Digital Elevation Model of Tampa Bay, Florida: Procedures, Data Sources, and Analysis

Prepared for the National Tsunami Hazard Mitigation Program (NTHMP) by the NOAA National Geophysical Data Center (NGDC)
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Summary

In September of 2014, NOAA's National Geophysical Data Center (NGDC) developed an integrated bathymetric–topographic digital elevation model (DEM) of Tampa Bay, Florida for the National Tsunami Hazard Mitigation Program (NTHMP). The DEM will be used to support modeling tsunami generation, propagation, and inundation. The DEM covers Tampa Bay including the communities of Tampa, St. Petersburg, Clearwater, Bradenton, and Sarasota and provides an updated DEM for the Tampa Bay region originally developed by NOAA's National Ocean Service (NOS) and the U.S. Geological Society (USGS) in 2001. Extents of this DEM, procedures, data sources, and analysis are described below. The methodologies used by NGDC in developing DEM are described in the NOAA Technical Memorandum-52 for Central California and San Francisco Bay (Carignan et al., 2011).

DEM Specifications

The Tampa Bay DEM was built to the specifications listed in Table 1. Figure 1 shows this 1/3 arc-second Tampa Bay integrated topographic–bathymetric DEM boundary in red, the 2001 NOS/USGS integrated topographic–bathymetric 1 arc-second DEM in green, and the 1998 NOS Estuarine bathymetric 1 arc-second DEMs for Tampa Bay and Sarasota Bay in blue.

Table 1. Specifications for the Tampa Bay, Florida DEM.

Cell Size	1/3 arc-second
Coverage	82.37° to 83.41° W, 27.22° to 28.26° N
Coordinate System	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)
Vertical Datum	NAVD 88
Vertical Units	Meters
Grid Format	ASCII raster grid

