

# WFO Taunton Storm Series Report # 2013-01

## *The March, 2010 Floods in Southern New England*



*Photo: Flooding of the Warwick Mall from the Pawtuxet River in Rhode Island.*

NOAA/National Weather Service  
445 Myles Standish Blvd  
Taunton, MA 02780



## **Foreword**

The objective of the National Weather Service (WFO) Taunton Storm Report Series is to provide a concise summary of a significant meteorological event that impacted the WFO Taunton County Warning Area (CWA). The WFO Taunton CWA includes all of Massachusetts except for Berkshire County; all of Rhode Island; Cheshire and Hillsborough Counties in southwest New Hampshire; and Hartford, Tolland and Windham Counties in northern Connecticut.

Use of the series is intended for training and WFO Taunton historical documentation only. Official storm reports can be found in *Storm Data*, published by the National Oceanic and Atmospheric Administration, National Climatic Data Center.

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Robert M. Thompson  
Meteorologist-In-Charge  
WFO Taunton, MA  
January, 2013

# 1. Introduction

Record rainfall and record flooding affected southern New England in March, 2010. The weather pattern was affected by two large scale influences: El Nino, which transported deep moisture from the Tropics and a persistent negative phase of the North Atlantic Oscillation, which featured a blocking pattern over eastern Canada. This led to an increased flood potential early in the month as frequent rainfall events produced overly moist antecedent conditions. In essence, the “pump was primed” for significant flooding during the middle and end of March, as three consecutive slow-moving low pressure systems brought excessive rainfall to the region.

## 2. Synoptic Overview and Resulting Flood Impacts

### March 13-15, 2010

A potent, slow moving low pressure system tracked from Virginia to south of Long Island over the course of a three day period (Figure 1). High pressure over eastern Canada provided a blocking mechanism and resulted in an anomalously strong low level easterly inflow of Atlantic moisture. A southerly upper level jet along the East Coast produced a deep plume of tropical moisture which fed into the system.

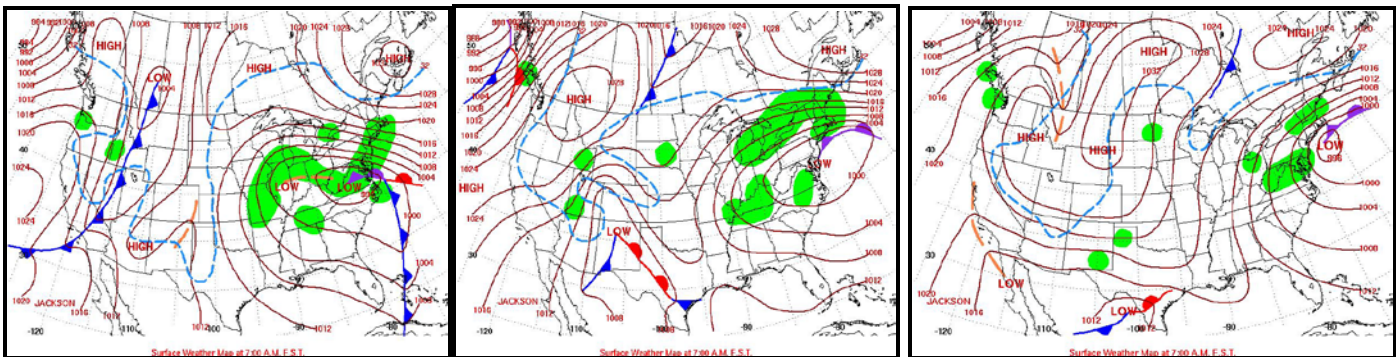


Figure 1: Surface Weather Maps at 12z on March 13<sup>th</sup> (left), 14<sup>th</sup> (center), and 15<sup>th</sup> (right), 2010

Heavy rain affected a large portion of the northeast U.S. but the heaviest rain fell in eastern Massachusetts near a coastal front (Figure 2). As much as 7 to 10 inches of rain fell from Methuen and Gloucester southward through Plymouth and Brockton. Totals of 4 to 6 inches fell just to the west, from south central New Hampshire to the Worcester Hills, Rhode Island, and far northeast Connecticut.

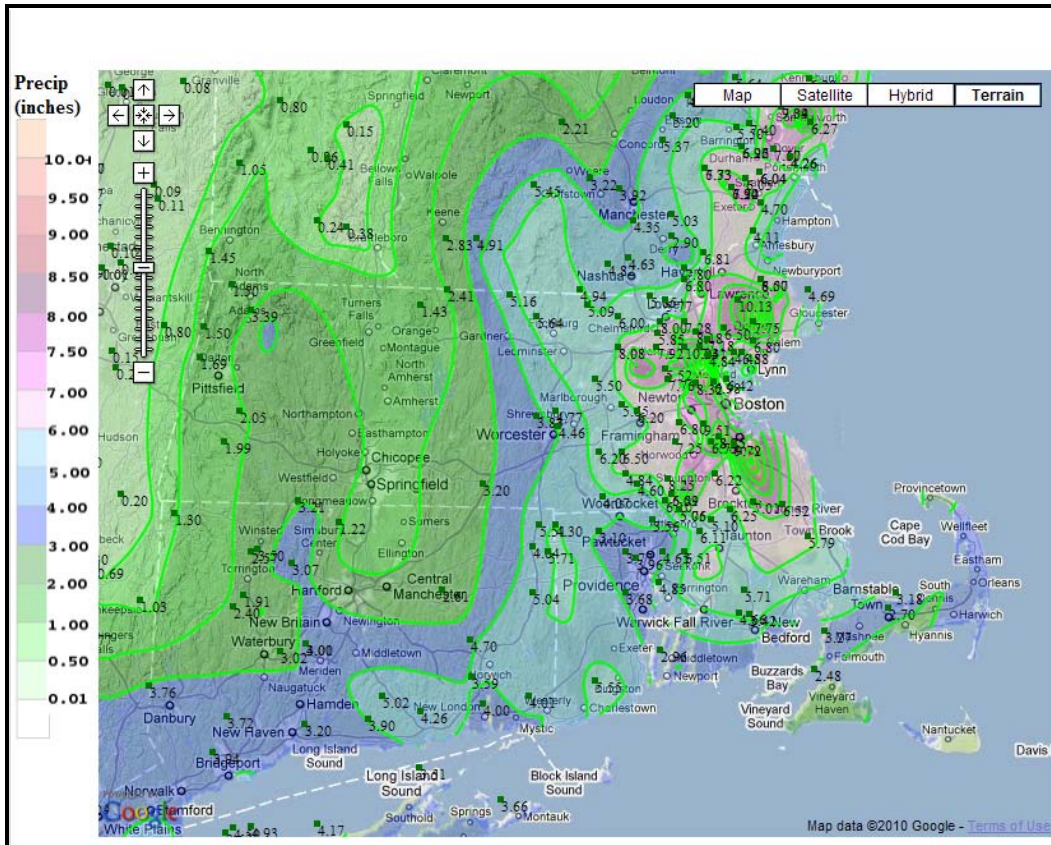


Figure 2: Observed Rainfall Totals from March 13<sup>th</sup> to 15<sup>th</sup>, 2010

The Nashua River experienced its worst flood in 23 years, resulting in substantial flooding in Lancaster and Clinton. In Pepperell, Route 119 and 111 were shut down. The gauge in East Pepperell maxed out at 14 feet, preventing accurate real time data from being transmitted. In Clinton additional impacts occurred to its downtown area when a 100 yard long mudslide pushed into Counterpane Brook and a culvert blew out at Coachlace Pond.

On the MBTA Green Line D branch in Newton, undermining occurred along a 50 foot long stretch of track, resulting in a closure of that route. In Norwood, part of the airport runways and tarmac were inundated by floodwaters from the Neponset River, resulting in a closure of the airport for several days. Record flooding occurred on the Taunton River, resulting in the first flood-related shutdown of Route 44 in Taunton in over 40 years. In Topsfield, the Ipswich River flooded Route 1. At Waltham’s Moody Street Dam, water overtopped an upstream training wall; this wall keeps water from flowing over the spillway. Significant erosion occurred at the site but the main portion of the dam remained stable until repairs could be made. Portions of Route 9 in Natick and Wellesley were shut down. Widespread urban flooding affected Boston, particularly on the south side of the city.

Record flooding occurred along the Pawtuxet River at Cranston, RI. The river crested at 14.98 feet, ½ foot higher than its previous record which was set on June 7, 1982. Flooding occurred from Warwick to West Warwick and Cranston. In Warwick, roughly 100 homes were evacuated. About 40 businesses and 500 cars were flooded. Arctic Dam in West Warwick was monitored for overtopping, but held its own.

