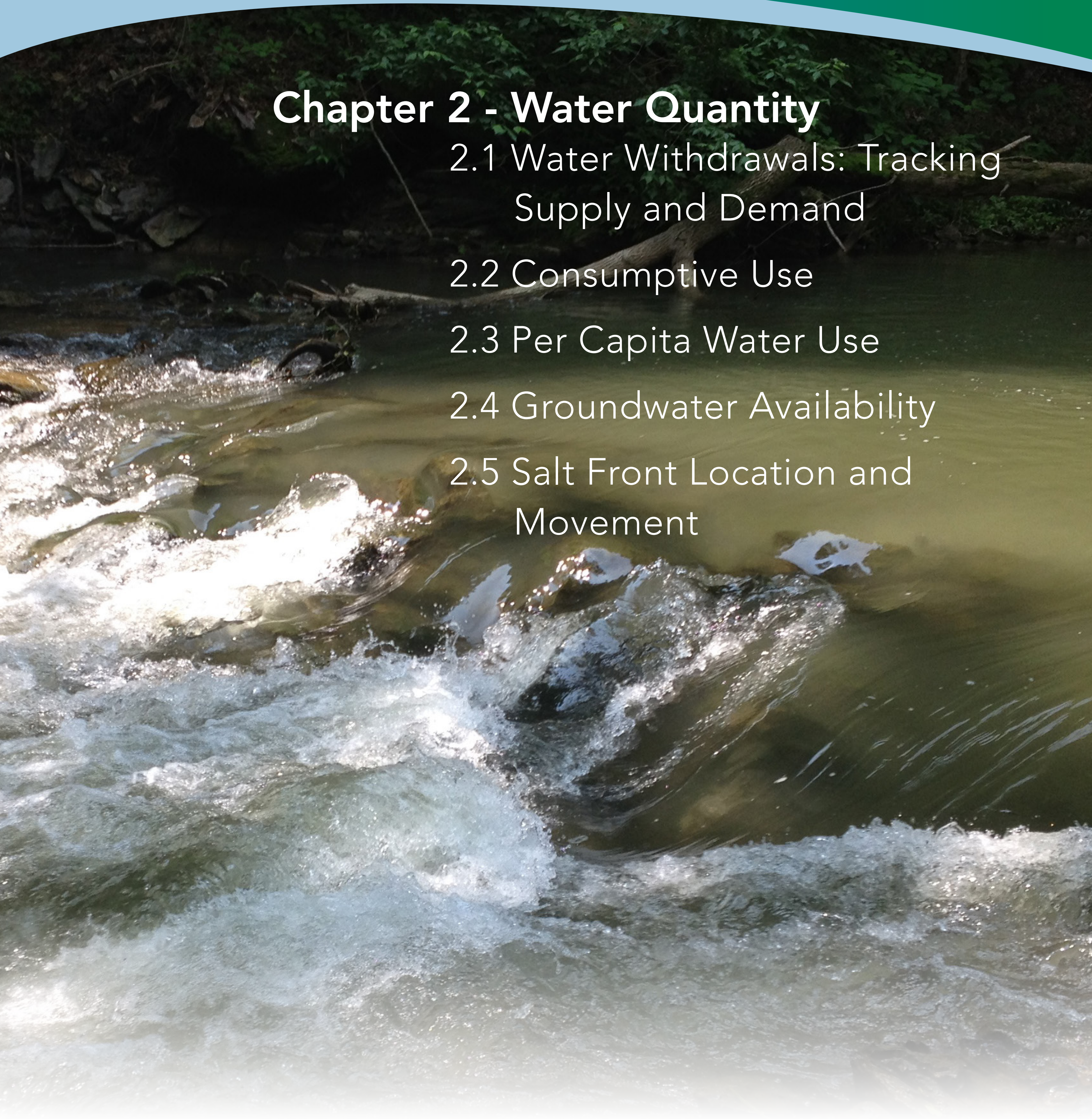

Chapter 2 - Water Quantity

Partnership for the DELAWARE ESTUARY

December, 2017 | Report No.17-07

A publication of the Partnership for the Delaware Estuary—A National Estuary Program

2. Water Quantity

J. Kent Barr
Delaware River Basin Commission

2.1 Water Withdrawals: Tracking Water Supply and Demand

2.1.1 Description of Indicator

Water withdrawals are tracked to identify key water-using sectors and trends. Accurate and comprehensive water use information enables the proper assessment, planning and management of water resources. As reporting improves, so does our accounting and understanding of the need for water among various water-using sectors. As noted above, 2014 water withdrawal data were compiled to generate a Basin-wide and regional assessment by water use sector. All data are based on withdrawals reported to state agencies except for data for the Self-supplied Domestic (individual homeowner wells) sector. Self-supplied domestic use was estimated based on the population from Census 2010 data for populations that reside outside of public water system (PWS) service areas. An estimated use of 75 gallons/capita/day, based on USGS estimates was applied to calculate water use by this sector.

Total water withdrawals from the Delaware River Basin Upper and Central regions, and the Lower and Bay regions, based on calendar year 2014 data are displayed in Figures 2.1.1, 2.1.2, and 2.1.3 respectively.

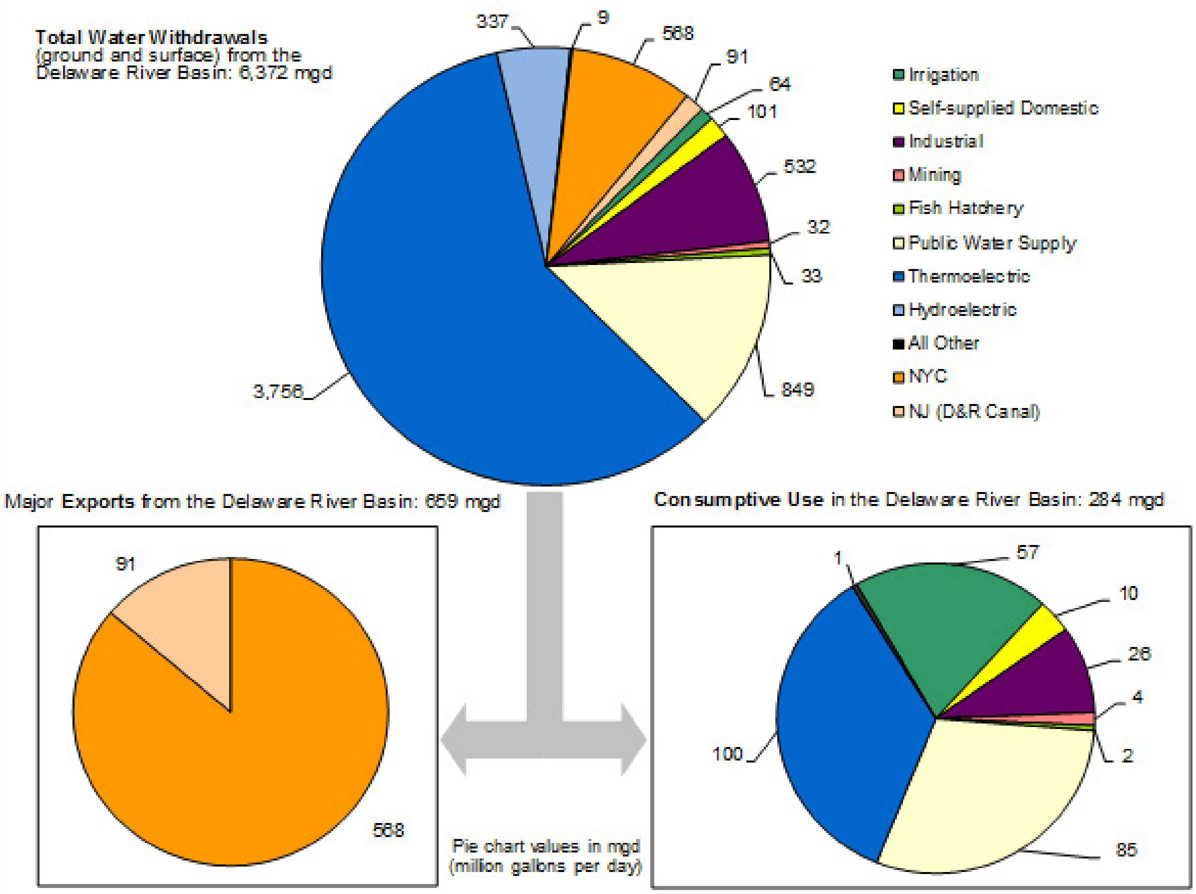

Figure 2.1.1 Total water withdrawals from the Delaware River Basin, 2014 in mgd (million gallons per day).

