Subcategory 5R Documentation

For

Point Source Dissolved Oxygen

Impaired Water

in the

Savannah River Basin,

Georgia and South Carolina

Savannah Harbor
R030601090318
HUC12: 03061090307

Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia
in Cooperation with
South Carolina Department of Health and Environmental Control
and the
Savannah River/Harbor Dischargers Group

Subcategory 5R Documentation for Point Source Dissolved Oxygen Impaired Water in the Savannah River Basin

Executive Summary

This plan documents the total pollutant loading of oxygen-demanding substances (5-day Carbonaceous Biochemical Oxygen Demand [$CBOD_5$] and ammonia) that can assimilate and still achieve the applicable water quality standards for the Savannah River Basin from Fort Pulaski (River Mile 0) to the Seaboard Coastline Railway Bridge (River Mile 27.4). The Savannah Harbor is located at the mouth of the Savannah River where it discharges to the Atlantic Ocean. The Savannah River, including the Harbor, serves as the boundary between Georgia and South Carolina.

This plan is based on Georgia's dissolved oxygen (DO) water quality criterion that was approved by EPA in March 2010 and the existing South Carolina DO water quality criterion established for the Savannah Harbor. This plan evaluates the sources of oxygen-demanding substances that may cause or contribute to the non-attainment of the applicable DO water quality standard. The Savannah River and Harbor DO Calculator Version 4.0 (June 2010) was developed as an efficient method to evaluate oxygen-demanding substances reduction strategies that will most practicably allow the DO water quality standard to be met. The Savannah River/Harbor Dischargers Group (Dischargers Group) applied the Savannah River and Harbor DO Calculator to develop a wasteload reduction implementation strategy that will most practicably allow the DO water quality criterion to be met. The Dischargers Group's process for deriving equitable waste load allocations for the 24 continuous NPDES dischargers is discussed in Appendix B.

The Georgia Environmental Protection Division (GA EPD), the South Carolina Department of Health and Environmental Control (SC DHEC), the Environmental Protection Agency (EPA), a Technical Modeling Advisory Group, and the Savannah River/Harbor Dischargers Group collaborated to develop the documentation contained in this plan, which supports the State's decision to place the impaired water under subcategory 5R on the State's Section 303(d) list. The supporting documentation contained in this plan includes (1) the watershed and waterbody identification, (2) description of applicable water quality standards, (3) source assessment for oxygen demanding pollutants, (4) description of the hydrodynamic and water quality models used to develop the Savannah River and Harbor DO Calculator for determining the effects of the 24 continuous NPDES dischargers on the DO levels in the Savannah Harbor, (5) schedule for reissuing the existing 24 NPDES permits to include effluent limits that will achieve water quality standards, and (6) a monitoring plan to track the effectiveness of the revised effluent limits. The appendices include the justification of the Savannah Harbor DO Model critical flow conditions used, the Dischargers Group's technical basis for the wasteload allocations, the memorandum of understanding between the dischargers to the Savannah River and Harbor, and the Savannah River and Harbor DO Calculator runs.

It is our understanding that the November 2006 EPA Savannah Harbor Total Maximum Daily Load (TMDL), which was based on the previous Georgia DO Standard, will be withdrawn upon EPA's approval of GA EPD's decision to list the impaired water contained in this plan under subcategory 5R on the Clean Water Act Section 303(d) list. It is our intent to remove the waterbody contained in this plan from subcategory 5R of the 303(d) list once the permits contain limits sufficient to implement the applicable water quality standard. The waterbody will be delisted as impaired once these limits are being met.

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1. Savannah Harbor Description

The Savannah River Basin is located on the border of eastern Georgia and western South Carolina and has a drainage area of 10,577 square miles. The Savannah River serves as the boundary between Georgia and South Carolina, and the Harbor is shared by both States. The portions of the Savannah River Basin included in this plan are the middle and lower watersheds encompassing the area from Thurmond Dam to the Atlantic Ocean. The Savannah Harbor watershed contains parts of the Southeastern Plains and Southern Coastal Plain physiographic provinces that extend throughout the south-eastern United States. Land uses within these watersheds are mostly forestlands, wetlands, and agriculture.

The area of concern is the Savannah Harbor from SR 25 (old US Hwy 17) to Elba Island Cut. This segment R030601090318 (HUC12: 03061090307) was identified on the State of Georgia's Section 303(d) list as impaired for dissolved oxygen (DO) beginning in 2002. This segment is located near the mouth of the Savannah River where the Savannah River flows into the Atlantic Ocean. The Savannah Harbor from Fort Pulaski (Mile 0) to Seaboard Coastline R/R Bridge (River Mile 27.4) is designated as Coastal Fishing.

EPA established a TMDL for this segment in 2006 based on its failure to meet the previous DO water quality standard associated with the State of Georgia's Coastal Fishing water quality designated use and data collected in the summers of 1997 and 1999. The portion of the Savannah Harbor that is currently listed as impaired for DO is limited to Georgia State waters. Since that time, EPA approved the State of Georgia's revised DO water quality standard for the Savannah Harbor. The information contained in this plan is based on Georgia's revised DO water quality criterion that was approved by EPA in March 2010.

The hydrodynamic and water quality models used to analyze the oxygen-demanding pollutant loadings extend upstream on the Savannah River to River Mile 61.0 near Clyo, Georgia, at United States Geologic Survey (USGS) station 02198500. The downstream end of the models extends approximately 25 miles offshore from Oyster Island to cover the navigational channel of Savannah Harbor. The models cover the Savannah River, the Front River, the Middle River, the Little Back River, the Back River, the South Channel, and the offshore portions in the Atlantic Ocean. Figure 1 is a map that shows overall location of the study area.

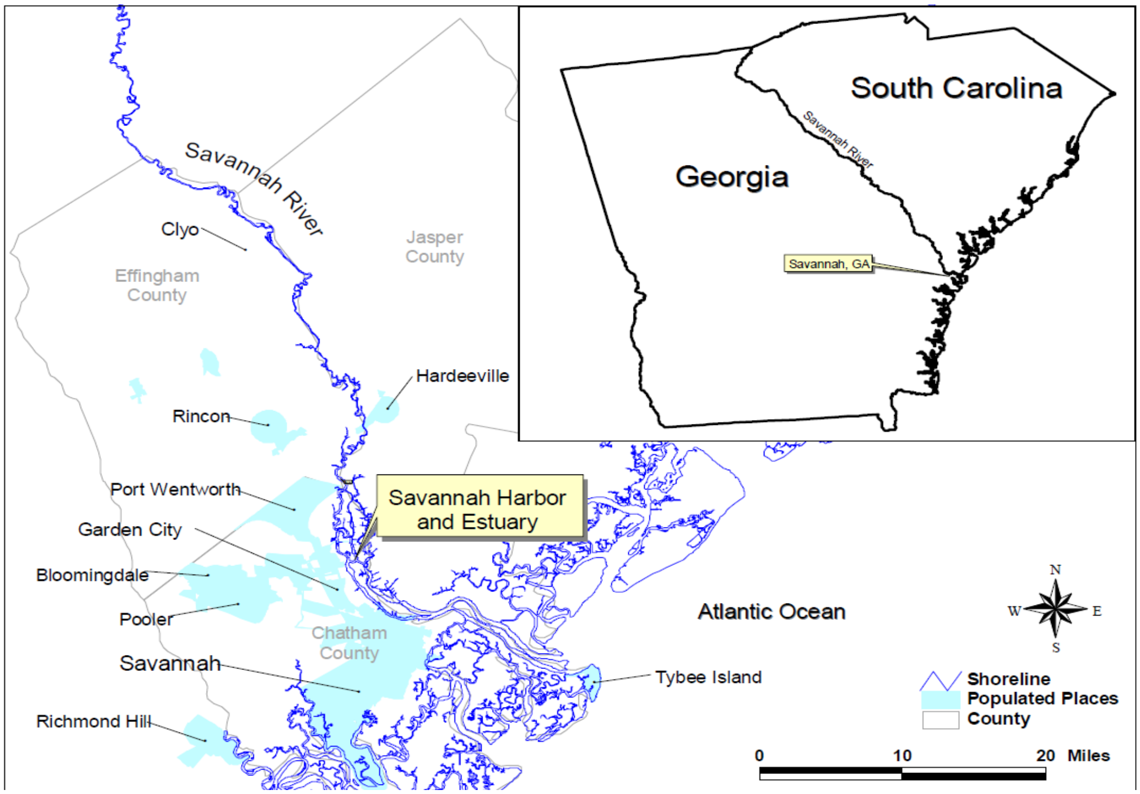

Figure 1 Savannah Harbor Location Map

Water quality studies conducted over the past twenty years were used to characterize the DO regime of the Harbor, determine the principle causes of impairment, and provide sufficient data and information to develop a complex hydrodynamic and water quality model. The data used in the calibration and confirmation of the hydrodynamic and water quality models were collected by the Georgia Ports Authority (GPA), the USGS, the GA EPD, the U.S. Army Corps of Engineers (USACE), and the United State Environmental Protection Agency (EPA). Figure 2 shows the original sampling locations for the 1999 study, some of which were also used for the 2008 data collection.

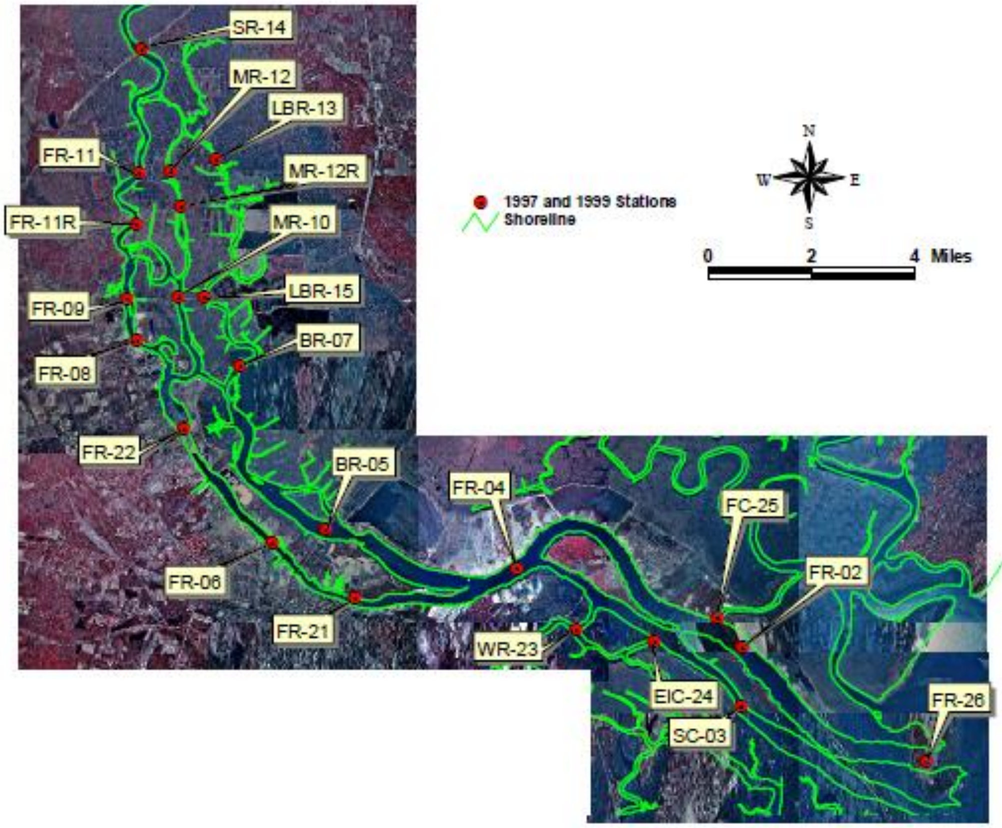

Figure 2 1999 Sampling Locations

2. Numeric Target

2.1. Georgia DO Standard for Savannah Harbor

The Georgia water use classification for the Savannah Harbor is Coastal Fishing. The dissolved oxygen criteria for the Savannah Harbor as stated in Georgia *Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03(17)(5)(i) (GA EPD 2014), were revised and are:

(d) Coastal Fishing: This classification will be applicable to specific sites when so designated by the Environmental Protection Division. For waters designated as "Coastal Fishing", site specific criteria for dissolved oxygen will be assigned. All other criteria and uses for the fishing use classification will apply for coastal fishing.

(i) DO: A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times. If it is determined that the “natural condition” in the waterbody is less than the values stated above, then the criteria will revert to the “natural condition” and the water quality standard will allow for a 0.1 mg/L deficit from the “natural” dissolved oxygen value. Up to a 10% deficit will be allowed if it is demonstrated that resident aquatic species shall not be adversely affected.

2.2. South Carolina DO Standard for Savannah Harbor

The South Carolina DO criteria state that “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. For purposes of section D of this regulation, the term “naturally low dissolved oxygen waterbody” is a waterbody that, between and including the months of March and October, has naturally low dissolved oxygen levels at some time and for which limits during those months shall be set based on a critical condition analysis. The term does not include the months of November through February unless low dissolved oxygen levels are known to exist during those months in the waterbody. For a naturally low dissolved oxygen waterbody, 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 pursuant to Section 48-1-83. The Department may modify permit conditions to require appropriate instream biological monitoring.

c. The dissolved oxygen concentrations shall not be cumulatively lowered more than the deficit described above utilizing a daily average unless it can be demonstrated that resident aquatic species shall not be adversely affected by an alternate averaging period.

3. Modeling Approach

The process of developing this plan for the Savannah Harbor included developing three computer modeling tools: (1) the Savannah River Model, (2) the Savannah Harbor Model, and (3) the Savannah River and Harbor DO Calculator. . The Savannah River Model and the Savannah Harbor Model were calibrated for calendar year 1999, when water quality data were collected in the Harbor. The Savannah River and Harbor DO Calculator Version 4.0 is based on hundreds of Savannah River Model and Savannah Harbor Model runs and provides an efficient method to calculate the effect various combinations of the 24 wastewater effluent dischargers had have on the DO levels in the Savannah River and Harbor. The Savannah River Model, the Savannah Harbor Model, and the Savannah River and Harbor DO Calculator are described in Sections 3.1, 3.2, and 3.3 respectively.

3.1. Savannah River Model

Georgia EPD developed the Savannah River Model for the Savannah River from the Augusta Canal diversion dam to the USGS gaging station (02198760) above Hardeeville, South Carolina. The Savannah River Model used for this 5R Plan is the hydrodynamic and water quality model developed using GA RIV-1 for the 2006 TMDL. The Savannah River Model includes all major point sources to the River and simulates the effects municipal and industrial discharges have on both water quality and flow and was calibrated to available data. Figure 3 and Figure 4 show the comparison of Savannah River Model simulations of flow and temperature to observed data. The Savannah River Model is used to simulate transport of oxygen demanding substances from their source in the river to the upstream boundary of the Savannah Harbor Model. The specifics of the Savannah Harbor Model are discussed in the Section 3.2. The Savannah River Model output data used as input for the Savannah Harbor Model includes hourly flow, DO, hourly temperature, CBOD (fast and slow) and ammonia boundary conditions. (2010 EPA Region 4) Using the output from the Savannah River Model as input for the Savanah Harbor Model provides a seamless connection for dissolved oxygen simulations.

