APPENDIX G

Fort Fisher Shore Protection and Beach Stabilization Project (Wilmington District)

G-1. Purpose. This appendix contains an example of a Wilmington District project that has been adequately referenced to the current NSRS orthometric datum and to the local tidal datum. The project consists of a 3,000 ft stone revetment sector that has an established reference baseline with local control on a legacy NGVD29 vertical datum. Beach monitoring surveys are performed in an area some two miles to the south of the revetment area, as shown on Figure G-1. The mean range of tide is 4.2 ft and the maximum known storm tide is 10.7 feet above MSL. Average annual shoreline retreat rate is approximately 15 ft in this area.

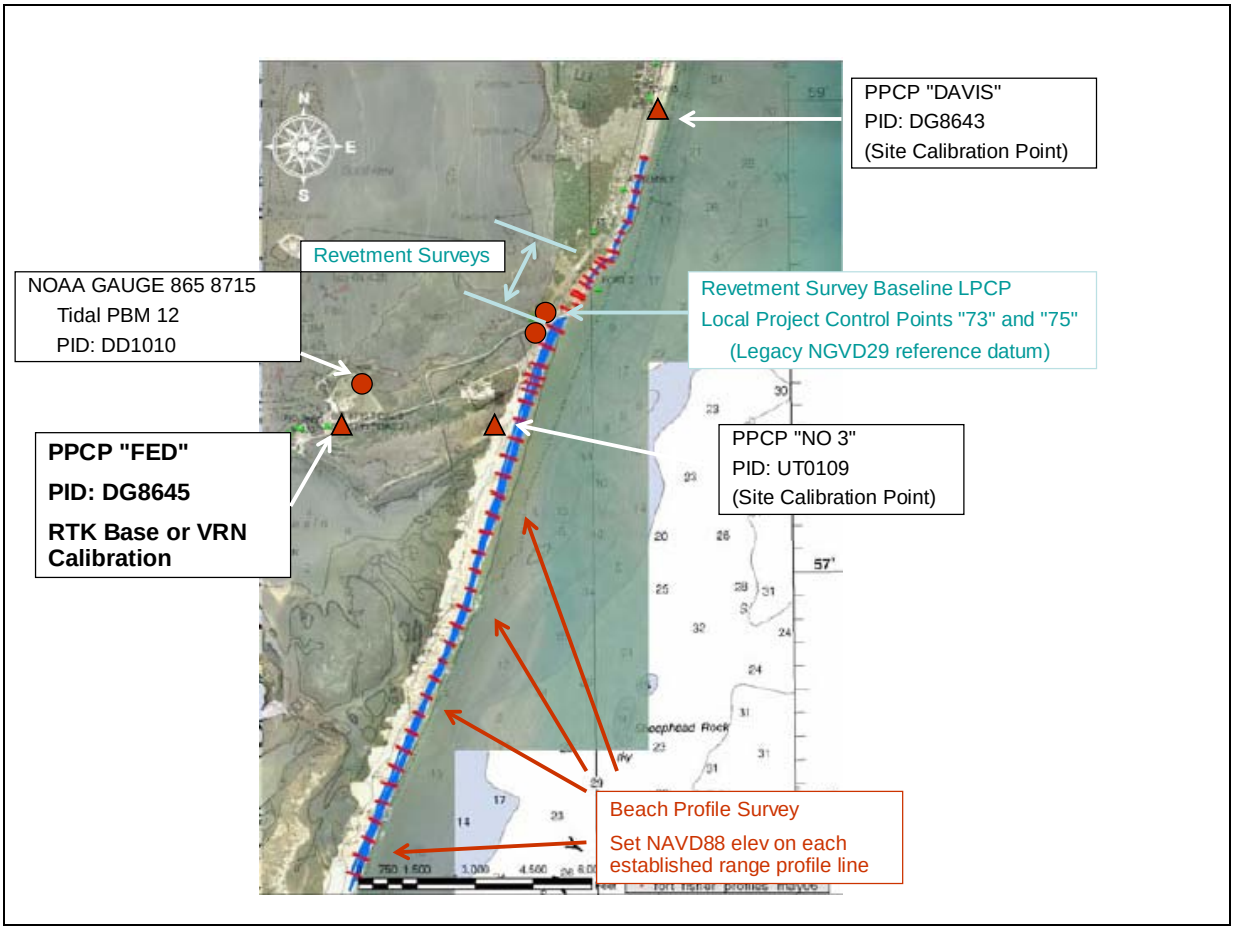

Figure G-1. Fort Fisher revetment and beach monitoring survey scheme.

G-2. Connections to NSRS and Tidal Datum References. The PPCP established for the project is PBM "FED," as shown on Figure G-1. This point is published in the NSRS and has observed NAD83/GRS80 ellipsoid height observations. Excerpts taken from the NOAA NGS published datasheet are shown in Figure G-2.

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DG8645 **********************************************************************
DG8645  DESIGNATION -  FED
DG8645  PID         -  DG8645
DG8645  STATE/COUNTY-  NC/NEW HANOVER
DG8645  USGS QUAD   -  KURE BEACH (1979)
DG8645
DG8645                        *CURRENT SURVEY CONTROL
DG8645  ______________________________________________________________________
DG8645* NAD 83(2007)-  33 57 37.24132(N)    077 56 28.77768(W)     ADJUSTED
DG8645* NAVD 88     -         5.992  (meters)      19.66   (feet)  ADJUSTED
DG8645  ______________________________________________________________________
DG8645  EPOCH DATE  -        2002.00
DG8645  X           -   1,106,339.885 (meters)                     COMP
DG8645  Y           -  -5,178,836.890 (meters)                     COMP
DG8645  Z           -   3,542,781.497 (meters)                     COMP
DG8645  LAPLACE CORR-          -4.76  (seconds)                    DEFLEC99
DG8645  ELLIP HEIGHT-         -31.476 (meters)          (02/10/07) ADJUSTED