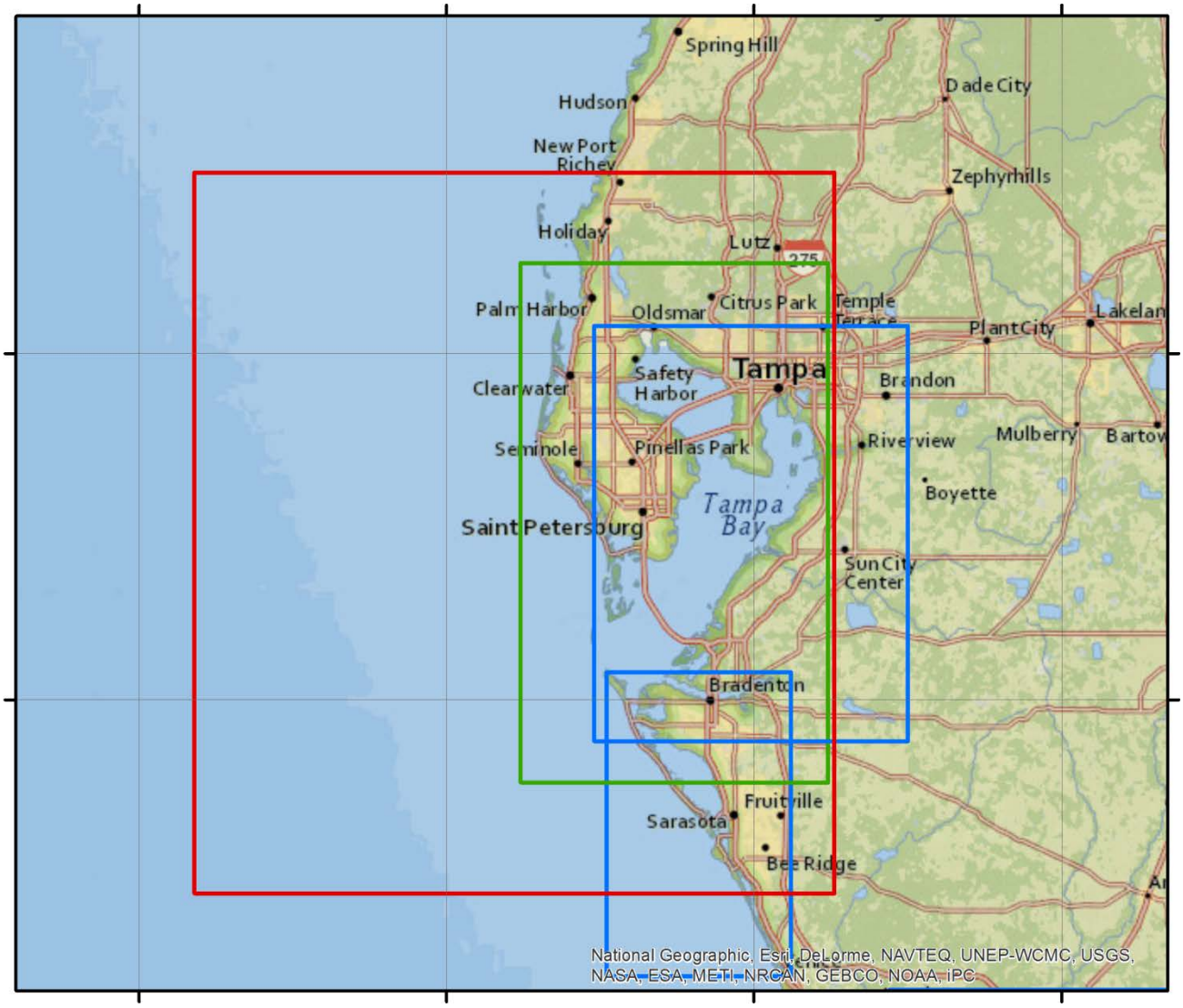

Figure 1. Map image of the boundaries for the 1/3 arc-second Tampa Bay DEM in red and the previously developed DEMs in blue and green.

Data Sources and Processing

Digital coastlines were extracted from NOAA's Office of Coast Survey (OCS) ENC Direct to GIS online extraction service (http://nauticalcharts.noaa.gov/csdl/ctp/encdirect_new.htm). These coastlines were merged and edited to match either recently acquired high resolution lidar data or imagery available via Google Earth and ESRI's World Imagery map service (http://www.arcgis.com/features/maps/imagery.html). Bathymetric and topographic data were downloaded from NOAA's Coastal Services Center (CSC), the U.S. Army Corps of Engineers (USACE), U.S. Geological Society (USGS), and NGDC. Figure 2 shows the source and coverage of the datasets used in developing the Tampa Bay DEM.

