A REPORT TO

THE HONORABLE TERENCE R. MCAULIFFE, GOVERNOR,

AND

THE GENERAL ASSEMBLY OF VIRGINIA

STATUS OF VIRGINIA'S WATER RESOURCES

A REPORT ON VIRGINIA'S WATER RESOURCES MANAGEMENT ACTIVITIES

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
COMMONWEALTH OF VIRGINIA

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ACRONYMS

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

EXECUTIVE SUMMARY

The *Report on Virginia's Water Resources Management Activities*, 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 describes the status of the state's surface and groundwater resources and provides an update of the Commonwealth's water resources management activities. Water quantity is the focus of the Annual Report, summarizing reported water withdrawals for the 2014 calendar year and providing an update on the Commonwealth's Water Resources Management Program. The Annual Report also includes summaries of current climatologic conditions and available hydrologic information for the Commonwealth during the 2015 water year.[1] Water quality issues are addressed in the most recent biennial *Water Quality Assessment Integrated Report*, published by the Department of Environmental Quality (DEQ).

The citizens of the Commonwealth are able to enjoy access to 100,923 miles of non-tidal streams and rivers, 248 publicly-owned lakes, 236,900 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. The publicly-owned lakes alone have a combined surface area of 162,000 acres, and there are hundreds of small, privately-owned lakes and ponds distributed throughout the state. Statewide, rainfall averages are close to 43 inches per year, and the total combined flow of all freshwater streams is estimated at about 22.5 billion gallons per day.

After a relatively dry winter, precipitation during the 2015 water year was generally normal to above normal across most of Virginia. Streamflows and groundwater levels in Climate Response Network observation wells were at normal or near normal levels during most of the spring and early summer months. Water supply storage reservoirs maintained water levels within or above normal ranges throughout most of the year. However, dry conditions that developed during the winter in portions of the Roanoke River basin and parts of central and eastern Virginia worsened during July through September. DEQ issued a Drought Watch declaration for the Virginia portion of the Roanoke River basin on September 15, 2015 (Appendix 1).

The DEQ Division of Water Planning, Office of Water Supply, coordinates the management of the quantity of water resources across the Commonwealth of Virginia through six programs: Groundwater Characterization, Water Supply Planning, Water Withdrawal Reporting, Groundwater Withdrawal Permitting, Virginia Water Protection Surface Water Withdrawal Permitting, and Drought Assessment and Response. Additional information can be found at Water Supply and Quantity on the DEQ webpage. The following are programmatic highlights during 2014:

- The Virginia Coastal Plain Groundwater Initiative was developed in response to the ongoing and long-term decline of groundwater levels, head loss, and growing concerns of land subsidence and salt water intrusion into the Coastal Plain confined aquifer system. In order to achieve the goal of protecting the aquifer system and providing for current and future water needs for the Commonwealth, DEQ identified and has begun discussions with the top 14 groundwater users about potential reductions in water withdrawals, which, if implemented could begin stabilizing the groundwater level declines in the aquifer. Stabilization cannot be achieved without withdrawal reductions, which in turn, will lay the foundation for long-term solutions.
- The State Water Resources Plan[2] was developed with information and data submitted in local and regional water supply plans.[3] In addition to local data, the Plan incorporates water withdrawal data

[1] The U.S. Geological Survey uses the term "water year" in reports that deal with surface-water supply, defining it as the 12-month period of October 1, for any given year through September 30, of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2015 is called the "2015 water year."
[2] 9VAC 25-780-140.I

submitted to the Virginia Water Use Data System through the Water Withdrawal Reporting program and contains the results of a cumulative impact assessment that will form the basis for staff activities for the next five years. During 2014, staff finalized the challenges and recommendations chapter and prepared the document for public comment.

- Efforts to continuously improve the clarity, predictability, and output of surface water withdrawal permitting were undertaken. A Citizen Advisory Group was established to work with staff on proposed revisions to the surface water portion of the Virginia Water Protection program regulations.[4] Revisions were necessary to clarify and streamline materials required by the Joint Permit Application and to address several statutory changes. Those proposed changes to the regulation are continuing through the regulatory development process.
- The Ambient Groundwater Quality Program was fully implemented, resulting in the collection of 30 trend and spot samples at wells and springs throughout the Commonwealth. Program implementation involves quarterly sampling of trend wells to monitor for salt water "upconing," or intrusion, and to document chloride concentrations in portions of the Coastal Plain aquifer system that may be vulnerable to upward migration of the fresh water/salt water interface. Spot sampling is done to document the groundwater quality in areas where groundwater geochemical data are limited or non-existent.
- Upgrades to VAHydroGW, the DEQ groundwater databases, were implemented to automatically generate groundwater model input files for analysis of new groundwater withdrawal permit applications and renewals. These enhancements have improved the timeliness of permit issuance and set the stage for completion of automatic generation of annual total permitted and current use model input decks in 2015-2016.
- Efforts to improve water withdrawal reporting within the golf course and agricultural communities were initiated. Development and implementation of the golf course outreach strategy resulted in approximately 120 new facility registrations for which water withdrawal data collection during the 2015 calendar year is anticipated. The agricultural outreach strategy was developed during 2014 and will begin implementation during 2015. Outreach to other water use categories, including but not limited to nurseries, sod farms, public and private educational institutions, and vineyards will be conducted over the next couple of years.
- An initiative to develop and implement consistent compliance practices for both surface water and groundwater withdrawal permitting was undertaken, beginning with a compliance and file review of all active surface water withdrawal permits.
- An ongoing effort by DEQ and Virginia Department of Health staff to work more closely together and improve information sharing between the agencies resulted in the combination of the separate well completion forms previously required: DEQ's GW-2 and VDH's Uniform Well Completion Report. The combined form allows well drillers to submit well completion documentation on a single form to be used by both agencies, ensuring that data captured by either agency can be used equally.
- Also of note is the Eastern Virginia Groundwater Management Advisory Committee, established pursuant to Va. Code § 62.1-256.1, to assist the State Water Commission and DEQ in "developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia Groundwater Management Area." The group convened its first meeting on August 18, 2015 and is due to present its recommendations to the State Water Commission and the DEQ Director no later than August 1, 2017. A summary of the activities of the Committee will be included in the next Annual Water Resources Report.

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[3] 9VAC25-780, et seq.
[4] 9VAC25-210, et seq.

I. INTRODUCTION

The *Report on Virginia's Water Resources Management Activities* (Annual Report), is submitted in October of each year to the Governor and the Virginia General Assembly in accordance with §62.1-44.40 of the Code of Virginia. The Annual Report describes the status of the state's surface and groundwater resources and provides an update of the Commonwealth's water resources management activities. Water quantity is the focus of the Annual Report, summarizing reported water withdrawals for the 2014 calendar year and providing an update on the Commonwealth's Water Resources Management Program. The Annual Report also includes summaries of current climatologic conditions and available hydrologic information for the Commonwealth as a whole for the 2015 water year [5](Appendix 1). Water quality issues are addressed in the most recent biennial *Water Quality Assessment Integrated Report*, published by the Department of Environmental Quality (DEQ) and available on the DEQ website.

PROGRAMS AND REGULATIONS GOVERNING WATER RESOURCES MANAGEMENT

Careful observation and analysis of groundwater levels and surface water flow is necessary for thoughtful and fair resource management decisions. The DEQ Division of Water Planning, Office of Water Supply (OWS), coordinates the management of the quantity of water resources across the Commonwealth of Virginia through six programs: Groundwater Characterization, Water Supply Planning, Water Withdrawal Reporting, Groundwater Withdrawal Permitting, Virginia Water Protection (VWP) Surface Water Withdrawal Permitting, and Drought Assessment and Response. The DEQ Office of Wetlands and Stream Protection currently manages the Surface Water Investigations Program; however, the program is briefly described in this report because the collection and evaluation of surface water discharge data is critical to the operation of all five OWS programs. The DEQ Water Supply and Water Quantity webpage provides additional information.

WATER SUPPLY PLANNING

Although Virginia has been managing water resources and supply since 1927, the drought of 1999-2002 led to a change in management philosophy. When the drought peaked in late August 2002, wildfire indices were at record levels, streamflows had reached record lows, a majority of agricultural counties had applied for Federal disaster designation, thousands of individual private wells had failed, and several public water supply systems were on the brink of failure. Following this experience, the General Assembly amended the Code of Virginia to require the establishment of a "comprehensive water supply planning process" [6] to ensure the availability of safe drinking water, to protect all other beneficial uses[7] of the Commonwealth's water resources, and to encourage development of alternative water sources. The Water Supply Planning Regulation[8] required development of local, regional, and state water supply plans describing, among other things, environmental resources, existing and anticipated water sources, and existing and projected water use and demand. Local and regional planning partners submitted their plans to DEQ no later than November 2011, depending upon statutory requirements. Following

[5] The U.S. Geological Survey uses the term "water year" in reports that deal with surface-water supply, defining it as the 12-month period of October 1, for any given year through September 30, of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2015 is called the "2015 water year."

[6] §62.1-44.38:1, *Code of Virginia*, 2003

[7] The term "beneficial uses" is defined in §62.1-44.3 of the *Code of Virginia* as "both in-stream and off-stream uses. In-stream beneficial uses include, but are not limited to, the protection of fish and wildlife resources and habitat, maintenance of waste assimilation, recreation, navigation, and cultural and aesthetic values. The preservation of in-streamflows for purposes of the protection of navigation, maintenance of waste assimilation capacity, the protection of fish and wildlife resources and habitat, recreation, cultural and aesthetic values is an in-stream beneficial use of Virginia's waters. Off-stream beneficial uses include, but are not limited to, domestic (including public water supply), agricultural uses, electric power generation, commercial, and industrial uses."

[8] 9VAC25-780, et seq., 2005

submission, staff reviewed all 48 plans (Figure 1) for consistency with the Regulation, completing the compliance evaluation process with the issuance of final compliance packages to all planning partners in late 2013. The water supply plans formed the basis of the *State Water Resources Plan*, which staff began developing concurrent with the plan review process. Completed in draft form in late 2014, the Plan was released for public comment in April 2015. DEQ reviewed the comments and drafted responses for inclusion in the final Plan, expected to be released in October 2015.

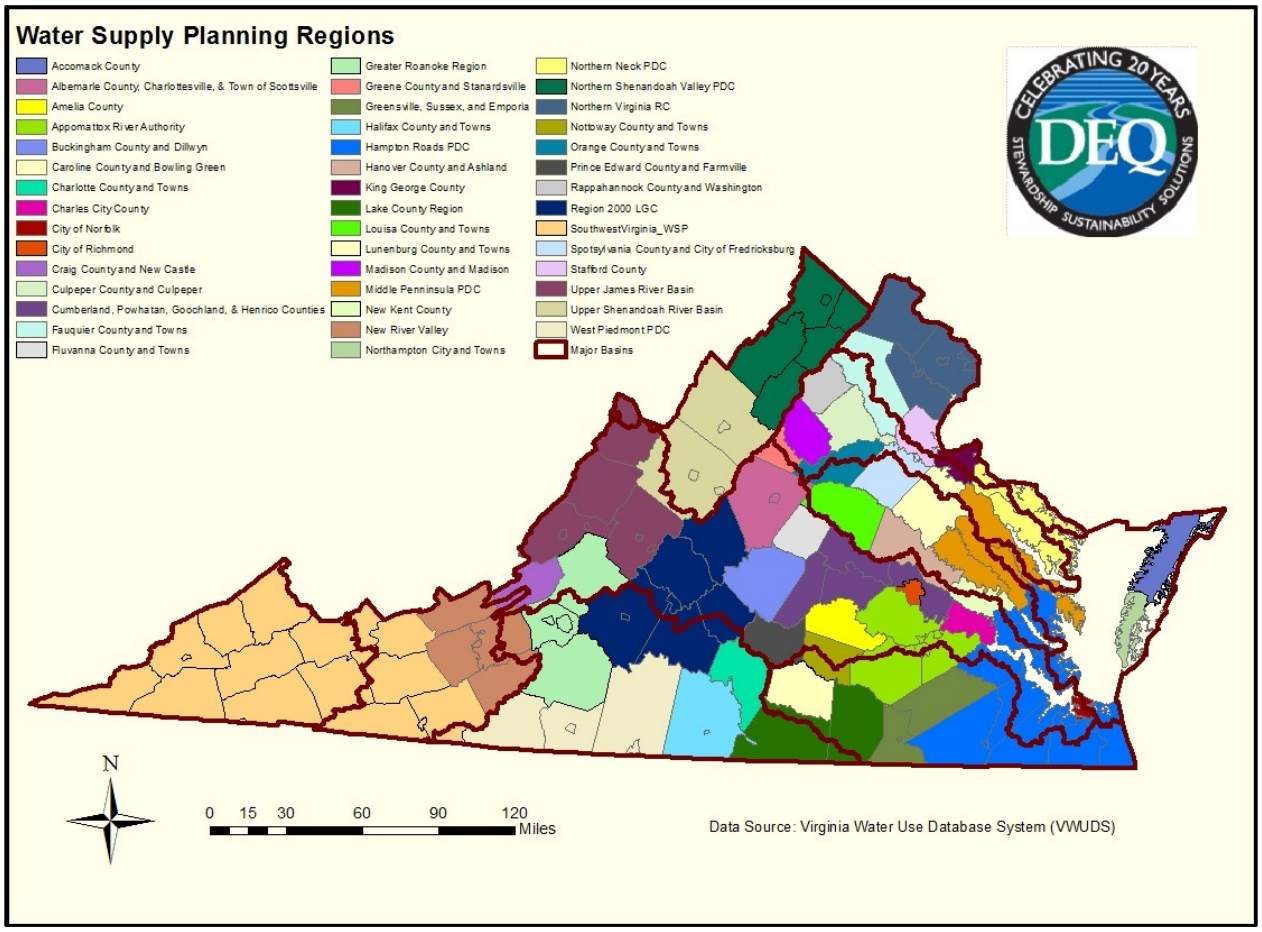

Figure 1: Water supply planning regions with major river basins

The *State Water Resources Plan* was the first of its kind in Virginia and is the primary planning mechanism for achieving sustainable water use for the future. The document provides a statewide look at information provided by local and regional water supply plans, and the results of a cumulative impact analysis conducted using data from the plans and water withdrawal data submitted by users under the Water Withdrawal Reporting (WWR) Regulation.[9] The Plan also describes major water supply challenges facing the Commonwealth through 2040 and makes recommendations for addressing those challenges.

The Plan will be updated every five years and accessible through DEQ's website. As such, it will be subject to incremental revision as DEQ, localities, and other stakeholders provide input through ongoing water supply planning efforts. It is anticipated that information provided by localities via a web-based, interactive platform will provide the basis for more efficient data collection, which in turn, will improve DEQ's understanding of the Commonwealth's water resources. In the interim, between five-year updates, this Annual Report will serve as a status report concerning the State Water Resources Plan.

[9] 9VAC25-200, et seq.

Water Withdrawal Reporting

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

The collection of water use data through water withdrawal reporting enables appropriate planning for the Commonwealth's future water needs. Automatically linked to the water supply modeling system, the water use reporting database enables staff to prepare up to date and accurate water budgets and conduct cumulative impact analyses in support of permit decision making and water supply planning efforts.

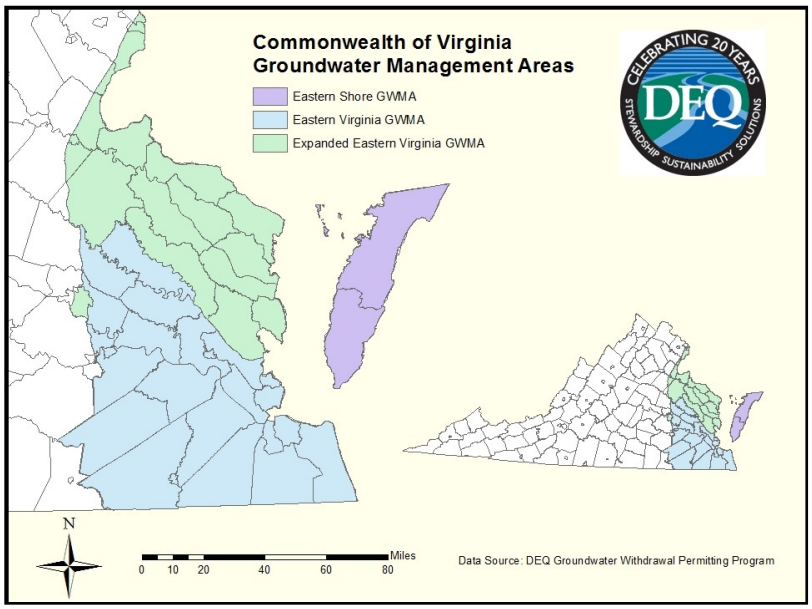

Figure 2: Virginia Groundwater Management Areas

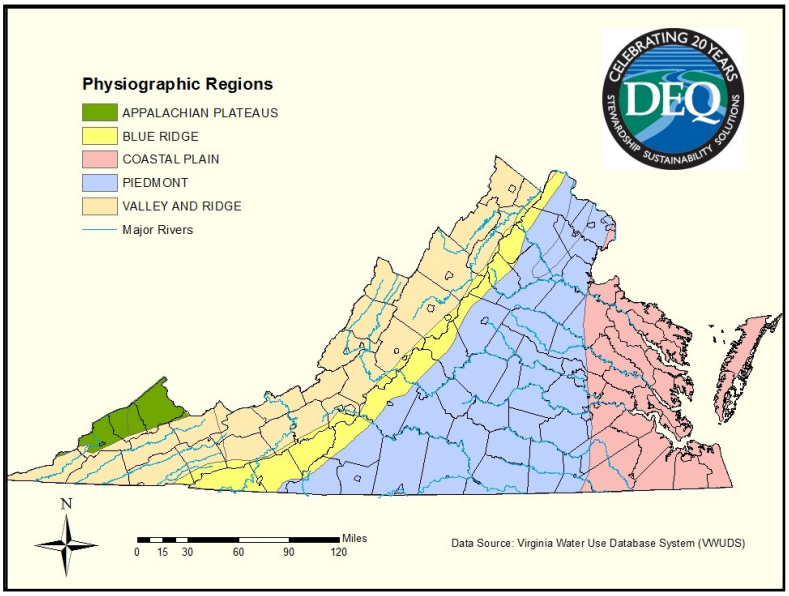

Figure 3: Virginia's Physiographic Provinces

Groundwater Management and Permitting

Virginia manages groundwater through a program that regulates withdrawals within designated Groundwater Management Areas (GWMA) (Figure 2), as originally described in the Groundwater Management Act of 1973. Enacted to address declining water levels in the confined aquifer system caused by increased industrial usage of groundwater, the Groundwater Management Act recognized the duty of the State Water Control Board to manage groundwater resources and establish GWMAs. In 1976, the Eastern Virginia GWMA, comprising most of the Coastal Plain

Physiographic Province (Figure 3), and the Eastern Shore GWMA were designated in response to increasing stresses on the resource. Amendments to the Act in 1986 added municipal water supplies as a regulated beneficial use and created a permitting threshold of 300,000 gallons per month. The Ground Water Management Act of 1992[10] removed a permittee's guaranteed right to withdraw at maximum daily values year-round on a continuous basis, and added agriculture as a regulated beneficial use.

Between 2009-2013, growing concerns over increased water use by new or expanding withdrawals, overlapping cones of depression[11], and declining water levels in the Coastal Plain aquifers compelled the Board to consider expanding[12] the Eastern Virginia GWMA to include all of the Coastal Plain east of I-95 in order to ensure comprehensive management of the aquifer system. Modifications to the Groundwater Withdrawal Regulations[13] accompanied the expansion, effective January 1, 2014, codifying the criteria for the declaration of groundwater management areas and for the issuance of groundwater withdrawal permits to withdrawers of groundwater in excess of 300,000 gallons per month in a declared area. Over 100 existing user permit applications were received during 2014 as a result of the Eastern Virginia GWMA expansion.

