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SUSQUEHANNA RIVER BASIN COMMISSION
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Report Summary

CUMULATIVE WATER USE AND AVAILABILITY STUDY

for the Susquehanna River Basin

OVERVIEW

The Cumulative Water Use and Availability Study (CWUAS) represents the Susquehanna River Basin Commission's (Commission) most comprehensive analysis to date to characterize water use and availability for the Susquehanna River Basin. The effort was driven by the Commission's mission to wisely manage the water resources of the Basin, to assure short-term water resource availability, and to achieve long-term balance between healthy ecosystems and economic viability (Susquehanna River Basin Commission Comprehensive Plan, 2013).

The purpose of the study was to develop and implement an approach to comprehensively assess consumptive water use (CU) within the Basin. As such, the study closely examined water sustainability within the context of existing and projected water use compared to the amount of water estimated to be available during drier, low flow conditions. Overall, the Basin is largely well-balanced in terms of sustainability, with over 82 percent of the watersheds showing adequate water availability when considering approved water use. However, certain areas of the Basin (9 percent) do show potential for availability limitations based on the analysis and warrant further examination of assessed parameters such as water demand and hydrology. Lastly, the study demonstrates that current management practices have the potential for positive effects on managing water resources during a drought.

The scope and findings of the study include:

- comprehensive quantification of consumptive water use;
- determination of water capacity and availability;
- development of two GIS-based assessment tools; and
- consideration of protection, mitigation and enhancement measures.

The study analyses were conducted for 170 distinct watersheds covering the entire Basin. The watersheds correspond to the U.S. Geological Survey's (USGS) designated 10-digit Hydrologic Unit Codes (HUC-10). It is important to note that study results are representative of calculations that broadly characterize conditions across each watershed, but water availability and use can still vary spatially and by season within the individual HUC-10 watersheds.

This summary discusses the methodologies employed for each of the study elements and the respective findings.

