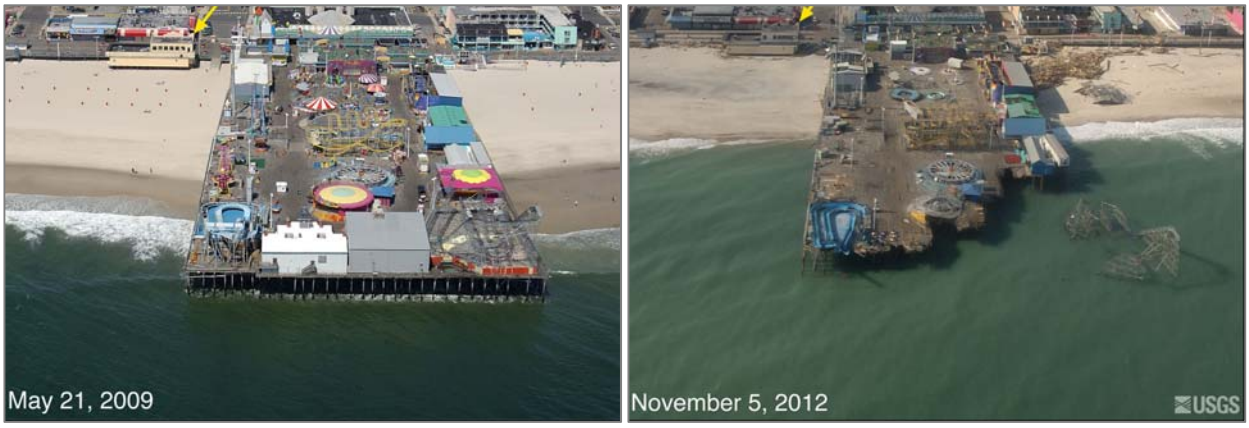
NEW JERSEY

GEOLOGICAL & WATER SURVEY

Technical Memorandum TM 13-1

New Jersey Water Supply Planning Activities in 2012



New Jersey Department of Environmental Protection
Water Resources Management
Division of Water Supply & Geosciences
New Jersey Geological & Water Survey
Bureau of Water Resources & Geosciences
Water Supply Modeling & Planning Section
2013

STATE OF NEW JERSEY
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NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

New Jersey Department of Environmental Protection's core mission is and will continue to be the protection of the air, waters, land and natural and historic resources of the State to ensure continued public benefit. The Department's mission is advanced through effective and balanced implementation and enforcement of environmental laws to protect these resources and the health and safety of our residents.

At the same time, it is crucial to understand how actions of this agency can impact the State's economic growth, to recognize the interconnection of the health of New Jersey's environment and its economy, and to appreciate that environmental stewardship and positive economic growth are not mutually exclusive goals: we will continue to protect the environment while playing a key role in positively impacting the economic growth of the state.

NEW JERSEY GEOLOGICAL & WATER SURVEY

The mission of the New Jersey Geological & Water Survey is to map, research, interpret and provide scientific information regarding the state's geology and groundwater resources. This information supports the regulatory and planning functions of DEP and other governmental agencies and provides the business community and public with information necessary to address environmental concerns and make economic decisions.

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on the cover: Pictures of the Seaside Heights, NJ, before and after Hurricane Sandy's impact. Pictures from the U.S. Geological Survey, retrieved from http://coastal.er.usgs.gov/hurricanes/sandy/photo-comparisons/newjersey.php

New Jersey Water Supply Planning Activities in 2012

by

Jeffrey L. Hoffman

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New Jersey Geological & Water Survey Reports (ISSN 0741-7357) are published by the New Jersey Geological & Water Survey, P.O. Box 420, Trenton, NJ 08625-0420.

More information on NJGWS reports is available on the Survey's website:

www.njgeology.org

Epigram

Principle No. 2 - Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels. The participatory approach involves raising awareness of the importance of water among policy-makers and the general public. It means that decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects.

-- From the Dublin Statement on Water and Sustainable Development, issued by the International Conference on Water and the Environment, Dublin, Ireland, January 26-31, 1992.

New Jersey Water-Supply Planning Activities in 2012

by
Jeffrey L. Hoffman

2013

I. Introduction

Water-supply planning must be an ongoing activity. As water supplies and demands change current plans must alter and new ones be developed.

This report is a short overview of water-supply planning activities during 2012 conducted by staff of the Water Supply Modeling & Planning Section (WSMP) in the Bureau of Water Resources & Geosciences, New Jersey Geological & Water Survey, Division of Water Supply & Geosciences. It does not go into detail on results, but instead provides references to the results. This report also summarizes work funded by the NJDEP and performed by the U.S. Geological Survey (USGS) and by Rutgers University.

Table 1. Staff of the Water Supply Modeling & Planning Section (WSMP)

Thomas L. Brand, P.E., Environmental Engineer 3	Alexandra A. Petriman, Hourly
Steven Domber, Environmental Specialist 4	Paul Schorr, P.E. Research Scientist 1
Richard Grabowski, Environmental Specialist 4	Ian Snook, Environmental Specialist 3
Jeffrey L. Hoffman, Acting Section Chief	Charles Thompson, Hourly
Joseph A. Miri, Research Scientist 1	

Table 2. Contact Information

Organization	Phone Number*	Web site*
New Jersey Department of Environmental Protection (NJDEP)	609-777-3373 v	http://www.state.nj.us/dep/
Division of Water Supply & Geoscience (DWSG)	(609) 292-7219 v	http://www.nj.gov/dep/watersupply/
New Jersey Geological & Water Survey (NJGWS)	(609) 292-1185 v (609) 633-1004 f	http://www.njgeology.org/
Water Supply Modeling & Planning section (WSMP)	(609) 292-1185 v (609) 633-1004 f	http://www.njgeology.org/
Bureau of Water Allocation and Well Permitting (BWAWP)	(609) 984-6831 v	http://www.nj.gov/dep/watersupply
U.S. Geological Survey, N.J Water Science Center (USGS)	(609) 771-3900 v (609) 771-3915 f	http://nj.usgs.gov/
Office of the New Jersey State Climatologist	(848) 445-4741 v	http://climate.rutgers.edu/stateclim/

* Correct as of March 2013

II. Completed NJDEP Water-Supply Studies

II.A. Guidance Manual for Estimating Safe Yield

In 2012 WSMP released the guidance manual "Estimating the safe yield of surface water supply reservoir systems" (NJDEP, 2012). This guidance manual is the result of several years of collaborative work among the NJDEP, New Jersey purveyors, and others. The report's purpose states:

> This manual provides guidance for the preparation and submittal of safe yield estimates. This applies to surface water supply reservoir systems that are regulated under the New Jersey Water Supply Management Act by the New Jersey Department of Environmental Protection (Department). The Department's intent is to: (1) establish a cooperative process with clear expectations between the Department and purveyors to ensure that all relevant aspects of each safe yield estimate are considered to the extent feasible; (2) ensure that the methods, assumptions and logic used to estimate safe yield are appropriate and are clearly and plainly documented in the engineer's report; and (3) ensure that sufficient information is available to enable the Department's final decision document to adequately address public concerns.
>
> By clearly listing what data and analysis should be included, the Department's approval process becomes more open and transparent. This helps purveyors prepare quality submissions and fosters predictable agency actions.

