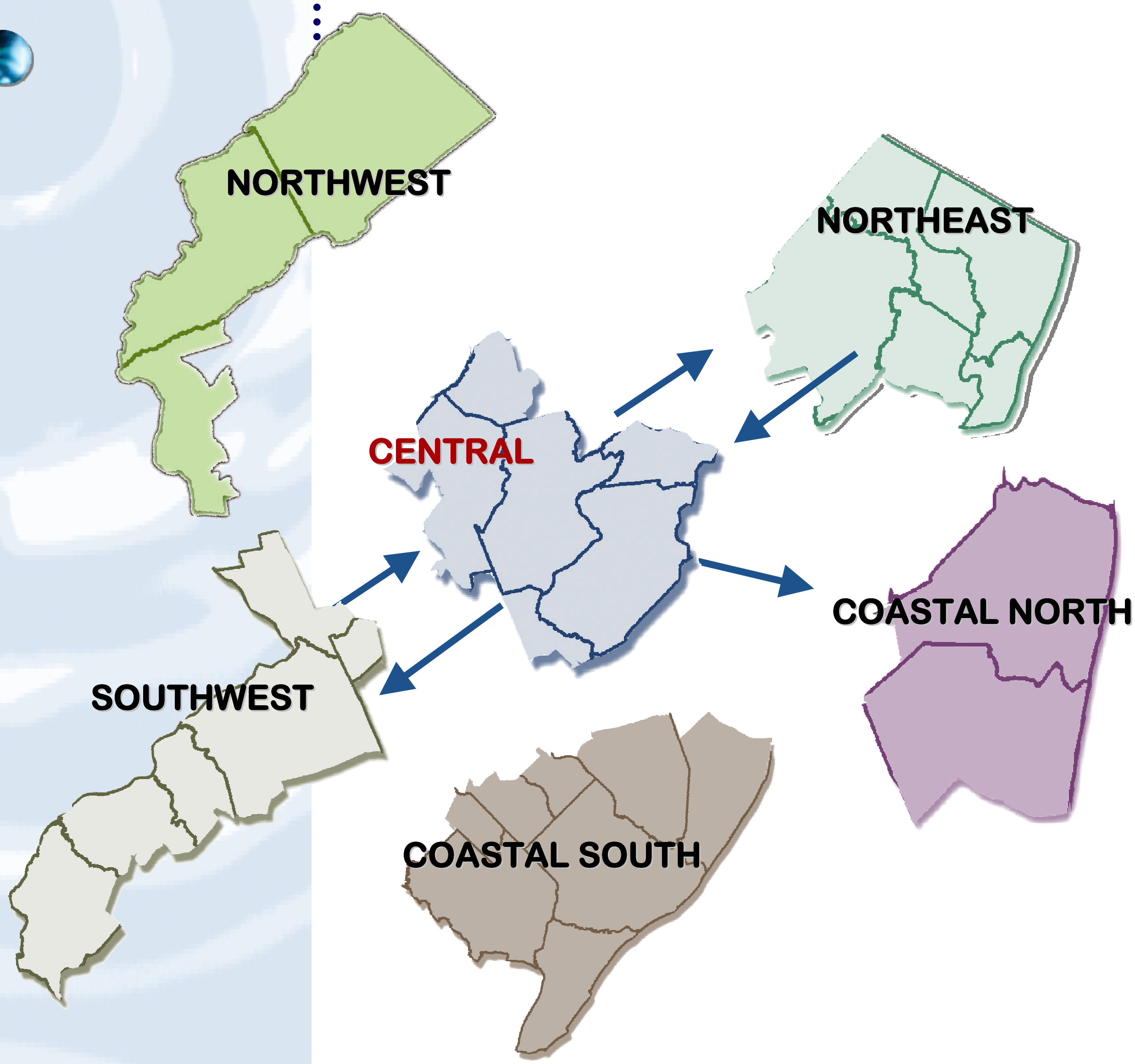
new jersey department of environmental protection

INTERCONNECTION STUDY MITIGATION OF WATER SUPPLY EMERGENCIES

Public Version



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Executive Summary

The New Jersey Department of Environmental Protection (NJDEP) issued a Request for Proposal (RFP) in 2004 to complete an Interconnection Study. The RFP included the following statement:

> "The study shall evaluate the existing primary water transmission infrastructure in New Jersey. Both physical (interconnections and major transmission routes) and financial (contracts and operational costs) will be evaluated to provide recommendations with estimated costs to:
>
> - Optimize current water diversions and transfers to avert and mitigate drought related water supply emergencies.
> - Mitigate the effects during water supply emergencies due to catastrophic loss.
> - Optimize current water diversions under 'normal operation'."

The goals of the Interconnection Study are threefold. First, the Study will develop recommendations on how to optimize current water diversions and transfers between systems in an effort to avert and mitigate drought related water supply emergencies. Second, the Study will identify procedures to lessen the impacts on the State's water supply systems due to catastrophic losses. Third, the Study will attempt to optimize the existing system interconnections during "normal operations" to help increase overall water transmission efficiencies across the State.

Similar to the 1986 Water Resources Interconnection Feasibility Study, this Interconnection Study is divided into six (6) tasks. The tasks were defined in the original RFP dated May 2004. Each task and the manner in which they were addressed are described below.

Task 1 – Physical Infrastructure & Capacity Evaluation

In this task the status and capacity of the existing Primary Water Transmission and Interconnection Infrastructure was determined. Primary Water Transmission Infrastructure has been defined as:

- Interconnections between water systems at least 12 inches in diameter and any pump station/pumping equipment that is integral to the operation of the interconnection.
- The RFP required water mains that are at least 24 inches in diameter or water main networks capable of transmitting a flow rate of 20 million gallons per day (mgd) under normal operating pressures. In many cases 16-inch mains were included. This is described in more detail in Chapter 2.

The goals of the Interconnection Study are to develop recommendations on how to optimize current water diversions and transfers between systems in an effort to avert and mitigate drought related water supply emergencies. The Study will identify procedures to lessen the impacts on the State's water supply systems due to catastrophic losses, and to identify deficiencies in existing interconnection infrastructure and recommend improvements and additional infrastructure. The Study will attempt to optimize the existing system interconnections during "normal operations" to help increase overall water transmission efficiencies across the State.

This task included the identification of deficiencies, including operational status, hydraulic restrictions, and contractual limitations in the existing interconnection infrastructure.

In completing this task, a list of information was developed that was required to complete this task as well as Tasks 2 - 6. The information was assembled from the Department archives and individual systems.

Task 2 – Hydraulic Model

This task requires the development of a hydraulic model of the existing primary interconnections and transmission routes in New Jersey. The model was developed from data collected in Task 1 and was utilized in Tasks 1, 3, 4, and 5.

Task 3 – Optimizing Existing Water Diversions During Drought Conditions

This task involves the evaluation of existing water diversions and operational conditions to identify what changes can be made to avert drought related water supply emergencies. As part of this task, a decision support tool was developed that can be used by the NJDEP to assist in making drought related decisions in the future. The process of developing the decision support tool is described in Chapter 6.

Task 4 – Catastrophic Infrastructure Failure

This task is intended to address both security and reliability concerns from a statewide perspective. The primary elements of this task involve the evaluation of community systems under a variety of catastrophic "what-if" scenarios and the subsequent determination of recommended improvements, in cases where the communities are deemed to be at risk as a result of the catastrophic scenarios.

The purpose of the evaluation is to identify a classification for each system for each of the what-if scenarios to assess a system's vulnerability to the respective catastrophic event.

Task 5 – Optimize Diversions During Normal Conditions

This task is intended to identify areas for possible improvement in water-supply planning during normal conditions. During normal conditions, optimization is focused on management and preparation for drought at the local level — within water systems.

Task 6 – Financial Infrastructure

This task is intended to address the impact on purveyors' financial condition when the State adopts regulations which change water diversions, water conservation measures, and transmission of water to confront water supply emergencies. The primary focus of this task is evaluating the existing financial infrastructure of the parties involved to determine if it will be necessary to propose changes in order to avoid disproportionate financial hardship or profits.

Organization of the Chapters of this Report

During this project and the development of this report it was determined that it would be better to organize them in the following fashion:

Chapter 2	Task 1 – Physical Infrastructure & Capacity Evaluation
Chapter 3	Task 2 – Hydraulic Model
Chapter 4	Task 4 – Catastrophic Infrastructure Failure
Chapter 5	Water Supply Management Decision Support Tool
Chapter 6	Task 3 – Optimizing Existing Water Diversions
Chapter 7	Task 5 – Optimize Diversions During Normal Conditions
Chapter 8	Evaluation of Recommendations
Chapter 9	Task 6 – Financial Infrastructure

Water Supply Prioritization & Recommendations

New Jersey, because of its relatively small size and extended potable water systems, has a unique opportunity to integrate most of their major water sources throughout the state. NJDEP's support for interconnections between regions will allow the potable water systems to have multiple redundancies at their disposal to address all types of catastrophes.

The recommendations of this report are as follows:

1. It is recommended that the NJDEP institute the Advisory Curve and Water Supply Management Decision Support Tool (WSMDST) as described in Chapter 6. This will require the Drought Management Rules be amended to give the NJDEP powers under a Drought Advisory similar to the powers under a Drought Warning (Water Supply Allocation Rules 7:19-11.6) which include, among other parameters, the ability for the NJDEP to mandate water transfers. These rules and the potential pricing arrangements are discussed in Chapter 9.

2. The greatest opportunity for demand transfer involves the New Jersey American Water Company (NJAWC)-Elizabethtown – Newark-North Jersey District Water Supply Commission (NJDWSC): These 3 systems are interconnected through the [NAME REACTED]. NJDWSC has conducted preliminary

investigations of an operational procedure change to provide a continuous supply of 10 mgd from the Elizabethtown system to the NJDWSC system via the Virginia Street Pumping Station. Their investigations indicate that if this had been in place between 1990 and 2003, the number of days the Wanaque Reservoir was below the drought warning curve would have been reduced from 221 days to only 29 days. This study identifies this interconnection as a critical reducing the length of droughts in the Northeast Region. This option merits support by the NJDEP.

3. It is recommended the NJDEP and United Water begin discussions to evaluate the potential for additional water supply. Based on the analysis in this study United Water was identified as a purveyor in deficit in six of the seven drought simulations. In addition, the United Water interconnection with Jersey City and NJDWSC were identified as the limiting interconnections during non-simulated drought emergencies.

4. It is recommended that [NAME REDACTED] and [NAME REDACTED] evaluate options that would allow them to be rated higher than vulnerable in the catastrophic infrastructure analysis. Both systems are classified as large systems serving more than 50,000 people, are somewhat isolated and have limited existing options. There are some nearby options that could assist that should be investigated.

5. It is recommended that NJDEP update their statewide Drought Management Plan to redefine roles of various state and local agencies during a drought emergency, to establish minimum requirements of local plans, and to provide guidance to local agencies for drought response. An updated statewide drought management plan will insure that agencies throughout the state implement consistent responses to the Drought Indicator System, thus encouraging an equitable distribution of hardship during drought emergencies. This plan should include, among other things, statewide conservation goals and minimum water use restrictions for each sector during each drought stage.

6. Reclaimed Water for Beneficial Reuse (RWBR) is a proven water supply management tool that has been used extensively in other areas of the country and shows great potential as a water supply management tool for New Jersey. As NJDEP continues to develop and promote its RWBR program, they should develop a strategic plan and long-term goals for the program. This plan should identify goal volumes of reuse to be achieved in the state as a whole and in individual regions, according to regional water needs. To better position themselves to meet their long term goals, New Jersey might consider establishing a program to provide financial incentives for agencies to evaluate the benefits and possibilities of reuse.

7. The distribution networks of the NJAWC's Elizabethtown and Short Hills systems currently are interconnected, and part of the Short Hills system demand is met with water from the Elizabethtown system. Modeling shows benefits of strengthening the connections between these 2 regions. The Short Hills system has an average demand of just under 40 mgd, about 30 of which is met with supplies in the Northeast Region. If this demand could be met with supplies from the Central Region, about 30 mgd of supply might be made available to meet demands in the Northeast Region on a regular basis. More detailed investigations are needed to determine the economic and political feasibility of this option.

8. Additional studies are also recommended to evaluate the feasibility, costs, and benefits of source optimization and demand transfer between surface water and groundwater within the Middlesex Water, NJAWC-Western and Sayreville systems.

9. Aquifer Storage and Recovery (ASR) appears to have great potential as a water supply management tool in New Jersey. It is recommended that NJDEP continue to promote ASR through programs that encourage utilities to incorporate ASR into their water supply planning. The current permitting process and monitoring requirements are extensive, intimidating and can take years to navigate, the discharge permit being the most difficult hurdle. Therefore, it is recommended that NJDEP review the process and consider streamlining these processes as much as possible, and assist in coordinating permitting activities among the various DEP Bureaus. It is further recommended that NJDEP encourage more utilities to pilot and hopefully adopt ASR for multi-year water storage or "banking". This technology provides drought management through the transfer of demand from year to year, storing during wet years and recovering during dry years.

10. NJDEP is interested in establishing standard recommendations even regulations for evaluating water losses and in determining the demand reduction that could be realized if systems are optimized. To this end, it is recommended that NJDEP require all utilities to conduct annual water audits using the IWA/AWWA Water Audit Method and to implement a leakage control plans. Once a uniform system for auditing and reporting water losses water is implemented statewide, it is recommended that NJDEP commission a detailed study and cost benefit analysis. This study would evaluate the potential for demand reduction that could be realized through enhanced water loss control and determine if the benefits of the reductions balance the cost of implementing control programs. The NJDEP could then use the results of this study to establish or modify their goal ILI based on achieving some desired level of demand reduction.

Financial Recommendations and Guidelines

In our initial discussions with the NJDEP it was considered that water transfers during a drought situation should be priced at the bulk purchase rate (bulk rate) in existing contracts or below so that supplying water systems would not profit from the drought situation. However, an alternative view was expressed during discussions with water purveyors. The consensus was that if the transfer of water during a drought was priced at bulk rate or below, there would be no incentive for water systems that habitually fall into a drought situation earlier than others due to inadequate water supply to set up long term contracts with the neighboring suppliers or to invest in alternative sources of water. It was a concern that these systems would always get "bailed out" at the expense of the supplying systems and their customers that funded the infrastructure in order to have an adequate water supply. On the other hand, if the supplying water systems are guaranteed a high rate for their water in a drought situation, these supplying systems may not have motivation to sign a long-term contract at a lower rate than their General Metered Service (GMS) rate. The following recommendations address these issues.

1. In preparation for emergencies, we recommend that the NJDEP, during the permitting process, enforce the requirement that water purveyors with physical interconnections with other water purveyors have an Emergency Water Transfer Pricing Schedule in place at all times, including a bulk rate for those systems that expect diversions over .1 mgd. These prices can be in accordance with the criteria outlined in the Water Supply Allocation Rules and would be used in case of a water transfer to a water system not currently engaged in a long term contract with the supplying water system.

2. In addition, the Emergency Water Transfer Pricing rules could be amended to include the stipulation that if a water purveyor is in a drought situation and is buying from a supplier who is not under water use restrictions, that the purchasing water supplier pay its own GMS rate and the difference between the bulk rate charged by the supplying system and its own GMS rate would then be used as a funding source for the State to supplement the 1981 bond fund and used for State sponsored projects. This structure could potentially create a funding source for needed projects but must be carefully considered as to not create a hardship situation for the purchasing water purveyor. However creative solutions between water purveyors should be encouraged, such as the use of standby fees and/or long-term contracts that would supersede the Emergency Water Transfer Pricing rules.

3. It is proposed that the water systems with interconnections develop a standby agreement which pays the supplying water purveyor a fee to have an assured source of water at a bulk rate price in an emergency (including drought) rather than being subject to the Emergency Transfer Pricing rules. This fee should be priced to compensate the rate payers of the supplying system for the investment in infrastructure. The consumption charge for the actual use could then be set to the

incremental cost of supplying the water or a bulk rate since the fixed costs have already been paid through the standby fee. Potentially, these standby fees could evolve to a steady purchase of water by the water systems in need, which could help mitigate water shortages under drought conditions.

4. If a water purveyor does not develop a contract as recommended above for an emergency, it is recommended that NJDEP impose an alternative based on the Emergency Water Transfer Price criteria. In this case, the water purveyor in need of water during a period of water restriction and without long term contracts with water suppliers would risk the price of water equal to the supplying water purveyors' GMS rate or its own GMS rate depending on the regulations. This risk may encourage the development of an alternative pricing strategy, the development of an alternate water source, or even prevent the water purveyor in need from buying the water, choosing instead to impose further restrictions on water use for its customers. In the long run, this approach may force an open dialogue with the rate payers. The water purveyor could describe the options and costs related to a long term contract, development of a new water supply and expanded water restrictions. In some cases the rate payers will accept rate increases to reduce the need for restrictions. In others the rate payers will prefer the restrictions to higher rates.

   This strategy could also create the impetus for the supplying water purveyor to be open to negotiation of terms. If the supplying water purveyor is aware that the water system in need is going through an evaluation of the alternatives they may be more inclined to consider negotiation in the terms when confronted with the risk of losing the opportunity altogether.

5. In addition, the Drought Management Rules should be amended to compensate intermediary water systems that "wheel" the water from one system to another. As stated earlier in this report, the fee should be based upon the allocated cost of pumping and transmission for the wheeling water system. However, absent a long term contract, the NJDEP should recommend a wheeling fee that equals the difference between the wheeling system's GMS rate and its Sales for Resale rate. In some instances the NJBPU may have to be included in these discussions.

6. Most importantly, we recommend that the Drought Management Rules be amended to give the NJ DEP powers under a Drought Advisory similar to the powers under a Drought Warning (Water Supply Allocation Rules 7:19-11.6) which include, among other parameters, the ability for the NJ DEP to mandate water transfers. The pricing mechanism is not discussed in the Water Allocation Rules for a Drought Warning, however we recommend using the Emergency Water Transfer Pricing rules and criteria if another contract is not in place. In addition, the Drought Management Rules should be amended to stipulate that if an agreement is not already in place the water purveyor in need of the water transfer (as indicated by the model referenced in this report) should pay any costs related to the rehabilitation

and activation of interconnections between water systems and completion of the interconnection flow tests.

7. Finally, it is also recommended that the NJDEP work with the water suppliers, public and private, who have take or pay contracts with other water purveyors to add flexibility to the use of the water supply. The purchasing water purveyor should be reimbursed for some or all of its contractual allocation of water if it is used by another water purveyor whose source of water is more limited. This reimbursement must be at least equal to the price paid for water via an alternate source used. This would allow for a more efficient distribution of water in a potential drought situation. NJDWSC is one of the largest water suppliers in the State and maintains take or pay contracts with various water purveyors. The Commission has indicated that the water purveyors on its system, through a series of contracts, have a mechanism to be reimbursed for their water allocation if it is used by another water purveyor in times of water shortages.

1.0 DEVELOPMENT OF INTERCONNECTION STUDY

The New Jersey Department of Environmental Protection (NJDEP) issued a Request for Proposal (RFP) in 2004 to complete an Interconnection Study. The RFP included the following statement:

> "The study shall evaluate the existing primary water transmission infrastructure in New Jersey. Both physical (interconnections and major transmission routes) and financial (contracts and operational costs) will be evaluated to provide recommendations with estimated costs to:
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> - Optimize current water diversions and transfers to avert and mitigate drought related water supply emergencies.
> - Mitigate the effects during water supply emergencies due to catastrophic loss.
> - Optimize current water diversions under 'normal operation'."

1.1 The Interconnection Study

The Interconnection Study is intended to be an update of previous interconnection studies, as well as providing a framework and recommendations to avert drought emergencies, mitigation of catastrophic events, and financial infrastructure. The following subsections provide greater detail regarding the goals and the scope of the Study, as well as a narrative outlining the organization of the Study and the methodologies employed to complete the Study.

1.1.1 Interconnection Study Goals

The goals of the Interconnection Study are threefold. First, the Study will develop recommendations on how to optimize current water diversions and transfers between systems in an effort to avert and mitigate drought related water supply emergencies. Second, the Study will identify procedures to lessen the impacts on the State's water supply systems due to catastrophic losses. Third, the Study will attempt to optimize the existing system interconnections during "normal operations" to help increase overall water transmission efficiencies across the State.

1.1.2 Scope of the Interconnection Study

The Interconnection Study focuses on water transmission and distribution systems that serve 10,000 people or more. Also included in the Study are reviews of existing 12-inch-diameter and larger interconnections, as well as existing water transmission mains that are 16-inch-diameter or larger. Another defining limitation of the Study is the inclusion of all transmission systems and mains that are capable of delivering 20 million gallons per day (mgd) or more.

The NJDEP specifically excluded some items form this study. They included:

- Evaluation of new sources of supply
- Evaluation of safe yield or passing flow determinations specified in Water Allocation Permits

In addition, the evaluation of "reduction in consumption" was limited to percentages necessary to facilitate the transfers, since it is the intent of the study to avoid getting into drought emergencies. The study was intended to be an infrastructure study and not a demand study.

1.1.3 Interconnection Study Organization and Task Descriptions

Similar to the 1986 Water Resources Interconnection Feasibility Study, this Interconnection Study is divided into six (6) tasks. The tasks were defined in the original RFP dated May 2004. Each task and the manner in which they were addressed are described below.

Task 1 – Physical Infrastructure & Capacity Evaluation

In this task the status and capacity of the existing Primary Water Transmission and Interconnection Infrastructure was determined. Primary Water Transmission Infrastructure has been defined as:

- Interconnections between water systems at least 12 inches in diameter and any pump station/pumping equipment that is integral to the operation of the interconnection.
- The RFP required water mains that are at least 24 inches in diameter or water main networks capable of transmitting a flow rate of 20 mgd under normal operating pressures. In many cases 16-inch mains were included. This is described in more detail in Chapter 2.

The goals of the Interconnection Study are to develop recommendations on how to optimize current water diversions and transfers between systems in an effort to avert and mitigate drought related water supply emergencies. The Study will identify procedures to lessen the impacts on the State's water supply systems due to catastrophic losses, and to identify deficiencies in existing interconnection infrastructure and recommend improvements and additional infrastructure. The Study will attempt to optimize the existing system interconnections during "normal operations" to help increase overall water transmission efficiencies across the State.

This task included the identification of deficiencies, including operational status, hydraulic restrictions, and contractual limitations in the existing interconnection infrastructure.

In completing this task, a list of information was developed required to complete this task as well as Tasks 2 - 6. The information was assembled from the Department archives and individual systems.

Task 2 – Hydraulic Model

This task requires the development of a hydraulic model of the existing primary interconnections and transmission routes in New Jersey. The model was developed from data collected in Task 1 and was utilized in Tasks 1, 3, 4, and 5.

Task 3 – Optimizing Existing Water Diversions During Drought Conditions

This task involves the evaluation of existing water diversions and operational conditions to identify what changes can be made to avert drought related water supply emergencies. As part of this task, a decision support tool was developed that can be used by the NJDEP to assist in making drought related decisions in the future. The process of developing the decision support tool is described in Chapter 6.

Task 4 – Catastrophic Infrastructure Failure

This task is intended to address both security and reliability concerns from a statewide perspective. The primary elements of this task involve the evaluation of community systems under a variety of catastrophic "what-if" scenarios and the subsequent determination of recommended improvements, in cases where the communities are deemed to be at risk as a result of the catastrophic scenarios.

The purpose of the evaluation is to identify a classification for each system for each of the what-if scenarios to assess a system's vulnerability to the respective catastrophic event.

Task 5 – Optimize Diversions During Normal Conditions

This task is intended to identify areas for possible improvement in water-supply planning during normal conditions. During normal conditions, optimization is focused on management and preparation for drought at the local level — within water systems.

Task 6 – Financial Infrastructure

This task is intended to address the impact on purveyors' financial condition when the State adopts regulations which change water diversions, water conservation measures, and transmission of water to confront water supply emergencies. The primary focus of this task is evaluating the existing financial infrastructure of the parties involved to determine if it will be necessary to propose changes in order to avoid disproportionate financial hardship or profits.

1.1.4 Organization of the Chapters of this Report

During this project and the development of this report it was determined that it would be better to organize them in the following fashion:

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1.2 History of Water Supply Planning in New Jersey

The general goals of a water supply plan are:

1. To provide a comprehensive assessment of water availability, water supply needs, and water usage for a given area;
2. Predict water demands over a pre-determined planning horizon (typically 30 to 50 years); and
3. To provide guidance for future development of water sources in the planning area in order to satisfy the projected water demands.

Water supply plans can be developed for a single water provider, or they can be prepared on a regional basis. Regional water supply plans also address the ability to transfer water from one service area to another, commonly referred to as "interconnections". These interconnections are beneficial by minimizing the impacts of droughts or water supply shortages found within the region.

1.2.1 Historical Droughts

The occurrences of significant droughts or water shortages often result in the development of new water supply plans, or revisions to existing documents. Over the years, there have been multiple droughts that have had a significant impact on water availability in New Jersey.

1980 Drought

One such drought occurred from 1980 until 1982. Drought conditions began in the summer of 1980, with rainfall amounts in August 1980 at 20% of the normal precipitation levels. The northeast portion of New Jersey was hardest hit by the drought due to poor distribution system conditions and a lack of sufficient interconnections with neighboring systems.

As a result of the water crisis, the Governor of New Jersey issued three executive orders, which placed water restrictions on potable water usage. These executive orders were only partially effective. As available water supply continued to diminish, under Executive Order No. 98, the Governor ordered mandatory water rationing, including indoor water use restrictions for specific municipalities in the northeastern portion of the State. The amount of available water continued to decrease over the fall of 1980. By the end of January 1981, the major reservoirs utilized by northeastern New Jersey were below 25% capacity.

In February 1981, the State Legislature approved emergency funding for the construction of new interconnections and overland pipelines to supplement the water supplies in the areas hardest hit by the drought. Three projects included interbasin transfers from:

- New York City Reservoirs across the George Washington Bridge to reduce drafts from the Oradell Reservoir (Hackensack/United Water Company);
- Lake Hopatcong in the Delaware River Basin by way of a pump station to the Rockaway River to reduce drafts from the Boonton Reservoir (Jersey City);
- Elizabethtown Water Company in the Raritan basin via the Virginia Street Pump Station to indirectly reduce drafts from the Wanaque and Pequannock Reservoirs (Newark).

Because New York State statutes prohibited routine transport of water across State lines, an interstate agreement first had to be reached and was predicated on New Jersey's Emergency Declaration, water use restrictions and an equal reduction in New Jersey's withdrawal from the Delaware Basin via the D&R Canal. The interconnection with New York City was approved and constructed but not utilized. The cost sharing and repayment formulas for interconnections were based on the proportionate share of total demand. The GWB interconnection has since been dismantled. The Lake Hopatcong interbasin transfer (Delaware to Passaic) pipeline remains in place. Its condition is not known, and the pump station has since been dismantled. The Virginia Street pump station remains in place with limited use since its construction.

The drought conditions started to ease in the spring of 1981, with heavy rainfall in May 1981 resulting in the combined reservoir levels increasing above 90% capacity. Reservoir levels fluctuated over the next 12 months, and on April 27, 1982, the State of New Jersey ended the water emergency via Executive Order No. 5.

<u>1985 Drought</u>

Another significant drought event occurred between April 1985 and March 1986. Due to experiences gained during earlier droughts, as well as the Emergency Water Supply Allocation Plan Regulations adopted in conjunction with the State's Water Supply Management Act (1981), New Jersey was better prepared to handle a water shortage event. The regulations established a statewide response system that included water supply and demand management elements that could be enacted in a statewide fashion, or limited to only areas affected by a drought.

Supply management was based on the transfer through interconnections of raw or finished water between purveyors after a "Warning" declaration. Emergency pricing regulations permitted the Department to establish water rates between sending and receiving systems in the event contracts were not sufficient. Demand management was based on Declaration of an Emergency and a sequential four-phase system that was to forestall the most severe economic and public health consequences by first restricting outdoor nonessential uses and thereafter restricting each class of water users comparably.

The system interconnections built during and after the 1980-1982 drought were also beneficial during the 1985-1986 drought. It has been documented that demand management strategies employed during the 1980-1982 drought resulted in a 25% reduction in peak water use in northeastern New Jersey.

1.2.2 Water Supply Regulations and Master Plans

As a result of historical droughts and inconsistencies associated with overall water supply and demand management, New Jersey enacted the Water Supply Management Act (NJSA 58:1 A-1 et seq.). This act provided a comprehensive water supply management program that better defined the role of the State relative to water supply management.

New Jersey also authorized the development of a comprehensive statewide Water Supply Master Plan, which was first adopted by the State in 1982. The plan was generated to serve as a planning tool to help guide the State in making proper water supply management decisions.

The Master Plan provided a list of recommended construction projects to bolster the water supply and distribution systems in the State, as well as guidance for the planning and implementation of future projects. The Master Plan was intended to be a working tool, requiring periodic reviews and revisions to address changes in the water supply systems in the State. Construction projects that were recommended for immediate implementation by the Master Plan were funded by the Water Supply Bond Act of 1981, which issued $350 million in bond monies.

An update to the Master Plan was completed in 1996. It recommended a number of initiatives, capital projects, and regional studies. Another update is in progress, and the draft report is expected to be issued in 2007.

1.2.3 Interconnection Analyses

Throughout the water supply planning history of New Jersey, interconnection analyses have been performed, including those accomplished as a direct result of major drought events. In the 1982 Water Supply Master Plan, there was an interconnection study, but it was limited to the evaluation of twenty-five (25) water purveyors who provided approximately two-thirds of the State's water demand at that time.

The interconnection study reviewed the transfer capacities under normal, drought, and disaster scenarios. The disaster scenarios assumed that there would be a total loss of the local water supply. The study concluded that approximately half of the water supply systems could not meet disaster demands based solely on the use of interconnections.

A stand-alone interconnection study, titled Water Resources Interconnection Feasibility Study, was completed in 1986. The 1986 study included one hundred and ninety (190) municipal and investor-owned water systems that served more than 5,000 people each. These systems represented approximately 95% of the total population in New Jersey at the time of the study.

The review of the water systems was based on the Water Supply Management Acts requirements associated with the satisfaction of certain levels (75% and 50%) of the average daily demand of the systems by use of interconnections alone, local sources, or a combination of both.

The study found that 75% of the water systems could supply 75% of the average daily demand through either interconnections alone or through a combination of interconnections and local sources. The study also determined that approximately 4% of the water systems could supply 50% of the average daily demand through interconnections alone. The remaining 21% of the water systems reviewed in the study did not meet the Water Supply Management Act requirements. The noncompliant systems lacked sufficient interconnection capacity, had inadequate standby power sources, or were remotely located and did not have any significant interconnections to neighboring systems. The largest systems were assumed to be self reliant because of their redundant treatment trains, even if interconnections could not provide 75% of the average daily demand. Based on these findings, the study provided a list of recommended projects to improve interconnection capacities. Most of the recommended projects involved additional standby power.

1.3 Recent Incidents Affecting Water Supply

There have been a number of events that have had a significant impact on water supply systems in New Jersey.

1.3.1 Large Infrastructure Failures

<u>1975 Trenton Water Crisis</u>

The City of Trenton suffered a significant water crisis that started on August 31, 1975. While the immediate crisis event ended on September 10, 1975, system deficiencies associated with the crisis were not completely addressed until March 8, 1976.

The water crisis began on August 31, 1975, when events, including human error, equipment failures, and design flaws resulted in the failure of service to the City of Trenton and adjacent portions of Ewing, Hamilton, and Lawrence Townships. The system failure affected approximately 200,000 residents.

To further complicate the crisis, there were no existing interconnections between the affected systems and neighboring water systems. Canvas hose interconnections were immediately put in place between the affected system and nearby water systems. Aboveground steel pipelines that had been stockpiled for civilian defense services replaced the canvas hoses. Regardless of these valiant efforts, the Trenton reservoir went dry, and distribution system pressures decreased dramatically. Residents at higher elevations of the service area had no water service at the height of the water crisis.

The crisis ended when pumping was restored on September 5, 1975. All customers were back in service by September 8, 1975; however, due to the fear of contamination resulting from the crisis, customers were asked to boil or chemically treat all potable water until September 10, 1975. Repairs to structural damage attributed to the water crisis were completed on March 8, 1976. During that time period, permanent interconnections were installed to help protect the Trenton system from future system failures.

United Water Transmission Main -1996

On February 7, 1996, a chain of events caused a major service interruption which affected a large portion of the service territory of United Water New Jersey. The service disruption was the result of a separation of a 54-inch-diameter water main and a subsequent valve failure. The incident resulted in a wide range of disruptions to a customer base of 175,000 water subscribers, representing over 750,000 water consumers in Bergen and Hudson Counties. An estimated 100,000 water subscribers experienced low pressure, and in some cases were without any water service for days. A boil-water advisory affected all United Water New Jersey (UWNJ) water subscribers. Water service was restored by February 10, with limited outages and low pressure cases persisting in higher elevation areas.

Raritan Millstone Plant Flooding -1999

Hurricane Floyd started as a tropical storm in the Atlantic and peaking as a Category 4 Hurricane. By the time Floyd hit the shore, it was significantly weaker than it was at sea; however, Floyd produced torrential rains and high winds throughout the Mid-Atlantic. Rainfall amounts peaked at 13.34 inches (339 mm) in Somerville, New Jersey. The Raritan River basin experienced record flooding as a result of Floyd's heavy rains. Bound Brook, New Jersey was especially hard hit by a record flooding event: 14.13 feet above flood stage, and sent 12 feet of water on Main Street.

The flood waters inundated Elizabethtown Water Company's Raritan Millstone Plant. The plant had a peak capacity of 210 mgd and supplied potable water to approximately one million people in Central New Jersey. During the plant outage, Elizabethtown was able to serve a large portion of the customers using other sources, including well supplies, their Canal Road Plant, and interconnections, but a significant section of the system lost pressure. Interconnections with Newark were available because of the higher system pressure of the Wanaque and Pequannock reservoirs and treatment plants that serve Newark. Customers were asked to boil all potable water. The system returned to partial service within 4 days and full service within 10 days.

Trenton 2006

The Trenton Water Plant had a history of trouble treating highly turbid water. The Trenton Water system also has a large treated water storage facility in the distribution system. Historically, during high turbidity events the Trenton Water Plant would be shut down, the system would draw from storage until the river turbidity dropped, and the plant would be placed back on line.

In 2006 the Delaware River experienced an extended period of highly turbid water during which Trenton Water came close to draining system storage. Existing interconnections were utilized to a limited extent. Since that time, the interconnection with NJAW's Elizabethtown System was improved with plans for additional enhancements.

Other Large Magnitude Infrastructure Failures

In addition to the failures listed above there have been several other significant infrastructure failures. The following is a partial listing.

- Newark's Pequannock Aqueduct Failure (Spring 1982)
- Jersey City Transmission Failure (July 1982)
- Jersey City Aqueduct Contamination with #2 Fuel Oil (Summer 1981)
- United Water Haworth Plant – High Turbidity (Hurricane Floyd, Sept 1999)

The above examples do not represent a complete list of significant infrastructure failures. The list is offered to provide a sense of the size and regularity of the occurrences.

1.3.2 Security Concerns

With the events of September 11, 2001, it is evident that the security environment must now be seen in a fundamentally different light. Every water system in the U.S. should be prepared regarding security. While no water system can be absolutely free from threats, it can be prepared.

Hardening of the assets, as recommended in the Best Management Practices (BMP) developed and adopted by the New Jersey Water Security Sector (a subgroup of the NJ Infrastructure Advisory Committee of the NJ Domestic Security Taskforce), is acknowledged.

However, redundancy is an important component to being prepared. Redundancy allows the system to maintain service or bounce right back into service after an unexpected event does occur. Interconnections are an important component in developing redundancy for water systems.

1.4 Water System Review

In addition to requesting infrastructure information and hydraulic models that are documented in Chapters 2 and 3, the draft report was presented April 18, 2007, to, and reviewed by, the "Big 25 Water Systems" group and to the Water Supply Advisory Council, April 20, 2007, and their submitted comments are recorded in the Appendix.

The "Big 25 Water Systems" group consists of representatives of the 25 largest water systems, which includes municipally owned; state and local government commission owned; and investor owned water systems.

The Water Supply Advisory Council (WSAC) was established under P.L. 1981, Chapter 262, to advise the Department and consists of representatives from the agricultural community, industrial and commercial water users, residential water users, private watershed protection associations, academic community, golf course superintendents of NJ, and two members each from investor owned water companies and municipal or county water companies along with a representative of the nursery/landscapers/irrigation contractors industry.

2.0 TASK 1: PHYSICAL INFRASTRUCTURE AND CAPACITY EVALUATION

2.1 Background and Objective

Task 1 involved documenting and developing information related to the Primary Water Transmission and Interconnection Infrastructure, which was subsequently used throughout the Interconnection Study. The primary objectives of Task 1 were as follows:

1. Identify and document the existing Primary Water Transmission and Interconnection Infrastructure for systems included in the study.
2. Estimate the capacities of the identified primary interconnections.
3. Identify factors that limit the capacities of the primary interconnections.

2.2 Definition of Primary Water Transmission and Interconnection Infrastructure

According to the RFP, the NJDEP defines primary transmission infrastructure as follows:

- Primary Interconnections between water systems are interconnections at least 12 inches in diameter, and any pump station/pumping equipment that is integral to the operation of the interconnection.
- Primary Transmission routes are water mains that are at least 24 inches in diameter or are water main networks capable of transmitting a flow rate of 20 mgd under normal operating pressures.

For the purpose of this study, Primary Transmission and Interconnection Infrastructure were further defined as follows:

- Primary Interconnection Infrastructure
  - ➢ An interconnection with a minimum reported size of 12 inches on the receiver and supplier side between systems serving a population of at least 10,000 people is defined as a "primary interconnection."
  - ➢ The primary interconnection infrastructure also includes any pump station/pumping equipment or control valves that are associated with the transfer of water at a primary interconnection.
- Primary Transmission Infrastructure
  - ➢ Water mains that are at least 24 inches in diameter or water main networks estimated to be capable of transmitting a flow rate of 20 mgd under normal operating pressures are considered "Primary Transmission Mains."
  - ➢ The primary transmission infrastructure also includes any pump station/pumping equipment, control valves, or storage facility that is integral to the flow of water in the primary transmission mains.
  - ➢ This definition was expanded to include 16 inch mains that were included in hydraulic models that were provided by the systems for this study.

2.3 Drought Regions

Following a period of drought in the late 1990s, the Department established a set of drought indicators to improve understanding and management of water resources during periods of water-supply drought. These indicators are designed to compile a large amount of information into simple summary indicators. The summary indicators are based on precipitation, streamflow, reservoirs, and groundwater levels. Data in this system are intended to be supplied in real-time, and the database of these indicators is continuing to grow. The Department divided the state into six drought regions as depicted in Figure 2-1. The regions correspond closely to natural watershed boundaries.

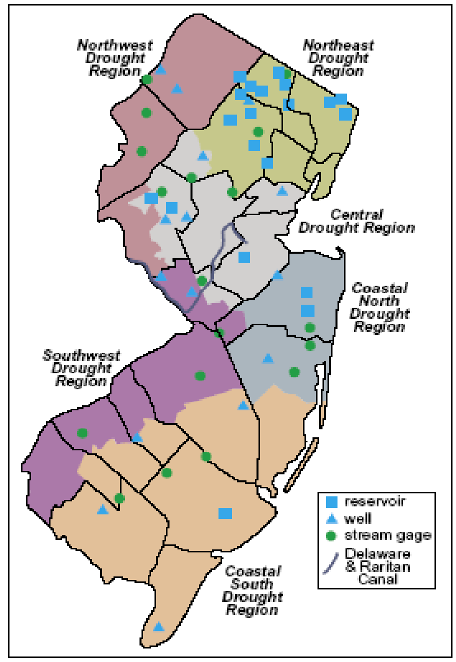

Figure 2-1 - Drought Regions

Drought Region	Reservoirs: New Jersey	Reservoirs: DE River Basin	Rivers	Unconfined Ground Water
Northeast	major	none	major	minor
Central	major	major	major	minor
Coastal North	major	none	minor	major
Coastal South	minor	none	minor	major
Northwest	minor	minor	major	major
Southwest	none	major	minor	major

Figure 2-2 - Water Source importance to New Jersey's water supply by drought region

It is important to recognize the State of New Jersey water infrastructure is made up of a complex network of water systems.

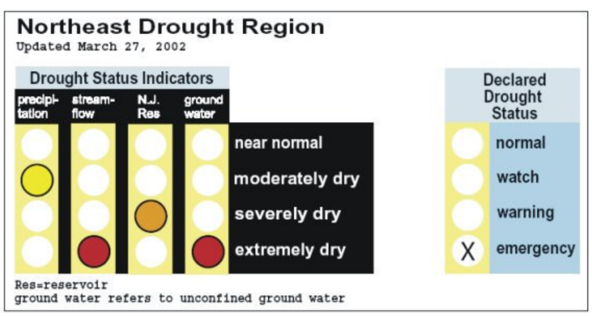

Figure 2-3 – Drought Indicators

In addition, as depicted in Figure 2-2, the regions depend upon different combinations of surface water and groundwater. As a result, droughts do not affect all of the state equally. Each drought is different.

The Department has developed drought indicators for all six drought regions. They provide an overview of the general water supply sources in a region. Figure 2-3 is an example from the Northeast Drought Region on March 27, 2002, and shows that the region was in a drought emergency at the time.

In developing this study it was decided that it would beneficial to utilize the drought regions. The system was established, had been accepted, and had historical data that could be utilized. The following is a brief description of each region.

2.3.1 Northeast Drought Region

The Northeast Drought Region has the largest population and the largest water demands. The region is primarily supplied by surface water and includes the majority of state's reservoirs.

Table 2-1
Northeast Region Reservoirs

Reservoir Name	Total Capacity (BG)	Water System
DeForest	5.7	United
Tappan	3.9	United
Woodcliff	0.9	United
Oradell	3.5	United
Monksville	7.0	NJDWSC
Wanaque	29.6	NJDWSC
Canistear	2.4	Newark
OakRidge	3.9	Newark
Clinton	3.5	Newark
Charlotteburg	2.9	Newark
EchoLake	1.8	Newark
Splitrock	3.3	JerseyCity
Boonton	7.6	JerseyCity

There are several regional water systems located in the Northeast Region. They include North Jersey District Water Supply Commission (NJDWSC), United Water - Haworth, Newark, PVWC, Jersey City, NJAW - Short Hills, Southeast Morris Co MUA, and Morris Co. MUA.

Table 2-2
Northeast Region Treatment Capacities

Water System	Treatment Capacities
Jersey City MUA	80 MGD
Morris County MUA	9.5 MGD
NJAW – Shorthills	20 MGD
NJDWSC	210 MGD
Newark	50 MGD
PVWC	100 MGD
Southeast Morris MUA	15 MGD
United Water	202 MGD

The systems have extensive interconnections within the region and are interconnected with the Central Region by way of NJAW-Shorthills and Newark.

2.3.2 Central Drought Region

In the Central Drought Region, the New Jersey Water Supply Authority (NJWSA) - Raritan system is the single largest supplier of raw water. It has a safe yield of 225 MGD that was recently reset and approved for 241 MGD. This new safe yield includes 65 MGD of safe yield from the Delaware and Raritan Canal. The region has the largest available safe yield and has been identified as the most likely location in the state for future water supply projects including the Confluence Pump Station and Kingston Quarry Reservoir. The NJAWC-Elizabethtown system, with a treatment capacity of 250 MGD, and Middlesex Water Company, with a treatment capacity of 85 MGD, are the regional water purveyors in the Central Region. Both systems receive most of their water from the NJWSA, already have significant interconnection capacity with the Northeast and Coastal North Regions and are expected to play significant roles in future water transfers to the Northeast and Coastal North drought regions.

2.3.3 North Coastal Drought Region

The NJWSA – Manasquan System, with a Safe Yield of 31 MGD, is the single largest provider of raw water in the North Coastal Region. The NJAW-Monmouth System, with 81 MGD of treatment capacity, is by far the largest water supplier. This area has experienced significant residential development during the last 20 years and has seen increasing water demands. The NJWSA – Manasquan System is nearing full allotment of its safe yield and no major potential water supply projects have been identified within the region. It is anticipated that future increases in demands will be satisfied by transfers from the Central Region.

2.3.4 Southwest Drought Region

The Southwest Drought Region runs along the western edge of the state along the Delaware River from Trenton to south of Camden. The region includes two regional water suppliers. The City of Trenton has a treatment capacity of 65 MGD and the NJAW- Western Division has a treatment capacity of 87 MGD (47 MGD Groundwater). Both draw surface water from the Delaware River. The systems are interconnected locally but do not have a regional interconnection between them. Trenton has existing interconnections with the Central Region by way of NJAW – Elizabethtown. It is anticipated that Trenton and NJAW – Elizabethtown will continue to improve their interconnection capacity and it may be worthwhile to consider a connection between Trenton and the NJAW- Western Division to reinforce both systems and the capability to transfer water between the regions.

2.3.5 Coastal South Drought Region

The Coastal South Drought Region is the largest and least densely populated region in the state. Most of the existing development is located along the Atlantic Ocean. It has three primary suppliers. The Atlantic City MUA and NJAW- Atlantic County systems both have treatment capacities of 21 MGD. The City of Wildwood has a treatment capacity of 18 MGD. Atlantic City

MUA and the NJAW – Atlantic County systems are interconnected but neither is connected to the City of Wildwood system. The area has seen significant residential and commercial development during the last 20 years. Because the region's developed areas are a considerable distance from other developed areas in the state, it is anticipated that increasing demands will have to be met with local solutions.

2.3.6 Northwest Drought Region

The largest water supplier in the Northwest Drought Region is Sparta Township with a treatment capacity of 2.3 MGD. A large portion of the water demand in the area is satisfied by private wells. There may be opportunities to interconnect some of the local public systems but the region does not have a need for nor offer much opportunity to interregional solutions.

2.4 Data Acquisition and Compilation

This study required the evaluation of 140 water systems. Many include far-reaching and complex pipe networks. Successful data acquisition and compilation would have a significant impact on the value of this project's recommendations.

In February 2005, the project team made a kickoff presentation to the Big 25 Water Systems. The project approach and confidentiality procedures were presented. During the presentation it became obvious that a number of systems had concerns about the NJDEP internal confidentiality procedures. It was agreed that the NJDEP would develop a protocol for data related to this project. The project team and NJDEP agreed that significant data collection could not occur prior to the development of this protocol. In April 2005, NJDEP issued a letter to the water systems that included a description of the security protocols that would be used for this project.

At that time the NJDEP maintained a library of hardcopy water system maps. The NJDEP had also documented, through previous reports, various other data pertaining to system capacities, interconnections, average daily demands, planning studies and operational data. It was the goal of the project team to use these two groups of resources to develop a significant amount of the geospatial and attribute data necessary for this project.

Early on in the initial data collection effort it became obvious that a substantial portion of the hard copy data was out of date and would require contacting the water systems directly. As individual systems were contacted, many were very helpful but some significant water systems were not providing the required information. Some were reluctant to provide the data, some had limited data available and others were unresponsive.

At the time the project team could have pushed forward with the analysis with the limited data that was available from the NJDEP. Recognizing that the success of this project was dependant on water system acceptance, it was decided to continue to pursue the most accurate data. The project team requested and received additional assistance from the NJDEP in acquiring the necessary data. Numerous meetings, site visits and phone interviews were arranged with the systems in question. In the end, it took close to two years to complete the data collection necessary to develop a worthwhile product.

Some systems provided electronic system maps, hydraulic models, pumping history, reservoir operational data, system storage data, etc… Others did not. The accuracy of the representation of each system in this report is directly related to the level of interaction/cooperation the project team had with the system.

Even at the completion of this project there are data limits and inconsistencies that are impacting the level of accuracy of the recommendations. In a few cases the missing data limited the ability to complete analysis required in the original RFP. (These omissions are identified in their respective sections.) As another example, inconsistencies have been noted between the water systems comments, NJDEP staff comments and electronic data. In these cases, the NJDEP staff was advised. In most cases the NJDEP comments were employed, but the NJDEP should confirm agreement with the respective systems and correct their own internal electronic data.

2.5 Identification of Primary Water Transmission and Interconnection Infrastructure

Available data was reviewed to identify the locations and details (size, status, etc.) of all primary water transmission and interconnection infrastructure. This data was subsequently used to develop the hydraulic model as part of Task 2 and to complete various analyses of the Interconnection Study. Based on available information, 225 primary interconnections were identified.

Preliminary identification of primary transmission and interconnection infrastructure was based on data obtained during the initial data collection effort. The primary source of the data for the preliminary identification was the New Jersey Environmental Management System (NJEMS), which included a database of available interconnection information. A Geographical Information System (GIS) map was developed to document the locations and details of the preliminary primary infrastructure locations and data. Locations of primary interconnections were identified in the GIS based on coordinate and intersection data from the interconnection database, when available. Service boundaries of all water systems serving greater than 10,000 people were also identified on the GIS map. This preliminary map was used to assist in identifying systems that have primary transmission infrastructure and correspondingly to identify systems to be included in the hydraulic model that was completed as part of Task 2. Based on this review and discussions with NJDEP, 20 systems were identified as having primary transmission infrastructure or were integral to the transfer of water throughout the regions of the state and thus were included in the hydraulic model. These 20 systems comprise 16 of the 25 "Big 25" systems in the state. A detailed discussion regarding the development of the model pipeline network and corresponding identification and documentation of the primary transmission infrastructure is provided in Chapter 3 of this Report. A list of the twenty (20) systems included in the model is provided in Table 2-3.

Table 2-3
Systems Included in Hydraulic Model

PWSID #	System Name
0102001	Atlantic City Municipal Utilities Authority
0119002	New Jersey American Water Company – Atlantic County
0238001	United Water New Jersey
0327001	New Jersey American Water Company – Western Division
0408001	Camden Water Department
0712001	New Jersey American Water Company – Short Hills
0714001	Newark Water Department
0901001	Bayonne Water Department
0906001	Jersey City MUA
0907001	Kearny Water Department
1111001	Trenton Water Department
1204001	East Brunswick Water Utility
1225001	Middlesex Water Company
1328002	Marlboro Township Municipal Utilities Authority
1345001	New Jersey American Water Company – Coastal North
1424001	Southeast Morris County Municipal Utilities Authority
1605002	Passaic Valley Water Commission
1613001	North Jersey District Water Supply Commission
1614001	Wayne Township Division of Water
2004002	New Jersey American Water Company – Elizabethtown

Based on a review of all available information, including information provided by individual systems, it was determined that the interconnection database provided by NJDEP contained errors and omissions. Corrections were made to and noted in the database, as needed, to complete the Interconnection Study and as data was available. In particular, the locations of many primary interconnections were inaccurate or were not included in the database. As part of the model development process, the x,y coordinates (based on the NJ State Plane Coordinate System) of 151 of the 225 primary interconnections were identified/verified and added to the database. For the remaining 74 primary interconnections, the x,y coordinates were established, when possible, based on location information (address, intersections, etc.) provided in the interconnection database. Approximately 35 of the 74 primary interconnections that were not verified are between systems that were not included. Detailed system mapping was not obtained from systems that were not included in the model, and thus the locations of these

35 interconnections could not be verified as part of this study. The locations of the remaining 39 primary interconnections were unable to be verified based on data available to complete the Study. The updated interconnection database includes a column identifying the primary interconnections for which the x,y coordinates were verified/updated. In addition to the 151 primary interconnections for which locations were verified, the x,y coordinates of approximately 36 non-primary interconnections were verified/updated during the model development process. (The scope of services for the Interconnection Study did not include identification or analyses of non-primary interconnections. The 36 non-primary interconnections identified were located in the routine process of the model development.) The updated interconnection database was provided to NJDEP as part of this Study.

2.6 GIS Database

The primary water transmission and interconnection infrastructure identified as described above was converted to a Geodatabase and provided to NJDEP as part of this Study. The Geodatabase includes location information, along with updated relevant data for all identified primary transmission and interconnection infrastructure. The Geodatabase also includes relevant background layers and corresponding features that were used in the development of the model and for use with other aspects of this study. The Geodatabase is projected in the NJ State Plane Coordinate System, North American Datum 1983, as units in feet for consistency with other NJEMS data. A list of the primary features included in the Geodatabase is provided below.

- Water Systems
  - Line Features
    - Primary transmission mains;
    - Mains associated with primary interconnections;
    - Additional water mains necessary for completion of hydraulic model.
  - Point Features
    - Primary interconnections
    - Pump stations associated with the transfer of water at a primary interconnection, integral to the flow of water in primary transmission mains, or necessary for completion of the hydraulic model.
    - Control valves associated with the transfer of water at a primary interconnection or integral to the flow of water in primary transmission mains, or necessary for completion of the hydraulic model.
    - Storage facilities integral to the flow of water in primary transmission mains, or necessary for completion of the hydraulic model.
    - Points of entry for sources of supply (treatment plants, wells, etc.) integral to the flow of water in primary transmission mains or necessary for completion of the hydraulic model.
  - Polygon Features
    - Water service area boundaries for systems serving greater than 10,000 people.

- Background Information
  - Line features
    - Road centerlines used as a background map during the creation of the hydraulic model.
    - County and municipal boundaries.
    - Digital Elevation Model (DEM) data used to assign model node elevations.

Attribute tables were created for each of the water system feature classes. The attribute tables are populated with and consistent with information from the hydraulic model. The attribute tables for the primary interconnections also contain additional information from the interconnection database. The interconnections are labeled using a unique identifier consistent with the interconnection ID used in the interconnection database. This will also allow the features to be linked to the NJEMS tables as needed.

2.7 Interconnection Capacity Evaluation

Task 1 required the calculation of estimated capacities for all primary interconnections. The method used to estimate the interconnection capacities was based on the method that was used in the 1980 New Jersey Statewide Water Supply Plan and the 1986 Water Resources Interconnection Feasibility Study. This method considers three (3) primary components of the capacity to transfer water through an interconnection: Availability of Excess Supply, Contractual Agreements, and Hydraulic Capacity. These components are defined later in this chapter.

The interconnection capacity estimates were completed through use of spreadsheets. The spreadsheets document existing information needed to complete the analyses and also document the calculations used to complete the evaluation. The evaluation required documentation of existing source of supply capacity and demands and projecting future demands. Sources of information for each of the respective data needed to complete the evaluation are documented in sections below. In all cases, the tabulated information used to complete the capacity estimates constitutes best available information based on the data sources used for this study. The information reflects review comments provided by NJDEP and water systems. However, due to the quantity of data involved in completing this evaluation and difficulties in obtaining data, it is acknowledged that there may be errors in the reported data. Thus, all capacity valves should be considered approximate, order of magnitude estimates. A description of the tabulation of existing information used to complete the evaluation, the methods used to complete the evaluation, and the results of the evaluation are provided in subsequent sections.

Two-way flow interconnections were identified based on the interconnection database, review comments, and additional available information. For two-way flow interconnections, the interconnection hydraulic capacity and the excess treated water supply capacity were estimated for supply in both directions, according to the methods described below. Additionally, the Interconnection Contractual Capacity was provided for supply in both directions, as applicable.

The hydraulic model developed as part of Task 2 provides a means to simultaneously analyze the components that impact the capacity to transfer water through an interconnection under a variety of system conditions. Thus, the model was used as a tool when estimating the capacities of primary interconnections between 2 systems included in the hydraulic model.

2.7.1 Demands

<u>Current Demands</u>

Current Average Day Demand (ADD) and Maximum Day Demand (MDD) were documented for each system serving greater than 10,000 people. The following sources of information were used in tabulating the historical demands (listed in order of precedence of use):

1. NJDEP supplied values
2. System Supplied Data
3. NJDEP Staff and Technical Reports
4. NJDEP Surplus\Deficit Data

Available historical ADD and MDD were documented for the years 2000 through 2005. This tabulation was initiated in 2005, and as such, information for most systems was only available through 2004. Further, for many of the systems, information was typically not available for all five (5) years between 2000 and 2004. In many cases, only 1 year of historical data was available. Based on the availability of data, a "Current" ADD was estimated to be an average of all reported ADD values (on a yearly basis) between 2000 and 2005. If only 1 year of historical ADD was available, that value was assumed to be the "Current" ADD. Further, any current ADD values directly provided by NJDEP were assumed to be the "Current" ADD.

When possible, historical MDD values were tabulated based on reported MDD values for a given year. When historical MDD values were unavailable, the NJDEP Staff and Technical Reviewer Reports and Surplus\Deficit Data were used to estimate a MDD. These sources of information based the MDD on the average daily demand for the peak demand month in a given year. Current MDD was assumed to be the maximum MDD between 2000 and 2005, determined as described above, or a current MDD value provided by NJDEP, if greater than the maximum value between 2000 and 2005. If an MDD was not available from any of the mentioned sources, the MDD was estimated based on an assumed MDD to ADD ratio of 2.0.

<u>Future Demands</u>

Future demands were projected for the year 2020 for each system serving greater than 10,000 people. Demand projections were provided by New Jersey American Water Company (NJAWC) – Western Division, Newark, and Marlboro. It was assumed that demand projections obtained from systems provide the best available information and thus were utilized when available. For all other systems, demand projections were developed based on per capita demand estimates and population projections.

A database of population served by municipality for each system was obtained; however, the data did not properly reflect populations served for bulk service customers. Further, errors were identified in populations served when considering other available information. As a result, effort was made to update and verify the current population served values in this database. In order to account for the populations served for a bulk service customer, estimates regarding the percentage of normal daily supply received through the bulk service connection were made. These estimates are presented in Table 2-4. *(Please note, because of the length of the remaining tables in Section2 they have been relocated to the end of this Section)* The assumed normal daily supply (based on a percentage of total daily supply) was estimated based on available information from system demand and production data, system treatment capacities, system inspection reports, allocation information, reviewed comments, and other available information. The estimated percentage of total daily supply for bulk service customers was then used to estimate the percentage of the total population served within the receiving system by the bulk supplying system. The estimated percentage of total daily supply was assumed to be directly correlated (equal) to the percentage of the total population served within the receiving system that is supplied by the bulk supplying system.

Current and projected population estimates by municipality developed by the Metropolitan Planning Organization, as provided by NJDEP, were obtained for use in projecting future demands. It was assumed that the population projections represent the best available information for the purpose of this study regarding future growth of the water systems and corresponding demands. The percentage of the total municipal population served by municipality for each water system was estimated based on the current population estimates and updated population served estimates, which account for bulk service between systems as described above. It was assumed that future growth of the water system would increase at the rate of growth of the population for the municipalities it serves (directly and via bulk service). The future population served for each system by municipality was estimated based on the projected municipal populations and the percentage of total municipal population served. A detailed breakdown of the current and projected populations served for each system by municipality is provided in Table 2-5.

A current per capita demand was estimated for each system based on the current ADD and the updated population served estimate. It is acknowledged that per capita residential demands are decreasing in some areas of the state as a result of the 1992 Energy Policy Act and general advances in water conservation of fixtures. However, sufficient historical data to analyze such trends on an individual system basis was not available for this study. Thus, it was assumed that the per capita demand for each system would remain constant in the future. The future ADD was then estimated based on the projected population served estimate and the estimated per capita demand. The future MDD was estimated based on the calculated current MDD to ADD peaking factor. A summary of the current and projected future demands is provided in Table 2-6.

Drought and Emergency Condition Demands

Demands for each system were estimated for drought and emergency conditions by applying assumed demand reduction factors to the system ADD values. Actual percentage reductions in demand for a given drought or emergency condition will vary greatly depending on the severity and duration of the given drought or emergency event and the customer base of the given system. Daily demand records from recent drought periods such as 1999 or 2002 could be used to estimate individual reduction factors for each system; however, daily demand records were not available from each system in the study. Thus, for the purpose of this study, uniform reduction factors that are assumed to be reasonable reduction goals were applied to all systems for a theoretical drought or emergency condition.

The theoretical drought condition assumes that the given system has already reached a Stage 4 – Drought Emergency. Section 6 of this report provides additional detail regarding systems response to drought conditions, including demand reduction goals for other states in the northeast United States. Based on the demand reductions goals recommended for the State of New Jersey, as described in Section 6, a demand reduction factor of 0.85 (15%) was used to estimate system demands during drought conditions. Estimated current and future drought condition demands are shown in Table 2-6.

The theoretical emergency condition assumes that the system is experiencing a severe water supply shortage of 35% or more and/or loss of a primary system facility. In the 1980 New Jersey Statewide Waster Supply Master Plan, emergency demands were estimated using a reduction factor between 0.33 (systems serving greater than 1,000,000 people) and 0.75 (systems serving less than 2,500 people). Based on feedback from NJDEP, it is believed that a reduction factor of 0.33 would be difficult to achieve for systems greater than 1,000,000 as the large, urban systems are less likely to abide by discretionary use restrictions. Based on the reduction factors utilized in the 1980 Plan, feedback from NJDEP, and a review of available literature regarding drought and emergency system conditions and response, a reduction factor of 0.50 was assumed for all systems. Estimated current and future emergency condition demands are shown in Table 2-6.

2.7.2 Source of Supply

Available information was reviewed to determine the total treated water supply capacity for each system for use in the interconnection capacity analyses, development of the hydraulic model, and for use with other tasks of this study. The total treated water supply capacity is a function of the available raw water supply and the capacity of the corresponding treatment plants and can be limited by either factor. The water supply limit for each system was based on Monthly Allocation Limits as reported in the on-line NJDEP Deficit/Surplus database, unless other information was directly provided by NJDEP or individual systems. The Monthly Allocation limits were converted to a daily average by dividing the monthly limit by 30.5 days per month for use in this study. The water supply limit is considered to be the available raw water supply for a system under normal conditions. The total safe yield is considered the available raw water supply for a given system under drought conditions. The total treatment plant capacity for each system was tabulated per information from a database provided by NJDEP, unless other information regarding the total system treated water supply capacity was provided by NJDEP or individual systems. The database provided capacities for individual treatment plants by system. The total treated water supply capacity for normal conditions is the lesser of the water supply limit and the treatment plant capacity. The total treated water supply capacity for drought conditions is considered to be the lesser of the total safe yield and the total treatment plant capacity. A summary of the total treated water supply capacities for each system is presented in Table 2-7. Table 2-7 also includes reported contract bulk purchase amounts for each system.

Several comments and assumptions regarding the source of supply data are noted below:

- Identified individual treatment plants for the following systems were listed as having a capacity of 0 mgd: Garfield Water Department, Jackson Township Municipal Utilities Authority (MUA), NJAWC - Lakewood, Park Ridge Water Department, Ridgewood Water Department, Sparta Township Water Department, and United Water - Rahway. It was conservatively assumed that the capacities of these plants are 0 mgd or they do not exist.
- The Water Supply Limits for North Brunswick, New Brunswick, and Middlesex were adjusted to include the contract limit for purchase of raw water from New Jersey Water Supply Authority - Raritan.
- The Water Supply Limit for New Jersey Water Supply Authority - Manasquan was not available. However, the limit is assumed to be greater than the Total Treatment Plant Capacity of 4.0 mgd based on available information and is listed as such in Table 2-7.

2.7.3 Interconnection Capacity Calculations

<u>Excess Supply Capacity</u>

The excess supply capacity is defined as the total available treated water supply capacity of a supplying system that, after supplying its ADD, can be transferred to another system. Excess supply capacity was first analyzed on a total system basis and then considered for transfers between systems for each of the primary interconnections. In many case drought supply capacities were not available and thus the drought excess supply capacity could not be calculated. The analysis was also conducted for existing and future demands.

The treated water supply capacity for a system was tabulated as described in Section 2.6.2, and was assumed to remain constant for current and future conditions for the purpose of this analysis. The demands of the supplying and receiving systems were assumed to be equal to the system ADD, which were tabulated as described in Section 2.6.3. The excess supply capacity for a system under normal conditions is thus assumed to be the total treated water supply capacity, less the system ADD. The excess supply capacity for a system under drought conditions is assumed to be the total safe yield, less the system ADD. A negative value for the excess supply capacity for a system indicates that the system demand is greater than the treated water supply capacity. All systems that have a negative excess supply capacity for current and future conditions, excluding Hammonton Water Department (Hammonton) and NJAWC – Lakewood, receive water through a bulk service interconnection on a normal basis to compensate for the lack of available supply within the given system. Analyses indicate a negative excess supply capacity for Hammonton and NJAWC – Lakewood for future conditions. According to available information, NJAWC – Lakewood has a contract to purchase up to approximately 4 mgd through bulk service connections, and thus it is assumed the system could utilize such connections to meet any source of supply needs in the future. The negative future excess supply capacity for Hammonton may indicate the need for additional supply for this system or the need for bulk purchase of water in the future. A summary of the excess supply capacities for each system serving greater than 10,000 people is provided in Table 2-8.

The excess supply capacities for each system were then used to estimate the excess supply that can be transferred between the supplying system and receiving system for each of the primary interconnections. For the purpose of calculating interconnection capacities, it was assumed that all excess supply capacity will be supplied to a single interconnected system and flow to interconnections with other systems from the supplying system will continue at normal flow rates. Systems that are bulk service providers were considered as an "Additional Supplier" for the corresponding receiving systems. Per NJDEP, it was assumed the excess supply capacity from the bulk supplier can be available to a primary interconnection between the normal bulk service receiving system and another system. In order to account for the normal supply to the receiving system, which is already reflected in the demands of the supplying system, the assumed normal supply to the receiving system was subtracted from the suppliers ADD when calculating the excess supply capacity. Thus, the normal supplies are included in the interconnection excess supply capacity. The assumed normal bulk service supplies used to complete the excess supply capacity estimates are documented in Table 2-4.

For the described method of calculation, it was not possible to consider limitations on the deliver of the excess supply capacity to a particular pressure zone or area of the receiving system considering system operations and capacity of system infrastructure. Thus, for the systems that were not included in the hydraulic model, the excess supply capacity was analyzed solely for transfers on a system to system basis assuming that the excess supply capacity can be conveyed to the primary interconnection. For primary interconnections between two systems in the model, the model was used to analyze the ability of the receiving system to transfer the excess supply capacity to the corresponding interconnection. The system to system excess supply capacity for the primary interconnections is presented in Table 2-9.

Contractual Capacity

The transfer of water between systems is often governed by a contractual agreement between the supplying and receiving system. The contractual agreements typically set forth maximum transfer flows and conditions. Contractual flow limits between systems were tabulated when available based on information from the following sources listed in order of precedence of use: system supplied data, NJDEP staff and technical reviewer reports, and NJDEP inspection reports. In all cases, the contractual capacity is considered to correspond to the system to system transfer capacity. Contractual capacities related to individual interconnections between systems that are interconnected at multiple locations typically do not exist and were not available for this study. The identified contractual capacities between systems with primary interconnections are shown in Table 2-10.

Hydraulic Capacity

The hydraulic capacity of an interconnection is dependent upon many factors. These factors include the following:

- Hydraulic capacity of the interconnection piping, valves, and pumping facilities;
- Hydraulic capacity of the primary transmission systems on the source and receiving sides of the interconnection;
- Demand conditions;
- Hydraulic gradient\pressure differential between interconnected systems;
- Capacity of system facilities; and
- Existing system flows and pressures.

A method was developed to calculate order of magnitude estimates of the hydraulic capacity of all primary interconnections by developing assumptions related to the factors that can influence the capacity. Additionally, the model was used to verify that the estimated hydraulic capacities of primary interconnections between two systems included in the model were reasonable.

The hydraulic capacity of a pumped interconnection was assumed to be equal to the design capacity of the corresponding pump station. It is assumed that the interconnection capacities available from the interconnection database for pumped interconnections are based on pump capacities, and thus were assumed to be representative of the hydraulic capacity for a pumped interconnection unless additional information regarding pump capacity was available from information provided by a system or another data source.

Flow capacities for gravity interconnections were estimated using a standard flow/headloss equation similar to the 1980 and 1986 studies. In addition to the estimate using the flow/headloss equation, an estimate of the flow capacity through the interconnection at a maximum velocity of 5 feet per second (fps) through the transmission mains connected to the interconnection was calculated and compared with the capacity calculated from the flow/headloss equation. This additional calculation attempts to account for headloss within the supplying and receiving systems by recognizing that high velocities in pipelines on either side of the interconnection may cause high headloss that exceeds the available differential pressure between the supplying and receiving systems. The flow capacity of a gravity interconnection is assumed to be limited by the minimum pipe diameter on either side of the interconnection. A summary of the estimated hydraulic capacities for the primary interconnections is provided in Table 2-11. A list of the assumptions used to develop the hydraulic capacity calculations is provided below:

- The flow/headloss equation utilized was the Hazen Williams Equation.
- A theoretical interconnection was assumed to consist of the following:
  - 25 feet of main on the receiving and supplying side of the interconnection
  - (2) 90-degree bends
  - 2 valves
  - 2 tee junctions
  - 1 meter
- The C Factor for all interconnection piping was assumed to be 100.
- If the diameter on the receiving and/or supplying side of the interconnection was unavailable, it was assumed to be 12 inches.
- The supplier and receiver normal pressures were obtained from the interconnection database unless other information was available. It was assumed that this pressure corresponds to a reading at the entrance and exit of the 25-foot sections of interconnection main.
- The estimated receiver emergency pressure was estimated to be 20 pounds per square inch (psi) less than the receiver's normal pressure, but not less than 40 psi. This assumes that the receiving system can operate at a lower pressure during emergency conditions.
- A normal pressure differential of 20 psi was assumed when the supplying or receiving pressure was not available; however, the minimum assumed pressure was assumed to be 40 psi.
- A gravity flow capacity was calculated for normal and emergency conditions if the corresponding pressure differential was greater than 0. If the pressure differential was 0 psi or negative (receiver pressure greater than the supplier pressure), the gravity flow capacity was assumed to be 0 mgd.
- The estimated interconnection hydraulic capacity is assumed to be equal to the maximum of the estimated pumped and gravity flow capacity estimates.
- The assumed gravity flow hydraulic capacity was set equal to values provided by individual systems, as appropriate.

2.8 Infrastructure Limitations

The excess supply capacities, contractual capacities, and hydraulic capacities were compared for transfer of water between systems at primary interconnections to identify the limiting capacity and corresponding factor that limits the capacity. The comparisons were completed on a system to system basis as information was generally not available regarding the excess supply capacity and the contractual capacity at individual interconnections. Thus, the sum of the total estimated hydraulic capacity was compared with the excess supply capacity and the contractual capacity. The tabulation of the interconnection capacities and corresponding limitations is provided in Table 2-12. Limitations were noted if the total estimated hydraulic capacity or contractual capacity was identified as the limiting factor. Additionally, limitations were noted for systems that cannot receive water through a primary interconnection. A summary of the identified limitations is provided below.

The identified infrastructure limitations can help identify the type of improvement that may be needed to increase the capacity of a given interconnection. However, an identified infrastructure limitation should not necessitate an improvement if the capacity of the given interconnection is adequate or if a given interconnection is not needed. Thus, improvements to address identified infrastructure limitations are not included as part of Chapter 2. The results of the catastrophic analyses, water supply management decision support tool, and optimization of existing water diversions, which are documented in Chapters 4, 5, and 6 of this report, were used to determine the need to address the identified limitations. Correspondingly, if necessary, improvements to address identified limitations are provided in subsequent chapters of this report.

Hydraulic Limitations

System-to-system transfers at primary interconnections that are limited by the estimated hydraulic capacity are noted as such in Table 2-12. Table 2-13 provides a summary of these primary interconnections that were identified as having a hydraulic limitation. Due to the method used to calculate the hydraulic capacities and corresponding level of accuracy, minor differences between available excess supply and hydraulic capacity are not considered of significant concern. However, an excess supply capacity that greatly exceeds the estimated hydraulic capacity may indicate that pipeline or system improvements could be implemented to allow transfer of a greater flow rate through the primary interconnection.

Table 2-14 provides a list of primary interconnections in which the difference between the diameter of the reported supplying and receiving transmission or interconnection mains are greater than 3 standard pipe diameters. (Standard pipe diameters are assumed as follows: 12-inch, 16-inch, 20-inch, 24-inch, 30-inch, 36-inch, 42-inch, 48-inch, 54-inch, 60-inch, and 72-inch.) These interconnections are noted as having a potential hydraulic restriction. The smaller diameter main at the interconnection or in the corresponding transmission main may be severely limiting the hydraulic capacity of the interconnection. Implementing pipeline improvements to increase the size of the smaller diameter main could significantly increase the capacity of the interconnection. However, as noted above, such improvements should be dictated by a specific need, and thus are not addressed as part of Chapter 2.

Contractual Limitations

System-to-system transfers at primary interconnections that are limited by the reported contractual capacity are noted in Table 2-12. Table 2-15 provides a summary of these primary interconnections that are impacted by a contractual limitation based on available data. In many cases, a written or unwritten agreement is formed between systems, which can override contractual limitations during specific situations of need. Thus, contractual limitations do not necessarily limit the transfer of water between systems during specific situations, and thus do not necessarily require immediate attention. However, resolution of contractual limitations could provide a simple means to avoid potential issues regarding contractual limitations when additional flow is needed. All systems that are listed in Table 2-15 should consider resolving any contractual issues that may limit the amount of water that can be transferred through an interconnection during a time of need. The urgency to address a specific contractual limitation should be based on the need to transfer water at a rate greater than the contractual capacity, the amount that the contractual capacity could be increased considering excess supply and hydraulic capacity, and existing relationships between the corresponding systems.

No Primary Interconnections

Systems that serve greater than 10,000 people, but are not able to receive water through a primary interconnection, are identified in Table 2-16. Of the 141 systems that serve greater than 10,000 people, 65 systems can receive water through one or more of the 226 identified primary interconnections. Of the remaining 76 systems, 45 systems can receive water through one or more non-primary interconnections as shown in Table 2-17. The remaining 31 systems cannot receive water through an interconnection with another system per available data. As noted above, the development of a primary interconnection for those systems that do not have a primary interconnection should be dictated by a specific need, considering the availability of non-primary interconnections, and thus are not addressed as part of Chapter 2.

Table 2-4
Summary of Assumed Normal Bulk Service Supplies

Receiving System		Assumed Supplying Systems		
PWSID #	System Name	PWSID #	System Name	Assumed Percentage of Supply(1)
0119002	NJ AMERICAN WATER CO ATLANTIC	0102001	ATLANTIC CITY MUA	15
		0119002	NJ AMERICAN WATER CO ATLANTIC	85
0901001	BAYONNE MUA	1613001	NJDWSC (WANAQUE SOUTH)	100
0701001	BELLEVILLE WATER DEPT	0714001	NEWARK WATER DEPT	100
0702001	BLOOMFIELD WATER DEPT	1613001	NJDWSC (WANAQUE NORTH & SOUTH; through Newark)	100
1103001	AQUA NJ - HAMILTON SQ	1111001	TRENTON CITY WATER DEPARTMENT	3
		1103001	AQUA NJ - HAMILTON SQ	97
0704001	CEDAR GROVE WATER DEPT	1613001	NJDWSC (WANAQUE SOUTH)	55
		0907001	KEARNY W DEPT	30
		1605002	PASSAIC VALLEY W COMM	15
1408001	DENVILLE TWP WATER DEPT	1432001	MORRIS CO MUA	17
		1408001	DENVILLE TWP WATER DEPT	83
0802001	DEPTFORD MUA	0327001	NJ AMERICAN WATER CO WESTERN DIV	40
		0802001	DEPTFORD MUA	60
0705001	EAST ORANGE WATER DEPT	0714001	NEWARK WATER DEPT	15
		0705001	EAST ORANGE WATER DEPT	85
1204001	EAST BRUNSWICK WATER UTILITY	1225001	MIDDLESEX W CO	100
1205001	EDISON WATER CO	2004002	ELIZABETHTOWN WATER CO	90
		1225001	MIDDLESEX W CO	10
0211001	ELMWOOD PARK WATER DEPT	1605002	PASSAIC VALLEY W COMM	100
0217001	FAIR LAWN WATER DEPT	0238001	UNITED WATER NJ	5
		1605002	PASSAIC VALLEY W COMM	50
		0217001	FAIR LAWN WATER DEPT	45
1808001	FRANKLIN TWP DEPT PUBLIC	2004002	ELIZABETHTOWN WATER CO	59
		1214001	NEW BRUNSWICK W DEPT	41
		1215001	NORTH BRUNSWICK W DEPT	<1
		1221004	SOUTH BRUNSWICK TWP W DI	<1
1316001	FREEHOLD TWP WATER DEPT	1326004	UNITED WATER MATCHAPONIX	10
		1316001	FREEHOLD TWP WATER DEPT	90
0221001	GARFIELD W DEPT	1605002	PASSAIC VALLEY W COMM	60
		0221001	GARFIELD W DEPT	40
1326001	GORDONS CORNER WATER CO	1328002	MARLBORO MUA	31
		1326004	UNITED WATER MATCHAPONIX	31
		1326001	GORDONS CORNER WATER CO	38
1603001	HALEDON WATER DEPT	1605002	PASSAIC VALLEY W COMM	100
0904001	HARRISON W DEPT	1605002	PASSAIC VALLEY W COMM	100
1207001	HIGHLAND PARK W DEPT	1225001	MIDDLESEX W CO	100
0905001	HOBOKEN WATER SERVICES	0906001	JERSEY CITY MUA	100
1321001	KEANSBURG WATER & SEWER DEPT	1345001	NJ AMERICAN W CO - COASTAL NORTH	10
		1321001	KEANSBURG WATER & SEWER DEPT	90
0907001	KEARNY W DEPT	1613001	NJDWSC (WANAQUE NORTH & SOUTH)	100
2004001	LIBERTY WATER COMPANY	0714001	NEWARK WATER DEPT	40
		2004002	ELIZABETHTOWN WATER CO	60
1416001	LINCOLN PARK WATER DEPT	1605002	PASSAIC VALLEY W COMM	100
0710001	LIVINGSTON TWP DIV OF WATER	0712001	NJ AMERICAN W SHORT HILLS	3
		0710001	LIVINGSTON TWP DIV OF WATER	97
0232001	LYNDHURST WATER DEPARTMENT	0906001	JERSEY CITY MUA	100
0233001	MAHWAH WATER DEPARTMENT	0238001	UNITED WATER NJ	15
		0233001	MAHWAH WATER DEPARTMENT	85
1328002	MARLBORO MUA	1225001	MIDDLESEX W CO	75
		1328002	MARLBORO MUA	25
1225001	MIDDLESEX W CO	2004002	ELIZABETHTOWN WATER CO	10
		1352005	NJWSA RARITAN (raw water)	60
		1225001	MIDDLESEX W CO	30
1213002	MONROE TWP MUA	2004002	ELIZABETHTOWN WATER CO	17
		1213002	MONROE TWP MUA	83
0713001	MONTCLAIR WATER BUREAU	1613001	NJDWSC (WANAQUE NORTH)	85
		0713001	MONTCLAIR WATER BUREAU	15
1421003	MONTVILLE TWP MUA	0906001	JERSEY CITY MUA	35
		1421003	MONTVILLE TWP MUA	65

Table 2-4
Summary of Assumed Normal Bulk Service Supplies

Receiving System		Assumed Supplying Systems		
PWSID #	System Name	PWSID #	System Name	Assumed Percentage of Supply[1]
0324001	MT LAUREL TWP MUA	0327001	NJ AMERICAN WATER CO WESTERN DIV	26
		0338001	WILLINGBORO TWP MUA	20
		0324001	MT LAUREL TWP MUA	54
0323001	MOUNT HOLLY WATER CO	0327001	NJ AMERICAN WATER CO WESTERN DIV	10
		0323001	MOUNT HOLLY WATER CO	90
0714001	NEWARK WATER DEPT	1613001	NJDWSC (WANAQUE NORTH & SOUTH)	43
		0714001	NEWARK WATER DEPT	57
1345001	NJAWC - COASTAL NORTH	1352005	NJWSA MANASQUAN (raw water)	5
		1345001	NJ AMERICAN W CO - COASTAL NORTH	95
1605001	NJ AMERICAN W CO LITTLE	1605002	PASSAIC VALLEY W COMM	75
		0713001	MONTCLAIR WATER BUREAU	25
0712001	NJ AMERICAN W CO SHORT HILLS	1605002	PASSAIC VALLEY W COMM	21
		2004002	ELIZABETHTOWN WATER CO	34
		1432001	MORRIS CO MUA	2
		0712001	NJ AMERICAN W CO SHORT HILLS	43
1214001	NEW BRUNSWICK W DEPT	1352005	NJWSA RARITAN (raw water)	25
		1214001	NEW BRUNSWICK W DEPT	75
1215001	NORTH BRUNSWICK WATER DEPT	1352005	NJWSA RARITAN (raw water)	100
0716001	NUTLEY WATER DEPT	1613001	NJDWSC (WANAQUE SOUTH; through PVWC)	100
		0714001	NEWARK WATER DEPT	<1
1209002	OLD BRIDGE MUA	1225001	MIDDLESEX W CO	60
		1209002	OLD BRIDGE MUA	40
1429001	PARSIPPANY-TROY HILLS WATER CO	0906001	JERSEY CITY MUA	4
		1429001	PARSIPPANY-TROY HILLS WATER CO	96
1605002	PASSAIC VALLEY W COMM	1613001	NJDWSC (WANAQUE NORTH)	45
		1605002	PASSAIC VALLEY W COMM	55
0239001	PVWC-NORTH ARLINGTON	1605002	PASSAIC VALLEY W COMM	100
1431001	PEQUANNOCK TWP WATER DEPT	0714001	NEWARK WATER DEPT	40
		1431001	PEQUANNOCK TWP WATER DEPARTMENT	60
0248001	RAMSEY WATER DEPARTMENT	0238001	UNITED WATER NJ	25
		0248001	RAMSEY WATER DEPARTMENT	75
1432003	RANDOLPH TWP PW DEPT	1432001	MORRIS CO MUA	100
0251001	RIDGEWOOD WATER DEPT	0238001	UNITED WATER NJ	10
		0251001	RIDGEWOOD WATER DEPT	90
0257001	SADDLE BROOK WATER DEPT	0238001	UNITED WATER NJ	100
1219001	SA YREVILLE W DEPT	1225001	MIDDLESEX W CO	25
		1219001	SA YREVILLE W DEPT	75
1339001	SHORELANDS WATER CO INC	1345001	NJ AMERICAN W CO - COASTAL NORTH	55
		1339001	SHORELANDS WATER CO INC	45
1221004	SOUTH BRUNSWICK TWP W DI	2004002	ELIZABETHTOWN WATER CO	70
		1221004	SOUTH BRUNSWICK TWP W DI	30
1424001	SOUTHEAST MORRIS COUNTY MUA	0712001	NJ AMERICAN W SHORT HILLS	30
		1424001	SOUTHEAST MORRIS COUNTY MUA	70
0719001	SOUTH ORANGE WATER DEPT	0705001	EAST ORANGE WATER DEPT	90
		0719001	SOUTH ORANGE WATER DEPARTMENT	10
1223001	SOUTH RIVER W DEPT	1204001	EAST BRUNSWICK WATER UTILITY	100
0238001	UNITED WATER NJ	1613001	NJDWSC (WANAQUE SOUTH; raw water only)	Unk.
		0906001	JERSEY CITY MUA	5
		0238001	UNITED WATER NJ	Unk.
2013001	UNITED WATER RAHWAY	1225001	MIDDLESEX W CO	1
		2013001	UNITED WATER RAHWAY	99
0720001	VERONA WATER DEPARTMENT	1605002	PASSAIC VALLEY W COMM	55
		0720001	VERONA WATER DEPARTMENT	45
1352003	WALL TWP WATER DEPT	1352005	NJWSA MANSQUAN	100
0265001	WALLINGTON WATER DEPT	1605002	PASSAIC VALLEY W COMM	100
1614001	WAYNE TWP DIVISION OF WATER	1613001	NJDWSC (WANAQUE SOUTH)	100
0721001	WEST CALDWELL WATER DEPT	0906001	JERSEY CITY MUA	98
		0715001	NORTH CALDWELL	2
0820001	WEST DEPTFORD TWP WATER DEPT	0327001	NJ AMERICAN WATER CO WESTERN DIV	45
		082001	WEST DEPTFORD TWP WATER DEPT	55

Table 2-4
Summary of Assumed Normal Bulk Service Supplies

Receiving System		Assumed Supplying Systems		
PWSID #	System Name	PWSID #	System Name	Assumed Percentage of Supply[1]
0822001	WOODBURY CITY WATER DEPT	0327001	NJ AMERICAN WATER CO WESTERN DIV	15
		0822001	WOODBURY CITY WATER DEPT	85

Notes:
(1) Estimated as the approximate percentage of the total system demand for the receiving system that is supplied by the supplying system for a typical year.

