

**TOTAL MAXIMUM DAILY LOADS
FOR
DISSOLVED OXYGEN
FOR
Beaufort River in the Salkehatchie River Basin,
South Carolina**

**HYDROLOGIC UNIT CODE: 03050208-100
(STATIONS : MD-001, MD-002, MD-003, MD-004, RO-02003)**

April 2006

SCDHEC Technical Report Number: 014 - 06



In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et.seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing a Total Maximum Daily Load (TMDL) for dissolved oxygen for the Beaufort River. Subsequent actions must be consistent with this TMDL.

James D. Giattina, Director
Water Management Division

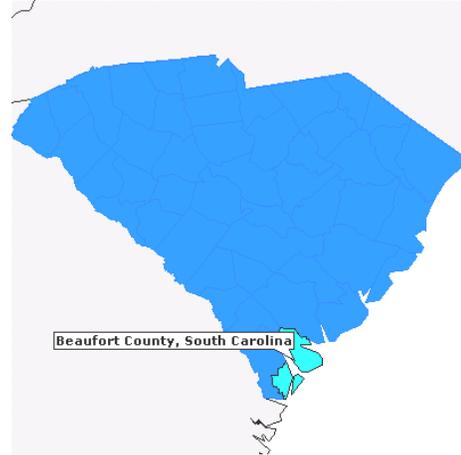
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TMDL at a Glance

Basin Name/Subbasin: Salkehatchie River Basin / Combahee/Ashepoo/ Broad River Subbasin



Waterbody of Concern: Beaufort River

Pollutant: Dissolved Oxygen

Designated Use: Primary and Secondary Contact Recreation, Shellfish Harvesting

Size of Listed Segment 20 miles

TMDL Target: Dissolved Oxygen depression of no more than 0.1 mg/l (Antidegradation Rules (R.61-68.D.4))

Wasteload Allocations:

Scenario 1	
Facility	Allocation (lbs/day Ultimate Oxygen Demand)
MCAS Water Reclamation Facility	88
Parris Island Water Reclamation Facility	346
Port Royal Water Reclamation Facility	618
Sum of the Allocations	1052

Scenario 2	
Facility	Allocation (lbs/day Ultimate Oxygen Demand)
MCAS Water Reclamation Facility	0
Parris Island Water Reclamation Facility	0
Port Royal Water Reclamation Facility	1593
Sum of the Allocations	1593

Load Allocation: Set at natural background conditions. No reductions required.

Margin of Safety: Implicit

1. INTRODUCTION

Background

The Beaufort River system is located in the south part of the South Carolina coast. The modeled area includes Beaufort River, Albergottie Creek, and Brickyard Creek (see Figure 1). The system is tidally influenced throughout.

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require the states to establish TMDLs for all waterbodies. Priority is given to development of TMDLs for waterbodies identified under Section 303(d)(1)(A) and (B) as not meeting applicable water quality standards.

Five ambient water quality monitoring stations on the Beaufort River (MD-001, MD-002, MD-003, MD-004, and RO-02003, see Figure 2) are considered to be impaired under criteria of Section 303(d) of the Clean Water Act and are listed on the S.C. 303(d) List for 2004. Further, USGS monitoring stations for the Beaufort Project (1998-2003, stations 02176585, 02176587, 02176589, 02176603, 02176611, 02176635 and 02176640) confirmed low dissolved oxygen concentrations. Therefore, the South Carolina Department of Health and Environmental Control (DHEC) is required to develop a TMDL for oxygen demanding substances for the Beaufort River. These violations are considered to be due to natural conditions exacerbated by point and non-point sources of pollution; therefore, Section 48-1-83 (Pollution Control Act) and Section D.4.a. of R.61-68 (Water Classification and Standards) apply. These provisions allow a lowering of DO of no more than 0.10 mg/L (the Tenth Rule) from natural background conditions.

In order to establish a TMDL for DO in the Beaufort River, Beaufort -Jasper Water & Sewer Authority initiated and directed the development of a statistical neural network (ANN), water quality model for SCDHEC to use in determining the assimilative capacity of the River (Assimilative Capacity Analysis for the Beaufort River: Water Quality Model Report, Beaufort-Jasper Water & Sewer Authority, November 2004). Results indicate the need for an overall reduction of approximately 93% of ultimate oxygen demand (UOD) to the Beaufort River from the currently permitted level of 13,844 lbs/day to meet the Scenario 1 allocation of 1,052 lbs/day.