Groundwater Withdrawal Permit applications for new or expanded (increase to existing withdrawal) 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 weighs the combined impacts from all existing lawful withdrawals. Existing lawful withdrawals include those permits issued under historic use conditions and current new or expanded use permits (Figure 4).

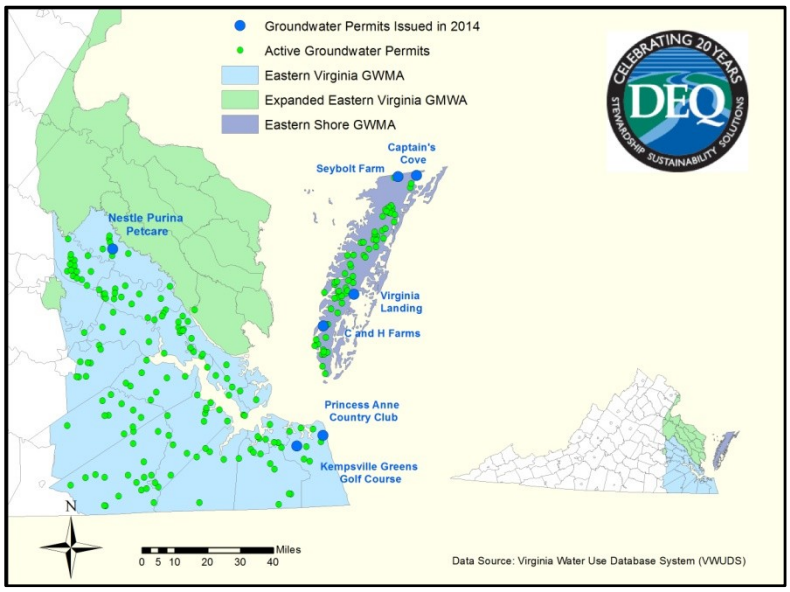

Figure 4: Virginia groundwater withdrawal permitting activities

DEQ staff meets with all prospective permit applicants to discuss the permitting process, administrative requirements, and technical requirements prior to application submission. Technical evaluations of impacts and resource sustainability are conducted by groundwater modeling contractors working closely with staff on proposed withdrawals. This ongoing collaborative effort enables program staff to provide technical support to applicants through review and comment on all proposals for field data collection in support of permit development.

[10] Title 62.1, Chapter 25-254, *Code of Virginia*

[11] "Cone of depression" means a localized reduction, or depression, of groundwater levels in an aquifer typically associated with increased rates of pumping. Groundwater levels are lowest at the point of withdrawal creating a concentric cone around the pumping center. The reduction may sometimes lead to issues of land subsidence due to compaction of sediments as a result of reduced groundwater in pore spaces.

[12] 9VAC25-600-20, effective January 1, 2014, and Figure 2

[13] 9VAC25-610, et seq.

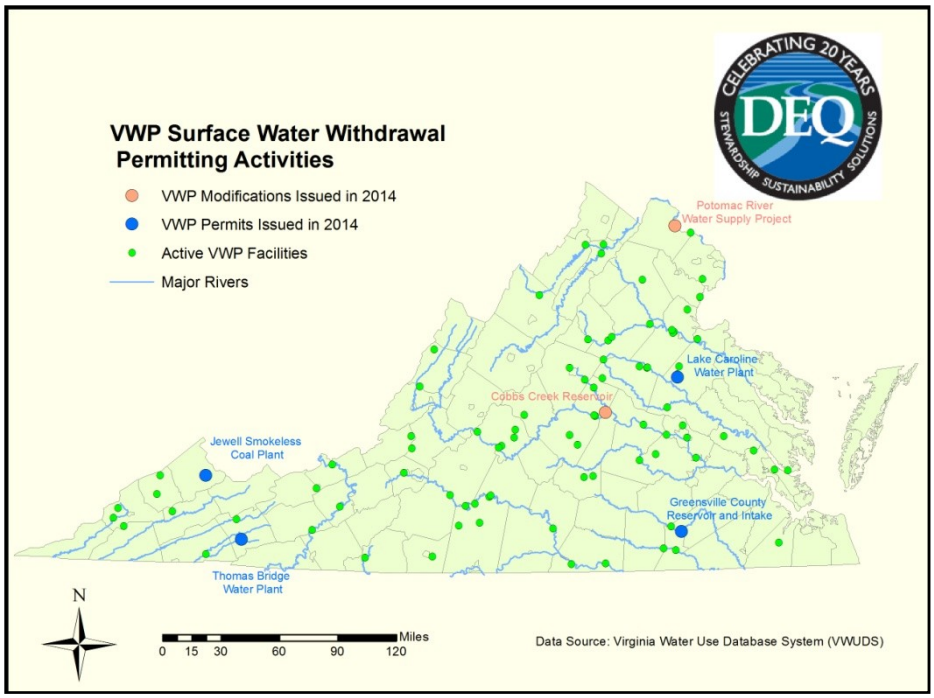

Figure 5: 2014 Virginia Water Protection Permit activities for surface water withdrawals

Surface Water Withdrawal Permitting

DEQ manages and permits surface water projects that withdraw greater than 10,000 GPD or one million gallons per day (MGD) for agricultural use from state waters such as non-tidal streams, lakes, and reservoirs under the VWP Permit Program.[14] VWP permits are required for withdrawals in tidal streams that are greater than 2 MGD, or 60 million gallons per month for agricultural use. Withdrawal projects may be exempt from the VWP permit program if they meet any of the exclusion criteria specified in the regulation.[15] VWP surface water withdrawal permits function as the vehicle for Section 401 Certification, as required by the Clean Water Act.[16]

Application for a surface water withdrawal permit is made through the submittal of a Joint Permit Application (JPA) to DEQ, the Virginia Marine Resources Commission (VMRC), and the U.S. Army Corps of Engineers (USACE). DEQ's evaluation of surface water withdrawal permit applications includes an in-depth analysis of the applicant's water demand and a cumulative impact analysis of the project to determine potential impacts on existing beneficial uses. To conduct these analyses, staff continues to develop and maintain an operational hydrologic model, which collates data on all streams and large impoundments in the Commonwealth. Each new or reissuance permit application is modeled to evaluate any potential impact to beneficial uses downstream of the withdrawal site. Staff uses the output of this analysis to inform the permit determination and to develop appropriate withdrawal limits and flow-by rates if a permit is issued. Figure 5 illustrates 2014 VWP surface water withdrawal permitting activities.

Groundwater Characterization

DEQ established the Groundwater Characterization Program in response to negative impacts experienced by many localities, businesses, and domestic well users during the drought of 2002 and the need for more information about groundwater for state and local water supply planning. The program protects Virginia's environment and promotes the health and well-being of its citizens by collecting, evaluating, and interpreting technical information necessary to manage groundwater resources of the Commonwealth. Staff also participates in outreach and educational opportunities in order to increase public awareness of the wide range of issues affecting Virginia's water resources.

[14] §§62.1-44.15.20 and 62.1-44.15.22, *Code of Virginia*, and 9VAC25-210, et seq.
[15] 9VAC25-210-60.B
[16] 33 U.S.C. §1251, et seq., 1972

Finally, staff manages the Ambient Groundwater Quality Monitoring Program, the goal of which is to characterize the quality of groundwater throughout the Commonwealth of Virginia. Described in the *Ambient Groundwater Quality Monitoring Strategy*[17], the program allows DEQ to establish a groundwater quality baseline across the state, identify areas of potential groundwater quality concern, and monitor the changes in groundwater quality over time. Figure 6 depicts the locations of surface and groundwater monitoring stations maintained by both USGS and DEQ staff.

Surface Water Investigations

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

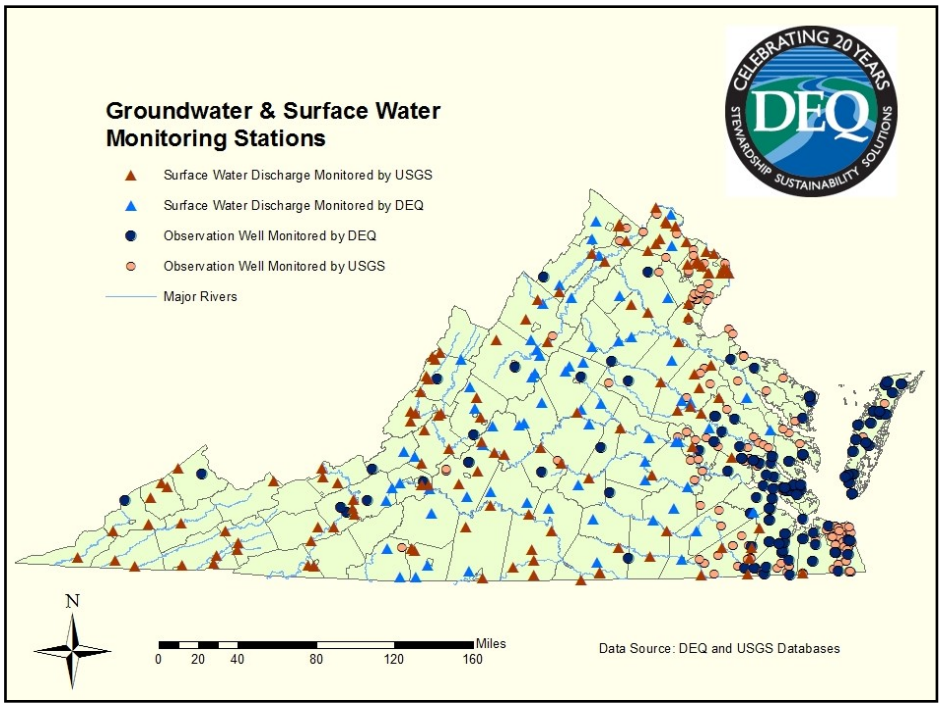

Figure 6: Location of groundwater and surface water monitoring stations. Monitoring at all of the USGS sites is performed by the USGS under contract for the DEQ.

SWIP field personnel monitor and process data from a network of 68 surface water discharge monitoring stations on a six to eight week schedule, or more frequently in times of drought or flood. Monitoring often occurs in extreme conditions such as low and high water, and involves the servicing of sensitive equipment, maintaining permanent gauging stations, and measuring streamflow ("discharge"). The data collected 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.

[17] DEQ, 2013, *Ambient Groundwater Quality Monitoring Strategy, Final – November 2013*, 88 p.

Drought Assessment and Response

Planning for conservation during water shortages allows all users to share the responsibility for the resource. Drought monitoring, assessment, and response protocols in the Commonwealth of Virginia follow the procedures described by the Virginia Drought Assessment and Response Plan.[18] DEQ coordinates drought monitoring activities through the Drought Monitoring Task Force (DMTF), as required by the *Drought Assessment and Response Plan.*

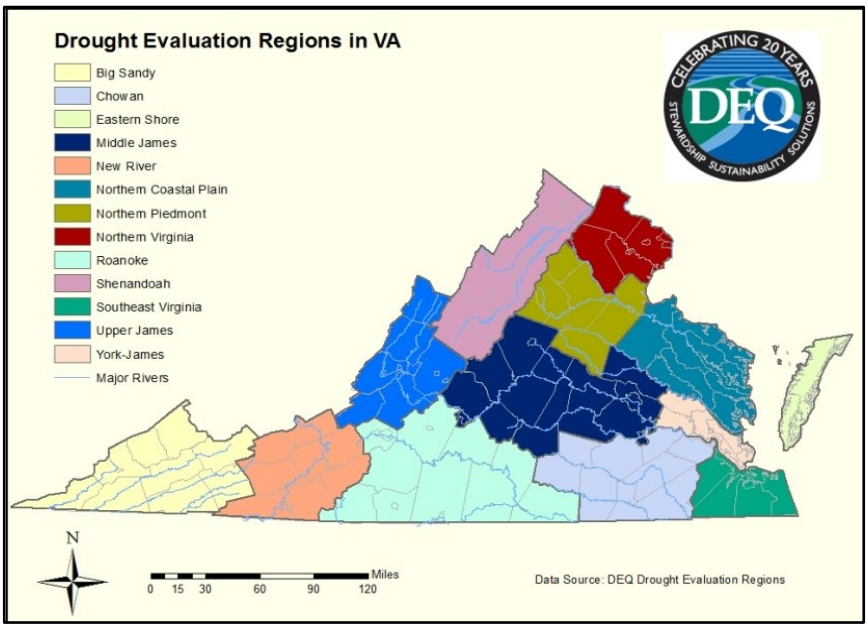

Figure 7: Drought Evaluation Regions

The DMTF is an interagency group of technical representatives from state and federal agencies[19] responsible for monitoring natural resource conditions and the effects of drought on various segments of society. The DMTF meets regularly to assess hydrologic conditions and make recommendations to the Virginia Drought Coordinator regarding drought status. After each meeting, the DMTF releases Drought Status Reports summarizing drought conditions in the Commonwealth. DEQ also maintains an online drought webpage that displays the status of a series of drought indicators across 13 Drought Evaluation Regions (Figure 7). The status of three of the four indicator types (precipitation deficit, streamflows, and groundwater levels) is updated daily. The fourth indicator, reservoir storage, is updated monthly, or more frequently depending upon drought conditions.

The Virginia Drought Coordinator issued a Drought Watch declaration for all of the Virginia portion of the Roanoke River basin on September 15th, 2015 (see Appendix 1).

[18] Virginia Drought Response Technical Advisory Committee, 2003, *Virginia Drought Assessment and Response Plan*, 22 p.
[19] State agencies with active representation on the DMTF include the departments of Game and Inland Fisheries, of Agriculture and Consumer Services, Emergency Management, Forestry, and Health. Federal agencies include the National Weather Service, USACE, Department of Agriculture, and the USGS.

II. SUMMARY OF 2014 WATER WITHDRAWALS

Water withdrawals were reported by 1,079 user facilities for 3,120 withdrawal measuring points during the calendar year 2014. Reported withdrawals were slightly greater than 7 billion GPD for all water use categories, including cooling water at nuclear and fossil fuel power generation facilities. Excluding power generation, reported 2014 withdrawals totaled approximately 1.2 billion GPD.[20]

VWUDS characterizes four water withdrawal source types: streams (including rivers), reservoirs, springs, and wells. Withdrawals from the first three of these sources are considered "surface water withdrawals." Springs discharge groundwater to surface water bodies and would naturally form the headwaters of watercourses as defined by the State Water Control Law[21] and are therefore categorized as surface water, rather than as groundwater. Groundwater withdrawals are typically derived from wells; however, there are a small number of withdrawals from dug farm ponds and quarries that intersect the groundwater table, and which are otherwise unconnected to a watercourse, that are also categorized as groundwater in VWUDS.

Water withdrawn in the Commonwealth may be used by the withdrawing entity or locality, or it may be "transferred" to another entity/locality. Ideally, the total amount of water reported as released from the transferring facility should equal the total reported as deliveries by the receiving facility. However, in reality, the amounts of reported deliveries are generally significantly less than the amount reported as released. This discrepancy is most likely due to incomplete reporting of deliveries from facilities that purchase water. In order to avoid double counting, this report will generally refer to "water use" as synonymous with "water withdrawn," and any reporting or illustration of water transfers will be clearly marked as "water transferred" or "water purchased." A more detailed explanation of how water transfers are stored in VWUDS occurs in Appendix 2. General descriptions of 2014 water withdrawals by source type, distribution across the state, and water use category occurs on subsequent pages with additional detail provided in the appendices as follows:

Appendix 3 provides a list of the top 20 non-power generating water withdrawals ranked by the amount of their 2014 reported withdrawals

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

WATER WITHDRAWALS BY SOURCE TYPE

Water withdrawals for non-power generation uses totaled approximately 1,219 MGD and predominantly occurred from surface water sources (streams, reservoirs, and springs) (Figure 8). Approximately 7.4 MGD of the 390 MGD shown as derived from reservoirs was categorized as groundwater (unconnected to a surface stream or watercourse). Pumping of groundwater wells totaled 127 MGD. The total 2014 non-power generation withdrawal rate was about 1.4% greater than the 2013 total of 1,202 MGD. The proportions of the total withdrawal rate by source type were also nearly the same as the previous year.

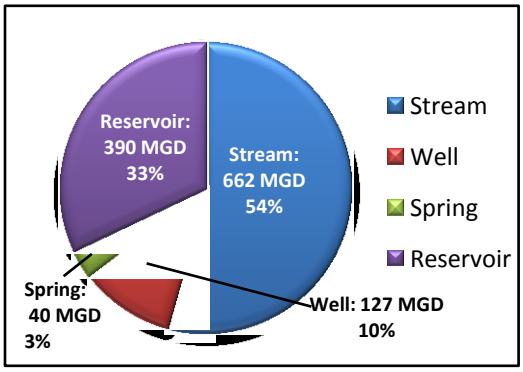

Figure 8: Total water withdrawals by source type

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

[21] §62.1-104, *Code of Virginia*

Water Withdrawals by Location

Analysis of the spatial distribution of 2014 water withdrawals in Virginia indicates that as in previous years, the largest groundwater withdrawals predominantly occurred in the Coastal Plain, Eastern Shore, and Shenandoah Valley regions (Figure 9). The largest volumes of groundwater were produced from karstic limestone formations in the Shenandoah Valley, within the Valley and Ridge physiographic province, and from aquifers within the Coastal Plain province in the downstream portions of the Chowan, James, and York River basins. Shallow aquifers on the Eastern Shore (part of the Coastal Plain province) also produce significant quantities of groundwater. Reported groundwater withdrawals from locations within GWMAs totaled 75.56 MGD for 2014, or approximately 56% of all groundwater withdrawals in the Commonwealth.

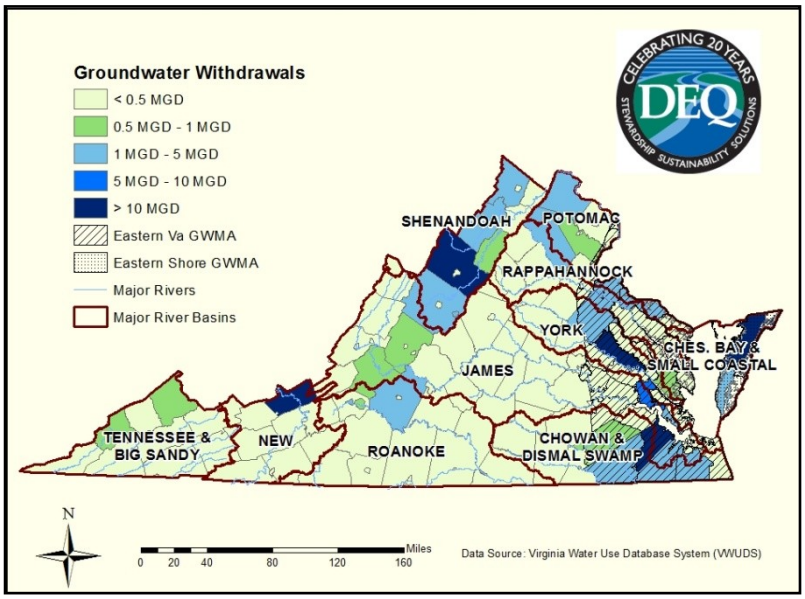

Figure 9: Groundwater withdrawals by locality

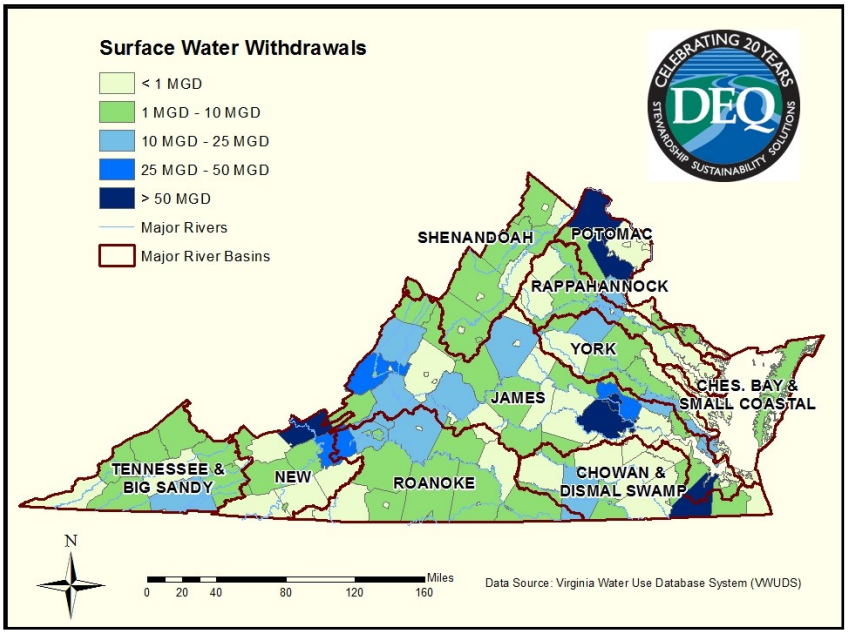

Figure 10: Surface water withdrawals by locality

Surface water withdrawals were distributed widely across the state and were greatest around cities and counties serving as population centers (Figure 10). Significant surface water volumes were also withdrawn in rural counties for irrigation and other uses. Surface water withdrawals are concentrated within the James, Potomac - Shenandoah, and New River basins, comprising 75% of the statewide total surface water withdrawal. Surface water withdrawals in the James River basin reached nearly 572 MGD, which is approximately 53% of the total surface water withdrawals and 47% of all withdrawals in Virginia, including groundwater.

