# Fecal Coliform Bacteria
# Total Maximum Daily Loads for
# Shellfish Monitoring Stations in Sand and Whooping Island Creeks
# Shellfish Management Area 12B
# HUC 030502060405


SC DEPARTMENT *of*
**ENVIRONMENTAL SERVICES**

Bureau of Water
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USEPA Approval Date:
Technical Report Number:

## Abstract

§303(d) of the CWA and USEPA's *Water Quality Planning and Management Regulations* (40 CFR - Protection of Environment 2017) require states to develop TMDLs for water bodies that are included on the §303(d) list of impaired waters. A TMDL is the maximum amount of pollutant a waterbody can assimilate while meeting WQS for the pollutant of concern. All TMDLs include a WLA for any NPDES permitted dischargers, an LA for all nonpoint sources, and an explicit and/or implicit MOS. This technical report describes the development of FC TMDLs for impaired shellfish monitoring stations 12B-47, 12B-50, and 12B-52 in Sand and Whooping Island creeks in Charleston County, SC. These stations have been included in SC's draft 2024 §303(d) list of impaired waters for exceeding FC WQS for SFH use and have been prioritized and accepted by EPA as metrics in the CWA §303(d) program performance measures.

SCDOT is an NPDES permitted TS4. For SCDOT, compliance with terms and conditions of its NPDES TS4 permit is effective implementation of the WLA to the MEP. Charleston County is an NPDES permitted MS4 in this watershed. SCDOT and Charleston County have been allocated WLAs.

Table Ab1. TMDLs for Sand and Whooping Island creeks. TMDLs are expressed as the mpn/100 mL and mpn/day, and allocations are expressed as % reductions.

| Station | Existing Conc. (mpn/ 100mL) | TMDL Conc. [1] (mpn/ 100mL) | TMDL Load [2] (WLA+LA+MOS) (mpn/day) | Implementation Targets [6] | | | |
|---|---|---|---|---|---|---|---|
| | | | | Continuous Sources [3] (mpn/100mL) | Intermittent MS4 [5] (%) | Intermittent TS4 SCDOT [4, 5] (%) | Nonpoint Sources (%) |
| **12B-47** | 343.9 | 43 | 1.35E+12 | See Note Below | 88.1% | 88.1% | 88.1% |
| **12B-50** | 71.3 | 43 | 3.19E+12 | See Note Below | 42.7% | 42.7% | 42.7% |
| **12B-52** | 49.5 | 43 | 2.18E+12 | See Note Below | 17.4% | 17.4% | 17.4% |

Table Notes:

1. TMDL = SFH WQS for SSM not to exceed 43 mpn/100 mL FC.
2. TMDL at average flow conditions calculated using estimated average tidal flow at the WQM station. See Appendix C - The Method Used to Calculate the Daily Load for example calculation.
3. WLA is expressed as a daily maximum of 43 mpn/100 mL FC. There are no continuous dischargers at this time. Future continuous discharges are required to meet the WQS for the pollutant of concern. Loadings to meet the WQS are developed based on the permitted flow and an allowable permitted maximum concentration of 43 mpn/100mL FC.
4. By implementing the BMPs that are prescribed in either the SCDOT annual SWMP or the SCDOT NPDES TS4 permit to address bacteria, the SCDOT will comply with this TMDL and its applicable WLA to the MEP as required by its NPDES TS4 permit.
5. Percent reduction applies to all NPDES permitted stormwater discharges, including current and future MS4s, construction, and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of stormwater discharge volumes and

recurrence intervals. Stormwater discharges are required to meet percentage reduction or the existing instream standard for the pollutant of concern in accordance with their NPDES Permit.

6. Refer to section 6.0 for the derivation of implementation targets.

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## List of Abbreviations and Symbols

| Abbreviation/ Symbol | Definition |
|---|---|
| ac | Acre |
| AVMA | American Veterinary Medical Association |
| BMP | Best Management Practices |
| CAFO | Confined Animal Feeding Operations |
| CFR | Code of Federal Regulations |
| cfu | Colony forming units |
| CWA | Clean Water Act |
| DA | Drainage Area |
| FC | Fecal Coliform |
| GIS | Geographic Information System |
| HUC | Hydrologic Unit Code |
| ISSC | Interstate Shellfish Sanitation Conference |
| LA | Load Allocation |
| MEP | Maximum Extent Practicable |
| MOS | Margin of Safety |
| MPN | Most Probable Number |
| MS4 | Municipal Separate Storm Sewer System |
| MSD | Marine Sanitation Device |
| NLCD | National Land Cover Database |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollution Discharge Elimination System |
| NSSP | National Shellfish Sanitation Program |
| ORW | Outstanding Resource Waters |
| R | Regulation |
| SA | Recreational Salt Waters |
| SB | Recreational Salt Waters |
| SC | South Carolina |
| SCDES | South Carolina Department of Environmental Services |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| SCDNR | South Carolina Department of Natural Resources |
| SCDOT | South Carolina Department of Transportation |
| SFH | Shellfish Harvesting |

| | |
|---|---|
| SFMA | Shellfish Harvesting Management Area |
| SRS | Systematic Random Sampling |
| SSM | Single Sample Maximum |
| SSO | Sanitary Sewer Overflow |
| SWMP | Stormwater Management Plan |
| SWPPP | Stormwater Pollution Prevention Plan |
| TMDL | Total Maximum Daily Load |
| TS4 | Transportation Separate Storm Sewer System |
| USDA | United States Department of Agriculture |
| USEPA | United States Environmental Protection Agency |
| USFDA | United States Food and Drug Administration |
| USGS | United States Geological Survey |
| WLA | Wasteload Allocation |
| WQ | Water Quality |
| WQM | Water Quality Management |
| WQS | Water Quality Standards |
| WWTP | Waste Water Treatment Plant |
| $mi^2$ | Square Mile |
| n | Sample size, population |
| % | Percent |
| § | Section |
| ∑ | Sum, Total |
| mL | milliliter |

# 1.0 Introduction

## 1.1 Background

The federal CWA requires each state to assess its waters, develop monitoring strategies, and establish WQS for various types and uses of water bodies. Furthermore, the CWA mandates states to review the monitoring results every two years to ensure compliance with the established WQS. If monitoring indicates that the WQS are not being met, the states are required to list the impaired bodies under §303(d) of the CWA. These listed sites are then assigned a priority ranking for restoration efforts, and the impairments are addressed through the implementation of TMDLs, as outlined in 40 CFR Part 130, based on their respective ranks (40 CFR - Protection of Environment 2017).

A TMDL is one part of a regulatory framework used to manage and control pollutant levels in water bodies that are impaired by pollutants. It establishes the maximum amount of a specific pollutant that a water body can receive from all sources, continuous point sources, intermittent point sources, and nonpoint sources, while still meeting WQS. The TMDL process includes estimating pollutant contributions from all sources, linking pollutant sources to their impacts on water quality, allocation of pollutant contributions to each source, and establishment of control mechanisms to achieve WQS.

A TMDL is comprised of the sum of individual WLAs (ΣWLAs) for continuous and intermittent point sources, and sum of LAs (ΣLAs) for nonpoint sources. In addition, the TMDLs include an MOS, either implicit or explicit, which is a buffer or safety factor included in the TMDL to account for uncertainties in the relationship between pollutant loads and water quality. Conceptually, this definition is represented by the equation:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

This TMDL document is a detailed analysis describing the development of FC bacteria TMDLs for three shellfish monitoring stations located in Sand and Whooping Island creeks in SFMA 12B, Charleston County, SC. Shellfish monitoring stations 12B-47, 12B-50, and 12B-52 have exceeded the shellfish harvesting WQS for “approved” classification. Station 12B-37 is the downstream boundary for these impaired stations, upstream of which is restricted for shellfish harvesting. All three impaired stations have been included in SC’s draft 2024 §303(d) list of impaired waters. These stations

have been prioritized and accepted by USEPA as metrics in the CWA §303(d) program performance measures.

In SC, oysters and clams are the two species of bivalve molluscan shellfish that are harvested commercially, recreationally, and utilized for aquaculture. These two species are Eastern or American oyster, *Crassostrea virginica*, and hard clam or Northern quahog, *Mercenaria mercenaria*. Both species are native to the North American Atlantic and Gulf coasts and have economic importance. Oysters in SC cluster together to form oyster beds and oyster reefs. These formations stabilize shorelines from erosion, provide nursery grounds as well as protection for other marine species. In South Carolina, 95% of oyster reefs are intertidal, meaning they are exposed during low tide and submerged during high tide.

Both oysters and clams are filter feeders, meaning they filter water for algae as a nutrient source. In brackish and saltwaters, there are naturally occurring bacteria and viruses. Also, there are other sources for bacteria and viruses to enter these waters as a result of human activities, some examples are agricultural runoff, malfunctioning septic systems, pet waste, sanitary sewer overflows, and stormwater runoff. An adult oyster can filter approximately 50 gallons of water a day, while an adult clam can filter approximately 24 gallons a day. These filter feeders can concentrate naturally occurring bacteria, such as pathogenic bacteria *Vibrio vulnificus* and *Vibrio parahaemolyticus*, and viruses that are in the water as well as those resulting from human-related activities.

The NSSP is the federal and state cooperative program recognized by both the USFDA and the ISSC. States have agreed, through participation in NSSP and membership in the ISSC, to enforce the Model Ordinance (USFDA 2021). The Model Ordinance supplies states with standards as well as administrative practices required for the sanitary control of shellfish produced and sold for human consumption.

The FC group of bacteria is usually not pathogenic, and they are used as indicator organisms. As an indicator, they may indicate the presence of other pathogenic bacteria. In the NSSP Model Ordinance (USFDA 2021) and in SC R. 61-47 Shellfish (SCDHEC 2017), the WQS for SFH with an "approved" classification is "…the geometric mean fecal coliform MPN shall not exceed fourteen per one hundred milliliters, nor shall the estimated ninetieth percentile exceed an MPN of forty three per one hundred milliliters (per five tube decimal dilution)". Shellfish R. 61-47 was promulgated by the statutory authority under S.C. Code Section 44-1-140. This regulation adopted the shellfish FC WQS as set forth in the NSSP Model Ordinance.

