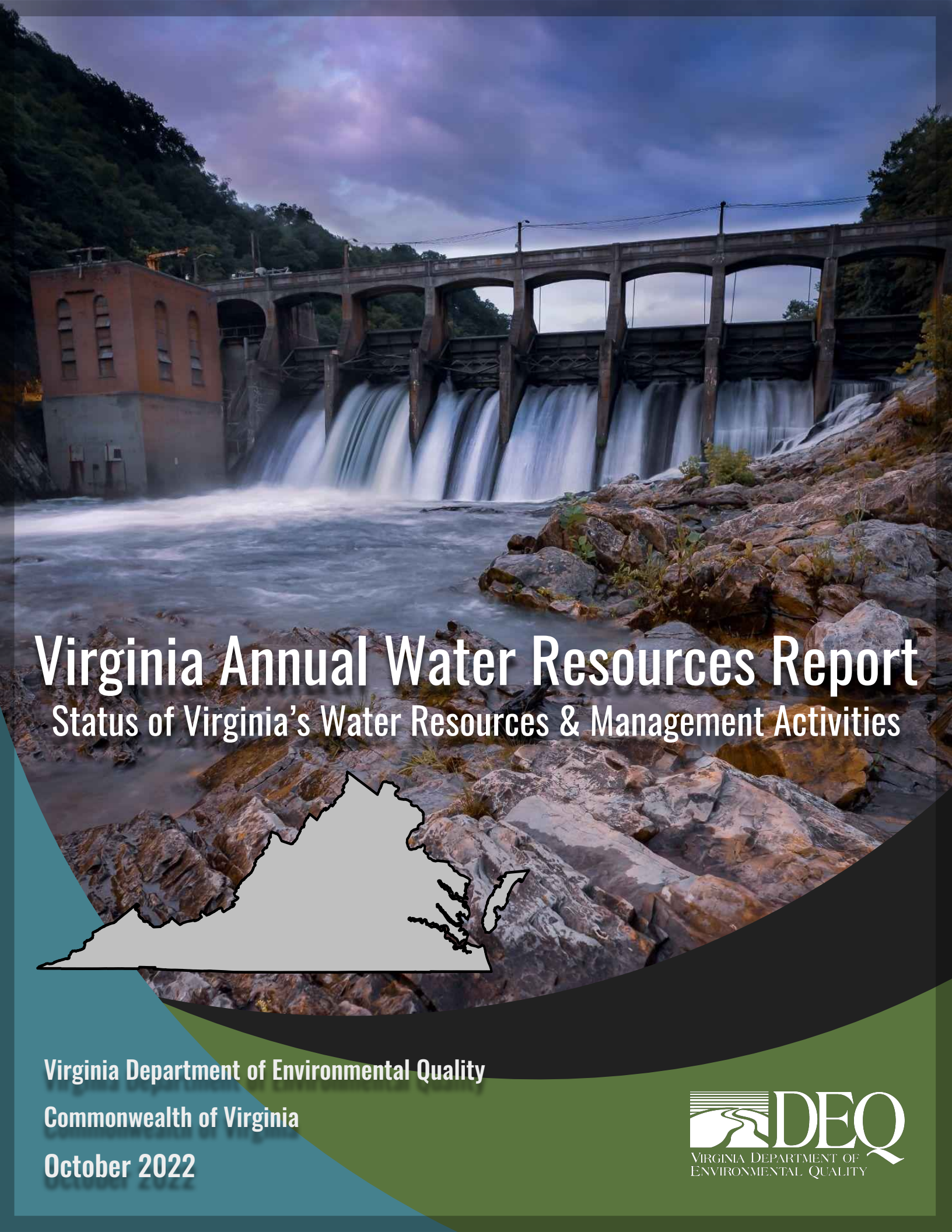

Virginia Annual Water Resources Report

Status of Virginia's Water Resources & Management Activities

Virginia Department of Environmental Quality

Commonwealth of Virginia

October 2022

DEQ
Virginia Department of Environmental Quality

Annual Water Resources Report cover photo by Trevor Lawson, 2021.

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Acronyms

BGD: Billion Gallons per Day
BGY: Billion Gallons per Year
CSO: Consent Special Order
DEQ: Virginia Department of Environmental Quality
FERC: Federal Energy Regulatory Commission
GPD: Gallons per Day
GW: Groundwater
GCMP: Groundwater Characterization and Monitoring Program
GWMA: Groundwater Management Area
HRSD: Hampton Roads Sanitation District
HUC: Hydrologic Unit Code
ICPRB: Interstate Commission on the Potomac River Basin
IFIM: Instream Flow Incremental Method
JPA: Joint Permit Application
MGD: Million Gallons per Day
NOV: Notice of Violation
NPDES: National Pollutant Discharge Elimination System
NWIS: USGS National Water Information System
OWS: Office of Water Supply
PDC: Planning District Commission
PWS: Public Water Supply
RAP: Regulatory Advisory Panel
SW: Surface Water
SWCB or Board: State Water Control Board
SWIFT: Sustainable Water Initiative for Tomorrow
SWIP: Surface Water Investigations Program
TAC: Technical Advisory Committee
TMDL: Total Maximum Daily Load
USACE: United States Army Corps of Engineers
USEPA: United States Environmental Protection Agency
USGS: United States Geological Survey
VT BSE: Virginia Tech Department of Biological Systems Engineering
VDH: Virginia Department of Health
VGIN: Virginia Geographic Information Network
VMRC: Virginia Marine Resources Commission
VWP: Virginia Water Protection (Permit Program)
WSP: Water Supply Plan
WSPA: Water Supply Planning & Analysis
WTP: Water Treatment Plant
WUDR: USGS Water Use Data and Research Program
WWTP: Waste Water Treatment Plant

Executive Summary

The Virginia Annual Water Resources Report (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 2021 calendar year, identifying water withdrawal trends, and providing an update on the Commonwealth's water resources management activities. Where applicable, the Annual Report also serves as a status report on activities associated with the State Water Resources Plan between five year updates. The 2020 State Water Resources Plan was released in January 2022 after completing an extensive public comment and stakeholder outreach process.

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

Chapter 1 provides an overview of water resource management activities and outcomes during 2021. This chapter discusses several DEQ programs including water withdrawal permitting and compliance, water supply planning and analysis, groundwater characterization and monitoring, surface water investigations, and drought assessment and response.

Chapter 2 provides a brief overview on how withdrawals are reported to DEQ, summarizes 2021 reported water withdrawals at the statewide level for all water use types, and compares 2021 reported withdrawals to average use over the past 5 years.

Chapter 3 provides an overview of water withdrawal reporting for the year 2021, as well as comparisons to reporting in recent years, for each of the following water withdrawal use categories: public water supply, commercial, manufacturing, power generation, mining, agriculture, and irrigation.

Chapter 4 identifies new, continuing, and future priorities, challenges, or other topics of specific interest for DEQ. These include updates on new legislative or regulatory actions, programmatic goals and achievements, and other items.

In addition to the main chapters, the report includes several appendices that provide: the top 20 largest reported withdrawals in 2021 (Appendix 1), reported use by locality (Appendix 2), an overview of Virginia's water resources and climatic conditions by the numbers (Appendix 3), and some additional information on water transfers (Appendix 4).

Water Withdrawal Permitting:

DEQ manages groundwater withdrawal permits within the Eastern Virginia Groundwater Management Area and Eastern Shore Groundwater Management Area as well as surface water withdrawal permits statewide. A significant focus of this administration and the DEQ Director is improving permit processing timelines. DEQ's agency-wide Permitting Enhancement and Evaluation Process (PEEP) is underway and is intended to improve efficiency and transparency throughout permitting processes and will be particularly beneficial in identifying critical path improvement for complex individual permit issuance processes. In preparation to integrate effectively into the PEEP process, DEQ's water quantity management programs are addressing a number of issues including: incorporating program data and data management into the DEQ enterprise system, working to bring on new hires to fill vacancies, and accelerating new hire training.

DEQ continues to process a backlog of water withdrawal permit applications with 125 groundwater withdrawal and 35 surface water withdrawal applications in progress. Since January 1, 2020, DEQ has issued 45 groundwater withdrawal permits and 4 surface water withdrawal permits. Review of water withdrawal applications requires extensive inter-agency coordination and a technical evaluation process, both of which contribute to longer permit processing timelines than is typical in other DEQ permit programs. Vacancy rates within the permit program remain a consistent challenge. In the past year, all of the program's senior permit writers retired or took promotional opportunities. DEQ continues to work to fill these vacancies through continuous recruitment strategies. While successful in filling a number of permit writer positions, filling supervisory positions remains a challenge in the current market.

Summary of 2021 Water Withdrawal Reporting and Trends:

In calendar year 2021, 1,176 facilities reported water withdrawals to DEQ. Total reported withdrawals in 2021 were approximately 5.66 billion gallons per day (BGD), including the cooling water withdrawals at nuclear and fossil fuel power generation facilities, which make up 77% of this total. The 2021 total reported withdrawal is 3.5% less than the five year average of 5.87 BGD due to a reduction in reported power generation withdrawals.

Excluding power generation, 2021 reported withdrawals totaled 1.27 BGD, a 2.9% increase compared to the five-year average, and a nearly 8% increase compared to 2020 reported withdrawals. The 2021 total is the highest within the last five years, and the highest since 1.31 BGD was reported in 2010. The increase over the last five years is largely driven by increased withdrawals from public water supply facilities. Reported use for many categories dropped in 2020 due to economic and social impacts associated with the COVID-19 pandemic. While lessening impacts from COVID-19 contributed to the increase in 2021 compared to 2020, 2021 reported water use also exceeded the volumes reported prior to the pandemic.

2021 public water supply withdrawals increased by 3.8% to 803 million gallons per day (MGD), which is the highest reported volume since 2007 (838 MGD). Despite successes in reducing per capita water use, reported public water supply withdrawals have steadily increased over the last ten years as Virginia's population continues to grow in the urban and suburban areas served by public water supplies. Other drivers of increased reported withdrawals in 2021 were increases in agricultural irrigation and manufacturing, which were 17.6% (3.4 MGD by volume) and 1.1% (3.9 MGD by volume) higher than the five year average respectively. Both 2020 and 2021 featured periods of drier than normal conditions which may be contributing to the increase in irrigation compared to the average.

Surface Water: Total reported surface water withdrawals increased by 2.6% compared to the five-year average and surface water withdrawals accounted for approximately 88% of total reported withdrawals in 2021. Public water supply remains the largest non-power use type for surface water withdrawals with 744 million gallons per day (MGD) reported in 2021. Surface water withdrawals for public water supply increased by 3.6% compared to the five year average. Approximately 78% (883 MGD) of 2021 reported surface water withdrawals was associated with unpermitted surface water intakes. Unpermitted surface water use is primarily from facilities that are exempt from permitting requirements.

Groundwater: 2021 reported groundwater withdrawals were the largest over the last five years and were 5.0% greater than the five-year average. Groundwater withdrawals accounted for approximately 12% of total withdrawals in 2021 with 147 MGD reported. Manufacturing and industrial use has historically remained the largest total withdrawal category for groundwater with 59.88 MGD reported in 2021, which is comparable to the five year average. However, 2021 reported groundwater withdrawals for public water supply (59.13 MGD) were nearly equal to manufacturing withdrawals and 6% higher than the five year average. Reported groundwater withdrawals for non-irrigation agricultural use were 19.4% higher than the five-year average. This is largely because 2020 and 2021 were the first years that 52 newly permitted poultry farms on the Eastern Shore began reporting. Reported groundwater withdrawals for commercial users was the only non-power category to decrease, and decreased by 5.8% in 2021 compared to the five year average. Fifty two percent of reported groundwater withdrawals by volume were associated with unpermitted groundwater wells. Reported unpermitted groundwater use is primarily from facilities located outside of groundwater management areas (GWMA).

Water Resources Priorities and Challenges:

The following section summarizes several of the water resource management priorities, challenges, or other topics of specific interest that are discussed in more detail in Chapter 4. These include updates on new legislative or regulatory actions, programmatic goals and achievements, and other items.

The Permitting Enhancement Evaluation Platform (PEEP): DEQ's new Permitting Enhancement Evaluation Platform (PEEP) will provide online public facing resources to communicate and track the critical steps to obtain permitting approvals from DEQ. Water withdrawal permitting is expected to be incorporated in future PEEP updates.

Potomac River Basin Environmental Flows: In 2021, the commissioners of the Interstate Commission on the Potomac River Basin (ICPRB) passed a Resolution on Enhancing Water Supply Resilience for the Washington Metropolitan Area. This resolution is the first step in potentially updating the two foundational agreements of the Washington metropolitan area cooperative water supply system: the Low Flow Allocation Agreement (LFAA) of 1978 and the Water Supply Coordination Agreement (WSCA) of 1982.

A two day workshop was convened by ICPRB in May of 2022 focusing on new approaches to determining environmental flows since the original agreements, and determining what data, analysis tools, and assessments are needed to make a scientifically defensible change to the existing agreements. DEQ participated in the workshop which also included representatives from Maryland, West Virginia, and Pennsylvania, as well as from federal agencies such as the Army Corps of Engineers, Environmental Protection Agency (EPA), United States Geological Survey (USGS), among other groups. ICPRB produced a Workshop Report summarizing the results of the workshop. DEQ will continue to support this important effort to evaluate environmental flows that support all human and environmental beneficial uses of the Potomac River.

Climate Change Modeling and Drought Forecasting: To address uncertainty related to the potential for climate change to impact streamflow, DEQ developed a series of climate change scenarios that simulate how streamflow may respond to various meteorological conditions that are within a reasonable bound based on predictions of the best available global climate models. These scenarios represent the initial effort by DEQ to address climate uncertainty related to surface water resources within the Chesapeake Bay drainage area. In 2021-2022, DEQ completed a project to expand climate change input meteorology data sets to include rivers outside of the Chesapeake Bay watershed. In addition, this project also expanded the climate change simulation period from 10 years (1990-2000) to 1984-present. These model improvements also allow DEQ to simulate future drought conditions using the baseflow recharge expected from current conditions as a starting point, potentially allowing better predictions of the severity of a summer or fall drought when winter and spring conditions suggest the potential for one.

Addressing Unreported Water Use: DEQ staff conduct compliance activities annually to identify users who meet the threshold for annual withdrawal reporting as well as to contact users who have previously reported but have failed to do so consistently. In addition, DEQ works to address known gaps in withdrawal reporting data through projects like a US Geological Survey (USGS) Water Use Data and Research grant funded project to develop estimates of unreported agricultural water use in Virginia which will be completed in Fall 2022.

Eastern Virginia Groundwater Management Area: One of the long-term water resource management challenges in Virginia is the historic over-allocation of groundwater from the Coastal Plain aquifer system in the Eastern Virginia Groundwater Management Area (GWMA), particularly from the Potomac Aquifer. The Hampton Roads Sanitation District's (HRSD) Sustainable Water Initiative for Tomorrow Project (SWIFT) proposes to inject treated water into the Potomac aquifer by constructing injection wells at sites across the Hampton Roads area. The first full-scale injection facility is nearing completion of the EPA Underground Injection Control Permit process for the HRSD James River Plant. Once completed this project may be capable of injecting up to 16 MGD to augment the Potomac Aquifer.

1 2021 Water Resources Management Updates

Citizens of the Commonwealth of Virginia enjoy access to over 100,000 miles of non-tidal streams and rivers, 248 publicly-owned lakes, 236,000 acres of tidal and coastal wetlands, 808,000 acres of freshwater wetlands, 120 miles of Atlantic Ocean coastline, and more than 2,300 square miles of estuaries. However, an increasing population and a growing economy can present challenges for managing water resources despite the relative bounty Virginia enjoys. Virginia benefits from a robust economy and an increasing population drawn by the many opportunities available. The state's water resources are shared across a variety of beneficial uses, including in-stream uses such as recreation, navigation, habitat for wildlife, and the aesthetic value of rivers and streams, as well as off-stream uses such as supplying drinking water, agricultural, commercial, or industrial facilities. Increasing demands coupled with limited resource availability and competition for water highlight the importance of active management of Virginia's water resources. This means placing a greater emphasis on collaboration with state and local governments, 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, particularly during periods of drought.

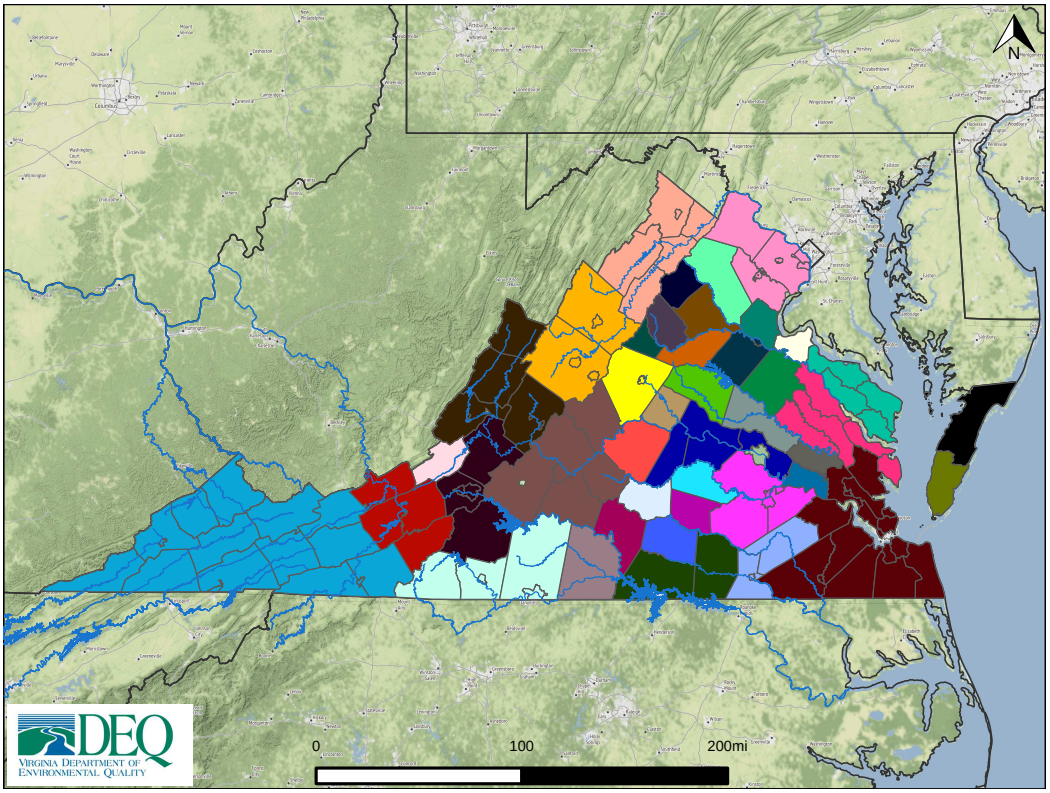
DEQ's mission is "to protect and enhance Virginia's environment, and promote the health and well-being of the citizens of the Commonwealth." State law determines how this mission is to be fulfilled with respect to water resources. More information on the statutes and regulations related to water resources management can be found on the DEQ website. The following sections briefly discuss the various DEQ programs involved in water resources planning and management (Water Supply Planning and Analysis, Water Withdrawal Permitting and Compliance, Groundwater Characterization and Monitoring, Drought Assessment and Response, and Surface Water Investigations) as well as updates on the work done by each program in 2021.

1.1 Water Supply Planning and Analysis

In response to the 2001-2002 drought, during which some water utilities and localities were unable to meet the demands as streamflows decreased to record levels, the Virginia General Assembly enacted a statute (Chapter 3.2 of the Code of Virginia) that required the development of a comprehensive water supply planning program requiring periodic development of local, regional, and state water supply plans that include information on environmental resources, existing and anticipated water sources, existing and projected water use and demand, the potential for water supply deficits, and proposals for new sources of water to address deficits if necessary. The Local and Regional Water Supply Planning Regulation was adopted in 2005 and localities and regional partnerships were required to submit their initial water supply plans to DEQ no later than November 2011. Following submission, staff reviewed a total of 48 plans (see Figure 1 for planning programs) for consistency with the regulations, completing the compliance evaluation process with the issuance of final compliance determinations to all planning partners in late 2013. Water supply plans are required to be reviewed and updated as necessary every five years and resubmitted every 10 years at minimum. In 2018, all 323 localities in Virginia reviewed their water supply plans and addressed compliance conditions by the required five year review deadline.

Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 1105) required the State Water Control Board (SWCB) to adopt regulations designating regional planning areas based primarily on river basins, to encourage the development of cross-jurisdictional water supply projects, and to estimate the risk that each locality and region in the Commonwealth will experience water supply shortfalls. This law also directs localities to participate in cross-jurisdictional, coordinated water resource planning, and to develop a single water supply plan for each regional planning area. A Regulatory Advisory Panel (RAP) made up of a variety of stakeholders advised DEQ in the development of proposed amendments for SWCB consideration through the collaborative approach of regulatory negotiation and consensus. The RAP meetings took place during the latter half of 2021 and concluded in the Spring of 2022. In June of 2022, the SWCB approved proceeding to a public comment period on the proposed amendments, and the proposed amendments are currently under executive review.

Figure 1: Current Water Supply Planning Programs according to 2011 Water Supply Plans



- Accomack County + Towns Regional WSP
- Albemarle County, City of Charlottesville, Town of Scottsville Regional Water Supply Plan
- Amelia County Water Supply Plan (LOCAL PLAN)
- Appomattox River Water Authority (ARWA) + Hopewell Regional WSP
- Buckingham County & Town of Dillwyn Regional Plan
- Caroline County & the Town of Bowling Green Regional WSP
- Charles City County (LOCAL PLAN)
- Charlotte County Regional WSP
- Craig County–Town of New Castle Regional WSP
- Culpeper County + Town Regional WSP
- Cumberland, Goochland, Henrico, and Powhatan Counties Water Supply Plans
- Fauquier County Regional Water Supply Plan
- Fluvanna County + Town of Columbia Regional WSP
- Greene County + Stanardsville Regional WSP
- Greensville, Sussex, Emporia Regional Water Supply Plan
- Halifax County and Towns
- Hampton Roads Planning District Commission (HRPDC) Regional WSP
- Hanover County & Town of Ashland Regional
- King George County WSP (LOCAL PLAN)
- Lake Country Regional WSP
- Louisa County and Towns
- Lunenburg County + Towns Regional WSP
- Madison County + Town Regional WSP
- Middle Peninsula Regional Water Supply Plan
- New Kent County WSP (LOCAL)
- New River Valley WSP
- Northampton County + Towns Regional WSP
- Northern Neck Regional WSP
- Northern Shenandoah Regional WSP
- Northern Virginia Regional Water Supply Plan
- Nottoway County and Towns
- Orange County Regional Water Supply Plan
- Prince Edward County and Town of Farmville Water Supply Plan
- Rappahannock County + Town of Washington WSP
- Region 2000 Regional Water Supply Plan
- Richmond, City of (LOCAL PLAN)
- Roanoke Valley Alleghany Regional Commission Regional WSP
- Southwest VA Regional Water Supply Plan
- Spotsylvania County and City of Fredericksburg Regional Water Supply Plan
- Stafford County Water Supply Plan (LOCAL PLAN)
- Upper James River Basin WSP
- Upper Shenandoah Regional WSP
- West Piedmont Planning District Commission Regional Water Supply Plan

Once adopted, the amended Local and Regional Water Supply Planning Regulation will substantially impact the process and requirements for the next plan submission cycle. DEQ will provide additional information on how this action may impact requirements for water supply plans as the regulatory process progresses. More information on the program and the ongoing regulatory process can be found on the DEQ website.