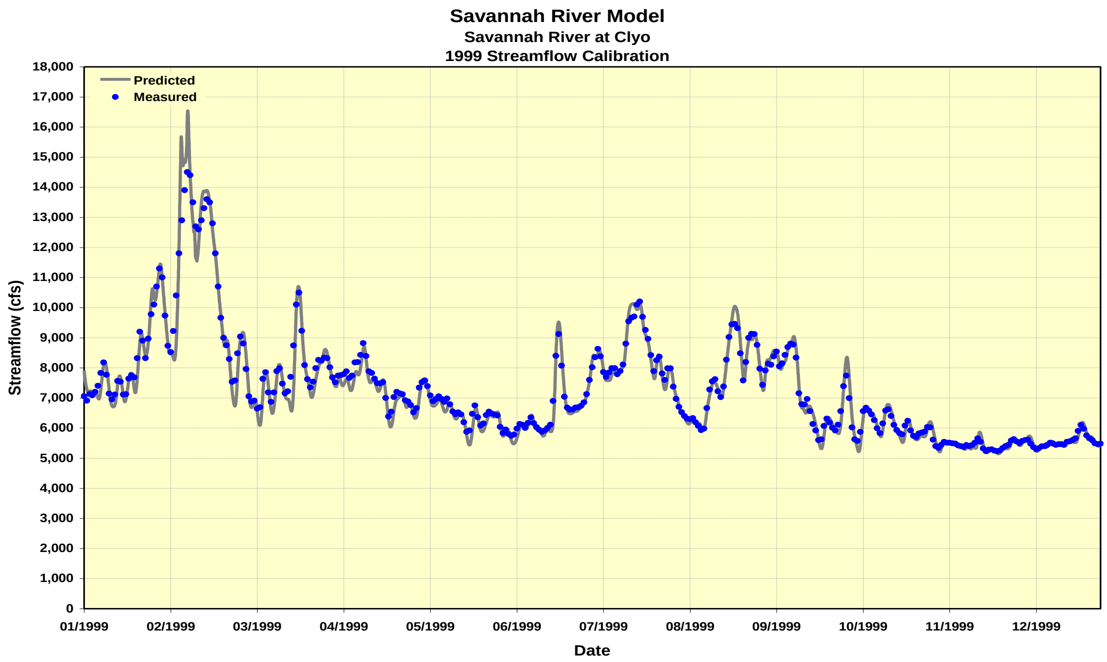

Figure 3 1999 Streamflow Calibration at Clyo

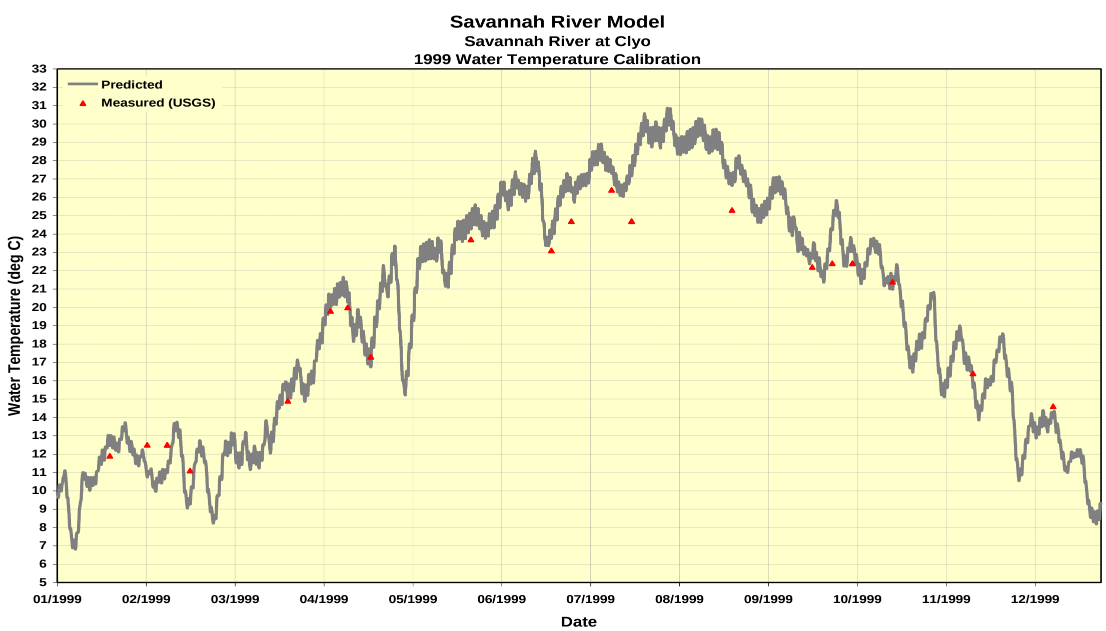

Figure 4 1999 Water Temperature Calibration at Clyo

3.2. Savannah Harbor Model

The Savannah Harbor Model used for this 5R plan is comprised of two components: the hydrodynamic component and the water quality component. The hydrodynamic component was developed by Tetra Tech using the Environmental Fluid Dynamics Code (EFDC) (Hamrick 1992). The water quality component is the Water Quality Analysis Simulation Program (WASP) model maintained by EPA.

The Savannah Harbor Model used for the 5R Plan was built upon the Enhanced USACE Model that was finalized on January 30, 2006 and the 2006 Harbor TMDL Model developed by EPA Region 4 (Tetra Tech 2004, Tetra Tech 2006, EPA 2010). The initial setup, calibration, and confirmation of the Enhanced USACE Model are well documented in the *Development of the Hydrodynamic and Water Quality Model for the Savannah Harbor Expansion Project, January 2006* (Tetra Tech 2006). Thanks to the intense efforts by several modelers and many agency meetings, final acceptance letters approving the use of the Enhanced USACE Model were issued by the EPA Region 4, GA EPD, SC DHEC, National Marine Fisheries, and the United States Fish and Wildlife Service (USF&W) in March 2006.

The improvements made to the 2006 Harbor TMDL Model resulting in the Savannah Harbor Model used for the 5R Plan are detailed below in sections 3.2.1 through 3.2.6. Reviewers of the Savannah Harbor Model included the Harbor Committee (MACTEC as their consultant), the USACE Engineer Research and Development Center, and the USGS.

3.2.1. Savannah Harbor Model Z-Grid Update

During 2007, EPA Region 4 determined there was a need to convert the sigma grid of the Savannah Harbor Model to a Z-Grid. This was based on the Savannah Harbor Model with the sigma grid having long run times and the issue of having grid layers “squeezed” or “compressed” in the shallow Middle, Back, and Little Back Rivers. As a consequence, the sigma grid approach created unrealistic DO concentrations in the surface and bottom layers.

The Z-Grid allows different number of vertical layers throughout the model domain. The original sigma grid had six vertical layers with widely varying layer depths and it was converted to a Z-Grid with five vertical layers in the navigation channel and one vertical layer in the Middle, Back, Little Back, and Upper Savannah Rivers, which allowed all the layers to be similar depths. The Z-Grid allowed for the invert of the river bottom elevation to be modified with one vertical layer going upstream from the I-95 Bridge to the Clyo USGS gage on the Savannah River. The longitudinal slope was evenly distributed from the headwater cell to above the I-95 Bridge by adjusting bottom elevations. The water surface elevation at the headwater boundary cell was raised to better match the gage height reported at the Clyo USGS gage. The Z-Grid model contains 608 horizontal cells and 1,778 total cells when including the vertical cells. Figure 5 shows the Harbor portion of the Z-Grid Savannah Harbor Model.

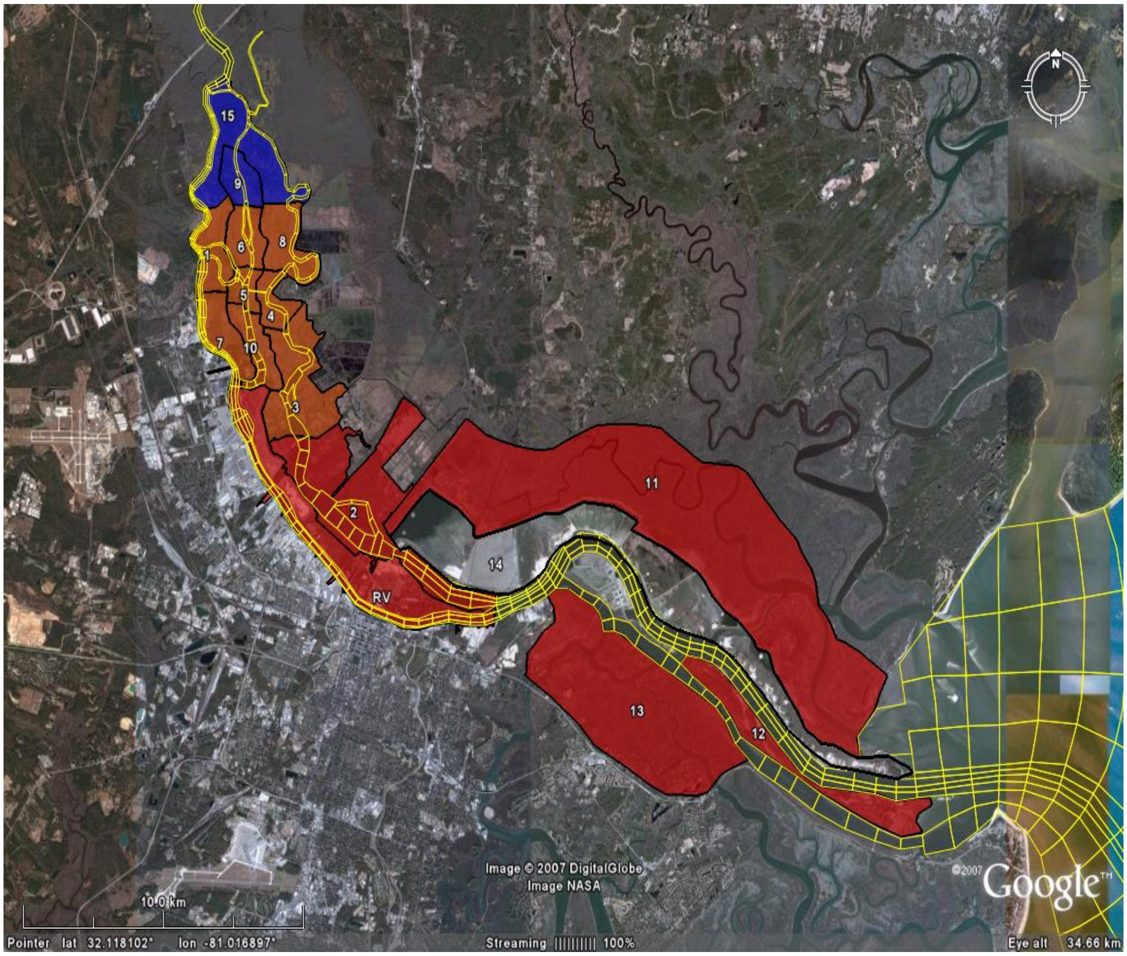

Figure 5 Z-Grid Harbor Cells and Existing Marsh Areas

3.2.2. Savannah Harbor Model Marsh Approach Update

The marsh areas included in the Savannah Harbor Model were also revised at the time of the Z-Grid update. The update added the areas downstream of Fort Jackson and one area upstream near the I-95 Bridge. Table 1 reflects the new marsh loadings. The color of each marsh indicates

Table 1 Existing Marsh Loads

Marsh	Actual Area (ac)	Actual Depth (m)	BODU Export Rate (kg/day/acre)	BODU (kg/day)	BODU (lbs/day)
Q1	742	0.12	6	4,454	9,820
Q2	3,467	0.25	12	41,606	91,726
Q3	1,682	0.18	6	10,089	22,243
Q4	421	0.21	6	2,527	5,570
Q5	310	0.20	6	1,862	4,104
Q6	570	0.16	6	3,423	7,546
Q7	731	0.29	6	4,384	9,665

Marsh	Actual Area (ac)	Actual Depth (m)	BODU Export Rate (kg/day/acre)	BODU (kg/day)	BODU (lbs/day)
Q8	845	0.14	6	5,070	11,177
Q9	485	0.21	3	1,456	3,210
Q10	602	0.22	6	3,613	7,966
Q11	12,676	0.15	12	152,114	335,353
Q12	1,548	0.15	12	18,580	40,963
Q13	5,819	0.15	12	69,822	153,931
Q14*	6,049	0.15		5,155	11,364 *
Q15	1,633	0.15	3	4,898	10,798
			TOTALS =	**329,053**	**725,436**

* Q14 is Dredge Disposal Area Managed by the Corps, the load was calculated based on the 5-day Biochemical Oxygen Demand (BOD_5) and weir flows as a peak load.

where it was included in the model as a freshwater (blue), brackish (orange) or saltwater (red) marsh.

To address seasonality of the marsh loads, a reference paper was used that measured dissolved inorganic carbon in tidal freshwater marshes in Virginia and the adjacent estuary. The paper is titled "Transport of dissolved inorganic carbon from a tidal freshwater marsh to the York River Estuary" by Scott C. Neubauer and Iris C. Anderson from the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary. The percentages in Table 2 below were derived from the referenced study and are applied to the loads listed in Table 1 (for existing marsh loads) to develop the monthly WASP loads for Ultimate Carbonaceous Biochemical Oxygen Demand (CBODu) from the marsh areas.

Table 2 Seasonal Distribution of Marsh Loads

Month	Percent of Total Load
January	20
February	20
March	40
April	40
May	60
June	80
July	100
August	100
September	80
October	60
November	40
December	40

3.2.3. Savannah Harbor Model Hydrodynamic Update

The initial Savannah Harbor Model flow, velocity, elevation and temperature predictions were calculated using the EFDC hydrodynamic model and calibrated to the extensive

1997 and 1999 data set (2006 Tetra Tech). The EFDC model inputs were updated to reflect more recent information. This information includes new flow and velocity data collected by USGS gages in the Harbor, long-term DO data at the USACE Dock, updates to the boundary conditions, connection to Savannah River Model, and updates to water quality kinetics.

3.2.3.1. Middle and Back Rivers Updated Hydrodynamics

The USGS collected detailed (15 minute) water surface elevation, velocity, and flow data during the fall and winter of 2008 – 2009 at the Middle and Back Rivers near the Houlihan Bridge crossings at Stations MR-10 and LBR-15 respectively. These data were used to improve the hydrodynamic predictive ability of the model in the Middle and Back Rivers. Updates focused on improving the width and depths of the river channels in the models and changing the marsh storage areas to better reflect the movement of water through the channels so the model would better reflect the measured flows, velocities, and elevations (2010 EPA Region 4). Figures 6 and 7 illustrate an example of the models predictive capabilities for gage height and flows for Little Back River at Houlihan Bridge. These figures show a very good correlation between model predictions and measured flow and gage height.

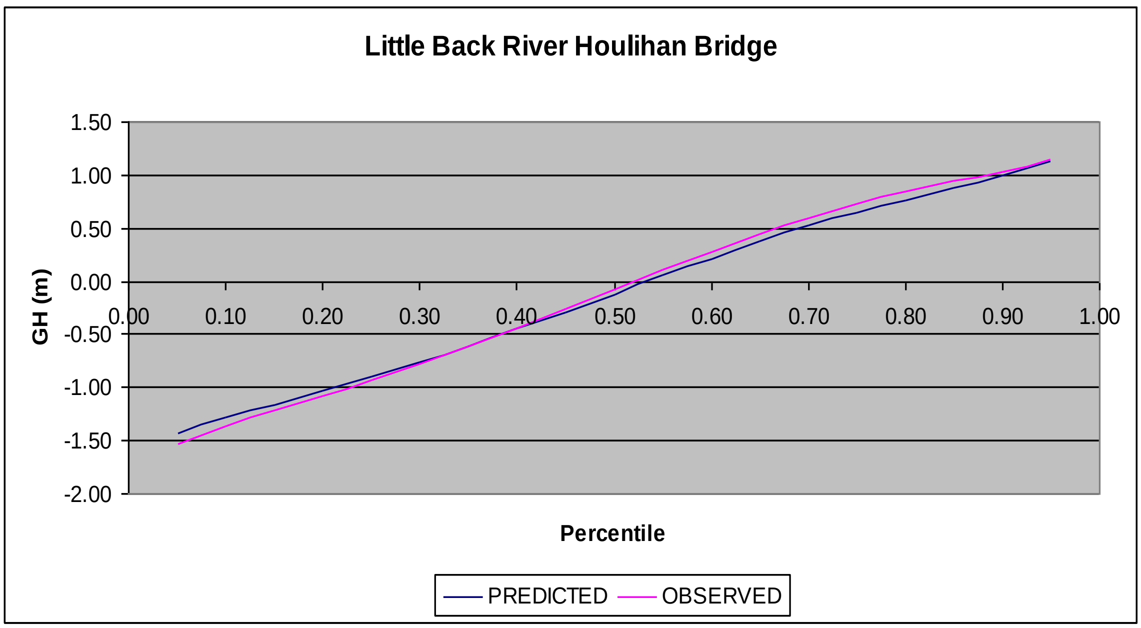

Figure 6 Percentile Comparisons of Predicted and Measured Gage Heights

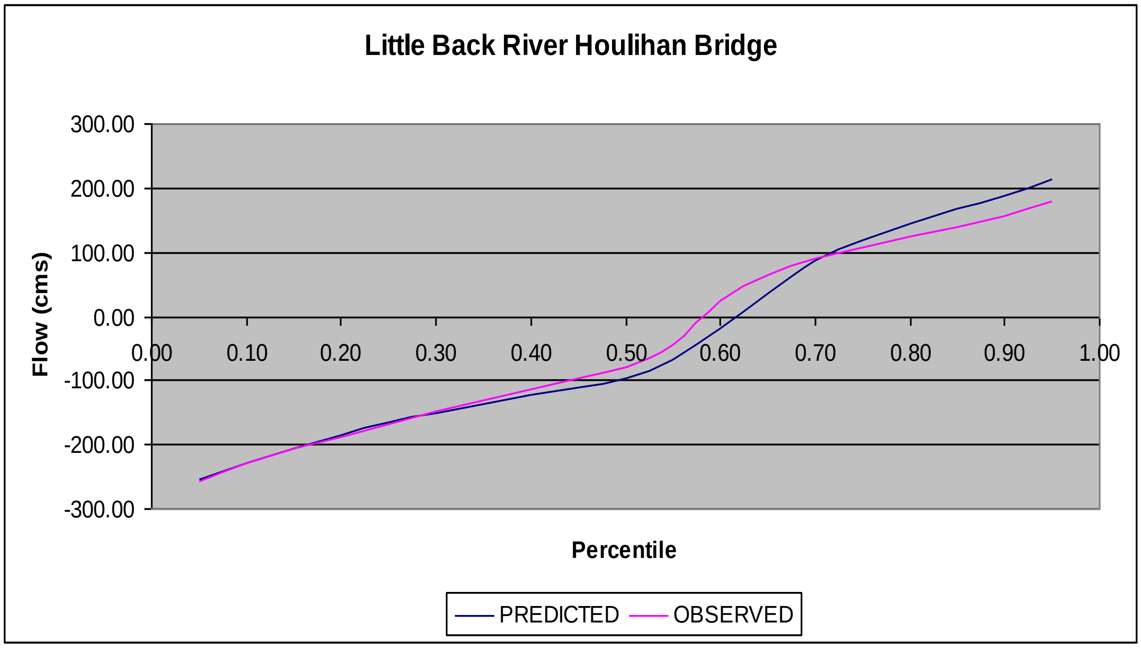

Figure 7 Percentile Comparisons of Predicted and Measured Flows

3.2.4. Water Quality Rates and Kinetics Update

The main changes to the water quality component (i.e. WASP) of the 2006 version of the Savannah Harbor Model (2006 Tetra Tech) were an update of the reaeration approach and a fine tuning of the CBOD decay rates. The main modeling parameters impacting the DO balance of the Harbor are the reaeration rates, the Sediment Oxygen Demand (SOD) rates, and the oxygen demanding substances (BOD and ammonia) decay rates. Table 3 provides a summary of the rates used in the Savannah Harbor Model for this 5R Plan.