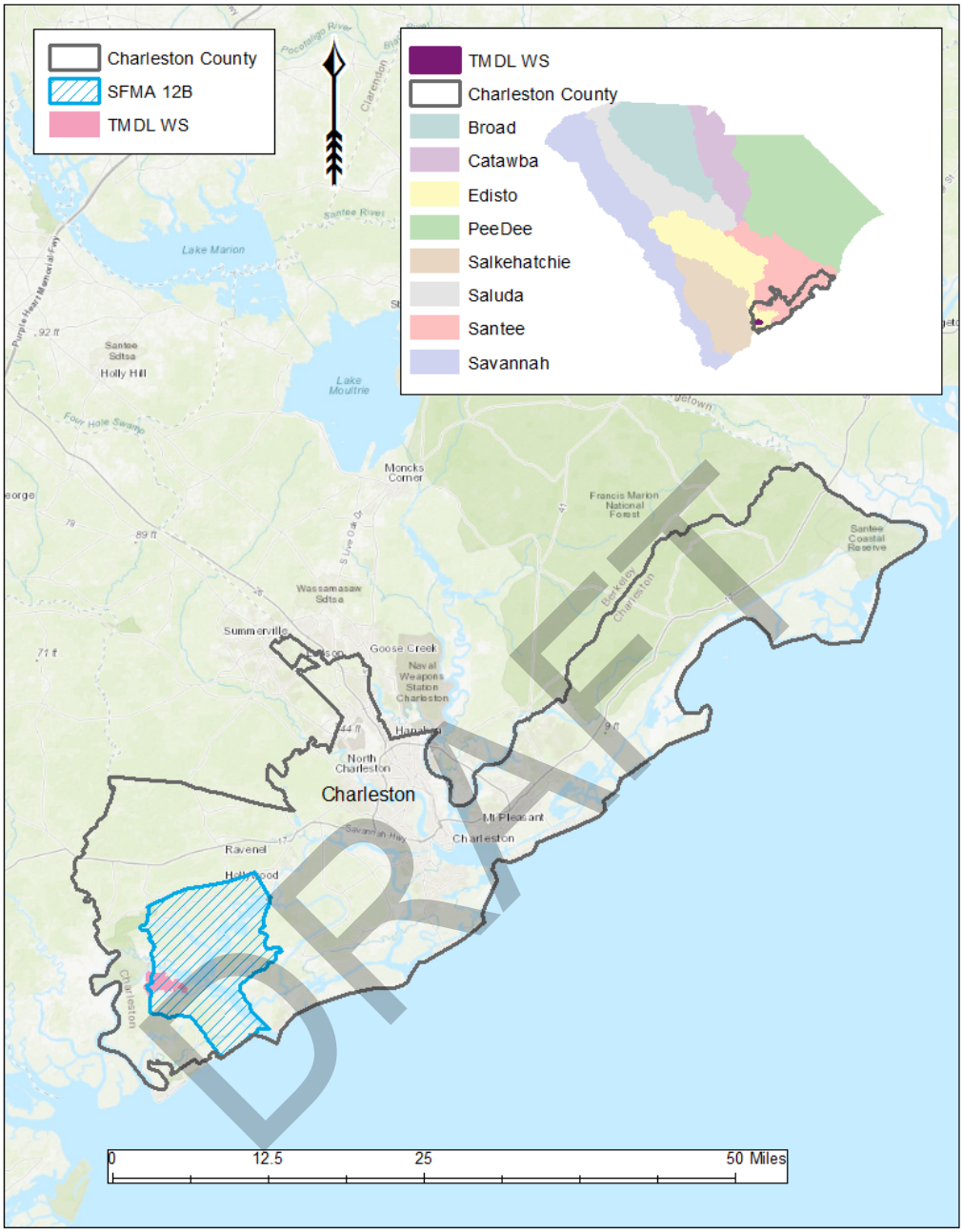


Figure 1. Locations of shellfish management area 12B, and Sand and Whooping Island creeks TMDL watershed in Charleston County, SC.

## 1.2 Watershed Description

Sand and Whooping Island creeks are tidal tributaries of North Edisto River and are located among Little Edisto and Whooping islands, situated southwest of the City of Charleston in Charleston County, SC. The creeks are encompassed within SFMA 12B and 12-digit HUC 030502060405 (Figure 1, Figure 2). The DA for the TMDL WQM

stations were delineated using USGS topographic maps and ArcGIS software. Sand and Whooping Island creeks TMDL DA is approximately 3.4 $mi^2$ (Figure 3).

Sand and Whooping Island creeks are located within the Sea Islands/Coastal Marsh ecoregion, characterized by the state's lowest elevations. This dynamic environment is shaped by elements such as wind, ocean waves, and river flows. Dominant forest types in this ecoregion include slash pine, cabbage palmetto, red cedar, and live oaks. Marshes play a significant role and are primarily populated by plant species like saltgrass, rushes, and various cordgrasses. Notably, these marshes serve as essential nursery grounds for a wide range of aquatic species, including shrimp, fish, crabs, and various other organisms (Griffith, et al. 2002).

SCDES formerly known as SCDHEC, currently has two active shellfish monitoring stations, 12B-52 and 12B-37, and two that are inactive, 12B-47 and 12B-50, in Sand and Whooping Island creeks (SCDHEC 2023). Stations 12B-47, 12B-50, and 12B-52 do not meet the FC WQS for SFH and are classified as "restricted" for shellfish harvesting. Per USFDA rules and regulations, station 12B-37 is the downstream boundary of the area restricted for shellfish harvesting (Figure 2) (Table 1). The TMDL watershed extends to but does not include the boundary station and the implementation targets in Table 7 apply to the entire watershed as shown in Figure 3.

Table 1. Sand and Whooping Island creeks shellfish monitoring stations and their location descriptions.

| Station | Description |
|---|---|
| **12B-37** | Steamboat Creek at Russel Creek |
| **12B-47** | Sand Creek Bridge at Highway 174 |
| **12B-50** | Sand Creek at Intake to Westend of Clam Farm |
| **12B-52** | Whooping Island Creek at Steamboat Creek |

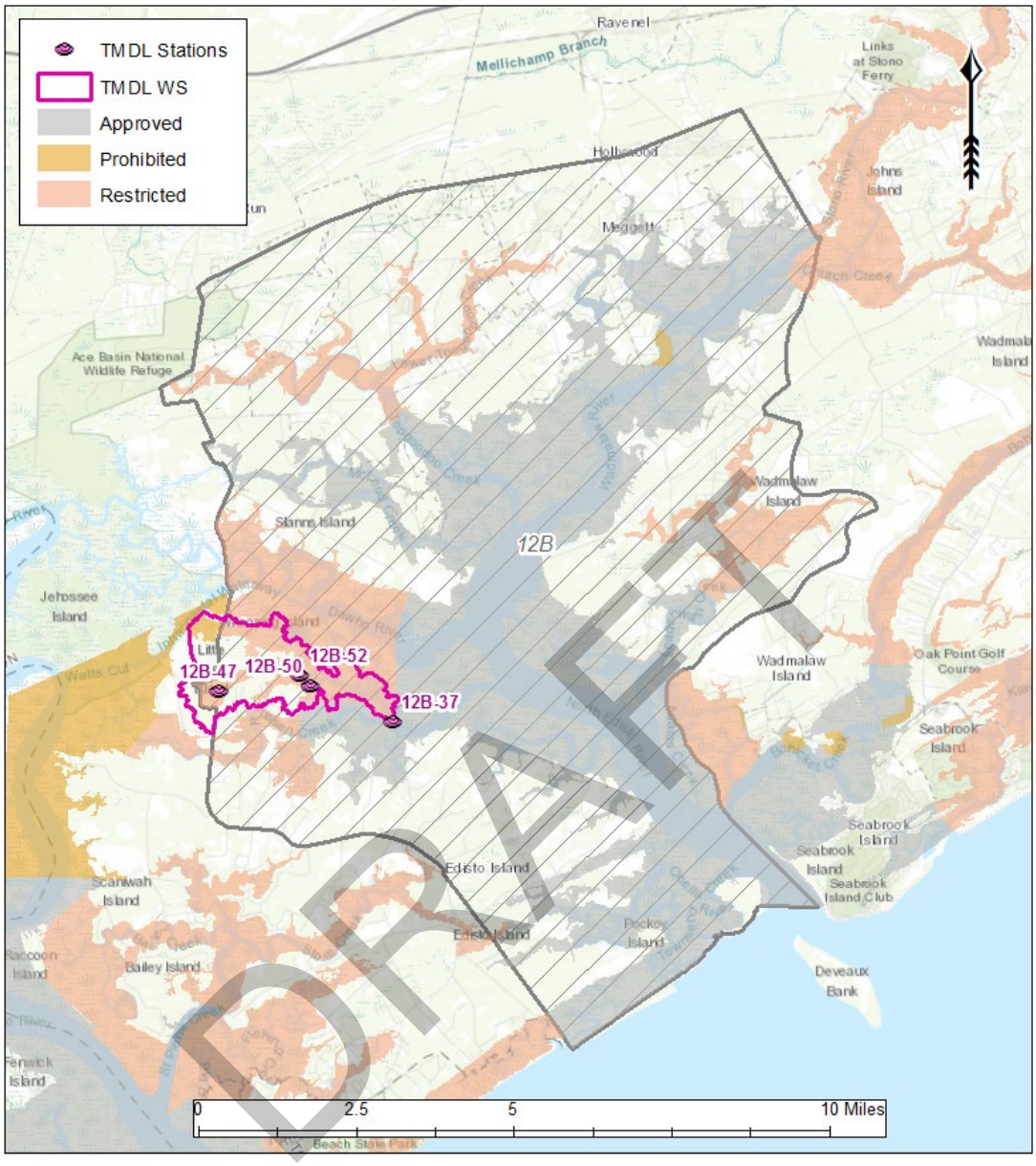


Figure 2. Sand and Whooping Island creeks TMDL watershed in SFMA 12B, impaired and boundary shellfish monitoring stations, and shellfish harvesting classifications.