1.1.1 Virginia State Water Resources Plan

The water supply plans and other water use reporting and source data collected by DEQ form the basis of the Virginia State Water Resources Plan (State Plan). The first iteration of the State Plan was published in October 2015. It includes the results of a cumulative impact analysis (CIA) conducted using data from local and regional water supply plans and water withdrawal data submitted by individual users under the Water Withdrawal Reporting Regulation.[1] In general, the goal and intent of the State Plan is to use the locally sourced data to conduct analysis that localities can use to inform future planning efforts and permit applications for future water withdrawal projects.

Using updated information submitted in the 2018 water supply plan five year review cycle, DEQ developed the 2020 State Plan. The 2020 State Plan includes updated demand and source information, improved discharge data, and enhanced CIA modeling, including new metrics and scenarios, including the first ever climate change CIA scenarios. Analysis was also conducted at a more localized scale with detailed summaries for each of the 20 minor basins on existing sources, demand projections, water use trends, and modeling results.[2]

1.1.2 VAHydro

Data used in the State Plan such as locality provided demand and source data, annual withdrawal reporting, and withdrawal permit reporting is collected via VAHydro, a web-based, interactive platform that provides the basis for more efficient data collection and analysis. VAHydro is designed to link modules pertaining to water withdrawal permitting, water supply planning, water withdrawal reporting, groundwater well registration, and drought monitoring/modeling of both surface water and groundwater (Figure 2). The goal for VAHydro is to give DEQ staff, as well as localities, water users, and regional stakeholders, the ability to use up-to-date water use data to inform decision making in every day local and regional water management efforts. Beginning in 2022, DEQ began a long-term project to migrate VAHydro data and functionality into the DEQ enterprise system. This project is expected to continue at least through 2023 during which time VAHydro will continue to operate.

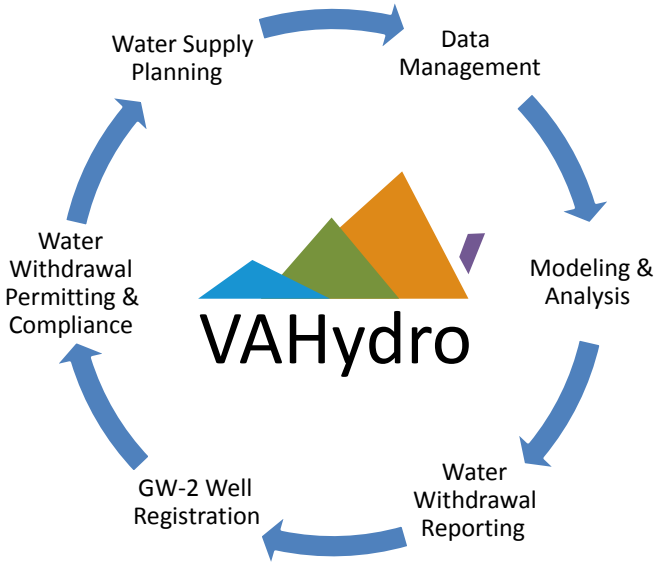
1.1.3 Modeling and Analysis

DEQ staff in the Water Supply Planning and Analysis program perform a number of highly technical functions to serve other DEQ programs. Foremost of all is maintaining and utilizing an operational surface water model to conduct cumulative impact analyses for individual surface water withdrawal permit applications as well as larger analyses such as those presented in the State Plan. DEQ modelers routinely update the VAHydro surface water model both internally and in collaboration with partners ranging from the United States Geological Survey (USGS), Virginia Tech Department of Biological Systems Engineering (BSE), and the Chesapeake Bay Program. Similarly, through a variety of grant and program funded projects, DEQ staff also advance the state of the science informing water resources management and frequently publish professional papers in journals to share those results. This section covers recent accomplishments both in terms of model improvement and primary science.

[1] 9VAC25-200.

[2] The nine major river basins within Virginia are further divided into 20 minor basins to provide a higher resolution, more localized scope for analysis. Minor basins are generally delineated around significant tributaries to the major river (for instance, Shenandoah Minor Basin is a tributary to the Potomac-Shenandoah Major Basin), or by physical characteristics of the area geography. For instance, the James River Basin is subdivided by the Upper James, Middle James, and Lower James minor basins, which are located in the Ridge and Valley, Piedmont, and Coastal Plain geographical regions of Virginia respectively.

Figure 2: Modules within VAHydro



In 2020, the Virginia Tech BSE Department and DEQ completed a two year project to improve estimates of consumptive use in Virginia, as well as to develop a suite of tools to transfer data on water withdrawals, discharges, and consumptive use between the National Pollutant Discharge Elimination System (NPDES), VAHydro, and USGS National Water Information System (NWIS) databases. This project was funded by a USGS WUDR grant and a paper summarizing the results was published in 2022 in the Journal of the American Water Resources Association: Estimating Facility-Level Monthly Water Consumption of Commercial, Industrial, Municipal, and Thermoelectric Users in Virginia. This research was also integrated into the surface water model and was instrumental in the cumulative impact modeling associated with the 2020 State Plan to better account for consumptive use. Evaluating consumptive use is critical for creating an accurate surface water budget and determining water availability in different locations across the Commonwealth.

A USGS WUDR grant award was also received by DEQ in 2020 based on a proposal to develop better estimates of agricultural water use. This project is also being completed in cooperation with the Virginia Tech BSE Department. Primary objectives for this project include the development of a set of coefficients to estimate unreported agricultural water withdrawals at the county level based on irrigation data from USDA and literature crop water requirements, the generation of monthly total irrigation withdrawal time-series for major agricultural counties in Virginia, as well as an estimation of a range of total irrigation withdrawals under different meteorological scenarios (e.g., average year conditions, moderate drought conditions, and extreme drought conditions). One of the major challenges localities had when preparing water supply plans was collecting information on water use from agricultural water users, and the majority of the plans have limited estimates for agricultural water use. Agricultural water use is also under reported, although DEQ continues to work to engage with agricultural communities to improve awareness of reporting requirements annually. This project helps address these gaps by improving estimates of water used for irrigation at the county level using USDA Agricultural Census data and DEQ water withdrawal reporting data. This project is expected to be completed in Fall of 2022.

In cooperation with the Virginia Institute of Marine Science (VIMS) and working closely with the Virginia Department of Health (VDH), DEQ is also overseeing a project titled "Assessing vulnerability of private wells to flooding." This project, funded by 106 Disaster Mitigation supplemental funding, is focused on

identifying the growing risk for contamination of drinking water aquifers from rising sea level and increasing coastal storm strength. The primary goals of this project include the development of a digital database of private wells for the study area (Virginia's Northern Neck - Northumberland and Lancaster counties), the establishment of flood probability zones based on tide records and sea level rise projections, the mapping of well locations to assess potential flood risk through the year 2100, and the development of database guidance and analytical protocols for extending analysis to additional localities. This project will result in a geo-referenced database that may be used to identify areas of highest risk, with the ability to interface with the latest models of aquifers and groundwater resources. This project will also be completed in Fall 2022.

1.2 Water Withdrawal Reporting

The Water Withdrawal Reporting Regulation requires the annual reporting of monthly water withdrawals (surface water and groundwater) of volumes greater than an average of 10,000 gallons per day (GPD) during any 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 that allows reporters to enter withdrawal data on a monthly basis, mail in reporting is also accepted. DEQ maintains withdrawal data as far back as 1982 and categorizes water withdrawals by water use types: agriculture, commercial, irrigation, manufacturing and industrial, mining, fossil fuel power, hydropower, nuclear power, and public water supply. The database also categorizes withdrawals by water source (groundwater, surface water, or transfer) and source sub-type (reservoir, spring, stream, or well). Analyses of the reported 2021 data are provided in Chapters 2 and 3, and in Appendices 1 and 2.

Annual water withdrawal reporting is one of the most important data sources for DEQ. Reporting of water withdrawals allows for informed modeling and planning decisions related to the Commonwealth's future water demands and availability. Reported water withdrawals are linked into the surface water model, which enables staff to prepare up-to-date and accurate water budgets and conduct cumulative impact analyses in support of permit decisions and water supply planning efforts. Withdrawal data is also used by other programs within DEQ, other agencies, and the public. The effectiveness of the Commonwealth's water resource management depends on the comprehensiveness and accuracy of this self-reported withdrawal information.

Each year DEQ works to increase the number and quality of withdrawal reports. A particular focus in the last few years has been agricultural water users. Efforts to improve water withdrawal reporting within agricultural communities continued in 2021. Livestock producers with permits for animal waste management were contacted and registered for reporting if their water withdrawals were estimated to meet or exceed the reporting threshold. Efforts to register additional poultry facilities to report annual water withdrawals will continue in 2022-2023. DEQ plans to also begin outreach to bottling plants in the state in 2022-2023. Outreach to users in other water use categories, including but not limited to data centers, public and private educational institutions, and vineyards will be conducted over the next couple of years as resources allow.

1.3 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[3], Virginia manages groundwater through a permit program regulating the withdrawal of groundwater in certain areas designated as Groundwater Management Areas (GWMAs). Currently, there are two GWMAs in the state. The Eastern Virginia GWMA comprises areas east of Interstate 95 and west of the Chesapeake Bay and Atlantic Ocean 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.

[3] § 62.1-254 et seq. of the Code of Virginia.

Projects involving surface water withdrawals from state waters and related permanent structures are permitted under the Virginia Water Protection (VWP) Permit Program Regulation as provided by Article 2.2 of the State Water Control Law[4]. DEQ issues VWP individual permits for such withdrawals through use of the Joint Permit Application (JPA) process.

A significant focus of this administration and the DEQ Director is improving permit processing timelines. DEQ's agency-wide Permitting Enhancement and Evaluation Process (PEEP) is underway and is intended to improve efficiency and transparency throughout permitting processes and will be particularly beneficial in identifying critical path improvement for complex individual permit issuance processes. In preparation to integrate effectively into the PEEP process, DEQ's water quantity management programs are addressing a number of issues including: incorporating program data and data management into the DEQ enterprise system, working to bring on new hires to fill vacancies, and accelerating new hire training.

DEQ continues to process a backlog of groundwater withdrawal and surface water withdrawal permit applications with 125 groundwater and 35 surface water applications in progress. Since January 1, 2020, DEQ has issued 45 groundwater withdrawal permits and 4 surface water withdrawal permits. Review of water withdrawal applications requires extensive inter-agency coordination and a technical evaluation process, both of which contribute to longer permit processing timelines than is typical in other DEQ permit programs. Vacancy rates within the permit program remain a consistent challenge. In the past year, all of the program's senior permit writers retired or took promotional opportunities. DEQ continues to work to fill these vacancies through continuous recruitment strategies and while successful filling a number of permit writer positions, filling supervisory positions remains a challenge in the current market.

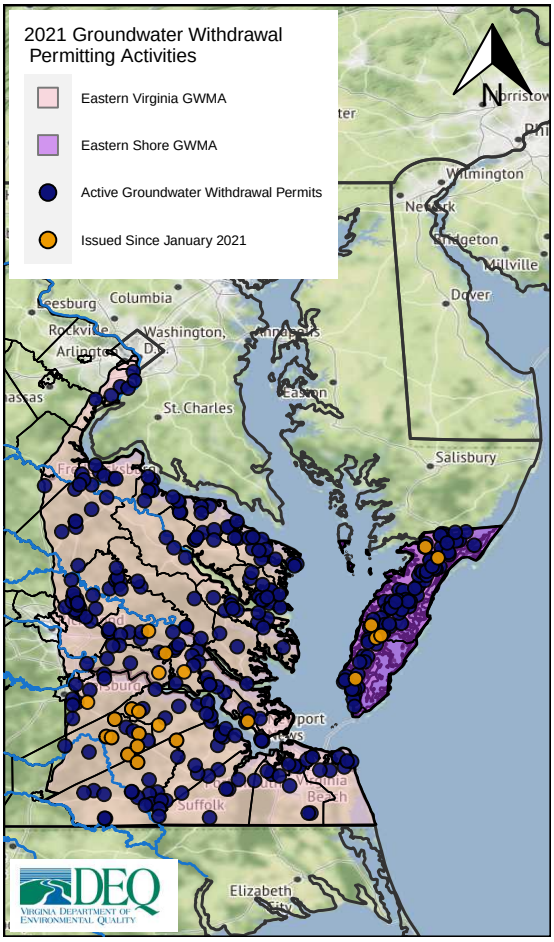
1.4 Groundwater Withdrawal Permitting

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.

As of October 1, 2022, DEQ administers a total of 364 groundwater withdrawal permits. These users are authorized to withdraw a combined total of approximately 44.7 BGY, which equates to an annual average withdrawal rate of 122.6 MGD. Figure 3 provides a spatial overview of groundwater withdrawal permitting activities in Virginia. A complete list of all active groundwater permits is available upon request.

[4] §§ 62.1-44.15:20 through 62.1-44.15:23.1 of the Code of Virginia.

Figure 3: 2021 Groundwater Withdrawal Permitting Activities



1.5 Surface Water Withdrawal Permitting

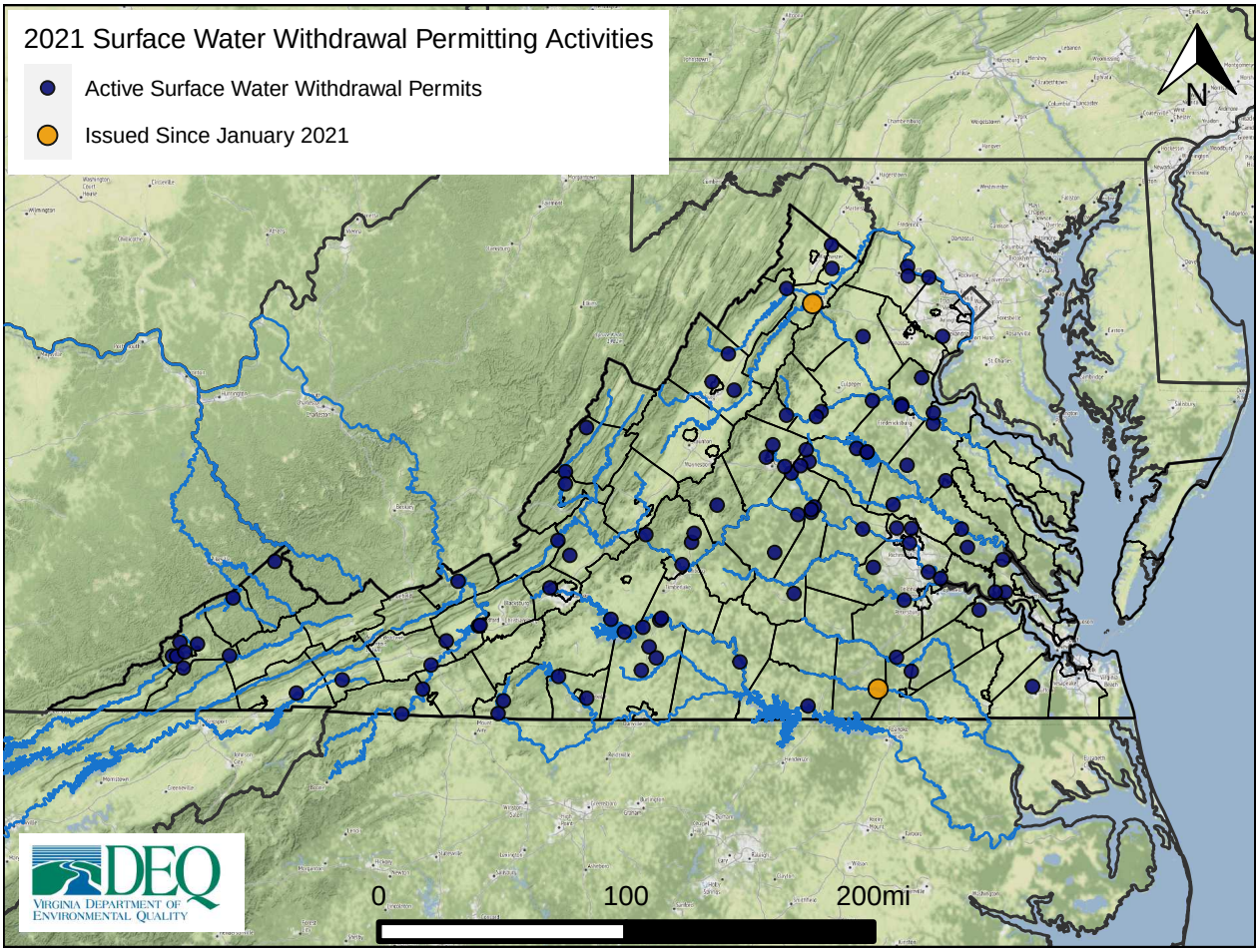
Application for a surface water withdrawal permit is made through the submittal of a JPA to DEQ, the Virginia Marine Resources Commission (VMRC), and the U.S. Army Corps of Engineers (USACE). DEQ's evaluation of surface water withdrawal permit applications includes an in-depth analysis of the applicant's water demand and a cumulative impact analysis of the project to determine potential impacts on existing in-stream and off-stream beneficial uses. To conduct these analyses, DEQ uses an operational hydrologic model to determine the cumulative impacts to aquatic life, water quality, recreation, and down stream water availability for existing intakes.

Each new or re-issuance 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 4 illustrates VWP surface water withdrawal permitting activities, including permits issued since January 2020. Currently, DEQ administers 103 VWP permits for surface water withdrawals.

An ongoing significant effort for the Water Withdrawal Permitting program is processing VWP permit applications for a large number of hydroelectric power facilities that are or will be applying for Federal Energy Regulatory Commission (FERC) relicensure as their 30 year licenses expire. Any applicant for a federal license or permit to conduct an activity which may result in a discharge to navigable waters must

apply for a Section 401 Certification. A Section 401 Certification is a statement from the state that there is reasonable assurance that the facility will comply with the Clean Water Act and any state established water quality standards. The DEQ VWP Permit Program serves as the Commonwealth's Section 401 Certification for FERC licenses as established by the VWP Regulation.[5] Ten of the twenty two regulated hydroelectric facilities in Virginia are currently undergoing or will be initiating the relicensing process with FERC and DEQ within the next five years, resulting in an increase in VWP permit applications overall. The VWP permitting process for these facilities will incorporate current scientific framework and regulatory requirements, which are more robust than those in place during the original Section 401 Certification issuance processes. Previous certifications generally required only a minimum release from the facility downstream. Once issued, current VWP permits provide enhanced data collection, instream flow management during droughts or low flow events, and better protections for instream beneficial uses, especially in regions where multiple hydroelectric facilities are located on the same river.

Figure 4: 2021 Surface Water Withdrawal Permitting Activities



[5] 9VAC25-210-340.

1.6 Groundwater Characterization and Monitoring

In 2021 the Groundwater Characterization and Monitoring Program (GCMP) acquired six new positions. The Program was restructured to accommodate a Groundwater Characterization Team, comprised of two geologists working primarily in the Coastal Plain's two Groundwater Management Areas (Eastern Virginia and Eastern Shore GWMAs). A separate Groundwater Monitoring Team of six groundwater geologists was established to focus on the management of data associated with the State Observation Well Network and the collection of ambient groundwater quality data. A new Program Manager position was created to manage both teams.

Significant funding was provided to the GCMP for a multi-project effort to occur through FY 2024. The first phase of project execution will be to construct an extensometer in the vicinity of the West Point Paper Mill. Extensometers are used to monitor elastic aquifer responses that can occur as a result of pressure changes within the aquifer system. Changes in aquifer pressures are typically associated with groundwater withdrawals, groundwater injection (which will be occurring at several locations within the Hampton Roads Sanitation District), natural recharge, and surface loading from tidal influences. The second phase of project completion will be to install 20 climate response network (CRN) wells in the hard rock portion of the state. These wells are intended to measure hydrostatic pressures within the shallow portions of fractured rock aquifer systems for the purpose of evaluating the relationship between long-term climactic trends and groundwater levels. The final stage of project completion will be the construction of 19 chloride monitoring wells in the Coastal Plain. In 2021, GCMP staff focused primarily on the identification of potential drill sites and the creation of a standard operating procedure for installation of CRN wells. Installation of the extensometer and the CRN wells is expected to being in 2022.

Groundwater resource investigations were conducted in the Piedmont, Blue Ridge, and Valley and Ridge provinces to better understand the complexities associated with the flow and storage of groundwater in fractured rock aquifers. During the 2021 calendar year, particular emphasis was placed on the collection and analysis of borehole geophysical and aquifer test data in the vicinity of Purcellville in Loudoun County, Virginia. Purcellville is one of several municipalities in the region that are heavily dependent on groundwater withdrawals from crystalline rock aquifers, and growing demand for the resource in this area has created a need for better understanding of these discrete aquifer systems. Results of the Purcellville investigation are presented in USGS Open File Report 22-01. Results from a similar investigation in the crystalline rocks of northern Fauquier County were published in the November 2021 issue of Hydrogeology Journal.

Data acquired from borehole logging is used to describe local hydrogeologic conditions in the vicinity of the wellbore. Borehole log data can also be used from multiple wells to describe aquifer systems in a more regional scope. An effort to archive historic borehole geophysical log data collected by DEQ staff was resumed in 2021. Logs will be stored in the USGS borehole geophysical log database and will be available for public access at the USGS - GeoLog Locator webpage.

The Real-Time State Observation Well Network was expanded to include three groundwater research stations in the southern Coastal Plain. Multi-aquifer research stations were installed near Franklin and Suffolk to monitor the vertical distribution of hydraulic pressure within the Coastal Plain aquifer system, requiring well completions in the Potomac, Piney Point, Aquia, Virginia Beach, Yorktown Eastover, and Surficial aquifers. A two-well groundwater research station was established at the City of Chesapeake's Lake Gaston Water Treatment Plant to monitor groundwater levels and chloride concentrations within the Potomac Aquifer.

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 saltwater "up coning," 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 saltwater intrusion in the Coastal Plain Aquifer System.

GCMP staff continued to play an active advisory role in the Mountain Valley Pipeline project. Staff conducted multiple closure plan reviews for portions of the Atlantic Coast Pipeline and continued to serve

as a point of contact for individuals and municipalities with groundwater related questions and concerns associated with construction of the Mountain Valley Pipeline.

DEQ staff provided technical support to groundwater withdrawal permittees and new applicants in multiple localities, including Fairfax and Essex Counties, DEQ geologists collected hydrogeological data and provided on-site support and quality control for permittees' contractors. Through detailed evaluation of borehole geophysical logs and drill cuttings, DEQ geologists determine the aquifer depths and characteristics at the well location. These determinations help to ensure that production wells are constructed in accordance with groundwater withdrawal permit conditions, with their screens and pumps correctly placed within the permitted aquifer.

A monitoring well assessment and maintenance initiative has been started by DEQ to evaluate the integrity of existing groundwater monitoring wells 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 297 State Observation Wells in the network exceed 30 years of age and are in need of repair, maintenance, or replacement/abandonment. Over time, monitoring wells can lose connection to the aquifer through sediment infill, development of mineral encrustation, or growth of bacterial mats. A prioritized quarterly implementation schedule has been developed to help guide well evaluation efforts as resources allow.