Table 2-5
Current and Projected Populations Served by Municipality

PWSID #	SUPPLYING SYSTEM NAME	MUNICIPALITY/SYSTEM SERVED[1]	Total Municipality Population[2] Current (2005)	Total Municipality Population[2] Future (2020)	Population Served: Estimated Current Population Served	Population Served: Percent of Current Municipal Population Served[3]	Population Served: Projected Population Served (2020)	Total Population Served by System[4] Current (2005)	Total Population Served by System[4] Future (2020)
0102001	ATLANTIC CITY MUA	Atlantic City	40,767	41,289	37,000	91%	37,470	50,213	53,645
		NJAWC - Atlantic Co			13,213		16,175		
0103001	BRIGANTINE WATER DEPT	Brigantine	12,825	13,468	15,000	100%	15,640	15,000	15,640
0112001	HAMILTON TWP MUA	Hamilton	22,856	30,819	16,123	71%	21,740	16,783	22,480
		Weymouth	2,354	2,652	660	28%	740		
0113001	HAMMONTON WATER DEPT	Hammonton	13,134	14,754	12,153	93%	13,650	12,153	25,803
0119002	NJ AMERICAN WATER CO ATLANTIC	Absecon	7,851	8,479	7,565	96%	8,170	88,088	107,830
		Egg Harbor Township	34,910	49,339	18,997	54%	26,850		
		Galloway	35,008	47,928	23,262	66%	31,850		
		Linwood	7,473	8,394	7,708	100%	8,630		
		Northfield	8,047	9,033	8,500	100%	9,490		
		Pleasantville	19,335	20,227	13,173	68%	13,780		
		Somers Point	11,712	11,942	8,883	76%	9,060		
0122001	VENTNOR CITY WATER & SEWER AUTH	Ventnor City	13,024	13,295	14,000	100%	14,270	14,000	14,270
0211001	ELMWOOD PARK WATER DEPT	Elmwood Park borough	19,190	20,080	18,925	99%	19,800	18,925	19,800
0217001	FAIR LAWN BORO WATER DEPT	Fair Lawn borough	31,830	32,910	32,000	100%	33,080	32,000	33,080
0221001	GARFIELD CITY WATER DEPT	Garfield city	30,940	32,650	29,749	96%	31,390	29,749	31,390
0232001	LYNDHURST WATER DEPT	Lyndhurst Township	19,420	20,260	19,800	100%	20,640	19,800	20,640
0233001	MAHWAH WATER DEPT	Mahwah Township	24,640	25,600	24,061	98%	25,000	24,061	25,000
0238001	UNITED WATER NJ	Allendale Borough	6,800	7,090	6,900	100%	7,190	824,431	871,710
		Alpine Borough	2,260	2,390	2,018	89%	2,130		
		Bergenfield Borough	26,910	28,430	26,215	97%	27,700		
		Bogota Borough	8,260	8,570	8,210	99%	8,520		
		Carlstadt Borough	5,940	6,170	5,973	100%	6,200		
		Cliffside Park Borough	23,130	23,920	22,954	99%	23,740		
		Closter Borough	8,480	8,880	8,484	100%	8,880		
		Cresskill Borough	7,850	8,060	7,861	100%	8,070		
		Demarest Borough	4,850	5,040	4,901	100%	5,090		
		Dumont Borough	17,510	18,110	17,533	100%	18,130		
		East Rutherford Borough	8,720	8,780	8,713	100%	8,770		
		Edgewater Borough	10,700	11,900	18,961	100%	20,160		
		Emerson Borough	7,280	7,550	7,265	100%	7,530		
		Englewood city	26,520	27,580	26,159	99%	27,200		
		Englewood Cliffs Borough	5,450	5,650	5,475	100%	5,680		
		Fair Lawn Water Dept			1,600		1,650		
		Fairview Borough	13,930	14,540	13,363	96%	13,950		
		Fort Lee Borough	37,250	38,540	36,963	99%	38,240		
		Franklin Lakes Borough	11,150	11,690	5,055	45%	5,300		
		Guttenberg Town	11,720	12,980	11,075	94%	12,270		
		Hackensack City	44,090	46,040	43,525	99%	45,450		
		Harrington Park Borough	4,840	5,000	4,757	98%	4,910		
		Hasbrouck Heights Borough	11,660	12,150	11,647	100%	12,140		
		Haworth Borough	3,390	3,580	3,407	100%	3,600		
		Hillsdale Borough	10,060	10,390	10,099	100%	10,430		
		Leonia Borough	9,160	9,490	8,888	97%	9,210		
		Little Ferry Borough	11,030	11,490	10,805	98%	11,260		
		Maywood Borough	9,600	10,080	9,511	99%	9,990		
		Mahwah Water Dept			3,609		3,750		
		Montvale Borough	7,200	7,490	7,277	100%	7,570		
		Moonachie Borough	2,810	2,980	2,810	100%	2,980		
		New Milford Borough	16,430	17,000	16,386	100%	16,950		
		North Bergen township	61,150	68,320	59,033	97%	65,950		
		Northvale Borough	4,530	4,640	4,530	100%	4,640		
		Norwood Borough	6,070	6,200	6,131	100%	6,260		
		Old Tappan Borough	5,750	5,940	5,194	90%	5,370		
		Oradell Borough	8,500	8,540	8,044	95%	8,080		
		Palisades Park Borough	18,460	19,350	17,801	96%	18,660		
		Paramus Borough	26,610	28,110	26,275	99%	27,760		
		Ramsey Water Dept			4,163		4,300		
		Ridgefield Borough	11,170	11,750	10,929	98%	11,500		
		Ridgefield Park Village	13,040	13,440	12,823	98%	13,220		
		Ridgewood Water Dept			6,170		6,310		
		River Edge Borough	11,000	11,000	10,988	100%	10,990		
		River Vale Township	9,860	9,860	9,723	99%	9,720		
		Rochelle Park Township	5,720	5,930	5,528	97%	5,730		
		Rockleigh Borough	400	430	397	99%	430		
		Rutherford Borough	18,040	18,250	18,047	100%	18,260		
		Saddle Brook Water Dept			13,155		13,650		
		Saddle River Borough	3,410	3,410	450	13%	450		
		Secaucus Town	16,310	18,560	15,882	97%	18,070		
		South Hackensack Township	2,310	2,440	2,286	99%	2,410		

Table 2-5
Current and Projected Populations Served by Municipality

PWSID #	SUPPLYING SYSTEM NAME	MUNICIPALITY/SYSTEM SERVED[1]	Total Municipality Population[2] Current (2005)	Total Municipality Population[2] Future (2020)	Population Served: Estimated Current Population Served	Population Served: Percent of Current Municipal Population Served[3]	Population Served: Projected Population Served (2020)	Total Population Served by System[4] Current (2005)	Total Population Served by System[4] Future (2020)
0238001	UNITED WATER NJ	Teaneck Township	40,370	41,880	39,169	97%	40,630		
		Tenafly Borough	14,220	14,710	13,951	98%	14,430		
		Teterboro Borough	20	20	18	90%	20		
		Union City city	69,610	77,420	66,902	96%	74,410		
		Upper Saddle River Borough	8,210	8,430	85	1%	90		
		Co	9,480	9,860	9,349	99%	9,720		
		Weehawken Township	13,580	14,860	13,411	99%	14,680		
		West New York Town	48,730	53,950	46,884	96%	51,910		
		Westwood Borough	10,960	11,390	11,016	100%	11,450		
		Woodcliff Lake Borough	5,810	6,070	60	1%	60		
		Wood-Ridge Borough	7,620	7,890	7,638	100%	7,910		
0239001	PVWC-NORTH ARLINGTON	Lyndhurst Township	19,420	20,260	15	0%	20	15,514	16,010
		North Arlington Borough	15,170	15,660	15,499	100%	15,990		
0242001	OAKLAND WATER DEPT	Oakland Borough	13,720	14,310	12,000	87%	12,520	12,000	12,520
0247001	PARK RIDGE WATER DEPT	Park Ridge Borough	9,020	9,140	13,458	100%	13,580	13,458	13,580
0248001	RAMSEY WATER DEPT	Allendale Borough	6,800	7,090	42	1%	40	16,653	17,190
		Mahwah Township	24,640	25,600	45	0%	50		
		Ramsey Borough	14,430	14,960	16,479	100%	17,010		
		Upper Saddle River Borough	8,210	8,430	87	1%	90		
0251001	RIDGEWOOD WATER DEPT	Glen Rock Borough	11,620	11,620	13,747	100%	13,750	61,700	63,070
		Midland Park Borough	6,930	7,140	3,414	49%	3,520		
		Ridgewood Village	25,110	26,370	28,971	100%	30,230		
		Wyckoff Township	16,850	16,850	15,568	92%	15,570		
0257001	SADDLE BROOK WATER DEPT	Saddle Brook Township	13,150	13,640	13,155	100%	13,650	13,155	13,650
0265001	WALLINGTON BORO DPW	Wallington Borough	11,600	12,210	12,000	100%	12,610	12,000	12,610
0303001	BORDENTOWN WATER DEPT	Bordentown City	4,031	4,390	4,422	100%	4,780	13,950	15,370
		Bordentown Township	10,183	11,300	8,928	88%	9,910		
		Fieldsboro Borough	585	660	600	100%	680		
0305001	BURLINGTON CITY WATER DEPT	Burlington City	9,838	10,370	9,835	100%	10,370	30,129	32,220
		Burlington Township	22,380	24,100	20,294	91%	21,850		
0313001	EVESHAM TWP MUA	Evesham Township	47,645	48,900	47,784	100%	49,040	47,784	49,040
0315001	FLORENCE TWP WATER DEPT	Florence Township	11,447	14,430	8,501	74%	10,720	8,501	10,720
0319001	MAPLE SHADE WATER DEPT	Maple Shade Township	19,345	19,340	19,200	99%	19,200	19,200	19,200
0320001	MEDFORD TWP DEP OF MUNIC UTIL	Medford Township	23,801	28,020	17,100	72%	20,130	17,100	20,130
0322001	TOWNSHIP OF MOORESTOWN	Moorestown Township	20,298	22,130	19,000	94%	20,710	19,000	20,710
0323001	MOUNT HOLLY WATER CO	Eastampton Township	6,839	8,530	4,881	71%	6,090	45,555	53,840
		Hainesport Township	6,313	7,500	5,961	94%	7,080		
		Lumberton Township	12,673	15,690	9,729	77%	12,050		
		Mansfield Twp Burlington Co	8,337	10,015	6,438	77%	7,730		
		Mount Holly Township	10,788	11,370	11,139	100%	11,720		
		Plumsted Township	7,890	9,980	1,395	18%	1,760		
		Southampton Township	11,130	11,980	720	6%	770		
		Westampton Township	8,277	10,390	5,292	64%	6,640		
0324001	MT LAUREL TWP MUA	Mount Laurel Township	40,644	43,600	40,000	98%	42,910	40,000	42,910
0325001	US ARMY FORT DIX	New Hanover Township	9,430	11,130	15,829	100%	17,530	15,829	17,530
0327001	NJ AMERICAN WATER CO WESTERN DIV	Audubon Borough	8,970	7,990	8,141	91%	7,250	282,928	287,390
		Audubon Park Borough	1,060	910	14	1%	10		
		Barrington Borough	7,120	6,690	5,365	75%	5,040		
		Bellmawr Borough	11,000	9,650	3,182	29%	2,790		
		Beverly City	2,688	3,010	2,875	100%	3,200		
		Burlington Township	22,380	24,100	378	2%	410		
		Camden City	79,320	78,330	21,502	27%	21,230		
		Cherry Hill Township	69,430	68,510	58,562	84%	57,790		
		Cinnaminson Township	15,179	15,870	17,396	100%	18,090		
		Clementon Borough	4,920	4,500	7	0%	10		
		Delanco Township	3,553	4,440	3,523	99%	4,400		
		Delran Township	16,982	17,425	14,741	87%	15,130		
		Edgewater Park Township	8,110	8,960	5,305	65%	5,860		
		Gibbsboro Borough	2,440	2,300	2,672	100%	2,530		
		Gloucester Township	66,240	72,900	16,684	25%	18,360		
		Haddon Heights Borough	7,380	6,680	6,964	94%	6,300		
		Haddon Township	14,260	13,030	1,134	8%	1,040		
		Haddonfield Borough	11,350	10,510	59	1%	50		
		Hi-Nella Borough	1,030	930	384	37%	350		
		Laurel Springs Borough	1,980	1,760	1,947	98%	1,730		
		Lawnside Borough	2,650	2,380	2,559	97%	2,300		
		Lindenwold Borough	17,410	17,220	7,993	46%	7,910		
		Magnolia Borough	4,480	4,060	4,335	97%	3,930		
		Maple Shade Township	19,345	19,340	103	1%	100		
		MOUNT HOLLY WATER CO			4,556		5,380		
		DEPTFORD MUA			10,400		11,040		

Table 2-5
Current and Projected Populations Served by Municipality

PWSID #	SUPPLYING SYSTEM NAME	MUNICIPALITY/SYSTEM SERVED[1]	Total Municipality Population[2]		Population Served			Total Population Served by System[4]	
			Current (2005)	Future (2020)	Estimated Current Population Served	Percent of Current Municipal Population Served[3]	Projected Population Served (2020)	Current (2005)	Future (2020)
0327001	NJ AMERICAN WATER CO WESTERN DIV	Mt Laurel Twp MUA			10,400		11,160		
		Wesr Deptford Twp Water Dept			9,000		10,130		
		Woodbury City Water Dept			1,649		1,600		
		Oaklyn Borough	4,110	3,620	3,640	89%	3,210		
		Palmyra Borough	7,878	7,580	6,055	77%	5,830		
		Pennsauken Township	34,970	33,040	2,784	8%	2,630		
		Riverside Township	8,030	8,910	7,110	89%	7,890		
		Riverton Borough	2,755	2,680	2,454	89%	2,390		
		Runnemede Borough	8,670	8,330	7,358	85%	7,070		
		Somerdale Borough	5,320	4,790	4,752	89%	4,280		
		Stratford Borough	7,360	6,520	6,119	83%	5,420		
		Voorhees Township	29,210	33,030	20,826	71%	23,550		
0329004	PEMBERTON TWP WATER DEPT MAIN SUPPLY	Pemberton Township	29,037	30,880	12,378	43%	13,160	12,378	13,160
0338001	WILLINGBORO TWP MUA	Mt Laurel twp MUA			8,000		8,580	47,999	51,170
		Westampton Township	8,277	10,390	3,000	36%	3,770		
		Willingboro Township	33,123	34,940	36,999	100%	38,820		
0405001	BERLIN BORO WATER DEPT	Berlin Borough	6,280	6,280	7,259	100%	7,260	13,121	12,810
		Berlin Township	5,420	5,070	5,632	100%	5,280		
		Voorhees Township	29,210	33,030	113	0%	130		
		Waterford Township	10,930	12,150	10	0%	10		
		Winslow Township	36,480	43,130	107	0%	130		
0408001	CAMDEN CITY WATER DEPT	Camden City	79,320	78,330	50,000	63%	49,380	50,000	49,380
0412001	COLLINGSWOOD BORO WATER DEPT	Collingswood Borough	14,100	13,560	14,100	100%	13,560	16,850	15,910
		Woodlynne Borough	2,750	2,350	2,750	100%	2,350		
0414001	GLOUCESTER CITY WATER DEPT	Gloucester City city	11,240	10,640	12,600	100%	12,000	12,600	12,000
0415002	AQUA NJ INC BLACKWOOD	Gloucester Township	66,240	72,900	49,190	74%	54,140	49,190	54,140
0416001	HADDON TWP WATER DEPT	Haddon Township	14,260	13,030	11,935	84%	10,910	11,935	10,910
0417001	HADDONFIELD BORO WATER DEPT	Haddonfield Borough	11,350	10,510	11,596	100%	10,760	11,616	10,780
		Tavistock Borough	20	20	20	100%	20		
0424001	MERCHANTVILLE PENNSAUKEN WATER COMM	Camden City	79,320	78,330	2,213	3%	2,190	48,997	46,800
		Cherry Hill Township	69,430	68,510	10,868	16%	10,720		
		Merchantville Borough	3,730	3,480	3,730	100%	3,480		
		Pennsauken Township	34,970	33,040	32,186	92%	30,410		
0428002	PINE HILL BORO MUA	Pine Hill Borough	11,900	13,270	12,411	100%	13,780	12,411	13,780
0436007	WINSLOW TWP MUN UTILITY-SICKLERVILLE	Waterford Township	10,930	12,150	2,955	27%	3,280	29,520	34,690
		Winslow Township	36,480	43,130	26,565	73%	31,410		
0508001	NJ AMERICAN W CO OCEAN CITY SYSTEM	Ocean City	15,828	17,179	27,135	100%	28,490	27,135	28,490
0514001	WILDWOOD CITY WATER DEPT	Middle	17,274	20,281	2,703	16%	3,170	17,996	19,940
		North Wildwood	5,086	5,540	5,086	100%	5,540		
		West Wildwood	467	521	467	100%	520		
		Wildwood	5,608	6,123	5,608	100%	6,120		
		Wildwood Crest	4,132	4,587	4,132	100%	4,590		
0601001	BRIDGETON CITY WATER DEPT	Bridegton	23,572	26,618	23,000	98%	25,970	23,000	25,970
0610001	MILLVILLE CITY WATER DEPT	Millville	27,946	32,126	27,500	98%	31,610	27,518	31,630
		Vineland	58,588	67,398	18	0%	20		
0614003	VINELAND CITY WATER & SEWER UTILITY	Vineland	58,588	67,398	33,000	56%	37,960	33,000	37,960
0701001	BELLEVILLE TOWN WATER DEPT	Belleville Township	36,140	37,110	35,129	97%	36,070	35,129	36,070
0702001	BLOOMFIELD TOWN WATER DEPT	Bloomfield Township	48,370	50,450	45,061	93%	47,000	45,061	47,000
0704001	CEDAR GROVE TWP WATER DEPT	Cedar Grove Township	12,470	12,830	12,300	99%	12,660	12,300	12,660
0705001	EAST ORANGE CITY WATER DEPT	East Orange City	70,180	73,720	69,824	99%	73,350	85,056	89,410
		South Orange Village Township			15,232		16,060		
0710001	LIVINGSTON TWP WATER DIVISION	Livingston Township	27,700	28,500	27,391	99%	28,180	27,391	28,180
0712001	NJ AMERICAN W SHORT HILLS	Bedminster Township	8,310	8,430	5,817	70%	5,900	243,366	257,710
		Belvidere Town	2,810	3,550	2,391	85%	3,020		
		Berkeley Heights Township	13,430	14,260	13,036	97%	13,840		
		Bernards Township	27,380	28,000	20,218	74%	20,680		
		Bernardsville Borough	7,700	8,550	5,076	66%	5,640		
		Chatham Township	10,130	9,960	7,576	75%	7,450		
		Chester Township	7,590	7,760	951	13%	970		
		Far Hills Borough	890	920	715	80%	740		
		Florham Park Borough	14,560	16,970	306	2%	360		
		Franklin Township Warren Co	3,210	3,860	198	6%	4,010		
		Frenchtown Borough	1,510	1,530	1,037	69%	1,050		
		Harding Township	3,250	3,580	101	3%	110		
		Hillside Township	21,860	23,430	56	0%	60		
		Irvington Township	61,460	63,740	24,964	41%	25,890		
		Livingston Twp Water Division			822		850		
		Long Hill Township	8,820	9,020	8,393	95%	8,580		
		Maplewood Township	24,280	24,970	18,923	78%	19,460		
		Mendham Borough	5,150	5,000	5,005	97%	4,860		
		Mendham Township	5,620	5,620	1,840	33%	1,840		

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PWSID #	SUPPLYING SYSTEM NAME	MUNICIPALITY/SYSTEM SERVED(1)	Total Municipality Population(2) Current (2005)	Total Municipality Population(2) Future (2020)	Population Served: Estimated Current Population Served	Population Served: Percent of Current Municipal Population Served(3)	Population Served: Projected Population Served (2020)	Total Population Served by System(4) Current (2005)	Total Population Served by System(4) Future (2020)
0712001	NJ AMERICAN W SHORT HILLS	Millburn Township	20,000	20,770	17,490	87%	18,160		
		Mount Olive Township	25,400	26,420	744	3%	770		
		New Providence Borough	11,950	12,710	10,648	89%	11,330		
		North Caldwell Borough	5,950	6,220	173	3%	180		
		Southeast Morris Co MUA			19,350		19,830		
		South Orange Village Township			4,231		4,460		
		Springfield Township Union Co	14,700	15,650	11,373	77%	12,110		
		Summit City	21,320	22,880	16,581	78%	17,790		
		Union Township union Co	55,740	59,850	365	1%	390		
		Warren Township	16,070	18,020	142	1%	160		
		Washington Borough	7,000	7,760	5,679	81%	6,300		
		Co	6,790	7,590	3,210	47%	3,590		
		Watchung Borough	5,820	6,100	167	3%	180		
		West Orange Township	45,550	47,240	33,359	73%	34,800		
		West Paterson Borough	11,250	11,800	2,429	22%	2,550		
0713001	MONTCLAIR TWP WATER BUREAU	Montclair Township	39,440	41,610	38,652	98%	40,780	49,464	51,950
		NJAWC - Litte Falls			2,812		2,940		
		Glen Ridge Boro Water Dept	7,330	7,560	8,000	100%	8,230		
0714001	NEWARK CITY WATER DEPT	Newark City	276,840	296,630	273,000	99%	292,520	427,854	457,360
		Pequannock Twp Water Dept			5,400		5,570		
		Bloomfield Twp Water Dept			45,061		47,000		
		Liberty Water Company			48,000		53,850		
		East Orange City			21,264		22,350		
		Belleville Township			35,129		36,070		
0716001	NUTLEY TWP WATER DEPT	Nutley Township	27,480	28,220	27,362	100%	28,100	27,362	28,100
0717001	ORANGE CITY WATER DEPT	City of Orange Township	32,850	34,640	33,000	100%	34,790	33,000	34,790
0719001	SOUTH ORANGE VILLAGE TWP WATER DEPT	South Orange Village Township	17,340	18,280	16,924	98%	17,840	16,924	17,840
0720001	VERONA TWP WATER DEPT	Cedar Grove Township	12,470	12,830	12	0%	10	13,641	14,210
		Verona Township	13,650	14,230	13,500	99%	14,070		
		West Orange Township	45,550	47,240	129	0%	130		
0721001	WEST CALDWELL TWP WATER DEPT	Fairfield Township	7,180	7,370	63	1%	60	10,485	11,150
		West Caldwell Township	11,680	12,430	10,422	89%	11,090		
0802001	DEPTFORD TWP MUA	Deptford Township	27,120	28,790	26,000	96%	27,600	26,000	27,600
0806001	GLASSBORO BORO WATER DEPT	Glassboro Borough	20,070	23,010	19,238	96%	22,060	19,238	22,060
0810004	MANTUA TWP MUA	Mantua Township	15,180	18,070	11,713	77%	13,940	11,713	13,940
0811002	MONROE TWP MUA	Monroe Twp Glouchester Co	30,330	38,250	27,080	89%	34,150	27,080	34,150
0818004	WASHINGTON TWP MUA	Co	49,220	55,320	48,000	98%	53,950	48,000	53,950
0820001	WEST DEPTFORD TWP WATER DEPT	West Deptford Township	20,020	22,530	20,000	100%	22,510	20,000	22,510
0822001	WOODBURY CITY WATER DEPT	Woodbury City	10,200	9,880	10,996	100%	10,680	10,996	10,680
0901001	BAYONNE MUA	Bayonne City	62,360	67,720	61,000	98%	66,240	61,000	66,240
0904001	HARRISON TOWN WATER DEPT	East Newark Borough	2,380	2,780	25	1%	30	14,425	16,670
		Harrison Town	14,680	16,960	14,395	98%	16,630		
		Kearny Town	40,890	44,680	5	0%	10		
0905001	CITY OF HOBOKEN	Hoboken City	42,730	46,230	39,000	91%	42,190	39,000	42,190
0906001	JERSEY CITY MUA	City of Hoboken			39,000		42,190	367,538	421,840
		Jersey City city	249,290	296,340	249,290	100%	296,340		
		Lyndhurst Township			19,800		20,640		
		United Water NJ			41,222		43,590		
		Montville Township			5,950		6,180		
		Parsippany-Troy Hills Water Co			2,001		1,970		
		West Caldwell Twp Water Dept			10,275		10,930		
0907001	KEARNY TOWN WATER DEPT	Harrison Town	14,680	16,960	25	0%	30	44,190	48,060
		Cedar Grove Water Dept			3,690		3,800		
		Kearny Town	40,890	44,680	40,475	99%	44,230		
1005001	CLINTON TOWN WATER DEPT	Clinton Town	2,650	2,780	2,732	100%	2,860	12,500	13,020
		Clinton Township	14,630	15,200	8,023	55%	8,340		
		Co	2,930	2,930	33	1%	30		
		Lebanon Borough	1,210	1,230	1,213	100%	1,230		
		Union Township hunterdon Co	6,530	7,290	499	8%	560		
1101002	EAST WINDSOR TWP MUA	East Windsor Township	26,576	28,860	25,000	94%	27,150	25,000	27,150
1103001	AQUA NJ INC HAMILTON SQ	Chesterfield Township	6,085	7,950	1,027	17%	1,340	45,863	50,960
		Hamilton Township	89,939	95,189	28,861	32%	30,550		
		Co	11,730	14,820	15,975	100%	19,070		
1111001	TRENTON CITY WATER DEPT	Ewing Township	36,137	37,857	39,000	100%	40,720	206,376	216,070
		Hamilton Township	89,939	95,189	61,000	68%	64,560		
		Hopewell Township	17,454	20,386	5,000	29%	5,840		
		Lawrence Township	29,774	31,814	15,000	50%	16,030		
		AQUA NJ INC HAMILTON SQ			1,376		1,530		
		Trenton City	85,477	87,885	85,000	99%	87,390		

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1204001	EAST BRUNSWICK WATER UTILITY	East Brunswick Township	47,520	53,700	47,000	99%	53,110	72,370	80,170
		Helmetta Borough	2,000	2,020	2,000	100%	2,020		
		South River Borough			15,330		16,720		
		Spotswood Borough	8,040	8,320	8,040	100%	8,320		
1205001	EDISON WATER CO	Edison Township	98,580	109,790	35,000	36%	38,980	35,000	38,980
1207001	HIGHLAND PARK BORO WATER DEPT	Highland Park Borough	14,160	15,890	14,000	99%	15,710	14,000	15,710
1209002	OLD BRIDGE TWP MUA	Old Bridge Township	63,390	70,750	58,300	92%	65,070	58,300	65,070
1213002	MONROE TWP MUA	Monroe Township Middlesex Co	35,890	42,340	25,335	71%	29,890	25,335	29,890
1214001	NEW BRUNSWICK CITY WATER DEPT	Franklin Township Somerset Co			19,270		22,360	50,090	58,840
		Milltown Borough	7,020	7,860	7,020	100%	7,860		
		New Brunswick City	51,480	61,910	23,800	46%	28,620		
1215001	NORTH BRUNSWICK WATER DEPT	North Brunswick Township	38,530	42,300	38,000	99%	41,720	38,056	41,780
		Franklin Township Somerset Co	57,690	66,930	56	0%	60		
1216001	CITY OF PERTH AMBOY	Perth Amboy City	49,670	58,740	47,300	95%	55,940	47,300	55,940
1219001	SAYREVILLE BORO WATER DEPT	Sayreville Borough	42,410	48,360	40,377	95%	46,040	40,377	46,040
1221004	S BRUNSWICK TOWNSHIP WATER DIV	Franklin Township Somerset Co	57,690	66,930	150	0%	170	38,650	46,890
		South Brunswick Township	39,990	48,530	38,500	96%	46,720		
1223001	SOUTH RIVER BORO WATER DEPT	South River Borough	16,000	17,450	15,330	96%	16,720	15,330	16,720
1225001	MIDDLESEX WATER CO	Carteret Borough	21,450	24,150	24,172	100%	26,870	403,543	446,970
		Clark Township	14,610	15,430	200	1%	210		
		East Brunswick Water Utility			72,370		80,170		
		Edison Water Co			3,500		3,900		
		Sayreville Boro Water Dept			10,094		11,510		
		Old Bridge MUA			34,980		39,040		
		Marlboro MUA			32,572		35,720		
		United Water Rahway			2,650		2,810		
		Edison Township	98,580	109,790	50,804	52%	56,580		
		Highland Park Borough			14,000		15,710		
		Metuchen Borough	13,160	14,930	21,444	100%	23,210		
		South Amboy City	7,880	8,970	11,468	100%	12,560		
		South Plainfield Borough	22,890	25,100	14,476	63%	15,870		
		Woodbridge Township	99,830	111,830	110,812	100%	122,810		
1315001	FREEHOLD BOROUGH WATER DEPT	Freehold Borough	11,050	11,270	10,999	100%	11,220	10,999	11,220
1316001	FREEHOLD TWP WATER DEPT	Colts Neck Township	11,430	12,190	831	7%	890	29,831	32,510
		Freehold Township	34,080	37,160	29,000	85%	31,620		
1321001	KEANSBURG WATER AND SEWER DEPT	Keansburg Borough	10,780	10,810	11,515	100%	11,550	11,515	11,550
1326001	GORDONS CORNER WATER CO	Manalapan Township	36,180	44,440	44,999	100%	53,260	44,999	53,260
1326004	UNITED WATER MATCHAPONIX	Freehold Township			2,983		3,250	19,033	22,340
		Gordons Corner Water Co			13,950		16,510		
		Manalapan Township	36,180	44,440	2,100	6%	2,580		
1328001	MARLBORO TWP MUA	Gordons Corner Water Co			13,950		16,510	43,430	47,630
		Marlboro Township	39,090	41,270	29,480	75%	31,120		
1339001	SHORELANDS WATER CO INC	Hazlet Township	21,560	22,110	22,000	100%	22,550	37,000	39,160
		Holmdel Township	16,550	18,840	11,500	69%	13,090		
		Keyport Borough	7,620	7,660	3,500	46%	3,520		
1340001	RED BANK BORO WATER DEPT	Red Bank Borough	11,950	12,220	10,198	85%	10,430	10,198	10,430
1345001	NJ AMERICAN WATER CO - COASTAL NORTH	Aberdeen Township	18,730	20,250	8,114	43%	8,770	278,148	292,410
		Allenhurst Borough	730	730	1,507	100%	1,510		
		Asbury Park City	17,820	20,000	6,923	39%	7,770		
		Bradley Beach Borough	4,790	4,790	4,293	90%	4,290		
		Colts Neck Township	11,430	12,190	6	0%	10		
		Deal Borough	1,080	1,120	2,848	100%	2,890		
		Eatontown Borough	14,280	14,440	7,696	54%	7,780		
		Fair Haven Borough	6,010	6,090	5,507	92%	5,580		
		Highlands Borough	5,130	5,240	3,523	69%	3,600		
		Holmdel Township	16,550	18,840	4,524	27%	5,150		
		Interlaken Borough	910	910	1,370	100%	1,370		
		Keansburg Water & Sewer Dept			11,515		11,550		
		Little Silver Borough	6,260	6,370	6,617	100%	6,730		
		Loch Arbour Village	280	280	384	100%	380		
		Long Branch City	33,000	34,000	18,917	57%	19,490		
		Middletown Township	68,300	69,790	54,445	80%	55,630		
		Monmouth Beach Borough	3,630	3,720	2,307	64%	2,360		
		Neptune City Borough	5,260	5,400	3,648	69%	3,750		
		Neptune Township	28,980	32,360	25,461	88%	28,430		
		Ocean Township Monmouth Co	28,230	29,090	21,049	75%	21,690		
		Oceanport Borough	5,870	6,060	5,314	91%	5,490		
		Red Bank Borough	11,950	12,220	3,359	28%	3,430		
		Rumson Borough	7,180	7,250	7,207	100%	7,280		
		Sea Bright Borough	1,870	2,030	1,384	74%	1,500		

Table 2-5
Current and Projected Populations Served by Municipality

PWSID #	SUPPLYING SYSTEM NAME	MUNICIPALITY/SYSTEM SERVED[1]	Total Municipality Population[2] Current (2005)	Total Municipality Population[2] Future (2020)	Population Served: Estimated Current Population Served	Population Served: Percent of Current Municipal Population Served[3]	Population Served: Projected Population Served (2020)	Total Population Served by System[4] Current (2005)	Total Population Served by System[4] Future (2020)
1345001	NJ AMERICAN WATER CO - COASTAL NORTH	Shrewsbury Borough	3,630	3,740	4,493	100%	4,600		
		Shrewsbury Township	1,110	1,140	279	25%	290		
		Shorelands Water Co			37,000		39,160		
		Tinton Falls Borough	16,170	19,540	15,059	93%	18,200		
		Union Beach Borough	6,770	6,980	6,842	100%	7,050		
		West Long Branch Borough	8,310	8,470	6,557	79%	6,680		
1352003	WALL TWP WATER DEPT	Wall Township	25,810	27,460	23,538	91%	25,040	23,538	25,040
1352005	NJWSA MANASQUAN	Wall Twp Water Dept			23,538		25,040	35,024	36,710
		Sea Girt borough	2,150	2,150	2,636	100%	2,640		
		Brielle Borough	4,960	5,160	2,100	42%	2,180		
		Spring Lake Borough	3,610	3,660	3,450	96%	3,500		
		Spring Lake Heights Borough	5,260	5,340	3,300	63%	3,350		
1408001	DENVILLE TWP WATER DEPT	Boonton Township	4,360	4,650	144	3%	150	16,000	16,330
		Denville Township	16,030	16,360	15,502	97%	15,820		
		Mountain Lakes Borough	4,360	4,310	153	4%	150		
		Parsippany-Troy Hills Township	51,590	50,790	48	0%	50		
		Randolph Township	25,510	26,400	42	0%	40		
		Rockaway Borough	6,470	6,340	12	0%	10		
		Rockaway Township	24,360	26,890	99	0%	110		
1409001	DOVER WATER COMMISSION	Dover Town	19,360	20,030	21,500	100%	22,170	27,806	28,500
		Mine Hill Township	3,680	3,860	21	1%	20		
		Randolph Township	25,510	26,400	2,661	10%	2,750		
		Rockaway Borough	6,470	6,340	2,040	32%	2,000		
		Victory Gardens Borough	1,550	1,520	1,497	97%	1,470		
		Wharton Borough	6,370	6,600	87	1%	90		
1410001	EAST HANOVER TWP WATER DEPT	East Hanover Township	11,470	11,370	11,393	99%	11,290	11,393	11,290
1411001	FLORHAM PARK BORO WATER DEPT	Florham Park Borough	14,560	16,970	8,846	61%	10,310	8,846	10,310
1416001	LINCOLN PARK BORO WATER DEPT	Lincoln Park Borough	10,930	10,720	11,000	100%	10,790	11,000	10,790
1417001	MADISON BORO WATER DEPT	Madison Borough	16,200	16,900	15,820	98%	16,500	15,820	16,500
1421002	MONTVILLE TWP MUA	Montville Township	21,020	21,840	17,000	81%	17,660	17,000	17,660
1424001	SOUTHEAST MORRIS COUNTY	Chatham Borough	6,910	6,660	57	1%	50	64,500	66,100
		Hanover Township	13,380	13,500	15,882	100%	16,000		
		Harding Township	3,250	3,580	3,493	100%	3,820		
		Mendham Township	5,620	5,620	297	5%	300		
		Morris Plains Borough	5,260	4,940	7,699	100%	7,380		
		Morris Township	21,470	22,530	23,757	100%	24,820		
		Morristown Town	19,250	19,850	13,315	69%	13,730		
1429001	PARSIPPANY TROY HILLS TWP WATER DEPT	Mountain Lakes Borough	4,360	4,310	36	1%	40	50,036	49,260
		Parsippany-Troy Hills Township	51,590	50,790	50,000	97%	49,220		
1431001	PEQUANNOCK TWP WATER DEPT	Lincoln Park Borough	10,930	10,720	300	3%	290	13,500	13,920
		Pequannock Township	14,670	15,150	13,200	90%	13,630		
1432001	MORRIS CO MUA	Denville Twp Water Dept			2,720		2,780	41,166	42,260
		Works			18,000		18,630		
		Mine Hill Township	3,680	3,860	3,679	100%	3,860		
		Mount Arlington borough	4,920	5,130	1,900	39%	1,980		
		Wharton borough	6,370	6,600	1,500	24%	1,550		
		NJAWC - Short Hills			4,867		5,150		
		Jefferson township	20,730	20,260	8,500	41%	8,310		
1432003	RANDOLPH TWP PUBLIC WORKS DEPT	Randolph Township	25,510	26,400	18,000	71%	18,630	18,000	18,630
1435002	ROCKAWAY TWP WATER DEPT	Rockaway Township	24,360	26,890	15,000	62%	16,560	15,000	16,560
1436002	ROXBURY WATER CO	Roxbury Township	23,570	24,260	11,230	48%	11,560	11,230	11,560
1506001	BRICK TWP MUA	Brick Township	77,350	90,100	77,379	100%	90,130	82,579	95,920
		Point Pleasant Beach Borough	5,370	5,980	5,200	97%	5,790		
1507005	UNITED WATER CO TOMS RIVER	Berkeley Township	45,680	51,240	19,431	43%	21,800	123,184	136,510
		Dover Township	93,510	104,160	100,119	100%	110,770		
		South Toms River Borough	3,630	3,940	3,634	100%	3,940		
1511001	JACKSON TWP MUA	Jackson Township	50,390	72,280	23,204	46%	33,280	23,204	33,280
1512001	LACEY TWP MUA	Lacey Township	25,850	31,900	25,850	100%	31,900	25,850	31,900
1514001	NJ AMERICAN WATER CO LAKEWOOD SYS	Howell Township	51,970	61,170	34,203	66%	40,260	58,847	68,320
		Lakewood Township	67,910	77,320	24,644	36%	28,060		
1514002	LAKEWOOD TWP MUA	Lakewood Township	67,910	77,320	17,201	25%	19,580	17,201	19,580
1516001	LITTLE EGG HARBOR TWP MUA	Little Egg Harbor Township	18,890	23,640	20,625	100%	25,380	21,141	26,070
		Tuckerton Borough	3,500	4,660	516	15%	690		
1518004	CRESTWOOD VILLAGE WATER CO	Manchester Township	45,030	50,290	14,855	33%	16,590	14,855	16,590
1518005	MANCHESTER TWP WATER UTILITY	Manchester Township	45,030	50,290	25,606	57%	28,600	25,606	28,600
1524001	POINT PLEASANT BORO WATER DEPT	Point Pleasant Borough	19,410	20,090	19,500	100%	20,180	19,500	20,180
1530004	STAFFORD TWP BEACH HAVEN WEST	Stafford Township	24,230	27,670	18,946	78%	21,640	18,946	21,640
1533001	BARNEGAT TWP WATER & SEWER UTILITIES	Barnegat Township	18,360	21,960	15,109	82%	18,090	15,109	18,090
1603001	HALEDON MUA	Haledon Borough	8,630	9,320	9,079	100%	9,770	12,545	13,540
		North Haledon Borough	9,570	10,400	3,424	36%	3,720		

Table 2-5
Current and Projected Populations Served by Municipality

PWSID #	SUPPLYING SYSTEM NAME	MUNICIPALITY/SYSTEM SERVED[1]	Total Municipality Population[2]		Population Served			Total Population Served by System[4]	
			Current (2005)	Future (2020)	Estimated Current Population Served	Percent of Current Municipal Population Served[3]	Projected Population Served (2020)	Current (2005)	Future (2020)
1603001	HALEDON MUA	Paterson City	148,420	164,820	24	0%	30		
		Totowa Borough	10,490	11,240	6	0%	10		
		Wayne Township	55,910	59,960	12	0%	10		
1604001	HAWTHORNE BORO WATER DEPT	Hawthorne Borough	18,340	19,470	19,094	100%	20,220	19,094	20,220
1605001	NJ AMERICAN W CO LITTLE FALLS	Cedar Grove Township	12,470	12,830	300	2%	310	11,247	11,770
		Little Falls Township	11,810	12,350	8,345	71%	8,730		
		North Caldwell Borough	5,950	6,220	173	3%	180		
		West Paterson Borough	11,250	11,800	2,429	22%	2,550		
1605002	PASSAIC VALLEY WATER COMM	Cedar Grove Twp Water Dept			1,538		1,580	586,365	631,040
		Clifton City	81,510	88,090	79,000	97%	85,380		
		Elmwood Park borough			18,925		19,800		
		Fairlawn Water Dept			16,000		16,540		
		Fairfield Township	7,180	7,370	8,000	111%	8,190		
		Harrison Town			14,425		16,670		
		North Haledon Borough	9,570	10,400	3,424	36%	3,720		
		NJAWC - Short Hills			51,107		54,120		
		North Caldwell Borough	5,950	6,220	900	15%	940		
		Nutley Twp Water Dept			27,362		28,100		
		Passaic City	71,230	78,530	68,000	95%	74,970		
		Paterson City	148,420	164,820	149,200	100%	165,600		
		Prospect Park Borough	5,780	6,250	6,700	100%	7,170		
		Totowa Borough	10,490	11,240	10,257	98%	10,990		
		Wallington Borough			12,000		12,610		
		West Paterson Borough	11,250	11,800	8,821	78%	9,250		
		Ringwood Borough	12,720	13,090	9,027	71%	9,290		
		Bloomingdale Borough	7,870	8,290	5,336	68%	5,620		
		Riverdale Borough	2,570	3,430	900	35%	1,200		
		Haledon MUA			12,545		13,540		
		Lincoln Park Water Dept			11,000		10,790		
		Verona Township			7,503		7,820		
		NJAWC - Little Falls			8,435		8,830		
		PVWC-North Arlington			15,514		16,010		
		Garfield City Water Dept			17,849		18,830		
		Lodi Borough	24,480	25,440	22,597	92%	23,480		
1609001	POMPTON LAKES BORO WATER DEPT	Pompton Lakes Borough	11,740	12,290	11,435	97%	11,970	11,435	11,970
1613001	NJDWSC	Newark City Water Dept			183,977		196,660	728,748	779,230
		Kearny Town Water Dept			44,190		48,060		
		Bayonne MUA			61,000		66,240		
		PVWC			263,864		283,970		
		Wayne Township Div of Water			46,485		49,850		
		Bloomfield Twp Water Dept			45,061		47,000		
		Montclair Twp Water			42,044		44,160		
		Nutley Water Dept			27,362		28,100		
		Cedar Grove Twp Water Dept			6,765		6,960		
		Glen Ridge Boro Water Dept			8,000		8,230		
1614001	WAYNE TWP DIVISION OF WATER	Wayne Township	55,910	59,960	46,485	83%	49,850	46,485	49,850
1707001	PENNSGROVE WATER SUPPLY CO	Carneys Point	7,669	7,398	5,810	76%	5,600	14,970	17,610
		Harrison Township	9,810	13,450	6,850	70%	9,390		
		Logan Township	6,560	7,140	1,085	17%	1,180		
		Oldmans	1,816	2,133	1,225	67%	1,440		
1708001	PENNSVILLE TWP WATER DEPT	Pennsville	13,168	12,703	15,000	100%	14,540	15,000	14,540
1808001	FRANKLIN TWP DEPT PUBLIC WORKS	Franklin Township Somerset Co	57,690	66,930	47,000	81%	54,530	47,000	54,530
1918004	SPARTA TWP WATER LAKE MOHAWK	Byram Township	8,650	9,600	1,319	15%	1,460	15,616	18,360
		Sparta Township	19,460	23,000	14,297	73%	16,900		
2004001	LIBERTY WATER CO	Elizabeth City	128,300	143,930	120,000	94%	134,620	120,000	134,620
2004002	ELIZABETHTOWN WATER CO	Bound Brook Borough	10,150	12,310	8,574	84%	10,400	821,479	898,910
		Branchburg Township	14,850	16,050	10,338	70%	11,170		
		Bridgewater Township	44,750	46,540	36,459	81%	37,920		
		Chester Borough	1,650	1,670	84	5%	90		
		Clark Township	14,610	15,430	15,108	100%	15,930		
		Cranbury Township	3,780	5,980	2,805	74%	4,440		
		Cranford Township	22,540	24,200	23,181	100%	24,840		
		Dunellen Borough	6,940	7,500	6,717	97%	7,260		
		Edison Township	98,580	109,790	4,329	4%	4,820		
		Edison Water Co			31,500		35,080		
		Fanwood Borough	7,180	7,560	7,740	100%	8,120		
		Franklin Township Somerset Co			27,730		32,170		
		Garwood Borough	4,140	4,420	4,659	100%	4,940		
		Green Brook Township	6,860	7,400	6,795	99%	7,330		
		Hillsborough Township	37,730	45,050	27,663	73%	33,030		
		Hillside Township	21,860	23,430	18,192	83%	19,500		

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2004002	ELIZABETHTOWN WATER CO	Hopewell Township	17,454	20,386	57	0%	70		
		Kenilworth Borough	7,670	8,060	9,399	100%	9,790		
		Lawrence Township	29,774	31,814	8,028	27%	8,580		
		Linden City	39,840	43,040	35,358	89%	38,200		
		Manville Borough	10,490	11,240	11,334	100%	12,080		
		Middlesex Borough	13,690	15,240	13,737	100%	15,290		
		Millstone Borough	460	770	255	55%	430		
		Montgomery Township	18,130	20,090	13,515	75%	14,980		
		Middlesex Water Co			40,354		44,700		
		Monroe Twp MUA - Middlesex			4,307		5,080		
		Mountainside Borough	6,580	6,900	7,680	100%	8,000		
		NJAWC - Short Hills			82,744		87,620		
		North Plainfield Borough	21,880	22,720	15,120	69%	15,700		
		Peapack and Gladstone	2,470	3,140	2,616	100%	3,290		
		Piscataway Township	51,890	58,040	36,633	71%	40,970		
		Plainfield City	47,810	52,480	31,368	66%	34,430		
		Plainsboro Township	22,820	26,360	11,772	52%	13,600		
		Princeton Borough	15,067	15,112	7,176	48%	7,200		
		Princeton Township	16,976	17,085	16,068	95%	16,170		
		Raritan Borough	6,370	6,930	6,909	100%	7,470		
		Raritan Township	23,130	23,830	10,113	44%	10,420		
		Readington Township	16,330	18,140	3,429	21%	3,810		
		Roselle Borough	21,670	23,420	16,224	75%	17,530		
		Roselle Park Borough	13,350	14,370	10,473	78%	11,270		
		Scotch Plains Township	22,750	23,970	22,782	100%	24,000		
		Somerville Borough	12,690	14,400	10,512	83%	11,930		
		South Bound Brook Borough	4,500	4,920	3,702	82%	4,050		
		S Brunswick Twp Water Div			27,055		32,820		
		South Plainfield Borough	22,890	25,100	13,365	58%	14,660		
		Tewksbury Township	6,030	6,550	399	7%	430		
		Union Township Union Co	55,740	59,850	51,576	93%	55,380		
		Warren Township	16,070	18,020	10,752	67%	12,060		
		Watchung Borough	5,820	6,100	4,497	77%	4,710		
		West Windsor Township	23,120	26,510	20,391	88%	23,380		
		Westfield Town	29,900	31,770	29,904	100%	31,770		
2013001	CITY OF RAHWAY DIVISION OF WATER	Rahway City	27,020	28,630	26,500	98%	28,080	26,500	28,080
2108001	HACKETTSTOWN MUA	Hackettstown Town	9,460	9,930	8,943	95%	9,390	18,249	19,250
		Independence Township	5,870	6,310	2,739	47%	2,940		
		Mansfield Township Warren Co	8,650	9,960	2,535	29%	2,920		
		Mount Olive Township	25,400	26,420	1,806	7%	1,880		
		Washington Township Morris Co	18,180	17,320	2,226	12%	2,120		
2119001	AQUA NJ INC PHILLIPSBURG	Greenwich Township Warren Co	5,360	6,080	120	2%	140	15,602	16,570
		Lopatcong Township	8,020	8,540	60	1%	60		
		Phillipsburg Town	15,350	16,260	15,350	100%	16,260		
		Pohatcong Township	3,480	5,470	72	2%	110		

Notes:
(1) Municipality/System Served includes all known municipalities that receive direct service from the corresponding supplying system and also water systems that receive bulk service from the corresponding supplying system. The estimated current and projected population served for bulk service customers corresponds to the estimated population by the supplying system within the recieving system. The current and future municipality population and the percent of current municipal population served does not apply for th service systems.
(2) Current and Future Municipality Population values developed by the Metropolitan Planning Organization, as provided by NJDEP.
(3) Percent of Municipal Population Served is equal to the Estimated Population Served for the given municipaility divided by the total current (2005) municipal population.
(4) Total Population Served by system is the total population served within each municipality and bulk service customer for the given supplying system.

Table 2-6
Demands Summary

PWSID #	SYSTEM NAME	Current					Future (2020)				
		ADD (mgd)[1]	Pop Served	MDD (mgd)[2]	Drought Demand (mgd)[3]	Emerg Demand (mgd)[4]	Pop Served	ADD (mgd)[5]	MDD (mgd)[6]	Drought Demand (mgd)[3]	Emerg Demand (mgd)[4]
0102001	ATLANTIC CITY MUA	12.69	50,213	18.28	10.78	6.34	53,645	13.55	19.53	11.52	6.78
0103001	BRIGANTINE WATER DEPARTMENT	2.17	15,000	4.04	1.84	1.09	15,640	2.26	4.21	1.92	1.13
0112001	HAMILTON TOWNSHIP MUA	1.91	16,783	2.55	1.62	0.95	22,480	2.55	3.42	2.17	1.28
0113001	HAMMONTON WATER DEPT	1.53	12,153	2.44	1.30	0.76	25,803	3.24	5.18	2.75	1.62
0119002	NJ AMERICAN W CO ATLANTIC	12.78	88,088	19.54	10.86	6.39	107,830	15.64	23.92	13.29	7.82
0122001	VENTNOR CITY W & S UTILITY	1.54	14,000	*3.08*	*1.31*	*0.77*	14,270	1.57	3.14	1.33	0.78
0211001	ELMWOOD PARK WATER DEPT	2.00	18,925	2.62	1.70	1.00	19,800	2.10	2.74	1.78	1.05
0217001	FAIR LAWN WATER DEPT	4.51	32,000	7.23	3.83	2.25	33,080	4.66	7.47	3.96	2.33
0221001	GARFIELD W DEPT	3.19	29,749	3.89	2.71	1.59	31,390	3.36	4.10	2.86	1.68
0232001	LYNDHURST WATER DEPARTMENT	2.70	19,800	3.27	2.30	1.35	20,640	2.82	3.41	2.40	1.41
0233001	MAHWAH WATER DEPARTMENT	4.45	24,061	6.99	3.78	2.23	25,000	4.62	7.26	3.93	2.31
0238001	UNITED WATER NJ	113.40	824,431	146.19	96.39	56.70	871,710	119.90	154.57	101.92	59.95
0239001	PVWC-NORTH ARLINGTON	2.17	15,514	2.63	1.84	1.09	16,010	2.24	2.71	1.90	1.12
0242001	OAKLAND WATER DEPT	1.67	12,000	2.63	1.42	0.83	12,520	1.74	2.74	1.48	0.87
0247001	PARK RIDGE WATER DEPT	2.23	13,458	3.47	1.89	1.11	13,580	2.25	3.50	1.91	1.12
0248001	RAMSEY WATER DEPT	1.56	16,653	2.54	1.33	0.78	17,190	1.61	2.62	1.37	0.81
0251001	RIDGEWOOD WATER DEPT	9.65	61,700	12.62	8.20	4.82	63,070	9.86	12.90	8.38	4.93
0257001	SADDLE BROOK WATER DEPT	1.59	13,155	2.46	1.35	0.80	13,650	1.65	2.56	1.40	0.83
0265001	WALLINGTON WATER DEPT	1.33	12,000	1.60	1.13	0.66	12,610	1.40	1.68	1.19	0.70
0303001	BORDENTOWN WATER DEPT	2.30	13,950	2.56	1.96	1.15	15,370	2.54	2.82	2.16	1.27
0306001	BURLINGTON TWP W DEPT	2.25	30,129	3.35	1.91	1.12	32,220	2.40	3.59	2.04	1.20
0313001	EVESHAM MUA	4.42	47,784	5.81	3.75	2.21	49,040	4.53	5.96	3.85	2.27
0315001	FLORENCE TWP W DEPT	1.44	8,501	1.72	1.22	0.72	10,720	1.82	2.17	1.54	0.91
0319001	MAPLE SHADE WATER DEPT	1.88	19,200	2.08	1.60	0.94	19,200	1.88	2.08	1.60	0.94
0320001	MEDFORD TWP DEPT OF MUNI	1.66	17,100	2.46	1.41	0.83	20,130	1.95	2.90	1.66	0.97
0322001	MOORESTOWN WATER DEPT	3.43	19,000	5.26	2.92	1.72	20,710	3.74	5.73	3.18	1.87
0323001	MOUNT HOLLY WATER COMPAN	4.56	45,555	7.27	3.88	2.28	53,840	5.39	8.59	4.58	2.69
0324001	MT LAUREL TWP MUA	4.95	40,000	6.63	4.21	2.47	42,910	5.31	7.11	4.51	2.65
0325001	US ARMY FORT DIX	1.82	15,829	2.52	1.55	0.91	17,530	2.02	2.79	1.72	1.01
0327001	NJAWC - WESTERN DIVISION	39.09	282,928	51.25	33.23	19.54	287,390	44.30	78.60	37.66	22.15
0329004	PEMBERTON TWP DEPT MAIN	1.10	12,378	1.44	0.93	0.55	13,160	1.17	1.53	0.99	0.58
0338001	WILLINGBORO MUA	5.36	47,999	6.88	4.56	2.68	51,170	5.72	7.33	4.86	2.86
0405001	BERLIN WATER DEPARTMENT	1.53	13,121	2.48	1.30	0.77	12,810	1.49	2.42	1.27	0.75
0408001	CAMDEN CITY WATER DEPT	10.63	50,000	13.08	9.04	5.32	49,380	10.50	12.92	8.92	5.25
0412001	COLLINGSWOOD WATER DEPT	2.07	16,850	2.38	1.76	1.03	15,910	1.95	2.25	1.66	0.98
0414001	GLOUCESTER CITY W DEPT	1.10	12,600	1.46	0.94	0.55	12,000	1.05	1.39	0.89	0.53
0415002	AQUA NJ W C BLACKWOOD	4.50	49,190	6.75	3.83	2.25	54,140	4.96	7.42	4.21	2.48
0416001	HADDON TWP WATER DEPT	1.01	11,935	1.21	0.86	0.51	10,910	0.93	1.11	0.79	0.46
0417001	HADDONFIELD WATER DEPT	1.06	11,616	1.59	0.90	0.53	10,780	0.99	1.48	0.84	0.49
0424001	MERCHANTVILLE PENNSAUKEN	6.24	48,997	9.77	5.30	3.12	46,800	5.96	9.33	5.07	2.98
0428002	PINE HILL BOROUGH MUA	1.02	12,411	1.49	0.86	0.51	13,780	1.13	1.65	0.96	0.56
0436007	WINSLOW TWP MUN UTIL SICKLERVILLE	3.03	29,520	4.89	2.58	1.52	34,690	3.56	5.75	3.03	1.78
0508001	NJAWC - OCEAN CTY	3.00	27,135	6.68	2.55	1.50	28,490	3.15	7.01	2.68	1.58
0514001	WILDWOOD CITY WATER DEPT	3.84	17,996	8.56	3.26	1.92	19,940	4.25	9.48	3.62	2.13
0601001	BRIDGETON CITY WATER DEPT	2.60	23,000	3.02	2.21	1.30	25,970	2.94	3.40	2.50	1.47
0610001	MILLVILLE WATER DEPARTMENT	3.53	27,518	4.93	3.00	1.76	31,630	4.05	5.67	3.44	2.03
0614003	VINELAND WATER & SEWER UTILITY	9.14	33,000	14.05	7.77	4.57	37,960	10.52	16.16	8.94	5.26
0701001	BELLEVILLE WATER DEPT	3.52	35,129	4.85	2.99	1.76	36,070	3.61	4.98	3.07	1.81
0702001	BLOOMFIELD WATER DEPT	5.62	45,061	6.34	4.78	2.81	47,000	5.86	6.61	4.98	2.93
0704001	CEDAR GROVE WATER DEPT	2.52	12,300	3.14	2.14	1.26	12,660	2.59	3.23	2.20	1.30
0705001	EAST ORANGE WATER DEPT	9.21	85,056	9.77	7.83	4.61	89,410	9.68	10.27	8.23	4.84
0710001	LIVINGSTON TWP DIV OF WATER	3.93	27,391	5.40	3.34	1.97	28,180	4.04	5.55	3.44	2.02
0712001	NJ AMERICAN W CO SHORT HILLS	38.24	243,366	49.89	32.51	19.12	257,710	40.50	52.83	34.42	20.25
0713001	MONTCLAIR WATER BUREAU	4.95	49,464	7.29	4.20	2.47	51,950	5.20	7.66	4.42	2.60
0714001	NEWARK WATER DEPT	83.32	427,854	93.50	70.83	41.66	457,360	92.00	129.00	78.20	46.00
0716001	NUTLEY WATER DEPT	4.02	27,362	4.75	3.42	2.01	28,100	4.13	4.88	3.51	2.06
0717001	ORANGE WATER DEPT	3.95	33,000	4.56	3.35	1.97	34,790	4.16	4.80	3.54	2.08
0719001	S ORANGE WATER DEPT	2.62	16,924	2.97	2.23	1.31	17,840	2.76	3.13	2.35	1.38
0720001	VERONA WATER DEPARTMENT	1.55	13,641	2.19	1.32	0.78	14,210	1.62	2.28	1.37	0.81
0721001	WEST CALDWELL WATER DEPT	1.42	10,485	1.91	1.20	0.71	11,150	1.51	2.03	1.28	0.75
0802001	DEPTFORD TWP MUA	2.69	26,000	4.09	2.28	1.34	27,600	2.85	4.34	2.42	1.43

Table 2-6
Demands Summary

PWSID #	SYSTEM NAME	Current ADD (mgd)[1]	Current Pop Served	Current MDD (mgd)[2]	Current Drought Demand (mgd)[3]	Current Emerg Demand (mgd)[4]	Future (2020) Pop Served	Future (2020) ADD (mgd)[5]	Future (2020) MDD (mgd)[6]	Future (2020) Drought Demand (mgd)[3]	Future (2020) Emerg Demand (mgd)[4]
0806001	GLASSBORO WATER DEPARTMENT	2.23	19,238	3.06	1.89	1.11	22,060	2.56	3.51	2.17	1.28
0810004	MANTUA TOWNSHIP MUA	1.14	11,713	1.98	0.97	0.57	13,940	1.36	2.36	1.15	0.68
0811002	MONROE TWP MUA	2.51	27,080	4.37	2.13	1.26	34,150	3.17	5.51	2.69	1.58
0818004	WASHINGTON TOWNSHIP MUA	5.36	48,000	7.99	4.55	2.68	53,950	6.02	8.98	5.12	3.01
0820001	WEST DEPTFORD TWP WATER DEPT	1.79	20,000	3.02	1.52	0.89	22,510	2.01	3.40	1.71	1.00
0822001	WOODBURY CITY W DEPT	1.49	10,996	1.70	1.26	0.74	10,680	1.44	1.65	1.23	0.72
0901001	BAYONNE MUA	8.80	61,000	9.97	7.48	4.40	66,240	9.55	10.83	8.12	4.78
0904001	HARRISON W DEPT	1.05	14,425	1.85	0.89	0.53	16,670	1.21	2.14	1.03	0.61
0905001	HOBOKEN WATER SERVICES	4.12	39,000	5.85	3.50	2.06	42,190	4.46	6.33	3.79	2.23
0906001	JERSEY CITY MUA	50.36	367,538	66.91	42.81	25.18	421,840	57.80	76.80	49.13	28.90
0907001	KEARNY W DEPT	6.58	44,190	9.46	5.59	3.29	48,060	7.16	10.29	6.08	3.58
1005001	CLINTON W DEPT	1.93	12,500	2.21	1.64	0.97	13,020	2.01	2.30	1.71	1.01
1101002	EAST WINDSOR MUA	2.81	25,000	3.85	2.39	1.41	27,150	3.05	4.18	2.59	1.53
1103001	AQUA NJ - HAMILTON SQ	3.41	45,863	5.30	2.90	1.71	50,960	3.79	5.89	3.22	1.90
1111001	TRENTON WATER DEPARTMENT	27.36	206,376	34.02	23.26	13.68	216,070	28.65	35.62	24.35	14.32
1204001	EAST BRUNSWICK WATER UTILITY	7.38	72,370	12.31	6.27	3.69	80,170	8.18	13.64	6.95	4.09
1205001	EDISON WATER CO	7.20	35,000	7.79	6.12	3.60	38,980	8.02	8.68	6.82	4.01
1207001	HIGHLAND PARK W DEPT	1.88	14,000	2.20	1.60	0.94	15,710	2.11	2.47	1.79	1.05
1209002	OLD BRIDGE MUA	7.30	58,300	10.10	6.21	3.65	65,070	8.15	11.27	6.93	4.07
1213002	MONROE TWP MUA	4.33	25,335	7.19	3.68	2.17	29,890	5.11	8.48	4.34	2.55
1214001	NEW BRUNSWICK W DEPT	14.04	50,090	15.00	11.93	7.02	58,840	16.49	17.62	14.02	8.25
1215001	NORTH BRUNSWICK W DEPT	5.86	38,056	7.25	4.98	2.93	41,780	6.43	7.96	5.47	3.22
1216001	PERTH AMBOY DEPT OF MUNI	5.69	47,300	6.61	4.84	2.85	55,940	6.73	7.82	5.72	3.36
1219001	SA YREVILLE W DEPT	6.19	40,377	8.31	5.26	3.10	46,040	7.06	9.48	6.00	3.53
1221004	SOUTH BRUNSWICK TWP W DI	5.32	38,650	7.87	4.52	2.66	46,890	6.46	9.55	5.49	3.23
1223001	SOUTH RIVER W DEPT	1.59	15,330	2.06	1.35	0.79	16,720	1.73	2.25	1.47	0.87
1225001	MIDDLESEX W CO	49.20	403,543	68.47	41.82	24.60	446,970	54.49	75.84	46.32	27.25
1315001	FREEHOLD BOROUGH WATER DEPT	1.42	10,999	1.67	1.20	0.71	11,220	1.44	1.71	1.23	0.72
1316001	FREEHOLD TWP WATER DEPT	4.33	29,831	7.74	3.68	2.17	32,510	4.72	8.44	4.01	2.36
1321001	KEANSBURG WATER & SEWER DEPT	0.91	11,515	1.15	0.78	0.46	11,550	0.92	1.15	0.78	0.46
1326001	GORDONS CORNER WATER CO	4.96	44,999	9.13	4.22	2.48	53,260	5.87	10.81	4.99	2.94
1326004	UNITED WATER MATCHAPONIX	2.83	19,033	3.13	2.41	1.42	22,340	3.33	3.67	2.83	1.66
1328002	MARLBORO MUA	5.34	43,430	8.63	4.54	2.67	47,630	5.70	12.30	4.85	2.85
1339001	SHORELANDS WATER CO INC	5.42	37,000	8.07	4.60	2.71	39,160	5.73	8.54	4.87	2.87
1340001	RED BANK WATER DEPT	1.67	10,198	2.50	1.42	0.83	10,430	1.70	2.55	1.45	0.85
1345001	NJAWC - COASTAL NORTH	41.27	278,148	56.52	35.08	20.64	292,410	43.39	59.42	36.88	21.69
1352003	WALL TWP WATER DEPT	2.86	23,538	4.06	2.43	1.43	25,040	3.04	4.32	2.59	1.52
1352005	NJWSA MANSQUAN	3.11	35,024	*6.23*	*2.65*	*1.56*	36,710	3.26	6.52	2.77	1.63
1408001	DENVILLE TWP WATER DEPT	2.13	16,000	3.04	1.81	1.06	16,330	2.17	3.10	1.85	1.09
1409001	DOVER WATER COMMISSION	2.56	27,806	2.87	2.18	1.28	28,500	2.62	2.94	2.23	1.31
1410001	EAST HANOVER TWP WATER D	1.98	11,393	2.95	1.68	0.99	11,290	1.96	2.92	1.66	0.98
1411001	FLORHAM PARK WATER DEPT	1.10	8,846	1.82	0.94	0.55	10,310	1.28	2.12	1.09	0.64
1416001	LINCOLN PARK WATER DEPT	1.11	11,000	1.50	0.94	0.55	10,790	1.09	1.47	0.92	0.54
1417001	MADISON WATER DEPT	2.19	15,820	3.32	1.86	1.10	16,500	2.29	3.46	1.94	1.14
1421003	MONTVILLE TWP MUA	2.39	17,000	3.56	2.03	1.20	17,660	2.48	3.70	2.11	1.24
1424001	SOUTHEAST MORRIS CO MUA	9.80	64,500	12.68	8.33	4.90	66,100	10.04	12.99	8.54	5.02
1429001	PARSIPPANY-TROY HILLS WATER CO	7.23	50,036	9.03	6.15	3.62	49,260	7.12	8.89	6.05	3.56
1431001	PEQUANNOCK TWP WATER DEPT	2.02	13,500	3.53	1.72	1.01	13,920	2.08	3.64	1.77	1.04
1432001	MORRIS CO MUA	3.42	41,166	6.16	2.91	1.71	42,260	3.51	6.32	2.98	1.75
1432003	RANDOLPH TWP PUBLIC WORKS DEPT	2.16	18,000	3.11	1.83	1.08	18,630	2.23	3.21	1.90	1.12
1435002	ROCKAWAY TWP WATER DEPT	1.50	15,000	2.08	1.27	0.75	16,560	1.65	2.30	1.41	0.83
1436002	ROXBURY WATER CO	1.07	11,230	1.33	0.91	0.53	11,560	1.10	1.37	0.93	0.55
1506001	BRICK TOWNSHIP MUA	9.80	82,579	12.21	8.33	4.90	95,920	11.38	14.18	9.67	5.69
1507005	UNITED WATER TOMS RIVER	12.77	123,184	19.20	10.86	6.39	136,510	14.16	21.28	12.03	7.08
1511001	JACKSON TWP MUA	2.73	23,204	4.78	2.32	1.36	33,280	3.91	6.86	3.32	1.95
1512001	LACEY TWP MUA	2.10	25,850	2.74	1.79	1.05	31,900	2.59	3.38	2.20	1.30
1514001	NJ AMERICAN W CO LAKEWOOD	6.97	58,847	9.34	5.92	3.48	68,320	8.09	10.84	6.88	4.04
1514002	LAKEWOOD TWP MUA	2.94	17,201	4.05	2.50	1.47	19,580	3.34	4.61	2.84	1.67
1516001	LITTLE EGG HARBOR TWP MUA	1.54	21,141	2.52	1.31	0.77	26,070	1.89	3.11	1.61	0.95
1518004	CRESTWOOD VILLAGE W CO	1.43	14,855	1.99	1.21	0.71	16,590	1.59	2.22	1.35	0.80
1518005	MANCHESTER TWP WATER UTILITY	1.74	25,606	3.30	1.48	0.87	28,600	1.94	3.69	1.65	0.97

Table 2-6
Demands Summary

PWSID #	SYSTEM NAME	Current ADD (mgd)(1)	Current Pop Served	Current MDD (mgd)(2)	Current Drought Demand (mgd)(3)	Current Emerg Demand (mgd)(4)	Future (2020) Pop Served	Future (2020) ADD (mgd)(5)	Future (2020) MDD (mgd)(6)	Future (2020) Drought Demand (mgd)(3)	Future (2020) Emerg Demand (mgd)(4)
1524001	POINT PLEASANT WATER DEPTMENT	2.04	19,500	2.70	1.73	1.02	20,180	2.11	2.79	1.79	1.05
1530004	STAFFORD TWP MUA BEACHHAVEN	1.64	18,946	2.29	1.39	0.82	21,640	1.87	2.62	1.59	0.94
1533001	BARNEGAT TWP WATER SEWER	1.39	15,109	2.38	1.18	0.70	18,090	1.66	2.85	1.41	0.83
1603001	HALEDON WATER DEPT	1.40	12,545	2.03	1.19	0.70	13,540	1.51	2.19	1.28	0.75
1604001	HAWTHORNE W DEPT	2.42	19,094	3.62	2.05	1.21	20,220	2.56	3.84	2.17	1.28
1605001	NJ AMERICAN W CO LITTLE	1.90	11,247	2.37	1.62	0.95	11,770	1.99	2.48	1.69	0.99
1605002	PASSAIC VALLEY W COMM	90.59	586,365	115.08	77.00	45.30	631,040	97.49	123.85	82.87	48.75
1609001	POMPTON LAKES WATER DEPT	1.12	11,435	1.54	0.95	0.56	11,970	1.17	1.62	1.00	0.59
1613001	NJDWSC	114.76	728,748	152.40	97.55	57.38	779,230	124.04	164.72	105.43	62.02
1614001	WAYNE TWP DIVISION OF WATER	7.56	46,485	12.86	6.43	3.78	49,850	8.11	13.79	6.89	4.06
1707001	PENNSGROVE WATER SUPPLY COMP	1.42	14,970	1.77	1.21	0.71	17,610	1.67	2.09	1.42	0.84
1708001	PENNSVILLE TWP WATER DEPT	1.24	15,000	1.40	1.05	0.62	14,540	1.20	1.36	1.02	0.60
1808001	FRANKLIN TWP DEPT PUBLIC	7.34	47,000	9.66	6.24	3.67	54,530	8.52	11.21	7.24	4.26
1918004	SPARTA TWP WATER LAKE MO	1.69	15,616	2.28	1.43	0.84	18,360	1.98	2.68	1.68	0.99
2004001	LIBERTY WATER COMPANY	15.32	120,000	18.26	13.02	7.66	134,620	17.19	20.48	14.61	8.59
2004002	ELIZABETHTOWN WATER CO	147.73	821,479	182.34	125.57	73.87	898,910	161.65	199.53	137.41	80.83
2013001	UNITED WATER RAHWAY	5.71	26,500	7.01	4.85	2.85	28,080	6.05	7.43	5.14	3.02
2108001	HACKETTSTOWN MUA	2.62	18,249	2.93	2.23	1.31	19,250	2.76	3.09	2.35	1.38
2119001	AQUA NJ W C PHILLIPSBURG	3.61	15,602	4.27	3.07	1.81	16,570	3.84	4.54	3.26	1.92

Notes:

(1) Current ADD estimated to be an average of all reported ADD values (on a yearly basis) between 2000 and 2005, unless "current" values were directly provided by NJ DEP.

(2) When possible, MDD values were based on the reported MDD for a given year. When historical MDD was unavailable, the MDD was based on the ADD for the peak demand month in a given year.

(3) Drought demand estimated to be equal to 85% of ADD for all systems.

(4) Emergency demand estimated to be 50% of ADD for all systems.

(5) Future ADD estimated based on the projected population served estimate and the estimated current per capita demand

(6) Future MDD estimated based on the calculated current MDD to ADD peaking factor

Table 2-7
Supply Capacity Summary[1]

PWSID #	System Name	Water Supply Limit (mgd)[2]	Total Safe Yield (mgd)	Total Treatment Plant(s) Capacity (mgd)	Total Treated Water Supply Capacity (mgd) Normal[3]	Drought[4]	Contract Bulk Purchase Limit (mgd)
0102001	ATLANTIC CITY MUA	26.000		21.000	21.000		---
0103001	BRIGANTINE WATER DEPT	3.770		5.910	3.770		---
0112001	HAMILTON TWP MUA	4.902		9.140	4.902		---
0113001	HAMMONTON WATER DEPT	2.541		5.900	2.541		---
0119002	NJAWC - ATLANTIC CO	23.344		21.750	21.750		3.049
0122001	VENTNOR CITY WATER & SEWER AUTH	2.795		5.810	2.795		
0211001	ELMWOOD PARK WATER DEPT	0.000	0.000	0.000	0.000	0.000	3.250
0217001	FAIR LAWN BORO WATER DEPT	3.380		4.700	3.380		3.400
0221001	GARFIELD CITY WATER DEPT	4.100		2.400	2.400		3.000
0232001	LYNDHURST WATER DEPT	0.000	0.000	0.000	0.000	0.000	3.500
0233001	MAHWAH WATER DEPT	4.960		7.700	4.960		7.000
0238001	UNITED WATER NJ	159.344		202.880	159.344		4.500
0239001	PVWC - NORTH ARLINGTON	0.000		0.000	0.000		4.500
0242001	OAKLAND WATER DEPT	4.066		4.400	4.066		---
0247001	PARK RIDGE WATER DEPT	3.770		6.100	3.770		---
0248001	RAMSEY WATER DEPT	2.323		2.520	2.323		3.500
0251001	RIDGEWOOD WATER DEPT	13.213		18.120	13.213		1.000
0257001	SADDLE BROOK WATER DEPT	0.000	0.000	0.000	0.000	0.000	2.850
0265001	WALLINGTON BORO DPW	0.000	0.000	0.000	0.000	0.000	2.500
0303001	BORDENTOWN WATER DEPT	2.951		5.242	2.951		---
0306001	BURLINGTON TWP WATER DEPT	3.705		7.634	3.705		---
0313001	EVESHAM TWP MUA	4.885		12.228	4.885		1.940
0315001	FLORENCE TWP WATER DEPT	2.574		3.480	2.574		---
0319001	MAPLE SHADE WATER DEPT	3.049		6.253	3.049		---
0320001	MEDFORD TWP DEP OF MUNIC UTIL	2.525		5.112	2.525		---
0322001	MOORESTOWN WATER DEPT	4.918		7.340	4.918		2.439
0323001	MOUNT HOLLY WATER CO	6.033		10.500	6.033		1.525
0324001	MT LAUREL TWP MUA	3.934		6.740	3.934		7.200
0325001	US ARMY FORT DIX	5.082		5.299	5.082		---
0327001	NJAWC - WESTERN DIV	98.446		87.600	87.600		---
0329004	PEMBERTON TWP WATER DEPT MAIN SUPPLY	1.270		1.790	1.270		---
0338001	WILLINGBORO TWP MUA	10.164		12.370	10.164		---
0405001	BERLIN BORO WATER DEPT	3.026		5.250	3.026		
0408001	CAMDEN CITY WATER DEPT	21.770		19.440	19.440		
0412001	COLLINGSWOOD BORO WATER DEPT	5.082		5.200	5.082		---
0414001	GLOUCESTER CITY WATER DEPT	3.049		6.480	3.049		---
0415002	AQUA NJ INC BLACKWOOD	6.508		9.569	6.508		0.100
0416001	HADDON TWP WATER DEPT	2.033		3.600	2.033		
0417001	HADDONFIELD BORO WATER DEPT	2.030		3.000	2.030		---
0424001	MERCHANTVILLE PENNSAUKEN WATER COMM	10.984		12.320	10.984		1.065
0428002	PINE HILL BORO MUA	1.639		2.828	1.639		0.350
0436007	WINSLOW TWP MUN UTILITY-SICKLERVILLE	4.984		8.134	4.984		---
0508001	NJAWC - OCEAN CITY	9.656		11.376	9.656		---
0514001	WILDWOOD CITY WATER DEPT	10.266		18.604	10.266		---
0601001	BRIDGETON CITY WATER DEPT	5.574		10.870	5.574		---
0610001	MILLVILLE CITY WATER DEPT	6.557		10.620	6.557		---
0614003	VINELAND CITY WATER & SEWER UTILITY	16.213		17.780	16.213		---
0701001	BELLEVILLE TOWN WATER DEPT	0.000	0.000	0.000	0.000	0.000	5.000
0702001	BLOOMFIELD TOWN WATER DEPT	0.000		0.500	0.000		7.810
0704001	CEDAR GROVE TWP WATER DEPT	0.000	0.000	0.000	0.000	0.000	3.300
0705001	EAST ORANGE CITY WATER DEPT	11.180		11.000	11.000		---
0710001	LIVINGSTON TWP WATER DIVISION	4.879		5.090	4.879		1.250
0712001	NJAWC - SHORT HILLS	36.492		20.000	20.000		42.474
0713001	MONTCLAIR TWP WATER BUREAU	1.869		1.800	1.800		4.777
0714001	NEWARK CITY WATER DEPT	57.934	49.100	50.000	50.000	49.100	59.170
0716001	NUTLEY TWP WATER DEPT	0.000	0.000	0.000	0.000	0.000	
0717001	ORANGE CITY WATER DEPT	4.590		10.210	4.590		---
0719001	S ORANGE VILLAGE TWP WATER DEPT	0.585		0.500	0.500		4.066
0720001	VERONA TWP WATER DEPT	1.134		1.116	1.116		2.131

Table 2-7
Supply Capacity Summary[1]

PWSID #	System Name	Water Supply Limit (mgd)[2]	Total Safe Yield (mgd)	Total Treatment Plant(s) Capacity (mgd)	Total Treated Water Supply Capacity (mgd)		Contract Bulk Purchase Limit (mgd)
					Normal[3]	Drought[4]	
0721001	WEST CALDWELL TWP WATER DEPT	0.000	0.000	0.000	0.000	0.000	2.000
0802001	DEPTFORD TWP MUA	4.033		8.730	4.033		0.000
0806001	GLASSBORO BORO WATER DEPT	3.443		7.578	3.443		0.072
0810004	MANTUA TWP MUA	1.869		3.096	1.869		0.072
0811002	MONROE TWP MUA	3.780		3.890	3.780		
0818004	WASHINGTON TWP MUA	8.138		10.150	8.138		---
0820001	WEST DEPTFORD TWP WATER DEPT	3.557		7.474	3.557		0.850
0822001	WOODBURY CITY WATER DEPT	4.033		5.200	4.033		
0901001	BAYONNE CITY WATER DEPT	0.000	0.000	0.000	0.000	0.000	12.600
0904001	HARRISON TOWN WATER DEPT	0.000	0.000	0.000	0.000	0.000	2.000
0905001	HOBOKEN WATER SERVICES	0.000	0.000	0.000	0.000	0.000	6.098
0906001	JERSEY CITY MUA	86.393	56.800	80.000	80.000	56.800	---
0907001	KEARNY TOWN WATER DEPT	0.000	0.000	0.000	0.000	0.000	13.000
1005001	CLINTON TOWN WATER DEPT	2.885		3.840	2.885		---
1101002	EAST WINDSOR TWP MUA	5.148		7.630	5.148		---
1103001	AQUA NJ INC HAMILTON SQ	6.567		7.830	6.567		3.000
1111001	TRENTON CITY WATER DEPT	44.262		65.000	44.262		---
1204001	EAST BRUNSWICK WATER UTILITY	0.000	0.000	0.000	0.000	0.000	16.516
1205001	EDISON WATER CO	0.000	0.000	0.000	0.000	0.000	12.578
1207001	HIGHLAND PARK BORO WATER DEPT	0.000	0.000	0.000	0.000	0.000	2.439
1209002	OLD BRIDGE TWP MUA	7.295		9.100	7.295		6.861
1213002	MONROE TWP MUA	10.270		11.360	10.270		1.080
1214001	NEW BRUNSWICK CITY WATER DEPT	20.500		18.000	18.000		---
1215001	NORTH BRUNSWICK WATER DEPT	8.131		10.000	8.131		---
1216001	PERTH AMBOY DEPT OF MUNIC UTIL	8.131		8.000	8.000		---
1219001	SAYREVILLE BORO WATER DEPT	9.344		11.000	9.344		8.233
1221004	SOUTH BRUNSWICK TWP WATER DIV	5.902		5.500	5.500		3.761
1223001	SOUTH RIVER BORO WATER DEPT	1.836		3.200	1.836		1.016
1225001	MIDDLESEX WATER CO	67.818		85.064	67.818		15.000
1315001	FREEHOLD BOROUGH WATER DEPT	2.010		5.020	2.010		---
1316001	FREEHOLD TWP WATER DEPT	8.689		8.390	8.390		0.762
1321001	KEANSBURG WATER AND SEWER DEPT	1.713		2.500	1.713		0.288
1326001	GORDONS CORNER WATER CO	6.623		11.320	6.623		5.082
1326004	UNITED WATER MATCHAPONIX	5.082		5.000	5.000		---
1328002	MARLBORO TWP MUA	3.934		4.500	3.934		7.623
1339001	SHORELANDS WATER CO INC	6.590		8.640	6.590		1.811
1340001	RED BANK BORO WATER DEPT	2.459		2.800	2.459		0.197
1345001	NJAWC - COASTAL NORTH	46.508		81.428	46.508		16.665
1352003	WALL TWP WATER DEPT	2.900		4.478	2.900		2.338
1352005	NJWSA MANASQUAN	>4.0		4.000	4.000		
1408001	DENVILLE TWP WATER DEPT	2.525		5.040	2.525		0.762
1409001	DOVER WATER COMMISSION	3.672		7.350	3.672		---
1410001	EAST HANOVER TWP WATER DEPT	2.370		4.720	2.370		---
1411001	FLORHAM PARK BORO WATER DEPT	1.779		3.380	1.779		
1416001	LINCOLN PARK BORO WATER DEPT	0.000	0.000	0.000	0.000	0.000	2.033
1417001	MADISON BORO WATER DEPT	3.557		8.370	3.557		---
1421003	MONTVILLE TWP MUA	3.377		4.680	3.377		1.016
1424001	SOUTHEAST MORRIS COUNTY	11.803		15.240	11.803		6.000
1429001	PARSIPPANY TROY HILLS TWP WATER DEPT	9.180		14.487	9.180		2.060
1431001	PEQUANNOCK TWP WATER DEPT	3.475		2.749	2.749		1.016
1432001	MORRIS CNTY MUA	6.557		9.520	6.557		0.500
1432003	RANDOLPH TWP PUBLIC WORKS DEPT	0.000	0.000	0.000	0.000	0.000	---
1435002	ROCKAWAY TWP WATER DEPT	2.262		3.066	2.262		0.609
1436002	ROXBURY WATER CO	1.803		3.492	1.803		---
1506001	BRICK TWP MUA	32.525		16.000	16.000		---
1507005	UNITED WATER CO TOMS RIVER	18.164		23.610	18.164		
1511001	JACKSON TWP MUA	6.852		8.930	6.852		---
1512001	LACEY TWP MUA	3.695		3.740	3.695		0.000
1514001	NJAWC - LAKEWOOD SYS	7.451		16.140	7.451		4.066

Table 2-7
Supply Capacity Summary(1)

PWSID #	System Name	Water Supply Limit (mgd)(2)	Total Safe Yield (mgd)	Total Treatment Plant(s) Capacity (mgd)	Total Treated Water Supply Capacity (mgd) Normal(3)	Total Treated Water Supply Capacity (mgd) Drought(4)	Contract Bulk Purchase Limit (mgd)
1514002	LAKEWOOD TWP MUA	6.191		8.220	6.191		0.305
1516001	LITTLE EGG HARBOR TWP MUA	3.695		6.218	3.695		---
1518004	CRESTWOOD VILLAGE WATER CO	2.295		5.830	2.295		---
1518005	MANCHESTER TWP WATER UTILITY	4.754		8.240	4.754		0.349
1524001	POINT PLEASANT BORO WATER DEPT	2.951		4.600	2.951		0.610
1530004	STAFFORD TWP BEACH HAVEN WEST	4.525		9.010	4.525		---
1533001	BARNEGAT TWP WATER & SEWER UTILITIES	4.098		5.440	4.098		---
1603001	HALEDON MUA	0.000	0.000	0.000	0.000	0.000	2.295
1604001	HAWTHORNE BORO WATER DEPT	5.475		7.220	5.475		---
1605001	NJAWC - LITTLE FALLS	0.000	0.000	0.000	0.000	0.000	4.114
1605002	PASSAIC VALLEY WATER COMM	76.230		100.000	76.230		42.600
1609001	POMPTON LAKES BORO WATER DEPT	1.967		3.040	1.967		
1613001	NJDWSC	135.689		210.000	135.689		---
1614001	WAYNE TWP DIVISION OF WATER	0.000	0.000	0.000	0.000	0.000	10.977
1707001	PENNSGROVE WATER SUPPLY CO	2.308		3.200	2.308		---
1708001	PENNSVILLE TWP WATER DEPT	1.780		2.820	1.780		---
1808001	FRANKLIN TWP DEPT PUBLIC WORKS	0.000	0.000	0.000	0.000	0.000	14.500
1918004	SPARTA TWP WATER LAKE MOHAWK	3.384		2.290	2.290		---
2004001	LIBERTY WATER CO	0.000	0.000	0.000	0.000	0.000	24.758
2004002	ELIZABETHTOWN WATER CO	221.689		250.520	221.689		---
2013001	UNITED WATER RAHWAY	7.869		6.000	6.000		0.200
2108001	HACKETTSTOWN MUA	4.056		3.470	3.470		---
2119001	AQUA NJ INC PHILLIPSBURG	5.836		8.300	5.836		---

Notes:

(1) The purpose of this table is to ducument existing sources of supply with a given system and does not consider bulk purchase of finished water.

(2) The water supply limit is based on Monthly Allocation Limits as reported in the on-line NJ DEP Deficit/Surplus database, unless other information was directly provided by NJ DEP or individual systems. The Monthly Allocation limits were converted to a daily average by dividing the monthly limit by 30.5 days per month.

(3) The total treated water supply capacity for normal conditions is the lesser of the water supply limit and the treatment plant capacity.

(4) The total treated water supply capacity for drought conditions is considered to be the lesser of the total safe yield and the total treatment plant capacity.

Table 2-8
Total System Excess Supply Capacity

PWSID #	SYSTEM NAME	Total Treated Water Supply Capacity (mgd)(1) Normal	Total Treated Water Supply Capacity (mgd)(1) Drought	ADD (mgd) Current	ADD (mgd) Future (2020)	Excess Supply Capacity (mgd)(2) Current Normal	Excess Supply Capacity (mgd)(2) Current Drought	Excess Supply Capacity (mgd)(2) Future Normal	Excess Supply Capacity (mgd)(2) Future Drought
0102001	ATLANTIC CITY MUA	21.0		12.7	13.6	8.3		7.4	
0103001	BRIGANTINE WATER DEPT	3.8		2.2	2.3	1.6		1.5	
0112001	HAMILTON TWP MUA	4.9		1.9	2.6	3.0		2.3	
0113001	HAMMONTON WATER DEPT	2.5		1.5	3.2	1.0		(0.7)	
0119002	NJ AMERICAN WATER CO ATLANTIC	21.8		12.8	15.6	9.0		6.1	
0122001	VENTNOR CITY WATER & SEWER AUTH	2.8		1.5	1.6	1.3		1.2	
0211001	ELMWOOD PARK WATER DEPT	0.0	0.0	2.0	2.1	(2.0)	(2.0)	(2.1)	(2.1)
0217001	FAIR LAWN BORO WATER DEPT	3.4		4.5	4.7	(1.1)		(1.3)	
0221001	GARFIELD CITY WATER DEPT	2.4		3.2	3.4	(0.8)		(1.0)	
0232001	LYNDHURST WATER DEPT	0.0	0.0	2.7	2.8	(2.7)	(2.7)	(2.8)	(2.8)
0233001	MAHWAH WATER DEPT	5.0		4.5	4.6	0.5		0.3	
0238001	UNITED WATER NJ	159.3		113.4	119.9	45.9		39.4	
0239001	PVWC-NORTH ARLINGTON	0.0		2.2	2.2	(2.2)		(2.2)	
0242001	OAKLAND WATER DEPT	4.1		1.7	1.7	2.4		2.3	
0247001	PARK RIDGE WATER DEPT	3.8		2.2	2.2	1.5		1.5	
0248001	RAMSEY WATER DEPT	2.3		1.6	1.6	0.8		0.7	
0251001	RIDGEWOOD WATER DEPT	13.2		9.6	9.9	3.6		3.4	
0257001	SADDLE BROOK WATER DEPT	0.0	0.0	1.6	1.7	(1.6)	(1.6)	(1.7)	(1.7)
0265001	WALLINGTON BORO DPW	0.0	0.0	1.3	1.4	(1.3)	(1.3)	(1.4)	(1.4)
0303001	BORDENTOWN WATER DEPT	3.0		2.3	2.5	0.6		0.4	
0306001	BURLINGTON TWP WATER DEPT	3.7		2.2	2.4	1.5		1.3	
0313001	EVESHAM TWP MUA	4.9		4.4	4.5	0.5		0.4	
0315001	FLORENCE TWP WATER DEPT	2.6		1.4	1.8	1.1		0.8	
0319001	MAPLE SHADE WATER DEPT	3.0		1.9	1.9	1.2		1.2	
0320001	MEDFORD TWP DEP OF MUNIC UTIL	2.5		1.7	1.9	0.9		0.6	
0322001	MOORESTOWN WATER DEPT	4.9		3.4	3.7	1.5		1.2	
0323001	MOUNT HOLLY WATER CO	6.0		4.6	5.4	1.5		0.6	
0324001	MT LAUREL TWP MUA	3.9		4.9	5.3	(1.0)		(1.4)	
0325001	US ARMY FORT DIX	5.1		1.8	2.0	3.3		3.1	
0327001	NJ AMERICAN WATER CO WESTERN DIV	87.6		39.1	44.3	48.5		43.3	
0329004	PEMBERTON TWP WATER DEPT MAIN SUPPLY	1.3		1.1	1.2	0.2		0.1	
0338001	WILLINGBORO TWP MUA	10.2		5.4	5.7	4.8		4.4	
0405001	BERLIN BORO WATER DEPT	3.0		1.5	1.5	1.5		1.5	
0408001	CAMDEN CITY WATER DEPT	19.4		10.6	10.5	8.8		8.9	
0412001	COLLINGSWOOD BORO WATER DEPT	5.1		2.1	2.0	3.0		3.1	
0414001	GLOUCESTER CITY WATER DEPT	3.0		1.1	1.1	1.9		2.0	
0415002	AQUA NJ INC BLACKWOOD	6.5		4.5	5.0	2.0		1.6	
0416001	HADDON TWP WATER DEPT	2.0		1.0	0.9	1.0		1.1	
0417001	HADDONFIELD BORO WATER DEPT	2.0		1.1	1.0	1.0		1.0	
0424001	MERCHANTVILLE PENNSAUKEN WATER COMM	11.0		6.2	6.0	4.7		5.0	
0428002	PINE HILL BORO MUA	1.6		1.0	1.1	0.6		0.5	
0436007	WINSLOW TWP MUN UTILITY-SICKLERVILLE	5.0		3.0	3.6	2.0		1.4	
0508001	NJ AMERICAN W CO OCEAN CITY SYSTEM	9.7		3.0	3.2	6.7		6.5	
0514001	WILDWOOD CITY WATER DEPT	10.3		3.8	4.3	6.4		6.0	
0601001	BRIDGETON CITY WATER DEPT	5.6		2.6	2.9	3.0		2.6	
0610001	MILLVILLE CITY WATER DEPT	6.6		3.5	4.1	3.0		2.5	
0614003	VINELAND CITY WATER & SEWER UTILITY	16.2		9.1	10.5	7.1		5.7	
0701001	BELLEVILLE TOWN WATER DEPT	0.0	0.0	3.5	3.6	(3.5)	(3.5)	(3.6)	(3.6)
0702001	BLOOMFIELD TOWN WATER DEPT	0.0		5.6	5.9	(5.6)		(5.9)	
0704001	CEDAR GROVE TWP WATER DEPT	0.0	0.0	2.5	2.6	(2.5)	(2.5)	(2.6)	(2.6)
0705001	EAST ORANGE CITY WATER DEPT	11.0		9.2	9.7	1.8		1.3	
0710001	LIVINGSTON TWP WATER DIVISION	4.9		3.9	4.0	0.9		0.8	
0712001	NJ AMERICAN W SHORT HILLS	20.0		38.2	40.5	(18.2)		(20.5)	
0713001	MONTCLAIR TWP WATER BUREAU	1.8		4.9	5.2	(3.1)		(3.4)	
0714001	NEWARK CITY WATER DEPT	50.0	49.1	83.3	92.0	(33.3)	(34.2)	(42.0)	(42.9)

Table 2-8
Total System Excess Supply Capacity

PWSID #	SYSTEM NAME	Total Treated Water Supply Capacity (mgd)[1]		ADD (mgd)		Excess Supply Capacity (mgd)[2]			
						Current		Future	
		Normal	Drought	Current	Future (2020)	Normal	Drought	Normal	Drought
0716001	NUTLEY TWP WATER DEPT	0.0	0.0	4.0	4.1	(4.0)	(4.0)	(4.1)	(4.1)
0717001	ORANGE CITY WATER DEPT	4.6		3.9	4.2	0.6		0.4	
0719001	SOUTH ORANGE VILLAGE TWP WATER DEPT	0.5		2.6	2.8	(2.1)		(2.3)	
0720001	VERONA TWP WATER DEPT	1.1		1.6	1.6	(0.4)		(0.5)	
0721001	WEST CALDWELL TWP WATER DEPT	0.0	0.0	1.4	1.5	(1.4)	(1.4)	(1.5)	(1.5)
0802001	DEPTFORD TWP MUA	4.0		2.7	2.9	1.3		1.2	
0806001	GLASSBORO BORO WATER DEPT	3.4		2.2	2.6	1.2		0.9	
0810004	MANTUA TWP MUA	1.9		1.1	1.4	0.7		0.5	
0811002	MONROE TWP MUA	3.8		2.5	3.2	1.3		0.6	
0818004	WASHINGTON TWP MUA	8.1		5.4	6.0	2.8		2.1	
0820001	WEST DEPTFORD TWP WATER DEPT	3.6		1.8	2.0	1.8		1.5	
0822001	WOODBURY CITY WATER DEPT	4.0		1.5	1.4	2.5		2.6	
0901001	BAYONNE CITY WATER DEPT	0.0	0.0	8.8	9.6	(8.8)	(8.8)	(9.6)	(9.6)
0904001	HARRISON TOWN WATER DEPT	0.0	0.0	1.1	1.2	(1.1)	(1.1)	(1.2)	(1.2)
0905001	HOBOKEN WATER SERVICES	0.0	0.0	4.1	4.5	(4.1)	(4.1)	(4.5)	(4.5)
0906001	JERSEY CITY MUA	80.0	56.8	50.4	57.8	29.6	6.4	22.2	(1.0)
0907001	KEARNY TOWN WATER DEPT	0.0	0.0	6.6	7.2	(6.6)	(6.6)	(7.2)	(7.2)
1005001	CLINTON TOWN WATER DEPT	2.9		1.9	2.0	1.0		0.9	
1101002	EAST WINDSOR TWP MUA	5.1		2.8	3.1	2.3		2.1	
1103001	AQUA NJ INC HAMILTON SQ	6.6		3.4	3.8	3.2		2.8	
1111001	TRENTON CITY WATER DEPT	44.3		27.4	28.6	16.9		15.6	
1204001	EAST BRUNSWICK WATER UTILITY	0.0	0.0	7.4	8.2	(7.4)	(7.4)	(8.2)	(8.2)
1205001	EDISON WATER CO	0.0	0.0	7.2	8.0	(7.2)	(7.2)	(8.0)	(8.0)
1207001	HIGHLAND PARK BORO WATER DEPT	0.0	0.0	1.9	2.1	(1.9)	(1.9)	(2.1)	(2.1)
1209002	OLD BRIDGE TWP MUA	7.3		7.3	8.1	(0.0)		(0.9)	
1213002	MONROE TWP MUA	10.3		4.3	5.1	5.9		5.2	
1214001	NEW BRUNSWICK CITY WATER DEPT	18.0		14.0	16.5	4.0		1.5	
1215001	NORTH BRUNSWICK WATER DEPT	8.1		5.9	6.4	2.3		1.7	
1216001	PERTH AMBOY DEPT OF MUNIC UTIL	8.0		5.7	6.7	2.3		1.3	
1219001	SAYREVILLE BORO WATER DEPT	9.3		6.2	7.1	3.2		2.3	
1221004	S BRUNSWICK TWP WATER DIV	5.5		5.3	6.5	0.2		(1.0)	
1223001	SOUTH RIVER BORO WATER DEPT	1.8		1.6	1.7	0.2		0.1	
1225001	MIDDLESEX WATER CO	67.8		49.2	54.5	18.6		13.3	
1315001	FREEHOLD BOROUGH WATER DEPT	2.0		1.4	1.4	0.6		0.6	
1316001	FREEHOLD TWP WATER DEPT	8.4		4.3	4.7	4.1		3.7	
1321001	KEANSBURG WATER AND SEWER DEPT	1.7		0.9	0.9	0.8		0.8	
1326001	GORDONS CORNER WATER CO	6.6		5.0	5.9	1.7		0.8	
1326004	UNITED WATER MATCHAPONIX	5.0		2.8	3.3	2.2		1.7	
1328002	MARLBORO TWP MUA	3.9		5.3	5.7	(1.4)		(1.8)	
1339001	SHORELANDS WATER CO INC	6.6		5.4	5.7	1.2		0.9	
1340001	RED BANK BORO WATER DEPT	2.5		1.7	1.7	0.8		0.8	
1345001	NJ AMERICAN WATER CO COASTAL NORTH	46.5		41.3	43.4	5.2		3.1	
1352003	WALL TWP WATER DEPT	2.9		2.9	3.0	0.0		(0.1)	
1352005	NJWSA MANASQUAN	4.0		3.1	3.3	0.9		0.7	
1408001	DENVILLE TWP WATER DEPT	2.5		2.1	2.2	0.4		0.4	
1409001	DOVER WATER COMMISSION	3.7		2.6	2.6	1.1		1.0	
1410001	EAST HANOVER TWP WATER DEPT	2.4		2.0	2.0	0.4		0.4	
1411001	FLORHAM PARK BORO WATER DEPT	1.8		1.1	1.3	0.7		0.5	
1416001	LINCOLN PARK BORO WATER DEPT	0.0	0.0	1.1	1.1	(1.1)	(1.1)	(1.1)	(1.1)
1417001	MADISON BORO WATER DEPT	3.6		2.2	2.3	1.4		1.3	
1421003	MONTVILLE TWP MUA	3.4		2.4	2.5	1.0		0.9	
1424001	SOUTHEAST MORRIS COUNTY	11.8		9.8	10.0	2.0		1.8	
1429001	PARSIPPANY TROY HILLS TWP WATER DEPT	9.2		7.2	7.1	2.0		2.1	
1431001	PEQUANNOCK TWP WATER DEPT	2.7		2.0	2.1	0.7		0.7	
1432001	MORRIS CO MUA	6.6		3.4	3.5	3.1		3.0	

Table 2-8
Total System Excess Supply Capacity

PWSID #	SYSTEM NAME	Total Treated Water Supply Capacity (mgd)(1)		ADD (mgd)		Excess Supply Capacity (mgd)(2)			
						Current		Future	
		Normal	Drought	Current	Future (2020)	Normal	Drought	Normal	Drought
1432003	RANDOLPH TWP PUBLIC WORKS DEPT	0.0	0.0	2.2	2.2	(2.2)	(2.2)	(2.2)	(2.2)
1435002	ROCKAWAY TWP WATER DEPT	2.3		1.5	1.7	0.8		0.6	
1436002	ROXBURY WATER CO	1.8		1.1	1.1	0.7		0.7	
1506001	BRICK TWP MUA	16.0		9.8	11.4	6.2		4.6	
1507005	UNITED WATER CO TOMS RIVER	18.2		12.8	14.2	5.4		4.0	
1511001	JACKSON TWP MUA	6.9		2.7	3.9	4.1		2.9	
1512001	LACEY TWP MUA	3.7		2.1	2.6	1.6		1.1	
1514001	NJ AMERICAN WATER CO LAKEWOOD SYS	7.5		7.0	8.1	0.5		(0.6)	
1514002	LAKEWOOD TWP MUA	6.2		2.9	3.3	3.3		2.8	
1516001	LITTLE EGG HARBOR TWP MUA	3.7		1.5	1.9	2.2		1.8	
1518004	CRESTWOOD VILLAGE WATER CO	2.3		1.4	1.6	0.9		0.7	
1518005	MANCHESTER TWP WATER UTILITY	4.8		1.7	1.9	3.0		2.8	
1524001	POINT PLEASANT BORO WATER DEPT	3.0		2.0	2.1	0.9		0.8	
1530004	STAFFORD TWP BEACH HAVEN WEST	4.5		1.6	1.9	2.9		2.7	
1533001	BARNEGAT TWP WATER & SEWER UTILITIES	4.1		1.4	1.7	2.7		2.4	
1603001	HALEDON MUA	0.0	0.0	1.4	1.5	(1.4)	(1.4)	(1.5)	(1.5)
1604001	HAWTHORNE BORO WATER DEPT	5.5		2.4	2.6	3.1		2.9	
1605001	NJ AMERICAN W CO LITTLE FALLS	0.0	0.0	1.9	2.0	(1.9)	(1.9)	(2.0)	(2.0)
1605002	PASSAIC VALLEY WATER COMM	76.2		90.6	97.5	(14.4)		(21.3)	
1609001	POMPTON LAKES BORO WATER DEPT	2.0		1.1	1.2	0.8		0.8	
1613001	NJDWSC	135.7		114.8	124.0	20.9		11.6	
1614001	WAYNE TWP DIVISION OF WATER	0.0	0.0	7.6	8.1	(7.6)	(7.6)	(8.1)	(8.1)
1707001	PENNSGROVE WATER SUPPLY CO	2.3		1.4	1.7	0.9		0.6	
1708001	PENNSVILLE TWP WATER DEPT	1.8		1.2	1.2	0.5		0.6	
1808001	FRANKLIN TWP DEPT PUBLIC WORKS	0.0	0.0	7.3	8.5	(7.3)	(7.3)	(8.5)	(8.5)
1918004	SPARTA TWP WATER LAKE MOHAWK	2.3		1.7	2.0	0.6		0.3	
2004001	LIBERTY WATER CO	0.0	0.0	15.3	17.2	(15.3)	(15.3)	(17.2)	(17.2)
2004002	ELIZABETHTOWN WATER CO	221.7		147.7	161.7	74.0		60.0	
2013001	UNITED WATER RAHWAY	6.0		5.7	6.0	0.3		(0.0)	
2108001	HACKETTSTOWN MUA	3.5		2.6	2.8	0.9		0.7	
2119001	AQUA NJ INC PHILLIPSBURG	5.8		3.6	3.8	2.2		2.0	

Notes:
(1) As documented in Table 2-5, the total treated water supply capacity includes only existing sources of supply with a given system and does not consider bulk purchase of finished water.
(2) A negative excess supply capacity indicates that the demand for the given system is greater than the total treated water supply capacity. For existing conditions, such a deficit is met through bulk purchase of finished water, as documented in Table 2-7.