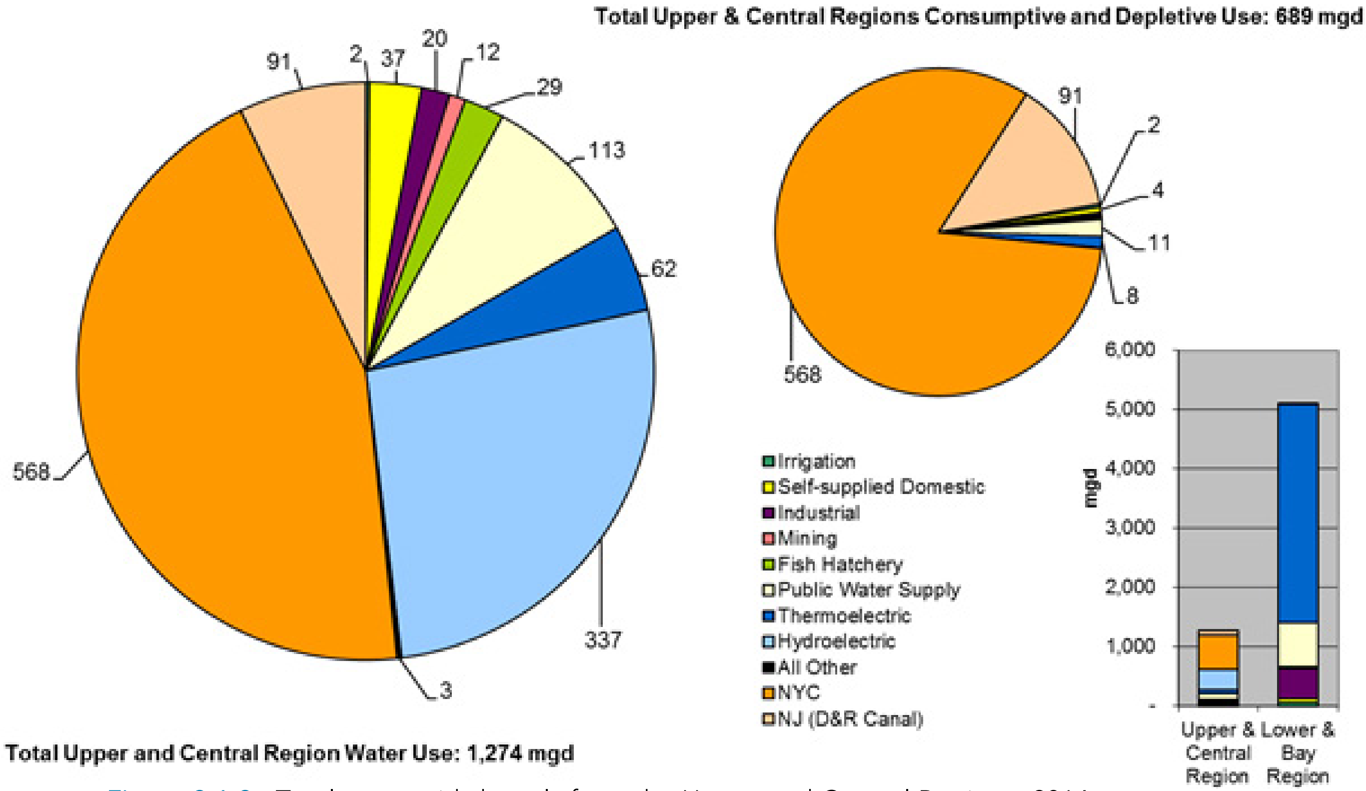

Figure 2.1.2 Total water withdrawals from the Upper and Central Regions, 2014.

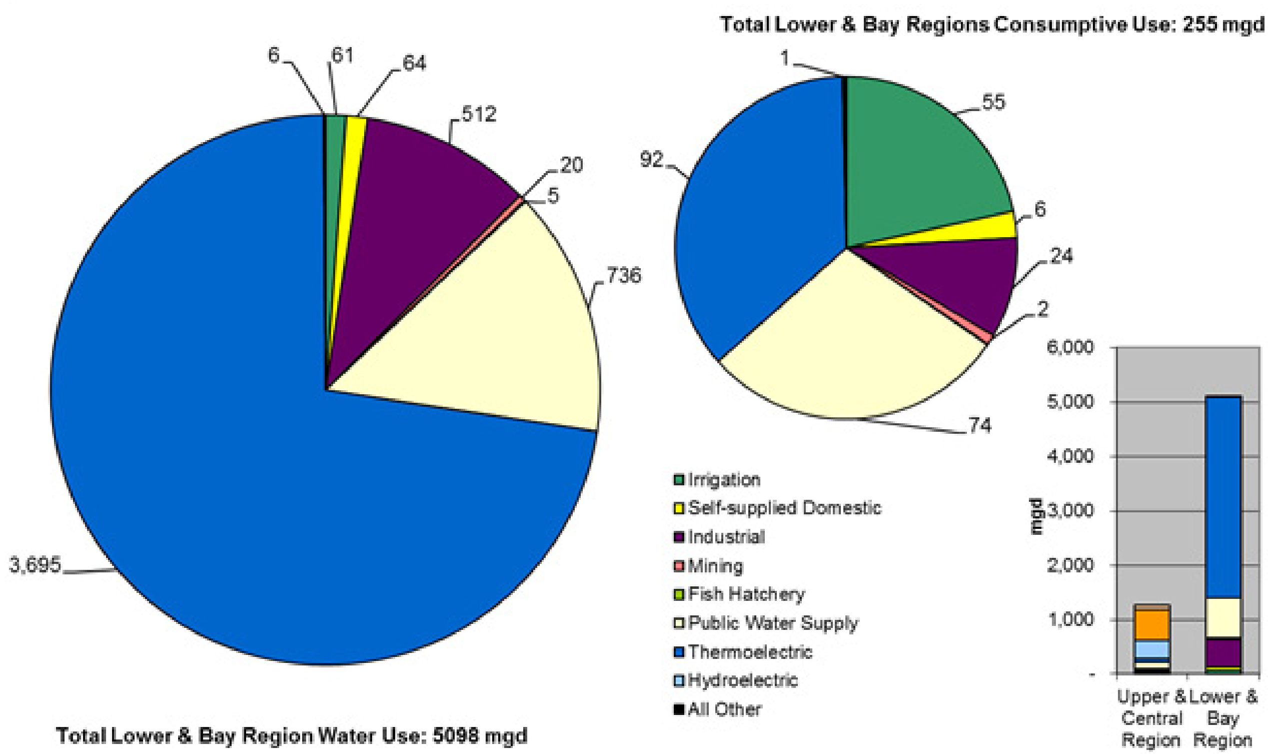

Figure 2.1.3 Total water withdrawals from the Lower and Bay Regions, 2014.

2.1.2 Present Status

Approximately 15 million people rely on water from the Delaware River Basin for their water needs. On average, over 6 billion gallons of Delaware River Basin water are used each day. This includes an average of approximately 570 million gallons per day (mgd) for populations in New York City and 90 mgd for northeastern New Jersey, which combined account for around 10% of total water withdrawals from the Basin. A system of reservoirs in the Upper Basin store water for export to New York City and make compensating releases to maintain downstream water temperatures and flows. New Jersey exports water from the Basin via the Delaware and Raritan Canal which draws from the mainstem Delaware River in Hunterdon County, NJ.

Within the Basin, uses related to power generation (thermoelectric) account for the majority of water withdrawals (59%) with the next largest use for public water supplies (13%). However, in managing water resources, the withdrawal volume may not be as important as where and when the water is returned to the system. Water not immediately returned is considered consumptive use (see Chapter 2.2 - Consumptive Use).

2.1.3 Past Trends

Over the past two decades the New York City diversion has decreased due in large parts to water conservation efforts. A long term chart of water exported from the Basin to meet New York City needs is shown in Figure 2.1.4. A five-period moving average was included on the chart to smooth the impact of short term fluctuations in water demand and the influence of weather patterns.

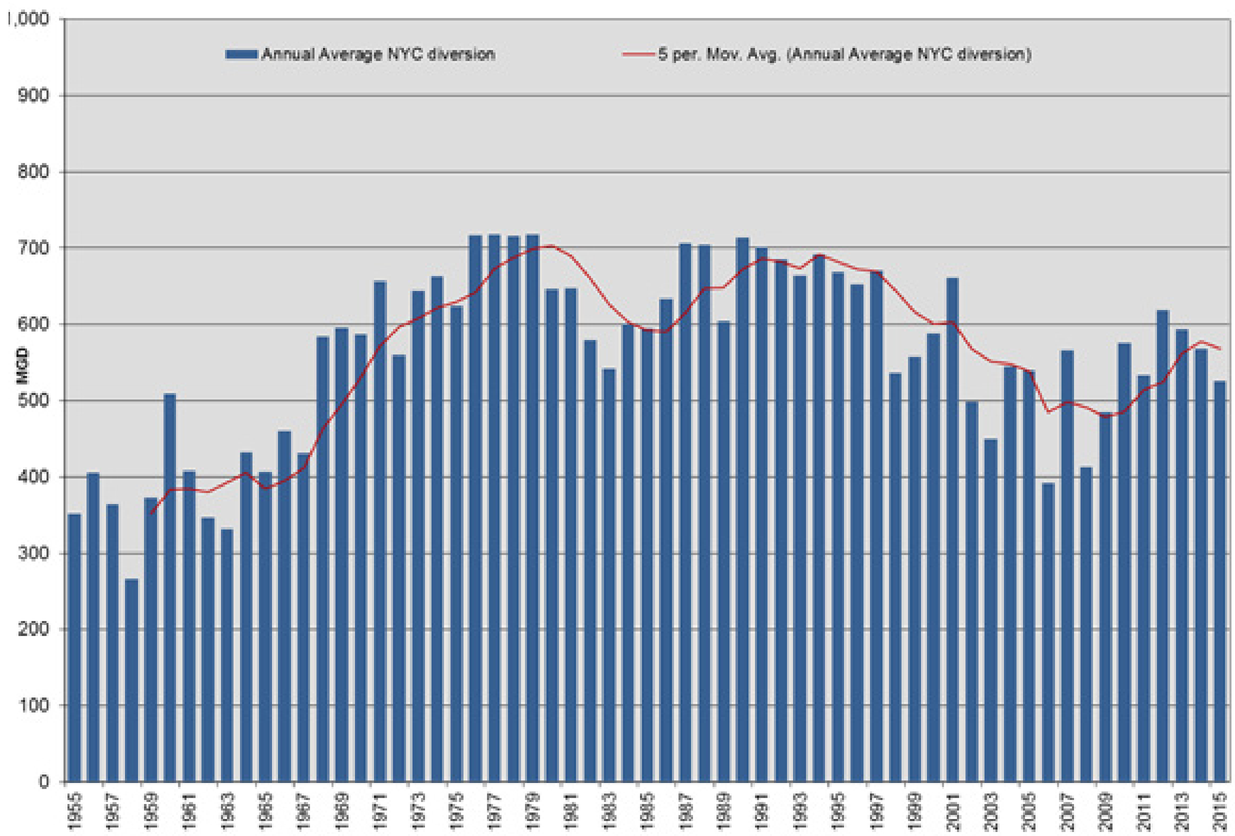

Figure 2.1.4 Water exported to New York City from Delaware River Basin 1955 - 2015 (Annual Data).

