

HURRICANE HARVEY

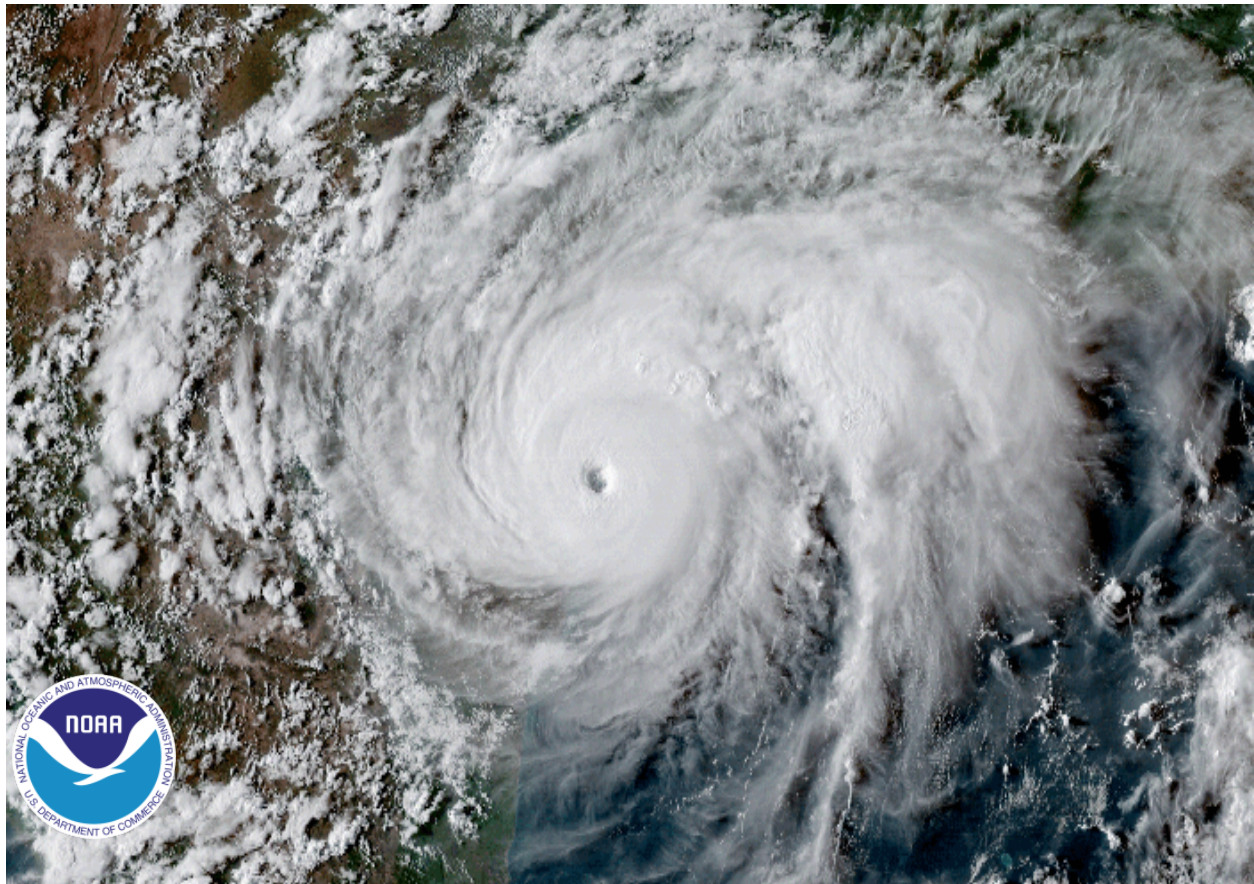


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noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Hurricane HARVEY

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January 2, 2018



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Overview

The National Oceanic and Atmospheric Administration (NOAA) Center for Operational Oceanographic Products and Services (CO-OPS) maintains a network of oceanographic and meteorological stations along the United States coastlines and Great Lakes to monitor water levels, winds (speed, direction and gusts), barometric pressure, and air/water temperature. This report documents the elevated water levels, high winds and reduced barometric pressures recorded at stations along the Gulf Coast of the U.S. from Texas to Louisiana during Hurricane Harvey, which occurred August 17 – September 1, 2017.

Station information and locations are displayed in Figures 2-4 and Appendices 1 & 2. Tidal stations are referenced to Mean Higher High Water (MHHW), based on the National Tidal Datum Epoch 1983-2001 (Appendix 3). Mean Higher High Water is the average of the highest high tide in a day and is used as a proxy for when flooding inundation may begin to occur. In addition, at several locations along the U.S. coast, water levels are provided relative to an orthometric datum, the North American Vertical Datum of 1988 (NAVD88), to assist in relating water levels to coastal inundation estimates.

Table 1 provides peak water level (storm tide) and predicted tide elevations for stations affected by Hurricane Harvey by geographic region, referenced to MHHW and the appropriate orthometric datum (where available). Included in Table 1 are the residuals corresponding to the times of maximum storm tides. Maximum residual levels (independent of overall peak water level) are summarized in Table 2, ranked by amplitude. Storm tides are the maximum observed water level elevations during a storm passage (Figure 1). Residuals are elevation differences between observed water levels and predicted tides and can result from numerous factors such as storm surge, rainfall runoff, and non-storm related oceanographic variability. Storm surge is the residual caused directly by the storm and includes the effects of wind stress, atmospheric pressure and wave setup.

In addition, the report highlights stations that have exceeded historical recorded maximum water levels because of Hurricane Harvey (Figure 5). The historical recorded maximum water levels are the maximum water elevations measured throughout a high tide cycle for the entire historical period. A complete high tide cycle is required to apply a best-fit curve to the observations and calculate the maximum tide elevation. These historic records may not have included the highest water levels measured at a station during an event if a complete high tide cycle was not measured due to station and /or sensor damage (Appendix 3).

Individual water level time series graphs are provided for each station (Figures 6 – 46). A twelve day window was chosen for time series graphs at all stations to capture water level response prior to, during and following the storm. A line denoting each official NHC landfall is depicted on all water level plots. This longer plot window shows the effects from this long duration storm and subsequent effects at many stations due to excessive runoff from record rainfall. For comparison and context, the historical recorded maximum water levels are displayed on the graphs, where available. Current speeds at several stations, which are part of Physical Oceanographic Real-Time Systems (PORTS[®]) in Texas and Louisiana, were significantly higher during and following Harvey. Table 4 and Figures 47-51 display peak currents at Texas stations installed at Matagorda Bay Entrance (Matagorda Ship Channel Marker 19, TX), Galveston Bay Entrance (Galveston Bay Entrance Channel LB 11, TX), Galveston Ship Channel (Fred Hartman Bridge, Houston Ship Ch., TX) and Sabine River (Rainbow Bridge, TX), as well as one installed at Calcasieu Pass, Louisiana (Cameron Fishing Pier, LA).

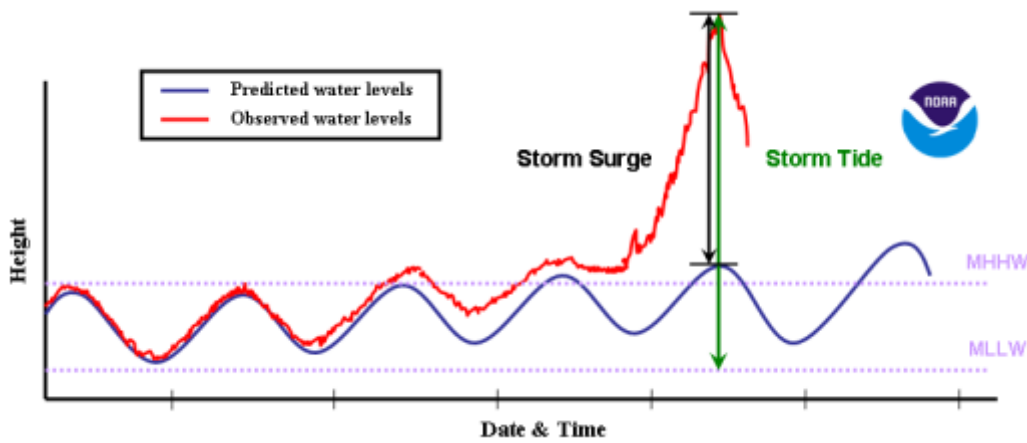


Figure 1: Storm tides are the maximum observed water level elevations measured by a water level station during a storm event.

Hurricane Harvey Summary

On August 17, 2017, Potential Tropical Cyclone Nine formed about 300 km (482 miles) east of Barbados in the Lesser Antilles. Later that day, an Air Force Reserve Hurricane Hunter aircraft found a well-defined circulation and the storm was upgraded to Tropical Storm Harvey. Harvey moved westward over the Windward Islands on Friday, August 18, bringing tropical storm force winds to Barbados, St. Lucia and St. Vincent and the Grenadines. The following day, Harvey degenerated into a tropical wave as wind shear and dry air weakened the system. The remnants of Harvey tracked west-northwest across the Caribbean over the next several days.

After the system crossed over the Yucatan Peninsula, a Hurricane Hunter aircraft found that Harvey had regenerated into a tropical depression within the Bay of Campeche on August 23. Later that day, Harvey once again strengthened into a tropical storm and hurricane and tropical storm warnings were issued by the National Hurricane Center for a portion of the Texas coast a few hours later. The National Hurricane Center also issued the first operational storm surge warning for Texas, highlighting areas where water levels were expected to reach at least 3 feet above ground (which can be approximated as MHHW along the coast). Harvey began to rapidly intensify the following day as it tracked northwest, due to very warm water and low wind shear, and reached hurricane strength around midday August 24.

About 12 hours later, Harvey reached Category 2 strength with winds of 44.7 m/s (87 kts) by early afternoon on the 25th. Harvey became a major hurricane with winds of 53.6 m/s (104 kts) while situated about 120 km (75 miles) east-southeast of Corpus Christi, Texas. Harvey continued to intensify and made landfall as a Category 4 storm with winds of 58.1 m/s (133 kts) between Port Aransas and Port O'Connor, Texas at 03:00 GMT on August 26.

Following landfall, Harvey moved inland and weakened to a tropical storm by midday August 26. The storm drastically slowed down and remained almost stationary through August 27 before drifting slowly to the east-southeast and reemerging over the Gulf of Mexico early on the 28th. Tropical Storm Harvey continued a slow southeasterly movement reaching about 160 km (100 miles) offshore before the track shifted once again. The storm then moved northeastward parallel to the Texas coast beginning early

on August 29 before curving north and making a second landfall near Cameron, Louisiana at 09:00 GMT on August 30 with winds of 20 m/s (39 kts). Harvey continued to track northward and became post-tropical on August 31. Harvey's slow meandering movement resulted in historic rainfall across eastern Texas and western Louisiana, including the Houston metropolitan area, causing catastrophic flooding.

Hurricane Harvey resulted in elevated water levels along the Texas and western Louisiana coast for several days due to storm surge and excessive rainfall runoff as the storm lingered over the region. Stations farther inland experienced some of the highest water levels as freshwater runoff from rainfall added to already elevated heights. The peak water level associated with initial landfall was 2.045 m (6.71 ft.) above MHHW, measured at Port Lavaca, Texas at 08/26/2017 08:42 GMT. Other notable peak water levels near the first landfall were 1.684 m (5.52 ft.) above MHHW at Seadrift, Texas on 08/26/2017 11:24 GMT and 1.628 m (5.34 ft.) above MHHW at Port Aransas, Texas on 08/26/2017 02:12 GMT. Along the Texas coast through 08/26/2017, peak water levels ranged from 0.311 m to 2.045 m (1.05 ft. to 6.71 ft.) above MHHW. The lowest peak water level elevations around the time of initial landfall were measured across southern Texas and western Corpus Christi Bay and the highest peak water level observations were observed at the entrance to Corpus Christi Bay, Port Aransas, San Antonio Bay and Matagorda Bay.

In the days following initial landfall, some stations continued to experience elevated and in some cases increasing water levels as heavy flooding rain continued to fall across the region. This was especially evident in the Houston Ship Channel and within the Intracoastal Waterway east of Galveston Bay. The highest overall water level observed during Harvey occurred at Manchester, Texas near the Port of Houston, where water levels reached 3.19 m (10.47 ft.) above MHHW on 8/29/2017 09:54 GMT. The significant increase in water level was likely caused by runoff through the relatively narrow Houston Ship Channel. Other notable peak water level observations were 1.263 m (5.07 ft.) above MHHW at High Island, Texas within the Gulf Intracoastal Waterway and 2.235 m (7.33 ft.) above MHHW on 8/30/2017 14:48 GMT at Lynchburg Landing, Texas (also within the Houston Ship Channel) before this station was destroyed by the storm. The extended window range through September 3 depicted on water level plots captures the long duration high water event at several stations, enhanced by excessive rainfall runoff.

Peak water levels from Sabine Pass, Texas to Grand Isle, Louisiana corresponding with the second landfall ranged from 0.393 to 1.085 m (1.29 to 3.56 ft.) above MHHW. The highest observation of 1.085 m (3.56 ft.) occurred at Lake Charles, Louisiana on 8/30/2017 14:54 GMT and likely included runoff in addition to storm surge.

The maximum storm surge (residuals) along the Gulf Coast, from Harvey ranged from 0.373 (1.22 ft.) to 3.502 (11.49 ft.). The highest residuals of 3.502 m (11.49 ft.) at Manchester, TX and 2.368 m (7.77 ft.) at Lynchburg Landing, TX were observed in the Houston Ship Channel, which were exacerbated by excessive rainfall runoff. Other notable storm surge residuals were 2.152 m (7.06 ft.) at Port Lavaca, TX and 1.758 m (5.77 ft.) at Seadrift, TX. Note that many of the peak residual values occurred within +/- 2 hours of low tide, diminishing inundation in comparison to peak residuals coinciding with high tide (see Tables 1 & 2).

The highest sustained wind speed recorded at NOS water level stations from southern Texas to Louisiana during Hurricane Harvey was 49.6 m/s (96.4 kts) at Aransas Pass, TX on 8/26/2017 01:42. The highest wind gust was also recorded at Aransas Pass, Texas and measured 59.3 m/s (115.3 kts) on 8/26/2017 02:42 GMT. The minimum barometric pressure recorded was 941.8 mb at Rockport, Texas on 8/26/2017 03:36 GMT. Both Port Aransas and Rockport were very near the center (eye) of the storm as it made landfall and the station at Rockport was destroyed by the storm.

The highest observed current speeds during and following Harvey was 3.93 m/s (7.69 kts), recorded at Fred Hartmann Bridge within the Galveston Ship Channel, TX on August 29. At this location, current speeds in the ebb direction (flowing from Houston into Galveston Bay) were several meters-per-second faster than usual tidal currents. Additionally, the excessive runoff resulted in increased freshwater inflow into Galveston Bay for over a week. Typically, tidal currents flow from Galveston Bay towards Houston for several hours daily associated with high tide moving up the estuary. At Rainbow Bridge, within Sabine River, TX, water flowed into Sabine Lake towards the Gulf of Mexico for over 2 weeks before the typical tidally-driven flow returned.

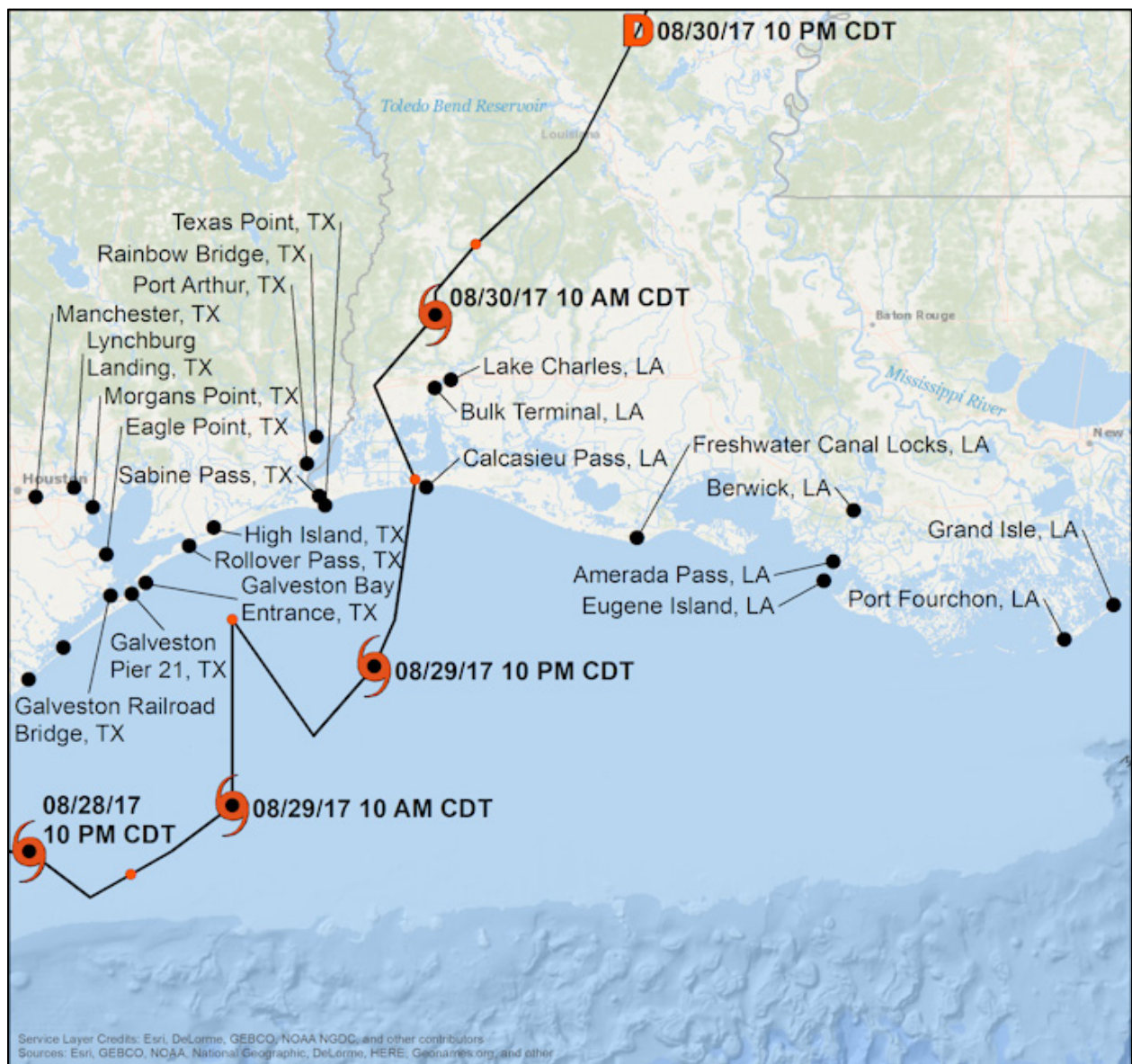


Figure 3: NOS stations affected by Harvey from Northern Texas to Louisiana.

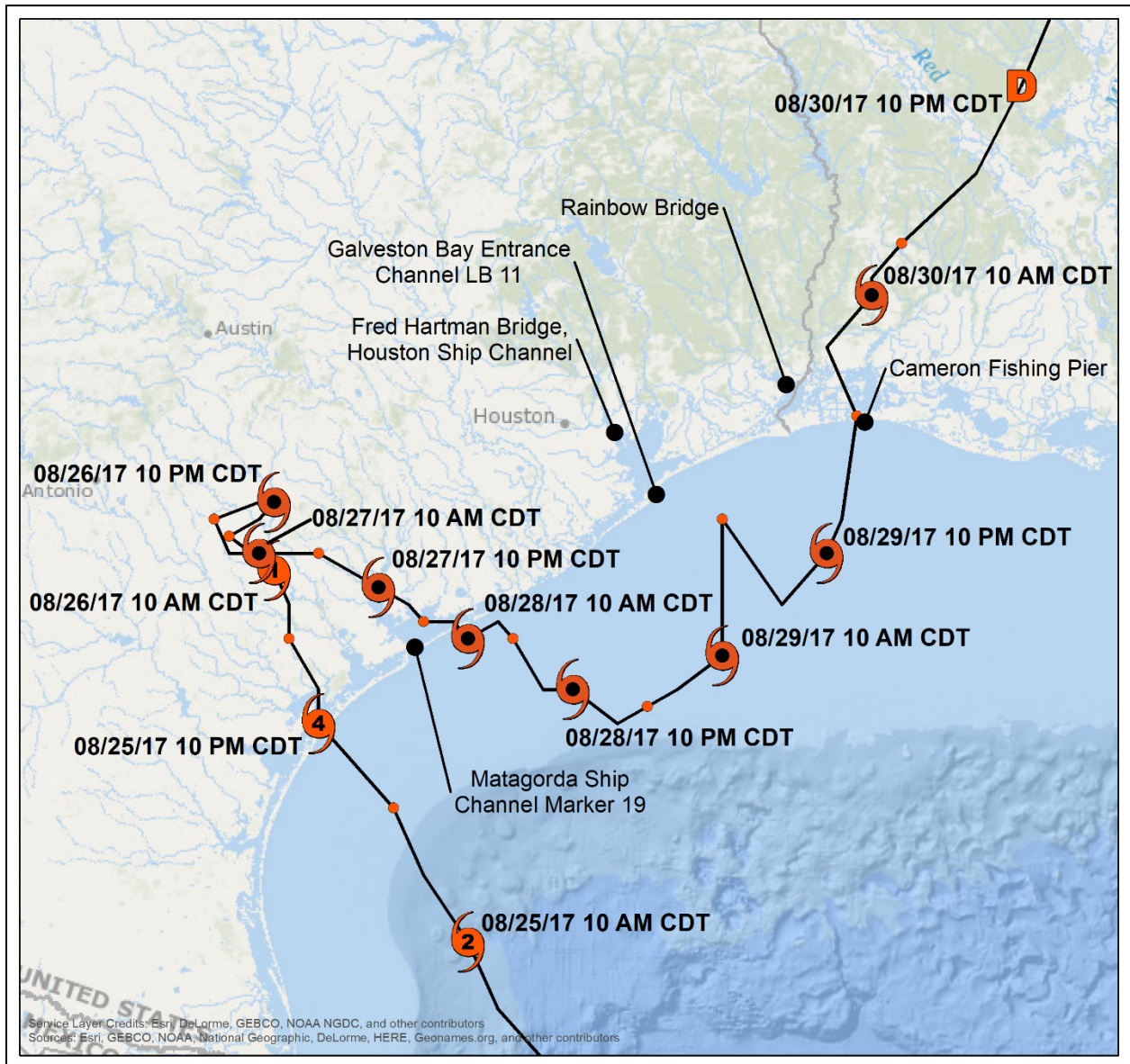


Figure 4: Select NOS tidal currents stations affected by Harvey from Northern Texas to Louisiana.

Table 1a: Maximum recorded water levels for Hurricane Harvey ordered geographically from Southern Texas to Central Louisiana, referenced to MHHW and the respective orthometric datum (where available). Storm tide represents the peak observed water level during the storm passage and storm surge (residual) represents the maximum observed water level minus the predicted astronomical tide at the denoted time. Stations where the historical maximum water level was exceeded are highlighted in gray.

