2

Water Quantity

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Chapter 2 – Water Quantity & Hydrology

Data Sources

Several of the indicators described in this chapter are based on water withdrawal datasets. These data are typically reported annually by water users to the state environmental agencies. To avoid duplication, data are provided to the Delaware River Basin Commission (DRBC) in order to complete Basin-wide assessments. Over the past two decades data collection has not always been comprehensive and timely, however in recent years the basin states have begun to implement web-based reporting processes which streamline data reporting and data management. As a result, the exchange of data has improved, although 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 effort. For the purposes of this report the calendar year 2007 was chosen as the target year for water withdrawals. Not all state agencies were able to provide data for this time period and in those cases, the latest available information has been used. 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 the DRBC's Surface Water Charging program which tracks the largest withdrawals from the Delaware River Basin. Precipitation impacts water availability over the long-term. For a discussion of this see Chapter 7-2.

Table 2.1. Summary of available water withdrawal data by state

State	Year	Number of Withdrawals	Volume of Withdrawals Mil. Gallons/Day (MGD) and Cubic Meters/Sec (CMS)	% of total by volume
DE	2003	352	754 (33)	10
NJ	2007	3,660	4,374 (192)	58
NY*	2007	36	13 (0.57)	<1
PA	2003	2,017	2,388 (105)	31

* The New York City Export is not part of the data presented in the above table, but is included in the analysis in this chapter.

1 – Water Withdrawals - Tracking Water Supply & Demand

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, 2007 water withdrawal data were compiled to generate a Basin-wide and regional assessment, by water-use sector. With the exception of data for the Agriculture and Self-supplied Domestic (individual homeowner wells) sectors, all data are based on withdrawals reported to state agencies. Water withdrawals reported for agricultural use in the Basin were not comprehensive and varied by state. To enable a uniform assessment, water use for agriculture was estimated from The Census of Agriculture (USDA, 2007). Self-supplied domestic use was estimated based on the population from Census 2010 data that reside outside of public water system (PWS) service areas. An estimated use of 75 gallons/capita/day (0.28 cubic meters) was applied to calculate water use by this sector.

Total water withdrawals from the Delaware River Basin, based on calendar year 2007 data are shown in Fig. 2.1. Figures 2.2 and 2.3 show total water withdrawals from the Upper and Central Regions and the Lower and Bay (Estuary) Regions, respectively.

1.2 Present Status

Approximately 15 million people rely on water from the Delaware basin for their water needs. On average, over 8 billion gallons (30 million cubic meter) of Delaware basin water are used each day. This includes an average of approximately 575 million gallons per day (MGD) (25 CMS) for populations in New York City and 90 MGD (3.94 CMS) for northeastern New Jersey, which combined account for around 7% 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 water temperatures and flows for downstream uses. 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 (68%). The next largest use is for public water supplies, or PWS (11%). 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 section 1.2).

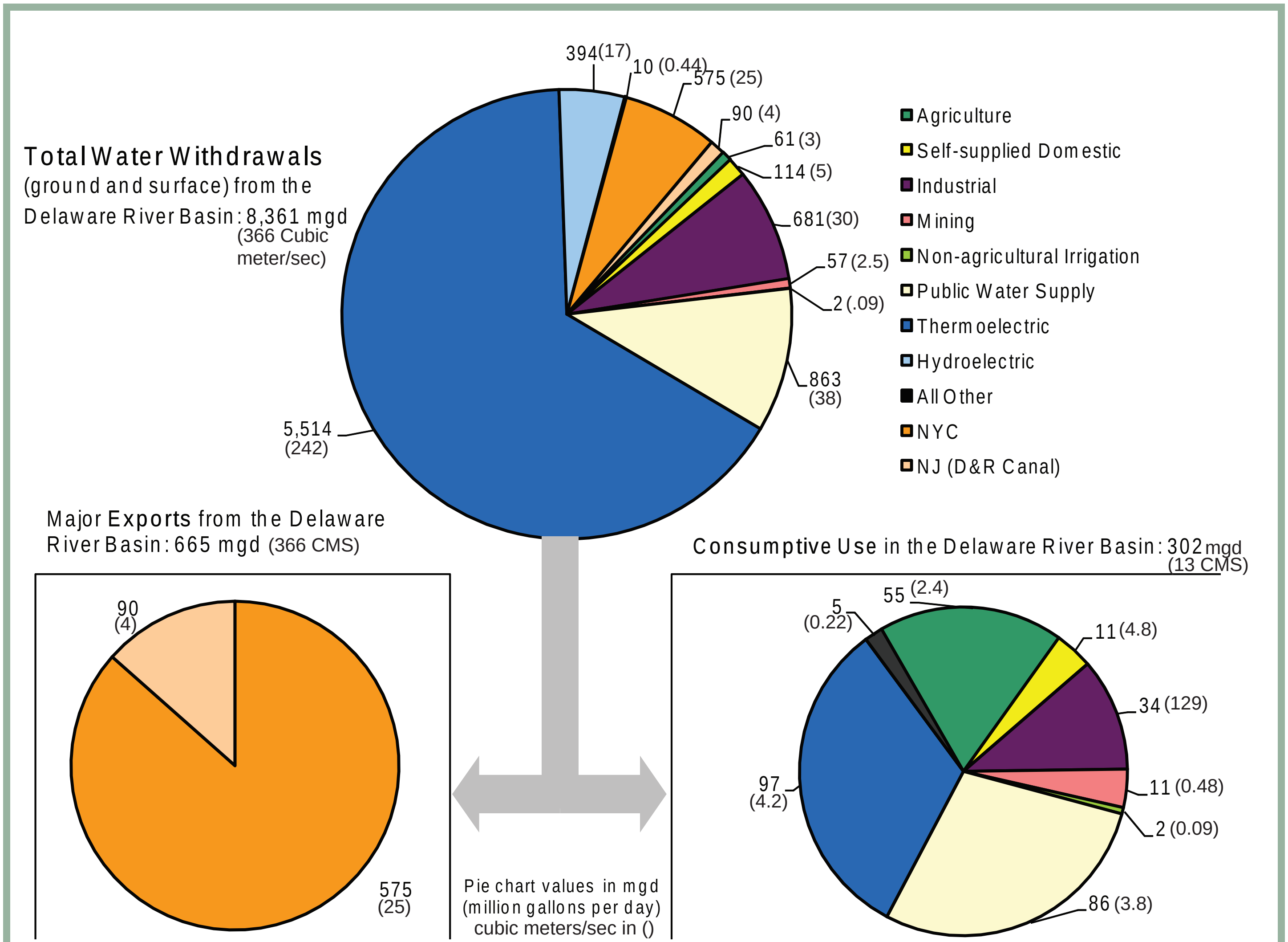

Fig. 2.1. Total Water Withdrawals for the Delaware River Basin, 2007

1.3 Past Trends

Over the past two decades the NYC diversion has decreased due in large parts to water conservation efforts. A long-term chart of water exported from the Basin to meet NYC needs is shown in Fig. 2.4. A five-year period moving average is included on the chart to smooth the impact of short-term fluctuations in water demand and the influence of weather patterns.

1.4 Future Predictions

Five-year water demand projections through the year 2030 were developed for each water-use sector under a collaborative project between the DRBC and the U.S. Army Corps of Engineers. These projections were published in 2008, under the title *Enhancing Multi-jurisdictional Use and Management of Water Resources for the Delaware River Basin, NY, NJ, PA, and DE.*

The projections were based on 2003 water withdrawal data. To improve accuracy of the projections a number of factors were considered including projected changes in population, employment, and historical trends in agriculture and power generation. Fig. 2.5 shows projected trends for all sectors.

