*}
TL_c &= \text{High Tide Value} - \left( \frac{R_c}{2} \right) \\
&= 1.14 - \left( \frac{1.60}{2} \right) \\
&= 0.34
\end{align*}
\]

\[
\begin{align*}
TL_s &= \text{High Tide Value} - \left( \frac{R_s}{2} \right) \\
&= 10.35 - \left( \frac{0.74}{2} \right) \\
&= 9.98
\end{align*}
\]
Amplitude Ratio Method

Now we can use the same formulas we used in the Standard Method to finish this datum calculation. First we will calculate $MTL_s$:

$$MTL_s = TL_s + MTL_c - TL_c$$
$$= 9.98 + 0.81 - 0.34$$
$$= 10.45$$

* $MTL_c$ is a published value that we also used in the Standard Method
Amplitude Ratio Method

Now we can calculate $MHW_s$ using the following formula:

$$MHW_s = MTL_s + \left( \frac{MR_s}{2} \right)$$

$$= 10.45 + \left( \frac{0.47}{2} \right)$$

$$= 10.69$$
• And finally we can relate our calculated datum to our point on the ground.
• Recall that SP-CST is at 12.73 on the station datum and, therefore, 2.04 feet above MHW based on this method.
An Overview of Our Results

**Method 1:**
SP-CST is 1.93 ft above MHW

**Method 2:**
SP-CST is 1.96 ft above MHW

**Method 3:**
SP-CST is 2.04 ft above MHW
Questions?