TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

DIVISION OF WATER RESOURCES

DRINKING WATER UNIT

Tennessee Groundwater Monitoring and Management

Groundwater 305(b) Report

2020

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1.0 Introduction

This report was prepared by the Tennessee Department of Environment and Conservation (TDEC), Division of Water Resources (Division) to meet the Section 305(b) reporting requirement of the Clean Water Act. In general, 305(b) reports describe the quality of surface waters and groundwater and existing programs to protect water quality. Section 305(b) of the Federal Water Pollution Control Act, commonly called the Clean Water Act, requires a biennial analysis of water quality in the state. The Tennessee Water Quality Control Act also requires that the Division produce a report on the status of water quality.

This report is an addendum to the primary 305b report prepared by the Division, which specifically addresses surface water quality. This addendum presents a summary of activities pertaining to the protection and monitoring of groundwater quality in the state. A more thorough description of the items contained in the report may be found on the Department's web site:

Division of Water Resources Page:
http://www.tn.gov/environment/topic/wr-wq-water-quality

Source Water Assessments Page:
https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/source-water-assessment.html
Drinking Water Program Page:
http://www.tn.gov/environment/topic/wr-wq-dw-drinking-water

2.0 Acknowledgements

The Director of the Division is Jennifer Dodd and the Deputy Director of the Technical Operations is April Grippo. The Division produced this report in cooperation with central and regional field office staff.

The Division of Water Resources (Division) maintains staff at eight of the regional Environmental Field Offices (EFO's) and the Division would like to express their appreciation to each office for their assistance in compiling information for this report.

The information compiled in the 2020 water quality assessment document included data provided by many state and federal agencies. These agencies include:

Duck River Management Agency
Fleming Training Center
Rural Communities Assistance Program
Tennessee Association of Utility Districts
Tennessee Department of Environment and Conservation Division of Water Resources Data Management Section
Tennessee Department of Environment and Conservation Division of Water Resources Drinking Water Unit
Tennessee Department of Environment and Conservation Division of Water Resources Watershed Management Section
Tennessee Department of Environment and Conservation Division of Water Resources Water Well Program
Tennessee Valley Authority
United States Department of Agriculture
United States Geological Survey
University of Memphis Ground Water Institute
University of Tennessee Center for Environmental Biotechnology
Water Resources Technical Advisory Committee

3.0 General Information

Tennessee has a wealth of water resources across the state and groundwater is a very important portion of these resources. With localized exceptions, Tennessee’s groundwater is good quality as is evidenced by the number of public water systems utilizing groundwater. Recognizing the importance of this resource, there continues to be an increased awareness that groundwater should be protected as a valuable resource.

The vulnerability of Tennessee's groundwater sources is inextricably linked to the geology of the state. Groundwater can be quite vulnerable to contamination, particularly in karst terrain (limestone characterized by caves, sinkholes and springs) and in unconfined sand aquifers.

The availability and the quality of drinking water are vital influences on public health and the economy. In Tennessee, approximately 4.6 million people rely on public water systems that use surface water as a source for their drinking water. Approximately 1.6 million people rely on public water systems that use groundwater as a source for their drinking water. There are approximately 260,000 people that receive their drinking water from a public water system whose source is a combination of groundwater and surface water (i.e., designated as groundwater under the influence of surface water). A 2014 United States Geological Survey report estimates that an additional 538,000 people get their drinking water from private wells and springs. Most west Tennessee citizens rely on groundwater for their drinking water.

Although the majority of the population in central and eastern Tennessee connected to public water systems are utilizing surface water sources, there are still significant uses of groundwater for public water supplies in these portions of the state as well. The unique hydrogeologic characteristics of aquifers in the central and eastern portions of the state are more susceptible to drought, highlighting the continued need for these systems to evaluate capacity and forecast water needs. The Division continues to encourage water systems to forecast for capacity development and system resiliency.

4.0 Statutory Requirements

Since 1985, the Division's Drinking Water Unit (DWU), formerly known as the Division of Water Supply (DWS), has worked to ensure that public drinking water supplies are safe. The Division also regulates the construction of non- federal dams, enforces the Safe Drinking Water Act, monitors water withdrawals, and regulates the licensing of well drillers. DWU coordinates the Source Water Protection (SWP) Program, the Underground Injection Control (UIC) Program and conducts monitoring and sampling as well as responds to groundwater complaints.

In addition to the federal requirements, the Tennessee Water Quality Control Act of 1977 requires a report to the governor and the general assembly on the status of water quality in the state. The report is prepared by the Division, titled Protection of Potable Water Supplies in Tennessee Watersheds, and includes a description of the water quality plan, regulations in effect, and recommendations for improving water quality. This report can be found on the Division's Web site at https://www.tn.gov/content/tn/environment/program-areas/wr-water-resources/water-quality/source-water-assessment.html

This report covers groundwater in Tennessee. The Division also submits a 305b report on surface water and that report can be found at: https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-quality-reports---publications.html The 2020 305(b) Report and addendum serve to fulfill the requirements of the federal law.

5.0 Public and Private Well/Spring Use

All public water systems are subject to strict testing and treatment requirements. Overall, public water systems in Tennessee have an excellent record of providing clean water to their customers. The Division is responsible for regulating all public water systems to protect the state's drinking water quality.

Tennessee does not require persons using a private water source to test for contaminants. Water well construction is regulated in Tennessee and the well drillers are required to have a license and submit a Notice of Intent (NOI) for the proposed wells that they drill along with a Driller Report after drilling is complete. Water well testing and maintenance are the responsibility of the individual homeowner. Springs used by private individuals are also not regulated by the state. Shallow wells and springs located in karst areas are more susceptible due to the occurrence of preferential pathways in the subsurface, allowing for more rapid transport of contaminants. Some examples of potential groundwater contamination sources include failing septic systems (resulting in discharge to groundwater), illicit dump sites, and spills that cause a release of contaminants to groundwater. Residents using private water sources should test their water sources and consider appropriate pretreatment before use.

Abandoned wells, both drilled and hand-dug can also be a significant hazard for contamination (illegal dumping, spills or contaminated runoff) as well as sinkhole dumps. Both wells and sinkholes have direct connections to groundwater. There are often limited resources available to address these potential areas of concern.

For more information on private water wells and how to maintain them, homeowners can contact the National Ground Water Association (NGWA) at www.wellowner.org or homeowners may take the Private Well Class sponsored by the Rural Communities Assistance Program (RCAP) through a grant from the Environmental Protection Agency (EPA) at www.PrivateWellClass.org. Other information on licensed water well contractors and information specific to Tennessee may be found at the State website http://www.tn.gov/environment/article/wr-wq-well-water.

6.0 Critical Groundwater Issues in Tennessee

Groundwater in Tennessee is an extremely valuable and finite resource. Groundwater contamination has had more than a quarter century of a head start over groundwater protection and management. The Ground Water Classification under the Tennessee Water Quality Control Act has been revised to better classify the waters of the state. Information on groundwater site specific classifications can be found at http://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20150406.pdf.

There are a number of issues in groundwater pollution prevention and groundwater management including, but not limited to, the following:

- Tennessee has variable and complex geology.
  - ♦ The limestone aquifers that are prevalent in Middle and East Tennessee enable the potential for rapid movements of contaminants and more complex flow paths.
  - ♦ East Tennessee faulting and folding associated with the Valley and Ridge Province is a complicating factor for delineating recharge areas and hydrogeologic conditions in that region.
  - ♦ The unconfined sand aquifers in West Tennessee are also vulnerable to contamination.

- Contamination is not obvious or easily monitored.
  - ♦ Groundwater itself and groundwater contamination can be difficult to monitor.
  - ♦ Wells are an extremely narrow "window" into the aquifer.
  - ♦ A contamination plume can be complex, irregular in shape and not evenly distributed within the aquifer.
  - ♦ Variations in the physical and chemical characteristics of contaminants can also cause the contaminants to take different flow paths through the aquifer.

- Sampling a well is significantly different from sampling a stream.
  - ♦ Upstream and downstream are not obvious when sampling groundwater.
  - ♦ Sampling protocol and equipment varies from location to location.
  - ♦ Locating the stream is not an issue, locating the groundwater can be.

- Contamination in groundwater tends to be from a different suite of chemicals and of much longer duration than in surface water.
  - ♦ Surface water is subject to more natural attenuation of contamination, with both physical and biological breakdown of the contaminants. In recent years, "emerging contaminants" such as human and veterinary pharmaceuticals, industrial and household wastewater products, and reproductive and steroidal hormones in water resources, have become more of a focus (USGS Fact Sheet FS-027-02, Pharmaceuticals, Hormones and Other Organic Wastewater Contaminants in U. S. Streams; June 2002

https://toxics.usgs.gov/pubs/FS-027-02/). Potential environmental pollutants include pharmaceutical, veterinary and illicit drugs, as well as active ingredients in personal care products (collectively referred to as PPCPs). These potential pollutants include prescription drugs and biologics, as well as diagnostic agents, fragrances, sunscreen agents, ingredients in cosmetics, food supplements and numerous others. The introduction of PPCPs into the environment is not just by sewage treatment plants, but also by nonpoint runoff and failing septic systems as well as large capacity conventional and drip disposal systems. The Division has been working with the Unwanted Pharmaceuticals Take Back Program in supporting the removal of unwanted medications and personal care products from the environment. Information on the Unwanted Pharmaceuticals Take Back Program can be found at:

https://www.tn.gov/environment/program-areas/opsp-policy-and-sustainable-practices/community-programs-and-services/unwanted-household-pharmaceuticals-takeback-program.html

- ♦ Each chemical's physical and chemical properties have an effect on its movement in groundwater.

- ♦ Groundwater contamination (see Figure 4) is typically chlorinated solvents or degreasers and gasoline. These are all very volatile (evaporate rapidly) and are thus not a problem in surface water; however, they are a serious problem in groundwater where they do not biodegrade and can be in the groundwater for decades. Most chlorinated solvents or degreasers and gasoline have a very low drinking water standard (several volatiles are at 5 parts per billion or less). Bacteria from septic tanks are a potential source of private water well or spring contamination.