In Fig. 2.5 water withdrawals for thermoelectric power generation show the greatest increase over the projection period. The trend is generated by extrapolating past usage patterns at existing facilities. The slope of the trend is also consistent with increased power generation predicted for the Mid-Atlantic Region by the U.S. Energy Information Administration. Water withdrawals for other sectors are projected to remain approximately flat. Additional information on demand projections is included in section 1.2.

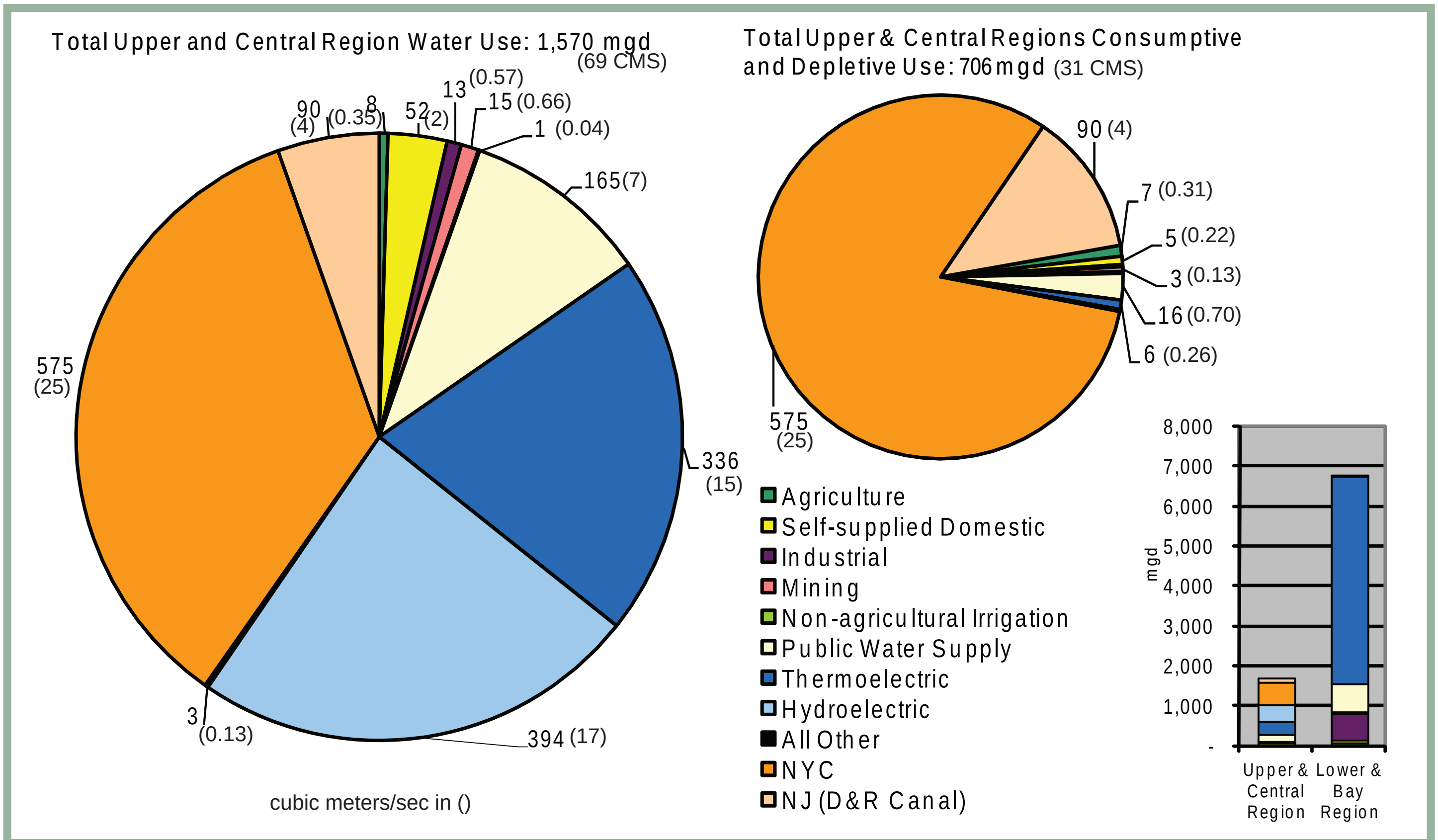

Fig. 2.2. Total Water Withdrawals For the Upper and Central Regions, 2007

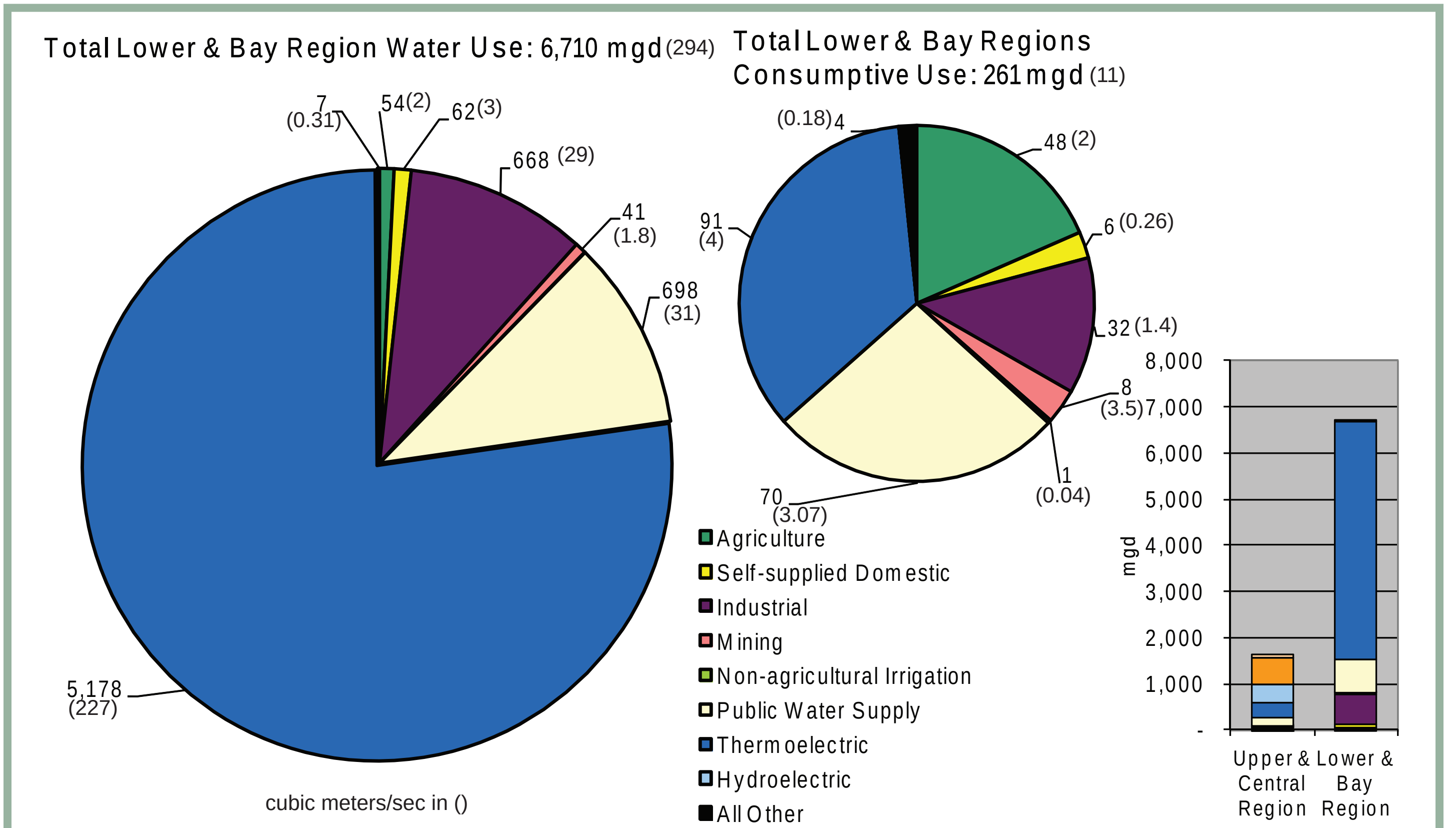

Fig. 2.3. Total Water Withdrawals For the Lower and Bay Regions, 2007

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 and there is still room for improvement.

Withdrawals for the agriculture sector are still estimated based on agriculture census data as the individual water withdrawals for the Basin are not complete or reliable. A better understanding of water use by this sector, which starts with accurate data reporting and collection, is needed in order to improve planning and management for this type of use.

Continued study 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.

Water use for natural gas development in the Delaware River Basin is likely to become an additional water demand on the system in future years. Initial projections estimate that during peak natural gas development (10 years in the future) water demand for this new sector may be 20mgd (0.88 CMS). Although the magnitude of estimated withdrawals in not large in a Basin-wide context, the water is likely to be sourced from the basin headwaters where this increase in demand will represent a significant increase compared to existing demand.