The guidance manual is available at

> http://www.nj.gov/dep/watersupply/pdf/safe-yield-manual.pdf

II.B. Updated Guidelines for Groundwater Allocation Permit Applications

WSMP staff led the effort to publish an updated set of guidelines designed to assist applicants in submitting groundwater allocation permit requests.

The Bureau of Water Allocation and Well Permitting (BWAWP), in the New Jersey Geological & Water Survey, Division of Water Supply & Geosciences, is responsible for reviewing applications for new groundwater allocation permits. Among other conditions, the applicant may be required to conduct an aquifer test and submit a hydrogeological report. Test and reporting procedures are based on specific hydrogeologic conditions. Past experience has shown that a detailed description of what BWAWP expects to receive assists the applicant in conducting and reporting test in a way that meets regulatory concerns.

Previous editions of the guidelines were published in 1989 and 1992. This update, titled "Hydrogeologic Testing and Reporting Procedures in Support of New Jersey Water Allocation Permit Applications" (Hoffman and others, 2012) is available at:

> http://www.njgeology.org/pricelst/tmemo/tm12-2.pdf

III. Ongoing NJDEP Water-Supply Studies

III.A. Passaic-Hackensack Safe Yield Model

NJDEP is committed to developing a computer model of the major surface-water-supply reservoir systems of the Passaic River and Hackensack River basins (fig. 1). Goals for the modeling effort include:

- Estimate the safe yields of individual reservoir systems in the basins based on existing infrastructure, current operating rules and recent system draft patterns;
- Estimate the safe yield of individual reservoir systems if operating rules were modified using existing infrastructure;
- Estimate how much additional safe yield could be obtained through more coordinated operation of various combinations of the of individual reservoir systems using existing infrastructure; and
- Investigate how new and improved infrastructure might increase the safe yield.

This is a multi-year research project. WSMP staff are using the RiverWare™ software package to develop a "water accounting" model of the reservoir systems. This model will simulate the flow of water through the systems and their watersheds, and the storage of water in the system's reservoirs, using a daily time-step. This model is being developed for water years 1922 - 2007.

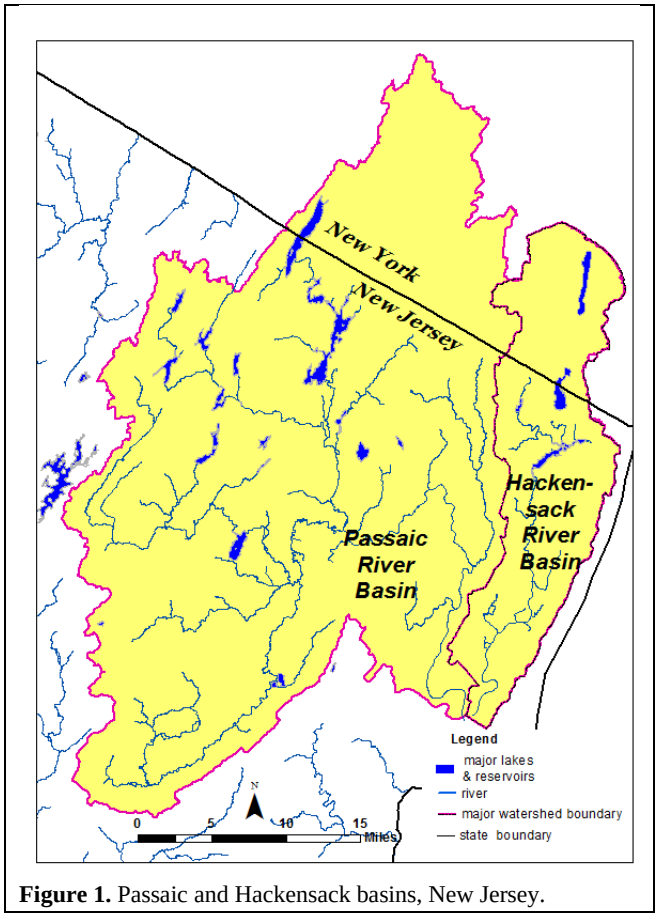

Figure 1. Passaic and Hackensack basins, New Jersey.

Recent work on this model consisted of a detailed investigation of the system's current infrastructure and operating rules. This included reviewing available design drawings and reports of dams, spillways, intakes, diversion structures, reservoirs, release mechanisms and pipelines. Hydraulic relationships for the infrastructure were compiled and developed. In addition, WSMP staff developed a preliminary model of the surface water-supply reservoir system of the Hackensack basin.

NJDEP contracted with the USGS to generate necessary input streamflows for this model. This process involves estimating what streamflows would have been if there had been no hydrologic modifications due to the reservoir systems. The effects of other hydrologic modifications during recent water years 1990 through 2007, such as those associated with waste water discharges and land-use changes, are being superimposed on earlier stream-flow gage data using statistical relations. This analysis had started in 2011 but was interrupted when WSMP staff were redirected to other projects. It restarted in mid-2012 and continued through the end of the year.

In 2013 NJDEP plans to set up a stakeholders group to assist in reviewing the model and determining potentially feasible operating conditions in order to estimate possible maximum safe yield under conjunctive operations.

III.B. Wanaque Water System Safe Yield Increase & Permit Modification

In 2005 the North Jersey District Water Supply Commission (NJDWSC) requested an increase in the Wanaque Water System's safe yield from 173 million gallons per day (mgd) to 208 mgd. This request was denied by NJDEP in January 2011. Later that year NJDEP and NJDWSC reached a settlement agreement for an increase to 190 mgd. This increase depends on additional pumping into the Wanaque Reservoir from the Pompton and Passaic Rivers. The revised water allocation permit does not allow for any increase in maximum monthly or maximum annual volumes of water diverted. A NJDEP staff report ("Reevaluation of the Wanaque Water System Safe Yield," September 19, 2011) documents the research into and justification for this increase.

NJDEP issued a request for public comment in February 2012 and received numerous comments. DWSG staff, with WSMP assistance, is currently preparing a response-to-comments document. This response had not been issued by the end of 2012.

III.C. Water Use and Transfers in New Jersey

During the past decade NJDEP has invested significant effort into the New Jersey Water Tracking Data Model (NJWaTr). This is a Microsoft Access 2000™ database that utilizes a conveyance-based approach to track the withdrawal, transfer, use and discharge of water throughout New Jersey (Tessler, 2003). The conveyance-based approach is the preferred way to manage water-use data and New Jersey has been identified as one of several states in the forefront of developing this approach (National Research Council, 2002). NJWaTr can be used to track water use at a range of geographic scales throughout the state and to determine the amount of total, consumptive, and depletive water use. These data are the basis for water planning.

NJWaTR holds monthly data from 1990 onward. NJDEP staff added water data for calendar years 2008 and 2009 to the NJWaTR database in 2012. The added data lag by several years for the following reasons:

- All water data for a calendar year are not required to be submitted to NJDEP by all purveyors, users and dischargers for several months into the following year.
- The quality control process is very involved and takes 6 to 12 months to complete given current availability of staff.
- Additional data are developed to quantify all sectors of water use (for example, domestic well withdrawals).
- Loading the data into NJWaTr is a multi-step process that requires significant staff time.

In 2009 the total withdrawal for all uses was 914,987 million gallons and consumptive use was 59,871 million gallons. Figure 2 shows the sources of all withdrawals.

