A REPORT TO

THE HONORABLE RALPH S. NORTHAM, GOVERNOR,

AND

THE GENERAL ASSEMBLY OF VIRGINIA

STATUS OF VIRGINIA'S WATER RESOURCES

A REPORT ON VIRGINIA'S WATER RESOURCES MANAGEMENT ACTIVITIES

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
COMMONWEALTH OF VIRGINIA

OCTOBER 2018

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ACRONYMS

AG: Agriculture
CAG: Citizen Advisory Group
CWS: Community Water System
DEQ: Department of Environmental Quality
DL: Delivery
DMME: Department of Mines, Minerals, and Energy
DMTF: Drought Monitoring Task Force
GIS: Geographic Information System
GPD: Gallons per Day
GPM: Gallons per Minute
GW: Groundwater
GWMA: Groundwater Management Area
JPA: Joint Permit Application
MAN: Manufacturing
MGD: Million Gallons per Day
NWIS: USGS National Water Information System
OWS: Office of Water Supply
PDC: Planning District Commission
PWS: Public Water System
RL: Release
RAP: Regulatory Advisory Panel
SD: System Delivery
SR: System Release
SW: Surface Water
SWCB or Board: State Water Control Board
SWIP: Surface Water Investigations Program
SWMA: Surface Water Management Area
SWRP or Plan: State Water Resources Plan
TMDL: Total Maximum Daily Load
USACE: United States Army Corps of Engineers
USEPA: U.S. Environmental Protection Agency
USGS: United States Geological Survey
VDH: Virginia Department of Health
VMRC: Virginia Marine Resources Commission
VWP: Virginia Water Protection (Permit Program)
VWUDS: Virginia Water Use Data System
WL: Withdrawal
WTP: Water Treatment Plant
WWR: Water Withdrawal Reporting (Regulation)

EXECUTIVE SUMMARY

The Report on Virginia's Water Resources Management Activities (Annual Report) is submitted in October of each year to the Governor and the Virginia General Assembly in accordance with § 62.1-44.40 of the Code of Virginia. The Annual Report focuses on water quantity and supply, summarizing reported water withdrawals for the 2017 calendar year, discussing water withdrawal trends, and providing an update on the Commonwealth's water resources management activities. The Annual Report also serves as a status report concerning the State Water Resources Plan between five year planning reviews.

Water quality issues are addressed in the most recent biennial *Water Quality Assessment Integrated Report*, published by the Department of Environmental Quality (DEQ).

State Water Resources Plan

The State Water Resources Plan (SWRP) was finalized and released to the public in October 2015. The SWRP identified some potential areas of concern as well as challenges for future water resources management and recommendations for action.

Data analysis conducted during development of the SWRP predicted a net increase of approximately 32% in mean daily water demand over the planning period, indicating that an estimated 450 million gallons per day (MGD) of additional water will be needed to meet projected 2040 demands. SWRP-related activities conducted during 2017 focused on facilitation of the five-year review of the local and regional water supply plans that are required by the Local and Regional Water Supply Planning Regulation (9VAC25-780) . Facilitation of the plan reviews is aimed at achieving the best possible revised estimates of projected future water demands. To assist in this effort, DEQ initiated a pilot project in 2017 to test a new Water Supply Planning module in the VaHydro water availability modeling and analysis tool in order to receive stakeholder feedback prior to a statewide release of the module. These efforts are also initial steps to address Recommendations 2 and 3 in the Joint Legislative Audit and Review Commission's (JLARC) October 2016 report titled "Effectiveness of Virginia's Water Resource Planning and Management" concerning surface water sustainability.

Cumulative impact analyses conducted during preparation of the SWRP indicated that projected surface water withdrawal increases may result in negative impacts during future drought situations, particularly within the James, Potomac-Shenandoah, and York River basins. These areas were prioritized for outreach and planning discussions regarding required five-year reviews which are due in December 2018. As of September 5, 2018, 183 localities (17 cities, 38 counties, and 128 towns) have completed the required five-year reviews for their water supply plans. There are 323 localities in Virginia: 38 cities, 95 counties, and 190 towns, all of which are required to have water supply plans, or to participate in a regional water supply plan.

The SWRP also identified gaps in water-withdrawal reporting as a challenge for water resource management. Efforts during 2017 to address this challenge focused on improving reporting by the agricultural sector, resulting in eight additional farm facilities registered through DEQ's outreach efforts. Additional information is obtained through the private water well registration program, which enables DEQ and Virginia Department of Health (VDH) to receive water well completion reports. As of December 31, 2017, 4,173 water well completion records were submitted online via VA Hydro.

Coastal Plain Aquifer System

While the Virginia Coastal Plain Groundwater Initiative has been successful in reducing permitted withdrawals from the coastal plain aquifer system by about 50%, these reductions alone are not

sufficient to ensure the availability of the aquifer system as a reliable water source for the future. To maintain the gains made through these reductions, new or expanding withdrawals from the Potomac Aquifer must also be limited. In all cases, groundwater withdrawal permit applicants seeking a withdrawal from confined coastal plain aquifers must supply a significant rationale supporting the necessity of the use of high-quality groundwater over other available sources such as surface water, re-use, or lower-quality groundwater from the surficial aquifer.

However, reductions are not the only method to address the resource issue. The Hampton Roads Sanitation District (HRSD) is currently working to reverse groundwater declines through direct injection of highly-treated water into the Potomac Aquifer. HRSD's Sustainable Water Initiative for Tomorrow (SWIFT) project seeks to eventually inject up to 120 MGD via injection sites across the HRSD service area. A pilot test is currently underway at the SWIFT Research Center where 1 MGD is being treated and injected. However, the ultimate benefits of large-scale injection may not be known for a decade or more.

DEQ is continuing to work with permitted groundwater withdrawal facilities to decrease net withdrawals, to identify alternate sources of water, and to investigate other innovative ways to increase supplies in order to maintain groundwater productivity and availability over the next 50 years and beyond.

In 2017, DEQ began a Compliance Assistance Framework outreach initiative designed to assist unpermitted groundwater users in the Groundwater Management Areas (GWMAs) to determine if a groundwater withdrawal permit is required and to begin the permitting process as necessary. As a result of this initiative, DEQ received 38 applications during 2017 and early 2018 from unpermitted groundwater users seeking to obtain groundwater withdrawal permits. This group includes a large number of poultry farms on the Eastern Shore with whom DEQ began a separate effort that will ultimately result in bringing additional unpermitted poultry facilities into compliance with the Groundwater Withdrawal Regulations (9VAC25-610).

The Eastern Virginia Groundwater Management Advisory Committee, established pursuant to § 62.1-256.1 of the Code of Virginia, to assist the State Water Commission and DEQ in "developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia Groundwater Management Area," held meetings during March, April, May, June, and July 2017. The committee presented its recommendations to the State Water Commission and the DEQ Director on August 4, 2017. The DEQ Director issued a report responding to the Committee's recommendations on November 1, 2017 pursuant to § 62.1-256.1(C) of the Code of Virginia. Information about the activities of the Committee is posted on the DEQ Eastern Virginia Groundwater Management Advisory Committee webpage. To address these recommendations, DEQ is continuing its efforts to reach out to unpermitted agricultural facilities regarding their water withdrawals. DEQ has also begun development of a methodology to coordinate and conduct technical evaluations of withdrawals from private wells proposed by certain large subdivisions in GWMAs pursuant to § 62.1-259.1 of the Code of Virginia (2018 Va. Acts Ch. 427).

On Tuesday, October 17, 2017, DEQ held its first groundwater stakeholder forum in Richmond, Virginia. At this meeting DEQ presented the results of its 2016-2017 simulation of groundwater surface elevations of reported use and total permitted use for the Eastern Virginia and Eastern Shore Groundwater Management Areas. DEQ also presented information on recent updates to its Virginia Coastal Plain and Virginia Eastern Shore Groundwater Models. Finally, the United States Geological Survey (USGS) presented information on its ongoing efforts to update the existing hydrogeologic

framework and conditions of the Eastern Shore aquifer system. The 2018 groundwater stakeholder forum is tentatively scheduled for Tuesday, October 30, 2018 in Richmond, Virginia.

WATER WITHDRAWALS

Water withdrawals were reported in January 2018 by 1,624 facilities for calendar year 2017. Compared to the recent five-year (2013-2017) average, the total volume of reported withdrawals from all water use categories (including fossil-fuel and nuclear power generation) decreased by approximately 7%. However, the total volume of reported withdrawals increased by 3% excluding the power generation use categories.

Surface water withdrawals had a higher proportion of the total water withdrawal volume by source type in 2017, which is comparable to 2013 through 2017. Surface water withdrawals also accounted for approximately 90% of total withdrawal volumes in 2017 (excluding withdrawals for power generation), which is equivalent to the five previous years.

Analysis of the spatial distribution of 2017 water withdrawals in Virginia indicates that, as in previous years, the largest groundwater withdrawals by volume predominantly occurred in the Coastal Plain, Eastern Shore, and Shenandoah Valley regions.

Withdrawals for Public Water Supply and for Manufacturing were again the largest sources of withdrawals for 2017 and for the average of the previous five-year period. Manufacturing makes up the highest proportion of groundwater withdrawals, whereas public water supply use accounts for the greatest proportion surface water withdrawals by volume.

I. INTRODUCTION

The waters of Virginia are among the state's most treasured resources. The citizens of the Commonwealth are able to enjoy more than 100,000 miles of non-tidal streams and rivers, 248 publicly-owned lakes, about 236,000 acres of tidal and coastal wetlands, about 808,000 acres of freshwater wetlands, 120 miles of Atlantic Ocean coastline, and more than 2,800 square miles of estuaries. In addition to the publicly-owned lakes, there are hundreds of small, privately-owned lakes and ponds distributed throughout the state. Statewide, rainfall averages are close to 43 inches per year, and the total combined flow of all freshwater streams is estimated at about 22.5 billion gallons per day.

DEQ coordinates the management of water quantity and supply across the Commonwealth of Virginia through five programs: Water Supply Planning, Water Withdrawal Permitting and Compliance, Groundwater Characterization, Environmental Data and Analysis, and Drought Assessment and Response. DEQ's Surface Water Investigations Program also supports water resources management because the collection and evaluation of surface water discharge data is critical to the operation of all DEQ water supply programs. Details regarding each program area are provided in Chapter II. The DEQ Water Supply and Water Quantity webpage provides additional information.

The Report on Virginia's Water Resources Management Activities (Annual Report) is submitted in October of each year to the Governor and the Virginia General Assembly in accordance with § 62.1-44.40 of the Code of Virginia. The Annual Report focusses on water quantity and supply, summarizing reported (including permitted) water withdrawals for the 2017 calendar year, discussing water withdrawal trends, and providing an update on the Commonwealth's water resources management activities. The 2017 annual water withdrawals were reported to DEQ in January 2018, then processed, analyzed, and formatted for presentation in the current Annual Report. The Annual Report also includes summaries of current climatologic conditions and available hydrologic information for the Commonwealth as a whole for the 2018 water year [1] (Appendix 1). The Annual Report also serves as a status report concerning the State Water Resources Plan between five year planning reviews.

Water quality issues are addressed in the most recent biennial *Water Quality Assessment Integrated Report*, published by DEQ and available on the DEQ website.

II. 2017 WATER RESOURCES MANAGEMENT UPDATES

Although Virginia historically has enjoyed plentiful water resources relative to demand, the growth of the Commonwealth's economy and population continues to present a challenge for maintaining both the quality and quantity of these resources for the duration of typical water supply planning periods. The state's water resources are used for a variety of important and sometimes competing in-stream and off-stream uses. Over the past decade, increased demand and competition for water have established a greater sense of urgency in Virginia's approach to resource management to avoid problems over the long term. This means placing a greater emphasis on collaboration with planning partners and permittees to find cost-effective solutions that conserve the Commonwealth's water resources and ensure their ability to support all beneficial uses into the future.

[1] The USGS uses the term "water year" in reports that deal with surface-water supply, defining it as the 12-month period of October 1, for any given year through September 30, of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2018 is called the "2018 water year."

DEQ's mission is "to protect and enhance Virginia's environment, and promote the health and well-being of the citizens of the Commonwealth." To that end, DEQ works to identify, quantify, and manage current and future risks to the productivity and availability of Virginia's water resources.

The Eastern Virginia Groundwater Management Advisory Committee, established pursuant to § 62.1-256.1 of the Code of Virginia, to assist the State Water Commission and DEQ in "developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia Groundwater Management Area," held meetings during March, April, May, June, and July 2017. The committee presented its recommendations to the State Water Commission and the DEQ Director on August 4, 2017. The DEQ Director issued a final report to the Governor in response to the Committee's recommendations on November 1, 2017 pursuant to § 62.1-256.1(C) of the Code of Virginia. The DEQ Eastern Virginia Groundwater Management Advisory Committee webpage provides additional information.

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The following sections briefly discuss the various DEQ programs involved in water resources planning and management (Water Supply Planning and Reporting, Water Withdrawal Permitting and Compliance, Groundwater Characterization, Drought Assessment and Response, Surface Water Investigations, and Environmental Data and Analysis) as well as updates for 2017. The DEQ Water Supply and Water Quantity webpage provides additional information.

Water Supply Planning

The Local and Regional Water Supply Planning Regulation[2] requires development of local, regional, and state water supply plans describing, among other things, environmental resources, existing and anticipated water sources, and existing and projected water use and demand. Local and regional planning partners submitted their plans to DEQ no later than November 2011, depending upon statutory requirements. Following submission, staff reviewed all 48 plans (Figure 1) for consistency with the regulations, completing the compliance evaluation process with the issuance of final compliance packages to all planning partners in late 2013.

The water supply plans formed the basis of the State Water Resources Plan (SWRP), which staff began developing concurrent with the plan review process. Completed in draft form in late 2014, the SWRP was released for public comment in April 2015. The final SWRP was published in October 2015.

The SWRP was the first of its kind in Virginia and is the primary planning mechanism for achieving sustainable water supplies for the future. The document provides a statewide look at information provided by local and regional water supply plans, and the results of a cumulative impact analysis conducted using data from the plans and water withdrawal data submitted by individual users under the

[2] 9VAC25-780-10 et seq.

Water Withdrawal Reporting Regulation.[3] The SWRP also describes major water supply challenges facing the Commonwealth through 2040 and makes recommendations for addressing those challenges. A summary of the challenges and recommendations is provided in Chapter V.

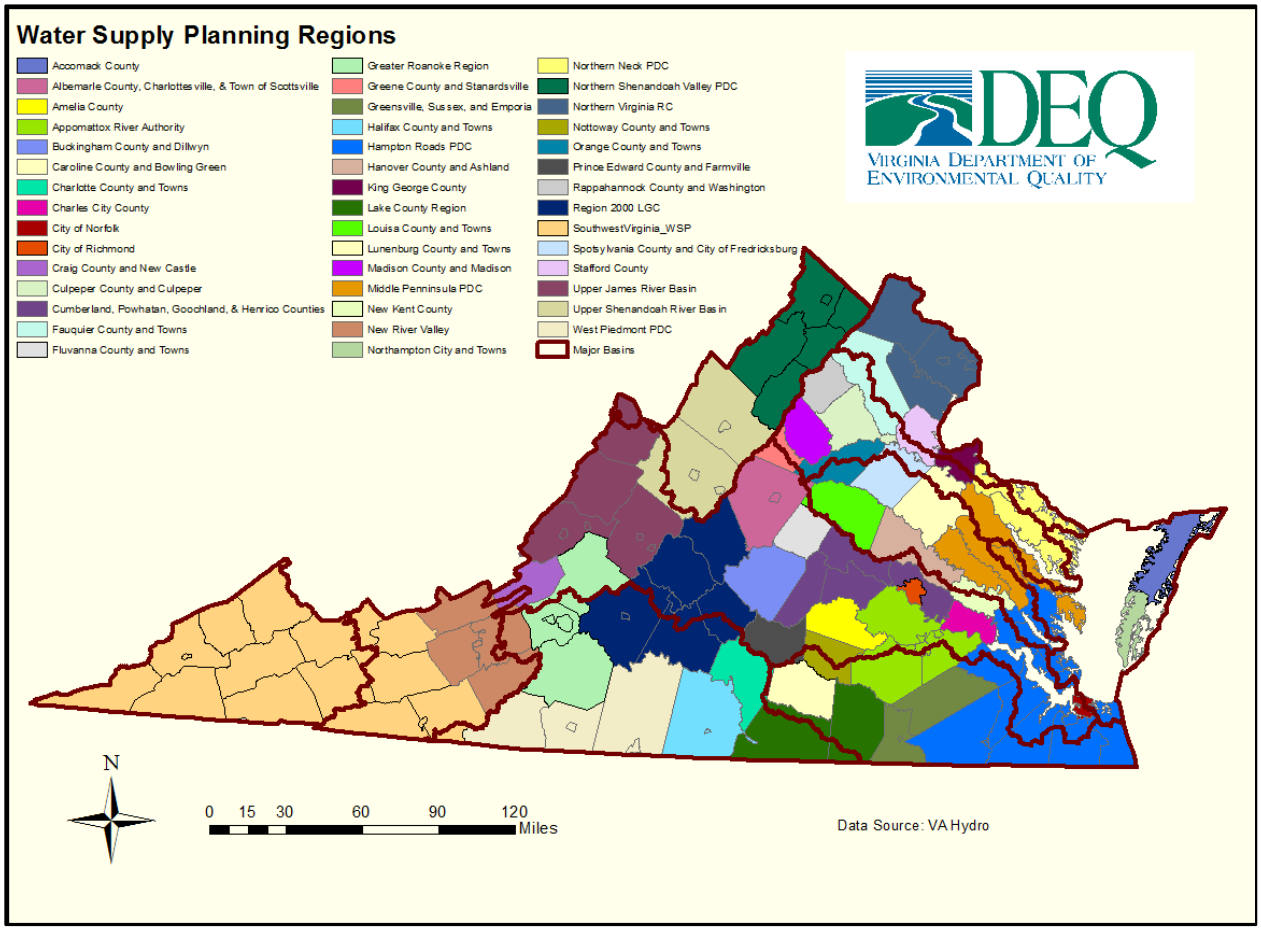

Figure 1: Water supply planning regions according to 2011 submittals, with major river basins delineated.

The SWRP will be reviewed every five years following updates or resubmittals of the local and regional water supply plans. The current review began in 2018. The SWRP is accessible through DEQ's website and will be subject to incremental revision as DEQ, localities, and other stakeholders provide input through ongoing water supply planning efforts. It is anticipated that information provided by localities via a web-based, interactive platform will provide the basis for more efficient data collection and analysis, which in turn, will continue to improve DEQ's understanding of the Commonwealth's water resources and any associated management risks. By adding this platform, DEQ has taken the first step to making water supply planning relevant in every day local and regional management efforts.

Staff is providing outreach and technical assistance to all localities and planning regions to ensure compliance conditions are addressed by the 2018 five year review deadline. Initial outreach was prioritized in those areas where shortfalls were projected based on the projected water demand information and analyses in the SWRP. There are 323 localities in Virginia: 38 cities, 95 counties, and 190 towns, all of which are required to have water supply plans, or participate in a regional water supply plan. As of September 5, 2018, 183 localities were compliant (Figure 2); including 17 cities, 38 counties, and 128 towns.

[3] 9VAC25-200-10 et seq.

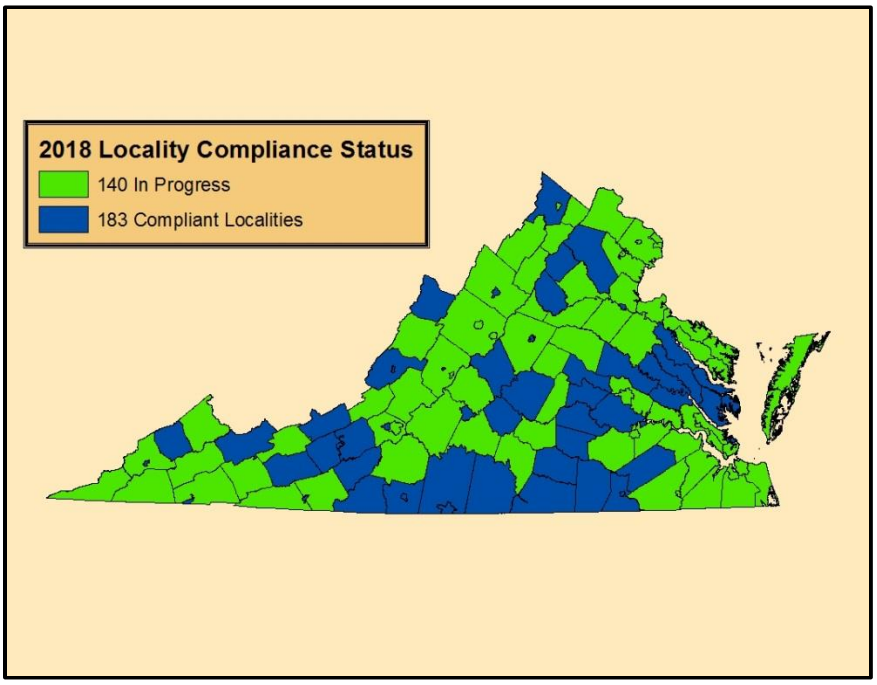

Figure 2: Localities in compliance with Water Supply Plan reviews (as of September 5, 2018).