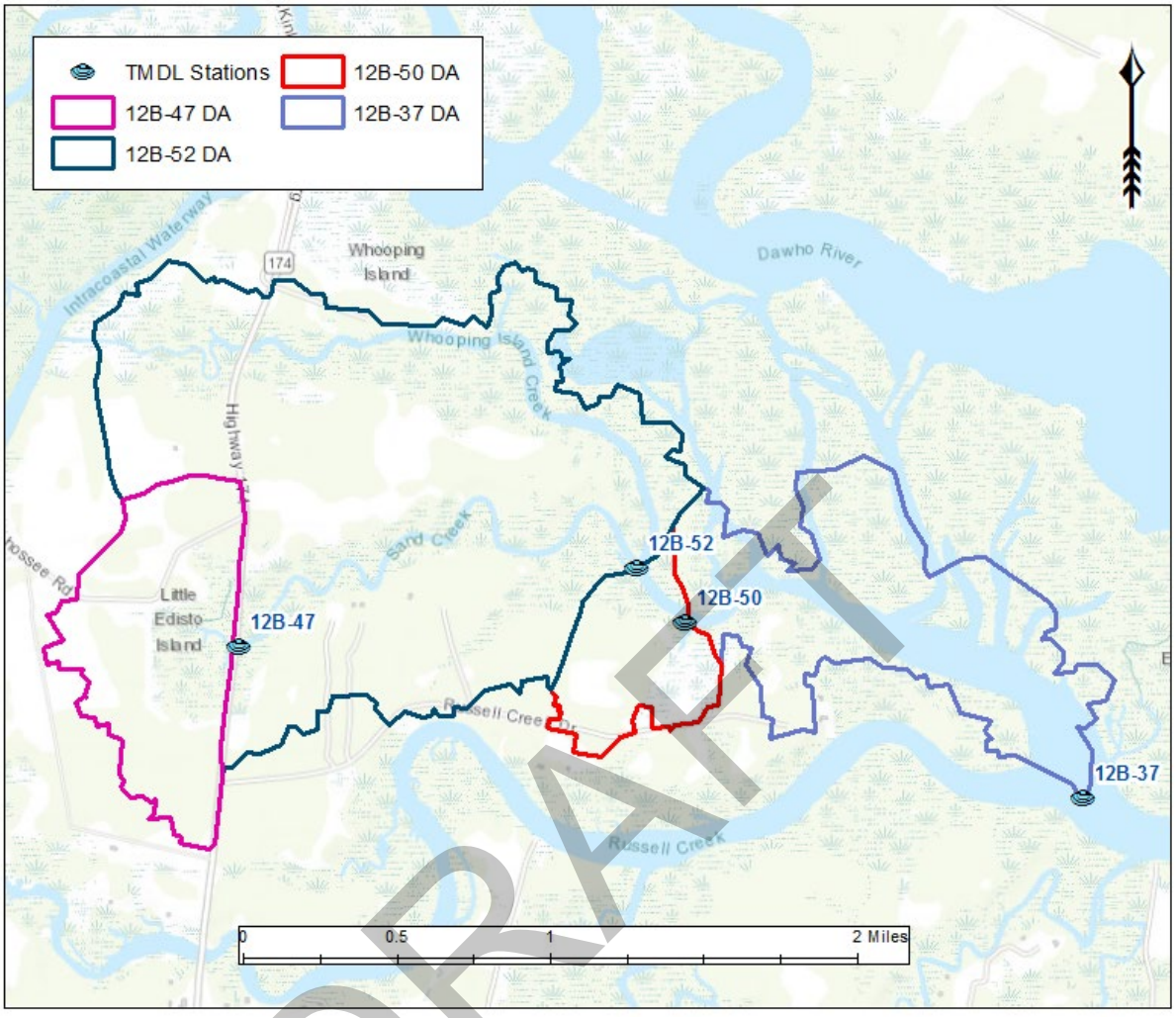


Figure 3. TMDL stations drainage areas.



### 1.3 Land Use

Land uses of impaired stations were calculated using the 2021 NLCD (Dewitz 2023) (Figure 4). Land use characteristics for station 12B-52 are summarized in Table 2. Remaining TMDL stations' land use summaries can be found in Appendix D – Land Uses.

Table 2. 2021 NLCD land uses of station 12B-52.

| 12B-52 | Area (ac) | % of Area |
|---|---|---|
| Open Water | 75.6 | 6.1 |
| Developed | 45.1 | 3.6 |
| Barren Land | 19.8 | 1.6 |
| Forest | 158.8 | 12.8 |
| Pasture/Hay | 44.3 | 3.6 |
| Cultivated Crops | 6.2 | 0.5 |
| Forested Wetlands | 247.3 | 19.9 |
| Non-forested Wetlands | 646.5 | 52.0 |
| Total | 1243.6 | 100.0 |

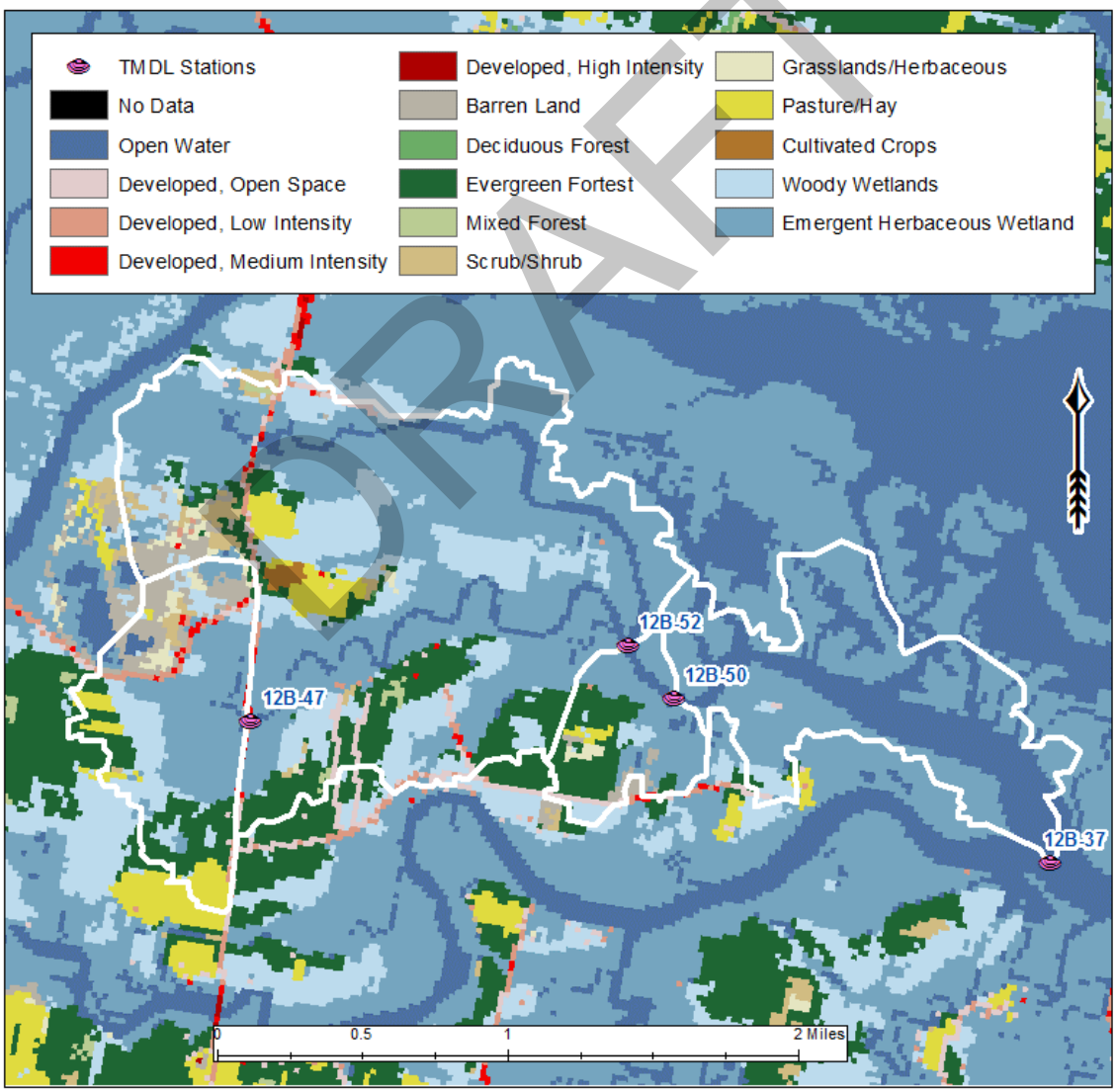


Figure 4. Land uses of the TMDL watershed based on 2021 NLCD.

### 1.4 Water Quality Standard

Sand and Whooping Island creeks are classified as SFH and ORW waters in SC R. 61-69 (SCDHEC 2012).

As defined in SC R. 61-68 (SCDHEC 2023):

> "Shellfish harvesting waters (SFH) are tidal saltwaters protected for shellfish harvesting and uses listed in Class SA and Class SB. Suitable for primary and secondary contact recreation, crabbing, and fishing. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora."

As defined in SC R. 61-68 (SCDHEC 2023):

> "Outstanding Resource Waters (ORW) are freshwaters or saltwaters which constitute an outstanding recreational or ecological resource or those freshwaters suitable as a source for drinking water supply purposes with treatment levels specified by the Department".

FC WQS for SFH waters as defined in SC R. 61-68 (SCDHEC 2023):

> "Not to exceed an MPN fecal coliform geometric mean of 14/100 mL; nor shall more than ten percent (10%) of the samples exceed an MPN of 43/100 mL."

## 2.0 Water Quality Assessment

The NSSP allows shellfish growing areas to be classified using either total or fecal coliform, and application of either standard to different water bodies within the state. There are also two sampling strategies for the application of the standards:

a) Adverse pollution control,
b) SRS (USFDA 2021).

The SCDES Shellfish Program currently utilizes the SRS strategy within SFMA 12B instead of sampling under adverse pollution control conditions. To ensure random sampling, sampling dates are computer-generated before the beginning of each quarterly period. Due to shipping requirements and manpower constraints, samples are collected on Mondays, Tuesdays, or Wednesdays.

To comply with NSSP guidelines, a minimum of 30 samples are required to be collected and analyzed from each station during the three-year review period. For harvest classifications, samples are collected according to the SRS strategy outlined in NSSP Guidance document for 12 months between January 1st and December 31st, for three

years. This allows for a maximum of 36 samples per station for three years yet provides a six-sample "cushion" (above the NSSP required 30 minimum) for broken samples, lab error, breakdowns, etc. This also allows each annual report to meet the NSSP Triennial Review sampling criteria.

The determination for 303(d) listing purposes is based on assessing three consecutive years of data from a shellfish station. For instance for the draft 2024 §303(d) list, shellfish data collected from 2020 - 2022 were used. Note that station 12B-37 meets the WQS and is the downstream boundary for the impaired stations in accordance with NSSP (USFDA 2021) and R. 61-47 (SCDHEC 2017). Data summaries for TMDL stations are presented in Table 3.

In addition to bacteriological samples, surface water temperatures are measured using a hand-held, laboratory-quality calibrated thermometer. Salinities are measured in the laboratory using an automatic temperature compensated refractometer. Additional field data collected during samplings are ambient air temperature, wind direction, tidal stage, date, and time of sampling.

Table 3. Data summaries of TMDL stations.

| Station | n | SSM WQS mpn/100mL | n Exceeding SSM WQS | % Exceeding SSM WQS | TMDL Data Period |
|---|---|---|---|---|---|
| **12B-37*** | 36 | 43 | 1 | 2.7 | 2020 - 2022 |
| **12B-47Ω** | 72 | 43 | 34 | 47.2 | 2000 - 2005 |
| **12B-50 Ω** | 101 | 43 | 18 | 17.8 | 2000 - 2008 |
| **12B-52** | 38 | 43 | 4 | 10.5 | 2021 - 2024 |

**12-37 is the downstream boundary station for the restricted area and meets the FC WQS for shellfish harvesting use. Data included for informational purposes.*

*Ω Stations have been discontinued and are no longer being sampled.*



## 3.0 Source Assessment

Surface waters can be contaminated by various sources of pathogens, which can be categorized as point sources, and nonpoint sources. Efforts to control pollution from continuous point sources, such as WWTPs, have significantly reduced their impact through the implementation of technology-based controls. These point sources are regulated under the CWA and are required to obtain an NPDES permit. In SC, NPDES permits mandate that dischargers with a bacteria limit to meet the WQS at the discharge point (end of pipe). While dischargers, mostly domestic and municipal, can occasionally be sources of pathogens, if they are operating within their permit limits,

they cannot be considered the cause of impairments. There are enforcement actions and mechanisms in place if these facilities fail to meet their permit requirements.

