

2014

Hydrologic Conditions in the Delaware River Basin



Ice jam at Trenton, N.J. during January 2014. (Photo courtesy of DRBC)



Prepared by Operations Section Staff
Water Resource Management Branch
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Annual Report 2014

Hydrologic Highlights

Ice Jams

Arctic air produced extensive icing throughout the Delaware River Basin (DRB) during January and February 2014. Although frigid temperatures kept the river ice stable and prevented serious flooding, two jams in the lower basin caused localized problems.

In early January, large chunks of ice formed a mile-long jam along the Delaware River at Trenton, N.J. The jam covered the river from bank to bank causing water to back up and raise the river above flood stage at the U.S. Geological Survey (USGS) gage at Trenton. Flood stage is 20 feet and the stage at the Trenton gage rose as high as 20.76 feet on January 8. The National Weather Service (NWS), concerned about flash flooding if the jam suddenly broke apart, issued flood warnings for Bucks County, Pa. and Mercer County, N.J. Fortunately, flash flooding did not occur, but several locations were impacted by ice and water displaced by the jam. The New Jersey State House garage was closed for two days due to ice impacts and several road closures occurred, including the southbound lanes of Route 29 in Trenton and Route 32 in Yardley, Pa. The U.S. Coast Guard sent three ice cutter boats to break apart the jam, but it was not until warmer temperatures arrived a few days later that the ice jam dissipated.

Around the time of the Trenton jam, an ice jam formed on the Lehigh River. The jam formed approximately two miles upstream of Easton, Pa. below the Glendon Highway Bridge. Water and ice spilled into nearby roadways and the NWS issued a flood warning for south central Northampton County, Pa. Like the Delaware River jam, the Lehigh River jam broke up without any serious flooding problems as air temperatures warmed.

Spring Flooding

Widespread, heavy rainfall of 2" to 6" fell April 29-30 and caused significant flooding in the central and lower regions of the basin. The main stem Delaware River was spared from flooding, but minor to moderate flooding occurred along numerous tributaries such as Neshaminy Creek, Perkiomen Creek, Schuylkill River, and the East Branch Brandywine Creek. Major flooding occurred in Pennsylvania locations along the Neshaminy Creek at Langhorne, the Perkiomen Creek at Graterford, the Schuylkill River at Norristown, and the Brandywine Creek at Chadds Ford. Record flooding occurred along the Brandywine Creek at Wilmington, Del., where it crested at 20.7 feet (two feet higher than the previous record set in August 2011). The upper basin received up to 2" total in some locations, which was less rain than the rest of the basin, and did not experience flooding.

Hurricane Arthur

The Atlantic Basin's 2014 hurricane season produced the fewest number of tropical cyclones and the fewest named storms since 1997. Beginning on June 1 and ending on December 1, the season generated only eight named storms compared to 14 during the 2013 hurricane season. The only tropical system to pose a threat to the DRB during 2014 was Hurricane Arthur. Arthur developed relatively early in the season and on July 3 came ashore in North Carolina as a Category 2 hurricane (Saffir-Simpson wind scale). Fortunately, the hurricane stayed far enough east so the majority of the DRB was not affected by the storm. Some coastal locations in

Delaware and New Jersey experienced wind and rain, but not flooding. No other hurricanes impacted the DRB during the remainder of the 2014 hurricane season.

Precipitation

Fifty-eight percent of the reported DRB counties experienced normal to above-normal precipitation during 2014¹. Annual precipitation totals ranged from 34.6 inches in Lackawanna County, Pa. to 56 inches in Ocean County, N.J. Departures from the annual normal ranged from 11.1 inches below normal in Lackawanna County to 10.5 inches above normal in Ocean County. [Figure 1](#) presents the annual precipitation by county in the basin.

The following precipitation amounts were recorded during 2014 at selected stations throughout the DRB². The observed precipitation above Montague, N.J. for 2014 was 42.4 inches, or 2.9 inches below normal. Similarly, observed precipitation above Trenton, N.J. was 43.2 inches, or 4.8 inches below normal. Precipitation at Wilmington, Del. was 50.9 inches, or 7.8 inches above normal. [Table 1](#) presents normal and observed monthly precipitation totals at selected stations in the DRB for 2014.

Streamflow

Observed monthly mean streamflow observations at selected stations along the main stem of the Delaware River and its two largest tributaries, the Lehigh and Schuylkill rivers, were above normal during January but decreased to below-normal levels through early spring. Streamflow at the selected stations improved after regular rainfall kept flows normal to above normal during the spring and summer months. Heavy rainfall in the lower basin during the last days of April produced many of the highest streamflows in 2014 and led to minor to record flooding in many of the DRB's tributaries (refer to "Spring Flooding" in the *Hydrologic Highlights* section on page one for more details).

Drier conditions returned to the basin by late summer and streamflow declined accordingly. By November, monthly streamflow on the Delaware River at Montague averaged 45 percent of the normal flow and averaged only 38 percent of normal at Trenton. The Lehigh River at Bethlehem averaged 32 percent of the normal monthly flow for November while the Schuylkill River at Philadelphia averaged 50 percent of normal. Streamflow at the selected stations averaged normal to below normal through the end of 2014.

[Table 2](#) presents observed monthly mean streamflow at selected stations for 2014. [Figure 2](#) and [Figure 3](#) present annual hydrographs for 2014 at Montague and Trenton, respectively.

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 2014. Consequently, the Delaware River Basin Commission's (DRBC) lower basin drought operating plan was not implemented.

¹This 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 the remaining four counties is not available. The NWS uses several precipitation stations to calculate an average precipitation total for each county. Annual precipitation departures are calculated by DRBC staff using the NWS MARFC data.

² Selected station precipitation data were provided by the NWS and the Delaware River Master's Office. Annual precipitation departures are calculated by DRBC staff using the provided data.

The commission directed a total of 3.7 billion gallons (BG) from Beltzville Reservoir during September through November 2014 to maintain the Delaware River flow objective of 3,000 cubic feet per second (cfs) at Trenton. Similarly, a total of 0.6 BG was directed from Blue Marsh Reservoir during late September and early October. [Figure 4](#) and [Figure 5](#) present 2014 reservoir elevations for Beltzville and Blue Marsh, respectively.

No releases were made from Merrill Creek Reservoir during 2014. 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.

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 2014; consequently, DRBC's basinwide drought operating plan was not implemented.

On January 1, 2014, combined storage in Cannonsville, Pepacton, and Neversink reservoirs was 233 BG, which is 86 percent usable capacity and approximately 8 BG above the long-term median usable storage for the date. Combined storage fell below the long-term median in early March. Rainfall and melting snowpack refilled the reservoirs to 100 percent usable capacity by mid- April. Combined storage seasonally declined, but remained above the long-term median for most of the summer. Drier conditions caused storage to drop below the median in early October, where it would remain through the end of the year. As of December 31, 2014, combined storage in Cannonsville, Pepacton, and Neversink reservoirs was 183 BG, which is 68 percent usable capacity and 42 BG below the long-term median usable storage for the date. [Figure 6](#) presents NYC reservoir storage levels for 2014.

Releases totaling approximately 43 BG⁴ were directed from the NYC reservoirs during August through November 2014. These releases were requested by the Delaware River Master to meet the normal flow target of 1,750 cfs on the Delaware River at Montague, N.J. By comparison, directed releases totaled 25 BG during 2013 and 101 BG during the drought year 2001.

