2015 Hydrologic Conditions in the Delaware River Basin

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

Prepared by Water Resource Operations Staff
May 2016

Hydrologic Conditions in the Delaware River Basin
Annual Report 2015

Hydrologic Highlights

Drought Declarations in Pennsylvania and New Jersey Due to Dry Conditions

Dry conditions impacted the northeastern portion of Pennsylvania during early 2015 resulting in low groundwater recharge. Due to below-normal groundwater levels, the Pennsylvania Department of Environmental Protection (PADEP) issued a drought watch on March 24 for 27 counties. Eight of these counties were in the Delaware River Basin (DRB): Berks, Carbon, Lackawanna, Luzerne, Monroe, Pike, Schuylkill, and Wayne. A drought watch is the first and least severe of three drought classifications in Pennsylvania. Residents in counties under the drought watch were requested to conserve water by limiting non-essential water use.

Below-normal precipitation continued through the spring and on June 17 the drought watch was expanded to 10 additional counties, including Lehigh and Northampton in the DRB. Conditions improved by early summer with above-normal rainfall during June. The 30-day average streamflow increased and groundwater levels returned to normal or above-normal conditions. Consequently, PADEP lifted the drought watch for all 37 counties on July 10, 2015.

A similar situation occurred in northern New Jersey later in 2015 due to low precipitation during the summer and stressed drinking water supply reservoirs. Concerned that the dry weather would continue into autumn, the New Jersey Department of Environmental Protection (NJDEP) issued a drought watch on September 23 for the Northeast, Central, and Coastal North regions of the state. These regions include small sections of the following DRB counties: Morris, Hunterdon, Mercer, Monmouth, and Ocean. NJDEP urged residents in these counties to conserve water, especially for non-essential uses such as lawn watering and car washing. Conditions did not improve during the remainder of the year and the drought watch was still in effect at the end of 2015.

Cannonsville Dam Repairs

Turbid water was observed coming from a rock embankment below Cannonsville Dam during July 2015. The observation was made as borings were being drilled at the dam site in preparation for a 14-megawatt hydroelectric facility. The turbid flow was the result of the drilling, which had released naturally pressurized groundwater and sediment from the borings into the West Branch Delaware River. As a precaution and to facilitate repairs, the New York City Department of Environmental Protection (NYCDEP) reduced Cannonsville's storage by increasing drinking water diversions and downstream releases. The turbid flow was stopped on August 1 after relief wells were used to pump groundwater from the pressurized aquifer that was discharging the sediment into the river. To complete the repair, the original bore holes were enclosed with casing and sealed with grout. The extra diversions and releases ceased as of August 5 and operations at Cannonsville returned to normal. During the July 15 - August 5 repair period, Cannonsville's storage was reduced from 97 percent to 73 percent through the extra diversions and releases. This represents an approximate 16.5-foot drop in the storage elevation.

Precipitation

The majority of the DRB counties (for which information is available) experienced below-normal precipitation during 2015[1]. Only 10 of the 38 reported counties, all located in the southern portion of the basin, recorded normal to above-normal precipitation during the year. Annual precipitation totals ranged from 35.3 inches in Lackawanna County, Pa. to 52.5 inches in Cumberland County, N.J. Departures from the annual normal precipitation ranged from 10.4 inches below normal in Lackawanna County to 9.1 inches above normal in Cumberland County. Figure 1 presents the annual precipitation by county in the DRB.

The precipitation amounts at Montague, N.J., Trenton, N.J., and Wilmington, Del. are used to represent the regional precipitation throughout the DRB[2]. The observed precipitation above Montague for 2015 was 43.3 inches, or 2.0 inches below normal. Similarly, observed precipitation above Trenton was 44.1 inches, or 3.9 inches below normal. Precipitation at Wilmington was 48.7 inches, or 5.7 inches above normal. Table 1 presents normal and observed monthly precipitation totals at selected locations in the DRB for 2015.

Streamflow

Observed monthly mean streamflows along the main stem of the Delaware River and its two-largest tributaries, the Lehigh and Schuylkill rivers, were below normal during much of the first half of the year. These low flows followed a period of below-normal precipitation that began during the autumn of 2014. The lowest monthly average streamflows of the year occurred during February, when Delaware River flows at Montague and Trenton were 38 and 34 percent of normal, respectively. Similar conditions were observed along the tributaries in February: Lehigh River flows at Lehighton and Bethlehem were 44 percent and 29 percent of normal, respectively, and Schuylkill River flows at Pottstown and Philadelphia averaged 40 percent and 37 percent of normal, respectively.

Above-normal rainfall in late June increased streamflows in July and resulted in some of the highest monthly average flows of 2015. The Delaware River at Montague and Trenton averaged 270 percent and 261 percent of normal flow, respectively, during this time. Tributaries throughout the basin also experienced above-normal flows during July. Lehigh River flows at Lehighton and Bethlehem averaged 318 percent and 249 percent of normal, respectively. Similarly, streamflow along the Schuylkill River at Pottstown and Philadelphia averaged 233 percent and 244 percent of normal, respectively. Normal to above-normal streamflow continued into September. Flows declined during the autumn months and generally averaged normal to below normal through the end of the year.

Table 2 presents observed monthly mean streamflow at selected stations for 2015. Figure 2 and Figure 3 present annual hydrographs for 2015 at Montague and Trenton, respectively.

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[1]This information is based on precipitation data from the National Weather Service Middle Atlantic River Forecast Center (NWS MARFC) for 38 of the 42 counties located either partially or completely in the Delaware River Basin. Data for four counties is not available. The NWS uses several precipitation gages in each county to calculate the average precipitation for each county. Annual precipitation departures are calculated by DRBC staff using the NWS MARFC data.

[2] Selected precipitation data was provided by the National Weather Service and the Delaware River Master's Office. Annual precipitation departures are calculated by DRBC staff using the provided data.

Reservoir Storage

Lower Basin

Both Beltzville Reservoir (located on the Pohopoco Creek, a tributary of the Lehigh River) and Blue Marsh Reservoir (located on the Tulpehocken Creek, a tributary of the Schuylkill River) maintained storage in the normal range during 2015. Consequently, the Delaware River Basin Commission's (DRBC) lower basin drought operating plan was not implemented. Additionally, the commission was not required to make releases from the Lower Basin reservoirs during 2015 to maintain the Delaware River streamflow objective of 3,000 cubic feet per second (cfs) at Trenton.

No releases were made from Merrill Creek Reservoir during 2015. Storage in this reservoir, located near Phillipsburg N.J., is used to replace evaporative losses caused by power generation when the basin is under DRBC-declared drought operations and the equivalent average daily flow target for the Delaware River at Trenton is below 3,000 cfs.

Figure 4 and Figure 5 present 2015 reservoir elevations for Beltzville and Blue Marsh, respectively. Beltzville's elevation was below normal at the start of 2015, resulting from drawdown due to DRBC-directed releases made the previous autumn to maintain Trenton's streamflow objective. Beltzville returned to normal elevation in early February 2015.

Figures 4 and 5 show a decrease in storage in Beltzville and Blue Marsh reservoirs during the period September 30- October 2, 2015. Based on weather forecasts, the U.S. Army Corps of Engineers released extra water to create additional storage space in the reservoirs in anticipation of Hurricane Joaquin; however, the final track of the storm did not impact the DRB.

Upper Basin

The three New York City (NYC) Delaware reservoirs -- Cannonsville, Pepacton, and Neversink -- are located in the upper DRB and are operated under the Flexible Flow Management Program (FFMP)[3]. Combined storage did not go below the drought watch level during 2015; consequently, DRBC's basinwide drought operating plan was not implemented.

On January 1, 2015, combined storage in Cannonsville, Pepacton, and Neversink reservoirs was 183 billion gallons (BG), which is 68 percent of their usable capacity and approximately 42 BG below the long-term median usable storage for that date. Combined storage decreased during the first quarter of the year to only a few billion gallons above the drought watch curve; this was deceiving, however, because significant storage was contained in the snowpack above the NYC reservoirs. On March 31, 2015, the snow survey conducted by NYCDEP indicated an average snow water equivalent (SWE) of 3.0 inches, or 49 BG. Historically, the snow water equivalent for late March is 17 BG. The snowpack surrounding the reservoirs melted as the spring season progressed, increasing storage and averting a drought watch condition. Although the reservoirs did not refill by the normal refill goal of May 1, they were full by July 1. Storage was above the long-term median until mid-October, after which below-normal storage persisted for the remainder of 2015. As of December 31, 2015, combined storage in Cannonsville, Pepacton, and Neversink reservoirs was 213 BG, which is 79 percent of the usable capacity and 12 BG below the long-term median usable storage for that date. Figure 6 presents NYC reservoir storage levels for 2015.