- ♦ Surface water contamination sources are typically nitrate (from fertilizer and animal waste), bacteria, protozoa and urban runoff (runoff from yards, asphalt, etc. that has heavy metals and pesticides/herbicides, etc.). There has been testing across the state showing atrazine (a herbicide) is getting into streams (eight across the state) after rains during growing season. Groundwater in karst areas that are impacted by surface water is also subject to these same contaminants. Atrazine has also been detected at one Middle Tennessee water system where its groundwater source is under the direct influence of surface water.

- ♦ The protozoan cryptosporidium is a serious problem for surface water systems or groundwater systems under the direct influence in that chlorine will not kill it and it is abundant in the environment. However, a well operated filtration system is efficient at removing cryptosporidium. EPA's Enhanced Surface Water Treatment Rule is predominantly the result of cryptosporidium concerns.

- <u>A more accurate picture of the health of Tennessee's aquifers is needed</u>.

- Historically there had not been a systematic statewide study of Tennessee's aquifers. The United states Geological Survey (USGS) conducted a "Reconnaissance of Quality of Water from Farmstead Wells in Tennessee 1989-90" https://pubs.usgs.gov/wri/1992/4186/report.pdf This study focused on nutrients in groundwater. The Division is currently looking at the USGS sampling location to augment the states sampling program.
- Tennessee's ambient (naturally occurring or "background" water quality) groundwater quality monitoring program is still in the formative stages.
- Public water systems sample the treated water served to their customers; however, less often sample raw groundwater.
- Private wells and springs are not routinely sampled in Tennessee.

7.0 Tennessee's Complex Geology

The geology of Tennessee makes certain aquifers more vulnerable to contamination where there is no clay confining layer or naturally filtering soil layer to deter contamination from reaching the groundwater. The unconfined sand aquifers of west Tennessee are vulnerable to contamination as are the limestone (carbonates) aquifers of middle and east Tennessee (see Figures 1 and 2). East Tennessee has the additional complicating factor of major rock deformation through faulting and folding associated with the Valley and Ridge Province.

The video "Hollow Ground: Land of Caverns, Sinkholes and Springs" https://www.youtube.com/watch?v=JEgNMEk6ojo addresses karst limestone areas in Tennessee. Additionally, the video "Drops of Water in Oceans of Sand: Ground Water Resources of West Tennessee" addresses the sand aquifers of west Tennessee. Further, there is a multi-part video on source water protection (protection of the sources of public water) available on the Division's website.

Tennessee has an abundance of limestone rock types (approximately 2/3 of the state), which are more susceptible to contamination. These limestone rock types develop a terrain that is referred to as karst. The term karst is a descriptor for areas underlain by carbonate bedrock where the dissolution of the soluble bedrock creates unique subsurface and topographic features. Karst is characterized by sinkholes, springs, disappearing streams and caves. Karst systems have rapid, highly directional groundwater flow in discrete channels or conduits. Karst aquifers have very high flow and contaminant transport rates under rapid recharge conditions such as storm events. This is a particular concern for public or private water supplies using wells or springs in karst areas where pathogenic organisms that would not be present in true groundwater can survive in groundwater under the influence of surface water.

Karst systems are quite easily contaminated since the waters can travel long distances through conduits with no chance for natural filtering processes of soil or bacterial action to diminish the contamination. Transport times across entire karst flow systems may be as short as hours or weeks, orders of magnitude faster than that in sand aquifers.

Water in karst areas is not distinctly surface water or groundwater. Surface water can enter into the groundwater directly through sinkholes and disappearing streams. There are a number of water systems in middle and east Tennessee relying on groundwater sources that have been determined to be under the direct influence of surface water. These systems are required to have filtration such as that required for surface water systems.

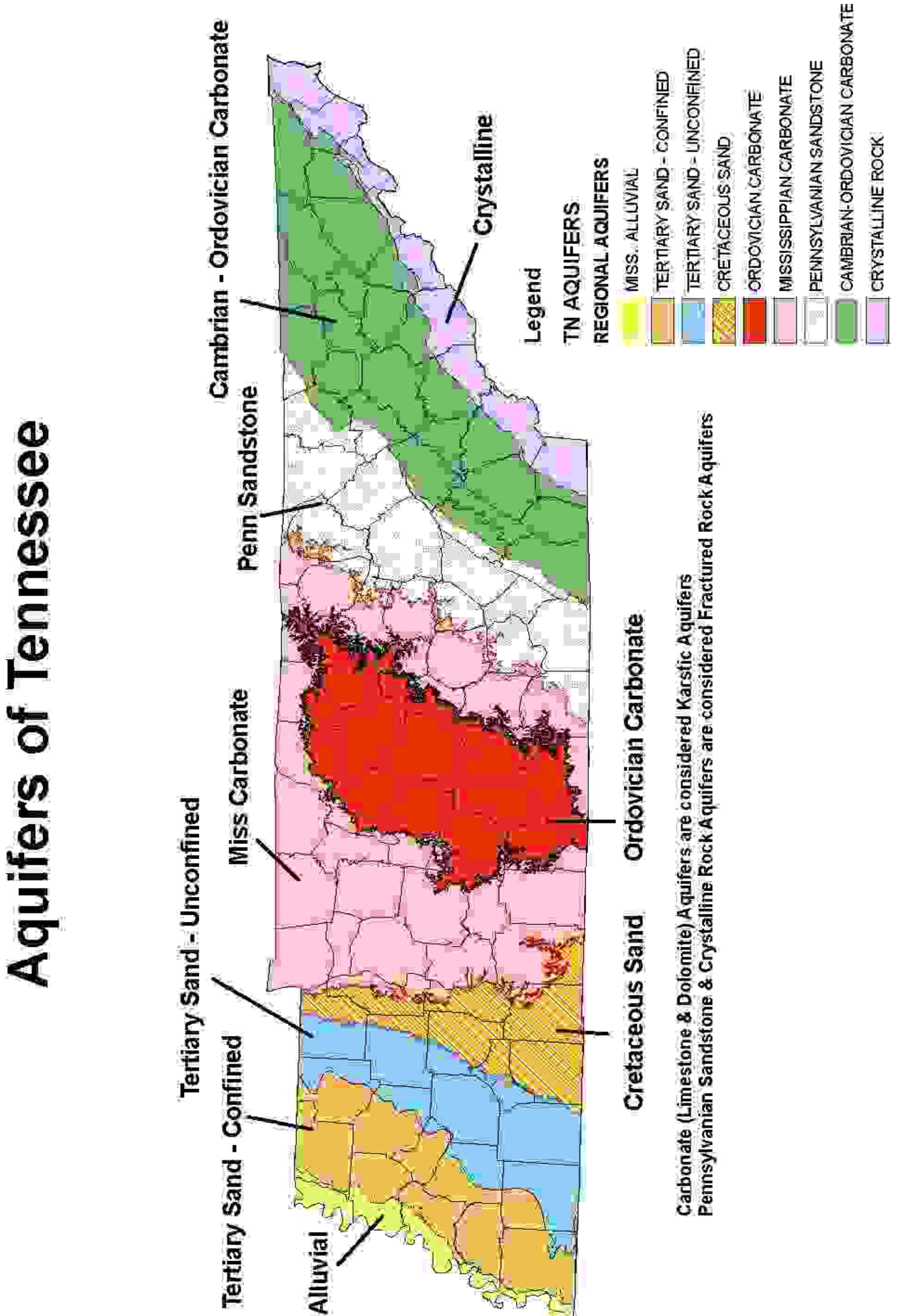

Aquifers of Tennessee
Alluvial
Tertiary Sand - Confined
Tertiary Sand - Unconfined
Miss Carbonate
Penn Sandstone
Cambrian - Ordovician Carbonate
Crystalline
Cretaceous Sand
Ordovician Carbonate
Legend
TN AQUIFERS
REGIONAL AQUIFERS
MISS. ALLUVIAL
TERTIARY SAND - CONFINED
TERTIARY SAND - UNCONFINED
CRETACEOUS SAND
ORDOVICIAN CARBONATE
MISSISSIPPIAN CARBONATE
PENNSYLVANIAN SANDSTONE
CAMBRIAN-ORDOVICIAN CARBONATE
CRYSTALLINE ROCK
Carbonate (Limestone & Dolomite) Aquifers are considered Karstic Aquifers
Pennsylvanian Sandstone & Crystalline Rock Aquifers are considered Fractured Rock Aquifers