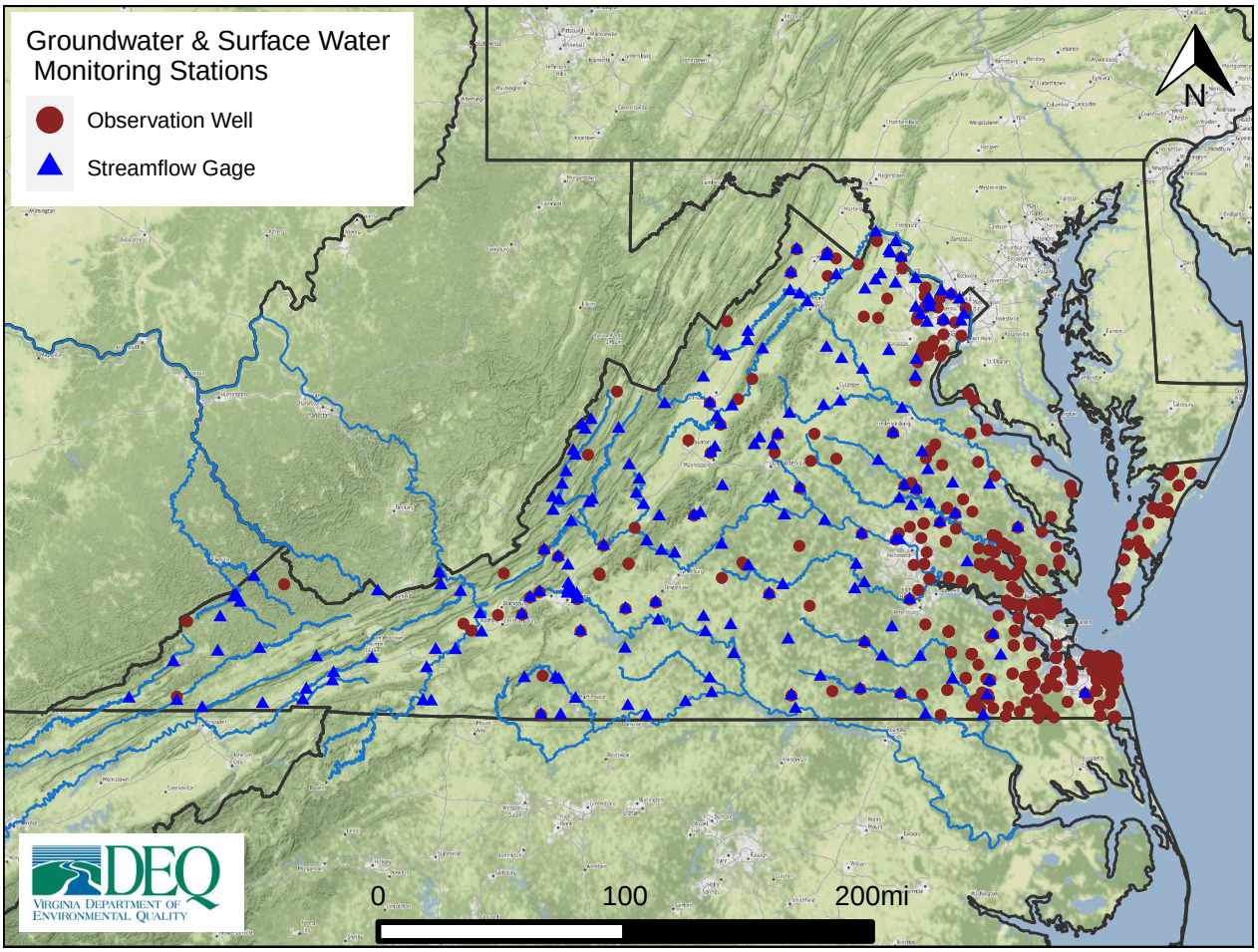
1.7 Surface Water Investigations

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. 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.

SWIP field personnel collected and processed data from the network of 69 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 October of 2022, SWIP will add eight additional surface water monitoring stations to its network.

Figure 5 provides a spatial overview of active surface water and groundwater monitoring stations in Virginia.

Figure 5: Groundwater and Surface Water Monitoring Stations



1.8 Drought Assessment and Response

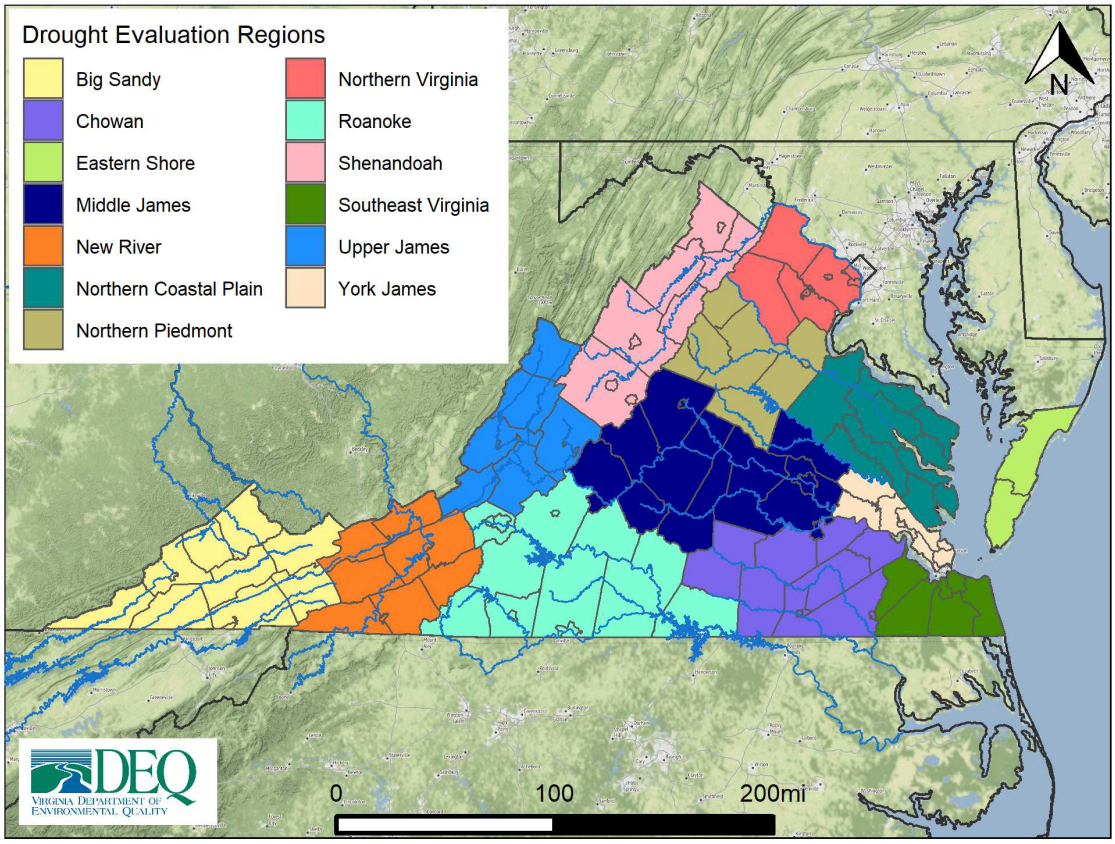
Since the adoption of the Virginia Drought Assessment and Response Plan in 2003, drought watch declarations have been issued for various regions nearly every year, but drought warning declarations have occurred less frequently. A Drought Emergency declaration has not been issued since the 2002 drought.

Normal precipitation conditions prevailed throughout most of 2021 in Virginia. Moderate drought conditions existed in early August across the western half of the Commonwealth (Shenandoah, Upper James, New River, Big Sandy, Northern Piedmont, and headwater portions of the Roanoke and Middle James drought evaluation regions). No drought advisories were issued however, as remnants of Tropical Storm Fred helped bring much needed precipitation to the region in mid-August.

Dry conditions returned in early winter, with moderate to severe drought conditions observed across the southern and southeastern portions of the Commonwealth. As a result, on December 21, 2021 DEQ issued a drought watch advisory for the Eastern Shore, York James, Southeast Virginia, Chowan and Roanoke drought evaluation regions. This advisory remained in place for the Chowan, York James, and Southeast Virginia regions until mid-February 2022, and the advisory was not lifted for the Eastern Shore and Roanoke regions until late-April 2022. As of September 30, 2022, dry conditions persisted across eastern Virginia and the Eastern Shore. There were no drought watch advisories issued at this time. Throughout the past year,

major water supply storage reservoirs maintained water levels within normal ranges. DEQ provides a drought indicator map that is updated daily and can be viewed online at Current Drought Conditions in Virginia.

Figure 6: Drought Evaluation Regions



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2 Summary of 2021 Water Withdrawal Reporting

Chapter 2 provides a brief overview on how withdrawals are reported to DEQ, summarizes 2021 reported water withdrawals at the statewide level for all water use types, and compares 2021 reported withdrawals to average use over the past 5 years. Also covered are withdrawals categorized by source type (groundwater and surface water), as well as how withdrawals vary across the state.

2.1 Background on Water Withdrawal Reporting in Virginia

Most facilities report withdrawals to DEQ through the Annual Water Withdrawal Reporting program, and withdrawals can be reported online or by mail. Facilities that report water withdrawals in compliance with surface water and groundwater withdrawal permits are also included in this report.

A total of 1,176 facilities reported water withdrawals to DEQ for the calendar year 2021, which is similar to the number of facilities reporting in recent years. Some annual variation in the number of facilities reporting is expected as facilities cease or start operation. Facilities that fail to report to the Annual Water Withdrawal Reporting program also contribute to this variation. DEQ staff prioritize compliance contacts to such facilities on an annual basis using criteria such as the relative size of withdrawal to the source and the potential for in-stream or off-stream beneficial uses of the source or sources to be impacted by withdrawals in the area. Compliance for facilities with withdrawal permits is managed by the Withdrawal Permitting and Compliance program; permitted facilities that fail to report are addressed through compliance and enforcement processes in accordance with current guidance.

Water withdrawals reported to DEQ are categorized as coming from either a surface water source such as a stream (including rivers), reservoir, or spring, or a groundwater source such as a well or dug pond that intersects the groundwater table. Water withdrawn in the Commonwealth may be used by the withdrawing entity or locality, or it may be "transferred" to another entity or locality. While some water transfers are reported to DEQ, they are not included in the withdrawal data presented in this chapter since the water is accounted for when it is initially withdrawn from the source. More information on water transfers reported to DEQ can be found in Appendix 4.

Water withdrawals are further categorized into use types according to how the water is used. Use type categories include: Agriculture, Commercial, Fossil Power, Irrigation, Manufacturing, Mining, Nuclear Power, and Public Water Supply. Specifics of what each of the use type categories includes can be found in Chapter 3, Sections 3.3 - 3.9.

DEQ staff continuously strive to improve the accuracy of reported withdrawal amounts and classification of data through a proactive data quality assurance/quality control process. Improvements in previously published data sets occur due to identification and correction of errors. As such, minor changes may be noted when comparing current data to prior publications of this report.

2.2 Consumptive Use

Although some portion of a withdrawal is generally returned to the source, facilities are required to report "gross" withdrawals to DEQ. In other words, the withdrawal totals in this report do not account for water returned back to a source through discharges or other means. The proportion of a withdrawal that is not returned to a source, for example water that infiltrates into the ground via irrigation or discharge into septic systems, or is lost to treatment processes or leaks, is considered "consumptive use".

DEQ accounts for the consumptive use of a facility when evaluating a permit application. However, because consumptive use can vary significantly across use-types and even across facilities within the same use type, it is not practical to account for consumptive use in the summary data presented in this report. Figure 7 provides ranges of consumptive use across use-types, and shows how these varying consumptive use rates would affect how a surface water withdrawal impacts flow in a stream.[6] Agriculture and irrigation have very high consumptive use as the water applied to those uses does not generally return to a stream in a manner that can be readily measured. Consumptive use for public water supply varies seasonally with higher consumptive use during the summer when irrigation increases and minimal consumptive use during the winter. Consumptive use for industrial facilities varies based on the specific water use, but most industrial facilities have low consumptive use. Power generation facilities that use water for once-through cooling systems return almost all water to the source.

Consumptive use also varies by source; while groundwater withdrawals from confined aquifers may be returned to surface water streams via discharges, they are not returned to the source aquifer so they are considered entirely consumptive in terms of their impact on the aquifer.

For more information on this subject, see the recent publication produced by DEQ and Virginia Tech which provides a review of consumptive use values across use types and discusses methodologies for estimating consumptive use.[7]

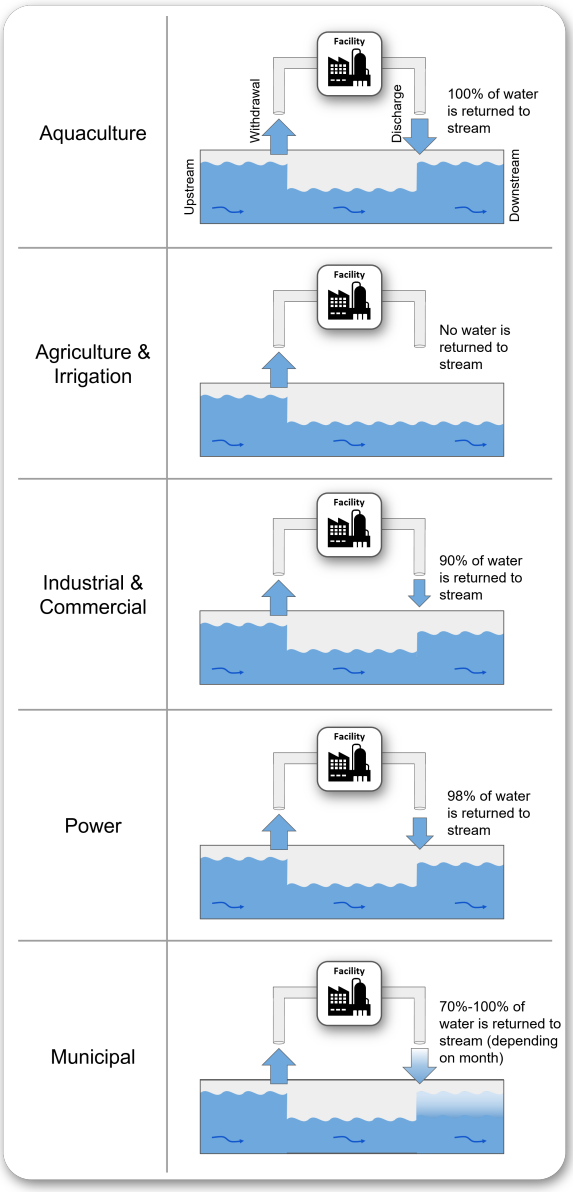


Figure 7: Impact of consumptive use across use-types on a source stream

[6] 2020 Virginia State Water Resources Plan (Section 4.2.6.1 Estimating Consumptive Use Factors).

[7] McCarthy, M., Brogan, C., Shortridge, J., Burgholzer, R., Kleiner, J., and Scott, D., 2022, *Estimating Facility-Level Monthly Water Consumption of Commercial, Industrial, Municipal, and Thermoelectric Users in Virginia*: Journal of the American Water Resources Association, https://doi.org/10.1111/1752-1688.13037.

2.3 2021 Reported Withdrawals

A summary of water withdrawals reported to DEQ from 2017-2021 are represented in Table 1. Total reported withdrawals in 2021 were approximately 5.66 billion gallons per day (BGD), including the cooling water withdrawals at nuclear and fossil fuel power generation facilities, which make up 77% of this total. The total reported withdrawal is a 3.5% decrease from the five year average of 5.87 BGD. The decrease is due to a reduction in reported power generation withdrawals. Because withdrawals associated with power generation are around 3.5 times greater than all other reported withdrawals, and are also largely non-consumptive, this report generally discusses withdrawals with power generation excluded. This lessens the likelihood that trends in reported use for other use categories are being obscured.

Excluding power generation, reported 2021 withdrawals totaled 1.27 BGD, which represents a 2.9% increase compared to the five-year average (2017-2021), and a nearly 8% increase compared to 2020 reported withdrawals. The 2021 total excluding power generation is the highest within the last five years, and the highest since 1.31 BGD was reported in 2010. The increase in reported use over the last five years is largely driven by increased withdrawals from public water supply facilities. Despite successes in reducing per capita water use, reported public water supply withdrawals have steadily increased over the last fifteen years as Virginia's population continues to grow in the urban and suburban areas served by water utilities. Reported use for many categories dropped in 2020 due to economic and social impacts from the COVID-19 pandemic. While some lessened impacts of COVID-19 continued in 2021, reported water use exceeded the volumes reported prior to the pandemic. A detailed discussion of reported withdrawals for each of the use types in Table 1 is provided in Chapter 3.

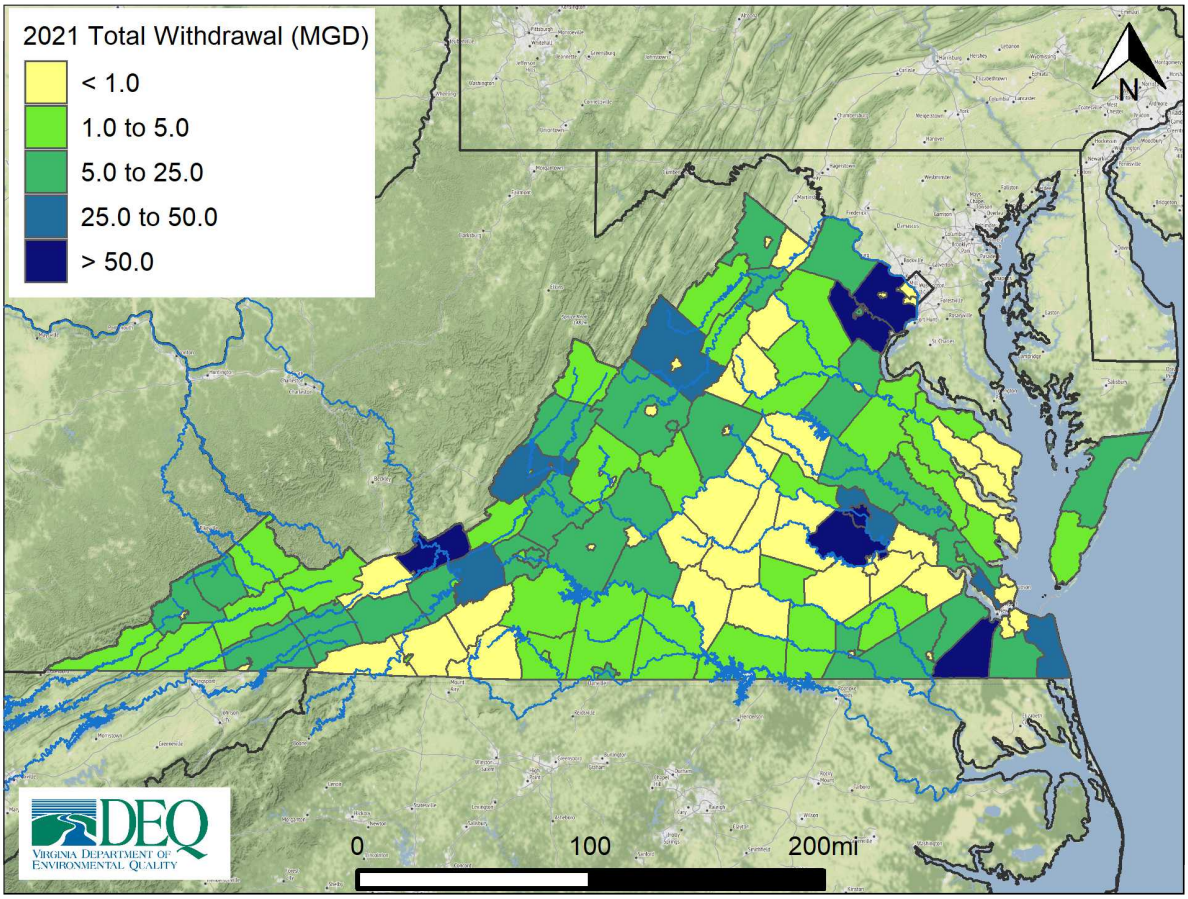
Table 1: Summary of Virginia Water Withdrawals by Use Category and Source Type 2017 - 2021 (MGD)

Category	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater							
Agriculture	0.70	0.88	1.22	1.32	1.29	1.080	19.4
Commercial	5.58	4.52	5.16	4.24	4.52	4.800	-5.8
Irrigation	1.65	1.74	2.01	1.93	1.89	1.840	2.7
Manufacturing	57.54	60.57	57.76	58.02	59.88	58.750	1.9
Mining	15.54	18.04	17.57	19.62	20.72	18.300	13.2
Public Water Supply	54.41	54.65	54.50	55.23	59.13	55.580	6.4
Fossil Power	0.09	0.12	0.07	0.07	0.06	0.080	-25.0
Nuclear Power	0.32	0.38	0.37	0.36	0.37	0.360	2.8
Surface Water							
Agriculture	30.59	32.70	30.98	29.73	28.58	30.520	-6.4
Commercial	9.54	7.98	9.94	6.38	8.81	8.530	3.3
Irrigation	18.54	12.89	20.12	15.78	21.06	17.680	19.1
Manufacturing	324.45	304.17	293.49	301.92	309.55	306.720	0.9
Mining	13.66	16.84	13.74	15.62	12.91	14.550	-11.3
Public Water Supply	719.22	727.72	727.44	671.65	744.07	718.020	3.6
Fossil Power	1102.08	1012.39	752.18	635.84	732.32	846.960	-13.5
Nuclear Power	3951.16	3705.29	3739.35	3863.89	3656.36	3783.210	-3.4
Total (GW + SW)							
Agriculture	31.29	33.58	32.20	31.05	29.87	31.600	-5.5
Commercial	15.12	12.51	15.10	10.62	13.33	13.340	-0.1
Irrigation	20.18	14.63	22.13	17.71	22.96	19.520	17.6
Manufacturing	381.99	364.74	351.25	359.95	369.43	365.470	1.1
Mining	29.19	34.88	31.31	35.24	33.63	32.850	2.4
Public Water Supply	773.63	782.37	781.93	726.88	803.20	773.600	3.8
Fossil Power	1102.17	1012.51	752.25	635.91	732.38	847.040	-13.5
Nuclear Power	3951.48	3705.67	3739.72	3864.25	3656.73	3783.570	-3.4
Total - without power							
Total Groundwater	135.42	140.41	138.21	140.37	147.44	140.370	5.0
Total Surface Water	1115.99	1102.30	1095.71	1041.08	1124.99	1096.010	2.6
Total (GW + SW)	**1251.41**	**1242.70**	**1233.91**	**1181.44**	**1272.43**	**1236.380**	**2.9**
Total - power only							
Total Groundwater	0.41	0.50	0.44	0.43	0.43	0.440	-2.3
Total Surface Water	5053.24	4717.68	4491.53	4499.73	4388.68	4630.170	-5.2
Total (GW + SW)	**5053.65**	**4718.18**	**4491.97**	**4500.16**	**4389.11**	**4630.614**	**-5.2**
Total All Categories							
Total (GW + SW)	**6305.06**	**5960.88**	**5725.88**	**5681.60**	**5661.54**	**5866.994**	**-3.5**

2.4 2021 Reported Water Withdrawals by Locality

Demand for water varies considerably across Virginia. Figure 8 shows the total 2021 reported withdrawals excluding power generation within each locality. As expected, the largest withdrawals were reported across major population centers like Northern Virginia, the greater Richmond area, and in the Tidewater area. Localities with significant industrial and mining facilities are also apparent.

