FIFTH REPORT TO THE GOVERNOR AND THE GENERAL ASSEMBLY

Regarding the Progress of the:

DELAWARE WATER SUPPLY COORDINATING COUNCIL

(The Drought of 2002)

January 17, 2003

Prepared by the:

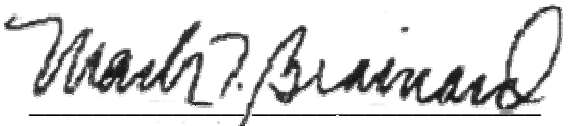
Delaware Department of Natural Resources and Environmental Control

Delaware Geological Survey

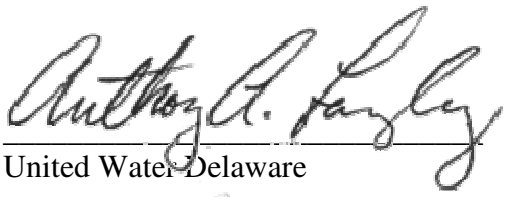
University of Delaware, College of Human Services, Education, and Public Policy
Institute for Public Administration - Water Resources Agency

FIFTH REPORT OF THE DELAWARE WATER SUPPLY COORDINATING COUNCIL
JANUARY 17, 2003

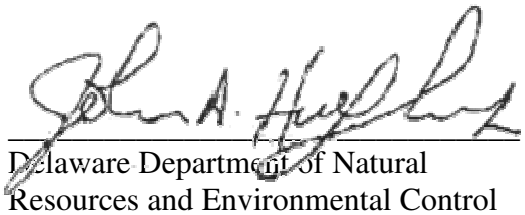
This report was prepared and approved by members of the Delaware Water Supply Coordinating Council. The members of the WSCC are in general concurrence and agree in principal with the findings and recommendations of the report as attested by:



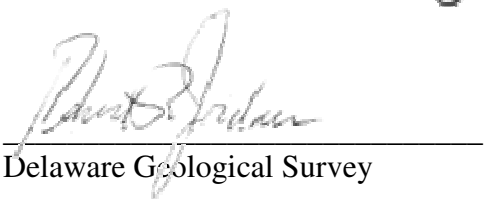
Governor's Chief of Staff



United Water Delaware



Delaware Department of Natural Resources and Environmental Control



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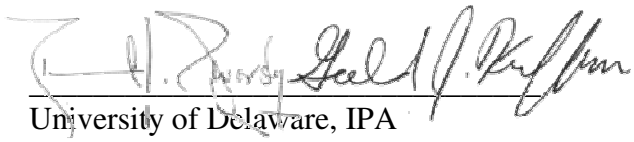

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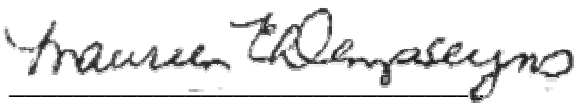
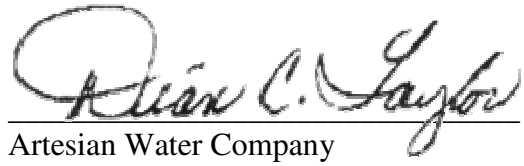


Delaware Division of Public Health

New Castle County Executive

Delaware River Basin Commission



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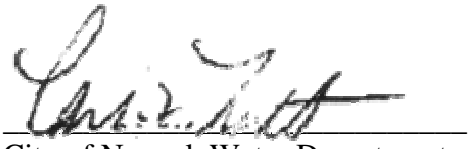
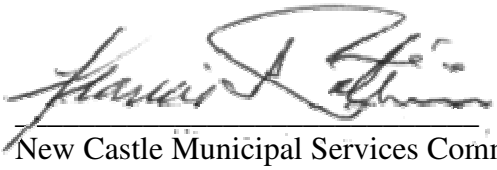
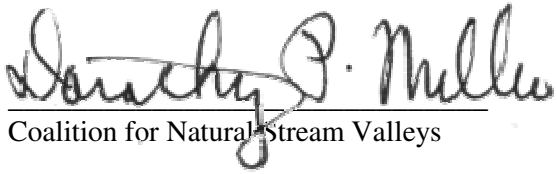


City of Newark Water Department

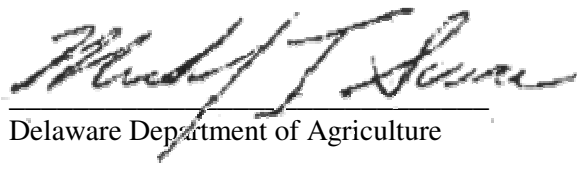
City of Wilmington Department of Public Works



New Castle Municipal Services Commission



Coalition for Natural Stream Valleys



Delaware Department of Agriculture

Delaware Public Service Commission

Delaware Emergency Management Agency

Delaware Public Advocate

Tidewater Utilities, Inc

New Castle County Chamber of Commerce

Delaware State Chamber of Commerce

Delaware Nursery and Landscape Association

Delaware Professional Grounds Management Society

Delaware Nature Society

Delaware State Golf Association

Michael Lee McDowell

for New Castle County Civic League

FIFTH REPORT OF THE DELAWARE WATER SUPPLY COORDINATING COUNCIL

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EXECUTIVE SUMMARY AND RECOMMENDATIONS

The Drought of 2002

As shown by indicators of precipitation and streamflow, the drought of 2002 is now a new drought of record in northern Delaware. Based on records at New Castle County Airport, the 12 - month precipitation for October 2001 through September 2002 totaled 28.33 inches or 69% of normal, the lowest since records began in 1894. On August 23, 2002, the Brandywine Creek at Wilmington stream gage recorded a mean daily flow of 21 million gallons per day (mgd), the lowest flow on record since 1947, eclipsing the record of 33 mgd set in September 1995. Daily record lows along the White Clay Creek, Red Clay Creek, and Christina River were also recorded during 2002. The drought of 2002 was statistically the 100-year drought or the drought with a 1% chance of occurring in any given year.

On March 5, 2002, Governor Ruth Ann Minner issued Executive Order No. 29 declaring a Drought Warning in Delaware and urging the voluntary conservation of water. Except for a wetter than normal June, the pattern of drier than normal months continued into the summer. With deteriorating water conditions, on August 2, 2002 the Governor, at the recommendation of the Governor's Drought Advisory Committee, issued Executive Order No. 32 declaring a Drought Emergency in Delaware north of the Chesapeake and Delaware Canal and imposing mandatory water use restrictions. Because ground-water supplies remained adequate in the southern part of the state, on the same date the Governor declared a Drought Warning with voluntary water use restrictions for Delaware south of the C&D Canal.

On October 11, 2002 in response to improving water levels in the streams and Hoopes Reservoir, Governor Minner declared the end of the drought emergency, lifted the mandatory restrictions and put a Drought Warning back in place requesting voluntary conservation of water statewide. Due to heavy autumn rains and snow, October, November and December were wetter than normal bringing stream flows up to above normal levels. The Governor's Drought Advisory Committee (DAC) convened on January 15, 2003 and recommended that the Governor lift the Drought Warning in Delaware.

During the drought of 2002, Delawareans cooperated to conserve water and reduce water demand below the goal of 70 mgd set by the Governor's Drought Advisory Committee. During a few days in July 2002, public water demand in northern New Castle County reached 83 mgd which was less than the peak day demands of 90 mgd normally experienced in a typical July. On July 18, 2002, the Governor's Drought Advisory Committee recommended a goal for Delaware residents and businesses to voluntarily achieve a 10% reduction in water use to reduce demand below 70 mgd. On August 2, the Governor imposed a Drought Emergency with mandatory restrictions, which ultimately reduced water demand by 23% from 80 mgd on the day before the declaration of Drought Emergency to 65 mgd a few weeks later. By September, water demands declined below 65 mgd where they remained for the rest of the fall.

Purpose

This is the fifth in a series of semiannual reports to the Governor and the General Assembly summarizing the progress of the Delaware Water Supply Coordinating Council. The WSCC was created by then Governor Carper and the General Assembly as part of water supply reform in Delaware following the drought of 1999. The work of the WSCC continues under the administration of Governor Minner. The first, second, third, and fourth reports were issued on May 31, 2000, March 1, 2001, July 27, 2001, and May 1, 2002 (available at www.wr.udel.edu).

Because the drought of 2002 is now the drought of record, Lt. Governor John Carney requested that the WSCC review prior water supply and demand projections for northern Delaware. The purpose of this report is to:

- Summarize the status of "A List" water supply projects underway since 1999 to provide over 1 billion gallons of additional water supply storage by 2003 in northern Delaware.
- Recompile supply/demand estimates for northern Delaware given that 2002 is the new drought of record.
- Identify, prioritize, and recommend additional "A List" water supply projects that could feasibly fill the need to provide additional water supplies over and above the 1 billion gallons.

Status of "A" List Projects

The December 2, 1999, *Governor's Water Supply Task Force Report* contained estimates of public water supply and demand in northern New Castle County for drought conditions for the planning years 2000, 2010, and 2020. The estimates assume a worst - case historic drought scenario with environmental standards for minimum instream flows (7Q10) in effect along the Brandywine Creek and White Clay Creek. The supply and demand curves forecast a deficit of 17 million gallons per day (mgd) or 1,020 million gallons (mg) for a 60-day drought period by the year 2020. The Water Supply Coordinating Council has been working since 1999 to develop a series of water supply projects to close the 17 mgd (1,020 mg) gap between supply and demand for the year 2020 in northern New Castle County. The water purveyors are implementing the following "A List" options, which have few environmental constraints, have community support, and are completed or are on schedule for completion by the end of 2003:

Table E-1
Water Supply Projects on Schedule for Completion by the End of 2003
Northern New Castle County, Delaware

"A List" Alternative	Targeted Capacity 12/2/99 Report	Capacity in Service December 2002	Status of Completion
Newark Reservoir	200 mg (3 mgd)	-0-	Groundbreaking May 14, 2002. Construction 50% complete. 317 mg reservoir on schedule by 2003.
Wilmington Hoopes Reservoir	500 mg (8 mgd)	500 mg (8 mgd)	Complete - Operating Plan provides top wedge for drought.
Artesian Water Co. Wells North C&D Canal	120 mg (2 mgd)	100 mg (2 mgd)	0.4 mgd from new Chesapeake City Road wells planned by end of 2003.
Newark South Wellfield Iron Treatment Plant	60 mg (1 mgd)	-0-	Construction began April 2002. 70% Complete. Completion Spring 2003.
Artesian Water Co. Aquifer Stor. & Recovery	300 mg (5 mgd)	120 mg (2 mgd)	AWC pumped 120 mg from ASR during the drought of 2002.
Total	1,180 mg (19 mgd)	720 mg (12 mgd)	
2020 Deficit	1,020 mg (17 mgd)		

To date, 720 mg of the goal to meet the projected deficit of 1,020 mg or 71% has been put into service and is available to meet peak water demands if needed during drought. When the Newark Reservoir and South Wellfield Treatment projects are completed as scheduled, an additional 377 mg of supply will be developed by the end of 2003, thus adding up to 1,097 mg of water supply implemented since 1999.

Updated Water Supply/Demand Projections

The drought of 2002 is a new drought of record in northern Delaware. Because streamflows on the Brandywine Creek reached all time record low flows thereby reducing safe yields, the Water Supply Coordinating Council reevaluated the supply and demand projections for northern Delaware.

By comparing the available water supply during drought with the maximum monthly demand, one can estimate the projected surplus or deficit in water supplies for northern New Castle County by 2020 as they relate to Scenarios 1, 2, 3A, and 3B based on drought of record (2002) conditions.

Table E-2
Water Supply Versus Demand Projections
Northern New Castle County, Delaware

Year/Scenario	Supply (mgd)	Demand (mgd)	Surplus/Deficit** (mgd)	(mg*)
2003				
1. Drought Emergency - No 7Q10 along BRCR & WCC	103.5	83.3	20.2	1,515
2. Existing - No 7Q10 BRCR but 7Q10 along WCC	97.5	83.3	14.2	1,065
3A. Future - 7Q50 along BRCR and 7Q10 along WCC	84.5	83.3	1.2	90
3B. Future - 7Q10 along BRCR and 7Q10 along WCC	82.0	83.3	- 1.3	- 97
2010				
1. Drought Emergency - No 7Q10 along BRCR & WCC	103.5	86.3	17.2	1,290
2. Existing - No 7Q10 BRCR but 7Q10 along WCC	97.5	86.3	11.2	840
3A. Future - 7Q50 along BRCR and 7Q10 along WCC	84.5	86.3	- 1.8	- 135
3B. Future - 7Q10 along BRCR and 7Q10 along WCC	82.0	86.3	- 4.3	- 322
2020				
1. Drought Emergency - No 7Q10 along BRCR & WCC	103.5	88.0	15.5	1,162
2. Existing - No 7Q10 BRCR but 7Q10 along WCC	97.5	88.0	9.5	712
3A. Future - 7Q50 along BRCR and 7Q10 along WCC	84.5	88.0	- 3.5	- 262
3B. Future - 7Q10 along BRCR and 7Q10 along WCC	82.0	88.0	- 6.0	- 450

* Volume required assuming a 75-day drought period.
** Assumes projects on "A List" are implemented by end of 2003 including Newark Reservoir, Hoopes Reservoir Deep Storage, Newark South Wellfield Treatment Plant, Artesian Water Company New Wells North of C&D Canal, and AWC Aquifer Storage and Recovery wells.

For 2020, the updated supply and demand projections indicate a healthy surplus of 1,162 mg and 712 mg for Scenario 1 (Drought Emergency - No 7Q10 Standards along Brandywine Creek and White Clay Creek at Stanton) and Scenario 2 (Existing Regulatory Condition - No 7Q10 Standard along Brandywine Creek and 7Q10 Standard along the White Clay Creek at Stanton and Newark), respectively. By 2020 the projections forecast a deficit of 262 mg for Scenario 3A (Future Condition - possible 7Q50 standard along the Brandywine Creek at Wilmington and 7Q10 along White Clay Creek at Stanton and at Newark) and a deficit of 450 mg for Scenario 3B (Future Condition - possible 7Q10 standard along the Brandywine Creek at Wilmington and 7Q10 along White Clay Creek at Stanton and at Newark).

The WSCC adopted these updated supply and demand projections for Delaware north of the C & D Canal at its October 17, 2002 meeting. For water supply planning purposes, the WSCC identified that 262 to 450 mg of additional storage would be needed by 2020 to meet peak demands during a drought of record. This is based on the assumption of a 7Q50 or 7Q10 instream flow standard that could be imposed in the future along the Brandywine Creek by 2020. The WSCC adopts these projections as the minimum water supply necessary to accommodate the water demand of the projected population at 2020 without water restrictions even with a recurrence of conditions that existed during the drought of 2002. These water supply/demand projections are based on a set of conservative, "worse case" scenario assumptions of a future environmental standard along the Brandywine Creek and peak monthly water demands occurring during a 75-day duration of the drought.

Additional Water Supply Options

At the November 21 and December 12, 2002 meetings, the WSCC identified a series of additional water supply projects that could be constructed to meet a projected 2020 deficit of 262 to 450 mg, depending on the assumption of a future 7Q50 or 7Q10 instream flow standard which could be imposed along the Brandywine Creek by 2020. Members of the WSCC then nominated projects that each would sponsor and have the potential for groundbreaking and/or

completion on a fast track status by the end of 2003. Each of the sponsors provided a report summarizing the status of their project with a conceptual evaluation of project feasibility and volume (mg/mgd) based on the following criteria:

Engineering - Estimate feasibility from a technical, hydraulic, and/or geologic perspective(s).
Environmental - List the environmental/ecological benefits and constraints.
Regulatory - List federal, state, and local permitting requirements.
Economic - Estimate the capital plus annual operating and maintenance costs.
Community - Will the project have community support?
Timing - Calculate the project's chances for groundbreaking and/or completion by end of 2003.

The WSCC decided that the following options are most practical for a new "A List" to close the 262 to 450 mg gap between water supply and demand in Northern New Castle County projected for 2020.

Table E-3
New "A List" of Additional Water Supply Options
Northern New Castle County, Delaware

Alternative	Sponsor(s)	Volume	Capital Cost	Cost/Volume
Raise water level in Hoopes Reservoir by 1 feet to 5 feet.	Wilmington/UWD	60 - 375 mg		
a. Raise water level 1 foot.		60 mg	$ 4.0 M	$ 66,667/mg
b. Raise water level 2 feet.		128 mg	$ 4.2 M	$ 32,812/mg
c. Raise water level 3 feet.		203 mg	$ 4.5 M	$ 22,167/mg
d. Raise water level 4 feet.		285 mg	$ 4.8 M	$ 16,842/mg
e. Raise water level 5 feet.		375 mg	$ 5.0 M	$ 13,333/mg
Increase Hoopes Pump Station Capacity	Wilmington			
a. Expand Brandywine Pump (12 mgd)		108 mg	$ 0.4M	$ 3,704/mg
b. Increase Wills Pump Station (4 mgd)		36 mg	$ 0.8M	$ 22,222/mg
c. New Red Clay Cr. Pump Station (24 mgd)		96 mg	$ 2.0M	$ 16,666/mg
d. New Pipe/Pumps to Hoopes Res. (30 mgd)		270 mg	$ 6.0M	$ 22,222/mg
AWC Aquifer Storage and Recovery	Artesian Water Co.	150 mg	$1.2M	$ 8,000/mg
UWD Aquifer Storage and Recovery	United Water DE.	225 mg	$4.0M	$ 17,777/mg
Tidal Capture Structure Operating Plan Modification	United Water DE.	TBD	$ TBD	$ TBD/mg

Note: Estimates of volume and cost are preliminary in nature and are subject to final engineering studies. Costs for raising water level in Hoopes Reservoir include new gate, spillway modification, and road construction. The Tidal Capture Structure Operating Plan Modification, report pending, may lead to a modification of the instream flow standard to a 7Q20 or 7Q50 level.

The following projects were placed on a reserve "B List" for possible implementation at a later date due to more significant environmental, cost, and timing constraints.

Table E-4
Reserve "B List" of Additional Water Supply Options
Northern New Castle County, Delaware

Alternative	Sponsor(s)	Volume
Philadelphia to Delaware pipeline	Delaware DNREC	1500 mg (20 mgd)
Brandywine River Flow Augmentation: River Water Recycling Scenario	Delaware DNREC	25 to 50 mgd
Brandywine River Flow Augmentation: Wastewater Recycling Scenario	Delaware DNREC	25 to 50 mgd
Desalination at the White Clay Creek Stanton Treatment Plant	United Water Delaware	TBD

Conclusions/Recommendations

The Delaware WSCC recommends the following actions as part of this Fifth Report to the Governor and General Assembly concerning the ability of water suppliers in northern Delaware to meet demands during future droughts:

1. Status of "A List" Projects

   Announce the status of the "A List" projects designed to develop over 1 billion gallons of additional water supply in northern Delaware by the end of 2003. To date, 720 mg of the goal to meet the projected deficit of 1,020 mg or 71% has been put into service and is available to meet peak water demands if needed during drought. When the Newark Reservoir (50% complete) and South Wellfield Treatment Plant (70% complete) projects are completed as scheduled, an additional 377 mg of water supply will be available by the end of 2003 thus providing 1,097 mg of additional water supply since 1999.

2. Updated Water Supply/Demand Projections

   Endorse the Delaware WSCC findings that an additional 262 to 450 mg of reserve water supply will be needed in northern Delaware by 2020 to meet peak demands during a drought of record if a 7Q50 or 7Q10 instream flow standard is imposed along the Brandywine Creek. Under the existing regulatory scenarios (1 and 2) with no passby flow requirement on the Brandywine, there will be a healthy surplus of water supply to meet projected peak demands of residents and commerce in northern Delaware during a repeat of the 2002 drought of record.

3. Additional Water Supply Projects

   Work with the water purveyors on the WSCC to develop a combination of the water supply options on the new "A List" to meet the projected deficit of 262 to 450 mg forecast by 2020. The most desirable options would entail groundbreaking and/or completion of the projects by the end of 2003.

4. Water Conservation Pricing

   Encourage implementation of water conservation pricing schedules by northern Delaware water purveyors by summer 2003. The University of Delaware Center for Energy and Environmental Policy (CEEP) Water Conservation Report, dated May 2002 concludes that water conservation pricing, in conjunction with community involvement and education, has the potential to reduce water demands. The Delaware Public Service Commission has utilized at least one form of water conservation rates in all the systems it regulates. Water conservation oriented rates (WCOR) are also strongly supported by the WSCC for municipal systems not under the control of the PSC. Presently Artesian Water Company, City of Newark, and New Castle Municipal Services Commission have forms of water conservation pricing. The Delaware River Basin Commission mandated that United Water Delaware complete a feasibility evaluation of conservation water rates.

5. Drought Operating Plan

   Amend the Delaware Drought Operating Plan by May 2003 to include a three-phase notice of impending drought tied to goals for water conservation. Presently Delaware has a two-phase drought advisory plan of (1) warning and (2) emergency. An amended drought operating plan will require approval of the Christina River Basin Drought Management Committee. In amending the drought operating plan, the WSCC will consider the following variables: precipitation, soil moisture, stream flow, groundwater, reservoir levels, chlorides, and season of the year. The amended drought operating plan may have the following framework:

Stage	Drought Status	Water Restrictions	Water Demand Conservation Goal
1. Watch	Potential	Voluntary	< 80 mgd
2. Warning	Imminent	Voluntary	< 70 mgd
3. Emergency	Emergency	Mandatory	< 65 mgd

FIFTH REPORT OF THE DELAWARE WATER SUPPLY COORDINATING COUNCIL
CHAPTER 1 - INTRODUCTION

The Drought of 2002

The drought of 2002 is now a new drought of record in northern Delaware. Based on records at New Castle County Airport, the 12 - month precipitation for the period October 2001 through September 2002 totaled 28.33 inches or 69% of normal, the lowest since records began in 1894. On August 23, 2002, flow on the Brandywine Creek at Wilmington recorded a mean daily flow of 21 million gallons per day (mgd), the lowest flow on record since 1947, eclipsing the record of 33 mgd set in September 1995. Daily record lows along the White Clay Creek, Red Clay Creek, and Christina River were also recorded during 2002. The drought of 2002 was statistically the 100-year drought or the drought with a 1% chance of occurring in any given year.

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On October 11, 2002 in response to improving water levels in the streams and Hoopes Reservoir, Governor Minner declared the end of the drought emergency, lifted the mandatory restrictions and put a Drought Warning back in place requesting voluntary conservation of water statewide. Due to heavy fall rains and snow, October, November and December were wetter than normal bringing stream flows up to median levels. The Governor's Drought Advisory Committee (DAC) convened on January 15, 2003 and recommended that the Governor lift the Drought Warning in Delaware.

Chronology of the Drought of 2002

Prologue

- November 15, 2001 - 250 ppm salt line within 0.5 mile of White Clay Creek Stanton Intake.
- December 18, 2001 - Delaware River Basin Commission declares Drought Emergency.
- February 12, 2002 - Governor Schweiker declares Drought Emergency for 24 counties in eastern Pennsylvania.
- February 28, 2002 - Record low monthly mean flows observed at DGS gages along the Brandywine Creek at Wilmington, White Clay Creek near Newark, and Red Clay Creek at Stanton.
- March 4, 2002 - Governor McGreevey declares statewide Drought Emergency for New Jersey.

Drought Warning

- March 5, 2002 - Governor Minner declares Drought Warning with voluntary restrictions in Delaware.
- June 6 - Newark curtails withdrawals from White Clay Creek as flow is below 14 mgd DRBC passby limit.
- July 4 - Public water demand in northern Delaware exceeds 80 mgd.
- July18 - Brandywine Creek at Wilmington declines below 7Q10 flow of 49 mgd.
- July 18 - Governor's Drought Advisory Committee urges voluntary 10% reduction in demand by Delawareans.
- July 31 - Wilmington begins releases from Hoopes Reservoir to Red Clay Creek for use by United Water Delaware.

Drought Emergency

- August 2, 2002 - Governor Minner declares Drought Emergency in northern Delaware with mandatory restrictions setting a goal to reduce water demand below 70 mgd. Drought Warning with voluntary restrictions continues south of the C & D Canal.