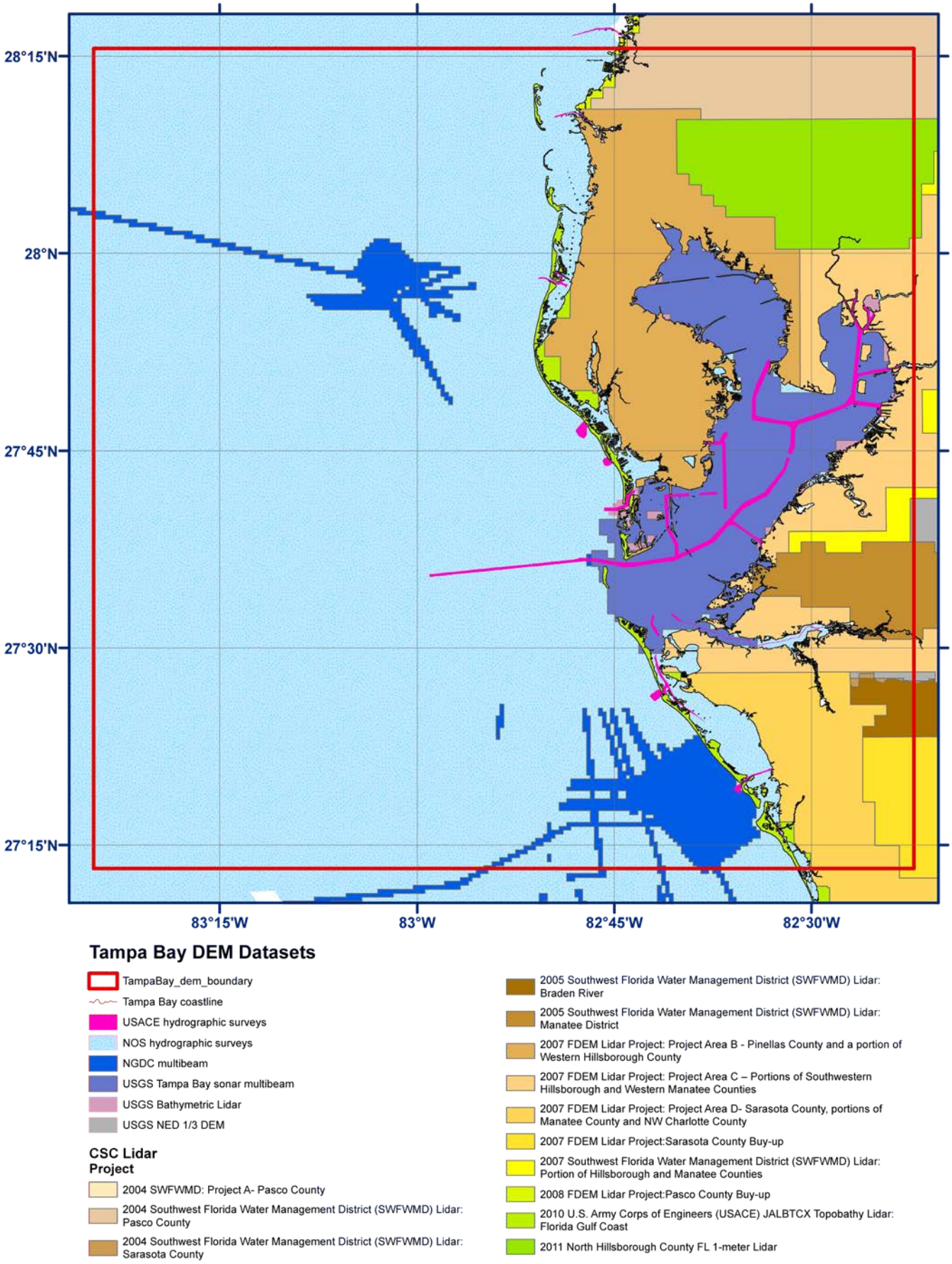

Figure 2. Source and coverage of the datasets used in compiling the Tampa Bay DEM.

Table 2 lists the bathymetry data used in the compilation of the Tampa Bay DEM including NOS hydrographic surveys (Appendix A) and multibeam surveys (Appendix B), USGS bathymetric lidar and sonar surveys, and USACE harbor surveys.

Table 2: Bathymetric data sources used in compiling the Tampa Bay DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
NOAA NOS	1886 to 2011	Hydrographic survey soundings	< 1 meter to several kilometers	Unknown, NAD 27 geographic, NAD 83 geographic, or NAD 83 UTM Zone 17 North	Mean Low Water (MLW) or Mean Lower Low Water (MLLW)
USACE	1999 to 2014	Hydrographic condition survey	< 5 meter point spacing and ~ 30 meter line spacing	NAD 83 FL State Plane West (survey feet)	MLLW
USGS	2001 to 2005	Bathymetric Lidar	2 meter grid	NAD 83 UTM Zone 17 North	NAVD 88
USGS	2001 to 2004	Bathymetric Sonar	~ 3 meter point spacing and greater than 100 meter line spacing	NAD 83 UTM Zone 17 North	NAVD 88
NGDC	2000 to 2003	Multibeam bathymetry	10 meter grid	NAD 83 geographic	Assumed Mean Sea Level (MSL)

Bathymetric data were transformed to WGS 84 geographic and NAVD 88 using GDAL and NOAA's VDatum transformation tool. Table 3 illustrates the range of vertical datums within Tampa Bay. Where recent, higher resolution data exists, older data were superseded. Topographic–bathymetric lidar data from CSC were downloaded from CSC's Digital Coast as separate datasets allowing the bathymetric data to be used in generating a bathymetric pre-surface (Table 4).

Table 3: Tampa Bay vertical datum information. Difference in vertical datums to MLLW in meters.

	CSX Rockport, McKay Bay Entrance	*Port Tampa, Old Tampa Bay*	*St. Petersburg, Tampa Bay*	*Port Manatee, Tampa Bay*	*Clearwater Beach, Gulf of Mexico*
Highest Observed Water Level	2.130	1.845	1.907	1.368	2.060
MHHW	0.814	0.749	0.688	0.669	0.841
MHW	0.710	0.652	0.602	0.585	0.737
MTL	0.433	0.394	0.360	0.349	0.446
MSL	0.440	0.391	0.366	0.355	0.452
MLW	0.155	0.136	0.117	0.112	0.155
NAVD88	0.508	-	0.443	0.471	0.539
MLLW	0	0	0	0	0
Lowest Observed Water Level	-0.743	-0.696	-0.754	-0.616	-0.784

Table 4: Topographic-Bathymetric data source used in compiling the Tampa Bay DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
CSC/USACE Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) Lidar: Gulf Coast of Florida	2010	Topographic-Bathymetric Lidar	< 1 meter	NAD 83 geographic	NAVD 88

The bathymetric data were converted to xyz format before combining with the coastline data to generate a bathymetric pre-surface at 1/3 arc-second. This bathymetric surface grid was converted to xyz format before incorporating in the final DEM.