Figure 8: 2021 Total Reported Water Withdrawals By Locality Excluding Power Generation



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Excluding power generation, the City of Hopewell has the highest total 2021 reported water use resulting from industrial facilities that withdraw from the tidal James River. The City of Suffolk, which contains two public water supply reservoirs operated by the City of Norfolk, followed by the counties of Fairfax, Giles, and Chesterfield make up the remainder of the top 5 localities with respect to reported withdrawals. Fairfax County withdrawals are primarily for providing public water supply to the large urban/suburban region. Giles County use is largely due to withdrawals associated with manufacturing and mining, while Chesterfield has significant public water supply and manufacturing users.

2021 reported withdrawals for each locality can be found in Table 21 located in Appendix 2.

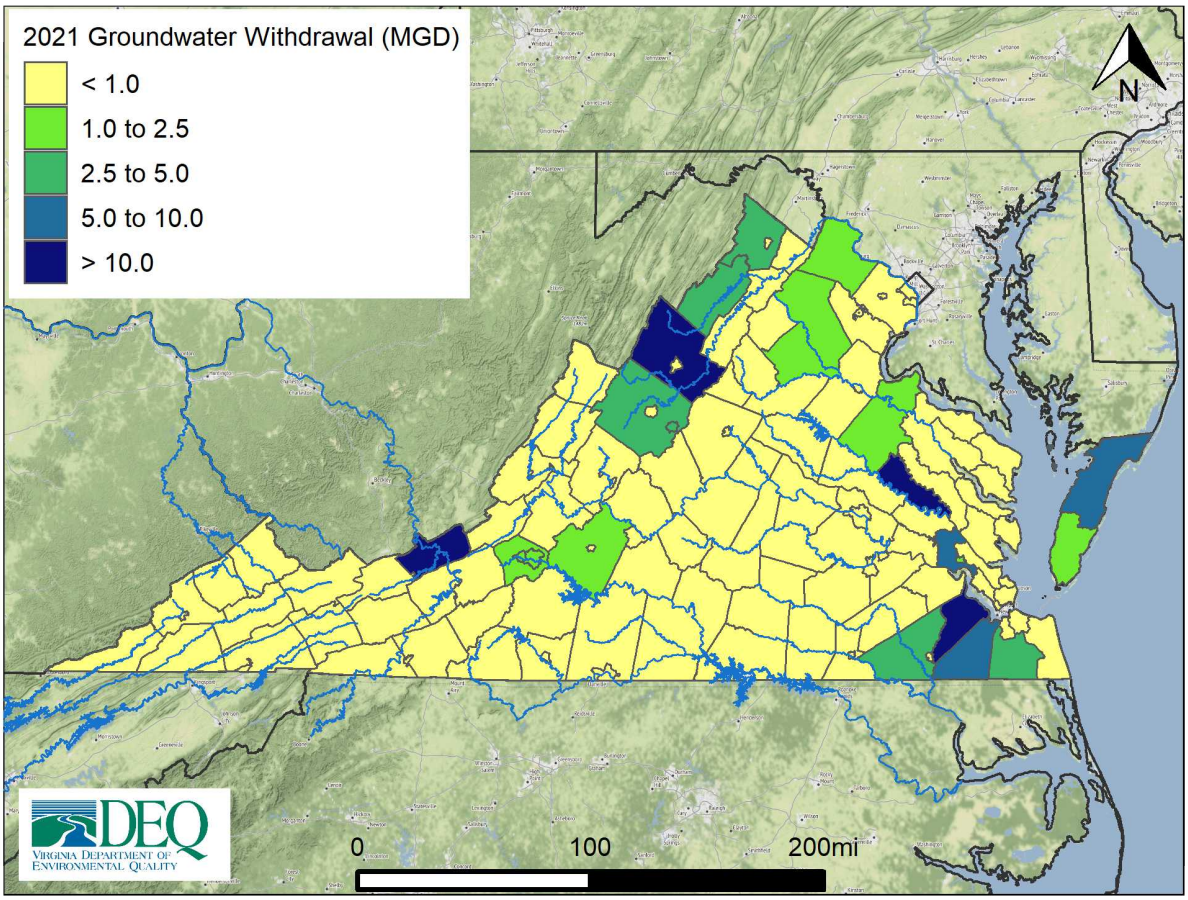
2.5 2021 Reported Water Withdrawals by Source Type

When comparing reported withdrawals based on the type of source (surface water or groundwater), there are several historic trends that continued in 2021. Surface water sources (streams, reservoirs, and springs) continued to supply the vast majority of water needs in Virginia, including for nuclear power facilities, large industrial facilities, and large public water suppliers that serve the major population centers of Virginia. In 2021, surface water sources comprised 88% of total reported withdrawals when excluding power generation, which is consistent with the average proportion over the last five years. Groundwater use is most prevalent in the Coastal Plain areas east of Interstate 95 and on the Eastern Shore where confined aquifers provide reliable and high quality water to areas with limited access to fresh surface water. Groundwater also supplies most rural public water supplies and small self-supplied facilities across use-types for which the relative affordability and accessibility of groundwater is crucial. The following section covers 2021 reported withdrawals categorized by groundwater and surface water in more detail.

Groundwater: As indicated in Table 1, 2021 reported withdrawals from groundwater sources excluding power generation totaled 147 MGD, which is an increase of approximately 5% when compared to the five-year average, driven by increasing demands from the public water supply, agriculture, and mining sectors. Public water supply facilities reported 59 MGD in withdrawals from groundwater sources, which was was the highest within the last five years and a 7% increase from 2020 reported values, with the lessening impacts from COVID-19 likely playing a major part in the increase between 2020 and 2021. Overall, groundwater use for public water supply has shown an increasing trend over the last five years. This trend is likely to continue to the extent that groundwater remains the most practical source for portions of the Commonwealth that are experiencing population growth, such as the Tidewater region, and parts of the Northern Neck and Middle Peninsula that are experiencing increased tourism and summer demand increases. The only use category for which groundwater withdrawals consistently exceed surface water withdrawals is mining, as such facilities typically withdraw groundwater for the purpose of dewatering the site.

Cumulative reported groundwater withdrawals within each locality are shown in Figure 9. For most localities in Virginia, reported groundwater use remains below 1 MGD. The largest reported groundwater withdrawals in 2021 continued to be from industrial facilities located in Isle of Wight and King William counties, as well as mining located in Giles County. Significant groundwater withdrawals are also evident in the Tidewater region where many public water suppliers including the cities of Suffolk and Norfolk, as well as James City County, use groundwater as their primary source or as a supplement to surface water, and largely make up the the highest non-industrial groundwater withdrawals. Groundwater use in areas such as the Eastern Shore and the Shenandoah Valley is relatively higher than other parts of the state due to several factors including the limited availability of surface water, a higher relative concentration of reporting agricultural facilities, and the presence of one or more industrial facilities that rely on groundwater.

Figure 9: 2021 Groundwater Withdrawals by Locality



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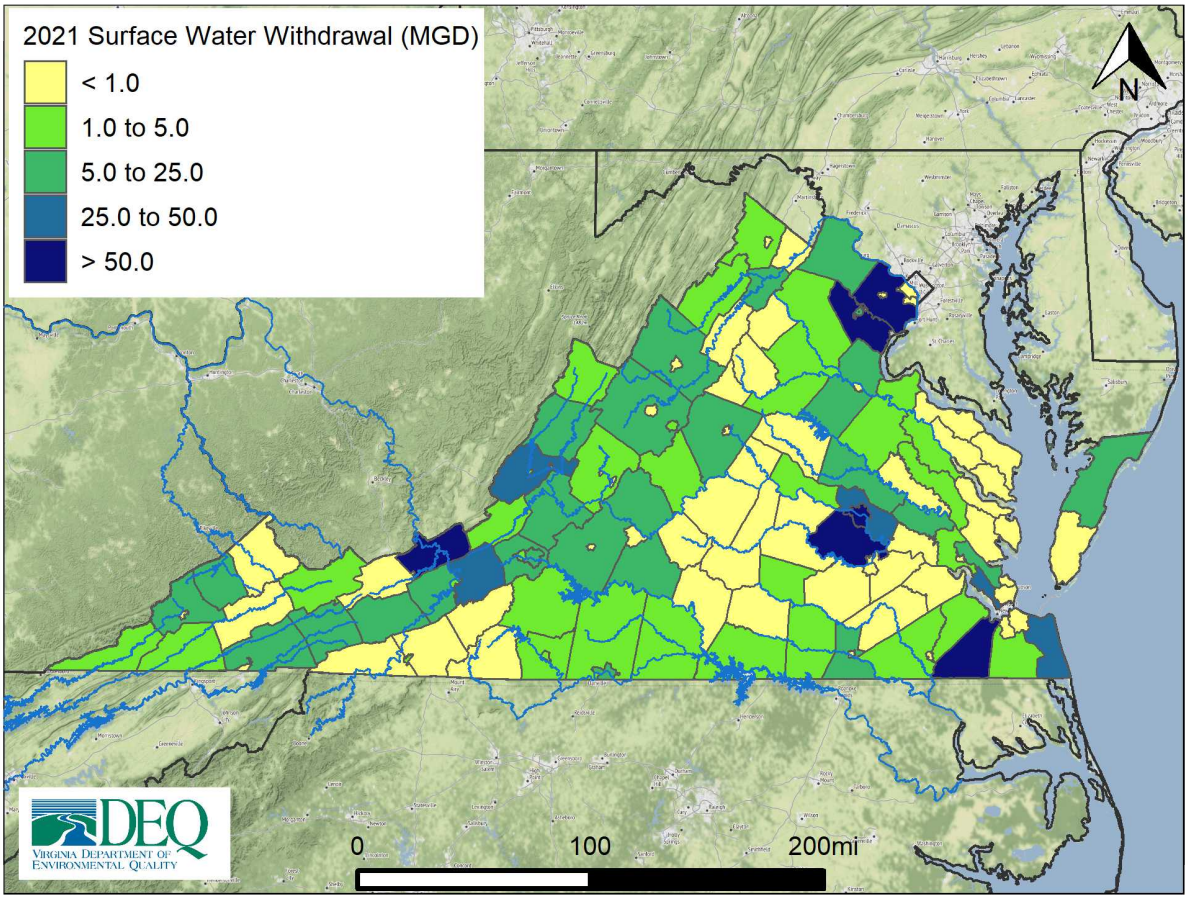
Surface Water: Total reported surface water withdrawals in 2021 decreased by 3.5% compared to the five-year average, which is a result of a 13.5% reduction in withdrawals for fossil power, which continue to decline as coal power plants are taken off-line, as well as a 3.4% reduction in withdrawals for nuclear power. However, when excluding power generation, reported surface water withdrawals for 2021 totaled 1125 MGD, which is an increase of 2.6% compared to the five year average, and an increase of 8% compared to 2020. This increase is largely the result of increased withdrawals for public water supply facilities. Reported surface water withdrawals increased by 84 MGD compared to 2020, with a lessening in the impacts from COVID-19 likely contributing to this year over year increase. As with groundwater, public water supply withdrawals for surface water continue to increase consistently due to population growth in the metropolitan areas primarily served by surface water. Reported surface water withdrawals for irrigation also increased approximately 19% compared to the average.

Cumulative reported surface water withdrawals within each locality are shown in Figure 10. Surface water withdrawals were distributed widely across the state and were greatest around cities and counties with dense population centers and significant manufacturing water uses. The largest reported surface water withdrawals occurred within the City of Hopewell, City of Suffolk, and Chesterfield County, driven by public water supply facilities in the City of Suffolk and Chesterfield County, as well as manufacturing facilities in the City of Hopewell and Chesterfield County. In addition, agriculture and irrigation use of surface water is spread throughout Virginia, although focused in more rural counties.

Figure 10: 2021 Surface Water Withdrawals by Locality



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2.6 2021 Permitted and Unpermitted (Excluded) Withdrawals

Unpermitted withdrawals make up a large portion of the total reported withdrawals within Virginia. Table 2 compares reported withdrawals from users that hold a VWP surface water withdrawal or groundwater withdrawal permit, and reported withdrawals from unpermitted facilities.[8] Unpermitted surface water withdrawals include withdrawals that are excluded from VWP permitting requirements pursuant to §62.1-44.15:22 of the Code of Virginia or 9VAC25-210-310, based on exclusions related to the size, age, and purpose of the withdrawal. Unpermitted groundwater withdrawals are those not required to obtain a groundwater withdrawal permit under the Ground Water Management Act of 1992. These include withdrawals located outside of a groundwater management area, those that withdraw less than 300,000 gallons in any month, and those that are otherwise excluded pursuant to 9VAC25-610-50.

In 2021, unpermitted withdrawals represented approximately 75% of the total reported withdrawals in Virginia when excluding power generation.[9] The majority of unpermitted withdrawals come from surface water sources, with 79% of reported surface water withdrawals associated with unpermitted facilities. Slightly more than half of reported groundwater withdrawals (52%) are from users operating under a Groundwater Withdrawal Permit. Of the top 20 largest reported withdrawals in 2021, 14 are from facilities that are unpermitted (see Table 20).

Table 2: 2021 Permitted and Unpermitted (Excluded) By Use Type Withdrawals (MGD)

	Annual Withdrawal Amount		**% of Total**	
Use Type	**Unpermitted**	**Permitted**	**Unpermitted**	**Permitted**
Groundwater				
Agriculture	0.22	1.07	0.15	0.73
Commercial	1.85	2.67	1.25	1.81
Irrigation	0.57	1.32	0.39	0.90
Manufacturing	21.89	37.99	14.85	25.77
Mining	20.72	0.00	14.05	0.00
Public Water Supply	31.80	27.33	21.57	18.54
Total Groundwater	**77.05**	**70.38**	**52.26**	**47.75**
Surface Water				
Agriculture	28.23	0.35	2.51	0.03
Commercial	7.33	1.48	0.65	0.13
Irrigation	20.77	0.30	1.85	0.03
Manufacturing	298.94	10.61	26.57	0.94
Mining	12.79	0.12	1.14	0.01
Public Water Supply	515.70	228.37	45.84	20.30
Total Surface Water	**883.76**	**241.23**	**78.56**	**21.44**

The largest unpermitted groundwater withdrawals are for manufacturing/industrial facilities, mining facilities, and public water supply facilities located outside of the groundwater management areas. Withdrawals for public water supply were the second largest contributor to total groundwater withdrawals in 2021, with 21.6% of the total reported groundwater withdrawals associated with unpermitted public water supply facilities located outside groundwater management areas. Note that groundwater withdrawals for domestic and

[8] Currently unpermitted facilities that have applied for withdrawal permits, and whose applications are currently under review, are counted as permitted withdrawals for the purpose of this table.

[9] Beginning this year, DEQ implemented an improved method for disaggregating unpermitted and permitted withdrawals from facilities that have both groundwater and surface water withdrawals, but only a single permit type (groundwater or VWP surface water). This improvement to summarizing data resulting in a 5.1% increase in the percentage of total reported withdrawals that are classified as unpermitted. In comparison to previous reports, the total volume of unpermitted and permitted use and the volume for each use-type may vary accordingly.

private well use are not included in the reported use totals, as such use falls below the reporting threshold and is not required to be reported to DEQ.

As with groundwater, unpermitted surface water withdrawals in 2021 were dominated by withdrawals associated with manufacturing and public water supply facilities. Withdrawals from unpermitted public water supply facilities made up 46% of the total reported public water supply surface water withdrawal volume in 2021, while unpermitted manufacturing facilities made up 27% of the total reported manufacturing surface water volume. Unpermitted withdrawals, whether groundwater or surface water, continue to present a significant challenge for management of the resource. More information on measures DEQ is taking to better evaluate the impacts from unpermitted users is provided in Chapter 4 of this report.

Unreported unpermitted withdrawals are not represented in Table 2, however unreported withdrawals are of interest to DEQ. These withdrawals consist primarily of those that do not exceed the reporting thresholds for their use type as stated in 9VAC25-200-30. Trends in increased private groundwater well completion reports received by DEQ and VDH point to an increase in private groundwater well construction. Since 2016, over 10,000 wells have been registered with DEQ through electronic submission; 2,129 wells were registered electronically with DEQ since Janaury 1, 2021 alone. Note that wells may also be registered via submission of a hard copy uniform water well completion form (GW-2) and this total does not include those.

Though water withdrawal data is not collected with groundwater well completion reports, the increase in private well construction can be viewed as a metric for evaluating increasing unreported and unpermitted groundwater withdrawals. Unreported and unpermitted withdrawals also includes users who may be withdrawing above the thresholds requiring reporting but are not in compliance with the regulation. Identification of such users is an ongoing effort for DEQ. More details on how DEQ continues to address this challenge can be found in Chapter 4.

3 Water Withdrawals By Use Category

Chapter 3 provides an overview of water withdrawal reporting for the year 2021, as well as comparisons to recent years reporting, for each water withdrawal use type. Water withdrawals reported annually to DEQ are grouped into the following categories:

- 3.3 Public Water Supply - includes water withdrawn and treated to produce water to supply municipal and non-municipal water systems that primarily provide residential use. Such systems may also supply commercial and industrial facilities located within their service area. Public water supply does not include private and domestic well withdrawals under 300,000 gallons per month, which are not required to be reported.
- 3.4 Agriculture - includes water withdrawn for raising livestock, fish farming/hatcheries and general farm use, but is not inclusive of water used for crop irrigation.
- 3.5 Irrigation - includes water withdrawn to promote crop growth, including but not limited to tobacco, corn, soybeans, turf grass, and nursery products.
- 3.6 Commercial - includes water withdrawn for use by golf courses, local and federal installations, hotels, resorts, and correctional centers, among others.
- 3.7 Mining - includes water withdrawn for the excavation, processing, and removal of bulk products such as coal, rock, sand, and gravel.
- 3.8 Manufacturing - includes water withdrawn for use by industrial facilities that generally produce goods such as paper mills, food processors, pharmaceutical companies, furniture manufacturing, and concrete plants, among others.
- 3.9 Power Generation - includes water withdrawn for fossil fuel power and nuclear power. Withdrawals or diversions of water for hydroelectric power (hydropower) generation are nearly all non-consumptive and are exempt from the annual water withdrawal reporting requirements.

3.1 Water Use by Use Category At A Glance

Figure 11 compares the average total water withdrawals from 2017-2021 to 2021 totals for each use-type category, excluding Power Generation (Nuclear Power and Fossil Fuel Power). Figures 12 and 13 split this comparison by source type as well. In summary, total withdrawals reported to DEQ increased across all categories except commercial and agriculture. The proportion of each use-type out of the total annual withdrawal has remained largely consistent from 2021 compared to the previous five years. The public water supply and manufacturing use-types continue to be the largest withdrawals in the state.

Figure 11: Groundwater + Surface Water Withdrawals, 2017-2021 Average and 2021 Total