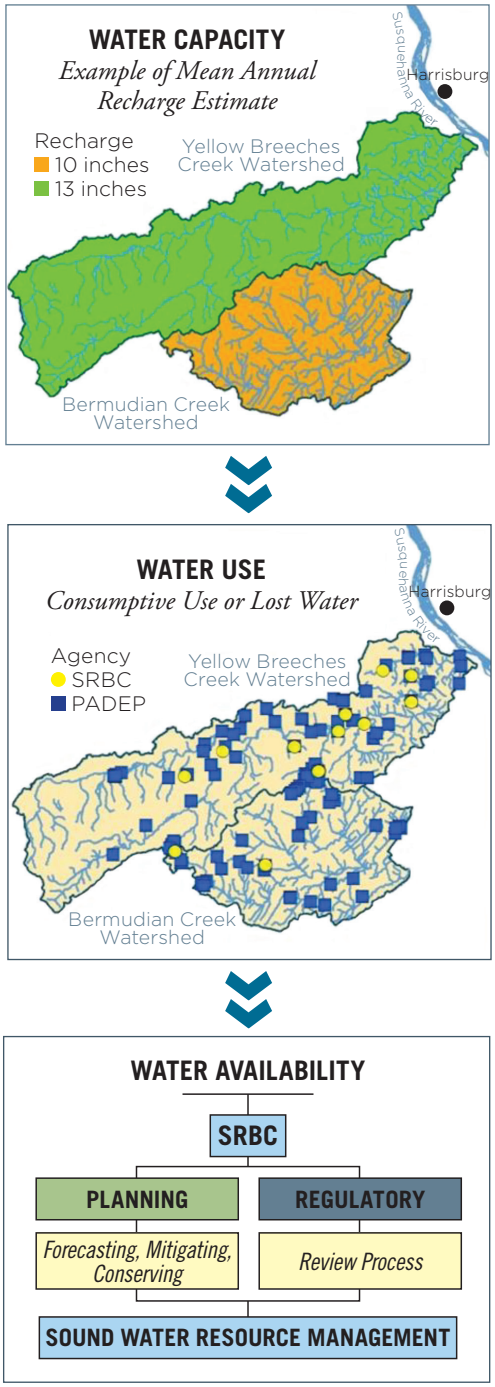
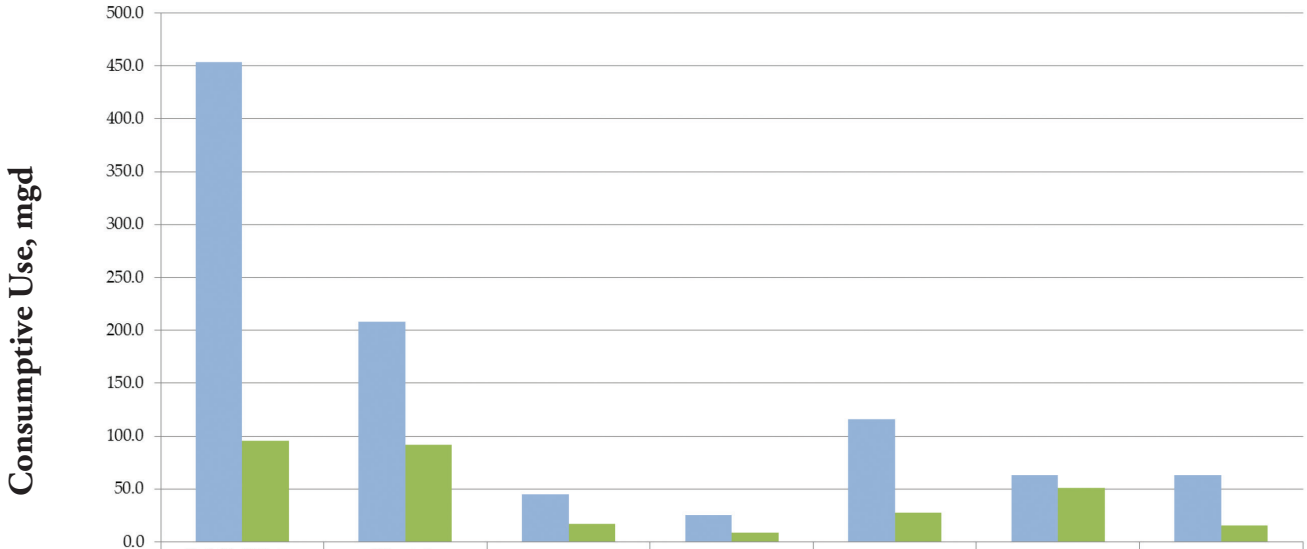


Figure 1. Conceptual model of key Cumulative Water Use and Availability Study *components.*

This is a summary of a full report that can be found at **www.srbc.net**.



	Public Water Supply	Electric Generation	Manufacturing	Mining	Natural Gas	Agriculture	Other
2014 Approved CU	453.8	208.0	45.1	25.3	116.0	63.1	63.4
2014 Reported CU	95.5	92.1	16.8	8.7	27.2	51.0	15.8

Figure 2. Baseline 2014 Approved and Reported Regulated Consumptive Use by Sector

WATER USE

For the purposes of the study, water use broadly refers to water withdrawals and/or CU by public water suppliers, industry, agriculture, and the general public. The Commission defines *consumptive water* use as the loss of water through any process by which the water is not returned to the Basin undiminished in quantity. Examples of CU can include water incorporated in food and beverage products, evaporation and uptake by plants from irrigation, evaporation from power generation as a means of cooling, and other such uses that result in water not being returned to the Basin's rivers and streams in the near-term.

In order to achieve such an assessment, the Commission undertook an unprecedented compilation effort to create a comprehensive water use database that integrates water use records from the Commission, as well as from New York, Pennsylvania, and Maryland state agency records.

Approved (permitted) and reported (actual) water use data were both evaluated for this study. Reported water use quantities were based on actual days used rather than annual averages. A combination of CU records and water withdrawal records converted to CU by applying published CU coefficients were compiled for analysis. Estimates of unregulated CU by the self-supplied residential and agricultural sectors were also generated to allow for a more comprehensive evaluation. Furthermore, projections of CU in 2030 were developed, based on trend analyses and published forecast information, to provide insight into future water use and availability conditions in the Basin.