Watershed Description

The Beaufort River is a complex estuarine system that connects the Coosaw River and St. Helena Sound to the north and Port Royal Sound to the south. The river experiences semidiurnal tides of approximately 9 feet at its confluence with Port Royal Sound. The Beaufort River lies in the Watershed 03050208-100. The watershed consists primarily of sea islands with varying levels of urban development separated by tidal creeks with no significant drainage area providing fresh water to the system.

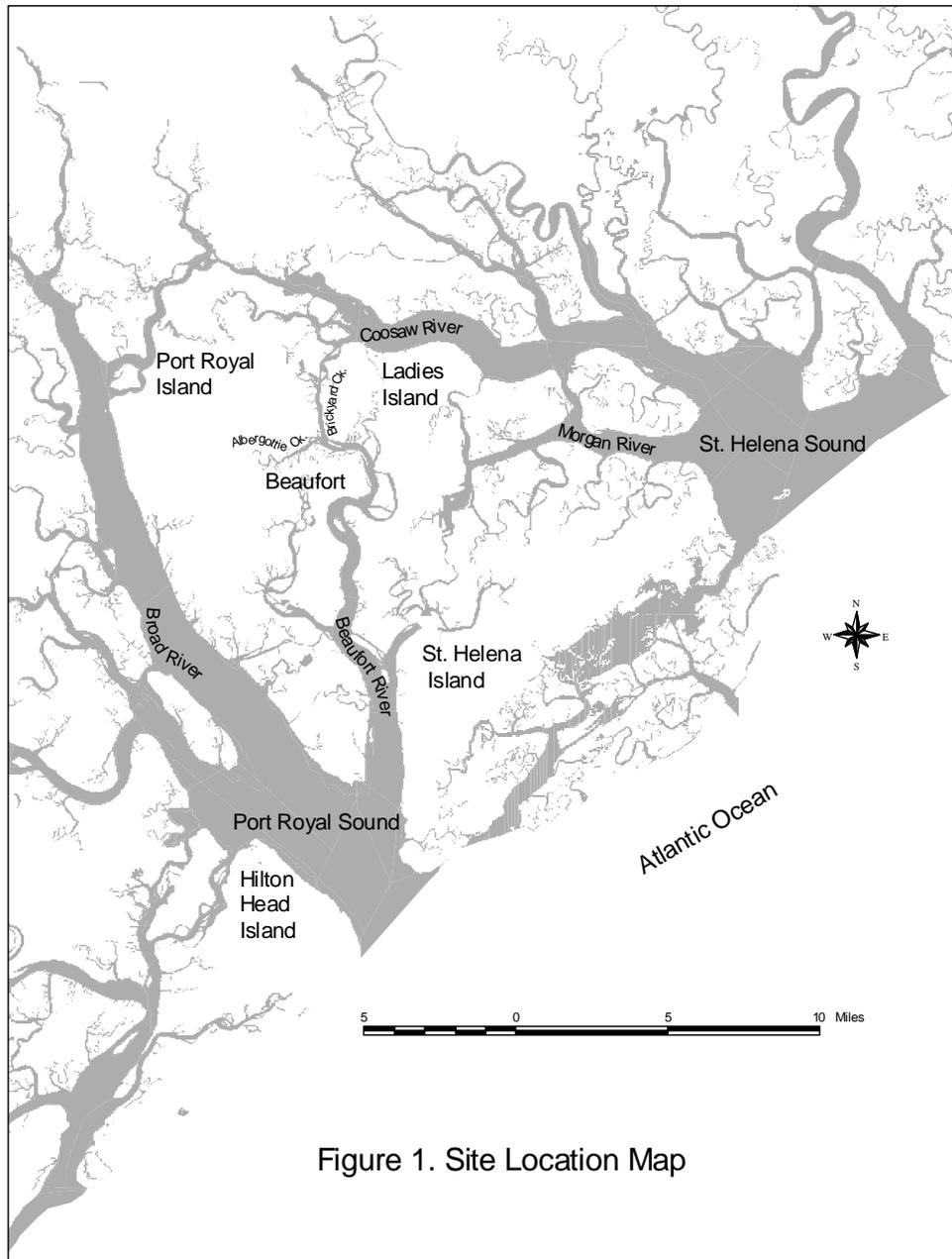


Figure 1. Site Location Map