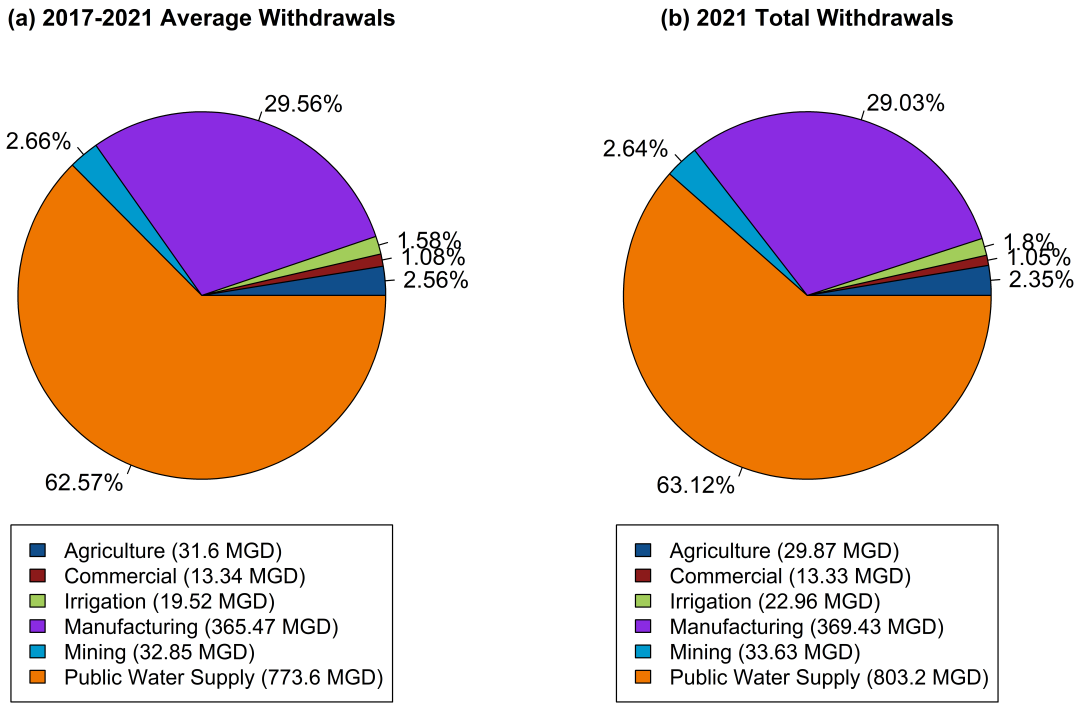


Figure 12: Groundwater Withdrawals, 2017-2021 Average and 2021 Total

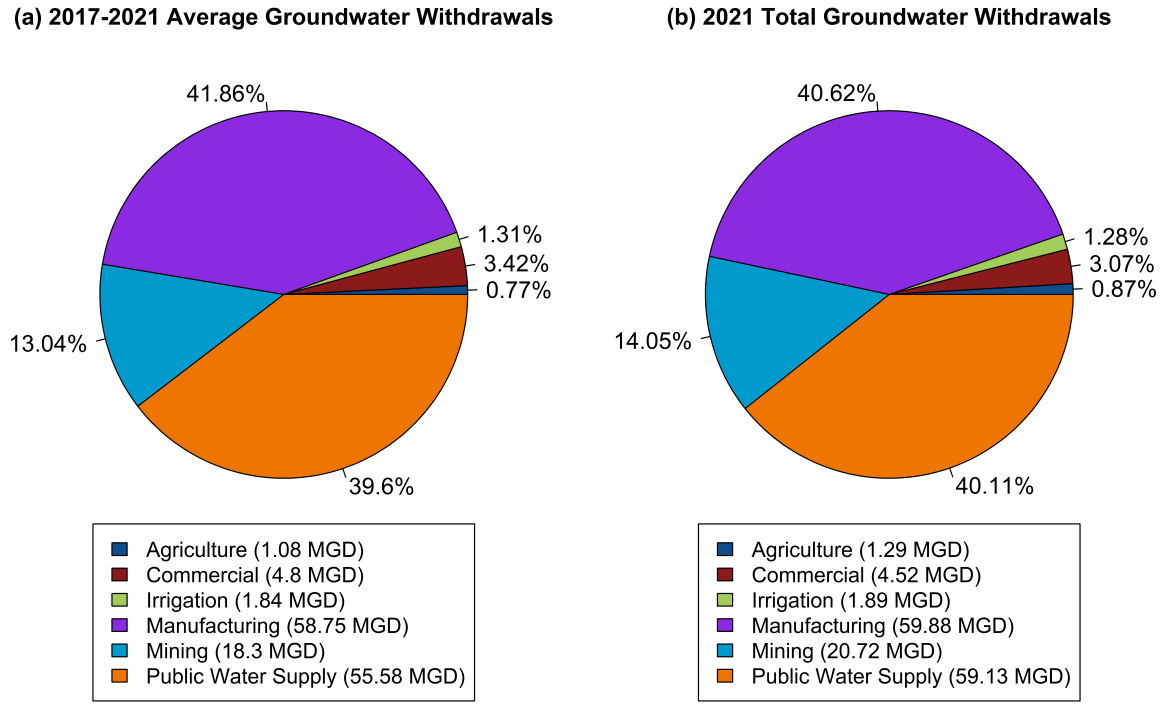
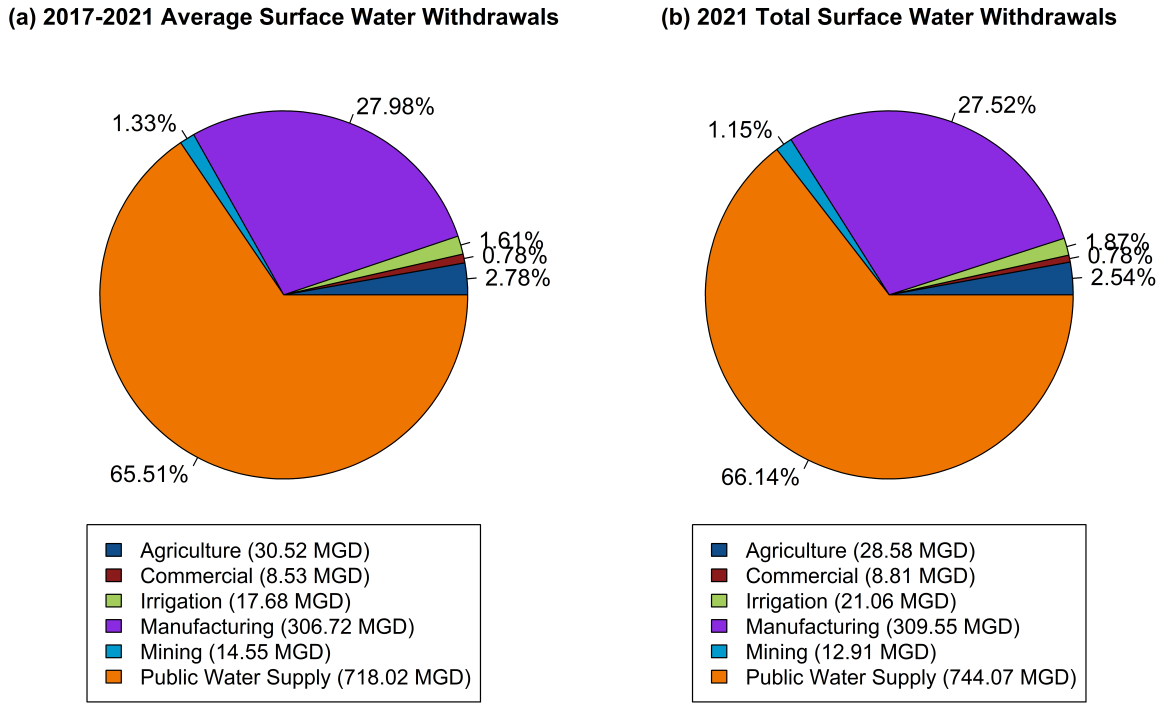


Figure 13: Surface Water Withdrawals, 2017-2021 Average and 2021 Total



3.2 Water Use Category Specific Section Overview

Each of the following sections includes the following for the relevant use-type category:

- A map depicting withdrawal point locations for each category, scaled by the magnitude of the 2021 reported annual withdrawal rate of individual measuring points (wells and surface water intakes)
- A table that lists reported withdrawals for the five-year period between 2017 and 2021 in terms of an annual average rate by source type (groundwater or surface water)
- A bar graph illustrating the reported quantity withdrawn for each source type (groundwater or surface water) between 2017 and 2021, as well as the withdrawal amounts relative to the five-year average
- A table listing facilities reporting the largest withdrawals for 2021, facility location, reported 2021 annual withdrawal rate, and the average annual withdrawal rate for the five-year period from 2017 to 2021

3.3 Public Water Supply

Water withdrawals for public water supply are primarily delivered to domestic users by both municipal and non-municipal community water systems; however, significant volumes are also delivered to commercial and industrial customers by water suppliers. 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 majority of reporting public water systems are small systems that use groundwater (over 80%), the majority of the population in Virginia is served by large surface water systems with extensive service areas. The largest public water supply withdrawals are located within or near population centers such as the Washington D.C., 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 are able to supply both the majority of the population within their localities as well as in some cases neighboring localities. Smaller public water supply systems are spread throughout the state serving small towns or communities. Figure 14 shows spatial locations and size of water use of public water supply systems across the Commonwealth.

Figure 14: All 2021 Public Water Supply Water Withdrawals by Withdrawal Point Location

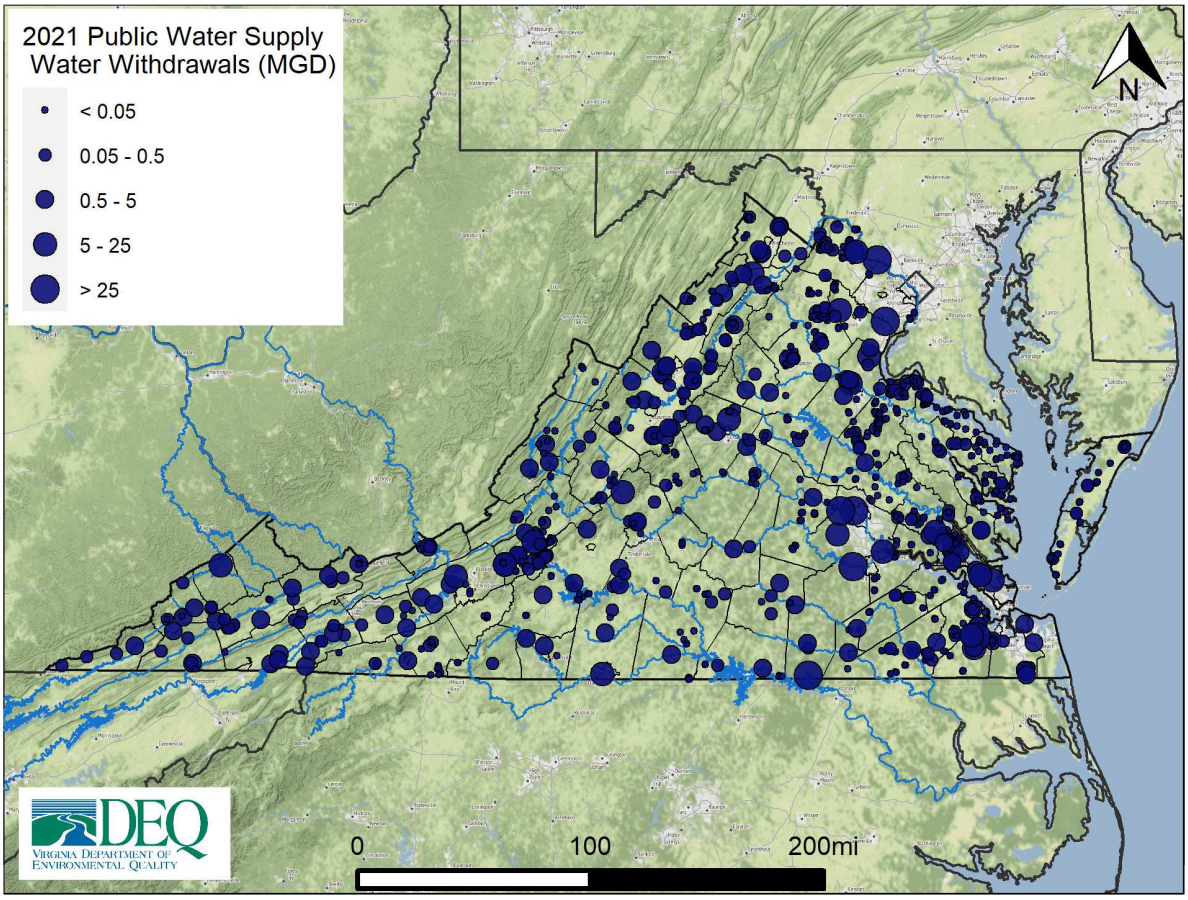


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Table 3: 2017 - 2021 Public Water Supply Water Withdrawals by Source Type (MGD)

Source Type	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater	54.41	54.65	54.50	55.23	59.13	55.58	6.4
Surface Water	719.22	727.72	727.44	671.65	744.07	718.02	3.6
Total (GW + SW)	**773.63**	**782.37**	**781.93**	**726.88**	**803.20**	**773.60**	**3.8**

Water withdrawals for public water supply make up approximately 65% of all non-power generation withdrawals in Virginia, so changes in this category can impact overall reported water use significantly. Reported 2021 water withdrawals for public water supply increased by 3.8% when compared to the average of the previous five years (see Table 3). A 3.6% increase in reported surface water withdrawals for public water supply water is the major driver of overall increases in this category, as surface water supplied 93% of the total reported withdrawals for 2021 public water supply. However, reported groundwater withdrawals for public water supply increased by 6.4% compared to the five year average.

There is an increasing trend in public water supply withdrawals reported over the last ten years (see Figure 15). Despite successes in reducing per capita water use, reported public water supply withdrawals have steadily increased over the last ten years as Virginia's population continues to grow in the urban and suburban areas served by public water supplies. The decrease in 2020 public water supply use is an outlier largely attributed to temporary closures and other mitigation strategies due to the COVID-19 pandemic.

Tables 4 and 5 list the five facilities that reported the largest groundwater and surface water public water supply withdrawals in 2021 respectively. Table 6 displays information supplied by VDH regarding the number of public water supply systems by type and the total population served by all such systems.

Figure 15: 2012-2021 Public Water Supply Water Withdrawal Trend

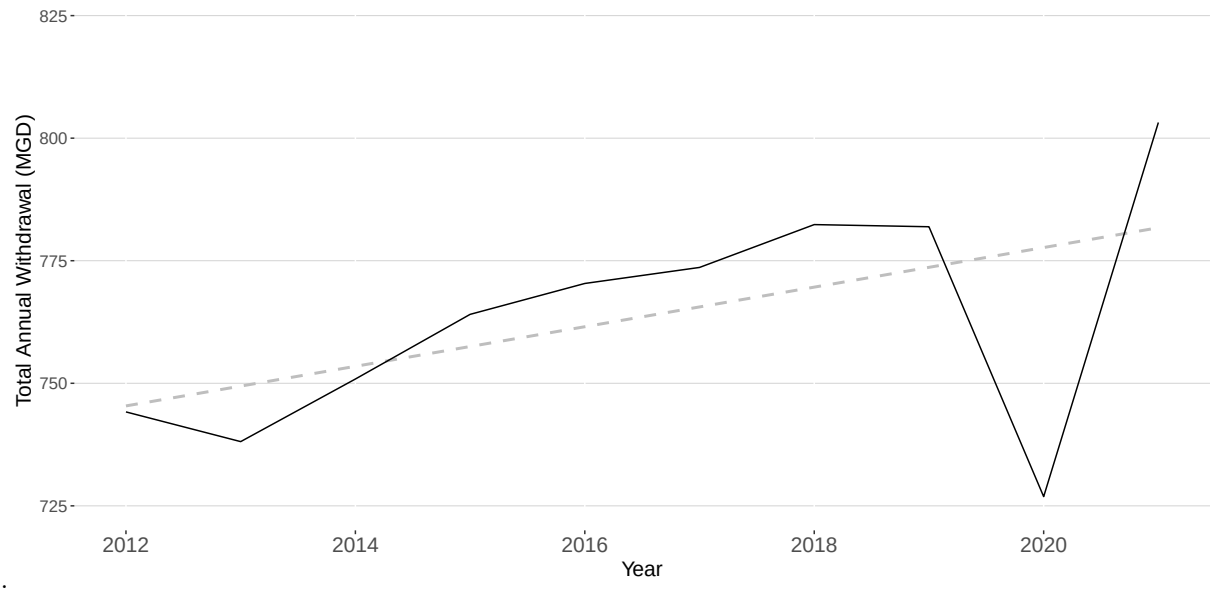

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Figure 16: 2017-2021 Public Water Supply Water Withdrawals by Source Type

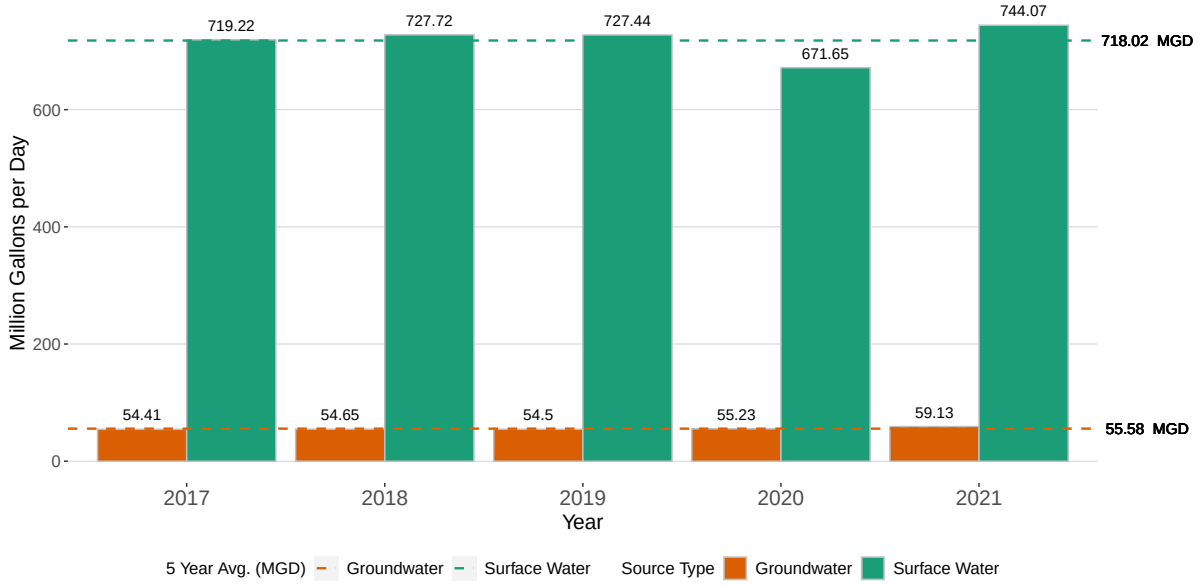

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Table 4: Highest Reported Public Water Supply Groundwater Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
James City Service Authority Central System	James City County	GW	5.4	5.3
City of Chesapeake Northwest River/Western Branch Systems	City of Chesapeake	GW	3.0	3.9
Western Tidewater Water Authority	City of Suffolk	GW	3.5	3.7
Rockingham County Three Springs Service Area	Rockingham County	GW	2.7	3.0
Frederick County Sanitation Authority	Frederick County	GW	1.8	2.7

Table 5: Highest Reported Public Water Supply Surface Water Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
Fairfax Water: Corbalis WTP	Fairfax County	SW	87.4	80.7
Fairfax Water: Griffith WTP	Prince William County	SW	64.6	72.1
City of Richmond WTP	City of Richmond	SW	66.0	68.5
City of Norfolk: Western Branch Reservoir	City of Suffolk	SW	70.2	66.1
Appomattox River Water Authority: Chesdin Reservoir WTP	Chesterfield County	SW	35.0	38.3

Table 6: Number of Public Water Supply Systems and Population Served in 2021

Category	Community Water Systems	Nontransient Noncommunity Water Systems	Transient Noncommunity Water Systems	Total
Number of Systems	1,081	505	1,219	2,805
Population Served	7,233,489	279,125	195,931	7,708,545

3.4 Agriculture (Non-Irrigation)

Withdrawals for agriculture includes non-irrigation withdrawals from livestock, poultry, and fish farms. Information concerning agricultural irrigation withdrawals is provided in the "Irrigation (Agricultural) Water Withdrawals" section 3.5 below. In total, withdrawals for non-irrigation agriculture make up 2.3% of all reported 2021 non-power generation withdrawals in Virginia. Figure 17 shows the spatial distribution of reported 2021 groundwater and surface water withdrawals for agricultural purposes statewide, with the highest number of withdrawals located on the Eastern Shore, within the Shenandoah Valley, and within the Virginia Coastal Plain. Table 7 provides the reported agriculture non-irrigation withdrawals in total as well as by source for the last five years. Overall, reported use in this category dropped by 5.5% compared to the five year average, driven by reductions in surface water withdrawals. The majority of water withdrawn for agricultural use is obtained from surface water (see Figure 18), primarily via springs located in western Virginia that support fish farms and hatcheries, including those operated by the Department of Wildlife Resources. Reported 2021 surface water withdrawals for agriculture uses decreased by 5.5% compared to the five-year average.

Figure 17: All 2021 Agriculture (Non-Irrigation) Water Withdrawals by Withdrawal Point Location

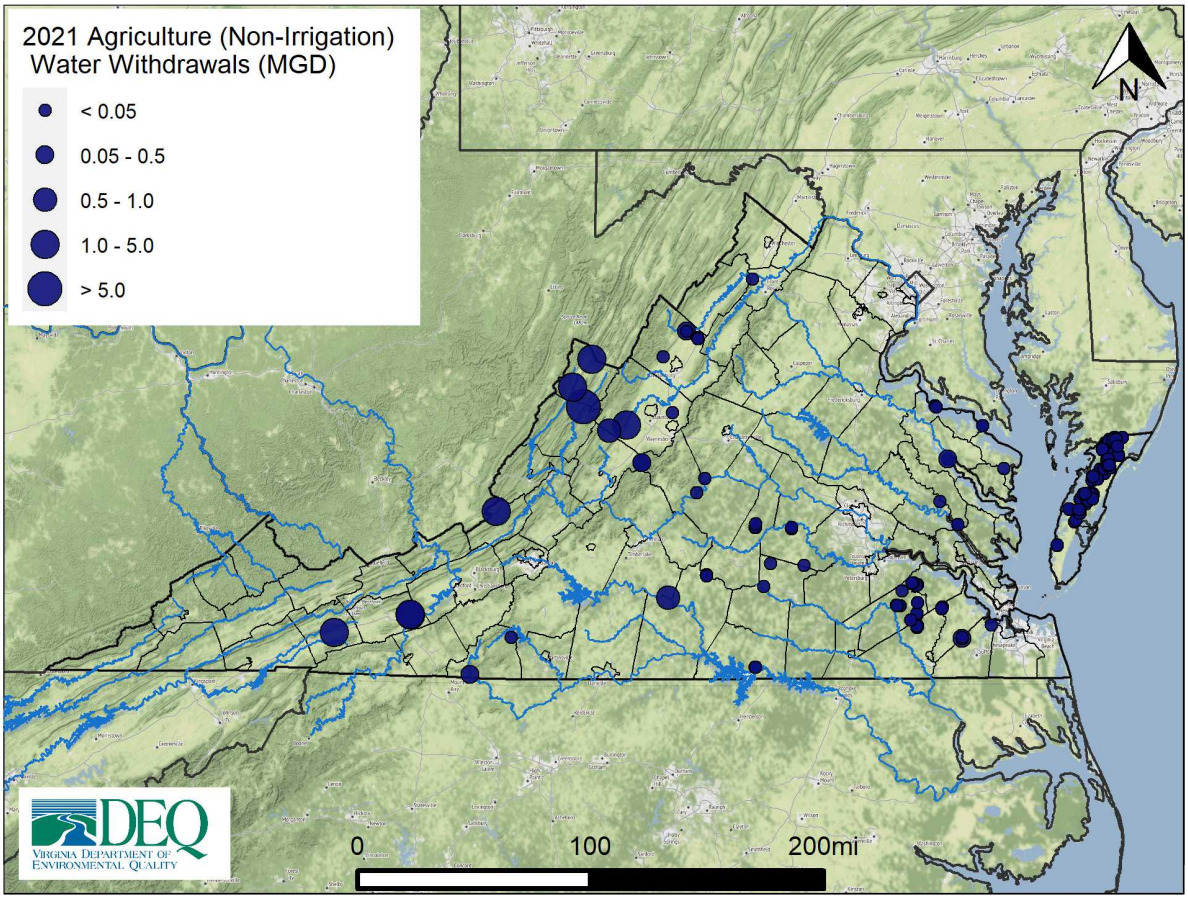

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Table 7: 2017 - 2021 Agriculture Water Withdrawals by Source Type (MGD)

Source Type	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater	0.70	0.88	1.22	1.32	1.29	1.08	19.4
Surface Water	30.59	32.70	30.98	29.73	28.58	30.52	-6.4
Total (GW + SW)	**31.29**	**33.58**	**32.20**	**31.05**	**29.87**	**31.60**	**-5.5**

Although surface water is the primary source by volume, the majority of farms reporting agriculture withdrawals make use of groundwater sources as well. Groundwater is generally used as a supplement for surface water during droughts or during high-flows where turbidity or water quality issues can limit use of surface water. Reported groundwater withdrawals increased by 19.4% when compared to the five-year average, an increase of approximately 200,000 gallons per day. This increase was largely the result of increased groundwater reporting from a group of existing and new poultry facilities located on the Eastern Shore that were identified through outreach efforts in 2019. Reported groundwater withdrawals among this group have continued to increase into 2021 as facilities that completed construction in 2019 or 2020 began operation in 2020. 2021 was the first full year of reporting for many of these facilities.

Table 8 lists the five facilities reporting the largest withdrawals for non-irrigation agriculture use in 2021, all of which are fish hatcheries. Note that most fish hatcheries typically have little to no consumptive use.