Table 3 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Reaeration Rate @ 20 °C (per day)	O'Connor-Dobbins Formulation
Sediment Oxygen Demand (g/m2/day) @20 °C	0.7 to 2.4
BOD (1) Decay Rate Constant @20 °C (per day)	0.06
BOD (2) Decay Rate Constant @20 °C (per day)	0.04
BOD (3) Decay Rate Constant @20 °C (per day)	0.02
Ammonia, nitrate, phosphorus rates @20 °C (per day)	0.015

3.2.5. Reaeration Rate and Sediment Oxygen Demand Update

The Savannah Harbor Model was also updated to employ the O'Connor-Dobbins reaeration formulation that uses velocity and total depth of the river (a WASP7 update) to determine the reaeration rates for the Savannah Harbor System. SOD rates were revised and ranged from 0.7 to 2.4 g/m^2/day at @20 °C:

- 0.7 g/m^2/day for Ocean, Middle and Back Rivers
- 1.6 g/m^2/day for Upper Savannah River Clyo to Hwy 17 bridge
- 2.0 g/m^2/day for main Harbor area
- 2.4 g/m^2/day for Sediment basin and Turning Basins

3.2.6. Pollutant Decay Rates Update

The WASP 7 component of the Savannah Harbor Model has the option of using up to three CBODu components i.e., the BOD loads to the model can be divided into three varying CBODu components. Based on analyses of the River's long-term BOD tests and the wastewater dischargers effluent long-term BOD tests, it was determined that the three CBODu decay rates of 0.02, 0.04 and 0.06 per day best reflected the BOD decay activity going on in the Harbor System. Each CBOD load to the system was partitioned into one of these components based on their specific long-term BOD characteristics.

- Marsh CBOD loads were put in the 0.04/day component
- River fast decaying CBOD loads in the 0.06/ day component
- River slow decaying CBOD loads in the 0.02/ day component
- Ocean CBOD concentrations/loads half in 0.06 and the rest in 0.02/ day components
- Dischargers CBOD loads in to their appropriate component based on their specific long-term data. More details are given in Section 4.

The 2006 version of the Savannah Harbor Model had a CBODu decay rate component of 0.12/day to reflect the decay of secondary treated wastewater in the Harbor. Presently, most of the wastewater is more highly treated and the 0.12/day decay rate is no longer appropriate.

3.3. Critical Conditions

For an estuarine analysis, critical conditions are more complex than the critical conditions typically considered for a river system (e.g., summer temperatures and 7Q10 flow). Tidal dynamics play an important role in the DO levels of the Savannah Harbor. The stream flows, tides, and metrological data from calendar year 1999 were determined to best represent the critical conditions. The conditions were used to develop the models and to construct the Savannah River and Harbor DO Calculator. Critical conditions were established to include an event that would occur once in ten years on the average or less often. Georgia EPD and South Carolina DHEC agreed to set the critical conditions for Savannah Harbor as:

- Upstream boundary conditions to the Savannah Harbor Model as determined by the Savannah River Model;
- Savannah Harbor Model kinetic rates and parameters as determined by the Savannah Harbor Model calibration;
- Physical conditions of the Harbor based on the 1999 Harbor bathymetry;
- A critical flow including a seven-day ten-year low-flow (7Q10), taking into account the low-flow release from Thurmond Dam; and
- Meteorological and tidal conditions based on 1999 data.

Critical conditions applied to the Savannah Harbor DO analysis are based on model runs for March through October 1999, which incorporated the existing harbor physical conditions and the upstream low flow, as well as actual 1999 tidal regimes, temperature, and other meteorological conditions measured during these periods.

Additional analysis of the critical condition was completed through the Technical Model Review Group. SC DHEC conducted a flow analysis of the Savannah River and concluded that the period of record from 1955 through 2008 was an appropriate time frame for evaluating for critical conditions. In addition, HydroQual (HQI) conducted a fifty year DO analysis and showed that 1999 was a year that adequately represented the past 50 years (2010 HQI). Details are provided in Appendix A.

3.4. Harbor Zones and Numeric Targets

The Savannah Harbor system was divided into 27 zones. The Savannah Harbor Model produced daily average DO time series for each zone. Table 4 provides a list of the zones, a description of their location, and the State waters each zone is located in.

Table 4 Zone Descriptions and Extents

Zone	Zone Name	GA and/or SC Waters
FR-01	Main Channel RM 0 to RM 2	GA/SC
FR-03	Main Channel RM 2 to RM 4	GA/SC
FR-05	Main Channel RM 4 to RM 6	GA/SC
FR-07	Main Channel RM 6 to RM 8	GA/SC
FR-09	Main Channel RM 8 to RM 10	GA/SC
FR-11	Main Channel RM 10 to RM12	GA/SC
FR-13	Main Channel RM 12 to RM 14	GA
FR-15	Main Channel RM 14 to RM 16	GA
FR-17	Main Channel RM 16 to RM 18	GA
FR-19	Main Channel RM 18 to RM 20	GA
FR-21	Main Channel RM 20 to RM 22	GA
FR-23	Main Channel RM 22 to RM 24	GA

Zone	Zone Name	GA and/or SC Waters
FR-25	Main Channel RM 24 to RM 26	GA
FR-27	Main Channel RM 26 to RM 28	GA/SC
FR-29	Main Channel RM 28 to RM 30	GA/SC
FR-35	Main Channel RM 30 to RM 40	GA/SC
FR-45	Main Channel RM 40 to RM 50	GA/SC
FR-55	Main Channel RM 50 to RM 60	GA/SC
MR-01	Lower Middle River	GA
MR-02	Upper Middle River	GA
BR-01	Back River	GA/SC
LBR-02	Lower Little Back River	GA/SC
LBR-03	Upper Little Back River	GA/SC
SC	South Channel	GA
Ocean1	Ocean Channel Mouth to 10 miles	GA/SC
Ocean2	Ocean Channel 10 to 20 miles	GA/SC
SedBas	Sediment Basin - connecting Back River to Main Channel	GA/SC

The "natural" Harbor DO was determined by running the Savannah Harbor Model and Savannah River Model with no point sources ("Natural" Model) and the daily average DO concentration per zone was computed. Figure 8 shows the "natural" daily average DO time series for Zone FR-13, one of the lower DO areas of the Harbor.

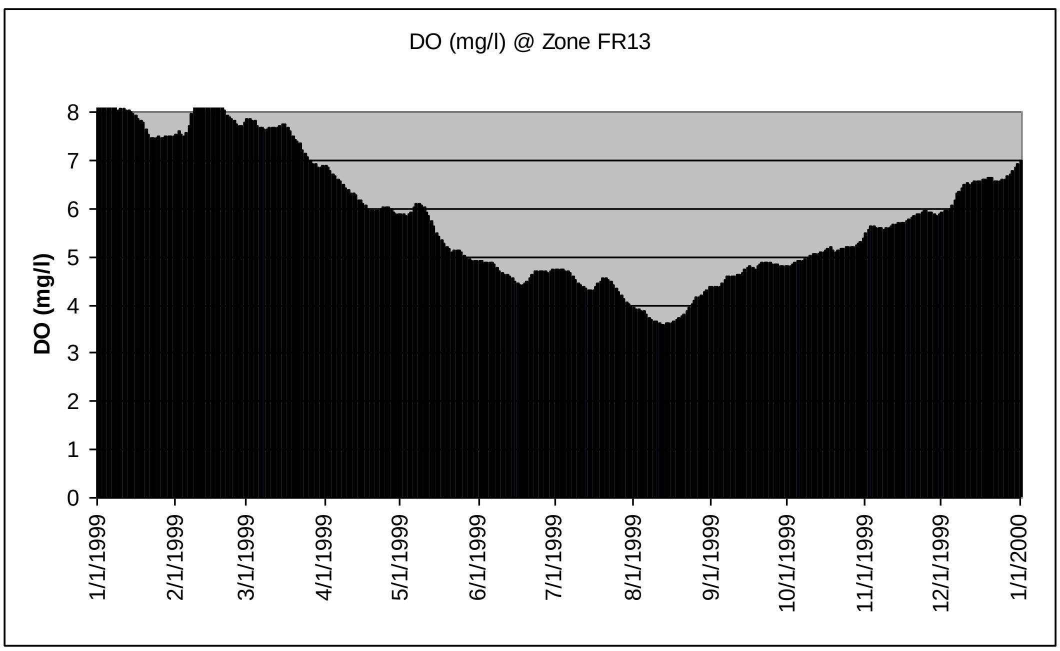

Figure 8 1999 Time Series Daily Average DO for Zone FR-13

Figure 9 shows the “natural” daily average DO August 30, 1999, for each of the 27 zones.

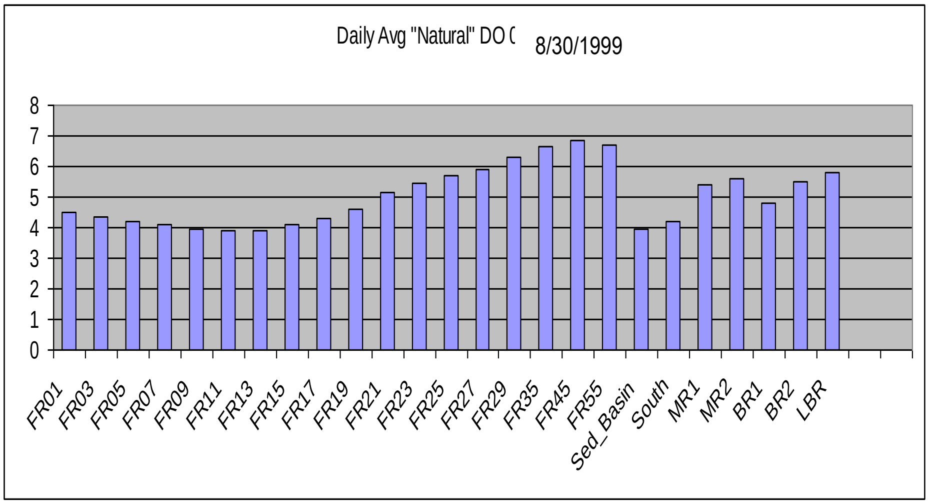

Figure 9 Daily Averages DO by Zones

A variety of model scenarios were simulated using various point source discharge CBOD and ammonia loads. The numeric target of 0.1 mg/l delta DO is calculated by subtracting the model scenario outputs from the “Natural” Model outputs for each zone and taking the 90 percentile of the daily DO differences for the time period March through October. This time frame is defined by SCDHEC regulations. Figure 10 shows the DO difference between the “Natural” and “Permitted Scenarios for each zone.

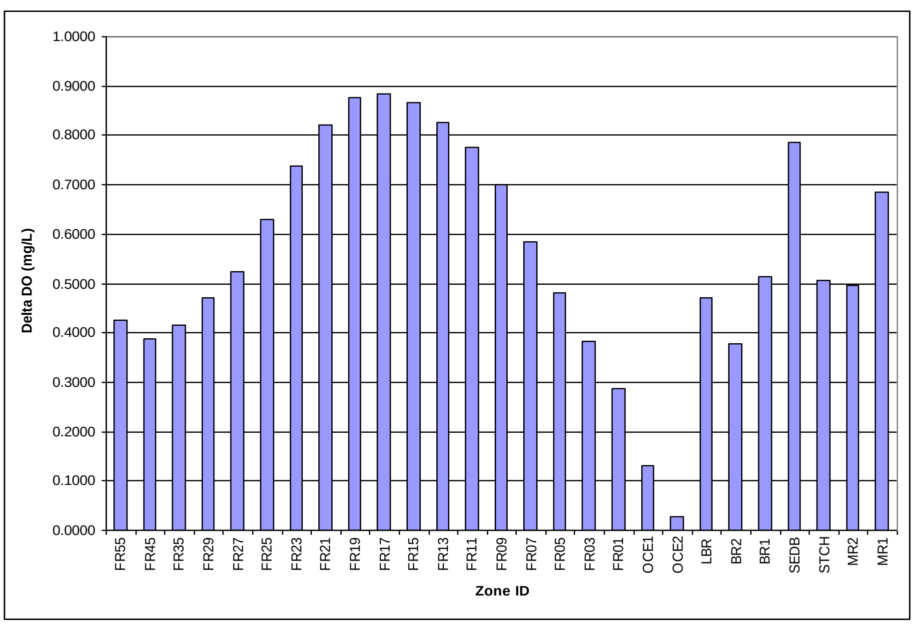

Figure 10 Delta DOs by Zone due to Point Sources at Permitted Loads

3.5. Time-Variable Loading Approach for NPDES Discharger Inputs

A traditional water quality analysis and load allocation approach uses steady state models with 7Q10 streamflows average tides, and constant Wastewater Treatment Facility (WTF) discharger loads incorporated into annual, seasonal, or monthly permit limits. The Time-Variable Discharge Approach included in the Savannah River Model and Savannah Harbor Model uses a three dimensional hydrodynamic model with actual flows, tides, meteorological data, and variable (daily) WTF discharger loads. These variable loads are incorporated into the analysis and are developed into appropriate NPDES monthly permit limits. The Time-Variable Loading Approach considers assimilative capacity of the flows above the 7Q10 and provides protection for flows below the 7Q10.

The variable discharger load time-series are based on historical wastewater effluent data for each facility and then simulated using monthly permit loads and a Coefficient of Variance (CV). For the smaller dischargers, a constant load based on the monthly permitted load and CV was used. For the five largest discharges, three years of daily time-series loading were used with each year time-series representing a high, medium and low loading year. These three loading years were based on and are representative of fifty years of simulated discharge loadings. HQI's 2010 report provides the details for each of the wastewater dischargers (2010 HQI). Figure 11 illustrates the relationship between the actual daily time-series $CBOD_5$ discharges and the monthly permitted loads.