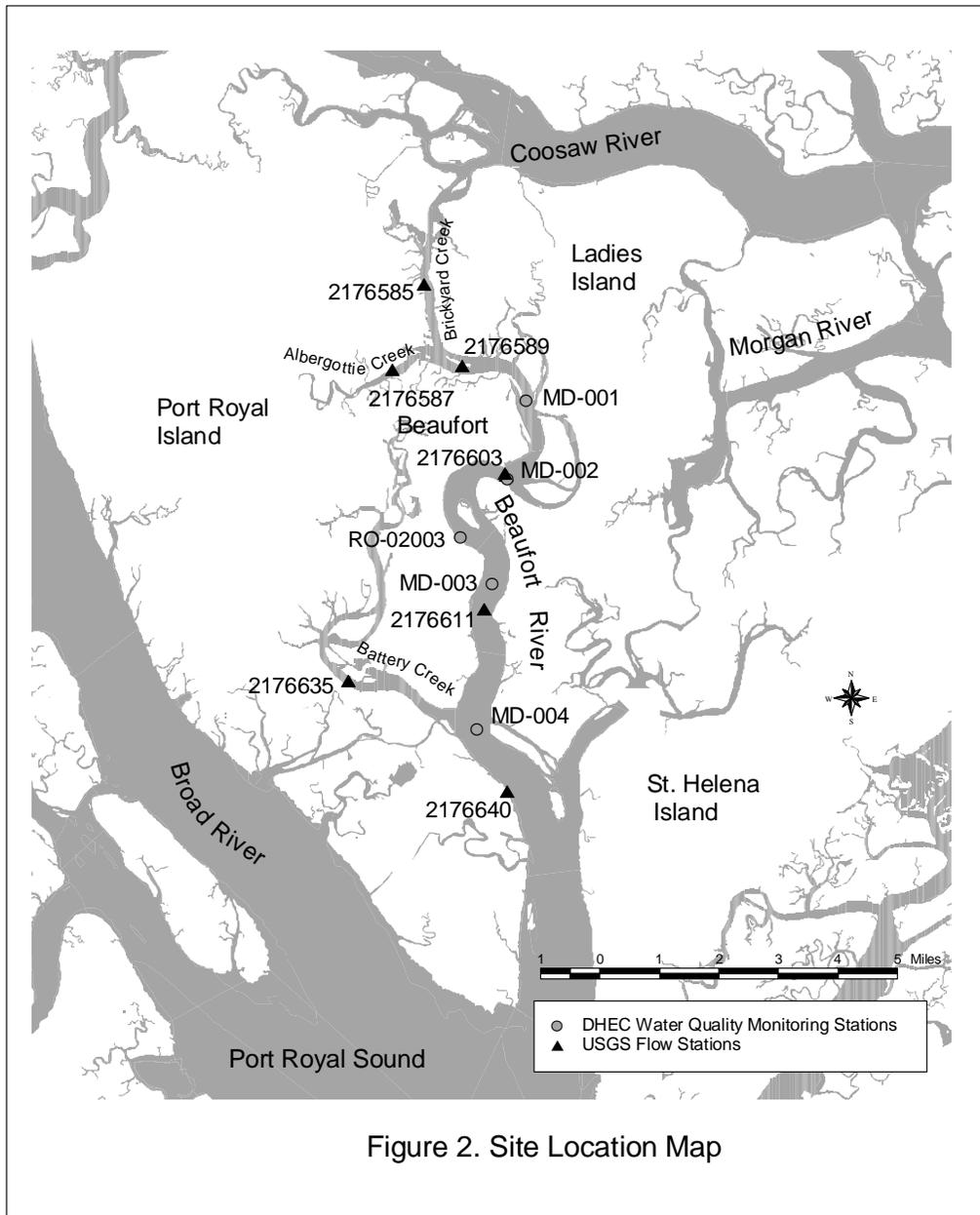


Figure 2. Site Location Map

Water Quality Standard

The Beaufort River is a complex estuarine system that connects the Coosaw River and St. Helena Sound and Port Royal Sound. The system includes Beaufort River, Albergottie Creek, and Brickyard Creek.

According to the SCDHEC Water Classifications & Standards (R.61-68) the Beaufort River is classified as Class SA (Saltwater Class A) and Class Shellfish Harvesting (SFH) waters (see Table 1). For these classifications, the dissolved oxygen criterion is expressed as a “daily average of not less than 5 mg/l with low of 4.0 mg/l”.

