

Watershed Management

Practice, Policies, and Coordination

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Anatomy of a Drought

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Introduction

The drought of 1995 was a significant event which severely reduced the availability of public water supplies in northern New Castle County (Delaware). The year-long drought was characterized by an extended period of deficit precipitation which resulted in near-record low stream flows in the Christiana watershed, declining groundwater levels, and a depleted Hoopes Reservoir (see Figs. 16.1 and 16.2). The dry conditions reduced the availability of stream flows for water supply purposes, nearly resulting in water shortages just after Labor Day in 1995. Fortunately, record rainfall during October averted the water emergency, and water conditions returned to normal.

The drought created hardships for the citizens and businesses of New Castle County, yet it highlighted opportunities for improvement of the regional water supply system. The following summary discusses the chronology of the drought and various drought management activities by state, county, local, and private water agencies. More importantly, this chapter discusses the lessons and actions which are needed to improve watershed management activities for future droughts.

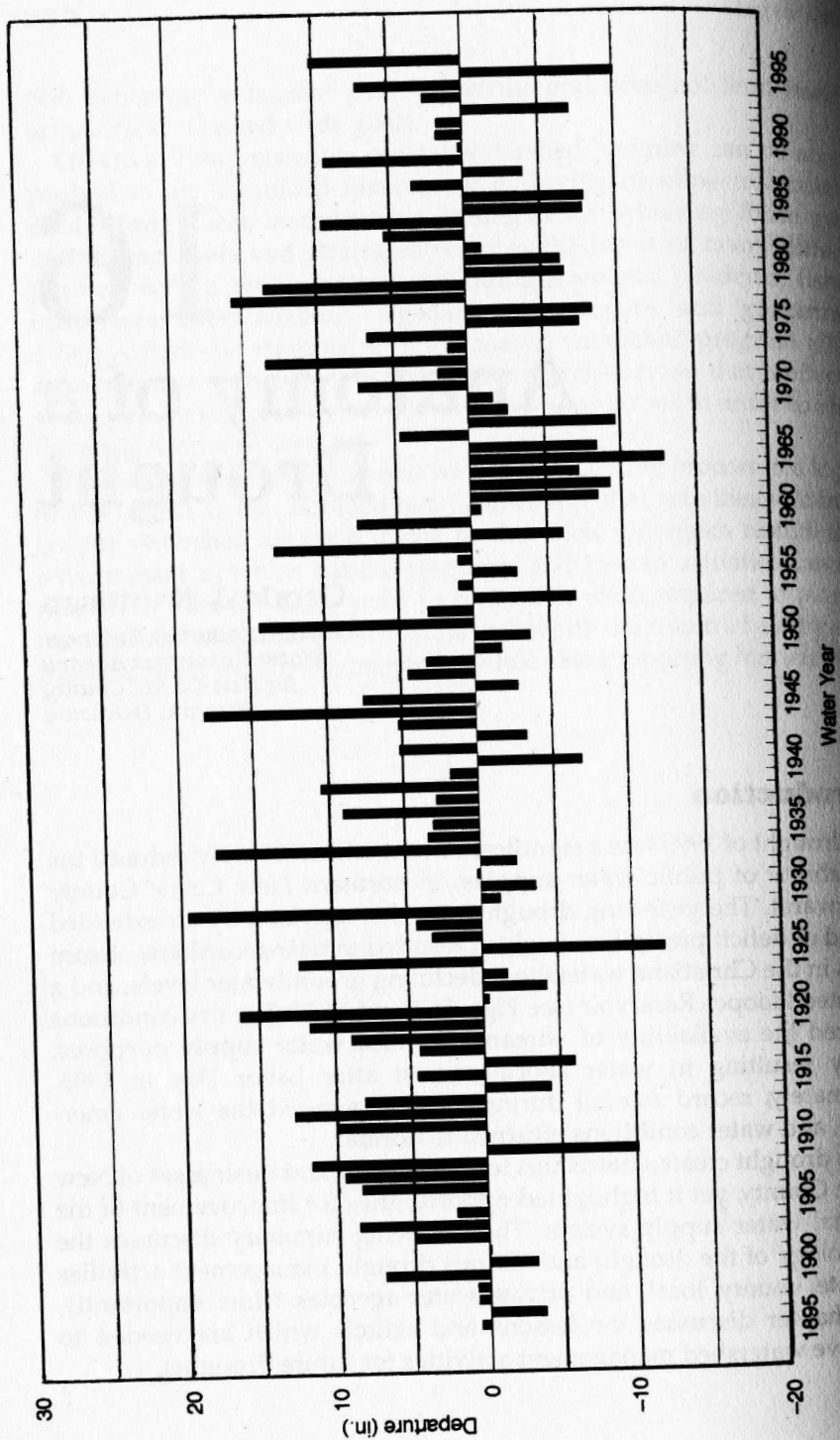


Figure 16.1 Average annual precipitation in northern New Castle County, 1895 to 1995.