- August 4 - Raw water chloride levels in White Clay Creek at Stanton increase to 250 ppm.
- August 9 - Public water demand declines below 70 mgd in northern Delaware.
- August 12 - Brandywine Creek at Chadds Ford declines below 27 mgd (91 yr record).
- August 12 - Chester Water Authority requests 20% reduction in water deliveries to Delaware purveyors.
- August 20 - CWA requests further reduction in water deliveries to Delaware to slow decline in Octoraro Reservoir water levels (which reached 42% of capacity on August 23, 2002).
- August 23 - Brandywine Creek at Wilmington at 21 mgd, record low streamflow breaking mark set in 1995.
- August 23 - Hoopes Reservoir at minus 6 feet at 82% capacity (-330 mg) leaving 1470 mg available.
- September 2 - Labor Day Rain. Brandywine Creek above 119 mgd. Wilmington refilling Hoopes Reservoir.
- September 6 - Public water demand declines below 60 mgd. Wilmington continues refilling Hoopes Reservoir.
- October 4 - Remnants of Tropical Storm Isidore help replenish water supplies in the Christina Basin.
- October 10 - Hoopes Reservoir full at 100% capacity.

Recovery

- October 11, 2002 - Governor Minner terminates Drought Emergency and ends mandatory restrictions in northern Delaware. Drought Warning remains urging voluntary water conservation statewide.
- October 10/11 - Tropical Depression Kyle deposits 3.93 inches of rain in northern Delaware.
- October 17 - Brandywine Creek at Wilmington streamflow exceeds 480 mgd.
- October 31 - Precipitation at Wilmington Porter Reservoir for October totals 7.63 inches (226% of normal).
- November 5 - CWA reports Octoraro Reservoir near full at 96% capacity.
- November 15 - Brandywine Creek at Wilmington streamflow above median level at 180 mgd.
- November 25 - Delaware River Basin Commission terminates Drought Emergency.
- November 30 - Precipitation at Wilmington Porter Reservoir totals 4.53 inches of rain during November (132% of normal). Ground-water level at DGS water table well Db24-10 below normal but increasing.
- December 21 - Governor Schweiker lifts drought emergency in southeastern Pennsylvania counties.
- December 31 - Precipitation at Wilmington Porter Reservoir for October, November, and December totals 17.52 inches or 7.11 inches above normal for the period.
- January 15, 2003 - Governor's Drought Advisory Committee to meet and consider lifting Drought Warning.

Purpose of Report

Because the drought of 2002 is now the drought of record, Lt. Governor John Carney requested the Delaware Water Supply Coordinating Council to reevaluate the water supply and demand projections for northern Delaware. Since July 2000 the WSCC has been working to develop 1 billion gallons of additional water supply in northern Delaware by a deadline of December 31, 2003. Currently 720 million gallons of new storage from Wilmington's Hoopes Reservoir and Artesian Water Company's new wells and Aquifer Storage and Recovery are available. With the completion of the 317 mg Newark Reservoir and the 60 mg Newark South Wellfield Treatment plant next year, 377 mg will be added to the 720 mg, thus creating over 1 bg of water supply by the end of 2003.

The purpose of this report is to:

- Summarize the status of "A List" water supply projects underway since 1999 to provide over 1 billion gallons of additional water supply by 2003 in northern Delaware.

- Recompile the supply and demand estimates for northern Delaware given that 2002 was the drought of record.

- Identify, prioritize, and recommend additional "A List" water supply projects that could feasibly fill the need to provide additional water supply over and above the 1 billion gallons.

This is the fifth in a series of semiannual reports to the Governor and the General Assembly summarizing the progress of the Delaware Water Supply Coordinating Council. Kevin Donnelly (Director) and Stewart Lovell (Water Supply Manager) of the Delaware DNREC Division of Water Resources; John Talley (Associate Director) and Stefanie Baxter (Geologist) of the Delaware Geological Survey; and Martin Wollaston (Senior Planner), Sara Wozniak, Kevin Vonck

(Graduate Research Assistants) and Gerald Kauffman (State Water Coordinator) of the University of Delaware, Institute for Public Administration - Water Resources Agency authored this report on behalf of the WSCC. The first, second, third, and fourth reports were issued on May 31, 2000, March 1, 2001, July 27, 2001, and May 1, 2002 (available at www.wr.udel.edu).

State Water Coordinator

In July 2000, then Governor Thomas Carper signed HB 549, which appointed the Water Resources Agency at the University of Delaware - Institute for Public Administration as the Temporary Water Coordinator. The appointment expires December 31, 2003 when the new water supply projects discussed in this report are scheduled for completion. The Water Coordinator works cooperatively with the water purveyors to ensure that new water supplies are developed on schedule by the end of 2003. Along with the Water Coordinator, HB 549 appointed the DGS and the DNREC as a triad of water advisors to the Delaware Water Supply Coordinating Council. This work continues under the direction of Governor Ruth Ann Minner.

Water Supply Coordinating Council

HB 549 also appointed the Delaware Water Supply Coordinating Council for a tenure extending until December 31, 2003. This state law appointed the following public and private entities to the WSCC:

Office of the Governor
Secretary of the Delaware Department of Natural Resources & Environmental Control (Chair)
Secretary of the Delaware Department of Public Safety
Secretary of the Delaware Department of Agriculture
Executive Director of the Public Service Commission
Director of the Delaware Emergency Management Agency
Director of the Delaware Geological Survey
Director of the Delaware Division of Public Health
Public Advocate
Executive Director of the Delaware River Basin Commission
New Castle County Executive
Artesian Water Company
City of Newark
City of Wilmington
New Castle Municipal Services Commission
Tidewater Utilities, Inc.
United Water Delaware
New Castle County Chamber of Commerce
Delaware State Chamber of Commerce
Delaware Nursery and Landscape Association
Delaware Professional Grounds Management Society
Delaware State Golf Association
Delaware Nature Society
Coalition for Natural Stream Valleys
New Castle County Civic League

The charges to the Water Supply Coordinating Council are to:

- Implement new water supplies in northern New Castle County to meet peak demands based on the drought of record by December 31, 2003.
- Work cooperatively in a public-private effort between government and water purveyors to manage water supplies more efficiently in Delaware.

The Delaware Water Supply Coordinating Council met on the following dates:

2000
- March 3 Carvel State Office Building, Wilmington, DE
- March 24 Carvel State Office Building, Wilmington, DE
- May 22 Delaware Geological Survey, Newark, DE
- July 31 New Castle County Chamber of Commerce, Churchman's Crossing, DE
- October 4 Artesian Water Company, Churchman's Crossing, DE

2001
- January 10 United Water Delaware, Stanton, DE
- March 14 Artesian Water Company, Churchman's Crossing, DE
- June 14 United Water Delaware, Stanton, DE
- October 4 Artesian Water Company, Churchman's Crossing, DE

2002
- February 5 United Water Delaware, Stanton, DE
- April 17 Artesian Water Company, Churchman's Crossing, DE
- July 10 Artesian Water Company, Churchman's Crossing, DE
- September 11 Artesian Water Company, Churchman's Crossing, DE
- October 17 Delaware DNREC, New Castle, DE
- November 21 Artesian Water Company, Churchman's Crossing, DE
- December 12 Artesian Water Company, Churchman's Crossing, DE

Governor's Drought Advisory Committee

The Governor's DAC recommends drought policy to the Governor, setting the provisions for declaring Drought Warning and Emergency in Delaware. Under State law, the Governor has the sole authority for the declaration of Drought Emergency through Executive Order. Members of the GDAC include:

- Governor's Chief of Staff (Chairman)
- Secretary of Delaware DNREC
- Secretary of Department of Public Safety
- Chairman of the Public Service Commission
- Director of the Delaware Geological Survey
- State Fire Marshall
- Secretary of Department of Agriculture
- Secretary of Department of Health and Social Services

The DAC met on the following dates, which were supplemented by scheduled conference calls on the Delaware Emergency Management Agency teleconference line.

2002
- February 26 Dover, DE
- April 15 Dover, DE
- May 29 Dover, DE
- June 28 Dover, DE
- July 18 Dover, DE
- August 2 Dover, DE
- August 14 Dover, DE
- October 4 Dover, DE
- October 11 Dover, DE
- January 15, 2003 Dover, DE

CHAPTER 2 – WATER CONDITIONS

Water Conditions Update

The drought in Delaware during 2001-2002 was the most severe on record. Record low precipitation, ground-water levels, and streamflows were established across Delaware from July 2001 though September 2002. As indicated earlier in this report, Governor Minner declared a Drought Warning in Delaware on March 5, 2002 calling for voluntary water restrictions as a result of significantly below normal hydrologic conditions. Hydrologic conditions continued to deteriorate during the spring and early summer, and Governor Minner declared a Drought Emergency on August 2, 2002, with associated mandatory water use restrictions.

The most severely impacted area of Delaware with respect to public water supplies was northern New Castle County because of its heavy reliance on surface water. Adequate supplies of ground water remained available for water supplies in southern New Castle, Kent, and Sussex counties during the drought. Most public water supplies in southern New Castle, Kent and Sussex counties are obtained from relatively deep unconfined aquifers and deep confined aquifers. There were isolated problems with domestic water supplies in central and southern Delaware; however, they were generally associated with very shallow wells or plumbing problems. Agriculture was adversely impacted throughout Delaware due to very dry topsoil and subsoil conditions for long periods of time. The Delaware Department of Agriculture reported that agriculture impacts were most severe with "dry land farming," those agriculture operations that did not have access to irrigation.

Preliminary statistical analysis of streamflow data from Brandywine Creek at Chadds Ford suggests that the drought of 2002 can be classified as a 100-year drought – an event with a return interval of 100 years or one having a one percent chance of occurring in a given year. Despite record setting precipitation, ground-water levels, and streamflows, we were able to manage our dwindling water supplies effectively and efficiently, thereby ensuring that we met demands through the critical summer period. This was made possible through a concerted cooperative effort between the Governor's Drought Advisory Committee, the Delaware Water Supply Coordinating Council, water utilities, water managers, scientists, and the public. The citizens of Delaware responded to the Governor's request for water conservation and their response resulted in a decrease in peak daily usage of 82 million gallons per day (mgd) in July to about 60 mgd during the most severe part of the drought in early September.

Precipitation

The precipitation deficit began to increase significantly in July 2001 and culminated in a cumulative deficiency of 15.51 inches for the period July 1, 2001 through September 30, 2002 in Wilmington**.** Precipitation for the 2002 Water Year was significantly below normal across Delaware with totals ranging from 37.08 inches at Lewes (84% of normal) to 28.33 inches at New Castle (69% of normal).

Table 1
Precipitation Totals During the Drought of 2002

Oct. 1, 2001 – Sept 30, 2002	New Castle (NWS)	Wilmington (Porter Res.)	Dover	Greenwood	Georgetown	Lewes
Total Precipitation	28.33"	34.28"	34.99"	35.84"	29.81"	37.08"
Normal Precipitation	40.84"	46.06"	44.14"	44.36"	43.79"	44.31"
Departure	-12.51"	-11.78"	-9.15"	-8.52"	-13.98"	-7.23"
Percent of Normal	69%	74%	79%	81%	68%	84%

- Record low monthly precipitation was recorded in November 2001 at Greenwood, Dover, and Georgetown.
- Record low monthly precipitation was recorded in February 2002 at New Castle, Wilmington, Dover, and Greenwood.
- Near record low monthly precipitation was recorded in October 2001 at New Castle, Wilmington, Greenwood, and Georgetown.
- Total precipitation at Wilmington for the period October 2001-February 2002 was the lowest 5-month total since at least 1949.
- Precipitation was below normal during 9 of 12 months in Sussex County, 7 months in Kent County, and 8 months in New Castle County.
- Record low annual precipitation for the period October 2001 - September 2002 was recorded at New Castle and Georgetown, and the second lowest total at Wilmington since at least 1949.

Precipitation has improved markedly since September 2002 in central and southern Delaware and since October 2002 in northern Delaware. Precipitation during this period ranged from 26.63 inches at Greenwood (196% of normal) to 18.28 inches at New Castle (140% of normal).

Table 2
Current Precipitation Conditions

Sept. 1, 2002 – Dec. 31, 2002	New Castle (NWS)	Wilmington (Porter Res.)	Dover	Greenwood	Georgetown	Lewes
Total Precipitation	18.28"	21.15"	25.75"	26.63"	22.82"	25.87"
Normal Precipitation	13.10"	14.36"	14.26"	13.60"	13.35"	13.51"
Departure	+5.18"	+6.79"	+11.49"	+13.03"	+9.47"	+12.36"
Percent of Normal	140%	147%	181%	196%	171%	191%

Shallow Ground-Water Levels

Ground-water levels in shallow water-table wells have been below normal for the most part since November 2001. The shallow water-table aquifer is the main source of stream base flow. Ground-water levels did not recover as they normally do during the late fall, winter, and early spring of 2001 - 2002 because of significantly below normal precipitation during the corresponding period. Record low ground-water levels were established for at least one month in seven of the nine wells measured monthly by the Delaware Geological Survey. The second lowest levels of record were observed in the two other wells. The shallow ground-water systems provide water in storage that is continually released to the surface to provide base flow or fair weather flow to streams and rivers when it is not raining. Ground-water discharge generally provides between 75% and 80% of streamflow, and up to 100% when it has not rained for about three days.

- Record low ground-water levels were recorded for six months in well Mc51-01; for five months in wells Db24-10 and Jd42-03; for four months in well Qe44-01, for two months in well Md22-01; and for one month in well Ng11-01.
- The second lowest ground-water levels of record were recorded throughout the year in all eight wells.
- Ground-water levels in Delaware have been recorded monthly in these wells since about 1950.
- Record low ground-water levels were recorded in an average of 9 wells for each month between February and September 2002 in the Christina River Basin in southeastern Pennsylvania.

Ground-water levels improved markedly during the past three months in response to recharge associated with

significantly above normal precipitation. November was the first month since April that water levels in well Db24-10 (northern New Castle County) were not at record lows. Water levels in central and southern Delaware exhibited sharp rising trends with water levels in mid-December in the normal to above normal range.

Ground-water levels have also recovered substantially in southeastern Pennsylvania in the Christina River Basin. Of 19 wells in which water levels are obtained in southeastern Pennsylvania, none were in the normal range and 18 were in the Drought Emergency range in September. At the end of November, 13 were back into the normal range and only 4 were in the Drought Emergency range. This is significant because a large percentage of the water that flows in the Brandywine, Red Clay, and White Clay creeks originates in Pennsylvania. High ground-water levels support high streamflows.

Deep Aquifer Water Levels

Water levels in the deeper confined aquifers remained in the normal range over the course of the drought in Delaware. These deeper aquifers, which provide much of the public water supply in Delaware, remained largely unaffected through the drought of record.

Streamflows

Streamflows were substantially below normal throughout Delaware for most of the 2002 Water Year (October 1, 2001 – September 30, 2002). At least one and up to five record low monthly mean streamflows were recorded on eight of nine streams and rivers monitored throughout Delaware.

- Record or near-record monthly mean streamflows were recorded during 8 of 12 months on Brandywine Creek at Wilmington, 10 of 12 months on Red Clay Creek at Stanton, 7 of 12 months on White Clay Creek near Newark, and 4 of 12 months on the Christina River near Coochs Bridge. All four streams are used for public water supplies in northern New Castle County.
- Record or near record low monthly mean streamflows were recorded during 7 of 12 months on St. Jones River near Dover and during 5 of 12 months on the Nanticoke River near Bridgeville.
- The annual daily mean streamflow of 109 mgd on Brandywine Creek at Wilmington during the 2002 Water Year was the lowest since records began in 1947.
- A record low average daily mean streamflow of about 50 mgd was established on Brandywine Creek during July, August, and September. The previous record low was about 70 mgd in 1957.
- Record daily mean streamflows were recorded on 57 days during July, August, and September and on a total of 138 days from November 6, 2001 through October 9, 2002 on Brandywine Creek.
- A record low daily mean streamflow of 21 mgd was observed on August 23 on Brandywine Creek eclipsing the previous record low flow established in 1995 by 13 mgd. There were 25 individual days in August and September when the daily mean streamflow was less than the previous historic daily low of 34 mgd.
- The lowest seven-day minimum flow of 25.6 mgd was on Brandywine Creek from August 8 through August 14. Preliminary statistical analysis suggests that this flow is greater than the 100-year event. The previous seven-day minimum flow of 34.9 mgd occurred in August 1999.
- The City of Newark Water Treatment Plant had to be shut down for 120 days between June 6 and October 11, 2002 as a result of low streamflows on White Clay Creek.
- As a result of extremely low streamflows on White Clay Creek at Stanton, United Water Delaware requested and was granted a waiver by the Delaware River Basin Commission from the 17.2 mgd pass by standard on White Clay Creek on August 12, 2002.

Due to record low stream flow, on August 5, 2002 UWDE requested that the DRBC issue a waiver from the 17.2 mgd minimum instream flow standard at the Stanton intake along the White Clay Creek. On August 12, the DRBC approved the waiver under the condition that UWDE: (1) conduct a financial feasibility analysis of a UWD funded project to increase the capacity of Hoopes Reservoir, (2) review the cost/benefit feasibility of desalination to supplement supplies from the tidal White Clay Creek, (3) develop a new operating plan that addresses the needs of the White Clay Creek near the Tidal Capture Structure to better understand the minimum flow needed to protect the ecology in this tidal setting, and (4) investigate the feasibility of adopting water conservation oriented rates.

Streamflows have improved significantly during October, November, and December as a result of well above normal precipitation. October and November streamflows were in the normal range (at or above the median) in northern New Castle County whereas they were above normal in central and southern Delaware. A very significant reversal in streamflow trends was observed on the Nanticoke River near Bridgeville where monthly mean streamflow was the third highest of record for October and December and the highest of record in November. Streamflows are expected to remain in the normal range if normal precipitation persists.

Interstate Water Transfers

Due to record high demand and record low reservoir supplies in the Chester Water Authority (CWA) system, CWA requested that its two Delaware customers, Artesian Water Company and United Water Delaware, reduce their purchases up to 20 percent or as much as possible.

Concurrently, Artesian Water Company requested an emergency approval from DNREC on August 7, 2002 to bypass normal permitting requirements to place into early operation a planned new production well in the Piedmont with a capacity of 648,000 gallons per day. This was to help meet demands in the area where CWA provides supply for Artesian's system (Hockessin - Pike Creek areas). DNREC approved the request the same day and a subsequent approval from the DRBC was granted on August 14, 2002. DRBC stipulated in its approval that they would be assessing Artesian's progress in improving safe water supply yield throughout its system to reduce the potential for adverse long-term impacts to the Basin's aquifers, and for the company to demonstrate cooperation with other purveyors.

In response to CWA's request, United Water Delaware eliminated its purchases from CWA on August 25, 2002. Artesian eventually reduced its purchases from CWA to the 0.3 MGD level approximately a month later. Following demand reductions and increased precipitation in the subsequent weeks, the CWA system has seen significant recovery in storage capacity and transfer rates are no longer restricted.

Chlorides

As a result of record and near record streamflows during the summer months on White and Red Clay creeks near Stanton, the salt line (250 ppm chlorides) migrated upstream along the tidal portion of White Clay Creek and reached United Water Delaware's surface water intake at its Stanton Filter Plant. In accordance with United Water Delaware's Chloride Monitoring Plan that was developed following the 1999 drought, United Water requested streamflow augmentation from Hoopes Reservoir into Red Clay Creek to dilute brackish water. United Water Delaware was able to keep chloride levels in its treated water below the SMCL of 250 ppm.

The salt line (250 ppm chloride isochlor) in the Delaware River was at River Mile 62 on July 1 (9 miles south of the Christina River). The salt front reached its maximum upstream location at River Mile 89 (18 miles upstream of the Christina River) on September 29. In response to significant rainfall in the Delaware River Basin during the past several months, the salt front migrated downstream and was at River Mile 64 on December 5, 9 miles further downstream than normal.

Hoopes Reservoir

Releases from Hoopes Reservoir began on July 31, 2002, in amounts ranging from 1 to 7 mgd. Releases were required intermittently through September 26, 2002. A total of 269 million gallons of water was released on 1 day in July, 24 days in August, and 10 days in September. Because of very low flows on Brandywine Creek, the City of Wilmington began releasing 7 to 13 mgd between August 14 and 22 back to Wilmington from Hoopes Reservoir. Thus, there was a 9-day period when water was being released to both the City of Wilmington and Red Clay Creek.

Prior to water being released from Hoopes Reservoir, the reservoir was 2 feet below full. During the release period, the level in the reservoir dropped 4 feet. At that time, August 22, there was 1,470 mg available for use (82% of capacity). When streamflows on Brandywine Creek increased in response to precipitation in late August and September, the City of Wilmington immediately began to refill Hoopes Reservoir. The reservoir reached 100% of

capacity on October 11 and is still full as of December 31 with a useable capacity of 1.8 billion gallons.

Marsh Creek Reservoir

Between October 1, 2001 and December 10, 2002, Pennsylvania released water from Marsh Creek Reservoir into Brandywine Creek on 229 days. Such releases are required when streamflows at the Brandywine Creek at the Chadds Ford, Pennsylvania stream gage decline below 140 cubic feet per second or 90 million gallons per day. Marsh Creek Reservoir is now at full capacity.

Octoraro Reservoir

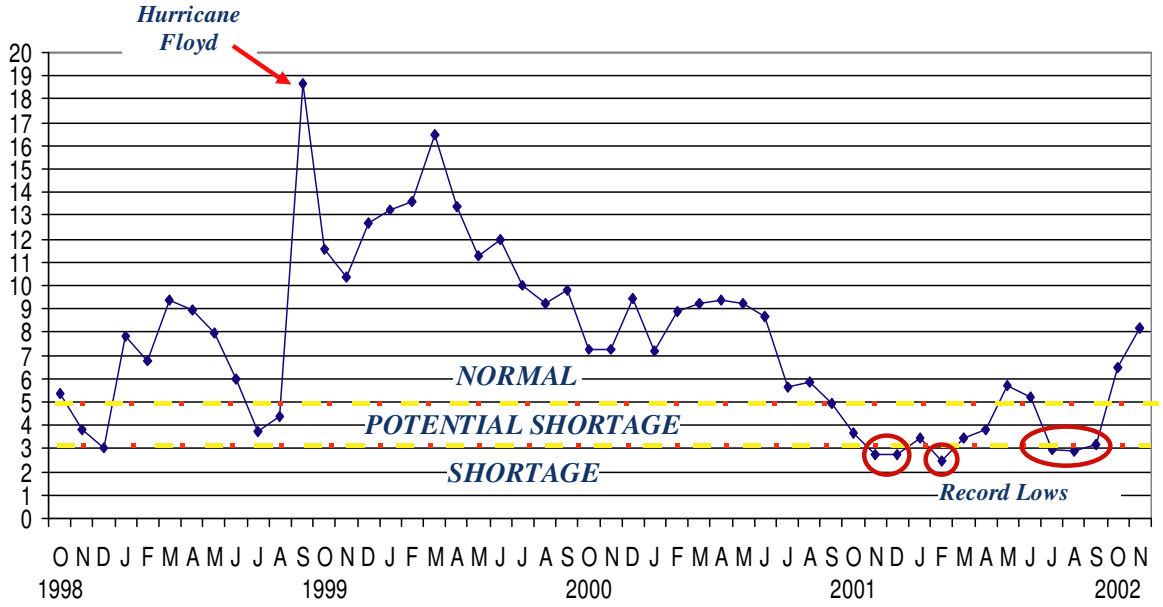
Water levels in the Chester Water Authority 2 bg - reservoir near Oxford, Pennsylvania declined from full on May 25 to 42% of capacity (840 mg remaining) on August 23, 2002. Reservoir water levels returned to full capacity by November 12, 2002. The Octoraro Reservoir is the source of 5% of northern Delaware's water supply during drought through interconnections from the Chester Water Authority.

DGS Water Conditions Index

The Water Conditions Index for New Castle County, developed by the DGS, is used as an indicator of water conditions in northern New Castle County. The formula for calculating the Index includes 6 - month antecedent precipitation at New Castle and Wilmington, ground-water levels in well Db24-10, streamflows on Brandywine Creek, and population of northern New Castle County. The severity of the 2002 drought is shown in the graph below which covers the period of October 1998 – November 2002. As indicated on the graph, dry conditions began to develop in 2000. The Index exhibited a general declining trend from about February 2000 to September 2002. The Index was generally in the "Potential Shortage" and "Shortage" range from August 2001 through September 2002. During that period, record low Indices were established in 6 individual months. The DGS has calculated Indices since 1962.