INTERCONNECTION EXCESS SUPPLY CAPACITY
TABLE 2.9

[REDACTED]

Table 2-10
Interconnection Contractual Capacity

Supplier		Supplier		Primary Interconnection		Contract Capacity (mgd)
PWSID #	System Name	PWSID #	System Name	ID #	Interconnection Name	
0102001	ATLANTIC CITY MUA	0119002	NJAWC - ATLANTIC CO	182337	ACMUA Interconnection #3	4.0
0232001	LYNDHURST WATER DEPT	0714001	NEWARK CITY WATER DEPT	183746	CHITTENDEN ROAD (reverse)	
0233001	MAHWAH WATER DEPT	0248001	RAMSEY WATER DEPT	182396	Franklin Turnpike Interconnection	1.0
				182397	Ridge Road Interconnection	
0238001	UNITED WATER NJ	0217001	FAIR LAWN BORO WATER DEPT	182476	United Water Pump Station	2.0
		0257001	SADDLE BROOK WATER DEPT	182477	Saddle Brook Water Dept.	2.9
				182480	Saddle Brook Water Dept.	
		0905001	HOBOKEN WATER SERVICES	182486	Hoboken	
		0906001	JERSEY CITY MUA	182484	Jersey City No. 2	7.0
				182776	UWNJ	
0239001	PVWC - NORTH ARLINGTON	0232001	LYNDHURST WATER DEPT	182402	North Arlington Emergency	
0315001	FLORENCE TWP WATER DEPT	0306001	BURLINGTON TWP WATER DEPT	182404	Florence Township	
0327001	NJAWC - WESTERN DIV	0408001	CAMDEN CITY WATER DEPT	182517	Camden Water Department Interconnect	
		0810004	MANTUA TWP MUA	663101	NJAWC-Mantua	0.7
0702001	BLOOMFIELD TOWN WATER DEPT	0704001	CEDAR GROVE TWP WATER DEPT	182656	Verona	
0704001	CEDAR GROVE TWP WATER DEPT	0713001	MONTCLAIR TWP WATER BUREAU	182660	Watchung/Grove Street	
0705001	EAST ORANGE CITY WATER DEPT	0710001	LIVINGSTON TWP WATER DIVISION	182664	East Orange Interconnection	
		0719001	S ORANGE VILLAGE TWP WATER DEPT	182668	White Oak Ridge and South Orange Ave.	
0712001	NJAWC - SHORT HILLS	0705001	EAST ORANGE CITY WATER DEPT	183607	Wyoming Ave	
		0710001	LIVINGSTON TWP WATER DIVISION	183609	Watersource	
		1411001	FLORHAM PARK BORO WATER DEPT	183622	Florham Park	
		1424001	SOUTHEAST MORRIS COUNTY	183626	Melanie Ln	6.0
				183628	Park Ave Booster	
		2004002	ELIZABETHTOWN WATER CO	183614	Ski Hill	0.0
				183615	Stirling Road	
0713001	MONTCLAIR TWP WATER BUREAU	0702001	BLOOMFIELD TOWN WATER DEPT	182679	Watchung Ave.	
		0704001	CEDAR GROVE TWP WATER DEPT	182682	Montclair	
0714001	NEWARK CITY WATER DEPT	0232001	LYNDHURST WATER DEPT	183746	CHITTENDEN ROAD	
		0701001	BELLEVILLE TOWN WATER DEPT	183709	Belleville Ave	4.0
				183713	Reservoir	
		0702001	BLOOMFIELD TOWN WATER DEPT	183711	Grove St.	6.5
				183721	Garrabrant	
				183722	BLOOMFIELD AVE	
				183723	Glennwood Ave.	
				183737	Bloomfield/Montclair	
		0705001	EAST ORANGE CITY WATER DEPT	183710	La France Ave.	3.0
		0713001	MONTCLAIR TWP WATER BUREAU	183705	GROVE STREET	
				183726	GROVE STREET	
		0716001	NUTLEY TWP WATER DEPT	183706	Nutley Water Dept.	
				183707	Nutley Water Dept.	
				183727	OVERBROOK HOSPITAL	
		0719001	S ORANGE VILLAGE TWP WATER DEPT	183719	SOUTH ORANGE AVE	
		0906001	JERSEY CITY MUA	182793N	CHITTENDEN ROAD - NEWARK & UWJC (reverse)	
		1431001	PEQUANNOCK TWP WATER DEPT	183729	Hopper Ave.	1.0
		1605002	PASSAIC VALLEY WATER COMM	183284	Newark # 6 (reverse)	
				183747	RTE 23	
		1613001	NJDWSC	183738	WAYNE PUMP STATION	
				183333	no local name (reverse)	
		1614001	WAYNE TWP DIVISION OF WATER	183739	Wanaque Station	2.0
				183740	Black Oak Ridge Road	
				183742	ALPS ROAD	
				183743	Jacobus Ave P.S.	
				183745	Edison Drive	
		2004001	LIBERTY WATER CO	183715	DAYTON STREET	10.5
				183716	Sherman Avenue	
				183717	Mount Olivet	
				183732	Trinity Place	
				183734	Carrington Street	
0811002	MONROE TWP MUA	0818004	WASHINGTON TWP MUA	182735	WTMUA Interconnection	
0905001	HOBOKEN WATER SERVICES	0238001	UNITED WATER NJ	183562	Hoboken/Jersey City	
0906001	JERSEY CITY MUA	0232001	LYNDHURST WATER DEPT	182768	no local name	2.5
				182769	no local name	
		0238001	UNITED WATER NJ	182779	Jersey City No. 1	
		0239001	PVWC - NORTH ARLINGTON	182767	16 Inch Jersey City	
				182775	12 Inch Jersey City	
		0721001	WEST CALDWELL TWP WATER DEPT	182778	Jersey City	2.0

Table 2-10
Interconnection Contractual Capacity

Supplier		Supplier		Primary Interconnection		Contract Capacity (mgd)
PWSID #	System Name	PWSID #	System Name	ID #	Interconnection Name	
0906001	JERSEY CITY MUA	0901001	BAYONNE CITY WATER DEPT	182774	Bayonne Water Dept	
				182784	Bayonne Water Dept	
				182785	Bayonne Water Dept	
				182786	Bayonne Water Dept	
				182787	Bayonne Water Dept	
				182788	Bayonne Water Dept	
				182790	Interconnection	
		0905001	HOBOKEN WATER SERVICES	182781	Hoboken Water Services	6.0
				182782	Hoboken Water Services	
				182783	United Water Jersey City	
		0907001	KEARNY TOWN WATER DEPT	182777	Kearny Water Dept	
				182780	Fish House Rd Interconnection w/ Jersey	
		1421003	MONTVILLE TWP MUA	182791	Jersey City Booster	2.5
		1605002	PASSAIC VALLEY WATER COMM	182793	CHITTENDEN ROAD - PVWC & UWJC #1	
		0714001	NEWARK CITY WATER DEPT	182793N	CHITTENDEN ROAD - NEWARK & UWJC	
		1613001	NJDWSC	182792	Noth Jersey Water Supply	
0907001	KEARNY TOWN WATER DEPT	0901001	BAYONNE CITY WATER DEPT	182795	Point of entry from Kearny	10.5
				182796	Penn.Ave & Central Ave Interconnection 2	
				182797	Central Ave Overpass So. Kearny 16	
		1605002	PASSAIC VALLEY WATER COMM	182798	Grand Pl & Belleville Turnpike 16 Inter	
1103001	AQUA NJ INC HAMILTON SQ	1111001	TRENTON CITY WATER DEPT	216196	Whitehorse-Mercerville Road (reverse)	3.0
1111001	TRENTON CITY WATER DEPT	1103001	AQUA NJ INC HAMILTON SQ	216196	Whitehorse-Mercerville Road	
		2004002	ELIZABETHTOWN WATER CO	183514	Princeton Pike (reverse)	
1204001	EAST BRUNSWICK WATER UTILITY	1214001	NEW BRUNSWICK CITY WATER DEPT	183568	East Brunswick	
		1221004	SOUTH BRUNSWICK TWP WATER DIV	183573	East Brunswick	
		1223001	SOUTH RIVER BORO WATER DEPT	183574	East Brunswick	1.0
				183575	East Brunswick	
1207001	HIGHLAND PARK BORO WATER DEPT	1205001	EDISON WATER CO	182832	Interconnection	
1214001	NEW BRUNSWICK CITY WATER DEPT	1204001	EAST BRUNSWICK WATER UTILITY	183568	East Brunswick (reverse)	
		1207001	HIGHLAND PARK BORO WATER DEPT	182843	HP-1	
		1215001	NORTH BRUNSWICK WATER DEPT	182842	NOB-1	
				182851	NOB-4	
		1808001	FRANKLIN TWP DEPT PUBLIC WORKS	182848	Landing Ln. Pump Station	
1216001	PERTH AMBOY DEPT OF MUNIC UTIL	1219001	SAYREVILLE BORO WATER DEPT	183682	Sayerville	
		1225001	MIDDLESEX WATER CO	182861	Perth Amboy #2 (reverse)	
				183684	Perth Amboy #3	
				183685	Perth Amboy #5	
1219001	SAYREVILLE BORO WATER DEPT	1225001	MIDDLESEX WATER CO	182855	Sayreville #2	2.0
1221004	SOUTH BRUNSWICK TWP WATER DIV	1213002	MONROE TWP MUA	183687	Forsgate Dr. Interconnection	0.4
		1204001	EAST BRUNSWICK WATER UTILITY	183573	East Brunswick (reverse)	
1225001	MIDDLESEX WATER CO	1204001	EAST BRUNSWICK WATER UTILITY	182863	East Brunswick #2	8.0
				182864	East Brunswick #1	
		1205001	EDISON WATER CO	182859	GPU R/W	2.0
				182865	Edison Township #1	
				182866	Woodbridge Avenue	
				182867	Edison Township #2	
		1207001	HIGHLAND PARK BORO WATER DEPT	182869	Middlesex Water Co, #2	4.0
				182870	Highland Park #1	
		1209002	OLD BRIDGE TWP MUA	182871	Old Bridge #1	9.0
		1216001	PERTH AMBOY DEPT OF MUNIC UTIL	182860	Perth Amboy #1	9.0
				182861	Perth Amboy #2	
				182862	Perth Amboy #4	
		1219001	SAYREVILLE BORO WATER DEPT	182872	Sayreville #1	7.5
		1328002	MARLBORO TWP MUA	182873	MIDDLESEX INTERCONNECTION	10.0
				182876	Marlboro #1	
		2013001	UNITED WATER RAHWAY	182874	Madison Avenue	0.1
				182875	New Brunswick Avenue	
1316001	FREEHOLD TWP WATER DEPT	1326001	GORDONS CORNER WATER CO	182893	Pond Rd.	
1326004	UNITED WATER MATCHAPONIX	1326001	GORDONS CORNER WATER CO	183753	Matchaponix	1.5
1328002	MARLBORO TWP MUA	1209002	OLD BRIDGE TWP MUA	182907	OLDBRIDGE INTERCONNECTION	
		1326001	GORDONS CORNER WATER CO	182908	Marlboro Township	1.5
		1345001	NJAWC - COASTAL NORTH	182911	Marlboro Interconnect #2	
1339001	SHORELANDS WATER CO INC	1345001	NJAWC - COASTAL NORTH	182922	NJAW - Cat Bird Alley Chamber	4.8

Table 2-10
Interconnection Contractual Capacity

Supplier		Supplier		Primary Interconnection		Contract Capacity (mgd)
PWSID #	System Name	PWSID #	System Name	ID #	Interconnection Name	
1345001	NJAWC - COASTAL NORTH	1321001	KEANSBURG WATER AND SEWER DEPT	182943	Palmer Place	1.8
		1328002	MARLBORO TWP MUA	182911	Marlboro Interconnect #2 (reverse)	
		1339001	SHORELANDS WATER CO INC	182931	Shorelands Middle Road Interconnect #2	9.6
				182934	Shorelands Crawfords Corner Interconnect	
			#N/A	748809	Asbury Ave	
1352005	NJWSA MANASQUAN	1352003	WALL TWP WATER DEPT	182965	WALL #2 METER	2.3
				182966	WALL #1 METER	
1424001	SOUTHEAST MORRIS COUNTY	0712001	NJAWC - SHORT HILLS	183628	Park Ave Booster (reverse)	
1432001	MORRIS CNTY MUA	0712001	NJAWC - SHORT HILLS	183047	N.J.American/Mendham	1.0
		1424001	SOUTHEAST MORRIS COUNTY	183089	SMCMUA	0.5
				183091	SMCMUA	
		1432003	RANDOLPH TWP PUBLIC WORKS DEPT	183052	no local name	0.0
				183054	no local name	
				183056	no local name	
				183067	no local name	
				183072	no local name	
				183073	no local name	
				183080	no local name	
				183081	no local name	
				183084	no local name	
1507005	UNITED WATER CO TOMS RIVER	1518005	MANCHESTER TWP WATER UTILITY	183145	Manchester Interconnection	1.0
1514001	NJAWC - LAKEWOOD SYS		#N/A	183173	Freehold Twp. NJLK-51	
1605001	NJAWC - LITTLE FALLS	0239001	PVWC - NORTH ARLINGTON	183641	16 inch Passaic Valley	
				183642	12 inch Passaic Valley	
1605002	PASSAIC VALLEY WATER COMM	0217001	FAIR LAWN BORO WATER DEPT	183207	Fairlawn # 2	
		0238001	UNITED WATER NJ	183216	United Water # 1	10.0
		0239001	PVWC - NORTH ARLINGTON	90002	North Arlington # 1	
		0702001	BLOOMFIELD TOWN WATER DEPT	183311	Garrabrant Ave.	
		0712001	NJAWC - SHORT HILLS	183266	New Jersey American Water # 5	25.0
				183281	New Jersey American Water # 10	
				183297	New Jersey American Water # 12	
				183312	PVBS = 183281	
		0713001	MONTCLAIR TWP WATER BUREAU	183274	Montclair # 4	
		0714001	NEWARK CITY WATER DEPT	183224	Newark # 9	
				183227	Newark # 10	
				183230	Newark # 11	
				183269	Newark # 12	
				183270	Newark # 4	
				183275	Newark # 5	
				183277	Newark # 7	
				183278	Newark # 8	
				183283	Newark # 3	
				183284	CHITTENDEN ROAD - PVWC & NEWARK	
				183305	Newark # 1	
				183306	Newark # 2	
		0720001	VERONA TWP WATER DEPT	183231	Verona # 1	
		0721001	WEST CALDWELL TWP WATER DEPT	183234	West Caldwell # 1	
				183235a	West Caldwell #2a	
				183235b	West Caldwell #2b	
				183236	West Caldwell # 3	
		0901001	BAYONNE CITY WATER DEPT	183237	Bayonne # 1	
		0904001	HARRISON TOWN WATER DEPT	183242	Harrison # 1	
				183243	Harrison # 2	
				183244	Radley St. & Schuyler Ave. Interconnecti	
		0906001	JERSEY CITY MUA	183276	CHITTENDEN ROAD - PVWC & UWJC #1	14.0
				183302	Jersey City # 4	
				183303	Jersey City # 5	
				183314	CHITTENDEN ROAD - PVWC & UWJC #2	
		0907001	KEARNY TOWN WATER DEPT	183238	Kearny # 1	
				183240	Kearny # 5	
				183241	Kearny # 4	
		1416001	LINCOLN PARK BORO WATER DEPT	183304	Lincoln Park # 1	
		1603001	HALEDON MUA	183293	Haledon # 8	
		1605001	NJAWC - LITTLE FALLS	183301	Nesser Lane	
		1609001	POMPTON LAKES BORO WATER DEPT	183310	PVWC	1.0

Table 2-10
Interconnection Contractual Capacity

Supplier		Supplier		Primary Interconnection		Contract Capacity (mgd)
PWSID #	System Name	PWSID #	System Name	ID #	Interconnection Name	
1613001	NJDWSC	0238001	UNITED WATER NJ	183341	Stiles Ct.	
		0704001	CEDAR GROVE TWP WATER DEPT	183331	North Jersey	5.0
				183340	no local name	
		0713001	MONTCLAIR TWP WATER BUREAU	183328	Montclair P.S.	
		0714001	NEWARK CITY WATER DEPT	183327	Belleville Res.	
				183333	no local name	
				183712	BELLEVILLE RESERVOIR	
				183738	WAYNE PUMP STATION (reverse)	25.0
		0901001	BAYONNE CITY WATER DEPT	183332	Main supply feed-point of entry	10.5
		0906001	JERSEY CITY MUA	182792	Noth Jersey Water Supply (reverse)	
		0907001	KEARNY TOWN WATER DEPT	183329	NJDWSC; Permanent source; Point of entry	13.0
		1416001	LINCOLN PARK BORO WATER DEPT	183339	Lincoln Park Connection	
		1605002	PASSAIC VALLEY WATER COMM	183263	New Jersey District Water Supply Commiss	
				183330	no local name	
				183342	Jackson Ave.	
		1614001	WAYNE TWP DIVISION OF WATER	183334	Wanaque P.S.	
				183337	West Belt P.S.	
1808001	FRANKLIN TWP DEPT PUBLIC WORKS	2004002	ELIZABETHTOWN WATER CO	183403	River Road	
2004002	ELIZABETHTOWN WATER CO	2004001	LIBERTY WATER CO	183504	Lidgerwood Avenue	
				183505	Westfield Avenue	
				183507	Morris Avenue	
		0712001	NJAWC - SHORT HILLS	183510	Colt St Booster	19.5
				183536	Diamond Hill Booster Station	
				183537	Chambers Brook	
				183538	Liberty Corners	
		0714001	NEWARK CITY WATER DEPT	183512	Pennsylvania Railroad	
		1111001	TRENTON CITY WATER DEPT	183514	Princeton Pike	
		1205001	EDISON WATER CO	183516	Talmadge Road	
				183518	Truman Drive	
				183519	Stelton Road	
		1207001	HIGHLAND PARK BORO WATER DEPT	183517	River Road	
		1213002	MONROE TWP MUA	183540	Prospect Plains Road	0.5
		1214001	NEW BRUNSWICK CITY WATER DEPT	183523	Easton Avenue	
		1221004	SOUTH BRUNSWICK TWP WATER DIV	183541	Independence Way	
				183542	Scotts Corner Road	
		1225001	MIDDLESEX WATER CO	183520	Elizabethtown #2	3.0
				183521	Woodbridge Avenue	
				183522	Menlo Park	
				183544	Randolph Road	
				183546	Elizabethtown #6	
				183548	Elizabethtown #7	
		1808001	FRANKLIN TWP DEPT PUBLIC WORKS	183524	River Road	
				183525	Amwell Road	
				183552	Weston Road	
3	UNITED WATER NY	0238001	UNITED WATER NJ	183768	United Water New York	

INTERCONNECTION ESTIMATED HYDRAULIC CAPACITY
TABLE 2.11

[REDACTED]

INTERCONNECTION CAPACITY SUMMARY
TABLE 2.12

[REDACTED]

PRIMARY INTERCONNECTIONS WITH IDENTIFIED HYDRAULIC LIMITATIONS
TABLE 2.13

[REDACTED]

PRIMARY INTERCONNECTIONS WITH POTENTIAL HYDRAULIC RESTRICTIONS
TABLE 2.14

[REDACTED]

PRIMARY INTERCONNECTIONS WITH IDENTIFIED CONTRACTURAL LIMITATIONS
TABLE 2.15

[REDACTED]

PRIMARY INTERCONNECTIONS BY SYSTEMS
TABLE 2.16

[REDACTED]

SYSTEMS WITH NO PRIMARY INTERCONNECTIONS
TABLE 2.17

[REDACTED]

3.0 TASK 2: HYDRAULIC MODEL

3.1 Background and Objective

Task 2 involved the development of a hydraulic model of the existing primary interconnection and transmission infrastructure in New Jersey. Primary interconnections and transmission infrastructure are defined in Section 2.1 of this report. The general process of the development of the model is described in Chapter 3. More detailed information regarding the development of the model is provided in the Model User Manual, which was submitted to NJDEP as part of this study. The User Manual includes data used to develop the model, assumptions, descriptions of model scenarios and alternatives, and other general notes to assist potential users in understanding the model. The model software includes significant on-line help and hard-copy references. The intent of the "User Manual" is thus not to provide a complete "how-to" or help reference on use of the model software, as this will be provided in the software documentation.

3.2 Software Selection

Bentley's WaterGEMS software was used to develop the "statewide" hydraulic model. WaterGEMS is a graphical hydraulic and water quality modeling software that provides a seamless integration with GIS applications. WaterGEMS has the capability of running within an ArcGIS environment. This integration allows overlay of the hydraulic model on the Department's and other agencies' existing GIS data. The seamless integration of the model and GIS allows for more efficient model development and enhanced model analyses as a result of the additional geospatial data analyses tools that are available within the ArcGIS software. The user-friendly Graphical User Interface (GUI) of WaterGEMS simplifies the learning process for model use and promotes easy and efficient model updates and modifications.

Existing WaterCAD or WaterGEMS models were available and obtained from the following systems: Atlantic City, Bayonne, Marlboro, Newark, New Jersey American Water Company – Short Hills, Coastal North, Atlantic County, Elizabethtown, Western Division, and Trenton. Additionally, shapefiles of existing model data that could be directly imported into WaterGEMS were obtained from United Water and Passaic Valley Water Commission. Thus, use of WaterGEMS for the current Interconnection Study simplified the model development process by allowing direct use of currently available system models. Additionally, use of common software among a large percentage of systems, particularly the larger systems, will help facilitate future communication and cooperation between NJDEP and the involved water systems.

3.3 Limits of Hydraulic Model

As described in Section 2.4, available data was reviewed to identify systems that have primary transmission infrastructure or are integral to the transfer of water throughout the regions of the state, and thus were included in the hydraulic model. Based on this review, the hydraulic model includes 20 systems, including 16 of the 25 "Big 25" systems in the state. The systems included in the model are listed in Table 2.1.

The model includes all primary transmission routes and primary interconnections between systems included in the model. The model also includes the sources of supply and critical distribution facilities including tanks, distribution pumps, and regulating valves for the identified 20 systems. Primary transmission routes were simulated as model pipelines based on available information. Primary interconnections between systems in the model are represented as a model node that connects pipes between two or more systems. Additionally, the model includes primary interconnections between a system in the model and a system not in the model. These interconnections were simulated as a model node. For normal bulk service connections, a bulk demand was applied to the corresponding node to represent the transfer of water at that primary interconnection. No demand was applied for emergency interconnections or other connections that are normally closed. 151 of the 225 primary interconnections identified in Task 1 were represented in the model. The remaining interconnections are between two systems not included in the model or that could not be located based on available data. The model pipeline network and all interconnections identified within the model are shown on Exhibit 3-1.

3.4 Model Development

As indicated in Section 3.2, existing models were obtained from half of the systems included in the hydraulic model. These models were reviewed, converted to the current version of WaterGEMS, as needed, and processed to ensure uniformity and individual model integrity within the "statewide" model. In addition, these models were skeletonized as needed to represent only the primary interconnections and transmission mains and other system infrastructure necessary for the completion of the model.

Hydraulic models were developed with WaterGEMS for water systems without existing models based on various forms of information including paper maps, AutoCAD files, and GIS data bases. The locations of pipelines, facilities, and interconnections for these systems included in the model were identified through use of a statewide road-base background map. These models were developed in a skeletonized manner to include only the primary interconnections and transmission mains.

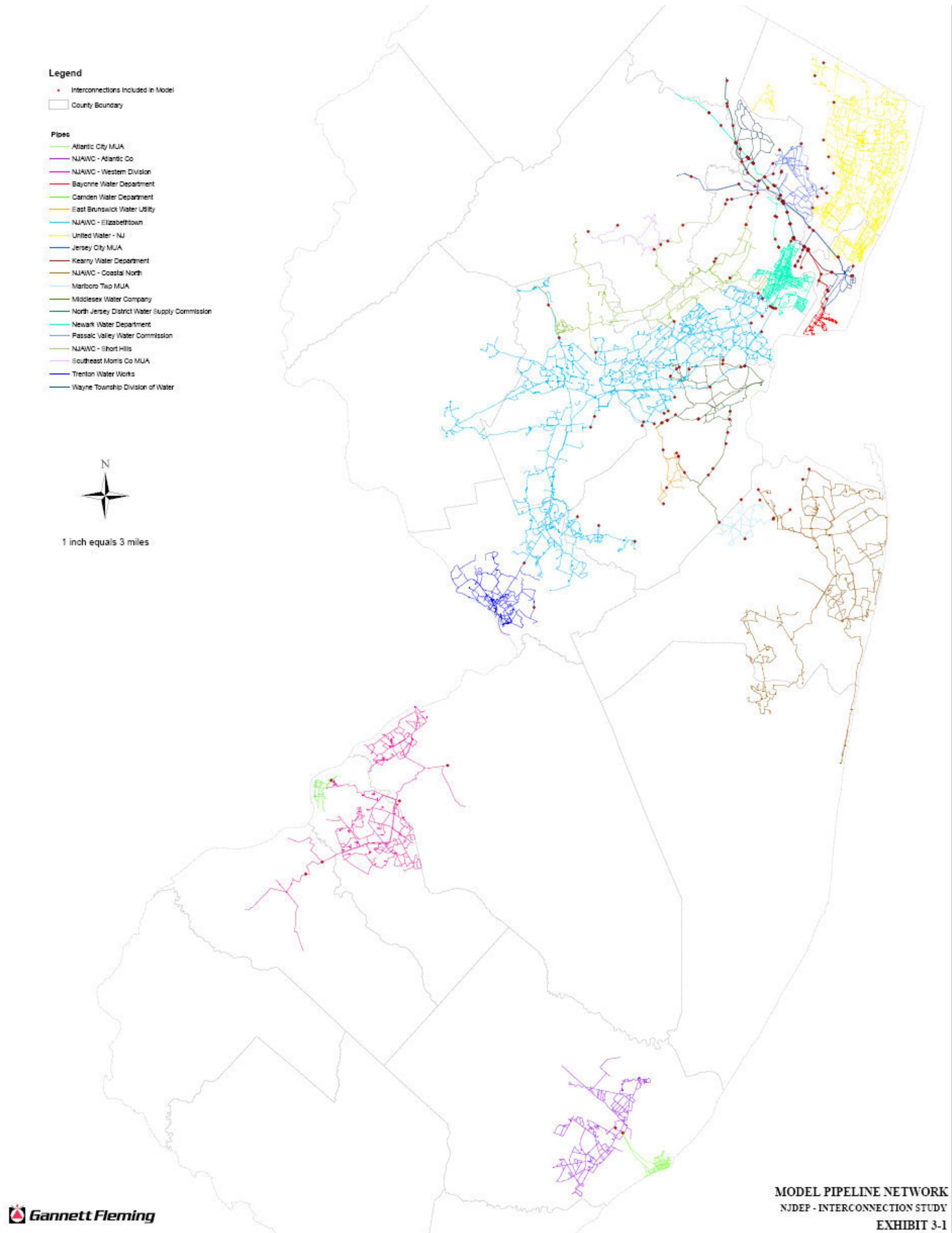
Legend
Interconnections Included in Model
County Boundary
Pipes
Atlantic City MUA
NJAWC - Atlantic Co
NJAWC - Western Division
Bayonne Water Department
Camden Water Department
East Brunswick Water Utility
NJAWC - Elizabethtown
United Water - NJ
Jersey City MUA
Kearny Water Department
NJAWC - Coastal North
Marlboro Twp MUA
Middlesex Water Company
North Jersey District Water Supply Commission
Newark Water Department
Passaic Valley Water Commission
NJAWC - Short Hills
Southeast Morris Co MUA
Trenton Water Works
Wayne Township Division of Water
N
1 inch equals 3 miles
Gannett Fleming
MODEL PIPELINE NETWORK
NJDEP - INTERCONNECTION STUDY
EXHIBIT 3-1

Figure 3-1

As needed, locations of primary transmission routes and facilities and corresponding data for facilities and sources of supply were assumed when data was unavailable in order to have a working model. A description of these assumptions is provided in the Model User Manual.

All new models created for this study were projected in the NJ State Plane Coordinate System, North American Datum 1983, as units in feet for consistency with other NJEMS data. As needed, existing models were also projected to the NJ State Plane Coordinate System, North American Datum 1983, as units in feet. The individual system models were subsequently joined together to complete the "statewide" model, which was facilitated by developing the models in the same projection. The joining process, however, required significant effort to resolve interconnection locations. Elevations for model junctions from existing models were set to the currently assigned elevations. Elevations for new model junctions were assigned using 30 meter Digital Elevation Model data obtained from the United States Geologic Survey (USGS) National Elevation Dataset (NED).

Facilities within systems with existing models were assumed to be accurately simulated in the existing model and thus were generally not adjusted. Facilities for systems that required the development of new models were simulated based on available information. As needed, assumptions were made to represent the facility in the model. The User Manual includes documentation regarding the assumptions that were required and includes specific information regarding the method of simulation for critical facilities and interconnections included in the model.

Current average day demands were assigned to each system in the model based on the values indicated in Table 2-4. It is assumed that the demand distribution for existing models provides a relatively high accuracy. Thus, the demand distribution was utilized "as is", and demands were scaled as needed to reflect the current ADD. Demands for new models were distributed evenly across a particular system. For all systems, identified bulk demands to a system not included in the model were represented in the model according to the assumed normal bulk supplies identified in Table 2-2. Additionally, a future year ADD model scenario was created based on the demand projections identified in Table 2-4. Model demand scenarios were also developed for current year drought and emergency system conditions according to the reduction factors described in Section 2.5.1.

A typical diurnal demand pattern was assigned to all model node demands for the purpose of developing a travel time/water age scenario, at the request of NJDEP. It should be noted, however, that the accuracy of travel time calculations is dependent upon numerous factors, such as the degree of model "skeletonizing", the existence of an accurate extended period simulation model, including accurate system demand distributions and diurnal demand patterns, the accuracy of pipeline headloss coefficients, and the accuracy of system facility representations in the model. Based on the overall objective of the study and corresponding required primary objective and degree of accuracy of the model, it is very likely that the accuracy of travel time calculations performed by the model will have a relatively high degree of uncertainty. In particular, the significant skeletonizing of the models will result in inaccuracies in travel time calculations, potentially greater than +/- 24 hrs. Due to these inaccuracies, the results of the travel time scenario should be used with discretion.

As indicated, individual system models were obtained from half of the systems that are included in the model. It is assumed that these existing system models are more detailed and assumed to be more accurate than what is required by this study. Additionally, pipeline roughness coefficients were provided by Passaic Valley Water Commission and United Water. For the remaining systems, a pipeline roughness C Factor value of 120 was assigned for ductile iron main, 100 for cast iron pipe, and 120 for unknown pipe materials. Actual system data and operating records were not available to perform a thorough assessment of the accuracy of model results; however, effort was made to verify that the model produced reasonable results. This effort involved a review of model output data to identify potentially unreasonable model results that could indicate an issue with the model input parameters. The review identified the following:

- High flow rates in and out of Tanks and Reservoirs (greater than 5 mgd)
- Extremely high and low pressures (less than 10 psi or greater than 250 psi)
- High velocities in pipelines (greater than 10 feet per second)
- Proper direction of flow in critical transmission mains.

As needed, adjustments were made to model input parameters to address the identified unreasonable results. Based on this review, it is assumed that the model is capable of performing the "planning level" analyses required by this study.

4.0 TASK 4 CATASTROPHIC INFRASTRUCTURE FAILURE

This task is intended to address both security and reliability concerns from a state-wide perspective. The primary elements of this task involve the evaluation of community systems under a variety of catastrophic “what-if” scenarios and the subsequent determination of recommended improvements, in cases where the communities are deemed to be at risk as a result of the catastrophic scenarios.

4.1 Identification of Scenarios

A series of catastrophic "what-if" scenarios were identified for each community water system serving a population of at least 10,000. The initial set of “what-if” scenarios for each system included the following:

1. Loss of the primary (largest capacity) source of supply for the system for an extended period of time (greater than a week).
2. Loss of the primary source of supply for the system for 24 hours.
3. Loss of a primary distribution system component for an extended period of time. For the purposes of the Task 4 analyses, a primary distribution system component will include:
   A. Transmission Mains 48-inch or greater
   B. 60 mgd or greater Pump Stations
   C. Finished Water Storage Facilities

Many of the systems evaluated did not contain transmission mains of 48-inch diameter or greater, nor 60 mgd Pump Stations. This left loss of finished water storage facilities and loss of primary source of supply as the main conditions for evaluation. As information pertaining to storage facilities was only reliably available for a small number of the larger systems, the principle scenario investigated involved loss of primary source of supply for an extended period of time.

In addition to the what-if scenarios for system specific catastrophic events, what-if scenarios for regional catastrophic events were identified to consider the extent of affected systems. The regional catastrophic scenarios included the following:

1. Loss of a regional water supply source for an extended period of time.
2. Loss of a regional primary distribution system component for an extended period of time.

While the scope of the study included investigation of how the presence or absence of emergency power supplies might affect the rating of a system, information from the systems about their emergency power supplies was largely unavailable. Given this limitation, our analysis must conclude that emergency power is not available in the systems. If additional information becomes available, it may be necessary to re-evaluate our conclusions.

4.2 Evaluation

The purpose of the evaluation is to identify a classification for each system for each of the "what-if" scenarios. In effect, the evaluation will assess a system's vulnerability to the respective catastrophic event. Every community water system included in the study is served by at least one primary source of supply. As information on system storage was largely unavailable, and the classifications require demands be met without use of system storage, the evaluation does not account for volume available in storage. However, relatively few communities will have 48-inch transmission mains or pump stations with a capacity greater than 60 mgd. Thus, for most systems, an evaluation was only conducted for catastrophic events involving loss of the primary source of supply and loss of the primary (largest capacity) finished water storage facility.

The classification system is defined as follows:

Self Sufficient: System shall be capable of providing (without system storage) at least 75% of average daily demand and maintain supply to all parts of the system without the use of interconnections.

Class A: System shall be capable of providing at least 75% of the average daily demand and maintain supply to all parts of the system with the use of interconnections with the following condition: no individual interconnection shall provide more than 50% of the total interconnection supply while relying on no more than 1 adjacent system for more than 25% of the average water supply of that system.

Class B: System shall be capable of providing at least 50% of the average daily demand and maintain supply to all parts of the system with the use of interconnections while relying on no more than 1 adjacent system for more than 35% of the average water supply of that system.

If a water system is not compliant with any of the above classifications it shall be classified as "Vulnerable."

The evaluation was conducted through use of spreadsheet/database tools and the hydraulic model, which was created as part of Task 2. For the majority of systems, a classification for the loss of primary source supply scenario is provided in Table 4-1. Where possible, a classification for each system for multiple "what-if" scenarios is provided based on the results of the evaluation. A description of the evaluation methods for the different types of what-if scenarios is provided below.

When evaluating interconnections, it was necessary to compare both hydraulic capacity and excess system capacity. The lower of the two values was determined to be the limiting factor. This lower value was used as the capacity for that interconnection. It was possible for interconnections to have hydraulic potential, but no excess capacity to share. Similarly, a system could have excess capacity, but no means to transfer water into a receiving system. This may be caused by pressure differentials across the systems. In situations where excess capacity is available, but hydraulically not possible, the systems should make every effort to correct the connection hydraulics.

System Specific

1. Loss of the primary source of supply for the system for an extended period of time.

   The available supply capacity for a particular system with its primary supply out of service was compared with the average daily demand for the particular system to determine the level of dependence of the system on the primary supply. It is assumed that storage facilities can not be used as a supplemental supply for an extended period. Consideration was given to whether the water can reach all parts of the system. This transmission component of the analysis was limited to systems included in the model.

   If a system was served solely through its own treated water capacity, the catastrophic capacity available was compared against the average daily demand. If the catastrophic capacity exceeded 75% of the average daily demand, the system was determined to be self-sufficient. If the system was served through a combination of self-produced supply and bulk purchase agreements, the largest source was evaluated as out of service. If the bulk purchase connection could provide additional flow to meet the average demand, based on hydraulics of the interconnection, then the system was classified as Class B. The source of primary and secondary flow becomes the one bulk purchase provider. This makes the reader aware that the flow is provided only through one source under emergency conditions. According to the definition of Class A, no more than 50% of emergency flows may be provided by any one single supplier.

   In some situations, water was purchased from a supplier, but multiple connection points exist. For example, Bloomfield has 5 points of interconnection with the City of Newark Water Supply System. Only 2 are used on a regular basis, however any combination of the 5 stations could be used to meet their bulk purchase agreement. When the primary connection stations were evaluated as unavailable and the secondary stations were used for supply, they were considered as interconnections. This highlights the fact that the primary connections are not in service and the system has moved to secondary sources. They may be able to draw water in accordance with their bulk purchase agreements through these secondary sources, but we felt it was necessary to distinguish these situations from normal operations.

2. Loss of the primary source of supply for the system for 24 hours.

   The available supply capacity for a particular system with its primary supply out of service was compared with the average daily demand for the particular system to determine the level of dependence of the system on the primary supply. Available storage capacity was considered as a viable supplemental supply for a 24 hour period.

   Though the intent was to evaluate this scenario for all of the systems, given the lack of available storage information, this analysis could not be performed. The NJDEP requested that we investigate the capacity of alternative power for each system. This data would have been used to analyze the impact of a regional power outage on the system, such as occurred in the Northeast in August of 2003. Despite requests to the systems in January of 2007, the information was largely unavailable and the analysis could not be performed.

3. Loss of a primary distribution system component for an extended period of time.

   A. Finished Water Storage Facility

      The available supply and storage volume for a particular system with its primary storage facility out of service was compared with the estimated peak hourly demand on an average demand day to determine the systems dependence on its primary storage facility in meeting peak demands. The systems included in the model were subject to an analysis of the need for that storage structure to provide adequate pressure.

   B. Transmission Main 48-inch or greater

      All transmission mains 48-inch and greater are included in the hydraulic model. Thus, for systems with transmission mains 48-inch or greater, the model was used to assess a system's ability to meet average day demands if the transmission main is out of service.

   C. 60 mgd or greater Pump Station

      All pump stations with a capacity of 60 mgd and greater are included in the hydraulic model. Thus, for systems with 60 mgd or greater pump stations, the model was used to assess a system’s ability to meet average day demands if the pump station is out of service.

<u>Regional</u>

1. Loss of a regional source of supply for an extended period of time.

   Systems impacted by the loss of a primary regional source of supply were identified. The available supply capacity for those affected systems with the primary regional supply out of service were compared with the average daily demand for the particular system to determine the regional level of dependence on the regional primary supply. It was assumed that storage facilities can not be used as a supplemental supply for an extended period. The systems included in the model received an analysis to determine the extent of the impact.

   This analysis affects only those systems whose primary source of supply is through bulk purchase agreements. Whereas in the loss of primary source analysis, systems were able to treat multiple source connections as back-up secondary interconnections, in this analysis, all supply from a regional supplier is considered to be unavailable. In situations where a system produces its own potable water, their internal facilities are considered functional for the regional analysis. For these systems, the regional analysis rating is a continuation of the primary source analysis and are shown as blank in Table 4-3.

2. Loss of a regional primary distribution system component for an extended period of time.

   Systems impacted by the loss of a particular regional primary distribution system component were identified. The model was used to assess a system's ability to meet average day demands with the primary regional distribution component out of service to determine the regional level of dependence on the component. The systems included in the model received an analysis to determine the extent of the impact.

4.3 Results

[SECTION 4.3 REDACTED]

Table 4-1
Summary
Catastrophic Infrastructure Failure Analysis

[TABLE 4-1 REDACTED]

[SECTION 4.3 REDACTED]

4.4 Infrastructure Needs

[SECTION 4.4 REDACTED]

Table 4-2
Results of Loss of Primary Supply for a Prolonged Period

[TABLE 4-2 REDACTED]

Table 4-3
Results of Loss of Regional Supply for a Prolonged Period

[TABLE 4-3 REDACTED]

[SECTION 4.4 REDACTED]

[SECTION 4.4 REDACTED]

[SECTION 4.4 REDACTED]

[SECTION 4.4 REDACTED]

TABLE 4-4
RESULTS OF CATASTROPHIC FAILURE ANALYSIS
LOSS OF REGIONAL SUPPLY SOURCE SCENARIO

[REDACTED]

TABLE 4-4
RESULTS OF CATASTROPHIC FAILURE ANALYSIS
LOSS OF REGIONAL SUPPLY SOURCE SCENARIO

[REDACTED]

TABLE 4-4
RESULTS OF CATASTROPHIC FAILURE ANALYSIS
LOSS OF REGIONAL SUPPLY SOURCE SCENARIO

[REDACTED]

TABLE 4-5
RESULTS OF CATASTROPHIC FAILURE ANALYSIS
LOSS OF PRIMARY SUPPLY SOURCE SCENARIO

[REDACTED]

TABLE 4-5
RESULTS OF CATASTROPHIC FAILURE ANALYSIS
LOSS OF PRIMARY SUPPLY SOURCE SCENARIO

[REDACTED]

TABLE 4-5
RESULTS OF CATASTROPHIC FAILURE ANALYSIS
LOSS OF PRIMARY SUPPLY SOURCE SCENARIO

[REDACTED]

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5.0 WATER SUPPLY MANAGEMENT DECISION SUPPORT TOOL (TASK 3 & TASK 5)

5.1 Introduction and Purpose

The overall objective of Task 3 of the Interconnection Study involves the evaluation of existing water diversions and operational conditions of selected utilities around the state to identify potential changes that might be made to avert drought related water supply emergencies. More specifically, the primary objectives of Task 3 include:

- Evaluate existing water diversions and operating conditions
- Identify alternative water diversions and operating conditions to avert drought related water emergencies
- Identify water transfer infrastructure deficiencies based on the alternatives
- Identify and evaluate infrastructure improvements to correct deficiencies

To achieve these objectives, a Water Supply Management Decision Support Tool (WSMDST) was developed, as described in the following section. The WSMDST integrates the use of 3 models that have been developed as part of the Interconnection Study:

- Hydraulic Model
- Interconnection Mass Balance Model (IMBM)
- Reservoir Mass Balance Model (RMBM)

The hydraulic model developed as part of Task 2 and described in Chapter 3 is used to evaluate existing interconnections and primary transmission infrastructure to optimize the use of existing water sources. The model also is used to identify water transmission infrastructure deficiencies and analyze corrective infrastructure improvements.

The interconnection mass balance and reservoir mass balance models are described in this chapter. Also, the NJ Water Supply Drought Indicator System is described, as the WSMDST is envisioned to supplement, not replace, this system. This chapter also includes a discussion of the various water supply scenarios that have been evaluated.

It should be noted that the WSMDST does not include a groundwater modeling component to it. In a meeting with NJDEP and NJGS in August 2006, it was determined that the data and level of effort required to complete such a task was beyond the scope of this study. Therefore, it was determined that groundwater would be treated as a constant supply at the well production capacity. Additionally, it was assumed in the WSMDST that systems having surface and groundwater sources of supply would use their groundwater capacity first and then resort to surface sources.

5.2 WSMDST

This tool was developed and used to evaluate alternatives as part of this project and will also assist the NJDEP in making drought related decisions in the future. The general objective of the decision support tool is to divert water, using available interconnection capacities, to mitigate excessive drawdown of water resources in localized areas and adjust the drawdown of each indicator to approximately coincide with the average drawdown rate in the drought region. The "fitness" of each solution of transfers is controlled by numerous constraints, including permit limits, inter-basin transfer limits, and passing flow requirements, among other factors that have been identified through discussions with NJDEP.

5.2.1 Relation to NJ Water Supply Drought Indicator System

The drought indicator system is a comprehensive data collection effort that provides NJDEP professionals, state officials, and water supply professionals with the information required to make drought mitigation strategy decisions. Some of the actions that can be taken as a result of the increased awareness provided by the drought indicator system include:

- Closer monitoring of indicators, system and regional demands
- Public awareness and education campaigns
- Reduction of passing flow requirements
- Transfers of water
- Water demand reductions

New Jersey is divided into 6 drought regions that roughly coincide with major watershed boundaries, as shown in Figure 5-1. Actual divisions are along municipal boundaries, as, in the event of a drought emergency, local municipal police would be the primary enforcement authority for drought remediation efforts. Drought regions allow NJDEP to respond to changing conditions without imposing restrictions on areas of the state not experiencing water shortages.

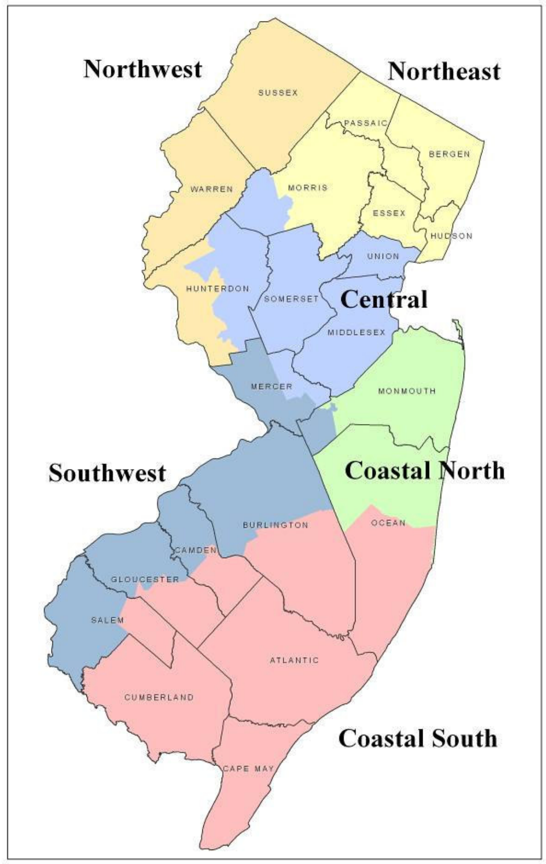

Figure 5-1: New Jersey Drought Regions

NJDEP has established four drought indicators: precipitation, streamflow, reservoir levels, and groundwater levels. The goal of each indicator is to summarize the status of a single factor affecting water supply in a given region.

Each indicator is assigned one of four possible conditions:

- Near or above normal
- Moderately dry
- Severely dry
- Extremely dry

These are updated weekly during dry periods and monthly during normal conditions. Based on the drought indicators, best professional judgment, and input from water purveyors, NJDEP will declare a drought status as follows:

- Normal
- Watch
- Warning
- Emergency

In each region, representative groundwater levels, streamflows, reservoir levels, and 90-day precipitation are compared to rule curves derived from statistical data which dictate a drought condition recommendation. Derivation of the rule curves is described in the Joint BPU and NJDEP Water Emergency Planning Team Final Report included in Appendix X. Reservoir rule curves are named observe, caution, and extreme and are often used interchangeably in this study with the drought condition which they describe: watch, warning, or emergency, respectively. Example rule curves are shown in Figure 5-2. The NJDEP Commissioner can declare or lift a drought watch or drought warning; only the Governor can declare or lift a drought emergency.

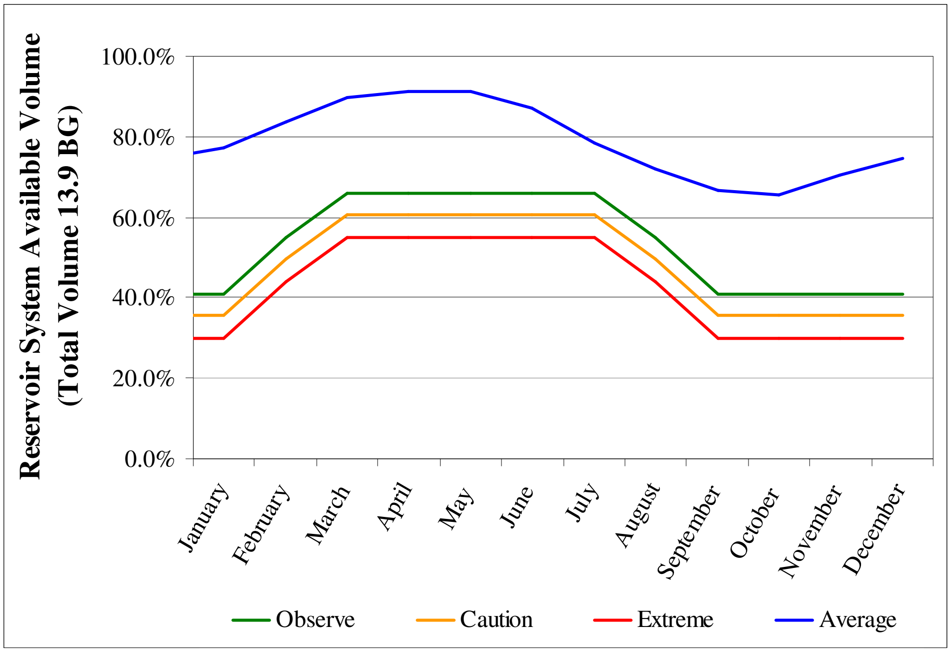

Figure 5-2: Rule Curves for United Water Reservoir System

5.2.2 Model Software

The WSMDST is a software model that builds on the framework of the drought indicator system. Armed with the understanding of when droughts are imminent and where they are most severe, decision-makers can use the support tool to gage the effectiveness of their mitigation plans. By anticipating possible drought scenarios, the WSMDST can guide long-term planning efforts to identify infrastructure improvements necessary to ease water supply shortages in severely affected regions. Specific application of the drought indicator system to the decision support tool is described in the following paragraphs.

The progressive status of a drought from watch to warning to emergency implies increasingly aggressive actions for mitigation. During normal conditions, interconnections between water purveyors are assumed to be used only for contractual water sale and purchase. The software model derives what these normal transfers are likely to be as a preliminary step in the analysis, but because of its express purpose for use in drought situations, the minimum drought condition is assumed to be drought watch. During drought *watch* conditions, the decision support tool allows the use of emergency interconnections within a drought region only — non-regular inter-regional water transfers are not allowed. In keeping with the progressive nature of response, a drought *warning* in any region will allow any inter-region interconnection to be used. NJDEP has non-emergency power to require water purveyors to transfer water during a drought warning following a public hearing. *Emergency* conditions also optimize water resources using inter-region interconnections, and a reduction in demand can be manually applied within the program to simulate mandatory water use limits.

The WSMDST also incorporates rule curves from the drought indicator system. The reservoir rule curves specify a combined reservoir system volume that varies throughout the year, lowest in the late summer and fall, and highest during the winter and spring. For example, if the combined volume of Monksville and Wanaque reservoirs on a specified date is below the volume specified by the "observe" rule curve for that date, but above the volume specified by the "caution" curve for that date, then that particular drought indicator will suggest a drought watch condition. These curves are used in the software as a reference for normalizing the drawdown of reservoir systems, so that ideally (if sufficient transfer capacity exists) no reservoir system will reach a drought warning condition until all other systems in the same region have drawn down to drought warning conditions. Similarly, once in a drought warning (and therefore inter-region transfers are available) no reservoir system should reach emergency status until all other sources become correspondingly exhausted. Because each reservoir system's unique rule curves reflect their differing recharge behavior, this normalization scheme takes into account differing risks of running dry. For example, Jersey City's reservoir system is one of the quickest to refill, and its "extreme" curve dips all the way to 25% of its total volume. The Spruce Run and Round Valley system refills much more slowly so its "extreme" curve only drops to 35% at its lowest point and ramps back up with a much more shallow slope. Systems that withdraw from rivers are given preference in the normalization scheme because there is no storage that requires recharge.

5.3 Interconnection Mass Balance Development

One of the key components of the WSMDST is the Interconnection Mass Balance Model (IMBM). Written in Visual Basic and drawing from an intuitive and easily accessible and editable database in Microsoft Excel spreadsheets, the IMBM is at the core of the decision support tool. In itself, it is not a hydraulic model, but it relies heavily on findings from the Task 2 hydraulic model that predicts the capacities of major interconnections throughout the state based on pipe diameters, relative pressures of neighboring purveyors, and pump curves. The IMBM finds the optimum use of water supply to meet demand by analyzing all of the available parallel and series paths for water transfer. This capability is important in determining how much transfer capacity exists for different drought scenarios so that existing infrastructure can be used most efficiently. It also identifies which interconnections have the highest usage rates and where additional or improved infrastructure (enlarged or parallel water mains, pump stations, new interconnections, etc) can be most effectively implemented.

5.3.1 Model Input Database

A large amount of data has been collected and organized into a database for use by the IMBM. Expansion and editing of this database to include newly documented or revised data is very simple. By modifying the input database, hypothetical improvements can be added to determine their value and effectiveness; emergency situations can be generated to simulate drought conditions, contaminated sources, treatment plants out of service, main breaks and other scenarios. This section describes all of the supply, demand, and interconnection data that are processed by the WSMDST.

Starting on the supply end of the mass balance equation are the water source and treatment plant data. Organized into two separate tables, one for groundwater supplies and one for surface water, the data fields include Public Water System Identification (PWSID), purveyor name, treatment plant capacity (peak vice firm capacity), allocation limit, treatment plant name, and a typical monthly supply pattern for each; where insufficient data has been available from suppliers reasonable values have been assumed. In the groundwater table, each well/wellfield operated by the same purveyor has been combined into a single source for simplicity and conciseness. The surface water table additionally summarizes from which reservoir or river system each plant draws. The database includes 33 groundwater sources with a combined capacity of 340 mgd and 21 surface water treatment plants with a combined capacity of 1,250 mgd. Table 5-1 and Table 5-2 summarize the treatment plant information included in the IMBM. (Abbreviated names are used in subsequent tables for improved readability.) The unabridged data for these and all other tables in this section are accessible in the IMBM software.

PWSID	Purveyor Name	Production Capacity (MGD)	PWSID	Purveyor Name	Production Capacity (MGD)
0102001	Atlantic City MUA	19	0802001	Deptford Township	8.73
0112001	Hamilton Township MUA	9.14	0810004	Mantua Township MUA	3.09
0119002	NJAWC - Atlantic System	21.75	1103001	Aqua New Jersey, Inc. - Hamilton Square	7.83
0201001	Allendale Water Department	1	1209002	Old Bridge MUA	9.1
0221001	Garfield City Water Department	2.4	1213002	Monroe Township MUA	11.36
0233001	Mahwah Water Department	7.7	1216001	City of Perth Amboy	8
0238001	United Water New Jersey	2	1219001	Sayreville Borough Water Department	11
0327001	NJAWC - Western Division	47.9	1221004	South Brunswick Twp Water Utility	5.5
0408001	Camden City Water Department	19.44	1225001	Middlesex Water Company	25.06
0506010	NJAWC - Neptune System	1	1328002	Marlboro Township MUA	4.5
0514001	Wildwood City Water Department	18.6	1345001	NJAWC - Monmouth System	15.43
0705001	East Orange Water Commission	11	1352003	Wall Township Water Department	4.478
0706001	Essex Fells Water Department	1	1424001	Southeast Morris County MUA	13.44
0710001	Livingston Township Water Division	5.09	1432001	Morris County MUA	9.52
0712001	NJAWC - Short Hills	20	1506001	Brick Township MUA	2.5
0713001	Montclair Township Water Bureau	1.8	2004002	NJAWC - Elizabethtown	11.08
0719001	South Orange Village Twp Water Dept	0.5			

Table 5-1: Groundwater production capacities of purveyors included in the WSMDST

PWSID	Purveyor Name	Treatment Plant Name	Production Capacity (MGD)	Source of Supply
0102001	Atlantic City MUA	Pleasantville Water Treatment Plant	21	Absecon Creek, Doughty Pond & Kuehnle Pond
0238001	United Water New Jersey	Haworth WTP	203	Hackensack River System
0327001	NJAWC - Western Division	Delaware River Regional WTP	40	Delaware River
0712001	NJAWC - Short Hills	Canoe Brook Station Plant No. 1 & 2	20	Passaic River and Canoe Brook
0714001	Newark City Water Department	Pequannock Water Treatment plant	50	Pequannock watershed
0906001	Jersey City MUA	Jersey City WTP	80	Boonton Reservoir
1111001	Trenton Water Works	Trenton Water Filtration Plant	65	Delaware River
1214001	New Brunswick City Water Department	New Brunswick Water Treatment Plant	18	Delaware & Raritan Canal and Raritan River
1215001	North Brunswick Water Department	Surface Water Treatment	10	Delaware-Raritan Canal
1219001	Sayreville Borough Water Department	Bordentown Avenue WTP	7	South River & Duhernal Water System, groundwater wells
1225001	Middlesex Water Company	Carl J. Olsen (CJO) Plant	60	Delaware & Raritan Canal
1345001	NJAWC - Monmouth System	Swimming River WTP	36	Swimming River Reservoir
1345001	NJAWC - Monmouth System	Jumping Brook WTP	30	Glendola Reservoir, groundwater wells, NJWSA
1352005	NJWSA Manasquan	Manasquan Water Treatment Plant	4	Manasquan River
1424001	Southeast Morris County MUA	Clyde Potts	2	Passaic River Basin
1506001	Brick Township MUA	William Miller WTP	16	Metedeconk River
1605002	Passaic Valley Water Commission	Little Falls WTP	100	Passaic and Pompton Rivers
1613001	North Jersey District Water Supply Commission	Wanaque Treatment Plant	210	Wanaque Reservoir
2004002	NJAWC - Elizabethtown	Rariton Millstone S.W. TP	179	Raritan and Millstone Rivers
2004002	NJAWC - Elizabethtown	Canal Road S.W. TP	60	Raritan and Millstone Rivers

Table 5-2: Surface water production capacity of purveyors included in the WSMDST

Purveyors can also receive water supply from contract interconnections, and for some this is the only source of supply. A separate sheet in the IMBM correlates suppliers and receivers along with their PWSIDs, contractual limits, interconnection identification numbers, and a typical monthly supply pattern. The database includes 38 contract interconnections totaling a combined capacity of nearly 300 mgd. These data are summarized in Table 5-3.

Supplier PWSID	Supplier Name	Purchaser PWSID	Purchaser Name	Contract Capacity (MGD)
0102001	Atlantic City	0119002	NJAWC - Atlantic	1.9
0327001	NJAWC - Western	0802001	Deptford	1.1
0705001	East Orange	0719001	South Orange	2.4
0712001	NJAWC - Short Hills	0710001	Livingston	0.1
0712001	NJAWC - Short Hills	1424001	Southeast Morris County	2.9
0714001	Newark	0701001	Belleville	3.5
0714001	Newark	0705001	East Orange	1.4
0906001	Jersey City	0232001	Lyndhurst	2.7
0906001	Jersey City	0238001	UWNJ	5.7
0906001	Jersey City	0905001	Hoboken	4.1
0907001	Kearny	0704001	Cedar Grove	0.8
1111001	Trenton	1103001	ANJI - Hamilton Square	0.1
1225001	Middlesex	1204001	East Brunswick	7.4
1225001	Middlesex	1205001	Edison	0.7
1225001	Middlesex	1207001	Highland Park	1.9
1225001	Middlesex	1209002	Old Bridge	4.4
1225001	Middlesex	1219001	Sayreville	1.5
1225001	Middlesex	1328002	Marlboro	4.0
1352005	NJWSA Manasquan	1214001	New Brunswick	3.5
1352005	NJWSA Manasquan	1215001	North Brunswick	5.9
1352005	NJWSA Manasquan	1225001	Middlesex	29.5
1352005	NJWSA Manasquan	1345001	NJAWC - Monmouth	2.1
1352005	NJWSA Manasquan	1352003	Wall	2.9
1432001	Morris County	0712001	NJAWC - Short Hills	0.8
1605002	Passaic Valley	0211001	Elmwood	2.0
1605002	Passaic Valley	0221001	Garfield	1.9
1605002	Passaic Valley	0704001	Cedar Grove	0.4
1605002	Passaic Valley	0712001	NJAWC - Short Hills	8.0
1605002	Passaic Valley	0904001	Harrison	1.1
1613001	NJDWSC	0704001	Cedar Grove	1.4
1613001	NJDWSC	0713001	Montclair	4.2
1613001	NJDWSC	0714001	Newark	35.8
1613001	NJDWSC	0901001	Bayonne	8.8
1613001	NJDWSC	0907001	Kearny	6.6
1613001	NJDWSC	1605002	Passaic Valley	40.8
1613001	NJDWSC	1614001	Wayne	7.6
2004002	NJAWC - Elizabethtown	0712001	NJAWC - Short Hills	13.0
2004002	NJAWC - Elizabethtown	1205001	Edison	6.5
2004002	NJAWC - Elizabethtown	1221004	South Brunswick	3.7
2004002	NJAWC - Elizabethtown	1225001	Middlesex	4.9

Table 5-3: Contract interconnections

Moving to the opposite end of the mass balance equation, retail demand is what drives groundwater and reservoir withdrawals. Demand data from each purveyor were analyzed for the period of record provided, and the results are tabulated in the demand sheet of the IMBM. The database includes an average day demand and monthly factors that describe the trends for each purveyor. Daily peaking factors are not considered because cumulative effects on reservoir drawdown follow average withdrawal rates. For purposes of the model, the average day demand during each month was considered. Demand data for all purveyors is included in Table 5-4 and a graphical representation of the monthly variation in demand is shown in Figure 5-3.

PWSID	Purveyor Name	Average Day Demand (MGD)	January	February	March	April	May	June	July	August	September	October	November	December
0102001	Atlantic City	12.7	0.92	0.86	0.91	0.89	0.98	1.08	1.26	1.23	1.07	0.99	0.92	0.90
0112001	Hamilton	1.9	0.85	0.77	0.85	0.85	1.10	1.16	1.31	1.25	1.06	0.99	0.87	0.95
0119002	NJAWC - Atlantic	12.8	0.82	0.72	0.79	0.82	1.09	1.23	1.43	1.35	1.15	0.96	0.83	0.84
0201001	Allendale	1.0	0.77	0.68	0.76	0.81	1.11	1.18	1.58	1.51	1.17	0.94	0.74	0.76
0211001	Elmwood	2.0	0.92	1.02	0.88	0.99	0.89	1.01	1.12	1.24	1.01	0.98	0.99	0.93
0221001	Garfield	3.2	0.95	0.96	0.91	0.93	0.97	1.05	1.08	1.17	1.04	1.02	1.01	0.92
0232001	Lyndhurst	2.7	0.91	0.90	0.99	0.93	0.81	1.13	1.26	1.26	1.06	0.90	0.96	0.89
0233001	Mahwah	4.5	0.70	0.80	0.90	0.95	1.00	1.00	1.00	0.95	0.90	0.80	0.85	0.75
0238001	UWNJ	113.4	0.95	0.86	0.92	0.89	1.03	1.08	1.24	1.17	1.03	0.98	0.91	0.94
0327001	NJAWC - Western	39.1	0.93	0.84	0.91	0.91	1.04	1.08	1.19	1.15	0.99	1.03	0.95	1.02
0408001	Camden	10.6	0.94	0.89	0.96	1.01	0.95	1.00	1.16	1.15	1.04	1.03	0.90	0.97
0506010	NJAWC - Neptune	1.0	0.82	0.77	0.84	0.84	1.05	1.17	1.39	1.33	1.10	1.00	0.90	0.86
0514001	Wildwood	3.8	0.58	0.52	0.57	0.71	1.11	1.43	1.92	1.96	1.25	0.81	0.57	0.56
0701001	Belleville	3.5	1.03	1.03	0.85	0.99	0.98	0.98	1.05	1.08	1.11	0.91	0.98	1.01
0704001	Cedar Grove	2.5	0.70	0.80	0.90	0.95	1.00	1.00	1.00	0.95	0.90	0.80	0.85	0.75
0705001	East Orange	9.2	1.04	0.93	1.02	0.97	1.00	1.01	1.06	1.07	0.93	1.00	0.96	1.01
0706001	Essex Fells	0.5	0.80	0.86	0.94	0.92	1.08	1.17	1.22	1.21	1.20	0.93	0.80	0.86
0710001	Livingston	3.9	0.92	0.80	0.85	0.87	1.03	1.15	1.34	1.29	1.08	0.95	0.86	0.85
0712001	NJAWC - Short Hills	38.2	0.95	0.86	0.92	0.91	1.04	1.09	1.25	1.17	1.04	0.98	0.90	0.93
0713001	Montclair	4.9	0.98	0.89	0.92	0.84	1.03	1.14	1.17	1.06	1.11	0.93	1.00	0.91
0714001	Newark	83.3	1.04	0.97	1.01	0.97	1.01	0.98	1.04	1.07	1.00	0.97	0.97	0.99
0715001	North Caldwell	1.0	0.70	0.80	0.90	0.95	1.00	1.00	1.00	0.95	0.90	0.80	0.85	0.75
0719001	South Orange	2.6	1.03	0.96	1.04	0.99	1.06	1.08	1.08	1.03	0.97	0.96	0.88	0.91
0802001	Deptford	2.7	0.86	0.79	0.85	0.91	1.06	1.12	1.31	1.28	1.05	0.98	0.90	0.89
0810004	Mantua	1.1	0.81	0.73	0.81	0.88	1.12	1.21	1.44	1.37	1.09	0.94	0.79	0.80
0901001	Bayonne	8.8	1.00	0.93	1.02	0.96	1.03	1.01	1.04	1.03	1.00	1.00	0.97	1.01
0904001	Harrison	1.1	1.17	1.03	1.28	0.95	0.94	0.79	0.93	0.90	0.86	0.96	1.07	1.13
0905001	Hoboken	4.1	1.00	0.93	1.01	0.98	1.00	0.97	1.01	1.04	1.01	1.04	1.00	1.00
0906001	Jersey City	50.4	1.06	0.94	0.95	0.89	0.94	1.05	1.15	1.15	1.03	0.97	0.91	0.96
0907001	Kearny	6.6	1.08	0.97	1.04	1.00	1.05	1.03	1.11	0.78	0.93	1.03	0.99	0.99
1103001	ANJI - Hamilton Square	3.4	0.81	0.73	0.83	0.87	1.07	1.27	1.40	1.27	1.11	0.99	0.83	0.82
1111001	Trenton	27.4	0.98	0.93	0.93	0.96	0.95	1.02	1.19	1.15	1.04	0.96	0.93	0.96
1204001	East Brunswick	7.4	0.88	0.79	0.81	0.87	1.05	1.15	1.38	1.24	1.11	1.03	0.86	0.84
1205001	Edison	7.2	1.03	0.92	0.98	0.94	1.00	1.02	1.07	1.10	1.02	0.98	0.94	1.00
1207001	Highland Park	1.9	1.06	0.99	1.02	0.92	0.96	0.96	1.09	1.10	1.03	0.98	0.92	0.96
1209002	Old Bridge	7.3	0.95	0.78	0.83	0.86	1.05	1.19	1.32	1.24	1.12	0.94	0.87	0.85
1213002	Monroe	4.3	0.72	0.63	0.70	0.80	1.15	1.31	1.59	1.48	1.22	0.95	0.71	0.73
1214001	New Brunswick	14.0	1.04	0.94	0.99	1.00	1.01	0.99	1.05	1.02	1.01	1.05	0.99	0.95
1215001	North Brunswick	5.9	1.00	0.90	0.94	0.92	1.01	1.04	1.18	1.13	1.02	1.00	0.96	0.97
1216001	Perth Amboy	5.7	0.93	0.91	0.92	1.01	1.03	1.05	1.12	1.02	1.04	1.02	0.98	0.98
1219001	Sayreville	6.2	0.88	0.80	0.87	0.91	1.10	1.13	1.21	1.25	1.12	1.02	0.85	0.85
1221004	South Brunswick	5.3	0.89	0.79	0.70	0.86	1.03	1.19	1.42	1.34	1.13	0.96	0.84	0.86
1225001	Middlesex	49.2	0.95	0.85	0.92	0.91	1.03	1.08	1.20	1.18	1.04	0.99	0.91	0.94
1328002	Marlboro	5.3	0.76	0.70	0.80	0.86	1.11	1.25	1.59	1.34	1.09	0.92	0.76	0.79
1345001	NJAWC - Monmouth	41.3	0.98	0.88	0.94	0.93	0.99	1.01	1.28	1.19	1.00	0.95	0.90	0.97
1352003	Wall	2.9	0.86	0.81	0.85	0.88	1.08	1.15	1.33	1.24	1.07	1.02	0.86	0.85
1352005	NJWSA Manasquan	3.1	0.70	0.80	0.90	0.95	1.00	1.00	1.00	0.95	0.90	0.80	0.85	0.75
1424001	Southeast Morris County	9.8	0.91	0.82	0.89	0.89	1.04	1.11	1.27	1.25	1.07	0.98	0.87	0.89
1432001	Morris County	3.4	0.70	0.80	0.90	0.95	1.00	1.00	1.00	0.95	0.90	0.80	0.85	0.75
1506001	Brick	9.8	0.89	0.79	0.88	0.90	1.14	1.16	1.25	1.11	1.05	1.00	0.90	0.92
1605002	Passaic Valley	90.6	0.97	0.91	1.00	0.97	1.02	1.05	1.16	1.15	1.01	0.96	0.91	0.90
1613001	NJDWSC	114.8	0.70	0.80	0.90	0.95	1.00	1.00	1.00	0.95	0.90	0.80	0.85	0.75
1614001	Wayne	7.6	0.87	0.76	0.79	0.84	1.05	1.13	1.41	1.29	1.11	0.99	0.87	0.88
2004002	NJAWC - Elizabethtown	147.7	0.95	0.88	0.95	0.95	1.04	1.08	1.15	1.14	1.08	0.96	0.90	0.90

Table 5-4: Average daily demand and monthly demand patterns

A complex web of interconnections link water supply sources to the demands of consumers. Under normal conditions, only a limited number of interconnections are used on a regular basis as a sole supply for small purveyors or as a supplement to purveyors of all sizes. In order to prevent an emergency, these interconnections can be opened to allow water to flow from unstressed sources to areas that normally rely on water sources that are temporarily stressed. By reducing withdrawals from stressed sources and allowing more recharge, local areas are less vulnerable to continuing drought conditions. The software model assumes that interconnection flow is limited only by interconnection capacity. For example, if water must pass through an intermediate purveyor's distribution system en route from an unstressed watershed to a stressed one, it is assumed to pass freely through that distribution system and only be restricted at the interconnection. These assumptions must be verified using the Task 2 hydraulic model.

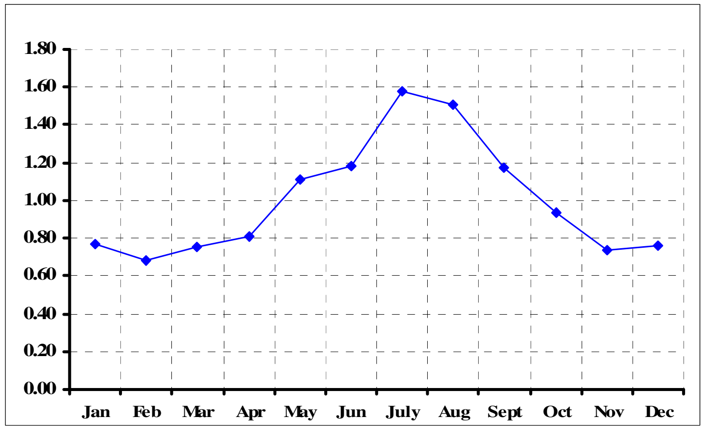

Figure 5-3: Monthly Demand Pattern for a Typical Purveyor

Coordinating the supply, demand, and interconnection tables is a list of major water purveyors throughout New Jersey. Among many critical functions in the programming code, this list has the significant importance of assigning each purveyor to a drought region. Fifty-five purveyors are interrelated in the IMBM. (All purveyors are listed in Table 5-4.)

The IMBM is only one half of the WSMDST. Notably absent from the above list of data is any information pertaining to the reservoirs and rivers from which water is taken. All of these and other hydrologic factors are partitioned within the WSMDST in the RMBM.

5.3.2 Optimization Criteria and Constraints

The compilation of data in the IMBM is an essential component of the entire decision support tool, but the processes performed by the Visual Basic coded program is the only way to decipher such complex relationships between the numerous variables to produce a useable and understandable output. The details of how these processes are implemented are outlined in the WSMDST User's Manual (Appendix X), but the following paragraphs describe in general terms how the model results are derived.

The goal of the optimization routine is the equitable hydrologic drawdown of the reservoir systems. The optimization routine, by using the rule curves established by NJDEP, reflects the refillability of the reservoir systems. It calculates the specific withdrawal rate for each reservoir system at which all reservoir systems have the same level of risk of going dry. During drought watch conditions, when inter-region transfers are not allowed, only those reservoir system drawdown rates within a region can be equalized. In the more severe warning and emergency conditions, the drawdown is optimized for the entire state.

The water distribution algorithm begins by supplying all purveyors with the maximum allocation of groundwater that each can produce. This is constrained by permitted limits and the capacities of pumping and treatment facilities. For systems that utilize both surface water and groundwater, the model assumes that the groundwater supplies will be maximized first. For each purveyor that cannot meet its demand with groundwater alone, surface water treatment plants are used to supplement supply up to the limits imposed by permits and treatment plant capacities. Finally, for those water suppliers that rely solely or partially on wholesale purchases of water, the contract interconnections flows are increased to meet demand. This progression of meeting demand by first groundwater, then surface water, and finally interconnections is an assumption that is based on the likely behavior of each purveyor to meet demand with its own source water, most easily and economically treated first, and with lowest preference given to bulk purchasing of water from another producer. It is understood that this type of progression is not always used by all water suppliers.

Under normal conditions, this first step would be sufficient to summarize supply and demand patterns for the major purveyors throughout the state. At this point, the user has the option to modify this initial output to account for specific knowledge of individual water system behaviors. For example, the model may predict that a water supplier produces water from its groundwater sources at maximum capacity, but perhaps the supplier has some reason to keep its surface water treatment plant production at a fixed rate and therefore lower its groundwater production rate. The user can adjust each of these rates to reflect real-world initial conditions prior to optimization for drought conditions.

The next step applies constraints to the withdrawals from reservoir systems. Using the RMBM and the supply pattern determined in the previous step, reservoir drawdown rates are determined for each reservoir system. These are summed to equal the combined drawdown rate for all systems. The drawdown is redistributed by adjusting treatment plant withdrawal rates such that the reservoir systems that are most stressed are drawn down the least and those reservoir systems that are least stressed are drawn down the most.

The target withdrawal rate for each reservoir system is divided among those treatment plants that withdraw from the given system. The algorithm that initially determined supply and demand is re-run with the new, constrained treatment plant production rates. In this scenario, however, emergency interconnections may be necessary to meet the demand of a purveyor that normally relies on a water source that is currently stressed.

The user has an opportunity to change the treatment plant production rates (limited by plant capacity) from the values recommended by the optimization routine, and the results for both the recommended and modified rates are recorded in the model output. In the event that a purveyor is not able to meet demand using the constrained treatment plant rate and supply through emergency interconnections, the treatment plant rate is increased above the target withdrawal rate, and the results are reflected by lower final reservoir levels in the RMBM.

5.3.3 Model Output

Just as there is an enormous amount of data that go into the IMBM, an equally unwieldy volume of data is generated by it. The results of a single model run (a single set of initial conditions and assumptions for future hydrologic factors) are summarized in several tables that outline the sources of water for each purveyor, the percent capacity at which their treatment plants operated and the usage of emergency interconnections. Interpretation of the data is sped by automatic call-outs that direct a user's attention to the significant results.

In the broadest look, a summary by drought region reports the total rate of production of groundwater and surface water and the interconnection supplies between each region. This big-picture synopsis is probably very predictable based on the starting conditions, but importantly provides an order of magnitude estimate of how much water is transferred between regions.

A table that summarizes all interconnection flow sharpens the focus down further to the individual purveyor level. Suppliers, receivers, and the rate of interconnection flow (mgd) are all listed, along with comments that reflect whether the receiver was able to meet demand through interconnections or if the emergency supply capacity was insufficient. Flow from the supplier to the receiver may be wheeled through several intermediary purveyors, and this chain consisting of multiple interconnection links is also listed by interconnection identification number. One such table stores the model results using the optimized data while a duplicate table stores the results following the user's modifications to the recommended values.

Another output displays the interconnection usage data in a different format. Instead of focusing on the suppliers and receivers, this table lists all of the interconnections individually, rather than in the supply chains for which they were used. This format allows easier comparison of interconnection capacities to simulation usages.

The most comprehensive output table lists all purveyors, their treatment plant usage as a percent of capacity, supply, demand, and emergency interconnection flow. Automatically generated comments focus on those purveyors for whom there are insufficient interconnection supplies.

5.4 Reservoir System Mass Balance Development

So far the optimization of water diversions during drought conditions has focused only on what is possible or necessary from the perspective of infrastructure and retail supply and demand. Referenced briefly in the explanation of optimization criteria and constraints in Section 5.3, the IMBM relies on the RMBM for an assessment of reservoir storage levels and hydrologic factors to determine how much water should be withdrawn and from where. The RMBM is a separate module of software that is written in the same Microsoft Excel and Visual Basic format that interfaces with the IMBM through a data exchange workbook that hands necessary information back and forth between the two models. The RMBM uses initial conditions; treatment plant withdrawals; statistical data for streamflows, precipitation, and evaporation; and reservoir operating rules to project the behavior of reservoir systems for a specified time into the future. This prediction is used to constrain the only variable in this complex equation — the treatment plant withdrawal rates. The reservoirs included in the RMBM are listed in Table 5-5.

The RMBM is a collection of "water balance" for each reservoir listed in Table 5-5 based on the conservation of mass. In the analysis, the reservoir is the control volume, and water entering and leaving the reservoir is an application of the Law of Conservation of Mass. The model adjusts the reservoir storage volume, between the bounds of usable volume and the spillway elevation, to equal the difference in the reservoir inflow and outflow. This is an iterative approach based on a daily time-step. The solution of the water balance equation occurs when the difference in reservoir inflow and outflow equals the change in reservoir storage volume. The following water balance equation is used by the model:

$$VOL_1 = [VOL_0 + INFLOW + PRECIP] - [TREAT + EVAP + SPILL + MIF]$$

The variables in the equation are defined as:

VOL_1	= reservoir volume at the end of the day
VOL_0	= reservoir volume at the beginning of the day
INFLOW	= volume of inflow during the day (direct or indirect streamflow)
PRECIP	= volume of precipitation on the reservoir during the day
TREAT	= treatment plant withdrawal volume during the day
EVAP	= volume of reservoir evaporation during the day
SPILL	= volume of reservoir spills during the day
MIF	= passing flow downstream of the dam and intake

Each reservoir modeled has unique characteristics for inflows and outflows, like off-line pump stations, raw water interconnections, or treatment demands from several Purveyors. The RMBM includes all of these inflow and outflow characteristics for each reservoir along with its reservoir operating rules as provided by NJDEP and the Purveyors. Summary tables with these assumptions for each individual reservoir were provided to the Purveyors for review and comment at the Big-25 meeting on January 2007. All comments were included into the RMBM.

5.4.1 Model Input Database

Between information provided by the USGS, the National Oceanographic and Atmospheric Administration (NOAA) and the NJDEP, there is a wealth of information to be considered when modeling water resources. For all of the information that does go into the

RMBM, however, the complexity of groundwater interaction with surface water was determined to be beyond the scope of this analysis. The vast amount of data in this portion of the WSMDST is not always as straight-forward as the hard numbers of supply, demand, and capacity. For example, there may be 60 years of daily data for a given streamgage, but this streamflow may only represent a fraction of the total surface flow into a reservoir. For the reservoir drainage area that bypasses the streamgage, some judgment must be applied in the analysis. Additionally, much of the data related to reservoir operating rules cannot be easily tabulated, but must be expressed through iterative processes. This is discussed further in Section 5.4.2: Optimization Criteria and Constraints.

Reservoir	Total Capacity (MG)	Drainage Area (mi2)
Lake DeForest	5,670	27.5
Lake Tappan	3,853	49
Woodcliff	871	19.4
Oradell	3,507	113
Monksville	7,000	40.4
Wanaque	29,630	90.4
Canistear	2,407	6.08
Oak Ridge	3,895	27.3
Clinton	3,518	10.5
Charlotteburg	2,964	56.2
Echo Lake	1,763	4.35
Splitrock	3,310	5.5
Boonton	7,620	119
Round Valley	55,000	5.7
Spruce Run	11,000	41.3
Swimming River	2,610	49.2
Manasquan	4,670	3.18
Glendola	1,000	1

Table 5-5: Summary of basic data for reservoirs included in RMBM

In addition to the in-stream and off-stream reservoirs included in the RMBM, consideration was given to the use of other "off-stream" reservoirs to mitigate water supply shortages. Specifically, PVWC's Point View Reservoir in the Northeast Region and Brick Township MUA's recently constructed reservoir in the Coastal North Region were considered. Point View Reservoir has a capacity of about 3 billion gallons, and Brick's Reservoir has a capacity of about 1 billion gallons. Both reservoirs are operated by pumping water into the reservoirs during high river flows with gravity release from the reservoirs directly to their respective treatment plants. Point View Reservoir is not used very often, and is considered more of a back-up supply in the event of an emergency. Brick's Reservoir has been in use only a few years, and so there is no historical use record. The intent is to use it when flow in the Metedeconk River is low or when water quality in the river is poor. This reservoir may be used on a more regular basis by Brick in the future to meet increased demands in the region.

Based on historical use patterns and the sizes of these reservoirs, their use as supplemental supplies to regularly mitigate water shortages is not considered viable. It is recommended that these reservoirs be continued to be used as a last resort when drought emergency conditions are realized. In this way, the use of these reservoirs would provide another option after all other options have been exhausted. Therefore, these reservoirs are not included in the RMBM.

One of the basic references of the RMBM is the storage curve for each individual reservoir. These geometric data are tabulated to correlate the stage or water surface height, volume, and surface area. The software most frequently deals with the water bodies in terms of volume, but the changing surface area of a reservoir as it fills and empties has the potential to significantly influence the water lost through evaporation. An example of a reservoir storage curve is shown in Figure 5-4. The comprehensive collection of data for reservoir storage curves and all other components of the RMBM database discussed in this section are accessible in the software.

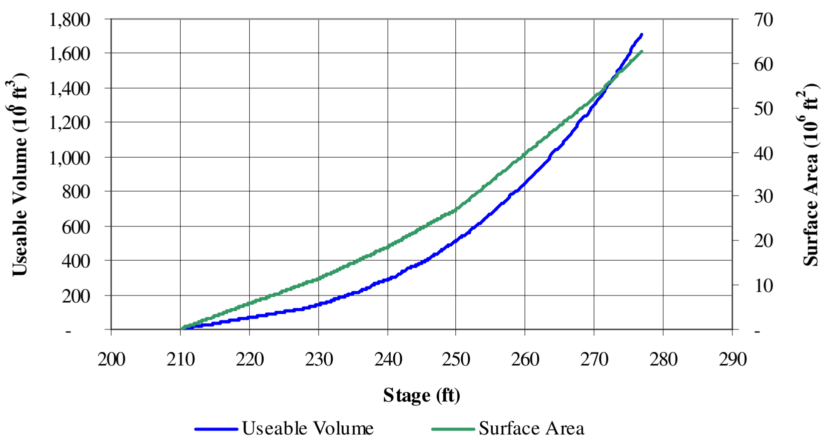

Figure 5-4: Stage/storage/surface area curve for Spruce Run Reservoir

The remaining tabular data are a statistical representation of all available historical data. This applies to reservoir levels, streamflows, precipitation, and evaporation.

One of the first attempts to develop an equitable hydrologic drawdown scheme for reservoir systems used statistical data based on historical reservoir levels. Some reservoir levels will vary greatly between seasons in a typical year while others experience only a slightly noticeable dip going into the fall. This difference is illustrated in Figure 5-5. Because of this diverse behavior, percentiles were used as the normalizing criteria, reflecting individual reservoirs' natural cycles. Trying to force reservoir systems to the same percentage full would be an unrealistic and unnatural goal, but driving them to the same percentile ensures that drought effects are felt equally across a region or across the state.

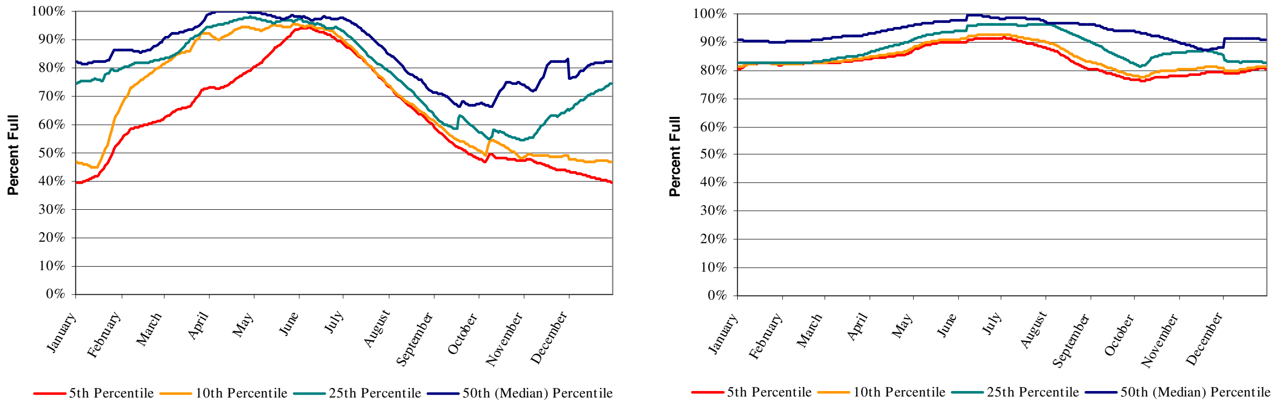

Figure 5-5: Comparison of drawdown characteristics of two different reservoir systems

This approach was abandoned, however, when results showed that it is not uncommon for some reservoir systems to reach undesirably low storage volumes on a more regular basis than others, and the equitable hydrologic drawdown scheme reinforced this trend. If, for example, one reservoir system has consistently faced water shortages in dry years, the normalization scheme would force that system into a water shortage simply because of the fact that it is a normal occurrence, even if it is undesirable.

The final algorithm for equalizing hydrologic drawdown uses the reservoir rule curves, average, minimum and maximum levels for normalization. This approach is similar to a forcing function that drives all reservoir levels to end a simulation at the same volume, relative to their unique rule curves. Tables have been developed for all reservoir systems that describe many graduated curves between the existing rule curves, average, and maximum and minimum constraints. (These curves are only used internally by the software and are transparent to the user.) Figure 5-6 is a graphical representation of these tables. The normalization scheme may, for example, force reservoir levels to a point that is one quarter of the way between the "observe" curve and the average curve. On the graphs below a 2-month optimized simulation starting on July 1 will ideally end with both reservoir levels on the same curve on September 1 (e.g. the blue dashed curve) regardless of on which curve they began.

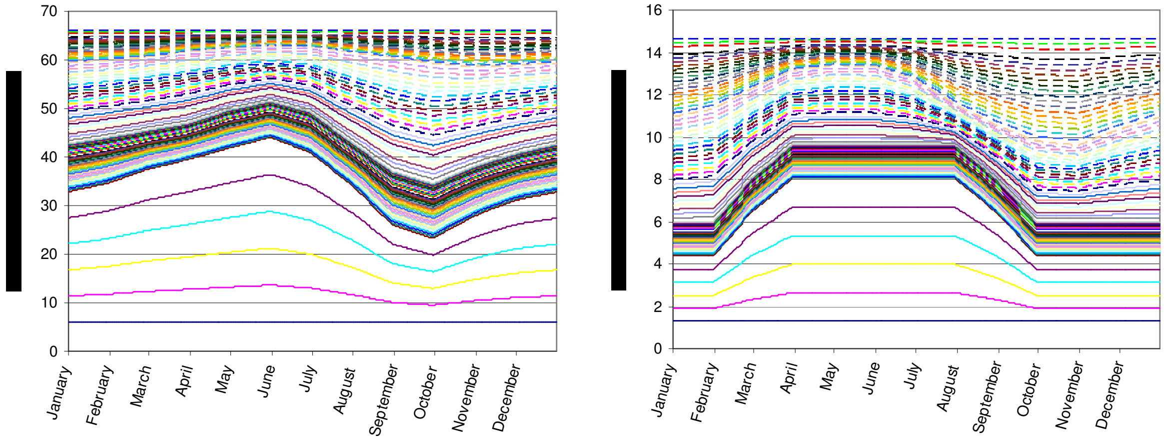

Figure 5-6: Example Normalization Curves for 2 Reservoir Systems

Streamflows are pertinent to reservoir modeling because they could represent a significant flow into or out of a reservoir. They may also be the basis of application of a particular operating rule that dictates how much augmentation flow must be released from a reservoir to meet passing flow requirements. Data were collected from USGS for all applicable streamgages and arranged into tables, several for each streamgage, which describe the flow on any given day of the year for several percentiles. The following paragraphs use the inflow to Spruce Run Reservoir as an example of how streamflow tables were typically derived.

All streamgage data in Spruce Run reservoir drainage area were combined and adjusted to account for any drainage area that is not gauged; for example, the drainage areas of streamgages might cover only half of the reservoir's total watershed area, so the data from these gages would be multiplied by 2 to account for areas not gauged. The data were averaged to produce a curve that characterizes the annual flow pattern into the reservoir. A graph of this curve is shown in Figure 5-7.

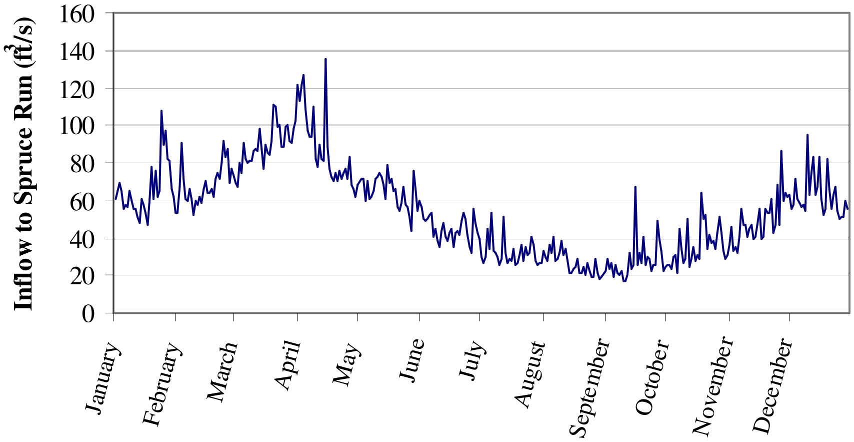

Figure 5-7: Inflow to Spruce Run Reservoir

The data are then analyzed to determine percentile factors of cumulative flow for a period beginning on a specific date. For example, the 1-month (30-day) cumulative inflow starting on January 1 is compiled by first adding inflow from January 1 to January 30 and repeating for every year on record. This generates a cumulative inflow for every year for this date as illustrated in Figure 5-8.

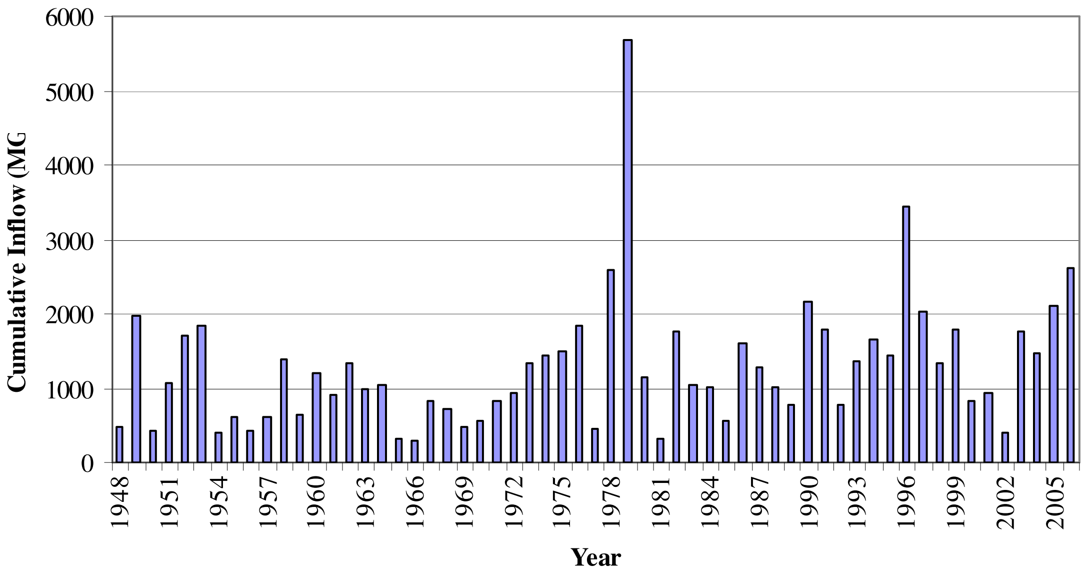

Figure 5-8: 1-Month Cumulative Inflow to Spruce Run Reservoir following January 1

Several cumulative streamflow percentiles are derived from these values. In the case of Spruce Run inflow, only 1 out of 100 years is likely to have a cumulative inflow less than 305 MG for this period and 1 out of 2 years is likely to have less than 1,075 MG. These numbers are divided by the average cumulative inflow for the same period to determine the final table value. This percentile factor is applied to the average inflow when generating simulation conditions in the RMBM.

This procedure has been repeated for every day of the year and was then repeated again for 2, 3, and 6-month cumulative periods for every applicable streamflow. The RMBM automatically applies the correct values based on the user-entered percentile, starting date, and the duration of the simulation.

Precipitation and evaporation data for several sites across New Jersey have been obtained through the NOAA website. The gages have been correlated to reservoir systems based on their geographic proximity. Between 2 to 5 precipitation gages in the vicinity of each reservoir system were cluster and averaged to produce the precipitation historic record for each reservoir system. Evaporation data were taken from 2 gages, one in Philadelphia and another in Newark. These 2 gages were averaged to produce the evaporation historic record. Throughout the historical record of reservoir levels, there are obvious acclivities caused by large, singular rainfall events. The RMBM does not have any capability of predicting these isolated events, so precipitation input is based on a smoothed, average curve of daily historical data — effectively simulating storm events by spreading them out to a light drizzle over a month. The resulting precipitation curve represents a smoothed yearly average precipitation record of daily values. This curve can be adjusted to simulate wet and dry years by adjusting the average curve with an appropriate adjustment factor. . For example, a normal year of precipitation would be represented by a factor of 1.0, while a wet year might have an adjustment factor of 1.2 (20% above normal precipitation) or 0.9 (10% below normal precipitation) for a dry year. Evaporation is projected in a similar manner. (Streamflows fluctuate rapidly and respond to discrete rainfall events, but these data are not smoothed. Reservoir operating rules reference streamflows; removing peaks and depressions may prevent these values from crossing certain thresholds that would occasionally change the operation of the reservoir. For this reason, the random storm events that skew data and are not likely to re-occur on the same date are used to project the future.) Example graphs of precipitation and evaporation data are shown in Figure 5-9.

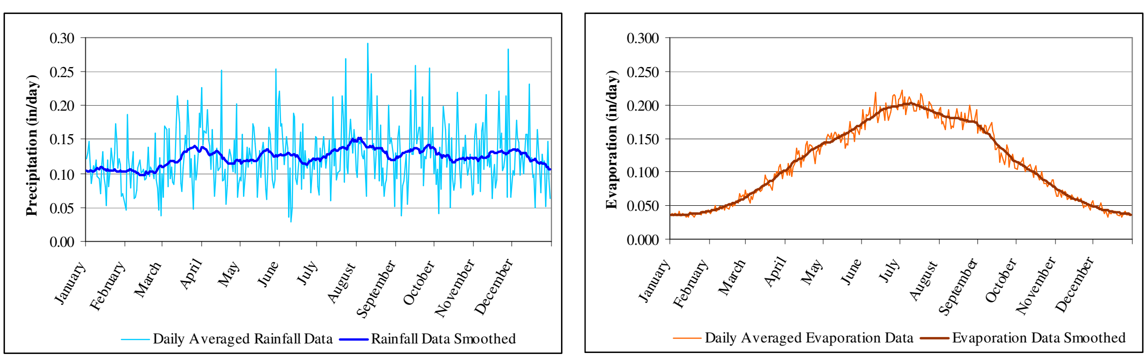

Figure 5-9: Precipitation and evaporation data used for reservoir modeling

This collection of data only starts the process of reservoir modeling. The following section explains the manipulation of data that takes place to ultimately recommend optimum water diversions.

5.4.2 Optimization Criteria and Constraints

The RMBM performs a daily, iterative algorithm that is unique to each reservoir to predict reservoir levels at a user-specified point in the future. This process is performed once at the start of a WSMDST simulation to predict levels with the current, normal withdrawal rates (based on demands at the start of the simulation), and again with rates adjusted to optimize diversions.

Though not discussed as a part of the input database, each unique algorithm is based on a large amount of information collected from NJDEP permits. The permits outline prescribed allocations and reservoir releases. These amounts vary depending on a set of logical rules that reference streamflows and other reservoir levels, among other factors. This makes the RMBM a complex web of interrelated information. Each reservoir has a dedicated sheet within the Excel model in which the calculations, logical tests, and references to other sheets are performed.

Forecasting future reservoir levels is the first step in making the necessary adjustments to treatment plant withdrawals to equalize the hydrologic drawdown across the region or state. After summing the volumes of all reservoirs in each system, and then summing the volumes of all systems in a region, and then regions in the state, the RMBM determines the achievable normalized level at which the reservoirs should operate. It then recommends adjusted treatment plant withdrawal rates that will bring each reservoir system to the same normalization curve as all others within a specified period of time. This process is performed on a drought region scale during drought watch and on a statewide scale during drought warning or emergency.

The RMBM passes the recommended treatment plant rates to the IMBM for further processing.

5.4.3 Model Output

The output of the RMBM requires much less interpretation than that of the IMBM. Its purpose, after all, is to provide input to the IMBM to achieve the overall objective of optimizing transfers to mitigate localized drought effects. The RMBM does, however, offer a look at the effect of withdrawal rates on reservoir level. These data can be plotted daily for the period simulated with normal, optimized, and user-adjusted treatment plant rates.

5.4.4 Historic Balance Development

The same algorithms and data that are used to forecast reservoir behavior can also be used to simulate past droughts. Rather than using streamflow and precipitation data derived from the compilation of all historical data, the historic RMBM uses actual streamflow, evaporation and precipitation data from periods of drought. When the model is used to predict future droughts, the uncertainties are almost entirely hydrologic, with a fairly high confidence in demand. On the other hand, when we try to recreate past droughts, it is the demand that is less certain as we look further into the past (because demand records from the 1960s, for example, are not available, and significant changes have occurred since then), and the hydrologic data of which we are much more certain. Simulations of historic droughts are discussed in section Section 5.5.