Station Name	Station ID	Date & Time GMT	Storm Tide	Predicted	Storm Surge/ Residual (m)	Storm Tide (m, ORTHO)	Storm Tide	Predicted	Storm Surge/ Residual (ft)	Storm Tide (ft, ORTHO)
			(m, MHHW)			(ft, MHHW)				
Port Isabel, TX	8779770	8/26/2017 1:24	0.430	-0.059	0.489	0.589	1.41	-0.19	1.60	1.93
^{3,4} SPI Brazos Santiago, TX	8779749	8/26/2017 0:48	0.423	-0.060	0.051	n/a	1.39	-0.20	1.67	n/a
⁴ South Padre Island CG Station, TX	8779748	8/26/2017 1:06	0.426	-0.103	0.482	n/a	1.40	-0.34	1.58	n/a
Bob Hall Pier, Corpus Christi, TX	8775870	8/25/2017 20:12	1.077	-0.213	1.290	1.438	3.53	-0.70	4.23	4.72
² Packery Channel, TX	8775792	8/26/2017 0:30	1.423	-0.029	1.452	1.678	4.67	-0.10	4.76	5.51
USS Lexington, TX	8775296	8/25/2017 18:00	0.311	-0.063	0.385	0.627	1.02	-0.21	1.26	2.06
^{1,4} Aransas, Aransas Pass, TX	8775241	8/25/2017 10:54	0.346	-0.098	0.496	n/a	1.14	-0.32	1.63	n/a
⁴ Port Aransas, TX	8775237	8/26/2017 2:12	1.628	-0.097	1.699	1.881	5.34	-0.32	5.57	6.17
¹ Rockport, TX	8774770	8/26/2017 4:48	0.566	-0.035	0.601	0.962	1.86	-0.11	1.97	3.16
⁴ Copano Bay, TX	8774513	8/26/2017 6:30	1.210	-0.045	1.246	n/a	3.97	-0.15	4.09	n/a
^{3,4} Aransas Wildlife Refuge, TX	8774230	8/26/2017 2:12	1.452	-0.010	1.512	n/a	4.76	-0.03	4.96	n/a
^{1,3,4} Matagorda Bay Entrance Channel, TX	8773767	8/25/2017 21:36	0.698	-0.186	0.841	n/a	2.29	-0.61	2.76	n/a
^{3,4} Port O'Connor, TX	8773701	8/26/2017 1:48	0.907	-0.073	1.020	n/a	2.98	-0.24	3.34	n/a
^{3,4} Port Lavaca, TX	8773259	8/26/2017 8:42	2.045	-0.098	2.152	n/a	6.71	-0.32	7.06	n/a
⁴ Matagorda City, TX	8773146	8/26/2017 9:42	0.964	-0.053	1.005	n/a	3.16	-0.17	3.30	n/a
^{1,4} Seadrift, TX	8773037	8/26/2017 11:24	1.684	-0.052	1.758	n/a	5.52	-0.17	5.77	n/a
^{3,4} Sargent, TX	8772985	8/29/2017 15:06	0.905	-0.024	0.973	n/a	2.97	-0.08	3.19	n/a
Freeport, TX	8772447	8/25/2017 22:00	0.769	-0.170	0.939	n/a	2.52	-0.56	3.08	n/a
⁴ San Luis Pass, TX	8771972	8/26/2017 0:42	1.013	-0.041	1.054	n/a	3.32	-0.13	3.46	n/a

¹ Sensor was damaged or destroyed and likely did not record a maximum water level

² Maximum recorded water level value exceeded historical maximum value

³ Maximum residual occurred within +/- 2 hours of low tide

⁴ No previously defined historical maximum value

Table 1b: Maximum recorded water levels for Hurricane Harvey ordered geographically from Southern Texas to Central Louisiana, referenced to MHHW and the respective orthometric datum (where available). Storm tide represents the peak observed water level during the storm passage and storm surge (residual) represents the maximum observed water level minus the predicted astronomical tide at the denoted time. Stations where the historical maximum water level was exceeded are highlighted in gray.

Station Name	Station ID	Date & Time GMT	Storm Tide	Predicted	Storm Surge/ Residual (m)	Storm Tide (m, ORTHO)	Storm Tide	Predicted	Storm Surge/ Residual (ft)	Storm Tide (ft, ORTHO)
			(m, MHHW)				(ft, MHHW)			
⁴ Galveston Railroad Bridge, TX	8771486	8/29/2017 9:36	0.840	-0.011	0.891	1.136	2.76	-0.04	2.92	3.73
Galveston Pier 21, TX	8771450	8/29/2017 4:18	0.822	-0.043	0.874	1.208	2.70	-0.14	2.87	3.96
Galveston Bay Entrance, North Jetty, TX	8771341	8/29/2017 3:54	0.786	-0.060	0.846	n/a	2.58	-0.20	2.78	n/a
Eagle Point, TX	8771013	8/29/2017 3:42	1.118	-0.147	1.276	n/a	3.67	-0.48	4.19	n/a
⁴ Rollover Pass, TX	8770971	8/26/2017 18:30	0.959	-0.203	1.162	n/a	3.15	-0.67	3.81	n/a
² Texas Point, Sabine Pass, TX	8770822	8/28/2017 10:12	0.938	-0.129	1.067	n/a	3.08	-0.42	3.50	n/a
^{3,4} High Island, TX	8770808	8/30/2017 14:48	1.263	-0.073	1.544	n/a	4.14	-0.24	5.07	n/a
^{2,3} Manchester, TX	8770777	8/29/2017 9:54	3.190	-0.111	3.502	n/a	10.47	-0.36	11.49	n/a
^{1,2} Lynchburg Landing, TX	8770733	8/29/2017 7:06	2.235	-0.132	2.368	2.699	7.33	-0.43	7.77	8.85
³ Morgans Point, TX	8770613	8/27/2017 13:30	1.077	-0.088	1.240	1.445	3.53	-0.29	4.07	4.74
Sabine Pass North, TX	8770570	8/28/2017 10:18	0.969	-0.078	1.047	n/a	3.18	-0.26	3.44	n/a
^{1,4} Rainbow Bridge, TX	8770520	8/30/2017 8:12	0.879	-0.100	1.029	n/a	2.88	-0.33	3.38	n/a
^{3,4} Port Arthur, TX	8770475	9/3/2017 9:42	1.122	-0.008	1.281	n/a	3.68	-0.03	4.20	n/a
Calcasieu Pass, LA	8768094	8/28/2017 11:48	0.846	-0.050	0.896	n/a	2.78	-0.16	2.94	n/a
² Bulk Terminal, LA	8767961	8/30/2017 14:12	0.983	-0.102	1.086	n/a	3.23	-0.33	3.56	n/a
² Lake Charles, LA	8767816	8/30/2017 14:54	1.085	-0.051	1.136	n/a	3.56	-0.17	3.73	n/a
³ Freshwater Canal Locks, LA	8766072	8/28/2017 13:54	0.969	-0.136	1.215	n/a	3.18	-0.45	3.99	n/a
Eugene Island, LA	8764314	8/30/2017 9:36	0.865	-0.082	0.955	n/a	2.84	-0.27	3.13	n/a
LAWMA, Amerada Pass, LA	8764227	8/30/2017 11:00	0.873	-0.063	0.936	1.140	2.86	-0.21	3.07	3.74
Berwick, Atchafalaya River, LA	8764044	8/30/2017 14:18	0.445	-0.286	0.731	n/a	1.46	-0.94	2.40	n/a
Port Fourchon, Belle Pass, LA	8762075	8/29/2017 12:30	0.406	0.015	0.391	n/a	1.33	0.05	1.28	n/a
Grand Isle, LA	8761724	8/30/2017 12:48	0.393	0.023	0.373	n/a	1.29	0.08	1.22	n/a

¹ Sensor was damaged or destroyed and likely did not record a maximum water level

² Maximum recorded water level value exceeded historical maximum value

³ Maximum residual occurred within +/- 2 hours of low tide

⁴ No previously defined historical maximum value

Table 2a: Maximum recorded storm surge (residual) ranked by amplitude for Hurricane Harvey. Storm surge (residual) represents the maximum observed water level (storm tide) minus predicted astronomical tide levels. Stations where the historical maximum water level was exceeded are highlighted in gray.

Station Name	Station ID	Date & Time GMT	Residual	
			in Meters	in Feet
^{2,3} Manchester, TX	8770777	8/29/2017 3:12	3.502	11.49
^{1,2} Lynchburg Landing, TX	8770733	8/29/2017 7:06	2.368	7.77
³ Port Lavaca, TX	8773259	8/26/2017 10:18	2.152	7.06
¹ Seadrift, TX	8773037	8/26/2017 11:30	1.758	5.77
Port Aransas, TX	8775237	8/26/2017 2:12	1.699	5.57
³ High Island, TX	8770808	8/30/2017 1:24	1.544	5.07
³ Aransas Wildlife Refuge, San Antonio Bay, TX	8774230	8/26/2017 2:12	1.512	4.96
² Packery Channel, TX	8775792	8/26/2017 0:30	1.452	4.76
Bob Hall Pier, Corpus Christi, TX	8775870	8/25/2017 20:12	1.290	4.23
³ Port Arthur, TX	8770475	9/3/2017 2:30	1.281	4.20
Eagle Point, TX	8771013	8/29/2017 2:24	1.276	4.19
Copano Bay, TX	8774513	8/26/2017 6:30	1.246	4.09
³ Morgans Point, TX	8770613	8/29/2017 2:54	1.240	4.07
³ Freshwater Canal Locks, LA	8766072	8/25/2017 17:30	1.215	3.99
Rollover Pass, TX	8770971	8/26/2017 18:30	1.162	3.81
² Lake Charles, LA	8767816	8/30/2017 14:54	1.136	3.73
² Bulk Terminal, LA	8767961	8/30/2017 14:12	1.086	3.56
² Texas Point, Sabine Pass, TX	8770822	8/28/2017 10:12	1.067	3.50
San Luis Pass, TX	8771972	8/26/2017 0:42	1.054	3.46
Sabine Pass North, TX	8770570	8/28/2017 10:18	1.047	3.44
¹ Rainbow Bridge, TX	8770520	8/30/2017 4:36	1.029	3.38
³ Port O'Connor, TX	8773701	8/25/2017 21:24	1.018	3.34
Matagorda City, TX	8773146	8/26/2017 9:42	1.005	3.30
³ Sargent, TX	8772985	8/29/2017 20:18	0.973	3.19
Eugene Island, North of, Gulf of Mexico, LA	8764314	8/30/2017 10:30	0.955	3.13
Freeport, TX	8772447	8/25/2017 22:00	0.939	3.08
LAWMA, Amerada Pass, LA	8764227	8/30/2017 11:00	0.936	3.07
Calcasieu Pass, LA	8768094	8/28/2017 11:48	0.896	2.94
Galveston Railroad Bridge, TX	8771486	8/29/2017 2:54	0.891	2.92
Galveston Pier 21, TX	8771450	8/29/2017 3:36	0.874	2.87
Galveston Bay Entrance, North Jetty, TX	8771341	8/29/2017 3:54	0.846	2.78
^{1,3} Matagorda Bay Entrance Channel, TX	8773767	8/25/2017 18:36	0.841	2.76
Berwick, Atchafalaya River, LA	8764044	8/30/2017 14:18	0.731	2.40
¹ Rockport, TX	8774770	8/26/2017 4:48	0.601	1.97
³ SPI Brazos Santiago, TX	8779749	8/26/2017 5:18	0.510	1.67

¹ Sensor was damaged or destroyed and likely did not record a maximum water

² Maximum recorded water level value exceeded historical maximum value

³ Maximum residual occurred within +/- 2 hours of low tide

Table 2b: Maximum recorded storm surge (residual) ranked by amplitude for Hurricane Harvey. Storm surge (residual) represents the maximum observed water level (storm tide) minus predicted astronomical tide levels. Stations where the historical maximum water level was exceeded are highlighted in gray.

Station Name	Station ID	Date & Time GMT	Residual	
			in Meters	in Feet
Port Isabel, TX	8779770	8/26/2017 2:54	0.501	1.64
¹ Aransas, Aransas Pass, TX	8775241	8/25/2017 7:18	0.496	1.63
South Padre Island CG Station, TX	8779748	8/25/2017 15:00	0.482	1.58
Port Fourchon, Belle Pass, LA	8762075	8/29/2017 12:30	0.391	1.28
USS Lexington, TX	8775296	8/25/2017 18:00	0.385	1.26
Grand Isle, LA	8761724	8/29/2017 14:00	0.373	1.22

¹ Sensor was damaged or destroyed and likely did not record a maximum water

² Maximum recorded water level value exceeded historical maximum value

³ Maximum residual occurred within +/- 2 hours of low tide

Table 3a: Maximum recorded wind speed ordered geographically from Southern Texas to Central Louisiana, wind gust and minimum barometric pressure for Hurricane Harvey.

Station Name	Station ID	Maximum Wind Speed			Maximum Wind Gusts			Minimum Atmospheric Pressure	
		Date & Time GMT	m/sec	knots	Date & Time GMT	m/sec	knots	Date & Time GMT	mbar
Port Isabel, TX	8779770	8/25/2017 11:30	11.0	21.4	8/25/2017 11:42	16.1	31.3	8/25/2017 11:54	1001.2
SPI Brazos Santiago, TX	8779749	8/25/2017 15:48	16.8	32.7	8/25/2017 14:54	20.3	39.5	8/25/2017 12:54	1000.1
South Padre Island CG Station, TX	8779748	8/25/2017 15:18	16.6	32.3	8/25/2017 13:48	20.6	40.0	8/25/2017 13:00	1000.9
Bob Hall Pier, Corpus Christi, TX	8775870	8/25/2017 22:42	25.7	50.0	8/25/2017 21:54	34.0	66.1	8/26/2017 1:12	986.3
Packery Channel, TX	8775792	8/25/2017 23:18	29.8	57.9	8/25/2017 22:42	36.9	71.7	8/26/2017 1:36	986.1
USS Lexington, TX	8775296	n/a	n/a	n/a	n/a	n/a	n/a	8/26/2017 2:42	987.8
Aransas, Aransas Pass, TX	8775241	8/26/2017 1:42	49.6	96.4	8/26/2017 2:42	59.3	115.3	8/26/2017 4:42	902.2
Port Aransas, TX	8775237	8/25/2017 22:42	25.6	49.8	8/25/2017 23:54	35.7	69.4	8/26/2017 2:24	959.3
Rockport, TX	8774770	8/26/2017 1:54	30.2	58.7	8/26/2017 1:48	48.3	93.9	8/26/2017 3:36	941.8
Copano Bay, TX	8774513	8/26/2017 3:06	40.7	79.1	8/26/2017 3:18	53	103.0	8/26/2017 4:00	944.0
Aransas Wildlife Refuge, TX	8774230	8/26/2017 1:12	35.6	69.2	8/26/2017 3:24	47.2	91.7	8/26/2017 4:24	970.5
Matagorda Bay Entrance Channel, TX	8773767	8/26/2017 2:24	29.6	57.5	8/26/2017 3:24	34.9	67.8	8/26/2017 1:30	993.9
Port O'Connor, TX	8773701	8/26/2017 10:54	27.5	53.5	8/26/2017 6:12	36.0	70.0	8/26/2017 3:54	994.2
Port Lavaca, TX	8773259	8/26/2017 8:06	27.2	52.9	8/26/2017 7:36	34.2	66.5	8/26/2017 9:42	993.3
Matagorda City, TX	8773146	8/26/2017 3:00	18.8	36.5	8/26/2017 9:42	24.8	48.2	8/28/2017 17:18	997.3
Seadrift, TX	8773037	8/26/2017 6:30	27.5	53.5	8/26/2017 6:18	38.1	74.1	8/26/2017 6:06	985.5
Sargent, TX	8772985	8/26/2017 7:42	22.0	42.8	8/26/2017 9:06	28.3	55.0	8/28/2017 20:24	998.3
Freeport, TX	8772447	8/26/2017 9:30	22.4	43.5	8/25/2017 16:42	27.0	52.5	8/28/2017 21:06	999.3
San Luis Pass, TX	8771972	8/26/2017 1:30	19.7	38.3	8/26/2017 5:12	30.3	58.9	8/29/2017 10:18	1002.9
Galveston Railroad Bridge, TX	8771486	8/29/2017 2:54	19.7	38.3	8/29/2017 2:54	26.5	51.5	8/29/2017 11:06	1000.3
Galveston Pier 21, TX	8771450	n/a	n/a	n/a	n/a	n/a	n/a	8/29/2017 18:54	998.6
Galveston Bay Entrance, North Jetty, TX	8771341	8/26/2017 13:48	23.7	46.1	8/26/2017 13:48	27.6	53.6	8/29/2017 19:00	998.3

Table 3b: Maximum recorded wind speed ordered geographically from Southern Texas to Central Louisiana, wind gust and minimum barometric pressure in geographic order for Hurricane Harvey.

Station Name	Station ID	Maximum Wind Speed			Maximum Wind Gusts			Minimum Atmospheric Pressure	
		Date & Time GMT	m/sec	knots	Date & Time GMT	m/sec	knots	Date & Time GMT	mbar
Eagle Point, TX	8771013	8/26/2017 3:54	18.6	36.2	8/26/2017 4:00	22.9	44.5	8/29/2017 11:06	1002.0
Rollover Pass, TX	8770971	8/28/2017 4:54	19.0	36.9	8/29/2017 3:12	22.6	43.9	8/29/2017 18:06	999.6
Texas Point, Sabine Pass, TX	8770822	8/29/2017 8:00	22.0	42.8	8/28/2017 10:06	27.0	52.5	8/30/2017 8:48	995.5
High Island, TX	8770808	8/29/2017 18:48	16.8	32.7	8/29/2017 18:48	21.0	40.8	8/29/2017 18:42	999.8
Manchester, TX	8770777	8/26/2017 7:06	12.3	23.9	8/27/2017 5:42	16.0	31.1	8/28/2017 9:00	1001.6
Lynchburg Landing, TX	8770733	8/27/2017 19:18	13.3	25.9	8/26/2017 13:42	18.8	36.5	8/28/2017 10:42	1003.2
Morgans Point, TX	8770613	8/26/2017 0:48	14.9	29.0	8/26/2017 4:12	20.6	40.0	8/29/2017 10:54	1002.3
Sabine Pass North, TX	8770570	8/26/2017 18:12	16.9	32.9	8/29/2017 7:48	24.0	46.7	8/30/2017 8:48	998.2
Rainbow Bridge, TX	8770520	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Port Arthur, TX	8770475	8/30/2017 1:24	13.6	26.4	8/29/2017 9:12	18.6	36.2	8/30/2017 9:36	996.1
Calcasieu Pass, LA	8768094	8/28/2017 5:54	17.7	34.4	8/30/2017 12:36	22.8	44.3	8/30/2017 7:48	992.0
Bulk Terminal, LA	8767961	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lake Charles, LA	8767816	n/a	n/a	n/a	n/a	n/a	n/a	8/30/2017 9:42	994.3
Freshwater Canal Locks, LA	8766072	8/30/2017 9:12	15.7	30.5	8/30/2017 7:42	20.4	39.7	8/30/2017 9:30	999.6
Eugene Island, North of, Gulf of Mexico, LA	8764314	8/30/2017 12:30	17.8	34.6	8/30/2017 9:18	21.4	41.6	8/30/2017 9:48	1002.5
LAWMA, Amerada Pass, LA	8764227	8/29/2017 8:12	9.2	17.9	8/29/2017 8:36	12.8	24.9	8/30/2017 9:42	1003.2
Berwick, Atchafalaya River, LA	8764044	8/30/2017 12:06	12.8	24.9	8/30/2017 12:06	16.7	32.5	8/30/2017 9:48	1003.5
Port Fourchon, Belle Pass, LA	8762075	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Grand Isle, LA	8761724	8/30/2017 15:42	11.9	23.1	8/30/2017 12:48	17.3	33.6	8/30/2017 8:48	1006.7

Table 4: Maximum recorded current velocity at select NOS PORTS® stations during Hurricane Harvey.

Station Name	Station ID	Sensor Orientation	Maximum Observed Velocity (m/s)	Maximum Predicted Velocity (m/s)	Maximum Observed Velocity (knots)	Maximum Predicted Velocity (knots)
Matagorda Ship Channel Marker 19, TX	mg0101	side	1.79	1.20	3.47	2.33
Galveston Bay Entrance Channel LB 11, TX	g06010	down	2.26	1.01	4.40	1.96
Fred Hartman Bridge, Houston Ship Ch., TX	g08010	side	3.93	0.53	7.65	1.03
Rainbow Bridge, TX	sn0501	side	2.68	0.61	5.21	1.18
Cameron Fishing Pier, LA	lc0201	side	2.20	1.70	4.27	3.30

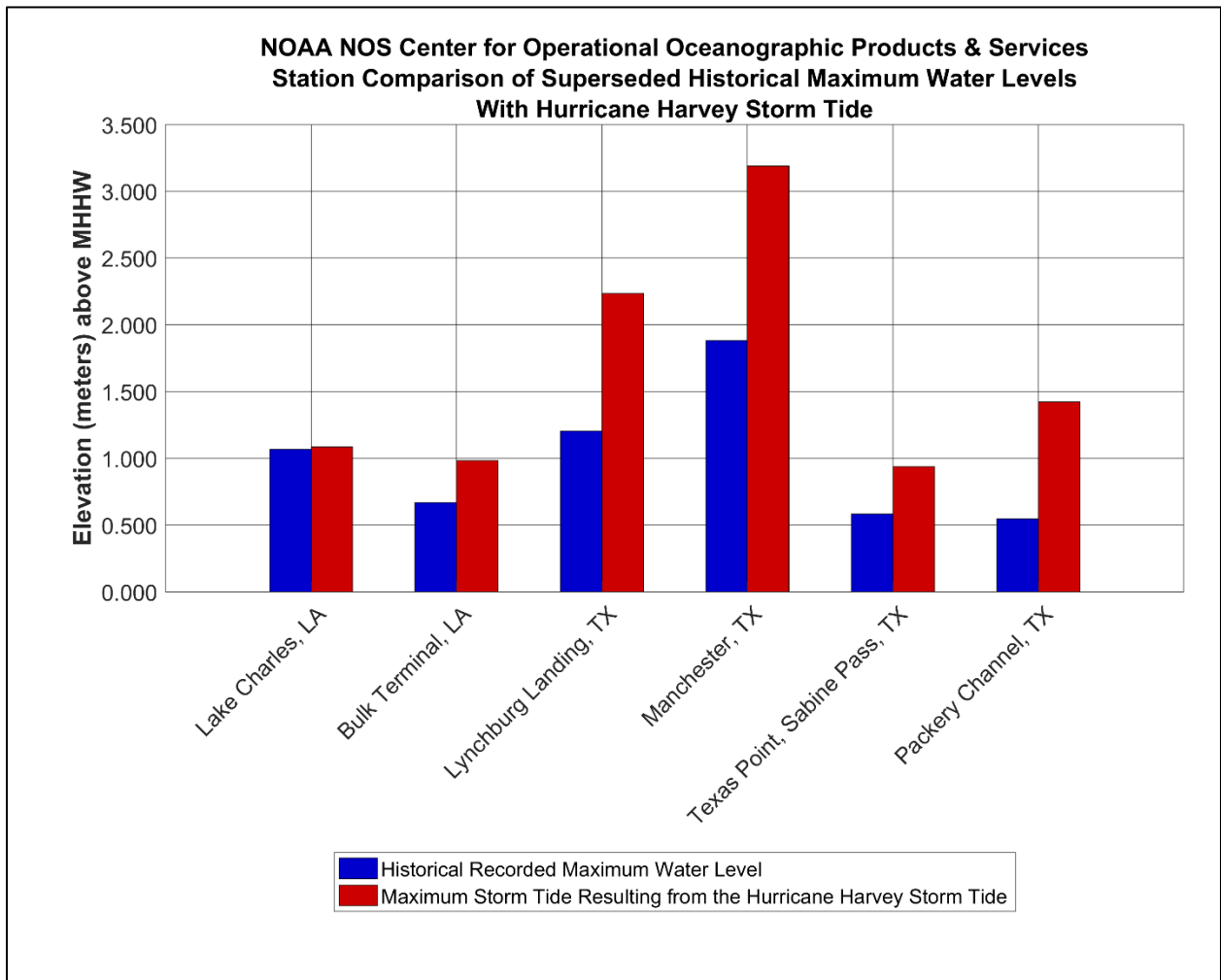


Figure 5. Stations that exceeded historical recorded maximum water levels during Hurricane Harvey.