Topographic data used in developing the Tampa Bay DEM are listed in Table 5. Transformations to WGS 84 geographic were done using GDAL. As all topographic data were available in NAVD 88, no vertical datum changes were necessary. All topographic data were converted to xyz format for the final gridding process. The converted xyz data files were clipped to the coastline to remove NoData values and returns over water as well as all elevation values below zero. Elevation values for the majority of the hundreds of small ponds and lakes were either not resolved in the lidar data or were misclassified during processing. A water surface elevation mask was used to provide elevation cell values for these areas as no accurate bathymetric information was available for much of the water bodies. The mask was generated using the University of South Florida, Center for Community Design and Research Tampa Bay Waterbody and Hillsborough County Bathymetric Polygon

geodatabases. These data provided surface water level elevation above MSL. Elevation values were converted to NAVD88 using 0.447 meters based on the average difference in datums from the tide stations.

Table 5: Topographic data sources used in compiling the Tampa Bay DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
CSC/SWFWMD Pasco District	2004	Lidar GeoTIFF	5 meter grid	NAD 83 geographic	NAVD 88
CSC/SWFWMD Sarasota District	2004	Lidar GeoTIFF	1 meter grid	NAD 83 geographic	NAVD 88
CSC/SWFWMD Braden River	2005	Lidar GeoTIFF	1 meter grid	NAD 83 geographic	NAVD 88
CSC/SWFWMD Manatee District	2005	Lidar GeoTIFF	1 meter grid	NAD 83 geographic	NAVD 88
CSC/SWFWMD Hillsborough and Little Manatee Districts	2007	Lidar GeoTIFF	1 meter grid	NAD 83 geographic	NAVD 88
CSC/FDEM SW Florida	2004 to 2008	Lidar GeoTIFF	2 meter grid	NAD 83 geographic	NAVD 88
USGS/EROS Hillsborough County	2011	Lidar LAS	< 2 meter LAS	NAD 83 HARN State Plane Florida West FIPS 0902 feet	NAVD 88
USGS NED	2013	Topographic DEM	1/3 arc second	NAD 83 geographic	NAVD 88
USF Waterbody Hydrography Layer and Hillsborough Co. Bathymetric Layer	2004 and 2007	Hydrography geodatabase	-	NAD 83 State Plane Florida West (feet) and NAD 83 HARN UTM Zone 17 North (meters)	MSL

DEM Development

Development of the Tampa Bay DEM followed procedures documented in NOAA Technical Memorandum NGDC-52 for Central California and San Francisco Bay (Carignan et al., 2011). Exceptions being the bathymetric pre-surface was generated at 1/3 arc-second. Gridding weight was modified to Table 6.

Table 6: Data hierarchy used to assign gridding weight in MB-System.

Dataset	*Relative Gridding Weight*
CSC 2010 lidar (topography)	1000
USGS/EROS Hillsborough County lidar	1000
USGS Bathymetric lidar	100
USACE hydrographic surveys	100
CSC/FDEM SW Florida	10
CSC/SWFWMD Hillsborough and Little Manatee Districts lidar	10
CSC/SWFWMD Manatee District lidar	10
CSC/SWFWMD Braden River lidar	10
CSC/SWFWMD Sarasota District lidar	10
CSC/SWFWMD Pasco District lidar	10
CSC 2007 Hillsborough lidar	10
NOS hydrographic surveys*	10
USGS multibeam surveys	10
USGS sonar bathymetry	10
USF water body surface elevation	10
1/3 arc-sec. bathymetric surface	10
Coastline	1
USGS NED DEMs	.1

***NOS hydrographic survey data collected pre NAD 1983 were only used in developing the bathymetric surface and not in the final grid.**

MHW DEM Development

The MHW Tampa Bay DEM was developed by generated a conversion grid based on VDatum software. The completed conversion grid was then applied to the NAVD 88 DEM.

DEM Analysis

The completed Tampa Bay DEM was compared to ENC sounding data, topographic benchmarks, and high resolution imagery. Inconsistencies were evaluated and resolved based on most current or reliable data available.

Acknowledgement

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Reference

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VDatum Version 3.3, Florida – Apalachicola to Anclote Key v.1 (2011). http://vdatum.noaa.gov/welcome.html [August 2014].