Advances in quantifying the in-stream needs of aquatic ecosystems are necessary for achieving a balance between in-stream and off-stream (withdrawal) water needs.

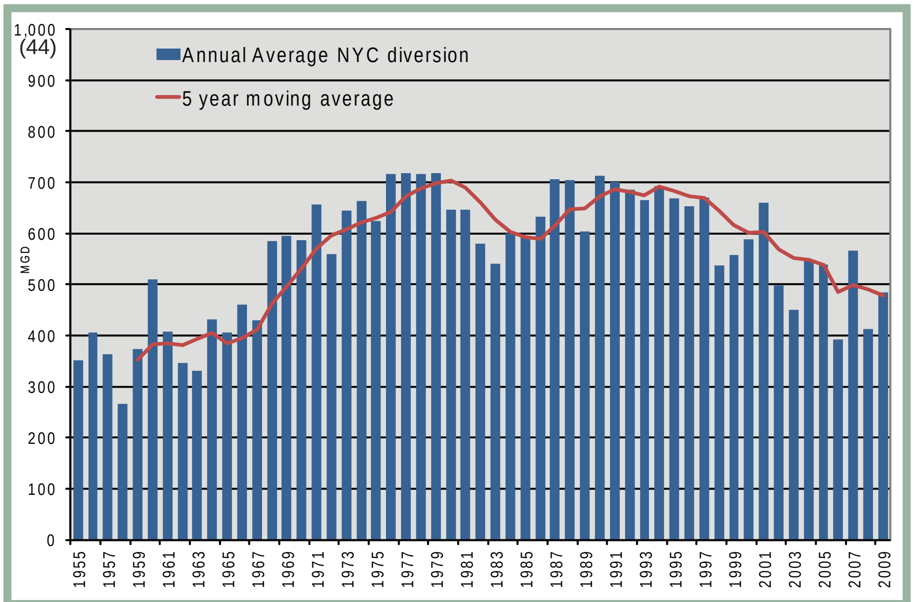

Fig. 2.4. Water Exported to New York City from Delaware River Basin 1955 - 2009 (Annual Data) (Cubic meters/sec in parentheses)

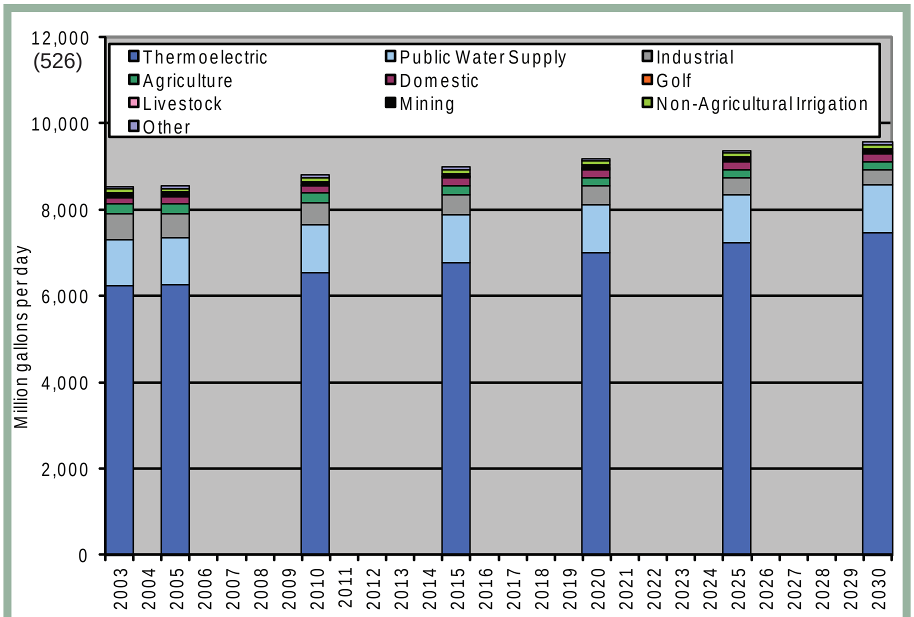

Fig. 2.5. Projected Trends in Water Withdrawals by Sector for the Delaware River Basin. (Cubic meters/sec in parentheses)

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.

2 – Consumptive Use

2.1 Description of Indicator

Section 1 described water withdrawals in the Delaware River Basin and Regions. However, in managing water resources a more important consideration than what is withdrawn is what is used or consumed which is known as *consumptive use.* Consumptive use is that portion of water withdrawn that is not immediately returned to the watershed. Different types of water use vary in their consumptive use. 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. PWS are typically considered to have a consumptive use of 10%, as only a small portion of water used in homes and cities is evaporated, the majority is returned 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 wastewater it generates outside the watershed is 100% 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 a highly variable consumptive use based on the types of cooling processes used, site-specific consumptive use factors were applied to increase the accuracy of the estimate. Similarly, all industrial users over 1 mgd (0.04 CMS) were investigated and given site-specific consumptive use factors based on empirical data.