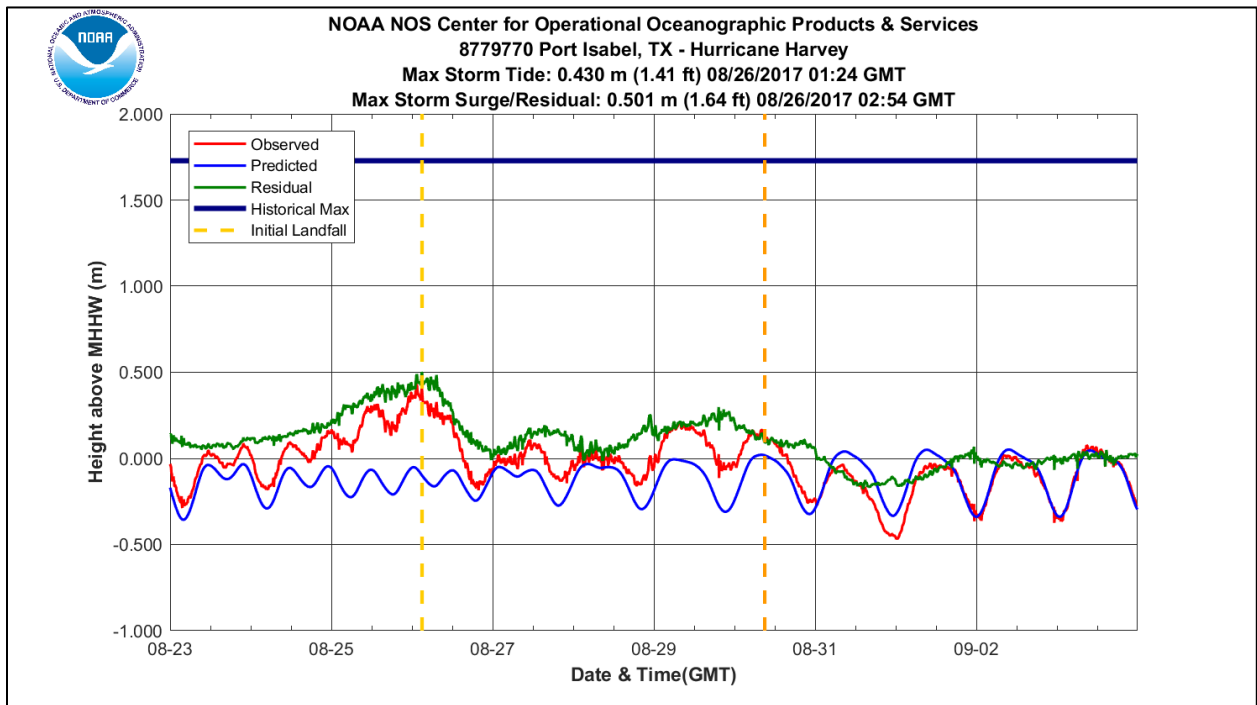


Figure 6: Water Levels above Mean Higher High Water (MHHW) at Port Isabel, TX. A line denoting the Historical Maximum Water Level is displayed.

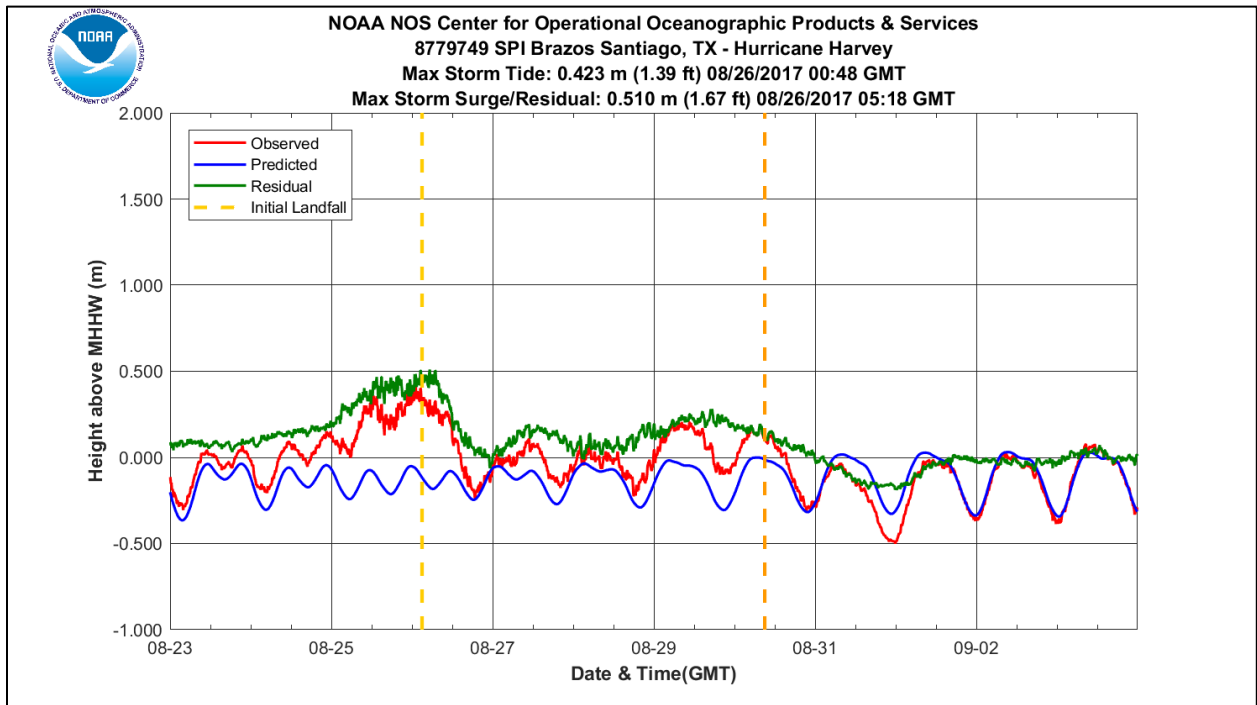


Figure 7: Water Levels above Mean Higher High Water (MHHW) at South Padre Island (SPI), Brazos Santiago Pass, TX. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

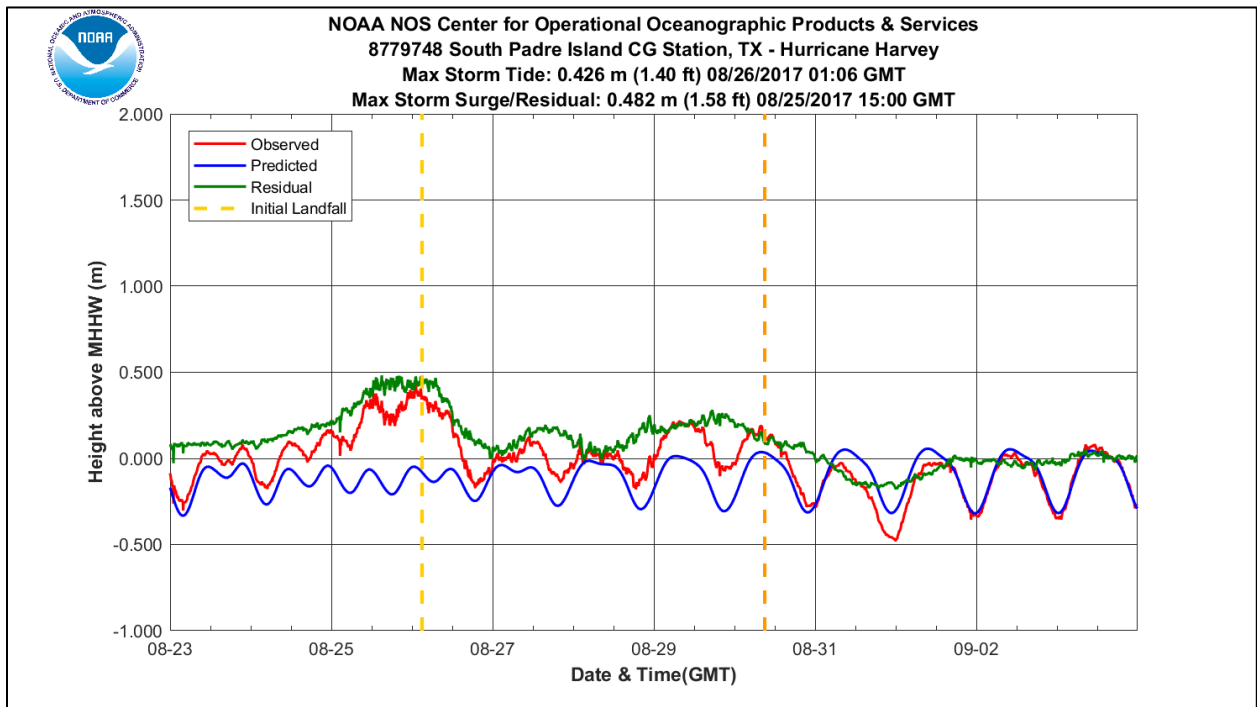


Figure 8: Water Levels above Mean Higher High Water (MHHW) at South Padre Island Coast Guard Station, TX. A Historical Maximum Water Level value does not exist at this station.

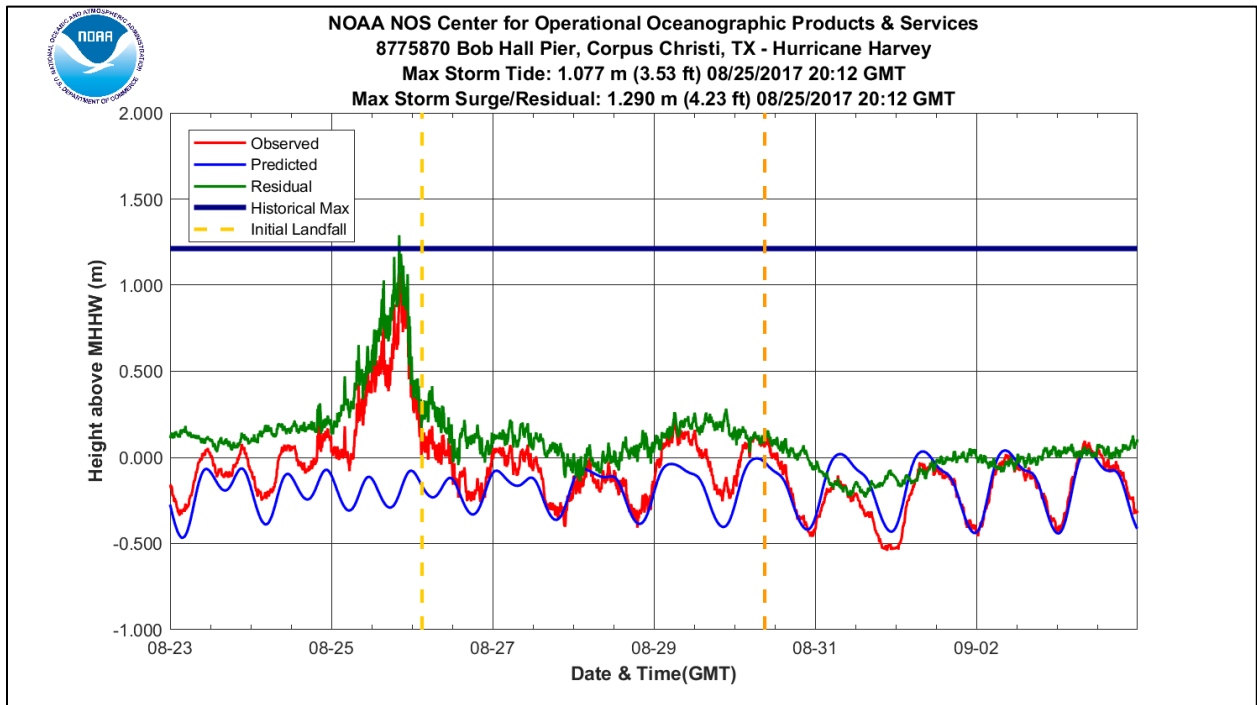


Figure 9: Water Levels above Mean Higher High Water (MHHW) at Bob Hall Pier, Corpus Christi, TX. A line denoting the Historical Maximum Water Level is displayed.

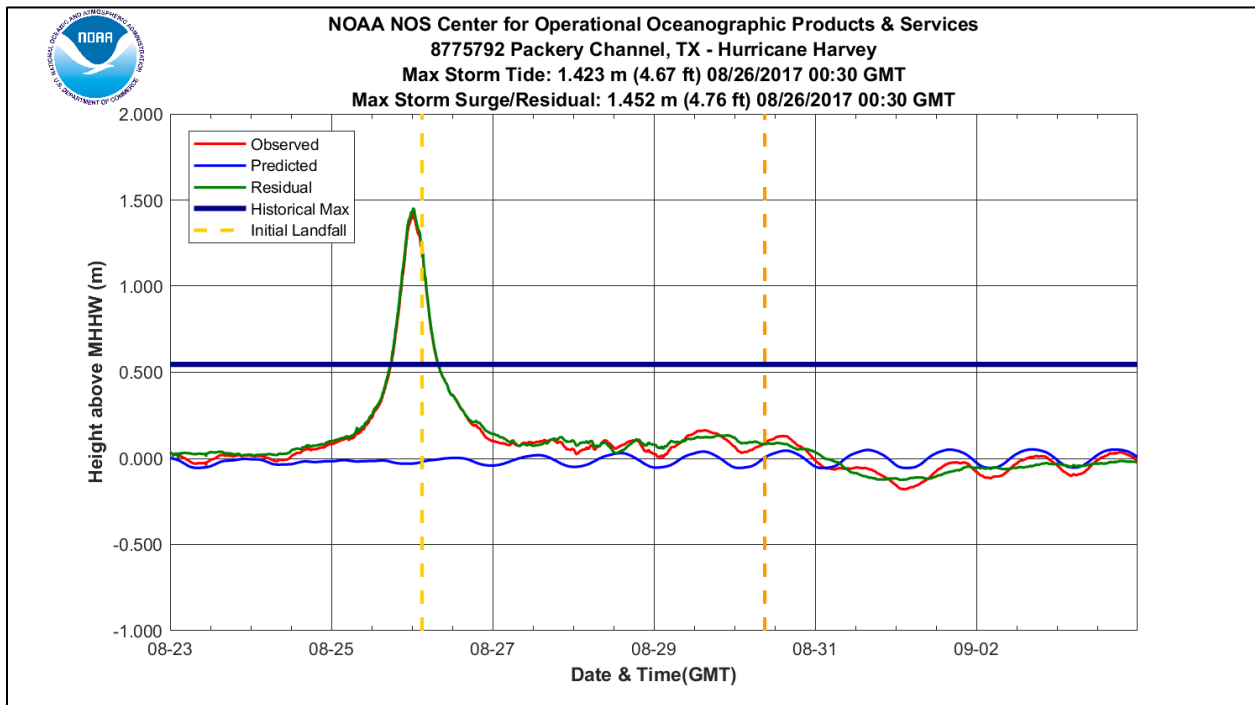


Figure 10: Water Levels above Mean Higher High Water (MHHW) at Packery Channel, TX. A line denoting the Historical Maximum Water Level is displayed. Maximum recorded water level value exceeded the historical maximum value.

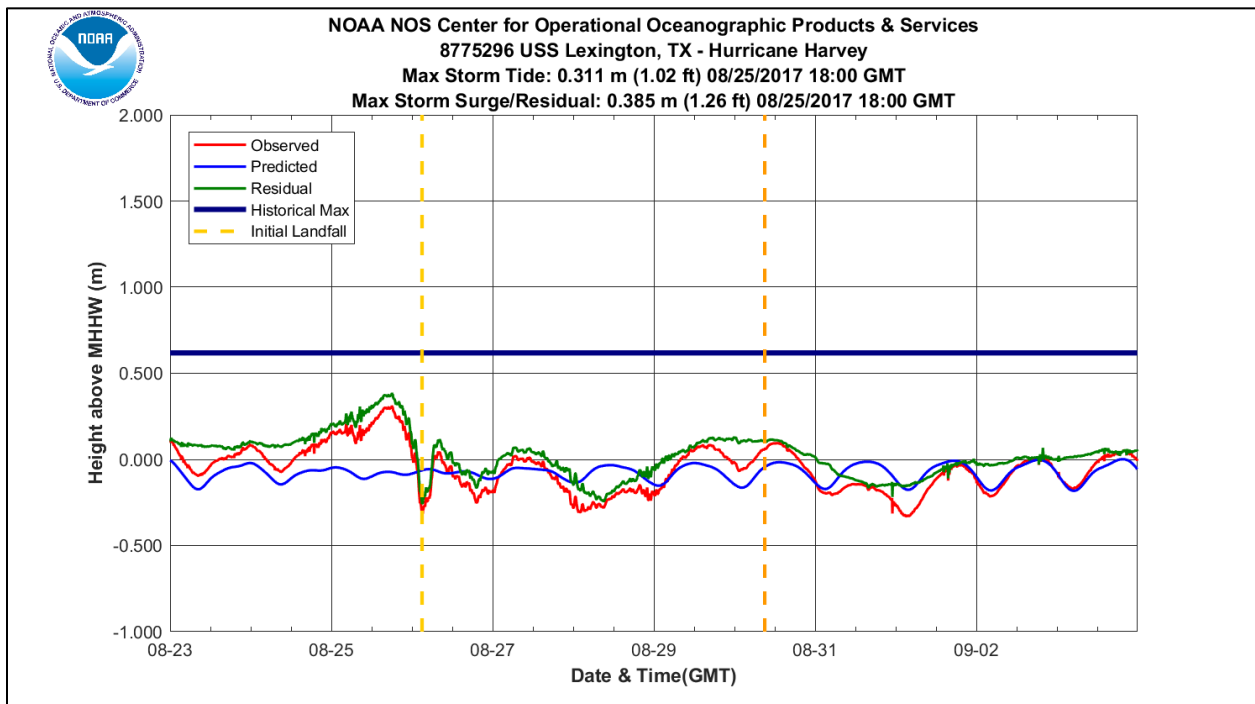


Figure 11: Water Levels above Mean Higher High Water (MHHW) at USS Lexington, TX. A line denoting the Historical Maximum Water Level is displayed.

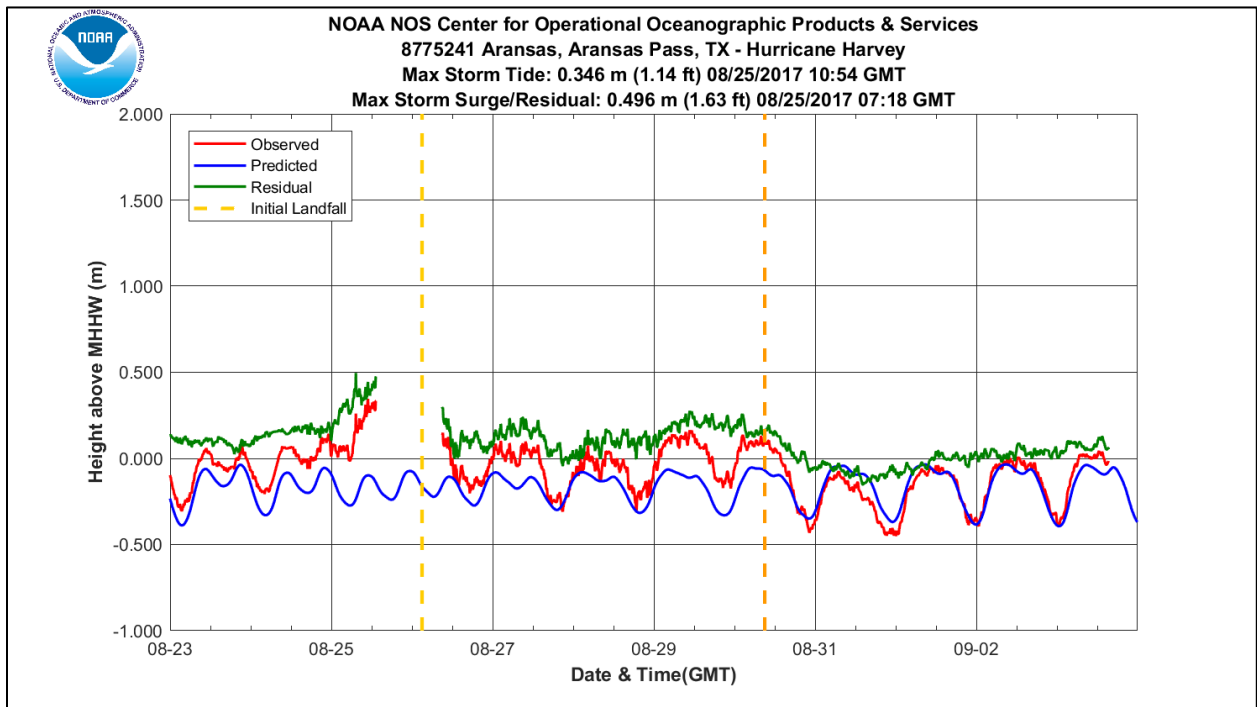


Figure 12: Water Levels above Mean Higher High Water (MHHW) at Aransas, Aransas Pass, TX. The sensors at this station malfunctioned during the Hurricane and likely did not record a maximum water level. A Historical Maximum Water Level value does not exist at this station.

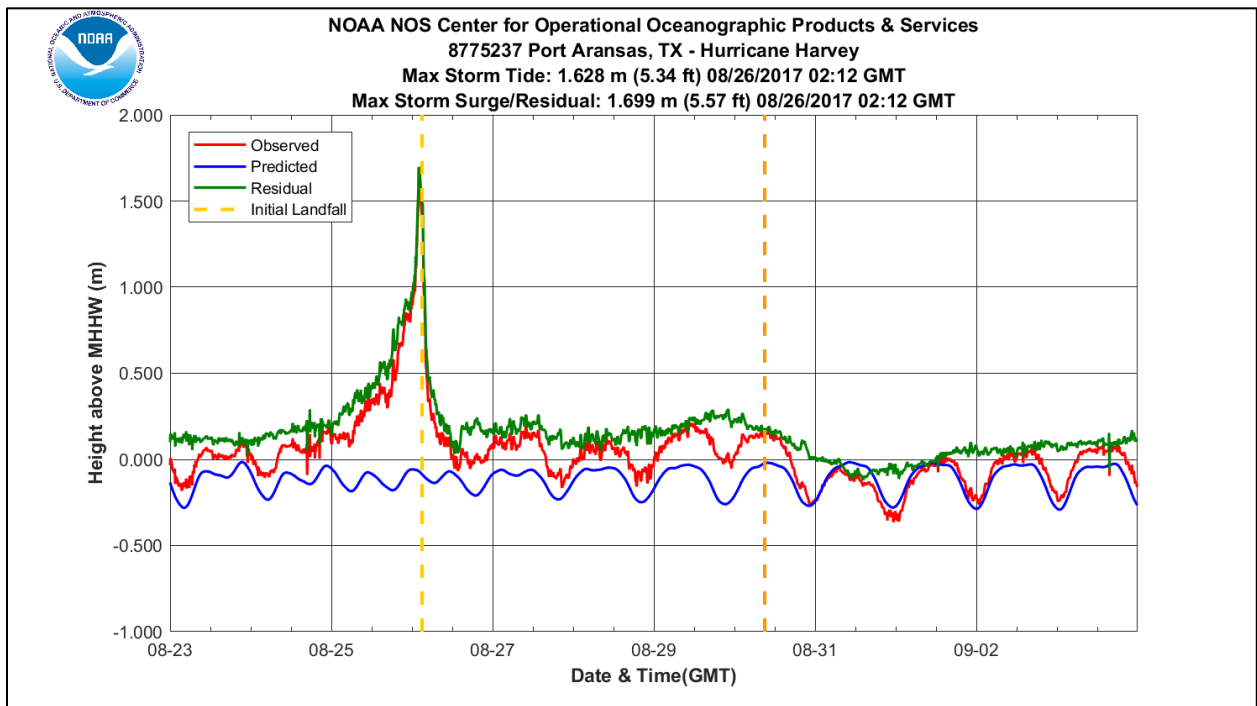


Figure 13: Water Levels above Mean Higher High Water (MHHW) at Port Aransas, TX. A Historical Maximum Water Level value does not exist at this station.

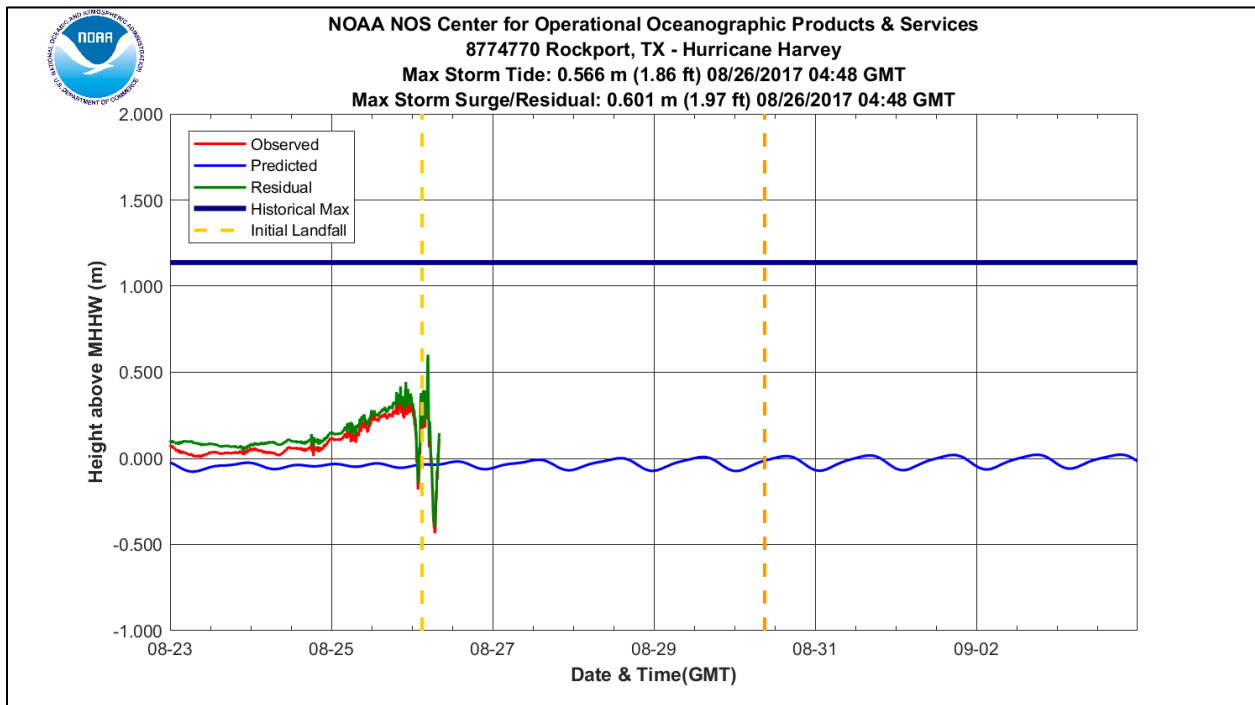


Figure 14: Water Levels above Mean Higher High Water (MHHW) at Rockport, TX. A line denoting the Historical Maximum Water Level is displayed. The station was destroyed during the storm and likely did not record a maximum water level.

