

**ATTACHMENT X  
BENCH MARK TIES**

TO  
SCOPE OF WORK FOR SHORELINE MAPPING  
UNDER THE  
NOAA COASTAL MAPPING PROGRAM

REMOTE SENSING DIVISION  
NATIONAL GEODETIC SURVEY  
NATIONAL OCEAN SERVICE  
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION  
U.S. DEPARTMENT OF COMMERCE

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# **ATTACHMENT X: BENCH MARK TIES**

## 1. INTRODUCTION

The purpose of these guidelines is to provide the information necessary to transfer an elevation from an existing NAVD88 benchmark that cannot be used for GPS observations to a nearby GPS station. The two stations must be “closeby” which is defined here as no more than four “set-ups” of the level instrument.

## 2. SINGLE MARK LEVEL TIE (3<sup>RD</sup> ORDER)

An assumed elevation for the bench mark can be used in the leveling since the principal concern is with the **difference of elevation** between the bench mark and the GPS station. It should be noted that the published elevation of the GPS station would only be published to the nearest centimeter. This is because the absolute elevation of the bench mark cannot be verified without incorporating other bench marks into the survey as a check. Many projects do not provide the resources required for this multiple mark check, but it is still imperative that the GPS station have the best precision allowable.

Record rod readings to millimeters or hundredths of feet. The model and type of instrument and rods (e.g., fiberglass, aluminum, single piece, etc.) as well as rod scale units (e.g., meters, feet, or bar code) should be entered on the “Observations of Bench Mark Ties” form where indicated. See Annex 1.

## 3. OBSERVING SEQUENCE FOR CONVENTIONAL LEVEL

**1.** Remove equipment from travel cases, attach level instrument to tripod, and let equipment acclimate to local conditions. Perform instrument check per the manufacturer’s instructions. Set up the instrument about halfway between the stations, but no more than 70 m (230 ft) away from either point or from one of the points and a turning pin in the case of multiple setup requirements. Backsight distance to foresight distance imbalance shall be less than 5 meters. Accumulated backsight to foresight distance imbalance shall be less than 10 meters in the case of multiple setups.

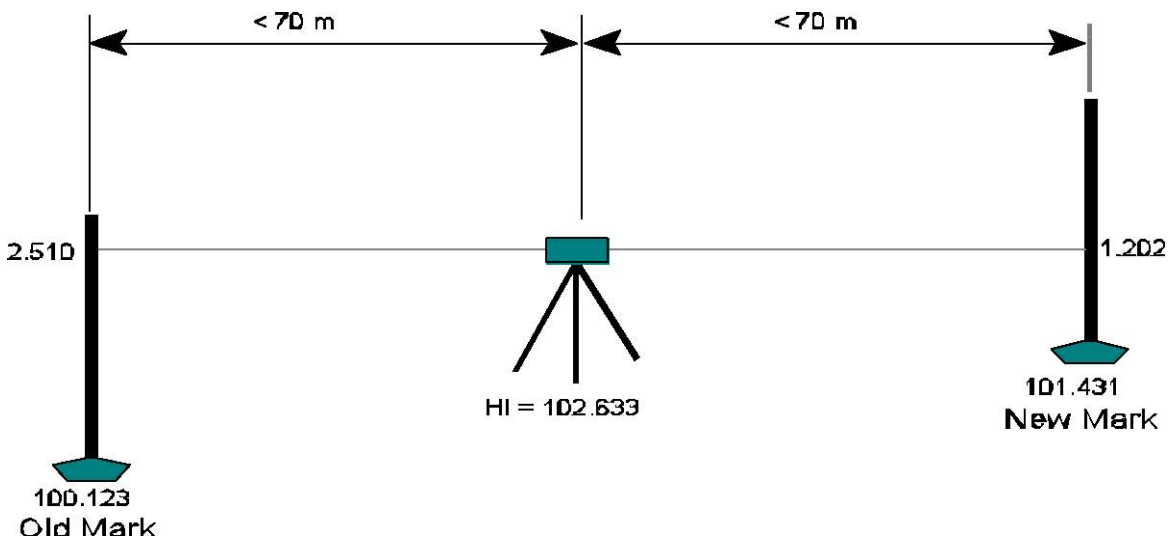


Figure 1. Direct old mark to new mark level tie. **Note:** Backsight-foresight distance imbalance should be less than 5 meters.