[3] Beginning in October 2007, the NYC reservoirs were operated in accordance with the FFMP, a temporary operations plan unanimously approved by the parties to the 1954 U.S. Supreme Court Decree (four basin states and NYC).

The Delaware River Master directed releases of water from the NYC reservoirs in 2015 to meet the normal flow objective of 1,750 cfs for the Delaware River at Montague. Between May and October, approximately 39 BG[4] was required to meet the Montague flow objective and more than 80 percent of these releases were made during the drier periods in September and October. In comparison, the River Master directed releases totaling 43 BG in 2014 and 101 BG during the drought year 2001.

Groundwater

New York

The groundwater levels in the Sullivan County well remained within the normal[5] to slightly above-normal range throughout much of the year. Periodic decreases below the 25th percentile were observed during drier periods in February-March and the autumn season. Figure 7 presents the observed and median depth to water levels in this USGS well.

Pennsylvania

Groundwater levels in five selected USGS county observation wells were used to represent Pennsylvania's groundwater conditions during 2015. The individual wells were selected according to their geographic locations in the Pennsylvania portion of the DRB: Wayne County WN 64 (northern), Schuylkill County SC 296 (western), Lehigh County LE 644 (central), Bucks County BK 1020 (eastern), and Chester County CH 10 (southern).

In the upper basin, water levels in the Wayne County and Schuylkill County observation wells decreased at the start of 2015. The Wayne County well was below the 25th percentile for most of the first half of the year before recovering to the normal to above-normal range during the remainder of the year. The Schuylkill County well water levels were variable, frequently below the 25th percentile during the drier first half of the year and again in the fall.

Water levels in the Lehigh County and Bucks County observation wells generally remained within the normal range for most of the year. The Lehigh County well level was below the 25th percentile in response to dry conditions during February-March and again during November-December. The Bucks County well seasonally declined throughout the summer months, but only briefly was below the normal range during October and December.

Levels in the Chester County well were variable throughout the year. Water levels briefly were below the 25th percentile during late winter and spring, but then recovered. Levels showed a seasonal decline during the summer and dropped below normal again by late August.

All five Pennsylvania observation wells ended the year within the normal range after the basin received above-normal precipitation during December. Figure 8 presents the observed and median depth of groundwater levels in the five observation wells.

[4] Directed release information supplied by the Office of the Delaware River Master.

[5] Water level ranges for the USGS wells are defined as: Above Normal (>75-percentile); Normal (25- to 75- percentile flows); Below Normal (<25-percentile).

Delaware

The groundwater level in the Delaware Geological Survey (DSG) coastal plain well located in New Castle County remained within the normal range during 2015. Figure 9 presents the historical depth to water levels as the 25th and 50th percentile values and the mean, as well as the 2015 groundwater observations.

New Jersey

The groundwater level in the USGS Cumberland County coastal plain well remained above the normal range for most of 2015. Figure 10 presents the historical groundwater levels as the 25th and 50th percentile values and the mean, as well as the depth to water observation from 2015.

Salt Front

The salt front is defined as the 250 parts-per-million (PPM) isochlor. The seven-day average location of the salt front is used by DRBC as an indicator of salinity intrusion in the Delaware Estuary. The salt front's location fluctuates along the main stem Delaware River as streamflow increases or decreases in response to inflows, diluting or concentrating chlorides in the river. Long-term median mid-month locations range from river mile 67 in April (two miles downstream of the Delaware Memorial Bridge) to river mile 76 in September (two miles downstream of the Pennsylvania-Delaware State line).[6]

The farthest upstream location of the salt front in 2015 was river mile 81 in late October. This location is three miles upstream of the Pennsylvania-Delaware state line. By comparison, the farthest recorded upstream location of the salt front measured during the 1960's drought of record was river mile 102. Figure 11 presents the seven-day average location of the 250-PPM isochlor during 2015.

[6] The normal salt front location has been updated based on data from January 1998-February 2013.

Figure 1: 2015 Annual Precipitation in the Delaware River Basin

Total Precipitation (top) and Total Departure from Normal (bottom) in Inches

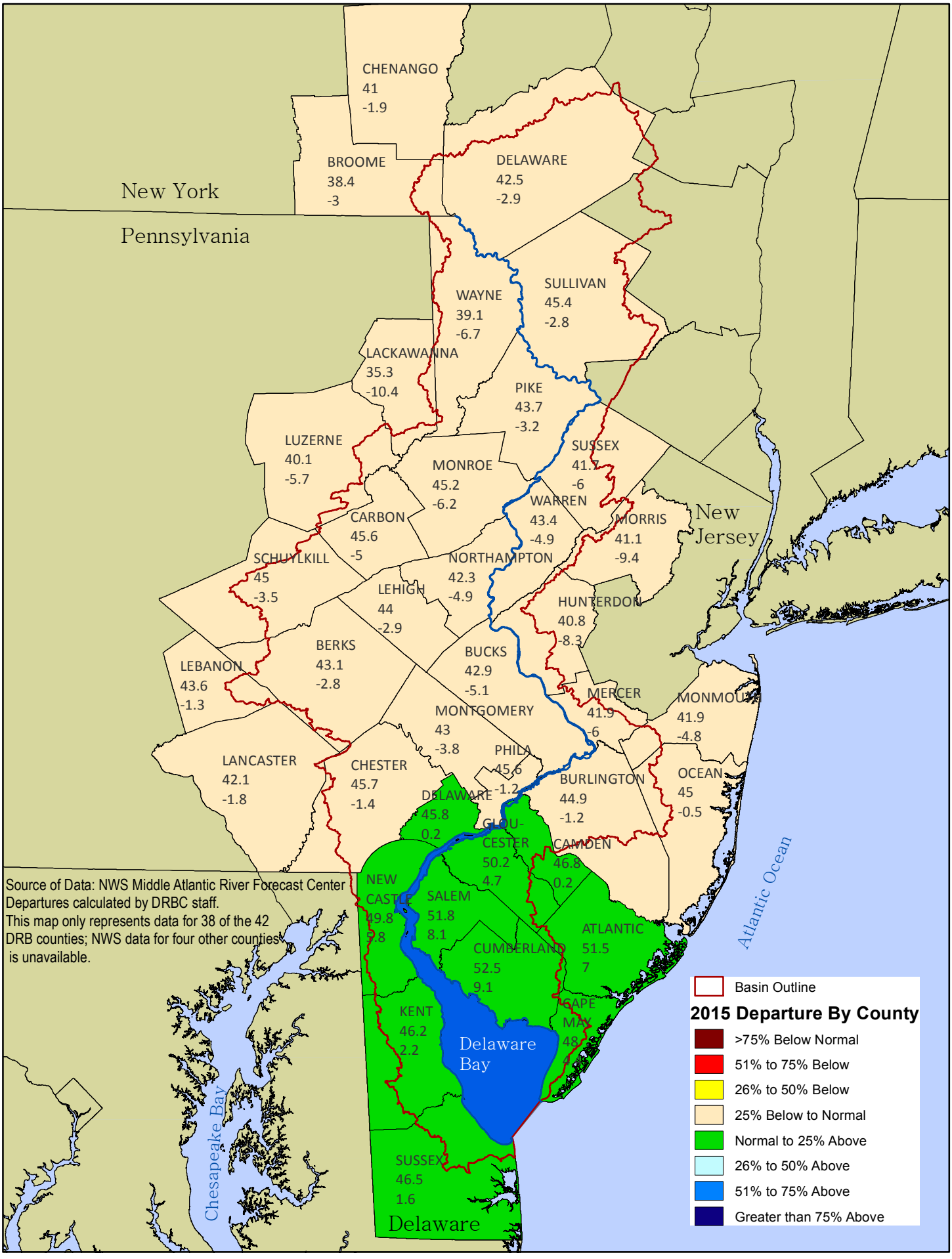


TABLE 1: 2015 PRECIPITATION AT SELECTED STATIONS IN THE DELAWARE RIVER BASIN (INCHES)