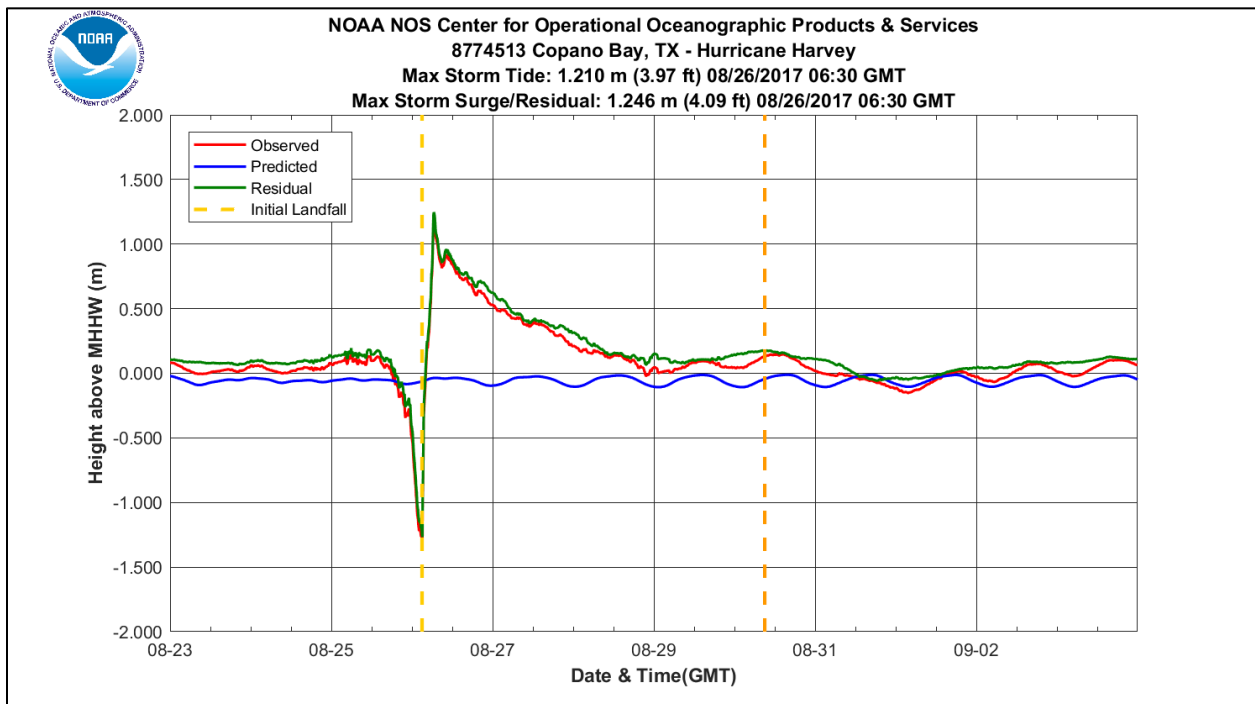


Figure 15: Water Levels above Mean Higher High Water (MHHW) at Copano Bay, TX. A Historical Maximum Water Level value does not exist at this station.

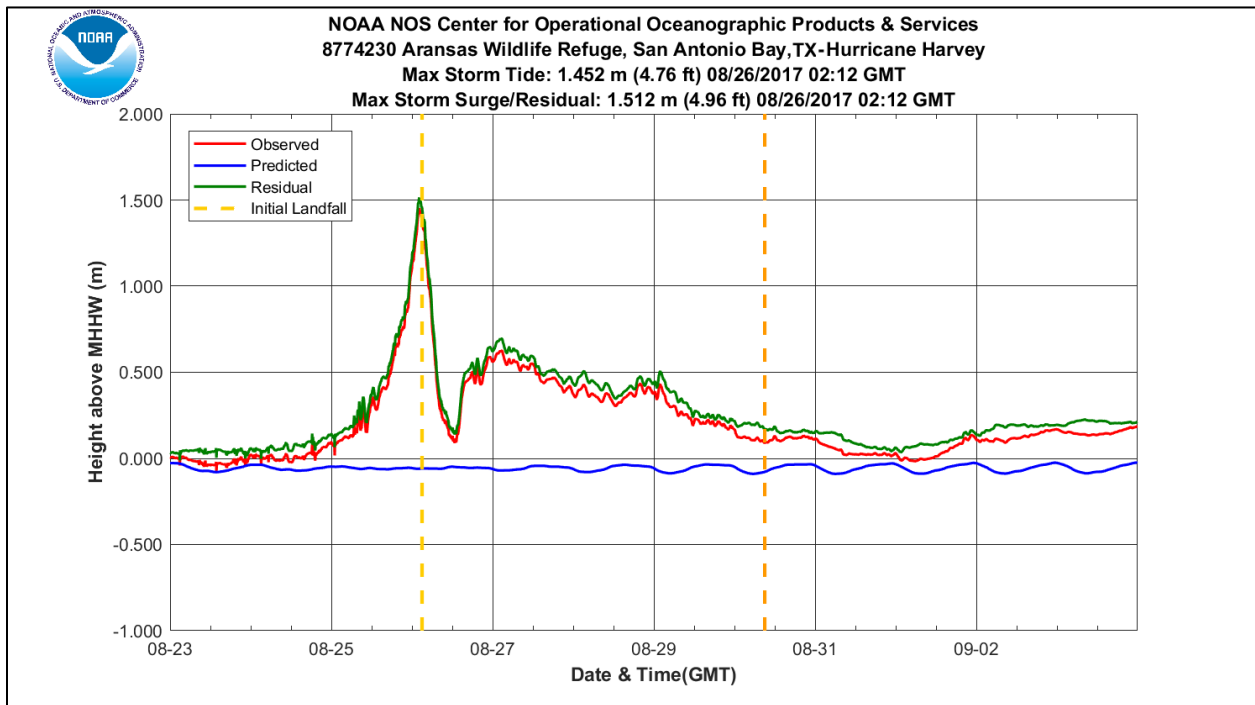


Figure 16: Water Levels above Mean Higher High Water (MHHW) at Aransas Wildlife Refuge, San Antonio Bay, TX. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

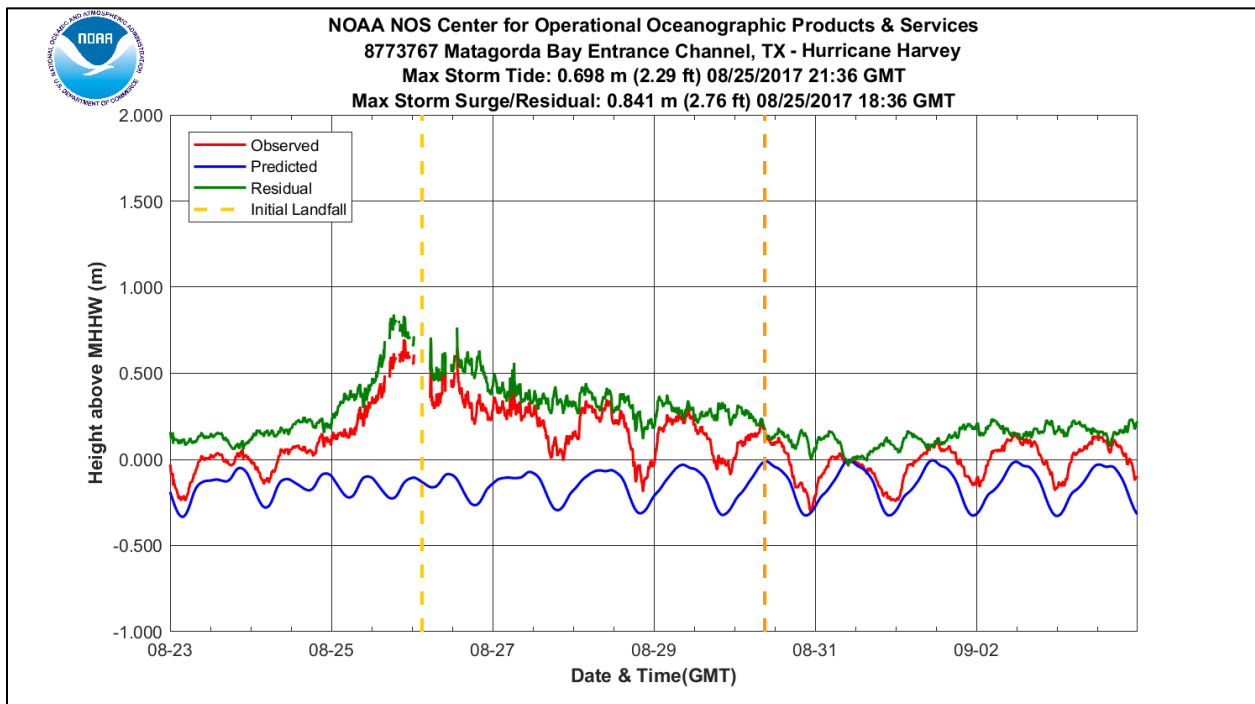


Figure 17: Water Levels above Mean Higher High Water (MHHW) at Matagorda Bay Entrance Channel, TX. The sensors at this station malfunctioned during the Hurricane and likely did not record a maximum water level. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

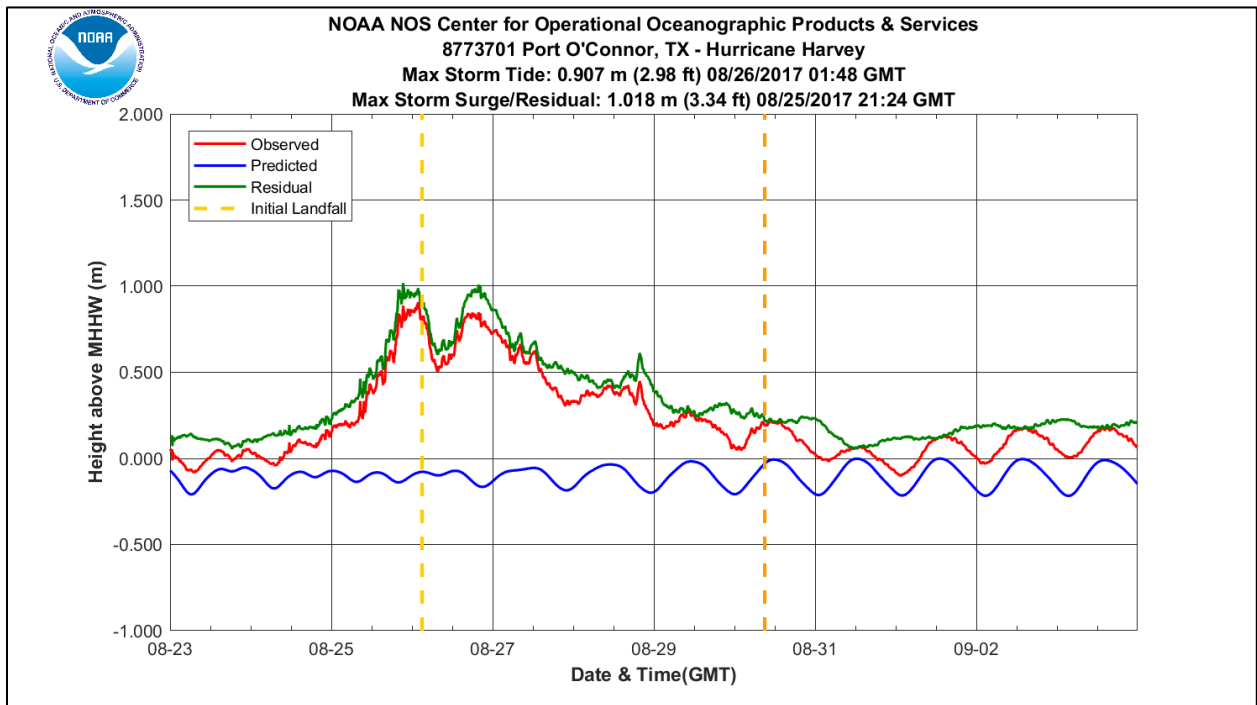


Figure 18: Water Levels above Mean Higher High Water (MHHW) Port O'Connor, TX. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

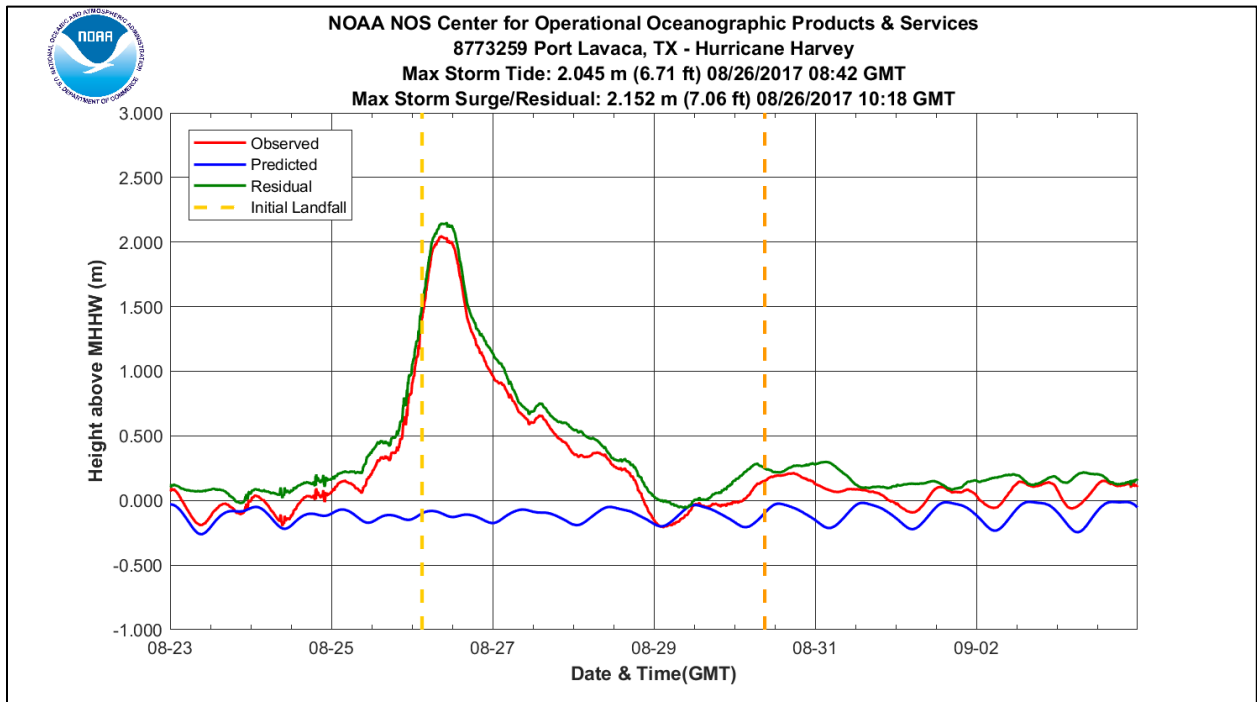


Figure 19: Water Levels above Mean Higher High Water (MHHW) at Port Lavaca, TX. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

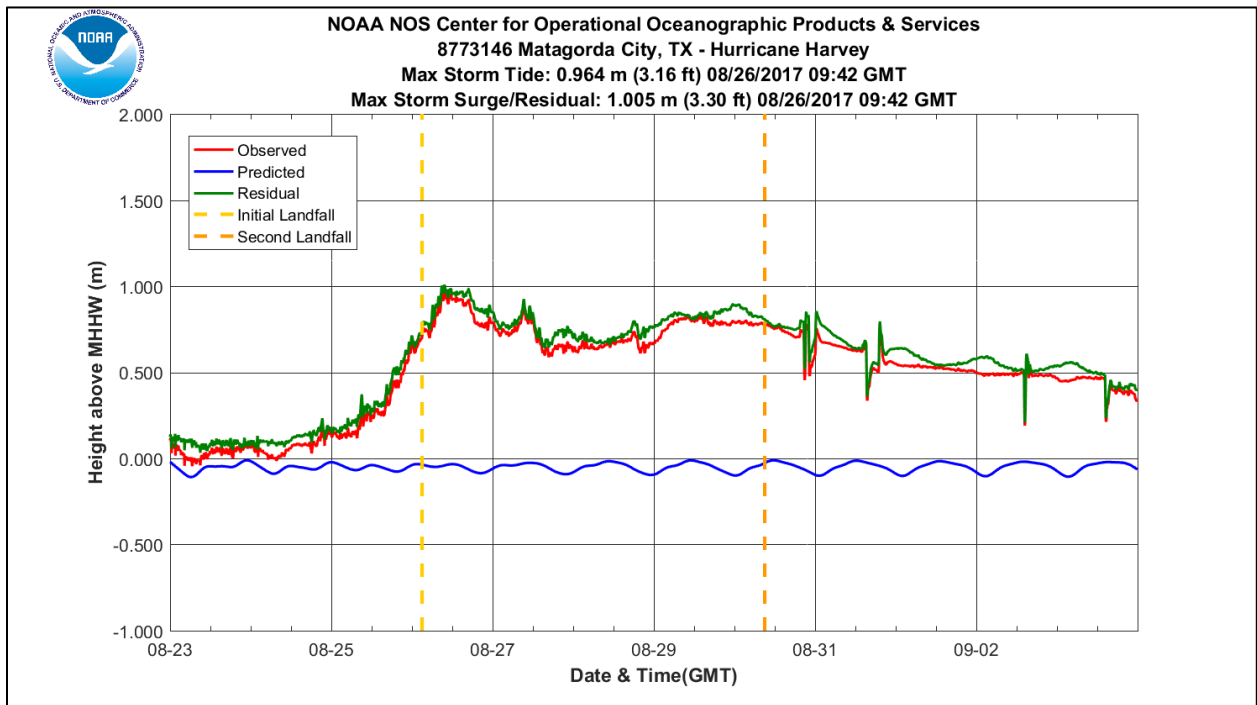


Figure 20: Water Levels above Mean Higher High Water (MHHW) at Matagorda City, TX. A Historical Maximum Water Level value does not exist at this station.

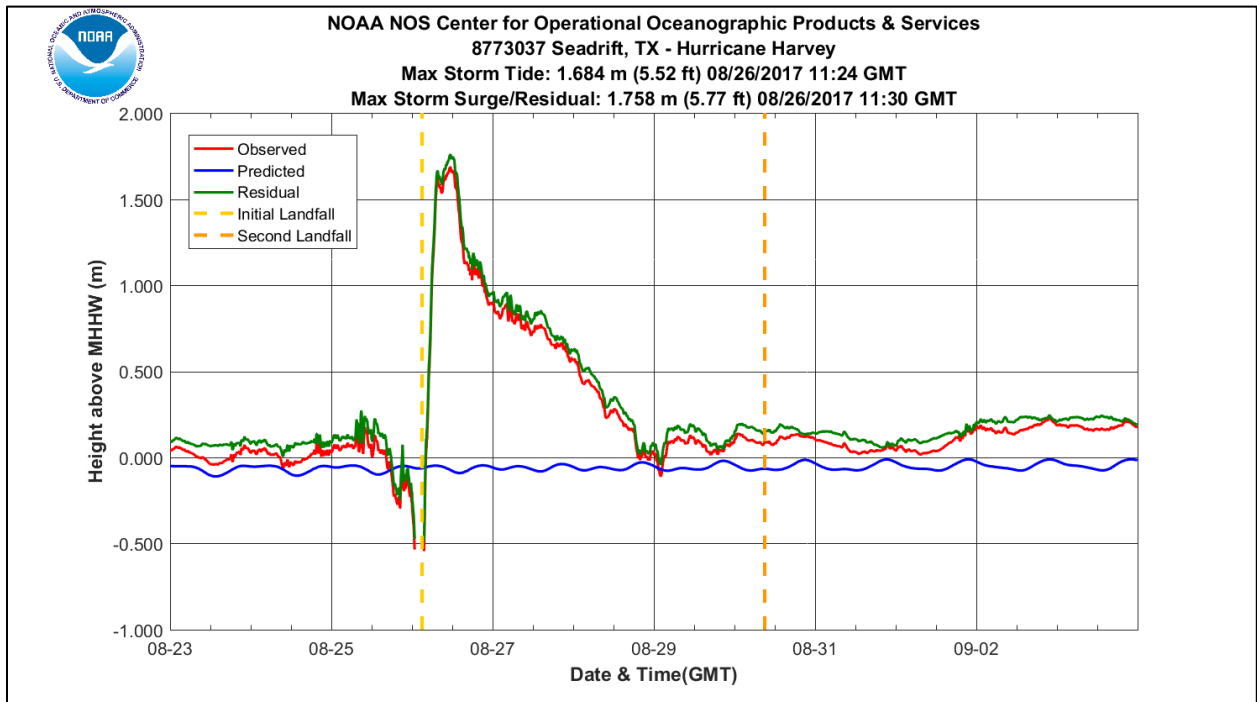


Figure 21: Water Levels above Mean Higher High Water (MHHW) at Seadrift, TX. The data gap signifies that area around the sensor dried out when water was drawn out of the immediate vicinity of the station. A Historical Maximum Water Level value does not exist at this station.