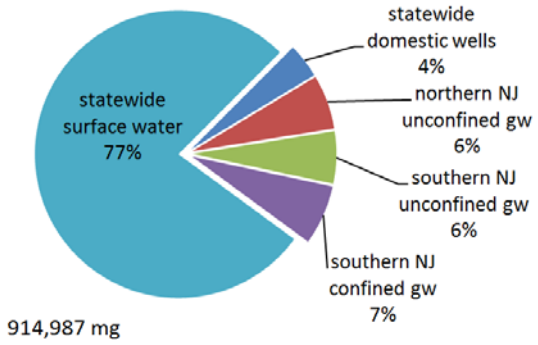

Figure 2. Sources of all fresh water withdrawals, 2009.

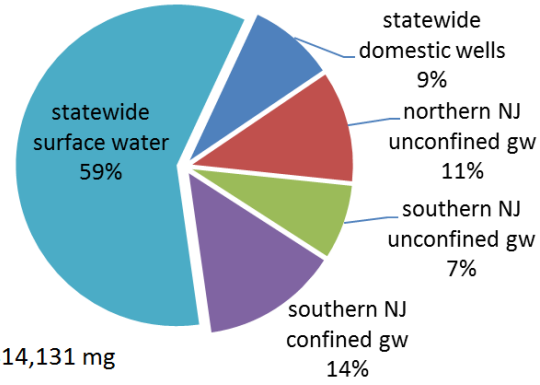

Figure 3. Sources of potable water supply, 2009.

Withdrawal solely for potable supply was 414,131 million gallons and consumptive use was 31,607 million gallons. Figure 3 shows the sources of potable supply.

These data are available online in the digital report 'New Jersey Water Transfer Model Withdrawal, Use, and Return Data Summaries' (NJGWS, 2012). The abstract of this product says:

> This New Jersey Geological Survey (NJGS) Digital Geodata Series (DGS) publication is a set of five Microsoft Access 2000™ databases that summarize information contained in the New Jersey Water Transfer Data Model (NJWaTr). The databases contain measured and estimated monthly withdrawal, use and return volumes by site. The five databases cover: 1) withdrawals by HUC14 drainage basin, 2) withdrawals by municipality, 3) use by site, 4) returns by HUC14 drainage basin, and 5) returns by municipality. Attribute data such as site owner, permit number, water use, water source, watershed name, and municipality are included with each database. Table and field description information is also included with each database. The databases do not contain site latitude and longitude locations.

This digital product contains monthly data from 1990 through 2009. It is available at:

> http://www.njgeology.org/geodata/dgs10-3.htm

III.D. CUAHSI Hydrologic Information System

The Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) has developed a Hydrologic Information System (HIS) that provides web services, tools, standards and procedures that enhance access to more and better data for hydrologic analysis. The CUAHSI HIS uses an information exchange schema called Water Markup Language (WaterML) to communicate hydrologic data over the internet. CUAHSI HIS and WaterML make hydrologic data more easily searchable over the internet and thus more useful. The U.S. Geological Survey is moving towards making its water data sets (streamflow, ground-water levels, and water quality) available through the CUAHSI HIS[1].

WSMP staff believe that making NJDEP's water quantity and quality data available through CUAHSI HIS would be useful to the regulated community and to researchers. In 2012 work began on a pilot project to put the NJWaTr water tracking data into a compatible format. These data would then be made easier to access by more researchers than is currently possible. This may also save staff time by not having to directly service requests for these data. A final decision about making more data available through the CUAHSI HIS will be made after the pilot project is finished.

The CUAHSI HIS is more fully explained at:

> http://www.cuahsi.org/History.aspx

[1] Joint USGS-CUAHSI press release "New Hydrologic Daily Values Web Services" available at http://his.cuahsi.org/documents/usgs-cuahsi-webservices.pdf

III.E. Aquifer Storage and Retrieval

Aquifer storage and retrieval (ASR) is the practice of taking water from a source during a time of surplus water, injecting it into a well for storage in an aquifer, and retrieving it when water demands increase. As New Jersey's population grows and demands increase ASR may become a significant source of water in some areas.

In New Jersey ASR is overseen by several programs in the NJDEP that deal with water supply and water quality. In the past, these programs have not efficiently processed ASR permits due to different interpretations of current regulations. In 2012 NJDEP staff met numerous times in order to set a consistent policy and to streamline the application, review and approval process. This work continues in 2013.

III.F. Wellhead Protection

In New Jersey all water table public supply wells are required to be protected by well head protection areas (WHPAs). These areas help guide local municipalities in making informed land use decisions for the areas that may contribute to the wells. Information about the technical details is provided by Spayd and Johnson (2003). This is a two-step process. First the well must be accurately located. Second, the well head protection areas are delineated based on the volumes of water pumped and on aquifer properties.

NJGWS has created well head protection areas for numerous wells in New Jersey. GIS shape files of WHPAs for public community water-supply wells are published in Digital Geodata Series DGS02-2 and available at:

http://www.njgeology.org/geodata/dgs02-2.htm

GIS shape files for public non-community water supply wells are published in Digital Geodata Series DGS04-5 and are available at:

http://www.njgeology.org/geodata/dgs04-5.htm

IV. Precipitation

The winter of 2012 was a rather uneventful season compared to the summer rain from Hurricane Irene and Tropical Storm Lee in August 2011. Winter precipitation was significantly below normal while temperatures where far above normal. Figure 4 shows average monthly precipitation in northern and southern New Jersey[2] in 2011 and 2012, along with 1-, 3-, 6-. 9-, and 12-month deviations from normal. Table 3 shows observed and average monthly values, and monthly deviations from average.

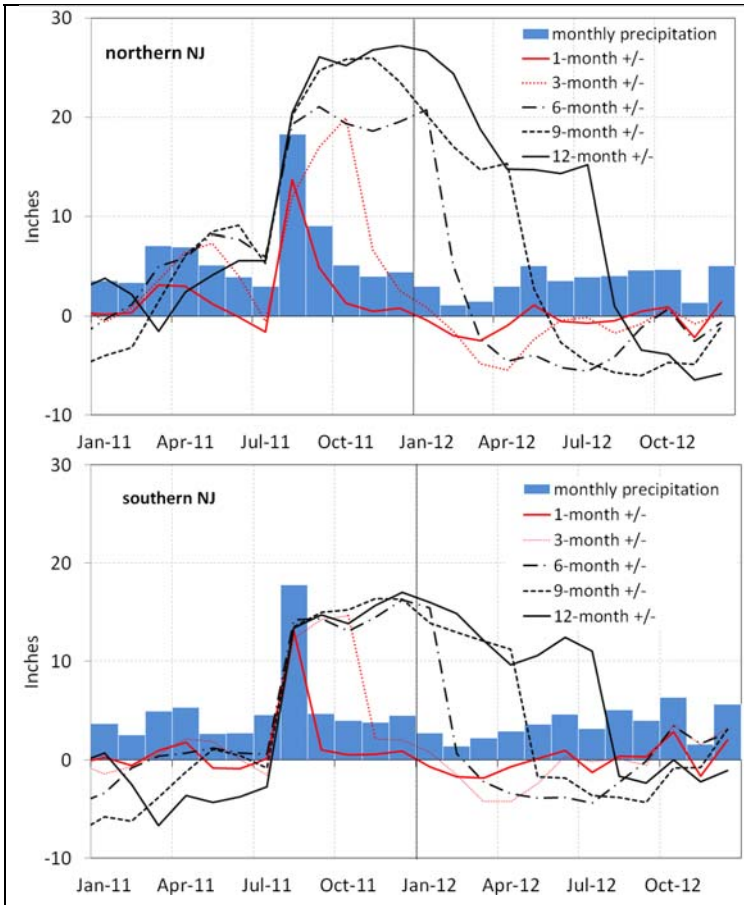

Figure 4. Northern and Southern New Jersey average monthly precipitation, and 1-, 3-, 6-. 9-, and 12-month cumulative deviations from normal, 2011-2102.