Groundwater

New York

The groundwater levels in the Sullivan County, N.Y. well remained within the normal⁵ range until October when dry conditions caused levels to dip below the 25th percentile. December's precipitation improved conditions and observed levels returned to the normal range by the end of 2014. [Figure 7](#) presents the observed and median groundwater levels for the USGS well in Sullivan County.

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).

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).

Pennsylvania

Groundwater movement in five selected USGS county observation wells are used to represent Pennsylvania's groundwater conditions during 2014. 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).

Water levels in three of the five observations wells (Lehigh, Bucks, and Chester counties) remained within the normal to above-normal range during the year. Water levels in the Wayne and Schuylkill county wells fell below the normal range during the drier fall months, but both wells showed signs of recovery at the end of 2014. [Figure 8](#) presents the observed and median groundwater levels in the five Pennsylvania observation wells.

Delaware

The groundwater level in the New Castle County, Del. coastal plain well remained within the normal range during 2014. [Figure 9](#) presents the observed and average groundwater levels for the Delaware Geological Survey (DGS) well in New Castle County.

New Jersey

The groundwater level in the Cumberland County, N.J. coastal plain well remained above the normal range throughout 2014. [Figure 10](#) presents the observed and average groundwater levels for the USGS well in Cumberland County.

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 changing 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 2014 was river mile 84 during early to mid-October. This location is six miles upstream of the Pennsylvania-Delaware State line. By comparison, the farthest recorded upstream location of the salt front, river mile 102, was measured during the 1960's drought of record. [Figure 11](#) presents the seven-day average location of the 250-PPM isochlor during 2014.

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

Figure 1: 2014 Annual Precipitation in the Delaware River Basin
 Total Precipitation (top) and Total Departure from Normal (bottom) in Inches

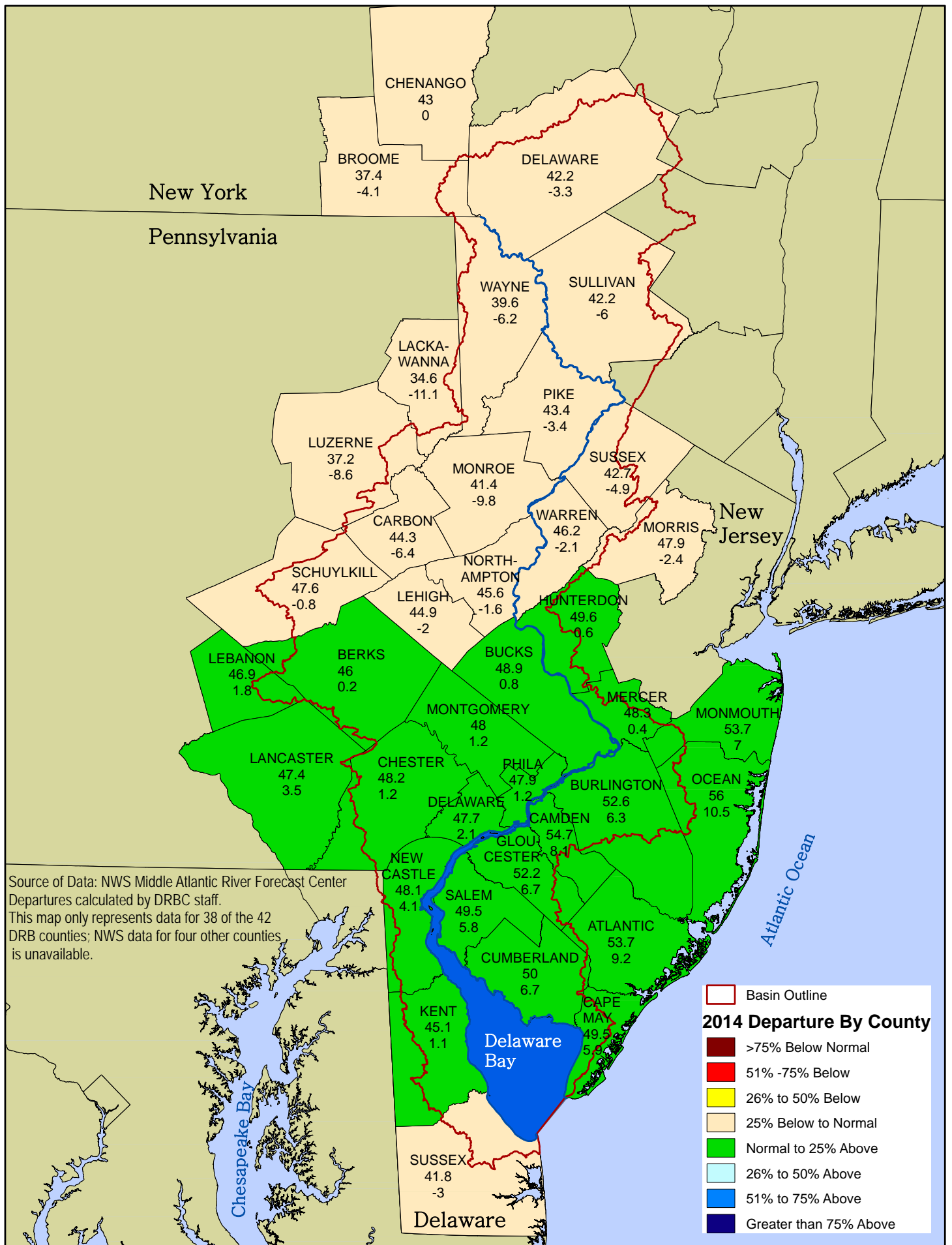


TABLE 1: 2014 PRECIPITATION AT SELECTED STATIONS IN THE DELAWARE RIVER BASIN (INCHES)

	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	2.75	3.03	4.54	3.28	3.20	3.05	3.48	3.03	3.55	3.01	3.23
FEBRUARY	2.58	3.75	2.70	4.45	2.79	3.90	2.48	3.20	2.65	5.12	2.68	5.35
MARCH	3.42	2.44	3.39	2.44	3.59	2.50	3.48	2.17	3.79	4.23	3.92	3.82
APRIL	3.92	2.82	3.56	6.60	4.04	5.10	3.77	6.47	3.56	6.69	3.5	6.84
MAY	4.20	4.71	4.14	4.27	4.36	3.80	2.68	3.50	3.71	2.91	3.95	3.09
JUNE	4.41	5.23	4.31	5.40	4.66	5.00	3.78	3.79	3.43	5.46	3.88	5.03
JULY	4.17	5.52	4.95	4.32	4.48	5.30	4.52	4.95	4.35	4.30	4.57	5.94
AUGUST	3.85	2.75	3.69	1.97	4.11	2.50	3.64	2.87	3.50	3.55	3.25	4.77
SEPTEMBER	4.35	1.36	4.62	1.53	4.65	1.30	4.34	1.80	3.78	1.69	4.32	2.84
OCTOBER	4.15	5.07	3.88	2.43	4.41	4.60	3.22	4.44	3.18	2.53	3.42	2.79
NOVEMBER	3.76	2.31	3.50	3.12	3.87	2.70	3.46	2.24	2.99	4.07	3.10	4.20
DECEMBER	3.38	3.69	3.58	3.65	3.76	3.30	3.29	2.90	3.56	3.27	3.48	3.01
TOTAL 2014	45.29	42.40	45.35	44.72	47.99	43.20	41.71	41.81	41.53	47.37	43.08	50.91
DIFF 2014		-2.89		-0.63		-4.79		0.10		5.84		7.83