The variable spatial distributions of groundwater and surface water withdrawals suggest that withdrawals also vary considerably between Virginia's major surface water basins (Figure 11, Table 1) and physiographic provinces (Figure 12, Table 2) illustrated on this and the following page.

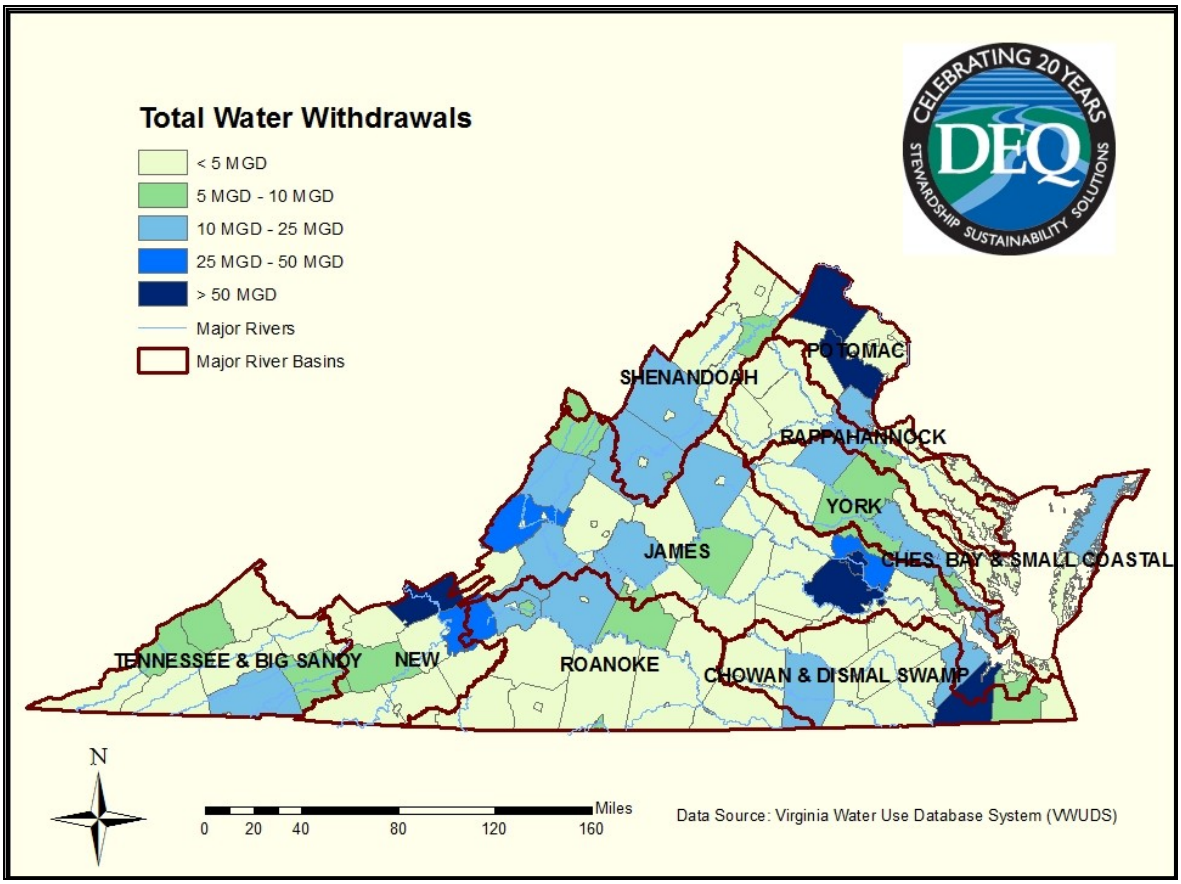

Figure 11: Total (groundwater plus surface water) withdrawals by locality and river basin

Table 1: 2014 Withdrawals by major surface water basin, excluding withdrawals for power generation

Basin Name	Basin Area in Virginia (mi^2)	Groundwater	Surface Water	Basin Total	Percent of Statewide Total Withdrawal
Albemarle-Chowan	4,220	21	11	32	3%
Chesapeake Bay-Small Coastal	1,601	14	5	19	2%
James	10,265	21	572	592	49%
New	3,068	14	98	113	9%
Potomac-Shenandoah	5,681	34	229	263	22%
Rappahannock	2,712	3	22	24	2%
Roanoke	6,393	6	64	70	6%
Tennessee-Big Sandy	4,132	2	46	48	4%
York	2,674	20	38	58	5%
TOTALS:	40,746	135	1,085	1,219	100%

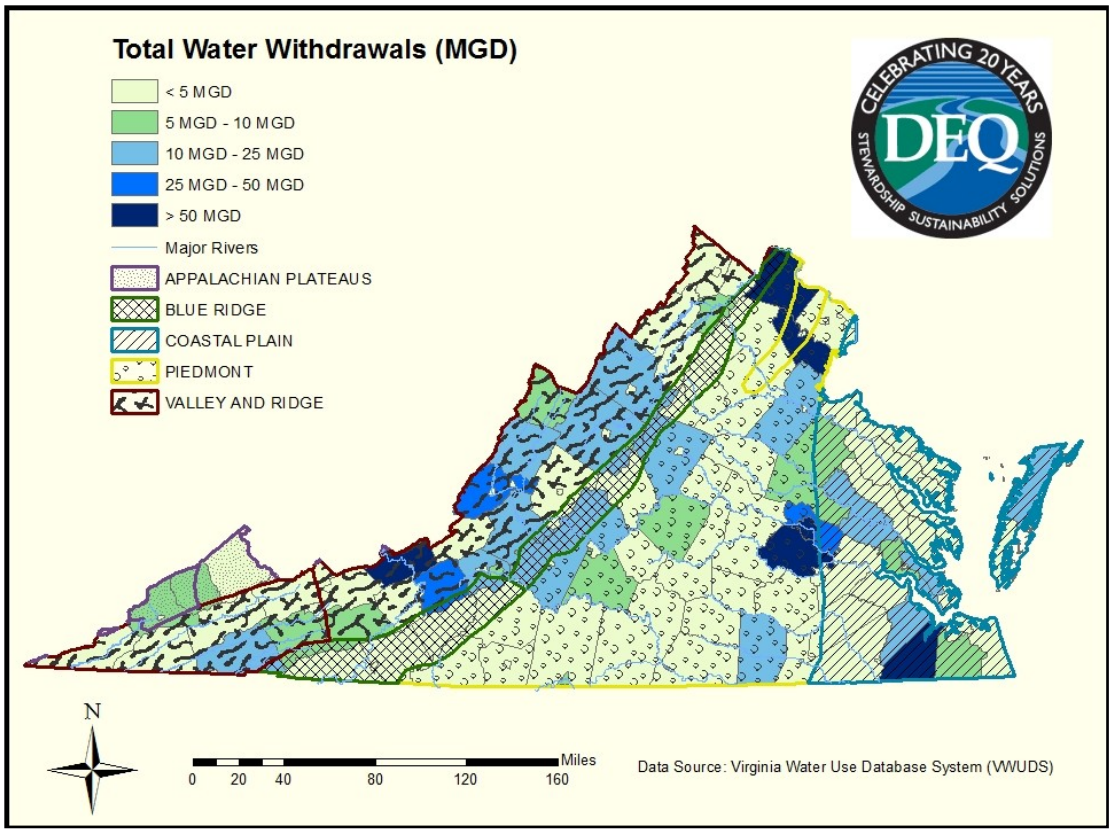

Figure 12: Total (groundwater plus surface water) withdrawals by locality and physiographic province

Table 2: Withdrawals by physiographic province, excluding withdrawals for power generation

Physiographic Province	Groundwater (MDG)	GW % of Total Withdrawal	Surface Water (MGD)	SW % of Total Withdrawal	Total (MGD)	Percent of Statewide Withdrawal
Appalachian Plateau	1	11%	9	89%	10	1%
Blue Ridge	7	9%	75	91%	82	7%
Coastal Plain	76	19%	324	81%	399	36%
Piedmont	7	2%	362	98%	368	33%
Valley and Ridge	43	17%	205	83%	248	22%
Totals:	134	12%	975	88%	1,109	100%

Table 2 water use totals only represent withdrawals with active spatial location information. Not all withdrawals in VWUDS have accurate spatial information. This causes groundwater, surface water, and total water use to be lower in Table 2 than other tables throughout the Annual Report.

Water Withdrawals by Water Use Category

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

Water withdrawals can fluctuate from year to year due to weather variability and economic or other factors; therefore, average water withdrawals from 2010 – 2014 are provided by source type for each category for comparison, excluding Power Generation (Nuclear Power and Fossil Fuel Power) (Figures 13 and 14). Average water withdrawals during this five-year period were calculated using the same source type categories (e.g., springs as surface water) as were the 2014 withdrawal totals. As a result, direct comparisons can be made between 2014 withdrawal totals and the 2010-2014 averages. Little difference is apparent between the pairs of charts comparing groundwater, surface water, and total withdrawals between 2014 and the 2010-2014 periods. Since 2011, year-to-year changes in totals for the three largest withdrawal categories (Public Water Supply, Manufacturing, and Agriculture) have been generally less than 5%.

Withdrawals for Public Water Supply and for Manufacturing were again the largest for 2014 and for the average of the previous five-year period. Pumping for Agriculture, Irrigation, Mining, and Commercial uses made up lesser, but still significant, portions of the totals. Reported agricultural withdrawal totals are dominated by state-owned fish hatcheries (24 MGD out of 32.5 MGD, or 74%).

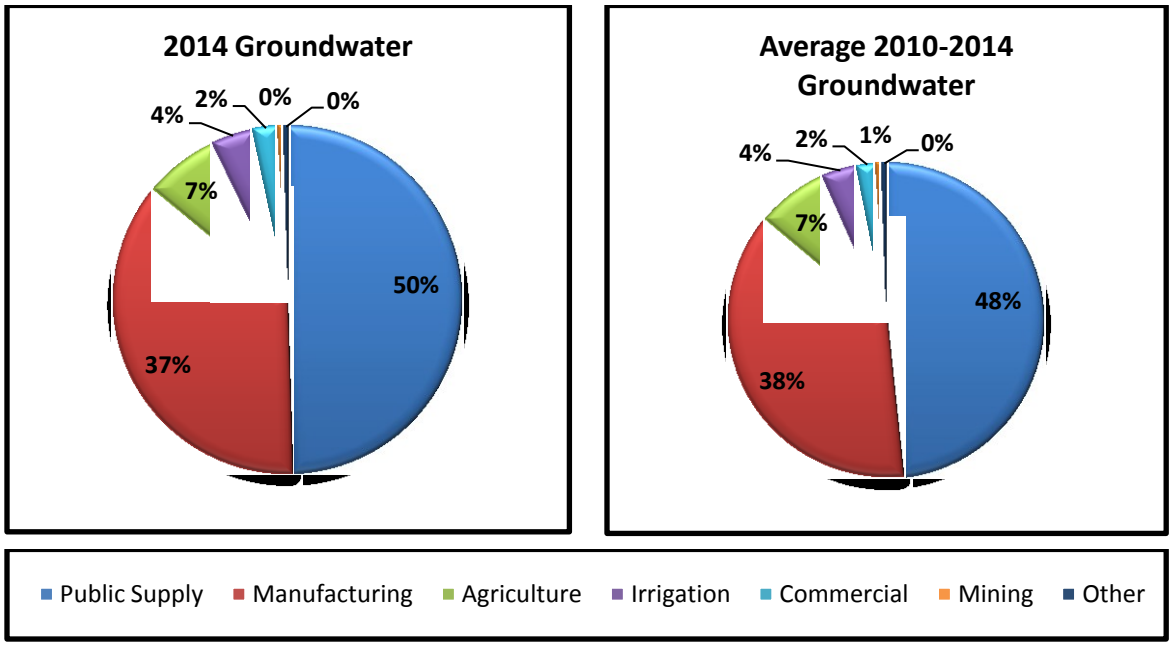

Figure 13: Groundwater withdrawals by use category for 2014 and the 2010-2014 average

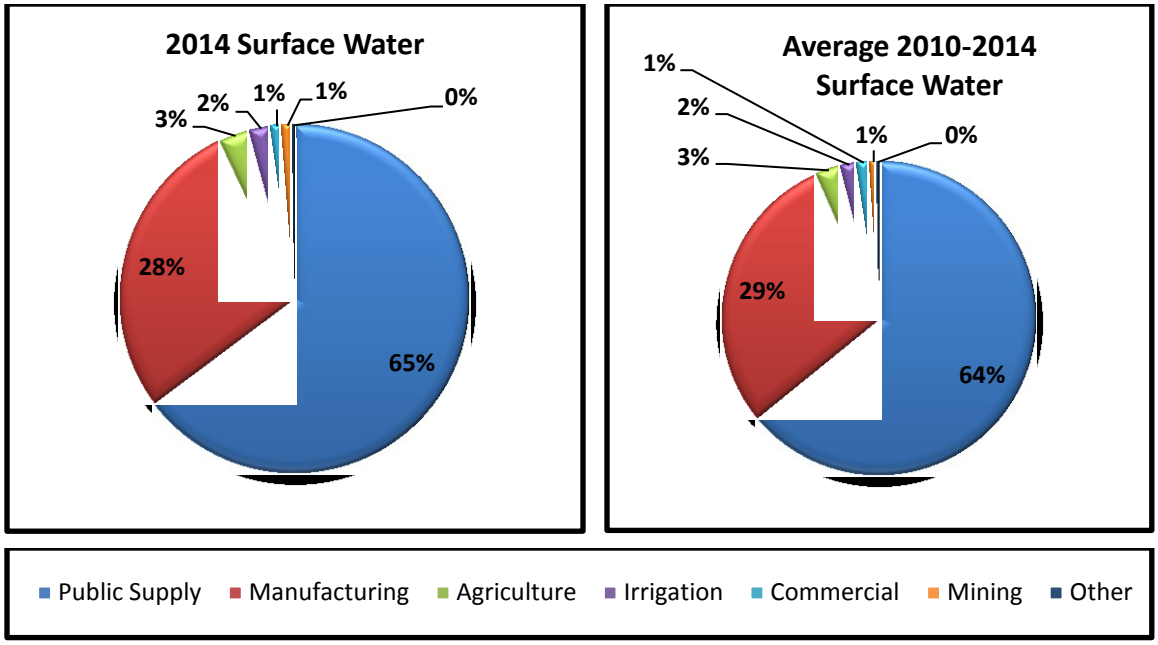

Figure 14: Surface water withdrawals by use category for 2014 and the 2010-2014 average

The proportions of 2014 and average 2010-2014 water use totals by category compare fairly well with the reported 2010 water use by category contained in the State Water Resources Plan (Figures 15 and 16). The Community Water Systems (CWS) category in the Plan is essentially the same as the Public Water Supply category in the Annual Report. Likewise, Agricultural use totals in the Plan are comparable to the sum of withdrawals from the VWUDS Agriculture plus Irrigation categories, and the total use from the Large Self-Supplied User category in the Plan is comparable to the sum of the withdrawals from the remaining VWUDS categories.

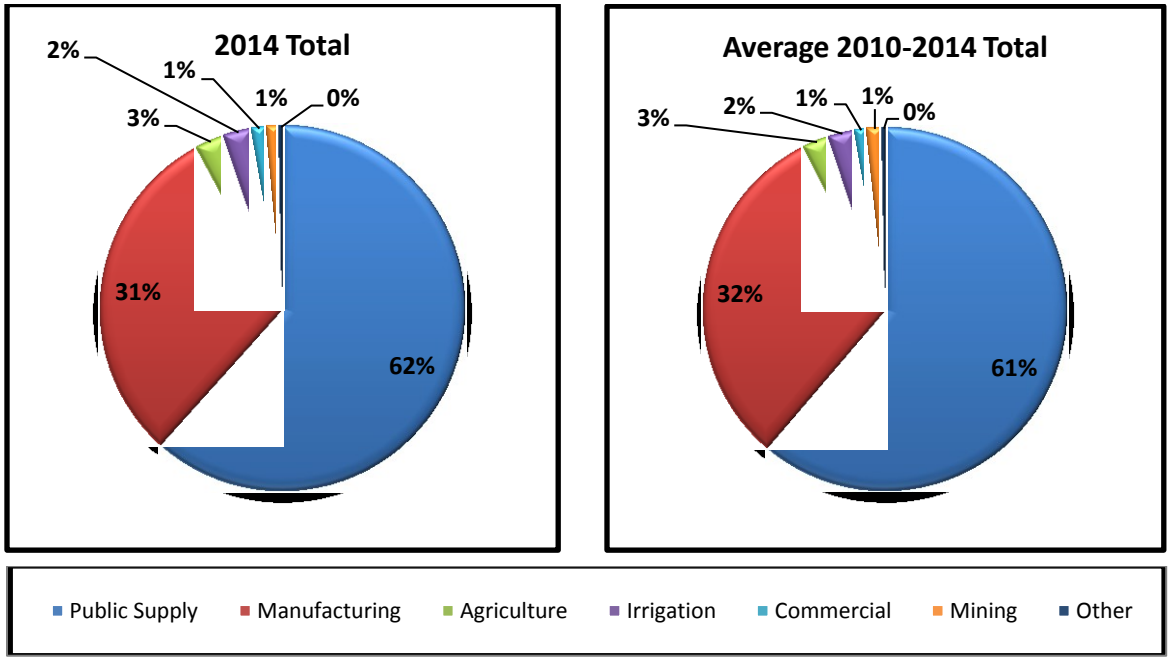

Figure 15: Total water withdrawals by use category for 2014 and the 2010-2014 average

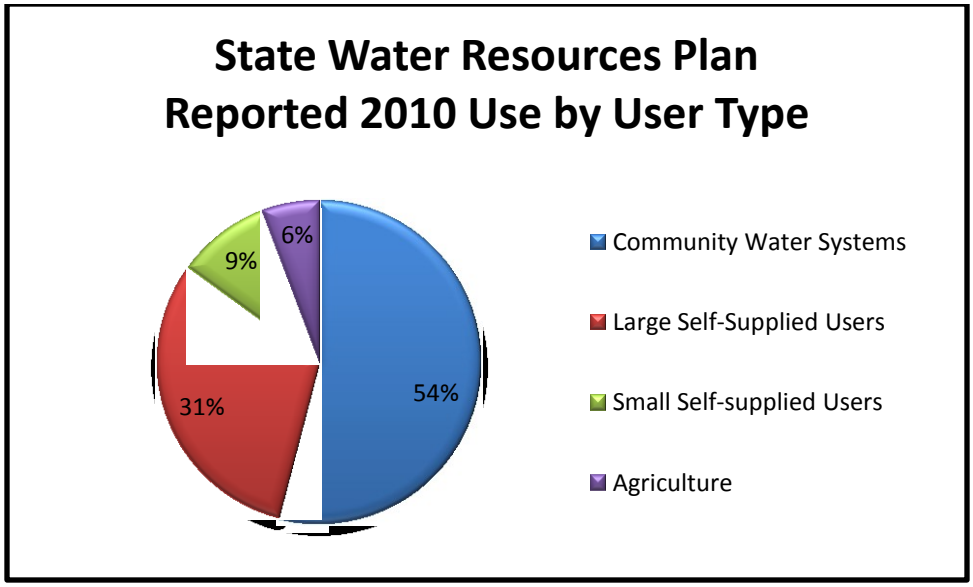

Figure 16: The percentages of 2010 statewide water use by Plan user category are similar to the withdrawal percentages by category obtained from the VWUDS database[22]

The main difference between the two compilations is the Small Self-Supplied User category identified in the Plan. This category includes small users who would generally fall beneath the reporting threshold for annual water withdrawal reporting and are not captured in VWUDS. As a result, Public Water Supply is a larger percentage of the total withdrawals (Figure 15) than that represented by CWS (Figure 16).