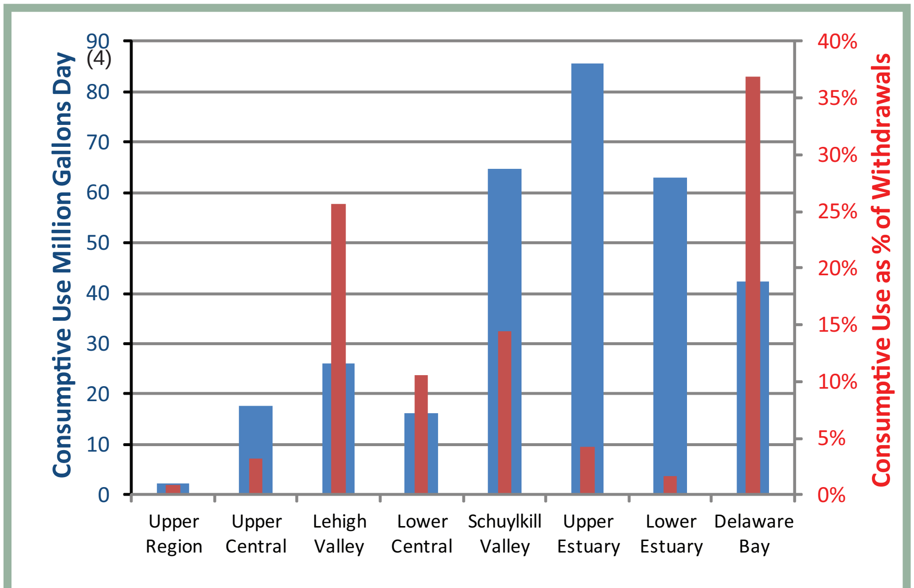

Fig. 2.6. Regional Consumptive Water Use (excluding NYC and NJ exports)

2.2 Present Status

Fig. 2.1 shows that the power generation and PWS sectors account for approximately 33% 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 uses. These exports were established as part of the 1954 Supreme Court Decree and are managed separately from other withdrawals and discharges in the Basin.

Fig. 2.6 shows in-basin consumptive water use and where this occurs by regional watershed. The figure shows the magnitude of consumptive use which is greater in the Lower and Bay regions. The figure also shows the percentage of the withdrawal that is consumptively used in each region. The percentage of consumptive use is highest in the Lehigh Valley and Delaware Bay subbasins; the high consumptive use factor in these sub-basins is primarily driven by estimated agricultural use which is a highly consumptive water use.

2.3 Past Trends

Consumptive use for the two largest sectors in the Delaware River Basin and Estuary has followed opposing trends in recent years. Consumptive use for PWS systems has decreased as withdrawals have decreased, most likely as a result of water conservation efforts. Fig. 2.7 shows total consumptive water use (estimated at 10% of PWS withdrawals) for the 38 largest 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. Collectively, these systems account for approximately 80% of total demand for all PWS systems in the basin. The downward trend 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. 2.7). However, it should be noted that water withdrawals, and therefore consumptive use, have increased in several 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 Fig. 2.7 indicate periods when one or more state agency 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.

Water use and consumptive use for power generation has gone up in the past twenty years (see Fig. 2.8 which shows monthly consumptive use values for the power sector and a linear trendline). In the most part, water use at existing facilities has increased and some new facilities have come online and begun to use water.

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%).

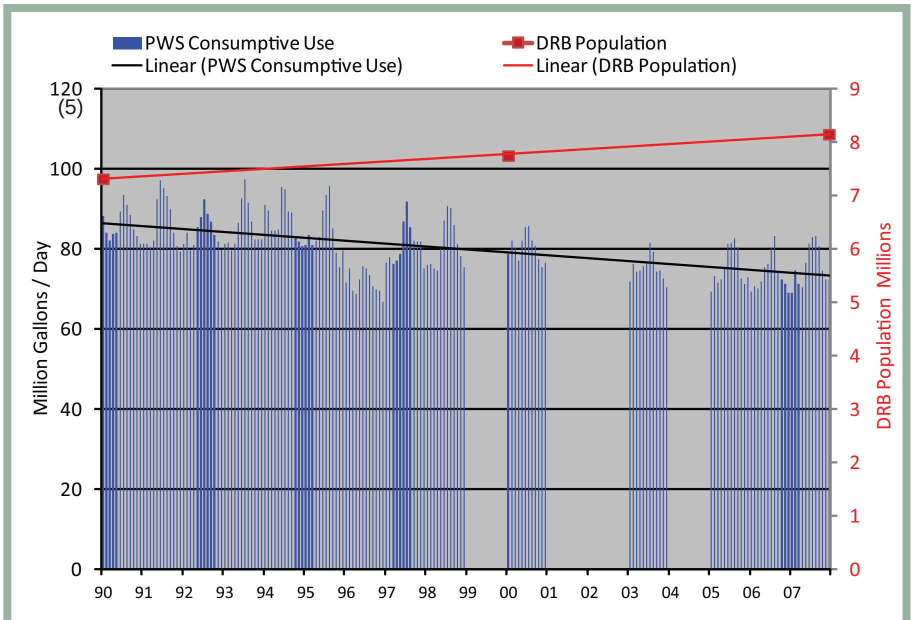

Fig. 2.7. Trends in Consumptive Water Use for Public Water Supply: Aggregate monthly water demand for 38 Large PWS Systems in the Delaware River Basin.

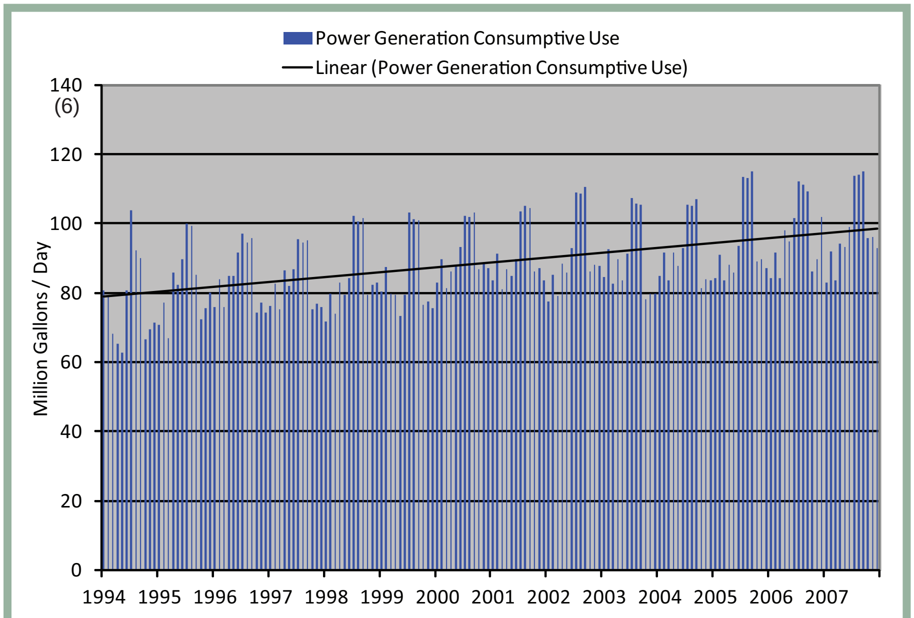

Fig. 2.8. Trends in Water Consumptive Water Use for Thermoelectric Power Generation: Aggregate monthly demand for 36 systems in the Delaware River Basin

The monthly data shown in Figures 2.7 and 2.8 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.

2.4 Future Predictions

Fig. 2.5 shows five-year water demand projections for the Delaware River Basin based on a collaborative study between the DRBC and the U.S. Army Corps of Engineers. Key findings of the study indicate that, at the Basin scale, future demand for the PWS sector is likely to remain flat due to continued efficiencies from implementation of water conservation appliances and practices. Water demand for the power generation sector was projected to increase between 2003 and 2030. In March 2010, U.S. EPA proposed regulations to enact the Clean

Water Act Section 316(b) rules (http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/). These regulations are designed to require the best technology available for minimizing adverse environmental impacts, particularly regarding impingement and entrainment (I&E) of fish and other organisms. The regulations are scheduled to be finalized in 2012 and could require power plants that currently use once-through cooling water systems to switch to recirculating water systems which require much less volumes of withdrawal (and hence reduce I&E impacts) but have a greater consumptive use. Due to the proposed rule change, it is likely that all new power generating facilities will require recirculating water systems that result in higher consumptive use. In addition to increasing the consumptive use in the basin, this switch potentially makes more upstream locations viable for the siting of power plants as recirculating cooling systems require a lesser volume of water withdrawal and could be accommodated further upstream, whereas once-through systems are typically constrained to the Estuary and Bay regions due to the large volumes of water required by these systems.