Results show that the largest water use sectors are public water supply, electric power generation, and agriculture. Basinwide 2014 approved and reported CU were approximately 1 billion gallons per day (bgd) and 370 million gallons per day (mgd), respectively. Projected Basinwide 2030 approved and reported CU, based on trend analysis and published forecast information, were approximately 1.2 bgd and 400 mgd, respectively.

The chart shown in Figure 2 depicts the 2014 CU values for all the major water use sectors. The majority of 2014 approved/reported CU was associated with the public water supply (47/31 percent) and electric power generation sectors (21/30 percent). Approved and reported CU by the natural gas industry were estimated to be 116 mgd (12 percent) and 27.2 mgd (9 percent), respectively. Approved CU was noted to be greater than 50 mgd for 7 percent of the watersheds in the Basin, primarily associated with mainstem rivers, with the use in these watersheds coinciding with populations centers and/or related to significant industrial uses. It is important to note that a large portion of the

For context, one million gallons of water is enough to fill two Olympic sized swimming pools. The average American uses 80-100 gallons of water per day. A community of 11,250 people would use approximately 1 million gallons of water per day.

public water supply CU includes the diversion of water outside of the Basin to the City of Baltimore and the Philadelphia area (Chester Water Authority).

The following provides a water use profile for the majority of the watersheds in the Basin:

- 74 percent had approved CU less than 10 mgd;
- 65 percent had approved CU less than 5 mgd; and,
- 32 percent had approved CU less than 1 mgd.

Water use was found to be greatest for mainstem river and major tributary watersheds, as a function of the cumulative nature of the analysis. These watersheds are also host to the major population centers and industrial facilities in the Basin. In general, areas of the Basin experiencing the least amount of water uses generally coincided with the smaller watersheds in more rural, forested settings. In some of the more populated areas of the Basin, such as Binghamton, Williamsport, Harrisburg, and York, consumptive water use by individual public water supply systems and industry generally ranges from 0.750 mgd to 3.0 mgd.

Evaporative cooling at certain types of power generation facilities represents a significant use of water in the Basin (Three Mile Island Nuclear Power Station pictured).

HYDROLOGIC ANALYSES

Hydrologic analyses were conducted to develop a comprehensive set of low flow, baseflow, mean flow, and monthly percent exceedance flow statistics for gaged and ungaged watersheds. For gaged watersheds, streamflow statistics were computed directly from USGS streamgage data. For calculating streamflow statistics in ungaged settings, a set of regression equations was developed based on watershed characteristics. The goal was to use the range of statistics to identify and assess several measures of water capacity, as defined in the next section, in order to establish estimates of sustainable limits for development of water resources in the Basin.

WATER CAPACITY

Water capacity is usually considered in the context of low flow conditions to ensure sustainable water resources. Typically, only a portion of the estimated water capacity is intended for development, while the remainder serves as reserved capacity to avoid conflicts among water users and ecological impacts.

After thorough analysis of various approaches and metrics, the l*ow flow margin method* was determined to be the water capacity determination approach that best addressed the Commission's objectives with respect to sustainable water development and ecosystem protection. The method establishes available capacity as 50 percent of the 10-year baseflow minus the September P75/P95 flow. The *10-year baseflow* component is the estimated quantity of groundwater flow to a stream during a low flow event, while the *September P75/P95* flow component is the minimal quantity of streamflow needed to provide protection

WATER CAPACITY
is the natural ability of a watershed to sustainably provide streamflow over time, during varied climatic conditions.
New Jersey Highlands Council, 2008

Staff measuring streamflow during normal conditions.

of the stream ecosystem during low flow conditions. The choice of the upper and lower low flow statistics to be used in the method was made by referring to two earlier Commission publications, the Groundwater Management Plan (GWMP) (SRBC, 2005) and the Low Flow Protection Policy (LFPP) (SRBC, 2012). The combination of both statistics and a safety factor was chosen by the Commission to represent the most reasonable management goal given its balanced approach.