2. Plumb the level rod on the highest point of the old mark. Let's call the old mark M 123. Record the designation of the point and its published elevation noting the reference vertical datum and units of measure.

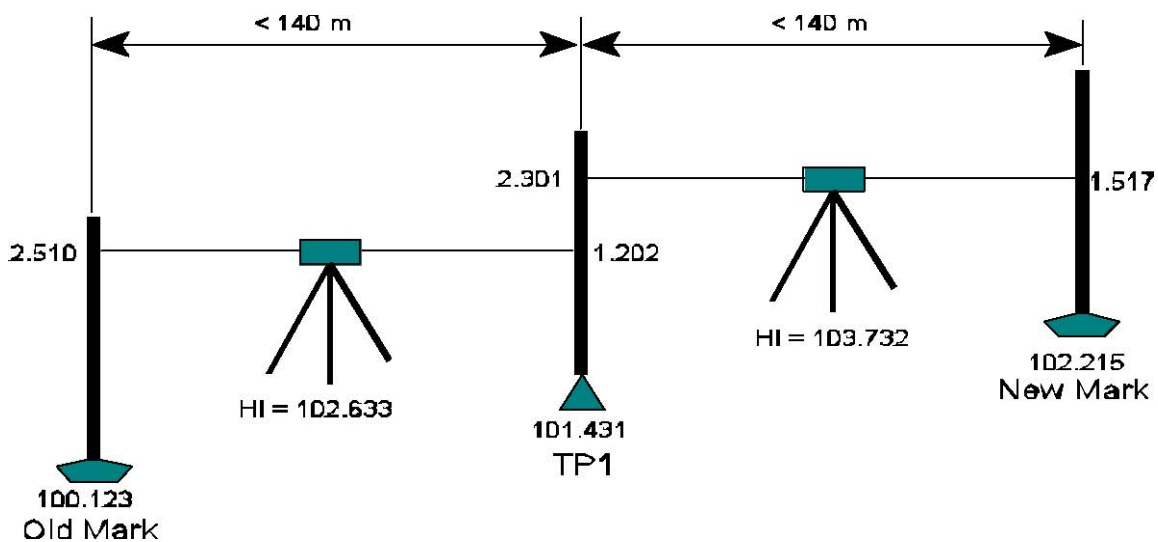


Figure 2. Old mark to new mark level tie for distances over 140 m. **Note:** Accumulated backsight-foresight setup imbalance should be less than 10 m.

3. Backsight Reading: Observe the intercept of the middle reticule of the rod scale as backsight reading. Record the rod reading to the nearest millimeter (or hundredths of a foot) as indicated above. Record the stadia reading to determine distance from the point to the instrument.

4. Compute height of instrument, HI, which is the sum of the backsight and the published elevation.

5. Plumb the rod on the highest point of the new bench mark. Record the designation of the new mark, e.g., M 123 RESET, or TP1 (for turning point 1 in the case of multiple setups).

6. Foresight Reading: Observe the intercept of the middle reticule of the rod scale as foresight reading. Record the stadia reading to determine distance from the point to the instrument.

**7.** Compute the elevation of the new point, new bench mark, or turning point, which is the difference of the HI minus the foresight.

**8.** Reset and re-level the instrument. Level backward from the new point to the old, in the same manner as steps 2 through 7.

**Note:** The elevation computed for the old point as a result of the backward leveling may differ by no more than  $\pm 12D$  (where D is the shortest length of section in kilometers one-way) from the published elevation.

