WATER SUPPLY AVAILABILITY IN THE RARITAN RIVER BASIN

A Technical Report for the Raritan Basin Watershed Management Project

New Jersey Water Supply Authority
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Executive Summary

The Raritan River Basin includes a number of major watersheds, comprising over 1,100 square miles. The New Jersey Department of Environmental Protection (NJDEP) has aggregated these watersheds into three Watershed Management Areas (WMAs), as shown in Figure 4 – Municipalities and Road Network within the Raritan Basin, of the technical report "Setting of the Raritan River Basin." These areas are the Upper Raritan WMA (WMA 8), the Lower Raritan WMA (WMA 9) and the Millstone WMA (WMA 10).

"Water supply availability" describes the quantities of developed and potential water supplies within a watershed, the current and protected demands upon those supplies, and the extent to which supplies are sufficient to meet demands, currently and in the future. The level of sustainable supply from surface waters is called the "safe yield" while the equivalent term for ground water supplies is "dependable yield." This technical report provides a detailed summary of water supply resources and demands, both current and projected, and the recommendations of recent plans for addressing potential deficits. This report draws heavily from water supply studies and plans of the New Jersey Department of Environmental Protection (NJDEP) that were developed over the last twenty years.

BASIN SUMMARY

The Raritan River Basin currently has a water supply availability of 360 million gallons per day (MGD), 225 MGD of which is surface water and 135 MGD from aquifers. Surface water safe yields are primarily the result of three facilities operated by the NJ Water Supply Authority – Spruce Run Reservoir, Round Valley Reservoir and the Delaware & Raritan Canal. These facilities have been in place for decades. Ground water dependable yields are the results of 1,100 square miles of aquifers – some poor and some prolific. Ground water availability has been reduced over time by pollution events in several urban and industrial areas.

Demand projections indicate that the 1990 demand of approximately 255 MGD will increase to approximately 350 MGD by the year 2040. Comparing current water supply availability of 360 MGD to a projected 2040 demand of 350 MGD (including demands for water that is transported out-of-basin), it is clear that the Basin will need to address potential water supply needs in the coming decades if projections do not change significantly. The need for a new water supply could be hastened or delayed by various factors, most of which are under society's control.

Two water supply projects, the Kingston Quarry Reservoir and the Confluence Pumping Station, have been identified as cost-effective projects that can provide 65 MGD and 53 MGD, respectively, with relatively limited environmental impacts. The Statewide Water Supply Plan anticipates that one of these projects will be built after 2030 to supply future needs, assuming that projections continue to hold steady and water conservation is effective in mitigating demands.

While the Basin overall has sufficient water supplies for public use, there are issues regarding possible limitations to and impairment of local ground water supplies, protection of aquatic ecosystems, meeting future demands within the Basin, and addressing out-of-basin needs.

WATERSHED MANAGEMENT AREA SUMMARIES

Most of the existing information on water availability is from reports published by the NJDEP. These reports were developed prior to establishment of the Watershed Management Areas, and therefore do not provide information appropriate to these geographic areas. Instead, information is available for the South River watershed (part of the Lower Raritan Watershed Management Area) and for the rest of the Raritan Basin (including the Upper Raritan, Millstone and remaining portions of the Lower Raritan Watershed Management Areas). NJDEP anticipates developing an update of its Water Balance Model for the NJ Statewide Water Supply Plan using watershed and Watershed Management Area boundaries. A future version of this report will incorporate the results of this update.

Purpose of the Characterization and Assessment for Water Availability

The Raritan River Basin supports a wide variety of New Jersey ecosystems within the Highlands, Piedmont and Coastal Plain geologic provinces. Many of these ecosystems rely heavily on the close proximity of surface waters, wetlands and high ground water tables. The Raritan River Basin is also a major source of potable and industrial water supplies in central New Jersey. Finally, the surface waters of the Basin are used for recreational and aesthetic purposes. The vitality and health of all these uses depends on the natural processes of precipitation, runoff and recharge. Therefore, for watershed management purposes it is critical to understand both the general and detailed water budget and hydrology of the Basin. The technical report on the Water Budget of the Raritan River Basin provides a detailed summary of current knowledge, and serves as a foundation for this technical report.

Using a water budget, it is possible to understand the extent to which water supplies for human purposes can be drawn from the environment without significant damage, through reliance on natural storage (e.g., aquifers) or artificial storage (e.g., reservoirs). The characterization portion of this technical report provides information on the current status of the water supply resources in the Raritan River Basin. The assessment portion compares the current resource status to current and projected demands to determine whether there are conflicts or gaps between water supply availability and water demand. Both portions of this report are prepared for use in the management planning process for the Raritan River Basin.

Laws, Plans and Regulations Affecting Water Availability

Over the last two centuries the English common law system that originally applied to New Jersey waters has been incrementally modified to meet the increasing demand for water and reflect the changing value society has placed on water. In New Jersey the most recent changes have been to incorporate the concept of the public trust doctrine. Under this doctrine, the waters of New Jersey are viewed as the property of the State, which acts as the trustee of the people. This public trust doctrine, linked with the riparian rights of common law, create a situation where the State allocates waters for use, ensuring that downstream water users are not harmed by upstream uses, and that the public trust in New Jersey waters is maintained. Sustainability of water availability is a fundamental concept of New Jersey water law. The concept applies to both ground and surface waters.

Programs Pursuant to the NJ Water Supply Management Act

In 1981, the Water Supply Management Act (WSMA, N.J.S.A. 58:1A-1 et seq.) was passed in an attempt to adopt a more complete administrative water law. The act states, "the water resources of the State and any water brought into the State must be planned for and managed as a common resource from which the requirements of various regions and localities in the state shall be met." This language meant that <u>all</u> water diverters would be subject to regulatory oversight and would be considered in any water resource management strategy. In addition, the law established a more regular system of water supply planning for New Jersey.

Water Supply Planning

The WSMA requires that the NJDEP prepare, adopt and periodically update a New Jersey Statewide Water Supply Plan (NJSWSP). The NJSWSP must identify existing water supply sources and current uses, project demands, recommend improvements to water supply facilities, and recommend "actions to provide for the maintenance and protection of watershed areas." In addition, the Water Supply Bond Act of 1981 (P.L. 1981, Chapter 261) provides guidance for the NJSWSP, including mandates for the identification of specific projects that may receive bond funding. From this process arose a need for regional water supply investigations and feasibility studies that both arose from and contributed to the NJSWSP. Planning under the WSMA must address both regional and statewide water supply issues. The most recent NJSWSP was adopted by NJDEP in 1996.

Water Allocation Program

The WSMA gave to the NJ Department of Environmental Protection the power to manage the water supply through a uniform water diversion permit system applying to both new <u>and</u> pre-existing water withdrawals if their withdrawals exceeded 100,000 gallons per day (gpd). This provision allowed for a comprehensive evaluation of the actual demand on the State's water supply sources of ground and surface water. The WSMA requires each permit to contain six minimum provisions, including:

- Fix the maximum allowable diversion expressed in terms of daily, monthly or annual diversions, and require metering and reporting of use;
- Identify and limit the use to which the water may be put;
- Require that all water diverted for non-consumptive water use be returned to a reasonably proximate body of water identified by the NJDEP.

The water allocation permit program is administered under N.J.A.C. 7:19-1 et seq., within the NJDEP's Water Supply Element. The current rules require all water withdrawals in excess of 3.1 million gallons per month to obtain a water allocation permit. The threshold is based on the 100,000 gallon per day (gpd) threshold that has been historically used with some exceptions for short-term uses.

However, by the time the NJDEP had been delegated the water allocation permit program, there were a number of aquifers that were being overused. Aquifer withdrawals were exceeding recharge and ground water levels were declining dramatically. Studies indicated that unless withdrawals were reduced the aquifers would continue to decline and threaten the long-term reliability of the supply. The limitation in the 1981 law prevented the NJDEP from ordering a reduction in the withdrawals absent an emergency order of the Governor; an action usually reserved for drought or other water supply emergencies. A 1993 WSMA amendment now allows the NJDEP to establish areas of water supply concern wherever it can be demonstrated that the safe and dependable yield of a water source is being exceeded or threatened by overuse. In these areas the NJDEP can reduce existing withdrawal privileges to the safe and dependable yield of that source even if this action results in a reduction in actual withdrawals. However, before taking such action, the NJDEP is required to identify alternate water supply sources and work with affected permittees to develop these supplies.

Minimum Passing Flow Issues

The WSMA requires the NJDEP to ensure that the water quality of water sources is maintained and that the water standards for the use of the water are met. NJDEP addressed this need in part by mandating that water withdrawals be limited to levels that did not excessively drain surface or ground waters. In surface waters, the primary mechanism is through mandates for allowing a certain water flow to pass by critical points in the stream system. For intakes not associated with reservoirs, a “passing” flow is established below which withdrawals cannot occur. For reservoirs, a “release” flow is established to ensure that downstream flows are maintained at a certain level. In both cases, the purpose of the flow is to provide usable water for downstream interests and to protect aquatic life. The passing flow or release flow levels are major factors in determining how much water is available for use in a watershed. The higher the passing or release flows, the less water is available for the user during dry periods. State law allows for reduction of the required passing flows during drought emergencies, so as to conserve water in reservoirs for public use. The many combinations of passing flows, reservoir releases, non-drought procedures and drought procedures make it difficult to predict and measure the actual safe yields of surface water supply systems. For planning purposes in NJDEP and here, the passing and release flows usually are assumed to be constant, providing some buffer in the analyses.