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 withdrawals 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 www.state.nj.us/dep/njgs/geodata/dgs10-3.htm and through the State Water Plan process in Pennsylvania.

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 almost 80% of in-basin consumptive use. There are also two significant exports from the Delaware River Basin as shown in Fig. 2.1 which can also be considered a form of consumptive use. These two exports combined account for more than twice the total quantity of in-basin consumptive use.

3 – Per Capita Water Use

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 from 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 (see Fig. 2.9).

Per capita water use was calculated basin wide, and for individual regional watersheds (Fig. 2.10). 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 of water 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 (see Fig. 2.9). As long as these limitations are acknowledged, per capita water use can be used as a measure of water use efficiency.

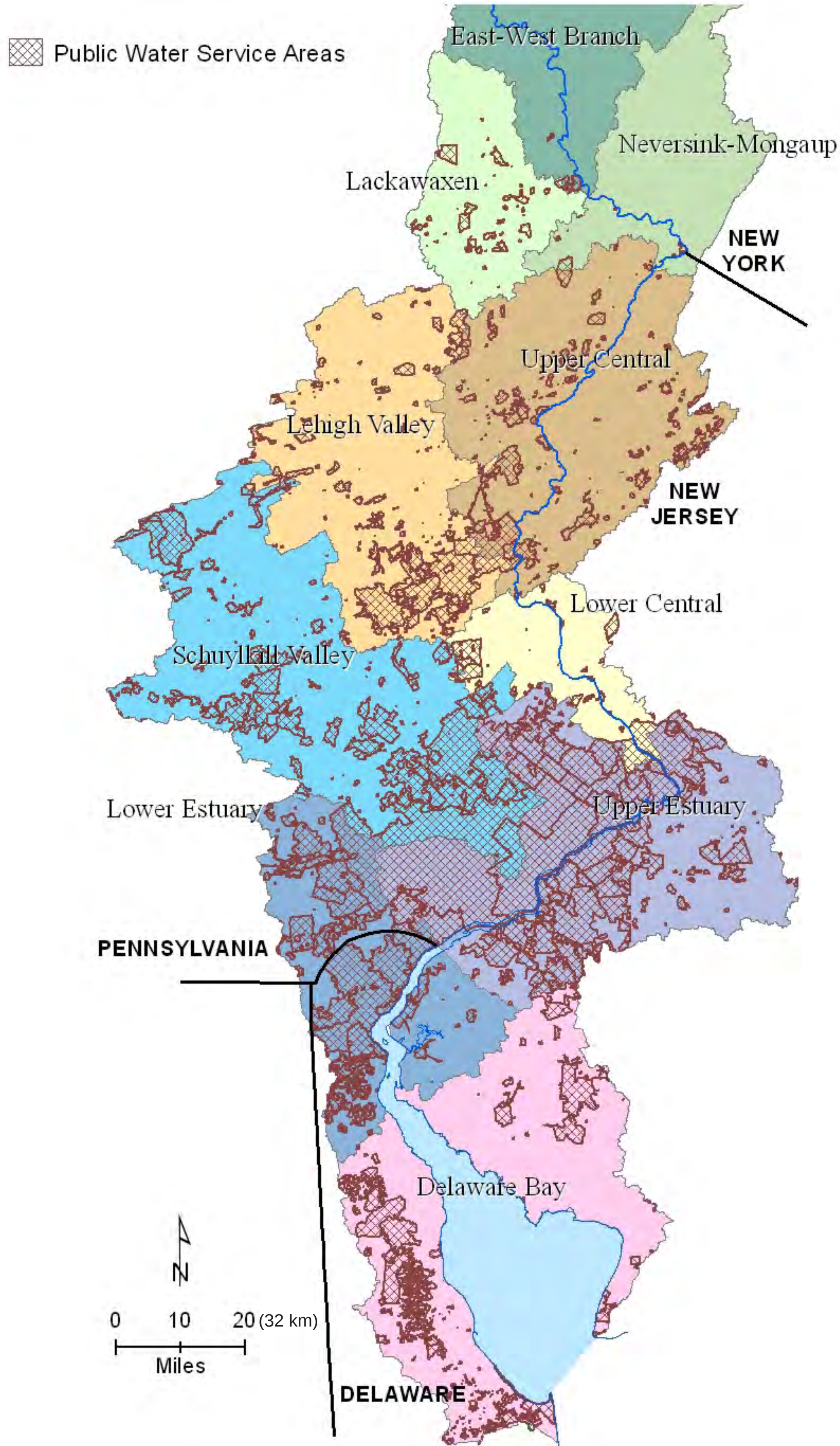

Fig. 2.9. Public Water Supply Service Area Coverage in the Delaware River Basin

3.2 Present Status

Moderate: Average per capita use in the Delaware River Basin is 116 gallons per capita per day (gpcd) (0.44CM/capita/day) and ranges from 78 gpcd to 171 gpcd (0.30 - 0.65 CM/capita/day) across the ten sub-basins. Fig. 2.10 shows Regional Per Capita Water Use for the ten subbasins. Average per capita water use is greater in the Lower and Bay Regions than in the Upper and Central Regions. The Schuylkill Valley sub-basin shows the highest per capita water use at 171 gpcd. Suburban areas with numerous residential developments and large lot-sizes would be expected to have a higher per capita use than heavily urbanized or rural areas.

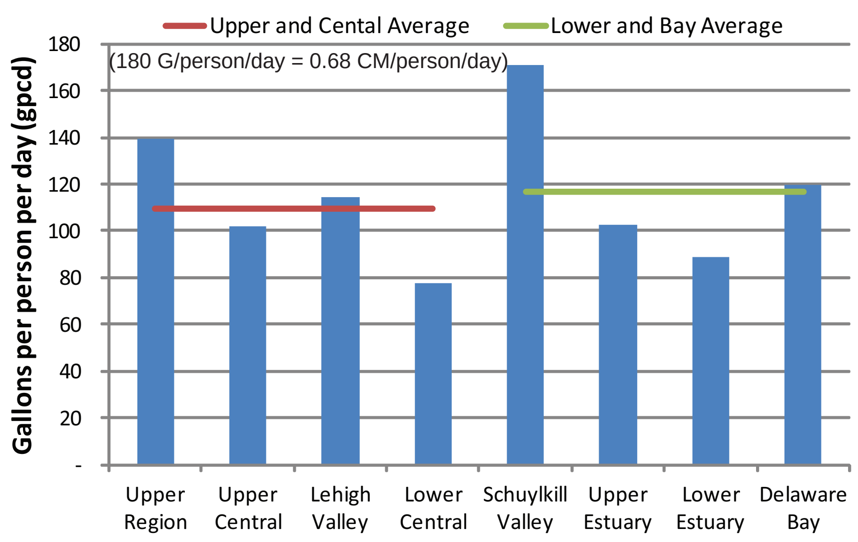

Fig. 2.10. Regional Per Capita Water Use

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 (0.5 cmcd) with a range between 90 and 190 gpcd (0.72 cmcd). Generally, per capita water use has decreased which is consistent with the trends shown in Fig. 2.7 which shows a decrease in public water supply withdrawals, despite increases in population.