2.1.4 Future Predictions

Understanding water withdrawals, water use, and supply is integral to the management of water resources. In recent years, understanding the ways in which water is withdrawn and used has improved greatly, as have the underlying systems in place to manage the data. This has led to more timely and comprehensive assessments.

Key Delaware River Basin water use facts:

- Total ground and surface water withdrawals from the Basin: 6,372 mgd (6.4 billion gallons per day);
- Major Exports from the Basin: 659 mgd;
- Consumptive Use in the Basin: 284 mgd;
- Over 90% of all water used in the Basin is obtained from surface waters
- Three dominant use sectors account for approximately 80% of total water withdrawals; these sectors are: power generation (Thermoelectric, 59%), public water supply (PWS, 13%), and industrial use (Industry, 8%).

DRBC tracks withdrawals and water use in these three dominant water using sectors closely. Currently, data for these key sectors extend through calendar year 2014 and provide a monthly time series spanning a period of over 20 years. Although Figures 2.1.5 and 2.1.6 contain some data gaps, an overall pattern and trend in water withdrawals and consumptive use is apparent. The public water supply and industrial sectors display decreasing trends in total water withdrawn as well as consumptively used. Downward trends in withdrawals for public water supply are primarily attributed to the influence of conservation practices, while downward trends in industrial use are more likely the result of facilities exiting the industrial sector through closure or relocation outside the Basin. The thermoelectric sector displays an overall decreasing trend in total water withdrawals, but increases in consumptive use. This is attributed to the increasing use of cooling towers as opposed to once through cooling for new or upgraded facilities. It is anticipated that these trends will continue, although the rate at which they occur may change over time.

2.1.5 Actions and Needs

Reporting of water withdrawals has improved in recent years due to electronic, web-based reporting, although state agencies are adopting this approach at different speeds so data improvements should continue. Additional studies of the potential growth in water demand for the thermoelectric sector is required due to the impact that large power generating facilities can have on water resources. Also, advances in quantifying the instream needs of aquatic ecosystems are necessary for achieving a balance between instream and offstream (withdrawal) water needs.

2.1.6 Summary

Recent advances in the collection and reporting of water withdrawals, primarily by state agencies, have improved our understanding of water use in the Delaware River Basin and its watersheds. The public water supply and industrial sectors display decreasing trends in total water withdrawn as well as consumptive use. The thermoelectric sector displays an overall decreasing trend in total water withdrawals, but increases in consumptive use, which are likely to continue. Major exports to supply portions of New York City have declined over the last few decades, but this trend may not continue, and annual exports may plateau in future years.

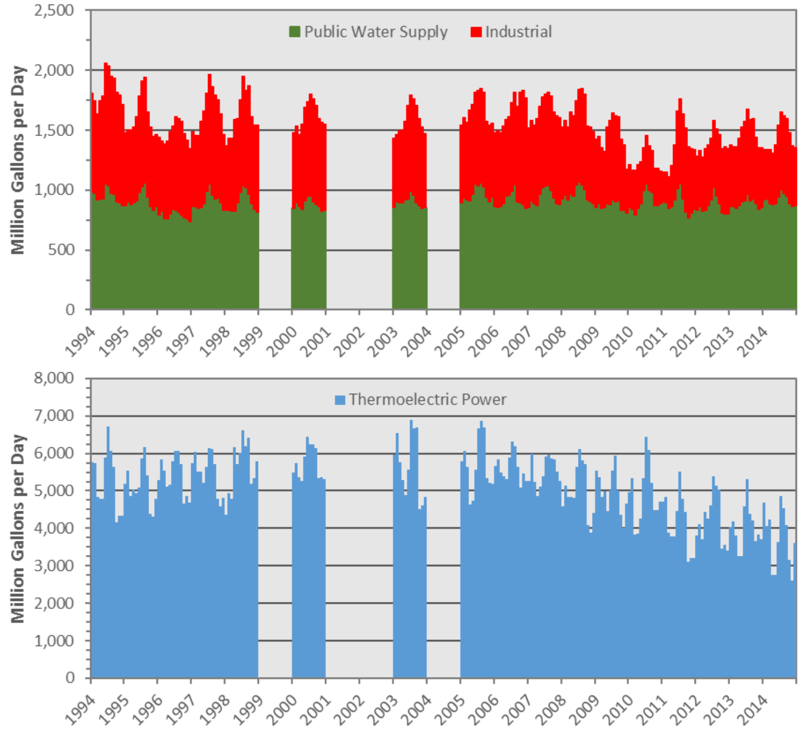

Figure 2.1.5 Monthly water withdrawals for three key sectors in the Delaware River Basin. (Note that no data are shown for months where data were incomplete to avoid visually skewing the trends).

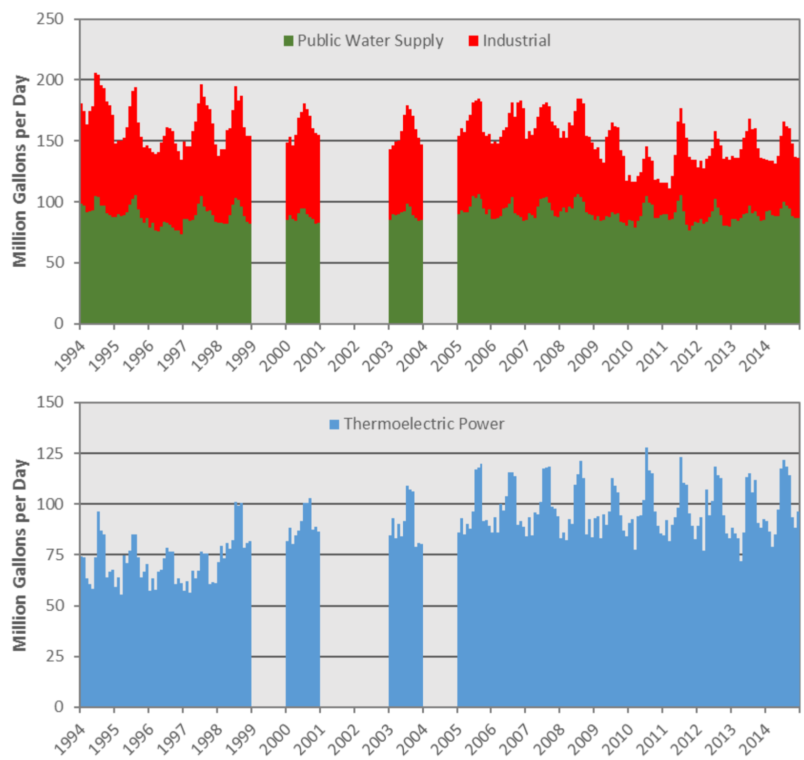

Figure 2.1.6 Monthly consumptive water use for three key sectors in the Delaware River Basin. (Note that no data are shown for months where data were incomplete to avoid visually skewing the trends).

2.2 Consumptive Use

2.2.1 Description of Indicator

Consumptive use is the portion of water withdrawn from the watershed and that is not immediately returned to the watershed. Section 1 described water withdrawals in the Delaware River Basin and Regions; however, a more important consideration in managing water resources is the amount of water consumed. Different types of water use vary in their consumptive withdrawls. For example, irrigation is highly consumptive (an estimate of 90% or greater is often used) as the water is absorbed by the plant or soil or lost to evaporation, while public water supplies (PWS) are typically considered to have a low consumptive use (~10%), as only a small portion of water used in homes and cities is not returned to the hydrologic system via sewerage systems. Another factor that influences consumptive use from a watershed perspective is the location of the withdrawal and discharge points. A PWS system that withdraws from a watershed but discharges the associated wastewater to a different watershed is 100% relative consumptive to the watershed from which it withdraws water. These types of issues need to be considered in a detailed water budget analysis. For the purposes of this report, sector-specific consumptive use factors were typically applied. However, for the power generation industry, which has highly variable consumptive use due to variability in cooling processes and industrial uses over 1 mgd, site-specific consumptive use factors were applied based on emperical data to increase the accuracy of the estimate.

2.2.2 Present Status

Figure 2.2.1 shows that the power generation and PWS sectors account for approximately 35% and 30%, respectively, of consumptive use in the Delaware River Basin and the Delaware Estuary. Agriculture and other irrigation-related uses (golf courses, nurseries) account for approximately another 20% of in-basin consumptive use. It should be noted that there are two major Basin exports to New York City and northern New Jersey, which can also be considered as consumptive uses and these two combined exports are twice the volume of all in-basin consumptive use. These exports were established as part of the 1954 Supreme Court Decree and are managed separately from other withdrawals and discharges in the Basin.

2.2.3 Past Trends

Consumptive use for the two largest sectors in the Delaware River Basin and Estuary have diverged in recent years. Consumptive use for PWS systems has remained relatively flat, most likely as a result of water conservation efforts. Figure 2.2.1 shows total consumptive water use (estimated at 10% of PWS withdrawals) for the PWS systems in the Delaware River Basin. Each data point represents a monthly consumptive use value and a linear trendline has been fitted to the data. The reason consumptive use has not followed increases in population has been driven by changes in plumbing codes, enacted in the early 1990s, which made plumbing fixtures and fittings more efficient. In addition, education and awareness of water conservation practices have played a role in decreasing water use for this sector despite increases in population (shown by the red line in Fig 2.2.1). However, it should be noted that water withdrawals, and therefore consumptive use, may have increased in some systems where there are population growth hot-spots and where water conservation practices cannot offset the more rapid increase in population.

