2025 Annual Monitoring Report

Western North Carolina Recreational Water Quality Monitoring Program

Division of Water Resources
North Carolina Department of Environmental Quality

Prepared By:

Rachel Rose
Program Coordinator for WNC Recreational Water Quality Monitoring Program
Water Quality Regional Operations, Division of Water Resources
Asheville Regional Office
North Carolina Department of Environmental Quality
2090 US-70
Swannanoa, NC 28778

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1.0 Executive Summary

Western North Carolina (WNC) is a heavily recreated region known for many outdoor activities centered on surface water related recreation activities. The North Carolina Department of Environmental Quality (NC DEQ), Division of Water Resources (DWR) developed the WNC Recreational Water Quality Monitoring Program (WNC Rec Program) to provide a state-managed program for monitoring water quality, specifically fecal indicator bacterium, at inland freshwater recreated sites.

The WNC Rec Program assesses water quality at frequently recreated freshwater sites throughout the recreational season (Memorial Day through Labor Day) using a dual approach: samples collected weekly at select locations that are analyzed in the lab and a real-time *Escherichia coli* (*E. coli*) estimator (i.e., modeling). In 2025, the WNC Rec Program sampled 54 frequently recreated sites across WNC (Figures 1-6). Figure 7 displays the 2025 sampling sites along with the impaired surface waters in WNC. This comparison shows that many of the frequently recreated sites in WNC are impaired for one or more North Carolina surface water standards (e.g., fecal coliform) which highlights the importance of a program that monitors water quality at these frequently recreated sites. The *E. coli* estimator leverages the statistical correlation between turbidity and *E. coli* at a prevalently recreated site along the French Broad River that allows for a statistical model that yields a real-time estimation of *E. coli* levels (French Broad at Pearson Bridge *E. Coli* Estimator). A third component of the program, currently in development, will utilize digital polymerase chain reaction (dPCR) analyses to add to the weekly analytical results and the *E. coli* estimator site. The application of dPCR analyses offers a more advanced and informative water quality indicator (e.g., human fecal genome marker HF183) compared to solely culture-growth-based *E. coli* samples.

In late 2024 and early 2025, the WNC Rec Program initiated an off-season (November 2024 through April 2025) water quality monitoring program to evaluate the impacts from Tropical Storm Helene. Data from that sampling effort allowed DWR staff to identify damaged wastewater infrastructure, monitor the recovery of recreated sites, and convey analytical results to inquiring citizens regarding impacts and ongoing water quality conditions during the cleanup and recovery process (Helene AMS Sampling Results Dashboard).

The 2025 recreational season also included the development of the GIS Dashboard map which was designed to publicly display detailed data collected by the WNC Rec Program in addition to the Swim Guide. The sites that DWR sampled throughout the 2025 recreational season had 42,000+ website views on Swim Guide and the new GIS Dashboard had 1,964 website views in the same time frame. The *E. coli* real-time estimator website had 7,800 website views from January through October. The WNC Rec Program processed a total of 840 samples from 54 recreational sites across WNC. During the 2025 recreational season, 24% of the *E. coli* results were within the primary recreational guidance values (<126 MPN/100mL), 59% were within the secondary recreational guidance values (126-886 MPN/100mL), and 17% were in the increased exposure/health risk recreational guidance values (>886 MPN/100mL).

2.0 Introduction

2.1 Program Purpose and Goals

With the substantial amount of surface water related recreational activities across WNC, concerns about the quality of the water and related risk of exposure for water recreationalists are abundant. Currently, there are no federally mandated inland recreational water quality standards equivalent to the BEACH Act. Due to the inherent variability of inland freshwater systems (e.g. rivers, creeks, lakes, etc.), a nationally mandated program has never been implemented. As a result, it's been up to the discretion of the individual states or local health programs whether they develop an inland freshwater recreational water quality monitoring program. Until 2022, North Carolina's only state agency based recreational monitoring program with appropriated funding was implemented under the Division of Marine Fisheries which monitors over 200 sites along the coast during the recreational season which is delegated from the BEACH Act (NC Recreational Water Quality Program). The WNC Rec Program was developed to fill the gap and provide a state managed program that provides water quality information for inland freshwater recreated sites. The WNC Rec Program combines efforts to provide inland freshwater water quality monitoring at frequently recreated sites throughout the recreational season by both taking weekly samples of *E. coli* and turbidity at select locations and by providing a real-time *E. coli* estimator to recreators in the region. The weekly water sampling effort uses traditional laboratory testing to provide accurate *E. coli* measurements but results in a delay between sampling and reporting. The *E. coli* estimator is a predictive tool developed by DWR which uses live turbidity readings to estimate *E. coli* levels in near real-time. This combined strategy bridges the gap between traditional monitoring and timely risk assessment communication, ensuring recreational users receive reliable and timely water quality information.

The mission of the WNC Rec Program is to engage existing community resources by ensuring sample quality, accurate interpretation, and aggregation of data in the development of a science based recreational water quality program in the Western region of North Carolina while improving upon risk communication regarding recreation in inland waters. One major benefit of the WNC Rec Program is the positive economic impact to North Carolinians, especially in Western North Carolina, through support of water recreationalists and the water-based tourism industry. The total economic impact of the French Broad River and its tributaries is estimated at $3.8 billion annually (French Broad Partnership Business and Recreation Work Group). The WNC Rec Program complements efforts by collaborating partners in supporting the regional recreational tourism economy through increased awareness of water quality conditions so users can make informed decisions regarding exposure. After the effects of Tropical Storm Helene, and the resulting impacts on river system, the WNC Rec Program is as important as ever to the economy of Western North Carolina.

2.2 Program Background

In FY22, the State legislature allocated $100,000 in state-appropriated, recurring funds for the development of a water quality monitoring program in WNC. This legislative funding was used to further develop and support the WNC Rec Program and is primarily used for staffing, field/lab equipment, and supplies. The WNC Rec Program has utilized two temporary staff for sampling collection and analyses (e.g., *E. coli*, turbidity, etc.) during the sampling seasons (May – September) since 2022. The DWR Asheville Regional Office (ARO) Water Quality Regional Operations Section staff along with the new permanent positions for the WNC Rec Program complement efforts by the WNC Rec Program's temporary staff assisting in sample collection and coordination (e.g. technical consult, sample collection, etc.) with collaborating entities to ensure overall program delivery.

Development of *E. coli* Recreational Guidance Values

From the program's inception in May 2019, it was recognized that a cornerstone of the program would need to include the establishment of a recreational advisory threshold for *E. coli* to interpret sampling data and predicative modeling. In the absence of a North Carolina surface water standard for *E. coli* at the time coupled with the growing river use industry in Asheville and continued monitoring by Riverkeepers in the area and across North Carolina for *E. coli*, consistent communication of the risks associated with *E. coli* exposure was needed. Beginning in June 2019, the WNC Rec Program initiated a series of discussions with key stakeholders including the North Carolina Department of Health and Human Services (NC DHHS), local health officials, DWR Classifications & Standards Branch staff, and others regarding the establishment of recreational advisory values that could be applicable to freshwater river systems. In March 2019, WNC Rec Program also requested that NC DHHS evaluate a secondary recreation value to better align with the recreational activity type commonly practiced (e.g. tubing, kayaking, fishing, and paddleboarding). WNC Rec Program provided NC DHHS with the January 2022 *White Paper, An Approach for Applying EPA's 2012 Recreational Water Quality Criteria Recommendation to Non-primary Contact Exposure Scenarios* (U.S. EPA, 2022) for reference.

By May 2022, NC DHHS had informally begun indicating that use of 126 MPN/100mL and 886 MPN/100mL for *E. coli* as a primary and secondary advisory value, respectively, would be the expected results of their ongoing evaluation. The basis of this decision was cited directly as the EPA's 2012 Recreational Water Quality Criteria (RWQC) for determination of the primary value (U.S. EPA, 2012). The secondary recreational value was calculated by NC DHHS using the 2022 EPA White Paper cited above in addition to other literature. The final NC DHHS decision on recreational advisory values was published on October 7, 2022 (NC DHHS, 2022).

Currently in North Carolina, many entities (e.g., Riverkeepers, County Health Departments, inland beach owners, etc.) sampling for recreational advisory purposes are providing guidance based on EPA's 2012 RWQC or their own regulations that adopt the RWQC approach. However, there are differences in application such as the use of 235 MPN/100mL *E. coli* as an advisory level for a single sample for some groups and others using 235 MPN/100 mL in combination with a geometric mean.

As NC DHHS' 2022 Water Quality Advisory Recommendation publication explains, the fresh water recreational guidance values for *E. coli* are 126 MPN/100mL for primary recreation and 886 MPN/100mL for secondary recreation. These guidance values were used to create the recreational guidance categories used by the WNC Rec Program for *E. coli* exposure in recreational waters in WNC. These three categories are <126 MPN/100mL for primary recreation, 126-886 MPN/100mL for secondary recreation, or >886 MPN/100mL for increased exposure/health risk. Primary recreation refers to full-body contact activities such as swimming and snorkeling that have a higher risk for ambient water *E. coli* ingestion or exposure. Secondary recreation refers to activities such as canoeing, kayaking, rafting, tubing, etc. that have a lower risk for ambient water *E. coli* ingestion or exposure. These guidance values are not enforceable standards but are intended to inform the public about the scenarios where there may be an elevated health risk.

3.0 Program Components

3.1 Program Partnerships

One of the key tenets of the WNC Rec Program is to actively leverage local non-profit groups, government entities, and volunteer networks that have a similar mission or goal centered around the water quality of WNC. Developing these partnerships has many benefits including sharing resources, expanding the breadth of the sampling area, gathering local information on new recreated sites to sample, obtaining permission to sample on private property, promoting local watershed groups, and reducing analytical costs for partners. The extent of engagement for these partnerships with the WNC Rec Program can range anywhere from assisting with the collection of the weekly analytical samples to obtaining permission to sample on their private property. While the degree of involvement from the partnerships varies, all partnerships with WNC Rec Program play an important role in supporting and developing the shared goal of improving water quality and communicating health risk related to exposure. For some partnerships, the WNC Rec Program can highlight these local groups and help increase public awareness of such groups and entities in the region. All partnerships involved with the WNC Rec Program are an integral part of the program and are greatly appreciated and valued for all the work and assistance they have provided to the program and to the recreators of WNC. Some of the key partnerships that have been highly involved with the WNC Rec Program since its inception are MountainTrue, Watershed Association of the Tuckasegee River (WATR), Swannanoa Watershed Action Network (SWAN), and Warren Wilson College. The WNC Rec Program would not have had the success it has had so far without these partnerships and all others that have been involved with the program as they are truly invaluable and vital to the core mission of the WNC Rec Program.

3.2 Surface Water Monitoring

For the 2025 recreational season, the WNC Rec Program conducted weekly water samples for analyses of *E. coli* and turbidity from 54 commonly recreated sites throughout WNC (Figures 1-6). *E. coli* is a diverse species of bacteria found in the intestines of warm-blooded animals and humans and is used as an indicator of fecal coliform pollution. The presence of *E. coli* at elevated levels can indicate potential fecal contamination, which has been shown to co-occur with gastrointestinal illness. Turbidity samples were collected as part of the development of the *E. coli* estimator project. Sample locations were selected based on commonly recreated sites in WNC, those suggested by partner organizations, and resource availability. Water samples were collected on a weekly basis by volunteers with program partner organizations as well as by DWR temporary and permanent staff. The water samples were then delivered to and analyzed by the ARO laboratory. Results were posted the day following sample collection by DWR staff or partner organizations onto DWR's GIS Dashboard map and onto the Swim Guide website. Swim Guide is a publicly viewable website designed to allow participating organizations to publish water quality information for a wide variety of beaches, lakes, and rivers. Swim Guide allows users to establish their own primary recreational standard, and the website indicates the date of the most recent sample and whether the sample was above or below the recreational standard. DWR's GIS Dashboard map provides a comprehensive view of the data that allows the viewer to quickly and

easily see if the *E. coli* levels are within the NC DHHS guidance categories for primary or secondary recreation.

Sampling Methods

All surface water samples were collected in accordance with the NC DEQ, Water Sciences Section, Ecosystems Branch, Ambient Monitoring System (AMS), and Random Ambient Monitoring System (RAMS) Standard Operating Procedures Manual: Physical and Chemical Monitoring (NC DEQ, 2024). *E. coli* and turbidity samples were both grab samples and were either direct grab samples or intermediate grab samples (NC DEQ, 2024). If the location was a deep or wide water body, or a particularly difficult or dangerous bank to navigate, samplers were provided with a sampling pole, a sterile 1L polypropylene bottle for each needed location, and zip ties to secure the bottle to the sampling pole for intermediate sampling. A new sterile 1L bottle was used at each sampling location that requires the intermediate sampling method. The turbidity samples were collected in 200 mL disposable bottles and kept at ≤ 6°C and have a maximum holding time of 28 days. The *E. coli* bottles were collected in 120 mL shrink-banded, sterile IDEXX bottles containing sodium thiosulfate for neutralizing at least 15 mg/L chlorine and have a maximum holding time of 6 hours.