Appendix 4 provides additional information on each water use category in the form of two-four page fact sheets for each user category containing tables that compare 2014 withdrawals to the five-year average (2010 to 2014), identify the top users and transfers, if applicable, and a map of 2014 water withdrawal distribution within Virginia.

Consumptive vs. Non-Consumptive Use of Water

A portion of all water withdrawn from groundwater or surface water sources is "consumed," or becomes unavailable for further use. "Consumptive water use" refers to that portion of a water withdrawal that is not returned to the source due to, for example, evapotranspiration, domestic use, incorporation into products or crops, or diversion from the source basin. The percentage of water consumed by agricultural, commercial, manufacturing, and mining facilities varies widely, depending on the specific use, product, or process at each facility. For example, most of the water withdrawn for crop irrigation is consumed by evapotranspiration and incorporation into the irrigated crop, and domestic consumptive use can vary significantly depending upon whether wastewater is returned to the source stream, or transported to another basin or stream within the same basin.

Weather patterns and seasonal variations can also affect domestic consumptive use. In 1995, estimates of domestic consumptive use made by the USGS for Virginia were approximately ten percent of annual withdrawal volumes.[23] Estimates of summertime public water supply related consumptive use in Ohio, Indiana, and Wisconsin in 2009 ranged from 16 to 20% of withdrawals, with an annual average range of

[22] Adapted from Figure 4-7 of the Draft *State Water Resources Plan*, 2015.
[23] Solley, Wayne B., 1998, *Estimated use of water in the United States in 1995*: U.S. Geological Survey Circular 1200, 71 p.

six to eight percent.[24] Without specific information about the types and distribution of end users, estimates of consumptive use from public water supply withdrawals can be very uncertain.

"Non-consumptive" water use is characterized by water that remains in, or is immediately returned to, the location in a stream or aquifer from which it was withdrawn with little or no water loss. Most non-consumptive water use involves some level of consumptive loss. Power generation withdrawals are often referred to as "non-consumptive," due to their relatively low rate of consumptive loss when compared to other categories. At thermoelectric power plants, the type of cooling system in use determines the relative amount of consumptive use. For example, "once-through" cooling systems return most of the diverted water to the original source, causing a relatively insignificant amount of consumptive use. In contrast, "closed-loop" cooling systems re-circulate diverted water through wet cooling towers and can lose a significant percentage of total water withdrawn to evaporation.[25] In Virginia, the thermoelectric power plants with the five largest water withdrawals employ once-through cooling systems. Other plants, with smaller water withdrawals, use wet cooling tower systems and may have relatively greater consumptive losses (see Power Generation Water Withdrawal fact sheet, Appendix 4).

[24] Shaffer, K.H., 2009, *Variations in withdrawal, return flow, and consumptive use of water in Ohio and Indiana, with selected data from Wisconsin, 1999–2004*: U.S. Geological Survey Scientific Investigations Report 2009–5096, 93 p.
[25] Diehl, T.H., Harris, M.A., Murphy, J.C., Hutson, S.S., and Ladd, D.E., 2013, *Methods for estimating water consumption for thermoelectric power plants in the United States*: U.S. Geological Survey Scientific Investigations Report 2013–5188, 78 p., http://dx.doi.org/10.3133/sir20135188.

III. WATER WITHDRAWAL TRENDS: 2010-2014

Total withdrawals reported to VWUDS have been fairly stable since 2010 (Table 3). Total 2014 withdrawals were approximately 17 MGD (1.4%) greater than those reported for 2013. The greatest annual change occurred between 2010 and 2011 when the total dropped 65 MGD (4.9%). This change was due primarily to the shutdown of the Yorktown Refinery in York County (late 2010), resulting in a decrease of nearly 42 MGD for manufacturing surface water withdrawals in 2011 relative to 2010. Groundwater withdrawals also decreased in 2011 due to the temporary shutdown of the International Paper plant in Franklin. Since then, the Franklin plant has resumed operations at a lower withdrawal rate, and the year-to-year changes in withdrawals represented by the two largest categories (Public Water Supply and Manufacturing) have been less than 3% of the previous year's total. As a result of these changes, the reported 2014 total withdrawals are within approximately 2% of the average for the five-year period.

Surface water withdrawals for agricultural purposes have increased slightly each year since 2010 (see Table 3). These steady increases are due, in part, to increases at the Commonwealth of Virginia Coursey Spring Fish Hatchery in Bath County, where withdrawals increased from an annual average of 6.2 MGD in 2010 to 11.8 MGD in 2014. Withdrawals for irrigation from both surface and groundwater sources have fluctuated significantly from year to year, since 2010. For example, surface water irrigation withdrawals dropped by nearly 40% (18.2 MGD to 11.0 MGD) between 2012 and 2013, and then increased by nearly 90%, to 20.8 MGD, in 2014. The reasons for these fluctuations may include annual weather variations, different water needs from crop rotations, and uneven reporting of withdrawals by irrigation facilities from year to year. Additional detail concerning water withdrawal trends by water use category can be found in Appendix 4.

	Category	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average	Absolute Change	% Change
Groundwater	Agriculture	<1	<1	<1	<1	<1	<1	<1	-18%
	Commercial	5	5	5	5	5	5	<1	8%
	Irrigation	11	9	12	8	9	10	<1	-8%
	Manufacturing	70	61	63	68	67	66	<1	1%
	Mining	2	3	2	3	3	3	<1	15%
	Other	1	1	1	1	1	1	0	-2%
	Public Water Supply	50	55	53	50	49	51	2	-4%
	Total (GW)	**139**	**134**	**136**	**136**	**134**	**136**	**2**	**-1%**
Surface Water	Agriculture	23	29	30	32	32	29	3	10%
	Commercial	9	8	7	7	10	8	2	24%
	Irrigation	24	19	18	11	21	19	2	12%
	Manufacturing	362	321	323	312	306	325	19	-6%
	Mining	20	16	12	13	11	14	3	-22%
	Other	3	2	2	2	2	2	0	-5%
	Public Water Supply	735	721	700	690	703	710	7	-1%
	Total (SW)	**1175**	**1116**	**1092**	**1067**	**1085**	**1107**	**22**	**-2%**
Total (GW + SW)	Agriculture	24	30	31	33	33	30	3	**9%**
	Commercial	14	13	12	12	15	13	2	**18%**
	Irrigation	35	29	30	19	30	29	1	**5%**
	Manufacturing	432	382	386	379	372	390	18	**-5%**
	Mining	22	19	14	16	14	17	3	**-16%**
	Other	3	3	3	3	3	3	0	**-4%**
	Public Water Supply	785	775	752	740	752	761	9	**-1%**
	Total (GW + SW)	**1314**	**1249**	**1228**	**1202**	**1219**	**1243**	**24**	**-2%**

Table 3: Summary of Virginia water withdrawals by use category and source type: 2010 - 2014

IV. EFFECT OF CURRENT WITHDRAWALS ON FUTURE WATER SUPPLY

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

Over the past decade, increased demand and competition for water have established a greater sense of urgency in Virginia's approach to resource management.

KEY FINDINGS AND INITIATIVES OF 2014

The mission of the Department of Environmental Quality is "to protect and enhance Virginia's environment, and promote the health and well-being of the citizens of the Commonwealth." To that end, staff of the Office of Water Supply work to identify, quantify, and manage threats to the productivity and availability of Virginia's water resources.

By design, the scientific efforts of the staff supports permitting activities and planning objectives. As scientific research and data analysis activities undertaken in 2013 and 2014 revealed the need to adjust to changing resource management circumstances, DEQ launched several initiatives in response, particularly with respect to groundwater resources in the Coastal Plain. Key findings and initiatives for 2014 are described briefly below.

Also of note is the Eastern Virginia Groundwater Management Advisory Committee established pursuant to Va. Code § 62.1-256.1 to assist the State Water Commission and DEQ in "developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia Groundwater Management Area." The group convened for its first meeting on August 18, 2015 and is due to present its recommendations to the State Water Commission and the DEQ Director no later than August 1, 2017. A summary of the activities of the Committee will be included in the next Annual Water Resources Report.

CRITICAL WATER RESOURCES OBSERVATIONS

- Groundwater levels are still declining north of the James River. While some short-term groundwater level recovery has been seen south of the James River since the reduction in water withdrawal by International Paper in 2011, increased use by the plant and others who have unused permitted amounts is expected to result in a return to groundwater level declines. DEQ is working with facilities to decrease net withdrawals in the short term in order to maintain groundwater productivity and availability over the next 50 years.
- VWP permitted withdrawals only amounted to 199.1 MGD, or 18.2% of all reported surface water withdrawals. Not all surface water withdrawals are currently reported to VWUDS, due in part to exclusions from the reporting requirements. However, comparison of reported withdrawals with water use estimates from the water supply plans indicates that water withdrawals from several

categories may be under-reported. Lack of information regarding water withdrawal rates causes additional uncertainty when making estimates of available water supply during drought events, particularly in GWMAs or in surface water basins where water withdrawal activities are concentrated.

- Data analysis conducted during development of the State Water Resources Plan predicted a net increase of approximately 32% in mean daily water demand over the planning period, indicating that an estimated 450 MGD of additional water will be needed to meet projected 2040 demands. Seventy-seven percent of the projected 2040 average daily demand is expected to be met by surface water resources, with the remaining 23% of total 2040 demand anticipated to come from groundwater resources. Cumulative impact analyses have indicated that these surface water withdrawal increases may result in potential negative impacts during future drought situations, particularly within the James, Potomac-Shenandoah, and York River basins.[26]
- Nearly 97% of the total projected 2040 surface water demand is proposed to come from approximately 25% of the stream reaches evaluated. With 16% of streams predicted to see a greater than five percent reduction in Drought of Record flows, there is a high probability that new management approaches and/or infrastructure will be required to maintain safe yields (the maximum amount of water available during a drought of record) at current levels. Systems that already have new storage, or are planning to build new storage in the short term, will probably have adequate reserves to meet the predicted reduced drought in-stream flows. However, systems without storage, or with demands that are nearing existing safe yield, will face stiff challenges as the cumulative demands on streams increases. In addition, with the majority of Virginia's future demand concentrated on so few surface water resources, the availability of accurate data will become essential to ensure accurate modeling.[27]

Virginia Water Resources Management Initiatives

- The Virginia Coastal Plain Groundwater Initiative was developed in response to ongoing and long-term decline of groundwater levels, head loss, and growing concerns of land subsidence and salt water intrusion into the Coastal Plain confined aquifer system. In order to achieve the goal of protecting the aquifer system and providing for current and future water needs for the Commonwealth, DEQ identified and has begun discussions with the top 14 groundwater users about potential reductions in water withdrawals, which, if implemented could begin stabilizing the groundwater level declines in the aquifer. Combined, these users represent approximately 87% of all groundwater withdrawals within the GWMA. Stabilization of groundwater level declines in the aquifer cannot be achieved without withdrawal reductions, which in turn, will lay the foundation for the development of long-term solutions.
- The *State Water Resources Plan*[28] includes information and data submitted in local and regional water supply plans.[29] In addition to local data, the Plan incorporates water withdrawal data submitted to the Virginia Water Use Data System through the Water Withdrawal Reporting program and contains the results of a cumulative impact assessment that will form the basis for staff activities for the next five years. During 2014, staff finalized the challenges and recommendations chapter and prepared the document for public comment.
- Efforts to continuously improve the clarity, predictability, and output of surface water withdrawal permitting were undertaken. A Citizen Advisory Group was established to work with staff on

[26] Draft *State Water Resources Plan*, Figure 4-11 and Table 5-10.
[27] Ibid., Chapter 5.
[28] 9VAC 25-780-140.I
[29] 9VAC25-780

proposed revisions to the surface water portion of the VWP regulations.[30] Revisions were necessary to clarify and streamline materials required by the JPA and to address several statutory changes. The revision to this regulation in continuing in the regulatory development process.

- The Ambient Groundwater Quality Program was fully implemented, resulting in the collection of 30 trend and spot samples at wells and springs throughout the Commonwealth. Program implementation involves quarterly sampling of trend wells to monitor for salt water "upconing," or intrusion, and to document chloride concentrations in portions of the Coastal Plain aquifer system that may be vulnerable to upward migration of the fresh water/salt water interface. Spot sampling is done to document the groundwater quality in areas where groundwater geochemical data are limited or non-existent.
- Upgrades to VAHydroGW, the DEQ groundwater databases, were implemented to automatically generate groundwater model input files for analysis of new groundwater withdrawal permit applications and renewals. These enhancements have improved the timeliness of permit issuance and set the stage for completion of automatic generation of annual total permitted and current use model input decks in 2015-2016.
- Efforts to improve water withdrawal reporting within the golf course and agricultural communities were initiated. Development and implementation of the golf course outreach strategy resulted in approximately 120 new facility registrations for which water withdrawal data collection during the 2015 calendar year is anticipated. The agricultural outreach strategy was developed during 2014 and will begin implementation during 2015. Outreach to other water use categories, including but not limited to nurseries, sod farms, public and private educational institutions, and vineyards will be conducted over the next couple of years.
- An initiative to develop and implement consistent compliance practices for both surface water and groundwater withdrawal permitting was undertaken, beginning with a compliance and file review of all active withdrawal permits.
- An ongoing effort by DEQ and Virginia Department of Health (VDH) staff to work more closely together and improve information sharing between the agencies resulted in the combination of the separate well completion forms previously required: DEQ's GW-2 and VDH's Uniform Well Completion Report. The combined form allows well drillers to submit well completion documentation on a single document to be used by both agencies, ensuring that data captured by both agencies can be accessed uniformly.
- As a result of 2014 amendments to the Ground Water Management Act of 1992 and the corresponding regulatory revision which established criteria for expansion of the GWMA and permit issuance, staff conducted an extensive public education and outreach effort and held numerous pre-application meetings that resulted in 127 existing user permit applications within six months. Processing and issuance of existing user permits will continue through 2015 and into 2016.
- A 1,530 foot geophysical borehole was drilled and logged adjacent to a core hole previously drilled by the USGS in 1984 at the Haynesville Correctional Facility in Richmond County. While a detailed core description is available from the 1984 coring project, no geophysical log data were collected from within the original core hole after extraction of the core. Paired borehole geophysical log and core data from these holes have allowed for a thorough hydrostratigraphic analysis of the Coastal Plain sediments and have helped to refine the Coastal Plain hydrogeologic framework in this portion of the Northern Neck, which is in the expanded portion of the Eastern Virginia GWMA. A groundwater research station is planned for future construction at this location by DEQ, as funding and time permit.

[30] 9VAC25-210, et seq.

- Currently unused groundwater wells were investigated with the borehole camera and geophysical logging system to determine their suitability for incorporation into the statewide groundwater level monitoring network. This network of wells provides real-time groundwater level data from multiple locations throughout the state. These data are becoming an increasingly important metric for regional water supply planning efforts and drought monitoring forecasts. Wells were investigated in Scott (Tennessee-Big Sandy River Basin), Floyd (New River Basin), and Powhatan counties (James River Basin). Determinations regarding the structural integrity, hydrologic isolation, and access requirements are ongoing.
- Virginia is the only state currently partnering with the USGS on the collection of real-time streamflow data where state-collected data are incorporated directly into the USGS database. Over 600 discharge measurements were made by DEQ personnel for the USGS gauging station network. Stream depth, width, and velocity are measured in the waterway in the vicinity of the gauging station to determine discharge. These data are then input in the online USGS stream current conditions for Virginia streamflow for floods, droughts, and permitting withdrawal and discharge, future water planning, and recreational usage. The USGS requires that these measurements be analyzed and processed within 48 hours of being read, which ensures the webpage is as up to date as soon possible for use by the Drought Task Force and other entities dependent upon the accuracy of this resource for analysis.

Future Challenges and Priorities

Investment Challenges for Water Resources Management

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

- The numbers of long-term monitoring data stations for surface water flow, groundwater levels, and groundwater quality have not kept pace with identified resource management needs. Federal funding cuts have recently resulted in the elimination of several important stations in Virginia. Sustained funding to support surface water flow and groundwater level data collection and analysis is essential to accurately quantify and manage the Commonwealth's water resources. Such surface and groundwater data are an integral part of many DEQ programs including numerous permitting programs, establishment of Total Maximum Daily Loads (TMDL), water supply planning, and overall water resource characterization; therefore, continued federal investment in the remaining stations is critical.
- Investment in regional water supply program implementation is necessary to build long-term local government stewardship of local and regional water resources. A secure source of funding for planning grants to local governments is a fundamental element to the success of the State Water Resources Plan implementation and long-term maintenance of the Plan. A recurring comment from local and regional entities about the State Water Resources Plan was that for the process to reach its full potential, local funding is essential to maintain long-term data gathering and planning.
- Improvements are needed in the way the transfer of water is tracked, both within systems and between entities. This information is important to understanding the extent of water loss due to inter or intra-basin transfers or other factors and can have a significant impact on water resource planning.
- In order to maintain Virginia's cooperative agreement between DEQ and the USGS for the collection of real-time streamflow data, DEQ staff must continue to receive state of the art training provided by USGS and the necessary equipment to maintain the existing gauging station network. Training for use of a sophisticated new data management system being implemented by USGS in April 2016 will be an emphasis for SWIP staff in the coming year.

Long-term Priorities Identified in the State Water Resources Plan

The State Water Resources Plan identifies 12 challenges for future water resources management and provides recommendations for action. A number of challenges concern the accuracy of existing data, which requires more intense scrutiny in order to determine the likelihood and significance of impacts to beneficial uses. Consequently, a number of recommendations suggest improvements to data collection and analysis that will increase DEQ's understanding of Virginia's water resources and ability to meet demand for future water supply. In response, a number of 2014 activities described in the Virginia Water Resources Management Initiatives section were focused on gathering, storing, and analyzing data in order to improve water resource management for the Commonwealth, many of which will continue into 2015 and beyond. Those recommendations addressing data concerns include the following:

- Understand the impact of water withdrawals that do not require a permit, including the potential growth in these withdrawals over time.
- Close gaps in water withdrawal reporting and address the lack of adequate data for some management purposes.
- Quantify current and future risks to groundwater availability and the interconnection to surface waters outside of current Groundwater Management Areas.
- Understand the impact of consumptive use on water availability.