Water Withdrawal Reporting

The Water Withdrawal Reporting Regulation requires the annual reporting of monthly water withdrawals (surface water and groundwater withdrawals) of volumes greater than an average of 10,000 gallons per day (GPD) during the month, or one million gallons per month for crop irrigation. The regulation allows the submission of metered and estimated water withdrawal information. DEQ offers electronic reporting into the VA Hydro data system, an interactive database that allows operators to enter withdrawal data on a monthly basis throughout the year and to view withdrawal reporting information from previous years. The VA Hydro data system stores withdrawal data as far back as 1982 and categorizes water withdrawals by water use types: agriculture, commercial, irrigation, manufacturing, mining, fossil fuel power, hydropower, nuclear power, and public water supply. The database also categorizes withdrawals by water source (groundwater or surface water) and source sub-type (reservoir, spring, stream, or well). Analyses of the reported data are provided in Chapters III and IV.

The collection of water use data through water withdrawal reporting enables much of the planning for the Commonwealth's future water needs. Automatically linked to the water supply modeling system, the water use reporting database enables staff to prepare up-to-date and accurate water budgets and conduct cumulative impact analyses in support of permit decision making and water supply planning efforts. The effectiveness of the Commonwealth's water resource management depends on the comprehensiveness and accuracy of this self-reported withdrawal information.

Efforts to improve water withdrawal reporting within agricultural communities continued in 2017. Livestock producers with permits for animal waste management are being contacted and registered for reporting if their water withdrawals are estimated to meet or exceed the reporting threshold. In 2017, eight farms were registered to report non-irrigation water withdrawals for a total of 27 farms registered through DEQ's outreach efforts. Outreach to users in other water use categories, including but not

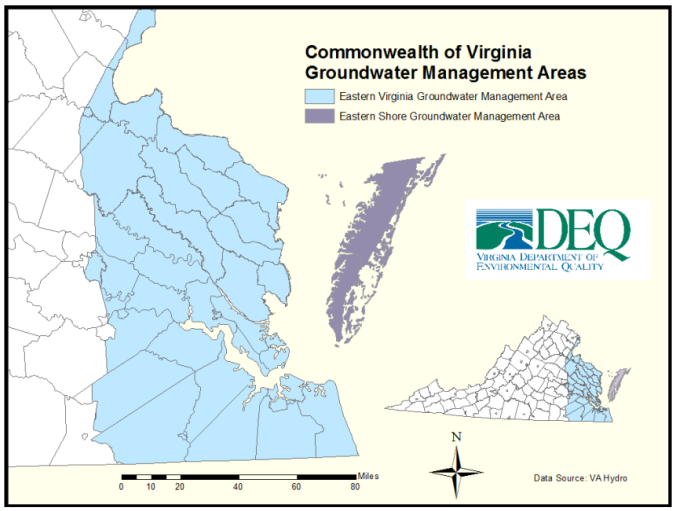

Figure 3: Virginia's Groundwater Management Areas

limited to nurseries, sod farms, public and private educational institutions, and vineyards will be conducted over the next couple of years as resources allow. These outreach efforts assist localities in meeting compliance conditions regarding the reporting of withdrawals.

Water Withdrawal Permitting and Compliance

This program administers the permitting and related compliance and reporting activities required by statutes aimed at the management and protection of groundwater and surface water resources. Under the Ground Water Management Act of 1992[4], Virginia manages groundwater through a permit program regulating the withdrawal of groundwater in certain areas designated as Groundwater Management Areas (GWMA). Currently, there are two GWMAs in the state (Figure 3). The Eastern Virginia GWMA comprises all areas east of Interstate 95 and west of the Chesapeake Bay and Atlantic coast. The Eastern Shore GWMA includes Accomack and Northampton counties. Any person or entity located within a declared GWMA must obtain a groundwater withdrawal permit to withdraw 300,000 gallons or more of groundwater in any one month.

Projects involving surface water withdrawals from state waters and related permanent structures are permitted under the Virginia Water Protection (VWP) Permit Program Regulation as directed by Article 2.2 of the State Water Control Law[5]. DEQ issues VWP Individual permits for such impacts through use of the Joint Permit Application process.

Groundwater Withdrawal Permitting

Between 2009-2013, growing concerns over increased water use by new or expanding withdrawals, overlapping cones of depression,[6] and declining water levels in the Coastal Plain aquifer system led the State Water Control Board to expand[7] the Eastern Virginia GWMA to include all of the Coastal Plain east of I-95 in order to ensure comprehensive management of the aquifer system. Modifications to the Groundwater Withdrawal Regulations[8] provided for the issuance of groundwater withdrawal permits to existing users in the additional areas accompanied the expansion, effective January 1, 2014. Permit applications were received from approximately 120 existing users during 2014 as a result of the Eastern Virginia GWMA expansion. Existing agency resources allowed for the issuance of 32 permits in 2015, 22 permits in 2016, 21 permits in 2017, and 13 permits during 2018 (as of August 31, 2018). The total maximum annual groundwater withdrawal volume authorized for these 88 existing user permits is

[4] §§ 62.1-254 et seq., *Code of Virginia*.
[5] §§ 62.1-44..15:20 through 62.1-44.15:23.1, *Code of Virginia.*
[6] "Cone of depression" means a localized reduction, or depression, of groundwater levels in an aquifer typically associated with increased rates of pumping. Groundwater levels are lowest at the point of withdrawal, creating a concentric cone around the pumping center. The reduction may sometimes lead to issues of land subsidence due to compaction of sediments as a result of reduced groundwater in pore spaces.
[7] 9VAC25-600-20.
[8] 9VAC25-610-10 et seq.

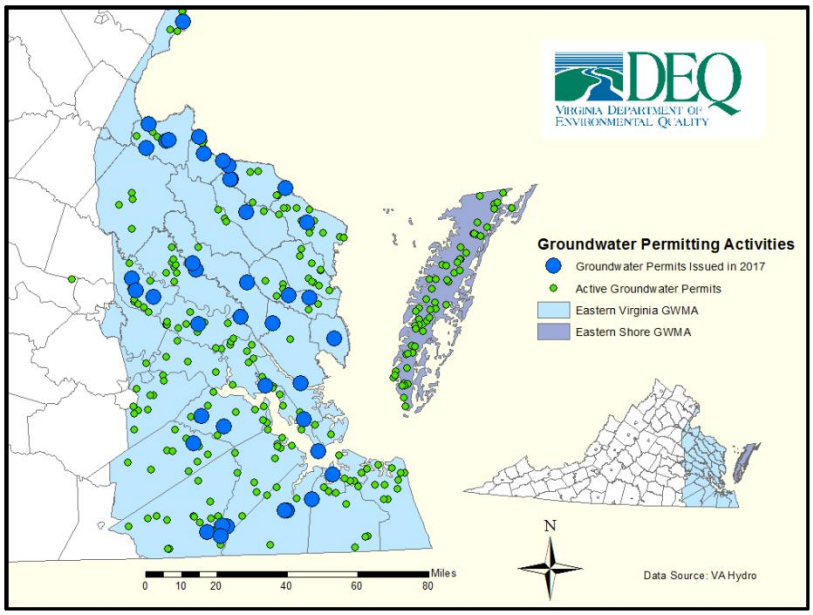

Figure 4: 2017 Virginia groundwater withdrawal permitting activities

approximately 2.08 billion gallons per year (BGY), which equates to an annualized average daily withdrawal rate of 5.7 million gallons per day (MGD).

Groundwater withdrawal permit applications for new or expanded withdrawals in a GWMA are evaluated to determine impacts of the proposed permit on the groundwater resource. The evaluation determines the area of impact, the potential for a proposed withdrawal to cause salt water intrusion, and assesses the impact of the combined drawdown from all existing lawful withdrawals. Existing lawful withdrawals include those permits issued under historic use conditions and current new or expanded use permits, as well as users that withdraw less than 300,000 gallons per month (Figure 4).

DEQ currently (as of August 31, 2018) administers 234 active new or expanded groundwater withdrawal permits (excluding Existing User permits) with a total maximum annual permitted volume of approximately 43.3 BGY (118.69 MGD annual average).

The Virginia Coastal Plain Groundwater Initiative was developed in response to an ongoing and long-term decline of groundwater levels, and growing concerns about land subsidence and salt water intrusion in the confined Coastal Plain aquifer system. In order to achieve the goal of protecting the aquifer system and providing for current and future water needs for the Commonwealth, DEQ identified and discussed potential reductions in water withdrawals with the largest 14 groundwater users in the Eastern Virginia GWMA, which, if implemented could begin stabilizing the groundwater level declines in the confined aquifers. Combined, these users represented approximately 80% of all permitted groundwater withdrawals within the Eastern Virginia GWMA. New permits were issued to all 14 users that, over their 10-year permit term, reduce their combined, non-drought maximum annual permitted withdrawal volumes by approximately 52%.

In 2017, DEQ began a Compliance Assistance Framework outreach initiative designed to assist unpermitted groundwater users in determining if a permit is required for their withdrawals and to begin the permitting process as necessary. As a result of this initiative, DEQ received over 60 applications from unpermitted groundwater users seeking to obtain groundwater withdrawal permits.

Surface Water Withdrawal Permitting

Application for a surface water withdrawal permit is made through the submittal of a Joint Permit Application (JPA) to DEQ, the Virginia Marine Resources Commission (VMRC), and the U.S. Army Corps of Engineers (USACE). DEQ's evaluation of surface water withdrawal permit applications includes an in-depth analysis of the applicant's water demand and a cumulative impact analysis of the project to determine potential impacts on existing beneficial uses. To conduct these analyses, staff continues to

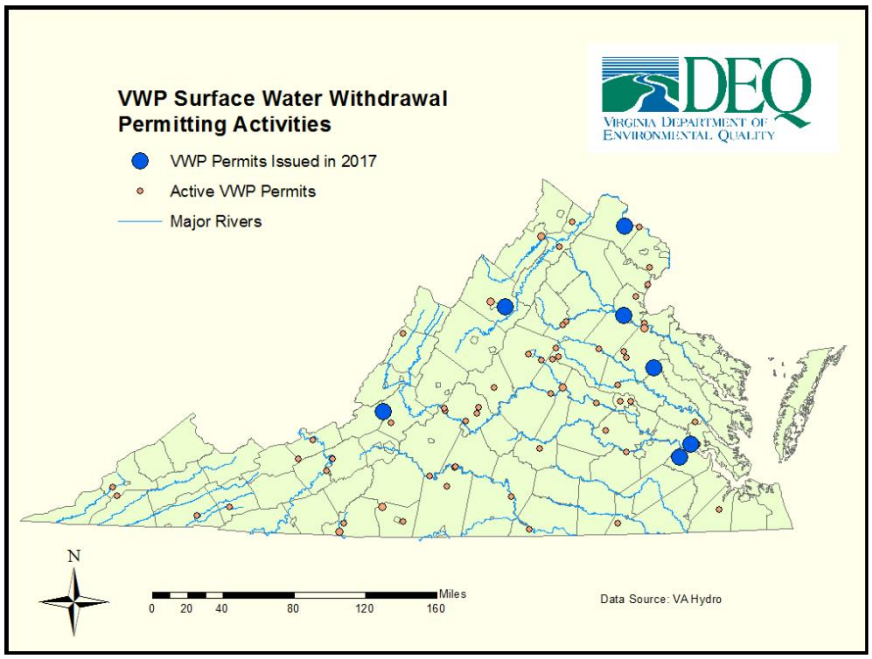

Figure 5: 2017 Virginia Water Protection Permit activities for surface water withdrawals

develop and maintain an operational hydrologic model, which incorporates data on all streams and large impoundments in the Commonwealth. Each new or reissuance permit application is modeled to evaluate any potential impact to beneficial uses downstream of the withdrawal site. Staff uses the output of this analysis to inform the permit determination and to develop appropriate limits on withdrawal volumes and minimum in-stream flow conditions if a permit is issued. Figure 5 illustrates 2017 VWP surface water withdrawal permitting activities, including permit issuances and modifications.

Currently, DEQ administers 93 VWP permits for surface water withdrawals, with a total permitted withdrawal volume of approximately 149 BGY (408 MGD annual average).

Groundwater Characterization

In 2013, the Groundwater Characterization Program (GWCP) added a minimal capacity to collect groundwater quality data which has improved the ability of the Program to execute its mission. DEQ resources allow the collection and analysis of no more than 40 groundwater samples state-wide each year. The Ambient Groundwater Quality Program was established to characterize the quality of groundwater throughout the Commonwealth of Virginia. As described in the Ambient Groundwater Quality Monitoring Strategy, the program establishes a groundwater quality baseline across the state, identifies areas of potential groundwater quality concern, and monitors the changes in groundwater quality over time as resources allow. In 2017, the Ambient Groundwater Quality Program continued to focus on the collection of groundwater samples from wells in the trend well network. Trend wells were selected for sampling on a quarterly basis to monitor both for salt water "upconing," the transient upwelling of salty groundwater that can occur in response to the local removal of non-saline groundwater by supply wells, and the more regional phenomena known as salt water intrusion in the Coastal Plain Aquifer System. A new chloride monitoring well, paid for by the applicant, was constructed in the Lee Hall area of Newport News to enable chloride monitoring in a portion of the Potomac Aquifer that has been shown to be potentially influenced by upconing. Siting and construction of the well was guided by recommendations published in USGS Scientific Investigations Report 2015-5117, a summary of DEQ funded research conducted by the United States Geological Survey (USGS) and the GWCP that describes the current distribution of chloride concentration in the Coastal Plain Aquifer System, and establishes a focused strategy for chloride monitoring. Thirty-three samples were collected during 2017 as part of this project. Additional groundwater samples (spot samples) were taken

elsewhere in Virginia to describe natural groundwater quality in data deficient areas, and to improve the overall coverage of groundwater quality data in Virginia.

Groundwater resource investigations were conducted in the fractured rock aquifer portion of the state to better understand the complexities associated with the flow and storage of groundwater in fractured rock settings. During the 2017 calendar year, particular emphasis was placed on collection and analysis of hydrogeologic data from the granitic and meta-sedimentary rocks in northern Fauquier County as part of a larger, ongoing study being conducted by the USGS to characterize the groundwater resources in the County. The northern portion of Fauquier County is under significant development pressure owing to its proximity to Interstate 66 and the Metro DC area, and is currently striving to meet current water demands. A better understanding of groundwater storage and availability in this complex geologic setting is needed to sustainably manage the resource and to help ensure water availability for a growing population. In the Valley and Ridge portion of Virginia, considerable time was devoted to the review of construction and routing plans for both the Mountain Valley Pipeline (MVP) and Atlantic Coast Pipeline (ACP). Due to the high permeability of limestone (karst) in many portions of the Valley and Ridge, much of the review process was focused on the provision and interpretation of hydrogeologic data to effectively communicate the need for avoidance of sensitive receptors and municipal water systems during pipeline construction, and to help develop proper mitigation plans in the event of contamination. Also in the Valley and Ridge portion of Virginia, a hydrogeologic study was conducted to characterize the seasonal component of groundwater storage and movement within the Staunton-Pulaski Thrust Sheet – a regionally significant geologic structure in the Great Valley. Findings of the study were published and presented at the Third Appalachian Karst Symposium held at Shepherdstown, West Virginia in April, 2018.

A cooperative effort with the USGS to characterize the hydrogeology of Virginia's Eastern Shore is ongoing. An improved understanding of the hydrogeology of the Eastern Shore is currently required to refine groundwater management strategies associated with sustainable extraction rates as well as regional contaminant fate and transport predictions (including saltwater intrusion). A large component of the research associated with describing the hydrogeology of the Eastern shore is associated with the delineation and hydrologic description of ancient paleochannels (remnants of ancient river beds) that transect the subsurface of the Eastern Shore. These paleochannels are significant because they are thought to significantly influence storage and movement within the regional groundwater system. Well cuttings description and interpretation and geophysical borehole log interpretation are ongoing in the study area to help delineate the regional hydrostratigraphy. A large subset of the geologic and geophysical logs generated from this effort will also be used to direct the vertical placement of well screens for users that seek permitted withdrawals in the Eastern Shore GWMA. The final published report of this work will also seve as the basis for revising the groundwater model used on the Eastern Shore.

Assistance for the Hampton Roads Sanitation District's Sustainable Water Initiative for Tomorrow (SWIFT) pilot underground injection well project is ongoing. On-site cuttings collection and description at the Gloucester Water Treatment Plan (WTP) injection well was conducted to identify formations, contacts and aquifers to assist with injection well design. Similar assistance is being provided for the injection well at the Williamsburg WTP, which is currently being drilled.

Final buildout of the Smithfield Groundwater level monitoring station occurred in 2017. Groundwater level data from these nested wells will be used to monitor a known cone of depression in the Potomac Aquifer that increases the potential for local salt water intrusion associated with groundwater withdrawals occurring in the Town of Smithfield.

A monitoring well assessment and maintenance initiative has been started by the Groundwater Characterization Program to evaluate the integrity of existing groundwater research stations to ensure

that measured groundwater levels are representative of hydraulic conditions in the aquifer. This is a critical need as more than 50% of the 243 monitoring wells in the network exceed 30 years of age and are showing signs of their age. Over time, observation wells can lose connection to the aquifer through siltation, development of mineral encrustation, or growth of bacterial mats. A prioritized quarterly implementation schedule has been developed to help guide evaluation efforts as resources allow. In 2017, multiple groundwater monitoring wells in Hampton Roads, Smithfield, the Middle Peninsula and Virginia Peninsula were evaluated.

Surface Water Investigations

DEQ's Surface Water Investigations Program (SWIP) and the USGS National Streamflow Information Program are the primary entities responsible for collecting surface hydrologic data in Virginia (Figure 6). Their collaboration provides a comprehensive picture of real-time and historical hydrologic conditions in the Commonwealth. The SWIP mission is the systematic collection of reliable hydrologic data concerning the quantity of surface water in the Commonwealth, using the same standards and procedures as the USGS. Virginia is currently the only state partnering with the USGS on the collection of real-time streamflow data where state-collected data are incorporated directly into the USGS database. Data accuracy, attained through use of state-of-the-art equipment and personnel training in USGS methods, is the key to maintaining this unique partnership.

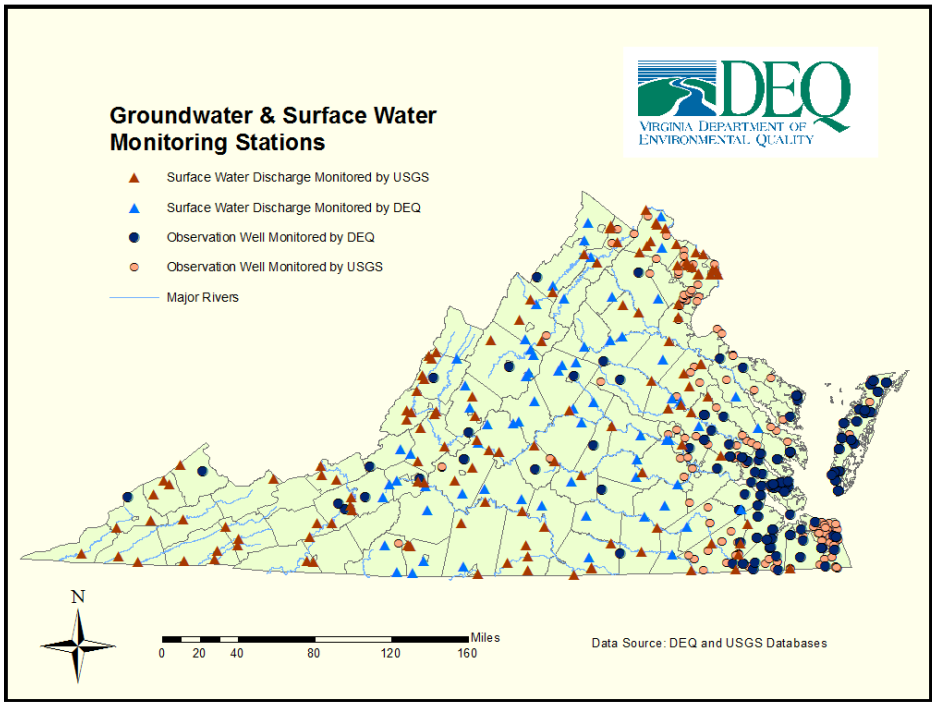

Figure 6: Location of groundwater and surface water monitoring stations. Monitoring at all of the USGS sites is performed by the USGS under contract for DEQ.

SWIP field personnel collect and process data from a network of 68 surface water discharge monitoring stations on a six to eight week schedule, or more frequently in times of drought or flood. Monitoring often occurs in extreme conditions such as low and high water, and involves the servicing of sensitive equipment, maintaining permanent gauging stations, and measuring streamflow ("discharge"). The data obtained from each surface water discharge monitoring station is continually measured and uploaded into the USGS National Water Information System (NWIS) database where it is accessible by citizens, localities, and state and federal agencies for water supply planning, emergency management response planning, water withdrawal permitting, and natural resource management purposes. Development of and access to this data is essential for the successful planning and management of the Commonwealth's water resources.

In addition to managing the network of surface water discharge monitoring stations, SWIP field personnel perform site specific stream flow measurements to support DEQ Total Maximum Daily Load (TMDL) development and water permitting programs.

In 2017, over 600 discharge measurements were made by DEQ personnel for the USGS gauging station network. Stream depth, width, and velocity are measured in the waterway in the vicinity of the gauging station to determine discharge. These data are then input into the online USGS current conditions database for Virginia data related to streamflow for floods, droughts, permitting withdrawals and discharges, future water planning, and recreational usage. The USGS requires that these measurements be analyzed and processed within 48 hours of being read, which ensures the webpage is as up to date as soon possible for use by the Drought Monitoring Task Force (DMTF) and other entities dependent upon the accuracy of this resource for analysis.