Water capacity for the Basin was estimated at 4.4 billion gallons per day. The following provides a water capacity profile for the watersheds in the Basin:

- For 56 percent of the watersheds, water capacity was greater than 25 mgd;
- For 88 percent of the watersheds, water capacity was greater than 10 mgd; and
- For 97 percent of the watersheds, water capacity was greater than 5 mgd.

In general, greater water capacities are observed along the mainstem Susquehanna River and in portions of the Upper and West Branch Susquehanna subbasins. Limited water capacities were estimated for headwater watersheds with drainage areas generally less than 100 square miles, with most of the watershed units with the lowest capacities in the Lower Susquehanna subbasin. Water capacity was largely controlled by a few key factors including drainage size, precipitation, and geology.

WATER AVAILABILITY *is defined as the hydrologic capacity of a water source or watershed to sustain additional water demands after considering current water uses and water conditions.*

Global Environmental Management Initiative, 2012

WATER AVAILABILITY

For the study, water availability for Basin watersheds was calculated by subtracting CU in the watershed from the calculated water capacity. The remaining balance represents additional water available for sustainable water resources development. Water availability deficits signify watersheds in which additional water planning and/or management efforts may be needed.

Total water availability for the Basin was calculated at 3.3 billion gallons per day based on total 2014 approved CU. The following provides a water availability profile for the watersheds in the Basin:

- For 54 percent of watersheds, water availability was greater than 25 mgd;
- For 82 percent of the watersheds, water availability was greater than 10 mgd; and
- For 91 percent of the watersheds, water availability was greater than 5 mgd.

In general, water availability was greatest in the northern and western portions of the Basin, typically corresponding to areas with higher water capacities and/or lower water usage. Conversely, the lower portions of the Basin exhibited more limited water

availability, with several watersheds in the Lower Susquehanna subbasin assessed at less than or equal to 0 mgd, or no remaining availability. Figure 3 shows how water availability varies throughout the Basin based on both approved (2014) and projected CU (2030). *Zero remaining availability* indicates that low water capacity and moderate/high water use may pose conflicts regarding water needed to support public health and safety and sustain healthy aquatic ecosystems during critical low flow conditions, but not that water use is depleting waterways completely.

The assessment of water availability for Basin watersheds also incorporated a review of watersheds previously identified as critical or stressed in related water planning efforts. These included Potentially Stressed Areas (PSA) and Water Challenged Areas (WCA) identified in the Commission's GWMP and Pennsylvania State Water Plan Critical Water Planning Area (CWPA) recommendations (Pennsylvania Department of Environmental Protection, 2009). These sensitive areas were mapped and used to validate water availability results generated during the study process. The effort also helped confirm the suitability of the selected water capacity threshold for assessing water availability in Basin watersheds.

Projections of future water use in the Basin were developed to provide insight into potential future water availability conditions. Availability based on total projected 2030 approved CU for the Basin decreased to approximately 3.2 bgd from 3.3 bgd in 2014. The most considerable decreases in water availability were attributed primarily to projected increases in public water supply use. Projected 2030 water availability was less than 2014 quantities for each subbasin, due to projected increases in total approved CU. However, none of the subbasins are projected to experience a reduction greater than 5 percent. Overall, 84 percent of the watersheds in the Basin are projected to experience a decrease in water availability from 2014 to 2030, although only 10 percent of them saw a reduction greater than 5 mgd.