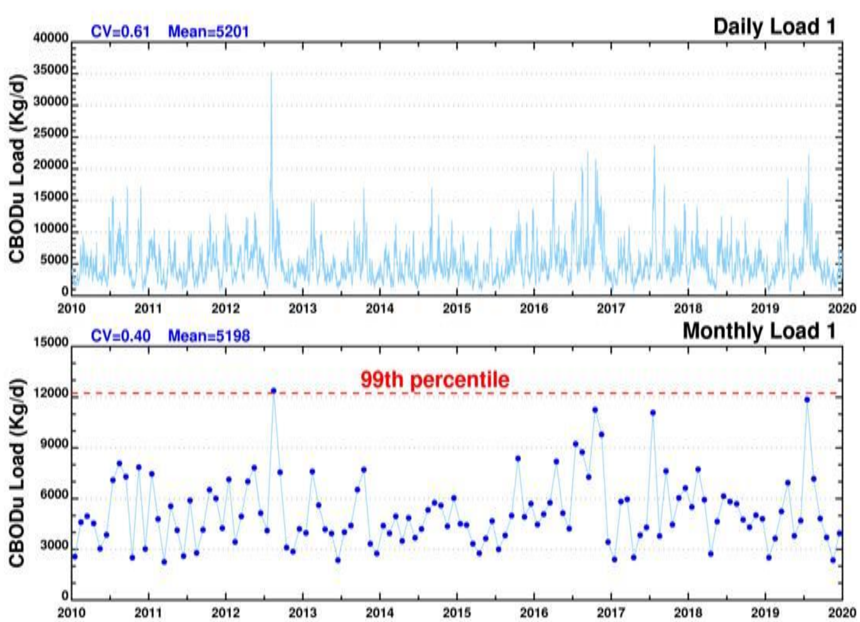

Figure 11 Monthly Permit CBODu Load and the 99th Percentile

The use of time-variable discharge loads in permits is not a new idea. The Westvaco P&P Mill in Virginia has a variable discharge NPDES permit. Also, *EPA's Technical Support Document (TSD) for Toxics* provides methodology and examples of incorporating variable load calculations in permits using the 99th percentile and an appropriate CV, while the Anacostia TMDLs set a clear precedent that daily maximum loads can allow for daily variability in continuous point sources. Additional details of this approach are laid out in the *Development of Time Variable Calculator and Supporting Documentation* (2010 HQI).

3.6. Savannah River and Harbor DO Calculator

The Savannah River and Harbor DO Calculator was developed as an efficient method to calculate the effect various combinations of the 24 wastewater effluent dischargers have on the DO levels in the Savannah River and Harbor (2010 HQI). The Savannah River and Harbor DO Calculator is based on hundreds of Savannah River Model and Savannah Harbor Model runs. It provides an accurate estimation of the DO impact of each discharger, and can be used to evaluate various discharge scenarios to develop the appropriate wasteload allocation that meets the applicable water quality standard. For purposes of this 5R process, the Savannah River and Harbor DO Calculator Version 4.0 (June 2010) will serve as the basis for criteria compliance assessment and for implementation of the 5R process, including the wasteload allocations as outlined in Appendix B. The targets governing the discharge of $CBOD_5$ and ammonia loads to the Savannah River and Harbor are:

1) 0.1 mg/L deficit from the "natural" DO value, and
2) Up to a 10% deficit is allowed if it is demonstrated that resident aquatic species shall not be adversely affected.

Since a demonstration has not been completed showing no impact on the resident aquatic species, the initial 5R water quality target is the 0.1 mg/L DO deficit. The daily average maximum decrease in DO during March through October should be less than 0.1 mg/L. If in the future a demonstration is completed showing an increased DO deficit (not to be greater than 10% of natural) does not impact the resident species and the demonstration meets the requirements of both Georgia and South Carolina Water Quality Standards, then the Savannah River and Harbor DO Calculator can be used to determine the revised effluent discharge limits.

With 24 wastewater dischargers, there are many combinations of wastewater effluent $CBOD_5$ and ammonia that could meet this delta DO constraint of 0.1 mg/L. Given the run time of an annual water quality model simulation, it is impractical to evaluate all the potential alternative wastewater combinations. However, because the magnitude of a wastewater facility's $CBOD_5$ and ammonia discharge is directly proportional to its calculated effect on the River's DO levels, the results of stored model simulations for each discharger at a specific $CBOD_5$ and ammonia input can be used to quickly calculate the change in river DO associated with different $CBOD_5$ and ammonia loads. Thus, the modeled DO level at a specific wastewater discharge is applied to determine the effect a specific wastewater load has on the DO levels in the River. For example, if a wastewater discharge decreases the DO levels in the Savannah River to 0.4 mg/L at an effluent of 10,000 lbs/day of $CBOD_{5,}$ then to reduce their impact to the DO levels in the River by half or to 0.2 mg/L, their effluent would need to also be reduced by half, or 5,000 lbs/day of $CBOD_5$. The sum of each wastewater facility's calculated decreases in river DO based on their respective $CBOD_5$ and ammonia loads produces the total decrease in DO for the Savannah River and Harbor. Therefore, many loading combinations can be evaluated without performing additional lengthy model runs.

Two unique features of the analysis for the Savannah Harbor are:

1) Allowance for a 10 percentile exceedance of the numeric target 0.1 mg/L delta DO calculated by subtracting the model scenario outputs from the "Natural" model outputs for each zone during the time period March through October, and
2) Representation of the significant wastewater loads as time variable rather than using the traditional approach of calculating the decrease in river DO when all dischargers are at their monthly permitted $CBOD_5$ limit, which is a highly improbable occurrence.

To be confident that the calculated DO deficit represents long term conditions, rather than one specific river flow condition, or one specific time-variable loading pattern for each discharger, a variety of years representing different Savannah River flow conditions in conjunction with many combinations of time variable loads from each discharger should be evaluated. However, the effort and number of Savannah River Model and Savannah Harbor Model runs to develop this long term condition evaluation would be impractical. As a consequence of extensive modeling analyses, it was determined that 1999 river hydrodynamics plus point source time variable $CBOD_5$ loads representing high, medium, and low loading conditions approximated very closely the delta DO derived from the modeling analysis using many combinations of Savannah River hydrology and time variable $CBOD_5$ loads. This approximation of using one representative model year, 1999, and three time-variable loading patterns for each major discharger in conjunction with the concept of using stored model results in the Savannah River and Harbor DO Calculator to compute the decrease in river DO for different effluent $CBOD_5$ and ammonia loads for each discharger allows a very cost-effective and efficient way of evaluating the DO compliance success of many combinations of loading patterns for the 24 wastewater dischargers to the Savannah Harbor and River System.

To further simplify the application of the Savannah River and Harbor DO Calculator, the smaller wastewater dischargers were represented with constant maximum monthly permit $CBOD_5$ and ammonia loads rather than three years of daily time variable loads. A factor was developed that was applied to the constant monthly permit load, such that the DO decrease computed from the time variable representation of these small loads, is approximately the same as is computed with constant monthly loads. This factor depends on the variability of the daily effluent for $CBOD_5$ and ammonia and the number of discharges. It is expressed as the CV for each individual discharger. For these small dischargers' $CBOD_5$ loads, it is estimated that this factor is between 0.6 and 0.7.

3.7. Modeling Technical Review Group

Interactive discussions between state and federal agency staff and dischargers regarding the Savannah Harbor DO issue have been ongoing for more than a decade. A group of technical experts from the Savannah Harbor Committee, Central Savannah River Area TMDL Group, and agencies was formed to provide ongoing input on model development for the River and Harbor. In 2011, the Savannah Harbor Committee and the Central Savannah River Area TMDL Group combined to form a single group: Savannah River/Harbor Dischargers Group. A modeling subgroup was formed with participants nominated by USEPA, GA EPD, SC DHEC, and the Savannah River/Harbor Dischargers Group for their expertise in modeling and for their specific knowledge of the Savannah River and Harbor ecosystem. The modeling subgroup reviewed and refined the modeling tools that were developed to prepare this plan to meet the Georgia Savannah Harbor DO criteria, approved by EPA in March 2010.

Recommendations from the Modeling Technical Review Group:

1. River and Harbor Models as refined during 2009 subgroup work effort provide sufficient tools to develop load reductions and effluent limits based on a relative change in DO concentrations (e.g. DO deficit). Use of the models for precise comparisons of predicted DO concentrations with individual aquatic species needs may require additional refinement.
2. A time-variable loading approach should be utilized for Savannah Harbor based on overall flow and DO target conditions developed by the modeling subgroup agency participants (see section 3.6).
3. The Savannah River and Harbor DO Calculator should be developed since it allows multiple alternative scenarios to be evaluated without hours of model runs for each scenario. The Savannah River and Harbor DO Calculator is based on a unit response for CBOD, ammonia, and DO discharged for each permit holder throughout all zones (2 mile segments) of the Harbor Model (see Section 3.7).
4. The verification process for dischargers simulated with a variable-loading approach should include annual comparison of achieved effluent quality with the distribution used in the final simulation. Format and details of this annual reporting requirement is an additional work task remaining to be done that should be worked out between agency staff and discharge representatives.
5. The modeling subgroup should remain a resource as technical questions arise that would benefit from the group discussions that have occurred over the past eleven months.

If new data becomes available that effects decay rates or other key model inputs used in the Savannah River Model or Savannah Harbor Model, this information will be reviewed by the Modeling Technical Review Group and if is determined that it will affect the

Harbor loads, then the Savannah River Model, Savannah Harbor Model, and/or Savannah River and Harbor DO Calculator will be updated as appropriate.

4. Source Assessment for Oxygen Demanding Pollutants

A required element of the documentation needed to support listing an impaired water in subcategory 5R on a State's Clean Water Act Section 303(d) list is the examination of the potential sources of the pollutant of concern in the watershed, including facilities regulated by the NPDES program, non-point sources, other sources of pollution, and background levels of the pollutant in the affected waterbody. The following sections discuss the source assessment of oxygen demanding substances in the Savannah River and Harbor.

4.1. NPDES Permits

The NPDES permitted discharges to the Savannah watershed can be separated in to three groups:

- Direct Discharges to the Harbor
- Direct Discharges to Savannah River below Thurmond Dam to Clyo, Georgia
- Watershed Discharges to Tributaries of the Savannah River

4.1.1. Harbor NPDES Dischargers

There are eleven NPDES permitted facilities to the Harbor that discharge oxygen demanding substances. Table 5 lists the relevant NPDES dischargers to the Harbor along with their permit number and existing permitted flow and loads. Long-term BOD analyses were completed (2000 and 2004 MACTEC; 2006 Tetra Tech; 2010 EPA Region 4) on the dischargers' discharge to develop the appropriated f-ratios and Ultimate Carbonaceous Biochemical Oxygen Demand (CBODu) category to input the $CBOD_5$ loads in to the Savannah Harbor Model. Table 6 lists the CBODu and ultimate Nitrogenous BOD (NBODu) loads to the Savannah Harbor Model from the eleven NPDES permitted facilities As well as the specific WTFs' CBODu division between fast and slow CBODu decay rates as detailed in the updated Harbor Modeling Report (2010, EPA). Figure 12 shows the location of the NPDES dischargers to and water withdrawals from the Harbor.

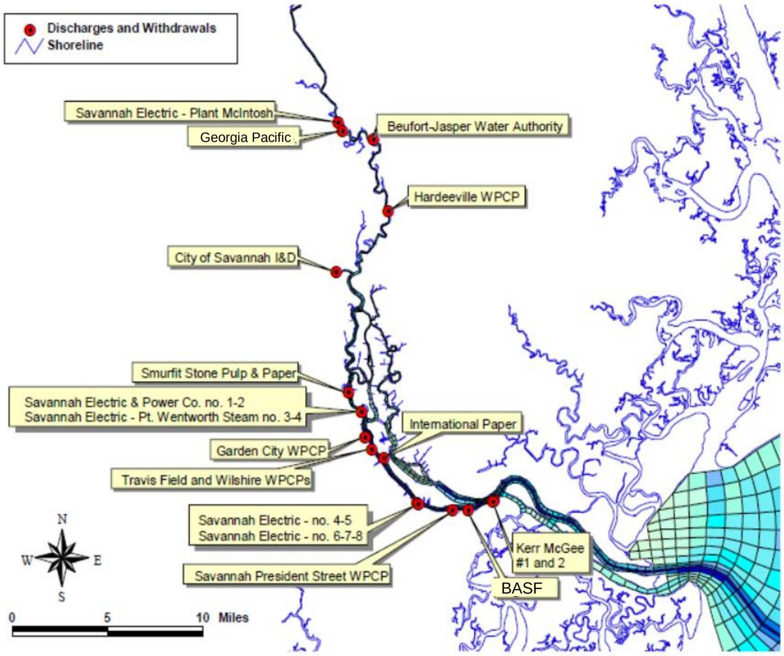

Figure 12 NPDES Dischargers to and Water Withdrawals from the Harbor

Table 5 NPDES Dischargers to the Harbor

Facility Name	Receiving Water	Permit Number	Effluent Flow Rate (MGD)	BOD5 (mg/L)	BOD5 (lbs/day)	Ammonia (mg/L)	Ammonia (lbs/day)
BASF	Harbor	GA0048330	1.2*	--	--	87.9*	880
Garden City WPCP	Harbor	GA0031038	2	30	500.4	17.4	290.2
Georgia Pacific - Savannah River Mill	Harbor	GA0046973	18	72.3*	10,850	2.0*	300
Hardeeville	Harbor	SC0034584	4	7.6	253	5.5	183
International Paper Company - Savannah Mill	Harbor	GA0001988	27.3	109.8*	25,000	2.0*	455
PCS Nitrogen Fertilizer	Harbor	GA0002356	4*	--	--	30*	1,000
Savannah - President Street WPCP	Harbor	GA0025348	27	18.5	4,166.7	12.6	2,837
Savannah - Travis Field WPCP	Harbor	GA0020427	2.0	20	334	12	200
Savannah - Wilshire WPCP	Harbor	GA0020443	4.5	30	1126	17.4	653
US Army - Hunter Airfield	Harbor	GA0027588	1.25	20	217	17.4	189
Weyerhaeuser Company - Port Wentworth	Harbor	GA0002798	13	61.8*	6,700	2.0*	216.8*

Note: Values in table do not necessarily represent permit limits. Not all dischargers have permitted flow limits. Some parameters were calculated from the permit limits. For example where no monthly average BOD_5 or ammonia mass limit was defined in a permit, the load was calculated using the average flow and concentration permit limit. Similarly, where no BOD5 or ammonia concentration limit is defined in a permit, the concentration was calculated using the average flow and mass permit limit. These calculated values are noted with a (*).

Table 6 NPDES Discharger Loads to the Savannah Harbor Model

Facility Name	Receiving Water	CBODu @ 0.02/day (lbs/day)	CBODu @ 0.04/day (lbs/day)	CBODu @ 0.06/day (lbs/day)	NBODu (lbs/day)
BASF	Harbor	--	--	--	4,022
Garden City WPCP	Harbor	--	2,762	--	1,326
Georgia Pacific - Savannah River Mill	Harbor	28,491	--	31,421	1,372
Hardeeville	Harbor	--	1,400	0	839
International Paper Company - Savannah Mill	Harbor	78,748	--	67,549	2,081
PCS Nitrogen Fertilizer	Harbor	--	--	--	4,570
Savannah - President Street WPCP	Harbor	--	22,995	--	12,965
Savannah - Travis Field WPCP	Harbor	--	1,841	--	915
Savannah - Wilshire WPCP	Harbor	--	6,215	--	2,984
US Army - Hunter Airfield	Harbor	--	1,197	--	862
Weyerhaeuser Company - Port Wentworth	Harbor	36,584	17,753	--	991
Totals		143,823	54,164	98,970	32,930

4.1.2. River NPDES Dischargers

There are 13 facilities that discharge to or near the Savannah River between Thurmond Dam and Clyo, Georgia. Table 7 lists these NPDES dischargers, along with their permit number and existing permitted flow and limits. Table 8 lists the CBODu and ultimate Nitrogenous BOD (NBODu) loads to the Savannah River Model from the 13 NPDES permitted facilities, as well as their specific CBODu division between fast and slow CBODu decay rates. The specific WTFs' CBODu division between fast and slow CBODu decay rates is detailed in the River Modeling Report (2010, GA EPD). Figure 13 shows the location of the NPDES discharges to the River and the Harbor.

The Savannah River Site (SRS) dischargers are multiple watershed discharges that were handled as a direct discharge because of its proximity to the River. A fifty percent decay of the effluent load was assumed, to account for the travel time to the River. The Columbia County South Carolina dischargers were assumed to enter the Savannah River at 100 percent of their load.