1907 Excess Diversion Law

The Excess Diversion Law provides an exception to the passing flow requirements. Under certain conditions and with payment of an “excess diversion fee” to the NJDEP, water supply purveyors – but no other holders of water supply permits – may reduce passing flows below the levels mandated by their water allocation permits. Some water supply systems are further limited by court orders that mandate continuation of certain passing flows regardless of the Excess Diversion Law, but there are examples in watersheds outside the Raritan Basin of stream flows being reduced essentially to zero during dry periods.

Water Supply Bond Act of 1981 & Its Subprograms

The Water Supply Bond Act of 1981 (P.L. 1981, Chapter 261) authorized the creation of a $350 million bond issue with a revolving loan fund for State or local projects to rehabilitate, repair or consolidate antiquated, damaged or inadequately operating water supply facilities and to plan, design, acquire and construct various State water supply facilities. The New Jersey Statewide Water Supply Plan (NJSWSP) is the planning mechanism by which the state defines its water needs. Inclusion in the NJSWSP is a prerequisite for the expenditure of funds under the Water Supply Bond Act of 1981 for projects and studies. The Act was modified in 1983 to allow for State expenditures on ground water and other studies that need not be repaid as loans unless they result in a capital project that is funded by a Water Bond Fund loan. A great deal of new knowledge about aquifer systems has been gained through the use of these funds.

Characterization of Water Availability in the Raritan Basin

Methodology and Information Sources

The water resources of the Raritan River Basin have been studied extensively since 1950. Primary resources used for this study were developed by or for the NJDEP and date from the 1980's and 1990's, including:

- New Jersey Statewide Water Supply Plan and reference documents
- Eastern Raritan Basin Water Feasibility Study
- NJDEP Water Balance Model (Raritan Basin portion)
- South River Water Supply Feasibility Study

Most of the information in this report is drawn from these documents and from the technical report "Setting of the Raritan River Basin". Rather than using detailed references and footnotes, the primary references are generally noted in and apply throughout each section.

Hydrology and Topography of the Raritan Basin

The ratio of ground water versus surface water withdrawals is highly variable between planning areas because of differences in geology, topography, population density, land use and proximity to major water bodies. Consequently, southern New Jersey is more dependent on ground water supplies and northern New Jersey is more dependent on surface water. The inherent geological characteristics determine the relative underground storage of water, while natural topography and land use influence the viability of water storage in above-ground reservoirs.

Variations in rock type and geologic history of different regions of the State have created three different physiographic provinces in the Raritan Basin with unique surface topographies: the Coastal Plain, Piedmont and Highlands provinces. Each province consists of different types of consolidated (i.e., rocks) and unconsolidated (i.e., sand, gravel and silt) deposits with characteristic properties (see Figure 6 of the technical report "Setting of the Raritan River Basin"). In the northwest portion of the Basin, glacial deposits cover parts of the Piedmont and Highlands. Each of the physiographic provinces and the glacial deposits are associated with characteristic aquifer units and ground water flow types. The major aquifer units within these physiographic provinces in the Raritan River Basin are discussed in the technical report "Setting of the Raritan River Basin."

The Basin is higher in elevation to the north, northwest and (in places) to the southwest (see Figure 5 of the technical report "Setting of the Raritan River Basin"), reflecting the hard rock geology of the Highlands and the basalt hills of the Watchung Mountains and Sourland Mountains. Surface water movement is generally from west to east in the central part of the Basin, from north to south in the northern portion, and from south to north in the southern portion of the Basin (see Figure 10 of the technical report "Setting of the Raritan River Basin"). Stream flow is monitored at a number of stations within the Basin through a cooperative network operated by the U.S. Geological Survey (USGS) for the NJDEP (see Figure 1). There are 100 municipalities and 7 counties partially or wholly within the Basin (see Figure 4 of the technical report "Setting of the Raritan River Basin").

Geography of Water Sources and Water Users

Water Sources

The Raritan Basin has a number of important water supply sources. Most of the Basin has ground water supplies that range from limited to prolific, depending on the geology of the area (see Figure 7 of the technical report "Setting of the Raritan River Basin"). Topographic relief in the northwestern part of the Basin also allows for important surface water supplies (see Figure 5 of the technical report "Setting of the Raritan River Basin"). Finally, the Delaware & Raritan Canal provides for the transfer of water from the Delaware River to the Raritan Basin.

- **Aquifer Systems** – The Coastal Plain covers the southeastern Raritan Basin, in eastern Middlesex County, western Monmouth County, and northeastern Mercer County. In cross section, it is a wedge shaped sequence of unconsolidated sediments composed of sand, gravel, silt and clay that thickens to the southeast. The sequence is composed of four major aquifer systems separated by clay or silt layers that act as confining or semi-confining barriers to separate them. The outcrop areas of major coastal plain aquifers are, from oldest to youngest: the Potomac-Raritan-Magothy (also referred to as the Lower, Middle and Upper aquifers), Englishtown, Wenonah/Mount Laurel, and Kirkwood-Cohansey. All are present in the Raritan Basin. Since these are unconsolidated sediments, water migrates through natural channels and pore spaces between the aquifer sediments, and the sandy nature of these formations makes them prolific water supplies for public wells. Contrary to earlier presumptions, many of these aquifers (other than the Cohansey) do not receive the majority of water through their recharge areas under current pumping conditions, except near where they "outcrop" at the land surface. Instead, they receive much or most of their water from overlying and underlying aquifers.

  The Piedmont covers a large portion of the Raritan Basin in Middlesex, Union, Somerset, Mercer and Hunterdon Counties. Sedimentary units such as the Stockton and Lockatong Formations and the Brunswick Group are the primary aquifers. Other formations in the Piedmont that have limited water bearing potential include the Sourlands Mountains at the southwest of the Basin and the Watchung Mountains at the northeast of the Basin. Water movement in the consolidated rocks is primarily through channels called joints, bedding planes and fractures that were created by the original deposition and movement of the rock formations. This type of flow allows relatively limited movement of water through the aquifer system, though some wells in the Brunswick Group can produce large volumes of water. Formations of the Piedmont are hydraulically connected with local streams, where semi-confining glacial deposits do not cover them.

  The Highlands Province covers most of the northwest Raritan Basin. Some of the Highlands rock formations are among the oldest in New Jersey. All but the dolomitic limestone formations in the Green Pond Outlier are poor aquifers. The limestone aquifers can be very prolific, with water movement through solution channels in the rock. These aquifers are also very vulnerable to pollution from the land surface. The Spruce Run and Peapack-Gladstone valleys are part of the Highlands Province and are underlain by these limestones. Similar to the Piedmont, water movement outside of the limestone areas is primarily through joints, fractures and in particular through bedding planes in the formations on a very local scale. The Precambrian aquifers do not generally produce large yields, except near streams or where wells intercept major fault zones and are often hydraulically connected with surface waters.

  Glacial deposits consist of unconsolidated stratified (layered) and unstratified (mixed) deposits of gravel, sand, silt and clay. The thickest glacial deposits generally occur in New Jersey north of the Wisconsonan terminal moraine line that extends from Perth Amboy through Morristown to Belvidere. Only a small portion of the northern Raritan Basin has glacial deposits. North of this line, upland areas are generally covered by a thin layer of discontinuous glacial till (unstratified, mixed sediments), usually less than 50 feet thick. The valleys are filled with stratified drift and lake bed sediments that comprise aquifers and confining units, sometimes up to 300 feet thick. Glacial aquifers supply important quantities of water in Northern New Jersey. These buried valley (or valley-fill) aquifers are frequently the main local water supply sources. Many wells that draw from the underlying aquifer are extensively recharged by streams flowing on top of the glacial deposits. The Lamington aquifer system is an example of glacial sediments lying over bedrock aquifers, both of which are used for public water supply purposes.

- **South River Aquifer Recharge Systems** – Two major aquifer recharge systems exist in the South River watershed. Middlesex Water Company operates one on behalf of the City of Perth Amboy. This system takes water from Deep Run and recharges it to the upper aquifer through a recharge basin. The Duhernal Water System (originally formed by Dupont, Hercules and National Lead; hence the name Duhernal) also uses surface water from Duhernal Lake, on the South River in Old Bridge and Spotswood, to recharge the upper aquifer.

- **Spruce Run/Round Valley Reservoirs** – These reservoirs were built by the State of New Jersey and are now operated by the NJ Water Supply Authority (see Figure 2). Spruce Run has a capacity of 11 billion gallons and is fed by natural stream flow. The two largest tributaries are Spruce Run and Mulhockaway Creek. Spruce Run Reservoir releases water as needed to the Spruce Run and thence to the South Branch of the Raritan River. Round Valley has a capacity of 55 billion gallons and is almost entirely reliant on water pumped from the South Branch at the Hamden Pumping Station. Water can be released as needed to either the Hamden Pumping Station or to the South Branch of Rockaway Creek (a tributary of the Lamington River) by gravity lines. The water released from either reservoir travels downstream to maintain flow at the intake of Elizabethtown Water Company (located at the confluence of the Raritan and Millstone Rivers) and at the intakes of other users.