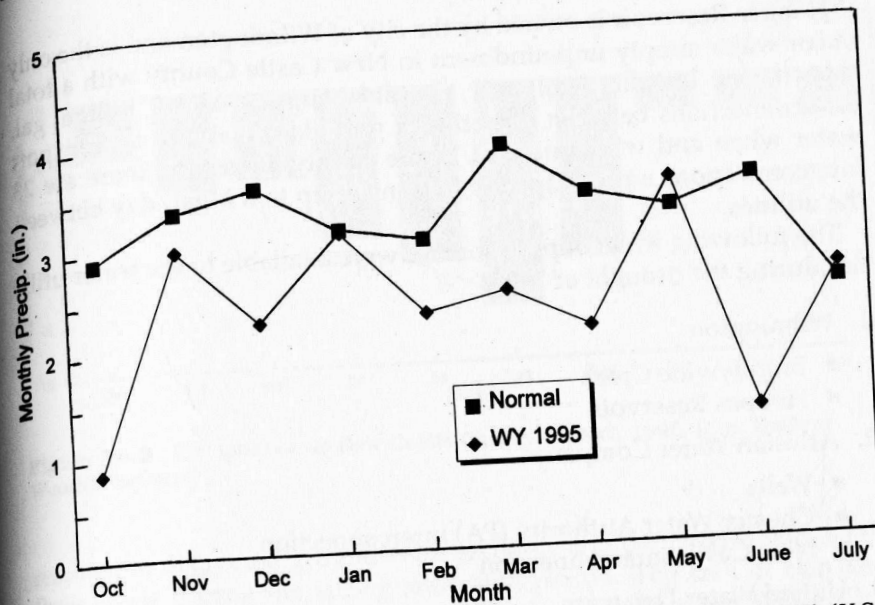


Figure 16.2 Precipitation in northern New Castle County, water year 1995. (U.S. National Weather Service.)

Public water supply system

Public water supplies in northern New Castle County are provided by five major public and private utilities. The city of Newark, city of Wilmington, and city of New Castle operate public water utilities which supply water in and around their respective municipalities. The Artesian Water Company and United Water Delaware are private investor-owned utilities which supply water to the suburbanizing areas of unincorporated New Castle County. Average water production for the five water suppliers ranges from 61 Mgal/day in March to 78 Mgal/day in June.

The five utilities obtain water from surface water in the Christiana drainage basin, groundwater, and interconnected supplies. Surface water supplies provide over 70 percent of the public water to New Castle County from Brandywine Creek, Red Clay Creek, White Clay Creek, and Christina River. Minimum 7Q10 in-stream flow requirements are in place along White Clay Creek at the Newark water treatment plant (WTP) and the United Water Delaware Stanton Filter Plant. Groundwater provides 30 percent of the public water supplies from the Cocksylville, Columbia, and Potomac aquifers. Supplemental supplies are provided to Artesian and United Water via interconnections.

Hoopes Reservoir is owned by the city of Wilmington and is the only major water supply impoundment in New Castle County with a total capacity of 2 billion gal and a usable supply of 1.5 billion gal. Interconnections between the utilities provide the ability to transport water when and where needed in the county. Presently, there are 23 interconnections with a capacity to transfer up to 8 Mgal/day between the utilities.

The following water supply sources were available to the water utilities during the drought of 1995:

1. Wilmington

- Brandywine Creek
- Hoopes Reservoir

2. Artesian Water Company

- Wells
- Chester Water Authority (PA) interconnection
- New Castle interconnection

3. United Water Delaware

- White Clay Creek and Stanton WTP—Hoopes Reservoir
- Christina River and Smalley's Pond
- CWA (PA) interconnection
- Artesian Water Company connection
- Wilmington interconnection

4. City of Newark

- White Clay Creek and surface WTP
- Wells
- United Water interconnection
- Artesian Water interconnection

5. New Castle Board of Water & Light

- Wells

Chronology of the Drought

October 1994 through May 1995—Prologue

The drought of 1995 actually started in the fall of 1994 when, after a wet summer, for several consecutive months there was less than normal precipitation. The dry conditions continued through the winter of 1995, and only one snowstorm occurred during January. The lack of snow

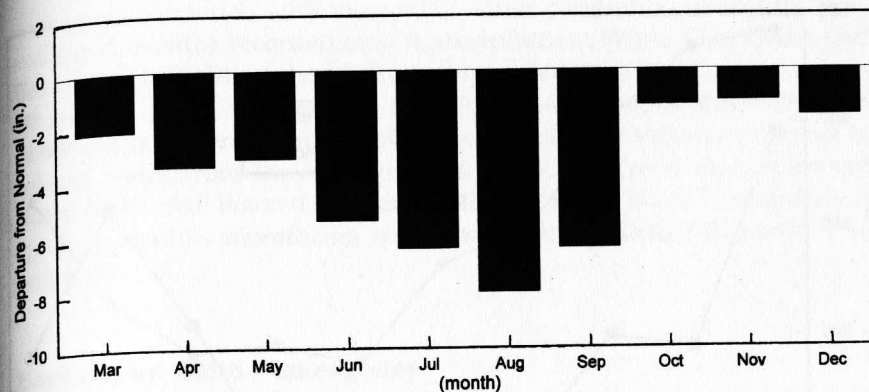


Figure 16.3 Precipitation at New Castle County Airport, 1995. (U.S. National Weather Service.)

resulted in decreased groundwater recharge and depleted stream base-flow levels during the spring snowmelt period. The lack of rain and snow resulted in April mean flows for the Red Clay and White Clay Creeks which were the lowest and third-lowest on record, respectively. By Memorial Day, the monthly precipitation at New Castle County Airport measured below normal for seven of the eight previous months of water year 1995, which began in October 1994 (see Fig. 16.3).

June 1995—decline

During June 1995, the low-water conditions continued. The cumulative precipitation deficit for water year 1995 approached 7 in, which was comparable to the drought year of 1966. The city of Newark considered the possibility of voluntary water restrictions due to declining stream flows at the White Clay Creek surface water treatment plant. The Department of Natural Resources and Environmental Control (DNREC) and the Delaware Geological Survey (DGS) were requested to prepare a press release notifying the public about the continuing dry conditions.