3.4 Future Predictions

Per capita water use may continue to decline, as a result of increased water use efficiency, if the successes of water conservation strategies continue into the future. Changes in plumbing fixtures and fittings, which went into effect 20 years ago, led to greater water use efficiency. New construction has included the more efficient plumbing and older homes have replaced older plumbing fixtures and installed more efficient appliances. The majority of the benefit gained from these efficiencies may have already been realized; without additional effort and advances water use efficiency may level off and consequently water withdrawals may increase in response to growing population. One way to further increase water efficiency would be to improve the management and condition of water distribution infrastructure, which tends to be old and in need of significant investment 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.

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 served more accurately. Such a model is highly data intensive and requires a significant commitment of staff resources to populate 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 moved and used around 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 in order to separate residential uses from other types of use.

3.6 Summary

Per capita consumption can provide an indication of water use efficiency 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 or may represent an area where increased incentives for water conservation could lead to a reduction in water demand and increased water use efficiency.

4 – Groundwater Availability

4.1 Description of Indicator

Stress on a water 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 No. 2 in south-central New Jersey which overlays the Potomac-Raritan-Magothy (PRM) aquifer (see Figure 2.11). New and/or expanded withdrawals in both of these critical areas are limited and managed subject to specific regulations which serve to allocate the resource on the basis of a sustainable long-term yield.

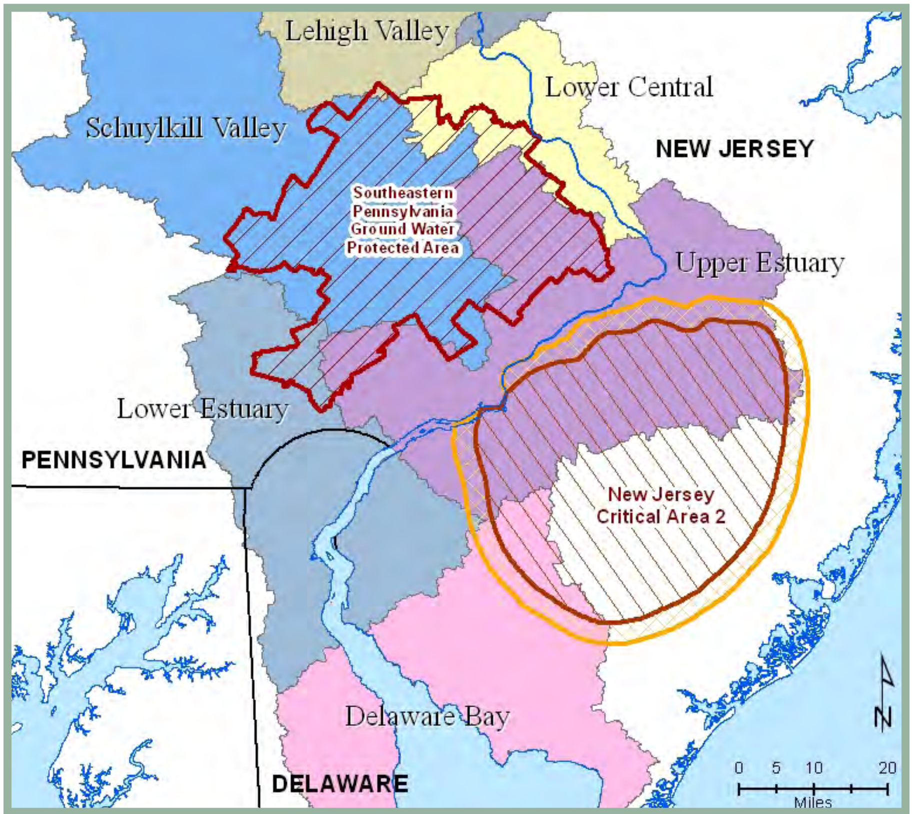

Fig. 2.11. Areas of Groundwater Stress in the Delaware River Basin. (20 mi = 32)

4.2 Present Status

Improving: Conjunctive use strategies and regional alternatives to the local supplies are easing the stress in these two areas.

In the South Eastern Pennsylvania Ground Water Protected Area (SEPA-GWPA) reductions in total annual ground water withdrawals have been observed over the past two decades. The DRBC created a management program for this area in 1980 and in 1999 numerical withdrawal limits were established for each of the area's 76 subbasins. This is the only area for which the Delaware River Basin Commission has cumulative water withdrawal limits. Between 1990 and 2007 total annual ground water withdrawals within the GWPA were reduced by approximately 3.9 billion gallons (10.9 mgd, 0.48 CMS). A significant cause of this reduction is the diversion of surface water from the Point Pleasant, PA intake on the Delaware River in the mid-1990s which alleviated the need for ground water withdrawals for two major public water supply systems in the area and also provided additional supply to Exelon's nuclear power station at Limerick, PA on the Schuylkill River. While this has had a significant impact on the development of the area, its impact in terms of reducing reliance on groundwater use is localized to a few sub-basins. There are other sub-basins that were identified as stressed, or potentially stressed, and their status has mostly remained static, as the management tool of sub-basin cumulative withdrawal limits has prevented further exacerbation of the problem.

4.3 Past Trends

Although individual sub-basin limits were not enacted until 1999, Fig. 2.12 shows several snapshots of the status of the 76 GWPA subbasins over a period of approximately 20 years, from 1990 to 2008. Only one sub-basin, the Upper Wissahickon watershed in Montgomery County, PA (circled in Fig. 2.12) was in excess of the withdrawal limit and that was in 1990 prior to the establishment of withdrawal limits. Groundwater pumping pressure was reduced on this sub-basin by the introduction of the Point Pleasant diversion which brought surface water from the Delaware River to the GWPA.

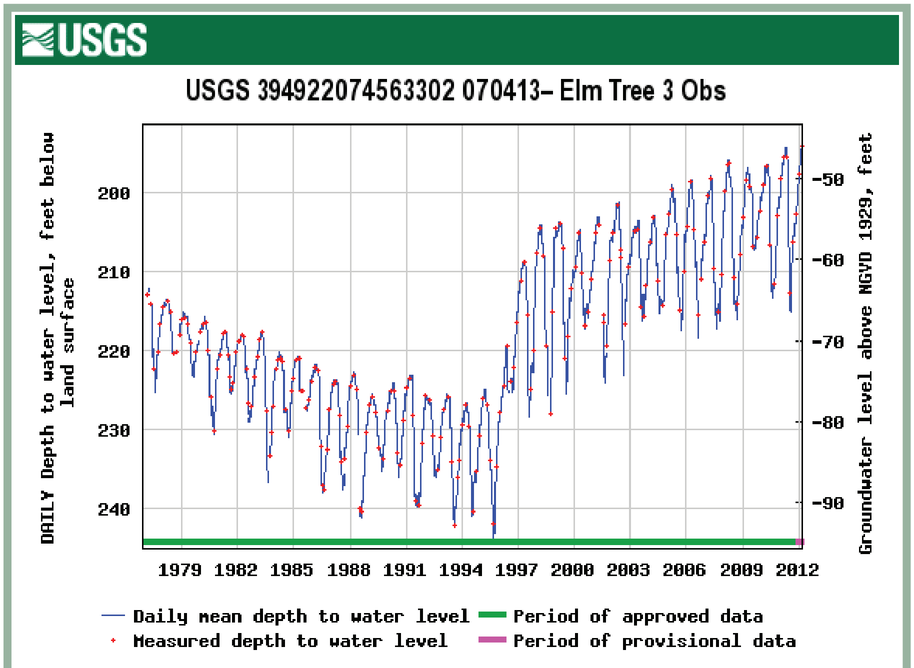

Fig. 2.12. USGS Elm Tree 3 Observation Well

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 (38 CM/mo) triggering regulatory review, as compared to 100,000 gallons/month (378 CM/mo) elsewhere in the Delaware River Basin.