Two fatalities were attributed to this first flood event. In Middleton MA, a man drowned in a flooded basement office. In West Greenwich RI, an off duty state police officer died after his car hydroplaned and crashed.



Tables 1 and 2 provide a list of gauged rivers and small streams that experienced flooding as a result of this event. Several locations experienced floods of record.

Site ID	River	Location	FS	Crest	Date	Time (Z)	Category	Record
CRAR1	Pawtuxet	Cranston	9.0	14.98	03/15/10	18:15	Major	Yes (1 <sup>st</sup> )
DNSM3	Nashua	East Pepperell	8.0	15.75	03/17/10	04:00	Major	
FBGM3	North Nashua	Fitchburg	6.5	7.99	03/15/10	15:30	Minor	
GFFN3	Piscataquog	Goffstown	9.0	10.10	03/15/20	13:00	Moderate	
HVRM3	Merrimack	Haverhill	15.0	16.29	03/16/10	19:15	Minor	
LCNM3	Concord	Lowell	8.0	9.74	03/17/20	18:45	Minor	Yes
LOWM3	Merrimack	Lowell	52.0	53.63	03/16/10	18:30	Minor	
LWMM3	Merrimack	Lawrence	20.0	23.40	03/16/10	12:00	Minor	
MAYM3	Assabet	Maynard	5.0	7.14	03/16/10	03:00	Major	
MTHM3	Spicket	Methuen	8.0	9.86	03/16/10	20:30	Minor	
NRWM3	Neponset	Norwood	9.0	11.07	03/15/10	18:15	Major	
PTRN3	Contoocook	Peterborough	5.5	6.03	03/15/10	10:45	Minor	
SAXM3	Sudbury	Saxonville	10.0	12.92	03/16/10	04:15	Moderate	
SIMC3	Farmington	Simsbury	12.0	12.61	03/16/10	03:00	Minor	
SOHN3	Souhegan	Merrimack	9.0	9.85	03/15/10	21:30	Minor	
WGTM3	Squannacook	West Groton	7.0	8.03	03/15/10	18:30	Minor	
WLMM3	Shawsheen	Wilmington	7.0	10.59	03/16/10	00:45	Major	Yes
WOOR1	Blackstone	Woonsocket	9.0	10.52	03/15/10	08:15	Minor	

Table 1: River Forecast Points that experienced flooding in mid-March 2010

Site ID	River	Location	FS	Crest	Date	Time (Z)	Cat	Record
BDGM3	Taunton	Bridgewater	10.5	14.51	03/17/10	10:30	Major	Yes (1 <sup>st</sup> )
BYFM3	Parker	Byfield	5.5	7.24	03/16/10	04:00	Moderate	
CLIM3	Nashua	Clinton	N/A	10.37	03/16/10	13:45	Major	
DIGM3	Segregansett	Dighton	5.0	5.70	03/15/10	08:45	Minor	
EABM3	Monatiquot	East Braintree	4.5	5.60	03/17/10	02:30	N/A	
IPSM3	Ipswich	Ipswich	7.0	9.96	03/17/10	08:30	Moderate	
INHM3	Indian Head	Hanover	6.0	7.32	03/16/10	01:30	N/A	
KNGM3	Jones	Kingston	4.5	6.20	03/16/10	01:00	N/A	
MEDM3	Charles	Medway	5.0	6.62	03/16/10	06:30	Moderate	
MUDM3	Muddy	Brookline	15.0	15.41	03/15/10	15:30	Minor	
NORM3	Wading	Norton	9.5	9.93	03/15/10	18:30	Minor	
SAGM3	Saugus	Saugus	5.5	7.34	03/16/10	00:15	Major	
SMMM3	Ipswich	S. Middleton	7.0	8.43	03/16/10	03:46	Moderate	
TNMM3	Mill	Taunton	8.5	10.17	03/17/10	16:45	N/A	
WASR1	S. Branch Pawtuxet	Washington	4.0	5.44	03/15/10	06:00	N/A	
WCHM3	Aberjona	Winchester	13.0	16.49	03/16/10	00:15	Major	
WLTM3	Charles	Waltham	5.0	7.56	03/16/10	00:30	Moderate	Yes
WODR1	Pawcatuck	Wood River Junction	6.0	6.25	03/15/10	23:45	N/A	
WSTR1	Pawcatuck	Westerly	7.0	9.28	03/15/10	00:15	N/A	
WTHM3	Old Swamp	South Weymouth	4.5	5.70	03/15/10	22:45	N/A	

Table 2: Other rivers and streams that experienced flooding in mid-March 2010

Rainfall totals were noticeably lower in southwest New Hampshire and in the Connecticut River Valley of Massachusetts and Connecticut, where as little as 2 to 3 inches of rain fell. Flood impacts were minimal in these areas.

### March 22-23, 2010

The second event produced a lesser degree of flooding but served to keep rivers and streams at elevated levels. A low pressure system emerged out of the Gulf Coast on March 21<sup>st</sup> and tracked steadily northeastward, producing heavy rain in southern New England on the 22<sup>nd</sup> and 23<sup>rd</sup> (Figure 3).

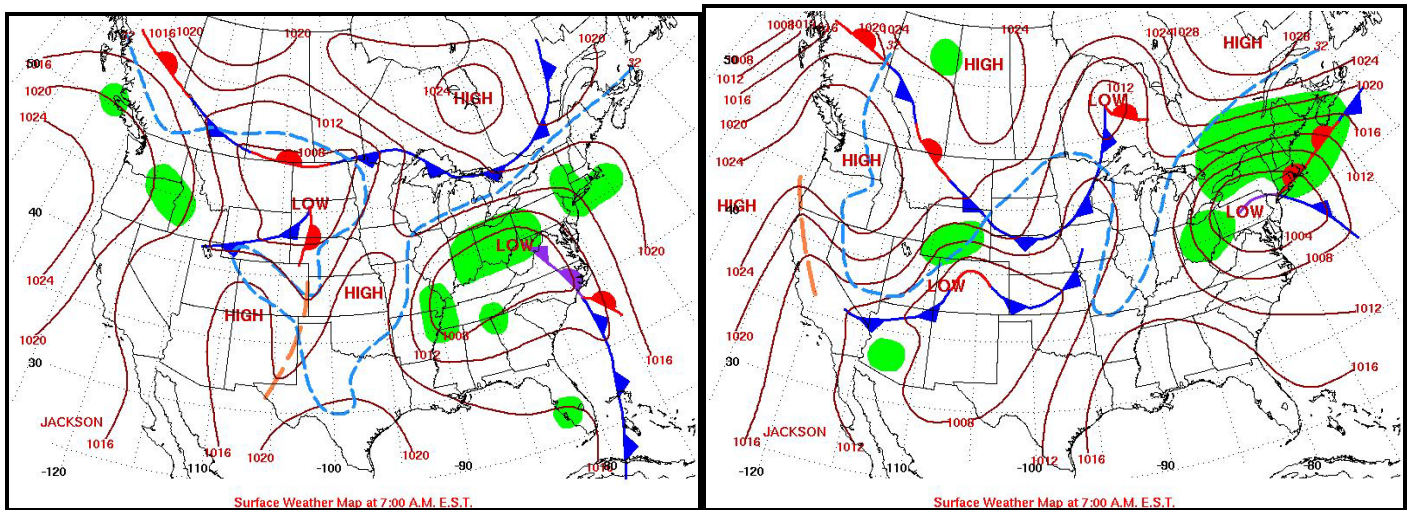
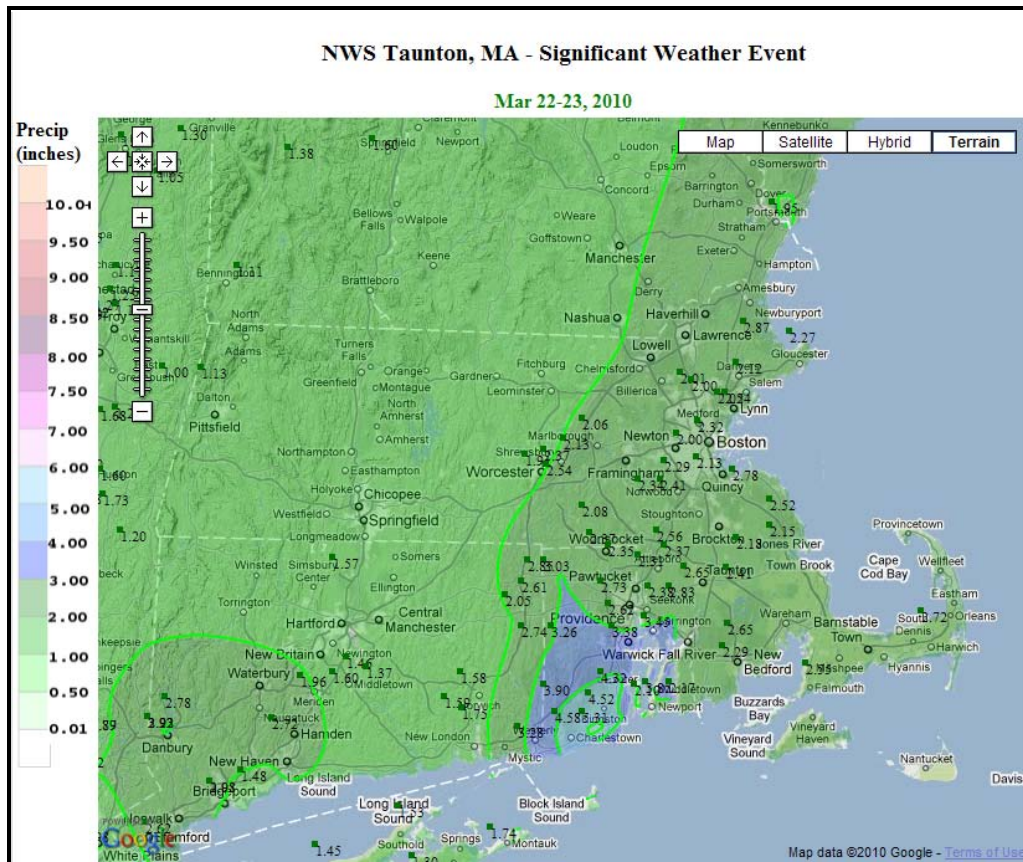


