Hydrologic Conditions in the Delaware River Basin

June 2006: Flooding in Yardley, Pennsylvania

Annual Report 2006

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Hydrologic Highlights of 2006 - Another Year of Drought and Flood

February-June: Statewide Drought Actions

Starting in February 2006, the basin experienced several months of below-normal precipitation. By April, dry weather began to have an impact on surface water and groundwater, prompting two states to take action to safeguard water supplies for the upcoming peak demand period. On April 11, Pennsylvania Department of Environmental Protection Secretary Kathleen A. McGinty declared a drought watch for all 67 counties in the state, including the 17 counties located either partially or completely within the Delaware River Basin. This was the first time the state had been under a drought declaration since 2003. On May 8, New Jersey Department of Environmental Protection Commissioner Lisa P. Jackson declared a statewide drought watch, the first since New Jersey had been under a statewide drought watch in autumn 2005. Delaware River Basin Commission (DRBC) drought actions were not triggered because Blue Marsh and Beltzville reservoirs in the lower basin and the New York City reservoirs in the upper basin maintained normal storage throughout this period.

June 24-28: Major Flooding…Again

Extremely heavy rainfall over the Delaware River Basin during the June 24-28 period caused flash flooding and record to near-record flood crests along many streams and rivers throughout the basin, including the main stem Delaware River. Although hydrologic conditions were normal to dry prior to Saturday, June 24, and Pennsylvania and New Jersey were still under drought watch declarations, the broad area of the rainfall and its intensity in the western half of the basin produced the flooding. Over this multi-day period, National Weather Service data indicated that six to fifteen inches of rain fell in the Schuylkill, Lehigh, and upper Delaware River watersheds, with higher amounts in isolated areas. At least five inches fell throughout nearly all of the Delaware River Basin, with the exception of portions of New Jersey and the immediate Philadelphia area, which received less. See the attached map, *Figure 1: Rainfall Produced from the June 24-28, 2006 Flood Event* for a map of precipitation totals.

The rain that produced the June flooding came in two parts. Upwards of five inches of rain in some portions of the basin during June 24-26 saturated the ground and produced bank full and minor flooding conditions by early Tuesday, June 27. A second storm on June 27 and early Wednesday, June 28 produced an additional two to six inches (or more) of rainfall in the Schuylkill, Lehigh, and Lackawaxen watersheds as well as in Sullivan and Delaware counties in New York State. The ground was saturated from heavy rain just the day before and provided little or no absorption, sending large amounts of runoff into already fast moving creeks, streams, and rivers. This high rate of runoff combined with already bank full conditions to produce near-record flooding. During the evening of June 27, National Weather Service flash flood warnings were in effect for nearly all counties in the Pennsylvania and New York portions of the basin. The Middle Atlantic River Forecast Center forecasted moderate to major flooding for nearly the entire basin.

Flood crests [1] on the main stem Delaware River occurred on June 28 and 29. The Delaware River at Montague, New Jersey crested 7.16 feet above flood stage, the third highest crest on record. This crest was 0.47 feet higher than the crest produced during the flood of April 2005. The Delaware River at Trenton, New Jersey crested at 5.09' above flood stage, the fifth highest on record. This crest was 0.24 feet ***lower*** than the crest produced by the flood of April 2005. Several major Delaware tributaries were also hit hard by the June flooding. In the upper basin, the West Branch Delaware River at Hale Eddy, New York crested at more than 8.1 feet above flood stage, the second highest level on record. Along the Schuylkill River, stream gage locations at Landingville,

[1] Flood crest data was obtained from the United States Geological Survey (USGS).

Berne, and Reading, Pennsylvania recorded their second highest flood crests on record, 9.11, 5.54, and 10.63 feet above flood stage, respectively.

Pennsylvania and New Jersey lifted their drought watches by June 30, 2006. Heavy rainfall made up for earlier deficits and brought annual precipitation totals to normal. Streamflows recovered and groundwater levels rebounded enough to provide ample base flows for streams and rivers as the basin moved into the hottest and potentially driest months of the year.