Additional challenges and recommendations presented in the State Water Resources Plan represent ongoing and long-term priorities for DEQ and its planning partners, including the following:

- Reservoir site development
- Threats to water quality
- Promoting increased water conservation to reduce long-term and short-term demand
- Critical infrastructure deficiencies
- Sea level rise, changes in precipitation patterns, and land subsidence
- Source water protection
- Conflict resolution
- Public education and outreach

The Plan will be updated every five years and will be accessible through DEQ's website. The Plan will be subject to incremental revision as DEQ, localities, and other stakeholders provide input through ongoing water supply planning efforts. It is anticipated that data provided by localities via a web-based, interactive platform, currently under development, will provide the basis for more efficient data collection, which in turn, will improve DEQ's understanding of the Commonwealth's water resources. In the interim, between five year updates, this Annual Report will serve as a status report concerning the State Water Resources Plan.

APPENDIX 1: WATER RESOURCES INFORMATION AND CLIMATIC CONDITIONS

State Population (2010 census) – 8,001,025
(2014 U.S. Census Bureau estimate) – 8.3 million

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

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

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

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

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

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

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

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

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

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

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

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

Publicly-Owned Lakes and Reservoirs

There are 248 publicly-owned lakes in the Commonwealth:

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

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

Freshwater Wetlands - 808,000 acres

Tidal and Coastal Wetlands - 236,900 acres

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

Atlantic Ocean Coastline - 120 Miles

Statewide Average Annual Rainfall – 42.9 inches

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

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

Climatic Conditions – After a relatively dry winter, precipitation during the 2015 water year (October 1, 2014 to September 30, 2015) was generally normal to above normal across most of Virginia. Streamflows and groundwater levels in Climate Response Network observation wells were at normal or near normal levels during most of the spring and early summer months. Water supply storage reservoirs maintained water levels within or above normal ranges throughout most of the year. However, dry conditions that developed in portions of the Roanoke River basin and parts of central and eastern Virginia in the winter worsened during July through September. DEQ issued a Drought Watch declaration for all of the Virginia portion of the Roanoke River basin on September 15th, 2015.

APPENDIX 2: WATER TRANSFERS IN THE VWUDS DATABASE

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

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

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

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

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

APPENDIX 3: TOP 20 WATER WITHDRAWAL SYSTEMS IN 2014 (excluding power generation)

Facility	Locality	Type	Major Source	Average MGD	2014 MGD	Category
Honeywell International Inc: Hopewell Plant	Hopewell	SW	James River	108.18	102.98	MAN
Fairfax County Water Authority: Potomac River WTP	Fairfax County	SW	Potomac River	89.71	89.75	PWS
Fairfax County Water Authority: Occoquan Reservoir	Prince William	SW	Occoquan Reservoir	62.31	64.66	PWS
City of Richmond: Richmond WTP	Richmond, City	SW	James River & Kanawha Canal	62.06	60.96	PWS
City of Norfolk: Western Branch Reservoir	Suffolk	SW	Western Branch Reservoir	58.6	59.48	PWS
Celanese Acetate LLC: Celco Plant	Giles	SW	New River	55.95	55.25	MAN
Meadwestvaco Corporation: Covington Plant	Alleghany	SW	Jackson River	39.18	40.11	MAN
Appomattox River Water Authority: Lake Chesdin WTP	Chesterfield	SW	Lake Chesdin	31.57	33.47	PWS
City of Portsmouth: Lake Kilby WTP	Suffolk	SW/GW	Lake Kilby, Lake Meade & 6 Wells	22.51	29.16	PWS
DuPont E I De Nemours & Co: Spruance Plant	Chesterfield	SW	James River	28.53	28.05	MAN
Henrico County: Henrico County WTP	Henrico	SW	James River	25.73	25.38	PWS
City of Virginia Beach: Virginia Beach Service Area	Virginia Beach	SW	Lake Gaston	25.24	21.34	PWS
Virginia American Water Co: Hopewell District	Hopewell	SW	Appomattox River	20.68	20.82	PWS
United States Government: Radford Ammunitions WTP 1	Montgomery	SW	New River	22.27	20.38	MAN
City of Newport News: Lee Hall WTP & ROF	Newport News	SW	Lee Hall Reservoir	23.9	20.27	PWS
RockTenn CP, LLC: Hopewell Plant	Prince George	SW	James River	16.48	17.99	MAN
GP Big Island, LLC: Georgia-Pacific Big Island WTP	Bedford	SW	James River	13.42	14.22	MAN
City of Manassas: Manassas Service Area	Prince William	SW	Lake Manassas	12.86	12.86	PWS
Commonwealth of Virginia: Coursey Spring Fisheries	Bath	GW	Coursey Spring	10.07	11.76	AG
Honeywell Resins & Chemicals LLC: Chesterfield Plant	Chesterfield	SW	James River	11.46	10.64	MAN

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

APPENDIX 4: WATER WITHDRAWALS BY USE CATEGORY

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

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

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

Appendix 4 is divided into sections, or two to four page fact sheets for most categories, each containing information regarding withdrawals reported for 2014, including the following:

- A map depicting withdrawal point locations for each category, scaled by the magnitude of the 2014 average annual withdrawal rate;
- a bar graph illustrating the reported quantity withdrawn for each category between 2010 and 2014, as well as the relative amounts by source type (groundwater or surface water);
- a table that lists withdrawals for 2010- 2014 in terms of an annual average rate, by source type and subtype (reservoir, spring, stream/river, or well); and
- a table listing facilities reporting the largest withdrawals for 2014, facility location, water source, reported 2014 average annual withdrawal rate, and the average annual withdrawal rate for the 2010 – 2014 period.

Additional tables and charts are included for the Commercial, Mining, and Manufacturing categories listing the top transfers of water for commercial use and withdrawals by subcategory for 2010 - 2014. The Commercial and Public Water Supply sections also contain tables listing the top 2014 transfers of water for each of these use types.

Several major transfers of water occur for public water supply; therefore, the total water used for public water supply by locality includes the water withdrawals in that locality, as well as water transferred into that locality from elsewhere, minus any water sold to other localities. The public water supply water withdrawal totals do not include water withdrawn by individuals from private wells, as those withdrawals are not required to report. The total only represents the water withdrawn by public or private community water systems. Additional information concerning water transfers can be found in Appendix 2.

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

AGRICULTURE (NON-IRRIGATION) WATER WITHDRAWALS

Withdrawals for Agriculture include the non-irrigation withdrawals from operations such as commodity farms, fish farms, and hatcheries. Information concerning Irrigation withdrawals associated with agriculture and other uses is provided on the Irrigation Water Withdrawals fact sheet. Figure 17 illustrates the distribution of reported 2014 groundwater and surface water withdrawals for agricultural purposes statewide. The majority of water withdrawn for agricultural uses is obtained from springs located in western Virginia (74%) and nearly all is withdrawn from surface waters (Figure 18). Agricultural withdrawals from springs have increased steadily over the past five years (Table 4) due, in part, to greater withdrawals at the Commonwealth of Virginia Coursey Spring Fish Hatchery in Bath County, where withdrawals increased from an annual average of 6.2 MGD in 2010 to 12.6 MGD in 2013 and 11.8 MGD in 2014 (Table 5). Groundwater is pumped at lower rates for livestock production in southeastern Virginia.

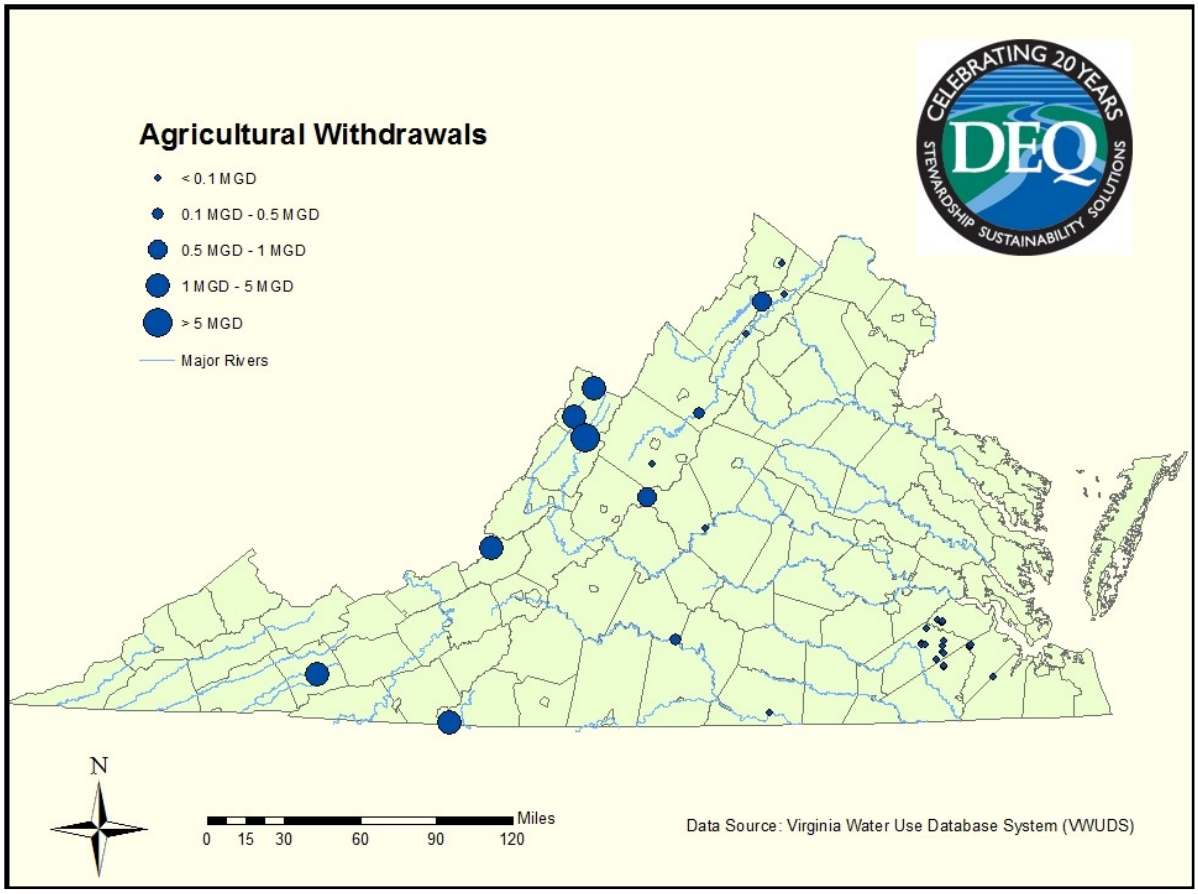

Figure 17: Agricultural (non-irrigation) water withdrawals by withdrawal point location

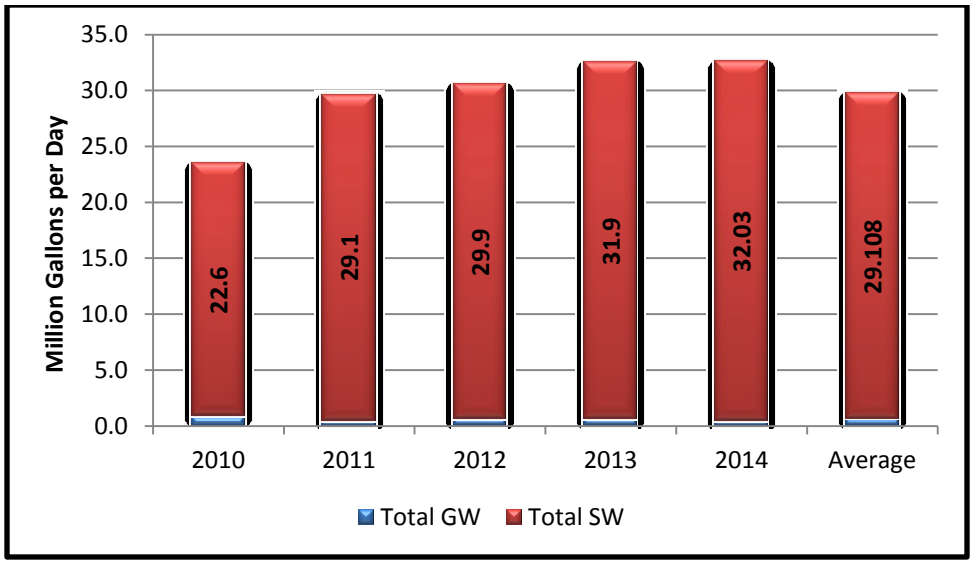

Figure 18: 2010-2014 Agricultural water withdrawals by source type

Table 4: 2010-2014 Agricultural water withdrawals by source type

Source Type	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW (Wells)	0.9	0.5	0.6	0.6	0.51	0.62	0.1	18
Total SW	22.6	29.1	29.9	31.9	32.03	29.11	2.9	10
Reservoirs	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0
Springs	17.3	22.0	22.9	25.1	24.12	22.28	1.8	8
Streams	5.3	7.1	7.0	6.8	7.91	6.83	1.1	16
Total GW + SW	23.5	29.6	30.5	32.5	32.54	29.73	2.8	9

[1] Absolute Change = difference between 2014 water withdrawals and average 2010-2014 water withdrawals
[2]% Change = percent difference in 2014 water withdrawals from average 2010-2014 water withdrawals

Table 5: Top water withdrawals by agricultural (non-irrigation) operations

Facility	Locality	Type	Major Source	Average[1] MGD	2014 MGD
Commonwealth of Virginia: Coursey Spring Fisheries	Bath	GW	Coursey Spring	10.07	11.76
Virginia Trout Company Inc: Terry Place Plant	Highland	GW	Blue Spring	4.56	4.42
Commonwealth of Virginia: Wytheville Fish Hatchery	Wythe	GW	Boiling and West Springs	3.35	3.33
Commonwealth of Virginia: Marion Fish Cultural Station	Smyth	SW	Staleys Creek	3.07	3.21
Virginia Trout Company Inc: Monterey Plant	Highland	GW	Vandevender Spring	2.4	2.36

[1]Average = Average water withdrawals from 2010-2014

IRRIGATION WATER WITHDRAWALS

Irrigation withdrawals promote growth in crops such as tobacco, corn, soybeans, turf grass, and ornamental nursery products. Figure 19 illustrates the distribution of reported 2014 groundwater and surface water withdrawals for irrigation purposes statewide. Surface water continues to be the major water source type for irrigation (Figure 20). The majority of the reported groundwater withdrawals for irrigation are from "dug" ponds or reservoirs in Accomack and Northampton counties on the Eastern Shore. Because these ponds do not have a direct connection with a perennial stream they are categorized in VWUDS as groundwater sources. There are no major transfers of water for irrigation, so water withdrawal figures also represent water use. Reported water withdrawals for irrigation in 2014 were similar to those reported for 2010 through 2012, and significantly greater than those reported for 2013 (Table 6). This discrepancy with 2013 irrigation withdrawals suggests a possible decrease in reporting of these withdrawals for that year.

As with previous years, most large-scale irrigation facilities are located in the northern Coastal Plain (Northern Neck) counties and on the Eastern Shore. The 2014 reported irrigation related groundwater withdrawals from wells in those areas totaled 1.5 MGD. The five facilities with the greatest withdrawals for irrigation in 2014 are listed in Table 7.

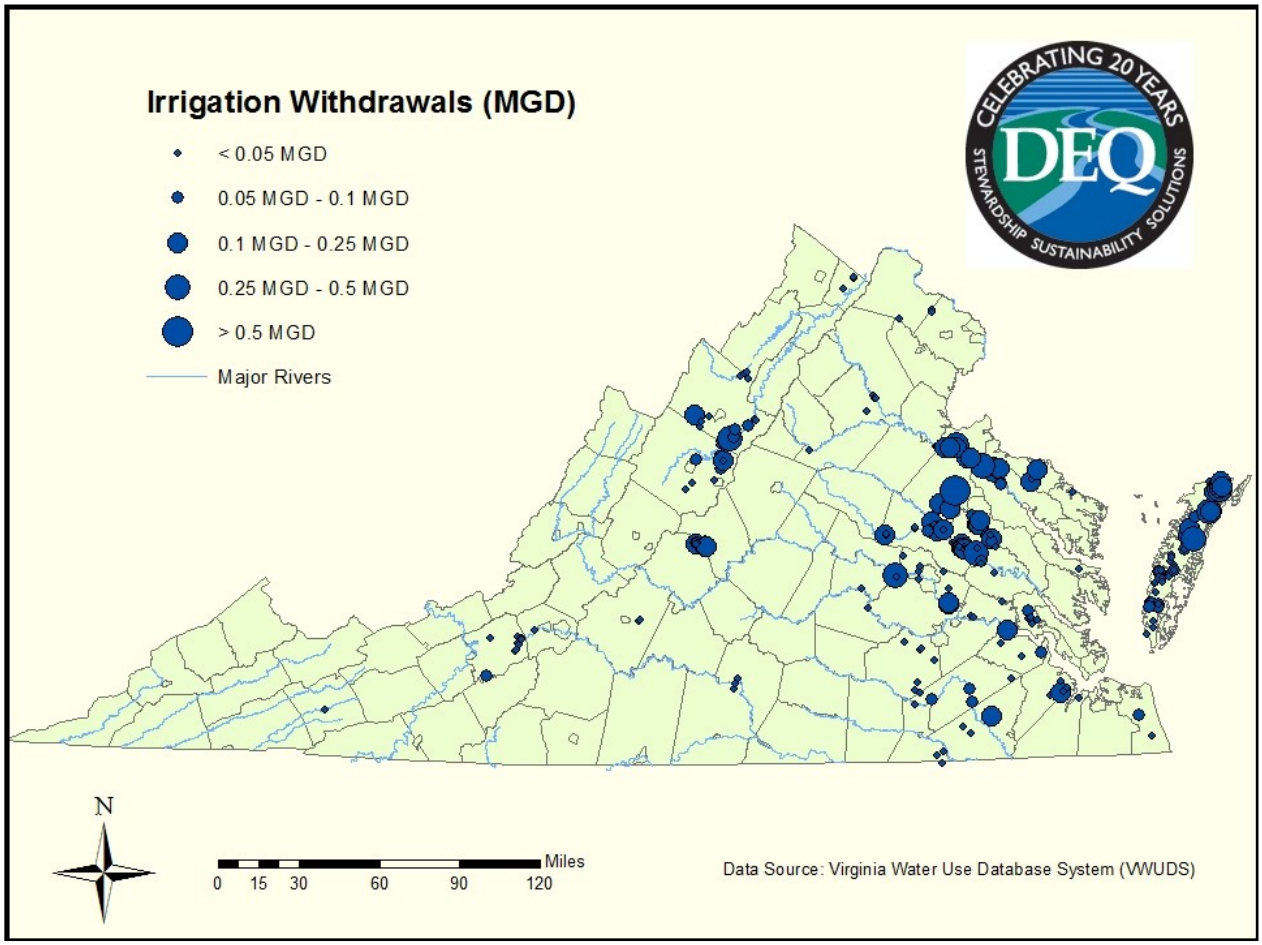

Figure 19: Irrigation (including agricultural) water withdrawals by withdrawal point location