- **Delaware & Raritan Canal** – The Canal was originally built in the early 1800's as a transportation route for barges. After transportation use of the Canal ended, the State of New Jersey purchased the facility. Extensive rehabilitation of the Canal by the NJ Water Supply Authority in the 1980's allowed the Canal to become a major water supply for the Raritan Basin. Up to 100 MGD may be transferred from the Delaware River to the Raritan Basin during normal periods, with reductions to a minimum of 65 MGD during Delaware Basin droughts. The Canal is primarily used by Middlesex Water Company, the City of New Brunswick, the Township of North Brunswick, and as a source of flow in the Raritan River above the Elizabethtown Water Company intake.

- **Lawrence Chain of Lakes** – The City of New Brunswick built this water supply system in the 1800's as a potable supply source. It consists of a series of lakes along the Lawrence Brook in Middlesex County (Davidson's Mill Pond, Farrington Lake, Weston's Mill Pond). The City is the sole user of this water supply.

Water Users

Through the NJ Statewide Water Supply Plan process, NJDEP developed an extensive water use database, using a combination of 1986-88 withdrawal data from major users, 1990 census data on domestic well use, and information on the service areas for potable water supplies and wastewater treatment. The New Jersey Water Supply Authority, a state-owned water supply utility, operates key water supply facilities in the Raritan Basin. The Authority's primary facilities are the Round Valley Reservoir, the Spruce Run Reservoir and the Delaware & Raritan Canal, with a total yield of

225 MGD. It does not actually supply retail water to individual customers in the Raritan River Basin. Rather, the Authority provides untreated (raw) water in bulk to other water purveyors who withdraw, treat and sell the finished water wholesale or retail. These water purveyors also sell the treated waters to other public water supply systems that actually deliver water directly to customers. Various ground water systems do not rely on NJWSA for bulk water. In addition, the City of New Brunswick has an independent supply (from the Lawrence Brook chain of lakes) along with its intake from the Canal.

- <u>Major Public Water Supply Systems</u> – The largest public water supply systems in the Basin use NJWSA water; they are Elizabethtown Water Company and Middlesex Water Company. Other systems using NJWSA water or having their own water supplies are listed below, with the nature of the supply being GW for ground water or SW for surface water:

  Borough of Sayreville Water Department (SW)
  City of Perth Amboy (operated by Middlesex Water Company) (GW)
  City of New Brunswick (SW)
  Morris County Municipal Utilities Authority (GW)
  Township of East Windsor Municipal Utilities Authority (GW)
  Township of Old Bridge Municipal Utilities Authority (GW)
  Township of North Brunswick (GW)
  Township of South Brunswick (GW)
  United Water-Matchaponix (SW)

- <u>Major Industrial Users</u> – Many of the major industries in the Basin are located on or near the tidal Raritan River. Some industries along the estuary use brackish water for facility cooling purposes. Other industries have their own potable or process water supplies, but most use water from one of the public water supply systems. Three of the largest, direct industrial users of fresh water supplies as of 1996 were:

  Dallanbach Sand Company (GW)
  Duhernal Water System (GW)
  Zeneca (GW)

- <u>Agricultural and Golf Course</u> – The NJ Statewide Water Supply Plan included estimates for water use by agriculture and golf courses. In both cases, the primary water use is for irrigation of plants (e.g., crops or lawns). Nearly all of these users are self-supplied (often from ground water or on-site ponds), as the cost of using potable water for irrigation at such a scale would be prohibitive. However, there are some examples where treated wastewater effluent is used for golf course irrigation. The 1995 estimated water use for agricultural and golf course irrigation in the Raritan River Basin was approximately 12 MGD. Agricultural areas are depicted on Figure 19 of the technical report "Setting of the Raritan River Basin." The same report discusses agricultural acreage in the Basin. Golf course locations are identifiable on aerial photography, but have not been mapped in detail at this time.

- <u>Domestic and Other Small Users</u> – The NJ Statewide Water Supply Plan includes estimates for domestic water use from wells for individual homes, based on 1990 Census information. In general, domestic wells supplied approximately 18 percent of the Basin's residential, potable water needs, with the vast majority of those wells being in the rural and lower-density suburban areas. Figure 3 shows the number of domestic wells by census tract, based on the 1990 Census. The Plan assumed that domestic wells will be sealed and the homes connected to public water supplies as development densities (and pollution threats) increase, and construction costs per home decrease. However, the number of domestic wells was assumed to increase in less-developed areas. The anticipated result was a fairly stable level of domestic well use for the Basin, but a shift of well concentrations from more-developed to less-developed areas. Other small water supply systems also exist in the Basin (e.g., for small businesses, schools, neighborhoods) but these do not play an extensive role in water supply.

Water Budgets and Available Water Yields

Water Budgets

The water budget of the Basin is discussed in depth in a separate, technical report titled "Water Budget in the Raritan River Basin". This technical report focuses on water budget issues directly related to public water supplies. In NJDEP's 1982 Water Supply Master Plan the NJDEP identified two areas where overuse was threatening the long-term reliability of ground water supplies. These areas are referred to as Water Supply Critical Areas (WSCA). In both areas, water levels in the major aquifers were declining and salt water intrusion was evident. One area, WSCA #1 is partially within the Raritan River Basin. It covers Monmouth County and portions of Middlesex and Ocean Counties and includes four depleted aquifers (the Englishtown, Mt. Laurel/Wenonah, Old Bridge and Farrington). In both water supply critical areas, water allocation permittees were required to reduce the use of ground water from the depleted aquifers and develop a replacement supply. In WSCA #1, the reductions in withdrawals went into effect in 1990. Since then, USGS has documented substantial increases in the water levels in each of the depleted aquifers. The Englishtown and Mt. Laurel-Wenonah Aquifers have shown very significant recoveries (over 100 feet of potentiometric head -- a measure of water pressure in a confined aquifer) by 1993. USGS ground water models predict the rise in water levels will continue for approximately ten years before they stabilize. A reanalysis of WSCA #1 is in progress.

Minimum Passing Flows

In the Raritan River Basin, ten minimum passing flows have been established. The entity responsible for ensuring compliance with the minimum passing flows is also identified.

LOCATION	PASSING FLOW	RESPONSIBLE ENTITY
Carnegie Lake	5.5 MGD	Princeton University
Stony Brook (tributary to Carnegie Lake)	0.65 MGD	Hopewell Valley Golf Club
Millstone River at Blackwell's Mill	32.2 MGD	NJ Water Supply Authority
South Branch Raritan River at Stanton	40 MGD*	NJ Water Supply Authority
Lamington River	9 MGD	Belle Mead Development
Raritan River at Manville	70 MGD*	NJ Water Supply Authority
Raritan River at Bound Brook	90 MGD*	NJ Water Supply Authority
Lawrence Brook below Weston's Mill Pond	5.6 MGD	City of New Brunswick
Deep Run (tributary to South River)	1.4 MGD	Middlesex Water Company
Matchaponix Brook	4.7 MGD	United Water-Matchaponix

* flow augmentation is necessary

In some cases, the entity must actually provide flow augmentation to ensure the minimum passing flows meet the indicated levels (indicated by an asterisk). In most cases, the entity must simply stop withdrawals once stream flows drop below the minimum passing flow. The minimum passing flows are important factors in determining how much water will be available for potable and industrial use during drought and non-drought periods. During non-drought periods, minimum passing flows will affect the rate of new reservoir storage, because the passing flows must be met while the reservoir is retaining stream flow for refilling. During drought periods, the minimum passing flow will often be greater than the natural stream flow (even though the passing flows are usually reduced during drought emergencies), and so releases must be made from reservoirs to maintain stream flow at the required levels. For "run of the river" intakes that lack other storage, the impact of droughts may be cessation of withdrawals (e.g., for self-supplied industries), or restrictions on withdrawals.

Safe Yields and Dependable Yields

The safe yields of surface water supply systems in the Raritan River Basin have been extensively studied and modeled. The New Jersey Institute of Technology prepared the primary model used in the Eastern Raritan Feasibility Study for NJDEP, covering the non-tidal Raritan River and its tributaries (i.e., excluding Lawrence Brook and South River). The NJ Water Supply Authority relies on a model prepared by the U.S. Geological Survey. The Lawrence Brook system has a nominal safe yield of 10 MGD based on earlier studies but has lost some of that safe yield due to sedimentation of the lakes. The South River is used primarily to recharge ground water systems in the Old Bridge area. Safe yields for the major surface water supplies are:

WATER SUPPLY	STORAGE	SAFE YIELD	RESPONSIBLE ENTITY
Round Valley/Spruce Run Reservoirs	66 billion gallons	160 MGD	NJ Water Supply Authority
Delaware & Raritan Canal	Not applicable	65 MGD	NJ Water Supply Authority
Lawrence Brook Chain of Lakes	Not available	8 MGD	City of New Brunswick

The dependable yields of aquifers in the Basin are more difficult to determine. Major aquifers tend not to be drought-sensitive, and so the primary issue becomes an aquifer's long-term ability to provide sufficient water for stream flow, human use and aquifer storage levels. The NJ Statewide Water Supply Plan estimated that 20 percent of the total ground water recharge in non-coastal aquifers could be used and not returned to the aquifer without significant harm to stream flows. Coastal aquifers can be sensitive to saltwater intrusion, and so the assumption was made that only 10 percent of total recharge is available from those areas. The NJDEP-NJ Geological Survey estimated ground water recharge in the early 1990's using baseflow analysis of streams within each watershed. The assumption made is that ground water recharge will equal stream baseflow over long periods, if ground water is not diverted through water supply withdrawals. Based on the NJGS analysis, the following quantities were used for annual average yields from Basin aquifers.