5.5 Scenario Development

Safe yield simulations were developed for each reservoir system to serve as a model validation check and to provide a relatively uniform basis for comparison of reservoir system behavior during drought and normal conditions. Historical hydrologic data were used with current reservoir configuration, operating rules, and permitted safe yield to simulate reservoir system drawdown and refill. Representative simulations are shown in Figure 5-10 and Figure 5-11.

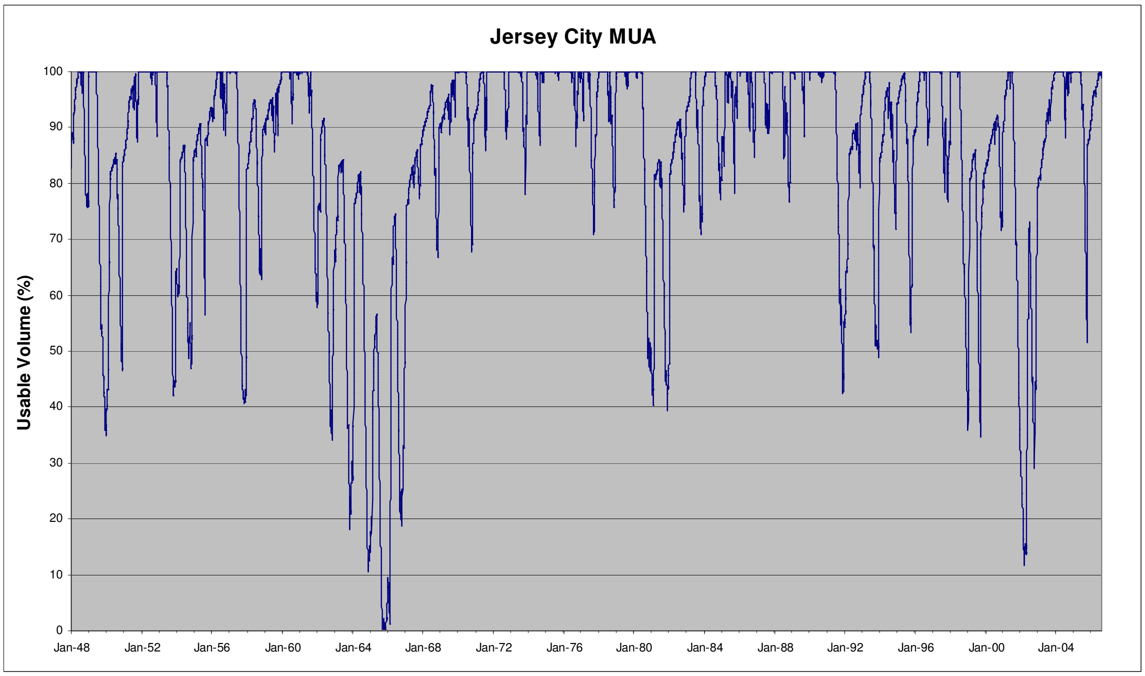

Figure 5-10: Safe yield reservoir system simulation, 1948-2006

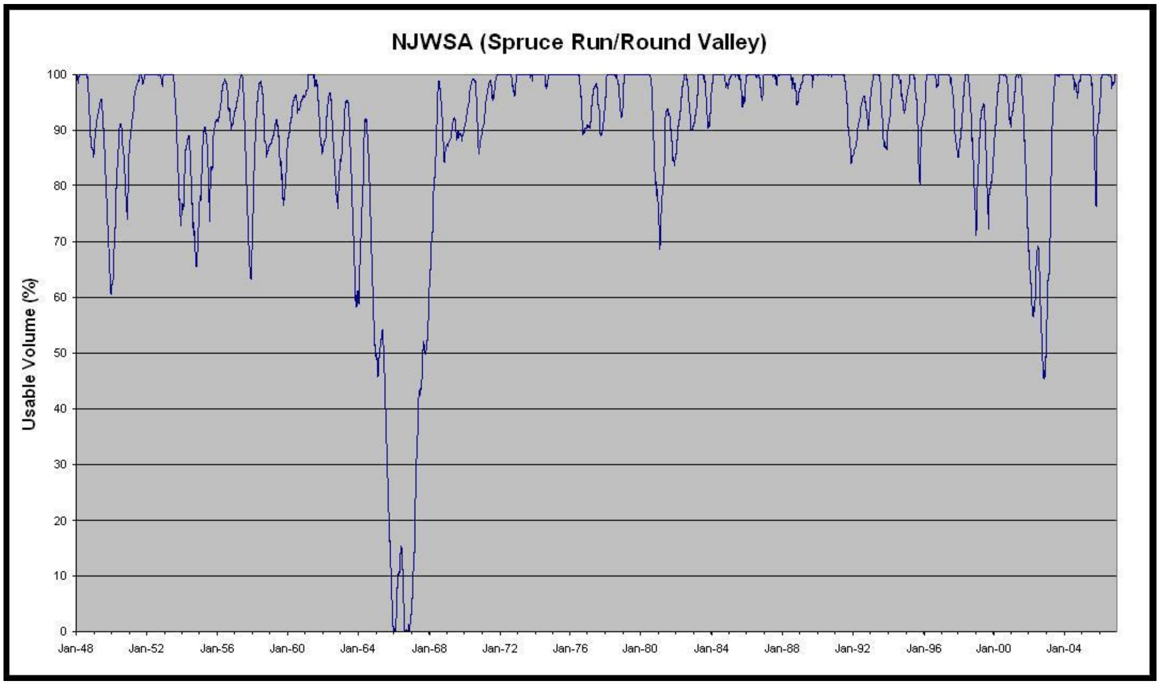

Figure 5-11: Safe yield reservoir system simulation, 1948-2006

5.5.1 Analysis of Drought History

The following drought analyses are based on current reservoir configuration, operation, and demand condition. Unfortunately, operational rules, treatment, consumer demand patterns, and conservation measures taken during these periods were not available. Therefore, the drought analyses below use historical streamflow, precipitation, and evaporation data, but current operational rules and treatment and consumer demand patterns. The analyses below show what would happen if the same hydrologic conditions were to occur today. The graphs below are for the Newark system and are used to divide the historical droughts into 4 categories – Emergency, Warning, Watch, and Normal – to form the basis for simulation of all reservoir systems in the WSMDST and later sections of the report.

Reservoir system drawdown is represented as percent usable volume remaining, and the events during which the reservoir drops to the lowest levels of usable volume are useful events for relative comparison. The 1960's drought period is considered the drought of record in the state, and a more detailed plot indicates that reservoir systems would have experienced Drought Emergency levels, as shown in Figure 5-12. The 2002 drought period results in another significant drop in usable storage on the heels of a less extreme drought event in 1999. These events are shown in Figure 5-13 and Figure 5-14, respectively. The 2002 drought draws the reservoirs down to Drought Emergency levels, while the 1999 drought reaches Drought Watch levels. The droughts of 1980-81 and 1985 drop the reservoirs to Drought Warning levels, as shown in Figures 5-15 and 5-16.

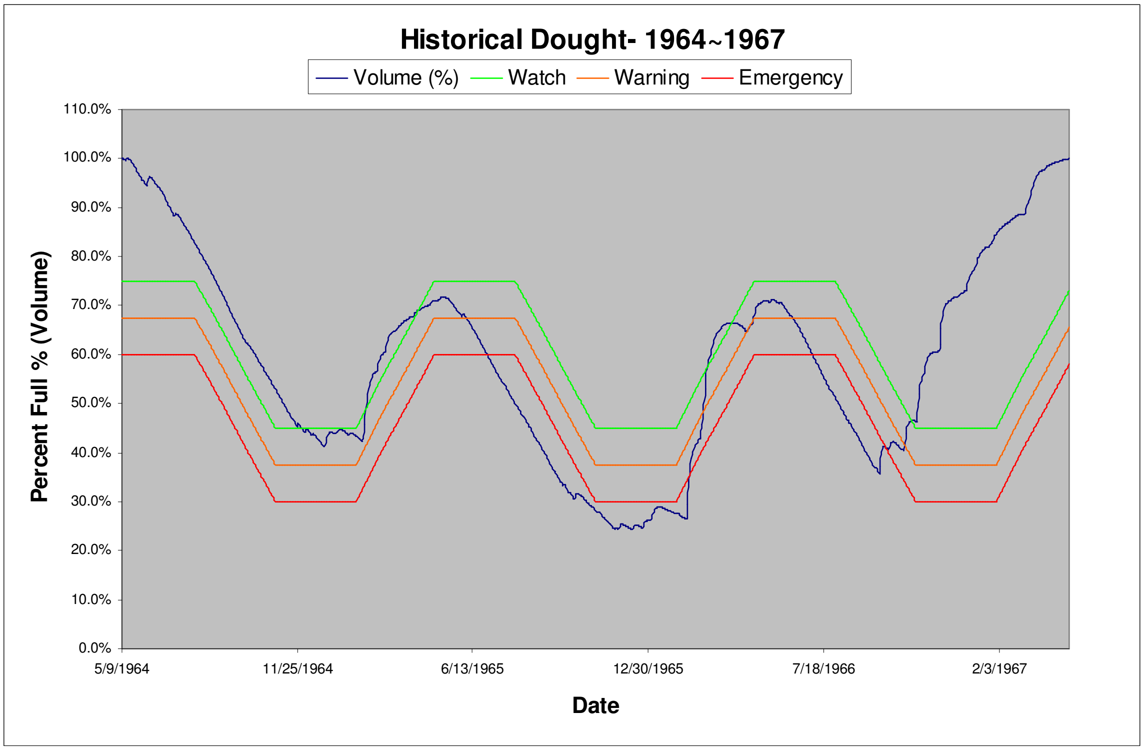

Figure 5-12: Simulated Drought Emergency Event

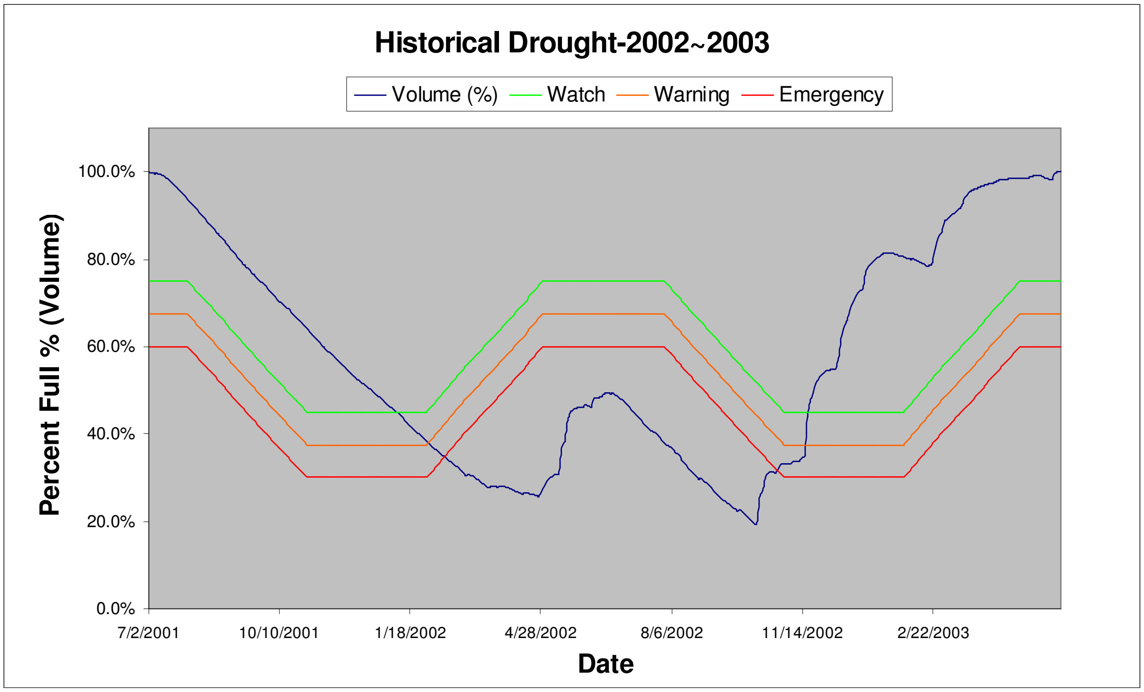

Figure 5-13: Simulated Drought Emergency Event

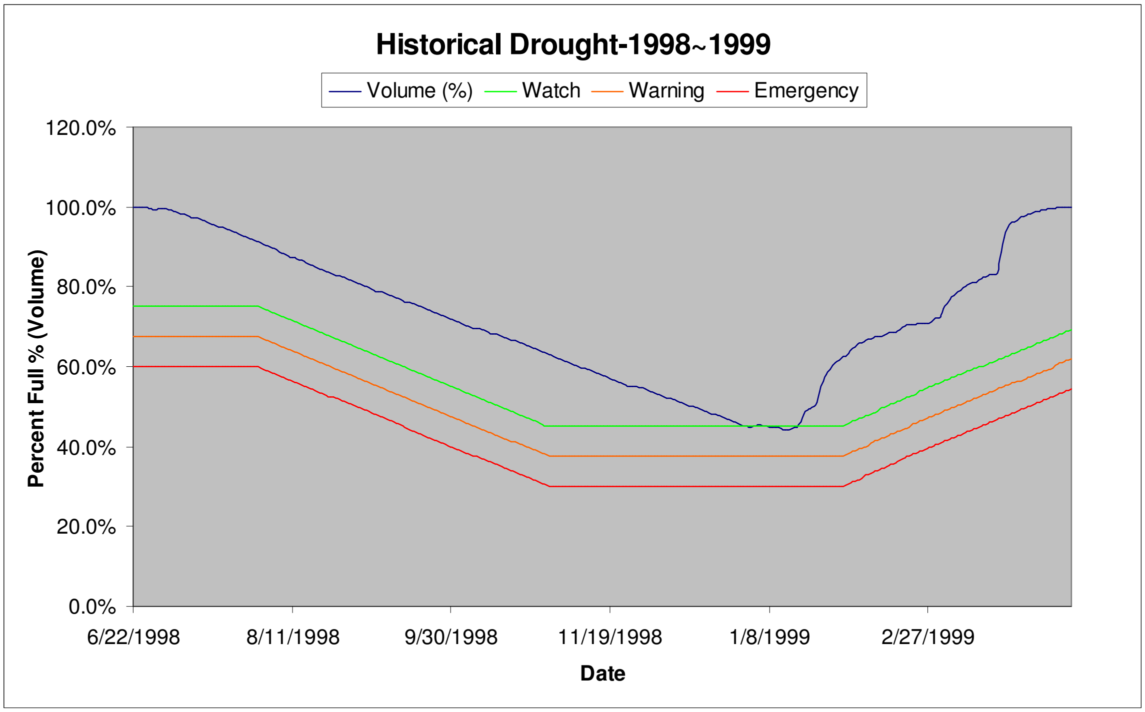

Figure 5-14: Simulated Drought Watch Event

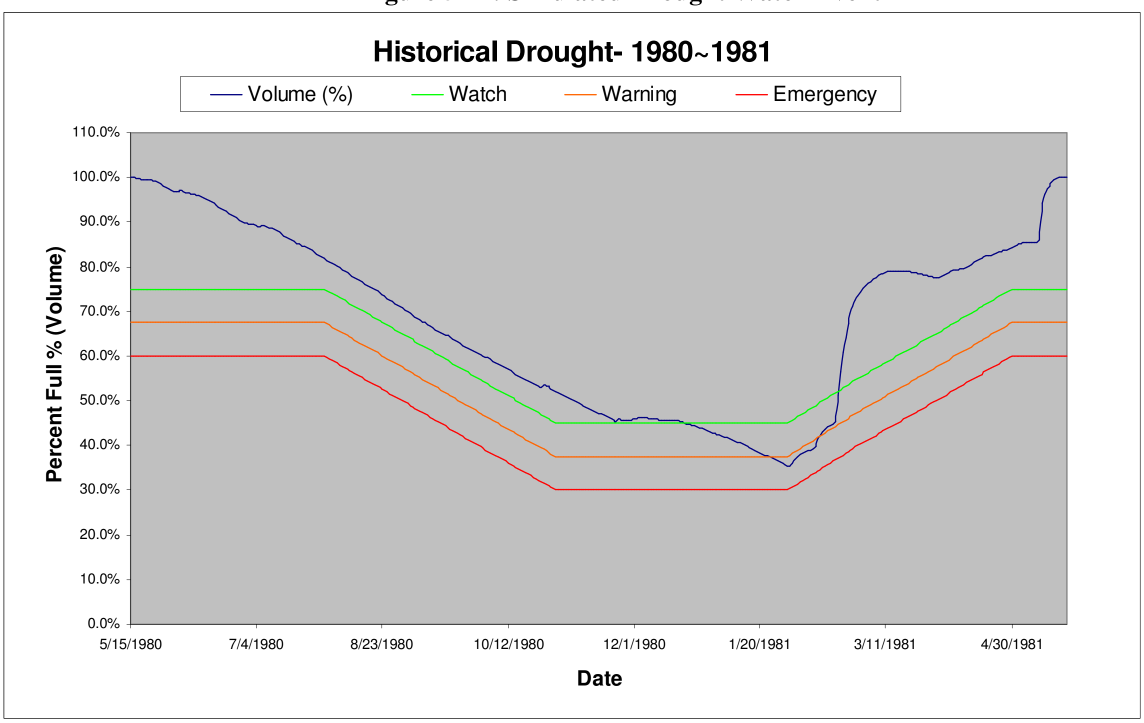

Figure 5-15: Simulated Drought Warning Event

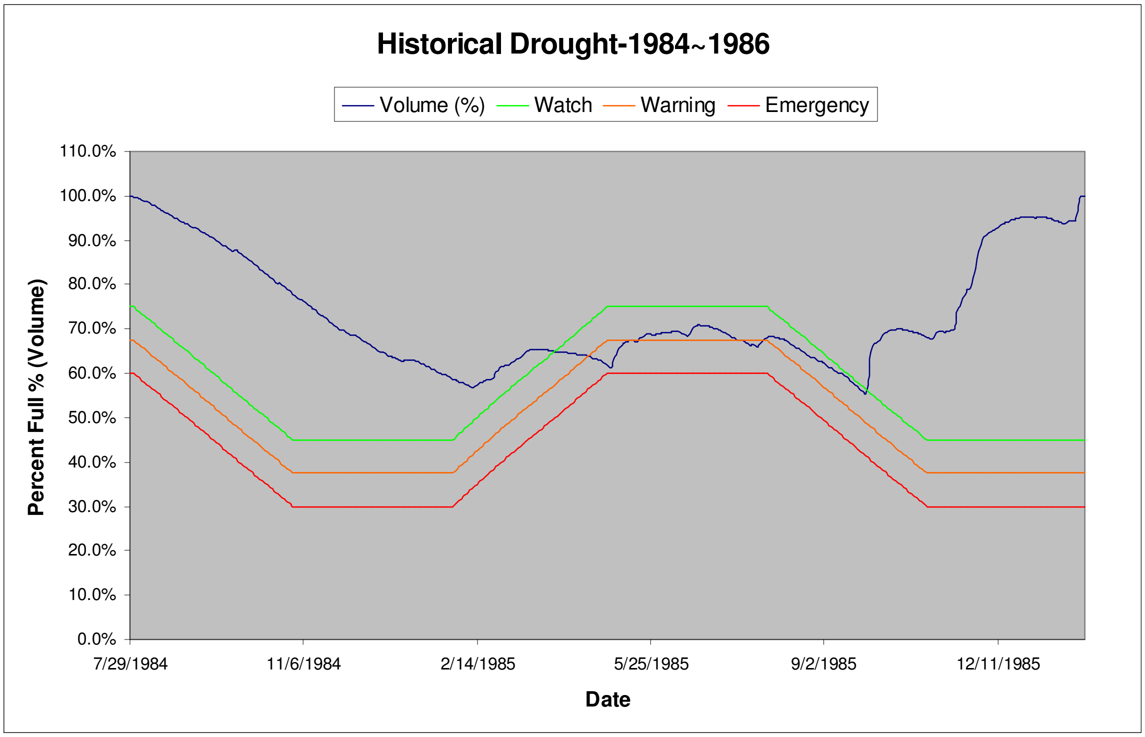

Figure 5-16: Simulated Drought Warning Event

5.5.2 Drought Scenarios

The following droughts are analyzed in detail in Section 6 to develop recommendations for infrastructure improvements:

- 1965 – Drought Emergency
- 2002 – Drought Emergency
- 1980-81 – Drought Warning
- 1999 – Drought Watch

5.5.3 Normal Scenarios

The following time periods are analyzed in Section 7 as a part of normal reservoir operation evaluation:

- 1998 – Normal
- 2005 – Normal

References

Hoffman, J., Domber S., *Development of Streamflow and Ground-Water Drought Indicators for New Jersey,* New Jersey Geological Survey, Open-file Report OFR 04-2, Trenton, NJ (2004).

New Jersey Joint Board of Public Utilities and Department of Environmental Protection Water Emergency Planning Team, *Final Report*, June 1989.

6.0 OPTIMIZE EXISTING WATER DIVERSIONS DURING DROUGHT CONDITIONS (TASK 3)

The series of Task 3 analyses were conducted to identify changes that could be made to the existing system to avert drought-related water supply emergencies at 3 levels of drought. The analyses include evaluation of existing infrastructure and operating conditions to identify apparent deficiencies and consideration of improvements. Analyses were performed for 4 different historic droughts using simulated and historical drought information. Section 6.1 focuses on the use of interconnections during droughts, while Sections 6.2 and 6.3 discuss reduction in consumption and non-potable uses, respectively.

6.1 Historic Drought Analysis and Recommendations

Development of a drought mitigation strategy requires that judgments be made with incomplete information. One will never, in the foreseeable future, be able to predict the weather, and this is the single factor that ultimately drives recharge of reservoirs. Discrete precipitation events can dramatically affect reservoir storage levels and can occur (or persistently refrain) in any season and at any time.

Even after the most thorough investigation of all factors, there is no crystal ball. There is a spectrum of mitigation strategies that start with proactive measures and ends with high-volume transfers at the last possible moment. Early action to normalize water resources across the state and shift demand to water-rich areas will require cooperation, possibly in the face of reduced revenues for water purveyors, if they are required to purchase water wholesale rather than produce it from their own resources. This approach also runs the risk of initiating costly mitigation when no drought materializes; however, this end of the spectrum will minimize the need for infrastructure improvements. If drought mitigation action is taken only when conditions have deteriorated to an unambiguous level, the volumes of water transfer required will necessitate expensive improvements to infrastructure. Even with these improvements, this approach may not be able to guarantee avoidance of a drought emergency and mandatory demand reductions under all possible conditions.

6.1.1 Drought Analysis Procedure

It has become clear from past droughts that by the time a drought watch or warning condition is identified, it may take very extreme measures or may be impossible to avert a drought emergency. In recent history (since the 1960s), 7 drought warnings have resulted in 5 drought emergencies, with an additional drought emergency in 1985 not preceded by any drought warning. While demand reductions are very effective in restoring reservoir storage once an emergency condition has been reached, they are considered to be a secondary means of mitigation after interconnection usage for the purpose of these analyses.

The WSMDST has been designed to predict the likelihood of reaching drought conditions within a specified time period. By following the procedure described below, water suppliers and purveyors will be able to weigh the risks and consequences of drought with sufficient time to take action.

Because of the consistently short time between drought watch and emergency, a new standard for initiating closer monitoring of reservoir levels has been identified — *the advisory level*. This proposed rule curve simply splits the difference between the already established "observe" curve and the average reservoir level. When compared to historical scenarios, this level strikes a reasonable balance between early identification of eminent drought and minimization of false alarms. This new curve is for NJDEP's internal use as a trigger for NJDEP to start observing the falling water levels and to use the WSMDST model to predict the likelihood of reaching drought conditions as explained in the following paragraphs. The advisory level is not a "rule curve" where transfers will be mandated.

If storage in any single reservoir system falls below the advisory curve, the WSMDST should be employed as frequently as once per week to forecast possible drought conditions. This prediction relies heavily on statistical theory and is only as valuable as the judgment used in its interpretation. Streamflow data in most cases has been collected for almost 60 years. This population of data is sufficient for drawing some conclusions, but a larger collection is always preferable. Statistical tables have been prepared for 1, 2, 3, and 6-month cumulative streamflows for all streams affecting the recharge of reservoir systems in the analysis. The first application of the WSMDST should be a 1-month projection of reservoir levels using an acceptable risk determined by NJDEP. Analyses of past droughts performed for this report have assumed an acceptable risk of 10%; therefore, reservoir levels were modeled using 10^{th} percentile, 1-month cumulative streamflow data. In other words, only 1 out of 10 years is expected to be as dry as what is predicted in the WSMDST. If the resulting reservoir levels at the end of this month are below the "observe" curve, initiation of water transfers is recommended. The amount of water transferred can be limited to that required to keep any single reservoir system from entering drought watch at the end of the projected month. If the model optimization results in all systems in a region normalizing to some level below the drought watch curve, inter-region transfers should be considered.

The same procedure is next applied to a 3-month period. The 10^{th} percentile, 3-month cumulative streamflows will be greater (less severely dry) than the 1-month streamflow because 3 consecutive months of dryness are less likely than dryness for only a single month. Just as in the 1-month simulation, if the model results in any system or region having reservoir levels below the drought watch curve, sufficient water should be transferred to keep all systems above the drought watch condition. This process is repeated again with 6-month statistics.

This approach allows NJDEP and purveyors an opportunity to make the minimum water transfers necessary to prepare for short or longer-term drought. This method will not, however, necessarily prevent drought emergencies. Using the 10^{th} percentile attempts to balance risk and expense. In 9 out of 10 years, the minimum transfers recommended by the WSMDST will prevent localized water shortages due to drought. However, 1 out of 10 years will require more extreme measures than those recommended by the WSMDST. As such a drought progresses, continued application of the WSMDST will result in more extreme optimization recommendations that reflect the deteriorating conditions.

In the text of the following analyses, the terms "predicted" and "forecasted" carry distinct meanings. Predicted curves are artificially generated by the WSMDST, but are based on actual historic streamflows and precipitation; "predicted" may be a slight misnomer as it has the benefit of hindsight. Forecasted curves are artificially generated by the WSMDST as well, but the streamflow and precipitation data are based on statistical tables discussed in Section 5.4.1, as if nothing were known about the hydrologic conditions after the starting date of the simulation. Furthermore, "optimized" curves are those that use the recommended interconnections; otherwise drawdown rates are based on operating rules without regard to any normalization effort.

Some raw water transfers are automatically implemented by the WSMDST based on operating rules. The performance of these transfers has been spot-checked to ensure that WSMDST simulations match fairly consistently with the historic records of transfers maintained by NJDEP.

The following sections describe the analyses that were conducted for the following droughts:

- 1960s
- 1981-82
- 1995
- 1998
- 1999
- 2001-2002
- 2005

6.1.2 1960s Drought Analysis

Analysis of the conditions that contributed to the 1960's drought is difficult for several reasons. The drought itself cannot be realistically analyzed due to the fact that so much has changed since the time of the drought. One can, however, simulate the effects on today's water systems if the same hydrologic conditions that caused that drought were to re-occur.

Since reservoir water surface elevations were not readily available for all reservoirs modeled in the WSMDST during the 1960s, reservoirs were assumed to start full and were given ample time to reset to normal conditions before the drought period analyzed. The optimization analysis began at the point where a single reservoir dropped below the advisory line, in this case UWNJ, around August 1, 1964. The reservoir volumes on that date were used as the starting volume for the optimization analysis.

Figures 6-1 through 6-5 illustrate the predicted reservoir levels that might be observed over a 3-year period if no demand reductions or interconnection transfers were employed. (The blue line ("observed") in these figures is intentionally absent because no actual reservoir observations were included in the data provided by NJDEP or purveyors.)

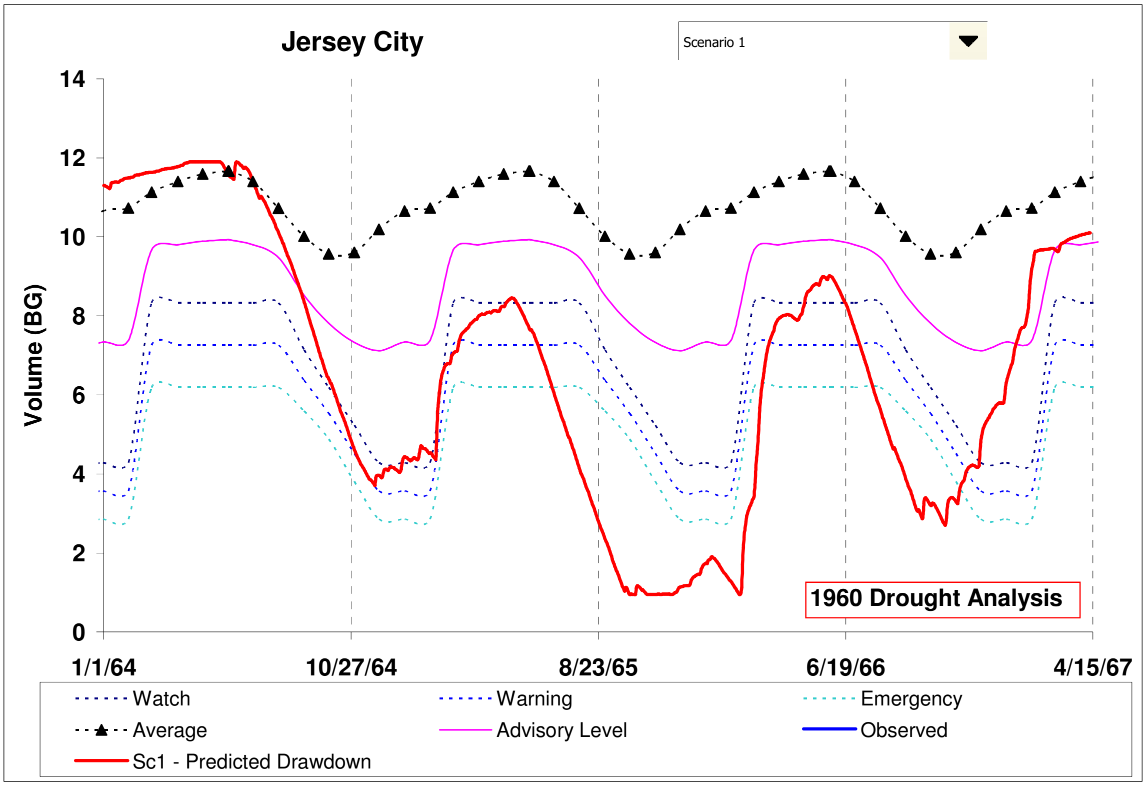

Figure 6-1: Jersey City MUA - Model Predicted Drawdown

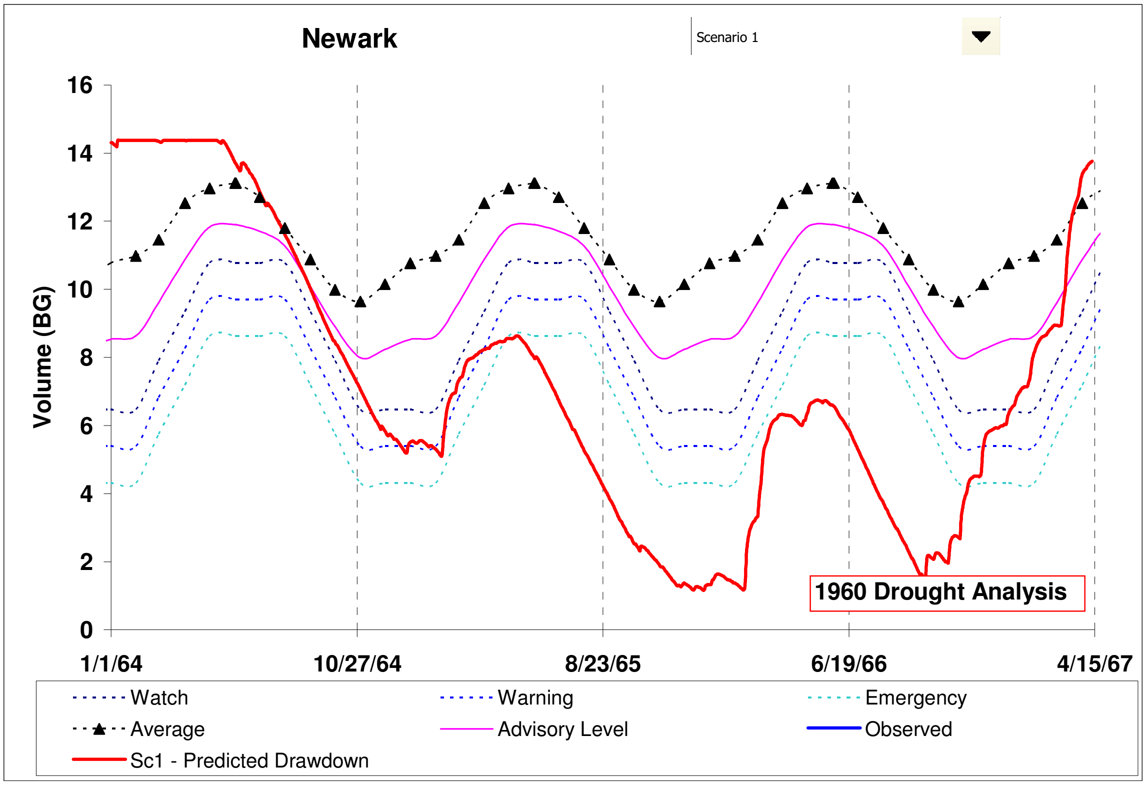

Figure 6-2: Newark - Model Predicted Drawdown

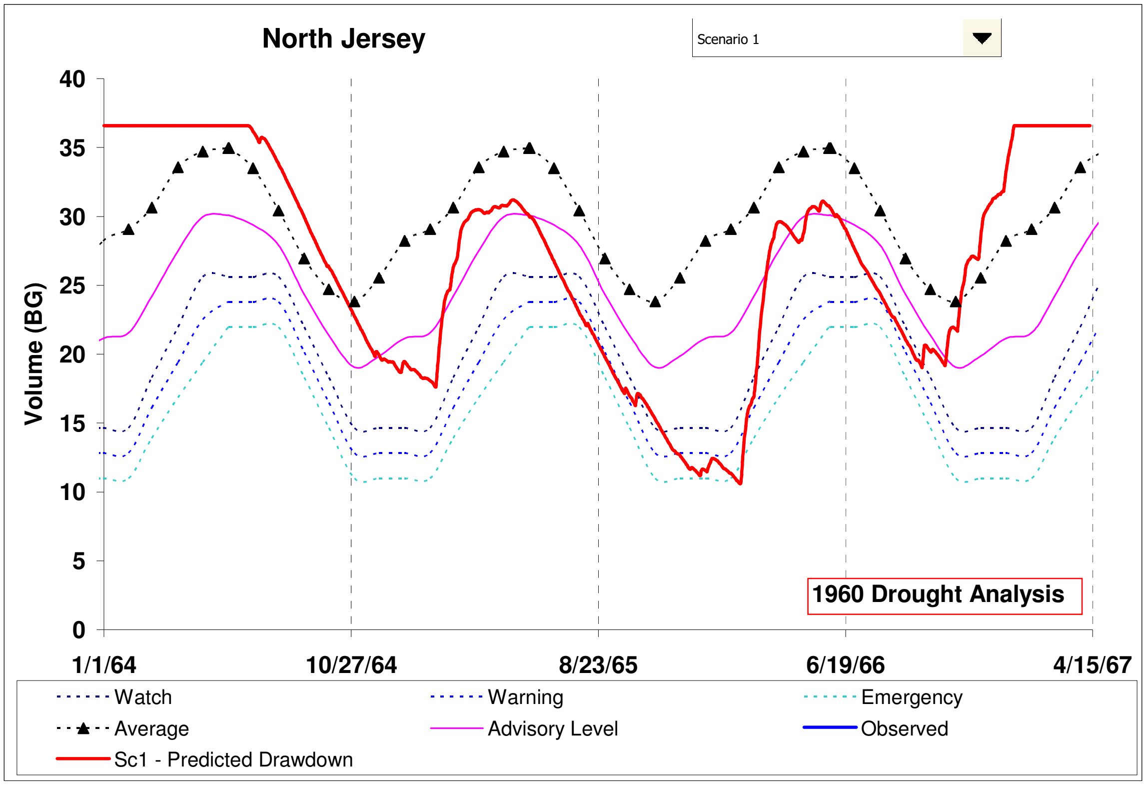

Figure 6-3: North Jersey DWSC - Model Predicted Drawdown

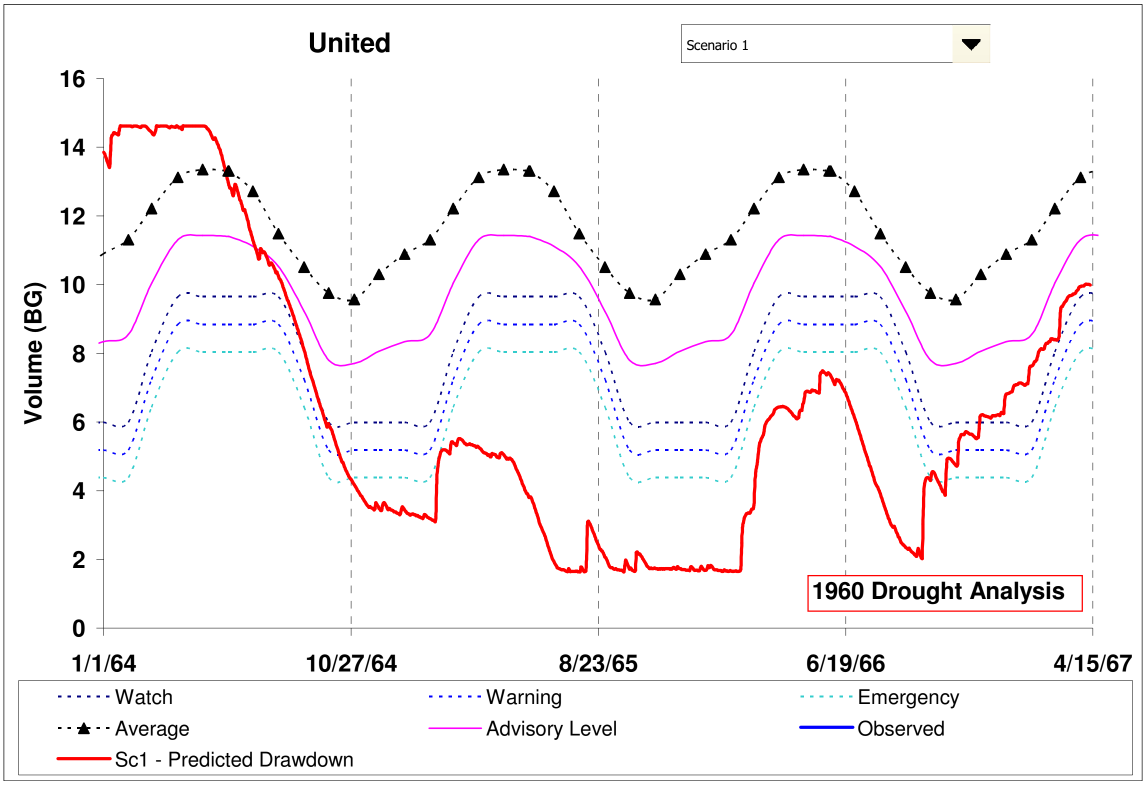

Figure 6-4: UWNJ - Model Predicted Drawdown

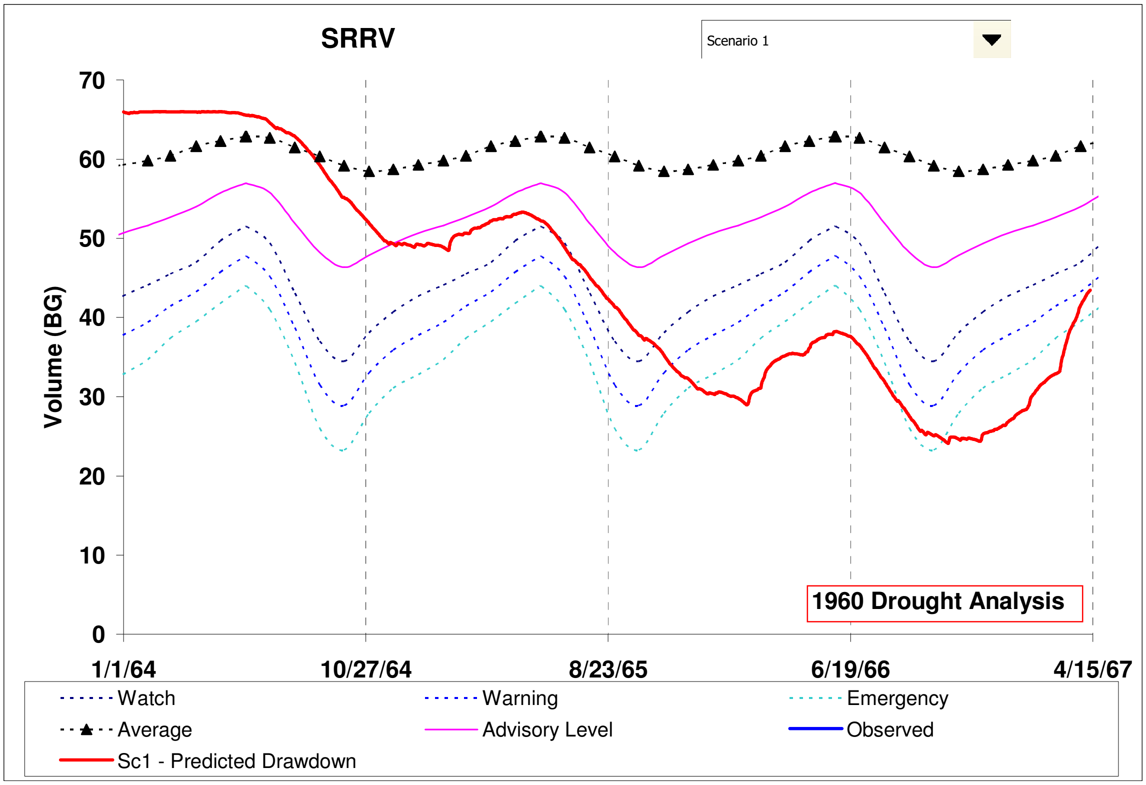

Figure 6-5: Spruce Run/Round Valley (SRRV) - Model Predicted Drawdown

The predictions above demonstrate those reservoir systems which recharge very quickly, like Jersey City, and those which refill much more slowly, like Spruce Run and Round Valley.

An abbreviated analysis of this drought was conducted for the first 6 months following August 1, 1964. After this time, the uncertainties within the model are too significant to derive any realistic conclusions. In the end, it is obvious that water transfers can only mitigate a drought if there is excess water to be moved, and this is not the case after 3 consecutive dry years. Conservation is the only strategy that can alleviate this condition in the long term.

6.1.3 1981-1982 Drought Analysis

Analysis of the 1981-82 drought was conducted in a similar manner as the 1960s drought. Starting water surface elevation for all reservoirs was determined following the procedure described in Section 6.1.2. As with the 1960s drought, streamflow, precipitation, and evaporation data were available for this period. Therefore, the same hydrologic conditions have been applied to existing reservoir operational conditions (demand and supply sources corresponded to the present). Figures 6-6 through 6-9 show the model predicted drawdown for different northeast reservoirs. (Again, blue lines ("observed") are intentionally absent from these figures because observed reservoir levels were not included in the data provided by NJDEP or purveyors.)

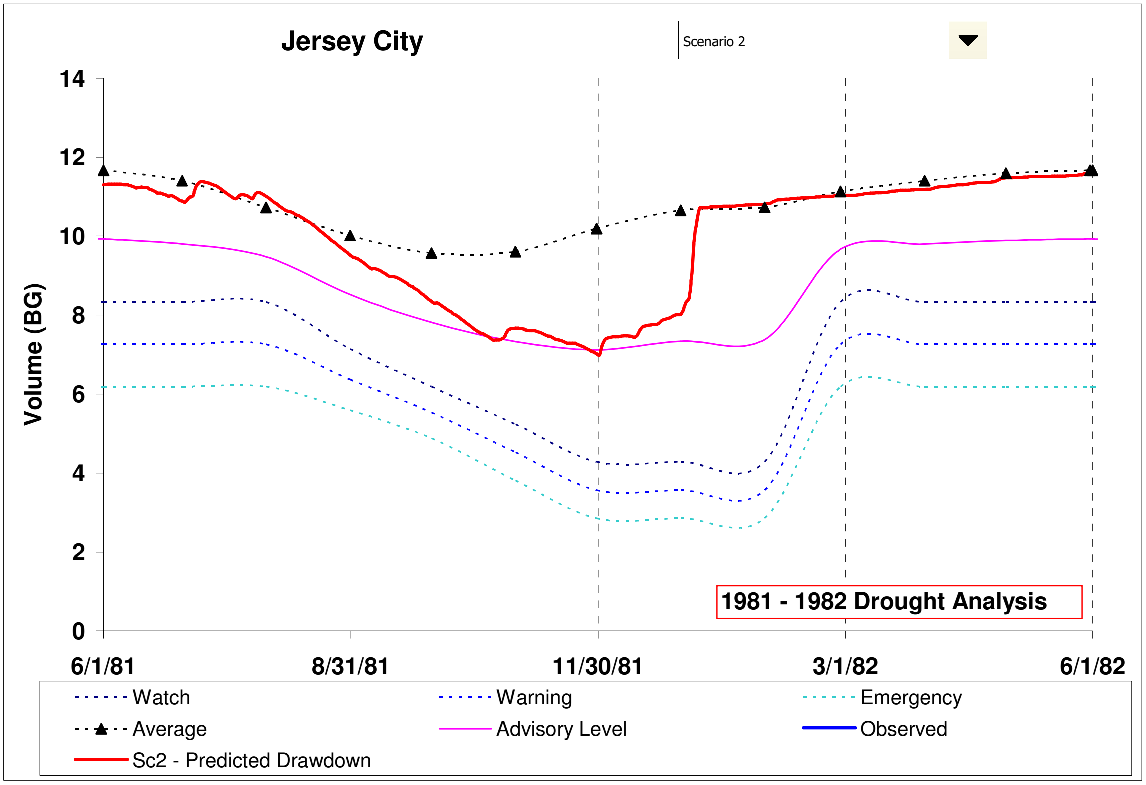

Figure 6-6: Jersey City MUA - Model Predicted Drawdown

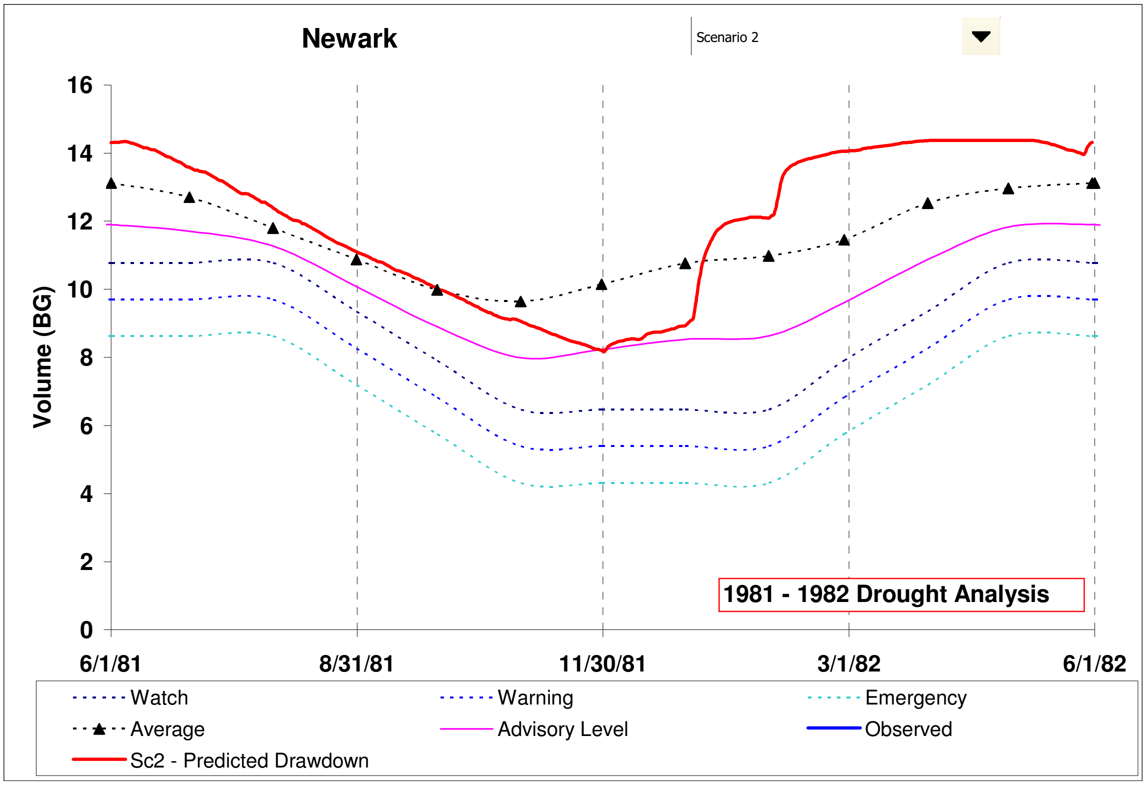

Figure 6-7: Newark - Model Predicted Drawdown

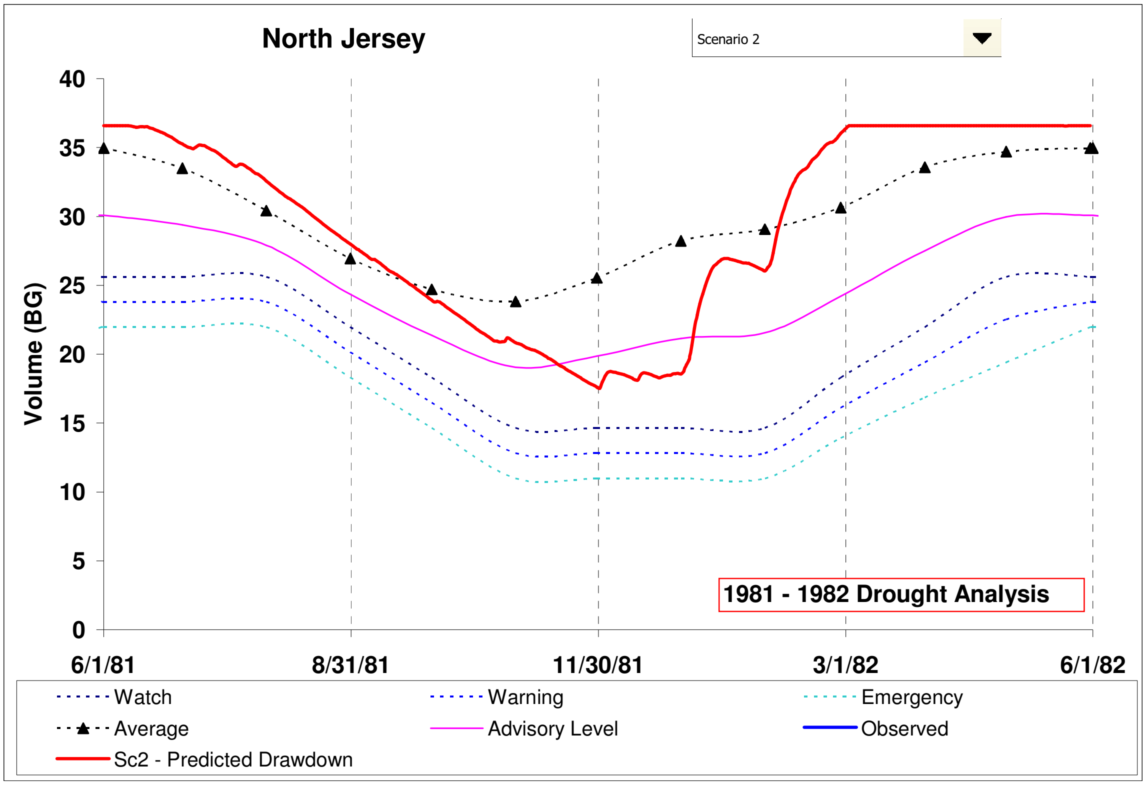

Figure 6-8: North Jersey DWSC - Model Predicted Drawdown

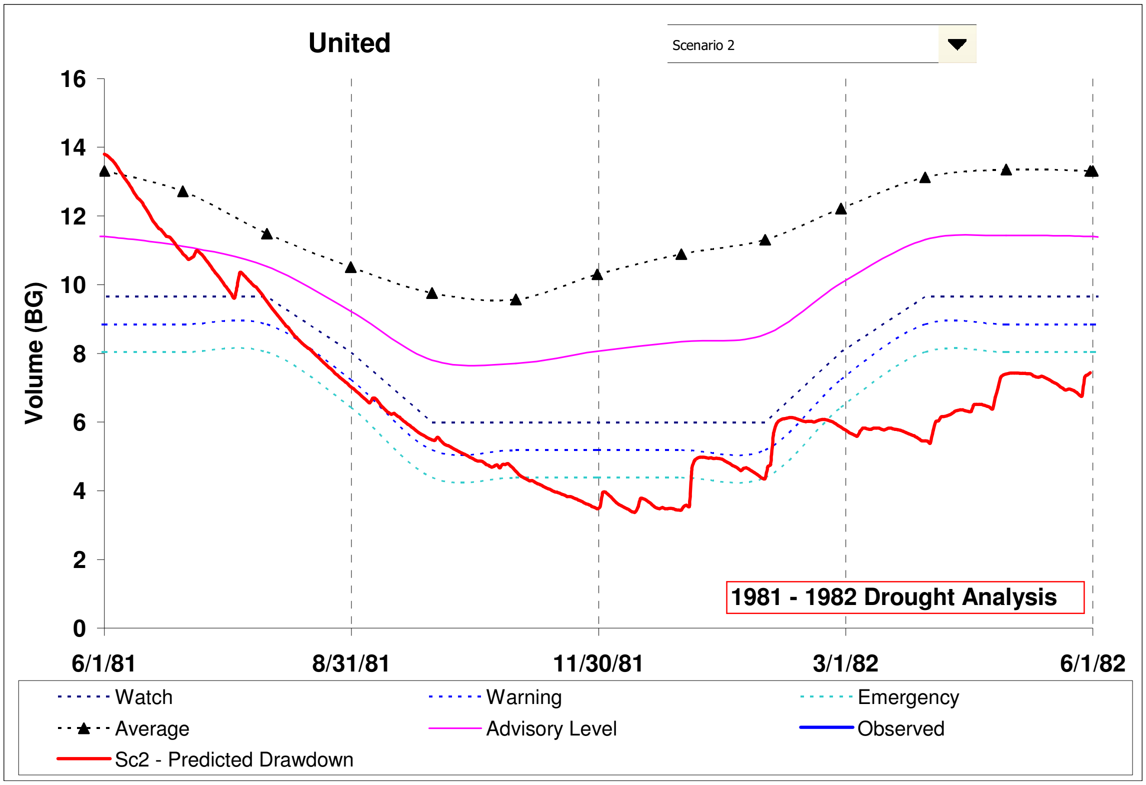

Figure 6-9: UWNJ - Model Predicted Drawdown

As shown in Figure 6-6 through Figure 6-9, UWNJ fell below its advisory curves on July 31, 1981, and was predicted to reach the "observe" level in one month. The WSMDST was used to optimize the northeast reservoirs for this drought period starting on July 31, 1981 for a period of 30 days. WSMDST model predicts that approximately 55 mgd of water is required to bring UWNJ out of watch conditions. During this period, NJDWSC reservoir has sufficient capacity to provide UWNJ with additional supply to come out of watch conditions; however, total emergency interconnection capacity to UWNJ is 40 mgd (from Task 1). Thus, based on the 1981-1982 drought, an additional emergency interconnection of 15 mgd is required from Jersey City to UWNJ or from NJDWSC to UWNJ. Figure 6-10 compares the predicted drawdown for UWNJ with the optimized drawdown using 55 mgd of supply through emergency interconnections.

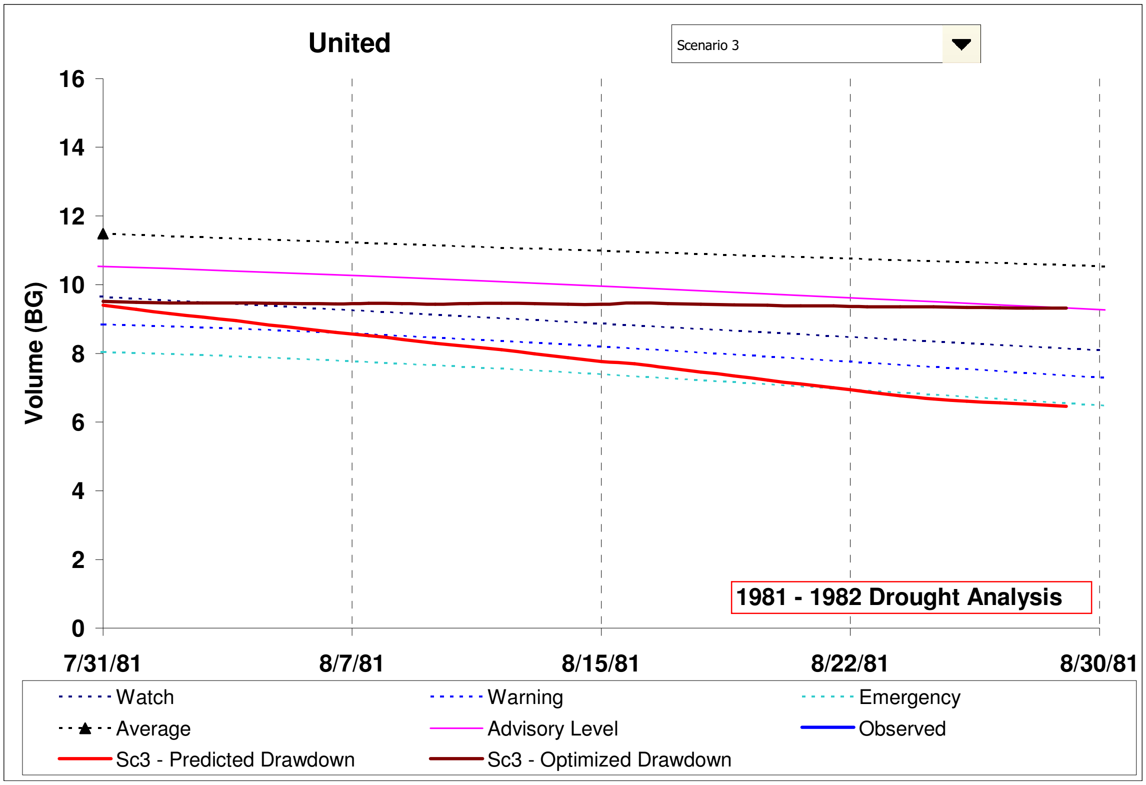

Figure 6-10: United - Predicted vs. Optimized Drawdown

6.1.4 1995 Drought Analysis

UWNJ reservoirs crossed the advisory curve on June 22, 1995. There was a gap in the data provided for Newark reservoirs for this year, and, therefore, starting volume of Newark reservoir was unknown. Because the starting volumes of these reservoirs significantly affect the outcome of the simulation, Newark is considered to play a negligible role as either supplier or receiver for this drought analysis. Figure 6-11 shows the observed level of UWNJ reservoirs, along with the calibrated model projection. The 2 lines remain close until they diverge in September 1995, when the actual reservoir levels dip into emergency, and the effects of demand reductions reduce the actual drawdown.

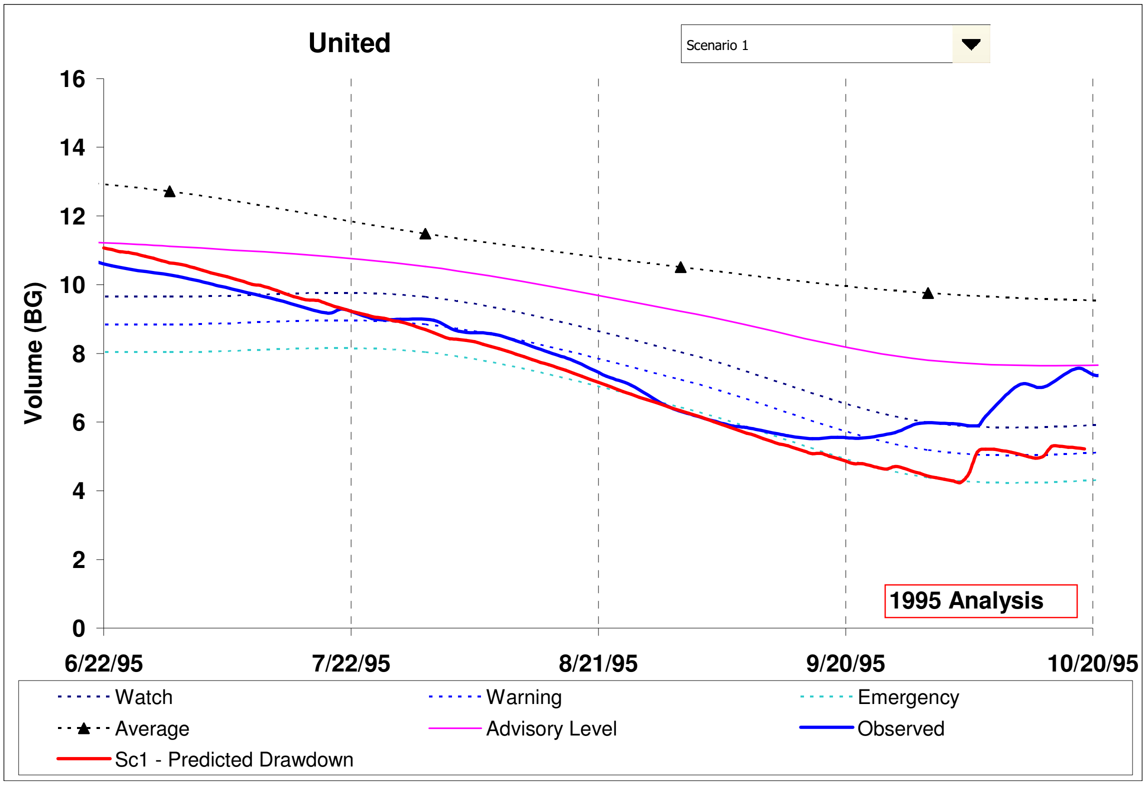

Figure 6-11: UWNJ - Observed vs. Predicted Drawdown

The 3-month drought projection from June 22 using 10th percentile for streamflow predicts that United Reservoir will fall into drought watch. Figure 6-12 shows UWNJ reservoirs for this period. Model predicted drawdown for United Reservoir was not as severe as the observed drawdown. The difference could be attributed to observed streamflow being less than the 10th percentile streamflow used for the model simulation. During this period, Jersey City was close to its advisory level and NJDWSC was slightly above its watch level. Modelers estimated that UWNJ can be brought out of watch condition by transferring 30 mgd of water to it from Jersey City and NJDWSC. Figure 6-13 shows the model predicted drawdown for United reservoirs if 30 mgd was transferred to it (20 mgd from Jersey City and 10 mgd from NJDWSC). For this scenario, historical streamflow and precipitation data were used. There is sufficient emergency interconnection capacity for this transfer.

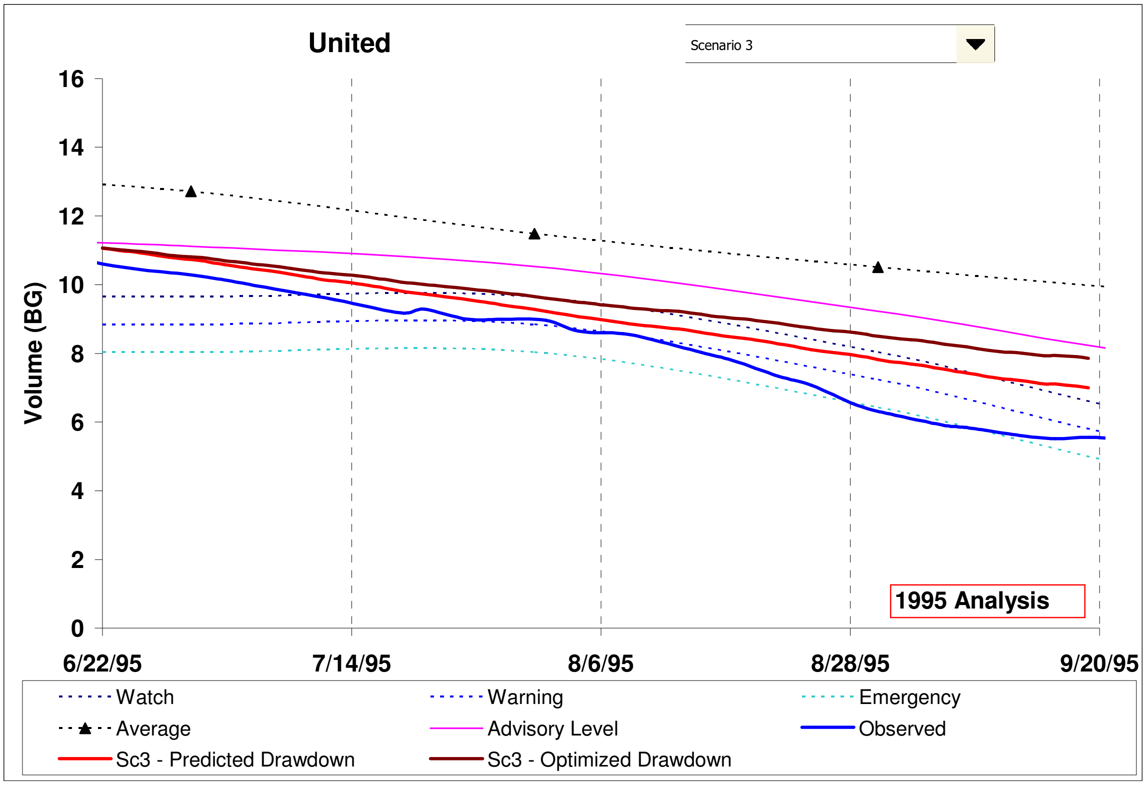

Figure 6-12: UWNJ – 3-Month Observed vs. Forecasted Drawdown

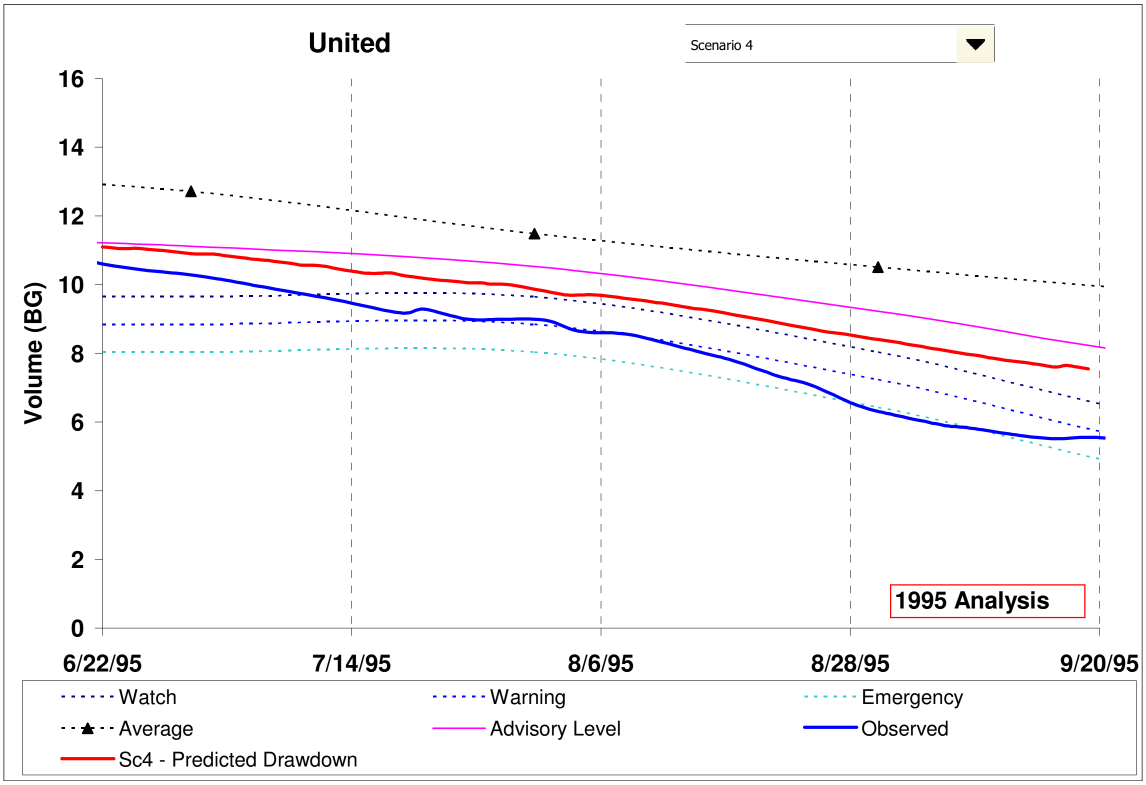

Figure 6-13: UWNJ– 3-Month Observed vs. Optimized Drawdown

Though there is much uncertainty about the actual conditions of this drought without complete data for the Newark reservoir system, it is clear that existing interconnection capacity would have been sufficient to avert the emergency experienced by UWNJ.

6.1.5 1998 Drought Analysis

North Jersey DWSC reservoirs fell below the advisory curve on September 29, 1998, with UWNJ dropping below the curve in early November. NJDWSC was the only reservoir during the 1998 drought to reach "observe" or "caution" levels, and a drought warning was declared from December 14, 1998 to February 2, 1999.

The WSMDST was initiated on September 29, 1998. Figure 6-14 shows a calibrated reservoir drawdown chart for the period of the drought.

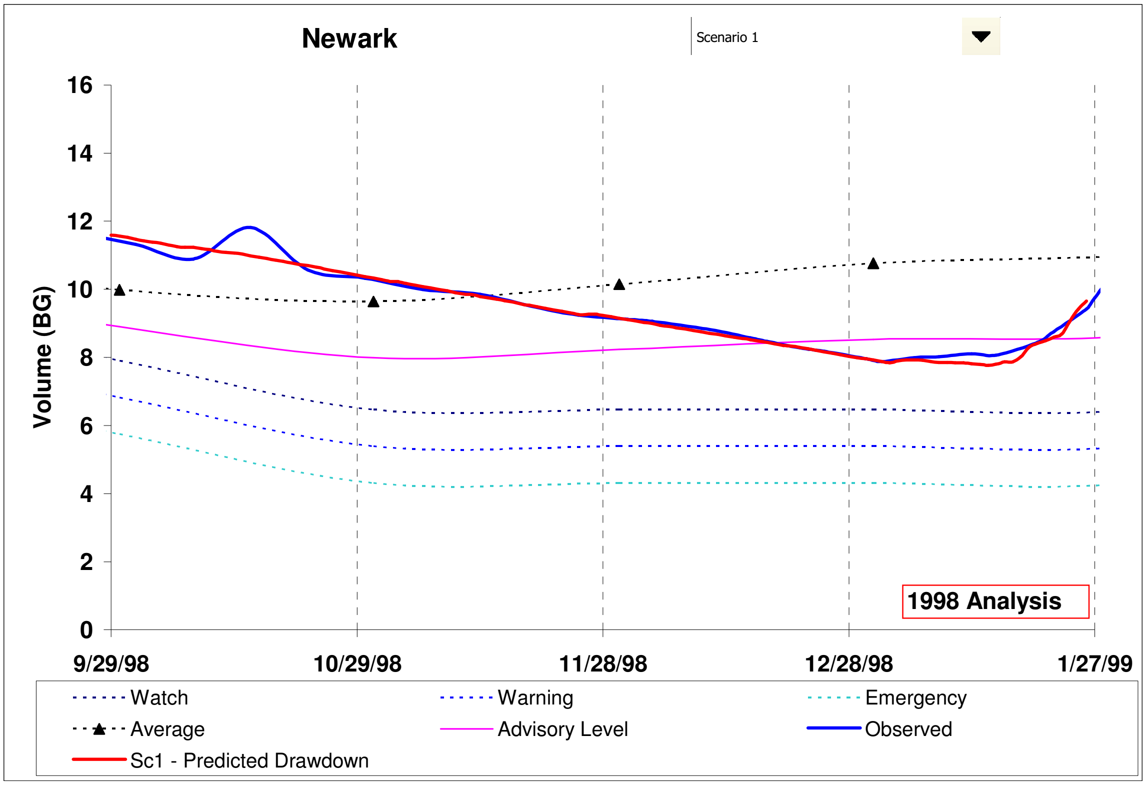

Figure 6-14: Newark - Observed vs. Predicted Drawdown

The model was then used for conducting a 1-month simulation starting at September 29, 1998, but using the streamflow percentile data rather than the observed streamflow and precipitation data. 10th percentile was used for streamflow data. *The model predicted that none of the reservoirs would reach watch condition and thus no transfer is required.* This matched closely with what was later on observed. Figure 6-15 shows the model forecasted drawdown for 1 month compared with the observed drawdown for Newark reservoir.

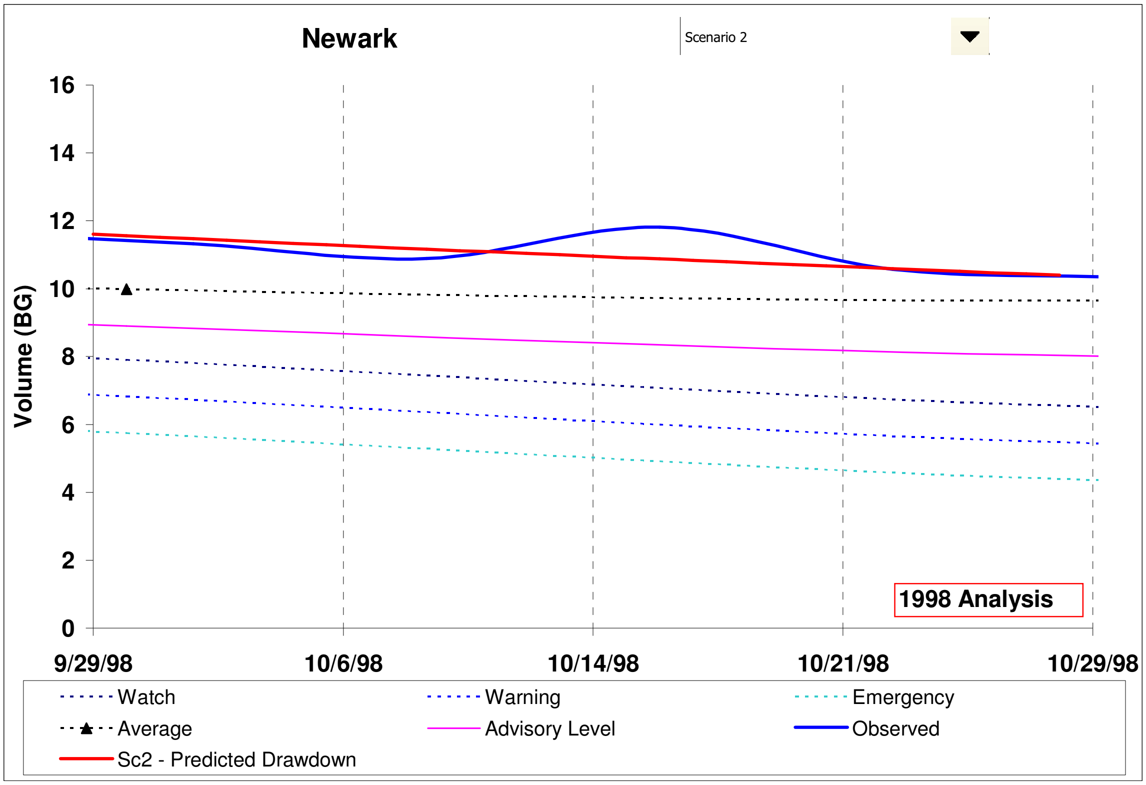

Figure 6-15: Newark - 1-Month Observed vs. Forecasted Drawdown

Next the model was used for forecasting the drawdown for 3 months into the future starting again at September 29, 1998. The model forecasted that NJDWSC will lower to watch conditions after approximately 2 months. The model predicts that approximately 25 mgd is required to keep NJDWSC out of watch condition. During this time, Jersey City and Newark were significantly above their watch levels and can provide emergency transfer to NJDWSC. Figure 6-16 shows the model predicted drawdown and the recommended optimized drawdown for NJDWSC.

During 1998 NJDWSC was the only reservoir that lowered to watch conditions; however, NJDWSC could have been prevented from reaching drought watch conditions by transferring water to it from Jersey City and Newark.

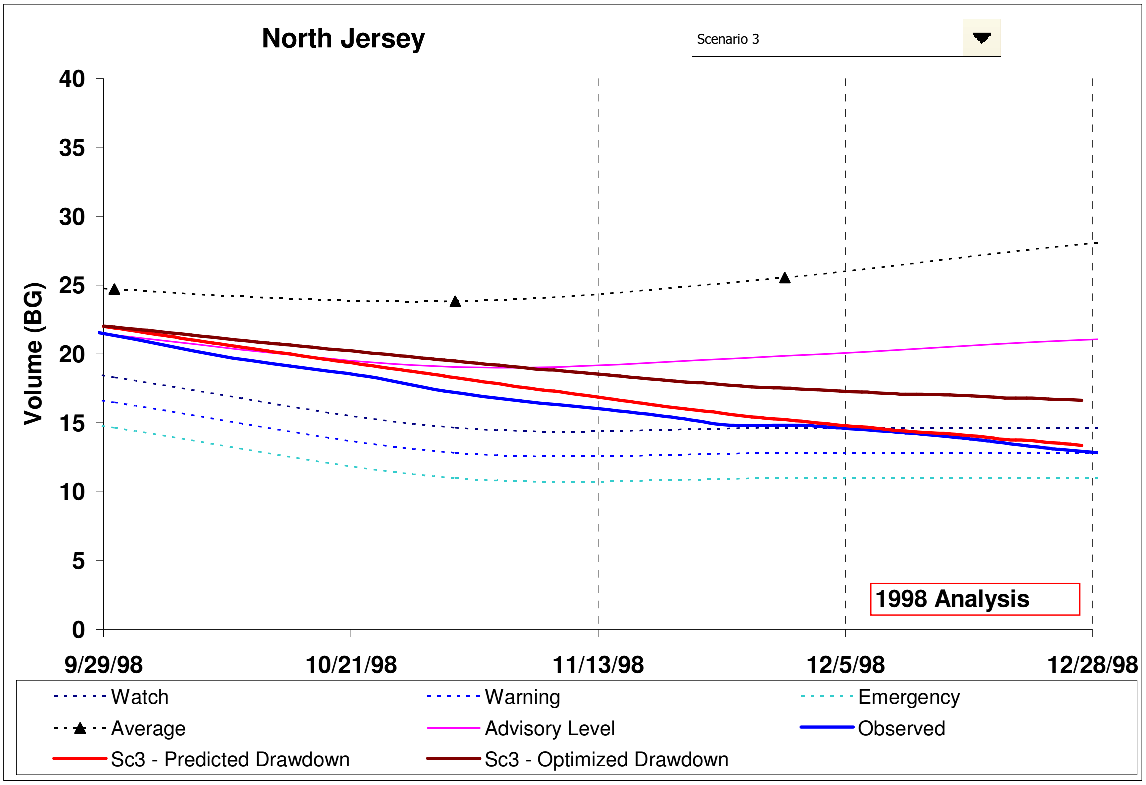

Figure 6-16: North Jersey DWSC - Observed vs. Predicted and Optimized Drawdown

6.1.6 1999 Drought Analysis

The signs of drought were first identified in this analysis when the UWNJ reservoir system dropped below the advisory curve on July 10, 1999. An initial run of the WSMDST was used to calibrate the model to observed reservoir drawdown. An example of a calibrated model run is shown in Figure 6-17. (The effect of demand reductions on actual reservoir levels becomes very apparent after the reservoir reaches emergency levels. These demand reductions are not accounted for in the WSMDST.)

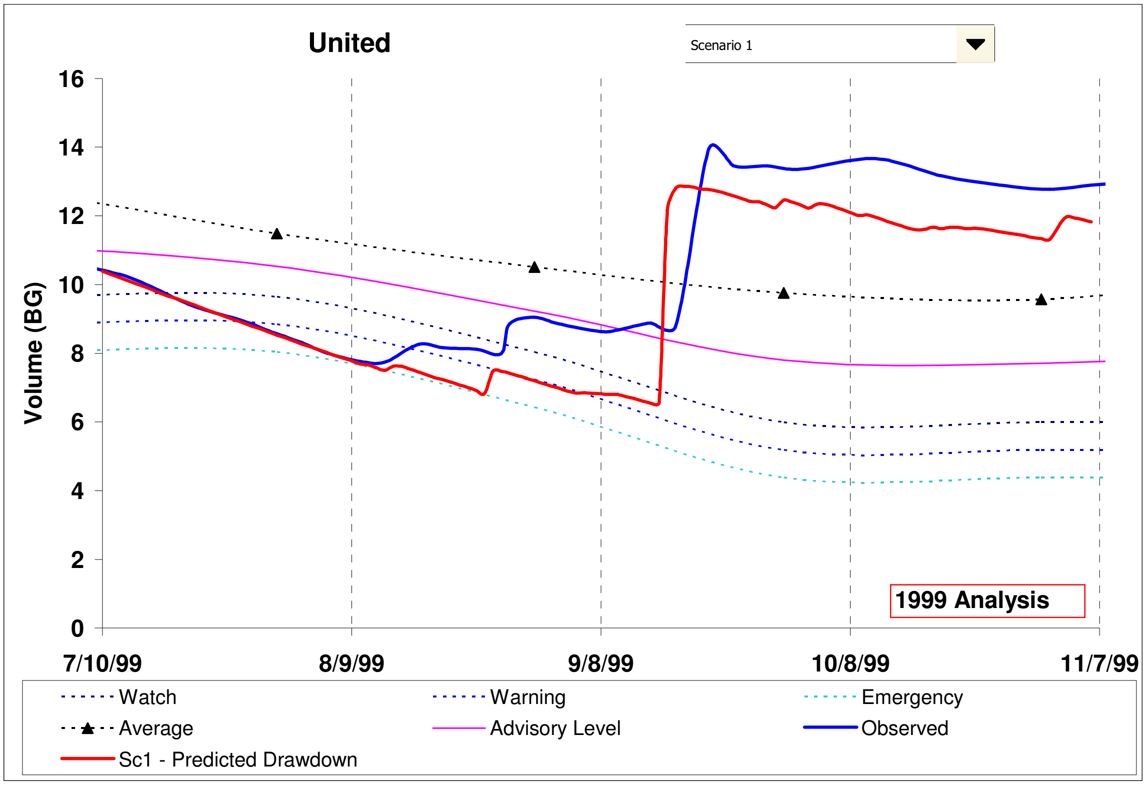

Figure 6-17: UWNJ - Observed vs. Predicted Drawdown

With all reservoir systems calibrated, modelers simulated a 1-month scenario using 5th percentile hydrologic factors from the start date of July 10. The results show that the Northeast region would have been able to stay out of drought watch with sufficient interconnection capacity. UWNJ would receive approximately 38 mgd from NJDWSC, and PVWC; Jersey City MUA also required 18 mgd from PVWC to stay out of drought watch. Figure 6-18 and 6-19 illustrate the actual, simulated, and optimized drawdown for these receiving purveyors.

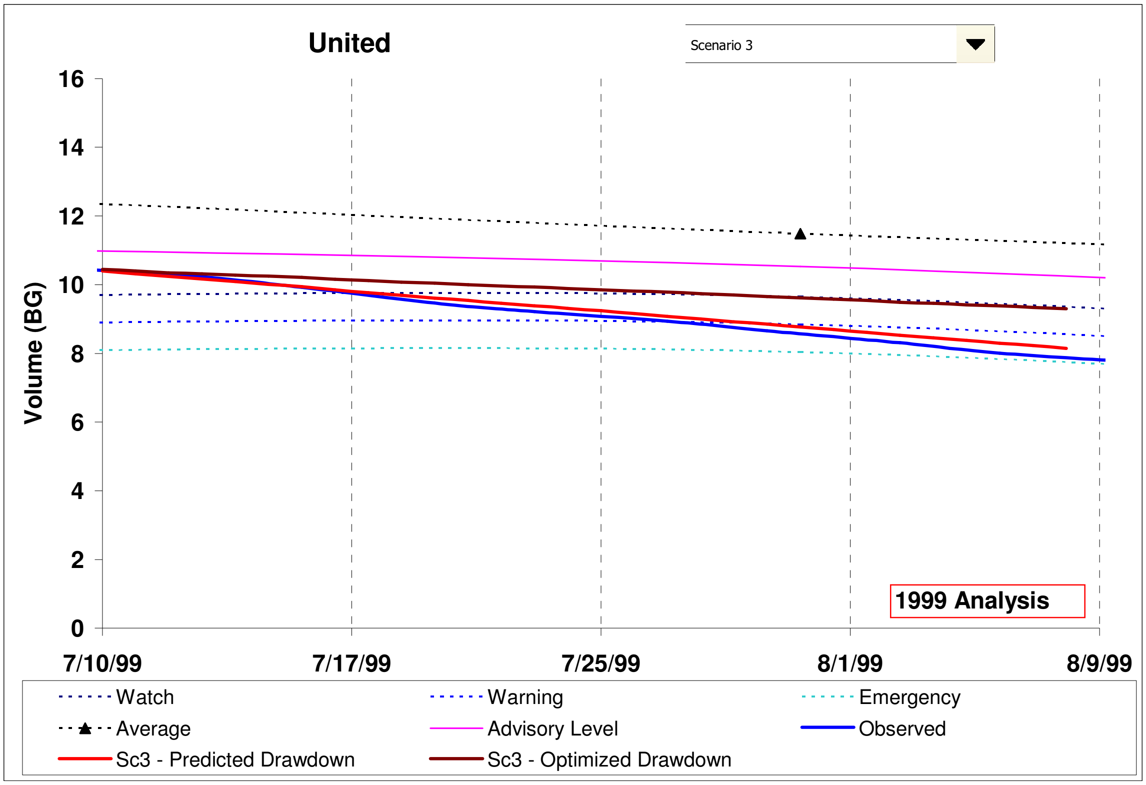

Figure 6-18: UWNJ - 1-Month Observed vs. Forecasted and Optimized Drawdown

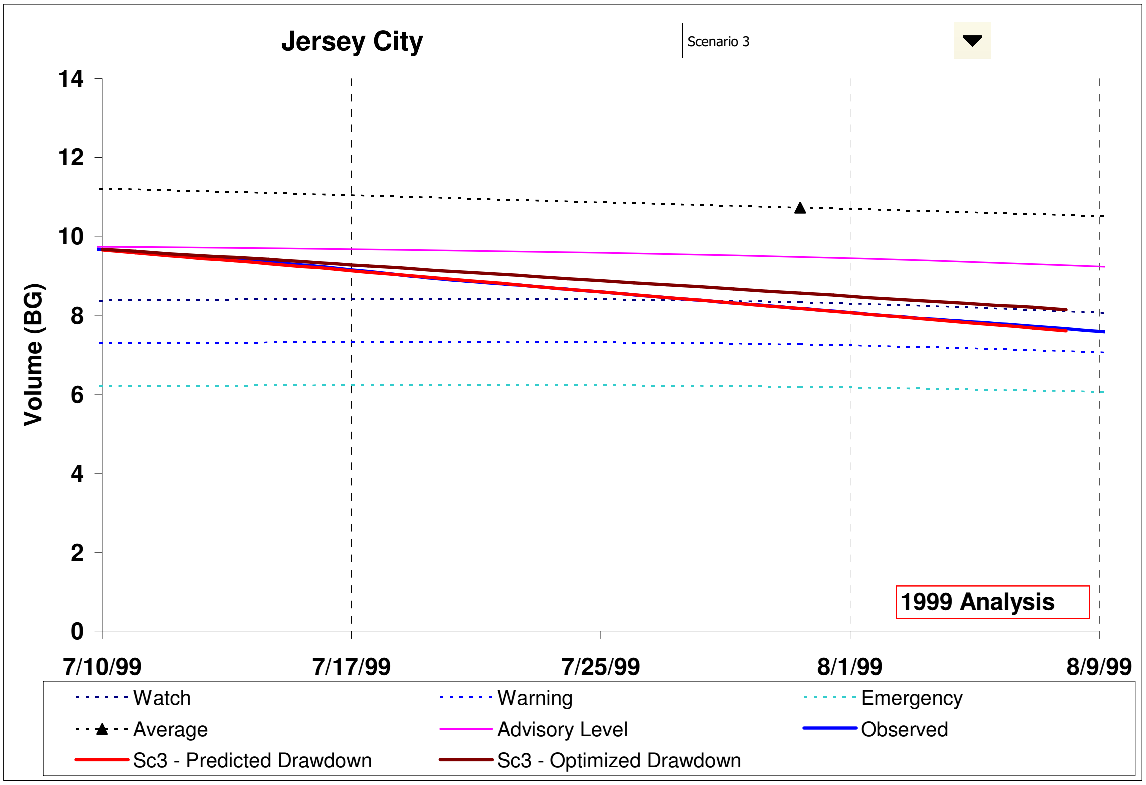

Figure 6-19: Jersey City - 1-Month Observed vs. Forecasted and Optimized Drawdown

Because the reservoir levels normalized to a level very close to drought watch for the Northeast Region, a 2-month simulation was considered appropriate in addition to longer term analyses. The results of the 2-month simulation indicated that additional water from outside the Northeast Drought Region was necessary to prevent drought watch. The model predicted that Jersey City requires 30 mgd and UWNJ 35 mgd to stay out of watch conditions. For this scenario PVWC had a surplus of 20 mgd which can be provided to Jersey City or UWNJ. The remaining deficit of 45 mgd has to be supplied by the Central region; however, this deficit cannot be met by Elizabethtown due to limited emergency interconnection capacity. Total capacity from Elizabethtown to Northeast reservoirs is 40 mgd (from Task 1). Also UWNJ has a total emergency interconnection capacity of 40 mgd (from Task 1) which is 5 mgd short of the requirement for staying out of watch condition.

The interconnection chain that connects NJAWC-Elizabethtown to Newark to Jersey City MUA to UWNJ is an essential component of statewide drought mitigation that, based on the analysis of 1999 drought, needs to be expanded.

6.1.7 2001-2002 Drought Analysis

The following paragraphs summarize the analysis of the 2001-2002 drought using the WSMDST procedure recommended previously.

Reservoir levels first became apparently low when the NJDWSC reservoir system crossed the advisory curve on October 26, 2001. Newark's Pequannock Watershed reservoirs dropped below the advisory level a few days later on October 31, with UWNJ and Jersey City MUA reservoir systems falling below the advisory curve in the second half of November.

This drought came with little warning and was far more severe than any drought in recent years. Figure 6-20 shows cumulative precipitation at a representative point in New Jersey for the 3 months preceding the initial advisory alert on October 26, compared with the same statistic for previous years.

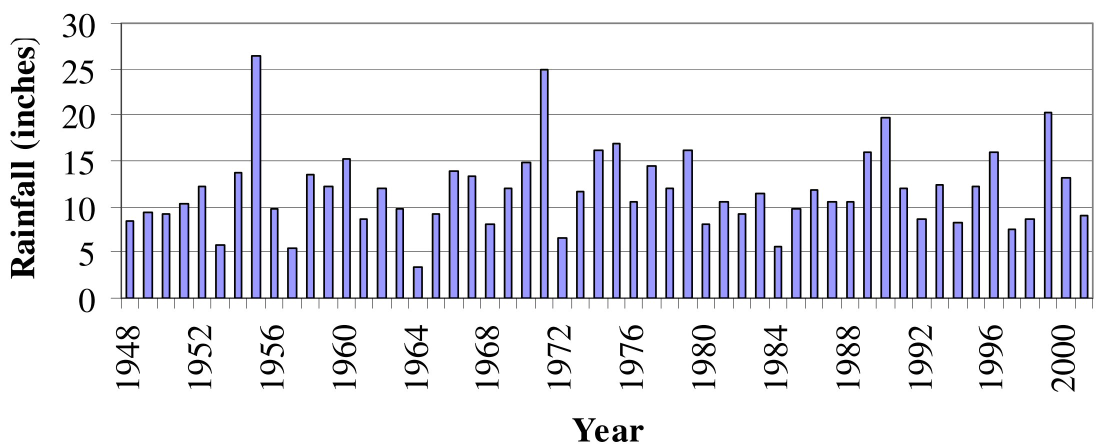

Figure 6-20: 3-Month Cumulative Precipitation Preceding October 26, 2001

The rainfall in 2001 is slightly below the average, but unexceptionally so. If the same statistic a few months later is re-examined, one can see how exceptional the winter of 2001-2002 became (Figure 6-21).

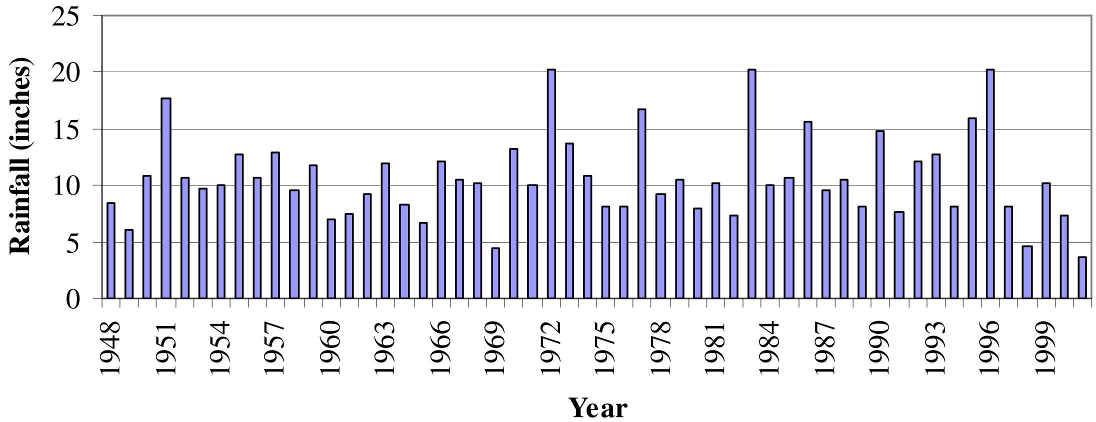

Figure 6-21: 3-Month Cumulative Precipitation Preceding December 26, 2001

Within only 2 months, the 3-month cumulative precipitation up to December 26 had dropped to the lowest in over 50 years. These conditions persisted until March of 2002. Demand reductions due to declaration of drought emergency and increased precipitation helped to returned reservoirs to normal levels, but it was nearly 2003 before all reservoirs were back above average levels.

The WSMDST was initiated on October 26, 2001. Modelers first used historical precipitation, evaporation, and streamflow data to calibrate the output of the WSMDST to observed behavior of the reservoirs. This is a luxury that will not be available when modeling the unknown future, but is beneficial in this case to account for known variables that change over time, such as demand and unknown factors not included in the model. By assuming that the sum of known and unknown factors remains constant for the duration of the period simulated and accounting for them, the projected reservoir levels are much more accurate. Figure 6-22 illustrates a reservoir system graph that has been calibrated to match the output to the observed historical behavior.