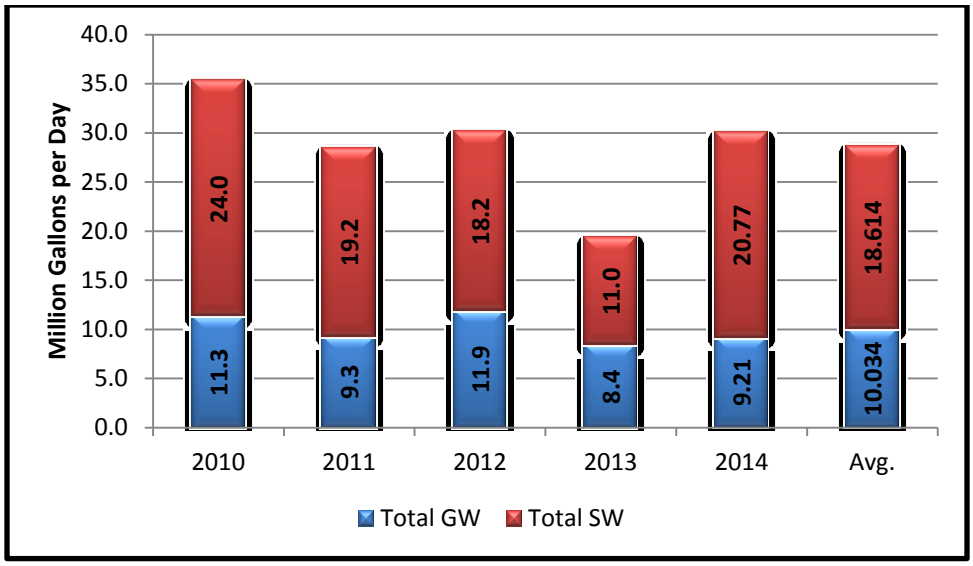

Figure 20: 2010-2014 Irrigation water withdrawals by source type

Table 6: 2010-2014 Irrigation water withdrawals by source type

Source Type	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	11.3	9.3	11.9	8.4	9.21	10.03	0.8	8
Reservoirs	8.5	6.7	9.1	6.6	7.21	7.61	0.4	5
Wells	2.9	2.6	2.8	1.7	1.99	2.39	0.4	17
Total SW	24.0	19.2	18.2	11.0	20.77	18.61	2.2	12
Reservoirs	8.1	8.2	7.0	5.2	8.64	7.42	1.2	16
Springs	0.2	0.3	0.3	0.2	0.19	0.23	0.0	19
Streams	15.8	10.8	11.0	5.6	11.82	10.97	0.9	8
Total GW + SW	35.3	28.5	30.2	19.3	29.98	28.65	1.3	5

[1]Absolute Change = difference between 2014 water withdrawals and average 2010-2014 water withdrawals
[2]% Change = percent difference in 2014 water withdrawals from average 2010-2014 water withdrawals
[3]Withdrawals from dug ponds or reservoirs that are not connected to perennial streams

Table 7: Top water withdrawals for irrigation (including agricultural)

Facility	City/County	Type	Major Source	Average[1] MGD	2014 MGD
Robert C Darby and Sons: Arbuckle Farms	Accomack	GW	6 Dug Ponds	5.12	5.28
E Phillip and David L Hickman: Dublin Farms Inc.	Accomack	SW/GW	13 Farm Ponds, 1 Dug Pond	2.2	1.95
Maxie Broaddus: Broaddus Farms	Caroline	SW/GW	Mattaponi River, Maracossic Creek, Farm Pond & Wells	0.55	1.02
Philip T and Philip R Minor: Glenwood	King and Queen	SW	Chapel Creek, Mattaponi River & 2 Ponds	0.5	0.69
John Yaros: Yaros Farms Inc	Northampton	SW/GW	Farm Reservoirs	0.56	0.68

[1]Average = Average water withdrawals from 2010-2014

COMMERCIAL WATER WITHDRAWALS

Commercial operations include golf courses, local and federal installations, hotels, resorts, and correctional centers, among others. Figure 21 illustrates the distribution of reported 2014 groundwater and surface water withdrawals and transfers for commercial purposes are spread throughout Virginia, predominantly near population centers. Surface water withdrawal totals are typically greater than groundwater withdrawal totals for commercial operations (Figure 22). Total water withdrawals for commercial operations in 2014 were slightly higher than the average withdrawals over the past five years (Table 8). This increase may be due in part to increased reporting by golf course facilities. The five facilities reporting the largest 2014 water withdrawals for commercial operations are listed in Table 9.

In addition to water withdrawals, the total commercial water use in some counties also includes water transferred from elsewhere (Table 10). Hotels and motels, sports and recreation clubs (i.e. private golf courses or country clubs and public golf courses) were the commercial subcategories with the largest reported 2014 withdrawals, together accounting for about 48% of the total commercial withdrawals (Table 11 and Figure 23).

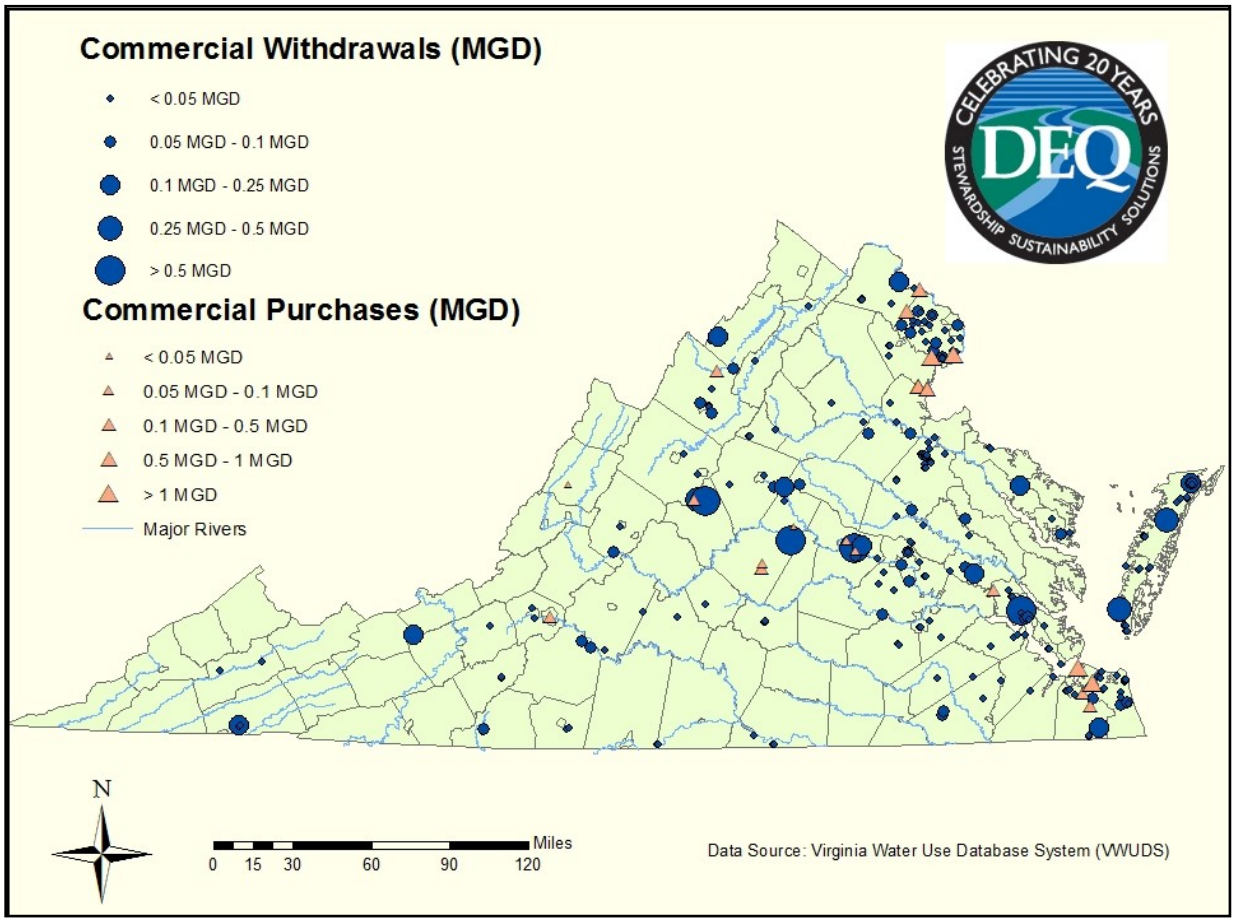

Figure 21: Commercial water withdrawals and purchases by withdrawal point location

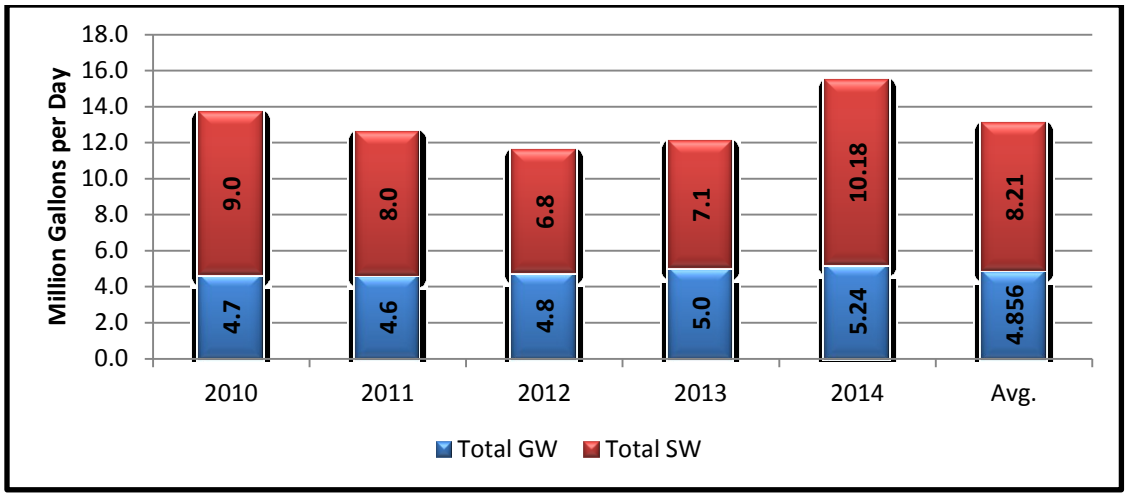

Figure 22: 2010-2014 Commercial water withdrawals by source type

Table 8: 2010-2014 Commercial Water Withdrawals by Source Type

Source Type	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW (Wells)	4.7	4.6	4.8	5.0	5.23	4.85	0.4	8
Total SW	9.0	8.0	6.8	7.1	10.18	8.21	2.0	24
Reservoirs	5.1	4.2	4.2	4.6	6.78	4.98	1.8	36
Springs	0.8	0.9	0.1	0.1	0.15	0.40	0.3	63
Streams	3.1	2.9	2.6	2.4	3.25	2.83	0.4	15
Total GW + SW	13.7	12.6	11.6	12.1	15.42	13.07	2.4	18

[1] Absolute Change = difference between 2014 water withdrawals and average 2010-2014 water withdrawals
[2]% Change = percent difference in 2014 water withdrawals from average 2010-2014 water withdrawals

Table 9: Top water withdrawals by commercial facilities

Facility	Locality	Source Type	Major Source	Average[1] MGD	2014 MGD
Colonial Williamsburg Inc: Colonial Williamsburg Hotel	Williamsburg	GW	6 wells	1.16	1.04
Wintergreen Partners, Inc.: Lake Monocan	Nelson	SW	Lake Monocan	0.89	1
Commonwealth of VA: James River Correctional Center	Goochland	SW	James River	0.7	0.61
Bay Creek Resort & Club	Northampton	SW	2 ponds	0.08	0.3
Valley Lands Inc.: Ole Monterey Golf Club	Roanoke	SW	Tinker Creek	N/A	0.29

[1]Average = Average water withdrawals from 2010-2014

Table 10: Top water transfers for commercial operations

Source	Purchaser	Purchaser Facility	Purchaser Location	Average[1] MGD	2014 MGD
Wintergreen Partners, Inc.-Lake Monocan	Nelson County Service Authority	Wintergreen Mountain Service Area	Nelson County	0.3	0.35
Commonwealth of VA - James River Correctional Facility	County of Goochland	Goochland Courthouse Service Area	Goochland County	0.11	0.08

[1]Average water withdrawals from 2010-2014

Table 11: 2010-2014 Commercial water withdrawals by subcategory

General Subcategory	Specific Sub-Category	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD
Amusement and Recreation Services	Public golf courses	3.09	2.45	2.24	1.8	2.4
	Membership sports and recreation clubs	2.87	2.53	2.52	1.74	2.23
Trucking and Warehousing	Special warehousing and storage	0.7	0.65	0.71	1.34	1.14
Hotels and Other Lodging Places	Hotels and motels	1.51	1.33	0.63	0.78	0.79
Justice, Public Order, and Safety	Correctional institutions	1.25	0.9	1.28	1.26	0.77
Executive, Legislative, and General	General government	0.14	0.14	0.12	0.15	0.13

**This table includes only those sub-categories with >0.1 MGD of self-supplied withdrawals in 2014

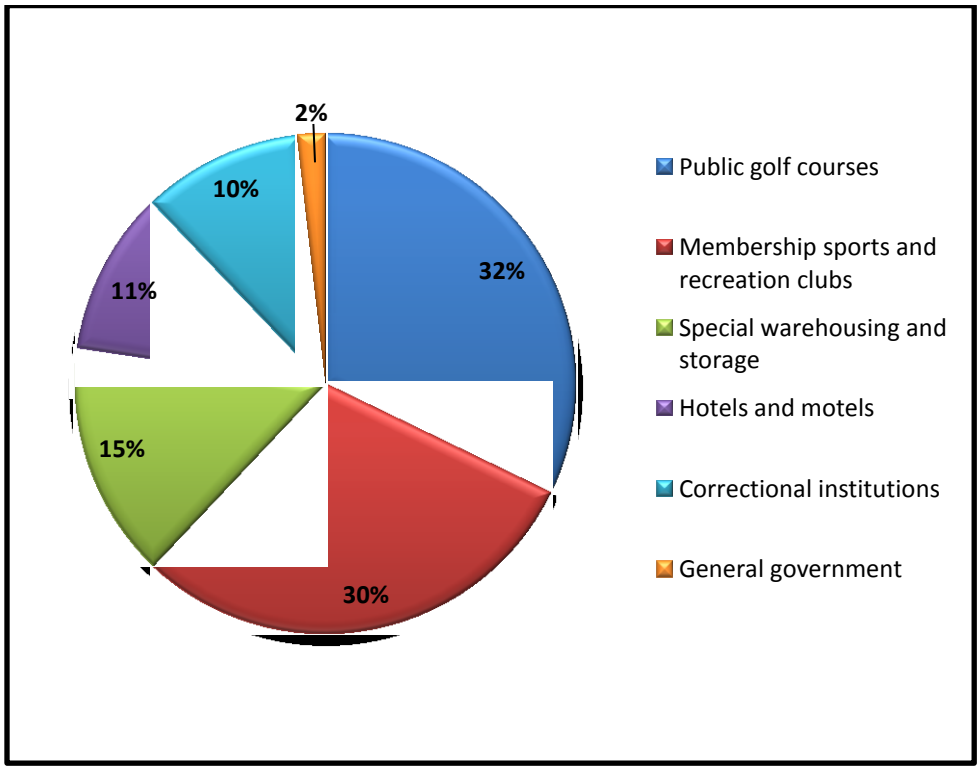

Figure 23: 2014 Commercial withdrawals by specific sub-category

MINING WATER WITHDRAWALS

Mining includes operations such as sand, rock, and coal mining. Figure 24 illustrates the distribution of reported 2014 groundwater and surface water withdrawals for mining purposes statewide. The majority of stone and sand mining facilities are located along the I-95 corridor. Coal mining withdrawals are located in the Appalachian Basin in southwestern Virginia. Water used for mining purposes comes from predominantly surface water sources (Figure 25). Total water withdrawals in 2014 for mining purposes were similar to those reported for 2012 and 2013, but were less than the 2010-2014 average (Table 12). Surface water remained the major water source type for mining purposes, with about 62% of the total supplied by reservoirs. Because there are no major transfers of water for mining purposes, the water withdrawals also represent water use. The five facilities reporting the largest 2014 mining withdrawals are listed in Table 13. Crushed and broken granite mining accounted for approximately 43% of the total 2014 water withdrawals for mining. Coal mining and processing activities made up 25% of mining withdrawals and quarrying for limestone, sand, and gravel accounted for most of the remainder (Table 14 and Figure 26). Withdrawals for construction sand and gravel were similar to the low levels reported for 2013 (0.1 MGD), indicating a significant decline compared to previous years.

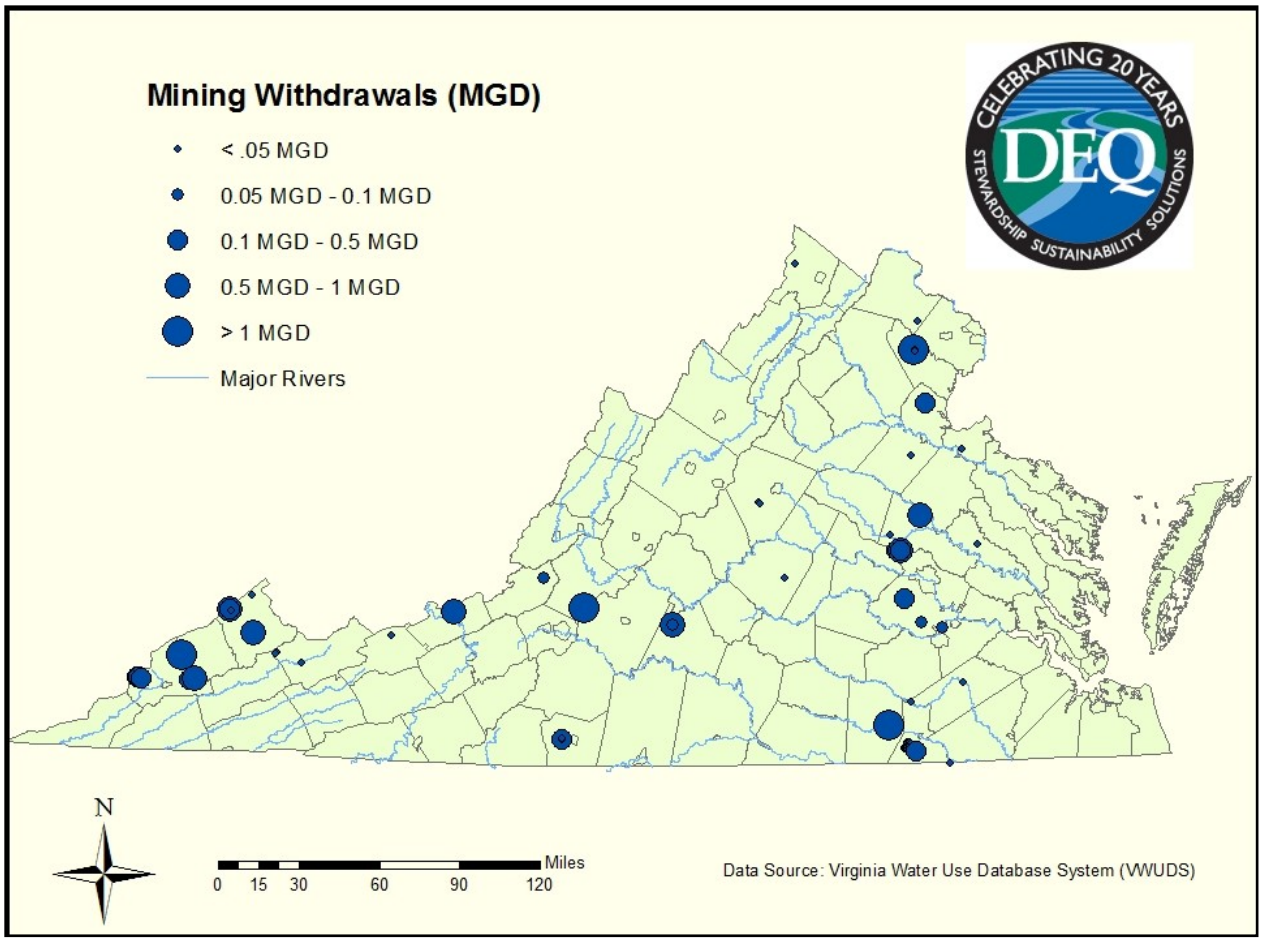

Figure 24: Mining water withdrawals by withdrawal point location

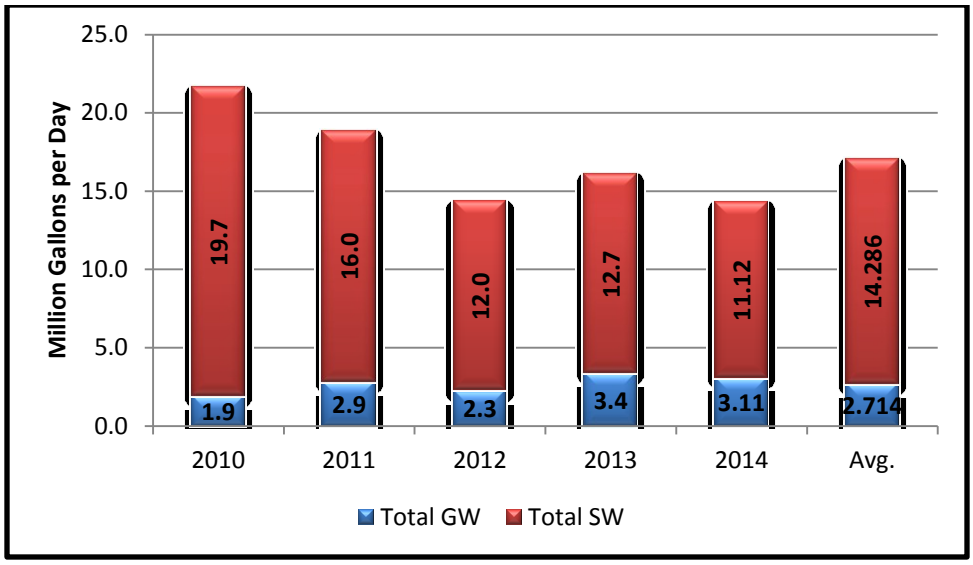

Figure 25: 2010-2014 Mining water withdrawals by source type

Table 12: 2010-2014 Mining water withdrawals by source type

Source Type:	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	1.9	2.9	2.3	3.4	3.11	2.71	0.4	15
Reservoirs	0.04	0.04	0.04	0.04	0.04	0.04	0.0	0
Wells	1.9	2.8	2.3	3.3	3.07	2.67	0.4	15
Total SW	19.7	16.0	12.0	12.7	11.12	14.29	3.2	22
Reservoirs	11.8	8.2	6.0	7.3	6.85	8.03	1.2	15
Streams	7.9	7.7	6.0	5.4	4.27	6.25	2.0	32
Total GW + SW	21.6	18.8	14.3	16.1	14.23	17.00	2.8	16