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: 2014 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	8,848	1,936	3,733	17,700	3,198	4,417
	% NORM	174.3%	152.4%	134.3%	126.4%	174.9%	161.0%
Feb	OBS	3,779	794	1,571	7,868	1,664	3,571
	% NORM	74.7%	76.7%	57.5%	67.0%	73.8%	92.5%
Mar	OBS	7,364	1,120	2,780	13,573	3,045	5,021
	% NORM	83.5%	63.3%	72.5%	74.5%	107.3%	109.2%
Apr	OBS	11,594	2,704	4,397	23,537	3,729	5,815
	% NORM	108.8%	154.3%	120.5%	116.9%	140.8%	146.5%
May	OBS	9,921	2,315	4,843	24,581	4,719	8,247
	% NORM	171.3%	180.6%	181.8%	210.5%	265.0%	315.7%
Jun	OBS	5,214	982	2,271	10,408	2,263	3,130
	% NORM	164.6%	101.9%	114.3%	144.9%	163.0%	169.5%
Jul	OBS	6,118	820	1,739	9,774	1,375	1,795
	% NORM	250.6%	123.7%	121.3%	179.3%	129.0%	133.7%
Aug	OBS	2,420	569	1,109	4,315	884	1,016
	% NORM	111.6%	115.4%	99.4%	97.1%	118.0%	93.7%
Sep	OBS	1,953	311	755	3,083	592	665
	% NORM	96.9%	65.2%	68.7%	69.5%	75.8%	60.3%
Oct	OBS	2,261	526	1,026	4,142	1,073	1,230
	% NORM	85.2%	54.2%	57.1%	68.8%	107.8%	89.0%
Nov	OBS	2,037	378	761	3,781	603	1,185
	% NORM	44.7%	29.2%	32.0%	37.7%	35.3%	50.1%
Dec	OBS	5,196	1,136	2,082	10,377	1,844	2,939
	% NORM	102.9%	60.5%	64.5%	80.3%	76.0%	81.4%

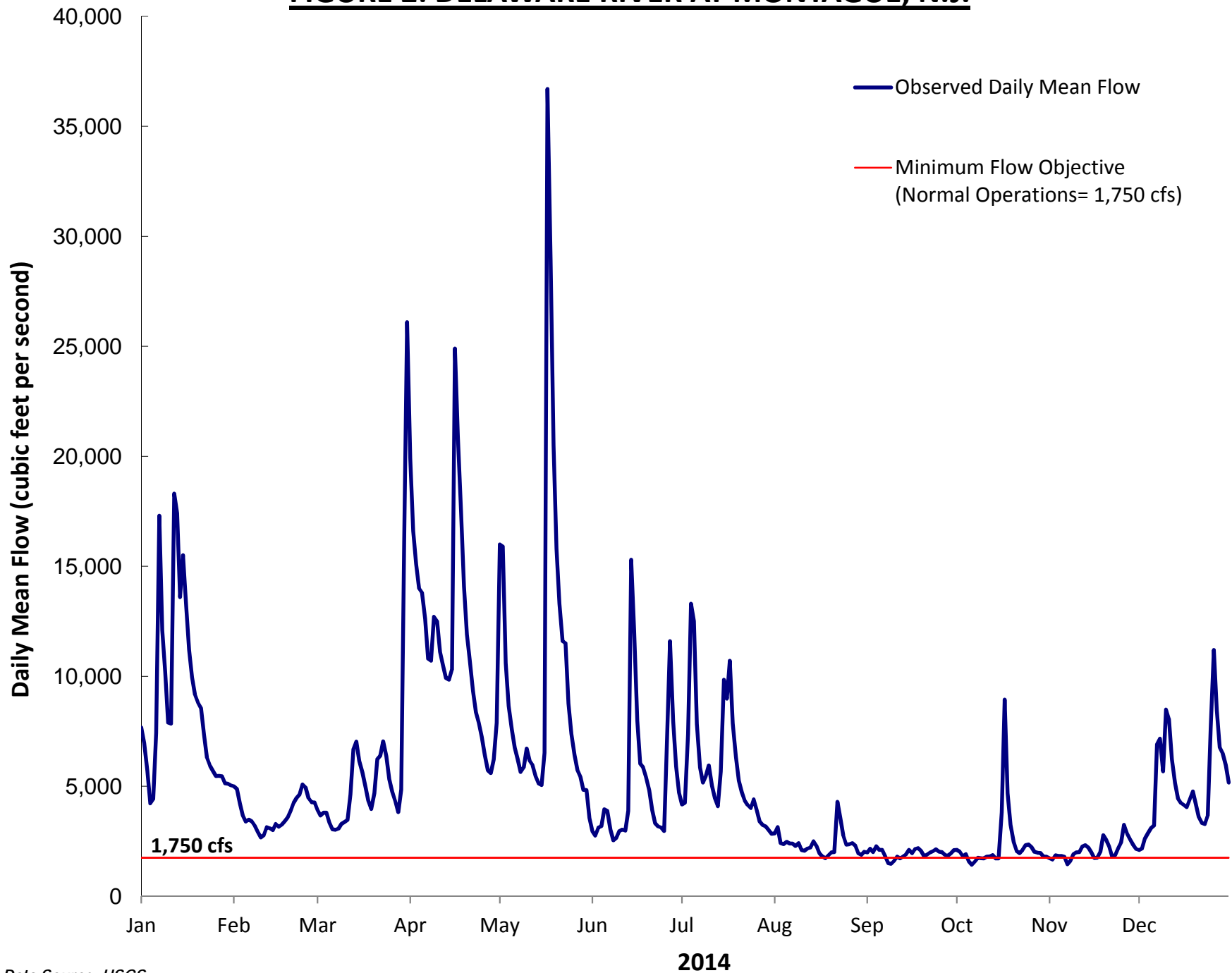
¹Median of monthly mean flow values for the following periods were used to calculate the normal monthly flow:

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

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

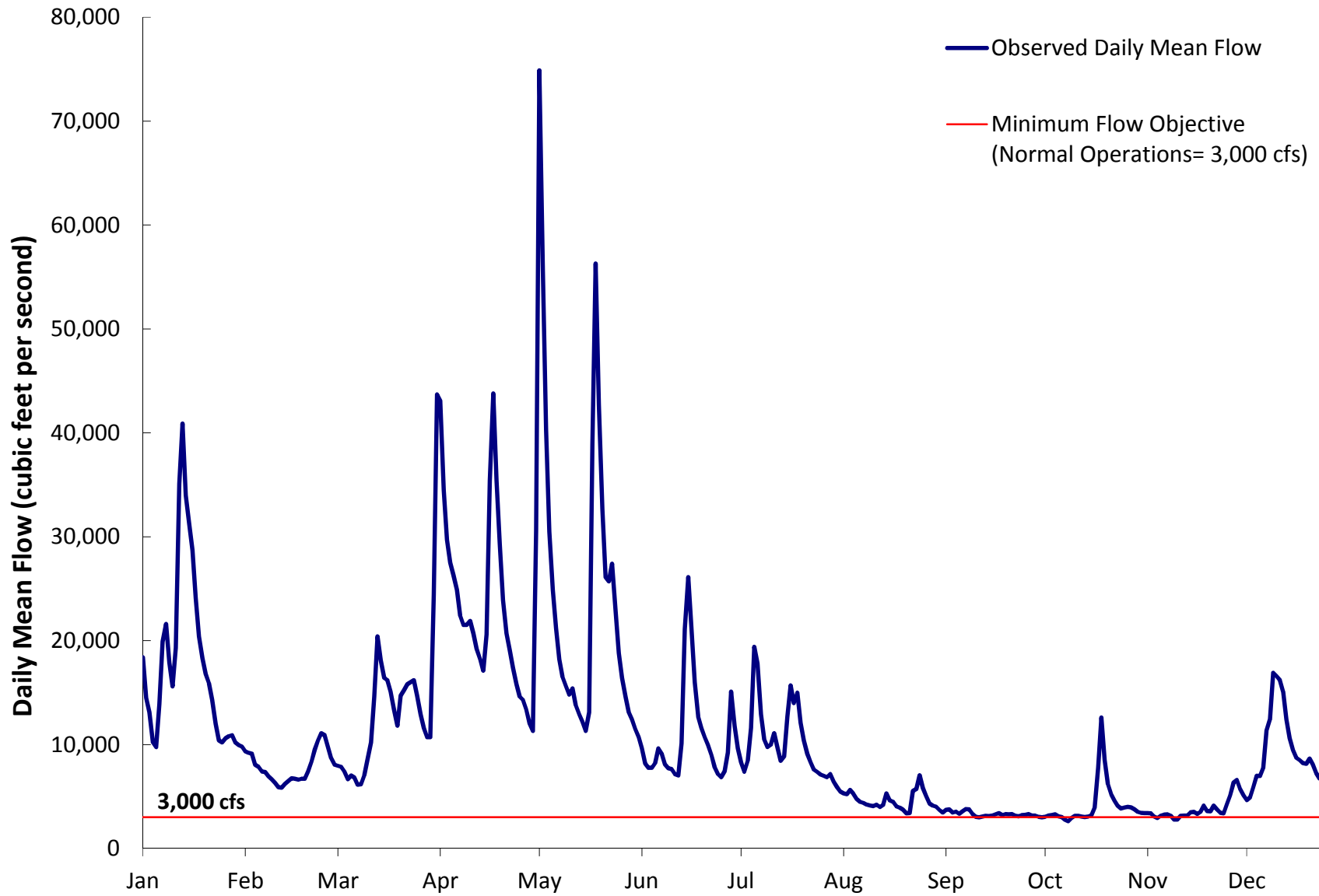
Note: Ice-affected flow measurements during January and February 2014 at Montague and Trenton have been adjusted with approved USGS flow estimates.

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



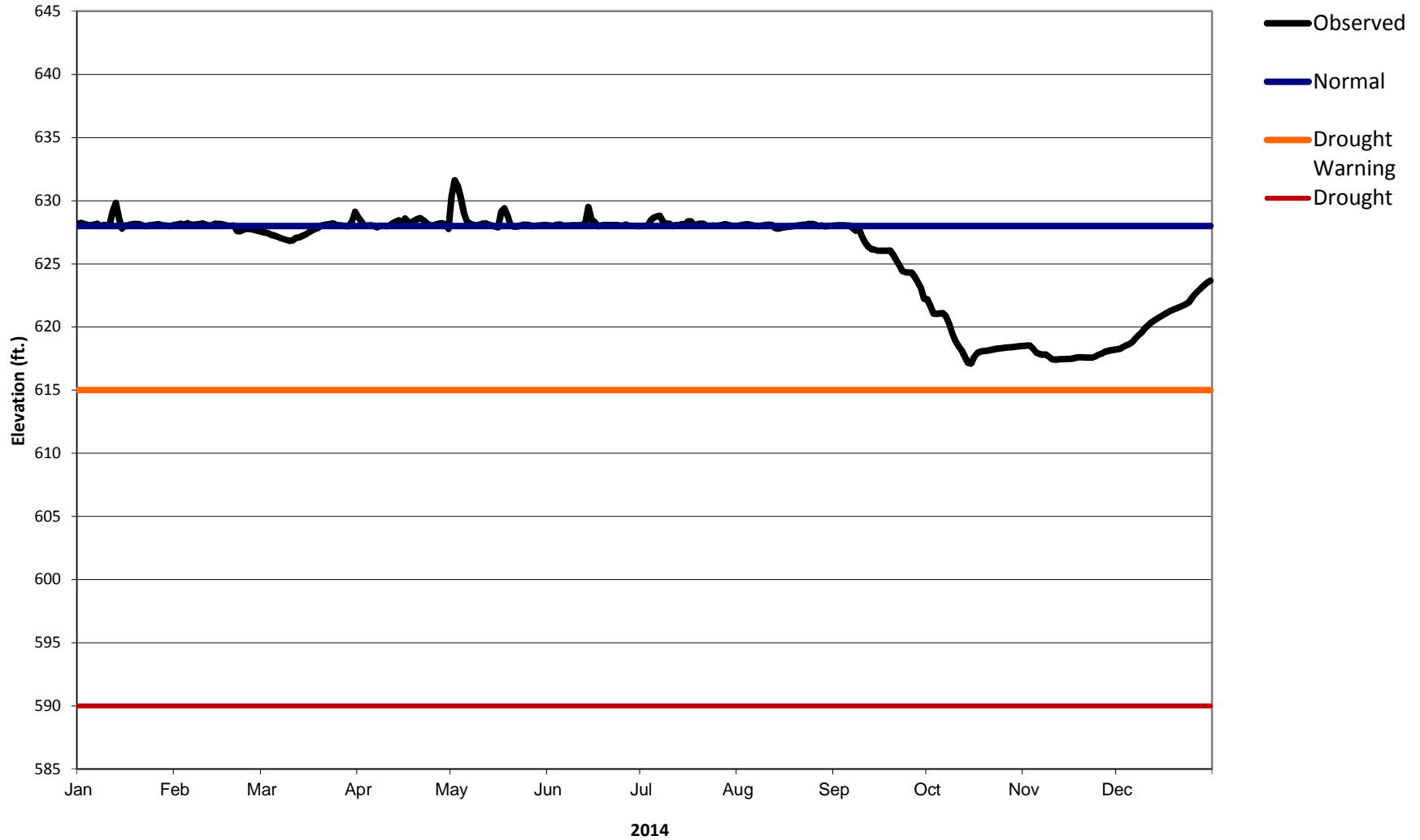
Data Source: USGS
Graph generated by DRBC staff.

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



Data Source: USGS
Graph generated by DRBC staff.