**9.** To compute the elevation difference from the old mark to the new, subtract the mean of the two elevations for the old mark from the elevation for the new mark.

#### 4. OBSERVING SEQUENCE FOR DIGITAL LEVEL

These observing procedures are intended for use with digital levels.

**1.** Remove equipment from travel cases, attach level instrument to tripod, and let equipment acclimate to local conditions. Perform instrument check and adjustment as outlined in the digital level manual.

**2.** Set up the instrument about halfway between the stations. Limit sight lengths to no more than 70 m (230 ft) from either point or from one of the points and a turning pin in the case of multiple setup requirements, e.g., distance between points is greater than 140 meters. Backsight distance to foresight distance imbalance shall be less than 5 meters. Accumulated backsight to foresight distance imbalance shall be less than 10 meters in the case of multiple setups.

**3.** Level up the instrument using the three foot screws while observing the bulls-eye bubble. Turn on the instrument and select the backsight/foresight level program. Confirm that you want to start then enter the starting elevation for the old mark. Set and confirm instrument parameters, e.g., meaning 3 measurements, display maximum decimal places, record readings to onboard module, and observing configuration, such as rod type, and metric units.

**4.** Plumb the level rod on the highest point of the old mark, e.g., domed top of disk M 123. Record the designation of the point and its published elevation, noting the reference vertical datum and units of measure.

**5. Backsight Reading:** Point using the vertical crosshair of the level instrument on the middle of the rod over the old mark and use the focusing knob to bring the image of the rod into sharp focus. Depress the measure button and record the rod reading. Note distance from rod to instrument. It should be less than 70 meters.

**6.** Plumb the rod on the highest point of the new bench mark. Record the designation of the new mark, e.g., M 123 RESET, or TP1 (for turning point 1 in the case of multiple setups).

**7. Foresight Reading:** Point and focus the level instrument on the rod over the new mark. Depress the measure button and record the rod reading. Note distance from rod to instrument. It should be less than 70 meters. Note imbalance between backsight and foresight distances. This difference shall be less than 5 meters.

**8.** The elevation of the new bench mark or turning point is computed as the sum of the backsight reading and the published elevation minus the foresight reading.

**9.** Reset and re-level the instrument. Level backward from the new point to the old, in the same manner as steps 2 through 7. Use the elevation determined from the forward leveling as the starting elevation for the backward leveling. The elevation computed for the old point as a result of the backward leveling may differ by no more than  $\pm 12D$  (where D is the shortest length of section in kilometers one-way) from the published elevation.

**10.** To compute the elevation difference from the old mark to the new, subtract the mean of the two elevations for the old mark from the elevation for the new mark. The elevation for the new bench mark will be this computed difference, mean of both forward and backward leveling, plus the published elevation of the old bench mark.

## 5. DATA SUBMISSION

The following **shall be supplied** by the submitting office:

1. Completed “Observations for Bench Mark Ties” form. See Annex 1.
2. Digital Levels: Paper as well as digital copy of leveling observations.

### ANNEX 1: Observations for Bench Mark Ties

Original Mark Stamping: PID (if known): Elevation: (ft / m) Datum: NGVD 29 or NAVD 88 (circle one)	Replacement Mark Stamping: Date of Leveling: Computed Elevation: (ft / m) (from below)
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State: County: Latitude: N Longitude: W Datum:

Leveling Equipment: Manufacturer Model Number Serial Number Level Instrument: Rod # 1: Rod # 2 (optional): Rod Scale Units:

Point	Backsight	H.I.	Foresight	Elevation	Length (ft/m)	Remarks
Forward Running: Old to New						

Backward Running: New to Old						

Agency / Firm: \_\_\_\_\_ Signed: \_\_\_\_\_  
 Address: \_\_\_\_\_ Telephone: ( ) \_\_\_\_\_  
 City / State / Zip: E-mail: \_\_\_\_\_