Field blanks and duplicate samples were collected at one random site every 10 sets of sampling locations per day for all samples collected by DWR staff (NC DEQ, 2024). Duplicate samples were collected at one random site every 10 sets of sampling locations per day for all samples collected by partnerships and volunteers for the WNC Rec Program (NC DEQ, 2024). Duplicate samples and field blank samples were used for quality control protocols for the ARO laboratory and sampling quality control procedures (NC DEQ, 2024). After the water samples were collected, the sampler filled out a provided field sheet with the date and time of the sample collection. Any notes of the water quality, sampling experience, weather, etc. from the sampler were notated on the field sheet. All samples collected by DWR staff also included field parameters dissolved oxygen (DO), pH, specific conductivity, and water temperature. These parameters were measured with an Aqua TROLL 500 multiparameter water sonde that was calibrated before each sampling route (NC DEQ, 2024).

All partnership and volunteer samplers were trained on proper sterile collection techniques, sampling routes (e.g. downstream to upstream), preservation/transportation steps, and appropriate documentation before the sampling starts for the recreational season. Sampling supplies were provided to partnerships and volunteers as needed.

Analytical Methods

E. coli samples were analyzed from the IDEXX Quanti-Tray/2000 System with Colilert-18® reagent which is suitable for the use with surface water samples (EPA Standard Methods, 9223 B). Turbidity samples were analyzed by the EPA Standard Methods 2130 B. The turbidity measurements were reported according to the table provided in the NC Wastewater/Groundwater Laboratory Certification Branch Procedure for the Analysis of Turbidity (Appendix I).

3.3 Real-Time *E. coli* Estimator

For the past four years, the WNC Rec Program, in collaboration with MountainTrue, has developed and maintained a near real-time *E. coli* estimator for Pearson Bridge, a heavily recreated location on the French Broad River near Asheville, North Carolina (35.608980, -82.578203). The estimator uses turbidity as a surrogate for *E. coli* based on the observed relationship between the two parameters at this location. Pearson Bridge is equipped with a permanent U.S. Geological Survey (USGS) gage that records turbidity at 15-minute intervals, allowing the model to generate near real-time estimates of *E. coli* concentrations.

The estimator is based on a log-linear regression developed from 258 paired turbidity and *E. coli* measurements collected between May 2019 and September 2024, prior to Tropical Storm Helene. The model equation is:

Estimated *E. coli* = 10^[1.16 + (1.12 × log10 turbidity)] × 1.24

The model produced an r^2 value of 0.72 and a root mean square error (RMSE) of 0.3 on the log scale. Across all modeled flow conditions, the estimator underpredicts actual *E. coli* concentrations in the upper range approximately 18% of the time, which represents the model's false-negative error rate. However, when the actual *E. coli* concentration exceeds the primary recreation guidance value of 126 MPN/100 mL, the estimator reliably predicts exceedances approximately 95% of the time. Model uncertainty is represented using error bars equal to plus or minus one standard deviation from the estimated value, equivalent to 0.3 on the log scale.

The primary advantage of this model is that it provides a near real-time estimated *E. coli* value instead of relying on laboratory analysis of water samples, which can take 18 hours or more before results are available. This near real-time capability is particularly important because turbidity and *E. coli* concentrations can change rapidly in response to rainfall and changing river conditions. This resource provides recreators and the public immediate risk advisory information. The real-time *E. coli* estimator along with historical data from this project can be found on the French Broad at Pearson Bridge E. Coli Estimator website. Importantly, the model is updated annually by incorporating data collected during the most recent recreational season.

3.4 dPCR Project

The polymerase chain reaction (PCR) is a tool that has been used in molecular biology since the 1980s to amplify target sequences of DNA of interest. Both Quantitative Real-Time PCR (qPCR) and modern digital PCR (dPCR) can quantify DNA of interest within a few hours. Both are reliable tools and can provide accurate results depending on intended use. The qPCR requires the use of a standard curve, like wet chemistry methods, to quantify results after analysis. The dPCR partitions each sample into thousands of subsamples and instead utilizes Poisson distribution to extrapolate a most probable number (MPN), the same statistical analysis used with IDEXX *E. coli* & *Enterococci* methods. Recently, dPCR is taking the forefront in many molecular laboratories due to useability, reproducibility, and reduction in PCR interferences.

The WNC Rec Program will use dPCR to quantify the human genome HF183 and the DNA of *E. coli* simultaneously from surface water samples at select recreational sites to aid in risk assessment to recreators and provide preliminary information regarding sources of pollution. This type of analysis also has the potential for shorter analytical turnaround times which can be utilized for local health advisories. The initial step in the implementation of dPCR is a site-specific study of the French Broad Recreational Corridor to build a comparative data set of *E. coli* analyzed via Colilert-18 and dPCR. These data will provide context to the results obtained from dPCR analysis. Once a relationship is established, dPCR can then be used to potentially provide same day results. The HF183 genome marker is known for its occurrence in human fecal samples and has been used to detect and quantify human fecal contamination worldwide (Haugland et al., 2010). Testing for the HF183 marker alongside *E. coli* in recreated waters in WNC will provide more accurate information and assist in risk assessment because of its stronger correlation with gastrointestinal disease or infection and other public health risks (Haugland et al., 2010). With the data collected from the dPCR project, the goal is to provide faster and more informative health advisory guidance than that solely derived from culture-growth based *E. coli* samples.

3.5 Tropical Storm Helene Sampling

In response to the damage from Tropical Storm Helene, the WNC Rec Program developed a post-Helene sampling strategy which involved the collection of *E. coli* samples from November 2024 through early April 2025 to assess water quality. The data were posted to a publicly accessible website (Helene AMS Sampling Results Dashboard). By leveraging the existing resources of the WNC Rec Program, DWR staff were able to work directly in the impacted waters to identify damaged wastewater infrastructure, monitor the recovery of recreated sites throughout Buncombe and Haywood counties and convey information to inquiring citizens regarding impacts and ongoing water quality conditions during the cleanup and recovery process. Because this program was already in place and funded, the utilization of resources was more easily and efficiently distributed during the recovery stages immediately following the tropical storm event.

4.0 Monitoring Results

4.1 Tropical Storm Helene Data

Shortly after the Tropical Storm Helene, *E. coli* samples were collected from eight WNC Rec Program sampling sites from November 2024 through April 2025 (Figures 8 and 9). It's important to note when reviewing this data that the post-Helene data was sampled mainly during winter which will have a natural decrease in bacteriological activities in surface water and should not be compared to samples taken within the recreational season. Tropical Storm Helene could have caused a wide variety of variables to impact the water quality across WNC. The 2024 post-Helene sampling project allowed DWR staff to evaluate the progression of the recovery in water quality of many highly recreated sites in ARO and other non-recreational related sites and to provide risk advisory information to those involved in recovery efforts. In addition, this sampling effort allowed DWR staff to detect and appropriately address sanitary sewer overflow (SSO) events caused by the events of Tropical Storm Helene.

4.2 2025 Sampling Results

The *E. coli* geomeans from all 54 sites that were sampled for the WNC Rec Program in the 2025 recreational season are displayed in Figure 10. This includes sites sampled by DWR and by the WNC Rec Program partners, WATR and SWAN. The highest *E. coli* geomean in 2025 that was taken from a non-lake river site was 1007 MPN/100mL which was at Hap Simpson Park (35.217630, -82.719994) along the French Broad River. The lowest *E. coli* geomean in 2025 taken from a non-lake river site was 12.8 MPN/100mL which was at Shook Cove Access (35.259562, -83.106658) along the Tuckasegee River. For a complete list of *E. coli* geomeans of all sites sampled in the 2025 recreational season for the WNC Rec Program organized by waterbody, see Appendix II. For these calculations and all that follow, two sampling sites (Haywood Bridge & Cane Creek Propane Area) were not considered because they each had less than two samples taken within the recreational season.

The risk advisory distribution of *E. coli* samples in each recreational guidance category can be seen in Figures 11 through 14 for each WNC Rec Program sampling site taken within the 2025 recreational season. During the 2025 recreational season, 494 *E. coli* samples (59%) were within the secondary recreation guidance category (126-886 MPN/100 mL) making secondary recreation values the highest percentage overall for the 2025 recreational season (Appendix III). *E. coli* samples taken for the WNC Rec Program that were within the primary recreation guidance category (<126 MPN/100mL) totaled to 202 samples (24%) for the 2025 recreational season (Appendix III). This leaves all *E. coli* samples taken for the 2025 recreational season that were within the increased exposure guidance category (>886 MPN/100mL) to be the lowest at a total of 144 samples (17%) (Appendix III). The risk advisory distribution for commonly recreated river segments in WNC can be seen in Figure 15. Figure 16 maps the distribution and locations of these commonly recreated river segment categories.

4.3 What do the results mean?

At its core, this program is intended to communicate recreational water quality risks to the public for inland waters. The program is designed to monitor recreated areas and provide risk information only; any additional conclusions drawn from these data are secondary. As many variables influence water quality, it is difficult to identify the causes of changes in *E. coli* results or draw broad conclusions from only one or two water quality parameters.

The program's data are most useful for improving the understanding of the variability in water quality indicators, like *E. coli* and turbidity, and how environmental conditions (e.g. sunlight, precipitation, temperature, etc.) affect water quality. While the data collected from this program can document interannual variabilities and trends, it alone is not intended to be used in that regard without additional study designs and investigation. Simply put, water quality can change rapidly in flowing natural waters, especially following rainfall events, and the sheer number of environmental variables makes analyzing water quality inherently complex.

5.0 2025 Key Accomplishments

5.1 2025 WNC Rec Program Metrics

The 2025 recreation season was the sixth consecutive year for the WNC Rec Program. Monitoring performed by DWR included the collection and analysis of 439 *E. coli* and turbidity samples from 31 recreated locations from April through August. An additional 402 samples from 23 locations were sampled by collaborative partners including WATR, SWAN, and students from Warren Wilson College. Combined, the WNC Rec Program processed a total of 840 samples this recreational season from 54 frequently recreated sites across WNC (Figure 1-6). The 2024 recreational season included 45 sampling sites from both DWR staff and partnerships. Buncombe County could not assist with the WNC Rec Sampling in the 2025 recreational season, so one sampling team/partnership was reduced in 2025 but the total number of sampling sites still increased by 10. Figure 7 shows the same 2025 sampling sites along with the impaired surface water in WNC. A considerable amount of the impaired surface water in WNC is sampled by this program like sections of Richland Creek, French Broad River, Cane Creek, Swannanoa River, and Tuckasegee River. This shows that many of the frequently recreated sites in WNC are impaired for one or more surface water standards which increases the importance of a program that monitors water quality at these sites. Sampling along the impaired surface water sections can help partnerships like MountainTrue, WATR, and SWAN gather more information and evidence to support their efforts in obtaining grant funding related to surface water use restoration.

5.2 GIS Dashboard

Similar to the Post-Helene Sampling Results Dashboard, a new GIS Dashboard map was launched in 2025 which was designed to publicly display the data collected by the WNC Rec Program. This GIS dashboard provides a comprehensive view of the data that allows the viewer to quickly and easily see if the *E. coli* levels are within the NC DHHS guidance categories. This dashboard additionally allows for the WNC Rec Program's partners WATR and SWAN to publish their data online. For now, only partnerships that process their samples in the ARO DWR laboratory are published on this GIS Dashboard. This GIS Dashboard is meant to provide more details including analytical trends over time compared to the original public information website used by the WNC Rec Program, the Swim Guide. Additionally, the GIS Dashboard allows viewers to see if the *E. coli* results are within the three recreational guidance categories while the Swim Guide only allows viewers to see if the latest results are above or below the primary recreational advisory level. The additional recreational guidance categories are important for the WNC region since many, if not the majority of, recreators in the region recreate in a form that is considered a secondary recreational activity (i.e. kayaking, paddle boarding, tubing, rafting, etc.). Furthermore, the Swim Guide currently doesn't implement a consistent primary recreational advisory level across all monitoring locations which can result in confusing and/or contradicting information to viewers. Results posted on Swim Guide during the 2025 recreational season had 42,000+ website views and the GIS Dashboard had 1,964 website views from Memorial Day through Labor Day. For the 2025 recreational season, the Swim Guide was still the public's main choice for water quality information.

5.3 Real-Time *E. coli* Estimator

Despite the events of Tropical Storm Helene, the *E. coli* estimator website was still up and running in 2025. The French Broad at Pearson Bridge *E. coli* estimator website had 7,800 website views from January 2025 through October 2025 showing it was still being used during the 2025 recreational season. This website is one of the unique, relevant, and innovative resources that the WNC Rec Program offers due to its "real-time" capabilities. The WNC Rec Program continues to evaluate the feasibility of establishing additional estimator sites in WNC.

5.4 2025 dPCR Project Progress

In beginning the first steps of development of the dPCR project, the 2025 recreational season included dPCR training for two DWR staff with the NC DHHS laboratory that utilizes a dPCR for Wastewater Monitoring for respiratory viruses (COVID-19, Flu A/B, RSV). As the dPCR project continues to develop, partnerships with teams like the DHHS Wastewater Monitoring team will be essential in developing a viable, feasible, and scientifically based project utilizing the dPCR laboratory.

6.0 Looking Ahead: 2026 Plans

The key goals for the upcoming recreational season include the utilization and development of the dPCR laboratory, outreach to additional partnerships to widen the scope of our sampling area, further development of the GIS dashboard, development of a QA/QC program, and promotion of the program through resources like signage, brochures, stickers, etc. A public survey of the program and its resources will be added to the promotional materials. This survey will allow the program to better analyze which program resources have the largest impact on the public and gauge the usefulness of those resources from the public's perspective.