Figure 1

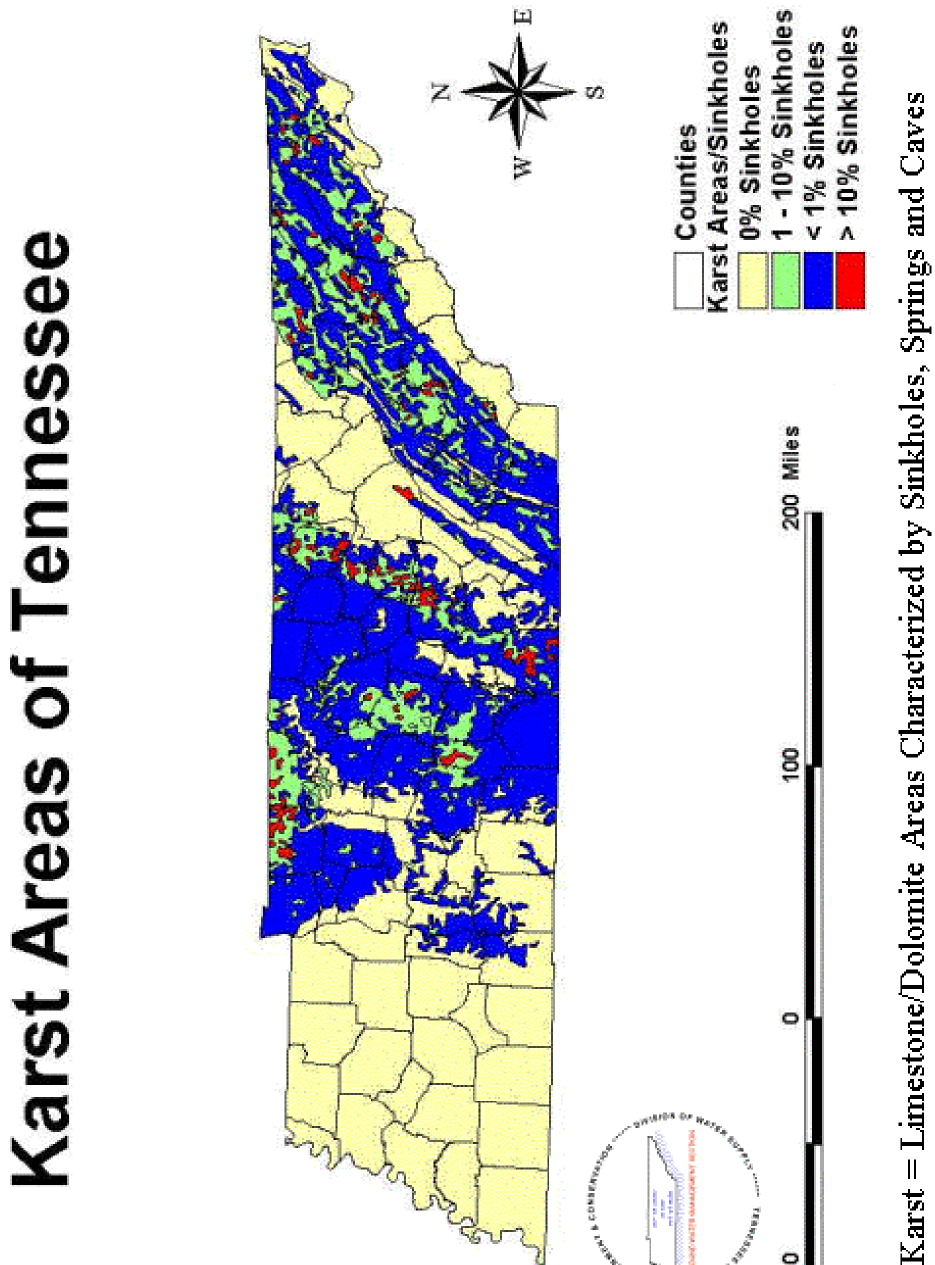
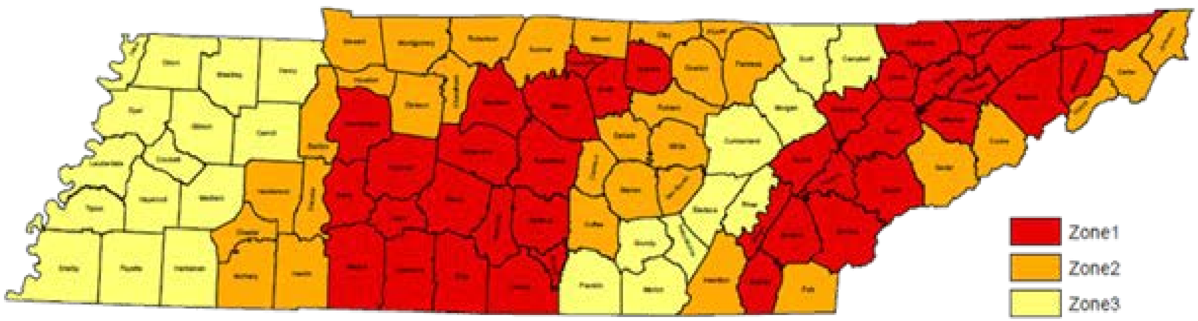

Karst Areas of Tennessee
Counties
Karst Areas/Sinkholes
0% Sinkholes
1 - 10% Sinkholes
< 1% Sinkholes
> 10% Sinkholes
N
E
S
W
100
0
100
200 Miles
Karst = Limestone/Dolomite Areas Characterized by Sinkholes, Springs and Caves

Figure 2

8.0 Naturally Occurring Radon

There are increasing concerns over naturally occurring levels of radon, uranium and arsenic in drinking water supplies nationwide. Tennessee is fortunate in that the geology is such that the naturally occurring arsenic that plagues a number of the western states is not present in this state. Neither does there appear to be a problem with uranium. Studies of public groundwater supplies across the state have determined that there are locations with elevated levels of radon (Figure 3).



Zone 1 - red - has a high risk factor for radon
Zone 2 - orange - has a moderate risk factor for radon
Zone 3 - yellow -has a low risk factor for radon

Figure 3

Testing conducted for radon in public water systems across the state in 1999 indicated that the radon in some water systems measured well above the EPA proposed 300 picocuries per liter (pCi/L) standard. Further radon testing was needed in that some of those systems were not in the expected geologic setting for high radon levels. The 1999 testing also appeared to indicate that lower flow volume wells and springs tend to have higher levels of radon, possibly due to there being less "flushing" of the relatively volatile radon gas. This trend of smaller systems having the higher radon readings is consistently holding true in the 2001 sampling as well. The high radon readings were typically from water systems with less than 200,000 gallons per day average daily production. (Figure 4)

It is not unexpected that there are high radon readings without corresponding uranium results in that the wells are typically going to be finished above shale formations. Wells are typically not drilled into shale formations that contain uranium for a groundwater source because they have water quality problems from high metal and sulfur content. Radon as a gas will enter the wells drilled into the carbonate rocks overlying shale formations.

Of the 92 wells and springs sampled in 2001, 34 were above the proposed 300 pCi/L standard and six were above 1000 pCi/L. With the exception of west Tennessee (where no radon was expected) and the Cumberland Plateau, the sample choices were intentionally chosen that would likely have high radon readings. Of the 92 samples, 33 of the wells/springs have been determined to be under the direct influence of surface water. Of those 33, 13 yielded radon results of 300 pCi/L or higher.

In 2013, Division staff sampled 85 wells and springs in which 45 were above the proposed 300 pCi/L standard and 13 were above 100 pCi/L. Again, with the exception of West Tennessee (where no radon was expected) and the Cumberland Plateau, the sample choices were intentionally made that would likely have high radon readings. Of the 85, 34 of these wells /springs were under the influence of surface water.

Table 1 shows the range by pCi/L of the samples for Radon taken in the 2001 and 2013 study. The number in parenthesis is the highest number for that sample year.

The most consistently high readings were for small community/noncommunity systems in the Highland Rim area of Middle Tennessee, although the highest reading was in East Tennessee. The majority of the high values for radon are from small community (subdivisions, trailer parks) or noncommunity (campgrounds) systems.

The Highland Rim wells/springs either side of Nashville have high readings as would be expected for Mississippian carbonates above the Chattanooga Shale. The Chattanooga Shale is the expected source of the radioactivity in that it has low levels of uranium found in it in much of the areas where it occurs. Similarly, in the Valley and Ridge (Cambrian Ordovician Carbonates) and Unaka Mountains (Crystalline Rock) of East Tennessee, there are shale formations that are expected to be low sources of low level radioactivity. The highest radon result in 2001 (3103 pCi/L) was from a subdivision in Polk County Tennessee in the southeastern corner of the state. The highest radon result in the 2013 study was from a school in Cocke County (8792 pCi/L).

The Division attempted to recreate the 2001 study in 2011-2012 but due to a laboratory error, only Gross Alpha and Gross Beta were analyzed. Staff collected a total of 106 samples, ninety-five (95) individual systems and eleven (11) duplicates samples. In comparison of the gross alpha and gross beta run in the 2001 sample event, there were no statistical differences to the 2001 and 2012 studies. Of the Gross Alpha, only three (3) systems were above the initial 5 pCi/L screening result which would have them scanned for Radium 226. None of these were above any published limits.

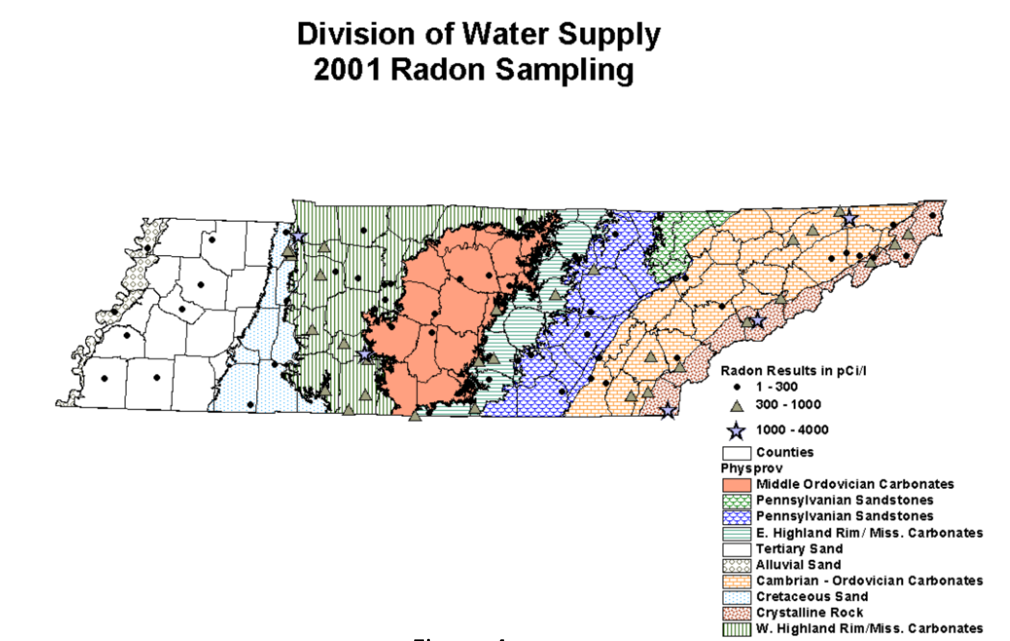

Division of Water Supply
2001 Radon Sampling
Radon Results in pCi/l
1 - 300
300 - 1000
1000 - 4000
Counties
Physprov
Middle Ordovician Carbonates
Pennsylvanian Sandstones
Pennsylvanian Sandstones
E. Highland Rim / Miss. Carbonates
Tertiary Sand
Alluvial Sand
Cambrian - Ordovician Carbonates
Cretaceous Sand
Crystalline Rock
W. Highland Rim/Miss. Carbonates