Regulated TS4, MS4, industrial, and construction site stormwater discharges are intermittent point sources. These intermittent sources are required to obtain discharge permits under the NPDES stormwater regulations. Each may be a source of pathogens. These sources are expected to meet the percentage reductions as prescribed in this TMDL document or the existing instream standard for the pollutant(s) of concern, to the maximum extent practicable (MEP), through compliance with the terms and conditions of their NPDES permit.

Nonpoint sources of bacteria in tidal streams include various land-use practices such as agricultural activities, silviculture, urban and rural runoff, malfunctioning septic systems, sanitary sewer overflows, pet waste, wildlife, and poorly managed livestock operations. These activities can contribute to the presence of bacteria in surface water through runoff, leaching, and direct discharge.

### 3.1 Point Sources

Point sources refer to specific locations where NPDES permitted effluent is discharged into the environment from identifiable sources such as pipes, outfalls, or conveyance channels. These sources can be traced to a single location such as industrial, municipal, domestic WWTPs, and NPDES regulated stormwater discharges. Point sources are further divided into “continuous” and “intermittent”.

#### 3.1.1 Continuous Point Sources

Industrial, municipal, and domestic WWTPs have the potential to harbor pathogenic bacteria if their effluent fails to meet the WQS at the discharge point, as defined by their NPDES permit. If these facilities are discharging wastewater that meets their permit limits, they are not contributing to a bacteria impairment. If any of these facilities fail to comply with their permit limits, enforcement actions and mechanisms are in place to address the situation.

Currently, there are no continuous point sources within the TMDL watersheds. Future NPDES dischargers to these creeks are required to comply with their permit limit for FC which will limit them to the WQS at the point of discharge.

### 3.1.2 Intermittent Point Sources – TS4 and MS4s

Intermittent point sources include all NPDES permitted stormwater discharges, including current and future TS4, MS4, construction, and industrial discharges covered under permits numbered SCS and SCR and regulated under *SC Water Pollution Control Permits*: R.61-9 (SCDHEC 2023). All regulated TS4 and MS4 entities have the potential to contribute bacteria and other pathogen loadings to the TMDL watersheds and are subject to the WLA for intermittent point sources.

The presence of developed land in a watershed leads to increased runoff from these areas following precipitation, which can contribute to pollution along with other sources. The "developed" land class, which encompasses open spaces, low, medium, and high-intensity areas, was determined for each TMDL stations' drainage area using ArcGIS and the NLCD 2021 (Dewitz 2023) dataset, and the results are shown station 12B-52 are shown in Table 2. Land use summaries for the remaining TMDL stations are in Appendix D – Land Uses.



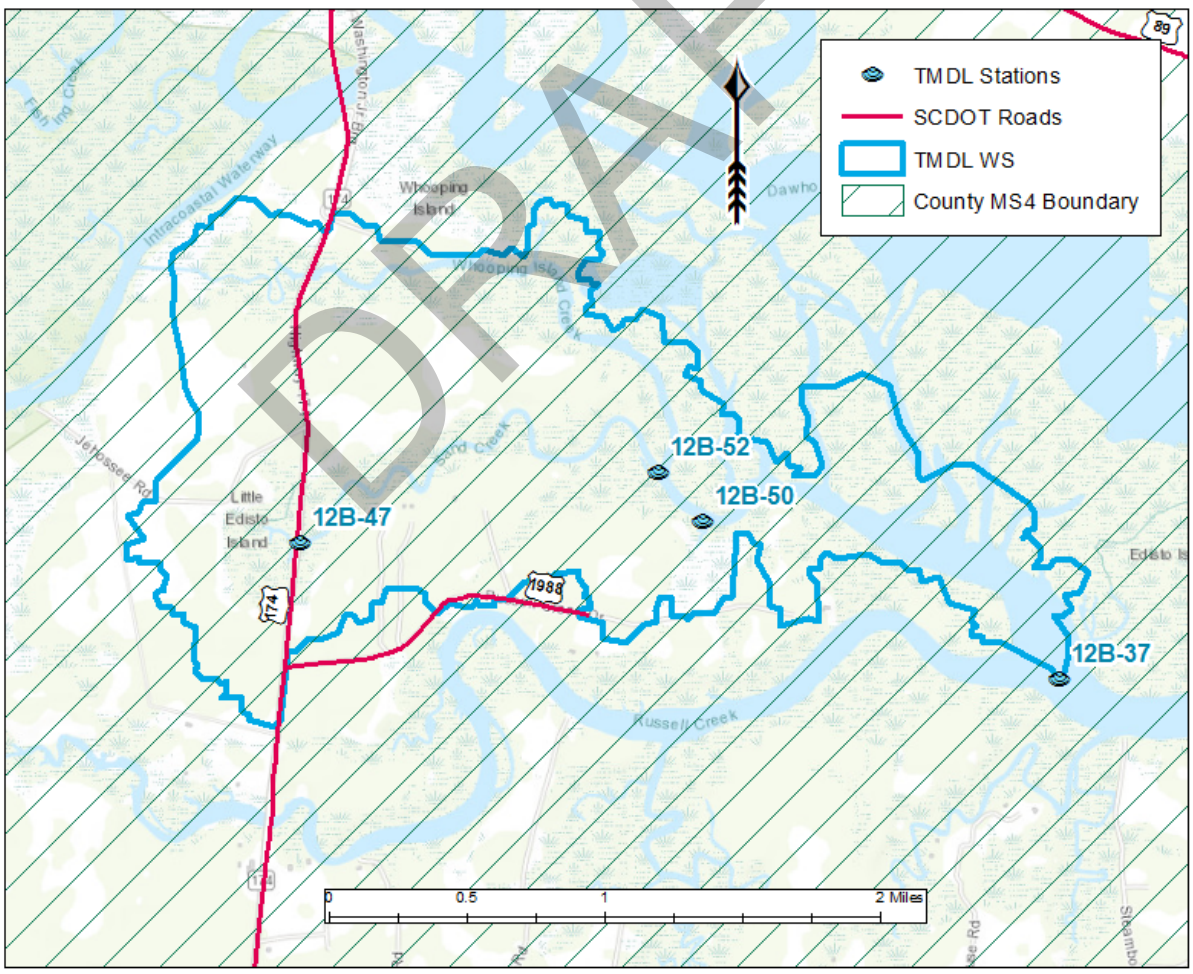


Figure 5. Location of SCDOT TS4 and Charleston County MS4.

The NPDES stormwater industrial general permit (SCR000000) regulates industrial facilities that could potentially cause or contribute to violations of WQS through stormwater discharges. Similarly, the NPDES stormwater construction general permit (SCR100000) applies to construction activities. If construction activities have the potential to impact a water body with a TMDL, the SWPPP must address pollutants of concern and comply with the WLAs specified in this TMDL document. It's important to note that some stormwater discharges in the watershed may not fall under the SCS and SCR permits, and therefore they are not subject to the WLA portion of the TMDL.

Stormwater discharges from all regulated TS4 and MS4 entities operating within the TMDL watersheds have the potential to contribute to bacteria and other pathogens and are subject to the WLA portion of the TMDL. The South Carolina Department of Transportation (SCDOT) is a designated TS4 within these TMDL watersheds, operating under NPDES TS4 permit SCS040001 (Figure 5). However, SCDOT is not a traditional MS4 as it lacks statutory taxing or enforcement powers, and does not regulate land use or zoning, or issue building or development permits. Charleston County and SCDOT have been allocated WLAs (Table 7).

SSOs are intermittent point sources that can have a significant impact on water quality when they release into surface waters. The responsibility for preventing SSOs lies with the NPDES wastewater discharger or the operator of the collection system for non-permitted systems that handle wastewater. However, it is important to note that SSOs are not always preventable or reported. There is no sewer service in the TMDL watershed, therefore SSOs are not considered as a source in this TMDL watershed.

The Department acknowledges that TS4 and MS4s may require multiple permit iterations to fully meet the assumptions and requirements of the TMDL. In order to comply with the TS4 and MS4 permit, making progress towards achieving the WLA reduction for the TMDL through compliance with the stormwater management plan (SWMP) may be considered sufficient, as long as the criteria of MEP met. This allows for flexibility in the implementation process.

For SCDOT NPDES permitted TS4, existing and future NPDES MS4 permittees, compliance with the terms and conditions of their NPDES permit is an effective implementation of the WLA to the MEP and demonstrates consistency with the assumptions and requirements of the TMDL. For existing and future NPDES construction and industrial stormwater permittees, compliance with the terms and conditions of their permit is an effective implementation of the WLA. SCDES recognizes

that adaptive management/implementation of these TMDLs might be needed to achieve the WQS.

## 3.2 Nonpoint Sources

Required load reductions in the LA portion of this TMDL can be implemented through voluntary measures and are eligible for the CWA §319 grants.

Nonpoint source pollution refers to pollution that originates from various sources across a large area, rather than being released through specific pipes. Nonpoint source pollution arises from a variety of land or water use activities, encompassing practices such as:

- Improper animal-keeping: Inadequate management of animal waste, runoff from livestock operations, and allowing livestock access to surface waters.
- Failing septic tanks: Malfunctioning or poorly maintained septic systems that release contaminants into groundwater or nearby water bodies.
- Agriculture: Runoff of fertilizers, pesticides, and sediment from agricultural lands.
- Forestry practices: Erosion and sedimentation resulting from logging activities and improper forest management.
- Wildlife: Animal waste and other natural sources contribute to water pollution.
- Urban and rural runoff: Surface runoff from developed areas (urban) and open spaces (rural), carrying pollutants like chemicals, oils, and litter into waterways.



These activities can lead to nonpoint source pollution, where pollutants are dispersed and do not have a single identifiable point of origin. These and other nonpoint source contributors located in unregulated areas can contribute to the presence of FC bacteria and other pathogens in these TMDL watersheds. Nonpoint sources in unregulated areas are addressed through the LA portion of the TMDL, rather than the WLA portion. During precipitation events, nonpoint source contributions of pathogens to tidal streams are likely to increase as runoff carries pollutants from the land into waterways. Annual update for SFMA 12B points to nonpoint sources and storm water runoff to be the major source of FC exceedances (SCDHEC 2023).

### 3.2.1 Wildlife

Wildlife, including deer, feral pigs, squirrels, raccoons, opossums, waterfowl, and other birds, can contribute to the presence of bacteria and pathogens in waterways. Their feces may directly enter surface waters or be transported into streams through runoff

after rainfall events. According to a study conducted in 2013, the South Carolina Department of Natural Resources (SCDNR) estimated deer density based on suitable habitats such as forests, croplands, and pastures. Based on this study, there is an estimated deer population of 30 to 45 per square mile in these TMDL watersheds (SCDNR 2013). Based on a study by Yagow (Yagow 2001), the bacteria production rate for deer was found to be 347 x 106 cfu/head-day, although only a portion of this bacteria will enter the water. As such, wildlife can be considered a potential source of FC and other pathogens in these watersheds.