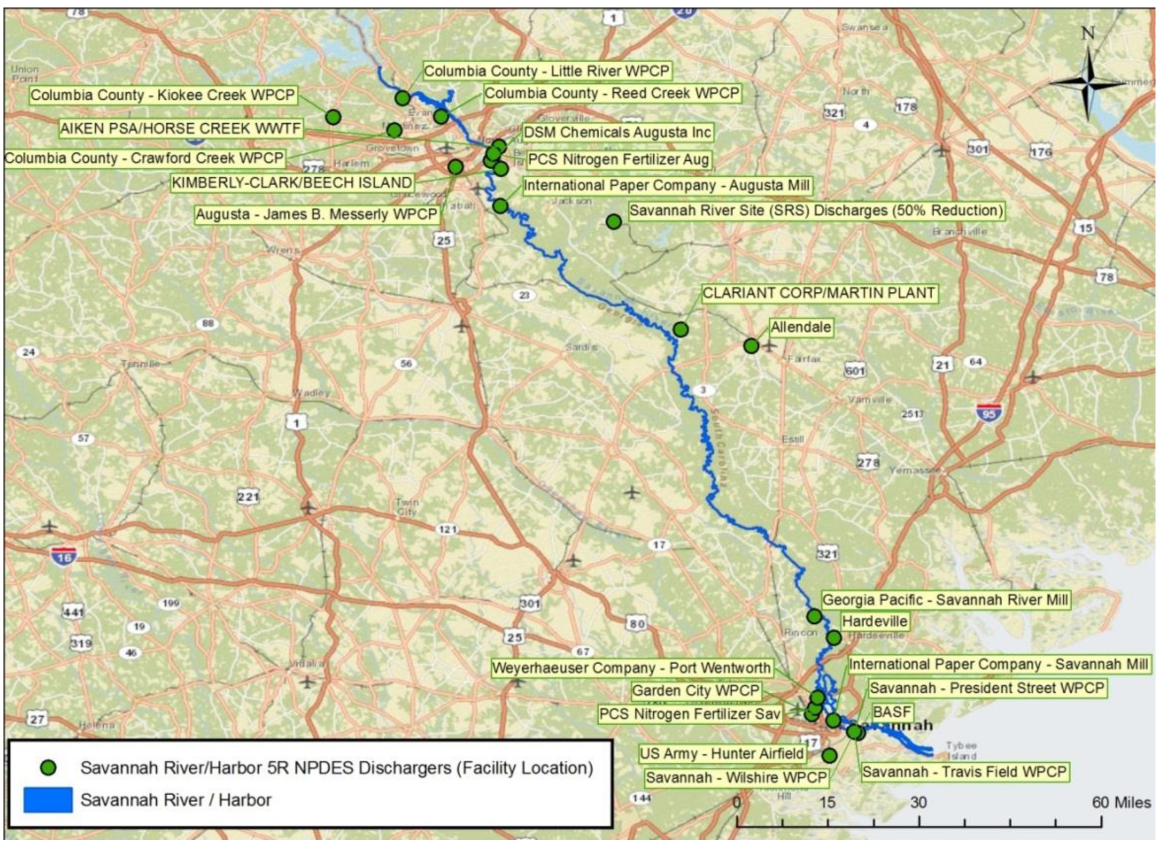

Figure 13 NPDES Permit Facility Locations

Table 7 NPDES Dischargers to the River

Facility Name	Receiving Water	Permit Number	Effluent Flow Rate (MGD)	Monthly Average BOD5 (mg/L)	Monthly Average BOD5 (lbs/day)	Monthly Average Ammonia (mg/L)	Monthly Average Ammonia (lbs/day)
Aiken PSA/Horse Creek WWTF	River	SC0024457	26	33	7,156	11	2,385
Allendale	River	SC0039918	4	25	834	20	667.2
Augusta - James B. Messerly WPCP	River	GA0037621	46.1	10	3,843	1.5	576
Clariant Corp/Martin Plant	River	SC0042803	1.63*	45.0*	612	109.6*	1,490
Columbia County - Crawford Creek WPCP	River	GA0031984	1.5	12	150	1.22	15
Columbia County - Little River WPCP	River	GA0047775	6	7.5	375	4.3	215
Columbia County - Reed Creek WPCP	River	GA0031992	4.6	10	383	2	76
Columbia County – Kiokee Creek WPCP	River	GA0038342	0.3	20	50	7	17
DSM Chemicals Augusta Inc.	River	GA0002160	3.01	29.0*	727	--	--
International Paper Company - Augusta Mill	River	GA0002801	42.0	85.6*	30,000	3.0	683
Kimberly-Clark/Beech Island	River	SC0000582	11	43.9*	4,031	--	--
PCS Nitrogen Fertilizer	River	GA0002071	1.4	30	350	99.5*	1,162
Savannah River Site (SRS) Discharges	Watershed	SC0000175	2.6*	20*	434	2.0*	43

Note: Values in table do not necessarily represent permit limits. Not all dischargers have permitted flow limits. Some parameters were calculated from the permit limits. For example where no monthly average BOD5 or ammonia mass limit was defined in a permit, the load was calculated using the average flow and concentration permit limit. Similarly, where no BOD5 or ammonia concentration limit is defined in a permit, the concentration was calculated using the average flow and mass permit limit. These calculated values are noted with a (*).

Table 8 NPDES Discharger Loads to the Savannah River Model

Facility Name	Receiving Water	CBODu @ 0.02/day (lbs/day)	CBODu @ 0.15/day (lbs/day)	NBODu (lbs/day)
Aiken PSA/Horse Creek WWTF	River	15,027	10,877	10,901
Allendale	River	1,751	1,268	3,048
Augusta - James B. Messerly WPCP	River	8,074	5,844	2,636
Clariant Corp/Martin Plant	River	1,285	930	6,809
Columbia County - Crawford Creek WPCP	River	315	228	70
Columbia County - Little River WPCP	River	788	570	983
Columbia County - Reed Creek WPCP	River	806	583	351
Columbia County – Kiokee Creek WPCP	River	105	76	80
DSM Chemicals Augusta Inc.	River	1,529	1,107	--
International Paper Company - Augusta Mill	River	63,018	45,613	3,122
Kimberly-Clark/Beech Island	River	8,458	6,122	--
PCS Nitrogen Fertilizer	River	736	532	5,310
Savannah River Site (SRS) Discharges	Watershed	911	659	198
Totals		102,802	74,409	33,507

4.1.3. Watershed NPDES Dischargers to Tributaries

The watershed NPDES discharges to the tributaries of the Savannah River that discharge at the levels that are equivalent to the tributary loadings used in the Savannah River Model have an insignificant impact on the DO levels in the Harbor and are not included as a factor in this analysis. However, the $CBOD_5$ and ammonia permitted loadings and any future discharges or expansions of existing dischargers that discharge to tributaries of the Savannah River over their 2009 loadings should be examined and are allowable if it is demonstrated through modeling that their loads are at background conditions by the time they reach the river.

4.1.4. Total Ultimate Oxygen Demand for NPDES Dischargers

The summary of the Ultimate Oxygen Demand (UOD) loads from the NPDES Dischargers to the Savannah Harbor and River System is listed in Table 9.

Table 9 Summary UOD Loads Used for Existing Conditions Model Scenarios

Receiving Water	CBODu @ 0.02/day (lbs/day)	CBODu @ 0.04/day (lbs/day)	CBODu @ 0.06/day (lbs/day)	CBODu @ 0.15/day (lbs/day)	NBODu (lbs/day)	UOD (lbs/day)
Harbor	143,823	54,164	98,970	0	32,930	329,887
River	102,802	0	0	74,409	33,507	210,717
TOTAL	246,625	54,164	98,970	74,409	66,437	540,605

As a matter of practice, EPA has established, acknowledged and approved *de minimis* thresholds below which dischargers are not subject to specific wasteload allocations or reduction expectations. Any new or existing discharger that can demonstrate that its loading is within natural background at the point where their discharge meets the main stem of the Savannah River or Harbor shall be considered a background source. For purposes of this 5R, background includes those dischargers whose impact on the delta DO deficit is of such an inconsequential nature that such discharges may be deemed part of the background load.

4.2. Background Sources and Nonpoint Sources

The vast majority of the nonpoint source loadings of oxygen-demanding substances are from natural background sources including detritus transported in the stream, detritus from marsh areas flowing directly into the Harbor, and tidally-transported detritus from the ocean. These natural background nonpoint source loads are not controllable and therefore additional nonpoint source reduction to improve water quality is not an option.

EPA evaluated oxygen-demanding loads from industrial and municipal stormwater sources discharging pursuant to an NPDES permit into, or upstream of, the Harbor. These loads were shown to have no measurable impact on the dissolved oxygen levels in the critical areas of concern in the

Harbor. During critical periods, permitted stormwater loads were considered to be equivalent to, and part of, the natural background.

5. Load Allocation Development

This plan documents the total pollutant loading of oxygen-demanding substances ($CBOD_5$ and ammonia) that can assimilate without exceeding the applicable water quality standard. This analysis includes determining the allowable loadings for facilities and sources regulated by the NPDES program, as well as from all other sources including natural background, and a margin of safety (MOS), to account for uncertainty in the analysis.

The allowable loadings are expressed in terms of oxygen-demanding substances as UOD, where:

UOD = CBODu + NBODu

CBODu = $CBOD_5$ multiplied times a f-ratio associated
with the appropriate CBODu decay rate(s).
NBODu = ammonia multiplied times 4.57 conversion factor

This analysis provides for the calculation of the appropriate $CBOD_5$ and ammonia effluent limits through the use of the Savannah River and Harbor DO Calculator Version 4.0.

Because of the distribution of the NPDES dischargers and associated loads throughout the Savannah Harbor and River system and the potential for numerous allocation strategies, the Savannah River/Harbor Dischargers Group applied the Savannah River and Harbor DO Calculator Version 4.0 to develop UOD and associated limits that comply with both the Georgia and South Carolina DO Standards.

5.1. NPDES Regulated Point Sources

This analysis determines the allocations for continuous non-storm water NPDES dischargers. At times during the months of March through October, the natural Harbor DO is below a daily average of 5 mg/L. Under SC DHEC regulation, the Harbor is considered a “naturally low dissolved oxygen waterbody” where NPDES permit limits during these months are set based on a critical conditions analysis. Similarly, the Savannah Harbor is also considered to have a DO “natural condition” less than 5 mg/L under the Georgia DO standard. Accordingly, the numeric target DO during this period is a daily average DO deficit of 0.1 mg/L (see Section 2). The wasteload allocations given in this 5R only apply during the critical months. NPDES permits may provide for different limits during the non-critical period.

The allocations for the permitted storm water dischargers discharges is established at background loading conditions and/or oxygen demanding pollutant concentrations such that they will not cause or contribute to further lowering of dissolved oxygen in the Harbor. It is expected that stormwater pollution prevention plans will continue to provide for use of best management practices to ensure that such stormwater loadings do not increase above natural background levels. As long as stormwater loads continue to be less than, or equivalent to, natural background loads, the 5R does not necessitate reductions to existing industrial and municipal stormwater sources discharging pursuant to an individual or general NPDES stormwater permit (e.g., (Municipal Separate Storm Sewer System [MS4], industrial and construction general permits).

5.2. Non-Regulated Sources

The majority of the non-NPDES loadings are from natural background sources. These sources are minor contributors of oxygen consuming wastes under critical low flow conditions because of the absence of storm water runoff. Therefore, the non-NPDES regulated sources are aggregated with the natural background loads.

If in the future, a significant upstream non-NPDES regulated source is identified, this analysis will be revised to account for this source.

The natural background loadings to the harbor are as follows:

- Upstream loads from natural riverine UOD = 85,000 lbs/day
- Marsh loadings = 145,000 lbs/day
- Ocean boundary conditions for CBODu = 5 mg/L and ammonia = 0.07 mg/L

The ocean influences cause the Savannah Harbor's natural DO levels to decrease due to the tidal flux for CBODu and ammonia into the Harbor system.

5.3. Margin of Safety

A margin of safety (MOS) accounts for the uncertainty in the relationship between the pollutant loads and the quality of the receiving waterbody. For Savannah Harbor, the amount of uncertainty is considered to be low. This system has been the subject of extensive study, including extensive data collection, and model development by various state and federal agencies. The Savannah Harbor MOS is implicitly provided by the abundance of data, the calibrated and verified three dimensional model and conservative critical condition assumptions used in this analysis.

5.4. Seasonal Variation

Seasonal variation is incorporated in this analysis by evaluating multiple years of data. For the hydrodynamic and water quality model components, the years of 1997 through 2008 were evaluated. This analysis recognizes that permit loads can be larger in the winter months when the DO standard of a daily average of 5.0 mg/L not less than 4.0 mg/L applies. Thus, the Savannah River Model and Savannah Harbor Model can also be used to develop seasonal wasteload allocations and NPDES permit limits that would apply during the non-critical period.

6. Load Reductions and Effluent Limits for Continuous NPDES Permits

6.1. Load Reductions

The major dischargers to the Savannah River from Augusta, Georgia through the Harbor initiated a facilitated process to derive equitable allocations among the 24 wastewater dischargers to achieve the DO water quality criterion provision that allows a 0.1 mg/L DO deficit from "natural" DO conditions. The Savannah River/Harbor Dischargers Group was facilitated by Clifton Bell, Tom Gallo, and Sandra Ralston of Malcolm Pirnie ARCADIS. The Savannah River/Harbor Dischargers Group used the Savannah River and Harbor DO Calculator Version 4.0 to evaluate various scenarios and develop a load reduction implementation strategy that will best allow the numeric DO water quality criterion to be met.

Information pertaining to the technical basis for determining the load reductions for each wastewater discharger is discussed in Appendix B. The Memorandum of Understanding between the dischargers to the Savannah River and Harbor is included in Appendix C, which reflects the consensus of the dischargers to the following allocations. The Appendix C waste load allocations will be used for the issuance of permits by Georgia and South Carolina for the included dischargers but it is not otherwise a final legal agreement by either state of the waste load allocation utilized proportionally by Georgia and South Carolina and agreement to this document does not waive any rights, ownership, or claims by either state to a different share of the waste load allocation. Appendix D contains the final Savannah River and Harbor DO Calculator Version 4.0 run.

The Savannah Harbor has been the subject of extensive study, including extensive data collection, and model development by various state and federal agencies. The modeling analysis used to develop the effluent limits for the point source discharges to the Savannah River and Harbor were based upon an abundance of data, a calibrated and verified three dimensional model, and conservative critical condition and permitting assumptions. For these reasons, based on the data and information available, once the effluent limitations and special conditions contained in all discharge permits for facilities in the Savannah River Basin are achieved, the discharges will not cause or contribute to exceedances of the Georgia and South Carolina water quality standards for dissolved oxygen. However, if it is determined that a dissolved oxygen deficit exists in the Savannah Harbor that contravenes the Georgia or South Carolina water quality standards for dissolved oxygen and is attributable to point source dischargers, then the regulatory agencies will work with all responsible parties to evaluate and implement viable options that will be incorporated into an updated 5R adaptive management plan and appropriate permits to ensure full attainment of the water quality standards.

The Savannah River and Harbor models account for the existing loads from the tributary wastewater dischargers as part of the background pollutant load to the Savannah River and Harbor. Future expansions and introduction of new facilities in tributaries that discharge to the Savannah River will have to meet a performance standard of demonstrating that their discharge is equal to the Savannah River background UOD concentration at the point of entry to the mainstem of the Savannah River.

6.2. Permit Issuance

When NPDES permits are reissued they will contain enforceable conditions to attain compliance with water quality standards. The State NPDES programs may, in accordance with the requirements of 40 CFR 122.47, include compliance schedules in permits to enable the wastewater facilities to attain the entire necessary load reductions in the most timely and effective means. Every effort should be made to reissue the NPDES permits in Table 10 within 3 years of finalizing this document to include conditions that will result in attainment of water quality standards. New applications may be requested from each permitted facility within sixty days of finalization of this document if needed. Submittal deadlines will be scheduled based on differing application and applicant requirements.

Table 10 NPDES Permits

Facility Name	**State**	**Type**
BASF	GA	Industrial
Garden City WPCP	GA	Municipal
Georgia Pacific -Savannah River Mill	GA	Industrial
Hardeeville	SC	Municipal
International Paper Company -Savannah Mill	GA	Industrial
PCS Nitrogen Fertilizer Savannah	GA	Industrial
Savannah -President Street WPCP	GA	Municipal
Savannah -Travis Field WPCP	GA	Municipal
Savannah -Wilshire WPCP	GA	Municipal
US Army -Hunter Airfield	GA	Municipal
Weyerhaeuser Company -Port Wentworth	GA	Industrial
Aiken PSA/Horse Creek WWTF	SC	Municipal
Allendale	SC	Municipal
Augusta -James B. Messerly WPCP	GA	Municipal
Clariant Corp/Martin Plant	SC	Industrial
Columbia County -Crawford Creek WPCP	GA	Municipal
Columbia County -Little River WPCP	GA	Municipal
Columbia County -Reed Creek WPCP	GA	Municipal
Columbia County -Kiokee Creek WPCP	GA	Municipal
DSM Chemicals Augusta Inc.	GA	Industrial
International Paper Company -Augusta Mill	GA	Industrial
Kimberly-Clark/Beech Island	SC	Industrial
PCS Nitrogen Fertilizer Aug	GA	Industrial
Savannah River Site (SRS) Discharges (50% red.)	SC	Industrial

6.3. Compliance Schedule and Monitoring Plan to Track Effectiveness

EPA endorses the full range of administrative and regulatory tools available to the States to provide flexibility in implementing the 5R process. EPA recognizes that the Clean Water Act does not limit compliance schedules to the five-year permit term where a longer period is justified under Section 502(17) of the Act and 40 CFR §§ 122.2 and 122.47. With respect to implementation of the Savannah Harbor 5R plan, EPA and the States recognize that the required process alterations and improvements will vary, and in some cases, the States may need to allow long-term compliance schedules consistent with the regulatory requirements noted above. Although some compliance schedules may exceed five-years, the schedules will have to include interim dates as required by 40 CFR 122.47(a)(3). While Federal Regulations require that interim dates not exceed one year, Georgia regulations require that interim dates not exceed nine months.