Gaps in the data of Figure 2.2.1 indicate periods when one or more state agencies did not collect records, or could not prepare a database of water withdrawals. These data gaps provide challenges in creating a comprehensive dataset for the Delaware River Basin; the introduction of web-based reporting processes for collecting water withdrawal and use information should lead to more comprehensive and timely datasets.

Consumptive use for power generation has gone up in the past twenty years (see Fig 2.2.2 which shows monthly consumptive use values for the power sector and a 12 month moving average). Water withdrawals for thermoelectric power generation are primarily used for cooling purposes. The cooling process is typically achieved by either highly evaporative cooling towers or a once-through cooling process that uses a condenser to absorb heat. The two types of cooling use water in different ways. Evaporative cooling towers require a smaller volume of withdrawal but consume the majority of the water (>90% consumptive use). Once-through cooling requires a much greater availability of water but the rate of loss to evaporation is very small (typically <1%). The need for energy production in the Basin continues to increase and other (smaller) facilities have come online to meet demand. The new facilities use evaporative cooling, which withdraws a lesser volume but evaporates a greater percentage of the withdrawal.

The monthly data shown in Figures 2.2.1 and 2.2.2 highlight the extent to which water withdrawals and consumptive use vary seasonally. Thermoelectric power generation experiences peaks in the summer months that are related to the increased power demand for residential and commercial cooling. Simultaneously, public water suppliers experience peak demands in the summer months when lawn watering and other outside uses are greatest.

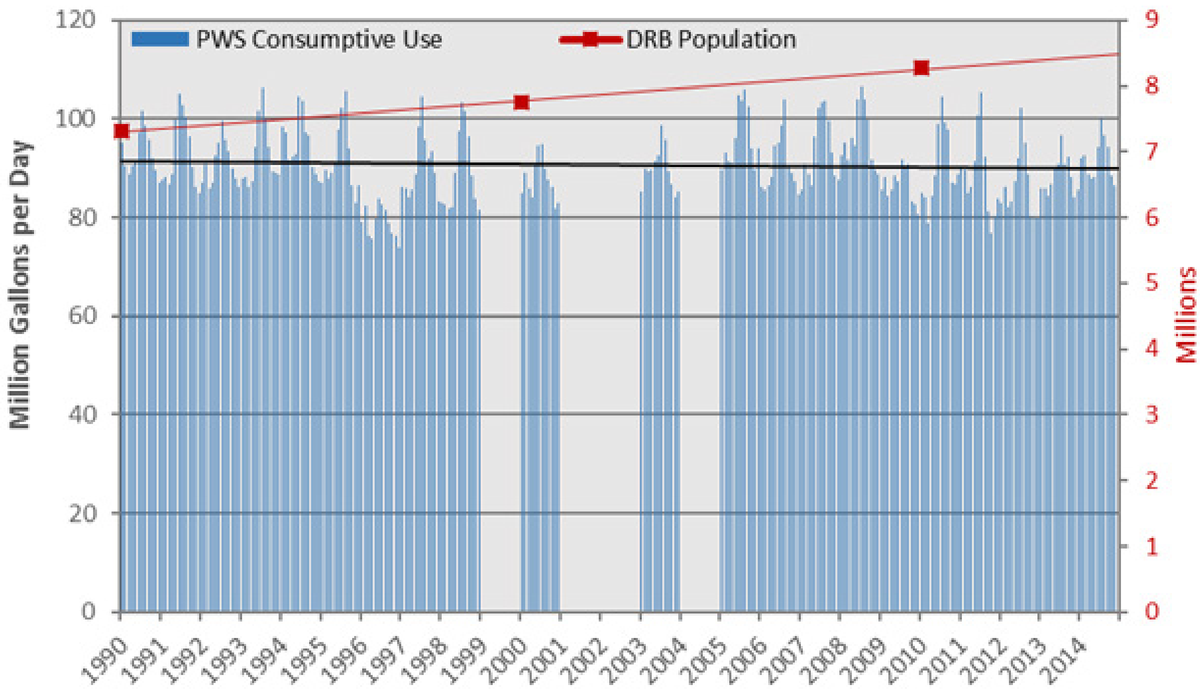

Figure 2.2.1 Trends in consumptive water use for public water supply.

2.2.4 Future Predictions

Consumptive use trends of the past two decades are expected to continue with respect to both the public water supply sector and the thermoelectric power sector. Most new thermoelectric power facilities will rely on cooling towers, which will result in greater levels of consumptive use for the sector overall. PWS withdrawals and corresponding consumptive use will likely continue to decline slightly as conservation initiatives continue to result in more efficient use of water for public supply. Additionally, detailed water auditing by public water suppliers will likely reduce overall withdrawal volumes and, thus, overall consumptive use for public water supply.

In 2009, DRBC amended its Comprehensive Plan and Water Code to implement an updated water audit approach to identify and manage water loss in the Basin. The purpose of the water audit is to track how effectively water is moved from its source to customers' taps and to ensure that public water supply systems quantify and address water losses. Approximately 6.7 million customers (80% of Basin residents) obtain

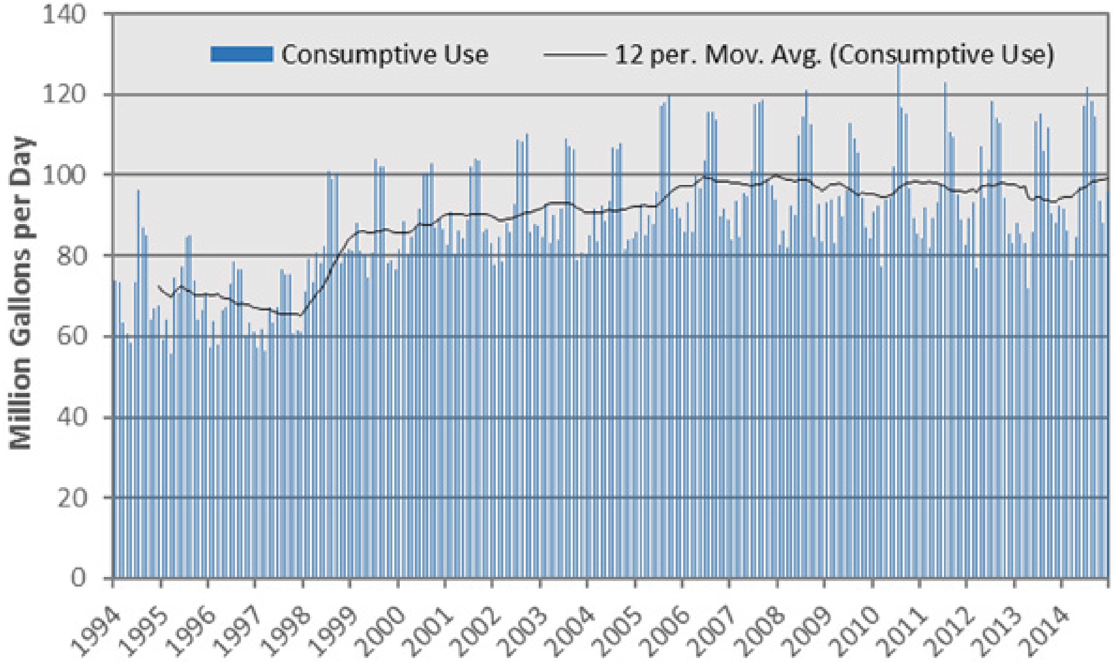

Figure 2.2.2 Trends in consumptive water use for thermoelectric power generation: aggregate consumptive demand for all systems in the Delaware River Basin.

their drinking water supply from public water supply systems. It is anticipated that significant reductions in water losses can be realized through this program. This will allow system operators, utility managers, and regulators to more effectively target their efforts to improve water supply efficiency, saving both water resources and money.

2.2.5 Actions and Needs

An accurate consumptive use characterization for a watershed requires a detailed analysis of each water use sector to determine accurate consumptive use factors representing site specific conditions. For example, at a small watershed scale, the simple assumption of 10% consumptive use for a PWS system that withdraws from the watershed but discharges wastewater outside the watershed would be inaccurate. This would need to be modeled as 100% consumptive, or as an export from the sending watershed and an import of wastewater (minus the 10% consumptive use) to the receiving watershed. More detailed tracking models that link withdrawal volumes more explicitly to discharge volumes are being applied in the Delaware River Basin, such as by New Jersey Geologic Survey's Water Transfer Data System and through the State Water Plan process in Pennsylvania.

2.2.6 Summary

An understanding of consumptive water use provides additional insight into water use patterns and is an important indicator in the management of water resources. Within the Delaware River Basin, the largest consumptive uses are from the thermoelectric, public water supply and agricultural water use sectors, accounting for approximately 85% of in-basin consumptive use. Slightly downward consumptive use trends are expected to continue in the public water supply sector while slightly upward trends may continue in the thermoelectric power sector. There are also two significant exports (to NYC and northern NJ) from the Delaware River Basin as shown in Figure 2.1.1, which can also be considered consumptive uses. These exports are expected to be relatively constant over time.

2.3 Per Capita Water Use

2.3.1 Description of Indicator

In managing water resources, it can be useful to have a metric for water use efficiency. One popular metric is per capita water use. This metric normalizes household water use for a given population. For the purposes of this report, per capita water use has been calculated as follows:

(Self supplied domestic water use+Public Water Supply) / Population

The above calculation excludes, where possible, water use by other sectors, such as power generation, which would skew any calculations. However, inclusion of some sectors could not be avoided because many public water supply systems provide water to a significant non-residential customer base (i.e., industrial or commercial customers). This use could not be separated out and may result in a higher per capita water use estimate in some regions. PWS service areas cover approximately 21% of the Delaware River Basin by area, but serve water to approximately 82% of the Basin's population (Fig 2.3.2).