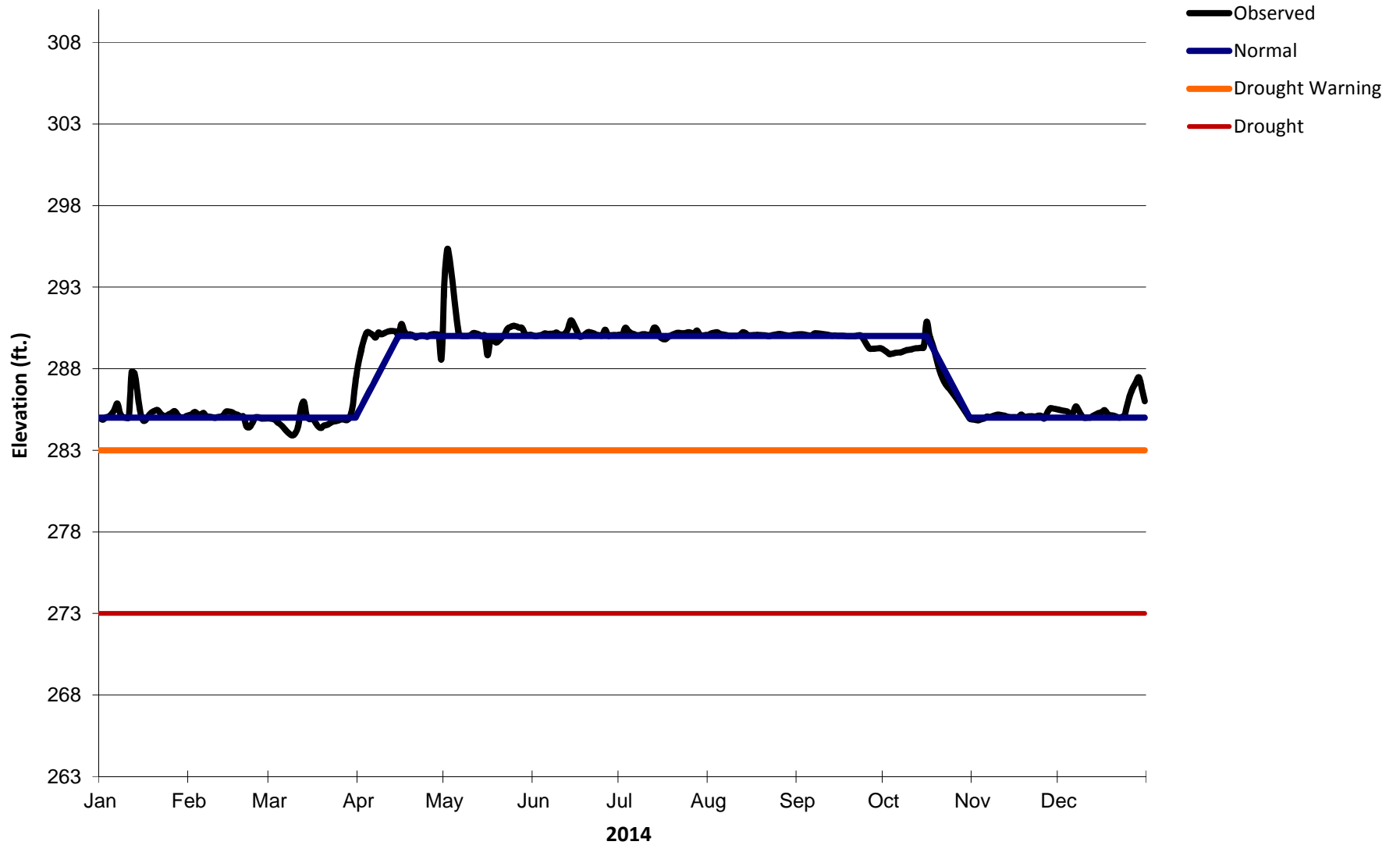
FIGURE 4: BELTZVILLE RESERVOIR ELEVATION



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 2014

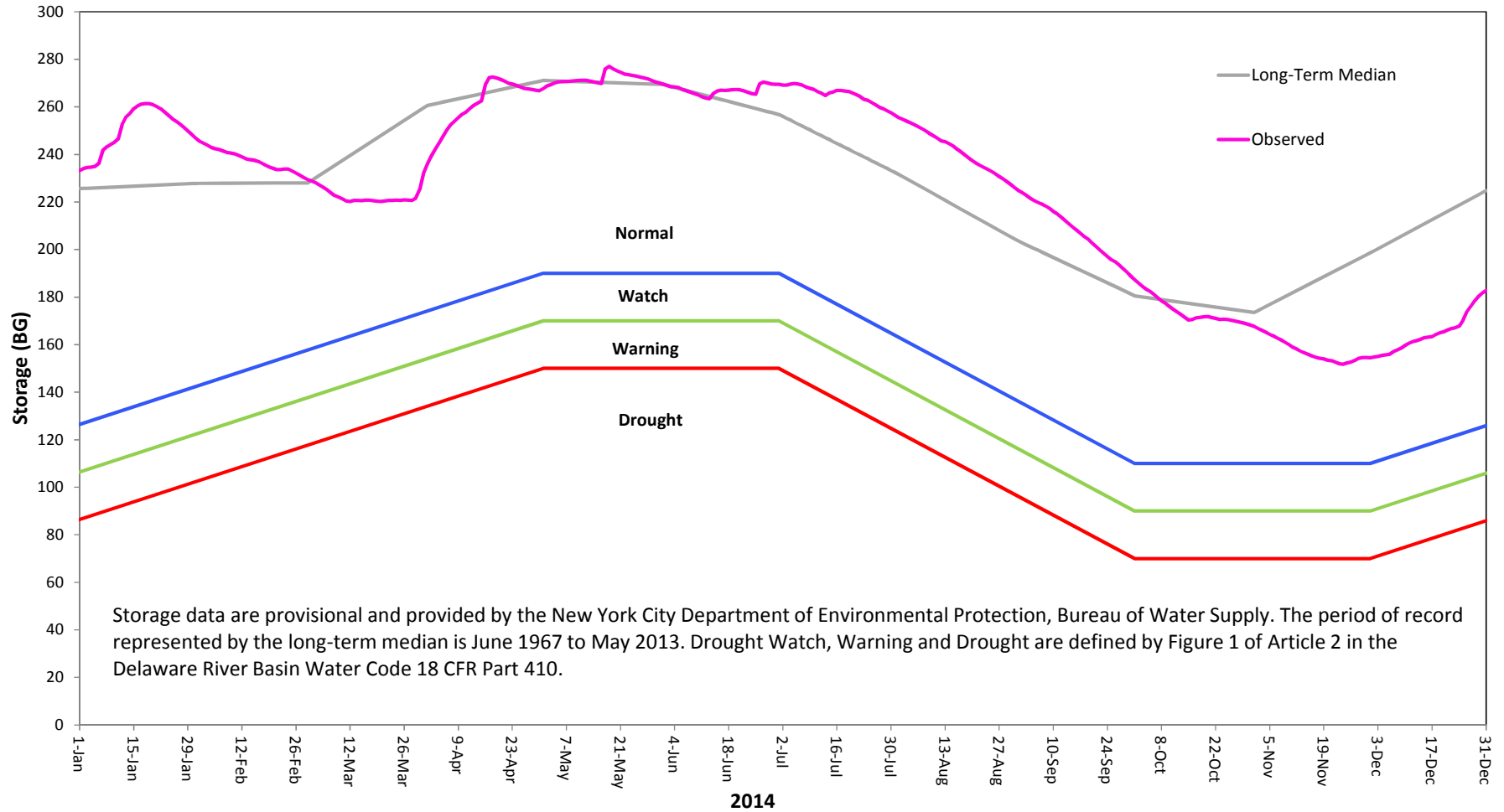


FIGURE 7: USGS WELL-SULLIVAN CO., NEW YORK
Median Depth to Water and 2014 Observations of Depth to Water