July 1995—advisory

During July 1995, drought management activities accelerated due to the continuing low-water conditions. The hottest day ever in Wilmington occurred on July 15, when the public water suppliers recorded a peak water demand of 87 Mgal/day. The governor's drought advisory committee convened and recommended on July 19 that the governor issue a

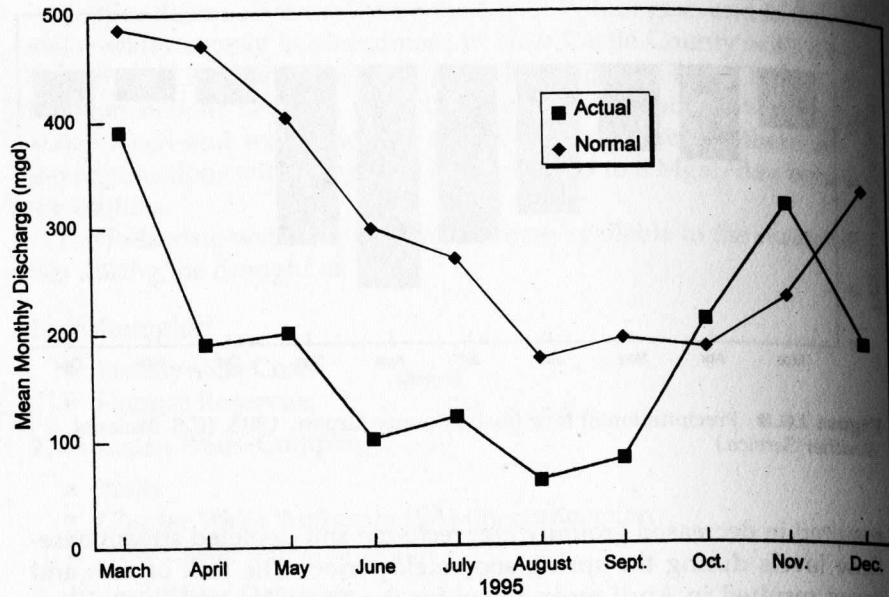


Figure 16.4 Mean monthly discharge (Mgal/day) at Brandywine Creek at Wilmington, Delaware. (U.S. Geological Survey.)

drought advisory with voluntary water restrictions for northern New Castle County. Water conditions continued to decline at the end of July when the cumulative precipitation deficit for water year 1995 exceeded 10 in and the stream flows reached 7Q5 (see Fig. 16.4). According to DNREC indicators, northern New Castle County was officially in "drought" status.

August 1995—warning

During August 1995, water conditions continued to deteriorate. On August 18, the city of Newark ordered voluntary water restrictions in its service area. The governor's drought advisory committee, on August 22, recommended that the governor declare a drought warning with possible mandatory water restrictions in northern New Castle County after a 20-day public notice period. Public water suppliers were requested by the governor's drought advisory committee to review their emergency contingency plans. On August 28, the city of Newark ordered mandatory water restrictions due to declining stream flows and the prospect of increased water demand during the new semester at the University of Delaware.

August concluded with worsening water conditions. Ten of the preceding 11 months recorded deficit precipitation. White Clay Creek and Brandywine Creek reached 7Q10 and recorded the third-lowest flows in 40 and 50 years, respectively (see Fig. 16.4). Hoopes Reservoir was observed at 65 percent of capacity. The city of Wilmington continued to release water from the reservoir into Red Clay Creek to supplement flows at United Water Delaware's Stanton Filter Plant. Groundwater levels in shallow monitoring wells continued to decline due to lack of recharge.

September 1995—emergency

September 1995 represented the trough or most critical period of the drought (see Fig. 16.5). On September 1, United Water Delaware ordered mandatory water restrictions due to declining White Clay Creek flows. With the drought emergency declaration, the minimum flow standard at the United Water Delaware Stanton Filter Plant was waived by the Delaware River Basin Commission (DRBC). On Labor Day, September 4, the city of Wilmington ordered mandatory water restrictions. On the same day, the governor of Delaware declared a drought emergency with the intent to declare mandatory water restrictions in northern New Castle County after a 7-day public notice period. Artesian Water Company followed with mandatory water restrictions

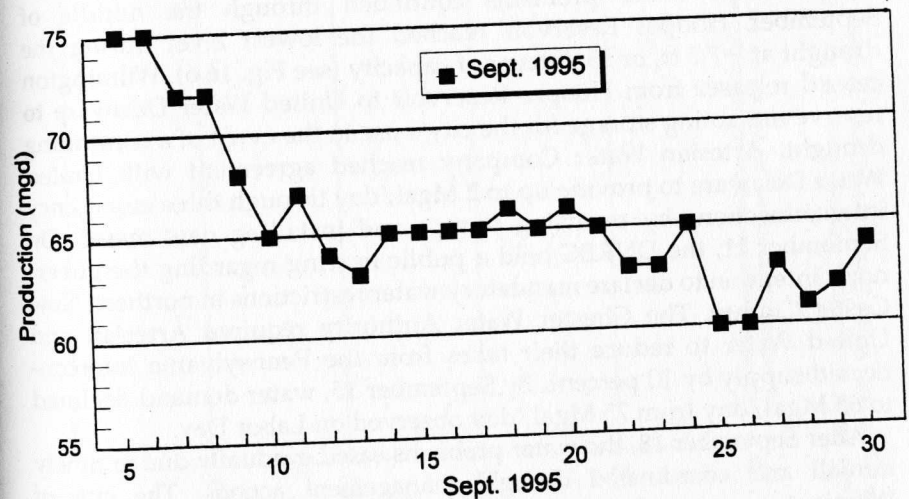


Figure 16.5 Public water supply production, northern New Castle County, Delaware. (Water Resources Agency for New Castle County.)

on September 5. On September 7, during a governor's drought advisory committee meeting, the Delaware Geological Survey reported that the water conditions index was in the "water shortage" range. DNREC requested industries to submit conservation plans to reduce water use by 25 percent. The Water Resources Agency for New Castle, Delaware (WRANCC) and United Water Delaware (UWD) petitioned Wilmington to continue releases from Hoopes Reservoir for use by UWD. The WRANCC was requested to track daily supply and demand of the five water suppliers. United Water reported that unless rainfall or supplemental flows from Hoopes Reservoir were received, a water shortage in its service area was imminent.