VDatum Version 3.3, Florida – Anclote Key to Naples v.1 (2013). http://vdatum.noaa.gov/welcome.html [August 2014].

Appendix A: NOS Surveys

Survey ID	*Date*	*Scale*	*Original Horizontal Datum*	*Original Vertical Datum*
F00456	2000	10000	NAD 83	MLLW
H01760	1886	40000	Unknown	MLW
H07082	1945 to 1947	5000	NAD 27	MLW
H07792	1950	100000	NAD 27	MLW
H07793	1950	100000	NAD 27	MLW
H07875	1950	10000	NAD 27	MLW
H07876	1950	10000	NAD 27	MLW
H07877	1950	20000	NAD 27	MLW
H07878	1950	10000	NAD 27	MLW
H07904	1951	10000	NAD 27	MLW
H07905	1950	20000	NAD 27	MLW
H07906	1951	5000	NAD 27	MLW
H07907	1951	5000	NAD 27	MLW
H07908	1951	10000	NAD 27	MLW
H07909	1951	20000	NAD 27	MLW
H07934	1951	80000	NAD 27	MLW
H07966	1951	10000	NAD 27	MLW
H07967	1951	10000	NAD 27	MLW
H07968	1951	20000	NAD 27	MLW
H07969	1952	10000	NAD 27	MLW
H07970	1952	10000	NAD 27	MLW
H07971	1952	20000	NAD 27	MLW
H08013	1954	100000	NAD 27	MLW
H08034	1953	10000	NAD 27	MLW
H08035	1954	10000	NAD 27	MLW
H08042	1953 to 1955	20000	NAD 27	MLW
H08043	1953 to 1954	20000	NAD 27	MLW
H08044	1954	10000	NAD 27	MLW
H08098	1954 to 1955	10000	NAD 27	MLW
H08099	1954	10000	NAD 27	MLW
H08100	1954	10000	NAD 27	MLW
H08152	1955	20000	NAD 27	MLW
H08154	1955	10000	NAD 27	MLW
H08379	1957	10000	NAD 27	MLW
H08380	1957	10000	NAD 27	MLW
H08411	1957 to 1958	10000	NAD 27	MLW
H08424	1958	20000	NAD 27	MLW

H08425	1958	10000	NAD 27	MLW
H08426	1958	10000	NAD 27	MLW
H08427	1958	20000	NAD 27	MLW
H08428	1958	20000	NAD 27	MLW
H08429	1958	20000	NAD 27	MLW
H08430	1958	10000	NAD 27	MLLW
H09338	1975	20000	NAD 27	MLW
H09350	1972 to 1973	20000	NAD 27	MLW
H09351	1973	20000	NAD 27	MLW
H09390	1973	20000	NAD 27	MLLW
H09509	1975	20000	NAD 27	MLW
H09510	1975	20000	NAD 27	MLW
H09511	1975	40000	NAD 27	MLW
H10270	1994 to 1995	10000	NAD 83	MLLW
H10536	1994	10000	NAD 83	MLLW
H10539	1994 to 1995	10000	NAD 83	MLLW
H10598	1995	10000	NAD 83	MLLW
H10599	1995	10000	NAD 83	MLLW
H10603	1995	10000	NAD 83	MLLW
H10606	1995	10000	NAD 83	MLLW
H10623	1995 to 1996	10000	NAD 83	MLLW
H10685	1996	10000	NAD 83	MLLW
H10709	1996	10000	NAD 83	MLLW
H11344	2004	10000	NAD 83	MLLW
H11345	2004	10000	NAD 83	MLLW
H12016	2009 to 2010	10000	NAD 83 UTM Zone 17	MLLW
H12017	2011	10000	NAD 83 UTM Zone 17	MLLW
H12018	2011	10000	NAD 83 UTM Zone 17	MLLW
H12019	2010-2011	20,000	NAD 83 UTM Zone 17	MLLW

Appendix B: NGDC multibeam Surveys

Survey ID	*Date*	*Ship*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
USF2000	2000	Bellows	University of South Florida (USF)	NAD 83 geographic	assumed MSL
USF2001	2001	Bellows	University of South Florida (USF)	NAD 83 geographic	assumed MSL
USF2002FLA	2002	Bellows	University of South Florida (USF)	NAD 83 geographic	assumed MSL
USF2003	2003	Bellows	University of South Florida (USF)	NAD 83 geographic	assumed MSL