DG8645  GEOID HEIGHT-         -37.37  (meters)                     GEOID03
DG8645  DYNAMIC HT  -           5.986 (meters)      19.64  (feet)  COMP
DG8645
DG8645  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
DG8645  Type    PID    Designation                       North   East  Ellip
DG8645  ----------------------------------------------------------------
DG8645  NETWORK DG8645 FED                                0.57   0.51   1.53
DG8645  ----------------------------------------------------------------
DG8645  MODELED GRAV-     979,620.0   (mgal)                      NAVD 88
DG8645
DG8645  VERT ORDER  -  SECOND    CLASS II
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Figure G-2. Portion of NGS datasheet for bench mark FED.

The 19.66 ft NAVD88 elevation of FED is based on adjusted leveling observations. The estimated 95% confidence of the ellipsoid height is less than 2 cm. Thus, this is an excellent point for use as an RTK base station from which all supplemental surveys can be referenced.

a. PPCP verification. The coordinates of PPCP "FED" were site calibrated against three nearby published bench marks in the NSRS—DAVIS, NO 3, and 865 8715 TIDAL 12. (DAVIS for horizontal only). These site calibration checks were based on RTK observations with the base station at FED. (Subsequent surveys used the North Carolina RTN rather than a RTK base at FED). Figure G-3 shows a typical field site calibration at PBM "NO 3." The 0.1 ft horizontal difference and 0.01 ft elevation difference are within acceptable measurement tolerances.

geodynamics
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RTK-GPS Pre-Survey Site Calibration

General

Date	5/3/2006
Project	USACE Fort Fisher Beach Profiles
Surveyor(s)	Freeman / Bernstein
Equipment	Trimble 5700 Basestation, Trimmark III 25 watt RTK Radio, Maxrad 5dB gain Antenna, Zepher Geodetic base antenna, Trimble 5700 RTK rover, Zepher antenna
Weather	Sunny, Few Clouds, 83 F, WNW Wind 15-20 kts.
Units	Meters
Notes	Tidal No 2- destroyed, FF 1-not found, Assembly - not found, FF3 found bubt not good for GPS Observations at the time
Coordinate System	NC State Plane, NAD83 (horiz), NAVD88 (vert)