The basin would be threatened by flood one more time in 2006. Tropical Storm Ernesto threatened the basin September 1-3. Heavy rainfall, producing two to six inches, fell during the week prior to Ernesto's arrival, saturating the ground and raising stream flows. Average basinwide rainfall estimates for Ernesto were in the three to six inch range, with locally higher amounts of seven to ten inches possible. The Middle Atlantic River Forecast Center forecasted possible significant river flooding during the period of September 2-4. It seemed very possible that the Delaware River Basin was going to be hit a fourth time in two years with major flooding. Fortunately, actual precipitation totals were much lower than those forecasted. The majority of the basin received less than two inches, with locally higher amounts of three to five inches occurring mainly in the lower portion of the basin. Only minor tributary and localized flooding occurred from Tropical Storm Ernesto.

Precipitation

Despite accumulated deficits during early 2006, the majority of the counties[2] within the Delaware River Basin recovered enough to report normal to above-normal annual precipitation totals by the end of the year. Annual departures ranged from 1.10 inches (2.5%) below normal in Kent County, Delaware to 13.50 inches (31.5%) above normal in Lebanon County, Pennsylvania. Year-end precipitation totals ranged from 42.80 inches (Kent Co., Delaware) to 60.90 inches (Monroe Co., Pennsylvania). See the attached map, *Figure 2: 2006 Annual Precipitation in the Delaware River Basin* for a depiction of precipitation totals and departures by county.

Regarding precipitation at selected stations around the basin, the observed precipitation above Montague, New Jersey for 2006 was 51.23 inches, or 7.97 inches above normal. Annual observed precipitation above Trenton, New Jersey was 54.22 inches, or 9.33 inches above normal. Finally, annual observed precipitation at Wilmington, Delaware was 49.41 inches, or 6.60 inches above normal. See the attached *Table 1: 2006 Precipitation at Selected Stations in the Delaware River Basin* for additional precipitation data.

Streamflow

January's streamflows averaged two to three times higher than normal at many locations throughout the basin due to above-normal precipitation and snow melt from a January thaw. A trend of below-normal precipitation began in February and impacted flows from late winter through early spring. Snow pack amounts had been below average during most of the 2005-06 winter season and much of the pack melted in mid-January and had not been replaced. The period of March through May recorded the lowest flows of the year during a time when rivers are usually brimming with water from snow melt and spring rain storms.

Two rain events at the end of June turned low flows to flood flows within a matter of days and produced the highest average monthly streamflows in 2006. During June 2006, the average monthly streamflow at the USGS gage at Montague, New Jersey was recorded as 20,185 cubic feet per second (cfs), which is 600 percent of normal for the month. Similarly, streamflow at the Trenton, New Jersey gage averaged 30,040 cfs (367 percent of normal). Average monthly streamflow at the Lehigh River gage in Bethlehem, Pennsylvania during June

[2] This information was based on precipitation data from the National Weather Service Middle Atlantic River Forecast Center 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. Departures from normal were calculated by DRBC staff.

was 5,251 cfs (264 percent of normal) and at the Schuylkill River at Philadelphia, the average streamflow for the month was 7,574 cfs (415 percent of normal).

Rain associated with Tropical Storm Ernesto in early September and several heavy rain events during the autumn months kept streamflows at normal to above-normal levels for the remainder of the year.

Please refer to the attached *Table 2: 2006 Streamflow in the Delaware River Basin* for additional information on average monthly streamflow at selected stations. Refer to *Figure 3: Delaware River at Montague, NJ* and *Figure 4: Delaware River at Trenton, NJ* for annual hydrographs of these two Delaware River stations.

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 2006. No directed releases were required from either of these reservoirs to meet the Delaware River flow objective of 3,000 cfs at Trenton, New Jersey. Please refer to *Figure 5: Blue Marsh Reservoir Elevation* and *Figure 6: Beltzville Reservoir Elevation* for 2006 reservoir elevations for these lower basin reservoirs.

Between June 15 and 16, 2006, the DRBC requested emergency releases ranging from 300 cfs to 600 cfs from Blue Marsh Reservoir. These releases were made in response to a cyanochloride compound contamination event in the Wissahickon Creek, a tributary to the Schuylkill River. The extra water was used to dilute concentrations of the contaminant in the Schuylkill River.

No replacement releases were required from Merrill Creek Reservoir during 2006. Merrill Creek Reservoir, located in Phillipsburg, New Jersey, provides storage when the basin is under DRBC drought operations. This storage is used for augmenting flows at Trenton, New Jersey by replacing evaporative losses caused by power generation. Several special releases, totaling approximately 346 million gallons, were made throughout the year to maintain the reservoir level below the maximum operating level of 922.80 feet.