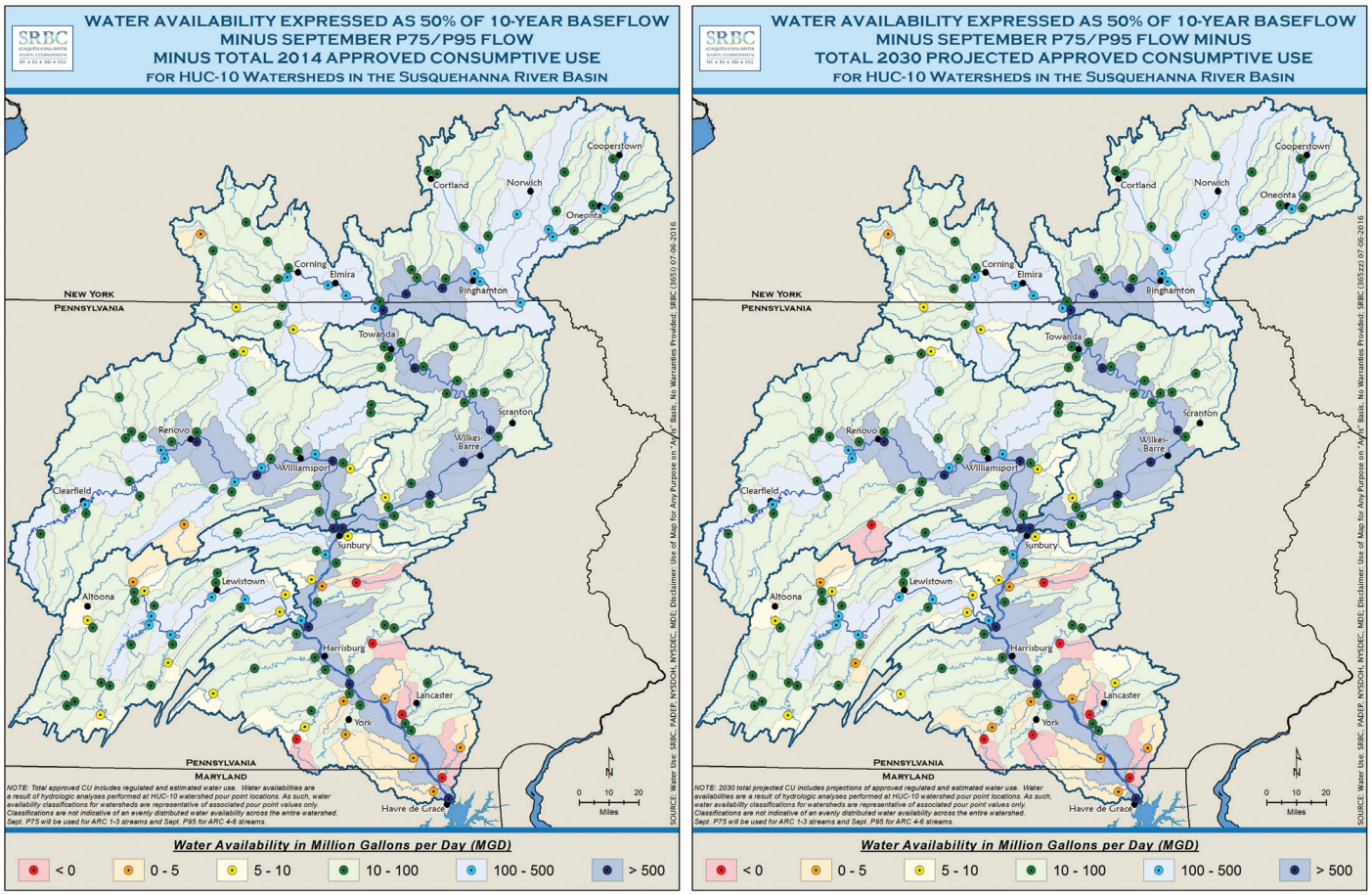


Figure 3. Water Availability for HUC-10 Watersheds Based on Total 2014 Approved and Total 2030 Projected Consumptive Use.

PROTECTION, MITIGATION, AND ENHANCEMENT MANAGEMENT MEASURES

As part of the study, various protection, mitigation, and enhancement (PM&E) management measures were evaluated with respect to effects on total water use and availability within Basin watersheds. The ability to assess the impact of these measures was particularly important for PSA and other regions with possible water supply and demand conflicts. PM&E measures were applied to water use amounts to simulate likely voluntary or mandatory reductions or offsets of CU during a drought. PM&E measures included water use reductions, passby flows, conservation releases, release of water to offset and mitigate CU, and others.

After evaluating each of the singular PM&E measures mentioned above, the Commission sought to assess the aggregate effects of these practices on water use and availability for Basin watersheds. The combined influence of 20 percent water use reductions, P95 passby flows, and CU mitigation releases resulted in over 500 mgd of CU reductions and offsets Basinwide, which is approximately half the overall estimated CU for the Basin.