Compliance with the revised effluent limitations contained in the reissued permits will have the corresponding effect of returning the impaired waterbody into compliance with the applicable DO water quality standard. As long as the NPDES BOD_5 or $CBOD_5$ and ammonia permit limits meet the numeric DO target as calculated by the Savannah River and Harbor DO Calculator, the DO water quality standard will be met following implementation of any needed facility improvements. Effluent limits required in each facility's operating permit will be reviewed, at a minimum, every 2-years for listing purposes consistent with the Section 303(d) listing cycle to evaluate whether water quality standards are being achieved. If the permit indicates compliance with their applicable effluent limits, then the waterbody may be moved from subcategory 5R to the appropriate attainment category on the State of Georgia's Integrated Report. If permit limits do not indicate compliance with their applicable effluent limits, additional pollution controls or compliance measures may be explored and implemented.

6.4. Future Conditions

If the River and Harbor conditions change due to future activities such as revisions to the drought contingency plan, different system operations, or one or more existing dischargers is further reduced or eliminated, the Savannah River Model and/or Savannah Harbor Model may need to be rerun to determine the allowable assimilative capacity available for any future discharge expansions or new dischargers. Any future assimilative capacity evaluations and wasteload allocations will be performed using the Savannah Harbor and River Models used for the 5R Plan. If these models are updated, the Savannah River and Harbor DO Calculator may need to be updated so that it can be used to evaluate the effects that the operational changes and/or new or expanded dischargers have on the Harbor DO. The current Savannah River and Harbor DO Calculator will be used to evaluate existing dischargers.

6.5. Pollutant Trading

Water quality trading (also called effluent trading) is an innovative way for water quality agencies and community stakeholders to develop cost-effective solutions to address water quality problems in their watersheds. EPA supports the concept of water quality trading in watersheds with multiple sources of pollutants, and specifically endorses the use of trading to implement the 5R process. Appropriate trading of pollutant allocations and/or DO deficits between or among sources, or through oxygen injection into the Harbor, is allowed under the 5R process as long as the total loading does not cause an exceedance of the DO deficit allocated to the regulated point sources. The Savannah River and Harbor DO Calculator will allow the States to evaluate and determine UOD (BOD_5 or $CBOD_5$ and ammonia) load and oxygen injection trading proposals to ensure that water quality standards will be met. Any water quality trading will have to be approved by the States and EPA, and will have to be reflected in the dischargers' NPDES permits.

On January 13, 2003, EPA issued a Water Quality Trading Policy ("policy") to provide guidance to States and Tribes on how trading can occur under the Clean Water Act and the regulations on implementations. The policy discusses Clean Water Act requirements that are relevant to water quality trading including: requirements to obtain permits, anti-backsliding provisions, and development of water quality standards including antidegradation policy, National Pollutant Discharge Elimination System permit regulations, TMDLs and water quality management plans (http://www.epa.gov/owow/watershed/trading/tradingpolicy.html). EPA has also developed a Water Quality Trading Toolkit that provides additional details about trading and how it works. The toolkit can be found at: (http://water.epa.gov/type/watersheds/trading/WQTToolkit.cfm).

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Appendix A: Savannah Harbor DO Model Critical Conditions for Savannah River Flow

The effect of NPDES oxygen demanding loads on dissolved oxygen (DO) in Savannah Harbor depends on upstream flow in the Savannah River. High river flow dilutes wastewater and helps flush the estuary, which reduces impact from effluent loading. The reverse is true during low flow conditions. The model endpoint delta DO is highly sensitive to river flow, so selection of the river design condition was an important consideration in the analysis. A dynamic upstream flow condition was chosen over the traditional steady 7Q10 approach to take full advantage of available data and modeling. In the dynamic approach, the model is run using an actual flow period that represents the range and distribution of hydrologic conditions.

The USGS gage at Clyo (02198500) is the upstream boundary in the Harbor Model. Daily mean stream discharge is continuously reported from 1929 forward. The Model Technical Review Group (MTRG) evaluated the Clyo data and considered three questions: 1) what historical period from the flow record best represents existing and future conditions? 2) which year, or combination of years, from the modeled period 1997 forward best represents the historical period? and 3) what to do if future conditions change due to Drought Plan modification or reauthorization of the Corps lakes?

Historical period. The period before completion of Thurmond Dam in 1954 does not represent current or foreseeable future conditions and was excluded. The record from 1955 forward shows a change in the flow data during the 1980s, when low flows appear to decrease. Conversations with Corps staff indicated project operation might have changed during the 1980s from maintaining downstream navigation flows to maintaining summer lake levels, which could have reduced downstream flows. Savannah River flows were compared to flows on Brier Creek (02198000), an unregulated tributary. Brier Creek showed a similar pattern of reduced low flows (Figure 14)b . Based on the comparison to the natural stream, the MTRG concluded that basin hydrology was a significant factor in addition to any possible effects from the dam. In order to capture the full range of hydrologic variation as well as any operational changes, the historical period from 1955 forward was evaluated.

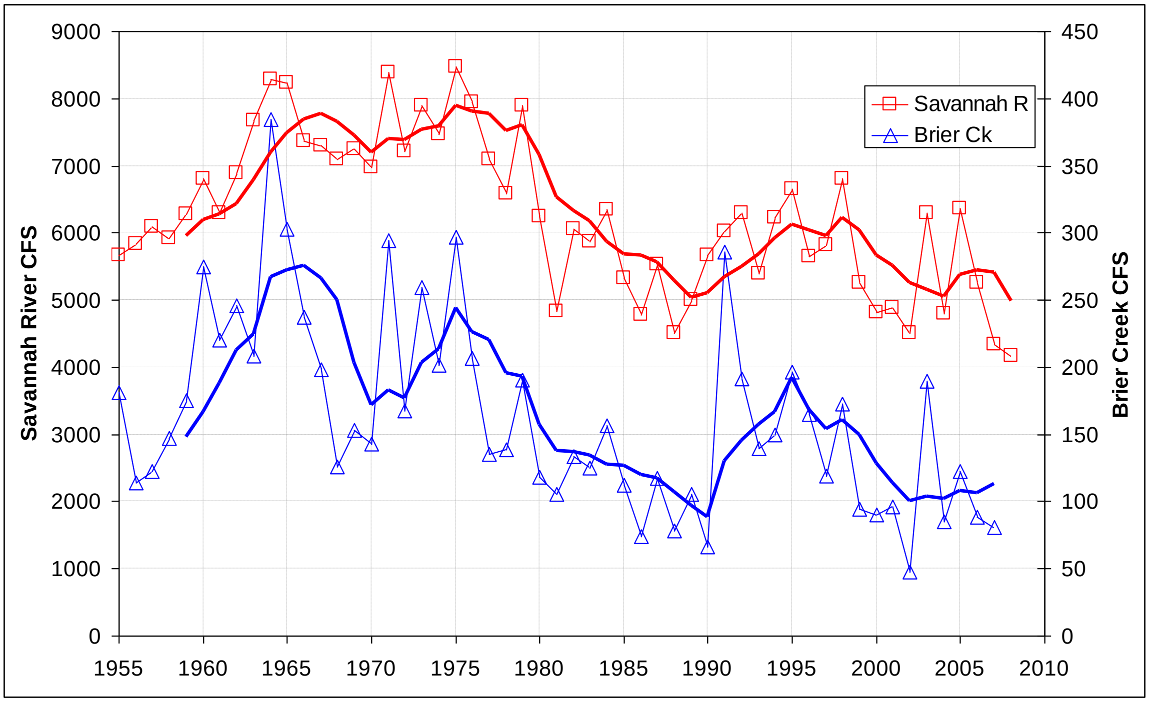

Figure 14 Savannah River and Brier Creek Flow Comparison

Representative year. It is not practical to simulate the entire period from 1955 forward in the DO model. Sufficient DO model input data are available only for recent years, and DO model runtime is a significant constraint. A representative year was selected from the modeled period in order to represent the variability in the historical record and to maximize the number of simulations that could be completed in a reasonable timeframe.

HydroQual completed a 50 year empirical modeling analysis (2010 HQI) and illustrated that 1999 was both a critical year and a year that represented the 1955 to 2008 period of record. Based on these analyses, the MTRG selected 1999 as the representative critical condition year for water quality modeling.

Future flow conditions. In response to the recent drought, state and federal agencies, and other stakeholders with an interest in Savannah basin water management issues are considering a range of alternatives including modification of the Savannah Drought Plan, which balances lake levels and downstream flows during drought conditions, and potential changes to the Federal Authorization of the Corps lakes, which determines authorized lake uses. This analysis is based on historical river flow conditions, which could change in the future depending on the outcome of these discussions. Proposed changes to these management plans would require NEPA review, and it is expected that issues arising from changes to the river flow regime would be addressed during the NEPA process.

DEVELOPMENT OF TIME VARIABLE TMDL CALCULATOR AND SUPPORTING ANALYSES

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CONTENTS

INTRODUCTION

The USEPA Region 4 and Georgia Environmental Protection Division (GAEPD) have calibrated time-variable models of the Savannah River from Augusta to the ocean for developing a Dissolved Oxygen (DO) TMDL of the Savannah River. Because the Savannah River DO is less than the current DO standard under natural conditions, the TMDL endpoint DO criterion is to limit the decrease in river DO from point source discharges to 0.10 mg/L for 90% of the time. USEPA Region 4 calibrated a time-variable Savannah River/Harbor DO model (EFDC-WASP) from Clyo to the ocean for the period 1997-2007 and GAEPD calibrated a Savannah River model (EPDRIV1) from Augusta to Clyo for this same period. These calibrated models are used to determine various combinations of point source BOD and ammonia (NH3) loads that will meet the DO criterion.

Because of the availability of these time-variable models, the allowable point source load impacts on Savannah River DO were evaluated with consideration of the day to day variability in river flow and effluent BOD5 and NH3. This is in contrast to the traditional and highly conservative approach of assuming that all point sources are simultaneously discharging at their monthly NPDES limits every day during critical low flow river conditions. The purpose of this report is to describe the TMDL calculator and the analyses that were performed to develop a methodology for efficiently evaluating the effects of many point source loads on Savannah Harbor DO.

Section 1.0 describes the development of an empirical model that approximates the results of the EFDC-WASP model but at a small fraction of the computer time required to run long term simulations with the EFDC-WASP model. The purpose of the empirical model is to calculate the long term (50 years), 90% DO decrease (delta) in the critical section of Savannah Harbor because this calculation is not practical with the EFDC-WASP model. The empirical model results serve as a basis for selecting a representative hydrologic year and key point source yearly loads that would be evaluated with the EFDC-WASP model but yet produce the same 90% delta DO if the EFDCWASP model had been run for a 50 year period.

There are 23 point source loads discharging to the Savannah River between Augusta and the ocean. Five of the point source loads are considered major loads and their effluent BOD5 load is represented as a time-variable input to the EFDC-WASP model. The remaining point source loads are input as constant monthly permit loads with a factor applied to closely approximate the results that would be obtained if they were input as time-variable loads. There are six to nine years of effluent BOD5 loading data for the five major dischargers. This effluent BOD5 load data was analyzed for each major discharger to develop the statistics that define the day to day variability in effluent BOD5 load. The statistics for each major load were used to generate 50 years of daily loading that is consistent with the statistics of the six to nine years of effluent BOD5 for each major discharger. Section 2 of this report presents the results of this analysis.

The first application of the empirical model was to determine a representative year or years from the eleven year calibration period (1997-2007) that is representative of long term conditions. Long term conditions for the Savannah River were defined as the fifty year period (1958-2008) since construction of the Thurmond Dam upstream of Augusta. Section 3 presents the analyses performed to determine a representative year. The second application of the empirical model was to determine if a subset of the 50 year point source BOD5 loading sequence derived for each major discharger could be selected but still produce the same results as if the entire 50 years of effluent data was modeled with the EFDC-WASP model. This analysis is presented in Section 4.

The representation of all 23 point source loads as time-variable inputs would require an unacceptable amount of computer run time. As a compromise, the smaller 20 point source loads were input at their monthly permit limits in the EFDC-WASP model. However, the representation of a point source load discharging at its monthly permit limit every day is clearly overly conservative and overstates the discharges effect on Savannah Harbor DO. Section 5 of the report describes an analysis that was performed to develop a factor that is used to reduce the model input monthly BOD5 and NH3 limits to approximate the results that would be obtained if these small point source loads were represented as time-variable inputs in the EFDC-WASP model.

The representations of point source loads as time-variable inputs to the EFDC-WASP model raises the question of how are monthly and daily BOD permit limits derived from a time-variable BOD loading pattern. Section 6 of the report presents a methodology for developing permit limits for the five major dischargers to the Savannah River.

Finally, Section 7 and Appendix A of the report describes the concept and details of an efficient computational tool called the "TMDL Calculator". The TMDL calculator is based on the concept that the change in river DO (delta) due to a BOD5 and NH3 point source load is directly proportional to the magnitude of the load. For example, if a BOD5 load of 1,000 lbs/day decreases the river DO at a certain location by 0.10 mg/L then a BOD5 load of 2,000 lbs/day will decrease the river DO at this same location by 0.20 mg/L. The TMDL calculator is essentially a spreadsheet that contains the calculated change in river DO for specific BOD5 and NH3 loads for each of the point source discharges. Rather than performing multiple EFDC-WASP model runs with different combinations of BOD5 and NH3 loads, stored "unit DO responses" for each point source discharger can be modified to account for new values of effluent BOD5 and NH3 and recombined with the results of the unit DO responses from the other point source discharges to calculate a new river DO decrease due to all BOD5 and NH3 dischargers.

1.0 DEVELOPMENT OF EMPIRICAL MODEL

Ideally a comprehensive evaluation of whether the allowable 0.10 mg/L decrease in river DO is met 90% of the time would be to run the time-variable models over many years (25 to 50 years) to be confident that the long term variability in river flow and point source effluent quality is properly represented. However, a significant limitation to implementing this approach is that the available 11 year (1997-2007) model calibration period is too limited and has a disproportionate number of drought years. This is shown in Figure 1-1 in which the daily, annual average and critical season (May-October) average flows are plotted for the period 1958-2008. This period represents conditions after completion of the upstream Thurmond Dam. An additional limitation to performing long term model simulations is that the computer run time would be prohibitively long. To address these issues an empirical model was developed to approximate the results of the EFDCWASP Savannah River/Harbor model at a small fraction of the computational time required by the EFDC-WASP model. The purpose of the empirical model is to determine if there is a representative year or sequence of years from the 51 years of available river flows that could be selected and still give results comparable to the more time consuming 51 year model simulation and also whether representative point source loading years could be used rather than the expected sequence of years that would occur over a 51 year model simulation period.

The tidal Savannah Harbor empirical model is quite simple in that it computes the maximum DO decrease in Savannah Harbor as a function of the point source ultimate BOD (BODu) discharged divided by the river flow and is represented by the following equation:

$$\Delta DO = f \text{ X } W/(Qx5.39)$$

Where: ΔDO is the maximum decrease in river DO (mg/L);
f = empirical factor;
W = point source BODu in lbs/day;
Q = river flow in cfs; and
5.39 is a units conversion factor.

The empirical factor, f, was developed by adjustment to achieve reasonable agreement between the empirical model and the results of numerous EFDC-WASP model runs.

The Savannah River/Harbor model was run with two hypothetical, time-variable BODu loads for the eleven year period (1997-2007). One load was assigned at the location of the International Paper (IP) Savannah Mill and the other load at the Clyo upstream model boundary. The time-variable load statistical properties were based on analysis of existing loads and were assigned as a log-normally distributed effluent BODu with a daily coefficient of variation of 0.55 with an auto-correlation coefficient of 0.80. A representative high, medium, and low BODu loading year was assigned to each load producing nine different yearly loading combinations. A comparison of the 1,000 days of WASP model simulation results versus the empirical model with a value of the empirical factor, f, assigned at 0.112 is shown in the top panel of Figure 1-2. The WASP calculated delta DO is at the critical zone in the Harbor. Considering the simplicity of the empirical model, the comparison is surprisingly good. The bottom panel presents the daily delta DO values computed with the EFDCWASP model versus the empirical model results as probability distributions. Although the empirical model over computes the low (<15%) and high (>99%) percentile delta DO values, the comparison is quite good for the 90% delta DO that is the target percentile for Savannah River delta DO compliance. Based on this analysis, it is concluded that the empirical model is suitable for evaluating representative hydrologic years and loading patterns that approximate the 90% delta DO that would result from a model simulation of 51 years with many combinations of time-variable loading patterns.