In 2026, the WNC Rec Program will develop a site-specific study of the French Broad Recreational Corridor to build a comparative data set of *E. coli* analyzed via Colilert-18 and dPCR and to create partnerships with the program specific to the dPCR project. Additionally, the program will evaluate the establishment of more *E. coli* estimator sites. The WNC Rec Program will continue to collect *E. coli* samples along with turbidity samples at all potential sites to evaluate the statistical correlation of turbidity and *E. coli*. Water samples will be collected from select USGS turbidity gage sites as part of the evaluation. In addition, the program will explore the installation of permanent turbidity gages that would be maintained by DWR or partner organizations. All options are being explored currently to ensure the best utilization of the resources that the WNC Rec Program offers.

Overall, the 2025 recreational season included major advances for the WNC Rec Program. The 2026 recreational season in conjunction with the progress made in 2025 will continue to support further development of the program and utilization of resources to improve upon risk communication regarding recreation of inland waters in WNC.

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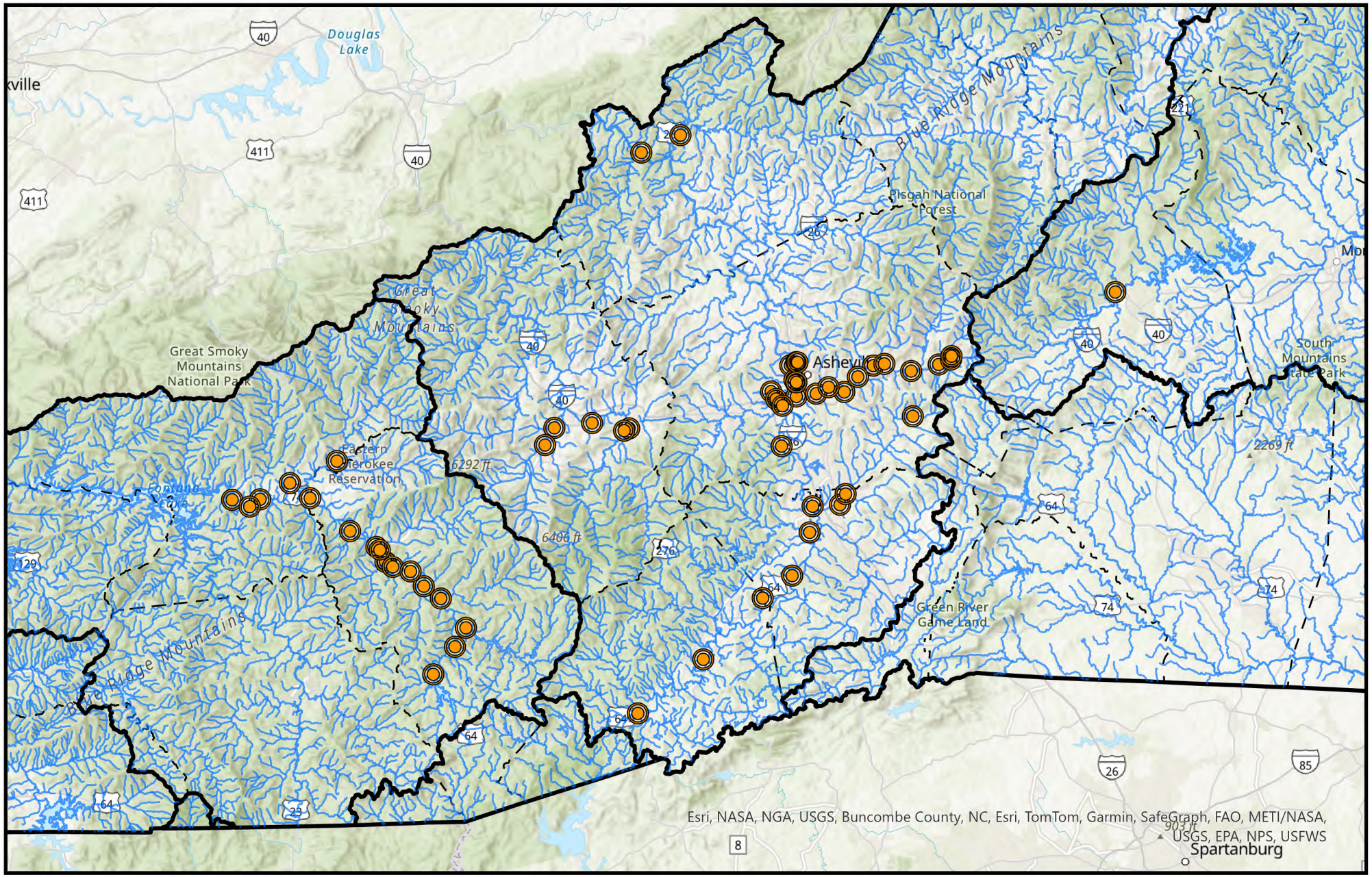
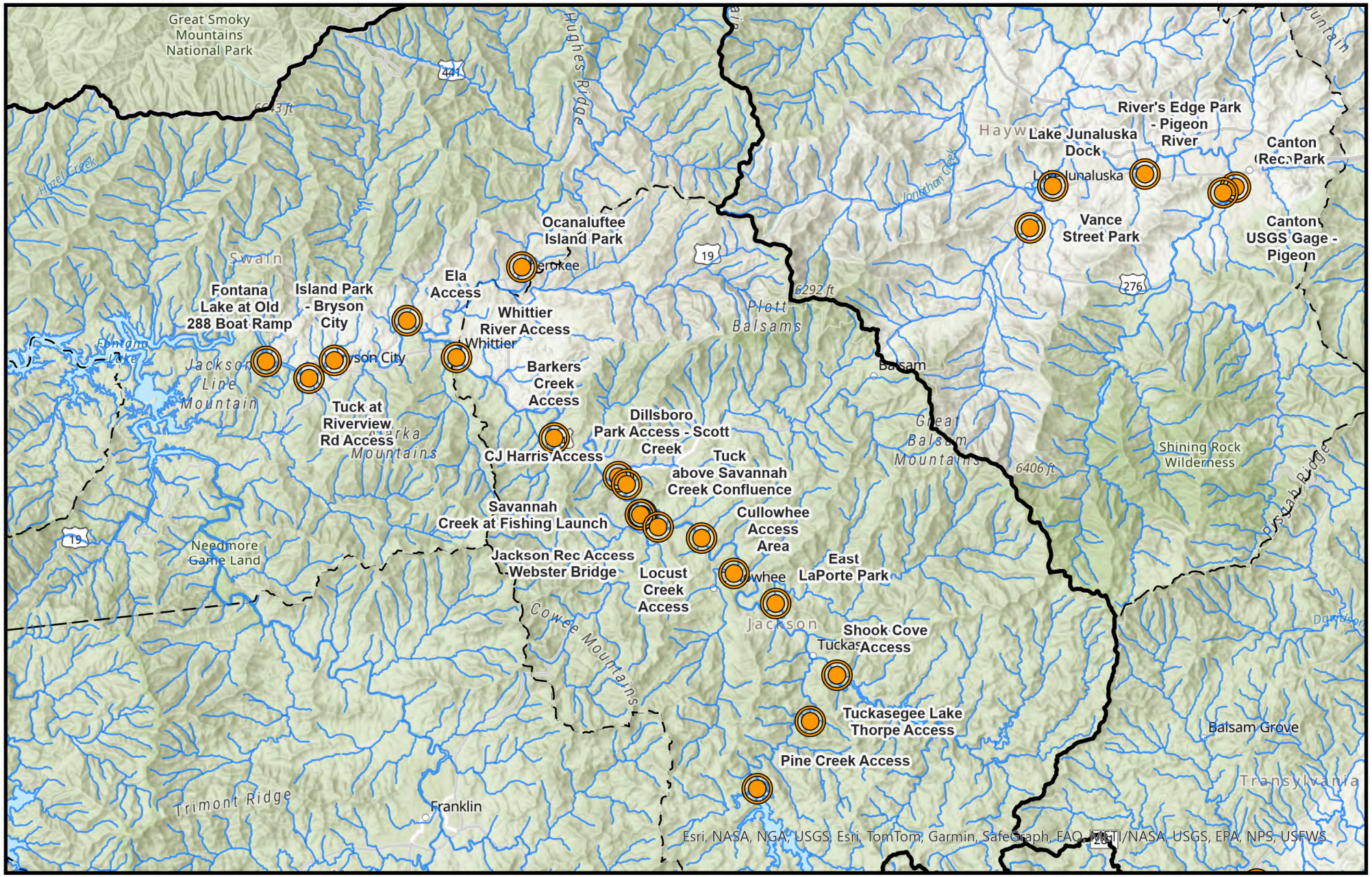
Figures & Tables

Figure 1. Map of 2025 Sampling Locations for WNC Rec Program



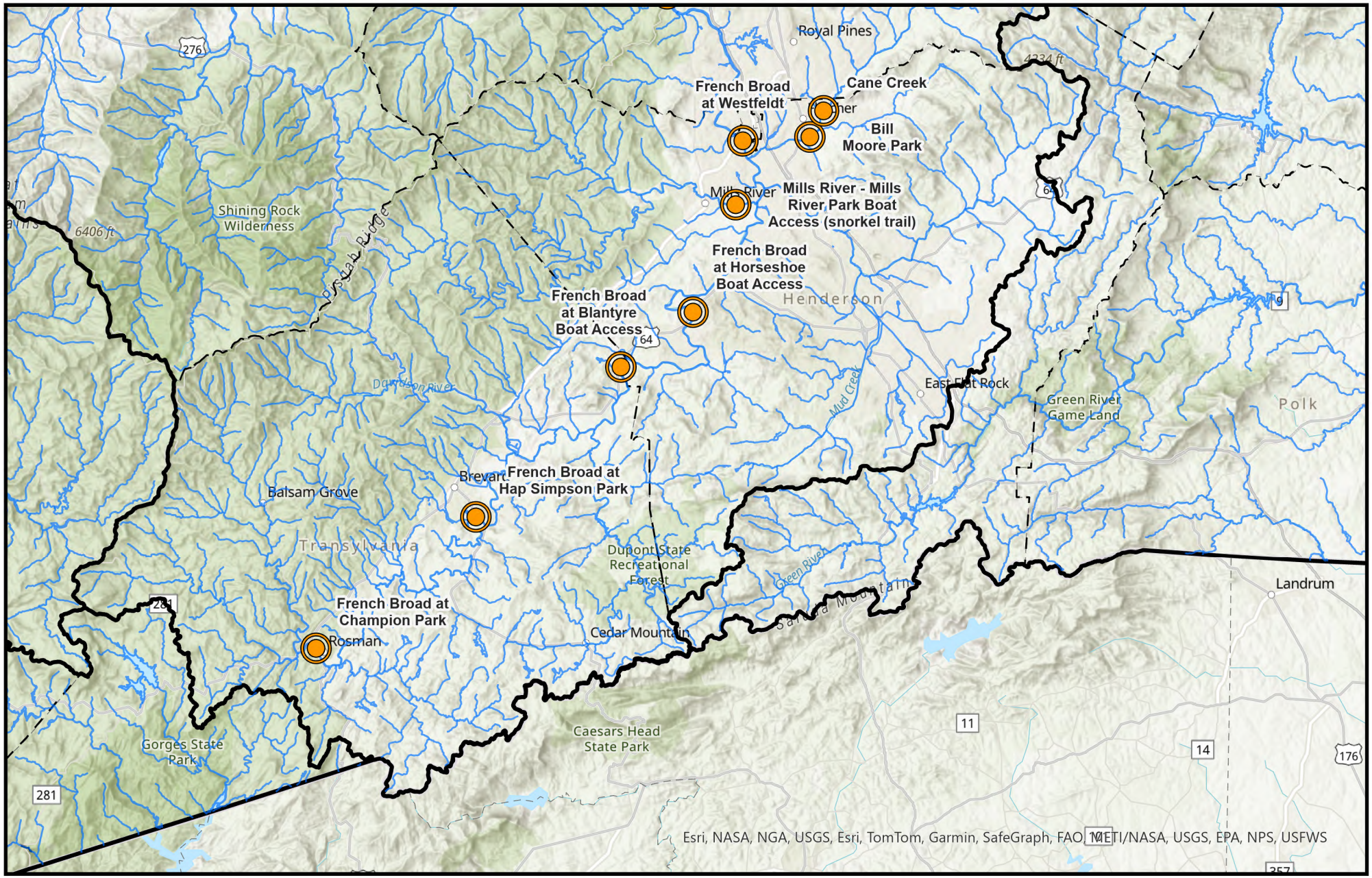
NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources,
Author: Rachel Rose

Figure 2. Map of 2025 Sampling Locations for WNC Rec Program with Site Names 1



NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources,
Author: Rachel Rose

Figure 3. Map of 2025 Sampling Locations for WNC Rec Program with Site Names 2



Major River Basins

NC Counties (DEQ Version with Regional Offices)