The New Jersey Water Supply Critical Area #2 was established in 1996 by NJDEP 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. As a consequence 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 hydrograph from USGS Elm Tree 3 Observation well (Fig. 2.12), which is located more than 700 ft (213 m) below land surface in the Middle PRM aquifer in Camden, NJ.

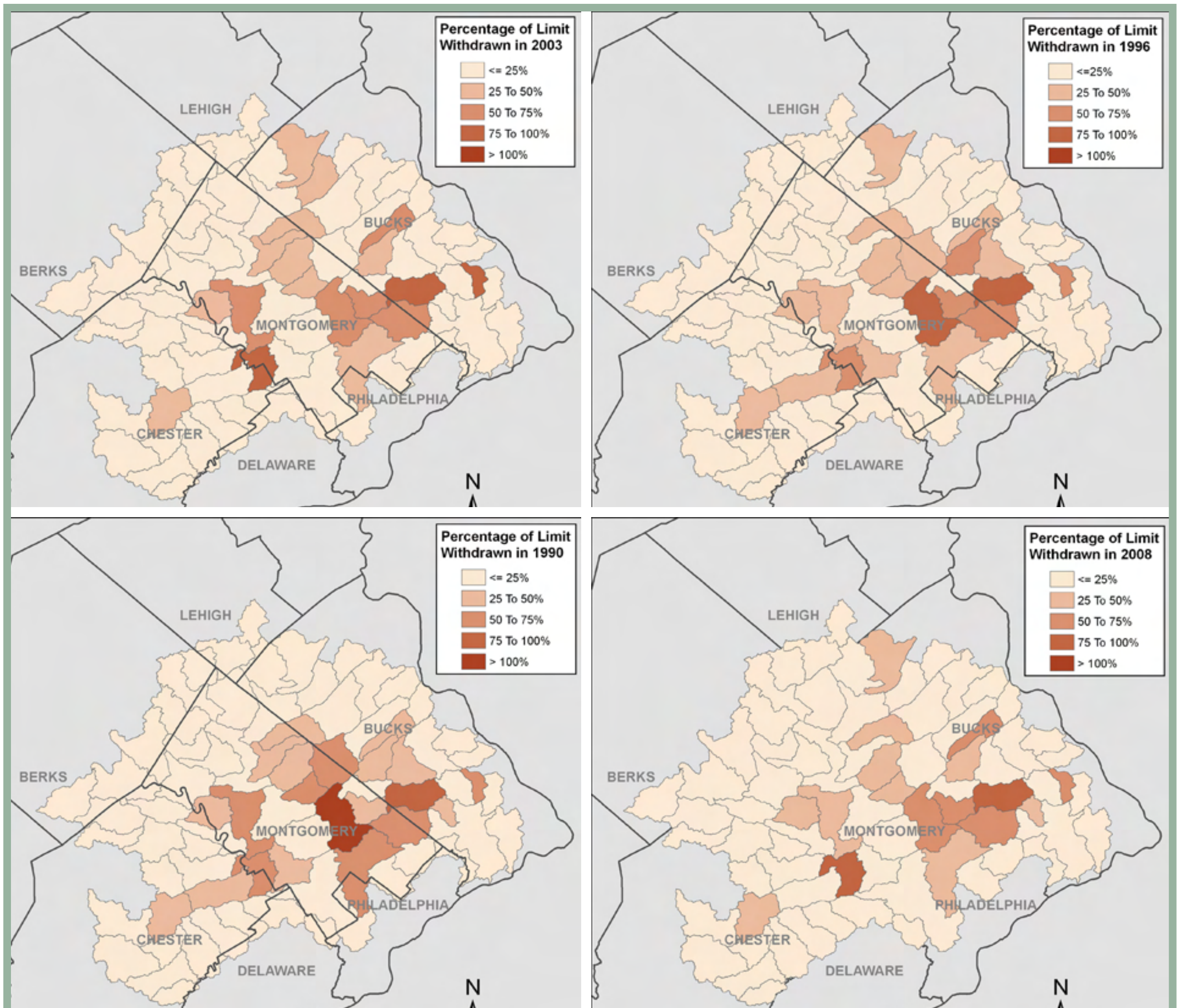

Fig. 2.13. Ground Water Withdrawals as a Percentage of GWPA Subbasin Withdrawal Limits, 1990-2008