The Index increased and has been in the "Normal" range since October. The increase was in response to significantly above normal precipitation with associated increases in streamflow and rising ground-water levels. We anticipate that the Index will continue to increase during the next several months, especially if we continue to receive normal to above normal precipitation.

Figure 1
Delaware Geological Survey Water Conditions Index for New Castle County



Public Water Demand

During the drought of 2002, Delawareans cooperated to conserve water and reduce water demand below the goal of 70 mgd set by the Governor's DAC. During a few days in July 2002, public water demands in northern New Castle County reached 83 mgd less than the peak day demand of 90 mgd often experienced in July. On July 18, 2002 the Governor's Drought Advisory Committee recommended a goal for Delaware residents and businesses to voluntarily achieve a 10% reduction in water use to reduce demand below 70 mgd. On August 2, the Governor imposed a Drought Emergency with mandatory restrictions that ultimately reduced water demand by 23% from 80 mgd on the day before the Drought Emergency to 65 mgd a few weeks later. By late August, water demands declined below 65 mgd. During September, demands fluctuated between 60 and 65 mgd indicating very little outdoor water use. During October, November, and December 2002, water demand remained at or below 60 mgd, which is the normal winter water demand and represents the base demand for northern New Castle County.

The peak daily demand during the drought of 2002 was 83 mgd or 91% of the peak recorded in 2001. The peak demand recorded last year on August 9, 2001 was 91 mgd. Water purveyors recorded the record peak day demand of 93 mgd on July 18, 1997.

The water purveyors recorded the following peak daily demands during 2002:

Table 3
Peak Daily Demands During Drought of 2002
Northern New Castle County

Water Purveyor	Peak Daily Demand (mgd)	Date (2002)
Artesian Water Co.	26.3	July 4
City of Newark	5.5	July 24
City of Wilmington	30.6	July 24
New Castle MSC	1.2	July 24
United Water Delaware	28.9	July 10

Table 4 summarizes the recorded mean monthly demands during 2002 in comparison to the monthly normal:

Table 4
Mean Monthly Water Demands During Drought of 2002
Northern New Castle County

Month (2002)	Mean Monthly (mgd)	Normal (mgd)*	% of Normal
June	72.2	73	99%
July	75.5	75	101%
August	68.7	71	97%
September	62.2	67	93%
October	59.3	64	93%
November	58.5	61	96%

* Normal monthly water demands determined from records compiled during 1997 - 2001.

The peak water transfer by the purveyors through interconnections was 6.0 mgd on August 21, 2002, which was 9 % of the supply needed to meet demand recorded that day.

CHAPTER 3 - STATUS OF "A LIST" WATER SUPPLY OPTIONS

The December 2, 1999 *Governor's Water Supply Task Force Report* compiled estimates of public water supply and demand in northern New Castle County for drought conditions for the planning years 2000, 2010, and 2020. The estimate assumes a worst case historic drought scenario with environmental standards for minimum instream flows (7Q10) in effect along the Brandywine Creek and White Clay Creek. The supply and demand curves forecast a deficit of 17 million gallons per day (mgd) or 1,020 million gallons (mg) for a 60-day drought period by the year 2020.

Future Water Supply Options

The Water Supply Coordinating Council is working to develop a series of water supply projects to close the 17 mgd (1,020 mg) gap between supply and demand for the year 2020 in northern New Castle County. The water purveyors have committed to the following "A List" options that have few environmental constraints, enjoy community support, and are scheduled to be completed by 2003:

Table 5
Water Supply Projects on Schedule for Completion by the End of 2003
Northern New Castle County, Delaware

"A List" Alternative	Targeted Capacity 12/2/99 Report	Capacity in Service December 2002	Status of Completion
Newark Reservoir	200 mg (3 mgd)	-0-	Groundbreaking May 14, 2002. Construction 50% complete. 317 mg reservoir on schedule by 2003.
Wilmington Hoopes Reservoir	500 mg (8 mgd)	500 mg (8 mgd)	Complete - Operating Plan provides top wedge for drought.
Artesian Water Co. Wells North C&D Canal	120 mg (2 mgd)	100 mg (2 mgd)	0.4 mgd from new Chesapeake City Road wells planned by end of 2003.
Newark South Wellfield Iron Treatment Plant	60 mg (1 mgd)	-0-	Construction began April 2002. 70% Complete. Completion Spring 2003.
Artesian Water Co. Aquifer Stor. & Recovery	300 mg (5 mgd)	120 mg (2 mgd)	AWC pumped 120 mg from ASR during the drought of 2002.
Total	1,180 mg (19 mgd)	720 mg (12 mgd)	
2020 Deficit	1,020 mg (17 mgd)		

To date, 720 mg of the goal to meet the projected deficit of 1,020 mg or 71% has been put into service and is available to meet peak water demands if needed during drought. When the Newark Reservoir and South Wellfield Treatment projects are completed as scheduled, an additional 377 mg of supply will be developed by the end of 2003, thus adding up to 1,097 mg of additional water supply.

The WSCC has made the following progress toward securing over 1 billion gallons of water by the end of 2003:

Artesian Water Company

- New Wells - In July 1999, AWC was granted an increased allocation of 0.7 mgd for its Old County Road Wellfield. In late 2001, AWC placed in service a new 0.2 mgd well at Artisans Village to re-distribute pumpage with no increase in overall allocation. AWC has also added a new well at Middle Run Crossing (0.4 mgd) to its supply during 2002 and plans to construct a well at Old Chesapeake City Road (0.4 mgd) by the end of 2003.

- Aquifer Storage and Recovery - AWC has completed ten cycles of its Aquifer Storage and Recovery (ASR) testing

program at a maximum rate of 2.0 mgd (120 mg for 60 days). AWC pumped 120 mg of water from the Llangollen ASR wells to meet peak demands during the summer of 2002. At the end of the 2002 drought, AWC discovered from as-built drawings that its Llangollen ASR well was not constructed as planned. The company has since re-constructed this ASR well to make the operation more efficient and improve yield.

City of Newark

- Newark Reservoir - Donald Durkin, Inc. of Southampton, Pennsylvania continues construction on the 317-mg reservoir, which would make the City nearly self-sufficient. The project is 50% complete with the intake pipeline in place and almost 1 million cubic yards of soil excavated. This will be the first public water supply reservoir built in Delaware in almost 70 years. The planned fill up and operation date is September 2003. Estimated cost of the project is $8M for land and $10M for construction.

- Newark South Wellfield Iron Treatment Plant - Hart Contractors, Inc. continues construction on the City's iron and manganese removal plant at its South Wellfield. The project is 70% complete with installation of the aeration unit underway. This project is expected to increase water supply from the South Wellfield by 1.0 mgd. The City is on schedule for this $3 M project with a planned completion date in April 2003.

City of Wilmington

- Hoopes Reservoir - The City contracted with O'Brien and Gere to conduct a dam safety inspection of Hoopes Reservoir. The dam safety inspection concluded the dam is structurally sound but in need of concrete surface spalling repairs. The City also authorized a study to evaluate the structural and hydraulic feasibility of raising the existing water level up to five feet to provide additional storage.

  The City of Wilmington completed an "Operating Plan for Hoopes Reservoir" which indicates that the City would release from 3 to 5 mgd (500 mg total) of raw water as requested by other utilities provided the reservoir level was between elevation 220 feet (full) and 210 feet (-10 feet). Below elevation 210 feet, the City will reserve the remaining contents of the reservoir for its internal use.

  On August 28, 2002, Wilmington City Council authorized a contract for the sale of water from Hoopes Reservoir for United Water Delaware to purchase up to 200 mg of raw water from the reservoir. The contract would provide water from the top wedge of Hoopes Reservoir for release to the Red Clay Creek to supplement the UWDE Stanton intake during low stream flow and/or elevated salt levels in the tidal creek. The contract is for an annual reservation charge for a volume of 50 mg to 200 mg with an additional usage charge for the actual volume of water released in a particular year. In the event UWD requests the City to release more than 200 mg and the City agrees, UWD shall pay the City an excess release charge.

New Castle Municipal Services Commission

- Wells - With a supply of 1.7 mgd and a peak demand of 0.5 mgd, the New Castle MSC has excess capacity from its wells and can presently sell water to AWC through interconnections as needed.

- Interconnection - Last summer, New Castle MSC completed construction of a new 1.0 mgd interconnection with AWC at the Riveredge Industrial Park that is now available for use.

United Water Delaware

- Bread and Cheese Island Reservoir - UWDE has completed preliminary geotechnical and wetland evaluations for a potential 320 mg reservoir at Bread and Cheese Island. UWDE has contacted various State and Federal agencies necessary to determine the extent of permitting for this project. A Request for Proposals (RFP) has been developed to determine costs associated with a detailed wetlands study. Funding for the necessary environmental studies remains an issue as Bread and Cheese Island is owned by private individuals (non-UWDE).

- Chloride Monitoring - UWDE has implemented a Chloride Monitoring Plan that includes three stations along the tidal Christina River and White Clay Creek to provide early warning of elevated salt levels at it's Stanton intake. This plan was activated during the drought of 2002 and is designed to optimize fresh water withdrawals from the creek and minimize sodium and chloride levels in drinking water supplies during low flows. The chloride monitoring plan was successful in retaining chloride levels in treated drinking water leaving the Stanton plant and ensured compliance with the USEPA secondary 250 ppm chloride standard.

- Aquifer Storage and Recovery - UWDE is evaluating future use of aquifer storage and recovery technology (225 mg) in its southern service areas just north of the C & D Canal.

- Christiana Water Treatment Plant - UWDE has begun preliminary evaluation of upgrades to its filter plant at Smalley's Pond. UWDE sought and recently received an operating permit from DNREC for an existing well (0.3 mgd) at the Christiana Treatment Plant to be used for dilution during high chloride events.

- Interconnections - UWDE signed an agreement with the City of Wilmington in October 2000 for the purchase of 3 mgd finished water through existing interconnections. The Chatham interconnection was upgraded in 2001 and the Atlas interconnection upgrades are underway.

- Tidal Capture Structure Operating Plan – UWDE is working with DNREC to develop a new operating plan for the TCS to recommend instream flow needs necessary to satisfy ecological concerns in the tidal White Clay Creek. The modified TCS operating plan is due to the Delaware River Basin Commission by October 1, 2003.

Interconnected System

- The water purveyors conducted hydraulic testing and modeling to increase the northern New Castle County interconnected system capacity to move water during drought. In December 2002, there are 25 interconnections in place compared to 1999 when 23 interconnections were in place. The peak water transfer by the purveyors through interconnections was 6.0 mgd on August 21, 2002 or 9% of the supply needed to meet demand recorded that day.

Conservation Water Rates

- The DNREC signed an agreement with the University of Delaware Center for Energy and Environmental Policy to evaluate the potential for adopting conservation water rates to reduce peak water demands. This work is under the direction of the Water Conservation Oriented Rate (WCOR) Subcommittee and was completed in March 2001. The study concluded that pricing mechanisms are effective demand management tools and the water utilities are encouraged to further investigate methods of implementation.
- AWC continues its conservation water rate structure that has been in place since 1992.
- Newark increased its water rates effective July 2001 to fund its proposed reservoir and water treatment plant improvements. The City temporarily discontinued its seasonal conservation water rate structure in place since 1999.
- The New Castle Municipal Services Commission recently instituted a new conservation water rate structure.
- The Delaware River Basin Commission has required that United Water Delaware conduct a study to evaluate the feasibility of adopting conservation water rates.

Northern New Castle County Ground-Water Modeling Study

- The DNREC Division of Water Resources signed a contract on May 23, 2000 with the US Army Corps of Engineers to estimate the long-term safe yield of ground water for supply in northern New Castle County. The Corps will update earlier studies by the USGS and DGS that indicated ground-water availability from northern New Castle County in the coastal plain to be about 32 mgd. The capacity of wells allocated by DNREC in this area is 31 mgd. The ground-water modeling area is in that portion of the Coastal Plain that extends from Wilmington to Middletown and from New Jersey across New Castle County into Maryland. The ground-water

investigation is currently nearing the end of the model construction phase with initial results planned for March 2003 and full project completion by June 2003. DGS has just completed a detailed review of the geologic database for the model to verify accuracy with the new geologic interpretation of the study area. Because of the scope of the project, this critical quality control process has resulted in some additional delay for the project. The Corps is preparing a revised schedule.

Green Industry Guidelines

- The DNREC Division of Water Resources, the UD Water Resources Agency, and the Delaware Geological Survey worked with the Green Industry to revise the rules for water use during drought as they pertain to the State's nurseries, golf courses, and landscaping firms. These rules were approved by the Governor's office and were useful to moderate economic impacts during the drought of 2002 declaration of Drought Emergency and mandatory restrictions. Evolution of these rules will continue in development of the proposed 3-tier drought operating plan.

Public Service Commission

- In July 2000, Governor Carper signed SB 370, which transferred the jurisdiction for issuing water supply franchise areas (Certificates of Public Convenience and Necessity or CPCNs) from DNREC to the PSC effective July 1, 2001. On June 5, 2001 the PSC adopted regulations governing the award of CPCNs to public and investor-owned water purveyors statewide.

- On November 19, 2002 the PSC issued Commission Order No. 6069 which opened an investigation into the water supply available to Artesian Water Company, Inc. and United Water Delaware, Inc: (a) during the drought between March 5 to October 11, 2002 and (b) over the next five years. Pursuant to the order, Artesian and United are required to each submit a report listing available supplies and estimating peak demands. The water suppliers are required to file the reports to the PSC by January 17, 2003. The order also directed the PSC staff to issue a report to the Commissioners at the conclusion of its investigation.

CHAPTER 4 - WATER SUPPLY

Because streamflows along the Brandywine Creek reached all time record low levels during the drought of 2002 thus reducing safe yields, the Water Supply Coordinating Council reevaluated the supply and demand assumptions for northern Delaware.

According to the schedule set forth in 1999, over 1 billion gallons of additional storage is on schedule for development in northern Delaware by the end of 2003. The following water supply projections assume that the "A List" projects such as Newark Reservoir and others will be online by the end of 2003.

During the drought of 2002, deficit rainfall, declining shallow ground-water levels, and dwindling stream flows threatened the adequacy of water supplies in northern New Castle County. Along with declining stream flows, the salt front migrated up White Clay Creek causing chloride concentrations to exceed the 250 ppm chloride standard in the raw water supply (chlorides never exceeded 250 ppm in the treated water by much) at the Stanton intake. The drought further reaffirmed that in northern New Castle County the availability of surface water supplies are dictated by several key factors: (1) minimum instream flow standards, (2) useable water in Hoopes Reservoir, the UWD Tidal Capture Structure, and by the end of 2003 in the Newark Reservoir, (3) stream chloride levels, and (4) adequacy of ground-water to maintain adequate base flows.

Instream Flow Scenarios

An analysis of the drought of 2002 was conducted to determine the availability of Hoopes Reservoir and future Newark reservoir and water availability from Brandywine Creek at Wilmington, White Clay Creek at Stanton, and White Clay Creek at Newark assuming the United Water Delaware Tidal Capture Structure is in operation, for the following minimum instream flow scenarios:

1. Drought Emergency - No 7Q10 minimum instream flow standard along Brandywine Creek at Wilmington. 7Q10 flow standard (17.2 mgd) waived along White Clay Creek at Stanton during drought emergency. 7Q10 flow standard (14 mgd) remains in place along White Clay Creek at Newark.

2. Existing Regulatory Condition - No 7Q10 minimum instream flow standard along Brandywine Creek whereas the existing 7Q10 minimum instream flow standard remains in effect along the White Clay Creek at Stanton (17.2 mgd) and Newark (14 mgd).

3a. Future Condition - 7Q50 minimum instream flow standard (38 mgd) which may be imposed sometime by 2020 along Brandywine Creek and the existing 7Q10 minimum instream flow standard remains in effect on White Clay Creek at Stanton (17.2 mgd) and Newark (14 mgd).

3b. Future Condition - 7Q10 minimum instream flow standard (49 mgd) imposed sometime by 2020 along Brandywine Creek and the existing 7Q10 minimum instream flow standard remains in effect on White Clay Creek at Stanton (17.2 mgd) and at Newark (14 mgd).

A streamflow simulation model was constructed to evaluate the operations of Hoopes Reservoir and the United Water Delaware Tidal Capture Structure for the four different water supply scenarios. Table 6 contains the capacity summary of the Hoopes Reservoir analysis for various scenarios during the drought of 2002.

Table 6
Summary of Hoopes Reservoir Simulations (mg) Drought of 2002

Scenario	Description	(1) Released To Wilm.	(2) Released To UWD	(3) Hoopes Refill	(4) Provided by TCS	(5) *Remaining Hoopes Reservoir Capacity	Begin Hoopes Releases	Low Hoopes Level	Hoopes Refilled
1.	No 7Q10	91	178	0	1138	1531 (85%)	Jul 31	Aug 22	Oct 11
2.	No 7Q10 BRCR/ 7Q10 WCC	91	586	216	1689	1339 (74%)	Jun 23	Sep 25	Oct 30
3a.	7Q50 BRCR/ 7Q10 WCC	1643	586	216	1689	-213 (-12%)	Jun 23	Oct 10	Jan 6, 2003
3b.	7Q10 BRCR & WCC	2054	586	216	1689	- 624 (-35%)	Jun 23	Oct 10	Jan 18, 2003

* (1800) – (1) – (2) + (3) = (5). Assumes Hoopes Reservoir is full at beginning of drought.

Supply-side Assumptions

The Delaware DNREC, Delaware Geological Survey, and University of Delaware, Institute for Public Administration - Water Resources Agency met with the Artesian Water Company, City of Wilmington, United Water Delaware, City of Newark, and City of New Castle Municipal Services Commission in September and October 2002 to review and concur on the following key assumptions regarding the supply side of the equation:

- Minimum Instream Flow Needs
  - Scenario 1 - No 7Q10 along Brandywine Creek and White Clay Creek at Stanton
  - Scenario 2 - No 7Q10 along Brandywine but 7Q10 along White Clay Creek at Stanton and Newark
  - Scenario 3a - 7Q50 along Brandywine Creek and 7Q10 along White Clay Creek at Stanton and Newark
  - Scenario 3b - 7Q10 along Brandywine Creek and White Clay Creek at Stanton and Newark

- Hoopes Reservoir total capacity = 2 bg; useable capacity = 1.8 bg. Hoopes Reservoir pump refill = 24 mgd.

- Useable capacity of future Newark Reservoir = 317 mg.

- Maximum ground - water supplies as per DNREC allocation permits and as sustained by pumping during the drought of 2002.

- Transfers from Chester Water Authority (CWA) interconnections as per drought of record (2002) conditions. Water demand records compiled by the UDWRA during the drought in August 2002 indicate that the CWA could reliably provide 0.5 mgd to UWD and up to 2 mgd to AWC.

- Maximum chloride levels in finished water at White Clay Creek at Stanton Intake = 250 mg/l as per USEPA secondary drinking water standard.

- The UWD Tidal Capture Structure is operating along the White Clay Creek at Stanton (14 mgd).

- Available streamflows based on drought of record (2002). Brandywine Creek at Wilmington = 21 mgd (August 23, 2002). White Clay Creek at Stanton (without Hoopes Reservoir Releases) = 6.8 mgd (August 15, 2002).

- Duration of drought = 75 days for Hoopes Reservoir releases if a future instream flow standard is put into effect along the Brandywine Creek at Wilmington (Scenarios 3A and 3B). Duration of Drought = 60 days assuming no instream flow standards along the Brandywine Creek (Scenarios 1 and 2)

Table 7
Accounting of Water Supply During Drought (Year 2003)
Northern New Castle County

Purveyor	1. No 7Q10	2. No 7Q10 BRCR/ 7Q10 along WCC	3A. 7Q50 along BRCR 7Q10 along WCC	3B. 7Q10 along BRCR and WCC
Artesian				
- Ground water (wells)	20.0	20.0	20.0	20.0
- CWA Interconnection	4.0	4.0	4.0	4.0
- ASR	1.7	1.7	1.7	1.7
United Water				
- Stanton WTP	20.0	14.0	14.0	14.0
- Hoopes Resvr. Contract	3.0	7.0	1.0	0.0
- Christina WTP	3.0	3.0	3.0	3.0
- CWA Interconnection	0.0	0.0	0.0	0.0
Wilmington				
- Brandywine Cr.	15.0	15.0	8.0	5.5
- Hoopes Reservoir	27.0	23.0	23.0	24.0
Newark				
- White Clay Cr. WTP	3.0	3.0	3.0	3.0
- Newark Reservoir	1.0	1.0	1.0	1.0
- Ground water (wells)	3.8	3.8	3.8	3.8
New Castle MSC				
- Ground water (wells)	2.0	2.0	2.0	2.0
Supply during drought	103.5 mgd	97.5 mgd	84.5 mgd	82.0 mgd

CHAPTER 5 - WATER DEMAND

The following water demand data are available for planning in Northern New Castle County:

- Historic Peak Day = 93 mgd (July 18, 1997)
- Drought 1999 Peak Day = 89 mgd (July 19, 1999)
- 2001 Peak Day = 91 mgd (August 9, 2001)
- Drought 2002 Peak Day = 83 mgd (July 10, 2002)
- Estimated Maximum Month = 86 mgd (Year 2000, Merna Hurd, Jan. 1998)
- Actual Maximum Month = 83 mgd (July 1999)

The drought of 2002 was useful to verify maximum water demand patterns in northern New Castle County. On July 10, 2002 the peak day for the drought, water purveyors reported water demands presented in Table 8.

Table 8
Water Demands for the Peak Day of July 10, 2002
Northern New Castle County

Purveyor	Demand (mgd)
Wilmington	
- Brandywine Filter Plant	8.5
- Porter Filter Plant	19.0
Subtotal	27.5
Artesian	
- Wells (No. above C&D Canal)	17.5
- ASR	1.1
- CWA Interconnection	3.6
- Wilmington Interconnection	2.4
- New Castle MSC Interconnection.	0.6
Subtotal	25.2
United Water Delaware	
- White Clay Creek at Stanton WTP	23.6
- Christina WTP	4.3
- CWA interconnection	1.0
- Wilmington Interconnection	0.0
- Artesian Interconnection	0.0
Subtotal	28.9
Newark	
- White Clay Creek WTP	1.6
- Wells	1.4
- United Water Interconnection	2.0
- Artesian Water Interconnection	0.0
Subtotal	5.0
New Castle MSC	
- Wells	1.1
Subtotal	1.1
Total	87.7
- Intracounty interconnections	5.0
Total Peak Demand	82.7 mgd

For this analysis, the Water Supply Coordinating Council decided to utilize the maximum monthly demand data published in Merna Hurd's report (1998) for 2000, 2010, and 2020. Hurd's report was adopted unanimously in March 1998 by the Project Management Committee for the Water Supply Plan for New Castle County comprised of representatives from the State of Delaware, New Castle County, University of Delaware Water Resources Agency, and the water purveyors (AWC, City of Newark, New Castle, UWD, and City of Wilmington). Predicted water demands of 86 mgd for the year 2000 contained in the Hurd report were within 4% of the actual maximum month demand for July 1999 (83 mgd). The Hurd report projected the demands to 2000, 2010 and 2020 based on expected population increases and allowances for business and industrial growth. Maximum monthly demands are used in this analysis because treated water storage tanks provide sufficient capacity to meet peak day demands in each supplier's system.

Water demands projected for United Water Delaware were reduced to account for reduced sales to the City of Newark after the construction of the Newark Reservoir (so as to not double count interconnections). The following maximum monthly water demand projections for northern New Castle County will be used as published in the 1998 Hurd report with modification due to construction of the Newark Reservoir:

Year	Maximum Monthly Demand (As per Hurd, 1998)*	Reduced Sales from UWD to Newark*	Demands assumed for this report**
2000 (or 2003)	86 mgd	2.7 mgd	83.3 mgd
2010	88 mgd	1.7 mgd	86.3 mgd
2020	90 mgd	2.0 mgd	88.0 mgd

* Before construction of Newark Reservoir
** After construction of Newark Reservoir

CHAPTER 6 - UPDATED WATER SUPPLY AND DEMAND PROJECTIONS

By comparing the available water supply during drought with the maximum monthly demand, one can estimate the projected surplus or deficit in water supplies for northern New Castle County as they relate to scenarios 1, 2, 3A, and 3B based on drought of record (2002) conditions.