Figure 3: Surface Weather Maps for 12z on March 22<sup>nd</sup> (left) and 23<sup>rd</sup> (right), 2010

The speed of this system was at least partly responsible for relatively lower rainfall totals (Figure 4). As much as 3 to 5 inches of rain fell over Rhode Island producing moderate flooding in the Pawtuxet River basin, and renewed flooding on the Pawcatuck River. Elsewhere 1 to 3 inches of rain fell, with the lowest totals in the Connecticut River Valley. Even with these lower amounts, minor flooding still occurred along several rivers including the lower Connecticut. Table 3 includes a listing of gauged rivers and streams that experienced flooding from this event.



*Figure 4: Rainfall totals from March 22<sup>nd</sup> to 23<sup>rd</sup>, 2010*

Site ID	River	Location	FS	Crest	Date	Time (Z)	Cat
CRAR1	Pawtuxet	Cranston	9.0	11.88	03/25/10	00:45	Moderate
DNSM3	Nashua	East Pepperell	8.0	8.18	03/25/10	17:00	Minor
HFDC3	Connecticut	Hartford	16.0	19.42	03/25/10	16:45	Minor
KNGM3	Jones	Kingston	4.5	4.60	03/24/10	11:30	N/A
MAYM3	Assabet	Maynard	5.0	5.44	03/24/10	23:15	Minor
MDDC3	Connecticut	Middletown	8.0	11.11	03/26/10	03:00	Minor
MNTM3	Connecticut	Montague	28.0	28.07	03/24/10	01:30	Minor
NHMM3	Connecticut	Northampton	112.0	112.2	03/24/10	11:00	Minor
NMIM3	Mill	Northampton	10.0	10.46	03/23/10	12:30	Minor
SAXM3	Sudbury	Saxonville	10.0	10.78	03/24/10	16:45	Minor
TMVC3	Connecticut	Thompsonville	5.0	5.47	03/25/10	06:15	Minor
WASR1	S. Branch Pawtuxet	Washington	4.0	4.02	03/24/10	19:00	Minor
WLTM3	Charles	Waltham	5.0	5.19	03/22/10	15:00	Minor
WODR1	Pawcatuck	Wood River Jct.	6.0	6.42	03/25/10	08:30	N/A
WSTR1	Pawcatuck	Westerly	7.0	9.35	03/24/10	15:00	N/A

*Table 3: Gauged rivers and streams that experienced flooding from the March 22<sup>nd</sup>-23<sup>rd</sup>, 2010 rains*



## March 28-31, 2010

On March 28<sup>th</sup>, yet another low pressure system emerged out of the Gulf Coast states. This system proceeded to track into the northeast U.S. on the 29<sup>th</sup> and lingered south of Long Island on the 30<sup>th</sup> and 31<sup>st</sup> (Figure 5) as high pressure over the Canadian Maritimes slowed the system down. Once again, a southerly upper level jet was in place, providing a deep plume of tropical moisture which fed into this system over the course of several days. Anomalously strong low level easterly winds transported Atlantic moisture into the coastal front, which provided a focus for deep moisture convergence near the coast. Although precipitable water values did not appear to be significant (Figure 6), they were near the 99<sup>th</sup> percentile for Chatham, MA in late March (Figure 7). Grumm and Nocera (2010) showed the larger scale evolution of this system including the application of Ensemble Prediction Systems in the forecast process.

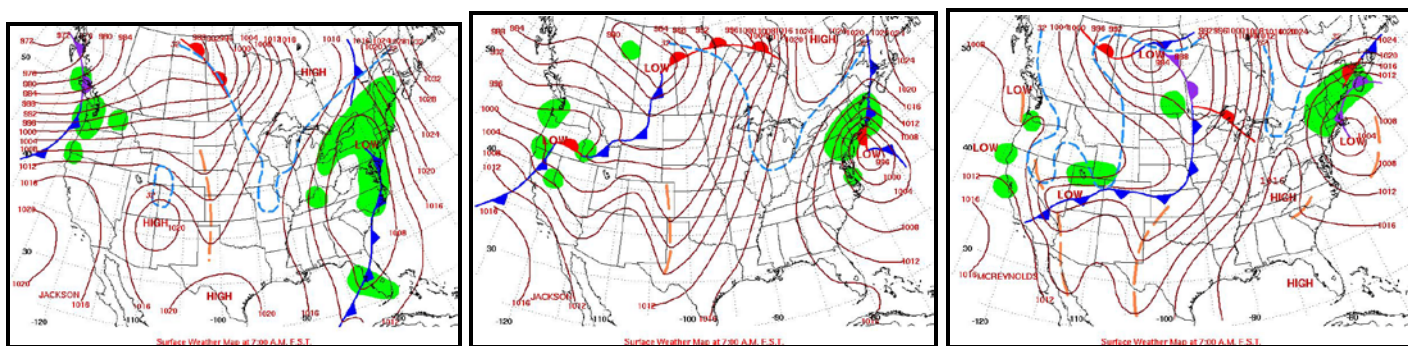
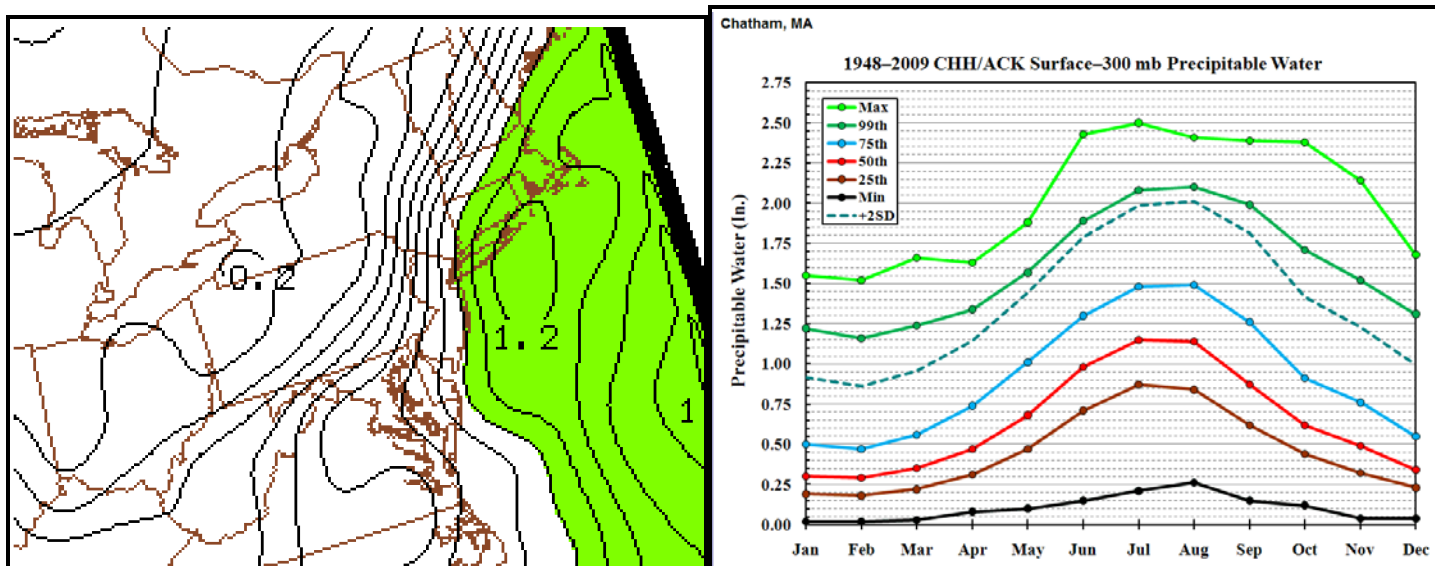


Figure 5: Surface Weather Maps for 12z on March 29<sup>th</sup> (left), 30<sup>th</sup> (center), and 31<sup>st</sup> (right), 2010



Figures 6 and 7: Precipitable water analysis (inches) for 12 UTC March 30, 2010 and Precipitable Water Climatology graph for Chatham, MA.