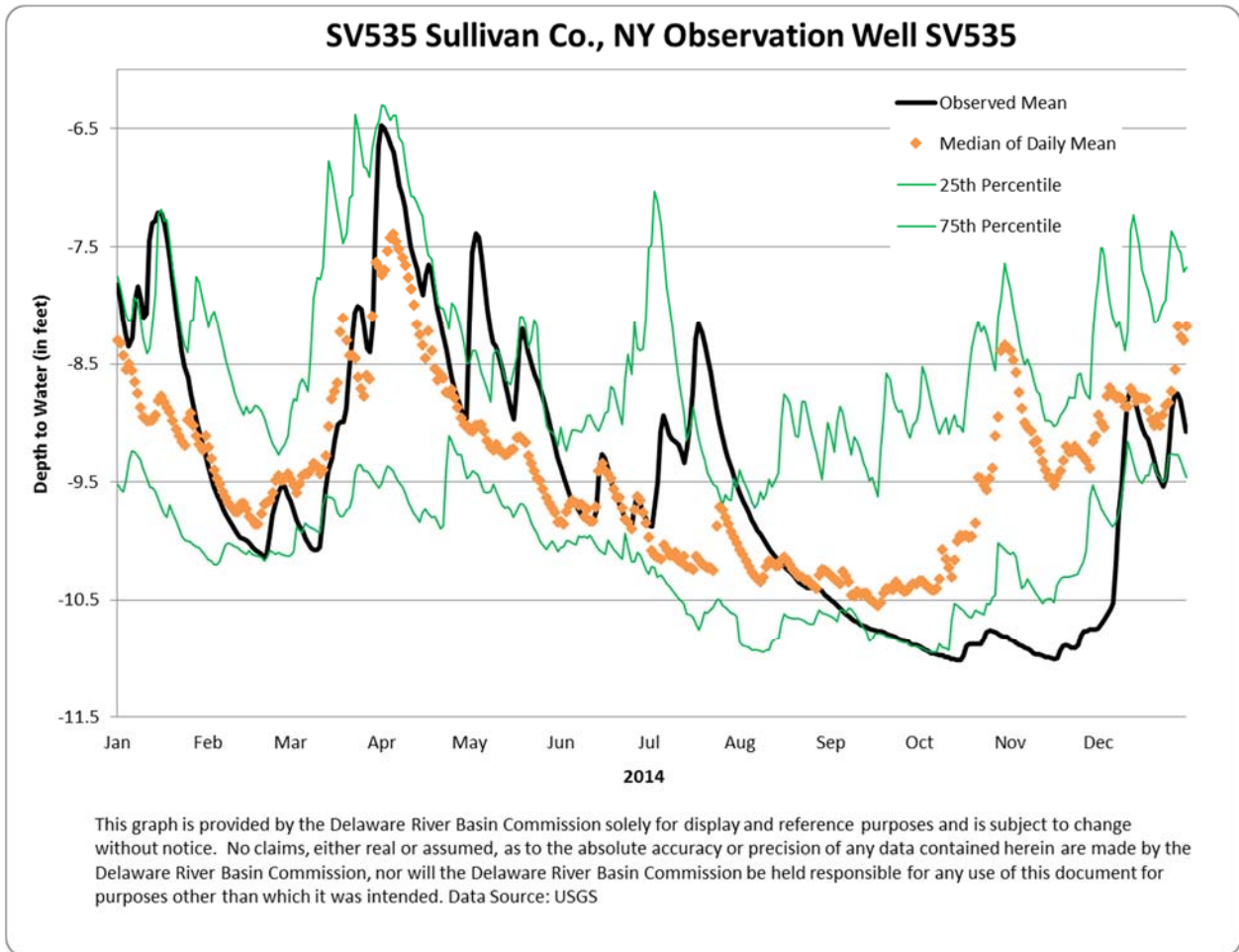


FIGURE 8: SELECTED USGS OBSERVATION WELLS LOCATED IN PENNSYLVANIA
Median Depth to Water and 2014 Observations of Depth to Water