Table 9
Scenario 1 - Drought Emergency - No 7Q10 Flow Standard along Brandywine Creek and White Clay Creek
Water Supply/Demand Calculations (mgd)
Northern New Castle County, Delaware

Supplier	2003			2010			2020		
	Supply	Maximum Monthly Demand	Surplus/ Deficit (+/-)	Supply	Maximum Monthly Demand	Surplus/ Deficit (+/-)	Supply	Maximum Monthly Demand	Surplus/ Deficit (+/-)
Artesian									
* Groundwater	20.0			20.0			20.0		
* CWA Interconnection	4.0			4.0			4.0		
* Aquifer Storage & Recovery	1.7			1.7			1.7		
	25.7	24.0	1.7	25.7	26.0	-0.3	25.7	27.1	-1.4
United Water									
* Stanton WTP	20.0			20.0			20.0		
* Hoopes Reservoir Contract	3.0			3.0			3.0		
* Christina WTP	3.0			3.0			3.0		
* CWA Interconnection	0.0			0.0			0.0		
	26.0	24.0	2.0	26.0	24.1	1.9	26.0	24.4	1.6
Wilmington									
* Brandywine Creek	15.0			15.0			15.0		
* Hoopes Reservoir (1800 mg/60 days = 30 mgd)	27.0			27.0			27.0		
	42.0	30.3	11.7	42.0	31.0	11.0	42.0	31.2	10.8
Newark									
* White Clay Cr. WTP	3.0			3.0			3.0		
* Newark Reservoir (300 mg/75 days = 4 mgd)	1.0			1.0			1.0		
* Groundwater	3.8			3.8			3.8		
	7.8	4.5	3.3	7.8	4.7	3.1	7.8	4.8	3.0
New Castle MSC	2.0	0.5	1.5	2.0	0.5	1.5	2.0	0.5	1.5
Subtotal	**103.5**	**83.3**	**20.2**	**103.5**	**86.3**	**17.2**	**103.5**	**88.0**	**15.5**

Water supply available during drought of record conditions with drought emergency:

(a) No minimum instream flow standards in effect along the Brandywine Creek at Wilmington.

(b) No 7Q10 instream flow standards in effect along White Clay Creek at Stanton. 7Q10 in effect at White Clay Creek at Newark.

(c) Groundwater supplies permitted by DNREC allocation permit as per drought of record (2002) conditions

(d) Transfers from Chester Water Authority as per drought of record (2002) condition

(e) Useable capacity Hoopes Reservoir = 1800 mg over 60 days (30 mgd), Newark Reservoir = 300 mg over 75 days (4 mgd)

(f) Drought of record low streamflows observed during 2002 drought: Brandywine Creek = 21 mgd (8/21/02), White Clay Creek at Stanton (without Hoopes Reservoir Releases) = 6.8 mgd (8/15/02)

(g) Maximum monthly demand projections per Merna Hurd report to DNREC, Jan. 1998

Table 10
Scenario 2 - Existing Condition - No 7Q10 along the Brandywine Creek but 7Q10 along the White Clay Creek
Water Supply/Demand Calculations (mgd)
Northern New Castle County, Delaware

Supplier	2003			2010			2020		
	Supply	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**	**Supply**	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**	**Supply**	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**
Artesian									
* Groundwater	20.0			20.0			20.0		
* CWA Interconnection	4.0			4.0			4.0		
* Aquifer Storage & Recovery	1.7			1.7			1.7		
	25.7	24.0	1.7	25.7	26.0	-0.3	25.7	27.1	-1.4
United Water									
* Stanton WTP (TCS)	14.0			14.0			14.0		
* Hoopes Reservoir Contract	7.0			7.0			7.0		
* Christina WTP	3.0			3.0			3.0		
* CWA Interconnection	0.0			0.0			0.0		
	24.0	24.0	0.0	24.0	24.1	-0.1	24.0	24.4	-0.4
Wilmington									
* Brandywine Creek	15.0			15.0			15.0		
* Hoopes Reservoir	23.0			23.0			23.0		
(1800 mg/60 days = 30 mgd)									
	38.0	30.3	7.7	38.0	31.0	7.0	38.0	31.2	6.8
Newark									
* White Clay Cr. WTP	3.0			3.0			3.0		
* Newark Reservoir	1.0			1.0			1.0		
(300 mg/75 days = 4 mgd)									
* Groundwater	3.8			3.8			3.8		
	7.8	4.5	3.3	7.8	4.7	3.1	7.8	4.8	3.0
New Castle MSC	2.0	0.5	1.5	2.0	0.5	1.5	2.0	0.5	1.5
Subtotal	**97.5**	**83.3**	**14.2**	**97.5**	**86.3**	**11.2**	**97.5**	**88.0**	**9.5**

Water supply available during drought of record conditions with existing regulatory condition:

(a) No minimum instream flow standards in effect along the Brandywine Creek at Wilmington.

(b) 7Q10 instream flow standards in effect along White Clay Creek at Stanton (17 mgd) and at Newark (14 mgd).

(c) Groundwater supplies permitted by DNREC allocation permit as per drought of record (2002) conditions

(d) Transfers from Chester Water Authority as per drought of record (2002) condition

(e) Useable capacity Hoopes Reservoir = 1800 mg over 60 days (30 mgd), Newark Reservoir = 300 mg over 75 days (4 mgd)

(f) Drought of record low streamflows observed during 2002 drought: Brandywine Creek = 21 mgd (8/21/02), White Clay Creek at Stanton (without Hoopes Reservoir Releases) = 6.8 mgd (8/15/02)

(g) Maximum monthly demand projections per Merna Hurd report to DNREC, Jan. 1998

Table 11
Scenario 3A - Future Condition - 7Q50 in Effect on Brandywine Creek and 7Q10 in Effect along White Clay Creek
Water Supply/Demand Calculations (mgd)
Northern New Castle County, Delaware

Supplier	2003			2010			2020		
	Supply	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**	**Supply**	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**	**Supply**	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**
Artesian									
* Groundwater	20.0			20.0			20.0		
* CWA Interconnection	4.0			4.0			4.0		
* Aquifer Storage & Recovery	1.7			1.7			1.7		
	25.7	24.0	1.7	25.7	26.0	-0.3	25.7	27.1	-1.4
United Water									
* Stanton WTP (TCS)	14.0			14.0			14.0		
* Hoopes Reservoir Contract	1.0			1.0			1.0		
* Christina WTP	3.0			3.0			3.0		
* CWA Interconnection	0.0			0.0			0.0		
	18.0	24.0	-6.0	18.0	24.1	-6.1	18.0	24.4	-6.4
Wilmington									
* Brandywine Creek	8.0			8.0			8.0		
* Hoopes Reservoir	23.0			23.0			23.0		
(1800 mg/75 days = 24 mgd)									
	31.0	30.3	0.7	31.0	31.0	0.0	31.0	31.2	-0.2
Newark									
* White Clay Cr. WTP	3.0			3.0			3.0		
* Newark Reservoir	1.0			1.0			1.0		
(300 mg/75 days = 4 mgd)									
* Groundwater	3.8			3.8			3.8		
	7.8	4.5	3.3	7.8	4.7	3.1	7.8	4.8	3.0
New Castle MSC	2.0	0.5	1.5	2.0	0.5	1.5	2.0	0.5	1.5
Subtotal	**84.5**	**83.3**	**1.2**	**84.5**	**86.3**	**-1.8**	**84.5**	**88.0**	**-3.5**

Water supply available during drought of record conditions for future regulatory scenario with:

(a) 7Q50 minimum instream flow standards in effect along the Brandywine Creek at Wilmington (38 mgd)

(b) 7Q10 instream flow standards in effect along White Clay Creek at Stanton (17 mgd) and at Newark (14 mgd).

(c) Groundwater supplies permitted by DNREC allocation permit as per drought of record (2002) conditions

(d) Transfers from Chester Water Authority as per drought of record (2002) condition

(e) Useable capacity Hoopes Reservoir = 1800 mg over 75 days (24 mgd), Newark Reservoir = 300 mg over 75 days (4 mgd)

(f) Drought of record low streamflows observed during 2002 drought: Brandywine Creek = 21 mgd (8/21/02), White Clay Creek at Stanton (without Hoopes Reservoir Releases) = 6.8 mgd (8/15/02)

(g) Maximum monthly demand projections per Merna Hurd report to DNREC, Jan. 1998

Table 12
Scenario 3B - Future Condition - 7Q10 in Effect on Brandywine Creek and 7Q10 in Effect along White Clay Creek
Water Supply/Demand Calculations (mgd)
Northern New Castle County, Delaware

Supplier	2003			2010			2020		
	Supply	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**	**Supply**	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**	**Supply**	**Maximum Monthly Demand**	**Surplus/ Deficit (+/-)**
Artesian									
* Groundwater	20.0			20.0			20.0		
* CWA Interconnection	4.0			4.0			4.0		
* Aquifer Storage & Recovery	1.7			1.7			1.7		
	25.7	24.0	1.7	25.7	26.0	-0.3	25.7	27.1	-1.4
United Water									
* Stanton WTP (TCS)	14.0			14.0			14.0		
* Hoopes Reservoir Contract	0.0			0.0			0.0		
* Christina WTP	3.0			3.0			3.0		
* CWA Interconnection	0.0			0.0			0.0		
	17.0	24.0	-7.0	17.0	24.1	-7.1	17.0	24.4	-7.4
Wilmington									
* Brandywine Creek	5.5			5.5			5.5		
* Hoopes Reservoir	24.0			24.0			24.0		
(1800 mg/75 days = 24 mgd)									
	29.5	30.3	-0.8	29.5	31.0	-1.5	29.5	31.2	-1.7
Newark									
* White Clay Cr. WTP	3.0			3.0			3.0		
* Newark Reservoir	1.0			1.0			1.0		
(300 mg/75 days = 4 mgd)									
* Groundwater	3.8			3.8			3.8		
	7.8	4.5	3.3	7.8	4.7	3.1	7.8	4.8	3.0
New Castle MSC	2.0	0.5	1.5	2.0	0.5	1.5	2.0	0.5	1.5
Subtotal	**82.0**	**83.3**	**-1.3**	**82.0**	**86.3**	**-4.3**	**82.0**	**88.0**	**-6.0**

Water supply available during drought of record conditions for future regulatory scenario with:

(a) 7Q10 minimum instream flow standards in effect along the Brandywine Creek at Wilmington (49 mgd)

(b) 7Q10 instream flow standards in effect along White Clay Creek at Stanton (17 mgd) and at Newark (14 mgd).

(c) Groundwater supplies permitted by DNREC allocation permit as per drought of record (2002) conditions

(d) Transfers from Chester Water Authority as per drought of record (2002) condition

(e) Useable capacity Hoopes Reservoir = 1800 mg over 75 days (24 mgd), Newark Reservoir = 300 mg over 75 days (4 mgd)

(f) Drought of record low streamflows observed during 2002 drought: Brandywine Creek = 21 mgd (8/21/02), White Clay Creek at Stanton (without Hoopes Reservoir Releases) = 6.8 mgd (8/15/02)

(g) Maximum monthly demand projections per Merna Hurd report to DNREC, Jan. 1998

Table 13
Water Supply Versus Demand Projections
Northern New Castle County

Year/Scenario	Supply (mgd)	Demand (mgd)	Surplus/Deficit** (mgd)	(mg*)
2003				
1. Drought Emergency - No 7Q10 along BRCR & WCC	103.5	83.3	20.2	1,515
2. Existing - No 7Q10 BRCR but 7Q10 along WCC	97.5	83.3	14.2	1,065
3A. Future - 7Q50 along BRCR and 7Q10 along WCC	84.5	83.3	1.2	90
3B. Future - 7Q10 along BRCR and 7Q10 along WCC	82.0	83.3	- 1.3	- 97
2010				
1. Drought Emergency - No 7Q10 along BRCR & WCC	103.5	86.3	17.2	1,290
2. Existing - No 7Q10 BRCR but 7Q10 along WCC	97.5	86.3	11.2	840
3A. Future - 7Q50 along BRCR and 7Q10 along WCC	84.5	86.3	- 1.8	- 135
3B. Future - 7Q10 along BRCR and 7Q10 along WCC	82.0	86.3	- 4.3	- 322
2020				
1. Drought Emergency - No 7Q10 along BRCR & WCC	103.5	88.0	15.5	1,162
2. Existing - No 7Q10 BRCR but 7Q10 along WCC	97.5	88.0	9.5	712
3A. Future - 7Q50 along BRCR and 7Q10 along WCC	84.5	88.0	- 3.5	- 262
3B. Future - 7Q10 along BRCR and 7Q10 along WCC	82.0	88.0	- 6.0	- 450

* Volume required assuming a 75-day drought period along the Brandywine Creek for Scenarios 3A and 3B and a 60 day drought along the Brandywine Creek for Scenarios 1 and 2.
** Assumes projects on "A" list implemented by end of 2003 including Newark Reservoir, Hoopes Reservoir Deep Storage, Newark South Wellfield treatment Plant, Artesian Water Company New Wells North of C&D Canal, and AWC Aquifer Storage and Recovery wells.

For 2020, the updated supply and demand projections indicate a healthy surplus of 1,162 mg and 712 mg for scenario 1 and scenario 2. By 2020 the projections forecast a deficit of 262 mg for scenario 3A and a deficit of 450 mg for scenario 3B.

The Delaware Water Supply Coordinating Council adopted these updated supply and demand projections at its October 17, 2002 meeting. For water supply planning purposes, the WSCC identified that the projected deficit would be 262 to 450 mg depending on the assumption of a 7Q50 or 7Q10 instream flow standard that could possibly be imposed along the Brandywine Creek by 2020. The WSCC adopts these projections as the minimum water supply necessary to accommodate the water demand of the projected population at 2020 without water restrictions even with a recurrence of conditions that existed during the drought of 2002. These water supply and demand projections are based on a conservative, "worst case" scenario with the following assumptions:

- 7Q50 or 7Q10 instream flow standard may be imposed along the Brandywine Creek sometime during the planning period before 2020.
- Streamflows at drought of record (2002) levels. The drought of 2002 record low along the Brandywine Creek at Wilmington was 21 mgd on August 23 breaking the previous low flow record of 33 mgd set in 1995.
- Duration of drought along the Brandywine Creek = 75 days. The drought of 2002 was one of the most severe droughts in terms of duration. Previous water supply/demand estimates based on the then record droughts of 1999 and 1966 were based on a 60-day drought.
- Maximum monthly demands of 83.3 mgd (2003), 86.3 mgd (2010), and 88.0 mgd (2020) assumed for every day of the 75-day drought. During the drought of 2002, the public responded by reducing demands below 80 mgd through voluntary restrictions and below 70 mgd through mandatory restrictions.

CHAPTER 7 - FUTURE WATER SUPPLY OPTIONS

At the November 21 and December 12, 2002 meetings, the Water Supply Coordinating Council identified a series of additional water supply projects that could be constructed to meet a projected 2020 deficit of 262 to 450 mg, depending on the assumption of a 7Q50 or7Q10 instream flow standard which could be imposed along the Brandywine Creek by 2020. Members of the WSCC then nominated projects that they would agree to sponsor and that would have the potential for groundbreaking and/or completion on a fast track status by the end 2003. The sponsors provided a report summarizing the status of their project (s) along with a conceptual evaluation of the project feasibility and project volume (mg and mgd) based on the following criteria:

Engineering - Estimate feasibility from a technical, hydraulic, and/or geologic perspective(s).

Environmental - List the environmental/ecological benefits and constraints.

Regulatory - List federal, state, and local permitting requirements.

Economic - Estimate the capital plus annual operating and maintenance costs.

Community - Will the project have community support?

Timing - Calculate the project's chances for groundbreaking and/or completion by end of 2003.

The most feasible alternatives would best fit all of the above EERECT criteria. The WSCC decided that the following alternatives should be evaluated (in no special order) to close the 262 to 450 mg gap between water supply and demand in Northern New Castle County projected for 2020:

Storage

- Raise water level in Hoopes Reservoir by 1 foot to 5 feet (60 – 375 mg)
  Sponsors: City of Wilmington and United Water Delaware
- Upgrade Hoopes Reservoir Pump Stations with the following options:
  Sponsor: City of Wilmington

  a. Increase capacity of Brandywine Pumping Station (12 mgd)
  b. Increase capacity of Wills Pumping Station (4 mgd)
  c. New Red Clay Creek Pumping Station (24 mgd)
  d. New Transmission Line to Hoopes Reservoir and New Pumps (30 mgd)

Pipelines

- Philadelphia to Delaware pipeline (1500 mg/20 mgd)
  Sponsor: Delaware DNREC
- Brandywine Creek Flow Augmentation: River Water Recycling Scenario (25 to 50 mgd)
  Sponsor: Delaware DNREC
- Brandywine Creek Flow Augmentation: Wastewater Recycling Scenario (25 to 50 mgd)
  Sponsor: Delaware DNREC

Groundwater

- AWC Aquifer Storage and Recovery (150 mg)
  Sponsor: Artesian Water Company
- UWD Aquifer Storage and Recovery (225 mg)
  Sponsor: United Water Delaware

Innovative Technologies

- Desalination at UWD Filter Plant White Clay Creek, Stanton (TBD mg)
  Sponsor: United Water Delaware
- Tidal Capture Structure Operating Plan Modification (TBD mg)
  Sponsor: United Water Delaware

Table 14
Summary of Water Supply Options

Option	Capacity	Cost Capital/ Annual O&M	Timing	Advantages	Concerns
Storage Raise water level in Hoopes Reservoir by 1 to 5 feet. Sponsors: City of Wilmington/United Water Delaware	60 - 375 mg	1 ft = $ 4.0 M 2 ft = $ 4.2 M 3 ft = $ 4.5 M 4 ft = $ 4.8 M 5 ft = $ 5.0 M	2004	- Inexpensive Storage - Dam already in place - Normal water level during non-droughts - Needed every 7 years or so.	- Temp. ponding may impact trees - Above 3 ft. require roadway modifications by DelDOT - Easement may be needed from 2 property owners.
Increase Hoopes Pumping Station Capacity Sponsor: City of Wilmington a. Increase Brandywine Pumping Station b. Increase Wills Pumping Station c. New Red Clay Creek Pumping Station d. New Pipe to Hoopes Reservoir and New Pumps	 12 mgd 4 mgd 24 mgd 30 mgd	 $ 0.4M $ 0.8M $ 2.0M $ 6.0M	2004	- Improves refill capacity of Hoopes Reservoir, thus adding volume during drought. - Relatively low cost.	- Capacity limited by number of storm events that occur infrequently during drought.
Pipelines Philadelphia to Delaware Pipeline Sponsor: Delaware DNREC	1500 mg	$31M/$ 0.7 M	2008	- Meets full deficit - Phila. has surplus H20 - Phila Philadewater rates inexpensive	- Institutional Complexity, 2 states, 3 counties - Goes through 3 water service areas - Water quality a concern - Most cost effective if year round
Brandywine Creek Flow Augmentation: Creek Water Recycling Scenario Sponsor: Delaware DNREC	25 to 50 mgd	$6.6 - $8.5 M/ $0.7 M	2006 -- 2008	- Volume of water available nearby	- Costly - Brackish water may negatively impact freshwater fishery in Brandywine Creek above Market St.
Brandywine Creek Flow Augmentation: Wastewater Recycling Scenario Sponsor: Delaware DNREC	25 to 50 mgd	$ 16 M/$0.1 M	2006 - 2008	-Volume of water available nearby - Form of water recycling	- Costly to build 4 mile pipeline. - Concern about effluent meeting Brandywine Cr. stream water quality standard vis - a- vis the TMDL.
Groundwater AWC Aquifer Storage and Recovery Sponsor: Artesian Water Company	150 mg	$1.2 M/ $0.07M	2003	- Proven technology at AWC Llangollen ASR - Cost effective, low $/volume - Serves as underground reservoir	- Recovery of recharged water - Requires careful monitoring of aquifer chemistry
UWD Aquifer Storage and Recovery (225 mg) Sponsor: United Water Delaware	225 mg	$4 M/ 0.1 M	2004	- Proven technology at AWC Llangollen ASR - Cost effective, low $/volume - Serves as underground reservoir	- Recovery of recharged water - Requires careful monitoring of aquifer chemistry
Innovative Technologies Desalination along the White Clay Creek Stanton Treatment Plant Sponsor: United Water Delaware	TBD mg	$ TBD		- Tidal water available in plentiful volume	-Limited by cost and power concerns.
Tidal Capture Structure Operating Plan Modification Sponsor: United Water Delaware	TBD mg	$ TBD		-Potential to add over 75 mg of water with little structural alteration.	- Instream flow needs concerns for aquatic habitat and fishery.

Following a discussion regarding the advantages and concerns about each alternative, the WSCC decided that the options in Table 15 are practicable to form a new "A List" to close the 262 to 450 mg gap between water supply and demand in northern New Castle County projected for 2020. These projects have few environmental and economic constraints and have the potential for groundbreaking and or completion by the end of 2003.

Table 15
New "A List" of Additional Water Supply Options
Northern New Castle County, Delaware

Alternative	Sponsor(s)	Volume	Capital Cost	Cost/Volume
Raise water level in Hoopes Reservoir by 1 feet to 5 feet.	Wilmington/UWD	60 - 375 mg		
a. Raise water level 1 foot.		60 mg	$ 4.0 M	$ 66,667/mg
b. Raise water level 2 feet.		128 mg	$ 4.2 M	$ 32,812/mg
c. Raise water level 3 feet.		203 mg	$ 4.5 M	$ 22,167/mg
d. Raise water level 4 feet.		285 mg	$ 4.8 M	$ 16,842/mg
e. Raise water level 5 feet.		375 mg	$ 5.0 M	$ 13,333/mg
Increase Hoopes Pump Station Capacity	Wilmington			
a. Expand Brandywine Pump (12 mgd)		108 mg	$ 0.4M	$ 3,704/mg
b. Increase Wills Pump Station (4 mgd)		36 mg	$ 0.8M	$ 22,222/mg
c. New Red Clay Cr. Pump Station (24 mgd)		96 mg	$ 2.0M	$ 16,666/mg
d. New Pipe/Pumps to Hoopes Res. (30 mgd)		270 mg	$ 6.0M	$ 22,222/mg
AWC Aquifer Storage and Recovery	Artesian Water Co.	150 mg	$1.2M	$ 8,000/mg
UWD Aquifer Storage and Recovery	United Water DE.	225 mg	$4.0M	$ 17,777/mg
Tidal Capture Structure Operating Plan Modification	United Water DE.	TBD	$ TBD	$ TBD/mg

Note: Estimates of volume and cost are preliminary in nature and are subject to final engineering studies. Costs for raising water level in Hoopes Reservoir include new gate, spillway modification, and road construction.

The following projects were placed on a reserve "B List" for possible implementation at a later date due to more significant environmental, cost constraints, and timing constraints.

Table 16
Reserve "B List" of Additional Water Supply Options
Northern New Castle County, Delaware

Alternative	Sponsor(s)	Volume
Philadelphia to Delaware pipeline	Delaware DNREC	1500 mg (20 mgd)
Brandywine Creek Flow Augmentation: River Water Recycling Scenario	Delaware DNREC	25 to 50 mgd
Brandywine Creek Flow Augmentation: Wastewater Recycling Scenario	Delaware DNREC	25 to 50 mgd
Desalination at the White Clay Creek Stanton Treatment Plant	United Water Delaware	TBD mg

1. Raise Water Level in Hoopes Reservoir by 1 foot to 5 feet (60 mg to 375 mg)
Sponsors: City of Wilmington and United Water Delaware

Project Description: The City of Wilmington has made substantial investments in the past to store sufficient water in Hoopes Reservoir to meet its own needs during a drought. Expansion of Hoopes Reservoir to meet the regional needs of other suppliers is contingent upon financial investments from the public sector (the State) and/or private suppliers. This alternative proposes to install an inflatable gate or Bascule gate at the spillway to temporarily raise water levels 1 to 5 feet during future droughts (60 to 375 mg).

Technical Feasibility: A dam safety and geotechnical engineering investigation of the dam indicates this option of raising the water level temporarily during droughts is feasible with some modifications. During non-drought periods, water levels would remain at current design levels. The reservoir water level can be raised up to 5 feet. This will result in an increase in storage capacity of up to 375 million gallons. Preliminary analysis of the dam structure under the increased loads indicates that additional post-tensioning steel anchors will be required for the spillway and some of the non-overflow sections of the dam. Modifications to the spillway channel will also be necessary to handle larger releases from the reservoir.