Environmental Data and Analysis

DEQ continues to develop VA Hydro, an integrated water availability modeling and analysis tool designed to ultimately link modules pertaining to water withdrawal permitting, water supply planning, water withdrawal reporting, GW-2 well registration, and drought monitoring/modeling of both surface water and groundwater (Figure 7).

During the calendar year 2017, DEQ initiated a pilot project for the Water Supply Planning module in order to receive stakeholder feedback prior to a statewide release. The pilot participants included Augusta County, Caroline County, Rockingham County, and the Hampton Roads Planning District Commission. VA Hydro allows locality and regional planning teams to interact with their water supply plan data and turn their plans into a "living document" that is updated dynamically as new data is entered. The pilot project period lasted from May 2017 to August 2017. The statewide release date for the VA Hydro Water Supply Planning application for approved locality and regional planning users was October 2017. There are currently 140 locality and regional planning users in VA Hydro.

Through VA Hydro, DEQ collects annual water withdrawal reporting to assist in permitting decisions, planning, and modeling as well as to better understand total water use in Virginia. DEQ staff undertook a thorough quality assurance process in VA Hydro during 2017 in order to identify duplicate facilities, correct facility status, and perform overall cleanup of facility information. In total, 1,623 annual water withdrawal reporting facilities submitted their data through VA Hydro for the 2017 reporting period out of 1,810 total known active facilities, representing a 90% reporting rate.

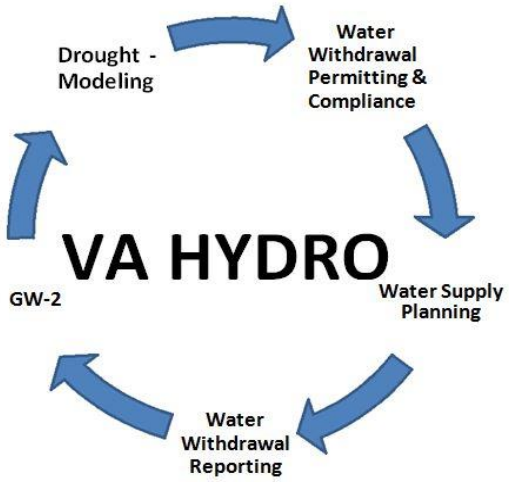

Figure 7: VA Hydro Modeling and Analysis Tool Diagram

During 2017, DEQ and Virginia Department of Health (VDH) staff continued to work together on activities related to the private water well registration program. Well drillers are able to use VA Hydro in order to submit Water Well Completion Reports (GW-2 forms) to both DEQ and VDH simultaneously. As of December 31, 2017, 4,173 water well completion records have been submitted online via VA Hydro.

Office of Water Supply modeling staff have continued working in cooperation with the USGS and the Virginia Tech Department of Biological Systems Engineering on several cooperative science projects. The primary focus of the past two years has centered on developing an instream flow framework for widely available hydrologic and ecological monitoring data. DEQ has taken an approach that combines state planning and reporting databases, multiple river and habitat models, and biometric assessment of fish and benthic monitoring data to develop a more geo-spatially specific understanding of the relative risk to aquatic life resulting from surface water withdrawals in Virginia. Two professional manuscripts outlining project methods, results and potential management implications are currently in the final stages of development and are expected to be published.

A second project has focused on consumptive use data transfer and analysis, facilitated through the USGS Water Use Data and Research (WUDR) Program and DEQ's ongoing collaboration with Virginia Tech. Primary objectives include the development of a suite of tools to transfer data on water withdrawal, discharge, and consumptive use between the National Pollutant Discharge Elimination System (NPDES), VAHydro, and USGS National Water Information System (NWIS) databases. DEQ plans to leverage this data to analyze trends in consumptive use over time and across different user categories, and to develop predictive models of consumptive use for missing time periods and users. This information is critical to create an accurate surface water budget and to determine water availability in different locations across the Commonwealth.

As a result of 2016 collaborative work exploring the role of evaporation from the over 70,000 small water bodies in Virginia, researchers at Virginia Tech developed a high resolution model of a watershed in Northern Virginia to examine the influence of common riser structures on storm and drought flows, and floodplain connectivity. The analysis concluded that small impoundment outlet structures reduce both storm flow peaks and extreme drought flows, while increasing medium flows, and significantly reduced floodplain connectivity and the resulting ecosystem services. It was also discovered that hourly flow analysis, rather than daily, is required to examine the effects in watersheds smaller than approximately 50 square miles. This work will inform analysis approaches of proposed reservoir construction and management in small riverine systems, as well as water budget forecasts for long term water supply planning.

The DEQ and Virginia Tech partnership also updated land use in the southern rivers portion of Virginia to contain data from the 2011 VGIN aerial imagery and land cover data sets. The Chesapeake Bay Program released the Phase 6 watershed model in early 2018, which included climate change projections for much of Virginia. The new land use and hydrologic model data sets will both be imported into the VAHydro modeling system in 2018-2019 for use in the upcoming State Water Resources Plan Five Year Review modeling analysis of future water supply conditions.

Drought Assessment and Response

Since the adoption of the Virginia Drought Assessment and Response Plan in 2003[9], drought watch declarations have been issued for various regions nearly every year, but drought warning declarations have occurred less frequently. A Drought Emergency declaration has not been issued since the 2002 drought.

[9] Virginia Drought Response Technical Advisory Committee, 2003, *Virginia Drought Assessment and Response Plan*, 22 p.

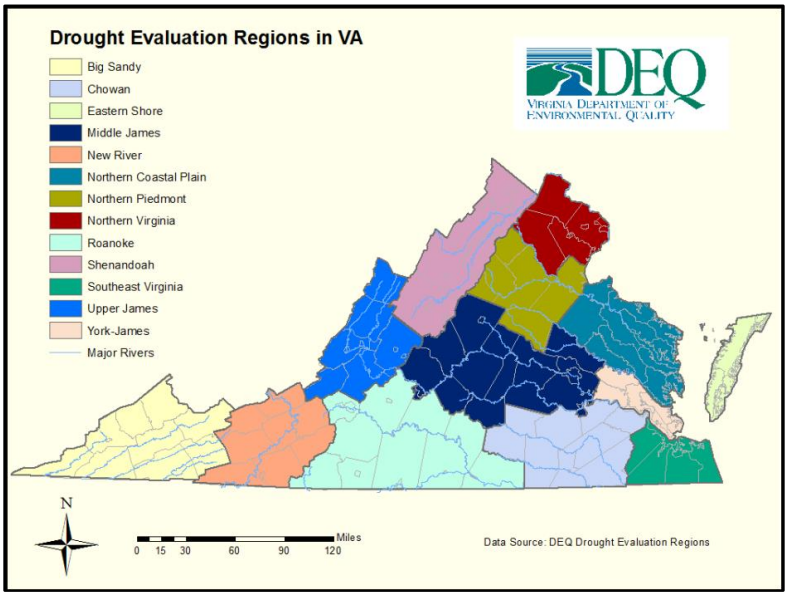

Figure 8: Drought Evaluation Regions

During March,2017, drought watch declarations were issued for the Northern Virginia and Northern Piedmont Drought Evaluation Regions (Figure 8) after an abnormally dry winter. The advisory was lifted for the Northern Virginia region in June, 2017. However, dry late summer and fall conditions resulted in a reissuance of the drought watch advisory in Northern Virginia and an extension to the Middle James, Roanoke River and Shenandoah regions in October, 2017. The 2017-2018 winter season was also drier than normal, and the drought watch was extended to the Chowan and Upper James regions. Wetter conditions in the Shenandoah Valley and Upper James resulted in lifting those advisories during the early spring. However, the remaining advisories were not lifted until June, 2018, after an extremely wet May across the Commonwealth. No advisories were in effect as of September 5, 2018.

III. SUMMARY OF 2017 WATER WITHDRAWALS

A total of 625 VA Hydro users reported their annual water withdrawals to DEQ covering 1,624 active facilities during calendar year 2017. Reported withdrawals were approximately 6.3 billion gallons per day (BGD) for all groundwater and surface water use categories, including cooling water at nuclear and fossil fuel power generation facilities. Excluding power generation, reported 2017 withdrawals totaled over 1.2 BGD.[10] Compared to 2016, total reported withdrawals from all water use categories increased by approximately 3% when excluding power generation withdrawals.

VA Hydro characterizes four water withdrawal source types: streams (including rivers), reservoirs, springs, and wells. Withdrawals from the first three of these sources are considered "surface water withdrawals." Springs discharge groundwater to surface water bodies and would naturally form the headwaters of watercourses as defined by the State Water Control Law[11] and are therefore categorized as surface water, rather than as groundwater. Groundwater withdrawals are typically derived from wells; however, there are a small number of withdrawals from dug farm ponds and quarries that intersect the groundwater table, and which are otherwise unconnected to a watercourse, that are also categorized as groundwater in VA Hydro.

[10] Withdrawal volumes reported to VA Hydro are "gross," rather than "net," and as such do not reflect the amount of water that was ultimately returned to the source water body. Water diverted for hydropower use is essentially non-consumptive use. These flows are exempted from the reporting requirement and are generally not reported to VA Hydro. A significant portion of water diverted for uses in Virginia related to fossil fuel and nuclear power generation is also non-consumptive. For these reasons, the summary of total statewide water withdrawals does not include water withdrawn for power generation.

[11] § 62.1-104, *Code of Virginia*.

Water withdrawn in the Commonwealth may be used by the withdrawing entity or locality, or it may be "transferred" to another entity or locality. Ideally, the total amount of water reported as released from the transferring facility should equal the total reported as deliveries by the receiving facility. However, in reality, the amounts of reported deliveries are generally significantly less than the amount reported as released. This discrepancy is most likely due to incomplete reporting of deliveries from facilities that purchase water. In order to avoid double counting, this report will generally refer to "water use" as synonymous with "water withdrawn," and any reporting or illustration of water transfers will be clearly marked as "water transferred" or "water purchased." A more detailed explanation of how water transfers are stored in VA Hydro is provided in Appendix 2. General descriptions of 2017 water withdrawals by source type, distribution across the state, and water use category occurs on subsequent pages with additional detail provided in the appendices as follows:

Appendix 3 provides a list of the top 20 non-power generating water withdrawals ranked by the amount of their actual 2017 reported withdrawals.

Appendix 4 provides detailed withdrawal information by major water use category, including fossil fuel and nuclear power generation water withdrawals, and excluding hydropower.

Water Withdrawals by Source Type

Water withdrawals for non-power generation uses totaled approximately 1,265 MGD and predominantly occurred from surface water sources (streams, reservoirs, and springs). The total reported 2017 non-power generation withdrawals was approximately 3% higher than the 2016 total of 1,232 MGD. Pumping of groundwater wells totaled 128 MGD. Surface water withdrawals accounted for 90% of total withdrawals in 2017 at 1,137 MGD when excluding power generation. Groundwater reported withdrawals decreased 10 MGD and surface water reported withdrawals increased 43 MGD from 2016 totals.

Water Withdrawals by Location

Analysis of the spatial distribution of 2017 water withdrawals in Virginia indicates that as in previous years, the largest groundwater withdrawals predominantly occurred in the Coastal Plain, Eastern Shore, and Shenandoah Valley regions (Figure 9). The largest volumes of groundwater were produced from karstic limestone formations in the Shenandoah Valley, within the Valley and Ridge physiographic province, and from aquifers within the Coastal Plain province. Shallow aquifers on the Eastern Shore (part of the Coastal Plain aquifer system) also produce significant quantities of groundwater. Reported use by permitted groundwater withdrawals from locations within GWMAs totaled about 70.6 MGD for 2017, or 55% of all groundwater withdrawals in the Commonwealth.

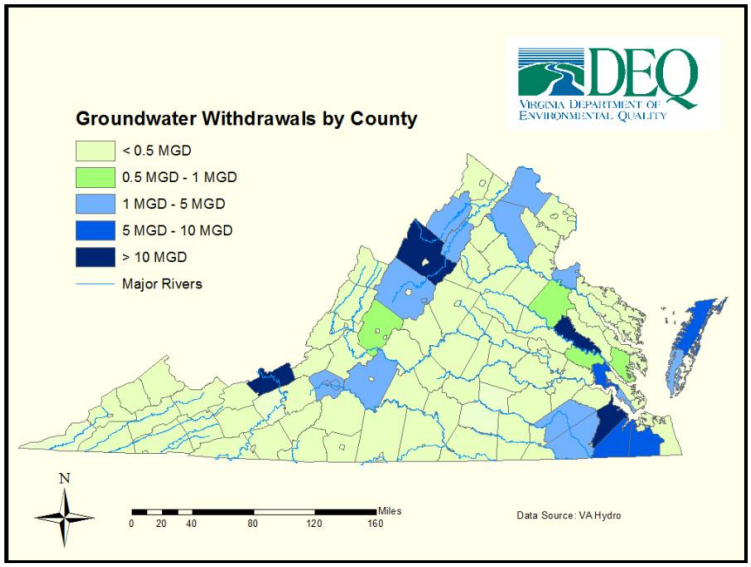

Figure 9: Groundwater Withdrawals for 2017 by County

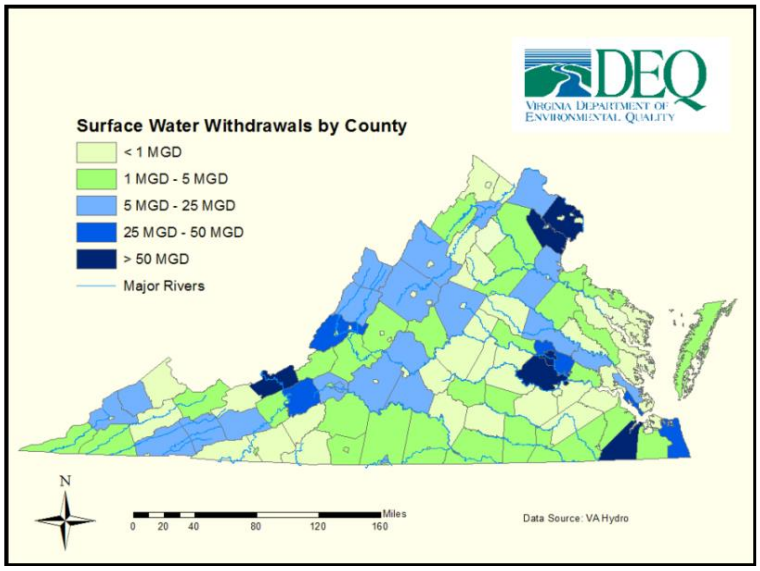

Figure 10: Surface Water Withdrawals for 2017 by County

Surface water withdrawals were distributed widely across the state and were greatest around cities and counties serving as significant population centers (Figure 10). Irrigation and agriculture account for the most significant withdrawals in rural counties. Surface water withdrawals are concentrated within the James, Potomac-Shenandoah, and New River basins, comprising approximately 75% of the statewide total surface water withdrawal. Public Water Supply use represents 65% of total surface water withdrawals in the Commonwealth, which is consistent with this category's 2016 proportion.

The variable spatial distributions of groundwater and surface water withdrawals suggest that withdrawals also vary considerably between Virginia's major surface water basins and physiographic provinces (Figure 11). Reported water withdrawals by county are included in Appendix 5.

Water Withdrawals by Water Use Category

Water withdrawals reported to VA Hydro are categorized by how, or for what purpose, the water withdrawal is used: Agriculture, Commercial, Fossil Power, Hydropower, Irrigation, Manufacturing, Mining, Nuclear Power, Public Water Supply, and Other uses. The "Agriculture" category includes water withdrawn for raising livestock, and for fish farming and hatcheries. The "Commercial" category includes water used by golf courses, local and federal institutions, hotels, resorts, and correctional centers, among others. The "Irrigation" category includes water used to promote crop growth, including but not limited to tobacco, corn, soybeans, turf grass, and ornamental nursery products. The "Other" category contains a small number of facilities for which the water use does not fit into one of the previously mentioned categories, such as short term infrastructure development.

Water withdrawals can fluctuate from year to year due to weather variability and economic or other factors; therefore, average water withdrawals from 2013-2017 are provided by source type for each category for comparison, excluding Power Generation (Nuclear Power and Fossil Fuel Power) (Figures 12 and 13). Average water withdrawals during this five-year period were calculated using the same source type categories (surface water and groundwater) as the 2017 withdrawal totals. This allows for direct comparisons to be made between 2017 withdrawal totals and the 2013-2017 averages. Little difference is apparent between the pairs of charts comparing groundwater, surface water, and total withdrawals between 2017 and the 2013-2017 periods.

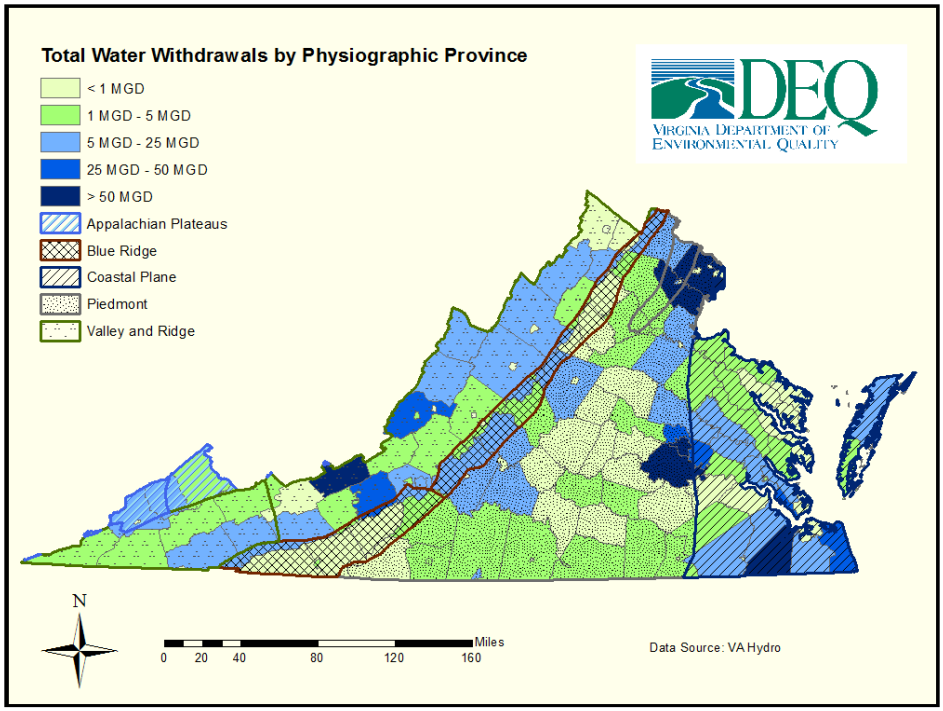

Figure 11: Total Withdrawals (Groundwater + Surface Water) for 2017 by County

Withdrawals for Public Water Supply and for Manufacturing were again the largest for 2017 and for the average of the previous five-year period. Manufacturing makes up the highest proportion of groundwater withdrawals whereas Public Water Supply use accounts for the greatest surface water withdrawals. Pumping for Agriculture, Irrigation, Mining, and Commercial uses made up lesser, but still significant, portions of the totals. Agriculture use tends to be largely driven by surface water withdrawals (98%) while irrigation and commercial use is more evenly distributed between surface water and groundwater.