Spring 2012 brought mild weather to New Jersey and a state-wide precipitation average of 8.86 inches. However, precipitation varied greatly. North Jersey and Coastal North regions received most of the rainfall. The southern part of New Jersey remained relatively dry. Noticeable drops in stream flows, as monitored by the hydrologic indicators program, were observed throughout New Jersey (fig. 6). Given the widening precipitation deficit (fig. 4) the need to ensure water supplies was at the forefront of NJDEP's actions. On April 25th the North Jersey District Water Supply Commission (NJDWSC) started pumping water from the Two Bridges pumping station on the Pompton River into Wanaque Reservoir. From April 25th to June 30th, NJDWSC pumped 9.94 billion gallons of water into the Wanaque Reservoir. This pumped water was critical in ensuring water supply through the high demand period of the summer because precipitation was steadily below average. NJDWSC pumped a total of 22.2 billion gallons into the Wanaque Reservoir in 2012.

Summer began with above average rainfall in June, alleviating some of the low streamflows and low reservoir levels but failed to equalize the precipitation deficit throughout the State. The above-average heat from July extended into August, but the precipitation pattern had finally been broken. August's precipitation was above average, starting the recovery of streamflows and unconfined groundwater levels throughout the State. This was followed by a wet September and October, alleviating the statewide rainfall deficit and reducing stresses on the hydrologic systems. November had less-than-average precipitation but December had more than average.

[2] Data from the webpage of the New Jersey State Climatologist, http://climate.rutgers.edu/stateclim_v1/data/index.html

Table 3. New Jersey monthly precipitation,2011-2012, by region and statewide.*

Month	Northern New Jersey precipitation (inches)			Southern New Jersey precipitation (inches)			Statewide precipitation (inches)		
	observed	average	deviation	observed	average	deviation	observed	average	deviation
2011									
Jan	3.56	3.39	0.17	3.74	3.47	0.27	3.63	3.44	0.19
Feb	3.37	3.04	0.33	2.56	3.13	-0.57	2.87	3.11	-0.24
Mar	7.08	3.95	3.13	4.99	4.04	0.95	5.67	3.99	1.68
Apr	6.93	3.94	2.99	5.40	3.63	1.77	5.85	3.72	2.13
May	5.15	3.94	1.21	2.70	3.52	-0.82	3.55	3.65	-0.1
Jun	3.93	4.05	-0.12	2.79	3.68	-0.89	3.11	3.79	-0.68
Jul	3.02	4.64	-1.62	4.61	4.45	0.16	3.88	4.48	-0.6
Aug	18.28	4.57	13.71	17.78	4.74	13.04	17.22	4.64	12.58
Sep	9.04	4.14	4.90	4.72	3.66	1.06	6.48	3.83	2.65
Oct	5.10	3.81	1.29	4.04	3.51	0.53	4.38	3.61	0.77
Nov	4.00	3.54	0.46	3.86	3.29	0.57	3.86	3.37	0.49
Dec	4.46	3.68	0.78	4.54	3.63	0.91	4.39	3.64	0.75
2012									
Jan	3.00	3.39	-0.39	2.78	3.47	-0.69	2.8	3.44	-0.64
Feb	1.08	3.04	-1.96	1.41	3.13	-1.72	1.32	3.11	-1.79
Mar	1.46	3.95	-2.49	2.24	4.04	-1.80	1.91	3.99	-2.08
Apr	2.96	3.94	-0.98	2.93	3.63	-0.70	2.92	3.72	-0.8
May	5.04	3.94	1.10	3.64	3.52	0.12	4.15	3.65	0.5
Jun	3.55	4.05	-0.50	4.65	3.68	0.97	4.38	3.79	0.59
Jul	3.91	4.64	-0.73	3.20	4.45	-1.25	3.34	4.48	-1.14
Aug	4.07	4.57	-0.50	5.11	4.74	0.37	4.7	4.64	0.06
Sep	4.60	4.14	0.46	4.02	3.66	0.36	4.29	3.83	0.46
Oct	4.72	3.81	0.91	6.37	3.51	2.86	6.32	3.61	2.71
Nov	1.37	3.54	-2.17	1.63	3.29	-1.66	1.52	3.37	-1.85
Dec	5.08	3.68	1.40	5.67	3.63	2.04	5.56	3.64	1.92

*Data from the web page of the New Jersey State Climatologist, http://climate.rutgers.edu/stateclim_v1/data/index.html.

V. Emergency Operations

V.A. Drought Monitoring

New Jersey is divided into six drought regions (fig. 5). On a regular basis WSMP staff evaluate a suite of hydrologic indicators in each region to determine possible threats to water supply (Hoffman, 2003). These indicators cover 90-day precipitation, 90-day streamflow, reservoirs in New Jersey, New York City's reservoirs in the upper Delaware River basin, and unconfined groundwater (Hoffman and Domber, 2004). They are evaluated weekly during dry periods and biweekly during wet times. Each indicator is assigned a status of near or above normal (green), moderately dry (yellow), severely dry (orange) or extremely dry (red). These are then made available to the public at:

www.njdrought.org

These indicators, along with best professional judgment and evaluation of other relevant factors are used in setting the water-supply drought status in each region.

Figure 5. New Jersey drought regions

Figure 6 shows the drought indicators for each evaluation cycle for each drought region in 2012. The year started with all green indicators. In February however, the 90-day precipitation indicator started dropping below normal. The lower-than-normal precipitation led to lower streamflows and groundwater levels. The evaluation cycle was changed from biweekly to weekly the first week of April. The weekly evaluation cycle was maintained throughout the spring and summer because precipitation did not significantly improve. However, by September precipitation improved and the evaluation cycle returned to biweekly.

Hurricane Sandy hit New Jersey on October 29-31, 2012. Precipitation was heaviest in southern New Jersey. However, extensive statewide power outages threatened water supplies. The Governor ordered a state of water emergency on October 31, 2012. The water-supply status was changed to red in all drought regions to reflect this order. The state of water emergency was lifted on December 20, 2012.