Raising the water level would have implications on three surrounding DelDOT roads. DelDOT conducted a survey of Hoopes Reservoir and surrounding areas using GPS to determine elevations with the following results:

	DelDOT Datum	Wilmington Datum
* Spillway Normal Water Elevation	217.3 ft.	220.0 ft.
* Top of Dam Elevation	230.3	233.0
* Causeway (Route 82) Road Elevation	221.6	224.3.
* Top of Flood Control Devices under Causeway	219.4	222.1
* Centreville Road	222.8	225.5
* Hillside Mill Road	222.4	225.1

Environmental Feasibility: Temporarily raising the water level during drought by up to 5 feet will have an impact on wetlands and forested areas along the shoreline. There are low lying areas around the stream and drainage tributaries on the northern end of the reservoir. Wetlands surrounding culvert outfalls will be impacted. There are also other shoreline wetlands and marshes that will be impacted.

Results of the DelDOT field survey and datum indicate that one could raise the water level:

- I foot above the spillway to DelDOT datum 218.3 feet without having to do any tree cutting. This would add 60 million gallons of storage.
- 2 feet above the spillway to DelDOT datum 219.3 feet without having to rebuild the flood control device and the culverts under the Route 82 causeway. Approximately 7 acres of trees would be impacted. This would add 128 mg of storage and no private property would be impacted.
- 3 feet above the spillway to DelDOT datum 220.3 feet without having to rebuild the entire causeway or surrounding roads. This would require re-building the flood control devices and culverts under Route 82, retaining an easement to private property, and impacting 20 acres of trees. This would provide 203 mg of storage.
- Over 3 feet would require raising the 3 DelDOT roads.

Field reconnaissance by a forester should be conducted to evaluate the tree's capacity to withstand temporary inundation for a period not to exceed 3 months depending on the tree species.

Economic Feasibility: The preliminary costs for raising the water level 3 feet and 5 feet is $4.5 million and $5 million respectively. This includes the installation of a weir gate (Bascule Gate), the installation of new post-tension anchors in the dam, and the modification of the spillway channel. These estimates also includes costs associated with raising sections of three adjoining roads an estimated 3.5 feet. These roads are Campbell Road (State Road 82), Centerville Road (RD 273), and Hillside Mill Road (RD269). There are also costs included for wetland mitigation. There may be other costs associated with private land easements that are unknown at this time. It is believed that the dam and

reservoir modifications will have minimal impact on the current operating and maintenance costs for the reservoir.

Regulatory Restraints: Permits for this type of construction will need to be secured from a number of state agencies including DNREC, DelDOT, etc.

Community Support: A project of this nature will enjoy support from the general community who would envision this as a way of making northern New Castle County more drought-proof. On the other hand, neighbors in the area may not be as supportive. The loss of woodlands and the reduction of the wooded buffer between the reservoir and private property are likely to generate some local opposition. In addition, if any private property is inundated by the raised water level, this may generate increased local opposition as well as potential political opposition.

Timing: The timing of this project will depend on whether the Mayor and City Council support it and how the project fits in with City priorities. Funding will be an issue, as this project would be competing for funds with other city water projects. With the go-ahead, a project of this nature could be engineered and constructed in about 18 to 24 months.

2. Increase Hoopes Reservoir Pumping Station Capacity
Sponsor: City of Wilmington

Project Description: This project consists of a series of options designed to provide upgrades to the City of Wilmington's raw water conveyance system to more efficiently convey water to Hoopes Reservoir:

a. Increase capacity of Brandywine Pumping Station (12 mgd)
b. Increase capacity of Wills Pumping Station (4 mgd)
c. New Red Clay Creek Pumping Station (24 mgd)
d. New Transmission Line to Hoopes Reservoir and New Pumps (30 mgd)

Two pump stations currently have the capability to pump to Hoopes Reservoir: Wills P.S. (24 mgd) and Brandywine P.S. (28 mgd). Both pump stations use the same 42 - inch diameter transmission line. During high rainfall events and when pumping to Hoopes, Wills P.S. is typically dedicated to supplying Porter Water Treatment Plant, and Brandywine P.S. is used to pump to Hoopes Reservoir. Porter requires about 24 mgd during normal operating conditions.

Based on allowable friction losses in the 42 inch transmission line to Hoopes, maximum flow to Hoopes through this line is approximately 40 mgd.

The general recommendation is to maximize the potential to convey water to Hoopes throughout the year. This can be accomplished by upgrading existing pump stations with variable speed pumps to allow for maximum pumping at high streamflows but also lower rate pumping throughout the year when streamflows allow, and/or installing new pumps and a new transmission line to increase total pumping capacity to Hoopes.

a. Brandywine Pumping Station

Add an additional 12 mgd pumping capacity (one pump) to the Brandywine Pumping Station to maximize the use of the existing transmission line to Hoopes Reservoir. This would bring pumping capacity at this station to approximately 40 mgd. The pump should be variable speed to allow for maximum pumping at high streamflow levels but also lower rate pumping throughout the year when streamflows allow. Approximate Cost - $400,000

b. Wills Pumping Station

Upgrade the two pumps at Wills Pump Station with variable speed pumps to allow for maximum pumping at high streamflow levels but also lower rate pumping throughout the year when streamflows allow. Maximum capacity would increase from 24 mgd to 28 mgd.. During lower streamflow periods, pumping capacity is limited by the wetwell capacity. Approximate Cost - $ 800,000.

c. New Pump Station on Red Clay

Construct a new 24 mgd pumping station with variable speed pumps on the Red Clay Creek near Hoopes Reservoir. Hoopes is located within approximately 1,000 feet of Red Clay Creek. The new pumping station could be used to pump during periods of high streamflow and also during lower streamflows. Streamflow in the Red Clay Creek is much lower than the Brandywine Creek, however, its proximity to Hoopes makes it an alternate source.

There are several downstream entities with surface water withdrawal permits from this creek. Most of these entities, particularly water suppliers would likely be opposed to this alternative. Water could only be pumped above a determined streamflow rate to allow for other downstream uses. Approximate Cost - $ 2,000,000

d. New Transmission Line to Hoopes and New Temporary Pump(s) at Brandywine Pumping Station

Construct a new 36 inch transmission line from the Brandywine Pumping Station to Hoopes Reservoir. This line would be approximately 6 miles in length. Construction would be difficult due to utilities, roads, and rock that will drive up the cost. Approximate cost - $ 6,000,000

Technical Feasibility: All options presented above are technically feasible. The existing conditions at the Brandywine Pumping Station allow for addition of one new pump with only minor piping modifications. An upgrade to the Wills Pumping Station requires the removal of existing pumps and replacement with new pumps with minor piping modifications. Construction of a new Pump Station on Red Clay Creek would require acquisition of land and delivery of power to the selected site. Construction of a new 36 inch transmission line will require a detailed geotechnical evaluation along the proposed route of the new pipeline, rock excavation, location, protection, and possible relocation of existing utilities, and traffic management.

Environmental Feasibility: Construction of any of the projects presented above will likely have minimal impacts on wetlands and forested areas. There are low lying areas and some wooded areas around the Brandywine Creek near Wills and Brandywine Pumping Stations, and the Red Clay Creek the may be temporarily impacted during construction. There may be concerns with additional impingement on the instream ecosystem caused by increased and more frequent withdrawals during drought conditions when streams are already stressed.

Economic Feasibility: The preliminary cost estimates for upgrading Brandywine Pumping Station and Wills Pumping Station is $400,000 and $ 800,000, respectively. The preliminary cost estimate for constructing a new pumping station on Red Clay Creek is $2,000,000 and includes construction of the structure, wet well, piping, electrical and instrumentation, grading and permitting. The preliminary cost estimate for constructing a new transmission line to Hoopes Reservoir is $6,000,000 and includes rock excavation, utility work, traffic management, and pipe installation. Theses option range from very economical (expand Brandywine Pump) to exceedingly expensive (New Pipe to Hoopes) based on cost per unit capacity. This is due to the limited number of days of excess available flow that would occur during drought. Debt and operating costs could be shared by water utilities which benefit from the project.

Regulatory Feasibility: Permits for the type of construction related to all projects above will need to be secured from a number of state and federal agencies including DNREC, DelDOT, Army Corps of Engineers, and DRBC. The City has never undergone project review approval by Delaware River Basin Commission (DRBC) for a new intake facility and has never increased its withdrawal capacity since 1961, when DRBC was created. The City also holds an "entitlement" (because of its grandfathered status) that exempts the City from paying water use charges to DRBC. These projects would require DRBC approval and the City would lose its entitlement and have to pay for water used above the historical limits. Most significant is that the permitting process could result in DRBC imposing a passby requirement on the Brandywine Creek for Wilmington.

Community Support: Projects of this nature would usually enjoy support from the general community who would see this as a way of making northern New Castle County more drought-proof. The construction of a new pipeline to Hoopes Reservoir from the Brandywine Plant would cause temporary but significant disruptions (noise, road blockage, etc.) due to the alignment which is predominantly through heavily urbanized areas. The other options would not have such impacts as they are either remotely located or are at existing sites. Because of the above noted permitting issue, however, any of these options which would invoke external review could be seen as undesirable. Even within Delaware, users downsteam of a new Red Clay Creek intake would be expected to oppose additional withdrawals during low flow conditions.

3. AWC Aquifer Storage and Recovery (150 mg)
Sponsor: Artesian Water Company

Project Description: Artesian Water Company is undertaking the drilling of test wells into the lower Potomac Formation at four of its existing wellfields with the intent to construct ASR wells at these sites. The wellfield locations are Glendale, Artisans Village, Wilmington Manor Gardens, and Collins Park. Two ASR wells will be constructed this winter, with testing to commence in the spring of 2003. Artesian anticipates that water will be in storage and available for use during the summer of 2003. The remaining two wells will be constructed during the second half of 2003, with testing scheduled for late 2003 or early 2004. At this time, it is anticipated that the four wells will yield about 2.0 mgd, which over the course of a 75-day drought would use 150 mg from storage. A fifth well is planned outside of the time frame of this effort at the Llangollen wellfield. This second well at Llangollen is anticipated to store and pump an additional 1.0 mgd over a 75-day drought period.

Technical Feasibility: Artesian has proven the technical feasibility of ASR elsewhere in northern New Castle County. The technique of storing water in aquifers when surface water supplies are plentiful for recovery and when stream flows drop is technically feasible at any location where an aquifer is available. The amount of water that can be injected and recovered is governed by the geologic and hydraulic properties of the aquifer.

Environmental Feasibility: Environmental constraints are minimal. Given that Artesian's program is focused on the lower Potomac formation, there is no risk of well contamination from activities on the land surface. The only property required is that around the ASR well and any associated monitoring wells.

Economic Feasibility: Capital and operating costs can be estimated from Artesian's experience with two ASR wells currently in operation. We anticipate capital costs of about $0.75 million for each 100 mg of storage, or about $1.2 million for the 150 mg of storage anticipated at these four ASR sites. Total annual operating costs once all four wells are operational are estimated at about $70,000/yr.

Regulatory Feasibility: Two permits are required from DNREC for each ASR well. These include a Public Supply Well permit and an Underground Injection Control permit. Fortunately, permitting is closely coordinated with the two branches within DNREC that issue these permits. The existing allocation permits will need to be modified to recognize the added wells, but there would be no change in the annual withdrawal allocation from any of the wellfields. The Division of Public Health must review and approve the facilities to be constructed. Additionally, limited approval is also required from New Castle County for the building permits to construct the well houses.

Community Support: The only visible activity is the construction of the well, which may cause some minor inconvenience, and the construction of the well house. With the construction taking place on property already owned by Artesian, no other facilities need to be constructed.

Timing: Exploratory and test drilling is underway and should be completed by the beginning of 2003. Construction of two ASR wells is budgeted for the spring of 2003, with initial testing scheduled for the summer of 2003. The remaining two wells are tentatively scheduled for construction in late 2003.

4. UWD Aquifer Storage and Recovery (225 mg)
Sponsor: United Water Delaware

Project Description: United Water Delaware (UWDE) began investigating the prospect of developing a multiple well Aquifer Storage and Recovery (ASR) facility in 2001. The general location of the potential facility was selected based on favorable conditions of the subsurface geohydrology and is in UWDE's southern service area. UWDE has retained, under contract, the consulting services of CH2M HILL. CH2M HILL, long considered the leader in the industry, has developed over thirty of the forty operational ASR facilities nationwide.

UWDE plans to install up to three ASR wells in close proximity at a single facility. Elements of this project completed to date include: preliminary site location studies, desktop geohydrology study, conceptual design and a modified Phase One Environmental Assessment. Preliminary studies indicate that as much as 1 mgd per well may be possible. Assuming the initial estimates are correct, the ASR wells will provide UWDE's southern district with a recovery capacity of upwards of 3 mgd or an additional 225 mg during a 75-day drought. Furthermore, this will allow UWDE the ability to shift current capacity dedicated to this area to other portions of the UWDE service territory.

Technical Feasibility: ASR technology is neither new nor unproven. Over forty ASR facilities are in operation throughout the United States. Many of the facilities consist of multiple ASR wells. Preliminary studies indicate that the aquifers contained in the Potomac Formation in northern Delaware may provide excellent storage zones for injecting treated, potable drinking water. What makes United Water's ASR effort unique is its intent to use treated surface water as a source of recharge water. Water from the White Clay and Red Clay creeks and Christina River will be collected, treated to ensure geochemical compatibility, and then injected into the deeper units of the Potomac Formation for use during drought conditions. Aquifer testing will further determine the technical feasibility of ASR for this location.

Environmental Feasibility: UWDE has completed a modified Phase One Environmental Audit of the project site. This audit primarily considered existing surface conditions. Since the property is essentially rural, no surface contamination issues were uncovered. Further, the target aquifers at the project site lie 500 to 800 feet below ground and are overlain by relatively impermeable clay confining beds that range in thickness up to 300 feet per unit.

Economic Feasibility: United Water anticipates the total capital costs for the development of the ASR to range from $4,000,000 to $5,000,000 or around $1,300,000 per mgd of recovery capacity. Annual operating costs expected to be $80,000 to $100,000 for 3-mgd peak recovery with 3 ASR wells.

Regulatory Feasibility: UWDE shall be required to secure a Public Supply Well Permit and an Underground Injection Control (UIC) Permit. A DNREC allocation permit will be required. Other permits or regulatory oversight might include the Division of Public Health and the State and/or County for miscellaneous building permits for small well house structures, pipelines and power drops.

Community Support: Since ASR is a proven technology and UWDE has selected a fairly rural facility location little or no negative response is anticipated from the general public.

Timing: UWDE anticipates that a Land Use Agreement with a private landowner will be executed during the month of December 2002. Installation of a test well will begin immediately following the execution of the Land Use Agreement with the current landowner and will confirm the feasibility of developing an ASR Facility at this location. If successful, during this phase, UWDE would immediately proceed to the design, permitting, and construction of an initial production well. Depending on the availability of recharge water, test cycles could commence around February 2004. If test cycles proceed smoothly, UWDE should be able to recharge water for system use in Summer 2004.

5. Tidal Capture Structure Operating Plan Modification (TBD mg)
Sponsor: United Water Delaware

Project Description: The current operating plan for United Water's Tidal Capture Structure was developed to allow United Water to capture additional quantities of raw water to meet on-going daily demands at the Stanton Filter Plant under various low stream flow conditions. At the time it was developed and approved by the DRBC (1996), the concern for rising levels of chlorides, which become present under conditions of prolonged low streamflow, were not factored into the plan. This project will modify the existing TCS Operating Plan to allow greater flexibility in using the TCS as a barrier to encroaching chlorides and enable United Water Delaware to maximize the available natural (and further augmented through Hoopes release) stream resource at acceptable chloride concentrations (below 250 ppm in the finished supply). The project may produce at least 75 mg (1 mgd over a 75 day drought).

Technical Feasibility: United Water Delaware has in place the existing controls and practical operational experience necessary to implement this plan without modification to physical facilities.

Environmental Feasibility: United Water Delaware completed an In-stream Flow Needs Fish Community Sampling Under Severe Drought Conditions in the Tidal Portions of the White Clay Creek Study in October of 2002. The results of this study indicated that this proposed operation would not negatively impact biota health. The study also revealed that some positive environmental impacts may be artificially created for portions upstream of TCS under these operating conditions by increasing the natural "pool" level and further reducing encroaching chlorides in these portions of the stream. Further evaluations of the environmental impacts of the proposed modified operating plan are on going in conjunction with DNREC.

Economic Feasibility: With the exception of any initial environmental studies, minimal operational costs would be required.

Regulatory Feasibility: United Water Delaware has been ordered by the DRBC, in conjunction with an Emergency Flow-by Waiver received in August of 2002, to develop a new operating plan that addresses minimum in-stream flow needs at the tidal/fresh interface near the TCS during normal and drought conditions. The new plan is to be submitted to the DRBC no later than October 1, 2003.

Community Support: The project will have minimal visual impact and is not expected to cause any negative environmental concern. Some positive upstream flow conditions, as previously mentioned, may be observed under extreme conditions.

Timing: New Operating Plan to be submitted to DRBC by October 1, 2003.

6. Philadelphia to Delaware Pipeline (1500 mg)
Sponsor: Delaware DNREC

Project Description: A new pipeline and pump station to convey up to 20 mgd of finished water from the City of Philadelphia to New Castle County is proposed. The pipeline would be connected to the City of Philadelphia's distribution system at the Philadelphia Airport and follow Route 291 and Route 13 to the Pennsylvania border to connect to United Water Delaware's distribution system on Governor Printz Boulevard. The source water would be from the Schuylkill River, treated at the Fairmount Treatment Works, or alternately from the Delaware River, treated at the Baxter Treatment Plant.

Technical Feasibility: Building the required facilities can be accomplished using proven, conventional construction techniques**.** However**,** the pipeline route is highly urbanized and a substantial number of physical barriers exist consisting of three interstate highways, a railroad (two crossings), four creeks including one 100 feet wide, and numerous other roads. Relocation of existing infrastructure can be expected and access may be restricted in certain portions of the alignment route. Upgrades to United Water Delaware's infrastructure would also be required at the interconnection at the Delaware state line.

Environmental Feasibility: Part of the pipeline route is adjacent to the John Heinz National Wildlife Refuge, which may cause wetland, noise, dewatering, and erosion impacts, all of which would have to be mitigated. Wetlands and erosion impacts from the stream crossings would also have to be mitigated. Encountering undiscovered contaminants during excavation is possible, requiring removal and disposal.

Economic Feasibility*: $31,000,000 for facilities, and $728,000 annual operations, assuming 20 mgd. A minimum continuous purchase is likely to be required.

Regulatory Feasibility: Permitting would be complex involving at least 20 agencies from municipal through federal jurisdictions. An Environmental Impact Statement would be required. There is uncertainty on whether or not the City of Philadelphia might restrict sales to Delaware for users within Pennsylvania high-demand/drought conditions. The contract would have a "hold-harmless" clause and it would not be permanent.

Community Support: No permanent impacts after construction other than the visibility of a new booster station. Construction impacts would involve disruption of vehicular and pedestrian traffic on through routes and neighborhoods streets used by residents and businesses**.** The demographics along the pipeline route would require examination of environmental justice issues.

Timing: Design, funding, permitting and construction should be expected to take a minimum of five years.

*A lower volume transfer would reduce costs proportionately, but not substantially due to the difficulties of the project site. The finished water would need to comply with EPA drinking water standards for DBPs which have been made more stringent recently, which may require additional treatment before entering the UWD system, thus adding to the cost.

7. Brandywine Creek Flow Augmentation: River Water Recycling Scenario (25 to 50 mgd)
Sponsor: Delaware DNREC

Project Description: Augment the flow in the Brandywine Creek, during drought conditions, from the dam below the Wilmington raw water intake to the navigable part of the River near the Market Street Bridge with between 25 to 50 mgd of river water to meet 7Q50 or 7Q10 requirements. The facilities required include a water intake structure in the north side of the river bed connected to a pumping station north of the river bank, 5,900 LF of 36 inch (25 mgd) or 48 inch (50mgd) force main constructed from the pumping station to Race Street, along Race and under Market Street to Glen Avenue and along the north side of the Brandywine Creek to the foot of the aforementioned dam. A pre-cast concrete box culvert, with outlets in the top flush with the river bottom, would be constructed the width of the stream to distribute the water uniformly.

Technical Feasibility: Building the required facilities can be accomplished using proven, conventional construction techniques**.** Construction of the water intake structure would require a cofferdam around the work area. The force main would be open cut for the most part with horizontal directional drilling under Market Street and elsewhere as needed.

Environmental Feasibility: Construction of the force main would produce noise and construction machinery exhaust in the vicinity of the work but would terminate upon completion. Vehicular traffic would be interrupted and require detours which also would end upon completion of the project. This project will be subject to internal DNREC review, external review by federal agencies such as the EPA, Department of the Interior, Army Corps of Engineers, and National Marine Fisheries, and review by the Delaware River Basin Commission (DRBC). This project will be subject to full DNREC review with special consideration by the Division of Fish and Wildlife due to the possible impacts to fisheries and stream biota as a result of pumping water with elevated chloride levels into a freshwater portion of the Brandywine River.

Economic Feasibility: The estimated project cost ranges from $6.6 million (25 mgd) to $8.5 million (50 mgd) with an annual operating cost of $40,300 (50 mgd). The estimated daily cost when pumping is $244. This project would likely require conventional financing with a 5% rate for 20 years. Debt service for the $8.5 million project with conventional financing would be approximately $682,000 per year, which could be reduced if grant assistance became available. Debt and operating costs could be shared by water utilities that benefit from the project.

Regulatory Feasibility: A permit to construct would be required from DNREC, and a permit would also be required from the Army Corps of Engineers to build the intake and distribution structures in the Brandywine River. A permit to construct and operate will be required from DNREC and DRBC (water allocation permit) because this is a new diversion of river water. There are risks involved with the DRBC project review due to the construction of new intake facilities and increased stream withdrawals similar to those associated with the Hoopes Reservoir Pump options.

Community Support: Building the intake structure and pumping station would create some noise and exhaust from engine powered construction machinery for approximately 6 to 8 months. The portion of the force main from the pumping station to Brandywine Park would necessitate some traffic detours and cause some noise and engine exhaust in the vicinity of the work. When completed, the public would be unaware of any water transmission except for the diffuser discharge.

Timing: Design, funding, permitting, and construction may require as long as four to six years.

8. Brandywine Creek Flow Augmentation: Wastewater Recycling Scenario (25 to 50 mgd)
Sponsor: Delaware DNREC

Project Description: Augment the flow in the Brandywine Creek, during drought conditions, from the dam below the Wilmington raw water intake to the navigable part of the creek near the Market Street Bridge with between 25 mgd to 50 mgd of tertiary treated wastewater. The facilities required include a pumping station drawing water from the Wilmington WWTP chlorine contact tank, 21,400 LF of either 36 or 48 inch force main constructed along the east and south sides of the WWTP polishing ponds, along the north side of E 12th Street crossing under Northeast Boulevard to Church Street, north on Church Street to Vandever Avenue, west on Vandever to Buena Vista, south on Buena Vista to Race Street, west on Race Street and under Market Street to Glen Avenue and along the north side of the Brandywine River to the foot of the aforementioned dam. A precast concrete box culvert, with outlets in the top, flush with the river bottom, would be constructed the width of the river to distribute the water uniformly into the riverbed.

Technical Feasibility: Building the required facilities can be accomplished using proven, conventional construction techniques. The effluent pumping station would likely require piles for foundation support with the structure being reinforced concrete. The force main would be open cut for the most part with boring and jacking required under the railroad and possibly under I-495 and approaches. Horizontal directional drilling would be used under Hay Road, a stream crossing on the north side of E 12th Street, Northeast Boulevard, Market Street and elsewhere as needed.

Environmental Feasibility: The easterly part of the force main is located near federal and/or state regulated wetlands. Should final alignment involve crossing wetlands, these sections could be drilled to avoid disturbance. Construction of the force main would produce noise and construction machinery exhaust in the vicinity of the work but would terminate upon completion. Vehicular traffic would be interrupted and involve detours which also end upon completion of the project. A new discharge of treated wastewater into the Brandywine River will require the issuance of an NPDES permit from DNREC; that permit will need be reviewed and approved by EPA Region 3. The federal process includes review by other federal agencies such as the Department of the Interior, Army Corps of Engineers, and National Marine Fisheries. This project will be subject to full DNREC review with special consideration by the Division of Fish and Wildlife.