Table 1

Beaufort River: From confluence of Albergottie Creek and Brickyard Creek to a boundary drawn between the upper bank of Battery Creek and Cat Island Creek From a boundary drawn between the Upper bank of Battery Creek and Cat Island Creek to the confluence with Port Royal sound	SA- Daily average not less than 5.0 mg/l with low of 4.0 mg/l SFH- Daily average not less than 5.0 mg/l with a low of 4.0 mg/l
Brickyard Creek: The entire stream tributary to Beaufort River	SFH- Daily average not less than 5.0 mg/l with a low of 4.0 mg/l
Albergottie Creek: The entire stream tributary to Beaufort River	SA- Daily average not less than 5.0 mg/l with low of 4.0 mg/l

Saltwater Class A (SA) waters are:

“Tidal salt waters suitable for primary and secondary contact recreation, crabbing, and fishing, except harvesting of clams, mussels, or oysters for market purposes or human consumption and uses listed in Class SB. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora.” (R.61-68)

Shellfish Harvesting (SFH) waters are:

“Tidal salt waters 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.” (R.61-68)

Coastal waters frequently do not meet dissolved oxygen standards due to natural conditions. The Antidegradation Rules of South Carolina’s water quality standards (R.61-68.D.4) recognize that natural conditions may cause a depression of dissolved

oxygen in surface waters below the numeric standard while existing and classified uses are still maintained. The standard states:

“ 4. Certain natural conditions may cause a depression of dissolved oxygen in surface waters while existing and classified uses are still maintained. The Department shall allow a dissolved oxygen depression in these naturally low dissolved oxygen waterbodies as prescribed below pursuant to the Act, Section 48-1-83, *et. seq.*, 1976 code of Laws:

- a. Under these conditions the quality of the surface waters shall not be cumulatively lowered more than 0.1 mg/l for dissolved oxygen from point sources and other activities, or
- b. Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable water quality standard established for that waterbody, the minimum acceptable concentration is 90 percent of the natural condition. Under these circumstances, an anthropogenic dissolved oxygen depression greater than 0.1 mg/l shall not be allowed unless it is demonstrated that resident aquatic species shall not be adversely affected.”

Section 4(a) is referred to as the “Tenth Rule” while section 4(b) is referred to as the “10% Rule”.

Waterbodies Impacted

<u>Watershed HUC</u>	<u>Waterbody</u>	<u>County</u>
03050208-100	Beaufort River	Beaufort
03050208-100	Albergottie Creek	Beaufort
03050208-100	Brickyard Creek	Beaufort

2. WATER QUALITY ASSESSMENT

There are five water quality monitoring stations on the Beaufort River: MD-001, MD-002, MD-003, MD-004, and random station RO-02003 (see Figure 2). Monthly, grab surface samples are taken at these stations for multiple parameters, including dissolved oxygen, temperature and pH. Four of these stations (MD-001, MD-002, MD-003, and MD-004) have been considered impaired for dissolved oxygen under criteria of Section 303(d) of the Clean Water Act and have been listed on the S.C. 303(d) List for 2000, 2002, and 2004. Three of those stations were listed on the S.C. 303(d) List for 1998. The random water quality monitoring station RO-02003 was sampled only in 2002 and is on the 303(d) list for 2004. Waters in which the excursions about the standard occur less than 10 percent of the time are considered to comply with the South Carolina water quality standard for dissolved oxygen. Waters with a greater than 10 percent excursion from the standard are considered impaired and listed on South Carolina’s 303(d) list for dissolved oxygen. The percentages of samples exceeding the standard for the monitoring stations are provided in Table 2.

Table 2.
Frequency of Violation of Applicable In-stream Dissolved Oxygen Criteria
By: Year Listed and DHEC Ambient Monitoring Station

% Violation of Daily Average Criteria (5 mg/l)						
303(d) list	Period	MD-001	MD-002	MD-003	MD-004	RO 002-003
2002	1996-2000	41.4	26.7	12.1	10.7	---
2004	1998-2002	36.8	31.3	14.3	18.4	41.7

Further, monitoring by USGS at seven stations for the Beaufort Project confirm that there are numerous violations of the DO standards (see Table 3). Continuous, real time data were collected at these stations for multiple parameters, including DO (salinity corrected), temperature and conductivity for the period December 1998 thru September 2003.

The discharges to the River are not considered of such a magnitude in comparison with tidal range and stream flow to alone cause DO impairment in the River. Modeling outputs confirm this conclusion as well (see Appendix A). As a result, it is concluded that the low dissolved oxygen concentration is a natural condition that is further exacerbated by point sources to the River; therefore, the Tenth Rule is applicable to the Beaufort River.

The pollutants of concern are oxygen demanding substances, carbonaceous and nitrogenous biochemical oxygen demand.