	AVG ABOVE MONTAGUE, NJ		ALLENTOWN, PA		AVG ABOVE TRENTON, NJ		READING, PA		PHILADELPHIA, PA		WILMINGTON, DE	
	NORM	OBS	NORM	OBS	NORM	OBS	NORM	OBS	NORM	OBS	NORM	OBS
JANUARY	3.10	2.21	3.03	2.72	3.28	2.50	3.05	2.31	3.03	4.52	3.01	4.45
FEBRUARY	2.58	1.59	2.70	1.83	2.79	1.80	2.48	1.43	2.65	2.36	2.68	2.16
MARCH	3.42	2.21	3.39	4.48	3.59	2.90	3.48	4.82	3.79	5.52	3.92	5.39
APRIL	3.92	3.37	3.56	1.77	4.04	3.00	3.77	1.69	3.56	3.58	3.5	4.29
MAY	4.20	2.05	4.14	0.82	4.36	2.76	2.68	1.66	3.71	1.19	3.95	2.39
JUNE	4.41	7.76	4.31	7.59	4.66	7.60	3.78	6.22	3.43	8.88	3.88	12.52
JULY	4.17	4.93	4.95	5.43	4.48	4.40	4.52	3.80	4.35	3.16	4.57	2.32
AUGUST	3.85	3.89	3.69	2.56	4.11	3.90	3.64	3.45	3.50	0.98	3.25	1.52
SEPTEMBER	4.35	4.77	4.62	4.70	4.65	4.60	4.34	5.32	3.78	6.27	4.32	2.50
OCTOBER	4.15	3.89	3.88	3.36	4.41	3.70	3.22	2.47	3.18	3.51	3.42	3.74
NOVEMBER	3.76	2.75	3.50	1.04	3.87	2.60	3.46	0.81	2.99	1.89	3.10	2.25
DECEMBER	3.38	3.92	3.58	4.20	3.76	4.30	3.29	3.56	3.56	5.14	3.48	5.21
TOTAL 2015	**45.29**	**43.34**	**45.35**	**40.50**	**47.99**	**44.06**	**41.71**	**37.54**	**41.53**	**47.00**	**43.08**	**48.74**
DIFF 2015		**-1.95**		**-4.85**		**-3.93**		**-4.17**		**5.47**		**5.66**

NOTES:

1. Average Above Montague, N.J. is based on weighted average of 10 stations.
2. Average Above Trenton, N.J. is based on the weighted average of 99 stations.
3. Precipitation normals for all stations represent average precipitation for period of record (POR) 1981-2010.

Source: National Weather Service, Mt. Holly, N.J.

NORM = Normal
OBS = Observed

TABLE 2: 2015 STREAMFLOW (IN CFS) IN THE DELAWARE RIVER BASIN

OBSERVED MONTHLY MEAN FLOW VERSUS NORMAL[1] MONTHLY FLOW							
		Delaware River @ Montague	Lehigh River @ Lehighton	Lehigh River @ Bethlehem	Delaware River @ Trenton	Schuylkill River @ Pottstown	Schuylkill River @ Philadelphia
Jan	OBS	3,336	821	1,451	7,105	1,400	2,310
	% NORM	65.7%	64.6%	52.2%	50.7%	76.6%	84.2%
Feb	OBS	1,919	454	796	3,943	896	1,422
	% NORM	37.9%	43.9%	29.1%	33.6%	39.7%	36.9%
Mar	OBS	3,984	967	2,765	11,533	3,944	6,426
	% NORM	45.2%	54.7%	72.1%	63.3%	139.0%	139.8%
Apr	OBS	12,265	1,879	3,219	19,563	2,207	2,890
	% NORM	115.1%	107.2%	88.2%	97.1%	83.4%	72.8%
May	OBS	2,545	687	1,293	5,555	975	1,188
	% NORM	44.0%	53.6%	48.5%	47.6%	54.8%	45.5%
Jun	OBS	4,854	1,596	2,620	10,490	2,091	2,738
	% NORM	153.3%	165.6%	131.9%	146.0%	150.6%	148.3%
Jul	OBS	6,586	2,112	3,568	14,199	2,486	3,271
	% NORM	269.7%	318.4%	248.9%	260.5%	233.2%	243.7%
Aug	OBS	2,484	760	1,322	5,341	925	1,122
	% NORM	114.6%	154.1%	118.4%	120.2%	123.6%	103.5%
Sep	OBS	1,946	446	1,170	4,269	983	1,192
	% NORM	96.6%	93.5%	106.5%	96.2%	125.9%	108.1%
Oct	OBS	2,801	706	1,420	5,659	1,411	1,965
	% NORM	105.5%	72.7%	79.1%	94.0%	141.8%	142.1%
Nov	OBS	4,393	797	1,586	8,351	1,005	1,459
	% NORM	96.5%	61.7%	66.8%	83.2%	58.9%	61.7%
Dec	OBS	5,258	1,112	2,413	10,925	1,985	2,771
	% NORM	104.1%	59.2%	74.8%	84.5%	81.8%	76.7%

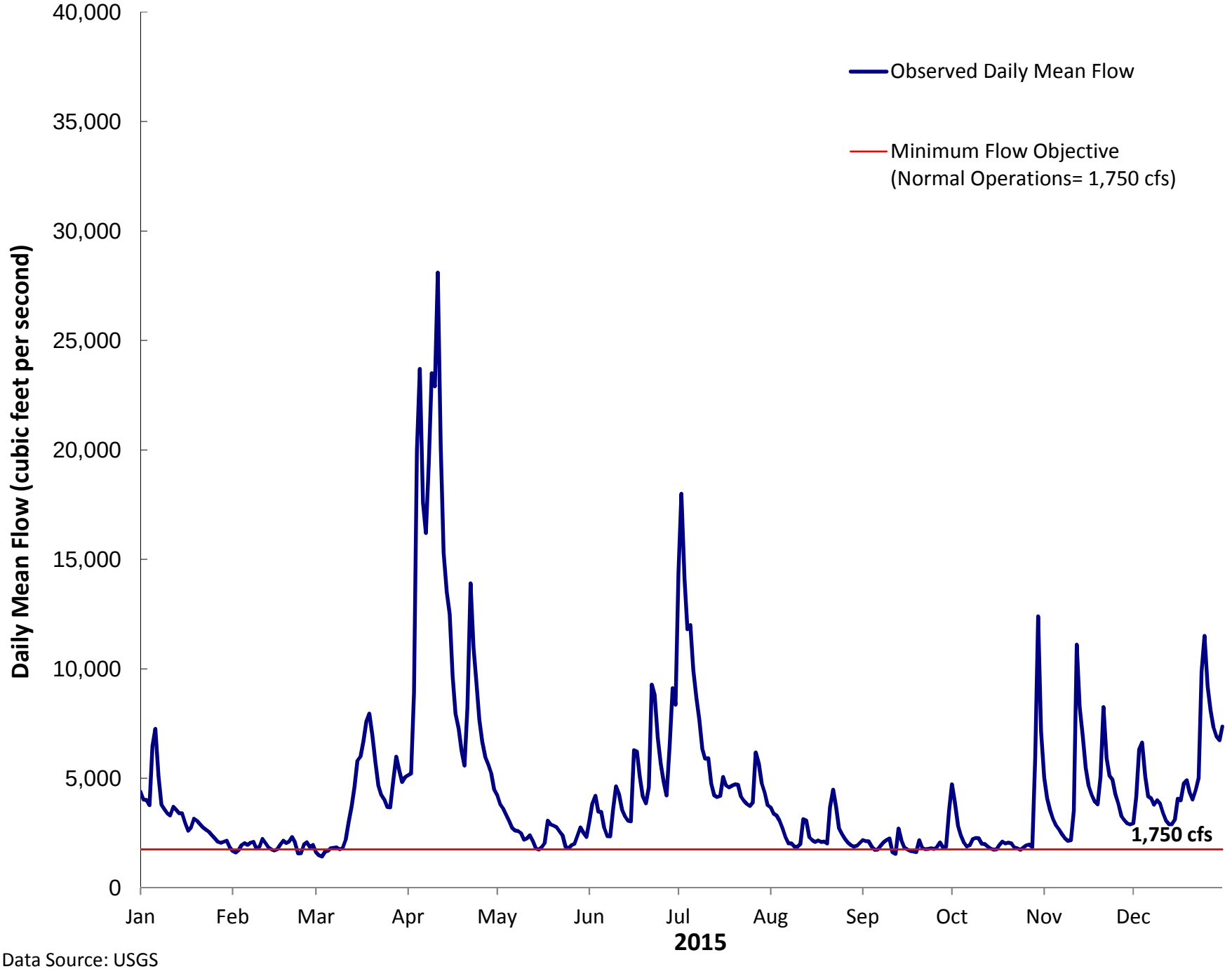
Source: United States Geological Survey streamgage measurements. Based on provisional data and subject to change.