Economic Feasibility: The estimated project cost of the aforementioned facilities is $16 million (48 inch force main) with an annual operating cost of $107,600. The estimated daily cost when pumping is $575. This project could qualify for CWSRF funding with a loan for 20 years at 3%. Debt service with this funding would be approximately $1,075,000 per year, which could be reduced if grant assistance is available. Debt and operating costs could be shared by water utilities that benefit from the project.

Regulatory Feasibility: A permit to construct would be required from DNREC and a permit would also be required from the Army Corps of Engineers to place the distribution structure in the Brandywine Creek. An NPDES permit approved by DNREC, EPA, and DRBC will be required for the discharge into the Brandywine Creek.

Community Support: The pumping station, over half of the force main and the discharge diffuser construction would be located in areas remote from housing and vehicular traffic. The remainder of the force main construction would have machinery noise and temporary traffic detours that should last less than four months. When completed, the public would be unaware of any wastewater transmission except for the water exiting the diffuser structure.

Timing: Design, funding, permitting and construction may require as much as four to six years.

9. Desalination along the White Clay Creek at Stanton Treatment Plant (TBD mg)
Sponsor: United Water Delaware

Project Description: Evaluate the feasibility of installing and operating both permanent and/or temporary desalination equipment at the Stanton WTP, which can be used to treat raw water with elevated levels of chloride to meet the EPA standard of 250 ppm chloride in the finished supply.

Technical Feasibility: Membrane technology exists in the current marketplace. Waste stream management will be a more complex issue.

Environmental Feasibility: Desalination processes generate a significantly higher concentrated chloride waste stream that must be managed properly. It is likely this waste stream would need to be piped from Stanton to a natural brackish waterway suitable for release.

Economic Feasibility: To be determined. Study underway.

Regulatory Feasibility: Would require an NPDES permit for waste stream discharge as well as review and approval of the Division of Public Health for a new public drinking water treatment process.

Community Support: Subject to economic feasibility and impact on water rates, this project appears to have wide public support on the basis of technical merit alone.

Timing: Feasibility analysis is underway through HDR Engineering Inc. Final Report to be available by February 1, 2003.

CHAPTER 8 - DROUGHT OPERATING PLAN

The Governor's Drought Advisory Committee and the Delaware Water Supply Coordinating Council sought to manage the drought of 2002 according to the following principles through a series of operating plans, agreements and contracts:

- Maintain adequate pressure and flow in the water supply system.
- Conserve storage in Hoopes Reservoir.
- Conserve water to reduce public water demand in northern New Castle below 70 mgd.
- Maintain chloride levels in treated drinking water below USEPA 250 ppm standard.
- Lessen economic losses.
- Minimize ecological damage.

Maintain Adequate Pressure and Flow

During the 2002 drought of record, the water purveyors were able to maintain adequate pressure and flow to customers in the water supply system. Treated water tanks were kept within normal operating ranges. The purveyors transferred water from areas of surplus supply to areas of increased demand through a series of 25 interconnections. On August 24, 2002, the purveyors transferred a peak of 6.0 mgd through interconnections, which amounted to 15% of the demand on that day. The terms of these water transfers are set forth in a series of inter-purveyor cost and capacity agreements that were negotiated prior to the drought of 2002.

Conserve Storage in Hoopes Reservoir

The City of Wilmington managed Hoopes Reservoir according to an operating plan which indicates that the City would release from 3 to 5 mgd (500 mg total) of raw water as requested by other utilities provided the reservoir level was between elevation 220 feet (full) and 210 feet (-10 feet). Below elevation 210, the City will reserve the remaining contents of the reservoir for its internal use.

On July 31, 2002, the City began releasing 1.2 mgd to United Water Delaware to repel the salt front at the Stanton intake. Between July 31 and September 26, 2002, the City released between 1.2 to 7 mgd to UWD or a total volume of 178 mg.

On August 14, 2002, due to declining stream flows along the Brandywine Creek, the City began releasing 13 mgd from Hoopes Reservoir back to Wilmington. Between August 14, and August 22, 2002 the City released between 7 mgd to 13 mgd back to Wilmington or a total volume of 91 mg.

On August 23, 2002, Hoopes Reservoir (1.8 bg useable) reached its lowest level during the drought at -6.0 feet leaving 1470 mg available or 82% of remaining capacity. At that point there remained 147 days of storage if releasing 10 mgd and 74 days capacity if releasing 20 mgd.

By comparison, the Chester Water Authority Octoraro Reservoir (2 bg) near Oxford, Pennsylvania reached 42% of capacity on August 23, 2002 leaving 921 mg available

On August 28, 2002, Wilmington City council announced it had signed a contract with United Water Delaware agreeing to release water from Hoopes Reservoir to UWD at a negotiated cost and capacity (200 mg)

Hoopes Reservoir Releases (drought of 2002)

	No. days	Avg. (mgd)	Volume (mg)
To United Water Delaware	34	5	178
To City of Wilmington	9	10	91
			269 mg

Several members of the WSCC have suggested that Drought Emergency and mandatory restrictions should be tied to the level in Hoopes Reservoir. For instance, Drought Emergency would be imposed when the water level declines 2 - 5 feet. During the drought of 2002, the drought emergency was declared several days after the City of Wilmington

first began releasing from Hoopes Reservoir.

Conserve Water/Reduce Water Demand

The WSCC maintains a daily water demand database whereby the 5 water purveyors in northern Delaware submit their individual water demands via email for compiling by the University of Delaware, Institute for Public Administration - Water Resources Agency. This ability to monitor daily water demands on a regional basis assisted the Governor's Drought Advisory Committee in establishing voluntary and mandatory water conservation policies during the course of the 2002 drought.

When the drought emergency with mandatory water restrictions was declared in northern Delaware on August 2, 2002, the GDAC set a goal for Delaware residents and businesses to reduce public water use to less than 70 mgd. By late August, Delawareans exceeded the goal and water use declined to less than 65 mgd remaining below that level through September, October, November, and December 2002. Following the droughts of 1995 and 1999, the Green Industry, which includes landscaping companies, garden centers, and golf courses, established an outdoor water conservation plan, which was used as the basis for setting the mandatory restrictions in 2002. The conservation in water demand was largely achieved through curtailment of outdoor watering by residents and businesses.

Several members of the Governor's DAC and WSCC have advocated that the conservation of water can be achieved though pricing. The DNREC signed an agreement with the University of Delaware Center for Energy and Environmental Policy to evaluate the potential for adopting conservation water rates to reduce peak water demands. This work was under the direction of the Water Conservation Oriented Rate (WCOR) Subcommittee and was completed in March 2001. The study concluded that pricing mechanisms are effective demand management tools and that water utilities are encouraged to further investigate methods of implementation. AWC continues its conservation water rate structure that has been in place since 1992. Newark has raised its water rates as of July 2001 to fund its proposed reservoir and water treatment plant improvements and has temporarily discontinued its seasonal conservation water rate structure in place since 1999. The New Castle Municipal Services Commission has recently instituted a new conservation water rate structure. The Delaware River Basin Commission has mandated that United Water Delaware complete a feasibility evaluation of conservation water rates.

Conservation of water may also be achieved by updating the drought operating plan for Delaware. Presently Delaware has a two-phase drought operating plan that is administered by the Governor's Drought Advisory Committee. The first phase is drought warning corresponding to drought being imminent with voluntary water conservation. The second phase is drought emergency corresponding to a "state of emergency" with mandatory water restrictions. Other states such as Pennsylvania and New Jersey have a three - phase drought operating plan with a (1) drought watch, (2) drought warning, and (3) drought emergency. A 3-phase drought operating plan would provide earlier notice of impending drought to the public in Delaware whereby the recommended level of water conservation or demand reduction could be tied to each phase of drought watch, drought warning or emergency.

Maintain Chloride levels below USEPA 250 ppm Standard

United Water Delaware manages chloride levels in the raw and treated water at its White Clay Creek Stanton Filter Plant though a chloride-monitoring plan which was established after the drought of 1999. When streamflows drop below 37 mgd in the White Clay Creek at Stanton, UWD begins chloride measurements at three locations below the Stanton intake with one at the Christina River at Newport, the second along the Christina River at the Churchman's boat ramp, and the third along the White Clay Creek downstream from the Tidal Capture Structure. Chlorides are monitored at all three locations on a daily basis as well as at the raw water intake and in the treated wastewater leaving the Stanton intake. When chlorides in the raw water at the Stanton intake begin to approach the USEPA 250 ppm standard, UWD contacts the City of Wilmington to begin releases from Hoopes Reservoir for salt front maintenance purposes. This year the City began Hoopes Reservoir releases to UWD on July 31, 2002 for this purpose. Through efficient use of the chloride monitoring plan, the tidal capture structure, and optimizing withdrawals at the Stanton intake in synchronization with the tides, UWD managed to retain chloride levels in the treated drinking water to less than the 250 ppm standard at all times during the drought of 2002.

Lessen Economic Losses

As in other states in the mid-Atlantic, certain water dependent businesses in Delaware realized economic losses due to the drought of 2002. Agriculture, landscaping, and golf courses suffered loss of crops and landscaping. Agriculture crop losses exceeded 50 % for corn, soybean, and small grains, resulting in a declaration of disaster by the Delaware Department of Agriculture and the U.S. Department of Agriculture. Several landscaping firms and garden centers reported decreases in sales of over 30% compared with the August through September period of 2001. Private homeowners lost newly planted lawns and landscaping. With the rains of fall, however, sales rebounded for landscapers and garden centers.

The duration of mandatory water restrictions and Drought Emergency on water dependent businesses were less in northern Delaware than in adjacent states as the Drought Emergency in Delaware went from August 2 to October 11, 2002 (69 days) compared to over 300 days in southeastern Pennsylvania and 200 days in southern New Jersey.

Minimize Ecological Damage

More field data are needed to assess the ecological damage from the drought of 2002. There were no reported fish kills in the Brandywine Creek, Red Clay Creek, White Clay Creek, or Christina River during the drought of 2002.

Under the "grandfathering" provisions as a pre-DRBC compact water user, there is no minimum flow standard along the Brandywine Creek at Wilmington for the 0.7 mile reach from the City dam to the head of tide at Market Street.

The Delaware River Basin Commission imposes minimum instream flow standards along the White Clay Creek at Stanton and Newark to protect the fishery and ecological habitat. The flow standard remained in place along the White Clay Creek at Newark. UWD requested a waiver from the flow standard at Stanton. Through operations of the Tidal Capture Structure, UWD was able to maintain a minimum 1 foot flow depth in the creek downstream from the Stanton intake during the 24-hour tidal cycle. The DRBC directed UWD to complete an instream flow needs analysis under drought conditions in the tidal portions of the White Clay Creek that is due by October 2003.

The drought of 2002 reached its most crucial low flow stage between August and October 2002. The most critical time for spawning of the fishery is from mid-March through May. There would be more concern if the drought reached its critical stage during the spring. More research is needed to discern whether measurable ecological damage occurred during the drought of 2002.

Water quality impacts from the drought of 2002 can be examined from real time monitoring at USGS gage 01481000 Brandywine Creek at Chadds Ford, Pennsylvania, which is a few miles upstream from the Delaware state line. By measures of water temperature, specific conductance (total dissolved solids), and dissolved oxygen; stream water quality during the drought of 2002 was not as good as normal. However with the fall rains, concentrations of these water quality parameters have returned to normal. Consequently the water quality impacts during the drought were relatively short term.

- Water temperature - Due to extreme heat, water temperatures were above normal during the drought of 2002. Water temperature in the Brandywine Creek exceeded 30° C (86 ° F) four times during July through September 2002 compared to no exceedances of this level during a similar period in 2001. Water temperatures have declined to seasonal normal levels below 5° C (41° F) by December 2002.
- Specific Conductance - SC can be used as an indirect measure of the total dissolved solids and turbidity in the stream. SC levels were higher than normal during the drought of 2002. Levels exceeded 400 ms/cm on 20 days between July and September 2002 as compared to 1 day during the corresponding period in 2001. With the rains of fall 2002, SC levels have declined to more normal seasonal levels.
- Dissolved Oxygen - Dissolved oxygen levels were lower than normal during the drought of 2002. DO levels declined below the Delaware stream water quality standard of 5.5 parts per million (ppm) on 20 days between July and September 2002 as compared to 3 days during a similar period in 2001. By November 2002, DO levels returned to more normal levels exceeding 8 ppm.

CHAPTER 9 - REFERENCES

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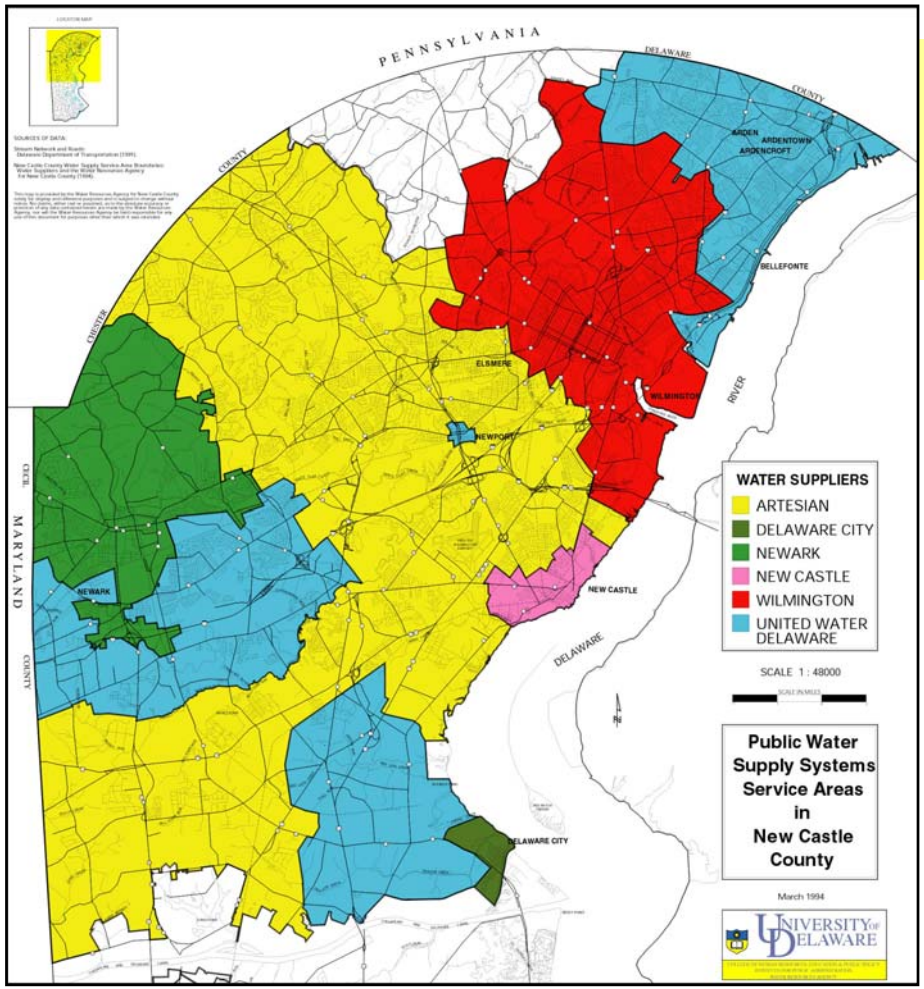


Figure 2:

New Castle County Public Water Supply System Service Areas

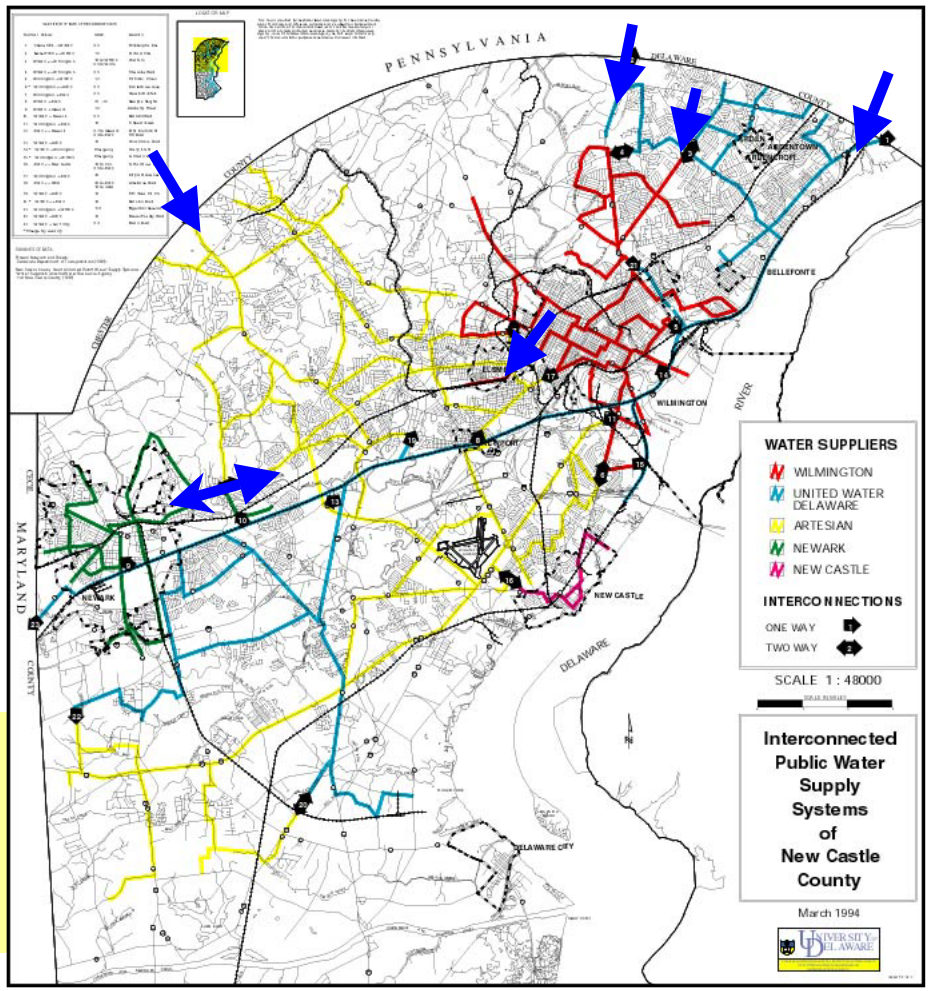


Figure 3:

New Castle County Public Water Supply System Interconnections

Figure 4: Brandywine Creek at Wilmington Streamflow Data, October 2001 - December 2002

*The 7Q10 is the minimum flow necessary to protect fishery and habitat that is likely to occur for 7 consecutive days, once every 10 years

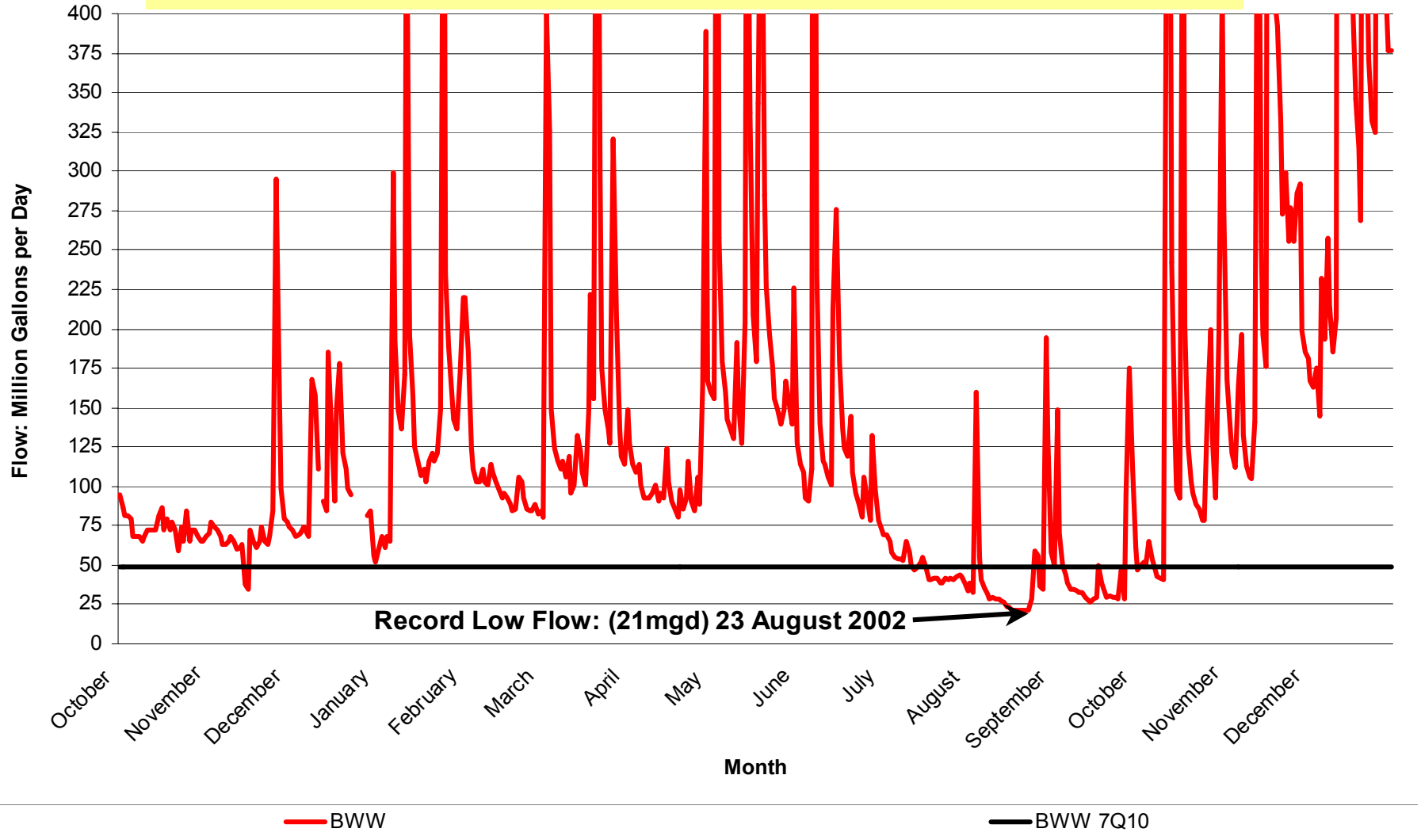


Figure 5: White Clay Creek at Stanton Streamflow Data, October 2001 - December 2002

*The 7Q10 is the minimum flow necessary to protect fishery and habitat that is likely to occur for 7 consecutive days, once every 10 years