[1] Absolute Change = difference between 2014 water withdrawals and average 2010-2014 water withdrawals
[2]% Change = percent difference in 2014 water withdrawals from average 2010-2014 water withdrawals
[3]Withdrawals from dug ponds or reservoirs that are not connected to perennial streams

Table 13: Top water withdrawals by mining operations

Facility	City/County	Source Type	Major Source	Average[1] MGD	2014 MGD
Boxley Materials Company: Blue Ridge Plant	Bedford	SW	Quarry	1.33	1.67
Vulcan Construction Materials: Manassas Plant	Prince William	SW	Pump Silting Basin #1	1.63	1.54
Dickenson-Russell Coal Co LLC: McClure #1 Mine & Prep Plant	Dickenson	SW	Caney Creek	0.96	1.14
Vulcan Construction Materials: Royal Stone Plant	Goochland	SW/GW	Little Tuckahoe Creek, Quarry Sump, & Well	1.17	1.07
Vulcan Construction Materials: Lawrenceville Quarry	Brunswick	SW	Pit Sump	0.85	1.05

[1]Average = Average water withdrawals from 2010-2014

Table 14: 2010-2014 Mining water withdrawals by sub-category

General Subcategory	Specific Sub-Category	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD
Nonmetallic Minerals, Except Fuels	Crushed and broken granite	8.7	7.89	5.89	6.51	6.13
	Crushed and broken limestone	3.32	2.43	2.07	2.82	3.09
	Construction sand and gravel	2.71	2.63	0.21	0.09	0.09
	Industrial sand	0.03	0.02	0.03	0.06	0.07
	Crushed and broken stone	0.05	0.06	0.05	0.61	0.06
	Clay and related minerals	0.06	0.06	0.06	0.08	0.02
	Miscellaneous nonmetallic minerals	0.02	0.02	0.02	0.03	0.01
Metal Mining	Metal ores	0.69	0.8	1	0.56	0.05
Coal Mining	Coal mining services	1.87	2.31	2.8	2.55	2.53
	Bituminous coal and lignite - surface	0.52	0.52	0.53	0.66	0.56
	Anthracite mining	0.4	0.37	0.47	0.26	0.26
	Bituminous coal - underground	0.15	0.18	0.12	0.08	0.11

**This table includes only those sub-categories with >0.1 MGD of self-supplied withdrawals in 2014

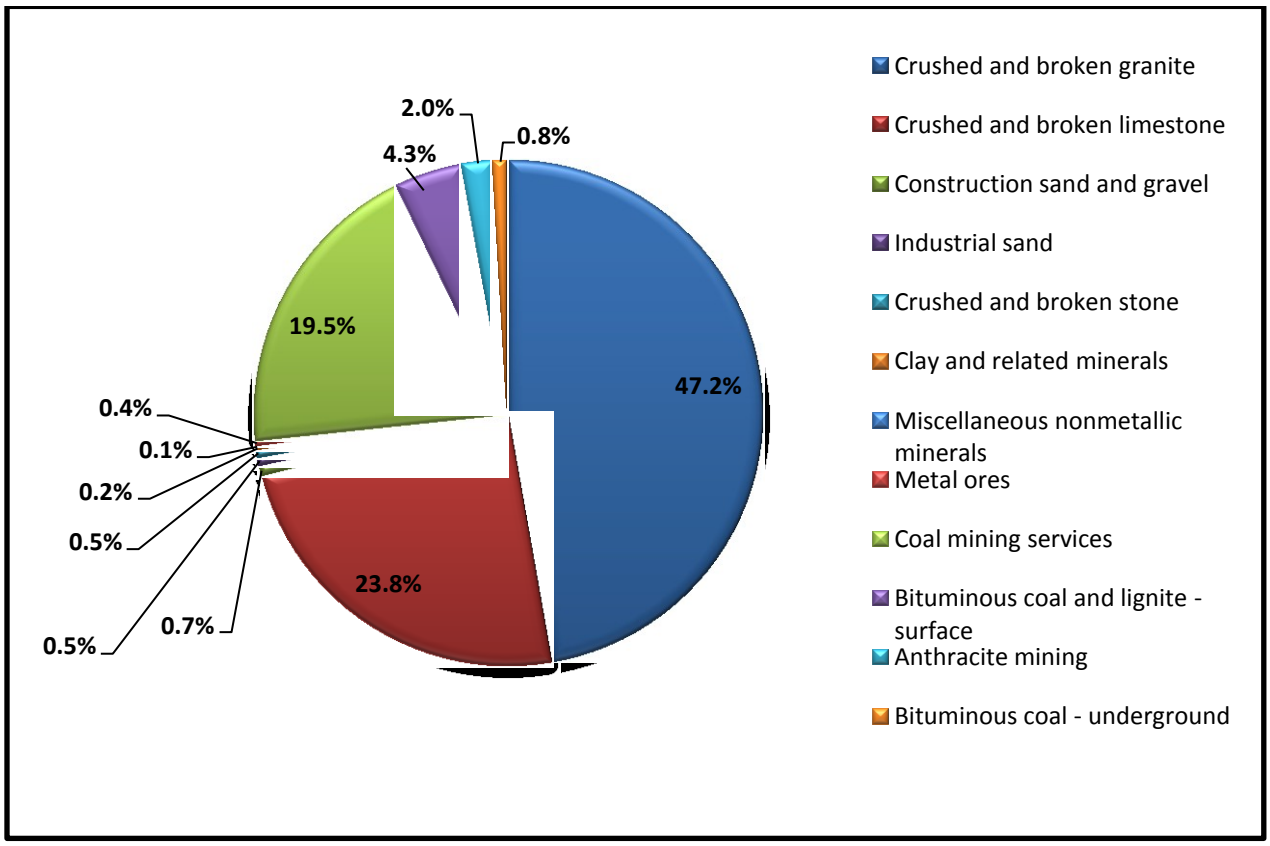

Figure 26: 2014 Mining water withdrawals by sub-category

MANUFACTURING WATER WITHDRAWALS

Manufacturing includes operations such as paper mills, food processors, drug companies, furniture, and concrete companies. Water withdrawals for manufacturing purposes are spread throughout much of Virginia (Figure 27). Clusters of large-scale withdrawals occur in the Tidewater, Richmond, and Shenandoah Valley regions, as well as the New River and the Jackson/Upper James River basins. All of the manufacturing locations with large withdrawals are situated on or near major rivers to facilitate water supply.

Figure 28 illustrates the distribution and annual changes in statewide totals of groundwater and surface water withdrawals for manufacturing from 2010-2014, respectively. Manufacturing withdrawals during 2014 declined very slightly relative to the previous year and totaled about 18 MGD (5%) less than the 2010 - 2014 average (Table 15). Surface water is the predominant water source type for manufacturing, accounting for about 82% of the total withdrawals in 2014. There are no major transfers of water reported for manufacturing purposes, so the water withdrawals generally represent water use. Table 16 lists the five largest facilities in terms of manufacturing water withdrawals in 2014, all of which happen to be surface water withdrawals. Four of these facilities manufacture chemicals and allied products or munitions while the fifth facility manufactures paper and allied products. Table 17 lists the top 5 manufacturing facilities in terms of groundwater withdrawals. Water used for chemical and allied products totaled about 233 MGD, which equals 62.5% of the 2014 total manufacturing withdrawals (Table 18 and Figure 29). Withdrawals for manufacturing paper and allied products totaled approximately 82 MGD (22%) of the 2014 manufacturing withdrawals. Water withdrawals by the chemical and paper industries together accounted for 315 MGD in 2014, or about 26% of all non-power generation withdrawals in Virginia.

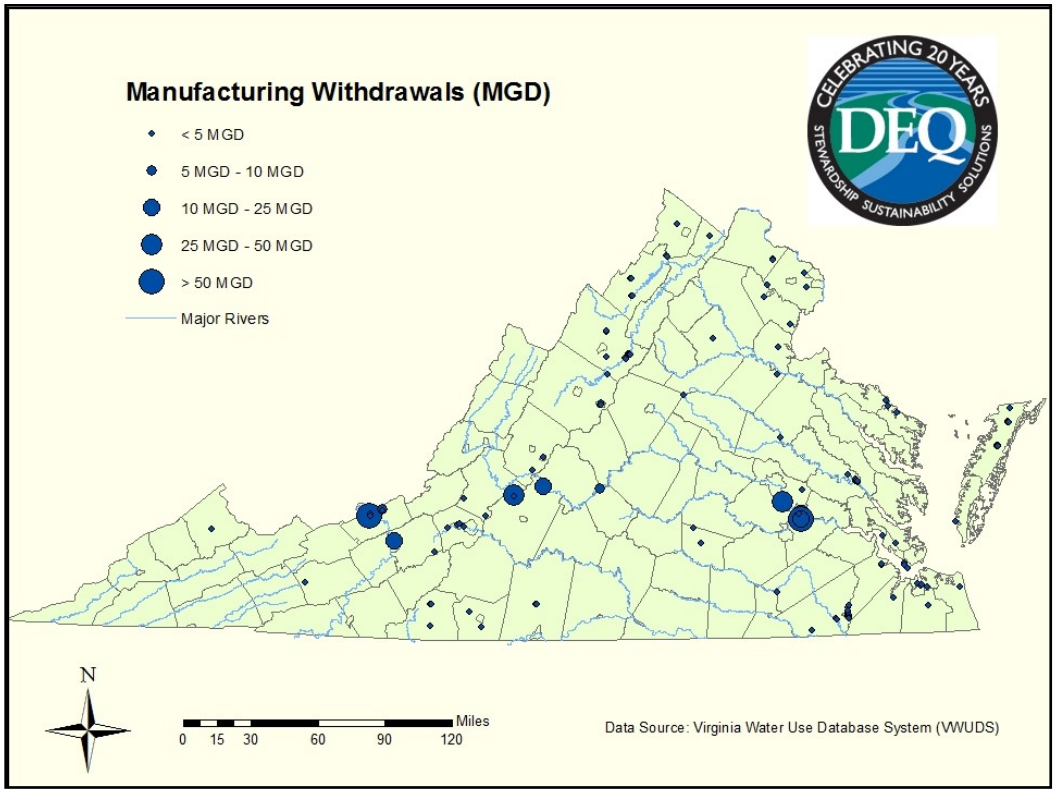

Figure 27: Manufacturing water withdrawals by withdrawal point location

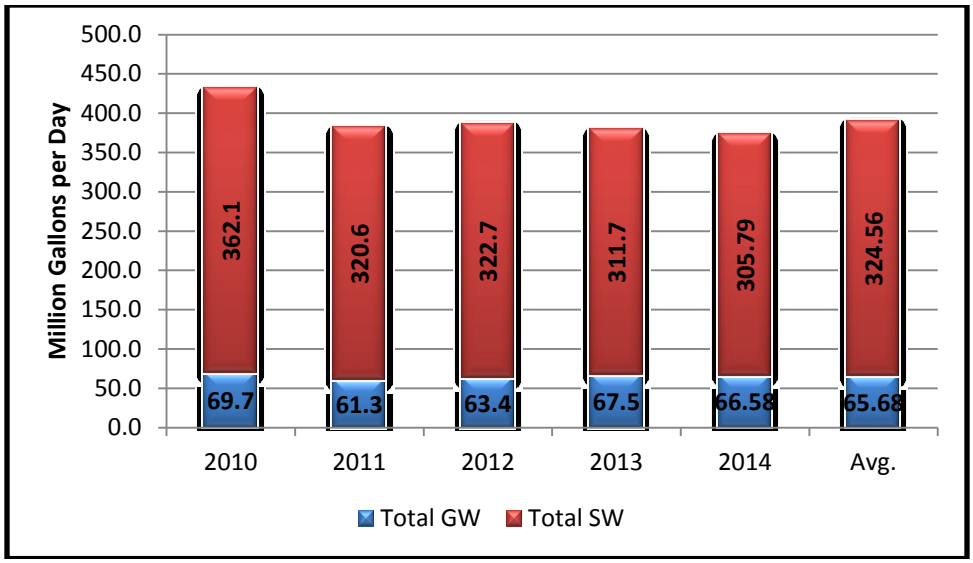

Figure 28: 2010-2014 Manufacturing water withdrawals by source type

Table 15: 2010-2014 Manufacturing water withdrawals by source type

Source Type:	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW (Wells)	69.7	61.3	63.4	67.5	66.58	65.68	0.9	1
Total SW	362.1	320.6	322.7	311.7	305.79	324.56	18.8	6
Reservoirs	2.9	3.0	3.1	3.0	2.85	2.95	0.1	3
Springs	0.2	0.2	0.6	0.4	0.19	0.30	0.1	36
Streams	359.0	317.4	319.1	308.4	302.76	321.32	18.6	6
Total GW + SW	431.8	381.9	386.1	379.2	372.37	390.24	17.9	5

[1] Absolute Change = difference between 2014 water withdrawals and average 2010-2014 water withdrawals
[2]% Change = percent difference in 2014 water withdrawals from average 2010-2014 water withdrawals

Table 16: Top surface water withdrawals by manufacturing facilities

Facility	Locality	Type	Major Source	Average[1] MGD	2014 MGD
Honeywell International: Hopewell Plant	Hopewell	SW	James River	108.18	102.98
Celanese Acetate LLC: Celco Plant	Giles	SW	New River	55.95	55.25
MeadWestvaco Corp.: Covington Plant	Alleghany	SW	Jackson River	39.18	40.11
DuPont E I De Nemours: Spruance Plant	Chesterfield	SW	James River	28.53	28.05
U.S. Govt.: Radford Ammunitions WTP 1	Montgomery	SW	New River	22.27	20.38

[1]Average = Average water withdrawals from 2010-2014

Table 17: Top groundwater withdrawals by manufacturing facilities

Facility	Locality	Type	Major Source	Average[1] MGD	2014 MGD
RockTenn - West Point Plant	King William	GW	15 Wells	19.15	17.79
International Paper - Franklin Plant	Isle Of Wight	GW	10 Wells	10.21	13.71
Lhoist North America of VA, Inc. - Kimballton Plant 1	Giles	GW	Quarry Well Dewatering	7.99	9.53
Merck & Co. - Elkton Plant	Rockingham	GW	11 Wells	7.68	7.07
Celanese Acetate LLC - Elco Plant	Giles	GW	4 Wells	4.1	3.09

[1]Average = Average water withdrawals from 2010-2014

Table 18: 2010-2014 Manufacturing withdrawals by sub-category

General Subcategory	Specific Sub-Category	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD
Chemicals and Allied Products	Chemical preparations	113.44	112.21	113.36	111.33	102.98
	Cellulosic manmade fibers	53.21	56.93	56.51	57.83	55.26
	Organic fibers, non-cellulosic	31.21	30.84	33.78	31.47	30.75
	Industrial inorganic chemicals	27.87	33.54	28.19	24.37	26.03
	Plastics materials and resins	11.41	10.86	12.67	12.71	10.65
	Medicinals and botanicals	8.51	7.87	7.79	7.17	7.07
Paper and Allied Products	Paperboard Mills	87.1	86.24	83.82	82.39	72.34
	Sanitary food containers	3.68	4.85	5.14	5.17	5.42
	Paper mills	15.25	7.58	12.95	16.91	4.02
Food and Kindred Products	Poultry slaughtering and processing	3.14	4.09	3.32	3.83	2.35
Stone, Clay, and Glass Products	Lime	7.78	8.34	7.64	7.4	9.72

[1]Average = Average water withdrawals from 2010-2014

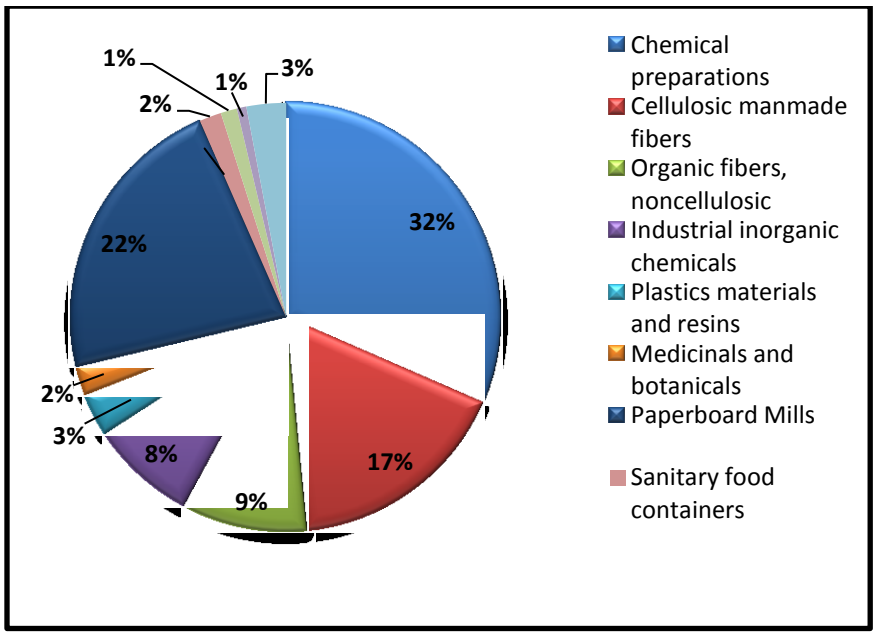

Figure 29: 2014 Manufacturing water withdrawals by sub-category

PUBLIC WATER SUPPLY WATER WITHDRAWALS

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

While the greatest number of systems are small systems that use groundwater (nearly 86%), the majority of the population is served by larger surface water systems. The largest public water supply withdrawals are located within or near population centers such as the Washington DC, Richmond, Hampton Roads, and Roanoke metropolitan areas. The largest public water supply purchases are located in the same areas, where water purveyors with large reservoirs or river withdrawals sell water to their neighbors. Smaller public water supply purveyors are scattered throughout the rest of the state (Figure 30).