Heavy rain fell from the mid Atlantic region to Maine, but once again the axis of heaviest rain fell over southern New England (Figure 8). As much as 6 to 10 inches of rain fell in Rhode Island and southern Connecticut; 5 to 8 inches fell in southeast Massachusetts; and 3 to 6 inches fell in central and northeast



Massachusetts as well as northern Connecticut. Less than 3 inches of rain fell in southwest New Hampshire and northwest Massachusetts.

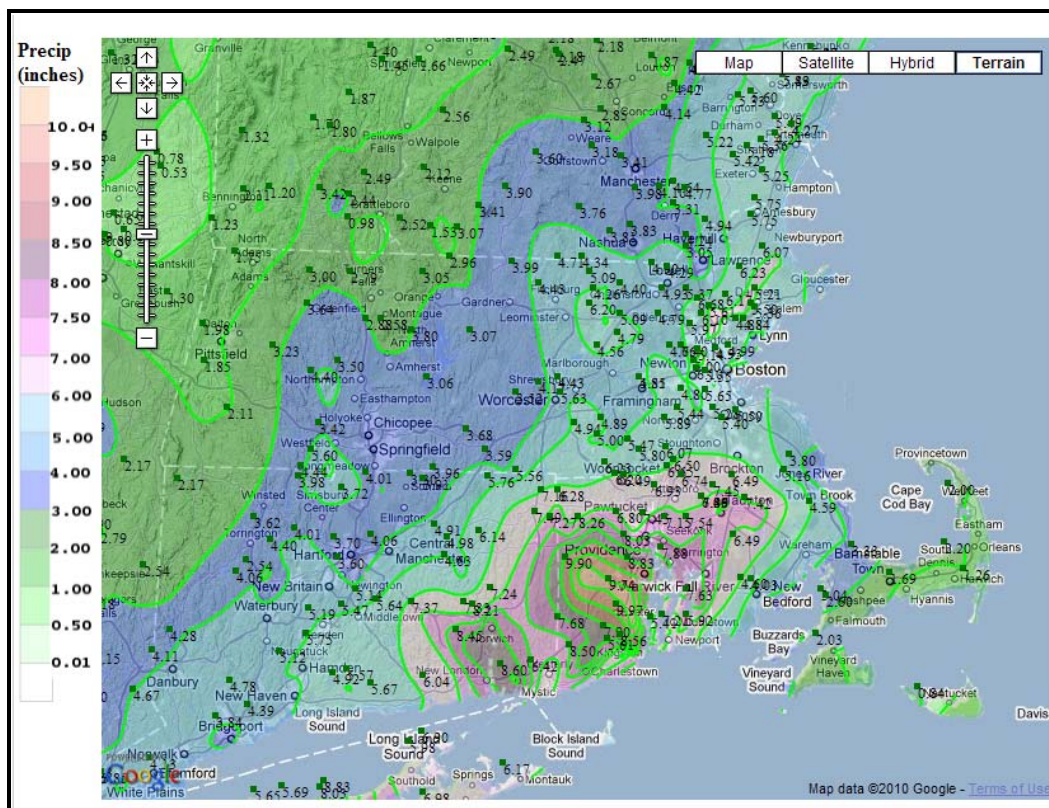


Figure 8: Rainfall totals from March 29-31, 2010.

Flood impacts were severe. Moderate to major flooding affected many rivers and streams in southern New England. Rhode Island was especially hard hit, where non-emergency state employees were told not to report to work and several communities canceled school.

The Pawtuxet River crested at 20.8 feet and exceeded the record set just two weeks earlier. The river flooded large sections of neighborhoods, especially in Warwick, West Warwick and Cranston. The West Warwick Waste Water Treatment Plant was substantially inundated by floodwaters, resulting in the release of raw sewage into the river. The Warwick Mall was flooded by two feet of water resulting in a prolonged closure of the mall. A portion of I-95 was shut down in Cranston, as well as the Airport Connector, which provides access from I-95 to TF Green Airport in Warwick. Sandbagging operations kept I-295 from being shut down, though there were ramps which were closed. The Scituate Reservoir, which feeds into the Pawtuxet River, recorded a pool elevation 6 feet higher than its previous record. Water flowed 3.5 feet above the flashboards. The reservoir had been spilling over its flashboards since late February and was a major contributor to the degree of flooding in Cranston. Figure 11 shows flood inundation from the Pawtuxet River in West Warwick.

Record flooding also occurred along the Pawcatuck River in southern Rhode Island. Numerous homes were impacted and stretches of state roads in the area were closed. Flooding was so severe that the Pawcatuck River did not fall back below flood stage until April 12<sup>th</sup>. A mile of railroad track in Westerly was inundated resulting in a suspension of Amtrak service along the heavily traveled Boston to New York corridor. Blue Pond Dam failed in the headwaters of the Wood River in Hopkinton causing damage to infrastructure in that area. These floodwaters also drained into the Pawcatuck River, which exacerbated the flooding. Flooding was so severe on Chapman Pond, adjacent to the Pawcatuck River, that Route 91 and Pound Road were closed for

several days, cutting off access to an entire neighborhood. Figure 12 shows flood inundation from the Pawcatuck River in Hopkinton.

In Fall River, the force of the flood waters popped manhole covers and ripped up pavement and utilities. Along the Taunton River flooding exceeded the record set just two weeks earlier at the Bridgewater gauge. This resulted in another shutdown of Route 44 in Taunton. In Wayland, a duck boat was used to transport residents to and from their homes.

Flooding from elevated lake levels impacted homes and businesses in southeast Massachusetts. This included Norton Reservoir and Lake Winnecunnet in Norton; West Pond, Big Sandy Pond and Kings Pond in Plymouth; Assawompset Pond in Lakeville; Long Pond in Freetown and Lakeville; Forge Pond in Freetown; and South Wattupa Pond in Westport.

Out of 36 river forecast points in the Hydrologic Service Area, 25 went into flood. Out of the small stream gages with established flood stages, 26 went into flood. Tables 4 and 5 provide specific crest information. Record flooding occurred at a number of gages in eastern Massachusetts and Rhode Island. Figures 9 and 10 show the AHPS hydrographs for the two river forecast points which experienced record flooding: the Pawtuxet River at Cranston, RI and the Sudbury River at Saxonville (Framingham), MA.

Site ID	River	Location	FS	Crest	Date	Time (Z)	Cat	Record
CRAR1	Pawtuxet	Cranston	9.0	20.79	03/31/10	13:15	Major	Yes
DNSM3	Nashua	East Pepperell	8.0	13.78	04/01/10	19:00	Moderate	
DOVM3	Charles	Dover	5.0	8.05	04/02/10	23:15	Major	
GFFN3	Piscataquog	Goffstown	9.0	9.79	03/31/10	10:15	Minor	
GOFN3	Merrimack	Goffs Falls	11.0	11.60	04/01/10	00:00	Minor	
HFDC3	Connecticut	Hartford	16.0	21.29	04/01/10	17:30	Minor	
HVRM3	Merrimack	Haverhill	15.0	16.71	04/01/10	09:45	Minor	
LCNM3	Concord	Lowell	8.0	9.64	04/03/10	15:45	Minor	
LOWM3	Merrimack	Lowell	52.0	54.64	04/01/10	13:45	Moderate	
LWMM3	Merrimack	Lawrence	20.0	24.30	04/01/10	12:00	Minor	
MAYM3	Assabet	Maynard	5.0	7.08	03/31/10	15:00	Major	
MDDC3	Connecticut	Middletown	8.0	12.96	04/02/10	06:45	Moderate	
MTHM3	Spicket	Methuen	8.0	9.13	04/01/10	05:46	Minor	
NBRM3	Blackstone	Northbridge	9.0	10.69	03/31/10	04:45	Minor	
NHMM3	Connecticut	Northampton	112.0	112.8	03/31/10	23:00	Minor	
NRWM3	Neponset	Norwood	9.0	11.16	03/30/10	21:15	Major	
NSHN3	Merrimack	Nashua	18.0	18.81	04/01/10	06:45	Minor	
PTRN3	Contoocook	Peterborough	5.5	5.76	03/31/10	04:00	Minor	
SAXM3	Sudbury	Saxonville	10.0	13.99	03/31/10	21:00	Major	Yes
SIMC3	Farmington	Simsbury	12.0	13.81	04/01/10	00:30	Minor	
SOHN3	Souhegan	Merrimack	9.0	9.19	03/31/10	20:30	Minor	
TMVC3	Connecticut	Thompsonville	5.0	5.97	04/01/10	08:15	Minor	
WGTM3	Squannacook	West Groton	7.0	7.56	03/31/10	14:00	Minor	
WLMM3	Shawsheen	Wilmington	7.0	9.42	03/31/10	16:15	Moderate	
WOOR1	Blackstone	Woonsocket	9.0	14.50	03/31/10	09:30	Moderate	