The week of September 8 through 15, 1995, was the nadir of the drought. Some areas had not received rain for 3 to 4 weeks. Brandywine Creek approached the 7Q10. White Clay Creek approached low levels not seen since the drought years of the early 1960s. Wilmington experienced difficulty in capturing the historically low stream flows along Brandywine Creek to meet water demand in the city. United Water Delaware curtailed water withdrawals to 30 percent of allocated capacity and constructed a low dam along White Clay Creek to capture tidal flow at the Stanton Filter Plant. Due to lack of stream flows, sodium and chloride levels in White Clay Creek continued to rise above the allowable limits set by the Delaware drinking water standards. The city of Newark ceased withdrawals at its White Clay Creek water treatment plant. The cumulative precipitation deficit for the water year reached -12 in, which had been exceeded only three times in 100 years.

The severe water problems continued through the middle of September. Hoopes Reservoir reached the lowest level during the drought at -7.5 ft, or 55 percent of capacity (see Fig. 16.6). Wilmington ceased releases from Hoopes Reservoir to United Water Delaware to reserve remaining storage for the city's use in the event of a continuing drought. Artesian Water Company reached agreement with United Water Delaware to provide up to 2 Mgal/day through three emergency interconnections by reversing pumps and installing new mains. On September 11, the DNREC held a public hearing regarding the governor's intention to declare mandatory water restrictions in northern New Castle County. The Chester Water Authority required Artesian and United Water to reduce their takes from the Pennsylvania interconnected supply by 10 percent. By September 15, water demand declined to 65 Mgal/day from 75 Mgal/day observed on Labor Day.

After September 18, the water problems eased gradually due to timely rainfall and coordinated drought management actions. The city of Wilmington approved emergency releases to United Water Delaware from a refilling Hoopes Reservoir. Industries utilized emergency surface water

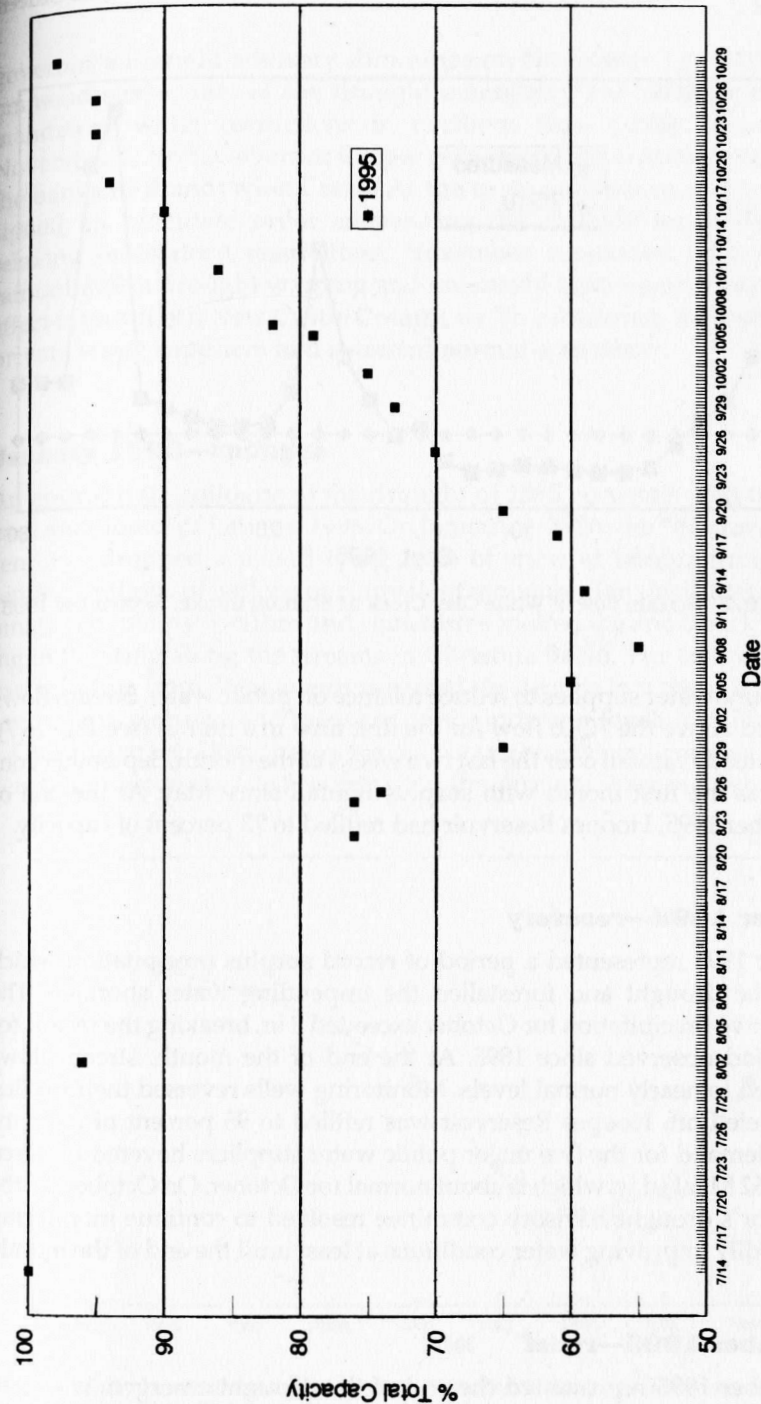


Figure 16.6 Capacity of Hoopes Reservoir for July through October, 1995. (City of Wilmington and Water Resources Agency for New Castle County.)