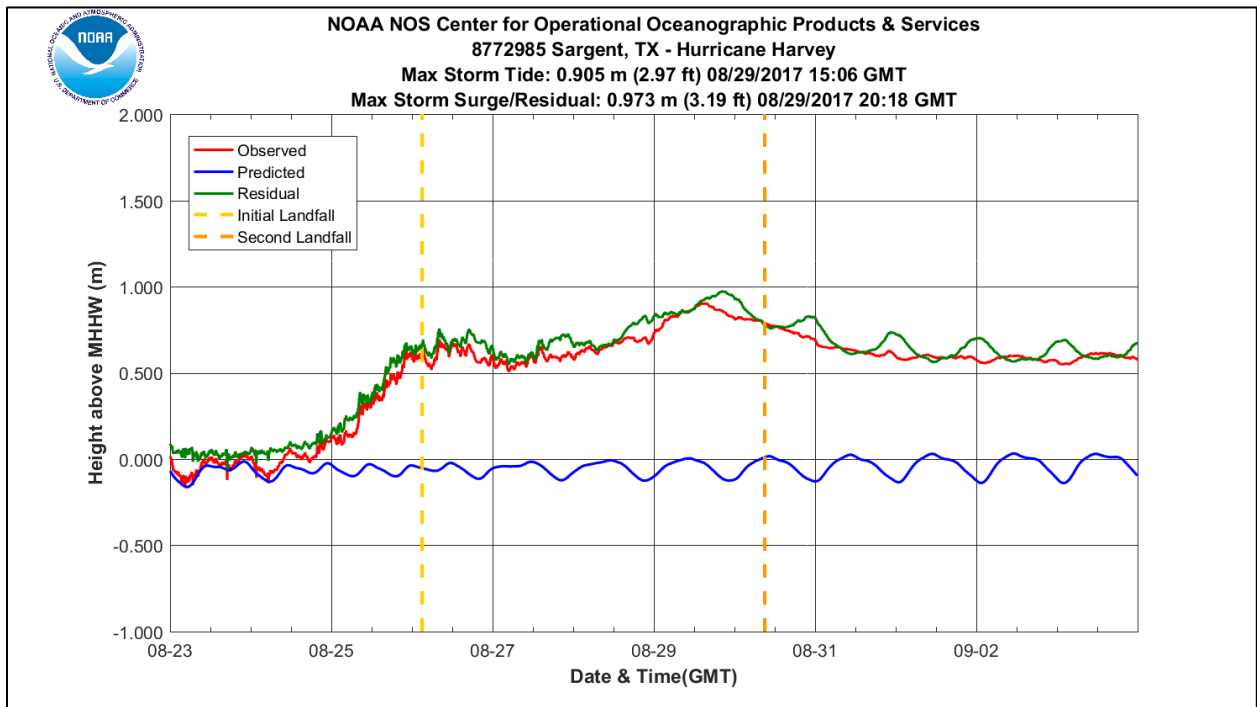


Figure 22: Water Levels above Mean Higher High Water (MHHW) Sargent, TX. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

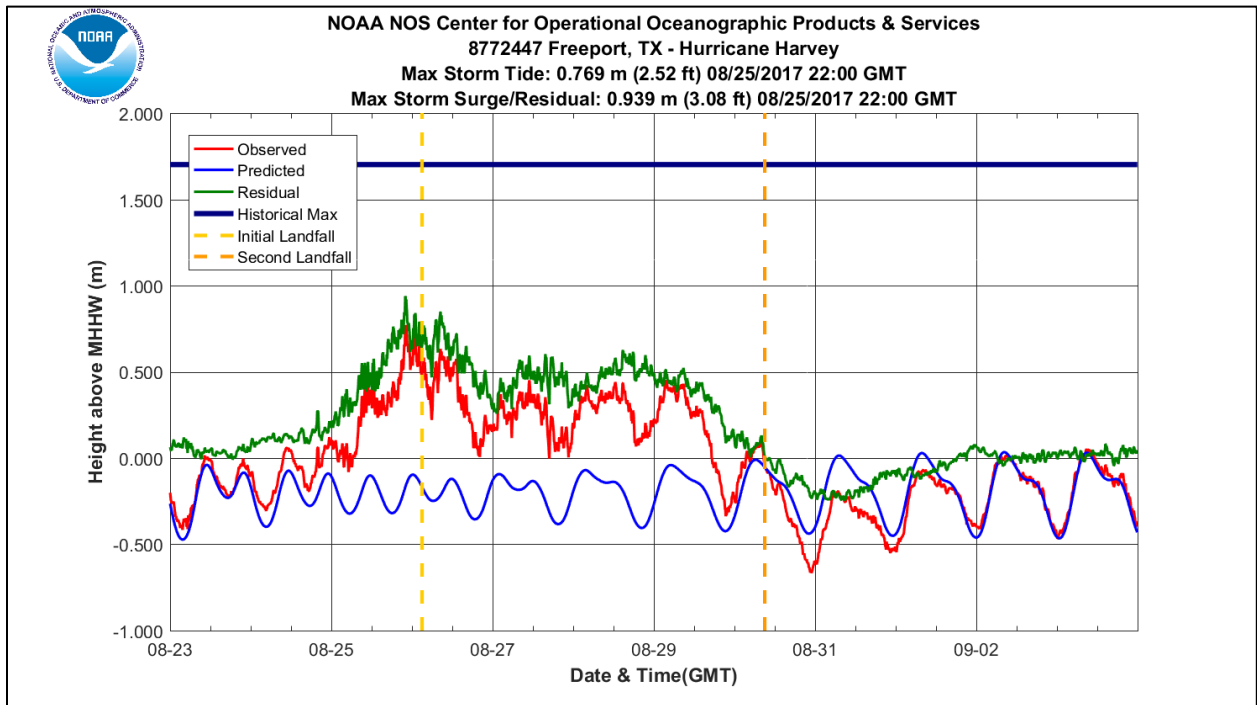


Figure 23: Water Levels above Mean Higher High Water (MHHW) at Freeport, TX. A line denoting the Historical Maximum Water Level is displayed.

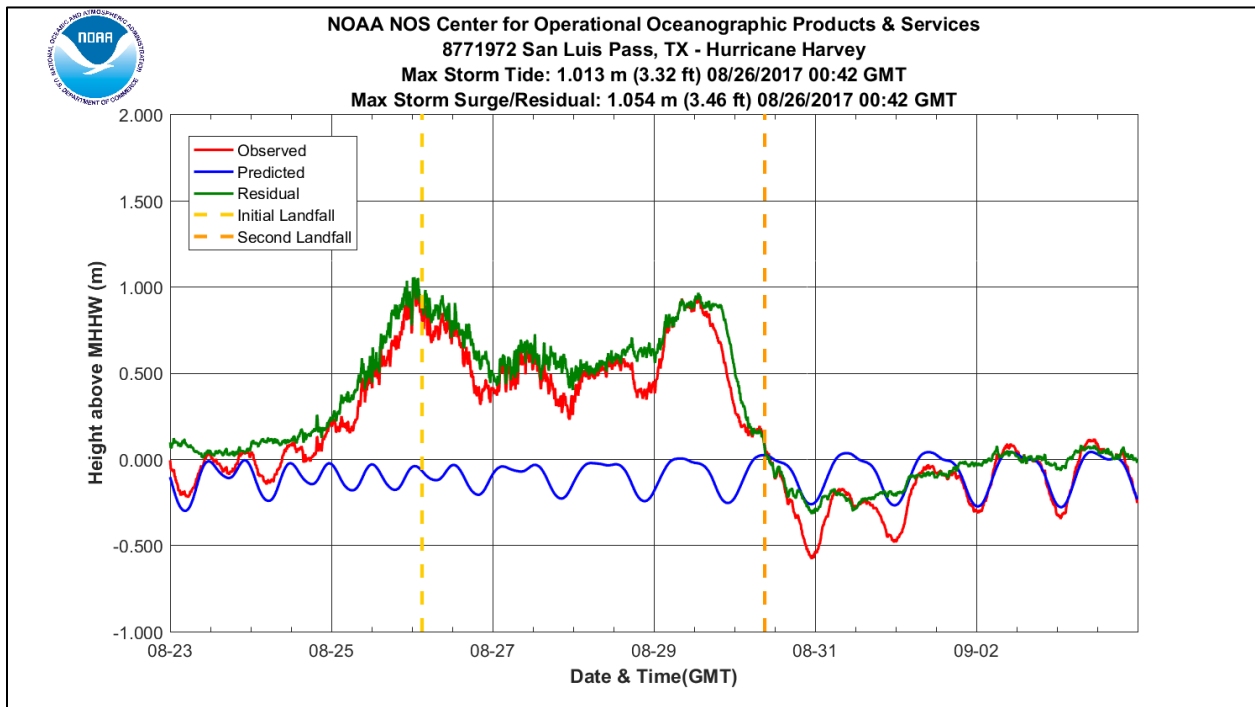


Figure 24: Water Levels above Mean Higher High Water (MHHW) at San Luis Pass, TX. A Historical Maximum Water Level value does not exist at this station.

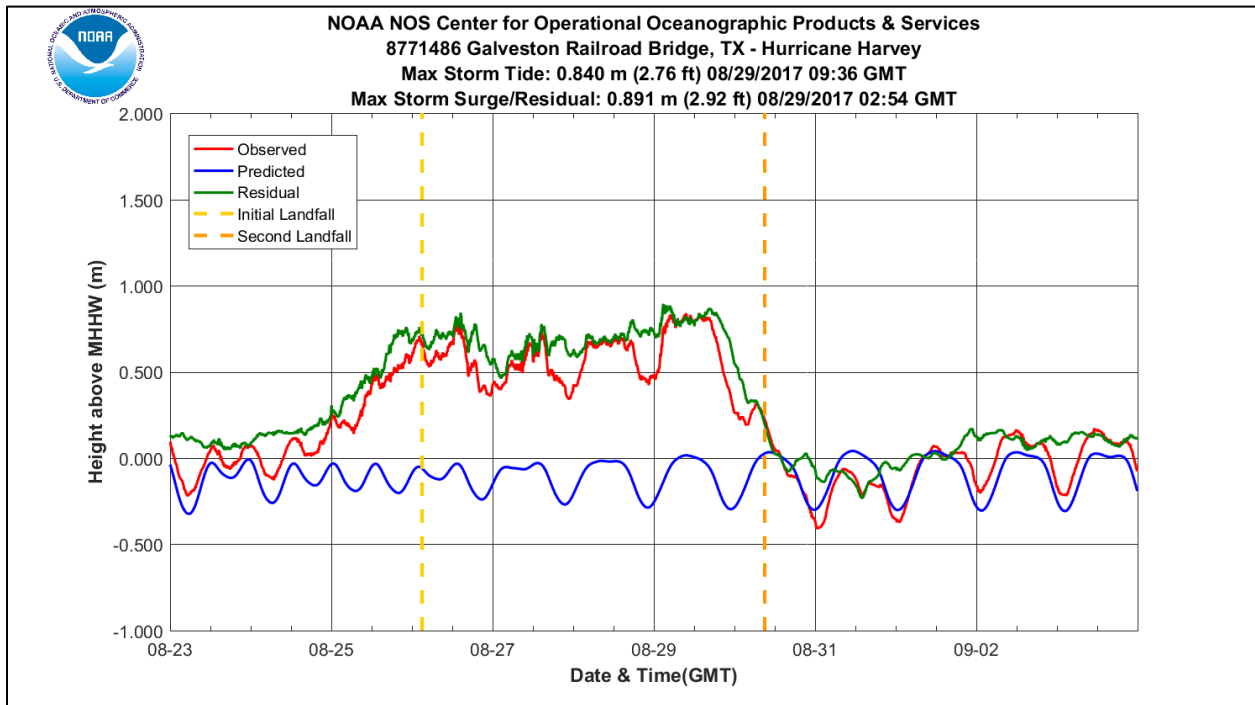


Figure 25: Water Levels above Mean Higher High Water (MHHW) at Galveston Railroad Bridge, TX. A Historical Maximum Water Level value does not exist at this station.

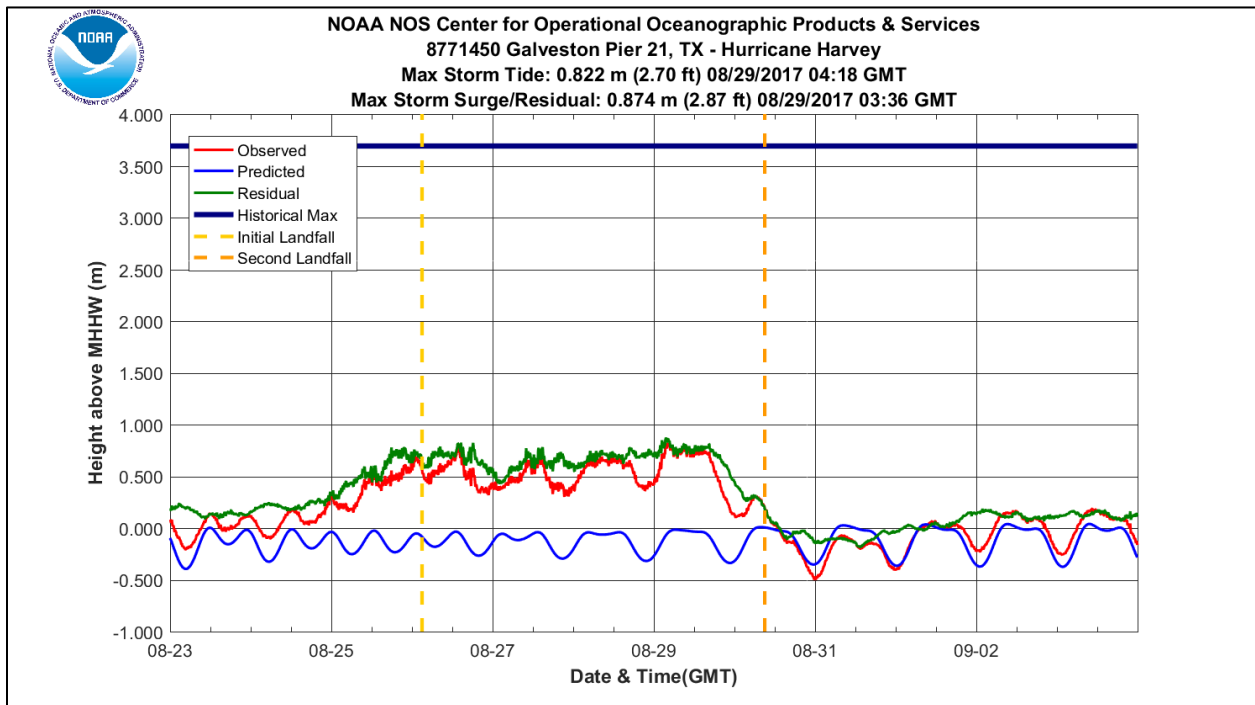


Figure 26: Water Levels above Mean Higher High Water (MHHW) at Galveston, Pier 21, TX. A line denoting the Historical Maximum Water Level is displayed.

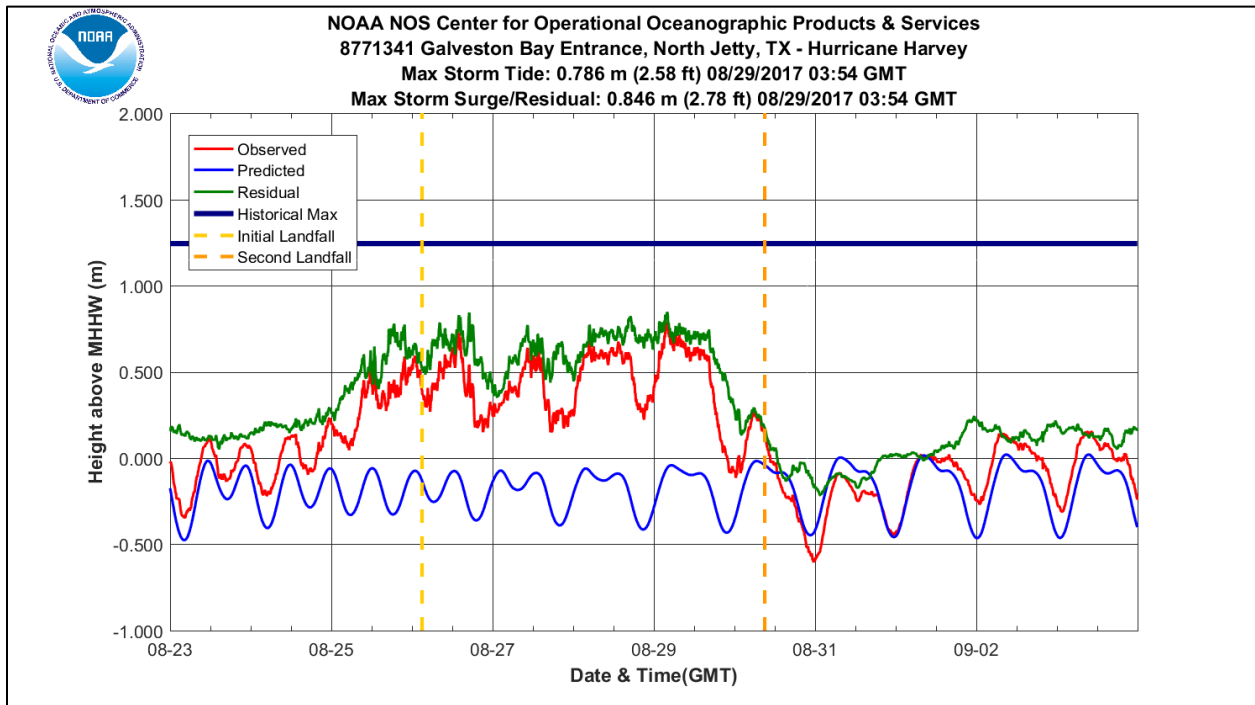


Figure 27: Water Levels above Mean Higher High Water (MHHW) at Galveston Bay Entrance, North Jetty, TX. A line denoting the Historical Maximum Water Level is displayed

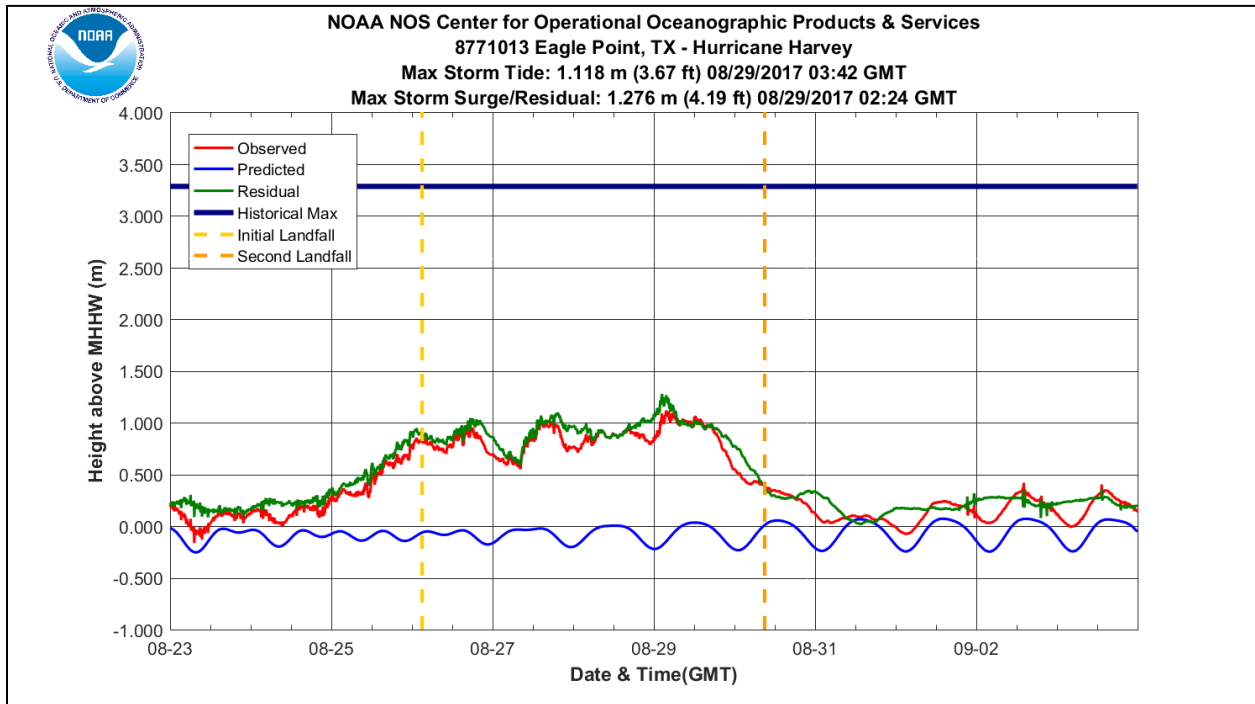


Figure 28: Water Levels above Mean Higher High Water (MHHW) at Eagle Point, TX. A line denoting the Historical Maximum Water Level is displayed.

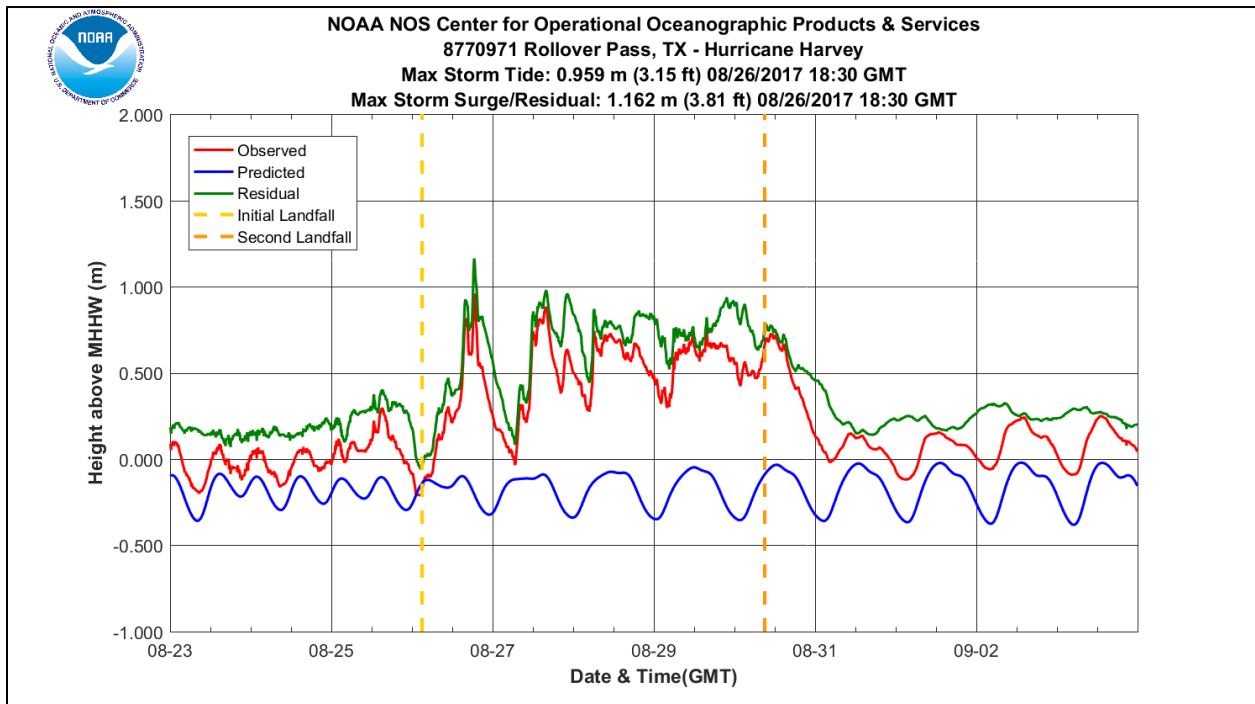


Figure 29: Water Levels above Mean Higher High Water (MHHW) at Rollover Pass, TX. A Historical Maximum Water Level value does not exist at this station.

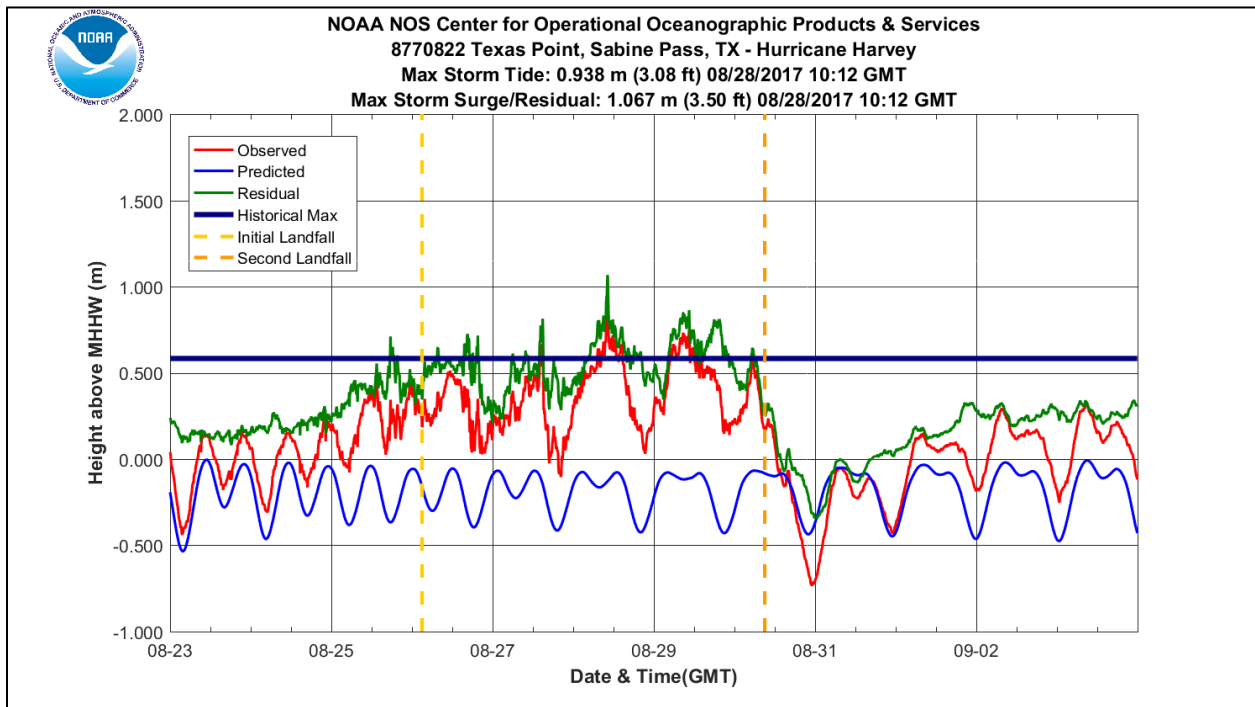


Figure 30: Water Levels above Mean Higher High Water (MHHW) at Texas Point, Sabine Pass, TX. A line denoting the Historical Maximum Water Level is displayed. Maximum recorded water level value exceeded the historical maximum value.