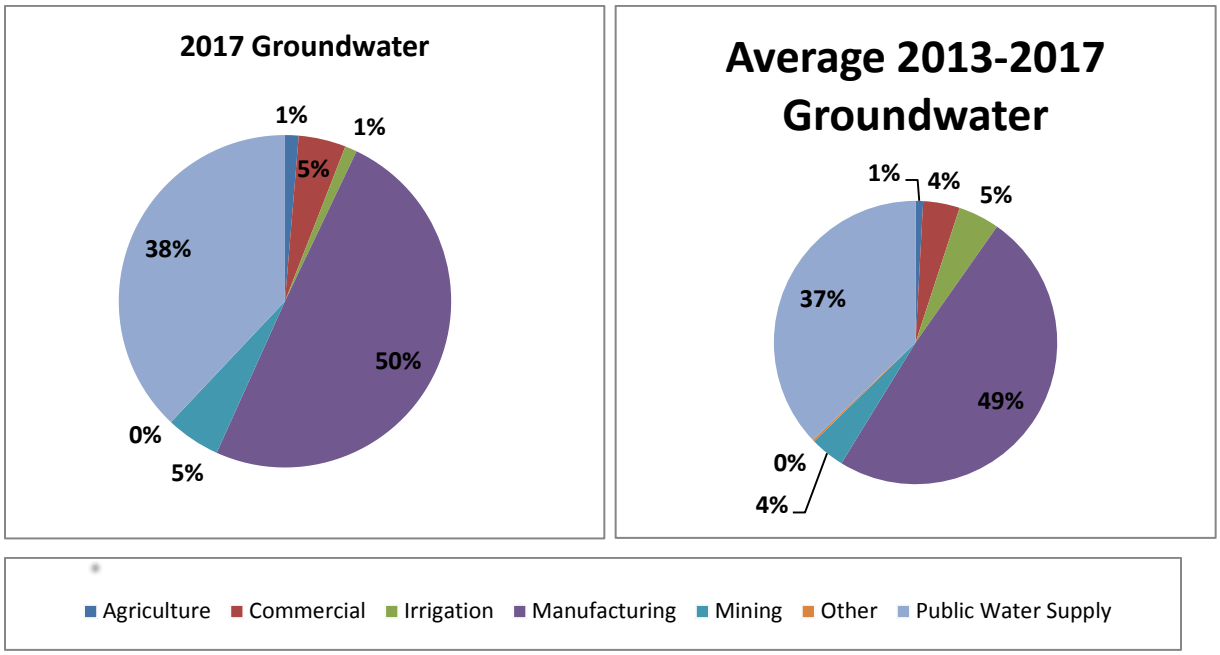

Figure 12: Groundwater withdrawals by use category for 2017 and the 2013-2017 average

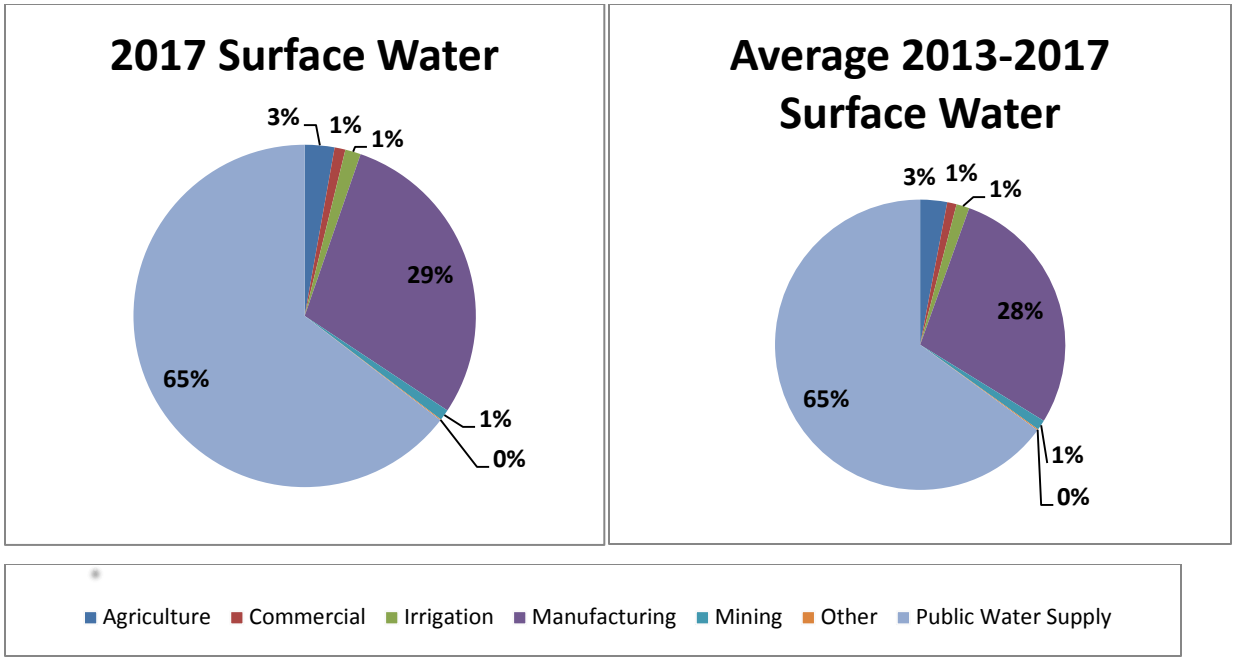

Figure 13: Surface water withdrawals by use category for 2017 and the 2013-2017 average

Similarly to 2016, the proportions of 2017 water use totals by category are comparable with the reported 2010 water use by category contained in the State Water Resources Plan (Figures 14 and 15). The Community Water Systems (CWS) category in the State Water Resources Plan can be compared to the Public Water Supply category in the Annual Report. Likewise, Agricultural use totals in the Plan are comparable to the sum of withdrawals from the VA Hydro Agriculture plus Irrigation categories, and the total use from the Large Self-Supplied User category in the Plan is comparable to the sum of the withdrawals from the remaining VA Hydro categories.

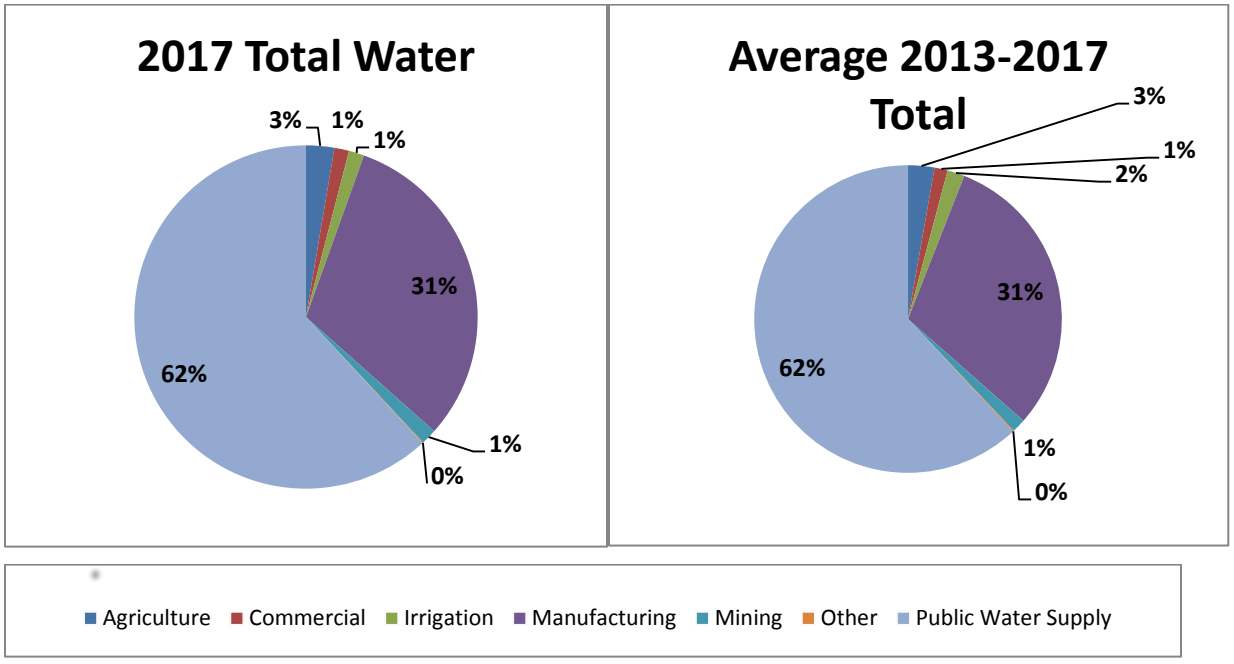

Figure 14: Total water withdrawals by use category for 2017 and the 2013-2017 average

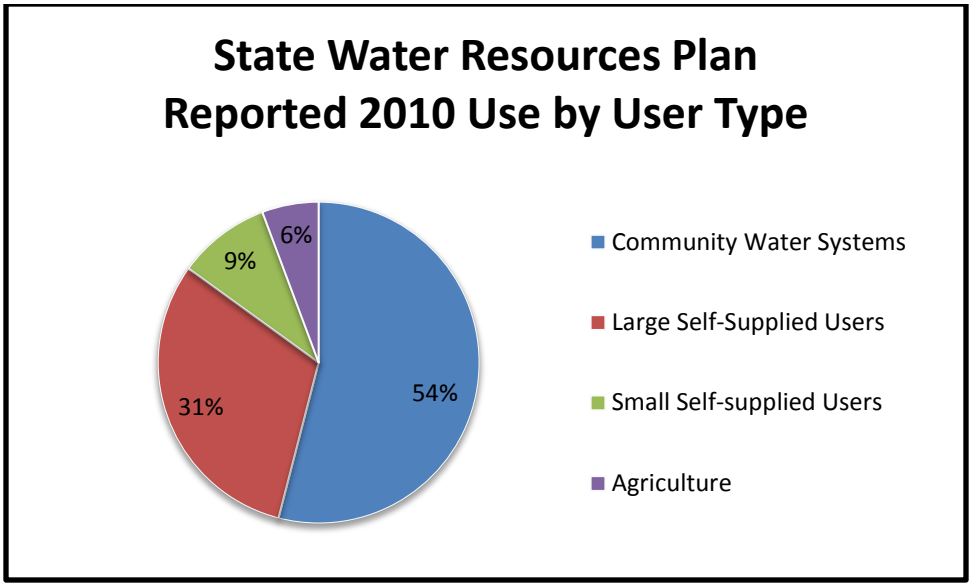

Figure 15: 2010 Water Use by Type as Reported in the State Water Resources Plan

The percentages of 2010 statewide water use by Plan user category are similar to the withdrawal percentages by category obtained from the VA Hydro database.[12] The main difference between the two compilations is the Small Self-Supplied User category identified in the Plan. This category includes small users who would generally fall beneath the reporting threshold for annual water withdrawal reporting (300,000 gallons/month) and are not captured in VA Hydro. As a result, Public Water Supply is a larger percentage of the total withdrawals (Figure 14) than that represented by the Community Water System category (Figure 15).

Appendix 4 provides additional information on each water use category. These fact sheets contain tables and graphs comparing 2017 withdrawals with the five-year average and annual withdrawal trends (2013-2017) for each use category. The top water users within each category are identified as well. In order to demonstrate the spatial distribution and magnitude of withdrawals, maps are included in the use category fact sheets.

Consumptive vs. Non-Consumptive Use of Water

A portion of all water withdrawn from groundwater or surface water sources is "consumed," or becomes unavailable for further use. "Consumptive water use" refers to that portion of a water withdrawal that is not returned to the source due to, for example, evapotranspiration, domestic use, incorporation into products or crops, or diversion from the source basin. The percentage of water consumed by agricultural, commercial, manufacturing, and mining facilities varies widely, depending on the specific use, product, or process at each facility. For example, most of the water withdrawn for agricultural irrigation is consumed by evapotranspiration and incorporation into the irrigated crop. Similarly, domestic consumptive use can vary significantly depending upon whether wastewater is discharged (i.e., returned) to the source stream, discharged to a stream within the same water basin, or discharged to a stream in another water basin. It is also noted that domestic consumptive use in public water supplies can vary significantly depending upon the amount of lawn irrigation and/or outdoor watering employed by consumers.

[12] Adapted from Figure 4-7 of the *State Water Resources Plan*, 2015.

Weather patterns and seasonal variations can also affect domestic consumptive use. In 1995, estimates of domestic consumptive use made by the USGS for Virginia were approximately 10% of annual withdrawal volumes.[13] Without specific information about the types and distribution of end users, estimates of consumptive use from public water supply withdrawals can be very uncertain.

"Non-consumptive" water use is characterized by water that remains in, or is immediately returned to, the location in a stream or aquifer from which it was withdrawn with little or no water loss. Most non-consumptive water use involves some level of consumptive loss. Power generation withdrawals are often referred to as "non-consumptive," due to their relatively low rate of consumptive loss when compared to other categories. At thermoelectric power plants, the type of cooling system in use determines the relative amount of consumptive use. For example, "once-through" cooling systems return most of the diverted water to the original source, causing a relatively insignificant amount of consumptive use. In contrast, "closed-loop" cooling systems re-circulate diverted water through wet cooling towers and can lose a significant percentage of total water withdrawn to evaporation.[14] In Virginia, the thermoelectric power plants with the five largest water withdrawals employ once-through cooling systems. Other plants, with smaller water withdrawals, use wet cooling tower systems and may have relatively greater consumptive losses. Hydro power plants are also exempt from reporting due to their low consumptive use (see Power Generation Water Withdrawal fact sheet, Appendix 4).

IV. WATER WITHDRAWAL TRENDS: 2013-2017

Total withdrawals reported to VA Hydro have been fairly stable since 2013 (Table 1). Total 2017 reported non-power generation withdrawals were approximately 33 MGD greater than those reported for 2016 and about 3% higher than the five-year average between 2013-2017. Manufacturing and public water supply experienced the largest increase in surface water withdrawals. Manufacturing surface water withdrawals increased by about 19 MGD and public water supply surface water withdrawals increased by 30 MGD. Total manufacturing reported withdrawals increased by over 20 MGD in consecutive years after reaching a 5-year low of 360 MGD in 2015. Total public water supply reported withdrawals increased over 20 MGD from 2016 after falling about 14 MGD from 2015 to 2016, which represents the highest reported withdrawal total over the past 5 years. Commercial withdrawals decreased by 4 MGD in 2017 compared to 2016, after increasing in all years previous to 2017.

Withdrawals for irrigation from both surface and groundwater sources have fluctuated significantly from year to year, since 2013. For example, total reported irrigation withdrawals in 2017 were similar to reported withdrawals in 2013, however reported irrigation withdrawals in 2014 reached 30 MGD. Reported irrigation withdrawals have decreased since 2014. The reasons for these fluctuations may include annual weather variations, different water needs from crop rotations, and uneven reporting of withdrawals by irrigation facilities from year to year. Agriculture withdrawals have stayed relatively consistent from 2013-2017. Total agriculture reported withdrawals in 2017 were only 0.4 MGD less than the 5-year average of 34 MGD. DEQ will continue to improve agriculture reporting as water supply planners are able to register more farms for annual water withdrawal reporting, which is a program priority.

[13] Solley, Wayne B., 1998, *Estimated use of water in the United States in 1995*: U.S. Geological Survey Circular 1200, 71 p.
[14] Diehl, T.H., Harris, M.A., Murphy, J.C., Hutson, S.S., and Ladd, D.E., 2013, *Methods for estimating water consumption for thermoelectric power plants in the United States*: U.S. Geological Survey Scientific Investigations Report 2013–5188, 78 p., http://dx.doi.org/10.3133/sir20135188.

Source	Use Category	2013	2014	2015	2016	2017	Avg. 2013-2017	2017 Diff. from Average	2017 % Diff. from Average
Groundwater	Agriculture	0.6	0.5	1.2	1.7	1.7	1.2	0.5	47%
	Commercial	5.0	5.2	5.7	6.2	5.9	5.6	0.3	5%
	Irrigation	8.4	9.2	8.5	4.1	1.5	6.3	-4.8	-76%
	Manufacturing	67.5	66.6	68.7	62.3	63.7	65.8	-2.1	-3%
	Mining	3.4	3.1	4.8	8.4	6.8	5.3	1.5	29%
	Other	0.7	0.7	0.1	0.0	0.0	0.3	-0.3	-97%
	Public Water Supply	50.0	49.1	45.1	55.8	48.7	49.7	-1.0	-2%
	Total (GW)	**135.5**	**134.4**	**134.0**	**138.5**	**128.3**	**134.2**	**-5.8**	**-4%**
Surface Water	Agriculture	31.9	32.0	33.8	34.5	31.9	32.8	-0.9	-3%
	Commercial	7.1	10.2	13.2	15.3	11.6	11.5	0.1	1%
	Irrigation	11.0	20.8	14.6	16.2	16.8	15.9	0.9	6%
	Manufacturing	311.7	305.8	291.8	310.6	329.8	309.9	19.9	6%
	Mining	12.7	11.1	12.9	13.0	11.8	12.3	-0.5	-4%
	Other	2.2	2.2	1.1	0.0	1.0	1.3	-0.3	-22%
	Public Water Supply	690.3	702.6	728.6	704.3	734.2	712.0	22.2	3%
	Total (SW)	**1066.7**	**1084.7**	**1096.0**	**1093.9**	**1137.1**	**1095.7**	**41.4**	**4%**
Total (GW + SW)	Agriculture	32.5	32.5	35.0	36.3	33.6	34.0	-0.4	**-1%**
	Commercial	12.1	15.4	18.9	21.4	17.5	17.1	0.4	**3%**
	Irrigation	19.3	30.0	23.1	20.3	18.3	22.2	-3.9	**-18%**
	Manufacturing	379.2	372.4	360.6	372.9	393.5	375.7	17.8	**5%**
	Mining	16.1	14.2	17.6	21.4	18.6	17.6	1.0	**6%**
	Other	2.9	2.9	1.2	0.0	1.0	1.6	-0.6	**-36%**
	Public Water Supply	740.3	751.7	773.7	760.1	782.9	761.7	21.2	**3%**
	Total (GW + SW)	**1202.3**	**1219.1**	**1230.0**	**1232.4**	**1265.4**	**1229.8**	**35.6**	**3%**

Table 1: Summary of Virginia water withdrawals by use category and source type, 2013-2017

2017 Permitted and Unpermitted (Excluded) Withdrawals

The following tables demonstrate the difference between 2017 reported permitted withdrawals and 2017 reported unpermitted withdrawals. Table 2 displays the aggregrate reported total withdrawals by water source type. The unpermitted surface water withdrawals listed in Table 2 represent those reported to VA Hydro that are excluded from the VWP permitting requirements. The unpermitted groundwater withdrawals in Table 2 are generally those not regulated by the GWP permitting program (those located west of I-95, outside of a GWMA). However, a small portion of the unpermitted groundwater withdrawals listed in Table 2 represent existing users in the expanded GWMA who have reported and submitted an application for a permit, but have not yet been issued an active permit. In general, total unpermitted withdrawals are higher than permitted withdrawals in Virginia. 74% of reported water withdrawals are unpermitted, which is largely driven by unpermitted surface water withdrawals. The percentage trends of 2017 unpermitted and permitted water withdrawals remain

consistent with the values from the 2016 Annual Water Resources Report. Table 3 disaggregates the permitted and unpermitted reported water withdrawals by use category.

Unreported unpermitted withdrawals are also of interest to DEQ. This type of withdrawal represents water users that do not exceed an average daily withdrawal of 10,000 gallons per day in any single month, and therefore, do not have to report to DEQ. However, trends in water well completion reports received by DEQ and VDH point to an increase in private well construction. Though water use data is not associated with the water well completion reports, the increase in private wells likely results in increases to overall water use. The importance of understanding unreported unpermitted withdrawals is essential to ensure that water resource management gains from permitting and permit reductions are not lost due to those unpermitted withdrawals.

Source	Description	2017 MGD	% of Total 2017 MGD
Groundwater	Permitted Withdrawals (In GWMA)	70.6	55%
Groundwater	Unpermitted Withdrawals	57.7	45%
Surface Water	Permitted Withdrawals	263.9	23%
Surface Water	Unpermitted Withdrawals	873.1	77%
Total Withdrawals	Permitted Withdrawals	334.5	26%
Total Withdrawals	Unpermitted Withdrawals	930.8	74%

Table 2: Summary of Virginia permitted and unpermitted withdrawals reported as of July 2018 by source type in 2017 (excluding the Other category)

Groundwater	Description	2017 MGD	% of Total 2017 MGD
Agriculture	Permitted Withdrawals	1.6	1.2%
Agriculture	Unpermitted Withdrawals	0.1	0.1%
Commercial	Permitted Withdrawals	3.6	2.8%
Commercial	Unpermitted Withdrawals	2.3	1.8%
Irrigation	Permitted Withdrawals	0.3	0.2%
Irrigation	Unpermitted Withdrawals	1.2	0.9%
Manufacturing	Permitted Withdrawals	36.6	28.5%
Manufacturing	Unpermitted Withdrawals	27.1	21.1%
Mining	Permitted Withdrawals	0	0.0%
Mining	Unpermitted Withdrawals	6.8	5.3%
Public Water Supply	Permitted Withdrawals	28	21.8%
Public Water Supply	Unpermitted Withdrawals	20.7	16.1%
Surface Water		**2017 MGD**	**% of Total 2017 MGD**
Agriculture	Permitted Withdrawals	0	0.0%
Agriculture	Unpermitted Withdrawals	30.6	2.7%
Commercial	Permitted Withdrawals	1.9	0.2%
Commercial	Unpermitted Withdrawals	10.8	0.9%
Irrigation	Permitted Withdrawals	0.3	0.0%
Irrigation	Unpermitted Withdrawals	16.6	1.5%
Manufacturing	Permitted Withdrawals	6.5	0.6%
Manufacturing	Unpermitted Withdrawals	321.1	28.2%
Mining	Permitted Withdrawals	0.01	0.0%
Mining	Unpermitted Withdrawals	11.8	1.0%
Public Water Supply	Permitted Withdrawals	255.2	22.4%
Public Water Supply	Unpermitted Withdrawals	482.2	42.4%

Table 3: Summary of Virginia permitted and unpermitted withdrawals reported as of July 2018 by use and source type in 2017 (excluding the Other category)

V. FUTURE CHALLENGES AND PRIORITIES

EFFECT OF CURRENT WITHDRAWALS ON FUTURE WATER SUPPLY

- While the Virginia Coastal Plain Groundwater Initiative has been successful in reducing permitted withdrawals from the Potomac Aquifer by about 50%, additional work needs to be done to ensure the availability of the Coastal Plain aquifer system as a reliable water source for the future. Unpermitted self supplied groundwater withdrawals continue to grow and represent an incremental reduction in the progress made in reducing the largest permitted withdrawals. In addition, the reductions made left some areas remaining below the critical water level. The reductions achieved do not provide any meaningful increase in the available capacity for new or expanded withdrawals. The regional benefits of the Hampton Roads Sanitation District's Sustainable Water Initiative for Tomorrow, while promising, is just now being tested at small injection volumes and its ultimate

benefit may not be known for a decade or more. DEQ is continuing to work with permitted facilities to decrease net withdrawals, to identify alternate sources of water, and to investigate other innovative ways to increase supplies in order to maintain groundwater productivity and availability over the next 50 years. Consideration should be given to implementation of the Eastern Virginia Groundwater Management Advisory Committee's recommendations to address resources and unpermitted withdrawals and the DEQ response. House Bill 358 (2018 Va. Acts Ch. 427) partially addressed one recommendation.