The Ernest F. Hollings ACE Basin National Wildlife Refuge, overseen by the U.S. Fish and Wildlife Service, lies to the northwest of Sand and Whooping Island creeks. Spanning 350,000 acres, this wetland ecosystem comprises upland and bottomland forests, as well as fresh and saltwater marshes, alongside managed impoundments. The refuge is home to a diverse range of wildlife, including waterfowl, resident and migratory birds, white-tailed deer, reptiles, amphibians, river otters, gray foxes, rabbits, and bobcats are observable throughout the year.

### 3.2.2 Agriculture

Agricultural activities involving livestock or animal waste can contribute to pathogen contamination of surface waters. Animal feces can enter waterways through runoff or direct deposition. The large quantity of bacteria associated with animal waste makes agricultural activities a significant source of bacteria which can affect water quality. Effective management of manure and animal waste is essential to prevent pathogen contamination in the TMDL watersheds.

#### 3.2.2.1 Agricultural Animal Facilities

Under SC R. 61-43, owners/operators of most commercial animal growing operations are required to obtain permits for the proper handling, storage, treatment, and disposal of manure, litter, and deceased animals (SCDHEC 2021). These regulations aim to safeguard water quality, ensuring that compliant facilities do not contribute to water quality impairments. South Carolina currently does not have CAFOs under NPDES coverage. Currently, there are no regulated agricultural operations within Sand and Whooping Island creeks TMDL watershed.

#### 3.2.2.2 Grazing Livestock

Livestock, particularly cattle, are recognized contributors of bacteria and other fecal-borne pathogens in waters. On average, cattle and horses typically produce approximately 1.0E+11 cfu/day and 4.20E+08 cfu/day per animal of FC bacteria, respectively. The presence of grazing cattle and other livestock can introduce bacteria into streams via runoff from pastures or through direct defecation into waters. The grazing of livestock in pastures is not regulated by SCDES.

The United States Department of Agriculture's National Agricultural Statistics Service's 2022 agricultural census reported 1,438 cattle and calves, and 503 horses and ponies in Charleston County (USDA 2024). Based on the assumption of an even distribution of cattle and horses across pasture/hay areas in Charleston County, approximate estimates of the cattle population within the TMDL watershed were calculated. It is estimated that cattle could contribute 5.32E+11 cfu and horses could contribute 7.69E+08 cfu per day to TMDL watersheds, with the possibility of some fraction entering the waterways (Table 4, Table 5).

The NLCD classification system, derived from the Anderson Land Cover Classification System, includes the "Pasture/Hay" category, which represents areas where grasses, legumes, or grass-legume mixtures are grown for livestock grazing or hay production on a perennial cycle. However, it should be noted that not all cattle included in the USDA census are grazed, as dairy cattle and feedlot cattle are often confined and not evenly distributed across Pasture/Hay areas. Therefore, the calculations provide an approximate estimation of the cattle population. Nonetheless, the direct discharge of fecal indicator bacteria and other pathogens into surface waters by cattle and other livestock remains a potential contributing source within the TMDL watersheds.

Table 4. Estimated bacteria contributions from cattle and calves in the TMDL watershed.

| WQM Station | Pasture/Hay Acres | n Cattle and Calves in Station DA | Bacteria Produced in Station DA cfu/day |
|---|---|---|---|
| **12B-37** | 0.7 | 0.04 | 4.48E+09 |
| **12B-47** | 31.4 | 2.01 | 2.01E+11 |
| **12B-50** | 6.9 | 0.44 | 4.42E+10 |
| **12B-52** | 44.26 | 2.8 | 2.83E+11 |

Table 5. Estimated bacteria contributions from horses and ponies in the TMDL watershed.

| WQM Station | Pasture/Hay Acres | n Horses and Ponies in Station DA | Bacteria Produced in Station DA cfu/day |
|---|---|---|---|
| **12B-37** | 0.7 | 0.0154 | 6.47E+06 |
| **12B-47** | 39.8 | 0.8756 | 3.68E+08 |
| **12B-50** | 6.9 | 0.1518 | 6.38E+07 |
| **12B-52** | 44.26 | 0.9737 | 4.09E+08 |

### 3.2.3 Land Application of Industrial, Domestic Sludge or Treated Wastewater

Industrial and domestic wastewater treatment processes that are permitted under the NPDES program may produce solid waste byproducts, known as sludge. Some facilities are authorized to apply this sludge to designated land areas under specific conditions. Similarly, there are NPDES permitted facilities that can apply treated wastewater effluent to land at designated locations and under specific conditions. The regulations governing land application permits for these facilities can be found in SC R. 61-9 (SCDHEC 2023).

Proper management of the waste application is crucial to ensure that pollutants are effectively incorporated into the soil or taken up by plants, preventing their entry into streams or groundwater. If not managed correctly, land application sites can become a source of fecal pathogens and contribute to stream impairments. It's important to note that land application sites are not permitted to discharge directly into waterways. Any direct discharges from these sites to surface waters are illegal and can result in enforcement actions by SCDES.

It is recognized that there may be operating, regulated land application sites located in this watershed. If properly managed, waste is applied at a rate that ensures pollutants will be incorporated into the soil or plants and pollutants will not enter streams. Land application sites can be a source of bacteria and other pathogens and contribute to stream impairment if not properly managed. The NPDES permitted land application sites are not allowed to directly discharge to surface waters. Direct discharges from land application sites to surface waters of the State are illegal and are subject to enforcement actions by SCDES. Currently, there are no NPDES permitted facilities with a land application permit for applying treated wastewater within these TMDL watersheds.

### 3.2.4 Leaking Sanitary Sewer and Illicit Discharges

Leaking sewer pipes and unauthorized sewer connections pose substantial risks to public health by releasing partially treated or untreated human waste into the environment. However, quantifying the full extent of these sources without direct monitoring is challenging, as their impact is contingent on variables like volume and proximity to surface water. Untreated domestic wastewater typically contains bacteria levels within the range of $10^4$ to $10^6$ MPN/100mL.

Illicit sewer connections reroute sewage into storm drains, causing direct sewage discharge through the storm drainage system's outfalls. To assess this issue, monitoring the storm drain outfalls during dry weather periods is crucial to determine the presence or absence of sewage within the drainage systems. This monitoring process is essential for identifying and documenting the extent of unauthorized sewer connections and their environmental impact.

Currently, there is no sewer service or sewer lines within the Sand and Whooping Island creeks TMDL watershed (SCDHEC 2023). Therefore, these are not considered as sources of bacteria impairments.

### 3.2.5 Failing Septic Systems

When installed and maintained properly, septic systems are safe, long-term options for treating wastewater and preserving valuable water resources. Regulations stipulate that permits for new septic tanks will not be issued when a wastewater treatment facility/public sewer line is accessible for connection.

SCDES has an enforcement program that investigates complaints regarding the functioning of an onsite wastewater system and if an unpermitted discharge of sewage or other domestic wastewater is identified, prompt timelines for compliance are issued to the responsible party in order to minimize the risk of any discharge presenting significant harm to the environment and public health. At present, the state lacks sufficient regulatory authority for maintenance and upkeep of onsite wastewater systems.

Based on the 2010 U.S. Census, there are approximately 44 housing units accommodating a population of 81 individuals within the TMDL watershed. According to the SFMA 12B annual update, sewer services are not present within the TMDL watershed, with waste management primarily reliant on septic systems. Failing septic

systems are identified as one of the potential sources contributing to bacteria exceedances in this TMDL watershed.

### 3.2.6 Stormwater Runoff

Domesticated pets, such as dogs and cats, are contributors of fecal indicator bacteria and other pathogens in urban and suburban areas. Wildlife species like deer, squirrels, raccoons, opossums, and birds also contribute to the overall bacteria load in these areas. Calculations based on the national pet statistics data from the AVMA suggest an estimated count of 51 dogs and 62 cats within the TMDL watersheds (AVMA 2022). These pets can contribute to the overall bacterial load in these specific areas.

Unregulated MS4 communities have the potential to contribute to fecal indicator bacteria and other pathogens through stormwater runoff. These unregulated entities are subject to the LA portion of the TMDL document.

### 3.2.7 Marinas, Boating Activities, and Structures

Currently, there are no marinas or pump out stations within the TMDL watershed, however, there are some private docks within the TMDL watershed area. Illegal discharges of untreated waste from boats can contribute to FC loadings in the TMDL watershed.

There are 3 main types of MSDs that are suitable for different kinds of marine vessels with varying effluent treatment levels. Every vessel with an MSD installed as of January 30, 1980, must be equipped with one of the three types of MSDs (The United States Code 2012). Properly maintained MSDs should not be causing or contributing to bacteria exceedances in impaired waters. It is prohibited under Federal law to discharge untreated sewage from vessels within navigable waters as stated in the Clean Vessel Act.

Discharges of untreated sewage from boats and other watercraft can contribute to bacteria exceedances in the Sand and Whooping Island creeks TMDL watershed.

## 4.0 Cumulative Probability Method

Cumulative probability distributions were used to calculate existing conditions and percent reductions necessary to meet SFH WQS for FC in Sand and Whooping Island creeks.

For the calculation of the cumulative probability distributions, data collected from each bacteria impaired monitoring station were used to calculate the percent reductions necessary to meet WQS. Data from these impaired stations are summarized in Table 3. For example, data collected from 2020 through 2022 were used to calculate the percent reductions for shellfish monitoring station 12B-52 (Appendix A – Data Used for Calculation of the TMDLs). Cumulative probability graphs were created using Cumulative Probability Plot 3.0 (Boeing 2003) and log base 10 of bacteria data. If the data follow a log-normal distribution, the data points on the plot will approximate a straight line (the normal distribution). This straight line is then compared to the WQS at the appropriate percentile. For SFH waters in South Carolina, the TMDL target equates to 43 mpn/100mL FC bacteria minus a 5% MOS (40.85 mpn/100mL, log10 1.61). Evaluating the data at the 90$^{th}$ percentile allows for the 10% exceedance as referenced in R. 61-68 (SCDHEC 2023), R. 61-47 (SCDHEC 2023), and NSSP (USFDA 2021). Figure 6 shows the cumulative probability plot for station 12B-47. Remaining cumulative probability plots are shown in Appendix B – Cumulative Probability Graphs.