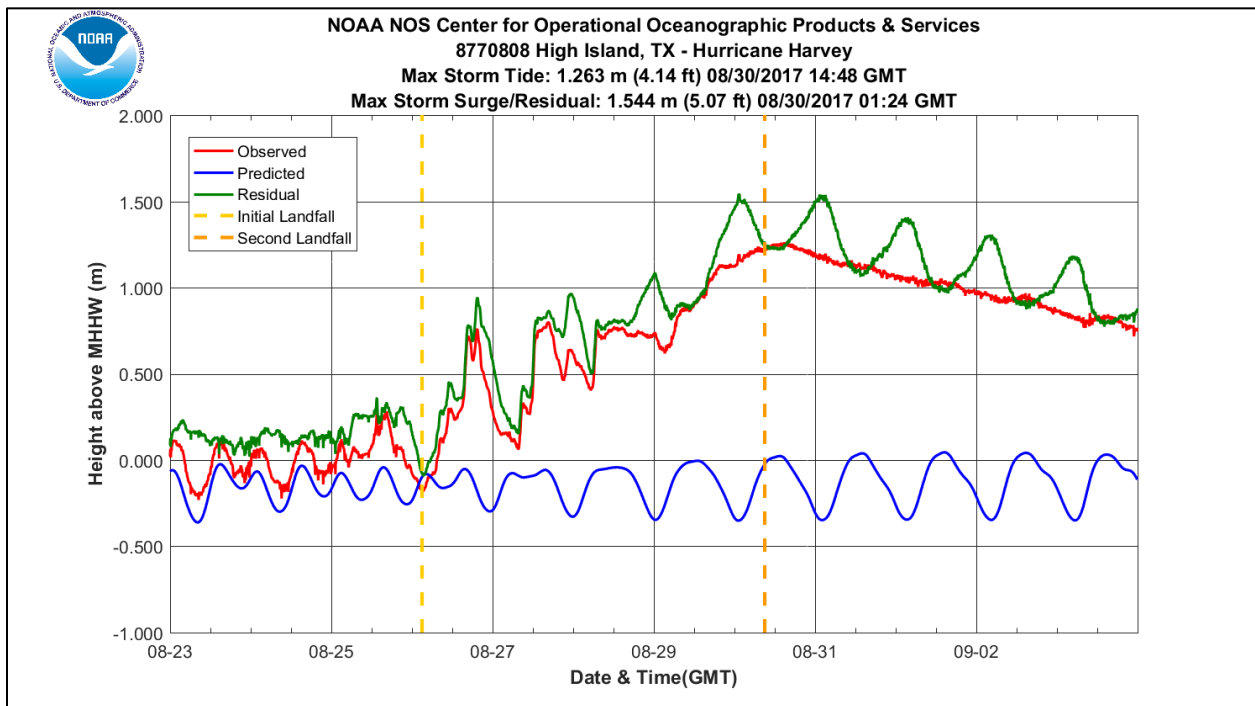


Figure 31: Water Levels above Mean Higher High Water (MHHW) at High Island, TX. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

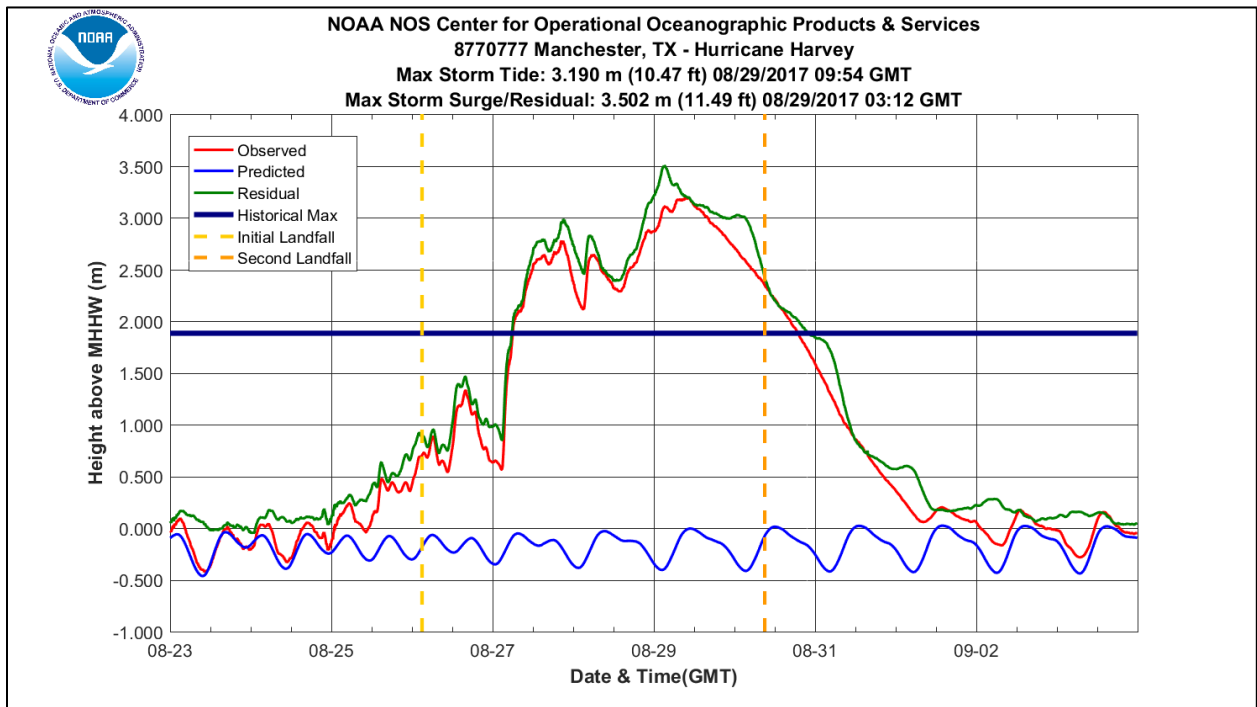


Figure 32: Water Levels above Mean Higher High Water (MHHW) at Manchester, Houston Ship Channel, TX. A line denoting the Historical Maximum Water Level is displayed. Maximum recorded water level value exceeded the historical maximum value. The maximum residual occurred within +/- 2 hours of low tide.

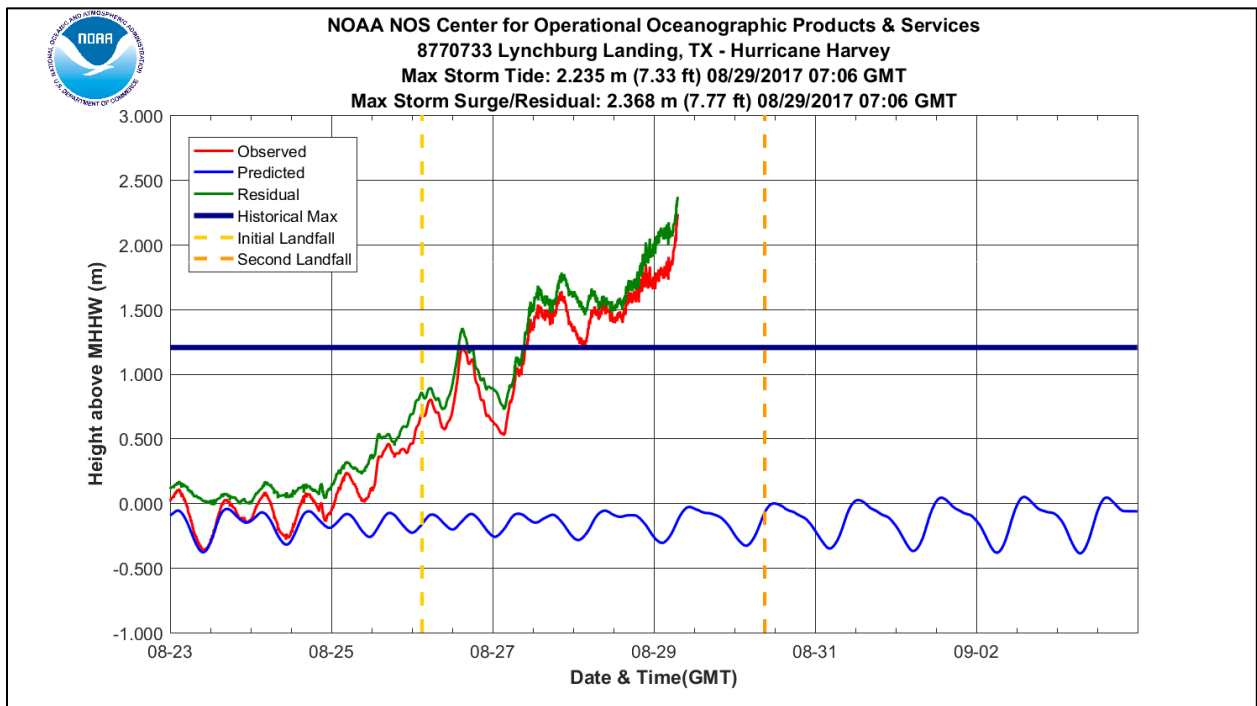


Figure 33: Water Levels above Mean Higher High Water (MHHW) at Lynchburg Landing, TX. A line denoting the Historical Maximum Water Level is displayed. The station was destroyed during the storm and likely did not record a maximum water level. Maximum recorded water level value exceeded the historical maximum value.

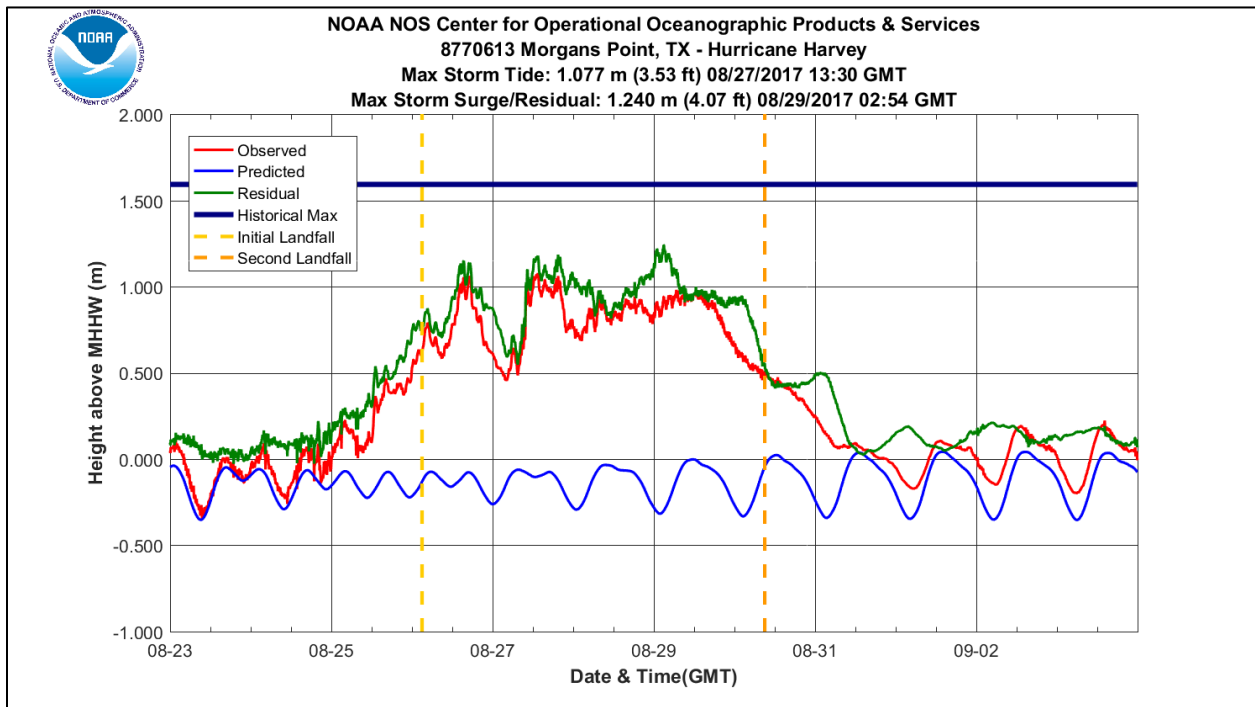


Figure 34: Water Levels above Mean Higher High Water (MHHW) at Morgans Point, TX. A line denoting the Historical Maximum Water Level is displayed. The maximum residual occurred within +/- 2 hours of low tide.

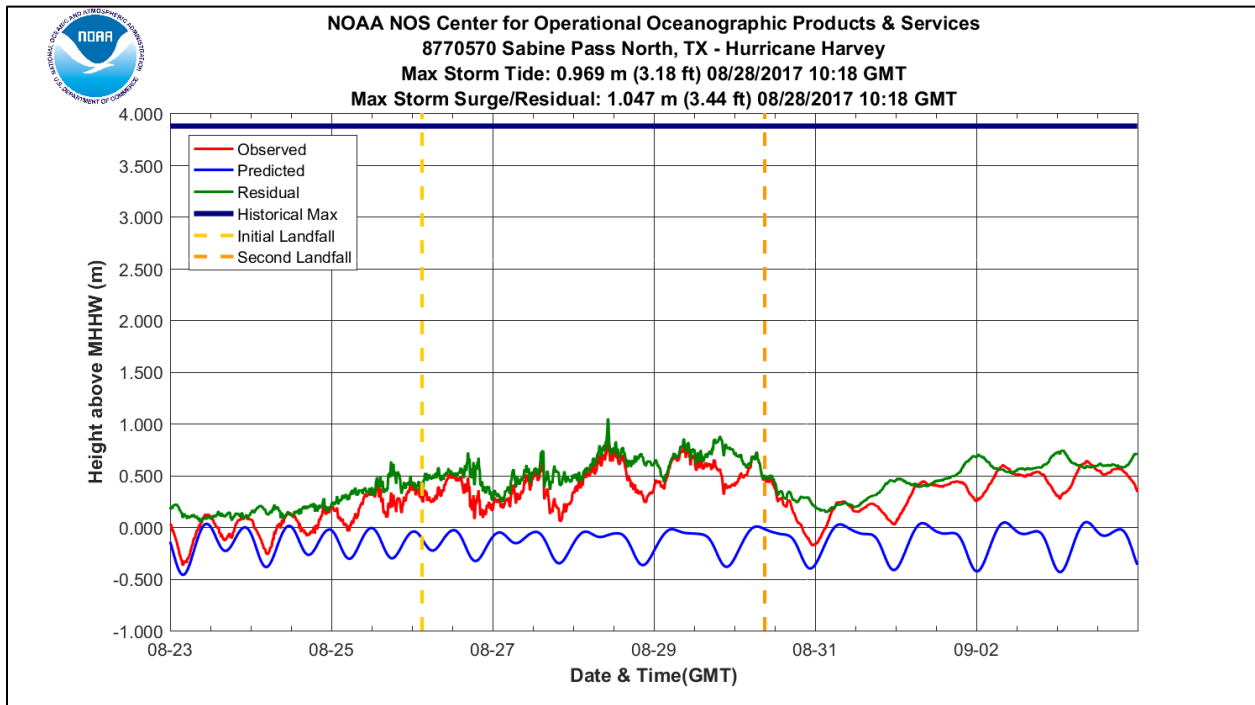


Figure 35: Water Levels above Mean Higher High Water (MHHW) at Sabine Pass North, TX. A line denoting the Historical Maximum Water Level is displayed.

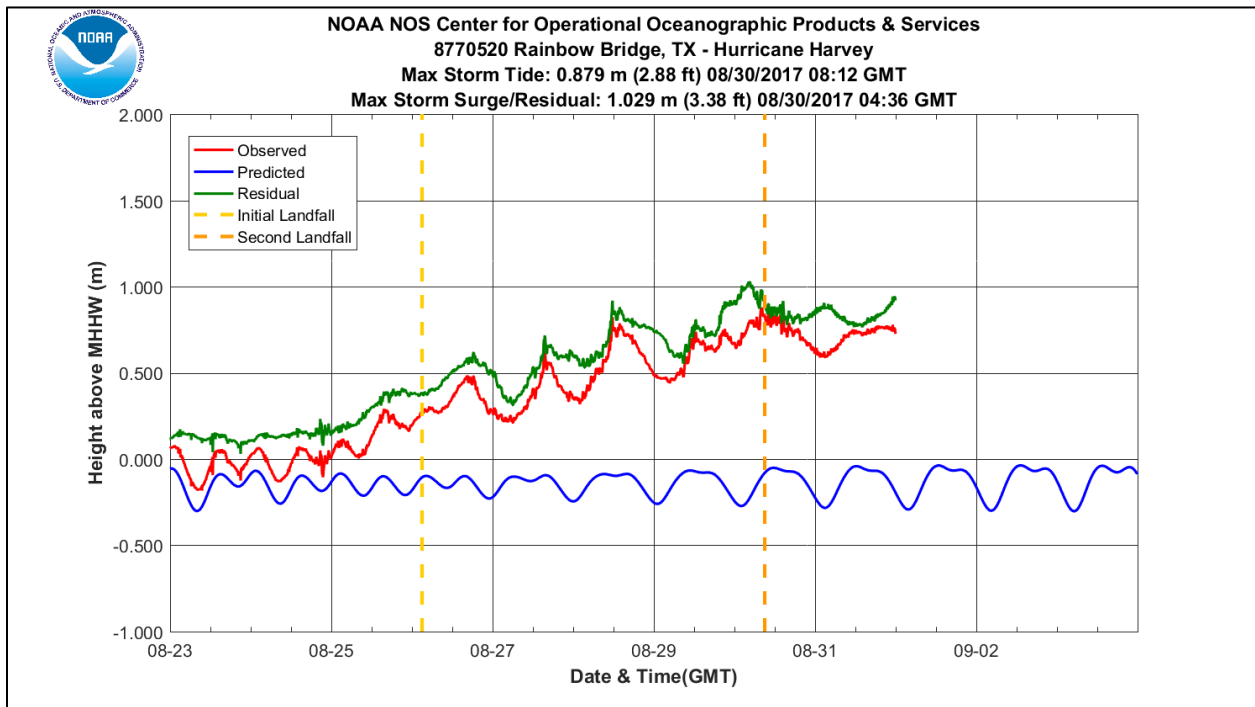


Figure 36: Water Levels above Mean Higher High Water (MHHW) at Rainbow Bridge, TX. The sensors at this station malfunctioned during the storm and likely did not record a maximum water level. A Historical Maximum Water Level value does not exist at this station.

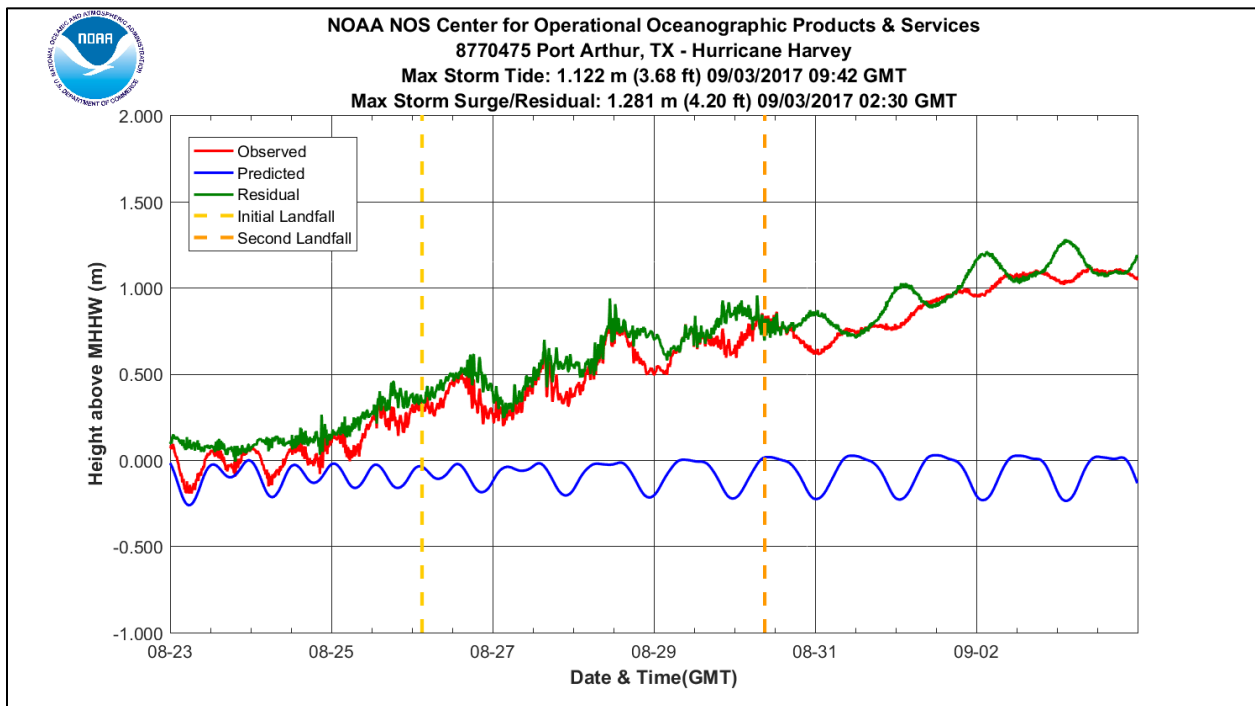


Figure 37: Water Levels above Mean Higher High Water (MHHW) at Port Arthur, TX. The maximum residual occurred within +/- 2 hours of low tide. A Historical Maximum Water Level value does not exist at this station.

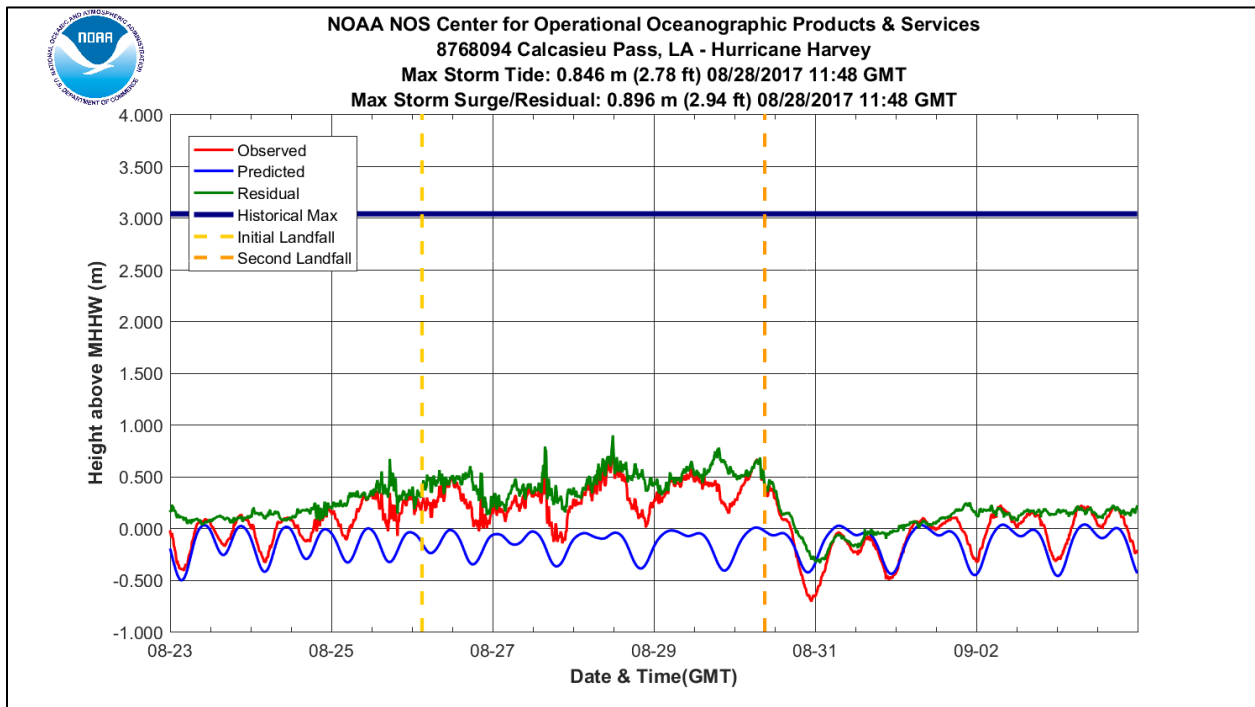


Figure 38: Water Levels above Mean Higher High Water (MHHW) at Calcasieu Pass, LA. A line denoting the Historical Maximum Water Level is displayed.