SurfaceWaterClassificati

SamplingSites

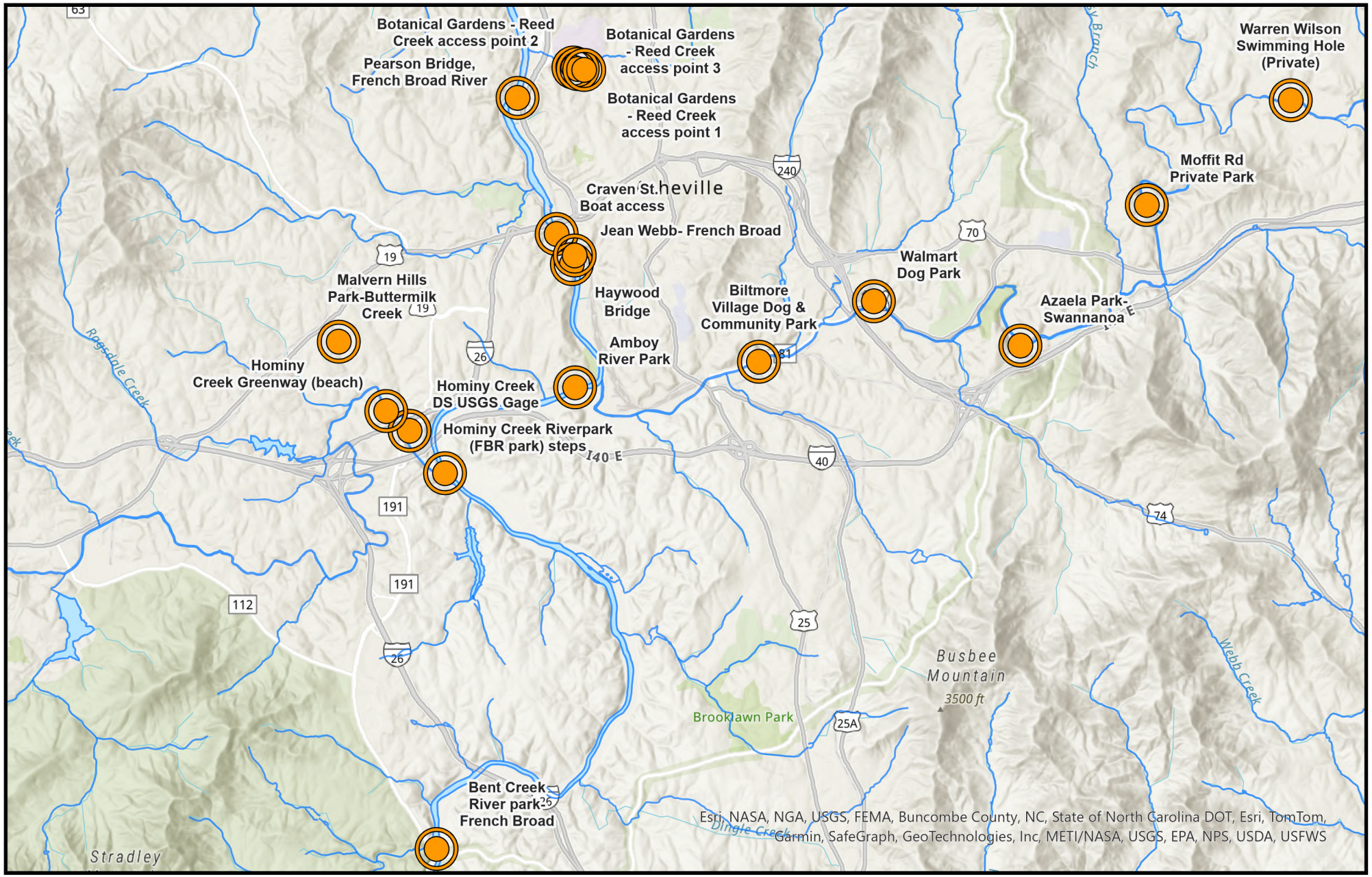
N

0 2 4 8 Miles

Scale: 1:384,659

NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources,
Author: Rachel Rose

Figure 4. Map of 2025 Sampling Locations for WNC Rec Program with Site Names 3



Major River Basins

NC Counties (DEQ Version with Regional Offices)

SurfaceWaterClassificati

SamplingSites

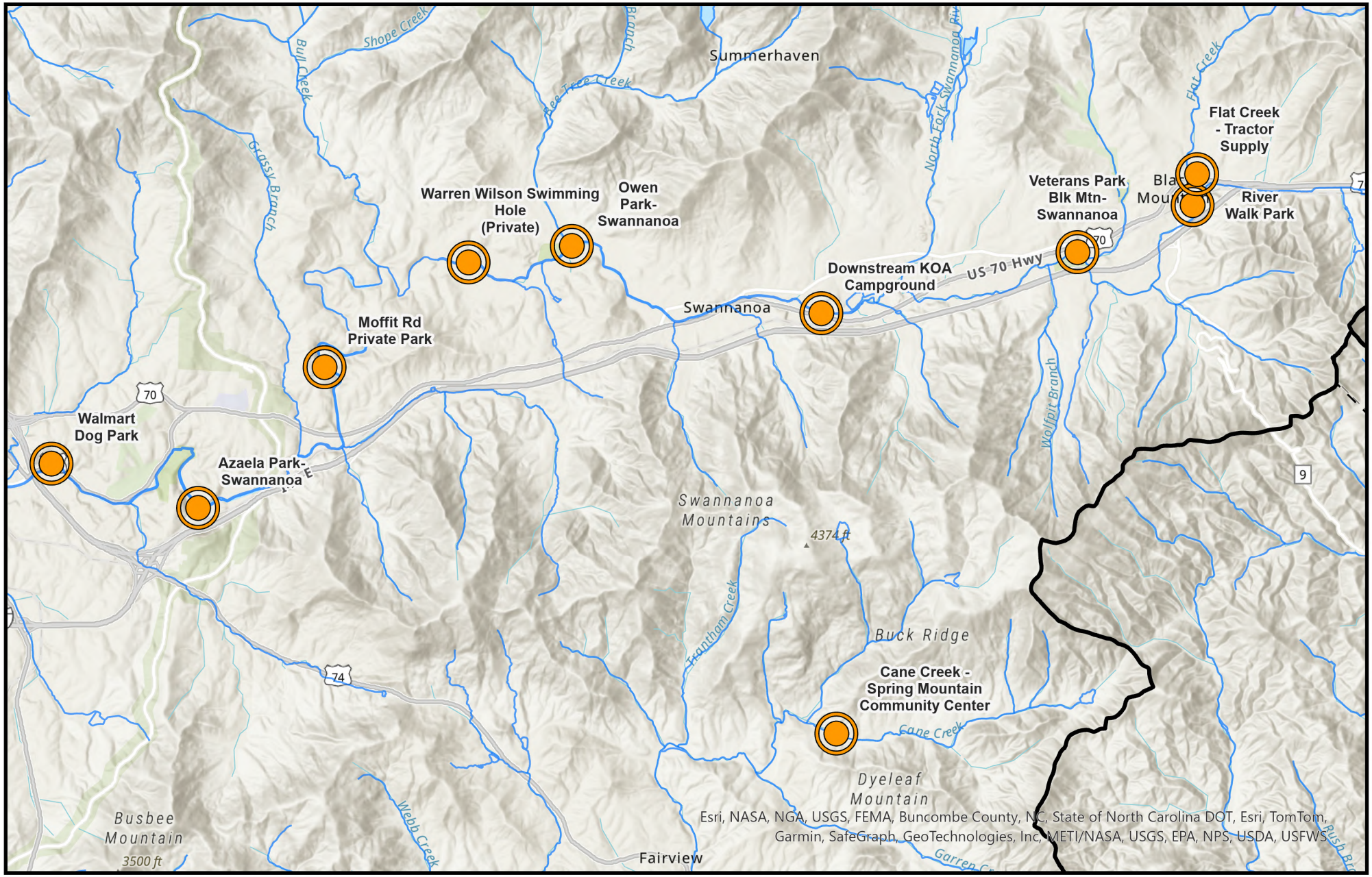
N

0 0.5 1 2 Miles

Scale: 1:100,836

NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources,
Author: Rachel Rose

Figure 5. Map of 2025 Sampling Locations for WNC Rec Program with Site Names 4



Major River Basins

NC Counties (DEQ Version with Regional Offices)

SurfaceWaterClassificati

SamplingSites

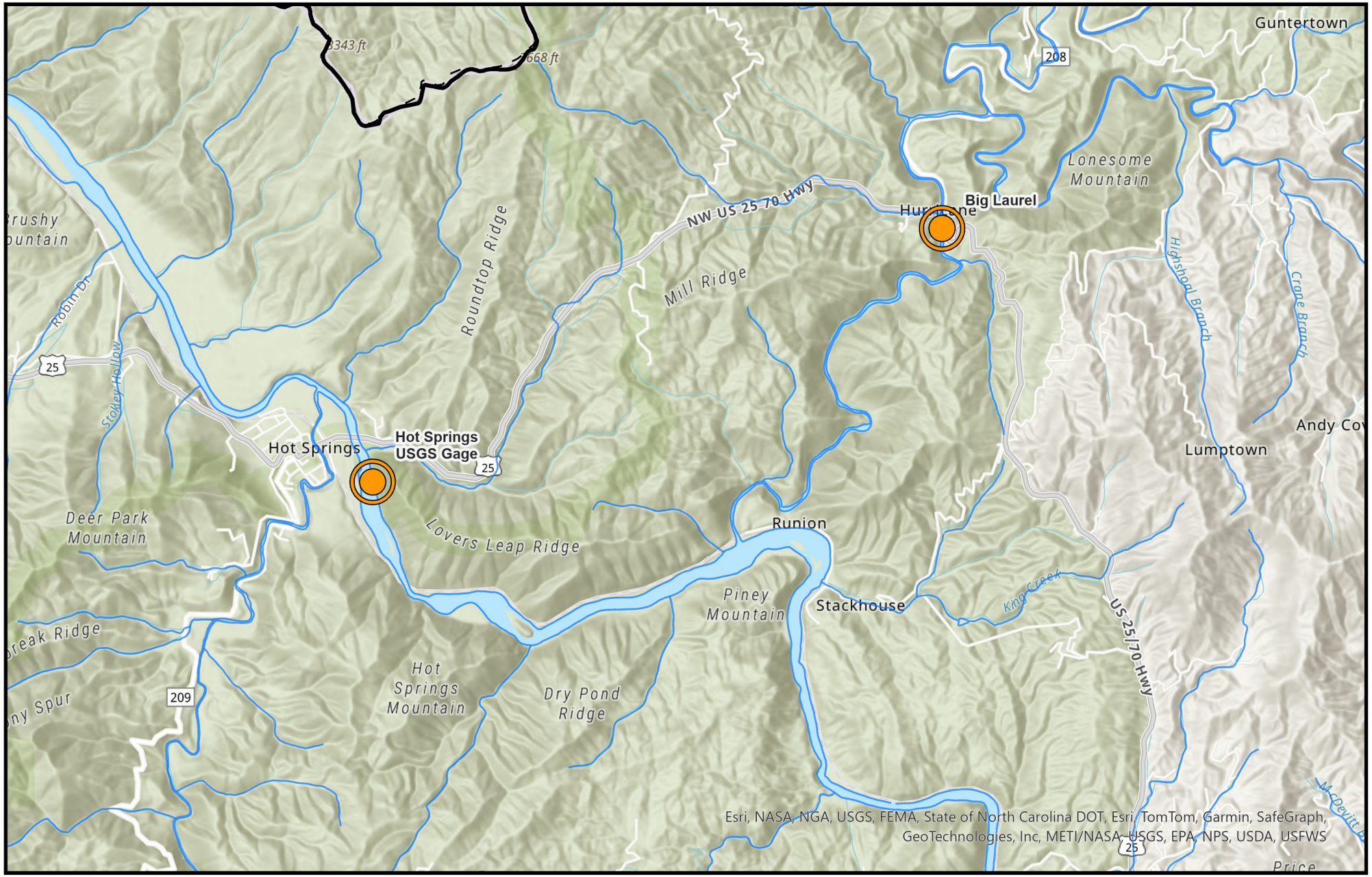
N

0 0.5 1 2 Miles

Scale: 1:100,836

NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources,
Author: Rachel Rose

Figure 6. Map of 2025 Sampling Locations for WNC Rec Program with Site Names 5



Major River Basins

NC Counties (DEQ Version with Regional Offices)