Per capita water use was calculated basin wide, and for individual regional watersheds (Fig 2.3.1). For the per capita water use calculations by region, not all transfers across watershed boundaries could be accounted for. Although the data were adjusted to account for the impact of the largest of these watershed transfers across sub-basin boundaries (Point Pleasant, PA diversion and NJ Delaware & Raritan Canal), some transfers could not be accounted for and may skew per capita water use comparisons between regions. For instance, some PWS water withdrawals are in one sub-basin, and the PWS service area is in a different sub-basin. Several of the largest service areas in the Delaware River Basin cross watershed boundaries, even at the sub-region watershed scale (Fig 2.3.2). These water accounting issues exemplify the limitations of the per capita water use as an indicator for water resource management. Yet as long as these assumptions are acknowledged, per capita water use can be used as a limited measure of water use efficiency.

2.3.2 Present Status

Average per capita use in the Delaware River Basin is 112 gallons per capita per day (gpcd) and ranges from 80 gpcd to 181 gpcd across the ten sub-basins. Figure 2.3.1 shows Regional Per Capita Water Use for the eight sub-basins. Average per capita water use is greater in the Lower and Bay Regions (114 gpcd) than in the Upper and Central Regions (103 gpcd). The Schuylkill Valley sub-basin shows the highest per capita water use at 181 gpcd. Suburban areas (such as the Schuylkill sub-basin) with numerous residential developments and large lot-sizes would be expected to have a higher per capita use than heavily urbanized or rural areas.

2.3.3 Past Trends

A detailed trend analysis is not available, however a previous study based on 2003 data estimated average Basin-wide per capita water use at 133 gpcd with a range between 90 and 190 gpcd. Generally, per capita water use has decreased which is consistent with the trends shown in Figure 2.2.1 which shows a decrease in public water supply withdrawals, despite increases in population.

2.3.4 Future Predictions

Per capita water use is expected to continue to decline, because of increased water use efficiency, assuming the successes of water conservation strategies continue. Changes in plumbing fixtures and fittings, which went into effect 20 years ago, have led to greater water use efficiency. New construction has included more efficient plumbing and older homes have been retrofitted with more efficient appliances. Most of the benefit gained from these efficiencies may have already been realized; without additional effort and technical advances, water use efficiency and per capita use will eventually level off. Consequently, water withdrawals and consumptive use (see Chapter 2.3.1 and Chapter 2.3.2) may increase in response to growing population.

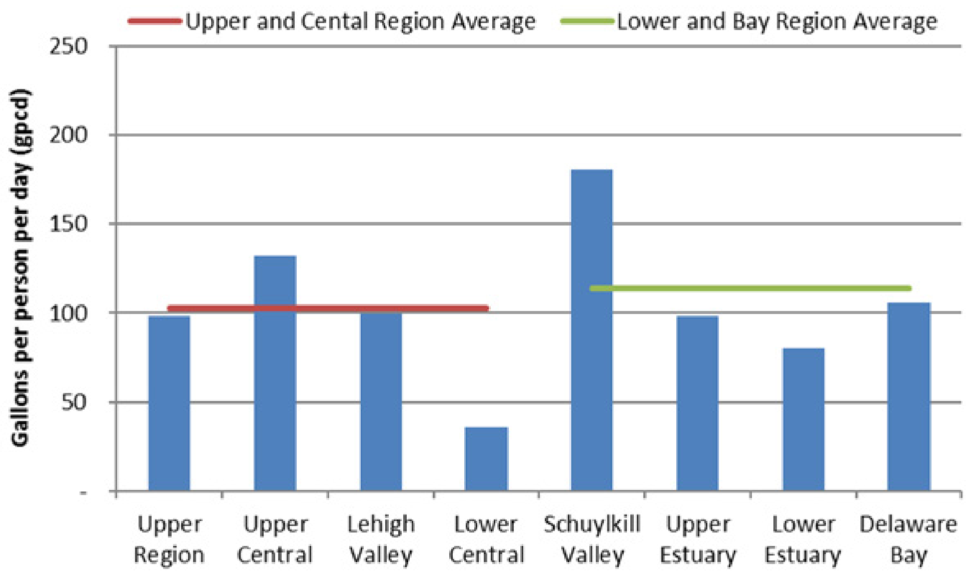

Figure 2.3.1 Regional per capita water use.

One way to further increase water efficiency would be to improve the condition and operation of water distribution infrastructure, which may be needed in many areas. In some areas, as much as 50% of the water put into distribution systems never reaches the customer as it is lost to leaky infrastructure or poor accounting practices by the water purveyor; hence there is great potential to increase water efficiency by focusing attention in this area. Increasing water efficiency could lead to decreased water demand and decreased withdrawals, which would result in cost savings for water purveyors in the form of a reduced need for system expansion. Increased completion of detailed water audits of public water supply systems (a DRBC requirement in the Delaware River Basin) will likely enable suppliers to better target capital improvements to old systems and may reduce overall water withdrawals and consumptive uses.

2.3.5 Actions and Needs

To improve the accuracy of per capita water use estimates, a detailed water use tracking model, such as that developed by the New Jersey Geological Survey, could be used to account for watershed transfers and link water withdrawals to the population with greater accuracy. Such a model is highly data intensive and would require a significant commitment of resources to compile and keep updated. However, the use of such a model, particularly in urbanized areas of the Delaware River Basin that have complex water distribution infrastructure and regional approaches to water supply management, would provide a greater understanding of how water is transfered and consumed within the watershed. Another measure to improve the accuracy and uniformity of the per capita consumption indicator would be to identify and report on PWS water use by customer type (e.g. residential, etc.).

2.3.6 Summary

Per capita consumption can provide an indication of water use efficiency over time and between different regions. The indicator needs to be interpreted carefully, as described above. Areas of above-average per capita water consumption may be a result of anomalous data and/or may represent an area where improved water conservation (e.g., through incentive programs) could lead to a reduction in water demand and increased water use efficiency.

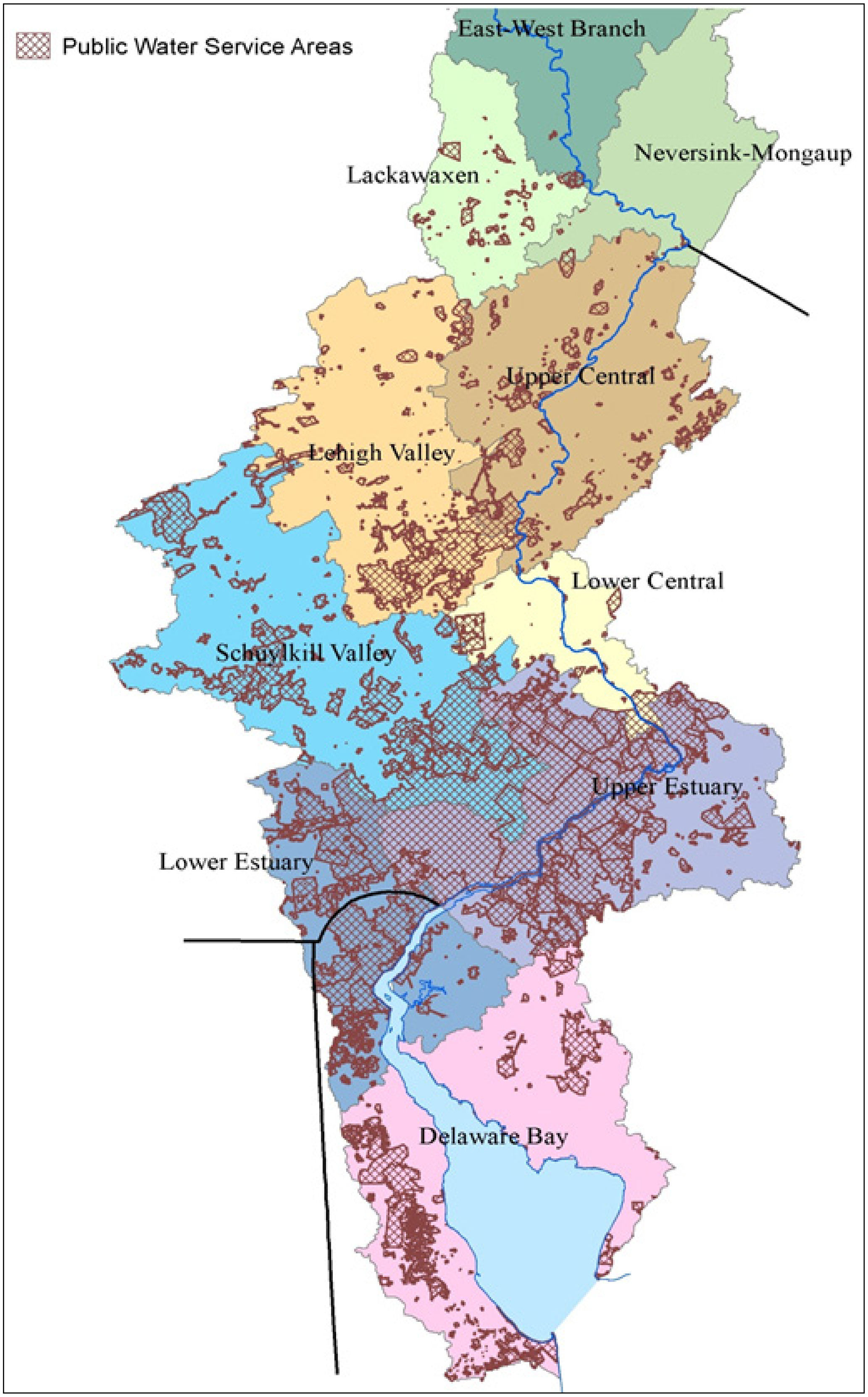

Figure 2.3.2 Public water supply service area coverage in the Delaware River Basin.