The CU reductions and offsets vary spatially throughout the Basin due to the nature of CU and the management measures available. Significant reductions and offsets were noted for the Basin as a whole (544.2 mgd). From that total, the Middle Susquehanna subbasin carries a large portion of the reductions and offsets at 238.4 mgd. The map shown in Figure 4 shows generally how reductions and offsets are distributed throughout the remainder of the Basin.

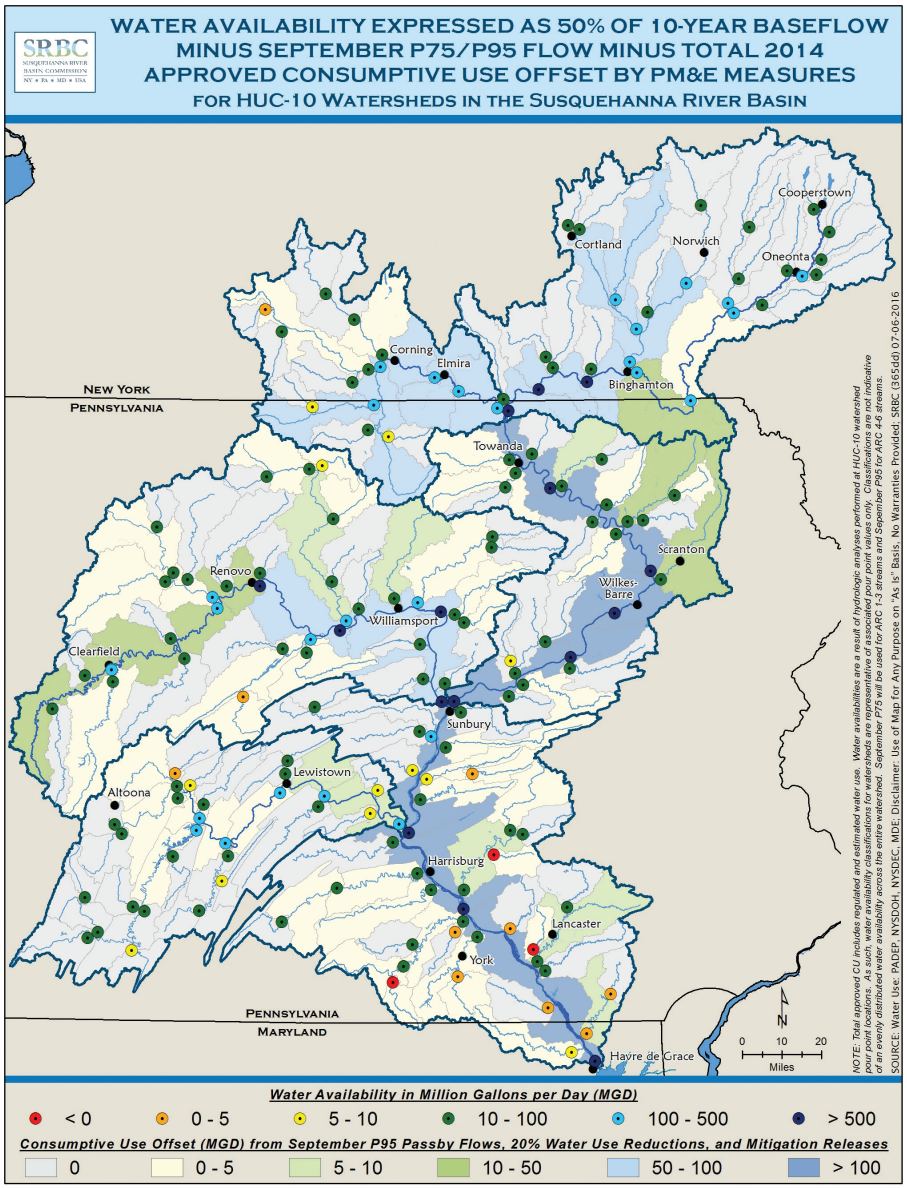


Figure 4. Water Availability Based on Consumptive Use Reductions & Offsets Realized from Simulation of Select PM&E Measures.