Note:

[1]Median of monthly mean flow values for the following periods of record (POR) were used to calculate the normal monthly flow:

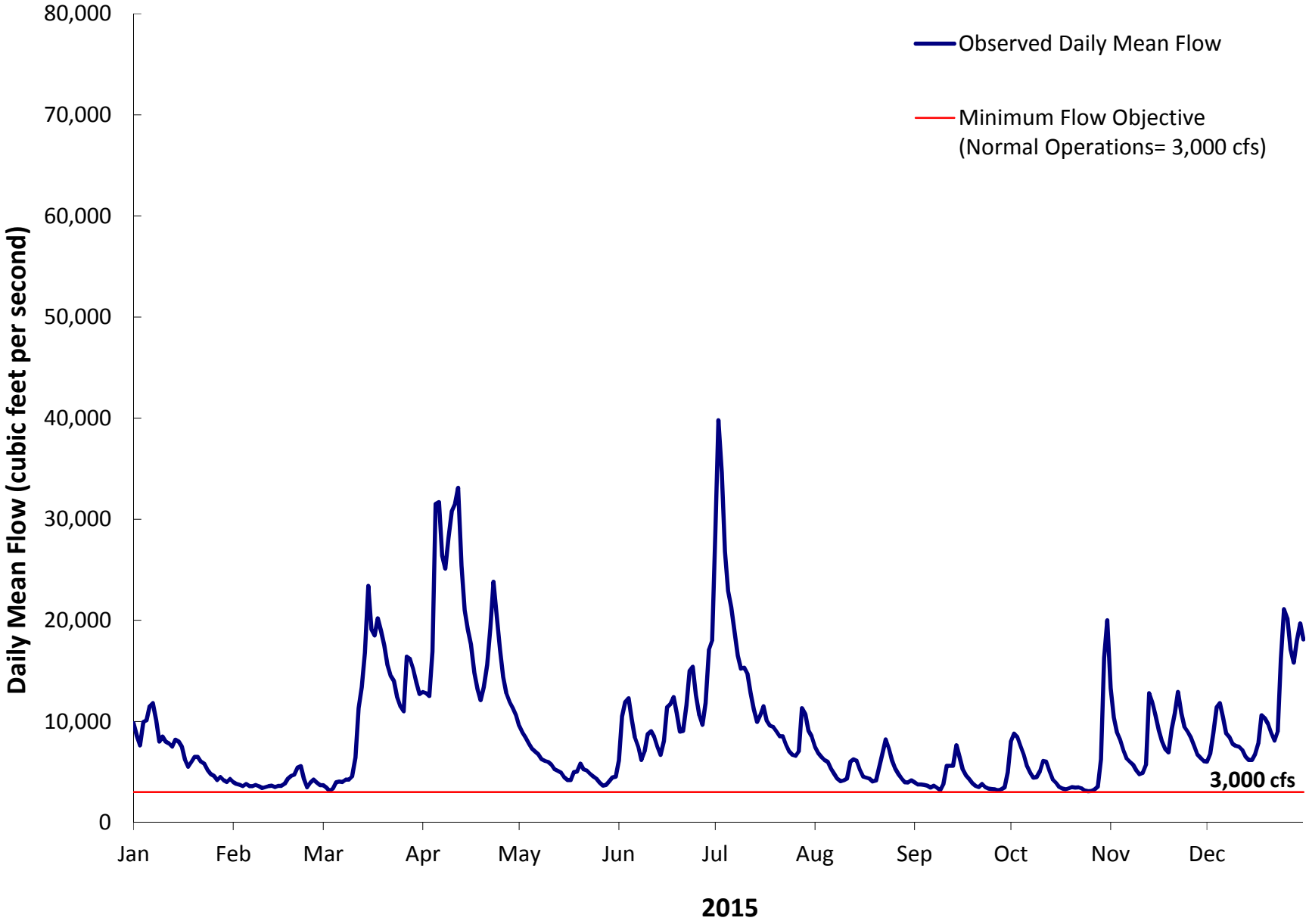
Gage	**POR for Median**
Montague	1956-2011
Lehighton	1983-2011
Bethlehem	1972-2011
Trenton	1972-2011
Pottstown	1980-2011
Philadelphia	1980-2011

FIGURE 2: DELAWARE RIVER AT MONTAGUE, N.J.



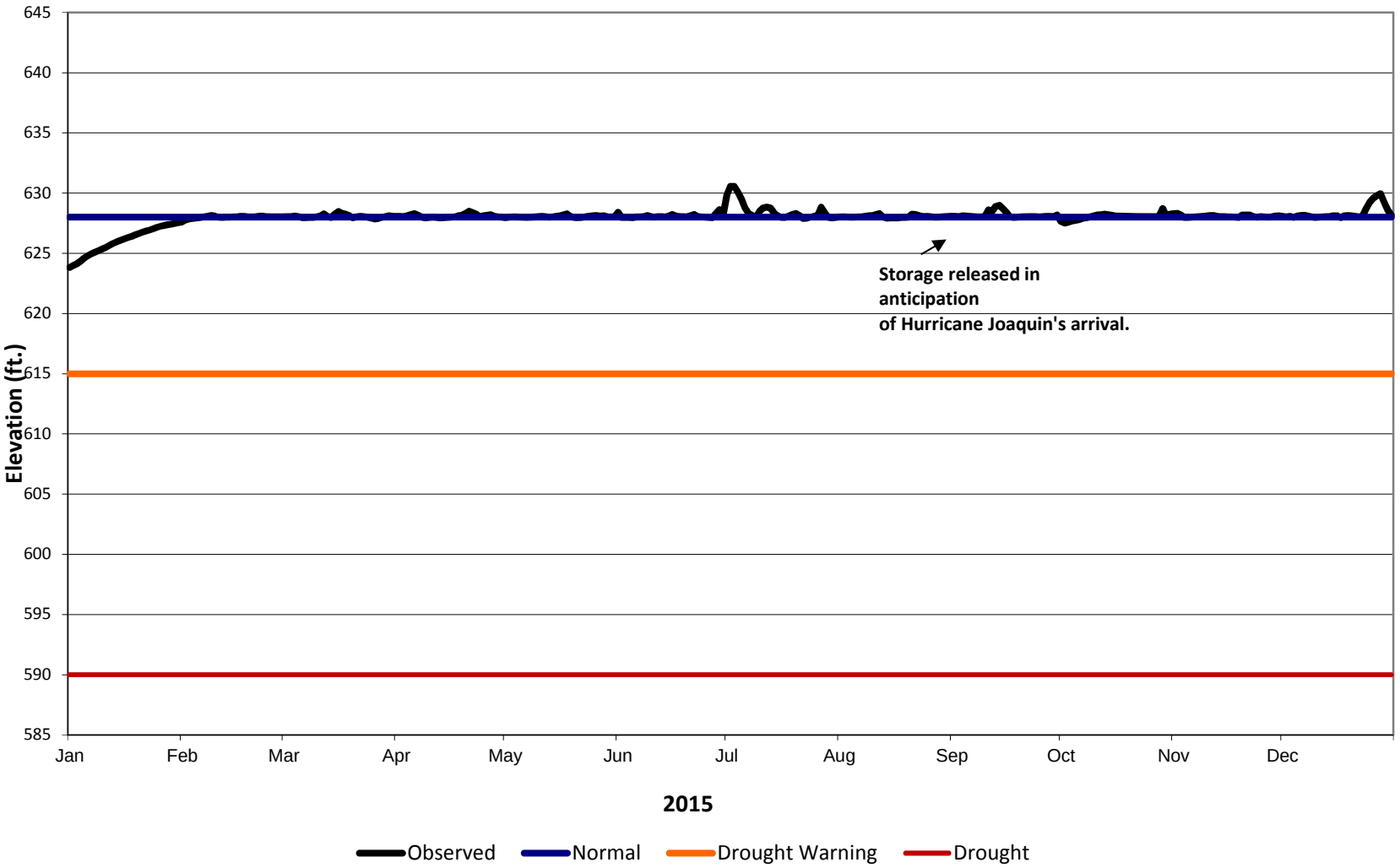
Data Source: USGS
Graph generated by DRBC staff.