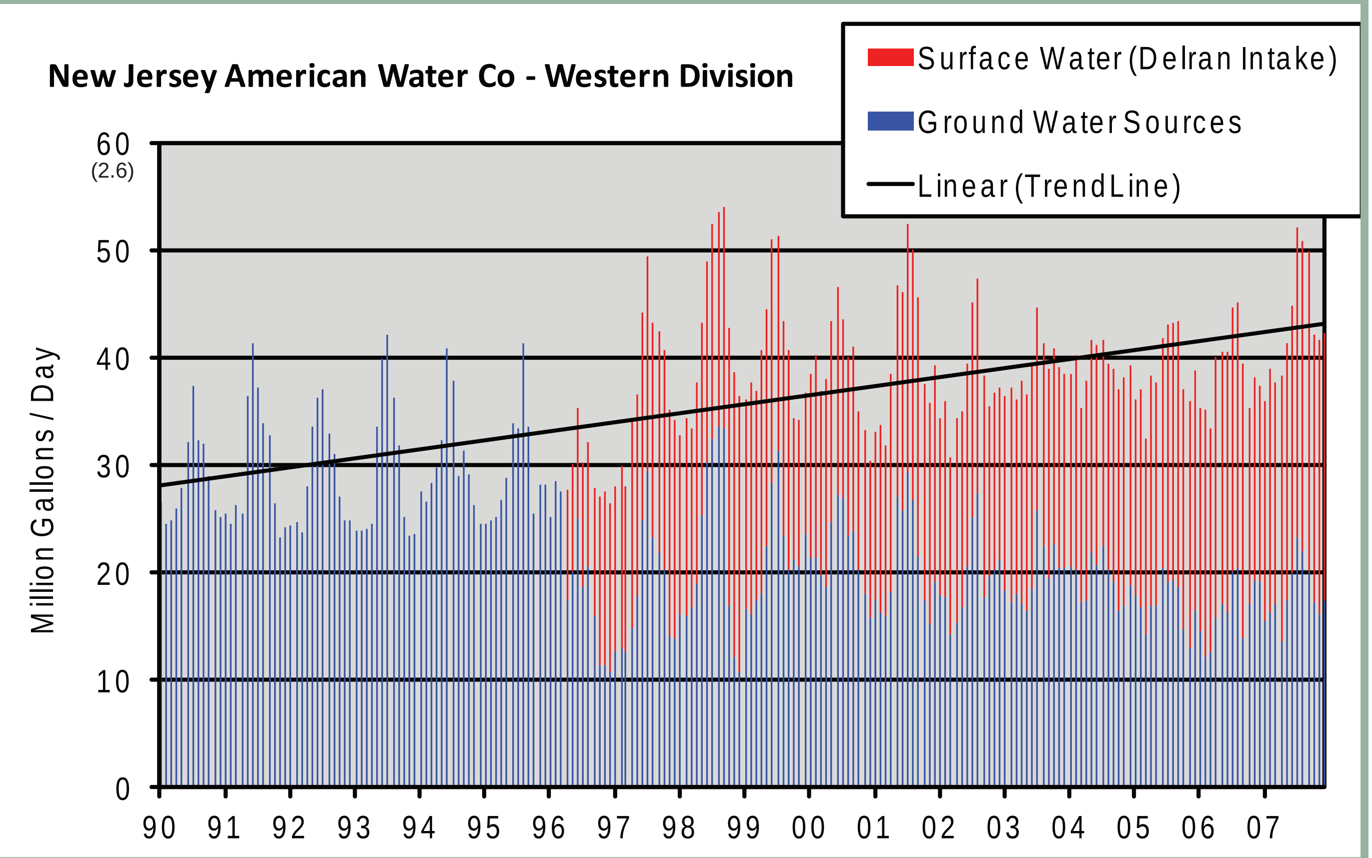

Fig. 2.14. Water Withdrawals by New Jersey American Water Company – Western Division

Fig. 2.14 shows water withdrawals by the New Jersey American Water Company (Western Division) over the past two decades and demonstrates how the Delran surface water intake has simultaneously provided water to meet an increasing demand and has reduced the need for pumping from groundwater sources.

4.4 Future Predictions

The PRM aquifer system extends under the Delaware River, through Delaware and into portions of Maryland. A 2008 report from the USACE on a ground water 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 placed 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.

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.

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.

5 –Salt Line Location & Movement

5.1 Description of Indicator

The salt line is an estimation of where the seven-day average chloride concentration equals 250 ppm along the tidal Delaware River. The location of the salt line 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 Philadelphia Water Department Baxter intake and the New Jersey American Water Company Delran intake. The intakes are both located at approximately river mile 110 (river kilometer 176). In addition, upstream migration of the salt line could adversely affect the PRM aquifer. High rates of pumping in the PRM draw tidal river water into the aquifer. If the salt line 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.

5.2 Present Status

Very good: Drinking water intakes in the tidal river are effectively protected and water quality in the PRM remains very good.

5.3 Past Trends

The salt line 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 line is between the Commodore Barry Bridge (RM 82/KM 131) and Artificial Island (RM 54/KM86). 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 cfs (84.9 CMS) 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 line has been successfully maintained below drinking water intakes, protecting drinking water supplies in the most urbanized area of the Basin (Fig. 2.15).

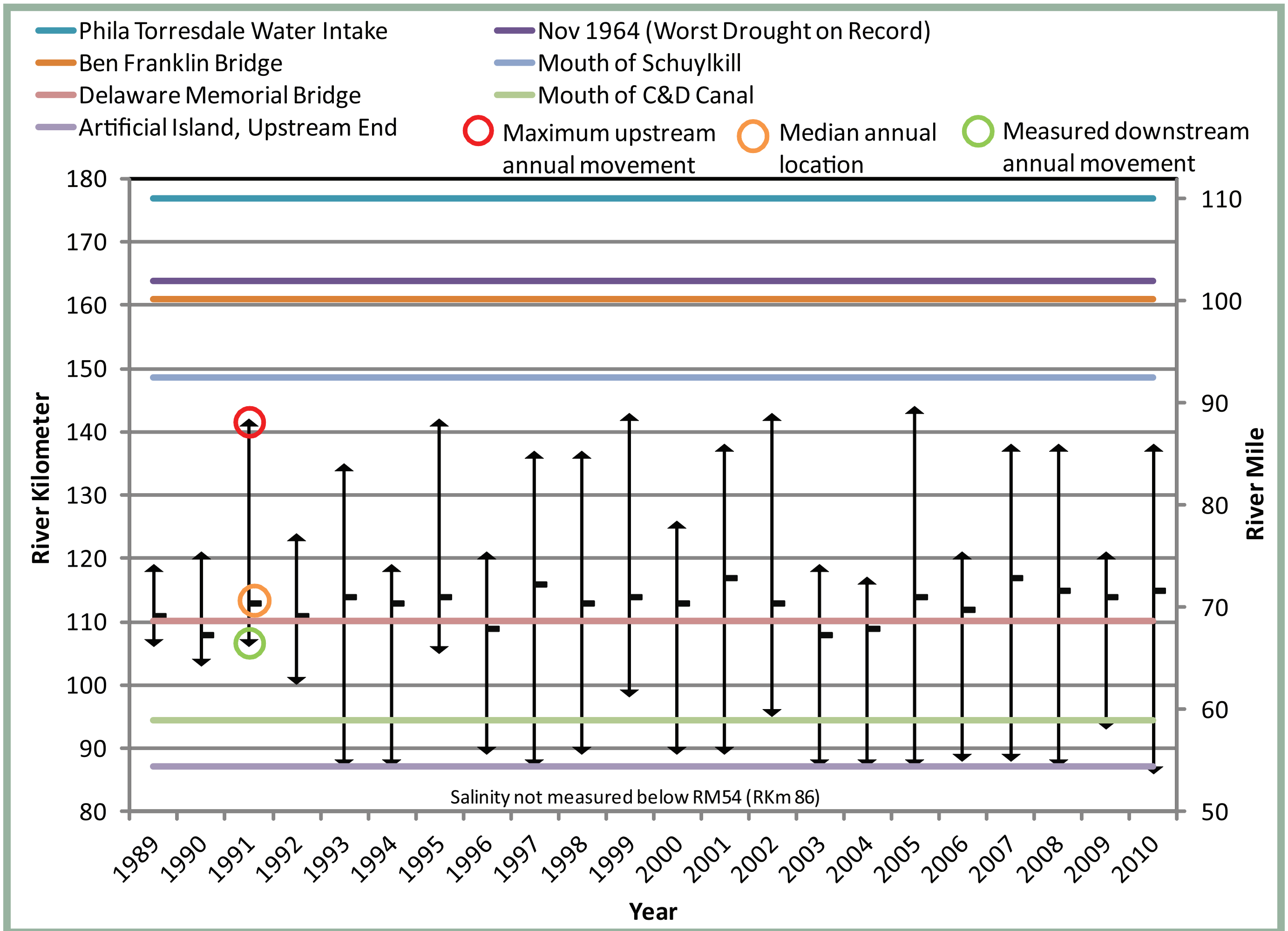

Fig. 2.15. Salt Line Movement 1989-2009.

Fig. 2.15 shows the maximum upstream location, lowest measured downstream location and median location of the salt line for each year during the period 1989 to 2010 compared to locations of interest along the Delaware River. (Note that the salt line 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. 2.15.) Fig. 2.16 shows similar information in map form.

Fig. 2.16. Map of Historic Salt Line Locations.

5.4 Future Predictions

Sea level rise, channel deepening, and increasing variability in flow from climatic change may create additional challenges for management of the salt line in the future.

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 (84.9 CMS) target at Trenton, NJ in repelling the salt line is also warranted.

5.5 Summary

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

Chapter 2 - References and Works Cited

United States Department of Agriculture 2009. 2007 Census of Agriculture. United States Summary and State Data Volume 1 Geographic Area Series Part 51

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