2.4 Groundwater Availability

2.4.1 Description of Indicator

Stress on a groundwater resource system can occur when withdrawals exceed natural recharge. Withdrawal of groundwater by wells is a stress superimposed on a previously balanced groundwater system. The response of an aquifer to pumping stress may result in an increase in recharge to the aquifer, a decrease in the natural discharge to streams, a loss of storage within the aquifer, or a combination of these effects, and impacts may extend beyond the limits of the aquifer being monitored.

Two major areas, primarily within the watersheds of the Upper Estuary and Schuylkill Valley, are showing signs of stress and are recognized as critical or protected areas: the Ground Water Protected Area in southeastern Pennsylvania and Critical Area #2 in south-central New Jersey which overlays the Potomac-Raritan-Magothy (PRM) aquifer (Fig 2.4.1). New and/or expanded withdrawals in both critical areas are limited and managed by specific regulations which serve to allocate the resource on the basis of a sustainable long-term yield.

2.4.2 Present Status

Conjunctive use strategies, or the practice of storing surface water in wet years for use during dry years, and regional alternatives to the local supplies are easing the stress in these two areas.

In the Southeastern Pennsylvania Ground Water Protected Area (SEPA-GWPA), reductions in total annual groundwater withdrawals have been observed over the past two decades (Fig 2.4.2). The DRBC and the Commonwealth of Pennsylvania created a management program for this area in 1980. In 1999 numerical withdrawal limits were established for each of the area's 76 sub-basins. This is the only area in the Basin for which the Delaware River Basin Commission has established cumulative water withdrawal limits. Between 1990 and 2013, total annual groundwater withdrawals within the SEPA-GWPA were reduced by approximately 8.5 billion gallons (23.4 mgd). A significant component of this reduction is the diversion of surface water from the Point Pleasant, PA intake on the Delaware River in the mid-1990s. The diversion alleviated the need for groundwater withdrawals for two major public water supply systems, as well as provided additional supply to Exelon's nuclear power station at Limerick, PA on the Schuylkill River. This diversion has provided a "conjunctive use" solution (i.e., adaptive use of both ground and surface water) that has reduced the reliance on groundwater in several sub-basins. Other sub-basins that were identified as stressed, or potentially stressed, have remained static, as sub-basin cumulative withdrawal limits have prevented further exacerbation of the stress.

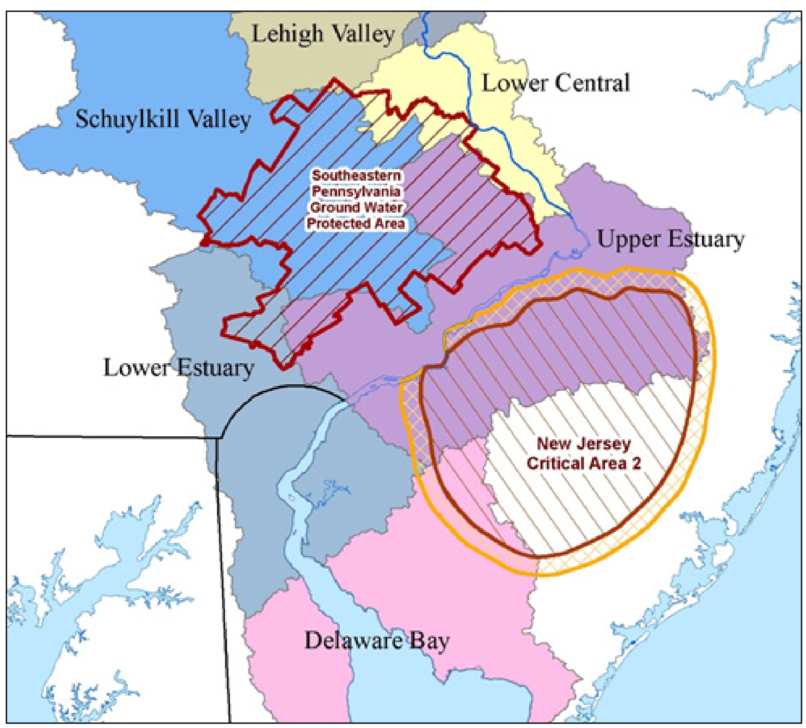

Figure 2.4.1 Areas of groundwater stress in the Delaware River Basin.

2.4.3 Past Trends

As shown in Figure 2.4.2, reduction in groundwater withdrawals in the SEPA-GWPA are largely due to the adoption of sub-basin withdrawal limits by DRBC in 1999. Groundwater pumping in several sub-basins has been reduced by the Point Pleasant diversion, which transfers surface water from the Delaware River to the GWPA. Other aspects of the management program administered by the DRBC in this area include a more aggressive water conservation program and a lower threshold of 10,000 gallons/month triggering regulatory review (as compared to 100,000 gallons/month elsewhere in the Delaware River Basin).

The New Jersey Water Supply Critical Area #2 was established by the State of New Jersey in 1996 and has resulted in reduced withdrawals from the Potomac-Raritan-Magothy (PRM) aquifer system. Many of the municipalities are now served by surface water diverted from the Delaware River near Delran, NJ. Because of conjunctive use of ground and surface water, aquifer levels have risen and appear to be stabilizing in most parts of Critical Area #2. An example is shown in the graph from USGS Elm Tree 3 Observation well (Fig 2.4.3), which is located more than 700 ft below land surface in the Middle PRM aquifer in Camden, NJ.

Further demonstrating the value of conjunctive use is Figure 2.4.4, which shows water withdrawals by the New Jersey American Water Company (Western Division) over the past two decades. The figure illustrates how the Delran surface water intake has simultaneously provided water to meet increasing demands and reduced the need for pumping from groundwater sources.

2.4.4 Future Predictions

Groundwater conditions in the SEPA-GWPA and NJ Critical Area #2 are expected to continue to improve over time due to management strategies of the DRBC, Pennsylvania, and New Jersey. Limits on groundwater withdrawals in conjunction with surface water diversion should allow continual recovery of those aquifers. An additional area of concern for groundwater resources is the PRM aquifer system, which extends from

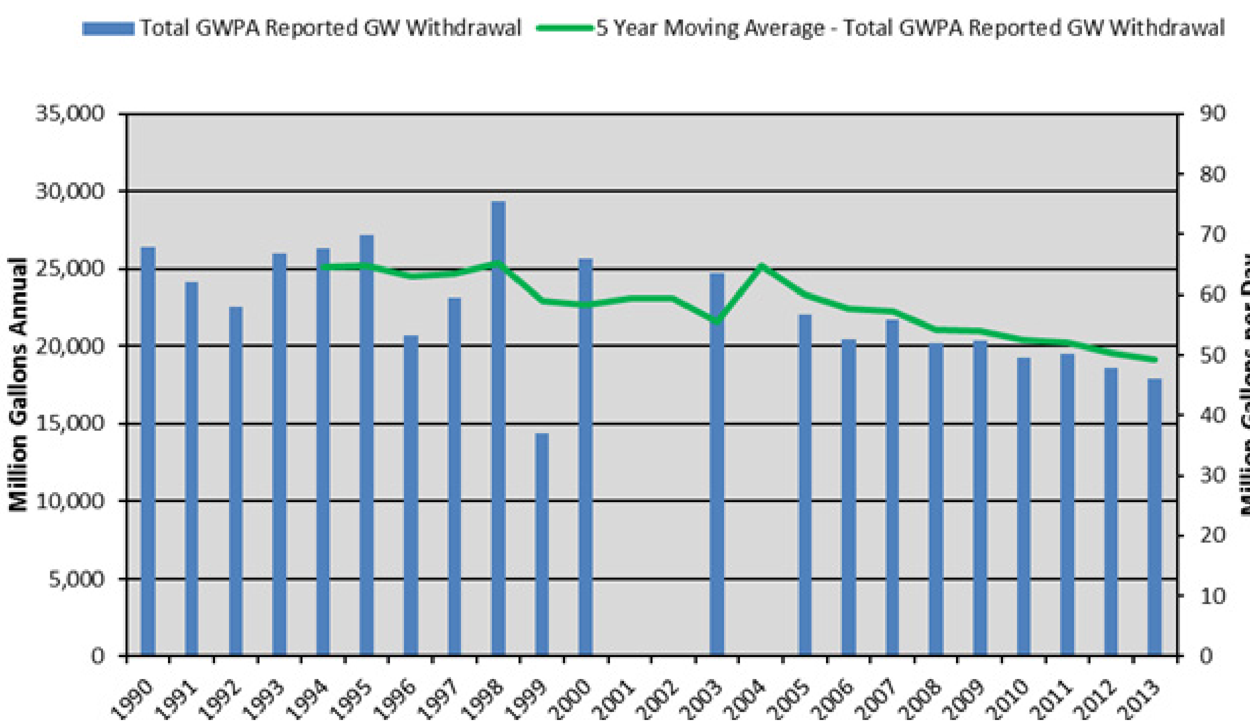

Figure 2.4.2 Groundwater withdrawals in the PA groundwater protected area 1990-2013.