FIGURE 3: DELAWARE RIVER AT TRENTON, N.J.



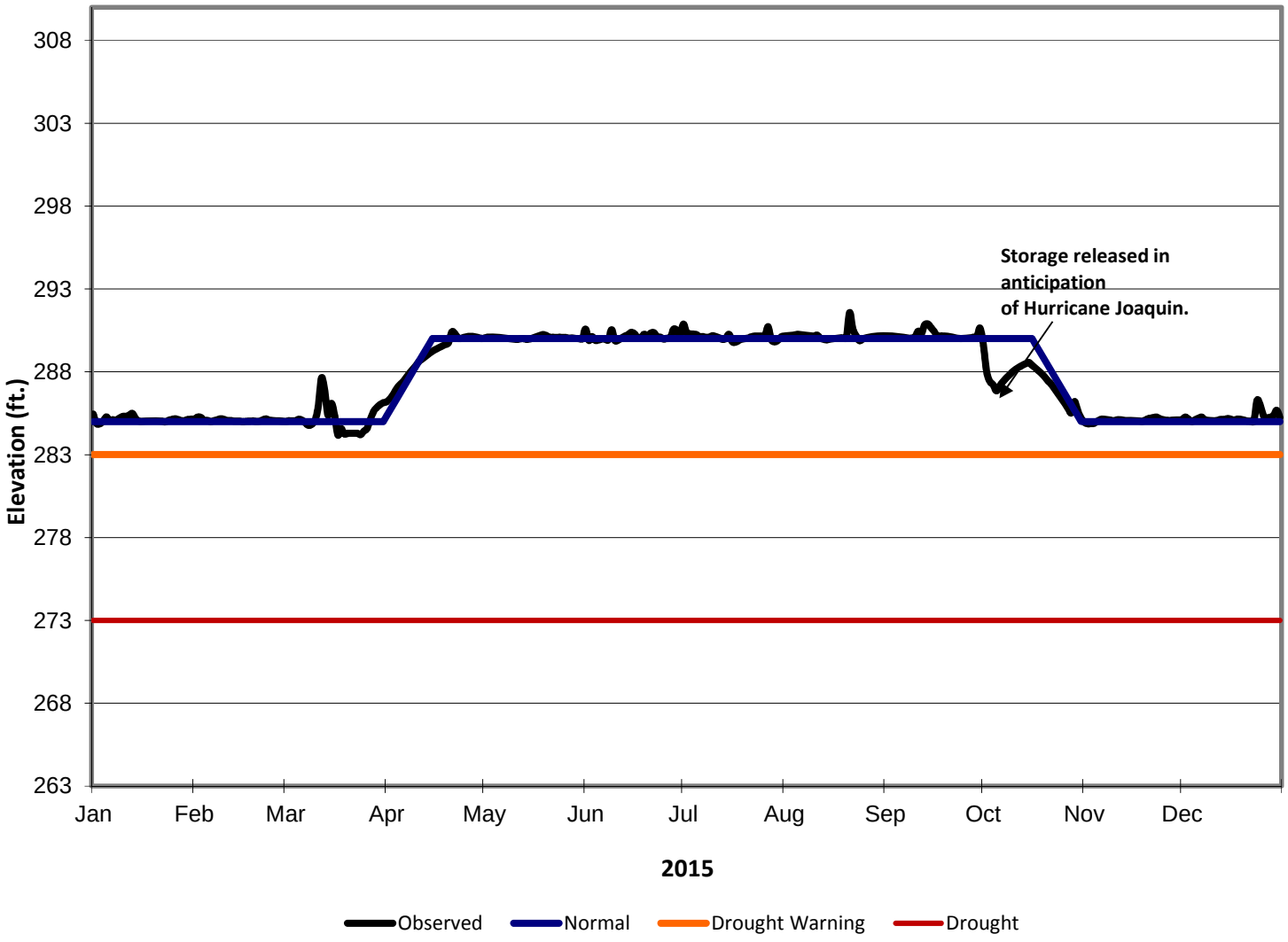
Data Source: USGS
Graph generated by DRBC staff.

FIGURE 4: BELTZVILLE RESERVOIR ELEVATION



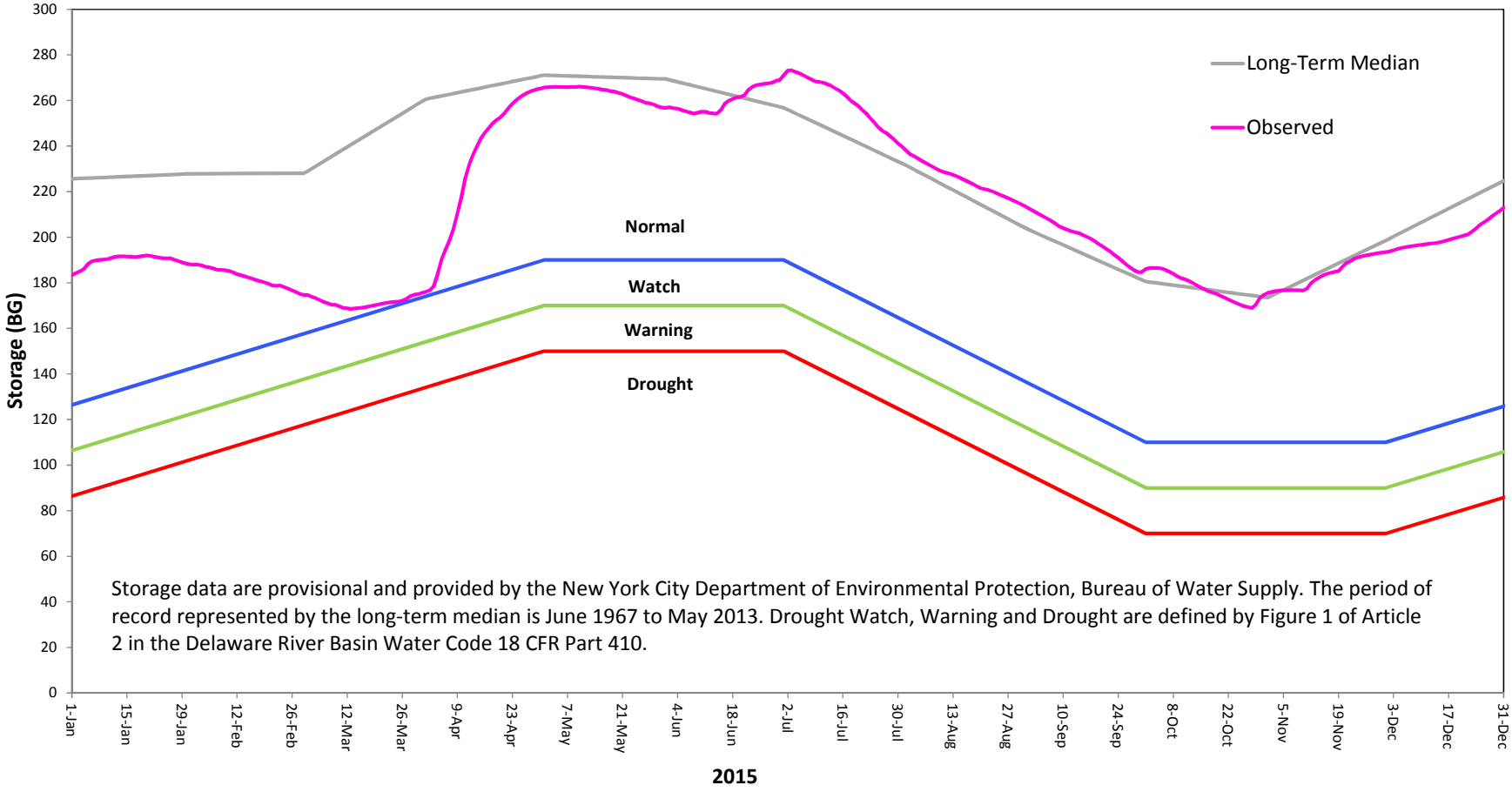
Notes:
1. The normal pool elevation is 628 feet.
2. Data was provided by the Army Corps of Engineers (morning values). Graph generated by DRBC staff.