Date		Northwest					Central						Southwest				
		Drought Indicators				STATUS	Drought Indicators					STATUS	Drought Indicators				STATUS
		90-Day Precip.	90-Day Stream	DRBC Res.	Unconf. Ground Water		90-Day Precip.	90-Day Stream	NJ Res.	DRBC Res.	Unconf. Ground Water		90-Day Precip.	90-Day Stream	DRBC Res.	Unconf. Ground Water	
Jan	1/4/2012	G	G	G	G	N	G	G	G	G	G	N	G	G	G	G	N
	1/18/2012	G	G	G	G	N	G	G	G	G	G	N	G	G	G	G	N
Feb	2/1/2012	G	G	G	G	N	LY	G	G	G	G	N	G	G	G	G	N
	2/15/2012	G	G	G	G	N	LY	G	G	G	LY	N	LY	LY	G	LY	N
	2/29/2012	LY	G	G	G	N	LY	G	G	G	LY	N	LY	G	G	LY	N
Mar	3/14/2012	LY	G	G	DY	N	LY	G	G	G	DY	N	LY	G	G	LY	N
	3/28/2012	DY	LY	G	DY	N	DY	DY	G	G	R	N	DY	DY	G	LY	N
April	4/4/2012	DY	DY	G	DY	N	DY	DY	G	G	R	N	DY	DY	G	DY	N
	4/11/2012	DY	R	G	DY	N	DY	DY	G	G	R	N	DY	DY	G	DY	N
	4/18/2012	DY	R	G	DY	N	DY	R	G	G	R	N	DY	R	G	DY	N
	4/22/2012	DY	R	G	R	N	DY	R	G	G	R	N	DY	R	G	DY	N
	4/29/2012	DY	R	G	DY	N	DY	R	G	G	R	N	DY	R	G	LY	N
May	5/6/2012	DY	R	G	DY	N	DY	R	G	G	DY	N	DY	R	G	DY	N
	5/13/2012	DY	R	G	DY	N	DY	R	G	G	R	N	DY	R	G	DY	N
	5/20/2012	DY	R	G	LY	N	LY	R	G	G	R	N	LY	R	G	DY	N
	5/27/2012	LY	R	G	LY	N	LY	R	G	G	R	N	LY	R	G	DY	N
June	6/3/2012	LY	R	G	G	N	LY	R	G	G	DY	N	DY	R	G	LY	N
	6/10/2012	LY	R	G	G	N	LY	R	G	G	DY	N	DY	R	G	DY	N
	6/17/2012	LY	R	G	G	N	LY	DY	G	G	DY	N	LY	R	G	LY	N
	6/24/2012	LY	DY	G	LY	N	LY	DY	G	G	DY	N	LY	R	G	DY	N
July	7/1/2012	LY	R	G	G	N	LY	DY	G	G	DY	N	LY	R	G	DY	N
	7/8/2012	LY	DY	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
	7/15/2012	LY	DY	G	G	N	LY	LY	G	G	DY	N	LY	DY	G	DY	N
	7/22/2012	LY	DY	G	LY	N	LY	LY	G	G	DY	N	LY	DY	G	R	N
	7/29/2012	LY	DY	G	LY	N	LY	DY	G	G	DY	N	LY	DY	G	DY	N
Aug	8/5/2012	LY	LY	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
	8/12/2012	LY	LY	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
	8/19/2012	LY	LY	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
	8/26/2012	LY	LY	G	LY	N	LY	LY	G	G	DY	N	LY	DY	G	DY	N
Sept	9/2/2012	LY	LY	G	LY	N	LY	LY	G	G	DY	N	LY	DY	G	LY	N
	9/9/2012	LY	LY	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
	9/16/2012	LY	LY	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
	9/23/2012	LY	LY	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
	9/30/2012	G	G	G	G	N	LY	DY	G	G	LY	N	LY	DY	G	DY	N
Oct	10/7/2012	G	G	G	LY	N	LY	LY	G	G	DY	N	LY	LY	G	DY	N
	10/14/2012	LY	LY	G	LY	N	LY	LY	G	G	DY	N	LY	DY	G	DY	N
	10/21/2012	G	G	G	G	N	LY	LY	G	G	DY	N	G	G	G	LY	N
	10/28/2012	G	G	G	G	E	LY	LY	G	G	DY	E	G	G	G	LY	E
Nov	11/4/2012	G	G	G	G	E	LY	LY	G	G	DY	E	G	G	G	LY	E
	11/11/2012	G	G	G	G	E	LY	LY	G	G	DY	E	G	G	G	LY	E
	11/18/2012	G	G	G	G	E	LY	LY	G	G	DY	E	G	LY	G	LY	E
	11/25/2012	G	G	G	G	E	LY	LY	G	G	DY	E	G	LY	G	LY	E
Dec	12/2/2012	G	G	G	LY	E	LY	LY	G	G	R	E	LY	LY	G	DY	E
	12/16/2012	LY	G	G	DY	N	LY	DY	G	G	R	N	LY	LY	G	DY	N
	12/30/2012	G	G	G	G	N	LY	LY	G	G	LY	N	G	LY	G	LY	N

Figure 6. Regional hydrologic indicators and water supply status for New Jersey drought regions, 2012.

Key to Hydrologic Indicators	
Near or above normal	G
Moderately dry	LY
Severely dry	DY
Extremely dry	R

Key to Status	
Normal	N
Emergency	E

Date		Northeast					Coastal North					Coastal South			
		Drought Indicators				STATUS	Drought Indicators				STATUS	Drought Indicators			STATUS
		90-Day Precip.	90-Day Stream	NJ Res.	Unconf. Ground Water		90-Day Precip.	90-Day Stream	NJ Res.	Unconf. Ground Water		90-Day Precip.	90-Day Stream	Unconf. Ground Water	
Jan	1/4/2012	G	G	G	G	N	LY	G	G	G	N	LY	G	G	N
	1/18/2012	G	G	G	G	N	LY	G	G	G	N	LY	G	G	N
Feb	2/1/2012	LY	G	G	G	N	LY	G	G	G	N	LY	G	G	N
	2/15/2012	LY	G	G	G	N	LY	G	G	LY	N	LY	G	LY	N
	2/29/2012	LY	G	G	LY	N	LY	G	G	LY	N	LY	G	LY	N
Mar	3/14/2012	LY	DY	G	LY	N	DY	DY	G	LY	N	LY	G	LY	N
	3/28/2012	DY	R	G	DY	N	DY	DY	G	DY	N	DY	LY	LY	N
April	4/4/2012	DY	R	G	R	N	DY	DY	G	LY	N	DY	LY	LY	N
	4/11/2012	DY	R	G	R	N	DY	DY	G	LY	N	DY	LY	LY	N
	4/18/2012	DY	R	G	R	N	DY	R	G	DY	N	DY	DY	DY	N
	4/22/2012	DY	R	G	R	N	DY	R	G	DY	N	DY	DY	DY	N
	4/29/2012	DY	R	G	R	N	DY	R	G	LY	N	DY	DY	LY	N
May	5/6/2012	DY	R	G	DY	N	DY	R	G	LY	N	DY	DY	LY	N
	5/13/2012	DY	R	G	DY	N	DY	R	G	LY	N	DY	DY	LY	N
	5/20/2012	DY	R	G	DY	N	LY	R	G	DY	N	LY	DY	DY	N
	5/27/2012	LY	R	G	LY	N	LY	R	G	LY	N	LY	DY	LY	N
June	6/3/2012	LY	R	G	LY	N	LY	R	G	LY	N	DY	DY	LY	N
	6/10/2012	LY	R	G	LY	N	LY	R	G	LY	N	DY	DY	DY	N
	6/17/2012	LY	R	G	LY	N	LY	DY	G	LY	N	LY	DY	DY	N
	6/24/2012	LY	DY	G	LY	N	LY	DY	G	LY	N	LY	DY	DY	N
July	7/1/2012	LY	DY	G	LY	N	LY	DY	G	LY	N	LY	DY	DY	N
	7/8/2012	LY	DY	G	LY	N	LY	DY	G	LY	N	LY	DY	LY	N
	7/15/2012	LY	LY	G	LY	N	LY	DY	G	DY	N	LY	DY	DY	N
	7/22/2012	LY	LY	G	LY	N	LY	DY	G	DY	N	LY	DY	DY	N
	7/29/2012	LY	LY	G	DY	N	LY	DY	G	DY	N	LY	DY	DY	N
Aug	8/5/2012	LY	LY	G	LY	N	LY	DY	G	DY	N	LY	DY	DY	N
	8/12/2012	LY	LY	G	LY	N	LY	DY	G	DY	N	LY	DY	DY	N
	8/19/2012	LY	LY	G	LY	N	LY	DY	G	DY	N	LY	DY	DY	N
	8/26/2012	LY	DY	G	DY	N	LY	DY	G	DY	N	LY	DY	DY	N
Sept	9/2/2012	LY	LY	G	LY	N	LY	LY	G	LY	N	LY	DY	LY	N
	9/9/2012	LY	LY	G	LY	N	G	LY	G	LY	N	G	LY	LY	N
	9/16/2012	LY	DY	G	LY	N	LY	LY	G	LY	N	G	LY	LY	N
	9/23/2012	LY	DY	G	LY	N	LY	G	G	LY	N	LY	LY	LY	N
	9/30/2012	LY	DY	G	LY	N	LY	G	G	LY	N	LY	LY	LY	N
Oct	10/7/2012	LY	LY	G	LY	N	LY	LY	G	LY	N	LY	LY	LY	N
	10/14/2012	LY	LY	G	LY	N	G	LY	G	LY	N	G	LY	LY	N
	10/21/2012	LY	LY	G	LY	N	G	LY	G	LY	N	G	G	LY	N
	10/28/2012	LY	LY	G	LY	E	G	LY	G	LY	E	G	G	LY	E
Nov	11/4/2012	LY	LY	G	LY	E	G	LY	G	LY	E	G	G	LY	E
	11/11/2012	LY	LY	G	LY	E	G	LY	G	LY	E	G	G	LY	E
	11/18/2012	LY	LY	G	LY	E	G	DY	G	LY	E	G	G	LY	E
	11/25/2012	LY	LY	G	LY	E	G	DY	G	LY	E	G	G	LY	E
Dec	12/2/2012	LY	DY	G	DY	E	LY	DY	G	DY	E	G	G	G	E
	12/16/2012	LY	DY	G	DY	N	LY	DY	G	DY	N	G	G	G	N
	12/30/2012	G	LY	G	LY	N	G	DY	G	G	N	G	G	G	N

