Hydrologic Conditions in the Delaware River Basin

View of the Delaware River from the Washington Crossing Bridge on October 30, 2003.

Annual Report 2003

Prepared by the Operations Branch of the Delaware River Basin Commission
May 2004

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Lingering Effects of the 2001-2002 Drought

Regulatory actions related to the 2001-2002 drought extended into early 2003. Although the Delaware River Basin Commission (DRBC) lifted its drought emergency in late-November 2002, state-implemented drought actions remained active during the first 90 days of 2003. New York City (NYC) remained under a drought watch through January 3, 2003. On January 8, New Jersey lifted the statewide drought emergency that had been in effect since March 2002 and Pennsylvania returned its final four Delaware Basin counties to normal status. By January 29, Delaware lifted its statewide drought warning. Finally, on March 21, state-implemented drought actions in the Delaware River Basin came to an end as New Jersey lifted the drought warning for its last two drought management areas. For more details regarding drought actions during 2003, please refer to the attached *Chronology of Drought in the Delaware River Basin*.

Precipitation

All counties within the Delaware River Basin reported above-normal precipitation at the end of 2003, with annual surpluses ranging from 5.80 inches to 23.70 inches. Year-end precipitation totals ranged from 48.0 inches (Chenango County, New York) to as much as 70.8 inches (Monroe County, Pennsylvania). See the attached map, *Figure 1: 2003 Annual Precipitation in the Delaware River Basin,* for a depiction of precipitation totals and departures by county.

The observed precipitation above Montague, New Jersey for 2003 was 54.42 inches, or 11.16 inches above normal. Annual observed precipitation above Trenton, New Jersey was 60.79 inches, or 15.90 inches above normal. See the attached *Table 1: 2003 Precipitation at Selected Stations in the Delaware River Basin* for additional precipitation data for selected basin locations.

Streamflow

Recovering ground water levels from ample rainfall received in late 2002 maintained the basin's streamflows at normal- to above-normal levels during the first 30 days of 2003. By February, streamflow levels began to fall as precipitation became locked in ice and snow and produced little runoff to streams and rivers. In late February, the basin's "frozen assets" began to thaw and both the main stem Delaware and its tributaries responded with normal- to above-normal streamflows. At the end of March, streamflows for the Delaware River at Montague and Trenton averaged 70 percent and 64 percent above normal for the month, respectively. Along the Lehigh and Schuylkill rivers, streamflows ranged from roughly 40-to 75-percent above normal.

Streamflow was variable throughout the rest of the spring as the basin received below-normal precipitation in April and normal- to above-normal precipitation in May. The arrival of June brought copious amounts of rainfall to the basin, with some areas receiving as much as 10 inches of rain during the month. By the end of June, the Delaware River's monthly flows at Montague and Trenton averaged 234 and 280 percent above normal, respectively. Along the Lehigh and Schuylkill rivers, streamflows averaged more than four times the normal levels for June. This wet weather pattern continued through the summer months into autumn. Above-normal streamflows throughout the basin during this period reflected the surplus of rain, particularly along the main stem Delaware where spilling reservoirs in the upper basin gave an additional boost.

September was another extremely wet month as heavy rainstorms, several tornadoes, and Hurricane Isabel paid successive visits to the basin. The Delaware River's flow at Montague averaged 12,724 cubic feet per second (cfs), or 488 percent above normal, during September. This set a record for the highest average streamflow for the month based on nearly 64 years of data collection by the U.S. Geological Survey (USGS). Similarly, the

flow of the river at Trenton averaged 22,448 cfs, or 349 percent above normal, also setting a new high based on 91 years of USGS record keeping. The mean streamflows during September for Montague and Trenton are 2,793 cfs and 5,919 cfs, respectively.