FIGURE 5: BLUE MARSH RESERVOIR ELEVATION



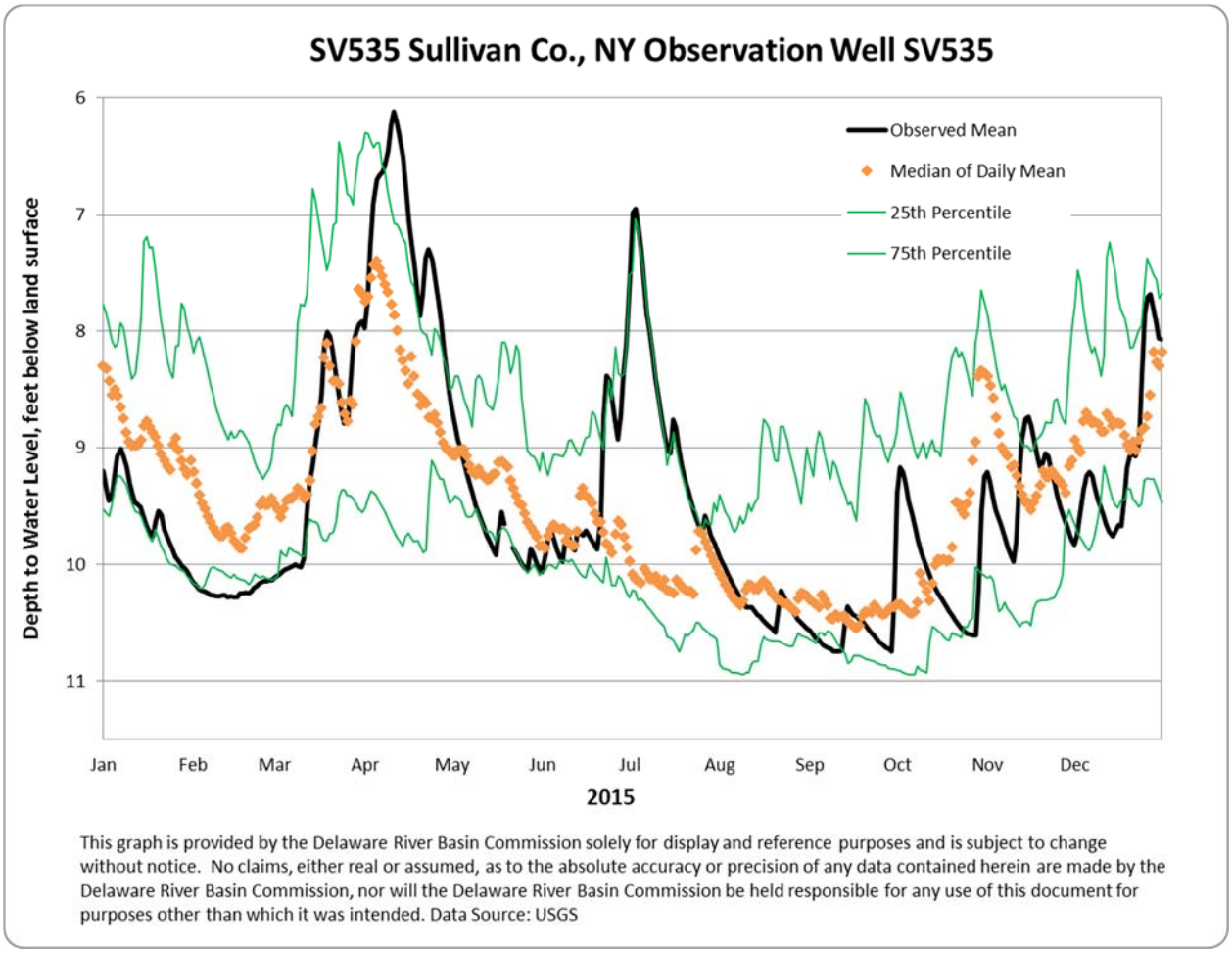
Notes:
1. Winter Pool=285 feet (October- March)/Summer Pool= 290 feet (April-September).
2. Data was provided by the Army Corps of Engineers (morning values). Graph generated by DRBC staff.

FIGURE 6: NEW YORK CITY DELAWARE RIVER BASIN STORAGE 2015



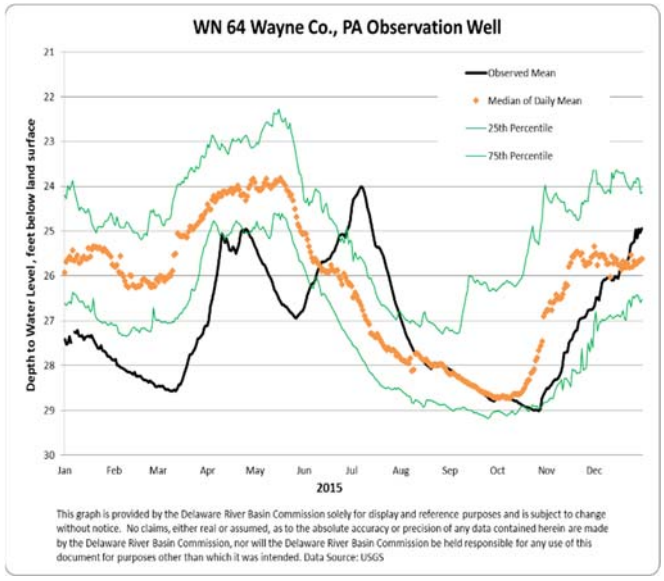
Storage data are provisional and provided by the New York City Department of Environmental Protection, Bureau of Water Supply. The period of record represented by the long-term median is June 1967 to May 2013. Drought Watch, Warning and Drought are defined by Figure 1 of Article 2 in the Delaware River Basin Water Code 18 CFR Part 410.

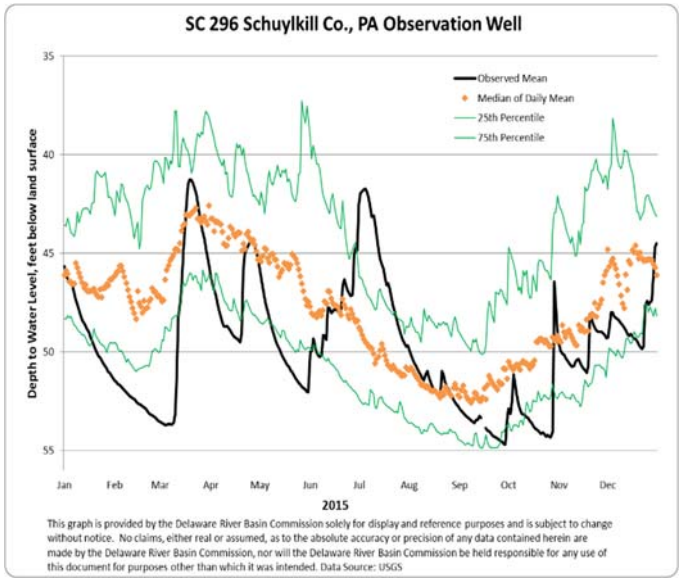
FIGURE 7: USGS WELL-SULLIVAN CO., NEW YORK
Median Depth to Water and 2015 Observations of Depth to Water