Figure 6. Regional hydrologic indicators and water supply status for New Jersey drought regions, 2012 (cont.).

Key to Hydrologic Indicators	
Near or above normal	G
Moderately dry	LY
Severely dry	DY
Extremely dry	R

Key to Status	
Normal	N
Emergency	E

V. C. Hurricane Sandy

V.C.1. Precipitation totals

Hurricane Sandy hit New Jersey on October 29-30, 2012, causing extensive damage throughout the State.[3] Meteorologists had predicted Hurricane Sandy's path several days in advance and New Jersey had some time to prepare. Concerned about the impact of this major rain event, the Governor ordered levels in several reservoirs in northern New Jersey lowered so as to better lessen anticipated flooding. On Sunday, October 28, 2012, the day before Sandy hit, the National Oceanic and Atmospheric Administration estimated that northern parts of the State would receive 3 to 4 inches of rain (fig. 7).

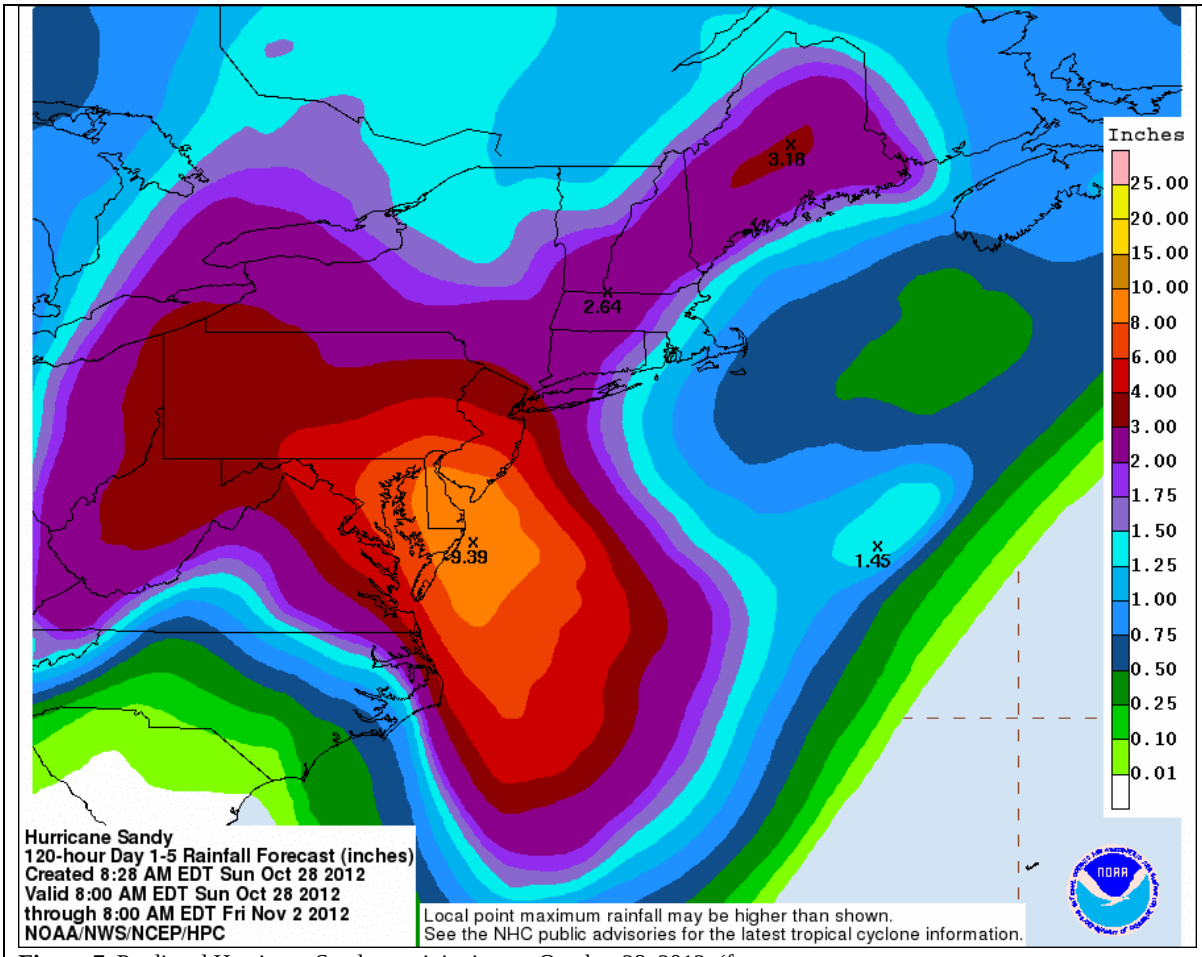

Figure 7. Predicted Hurricane Sandy precipitation on October 28, 2012. (from: http://www.washingtonpost.com/blogs/capital-weather-gang/post/cause-for-concern-the-7-most-alarming-hurricane-sandy-images/2012/10/28/615bbbfe-210b-11e2-ac85-e669876c6a24_blog.html)

Precipitation was heaviest in southern New Jersey, where between 8 and 12 inches fell (fig. 8). Across northern New Jersey total precipitation amounts were less than 2 inches. The significant flooding that occurred along the State's

[3] http://www.nasa.gov/mission_pages/hurricanes/archives/2012/h2012_Sandy.html

coasts was primarily caused by storm surge associated with Hurricane Sandy's arrival at high tide during a full moon.