This evaluation is consistent with the NSSP approach under the SRS scheme. According to the NSSP approach under an SRS scheme, if the data do not meet the SSM WQS, a line is drawn parallel to the original normal distribution line that intersects the standard at the 90$^{th}$ percentile. Drawing the line parallel to the original distribution assumes that the coefficient of variation remains the same for the original data and the desired water quality data (Novotny 2004). The necessary percent reduction is calculated as the difference between the distributions at the 90$^{th}$ percentile:

$$\frac{\text{Existing 90th \%tile concentration} - (\text{WQS} - \text{MOS})}{\text{Existing 90th \%tile concentration}} \times 100$$

Targeting SSM percent reductions will also be protective of the geometric mean standard. To demonstrate, SSM and geometric mean percent reductions were calculated using data periods used for the TMDL calculations and compared to the overall SSM and geometric mean WQSs, which are 43 mpn/100 mL and 14 mpn/100 mL, respectively. As shown in Table 6, the estimated percent reductions for the geometric means is less than the percent reductions for the SSM, so targeting the SSM should be protective of the geometric WQS. Note that, SSM and geometric mean percent reductions shown on Table 6 are based on 43 mpn/100 mL and 14 mpn/100 mL for SFH. Percent reductions shown on the Table 7 are based on SSM minus 5% MOS, and therefore are different than those on Table 6.

Table 6. Single sample maximum and geometric mean percent reduction comparisons.

| Station | n | SSM % Reduction | Geomean % Reduction | TMDL Data Period |
|---|---|---|---|---|
| **12B-47** | 72 | 87.5 | 5.12 | 2000-2005 |
| **12B-50** | 101 | 39.7 | 6.35 | 2000-2008 |
| **12B-52** | 38 | 13.1 | 11.8 | 2021-2024 |

TMDLs for the impaired stations listed in this document were calculated by estimating the cross-sectional area of the channel at the impaired station and estimating average tidal flow. TMDL loads were based on the SSM WQS. Detailed description of the methodology along with an example calculation can be found in Appendix C - The Method Used to Calculate the Daily Load.

This method provides an estimate of the target daily load based on average tidal flow. Actual tidal flows and loads are highly variable at these locations. The estimated daily loading calculations are based on multiple assumptions such as dated NOAA station data, channel geometry, cross sectional area of the channel, flow velocities, channel depth, and the dynamic nature of the environment. Therefore, the resulting loadings are only provided as an example.



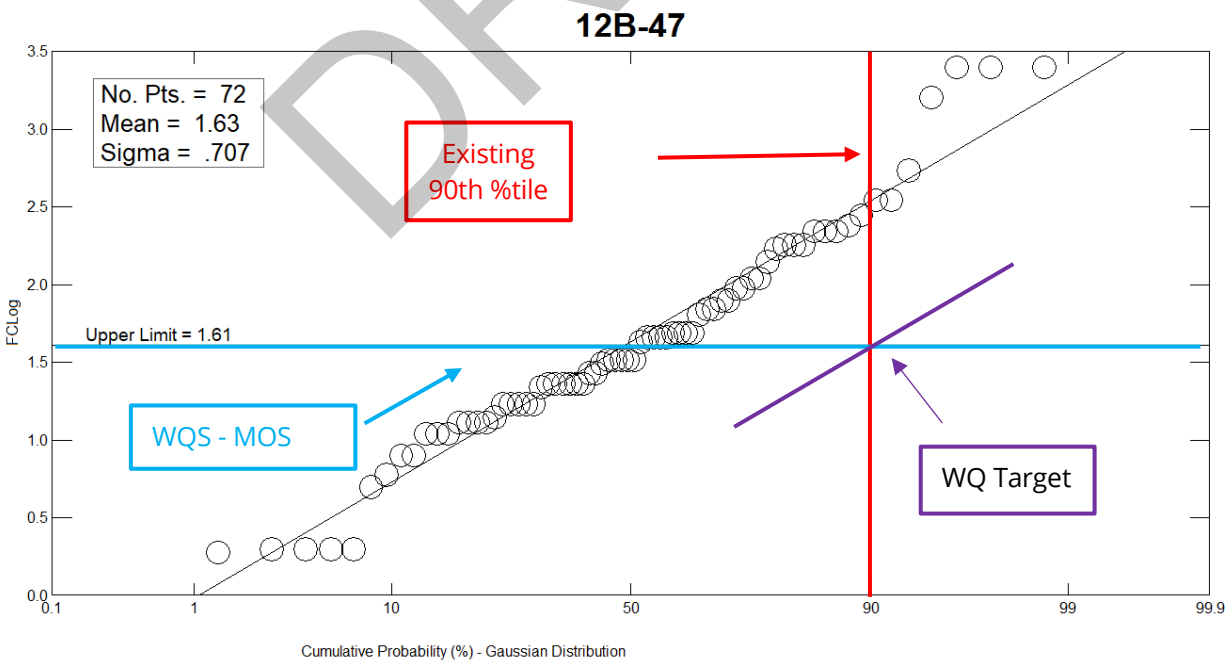


Figure 6. Cumulative probability plot for station 12B-47

# 5.0 Development of the TMDL

## 5.1 Critical Conditions

Critical conditions are factors that either in combination or individually cause violations of WQS. In these TMDL watersheds, characterized by their tidal and complex hydrologic nature, determining a singular critical flow remains ambiguous. The implicit inclusion of critical conditions is achieved by considering data collected across all seasons over multiple years, diverse tidal states, and varying weather conditions during which the water samples were collected. This approach inherently addresses the range of potential critical conditions within the system.

## 5.2 Wasteload Allocation

The WLA is the portion of the TMDL allocated to NPDES permitted point sources. These point sources typically include industrial facilities, wastewater treatment plants, and other regulated dischargers.

It is important to note that the WLA does not cover illicit dischargers, including SSOs or other illegal sources. Illicit discharges are considered unauthorized and are not granted any allocation under the TMDL. These sources are illegal because they introduce pollutants into the water without proper permits or compliance with regulatory requirements.

The WLA is specifically designed to address the allowable pollutant loadings from permitted point sources, while other mechanisms and enforcement actions are typically employed to address and reduce the impacts of illicit discharges and SSOs to protect water quality and public health.

### 5.2.1 Continuous Point Sources

Sand and Whooping Island creeks are classified as ORW, SFH, and recreational salt waters and dischargers to these waters are allowable if SCDES deems appropriate. Currently, there are no continuous NPDES permitted discharges to the affected TMDL watersheds with a bacteria effluent limit on their NPDES permit. Future continuous discharges are required to meet the prescribed loading for the pollutant of concern based on permitted flow and assuming an allowable permitted SSM of 43 mpn/100 mL. Continuous point source permit limits for bacteria are equivalent to the WQS.

### 5.2.2 Intermittent Point Sources

Intermittent point sources include all NPDES permitted stormwater discharges, including current and future TS4, MS4s, construction and industrial stormwater discharges covered under permits numbered SCS000000 & SCR100000 regulated under SC *Water Pollution Control Permits* Regulation R. 61-9 (SCDHEC 2023). Illicit discharges, including SSOs, are not covered under any NPDES permit and are subject to enforcement mechanisms. Other non-urbanized areas may be required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater.

SCDOT TS4 and Charleston County MS4 are the regulated NPDES transportation and municipal MS4s located in the TMDL watersheds. SCDOT operates under NPDES TS4 Permit SCS040001 and owns and operates roads within the watershed. However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. SCDOT does not regulate land use or zoning, or issue building or development permits.

Waste load allocations for stormwater discharges are expressed as a percent reduction instead of a numeric concentration due to the uncertain nature of stormwater discharge volumes and recurrence intervals. All current and future regulated stormwater discharges are required to meet the percentage reduction or the existing instream standard for the pollutant of concern. Table 7 presents the reductions needed for the impaired segments. The percent reductions identified for the impaired stations in this document also apply to the bacteria waste loads attributable to those areas of the watershed which are covered or will be covered under TS4 and MS4 NPDES permits.



## 5.3 Load Allocation

The LA addresses nonpoint sources of FC, including unregulated processes and entities, and is expressed as a percentage reduction. Table 7 present the LA for the TMDL stations as percentage reduction. If these nonpoint sources or any currently unregulated sources become regulated under NPDES TS4 or MS4 and are subject to SC Regulation 61-68, they will be required to achieve the load reductions specified in the WLA component of the TMDL. This requirement also applies to future discharges from industrial and construction activities subject to SC Regulation 61-9 (SCDHEC 2023).

## 5.4 Existing Load

Due to the tidal nature of the system, it is difficult to calculate an existing load for this system. For this reason, existing conditions are given as a concentration. The existing concentration is calculated as the concentration of FC bacteria at the 90th percentile based on the normal line fit to the monitoring data. The 90th percentile of the existing data is used to allow for the 10% exceedance outlined in the R. 61-68 and R. 61-47. The existing $90^{th}$ %tile concentrations for impaired stations are shown in Table 7.

## 5.5 Margin of Safety

A MOS allows for an accounting of the uncertainty in the relationship between pollutant loads and receiving waters. MOS can be incorporated either explicitly or implicitly by using conservative assumptions. These TMDLs have an explicit 5% MOS. Water quality data collected from shellfish monitoring stations were compared to 40.85 mpn/100mL which is the SSM WQS minus 5% for FC for SFH.

## 5.6 Calculation of the TMDL

Bacteria data summarized in Table 3 and shown in Appendix A – Data Used for Calculation of the TMDLs were used to calculate the TMDLs for the impaired stations. Station 12B-37, although not impaired, serves as the downstream station delineating the boundary for the area restricting shellfish harvest. Consequently, no reductions were computed for station 12B-37.

## 5.7 Reasonable Assurance

When a TMDL is developed for a pollutant that originates from both point and nonpoint sources, or from nonpoint sources only, EPA guidance emphasizes the need to provide reasonable assurances that nonpoint source controls will effectively achieve their expected load reductions. For point sources, such as NPDES permitted dischargers, the WLA provided in their permits already ensures this assurance.

However, for unregulated nonpoint sources of pollutants, achieving the necessary load reductions can be more challenging. To address this, various measures can be employed, including the implementation of BMPs, local ordinances, and outreach and educational efforts. CWA §319 grant funding may be available to interested parties for the purposes of implementing these measures.

Based on the information available at this time, the portions of the watersheds that drain directly to a regulated TS4 and MS4 and that which drain through the non-regulated TS4 and MS4 have not been clearly defined. Loading from both types of sources (regulated and non-regulated) typically occurs in response to rainfall events, discharge volumes and recurrence intervals are largely unknown. Therefore, where applicable, the regulated TS4 and MS4 are assigned the same percent reductions as the non-regulated sources in the watershed. Compliance with the TS4 and MS4 permit regarding this TMDL document is determined at the point of discharge to the waters of the state. The regulated MS4 entity is only responsible for implementing the TMDL WLA by following their MS4 permit requirements and is not responsible for reducing loads prescribed as LA in this TMDL document.