Figure 18: 2017-2021 Agriculture Water Withdrawals by Source Type

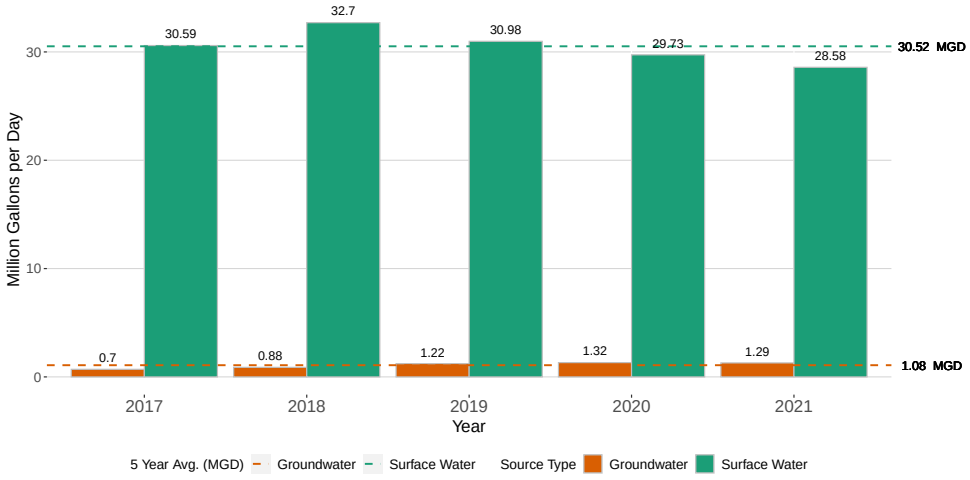

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Table 8: Highest Reported Agriculture Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
Coursey Spring Fisheries	Bath County	SW	12.2	11.4
Paint Bank Fish Cultural Sta.	Craig County	SW	3.4	3.1
Wytheville Fish Hatchery	Wythe County	SW/GW	3.1	3.0
Marion Fish Cultural Station	Smyth County	SW	3.2	2.8
Laurel Hill Trout Farm-South Monterey	Highland County	SW	3.3	2.8

3.5 Irrigation (Agricultural)

Agricultural irrigation withdrawals are associated with farms irrigating crops such as corn, soybeans, sod, as well as nursery products. Water withdrawals from agricultural irrigation made up 1.8% of all non-power generation withdrawals in Virginia for 2021, totaling 22.96 MGD in reported withdrawals. Figure 19 illustrates the distribution of reported 2021 groundwater and surface water withdrawals for irrigation purposes statewide. As with previous years, most large-scale irrigation facilities are located in the Coastal Plain, the Eastern Shore, and Shenandoah Valley. Reported water withdrawals for irrigation in 2021 were 17.6% more than the five year average (Table 9). The increased withdrawals may be a result of precipitation patterns in 2021 leading to additional irrigation needs. Surface water continues to be the major water source type for irrigation, representing approximately 91.7% of 2021 total irrigation withdrawals (Figure 20).

The five facilities reporting the highest withdrawals for irrigation in 2021 are listed in Table 10.

Figure 19: All 2021 Irrigation (Agricultural) Water Withdrawals by Withdrawal Point Location

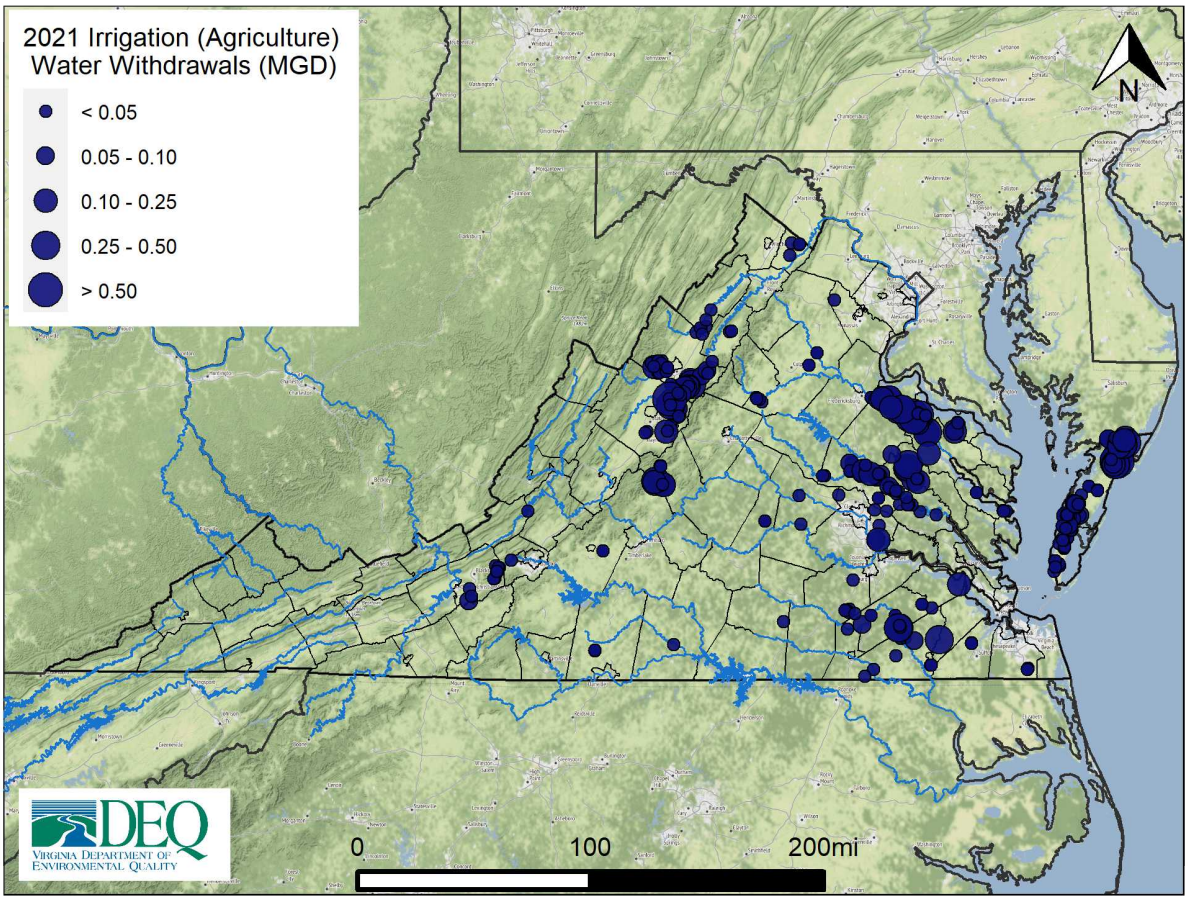

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Table 9: 2017 - 2021 Irrigation Water Withdrawals by Source Type (MGD)

Source Type	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater	1.65	1.74	2.01	1.93	1.89	1.84	2.7
Surface Water	18.54	12.89	20.12	15.78	21.06	17.68	19.1
Total (GW + SW)	**20.18**	**14.63**	**22.13**	**17.71**	**22.96**	**19.52**	**17.6**

Figure 20: 2017-2021 Irrigation Water Withdrawals by Source Type

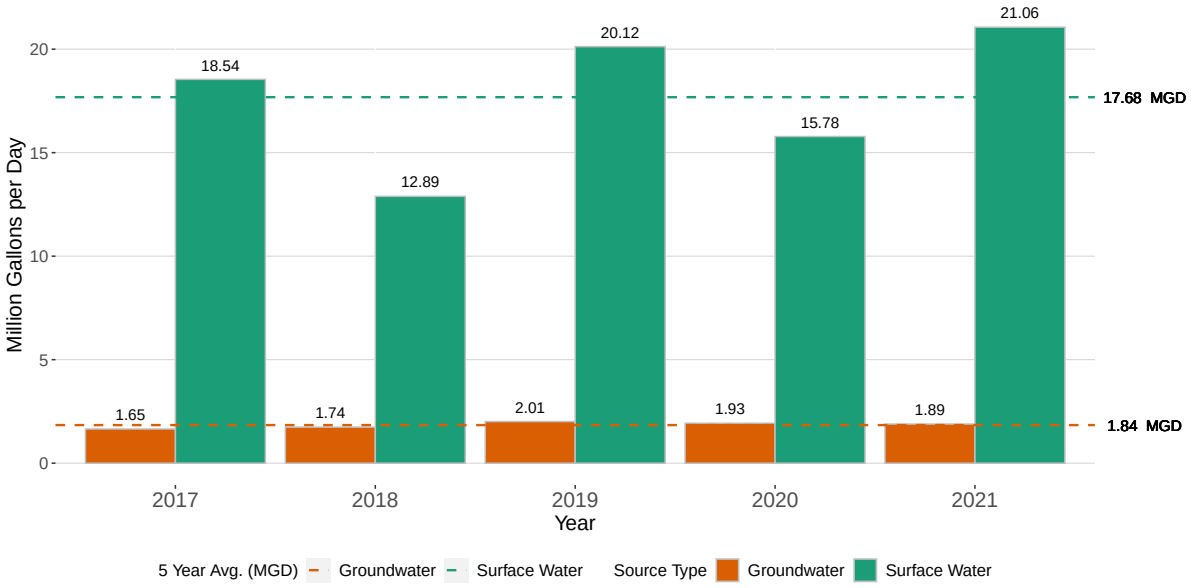

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Table 10: Highest Reported Irrigation Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
Arbuckle Farms	Accomack County	SW	2.6	2.8
Dublin Farms Inc.	Accomack County	SW	1.8	2.2
Cloverfield Farm	Essex County	SW	0.7	1.2
Glenwood	King and Queen County	SW	1.0	1.1
Saunders Brothers, Inc.	Nelson County	SW/GW	1.0	1.0

3.6 Commercial

Commercial operations include golf courses, universities, hotels, resorts, among others. Water withdrawals from commercial activities make up 1.05% of all reported non-power generation withdrawals in Virginia. Figure 21 illustrates the distribution of reported 2021 groundwater and surface water withdrawals for commercial purposes, which are located predominantly near population centers. Reported commercial water withdrawals decreased by 0.1% compared to the five year average (Table 11), and continued to rely primarily on surface water sources (Figure 22). However, withdrawals increased by 2.71 MGD from 2020 to 2021. Withdrawals had fallen by almost 25% during the previous reporting cycle (2019 to 2020), likely as a result of the COVID-19 pandemic. The increase in withdrawal in 2021 may be the result of businesses reopening as COVID-19 response measures are lessened. Reported commercial withdrawals are still well below the pre-pandemic volume of 15.10 mgd in 2019. The five facilities reporting the largest 2021 water withdrawals for commercial operations are listed in Table 12. 2021 withdrawal volumes for the top 5 users are consistent with the 5 year average.

Figure 21: All 2021 Commercial Water Withdrawals by Withdrawal Point Location

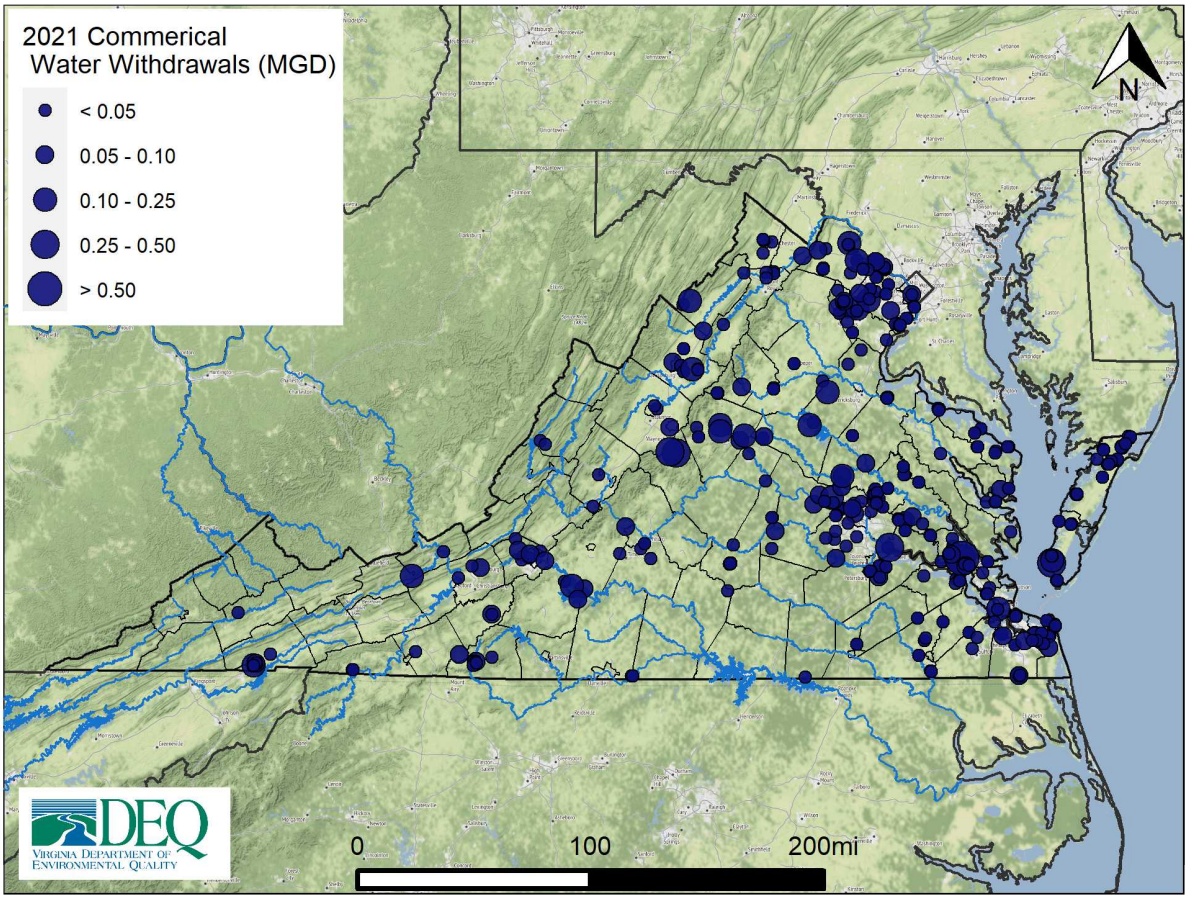

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Table 11: 2017 - 2021 Commercial Water Withdrawals by Source Type (MGD)

Source Type	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater	5.58	4.52	5.16	4.24	4.52	4.80	-5.8
Surface Water	9.54	7.98	9.94	6.38	8.81	8.53	3.3
Total (GW + SW)	**15.12**	**12.51**	**15.10**	**10.62**	**13.33**	**13.34**	**-0.1**

Figure 22: 2017-2021 Commercial Water Withdrawals by Source Type

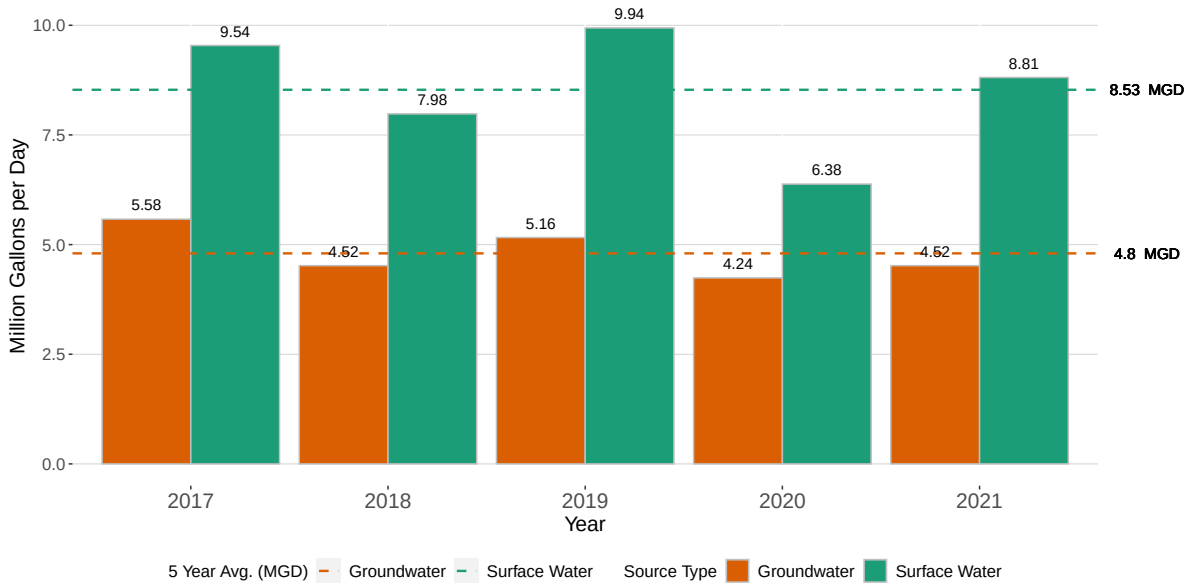

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Table 12: Highest Reported Commercial Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
Colonial Williamsburg	City of Williamsburg	GW	1.0	1.0
Lake Monacan-Stoney Creek (Wintergreen)	Nelson County	SW	0.9	0.9
Bay Creek Resort & Club	Northampton County	SW	0.5	0.5
Port Tobacco	Charles City County	SW	0.3	0.4
Massanutten Resort Surface Water Withdrawal Project	Rockingham County	SW	0.3	0.3

3.7 Mining

The mining use category includes withdrawals for operations such as sand, rock, and coal mining. Reported water withdrawals from mining operations were approximately 2.6% of all non-power generation withdrawals in Virginia. Figure 23 illustrates the distribution of reported 2021 groundwater and surface water withdrawals for mining purposes statewide. The majority of stone and sand mining facilities are located along the Interstate 95 corridor. Additional stone and coal mining withdrawals are located in southwestern Virginia. Total reported water withdrawals for mining purposes in 2021 increased by 2.4% as compared to the five-year average (Table 13). The increase in 2021 over the five-year average was largely due to increases from groundwater use within the category. In 2021, the majority of reported withdrawals for mining continued to be from groundwater sources (Figure 24). This is largely due to the dewatering of the water table that must be completed for many types of mining, which is done through wells constructed in the water table. Such withdrawals are reported under groundwater withdrawals. The five facilities reporting the largest 2021 mining withdrawals are listed in Table 14.

Figure 23: All 2021 Mining Water Withdrawals by Withdrawal Point Location

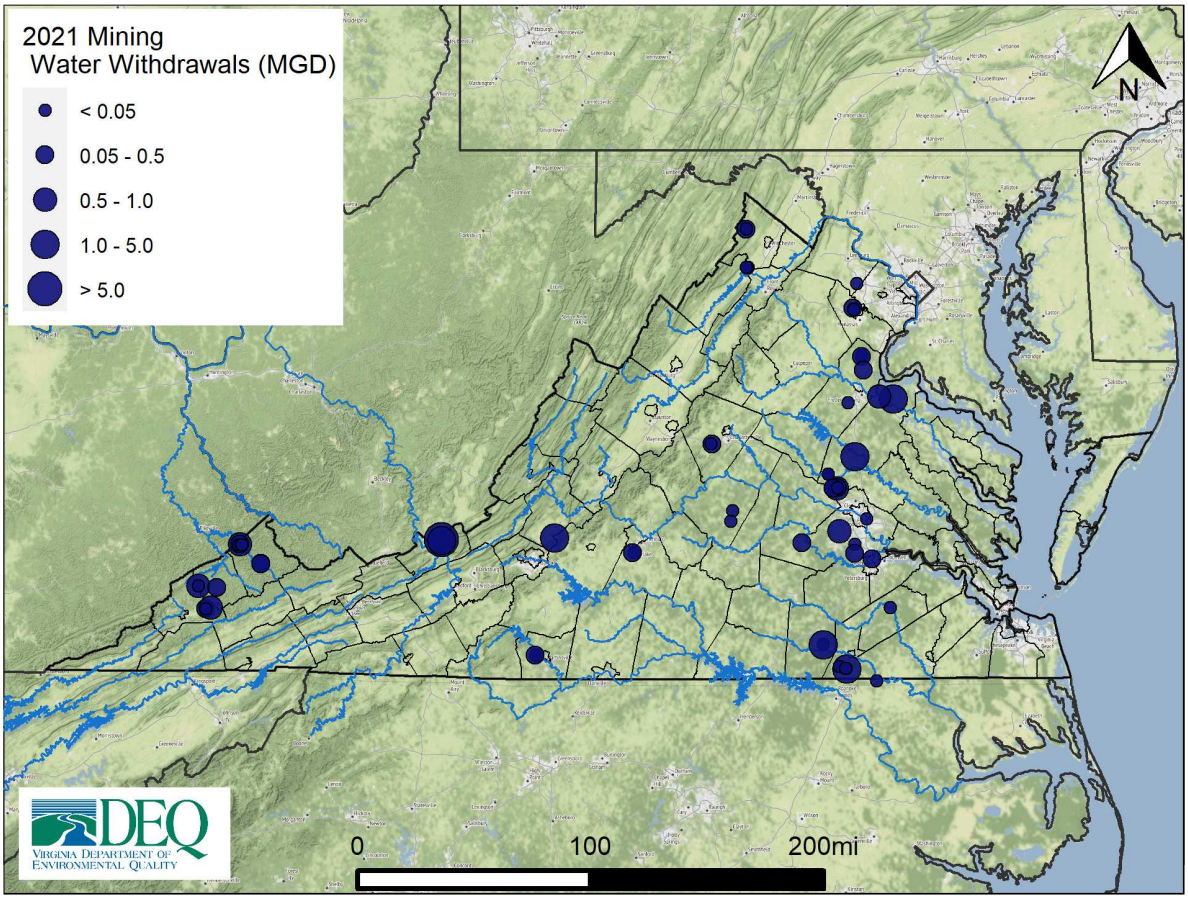

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Table 13: 2017 - 2021 Mining Water Withdrawals by Source Type (MGD)

Source Type	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater	15.54	18.04	17.57	19.62	20.72	18.30	13.2
Surface Water	13.66	16.84	13.74	15.62	12.91	14.55	-11.3
Total (GW + SW)	**29.19**	**34.88**	**31.31**	**35.24**	**33.63**	**32.85**	**2.4**