V.C.2. Water-supply impacts

From a water-supply point of view Hurricane Sandy's primary impact was on disruption of service. Significant power disruptions throughout New Jersey caused numerous potable supply facilities to rely on backup power systems. Restoring power to all facilities took days to weeks to complete. Maintaining an adequate fuel supply to run the backup generators was initially difficult because downed trees blocked many roads for days. In some systems the loss of power meant the system pressure could not be maintained. In such cases water quality could not be assured and boil-water advisories were issued.

The Governor declared a statewide emergency on October 27, 2012 (Executive Order 104) in anticipation of the impact of Hurricane Sandy. The hurricane's impact included the downing of numerous power lines causing a lack of power to many water supply plants. In response the Governor declared a state of water emergency in on November 1, 2012 (Executive Order 106). The NJDEP Commissioner instituted statewide water restrictions (Administrative Order 2012-12) in order to limit water demands and thus energy needs. This water emergency continued until lifted on December 20, 2012 (Executive Order 120). NJDEP also lifted water restrictions that day (Administrative Order 2012-19).

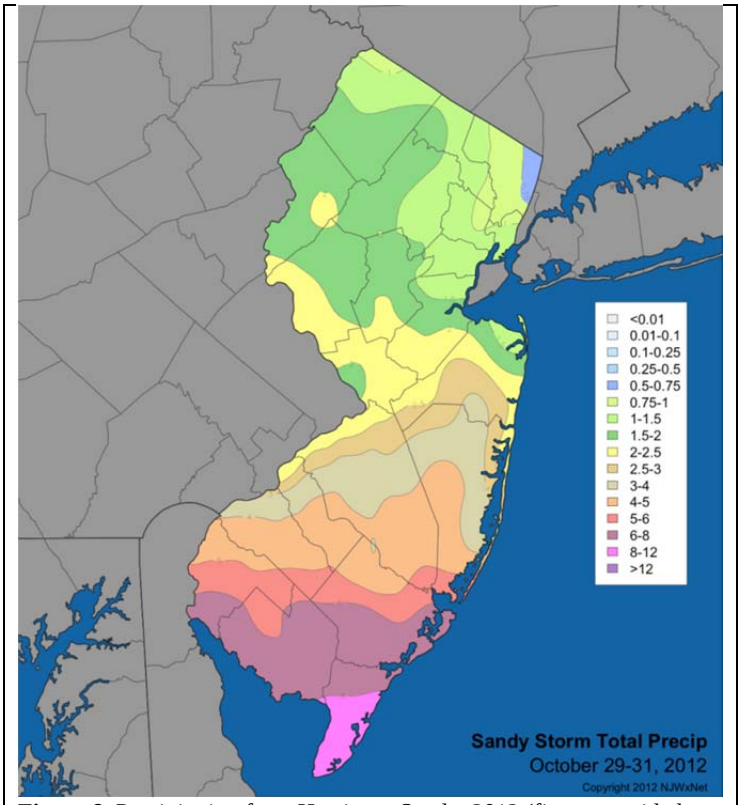

Figure 8. Precipitation from Hurricane Sandy, 2012 (figure provided by Dr. David Robinson, New Jersey State Climatologist)

V.C.3. Reservoir Releases and Evaluation

On Friday, October 26, 2012, Governor Christie ordered the lowering of water levels in several reservoirs and lakes in northern New Jersey (table 4). The lowerings were to take effect for 20 to 30 hours, sufficiently in advance of the forecast rain so that the released water would flow downstream past areas that might flood when the rain arrived. The goal was to create a void in the reservoirs that would fill during the hurricane and thus mitigate downstream flooding.

WSMP staff are currently reviewing the impact of this planned lowering on final reservoir levels. This analysis is expected to be completed in summer 2013.

Local municipal and county officials also ordered the partial draining of lakes in advance of Hurricane Sandy. An internet search of newspaper reports disclosed 14 such lowerings (table 5).

Table 4. Lakes and reservoir lowerings ordered by the Governor in advance of Hurricane Sandy, October 2012.

Owner/Operator	Lake/Reservoir
United Water New Jersey	Woodcliffe Lake
	Lake Tappan
	Oradell Reservoir
City of Newark	Charlottesburg Reservoir
North Jersey District Water Supply Commission	Wanaque Reservoir
Jersey City	Boonton Reservoir
New Jersey Dept. of Environmental Protection	Pompton Lake
	Lake Hopatcong

Table 5. Lake, pond and reservoir lowerings ordered by municipal and county officials in advance of Hurricane Sandy, October 2012.

Lake/Pond	Municipality	County	Ordered by
Peddie Lake	Hightstown	Mercer	municipality
Brainerd Lake	Cranbury	Middlesex	municipality
Nomahegan Lake	Cranford	Union	county
Clark Reservoir	Clark	Union	county
Bloodgoods Pond	Clark	Union	county
Jackson Pond	Clark	Union	county
Milton Lake	Rahway	Union	county
Verona Park Lake	Verona	Essex	county
Diamond Mill Pond	Millburn	Essex	county
Lake Lefferts	Matawan	Monmouth	municipality
Spring Lake	Spring Lake	Monmouth	municipality
Lake Como	Belmar	Monmouth	municipality
Lake Weamaconk	Englishtown	Monmouth	municipality
Lake of the Lillies	Point Pleasant	Ocean	municipality

VI. Delaware River Basin

In 1954 the U.S. Supreme Court issued a Decree that resolved a case between the states of New Jersey and New York and New York City. This decree "established an equitable allocation [*of the Delaware River*] under federal common law." [4] To aid in the management of the Basin's water resources the federal government and the states of Delaware, New Jersey, New York and Pennsylvania agreed to the Delaware River Basin Compact.[5] The Compact set up the Delaware River Basin Commission (DRBC) to "adopt and promote uniform and coordinated policies for water conservation, control, use and management in the basin" (section 3.1). This Compact works in conjunction with the Decree to sustainably manage the water resources utilized by over 15 million people.

The diversions, releases and flow targets have been periodically revised over time to reflect an increased understanding of water availability and to address issues not identified in the earlier agreements (for example, fisheries flows and flood mitigation). The current program is referred to as the Flexible Flow Management Program (FFMP) and was established in 2007. It was revised in 2008 and 2011.

The FFMP expired in May 2012. NJDEP worked with the Decree Parties to address several outstanding issues with the agreement, but was unable to come to long-term resolution. As a result the agreement was renewed unchanged for a one-year period (June 1, 2012 through May 31, 2013). NJDEP continues to meet with the Decree Parties to resolve the outstanding issues:

- a permanent increase of the Delaware and Raritan Canal diversion to 85 mgd during drought
- increased flood mitigation downstream of the NYC reservoirs
- an appropriate Excess Release Quantity bank
- adequate fisheries releases

VII. United States Geological Survey

The New Jersey Department of Environmental Protection funds extensive monitoring, applied research, and basic research by the United States Geological Survey (USGS). The results of this work are described in more detail on the web page of the USGS New Jersey Water Science Center:

http://nj.usgs.gov/

What follows is not a comprehensive list of USGS work in New Jersey but an overview of the work that is useful to water-supply planning activities and was wholly or partially funded by NJDEP.