Basestation Information

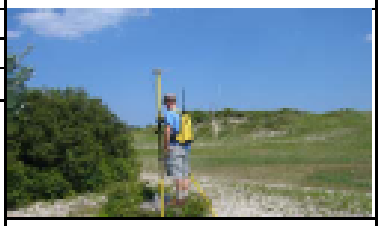
Designation	FED
PID	DG8645
Agency	US Coast Guard
Horiz Order	1
Vert Order	2
N	23857.459
E	707461.906
Z	5.992

Datasheet WWW Link

Benchmark Checks

Designation	NO 3
PID	UT0109
Agency	US BM 1911
Horiz Order	2
Vert Order	2

	Recorded	Published	Difference
N	23869.183	23869.135	-0.048
E	707419.36	707419.549	0.189
Z	1.793	1.804	0.011



Notes

Figure G-3. Site calibration RTK observations at PBMs "FED" and "NO 3."
(Checks to other site calibration points were made but are not shown in this figure)

b. Local PBM and TBM control. Figure G-4 lists the local reference PBMs and TBMs that were connected to the PPCP for the project using RTK positioning methods and differential leveling. The legacy NGVD29 elevation was retained for the two reference points used for the stone revetment monitoring survey area (USACE "73" and USACE "75"). The beach monitoring TBMs for each profile range were positioned using total station and RTK methods, and set relative to previously established monitoring range locations. Differential levels were also run through these points and the leveled elevations were held over the RTK elevations. All elevation measurements were relative to PPCP "FED" on the NAVD88 reference datum.

NGS Mon "FED", Stamped "FED 1993"
NAD '83 (2007)
N: 78, 271.26'
E: 2,321,065.58'
Elevation: 19.66' (adjusted) NAVD"88

NGS data sheet attached, below

Rock Revetment Survey based on (NGVD'29):

Point	Baseline Station	Northing	Easting	Elevation	Description
73	568+91.19, -225	81,832.0151	2,328,078.783	15.16'	USACOE Monument
75	566+38.80, -200	82,051.6633	2,328,251.723	21.40'	USACOE Monument

Beach Profile Temporary Survey Control, NAVD'88

Point	Northing	Easting	Elevation	Description
1005	83,131.9915'	2,329,171.5304'	8.93'	18" WOOD STAKE
1006	83,637.4330'	2,329,405.8200'	12.82'	18" WOOD STAKE
1007	84,023.9970'	2,329,509.8780'	13.14'	18" WOOD STAKE
1008	84,417.9320'	2,329,587.6850'	14.33'	18" WOOD STAKE
1009	84,807.9160'	2,329,677.6160'	14.91'	18" WOOD STAKE
1010	85,292.8280'	2,329,800.0250'	15.17'	18" WOOD STAKE
1011	85,378.4740'	2,329,879.1460'	15.36'	18" WOOD STAKE
1014	81,278.5780'	2,328,047.0970'	9.50'	18" WOOD STAKE
1019	79,480.3100'	2,326,830.2700'	9.04'	18" WOOD STAKE
1023	82,644.5270'	2,328,815.5440'	10.86'	18" WOOD STAKE
1024	82,014.4670'	2,328,323.9140'	22.59'	40D NAIL
1025	80,118.1730'	2,327,103.5670'	19.01'	18" WOOD STAKE
4010	82,016.5763'	2,328,322.6362'	23.52'	18" WOOD STAKE
4011	81,297.8452'	2,328,013.0360'	9.60'	18" WOOD STAKE
4105	76,622.5126'	2,326,039.5377'	16.82'	18" WOOD STAKE
4109	77,659.4700'	2,326,346.0500'	12.45'	18" WOOD STAKE
4121	75,134.2843'	2,325,579.0767'	13.44'	18" WOOD STAKE
4125	74,195.2775'	2,325,347.2231'	11.84'	18" WOOD STAKE
4130	73,268.5720'	2,324,986.0883'	15.12'	18" WOOD STAKE
4134	72,341.6740'	2,324,640.1954'	13.26'	18" WOOD STAKE
4143	70,966.8913'	2,324,028.6202'	10.84'	18" WOOD STAKE
4148	70,059.4353'	2,323,607.9422'	12.62'	18" WOOD STAKE
4442	70,805.7718'	2,323,964.7684'	7.52'	18" WOOD STAKE
4450	78,271.1098'	2,321,065.5552'	19.44'	18" WOOD STAKE
4459	70,805.6693'	2,323,964.8716'	7.47'	18" WOOD STAKE
4616	70,805.7390'	2,323,964.8300'	7.37'	18" WOOD STAKE
8097	82,729.9630'	2,329,006.9098'	10.44'	18" WOOD STAKE
8331	79,534.2030'	2,326,908.7685'	14.60'	18" WOOD STAKE
25018	83,377.3410'	2,329,272.9640'	8.47'	18" WOOD STAKE