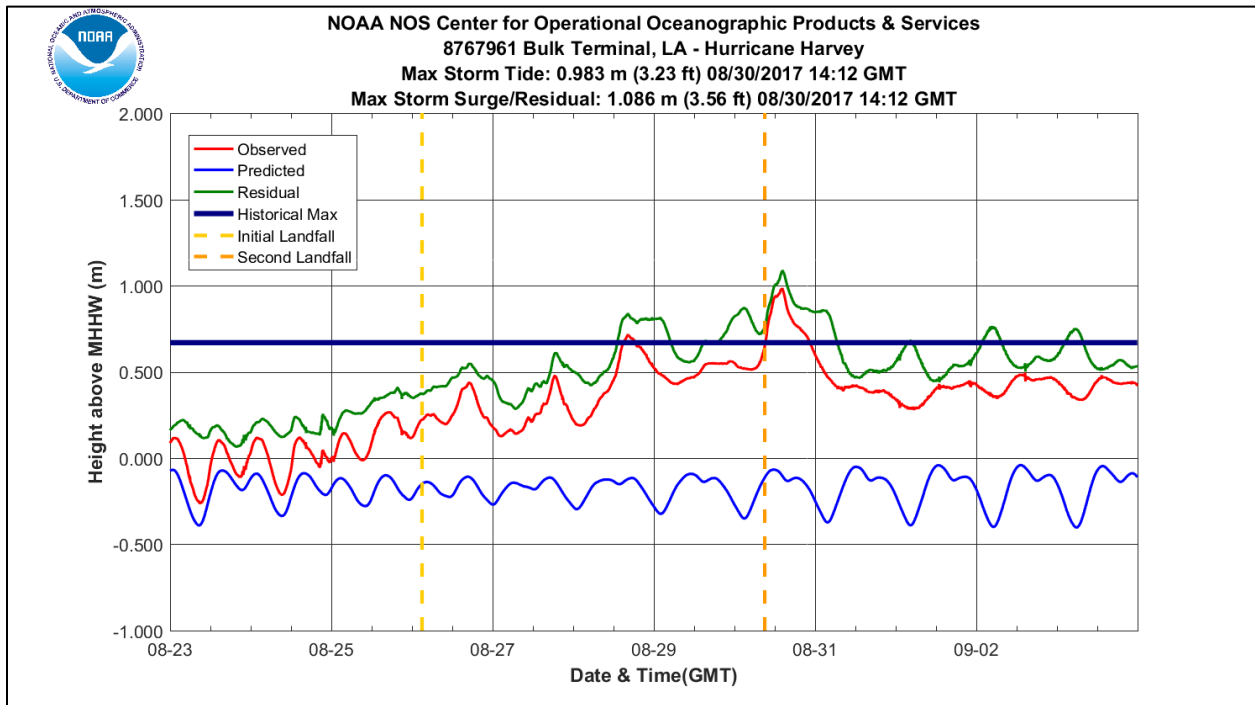


Figure 39: Water Levels above Mean Higher High Water (MHHW) at Bulk Terminal, LA. A line denoting the Historical Maximum Water Level is displayed. Maximum recorded water level value exceeded the historical maximum value.

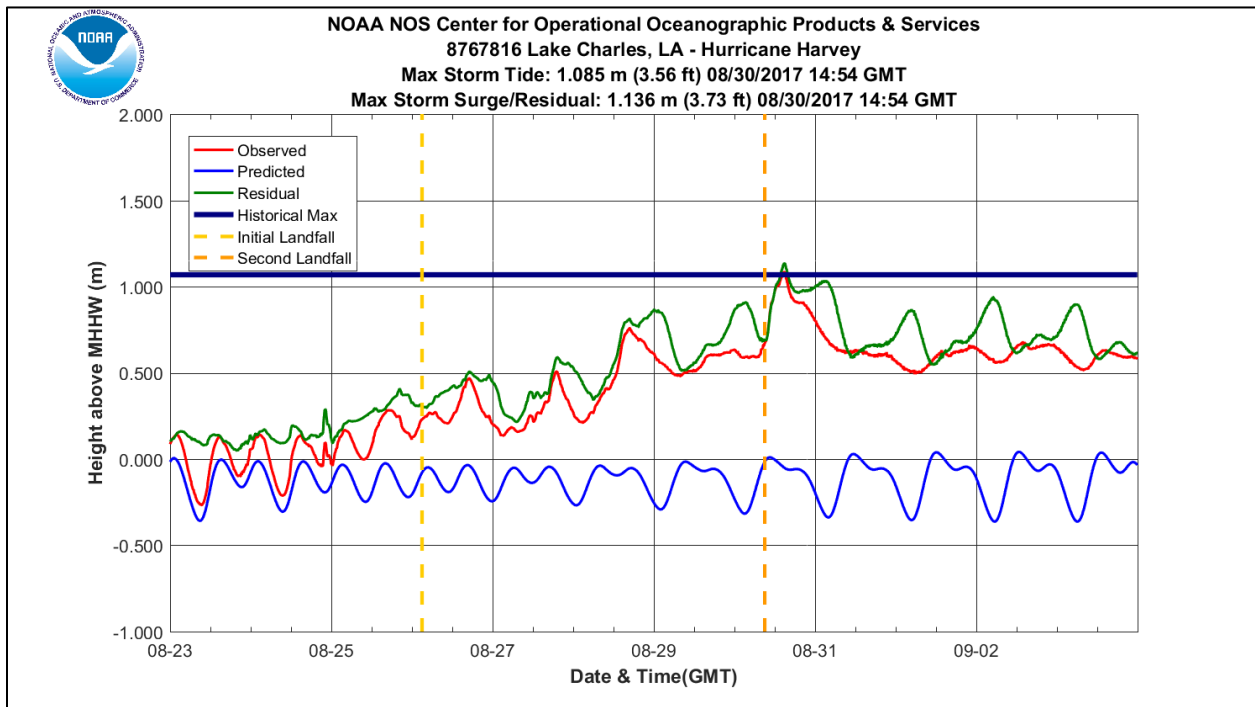


Figure 40: Water Levels above Mean Higher High Water (MHHW) at Lake Charles, LA. A line denoting the Historical Maximum Water Level is displayed. Maximum recorded water level value exceeded the historical maximum value.

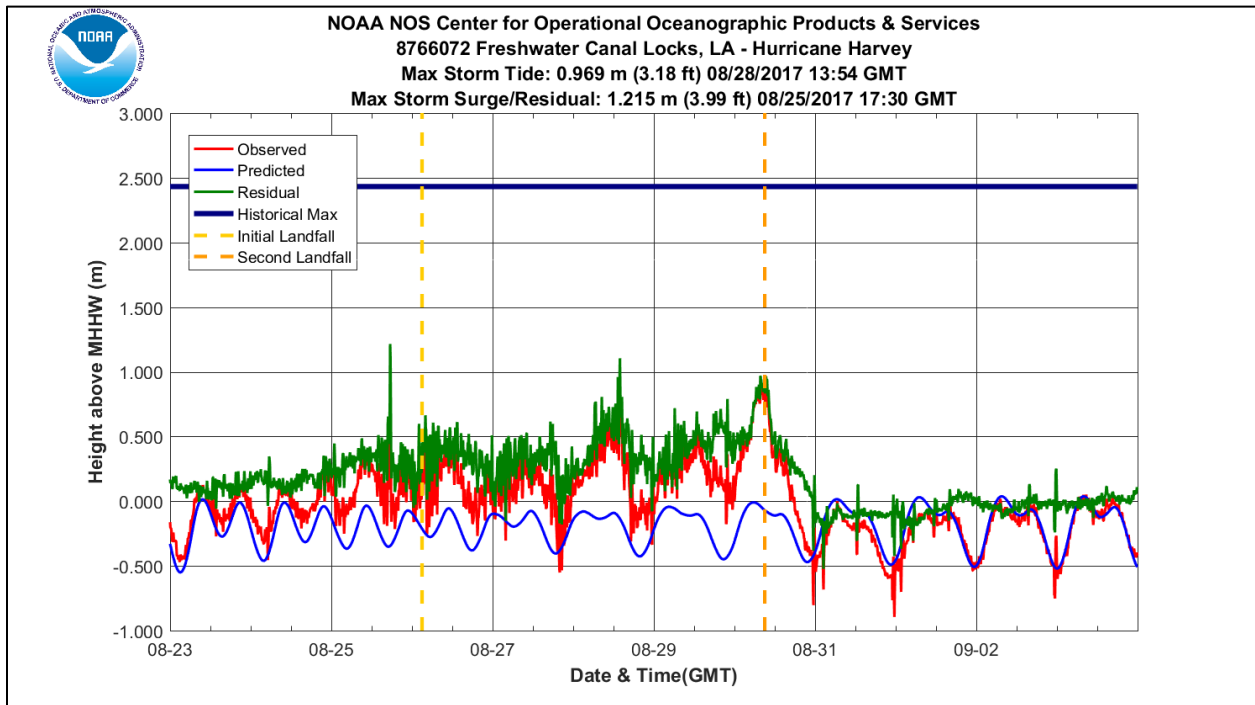


Figure 41: Water Levels above Mean Higher High Water (MHHW) at Freshwater Canal Locks, LA. A line denoting the Historical Maximum Water Level is displayed. The maximum residual occurred within +/- 2 hours of low tide.

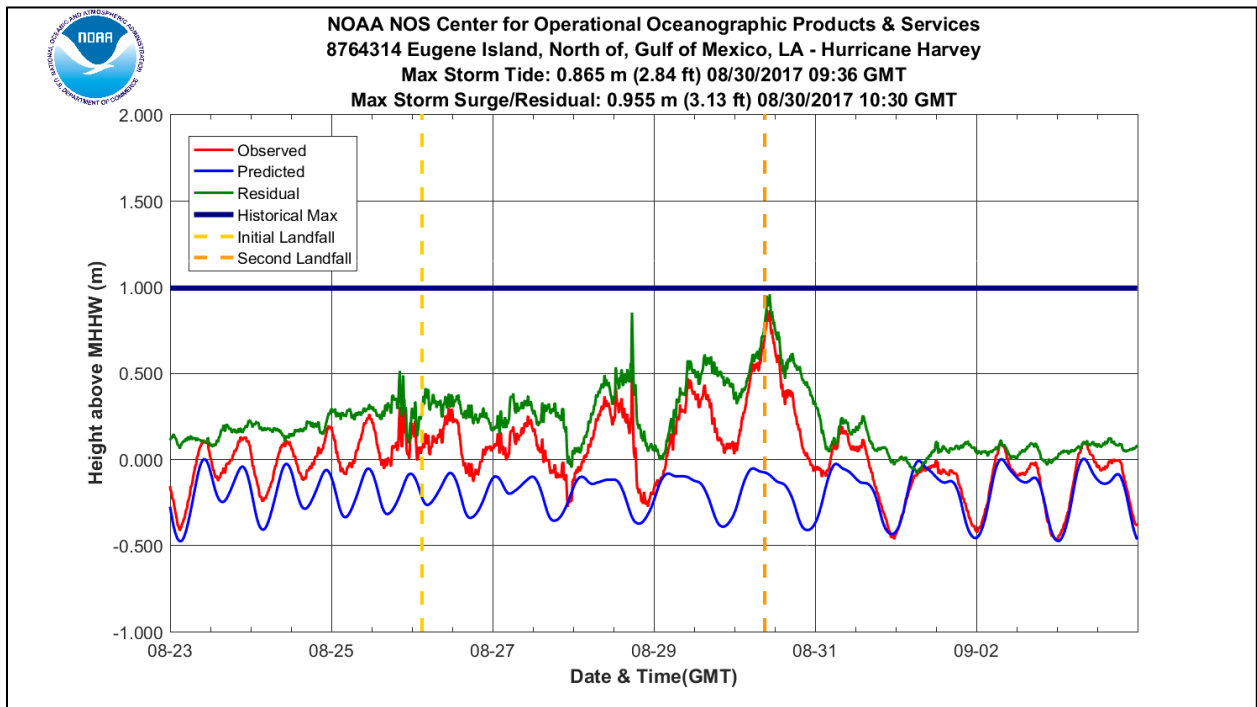


Figure 42: Water Levels above Mean Higher High Water (MHHW) at Eugene Island, North of, LA. A line denoting the Historical Maximum Water Level is displayed.

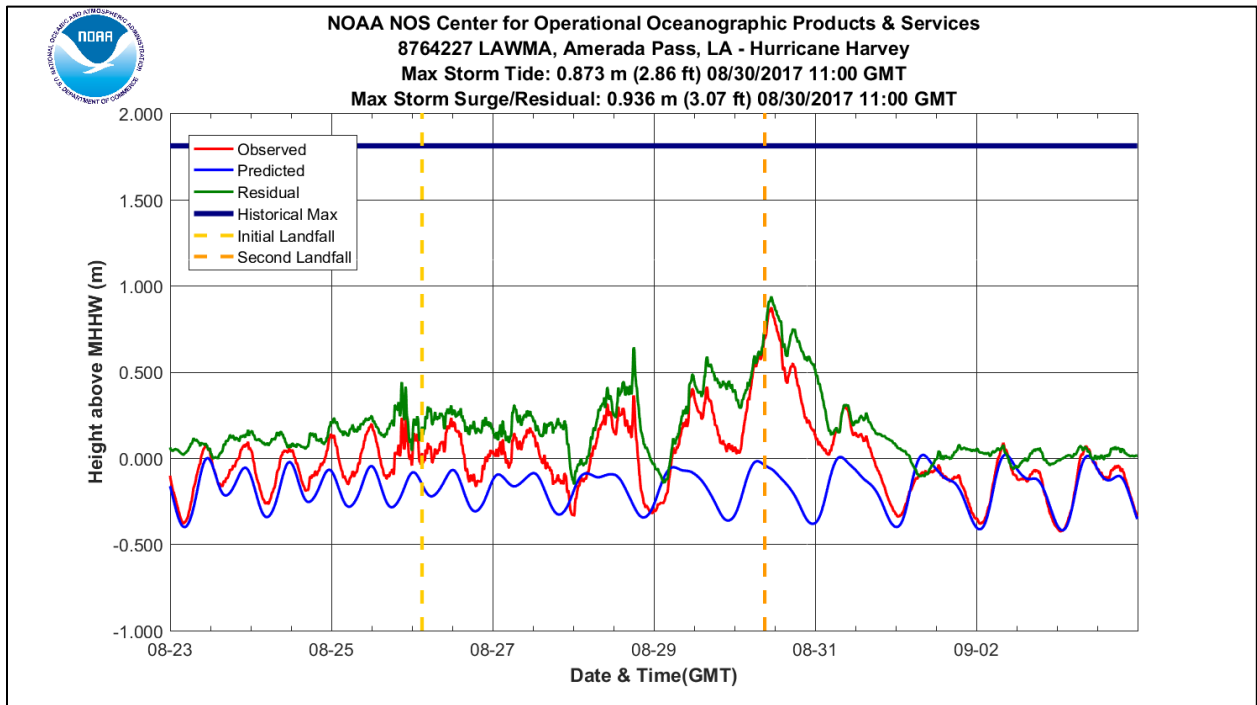


Figure 43: Water Levels above Mean Higher High Water (MHHW) LAWMA, Amerada Pass, LA. A line denoting the Historical Maximum Water Level is displayed.

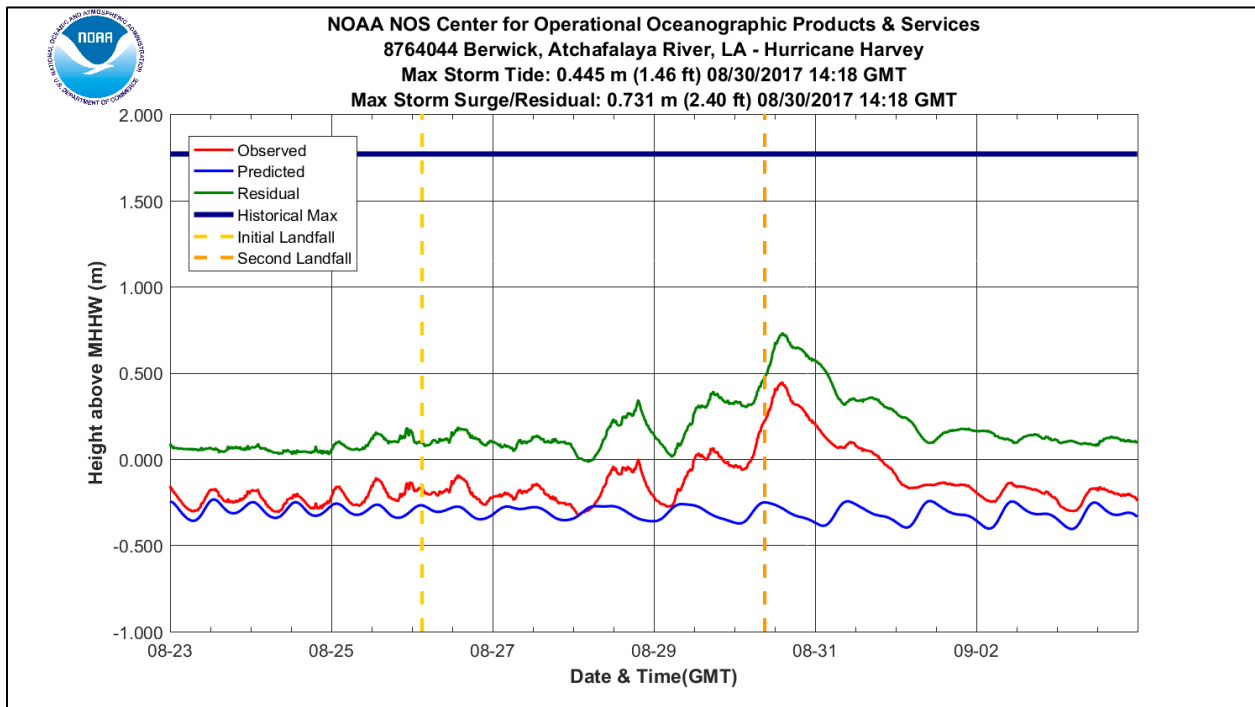


Figure 44: Water Levels above Mean Higher High Water (MHHW) at Berwick, Atchafalaya River, LA. A line denoting the Historical Maximum Water Level is displayed.

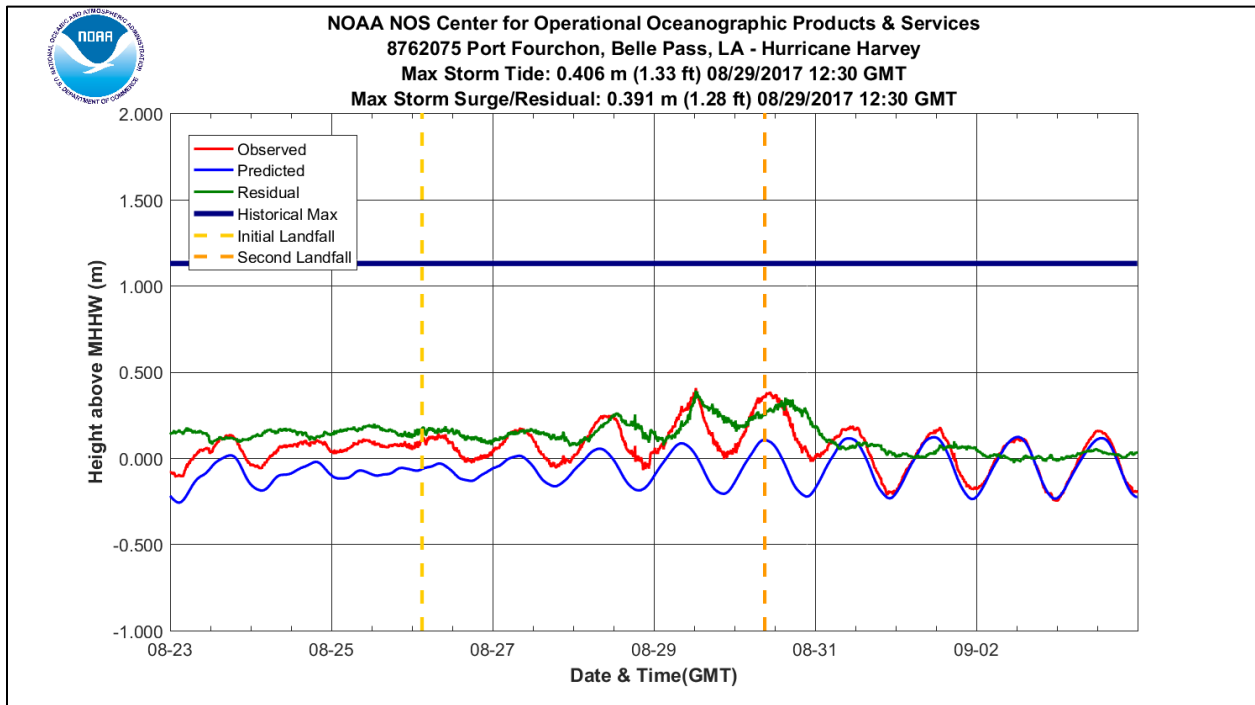


Figure 45: Water Levels above Mean Higher High Water (MHHW) at Port Fourchon, LA. A line denoting the Historical Maximum Water Level is displayed.

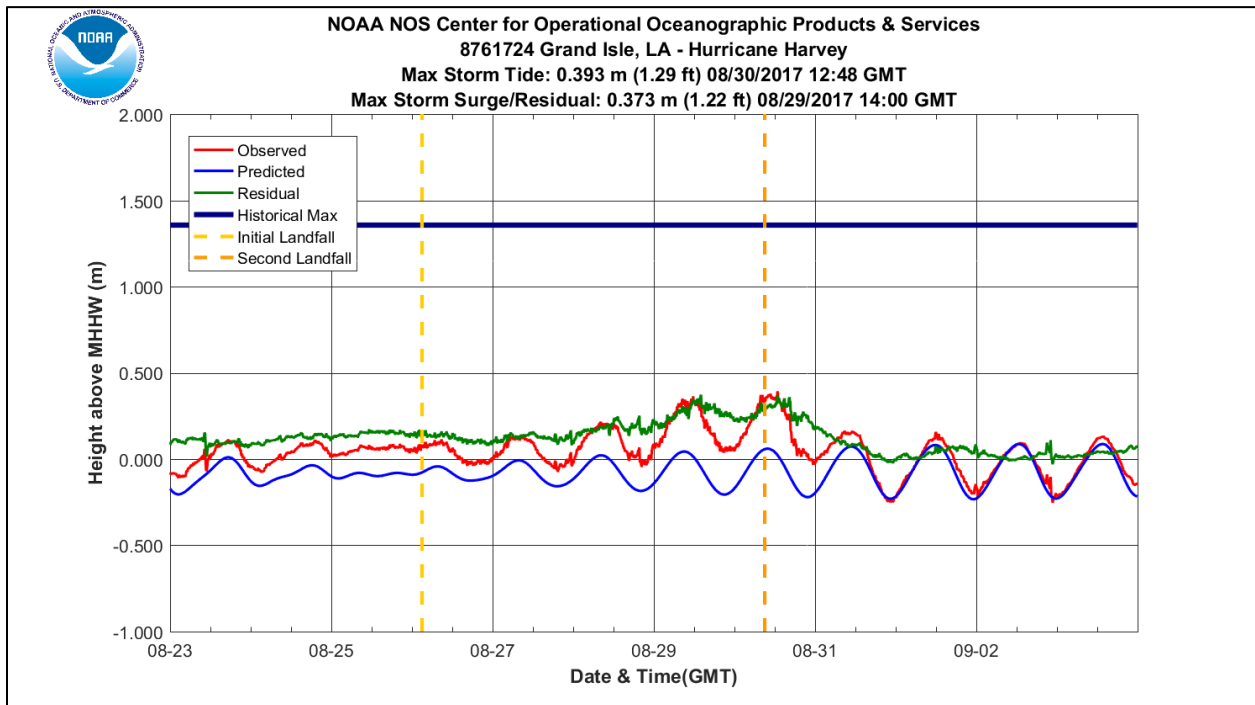


Figure 46: Water Levels above Mean Higher High Water (MHHW) Grand Isle, LA. A line denoting the Historical Maximum Water Level is displayed.