Figure 4

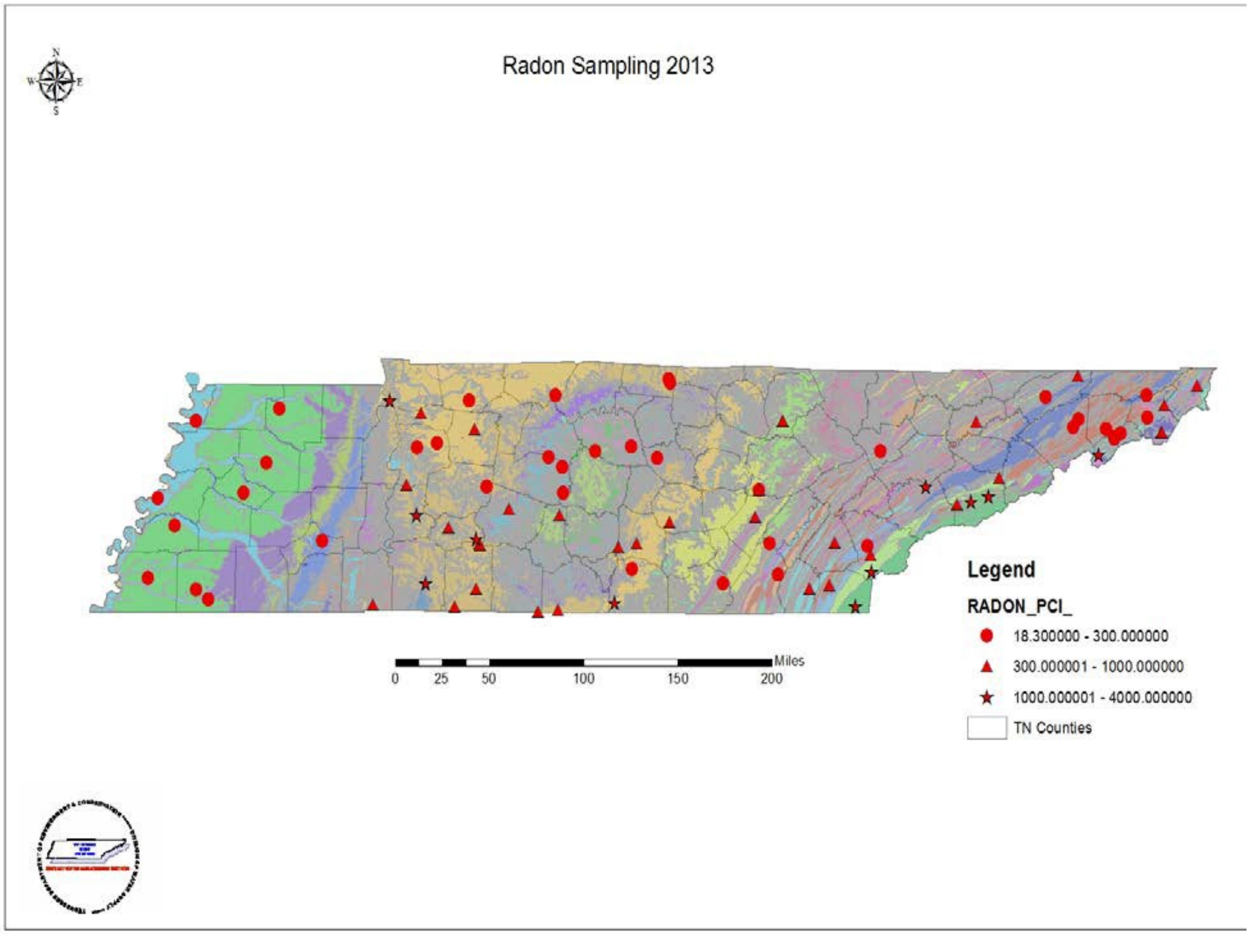


Figure 5

Range by pCi/L	2001 number of Systems	2013 number of Systems
0-300	62	40
301-400	13	11
401-500	7	6
501-600	4	3
601-700	5	3
701-800	3	5
801-900	0	3
901-1000	1	1
1001-2000	4	8
2001-3000	1	3
3001-	1 (3103)	2 (8792)

Table 1

9.0 Ongoing Activities

The Division continues to evaluate groundwater quality in the state and implement groundwater protection programs.

9.1 Well Head Protection Work

Public water systems in Tennessee are required to update Source Water/Well Head Protection Plans on continued three-year cycle. The update includes the observation and documentation of any new potential contaminant source, new photographs and maps showing any new protection strategies that have been employed by the water system.

9.2 Department of Agriculture Pesticide Sampling Micro Pesticide Data Program (MPDP) and Ground Water Quality Assessment Study

The Division assisted the United States Department of Agriculture (USDA) in the collection of pesticide samples from twenty schools and head start facilities that utilize groundwater across the state. (Figure 6) These samples were collected by Division staff from March 2011 through November 2011 and were analyzed by the Department of Agriculture. The study was one of the most comprehensive studies completed in Tennessee for groundwater systems. The study was conducted in order to establish a baseline of micro pesticides data (MPD) in groundwater. Previously, there had been very little MPD testing in Tennessee.

With the use of advanced analytical technology that is capable of accurately reflecting amounts in parts per trillion concentrations, Tennessee's waters were carefully sampled statewide for 146 specific compounds. As experienced in similar research across the country, certain MPDs were identified in some of Tennessee's groundwater sources;however, it is important to note that none of the laboratory results reflected contaminants over published health advisory limits or EPA Maximum Contaminant Levels (MCL).

In frequency of occurrence, Desethyl atrazine (herbicide metabolite) was the most commonly encountered, followed by Tebuthiuron (herbicide), then Metolachlor ethanesulfonic acid (ESA) (herbicide metabolite).

This research was conducted through a partnership with the USDA and the Division and reflects a proactive effort to gain a statewide snapshot into certain micro pesticide levels in groundwater sources. Perhaps equally as important, this research project has proven to be an effective communications tool in reminding citizens of our collective responsibility to protect our waters through important efforts, such as properly using and disposing of unused pesticides.

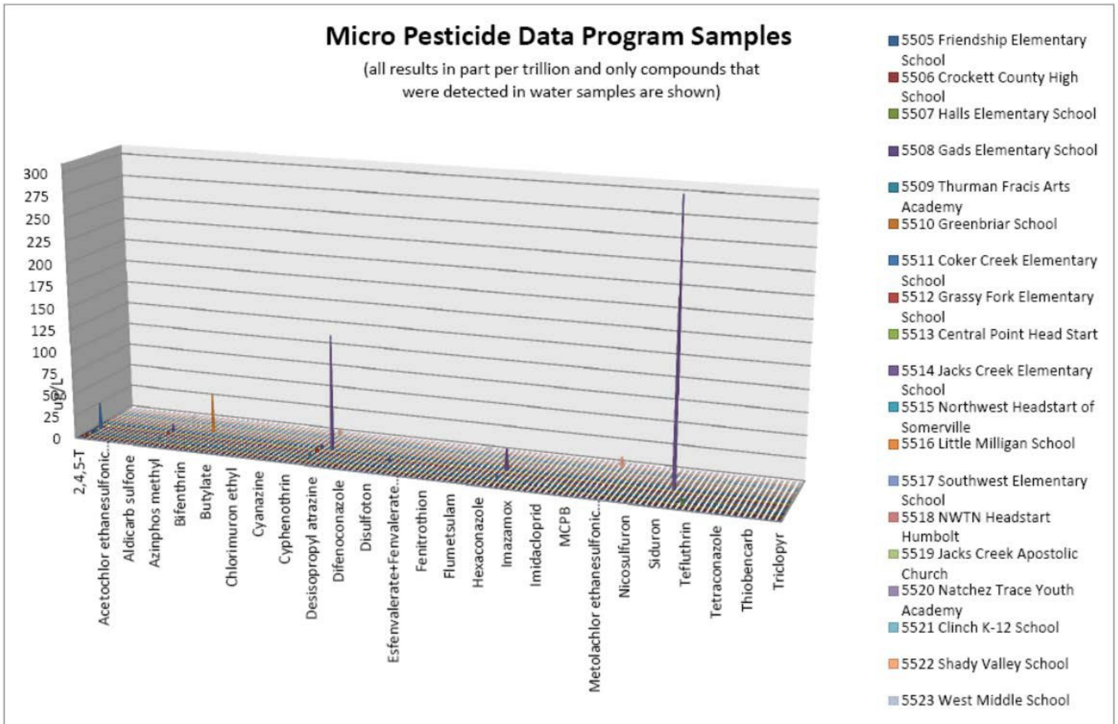


Figure 6

9.3 Pharmaceutical and Personal Care Product Sampling

The Division entered into a contract with the University of Tennessee in 2012. This contracted project was to provide TDEC with information on the prevalence and concentration of pharmaceutical compounds in select raw water treatments in Tennessee. The specific goals were to:

1) Analyze raw water treatment samples for select pharmaceutical compounds using analytical chemistry methods; and
2) Analyze raw water treatment samples for endocrine disrupting potential using recombinant yeast (*Saccharomyces cerevisiae*) bioreporter strains.

This project surveyed raw waters in Tennessee (surface water and groundwater) for the presence of both pharmaceutical compounds and endocrine disrupting compounds. Initially, select pharmaceutical compounds, including: caffeine, carbamazepine, DEET, 17α-ethinyl estradiol, fluoxetine and ibuprofen were analyzed using GC/MS or LCMS analytical methods. In order to supplement analytical testing for endocrine disrupting compounds, bioluminescent-based yeast (*Saccharomyces cerevisiae)*, reporters for the detection and quantification of estrogenic and androgenic chemicals were used on each sample (Sanseverino et al. 2008). The combined use of these two strains allowed testing of chemicals for estrogenic and androgenic activity and provided rapid assessment of the prevalence of endocrine disrupting chemicals in water samples.

Fifteen chemicals were analyzed by gas chromatography mass spectroscopy (GC/MS) and hormonal activity for both estrogens and androgens using bioassays (Table 1). These compounds were selected to represent a range of chemical classes including household and industrial chemicals, herbicides, prescription and over the counter drugs and fecal indictors. The only chemical tested with a regulatory limit set by EPA was atrazine (3 µg/L) and no samples contained concentrations above this concentration. When detected, the chemical concentrations were consistent with the range of values reported for surface and drinking water (*1-3*) at concentration in the low ppb range (µg/L) and lower. The literature also indicates that chemical concentrations are generally higher and more frequently detected in surface than groundwaters.

Table 2 conveys the Compounds tested, the functional class, the minimum detection limit, the maximum concentration detected in any of the 348 samples tested and reported acceptable concentrations.