Table 4: River Forecast Points which experienced flooding as a result of the March 29<sup>th</sup> to 31<sup>st</sup>, 2010 rains

Site ID	River	Location	FS	Crest	Date	Time (Z)	Cat	Record
BDGM3	Taunton	Bridgewater	10.5	14.97	04/01/10	10:00	<b>Major</b>	Yes(2 <sup>nd</sup> )
BYFM3	Parker	Byfield	5.5	6.28	03/31/10	17:30	Minor	
CENR1	Woonasquatucket	Centerdale	5.5	9.20	03/30/10	21:30	<b>Major</b>	Yes
CLIM3	Nashua	Clinton	N/A	9.86	03/31/10	19:45	N/A	
CVTC3	Willimantic	Coventry	8.0	9.31	03/31/10	00:30	Minor	
DIGM3	Segregansett	Dighton	5.0	8.66	03/30/10	18:15	N/A	Yes
EABM3	Monataquoit	East Braintree	4.5	5.17	04/01/10	02:30	N/A	
EPPR1	Ten Mile	East Providence	7.5	10.79	03/31/10	10:15	N/A	
FDLR1	Branch	Forestdale	10.0	12.05	03/31/10	05:30	N/A	
INHM3	Indian Head	Hanover	6.0	6.51	03/31/10	04:30	N/A	
IPSM3	Ipswich	Ipswich	7.0	8.53	04/02/10	02:45	Minor	
KNGM3	Jones	Kingston	4.5	6.16	03/31/10	05:15	N/A	
MEDM3	Charles	Medway	5.0	7.21	03/31/10	12:45	<b>Major</b>	Yes
NMIM3	Mill	Northampton	10.0	11.83	03/31/10	02:00	Moderate	
NONM3	Canoe	Norton	8.0	8.15	04/01/10	06:45	N/A	
NORM3	Wading	Norton	9.5	11.48	03/31/10	03:45	Moderate	Yes
QBGC3	Quinebaug	Putnam	6.0	6.77	03/31/10	00:30	Minor	
SAGM3	Saugus	Saugus	5.5	5.70	03/31/10	07:15	Minor	
SMMM3	Paskamanset	South Dartmouth	7.0	7.67	03/31/10	16:30	Minor	
TNMM3	Mill	Taunton	8.5	11.54	04/01/10	06:15	N/A	
WASR1	S. Br. Pawtuxet	Washington	4.0	9.22	03/31/10	09:30	<b>Major</b>	Yes
WCHM3	Aberjona	Winchester	13.0	15.58	03/31/10	10:30	<b>Major</b>	
WLTM3	Charles	Waltham	5.0	6.46	03/31/10	17:15	N/A	
WODR1	Pawcatuck	Wood River Junction	6.0	11.16	03/31/10	12:30	<b>Major</b>	Yes
WRNC3	Mount Hope	Warrenville	7.0	7.92	03/30/10	21:45	Minor	
WSTR1	Pawcatuck	Westerly	7.0	15.38	03/31/10	02:45	<b>Major</b>	Yes
WTHM3	Old Swamp	South Weymouth	4.5	5.46	03/30/10	18:45	N/A	

Table 5: Other river and streams which experienced flooding as a result of the March 29<sup>th</sup>-31<sup>st</sup>, 2010 rains

As severe as the event was, there were no fatalities as a result of the late March floods.



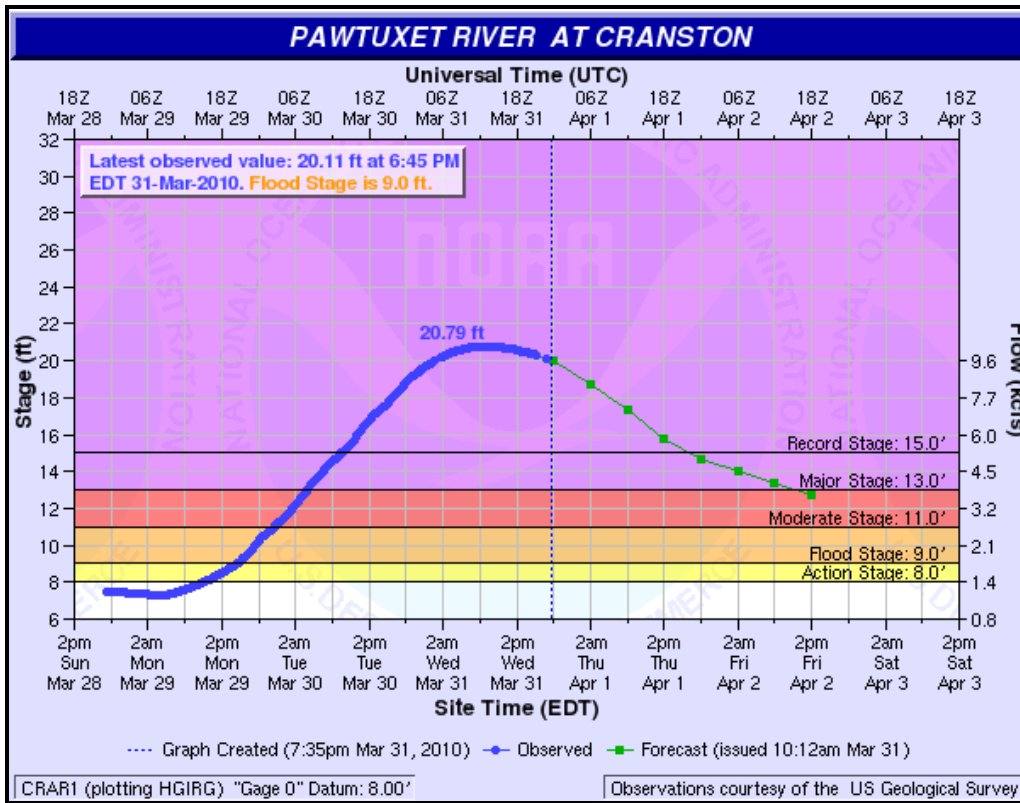


Figure 9: AHPs hydrograph for the Pawtuxet River at Cranston in late March and early April, 2010.

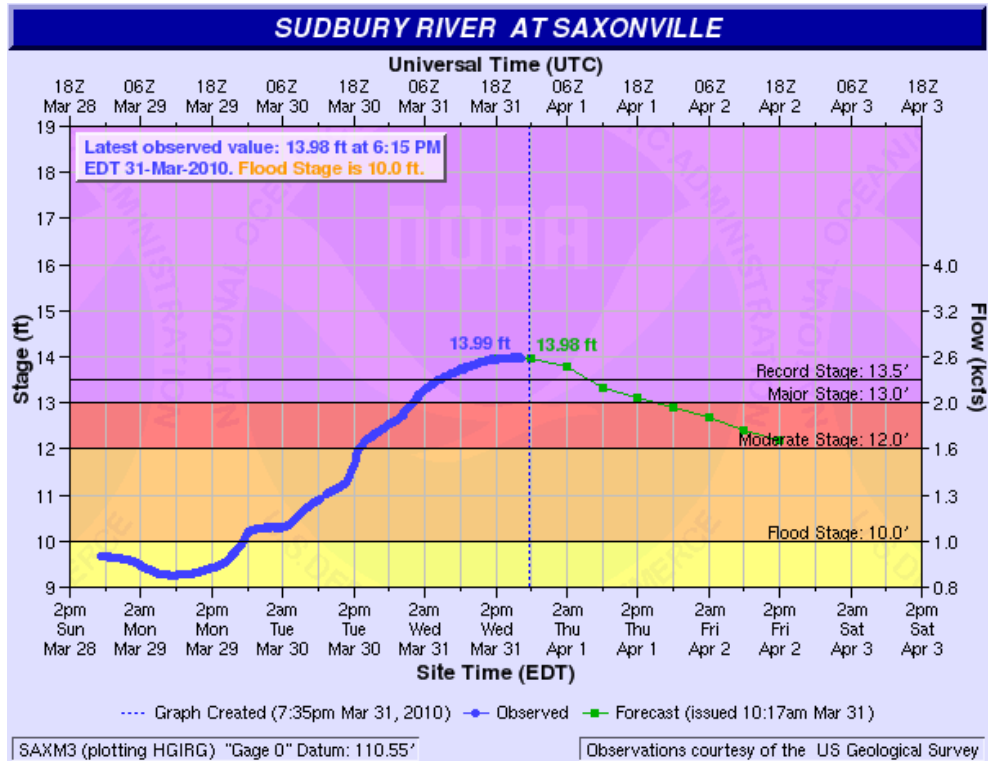


Figure 10: AHPS hydrograph for the Sudbury River at Saxonville (Framingham) MA



*Figure 11: Inundation from record flooding on the Pawtuxet River on Providence Street in West Warwick, RI (WFO Taunton Storm Survey photo)*