- On the Eastern Shore, DEQ is currently addressing a large cohort of unpermitted groundwater withdrawals associated with poultry farming operations. Some of these facilities have been in existence for decades and are relatively small withdrawals. However, in the last couple of years the industry has expanded, with a significant number of new facilities located in Accomack County. Many of these new facilities are large enough that withdrawals may exceed the threshold requiring a groundwater withdrawal permit. In 2018, DEQ proposed the use of consent orders to bring the unpermitted facilities into compliance until permit decisions can be made. A total of 57 facilities are addressed in the draft consent orders. The draft consent orders, if approved by the State Water Control Board, include withdrawal limits for each facility and require monitoring and reporting of withdrawals, providing critical water use data that are necessary for the permitting process. To continue operation beyond the time frame of the consent orders, each facility will need to work through the permitting process to attain a groundwater withdrawal permit. However, with any large influx of new withdrawals in a region there may be resource allocation challenges. The agency must ensure each withdrawal meets the permit criteria within the Groundwater Management Act of 1992. Bringing the withdrawals into compliance while allowing for continued growth for other beneficial uses in the region will likely require a collaborative approach involving a range of Eastern Shore stakeholders.

- VWP permitted withdrawals in 2017 amounted to approximately 264 MGD and known excluded (unpermitted) surface water withdrawals amounted to approximately 873 MGD. A comparison of reported withdrawals with water use estimates from the water supply plans indicates that water withdrawals from several categories may be under-reported. Lack of information regarding water withdrawal rates causes additional uncertainty when making estimates of available water supply during drought events or in surface water basins where water withdrawal activities are concentrated.

- Analyses conducted during preparation of the SWRP indicated that nearly 97% of the total projected 2040 surface water demand is proposed to come from approximately 25% of the stream reaches evaluated. Cumulative impact analyses indicated that these projected surface water withdrawal increases may result in potential negative impacts to public water supplies during future drought situations, particularly within the James, Potomac-Shenandoah, and York River basins.[15] Withdrawal systems within these basins that do not have offline storage available may be at risk during extended drought periods. For example, the operations of several small hydroelectric facilities in the Shenandoah basin that are exempted from FERC licensing requirements can negatively affect downstream water availability to public water supplies during low flow periods. The current lake-level contingency operations plan at Lake Anna can reduce downstream flow in the Pamunkey River for extended periods.

[15] *State Water Resources Plan*, Figure 4-11 and Table 5-10.

- DEQ continued collection of groundwater samples in order to monitor for salt water "upconing," the upwelling of salty groundwater that can occur in response to the local removal of non-saline groundwater by water wells in the Coastal Plain Aquifer System.

Long-term Priorities Identified in the State Water Resources Plan

The State Water Resources Plan identified 12 challenges for future water resources management and provided recommendations for action. A number of the 2017 activities described in Chapter II above were focused on gathering, storing, and analyzing data in order to improve water resource management for the Commonwealth. Progress in addressing the challenges and implementing the recommendations includes the following:

- Challenge: Understanding the Impact of Unpermitted Water Withdrawals. DEQ has continued collaboration with VDH to estimate the number of unpermitted private wells in the Eastern Virginia GWMA. VDH previously reported that approximately 275,000 to 300,000 homes are served by private wells in the Eastern Virginia GWMA. It was also estimated that approximately 1,500 new private wells are permitted annually by VDH for construction in the GWMA. Based on estimated usage by use type (irrigation, drinking water, etc.), additional unpermitted groundwater demands of approximately 1 MGD per year are anticipated.

- Challenge: Gaps in Water Withdrawal Reporting, Differences in Reporting Thresholds between WSP and VWWR Regulations, and Lack of Adequate Data. The data gaps in withdrawal reporting have led to a systematic approach to improve reporting which initially focused on golf courses and continues with the agricultural community. In 2017, the efforts to improve reporting resulted in an additional eight farms registered to report withdrawals annually for a total of 27 farms registered through DEQ's outreach efforts.

- Challenge: Quantifying Current and Future Risks to Groundwater Availability Outside of Current Groundwater Management Areas. Groundwater resource investigations were conducted in the fractured rock aquifer portion of the state to better understand the complexities associated with the flow and storage of groundwater in fractured rock settings. During the 2017 calendar year, particular emphasis was placed on collection and analysis of hydrogeologic data from the granitic and meta-sedimentary rocks in northern Fauquier County as part of a larger, ongoing study being conducted by the USGS to characterize the groundwater resources in the county.

- Challenge: Threats to Stream Water Quality. DEQ continued its collaboration with USGS and Virginia Tech to evaluate streamflow metrics to improve cumulative impact analyses for surface water withdrawals.

- Challenge: Public Education and Outreach. In 2017, over 50 localities received training in the use of the VA Hydro database as a water supply planning tool. Technical assistance and outreach to localities and planning regions continues to facilitate compliance with the water supply planning 5-Year review requirements. As of August 15, 2018, 165 of the 323 localities statewide are in full compliance.

- Challenge: Understanding the Impact of Consumptive Use on Water Supply. DEQ obtained USGS grant funding to improve consumptive use data analysis, transfer, and export. DEQ has partnered with USGS and Virginia Tech to initiate a study of consumptive use trends and predictive model development to better understand and track impacts of water transfers.

- Challenge: Conflict Resolution. DEQ provided leadership and coordination of the work of the Eastern Virginia Groundwater Management Advisory Committee and associated subcommittees. This Committee was formed to assist the State Water Commission and DEQ in developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia GWMA.

Investment Challenges for Water Resources Management

Continued financial investment is necessary for program development and implementation, and improved local government and public participation as DEQ strives to effectively manage Virginia's water resources for current and future generations. Identified investment challenges include:

- The Eastern Virginia Groundwater Management Advisory Committee noted that an updated unregulated use estimation methodology is necessary to more accurately quantify and manage the Commonwealth's water resources. DEQ's groundwater model currently uses an estimate of 29 MGD for "unregulated use" based on a methodology developed by the USGS and published in 2008. DEQ also estimated that by 2016 unregulated use increased to 39 MGD since the publication of the report. Securing additional funding to update the unregulated use methodology will be a significant factor in the success of ongoing groundwater modeling efforts.

- The numbers of long-term monitoring stations for surface water flow, groundwater levels, and groundwater quality have not kept pace with identified resource management needs. Sustained funding to support surface water flow and groundwater level data collection and analysis is essential to accurately quantify and manage the Commonwealth's water resources. Such surface and groundwater data are an integral part of many DEQ programs including numerous permitting programs, establishment of Total Maximum Daily Loads (TMDL), water supply planning, and overall water resource characterization; therefore, continued local, state, and federal investment in these stations is critical.

- Maintenance and rehabilitation of wells in the statewide groundwater level monitoring network will be a priority for the near future. There are approximately 300 wells in the network managed by both DEQ and USGS. Aging well infrastructure associated with many of the wells in the network will require a case-by-case evaluation of well integrity and subsequent well rehabilitation (if needed) in order to insure that hydrostatic pressures in the aquifer continue to be accurately represented by the water level in the observation well.

- Investment in regional water supply program implementation is necessary to build long-term local government stewardship of local and regional water resources. A secure source of funding for planning grants to local governments is a fundamental element to the success of the State Water Resources Plan (SWRP) implementation and long-term maintenance of the SWRP. A recurring comment from local and regional entities about the SWRP is that for the process to reach its full potential, funding to support local water supply planning efforts is essential to maintain long-term data gathering and planning.

- As part of the effort to monitor chloride concentrations in the Coastal Plain aquifer system, additional monitoring wells will need to be drilled in order to sample in the portions of the system that are thought to be most vulnerable to "up-coning" or the landward movement of the freshwater/saltwater interface. Prioritization of new monitoring well locations will be guided by the cooperatively prepared USGS chloride monitoring strategy funded by DEQ (USGS Scientific Investigations Report 2015-5117). Securing additional funding for the installation of new chloride monitoring wells will be a major factor in starting this monitoring program.

- In order to maintain Virginia's cooperative agreement between DEQ and the USGS for the collection of real-time streamflow data, DEQ staff must continue to receive state of the art training provided by USGS and the necessary equipment to maintain the existing gauging station network. Continued training for use of USGS' recently-implemented sophisticated data management system remains an emphasis for SWIP staff.

- Improvements are needed in the way the transfer of water is tracked, both within systems and between entities. This information is important to understanding the extent of water loss due to inter or intra-basin transfers or other factors and can have a significant impact on water resource planning.

- As part of the effort to monitor land subsidence in the Coastal Plain, securing additional funding for the operation, and maintenance of existing extensometers will be a major factor in the success of monitoring land subsidence. At least one additional extensometer will need to be installed in the region that is thought to be most vulnerable to movement as a result of ongoing groundwater withdrawals. The Eastern Virginia Groundwater Management Advisory Committee identified West Point, Virginia as a potential location of a new extensometer. DEQ's groundwater model estimates nearly a foot of subsidence has occurred near West Point since 1910.

APPENDIX 1: WATER RESOURCES INFORMATION AND CLIMATIC CONDITIONS

State Population (2010 census) – 8,001,025
(2017 U.S. Census Bureau estimate) – 8.47 million

State Surface Area – 42,775 square miles (39,493 sq. miles total land area, 3,282 sq. miles inland waters)

Major River Basins (with Current Estimates of Annual Mean River Flow):

Tennessee-Big Sandy (4,132 sq. miles, 2,986 MGD)

Albemarle Sound-Chowan River (4,220 sq. miles, 1,724 MGD)

James (10,265 square miles, 5,437 MGD)

New (3,068 square miles, 3,229 MGD)

Rappahannock (2,712 square miles, 1,085 MGD)

Roanoke (6,393 square miles, 4,955 MGD)

Potomac-Shenandoah (5,681 sq. miles, 1,842 MGD)

Chesapeake Bay-Small Coastal (3,592 sq. miles, 97 MGD)

York (2,674 square miles, 1,053 MGD)

Total Non-tidal River/Stream Miles - 100,927 (This estimate represents mileage determined by the USGS National Hydrography Dataset)

Publicly-Owned Lakes and Reservoirs

There are 248 publicly-owned lakes in the Commonwealth:

Larger than 5,000 acres -	5	109,838 acres
Smaller than 5,000 acres -	243	52,392 acres
Total	248	162,230 acres

Additionally, hundreds of small privately-owned lakes and ponds are distributed throughout the state.

Freshwater Wetlands - 808,000 acres

Tidal and Coastal Wetlands - 236,900 acres

Estuary (excluding small coastal areas) - 2,308 sq. miles

Atlantic Ocean Coastline - 120 Miles

Statewide Average Annual Rainfall – 42.9 inches

Average Freshwater Discharge of All Rivers - Approximately 22.5 billion gallons per day

Average Freshwater Discharge into the Chesapeake Bay – Approximately 9.5 billion gallons per day

Climatic Conditions: As of September 5, 2018, the 2018 water year (October 1, 2017 through September 30, 2018) precipitation totals varied across Virginia, depending upon location. Precipitation totals were above normal across northern and western Virginia, and normal to slightly below normal in south-central and southeastern Virginia and the Eastern Shore. During the first six months of the 2018 water year, dry conditions prevailed across most of the Commonwealth, where Drought Watch declarations were in effect for the Northern Virginia, Northern Piedmont, Middle James, Roanoke and Chowan drought evaluation regions until early June . Much wetter than normal conditions returned during May in most areas, followed by normal conditions during June and July. By September, stream flows at most gaging stations and groundwater levels in the majority of Climate Response Network observation wells were at or above normal levels. Water supply storage reservoirs throughout the Commonwealth maintained water levels within normal ranges throughout the water year.

APPENDIX 2: WATER TRANSFERS IN THE VA HYDRO DATABASE

Water use is tracked in the VWUDS database by recording different actions, identified as follows:

- WL = Withdrawal
- RL = Release
- DL = Delivery
- SR = System Release
- SD = System Delivery

In general, withdrawals from a water source (groundwater or surface water) account for the largest portion of a locality's actual water use. Water is also *transferred*, or sold, both within a water system and between water purveyors and water users. "System release" and "system delivery" records established in the VA Hydro database refer to situations where both the water treatment plant and the service area are owned and operated by the same waterworks entity. System release records contain data regarding the amounts of water released from a water treatment facility to a service area within a particular water system. System delivery records contain data about water received within a particular service area from, for example, a water treatment plant. Water is generally "released from" or, sold to, a water treatment plant, and "delivered to," or purchased by, a service area, or water distribution system.

In addition to system releases and system deliveries within their own water treatment and distribution systems, some entities report the sale or purchase of water to/from a customer outside of their own system as well as system releases and deliveries. These transactions are established in the VA Hydro database as "releases" to outside customers and "deliveries" of water from another outside customer.

Currently, not all water transfers are consistently reported to the VA Hydro database, in part because many systems lack the technology necessary to track water transfers that closely. For example, in several instances, there are localities that have reported water releases (RL), but there are no corresponding records indicating the water has been received and used by another locality (DL) or entity. Some entities reportedly sell water (RL), but have no reported means of receiving water (WL, DL, or SR). Improvements in the way DEQ tracks the transfer of water, both within systems and between entities, are important to understanding the extent of water loss due to aging infrastructure, as an example, or other factors and can have a significant impact on water resource planning.

APPENDIX 3: TOP 20 WATER WITHDRAWAL SYSTEMS IN 2017 (excluding power generation)

Facility	City/County	Type	Major Source	Avg. MGD	2017 MGD	Category
Honeywell International: Hopewell Plant **	Hopewell	SW	James River	106.8	110.69	Manufacturing
Fairfax Water Authority: Potomac River WTP **	Fairfax	SW	Potomac River	90.1	87.85	Municipal
Norfolk: Western Branch Reservoir **	Suffolk	SW	Western Branch Reservoir	63.0	72.6	Municipal
Fairfax Water Authority: Occoquan Reservoir **	Prince William	SW	Occoquan Reservoir	64.2	67.32	Municipal
City of Richmond: Richmond WTP **	Richmond, City	SW	James River	63.4	65.16	Municipal
Celanese Acetate LLC: Celco Plant **	Giles	SW	New River	53.1	54.56	Manufacturing
WestRock Virginia: Covington Plant **	Alleghany	SW	Jackson River	38.5	37.96	Manufacturing
Appomattox River Water Authority: Chesdin Reservoir WTP *	Chesterfield	SW	Chesdin Reservoir	31.8	32.65	Municipal
Portsmouth: Lake Kilby WTP *	Suffolk	SW/GW	Lake Kilby, Meade & 6 wells	25.7	29.85	Municipal
Virginia Beach: Virginia Beach Service Area **	Virginia Beach	SW	Lake Gaston	25.0	28.42	Municipal
DuPont E I De Nemours: Spruance Plant **	Chesterfield	SW	James River	29.1	26.96	Manufacturing
Henrico County: Henrico County WTP *	Henrico	SW	James River	25.3	25.21	Municipal
Honeywell Resins & Chemicals: Chesterfield Plant **	Chesterfield	SW	James River	15.8	25.14	Manufacturing
Newport News: Lee Hall WTP & ROF **	Newport News	SW	Lee Hall Reservoir	23.3	22.02	Municipal
Virginia American Water: Hopewell District **	Hopewell	SW	Appomattox River	20.6	20.75	Municipal
US Government: Radford Ammunitions Water Treatment Plant **	Montgomery	SW	New River	20.9	19.4	Manufacturing
WestRock CP, LLC: West Point Mill Water System *	King William	GW	12 Wells	18.5	18.04	Manufacturing
Newport News: Harwood's Mill WTP **	York	SW	Harwood's Mill Reservoir	19.1	17.38	Municipal
GP Big Island, LLC: Georgia-Pacific Big Island WTP **	Bedford	SW	James River	13.6	14	Manufacturing
Western VA Water Authority: Roanoke Service Area **	Roanoke	SW/GW	Carvins Cove, Crystal Spring & 4 wells	14.4	13.94	Municipal

AG: Agriculture; GW: Groundwater; MAN: Manufacturing; PWS: Public Water Supply; SW: Surface Water

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 4: Top 20 Water Withdrawal Systems in 2017

APPENDIX 4: WATER WITHDRAWALS BY USE CATEGORY

Water withdrawals reported annually to VA Hydro are grouped into the following categories:

- Agriculture
- Commercial
- Fossil Fuel Power
- Hydropower
- Irrigation
- Manufacturing
- Mining
- Nuclear Power
- Public Water Supply
- Other

The "Agriculture" category includes water withdrawn for raising livestock, and for fish farming and hatcheries, but is not inclusive of water used for crop irrigation. The "Commercial" category includes water used by golf courses, local and federal installations, hotels, resorts, and correctional centers, among others. The "Irrigation" category includes water used to promote crop growth, including but not limited to tobacco, corn, soybeans, turf grass, and ornamental nursery products. "Mining" includes water withdrawn for the excavation, processing, and removal of bulk products such as coal, rock, sand, and gravel. "Manufacturing" facilities include paper mills, food processors, pharmaceutical companies, furniture manufacturing, and concrete plants, among others. "Public Water Supply" includes water withdrawn and treated to produce water for drinking water, and other domestic and residential uses. It also includes water that is processed and sold to commercial or institutional facilities that are not self-supplied. The "Other" category contains a small number of facilities for which water use does not fit into one of the previously mentioned categories.

Appendix 4 is divided into sections, or two to four page fact sheets for most categories, each containing information regarding withdrawals reported for 2017, including the following:

- A map depicting withdrawal point locations for each category, scaled by the magnitude of the 2017 reported annual withdrawal rate of individual facilities;
- A bar graph illustrating the reported quantity withdrawn for each category between 2013 and 2017, as well as the relative amounts by source type (groundwater or surface water);
- A table that lists withdrawals for 2013-2017 in terms of an annual average rate by source type (groundwater or surface water); and
- A table listing facilities reporting the largest withdrawals for 2017, facility location, water source, reported 2017 annual withdrawal rate, and the average annual withdrawal rate for the 2013-2017 period.

Several major transfers of water occur for public water supply; therefore, the total water used for public water supply by locality includes the water withdrawals in that locality, as well as water transferred into that locality from elsewhere, minus any water sold to other localities. The public water supply water withdrawal totals do not include water withdrawn by individuals from private wells, as those withdrawals are not required to be reported. The total only represents the water withdrawn by public or

private community water systems. Additional information concerning water transfers can be found in Appendix 2.

Withdrawals or diversions of water for hydroelectric power generation are nearly all non-consumptive and are exempt from the annual water withdrawal reporting requirements. As a result, reported withdrawals for this category are mostly incomplete and a detailed description for Hydropower is not included; however, a discussion of Consumptive Use of Water is provided in Chapter III. Fossil Fuel Power and Nuclear Power are combined as one section entitled Power Generation Water Withdrawals.

AGRICULTURE (NON-IRRIGATION) WATER WITHDRAWALS

Withdrawals for Agriculture include the non-irrigation withdrawals from operations such as commodity farms, fish farms, and hatcheries. Information concerning Irrigation withdrawals associated with agriculture and other uses is provided on the Irrigation Water Withdrawals fact sheet. Figure 16 illustrates the distribution of reported 2017 groundwater and surface water withdrawals for agricultural purposes statewide. The majority of water withdrawn for agricultural uses is obtained from springs located in western Virginia and nearly all is withdrawn from surface waters (Figure 17 and Table 5). Reported groundwater withdrawals remained consistent at 1.7 MGD from 2016 and 2017. Agricultural withdrawals from springs had been increasing steadily over the past four years. However, reported 2017 withdrawals from surface water sources fell by 2.6 MGD to 31.9 MGD (Table 5). Groundwater is pumped at lower rates for livestock production in southeastern Virginia. Water withdrawals from agriculture make up about 3% of all reported non-power generation withdrawals in Virginia.