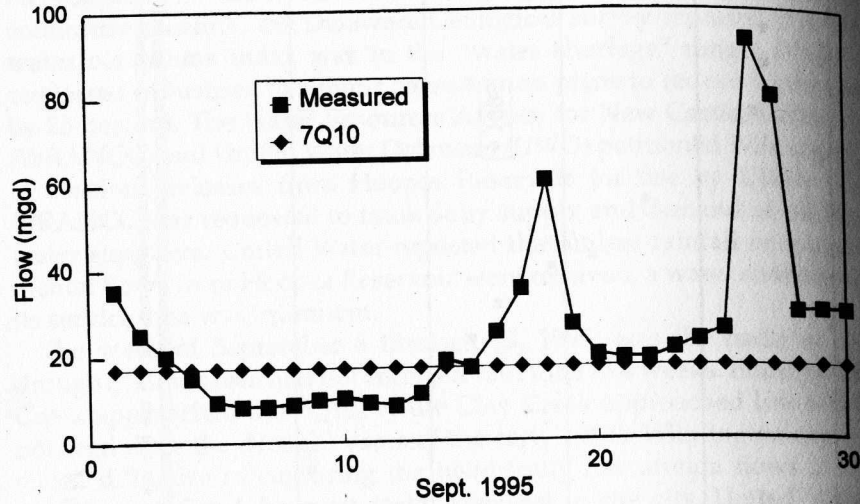


Figure 16.7 Stream flow at White Clay Creek at Stanton intake, September 1995.

and groundwater supplies to reduce reliance on public water. Stream flows increased above the 7Q10 flow for the first time in a month (see Fig. 16.7). Due to steady rainfall over the last two weeks of the month, September concluded as the first month with surplus rainfall since May. At the end of September 1995, Hoopes Reservoir had refilled to 73 percent of capacity.

October 1995—recovery

October 1995 represented a period of record surplus precipitation which eased the drought and forestalled the impending water shortage. The cumulative precipitation for October exceeded 8 in, breaking the record for the period observed since 1895. At the end of the month, stream flows increased to nearly normal levels. Monitoring wells reversed their decline and leveled off. Hoopes Reservoir was refilled to 95 percent of capacity. Water demand for the five major public water suppliers hovered between 60 and 62 Mgal/day, which is about normal for October. On October 26, the governor's drought advisory committee resolved to continue monitoring the steadily improving water conditions at least until the end of the month.

November 1995—relief

November 1995 represented the end of the drought emergency. Due to improved precipitation, stream, groundwater, and reservoir levels, the

governor's drought advisory committee on November 3 agreed to recommend suspension of the drought emergency and relaxation of the mandatory water restrictions in northern New Castle County. On November 6, 1995, Governor Carper convened a press conference along the banks of Brandywine Creek. At the press conference, the governor signed an executive order suspending the drought emergency and relaxing mandatory restrictions. November concluded with surplus rainfall with a drought warning and voluntary water restrictions still in effect for northern New Castle County. By Thanksgiving, the public and private water suppliers had resumed normal operations.

January 1996—epilogue

An appropriate epilogue to the drought of 1995 occurred with the blizzard and floods of January 1996. On January 8, 1996, the "blizzard of the century" dropped a record-tying 22 in of snow at Wilmington, representing millions of gallons of equivalent moisture. Ten days later, a combination of balmy weather and rainstorms melted the snowpack, resulting in flooding along the streams in Christina Basin. The above-normal precipitation from these events reversed the decline in water conditions, resulting in recharge and recovery of groundwater levels (see Fig. 16.8).

On February 9, 1996, the governor's drought advisory committee convened and recommended terminating the drought warning, which had

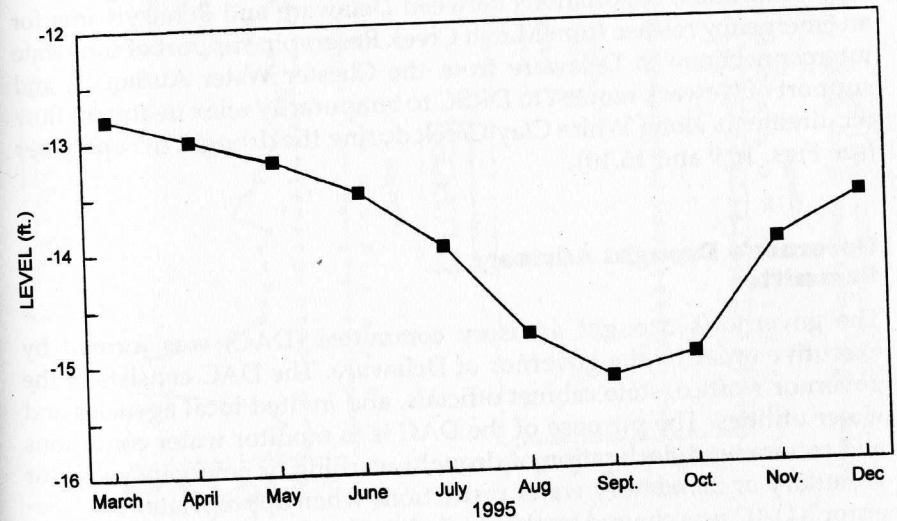


Figure 16.8 Level of water table well in New Castle County, Delaware, for March to December 1995. (Delaware Geological Survey.)

been in effect for the last 7 months. At the end of February, hydrologic indicators registered above normal, indicating the end of the drought.

Drought Coordination

Drought coordination activities were administered by three committees which worked to avert a water shortage in New Castle County. The responsibilities of these committees included monitoring of water conditions, coordination of water supplies between the utilities, and declaration of drought warnings and water restrictions. The activities of the drought coordination committees are described below.