Compound	**Class**	**MDL (µg /L)**	**Maximum Conc (µg/L)**
Diethyl phthalate	Plasticizer	10	4000 = 4.000 µg/L
Bisphenol A	Plasticizer	100	2305 = 2.3 µg/L
4-tert-Octylphenol	Nonionic detergent	10	92 = 0.092 µg/L
4-nonylphenol	Nonionic detergent	10	123 =0.123 µg/L
Irgasan (Triclosan)	Antimicrobial	250	324 = 0.324 µg/L
Atrazine	Herbicide	10	857 = 0.857 µg/L
DEET	Insect repellant	10	43 = 0. 043 µg/L

Fluoranthene	PAH	4	26 =0.026 µg/L
Ibuprofen	OTC painkiller	1000	5236 =5.236 µg/L
Cotinine	Nicotine metabolite	50	445 = 0.445 µg/L
Caffeine	Stimulant	10	210 = 0.21 µg/L
Fluoxetine (Prozac)	Antidepressant	50	0
Carbamazepine	Anticonvulsant	100	146 = 0.146 µg/L
Sertraline (Zoloft)	Antidepressant	10	281 = 0.281 µg/L
Coprostanol	fecal steroid	75	912= 0.912 µg/L
Estrogen	Hormone	0.5	10.3 = 0.010 µg/L
Androgen	Hormone	9	0

Table 2

Of the 348 water samples collected, positive for a particular chemical ranged from a high of 166 for diethyl phthalate (48%) to 0 (0%) for fluoxetine (Figure 9). The most frequently detected class of chemicals was the plasticizers, pesticides and detergents. The least frequently detected compounds were the pharmaceutical compounds (except sertraline). The number of chemicals detected out of 16 ranged from 0 to 10 (Figure 10). No chemicals were detected in 31% of the samples and only one chemical was detected in another 28% of the samples. Four or more chemicals were detected in 15% of the samples.

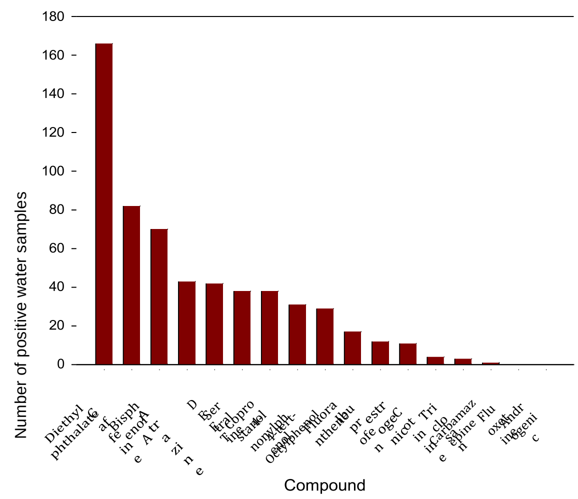


Figure 7. Number of water samples (out of 384 samples) positive for each chemical.

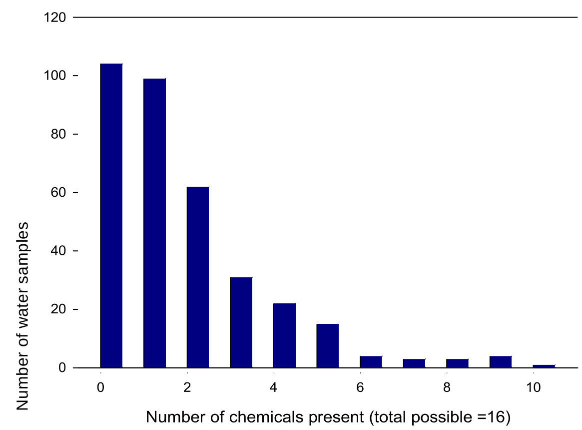


Figure 8. Number of chemicals (maximum 16) detected in each water sample (384 samples).

The percent of water samples with at least one detection at 69% is similar to percentages reported for groundwater (81%) (*3*), untreated drinking water sources (91%) (*2*), streams (80%) (*1*) and summarized by USGS: http://toxics.usgs.gov/highlights/gwsw_ec.html. Also, several compounds measured in the TN water samples and the 3 other studies were found at similar frequencies. For example, bisphenol A was found in 20% to 40% of the water samples in the above studies and at 20% in this study and ibuprofen was less abundant and found in 1.4% to 9.5% of the water samples in the above studies and in 3.4% of these water samples. Fluoxetine and androgens were not found in any of the samples.

In order to determine whether there was a difference in frequency or types of chemicals detected in surface water versus groundwater, the dataset was sorted by water source with 185 samples representing groundwater and 163 samples representing surface water. The surface water data contained a higher number of samples with 4 or more chemicals detected and fewer samples with <1 chemical detected than the groundwater samples (Figures 11 & 12). In the surface water, the average number of chemicals detected for each sample was 4.7 whereas in groundwater the average number of chemicals detected was 1.1. The frequency of detection for several chemicals also differed greatly between the surface water and groundwater, with caffeine and coprostanol found in 22- and 13- fold more frequently in surface water than groundwater and DEET, diethyl phthalate, atrazine, Ibuprofen was found 2- to 5- fold more frequently in surface water than groundwater. Two compounds, bisphenol A and 4- nonylphenol, were found more frequently in groundwater than surface water.

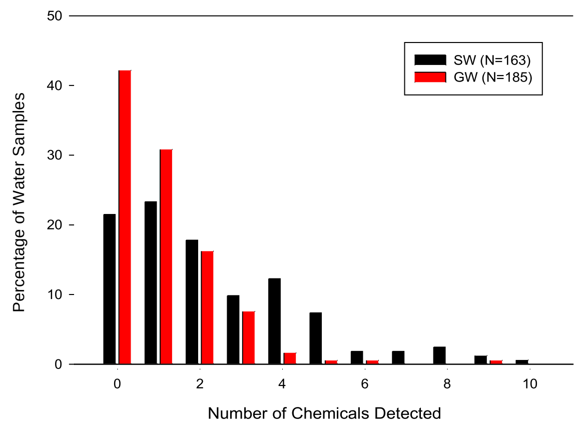


Figure 9. Percentage of surface water (SW samples and groundwater samples containing 0 to 10 chemicals.

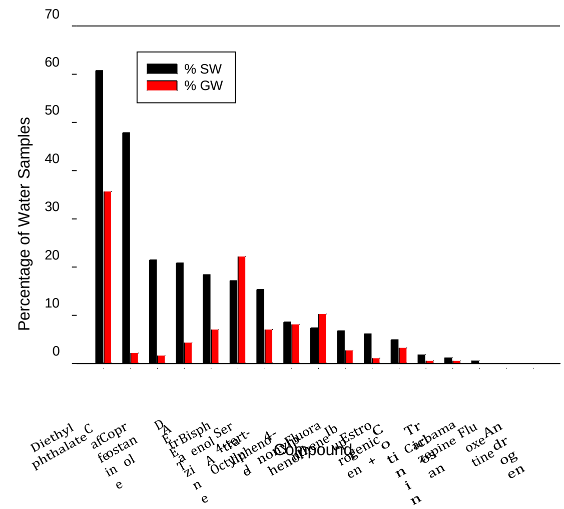


Figure 10. Percentage of surface water (SW) and groundwater (GW) samples positive for each chemical.

These results suggest that untreated drinking water sources in Tennessee have similar levels of trace organic contaminants with respect to both concentration and frequency of occurrence to water found in other parts of the United States. In addition, as may be expected, the frequency of detection of most of the chemical contaminants was higher in surface water than groundwater.

9.4 Development of Groundwater Sampling Database

The groundwater sampling project allows the State to collect data from approximately 50 different locations across the state to help in the development of a groundwater monitoring network. These initial locations were chosen primarily due to the fact that each of these systems were the source of drinking water for children, youth, and young adults. This project also allows the state to collect information on water systems that only operate during a short time frame but reach a large population of children and youth.

Tennessee is currently developing a process and pattern for a more comprehensive groundwater monitoring program. Future plans include a more robust analysis of historical data available for groundwater quality from other sources (e.g., USGS) and a more detailed evaluation of spatial distribution of historical and current sampling locations as it relates to different aquifer regions in the state. A series of six spring locations were recently added to the ambient groundwater monitoring network due to their significance in representing groundwater quality for large karst groundwater recharge basins.

The groundwater monitoring program continues to be refined to a list of parameters that twill be sampled at these sites in the future. The project continues to aim at providing insight to aquifer characteristics and water quality in aquifers to inform the citizens of Tennessee.

This project will meet several of EPA's strategic goals listed in the states 106 groundwater work plan. These strategic goals include: groundwater monitoring, we will be establishing the criteria and honing the sampling protocols for monitoring and data collection; environmental justice, several of these sites are head start facilities that are established in rural areas; wellhead protection activities, some of these locations serve systems with well head protection areas and will allow staff to conduct on the ground surveys of the facilities; data management, all information collected will be placed in an electronic format and used in GIS mapping; and aquifer characterization, this sampling will allow the state to start collecting information on certain aquifers within the state in hopes to better understand groundwater quality.

9.5 TNH2O Tennessee's Water Plan

In January 2018, Governor Bill Haslam appointed a steering committee of leaders from federal, state, and local governments; industry; academia; public and private utilities; and environmental advocacy groups to develop a statewide plan for future water availability in Tennessee looking out to 2040. The plan, *TN H2O: Tennessee's Roadmap to Securing the Future of Our Water Resources*, assesses current water resources and makes recommendations to ensure that Tennessee has abundant water resources to support future population and economic growth through 2040.

A copy of the plan can be reviewed at:

https://www.tn.gov/content/dam/tn/environment/documents/TN_H2O_REPORT.pdf

9.6 PER AND POLYFLUOROALKYL SUBSTANCES (PFAS)

EPA is required under the Unregulated Contaminate Monitoring Rule (UCMR) to evaluate if any new contaminates need to be regulated. In the 2013-2015 UCMR requirements EPA placed five perfluoroalkly substances on the list. Samples collected from January 2013 – December 2015 by Public Water Systems (PWSs) serving >10,000 people. That meant that one hundred thirty-one (131) Tennessee community Water Systems monitored quarterly for 1 year. During that time period Tennessee had only one (1) detection of a PFOA. This detection was not in groundwater but in a surface water intake on the East Fork of the Stones River.