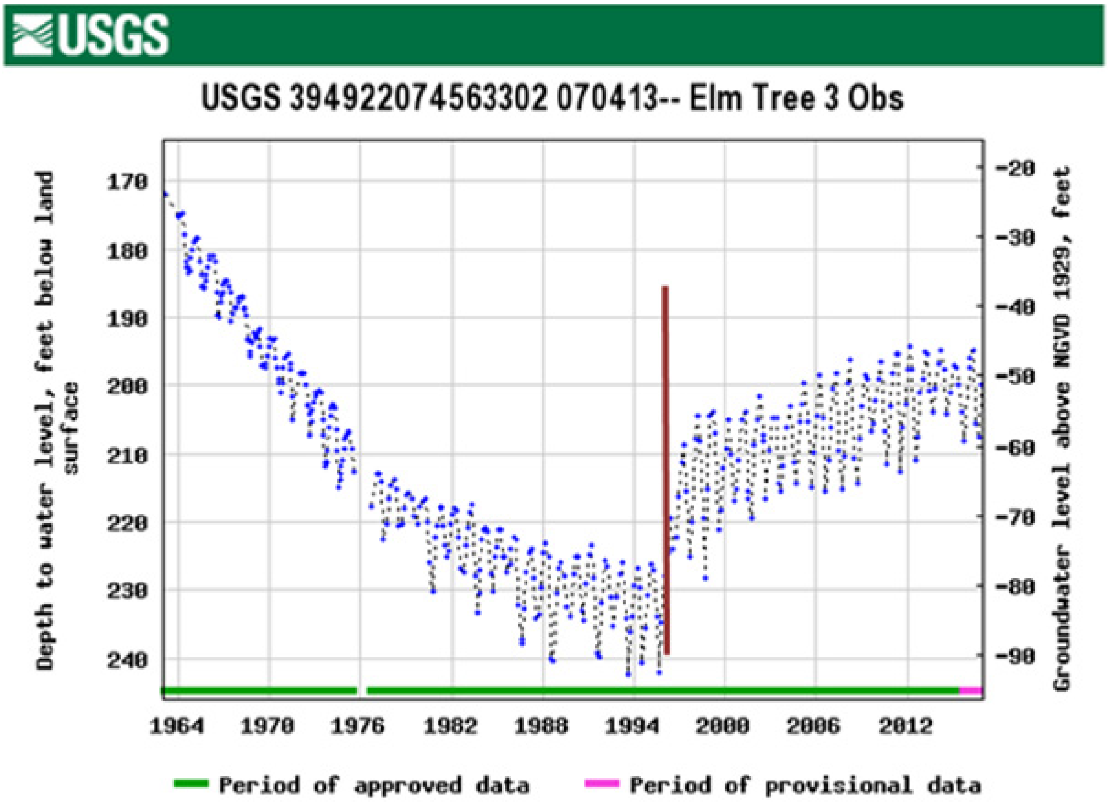

Figure 2.4.3 USGS Elm Tree 3 Observation Well.

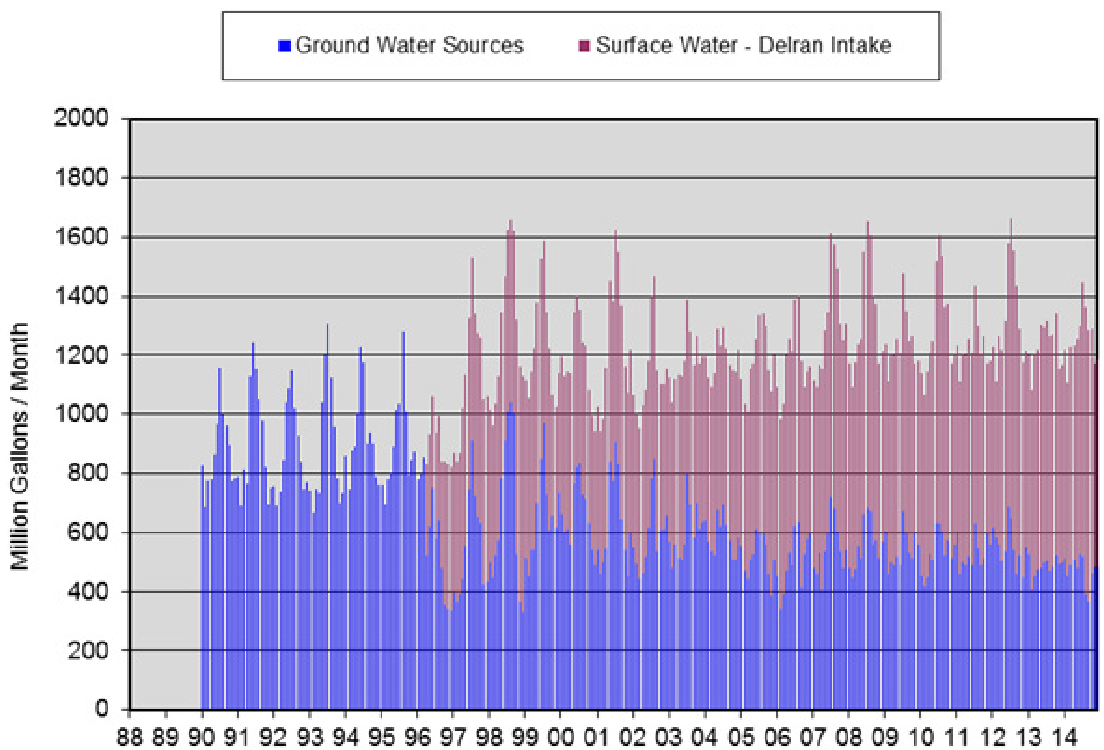

Figure 2.4.4 Water withdrawals by New Jersey American Water Company – Western Division.

New Jersey under the Delaware River, through the State of Delaware and into portions of Maryland. A 2007 report from the USACE on a groundwater model developed for northern New Castle County in Delaware concluded that groundwater withdrawals in Delaware have resulted in diminishing stream baseflows and cones of depression. The impact of these withdrawals extends into Maryland and New Jersey. In recent years, Delaware has developed a program to enhance water supplies from surface sources for northern New Castle County and is better positioned to withstand pressures of additional demand or a prolonged drought. Baseflow declines are still of concern in the Salem-Gloucester area and the Maurice River basin of southern New Jersey. New and/or expanded allocations are being denied or restricted to limit adverse impacts on the aquifers and to protect stream flows.

2.4.5 Actions and Needs

The progress made in recent years to improve water use reporting needs to be continued in order to provide the necessary data to monitor conditions in sensitive areas such as the southeastern Pennsylvania Ground Water Protected Area and the New Jersey Water Supply Critical Area #2. The metrics used to quantify groundwater availability in the GWPA could easily be applied to other areas of the Basin for assessment purposes. Attention should be paid to the PRM aquifer system, which extends through New Jersey, Delaware and into portions of Maryland, and is being impacted by groundwater withdrawals in Delaware.

2.4.6 Summary

The two groundwater areas described in this section are examples of successful, proactive management strategies that could be applied to other areas undergoing stress as a result of pumping groundwater. Further assessment of the PRM aquifer system is needed so plans to alleviate the impact of groundwater withdrawals in Delaware may be put in place.

2.5 Salt Front Location and Movement

2.5.1 Description of Indicator

The salt front is an estimation of where the seven-day average chloride concentration equals 250 ppm (parts per million) along the tidal Delaware River. The location of the salt front plays an important role in the Delaware River Basin water quality and drought management programs because upstream migration of brackish water from the Delaware Bay during low-flow and drought conditions could increase sodium concentrations in public water supplies, presenting a health concern. Critical intakes on the Delaware River that could be adversely affected by salinity moving upstream are the Philadelphia Water Department's Baxter intake and the New Jersey American Water Company's Delran intake. Both intakes are located at approximately river mile 110 (river kilometer 176). In addition, upstream migration of the salt front could adversely affect the PRM aquifer. High rates of pumping in the PRM draw tidal river water into the aquifer. If the salt front were to move too far upstream for an extended period of time, the presence of sodium could reduce the quality of water in the aquifer.

2.5.2 Present Status

The present day status of drinking water intakes are very good since the Tidal River is effectively protected by normal hydrologic conditions. Reservoir operations and water quality in the PRM remain very good.

2.5.3 Past Trends

The salt front naturally advances and retreats with each tidal cycle and with seasonal variations in freshwater flow. For most of the year, the location of the salt front is between the Commodore Barry Bridge (RM 82/KM 131) and Artificial Island (RM 54/KM 86). During droughts and periods of very low inflow to the Estuary, a management program releases water from upstream reservoirs to augment flows and to meet a daily flow target of 3,000 cubic feet per second (84.9 cubic meters per second) in the Delaware River at the Trenton, NJ gage. The program has worked well; since 1970, low-flow values that once occurred 10% of the time now occur only 1% of the time. The salt front has been successfully maintained below drinking water intakes, protecting drinking water supplies in the most urbanized area of the Basin (Fig 2.5.1).

Figure 2.5.1 shows the maximum upstream location, lowest measured downstream location and median location of the salt front for each year during the period 1989 to 2016 compared to locations of interest along the Delaware River. (Note that the salt front location is not tracked and recorded below river mile 54 (river kilometer 86), and that the 250 ppm isochlor may move further downstream than this location, but this is not shown in Fig 2.5.1). Figure 2.5.2 shows similar information in map form.

2.5.4 Future Predictions

Sea level rise and increasing variability in flow from climate change may create additional challenges for management of the salt front in the future.

2.5.5 Actions and Needs

An investigation of additional sources of chlorides, such as from road salts and runoff, is warranted. An evaluation of the adequacy of the 3,000 cfs target at Trenton, NJ in repelling the salt front is also warranted.