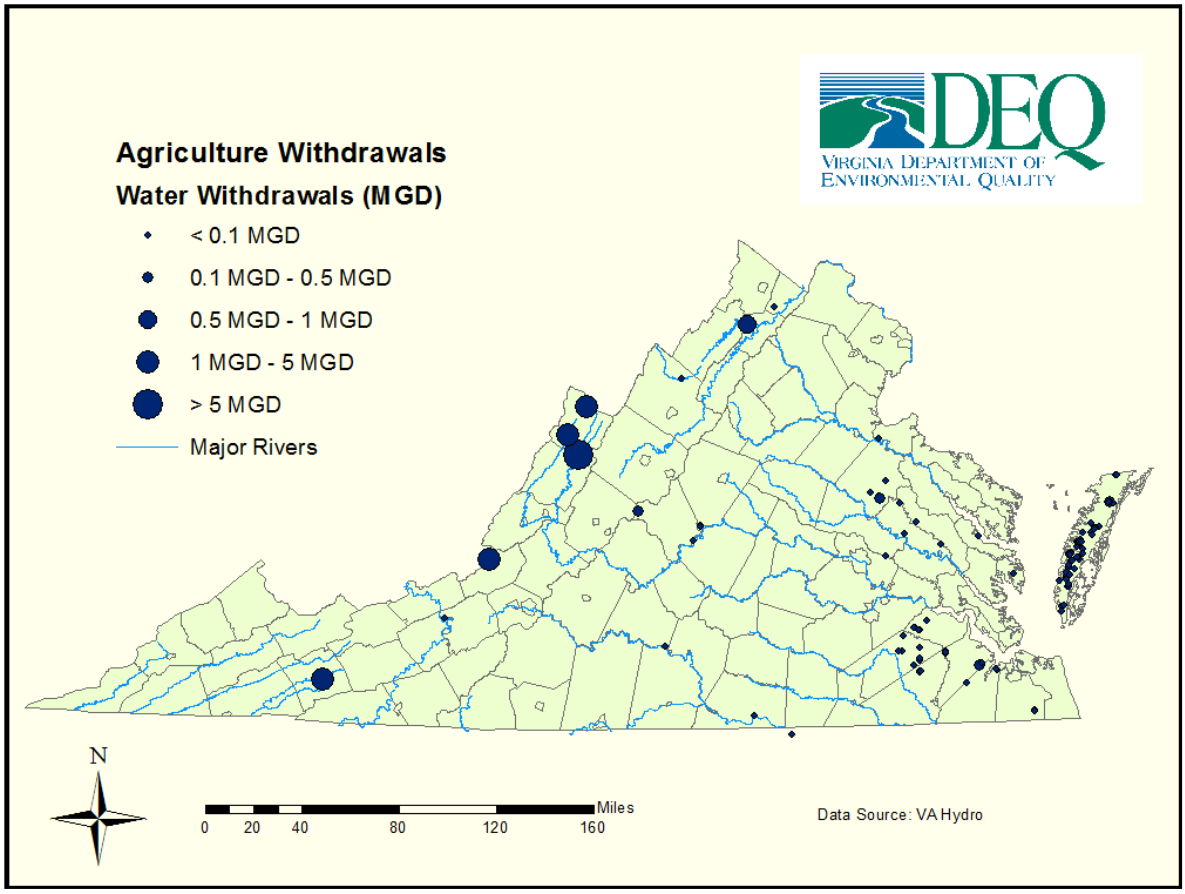

Figure 16: Agricultural (non-irrigation) water withdrawals by withdrawal point location

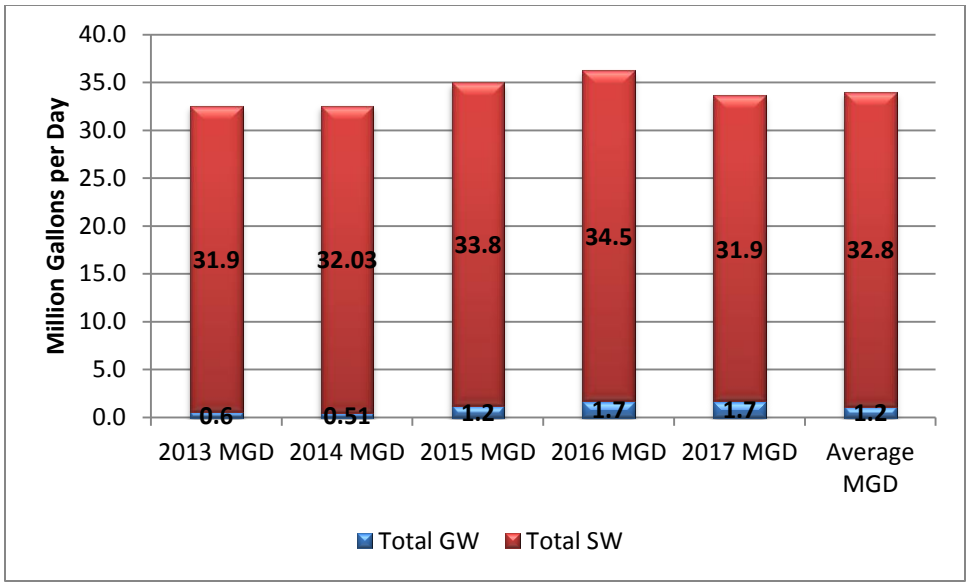

Figure 17: 2013-2017 Agricultural water withdrawals by source type

Source Type	2013 MGD	2014 MGD	2015 MGD	2016 MGD	2017 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	0.6	0.51	1.2	1.7	1.7	1.2	0.0	0
Total SW	31.9	32.03	33.8	34.5	31.9	32.8	2.6	8
Total GW + SW	32.5	32.5	35.0	36.3	33.6	34.0	2.7	7

[1] Absolute Change = difference between 2017 water withdrawals and 2016 water withdrawals
[2]% Change = percent difference in 2017 water withdrawals from 2016 water withdrawals

Table 5: 2013-2017 Agricultural water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
Commonwealth of Virginia: Coursey Spring Fisheries **	Bath	SW	Coursey Spring	10.7032	11.5
Virginia Trout Company Inc: Terry Place Plant **	Highland	SW	Blue Spring	4.5168	3.96
Commonwealth of Virginia: Marion Fish Cultural Station **	Smyth	SW	Staleys Creek	3.1944	3.38
Commonwealth of Virginia: Paint Bank Fish Cultural Station **	Craig	SW	Pain Bank Branch	2.9144	3.26
Commonwealth of Virginia: Wytheville Fish Hatchery **	Wythe	SW	Boiling and West Springs	3.284	3.1

[1]Average = Average water withdrawals from 2013-2017

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 6: Top water withdrawals by agricultural (non-irrigation) operations

IRRIGATION WATER WITHDRAWALS

Irrigation withdrawals promote growth in crops such as tobacco, corn, soybeans, turf grass, and ornamental nursery products. Figure 18 illustrates the distribution of reported 2017 groundwater and surface water withdrawals for irrigation purposes statewide. Surface water continues to be the major water source type for irrigation, representing about 90% of total irrigation withdrawals (Figure 19). The majority of the reported groundwater withdrawals for irrigation are from "dug" ponds or groundwater filled reservoirs in Accomack and Northampton counties on the Eastern Shore. Because these ponds do not have a direct connection with a perennial stream they are categorized in VA Hydro as groundwater sources. There are no major transfers of water for irrigation, so water withdrawal figures also represent water use. Reported water withdrawals for irrigation in 2017 are 2 MGD less than the reported withdrawals in 2016 and 3.9 MGD less than the five-year average (Table 7).

As with previous years, most large-scale irrigation facilities are located in the northern Coastal Plain (Northern Neck) counties and on the Eastern Shore. The five facilities with the greatest withdrawals for irrigation in 2017 are listed in Table 8. Water withdrawals from irrigation make up about 1% of all non-power generation withdrawals in Virginia.

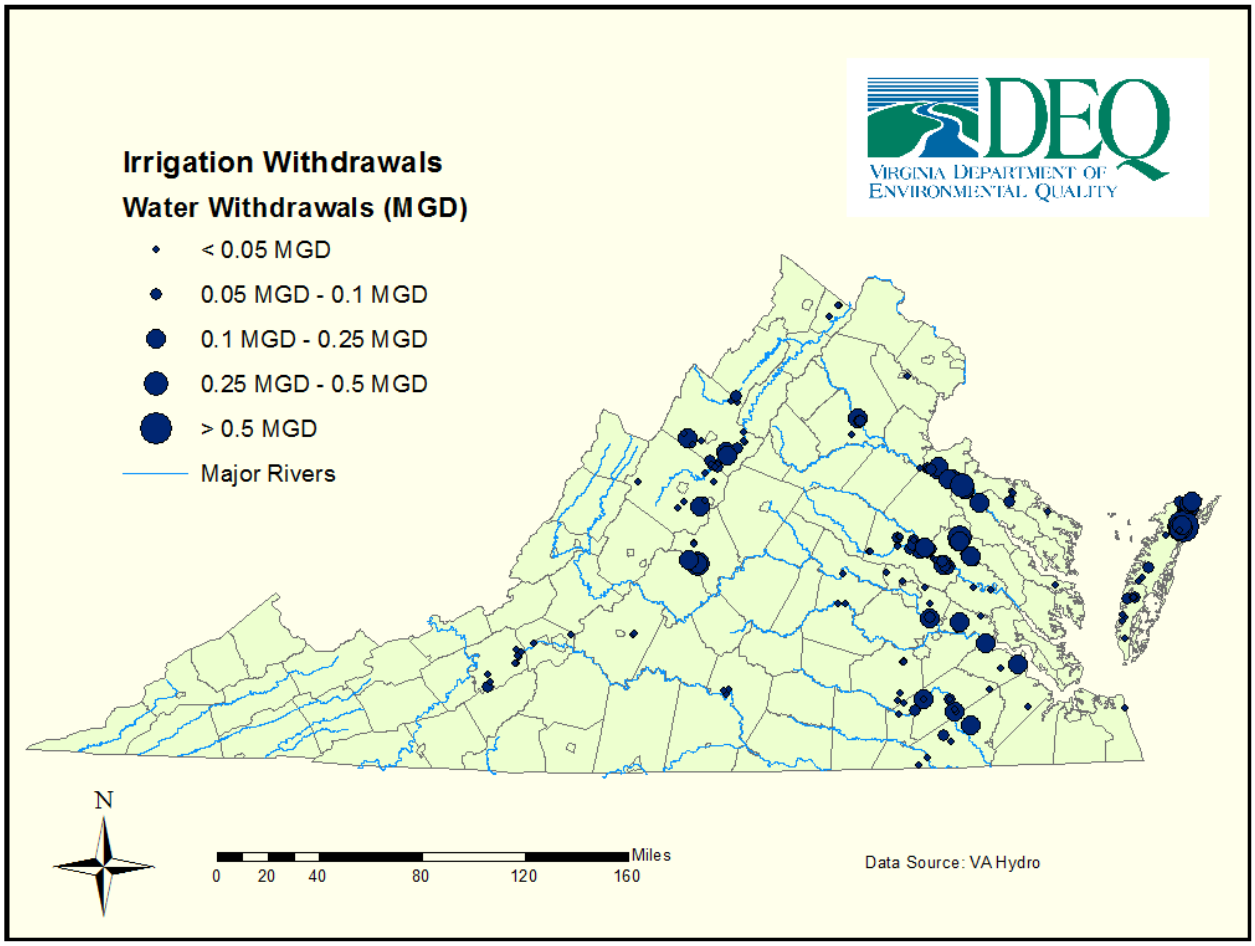

Figure 18: Irrigation (agricultural) water withdrawals by withdrawal point location

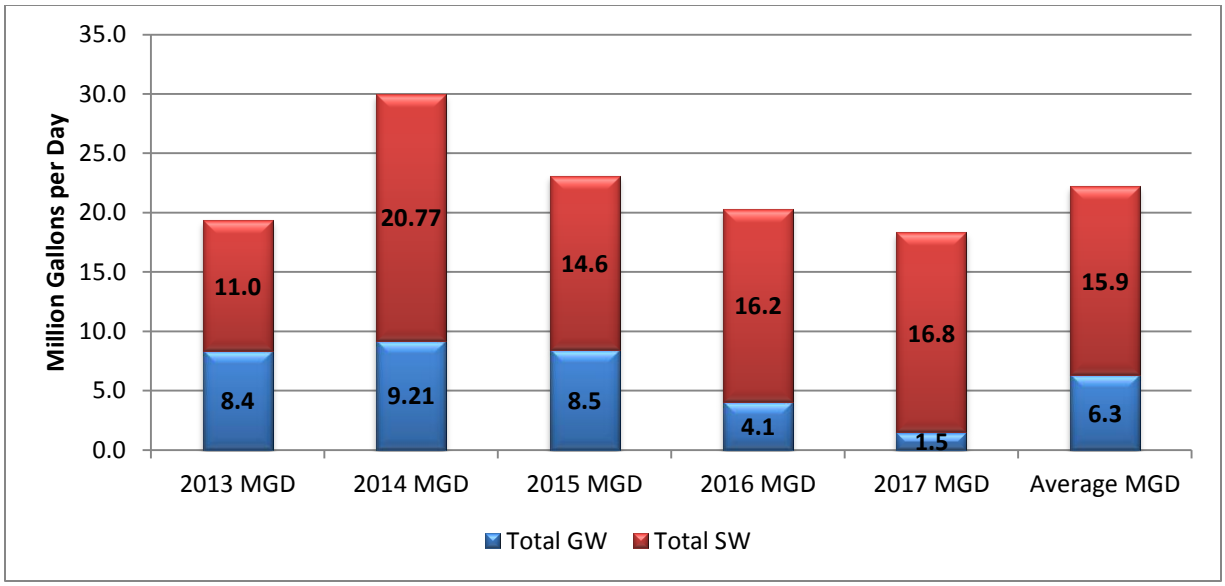

Figure 19: 2013-2017 Irrigation (agricultural) water withdrawals by source type

Source Type	2013 MGD	2014 MGD	2015 MGD	2016 MGD	2017 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	8.4	9.21	8.5	4.1	1.5	6.3	2.6	63
Total SW	11.0	20.77	14.6	16.2	16.8	15.9	0.6	4
Total GW + SW	19.3	30.0	23.1	20.3	18.3	22.2	2.0	10

[1]Absolute Change = difference between 2017 water withdrawals and 2016 water withdrawals
[2]% Change = percent difference in 2017 water withdrawals from 2016 water withdrawals

Table 7: 2013-2017 Irrigation (agricultural) water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
Robert C Darby and Sons: Arbuckle Farms **	Accomack	GW	6 Dug Ponds	4.536	2.2
E Phillip and David L Hickman: Dublin Farms Inc **	Accomack	SW/GW	13 Farm Ponds, 1 Dug Pond	2.06	1.5
Saunders Brothers Inc **	Nelson	SW/GW	Tye River, Allen Creek, Farm Ponds, and Two Wells	0.726	0.99
Philip T & Philip R Minor: Glenwood **	King and Queen	SW	Chapel Creek and Ponds	0.796	0.98
Cloverfield Enterprises: Cloverfield Farm **	Essex	SW/GW	2 Ponds, Rappahannock River	0.534	0.67

[1]Average = Average water withdrawals from 2013-2017
*Permitted Withdrawal
**Unpermitted Withdrawal

Table 8: Top water withdrawals for irrigation (agricultural)

COMMERCIAL WATER WITHDRAWALS

Commercial operations include golf courses, local and federal installations, hotels, resorts, and correctional centers, among others. Figure 20 illustrates the distribution of reported 2017 groundwater and surface water withdrawals and transfers for commercial purposes are spread throughout Virginia, predominantly near population centers. Surface water withdrawal totals are typically greater than groundwater withdrawal totals for commercial operations (Figure 21). Reported surface water withdrawals fell for the first time in several years after increasing from the 2013-2016 period (Table 9). Reported groundwater withdrawals remained consistent around 6 MGD. Total water withdrawals for commercial operations in 2017 were almost identical to the average withdrawals over the past five years (Table 9). The five facilities reporting the largest 2016 water withdrawals for commercial operations are listed in Table 10. Water withdrawals from commercial activities make up about 1% of all non-power generation withdrawals in Virginia.

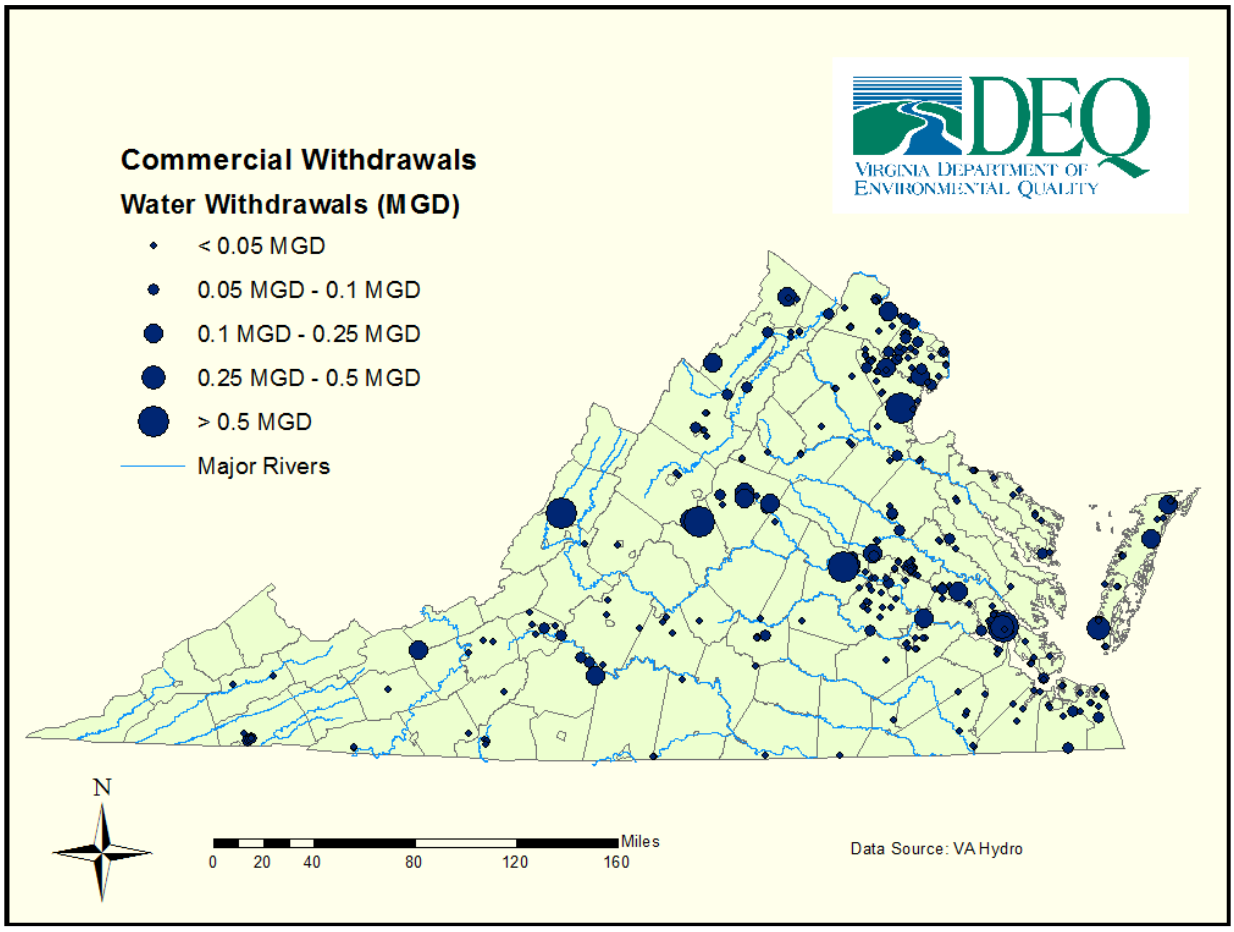

Figure 20: Commercial water withdrawals by withdrawal point location

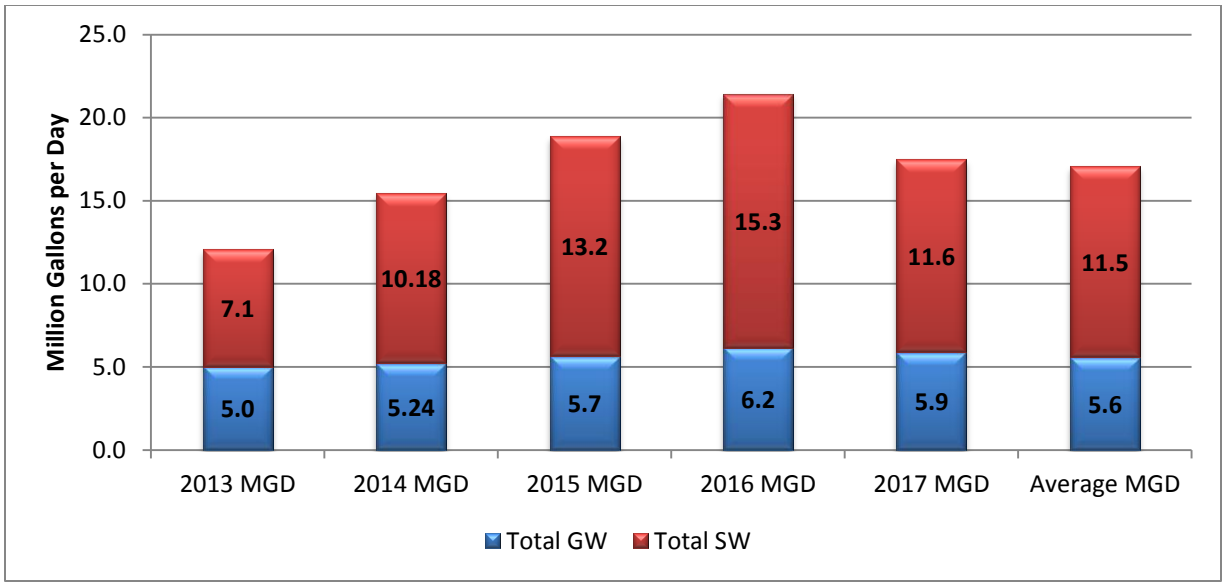

Figure 21: 2013-2017 Commercial water withdrawals by source type

Source Type	2013 MGD	2014 MGD	2015 MGD	2016 MGD	2017 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	5.0	5.24	5.7	6.2	5.9	5.6	0.3	5
Total SW	7.1	10.18	13.2	15.3	11.6	11.5	3.7	24
Total GW + SW	12.1	15.4	18.9	21.4	17.5	17.1	3.9	18

[1] Absolute Change = difference between 2017 water withdrawals and 2016 water withdrawals
[2]% Change = percent difference in 2017 water withdrawals from 2016 water withdrawals

Table 9: 2013-2017 Commercial Water Withdrawals by Source Type

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
Colonial Williamsburg Hotel *	Williamsburg	GW	3 Wells	1.1208	1.1
US Government: Post Camp Water Treatment Plant **	Prince William	SW	Breckenridge Reservoir	1.0324	0.97
Wintergreen Partners, Inc: Lake Monocan **	Nelson	SW	Lake Monocan	0.9252	0.89
Homestead Water Co: Virginia Hot Springs **	Bath	SW	3 Springs	0.6188	0.75
Bay Creek Resort & Club: Bay Creek Resort & Club **	Northampton	SW	Two Lakes	0.4852	0.57

[1]Average = Average water withdrawals from 2013-2017

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 10: Top water withdrawals by commercial facilities

MINING WATER WITHDRAWALS

Mining includes operations such as sand, rock, and coal mining. Figure 22 illustrates the distribution of reported 2017 groundwater and surface water withdrawals for mining purposes statewide. The majority of stone and sand mining facilities are located along the I-95 corridor. Coal mining withdrawals are located in the Appalachian Basin in southwestern Virginia. Water used for mining purposes comes from predominantly surface water sources, though groundwater makes roughly 37% in 2017 (Figure 23). This is mainly due to the Kimballton Plant 2 facility withdrawing over 2 MGD more than their five-year average (Table 12). Total water withdrawals in 2017 for mining purposes decreased by 2.8 MGD from the previous year (Table 11). Because there are no major transfers of water for mining purposes, the water withdrawals also represent water use. The five facilities reporting the largest 2017 mining withdrawals are listed in Table 12. Water withdrawals from mining make up about 1% of all non-power generation withdrawals in Virginia.