Christina Basin Drought Management Committee (CBDMC)

This committee consists of state and county agencies and public and private water utilities in the Pennsylvania and Delaware portions of Christina Basin. The purpose of the CBDMC is to coordinate interstate drought management activities within Christina Basin in Pennsylvania, which provides 40 percent of the water for Chester County, and Delaware, which provides 70 percent of the water for New Castle County. Significant actions by the CBDMC during the drought of 1995 included recommendations to convene the governor's drought advisory committee, negotiations between Delaware and Pennsylvania for an emergency release from Marsh Creek Reservoir, support of interstate interconnections to Delaware from the Chester Water Authority, and support of Newark request to DRBC to temporarily relax in-stream flow requirements along White Clay Creek during the drought in September (see Figs. 16.9 and 16.10).

Governor's Drought Advisory Committee

The governor's drought advisory committee (DAC) was formed by executive order by the governor of Delaware. The DAC consists of the governor's office, state cabinet officials, and invited local agencies and water utilities. The purpose of the DAC is to monitor water conditions and recommend declaration of drought warning or emergency and/or voluntary or mandatory water restrictions when appropriate. The governor's DAC was chaired by the chief of staff and met weekly during the drought of 1995.

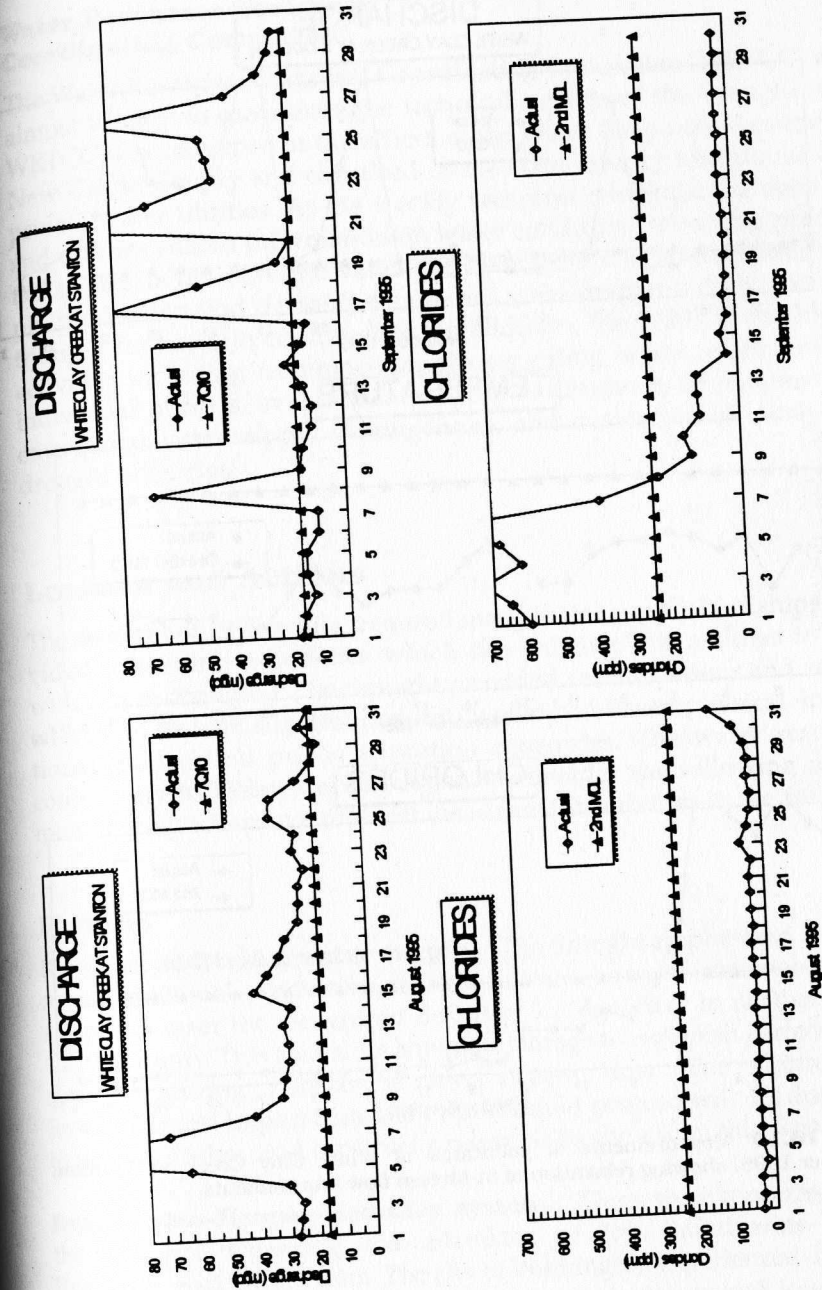


Figure 16.9 Comparison of discharge and chlorides at White Clay Creek at Stanton, August and September 1995.