Figure 24: 2017-2021 Mining Water Withdrawals by Source Type

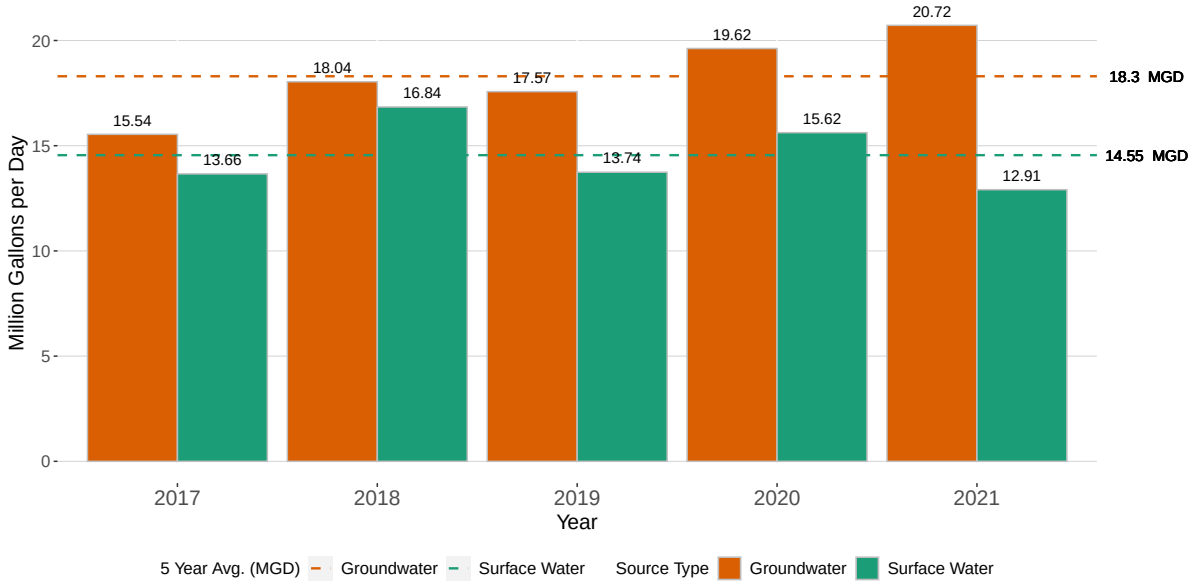

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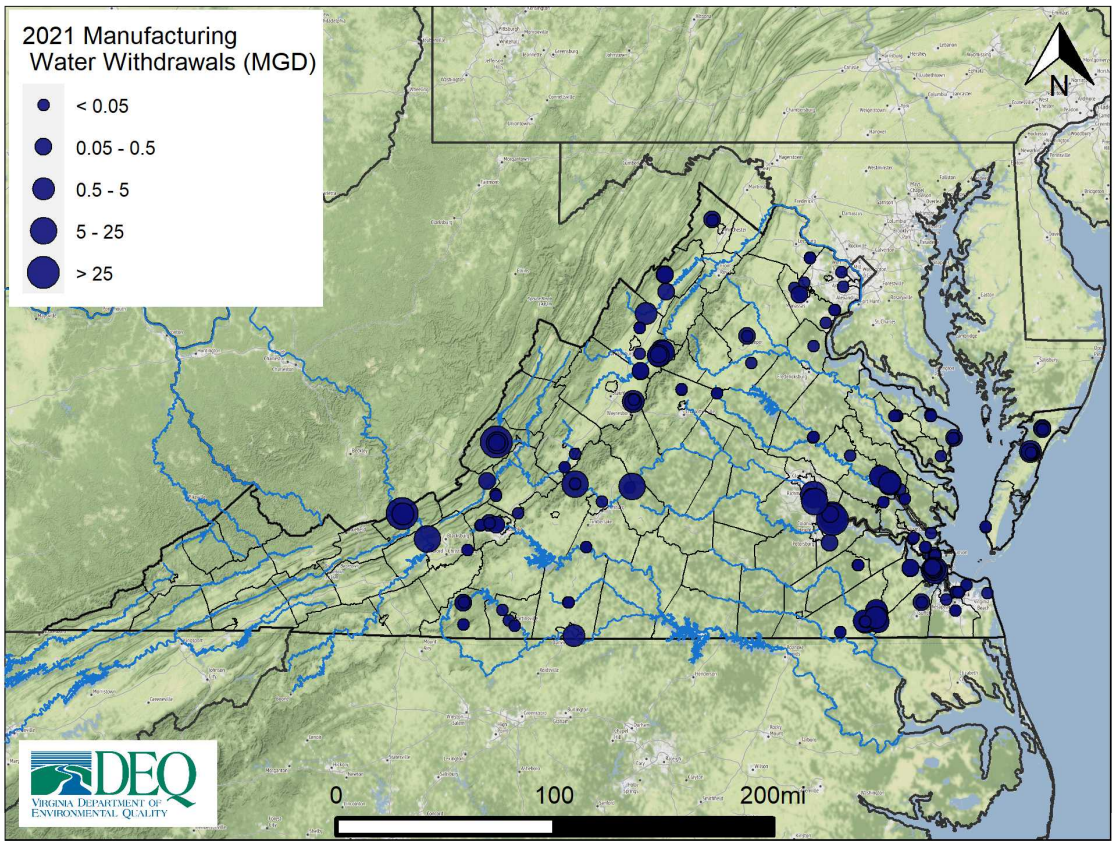
Table 14: Highest Reported Mining Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
Lhoist North America: Kimballton Plant 1	Giles County	GW	11.3	15.3
Lhoist North America: Kimballton Plant 2	Giles County	SW/GW	5.2	3.5
Boxley Materials: Blue Ridge Plant	Bedford County	GW	1.8	1.5
Vulcan Construction Materials: Lawrenceville Quarry	Brunswick County	SW/GW	1.3	1.4
Vulcan Construction Materials: Skippers Plant	Greensville County	SW/GW	1.1	1.3

3.8 Manufacturing

The manufacturing use category includes industrial operations such as chemical and plastics manufacturing, paper mills, food processors, and other manufacturing related withdrawals. Water withdrawals from manufacturing users account for 29.03% of all reported non-power generation withdrawals in Virginia in 2021. Manufacturing water withdrawals are spread throughout much of Virginia (Figure 25) as such facilities can be found in both rural and urban areas. The major determining factor for siting manufacturing facilities is access to sufficient quantity and quality of water, whether it be groundwater or surface water. Clusters of large-scale manufacturing withdrawals occur in the Middle James River Basin around the City of Richmond, as well as in the New and the Upper James river basins. Facilities that rely on groundwater are generally located in the Coastal Plain with wells constructed in the productive Potomac Aquifer or along productive fractures in the Western region of the State. All of the locations with large surface water withdrawals are situated on or near major rivers to facilitate water supply.

Figure 25: All 2021 Manufacturing Water Withdrawals by Withdrawal Point Location



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Reported 2021 manufacturing withdrawals increased by 1.1% compared to the five year average, as shown in Table 15. This increase is in contrast to the overall trend of reduced manufacturing withdrawals observed over the last five years. Surface water is the predominate water source type for manufacturing, accounting for approximately 84% of reported withdrawals in 2021 (See Figure 26).

Table 16 lists the five facilities reporting the largest groundwater withdrawals associated with this category in 2021 and Table 17 lists the facilities reporting the largest surface water withdrawals associated with this category in 2021.

Table 15: 2017 - 2021 Manufacturing and Industrial Water Withdrawals by Source Type (MGD)

Source Type	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater	57.54	60.57	57.76	58.02	59.88	58.75	1.9
Surface Water	324.45	304.17	293.49	301.92	309.55	306.72	0.9
Total (GW + SW)	**381.99**	**364.74**	**351.25**	**359.95**	**369.43**	**365.47**	**1.1**

Figure 26: 2017-2021 Manufacturing Water Withdrawals by Source Type

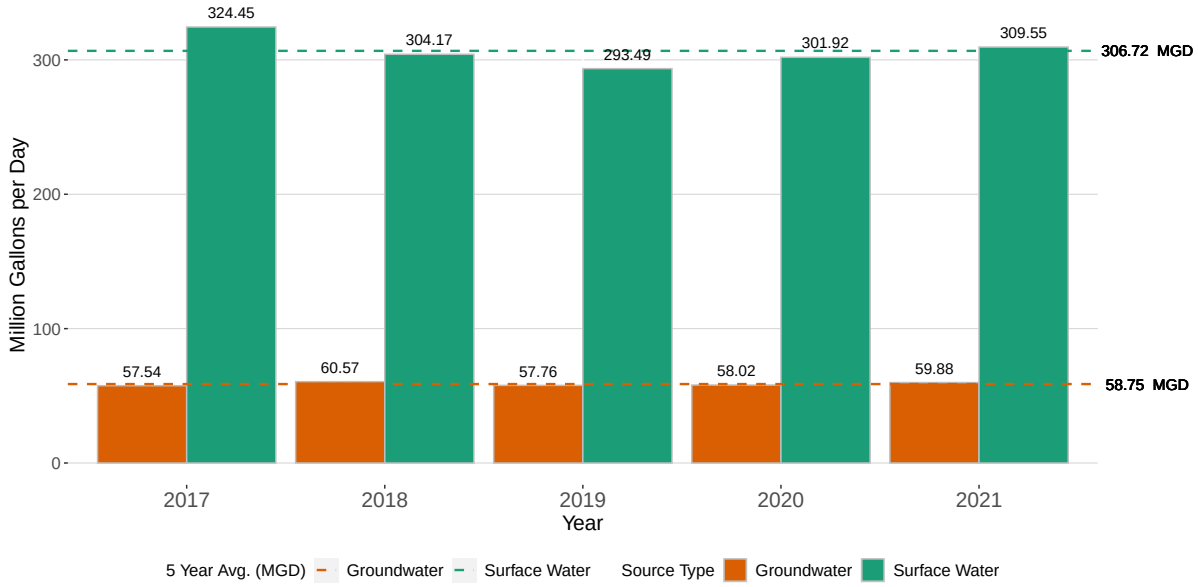

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Table 16: Highest Reported Manufacturing and Industrial Groundwater Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
WestRock CP, LLC: West Point Mill Water System	King William County	GW	16.8	16.1
International Paper: Franklin Virginia Mill	Isle of Wight County	GW	13.7	14.0
Merck & Co: Elkton Plant	Rockingham County	GW	5.9	6.1
Celanese Acetate LLC: Celco Plant	Giles County	GW	5.3	5.8
The LYCRA Company: Waynesboro Plant	City of Waynesboro	GW	3.7	3.8

Table 17: Highest Reported Manufacturing and Industrial Surface Water Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
AdvanSix Resins & Chemicals: Hopewell Plant	City of Hopewell	SW	104.0	103.8
Celanese Acetate LLC: Celco Plant	Giles County	SW	53.1	55.7
WestRock Virginia Corporation: Covington Plant	Alleghany County	SW	37.5	37.9
U.S. Radford Ammunitions WTP 1	Montgomery County	SW	19.1	23.5
Dupont E I De Nemours & Co: Spruance Plant	Chesterfield County	SW	23.9	21.9

3.9 Power Generation

The power generation use category category includes water withdrawn for fossil fuel power and nuclear power. Withdrawals or diversions of water for hydroelectric power (hydropower) generation are nearly all non-consumptive and are exempt from the annual water withdrawal reporting requirements. As a result, a detailed description for hydropower is not included; however, a brief discussion of consumptive use of water is provided in Chapter 2.

The largest power generation facilities are located in central and eastern Virginia (see Figure 27) , including two nuclear-power generating plants located in Louisa and Surry counties, which alone account for approximately 64% of all reported withdrawals in 2021, although very little of the water withdrawn for these facilities is not returned to the source after use for cooling. Total power generation withdrawals in 2021 decreased by 5.2% as compared to the five-year average (Table 18). This was largely driven by a continuing trend in decreased use for fossil power as coal plants continue to be taken off-line or into cold storage. A reduction in withdrawals for nuclear power was also a contributor to this decline. 2021 was the fourth consecutive year with reported power generation withdrawals under 5,000 MGD. Groundwater withdrawals reported by power generation facilities in 2021 remain insignificant compared to surface water withdrawals, which is consistent with historical trends (Figure 28). Total (surface water and groundwater) withdrawals decreased slightly from 2020 to 2021 with 4,500 MGD and 4,389 MGD respectively. The five power generation facilities with the highest reported withdrawals are listed in Table 19. All five facilities saw a decrease in water usage as compared to the five-year average.

Figure 27: All 2021 Power Generation Water Withdrawals by Withdrawal Point Location

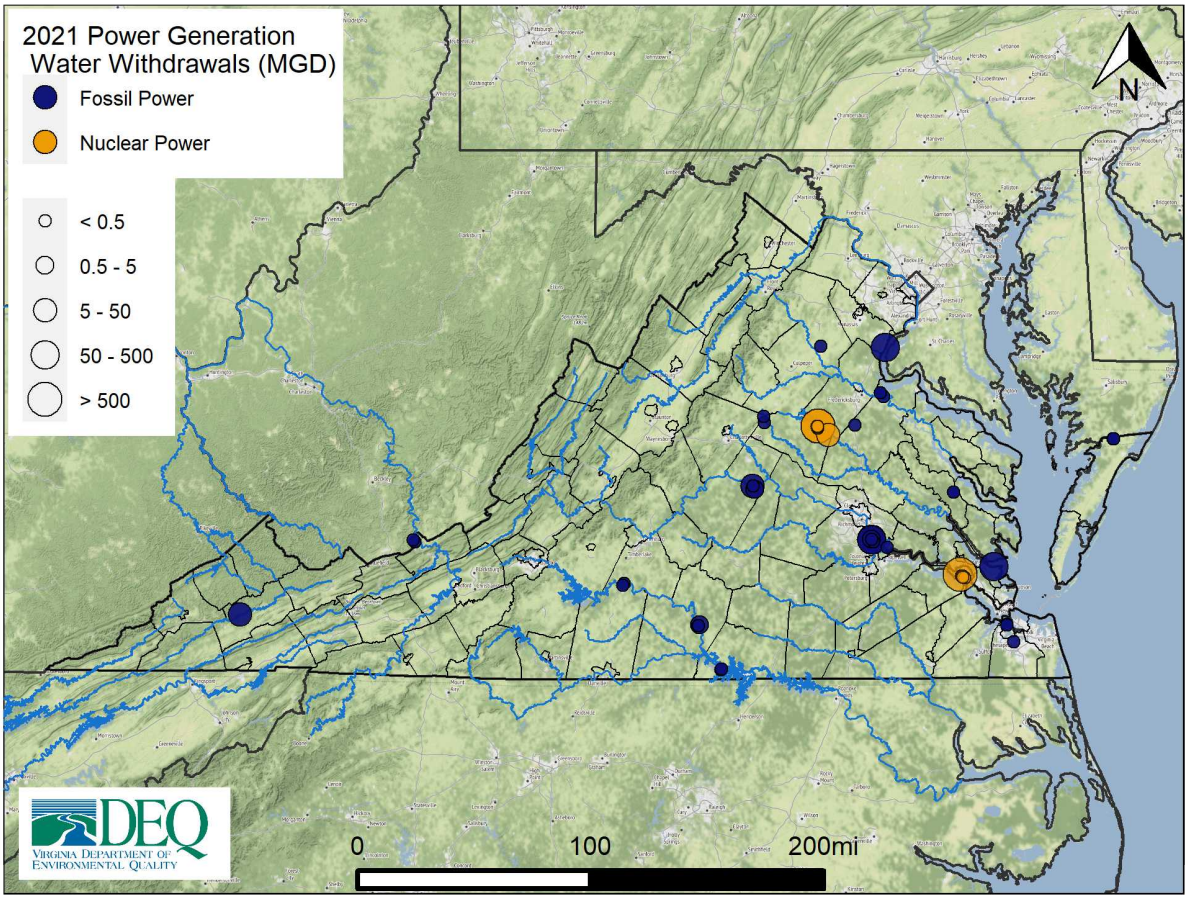

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Table 18: 2017 - 2021 Power Generation Water Withdrawals by Source Type (MGD)

Power Type	2017	2018	2019	2020	2021	5 Year Avg.	% Change 2021 to Avg.
Groundwater							
Fossil	0.09	0.12	0.07	0.07	0.06	0.080	-25.0
Nuclear	0.32	0.38	0.37	0.36	0.37	0.360	2.8
Total Groundwater	0.41	0.50	0.44	0.43	0.43	0.440	-2.3
Surface Water							
Fossil	1102.08	1012.39	752.18	635.84	732.32	846.960	-13.5
Nuclear	3951.16	3705.29	3739.35	3863.89	3656.36	3783.210	-3.4
Total Surface Water	5053.24	4717.68	4491.53	4499.73	4388.68	4630.170	-5.2
Total (GW + SW)	**5053.65**	**4718.18**	**4491.97**	**4500.16**	**4389.11**	**4630.614**	**-5.2**

Figure 28: 2017-2021 Power Generation Water Withdrawals by Source Type

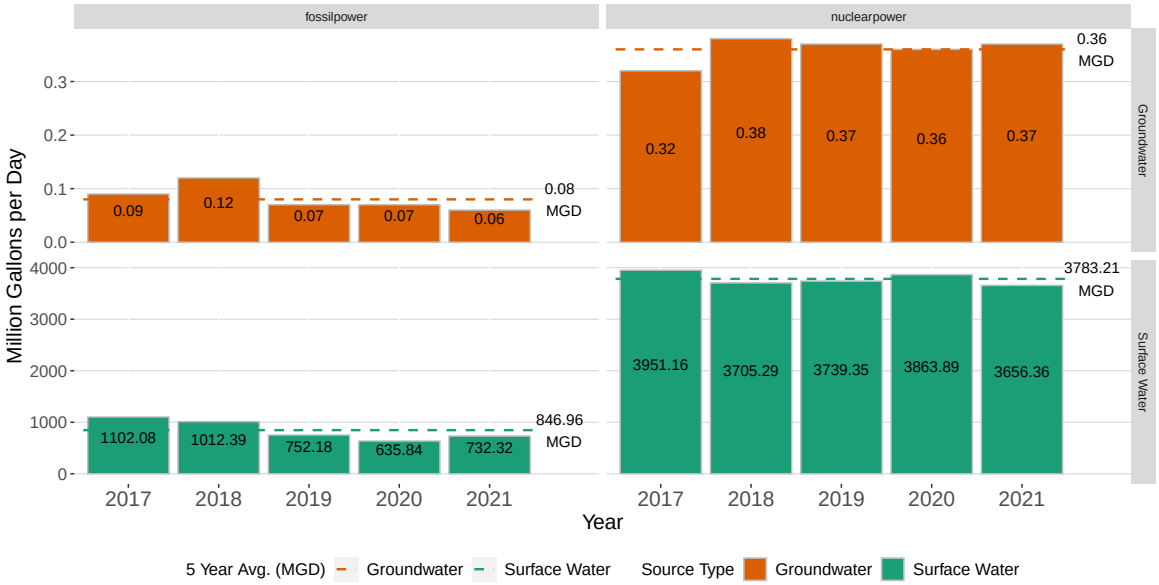

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Table 19: Highest Reported Power Generation Withdrawals in 2021 (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal
North Anna Nuclear Power Plant	Louisa County	SW/GW	1881.7	1855.6
Surry Power Station	Surry County	SW/GW	1901.8	1801.2
Chesterfield Power Station	Chesterfield County	SW	530.2	506.2
Yorktown Fossil Power Plant	York County	SW	233.3	157.2
Possum Point Power Station	Prince William County	SW	69.0	52.9

4 Water Resource Priorities and Challenges

The following section identifies new, continuing, and future priorities, challenges, or other topics of specific interest in terms of water resources management at DEQ. These include updates on new legislative or regulatory actions, programmatic goals and achievements, and other items.

4.1 Permitting Enhancement & Evaluation Platform (PEEP)

DEQ has initiated a new program called the Permitting Enhancement & Evaluation Platform (PEEP) that leverages technological improvements to foster transparency, collaboration, and efficiency in DEQ permit processes. The program will include public-facing online resources that convey and track the critical steps to obtaining approvals from DEQ, including to the maximum extent practicable the steps needed from the applicant and other agencies. PEEP will be a Critical Path Management (CPM) tool that will assist permit writers, project managers, applicants and their agents, as well as the public, to understand the permit processes and steps needed to ensure timely decisions. This will increase transparency for external users, and offer new ways for permit writers and managers to organize and monitor progress on applications.

4.2 Potomac River Basin Environmental Flows

In 2021, Commissioners of the Interstate Commission on the Potomac River Basin (ICPRB) passed a Resolution on Enhancing Water Supply Resilience for the Washington Metropolitan Area. This resolution is the first step in updating the two foundational agreements of the Washington metropolitan area cooperative water supply system: the Low Flow Allocation Agreement (LFAA) of 1978 and the Water Supply Coordination Agreement (WSCA) of 1982. The resolution called for several action items:

- Develop a Task Force on the WSCA to re-initiate dialogue on revisions that would accurately reflect changing conditions;
- Convene a Work Group to discuss the ten sets of options identified in the 2018 review of the LFAA; and
- Convene scientific workshops on state-of-the-art approaches to environmental flows for large river systems.

A two day workshop was convened by ICPRB in May of 2022 focusing on identifying any new approaches to determining environmental flows since the original agreements, and determining what data, analysis tools, and assessments are needed to make a scientifically defensible change to the existing agreements. DEQ staff participated in the workshop which also included representatives from Maryland, West Virginia, and Pennsylvania, as well as from federal agencies such as the Army Corps of Engineers, EPA, and USGS, among other groups. DEQ staff presented data indicating that water supply withdrawals may reduce mean monthly flow by as much as 40% during moderate and extreme drought flows, that the original habitat study conducted by the State of Maryland indicated many of the species experience reductions in habitat during drought despite being generalist species, and that future studies focused on more flow sensitive species may find greater impacts. This is significant given that the majority of the instream flow literature indicates that species impacts can be seen with a 20% reduction in river flow.

ICPRB produced a Workshop Report summarizing the results of the workshop. DEQ staff will continue to support this important effort to establish environmental flows that support all human and environmental beneficial uses of the Potomac River.

4.3 Climate and Drought Modeling

To address uncertainty related to the potential for climate change to impact streamflow, DEQ developed a series of climate change scenarios that simulate how streamflow during a drought may change based on meteorological conditions that are within a reasonable bound based on predictions of the best available global climate models. These scenarios represent the initial effort by DEQ to address climate uncertainty

related to surface water resources within the Chesapeake Bay drainage area. In 2021-2022, DEQ completed a project to expand climate change input meteorology data sets to include rivers outside of the Chesapeake Bay watershed. In addition, this project also expanded the climate change simulation period from 10 years (1990-2000) to 1984-present. These model improvements also allow DEQ to simulate future drought conditions using the baseflow recharge expected from current conditions as a starting point, potentially allowing better predictions of the severity of a summer or fall drought when winter and spring conditions suggest the potential for one.

While the models suggest an overall increase in precipitation, the potential for more severe drought periods due to increasing evaporation remains. Water supply planning should occur at a scale that facilitates a regional evaluation of sources and economic demand, as well as evaluating regional opportunities for diversifying sources, developing storage, and building interconnections and redundancy where possible among neighboring systems. The ability to provide a predictable and reliable water supply under any climatic condition is critical to Virginia's economic well-being. Therefore, developing a process for incorporating the evaluation of climate change into existing management programs, including water withdrawal permitting and water supply plan development and review, could be an important element of resiliency planning.

4.4 Addressing Unpermitted and Unreported Water Use

Evaluating and addressing impacts from water users that are statutorily exempt from the requirement to obtain a VWP surface water or groundwater withdrawal permit, or otherwise are unpermitted, continues to be a challenge in managing both surface water and groundwater to provide certainty that this water will be available for future growth over the long term under all conditions. Reported surface water withdrawals not subject to permitting requirements made up approximately 79% of total reported surface water withdrawals in 2021 (see Table 2). Exempt in this context means a surface water facility that is exempt pursuant to the criteria in § 62.1-44.15:22B of the Code of Virginia. One of the challenges in evaluating impacts from exempt surface water users is the multiple types of data cited to support exempt demand amounts ranging from the capacity of the intake to the safe yield of the source. There is considerable variation across these values for any given facility, and this variation only increases when evaluating the cumulative impact of a stream with multiple exempt users.

If facilities were to operate at the maximum possible exempt demand among these possible values, issuance of VWP applications for new withdrawals would be unlikely or even impossible in portions of every major river basin in Virginia due to unacceptable impacts to downstream beneficial uses, which includes other water users, aquatic life, and the maintenance of water quality. A process to incorporate the evaluation of potentially exempt demands into the VWP permit application review process needs to be developed.

The proportion of groundwater use that is exempt from permitting, or otherwise unpermitted, although smaller in absolute terms than exempt surface water demands, is more difficult to estimate since much of it comes from domestic or private wells with no requirement to report withdrawals. There are few exemptions from the requirement to obtain a permit for groundwater withdrawals in a declared groundwater management area, and therefore those that are considered unpermitted are generally either very small users such as domestic/residential wells, or facilities that do withdraw enough groundwater to require a permit but have not obtained one. Particularly in the groundwater management areas, continuing to improve estimates of domestic use remains a key goal given the increasing demands on the aquifer system by the growing population of homeowners with individual wells.