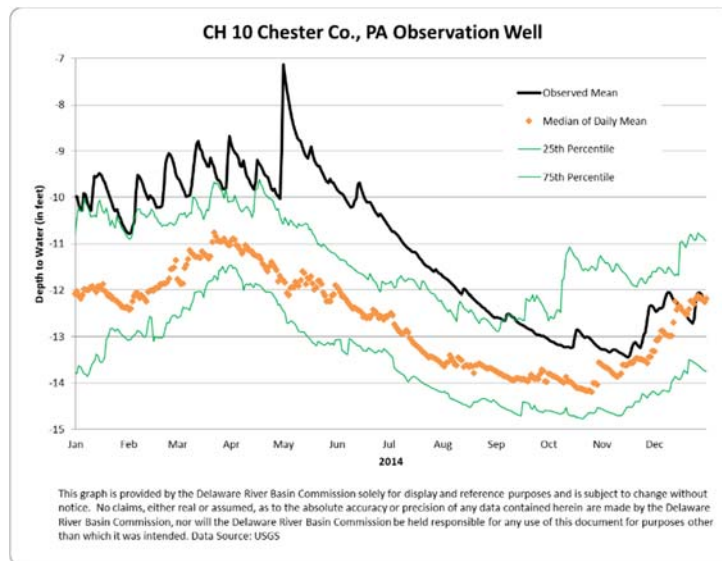
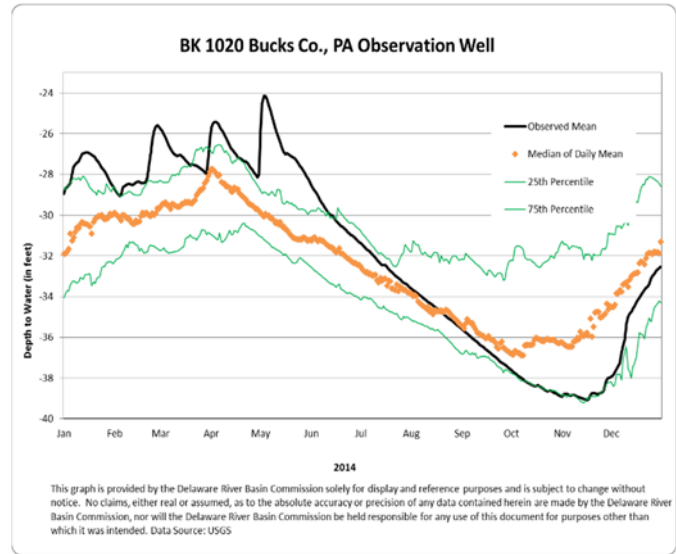
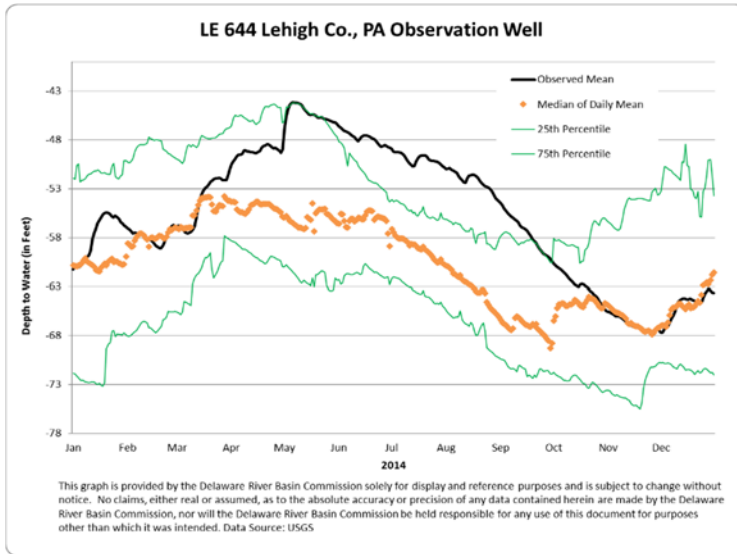
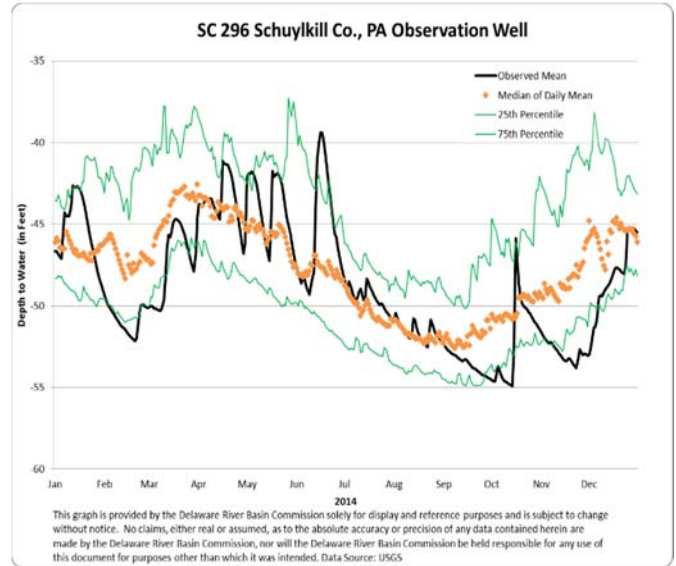
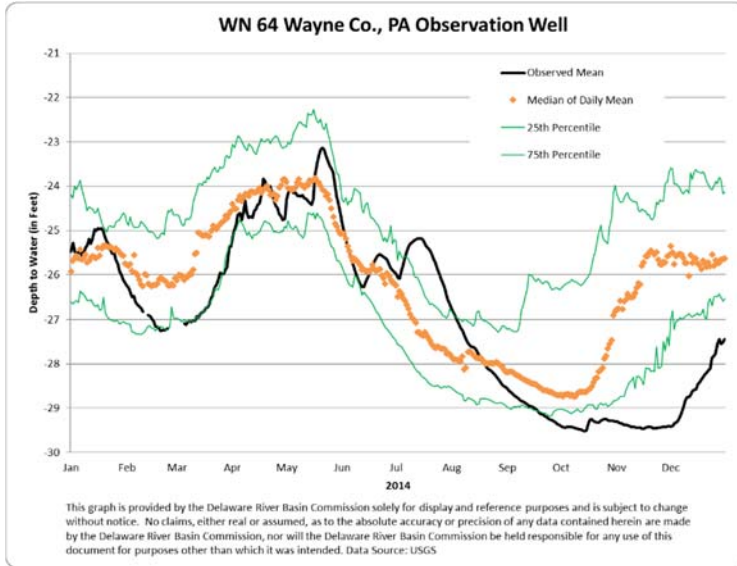
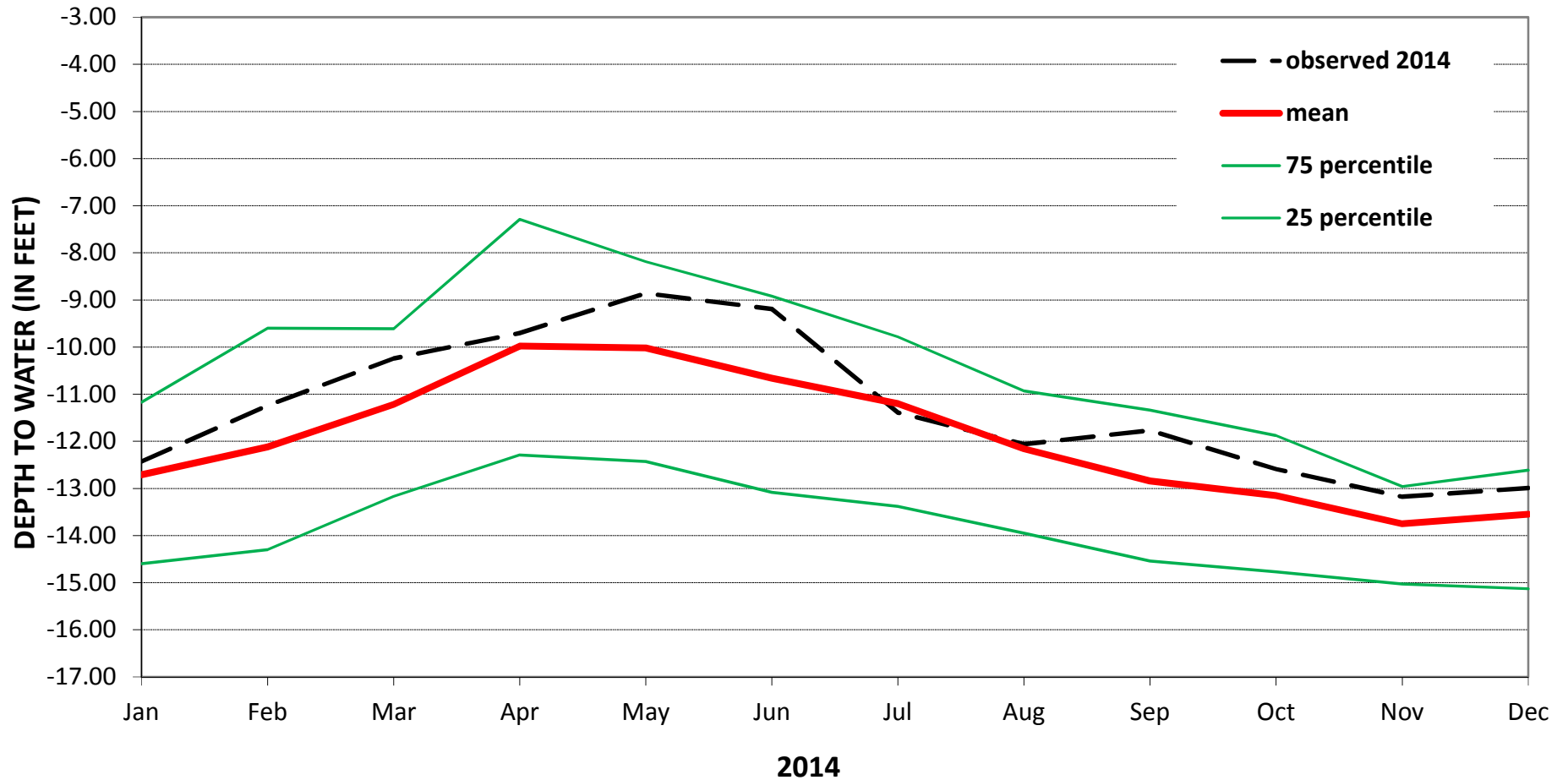
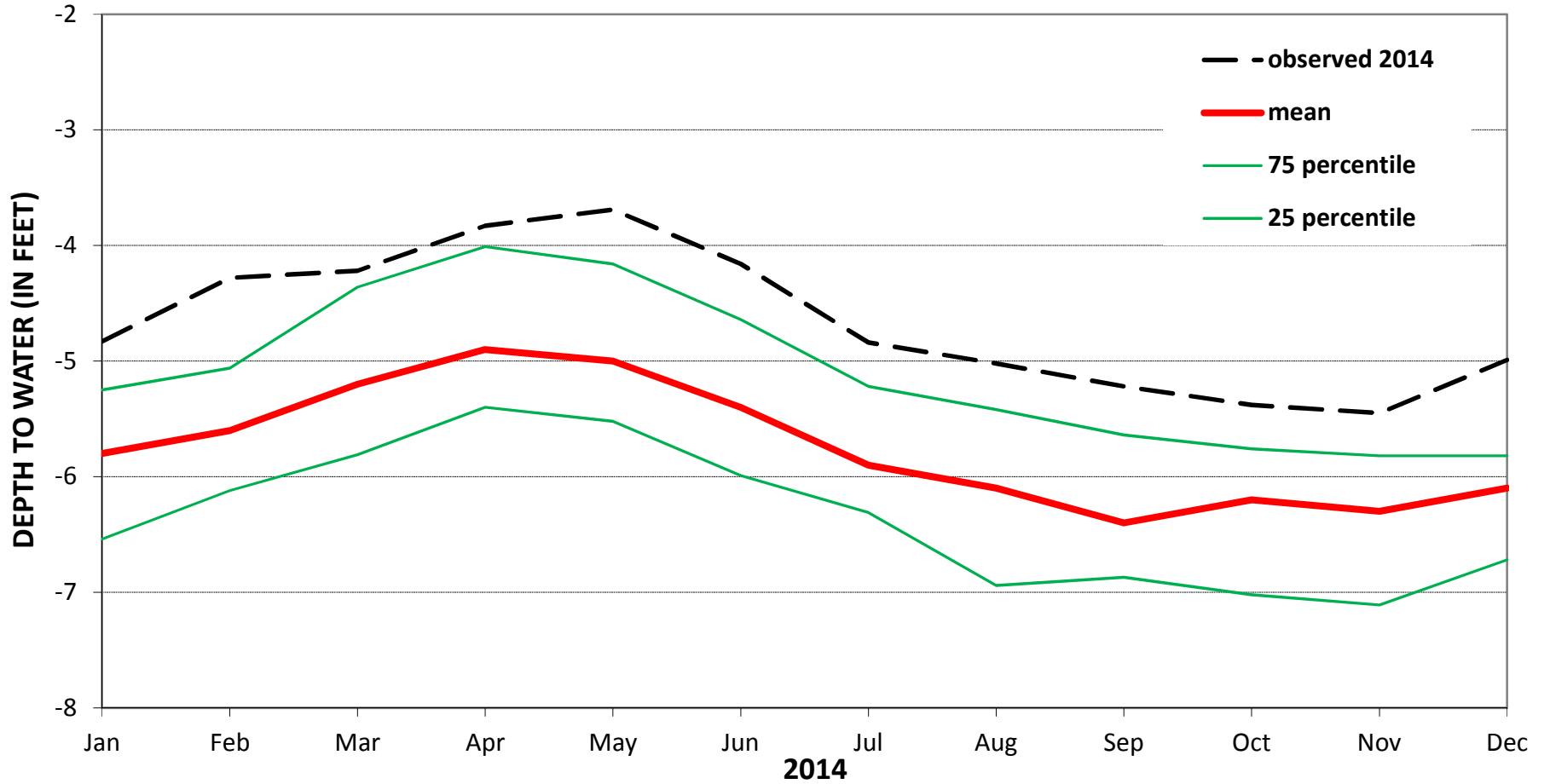