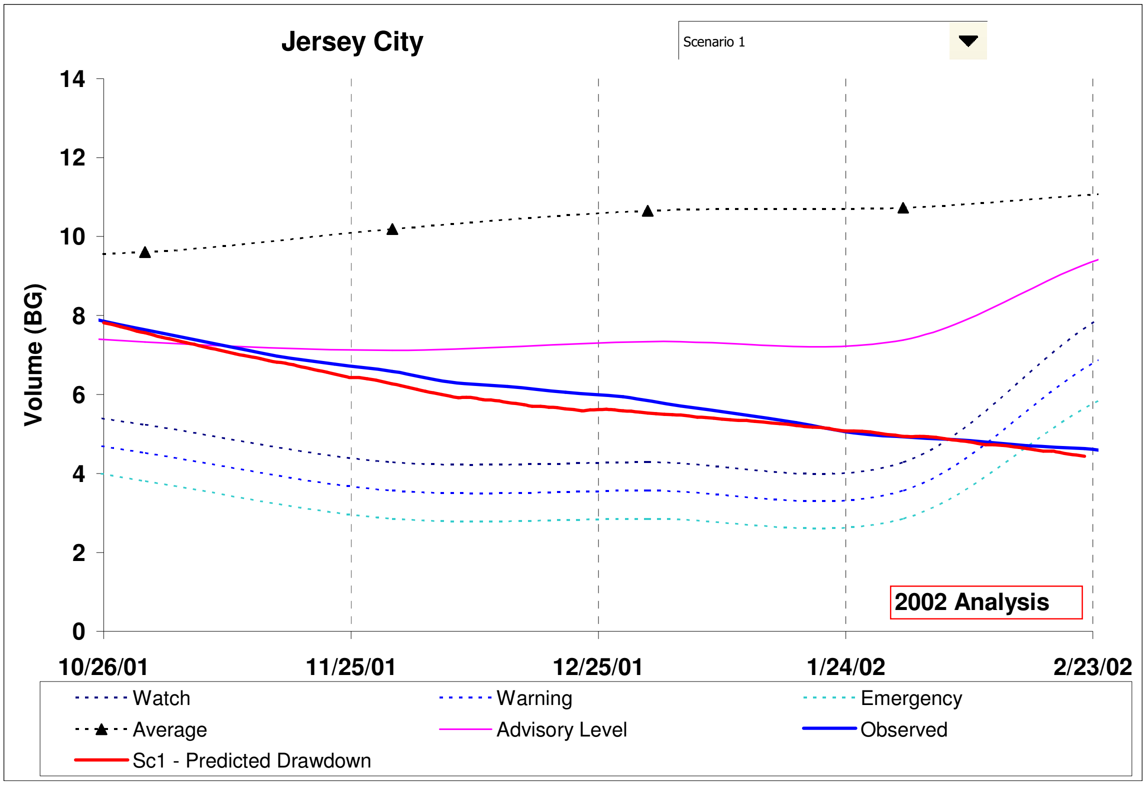

Figure 6-22: Jersey City MUA - Observed vs. Predicted Drawdown

With the model calibrated for all reservoir systems, a projected forecast of streamflow and precipitation based on the driest 1 out of 10 years was applied from the start date for a duration of 1 month. Figure 6-23 illustrates the historic drawdown compared with the drawdown that would be observed by applying predicted hydrologic factors. (Similar graphs are generated for all reservoir systems but not included here for brevity.) However, one can see from the historical data that the period simulated turned out to be much worse than 1 out of 10 years.

The simulation was repeated for 3-month durations with a projected forecast of streamflow and precipitation based on the driest 1 out of 100 years. Figures 6-24 – 6-27 Illustrate the historic drawdown, model simulated drawdown, and optimized drawdown during emergency conditions. Table 6-1 lists the surplus and deficit for different reservoir systems. As shown in the table, the Northeast Region as a whole required 131 mgd of water over a course of 3 months to stay out of watch conditions. PVWC has a surplus of 18 mgd and NJAWC-Elizabethtown a surplus of 100 mgd. Water from PVWC can be easily transferred within the Northeast Region through the existing interconnections. However, NJAWC-Elizabethtown only has a 41 mgd interconnection with Newark, so even though it has surplus supply, limited infrastructure prohibits the transfer of water. Building sufficient interconnection capacities to mitigate the effects of this drought would require increasing the capacity of the NJAWC-Elizabethtown interconnection to the Northeast Region.

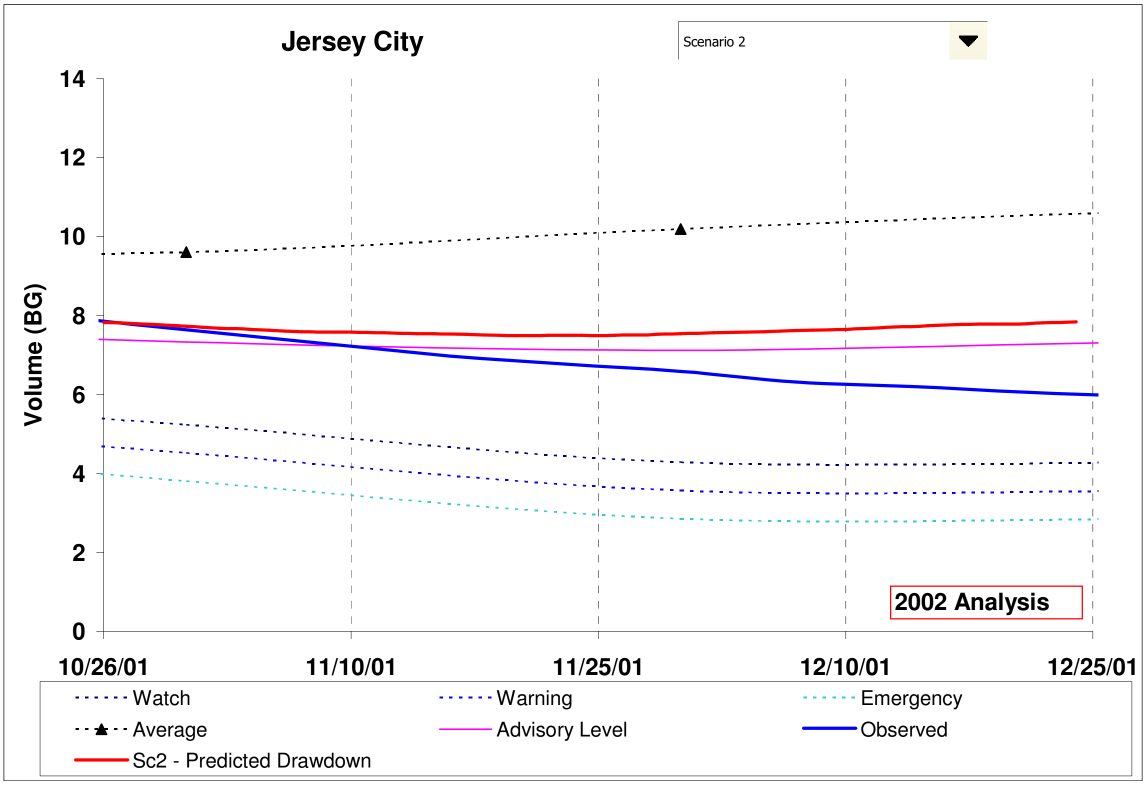

Figure 6-23: Jersey City MUA - Observed vs. Forecasted Drawdown

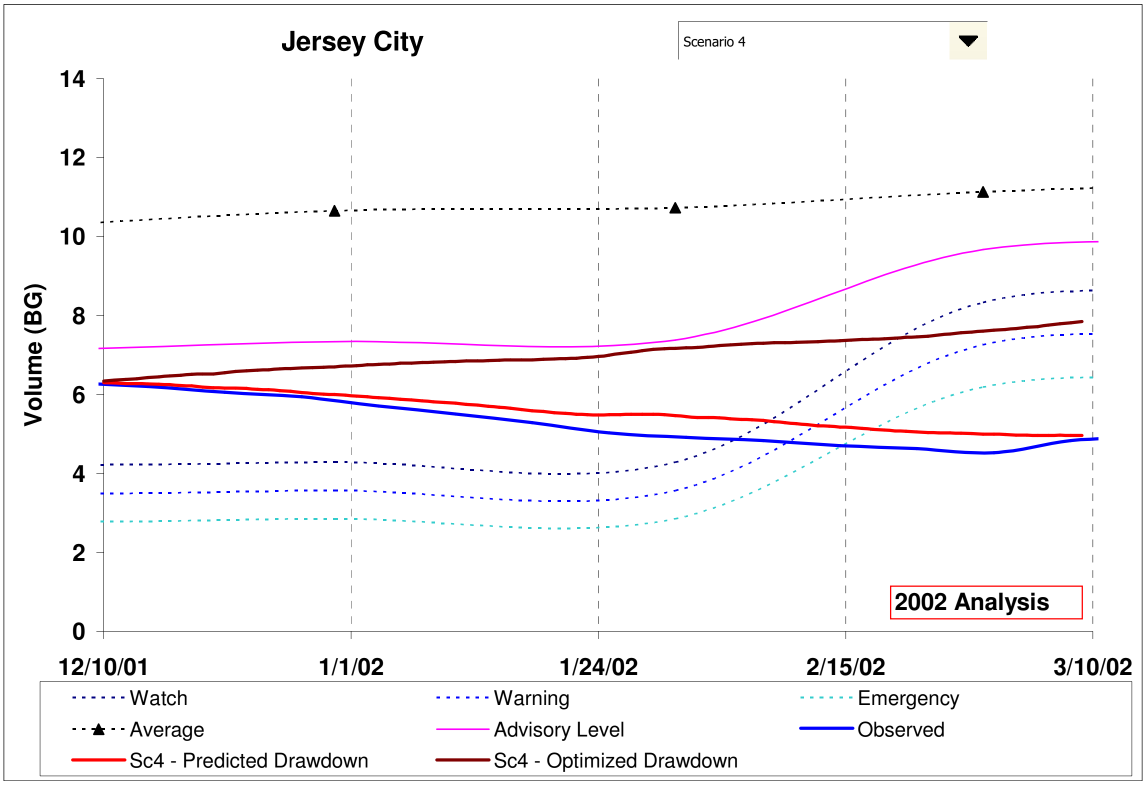

Figure 6-24: Jersey City MUA - Observed vs. Forecasted Drawdown vs. Optimized Drawdown

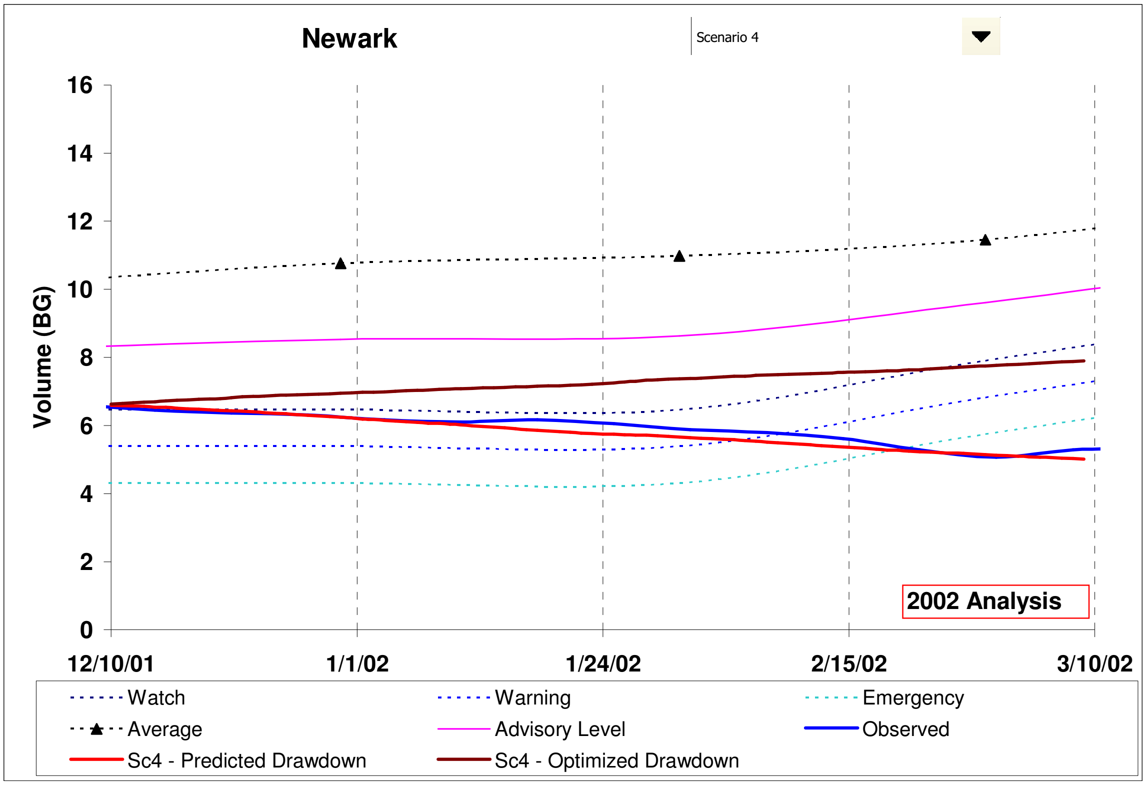

Figure 6-25: Newark - Observed vs. Forecasted Drawdown vs. Optimized Drawdown

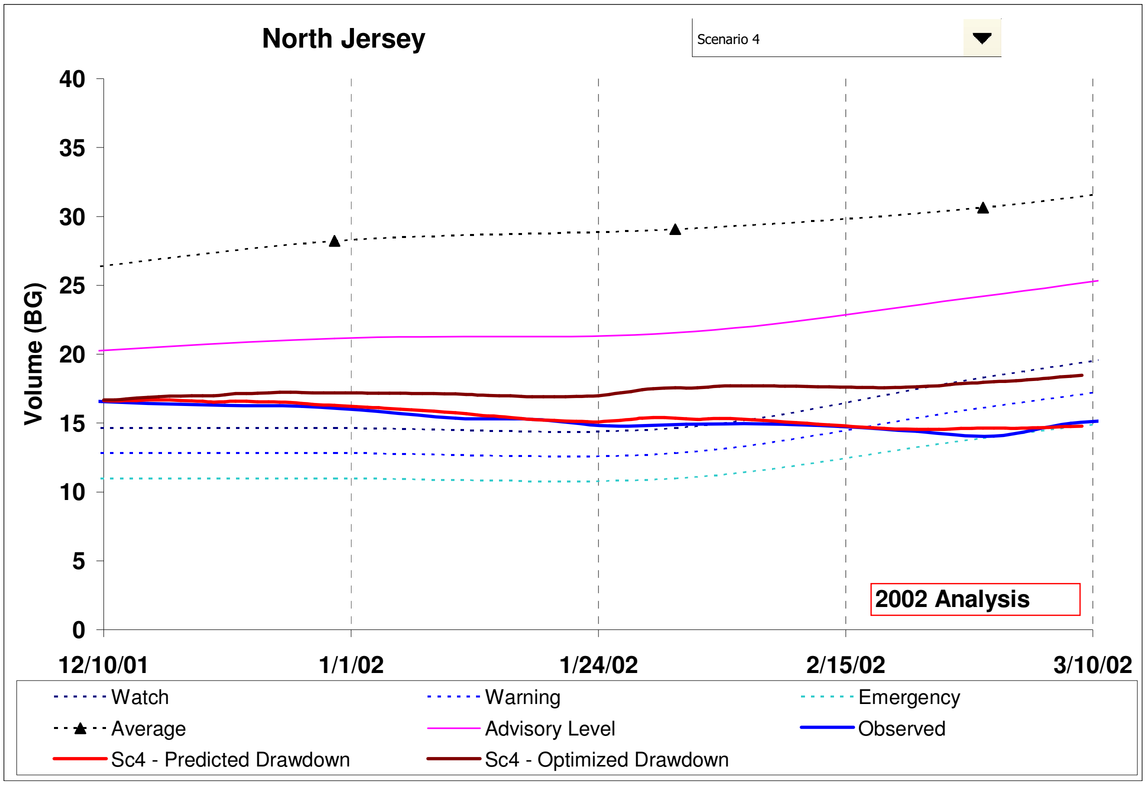

Figure 6-26: NJDWSC - Observed vs. Forecasted Drawdown vs. Optimized Drawdown

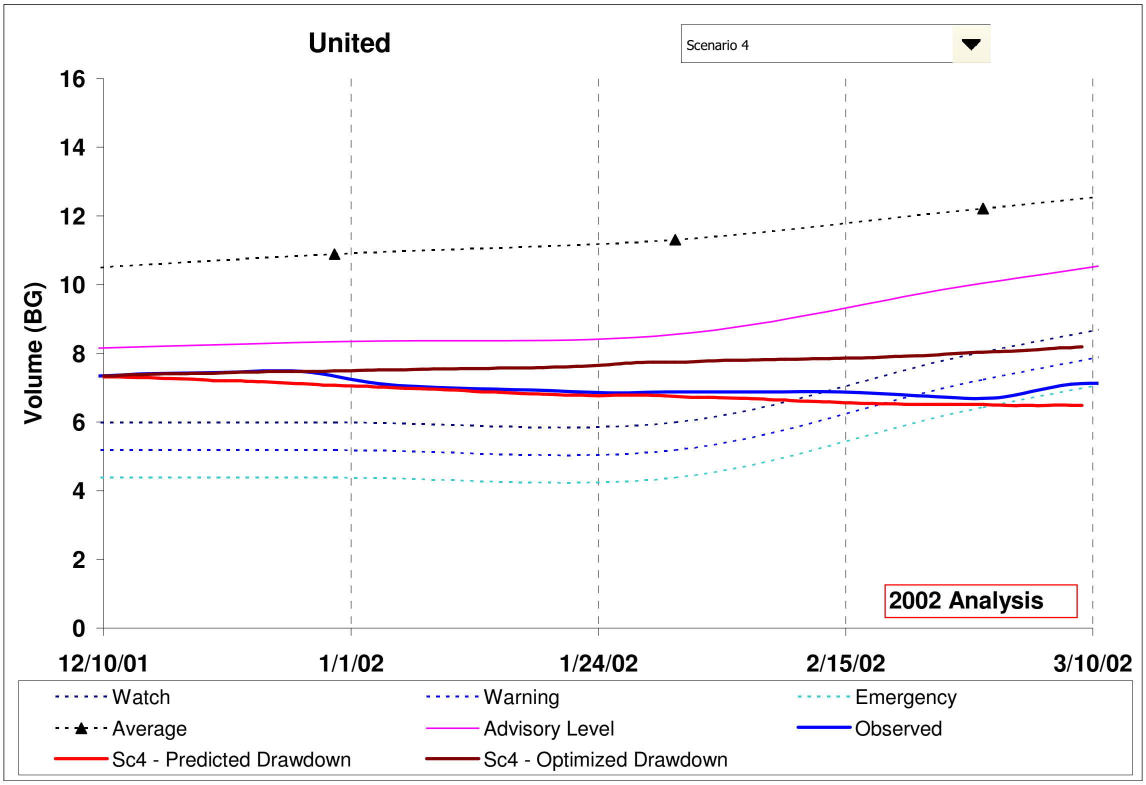

Figure 6-27: United - Observed vs. Forecasted Drawdown vs. Optimized Drawdown

Table 6-1: Transfer Required for Minimal Optimization

Purveyor Name	Region	Supply Required to bring to Watch conditions (MGD)	Surplus (MGD)
Jersey City Municipal Utility Authority	Northeast	35	NA
North Jersey District Water Supply Commission	Northeast	44	NA
Newark City Water Department	Northeast	32	NA
United Water New Jersey	Northeast	20	NA
Passaic Valley Water Commission	Northeast	NA	18
New Jersey American Water Company - Elizabethtown	Central	NA	100

6.1.8 2005 Drought Analysis

North Jersey DWSC and UWNJ fell below their advisory curves on August 1, 2005. North Jersey DWSC and UWNJ reservoirs both reached watch levels in the first week of September, 2005. The WSMDST was initiated on August 1, 2005. Figure 6-28 shows a calibrated reservoir drawdown graph for the period of the drought.

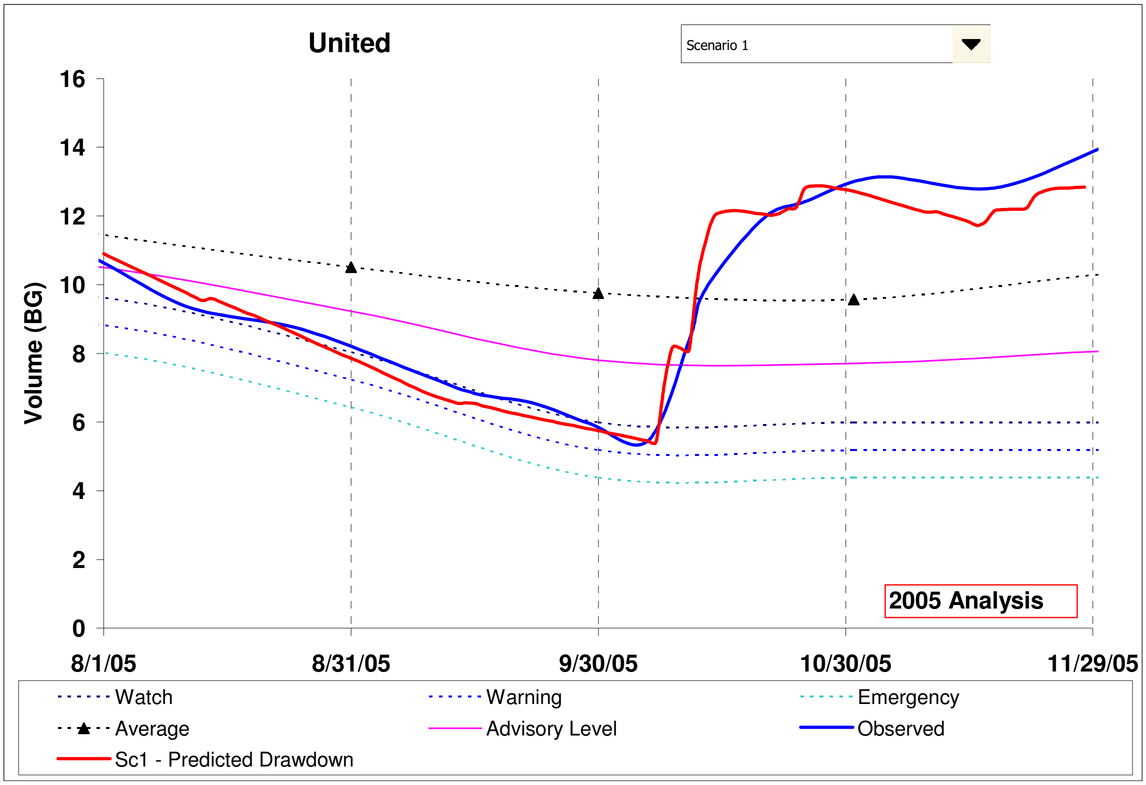

Figure 6-28: UWNJ - Observed vs. Predicted Drawdown

The model was then used to conduct a 1-month simulation starting at August 1, 2005 using 10th percentile streamflow data. *The model forecasted that none of the reservoirs would reach watch condition and thus no transfer is required.* This matched closely with what was later on observed. Figure 6-29 shows the model forecasted drawdown for one month compared with the observed drawdown for NJDWSC reservoir.

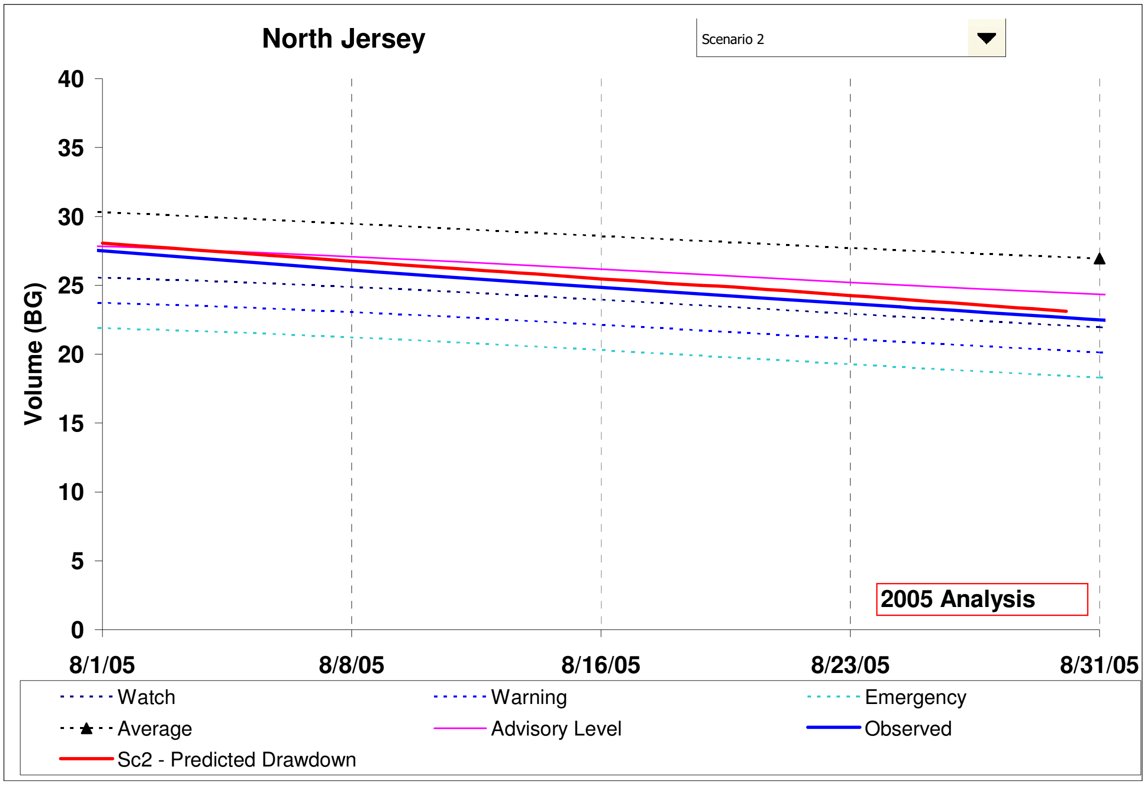

Figure 6-29: North Jersey DWSC - Observed vs. Forecasted Drawdown

Next the WSMDST was used for forecasting the drawdown for three months starting again at August 1, 2005. The model forecasted that NJDWSC and UWNJ would hit watch conditions after approximately 40 days. However, NJDWSC barely touched the watch condition and never went below the watch curve. As such no transfer is recommended for this reservoir. UWNJ could have avert drought watch by getting emergency supply through PVWC which has no downstream users and is the first choice for transfers required for averting droughts. Figure 6-30 show the model forecasted drawdown and the recommended optimized drawdown for UWNJ.

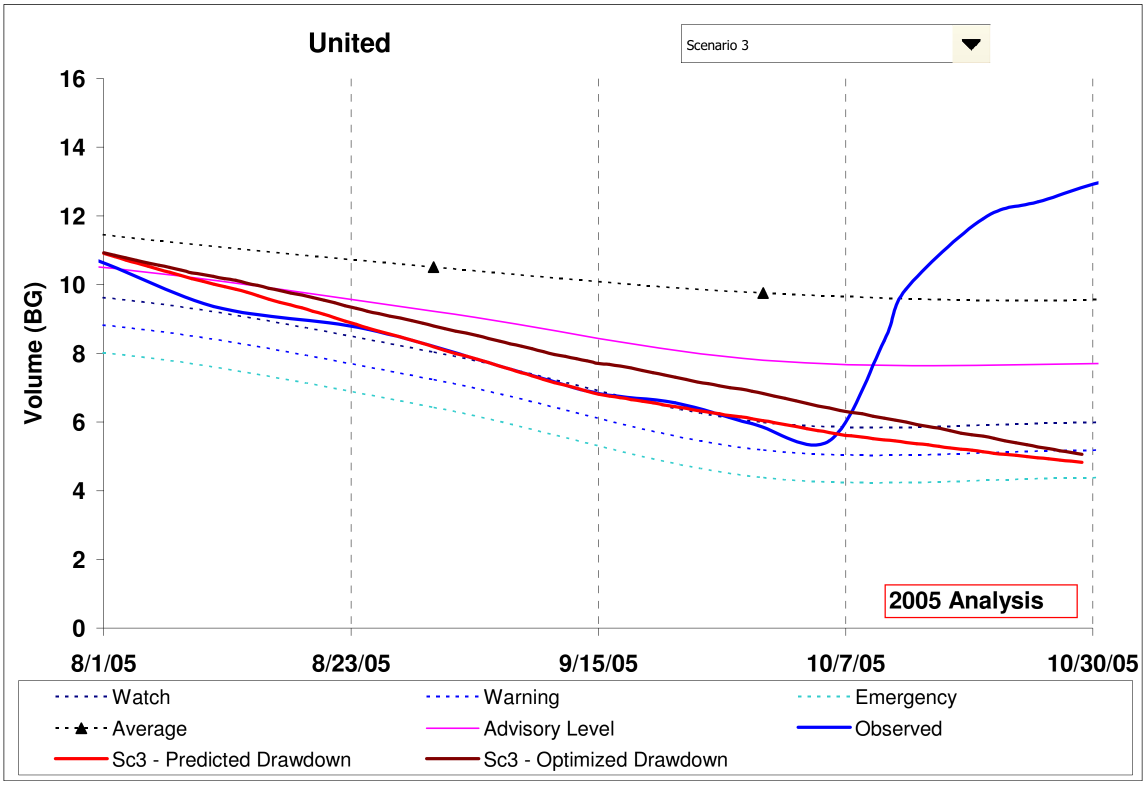

Figure 6-30: UWNJ - Observed vs. Forecasted and Optimized Drawdown

Recommended Improvements based on Historical Drought Analysis

Table 6-2 summarizes the recommendations for infrastructure improvements based on the various historical droughts analyzed above.

Table 6-2: Summary of Recommendations based on Historical Drought Analysis

	Drought Condition	**Purveyors in deficit**	**Interconnection required to stay out of drought watch**	**Existing interconnection capacity**	**Purveyors with surplus**	**Limiting interconnections**	**Comments**
1960's	Emergency	All	No surplus water in New Jersey	(See Table 1 for breakdown)	None		By early February 1965 no water systems had surplus water to share.
1981-1982	Emergency	United	55 mgd required	40 mgd (See Table 1 for breakdown)	Jersey City, Newark, NJDWSC, PVWC	Interconnection from NJDWSC to UWNJ	Model predicted using emergency interconnections through other Northeast reservoirs and PVWC to provide water to United, to avert hitting watch conditions.
1995	Warning	United	30 mgd required	40 mgd (See Table 1 for breakdown)	Jersey City, Newark, NJDWSC, PVWC	None	30 MD can be provided through Jersey City and NJDWSC.
1998	Watch	NJDWSC.	25 mgd required	81.8 mgd (See Table 1 for breakdown)	Jersey City, Newark & United.	None	
		United	35 mgd required	40 mgd (See Table 1 for breakdown)	PVWC, NJAWC - Elizabethtown	Interconnection from Jersey City to UWNJ	PVWC supplied 20 MGD. UWNJ's interconnection supply was limited by flow through Jersey City (short by 5 MGD). Flow to Northeast reservoir from Elizabethtown is also limited to 40 MGD (short by 5 MGD).
1999	Warning	Jersey City	30 mgd	176.50 mgd (See Table 1 for breakdown)	PVWC, NJAWC - Elizabethtown	None	Jersey City had sufficient interconnection capacity to stay out of drought watch in the near and long term.
		Jersey City	35 mgd required	113 mgd through PVWC			
		NJDWSC.	44 mgd required	40 mgd from PVWC			
		Newark	32 mgd required	46 mgd from PVWC & 41 MGD from Elizabethtown			
2002	Emergency	United	20 mgd required	7 mgd from PVWC	PVWC had a surplus of 18 mgd and Elizabethtown had a surplus of 100 mgd	Through Elizabethtown	Total of 131 MGD was required to bring all the Northeast reservoirs out of drought watch condition with out demand reductions. Even though Elizabethtown had a surplus of 100 MGD the emergency interconnection capacity from Elizabethtown to Northeast reservoirs is only 41 MGD.
2005		United	10 mgd required	40 mgd (See Table 1 for breakdown)	Jersey City, Newark & PVWC	None	Model predicted using interconnection with PVWC to receive the required 10 MGD.

6.2 Reduction in Consumption from Drought Restrictions

Mandatory and voluntary calls for reduction in consumption are common components of drought management plans at the utility, community, and state levels. These short-term water conservation strategies serve to temporarily reduce potable water demands by encouraging or requiring reductions in non-essential water use by domestic, commercial, and industrial users. Such programs are typically implemented using a phased approach, with voluntary reductions being called for during the initial drought stages and mandatory reductions or even rationing being instituted during drought emergencies. When water use restrictions are in place, domestic, commercial, and industrial water uses are expected to limit non-essential water use by reducing or refraining from activities such as lawn and garden irrigation, vehicle washing, street/sidewalk cleaning, and filling of pools. As the severity of a drought situation progresses from a watch to an emergency, non-essential uses should be incrementally reduced and may ultimately be eliminated. In addition to reducing water use, consumers are often asked to optimize indoor and outdoor water use by identifying and addressing leaks in plumbing, reducing overspray from sprinkler systems, timing outdoor watering to occur during the coolest hours of the day, installing low water use fixtures, and reducing shower length, among other activities. Table 6-3 provides an example of typical drought management stages.

Table 6-3: Sample Drought Management Strategy

Drought Stage	Water Supply Deficit*	Demand Reduction Goals**	Water Use Restrictions and Outreach Activities
Stage 1 – Prevention (normal conditions)		0 – 5 %	Public education, voluntary conservation
Stage 2 – Drought Watch	5 – 10%	5 – 15%	Increased public education, provide guidelines for voluntary conservation activities, water audits, scheduled out-door watering, incentives (hand-outs, rebate programs)
Stage 3 – Drought Warning	10 – 20%	5 – 20%	Increased public education, provide guidelines for voluntary or mandatory water use restrictions, water audits, scheduled out-door watering
Stage 4 – Drought Emergency	20 – 35%	10 – 25%	Mandatory reductions in non-essential uses, rationing, patrolling and enforcement, conservation pricing
Stage 5 – Critical Water Supply Emergency	35 - 50%		Mandatory elimination of non-essential uses, water rationing

* From, American Water Works Association Drought Management Handbook, 2002
**Compiled from drought management plans for select northeast states.

Short-term demand management programs, when carefully implemented and enforced, have been shown to be quite effective in delaying the on-set of a drought emergency.

6.2.1 Example Utility Plan Implementation

The City of Austin, Texas is an example of the successful implementation of a drought contingency plan (Gregg, 2002). The City relied upon short-term conservation measures to manage demand during 5 consecutive summers while new sources were developed to meet the rapidly growing residential demand. At the on-set, the City revised its drought contingency plan, which among other things, called for automatically implementing Stage 1 drought restrictions from May through September each year. For 4 years the intensive public awareness efforts and requests for voluntary conservation efforts were effective at maintaining demands at safe levels. However, during the 5th year the city was forced to declare and implement Stage 2 drought restrictions when the demand peaked at within 7 mgd of the system capacity. Stage 2 drought restrictions called for mandatory reductions in non-essential uses. Implementation of Stage 2 restrictions included staffing a 24-hour hotline, patrolling for and reporting violations, and issuing warnings and citations. The city was under water use restrictions for over 2 months, but the efforts worked, with the demand falling below the action level within a few days of notification and staying at safe levels throughout the unusually long hot summer. The City's public outreach and enforcement measures and the resulting consumer cooperation averted the need for more severe demand reduction strategies like rationing and increased rates.

6.2.2 Example State Programs

The state of Georgia implemented state-mandated water-use restrictions in May 2000, in response to severe water supply deficit statewide. This was the first time such restrictions had been mandated. The campaign overall was believed to be successful, but many lessons were learned. The restrictions included time-off daily watering restrictions, which limited outdoor watering to specific morning and evening hours. Evaluation of demand data from utilities throughout the region showed that adherence to these restrictions resulted in unusual diurnal demand patterns and extreme peaks in demand during the prescribed watering hours (Comstock, 2002). In response, the restrictions were modified to include odd/even day requirements, which further restricted water based on house number. This modification was effective in reducing the extreme peaks and proved to be a more effective strategy. Since that time, the State has revised their Drought Management Plan. The latest revision includes odd/even day watering restrictions even during non-drought periods, with successively more strict hourly restrictions for each drought phase (Georgia Drought Management Plan, 2003).

State environmental agencies throughout the country have developed drought management plans. These plans vary in their level of detail. Some only address various agency roles during a drought emergency, while others include statewide drought indicator systems, defined goal reductions in consumption, and water use restrictions for each drought stage. Table 6-4 summarizes reduction in consumption goals for states in the northeast that have more detailed drought management plans. New York City's goals are included, as New York State does not have defined goals. The goals are fairly consistent from state to state within the region and are consistent with goals from states throughout the country.

Table 6-4: Select Reduction in Consumption Goals

Drought Stage	**Reduction Goals by Agency**				
	VA DEQ*	CT DEP**	MD DEP^	NYC DEP^^	PA DEP^^^
Advisory		10%			
Watch	5%	15%	5-10%	15%	5%
Warning	5-10%	20%	10-15%	20%	10-15%
Emergency	10-15%	25%	15-20%	25%	25%

* VA Drought Assessment and response Plan, March 2003
**Connecticut Drought Preparedness and Response Plan, August 2003
^ Maryland Statewide Water Conservation Advisory Committee report, Nov 2000
^^ NYCDEP website - access Feb 2007
^^^ PADEP Fact Sheet - Drought Management in Pennsylvania, Sep 2005

6.2.3 Long-Term Conservation Efforts

In addition to short term reductions in non-essential uses, many drought management programs encourage long-term conservation efforts. Long-term conservation programs are implemented under normal water supply conditions in an effort to achieve a sustained reduction in demand. Sustained reductions in demand extend water supplies and serve as a drought prevention measure. Successful conservation programs can result in reductions in consumption of 10 - 20% over 10 - 20 years (Maddaus, 1996). Water conservation plans are developed based on demand reduction goals and demand projection forecasts and include both supply-side (water purveyor) and demand-side (water consumer) conservation measures. The United States Environmental Protection Agency (USEPA) promotes conservation plans as a means to extend the life of water and wastewater utility infrastructure, and many state regulatory agencies require that utilities develop conservation plans as part of their permitting process. NJDEP does require water conservation for all utilities through the water allocation permit process; however, there is no mechanism for follow-up on plan implementation.

6.2.4 NJDEP Program

New Jersey's statewide drought management plan was developed in 1989. The plan, which is entitled "Joint BPU and DEP Water Emergency Planning Team (WEPT) Final Report," provided recommendations as to how the state agencies could improve their drought management activities. The report addressed 3 main issues: the identification of triggers and responses, the development of enforcement policies, and the importance of delivering consistent and effective public outreach at the state and local levels. The plan established: a set of drought triggers based on precipitation amounts and reservoir levels, a consistent set of terminology to be used in describing a drought (including defining of the various drought phases), a model ordinance for local enforcement of drought restrictions, suggested tariff language to allow for the adoption of conservation rates, and a "Drought Emergency Communications Plan" to insure effective communication among the state and local agencies and the public. The report identified 5 drought phases as listed in Table 6-5, with each phase tightening restrictions for a different class of users. The report did not, however, establish goal reductions for each of these phases. Though the report was comprehensive, it is rather dated, and as such, parts of it have been updated or superseded. For example, the Drought Indicator System now in place evolved out of the triggers developed in the report.

Table 6-5: Summary of NJDEP Drought Status and Restrictions - 1989

Drought Status	Restrictions	Enforcement
Advisory	None	None
Warning	Voluntary conservation	None
Emergency Phase I	Mandatory outdoor restrictions	Discontinuance
Emergency Phase II	Mandatory outdoor and indoor restrictions	Discontinuance
Emergency Phase III	Mandatory residential, industrial and commercial restrictions	Discontinuance

Adapted from "Joint BPU and DEP Water Emergency Planning Team (WEPT) Final Report", 1989

NJDEP requires all purveyors to develop a "Water Supply Emergency Response Plan" that outlines system specific triggers and responses for various drought phases. Applicants for water allocation permits must provide information from this plan; however, there do not appear to be guidelines for developing the plans or minimum requirements of the plans.

Other agencies in New Jersey that have authority over water withdrawals are the Delaware River Basin Commission (DRBC) and the New Jersey Pinelands Commission. DRBC has adopted conservation policies that address both supply-side and demand-side measures. DRBC requires that all purveyors distributing more than 100,000 gallons per day (gpd) implement leak detection and repair programs, and that all service connections be metered. Purveyors are also required to submit conservation plans with all new or expanded water withdrawal permit applications and applicants with withdrawals of greater than 1 mgd must include an evaluation of the feasibility of implementing a water conservation pricing structure and billing program in the plan. In 2001 DRBC amended their Comprehensive Plan and Water Code to establish water usage reporting requirements for all withdrawals greater than 100,000 gpd. Finally, DRBC established minimum performance standards for plumbing fixtures and fittings. NJDEP is designated as the administrator of some of these policies, and has implemented those policies statewide through the water allocation permitting process.

6.2.5 Recommended Action Items

It is recommended that NJDEP update their statewide Drought Management Plan to redefine roles of various state, county, and local agencies during a drought emergency, to establish minimum requirements of local plans, and to provide guidance to local agencies for drought response. NJDEP has already implemented the NJ Water Supply Drought Indicator System, which is described in Chapter 3. This system provides decision makers at the state and local levels with reliable and consistent information upon which to base drought response decisions. Having such a system is an important component of a statewide drought management plan. An updated statewide drought management plan will insure that agencies throughout the state implement consistent responses to the Drought Indicator System. The statewide plan should include delineation of agency roles during a drought emergency and an outline of minimum recommendations for reduction in water use by each sector during each drought stage. Additionally, the state should provide easily accessible resources for local agencies and utilities for developing individual or system-specific drought plans, establishing drought ordinances at the local level, developing and implementing enforcement actions, conducting public outreach campaigns, and developing conservation pricing.

It is recommended that NJDEP develop goals similar to those established by other states for reduction in consumption at each drought stage, as well as guidelines for voluntary reductions and water use restrictions. This type of conservation strategy would be implemented in response to the existing Drought Indicator System. Table 6-6 outlines the suggested structure for a drought related conservation strategy for New Jersey.

Table 6-6: Recommended Reduction in Consumption Strategy

Drought Stage	Demand Reductions Goals	Activities
Stage 1 – Prevention (normal conditions)	0 – 5%	Ongoing public education, promoting voluntary conservation
Stage 2 – Drought Watch	5 – 10%	Increased public education, guidelines for voluntary conservation activities, water audits, scheduled out-door use, incentive programs, (hand-outs, rebate programs)
Stage 3 – Drought Warning	10 - 15%	Increased public education, mandatory water use restrictions (scheduled out-door watering, vehicle washing, paved surface cleaning), patrolling and enforcement
Stage 4 – Drought Emergency	15 - 20%	Mandatory reductions/elimination of non-essential uses, patrolling and enforcement, rationing, conservation pricing

In addition to implementing the drought related reductions in consumption outlined above, NJDEP might consider evaluating the potential benefits associated with long-term water conservation efforts. To achieve this, a more detailed understanding of customer water use is needed. Examining the seasonal patterns of monthly water use is particularly useful for identifying typical indoor and outdoor water use. Indoor water use is generally equated to the lowest month's water use during a year. Seasonal peak water use is often associated with outdoor use, such as landscape watering. In humid areas, summer water can be double the winter water use. In the arid western US, water use can increase by a factor of 5 to 6 from winter to summer (AWWA, 2006). An examination of peak-day ratios could provide an estimate of seasonal use, if a system's peak day use is associated with seasonal water use, and is not attributable to a water main break or other high water use factors. The peak-day ratio is calculated using the water produced on the highest water use day divided by the annual average daily water use for the system. The state of New Jersey could examine seasonal water use trends using high peak-day ratios as an indicator of possible high outdoor water use.

Once the seasonal trends and uses contributing to peak-day demands are determined, NJDEP might consider developing statewide guidance for reducing peak-day demands during normal conditions. Such guidance would recommend community and utility based actions that would reduce peak demands under normal conditions and thus reduce stress on water systems and water supplies under drought conditions. Actions that might achieve such reductions include: outdoor water use restrictions (day and time, recommend watering every 4 to 5 days during morning and evening hours) implemented throughout the growing season (April - October), required installation of water efficient irrigation systems in all new construction and redevelopment for residential, commercial and public lands, promote beneficial reuse for irrigation, street cleaning and sewer jetting where possible, and scheduled utility maintenance activities such as main flushing and sewer jetting. However, it is noted that peak-day ratios and the contributing factors to peak-day flow may vary from system to system. If this is the case in New Jersey, statewide policy may not be appropriate.

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7.0 OPTIMIZE EXISTING WATER DIVERSIONS DURING NORMAL CONDITIONS (TASK 5)

This task is intended to identify areas for possible improvement in water supply planning during normal conditions. During normal conditions, optimization was focused on management and preparation for drought at the local level within water systems.

7.1 Optimize Existing Reservoir Storage Capacity

Optimization of the available storage capacity in systems with multiple reservoirs in the same watershed can improve drought preparedness or help mitigate short duration droughts. This section evaluates the benefits and practicality of the use of pumped transfer to equalize recharge rates between lower and higher elevation reservoirs. The analyses do not include any changes to existing safe yields or passing flow criteria already in place for the reservoir systems.

7.1.1 Jersey City MUA

Jersey City MUA operates a surface water system composed of Split Rock and Boonton reservoirs. Split Rock Reservoir is located at the upstream end of Beaver Brook. It has a drainage area of approximately 5.5 mi^2 and a storage volume of approximately 3.3 BG. Boonton Reservoir is located on the Rockaway River, with a drainage area of approximately 119 mi^2 and a storage volume of approximately 8.1 BG. Split Rock and Boonton reservoirs have passing flow requirements of 1 and 7 mgd, respectively. Split Rock Reservoir is used to augment flow to Beaver Brook which feeds Rockway River upstream of Boonton Reservoir.

During severe drought events, Split Rock releases undergo significant evaporation and infiltration losses as flow makes it way downstream to Boonton Reservoir. One option that has been considered is constructing a pipeline between the Split Rock and Boonton reservoirs to minimize release losses and permit pump back of water from Boonton Reservoir to Split Rock Reservoir. The concept involves pumping water from Boonton Reservoir to Split Rock Reservoir when Boonton Reservoir is spilling. When Boonton Reservoir is low, water would be released from Split Rock and routed directly to Boonton via the same pipeline. The piping of water from Split Rock to Boonton would eliminate the significant loss of water that now occurs through groundwater recharge in the stream connecting the two reservoirs. The implementation of this concept poses a number of challenges:

- Construction of a large pipeline through a relatively pristine area.
- Potential reduction of the current recharge that would occur in the stream when Split Rock would be spilling and the potential adverse impacts on the groundwater system.
- Timing of the transfer of water – based on discussions with reservoir operations staff, most times when Boonton is low, Split Rock also is low; and when Boonton is high, Split Rock also is high. Transfer would have to be timed when Split Rock

is low and Boonton is high, considering that Boonton recharges faster than Split Rock and would recover quickly.

- Effects on the local ecology of reducing the overall volume of water in the stream that now travels between the 2 reservoirs via the stream. passing flow requirements would not be changed.

For these reasons, the physical "connection" of these 2 reservoirs is not considered feasible and is not recommended at this time. A more detailed analysis of these and other issues must be undertaken to be able to definitively say that this is a viable alternative.

7.1.2 United Water New Jersey

United Water New Jersey operates a 4-reservoir system, DeForest Lake, Lake Tappan, Woodcliff Lake, and Oradell Reservoir. DeForest Lake is located on the Hackensack River just upstream of Lake Tappan with a drainage area of approximately 27.5 mi^2 and a storage capacity of about 5.7 BG. DeForest Lake capacity is shared with United Water New York and the Village of Nyack. Lake Tappan is located on the Hackensack River upstream of Oradell Reservoir with a drainage area of approximately 49 mi^2 and a storage capacity of around 3.8 BG. Woodcliff Lake is located on the Pascack Brook upstream of Oradell Reservoir with a drainage area of 19.4 mi^2 and a storage capacity of approximately 0.87 BG. Oradell Reservoir is the most downstream reservoir in the United Water New Jersey system. Located on the Hackensack River, it has a drainage area of approximately 113 mi^2 and a storage capacity of 3.5 BG.

In the past, studies have considered the benefit of connecting Oradell Reservoir to Woodcliff Lake with a pipeline. Results showed that such a connection is not beneficial based on a cost/benefit analysis. Woodcliff Lake is a small reservoir that cannot provide significant flow contribution for a prolonged period of time. Supplying approximately 20% of UWNJ raw water demand would drain the reservoir in about a month. A similar analysis connecting Oradell Reservoir to Lake Tappan yields similar results. In addition, Lake Tappan and Oradell Reservoir have similar drainage area to storage capacity ratios, which is an indicator of their refillability. Typically, when Oradell Reservoir is spilling, Lake Tappan is spilling as well.

7.1.3 North Jersey District Water Supply Commission

NJDWSC operates Monksville and Wanaque reservoirs. Monksville Reservoir is located on the Pompton River, just upstream of Wanaque Reservoir. It has a drainage area of approximately 40.4 mi^2 and a storage capacity of around 7 BG. Wanaque Reservoir has a drainage area of approximately 90.4 mi^2 and a storage capacity of approximately 29.6 BG.

NJDWSC reservoir system would not benefit from connecting both reservoirs with a pipeline, as they are close to each other in proximity and operate virtually as one reservoir. Typically, when Wanaque Reservoir is full, Monksville Reservoir is almost full or also full.

7.1.4 City of Newark

The City of Newark operates a reservoir system that includes Canistear, Oak Ridge, Clinton, and Charlotteburg reservoirs and Echo Lake. The supply from this reservoir system might be enhanced by optimized operations and/or connecting pipelines to transfer water between reservoirs. However, stage/storage information on these reservoirs was not received, and so this information is needed to conduct any analyses to optimize this reservoir system.

7.2 Demand Transfer between Sources

Optimization of source water selection during normal conditions can be a drought prevention measure, conserving water during times of excess for use in times of shortage. Water systems with multiple sources, surface water and groundwater, may have the opportunity to transfer demand from one source to another in order to optimize the individual sources. For example, a purveyor might opt to withdraw more from a surface water when a reservoir is spilling or a river source is running high, meanwhile reducing their groundwater withdraw. This practice would reserve the groundwater source for later use when the surface water is less abundant. The reverse scenario may also be considered, that a purveyor increase groundwater withdrawal when the groundwater levels are high and surface water quantity is below normal.

In order to evaluate the potential for demand transfer between surface and ground sources in New Jersey, all water systems included in the scope of this study were evaluated to identify systems which have both surface and groundwater sources and which have the potential for significant demand reduction through optimization. For the purpose of this analysis, "having significant opportunity for demand reduction" was defined as having a secondary source of supply that accounts for at least 20% of the total supply capacity. Of all of the systems included in this study, the 10 systems listed in Table 7-1 below were identified as having both surface and groundwater supplies. Of these 10 systems, 5 systems were removed from consideration for further evaluation because their secondary source contribution is too low. For example, NJAWC-Elizabethtown is not a candidate for demand transfer between sources because their groundwater capacity is less than 10% of their total capacity. The 5 remaining systems are considered to have demand transfer opportunities. These systems, which are in italics in Table 7-1, include: Atlantic City MUA, Middlesex Water, NJAWC-Short Hills, NJAWC-Western, and Sayreville. For each of these systems, the secondary supply source (either surface or groundwater) is at least 20% of their total supply capacity.

Table 7-1: Water Systems with both Surface and Groundwater Sources

PWSID	System Name	Groundwater Source	GW Cap. (mgd)*	Surface Water Source	SW Cap. (mgd)
0102001	*Atlantic City MUA*	*K-C, 800-ft Sand*	*19 (22.1)*	*Absecon Watershed*	*9.3*
1506001	Brick Twp MUA	PRM, K-C	2.5	Metedeconk River	16
1225001	*Middlesex Water Company*	*Brunswick, Sand & Gravel*	*25.1*	*D&R Canal*	*60*
1345001	NJAWC – Monmouth	PRM	15.4	Swimming River, Glendola & Manasquan Res	77
2004002	NJAWC-Elizabethtown	PRM, Brunswick & Stockton	11 (23.5)	Rariton & Millstone Rivers, D&N Canal	239
0712001	*NJAWC – Short Hills*	*Brunswick*	*20 (17.0)*	*Passaic R. & Canoe Br Res*	*20*
0327001	*NJAWC – Western*	*PRM, Englishtown & Mount Laurel*	*47.9*	*Delaware River*	*40*
1219001	*Sayerville*		*11*	*Duhernal System*	*7*
1424001	Southeast Morris County MUA	Brunswick and Buried Valley	13.4	Passic River Basin-Clyde Potts Res.	1.8
0238001	United Water New Jersey	Brunswick	2	Hackensack River System	203

Note: Italicized systems are being considered for demand transfer.
*The numbers in table are based on information obtained during the study and are the numbers used in the model. The numbers in parenthesis represent data since provided by NJDEP or systems. Discrepancies between the two need to be resolved.

These five systems with sufficient capacity from both sources were further investigated to evaluate the potential benefits that might be gained through demand transfer. A few general observations are worth noting.

- Most of these systems have river sources, and none are directly fed by the reservoirs modeled and analyzed in Section 7.1 above. This is significant because the tools developed to evaluate and optimize the reservoirs are not applicable to optimization of river sources. If this evaluation finds that there is a significant opportunity for demand transfer for a particular system, it is recommended that a detailed hydraulic analysis of the source water be conducted as part of a demand transfer optimization.
- One of the systems (NJAWC-Western) is located in a Critical Water Supply Area. This is significant as it limits the potential for transfer of demand to groundwater, and it is likely that NJAWC is already optimizing its surface water use. For example, NJAWC-Western built the Tri-County Water Treatment Plant to reduce groundwater dependence in Camden County and the surrounding area.
- Finally, under normal conditions, water system operating scenarios are determined based on several factors, including source water quality, quantity, and cost. Understanding all of these is critical in optimizing a water system's source ratio. Therefore, if this evaluation finds that there is a significant opportunity for demand transfer for a particular system, it is recommended that a detailed analysis of that system's operating conditions be included as part of a demand transfer optimization.

Taking these observations into consideration, demand transfer opportunities are discussed for each of the 5 systems individually.

ACMUA has some opportunity for demand transfer between their groundwater allocation of 19 mgd and surface water allocation of 9.3 mgd from the Absecon Creek. The firm capacity of the plant will be 25 mgd once planned upgrades are completed. Maximizing use of the surface water source is recommended when the ponds are full and flow in the creek is high. Additionally, ACMUA is in the permitting phase for an Aquifer Storage Recovery well (ASR). If their piloting is successful, this technology will provide additional opportunity for demand transfer, storing treated water during wet periods to supplement supplies during peak or dry periods. Dependent upon completion of full scale ASR operations at this site, ACMUA is planning for the installation of additional ASR wells with the goal of achieving 4 – 5 mgd of storage. ACMUA intends to use ASR to manage their water supply and meet future demands without requiring new allocations. ACMUA is already working to optimize their water supply; therefore, no major changes are recommended.

Middlesex Water Company has opportunity for demand transfer given a contract with NJSWA allowing them to withdraw 60 mgd from the D&R Canal and a groundwater allocation of 25.1 mgd, mostly from the Brunswick formation. Middlesex Water has already taken measures to reduce groundwater withdrawals in neighboring Critical Water Supply Area 1 through construction of a transmission main to serve communities south of the Raritan River. Middlesex Water has limited use of their Tingley Lane well field as a result of poor water quality (very high hardness). As a result, Middlesex tends to rely on their Park Lane wells and D&R Canal supply to meet their demands with a general strategy being to maintain fairly consistent withdraw from both sources. It is recommended that Middlesex Water make efforts to maximize their use of their surface water supply from the D&R Canal during high flow periods, reserving their groundwater supplies. It is also recommended that Middlesex Water evaluate the costs associated with treatment of their Tingley Lane wells for removal of hardness. Having those sources available for more frequent use would provide additional flexibility particularly during times of low surface water availability.

NJAWC-Short Hills has multiple opportunities for demand transfer. They can transfer internally between their groundwater source, which includes 20 mgd from the Brunswick aquifer, and their surface water supply, which includes 20 mgd from Canoe Brook reservoirs. The Short Hills system can also be fed from the NJAWC-Elizabethtown system via 2 interconnections. This provides additional opportunity for demand transfer. The NJAWC-Elizabethtown system is primarily surface water, so increased transfer to Short Hills could result in a transfer from groundwater to surface water or a transfer between multiple HUC11 watersheds. It is recommended that the Short Hills system maximize their use of the connection to Elizabethtown when the flow in the Raritan Basin is high. Consideration also might be given to supplying all of the Canoe Brook service area with water from the NJAWC-Elizabethtown system. If this were done, groundwater and the connection to Elizabethtown would be used to meet the demand, Canoe Brook allocation might be available for transfer to another system within the Passaic Basin. It is recommended that a feasibility study be conducted to evaluate the effects of increased demand on the Elizabethtown systems and the potential benefits of making the Canoe Brook allocation available to another purveyor within the region.

NJAWC-Western has opportunities for demand transfer between their groundwater source which includes an allocation of 48 mgd from various aquifers and 40 mgd from the Delaware River. As mentioned above, NJAWC-Western is located in Critical Water Supply Area 2, and the Tri-County Plant was constructed to reduce groundwater demand in the region. NJAWC-Western is currently expanding the plant to further utilize their surface water allocation. NJAWC-Western should maximize use of their surface water supply when the Delaware River is at or above normal flows in order to reduce groundwater withdrawals. Additionally, NJAWC-Western might consider conducting an ASR feasibility study to assess the benefits of using ASR as a demand management and demand transfer technique. NJAWC-Western's wells are located within aquifers that have been shown by other utilities to be conducive to ASR. The addition of ASR to this system would provide additional ability to take advantage of the surface water or groundwater supplies when levels are high and provide storage of that water within the system for use during dry periods.

Sayreville is a relatively small system that has both ground and surface water sources. There is potential for demand transfer under normal conditions when the demand is relatively low; however, given the system's size, the benefits of demand transfer may be minimal. It is recommended that Sayreville investigate opportunities for source optimization and demand transfer within their system. This investigation should include a cost/benefit analysis to determine cost effectiveness of the demand transfer.

As discussed above, there are some opportunities for transfer of demand from groundwater to surface water, and vice versa, in a few of the systems throughout the state. However, taking into account the groundwater restrictions that have been in place during the past 1 to 2 decades, along with individual systems' efforts to comply, and the understanding that multiple factors come into play in determining optimized source ratios, it is believed that most systems are already optimizing their supplies. The greatest opportunity for demand transfer probably lies in the NJAWC-Short Hills system and the continuous delivery of NJAWC-Elizabethtown water to meet the Canoe Brook service area demands. Therefore, additional studies are recommended to evaluate the feasibility, cost, and regional implications of this opportunity. Additional studies are recommended to evaluate the feasibility, costs, and benefits of source optimization and demand transfer within the Middlesex Water, NJAWC-Western, and Sayreville systems.

7.3 Interbasin Transfer Changes

Optimization of diversions for systems with sources supplied from more than one watershed (at HUC 11 scale) could serve as an alternative means of transferring demand from one watershed to another to better equalize supplies during normal demand conditions. An examination of the opportunities for transfers within systems revealed opportunities that were previously discussed in Section 7.2, *Demand Transfer between Sources*. During development of the WSMDST, several other opportunities were identified between drought regions, which generally correspond to river basins that could provide opportunities for routine transfers in normal conditions that would help minimize the occurrence of water shortage or drought conditions.

7.3.1 Central and Northeast Regions

Opportunities to strengthen connections between the Northeast and Central regions can occur through two major system connections.

- NJAWC-Elizabethtown – NJAWC-Short Hills: The distribution networks of the NJAWC's Elizabethtown and Short Hills systems currently are interconnected, and part of the Short Hills system demand is met with water from the Elizabethtown system. Modeling shows benefits of strengthening the connections between these 2 regions. The Short Hills system has an average demand of just under 40 mgd, about 30 of which is met with supplies in the Northeast Region. If this demand could be met with supplies from the Central Region, about 30 mgd of supply might be made available to meet demands in the Northeast Region on a regular basis. More detailed investigations are needed to determine the economic and political feasibility of this option.
- NJAWC-Elizabethtown – Newark-NJDWSC: These 3 systems are interconnected through the [REDACTED] . The operation of the [REDACTED] could be modified to allow transfer of supply from the Elizabethtown system to the Newark and NJDWSC systems to maintain reservoir levels under normal conditions. NJDWSC has conducted preliminary investigations of an operational procedure change to provide a continuous supply of 10 mgd from the Elizabethtown system to the NJDWSC system via the [REDACTED]. Their investigations indicate that if this had been in place between 1990 and 2003, the number of days the Wanaque Reservoir was below the drought warning curve would have been reduced from 221 days to only 29 days. To assure the operation of the [REDACTED] for this purpose, transmission improvements would be needed in the Elizabethtown and Newark systems, and a new pumping station would be needed at the Belleville Reservoir site. This option merits further investigation to verify its feasibility and to determine whether alternate operations may have provided a similar benefit.
- Jersey City – United Water NJ: These systems currently are interconnected, and Jersey City currently supplies water to United Water on a regular basis. It may be feasible to increase the normal flow from Jersey City to United Water to provide a better balance of water in the Northeast Region.

7.3.2 Central and Coastal North Regions

Middlesex Water Company currently supplies water from its CJO Plant to communities south of the Raritan River in Monmouth County. The transmission mains that convey this water extend through Old Bridge to Marlboro and the Gordon's Corner Water Company. The extension of existing piping bringing water from Middlesex Water Company through the Marlboro system to the NJAWC's Monmouth System could provide a transfer of supply into the Coastal North.

7.3.3 Central and Southwest Regions

Opportunities to strengthen connections between the Central and Southwest regions can occur through two major system connections.

- Trenton – NJAWC-Elizabethtown: The Trenton and Elizabethtown systems currently are interconnected, and plans are underway to strengthen the interconnection between these two systems. This will allow transfer of water between the Central Region and the northern portion of the Southwest Region.
- NJAWC-Elizabethtown - NJAWC Western Division: Transmission/distribution piping in each of these systems currently ends about 5 miles from each other. Connecting these two systems would permit the transfer of water between the Central Region and lower portion of the Southwest Region.

7.4 Evaluation of Non-Potable Uses

Water reuse or reclamation is a water supply management tool that has seen widespread use in the southwestern states, which have long recognized and struggled with limited water resources. It has not yet been fully accepted or widely implemented in areas of the country that historically have had seemingly abundant water supplies, including the mid-Atlantic and northeast. But in recent years, increases in population and development, along with several extreme drought periods have stressed water supplies in these once "water-rich" areas of the country. As a result, water purveyors, states, and other stakeholders are reevaluating their water supply management plans and seeking new tools to conserve and protect their precious water supplies. Water reuse is one such tool. Through water reuse, wastewater, which is a renewable resource, is highly treated and used to meet non-potable water demands such as irrigation, industrial applications, and public works activities, thus reducing and stabilizing potable water demands. Typical sources and users of non-potable supply are listed in Table 7-2.

The NJDEP has been actively developing and promoting water reuse for the past decade. A severe drought in New Jersey in 1999 stressed the state's water supply, heightened awareness of this limited resource, and highlighted the need for water supply management and contingency planning. In response, the NJDEP expanded its Reclaimed Wastewater for Beneficial Reuse (RWBR) program, establishing a regulatory framework and releasing a guidance manual for facilities interested in pursuing reuse. The Department became an advocate of RWBR, promoting it as a drought mitigation strategy and a long term water supply management tool. At the time, RWBR was practiced by only a few facilities in New Jersey. A record breaking drought in 2002 again brought attention to water supply issues in New Jersey. During the drought, NJDEP continued to promote reuse as a demand reduction strategy, approving over 70 temporary reuse authorizations under a drought emergency administrative order. This allowed utilities and municipalities to reuse water for activities such as street sweeping, sanitary sewer jetting, and roadside watering. Additionally, the Department released an updated "Technical Manual for Reclaimed Water for Beneficial Reuse" in January 2003. This document has since been updated and was re-released in January 2005.

Table 7-2: Typical Sources and Users of Non-potable Supplies

Sources	Users/uses
• Domestic wastewater plants	• Industries – cooling water, landscape irrigation, cleaning of paved surfaces
• Industrial waste treatment plants	• Municipal governments – street cleaning, sewer jetting, landscape irrigation (parks, schools, playing fields)
•	• Golf Courses - irrigation
•	• Agriculture – irrigation of non-edible crops, wash-down
•	• Business centers, Universities, Schools – landscape irrigation
•	• Residential developments – landscape irrigation.
•	• Ski resorts – snow making

7.4.1 Example State Programs

NJDEP continues to promote RWBR, looking to existing programs in Florida, California, Arizona, and elsewhere for guidance. These states use a combination of regulations and financial incentives to promote RWBR. The states of Florida and California both have formal reuse strategies, recommendations, and long-term goals for expansion of their reuse programs. In 2005 there were 438 reuse systems in Florida with a total capacity of 1,325 mgd and average production of 660 mgd (FLDEP, 2005). Florida's goal for 2020 envisions that all domestic wastewater treatment plants greater than 0.1 mgd will be practicing reuse with a statewide total of about 65% of all effluent being reclaimed and reused. California's long-term goal is to expand their existing reuse program from approximately 500,000 acre-feet per year (448 mgd) to 1.5 million acre-feet per year (1339 mgd) by the year 2030 (CA Task Force, 2003). These goals address both reduction in discharge necessary to protect receiving waters and the quantity of reuse needed to relieve potable water demands and help meet future demand.

Florida DEP helps to fund domestic wastewater projects, including reuse projects, through the State Revolving Loan Fund, the State Financially Disadvantaged Small Community Grant, and the State Bond Loan programs. Additionally, the combined regional water management districts offer cost-share funds matching state funds for up to 20% of the construction costs for reuse projects, more for other alternative supply projects. California provides ongoing grant funding, up to $75,000, for reuse feasibility studies, as well as grant and low interest loan opportunities for construction.

From a regulatory perspective, Florida has adopted a mandatory reuse policy which requires the development of reuse programs within *water resource caution areas*, unless reuse is proven to be economically, environmentally, or technically unfeasible. *Water resource caution areas* are areas that have current or anticipated critical water supply problems. Florida also has an Anti-degradation Policy which discourages new or expanded surface water discharges from domestic wastewater treatment plants and encourages development of reclamation and reuse capabilities.

7.4.2 Water Reuse in New Jersey

New Jersey continues to refine their regulatory framework and promote RWBR. In April 2006, NJDEP issued a General Permit for RWBR for restricted access. This permit will simplify the authorization process for restricted access reuse projects and will automatically grant re-authorization for facilities who had previously received temporary drought authorization. The NJDEP has proposed to require reuse feasibility studies associated with Water Quality Management Plans, and will propose to require reuse feasibility studies to satisfy NJPDES rules.

NJDEP also instituted several financial programs in the past four years. In addition to making low interest loans available for RWBR projects through the Environmental Infrastructure Financing Program, New Jersey adopted rules to allow tax credit or refunds for "treatment and conveyance equipment purchased exclusively for the purpose of reusing effluent from industrial processes." In 2004, NJDEP initiated a contract program to fund RWBR demonstration projects, requesting proposals from over 450 water suppliers, wastewater dischargers, and agricultural users and receiving 52 proposals. NJDEP selected 23 of the projects to receive a total of $35 million from the 1981 Water Supply Bond Fund. The projects will preserve more than 6 mgd of potable water. Of the 23 projects funded, 11 involve RWBR for irrigation, cooling operations, and other industrial applications. These demonstration projects are shown graphically in Figure 7-1 and are listed in Table 7-3.

Additionally, the Division of Water Supply is now incorporating RWBR into allocation decisions for highly consumptive, nonpotable uses. Similarly, consideration of RWBR is being required by NJDEP through permit violation negotiations and settlements. In one such case, the delinquent permittee will pay a reduced fine and develop a reuse system for golf course irrigation in retribution for 4 years of exceeding its allocation permit. This type of settlement is a win-win situation, meeting the state's requirements while allowing the county to put fine monies toward a project that will insure long term a supply of irrigation water, eliminate future violations, and conserve valuable potable water supply. Simplifying the regulatory process and providing financial incentives will make RWBR an attractive management tool for wastewater utilities and water users alike.

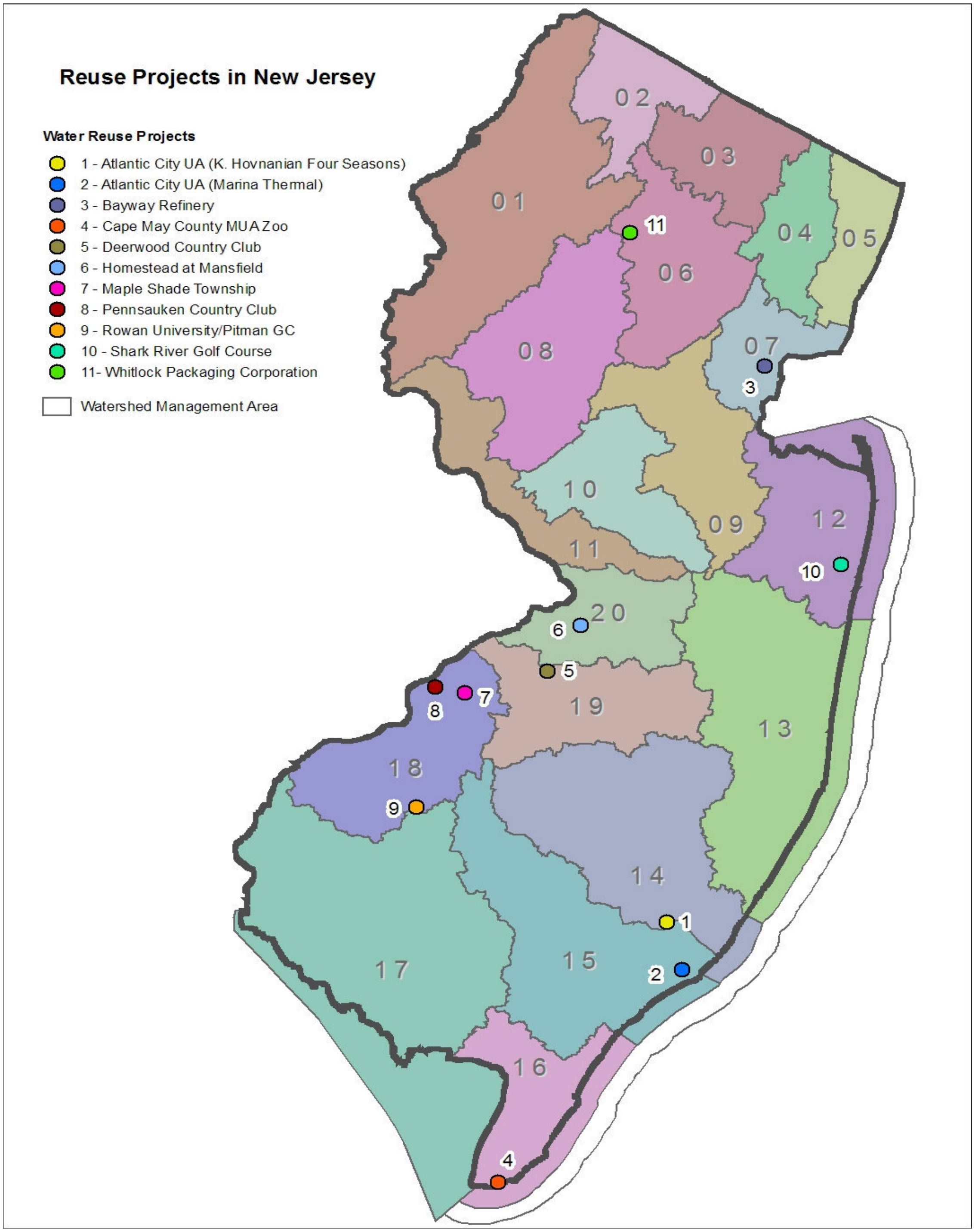

Figure 7-1: Reuse Demonstration Projects

Table 7-3: Reuse Demonstration Projects

Project	Type
ACUA (Marina Thermal)	Non-contact cooling water
Bayway Refinery	Non-contact cooling water
Whitlock Packaging Corporation	Pilot anaerobic/aerobic system
Homestead at Mansfield	Irrigation (residential)
ACUA (K. Hovnanian Four Seasons)	Irrigation (residential)
Maple Shade Township	Irrigation (recreational)
Shark River Golf Course	Irrigation (golf course)
Pennsauken Country Club	Irrigation (golf course)
Deerwood Country Club	Irrigation (golf course)
Rowan University/Pitman GC	Irrigation (athletic fields & golf course)
Logan Township MUA	RWBR and ASR
Cape May County MUA Zoo	Irrigation, wash down water & toilets

NJDEP's efforts to promote RWBR activities have been successful. The first public access RWBR application in the state was implemented in the spring of 2002 when Evesham Township began using reclaimed water for golf course irrigation. The project was an immediate success, effectively maintaining the course through the record drought that summer. In 2005 there were 34 facilities with RWBR authorization in their NJPDES permits as listed in Table 7-4. Of these, 10 facilities had operational RWBR activities utilizing a total of approximately 1.75 billion gallons of reclaimed water in 2005. Approved RWBR projects include both restricted and public access applications, ranging from spray irrigation and landscaping to street and sewer cleaning to industrial applications. In August of 2006, the first residential application of RWBR in the state was implemented at an active adult community. Reclaimed water from the on-site treatment plant is being used to maintain the extensive grounds of the community.

The success and experience of these initial RWBR projects and the demonstration projects that will likely come on-line in the next few years will provide reassurance and incentive for more widespread implementation. One of the greatest obstacles to RWBR is perception within the industry, and especially in the public eye. Public outreach and demonstration of successful endeavors will help to change this perception, creating more opportunities for reuse and making future implementation easier.

Table 7-4: New Jersey 2005 RWBR Summary*

Facility	**NJPDES #**	**Total 2005 Reuse (gal)**
Atlantic County Utilities Authority	24473	1,202,139,900
Bergen County Utilities Authority	20028	511,034,000
Bernardsville Borough	26387	0
Beta Realty	141801	
Bristol -Myers Squibb	795	2,139,688
Clinton MUA	20389	5,700
CMCMUA/Lower Regional	23809	
CMCMUA Wildwood/Lower	53007	
Cumberland County U.A.	24651	
Evesham Twp MUA - Elmwood	24031	13,692,240
Exxon-Mobil	35084	1,603,100
Hammonton, Town of	104990	
Harrison Township-Mullica Hill	20532	0
Hawke Point	136336	0
Hightstown Advanced WTP	29475	1,100
Homestead at Mansfield	98663	0
Joint Meeting of Essex & Union Co.	24741	0
Landis Sewerage Authority	25364	0
Linden-Roselle SA	24953	17,293,327
Logan Township	27545	0
Lower Township MUA	23809	0
Maple Shade	69167	0
Medford Township MUA	26832	960,000
Mt Laurel Twp MUA - Hartford	25178	
OCUA-Southern	26018	0
Palmyra Boro STP	24449	
Princeton Meadows	21401	0
Riverside STP	22519	65,263
Route 12 Business Park	145891	
Secaucus MUA - Koelle Blvd	25038	0
Stony Brook-Pennington	35319	0
Stony Brook-Hopewell	35301	0
Western Monmouth MUA	23728	
Woodbine Airport	142026	
Total flow from 34 projects:		1,748,934,318

* Table courtesy of NJDEP

7.4.3 Recommended Action Items

RWBR is a viable water supply management tool for New Jersey. It will not create new potable supply, but will conserve the existing potable supply and stabilize potable demand. Conserving potable supply today is critical for maintaining a sustainable water supply to meet residential and industrial demands now and in the future. Stabilization of demand will make forecasting easier and can be particularly valuable in drought mitigation.

As NJDEP continues to develop and promote its RWBR program, they should develop a strategic plan and long-term goals for the program. This plan should identify goal volumes of reuse to be achieved in the state as a whole and in various areas of the state. These goals should take into consideration RWBR as a supplement to potable water supplies and as a means to reduce pollutant loads to streams, as well as limitations on RWBR in areas where discharge is critical to maintaining in-stream flows. Similar quantifiable goals to those previously described for Florida and California, for New Jersey, would provide a benchmark for measuring the success of the program and a context within which to promote the program's activities. The plan might also identify specific sectors in which to pursue reuse including: agriculture (irrigation (crops, nurseries, etc..) wash down), recreation (irrigation of golf courses, parks, public, and private fields), education (irrigation of public and private campuses), industry (landscape irrigation). To better position themselves to meet their long term goals, it is recommended that NJDEP aggressively implement ongoing mechanisms to provide incentives and/or require reuse, particularly in sensitive Critical Water Supply Areas. The previously referenced permit violation negotiation is an example of one such requirement, as is the Hamilton Township MUA allocation permit, which prohibits the utility from servicing users who have more than 50% consumptive use.

New Jersey might consider establishing a program similar to those previously described for California and Florida to provide financial incentives for agencies to evaluate the benefits and possibilities of reuse. More specifically, it is recommended that additional funding should be provided to targeted municipalities or regional water purveyors in critical areas or areas with high reuse opportunities to develop Water Reuse Master Plans. These plans take a holistic approach to water supply and reuse within a defined region, identifying all of the sources and users of non-potable water, considering various strategies for meeting non-potable demands, developing cost estimates for implementation considering treatment and distribution costs, and making recommendations for implementation. Several cities in North Carolina have recently completed this type of plan. Perhaps legislative action is required to provide such a funding source.

Finally, NJDEP should work collaboratively with other state agencies to promote reuse. Collaboration with the Department of Agriculture may help New Jersey to expand reuse in the agricultural community for crop irrigation and other uses. Agricultural irrigation represents the greatest area of reuse in California, and there has been significant collaboration between the respective state agencies. New Jersey also has significant opportunity for reuse in the agricultural industry. While New Jersey regulations for water usage certification require the use of reclaimed water for non-edible crops where feasible (NJAC 7:20A), collaboration between the two departments in areas such as identifying funding sources, identifying potential regions or users and suppliers of reclaimed water, and negotiating contracts might increase reuse feasibility and opportunities. Droughts often occur during periods of high agricultural irrigation demand and lead to increased irrigation demand, thus irrigation can exasperate a drought situation. Providing an alternative source of water for agricultural irrigation will greatly reduce the potable demand during drought situations and will potentially provide a more reliable source, reducing the need for restrictions on irrigation and ultimately increasing agricultural productivity.

Collaboration with the Board of Public Utilities would allow for the development of rate structures that allow utilities to recover their investment in reuse. In Florida, the DEP has worked with their Public Service Commission to develop statutes that require 100% of reclamation plant costs be recovered. The statutes also provide for reuse costs to be recovered from a utility's potable water, wastewater, or reclaimed water customers. Sharing reuse costs between the potable water, wastewater, and reclaimed water customers is justified on the basis that all customers, including potable water customers, benefit from the preservation of the water supply. This type of intra-agency collaboration will demonstrate acceptance of RWBR throughout the state agencies, and enhance utility and public acceptance of RWBR.

7.5 Aquifer Storage and Recovery (ASR) as a Water Supply Management Tool for New Jersey

ASR is the practice of utilizing a suitable aquifer for temporary storage of water. The water to be stored, which can be treated drinking water, reclaimed water, or untreated or partially treated surface or groundwater, is injected into the aquifer via an injection well. The stored water is later withdrawn or recovered via the same well. The aquifer can be freshwater, saltwater or brackish, confined or unconfined. ASR is a fairly new water supply management practice that is becoming more popular as the demand for already limited potable water sources increases. ASR does not provide a new water source; rather it provides storage and allows utilities to better manage their existing sources. An ASR well is typically used for storage of water when the demand is low relative to the supply and recovery when demands are high. ASR provides the benefit of storage without the capital investment or the technical, political, and environmental challenges that are often associated with conventional above or below ground storage tanks. ASR also has the potential to retard or reverse salt water intrusion into potable water supplies, as the stored water acts as a barrier to the brackish or salt water.

7.5.1 Background of ASR Technology

The practice of storing water in an aquifer was first documented in the United States in Wildwood, NJ in 1968 (Lacombe, 1996). Being a resort town, Wildwood experienced a major increase in demand during the summer months, with a comparatively low demand throughout the rest of the year. Conventional wells on the barrier island communities, which had experienced salt water intrusion, were converted to ASR wells and used to store water withdrawn from inland wells during the off-peak season. The water was then recovered during the peak summer months. This practice reduced demand from the inland wells during the peak season and lessened stress on the transmission line from the inland well fields to the barrier islands. The first two wells drilled were successful but ultimately taken out of operation as a result of operational problems. Four additional wells are still in use. The Wildwood Public Utility has used ASR to manage seasonal variation in demand for nearly 40 years.

More widespread use of ASR for water supply management did not begin until the 1980s, with the number of ASR systems increasing from 3 to 69 between 1983 and 2004, with many more systems under development (ASR Systems, 2006). Florida, New Jersey, California, Texas, Oregon, and Washington states all have multiple ASR systems in operation and more under development. In general, these systems store fully treated drinking water for the purposes of meeting seasonal or emergency demands, or providing longer term storage. The Comprehensive Everglade Restoration Program currently being implemented in Florida includes over 330 ASR wells, which would make it the largest ASR program in the world (SJWMD, 2004).

The increase in the number of ASR systems over the past two decades is likely related to increasing demands for high quality, cost efficient water supplies, coupled with increasing operational experience and technical expertise. Challenges that have been encountered at various ASR systems include insuring adequate recovery efficiencies and addressing water quality concerns in the recovered water and the native groundwater.

For ASR to be an effective water supply management tool, it is imperative that the utility be able to recover most, if not all, of the stored water. The recovery efficiency is a measure of the volume of water recovered, as compared to the volume stored. Typically, recovery volumes are low during the initial operating cycles of an ASR well; however, as the storage zone becomes established, the recovery efficiency increases and eventually stabilizes (Pyne, 1996). The ultimate recovery efficiency will vary depending upon operational protocols and the hydrogeology of the well. Efficiencies can be limited by clogging of the well and by excessive mixing of the stored and native waters, both of which can be reduced through proper operation of the well. Clogging can be controlled through periodic back-flushing of the pump during recharge, and if necessary, chemical treatment of the recharge water to prevent precipitation. Mixing of the injected and native waters can be controlled through optimization of the injection rate, which can be accomplished through modeling efforts and piloting. ASR wells that have been in operation for over 5 years in Florida have been reported to have 100% recovery efficiency (SJRWMD, 2004); however, this is not always the case. Acceptable recovery efficiencies will vary from region to region depending on economic, political, and public perception factors.

7.5.2 Water Quality Issues

From a water quality perspective, there are concerns as to how the recharge water will affect the quality of the native environment, as well as how interactions with the groundwater environment will affect the stored water. Specific issues include introduction of Disinfection By-products (DBPs), pathogenic micro-organisms, and other contaminants into the native groundwater, and the dissolution of otherwise sequestered trace metals (including arsenic) into the stored water. Much research has been and continues to be conducted to investigate these concerns. It has been shown that DBPs attenuate as the result of mixing, dilution, and natural microbial activity. Microbial degradation of DBPs occurs under both aerobic and anaerobic conditions. Haloacetic Acids (HAAs) are degraded first, under aerobic conditions, while Trihalomethane (THM) degradation occurs once anaerobic conditions are established (Dillion and Toze, 2005). In addition to allowing for the reduction of DBPs, the studies also showed the reduction in DBP formation potential resulting from the degradation of precursor materials during ASR. The microbial degradation of DBPs and DBP precursor material is a function of oxidation state and storage time, thus rates of attenuation will vary from individual ASR applications. This natural attenuation usually improves the quality of the stored water, while at the same time insuring that DBPs do not contaminate the aquifer.

The introduction of pathogenic microorganisms into the aquifer is not such a concern when treated drinking water is being stored given the disinfection process; however, it can be of concern when untreated or minimally treated water is being stored. Studies in Australia and Florida have shown that natural aquifer conditions, including the presence of natural biota and aquifer temperature and salinity, create an unfavorable environment resulting in the attenuation of introduced microorganisms (SJRWMD, 2004, Dillion and Toze, 2005). This natural attenuation is so effective that it is used as a means of disinfection in some European countries where chemical disinfection is not practiced. It is also noted, that when brackish aquifers are used for ASR, microbial contamination of the groundwater supply is not a concern.

Arsenic and other metals can be released into the water column as a result of the oxidization of pyrite and other iron oxides naturally occurring in the aquifer. This oxidization occurs when the pyrite is exposed to dissolved oxygen present in the stored water. The discovery of arsenic in recovered waters in Florida in the late 1990s led to renewed concern about the viability of ASR as a water supply management tool. Advocates of ASR initiated extensive research efforts to better understand the interactions promoting the dissolution of arsenic. Initial studies showed that the oxidation and release of arsenic typically occurs only during the initial cycles of ASR when the storage zone is being established and the storage environment is coming to a new equilibrium. Once that equilibrium is reached, the dissolution of arsenic decreases, as do measured levels of arsenic in the recovered water (SJRWMD, 2004); however, this is not always the case. In some cases, the arsenic continues to be present in the recovered water cycle after cycle, necessitating pre or post-treatment of the injected water. There is also concern that the dissolved arsenic will persist in the aquifer as the stored water mixes with the native groundwater. Research in Florida and the Netherlands has shown that this is not the case; rather, any dissolved arsenic that mixes with the native water will re-precipitate as a result of changing oxidation conditions within the aquifer. The oxidation potential of the recharge water is one of the main factors affecting arsenic dissolution, thus pretreatment of the recharge water is an option if arsenic in the recovered water exceeds regulatory levels. Additionally, ASR facilities storing groundwater, which has a low dissolved oxygen concentration, are less likely to have arsenic issues than those using surface water (SJRWMD, 2004). Dissolution of other metals, mostly iron and manganese, can also present water quality challenges. These metals are naturally occurring in many mineral formations and may be released into the stored water as a result of oxidation reactions. If iron and manganese are present, the recharge water can be treated to prevent dissolution, usually by increasing the pH, or the recovered water can be treated to remove the metals.

7.5.3 ASR in New Jersey

ASR is already used as a water supply management tool in southern New Jersey. This technology is practical for southern New Jersey, as the hydrogeologic characteristics appear to be favorable for ASR, and ASR addresses some of the water supply concerns facing New Jersey utilities in that part of the state. ASR can act as a barrier against salt water intrusion and utilize abandoned brackish wells. It allows for withdrawal and storage of water during wet periods and recovery during dry periods, thus providing a drought management alternative, and it offers an economical solution to meeting the varied seasonal demands that are particularly dramatic in the state's resort towns.

ASR does have some limitations, both from an operational and a water quality perspective. Operationally, maintaining sufficient recovery efficiency is of greatest importance. Recovery efficiency will be affected by the mode of operation of the well and the inherent characteristics of the aquifer. As previously mentioned, water quality concerns include both contamination of the aquifer and degradation of the stored water. Both of these concerns are related to the interaction between the injection water and the aquifer environment and can be limited by controlling the quality of the injected water. Additionally, degradation of the stored water can be resolved through treatment of the recovered water prior to distribution. Specific water quality concerns in New Jersey include leeching of metals, Fe, Mn, and As, from the aquifer environment, elevated chloride concentrations, and high turbidities. Understanding the water quality characteristics of the stored and native waters, as well as the geology of the aquifer, can help predict potential water quality problems. Geochemical modeling, which simulates the mixing and resulting chemical reactions between the stored and native waters, is another tool for predicting potential water quality problems. Piloting and monitoring of a test well is the final step to insure that interactions within the well do not result in degradation of the stored and native waters.

Most of the ASR wells in NJ are located in the southern half of the state, in the Coastal Plain geologic province. This area, which is characterized by highly permeable, unconsolidated beds of sand, gravel, silt, and clay, and the formation of aquifers that are segregated vertically by silt and clay confining beds, is more conducive to ASR than the northern half of the state, where most of the aquifers are formed in bedrock. The major aquifers in the southern half of the state are the Kirkwood-Cohansey system, the Atlantic City 800-foot sand, the Wenonah-Mount Laurel aquifer, the Englishtown aquifer, and the Potomac-Raritan-Magothy (PRM) system, all of which are confined aquifers, except the Kirkwood-Cohansey system. The majority of the existing ASR wells are located in the PRM and store treated surface or groundwater.

There is one area in the northern part of the state where the geology suggests that there may be opportunities for ASR. The buried valley region, which is located in the northeastern part of the state, has a rather unique geology characterized by a series of historic river valleys that were filled with sediment during the last glacial retreat. These valleys now provide some of the most productive aquifers in the region, particularly those that are filled with well sorted sands and gravels. There is speculation that these highly productive aquifers may be suitable for ASR; however, there have not been any detailed feasibility studies to evaluate this potential. To date, it seems the cost of pursuing ASR has outweighed the benefits; however, as water supplies continue to become more stressed, the balance may become more favorable toward ASR. This area may be an untapped resource for ASR in the northeast region, or it may not. The transmissivity of the aquifers and the extensive pumping already occurring on a daily basis may promote mixing and transport of injected water, thus reducing the ability to recover an adequate percent of the stored volume. A detailed study of the aquifer's hydrogeology and geochemistry is needed to evaluate these and other potential derailers.

Currently, there are 14 utilities in southern NJ using ASR as a water supply management tool. These utilities are shown geographically on Figure 7-2 and listed in Table 7-5. Most of the utilities use ASR to effectively manage seasonal variation in demand. Some of the utilities reported using ASR to address temporally variable source water quality, storing when the source water quality is high and recovering when it is poor, or storing groundwater to be used when surface water quality is poor. Finally, some utilities use ASR as a cost management tool. They purchase and store water when the cost is low, then use the stored water to reduce their demand when the cost of their primary supply is high.

One utility is currently piloting ASR for multi-year storage or "water banking." Under this permit the utility is able to store water for up to 3 years before recovery, but the permit can be revoked if more water is recovered over the 3-year period than was injected. All other permits require recovery within a year of storage. The longer-term storage option provides additional flexibility that could be used for drought preparedness and mitigation. Excess water could be stored during particularly wet years and recovered during dry years.

In addition to the ASR applications listed in Table 7-5, the NJDEP has provided partial funding for three more ASR projects as part of their alternative water supply demonstration projects. These projects are located in the Boroughs of Clayton and Glassboro and in Logan Township. Clayton evaluated feasibility of ASR, but found conditions unfavorable. Glassboro is planning to use ASR to enhance water quality, reducing sodium though dilution with system water when chloride levels are high. Logan Township is evaluating the use of ASR for storage of highly treated reclaimed water. The township proposes to upgrade their existing treatment facilities to meet underground injection and reclaimed water for beneficial reuse standard, and use an ASR well for storage of the reclaimed water prior to non-potable reuse. The project is still in the planning phases. The treatment processes have been identified and piloted, but the ASR portion of the project has not yet been fully developed or tested. In addition to hydrogeologic, engineering, and permitting challenges, Logan Township must also deal with the issues of public perception and acceptance of RWBR. If this project is successful, it would be the first application of ASR for storage of reclaimed water in New Jersey, and would potentially open many opportunities for both ASR and RWBR.

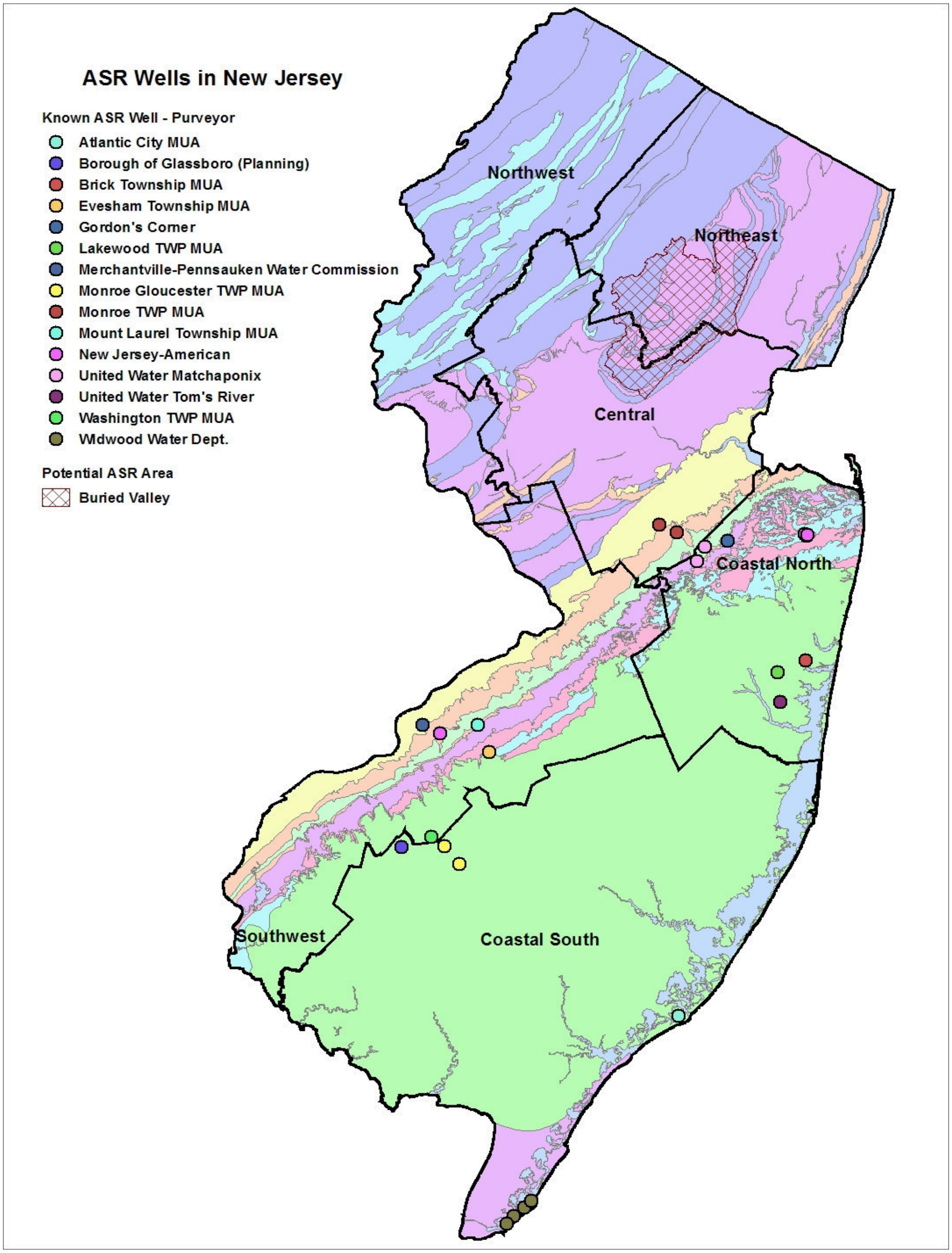

Figure 7-2: ASR Systems in New Jersey

Table 7-5: ASR Wells in New Jersey

Utility	# of ASR Wells	Aquifer Used	Type of Water Stored
Mount Laurel Township MUA	1	Lower PRM	Treated groundwater
Monroe TWP MUA	2	Farrington & Old Bridge	Treated surface & groundwater
Wildwood Water Dept.	4	Kirkwood Cohansey 800-foot Sand	Treated groundwater
Merchantville-Pennsauken Water Commission	1	Lower PRM	Treated groundwater
Monroe Gloucester TWP MUA	2	Upper PRM	Treated Cohansey
Washington TWP MUA	1	Upper PRM	Treated groundwater
New Jersey-American	2	PRM	Treated surface & groundwater
United Water Tom's River	2	Middle PRM	Treated groundwater
Lakewood TWP MUA	1	Englishtown	Treated Cohansey
United Water Matachaponix	2	Middle PRM	Treated surface water
Evesham Township MUA	1	PRM	Treated Mount Laurel
Brick Township MUA	1	Middle PRM	Treated surface & groundwater
Gordons Corner	1	PRM	Treated groundwater
Atlantic City MUA*	1	800-foot Sand	Treated surface & groundwater

*Note: ACMUA is still in testing and application phase, and is not fully permitted.