The Division also intends to utilize State Revolving Fund (SRF) Set Aside monies to sample PFOAs/PFAS at public water systems in the future.

10.0 Source Water Protection: Protecting Public Drinking Water Supply Sources

10.1 Regulatory Changes

There have been significant developments at the State level since EPA's approval of Tennessee's Source Water Assessment Program in 1999 and the submittal of the assessments to EPA in 2003. Most significant for Source Water Protection are the changes made in the Tennessee Safe Drinking Water Act in 2002 at the request of the Division of Water Resources. Prior to this amendment, Tennessee Code Annotated (TCA) §68-221-711 (5) prohibited only the discharge of sewage above an intake.

After some difficulties in addressing a specific problem where it was difficult to ascertain which agency should/could respond, language was successfully added (bolded in italics) that prohibits:

> "The discharge by any person of sewage ***or any other waste or contaminant*** at such a proximity to the intake, ***well or spring*** serving a public water system in such a manner or quantity that it will or will likely endanger the health or safety of customers of the system or cause damage to the system."

Tennessee considers this a significant achievement toward Source Water Protection that is not available at the federal level. In addition, another amendment was proposed and successfully added to the Tennessee Safe Drinking Water Act that incorporates water quantity issues but that can easily become a water quality issue as well. Prior to amendment, TCA §68-221-711(8) prohibited heavy withdrawal from a water supply (water supply lines).

After concerns over addressing a major commercial water withdrawal in vicinity to a water supply spring and at the request of the Division of Water Resources, an additional prohibition was added (bolded in italics):

> "The heavy pumping or other heavy withdrawal of water from a public water system ***or its water supply source*** in a manner that would interfere with existing customers' normal and reasonable needs or threaten existing customers' health and safety."

With this new authority to protect water supply sources within the Act, the Division of Water Resources promulgated regulations in October of 2005 to include complimentary language to the former Wellhead Protection Rule 0400-45-1-.34. Language was added to the Rule that gives the Division authority to address certain high risk activities in the vicinity of water supply intakes, wells and springs that might otherwise be unregulated. The Rule is now titled "Drinking Water Source Protection" and also includes contaminant inventory and emergency operation requirements for water systems using surface water intakes in addition to the wellhead protection requirements for groundwater systems that were present previously.

In 2016 the Division changed the timeframe for submittal of Source Water Protection Area reports which are now due to the Division. The new requirements in Rule 0400-45- 01-.34(h) state; "Community and nontransient noncommunity systems using a surface water source shall submit complete contaminant source inventories, including maps, showing the potential contaminant sources at three-year intervals beginning on December 31, 2015. New water supply sources shall have source approvals in writing by the Department prior to initiation of operation as a public water supply source. An existing water system that was previously not designated as a public water system shall have sixty days upon notification of the determination as a public water system to submit source approval documentation for the Department's review". The systems are still required to maintain a yearly inventory for Sanitary Survey review.

10.2 Source Water Updates

The Division completed an update of potential contaminant sources within various source water protection areas across the state. During this effort, Division staff also verified the location of surface intakes and springs used to supply public water. An emphasis in the work completed was the location of on-site waste disposal systems and for any illicit discharges to the source water protection area. These efforts focused on areas shown by the State–EPA Nutrient Innovations Task Group when they released a document in August 2009 entitled "An Urgent Call to Action" which can be found at https://www.epa.gov/nutrient-policy-data/nutrient-innovations-task-group-documents . Water systems threatened by nutrients, pathogens, and Total Organic Carbon (TOC) are illustrated in Appendix A.

Every community public water system is also required to address their source water assessment in the Consumer Confidence Report (CCR). This report is required to be made available to the water system's customers annually.

The Drinking Water Unit, in conjunction with the Tennessee Association of Utility Districts, is working with other state and local agencies, water systems and local governments to develop localized source water protection plans within counties and watersheds. Also, the Division worked with the University of Memphis to produce a multi-part video on source water protection, which is available at https://www.youtube.com/watch?v=mD-NYVJgjdY.

10.3 Water Resources Technical Advisory Committee (WRTAC)

TDEC partnered with the federal and state agencies, nongovernmental organizations and other regional planning experts to form a Water Resources Technical Advisory Committee (WRTAC) and to initiate a water resources planning pilot in two areas significantly impacted by the drought of 2007.

WRTAC was authorized by the Tennessee Water Resources Information Act in 2008. One of the first tasks that the committee completed was the development of a framework for regional water supply planning, The committee then developed a rationale for establishing a ranking system for regional water supply plans as it relates to the State Revolving Fund (SRF) funding. This allowed regional plans to receive a higher ranking in the funding formula and also allowed a quicker review of regional plans with respect to TDEC reviews.

The Commissioner had requested that the committee produce a "Statewide System of basic Hydrologic and Water System Information." The committee also produced the "Regional Water Supply Plans Approval Process for Tennessee." Both of the documents can be found at:
https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-resources-regional-planning.html

10.4 North Central Tennessee Region, Southern Cumberland Region, and Proposed Southwest Highland Rim Studies Water Resources Planning Pilot

In late 2008, TDEC partnered with the U.S. Army Corps of Engineers Nashville District, members of the Advisory Committee and other regional planning experts to initiate a water resources planning pilot in two areas significantly impacted by the drought of 2007:

1) **North Central Tennessee region** – Sumner County, including Portland, Gallatin, Castalian Springs/Bethpage, White House and Westmoreland; and

2) **Southern Cumberland region –** consisting of portions of Franklin, Grundy, Marion, and Sequatchie Counties and the towns of Tracy City, Sewanee, Altamont and Monteagle.

The final reports for the South Cumberland Regional Water Resources Planning Study (June 2011) and the North Central Regional Water Resources Planning Study (December 2011) can be found at https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-resources-regional-planning.html .

11.0 Groundwater Protection and Remediation Activities

The Division serves as the state's coordinating agency for the development of a Comprehensive State Ground Water Protection Plan with EPA. A major focus of the program is Wellhead Protection under the Source Water Protection Program, which is protecting groundwater sources of public water systems. The Division also regulates groundwater discharges through management of the Underground Injection Control (UIC) program.

Primacy for the UIC program within Tennessee has been delegated to the Division and is currently administered by the Drinking Water Unit. Rule 0400-45-6 classifies injection wells as Class I through Class V. Tennessee has opted to ban all Class I hazardous waste injection wells (0400-45-6-.10(1)(a)) and Tennessee does not possess the mineral resources for Class III wells. Tennessee regulations do exist for Class I, Class II, Class III, Class IV, and Class V injection wells. Class IV wells are prohibited by Federal regulations, by provisions of state Rule 0400-45-6-.13 and are closed when encountered with the exception of operating these wells as part of an EPA- or state-authorized groundwater clean-up action. Tennessee's UIC program maintains primacy for Classes I-V of injection wells of the Underground Injection Control Program. EPA maintains primacy for Class VI injection wells which are a newer class of wells intended for geosequestration of carbon dioxide in the subsurface which continues to be a new field of research. There are no Class VI injection wells currently in Tennessee.

11.1 UIC Activities

Class I Injection Wells

11.1.1 Class I wells inject hazardous and non-hazardous wastes into deep, isolated rock formations that are thousands of feet below the lowermost Underground Source of Drinking Water (USDW).

Class I wells are used mainly by the following industries:

- Petroleum Refining
- Metal Production
- Chemical Production
- Pharmaceutical Production
- Commercial Disposal
- Food Production
- Municipal Wastewater Treatment

Currently, there are no Class I injection wells. Previously, Tennessee had a total of eleven Class I wells; however, all Class I wells have been plugged and abandoned and all Class I hazardous wells are now banned in Tennessee.

Historical Class I wells:

- 1966 DuPont chemical –New Johnsonville 6 wells drilled injection depth from 3650 to 7000 feet all closed by 1998
- 1969 Stauffer Chemical (ICI, Zeneca) –Mount Pleasant 4 wells drilled injection depth from 3000 to 6500 feet all closed by 1997
- 1979 Mobil Chemical (Rhone-Poulenc Chemical) –Mount Pleasant 1 well drilled injection depth from 4583 to 6413 ft. closed 1990

11.1.2 Class II Injection Wells

Class II wells inject fluids associated with oil and natural gas production. Most of the injected fluid is saltwater (brine), which is brought to the surface in the process of producing (extracting) oil and gas. In addition, brine and other fluids are injected to enhance (improve) oil and gas production.

For Fiscal Year 2019, there were 34 Class II injection wells.

11.1.3 Class III Injection Wells

Class III wells inject fluids to dissolve and extract minerals such as uranium, salt, copper, and sulfur. More than 50 percent of the salt and 80 percent of the uranium extraction in the United States involves the use of Class III injection wells.

Currently, there are no Class III injection wells in Tennessee.

11.1.4 Class IV Injection Wells

Class IV wells are shallow wells used to inject hazardous or radioactive wastes into or above a geologic formation that contains a USDW. In 1984, EPA banned the use of Class IV injection wells for disposal of hazardous or radioactive waste. At this time, these wells may only be operated as part of an EPA- or state-authorized groundwater clean-up action.

11.1.5 Class V Injection Wells

Class V wells are used to inject non-hazardous fluids underground. Most Class V wells are used to dispose of wastes into or above underground sources of drinking water and can pose a threat to groundwater quality, if not managed properly.

Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground. There are over 20 well subtypes that fall into the Class V category and these wells are used by individuals and businesses to inject a variety of non- hazardous fluids underground.

For Fiscal Year 2019, there were 4,956 Class V injection wells.