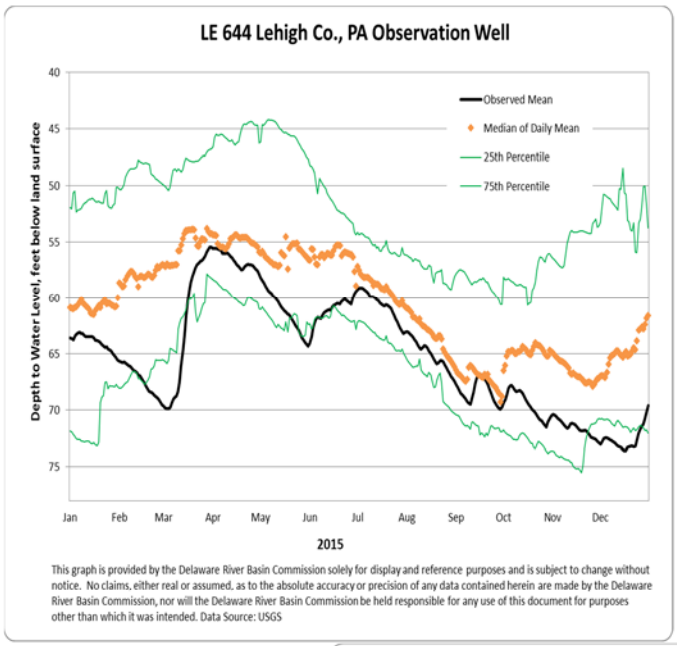


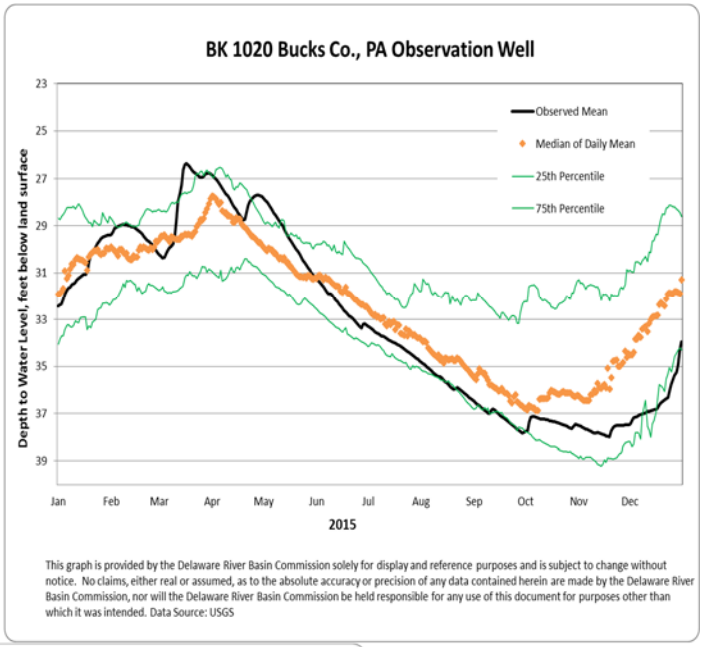
This graph is provided by the Delaware River Basin Commission solely for display and reference purposes and is subject to change without notice. No claims, either real or assumed, as to the absolute accuracy or precision of any data contained herein are made by the Delaware River Basin Commission, nor will the Delaware River Basin Commission be held responsible for any use of this document for purposes other than which it was intended. Data Source: USGS

FIGURE 8: SELECTED USGS OBSERVATION WELLS LOCATED IN PENNSYLVANIA
Median Depth to Water and 2015 Observations of Depth to Water









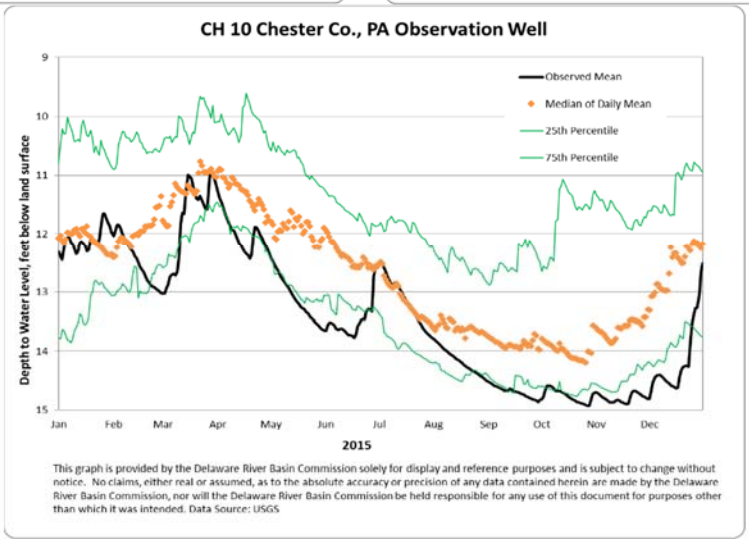


FIGURE 9: DGS WELL-NEW CASTLE CO., DELAWARE
Average Depth to Water and 2015 Observations of Depth to Water

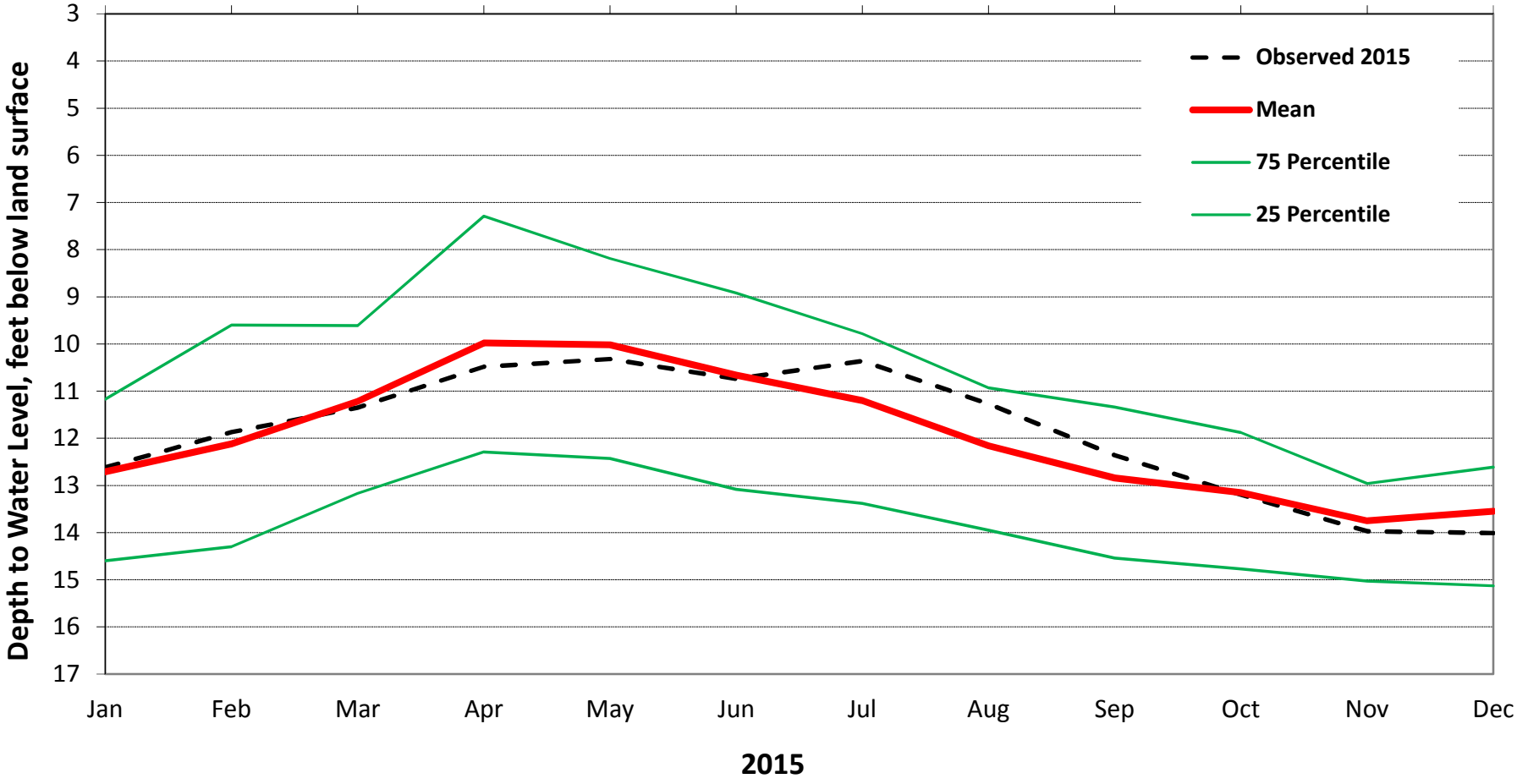


FIGURE 10: USGS WELL-CUMBERLAND CO., NEW JERSEY
Average Depth to Water and 2015 Observations of Depth to Water