Discussions with representatives of the utilities that employ ASR revealed that ASR has generally met their operational objectives and that it is a valuable part of their water supply management scheme. Some did report water quality struggles, both during testing or start-up, and long-term. Even those who encountered ongoing water quality problems found that pre-injection or post-recovery treatment was successful and worth the added costs. Water quality challenges encountered include elevated iron, high turbidity, and musty odor in the recovered water, all of which were successfully addressed through treatment or operational adjustments. The general consensus of those contacted was that ASR is a reliable tool, worth the operational and water quality challenges it presents; however, it was mentioned that the permitting requirements have become so extensive as to be prohibitive. One utility representative even mentioned that they would like to convert more conventional wells to ASR but are reluctant to do so primarily because of the monitoring and permitting requirements and costs.

7.5.4 ASR Recommendations

ASR appears to have great potential as a water supply management tool in New Jersey. It is recommended that NJDEP continue to promote ASR through programs that encourage utilities to investigate and demonstrate the feasibility of the technology. The existing permitting requirements are extensive, difficult to navigate, and can take years to complete. Multiple utilities reported that the permitting process took 3 or more years for final approval. Under the current regulatory program, a utility is required to get permits from three NJDEP Bureaus (Non-point Pollution Prevention, Water Systems, and Well Permitting and Water Allocation). In addition, the well is treated as an underground injection facility, even if treated drinking water is being injected. NJDEP personnel have worked closely with utilities interested in pursuing ASR, but still the process is intimidating and daunting. Beyond the permitting process, monitoring requirements for active ASR wells are extensive and costly, another potential barrier for a utility considering ASR. It is recommended that NJDEP streamline these processes as much as possible. Perhaps a single person could be assigned to assist utilities to meet permitting requirements for all three Bureaus. This person would have a full understanding of the requirements of each Bureau and could act as a caseworker of sorts for utilities pursuing ASR.

Most of the ASR applications in New Jersey are operated on a seasonal storage and recovery basis. It is recommended that NJDEP continue to investigate the use of ASR for multi-year banking, using the current and future banking pilot studies to evaluate the benefits, as well as any potentially negative effects of multi-year water storage. It is noted that using ASR for longer-term storage will provide more opportunity for migration of the injected water within the aquifer. This would need to be thoroughly investigated, and would require more extensive modeling and testing to ensure the aquifer is not compromised. Allowing and encouraging banking would expand the use of ASR from a seasonal or emergency storage strategy to a drought preparation and mitigation strategy. Under annual withdrawal schedule, a utility may only withdraw an amount equal to what it stored in any given year. Under a banking scenario, the utility would store as much water as possible during a wet year, and have the ability to recover the water that same year or during future dry years as needed. Operating in this mode, ASR can be used as a demand transfer strategy during drought conditions, transferring demand from a stressed surface or groundwater supply to the stored water. Multi-year banking can be particularly useful if paired with a program to allow or even promote the capture of access water during wet periods. In this scenario, a utility could capture access water during periods of high flow and store that water for use during future dry years. It may even be possible to capture access flow in regions not conducive to ASR and transport that water via raw water pipelines or interconnections to a region with more favorable conditions. This type of strategy would require significant investment in infrastructure and may not be cost effective. But, as water resources in New Jersey become more and more scarce, NJDEP might consider conducting a detailed analysis to evaluate the feasibility of such transfers.

For ASR to truly realize its potential as a supply management tool in New Jersey, it may be necessary for NJDEP to reconsider how they allocate water. Monthly allocation permits limit the amount of water that utilities can withdraw regardless of conditions (wet versus dry) or if the water is used or stored for later use. Perhaps it would make sense to revaluate these permits considering available supply at the time of withdrawal and the intended use. Is it possible to increase allocations when rivers are running high and reservoirs are overflowing, so that this water may be captured and stored in ASR wells for later use? Whether it is a change in the permit amount during typical "wet" months, a relaxing of the permit limits when average flow exceeds some minimum value, or a change in how water withdrawn for ASR is accounted for, having the ability to withdraw more during times of excess would make ASR an even more effective water supply management tool, allowing for more demand transfer during peak or dry periods. This would be particularly applicable for utilities that are the last users of surface water and have existing ASR wells, such as ACMUA, Brick Township MUA, and United Water Matachaponix. This would also make ASR more attractive to other utilities that have surface water sources and recognize a need for supplies and storage opportunities.

Finally, the Logan Township RWBR and ASR project is a truly innovative project that could potentially expand the application of both ASR and RWBR. Coupling ASR storage with RWBR will allow for storage of the reclaimed water during low use periods and recovery during higher demand periods. This would be particularly effective in managing seasonal irrigation demands for RWBR for recreational, landscape, or agricultural applications.

7.6 Unaccounted-for-Water (Non-revenue Water)

Unaccounted-for Water (UFW) is a term that has been widely used by utilities and regulatory agencies to loosely describe non-revenue water, water loss, or water that is not billed. Reduction of water losses or "UFW" is a supply side conservation measure, as well as a water accounting exercise. Within the scope of this study, conserving water through evaluation and minimization of water losses will reduce system demands during normal conditions and drought emergencies, thus reducing overall stress on water supplies.

Water loss occurs in two ways:

1. Actual water lost from the distribution system through leaks, tank overflows, flushing of water lines, and fire suppression. These are called real losses.
2. Water that reaches a customer that is not properly measured or tabulated. These are referred to as apparent losses.

Real losses require water suppliers to supply, treat, and transport greater volumes of water than their customer demand requires. Leakage is the most common form of real losses for water suppliers. Apparent losses do not result in the physical losses as that of real losses, but exert a significant financial effect on water supplies. These losses represent service rendered without payment. Apparent loses of water occur as errors in water flow measurement, errors in water accounting, and/or unauthorized usage.

7.6.1 Reducing Water Losses

Addressing water losses within a system is a multi-step process. The first step involves quantifying losses by conducting a system audit. This will provide an understanding of the extent of the problem, a characterization of the types of losses occurring (real or apparent), and a baseline for goal setting and benchmarking. Once the audit is complete the utility should develop a water loss control plan to identify reduction goals and measures that can be taken to achieve those goals. These measures should address both real and apparent losses.

In the past, the American Water Works Association (AWWA) had broadly recommended a goal of 10% for UFW (AWWA, 1996). As a result, many utilities and regulatory agencies established similar goals. A national survey of state and regional regulatory agencies found that most have loosely defined UFW goals of 10% – 20% (Beecher, 2002). However, quantifying water losses as a ratio of UFW to total input volume is no longer considered a reasonable approach for reporting water losses, and AWWA is now recommending against that method for several reasons. First of all, expressing losses as a percentage of total input volume may be quite misleading, as water systems with lower demands will never be able to compete with those with larger demands. Additionally, no standardized definition for UFW currently exists. Some utilities consider UFW as all water that is not metered and sold while others may consider it as only that water which is lost through leaks (AWWA, 2003). Measuring water loss as a percentage of total input volume also does not take into account system specific parameters such as number of service connections, length of mains, operating pressure, etc. For these reasons, UFW is no longer considered as a reliable means of evaluating water loss.

In 1997 the International Water Association (IWA) Task Force on Water Losses, a committee made up of members from five countries with nominated representation from AWWA, began a study to develop a standardized method for conducting water audits. The resulting IWA/AWWA Water Audit Method is now being recommended by the AWWA as the best practice method and will be incorporated into the next version of the AWWA M36 publication, *Water Audits and Leak Detection*, which is expected to be released in late 2007/early 2008.

The IWA/AWWA Water Audit Method is a detailed, system-specific approach to determine water loss. It assumes that all water entering the distribution system can be accounted for, via metering or estimation, as either a use or a loss (AWWA, 2003). Therefore, the term "Unaccounted for Water" has been dropped and replaced with a more definitive term, "non-revenue water." The water balance used for this method is shown in Figure 7-3.

As shown in Figure 7-3, non-revenue water consists of all water that is not billed. All non-revenue water, however, is not considered water loss. Water loss is only that water which is not billed and not authorized by the water utility. Again, water losses are broken into two categories, apparent losses and real losses. The IWA/AWWA recommends quantifying water losses in terms of gallons/service connection/day for larger pressurized systems and in gallons/mile of mains/day for smaller pressurized systems. These normalized values provide system specific references for water loss reporting.

<table>
<tr><td rowspan="10">System Input Volume (corrected for known errors)</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metering</td></tr>
<tr><td colspan="5">Note: All data in volume for the period of reference, typically one year.
Figure taken from AWWA's website, Water Wiser: Water Loss Control
http://www.awwa.org/waterwiser/waterloss/, last accessed 02/07/07.</td></tr>
</table>

Figure 7-3: IWA/AWWA Water Balance

The IWA/AWWA water audit method recognizes several types of performance indicators for water loss comparisons as shown in Table 7-6. The indicators for real losses are of particular interest. The Unavoidable Annual Real Losses (UARL) is a theoretical reference value which represents the lowest practical value for leakage for a specific system, under which it would be uneconomical to detect and repair. The UARL is a function of an individual system's size (length of mains and number of connections) and operating pressure.

The Infrastructure Leakage Index (ILI) is a ratio of the normalized real losses for a given year to the URAL. The Economic Level of Leakage (ELL) is defined as the appropriate level of leakage for a utility to target. The ELL is utility specific and represents the level a leakage below which the cost of leakage reduction measures would exceed the cost of water losses. According to the AWWA Water Loss Control Committee Report, *Applying Worldwide BMPs in Water Loss Control*, while an ILI of 1.0 would be ideal, systems with ILI values between 2.0 and 8.0 represent reasonable control over their system leakage (AWWA, 2003).

The target ILI for an individual utility will vary depending upon several factors, including availability and cost of the water supply and the cost of treatment. Systems with highly limited supplies or supplies requiring extensive treatment would likely have a lower ILI goal approaching 1, while those with sufficient high quality water supplies to meet current and future demands may have a higher ILI goal.

Table 7-6: Performance Indicators for Non-revenue Water and Water Losses

Performance Indicator	Function	Comments
Volume of Non-revenue water as a percentage of system input volume	Financial - Non-revenue water by volume	Can be calculated from a simple water balance; good only as a general financial indicator
Volume of Non-revenue water as a percentage of the annual cost of running the water system	Financial - Non-revenue water by cost	Allows different unit costs for Non-revenue water components
Volume of Apparent Losses per service connection per day	Operational - Apparent Losses	Basic but meaningful indicator once the volume of apparent losses has been calculated or estimated
Real Losses as a percentage of system input volume	Inefficiency of use of water resources	Unsuitable for assessing efficiency of management of distribution systems
Normalized Real Losses - Gallons/service connection/day when the system is pressurized	Operational: Real Losses	Good operational performance indicator for target-setting for real loss reduction
Unavoidable Annual Real Losses (UARL)	UARL (gallons/day) = (5.41Lm + 0.15Nc + 7.5Lp) x P Where: Lm = length of water mains, miles Nc = number of service connections Lp = total length of private pipe, miles = Nc x average distance from curbstop to customer meter P = average pressure in the system, psi	A theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. A key variable in the calculation of the Infrastructure Leakage Index (ILI) It is not necessary that systems set this level as a target unless water is unusually expensive, scarce or both
Infrastructure Leakage Index (ILI)	Operational: Real Losses	Ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL); good for operational benchmarking for real loss control.

Note: Table taken from AWWA's website, *Water Wiser: Water Loss Control* http://www.awwa.org/waterwiser/waterloss/. Last accessed 02/07/07.

7.6.2 Leakage Control Plan

Using the information gained through the audit, the utility can develop or refine their leakage control plan. Leaks can be broadly categorized into large highly visible main breaks, which tend to draw almost immediate utility response, and small hidden leaks which often go undetected. Although the large leaks appear to result in high losses, it is the smaller leaks that go undetected for long periods of time that contribute the greatest water loss (AWWA, 2003). Therefore, key components to a leakage control plan include prevention, detection, and response. Most utilities have effective response plans for large and small leaks once they are detected. It is prevention and detection of smaller leaks that can often be improved. Recent advances in metering, monitoring equipment, and modeling has made prevention and detection of small hidden leaks easier. Monitoring flow in the distribution system at regular intervals to establish a baseline of water use is one method of identifying potential leaks. This can be accomplished by defining small zones within the distribution system, known as District Metered Areas (DMAs), and tracking water use in those zones. Sudden or sometimes subtle changes in water use patterns might be indicative of a leak and warrant further investigation. Other methods for identifying leaks include night-flow monitoring, metering of pressure zones, regular inspection of water main fittings and joints, and use of leak detecting instruments. Leak detection instruments can be sounding devices that attach to valve boxes or pipes and use noise measurement to detect leaks or automatic readers that detect steady flows and relay an alarm. Leak prevention can be accomplished through frequent assessment of the distribution infrastructure, proactive main replacement programs, and management of system pressure. Utilities operate to maintain adequate pressure throughout the system. Careful monitoring of system pressure and maintenance of different pressure zones might allow utilities to operate just above their minimum standard of service. Reducing pressure in the system will help to reduce both the number of breaks and the volume lost through existing breaks. Finally, utilities must have in place a protocol to allow for rapid response to detected leaks.

7.6.3 Recommendations for Controlling Water Losses

Utilities and regulatory agencies in the US are becoming more proactive in controlling their water losses. The Texas Water Development Board requires that utilities conduct water audits annually and aids utilities by providing a manual and offering on-site training and 4-hour training sessions on the IWA/AWWA Audit method. Major cities in the southwest are using leak detection devices throughout their distribution systems to aid in identifying small leaks. The Texas Water Development Board loans leak detection devices to utilities free of charge.

NJDEP is interested in establishing standard recommendations, even regulations for evaluating water losses and in determining the demand reduction that could be realized if systems are optimized. However, without having a common basis for determining and reporting water losses, it is not possible to effectively implement either of these. Therefore, it is recommended that NJDEP require all utilities to conduct annual water audits using the IWA/AWWA Water Audit Method and to implement leakage control plans. Using this method, water utilities could evaluate the effectiveness of their current leakage control based on system-specific parameters and then target future leak control efforts toward specific areas in need of improvement. If NJDEP does adopt such a requirement, it is recommended that they offer training and support on the IWA/AWWA method and the development and implementation of leakage control plans.

NJDEP might also consider establishing a goal or standard ILI, above which utilities would have to demonstrate that they are actively working to improve their leakage control. The goal ILI would be above the acceptable range of 2 – 8, perhaps 15 or 20. It is important to remember that the target ILI may differ among utilities, depending on individual system characteristics. As such, NJDEP should be sure not to establish a goal ILI that is too restrictive and should focus on progress made toward achieving the goal. NJDEP could require that all utilities exceeding the goal ILI submit their leakage control plan and document their progress as part of their annual compliance reports. Utilities that do not show progress could then be fined or otherwise penalized.

The ILI is not the only suitable indicator; NJDEP could opt to define statewide goals based on other indicators. The key is to identify an indicator or set of indicators that accurately reflect system variables. For instance, some utilities believe that losses expressed as gal/connection/day is a good operational and financial indicator. Whatever indicator NJDEP opts for, it is imperative that it is clearly defined so that all utilities are accurately reporting and evaluating their system losses using a consistent method.

Once a uniform system for auditing and reporting water losses is implemented statewide, it is recommended that NJDEP commission a detailed study and cost benefit analysis. This study would evaluate the potential for demand reduction that could be realized through enhanced water loss control and determine if the benefits of the reductions balance the cost of implementing control programs. The NJDEP could also use the results of this study to establish or modify their goal ILI based on achieving some desired level of demand reduction.

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8.0 EVALUATION OF RECOMMENDATIONS

A number of evaluations were completed in the preceding chapters. Many of these analyses resulted in recommendations. In this Chapter the recommendations that are considered most important are identified, summarized, and compared. At the end of the Chapter the recommendations will be prioritized.

8.1 Recommendations of Other Chapters

8.1.1. Chapter 4 – Task 4 Catastrophic Infrastructure Failure

Under the loss of primary source evaluation, 58.9% of the systems were determined to be self-sufficient. This includes 74 systems serving populations of fewer than 50,000 people, and 9 systems serving more than 50,000 people. Sixteen systems or 11.3 percent of the systems were found to be Class A. The Class B systems totaled 25, with 18 serving populations less than 50,000. Seventeen systems were determined to be vulnerable, or unable to provide at least 50% of their average daily demand under emergency conditions. This includes 13 systems serving a population of less than 50,000 people, and four systems serving a population larger than 50,000. The full results are displayed in Table 4-4.

Table 8-1
Summary
Catastrophic Infrastructure Failure Analysis

Scenario	Self-Sufficient	Class A	Class B	Vulnerable
Primary Loss	58.9%	11.3%	17.7%	12.1%
Regional Loss	61.0%	5.67%	16.31%	17.02%

It should be noted that the results of the analysis are subject to the constraints of the study. Only pipes of 12 inches diameter and larger were included in the study. A system may have been classified as vulnerable because of the appearance of no emergency interconnections. If the system has multiple 8-inch interconnections, the system may have very adequate emergency supplies. The results are also subject to the availability of information. If descriptions of multiple interconnections were unavailable, the system was assumed to have only one point of interconnection with a particular system.

Several systems were categorized as Class B due to the appearance of only 1 back-up supply source. In accordance with the definition of a Class A system "no individual interconnection shall provide more than 50% of the total interconnection supply." This implies that a system which can produce enough flow to meet its average daily demand, but lacks capacity under emergency conditions (its catastrophic supply) and maintains only one interconnection with an adjacent system for emergencies, would be a Class B system. Regardless of the amount of flow provided by the interconnection, the fact of having only outside supply source qualifies it as a Class B system.

The results of the regional source disruption analysis show that an increased number of systems become vulnerable when a regional supply is disrupted for a prolonged period. This is because they may have multiple interconnection points with the regional supplier. For the primary source evaluation, the one or two primary interconnections were removed and the secondary connections were evaluated. For the regional analysis, all connections with the regional supplier were considered inoperable. Keep in mind that the results of the regional analysis are only meaningful for systems which purchase most of their water.

Infrastructure Needs

All water systems serving at least 50,000 people were expected to be classified as Self Sufficient or Class A. Water systems serving between 10,000 and 50,000 people must be classified as Class B or higher. For systems that did not meet these two requirements based on the results of the evaluation described above, infrastructure needs were identified to mitigate the effects of a particular what-if scenario. As shown below, most of the systems met this requirement and further infrastructure improvements may not be necessary.

Table 8-2
Results of Loss of Primary Supply for a Prolonged Period

	Self-Sufficient	Class A	Class B	Vulnerable
< 50,000 population	74	10	18	13
> 50,000 population	9	6	7	4

Table 8-3
Results of Loss of Regional Supply for a Prolonged Period

	Self-Sufficient	Class A	Class B	Vulnerable
< 50,000 population	72	6	17	20
> 50,000 population	14	2	6	4

Large Vulnerable Systems

[SECTION REDACTED]

[SECTION REDACTED]

[SECTION REDACTED]

[SECTION REDACTED]

8.1.2 Chapter 6 – Task 3 Optimize Existing Water Diversions during Drought Conditions

Using Advisory Curve and WSMDST

In developing Chapter 6 it became clear from past droughts that by the time a drought watch or warning condition is identified, it may take very extreme measures or may be impossible to avert a drought emergency. In recent history (since the 1960s), seven drought warnings have resulted in five drought emergencies with an additional drought emergency in 1985 not preceded by any drought warning. There was a consistently short period of time between drought watch and emergency. Preliminary evaluations were completed to determine the volume of water that would be transferred to respond and maintain reduce drought emergencies. The required transfers were on the order of 100 MGD. It was estimated the infrastructure necessary to occasionally deliver this water for very short periods of time would cost in excess of $40 million.

Because of the consistently short time between drought watch and emergency, and substantial infrastructure requirement a new standard for initiating closer monitoring of reservoir levels has been identified — *the advisory level*. This proposed rule curve simply splits the difference between the already established "observe" curve and the average reservoir level. When compared to historical scenarios this level strikes a reasonable balance between early identification of eminent drought and minimization of false alarms. It is recommended that NJDEP use this curve as an internal trigger. If storage in any single reservoir system falls below the advisory curve, the WSMDST should be employed as frequently as once per week to forecast possible drought conditions. This approach allows NJDEP and purveyors an opportunity to make the minimum water transfers necessary to prepare for short or longer-term drought.

The WSMDST was used in Chapter 6 to simulate historic drought conditions with today's demands. The historic droughts were 1960s, 1981-2, 1995, 1998, 1999, 2002, and 2005. The results of the simulations are tabulated in Table 6-7. Five of these seven droughts resulted in drought emergencies.

Applying this approach to the historic droughts had the following outcomes:

1. The 1960s and 2002 Droughts were severe and cannot be corrected using these strategies. As expected in severe droughts, demand management will have to be utilized.
2. The management strategies did limit one of the drought emergencies to watch and two emergencies to warning or better.
3. The one drought watch and one drought warning were able to be limited to advisory.

Surprisingly almost all of the manageable droughts can be addressed using existing interconnections. There is one exception. In recreating the 1999 drought, the interconnection between Jersey City and United Water was identified as a limiting interconnection.

<u>United Water</u>

In looking at the 7-drought analysis completed in Chapter 6, United Water is identified as a purveyor in deficit six times. In addition, United Water's interconnection with Jersey City and NJDWSC were identified as the limiting connections in the 1981 and 1999 Droughts. It appears United Water should consider additional water supplies to limit the number of times it finds itself in deficit.

<u>Conservation</u>

It is recommended that NJDEP update their statewide Drought Management Plan to redefine roles of various state and local agencies during a drought emergency, to establish minimum requirements of local plans, and to provide guidance to local agencies for drought response. An updated statewide drought management plan will insure that agencies throughout the state implement consistent responses to the Drought Indicator System, thus encouraging an equitable distribution of hardship during drought emergencies. This plan should include, among other things, statewide conservation goals and minimum water use restrictions for each sector during each drought stage.

8.1.3 Chapter 7 – Task 5 Optimize Existing Water Diversions during Normal Conditions

Interbasin Demand Transfers

Central and Northeast Regions

The greatest opportunity for demand transfer involves the NJAWC-Elizabethtown – Newark-NJDWSC: These 3 systems are interconnected through the Virginia Street Pumping Station. The operation of the Virginia Street Pumping Station could be modified to allow transfer of supply from the Elizabethtown system to the Newark and NJDWSC systems to maintain reservoir levels under normal conditions. NJDWSC has conducted preliminary investigations of an operational procedure change to provide a continuous supply of 10 mgd from the Elizabethtown system to the NJDWSC system via the Virginia Street Pumping Station. Their investigations indicate that if this had been in place between 1990 and 2003, the number of days the Wanaque Reservoir was below the drought warning curve would have been reduced from 221 days to only 29 days. To assure the operation of the Virginia Street Pumping Station for this purpose, transmission improvements would be needed in the Elizabethtown and Newark systems, and a new pumping station would be needed at the Belleville Reservoir site. This option merits support by the NJDEP.

NJAWC-Elizabethtown – NJAWC-Short Hills: The distribution networks of the NJAWC's Elizabethtown and Short Hills systems currently are interconnected, and part of the Short Hills system demand is met with water from the Elizabethtown system. Modeling shows benefits of strengthening the connections between these 2 regions. The Short Hills system has an average demand of just under 40 mgd, about 30 of which is met with supplies in the Northeast Region. If this demand could be met with supplies from the Central Region, about 30 mgd of supply might be made available to meet demands in the Northeast Region on a regular basis. More detailed investigations are needed to determine the economic and political feasibility of this option.

Jersey City – United Water NJ: These systems currently are interconnected, and Jersey City currently supplies water to United Water on a regular basis. It may be feasible to increase the normal flow from Jersey City to United Water to provide a better balance of water in the Northeast Region.

Central and Coastal North Regions

Middlesex Water Company currently supplies water from its CJO Plant to communities south of the Raritan River in Monmouth County. The transmission mains that convey this water extend through Old Bridge to Marlboro and the Gordon's Corner Water Company. The extension of existing piping bringing water from Middlesex Water Company through the

Marlboro system to the NJAWC's Monmouth System could provide a transfer of supply into the Coastal North.

Central and Southwest Regions

Trenton – NJAWC-Elizabethtown: The Trenton and Elizabethtown systems currently are interconnected, and plans are underway to strengthen the interconnection between these two systems. This will allow transfer of water between the Central Region and the northern portion of the Southwest Region.

NJAWC-Elizabethtown - NJAWC Western Division: Transmission/distribution piping in each of these systems currently ends about 5 miles from each other. Connecting these two systems would permit the transfer of water between the Central Region and lower portion of the Southwest Region.

Aquifer Storage & Recharge

ASR appears to have great potential as a water supply management tool in New Jersey. It is recommended that NJDEP continue to promote ASR through programs that encourage utilities to incorporate ASR into their water supply planning. The current permitting process and monitoring requirements are extensive, intimidating and can take years to navigate, the discharge permit being the most difficult hurdle. Therefore, it is recommended that NJDEP review the process and consider streamlining these processes as much as possible, and assist in coordinating permitting activities among the various DEP Bureaus. It is further recommended that NJDEP encourage more utilities to pilot and hopefully adopt ASR for multi-year water storage or "banking". This technology provides drought management through the transfer of demand from year to year, storing during wet years and recovering during dry years.

Unaccounted-for Water

NJDEP is interested in establishing standard recommendations, even regulations for evaluating water losses and in determining the demand reduction that could be realized if systems are optimized. To this end, it is recommended that NJDEP require all utilities to conduct annual water audits using the IWA/AWWA Water Audit Method and to implement a leakage control plans. Once a uniform system for auditing and reporting water losses is implemented statewide, it is recommended that NJDEP commission a detailed study and cost benefit analysis. This study would evaluate the potential for demand reduction that could be realized through enhanced water loss control and determine if the benefits of the reductions balance the cost of implementing control programs. The NJDEP could then use the results of this study to establish or modify their goal ILI based on achieving some desired level of demand reduction.

Water Reuse

RWBR is a proven water supply management tool that has been used extensively in other areas of the country and shows great potential as a water supply management tool for New Jersey. As NJDEP continues to develop and promote its RWBR program, they should develop a strategic plan and long-term goals for the program. This plan should identify goal volumes of reuse to be achieved in the state as a whole and in individual regions, according to regional water needs. To better position themselves to meet their long term goals, New Jersey might consider establishing a program to provide financial incentives for agencies to evaluate the benefits and possibilities of reuse. More specifically, it is recommended that NJDEP provide funding to targeted municipalities or regional water purveyors to develop water reuse master plans. Finally, NJDEP should work collaboratively with other state agencies, including the Department of Agriculture and the Board of Public Utilities to promote reuse. It is our understanding that the Water Quality Management Plans (WQMP) now require reuse feasibility studies, NJDEP has proposed the NJPDES rules also include reuse feasibility studies and the NJDEP Division of Water is requiring reuse feasibility studies in the allocation process.

8.2 Assessment Components

When this study was initiated, it was anticipated that numerous capital projects were going to be required to facilitate moving water between regions and the equitable hydrologic drawdown of New Jersey's water resources. As we describe in Chapter 6, many of the goals of this study can be satisfied by earlier involvement by the NJDEP, greater coordination between the water systems, and the implementation of some statewide initiatives. These recommendations do not have the environmental impacts, capital costs, and viability concerns that multiple capital projects would require to be compared.

8.3 Prioritization & Recommendations

New Jersey, because of its relatively small size and extended potable water systems, has a unique opportunity to integrate most of their major water sources throughout the state. NJDEP's support for interconnections between regions will allow the potable water systems to have multiple redundancies at their disposal to address all types of catastrophes.

The recommendations of this report are as follows:

1. It is recommended that the NJDEP institute the Advisory Curve and WSMDST as described in Chapter 6. This will require the Drought Management Rules be amended to give the NJDEP powers under a Drought Advisory similar to the powers under a Drought Warning (Water Supply Allocation Rules 7:19-11.6) which include, among other parameters, the ability for the NJDEP to mandate water transfers. These rules and the potential pricing arrangements are discussed in Chapter 9.

2. The greatest opportunity for demand transfer involves the New Jersey American Water (NJAW) -Elizabethtown – Newark and North Jersey District Water Supply Commission (NJDWSC): These 3 systems are interconnected through the Virginia Street Pumping Station. NJDWSC has conducted preliminary investigations of an operational procedure change to provide a continuous supply of 10 mgd from the Elizabethtown system to the NJDWSC system via the Virginia Street Pumping Station. Their investigations indicate that if this had been in place between 1990 and 2003, the number of days the Wanaque Reservoir was below the drought warning curve would have been reduced from 221 days to only 29 days. This study identifies this interconnection as a critical reducing the length of droughts in the Northeast Region. This option merits support by the NJDEP.

3. It is recommended the NJDEP and United Water begin discussions to evaluate the potential for additional water supply. Based on the analysis in this study United Water was identified as a purveyor in deficit in six of the seven drought simulations. In addition, the United Water interconnection with Jersey City and NJDWSC were identified as the limiting interconnections during non-simulated drought emergencies.

4. It is recommended that Atlantic City MUA and Brick Township MUA evaluate options that would allow them to be rated higher than vulnerable in the catastrophic infrastructure analysis. Both systems are classified as large systems serving more than 50,000 people, are somewhat isolated and have limited existing options. There are some nearby options that could assist that should be investigated.

5. It is recommended that NJDEP update their statewide Drought Management Plan to redefine roles of various state and local agencies during a drought emergency, to establish minimum requirements of local plans, and to provide guidance to local agencies for drought response. An updated statewide drought management plan will insure that agencies throughout the state implement consistent responses to the Drought Indicator System, thus encouraging an equitable distribution of hardship during drought emergencies. This plan should include, among other things, statewide conservation goals and minimum water use restrictions for each sector during each drought stage.

6. Reclaimed Water for Beneficial Reuse (RWBR) is a proven water supply management tool that has been used extensively in other areas of the country and shows great potential as a water supply management tool for New Jersey. As NJDEP continues to develop and promote its RWBR program, they should develop a strategic plan and long-term goals for the program. This plan should identify goal volumes of reuse to be achieved in the state as a whole and in

individual regions, according to regional water needs. To better position themselves to meet their long term goals, New Jersey might consider establishing a program to provide financial incentives for agencies to evaluate the benefits and possibilities of reuse. It is our understanding that the Water Quality Management Plans (WQMP) now require reuse feasibility studies, NJDEP has proposed the NJPDES rules also include reuse feasibility studies and the NJDEP Division of Water is requiring reuse feasibility studies in the allocation process. These are positive initial steps in expanding RWBR in the State.

7. The distribution networks of the NJAW's Elizabethtown and Short Hills systems currently are interconnected, and part of the Short Hills system demand is met with water from the Elizabethtown system. Modeling shows benefits of strengthening the connections between these 2 regions. The Short Hills system has an average demand of just under 40 mgd, about 30 of which is met with supplies in the Northeast Region. If this demand could be met with supplies from the Central Region, about 30 mgd of supply might be made available to meet demands in the Northeast Region on a regular basis. More detailed investigations are needed to determine the economic and political feasibility of this option.

8. Additional studies are also recommended to evaluate the feasibility, costs, and benefits of source optimization and demand transfer between surface water and groundwater within the Middlesex Water, NJAW-Coastal and Sayreville systems.

9. Aquifer Storage and Recovery appears to have great potential as a water supply management tool in New Jersey. It is recommended that NJDEP continue to promote ASR through programs that encourage utilities to incorporate ASR into their water supply planning. The current permitting process and monitoring requirements are extensive, intimidating and can take years to navigate, the discharge permit being the most difficult hurdle. Therefore, it is recommended that NJDEP review the process and consider streamlining these processes as much as possible, and assist in coordinating permitting activities among the various DEP Bureaus. It is further recommended that NJDEP encourage more utilities to pilot and hopefully adopt ASR for multi-year water storage or "banking", contingent on geology of the area allowing the stored water to remain for multi-years. This technology provides drought management through the transfer of demand from year to year, storing during wet years and recovering during dry years.

10. NJDEP is interested in establishing standard recommendations even regulations for evaluating water losses and in determining the demand reduction that could be realized if systems are optimized. To this end, it is recommended that NJDEP require all utilities to conduct annual water audits using the IWA/AWWA Water Audit Method and to implement a leakage control plans. Once a uniform system

for auditing and reporting water losses water is implemented statewide, it is recommended that NJDEP commission a detailed study and cost benefit analysis. This study would evaluate the potential for demand reduction that could be realized through enhanced water loss control and determine if the benefits of the reductions balance the cost of implementing control programs. The NJDEP could then use the results of this study to establish or modify their goal ILI based on achieving some desired level of demand reduction.

9.0 TASK 6: FINANCIAL INFRASTRUCTURE

9.1 Introduction

The purpose of Task 6 of the Interconnection Study is to analyze and propose changes, if determined necessary, to the existing financial infrastructure such that alterations to the supply, conservation measures, transmission and the construction and maintenance of Water Supply Emergency Infrastructure do not cause disproportionate financial hardship, or profits, to the parties involved.

As Tasks 1 through 5 do not recommend new regional/statewide capital additions to the water supply infrastructure, this section of the report will not address funding for that type of capital improvements. However, the recommendations do include numerous individual system improvements and the implementation of a Drought Caution Curve in order to preempt a region from falling into a drought warning situation. We have incorporated the effect of a Drought Caution in our analysis.

Our process of discovery included gathering cost and rate information from the largest water systems in the State of New Jersey. We met with certain representatives of the critical systems, representatives of NJ DEP and representatives of the Board of Public Utilities in order to discover their concerns related to the pricing of water transfers recommended in the Tasks 1 through 5 of the Report.

Included in this section is a summary of current regulations for rate determination for drought emergencies and warnings, a discussion of the rate and financial barriers that currently exist, potential rate solutions, and recommendations and guidelines. Current issues with rate design and financial barriers exist with implementing the recommendations of Task 1 through 5 of this report. Our recommendations address water transfer rates in various drought situations, either voluntary or imposed.

9.2 Current Regulations Related to Drought Avoidance Rate Design and Financing of Infrastructure

<u>NJ DEP Water Supply Allocation Rules enacted in 1982</u>

<u>Interconnections</u> – "In order to assure the availability of water during times of emergency, including drought, the Department may require interconnections….to the extent practicable and economically feasible." The regulations further stipulate that costs of creating interconnections to avert water shortages will be shared by benefited Water Purveyors in proportion to those benefits, as approved by the NJDEP.

Water Surcharge Schedule – The regulations state that in the case of a water emergency and at the initiation of Phase II (indoor water reductions), the Drought Coordinator (as defined in the regulations) can implement the water surcharge schedule as follows:

Residential – allowance of 50 gallon per capital daily and any usage above the allowance incurs the normal water rate plus $5 surcharge for every additional 100 CF. Surcharge can be raised to up to $10.

Non-Residential – charged normal water rate plus a surcharge of 33% of the normal rate. This surcharge can be raised to a maximum of 50%.

Anecdotally, implementing this surcharge schedule was not popular within the State when it was implemented and eventually the monies were rebated to the Water Users.

Emergency Water Transfer Pricing – "In the event an emergency transfer of water is ordered by the Commissioner, the price charged to the receiving system should be based upon fair compensation, reasonable rate relief and just and equitable terms as to not create a situation wherein the customers or owners of the supplying systems are subsidizing the transfer."

Criteria include:

a) If an emergency transfer is ordered, and it requires a reduction in the amount of water used by existing customers of the supplying system, the supplying system should recover its costs. This could be interpreted to be the General Metered Service (GMS) rate.
b) If an emergency transfer is ordered, and it requires no reduction in the amount of water used by existing customers of the supplying system, normal bulk rates should apply
c) If no bulk rate is established, the supplier may recover the costs of O&M, depreciation, taxes, and return or debt service related to the facilities utilized.

These prices, per the regulations, must be in place at all times for those water purveyors which have interconnections to other water systems. However, when water purveyors were asked to produce their Emergency Water Transfer Pricing Rates, none were able to comply.

Drought Warning Requirements – NJDEP may require the following during a drought warning:

1) Develop an alternative water supply if possible.

2) Rehab and activate interconnections between water systems.

3) Complete interconnection flow tests

4) Transfer water from other water systems

5) Other measures to insure adequate water supply.

9.3 Example Water Transfer Agreement between Large Water Purveyors, Expired 2006

We examined an agreement between water purveyors for the transfer of water during various drought and non-drought situations. The agreement allowed water to be transferred from one water purveyor to another water purveyor using several pricing parameters. These included:

a) If the transfer was not mandated by the State, the supplier of water would charge its sales to other systems rate or bulk rate.

b) If the transfer was mandated and the supplier's customers were not under restrictions, the supplier would charge $680 per MG. This rate was determined by adding the price of purchased water, water treatment costs, pumpage costs, gross receipts and franchise taxes and operation and maintenance costs.

c) If the transfer was mandated and the supplier's customers were under restrictions, the GMS rate would be used.

The term of the agreement was 5 years with an option to extend for up to 10 years.

9.4 Rate and Financial Barriers

In the State of New Jersey, rate and financial barriers exist to adequately, efficiently and equitably transfer water where needed in a drought watch, warning and drought emergency situations. These include the following:

1. Certain water purveyors caution that the rate structure for the transfer of water in a non-emergency situation should not subsidize water purveyors who have not planned to avoid shortages. This would penalize not only the water systems who did plan ahead but also the rate payers of that water system. A system must be in place which encourages long term contracts between interconnecting water systems so that during a drought situation, water could be transferred at a price that is equitable for both parties.

2. Water purveyors may lose their GMS rate revenue to bulk rate if forced to transfer water during an emergency drought situation assuming that their customers are under water use restrictions.

3. Some purveyors have entered into long term contracts to reserve a water allocation which is expensed whether the water is used or not. The economic motivation for these water purveyors is to use this allocated water first then look to other sources for water. However, this may not be the most efficient use of water resources for the entire region.

4. Water may pass through another system on its way to supply other water users with water. Though the system that is transferring the water is not the supplying water system, this "pass through" system should be compensated for pumping and transmission costs, etc. for this transfer. There is no mention of "wheeling fees" in the State's Emergency Water Transfer Pricing regulations.

5. Due to the wide variety of water purveyors in the State of New Jersey, certain purveyors could pay more for purchased water than it costs them to produce in a drought situation.

6. Most water purveyors do not have an Emergency Water Transfer Pricing schedule as required by the Water Supply Allocation Rules.

9.5 Potential Rate Solutions

There are various rate designs that address the rate problems and financial barriers listed above.

9.5.1 Standby Fees

This rate structure could be used by water purveyors which are habitually in need of water during minor drought situations. The water purveyor could pay a standby fee to the supplying purveyor in order to receive water when needed at a guaranteed rate. This standby fee would be set to compensate the rate payers of the supplying water system for their investment (fixed O&M, depreciation and return) in the water system which ensures an adequate supply. The consumption charge when actual usage occurs would be the unit cost of production, paying for the incremental cost of supplying the water.

The added benefit of standby fees is that purchasing systems can include the standby fees in their operating budget and recover such fees from their customers in the rate structure.

9.5.2 Wheeling Fees

The cost of transferring water from one system, through an intermediary system, to the water system in need should be recognized. This fee for the intermediary should be calculated based on the allocated costs of pumping and transmission for the facilities used for wheeling the water through the system.

9.5.3 Water Trading

Water trading is effective when each system has a similar cost structure and the water needs are complementary. This water "banking" has proved to be effective for certain water purveyors and should continue.

9.5.4 Sale of Reserved Capacity

A water purveyor who has a reserved capacity allocation which is expensed whether the water is used or not, must be allowed to be reimbursed for this allocation in order to promote the efficient use of water in a region.

9.6 Recommendations and Guidelines

The Task 6 recommendations and guidelines are as follows:

In our initial discussions with the NJ DEP regarding Task 6, it was considered that water transfers during a drought situation should be priced at the bulk purchase rate (bulk rate) in existing contracts or below so that supplying water systems would not profit from the drought situation. However, an alternative view was expressed during discussions with water purveyors. The consensus was that if the transfer of water during a drought was priced at bulk rate or below, there would be no incentive for water systems that habitually fall into a drought situation earlier than others due to inadequate water supply to set up long term contracts with the neighboring suppliers or to invest in alternative sources of water. It was a concern that these systems would always get "bailed out" at the expense of the supplying systems and their customers that funded the infrastructure in order to have an adequate water supply. On the other hand, if the supplying water systems are guaranteed a high rate for their water in a drought situation, these supplying systems may not have motivation to sign a long-term contract at a lower rate than their General Metered Service (GMS) rate. The following recommendations address these issues.

1. In preparation for emergencies, we recommend that the NJDEP, during the permitting process, enforce the requirement that water purveyors with physical interconnections with other water purveyors have an Emergency Water Transfer Pricing Schedule in place at all times, including a bulk rate for those systems that expect diversions over .1 MGD. These prices can be in accordance with the criteria outlined in the Water Supply Allocation Rules and would be used in case of a water transfer to a water system not currently engaged in a long term contract with the supplying water system.

2. In addition, the Emergency Water Transfer Pricing rules could be amended to include the stipulation that if a water purveyor is in a drought situation and is

buying from a supplier who is not under water use restrictions, that the purchasing water supplier pay its own GMS rate and the difference between the bulk rate charged by the supplying system and its own GMS rate would then be used as a funding source for the State to supplement the 1981 bond fund and used for State sponsored projects. This structure could potentially create a funding source for needed projects but must be carefully considered as to not create a hardship situation for the purchasing water purveyor. However creative solutions between water purveyors should be encouraged, such as the use of standby fees and/or long-term contracts that would supersede the Emergency Water Transfer Pricing rules.

3. It is proposed that the water systems with interconnections develop a standby agreement which pays the supplying water purveyor a fee to have an assured source of water at a bulk rate price in an emergency (including drought) rather than being subject to the Emergency Transfer Pricing rules. This fee should be priced to compensate the rate payers of the supplying system for the investment in infrastructure. The consumption charge for the actual use could then be set to the incremental cost of supplying the water or a bulk rate since the fixed costs have already been paid through the standby fee. Potentially, these standby fees could evolve to a steady purchase of water by the water systems in need, which could help mitigate water shortages under drought conditions.

4. If a water purveyor does not develop a contract as recommended above for an emergency, it is recommended that NJDEP should impose an alternative based on the Emergency Water Transfer Price criteria. In this case, the water purveyor in need of water during a period of water restriction and without long term contracts with water suppliers would risk the price of water equal to the supplying water purveyors' GMS rate or its own GMS rate depending on the regulations. This risk may encourage the development of an alternative pricing strategy, the development of an alternate water source, or even prevent the water purveyor in need from buying the water, choosing instead to impose further restrictions on water use for its customers. In the long run, this approach may force an open dialogue with the rate payers. The water purveyor could describe the options and costs related to a long term contract, development of a new water supply and expanded water restrictions. In some cases the rate payers will accept rate increases to reduce the need for restrictions. In others the rate payers will prefer the restrictions to higher rates.

   This strategy could also create the impetus for the supplying water purveyor to be open to negotiation of terms. If the supplying water purveyor is aware that the water system in need is going through an evaluation of the alternatives they may be more inclined to consider negotiation in the terms when confronted with the risk of losing the opportunity altogether.

5. In addition, the Drought Management Rules should be amended to compensate intermediary water systems that "wheel" the water from one system to another. As stated earlier in this report, the fee should be based upon the allocated cost of pumping and transmission for the wheeling water system. However, absent a long term contract, the NJDEP should recommend a wheeling fee that equals the difference between the wheeling system's GMS rate and its Sales for Resale rate. In some instances the New Jersey Board of Public Utilities will have to be included in these discussions.

6. Most importantly, we recommend that the Drought Management Rules be amended to give the NJDEP powers under a Drought Advisory similar to the powers under a Drought Warning (Water Supply Allocation Rules 7:19-11.6) which include, among other parameters, the ability for the NJ DEP to mandate water transfers. The pricing mechanism is not discussed in the Water Allocation Rules for a Drought Warning, however we recommend using the Emergency Water Transfer Pricing rules and criteria if another contract is not in place. In addition, the Drought Management Rules should be amended to stipulate that if an agreement is not already in place the water purveyor in need of the water transfer (as indicated by the model referenced in this report) should pay any costs related to the rehabilitation and activation of interconnections between water systems and completion of the interconnection flow tests.

7. Finally, it is also recommended that the NJDEP work with the water suppliers, public and private, who have take or pay contracts with other water purveyors to add flexibility to the use of the water supply. The purchasing water purveyor should be reimbursed for some or all of its contractual allocation of water if it is used by another water purveyor whose source of water is more limited. This reimbursement must be at least equal to the price paid for water via an alternate source used. This would allow for a more efficient distribution of water in a potential drought situation. NJDWSC is one of the largest water suppliers in the State and maintains take or pay contracts with various water purveyors. The Commission has indicated that the water purveyors on its system, through a series of contracts, have a mechanism to be reimbursed for their water allocation if it is used by another water purveyor in times of water shortages.

9.7 Summary

In summary, in order for the Interconnection Study to be effective, a fair and equitable rate design must be encouraged by the NJDEP in order to ensure compliance by the various water systems. The Water Allocation Rules should be amended so that the NJDEP can mandate certain water transfers in times of Drought Caution but responsibility ultimately lies with the individual water systems and their management to create an equitable pricing mechanism for these transfers or absent such pricing mechanism, risk that they would be subject to pricing mandated by the NJDEP rules.

Appendix 1

Glossary of Terms

Glossary

Average-day demand: a water system's average daily use based on total annual water production divided by 365.

Average-year demand: water demand under average daily use based on total annual water production divided by 365.

Average-year water supply: the average amount of water available annually through a water system.

Avoided cost: the savings achieved by undertaking a given activity such as implementing a water-efficiency measure; can be used to establish the least-cost means of achieving a specified goal.

Beneficial use: the use of water resources to benefit people or nature; irrigation water that satisfies some or all of the following needs or conditions-evapotranspiration, leaching, water stored in the soil for use by crops, or special cultural practices; usually expressed as a depth of water in inches or feet.

Benefit-cost ratio: benefits and costs measured in terms of money are expressed as a ratio, with benefits divided by costs.

Best management practice (BMP): a conservation measure or system of business procedures that is beneficial, empirically proven, cost-effective, and widely accepted in the professional community; also an urban water conservation measure that member agencies of the California Urban Water Conservation Council agree to implement under the Memorandum of Understanding Regarding Urban Water Conservation in California.

Conservation: (1) the act of conserving; preservation from loss, inquiry, decay, or waste. (2) the protection of rivers, forests, and other natural resources. See also *water conservation.*

Conservation pricing: water rate structures that encourage consumers to reduce water use.

Customer class: a group of customers (e.g., residential, commercial, industrial, institutional, wholesale) defined by similar water-use patterns and costs of services.

Declining (or decreasing) block rate: a pricing structure in which the amount charged per unit of water (i.e., dollars per 1,000 gallons) decreases as customer water consumption increase.

Demand forecast: a projection of systemwide future water demand or of future demand by a specific customer class.

Demand management: water-efficiency measures, practices, or incentives implemented by water utilities to reduce or change the pattern of customer water demand.

Demographic: having to do with human population or socioeconomic conditions.

Domestic water use: in this report, water used by sanitary plumbing fixtures (toilets, urinals, faucets, and showerheads) and appliances (cloths washers and dishwashers) in nonresidential settings such as industrial, commercial, and institutional properties; in other contexts, sometimes synonymous with *residential water use*, or water used for household purposes, such as drinking, food preparation, bathing, washing cloths and dishes, flushing toilets, and watering lawns and gardens.

Drought: a period of unusual or persistent dry weather (compared to a long term average) of a duration and degree that results in a shortage of water and adverse affects. There are different types of drought, as determined by resultant conditions and/or the impact on users, including the environment. A precipitation drought occurs when recorded rainfall is significantly below normal for a sufficiently long period of time. An agricultural drought occurs when the soil-moisture deficit hinders crop growth. An environmental drought occurs when an ecological community is affected by a lack of water (for example, low stream flows stressing fish). This Plan concentrates on water-supply droughts. A water-supply drought occurs when water demands exceed available water supplies. This definition combines: (1) amount of water in storage, (2) anticipated water demands, (3) the severity of the precipitation deficit, and (4) specific water sources available to the affected area.

gpcd gallons per capita per day.

gpd gallons per day

gphd gallons per household per day

gpm gallons per minute

Groundwater: water beneath the earth's surface; specifically, that portion of subsurface water in the saturated zone, where all pore spaces in the alluvium, soil, or rock are filled with water.

Groundwater recharge: replenishment of a groundwater supply through natural conditions (e.g., percolation) or artificial means (e.g., injection).

Inclining block (or increasing block) rate: a pricing structure in which the amount charged per unit of water (i.e., dollars per 1,000 gallons) increases as customer water consumption increase.

Leak detection: methods for identifying water leakage from pipes, plumbing fixtures, and fittings.

Low-volume faucet: a faucet that uses no more than 2.5 gallons per minute at 80 pounds of pressure per square inch; also referred to as *low-flow faucet.*

Low-volume showerhead: a showerhead that uses no more than 2.5 gallons per minute at 80 pounds of pressure per square inch; also referred to as *low-flow showerhead.*

Low-volume toilets (water closet): a toilet that uses no more than 1.6 gallons per flush; also referred to as *low-flow toilet.*

Low-volume urinal: a urinal that uses no more than 1.0 gallons per flush; also referred to as *lo-flow urinal.*

MGD: million gallons per day.

Nonresidential water use: water use by industrial, commercial, institutional, public, and agricultural users.

Peak demand (water): the highest total water use experienced by a waters supply system, measured on an hourly, daily, monthly, or annual basis.

Per capita residential use: residential water use divided by the total population served.

Per capita use: the amount of water used by one person during a standard period of time; in relation to water use, expressed in gallons per capita per day.

Reclaimed water (or reclaimed wastewater): treated, recycled wastewater of a quality suitable for nonpotable applications, such as landscape irrigation, decorative water features, and nonfood crops; also described as *treated sewage effluent.*

Residential water use: water use in homes (e.g., for drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and water lawns and gardens).

Retrofit: to change, alter, or adjust plumbing fixtures or other equipment or appliances to save water or make them operate more efficiently.

Reuse: (1) the additional use of previously used water; see also *recycled water*. (2) the beneficial use of treated wastewater; see also *reclaimed water.*

Seasonal rate: a pricing structure in which the amount charged per unit of water varies by season; higher rates are usually charged during the peak-demand season (usually the summer months).

Surcharge: a special charge included on a water bill to recover costs associated with a particular activity or use or to convey a message about water prices to customers.

Unaccounted-for water: water that does not go through meters (e.g., water lost from leaks or theft) and thus cannot be accounted for by the utility.

Unmetered water: water delivered but not measured for accounting and billing purposes.

Water audit: an on-site survey and assessment of water-using hardware, fixtures, equipment, landscaping, irrigation systems, and management practices to determine the efficiency of water use and to develop recommendations for improving indoor and outdoor water-use efficiency. Also referred to as a *water-use survey.*

Water conservation: (1) any beneficial reduction in water loss, waste, or use. (2) reduction in water use accomplished by implementation of water conservation or water-efficiency measures. (3) improved water management practices that reduce or enhance the beneficial use of water.

Water conservation incentive: a policy or regulation, rate strategy, or public education campaign designed to promote customer awareness about the value of reducing water use and to motivate consumers to adopt specific water conservation measures.

Water conservation measure: an action, behavioral change, device, technology, or improved design or process implemented to reduce water loss, waste, or use.

Water reclamation: the treatment of wastewater to make it reusable, usually for nonpotable purposes; includes water recycling.

Water recycling: the treatment of urban wastewater to a level rendering it suitable for a specific, direct, beneficial use.

Appendix 2

Water Emergency and Drought Plan

STATE OF NEW JERSEY

Joint BPU and DEP
Water Emergency Planning Team (WEPT)
Final Report

THE GREAT SEAL OF THE STATE OF NEW JERSEY

Thomas H. Kean
Governor

Let's protect our earth

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

NJ BOARD OF PUBLIC UTILITIES

JUNE 1989

Christopher J. Daggett, Commissioner
Department of Environmental
Protection

Christine Todd Whitman-President
Board of Public Utilities

Joint BPU and DEP

Water Emergency Planning Team (WEPT)

Final Report

June 1989
Jeanne M. Fox
Director
Division of Water and Sewer
Board of Public Utilities
WEPT Chairperson

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WATER EMERGENCY PLANNING TEAM

A. Organization and Goals

The Water Emergency Planning Team (WEPT), composed of representatives from the BPU, DEP, Monmouth County and the water industry, was formed in July 1988 at the recommendation of BPU President Christine Todd Whitman. The main reason for the formation of WEPT was the water supply and/or delivery problems of many water purveyors within the State caused, at least in part, by the adverse weather conditions and the unprecedented demands being experienced at that time. The initial mission of WEPT as formed was, for the short-term, 3-fold:

1. To determine the extent of the emerging crisis situation which resulted in out-of-service episodes and/or water use restrictions to the utilities' customers;
2. To determine the root causes and what was being done to alleviate the situation and also to identify what more can be done and by whom. In this regard it was recognized that there is a shared or overlapping responsibility between the BPU, the water purveyors and the DEP;
3. To establish efficient communication, coordination and reporting procedures between the BPU, the DEP and water purveyors for emergency situations caused by demand and/or supply problems so that each entity could effectively discharge its responsibilities in this regard.

The on-going mission of WEPT is to meet the following objectives and submit WEPT recommendations by May of 1989, the beginning of the next high water demand season:

1. To gain a better understanding of the water supply and demand situation in the State including interconnections between purveyors as well as future water supply plans;

2. To identify and evaluate alternative courses of action which could be taken to protect water systems during emergency situations while at the same time maintaining sufficient supplies and pressures for essential purposes (e.g. fire protection);

3. To establish "trigger points", i.e. at what phase or point in time specific restrictions are appropriate and should be implemented;

4. To study the various enforcement possibilities at all levels, e.g. utility (via BPU approved tariff provisions), municipal, county, DEP or an Emergency Water Declaration. New or revised regulations should be considered;

5. To delineate and update existing communication responsibilities and procedures among the water purveyors, BPU, DEP, other government entities and the public so that communications regarding emergency water situations and water use restrictions is accomplished in a timely, straight-forward and efficient manner;

6. To consider possible educational opportunities which should include the teaching of water conservation objectives;

7. To define common terminology used during water emergency situations.

The initial meeting of the WEPT Committee was held in August, 1988 and has met many times since, generally on a monthly basis. The Committee meetings were chaired by Jeanne M. Fox, BPU - Director of the Division of Water and Sewer.

The Committee's goals were established as outlined above and it was agreed that those goals should be accomplished by May 1989 in order to better avoid a reoccurrence of the 1988 adverse water supply and/or demand situation.

In order to accomplish WEPT goals in the relatively short time frame, three independent Subcommittees were formed to meet separately to address certain specific issues in detail and report back to the full Committee concerning those issues. The subcommittees were:

Definitions and Triggers Subcommittee
Chaired by Paul Schorr, Project Specialist
Department of Environmental Protection
Division of Water Resources

Enforcement Subcommittee
Chaired by Michael Walsh, President
Shorelands Water Company

Communications and Education Subcommittee
Chaired by Donald Conyers, Manager
New Jersey American Water Company - Northern Division

A listing of the members of the WEPT Committee along with their affiliations is included here as Appendix A

B. Summary of Recommendations and Actions

The following is a brief summary of the recommendations and actions initiated by WEPT presented by Subcommittee grouping. Formal Subcommittee reports are included here as Appendices. It should be emphasized that the substance of these reports was reviewed and approved by the full WEPT Committee.

1. Definitions & Triggers (See Appendix B)

It was recognized that one of the major reasons why it was difficult to achieve compliance with water use restrictions by the public during the summer of 1988 was due to poor and often confusing communications concerning the water emergency situation and the need to conserve water. A first step in curing this problem was obviously to identify and define terms that would be clearly understood and useful for communication between involved entities and with the public. Toward this end a Glossary of terms and their definitions was prepared and is included in the Subcommittee report.

In preparing the glossary it was found that there was not uniformity of those terms which denote the degree of emergency (e.g. Phase 1, Phase 2 etc.) amongst the purveyors state agencies and the Delaware River Basin Commission. The descriptions now included in the glossary are meant to be uniform and will be used by DEP, BPU and water purveyors in describing the degree of a water supply shortage and the corresponding actions necessary. We urge other state agencies and other entities to use this Glossary as well.

In addition the Subcommittee prepared descriptions of the various emergency situations which could be encountered (drought, extraordinary demand, mechanical failures and contamination) along with responses required by state agencies and purveyors to contain or ameliorate the emergency.

Another goal of the subcommittee was to develop a methodology to be used by purveyors to develop methods ("triggers") which would signal drought warnings and drought emergency conditions. It was recognized that the triggers could not be uniform since they are highly dependent on specific water supply system and demand characteristics. The methodologies proposed herein are intended to be used by purveyors in formulating their individual triggering mechanisms based on continuous monitoring of system parameters and climatological conditions. It is noted in this respect that the DEP requires all water purveyors in the state to submit a Water Supply Emergency Response Plan which would outline what would trigger the various drought warning and drought emergency phases in their respective systems and outlining responses to those phases.

2. <u>Enforcement Subcommittee</u> (See Appendix C)

WEPT recognized that when an emergency water supply or demand situation arises which dictates the imposition of water conservation practices on water users (customers) that enforcement of those restrictions by state agencies is difficult. It was also recognized that, for the most part, water emergencies are generally <u>not</u> statewide but are confined to portions of the State and in some cases only to the service areas of specific purveyors. The DEP, which has general control over water supply and water quality within the State, cannot itself declare an emergency situation and enforce water use restrictions without the Governor's Emergency Proclamation. The only entities which can effectively mandate water use restrictions and enforce those restrictions appear to be the municipal and county governments.

Considering the above and the fact that water purveyors may find it necessary to act expeditiously in an emergency situation to protect their system so as to be able to continue to supply water for essential uses (in house uses and firefighting), the Committee reached a consensus that several items would be helpful namely: a model municipal ordinance for adoption by municipalities and certain changes to the language of water utility tariffs on file with the BPU designed to give the individual utilities some authority to act immediately to counteract threats to their water systems.

The WEPT Committee recommendations concerning the ordinance and tariff were presented to the Board of Public Utility Commissioners for consideration on April 26, 1989 and were approved. A Board Order was then promulgated directing all water utilities under BPU jurisdiction to revise their tariff documents to include the language recommend by WEPT. In addition a copy of the proposed Model Municipal Ordinance was subsequently sent to all municipalities within the State with the BPU's and DEP's recommendation that the ordinance be enacted. It can then be activated at anytime by a simple resolution of the governing body to mandate the required water conservation measures and trigger the enforcement mechanisms.

3. Communications and Education Subcommittee
(See Appendix D)

One of the major problems encountered during a drought emergency condition was recognized to be in the areas of communication of the problem to the public and soliciting their compliance with recommended water conservation measures. Often, in the past, the messages put out by the state agencies, the purveyors and the media were not clear and in some cases were conflicting. This created a feeling of distrust which resulted in the public ignoring the requests for water conservation measures. It was also recognized that, in general terms, most people who are convinced that a real emergency exists or is imminent will cooperate in combating or averting the emergency to the best of their ability.

The Report prepared by the Communications and Education Subcommittee is essentially a working outline as to how to achieve effective and accurate communication between state agencies and purveyors in emergencies and how to coordinate the release of information to the public in a timely and effective manner during the various states of drought warning and drought emergency situations.

C. Additional WEPT Benefits

In addition to addressing its initial objectives WEPT provided a forum for discussion of other items of mutual concern. Many other areas were explored during meetings some of which are specifically noted herein for future action. All members were aware that many problems, in the area of water supply and demand, will be facing the State and its water purveyors in the near future and that the cots of providing safe, adequate and proper water service to the State's population will certainly start escalating. WEPT, with it broad representation, provided an excellent forum for discussion of these issues and for close coordination between the various entities involved in the State's water business. Even though WEPT's role has ended, the lines of communication and coordination that were opened up will remain in tact and will be utilized in the future.

In retrospect, the timing of the WEPT Committee was fortuitous in another respect. Several other committees were established in the State, concurrent with WEPT and several members of WEPT also served on those Committees. In this way we were able to extend our experience and recommendations to these committees. The following briefly outlines the committees referred to:

In August of 1988, the Monmouth County Board of Chosen Freeholders having been alerted by the New Jersey American Water Company declared a water supply emergency to exist in parts of Monmouth County and organized a Task Force chaired by Arnold Kleeberg, the Monmouth County Emergency Coordinator. This Task Force was organized for the purpose of implementing and assisting in the enforcement of the proclaimed mandatory water use restrictions.

In June, 1988, the DEP initiated discussion among purveyors in northeast New Jersey to define drought warning and drought emergency triggers and responses.

In March 1989 the DEP organized a state Water Emergency Task Force in response to drought warnings proclaimed by the Delaware River Basin Commission. At that time the Delaware River Basin was in a drought warning state (based on the Commission's rule curves) and it appeared imminent that the drought emergency phase would be triggered shortly.

In summary, much of the information generated by WEPT and these other committees was in this way communicated to one another. Thus, one of WEPT's main goals, i.e. coordination with all entities involved, was extended and enhanced.

D. Other Items Addressed

1. Electrical Utility Demand Charges

The WEPT Committee has asked BPU to look into electrical demand charges as they are applied to water supply pumping facilities associated with pumped storage reservoirs.

The North Jersey District Water Supply Commission (NJDWSC), the New Jersey Water Supply Authority (NJWSA), the Passaic Valley Water Commission (PVWC), the Hackensack Water Company and the New Jersey American Water Company all operate off-stream or pumped storage reservoirs. These reservoirs are not filled naturally by runoff from watershed areas, but depend on water being pumped into them from downstream rivers during those periods when the river flows are high (late fall, winter and early spring). If this water is not pumped into reservoirs when it is available it is lost in terms of water supply.

The pumps are generally very high capacity pumps since they are designed to capture as much of the excess flows as possible during the relatively short time when those flows become available and store it in reservoirs for subsequent use when river flows are at their lowest and water demands are highest (in the summer).

The purveyors feel that imposing a high electrical demand charge on this use is contrary to the rationale for demand charges in that they use power during periods of reduced electrical demands, not during peak demand periods. Their use does not add to peak demands which would require additional plant and equipment investments by electric utilities.

The representatives of the water purveyors, indicated above, have requested that the BPU investigate this matter further to determine if any relief can be obtained through tariff revisions.

2. Conservation

Extraordinary demand was created in large part by the use of automatic lawn sprinklers. The most direct procedure for regulating their installation is through local plumbing codes. The New Jersey Department of Community Affairs is presently considering revisions to National and State Plumbing Codes. Any efforts to reasonably ensure that sprinkler use is restricted when the water supply system is jeopardized by extraordinary demand should be supported. The DEP may provide specific recommendations.

The (Agricultural) Cooperative Extension Services of the Rutgers has published a "Watering Guide" which recommends lawn watering frequency. WEPT recommends that both agencies seriously study and consider the issue of lawn sprinklers, e.g. timers, differential rates, etc.

3. Enforcement - Private Wells

Enforcement: When an emergency declaration restricts outside lawn watering, enforcement, at this time is not feasible unless the restrictions are observed by everyone even by homeowners with private wells. Arguments by private well owners and well drillers, that they should be exempted are not practicable at this time. The State Office of Emergency Management should be supported in its efforts to restrict use of private wells for lawn watering. If the County or local authorities develop an administrative process to simplify verification of private well use then it should be presented to the Department.

E. Conclusion

The foregoing briefly summarized the deliberations, recommendations, actions and achievements of WEPT. The final WEPT meeting was held at Middlesex Water Company on May 31, 1989 and the Committee was dissolved. However, as indicated previously, we expect coordination between the various members to continue into the future.

Appendix A

WEPT COMMITTEE MEMBERS

FOR BPU

Chairperson — Jeanne M. Fox, Director, Division of Water and Sewer

Suzanne N. Patnaude, Regulatory Officer

John F. Fitzpatrick, Principal Engineer, Division of Water and Sewer

FOR DEP - DIVISION OF WATER RESOURCES

Steven Nieswand, Assistant Director

Paul Schorr, Project Specialist

Barker Hamill, Bureau Chief

Robert Mancini, Section Chief

Richard Kropp, P.E., Chief, Bureau of Water Allocation

Michael Miller - Engineer

William Laffey - Acting Section Chief

Asghar Hasan - Supervising Environmental Engineer

FOR WATER UTILITIES

L.W. Brokaw, Asst. Manager
NJAWC - WD

Michael P. Walsh, President
Shorelands Water Company

Edward Hughmanic, Vice President
Toms River Water Company

Ronald F. Williams, Vice President
Garden State Water Company

Thomas McKeon, Vice President
Hackensack Water Company

Roy W. Mundy, II, Manager
NJAWC-ED

Donald L. Conyers, Manager
NJAWC-ND

Paul Hartelius, Manager
NJAWC-ND

Norbert Wagner, Vice President
Elizabethtown Water Company

Irene Lanza, Executive Ass't
to the President
Gordons Corner Water Company

Dennis Sullivan, General Counsel
Middlesex Water Company

B.M. Cabiness, Manager
NJAWC-SD

Pen Tao, Director of Research
and Development
Hackensack Water Company

Howard J. Woods, Jr., P.E., Manager
of Operational Services American
Water Works Service Company

Maxine L. Rosen, Director of
Communication American Water Works
Service Company

AUTHORITIES & COMMISSIONS

Rocco Ricci, Executive Director
New Jersey Water Supply Authority

Dean C. Noll, Chief Engineer
North Jersey District Water Supply Commission

OTHER

Arnold Kleeberg, Coordinator
Monmouth County Office of Emergency Management

SECRETARIAL SERVICES

Lauren Mattox, Secretary
Board of Public Utilities
Division of Water and Sewer

APPENDIX B

DEFINITIONS AND TRIGGERS

SUBCOMMITTEE REPORT

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES
CN 029
Trenton, N.J. 08625-0029

Jorge H. Berkowitz, Ph.D.
Acting Director

(609) 292-1637
Fax # (609) 984-7938

APPENDIX B

M E M O R A N D U M

June 2, 1989

TO: W.E.P.T.

FROM: Paul Schorr

SUBJECT: Water Emergency Planning Team Triggers and Definition (TIDE)

The subcommittee on Triggers and Definitions has completed a Glossary of Terms, an Overview of the Department's Response to Water Supply Shortages and a more detailed Description of Triggers and Responses. All subcommittee members gave of their time. Their input has been critical to the work done to date.

In addition to these outputs, the subcommittee recognizes three other areas in which additional work remains: conservation, enforcement, and preparedness. A brief description of these remaining areas follows.

Conservation: Extraordinary demand in 1988 was created in part by the use of automatic lawn sprinklers. The most direct procedure for regulating the type of equipment installed is through local plumbing codes. The New Jersey Department of Community Affairs (DCA) is presently considering revisions to State Plumbing Codes. Any efforts to reasonably restrict the use of sprinklers to prevent draining or contaminating the water distribution system should be supported. A secondary basis for regulating their installation would be to conserve water.

Enforcement: When an emergency declaration restricts outside lawn watering, enforcement is not feasible unless the restrictions are observed even by homeowners with private wells. Arguments by private well owners and well drillers, that they should be exempted are not practicable at this time. The State Office of Emergency Management should be supported in its efforts to restrict private wells from being used for lawn watering. However the jurisdictional issues related to enforcement of local or county declared drought emergencies may vary.

Preparedness: To forestall a localized or regional drought, water may have to be transported from surplus to deficit areas. However, existing rate and pricing arrangements may provide disincentives. For example, pumping costs for even a brief period may be high because they are linked to demand charges for periods when the pumps are not used. In other cases pricing agreements must be negotiated between purveyors for these occurrences. In both instances prior resolution of these pricing issues can clear away hurdles that improve preparedness and early response to drought.

In general the Committee recognizes one area of concern in the Department's overall water strategy to manage shortages. That concern is for the authority of the Department to manage use of interconnections during a Drought Alert or Drought Warning which precedes an Emergency.

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

RESPONSE TO WATER SUPPLY SHORTAGES

OVERVIEW

The Department responds to various water supply shortages. Response to water shortages is complicated by the unpredictability of weather patterns and our ability and inability to manage the distribution and use of water equitably during a time of shortage. We may characterize water shortages by their cause: drought, extraordinary demand, and source limitations. Shortages are also induced by mechanical failure and by contamination. Shortages for brief periods of time may be little more than an inconvenience. However, as the shortage grows in time and extent, other problems arise that can threaten the public's health, safety and welfare.

The Department may seek predetermined solutions to a shortage only to find there is no consensus on problems or priorities. Often, however, until normal conditions return, our responses will forestall the worst economic and environmental impacts.

Our responses reflect the limitations of our regulatory and legislative tools. Prior to the declaration of an Emergency by the Governor, the Department's authority to manage a water supply shortage is limited. Greater powers exist after the Declaration of an Emergency by the Governor. After the Declaration is made, the Department designates an emergency coordinator and delegates authority to him to manage the crisis. A brief description of the Department's response before and after a water shortage emergency follows.

It is recommended that additional work be undertaken to develop authority to forestall a Declaration of a Drought Emergency. The working paper on Triggers and Responses to Drought proposes a concept of when to Declare a Drought Warning or Emergency. This paper provides a framework for that additional work.

DROUGHT

A drought may be precipitated by an extreme deficit over as brief a period as five months (1989) or by a cumulative deficit over as long a period as two years (1964 - 1965). The variability of precipitation both in intensity and location can result in real and perceived problems. Prior to the declaration of a Drought Emergency, there must be a process to trigger the declaration of Warning and Emergency. Additional regulatory and legislative authority may be needed by the Department of Environmental Protection (Department) to initiate actions prior to a Drought Emergency declaration.

The proposed process considers precipitation and reservoir storage levels as drought indicators. Prior to an Emergency Declaration, the purveyor meets demands, but may forestall the Emergency by conserving storage, by using an alternate source of water, or by instituting some form of demand management. These pre-Drought Emergency issues are described in the Description of Triggers and Responses to Drought.

If the dry spell worsens, a Drought Emergency must be declared by the Governor. That declaration initiates administrative actions by the State Department of Environmental Protection and the State Office of Emergency Management. A Drought Coordinator is designated and a State Water Emergency Task Force is convened. The objective shifts from meeting demands to adjusting and restricting demands.

Restricting demands once an Emergency is declared is done according to an Allocation Plan. Allocation of water in short supply must be equitable, so that potential losses and hardship are borne fairly by each class of user. Appeals from administrative actions and for hardship must be heard.

Furthermore, restrictions are phased to protect highest priority uses. In order of lowest priority first, these uses are: outdoor uses, indoor nonessential uses, industrial and commercial uses, public health uses, crop production, drinking and sanitary water in the home, and fire protection.

The first three Phases of drought Emergency tighten restrictions on different classes of users and adjustable uses: outdoor uses (Phase I), indoor rationing (Phase II), and industrial and commercial curtailment (Phase III). Restrictions in Phases I and II are not to cause job layoffs or business failures. The fourth Phase (Phase IV) is when the emergency has become a disaster and quality cannot guaranteed. In prior droughts of 1980s and 1985, the Emergency reached Phase II.

Concurrently with demand management, actions are typically taken to conserve storage and utilize alternate sources of water. As rainfall occurs, there is a transition from emergency to normal conditions. The transition must also be managed. Until such time as reservoir storage is beyond doubt, the emergency may not be terminated. An official Termination notifies everyone that the Drought Emergency has ended.

To improve our response to drought we must act earlier. Some activities could be undertaken once a warning trigger has been tripped. However, to set those triggers, basic activities such as evaluation of precipitation deficits, reservoirs storage and demands need to be routinely updated. Some activities may be costly such as rehabilitation and testing interconnections. Some actions such as using an alternate supply may be wasted if heavy rains fill reservoirs subsequently. These actions prior to the Declaration of an Emergency will require funding and may require new legislation if purveyors are required to implement them.

Since 1980 a Drought Emergency or Warning has been declared by the State, the Delaware River-Basin Commission, or County five times. There is a direct cost to government, industry, and the water user as well as an indirect cost to our productivity and environment by this start and stop mode of operation.

For surface water supplies in northeast New Jersey the expense of developing new supplies may justify the costs of optimizing use of existing storage, treatment and distribution facilities.

MECHANICAL FAILURE

Equipment may fail either due to physical stress, operating stresses, deterioration, vandalism or fire. The failure may be gradual and hidden from view or it may be sudden and out in the open. The failure may create other hazards. The problem may be corrected with standby equipment that is automatically activated, with equipment or installation expertise from outside vendors or with assistance that goes beyond normal contractual avenues or financing. The purveyor is normally responsible for repairing the problem.

If pressure and volume demands cannot be met then a local, county or State emergency declaration may be warranted. The State Department of Environmental Protection, State Police Office of Emergency Management and the Board of Public Utilities will be involved at that point.

Since outages are routine to some extent, the Bureau of Safe Drinking Water (Bureau) presently requires redundant facilities for critical treatment units and valves to isolate parts of the distribution system. In addition either system storage or alternative sources capable of meeting peak demands are required.

Despite these precautions, the situation may require declaration of an Emergency and phased reductions in demand. If commercial or industrial operations were curtailed then issues related to hardship could trigger State actions. Lastly, if conditions worsened, mobilization of the National Guard through the State Office of Emergency Management to deliver water may be required.

This was the case from August 31 to September 8, 1985 when Trenton lost its treatment plant. System storage and interconnections could have helped to meet demands in that and other instances of pipeline failures. However, some systems do not as yet have interconnections or system storage in working order and remain at risk. Most purveyors must have interconnections capable of supplying 75% of their average demand with no interconnected system providing more than 25% of its total capacity.

Mechanical failure triggers two other responses. A report must be filed with New Jersey Department of Environmental Protection (Department) and Board of Public Utilities by regulated purveyors within the required timeframe. In addition a boil water Order may be issued. When the problem is corrected and the system tested satisfactorily for microbiological safety, the Boil Water Order and Emergency Declaration must be terminated officially.

CONTAMINATION

The source, treatment plant or distribution system may be contaminated microbiologically or chemically. The origin of the contaminants may be known or unknown. Distribution system contamination may occurr after a cross connection or backflow prevention fails. Treatment plant contamination may involve inadvertent release of caustic, acid, permanganate or chlorine into the water. Equipment failure may shutoff a chlorine feed and allow microbiological contamination to enter the system. At the source, contamination from industrial or commercial or residential waste may temporarily or permanently degrade a drinking water source.

Responses may involve switching to an alternate supply or temporary treatment for an immediate response. The State Office of Emergency Management may be called to truck in fresh water if an emergency is declared. Longer term responses must also be developed.

If the nature of the contamination is unknown, that is the health risk or the extent of the contamination is unknown, then the Declaration of an Emergency may also be warranted. However, the immediacy of the problem and lack of information is the typical handicap to a sure response.

The Department's Office of Emergency Response is often involved in the initial notification and assessment if a spill occurred. Most other problems are handled by the Bureau of Safe Drinking Water with support from the Division of Water Resources Enforcement unit. A Boil Water Order may be issued when necessary. Both the Boil Water Order and Emergency Declaration must be officially terminated when appropriate.

In those instances where the private wells of public non-community supply (serving less than 25 people) are contaminated, the Department can assist and advise local health departments on appropriate alternatives.

EXTRAORDINARY DEMAND

Lawn watering with automatic irrigation systems at residential and commercial sites has created an extraordinary demand on purveyors. Peak demands have been recorded at 5 to 7 times average for small systems (Park Ridge) serving less than 10,000 people. Even systems serving more than 250,000 people have experienced record peak demands (New Jersey American Water Company - Eastern Division).

In combination with pool filling and other water intensive activities, demands during any extended hot and dry period can rapidly deplete system storage, and exceed the pumping capacity to refill storage. These demands may result in loss of water service, low pressure, unfilled storage tanks, and dangerous public health problems.

Long term solutions to these problems can be addressed by new facilities. The Department requires that peak demands be met. Where distribution storage is inadequate, additional pumping capacity or storage may be added. Where well yields were insufficient, additional wells may be authorized, subject to Critical Area rules. Where treatment capacity is inadequate, additional capacity may be added. These measures may be essential for the future after the cause of the extraordinary demand is determined.

For a short term response, the purveyor may purchase water through interconnections. In an extreme case they may ask for treated water to be delivered by water tankers. However, typically demand management may be required. Then the ability of the purveyor to communicate the immediacy of the problem to a large number of people is critical. In those instance where public health and safety are jeopardized, an Emergency Declaration may be appropriate.

Large volume service shut offs or even residential shutoffs may be necessary. The authority and responsibility of government and the purveyor to respond must be developed.

Both the Board of Public Utilities, the State Department of Environmental Protection, and the State Police's Office of Emergency Management are to be involved in developing responses. They are also to be notified of any Emergency within the regulated timeframe. All Emergency Declarations must be officially terminated.

SUMMARY

In summary, the Department has existing authority and responsibility to respond to each cause of water shortage before and after an Emergency condition has been reached. Furthermore the State Police's Office of Emergency Management has authority and responsibility once an emergency has been declared. They often assist during a water supply emergency by providing water tankers. In most instances, the purveyor must initiate actions to forestall the Emergency. Additional authority for the the Department to guide purveyors during a drought and prior to a Drought Emergency may be warranted.

PS:WSSHORT:sr

Description of Triggers and Responses

Working Paper

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

DROUGHT SHORTAGES

The following procedures, to Trigger the Declaration of Drought Warning and Drought Emergency, amplify the description in the Overview. Possible responses are also presented.

Drought Emergency was declared by the Governor in September 1980 and April 1985 because of a lack of precipitation. In each instance, hindsight suggested that the Emergency should have been declared earlier. However, there is a built-in reluctance by the purveyor and State to declare an Emergency.

An Emergency Declaration brings both administrative costs and a loss of water revenues. It reverses the normal order of operations. It assumes that there will be less precipitation in the future which is contrary to our expectations. The variability and unpredictability of weather patterns affects our response to the real and perceived problems. It may be only natural in these circumstances to delay an Emergency Declaration. On the otherhand if restrictions are called to late then the water that could have been conserved may have already been used. Therefore, it may be more appropriate to initiate a Drought Warning and to regulate demand management or to order water transfers rather than wait till a Drought Emergency occurs.

Once a Drought Emergency is declared it is difficult to rescind until we are certain the dry spell has ended. The 1980/1981 Drought was not officially terminated until April 1982. The 1985/1986 Drought was not officially terminated until March 1986.

In general an appropriate response to an extended dry spell involves timely use of alternate supplies, new sources, demand management and required reservoir releases. The mix will be determined by the severity of drought, the season, the expected demands and the availability and cost of alternate supplies and new sources. Therefore responses may vary from year to year and from purveyor to purveyor.

Short term goals should be set for each set of reponses. These goals help measure the effectiveness of the response and determine if mid-course corrections are needed. Goals must specify a measureable objective and a time frame.

Measurable objectives include specific reservoir levels, reductions in demand, quantities of water transferred, and possibly, construction of needed interconnections or new sources. Objectives must be achievable and monitored on a daily and weekly basis. The time frame should include critical dates that allow for subsequent more stringent actions. At the height of a drought, the time frame for shifting resources may decrease from a month to a week.

The Declaration of a Drought Warning or Drought Emergency will be triggered by hydrological indicators that are measurable and widely acceptable. However, prior to the actual Declaration general and specific discussions must be initiated with all affected purveyors and agencies. The Governor must designate the area.

At the time a Drought Emergency is declared, a Drought Coordinator must be designated. The Coordinator has the responsibility and the authority to direct the timing and severity of restrictions. The Coordinator must advise the Commissioner and the Governor of the appropriate area to be covered by the different Phases of a Drought Emergency.

In New Jersey two indicators are proposed for use: reservoir storage and precipitation deficits. The first, reservoir storage depicted in Graph A, reflects the runoff from the watershed into the reservoir, evaporation from the reservoir, demand and releases from the reservoir into streams below the dam to meet downstream requirements. The second, precipitation deficits, depicted in Graph B, indicates the severity of the drought and how much rain may be needed before normal conditions return.

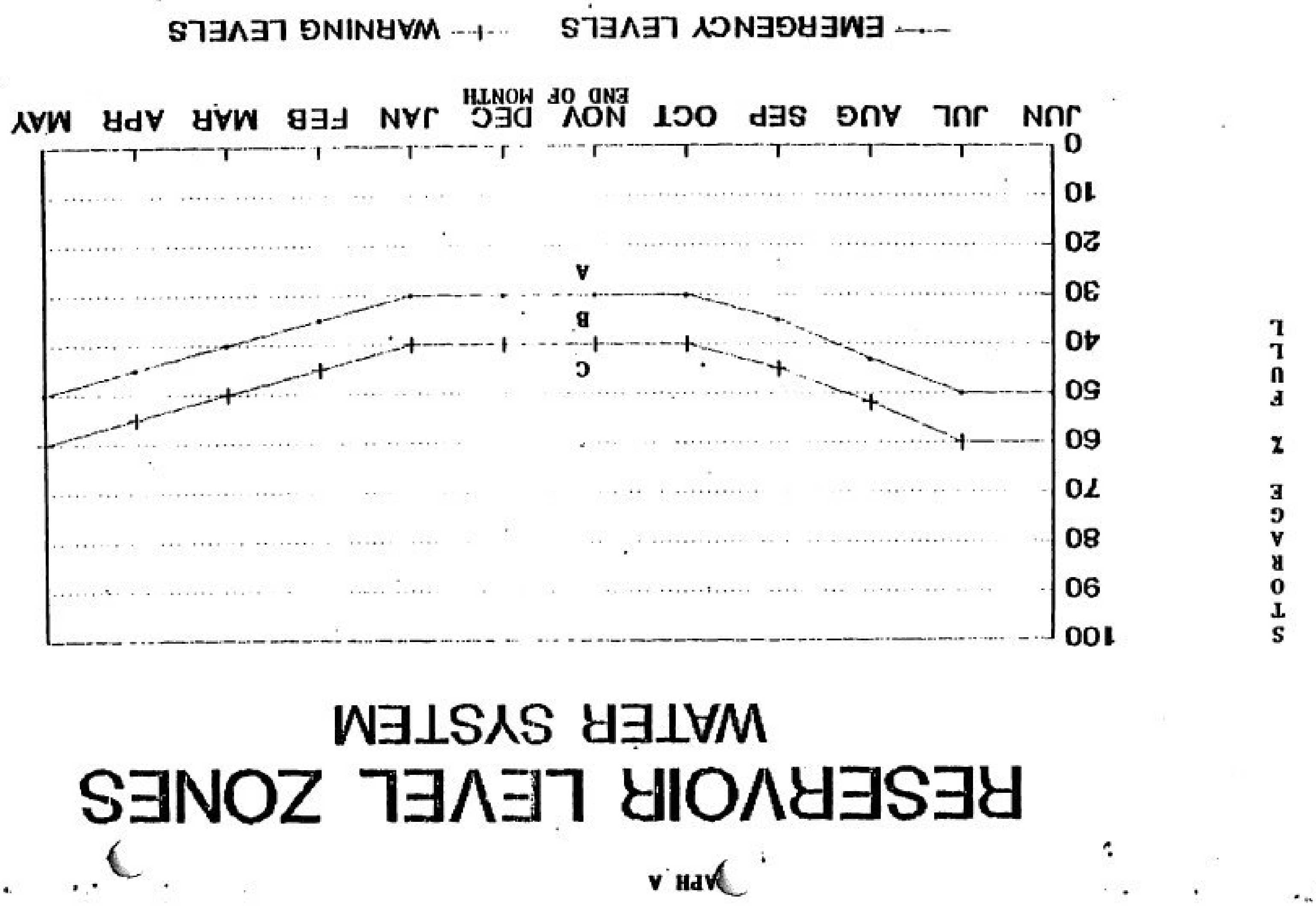
For sections of New Jersey these indicators have been combined to describe the water supply condition. This is depicted in Table C. The water supply condition is related not only to the hydrological indicators, precipitation and reservoir storage, but also to the season, the assumed demands and potential responses. Since these Graphs and Tables are based on past events for the most part they must be updated.

If these hydrologic triggers are adjusted, the effect is to increase or decrease the frequency at which the responses are tripped. Table D gives an example of the historic response to a set of triggers. The time required to implement the response should guide us in determining the frequency with which triggers are tripped. The first response once an alert has been sounded is to draw the purveyors together and discuss the situation and review the next set of triggers and responses.

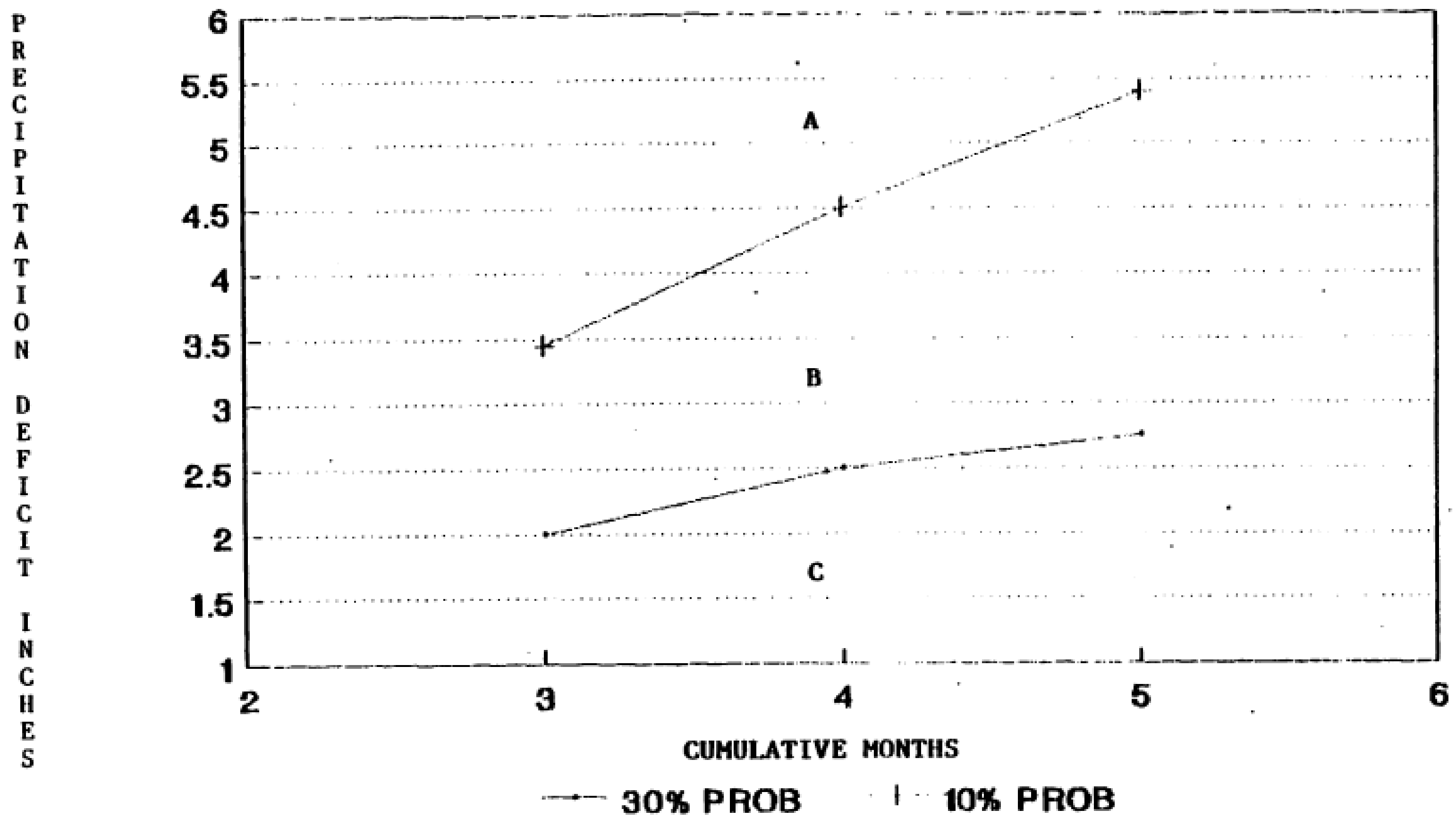
In New Jersey the hydrologic record was checked and the frequency of occurrence is noted on Table D. It indicates that a Drought Emergency would be declared less than 1% of the time, while a Drought Warning would occur 3% of the time. The analysis makes certain assumptions about demands and environmental constraints.

Summary

Triggers for areas of New Jersey are needed and are being developed. However, at this time it remains the purveyors responsibility to develop appropriate responses until the unexpected severity of a drought necessitates the Declaration of a Drought Emergency. Therefore, if the Drought Warning Triggers are to be utilized, it may be necessary to develop additional authority for the Department to initiate purveyor actions, especially after a Drought Warning has been tripped.


EMERGENCY LEVELS
WARNING LEVELS
END OF MONTH
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
0
10
20
30
40
50
60
70
80
90
100
A
B
C
% STORAGE FULL
WATER SYSTEM
RESERVOIR LEVEL ZONES

GRAPH B
NEW JERSEY PRECIPITATION DEFICIT ZONES
FEBRUARY & MARCH



6-1-89

EXAMPLE

TABLE C

WATER SUPPLY CONDITION	STORAGE	PRECIPITATION
NORMAL	C	C
	B	C (June to Oct.)
	C	B
ALERT	C	A
	B	C (Nov. to May)
	B	B (June to Oct.)
WARNING PHASE 1	A	C
	B	B (Nov. to May)
WARNING PHASE 2	A	B
	B	A
EMERGENCY	A	A

EXAMPLE

TABLE D

FREQUENCY OF OCCURRENCE
WATER SUPPLY SYSTEM

(Note: - This Table should be read in conjunction with Precipitation & storage Graphs)

WATER SUPPLY CONDITION (month/year)	STORAGE vs. PRE.DEF.	NUMBER OF OCCURRENCES (Months)	FREQUENCY (PERCENT)
NORMAL	C/C B/C (June to Oct.) C/B	601 out of 705	85.2
ALERT	C/A B/C (Nov. to May) B/B	81 out of 705	11.5
WARNING 1	A/C B/B (Nov. to May)	11/38;11/39;11/49;12/49; 10/53;11/57;10/65 11/65;12/65; = 9 out of 705	1.3
WARNING 2	A/B B/A	12/39;1/40;2/40;11/53;8/57; 9/57;10/57;10/63; 10/64;12/64;8/65;9/65; = 12 out of 705	1.7
EMERGENCY	A/A	11/41;11/64 = 2 out of 705	0.3

Phases I, II, III, or IV

Pre. Def. = Precipitation deficit as described in Graph B
Storage = Reservoir storage as described Graph A

GLOSSARY OF WATER SHORTAGE TERMINOLOGY

This glossary describes some common terms used during a water shortage. By disseminating this glossary it is hoped that information may be passed on to the public with a minimum of confusion. These descriptions are not to be used as precise definitions for drought related events. Furthermore since media in New York and Pennsylvania reach into New Jersey, we have attempted to keep our terminology comparable to their terminology. However, New Jersey statutes and regulations have given definition to some terms. Those instances are noted.

1. NORMAL - Weather conditions are typical of those patterns of rainfall or dryness which occur routinely during particular seasons and from year-to-year.

2. DROUGHT ALERT OR DROUGHT ADVISORY - This term describes a precipitation deficit sufficient to prepare for a drought warning.

3. WATER SUPPLY WARNING - Weather events that may lead to shortages or operating conditions that cannot be met with existing facilities. Management of supply facilities and customer demand may be needed to assure safe, adequate and proper service in the near future. Supply management practices must focus on the increasing storage. Typical demand management practices include restricting lawn sprinkling. Out of basin transfers may be restricted as is done by the Delaware River Basin Commission (D.R.B.C.). DRBC regulations allow a Stage 1 or 2 Drought Warning to be declared. (D.R.B.C./N.J.A.C. 7:19A-5.1(d).

4. PHASE I, WATER SUPPLY DROUGHT EMERGENCY - Weather events and operating conditions that stress the capacity of existing facilities. A potential threat to maintain public health and safety exists. Adjustable uses may have voluntary or mandatory reductions with reasonable exemptions for hardship or matters related to the maintenance of public health and safety. Voluntary water conservation for indoor residential uses should be encouraged. (N.J.A.C. 7:19A-5.3).

5. PHASE II, WATER SUPPLY DROUGHT EMERGENCY - Weather events and operating conditions that jeopardize the ability of existing facilities to maintain public health and safety. Adjustable uses must be restricted. Residential use must be restricted to 50 gallons per person per day and fines/surcharges imposed for exceeding restrictions. Voluntary commercial and industrial reductions are to be encouraged. (N.J.A.C. 7:19A-5.4)

6. PHASE III, WATER SUPPLY DROUGHT EMERGENCY - Weather events and operating conditions that exceed the capacity of existing facilities to maintain public health and safety. Adjustable uses must be restricted. Residential uses must be restricted to 50 gallons per person per day. Industrial and commercial facilities will be subject to restrictions and possible shutdown. Fines shall be imposed for uses which exceed curtailment criteria. (N.J.A.C. 7:19A-5.5).

7. PHASE IV, WATER SUPPLY DROUGHT EMERGENCY - DISASTER - Public health and safety cannot be guaranteed. The availability of a continuous supply of water and its quality cannot be assured. Restrictions in force at Phase III will be continued and supplemented with selected business closing by order of the New Jersey Department of Environmental Protection and State Office of Emergency Management. (N.J.A.C. 7:19A-5.6/App. A:9-33).

8. DROUGHT - A condition of dryness due to lower than normal precipitation (N.J.A.C. 7:19-6.2).

9. PRECIPITATION DEFICIT - The difference between average monthly rainfall and actual monthly rainfall.

10. SAFE YIELD - The water that can be supplied throughout the most severe drought of record including releases from reservoirs to maintain stream flows (N.J.A.C. 7:19-6.2).

11. SHORTAGE - A condition which exists when the water that can be supplied by a system is less than the customer demand for reasons of drought, lack of pumping capacity, or mechanical failure in the system.