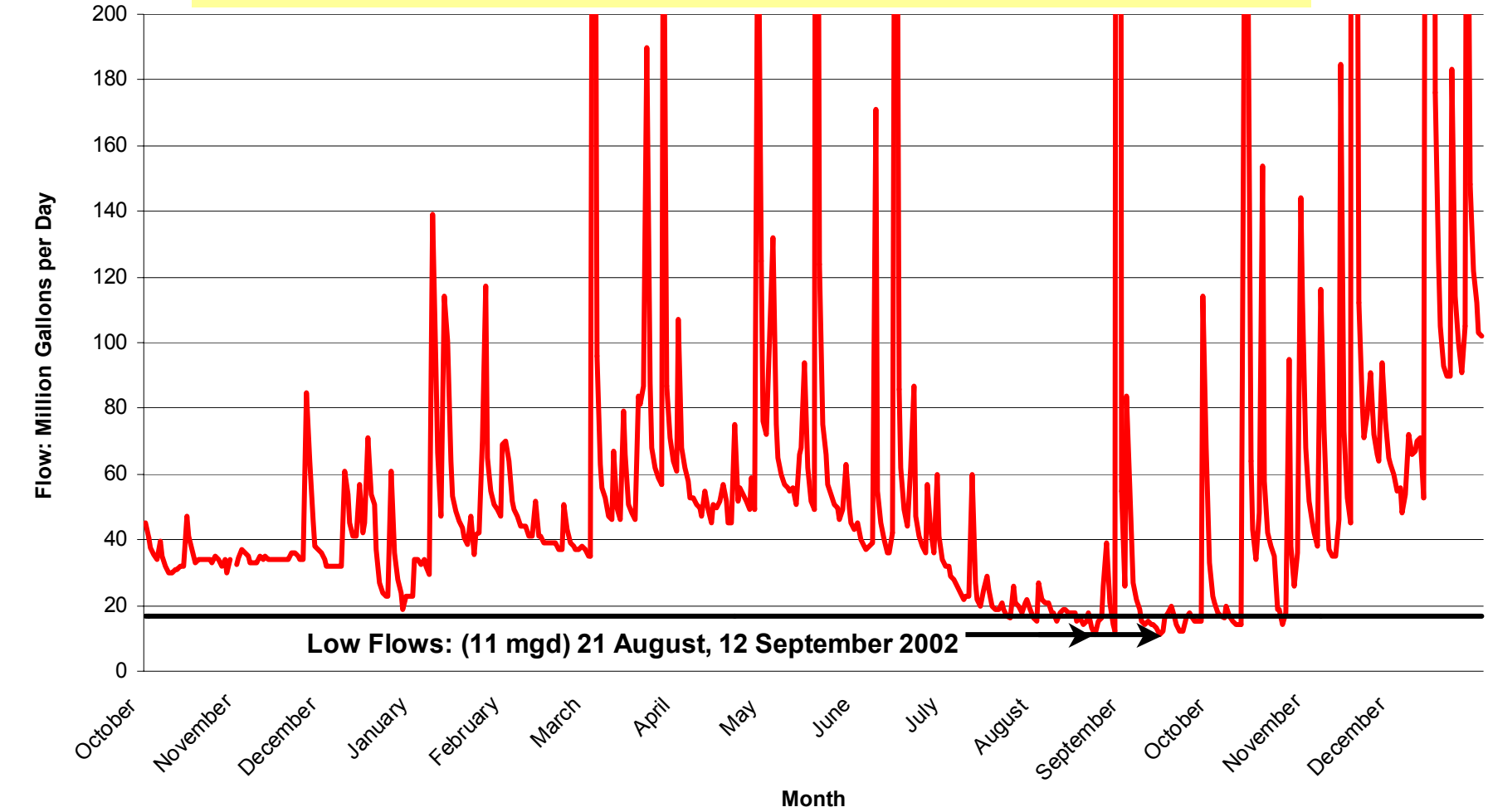


Figure 6: White Clay Creek at Newark Streamflow Data, October 2001 - December 2002

*The 7Q10 is the minimum flow necessary to protect fishery and habitat that is likely to occur for 7 consecutive days, once every 10 years

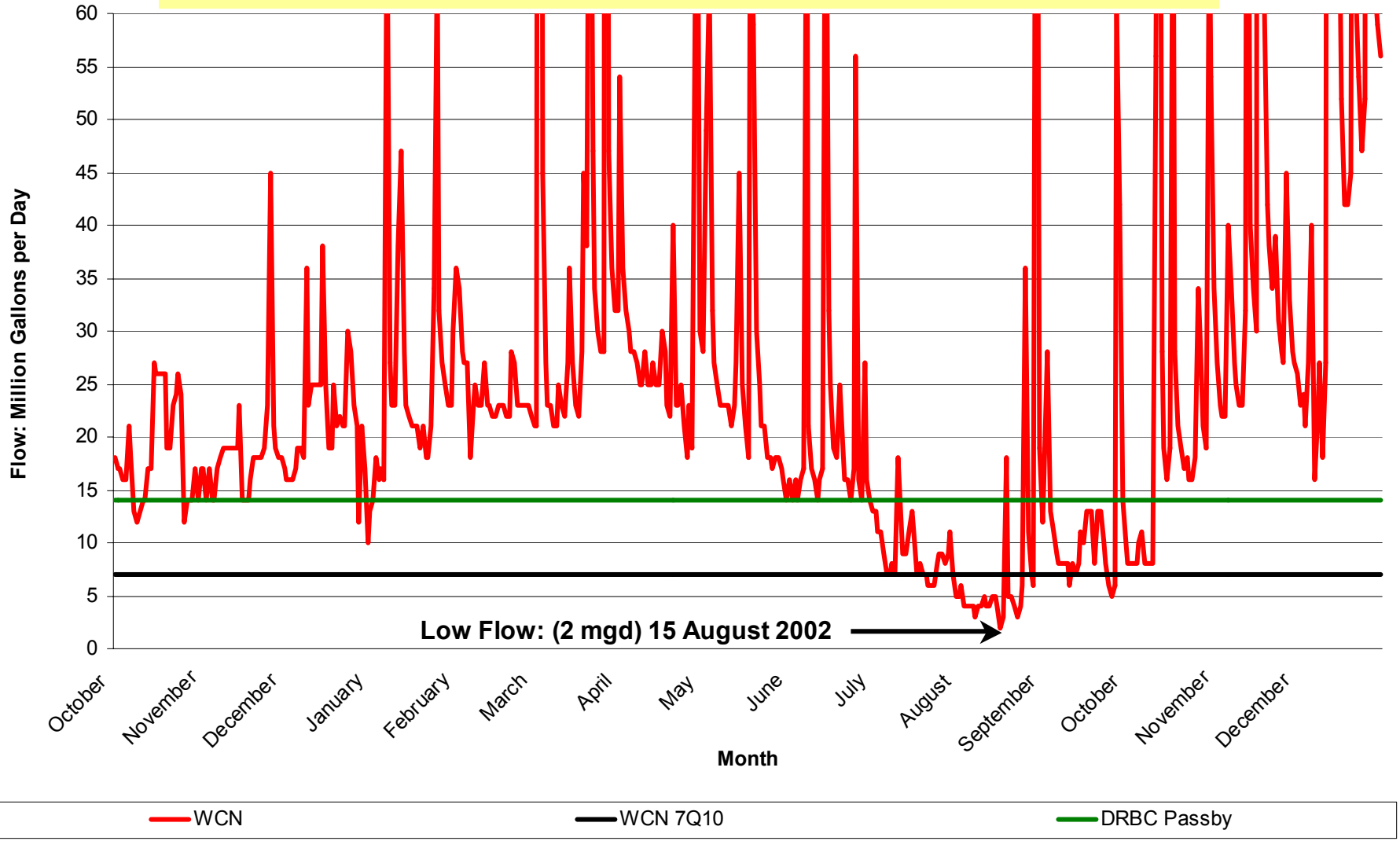
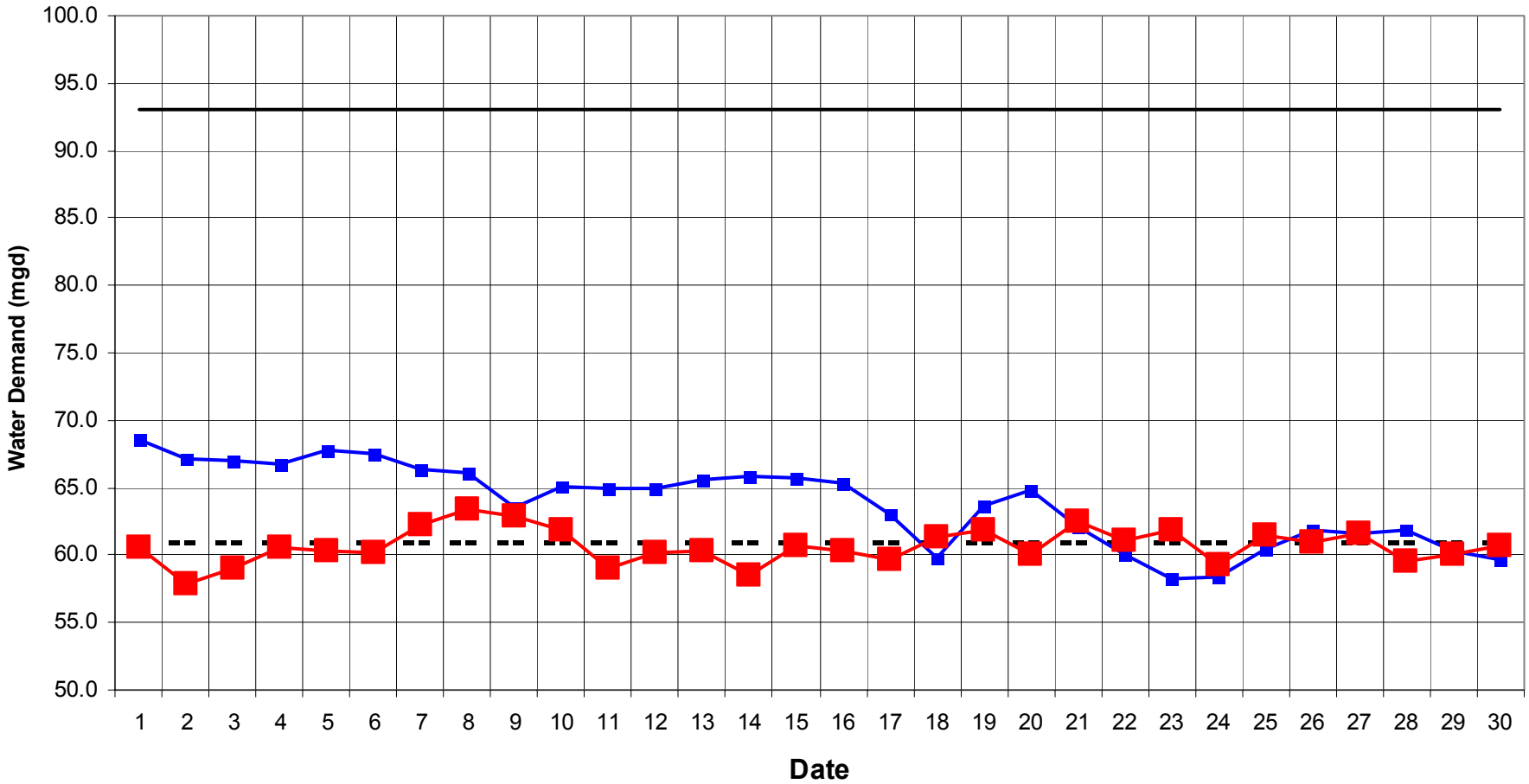
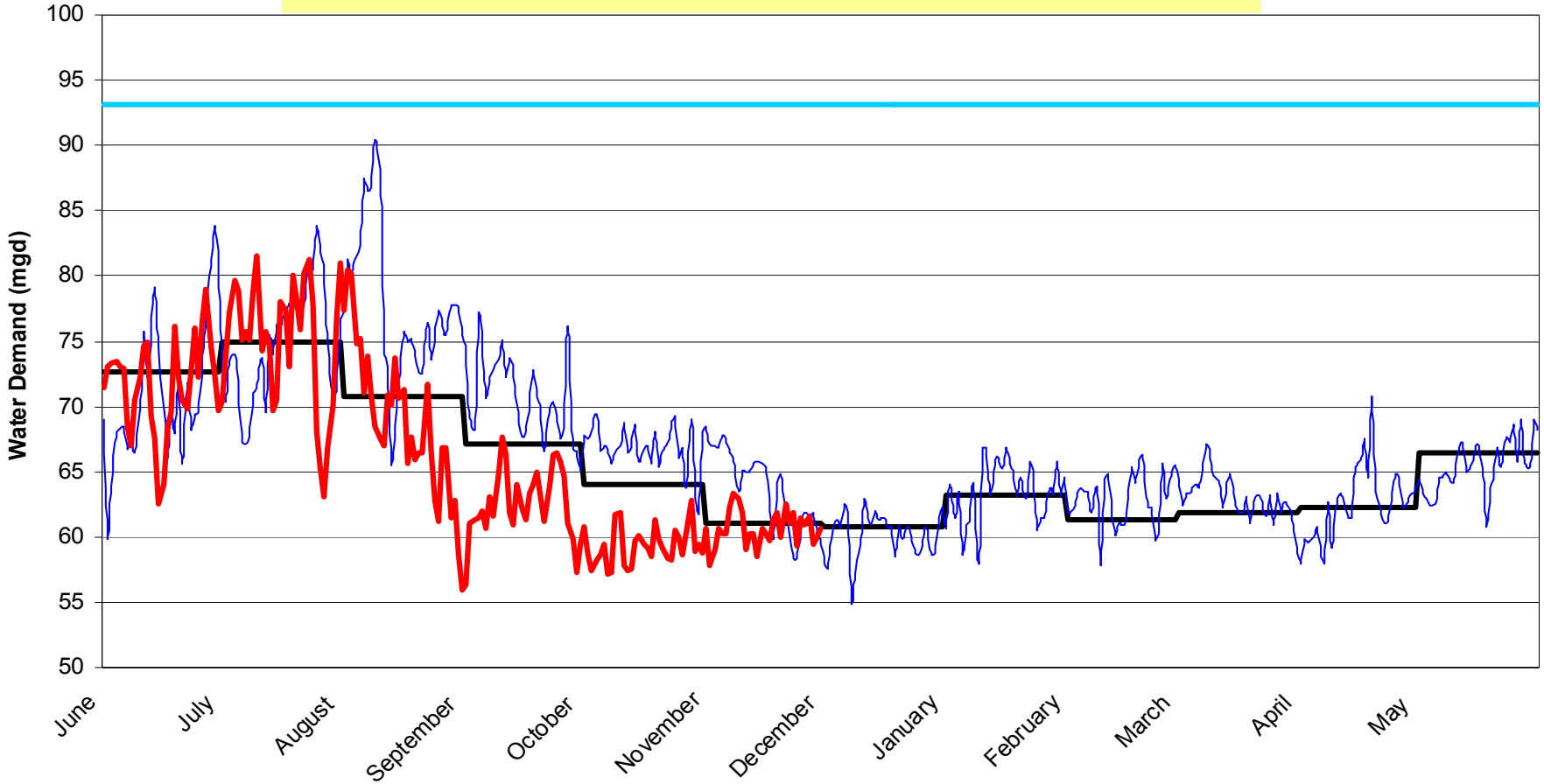


Figure 7: Public Water Demand: Northern New Castle County, November 2002



Compiled by the University of Delaware, Institute for Public Administration, Water Resources Agency, using data from: Artesian Water Co., City of Newark, City of Wilmington, New Castle Municipal Services Commission, and United Water Delaware

Figure 8: Public Water Demand: Northern New Castle County June 2001 - November 2002



Compiled by the University of Delaware, Institute for Public Administration, Water Resources Agency, using data from: Artesian Water Co., City of Newark, City of Wilmington, New Castle Municipal Services Commission, and United Water Delaware

Monthly Average — Historic Peak (7/18/97) — June 2001 - May 2002 — June 2002 - May 2003

Figure 9: Hoopes Reservoir Water Level, July 2002 - November 2002

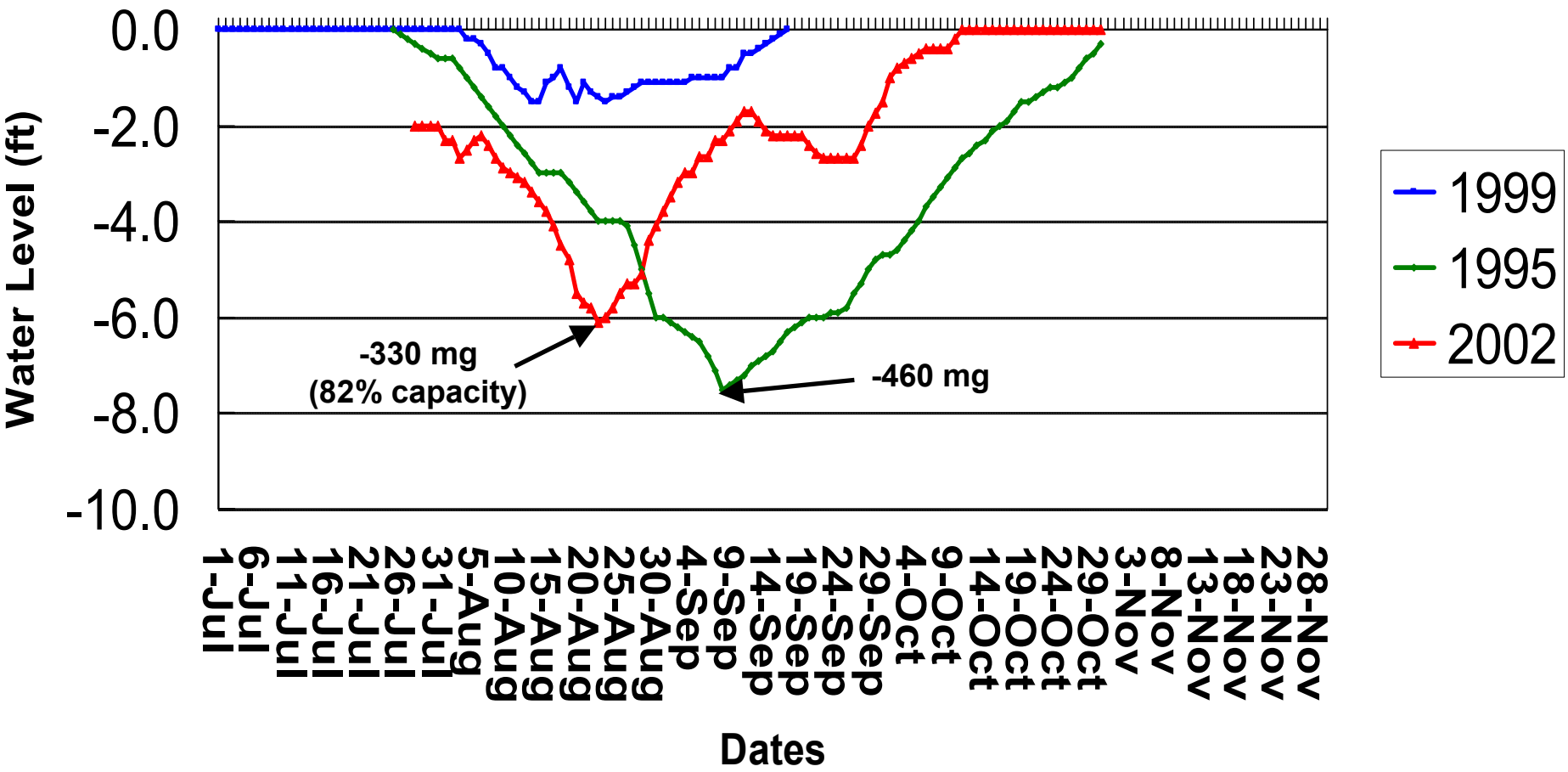


Figure 10: Octoraro Reservoir Water Level, January 2002 – November 2002

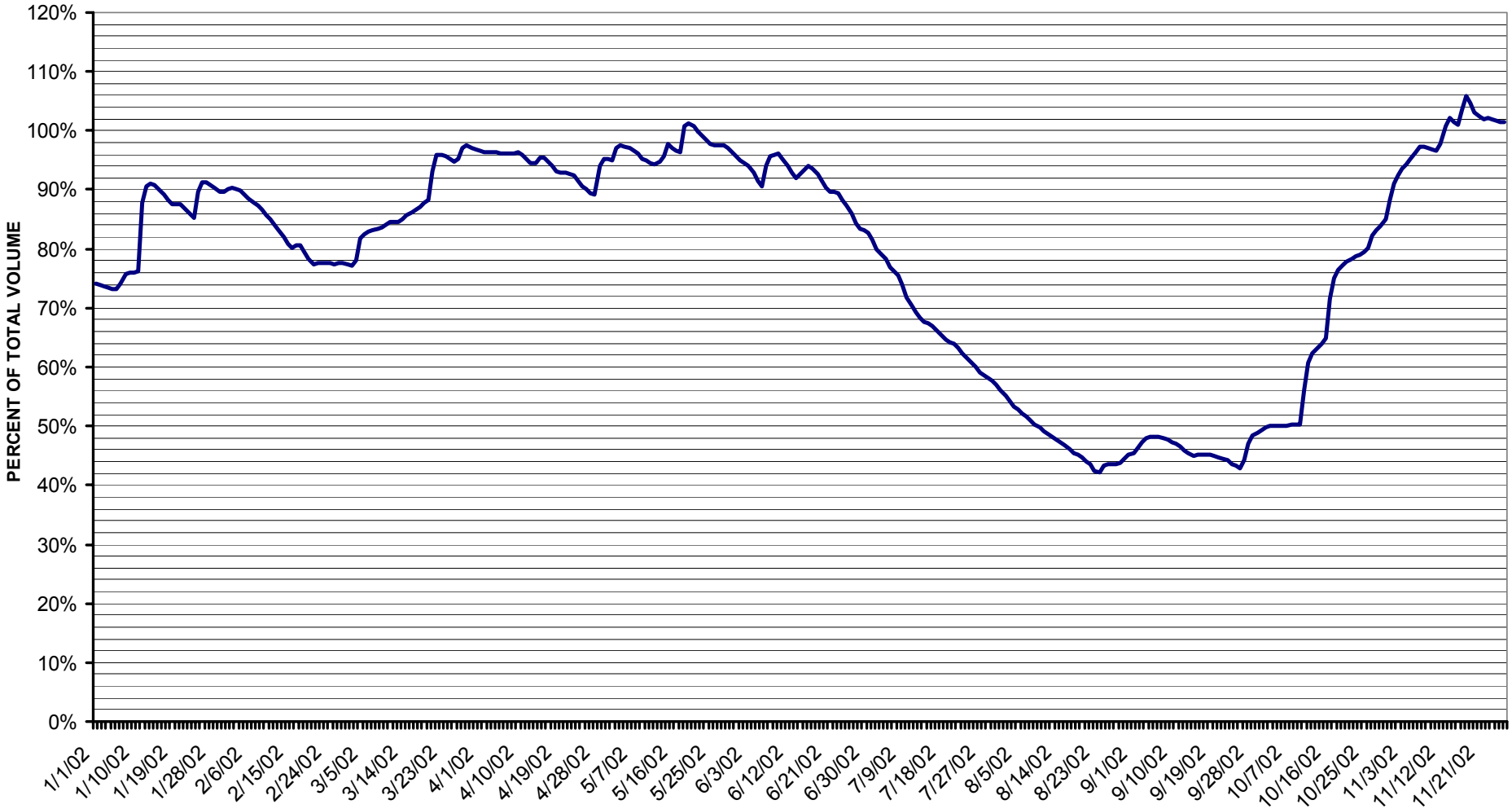


Figure 11: Chlorides, White Clay Creek at Stanton, July 2002 - November 2002

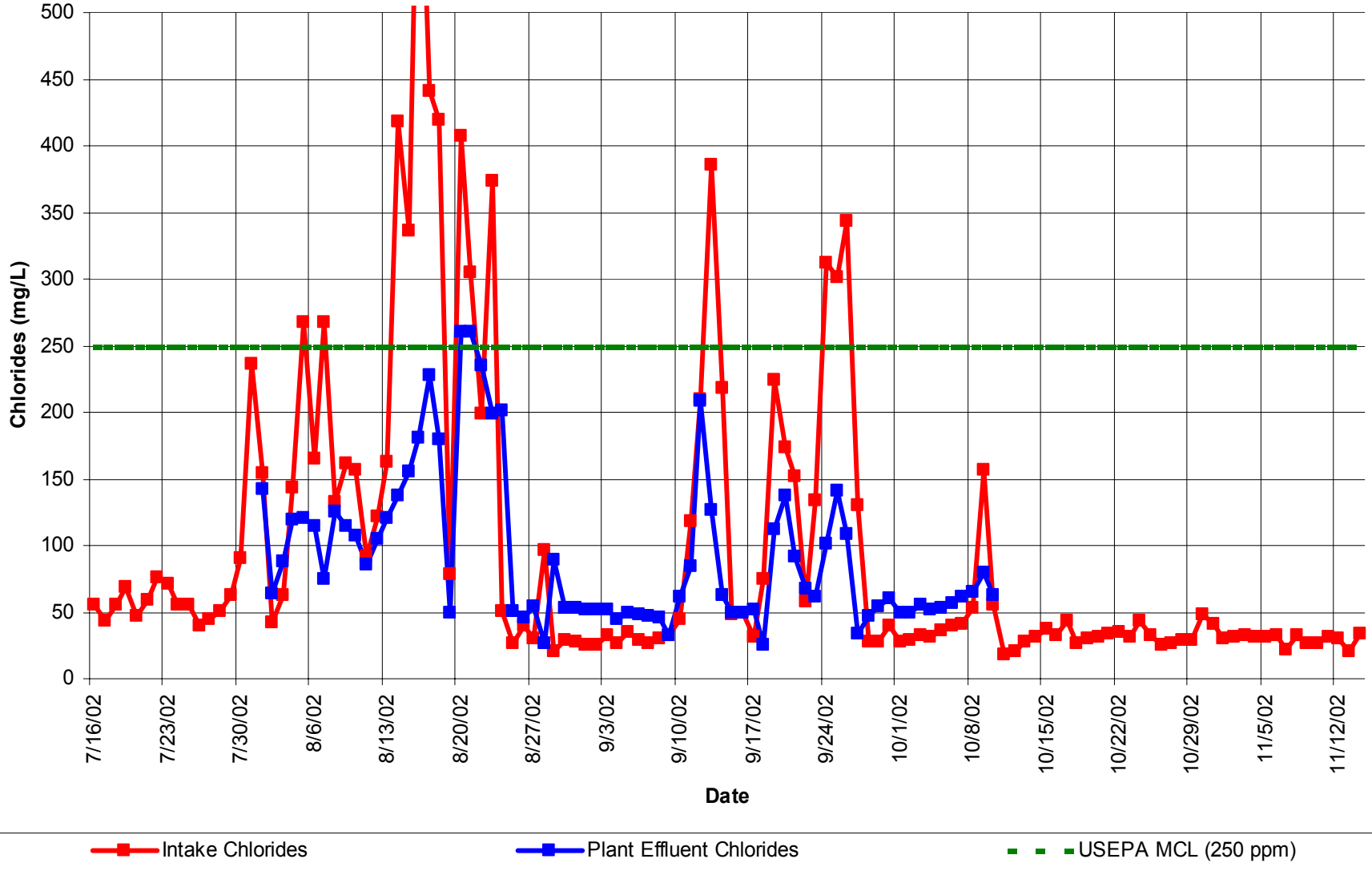


Figure 12: Water Supply and Demand Projections: Northern New Castle County, Delaware, All Scenarios: Through 2020