FIGURE 9: DGS WELL-NEW CASTLE CO., DELAWARE
Average Depth to Water and 2014 Observations of Depth to Water



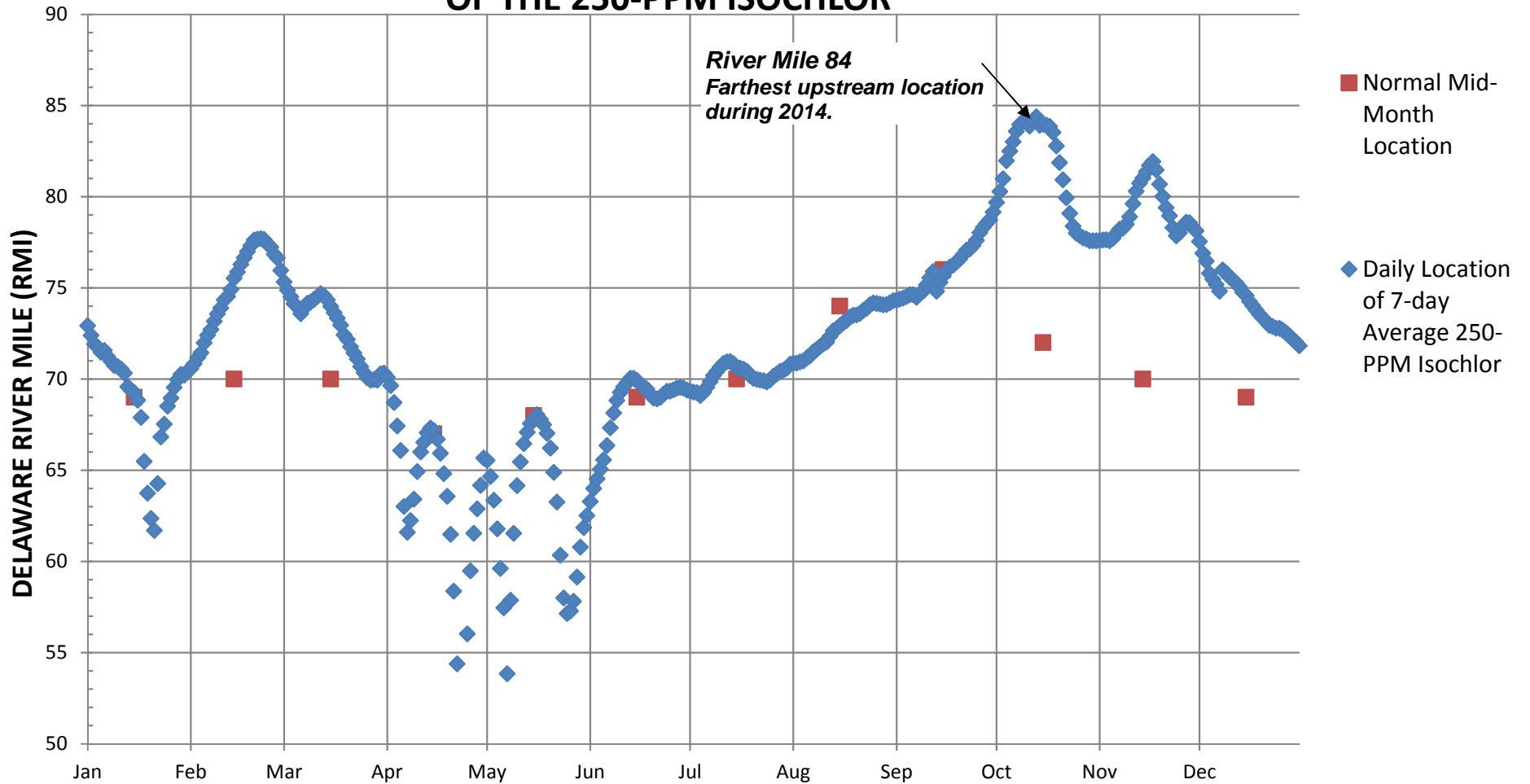
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FIGURE 10: USGS WELL-CUMBERLAND CO., NEW JERSEY
Average Depth to Water and 2014 Observations of Depth to Water



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**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

2014