Figure G-4. Primary, local, and baseline range control for Fort Fisher project.

c. Conversion from NAVD88 to NGVD29. The survey specifications required that range profile data be referenced to NGVD29 in order to compare prior surveys on that legacy datum. All topographic and hydrographic surveys of each profile range observed on NAVD88 were converted to NGVD29 based on an average VERTCON difference of (-) 0.956 ft (NAVD88 - NGVD29). This conversion assumed prior surveys referenced to NGVD29 were based on published NSRS connections. (It would have been preferable to establish NAVD88 on an existing mark with a published agency elevation to derive the conversion value.)

d. Tidal reference datum. The tidal relationship to NAVD88 was estimated using the nearest NOAA gage to the project site. Figure G-5 shows a number of NOAA gages in the region; however, only the Wilmington Beach gage on the coast is most representative of the project site to the south. The Southport gage to the south has similar mean and diurnal tide ranges as the Wilmington Beach gage. Therefore, the interpolated tidal characteristics at the project site are likely representative of these gages.

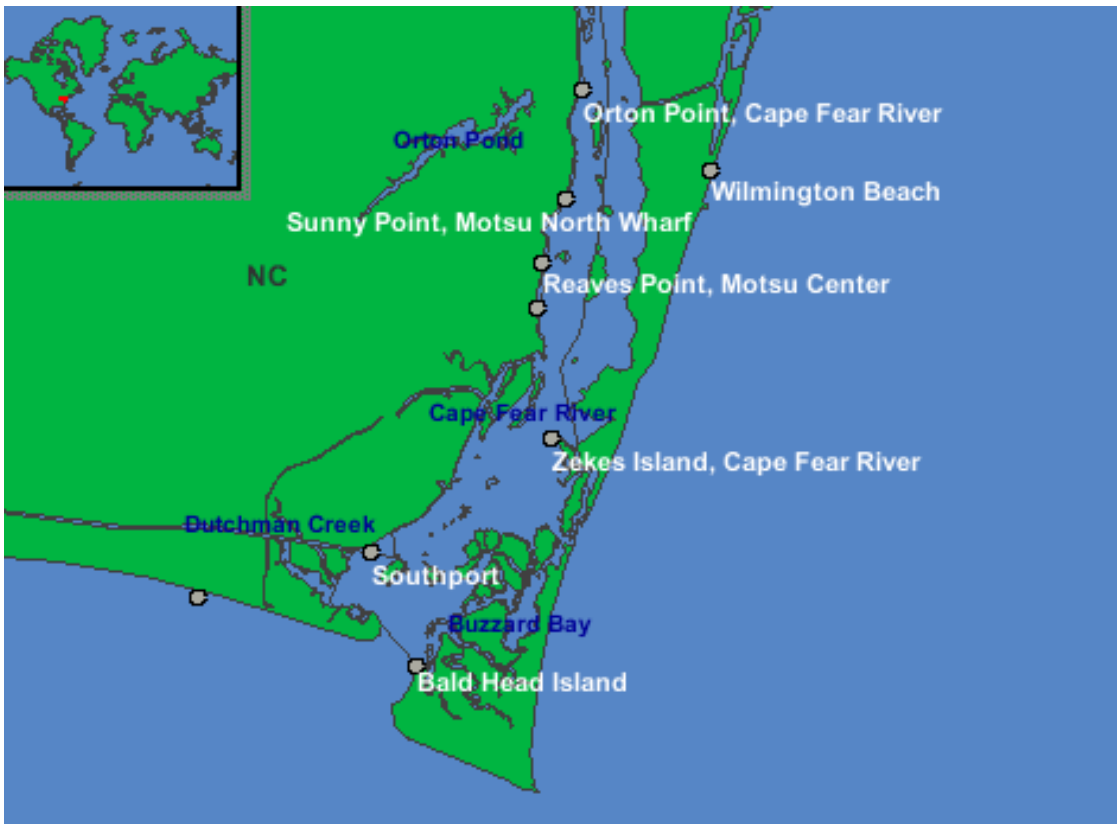


Figure G-5. Published NOAA/CO-OPS gage data in vicinity of Fort Fisher, NC.

(1) The NOAA CO-OPS station tabulation for this gage is shown in Figure G-6.

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Tidal datums at WILMINGTON BEACH [865 8559] based on:

     LENGTH OF SERIES:      4 MONTHS
     TIME PERIOD:           March 1977 - June 1977
     TIDAL EPOCH:           1983-2001
     CONTROL TIDE STATION:  8658120 WILMINGTON, CAPE FEAR RIVER


Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in METERS:

     MEAN HIGHER HIGH WATER (MHHW)                =  1.433   [4.70 ft]
     MEAN HIGH WATER (MHW)                        =  1.329
     NORTH AMERICAN VERTICAL DATUM-1988 (NAVD)    =  0.902   [2.96 ft]
     MEAN TIDE LEVEL (MTL)                        =  0.688
     MEAN SEA LEVEL (MSL)                         =  0.686   [2.25 ft]
     MEAN LOW WATER (MLW)                         =  0.047
     MEAN LOWER LOW WATER (MLLW)                  =  0.000
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Figure G-6. NOAA tide gage Wilmington Beach.

(2) Based on the data in Figure G-6, NAVD88 is 0.71 ft above MSL (0.902 m – 0.686 m). The difference between NGVD29 and MSL is then 0.25 ft (0.96 ft – 0.71 ft). The difference between NAVD88 and MSL is assumed the same at the project site to the south. (A VDatum model may show slight variations).

(3) The gage at NOAA historical tide station 865 8715 is no longer published by NOAA CO-OPS. This gage would not be relevant to this project given its interior location.

(4) Based on the above data, the geodetic and tidal relationships at PPCP "FED" could be tabulated as shown in Table G-1.

Table G-1. Elevations at PPCP "FED."

Datum [1]	Elevation	Referenced From	Estimated Uncertainty	Relative to
MLLW	22.62 ft	NOAA gage 865 8559	±0.2 ft	NWLON
NGVD29	20.62 ft	VERTCON transform	±0.3 ft	NSRS
MSL	20.37 ft	NOAA gage 865 8559	±0.2 ft	NWLON
NAVD88	19.66 ft	NSRS	±0.1 ft [2]	NSRS
MHW	17.92 ft	NOAA gage 865 8559	±0.2 ft	NWLON
Ellipsoid	-103.27 ft	GPS observations	±0.05 ft	NAD83/GRS80

[1] Tidal datum elevations are estimated based on NOAA gage 865 8559 (Wilmington Beach).

[2] Uncertainty relative to NSRS not factored in to supplemental surveys.