2.0 STATISTICAL CHARACTERIZATION OF POINT SOURCE BOD5 LOADING

2.1 Analysis of Point Source Effluent BOD5 Data

For each individual point source, several statistical analyses were performed on monitored effluent flow and BOD5 data. Based on multiple year time series plots of effluent flow, BOD5 concentration and BOD5 loading, temporal variability trends were identified. Time periods with flow and BOD5 trends that did not represent current conditions were discarded. Subsequently, in coordination with the dischargers, the remaining loading data was slightly modified to represent expected future loading conditions. These modifications consisted mainly in the removal of intermittent BOD5 spikes not likely to occur in the future. The majority of the dischargers considered their actual loading variability to be a good representation of future loading variability and, therefore, no loading modifications were necessary. Once the best estimate of the expected future BOD5 loading variability was established, several statistical descriptors were computed. Two statistical parameters were essential for a proper characterization of the daily BOD5 loadings: the daily coefficient of variation and the 1-day auto-correlation coefficient. Table 2-1 presents the computed daily statistics for the five major point sources. Probability analysis of the daily and monthly BOD5 loads indicated that a log-normal distribution was a good representation of the daily and monthly data variability. Figures 2-1 to 2-5 present temporal and probability plots of the effluent flow and BOD5 data for each of the 5 major point sources.

Table 2-1. Point Source Daily BOD5 Statistics

Point Source	Coefficient of Variation	Autocorrelation Coefficient
International Paper Company - Augusta Mill	0.41	0.82
International Paper Company - Savannah Mill	0.52	0.86
Weyerhaeuser Company - Port Wentworth	0.61	0.74
Georgia-Pacific – Savannah River Mill	0.64	0.85
Savannah - President Street WPCP	0.63	0.59

2.2 Generation of Long Term BOD5 Loads

The intention of statistically characterizing point source effluent BOD5 loadings is to generate long term, time-variable loads that are statistically representative of the actual loads but not limited to the actual loading patterns measured during the six to nine year period of available data. To achieve this, an approach that employed actual daily BOD5 load data statistics to generate long term daily loads was implemented. A probabilistic analysis program was employed in conjunction with the BOD5 data daily coefficient of variation and 1-day auto-correlation coefficient to generate 50 years of daily BOD5 loading for each point source. The specification of the daily coefficient of variation generated log-normal loading distributions and ensured that the day to day variability of the actual data was properly represented. The specification of the 1-day auto-correlation coefficient ensured that the generated daily loading values were properly correlated with respect to the previous day's generated values. The daily load variation and the degree of tendency for a daily load to remain in the same state (magnitude) or not from one day to the next were important features of the discharge data to maintain from the actual monitored data in order to properly represent the existing relationships between daily and monthly average loads.

As an illustration, a chronological plot of the BOD5 load for the IP Savannah Mill is plotted in Figure 2-6. The first six years (2002-2007) represent actual conditions and the next 50 years (2008- 2057) represent a loading pattern generated based on the statistics of the six year period 2002-2007. Note that there are monthly BOD5 loads in the generated 50 year sequence that are both higher and lower than BOD5 loads measured between 2002 and 2007. By simulating a 50 year long term BOD5 loading pattern for each time-variable discharge, future loads that are consistent with the statistics of the data collection time period but not measured are represented in the calculation of the delta DO decrease in Savannah Harbor associated with point source discharges.

3.0 DETERMINATION OF REPRESENTATIVE HYDRODYNAMIC YEAR

The EFDC-WASP model was used to compute the 90% delta DO for each of the eleven years (1997-2007) and the empirical model was used to calculate the 90% delta DO for the 51 year long term period (1958-2008) with the same two hypothetical BOD loads used in the development of the empirical model. The computed 90% delta DO's are shown in Table 3-1. The calculated long term (1958-2008) 90% critical delta DO is 0.134 mg/L for the example loads used in this analysis. The EFDC-WASP model calculated delta DO ranges from 0.09 mg/L for the high flow years (2003, 2005) to 0.18 mg/L for the low flow years (2000, 2007) with an average of 0.158 mg/L for the eleven year period. The eleven year average 90% delta DO of 0.158 mg/L is greater than the long term average of 0.134 mg/L because there are a disproportionate number of low flow years during 1997-2007. The results in Table 3-1 indicate that 1999 flows produces a 90% delta DO of 0.135 mg/L which is nearly equal to the long term average 90% delta DO of 0.134 mg/L. Therefore, it is concluded that calculation of the 90% delta DO from point sources in the Savannah River/Harbor model with 1999 flow conditions produces nearly the same results if the 90% delta DO had been calculated with the full 51 year flow record and that point source impacts on Harbor DO levels will be based on the year 1999 hydrology.

Table 3-1. Calculated 90% Delta DO at Critical Savannah Harbor Model Zone (May-October)

Year	May-Oct Flow (cfs)	90% Delta DO (mg/L)
1997	8,864	0.110
1998	11,070	0.101
1999	7,060	0.135
2000	5,596	0.180
2001	5,605	0.177
2002	4,896	0.199
2003	15,514	0.091
2004	8,625	0.166
2205	12,813	0.092
2206	6,464	0.143
2007	5,566	0.183
Avg (1997-2007)	8,370	0.158
(1958-2008)	9,427	0.134

4.0 SELECTION OF REPRESENTATIVE LOADING PATTERNS

Use of the generated long term BODu loads (i.e., 50 years), that are statistically representative of the actual BODu loads for the five major point source, in the river and harbor models posed a level of effort that was considered highly impractical and inefficient. An alternate approach was implemented that methodically selected 3 years out of the 50 years of generated BODu loads that produced similar decreases in DO as compared to the long term loads.

Having defined the representative hydrodynamic conditions (1999) that represent the long term system response, the objective was the selection of loading patterns that when applied to the 1999 hydrology would produce a similar decrease in DO as if 50 years of daily loads were indeed applied. The selected approach consisted of the selection of 3 loading patterns (loading years) whose annual averages (μ) represented one standard deviation (M) above and below the 50th percentile, as well as the 50th percentile itself, out of the 50 year annual average distributions for long term loads per each point source. The 90% delta DO decrease was computed with the empirical model for the selected loading patterns (1,095 days) and the 1999 hydrology and also with the long term loads (50 years) with the 1999 hydrology. The resulting decreases in DO for both loading conditions were then compared, specifically, with the 90th percentile. Both loading conditions produced similar results.

Based on this analysis, it was concluded that the selected loading patterns may be used in place of the long term 50 year loads in the context of DO decrease calculations. The three selected loading years are referred to as high, medium, and low BODu loading conditions for each time-variable point source. As an example, the equivalent low, medium, and high load years for the IP Savannah Mill BODu are shown in Figure 4-1. The upper panel shows the 50 years of generated annual average BODu loads with the 50%, 16% (μ-M), and 84% (μ+M) annual loads shaded. The lower panel shows the daily BODu loads for the three representative years.

5.0 DERIVATION OF THE TIME VARIABLE "CORRECTION" FACTOR

The five major point sources (IP Savannah, IP Augusta, Weyerhaeuser, Georgia-Pacific, President Street WPCP) were represented as time-variable BODu loads in the calculation of the 90% delta DO decrease. In the model, the remaining point sources (BODu and NH_3) were represented by constant loadings equal to their monthly permit as is usually done in the traditional modeling approach. This simplification was agreed upon based on the level of complexity already present with five time-variable point sources as well as the relatively small contribution to the DO decrease by these additional point sources. To account for the fact that these point source discharges do not discharge at their monthly permit limit every day, a scale factor for the monthly permit load was developed to produce the same 90% delta DO as a time-variable representation of these loads.

To develop this scale factor for the point source dischargers represented as constant loads equal to the monthly permit, a modeling analysis was performed with the five major point source dischargers represented as constant loads equal to their permit loads. The 90% delta DO computed at the critical zone in Savannah Harbor with the constant load representation of the five major point sources was 1.63 times the 90% delta DO computed with these same loads represented time variably. This ratio is dependent on the effluent loads coefficient of variability and auto-correlation. A review of a limited number of the smaller point source dischargers indicated that their effluent load statistics are similar to the five major dischargers. Because of some uncertainty in the statistics of all the smaller discharger's effluent BOD5 and NH3 loads, a factor of 1.5 was assumed to be appropriate. Based on this approximation of the overestimation of computed 90% delta DO decreases calculated with constant versus time-variable representation of effluent loads, the smaller dischargers will be represented in the model with a constant load equal to the monthly permit load divided by 1.5.

6.0 DEVELOPMENT OF EFFLUENT BOD5 LIMITS FROM TIME-VARIABLE MODELS

The time-variable model of the Savannah River/Harbor represents the day to day variability in the major point source effluent BOD5 loads in the calculation of river and harbor daily average decrease in DO levels for a multiple year simulation. The daily and monthly average BOD5 distributions shown in Figure 6-1 are the distributions of a sample time-variable loading that achieves compliance with a specified decrease in dissolved oxygen of 0.10 mg/L during the multiple year simulation. The daily coefficient of variation and 1-day auto-correlation coefficient are 0.52 and 0.86, respectively. This section addresses the issues in writing BOD5 permit limits based on these BOD5 distributions.

From a purely scientific perspective, there are a variety of methods for describing these BOD5 distributions including the median and coefficient of variation or a certain percentile with the corresponding acceptable number of exceedances per permit cycle. For example, one approach for developing a monthly limit would be to select a 95th percentile BOD5 load of 15,500 lbs/day and set this as the permit limit with the specification that this sample point source could exceed 15,500 lbs/day 5% of the time (3 months per 60 month permit cycle) and not be in violation of its permit limit. Although this is scientifically appropriate, it creates practical issues for enforcement of these permit limits. The principal problem is that compliance with permit limits can not be evaluated on a month to month basis and must be defined for a period varying from months to the entire 5 year permit cycle.

An alternative to waiting many months to judge compliance with permit limits is to select a BOD5 value from the distribution that can be viewed as a never to exceed number. This approach allows the regulatory agencies to continue to evaluate permit compliance on a month by month basis as is currently the practice. The question then becomes what percentile to select from the effluent BOD5 distribution that would be acceptable as a never to exceed permit limit. Certainly a 95th percentile monthly BOD5 limit with an expected exceedance frequency of 3 months for a 5 year permit cycle is unacceptable. A reasonable approach might be to select a 99th percentile of 19,000 lbs/day from Figure 6-1 as the monthly limit, which has an expected exceedance of 1 in a 100 months or once every 1.67 permit cycles or less than once per 5 year permit cycle. It should be emphasized that the assignment of any percentile from the effluent monthly BOD5 distribution does not change the fact that river and harbor decreases in DO standards are met with this BOD5 distribution in the time-variable model simulations. Selecting the 99th percentile monthly BOD5 would reduce the chance of falsely being considered in violation of the permit.

The corresponding daily BOD5 limit could be developed on the basis of maintaining the same risk level used in the derivation of the monthly limit which is one exceedance every 1.67 permit cycles. One daily exceedance over 1.67 permit cycles would be one day in 3,048 days (1.67 x 1,825 days/permit cycle) or 99.97th percentile. From Figure 6-1 this corresponds to a daily BOD5 limit of 48,000 lbs/day. As a consequence of applying the same procedure used in the assignment of the monthly BOD5 limit, there is the same low chance of falsely being considered in violation of the daily BOD5 permit limit.

In this example, the ratio of the proposed daily BOD5 permit limit (48,000 lbs/day) to the monthly limit (19,000 lbs/day) is 2.5, which is close to the common approach of assigning the daily BOD5 of an industrial discharger at twice the monthly permit limit. In any case, the ratio of the daily to monthly permit limits is dependent on the variability and auto-correlation of the daily BOD5 load as shown on Figure 6-2. This figure presents the ratio of daily to monthly permit limits for different values of daily load coefficient of variation and auto-correlation coefficient.

Compliance with the 99th percentile of the monthly BOD5 load distributions can be achieved by a variety of BOD5 load distributions that are not the same distribution used in the final TMDL calculation. As an example of an extreme and improbable occurrence, a discharger could theoretically discharge a long term BOD5 load that has a 50th percentile (median) of 15,000 lbs/day versus the assumed 10,000 lbs/day used in the example and still comply with the monthly 99% of 19,000 lbs/day. It is likely this BOD5 loading pattern would contribute to a higher frequency of exceedance of the 0.10 mg/L delta DO than the allowable 10% because the average BOD5 load would be higher, and in particular, the BOD5 loads between the 90th and 99th percentile that frequently contribute to a violation of the delta DO standard would be also higher. To assist the regulatory agencies in judging effluent BOD5 compliance with the distribution used in the final TMDL calculator, the discharger could report a comparison of probability distributions of its daily and monthly BOD5 loads versus the distributions used in the final TMDL calculation. As a minimum this could be done after the first year of the permit and updated each year of the permit. If the actual daily and monthly effluent BOD5 load distributions are different than those used in the TMDL, an evaluation can be performed with the EFDC-WASP model to determine if daily and monthly BOD5 permit load limits should be adjusted. However, it is highly unlikely that there will be a significant change in slope of the daily and monthly BOD5 load distributions because the factors (daily coefficient of variation and auto-correlation coefficient) that govern the slope of these distributions are unlikely to change much as long as there is biological wastewater treatment.

7.0 DEVELOPMENT OF THE TMDL CALCULATOR

The Savannah Harbor DO TMDL calculator was developed as an efficient method to calculate the effect of various combinations of 21 wastewater effluent dischargers on the DO levels in the Savannah Estuary. In reality 23 dischargers are included in this study but for the purposes of the TMDL Calculator, three of them are represented by one point source only. The current criterion governing the discharge of wastewater BOD5 and NH3 to the Savannah River/Harbor is that the maximum decrease in DO during March through October should be less than 0.10 mg/L 90% of the time. With 21 wastewater dischargers, there are many combinations of wastewater effluent BOD5 and NH3 that could meet this delta DO constraint of 0.10 mg/L. Given the run time of an annual water quality model simulation, it is impractical to evaluate a sufficient number of wastewater BOD5 and NH3 loading combinations to adequately satisfy all the requests for loading options by the wastewater dischargers. However, because the calculated decreases in river DO for a specific wastewater discharge is directly proportional to the magnitude of the wastewater BOD5, results of stored model simulations for each discharger at a specific BOD5 input can be used to quickly calculate the decrease in river DO associated with a different BOD5 load. For example, if the model calculates that one of the 21 wastewater dischargers decreases the river DO by 0.4 mg/L when the effluent BOD5 is 10,000 lbs/day, the calculated decrease in river DO would be 0.2 mg/L if its effluent BOD5 in the model is halved to 5,000 lbs/day. Therefore, knowing the calculated decrease in river DO at one specific BOD5 wastewater load allows the calculation of the decrease in river DO at any other BOD5 without an additional model run. This is accomplished by simply modifying the model calculated decrease in river DO at a specific BOD5 load by the ratio of the new BOD5 to the specific BOD5 load used in the model calculation. Having these individual calculated decreases in river DO for each wastewater BOD5 and NH3 load, it is a simple matter of summing them up to produce the total decrease in river DO. Therefore, many loading combinations can be evaluated without performing additional lengthy model runs.

The previous discussion of the TMDL calculator is conceptual and does not deal with all the specifics of the Savannah River/Harbor model. A review of some specifics is given in previous sections of this report. Two unique features of the Savannah TMDL are the allowance for an exceedance of the maximum 0.10 mg/L decrease in river DO 10% of the time and the representation of the significant wastewater loads as time-variable rather than the traditional approach of calculating the decrease in river DO when all dischargers are at their monthly BOD5 limit, a highly improbable occurrence. The calculation of the allowable 10% exceedance of the maximum allowable river DO decrease of 0.10 mg/L implies that a variety of years representing different Savannah River flow conditions in conjunction with many combinations of time-variable loads from each discharger should be evaluated to be confident that the calculated 10% exceedance represents long term conditions rather than one specific river flow condition or one specific time-variable loading pattern for each discharger. However, the effort and number of model runs to develop this long term condition evaluation would be impractical. As a consequence of extensive modeling analyses, it was determined that performing the river delta DO compliance analysis with the river hydrodynamics for the year 1999, plus point source time-variable BOD5 loads representing high, medium, and low loading conditions approximated very closely the 10% exceedance delta DO derived from the modeling analysis using many combinations of Savannah River hydrology and time-variable BOD5 loads. This approximation of using one representative model year, 1999, and three time-variable loading patterns for each major discharger in conjunction with the concept of using stored model results in the TMDL calculator to compute the decrease in river DO for different effluent BOD5 and NH3 loads for each discharger allows a very cost-effective way of evaluating the DO compliance success of many combinations of loading patterns for the 21 wastewater dischargers on the Savannah River.