Above-normal rainfall, saturated soils, recovered ground water supplies, and spilling reservoirs maintained above-normal streamflows in the Delaware River and its tributaries for the remainder of the year. Based on USGS data, the average Delaware River streamflow for the 90-day period from September to November was the highest on record for both Montague and Trenton. See the attached *Table 2: 2003 Streamflow in the Delaware River Basin* for average monthly streamflow at selected stations. Also, please refer to *Figure 2: Delaware River at Montague, NJ* and *Figure 3: 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 2003. No directed releases were required from either of these reservoirs to meet the Delaware River flow objective of 3,000 cfs at Trenton. Please refer to *Figure 4: Blue Marsh Reservoir Elevation* and *Figure 5: Beltzville Reservoir Elevation* for 2003 reservoir elevations for these lower basin reservoirs.

No releases were made from Merrill Creek Reservoir (located near Phillipsburg, New Jersey) during 2003 to augment flows at Trenton and to replace evaporative losses caused by power generation. However, releases totaling 201.793 million gallons (MG) were made late in the year to maintain a desirable reservoir level after wet weather left the reservoir brimming with storage. These releases took place from late November through late December during four separate periods each lasting about 24 hours to maintain storage below the desired operating elevation of 922.80 feet.

Upper Basin

The NYC reservoirs in the upper Delaware River Basin began the year with above-normal storage and snow pack. As of January 1, the reservoirs had a combined storage of 224.978 billion gallons (bg), which was more than 35 bg above normal. This above-normal storage can be attributed to the ample precipitation that fell during the last four months of 2002. In addition to the above-normal storage in the reservoirs, nearly 63 billion gallons of water equivalent was stored in the snow pack above the reservoirs according to the first snow survey conducted by the USGS in early January.

Minor fluctuations in storage occurred in the NYC Delaware reservoirs during the first two and one-half months of 2003. Snow pack continued to accumulate in the upper basin and a water equivalent of more than 80 billion gallons was reported as of the mid-February USGS snow survey. By mid March, reservoir storage was on the rise as warmer temperatures caused the snow pack to melt and run off. The three NYC Delaware reservoirs refilled to capacity on March 26. Because the reservoirs never refilled in 2002, this was the first time the reservoirs were at capacity since May 2001.

Heavy rain in the upper basin during late March and early April melted the last of the snow above the reservoirs. By March 28, Cannonsville, Pepacton, and Neversink reservoirs were spilling excess water into the tributaries below the reservoirs. The spilling from Cannonsville had begun in mid January. Fueled by frequent rain events, the reservoirs remained at or above capacity through June 30 and spilling continued, from one reservoir or another, through early July.

In early July, water supply storage in the three reservoirs began to decline, as is normal for that time of year, but remained above median storage levels. On July 1, usable storage in the NYC Delaware reservoir system totaled 270.483 bg, or 13.403 bg above normal. By July 31, storage had further declined to 259.597 bg, although this was still 27.165 bg above the median storage level for that date. Streamflow also began to decline during July and directed releases to maintain the flow target of 1,750 cfs at Montague were necessary. The first releases of the year were directed by the Delaware River Master on July 20-21.

During the first week of August, 1.5- to 2.5-inches of rain fell in the upper basin. The Cannonsville, Pepacton, and Neversink reservoirs refilled to their usable capacity on August 13 and, for the first time in their history, spilled water in August. Spill amounts dwindled over the course of the month and by the last days of August and into early September; directed releases were once again necessary to augment the streamflow at Montague. The last directed release of 2003 was made on September 3. A total of only 3.18 bg was released during 2003, compared to 47.25 bg and 102.60 bg released in 2002 and 2001, respectively.

September brought heavy rain storms to the upper Delaware River Basin and rainfall averaged 10.39 inches above Montague. More than half of this amount fell during the first four days of September. On September 4, the NYC Delaware reservoirs refilled briefly for the third time in 2003 and began to spill. Total reservoir storage dropped to below capacity by September 12, but refilled once again just 10 days later when a storm dropped another 1.5- to 2.0-inches of rain above the reservoirs. Spilling continued from the NYC Delaware reservoir system for the remainder of September (never ceasing from the first heavy rain event earlier in the month) and continued through December 31. For more information regarding spill amounts from the NYC Delaware reservoirs, please refer to *Table 3: 2003 Snapshot of the NYC Delaware Reservoirs* and *Figure 6: NYC Delaware Reservoirs - Spill in Billion Gallons and Percent of Total.*

Combined storage in the NYC reservoirs was the highest on record for the first day of October. Storage remained between 99 and 103.7 percent of usable capacity during the month. Record storage continued into November as the combined storage in the reservoirs remained at or above usable capacity for all but a single day. December's record storage was a repeat of November's and storage remained above usable capacity for the entire month.