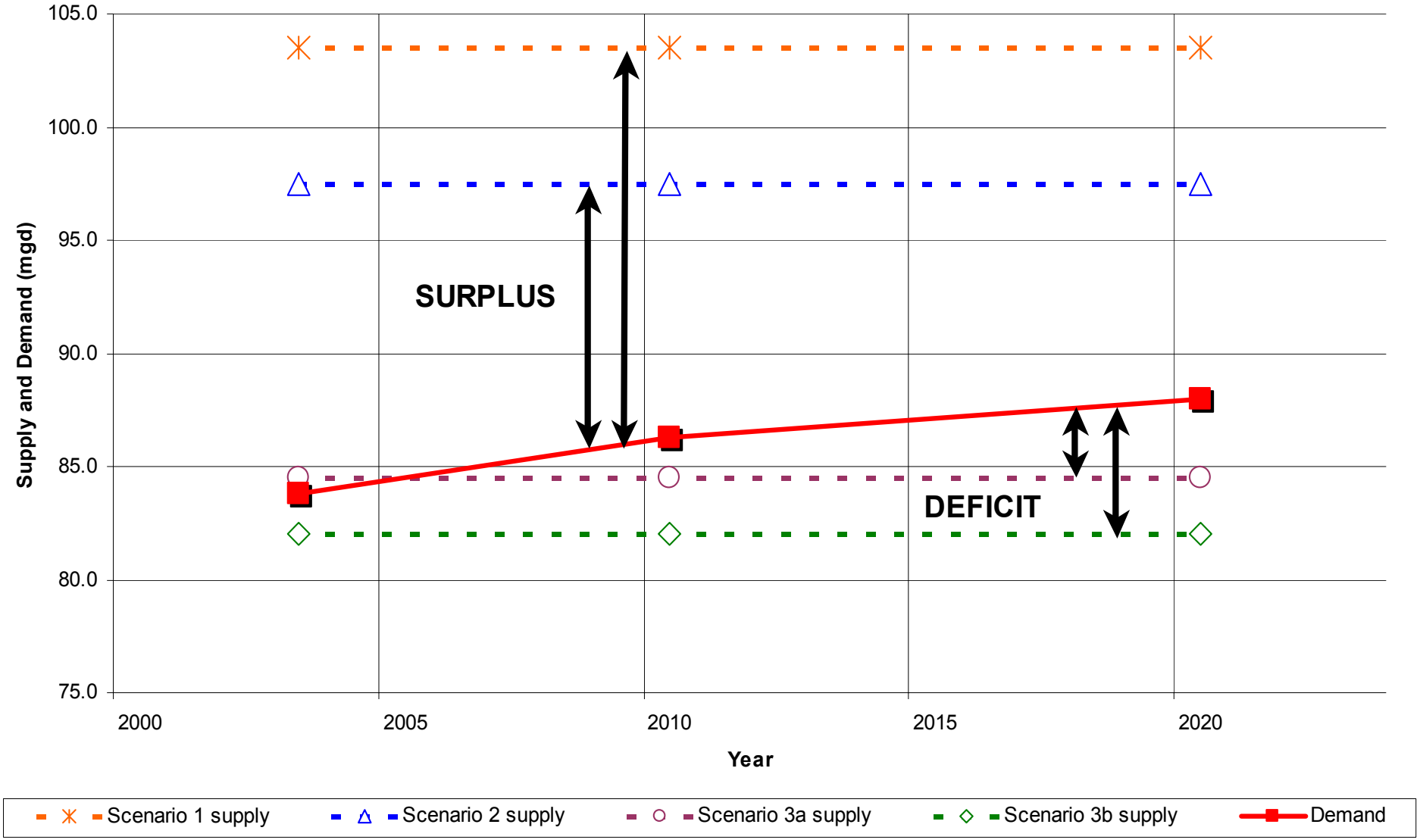


Figure 13: Newark Reservoir

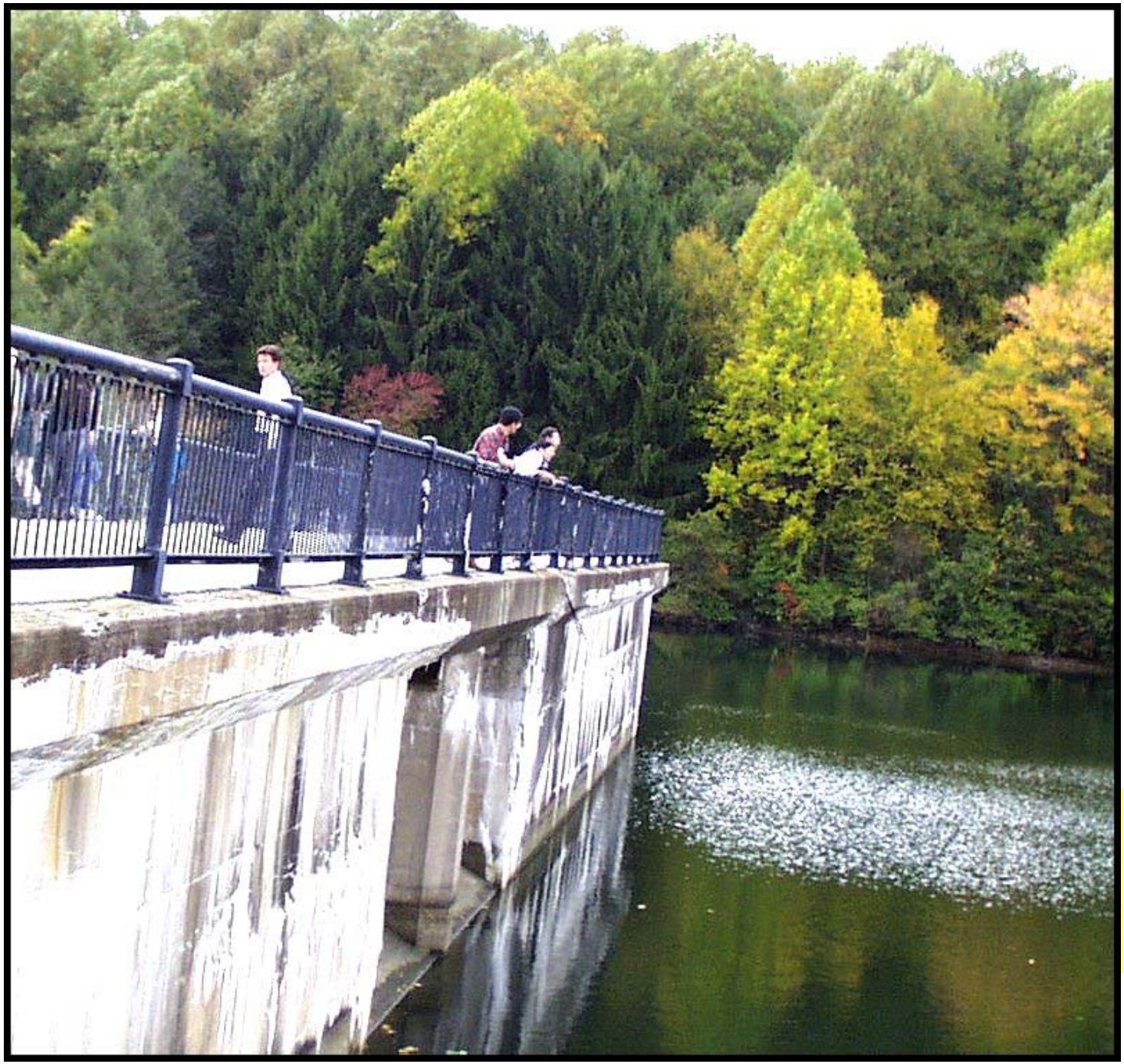


Figure 14: Hoopes Reservoir

Figure 15: Daily Discharge (cfs), Brandywine Creek at Chadds Ford

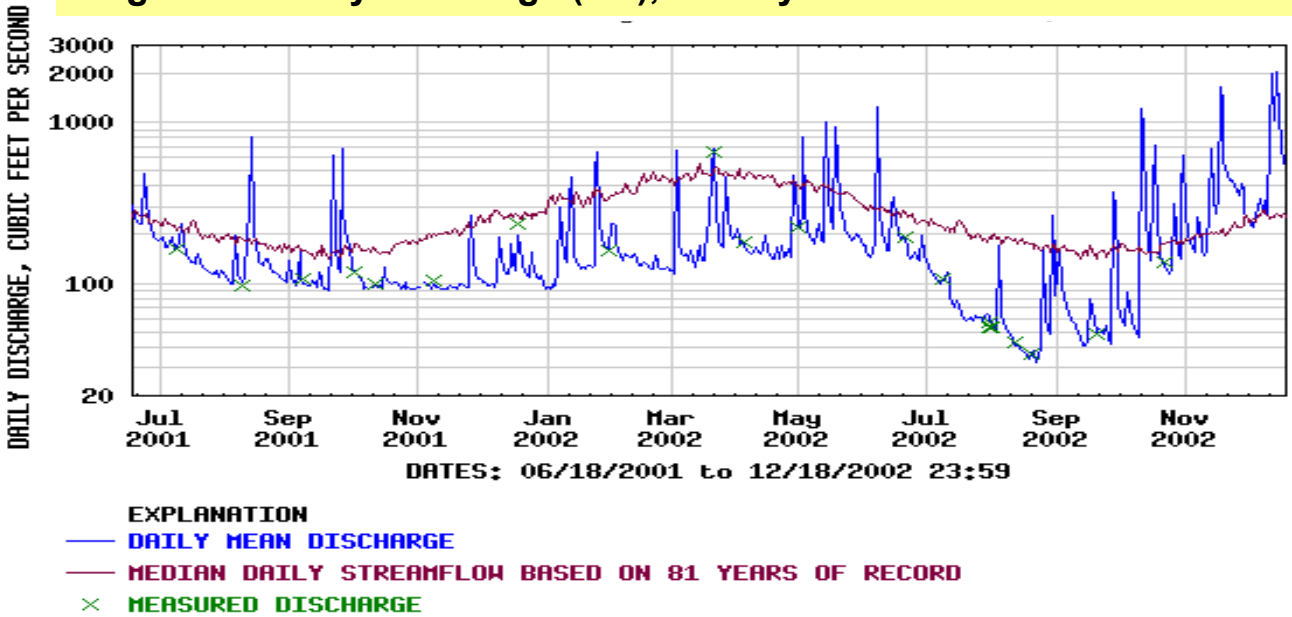


Figure 16: Daily Temperature (C), Brandywine Creek at Chadds Ford

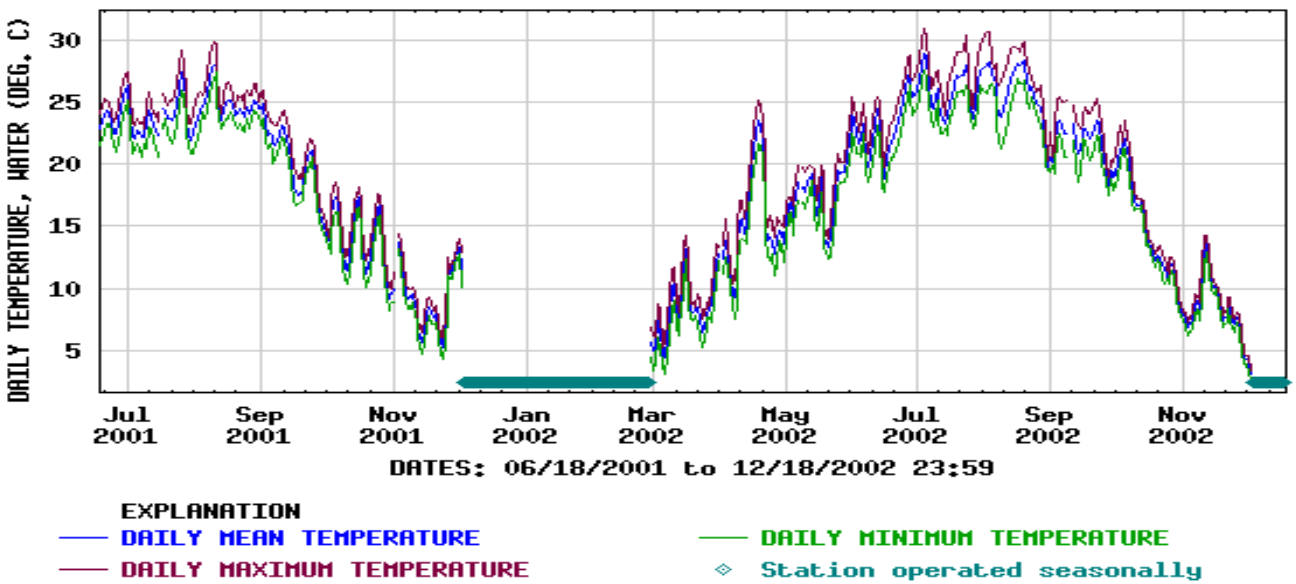


Figure 17: Daily Dissolved Oxygen (mg/L), Brandywine Creek at Chadds Ford

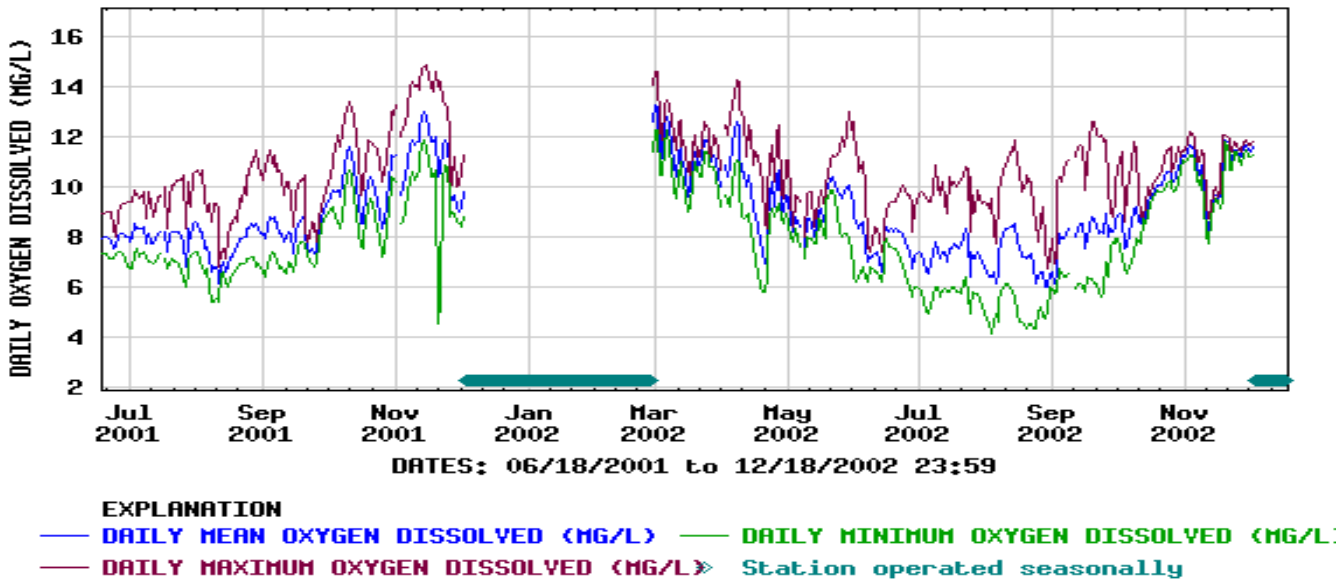


Figure 18: Daily Specific Conductance (µs/cm), Brandywine Creek at Chadds Ford

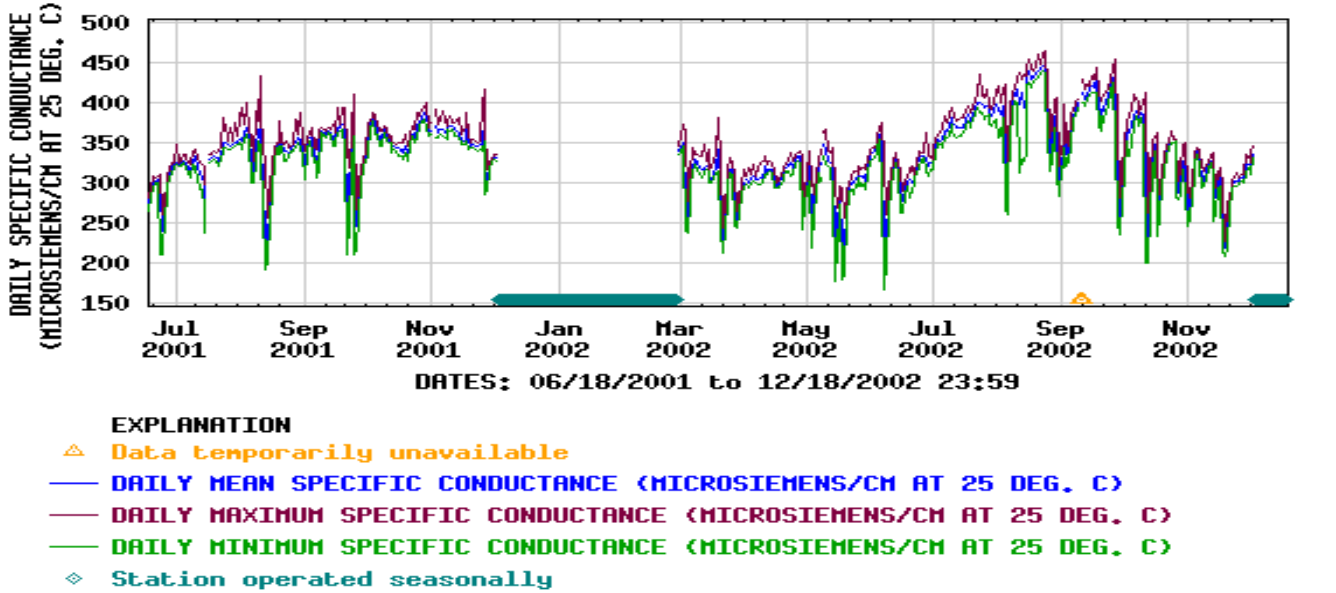
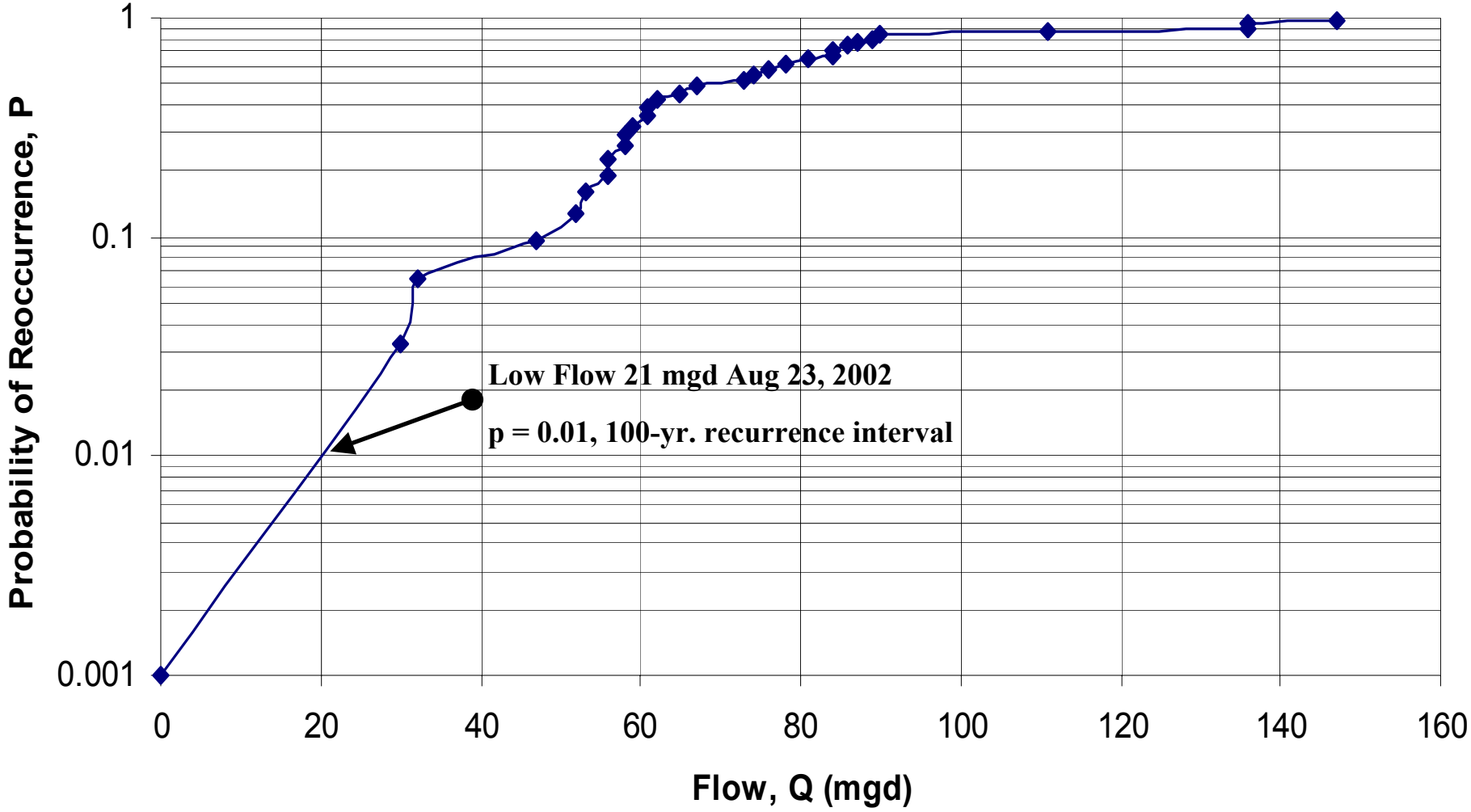


Figure 18.

Estimate of Low Flow Recurrence Interval with the Weibull Distribution

Brandywine Creek at Chadds Ford - 1972-2001



FLOW (mgd)	YEAR	RANK	P
0	-	-	0.001
30	1999	1	0.0323
32	1995	2	0.0645
47	1978	3	0.0968
52	1998	4	0.1290
53	1997	5	0.1613
56	1981	6	0.1935
56	1986	7	0.2258
58	1985	8	0.2581
58	2001	9	0.2903
59	1991	10	0.3226
61	1987	11	0.3548
61	1992	12	0.3871
62	1994	13	0.4194
65	1983	14	0.4516
67	1977	15	0.4839
73	1988	16	0.5161
74	1976	17	0.5484
76	1993	18	0.5806
78	1982	19	0.6129
81	1996	20	0.6452
84	1989	21	0.6774
84	2000	22	0.7097
86	1972	23	0.7419
87	1990	24	0.7742
89	1974	25	0.8065
90	1973	26	0.8387
111	1984	27	0.8710
136	1979	28	0.9032
136	1980	29	0.9355
147	1975	30	0.9677