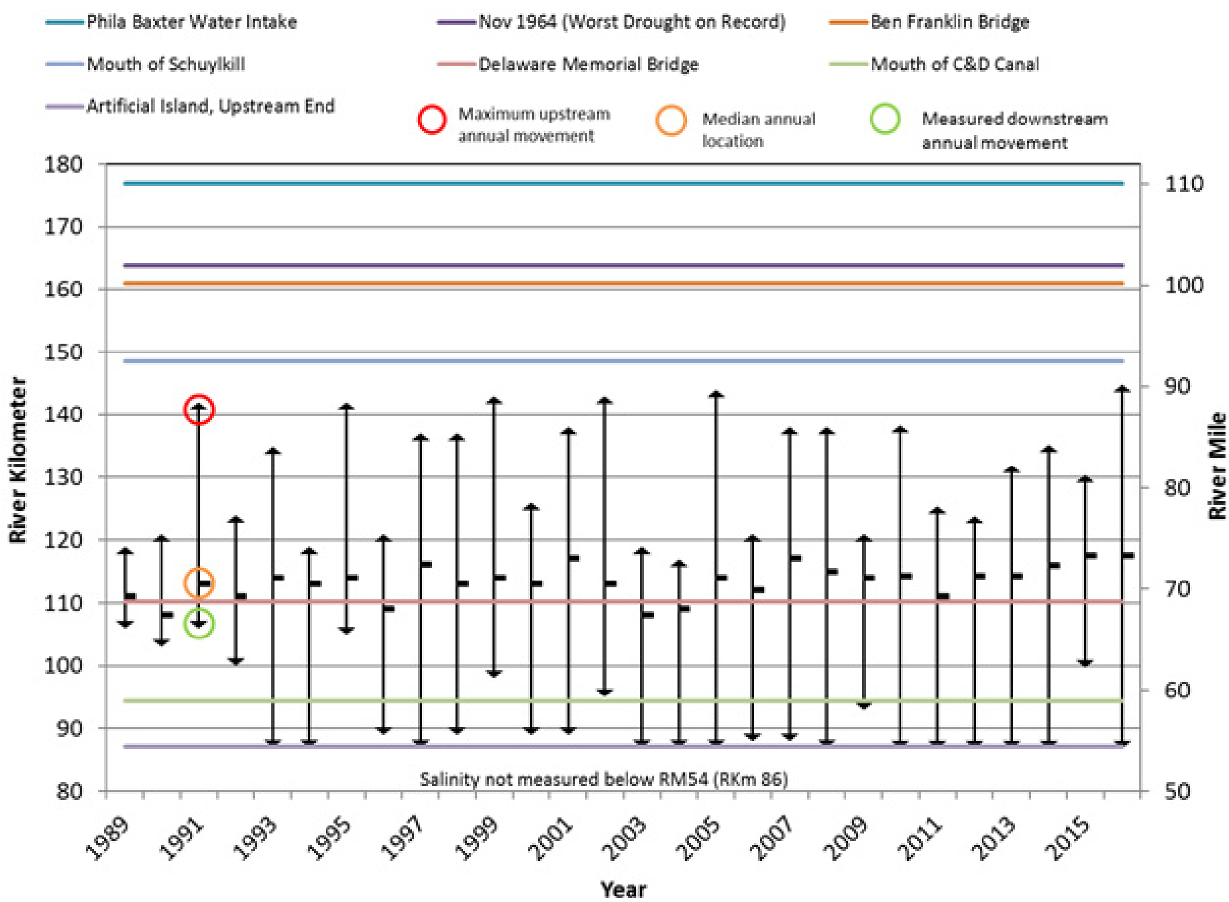

Figure 2.5.1 Range of annual salt front locations From 1989-2016. The salt front river mile location is estimated by DRBC using data provided by USGS and the Kimberly Clark Corporation.

2.5.6 Summary

Flow management strategies have been successful in restricting the upstream movement of the salt front and have effectively protected drinking water intakes in the most densely populated area of the Basin.

Data Sources

Several of the indicators described in this chapter are based on water withdrawal datasets (Table 2.5.1). These data are typically reported annually by water users to the state environmental agencies. To avoid duplication, data are provided by the state agencies to DRBC in order to complete Basin-wide assessments. In recent years several of the basin states have implemented web-based reporting processes which streamline data reporting and data management. As a result, the exchange of data has greatly improved, while further improvements are still necessary to achieve complete and timely data exchange. The merging, data checking, and compilation of water withdrawal data from the four Basin states requires significant staff and computational effort. For the purposes of this report, the calendar year 2014 was chosen as the target year for water withdrawals. In some cases, to fill data gaps or to obtain more recent data, the DRBC's own data sources have been used where available. These data come from DRBC's Surface Water Charging program which tracks surface water withdrawals from the Delaware River Basin.

Table 2.5.1 Summary of available water withdrawal data by state.

State	Year	Number of Withdrawals **	Volume of Withdrawals Million Gallons/Day (MGD)	Total Volume (%)
DE	2014	720	688	12
NJ	2014	3950	3611	63
NY*	2014	52	13	<1
PA	2014	2879	1390	24

* The New York City and New Jersey exportation of water from the Delaware River Basin and associated domestic use are not part of the data presented in the above table, but are included in the analysis in this chapter.

**The total number of withdrawals was calculated based on the total number of withdrawal points that reported data at some point during the period from 2010 through 2014.

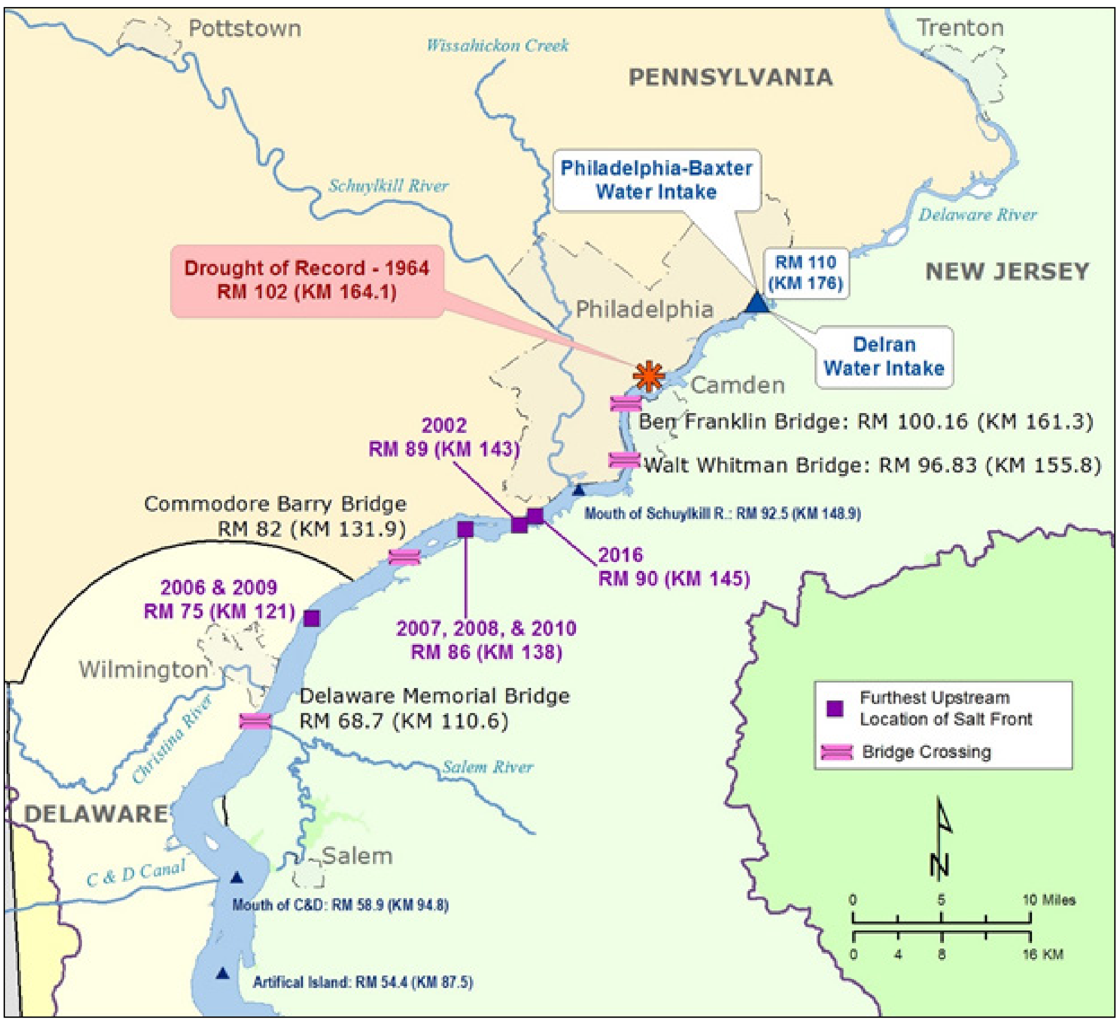

Figure 2.5.2 Map of historic salt front locations.

References

Delaware Department of Natural Resources and Environmental Control. 2014 Water Use Data. Staff Correspondence. Sept. 11, 2015.

Delaware River Basin Commission. 2017 Water Resources Program FY 2017-2019. Delaware River Basin Commission. West Trenton, NJ. March 15, 2017.

Najjar, K.F., Barr, J.K. 2016. Analysis of Calendar Year 2014 Water Audit Data from Public Water Supply Systems in the Delaware River Basin. Delaware River Basin Commission. West Trenton, NJ. February 2016.

New Jersey Department of Environmental Protection. 2014 Water Use Data. Staff Correspondence. May 20, 2015.

Najjar, K.F., Barr, J.K. 2016. Analysis of Calendar Year 2014 Water Audit Data from Public Water Supply Systems in the Delaware River Basin. Delaware River Basin Commission. West Trenton, NJ. February 2016.

U. S. Army Corps of Engineers, Philadelphia District (USACE). 2007. Updated Draft Groundwater Model Production Run Report; Upper New Castle County, Delaware. <http://www.civicleagueforncc.org/clop/water/report.pdf>

United States Department of Commerce. "2010 Census Data." Bureau of the Census. census.gov. 21 Dec. 2010.

U.S. Geological Survey. USGS 394922074563302 070413-- Elm Tree 3 Obs. March 15, 2017. Retrieved from https://nwis.waterdata.usgs.gov/nj/nwis/gwlevels/?site_no=394922074563302&agency_cd=USGS

Further Reading

New Jersey Water Supply Plan 2017-2022 http://www.nj.gov/dep/watersupply/pdf/wsp.pdf

Suggested Citation for this Chapter

Barr, J. K. 2017. 2017. "Chapter 2 - Water Quantity" in the Technical Report for the Delaware Estuary and Basin. Partnership for the Delaware Estuary. PDE Report No. 17-07, pp. 77-95.

Back to Table of Contents