SurfaceWaterClassificati

SamplingSites

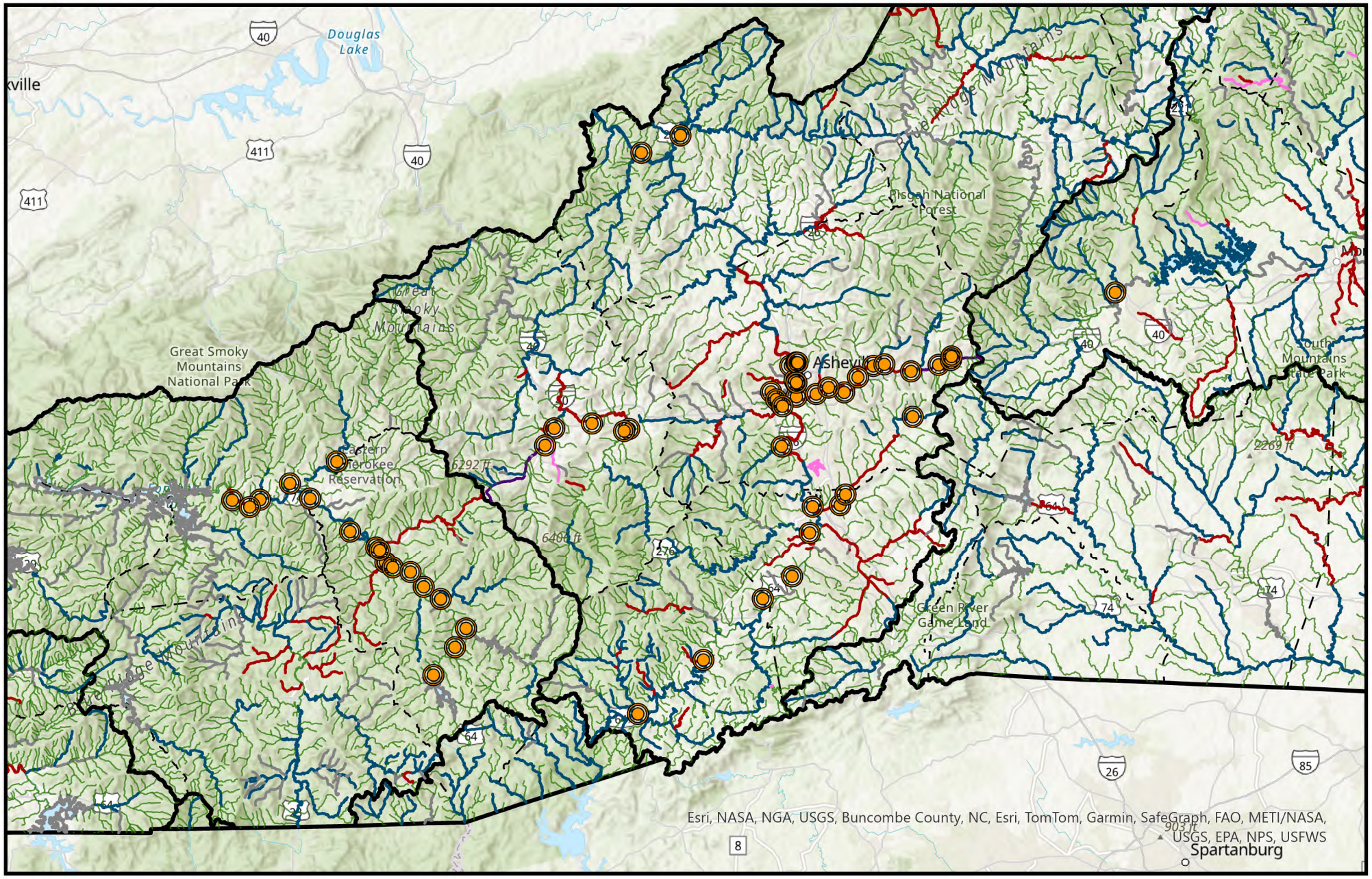
N

0 0.33 0.65 1.3 Miles

Scale: 1:64,535

NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources,
Author: Rachel Rose

Figure 7. Map of 2025 Sampling Locations & Impaired Surface Waters in WNC



2022 IR Overall (Streamlines)

- No Data
- Meeting Criteria
- Data Inconclusive
- Exceeding Criteria (Cat. 4)
- Exceeding Criteria (Cat. 5)
- Exceeding Criteria (Cat. 5r)
- Major River Basins
- NC Counties (DEQ Version with Regional Offices)
- SamplingSites

N

0 5 10 20 Miles

Scale: 1:939,108

NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources,
Author: Rachel Rose

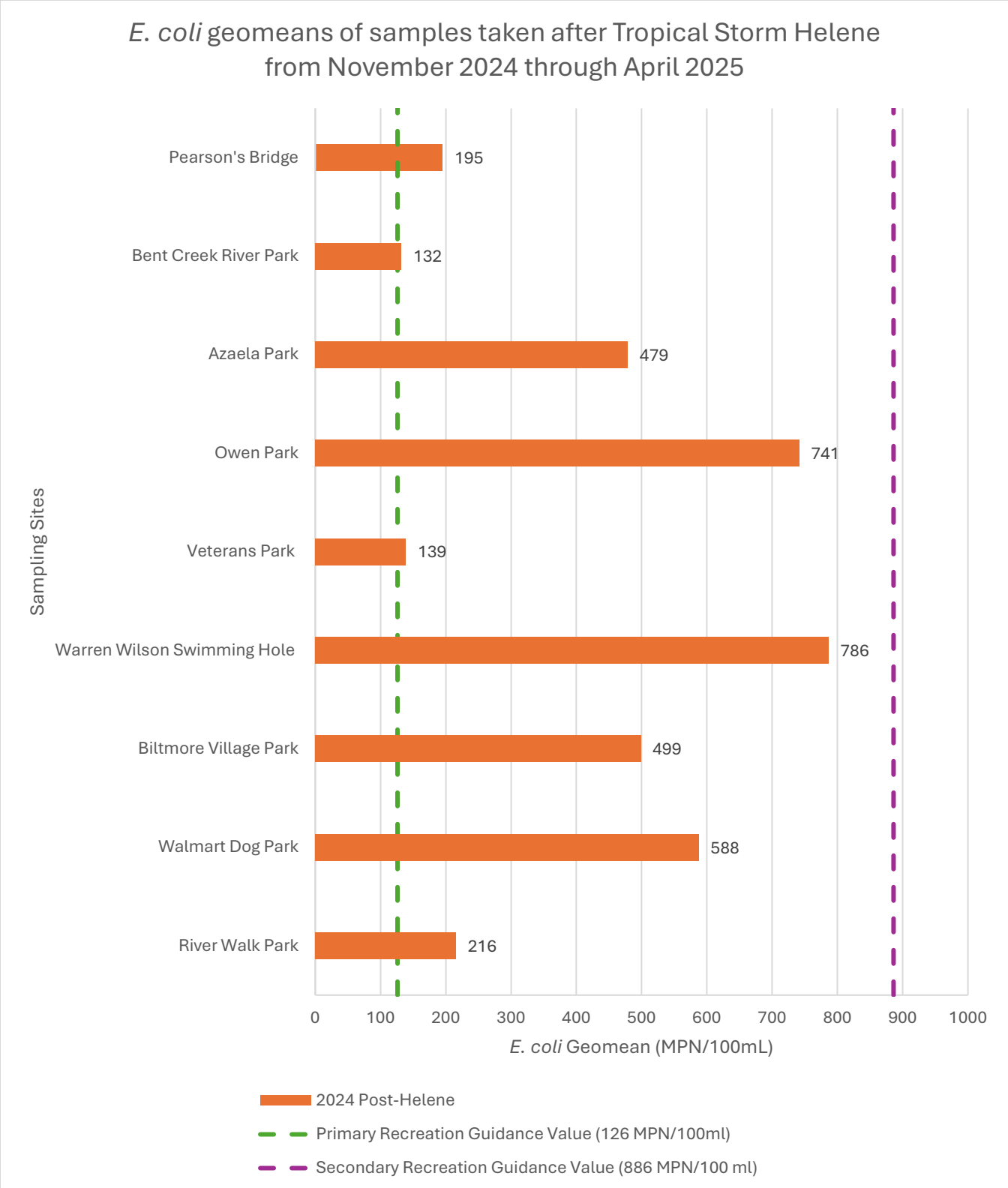


Figure 8. *E. coli* geomeans of samples taken after Tropical Storm Helene from November 2024 through April 2025

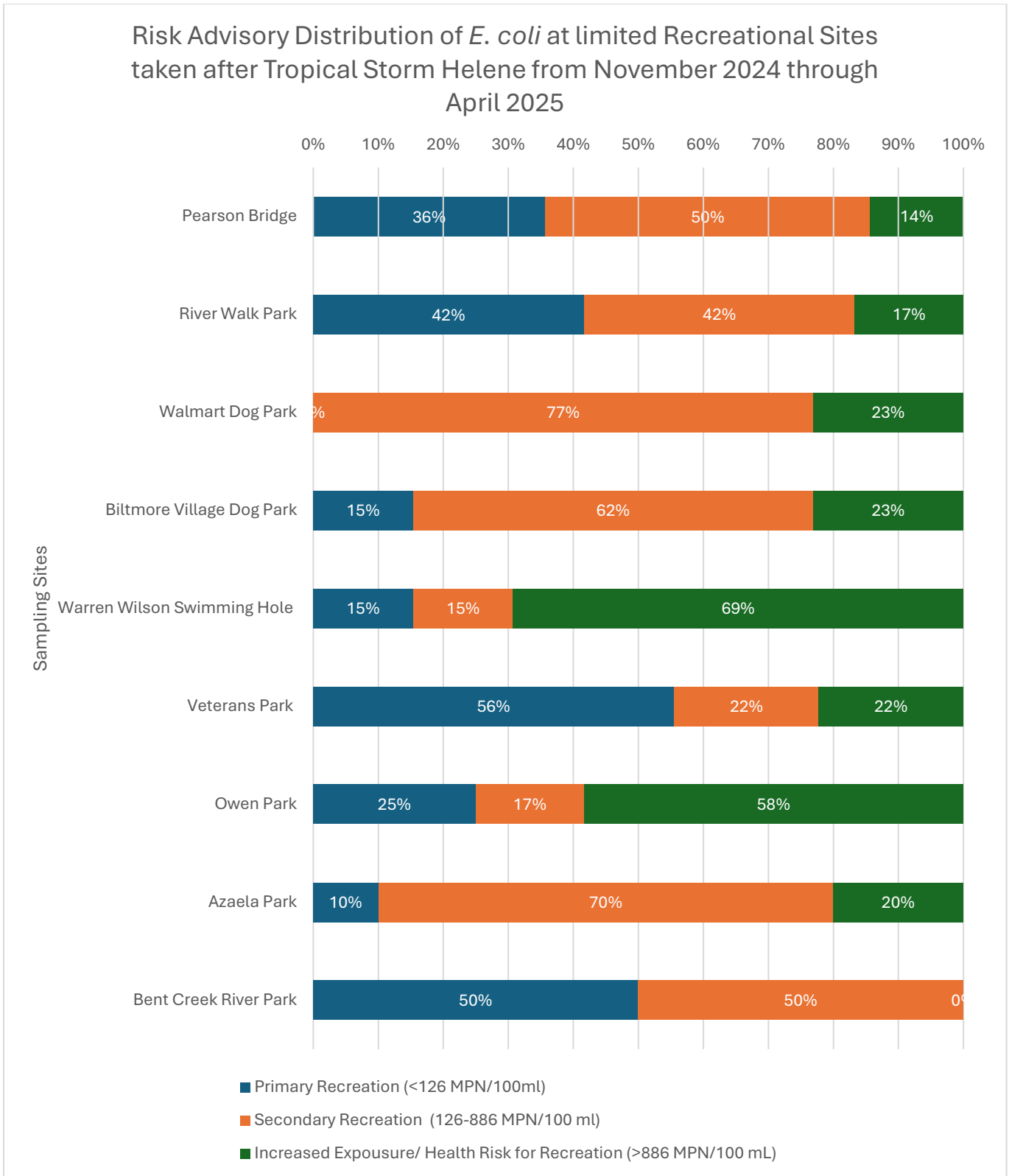


Figure 9. Risk Advisory Distribution of *E. coli* at limited Recreational Sites taken after Tropical Storm Helene from November 2024 through April 2025

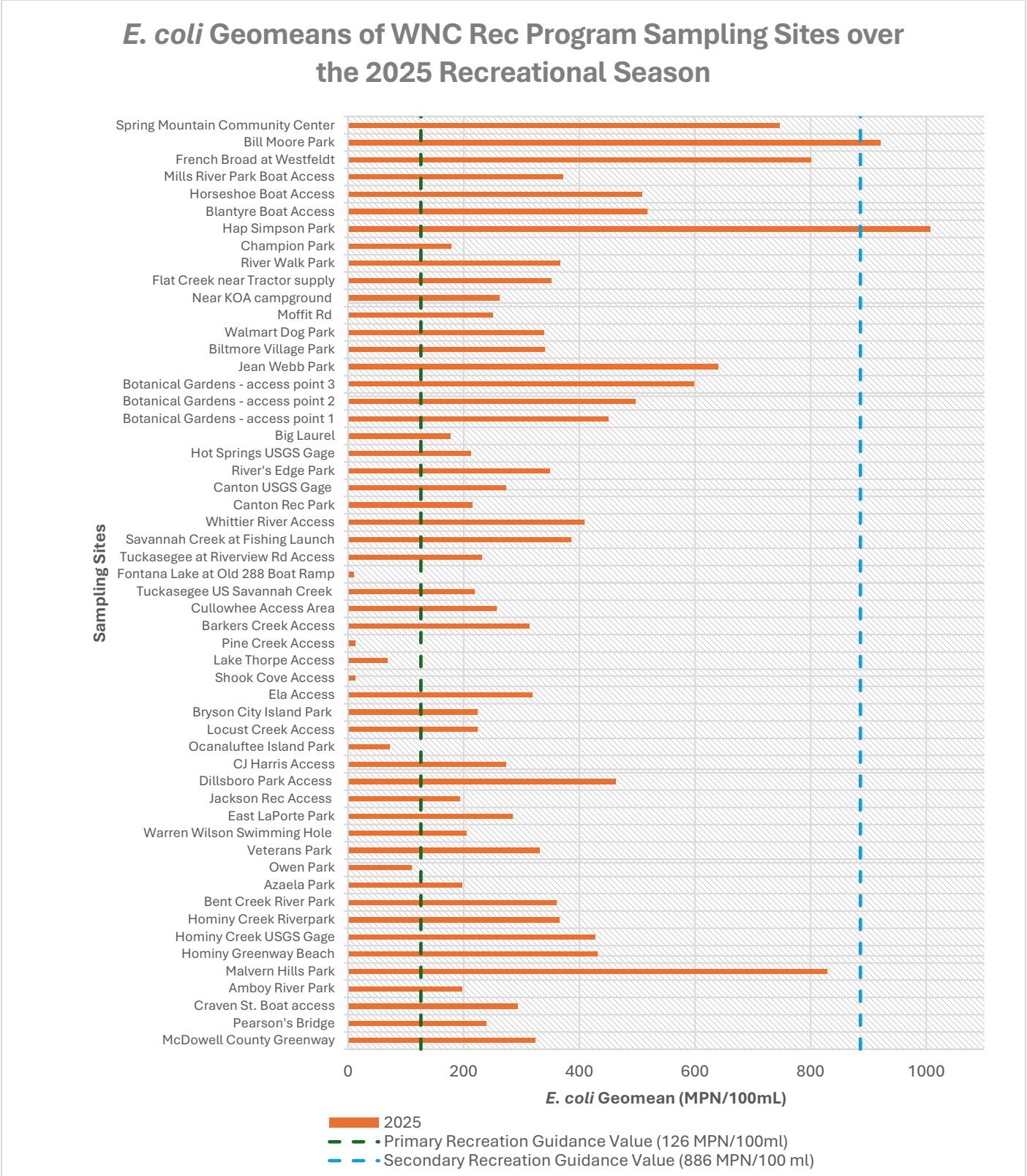


Figure 10. *E. coli* Geomeans of WNC Rec Program Sampling Sites over the 2025 Recreational Season