12.0 Public Education and Outreach

April 2016	Remediation Workshop Knoxville
May 2016	EPA State Directors Meeting
May 2016	Tennessee Oil And Gas Association
June 2016	Tennessee Emergency Management Agency
July 2016	Tennessee Kentucky Water Conference
September 2016	Brentwood Environmental Education Day
October 2016	EPA State Directors Meeting
November 2016	West Tennessee Water Well Meeting
November 2016	Elk River Watershed Meeting
November 2016	Belvidere Source Water Meeting
February 2017	Tennessee Source Water Forum
February 2017	Middle Tennessee State University Geology Masters Series
March 2017	Tennessee Water Well Association
March 2017	Area Wide Optimization Program (AWOP) meeting
April 2017	Middle Tennessee State University Geology Masters Series
April 2017	Remediation Workshop Nashville
April 2017	American Water Works Association meeting
May 2017	Remediation Workshop Knoxville
May 2017	Duck River Watershed Meeting
June 2017	Smyrna Water Fest Day
October 2017	Brentwood Education Day
November 2017	Elk River/Duck River Watershed
November 2017	West Tennessee Water Well Drillers
February 2018	Small System Training Fleming Training Center
February 2018	West Tennessee Water Symposium
March 2018	Tennessee Association of Utility Districts Class
March 2018	Tennessee Water Well Association
March 2019	Tennessee Association of Utility Districts Class
March 2019	Tennessee Water Well Association (East Region)
April 2019	Tennessee Water Resources Symposium
May 2019	Environmental Show of the South
September 2019	Stones River Waterfest
October 2019	Brentwood Environmental Education Day
November 2019	Tennessee Water Well Association (West Region)

13.0 Groundwater Withdrawals and Use

13.1 Water Withdrawal Registration

The Division collects information on the withdrawal and use of water within Tennessee. The information is used to identify water uses and resources that may require management at critical times, especially drought conditions. The purpose of the program is to protect the water resources of Tennessee from over-utilization.

Under the authority of the Water Resources Information Act of 2002 and TCA Section 69-7-301, water withdrawals of 10,000 gallons or more on any day in Tennessee must be registered. The Division of Water Resources collects water withdrawal data from public water systems and industrial systems through a self-reported system. This data is shared with the USGS on a five year cycle to support their development of a five year report on water use in the United States. The USGS report is supplemented with modeled data for domestic and agricultural withdrawals, which are not collected by the Division. Reported below are nationwide and Tennessee-specific data from USGS Circular 1441.

Tennessee's Annual Water Withdrawal (2015):

- Total= 2,343,300 MG
- Surface Water = 2,186, 350 MG or ~ 93%
- Groundwater = 195,535 MG or ~7%

Tennessee's groundwater utilization is highest as a percentage of total withdrawals in west Tennessee (Figure 11). West Tennessee's access to the Memphis Sands Aquifer distinguishes it from the counties in the rest of the state which are more likely to rely on surface water withdrawals.

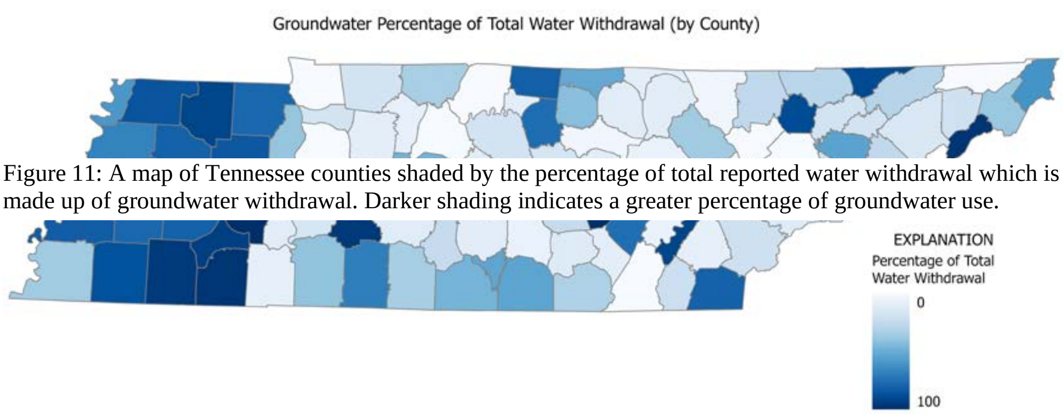


Figure 11: A map of Tennessee counties shaded by the percentage of total reported water withdrawal which is made up of groundwater withdrawal. Darker shading indicates a greater percentage of groundwater use.

Otherwise, the majority of Tennessee's annual water withdrawals come from surface water, which are largely used to support thermoelectric power generation, followed by industrial applications, and public water supply (Figure 12, Table 3). Over half of the state's reported daily groundwater withdrawals are for public water supplies (making up approximately one quarter of the sector's source water statewide).

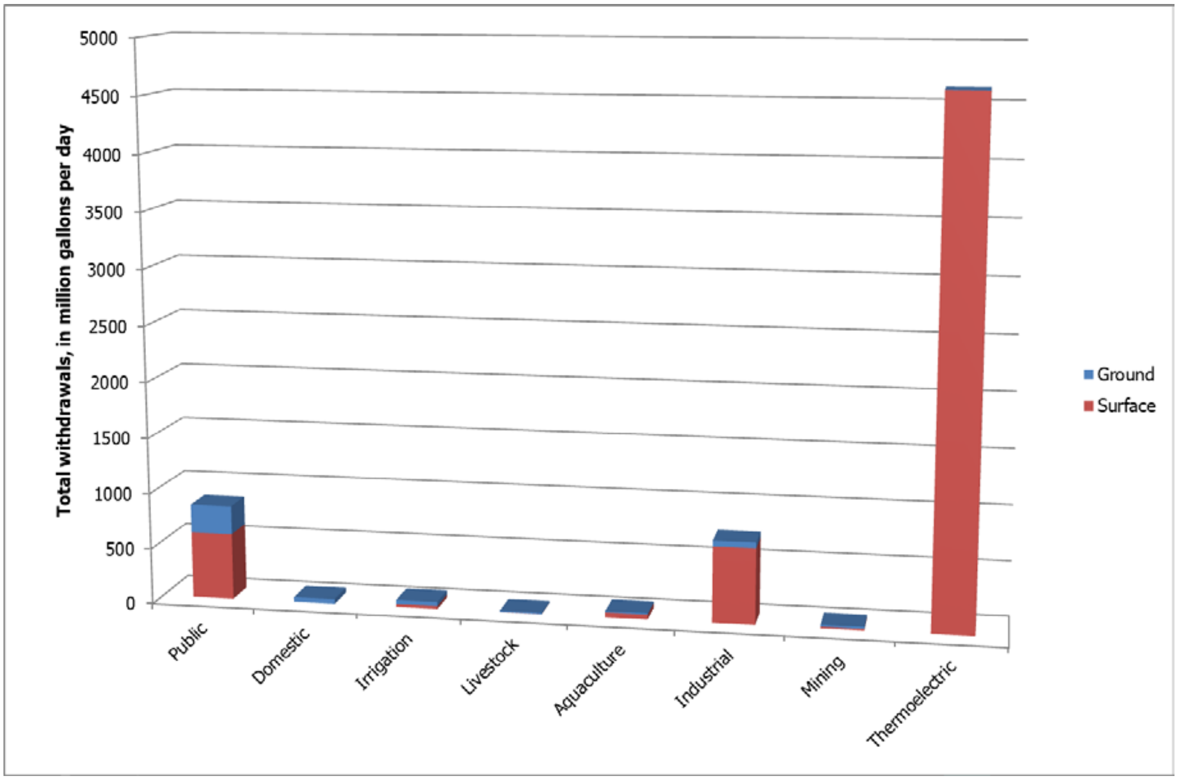


Figure 12: Stacked bar chart displaying total withdrawals in million gallons per day by use category from 2015. Contributions of groundwater and surface water to are delineated by color in each bar.

Table 3: Surface and groundwater withdrawals reported in million gallons per day by use category from 2015. Data is displayed in Figure 2.

	Surface (MGD)	Ground (MGD)
Public	594	256
Domestic	0	42.8
Irrigation	27.4	36.4
Livestock	1.5	12
Aquaculture	45.2	11.7
Industrial	682	51.6
Mining	14.2	17.1
Thermoelectric	4620	2.18
Total (MGD)	5,990	430

The distribution of Tennessee's water withdrawals by category are similar to other states in the Eastern U.S. where thermoelectric power generation receives the proportion and supply (Figure 13). Tennessee has five TVA coal-fired power plants and two nuclear power plants. Tennessee's lower utilization of groundwater compared to surface water is also similar to the water withdrawal patterns of states in the Eastern U.S..