3. TMDL TECHNICAL BASIS

Target Identification

The Beaufort River is considered to be water quality limited for oxygen demanding substances due in part to naturally occurring, low dissolved oxygen conditions. The Tenth Rule applies and the water quality target for this TMDL is a depression of no more than 0.1 mg/l of dissolved oxygen below natural background. Meeting this target will result in compliance with R.61-68.D.4 (Antidegradation Rules); however, it will not result in compliance with the numeric dissolved oxygen criteria (a daily average of 5.0 mg/l with a low of 4.0 mg/l) for class SA and SFH waters. The pollutant of concern is biochemical oxygen demand, both carbonaceous and nitrogenous, the combination of which can be expressed as ultimate oxygen demand (UOD). The UOD is calculated using Equation 1 or Equation 2 below, depending on whether the effluent monitoring data are in the form of (1) flow and concentration or (2) load. The TMDL will be in terms of UOD, based on the waterbody's ability to assimilate oxygen-demanding substances from point source dischargers without exceeding the allowable 0.1 mg/l deficit. NPDES permit limits will include a numeric limit for UOD.

Table 3
Frequency of Violation of Applicable In-Stream Dissolved Oxygen Criteria
By: USGS Ambient Monitoring Station and Month
December 1998 thru September 2003

% Violation of Daily Average Criteria (5 mg/l)

Station	April	May	June	July	August	Sept	Oct
2176585	2.2	14.8	71.3	82.4	89.1	59.5	18.8
2176587	0.0	21.2	90.2	100.0	95.3	67.1	11.3
2176589	0.0	29.4	61.5	71.2	87.1	65.4	14.5
2176603	4.0	16.6	57.6	83.4	90.7	65.7	16.3
2176611	12.0	10.1	48.0	84.1	88.7	66.2	13.9
2176635	5.3	45.4	66.2	93.0	96.5	69.1	23.1
2176640	0.0	4.4	26.8	41.9	50.4	27.6	12.6

% Violation of daily Minimum Criteria (4 mg/l)

Station	April	May	June	July	August	Sept	Oct
2176585	0.7	7.0	40.9	59.7	72.6	24.8	3.4
2176587	1.5	18.2	85.4	98.7	90.6	64.8	6.5
2176589	0.0	11.0	46.2	44.9	67.3	37.0	6.5
2176603	1.3	29.8	43.8	47.0	70.9	34.3	5.7
2176611	9.3	0.0	8.9	31.7	41.8	19.0	4.4
2176635	5.3	36.9	54.9	80.4	85.2	54.4	13.7
2176640	0.7	6.6	10.2	12.2	24.5	3.9	0.0

$$UOD = Qd * 8.34 * (BOD5 * F-Ratio + NH3-N * 4.57) \dots\dots\dots(1)$$

where UOD = ultimate oxygen demand in lbs/day,
 Qd = effluent flow in MGD,
 8.34 = units conversion factor,
 F-Ratio = ratio of ultimate biochemical oxygen demand to five- day biochemical oxygen demand,
 BOD5 = five-day biochemical oxygen demand in mg/l,
 4.57 = units of oxygen consumed per unit of NH3-N oxidized,
 NH3-N = ammonia nitrogen in mg/l.

$$UOD = BOD5 * F-Ratio + NH3-N * 4.57 \dots\dots\dots(2)$$

where UOD = ultimate oxygen demand in lbs/day
 F-Ratio = ratio of ultimate biochemical oxygen demand to five- day biochemical oxygen demand,

BOD5 = five-day biochemical oxygen demand in lbs/day,
 4.57 = units of oxygen consumed per unit of NH3-N oxidized,
 NH3-N = ammonia nitrogen in lbs/day.

Based on discussions with model developers, the F- Ratio of 3.0 for all dischargers was assigned due to characteristics of the wastewater (see Appendix A).

Point Sources

At the time when the dynamic water quality model was developed, four facilities discharged to the Beaufort River (see Figure 3): US Marine Corps Parris Island Recruit Depot (SC0002577), US Marine Corps Air Station (SC0000825), BJWSA Southside WWTP (SC0021016), and BJWSA Shell Point WWTP (SC0042609). BJWSA had a permit for a third plant (St. Helena WWTP, SC0039811), but this facility never had a surface water discharge and the permit was inactivated in 2004. The Southside and Shell Point WWTPs were evaluated together due to the proximity of their discharge points. In the future, the new Port Royal Island WWTP (SC0048348) will replace the Shell Point and Southside WWTPs at the same location.

Table 4.