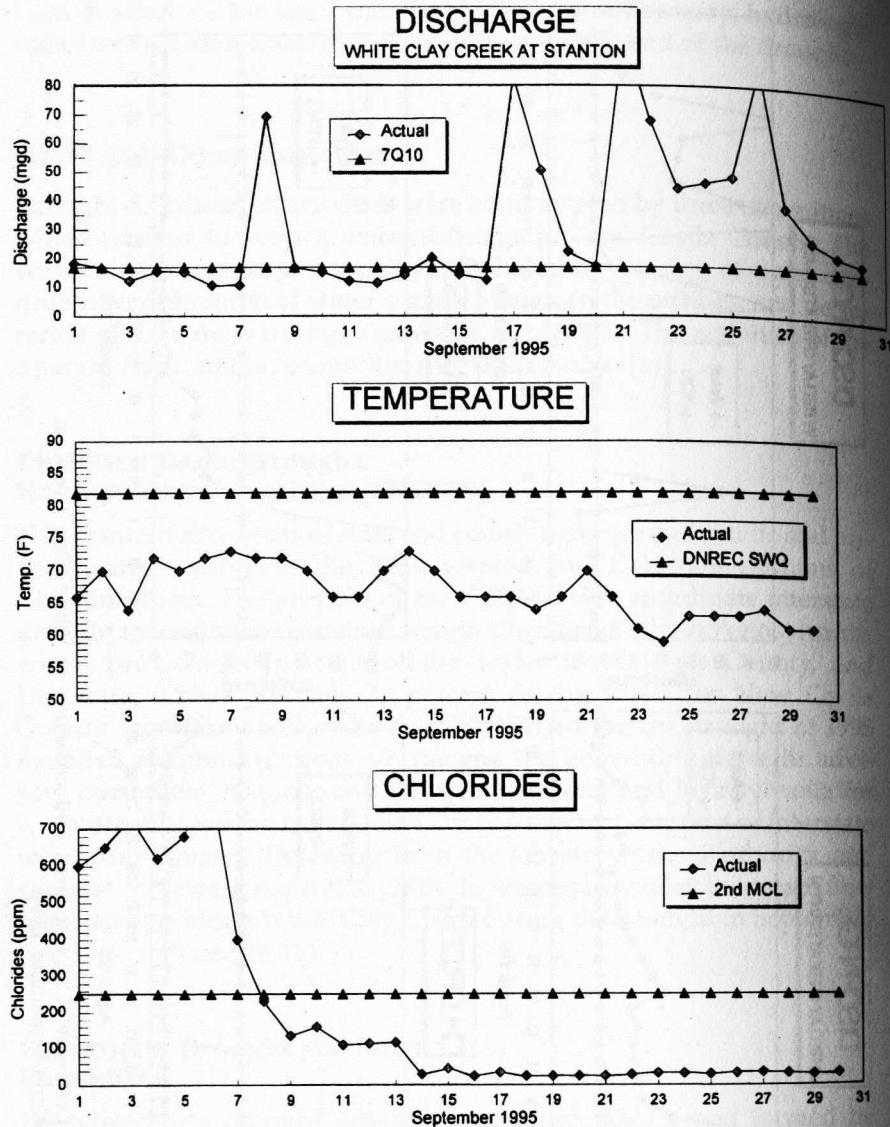


Figure 16.10 Measurements of pollutants at White Clay Creek at Stanton, September 1995, showing relaxation of in-stream flow requirements.

Water Resources Technical Coordinating Committee

The Water Resources Technical Coordinating Committee (WRTCC) met almost weekly to coordinate the technical aspects of the drought. The WRTCC was convened at the offices of the Water Resources Agency for New Castle County and consisted of the state, county, and public and private water utilities. At the weekly technical meetings, the agencies and utilities shared information on water conditions involving precipitation, stream flow, groundwater levels, and reservoir levels. Water supply production and demand summaries were prepared daily and distributed for drought coordination. In addition, the WRTCC conducted activities including recommendations regarding water restrictions by individual utilities, evaluations of Hoopes Reservoir, development of emergency water supply contingencies, and evaluation of worst-case drought scenarios.

Lessons and Actions

The drought of 1995, while it caused many water supply hardships, provided a learning experience which can enhance our abilities to cope with future droughts. The drought provided certain lessons and actions which can be logically grouped into watershed-based physical, institutional, policy, and public education categories. The water resources community in Delaware was urged to consider the following recommendations to improve drought management activities in the future.

Physical

Need for additional water supply. The drought emphasized the need for an additional, permanent, reliable, in-state source of sustainable water supply to meet the recognized deficit of 20 Mgal/day in northern New Castle County. This area lacks adequate storage to replenish surface water supplies during periods of low stream flow. The Churchmans Environmental Impact Statement (EIS) should proceed with all due speed to permit, design, and construct a reservoir by the end of this century.

Brandywine-Hoopes-Red Clay system. There were concerns during the drought regarding the adequacy of the Brandywine-Hoopes Reservoir-Red Clay system. The city of Wilmington experienced difficulty withdrawing water from Brandywine Creek during record low stream flow levels. There were questions regarding the actual capacity and con-

ditions of pumps which withdraw water from Brandywine Creek and fill and drain Hoopes Reservoir. An infrastructure assessment should be conducted to evaluate the capacity and condition of gates, canals, tailraces, pump stations, and pipelines in this vital system.

Hoopes Reservoir operating plan. During the drought, there were questions about the actual capacity of Hoopes Reservoir and whether sufficient storage was available for Wilmington and United Water Delaware through the end of the drought. There were questions regarding the capacity of the reservoir depending on the condition of the outlet gates, accumulated sediment in the impoundment, and water quality based upon predicted high levels of manganese at lower depths. When Hoopes reached 55 percent of capacity, the city ceased releases to United Water Delaware to reserve the balance of storage for the city during continuing drought. A Hoopes Reservoir operating plan should be developed which addresses the questions about actual volume, outlet structure condition, and water quality. The plan should specify written operating guidelines, similar to those for Marsh Creek Reservoir, which dictate storage commitments and required releases for the city of Wilmington and United Water Delaware during normal and drought periods.

Interconnected network. The interconnected network was one reason that a water shortage was averted in northern New Castle County. During the critical dry period in early September 1995, up to 5 Mgal/day was transferred between the utilities to meet demand in service areas of short supply. Artesian Water Company installed three emergency interconnections which conveyed 2 Mgal/day to United Water by reversing pumps and laying new mains. A hydraulic evaluation should be conducted to identify opportunities for increased interconnections between the utilities during normal and drought emergency periods. Also, formal interconnection agreements should be prepared by the utilities which specify capacity, duration, and financial arrangements during normal and drought periods.