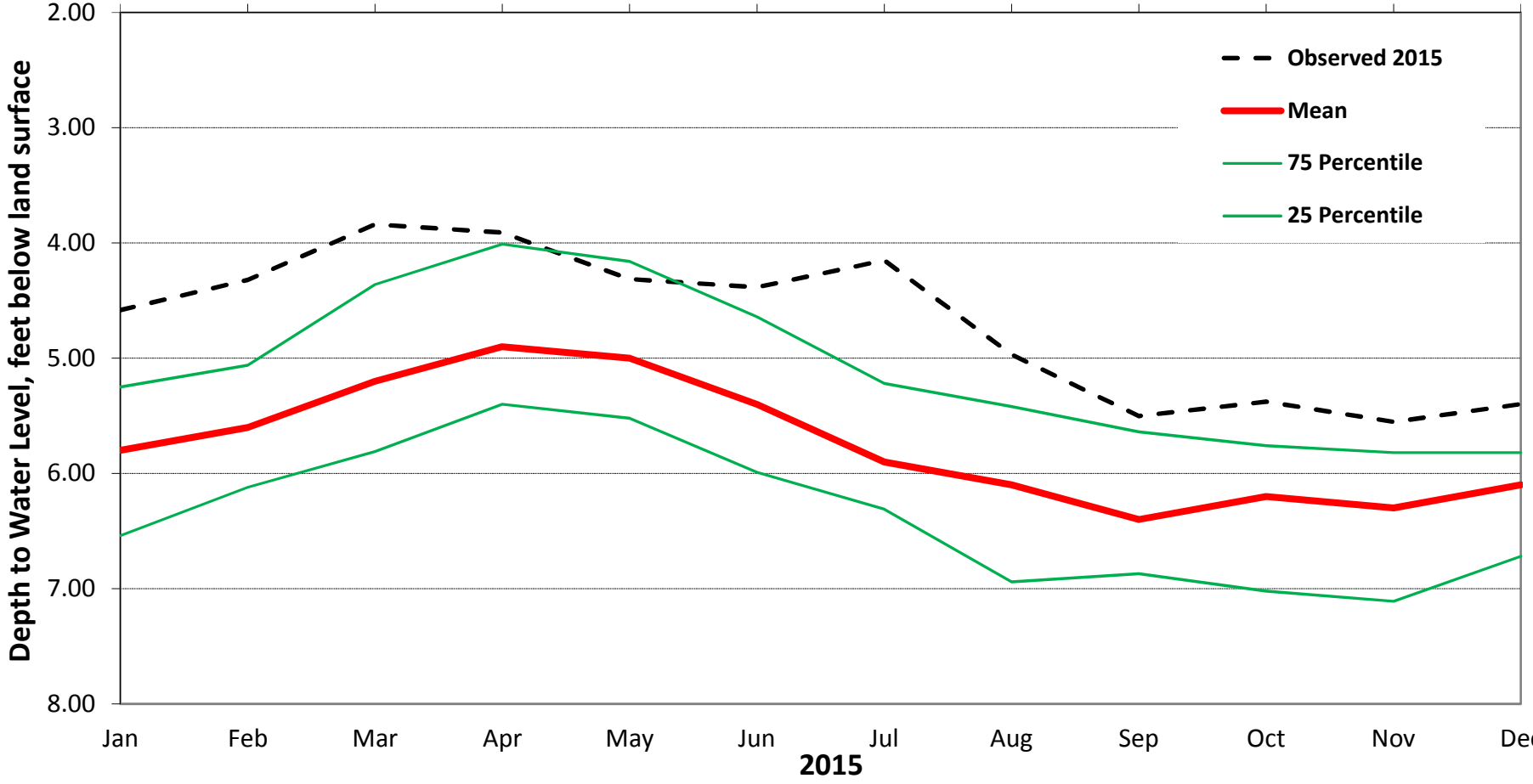
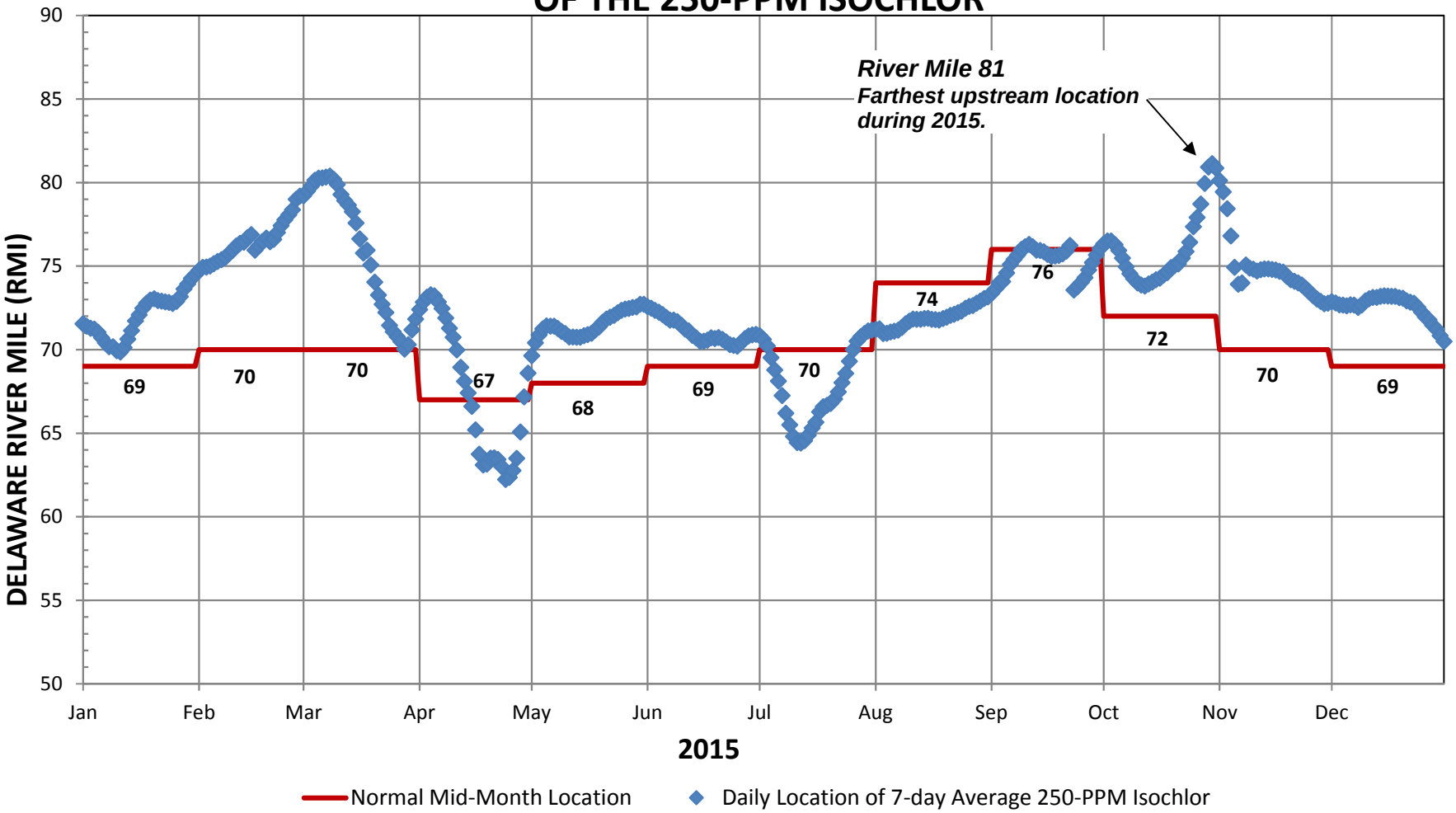


FIGURE 11: 7-DAY AVERAGE LOCATION OF THE 250-PPM ISOCHLOR



Notes:
1. DRBC does not estimate locations below river mile 54.
2. The normal mid-month location of the salt line represents the median location based on data from January 1998 through February 2013.
3. Data sources are USGS and Kimberly Clark Corporation.
4. PPM=parts per million