AQUIFER	DEPENDABLE YIELD
Raritan River Basin (except below)	110.5 MGD
South River/Lawrence Brook Watersheds	24.7 MGD
TOTAL	135.2 MGD

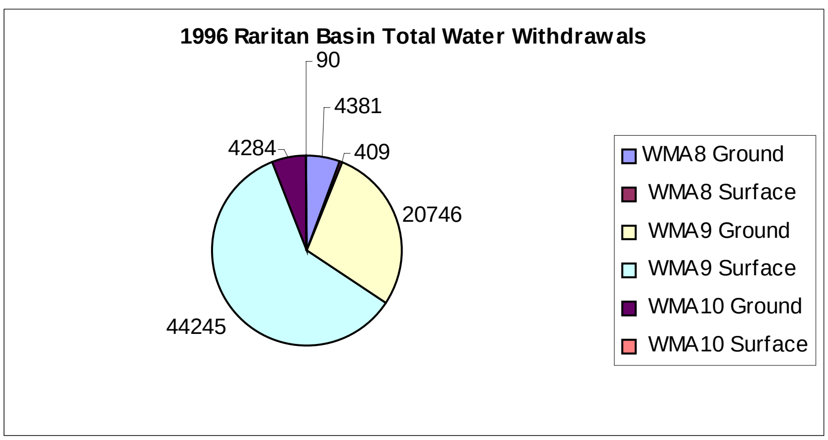
Because the South River area is included within the Water Supply Critical Area #1 and is subject to extensive restrictions on ground water withdrawals, NJDEP assumed that little if any additional ground water is available from that region. It should be recognized that the estimates for dependable yields of ground water are general estimates for large areas, and are not appropriate for use in small watersheds, site-specific or municipal planning, etc. For such localized applications, estimates should be tailored to the actual area. In addition, assessments must consider yield losses from ground water pollution in certain areas. Rural, urban and industrial areas have all been affected. A number of public water supply wells have been taken "off line" due to contamination; industrial solvents and petroleum hydrocarbons are the most frequent causes. However, the impacts are difficult to generalize. Some contaminated wells have been replaced by new wells in nearby parts of the same aquifer. Others could be restored to use by adding water treatment systems, but are currently not used. In the latter case, surface water supplies have been used to replace the “off line” or abandoned wells.

Allocations of and Demands on Water Availability

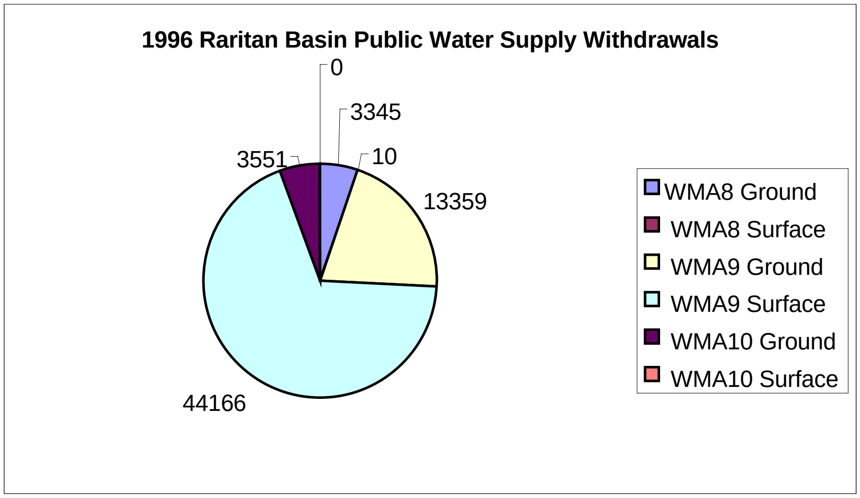
The Statewide Water Supply Plan was based in part on a series of consultant reports that estimated water availability (as discussed above), 1990 demands and demand projections to 2040. For the Raritan Basin (as with all areas of the State), the permitted allocations of water (controlling the maximum withdrawal rates) considerably exceeded the actual withdrawals. Also, some water uses are temporary withdrawals with subsequent discharge to the same location, such as for sand mining. The major users of ground and surface water in the Basin were described above, as were some of the lesser uses. The total withdrawals of water in the Basin for 1990 exceeded 207 MGD, with approximately 104 MGD of that from ground water (including domestic wells, public water supplies, industrial use, and agricultural irrigation use). As has been mentioned, the expectation was that ground water use in the South River watershed would decrease; the reductions would be replaced by surface water supplies imported from the rest of the Raritan Basin.

Withdrawals Through Water Allocation Permits

NJDEP has continued to track water demand in the State for withdrawals permitted under the Water Supply Management Act. The Water Use Database has been completed for the year 1996 (Hoffmann, 2000). The withdrawal data are summarized on Table 1. The total 1996 withdrawals from the Basin for all water allocation permittees was 74,155 million gallons per year or an average of 203 MGD. Withdrawals in the Lower Raritan Watershed Management Area (WMA 9) constituted over 87 percent of the total. Ground water was slightly less than 40 percent of total permitted withdrawals for the Basin.



Public water supply systems account for more than 86 percent of total, permitted withdrawals in the Basin, with ground water constituting less than 32 percent of that quantity. The New Jersey Statewide Water Supply Plan estimated that approximately 36 percent of all New Jerseyans rely on public ground water supplies, and so public water supply systems of the Raritan Basin are slightly more dependent on surface water than the statewide average. The Lower Raritan Watershed Management Area (WMA 9) is even more dominant regarding public water supply withdrawals, with more than 89 percent of the Basin total.



Depletive Water Use, Water Imports and Exports

A depletive use is one that removes water from its original source and does not return it, usually due to inter-watershed transfers or ocean discharge of treated sewage effluent. A consumptive use, on the other hand, removes water from a source and does not replace it due to evaporation, transpiration or incorporation into products. Irrigation, food processing and power plant cooling are common consumptive uses. NJDEP performed an analysis of depletive water uses with data from the late 1980's (Zripko and Hasan, 1994) and used the results in the New Jersey Statewide Water Supply Plan. The primary use of the analysis was in the development of a Water Balance Model for the plan. The data were organized by Regional Water Resource Planning Areas (RWRPAs) as used in the water supply plan. The South River watershed is RWRPA 11 and the remainder of the Raritan Basin is RWRPA 10. The depletive uses were broken into three categories – surface water depletive use, ground water depletive use and "Interbasin Transfers." The results from that report are shown in the tables below. The first table reflects the removal of local waters from that area, and do not reflect the importation of water. The second table addresses the movement of water to and from other areas.

As can be seen from the table below, the Raritan RWRPA as of the late 1980's had a significant depletive use of surface water, while the South River RWRPA had almost none. Conversely, the smaller South River area shows a greater depletive use of ground water than the much larger Raritan area. This situation reflects the status of water supply development in the two areas as of that time, when the South River aquifers were being overextended.

RWRPA	DEPLETIVE USE OF GROUND AND SURFACE WATERS (MGD) IN 1988
10 – Raritan (except below)	87.52 Surface Water 23.49 Ground Water 111.01 TOTAL
11 – South River	0.84 Surface Water 40.25 Ground Water 41.09 TOTAL

Much of the water entering the South River watershed was derived from surface water supply sources in Raritan (RWRPA 10), as shown in the table below. As discussed in the Statewide Water Supply Plan, that transfer was expected to increase as Raritan Basin surface water supplies replaced the overextended ground water supplies of the South River watershed. The result would be an increase of net out-transfers from RWRPA 10 and both an increase of net in-transfers to RWRPA 11 and a reduction of ground water depletive use.

RWRPA	INTERBASIN TRANSFERS (MGD) IN 1988	NET TRANSFERS (MGD)
10 – Raritan (except below)	-90.3 (Transfer out by service connections) +48.2 (Transfer in by Delaware & Raritan Canal) -8.9 (Transfer out from Farrington Lake) -4.0 (Transfer out from Spruce Run/Round Valley Reservoirs	-55.0
11 – South River	+6.8 (Transfer in by service connections) +8.9 (Transfer in from Farrington Lake) +18.5 (Transfer in from Delaware & Raritan Canal) +4.0 (Transfer in from Spruce Run/Round Valley Reservoirs)	+38.3

NJDEP anticipates updating the Water Balance Model in Fiscal Year 2001 or 2002, including updates of the depletive use and interbasin transfer estimates. A future version of this technical report will incorporate those results.

Surface Water Quantity and Quality Interactions

Three major justifications for the establishment of minimum passing flows are the provision of flows to support aquatic life, the assurance of flows to downstream water users under the riparian doctrine, and the provision of adequate flow to dilute pollution. The last reason is no longer acceptable under water pollution control laws, but apparently was a major factor in the establishment of minimum passing flows for the Raritan River at Manville and Bound Brook. At the time that the Spruce Run/Round Valley Reservoir system was established, water pollution control laws were weak. The Manville/Bound Brook area hosted a wide array of industrial facilities that discharged effluent into the Raritan River.

Over the last several decades, major improvements in wastewater treatment and the closure of many major industrial facilities such as Johns-Manville Corporation and American Cyanamid in the Manville/Bound Brook area have improved water quality. However, many of the affected areas are downstream of the major water supply intakes and therefore do not directly affect the supply of water for potable uses. Upstream of the intakes, the technical report "Evaluation of Water Quality Status in the Raritan River Basin, Water Years 1991-97" indicates that water quality is improving in some locations and for some pollutants, but also is declining for some locations and pollutants. At this time, water purveyors in the Basin have water supply treatment systems capable of handling pollutant loadings that customarily are found in Raritan Basin surface waters. Increased pollutant loadings could increase the cost of treatment, create a need to build new water treatment facilities, or cause the temporary or permanent abandonment of specific intakes (all of which have occurred in the Passaic River Basin).