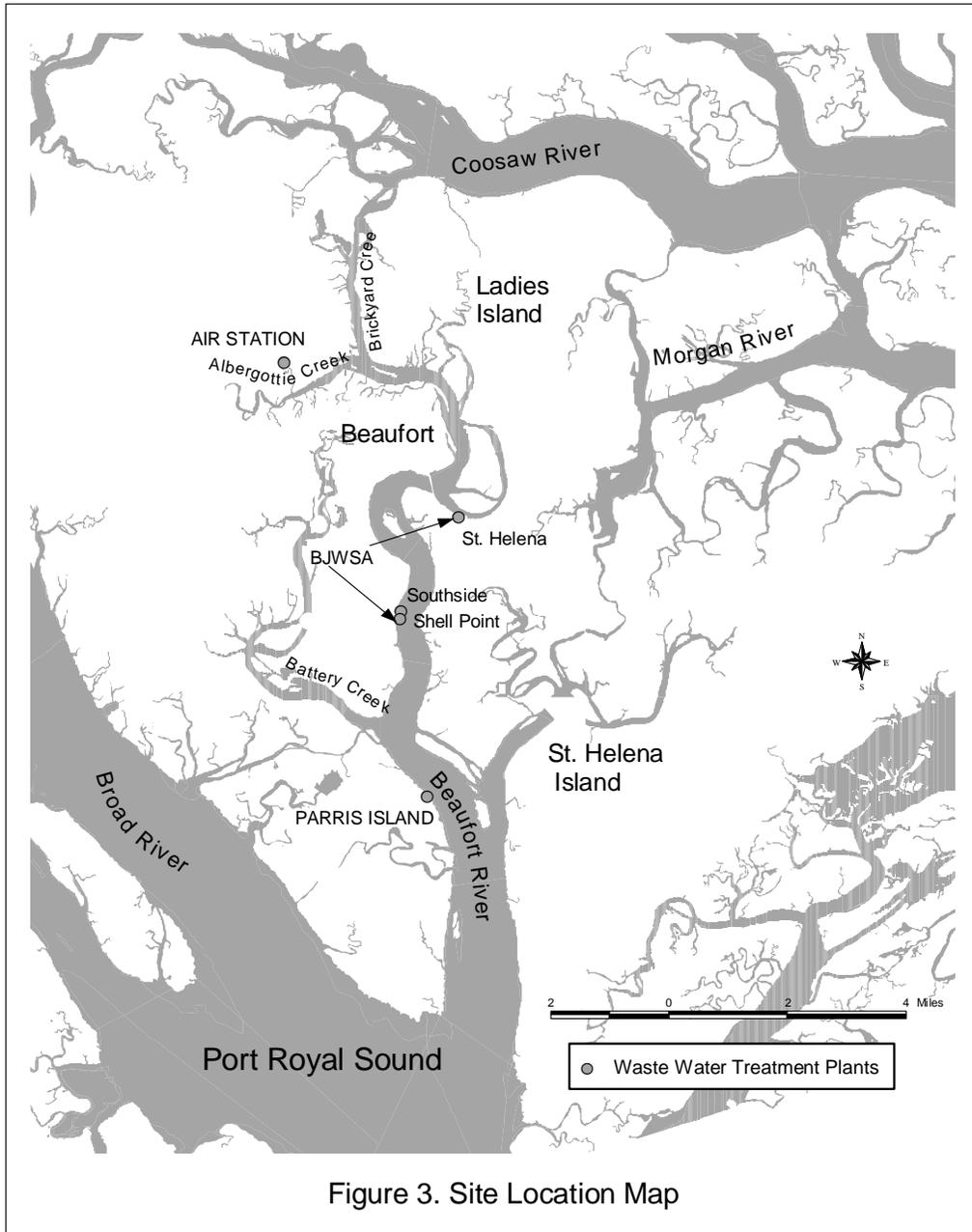
Monthly Average NPDES Permit Limits and Permitted Loadings at Time of Model Development

WWTF		NPDES Permit No.	Flow	BOD5		NH3-N		UOD
				MGD	mg/l	lbs/day	mg/l	lbs/day
BJWSA	Southside	SC0021016	4	30	1001	20	667	6052
	Shell Point	SC0042609	0.8	30	200	20	133	1210
	St. Helena	SC0039811	0.6	30	150	20	100	908
Parris Island		SC0002577	3	30	751	20	500	4539
Air Station		SC0000825	0.75	30	188	20	125	1135

* Permits for Southside, Parris Island, and Air Station WWTPs require monitoring and reporting of ammonia; 20 mg/l is the assumed effluent concentration.

Nonpoint Sources

Nonpoint source loadings (anthropogenic and natural) during rainfall events may be a large source of oxygen consuming constituents to streams. The Beaufort River model simulates a continuous 2.5-year period that includes periods of rainfall. In the model, the change in DO resulting from the point source loads is calculated by comparing model runs with and without the point source loads included. Therefore, change in DO resulting from the point sources is independent of the nonpoint source impact.