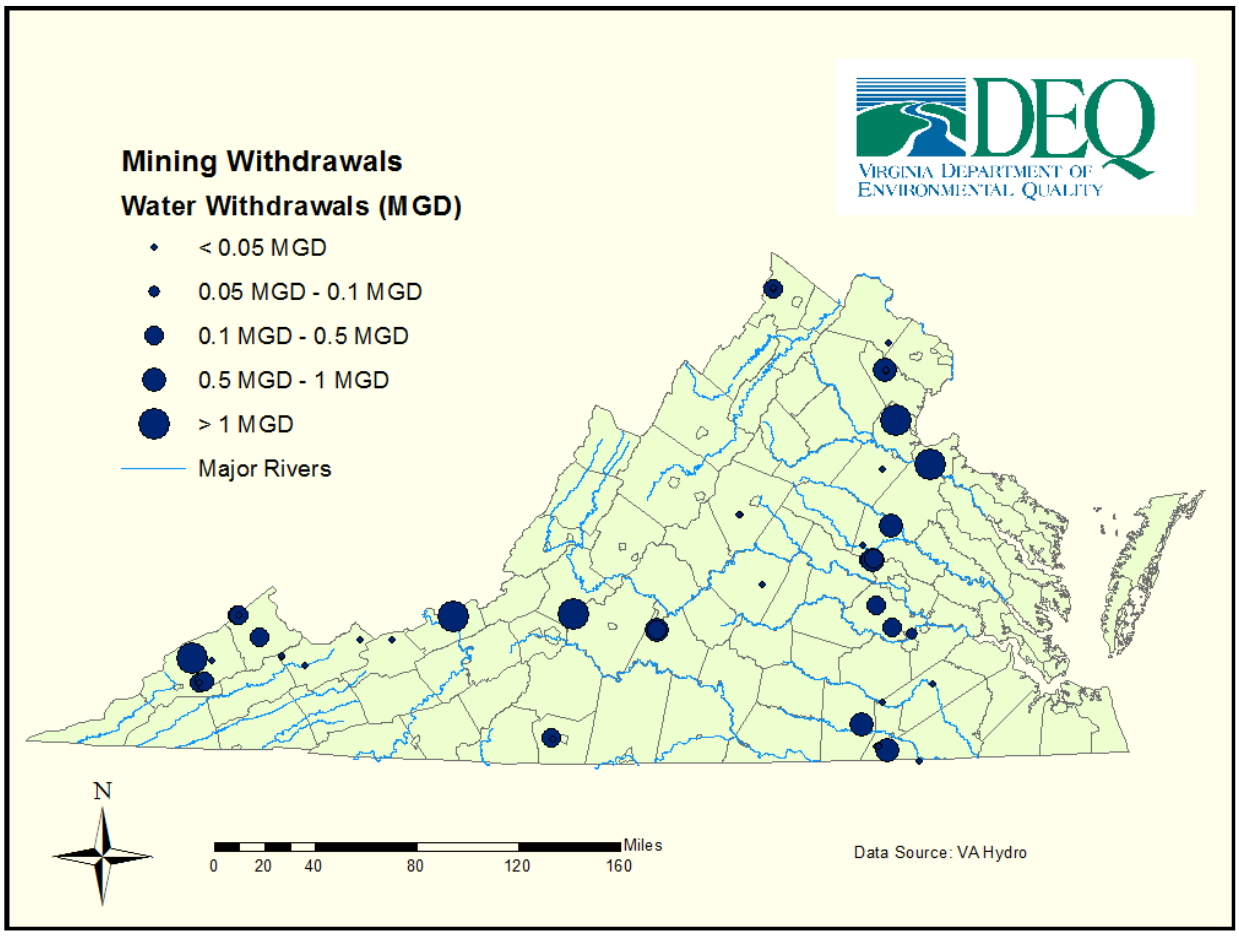

Figure 22: Mining water withdrawals by withdrawal point location

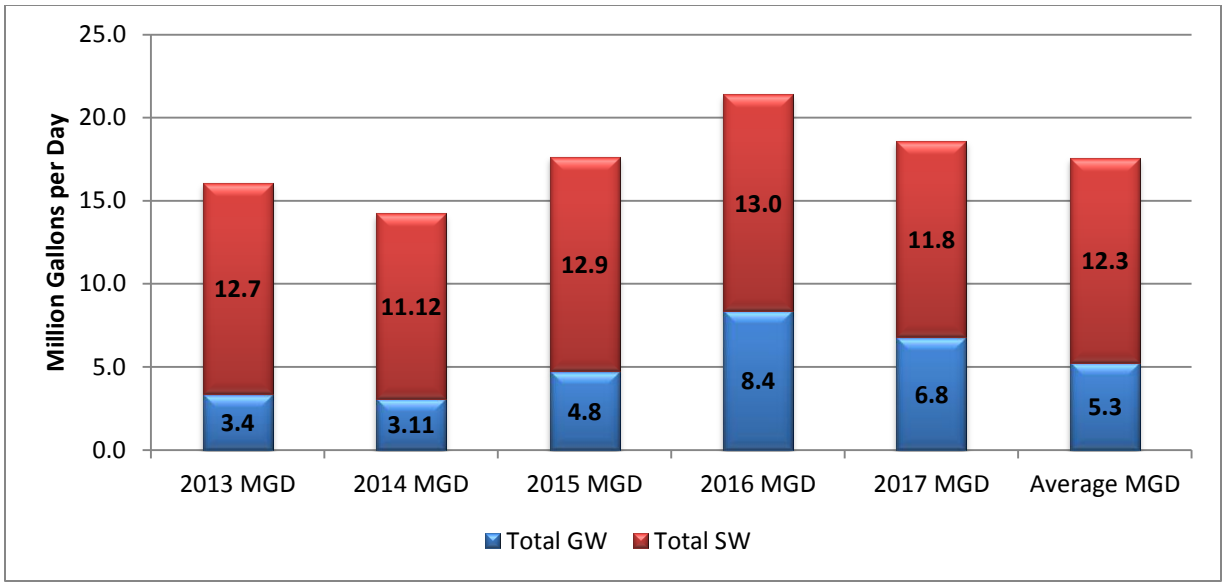

Figure 23: 2013-2017 Mining water withdrawals by source type

Source Type	2013 MGD	2014 MGD	2015 MGD	2016 MGD	2017 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	3.4	3.11	4.8	8.4	6.8	5.3	1.6	19
Total SW	12.7	11.12	12.9	13.0	11.8	12.3	1.2	9
Total GW + SW	16.1	14.2	17.6	21.4	18.6	17.6	2.8	13

[1] Absolute Change = difference between 2017 water withdrawals and 2016 water withdrawals
[2]% Change = percent difference in 2017 water withdrawals from 2016 water withdrawals

Table 11: 2013-2017 Mining water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
Lhoist North America of Virginia, Inc: Kimballton Plant 2 **	Giles	SW/GW	Stony Creek and Quarry Well	2.552	5.2
Boxley Materials Company: Blue Ridge Plant **	Bedford	SW	Quarry	1.468	1.5
Mid-Atlantic Materials: Rappahannock Farms Sand & Gravel **	King George	SW	Rappahannock River	0.936	1.4
Dickenson-Russell Contura, LLC: McClure Mine & Prep Plant **	Dickenson	SW	Caney Creek	1.136	1.2
Vulcan Construction Materials: Stafford Plant **	Stafford	SW	Quarry	0.668	1.1

[1]Average = Average water withdrawals from 2013-2017

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 12: Top water withdrawals by mining operations

MANUFACTURING WATER WITHDRAWALS

Manufacturing includes operations such as chemical and plastics manufacturing, paper mills, food processors, drug companies, furniture, and concrete companies. Water withdrawals reported in 2017 for manufacturing purposes are spread throughout much of Virginia (Figure 24). Clusters of large-scale withdrawals occur in the Tidewater, Richmond, and Shenandoah Valley regions, as well as the New River and the Jackson/Upper James River basins. All of the manufacturing locations with large withdrawals are situated on or near major rivers to facilitate water supply.

Figure 25 illustrates the distribution and annual changes in statewide totals of groundwater and surface water withdrawals for manufacturing from 2013-2017, respectively. Reported manufacturing withdrawals during 2017 increased by over 20 MGD than reported withdrawals in 2016 and are about 14.6 MGD more than the five-year average (Table 13). Surface water is the predominant water source type for manufacturing, accounting for about 84% of the total withdrawals in 2017 and the majority of the increase in withdrawals from 2016. There are no major transfers of water reported for manufacturing purposes, so the water withdrawals generally represent water use. Table 14 lists the five largest facilities in terms of manufacturing water withdrawals in 2017, all of which are surface water withdrawals. Table 15 lists the top 5 manufacturing facilities in terms of groundwater withdrawals. Water withdrawals from manufacturing make up about 31% of all non-power generation withdrawals in Virginia.

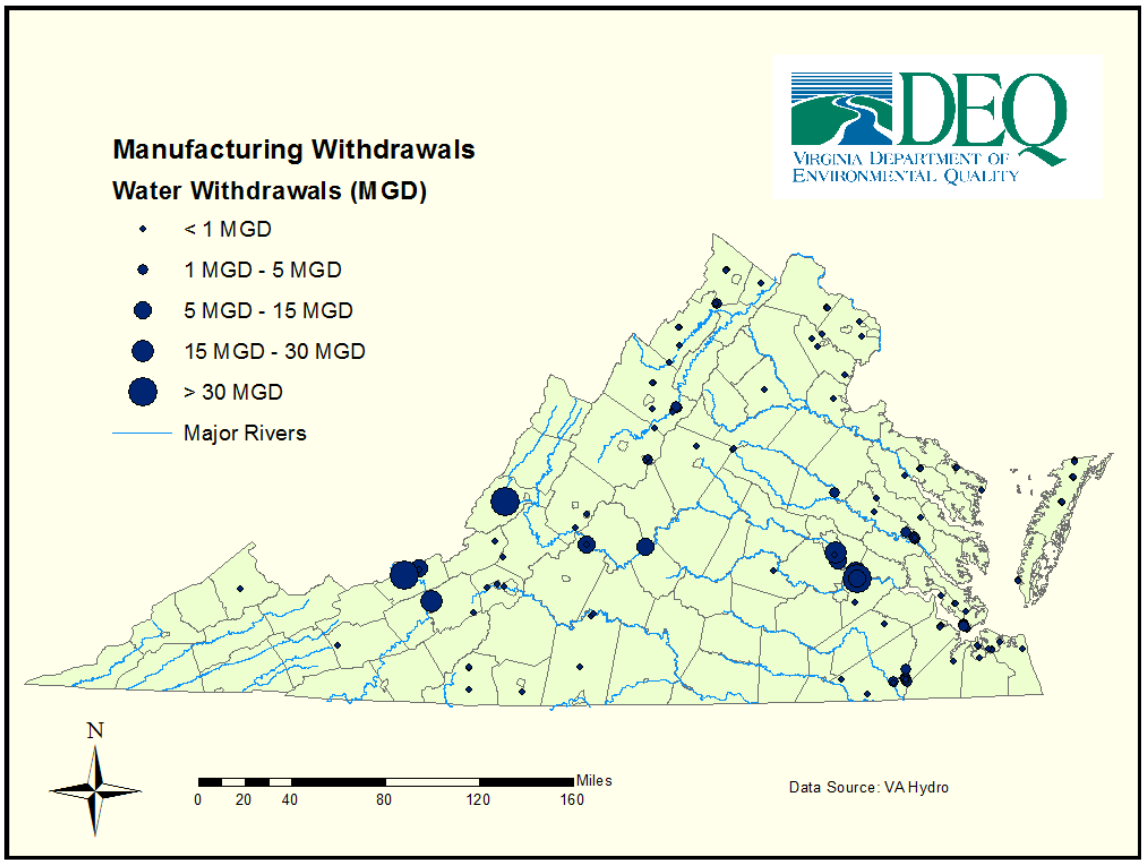

Figure 24: Manufacturing water withdrawals by withdrawal point location

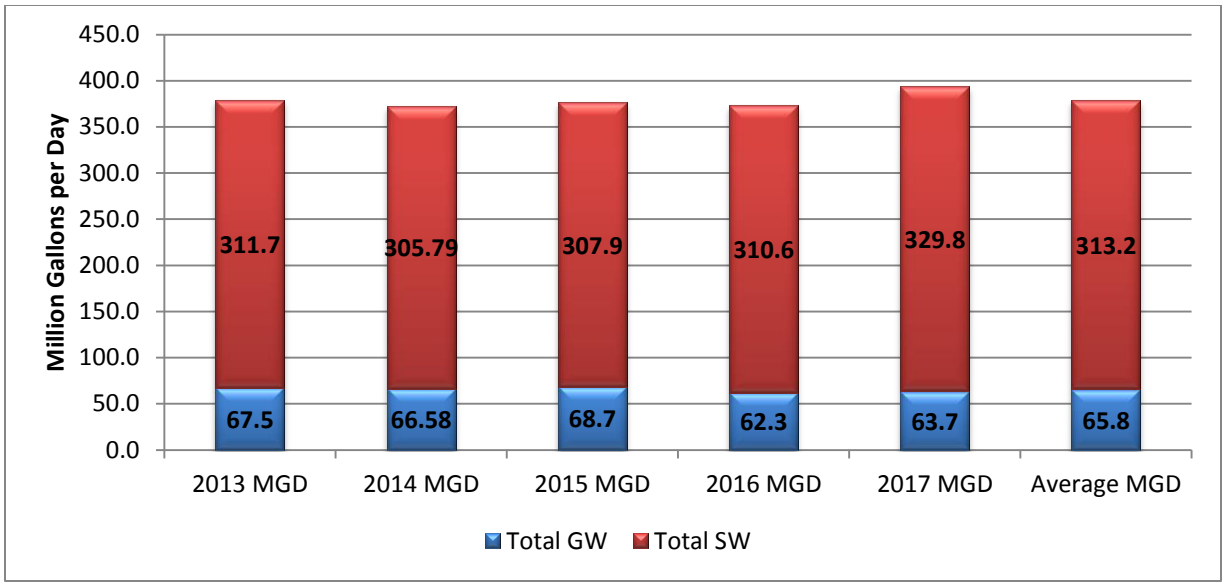

Figure 25: 2013-2017 Manufacturing water withdrawals by source type

Source Type	2013 MGD	2014 MGD	2015 MGD	2016 MGD	2017 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	67.5	66.58	68.7	62.3	63.7	65.8	1.4	2
Total SW	311.7	305.79	307.9	310.6	329.8	313.2	19.2	6
Total GW + SW	379.2	372.4	376.6	372.9	393.5	378.9	20.6	5

[1] Absolute Change = difference between 2017 water withdrawals and 2016 water withdrawals
[2]% Change = percent difference in 2017 water withdrawals from 2016 water withdrawals

Table 13: 2013-2017 Manufacturing water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
Honeywell International: Hopewell Plant **	Hopewell	SW	James River	106.7668	110.69
Celanese Acetate LLC: Celco Plant **	Giles	SW	New River	53.1312	54.56
WestRock Virginia: Covington Plant **	Alleghany	SW	Jackson River	38.508	37.98
DuPont E I De Nemours: Spruance Plant **	Chesterfield	SW	James River	29.1024	26.96
Honeywell Resins & Chemicals: Chesterfield Plant **	Chesterfield	SW	James River	15.828	25.14

[1]Average = Average water withdrawals from 2013-2017

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 14: Top surface water withdrawals by manufacturing facilities

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
WestRock CP, LLC: West Point Mill Water System *	King William	GW	14 Wells	18.112	18.04
International Paper: Franklin Plant *	Isle of Wight	GW	10 Wells	10.432	12.12
Lhoist North America of VA, Inc: Kimballton Plant 1 **	Giles	GW	Quarry Well Dewatering	8.4092	8.71
Merck & Co: Elkton Plant **	Rockingham	GW	11 Wells	6.9564	5.71
Solenis LLC: Solenis *	Southampton	GW	4 Wells	2.706	2.69

[1]Average = Average water withdrawals from 2013-2017

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 15: Top groundwater withdrawals by manufacturing facilities

PUBLIC WATER SUPPLY WATER WITHDRAWALS

Water withdrawals for public water supply are primarily delivered to domestic users by both municipal (public) and private water purveyors; however, significant volumes are also delivered to commercial and industrial customers. Deliveries to specific users are generally not reported to DEQ; therefore, the reported withdrawals for public water supply do not differentiate between the categories of end users.

While the greatest number of systems are small systems that use groundwater (nearly 86%), the majority of the population is served by larger surface water systems. The largest public water supply withdrawals are located within or near population centers such as the Washington DC, Richmond, Hampton Roads, and Roanoke metropolitan areas. The largest public water supply purchases are located in the same areas, where water purveyors with large reservoirs or river withdrawals sell water to their neighbors. Smaller public water supply purveyors are scattered throughout the rest of the state (Figure 26).

Total water withdrawals for public water supply during 2017 were about 22 MGD greater than both the 2016 total and the average for the 2013-2017 period (Figure 27). As with manufacturing, surface water is the major source of water for public water supply in terms of the overall quantities used. Surface water supplied about 94% of the total 2017 public water supply withdrawals in Virginia (Table 16). Table 17 lists the ten facilities that withdrew water for public water supply at the greatest rates during 2017.

There are several major transfers of water that occur for public water supply; therefore, the total water used for public water supply in each locality includes the water withdrawals in that locality, as well as water transferred into that locality from elsewhere, minus any water sold to other localities. The public water supply water withdrawal total does not include water withdrawn by individuals from private wells, as those withdrawals are not required to report. The total only represents the water withdrawn by public or private community water systems. Table 18 displays information from VDH's 2016 Public Drinking Water Annual Compliance Report. The report lists the number of public water supply waterworks by type and the total population served by all of these systems (population served by type of waterworks was not available).