Upper Basin

The New York City (NYC) reservoirs in the upper Delaware River Basin began the year with storage above the long-term median. As of January 1, 2006 the Cannonsville, Pepacton, and Neversink reservoirs had a combined storage of 247.668 billion gallons (bg), which is 91.4 percent of usable storage and 58.105 bg above the long-term median storage for the date.

Runoff produced from rainfall and melting snow pack combined to increase reservoir storage to 281.750 bg (104 percent of usable storage) by January 19. Although it remained well-above the long-term median, storage generally declined during February and March. These two months were very dry periods and precipitation in the upper basin averaged 50- to 60- percent below normal[3]. Below-normal precipitation and below-average end-of-season snow pack began to impact storage and storage had declined to slightly below the median storage by April 1.

April experienced normal precipitation and the NYC Delaware Basin reservoirs refilled by April 25. The reservoirs remained full as of May 1, the median date for refill, and remained slightly above the median until the end of June when flood-producing rains impacted the upper basin. Runoff from the flood event spiked

[3] Calculated from precipitation data provided by the Delaware River Master (Table 1, Average Precipitation above Montague, NJ).

storage to an annual high of 289.426 bg (106.9 percent of usable storage) on June 29, 2006. The reservoirs remained well above the long-term median storage level throughout the summer months.

Directed releases to maintain the flow target of 1,750 cfs at Montague, New Jersey were made only for a brief period during mid-summer 2006. From July 30 through August 30, the Delaware River Master directed releases from the three NYC Delaware Basin reservoirs totaling approximately 14 bg[4].

A Temporary Spill Mitigation Program was approved by the DRBC and the parties to the 1954 U.S. Supreme Court Decree in September 2006. The goal of the program was to make larger releases during periods of above-normal storage to reduce the frequency and volume of spills from the NYC Delaware Basin reservoirs. Releases for the program began on September 22, 2006 and by the end of the year nearly 93 billion gallons had been released[5].

Storage remained well above the long-term median until the end of the calendar year. As of December 31, total usable storage in the three NYC Delaware Basin reservoirs was 254.298 bg (93.9 percent of usable storage) which is 65.470 bg above the long-term median storage for the date. For a graphical presentation of NYC Delaware Basin reservoir storage levels for 2006, please refer to *Figure 7: New York City Delaware River Basin Storage 2006*.

Groundwater

The average observed groundwater levels in eight reported USGS observation wells in the Pennsylvania portion of the basin remained above the long-term average for the first two months of the calendar year. However, below-normal precipitation in February and March caused levels to decline. March's measurements averaged below the long-term average, a trend which would continue into early summer. Heavy rains in late June recharged groundwater supplies and measurements taken in July showed the average water level of the eight wells had recovered to above the long-term average. Groundwater levels remained above average for the remainder of 2006.

Monthly measurements of groundwater within two coastal plain wells (New Castle County, Delaware and Cumberland County, New Jersey) recorded levels within the normal (25- to 75-percentile) to above-normal (greater than 75-percentile) range for nearly all of 2006. The one exception to this occurred with the Cumberland County well; monthly measurements taken there from April through June recorded groundwater levels below the 25-percentile, but levels had recovered to normal by the July measurement.

Please refer to the attached *Figure 8: USGS Network Wells-Pennsylvania*, *Figure 9: DGS Well-New Castle Co., Delaware*, and *Figure 10: USGS Well- Cumberland Co., New Jersey* for graphical presentations of groundwater levels throughout 2006.

Salt Front

The *salt front* is defined as the 250 parts-per-million isochlor and the seven-day average location of the salt front is used by DRBC as an indicator of salinity intrusion in the 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 average mid-month locations range from river mile

[4] Directed release data was calculated by DRBC staff using the Office of the Delaware River Master's *Reservoir and Streamflow Data* weekly reports.

[5] Releases through the Spill Mitigation Program were calculated by DRBC staff from the NYC DEP *Provisional Data* daily reports. Release amounts are based on provisional data and are subject to change.

61 (0.5 miles below Pea Patch Island, Delaware) in mid-April to river mile 81 (Marcus Hook, Pennsylvania) in mid-October.

During 2006, the salt front location ranged from as far downstream as river mile 38 to as far upstream as river mile 75 (three miles downstream of the Delaware-Pennsylvania state line). See the attached *Figure 11: 7-Day Average Location of the 250-PPM Isochlor* for an overview of salt front locations along the Delaware River during 2006.