Another ongoing priority is evaluating and addressing unreported use below the regulatory threshold requiring withdrawal reporting (domestic or private well use for instance), and use above the regulatory threshold that is nonetheless not currently being reported. DEQ staff conduct compliance activities annually to identify users who meet the threshold for annual withdrawal reporting as well as to contact users who have previously reported but have failed to do so consistently. The extent of these contacts is highly dependent on available staff resources each year and must be balanced against other program responsibilities. In addition, DEQ works to address known gaps in this data through projects like the 2020-2021 USGS Water-Use Data and

Research Grant project to develop estimates of unreported agricultural water use in Virginia (discussed in more detail in Chapter 1) which will be completed in Fall of 2022.

In FY22, DEQ contracted with the USGS to establish a new baseline estimate and a method to annually update these estimates of domestic and private groundwater use. This information is used to inform the total pumping used for groundwater modeling scenarios that determine the water available to each permittee. It is increasingly important to keep this information updated from year to year to ensure that decisions are made based on the most up to date information. DEQ registers new private well information in groundwater management areas via water well completion forms that will be used by USGS and DEQ, in conjunction with other data, to refine domestic use estimates. The most recent estimate of domestic groundwater withdrawals from confined aquifer systems in the Coastal Plain was more than 30 MGD, or almost half the volume (66 MGD) of the reported groundwater withdrawals associated with permitted facilities referenced in the 2019-2020 Virginia Coastal Plain Model Report.[10] As Virginia's population continues to grow, it will be important to update these estimates to better inform water availability in the Coastal Plain aquifers.

4.5 Eastern Virginia Groundwater Management Area

Hampton Roads Sanitation District's (HRSD) Sustainable Water Initiative for Tomorrow Project (SWIFT) pilot program offers reason for cautious optimism. A pilot injection well at HRSD's SWIFT Research Center is providing field data on how injections impact pressure in the Potomac and overlying aquifers.[11] The center currently collects data from observation wells and from an extensometer operated by USGS which measures changes in land elevation in response to the injection. These data are critical to evaluating model results and calibrating the model with respect to the simulation of the proposed injections. The first full-scale injection facility is nearing completion of the EPA Underground Injection Control Permit process for the HRSD James River Plant. Once completed this project may be capable of injecting up to 16 MGD to augment the Potomac Aquifer. If the final permit is issued, it will remain in effect for 10 years.

Recent legislation has paved the way for the first general permits from the surficial (water table) aquifer for groundwater withdrawals in the Eastern Virginia and Eastern Shore GWMAs for irrigation and agricultural use respectively. These general permits will offer a streamlined permit process and are intended to increase withdrawals from the surficial (water table) aquifer, which recharges more readily, and thereby reduce withdrawals from confined aquifers. Withdrawals from confined aquifers such as the Potomac Aquifer cannot be permitted under these general permits given the technical criteria that must be evaluated for withdrawals from a confined aquifer.

4.6 Eastern Shore Groundwater Management Area

In 2019, an update to the Hydrogeologic Framework of the Virginia Eastern Shore, a joint effort between USGS and DEQ was published.[12] This study was a significant updating of the prior hydrogeologic framework that was published in 1994, and includes significant improvements in our understanding of the saltwater-fresh water interface, and the location and effect of paleochannels on aquifer flow patterns and well yields. This work was made possible by data collected through the groundwater withdrawal permit program and the work of DEQ geologists. A new groundwater model is in its third year of development and is expected to be completed in the next year. The new model will include the updated hydrogeologic information and the results of a detailed review of water use, including better characterization of surficial aquifer use.

[10] Virginia Coastal Plain Model (VAHydroGW-VCPM) 2019-2020 Annual Simulation of Potentiometric Groundwater Surface Elevations of Reported and Total Permitted Use.

[11] https://www.hrsd.com/swift/about

[12] McFarland, E.R., and Beach, T.A., 2019, Hydrogeologic framework of the Virginia Eastern Shore: U.S. Geological Survey Scientific Investigations Report 2019–5093, 26 p., 13 pl., https://doi.org/10.3133/sir20195093.

4.7 Evaluating Impacts to Aquatic Life from Surface Water Withdrawals

In managing water resources to protect all beneficial uses, the expectation is that DEQ use the most current science and best available evaluation methods when reviewing project impacts. Two DEQ led publications[13] [14] in the Journal of American Water Resources Association present a new method of evaluating impacts on species richness as a result of changes in flow: the elfgen R package. This work was selected as the best technology paper by the Journal's editors in 2021. The technique will allow for project scale evaluation of potential aquatic impacts to be completed at less cost to applicants than traditional field methods such as Instream Flow Incremental Methodology while resulting in similar data value.

4.8 Evaluating Tidal Fresh Surface Water Withdrawals

Groundwater limitations in the Coastal Plain region have led water users to consider alternatives that they previously considered to be cost prohibitive. Recently, several applications for the construction of tidal fresh surface water withdrawal intakes in the Appomattox and Rappahannock rivers have been received and are under review by DEQ. The water quality in a tidal system is dynamic and the amount of available freshwater can improve or reduce local water quality during critical periods. Reducing freshwater inflows into a tidal system can shift the location further upstream where low salinity and high salinity water combine. Reducing freshwater inflows can also increase residence time in the estuary, which can increase the likelihood of negative water quality consequences like algal blooms as seen in parts of the tidal James River. A future need is the development of new modeling techniques and the application of updated water quality models for use in these evaluations.

[13] Kleiner et al. - DOI: https://doi.org/10.1111/1752-1688.12876.
[14] Rapp et al. - DOI: https://doi.org/10.1111/1752-1688.12876.

4.9 Recent and Ongoing Legislative and Regulatory Actions

Over the past year, DEQ coordinated several regulatory actions related to water resources management in response to legislation passed by the General Assembly. A summary of each action and the current status is provided below:

- Legislation enacted following the 2019 General Assembly Session (2019 Va. Acts Ch. 755) directed the SWCB to adopt regulations providing incentives, such as an expedited general permit process, for the withdrawal of groundwater from the surficial aquifer, rather than the confined aquifer, in the Eastern Shore GWMA. In 2019, DEQ published a NOIRA to establish the framework for the issuance of a general permit for withdrawals from the surficial aquifer in the Eastern Shore GWMA as a way to incentivize surficial aquifer withdrawals. The final regulation was approved by the SWCB on December 14, 2021 and will be effective later this year.

- Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 1105) requires the SWCB to adopt regulations designating regional planning areas based primarily on river basins, to encourage the development of cross-jurisdictional water supply projects, and to estimate the risk that each locality and region in the Commonwealth will experience water supply shortfalls. This law also directs localities to participate in cross-jurisdictional, coordinated water resource planning, and to develop a single water supply plan for each regional planning area. A RAP was formed and met six times during 2021-2022. Proposed amendments were developed and presented to the SWCB on June 22, 2022, and the SWCB approved public notice of the proposed amendments pending executive review.

- Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 670) prohibits construction of wells for non-agricultural irrigation in aquifers other than the surficial (water table) aquifer, unless DEQ determines this aquifer is inadequate to meet the proposed beneficial use, once the SWCB adopts a general permit for regulation of withdrawals from the surficial aquifer. A Technical Advisory Committee (TAC) was formed and met through June, 2021. The proposed regulation was approved by the SWCB on December 14, 2021, and a public comment period concluded on May 15, 2022. The SWCB approved the final regulation on June 22, 2022 and it should be effective later this year.

- Legislation enacted following the 2021 General Assembly Special Session I (2021 Special Session I Va. Acts Ch. 100) will improve the efficiency and effectiveness of water use by requiring all applications for Virginia Water Protection (VWP) permits for surface water withdrawals and Ground Water Withdrawal permits to include: 1) a water auditing plan, and 2) a leak detection and repair plan that satisfy the requirements in regulations to be adopted by the SWCB. These plans would also, once approved, be incorporated by reference as conditions in the permit. A regulatory advisory panel (RAP) was formed and met four times. The RAP is expected to complete its work on a set of proposed regulations by the time this report is published. Once completed, DEQ will present proposed amendments to the SWCB.

- Legislation enacted following the 2022 General Assembly Session (Chapter 356 of the 2022 Acts of Assembly) limits the authority of the SWCB to the issuance of regulations, and transfers the SWCB's existing authority to issue permits and orders to DEQ. DEQ addressed this statutory change in a substantial regulatory package provided to the SWCB on August 25.

4.10 Program Funding

DEQ's responsibilities and authorities in terms of managing water supply are complex and increasingly rely on extensive and regular data collection and the development and on-going maintenance of evaluation models that are expensive. Continued financial investment is necessary to allow for proactive and responsive management to ensure that these resources can be put to beneficial uses that foster Virginia's prosperity. Investment in the science and personnel that underpin data driven management decisions is necessary to maintain currency with the changing world. The FY2021-2022 budget provided significant funding for a multi-year project to install a new extensometer, climate response network wells for drought monitoring in underserved rural areas west of Interstate 95, and 19 chloride monitoring wells within the groundwater management areas to monitor the movement of saltwater that could put water supplies at risk of expensive and unanticipated treatment costs. This significant investment will address existing monitoring gaps in rural areas and ensure DEQ is able to monitor trends in aquifer recovery, groundwater quality, and continue collecting data to inform management decisions. More information on this project is found in Chapter 1.

Investment is still needed to address regional planning for sustainable water supplies. Investment in regional water supply program implementation is necessary to build long-term local government stewardship of local and regional water resources so that they can thrive economically. A secure source of funding for planning grants to local governments is a fundamental element to the success of plan implementation and long-term maintenance. A recurring comment from local and regional programs is that for the statewide planning process to reach its full potential, funding to support water supply planning efforts is essential to maintain long-term data gathering and planning. As a result of 2020 Va Acts Ch. 1105, planning areas are changing and in many cases this will impact existing planning relationships, and form new ones. The lack of funding to support these efforts continues to be a common concern expressed by localities as they prepare for the next plan development process.

Appendix 1: Top 20 Reported Water Withdrawals in 2021 (Excluding Power Generation)

SW: Surface Water, GW: Groundwater, *Permitted Withdrawal, **Unpermitted Withdrawal

Table 20: Top 20 Reported Water Withdrawals in 2021 Excluding Power Generation (MGD)

Facility	Locality	Type	5 Year Avg.	2021 Withdrawal	Category
AdvanSix Resins & Chemicals: Hopewell Plant**	City of Hopewell	SW	104.0	103.8	Manufacturing
Fairfax Water: Corbalis WTP**	Fairfax County	SW	87.4	80.7	Municipal
Fairfax Water: Griffith WTP**	Prince William County	SW	64.6	72.1	Municipal
City of Richmond WTP**	City of Richmond	SW	66.0	68.5	Municipal
City of Norfolk: Western Branch Reservoir**	City of Suffolk	SW	70.2	66.1	Municipal
Celanese Acetate: Celco Plant**	Giles County	SW/GW	58.4	61.6	Manufacturing
WestRock Virginia Corporation: Covington Plant**	Alleghany County	SW/GW	37.8	38.7	Manufacturing
Appomattox River Water Authority: Chesdin Reservoir WTP*	Chesterfield County	SW	35.0	38.3	Municipal
City of Virginia Beach Service Area**	City of Virginia Beach	SW	27.1	31.4	Municipal
Henrico County WTP and Service Area*	Henrico County	SW	25.0	26.1	Municipal
U.S. Radford Ammunitions WTP 1**	Montgomery County	SW	19.1	23.5	Manufacturing
Virginia American Water: Hopewell District**	City of Hopewell	SW	22.1	22.7	Municipal
Dupont E I De Nemours & Co: Spruance Plant**	Chesterfield County	SW/GW	24.0	22.2	Manufacturing
City Of Newport News: Waterworks Lee Hall*	City of Newport News	SW/GW	21.6	20.7	Municipal
City of Newport News: Harwood's Mill WTP**	York County	SW	18.3	19.9	Municipal
City of Portsmouth: Lake Kilby WTP*	City of Suffolk	SW/GW	16.7	16.9	Municipal
International Paper Company: Franklin Virginia Mill*	Isle of Wight County	SW/GW	16.0	16.2	Manufacturing
WestRock CP LLC: West Point Mill Water System*	King William County	SW/GW	16.8	16.1	Manufacturing
Lhoist North America: Kimballton Plant 1**	Giles County	GW	11.3	15.3	Mining
Georgia-Pacific Big Island WTP**	Bedford County	SW/GW	14.8	14.8	Manufacturing

Appendix 2: Water Withdrawals Within Localities in 2021 (MGD) (Excluding Power Generation)

Table 21, shown below, lists the reported water withdrawals, both permitted and unpermitted, that occurred in 2021 within individual localities.

Table 21: Water Withdrawals Within Localities in 2021 (MGD)

Locality	GW Withdrawal	SW Withdrawal	GW + SW Total	Percent of Total Withdrawal
Accomack County	5.28	5.33	10.61	0.83
Albemarle County	0.18	11.34	11.52	0.91
Alleghany County	0.73	39.25	39.98	3.14
Amelia County	0.12	0.08	0.19	0.02
Amherst County	0.00	19.03	19.03	1.50
Appomattox County	0.00	0.00	0.00	0.00
Arlington County	0.01	0.09	0.10	0.01
Augusta County	3.44	8.18	11.62	0.91
Bath County	0.15	12.41	12.56	0.99
Bedford County	1.54	17.19	18.73	1.47
Bland County	0.06	0.15	0.20	0.02
Botetourt County	0.58	5.27	5.85	0.46
Brunswick County	0.01	2.44	2.45	0.19
Buchanan County	0.24	0.89	1.13	0.09
Buckingham County	0.00	0.36	0.36	0.03
Campbell County	0.08	5.99	6.07	0.48
Caroline County	1.41	2.30	3.70	0.29
Carroll County	0.23	0.33	0.56	0.04
Charles City County	0.07	0.65	0.72	0.06
Charlotte County	0.13	0.11	0.24	0.02
Chesterfield County	0.37	84.04	84.41	6.63
City of Alexandria	0.00	0.00	0.00	0.00
City of Bedford	0.00	0.00	0.00	0.00
City of Bristol	0.00	0.00	0.00	0.00
City of Buena Vista	0.05	0.03	0.08	0.01
City of Charlottesville	0.00	0.00	0.00	0.00
City of Chesapeake	4.26	3.33	7.59	0.60
City of Clifton Forge	0.00	0.00	0.00	0.00
City of Colonial Heights	0.00	0.00	0.00	0.00
City of Covington	0.00	2.98	2.98	0.23
City of Danville	0.00	5.45	5.45	0.43
City of Emporia	0.00	0.97	0.97	0.08
City of Fairfax	0.01	0.02	0.03	0.00
City of Falls Church	0.00	0.00	0.00	0.00
City of Franklin	0.80	0.00	0.80	0.06
City of Fredericksburg	0.00	0.00	0.00	0.00
City of Galax	0.00	1.78	1.78	0.14
City of Hampton	0.21	0.00	0.21	0.02
City of Harrisonburg	0.00	0.07	0.07	0.01
City of Hopewell	0.00	137.13	137.13	10.78
City of Lexington	0.00	0.00	0.00	0.00

City of Lynchburg	0.02	0.00	0.02	0.00
City of Manassas	0.29	12.17	12.46	0.98
City of Manassas Park	0.00	0.00	0.00	0.00
City of Martinsville	0.00	1.79	1.79	0.14
City of Newport News	0.27	34.81	35.08	2.76
City of Norfolk	0.04	0.81	0.86	0.07
City of Norton	0.00	0.75	0.75	0.06
City of Petersburg	0.01	0.01	0.01	0.00
City of Poquoson	0.00	0.00	0.00	0.00
City of Portsmouth	0.12	0.00	0.12	0.01
City of Radford	0.00	2.70	2.70	0.21
City of Richmond	0.10	68.59	68.69	5.40
City of Roanoke	1.19	11.78	12.97	1.02
City of Salem	1.41	2.70	4.11	0.32
City of South Boston	0.00	0.00	0.00	0.00
City of Staunton	0.00	0.00	0.00	0.00
City of Suffolk	7.13	88.81	95.94	7.54
City of Virginia Beach	0.16	31.56	31.71	2.49
City of Waynesboro	4.95	1.46	6.41	0.50
City of Williamsburg	1.03	0.00	1.03	0.08
City of Winchester	0.00	0.00	0.00	0.00
Clarke County	0.07	0.63	0.70	0.06
Craig County	0.07	3.22	3.29	0.26
Culpeper County	1.12	1.46	2.58	0.20
Cumberland County	0.02	0.11	0.13	0.01
Dickenson County	0.00	6.12	6.12	0.48
Dinwiddie County	0.04	0.25	0.29	0.02
Essex County	0.50	1.70	2.20	0.17
Fairfax County	0.24	81.32	81.56	6.41
Fauquier County	1.79	1.19	2.98	0.23
Floyd County	0.12	0.11	0.23	0.02
Fluvanna County	0.14	0.71	0.85	0.07
Franklin County	0.14	1.04	1.18	0.09
Frederick County	3.12	4.49	7.61	0.60
Giles County	25.80	55.73	81.54	6.41
Gloucester County	0.67	0.77	1.44	0.11
Goochland County	0.09	1.98	2.07	0.16
Grayson County	0.16	0.05	0.21	0.02
Greene County	0.02	0.77	0.78	0.06
Greensville County	0.04	5.16	5.19	0.41
Halifax County	0.11	1.80	1.91	0.15
Hanover County	0.45	5.14	5.59	0.44
Henrico County	0.02	26.47	26.48	2.08
Henry County	0.00	3.43	3.43	0.27
Highland County	0.05	4.87	4.92	0.39
Isle of Wight County	16.56	4.27	20.84	1.64
James City County	5.41	4.58	9.99	0.79
King George County	1.37	2.11	3.49	0.27
King William County	16.79	0.69	17.48	1.37
King and Queen County	0.01	1.17	1.18	0.09

Lancaster County	0.43	0.08	0.51	0.04
Lee County	0.00	2.22	2.22	0.17
Loudoun County	1.53	13.83	15.37	1.21
Louisa County	0.33	0.59	0.91	0.07
Lunenburg County	0.00	0.55	0.55	0.04
Madison County	0.04	0.10	0.14	0.01
Mathews County	0.03	0.00	0.03	0.00
Mecklenburg County	0.10	1.85	1.94	0.15
Middlesex County	0.26	0.03	0.29	0.02
Montgomery County	0.11	30.63	30.74	2.42
Nelson County	0.16	2.66	2.82	0.22
New Kent County	0.96	16.24	17.20	1.35
Northampton County	1.14	0.93	2.07	0.16
Northumberland County	0.33	0.01	0.34	0.03
Nottoway County	0.01	1.24	1.25	0.10
Orange County	0.07	2.01	2.08	0.16
Page County	1.00	0.87	1.87	0.15
Patrick County	0.11	0.87	0.98	0.08
Pittsylvania County	0.00	1.46	1.47	0.12
Powhatan County	0.11	0.13	0.24	0.02
Prince Edward County	0.09	0.91	0.99	0.08
Prince George County	0.29	0.16	0.46	0.04
Prince William County	0.34	73.72	74.07	5.82
Pulaski County	0.00	5.02	5.02	0.39
Rappahannock County	0.04	0.00	0.04	0.00
Richmond County	0.31	0.00	0.31	0.02
Roanoke County	1.25	12.26	13.51	1.06
Rockbridge County	0.33	1.39	1.72	0.14
Rockingham County	15.95	10.96	26.91	2.11
Russell County	0.43	0.77	1.20	0.09
Scott County	0.13	1.26	1.39	0.11
Shenandoah County	2.71	2.02	4.73	0.37
Smyth County	0.75	5.43	6.18	0.49
Southampton County	3.22	2.30	5.52	0.43
Spotsylvania County	0.27	11.93	12.20	0.96
Stafford County	0.00	13.44	13.45	1.06
Surry County	0.21	0.15	0.36	0.03
Sussex County	0.99	0.91	1.90	0.15
Tazewell County	0.05	4.49	4.54	0.36
Warren County	0.14	7.77	7.92	0.62
Washington County	0.13	9.27	9.39	0.74
Westmoreland County	0.87	0.79	1.66	0.13
Wise County	0.14	7.11	7.26	0.57
Wythe County	0.10	8.20	8.30	0.65
York County	0.39	21.97	22.36	1.76
Total	**147.44**	**1124.99**	**1272.43**	**100.00**

Appendix 3: Water Resources Information and Climactic Conditions

State Population
(2020 census) – 8,644,727
(2021 Weldon Cooper Center Estimate[15]) – 8,655,608

State Surface Area – 42,775 square miles (39,490 sq. miles total land area, 3,285 sq. miles inland waters)

Major River Basins (with Current Estimates of Annual Mean River Flow):
- Tennessee-Big Sandy (4,132 sq. miles, 3,225 MGD)
- Albemarle Sound-Chowan River (4,252 sq. miles, 1,748 MGD)
- James (10,236 square miles, 5,501 MGD)
- New (3,068 square miles, 3,304 MGD)
- Rappahannock (2,714 square miles, 1,100 MGD)
- Roanoke (6,274 square miles, 5,120 MGD)
- Shenandoah (3,041 sq. miles, 1,797 MGD)
- Chesapeake Bay-Small Coastal (3,157 sq. miles, 97 MGD)
- York (2,669 square miles, 1,060 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 – 44.3 inches

Average Freshwater Discharge of All Rivers - Approximately 22,850 MGD

Average Freshwater Discharge into the Chesapeake Bay – Approximately 9,500 MGD

[15] University of Virginia Weldon Cooper Center, Demographic Research Group. (2021). Virginia Population Estimates. Retrieved from https://demographics.coopercenter.org/virginia-population-estimates.

Appendix 4: Water Transfers

Water transfers means water that has been withdrawn from surface or groundwater and transported via water pipelines, or other means of conveyance, to a different facility or service area. Water transfers generally represent water that is purchased, sold, or distributed to other water users or customers from a main supplier, although large water utilities may transfer water between sources and service areas they own. Transferred water data is reported to DEQ as a release (the point the water is sent from) or a delivery (the point where water is received). In some cases a transfer is reported from both sides of the transaction but in others only one side reports the transfer.

In 2021, 85 water transfers were reported to VAHydro with approximately 490 MGD transferred on average each day. Transfers primarily occurred within regional water distribution systems that sold or purchased water from a larger primary source such as a reservoir. In general, withdrawals from a water source (groundwater or surface water) account for the largest portion of a locality's water use. Transferred water provides an additional supply connection that can be a primary water source or supplementary during drought or other conditions.

The largest water transfers occurred within Richmond, Hampton Roads, and Northern Virginia. The City of Richmond provides water supply to numerous customers including Chesterfield, Hanover, and Henrico Counties. The Hampton Roads region includes many of the reported water transfers with the Cities of Norfolk and Virginia Beach the primary provider and recipient. The City of Virginia Beach is primarily supplied by transferred water that originates from Lake Gaston located in south central Virginia. The raw water is initially transferred to the City of Norfolk for processing and finished water is transferred to the City of Virginia Beach. This system represents the greatest travel distance of any transfer in Virginia. Additionally, Northern Virginia localities are largely interconnected and supplied by water authorities in the region including Fairfax Water and Loudoun Water.

Currently, not all water transfers are consistently reported to VAHydro, in part because many systems lack the technology or resources to track and report water transfers. For example, there are localities that have reported water releases, but there are no corresponding records indicating the water has been received and used by another locality or entity. Some entities reportedly sell water, but do not track where the water is sent. Improvements in the quality of reporting and methods DEQ uses to track the transfer of water, both within systems and between entities, are necessary to better understand the impact transfers have in Virginia.