Projection of Water Demands

Projections from Eastern Raritan Feasibility Study

The Eastern Raritan Feasibility Study relied on population estimates from 1985 and 1989, with population projections to the year 2030 developed by the NJ Department of Labor, Office of Demographic and Economic Analysis. The consultants extrapolated the 2030 results to the year 2040 for a fifty-year planning period. Because the projections were developed on a county basis, the projected growth for five of the seven counties had to be allocated to municipalities within and outside of the Raritan River Basin. The consultants used the 1989 Preliminary State Development and Redevelopment Plan (Corridor and Nodes scenario) to allocate projected population. Water demands are projected through the use of estimated water use rates in “gallons per capita per day” of “gpcd.” The initial (1990) water use rates combine residential, commercial, industrial and institutional use of public water supply systems. Projections are based on assumptions regarding future changes in the use rate. The consultants for the Eastern Raritan Feasibility Study assumed that 1990 average use rates of 140 gpcd would increase by 0.5 gpcd per year until they reached 150 gpcd (in 2010), and then level off. The use rates are then multiplied by the projected population. The results are shown below. Most of the potable water in the Basin is supplied by public water supply systems, according to the study (e.g., all but 15 MGD in 1990, and all but 6-9 MGD in 2040).

WATER DEMAND PROJECTIONS, 1990-2040 (in MGD)				
Year	Eastern Raritan Study*	NJ Statewide WS Plan, Task 3 Report*	NJ Statewide WS Plan, Final Report	NJDEP FY2001 Update (to be added)
1990	238	255	202	
2000	257 – 277	260 – 278		
2010	276 – 314	266 – 297	240	
2020	284 – 331	276 – 311		
2030	293 – 349	286 – 324		
2040	301 – 364	295 – 338	281	

*includes areas out-of-basin that are served by purveyors using Raritan Basin supplies.

Projections from NJ Statewide Water Supply Plan

The NJ Statewide Water Supply Plan relied on 1990 census information plus projections to the year 2010 developed for the NJ State Planning Commission by the Rutgers Center for Urban Planning Research (CUPR). The 1990 census estimates were considerably lower than had been expected by earlier population forecasts. The CUPR projections for 2010 were significantly lower than the projections for 2010 used for the Eastern Raritan Feasibility Study, both statewide and for the Basin. Figures 23, 24, 26 and 33 of the technical report “Setting of the Raritan River Basin” show past and projected population for the Raritan Basin. The consultants then extrapolated the CUPR projections through the year 2040, providing a planning horizon equal to that of the Eastern Raritan Feasibility Study. Water demand projections were then derived in a similar manner. The results are shown above along with those of the Eastern Raritan report. The NJ Statewide Water Supply Plan used a different basis for computing demands that included the effects of interbasin transfers, thereby showing lower demands but also lower available water for each time period. The projected surpluses and deficits through 2040 were essentially the same as for the Eastern Raritan Water Supply Feasibility Study.

Updated Projections

As part of the development process for the second NJ Development and Redevelopment Plan, the NJ State Planning Commission has developed a new set of population projections. The NJDEP-Division of Watershed Management anticipates an update to the NJDEP's Water Balance Model (which includes the population projection module developed by the consultants to the NJ Statewide Water Supply Plan) to develop new water demand projections. A future version of this report will provide the results.

Comparison of Projections

As can be seen, there are some significant differences among the projections. Each was developed using a different base population, which results in a different trend line. As trends are a critical factor (though not the only one) in population projections, differences result. However, updated population projections based on the 1990 Census provided water demand projections that were significantly lower than previously accepted. Assuming that these projections continue to be on track, water demands will rise less steeply, lengthening the time before new water supply facilities must be constructed.

Uncertainties in Demand Projections

Estimated future populations and their consequent water supply needs are just that -- estimates. The development of projections is not an exact science, especially in a complex state like New Jersey. There are many factors that influence future populations and water demand, including: demographic, economic, sociopolitical, climatic and technological.

- **Demographics** – Of the demographic factors, population has the most influence on water demand. The influx of people into an area not only increases the residential component of water demand, but also increases the industrial and commercial components as a result of the increased labor force and the need to provide goods and services to the increased population. Using the CUPR projections as the base for the population projections allowed NJDEP to address other demographic factors including: housing density, type of housing, household size, and irrigated land (lawn) area. As noted above, further information on population projections is available in the technical report "Setting of the Raritan River Basin."

  It must be realized that projections are generally less reliable as the planning period increases. As mentioned before, population trends may change at any time during the 50-year planning period. As such, a periodic update must be undertaken in each area of the state. This update will allow more accurate conclusions to be drawn at each point in time. A careful accounting of present and future population is crucial to the precise development of water demands.

- **Economics** – This factor is an important element in how much a region grows and where this growth occurs and is built into the CUPR projections. A strong economy, which New Jersey enjoys over the long-term, is usually accompanied by more than average growth. However, much of New Jersey's growth is anticipated to be in the suburbs where, as previously discussed, this type of development can have harmful effects on the State's water supplies unless this growth is well planned from a regional water supply perspective and safeguards are implemented. This trend poses a potential conflict; while many would aspire to take residence in New Jersey's suburbs, poorly planned, designed and constructed development that impairs water supplies can give the impression of an undesirable quality of life, thus reducing the desirability of the suburbs.

Another key economic factor is the ongoing shift from water-intensive manufacturing to water-conserving manufacturing, and from manufacturing to office and research businesses in New Jersey. This trend is noted in the technical report "Setting of the Raritan River Basin" which shows a significant decline in manufacturing employment and a significant increase in service sector employment.

- **Sociopolitical** – Perhaps the greatest sociopolitical influence of future growth and consequent water demand would be the implementation of the State Development and Redevelopment Plan (SDRP). No other planning efforts seek to deliberately change land use patterns over such large areas. Implementation of the SDRP could alter the demand projections for various areas due to the change in predicted growth areas. This growth may cause an increase in water demand for existing water companies and also spur the development of small water companies in less urban areas.

- **Climatic** – Global warming theoretically could, in the decades or centuries to come, affect both water availability and demand. Warming might raise sea level and cause saltwater intrusion into the state's estuaries and aquifers. Extended warmer temperatures would substantially increase demand. Scientific consensus is building that global warming is occurring, but the small-scale impacts are still being debated. Therefore, it is too early to formally act on this issue until debate over the New Jersey impacts evolves closer to consensus. New Jersey has experienced both wet and dry periods in the last 40 years. The 1960's are famous for the extended drought of that period. The 1970's are generally considered a wet decade. There have been sharp, short droughts in the 1980's and 1990's, but the 1990's have also included near-record wet periods such as the first six months of 1998. Predictions are difficult. For this reason, water supply models use long-term stream flow records to assess the risks of drought.

- **Technological** – Advances in technology could also potentially affect supply and demand. Desalination continues to become less expensive and is used in Cape May County. Much progress is being made in the treatment of contaminants, possibly increasing water supply. Computer technology allows for a better understanding of aquifers and surface water supplies that, in turn, allows for the development of water optimization systems that can extend regional supplies. On the demand side, improved technology has significantly reduced water demand for power generation, manufacturing, irrigation and other uses such as residential plumbing devices. Low flow shower heads, toilets and more efficient appliances have all contributed to a stabilization or decline in per customer consumption where they have been fully implemented.

Summary of the Characterization

The water budget, water uses and water demands of the Raritan River Basin are fairly well described in past studies. However, there are inevitable uncertainties in each area. To the extent that watersheds within the Basin have water resources well beyond current demands, the uncertainty can be factored into planning efforts. Where high stresses exist, consideration can be given to more detailed research and analysis leading to a more precise characterization.

The overall annual average precipitation in the Basin is 2500 million gallons per day (MGD), or 2.19 MGD per square mile. Because of the different geology underlying parts of the Basin, the average figures must be used with caution. Varying percentages of precipitation exit the Basin through evapotranspiration, human uses and stream flow, based on differences in land cover, geology, soils and human uses of water.

The safe yields of surface water supply systems have been studied extensively. Estimated surface water safe yields for the Basin are currently 225 MGD. Dependable yields for aquifers of the Basin are more difficult to assess, though various studies have been published with estimates. Estimated ground water dependable yields for the Basin are 135 MGD according to the NJ Statewide Water Supply Plan, but 79 MGD according to the Eastern Raritan Water Supply Feasibility Study. Total available water supply for the Basin is approximately 360 MGD, based on the statewide plan. Damage to both safe yields (surface water) and dependable yields (ground water) can be caused by water quality degradation, intensive localized use, recharge loss, inter-watershed transfers, etc. They can be increased by recharge augmentation, conjunctive use and water quality improvements.

1990 demand for potable water supply uses is fairly well known, and was estimated at approximately 140 gallons per day on average, statewide. Rates vary across the state based on the amount that industry and commercial businesses use in each area. The rates for residential and agricultural uses are generally much higher in summer than winter, due to irrigation of lawns and crops.

Projected water supply demands through the year 2040 differ somewhat based on the date they were prepared, but in general suggest a continuing growth of population, especially in the southern and western portions of the Basin. The 1990 demand was approximately 225 MGD, with projected increases to approximately 350 MGD by 2040, according to the Statewide Water Supply Plan.