*Figure 12: Inundation from flooding along the Pawcatuck River along Route 3 in Hopkinton, RI. (WFO Taunton Storm Survey photo)*



### 3. Damage Assessment and Monthly Precipitation

The following rivers recorded four flood crests in the five week period from late February through the end of March: Pawtuxet River at Cranston, Pawcatuck River at Westerly, Sudbury River at Saxonville, Assabet River at Maynard, and the Nashua River at East Pepperell. The Sudbury River was in flood for nearly 3 ½ weeks.

More than 37,000 Massachusetts residents applied for federal assistance, and \$93 million in disaster assistance was approved for individuals and business owners. According to FEMA, this is almost twice the disaster aid provided from the Mother’s Day Floods in 2006 for the Commonwealth. In Rhode Island, nearly 26,000 residents applied for assistance, and \$79 million in disaster assistance was approved for individuals and business owners. In Connecticut, \$4 million in assistance was provided to individuals and households. Counties included in FEMA Disaster Declarations can be seen in Figure 13.

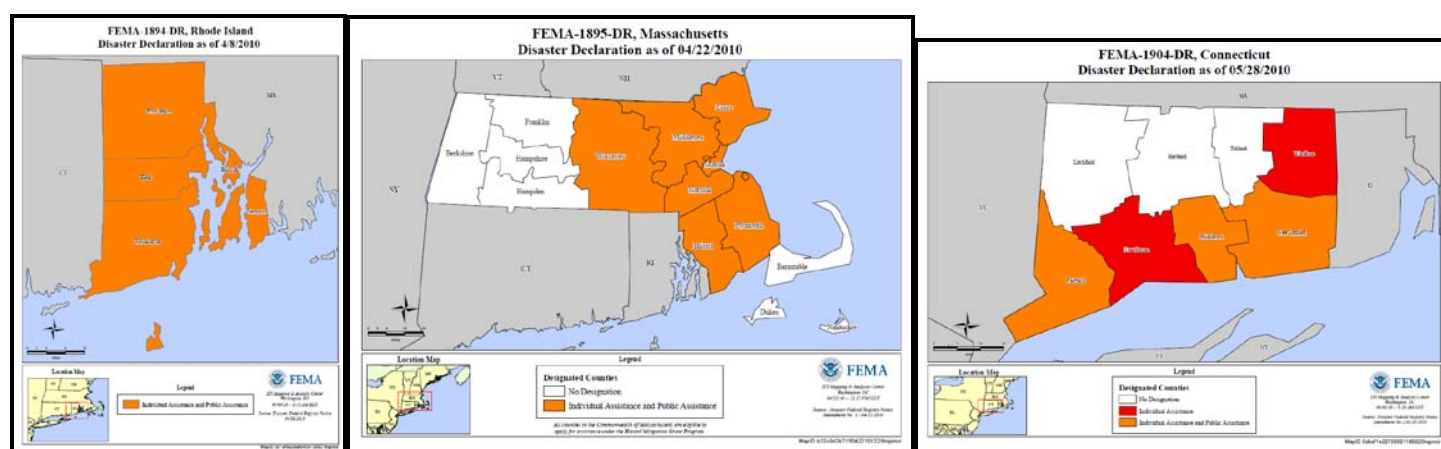


Figure 13: FEMA maps showing counties under Disaster Declarations as a result of the March, 2010 floods.

Preliminarily, according to the USGS, 8 of 30 long term network gages in Massachusetts broke previous record crests during the month of March. In Rhode Island, 22 of 27 long term network gages broke previous record crests.

Not surprisingly, rainfall records were also exceeded in March, 2010. At Logan Airport in Boston, 14.87 inches of precipitation fell, setting a new March record. The previous record was 11.00 inches in March, 1953. It was also the 2<sup>nd</sup> wettest month on record, not quite reaching the 17.09 inches of rain produced largely by Connie and Diane in August of 1955. At the Blue Hill Observatory in Milton, 18.81 inches of precipitation fell, setting the all time wettest March and monthly rainfall record. The previous record was 18.78 inches from August of 1955. T.F. Green Airport in Warwick received 16.34 inches of precipitation which was an all time March and monthly rainfall record. The previous monthly record was 15.38 inches from October 2005.

March rainfall totals ranged from 10 to 20 inches across the eastern half of Massachusetts, Rhode Island and southeast New Hampshire. To the west, lesser totals of 5 to 10 inches occurred (Table 6 and Figure 14).

<i>Location</i>	<i>March Precipitation</i>	<i>Departure (Inches)</i>	<i>Wettest March Ranking</i>	<i>Wettest Month Ranking</i>
<i>Boston</i>	14.87	+11.02	1 <sup>st</sup>	2 <sup>nd</sup>
<i>Worcester</i>	10.24	+6.01	2 <sup>nd</sup>	-
<i>Providence</i>	16.34	+11.91	1 <sup>st</sup>	1 <sup>st</sup>
<i>Hartford</i>	6.81	+2.93	4 <sup>th</sup>	-

Table 6: March, 2010 precipitation data for long term climate sites in southern New England

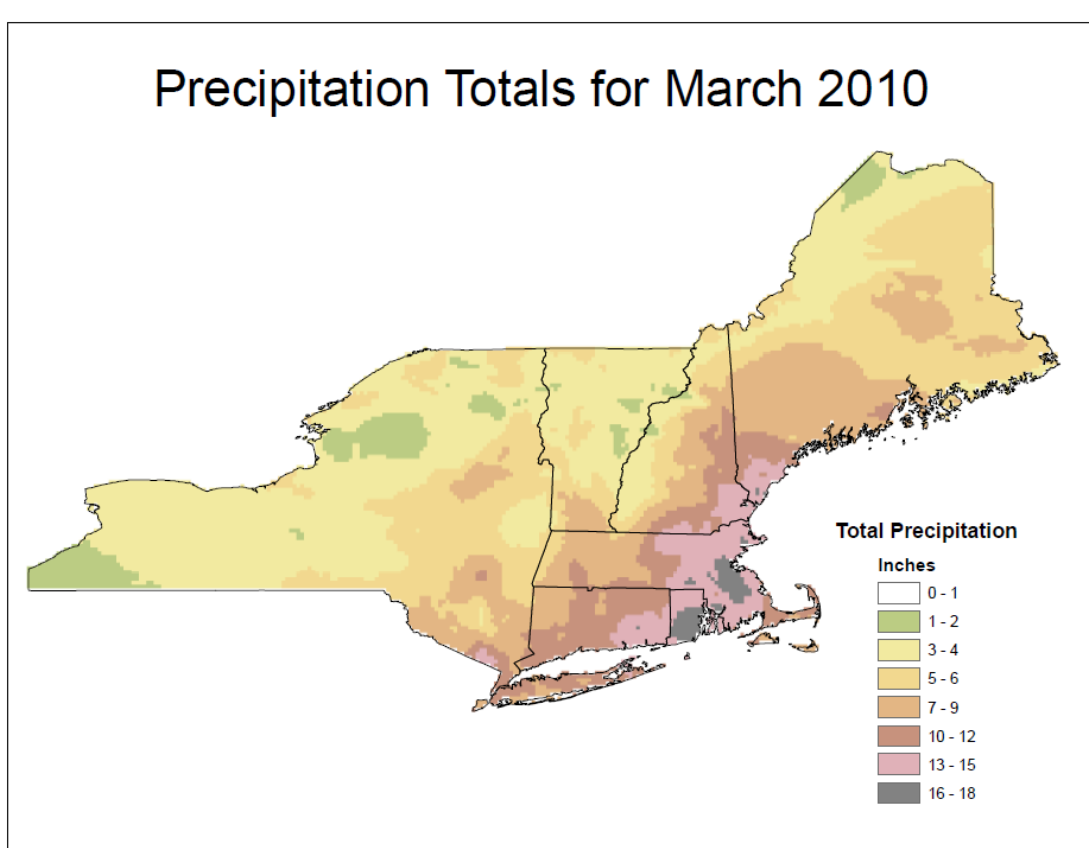


Figure 14: Precipitation Totals for March 2010 (NWS Northeast River Forecast Center).