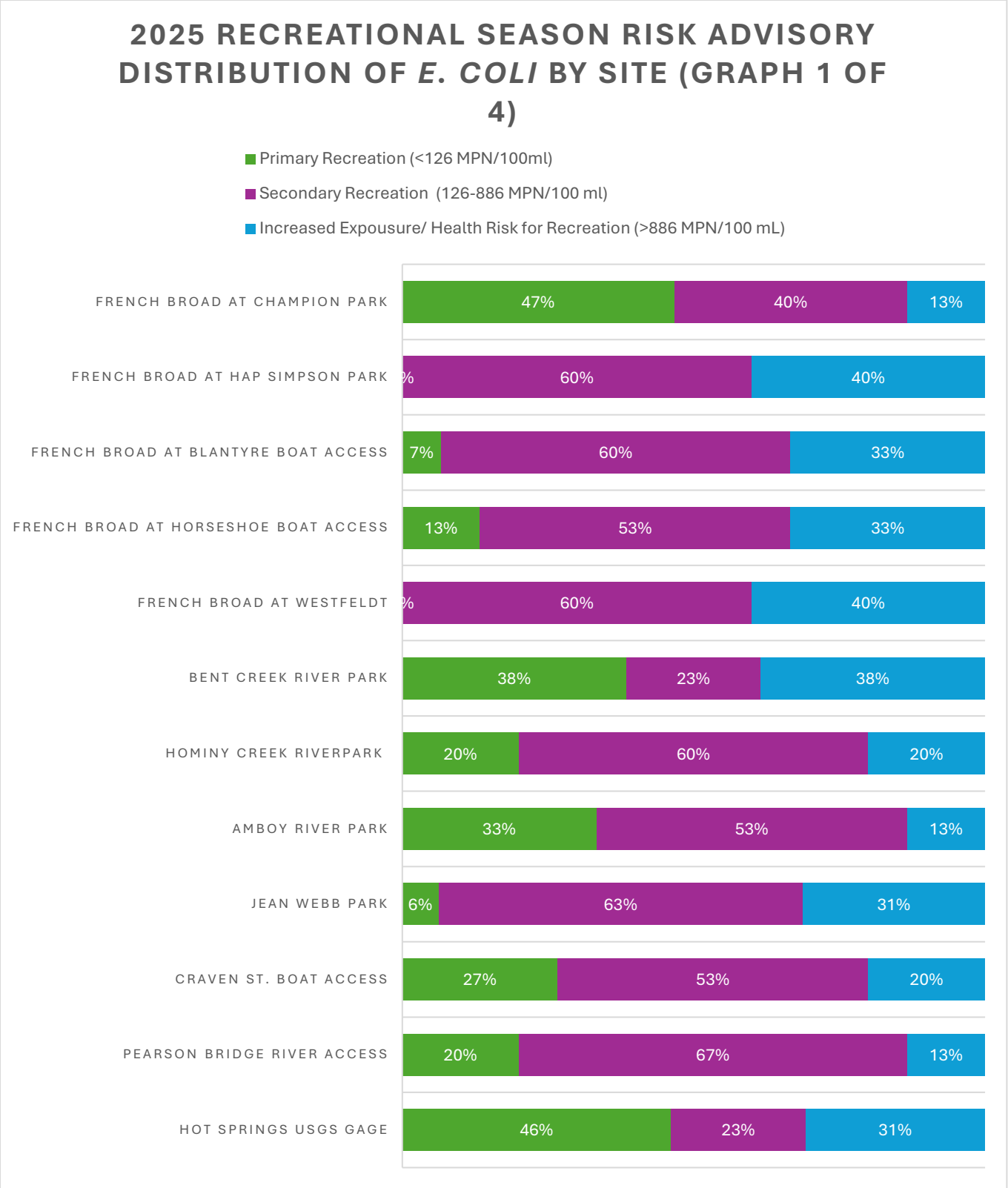


Figure 11. 2025 Recreational Season Risk Advisory Distribution of *E. coli* by Site (Graph 1 of 4)

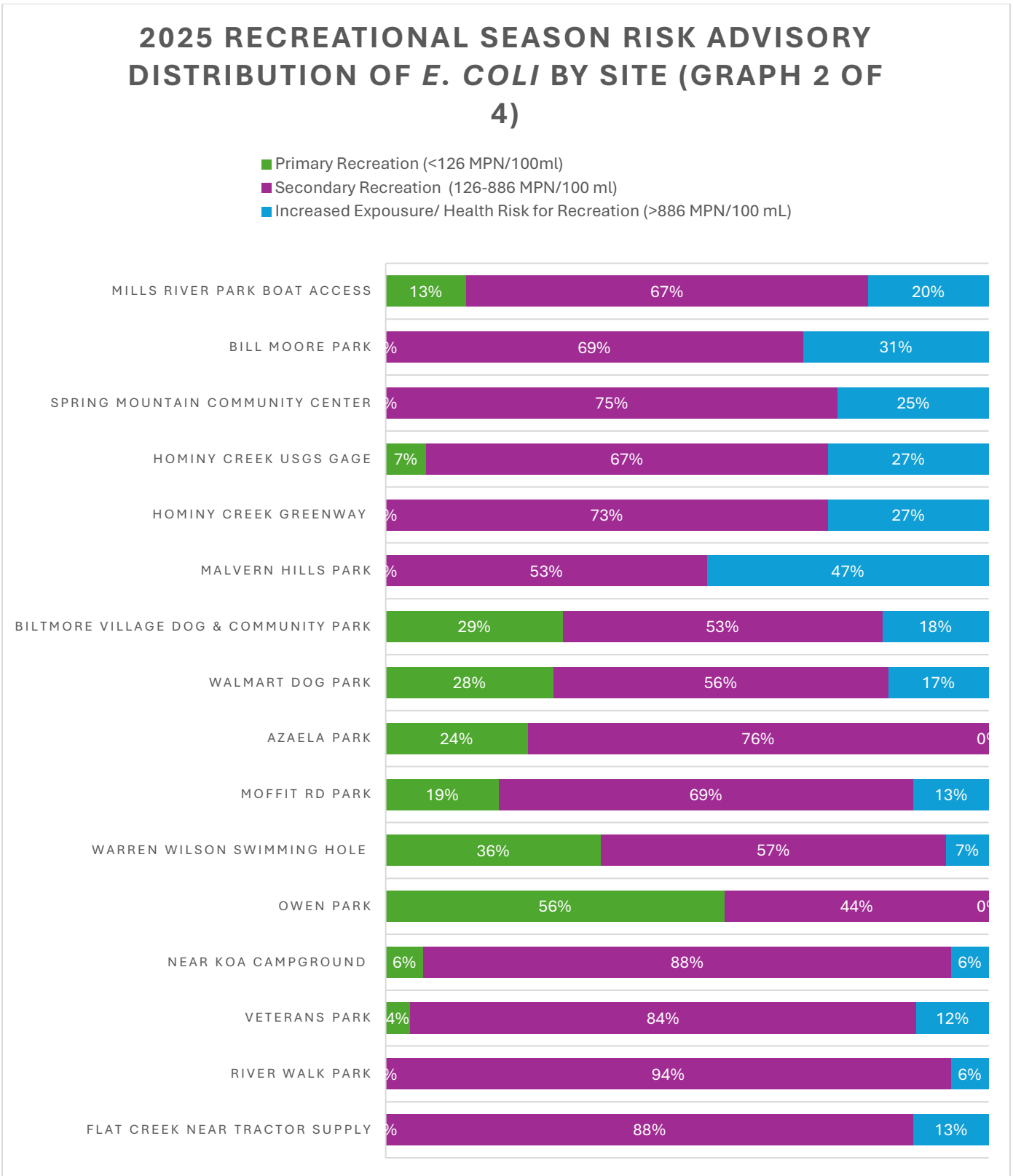


Figure 12. 2025 Recreational Season Risk Advisory Distribution of *E. coli* by Site (Graph 2 of 4)

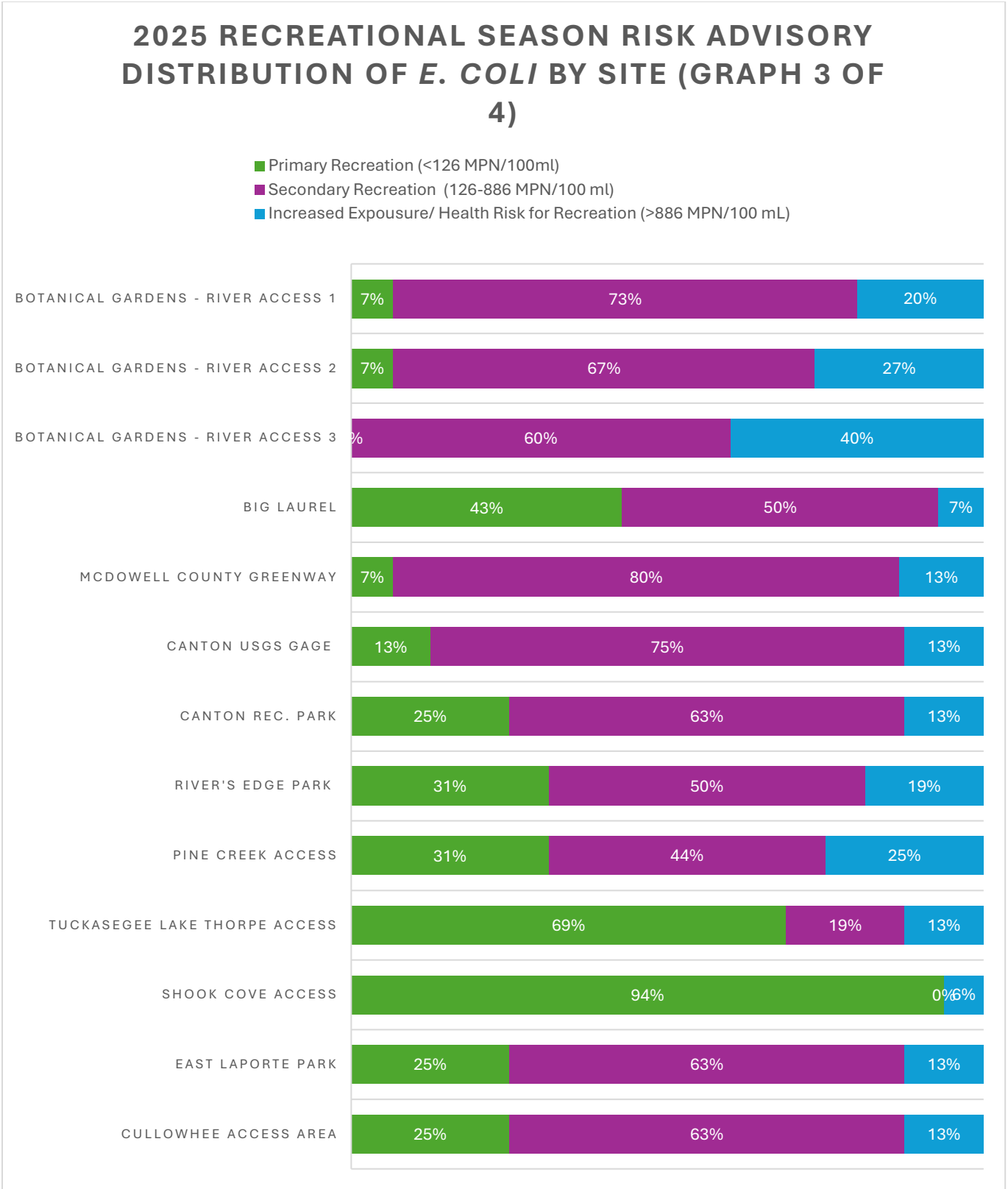


Figure 13. 2025 Recreational Season Risk Advisory Distribution of *E. coli* by Site (Graph 3 of 4)