Assessment of Water Availability

Methodology and Information Sources

Water availability has been studied extensively by the NJDEP over the last 20 years, culminating in the designation of a Water Supply Critical Area affecting the South River watershed area, construction of a pipeline to move surface water supplies to that area, and adoption by NJDEP of a NJ Statewide Water Supply Plan with recommendations for future water supply projects in the Raritan Basin. This assessment relies heavily on the reports and planning documents developed by NJDEP.

Adequacy of Current Supplies for Current Demands

Summary and Comparison of Existing Assessments

All the recent feasibility studies and plans developed by or for NJDEP agree that existing water supply sources are sufficient for current demands, when looked at regionally. The major, local exception is in the South River watershed, where over-pumping of the confined aquifers led NJDEP to declare this area as Water Supply Critical Area #1 and require a 50% reduction in ground water withdrawals from those aquifers. There are also areas in the western portion of the Basin where poor aquifers constrain the density of domestic wells that can be supported without loss of supplies during drought periods.

Uncertainties in Adequacy Assessment

The extent to which current regional supplies exceed demands in the 1990’s indicates that any uncertainties have a limited impact on the conclusion. Regional supplies are more than adequate for regional demand as of the year 2000.

Conclusion

Aside from localized constraints on ground water, the current water supplies of the Raritan Basin are sufficient to handle current demands. In the most significant area of ground water shortages (the South River watershed area), surface waters from the NJ Water Supply Authority system have been provided as a replacement supply by Middlesex Water Company.

Adequacy of Current Supplies for Future Demands

Summary and Comparison of Existing Assessments

The original Eastern Raritan Feasibility Study concluded that a new water supply project would need to be constructed for the Basin as early as 2010. NJDEP in its "Implementation Plan for the Eastern Raritan Basin Water Supply Feasibility Study" made use of population and demand projections developed for the NJ Statewide Water Supply Plan, and concluded that a new project likely would be needed, but probably not until sometime near the end of the 2040 planning period. NJDEP adopted a planning schedule where specific actions would be triggered by Basin water use, rather than by set dates. The NJ Statewide Water Supply Plan adopted the recommendations of the "Implementation Plan." The consensus judgement is that additional water supply needs in the Raritan River Basin will eventually trigger the need for a new water supply facility, and that effective and aggressive water conservation efforts (primarily focused on structural improvements) would help delay the day of need for these projects.

Uncertainties in Adequacy Assessment

The NJDEP "Implementation Plan" contained an Appendix E that suggested a variety of factors that could alter water supply availability and demand. Perhaps the most critical factors involve the uncertainties of population projections, the extent to which baseflow reductions or additional transfers to out-of-basin locations occur, and the impacts of any reanalysis of safe yields and dependable yields. An additional factor is the continuing loss of public water supply wells to pollution, such as has been experienced by Elizabethtown Water Company. Finally, development of the ground water supplies of the upper South Branch of the Raritan River and Millstone River could affect the safe yield of surface water supplies in the Basin. Although the NJDEP has used a threshold for ground water availability of 20% of the total recharge, this figure is a general guide for planning purposes and cannot be relied upon for watershed-specific management decisions.

Conclusion

The Raritan River Basin has sufficient public water supplies, especially of surface water, to weather a return of the 1964-66 precipitation period (the "drought of record") at this time. Continued development of the Basin is likely to require construction of an additional water supply in the first half of the 21st Century. Development, in turn, may have impacts on ground water availability (through recharge reduction), baseflow of streams, safe yields and water quality.

Changes to Future Adequacy – New Supplies and Changing Demands

Summary of Existing Plans

The recent feasibility studies and water supply plans have agreed on two major points. First, the confined aquifers of the South River watershed area were overused in the early 1980's and needed to be protected. The result was NJDEP's declaration of a Water Supply Critical Area for eastern Middlesex County, much of Monmouth County and part of northern Ocean County. The

Critical Area designation led to construction of a Middlesex Water Company pipeline to the area and a cutback of 50% (17 MGD) in ground water withdrawals. Second, a new supply in the Raritan Basin will be needed at some time in the next 30 to 50 years. In the meantime, the Basin was estimated (in 1992) to have 74 MGD available in surface and ground water to meet future demands.

The NJDEP's "Implementation Plan" recommended two potential projects as having the greatest water supply benefits, the least environmental impacts and the greatest cost-effectiveness (see Figure 2). The NJ Statewide Water Supply Plan adopted the recommendation as formal NJDEP policy. One project is the Kingston Quarry Reservoir, where a current hard-rock quarry along the Delaware & Raritan Canal would be transformed into an off-stream storage reservoir, available for pumping during drought periods. The quarry is privately owned at this time, and transfer of ownership at the right time will be critical. The other project is a pump station and pipeline from the confluence of the North and South Branches of the Raritan River, back upstream to the Round Valley Reservoir. The Confluence Pumping Station site and pipeline right-of-way is already state-owned. Because the Kingston site is a quarry and the Confluence project would not involve creation of a reservoir, the consultants to NJDEP found that direct environmental impacts from these two projects would be very limited.

The primary policies and programs affecting water conservation are two. First, NJDEP has adopted regulations requiring that water purveyors develop water conservation plans. One aspect of these plans is a focus on water losses through leaks in transmission pipelines, etc. The intent is to improve the efficiency of water delivery so that less water needs to be withdrawn from the source. Second, the State of New Jersey has adopted water conservation standards equivalent to federal standards and those of the Delaware River Basin Commission. New construction and replacement fixtures must use water-conserving fixtures (e.g., toilets, sink faucets, shower heads) that conserve a considerable amount of water.

Potential Effects on Available Supplies

The Kingston Quarry Reservoir is estimated to provide an additional 65 MGD for a cost in 1992 dollars of $57 million, or $0.87 million per MGD. The Confluence Pumping Station is estimated to provide an additional 53 MGD for a cost of $71 million, or $1.34 million per MGD. Both costs compare favorably to the costs of a potential new reservoir that was also studied; Six-Mile Run Reservoir was estimated to provide 24 MGD for $65 million, or $2.71 million per MGD. In both cases, the results of the preferred options would be significant increases in available surface water supplies, equivalent to at least 23 percent of existing surface water safe yield and 15 percent of total available water supply (ground and surface water).

Potential Effects on Projected Demands

The lower estimates from NJDEP's planning efforts take water conservation into account. Even with the savings projected, the expectation is that a new water supply facility will be needed within the first half of the 21st Century.

Summary of the Assessment

Although there is a need to periodically update demand projections, water use estimates and water availability estimates, the assessments above make clear that some parts of the Raritan Basin (especially the confined aquifers of the South River watershed area) face significant constraints on ground water development. Other areas have some room for additional ground water use, but perhaps limited to approximately 25 MGD. Even that water will be available only if withdrawals are located strategically so that no significant, localized impacts occur. No single area can expect to provide more than a small fraction of that 25 MGD. Surface water supplies seem sufficient for the next two to three decades. Water conservation can extend these supplies, while poorly managed water supply and land development can shorten the time before a new supply is needed. At least two potential surface water supply projects are available at reasonable cost.

Data, Information and Assessment Needs for Water Availability

As mentioned in this report, the primary needs for assessing water availability are:

1. Periodic updates of depletive and consumptive water uses;

2. Periodic updates of surface water or ground water withdrawals;

3. Periodic assessments of total water availability and demand, both current and into the future;

4. An improved understanding of ground water dependable yields at a watershed scale, replacing the current analyses at a near-Basin scale.

Conclusions

The Raritan River Basin currently has a water supply availability of 360 MGD, 225 MGD of which is surface water supplies. Considerable uncertainty exists regarding the true dependable yields of aquifers in the Basin, but estimates for planning purposes indicate up to 135 MGD from aquifers throughout the region. Surface water safe yields are the result of individual facilities, while ground water dependable yields are the results of 1,100 square miles of aquifers – some poor and some prolific. Protection and proper development and use of these supplies will safeguard the supply of available water, but mismanagement can reduce the available supply below the 360 MGD currently thought to exist. Localized constraints on ground water development do and will exist.

Demand projections indicate that the 1990 demand of approximately 255 MGD will increase to approximately 350 MGD by the year 2040. However, such long-range estimates should only be used for planning purposes – they are not reliable for definitive answers. Therefore, periodic updates are required to ensure the availability of sufficient supplies over time.

Comparing current water supply availability of 360 MGD to a projected 2040 demand of 350 MGD, it is clear that the Basin will need to address potential water supply needs in the coming decades if projections do not change significantly. The need for a new water supply could be hastened by increased population growth, supply losses due to contamination, changes in the water budget that emphasize increase runoff and decreased infiltration, heavier reliance on surface water supplies than ground water supplies, a need for supplies to other watersheds, etc. The need could be delayed by protection of water supplies, improved conservation, slower-than-projected population growth, reduced needs for non-residential supplies, reduced per capita demands, etc.

Two water supply projects, the Kingston Quarry Reservoir and the Confluence Pumping Station, have been identified as cost-effective projects that can provide 65 MGD and 53 MGD, respectively, with relatively limited environmental impacts. The Statewide Water Supply Plan anticipates that one of these projects will be built after 2030 to supply future needs, assuming that projections continue to hold steady and water conservation is effective in mitigating demands.

Glossary of Terms for Water Availability

"Aquifer" means any water-saturated zone in sedimentary or rock stratum that is significantly permeable so that it may yield sufficient quantities of water from wells or springs in order to serve as a practical source of water supply.