Total water withdrawals for public water supply during 2014 were only about 1% less than the average for the 2010 - 2014 period (Figure 31) and slightly greater than the reported 2013 withdrawals. As with manufacturing, surface water is the major source of water for public water supply in terms of the overall quantities used. Surface water reservoirs supplied about 47% of the total 2014 public water supply withdrawals in Virginia and about 29% of all non-power generation withdrawals (Table 19). Table 20 lists the ten facilities that withdrew water for public water supply at the greatest rates during 2014. Note that the facilities and withdrawal rates in this list are not identical to those listed in Appendix 2 because the latter reports the total public water supply system withdrawals. That is, some public water supply systems contain multiple facilities that, while not large enough individually to be reported by Table 20, are larger when considered cumulatively.

There are several major transfers of water that occur for public water supply; therefore, the total water used for public water supply in each locality includes the water withdrawals in that locality, as well as water transferred into that locality from elsewhere, minus any water sold to other localities. The public water supply water withdrawal total does not include water withdrawn by individuals from private wells, as those withdrawals are not required to report. The total only represents the water withdrawn by public or private community water systems. Table 21 lists the ten largest water transfers for public water supply. Table 22 displays information from the USEPAs most recent report tabulating the number of public water systems in Virginia as of Federal Fiscal Year 2011 (ending September 30, 2012, the most recent year for which data is available) and the corresponding population served by these systems.

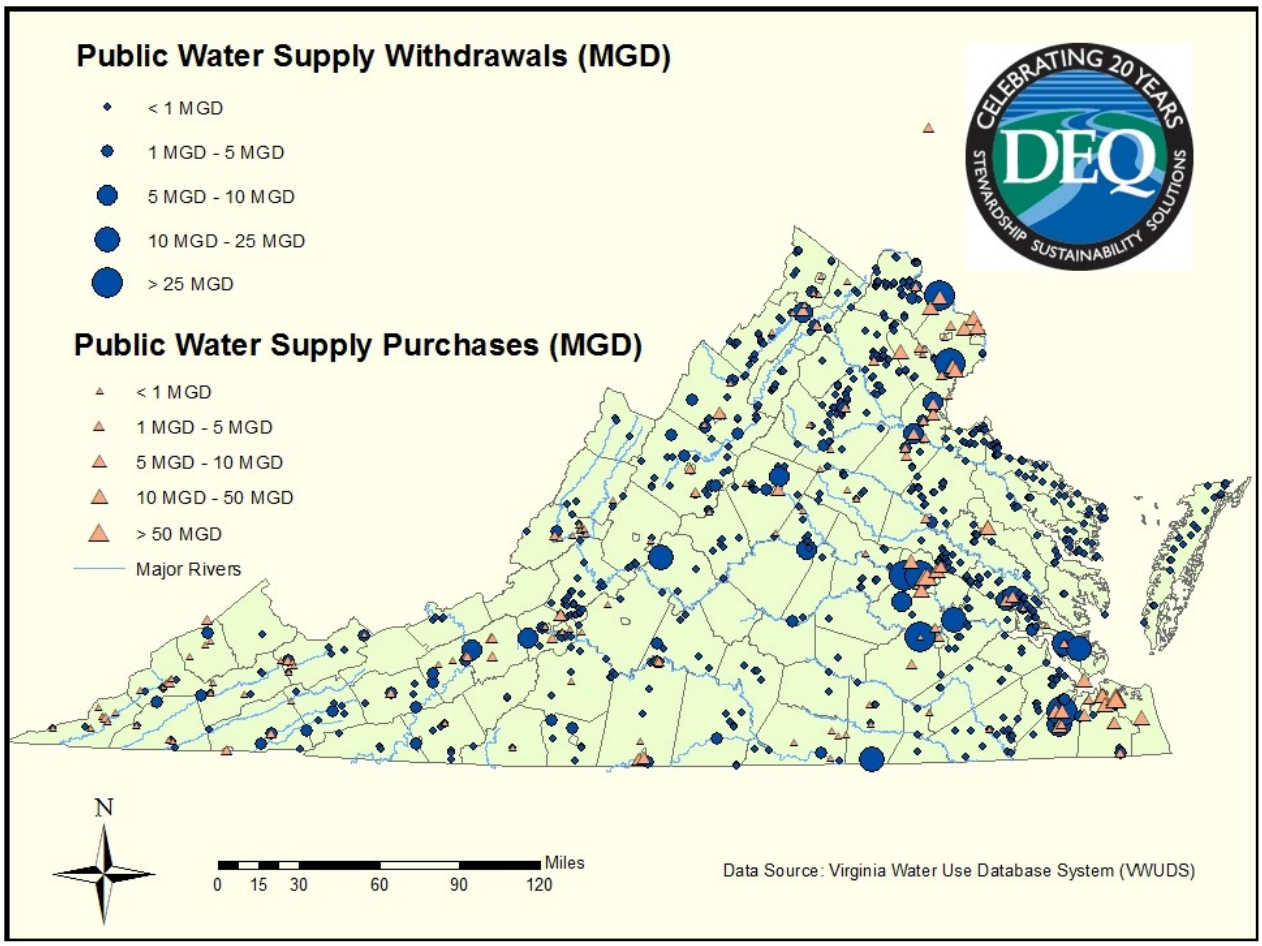

Figure 30: Public water supply withdrawals and purchases by withdrawal point location

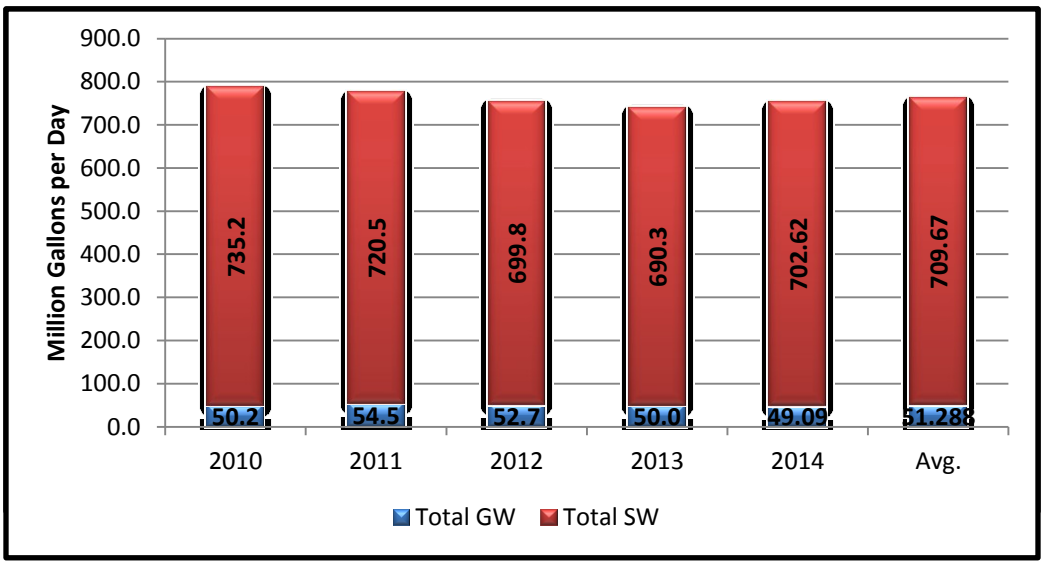

Figure 31: 2010-2014 Public water supply water withdrawals by source type

Table 19: 2010-2014 Public water supply water withdrawals by source type

Source Type:	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	50.2	54.5	52.7	50.0	49.09	51.29	2.2	4
Reservoirs	0.4	0.4	0.4	0.4	0.00	0.31	0.3	100
Wells	49.8	54.1	52.3	49.6	49.09	50.98	1.9	4
Total SW	735.2	720.5	699.8	690.3	702.62	709.67	7.0	1
Reservoirs	366.5	363.6	364.0	356.6	356.52	361.44	4.9	1
Springs	17.4	16.3	14.5	13.7	14.95	15.35	0.4	3
Streams	351.3	340.4	321.1	319.8	331.14	332.74	1.6	0
Total GW + SW	785.4	775.0	752.4	740.3	751.71	760.96	9.2	1

[1] Absolute Change = difference between 2014 water withdrawals and average 2010-2014 water withdrawals
[2] % Change = percent difference in 2014 water withdrawals from average 2010-2014 water withdrawals
[3] Withdrawals from quarries or reservoirs that are not connected to perennial streams

Table 20: Top water withdrawals by public water supply facilities

Facility	Locality	Type	Major Source	Average[1] MGD	2014 MGD
Fairfax Water Authority: Potomac River WTP	Fairfax	SW	Potomac River	89.71	89.75
Fairfax Water Authority: Occoquan Reservoir	Prince William	SW	Occoquan Reservoir	62.31	64.66
City of Richmond: Richmond WTD	Richmond, City	SW	James River & Kanawha Canal	62.06	60.96
Norfolk: Western Branch Reservoir	Suffolk	SW	Western Branch Reservoir	58.6	59.48
Appomattox River Water Authority: Lake Chesdin WTP	Chesterfield	SW	Lake Chesdin	31.57	33.47
Portsmouth: Lake Kilby WTP	Suffolk	SW/GW	Lake Kilby, Meade & 6 Wells	22.51	29.16
Henrico County: Henrico County WTP	Henrico	SW	James River	25.73	25.38
Virginia Beach: Virginia Beach Service Area	Virginia Beach	SW	Lake Gaston	25.24	21.34
Virginia American Water: Hopewell District	Hopewell	SW	Appomattox River	20.68	20.82
Newport News: Lee Hall WTP & ROF	Newport News	SW	Lee Hall Reservoir	23.9	20.27

[1]Average = Average water withdrawals from 2010-2014

Table 21: Top water transfers for public water suppliers

Source (From)	Supplier (From)	Purchaser Owner Name (To)	Purchaser Facility (To)	2014 MGD
City of Norfolk	Norfolk Service Area	City of Virginia Beach	Virginia Beach Service Area	31.43
US Government	Dalecarlia WTP	Arlington County	Arlington Service Area	22.13
Appomattox River Water Authority	Lake Chesdin WTP	Chesterfield County	Chesterfield County Service Area	21.91
Fairfax Water Authority	Occoquan Reservoir	Prince William Service Authority	OWDT Service Area	21.01
Fairfax Water Authority	Potomac River WTP	Loudoun Water	Lower Broad Run Service Area	19.38
Virginia American Water	Alexandria Service Area	City of Alexandria	Alexandria Service Area	15.46
Fairfax Water Authority	Occoquan Reservoir	Virginia American Water	Alexandria Service Area	15.42
US Government	Dalecarlia WTP	City of Falls Church	Falls Church Service Area	14.24
City of Richmond	City of Richmond Service Area	Henrico County	City-County Contract Service Area	10.96
City of Richmond	City of Richmond Service Area	Chesterfield County	Chesterfield County Service Area	7.85

Table 22: Number of public water systems and population served, Federal FY ending September 30, 2011

	Groundwater	Surface Water	Total
Number of Systems	2,395	392	2,787
Population Served	751,035	6,339,013	7,090,048

Source: http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/upload/epa816r13003.pdf (page 14, accessed 9/3/14)

POWER GENERATION WATER WITHDRAWALS

Withdrawals for power generation are treated separately because most of the water diverted for these purposes is used non-consumptively (see page 14 for a description of non-consumptive water use). Withdrawals during 2014 by nuclear and fossil fuel power generating plants are listed on this fact sheet. Water diverted for hydropower use is exempted from reporting and is nearly all non-consumptive use; therefore, these flows are generally not reported to the VWUDS database.

Most of the large fossil-fuel facilities are located in central or eastern Virginia. Virginia has two nuclear-powered generating plants, located in Louisa and Surry counties (Figure 32).Groundwater withdrawals by power generators in 2014 were insignificant compared to surface water withdrawals (Figure 33). Total power generation withdrawals continued a slight declining trend over the past five years (Table 23), with total withdrawals reaching approximately 5,812 MGD in 2014, or 8.4% less than the reported 2010 totals. The five power generation facilities with the greatest 2014 withdrawals are listed in Table 24.

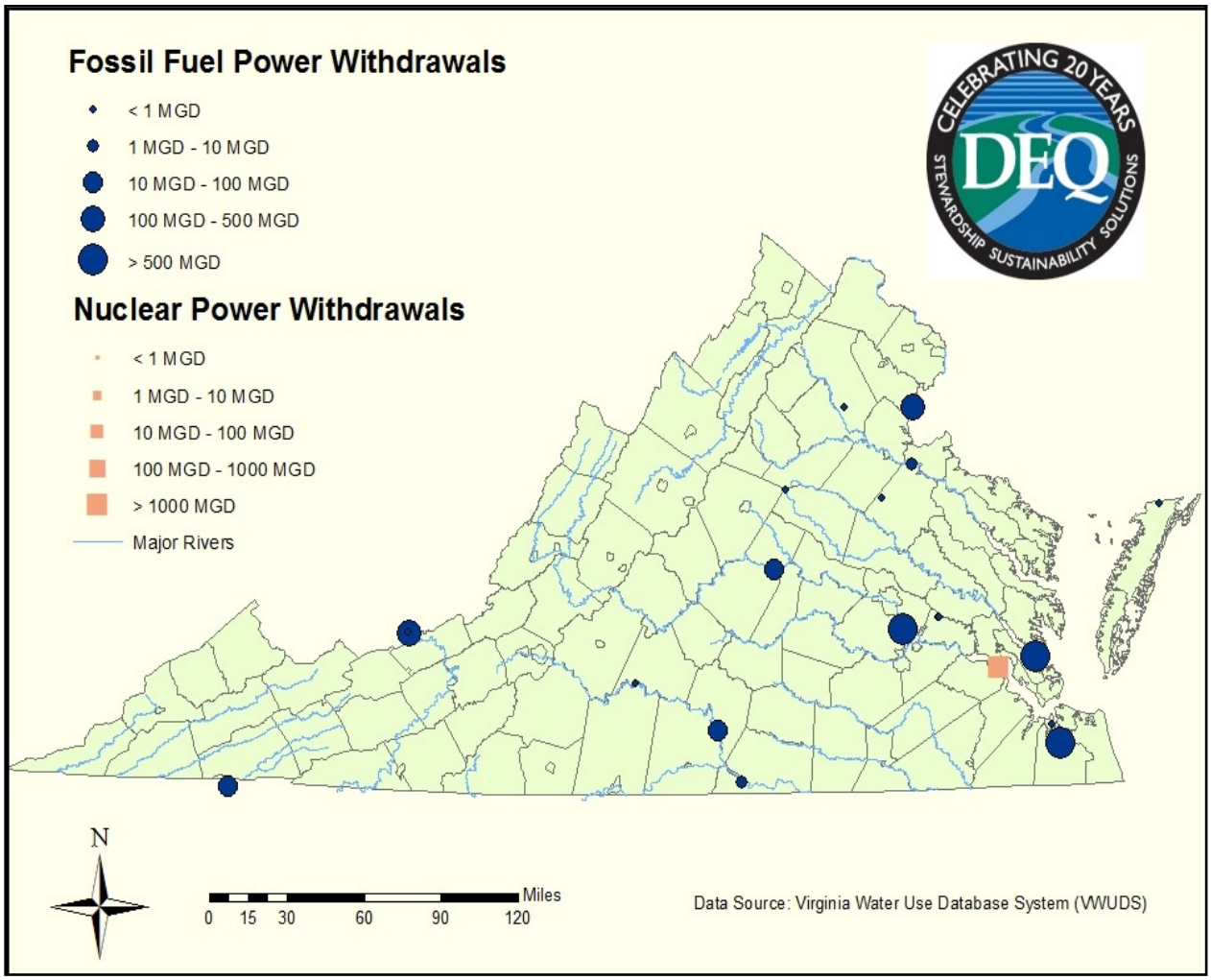

Figure 32: Power generation withdrawals by withdrawal point location

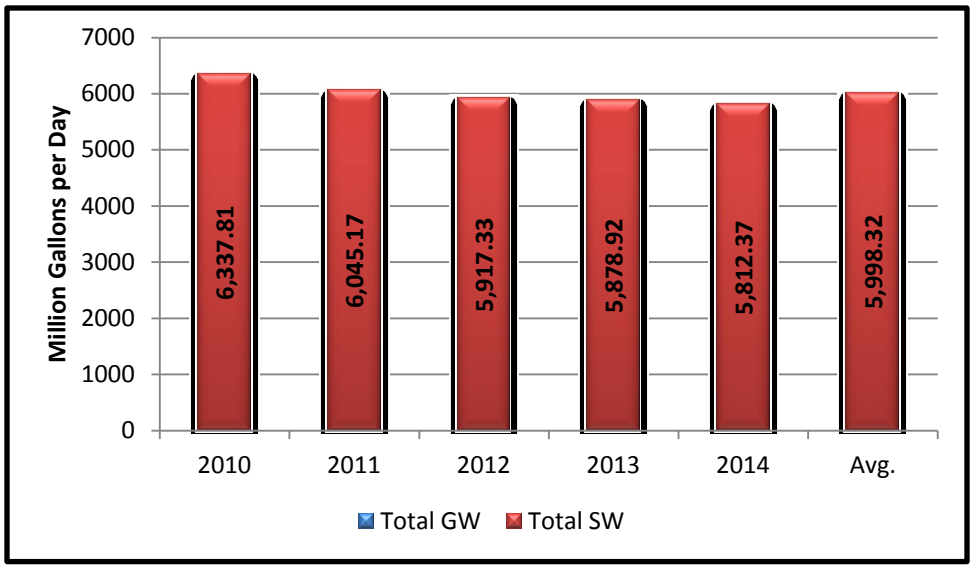

Figure 33: 2010-2014 Power generation withdrawals by source type

Table 23: Power generation withdrawals by Source Type for 2010 – 2014 (excluding hydropower)

Source Type:	2010 MGD	2011 MGD	2012 MGD	2013 MGD	2014 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW:	1.6	0.3	0.5	0.3	0.7	0.7	0.0	2
Wells-Fossil	1.2	0.0	0.2	0.02	0.5	0.4	0.1	30
Wells-Nuclear	0.4	0.3	0.3	0.3	0.2	0.3	0.1	33
Total SW:	6,308	6,016	5,872	5,844	5,764	5,961	197	3
Reservoirs-Fossil	1	1	1	1	1	1	0	0
Reservoirs-Nuclear	1,820	1,732	1,909	1,695	1,740	1,779	39	2
Streams-Fossil	2,580	2,335	2,024	2,184	2,068	2,238	170	8
Streams-Nuclear	1,907	1,948	1,938	1,964	1,955	1,942	13	1
TOTAL GW + SW:	6,310	6,016	5,873	5,844	5,765	5,962	197	3

[1] Absolute Change = difference between 2014 water withdrawals and average 2010-2014 water withdrawals
[2]% Change = percent difference in 2014 water withdrawals from average 2010-2014 water withdrawals

Table 24: Top water withdrawals by power generation facilities

Facility	Locality	Type	Major Source	Average[2] MGD	2014 MGD
Dominion Generation: Surry Nuclear Plant	Surry	N[1]	James River	1,943.6	1,955.14
Dominion Generation: North Anna Nuclear Power Plant	Louisa	N	Lake Anna	1,808.4	1,781.87
Dominion Generation: Chesterfield Power Station	Chesterfield	F	James River	821.2	786.73
Dominion Generation: Yorktown Fossil Power Plant	York	F	York River	641	503.8
Dominion Generation: Chesapeake Energy Center	Chesapeake	F	South Branch, Elizabeth River	457.3	319.29

[1]N = Nuclear; F = Fossil
[2]Average = Average water withdrawals from 2010-2014