12. WATER SUPPLY EMERGENCY RESPONSE PLAN - The documents submitted by each purveyor to the NJDEP outlining actions it will take to assure water supply during a water emergency (N.J.A.C. 7:19A-1.4).

13. GROUND WATER BASIN SAFE YIELD - The maximum rate of withdrawal that can be sustained by a complete hydrogeologic system in a groundwater basin without causing long term and unacceptable lowering of water levels, irreversible water quality degradation, or the permanent loss of well capacity. (Conn. App. C Sed 25-32d-01).

14. WELL SAFE YIELD - The maximum amount of water that can be removed from a well without damaging the well or pumping equipment. The safe yield of a well may be estimated by evaluating the performance of the well and aquifer over a historic drought (N.J.A.C. 7:19-6.2).

15. PALMER DROUGHT SEVERITY INDEX - A numerical index value calculated by the National Oceanic & Atmospheric Administration which depicts prolonged abnormal dryness or wetness. The index reflects soil moisture, run-off, recharge, percolation, as well as evapotranspiration. The index is useful in measuring effects or prolonged dryness or wetness on agricultural and outdoor uses.

16. ADJUSTABLE WATER USES - Those uses of water that are not essential to our health, safety or welfare. Typically they are for aesthetic or ornamental purposes (lawn water for example). Water so used typically is substantially lost to evaporation (N.J.A.C. 7:19A-1.4).

17. EXEMPTIONS - Those uses for which an exception may be granted if specific restrictions are obeyed to avoid undue hardship and to minimize water losses.

18. EXTRAORDINARY DEMAND - Water supply needs which occur on a single or consecutive days that exceed the capacity of pumping, treatment, or storage facilities. If low pressure conditions are widespread or it is not possible to refill equalization storage

during any day, then demand management is warranted. Furthermore, if the purveyor is not able to communicate the immediacy of the problem and the need for demand management to a large number of people then the Emergency Declaration is appropriate.

PS:GLOSSARY:sr

APPENDIX C

ENFORCEMENT SUBCOMMITTEE

REPORT

...Union Avenue • P.O. Box 158 • Hazlet, New Jersey 07730 • (201) 26—55.0

To : Water Emergency Planning Team (W.E.P.T.)

From: Michael P. Walsh, Chairman
Team Enforcement and Restrictions (T.E.A.R.)

Date: May 1989

The Enforcement Subcommittee recommends that the Water Emergency Planning Team approve the proposed tariff language (Exhibit A) and the proposed Model Ordinance (Exhibit B) dealing with potable water emergency conditions.

The following schedule suggests the appropriate restrictions, enforcement and communication responses to various status conditions:

Local Purveyor Responses

Status	Restriction	Enforcement	Comment
Advisory	None	None	Public notification TV, radio, newspapers
Warning	Voluntary Conservation	None	Public notification
* Emergency I	Mandatory Outdoor Use Restriction	Discontinuance	Public notification, plus door tags
* Emergency II	Mandatory Outdoor and Indoor Use Restrictions	Discontinuance	Public notification, plus door tags

* Door tags will be sequentially numbered and include the location and time of violation. Purveyor will account for all door tags.

The suggested tariff language provides actions which a purveyor may take in response to extraordinary demand and/or diminished supply conditions. In choosing an appropriate response, a purveyor must provide reasonable notice to its customers by newspapers or other form acceptable to the B.P.U. and must be prepared to substantiate its actions to the B.P.U.

C-1

In drafting the Model Ordinance an effort was made to be generic. In doing so, however, we did not intend to limit a municipality's flexibility. In order to be expeditious, the municipality may choose a single individual, such as the Mayor, Administrator, or Clerk to declare the emergency rather than the governing body.

Legislation in some form may be required in order to implement the various provisions of W.E.P.T. In recognition of the required timeframe to draft, introduce, and sign into law any new legislation, the legislative effort should parallel B.P.U., D.E.P. and municipal implementation.

The Enforcement Subcommittee recommends the following:

A. Submission of the proposed Tariff language to the Board of Public Utilities for their approval.

B. Delivery of the proposed Model Ordinance to the State's 567 municipalities for their adoption.

C. Legislative action be pursued by the D.E.P., B.P.U. and all Committee members.

Respectfully Submitted,

Michael P. Walsh, Chairman
Enforcement Subcommittee

MPW:mk

12-a
4/26/89

BOARD OF PUBLIC UTILITIES
LEGAL DIVISION

MEMORANDUM

TO: President Christine Todd Whitman
Commissioner George H. Barbour
Commissioner Robert N. Guido

FROM: Jeanne M. Fox, Director
Division of Water & Sewer

Suzanne N. Patnaude
Regulatory Officer

DATE: April 14, 1989

SUBJECT: Water Emergency Planning Team
Proposed Model Tariff and Ordinance

The Water Emergency Planning Team (W.E.P.T.) respectfully requests that the Board approve the Committee's recommendations and require all water purveyors under its jurisdiction to adopt uniform tariff language (Exhibit A) enabling the utilities to deal with conditions of extraordinary demand and/or diminished supply. Should the Board concur, an Order will be prepared for your signature.

The Committee further recommends that the Board use the full prestige of its office to encourage the adoption of the Model Ordinance (Exhibit B) by all New Jersey municipalities.

The representatives of State government and the industry who participated in drafting these proposals believe that the conclusions reached and recommendations made will alleviate confusion associated with water emergency declarations and will minimise restrictions by enforcing uniform compliance.

We are available to discuss these recommendations at your convenience.

Respectfully submitted,

Jeanne
Jeanne M. Fox

Suzanne Patnaude

SNP/mdp
Attachments

C-3

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4/29/86

EXHIBIT-A

1. EMERGENCY RESPONSES DUE TO EXTRAORDINARY DEMAND AND/OR DIMINISHED SUPPLY

1.1 Discontinuance of service for failure to comply with use restrictions.

For compliance by the utility in good faith with any governmental order or directive, notwithstanding that such order or directive subsequently may be held to be invalid, the Company may, upon reasonable notice, as set forth in sections 2.1 and 2.3 herein, suspend, curtail, or discontinue service pursuant to N.J.S.A. 48:2-23, N.J.S.A. 48:2-24, and N.J.A.C. 14:3-3.6 for any of the following acts or omissions on the part of the customer:

(1) Connecting or operating any piping or other facility, including but not limited to, lawn sprinkling on the customer's premises or such a manner as to adversely affect the safety or adequacy of service provided to other customers present or prospective; or

(2) Continuing waste of water by customers after notice from the utility through improper or imperfect pipes, fixtures, or failure to compl with restrictions; or

(3) Failure to comply with the standard terms and conditions contained in this tariff or failure to comply with any state law, or the rules, regulations, orders or restrictions of any governmental authority

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having jurisdiction.

1.2 Water service shall be restored when the conditions under which such service was discontinued, as specified above, are corrected and upon the payment of the SPECIAL RESTORATION OF SERVICE CHARGE of $100.00 for each restoration.

2.1 The Company will endeavor to provide a regular and uninterrupted supply of water through its facilities. However, if because of emergencies beyond the control of the Company, including governmental mandate, service is interrrupted, irregular, defective or fails, the Company will not be liable for damage or inconvenience resulting therefrom. In the event of an extraordinary demand and/or diminished supply, the Company may restrict the use of water whenever the public welfare may require it and, if necessary, may shut off the water in its mains and pipes. In such cases the company shall advise its customers by placing a prominent advertisement detailing the conditions and restrictions in a newspaper of general circulation in the utility service area. The notice will state the purpose and probabl duration of the restriction or discontinuance. Failure to provide regular and uninterrrupted service due to breakdowns is covered under other sections of this tariff.

2.2 The Company may restrict water service during certain periods, where the Company advises the Board of Public Utilities, in order to protect the public water supply, or otherwise to comply with any regulations, orders o decrees issued by the Governor of New Jersey or the Department of

Environmental Protection pursuant to the Water Supply Management Act. Such interruptions or restrictions shall be reported to the Department of Environmental Protection and the Board by each utility by the speediest means of communications available, followed by a detailed written report, pursuant to the provisions of N.J.A.C. 14:3-3.9(b), within one week. Thereafter the utility shall provide weekly reports for the duration of the emergency.

2.1 When the supply of water to individual customers is to be shut off or curtailed for failure to comply with emergency water restrictions imposed because of extraordinary demand or diminished supply, the company shall advise its customers by placing a doortag on the front door of the home of the individual(s) in violation of the restrictions, at least twenty-four (24) hours prior to discontinuance or curtailment, or by giving another form of notice acceptable to the Board. The company will advise business and commercial customers, in writing, by mailing a notice to the customers billing address. In the case of doortags, they shall be sequentially numbered and include the date, time and nature of the violation and the procedure for restoration of service. All such notices shall be accounted for by the utility.

AGENDA DATE: 4/26/89

STATE OF NEW JERSEY
BOARD OF PUBLIC UTILITIES
TWO GATEWAY CENTER
NEWARK, N.J. 07102

WATER AND SEWER/LEGAL

UNIFORM REVISION OF WATER UTILITY TARIFFS)
)

ORDER
DOCKET NO. WT89040372

BY THE BOARD:

In response to the extraordinary water demand and/or diminished supply problems experienced by New Jersey water utilities in recent years, a Water Emergency Planning Team (W.E.P.T.) was established in the fall of 1988 at the direction of this Board. Representatives of the Board of Public Utilities, the Department of Environmental Protection and the water industry served on the W.E.P.T.

W.E.P.T. members met frequently in order to assess the potential for future occurences and to recommend procedures to be followed. W.E.P.T. recommended the adoption of uniform tariff language enabling the utilities to deal with conditions of extraordinary demand and/or diminished supply.

Pursuant to N.J.S.A. 48:2-13, vesting the Board with general jurisdiction over utilities and their facilities, N.J.S.A. 48:2-23, which requires the utilities to furnish safe, adequate and proper service, N.J.S.A. 48:2-24, N.J.A.C. 14:3-3.6 (B) 3 viii and ix, the Board ACCEPTS the revised tariff language, attached hereto.

Pursuant to N.J.A.C. 14:1-6.15, the Board HEREBY DIRECTS each water purveyor subject to its jurisdiction to submit revised tariff pages, including the language attached, within thirty (30) days of the effective date of this Order.

This Order shall take effect immediately.

DATED: April 26, 1989

BOARD OF PUBLIC UTILITIES
BY:

CHRISTINE TODD WHITMAN
PRESIDENT

GEORGE H. BARBOUR
COMMISSIONER

ATTEST:

MARGARET M. FOTI
SECRETARY

Mayor and Council:

In response to the water emergencies of the recent past, representatives of the Board of Public Utilities, the Department of Environmental Protection and the water industry of the State of New Jersey formed the Water Emergency Planning Team (W.E.P.T.). The Committee met many times over the September 1988-April 1989 timeframe in order to assess the potential for future occurrences and to recommend procedures to be followed.

A subcommittee of W.E.P.T was formed to specifically address enforcement and regulation. The makeup of the membership of the Enforcement Subcommittee mirrored that of the main W.E.P.T. Committee. As a result of these committee meetings, the ordinance empowering the governing body of the municipality to declare a water emergency has been prepared, copy attached.

We urge each municipality to enact without delay an ordinance similar to the model. The model ordinance is designed to remain dormant until such time as the "governing body" passes a resolution declaring a water emergency. The term "governing body" may be revised to name a specific official who is charged by the municipality with declaring the water emergency. When drafting the declaratory resolution, the governing body may include specific restrictions and may identify special exemptions, such as landscapers, nurserymen, laundromats, car washes, etc. The use of private wells should not in and of itself be a basis for an exemption from outside water use restrictions. Prior droughts indicate that serious enforcement problems arise if restrictions are not uniformly followed.

It is our hope that by use of this model ordinance, your municipality will have better control over its water resources during times of extraordinary demand. If conditions warrant the

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declaration of an emergency by the State, then the State's regulations would take precedence.

In the event that you have any questions, please contact either John Fitzpatrick, at the Board of Public Utilities ((201) 648-7665) or Paul Schorr, at the Department of Environmental Protection ((609) 292-5550).

Sincerely,

Christine Todd Whitman
President
Board of Public Utilities

George H. Barbour
Commissioner
Board of Public Utilities

Christopher J. Daggett
Commissioner
Department of
Environmental Protection

CTW/SNP/mdp
Enclosures

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EXHIBIT-B

4/26/89

AN ORDINANCE EMPOWERING THE GOVERNING BODY OF THE MUNICIPALITY TO DECLARE A WATER EMERGENCY WITHIN THE MUNICIPALITY AND ESTABLISHING WATER USE RESTRICTIONS DURING A WATER EMERGENCY IN THE MUNICIPALITY IN THE COUNTY OF ____________ AND STATE OF NEW JERSEY

WHEREAS, the Water Company has identified a water emergency within the municipality and has adopted water use restrictions in an effort to maintain the quality of water service; and

WHEREAS, pursuant to N.J.S.A. 40:48-2, the municipality has the power to adopt ordinances necessary and proper for the protection of persons and property and the preservation of the public health, safety and welfare; and

WHEREAS, the governing body finds, for the purpose of responding to all water emergencies occurring in the future, that it requires the adoption of procedures for the implementation and enforcement of water use regulations in the Municipality in order to protect the residents, businesses and property and to preserve the public health, safety and welfare;

NOW THEREFORE, BE IT ORDAINED by the governing body of the municipality in the County of ________ and State of New Jersey as follows

1. Declaration of Water Emergency. Whenever the governing body

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4/26/89

shall be satisfied and finds that a water emergency exists in the municipality, it may adopt a resolution declaring that a water emergency exists in the municipality. Such resolution shall be adopted by the governing body at any regular, special, adjourned or emergency public meeting of the governing body. Such resolution shall identify that portion of the municipality affected by the water emergency, which may include the entire municipality and shall specify which of the water use regulations contained in Paragraph 2 of this ordinance is being imposed as well as any exemptions as may be authorized. Such resolution shall be effective immediately upon publication according to law and shall continue in effect for ninety (90) days, unless extended or repealed as set forth in paragraph 3 of this ordinance. For the purpose of this paragraph, a water emergency shall exist, for any of the following reasons:

a. the public utility providing water service to all or a portion of the municipality has adopted water use restrictions, has notified the municipality, the New Jersey Board of Public Utilities, an[illegible] the New Jersey Department of Environmental Protection, as well as any ot[illegible] State, county or local agency entitled to notice of such restrictions and such restrictions are not overruled or declared invalid by any State, county or local agency or court having the jurisdiction and power to do so or

b. the governing authority is otherwise satisfied that a water emergency exists in the municipality.

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2. Water Use Restrictions. Upon adoption by the governing body of a resolution declaring that a water emergency exists in the municipalit in accordance with Paragraph 1 of this ordinance, all citizens shall be urged to observe voluntary indoor conservation measures and, any of the following water use restrictions shall be imposed and shall be applicable to all residents and tenants, including those with private wells, except where a bona fide health emergency exists and to exempt businesses, as specified during the water emergency:

a. the complete ban and prohibition of outside water usage, including the watering of lawns and plants, the filling of pools and the washing of cars; or

b. outside water usage on alternate days allowing outside wat usage by persons or businesses having even house or box numbers on even days and those having odd house or box numbers on odd days with outside water usage being completely banned and prohibited on the thirty-first da of any month during the water emergency; or

c. any other water use restriction specified by the governing body in the resolution required by Paragraph 1 of this ordinance which is reasonable under the circumstances considering the nature and extent of t water emergency. Any water restriction imposed pursuant to this paragra shall be limited in application to that portion of the municipality, whi may include the entire municipality, identified as being affected by the water emergency in the resolution of the governing body adopted in

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accordance with Paragraph 1 of this ordinance.

3. <u>Duration of Water Use Restrictions.</u> The resolution of the governing body required by Paragraph 1 of this ordinance shall, in addition to complying with Paragraph 1, provide a period of time during which the water use restrictions imposed shall be applicable and which shall be no longer than reasonably necessary to abate the water emergency under the circumstances considering the nature and extent of the water emergency. At the expiration of the time period specified in the resolution, the water use restriction shall lapse and be inapplicable and unenforceable. If the governing body shall be satisfied that the water emergency has been abated prior to the expiration of the time period specified in the resolution, it shall adopt a resolution declaring the water emergency ended and the water use restrictions inapplicable. If, at the expiration of the time period specified in the resolution, the governing body shall be satisfied that the water emergency continues to exists, it may adopt a resolution in accordance with the requirements of this ordinance continuing the water use restrictions.

4. <u>Enforcement of Water Use Restrictions.</u> The water use restrictions imposed pursuant to this ordinance shall be enforced during a water emergency by the local authorized official(s). Whenever a local authorized official shall find a violation of the water use restrictions, such authorized official shall give the violator a written warning and explain the penalties for a second and third offense as provided by Paragraph 5 of this ordinance. The local authorized official shall keep

such records as may be reasonable and necessary for the purpose of determining the persons and businesses who have been warned upon a first or any subsequent offense. The local authorized official is hereby empowered to write summonses for the violation of the water use restrictions imposed pursuant to this ordinance.

5. Penalties. After a first offense in accordance with Paragraph 4 of this ordinance, any person or business who thereafter violates the water use restrictions imposed pursuant to this ordinance shall be fined or imprisoned in accordance with this paragraph. For a second offense, the fine imposed shall be a minimum of $100.00 up to a maximum of $500.00 or imprisonment for ten days or both. For a third and subsequent offense, the fine imposed shall be $1,000.00 or imprisonment for thirty days or both.

6. Severability. If any section, paragaph, subdivision, clause or provision of this ordinance shall be adjudged invalid, such adjudication shall apply only to the section, paragraph, subdivision, clause or provision invalidated and the remainder of this ordinance shall be valid and enforceable.

7. Repealer. All ordinances and resolutions or parts thereof inconsistent with this ordinance are hereby repealed.

APPENDIX D

COMMUNICATIONS AND EDUCATION

SUBCOMMITTEE REPORT

06-15-89 THU 14:23 NJ AMERICAN-NORTHERN

New Jersey-American Water Company

Northern Division • 233 Canoe Brook Road • Short Hills, NJ 07078

(201) 376-8800

D.L. Conyers
Division Manager

June 14, 1989

COMMUNICATIONS SUBCOMMITTEE REPORT

The press and public should be educated in terms of drought definitions as well as basic "trigger" explanations that any layman could comprehend. Once these terms are explained and understood, it is important that all future communications utilize these terms throughout the emergency so as not to confuse the public.

The communications to the public and to the purveyors should be disseminated on a uniform basis. We recommend that a spokesperson who is responsible for communications for the BPU and also an individual who is responsible for communications for the DEP, along with a representative of each water purveyor, meet and arrive at a uniform method of communicating with the public or our customers. The media for communications would be a coordinated effort with the various major newspapers for the State along with independent television such as New Jersey network TV and radio stations which service the major areas of the State.

The Communication Subcommittee has set in motion the following program for 1989. A TV program with New Jersey network TV and a spot on the program for the fall meeting of the League of Municipalities.

Finally, individual water systems that experience "stress" due to hydraulic problems such as low system pressures due to high demands, should not be interpreted as a need to put the whole State on "alert" status. These localized problems are best dealt with on a system by system basis, and only very selective communication should be practiced to avoid alarming misinterpretations of such incidents.

Very truly yours,

D L Conyers

D. L. Conyers
Chairman, WEPT Communication Subcommittee

D-1

June 14, 1989

DROUGHT EMERGENCY COMMUNICATIONS PLAN

I. "Normal Communications" (Routine)

Normal lines of communication between water purveyors in the State (includes private, public, municipal, authorities, and the DEP etc.) are necessary on a predetermined frequency to establish a database of "trigger components" (i.e. temperature, rainfall, ground water levels, stream or river levels, etc.). This information should be received, digested and analyzed for "trigger" signals. The resulting analysis and data could be released in the form of a general water supply/meterological report distributed to all contributors as well as key State agencies such as the BPU. Two reports entitled "Climatological Data-New Jersey" by N.O.A.A. and "Summary of Monthly Hydrologic Conditions in N.J." by U.S.G.S./D.E.P. presently exist and could be modified to include a "Drought Trigger Water" analysis which would advise subscribers of factors (as defined by the Trigger Subcommittee) indicative of a pending drought in its earliest stages. (It should be noted that "local triggers" may not be enough to warrant a State-level alert such as was the case in Monmouth County during the summer of 1988.)

II. "Drought Advisory"

As trends in the weather pattern dictate, certain "triggers" would be identified and analyzed, and should these conditions meet the proper "trigger criteria", a "trigger alert" would be issued by the DEP, notifying purveyors that they should assume a stand-by status until further notice. Communications at this phase could consist of a written notice issued by the DEP advising that unless conditions improve, a water supply problem may develop in the near future and that all purveyors should start "dusting off" drought emergency plans. The Individuals responsible for the communication function of the WEPT Plan will meet to prepare for the communication activities outlined in the communication plan as set forth below. No further communications at this point are necessary.

III. "Drought Warning"

"Trigger" mechanisms at this point would indicate that unless a significant change in weather patterns develops, a "drought emergency" may be declared. Purveyors would be notified first by telephone followed, by written confirmation via Fax from the DEP, that curtailment of certain water use activities should be considered on a voluntary basis for their customers. Communications at this time would consist of a notice from the DEP to the BPU, purveyors and key State agencies, thereafter, a general news release should be issued to the wire services and public service announcements on radio and TV to "use water wisely". A special mailing for customer notification should be prepared in the event a "Drought Emergency" phase be reached. (Should conditions warrant it on a local level, water systems experiencing more advanced "Trigger" indications should issue their own news releases or customer notification depending on the situation.

IV. "Drought Emergency" Phase I

At this point in time most "Trigger" mechanisms have been "tripped" and the first phase of mandatory water use restrictions is placed into effect. Communication at this phase should begin with an issued "drought emergency" by the DEP to all purveyors and municipal and county officials including the County Emergency Management Network (enforcement of mandatory water use restrictions will be required at this point at which may be State-wide or regional). A State-wide or regional drought emergency will be officially proclaimed in a news release/conference by the Governor and some formal mandatory restrictions including rationing may be imposed.

All customers subject to mandatory restrictions should receive a special communication from their purveyor explaining the restrictions and penalties associated with violation of the restrictions. The mailing should also inform customers that more stringent mandatory water use restrictions could be implemented if drought conditions warrant. Individual water supply problems experienced by purveyors should be reported to a single DEP & BPU phone number. A standard "short form" water supply report should be submitted to the designated DEP "Drought Command Post" with a copy to the BPU on a weekly basis. A DEP drought status report should be released periodically in the form of a news release to keep the public advised of any change in status on restrictions.

The DEP will establish a toll free "800" number to respond to customer inquiries regarding the drought emergency.

V. "Drought Emergency" Phase II

All purveyors, municipalities and county agencies should receive written notification from the DEP advising of the state-of-emergency. All water purveyors should report their water supply status to the designated drought command post on a weekly basis using a standardized "short form" with a copy to the BPU on a weekly basis. Water supply emergencies or problems should be reported to the 24 hour DEP Emergency phone number (609-292-7172). Should special "local" supply problems exist, the purveyor should issue a news release to the local papers. Customers should be notified by individual mailings using the language developed specifically by this committee. Drought Status reports should be issued weekly by the DEP in the form of a news release.

VI. "Drought Emergency" Phase III

Refer to communication in Phase II

VII. "Drought Emergency" Phase IV - Disaster

Refer to communication in Phase II

VIII. Cancellation of Drought

When weather conditions are such that the "trigger" mechanisms indicate that recovery from the drought is in progress and that restrictions can be lifted, The Governor should officially proclaim the drought emergency has passed in whole or in part through a news release and that specific water use restrictions are lifted (as warranted). The DEP should notify, in writing all purveyors, municipal and county agencies that the emergency is over and identify the restrictions (if any) to remain in effect. Depending on the speed of recovery, purveyors should notify customers via news releases, that the emergency is over, but, to continue to use water wisely.

In conclusion, the above stated "plan" is very basic, yet establishes numerous critical points where communication is essential in the event of a drought or near-drought. It is important to keep the lines of communication simple, yet concise. One DEP central drought "command post" should be established along with the DEP emergency (24 hour) phone number and specific people to contact (only one contact should need to be made). The reporting information should be kept to a minimum and a standard "short form" (one side of one 8-1/2" x 11" page) should be developed and submitted to the DEP "command post" with copy to the BPU. Emergency communication channels within the State should then see to it that all proper State authorities are kept informed eliminating the need for the purveyors to notify several agencies or file a multitude of different reports basically stating the same information.

Submitted by:
Communication Subcommittee

Drought Warning

RECEIVED
AUG 11 1989
CHIEF ENGINEER

Let's protect our earth

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES
CN 029
Trenton, N.J. 08625-0029

Jorge H. Berkowitz, Ph.D.
Acting Director

(609) 292-1637
Fax # (609) 984-7938

August 7, 1989

Dean C. Noll, P.E.
Chief Engineer
North Jersey District Water Supply Commission
1 S.A. Orecchio Drive
Wanaque, New Jersey 07465

Dear Dean:

Re: Drought Warning and Drought Emergency

The purpose of this letter is to obtain your concurrence with enclosed criteria including graphs used to describe various water supply shortage conditions. Your comments on suggested responses are also requested.

The Reservoir Storage graphs are specific to each reservoir system in northeast New Jersey: Newark, Hackensack, Jersey City, and North Jersey District Water Supply. Precipitation Deficit graphs for northeast New Jersey are also attached. Each graph has been divided into three zones based on the 10th and 30th percentile event. When the Precipitation Deficit and Reservoir Storage graphs are combined as is done in Table A, water supply shortage conditions ranging from normal, alert, warning, to emergency can be defined.

The frequency with which different water supply conditions could be triggered can be changed by adjusting one or both graphs. An historical analysis of the proposed system with existing conditions for the N.J.D.W.S. Commission indicates: Drought Alert would have been triggered 81 of 705 months; Drought Warning would have been triggered 21 of 705 months, eight times in 60 years; Drought Emergency would have been triggered two of 705 months, twice in 60 years. It is also noteworthy that an Alert or Warning would have been triggered at least one month before each Drought Emergency. Furthermore, both Drought Emergencies would have been triggered at times of acknowledged drought severity in November 1941 and November 1964.

At this time responses to be taken by the DEP and each purveyor may be generally described. At the onset of a Drought Alert DEP staff in the Division of Water Resources would update plans, hydrologic and system data. If a Drought Warning were triggered for one or more systems, purveyors would continue to meet demands. However to conserve storage, they would be guided to reduce drafts from sources with water deficits by increasing transfers from other water supply systems. The DEP Commissioner might declare a Drought Warning and the public served by the water deficient system may be requested to conserve water voluntarily. If a drought emergency occurred for one or more systems, in all probability the Governor would declare a Drought Emergency for the region served by the systems. He would also define uses to be restricted. The need to augment or to reduce streamflow releases would be evaluated. Administrative orders to transfer water or tap into new sources could be given. The general objective would be to match supplies with demands.

Lastly, Reservoir Storage graphs assume that reservoirs are 100% full in June of the preceding year. In other words, storage of 60% or 75% in June indicates a stressed condition that should have triggered an Alert, Warning or Emergency previously.

It is recommended that each spring a Drought "tabletop exercise" be undertaken jointly by the N.J.D.E.P. , the State Police and purveyors to reacquaint old and new representatives of regulations and facilities.

Your specific responses and comments are sought at this time. If you have any questions with the triggers and responses, please contact Paul Schorr at (609) 292-5550.

Very truly yours,

Steven Nieswand, P.E.
Assistant Director
Water Supply Element

SN:PS:DW&DE:kr

c: Director Jorge Berkowitz

Enclosures

cc: M. Restaino
R. Willard
K. Pottick
P. Tao
8-11-89

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION 1989
DIVISION OF WATER RESOURCES

TABLE A

WATER SUPPLY SHORTAGE CONDITIONS*

WATER SUPPLY CONDITION	STORAGE	PRECIPITATION DEFICIT	STORAGE VS. PRECIPITATION DEFICIT
NORMAL	C	C	C/C
	B	C	B/C (June to Oct.)
	C	B	C/B
ALERT	C	A	C/A
	B	C	B/C (Nov. to May)
	B	B	B/B (June to Oct.)
WARNING	A	C	A/C
	B	B	B/B (Nov. to May)
	A	B	A/B
	B	A	B/A
EMERGENCY	A	A	A/A

STORAGE = reservoir level graph
PRECIPITATION DEFICIT = precipitation deficit graph

* The descriptive conditons must be interpreted and updated to account for current demands and facilities. If a Drought Emergency is declared by the Governor, there are four phases according to the severity of the Drought. (R.S. 7:19(a)1 et. seq.)

1989

ATTACHMENT A

ASSUMPTIONS

The basic assumptions used to formulate the graphs are noted below:

DEMANDS: The average annual demands (recorded in the 1970's) were apportioned throughout the year for each month. These demands were assumed in calculating all reservoir storage levels greater than the emergency level.

INFLOW: Monthly inflow was based on actual historical reservoir levels, downstream releases and demands. The 10th and 30th lowest values were used to calculate emergency and warning reservoir storage levels.

PRECIPITATION DEFICITS: Monthly rainfall data observed at gauges in reservoir watersheds was averaged over the period of record and the region. Cumulative deficits for three, four and five months were ranked for different seasons. The 10th and 30th greatest deficit values were used to represent a warning and emergency level.

DOWNSTREAM RELEASE REQUIREMENTS: The minimum daily release requirement specified in N.J.A.C. and N.J.S.A. are assumed.

PS:MONTHLYI

1989

ATTACHMENT B

MONTHLY INFLOW (MILLION GALLONS)

	HACKENSACK		JERSEY CITY		NEWARK		NJDWS	
	10%	30%	10%	30%	10%	30%	10%	30%
JAN	1687	2722	1810	3246	1184	1684	1461	2397
FEB	2380	3272	2507	3630	1392	2025	1700	2772
MAR	4081	4658	4545	5582	2943	3685	3644	5131
APRIL	2828	3918	3284	5263	1877	3070	2395	3973
MAY	2126	2813	2183	3636	1212	1953	1496	2346
JUNE	1093	1600	1063	1761	622	1005	503	978
JULY	678	1227	365	949	171	508	209	514
AUG	597	1016	449	877	117	357	93	349
SEPT	649	982	306	845	110	310	187	422
OCT	802	1124	701	1243	198	444	340	569
NOV	1214	1703	1064	2165	667	1231	598	1115
DEC	1312	2481	1759	3209	987	1816	1168	2195
LOW MGM (Summer)	597	982	306	845	110	310	93	349
HIGH MGM (Spring)	4081	4658	4545	5582	2943	3685	3644	5131

10% =The actual calculated value 10th lowest from 1929 to 1988
30% =The actual calculated value 30th lowest from 1929 to 1988

The low and minimum values observed in the summer are due in part to evapotranspiration. The Table below is the overal average, minimum and maximum for each system.

	HACKENSACK	JERSEY CITY	NEWARK	NJDWS
AVG MGM	3700	4300	2600	3400
MIN MGM	115	57	1	5
MAX MGM	14805	20977	13214	19930

1989

ATTACHMENT C

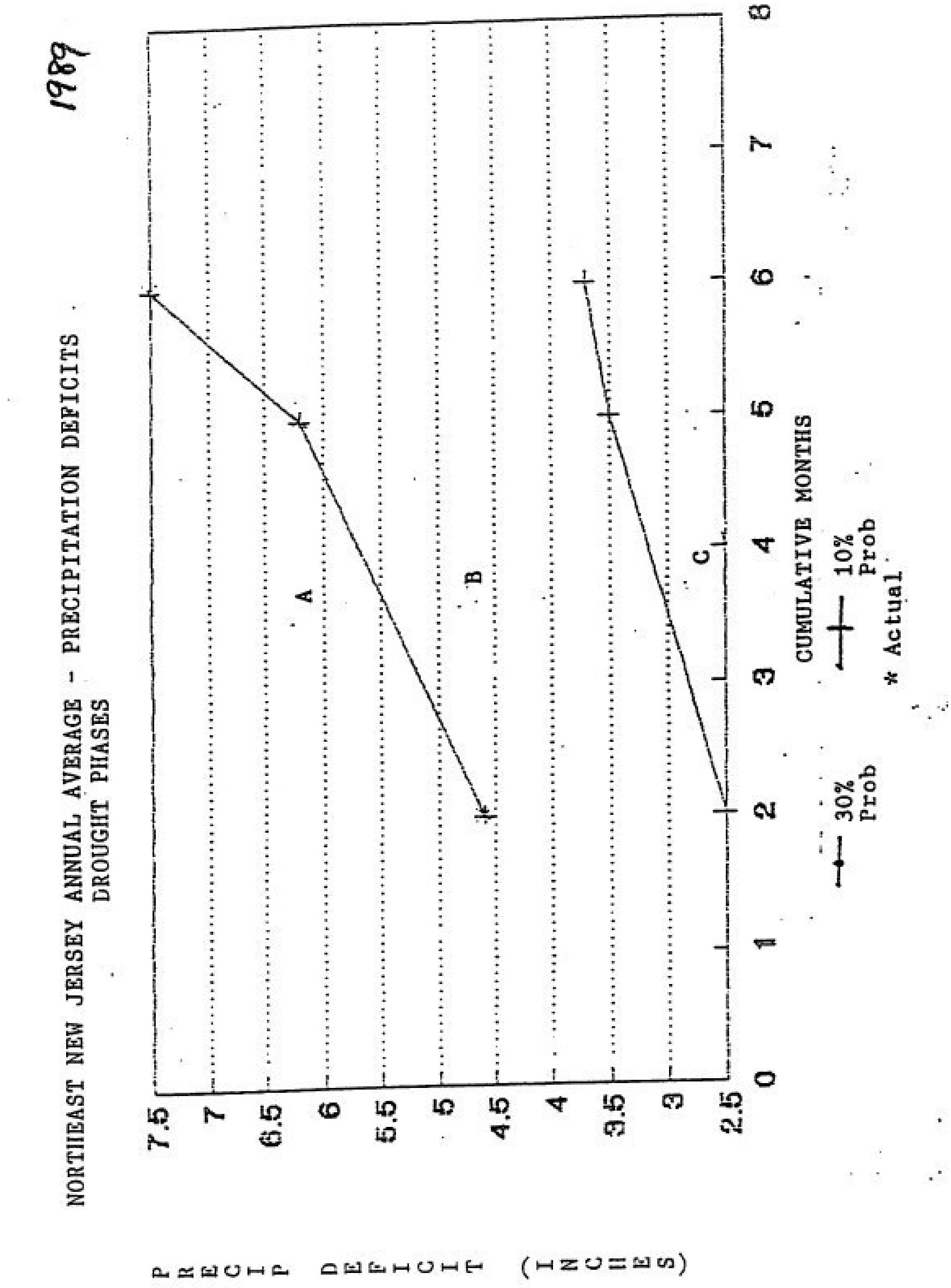
MONTHLY SYSTEMS DRAFTS
(AVERAGE OF 1971 - 79) MILLION GALLONS

	NEWARK	JERSEY CITY	HACKENSACK	NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION
JAN	2180	2070	3523	4142
FEB	1970	1910	3174	3693
MAR	2180	2070	3885	4157
APRIL	2110	2080	3810	4185
MAY	2180	2070	4093	4715
JUNE	2180	2080	4220	4626
JULY	2250	2150	4425	4799
AUG	2250	2180	4425	4985
SEPT	2020	2090	4020	4578
OCT	2080	2120	4155	4579
NOV	2080	1970	3750	4413
DEC	2140	2010	3430	4058
SUB-TOTAL	25620	24800	46910	52928
ANNUAL DAILY AVERAGE (MGD)	70.2	67.9	128.5	145

ATTACHMENT D

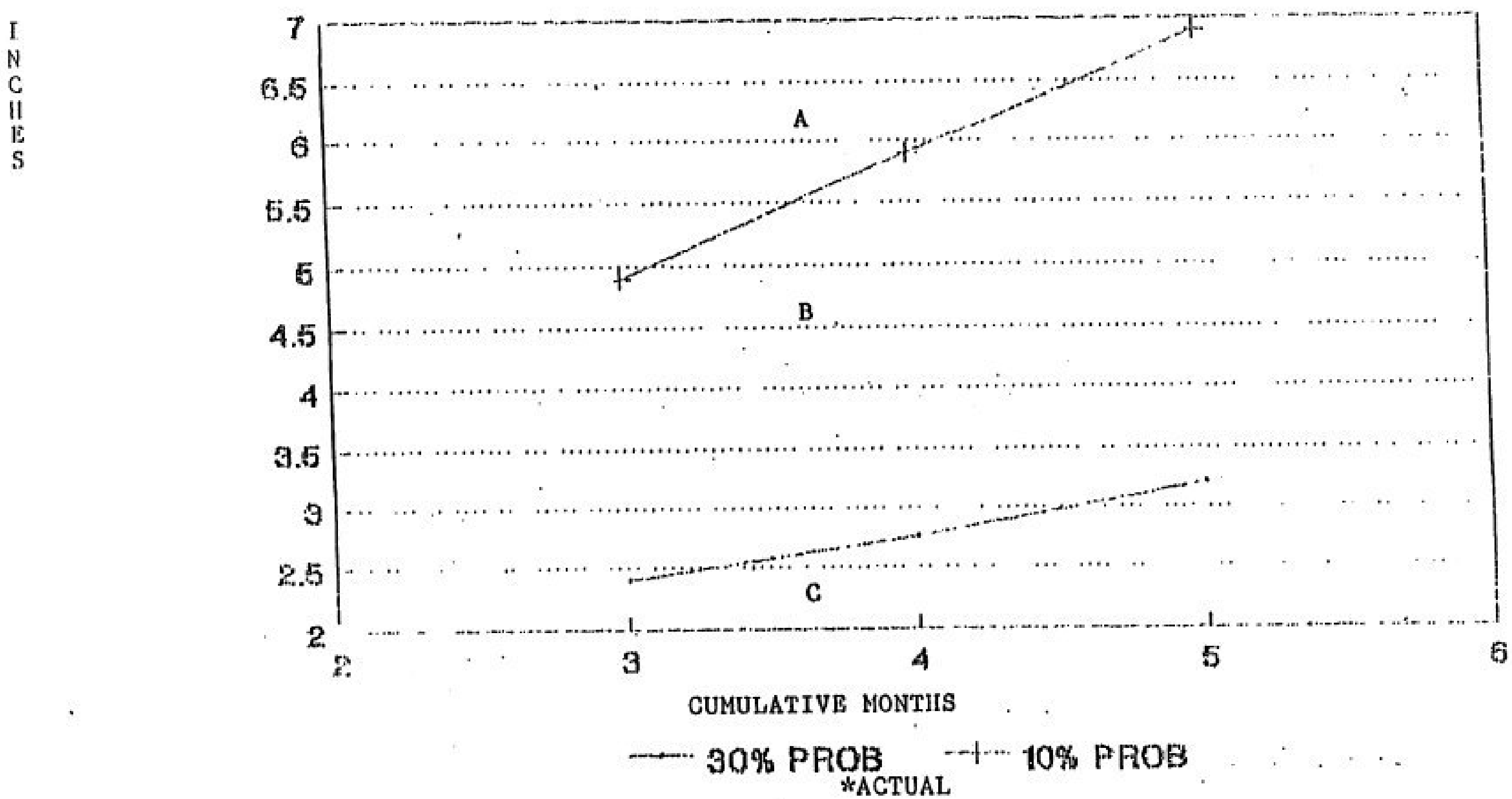
PRECIPITATION DEFICITS (INCHES) - NORTHEAST REGION
10th GREATEST/30th GREATEST

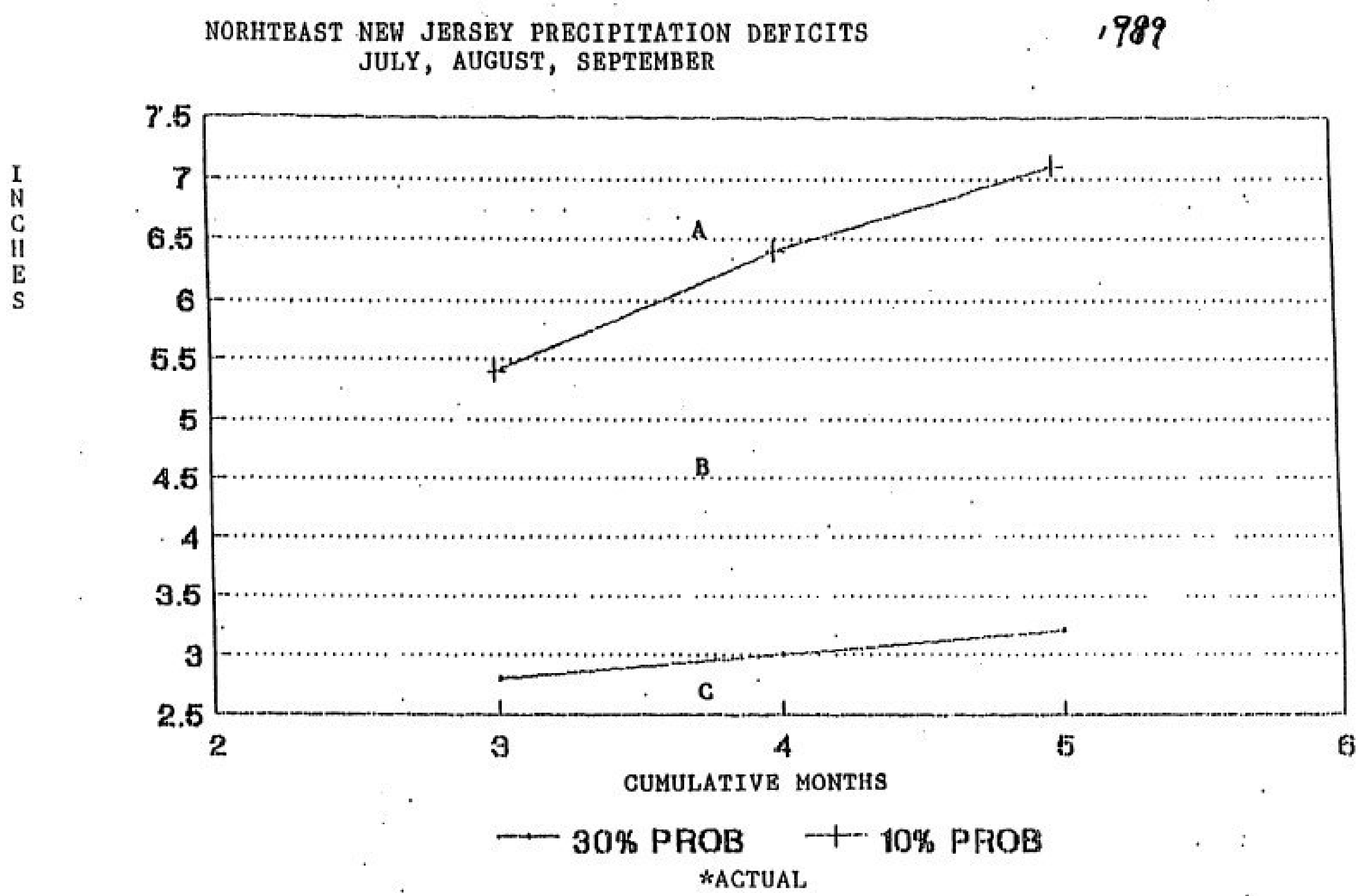
	CONSECUTIVE PERIOD		
	3 MONTHS	4 MONTHS	5 MONTHS
FEB & MAR	3.42/2.08	4.56/2.49	5.36/2.83
APRIL, MAY & JUNE	4.44/2.32	5.2/2.7	5.9/2.97
JULY, AUG & SEPT	5.4/2.62	6.43/2.94	7.11/3.2
OCT, NOV, DEC, & JAN	4.88/2.39	5.88/2.75	6.88/3.21


NORTHEAST NEW JERSEY ANNUAL AVERAGE - PRECIPITATION DEFICITS
DROUGHT PHASES
1989
PRECIP DEFICIT (INCHES)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
0
1
2
3
4
5
6
7
8
A
B
C
CUMULATIVE MONTHS
30% Prob
10% Prob
* Actual

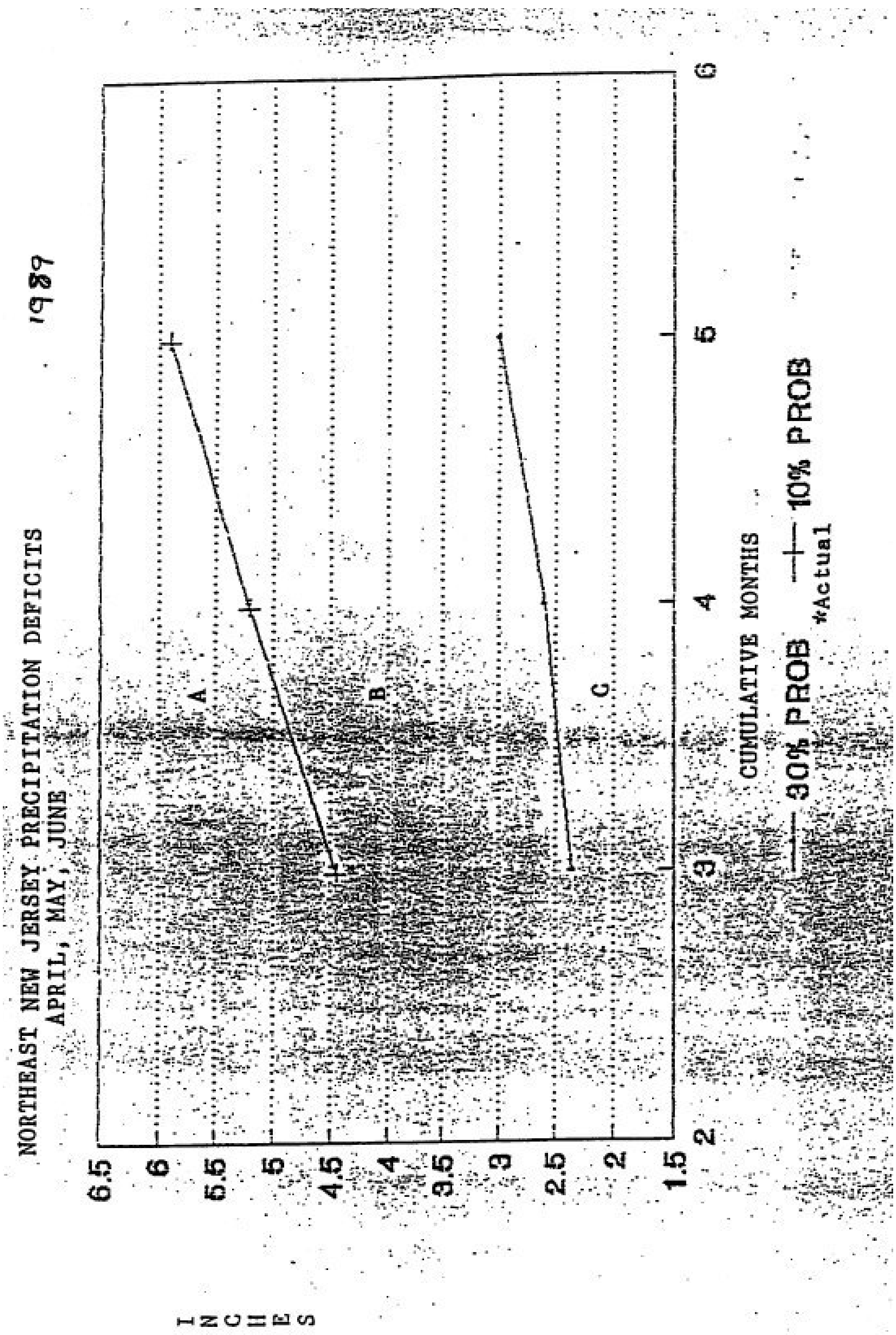
NORTHEAST NEW JERSEY PRECIPITATION DEFICITS 1989

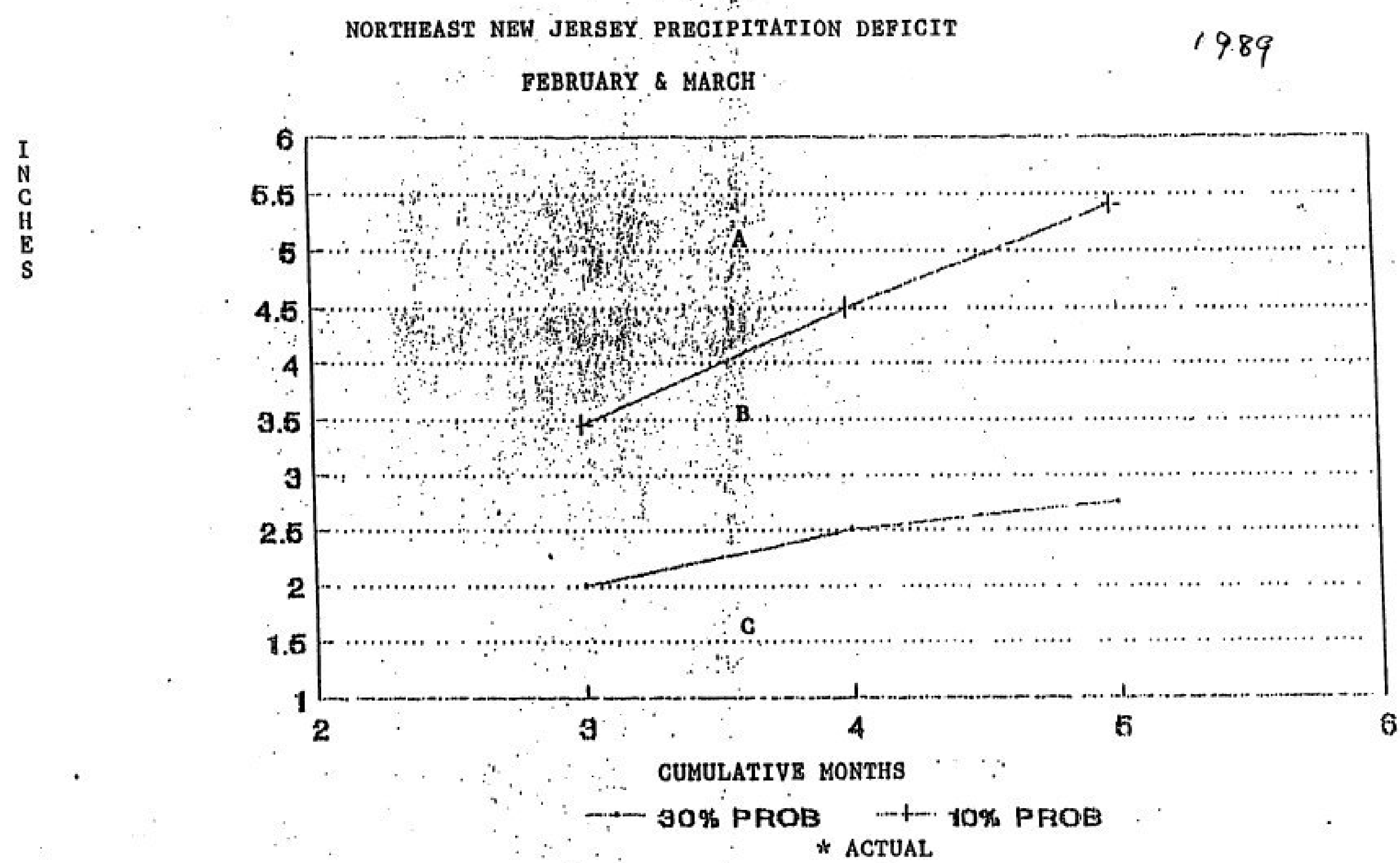
OCTOBER, NOVEMBER, DECEMBER, JANUARY

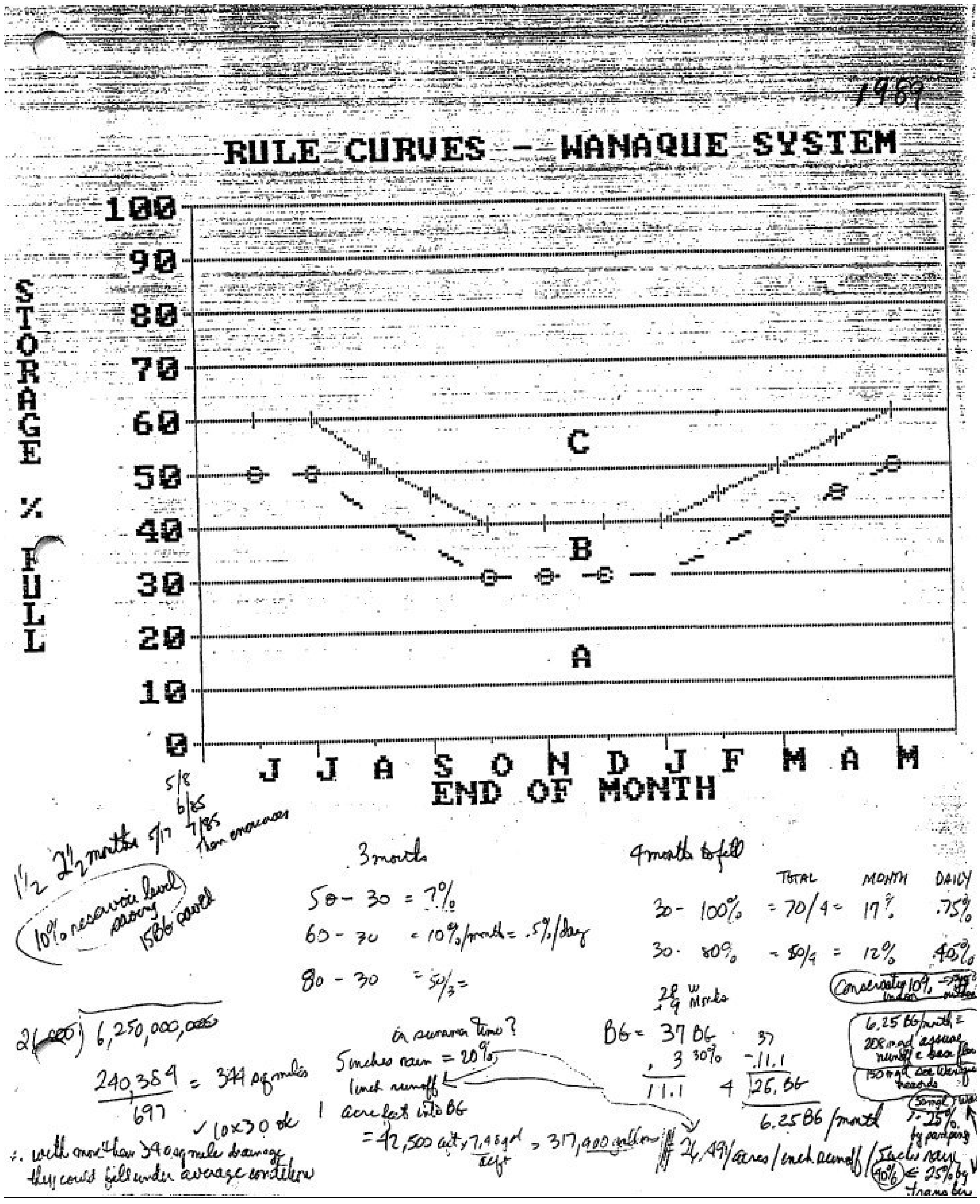




NORHTEAST NEW JERSEY PRECIPITATION DEFICITS
JULY, AUGUST, SEPTEMBER
1989
INCHES
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
A
B
C
2
3
4
5
6
CUMULATIVE MONTHS
30% PROB
10% PROB
*ACTUAL


NORTHEAST NEW JERSEY PRECIPITATION DEFICITS
APRIL, MAY, JUNE
1989
INCHES
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
A
B
C
2
3
4
5
6
CUMULATIVE MONTHS
30% PROB
10% PROB
*Actual


NORTHEAST NEW JERSEY PRECIPITATION DEFICIT
FEBRUARY & MARCH
1989
INCHES
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
A
B
C
2
3
4
5
6
CUMULATIVE MONTHS
30% PROB
10% PROB
* ACTUAL


1989
RULE CURVES - WANAQUE SYSTEM
STORAGE % FULL
100
90
80
70
60
50
40
30
20
10
0
C
B
A
J J A S O N D J F M A M
END OF MONTH
3 months
4 months to fill
TOTAL
MONTH
DAILY
50 - 30 = 7%
30 - 100% = 70/4 = 17% .75%
30 - 80% = 50/4 = 12% .40%
6,250,000,000
240,384 = 344 sq miles
5 inches rain = 20%
1 inch runoff
1 acre foot into BG
6.25 BG/month

1989

DROUGHT RULE CURVES FOR RESERVOIR MANAGEMENT

By Asghar Hasan

INTRODUCTION:

During droughts and low flow stress conditions it becomes necessary to impose meaningfull restrictions on withdrawal of water from surface reservoirs. In order to achieve management goals of timely problem recognition and appropriate levels of response, a simple to apply but accurate system of "Drought Rule Curves" was designed for four reservoir systems located in the Northeast New Jersey. These reservoir systems are located in Hackensack River Basin, Pequannock River Basin, Rockaway River Basin, and Wanaque River Basin, operated by Hackensack Water Company, Newark Water Department, Jersey City Water Department, and North Jersey District Water Supply Commission respectively. Based on historical record of precipitation and flow for over 50 years, a technique, called herein after, Drought Pattern Search, was developed. This technique was then applied to develop drought rule curves. Following text explains the above technique step by step:

DROUGHT PATTERN SEARCH:

Step 1: The cumulative flows for 6 months starting in June and ending in November of each year of record are computed.
Step 2: The cumulative flows for 10 months starting in June of year `N' and ending in March of year `N+1' for each year of record are computed.
Step 3: 10 % and 30 % non-exceedance probability of occurance of flows were used to establish two stages of drought severity. The 30 % probability was designated as drought warning mode and 10 % as drought mode.
Step 4: Each of the above two probabilities extending through steps 1 and 2 then gave 10 most critical months in one year, defining drought and drought warning scenarios. This completed the Drought Pattern Search for flows.

CONCEPT BEHIND SELECTING STEPS 1 & 2:

A universal definition of drought is difficult to give due to diverse interest and opinions of engineers and scientists. However, it can broadly be defined as deficiency in supply over a certain period ,called herein after the drought duration. The drought duration should therefore vary with the purpose of the water use, the quantitative water demand, and the time frame of such demand. The severity of deficiency in supply may increase if demand increases or it may decrease if the demand is truncated. This situation thereby calls for a carefull selection of the drought duration. From surface water view point, June 1 of year `N' to March 31 of year `N+1', in our study, is adopted as a period when the severity of deficiency in water supply will

1989

define this period as the drought duration. This was done due to the reason that it is desirable to have the reservoirs at their maximum capacity at end of May during normal years or at such a safe level at the end of May during deficient flow years which will not jeopardize the availability of water from a reservoir if deficient flows occur in the following summer months when the water withdrawal from such source is high. The 6-month period in Step 1, was adopted due to fact that during months of June to November a combination of high water demand and low surface water run-off usually causes the maximum depletion of reservoir levels. Also, deficiency in precipitation during this 6-month period may seriously impede the normally higher rate of reservoir recovery in the forthcoming months of December to March. Moreover, if the precipitation deficiency continues during the months of December to March then this may cause further reduction in the water run-off during the forthcoming summer months. This was the other reason for considering the 10-month period in Step 2, extending to month of March, and by doing this we would also incorporate a longer drought duration.

DROUGHT PATTERN SEARCH APPLIED TO PREPARE RULE CURVES:

The drought pattern search (as per Steps 1 thru 4), resulted into determining those years when the cumulative flows from June of Year 'N' to November of Year 'N' and the cumulative flows of June of Year 'N' to March of Year 'N+1' both had the same probability of non-exceedance, (either 10 % or 30 %, which ever was being considered). The monthly flows of these drought durations for such years were then used in computing the monthly gain or loss in reservoir storages by applying the appropriate draft on a system. This analysis was performed for each of the above -mentioned four systems. The monthly flows in Ramapo River and Passaic River at Two Bridges (pro-rated from Passaic River at Little Falls) during the selected years were used to determine the flows available to Wanaque and Hackensack Reservoirs systems due to authorized pumping under the Wanaque South Project. Following Table lists the probability modes and the corresponding years for each system studied:

SYSTEM	PROBABILITY OF NON-EXCEEDANCE	YEAR
HACKENSACK	10 %	June'53-Mar'54
	30 %	June'25-Mar'26
PEQUANNOCK	10 %	June'49-Mar'50
	30 %	June'43-Mar'44
ROCKAWAY	10 %	June'65-Mar'66
	30 %	June'44-Mar'45
WANAQUE	10 %	June'80-Mar'81
	30 %	June'43-Mar'44

The end of the month storage status of the four systems were then computed by using the actual natural flows during the above years for each system. The monthly drafts used for each system to compute the drawdown were the actual monthly drafts averaged for the period of 1971 to 1979 for each month, plus the safe yield from Wanaque South added to Hackensack and Wanaque Systems only. A trapezoidal shape curve was first plotted for 10 % probability mode for the drought duration representing the reservoir depletion and recovery trend for this period. Anytime the reservoirs levels are below this line, a drought condition is in effect. However, we should not let the reservoir storage drop to such levels before taking any actions. For this purpose a Warning Curve was deemed necessary. To establish this warning curve, called Drought Warning Curve, the 30 % probability mode was used. The monthly depletion trend for this mode was computed for individual system. This trend, was then applied to establish the Drought Warning Curve. This was done with the idea that if a drought of some less severity is occuring (in our study case a 30 % mode), then it is necessary to know whether continuation of this trend is going to deplete the reservoir storage to that of drought at the end of current month. The current month's depletion or recovery rate of 30 % mode when added to the next month's status as determined for 10 % mode, established the reservoir's storage levels for current month representing the Drought Warning conditions.
Drought and Drought Warning Curves were plotted for each system individually. A set of curves was also prepared by combining all four systems into one system. This set would be advantageous in overall decision making as to the severity of drought impact on all system as a whole and determination for need of tranfer of water from one system to the other depending on the water storage of individual system.

DROUGHT INDICATOR:
The above methodology uses the cumulative streamflows only . However, the deficiency in streamflow is directly related to the deficiency in precipitations. Precipitation during the array of antecedent months which is effectively contributing to the runoff into current month and, possibly into succeeding months, depends not only on the total amount fallen but also on how it was distributed in that time period. The cumulative deficiencies in precipitations from long term precipitation for the above probability scenarios during the selected drought durations were therefore used as the indicators of occurance of drought of those probabilities. This was necessary due to reason that precipitation is the most easily noticeable parameter to recognize if an excess or deficiency has occured in the past. Besides, this is the sole variable, producing the water runoff. Based on the 10 % and 30 % probability scenarios for the above-analysed drought durations, a set of

curves for precipitation deficiencies was prepared for each of the four systems. These curves should be used in conjunction with the drought rule curves to impose any restrictions on the water withdrawal from any of the four systems. The attached self-explainatory tables and plots show the results of these analyses.

1989

LOWEST CUMULATIVE PRECIPITATION OCCURRANCES DURING DROUGHT DURATION

WITH 10 % & 30 % PROBABILITY SCENARIOS

SYSTEM: HACKENSACK

No. of Months cumulative	10 % SCENARIO Controling period	Normal precip	Actual precip	Deficit	30 % SCENARIO Controling period	Normal precip	Actual precip	Deficit
4	Aug-Nov'53	15.10	8.87	6.23	Aug'25-Nov25	15.10	11.80	3.30
6	Aug'53-Jan54	21.95	15.23	6.72	Aug'25-Jan26	21.95	17.15	4.80
8	Aug'53-Mar54	28.87	20.51	8.36	Aug'25-Mar26	28.87	25.07	3.80
10	Jun'53-Mar54	36.59	29.37	7.22	Apr'25-Jan26	37.51	33.33	4.18

PLOTTED DATA (10 % SCENARIO)

4.00	6.23
6.00	6.72
10.00	7.22

PLOTTED DATA (30 % SCENARIO)

4.00	3.30
8.00	3.80
10.00	4.18

1989

LOWEST CUMULATIVE PRECIPITATION OCCURRANCES DURING DROUGHT DURATION

WITH 10 % & 30 % PROBABILITY SCENARIOS

SYSTEM: JERSEY CITY

No. of Months cumulative	10 % SCENARIO Controling period	Normal precip	Actual precip	Deficit	30 % SCENARIO Controling period	Normal precip	Actual precip	Deficit
4	Apr'65-Jul'65	16.83	7.39	9.44	May'44-aug'44	17.22	10.51	6.71
6	May'65-Oct'65	25.08	13.41	11.67	Feb'44-Jul'44	23.58	18.31	5.27
8	Jan'65-Aug'65	31.43	20.36	11.07	Dec'43-Jul'44	30.64	24.93	5.71
10	Oct'64-Jul'65	38.40	24.67	13.73	Nov'43-Aug'44	39.41	31.54	7.87

PLOTTED DATA (10 % SCENARIO)

4.00	9.44
6.00	11.67
10.00	13.73

PLOTTED DATA (30 % SCENARIO)

6.00	5.27
8.00	5.71
10.00	7.87

LOWEST CUMULATIVE PRECIPITATION OCCURRANCES DURING DROUGHT DURATION

1989

WITH 10 % & 30 % PROBABILITY SCENARIOS

SYSTEM: NEWARK

No. of Months cumulative	10 % SCENARIO: Controling period	Normal precip	Actual precip	Deficit	30 % SCENARIO: Controling period	Normal precip	Actual precip	Deficit
4	Oct'49-Jan'50	16.01	9.58	6.43	Nov'43-Feb'44	15.54	10.51	5.03
6	Jun'49-Nov'49	26.22	18.35	7.87	Aug'43-Jan'44	25.03	18.96	6.07
8	Jun'49-Jan'50	33.92	23.99	9.98	Feb'43-Sep'43	34.14	24.60	9.54
10	Mar'49-Dec'49	43.17	31.40	11.77	Dec'42-Sep'43	41.89	33.33	8.56

PLOTTED DATA (10 % SCENARIO)

4.00	6.43
6.00	7.87
8.00	9.98
10.00	11.77

PLOTTED DATA (30 % SCENARIO)

4.00	5.03
6.00	6.07
10.00	8.56

3/16/89

TABLE 6

CUMULATIVE MONTHS PRECIPITATION DEFICITS WITH 10 % & 30 % RISK - EXCEEDANCE PROBABILITIES

3 - MONTHS CUMULATION

SYSTEM:	CUMULATION ENDING IN THE MONTH OF :- JANUARY 30 %	JANUARY 10 %	FEBRUARY 30 %	FEBRUARY 10 %	MARCH 30 %	MARCH 10 %	APRIL 30 %	APRIL 10 %	MAY 30 %	MAY 10 %	JUNE 30 %	JUNE 10 %	JULY 30 %	JULY 10 %	AUGUST 30 %	AUGUST 10 %	SEPTEMBER 30 %	SEPTEMBER 10 %	OCTOBER 30 %	OCTOBER 10 %	NOVEMBER 30 %	NOVEMBER 10 %	DECEMBER 30 %	DECEMBER 10 %
[illegible]	2.42	4.50	1.66	3.40	1.60	3.79	2.40	3.93	2.00	4.06	2.26	4.57	2.45	3.16	2.01	3.57	2.27	3.30	2.52	4.75	2.00	4.33	1.98	3.91
[illegible]	2.44	4.48	2.19	3.49	2.09	3.44	2.14	4.30	2.55	4.16	2.55	4.37	2.77	3.72	2.70	4.79	2.42	3.85	2.41	4.91	2.17	4.94	2.07	4.52
[illegible]	2.78	5.41	2.56	3.59	2.27	3.36	1.74	4.23	2.40	4.71	2.50	5.41	3.23	5.36	3.40	5.44	3.60	5.44	3.10	5.40	2.41	5.30	2.71	4.91
[illegible]	1.93	4.47	2.12	3.00	2.11	3.29	2.40	4.07	2.40	4.56	2.26	4.69	2.51	4.77	3.13	4.94	3.40	4.09	2.97	5.53	2.41	5.19	2.03	4.79
[illegible]	2.39	4.82	2.09	3.56	2.07	3.20	2.09	4.18	2.46	4.38	2.40	4.76	2.79	5.25	2.74	5.23	2.92	5.23	2.76	5.17	2.54	4.99	2.06	4.53

4 - MONTHS CUMULATION

[illegible]	2.06	4.66	2.34	4.50	1.89	3.71	2.42	3.90	2.30	4.90	2.93	5.60	2.57	5.39	2.29	4.55	2.54	4.02	2.71	5.41	2.39	4.23	2.80	5.41
[illegible]	2.52	5.46	2.48	5.64	2.82	4.49	3.08	5.12	2.45	4.93	3.15	5.78	3.06	5.55	3.19	7.21	3.20	4.62	3.07	4.55	2.17	4.19	2.32	5.67
[illegible]	2.59	5.54	2.97	5.64	2.51	3.98	2.25	4.87	2.67	5.15	2.81	5.61	2.31	4.27	2.66	7.69	3.55	4.48	3.19	4.79	3.39	4.33	2.90	5.70
[illegible]	2.60	5.87	2.34	5.36	2.54	4.35	2.05	5.31	2.89	5.28	2.05	4.23	2.67	4.78	3.25	4.55	4.01	4.02	3.19	4.50	3.15	4.44	2.79	5.58
[illegible]	2.44	5.28	2.53	5.60	2.45	4.13	2.59	4.60	2.57	5.11	2.98	5.49	2.63	5.99	2.85	7.60	3.33	4.29	2.99	4.74	2.98	4.30	2.62	5.68

5 - MONTHS CUMULATION

[illegible]	3.53	5.95	2.28	4.90	2.76	4.61	2.46	4.00	2.29	5.76	3.61	5.00	3.26	5.43	2.92	5.70	3.20	7.59	3.02	4.60	3.05	4.71	2.55	6.37
[illegible]	2.75	6.50	2.78	5.43	2.67	5.44	3.37	6.40	2.90	6.28	2.81	5.79	3.40	6.50	2.69	7.45	3.85	8.14	3.01	6.69	2.01	6.54	3.14	6.53
[illegible]	2.24	7.43	3.51	5.16	3.33	5.78	2.90	5.90	2.95	6.76	3.28	6.17	2.97	6.01	2.71	8.06	3.45	8.07	3.76	5.96	4.20	6.26	3.06	6.91
[illegible]	2.91	7.65	2.76	5.41	3.40	5.67	2.84	6.05	3.14	6.41	2.96	6.21	2.33	6.71	3.44	7.31	3.89	7.25	3.27	7.16	4.05	7.34	3.65	6.88
[illegible]	2.95	6.80	2.82	5.33	2.84	5.38	2.90	5.72	2.82	6.10	3.19	5.79	3.01	6.30	2.95	7.10	3.65	7.76	3.27	6.45	3.21	6.71	3.69	6.67

1989

LOWEST CUMULATIVE PRECIPITATION OCCURRANCES DURING DROUGHT DURATION

WITH 10 % & 30 % PROBABILITY SCENARIOS

SYSTEM: WANAQUE

No. of Months cumulative	10 % SCENARIO Controling period	Normal precip	Actual precip	Deficit	30 % SCENARIO Controling period	Normal precip	Actual precip	Deficit
4	Oct'80-Jan'81	15.34	9.06	6.28	Nov'43-Feb'44	14.95	10.45	4.50
6	Aug'80-Jan'81	23.97	11.76	12.21	Apr'43-Sep'43	25.66	18.56	7.10
8	Jun'80-Jan'81	32.66	18.21	14.45	Feb'43-Sep'43	33.07	23.73	9.43
10	Jun'80-Mar'81	40.07	27.40	12.67	Dec'42-Sep'43	40.49	32.83	7.66

PLOTTED DATA (10 % SCENARIO)

4.00	6.28
6.00	12.21
8.00	14.45

PLOTTED DATA (30 % SCENARIO

4.00	4.50
6.00	7.10
8.00	9.43

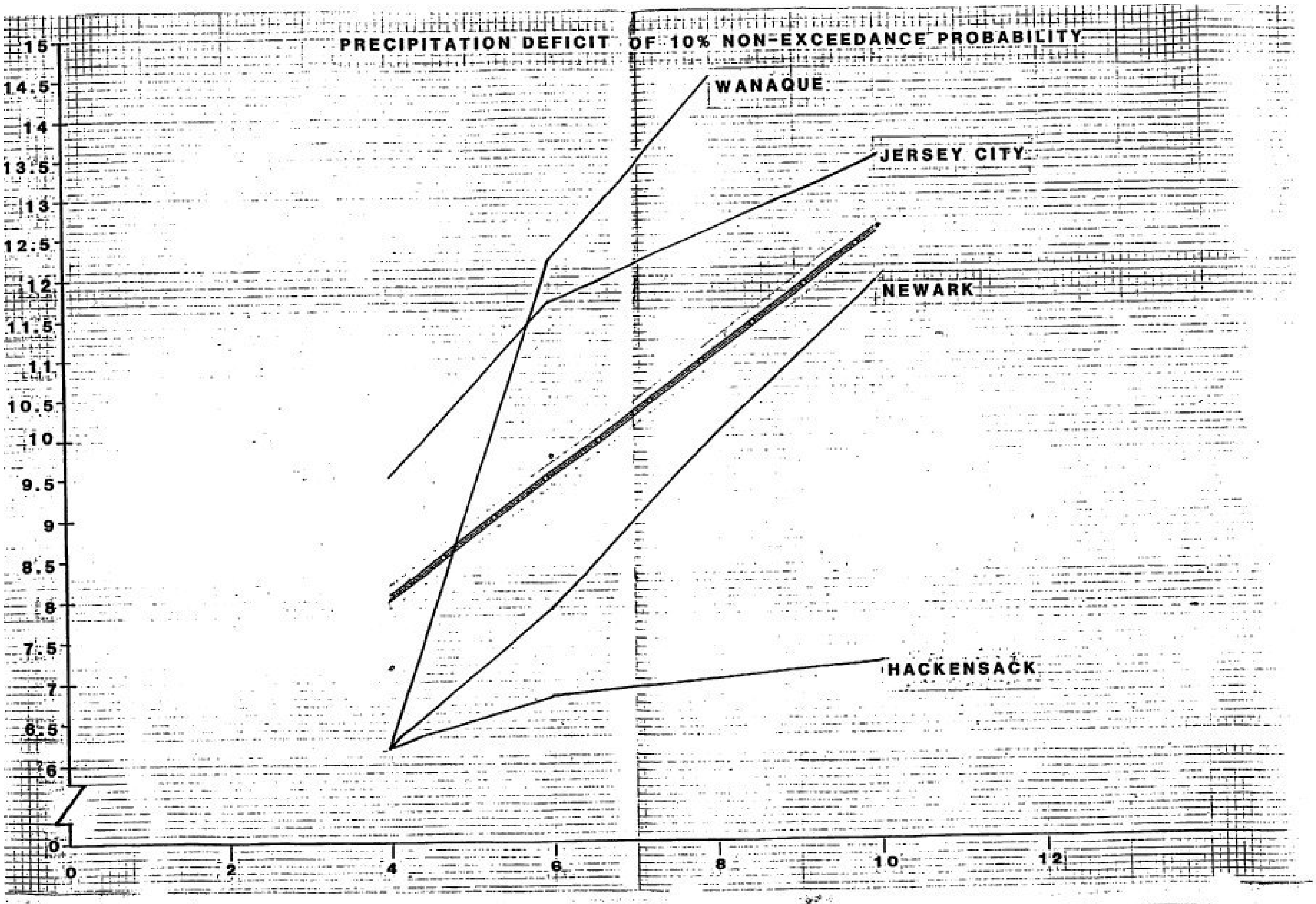
12/1988

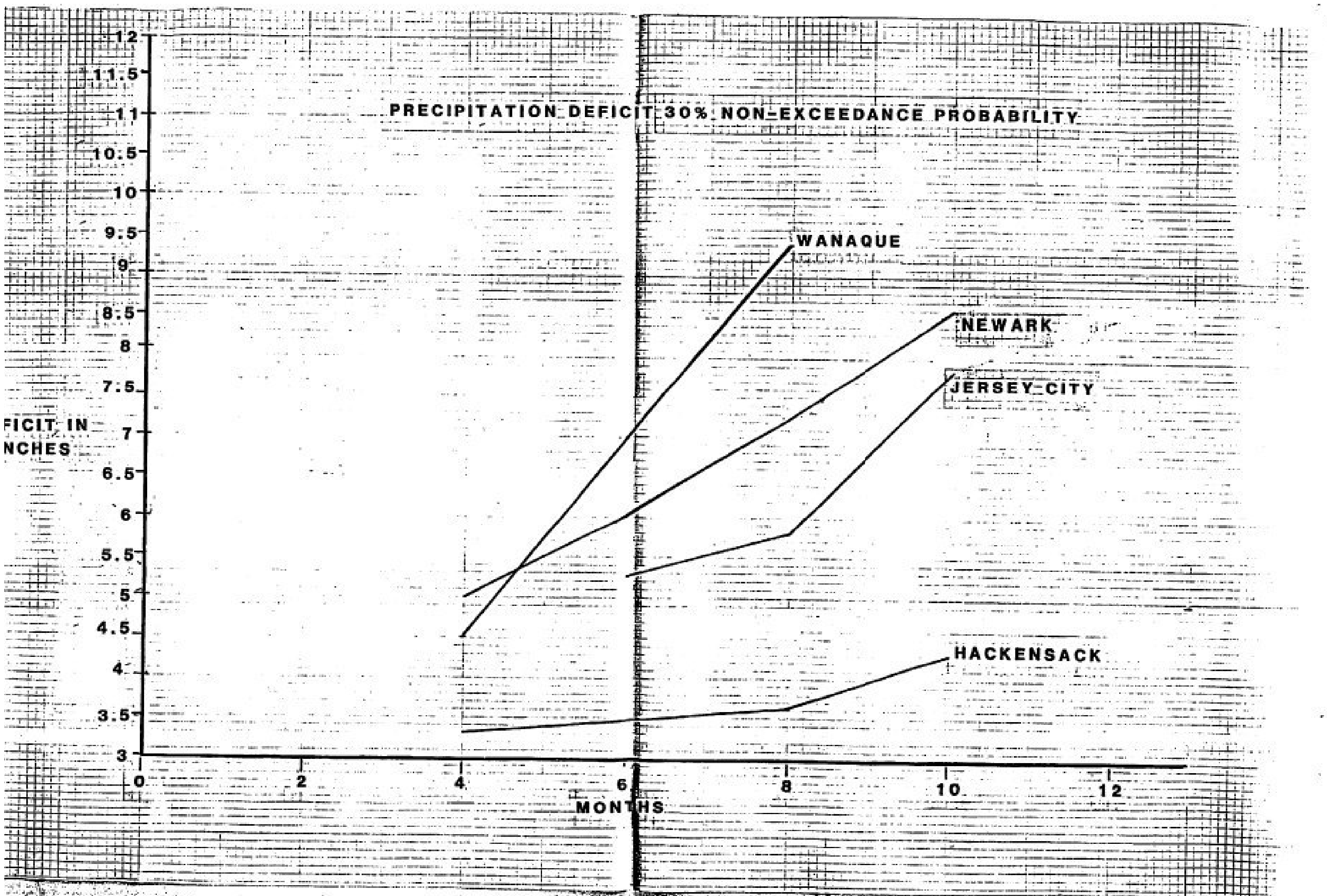
PRECIPITATION DEFICITS (INCHES)
TO BE USED IN DECLARATION OF WARNING & EMERGENCY PHASES OF DROUGHT
FOR MAJOR RESERVOIRS SYSTEMS IN NORTHEAST NEW JERSEY

SYSTEM	3- MONTHS		5- MONTHS		6- MONTHS	
	10 %	30 %	10 %	30 %	10 %	30 %
HACKENSACK	4.65	2.08	4.87	3.01	6.72	3.21
JERSEY CITY	4.79	1.97	6.50	2.79	7.19	2.80
NEWARK	5.02	3.09	5.49	3.95	7.87	3.45
WANAQUE	4.30	2.80	7.77	3.36	8.30	3.90
AVERAGE	4.69	2.49	6.16	3.28	7.52	3.34

ABOVE AVERAGES ARE USED IN PREPARATION OF FOLLOWING TABLE

MONTHS	WARNING	EMERGENCY
3.00	2.49	4.69
5.00	3.28	6.16
6.00	3.34	7.52


PRECIPITATION DEFICIT OF 10% NON-EXCEEDANCE PROBABILITY
WANAQUE
JERSEY CITY
NEWARK
HACKENSACK
15
14.5
14
13.5
13
12.5
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
0
0
2
4
6
8
10
12


PRECIPITATION DEFICIT 30% NON-EXCEEDANCE PROBABILITY
WANAQUE
NEWARK
JERSEY CITY
HACKENSACK
FICIT IN
NCHES
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
0
2
4
6
8
10
12
MONTHS

(COMBINED LEVEL)

NORMAL LEVEL OF MAJOR RESERVOIRS IN NORTHEAST
AT THE END OF MONTH

MONTH	<WITHOUT MONKSVILLE> B.G.	%	<-WITH MONKSVILLE-> B.G.	%
JAN	60.62	87.4	67.62	88.6
FEB	63.05	90.9	70.05	91.7
MAR	68.32	98.5	75.32	98.6
APR	68.67	99.0	75.67	99.1
MAY	67.69	97.6	74.69	97.8
JUN	63.80	92.0	70.80	92.7
JUL	58.47	84.3	65.47	85.7
AUG	54.10	78.0	61.10	80.0
SEP	49.73	71.7	56.73	74.3
OCT	48.00	69.2	55.00	72.0
NOV	51.47	74.2	58.47	76.6
DEC	57.50	82.9	64.50	84.5

The old charts has these levels

DROUGHT RULE CURVES
RESERVOIR LEVELS (% FULL)
SYSTEM: COMBINED

MONTH End Of Mon.	DROUGHT WARNING	DROUGHT EMERGENCY
MAY	68	53
JUNE	68	53
JULY	68	53
AUGUST	61	53
SEPTEMBER	54	45
OCTOBER	47	38
NOVEMBER	43	30
DECEMBER	43	30
JANUARY	43	30
FEBRUARY	58	45
MARCH	66	53
APRIL	68	53

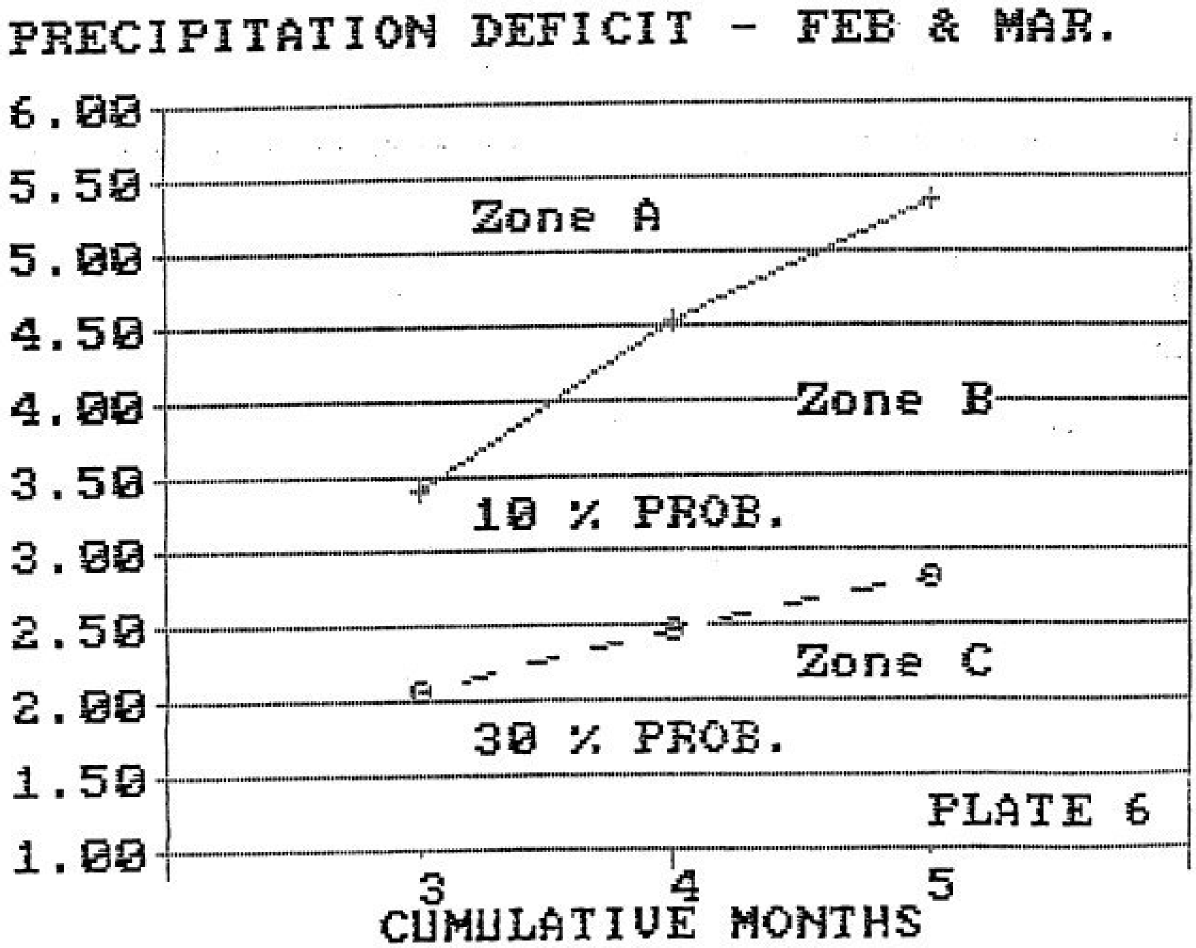
3/16/89

TABLE 7

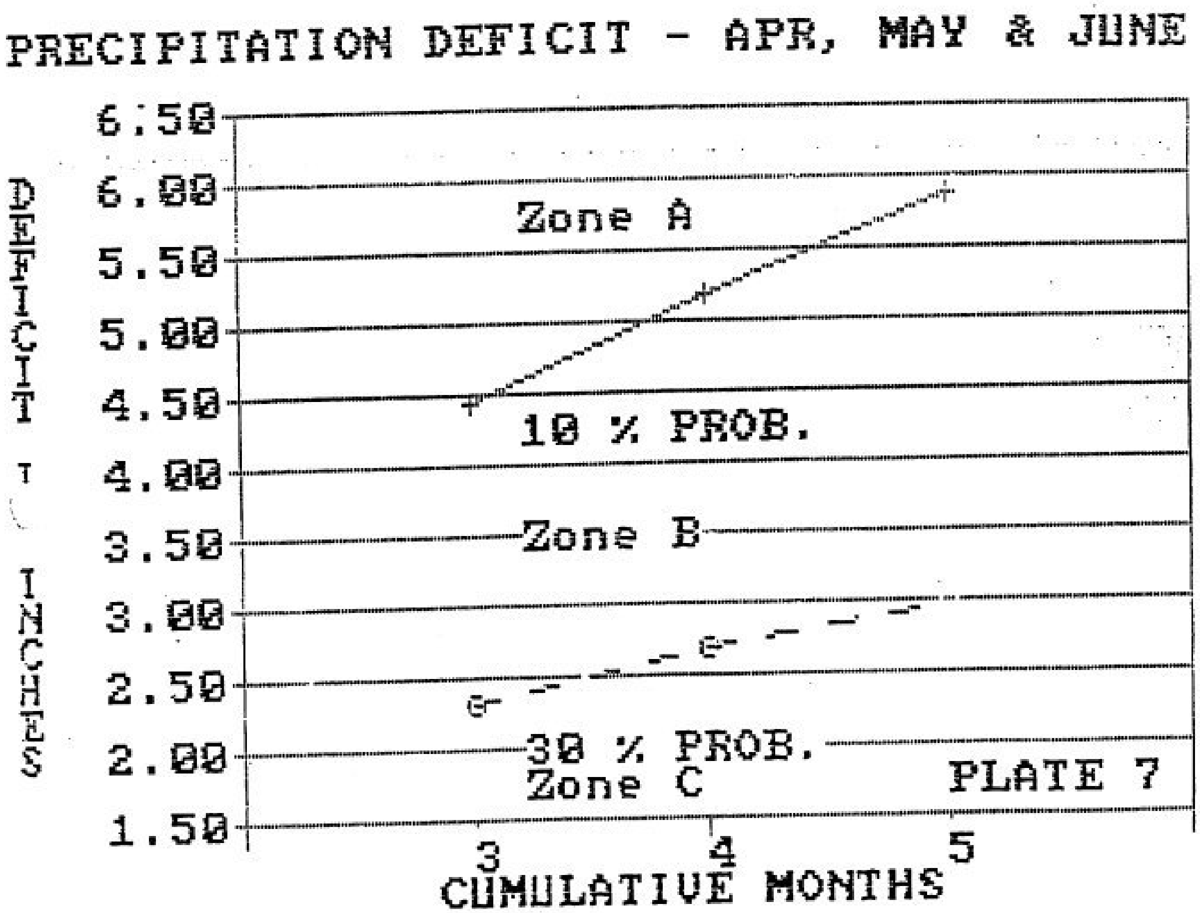
PRECIPITATION DEFICITS OF CUMULATIVE
3, 4, & 5 MONTHS ENDING IN INDICATED MONTHS

CUMULATIVE MONTHS	FOR MONTHS OF FEB, MAR		FOR MONTHS OF APR, MAY, JUN		FOR MONTHS OF JUL, AUG, SEP		FOR MONTHS OF OCT, NOV, DEC, JAN	
	10 %	30 %	10 %	30 %	10 %	30 %	10 %	30 %
3	3.42	2.08	4.44	2.32	5.40	2.82	4.88	2.39
4	4.56	2.49	5.20	2.70	6.45	2.94	5.88	2.75
5	5.36	2.83	5.90	2.97	7.11	3.20	6.88	3.21

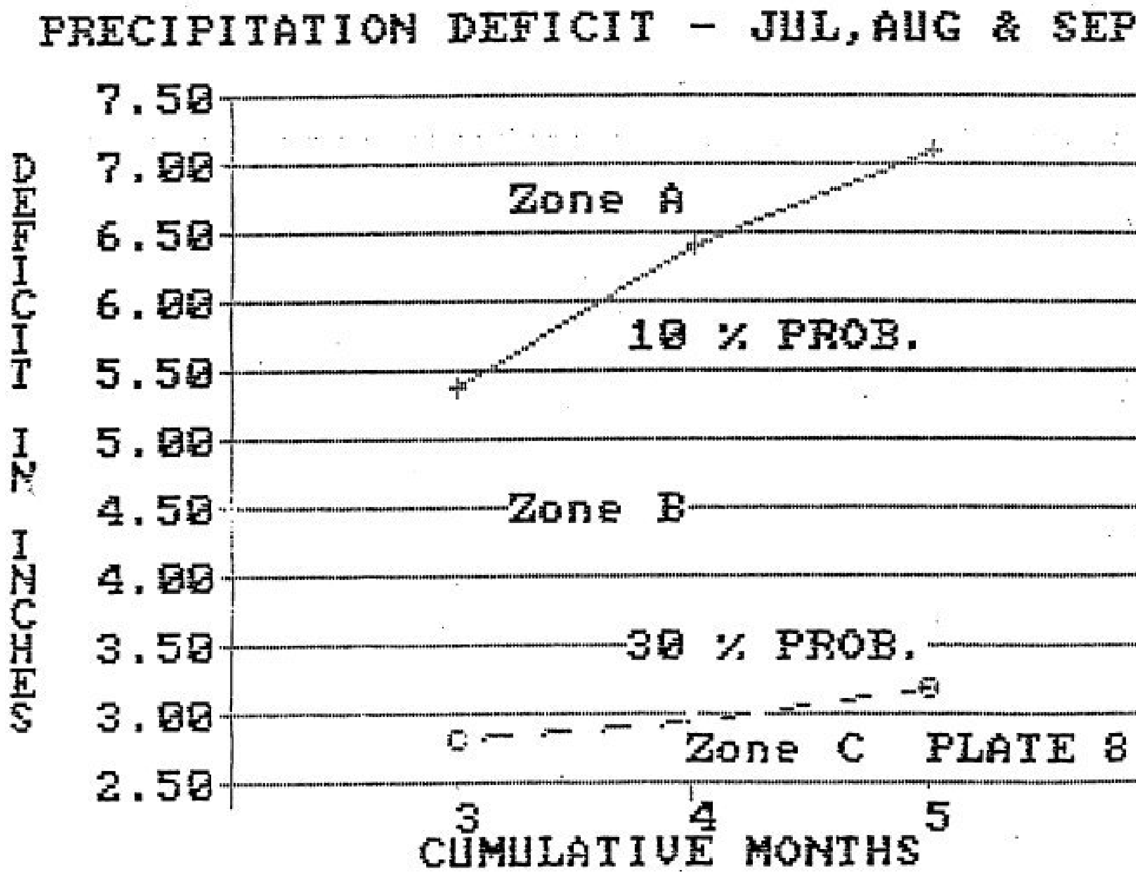
3/16/89


PRECIPITATION DEFICIT - FEB & MAR.
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
Zone A
Zone B
10 % PROB.
Zone C
30 % PROB.
PLATE 6
3
4
5
CUMULATIVE MONTHS

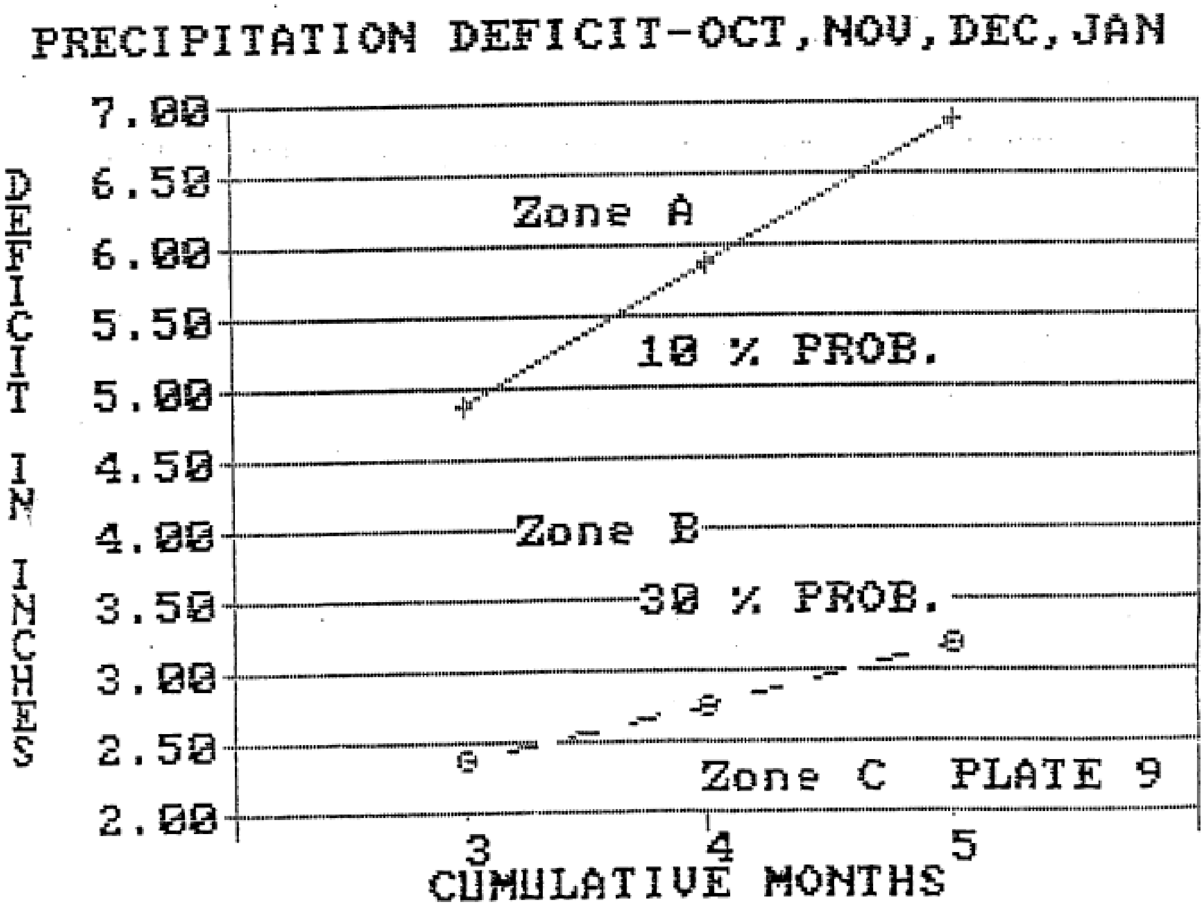
3/16/99


PRECIPITATION DEFICIT - APR, MAY & JUNE
DEFICIT - INCHES
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
Zone A
10 % PROB.
Zone B
30 % PROB.
Zone C
PLATE 7
3
4
5
CUMULATIVE MONTHS