"Allocation permit" means the document issued by the NJDEP to a person, granting that person the privilege, so long as the person complies with the conditions of the permit, to divert water for any purpose other than agricultural or horticultural use.

"Confined aquifer" is an aquifer that is overlain by a relatively impermeable or significantly less permeable material so that its water is under pressure. If a well were installed, the water would rise above the top of the aquifer.

"Confining Unit" means a body of relatively impermeable material that is above or below one or more aquifers, restricting the flow of water to or from the aquifer(s)

"*Consumptive water use*" means the use of water in such as way that a portion of the water used is lost to evaporation, transpiration, incorporation in product, etc., and not discharged to any location.

"Critical water supply area" or "critical area" means a water supply area in which it is officially determined by the New Jersey Department of Environmental Protection, after public notice and a public meeting, that adverse conditions exist, related to the ground or surface water, which require special measures in order to achieve the objectives of the Water Supply Management Act.

"Dependable yield of combined surface/ground water sources" means the yield of water by a water system that is available continuously throughout a repetition of the most severe drought of record, without causing undesirable effects.

"Depletive water use" means the withdrawal of water from a water supply resource (ground or surface water) where the water, once used, is not discharged to the same water supply resource in such a manner as to be useable within the same watershed.

"Drought" means a condition of dryness due to lower than normal precipitation, resulting in reduced stream flows, reduced soil moisture and/or lowering of the potentiometric surface in wells.

"Facility" means a medium through which the base source is transmitted to the user. It is either man-made or manipulated in an attempt to maximize the water that may be derived from a base source. A facility for ground water is a well or well field and for surface waters is a reservoir or intake facility.

"Fresh water" means all nontidal and tidal waters generally having a salinity due to natural sources of less than or equal to 3.5 parts per thousand at near high tide.

"Interbasin transfer" means the movement of water (as raw, treated or used water) from one watershed to another.

"Multiple sources" means one or more production wells, surface water intakes, or interconnection or a combination of wells, surface water intakes or interconnections utilized to meet the demands of a public community water system.

"Normal demand" means the annual average demand during the three preceding non-drought years, including normally occurring peaks.

"Potable water" means water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for domestic consumption using conventional water treatment processes (e.g., chemical coagulation/flocculation, clarification, filtration, disinfection).

"Purveyor" means any company, authority, or person who owns or operates a public community water supply system.

"Safe yield from surface sources" means the yield maintainable by a water system continuously throughout a repetition of the most severe drought of record, after compliance with requirements of maintaining minimum passing flows, assuming no significant changes in upstream or upgradient depletive withdrawals.

"Semi-confined aquifer" is an aquifer that is overlain by a layer of material with low permeability, which permits water to slowly flow through it to recharge the underlying aquifer.

"Single prime source" means a single diversion of surface or ground water, including an interconnection, capable of providing the peak water demand of a public community water supply system.

"Stipulated surface water withdrawals" these are surface water uses that are not supported by storage, have no associated safe yield, and can be rescinded during droughts.

"Treated wastewater" means the treated spent water of a community. From the standpoint of source, it may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any ground water, surface water, and storm water that may be present.

"Unconfined aquifer" means an aquifer close to the land surface with continuous layers of materials with high permeability, extending from the land surface to the base of the aquifer. This type of aquifer has a water table.

"User" means any person or other entity that utilizes water.

"Water allocation: or certification" means the authority to withdraw surface or groundwater for use, pursuant to a permit issued under N.J.A.C. 7:19-1 et seq. or 7:20A-1.1 et seq.

"Watershed" means a geographic area in which all water, sediments and dissolved material drain to a particular receiving body.

"Watershed Management Plan" means a strategy of which the goals and objectives are to achieve the restoration, protection and management of the water resources and any associated uses within the watershed.

"Water supply deficit" means the amount or amounts by which the available resources fall short of a given demand.

"Water supply system" means a facility for providing potable water.

"Water table" means the surface of the water-saturated zone that is at atmospheric pressure.

"Water table aquifer" is synonymous with unconfined aquifer.

"Yield of a water resource system" means the output of water from a system, available with monthly variations corresponding to the needs of the system.

Common Acronyms for Water Availability

cfs	cubic feet per second
gpd	gallons per day
gpcd	gallons per capita (person) per day
MGD	million gallons per day
NJDEP	NJ Department of Environmental Protection
NJGS	New Jersey Geological Survey
NJPDES	NJ Pollutant Discharge Elimination System
NJSWSP	1995 NJ Statewide Water Supply Plan
RWRPA	Regional Water Resource Planning Areas
USGS	US Geological Survey
WBM	Water Balance Model
WSCA	Water Supply Critical Area
WSMA	Water Supply Management Act

References for Water Availability

Hoffmann, J. 2000. Personal communication. NJ Department of Environmental Protection, Trenton, NJ.

New Jersey Department of Environmental Protection. 1992. Eastern Raritan Basin Water Supply Feasibility Study, Final Report, Task Report 12. Prepared by Alfred Crew Consulting Engineers and Hazen and Sawyer.

New Jersey Department of Environmental Protection. 1994. Implementation Plan for the Eastern Raritan Basin Water Supply Feasibility Study.

New Jersey Department of Environmental Protection. 1996. New Jersey Statewide Water Supply Plan – with Appendixes.

CH2M Hill, Metcalf & Eddy, NJ First. 1992-94. New Jersey Statewide Water Supply Plan – Consultant Reports

New Jersey Department of Environmental Protection and Metcalf & Eddy. 1995. New Jersey Statewide Water Supply Plan – Water Data Model.

Zripko, N.P., and Hasan, A. 1994. Depletive Water Use Project for Regional Water Resource Planning Areas of New Jersey. NJ Department of Environmental Protection, Trenton, NJ.