4. TMDL DEVELOPMENT

Model Development

In the past, DHEC used the steady state, tidally averaged water quality model CWQM (Comprehensive Water Quality Model) to evaluate discharges to the Beaufort River. Due to limitations of this tidally averaged model, the CWQM was not considered appropriate for TMDL development.

In order to establish a TMDL for oxygen demanding substances in the Beaufort River, BJWSA initiated and directed the development of a dynamic water quality model for DHEC to use in determining the assimilative capacity of the river. As a result, an Artificial Neural Network model (ANN) was developed in 2001 by a project team of scientists and engineers from Jordan, Jones & Goulding (JJG), Advanced Data Mining (ADMi) and the U.S. Geological Survey (USGS). The model encompasses Albergottie Creek, Brickyard Creek, and the Beaufort River to the confluence with the Broad River.

The Beaufort River TMDL model is a statistical model and incorporates all real time data at the seven USGS gaging stations (see Fig. 2) during the modeling period December 1998- September 2001. Data include water level, temperature, specific conductance, and dissolved oxygen concentration. Precipitation data are taken at the Albergottie Creek gage. The network of gaging stations in the Beaufort River provides a view of hydrodynamics and water quality. Values between stations are estimated by spatial interpolation.

Also, the model incorporates two years of point source effluent data that were obtained from the four wastewater reclamation facilities permitted to discharge to the Beaufort River. The WWTPs collected effluent samples weekly. Data from the facilities consist of measurements of flow, biochemical oxygen demand (BOD5), and ammonia (NH₃-N). To estimate a time series of historical loading to the system in terms of UOD, the weekly loading values are interpolated.

In the model, the change in dissolved oxygen associated with the discharges (delta DO) is calculated between the DO of load and no load conditions for each day of the modeling period. The model assumes that the Beaufort River is divided into two segments with the segment boundary just below the USGS gage 2176611. The model segmentation provides for two equal volume river segments. Model results for dissolved oxygen are compiled using volumetric averaging within these two segments. For more detailed information on model development, see Appendix A.

Model Review

DHEC participated in model design and development and reviewed the final model. AMEC, a private consulting company working for the Department of the Navy, also conducted an in depth review of the model. The review process resulted in several revisions to the model. The final model was provided to SCDHEC in November 2003.

The final model is considered an appropriate tool for determining wasteload allocations for TMDL.

Results of the modeling process indicate the need for an overall reduction of approximately 90% in the permitted load of ultimate oxygen demand (UOD) to the Beaufort River to meet the Tenth Rule. The proposed loads lie in the range of the actual load discharged to the river during the modeling period. This gives confidence in the model predictions.

Critical Conditions

Water quality standards require that a TMDL be protective during critical conditions, periods when assimilative capacity is limited. Usually, critical conditions include a critical flow period, temperatures, water quality boundary conditions, point source inputs, and meteorological conditions. Critical condition models are generally used to develop loadings that are considered protective when flow conditions are equal to or greater than the defined critical low flow.

The Beaufort River TMDL model does not use a single, or representative, critical period. However, similar to a critical condition model, the goal is to be protective of the stream. To ensure this is the case, the maximum allowable loading is considered to be the loading which results in a delta DO of less than or equal to 0.10 mg/l below natural background. The allowable delta DO is applied as a volume weighted average over two river segments. The segment to the north of the segment boundary is considered the critical segment.

The Beaufort River TMDL model predicts point source loadings of oxygen-consuming constituents for each day of the 2.5 years simulation that will not exceed the chosen delta DO for both segments. As a result, we have a time frequency distribution of optimized allowable point source loadings (BOD5 & NH3-N) into the Beaufort River for each day of the modeling period for each discharge. The 5th percentile of the time frequency distribution of optimized allowable point source loadings (BOD5 & NH3-N) is calculated. These loadings are considered to comply with Tenth Rule requirements that DO concentrations not be reduced more than 0.1 mg/l below natural conditions. As a further test, the model is run with these loadings as constant inputs for the dischargers and the output of the model is evaluated to ensure the delta DO (No Load minus Load) for each segment is less or equal to 0.1 mg/l. If the goal is not reached, the steps could be repeated.

Analysis shows that the results of the modeling are more protective if the entire modeling period is used to determine the allowable loading rather than using a defined critical period within the 2.5 years simulation.