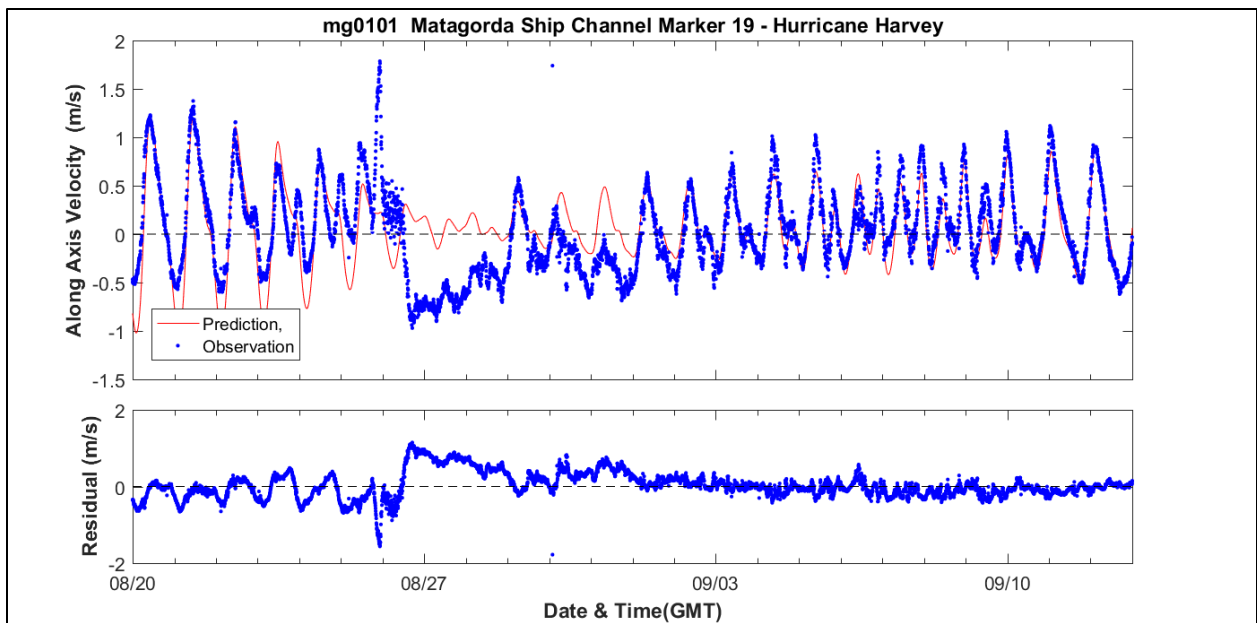


Figure 47: Current velocity (m/s) along the major tidal current axis at Matagorda Ship Channel, Marker 19, TX. A line denoting current velocity predictions is displayed.

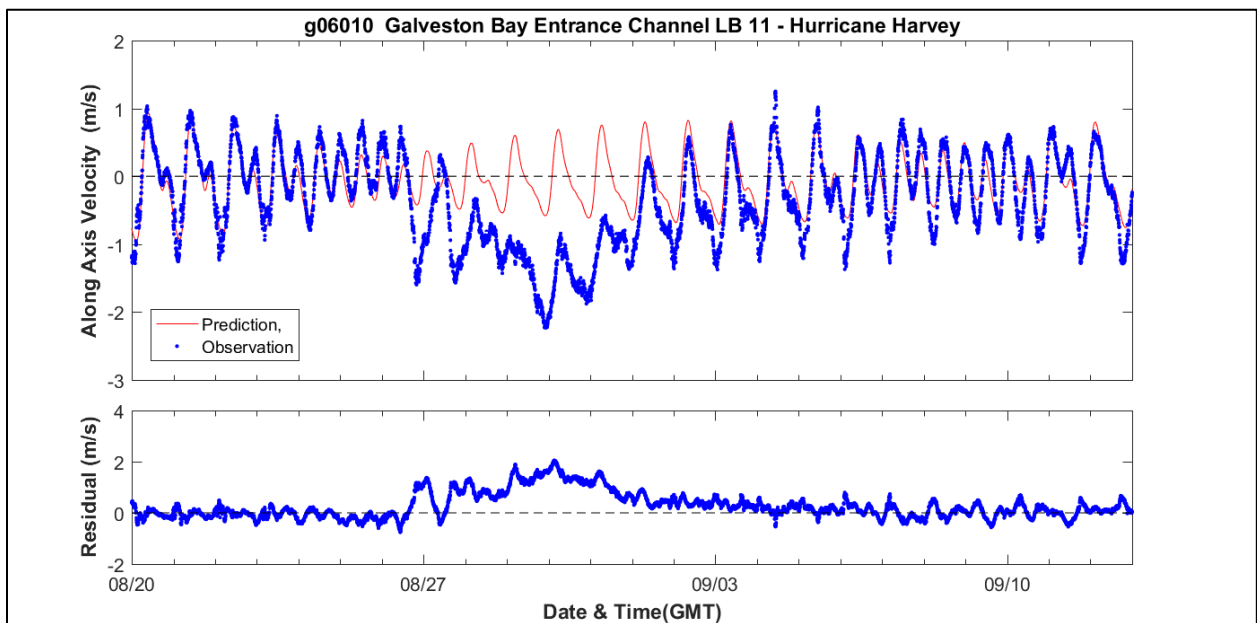


Figure 48: Current velocity (m/s) along the major tidal current axis at Galveston Bay Entrance Channel LB 11, TX. A line denoting current velocity predictions is displayed.

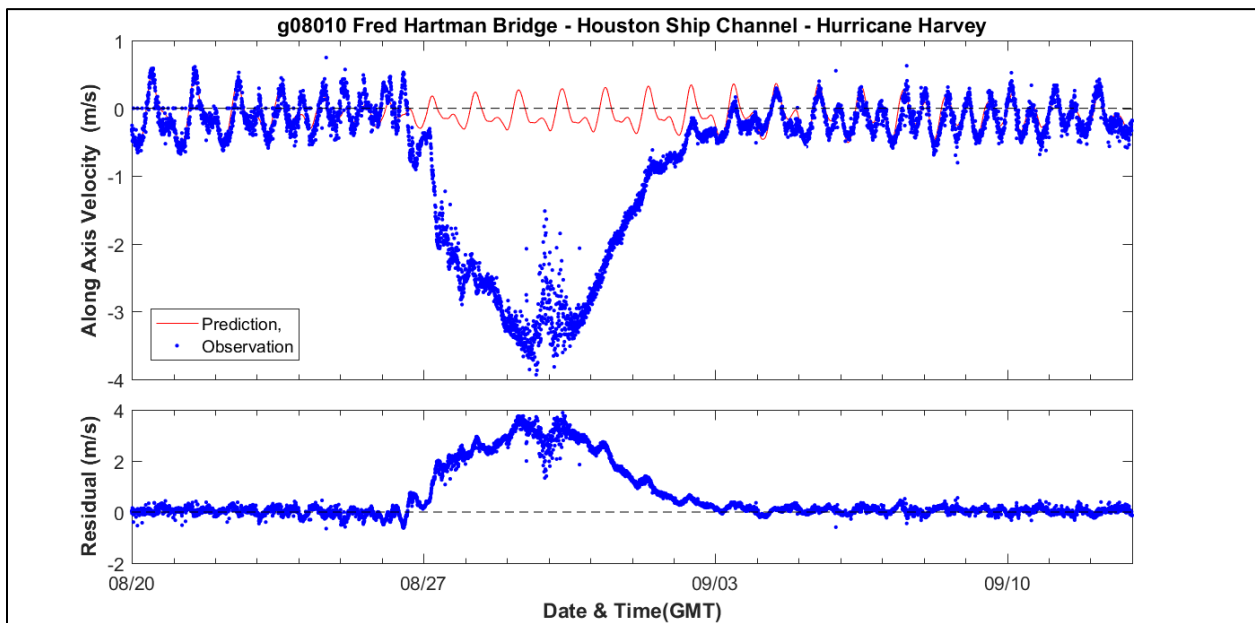


Figure 49: Current velocity (m/s) along the major tidal current axis at Fred Hartman Bridge, Houston Ship Channel, TX. A line denoting current velocity predictions is displayed.

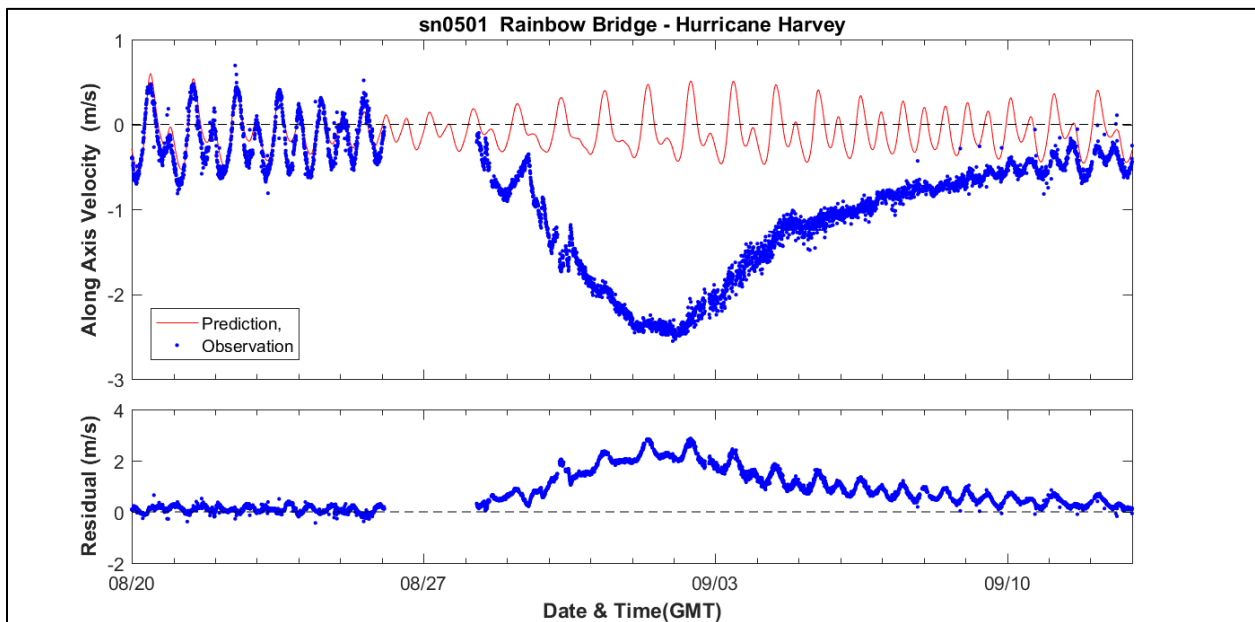


Figure 50: Current velocity (m/s) along the major tidal current axis at Rainbow Bridge, Sabine River, TX. A line denoting current velocity predictions is displayed. Data gap was due to a power outage, which affected station equipment.

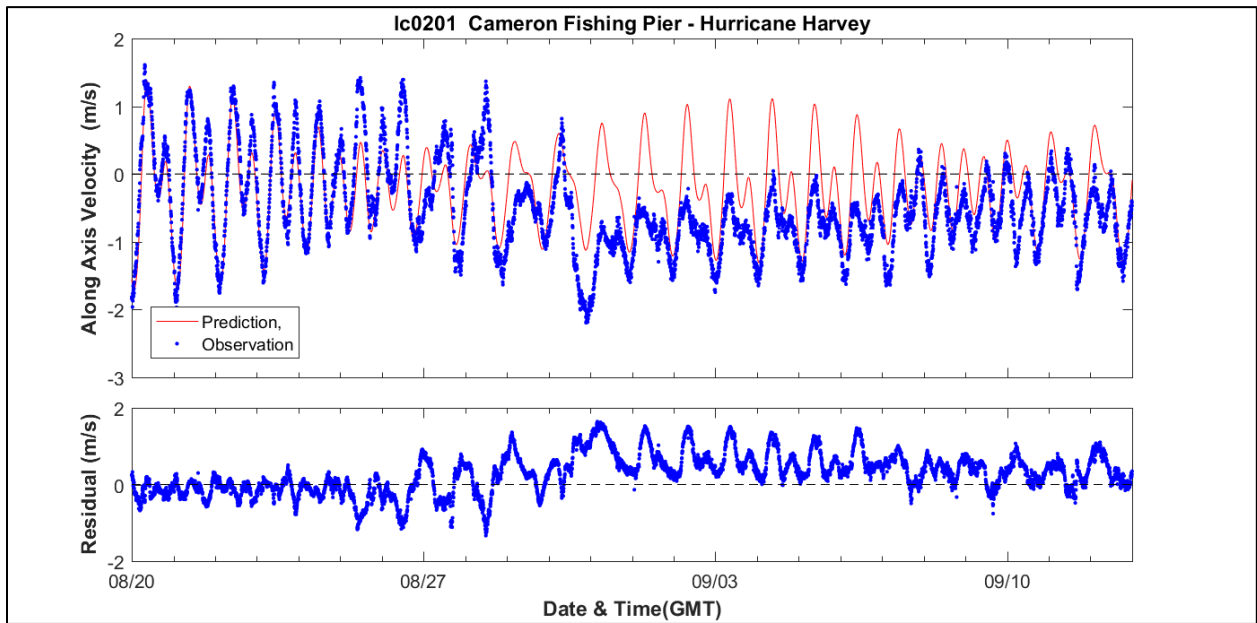


Figure 51: Current velocity (m/s) along the major tidal current axis at Cameron Fishing Pier, Calcasieu Pass, LA. A line denoting current velocity predictions is displayed.

Acknowledgements:

This report represents the cumulative efforts of the personnel of the Center for Operational Oceanographic Products and Services (CO-OPS). We would like to thank the Oceanographic Division's Data Processing Team who were responsible for the processing, analysis and verification of the data incorporated into this report. We would like to thank the Continuous Operational Real-Time Monitoring System (CORMS) team who performed an around-the-clock thorough QA/QC assessment on all real-time data. We would like to thank the Field Operations Division personnel who operated and maintained all stations to ensure that a reliable and robust source of real-time data was readily available.

Appendix 1: Contact Information

For further information or updates on the Storm Technical Reports and Storm QuickLook product, contact:

Storm QuickLook
Center for Operational Oceanographic Products and Services (CO-OPS)
1305 East-West Highway
Silver Spring, MD 20910-3281
Phone: (240) 533-0580
Fax: (301) 713-4437
E-mail: Storm QuickLook (tide.predictions@noaa.gov)

Appendix 2: Station Locations

Water Level Stations			
Station Name	Station ID	Latitude	Longitude
Port Isabel, TX	8779770	26.06117	-97.21553
SPI Brazos Santiago, TX	8779749	26.06739	-97.15478
South Padre Island CG Station, TX	8779748	26.07306	-97.16750
Bob Hall Pier, Corpus Christi, TX	8775870	27.58000	-97.21670
Packery Channel, TX	8775792	27.63331	-97.23669
USS Lexington, TX	8775296	27.81492	-97.38917
Aransas, Aransas Pass, TX	8775241	27.83660	-97.03910
Port Aransas, TX	8775237	27.83972	-97.07250
Rockport, TX	8774770	28.02170	-97.04670
Copano Bay, TX	8774513	28.11444	-97.02439
Aransas Wildlife Refuge, San Antonio Bay, TX	8774230	28.22756	-96.79656
Matagorda Bay Entrance Channel, TX	8773767	28.42689	-96.33011
Port O'Connor, TX	8773701	28.44586	-96.39556
Port Lavaca, TX	8773259	28.64056	-96.60978
Matagorda City, TX	8773146	28.71006	-95.91400
Seadrift, TX	8773037	28.40686	-96.71244
Sargent, TX	8772985	28.77142	-95.61717
Freeport, TX	8772447	28.94331	-95.30250
San Luis Pass, TX	8771972	29.08097	-95.13133
Galveston Railroad Bridge, TX	8771486	29.30239	-94.89653
Galveston Pier 21, TX	8771450	29.31000	-94.79331
Galveston Bay Entrance, North Jetty, TX	8771341	29.35733	-94.72483
Eagle Point, TX	8771013	29.48000	-94.91831
Rollover Pass, TX	8770971	29.51556	-94.51056
Texas Point, Sabine Pass, TX	8770822	29.68939	-93.84192
High Island, TX	8770808	29.59453	-94.38958
Manchester, TX	8770777	29.72622	-95.26578
Lynchburg Landing, TX	8770733	29.76486	-95.07886
Morgans Point, TX	8770613	29.68169	-94.98500
Sabine Pass North, TX	8770570	29.72840	-93.87010
Rainbow Bridge, TX	8770520	29.98119	-93.88469
Port Arthur, TX	8770475	29.86708	-93.93100
Calcasieu Pass, LA	8768094	29.76817	-93.34289
Bulk Terminal, LA	8767961	30.19019	-93.30081
Lake Charles, LA	8767816	30.22364	-93.22167
Freshwater Canal Locks, LA	8766072	29.55169	-92.30519
Eugene Island, North of, Gulf of Mexico, LA	8764314	29.36750	-91.38389

Water Level Stations (Continued)			
Station Name	Station ID	Latitude	Longitude
LAWMA, Amerada Pass, LA	8764227	29.44961	-91.33811
Berwick, Atchafalaya River, LA	8764044	29.66750	-91.23761
Port Fourchon, Belle Pass, LA	8762075	29.11425	-90.19925
Grand Isle, LA	8761724	29.26333	-89.95667

Current Stations			
Station Name	Station ID	Latitude	Longitude
Matagorda Ship Channel Marker 19, TX	mg0101	28.44769	-96.35617
Galveston Bay Entrance. Channel LB 11, TX	g06010	29.34222	-94.74083
Fred Hartman Bridge, Houston Ship Channel, TX	g08010	29.70350	-95.01892
Rainbow Bridge, TX	sn0501	29.98111	-93.87111
Cameron Fishing Pier, LA	lc0201	29.76414	-93.34292

Appendix 3: Definitions

Excerpts From: *Tide and Current Glossary*, NOAA National Ocean Service, Silver Spring, MD, 2000 (<https://www.tidesandcurrents.noaa.gov/publications/glossary2.pdf>), the Tidal Datums homepage (https://www.tidesandcurrents.noaa.gov/datum_options.html), the Storm QuickLook homepage (<https://tidesandcurrents.noaa.gov/quicklook.html>), the NGS webpage on Vertical Datums (<https://www.ngs.noaa.gov/datums/vertical>), and NOAA's Vertical Datum Transformation webpage (<https://vdatum.noaa.gov/docs/datums.html>)

Bench mark (BM): A fixed physical object or mark used as reference for a horizontal or vertical datum. A tidal bench mark is one near a tide station to which the tide staff and tidal datums are referred. A primary bench mark is the principal mark of a group of tidal bench marks to which the tide staff and tidal datums are referred.

Chart datum: The datum to which soundings on a chart are referred. It is usually taken to correspond to a low-water elevation, and its depression below mean sea level is represented by the symbol Z. Since 1980, chart datum has been implemented to mean lower low water for all marine waters of the United States, its territories, Commonwealth of Puerto Rico, and Trust Territory of the Pacific Islands.

Datum (vertical): For marine applications, a base elevation used as a reference from which to reckon heights or depths. It is called a tidal datum when defined in terms of a certain phase of the tide. Tidal datums are local datums and should not be extended into areas which have differing hydrographic characteristics without substantiating measurements. In order that they may be recovered when needed, such datums are referenced to fixed points known as bench marks. See chart datum and bench marks.

Geodetic datum: The NOAA National Geodetic Survey defines a geodetic datum as: "A set of constants used for calculating the coordinates of points on the Earth." In surveying and geodesy, a datum is a reference point on the earth's surface against which position measurements are made, and an associated model of the shape of the earth for computing positions. Horizontal datums are used for describing a point on the earth's surface, in latitude and longitude. Vertical datums are used to measure elevations or underwater depths.

Historical Recorded Maximum Tide Level: The maximum tide elevation measured by a water level station with a continuous time series throughout a high tide cycle. A complete cycle is required to calculate the maximum tide elevation, using a best fit curve of the observations. These historical records may not have included the highest water levels measured at a station during an event if a complete high tide cycle was not measured due to station/sensor damage. See storm tides.

Mean Lower Low Water (MLLW): A tidal datum. The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch. See National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

Mean Higher High Water (MHHW): A tidal datum. The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

Mean Sea Level (MSL): A tidal datum. The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; e.g. monthly mean sea level and yearly mean sea level.

National Tidal Datum Epoch: The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present National Tidal Datum Epoch is 1983 through 2001. It is reviewed annually for possible revision and must be actively considered for revision every 25 years.

North American Vertical Datum of 1988 (NAVD 1988): A fixed reference for elevations determined by geodetic leveling. The datum was derived from a general adjustment of the first-order terrestrial leveling nets of the United States, Canada, and Mexico. In the adjustment, only the height of the primary tidal bench mark, referenced to the International Great Lakes Datum of 1985 (IGLD 1985) local mean sea level height value, at Father Point, Rimouski, Quebec, Canada was held fixed, thus providing minimum constraint. NAVD 1988 and IGLD 1985 are identical. However, NAVD 1988 bench mark values are given in Helmert orthometric height units while IGLD 1985 values are in dynamic heights.

National Tidal Datum Epoch: The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present NTDE is 1983 through 2001 and is actively considered for revision every 20-25 years. Tidal datums in certain regions with anomalous sea level changes (Alaska, Gulf of Mexico) are calculated on a Modified 5-Year Epoch.

National Water Level Observation Network (NWLON): The network of tide and water level stations operated by the National Ocean Service along the marine and Great Lakes coasts and islands of the United States.

Neap tides: Tides of decreased range occurring semimonthly as the result of the Moon being in quadrature (first or last quarters).

Non-tidal: Water levels may be classified as tidal or non-tidal. Water bodies with little or no range in tide and where the rise and fall of the water surface can no longer be practically measured in a predictable rhythm due to masking of the tide by hydrologic, wind, or other effects are non-tidal.

Ortho: Abbreviation for “orthometric” datum (employs the Earth’s gravity field). Any height referenced to the Earth’s gravity field can be called a “geopotential height,” which represents the distance between the geoid and a point on the Earth’s surface measured along the plumb line. A geoid is a specified equipotential surface, defined in the Earth’s gravity field, which best fits, in a least squares sense, global mean sea level. The orthometric datums corresponding to the continental United States, Puerto Rico and the U.S. Virgin Islands are NAVD88, PRVD02 and VIVD09, respectively.

PORTS® (Physical Oceanographic Real-Time System): An integrated system of sensors concentrated in seaports that provide commercial vessel operators with accurate and reliable real-time information about environmental conditions. PORTS® measures and disseminates observations, predictions and nowcast/forecasts for water levels, currents, bridge air gap, salinity and meteorological parameters (e.g., winds, waves, atmospheric pressure, visibility, air and water temperatures).

Range of tide: The difference in height between consecutive high and low waters. The mean range is the difference in height between mean high water and mean low water. The great diurnal range or diurnal range is the difference in height between mean higher high water and mean lower low water. For other ranges see spring, neap, perigean, apogean, and tropic tides; and tropic ranges.

Tide: The periodic rise and fall of a body of water resulting from gravitational interactions between Sun, Moon, and Earth. The vertical component of the particulate motion of a tidal wave. Same as astronomic tide.

Tide (water level) gauge: An instrument for measuring the rise and fall of the tide (water level). Water levels may be classified as tidal and non-tidal.

Spring tides: Tides of increased range occurring semimonthly as the result of the Moon being new or full.

Storm Surge/Residual: The onshore rush of sea or lake water caused by the high wind and the low pressure centers associated with a landfalling hurricane or other intense storm. The amplitude of the storm surge at any given location is dependent upon the orientation of the coast line with the storm track, the intensity, size and speed of the storm, and the local bathymetry. In practice, storm surge is usually estimated by subtracting the normal or astronomical tide from the observed storm tide at tide stations. This difference between observed storm tides and astronomical tide can have other components such as regional elevated mean sea levels in the Gulf of Mexico due to the Loop Current, elevated sea levels on the West Coast due to El Niño Southern Oscillation (ENSO), or local elevated sea levels due to river runoff in tidal rivers.

Storm Tide: The maximum water level elevation measured by a water level station during storm events. Depending on location, the storm tide is the potential combination of storm surge, local astronomical tide, regional sea level variations and river runoff during storm events. Since wind generated waves ride on top of the storm surge (and are not included in the definition), the total instantaneous elevation may greatly exceed the predicted storm surge plus astronomical tide. It is potentially catastrophic, especially on low lying coasts with gently sloping offshore topography.