3/16/89


PRECIPITATION DEFICIT - JUL, AUG & SEP
DEFICIT IN INCHES
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
Zone A
10 % PROB.
Zone B
30 % PROB.
Zone C
PLATE 8
3
4
5
CUMULATIVE MONTHS

3/16/89


PRECIPITATION DEFICIT-OCT,NOV,DEC,JAN
DEFICIT IN INCHES
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
Zone A
10 % PROB.
Zone B
30 % PROB.
Zone C
PLATE 9
3
4
5
CUMULATIVE MONTHS

OVERALL PRECIPITATION DEFICIENCY

DURATION MONTHS

	3	4	5	6
A	C	A	A	A
	C	B	A	A
	C	C	A	A
	B	B	A	A
B	B	B	B	A
	B	B	B	B
C	C	B	B	A

weigh 4, 5 & 6 the most

TWO BRIDGES-RAMAPO DIVERSION SIMULATION

WANAQUE RESERVOIR DRAFT= 173.0 MGD
PVWC DIVERSION AT T.B. = 75.0 MGD

WANAQUE CAPACITY = 28000. MG
MONKSVILLE CAPACITY= 6900. MG (after JAN 1, 1920)

	FLOWS W/O WANAQUE SYSTEM (MG)					DIVERSIONS (MG)					RELEASES		FLOWS WITH TB/R PROJ. (MG)					STORAGE (MG)			MONKSVILLE RESERVOIR		
	TWO BRIDGES		L. FALLS	P. LAKE		P. LAKE	PT. VIEW	TWO BRIDGES			WAN RSV	PT. VIEW RSV	TWO BRIDGES		L. FALLS	P. LAKE	PT. VIEW	POINT VIEW RSV	WANAQUE RSV	DEAD RIVER DIV	INFLOW MG	SPILL. MG	STORAGE MG
DT	PSC	PMPT	PSC	RMPO	ENGE	RMPO	PMPT	PSC	PMPT	TOTAL			PSC	PMPT	PSC	RMPO	PMPT						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1/66	4241	5171	10022	3318	1576	1847	0	2417	2190	4608	310	0	631	0	1240	1470	2615	2900.	7153.	0	993	0	532.
2/66	9109	10349	20764	7008	2218	2317	0	1904	4023	5928	280	0	6492	2921	10218	4450	7814	2900.	13059.	0	2239	0	2772.
3/66	11327	16283	28645	11577	3364	4579	0	1488	6177	7665	310	0	9378	3662	14076	6998	9745	2900.	23013.	0	3063	0	5835.
4/66	5249	5460	11279	3570	874	2282	0	2412	1810	4223	300	0	1703	189	2523	1288	2392	2900.	25087.	0	816	0	6651.
5/66	8069	6823	15611	4688	1973	3038	0	0	0	0	310	0	8069	1440	10228	1622	2897	2900.	24227.	0	1053	804	6900.
6/66	3698	3712	7936	2477	353	993	0	0	0	0	300	0	3665	501	4692	1483	2203	2900.	19008.	0	163	163	6900.
7/66	2652	1459	4857	674	-79	0	0	0	0	0	310	0	1767	0	2232	674	1255	2900.	13752.	0	51	51	6900.
8/66	2757	1433	4656	599	148	0	0	0	0	0	310	0	1808	43	2331	599	1189	2900.	7738.	0	106	106	6900.
9/66	4428	4000	9007	2664	1472	667	0	0	0	0	300	0	3846	1664	6090	1397	2737	2900.	4160.	0	419	419	6900.
10/66	5776	7010	13468	4871	6122	2393	0	0	0	0	310	0	5774	2293	8750	2477	3715	2900.	6919.	0	1305	0	3635.
11/66	5943	11303	18030	8294	2893	3913	0	1975	4156	6133	300	0	3150	1799	3732	4380	5993	2900.	13988.	0	2229	0	5689.
12/66	6775	10122	17710	6832	2293	4225	0	474	1961	2435	310	0	6067	1872	8724	2607	4683	2900.	17709.	0	1609	397	6900.
1966 YEARLY TOTAL IN B.G.																							
TOT	76.02	83.58	161.69	56.0	22.61	26.48	.00	10.67	20.32	31.00	3.65	.00	52.36	16.39	76.94	29.49	46.52			.000	14.050	1.944	
1/67	9138	11429	21454	7259	4680	3893	0	0	0	0	310	0	9138	9210	15235	3365	6109	2900.	20964.	0	2193	2193	6900.
2/67	7371	8812	16901	5690	3079	3765	0	0	0	0	280	0	7371	2946	11035	1924	3969	2900.	23051.	0	1393	1393	6900.
3/67	24578	22526	48414	15405	9972	2151	0	0	0	0	2149	0	24578	19889	45777	13093	19495	2900.	28000.	0	4530	4530	6900.
4/67	11179	12214	24255	7845	4001	1634	0	0	0	0	570	0	11179	8719	20761	6631	9475	2900.	28000.	0	1818	1818	6900.
5/67	13379	12417	26712	7998	4896	1667	0	0	0	0	1171	0	13379	9286	23582	7152	10075	2900.	27811.	0	2272	2272	6900.
6/67	4375	4122	9063	2733	944	1291	0	0	0	0	300	0	4374	581	5521	1441	2207	2900.	24200.	0	436	436	6900.
7/67	6689	6945	12295	3257	1590	0	0	0	0	0	310	0	6689	2620	9770	3257	6299	2900.	19895.	0	630	630	6900.
8/67	11990	10565	23421	6850	3907	0	0	0	0	0	310	0	11990	8240	21096	6850	9258	2900.	17639.	0	2063	2063	6900.
9/67	3793	3342	7676	2083	938	746	0	0	0	0	300	0	3747	391	4679	1336	2132	2900.	13606.	0	417	417	6900.
10/67	4264	5111	9981	3469	1480	1494	0	0	0	0	310	0	4261	1254	6161	1974	2961	2900.	10824.	0	659	659	6900.
11/67	5335	6838	14879	6205	3204	3737	0	1011	2155	3167	300	0	3904	1114	5724	2468	4007	2900.	15362.	0	1630	1630	6900.
12/67	15997	17484	34533	12397	6537	4453	0	0	0	0	310	0	15997	10705	27774	7943	10988	2900.	21118.	0	3085	3085	6900.
1967 YEARLY TOTAL IN B.G.																							
TOT	118.10	121.81	249.61	81.2	45.32	24.84	.00	1.01	2.16	3.17	6.74	.00	116.61	71.00	197.32	59.41	85.08			.000	21.172	21.172	
1/68	8912	8361	18032	5591	3017	3380	0	0	0	0	310	0	8912	2456	12127	2010	3723	2900.	22394.	0	1335	1335	6900.
2/68	8304	8814	17935	5831	3125	2807	0	0	0	0	250	0	8802	3433	12952	3023	4567	2900.	23401.	0	1440	1440	6900.
3/68	15561	16824	33425	11898	6690	2963	0	167	215	382	412	0	15291	11536	27836	9037	11946	2900.	28000.	0	3109	3109	6900.
4/68	8297	7942	16567	4802	3215	2110	0	0	0	0	300	0	8292	3186	12207	2691	4404	2900.	28000.	0	1462	1462	6900.
5/68	15763	23370	40265	14020	9253	2170	0	0	0	0	5841	0	15763	24407	41302	17389	24240	2900.	28000.	0	3961	3961	6900.
6/68	21281	20910	43325	10875	7373	1228	0	0	0	0	3037	0	21281	20169	42085	12384	20234	2900.	28000.	0	3413	3413	6900.
7/68	4157	4311	9041	2498	1033	0	0	0	0	0	310	0	4093	2050	6716	2498	3763	2900.	23057.	0	526	526	6900.
8/68	3757	2300	6579	899	185	0	0	0	0	0	310	0	3537	203	4254	899	1993	2900.	17000.	0	115	115	6900.
9/68	3419	2201	6123	927	323	165	0	0	0	0	300	0	3041	164	3707	761	1711	2900.	11851.	0	145	145	6900.
10/68	3283	1838	5624	840	787	0	0	0	0	0	310	0	2704	92	3299	840	1530	2900.	6591.	0	176	169	6536.
11/68	6183	6505	13304	4378	2248	2260	0	2899	2666	5566	300	0	2069	545	3337	2130	3352	2900.	11385.	0	1035	0	6537.
12/68	8287	10330	19429	7291	3491	4000	0	1309	2533	3842	310	0	6467	1982	9261	3296	5076	2900.	17473.	0	1943	1580	6900.
1968 YEARLY TOTAL IN B.G.																							
TOT	107.71	112.92	229.74	69.9	40.64	21.29	.00	4.38	5.42	9.79	12.03	.00	100.26	70.22	179.58	56.97	88.55			.000	18.666	17.281	

[illegible]

[illegible] PVWC DIVERSION AT T.B. = 75.0 MGD   MONKSVILLE CAPACITY= 6900. MG (after JAN 1, 1990)

3   4 - 5 - 6

	FLOWS W/O WANAQUE SYSTEM (MG)					DIVERSIONS (MG)					RELEASES		FLOWS WITH TW/R PROJ. (MG)					STORAGE (MG)			MONKSVILLE RESERVOIR		
	TWO BRIDGES		L. FALLS	P. LAKE		P. LAKE	PT. VIEW	TWO BRIDGES				PT. VIEW	TWO BRIDGES		L. FALLS	P. LAKE	PT. VIEW	POINT VIEW	WANAQUE	DEAD RIVER	INFLOW	SPILL.	STORAGE
DAY	PSC	PMPT	PSC	RAPO	WNQE	RAPO	PMPT	PSC	PMPT	TOTAL	WNQE RSV	RSV	PSC	PMPT	PSC	RAPO	PMPT	RSV	RSV	DIV	MG	MG	MG
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1/63	5296	6951	12471	4129	1492	2778	0	1656	1991	3647	310	0	2724	297	3719	1361	2854	2900.	26000.	0	1237	0	6262.
2/63	5113	5136	10845	3307	1517	2121	0	1712	1705	3418	290	0	2455	91	3145	1126	2261	2900.	22339.	0	991	353	6900.
3/63	14638	20909	36710	14131	8191	3113	0	441	319	760	1300	0	14068	15351	31511	12037	16371	2900.	28000.	0	3752	3752	6900.
4/63	5438	7034	13134	4543	2136	1932	0	0	0	0	300	0	5438	3632	8952	2611	4203	2900.	26743.	0	820	820	6900.
5/63	5205	5734	11570	3164	2156	1904	0	0	0	0	310	0	5205	1485	7341	1260	3039	2900.	24911.	0	887	887	6900.
6/63	3559	3084	7187	1342	1234	0	0	0	0	0	300	0	3558	833	4537	1342	2594	2900.	20379.	0	537	537	6900.
7/63	3235	2535	6378	1154	564	0	0	0	0	0	310	0	3065	470	4033	1154	2251	2900.	14968.	0	222	222	6900.
8/63	2864	1997	5349	718	209	0	0	0	0	0	310	0	2465	75	3024	718	1720	2900.	9015.	0	120	120	6900.
9/63	3025	1749	5233	599	335	66	0	0	0	0	300	0	2344	112	2536	522	1404	2900.	3699.	0	148	148	5900.
10/63	2351	1716	5160	582	5690	0	0	0	0	0	310	0	2321	21	2833	582	1627	2900.	3632.	0	169	0	1622.
11/63	6640	6201	12512	3721	3050	1789	0	2258	2709	4967	300	0	3358	475	4505	1932	3600	2900.	7269.	0	734	0	327.
12/63	5537	4065	14464	5122	1525	2963	0	2237	3357	5895	310	0	2294	226	3231	2150	4104	2900.	13017.	0	1450	0	1748.
1963 YEARLY TOTAL IN B.G.																							
TOT	63.63	70.92	141.79	42.5	28.02	16.73	.00	8.43	10.26	18.69	4.65	.00	49.27	23.25	50.30	26.81	46.03			.000	11.038	6.838	
1/64	11551	17027	29634	11539	3566	3811	0	1209	4187	5397	310	0	9867	7178	19160	7727	11208	2900.	20672.	0	3336	0	5004.
2/64	7844	9447	18050	6275	1925	3790	0	470	769	1240	290	0	7057	2987	10843	2485	4503	2900.	22500.	0	1568	0	6653.
3/64	12926	12837	26581	9043	4623	4282	0	173	206	377	310	0	12657	5121	19696	4761	6986	2900.	26448.	0	2364	2117	6900.
4/64	17589	14534	33320	9441	6146	1999	0	0	0	0	1568	0	17967	11552	30538	8710	12015	2900.	28000.	0	2766	2746	6900.
5/64	7896	6259	14837	3612	1765	1881	0	0	0	0	310	0	7896	2053	10631	3734	3602	2900.	25755.	0	757	775	6882.
6/64	3919	4178	8661	1939	1015	394	0	0	0	0	300	0	3915	1347	5826	1334	2088	2900.	21590.	0	402	394	6900.
7/64	3612	2220	6350	943	575	0	0	0	0	0	310	0	3221	286	4925	943	1676	2900.	16190.	0	208	208	6900.
8/64	2748	1394	4522	493	207	0	0	0	0	0	310	0	1713	0	2197	493	1060	2900.	10257.	0	120	120	6900.
9/64	2426	1305	4178	325	233	0	0	0	0	0	300	0	1435	39	1926	325	1084	2900.	4752.	0	124	124	6900.
10/64	2593	1323	4400	528	5721	0	0	0	0	0	310	0	1599	0	2075	528	1079	2900.	4716.	0	178	0	1631.
11/64	2805	1477	4773	678	2228	61	0	513	348	861	300	0	1109	0	1600	616	1100	2900.	2296.	0	210	0	0.
12/64	3083	3953	9649	2341	1281	867	0	2669	2060	4729	310	0	1115	0	1727	1474	2475	2900.	3938.	0	376	0	0.
1964 YEARLY TOTAL IN B.G.																							
TOT	81.37	75.87	165.26	47.2	29.27	17.28	.00	5.03	7.57	12.61	4.93	.00	69.60	31.57	109.19	31.16	50.05			.000	12.416	6.498	
1/65	4725	4918	10253	3359	1610	3119	0	2803	1850	4653	310	0	545	0	1157	1240	2121	2900.	7001.	0	732	0	70.
2/65	9169	13845	23085	9464	3087	3020	0	1369	4418	5787	280	0	7209	4339	12769	6435	9209	2900.	14145.	0	2476	0	2345.
3/65	6837	8031	15624	5836	1792	4011	0	3898	3020	6918	310	0	1614	0	2369	1025	2956	2900.	21494.	0	1544	0	3890.
4/65	5771	6515	12947	4670	1255	3417	0	2531	1609	4140	300	0	3257	229	3138	1253	2254	2900.	24981.	0	1022	0	4912.
5/65	4174	4097	9669	3194	871	1853	0	0	0	0	310	0	4174	718	5490	1340	2390	2900.	21814.	0	660	0	5572.
6/65	2853	2388	5728	1384	192	371	0	0	0	0	300	0	2498	121	3107	1013	1625	2900.	16612.	0	189	0	5761.
7/65	2723	1419	4625	647	176	0	0	0	0	0	310	0	1752	66	2300	647	1158	2900.	10812.	0	148	0	5909.
8/65	2635	2153	5337	1126	316	0	0	0	0	0	310	0	2156	357	3012	1126	1853	2900.	4966.	0	192	0	6101.
9/65	2809	2228	5531	1217	309	313	0	0	0	0	300	0	2301	172	2968	904	1572	2900.	-130.	0	186	0	6288.
10/65	3633	5320	9543	3526	6141	1662	0	0	0	0	310	0	3633	1333	5535	1864	3011	2900.	1916.	0	310	0	1151.
11/65	3313	3070	6922	1800	1881	411	0	1639	1555	3193	300	0	528	0	1065	1389	2210	2900.	1833.	0	242	0	0.
12/65	4189	4937	9742	3145	1659	1759	0	2330	2073	4424	310	0	618	0	1233	1385	2328	2900.	4440.	0	733	0	0.
1965 YEARLY TOTAL IN B.G.																							
TOT	52.86	59.76	119.81	39.4	19.23	18.95	.00	14.59	14.53	29.12	3.65	.00	29.29	7.88	44.37	20.43	32.96			.000	8.459	.000	

TWO BRIDGES-RAMAPO DIVERSION SIMULATION

WANAQUE RESERVOIR DRAFT= 173.0 MGD
PVWC DIVERSION AT T.B. = 75.0 MGD

WANAQUE CAPACITY = 28000. MG
MONKSVILLE CAPACITY= 6900. MG (after JAN 1, 1920)

DAY	FLOWS W/O WANAQUE SYSTEM (MG): TWO BRIDGES PSC	TWO BRIDGES PMPT	L. FALLS PSC	P. LAKE RMPO	WAQE	DIVERSIONS (MG): P. LAKE RMPO	PT. VIEW PMPT	TWO BRIDGES PSC	TWO BRIDGES PMPT	TWO BRIDGES TOTAL	RELEASES: WAQE RSV	PT. VIEW RSV	FLOWS WITH TB/R PROJ. (MG): TWO BRIDGES PSC	TWO BRIDGES PMPT	L. FALLS PSC	P. LAKE RMPO	PT. VIEW PMPT	STORAGE (MG): POINT VIEW RSV	WANAQUE RSV	DEAD RIVER DIV	MONKSVILLE RESERVOIR: INFLOW MG	SPILL. MG	STORAGE MG
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1/60	15901	14900	30878	6819	4932	4253	0	0	0	0	310	0	15901	7422	24299	4565	8099	2900.	25394.	0	2276	2276	6900.
2/60	17434	16084	34484	10504	6340	1944	0	0	0	0	1051	0	17434	12686	31124	9321	12967	2900.	27988.	0	3028	3028	6900.
3/60	10502	10447	21955	5441	3050	2623	0	0	0	0	627	0	10502	6026	17334	4145	7149	2900.	28000.	0	1521	1521	6900.
4/60	21529	25133	47664	13666	8457	1638	0	0	0	0	5122	0	21329	26067	48599	16050	25775	2900.	27947.	0	4077	4077	6900.
5/60	8771	8666	18193	5028	2716	2915	0	0	0	0	310	0	8771	3426	12953	2113	4706	2900.	27687.	0	1282	1282	6900.
6/60	4061	4990	9640	3164	1599	1804	0	0	0	0	300	0	4061	935	5383	1359	2510	2900.	25324.	0	951	951	6900.
7/60	4521	7097	12268	5129	2019	0	0	0	0	0	310	0	4506	4787	9943	5129	6237	2900.	21368.	0	1388	1388	6900.
8/60	7554	15982	24432	11542	5090	0	0	0	0	0	310	0	7554	13637	22107	11542	14211	2900.	20206.	0	2232	2232	6900.
9/60	16683	29160	37900	10417	6442	3470	0	0	0	0	300	0	16683	14440	32150	6947	14621	2900.	24400.	0	3172	3172	6900.
10/60	5283	6478	12357	3370	889	2049	0	0	0	0	310	0	5283	3064	7985	1321	3663	2900.	21582.	0	412	412	6900.
11/60	5390	6569	12572	3567	1393	2248	0	0	0	0	300	0	5390	2670	8093	1320	3567	2900.	19652.	0	717	717	6900.
12/60	5564	7477	13716	3983	1926	3617	0	0	0	0	310	0	5564	2536	8774	1365	4083	2900.	18990.	0	950	950	6900.
1960 YEARLY TOTAL IN B.G.																							
TOT	123.00	143.22	276.09	85.6	44.80	23.57	.00	.00	.00	.00	9.57	.00	122.99	96.12	225.98	65.98	107.51			.000	22.013	22.013	
1/61	7975	9256	17981	5091	2705	3368	0	0	56	56	310	0	7975	3306	12031	1522	4645	2900.	20000.	0	1301	1301	6900.
2/61	16599	20011	37651	12321	6682	3012	0	311	1439	1751	280	0	16109	13637	30787	9309	14816	2900.	26600.	0	3310	3310	6900.
3/61	29412	33467	64343	17692	10573	300	0	0	0	0	4538	0	29412	35070	65947	21621	34139	2900.	28000.	0	4246	4246	6900.
4/61	24715	28590	54598	15677	8324	428	0	0	0	0	3749	0	24715	29561	55369	18698	28842	2900.	27977.	0	3808	3808	6900.
5/61	11571	15993	28377	9417	4376	1820	0	0	0	0	645	0	11571	12083	24567	7952	12757	2900.	27947.	0	2113	2113	6900.
6/61	4290	6003	10901	3729	1380	2195	0	0	0	0	300	0	4290	1559	6455	1534	3106	2900.	25757.	0	687	687	6900.
7/61	4528	4164	9277	1960	464	0	0	0	0	0	310	0	4487	1881	6952	1960	3644	2900.	20245.	0	248	263	6885.
8/61	4580	3366	8512	1369	305	0	0	0	0	0	310	0	4530	1090	6187	1369	2935	2900.	14388.	0	188	174	6900.
9/61	3049	3056	6603	1486	25	332	0	0	0	0	300	0	2977	546	4020	1153	2372	2900.	9028.	0	74	74	6900.
10/61	3034	2172	5708	832	3372	0	0	0	0	-0	310	0	2824	57	3383	832	1868	2900.	6643.	0	91	38	3615.
11/61	3791	4227	8565	1801	1662	328	0	2193	2486	4679	300	0	561	0	1187	1273	3194	2900.	7941.	0	204	0	2413.
12/61	5076	5376	11077	3297	753	1723	0	2739	2534	5274	310	0	1130	0	1754	1574	2963	2900.	10456.	0	694	0	3298.
1961 YEARLY TOTAL IN B.G.																							
TOT	118.63	135.39	263.60	74.7	40.63	13.91	.00	5.24	6.52	11.76	11.66	.00	110.39	98.60	218.57	68.78	115.28			.000	17.761	16.619	
1/62	8031	10802	19654	7300	2068	3661	0	2506	3846	6352	310	0	4542	1952	7316	3639	5836	2900.	17218.	0	1959	0	5257.
2/62	5031	4756	11186	2787	866	1516	0	2130	2121	4271	280	0	2394	104	3298	1271	2601	2900.	19114.	0	892	0	6149.
3/62	18901	21359	41484	14472	7188	4032	0	1098	1901	3000	310	0	17473	13429	32127	10459	14848	2900.	28000.	0	3705	2953	6900.
4/62	17656	16677	35378	11330	5848	1250	0	0	0	0	2230	0	17656	15107	33808	12030	15421	2900.	27842.	0	2666	2666	6900.
5/62	5123	4987	10715	2919	1113	1436	0	0	0	0	310	0	5123	1225	6953	1482	2928	2900.	24500.	0	436	436	6899.
6/62	3592	2639	6742	1358	384	139	0	0	0	0	300	0	3527	314	4352	1219	2134	2900.	19250.	0	160	159	6900.
7/62	3041	1944	5474	698	39	0	0	0	0	0	310	0	2566	94	3149	698	1671	2900.	13312.	0	78	78	6900.
8/62	3642	2304	6463	943	261	0	-0	0	0	0	310	0	3332	288	4138	943	1981	2900.	7411.	0	133	133	6900.
9/62	3707	2418	6626	900	228	0	0	0	0	0	300	0	3539	337	4376	900	2098	2900.	1921.	0	123	123	6900.
10/62	4740	5859	11223	3334	6479	1614	0	0	0	0	310	0	4740	1919	7283	1720	3512	2900.	4258.	0	572	0	2025.
11/62	7724	13176	21775	9172	4072	4391	0	2149	5124	7273	300	0	4894	2090	7060	4781	7187	2900.	14423.	0	2569	0	3365.
12/62	5639	9377	15762	6177	2039	3453	0	1222	1498	2721	310	0	3794	2723	7262	2723	4776	2900.	17402.	0	1660	0	5025.
1962 YEARLY TOTAL IN B.G.																							
TOT	67.63	96.30	192.49	61.4	30.58	21.50	.00	9.13	14.49	23.62	5.58	.00	73.79	39.59	121.93	41.87	65.00			.000	14.957	6.553	

1988

OCCURANCES OF VARIOUS PHASES OF DROUGHT
RULE CURVES ON WANAQUE SOUTH-MONKSVILLE
DIVERSION SIMULATION WITH 173 MGD DRAFT

(Note:- This Table should be read in conjunction with precipitation & storage Rule Curves of Wanaque System)

CONSERVATION MODE	STORAGE Vs. PRE.DEF.	OCCURANCES (Month / Year)	PERCENT
NORMAL	C/C B/C (Mar-Sep) C/B	621 Occurances out of 705	81.1
ALERT	C/A B/C (Oct-Feb) B/B (Oct-May)	11/22; 10/23; 8/23; 5/26; 6/26; 10/30; 12/30; 7/32; 2/34; 8/41; 8/44; 1/47; 2/47; 7/57; 11/57; 9/48; 6/49; 5/55; 5/56; 6/65; 10/66; 10/68; 8/77; 10/78; 11/78; = 26 Occurances	3.7
WARNING	A/C B/B (Jun-Oct) A/B B/A	11/31; 12/31; 9/32; 10/32; 9/35; 10/35; 9/36; 10/36; 11/36; 9/39; 10/39; 2/40; 10/41; 12/41; 9/44; 11/44; 10/48; 11/48; 10/49; 11/49; 1/50; 9/53; 12/53; 7/62; 8/62; 4/62; 10/62; 8/63; 9/63; 11/63; 8/64; 9/64; 7/65; 8/66; 9/66; 9/70; = 36 Occurances	5.1
EMERGENCY	A/A	11/39; 12/39; 1/40; 11/40; 10/44; 12/49; 10/53; 11/53; 8/57; 9/57; 10/57; 10/63; 10/64; 11/64; 12/64; 1/65; 8/65; 9/65; 10/65; 11/65; 12/65; 1/66; = 22 Occurances	3.1

3/16/89

OCCURANCES OF VARIOUS PHASES OF DROUGHT
RULE CURVES ON WANAQUE SOUTH-MONKSVILLE
DIVERSION SIMULATION WITH 145 MGD DRAFT

(Note:- This Table should be read in conjunction with precipitation & storage Rule Curves of Wanaque System)

SUPPLY MODE	STORAGE Vs. PRE.DEF.	OCCURANCES (Month / Year)	PERCENT
NORMAL	C/C B/C (Jun to Oct) C/B	601 Occurances out of 705	85.2
ALERT	C/A B/C (Nov to May) B/B (Jun to Oct)	81 Occurances out of 705	11.5
WARNING 1	A/C B/B (Nov to May)	11/36; 11/39; 11/49; 12/49; 10/[illegible]; 11/57; 10/65; 11/65; 12/65; = 9 Occurances out of 705	1.3
WARNING 2	A/B B/A	12/39; 1/40; 2/40; 11/[illegible]; 8/57; 9/57; 10/57; 10/63 10/64; 12/64; 9/65; 9/65; = 12 Occurances out of 705	1.7
EMERGENCY	A/A	11/[illegible]; 11/64 =2 Occurances out of 705	0.3

122 occurrences @ 3%

Appendix 3

Big 25/WSAC Comments to Draft Plan

Interconnection Study Draft Report Comments - Passaic Valley Water Commission					
ID	**Section**	**Page(s)**	**Commenter**	**Purveyor**	**Comment**
1	2.5.1	14 2nd ¶	PVWC	PVWC	Residential demands are declining in New Jersey at rates of approximately 0.5 to 1.0% per year as a result of the implementation of the 1992 Energy Policy Act. This is partially offsetting growth in some systems while in others it is driving an overall decline in use/production.
2	2.5.2	14 4th ¶	PVWC	PVWC	Too much is being made of the impact of industrial and manufacturing uses within public water supply systems. This is generally a small category of use in relation to residential use and in many of the older cities, industrial/manufacturing uses are all but gone.
3	2.5.2	15 First bullet	PVWC	PVWC	A further explanation of the reason these plants were considered to have zero drought capacity is needed. Although a conservative approach is desirable, this does not adequately explain why these plants were singled out.
4	2.5.3	16 3rd ¶	PVWC	PVWC	To the extent that DEP approved contracts exist between a bulk supplier and a bulk purchaser, these contracts should have been considered as firm capacity. In its review, DEP encumbers the allocation and production capacity of the contract supplier. The stated approach is likely to inflate the need to make transfers by underestimating the available supply for some systems.
5	Table 2-6	Page 2 of 2	PVWC	PVWC	This calculation suggests PVWC is in deficit because the analysis does not reflect the firm capacity available to PVWC by virtue of the Wanaque North contract with NJDWSC. Elsewhere in this report, PVWC is shown to have substantial surplus capacity as is truly the case.

6	Table 5-3	35	PVWC	PVWC	With respect to the systems supplied by NJDWSC, a distinction should be drawn between Wanaque North and Wanaque South customers as per the contracts. These groups utilize and pay for different classes of assets. The ability of any one user and any one class of customer to use "unused capacity" of another user has financial implications. The table should also note that the Newark contract capacity includes water used by Bloomfield. The Glen Ridge (0.7 MGD) and Nutley (3.0 MGD) systems are absent from this list of NJDWSC supply users. Finally, this list includes only finished water users and it does not show the raw water contract to United Water New Jersey (39.5 MGD).
7	Table 5-4	36	PVWC	PVWC	Bloomingdale, Cedar Grove, Fairfield, Fairlawn, Haledon, Hawthorne, Lincoln Park, West Caldwell, North Caldwell, Ringwood, Totowa, Verona, Wallington, West Paterson and Riverdale are also contract customers of PVWC but these are not included in the table.
8	5.3.2	38 First full ¶	PVWC	PVWC	In general terms, this is not consistent with typical operational practice. Systems with both surface and ground water sources tend to base load surface supplies because these are more efficient to operate at consistent rates. In addition, wide variations in flow are less desirable for a host of operational reasons. Ground water sources are generally used to supplement the surface water flow and meet peak demands. Furthermore, contract purchases are often used first of all because these typically are take-or-pay arrangements that require the buyer to pay for the water even if it is not used.
9	5.4.1	41 Table 5-5	PVWC	PVWC	Why isn't Greenwood Lake included in the RMBM?
10	5.5.3	51	PVWC	PVWC	This characterizes 2005 as "normal" but it should be noted that very dry conditions existed between the start of June and the start of October. Had a 6-inch rainfall event not occurred at the beginning of October, DEP was prepared to hold Drought Hearings and at least declare a Warning. Had this singular rainfall event not happened, and had the dry conditions persisted through the end of October, a condition worse than the 2001/2002 drought would have been recorded.

11	6.0 & 6.1	53 - 96	PVWC	PVWC	This section attempts to simulate the impact of transfer strategies with the goal of mitigating the severity of demand-management drought restrictions. It is important to note that the "deficits" described herein do not equate to a deficit in safe yield as defined by current DEP regulation. The point of this exercise is to mitigate the level of drought restriction imposed, it is not to identify safe yield deficits or the means to satisfy such deficits. It is important to note, for example that the analysis in Section 6.1.7 is NOT suggesting that NJDWSC has a deficit in safe yield of 97 MGD under such conditions.
12	6.1.2	61	PVWC	PVWC	PVWC has the ability to transfer 12 MGD to United and has done so under contract in the past and on an emergent basis in recent droughts. This could be done by suspending regular bulk sales to other contract purchasers who have alternate, out-of-basin supplies, so long as UWNJ compensates those other purchasers for their incremental increases in the cost of procuring replacement water. If UWNJ has such a shortfall (24 MGD), it seems obvious that they may have failed to make appropriate investments in source capacity, or alternatively to contract to purchase adequate supplies under contract, to keep pace with growing customer demands.
13	6.1.3	61	PVWC	PVWC	Published reservoir level data are available for this period from USGS. The published data would provide the actual starting reservoir levels for this analysis.
14	6.1.4	70 1st ¶	PVWC	PVWC	At 5 MGD, this would not be necessary. PVWC could supply the 5 MGD directly to UWNJ from its surplus or by diverting wholesale water normally sent to other contract customers with alternate, out-of-basin supplies in an equal amount. The cost to UWNJ should be the PVWC retail rate, paid to PVWC and the incremental increased cost of production incurred by other contract customers adversely effected by the suspension of PVWC supplies. For example, as in past drought conditions, such diversions were made by PVWC with respect to sales to NJAW. In these cases, NJAW purchased additional raw water from the NJ Water Supply Authority for treatment at its own production facilities. In the future, if such an arrangement were to cause NJAW to maintain plant capacity for UWNJ's benefit, some standby fee should be paid to NJAW by UWNJ to maintain this capacity.

15	6.1.5	76 1st ¶	PVWC	PVWC	Making such a reduction represents an unmitigated cost to Newark. The monies due to NJDWSC are on a take-or-pay basis by contract. If Newark is not allowed to take the water and must produce water from its own sources or buy replacement water from other supplies, their costs are increased to provide a benefit to some other entity. In this simulation, the question becomes this: Who benefited from this shifting if NJDWSC's safe yield was adequate to produce the 173 MGD they are contractually obligated to provide? This would artificially support reservoir levels within the wholesale water supply while the focus should be on the adequacy of retail level suppliers to meet customer demands in dry periods.
16	6.1.7 Table 6-5	91	PVWC	PVWC	NJDWSC is a wholesale supply. Shouldn't we be more concerned with the ultimate retail suppliers of water? In other words, if we concern ourselves with the ability of the NJDWSC wholesale customers to meet the respective demands of their customers from both NJDWSC and other sources, we could rely more comfortably on the designed operating range of the Wanaque/Monksville system in the simulations. Each retail level supplier should have adequate safe yield to meet the normal demands of its customers and this safe yield should include the contract commitment made by NJDWSC plus safe yield available from other sources. This would allow us to focus on transfers needed to assure a reliable supply at the retail level and avoid consideration of the need to make a 97 MGD transfer to NJDWSC to artificially support reservoir levels.
17	7.4.1	125	PVWC	PVWC	A table showing the purveyors who have gone into deficit in the simulations from Chapter 6 and their current Non-Revenue Water percentages, as per current DEP rules, should illuminate an additional drought mitigation strategy.
18	9.6 (6)	142	PVWC	PVWC	Standby fees are only needed when the water is not likely to be used routinely. This would protect the supplying system's customers from inadvertently subsidizing the cost of capital related facilities in the receiving system.

19	9.6 (2)	141	PVWC	PVWC	This recommendation seems to confer some special status on NJDWSC. NDJWSC is simply a wholesale supplier of treated and untreated water. The NJDWSC implements projects on behalf of municipal entities and water utilities who request that the NJDWSC develop and operate needed supplies. Many of the water systems that use water supplies developed by NJDWSC also have access to other supplies of their own or supplies that have been acquired under contract. DEP should focus its attention on these ultimate suppliers of water to be sure that each has adequate supplies to meet the normal demands customers impose on each system. It should also be noted that the various contracts governing the provision of water to the Wanaque North and South customers already address the issue of reimbursement for purveyors who allow their unused Wanaque North or South capacity to be sold to other entities that need more than their contracted allotment. Care should be taken by DEP to avoid contravening these contractual relationships, especially since these provisions have been honed by litigation over many years.

Interconnection Study Draft Report Comments - United Water					
ID	**Section**	**Page(s)**	**Commenter**	**Purveyor**	**Comment**
1	In general	all	C. Beckers, Consultant	UWNJ	An unstated limitation of this document, implicit throughout, appears to be that it focuses solely on Finished Water. Opportunities to transfer raw water in support of systems experiencing deficits, such as the raw water interconnection between Wanaque Reservoir and Oradell Reservoir, are not addressed. There are some places where this limitation does not appear to prevail (e.g., Table 2-2). There is no explanation anywhere in the report as to how the distinction between raw and finished water was made and applied. This limitation should be explicitly stated, so that the reader is aware of the focus.
2	In general	all	C. Beckers, Consultant	UWNJ	The study is unclear whether the goal is to prevent water supply system failure (meaning one or more reservoirs dry out) or to minimize the occurrence of situations in which water supplies fall below various trigger levels. While falling below a trigger level may require the public to begin to take action to conserve water and be politically unpopular, it does not constitute a public emergency in the same sense as a dry reservoir does. The report needs to justify the importance of preventing water supplies from falling below various trigger levels, if that is the approach NJDEP is intent on. Is it appropriate to spend $$ for transfers that are only intended to prevent the crossing of an artificial line that, in itself, is intended to have the same effect as the transfers?
3	In general	all	C. Beckers, Consultant	UWNJ	The study does not appear to address the potential for having to transfer water back to a system or region that previously supplied water to other systems or regions, as a drought progresses and different regions are affected differently.

4	In general	all	C. Beckers, Consultant	UWNJ	The report does not contain any results or information that would allow the reader to form an opinion about the reliability of the models that form the entire basis for the conclusions presented in the report. Provide results for each model that could be described as "calibration", "verification" or "validation" results. The few comparisons made in Chapter 6 are inadequate to this purpose, because the conditions modeled are not clearly described. Claims that data are not available for the purpose are inaccurate.
5	In general	all	C. Beckers, Consultant	UWNJ	The report presents what could be broadly described as a systems analysis. The first step in developing any systems analysis is to carefully and completely define the system being analyzed, with particular care regarding what things are within the system and what things are external to the system. The report does not present an explicit definition of which raw and finished water elements are included within the "system".
6	In general	all	C. Beckers, Consultant	UWNJ	The analysis appears to view groundwater as an infinite resource. Why is there no model component in the WSMDST for groundwater similar to the RMBM? This is a separate question from the issue of surface-groundwater interaction commented on in Section 5.4.1 (pg. 40).
7	In general	all	C. Beckers, Consultant	UWNJ	Before it becomes a public document, the report needs a thorough review by a professional technical editor. For example, on page 56, does "re-occur" mean the same as "recur"?
8	In general	all	C. Beckers, Consultant	UWNJ	Throughout the analyses presented, the study appears to assume more water is available from PVWC than is currently allocated. If this is intentional, the production capacity assigned to PVWC should be stated explicitly and thoroughly justified, especially with regard to what can be expected to be available at its intakes during drought conditions. The relationship between the current allocation and what is assumed in the report should also be discussed.
9	In general	all	C. Beckers, Consultant	UWNJ	Why is there no discussion of groundwater and southern NJ droughts?

10	1.2.1	4	C. Beckers, Consultant	UWNJ	This section cannot be reviewed until the missing text under the title "United Water Transmission Main" is provided. What pipe is the intended topic?
11	2.2	9	C. Beckers, Consultant	UWNJ	The draft report cannot be fully reviewed until the contents of this section are provided. Provide contents of the section for review.
12	2.3	9	C. Beckers, Consultant	UWNJ	If only the "available data" were reviewed, how do you know that "all primary water transmission and interconnection infrastructure" was identified? Can you provide an estimate of what percentage the 225 identified items are of the total such interconnections? Do you think you got most or 50% or just 20%? How certain are you that all UWNJ interconnections are included in the model? Provide sufficient information so that UWNJ can verify that all its interconnections are included correctly.
13	2.3	9	C. Beckers, Consultant	UWNJ	Of the 20 systems identified for inclusion, which 16 are the ones that are part of the "Big 25"? Why weren't all of the Big 25 included in the model? Does everyone know what the Big 25 systems are? Who was left out and why? Provide a list of the Big 25 and explain why only 16 were included in the model. Suggest expanding Table 2-1 to cover this information.
14	2.3	10	C. Beckers, Consultant	UWNJ	How were the inaccuracies corrected? What types of inaccuracies were there and where did you get the information to make the corrections? Were any of these inaccuracies related to a United Water system? If so, what were they and how were they rectified?
15	2.4	11	C. Beckers, Consultant	UWNJ	Provide United Water portions of GIS so that information contained in GIS and hydraulic model related to UW systems can be verified as accurate and complete.

16	2.5.2	15	C. Beckers, Consultant	UWNJ	It is possible for the water supply limit to be smaller than the safe yield. It is also possible for the water supply limit to be greater than the safe yield. Why was safe yield chosen as one of the constraints for drought conditions? Also, how were surface water systems without reservoirs, like the Passaic Valley system evaluated during drought conditions?
17	3	21-23	C. Beckers, Consultant	UWNJ	In general, the section provides insufficient information to make a judgment regarding the accuracy or the adequacy of the hydraulic modeling.
18	3.2	21	C. Beckers, Consultant	UWNJ	UWNJ did not provide a calibrated WaterGEMS model; UWNJ provided only a shape file including principal finished water system components, with minimal property information. How was the UWNJ part of the hydraulic model calibrated? Provide results demonstrating that the hydraulic model accurately represents the UWNJ part of the system.
19	3.3	22	C. Beckers, Consultant	UWNJ	Provide an evaluation of the importance of omitting about 33% (151 included out of 225) of the identified interconnections from the hydraulic model. How good are the model results without these omitted interconnections?
20	3.4	22	C. Beckers, Consultant	UWNJ	Specifically what data necessary for "a working model" were missing and what assumptions were made for each missing value? The reader does not have the "Model User Guide" and there is no other reference to it in the draft report.

21	3.4	23	C. Beckers, Consultant	UWNJ	Specifically, which interconnections presented problems in the joining process and how was each problem resolved?
22	3.4	23	C. Beckers, Consultant	UWNJ	The meaning of the following phrase is not clear: "Additional future year ADD according to the demand projections identified in Table 2-4."?
23	5	in general	C. Beckers, Consultant	UWNJ	Section 5 of the report does not provide sufficient factual information to permit the reader to form a conclusion regarding the validity, usefulness, or, most importantly, safety of the model.
24	5.2.1	31	C. Beckers, Consultant	UWNJ	While the rule curves shown in Figure 0-2 may be those in use by the NJ Water Supply Drought Indicator System, they are *not* the operating rule curves developed under the current WAP 5111 and approved by NJDEP for the UWNJ 4-reservoir system. Expand the caption to clarify the example or choose another example.
25	5.2.1	32	C. Beckers, Consultant	UWNJ	The example cited for the Jersey City extreme curve does not appear to be correct. Provide the storages used to compute the 25% value.
26	5.3.1	34	C. Beckers, Consultant	UWNJ	In Table 5-1, provide the detail that went into the calculation of the 2 mgd groundwater production assigned to UWNJ. The value is inconsistent with existing WAPs.
27	5.3.1	34	C. Beckers, Consultant	UWNJ	In Table 5-2, the "source of supply" for UWNJ should read "Hackensack River System, Wanaque Reservoir, Saddle River Diversion, Hershfield and Sparkill Creek Diversions and Raw water Wells
28	5.3.1	35	C. Beckers, Consultant	UWNJ	In Table 5-3, verify that Mahwah is the only buyer of bulk finished water from UWNJ. Also verify quantity.
29	5.3.1	36	C. Beckers, Consultant	UWNJ	The seasonal demand pattern cited in Table 5-4 for UWNJ does not appear consistent with the available information from UWNJ. Provide details of what period(s) of time the data used to calculate the profile represented and the source.
30	5.3.1	37	C. Beckers, Consultant	UWNJ	Provide or point to a list of the 55 purveyors included in the IMBM.
31	5.3.2	37	C. Beckers, Consultant	UWNJ	The review of the draft report cannot be completed until the appendix identified as "Appendix X" is provided for review.

32	5.3.2	37	C. Beckers, Consultant	UWNJ	The study adopts the goal of equalizing the risk of going dry. This is a significant decision that requires greater emphasis. Is this the best goal? Does this goal provide for a soft failure of the water supply system, or is it an "all or nothing" approach? Wouldn't it be better to have some reservoirs fail before others, to distribute the problem over a longer period of time? With this approach, if we experience a new drought of record, the entire State of New Jersey (or at least an entire drought region) goes dry at the same time. This appears to be a very dangerous optimization goal, from a public policy perspective.
33	5.3.2	38	C. Beckers, Consultant	UWNJ	Justify the use of groundwater before surface water. What analyses were performed to determine that this is the best approach? Studies in at least one other state have demonstrated that it is best to use surface water before groundwater and desalination. State why New Jersey is different in this regard.
34	5.3.2	39	C. Beckers, Consultant	UWNJ	There is no discussion of what happens when groundwater tables begin to fall below well screen elevations and wells begin to fail during a drought. Provide an evaluation or explanation for why this is not considered.
35	5.4.1	41	C. Beckers, Consultant	UWNJ	Table 5-5 lists Lake DeForest, which is wholly in New York, as one of the reservoirs incorporated into the RMBM. Under the rules governing operation of Lake DeForest, only a portion of the water stored in that reservoir is available to UWNJ at any point in time, and the rate at which that water can be transferred to New Jersey is strictly regulated. Unlike New Jersey reservoirs, NJDEP cannot use a drought emergency to mandate changes in Lake DeForest operations. Provide a detailed explanation of how Lake DeForest is represented in the RMBM.

36	5.4.1	42	C. Beckers, Consultant	UWNJ	Point View Reservoir does not release its water "directly to [its] respective treatment [plant]." It was designed for the release to return the water to the Pompton River. More recently, it can now pipe its water indirectly to the PVWC plant via the Wanaque South Aqueduct, but that can only be done when the aqueduct is not being used to send water from the Wanaque South Pump Station to the Wanaque Reservoir. During a drought, the Wanaque South Pump Station can be expected to be in nearly continuous use. Provide a detailed explanation of how Point View Reservoir was represented in the RMBM.
37	5.4.1	42	C. Beckers, Consultant	UWNJ	Provide a detailed justification for the conclusion that use of Point View Reservoir "to regularly mitigate water shortages is not considered viable." A study for UWNJ and NJDWSC demonstrates that coordinated use of Point View Reservoir with Wanaque Reservoir and Oradell Reservoir can increase the safe yield of that system by about 6 mgd during the drought of record.
38	5.4.1	42	C. Beckers, Consultant	UWNJ	How does the RMBM incorporate evaporation? What rates were used? Does it also incorporate direct precipitation to the surface of the reservoir? If not, why not? If so, how was the calculation done and what rates were used?
39	5.4.1	42	C. Beckers, Consultant	UWNJ	Clarify the last sentence immediately above Figure 5-5.
40	5.4.1	42	C. Beckers, Consultant	UWNJ	For multiple-reservoir systems, how was the fundamental hydrology handled? For example, what does RMBM do when an upstream reservoir fills to capacity? Or does it assume that all reservoirs fill simultaneously?
41	5.4.1	42	C. Beckers, Consultant	UWNJ	For multiple-reservoir systems, how were operating rules incorporated into the model? What rules were incorporated for the UWNJ system?
42	5.4.1	43	C. Beckers, Consultant	UWNJ	It is not immediately apparent why a percent-based system would produce the results described in the first paragraph on page 43. Expand the statement.
43	5.4.1	43	C. Beckers, Consultant	UWNJ	The second paragraph on page 43 and Figure 5-6 are unclear. Provide a key for the graphs in Figure 5-6 and expand the paragraph so that it relates to the figures in a way that makes the concept clear.
44	5.4.1	45	C. Beckers, Consultant	UWNJ	Explain how one determines an "appropriate adjustment factor" to make the average precipitation curve represent "wet and dry years".

45	5.4.2	46	C. Beckers, Consultant	UWNJ	The order of calculation is unclear. Once the RMBM determines how much water each plant can produce while drawing down the reservoirs proportionally, is that water immediately taken from the reservoirs? What if the infrastructure does not allow the system to take full advantage of the available water? Is the unused water put back into the reservoirs (or never taken out)?
46	5.5	47-48	C. Beckers, Consultant	UWNJ	Add actual storage curves to Figures 5-10 and 5-11, so the reader can understand how these idealized curves compare with reality. Explain any differences.
47	5.5	47-48	C. Beckers, Consultant	UWNJ	Provide a description of the scenario conditions used for the idealized runs. It is not clear what they represent.
48	5.5.1	48	C. Beckers, Consultant	UWNJ	If this is for a specific reservoir, say which reservoir. If for a generic reservoir, say so, explain how similar it is to the actual reservoirs in the model, and explain how the simulation was created.
49	5.5.1	48	C. Beckers, Consultant	UWNJ	The text says "…***would have*** [emphasis provided] experienced Drought Emergency levels…." Explain the conditions under which this "would have" occurred. Explain how those conditions differ from what actually occurred during the Drought of Record.
50	5.5.1	49-50	C. Beckers, Consultant	UWNJ	Are Figure 5-12 through 5-15 for a specific reservoir, all the reservoirs modeled, or a generic reservoir? If for a specific reservoir or for all modeled reservoirs, add the actual performance during the period to each graph, so the reader can understand how well the simulation represents what actually occurred. This will develop a level of confidence in the model that is not created by the figures as presented.
51	6.1	53	C. Beckers, Consultant	UWNJ	Provide a technical reference for the broad statement "One will never, in the foreseeable future, be able to predict the weather…" or reword the sentence to reflect the actual status of weather forecasting today and relate what is said to the needs of drought management.
52	6.1.1	54	C. Beckers, Consultant	UWNJ	Explain what you mean by "an acceptable risk of 10%." Does it mean the probability of some event occurring? If so, what event? If it means 10% likelihood of running out of water in a given drought management region, that seems extraordinarily high. Cite the specific "prior analyses".

53	6.1.1	55	C. Beckers, Consultant	UWNJ	Why does the recommended procedure start with the 10th percentile situation? Why not provide a procedure that compares recent data with historical data to decide what kind of drought situation you are in? What if it is only a 20% situation? You would be overreacting, if you based your decisions on 10th percentile statistics. On the other hand, what happens if it is really a 5 percentile situation? You can easily end up "behind the power curve", as pilots say. The report says it is an attempt to balance risk and cost, but how was that judgment made? Justify the selection of 10th percentile with more than the assertion of judgment.
54	6.1.2	56	C. Beckers, Consultant	UWNJ	Why wasn't the analysis started at a condition representative of what actually occurred at the beginning of the 60's drought? That would be more representative of what a user would "see" if the 60's drought were to recur.
55	6.1.2	56	C. Beckers, Consultant	UWNJ	Compare the model results that show UWNJ falling below the advisory curve about 8/1/64 with what actually happened.
56	6.1.2	56	C. Beckers, Consultant	UWNJ	In modeling the 60's drought, what assumptions were made regarding Lake DeForest and the United Water NEW YORK diversion from Lake DeForest? Also, what assumptions were made regarding the Nyack (NY) diversion from the Hackensack River?
57	6.1.2	56	C. Beckers, Consultant	UWNJ	In modeling the Hackensack system during the 60's drought, what assumptions were made regarding transfer of raw water from Wanaque Reservoir to Oradell Reservoir?
58	6.1.2	56	C. Beckers, Consultant	UWNJ	In modeling the Wanaque system during the 60's drought, what assumptions were made regarding transfer of raw water from Wanaque Reservoir to Oradell Reservoir and regarding use of the Wanaque South and Ramapo pump stations?
59	6.1.2	56-60	C. Beckers, Consultant	UWNJ	The legends on Figures 6-1 through 6-5 do not correspond to the curves shown on the graphs. Correct or provide an explanation of the meaning of each curve. (It is understood that the "blue" line is intentionally missing. This comment refers to the other 4 lines not listed in each legend.)
60	6.1.2	56	C. Beckers, Consultant	UWNJ	The statement that no actual reservoir observations are available for the 60's drought period is inaccurate. The report would benefit from the inclusion of those data here.

61	6.1.2	60	C. Beckers, Consultant	UWNJ	"Conservation is the only strategy that can alleviate this condition in the long term." The safe yields for all the reservoir systems shown are based on a repetition of the 60's drought. If the water allocations are, in turn, based on the safe yields, then there is no condition to alleviate. Each reservoir will survive with about the same reserve storage as was incorporated into the corresponding safe yield analysis. The concern is for occurrence of a multi-year drought that turns out to be a new Drought of Record. Such a drought can only be managed by reduction of demand, by definition of Drought of Record.
62	6.1.2	60-61	C. Beckers, Consultant	UWNJ	The choice of verb tenses should clearly indicate that the results being presented are conditional and based on the modeling assumptions, not a reporting of what actually occurred.
63	6.1.2	60-61	C. Beckers, Consultant	UWNJ	Present figures similar to Figures 6-1 through 6-5 to illustrate the "what would have happened if" case being discussed.
64	6.1.3	61	C. Beckers, Consultant	UWNJ	The statement that no actual reservoir observations are available for the 80's drought period is inaccurate. The report would benefit from the inclusion of those data here.
65	6.1.3	61-65	C. Beckers, Consultant	UWNJ	The legends on Figures 6-6 through 6-9 do not correspond to the curves shown on the graphs. Correct or provide an explanation of the meaning of each curve. (It is understood that the "blue" line is intentionally missing. This comment refers to the other 3 lines not listed in each legend.)
66	6.1.3	65	C. Beckers, Consultant	UWNJ	None of the figures shows any of the reservoirs coming close to drying out. Provide an explanation of why the water purveyors should incur the expense of water transfers when every one of them is shown to have more than enough water to get through the 80's drought. Reservoirs are designed to come close to drying out during dry periods; it is exactly what they are intended to do, even though the lay public may get worried about seeing bare bottom. Transfer of water should be better justified than just alleviating worries over bare bottom.
67	6.1.3	65	C. Beckers, Consultant	UWNJ	Are we trying to avert falling below a drought condition curve, or are we trying to avert failure of the water supply system due to drought (meaning one or more reservoirs dries out)?

68	6.1.3	66	C. Beckers, Consultant	UWNJ	Table 6-1: (1) Why is NJDWSC plant production so much below capacity? (2) Why does PVWC production exceed the maximum daily allocation of 75 mgd?
69	6.1.3	66	C. Beckers, Consultant	UWNJ	Table 6-2: Explain what the phrase "Mass Balance Satisfied for Receiver" means and what the significance is.
70	6.1.4	69	C. Beckers, Consultant	UWNJ	The statement that reservoir data for the Newark reservoirs is not available for 1995 is inaccurate.
71	6.1.4	71	C. Beckers, Consultant	UWNJ	Figure 6-14 leaves this reader wondering which had the better effect, allowing the drought emergency to trigger conservation or using the proposed procedures to extend the pre-trigger period at the expense of water transfer. The report should discuss this and justify the approach taken.
72	6.1.4 - 6.1.8	various	C. Beckers, Consultant	UWNJ	Comments on these sections are mostly repeats of prior comments on Chapter 6, so are not listed here, with the exception of the following.
73	6.1.6	82	C. Beckers, Consultant	UWNJ	In Table 6-3, why is PVWC production shown in excess of maximum daily allocation?
74	6.1.7	87	C. Beckers, Consultant	UWNJ	Where, geographically, is the "representative point" shown in Figures 6-29 and 6-30?
75	6.1.7	91	C. Beckers, Consultant	UWNJ	In Table 6-5, what was the assumed production for PVWC?
76	6.1.8?	95	C. Beckers, Consultant	UWNJ	Table 0-6 (?) cannot be reviewed until the questions and comments related to Section 6 are resolved.
77	6.3	101	C. Beckers, Consultant	UWNJ	Water reuse in Florida is second only to that in California.
78	7.2	113	C. Beckers, Consultant	UWNJ	How can optimization of source water selection prevent a drought? Droughts are natural processes not subject to intervention by mankind. Optimization can mitigate the effects of drought, but not prevent one.
79	More comments on tables 2.3, 2.4, 2.5, 2.6 and 2.7 will follow by May 27, 07				

UWJC's Comments by John Hroncich

ID	Section	Page(s)	Commenter	Purveyor	Comment
1	Table 2-2		John Hroncich	UWJC	Lyndhurst Water Department is served by United Water Jersey City not United Water New Jersey. The percentage of water supply is 100%.
2	Table 2-2		John Hroncich	UWJC	United Water Jersey City supplies only a small portion of the demand for Montville not the 100% suggested. The average demand for Montville is 0.30 MGD from UWJC.
3	Table 2-2		John Hroncich	UWJC	United Water Jersey City supplies a small portion of the total water for Parsippany which is not included in the table. The average demand for Parsippany is 0.30 MGD from UWJC.
4	Table 2-3	4 of 7	John Hroncich	UWJC	United Water Jersey City serves 100% of the population of Jersey City not 92% as indicated.
5	Table 2-5	1 of 3	John Hroncich	UWJC	West Caldwell average daily demand (ADD) is about 1.2 MGD from UWJC. Table 2-5 indicates 0.
6	Table 2-7	2 of 6	John Hroncich	UWJC	Lyndhurst Water Department has only 2 interconnections noted when they actually have 4.
7	Table 2-8	2 of 6	John Hroncich	UWJC	The North Bergen interconnection between UWNJ and UWJC is not listed on the table.

Interconnection Study Draft Report Comments - NJDWSC					
ID	**Section**	**Page(s)**	**Commenter**	**Purveyor**	**Comment**
1	1.1.1	1		NJDWSC	how did poor distribution system conditions increase drought impacts?
2	1.1.1	1,2		NJDWSC	in discussion of historical droughts why is there no mention of the 3 most recent drought emergencies, occurring in the past 12 years?
3	1.1.3	3		NJDWSC	how can 95% of the population be served by 190 systems; when the DEP estimated in 1992 that 12% of the population was served by private wells?
4	1.2	3		NJDWSC	Why is there no discussion of the water supply emergencies caused by regional power outage such as the incident which occurred on August 14, 2003?
5	1.2.1	4		NJDWSC	capacity of Raritan-Millstone plant is stated as 210 MGD here but 155 MGD in other sections of the report
6	1.2.1	4		NJDWSC	there is no text under heading of United Water Transmission Main
7	1.2.1	5		NJDWSC	there is no text under heading of Trenton 2006
8	1.3.1	5		NJDWSC	wasn't a major goal of the study to identify interconnection deficiencies and to recommend infrastructure improvements?
9	2.3	9,10		NJDWSC	several large and/or potentially significant systems are omitted from the model - East Orange; Perth Amboy; Franklin Twp/Somerset; New Brunswick; United Water Toms River; Liberty Water Co.; Mt. Holly Water Co.

10	2			NJDWSC	were any field inspections or testing of critical interconnections performed? If yes, what were the findings? If not, why not?
11	2			NJDWSC	why is there no discussion of any specific major existing interconnection?
12	2			NJDWSC	where are the recommendations for correction of interconnection deficiencies? (scope Task 1C)
13	2			NJDWSC	where are the recommendations for returning non-operational interconnections to service? (scope Task 1C)
14	2			NJDWSC	where is the evaluation and recommendation for implementing new interconnections for systems serving over 10,000 people with no primary interconnections? (Scope Task 1C)
15	2.5.1	13		NJDWSC	why would availability of system demand data be so limited, when every PWS in the State is required to file diversion reports, treatment reports, water accountability reports, etc. with the State?
16	2.5.1	13		NJDWSC	a blanket assumption of a max day to avg day ratio of 2.0 is not appropriate for many systems; some may be much higher and others could be lower
17	2.5.1	14		NJDWSC	why use 40 year old data (1963-67) when the State has had 3 drought emergencies in the past 12 years? Can't any analysis of demands during these recent droughts be performed?

18	2.5.1	14		NJDWSC	what system in NJ directly serves a population of over 1 million people? Is this intended to include wholesale customers?
19	2.5.1	14		NJDWSC	The population of the largest systems in NJ is not entirely urban and in several cases is predominantly suburban not urban
20	2.5.2	15		NJDWSC	what efforts were made to verify status and capacity of plants listed as zero before assuming zero is correct?
21	2.5.2	15		NJDWSC	how can the water supply limit for the NJWSA not be known? It is a State agency- did anybody ask them? Doesn't NJDEP have this data?
22	2.6	19,20		NJDWSC	there are 2 references to recommendations made in chapter 8 regarding correction of deficiencies; chapter 8 does not contain any such recommendations
23	2.6	20		NJDWSC	there is a statement that an assessment made of systems with no primary interconnections, but there is no discussion of such assessment and no recommendations
24	table 2.2			NJDWSC	Table states that Elizabethtown Water gets 6% of its water from Newark, which would be at least 7 MGD; Elizabethtown actually buys an essentially negligible amount from Newark
25	table 2.2			NJDWSC	Middlesex Water does not get water from the NJWSA Manasquan system

26	table 2.2			NJDWSC	Newark gets water from both Wanaque North and Wanaque South
27	table 2.2			NJDWSC	New Brunswick does not get water from the NJWSA Manasquan system
28	table 2.2			NJDWSC	New Brunswick does not get water from the NJWSA Manasquan system
29	table 2.2			NJDWSC	New Brunswick normally obtains less than 50% of its supply from its own source and over 50% from NJWSA Raritan System
30	table 2.2			NJDWSC	Pequannock Twp gets far less than 50% of its supply from Newark
31	table 2.2			NJDWSC	why are there no sources listed for UWNJ other than Wanaque?

32	table 2.2			NJDWSC	UWNJ gets supply from Wanaque South not Wanaque North
33	table 2.2			NJDWSC	UWNJ gets substantial supply from Jersey City - why is this not indicated?
34	table 2.2			NJDWSC	why is NJ American Monmouth system not listed as receiving water from NJWSA Manasquan system?
35	table 2.2			NJDWSC	Wayne Twp gets water from Wanaque South not Wanaque North
36	table 2.2			NJDWSC	Nutley gets water from Wanaque South not Wanaque North; Nutley also buys water from Newark

37	table 2.2			NJDWSC	Bayonne gets water from Wanaque South not Wanaque North
38	table 2.2			NJDWSC	Bloomfield gets water from both Wanaque North and Wanaque South
39	table 2.2			NJDWSC	Cedar Grove gets water from Wanaque South not Wanaque North
40	table 2.2			NJDWSC	Kearny gets water from both Wanaque North and Wanaque South
41	table 2.2			NJDWSC	some wholesale customers of PVWC are not listed- Fairfield; Totowa, West Paterson, Ringwood, Riverdale, Bloomingdale

42	table 2.2			NJDWSC	NJ American Western has numerous wholesale customers that are not listed
43	table 2.2			NJDWSC	Lawrenceville Water Co. is not listed as a wholesale customer of Elizabethtown
44	table 2.2			NJDWSC	NJ American Monmouth has several wholesale customers that are not listed
45	table 2.3			NJDWSC	not reviewed
46	table 2.4			NJDWSC	not reviewed
47	table 2.5			NJDWSC	not reviewed in detail; why is there no safe yield data for any system?
48	table 2.7			NJDWSC	not reviewed in detail; Lyndhurst is not connected to Newark at Chittenden Road

49	table 2.8			NJDWSC	not reviewed
50	table 2.9			NJDWSC	Lyndhurst is not connected to Newark at Chittenden Rd
51	table 2.9			NJDWSC	Newark can supply PVWC at more than two locations
52	table 2.9			NJDWSC	Newark's 60-inch main cannot supply NJDWSC's 74-inch main by gravity at Belleville reservoir

53	table 2.9			NJDWSC	The Wayne Pump Station interconnections pumps from NJDWSC to Newark, not visa versa
54	table 2.9			NJDWSC	why aren't Jersey City and PVWC listed as receiving systems from Newark at the Chittenden Rd interconnection?
55	table 2.9			NJDWSC	the interconnection from UW Jersey City to West Caldwell is pumped not gravity
56	table 2.9			NJDWSC	why isn't Newark listed as a receiver from UW Jersey City at Chittenden Rd?

57	table 2.9			NJDWSC	New Brunswick cannot supply East Brunswick by gravity
58	table 2.9			NJDWSC	New Brunswick cannot supply Franklin by gravity
59	table 2.9			NJDWSC	NJ American Lakewood system is not interconnected with Freehold Twp
60	table 2.9			NJDWSC	NJAW Little Falls system is not interconnected with North Arlington

61	table 2.9			NJDWSC	There are 11 interconnections listed showing gravity supply from PVWC to Newark; this cannot be correct; Newark's gradient is higher than PVWC in most locations
62	table 2.9			NJDWSC	there are inconsistencies in indicating which interconnections are pumped versus gravity in cases where the pump station is remote from the actual point of interconnection; for example the PVWC to NJAW Short Hills interconnections; both have pump stations but one is indicated as gravity
63	table 2.9			NJDWSC	there are 2 separate interconnections from NJDWSC to Newark at Belleville Reservoir
64	table 2.9			NJDWSC	Why is the most prominent interconnection in the State, commonly known as "Virginia Street," named "Pennsylvania Railroad" in this table?
65	table 2.9			NJDWSC	Existing maximum daily transfer capacity of the E'town-Newark interconnection was determined during the 2002 drought to be approximately 30 MGD. This was well documented in a report completed in response to an NJDEP Administrative Order. The 30 MGD rate was based on field testing; actual operations over an extended period, and detailed hydraulic analysis of the sending and receiving systems. Please explain why an estimated transfer capacity of 40 MGD is now being reported.

66	table 2.9			NJDWSC	the interconnection from NJDWSC to PVWC at Little Falls appears to be missing. This is a 50+ MGD interconnection
67	table 2.9			NJDWSC	Newark cannot receive water from Lyndhurst at Chittenden Road
68	table 2.10			NJDWSC	not reviewed
69	table 2.11			NJDWSC	not reviewed
70	3	21		NJDWSC	not enough information presented to make any comments; the text in section 3 is little more than discussion of the scope of the task.
71	3	21,23		NJDWSC	does the model include major interconnection pump stations and pump curves, i.e. Virginia Street PS; Chittenden Rd PS?
72	4	24		NJDWSC	no discussion of evaluation of specific systems is provided.
73	4.3	27		NJDWSC	there is indication that recommendations for improvements are made but there is no discussion or identification of any such improvements
74	tables 5.1 and 5.2	34		NJDWSC	what is the definition of "production capacity" as used in these tables? There are some inconsistencies in how plant capacities are reported; i.e. for some plants the reported capacity appears to be the firm capacity and for others it appears to be the peak capacity
75	table 5.2			NJDWSC	capacity of Elizabethtown Canal Rd plant is more than 40 MGD

76	table 5.3	35		NJDWSC	where is the NJWSA contract for sale of Manasquan water to NJ American Monmouth?
77	table 5.3			NJDWSC	why are no contracts list for supply from NJWSA Raritan system?
78	table 5.3			NJDWSC	where is the contract from NJAW Elizabethtown to Franklin?
79	table 5.3			NJDWSC	numerous contracts for customers of NJAW Western are not listed
80	table 5.3			NJDWSC	numerous contracts for customers of PVWC are not listed

81	table 5.3			NJDWSC	contracts from Essex Fells to Caldwell and Roseland are not listed
82	table 5.3			NJDWSC	only one of the several contracts for sale of water from Morris County MUA is listed
83	table 5.3			NJDWSC	several contracts for customers of Newark are not listed
84	table 5.3			NJDWSC	NJDWSC contracts as listed in this table are incomplete
85	table 5.4	36		NJDWSC	NJDWSC has wholesale demand only - what is the significance of the 5.6 MGD demand?

86	5.4.1	40		NJDWSC	does the model properly account for the pumped intakes that supplement certain on-stream reservoirs; i.e. the Wanaque South and Ramapo pump stations for the Wanaque Reservoir? Wanaque South to Oradell reservoir?
87	table 5.5	41		NJDWSC	this table appears to be specific to on-stream reservoirs; however, the Round Valley, Glendola, and Manasquan reservoirs are all off-stream, getting nearly all of their water from pumped intakes
88	5.4.1	41		NJDWSC	It is correct to state that the use of Point View Reservoir by PVWC to regularly mitigate water shortages is "not viable" based on its historical use, an independent study, however, by HDR/LMS concluded that if the Point View Reservoir is operated jointly with the Wanaque Water System, with no capital investment required, at least 6 MGD of net increase in water supply of the combined systems during the 1964-65 drought-of-record can be obtained.
89	6.1	53		NJDWSC	historic drought analyses: it would be very helpful to clarify the analysis by explaining more specifically which interconnections were used in the simulated transfers.
90	6.1.2 Figure 6-3	58		NJDWSC	It has been verified by using two simulation models (one was developed in-house and another was developed by consulting engineers) that the lowest Wanaque Reservoir level will be at 10.4 BG when a critical dry period such as the 1964-65 drought-of-record is repeated and the water demand is at 173 MGD. Under the same drought-of-record scenario, if the demand is increased to 208 MGD, the lowest storage level will be at 4.1 BG. Why the predicted drawdown of the Wanaque Water System, as shown in Fig.6-3, indicated that reservoir would be run dry?
91	6.1.4	69		NJDWSC	how could Newark reservoir level data for 1995 not be available? What efforts were made to obtain the data?
92	table 0-6			NJDWSC	A surplus capacity of 117 MGD is indicated for Elizabethtown. Table 2.7 states the surplus as 90 MGD; which is correct?
93	table 0.6			NJDWSC	A surplus capacity of 56 MGD is indicated for PVWC; Table 2.7 states that PVWC has a deficit of 5.7 MGD; which is correct?

94	Table 6-5 and Table 0-6	96 and 91		NJDWSC	These tables indicated that a surplus of 56 MGD for PVWC and 97 MGD is required for NJDWSC. It is inconsistent with the fact that PVWC obtained 35.5 MG supply from NJDWSC on a constant daily basis.
95	table 0-6			NJDWSC	this table is stated to include recommended infrastructure improvements, but does not include any such recommendations
96	table 0-6			NJDWSC	interconnection capacity from E'town to Northeast reservoirs is less than the stated 41 MGD
97	6			NJDWSC	this entire section is limited to mitigation of drought conditions in the Northeast region. Where is the analysis and recommendations to mitigate drought impacts in other parts of the State? Is the implication that no other region suffers from droughts? What about Coastal North and Coastal South- these regions are fast growing and have had significant problems in recent years? What consideration was given towards mitigation of a drought declaration by the DRBC, which would restrict NJ's supply from the Delaware River?
98	6			NJDWSC	where is the discussion of the hydraulic model analyses of the transfers between systems? Are the contemplated transfers feasible while the sending systems are experiencing peak demands, or is it assumed that demand reductions would be necessary?
99	6			NJDWSC	The analysis of optimizing diversions appears to consider only 5 water systems in the NE Region, and addresses only surface water diversions. Doesn't the scope require addressing at least every system with Primary Interconnections or Primary Transmission Mains? Doesn't the scope also require analysis of optimizing groundwater diversions?
100	7.1	111		NJDWSC	this analysis was limited to 3 systems. Are there no other systems in the State with multiple reservoirs in the same watershed? For example, Newark.

101	7.1			NJDWSC	The conclusions for the United Water reservoirs seem to be nothing more than opinions based on vaguely referenced "past studies" and assumptions without any real technical analyses or cost/benefit analyses.
102	7.1			NJDWSC	The review of the Jersey City reservoirs concludes that "a more detailed analysis is necessary;" why wasn't a more detailed analysis performed? The Scope of Services for this Task required evaluation of environmental impacts.
103	7.2	113		NJDWSC	Elizabethtown derives about 10% of its annual supply from wells; the report erroneously states that this amount is less than 5% and therefore did not evaluate demand transfer between sources for Elizabethtown. It is also known that Elizabethtown has a number of wells that are out of service for various reasons but which are still permitted sources
104	7.2			NJDWSC	why doesn't the report address the numerous systems that have their own groundwater sources plus purchased surface water supplies?
105	7.2	115		NJDWSC	There is a statement that the NJAW Short Hills system was recently connected to the NJAW Elizabethtown system via a new pipeline. These systems have actually been connected at multiple interconnections for decades.
106	7.2			NJDWSC	The conclusion of this section is that "additional studies" are required. Why weren't these studies performed? The scope for this task required identification of infrastructure required to implement demand transfers as well as evaluation of environmental impacts of operational changes.
107	8.1.3	134		NJDWSC	The report states that there is a potential to transfer 20 MGD of surface water from the NJ American Water Canoe Brook reservoirs to another purveyor. The safe yield of the Canoe Brook reservoirs is not 20 MGD.

108	8.2	134		NJDWSC	The report appears to conclude that there are no capital improvements required to any primary interconnections in New Jersey; nor any need for new interconnections. This conclusion appears to be contrary to the NJDEP-supported, ongoing initiatives to upgrade the Elizabethtown/Newark/NJDWSC interconnection. The report also makes no mention of the ongoing project to construct new interconnections between Trenton and Elizabethtown - which represents the largest new emergency interconnection project in NJ in at least 20 years.
109	8.2			NJDWSC	The report indicates that drought mitigation transfers can, for the most part, be achieved through existing interconnections. However, the current operational condition of such interconnections does not seem to be addressed. For example, was any consideration given towards the current condition of the Chittenden Road Pump Station, which would be a key element of the proposed transfers?
110	8.2			NJDWSC	The report concludes that interconnection capacity between Jersey City and United Water is deficient, but the report does not make any specific recommendation for improving this interconnection capacity.
111	8.2	136		NJDWSC	Item # 5, does "Passaic Valley" means "Passaic River basin"?

Interconnection Study Draft Report Comments - NJAW

ID	Section	Page(s)	Commenter	Purveyor	Comment
1	2	Table 2-2, Page 1		NJAW	Elizabethtown Water Co: Assumed Percentage of Normal Yearly Supply should read 100% Elizabethtown Water Co.
2	2	Table 2-4, Page 1		NJAW	MDDs in Table 2-4 are monthly peaks. 2020 MDD of 78.60 mgd for NJAW Western Div is NJAW's 95% CI peak day projection. NJAW's projected 50% CI 2020 "monthly peak" MDD is 54.516 mgd.
3	2	Table 2-4, Page 2		NJAW	Little Falls: Table 2-4 shows estimated existing MDD of 3.80 mgd. Average MDD for 2002 through 2006 was approximately 2.2 mgd.
4	2	Table 2-5, Page 1		NJAW	NJAW Atlantic County System: 1) Table shows 19.990 mgd Water Supply Limit. Per definition on page 15, Water Supply Limit should read 23.344 mgd. Total Treated Water Supply Capacity should be adjusted accordingly. 2) Table states 4.098 mgd Contract Bulk Purchase. Per definition on page 15, Contract Bulk Purchase should read 3.049 mgd.
5	2	Table 2-5, Page 1		NJAW	Mt. Holly System: 1) Table shows 12.670 mgd Total Treatment Plant(s) Capacity. Total treatment Plant(s) Capacity is approximately 10.50 mgd. 2) Table shows 1.148 mgd Contract Bulk Purchase. Per definition on page 15, Contract Bulk Purchase should read 1.525 mgd.
6	2	Table 2-5, Page 1		NJAW	NJAW Western Div: Table shows 114.710 mgd Total Treatment Plant(s) Capacity. Total treatment Plant(s) Capacity should read 87.6 mgd. Total Treated Water Supply Capacity should be adjusted accordingly.
7	2	Table 2-5, Page 1		NJAW	Table 2-5 Supply Capacity Summary, Ocean City System: Table states 8.980 mgd Total Treatment Plant(s) Capacity. Total treatment Plant(s) Capacity is approximately 11.376 mgd. Total Treated Water Supply Capacity should be adjusted accordingly.
8	2	Table 2-5, Page 3		NJAW	Elizabethtown System: 1) Table shows 232.548 mgd Water Supply Limit. Per definition on page 15, Water Supply Limit should read 221.689 mgd. 2) Table shows 244.080 mgd Total Treatment Plant(s) Capacity. Per Elizabethtown Master Permit, Total treatment Plant(s) Capacity is 250.52 mgd. Total Treated Water Supply Capacity should be adjusted accordingly.

9	2	Table 2-7, Page 1	NJAW	East Hanover not listed as a Receiver under Short Hills Supplier. East Hanover interconnect with Short Hills system appears to meets definition of a Primary interconnect (12-inch interconnect, 36-inch WaterSource pipeline transmission main, over 10,000 population)
10	2	Table 2-7, Page 1	NJAW	Short Hills Supplier, Livingston Twp Water Division Receiver: Livingston listed as receiving 1.2 mgd as normal supply through Watersource pipeline. Average through Watersource pipeline is approximately 0.1 mgd.
11	2	Table 2-7, Page 4	NJAW	Morris County MUA Supplier, NJAW Short Hills Receiver: Short Hills listed as receiving 1.8 mgd as normal supply. Average is approximately 0.7 mgd.
12	2	Table 2-7, Page 4	NJAW	PVWC Supplier, NJAW Short Hills Receiver: Short Hills listed as receiving 13.4 mgd as normal supply. Average is approximately 8 mgd.
13	2	Table 2-7, Page 6	NJAW	Elizabethtown Supplier, NJAW Short Hills Receiver: Short Hills listed as receiving 7.6 mgd as normal supply. Average is approximately 13 mgd.
14	2	Table 2-8, Page 1	NJAW	NJAW Short Hills Supplier, Southeast Morris County Receiver: Contract Capacity should read 6 mgd.
15	2	Table 2-8, Page 1	NJAW	NJAW Short Hills Supplier, Elizabethtown Receiver: Contract Capacity should read 0 mgd.
16	2	Table 2-9, Page 1	NJAW	NJAW Western Div Supplier, Camden City Water Dept Receiver: Hydraulic capacity is approximately 2 mgd under normal conditions and 4 mgd under emergency conditions.
17	2	Table 2-9, Page 5	NJAW	Elizabethtown Supplier, Trenton Receiver: Normal hydraulic capacity is approximately 5 mgd.
18	2	Table 2-10, Page 3	NJAW	NJAW Monmouth System Supplier, Marlboro Twp MUA Receiver: Hydraulic capacity and limiting factor should read 0 mgd under normal and emergency conditions.
19	5	34	NJAW	Table 5-1 Groundwater Production Capacities, Monmouth System - Table states 5.59 mgd for the Monmouth system. Groundwater Firm Capacity of the Coastal North system (which includes Monmouth, Lakewood, and Ocean County systems) is approximately 12.93 mgd.
20	5	34	NJAW	Table 5-1 Groundwater Production Capacities, Elizabethtown System - Table states 11.08 mgd. Per Elizabethtown Master Permit, groundwater capacity is 23.52 mgd total and 16.5 mgd firm
21	5	34	NJAW	Table 5-1 Groundwater Production Capacities, Neptune System (Cape May Court House) - Table states 1 mgd. Groundwater capacity is approximately 2.73 mgd total.

22	5	34		NJAW	Table 5-1 Groundwater Production Capacities, Short Hill System - Table states 9.35 mgd. Groundwater capacity is approximately 16.11 mgd total and 14.67 mgd firm
23	5	34		NJAW	Table 5-2 Surface Water Production Capacities, Swimming River WTP: Total capacity is approximately 42 mgd.
24	5	34		NJAW	Table 5-2 Surface Water Production Capacities, Glen Oak WTP: Total capacity is approximately 7.5 mgd.
25	5	34		NJAW	Table 5-2 Surface Water Production Capacities, Rariton Millstone WTP: Total capacity is approximately 155 mgd.
26	5	34		NJAW	Table 5-2 Surface Water Production Capacities, Canal Road WTP: Total capacity is approximately 72 mgd.
27	5	35		NJAW	Table 5-3 Contract Interconnects, Elizabethtown Supplier, Middlesex Water Company Receiver: Contract Capacity should read 3 mgd.
28	5	35		NJAW	Table 5-3 Contract Interconnects, Elizabethtown Supplier, Monroe Twp MUA Receiver: Contract Capacity should read 0.625 mgd.
29	5	35		NJAW	Table 5-3 Contract Interconnects, NJAW Western Division Supplier, Deptford Twp MUA Receiver: Contract Capacity should read 1.4 mgd.
30	8 and 9	136 and 137		NJAW	Section 8.2 Prioritization & Recommendations, recommendation #5 (page 136) discusses the "opportunity" of decommissioning Canoe Brook and transferring or selling 20 mgd of surface water to another purveyor in the Passaic Valley. Section 9.0 Task 6 – Financial Infrastructure (page 137) states that the report does not make recommendations that require new capital additions to the water supply infrastructure. If Canoe Brook is decommissioned, NJAW would need to make extensive capital expenditures to construct new interconnect(s) between the Etown system and the Short Hills system to deliver finished water to the Short Hills system to make up for the water no longer produced at Canoe Brook.
	The following comments are extracts from NJAW cover letter to their excel file comments. Refer to the letter for the full text.				
31	ch 6		NJAW Cover letter to comments	NJAW	Drought Mitigation Strategy Ensure water purveyors have adequate available and committed supply capacity to meet critical dry period and peak demand needs.
32	ch 6		NJAW Cover letter to comments	NJAW	Drought Mitigation Strategy Ensure efficient day-to-day use of water

33	ch 6	NJAW Cover letter to comments	NJAW	Drought Mitigation Strategy Promote the use of the lowest quality water for its intended use.
34	ch 6	NJAW Cover letter to comments	NJAW	Drought Mitigation Strategy Develop and utilize an accurate, comprehensive and selective Drought/Water Supply Indicator system
35	ch 6	NJAW Cover letter to comments	NJAW	Drought Mitigation Strategy Consistently implement drought related water use restrictions based upon improved regional Drought/Water Supply Indicator system.
36	ch 6	NJAW Cover letter to comments	NJAW	Drought Mitigation Strategy Consistently implement drought related water transfers based upon improved regional Drought/Water Supply Indicator system. Water transfers can be an appropriate to help manage droughts, but the power to order transfers should not come until other long term and short team measures have been implemented. While using water transfers may seem like an equitable way to minimize impacts to certain customer groups, in the long term, the water transfers provide a disincentive the purveyors to solve and to address the root cause water supply adequacy issues.
36	ch 6	NJAW Cover letter to comments	NJAW	Drought Mitigation Strategy Consistently implement drought related water transfers based upon improved regional Drought/Water Supply Indicator system. Improvements have been made by the Project Team to the financial proposals to attempt to provide economic incentives through proper pricing of short term water to fix the root cause issues. However, depending upon circumstances, the economics could still work in favor of reliance upon high priced relatively short-term water transfers and water purchases versus investment in adequate supplies or commitment to long term water supply contracts.
37	ch 6	NJAW Cover letter to comments	NJAW	Drought Advisory
38	ch 8	NJAW Cover letter to comments	NJAW	No projects recommended

39	7.2	NJAW Cover letter to comments	NJAW	Canoe Brook Discussions NJAW believes it is premature to discuss the decommissioning of the NJAW Canoe Brook water treatment plant in this study. The Canue Brook WTP treats water from a system of reservoirs that provide safe yield into the Passic Basin and the North East drought region. The Passic Basin is clearly not "supply rich" and the recommendations to decommission the Canue Brook WTP should not be made, especially without firm plans to maintain the safe yield. The report conclusions discuss the possible sale of up to "20 mgd of surface water" to another purveyor. The conclusion is not valid since the safe yield of the surface water system is only 10.8 mgd and the yield is dependent upon storage from three reservoirs that are not mentioned in the report.
40	General	NJAW Cover letter to comments	NJAW	Definitions and labels The report findings would be clearer if consistent definitions and consistent naming convention was used for drought conditions.

Interconnection Study Draft Report Comments NJWSA					
ID	**Section**	**Page(s)**	**Commenter**	**Purveyor**	**Comment**
1	1.1	1	NJWSA	NJWSA	Spruce Run and Round Valley have never been below 41.8% combined storage (that was in February 1981).
2	1.1	2	NJWSA	NJWSA	Include the drought of 1999-2002. Note the Governor reduced minimum passing flows.
3	1.3.2	5	NJWSA	NJWSA	The limitation is the exclusion of systems/mains less than 20 mgd.
4	1.3.2	5,6	NJWSA	NJWSA	2 sections are numbered 1.3.2.
5	1.3.2/Task 1	5,6	NJWSA	NJWSA	1st section says transmission mains 16-in or greater. 2nd under Task 1 says transmission mains 24-in or greater.
6	2.5.1	14	NJWSA	NJWSA	What were actual demand reductions in the 1999-2002 drought? Why not use current NJ data?
7	2.5.2 - 2nd bullet		NJWSA	NJWSA	The New Brunswick system purchases raw water from NJWSA on an augmentation basis. They have a separate supply also.
8	2.5.2 - 3rd bullet		NJWSA	NJWSA	NJWSA-Manasquan. Plant capacity is 4.0 mgd. Other water is bulk wholesaled to other systems.
9	Table 2-2		NJWSA	NJWSA	NJWSA-Raritan provides raw water to Middlesex Water Company. There are no water transfers between Manasquan and Middlesex Water Co.
10	Table 2-2		NJWSA	NJWSA	NJWSA-Raritan provides raw water to New Brunswick. The contracted amount is for more than what is normally used. There are no water transfers between Manasquan and New Brunswick.
11	Table 2-2		NJWSA	NJWSA	NJSWA-Raritan provides raw water to North Brunswick. There are no water transfers between Manasquan and North Brunswick
12	5.2.2	32	NJWSA	NJWSA	What demand was used to develop the "extreme" curves?
13	5.3.2	37	NJWSA	NJWSA	Is an equal risk of going dry the most appropriate goal? The ratepayers are the ultimate "owner" of the system, not the purveyors, because the bond is repaid from users fees over the long term. Should all ratepayers be subjected to the same risk when they are not paying the same rate for their water?

14	5.4.1	40	NJWSA	NJWSA	Purveyors were consulted for data also.
15	5.4.1	43	NJWSA	NJWSA	Last paragraph should read "…data in the Spruce Run Reservoir drainage area…"
16	Figure 5-11	48	NJWSA	NJWSA	What demand was used? SR/RV was not below 74% of total storage in 2002
17	Figures 5-12 - 5-16	49-51	NJWSA	NJWSA	Figures do not match historical data. What demands were used?
18	Figure 6-5	60	NJWSA	NJWSA	SRRV in the figure should be Spruce Run/Round Valley
19	6.1.7	90	?		How does Etown have a surplus capacity of 117 mgd?
20	6.2	97	NJWSA	NJWSA	Look at purveyor data from 1998-2006 to determine the reducible amount of demand via water conservation in New Jersey by comparing wet and normal years with dry years.
21	6.2.5	101	NJWSA	NJWSA	Who patrols and enforces water conservation? What does NJDEP need to do to ensure that enforcement officials (DEP or others) are ready and available to do so? How were restrictions enforced in the past and was enforcement successful?
22	6.3	101-102	NJWSA	NJWSA	Before implementation of RWBR, NJDEP needs to consider where the water was previously discharged, impacts to streamflows and base flows and how safe yields will be affected.
23	7.2	115	NJWSA	NJWSA	Middlesex Water has other surface water allocations? First full paragraph says 60 mgd.
24	8.1.2	132	NJWSA	NJWSA	What is the purpose of the advisory level? Will purveyors be willing to transfer water based on WSMDST results? Will NJDEP have staff to run the model?
25	8.1.3	134	NJWSA	NJWSA	What is the advantage of decommissioning a source (Canoe Brook) when the Northeast is short water? How does the transfer to gw allow 20 mgd surface water to Passaic Valley?
26	8.2 3rd bullent	135	NJWSA	NJWSA	The State's Drought Management Program should establish enforcement responsibilities and mechanisms.

Interconnection Study Draft Report Comments - Marlboro MUA

ID	Section	Page(s)	Commenter	Purveyor	Comment
1	9.1	137	Peter Wersinger, Esq. Executive Counsel	MTMUA	If the Study has found that 21% of the evaluated water systems did not meet the Water Supply Management Act requirements and that the noncompliant systems lacked sufficient interconnection capacity, had inadequate standby power sources and did not have sufficient interconnections with neighboring systems [Section 1.1.3; Page 3], it is puzzling why “Tasks 1-5 do not recommend new capital additions to the water supply infrastructure.” This circumstance [absence of recommendations to require infrastructure construction] continues to enable noncompliant water systems to remain deficient and, by virtue of the various Recommendations contained in the Report, the study seeks to burden other purveyors with the ills and adverse conditions created by water purveyors that have not planned to avoid shortages. In that regard, it is noted in the Report [Section 9.5.1; Page 140] that certain water purveyors are “habitually” in need of water during even “minor drought situations.” These circumstances beg the broader questions of: (a) Why should responsible water systems pay the price for the failure of certain municipalities to regulate their zoning densities and development approvals? (b) Why has NJDEP continued to permit the extension of water mains and new water service connections [CP-1 and/or BSDW permits] in municipalities where water supplies are insufficient? (c) Why now should responsible water purveyors be called upon to bail out deficient and/or noncompliant systems?

2	9.6	141-142	Peter Wersinger, Esq. Executive Counsel	MTMUA	It is hereby suggested that, rather than the issue of "pricing," the initial recommendation should be for NJDEP to enforce and apply the existing regulations that permit NJDEP to require interconnections whenever same are deemed to be practical and economically feasible. It is further suggested that, given the abiding concern for water supply emergencies, droughts and other incidents that affect water supply, the aforementioned regulations should, perhaps, be expanded to require interconnections to be constructed by deficient systems regardless of current "economic feasibility." In that regard, it is respectfully submitted that NJDEP was not overly concerned with "economic feasibility" relative to the designation of Critical Water Supply Area No. 1 or the imposition of mandates that required water purveyors within said Critical Area to expend substantial sums of money in securing non-critical water supplies, while at the same time continuing to finance and pay for groundwater systems, which, in certain instances, had been recently expanded and constructed with the express approval of NJDEP. From direct experience, the Authority has, in the past when seeking relief or other dispensation because of financial constraints or economic burdens, been advised by representatives of NJDEP, that "NJDEP is not concerned with finances" and that "NJDEP is an environmental protection agency, not an economic agency." Accordingly, it is both ironic and a bit disingenuous for the scope of the 2007 Interconnection Study to include a tasking for the development of financial recommendations that extend to ratemaking and the pricing of water transfers.

3	9. 3	139	Peter Wersinger, Esq. Executive Counsel	MTMUA	The proffered example of the pricing elements, and the magnitude thereof, that may be included in a Water Transfer Agreement are a bit misleading and misrepresentative of what may and should be expected under more realistic circumstances. If the example presented in the Draft Report is to remain in the final version of the Study, it would certainly be desirable that supporting documentation for the stated "charge of $680.00 per MG" be included. The utilization of the aforesaid rate gives a false impression that inter-system transfers of water are, or even should be, available at bargain prices. Within central New Jersey there is not a single purveyor who would charge such a rate and, in fact, the Authority's cost of purchased water from Middlesex Water Company is in excess of $2,000.00 per MG, which said rate does not take into account the Authority's own capital costs, O & M expenses and other administrative and related costs. From a practical perspective, inter-system transfers would be priced at a minimum of $3,000.00 per MG, and probably higher.
4	9.2	137-138	Peter Wersinger, Esq. Executive Counsel	MTMUA	Although current regulations may require every water purveyor to have in place, at all times, Emergency Water Transfer Pricing Rates, it is not surprising, as indicated in the Draft Report that no water purveyors were able to produce a schedule of such rates. In that regard, ratemaking is not and should not be a "cookie cutter" process. There are myriad factors that must be considered in establishing an appropriate and reasonable rate for all categories of customers. Were it otherwise, regulated water purveyors and the New Jersey Ratepayer Advocate, as well as authorized interveners, would not spend months before the Board of Public Utilities Commission engaged in adversarial proceedings relative to the determination of just and equitable rates based upon cost of service considerations and other fundamental ratemaking criteria. With respect to the foregoing, Emergency Water Transfer Pricing is in the nature of standby rates for unpredictable and uncertain demands for water service.

					To assume that fair and reasonable rates can be determined in a vacuum without ascertaining the actual demands that will be placed upon a water system is utter fantasy. As important, is the reality that extensive infrastructure will not be voluntarily constructed and significant capital expenditures will not be voluntarily incurred for improvements that will be little used. It is respectfully submitted that the model of "water transfers" presented by the Draft Report simply proceeds from a flawed philosophy. That is to say, deficient and/or noncompliant water systems and, in particular, those purveyors who habitually are in need of water during even minor drought situations, should not be allowed to peak off of other systems. A more logical and long-term, cost-effective approach would require such water systems to utilize interconnections to secure consistent base loads of water supplies to be used conjunctively with other available supplies of water, while reserving a portion of their own water supply resources to address emergent or drought conditions.
5	9.5	140-141	Peter Wersinger, Esq. Executive Counsel	MTMUA	NJDEP should tread very carefully in the area of ratemaking. Moreover, it is respectfully submitted that the Department should refrain from entering that arena to a greater extent than is already authorized. In that regard, the current regulations, which generally provide that Emergency Water Transfer Pricing should be based upon fair compensation and reasonable rate relief so as not to create a situation wherein the customers or owners of the supplying systems are subsidizing a transfer, are already sufficient. Any effort to develop specific rates to be imposed upon the owners or customers of a supplying system must ensure that resultant pricing is not confiscatory and does not create an unconstitutional taking or use of property without just compensation. The concern regarding "Wheeling Fees" may be misplaced. In that regard, it is respectfully submitted that such fees are not precluded by existing regulations. Simply, if a receiving system is required to utilize the infrastructure of another water purveyor, in order to receive a water transfer, the receiving system would be required to pay for such use, whether under emergency pricing, or otherwise. The bottom line is that two water purveyors that are not directly interconnected cannot negotiate or implement a water service transfer without dealing with an intervening water system.

6	1.3.2	7	Peter Wersinger, Esq. Executive Counsel	MTMUA	There is a troubling theme that is woven through the fabric of the Draft Report that pertains to the financial impact upon deficient, noncompliant water purveyors and/or water systems that may otherwise have a need for water transfers. In that regard, there is an express agenda to "avoid disproportionate financial hardship or profits" [Section 1.3.2; Page 7], as well as a stated objective of "encouraging an equitable distribution of hardship during drought emergencies" [Section 8.2; Page 135] and a concern regarding the magnitude of emergency water transfer pricing. It is respectfully submitted that no such concerns or objectives were associated with the establishment and regulation of Critical Water Supply Area No. 1. [Cont...] In that regard, there was no statewide sharing of costs associated with the development and securing of non-critical water supplies. Water purveyors within the Critical Area were not assisted by water systems located outside of the Critical Area in defraying the costs of significant interconnections and other infrastructure improvements, which said facilities are now being considered for use in transferring water supplies to water systems that did not contribute financially to their construction. While the transfer of water to needy water systems is, indeed, appropriate, the financial impact upon the receiving system(s) should not be a consideration of this Study. Rather, pricing should be left to evolve in the marketplace and governed by traditional ratemaking criteria, including the regulatory oversight of BPU when investor-owned companies are involved.