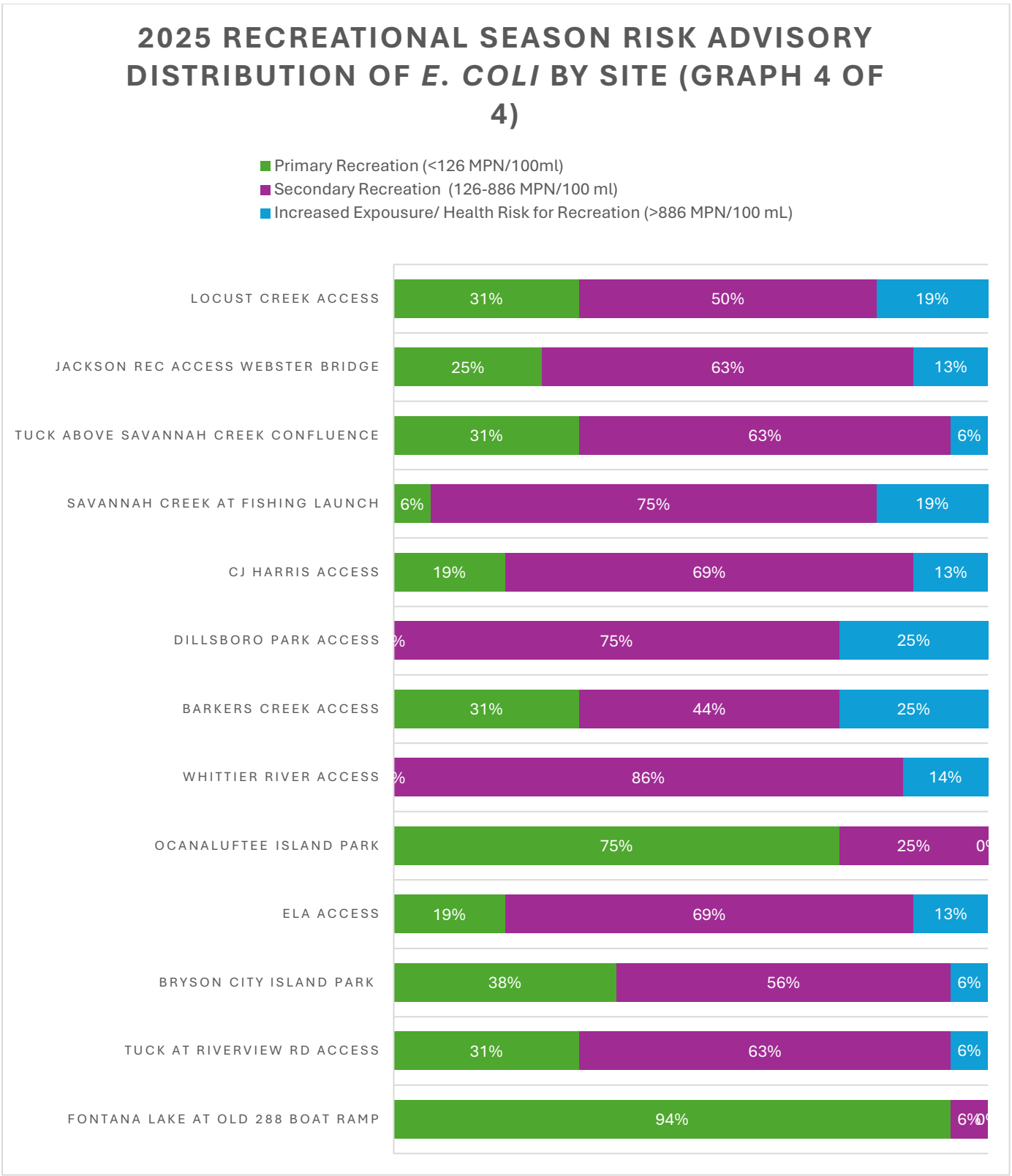


Figure 14. 2025 Recreational Season Risk Advisory Distribution of *E. coli* by Site (Graph 4 of 4)

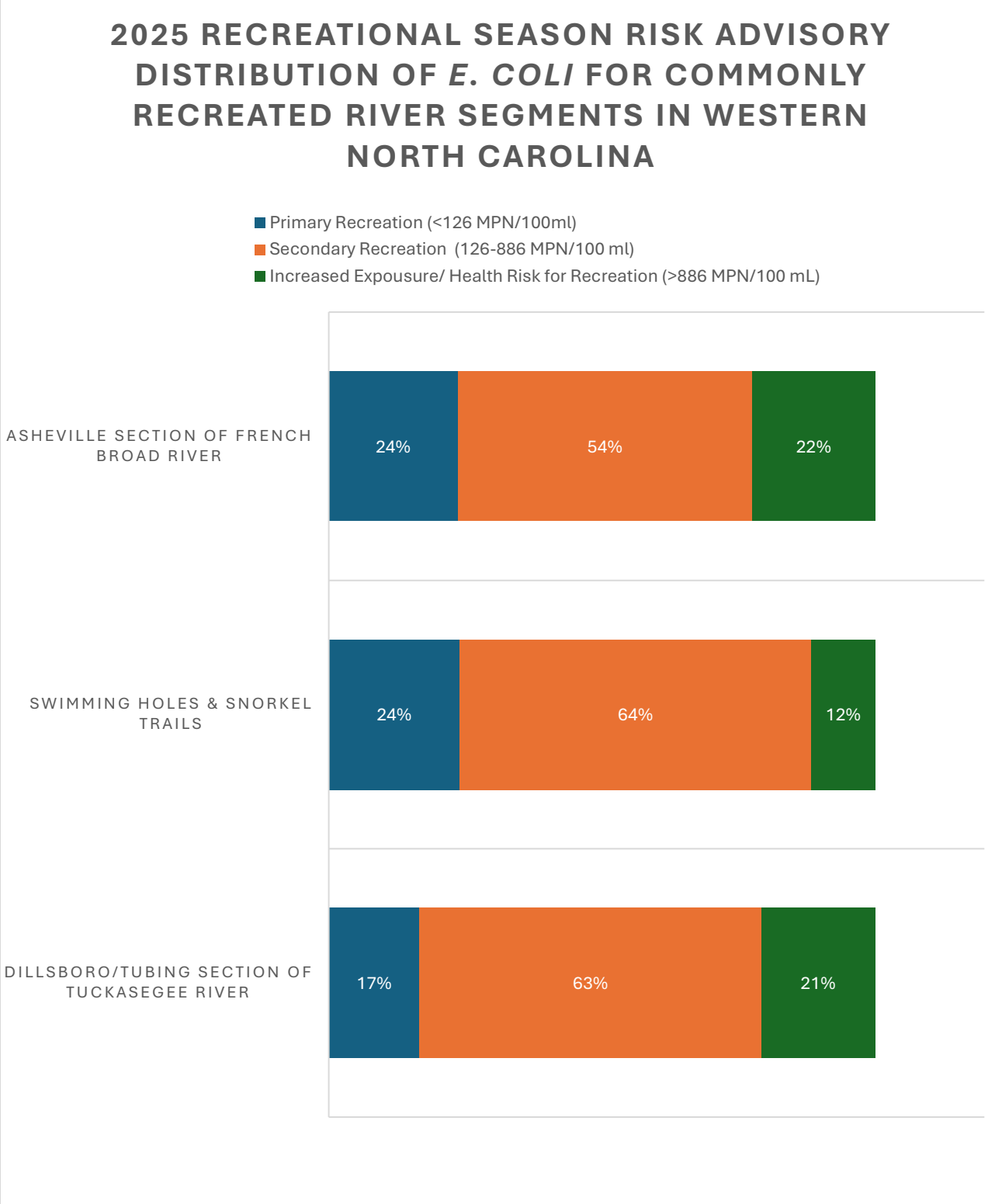
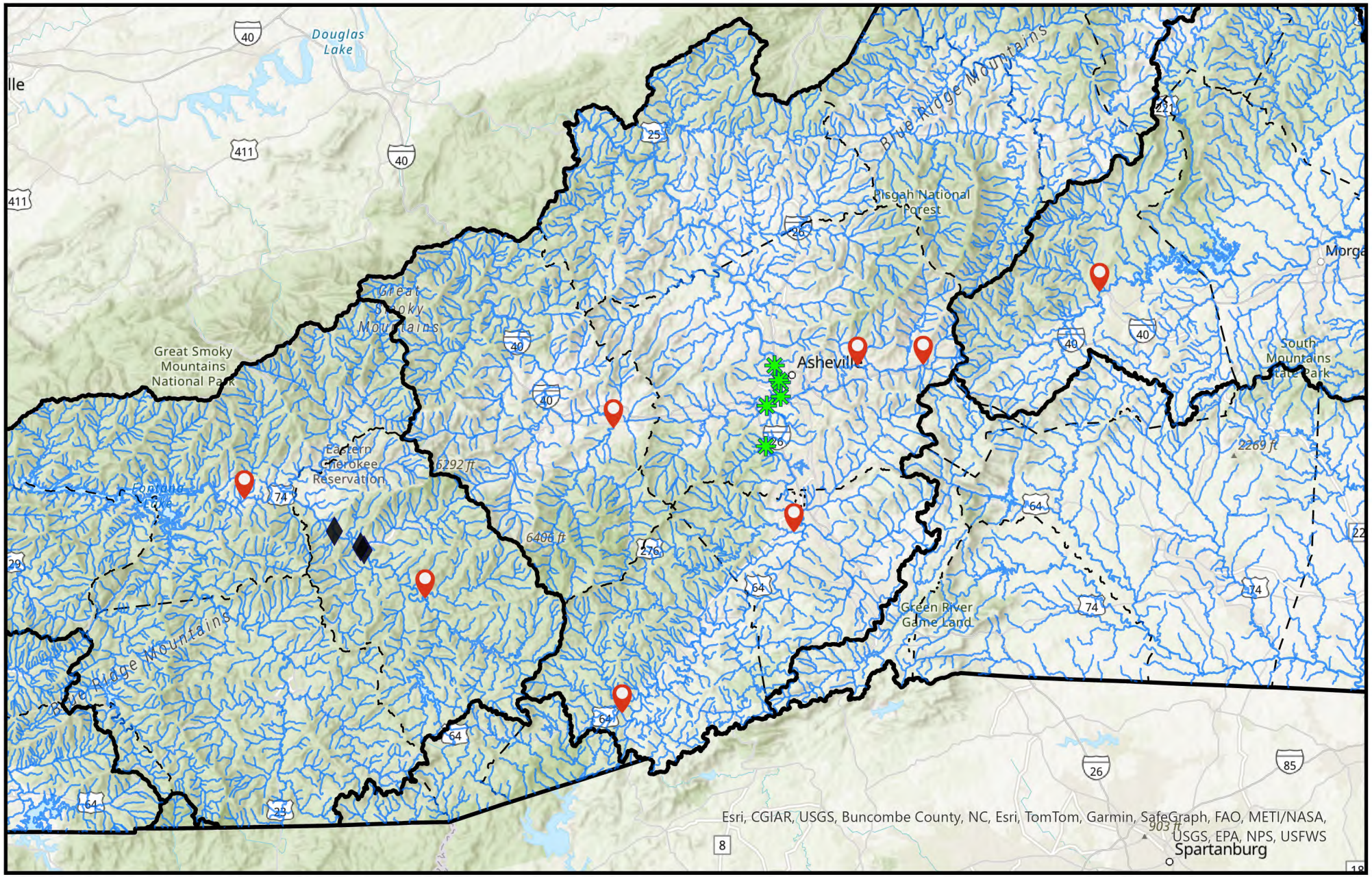


Figure 15. 2025 Recreational Season Risk Advisory Distribution of *E. coli* for Commonly Recreated River Segments in Western North Carolina

Figure 16. Map of Commonly Recreated River Segment Categories



2025 Commonly Recreated Segments WNC Recreational WQ Monitoring Program

- Swimming Holes & Snorkel Trail Sites
- Asheville Section of French Broad River
- Dillsboro/Tubing section of Tuckasegee River

- SurfaceWaterClassifications
- Major River Basins
- NC Counties (DEQ Version with Regional Offices)

N

0 5 10 20 Miles

Scale: 1:939,108

NCDEQ - Division of Water Resources, NC DEQ - Div. of Water Resources, Author: Rachel Rose

Appendix I

North Carolina's Wastewater/Groundwater Laboratory Certification Branch Approved Procedure for the Analysis of Turbidity

NORTH CAROLINA WASTEWATER/GROUNDWATER LABORATORY CERTIFICATION BRANCH APPROVED PROCEDURE FOR THE ANALYSIS OF TURBIDITY

According to Standard Methods 2130 B – 2020

This document provides an approved procedure for the analysis of Turbidity for compliance monitoring per 15A NCAC 02H .0805 (a) (7) and (g) (4).

Turbidity is considered a method-defined parameter per the definition in the Code of Federal Regulations, Part 136.6, Section (a) (5). This means that the method may not be modified per Part 136.6, Section (b) (3).

Holding Time:

- Samples must be analyzed within 48 hours of collection (40 CFR Part 136.3 Table II).
- Samples must be stored above freezing and ≤6 °C, if not analyzed immediately.

General Information:

- Sample duplicates are not a required quality control element for Field parameters.
- A nephelometer must be used for the analysis of Turbidity.
- Turbidity samples are not to be diluted unless their concentration falls outside the allowable calibration range of the meter.
- A post-analysis calibration verification must be performed at the end of the run anytime the meter is transported by vehicle to another location after calibration. It is recommended that a mid-day or a mid-batch calibration verification be performed when samples are analyzed over an extended period of time. The value obtained for the post-analysis calibration verification check-standard must read within 10% of the standard's true value. If the obtained value is outside of the ±10% range, corrective action must be taken. If recalibration is necessary, all samples analyzed since the last acceptable calibration verification must be reanalyzed, if possible. If samples cannot be reanalyzed, the data must be qualified.