Figure 1

Stream Gauging Stations within the Raritan Basin

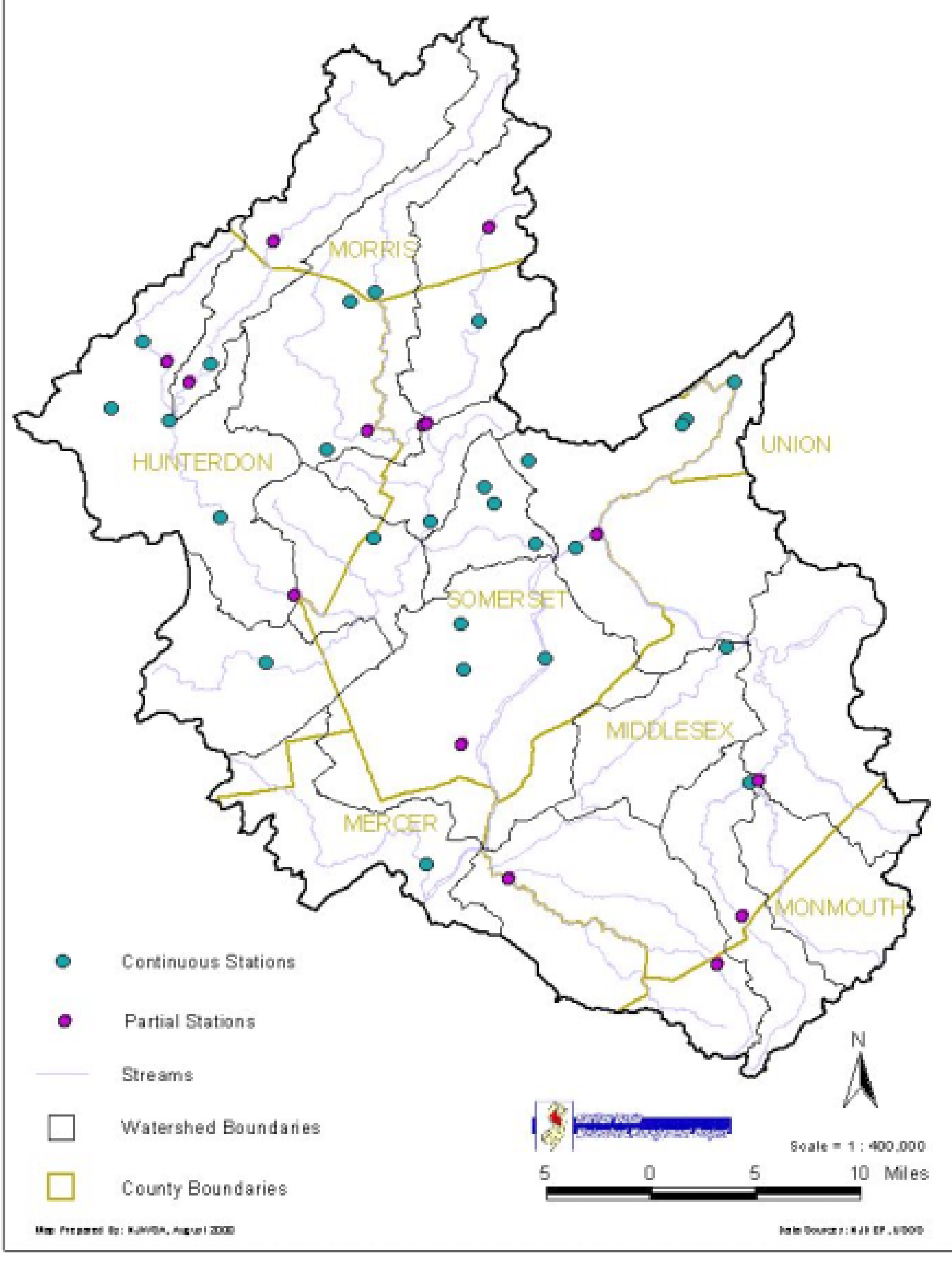
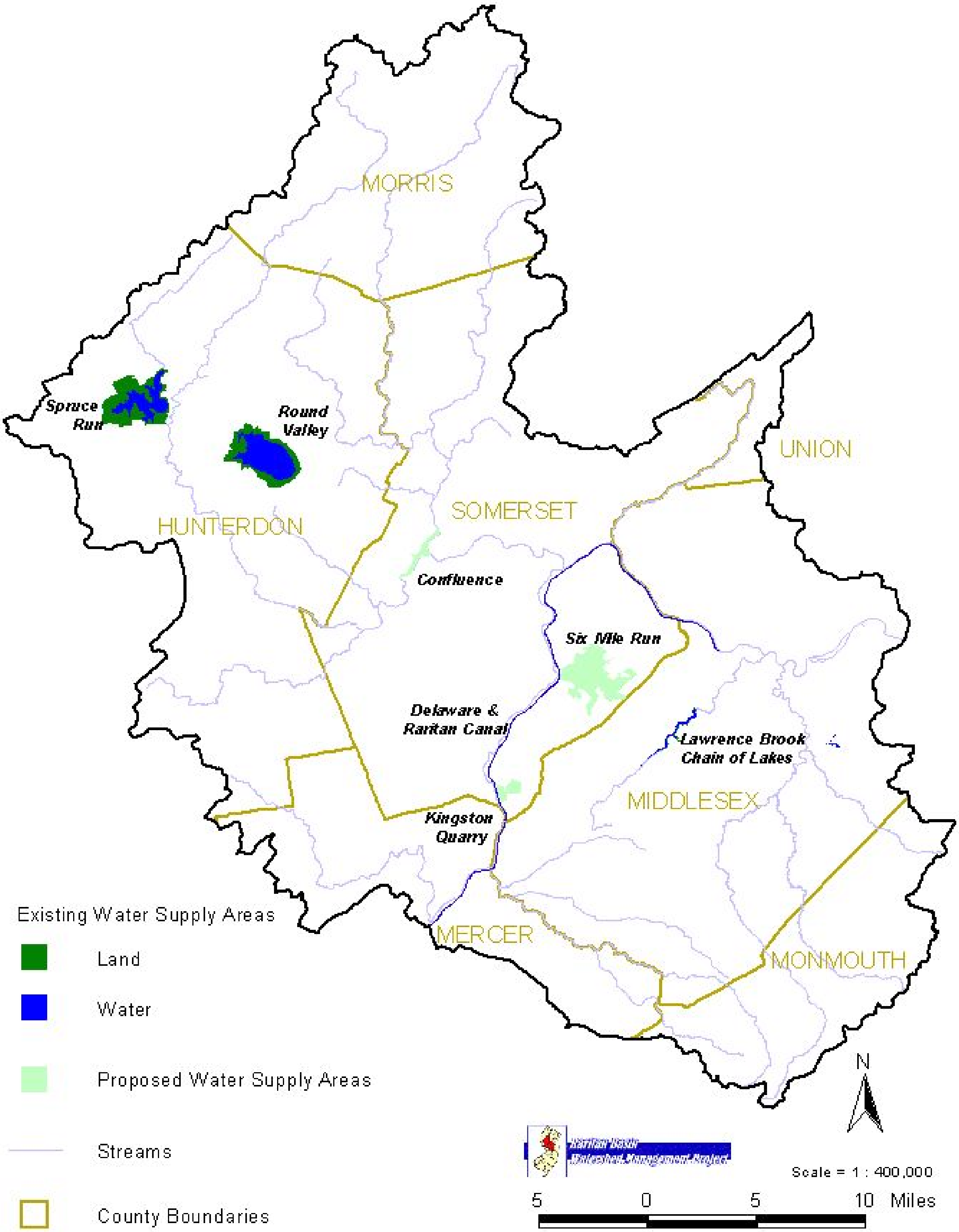


Figure 2

Major Current and Planned Surface Water Supply Facilities within the Raritan Basin

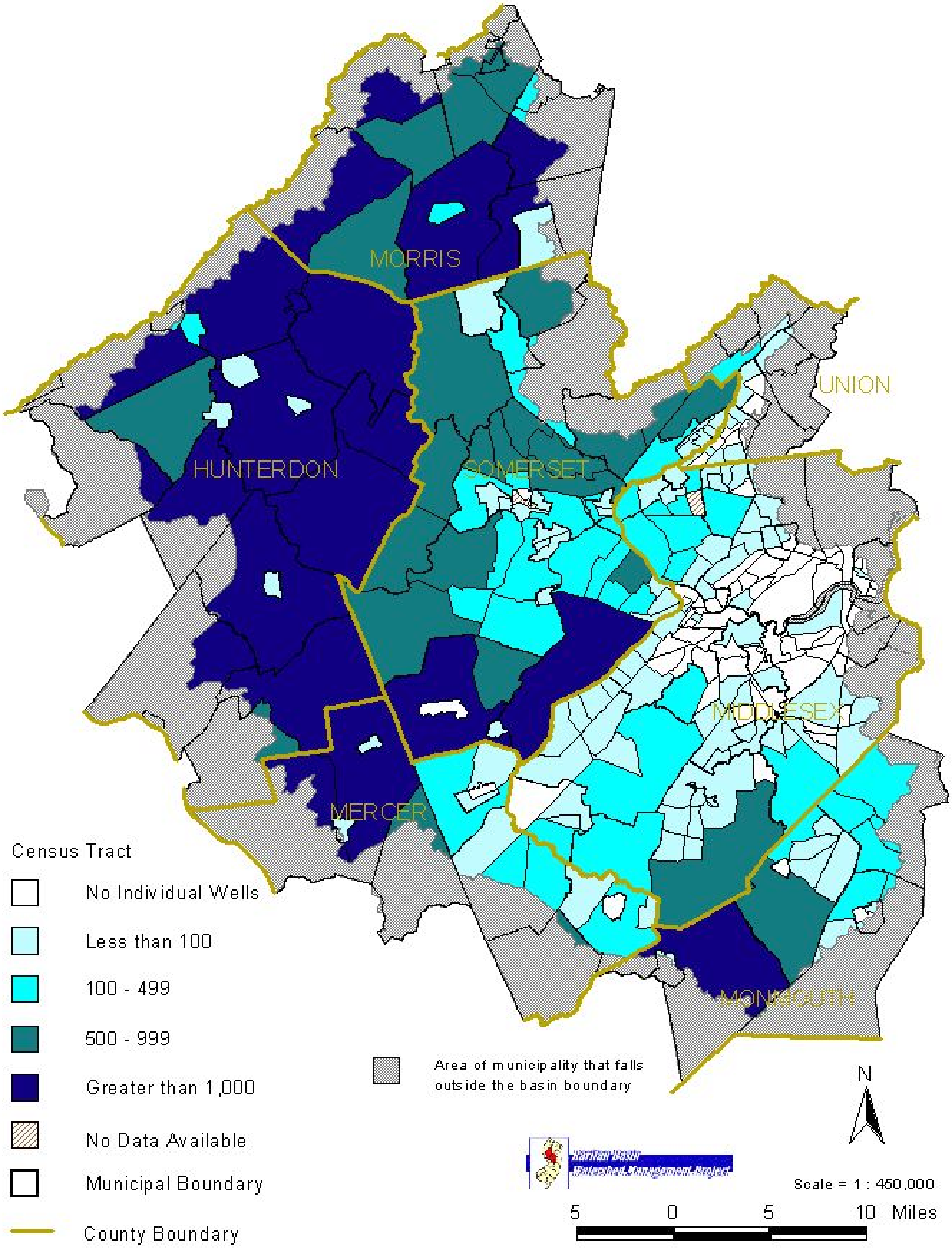


Map Prepared By: NJWSA, August 2000

Data Sources: NJDEP, NJ Green Acres, USGS

Figure 3

1990 Households Using Individual Wells within the Raritan Basin



Map Prepared By: NJWSA, August 2000

Data Sources: NJDEP, ESRI, US Census Bureau

TABLE 1
RARITAN BASIN 1996 WATER WITHDRAWALS

ALL WATER ALLOCATION PERMITS

SOURCE	WMA	MGY	Average MGD	% Basin
GROUND	8	4381		
SURFACE	8	409		
TOTAL	**8**	**4790**	13	6.5
GROUND	9	20746		
SURFACE	9	44245		
TOTAL	**9**	**64992**	178	87.6
GROUND	10	4284		
SURFACE	10	90		
TOTAL	**10**	**4374**	12	5.9
GROUND	BASIN	29412		
SURFACE	BASIN	44744		
TOTAL	**BASIN**	**74155**	203	100

PUBLIC WATER SUPPLY SYSTEMS

SOURCE	WMA	MGY	Average MGD	% Basin
GROUND	8	3345		
SURFACE	8	10		
TOTAL	**8**	**3355**	9	5.2
GROUND	9	13359		
SURFACE	9	44166		
TOTAL	**9**	**57526**	158	89.3
GROUND	10	3551		
SURFACE	10	0		
TOTAL	**10**	**3551**	10	5.5
GROUND	BASIN	20255		
SURFACE	BASIN	44176		
TOTAL	**BASIN**	**64431**	177	100

Data Source: Hoffmann, 2000.