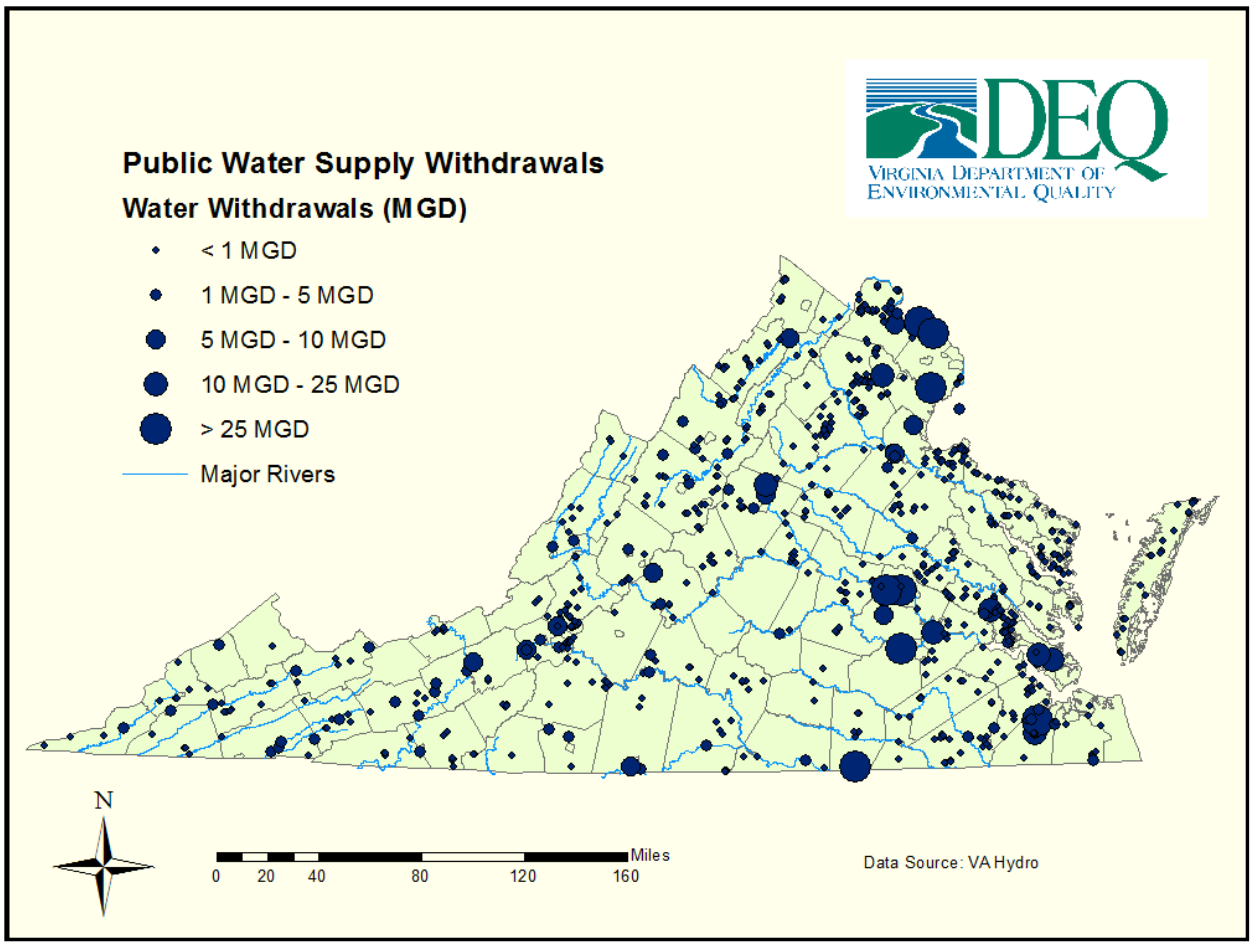

Figure 26: Public water supply withdrawals by withdrawal point location

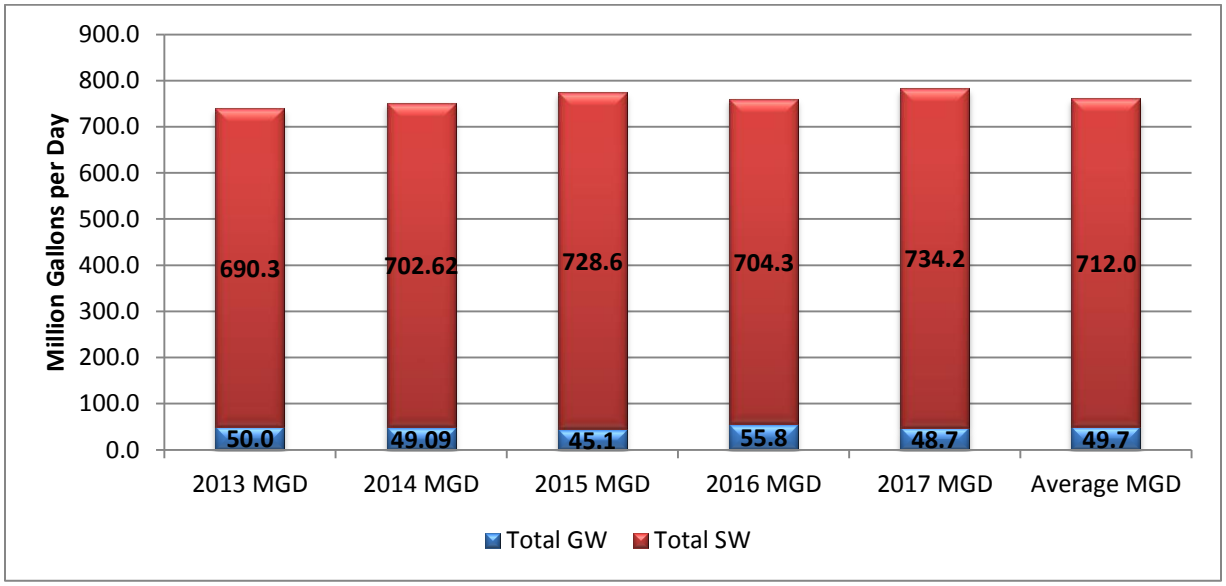

Figure 27: 2013-2017 Public water supply water withdrawals by source type

Source Type	2013 MGD	2014 MGD	2015 MGD	2016 MGD	2017 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	50.0	49.09	45.1	55.8	48.7	49.7	7.1	13
Total SW	690.3	702.62	728.6	704.3	734.2	712.0	29.9	4
Total GW + SW	740.3	751.7	773.7	760.1	782.9	761.7	22.8	3

[1] Absolute Change = difference between 2017 water withdrawals and 2016 water withdrawals
[2] % Change = percent difference in 2017 water withdrawals from 2016 water withdrawals

Table 16: 2013-2017 Public water supply water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
Fairfax Water Authority: Potomac River WTP **	Fairfax	SW	Potomac River	90.114	87.85
Norfolk: Western Branch Reservoir **	Suffolk	SW	Western Branch Reservoir	62.9664	72.6
Fairfax Water Authority: Occoquan Reservoir **	Prince William	SW	Occoquan Reservoir	64.2448	67.32
City of Richmond: Richmond WTP **	Richmond, City	SW	James River	63.3552	65.16
Appomattox River Water Authority: Chesdin Reservoir WTP *	Chesterfield	SW	Chesdin Reservoir	31.762	32.65
Portsmouth: Lake Kilby WTP *	Suffolk	SW/GW	Lake Kilby, Meade & 6 wells	25.7364	29.85
Virginia Beach: Virginia Beach Service Area **	Virginia Beach	SW	Lake Gaston	24.9528	28.42
Henrico County: Henrico County WTP *	Henrico	SW	James River	25.3476	25.21
Newport News: Lee Hall WTP & ROF **	Newport News	SW	Lee Hall Reservoir	23.3288	22.02
Virginia American Water: Hopewell District **	Hopewell	SW	Appomattox River	20.6444	20.75

[1]Average = Average water withdrawals from 2013-2017

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 17: Top water withdrawals by public water supply facilities

Category	Community Waterworks	Nontransient Noncommunity Waterworks	Transient Noncommunity Waterworks	Total
Number of Systems	1,110	520	1,168	2,798
Population Served	--	--	--	7,519,576

Source: VDH 2017 Pubic Drinking Water Annual Compliance Report (accessed 7/06/2018)

Table 18: Number of public water systems and total population served, 2017

POWER GENERATION WATER WITHDRAWALS

Withdrawals for power generation are treated separately because most of the water diverted for these purposes is used non-consumptively (see Chapter III for a description of non-consumptive water use). Withdrawals during 2017 by nuclear and fossil fuel power generating plants are listed below. Water diverted for hydropower use is exempted from reporting and is nearly all non-consumptive use; therefore, these flows are generally not reported to the VA Hydro database.

Most of the large fossil-fuel facilities are located in central or eastern Virginia. Virginia has two nuclear-powered generating plants, located in Louisa and Surry counties (Figure 28).Groundwater withdrawals by power generators in 2017 were insignificant compared to surface water withdrawals, which is true historically as well (Figure 29). Total power generation withdrawals decreased 323 MGD from 2016 totals, though that only represents a 6% decrease (Table 19). Surface water and groundwater withdrawals reached 5,047 MGD in 2017. The five power generation facilities with the highest 2017 withdrawals are listed in Table 20.

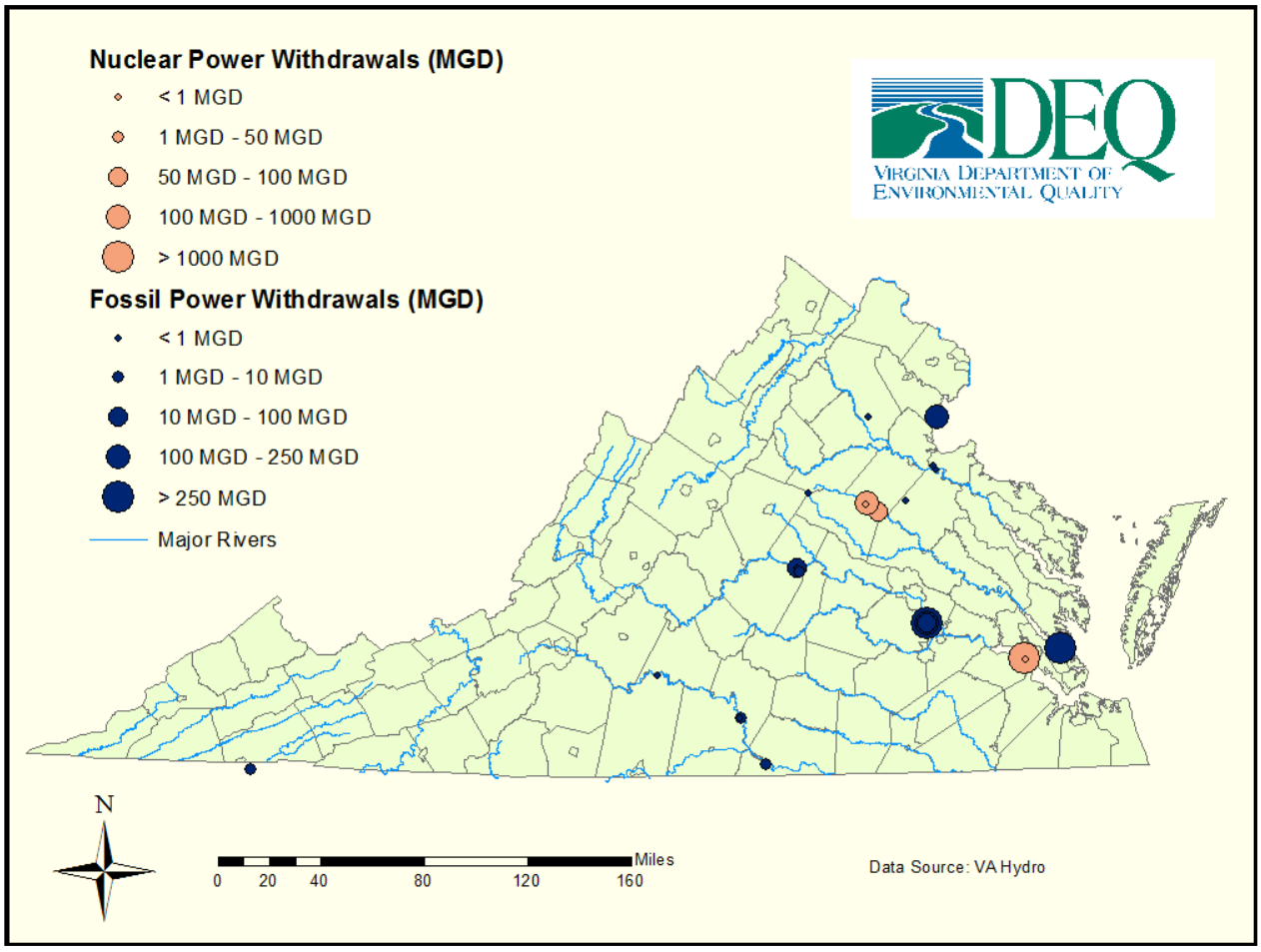

Figure 28: Power generation withdrawals by withdrawal point location

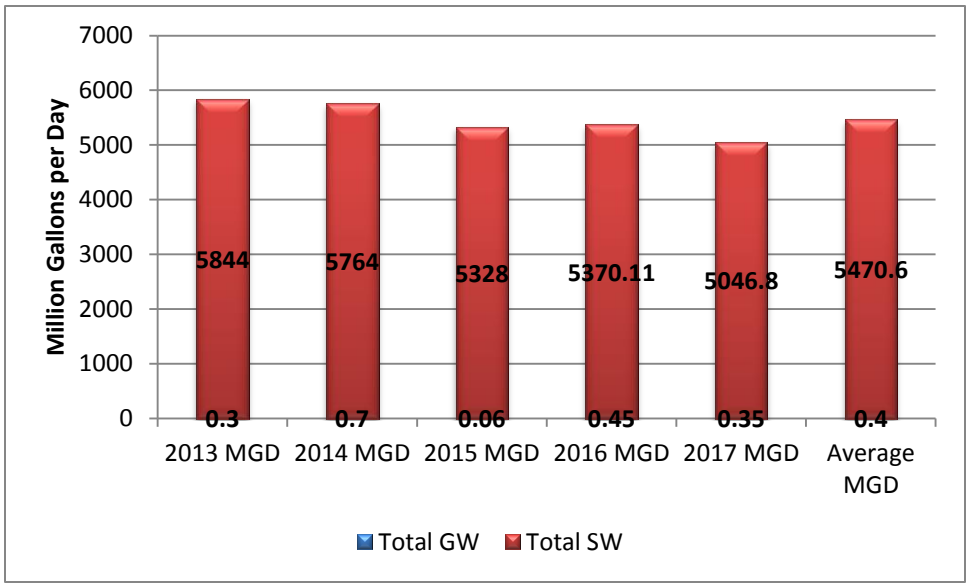

Figure 29: 2013-2017 Power generation withdrawals by source type

Source Type	2013 MGD	2014 MGD	2015 MGD	2016 MGD	2017 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW:	0.3	0.7	0.06	0.45	0.35	0.4	0.1	22
Fossil - GW	0.02	0.5	0.05	0.08	0.03	0.1	0.05	62
Nuclear - GW	0.3	0.2	0.01	0.37	0.32	0.2	0.05	13
Total SW:	5844	5764	5328.28	5370.11	5046.8	5470.6	323.3	6
Fossil - SW	2185	2069	1576.28	1348.67	1095.6	1654.9	253.1	19
Nuclear - SW	3659	3695	3752	4021.44	3,951.20	3815.7	70.2	2
Total GW + SW	5844	5765	5328.34	5370.56	5047.15	5577.0	323.4	6

[1] Absolute Change = difference between 2017 water withdrawals and 2016 water withdrawals
[2]% Change = percent difference in 2017 water withdrawals from 2016 water withdrawals

Table 19: Power generation withdrawals by Source Type for 2013-2017 (excluding hydropower)

Facility	Locality	Type	Major Source	Average MGD	2017 MGD
Dominion Generation: Surry Nuclear Power Plant **	Surry	N	James River	2003.1464	2014.1
Dominion Generation: North Anna Nuclear Power Plant **	Louisa	N	Lake Anna	1812.224	1937.4
Dominion Generation: Chesterfield Power Station **	Chesterfield	F	James River	791.6304	682.4
Dominion Generation: Yorktown Fossil Power Plant **	York	F	York River	477.8264	256.7
Possum Point **	Prince William	F	Potomac River	146.308	112.3

[1]N = Nuclear; F = Fossil
[2]Average = Average water withdrawals from 2013-2017

*Permitted Withdrawal

**Unpermitted Withdrawal

Table 20: Top water withdrawals by power generation facilities

APPENDIX 5: WATER WITHDRAWALS BY LOCALITY IN 2017 (excluding power generation and Dalecarlia Water Treatment Plant)

Locality	GW Withdrawal MGD	SW Withdrawal MGD	GW+SW Withdrawal MGD	% of Total Withdrawal
Accomack	5.6	3.9	9.5	0.8%
Albemarle	0.1	12.6	12.7	1.0%
Alexandria	0.02	0.01	0.03	0.0%
Alleghany	0.2	38.8	39.0	3.1%
Amelia	0.1	0.06	0.2	0.0%
Amherst	0.0	16.8	16.8	1.3%
Appomattox	0.0	0.02	0.02	0.0%
Arlington	0.02	0.1	0.1	0.0%
Augusta	3.3	6.2	9.5	0.8%
Bath	0.1	12.4	12.5	1.0%
Bedford	1.6	17.3	18.9	1.5%
Bland	0.04	0.1	0.2	0.0%
Botetourt	0.2	1.7	1.9	0.2%
Bristol	0.0	0.0	0.0	0.0%
Brunswick	0.01	1.6	1.6	0.1%
Buchanan	0.3	1.0	1.3	0.1%
Buckingham	0.0	6.8	6.8	0.5%
Buena Vista	0.0	0.02	0.02	0.0%
Campbell	0.1	6.0	6.1	0.5%
Caroline	0.8	3.2	3.9	0.3%
Carroll	0.2	0.3	0.5	0.0%
Charles City	0.1	1.1	1.1	0.1%
Charlotte	0.1	0.2	0.3	0.0%
Charlottesville	0.0	0.0	0.0	0.0%
Chesapeake	3.2	2.3	5.5	0.4%
Chesterfield	0.3	98.6	98.8	7.8%
Clarke	0.1	0.6	0.7	0.1%
Covington	0.0	2.2	2.2	0.2%
Craig	0.1	3.3	3.4	0.3%
Culpeper	0.1	2.1	2.2	0.2%
Cumberland	0.0	0.0	0.00	0.0%
Danville	0.0	5.3	5.3	0.4%
Dickenson	0.1	6.2	6.2	0.5%
Dinwiddie	0.0	0.4	0.4	0.0%
Emporia	0.0	0.9	0.9	0.1%
Essex	0.9	0.0	0.9	0.1%
Fairfax County	0.4	89.0	89.4	7.1%
Fairfax City	0.0	0.0	0.05	0.0%
Fauquier	1.8	1.4	3.2	0.3%
Floyd	0.1	0.1	0.2	0.0%
Fluvanna	0.1	0.7	0.9	0.1%
Franklin	0.1	1.1	1.2	0.1%
Frederick	1.3	3.9	5.1	0.4%
Fredericksburg	0.0	0.0	0.02	0.0%
Galax	0.0	1.8	1.8	0.1%

Locality	GW Withdrawal MGD	SW Withdrawal MGD	GW+SW Withdrawal MGD	% of Total Withdrawal
Giles	18.9	50.6	69.5	5.5%
Gloucester	0.7	0.7	1.5	0.0%
Goochland	0.0	1.9	1.9	0.2%
Grayson	0.2	0.1	0.2	0.0%
Greene	0.0	0.6	0.6	0.0%
Greensville	0.0	2.0	2.0	0.2%
Halifax	0.1	1.9	2.0	0.2%
Hampton	0.0	0.0	0.0	0.0%
Hanover	0.5	6.3	6.8	0.5%
Harrisonburg	0.0	0.1	0.1	0.0%
Henrico	0.0	25.6	25.6	2.0%
Henry	0.0	3.3	3.4	0.3%
Highland	0.1	6.3	6.4	0.5%
Hopewell	0.0	144.7	144.7	11.4%
Isle of Wight	13.1	4.7	17.8	1.4%
James City	5.7	3.1	8.8	0.7%
King and Queen	0.0	1.1	1.2	0.1%
King George	1.5	1.8	3.3	0.3%
King William	18.4	0.8	19.2	1.5%
Lancaster	0.4	0.1	0.5	0.0%
Lee	0.0	2.4	2.4	0.2%
Loudoun	1.5	10.2	11.8	0.9%
Louisa	0.3	0.4	0.7	0.1%
Lunenburg	0.0	0.519	0.5	0.0%
Lynchburg	0.0	0.1	0.1	0.0%
Madison	0.1	0.09	0.2	0.0%
Manassas	0.3	13.0	13.3	1.1%
Manassas Park	0.0	0.03	0.0	0.0%
Martinsville	0.0	2.2	2.2	0.2%
Mathews	0.01	0.0	0.0	0.0%
Mecklenburg	0.0	1.8	1.9	0.1%
Middlesex	0.2	0.1	0.2	0.0%
Montgomery	0.1	26.4	26.5	2.1%
Nelson	0.1	2.8	2.9	0.2%
New Kent	0.8	17.9	18.7	1.5%
Newport News	1.1	31.9	33.0	2.6%
Norfolk	0.05	0.4	0.4	0.0%
Northampton	1.1	1.5	2.6	0.2%
Northumberland	0.3	0.0	0.3	0.0%
Norton	0.0	0.8	0.8	0.1%
Nottoway	0.0	1.1	1.1	0.1%
Orange	0.02	1.7	1.7	0.1%
Page	1.0	0.8	1.8	0.1%
Patrick	0.2	0.5	0.6	0.1%
Petersburg	0.04	0.04	0.1	0.0%
Pittsylvania	0.01	2.5	2.5	0.2%
Portsmouth	0.1	0.0	0.1	0.0%
Powhatan	0.1	0.1	0.2	0.0%

Locality	GW Withdrawal MGD	SW Withdrawal MGD	GW+SW Withdrawal MGD	% of Total Withdrawal
Prince Edward	0.1	1.1	1.2	0.1%
Prince George	0.3	0.1	0.4	0.0%
Prince William	0.5	69.1	69.6	5.5%
Pulaski	0.0	4.4	4.4	0.3%
Radford	0.0	2.4	2.4	0.2%
Rappahannock	0.03	0.0	0.0	0.0%
Richmond County	0.3	0.0	0.3	0.0%
Richmond City	0.18	65.4	65.6	5.2%
Roanoke County	1.17	10.3	11.5	0.9%
Roanoke City	1.5	12.8	14.3	1.1%
Rockbridge	0.5	1.3	1.8	0.1%
Rockingham	14.0	10.3	24.3	1.9%
Russell	0.3	0.9	1.2	0.1%
Salem	1.2	3.0	4.2	0.3%
Scott	0.1	1.1	1.1	0.1%
Shenandoah	3.1	3.3	6.4	0.5%
Smyth	0.2	5.5	5.7	0.4%
Southampton	3.5	4.2	7.7	0.6%
Spotsylvania	0.1	10.9	11.0	0.9%
Stafford	0.0	12.1	12.1	1.0%
Suffolk	4.8	106.5	111.3	8.8%
Surry	0.2	0.1	0.3	0.0%
Sussex	1.0	0.5	1.5	0.1%
Tazewell	0.01	4.2	4.2	0.3%
Virginia Beach	0.1	28.6	28.7	2.3%
Warren	0.1	9.8	9.9	0.8%
Washington	0.2	10.7	10.9	0.9%
Waynesboro	4.0	0.8	4.8	0.4%
Westmoreland	0.4	0.7	1.1	0.1%
Williamsburg	1.0	0.0	1.0	0.1%
Wise	0.0	6.2	6.2	0.5%
Wythe	0.2	7.4	7.6	0.6%
York	0.4	17.4	17.8	1.4%
Totals	128.1	1136.1	1264.1	100%

Table 21: Water Withdrawals by Locality, 2017