#### 4. WFO Taunton Forecast Services

##### Mid-March Floods

Hazardous Weather Outlooks (HWOs) highlighted the possibility of significant rainfall as early as Sunday, March 7<sup>th</sup>, a full week in advance of the storm. The 417 pm March 7<sup>th</sup> HWO stated “A slow moving low pressure system may affect the region from Friday night through the weekend with the potential for a period of strong winds and significant rain...possibly some snow.” The initial Flood Watch (FFA) for southern New England was issued at 429 pm Friday March 12<sup>th</sup>. An enhanced statement was included on the 442 am Saturday FFA issuance: “One of the

*heaviest widespread single storm long duration rain events since spring 2006 appears imminent.”* Expected rainfall was up to 6 inches in eastern MA with 2 to 4 inches of rain anticipated for the remainder of the area. A large, long duration Flood Warning (FLW) was issued at 1142 pm on March 13<sup>th</sup> for Windham County CT, Worcester County MA, all of Rhode Island, and all of eastern MA except for Cape Cod and the Islands. This warning was accurate in its depiction of the majority of flood impacted counties in WFO Taunton’s CWA. **Lead time to flooding was at least 6 to 9 hours.** Follow up warnings were issued prior to the previous product expiration, except for one occurrence when a 6 minute gap occurred while flooding was ongoing.

Over the course of the mid-March floods, WFO Taunton issued 34 River FLWs (13 of these were upgrades to moderate or major flooding). Probability of Detection (POD) was 0.85, False Alarm Ratio (FAR) was 0.11 and the average Lead Time (LT) to Flood Stage was 8 hours and 34 minutes. POD exceeded the yearly NWS GPRA+ goal of 0.82.

One item that lacked in this event was Emergency Manager Conference Calls, though WFO BOX flood products and HWOs handled the event very well. *A recommendation is to schedule these conference calls for any widespread flood event.* While record flooding was not forecast, the historical reference to May 2006 was a good analogy, since many areas hit hard by the mid March flood event were also hit hard by that event.

In addition, there was a template problem with Riverpro. This resulted in missing data for river stage forecasts including forecast crest, time to reach flood stage, and time of crest in some FLWs. Templates were updated during the event to solve the problem but several statements were issued without key information. However, the impact to stakeholders was minimal, since most of them use AHPS for river forecast information. Nonetheless, the staff was reminded to proofread all Flood Statements to ensure key information is available in text products. Also, the Service Hydrologist and Hydrology Focal Point should ensure the latest templates from the WHFS support team have been downloaded into AWIPS prior to significant events.

A final lesson learned was that at 14.07 feet, the Nashua River at East Pepperell gage reached its maximum recordable level and a “flat line” was then recorded even though the river rose to 15.75 feet and then gradually fell. The USGS made a trip to the gage shortly after it happened but the top of the staff gage had snapped off, so no manual gage reading was possible. WFO Taunton staff made a trip to the gage the following day and was able to make a staff gage reading. *A lesson learned here was that maximum recordable river levels should be known by NWS staff, not only so staff aren’t surprised when this type of issue arises, but also to notify USGS personnel so that they can install a temporary gage and remove or elevate threatened equipment.*



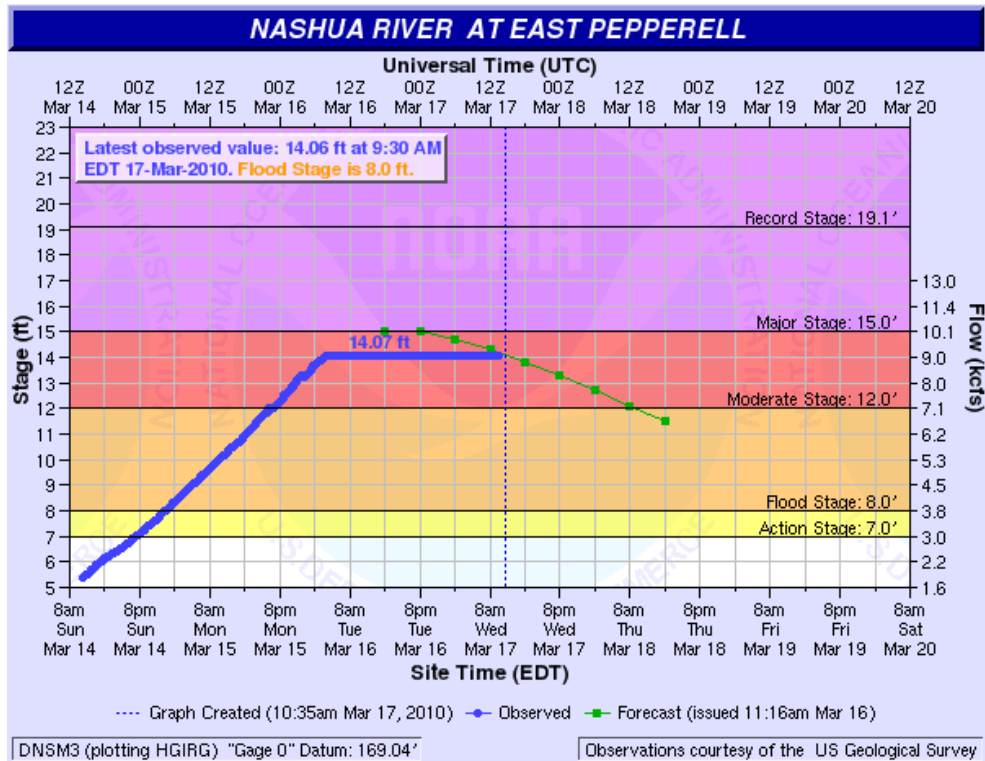


Figure 15: AHPS hydrograph for the Nashua River at East Pepperell, MA during the mid March, 2010 floods. Note the gauge “flat-lined” at the maximum recordable level on Monday March 15<sup>th</sup>. Even after the river fell below 14.07 feet, the gauge continued to record at that level until the USGS was able to make repairs.

As a Best Practice, the staff freed the Service Hydrologist and Hydrology Focal Point to travel to various portions of the CWA to complete flood surveys. To maximize coverage due to the widespread nature of the flooding, the MIC, Service Hydrologist and Hydrology Focal Point met each morning to decide which areas were to be covered. For instance, the Hydrology Focal Point covered a large amount of the Sudbury River watershed, an area where record flooding occurred. The Service Hydrologist surveyed a large area of the Taunton River Watershed, allowing for a suite of impact statements to be generated where previously little information was known.

## Late March Floods

This event was identified on Tuesday, March 23<sup>rd</sup> when the following statement was included into the HWO: “There are also some early signals for another heavy rain event early next week.” By Thursday, March 25<sup>th</sup> enhanced wording was included: “Those with travel plans and/or flood responsibilities early next week should be monitoring forecasts and the forecast trends for the next several days.” On Friday, March 26<sup>th</sup> forecasters expected the Pawtuxet River at Cranston to at least rise above moderate flood stage once again. Other forecast points were forecast to experience renewed flooding as well. Phone briefings were made to RIEMA and Providence Water (which manages Scituate Reservoir) to notify them of the potential flood threat.

Notification of a significant flood threat began on Saturday, March 27<sup>th</sup>. Emergency Management (EM) conference calls mentioned widespread minor to moderate flooding, with major flooding on the Sudbury River at Saxonville (Framingham) and on the Pawtuxet River at Cranston, with Cranston coming close to its record flood set two weeks earlier.

A FFA was issued at 354 pm on Saturday, March 27<sup>th</sup> for the western two-thirds of the CWA, including Rhode Island and Worcester County, MA. On Sunday, March 28<sup>th</sup> the FFA was expanded to cover the entire CWA for rainfall amounts of 3 to 6 inches with locally higher amounts. At 407 pm on the 28<sup>th</sup>, the FFA included the following statement: *“There is a high confidence of moderate to major flooding occurring across portions of the region. This includes river and stream flooding as well as significant urban flooding. Individuals who have experienced flooding in the past month should be taking precautions at this time and be prepared for the potential of a major flood event.”* The initial FFA provided lead time of more than 48 hours.

Nearly 30 EM conference calls were held from Monday, March 29<sup>th</sup> through Wednesday, March 31<sup>st</sup>. WFO Taunton and NERFC participated in several focused calls with the Governor of Rhode Island and State EMA on the severity of flooding along the Pawtuxet as well as the potential for dam failures along the Pawcatuck. Other targeted calls were held with individual cities and towns in Rhode Island and Massachusetts under the greatest flood threat.