Table 7. TMDLs for Sand and Whooping Island creeks. TMDLs are expressed as mpn/100 mL and mpn/day, and allocations are expressed as % reductions.

| Station | Existing Conc. (mpn/ 100mL) | TMDL Conc. [1] (mpn/ 100mL) | TMDL Load [2] (WLA+LA+MOS) (mpn/day) | Implementation Targets [6] | | | |
|---|---|---|---|---|---|---|---|
| | | | | Continuous Sources [3] (mpn/100mL) | Intermittent MS4 [5] (%) | Intermittent TS4 SCDOT [4, 5] (%) | Nonpoint Sources (%) |
| **12B-47** | 343.9 | 43 | 1.35E+12 | See Note Below | 88.1% | 88.1% | 88.1% |
| **12B-50** | 71.3 | 43 | 3.19E+12 | See Note Below | 42.7% | 42.7% | 42.7% |
| **12B-52** | 49.5 | 43 | 2.18E+12 | See Note Below | 17.4% | 17.4% | 17.4% |

Table Notes:

1. TMDL = SFH water WQS for SSM not to exceed 43 mpn/100 mL fecal coliform.
2. TMDL at average flow conditions calculated using estimated average tidal flow at the WQM station. See Appendix C for example calculation.
3. WLA is expressed as a daily maximum of 43 mpn/100 mL FC. There are no continuous dischargers at this time. Future continuous discharges are required to meet the WQS for the pollutant of concern. Loadings to meet the WQS are developed based on the permitted flow and an allowable permitted maximum concentration of 43 mpn/100mL FC.
4. By implementing the BMPs that are prescribed in either the SCDOT annual SWMP or the SCDOT NPDES TS4 permit to address bacteria, the SCDOT will comply with this TMDL and its applicable WLA to the MEP as required by its NPDES TS4 permit.
5. Percent reduction applies to all NPDES permitted stormwater discharges, including current and future MS4s, construction, and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of stormwater discharge volumes and

recurrence intervals. Stormwater discharges are required to meet percentage reduction or the existing instream standard for the pollutant of concern in accordance with their NPDES Permit.

6. Refer to section 6.0 for the derivation of implementation targets.

## 6.0 Implementation

As implementation strategies progress, SCDES will continue to monitor the effectiveness of these measures and evaluate water quality where deemed appropriate. SCDES recognizes that adaptive management might be necessary to achieve the WQS and we are committed to targeting the load reductions needed to improve water quality in these TMDL watersheds. As additional data and/or information become available, it may become necessary to revise and/or modify the TMDL target accordingly. The implementation strategies presented below are not inclusive and are only provided as guidance.

### 6.1 Continuous Sources

NPDES permitted continuous point sources are required to meet the instream WQS for bacteria at the discharge point (end of pipe). Currently, there are no point source discharges to TMDL watersheds described in this document.

### 6.1 Intermittent Point Sources – MS4s

NPDES permitted TS4 and MS4 entities are required to target and show progress towards implementing the calculated percent reductions to the MEP with each permit cycle by following their permit requirements. These entities are responsible for documenting and reporting their progress toward achieving the percent reductions allocated to the TS4 and MS4 in these TMDL watersheds.

An iterative approach of water quality monitoring, illicit source detection and elimination, deploying BMPs and evaluation of their effectiveness, outreach and education, optimization of other tools such as local ordinances, and revision of their SWMP as needed in reducing bacteria loading to these TMDL watersheds is expected to show improvements in water quality.

For SCDOT TS4, Charleston County MS4, and future NPDES MS4 permittees, compliance with terms and conditions of its NPDES permit is effective implementation of the WLA to the MEP. For existing and future NPDES construction and industrial stormwater permittees, compliance with the terms and conditions of its permit is an effective implementation of the WLA.

### 6.2 Nonpoint Sources

South Carolina has several tools available for implementing the nonpoint source component of this TMDL. The Nonpoint Source Management Plan document is one example (SC DHEC, 2019).

Required load reductions in the LA portion of this TMDL can be implemented through voluntary measures and are eligible for CWA §319 grants. Interested parties such as local stakeholder groups, universities, local governments, etc., may be eligible to apply for CWA §319 grants to install BMPs that will implement the LA portion of these TMDLs and reduce nonpoint source bacteria and other pathogen loadings to impaired waters. Congress amended the CWA in 1987 to establish the §319 Nonpoint Source Management Program. Under §319, States receive grant money to support a wide variety of activities including the restoration of impaired waters. TMDL implementation projects are given the highest priority for §319 funding. CWA §319 grants are not available for implementation of the WLA component of these TMDLs but may be available for the LA component within permitted TS4 and MS4 jurisdictional boundaries.

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## Appendix A – Data Used for Calculation of the TMDLs

| Date 12B-47 | mpn/100 mL |
|---|---|
| 1/17/2000 | 13 |
| 2/2/2000 | 2 |
| 3/7/2000 | 64 |
| 4/12/2000 | 43 |
| 5/23/2000 | 23 |
| 6/7/2000 | 23 |
| 7/25/2000 | 2500 |
| 8/2/2000 | 46 |
| 9/11/2000 | 49 |
| 10/17/2000 | 33 |
| 11/13/2000 | 17 |
| 12/6/2000 | 5 |
| 1/2/2001 | 2 |
| 2/26/2001 | 13 |
| 3/14/2001 | 23 |
| 4/9/2001 | 23 |
| 5/23/2001 | 95 |
| 6/12/2001 | 46 |
| 7/17/2001 | 180 |
| 8/8/2001 | 6 |
| 9/23/2001 | 8 |
| 10/15/2001 | 33 |
| 11/27/2001 | 170 |
| 12/3/2001 | 17 |
| 1/16/2002 | 2 |
| 2/6/2002 | 27 |
| 3/6/2002 | 8 |
| 4/9/2002 | 2 |
| 5/13/2002 | 13 |
| 6/18/2002 | 17 |
| 7/22/2002 | 2 |
| 8/6/2002 | 23 |
| 9/9/2002 | 79 |
| 10/15/2002 | 280 |
| 11/4/2002 | 350 |
| 12/10/2002 | 33 |

| Date 12B-50 | mpn/100 mL |
|---|---|
| 1/17/2000 | 5 |
| 2/2/2000 | 7 |
| 3/7/2000 | 5 |
| 4/12/2000 | 2 |
| 5/23/2000 | 13 |
| 6/7/2000 | 2 |
| 7/25/2000 | 2500 |
| 8/2/2000 | 17 |
| 9/11/2000 | 49 |
| 10/17/2000 | 2 |
| 11/13/2000 | 540 |
| 12/6/2000 | 7 |
| 1/2/2001 | 2 |
| 2/26/2001 | 8 |
| 3/14/2001 | 9 |
| 4/9/2001 | 17 |
| 5/23/2001 | 8 |
| 6/12/2001 | 5 |
| 7/17/2001 | 46 |
| 8/8/2001 | 2 |
| 9/23/2001 | 8 |
| 10/15/2001 | 33 |
| 11/27/2001 | 350 |
| 12/3/2001 | 11 |
| 1/16/2002 | 2 |
| 2/6/2002 | 5 |
| 3/6/2002 | 2 |
| 4/9/2002 | 2 |
| 5/13/2002 | 4 |
| 6/18/2002 | 2 |
| 7/22/2002 | 5 |
| 8/6/2002 | 46 |
| 9/9/2002 | 8 |
| 10/15/2002 | 920 |
| 11/4/2002 | 110 |
| 12/10/2002 | 8 |

| Date 12B-52 | mpn/100 mL |
|---|---|
| 1/13/2021 | 7.8 |
| 2/10/2021 | 33.0 |
| 3/2/2021 | 33.0 |
| 4/19/2021 | 13.0 |
| 5/19/2021 | 11.0 |
| 6/21/2021 | 79.0 |
| 7/19/2021 | 13.0 |
| 8/11/2021 | 4.0 |
| 9/13/2021 | 2.0 |
| 10/12/2021 | 7.8 |
| 11/15/2021 | 33.0 |
| 12/14/2021 | 23.0 |
| 1/19/2022 | 11.0 |
| 2/14/2022 | 2.0 |
| 3/2/2022 | 4.5 |
| 4/13/2022 | 33.0 |
| 5/23/2022 | 11.0 |
| 6/15/2022 | 13.0 |
| 7/20/2022 | 6.8 |
| 8/22/2022 | 33.0 |
| 9/12/2022 | 13.0 |
| 10/25/2022 | 170.0 |
| 11/13/2022 | 7.8 |
| 12/14/2022 | 6.8 |
| 7/24/2023 | 2 |
| 8/8/2023 | 2 |
| 10/3/2023 | 8 |
| 11/14/2023 | 35 |
| 12/11/2023 | 49 |
| 1/31/2024 | 8 |
| 2/14/2024 | 23 |
| 3/20/2024 | 8 |
| 4/10/2024 | 23 |
| 5/20/2024 | 49 |
| 6/17/2024 | 2 |
| 7/29/2024 | 2 |

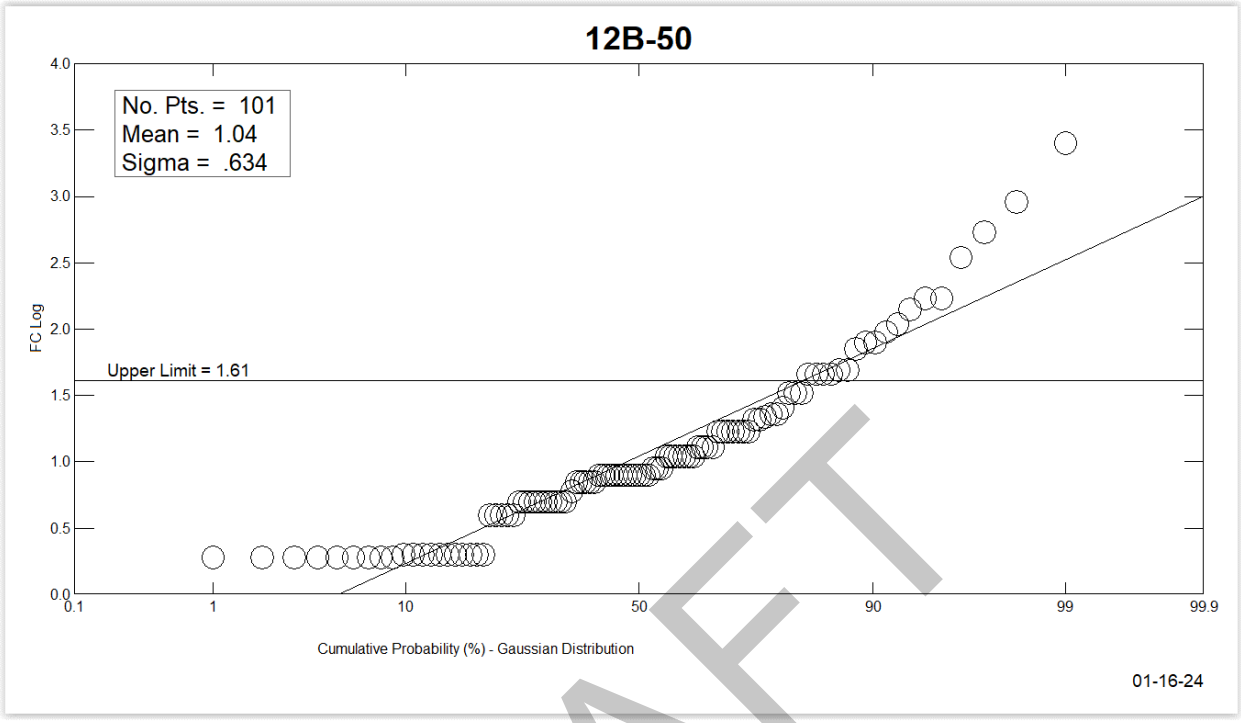
| Date 12B-47 | mpn/100 mL |
|---|---|
| 1/6/2003 | 13 |
| 2/18/2003 | 11 |
| 3/3/2003 | 17 |
| 4/9/2003 | 2500 |
| 5/28/2003 | 49 |
| 6/3/2003 | 33 |
| 7/9/2003 | 240 |
| 8/13/2003 | 22 |
| 9/17/2003 | 11 |
| 10/20/2003 | 110 |
| 11/5/2003 | 140 |
| 12/3/2003 | 23 |
| 1/26/2004 | 11 |
| 2/18/2004 | 1600 |
| 3/10/2004 | 70 |
| 4/19/2004 | 220 |
| 5/19/2004 | 70 |
| 6/2/2004 | 180 |
| 7/7/2004 | 17 |
| 8/11/2004 | 95 |
| 9/21/2004 | 33 |
| 10/19/2004 | 31 |
| 11/2/2004 | 110 |
| 12/20/2004 | 27 |
| 1/12/2005 | 49 |
| 2/15/2005 | 14 |
| 3/2/2005 | 49 |
| 4/5/2005 | 350 |
| 5/18/2005 | 2500 |
| 6/20/2005 | 46 |
| 7/20/2005 | 46 |
| 8/15/2005 | 220 |
| 9/27/2005 | 180 |
| 10/11/2005 | 220 |
| 11/2/2005 | 79 |
| 12/7/2005 | 540 |