By late December, record storage in the reservoirs led to concerns over the potential of late-winter and early-spring flooding in the upper basin. Conditions were ripe for flooding due to the above-normal snow pack, the uncontrolled spill from the brimming reservoirs, and the potential for ice jam formation on the tributaries below the reservoirs. A spill reduction program at Pepacton Reservoir, authorized by the parties to the 1954 U.S. Supreme Court decree, was implemented on December 19 to gradually reduce the excess storage and resulting spill from the reservoir. Controlled releases (i.e., above the normal conservation release) were made daily to gradually reduce the storage in the reservoir. Releases from this program averaged 272 million gallons a day for the remainder of December.

As of December 31, total usable storage in the three NYC Delaware reservoirs was 274.820 bg (101.5 percent of usable storage), or more than 85.992 bg above the median storage level for that date. For a graphical presentation of NYC reservoir storage levels during 2003, please refer to *Figure 7: New York City Delaware River Basin Storage 2003.*

Ground Water

Due to the extremely moist autumn and early winter of 2002, water levels in many basin wells had recovered significantly by the start of 2003. The average ground water level in eight reported USGS observation wells in the Pennsylvania portion of the basin was above the normal range in January. Since October 2002, water levels recovered between three and 11 feet in the southeastern Pennsylvania wells and between six and 40feet in wells located farther north. Water levels in three observation wells in the coastal plain region of Delaware (New Castle County and Kent County) and New Jersey (Cumberland County) also showed significant improvement. Water levels at the two Delaware wells were back in the normal range by January 2003. Water levels at the New Jersey well, although significantly recovered, remained below the normal range.

Generally, ground water levels continued to improve during the winter months and early spring. The one exception was the average water level in the eight Pennsylvania observation wells, which declined to slightly below normal during February. The average ground water level in the observation wells briefly recovered to above normal during March, but then returned to slightly below normal during April and May. By June, however, the average water level at the eight wells had recovered once again to above the average level. A surplus of rainfall maintained the above-normal level for the remainder of 2003.

Ground water levels in the Delaware observation wells continued to remain within their normal range throughout the spring. By May, water levels in both the New Castle County and Kent County wells climbed to above-normal levels (75-percentile or greater) and remained at these levels during the remainder of 2003. The water level in the Cumberland County well recovered to within the normal range during March. The well continued to improve to above the normal range during July, remaining at this level for the rest of the year.

Please refer to the attached *Figure 8: USGS Network Wells-Pennsylvania*, *Figure 9: DGS Well-New Castle Co., Delaware*, *Figure 10: USGS Well-Kent Co., Delaware*, and *Figure 11: USGS Well-Cumberland Co., New Jersey* for graphical presentations of ground water levels throughout 2003.

Chlorides

The seven-day average of the 250 parts-per-million isochlor (salt line) was located downstream of its normal location at the beginning of 2003. This was due to the above-normal streamflow experienced during December 2002. By late January and early February, streamflow declined and the salt line migrated upstream to above its normal location. On February 22, the salt line reached river mile 74, its farthest upstream location for the year. This location, which is approximately four miles below the Delaware-Pennsylvania state line, was six miles upstream of the normal mid-February location. As the snow pack began to melt in March, rising streamflows caused the salt line to retreat to below the normal location for March, followed by an incursion above its normal location during April and May. Above-normal amounts of rainfall during the remainder of the spring, summer, and autumn months kept the salt line far below its normal location for the remainder of the year. The year closed with the salt front below river mile 54, which is more than twenty miles below the normal mid-month location for December. See the attached *Figure 12: Location of the 7-Day Average of the 250-PPM Isochlor* for an overview of salt line locations along the Delaware River during 2003.