During the period modeling data were collected, South Carolina experienced a severe drought from the period of the El Nino event in the spring of 1998 until the increased rainfall during the late summer of 2002. This raised questions as to the appropriateness of

the sampling period. The drought may have not been as severe for coastal regions as for the Midlands and Piedmont of South Carolina. For example, in June of 1999 the Beaufort area experienced the wettest June on record despite the drought throughout the rest of the state. As a result, due to the variety of experienced meteorological conditions, the modeling period was considered to be appropriate for determining wasteload allocations.

Critical Conditions Loading

The model simulations were developed assuming that the waste load to the Beaufort River would be allocated at the ratio of the current permits. BJWSA is currently allocated at 59% of the permitted load to the river. Parris Island and MCAS are allocated at 33% and 8% of the permitted load, respectively.

The following two model scenarios were used in the development of the TMDL:

1. Maintain all three existing discharges at existing locations.
2. Eliminate both the MCAS and Parris Island discharges and relocate those flows to the BJWSA location.

The allocations are shown in Table 5. Although the sum of the scenarios presented in Table 5 results in differing loads (based on differing locations of the outfalls), both scenarios attain the goal of having a delta DO associated with the discharges of no more than 0.10 mg/l below natural conditions, which thus meets South Carolina antidegradation rule (R.61-68.D.4).

**Table 5
Allocations Scenarios to the Beaufort River**

Scenario 1- Three discharges		
Dischargers	Total UOD Allocation (pounds per day)	
	Load, #/day	% of Allocation
MCAS WRF	88	8%
Parris Island WRF	346	33%
Port Royal WRF	618	59%
Sum Load	1052	100%
Scenario 2- One discharge		
Dischargers	Total UOD Allocation (pounds per day)	
	Load, #/day	% of Allocation
MCAS WRF	0	0%
Parris Island WRF	0	0%
Port Royal WRF	1593	100%
Sum Load	1593	100%

Seasonality

Consideration of seasonality is required when determining TMDL limits. Seasonal variation is incorporated in the Beaufort River TMDL by simulation of a continuous 2.5-year period.

Margin of Safety

TMDLs are required to include a margin of safety (MOS) to account for uncertainty in the technical evaluation. For Beaufort River, the amount of uncertainty is considered to be low. Margin of safety was achieved due to:

- a continuous 2.5-year period of data which was used for model simulation;
- model accuracy (R^2) for dissolved oxygen prediction which was usually higher than 0.9 (see Appendix A);
- developing a TMDL that results in a delta DO, attributed to the discharges, of less than 0.1 mg/l 95% of the time.

5. IMPACT ON ENDANGERED SPECIES

The Beaufort River is contained within the borders of Beaufort County. Of the endangered species known to occur in this county, the shortnose sturgeon, *Acipenser brevirostrum*, is the species likely to be most affected by any change in Beaufort River oxygen concentrations.

Application of the Tenth Rule will allow a *de minimis* lowering of natural dissolved oxygen levels in the Beaufort River. The TMDL will allow a lowering of dissolved oxygen of one tenth of one part per million (0.10 mg/l) below natural conditions. This will protect the aquatic life uses of all species, including the shortnose sturgeon, as related to dissolved oxygen.

6. Public Participation

Responsiveness Summary Beaufort River TMDL April 2006

In response to the public notice of the proposed Beaufort River TMDL, comments were received from one entity, the Beaufort/Jasper Water and Sewer Authority. Responses to individual comments are provided below.

Comment 1. The commenter points out that additional information is needed to better describe and document the information used to determine the frequency of violations of dissolved oxygen criteria in the Beaufort River. They further note the need to explicitly state on the tables that these statistics are based on historical data.

Response: We concur that additional descriptive information is needed. Information on the type sampling (grab or continuous), the period of data collection, and parameters measured has been added in the body of the report. In addition, table headings have been modified to reflect the stated percentage of violations is of in stream dissolved oxygen criteria at ambient monitoring stations

Comments 2 & 3. These comments express the desire of the commenter to have it expressly stated in the report, both in written and tabular form that reductions in permitted loading to the Beaufort River will not result in the attainment of numeric criteria. It is pointed out that wording in the critical conditions discussion may be misinterpreted by the public.

Response: We concur that clarification is needed that the proposed load reductions will result in compliance with antidegradation requirements that naturally low dissolved oxygen levels not be decreased by more than 0.1 mg/l but will not result in attainment of numeric criteria. Wording has been added to the Target Identification and Critical Conditions sections to clarify this point. We believe that this clarification is adequate; therefore, a table is not needed.

Comment 4: This comment points out that in several places the change in DO concentration (delta DO) resulting from the discharges is referred to as “load minus no load” and should be “no load minus load”.

Response: We concur that this is the appropriate way to refer to the delta DO. These references have been changed.