Existing PM&E measures have not historically been in place in watersheds with limited water availability, which represents an opportunity for improved management. Future study efforts are expected to integrate a more inclusive list of potential water quantity PM&E practices.

On average, golf courses in the Basin consumptively use approximately 70,000 gallons of water per day to irrigate their fairways and greens during the summer season. Based on this average, it would take approximately 15 golf courses to consumptively use 1 million gallons of water per day.

Basin stream under low flow conditions.

PLANNING TOOLS

Two planning tools were developed to capitalize on study findings and advance the applicability of the comprehensive water use database and water capacity metrics for assessing water availability throughout the Basin. The Commission developed a data-driven, GIS-based web tool that provides a series of analytical components for automating the quantification of water use, capacity, and availability at user-defined locations throughout the Basin. The tool allows Commission and member agency staff to delineate a watershed, generate watershed characteristics and flow statistics, compute regulated, estimated, and projected CU, and calculate water capacity and availability.

The Commission also developed a publicly accessible, interactive web map for use by project sponsors, consultants, agencies, non-governmental organizations, academicians, and the public. The web map displays map layers depicting approved and reported CU, water capacity, and water availability summarized by watershed. Users can select a watershed of interest and identify key attributes related to water use, capacity, and availability. The web map is available among the suite of mapping applications found on the Commission's website at www.srbc.net.

CONCLUSIONS

The study provides valuable insight regarding the existing and projected state of water use and availability in the Susquehanna River Basin, along with an evaluation of the potential influence of various management measures in mitigating impacts during low flow conditions.

The conclusions include:

- Water capacity for most Basin watersheds was found to be adequate to satisfy existing/projected consumptive use while avoiding water demand conflicts and adverse ecological impacts.
- Water availability for approximately 9 percent of Basin watersheds shows potential for limitations based on the analyses and warrant further study to better understand local conditions.
- Simulating implementation of various protection, mitigation, and enhancement measures, including passby flows and consumptive use mitigation releases, found the measures to be effective in curtailing, reducing, or offsetting consumptive use, to varying degrees, during low flow conditions.

In addition:

- Two planning tools were developed to leverage study results, enhance interagency coordination and data sharing, inform water resources management decision making, and provide increased transparency for the regulated community, Basin stakeholders, and the general public.

RECOMMENDATIONS

The Commission developed a set of recommendations for improving evaluations of cumulative water use and availability to address water resource management challenges. They are intended to serve as a guide for Commission staff and water resources professionals involved in development and management of the water resources of the Basin.

The recommendations include:

- Verifying water use and discharge information associated with significant projects located in watersheds with relatively high cumulative consumptive use, and taking steps where necessary to fill existing information gaps regarding accurate valuations of unregulated water uses.
- Confirming low flow characteristics with continuous streamflow monitoring and/or field investigations during drought events for identified watersheds with limited water capacity available to support water resources development.
- Conducting finer scale water availability analyses and/or detailed water budget studies, in partnership with local stakeholders, for identified watersheds with relatively low water availability.
- Continuing to impose appropriate limiting conditions on water uses recognizing reasonable foreseeable needs, standards for passby flows, conservation releases, and consumptive use mitigation requirements, particularly in watersheds identified as having limited water capacity and/or availability.

REFERENCES

Global Environmental Management Initiative. 2012. *GEMI Local Water Tool*. Washington D.C.

New Jersey Highlands Council. 2008. *Water Resources Volume II Water Use and Availability*. Technical Report in Support of the Highlands Regional Master Plan.

Pennsylvania Department of Environmental Protection. 2009. *The Pennsylvania State Water Plan and Act 220 of 2002*. Harrisburg, Pennsylvania.

Susquehanna River Basin Commission. 2013. *Comprehensive Plan for the Water Resources of the Susquehanna River Basin*. Harrisburg, Pennsylvania.

Susquehanna River Basin Commission. 2012. *Technical Guidance for Low Flow Protection Related to Withdrawal Approvals*. Under Policy 2012-01. Harrisburg, Pennsylvania.

Susquehanna River Basin Commission. 2005. *Groundwater Management Plan for the Susquehanna River Basin*. Publication No. 236. Harrisburg, Pennsylvania.