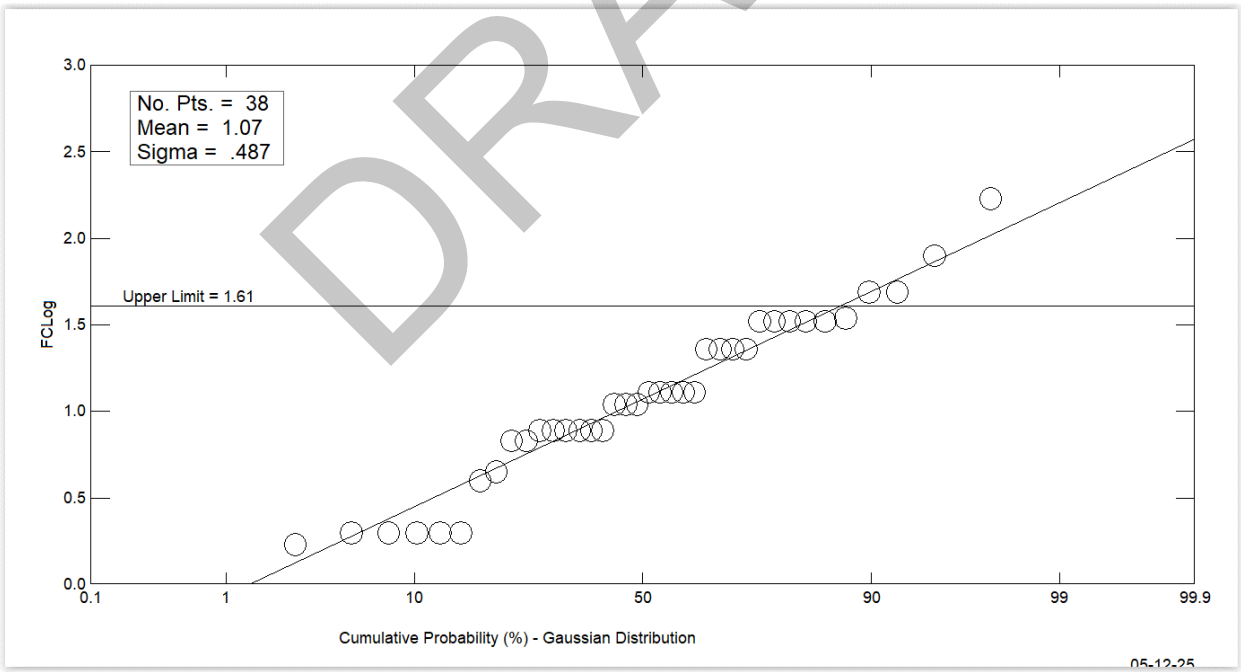
| Date 12B-50 | mpn/100 mL |
|---|---|
| 1/6/2003 | 5 |
| 2/18/2003 | 8 |
| 3/3/2003 | 2 |
| 4/9/2003 | 170 |
| 5/28/2003 | 9 |
| 6/3/2003 | 7 |
| 7/9/2003 | 17 |
| 8/13/2003 | 13 |
| 9/17/2003 | 6 |
| 10/20/2003 | 26 |
| 11/5/2003 | 33 |
| 12/3/2003 | 4 |
| 1/26/2004 | 2 |
| 2/18/2004 | 2 |
| 3/10/2004 | 46 |
| 4/19/2004 | 5 |
| 5/19/2004 | 5 |
| 6/2/2004 | 49 |
| 7/7/2004 | 5 |
| 8/11/2004 | 8 |
| 9/21/2004 | 17 |
| 10/19/2004 | 2 |
| 11/2/2004 | 11 |
| 12/20/2004 | 4 |
| 1/12/2005 | 46 |
| 2/15/2005 | 2 |
| 3/2/2005 | 4 |
| 4/5/2005 | 23 |
| 5/18/2005 | 140 |
| 6/20/2005 | 22 |
| 7/20/2005 | 17 |
| 8/15/2005 | 11 |
| 9/27/2005 | 11 |
| 10/11/2005 | 11 |
| 11/2/2005 | 79 |
| 12/7/2005 | 8 |
| 1/4/2006 | 8 |
| 2/21/2006 | 13 |
| 3/21/2006 | 7 |
| 4/17/2006 | 17 |

| Date 12B-52 | mpn/100 mL |
|---|---|
| 9/10/2024 | 13 |
| 11/18/2024 | 23 |

| Date 12B-50 | mpn/100 mL |
|---|---|
| 5/16/2006 | 9 |
| 6/27/2006 | 11 |
| 8/21/2006 | 21 |
| 9/19/2006 | 79 |
| 10/25/2006 | 2 |
| 11/15/2006 | 33 |
| 12/19/2006 | 170 |
| 1/22/2007 | 21 |
| 2/7/2007 | 4 |
| 3/6/2007 | 2 |
| 4/3/2007 | 13 |
| 5/29/2007 | 11 |
| 6/12/2007 | 95 |
| 7/23/2007 | 2 |
| 8/21/2007 | 2 |
| 9/4/2007 | 7 |
| 10/17/2007 | 2 |
| 11/27/2007 | 8 |
| 12/4/2007 | 8 |
| 1/9/2008 | 8 |
| 2/20/2008 | 23 |
| 3/4/2008 | 70 |
| 4/1/2008 | 17 |
| 5/27/2008 | 5 |
| 6/10/2008 | 2 |

## Appendix B – Cumulative Probability Graphs



## Appendix C - The Method Used to Calculate the Daily Load

Calculating a target load begins with the determination of average tidal flow. First, the average cross-sectional area of the waterway at the sampling station is estimated using the mean tidal range, average depth at low tide, the average width of the channel, and channel geometry (rectangular vs triangular). Lacking site-specific data, average depth at low tide and average widths may be obtained from navigation charts, satellite imagery, topo maps, etc. Mean tidal range is determined as the difference between mean high and mean low water levels and is retrieved from NOAA's Tides and Currents web page using the NOAA station most appropriate for the sampling location. Though infrequently, mean tidal range may also be readily available for some stations. Where available, tidal velocity is determined from the time of travel or flow study data. Usually, these data are not available and default ranges are used Table 8.

Table 8. Default velocities to be used in the absence of site-specific data.

| Velocity (ft/sec) | Waterbody Characteristic |
|---|---|
| **0.5 – 1.0** | Relatively slow, constricted estuaries |
| **1.0 – 2.0** | Moderate, free-flowing estuaries |
| **2.0 – 3.0** | Rapid, highly tidal estuaries |

Average tidal flow is calculated by multiplying velocity by the cross-sectional area of the waterbody at the sampling station.

The TMDL loads are then calculated by subtracting the 5% MOS from the WQS and multiplying the resulting concentration by average tidal flow and a conversion factor (24,465,758.4 sec*mL / ft3*day) as demonstrated below.

This method provides an estimate of the target daily load based on average tidal flow. Actual tidal flows and loads are highly variable at this location. Therefore, the TMDL expression includes concentration and percent reduction targets for implementation.

Calculations for 12B-47:
Average depth at low tide: 1.96 ft
Average width: 257 ft
Mean tidal range: 6.02 ft
Channel shape: triangular
Channel area = 2{(257/2) * (0.5 (1.96 + 6.02/2))} = 638.65 ft2
Average tidal flow = 638.65 ft2 * 2 ft/s = 1277.29 cfs

WLA + LA = 40.85 mpn/100 mL
WLA + LA load = 40.85 mpn/100 mL * 1277.29 ft3/sec * 24,465,758.4 sec*mL/ft3*day
= 1.28E+12 mpn/day
MOS Load = 2.15 mpn/100 mL * 1277.29 ft3/sec * 24,465,758.4 sec*mL/ft3*day
= 6.72E+10
TMDL = 1.34E+12

## Appendix D – Land Uses

| 12B-37 | Area (ac) | % of Area |
|---|---|---|
| **Open Water** | 182.1 | 40.4 |
| **Developed** | 1.3 | 0.3 |
| **Forest** | 2.0 | 0.4 |
| **Pasture/Hay** | 0.7 | 0.1 |
| **Forested Wetlands** | 9.3 | 2.1 |
| **Non-forested Wetlands** | 255.1 | 56.6 |
| **Total** | 450.6 | 100.0 |

| 12B-47 | Area (ac) | % of Area |
|---|---|---|
| **Open Water** | 7.8 | 2.5 |
| **Developed** | 16.0 | 5.1 |
| **Barren Land** | 33.8 | 10.8 |
| **Forest** | 58.7 | 18.7 |
| **Pasture/Hay** | 31.4 | 10.0 |
| **Forested Wetlands** | 56.7 | 18.1 |
| **Non-forested Wetlands** | 109.0 | 34.8 |
| **Total** | 313.4 | 100.0 |

| 12B-50 | Area (ac) | % of Area |
|---|---|---|
| **Open Water** | 8.9 | 5.9 |
| **Developed** | 4.2 | 2.8 |
| **Barren Land** | 6.7 | 4.4 |
| **Forest** | 46.3 | 30.5 |
| **Pasture/Hay** | 6.9 | 4.5 |
| **Forested Wetlands** | 11.6 | 7.6 |
| **Non-forested Wetlands** | 67.4 | 44.4 |
| **Total** | 151.9 | 100.0 |