[4] Delaware River Bain Commission website - http://www.state.nj.us/drbc/programs/flow/decree.html
[5] Delaware River Basin Commission website - http://www.state.nj.us/drbc/library/documents/compact.pdf

VII.A. Monitoring

The USGS monitors streamflows, reservoir levels, precipitation amounts, tidal fluctuations, water quality and groundwater levels at numerous points throughout New Jersey. NJDEP makes a significant monetary contribution to this monitoring. Measurements at some gages are reported over the internet for real-time-analysis purposes. The data are reported on the USGS web site listed above and on the USGS NWIS data web site for New Jersey:

http://waterdata.usgs.gov/nj/nwis/nwis

In 2012 the NJDEP facilitated an agreement between the USGS and the Trenton Water Department for installation of a new real-time water-quality gage for the Delaware River at Frenchtown. This gage will report data on turbidity, dissolved oxygen, pH, specific conductance and water temperature. These data will give the Trenton Water Department advance notice of changing water quality in the Delaware River. This will assist them in preparing their treatment plant for such changes. The NJDEP is helping to fund the installation of this new station. This gage will be installed in 2013.

VII.B. Studies

VII.B.1. Great Egg Harbor-Mullica Groundwater-Withdrawal Strategies

USGS finished a major study of possible alternative groundwater-withdrawal strategies of the Great Egg Harbor and Mullica River basins in southeastern New Jersey (Pope and others, 2012). NJDEP funded this study to investigate the possibility of shifting pumpage between the unconfined and confined aquifers in order to minimize the impact on surface waters. This report, **"**Simulated Effects of Alternative Withdrawal Strategies on Groundwater Flow in the Unconfined Kirkwood-Cohansey Aquifer System, the Rio Grande Water-Bearing Zone, and the Atlantic City 800-Foot Sand in the Great Egg Harbor and Mullica River Basins, New Jersey," is available at:

http://pubs.usgs.gov/sir/2012/5187/

VII.B.2. Coastal Plain Synoptic

Every five years the USGS conducts a systematic monitoring of water levels in the confined aquifers of the New Jersey Coastal Plain. The NJDEP helps to fund this activity. The results are a major way by which NJDEP estimates the impact of withdrawals. The last survey was conducted in 2008. USGS provided the NJDEP with a preliminary report including potentiometric maps, water use, and long-term changes in water levels and chloride conditions. USGS plans to publish the final report on 2008 water levels in 2013.

The next survey of confined-aquifer water levels will be in 2013.

VII.B.3. New Jersey Coastal Plain Water-Table Web Page

In late 2012 NJDEP funded work by USGS to develop a web page that provides the public with a way to easily see published water-table maps. The USGS has conducted several surficial aquifer studies of watersheds in the New Jersey Coastal Plain that include water-table maps. Currently these are only available in digital form as PDF files. In contrast, the USGS water-table maps of Long Island are available at:

http://ny.water.usgs.gov/maps/LI_maps06/

This project will start by making New Jersey's Coastal Plain water-table maps more easily available on a GIS-based web page along with current water-level data from observation wells. Unfortunately not all of the Coastal Plain has been mapped. The biggest data gap is in the northeast Coastal Plain where Monmouth County does not have a water-table map. The data gaps, as well as making a consistent water-table map of the entire Coastal Plain and a depth-to-water map, may be addressed in the future if funding becomes available.

VII.B.4. Reservoir Levels Web Page

The USGS reports levels of several reservoirs in New Jersey. It also reports streamflows downstream of these reservoirs. During a flood crisis, managers refer to these data by switching back and forth between web pages. In 2012 NJDEP funded USGS to develop a single web page which will integrate both reservoir levels and downstream flows. This will make it easier for first responders and managers to quickly evaluate current conditions.

USGS provided drafts of the summary web page in late 2012. The final product is due in early 2013.

VII.B.5. Low Flow Indices

In 2012 USGS continued work on a limited-access web page based on the currently available StreamStats web application to enable easy estimation of selected low-flow statistics at any point on a stream. This work is part of a joint NJDEP-USGS research project on the ecological flow needs that began in 2000 (Hoffman and Rancan, 2009). The final web page should be available in early 2013. The New Jersey StreamStats web page is at:

http://water.usgs.gov/osw/streamstats/new_jersey.html

VII.B.6.Streamflow Reconstruction

As part of NJDEP's development of a safe-yield model of the surface-water-reservoir systems in the Passaic and Hackensack basins, the USGS was contracted to develop a set of streamflows at gaged and ungaged control points that would be consistent with model needs. USGS staff worked closely with NJDEP staff in 2012 to develop this set of streamflows.

VII.B.7. New Jersey Water Tracking Model

USGS staff also worked with NJDEP staff to populate the New Jersey Water Tracking Model (NJWaTr) with withdrawal, transfer and discharge data up through 2010. Work was also done to improve the data loading and extraction programs and the full-allocation estimator for individual wells.

VII.B.8. Cape May County

USGS staff worked with NJDEP staff to assess salt water intrusion in lower Cape May County, particularly the recently identified intrusion at the Wildwood well field. The USGS was funded to help develop, run and analyze six

possible water-supply-allocation scenarios using the variable-density shallow-aquifer model and the combined regional and subregional models previously developed for the area (Lacombe and others, 2009). USGS plans to submit a draft summary of the scenarios to NJDEP in 2013.

VII.B.9. Cumberland County

USGS staff are completing a computer groundwater-flow model of the Kirkwood-Cohansey aquifer in Cumberland County. This model is designed to be useful in making water-supply decisions about additional withdrawals from the water-table aquifer and potential impacts on streamflow and water levels by simulating streamflow routing and groundwater flow.

VIII. Rutgers University

NJDEP contracts with Rutgers University to conduct water-supply-related research. In 2012 this included three research areas –weather stations, soil moisture and droughts, and water needs of agricultural crops.

VIII.A. New Jersey Mesonet

The New Jersey Mesonet is a state-of-the-art network of 15 automated weather stations operated by the State Climatologist. These stations provide real-time data on weather conditions. They also allow for retrieval of historical data. Data from the New Jersey Mesonet are reported on the New Jersey Weather and Climate Network :

http://climate.rutgers.edu/njwxnet/

NJDEP provided funds to initially install these stations. NJDEP now helps fund the operation and maintenance of the Mesonet.

VIII.B. Soil-Moisture Drought-Assessment Tool

Several of the New Jersey Mesonet stations are equipped with probes that record soil moisture at different depths. These data enable an estimate to be made of both the rate of groundwater recharge and an estimate of the severity of any soil moisture deficit. NJDEP is funding research by Rutgers Department of Environmental Sciences on automated methods to calculate this recharge and to predict the severity of region-wide droughts based on measurements at the Mesonet stations.

VIII. C. Agricultural Water Use

The NJDEP is funding a research project conducted by the Rutgers Department of Environment Sciences that focuses on agricultural water use in New Jersey. The goal of this project is to quantify the impact of agriculture on water demand in New Jersey by measuring crop-specific water needs and groundwater recharge at farms throughout the state. In the first year of the study (2011) water demand was measured for sweet corn and tomatoes, and this past summer (2012), the project focused on potatoes. The researchers plan to concentration on a vegetable crop in 2013.

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Note: all internet links active as of April, 2013.