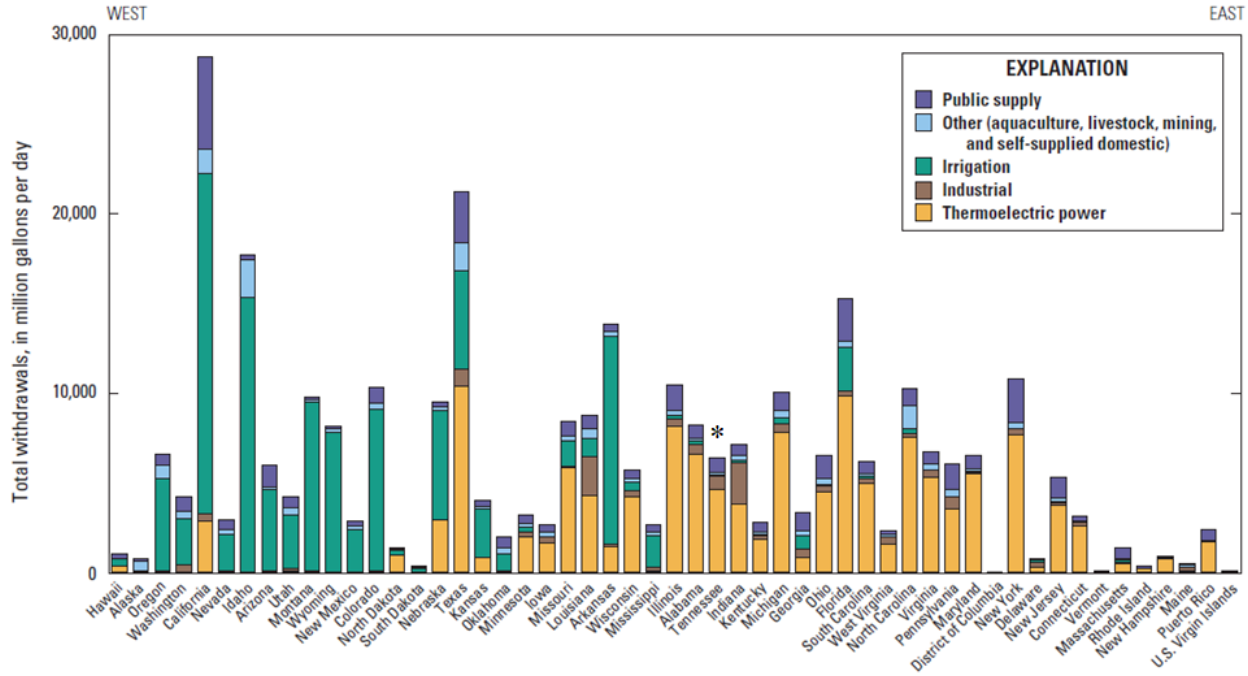
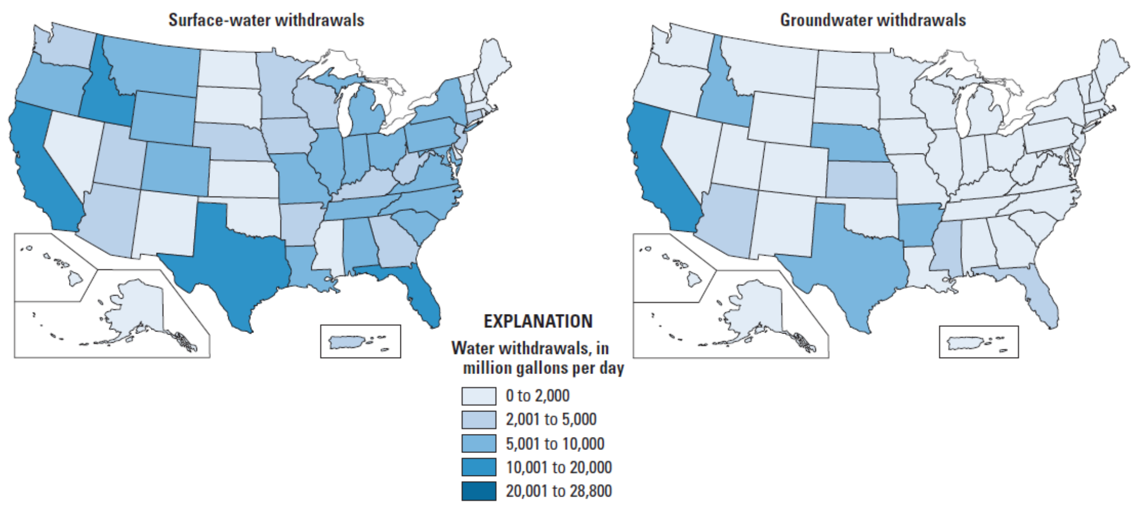


Figure 13: Total water withdrawals by state, and bar chart showing categories by State from west to east, 2015. Taken from USGS Circular 1441. Asterisk added Tennessee for emphasis.



Further information regarding groundwater withdrawals and use can be found in USGS circular 1441:

Dieter, C.A., Maupin, M.A., Caldwell, R.R., Harris, M.A., Ivahnenko, T.I., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2018, Estimated use of water in the United States in 2015: U.S. Geological Survey Circular 1441, 65 p., https://doi.org/10.3133/cir1441. [Supersedes USGS Open-File Report 2017–1131.]

The Division of Water Resources will be organizing its 2016-2020 withdrawal data in early 2021 to submit to USGS for its next five year report on nationwide water use.

13.2 Water Wells Program

The Water Well Program housed in the Drinking Water Unit licenses well drillers and associated activities. Licensed individuals must develop wells and install equipment according to standards, which are designed to protect the resource and insure consumers of a safe and reliable structure. A list of total number of wells reported since 2007 is provided in Table 4.

The duties of the Commissioner are given in TCA Section 69-10 and include, among other things, the authority to:

- License drillers, pump installers, and water treatment device installers
- Inspect well construction
- Investigate complaints
- Promulgate Rules relative to well construction

Year	Total Number of Wells Reported
2007	5158
2008	4173
2009	2713
2010	2365
2011	2554
2012	2868
2013	2606
2014	2231
2015	2128
2016	2493
2017	2106
2018	2202
2019	2131

Table 4

A breakdown of newly drilled water wells and geothermal wells drilled in 2019 by county shows the most active counties for groundwater use by private citizens. At this time, there is no requirement for test wells or monitoring wells to be reported. A listing of well types by county for 2019 is shown in Table 5.

Table 5

2019 Water Well Data by County and Use

County	Commercial	Farm	Heat Pump	Industrial	Irrigation	Municipal	Other	Residential	Test	Grand Total
ANDERSON								2		**2**
BEDFORD		14			2			7		**23**
BENTON								18		**18**
BLEDSOE		1			2		1	24		**28**
BLOUNT					4			32		**36**
BRADLEY	1	1						17		**19**
CAMPBELL					1		1	8		**10**
CANNON					1			17		**18**
CARROLL					1			15		**16**
CARTER	1							20		**21**
CHEATHAM			1		1			13		**15**
CHESTER		2			1			33		**36**
CLAIBORNE		10						23		**33**
CLAY		2								**2**
COCKE		2						45		**47**
COFFEE		1	1		1			10		**13**
CROCKETT					1	1		10		**12**
CUMBERLAND			1		1			11		**13**
DAVIDSON	1	1	13		3			4		**22**
DECATUR								7		**7**
DEKALB		3			2			6		**11**
DICKSON			1		2			17		**20**
DYER		2					3			**5**
FAYETTE		3			2		2	95		**102**
FENTRESS		2			1			6		**9**
FRANKLIN		4			3			5		**12**
GIBSON	1	6			2			26		**35**
GILES		2	1					5		**8**
GRAINGER		23						38		**61**
GREENE		5			1			14		**20**
GRUNDY		2					1	12		**15**
HAMBLEN		2						5		**7**
HAMILTON	2	2			2			13		**19**
HANCOCK		13						23		**36**
HARDEMAN		5						40		**45**
HARDIN					1			2		**3**
HAWKINS		12					1	37		**50**
HAYWOOD		1						9		**10**
HENDERSON		1						8		**9**

HENRY	1	2					1	21		**25**
HICKMAN								30		**30**
HOUSTON		1						6		**7**
HUMPHREYS	1						3	51		**55**
JACKSON		3						5		**8**
JEFFERSON		4			1			46		**51**
JOHNSON		1				2		19		**22**
KNOX					13			30		**43**
LAKE					6		5			**11**
LAUDERDALE		1						2		**3**
LAWRENCE	1					2		46	1	**50**
LEWIS	1	2			1			28		**32**
LINCOLN	1	1			3			4		**9**
LOUDON					1			11		**12**
MACON		5						4		**9**
MADISON	2	3		1		1		36		**43**
MARION		1					1	30		**32**
MARSHALL		2	1		1			37		**41**
MAURY	1	1	3		1			8		**14**
MCMINN		3						45		**48**
MCNAIRY		1						10	1	**12**
MEIGS		1						11		**12**
MONROE		3						38		**41**
MONTGOMERY								2		**2**
MOORE		2						1		**3**
MORGAN								4		**4**
OBION					4			2		**6**
OVERTON		1	1					9		**11**
PERRY		1			4	1		7		**13**
POLK		1						16		**17**
PUTNAM	2	1						6		**9**
RHEA		1			6			7		**14**
ROANE	1							7		**8**
ROBERTSON		1						5		**6**
RUTHERFORD	1	4	5		19			17		**46**
SCOTT								1		**1**
SEQUATCHIE	1	1						11		**13**
SEVIER	1	1						135		**137**
SHELBY					3		2	1		**6**
SMITH		1						3		**4**
STEWART		1						21		**22**
SULLIVAN		3					2	9		**14**
SUMNER		1	3		3			8		**15**

TIPTON					2		1	14		**17**
UNICOI								12		**12**
UNION		2						28		**30**
VAN BUREN		2						13		**15**
WARREN		2			4			1		**7**
WASHINGTON		2	1					10		**13**
WAYNE								22		**22**
WEAKLEY		24		1	1		5	34		**65**
WHITE		2			3			3		**8**
WILLIAMSON		3	15		41		1	29		**89**
WILSON		5	2		5			12		**24**
Grand Total	**20**	**219**	**49**	**2**	**157**	**7**	**30**	**1645**	**2**	**2131**

APPENDIX A

Acronyms

CCR	Consumer Confidence Report
DRMA	Duck River Management Authority
DWS	Division of Water Supply
DWU	Drinking Water Unit
EFO	Environmental Field Office
EPA	Environmental Protection Agency
GC/MS	Gas Chromatography Mass Spectroscopy
GIS	Geographic Information System
µg/L	Microgram per liter
M/gal	Million Gallons
MCL	Maximum Contaminate Level
MPDP	Micro Pesticide Data Program
NGWA	National Ground Water Association
NOI	Notice of Intent
pCi/L	Picocurie per liter
PPCP	Pharmaceutical and Personal Care Product
RCAP	Rural Communities Assistance Program
SRF	State Revolving Fund
SWPA	Source Water Protection Area
TAUD	Tennessee Association of Utility Districts
T.C.A.	Tennessee Code Annotated
TDEC	Tennessee Department of Environment and Conservation
TDG	Tennessee Division of Geology
TGS	Tennessee Geologic Survey
TOC	Total Organic Carbon
TVA	Tennessee Valley Authority
UIC	Underground Injection Control
UM GWI	University of Memphis Ground Water Institute
USDA	United States Department of Agriculture
USDW	Underground Source of Drinking Water
USGS	United States Geologic Survey
UT CEB	University of Tennessee Center for Environmental Biotechnology
WHPA	Well Head Protection Area
WPC	Water Pollution Control
WRTAC	Water Resource Technical Advisory Committee

APPENDIX B

References

USGS Fact Sheet FS-027-02, Pharmaceuticals, Hormones and Other Organic Wastewater Contaminants in U. S. Streams; June 2002

USGS Circular 1344 Use of Water in the United States in 2005

Layton, Alice, Fu-Min Menn and Melanie Eldridge, Survey of pharmaceuticals and personal care products in untreated drinking water, University of Tennessee Center For Environmental Biotechnology June 2011

Protection of Potable Water Supplies In Tennessee Watersheds 2014 Report, Tennessee Department of Environment and Conservation Division of Water Resources 2014

The South Cumberland Regional Water Resources Planning Study and the North Central Regional Water Resources Planning Study can be found at the Water Resources Regional Planning web site: http://www.tn.gov/environment/regionalplanning/