A FLW for urban areas and small streams was issued at 1149 am EDT Monday March 29<sup>th</sup> for all of Rhode Island, northern Connecticut, and the majority of Massachusetts: the warning was valid for 24 hours. The warning included the strong language that *“Flooding will be at least as worse (bad) as it was 2 weeks ago. This is going to be a prolonged period of urban and small stream flooding from this afternoon...lasting well into Tuesday morning.”* The first flood reports occurred at 940 pm yielding **10 hours of lead time** to the first substantial impacts. Numerous flood reports were relayed to WFO Taunton during the overnight hours of the 29<sup>th</sup> to 30<sup>th</sup>. Subsequent FLWs mentioned *“widespread and potentially severe dangerous flooding.”*

The first River FLW to be issued was for the Pawtuxet River at Cranston at 1152 am Monday, March 29<sup>th</sup>. The forecast crest (16.1 feet) was higher than the record set two weeks earlier (14.98 feet), with additional rises possible thereafter. WFO Taunton issued 27 River FLWs for this event (out of its 36 River Forecast Points). **The POD was 0.95, with a FAR of 0.19. Average LT to Flood Stage was 18 hours and 19 minutes.** The POD far exceeded the NWS GPRA+ goal of 0.82.

There were several Best Practices from this event. Firstly, *WFO Taunton and ERH coordinated on augmenting staffing prior to the event.* Two staff members from ER HSD were sent to assist with flood operations. This proved to be very helpful during the height of the flooding and relieved staff to accomplish other mission critical duties. In addition, *WFO Taunton and NERFC saw the threat of several forecast points climbing above the maximum height of their associated rating tables.* As a result WFO Taunton contacted surrounding USGS offices to request rating curve extensions for those locations. NERFC forecasts indicated the threat that the Nashua River at East Pepperell would exceed its maximum recordable stage of 14.07 feet as it did during the middle of the month. WFO Taunton notified the USGS MA/RI Water Science Center and the USGS installed a temporary river gage on top of the gage house to allow for river stage data to be transmitted from the site beyond the physical capabilities of the existing equipment. The river rose to within a few tenths of a foot of the maximum recordable stage. Finally, *the WFO Taunton Service Hydrologist was again freed up to complete a flood survey of the Pawtuxet River shortly after the river crested, and was also freed up to survey the Pawcatuck River in order to create impact statements for the Westerly gauge.*

One lesson learned dealt with keen interest in the preceding flood crests by media and other external partners. Multiple requests were made for river crest information from the mid-March flood event to be available via AHPS. Many of these crests were entered into the database as time allowed in-between mission critical duties, but a comprehensive listing was not completed. *In the future, it is recommended to ensure recent crests are entered into Hydrobase as soon as possible.*

A second lesson learned was that there was a need for more information on the Pawcatuck River watershed in RI. At the time, no Pawcatuck River gauges and associated flood stages were available on AHPS. The media requested that more information become available for this river, in particular for Westerly. As a result, WFO Taunton and NERFC will establish a daily forecast point along the Pawcatuck at Westerly beginning in March, 2013.

The March, 2010 floods were historical. As a result, an extraordinary number of local and national media briefings were provided by WFO Taunton and NERFC. Ed Capone, Service Coordination Hydrologist at NERFC, was even interviewed by Brazil's Globo TV! The following are some comments from external partners from the March, 2010 flood events:

*"I would like to state that your info starting Sunday, 3/28 and proceeding forward was right on the button. Your conference calls and summaries were great and allowed me to provide meaningful and accurate info. Could not ask for more."*

*"...the whole team at the NWS Offices in Taunton, including the NERFC, as always do a fantastic job on behalf of the population in Southern New England. Your expertise, professionalism and caring set you apart from your counterparts across the country. I am never ashamed to tell folks when I travel that we enjoy such a terrific relationship with our Weather Office. You are many times the unsung heroes of these events. Keep up the great work!"*

*"I thought the conference calls and services provided were outstanding!"*

*"I think the communication on scope and severity was on target and frankly probably allowed more preparation than would have occurred without it. I believe most people understand this is not an exact science, but think you had a measured response and issued timely alerts to get attention and action when needed."*

*"Thank you all very much for your expertise, guidance, and heart during the month of March 2010. I know all of you and your staffs went above and beyond being personally committed to your mission...Your team dedication to emergency management is truly appreciated."*

*"Why is there no information (hydrograph/flood stage) information on the Pawcatuck River in the Westerly area of Rhode Island on this site? All I could find from the main page was a "current stage" that I get by sliding my cursor over the New England map."*

## **5. Summary of Best Practices and Recommendations**

A weather pattern featuring deep tropical moisture and persistent blocking over eastern Canada brought excessive rainfall and record flooding to southern New England in March, 2010. WFO Taunton forecasters identified the potential for significant flooding up to one week prior to each of the three events and held focused conference calls with the most vulnerable communities.

The following is a summary of Best Practices from the March, 2010 floods:

- 1. WFO Taunton accurately conveyed the threat for significant flooding.** The potential for significant flooding was highlighted in HWOs up to one week in advance of each event. FFAs were issued with up to 48 hours of lead time. Areal FLWs provided 6 to 10 hours of lead time. River FLWs far exceeded FY 2010 GPRA+ Goals and gave more than 18 hours of lead time.
- 2. The use of historical reference (Mother's Day Floods of 2006) and enhanced wording ("There is a high confidence of moderate to major flooding") in flood products conveyed the significance of the flood threat to external partners.**
- 3. WFO Taunton and ERH coordinated on augmented staffing prior to the event.** Two staff members from ER HSD were sent to assist with flood operations. This proved to be very helpful during the height of the flooding and relieved staff to accomplish other mission critical duties.

4. ***WFO staff contacted the USGS when gauges malfunctioned.*** Prior to the second and third flood events, the Service Hydrologist provided instructions to the staff on contacting the USGS. This enhanced quick turnarounds on repairs or helped explain deficiencies during the height of the flood events.
5. ***WFO staff contacted the USGS to request rating curve extensions when several forecast points threatened to exceed their rating table thresholds.*** USGS was also able to install a temporary gauge on the Nashua River at East Pepperell when the maximum recordable level was threatened.
6. ***Flood surveys were conducted during and after the events.*** WFO staff helped cover flood operations in order to free up the Service Hydrologist and Hydrology Focal Point. This allowed for significant enhancements or creation of new impact statements for key river gages.
7. ***The staff “adopted” forecast points to help enhance river gauge impact statements based on flood reports from the two high water events.*** This teamwork resulted in updated impact statements for several river gauges and greatly assisted the Service Hydrologist, since there were so many river gauges which were impacted by significant or record flooding.

The following are Recommendations from the March, 2010 floods:

1. WFO staff did an outstanding job on keeping up with numerous flood related products, including HWOs, FFAs and FLWs. There were only a couple of instances where a FLW extension occurred within a minute or a few minutes after the preceding product expired. ***Staff should remain vigilant of extending FLWs, when warranted, with a buffer of at least one hour on very long duration (12 hour or more) FLWs.***
2. WFO did not conduct EM conference calls prior to the first flood event. ***EM conference calls should be scheduled for any widespread flood events.***
3. During the first flood event, some river stage forecasts failed to appear in FLWs or FLSs but were available on AHPS. ***WFO staff should thoroughly proofread River FLWs and FLSs to ensure critical information is not missing. In addition, the Service Hydrologist should ensure that the latest Riverpro templates from the WHFS support team are in Riverpro.***
4. If a gauge reaches its maximum recordable level, the observe hydrograph will “flatline” and will falsely indicate the river is cresting. ***Maximum recordable river levels for River Forecast Points should be researched, in particular so that when a river gage is forecast to reach or exceed that level, collaboration with the local USGS office can occur and concern can be conveyed to WFO staff.***
5. There is a need for observed and forecast river levels along the Pawcatuck River. During the floods, the media requested that more information become available, in particular for Westerly. ***WFO and NERFC should establish a daily forecast point along the Pawcatuck at Westerly. Flood categories and impact statements should be added to AHPS. (Addendum: Daily forecast services will commence in March, 2013).***
6. There was high interest in preceding flood crests by media and other external partners. Multiple requests were made for river crest information from the mid-March flood event to be available via AHPS. Many of these crests were entered into the database as time allowed in-between mission critical duties. ***It is recommended to ensure recent crests are entered into Hydrobase as soon as possible.***



## **6. Acknowledgements**

This Storm Series Report was written by Senior Service Hydrologist Nicole Belk and Science and Operations Officer Joe DelliCarpini. It was reviewed by the WFO Taunton Science and Training Team and NERFC HIC David Vallee.

## **7. Reference**

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