Interim water supply alternatives. The drought highlighted the need to develop all possible water supplies to meet deficits over the next few years. The following projects should be developed to maximize water supplies over the next several years until a regional water supply alternative is implemented by the Churchmans EIS:

- Continued CWA interconnections from Pennsylvania
- UWD tidal enhancement structure along White Clay Creek
- Water treatment plant at Newark south well field

Stream gauging. During the drought, the media incorrectly reported problems at the gauge along Brandywine Creek at Wilmington during record low stream flows. The Delaware Geological Survey performed outstanding work by continuing difficult stream gauging measurements during record low flows when levels dropped "off the chart."

Institutional

Drought emergency preparedness plan. The critically low water supply conditions emphasized the need to prepare a statewide drought emergency preparedness plan. Such a plan should be prepared by the Delaware Emergency Management Agency (DEMA) and should describe emergency water supplies (tankers, desalting plants, etc.), priority service areas (nursing homes, hospitals, etc.), and a chain of command for drought coordination during an emergency. The drought emergency plan should be similar in scope and scale to the plans prepared for floods, fires, snowstorms, and other natural disasters.

Marsh Creek Reservoir accord. During the critical drought period in early September, Delaware requested Pennsylvania to provide an emergency release from Marsh Creek into Brandywine Creek for capture by the city of Wilmington. While the terms of the release were being negotiated, the drought eased, stream flows increased and the emergency release from Marsh Creek was deemed no longer necessary. While in a nondrought period, the two states should finalize the paperwork regarding an emergency release from Marsh Creek, should it be needed in the future. The agreement should specify that a release would be requested only as a contingency, in an emergency, and only as a last resort to supplement low flows in Brandywine Creek at Wilmington.

Water master. During the drought emergency, there was debate and difficulty allocating stream flows, withdrawals, and reservoir storage for use by water suppliers with the greatest need. In the Delaware River basin, a "river master" is appointed as an impartial party to equitably apportion stream flow, withdrawals, and reservoir storage in accordance with negotiated agreements. A similar impartial position, perhaps a "water master," should be considered to allocate water supplies during a drought emergency in Christina basin. The water master would be appointed as a position within DEMA with duties specified through negotiated agreements among public agencies and the water utilities.

Relaxed water standards. A water shortage in northern New Castle County was averted partially through the relaxation of water standards during the drought emergency. Water utilities were permitted to temporarily exceed well allocation standards. Drinking water standards for sodium and chlorides were exceeded for two weeks in White Clay Creek due to lack of freshwater flow. Minimum in-stream flow standards were waived during the duration of the drought emergency along White Clay Creek at the Newark WTP and the UWD Stanton Filter Plant. Additional storage is needed to supplement existing water supplies so water quantity and quality standards are not compromised during future droughts.

Policy

Three-phase drought declaration. The drought outlined the need to update the DNREC drought management plan. The current plan specifies a two-phase drought declaration (warning and emergency) which provides little opportunity for an early public "advisory" and is inconsistent with the existing three-phase drought declaration policy in use by neighboring Chester County, Pennsylvania. The following three-phase drought declaration policy should be developed in Delaware depending on the severity of water conditions:

- Advisory (voluntary restrictions)
- Warning (voluntary restrictions)
- Emergency (mandatory restrictions)

Public notice for drought emergency and mandatory restrictions.

The current Delaware drought management plan specifies a minimum 20-day public notice period before a drought emergency and mandatory restrictions can be declared by the governor. The recent drought indicated that water conditions can decline from warning to emergency status more rapidly than 20 days. A shorter public notice period, say 7 days, should be instituted to permit a more expedient declaration of drought emergency and mandatory restrictions in the event of rapidly declining water conditions.

Drought forecast index. The current DNREC drought forecast index (bowling chart) measures only Brandywine Creek and precipitation levels as indicators of water conditions in northern New Castle County. The recent drought exemplified the need to monitor other water conditions such as groundwater and reservoir levels as indicators of impending drought. The DNREC drought forecast index should be revised to incorporate factors based on

- Precipitation
- Soil moisture
- Stream flow
- Groundwater level
- Reservoir level

Drought emergency expiration. While the policies for entering a drought are well defined, there is no clear policy for expiration of a drought emergency or warning. An automatic expiration date should be included in a governor's drought emergency executive order to avoid the embarrassment of calling off a drought during a wet period.

Public education

Drought education. The recent drought illustrated public misconceptions about the need to order mandatory restrictions and declare drought emergency. A public education program should be enacted to inform the public about watershed-based drought management and water conservation activities.

Media visibility and relations. Considerable television and newspaper coverage was provided during this drought (see Fig. 16.11). Most of the media coverage was desirable, to communicate the need to conserve water. However, certain articles were not factual and created a false public perception regarding the competence of drought management activities by public agencies and the utilities.

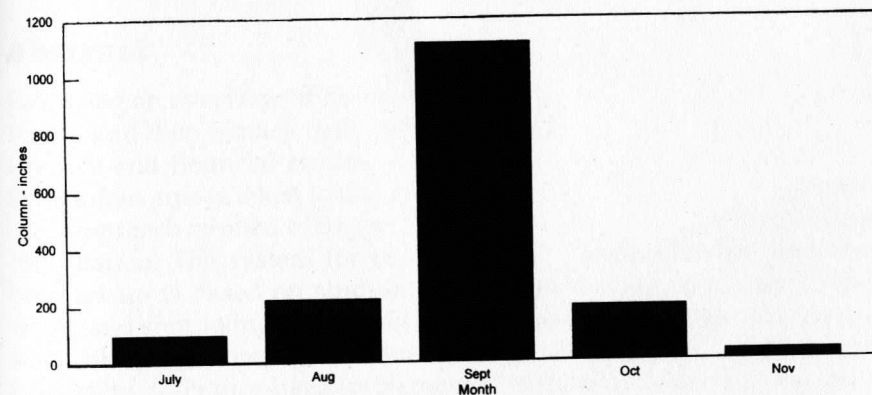


Figure 16.11 Extent of media coverage during the drought of 1995. (*The News Journal, Wilmington, Delaware.*)