Interferences

- Light-absorbing materials such as activated carbon (when present in significant concentrations) or presence of dissolved, color-causing substances can cause a negative interference. Samples with very high turbidity and/or colored samples may benefit from analysis using the Ratio mode that is available on some meters.
- Dirty glassware and air bubbles give false results. Remove air or other entrained gases in the sample before measurement. Preferably degas even if no bubbles are visible. Degas by applying a partial vacuum, adding a nonfoaming-type surfactant, using an ultrasonic bath, or applying heat. In some cases, two or more of these techniques may be combined for more effective bubble removal. For example, it may be necessary to combine addition of a surfactant with use of an ultrasonic bath for some severe conditions. Any of these techniques, if misapplied, can alter sample turbidity; use with care. If degassing cannot be applied, bubble formation will be minimized if the samples are maintained at the temperature and pressure of the water before sampling.
- Keep the sample cell clean when not in use. Handle sample cells only by the top to avoid dirt and fingerprints within the light path. Discard when they become scratched or etched. A light coating of silicon oil may be used to mask minor imperfections in glass tubes.
- Condensation may occur on the outside surface of a sample cell when a cold sample is being measured in a warm, humid environment. This interferes with turbidity measurement. Remove all moisture from the outside of the sample cell before placing the cell in the instrument. If fogging recurs, let sample warm slightly by letting it stand at room temperature or by partially immersing it in a warm water bath for a short time. Make sure samples are again well mixed.

Definitions:

- A nephelometer is defined as a turbidimeter with scattered-light detectors located at 90° to the incident beam.
- NTU: Nephelometric Turbidity Units
- Primary standards are defined as liquid suspensions prepared from hydrazine sulfate and hexamethylenetetramine or a commercially certified stock formazin suspension.

- Secondary standards are defined as commercially prepared, stabilized, sealed liquid or gel turbidity standards calibrated against properly prepared and diluted formazin or styrene divinylbenzene polymers.

Meter:

To minimize differences in measured values due to instrument design, the following design criteria must be met:

- Tungsten-filament lamp.
- Total distance traversed by incident light and scattered light within the sample tube is not to exceed 10 cm.
- Detector centered at 90° to the incident light path and not to exceed ±30° from 90°. The detector and filter (if used) shall have a spectral peak response between 400 and 600 nm.
- Instruments with an LED or Laser light source are not compliant with the SM 2130 B-2020 method.

Standards:

CAUTION: Hydrazine sulfate is a carcinogen; avoid inhalation, ingestion, and skin contact. Formazin suspensions can contain residual hydrazine sulfate.

Stock Primary standard preparation instructions:

1. Solution 1 – Dissolve 1.000 g hydrazine sulfate, $(NH_2)_2 \cdot H_2SO_4$, in distilled water and dilute to 100 mL in a volumetric flask.

2. Solution 2 – Dissolve 10.00 g hexamethylenetetramine, $(CH_2)_6N_4$, in distilled water and dilute to 100 mL in a volumetric flask.

3. Stock Solution – Mix 5.0 mL of Solution 1 and 5.0 mL of Solution 2 in a flask. Let stand for 24 hours at 25 ± 3°C. This makes a 4000 NTU suspension. Store in amber glass or other UV-light-blocking container. Stock solution is stable for up to 1 year. Prepare calibration standards from this stock solution for calibration.

   Note: prepare stock standard and calibration standards using reagent water passed through a filter with pore size no larger than 0.1 µm. The usual filter used for bacteriological examinations is not satisfactory for this.

Secondary standards may be used beyond their expiration date only if their concentrations are verified against a primary standard by the date of expiration and quarterly thereafter and are shown to be within 10% of their original concentration. This must be documented and kept on file.

Procedure:

- Allow instrument sufficient time to warm up.
- Calibrate the meter according to manufacturer's instructions, with at least one calibration or verification standard in each instrument range to be used.
- Gently agitate sample to ensure homogeneity and wait for air bubbles to disappear.
- Pour sample into sample vial. Ensure no air bubbles are present.
- Wipe vial with a lint-free cloth or Kimwipe to remove any condensation, moisture or fingerprints. A thin layer of silicon oil may be applied (optional).
- Gently invert the sample to ensure homogeneity and place in turbidimeter.
- Close chamber lid and read turbidity from instrument display at first stable reading.
- Document turbidity measurement from instrument display.
- If sample dilutions are performed, analyze the dilution water to demonstrate a concentration ≤ 0.02 NTU.
- Report turbidity readings, along with qualification if applicable, as follows:

Measured Turbidity Range *NTU*	Report to the Nearest *NTU*
0 – 1.0	0.05
1 – 10	0.1
10 – 40	1
40 – 100	5
100 – 400	10
400 – 1000	50
> 1000	100

Documentation:

The following must be documented in indelible ink whenever sample analysis is performed:

1. Date and time of sample collection
2. Date and time of sample analysis to verify the 48-hour holding time is met
3. Permitted facility name or permit number, and sample site (ID or location)
4. Collector's/analyst's name or initials
5. Meter calibration and meter calibration time(s)
6. True values of the calibration and/or verification standards (determined by the manufacturer's calibration procedure)
7. True value and value obtained for the post-analysis calibration verification(s), when applicable
8. Quality control assessments
9. Indication of when the post-analysis calibration verification was performed (e.g., time of analysis, end-of-day analysis, etc.)
10. Measured value
11. Units of measure (NTU)
12. Traceability for chemicals, reagents, standards and consumables
13. Unique instrument identification (serial number preferred)
14. Parameter analyzed
15. Method reference or Standard Operating Procedure
16. Data qualifiers, when necessary

Ref: Standard Methods 2130 B – 2020

Appendix II

WNC Rec Program's *E. coli* Geomeans in 2025 Recreational Season by Water Body

Water Body	Location Name	*E. coli* Geomean (MPN/100mL)
Catawba River	McDowell County Greenway	324
French Broad River	Pearson's Bridge River Access	239
French Broad River	Craven St. Boat access	293
French Broad River	Amboy River Park	197
French Broad River	Hot Springs USGS Gage	213
French Broad River	Bent Creek River Park	361
French Broad River	Jean Webb	641
French Broad River	Champion Park	178
French Broad River	Hap Simpson Park	1007
French Broad River	Blantyre Boat Access	517
French Broad River	Horseshoe Boat Access	508
French Broad River	French Broad at Westfeldt	801
Hominy Creek	Hominy Greenway Beach	431
Hominy Creek	Hominy Creek USGS Gage	428
Hominy Creek	Hominy Creek Riverpark	365
Swannanoa River	Biltmore Village Park	340
Swannanoa River	Walmart Dog Park	338
Swannanoa River	Moffit Rd	250
Swannanoa River	DS KOA campground	261
Swannanoa River	River Walk Park	367
Swannanoa River	Azaela Park	198
Swannanoa River	Owen Park	110
Swannanoa River	Veterans Park	331
Swannanoa River	Warren Wilson Swimming Hole	205
Flat Creek	Flat Creek - Tractor supply	351
Buttermilk Creek/Unnamed Tributary to Hominy Creek	Malvern Hills Park	828
Reed Creek	Botanical Gardens - Reed Creek access point 1	450
Reed Creek	Botanical Gardens - Reed Creek access point 2	498
Reed Creek	Botanical Gardens - Reed Creek access point 3	598
Mills River	Mills River Park Boat Access	372
Cane Creek	Bill Moore Park	921

Cane Creek	Spring Mountain Community Center	746
Big Laurel Creek	Big Laurel	177
Pigeon River	Canton Rec Park	215
Pigeon River	Canton USGS Gage – Pigeon River	274
Pigeon River	River's Edge Park - Pigeon River	349
Tuckasegee River	East LaPorte Park	284
Tuckasegee River	Jackson Rec Access	194
Tuckasegee River	CJ Harris Access	273
Tuckasegee River	Locust Creek Access	224
Tuckasegee River	Bryson City Island Park	224
Tuckasegee River	Ela Access	319
Tuckasegee River	Shook Cove Access	13
West Fork of Tuckasegee River	Lake Thorpe Access	68
Lake Thorpe/Lake Glennville/West Fork of Tuckasegee River	Pine Creek Access	13
Tuckasegee River	Barkers Creek Access	313
Tuckasegee River	Cullowhee Access Area	256
Tuckasegee River	Tuckasegee US Savannah Creek	219
Tuckasegee River Arm of Fontana Lake	Fontana Lake at Old 288 Boat Ramp	10
Tuckasegee River	Tuckasegee at Riverview Rd Access	231
Tuckasegee River	Whittier River Access	408
Scott Creek	Dillsboro Park Access	463
Oconaluftee River	Oconaluftee Island Park	72
Savannah Creek/Unnamed Tributary to Tuckasegee River	Savannah Creek at Fishing Launch	386

Appendix III

WNC Rec Program's 2025 Recreational Season Risk Advisory Distribution of *E. coli* by Site

Site Name	Samples in Primary Recreational Guidance Category (<126 MPN/100mL)	Samples in Secondary Recreational Guidance Category (126 886 MPN/100mL)	Samples in Increased Exposure/Health Risk Recreational Guidance Category (>886 MPN/100 mL)	Total Samples per site	Percent of Samples in Primary Recreational Guidance Category (<126 MPN/100mL)	Percent of Samples in Secondary Recreational Guidance Category (126 886 MPN/100mL)	Percent of Samples in Increased Exposure/Health Risk Recreational Guidance Category (>886 MPN/100 mL)
French Broad at Champion Park	7	6	2	15	47%	40%	13%
French Broad at Hap Simpson Park	0	9	6	15	0%	60%	40%
French Broad at Blantyre Boat Access	1	9	5	15	7%	60%	33%
French Broad at Horseshoe Boat Access	2	8	5	15	13%	53%	33%
French Broad at Westfeldt	0	9	6	15	0%	60%	40%
Bent Creek River Park	5	3	5	13	38%	23%	38%
Hominy Creek Riverpark	3	9	3	15	20%	60%	20%
Amboy River Park	5	8	2	15	33%	53%	13%
Jean Webb Park	1	10	5	16	6%	63%	31%
Craven St. Boat Access	4	8	3	15	27%	53%	20%
Pearson Bridge River Access	3	10	2	15	20%	67%	13%
Hot Springs USGS Gage	6	3	4	13	46%	23%	31%

Mills River Park Boat Access	2	10	3	15	13%	67%	20%
Bill Moore Park	0	9	4	13	0%	69%	31%
Spring Mountain Community Center	0	9	3	12	0%	75%	25%
Hominy Creek USGS Gage	1	10	4	15	7%	67%	27%
Hominy Creek Greenway	0	11	4	15	0%	73%	27%
Malvern Hills Park	0	8	7	15	0%	53%	47%
Biltmore Village Dog & Community Park	5	9	3	17	29%	53%	18%
Walmart Dog Park	5	10	3	18	28%	56%	17%
Azaela Park	4	13	0	17	24%	76%	0%
Moffit Rd Park	3	11	2	16	19%	69%	13%
Warren Wilson Swimming Hole	10	16	2	28	36%	57%	7%
Owen Park	9	7	0	16	56%	44%	0%
Near KOA campground	1	14	1	16	6%	88%	6%
Veterans Park	1	21	3	25	4%	84%	12%
River Walk Park	0	15	1	16	0%	94%	6%
Flat Creek near Tractor Supply	0	14	2	16	0%	88%	13%
Botanical Gardens - River Access 1	1	11	3	15	7%	73%	20%
Botanical Gardens -	1	10	4	15	7%	67%	27%

River Access 2							
Botanical Gardens - River Access 3	0	9	6	15	0%	60%	40%
Big Laurel	6	7	1	14	43%	50%	7%
McDowell County Greenway	1	12	2	15	7%	80%	13%
Canton USGS Gage	2	12	2	16	13%	75%	13%
Canton Rec. Park	4	10	2	16	25%	63%	13%
River's Edge Park	5	8	3	16	31%	50%	19%
Pine Creek Access	5	7	4	16	31%	44%	25%
Tuckasegee Lake Thorpe Access	11	3	2	16	69%	19%	13%
Shook Cove Access	15	0	1	16	94%	0%	6%
East LaPorte Park	4	10	2	16	25%	63%	13%
Cullowhee Access Area	4	10	2	16	25%	63%	13%
Locust Creek Access	5	8	3	16	31%	50%	19%
Jackson Rec Access Webster Bridge	4	10	2	16	25%	63%	13%
Tuck above Savannah Creek Confluence	5	10	1	16	31%	63%	6%
Savannah Creek at Fishing Launch	1	12	3	16	6%	75%	19%
CJ Harris Access	3	11	2	16	19%	69%	13%
Dillsboro Park Access	0	12	4	16	0%	75%	25%

Barkers Creek Access	5	7	4	16	31%	44%	25%
Whittier River Access	0	6	1	7	0%	86%	14%
Oconaluftee Island Park	12	4	0	16	75%	25%	0%
Ela Access	3	11	2	16	19%	69%	13%
Bryson City Island Park	6	9	1	16	38%	56%	6%
Tuck at Riverview Rd Access	5	10	1	16	31%	63%	6%
Fontana Lake at Old 288 Boat Ramp	15	1	0	16	94%	6%	0%
Totals:	201	499	148	848	24%	59%	17%