A further simplification in applying the Savannah River DO TMDL calculator was to represent the smaller wastewater dischargers with constant maximum monthly permit BOD5 and NH3 loads rather than three years of daily time-variable loads. However, as described in Section 5 of this report, a factor was developed from modeling analyses that is applied to the input constant monthly permit load such that the 90% delta DO decrease computed from the constant representation of these small loads is approximately the same as is computed with time-variable BOD5 and NH3 loads. This factor depends on the variability of the daily effluent for BOD5 and NH3, and the number of discharges, but it is estimated that this factor is about 0.67 (1/1.5).

A FORTRAN program was developed to easily perform the scaling and addition of individual point source stored “unit DO responses” to user desired BOD5 and NH3 point source loading levels. A simple spreadsheet was also built and linked to the FORTRAN core program to operate as a user interface for data input and output visualization. Appendix A provides a detailed description of the calculator implementation and development of the necessary internal calculations.

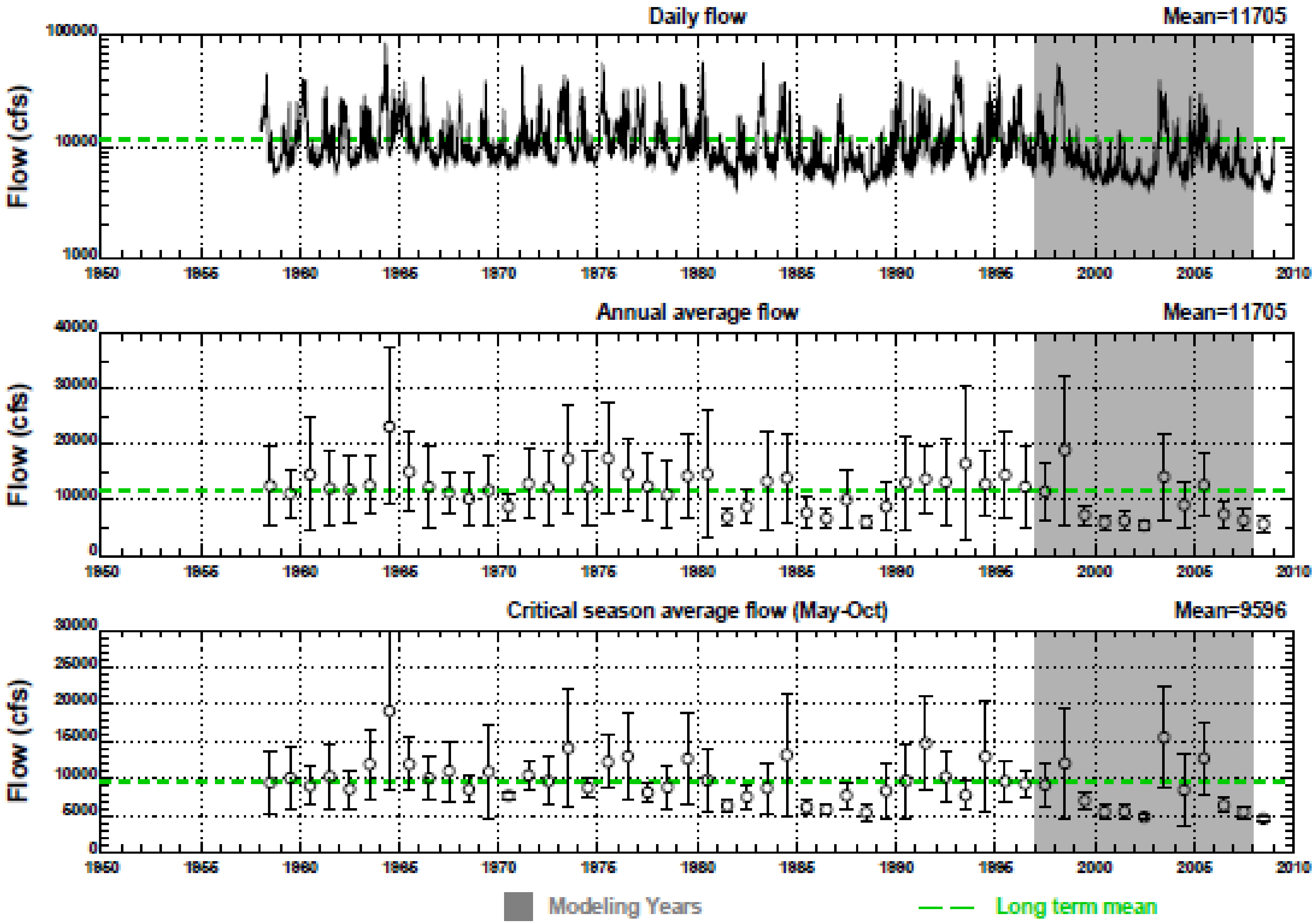


Figure 1-1. Flow at Savannah River near Clyo, GA USGS 02198500 (1958-2008)

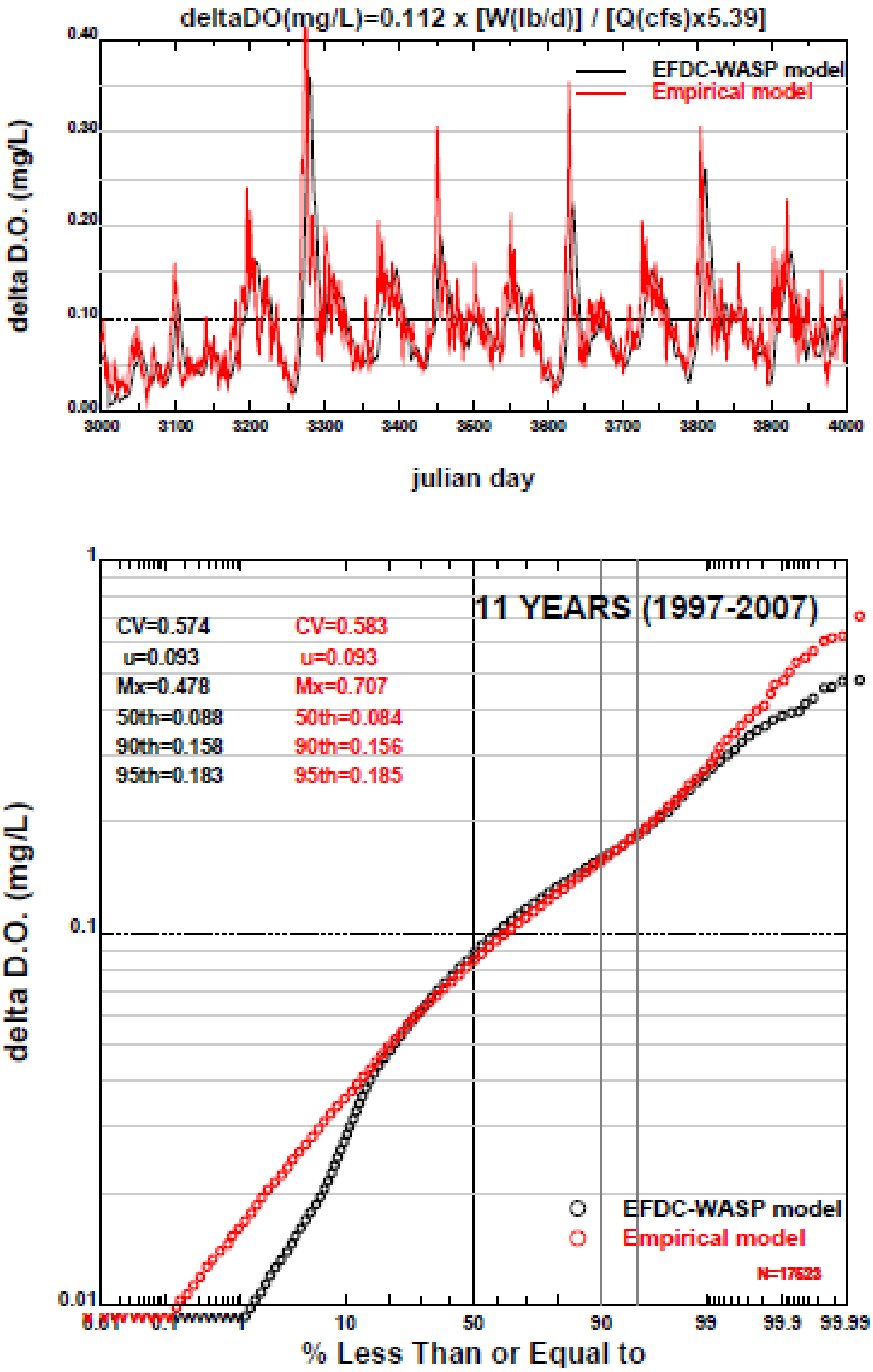


Figure 1-2. Comparison of Empirical Model versus EFDC-WASP Model Results

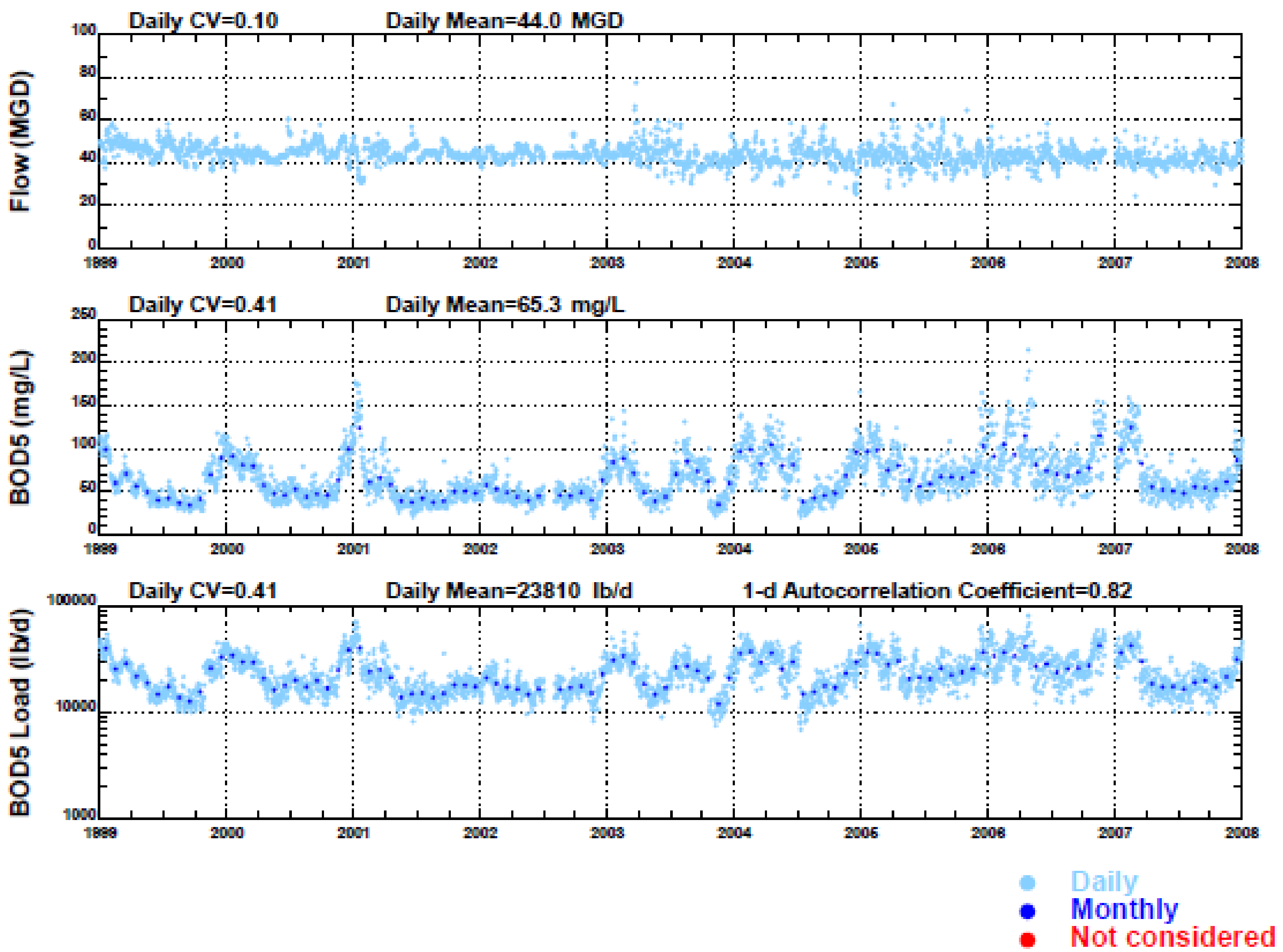
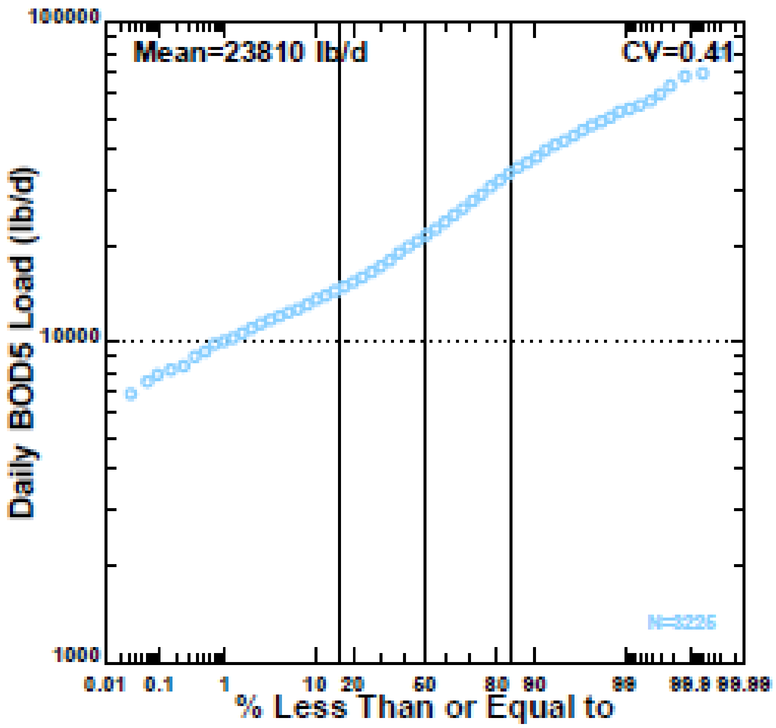


Figure 2-1a. International Paper at Augusta Flow and BOD5 Effluent Data (1999-2007)



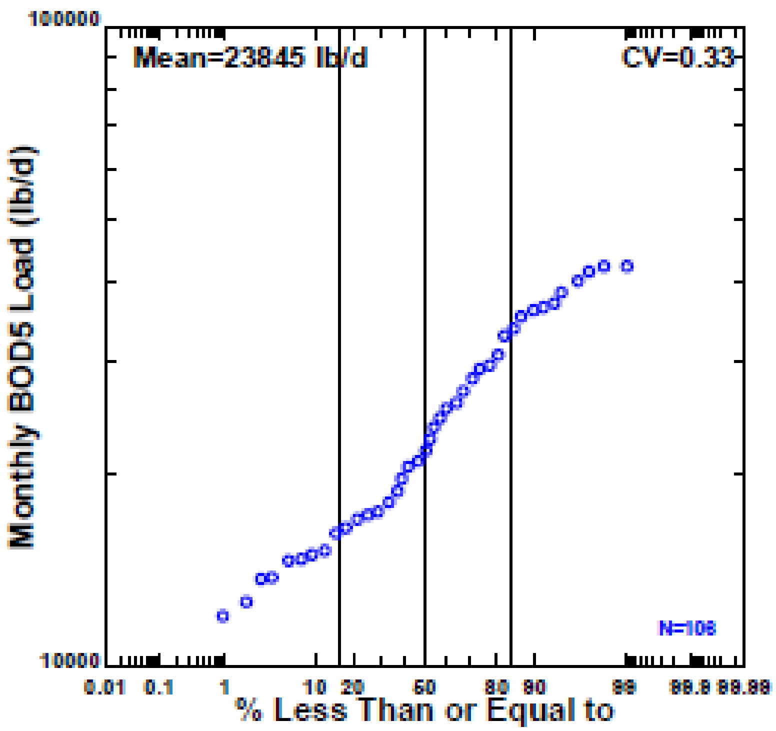


Figure 2-1b. International Paper at Augusta Flow and BOD5 Effluent Data (1999-2007)

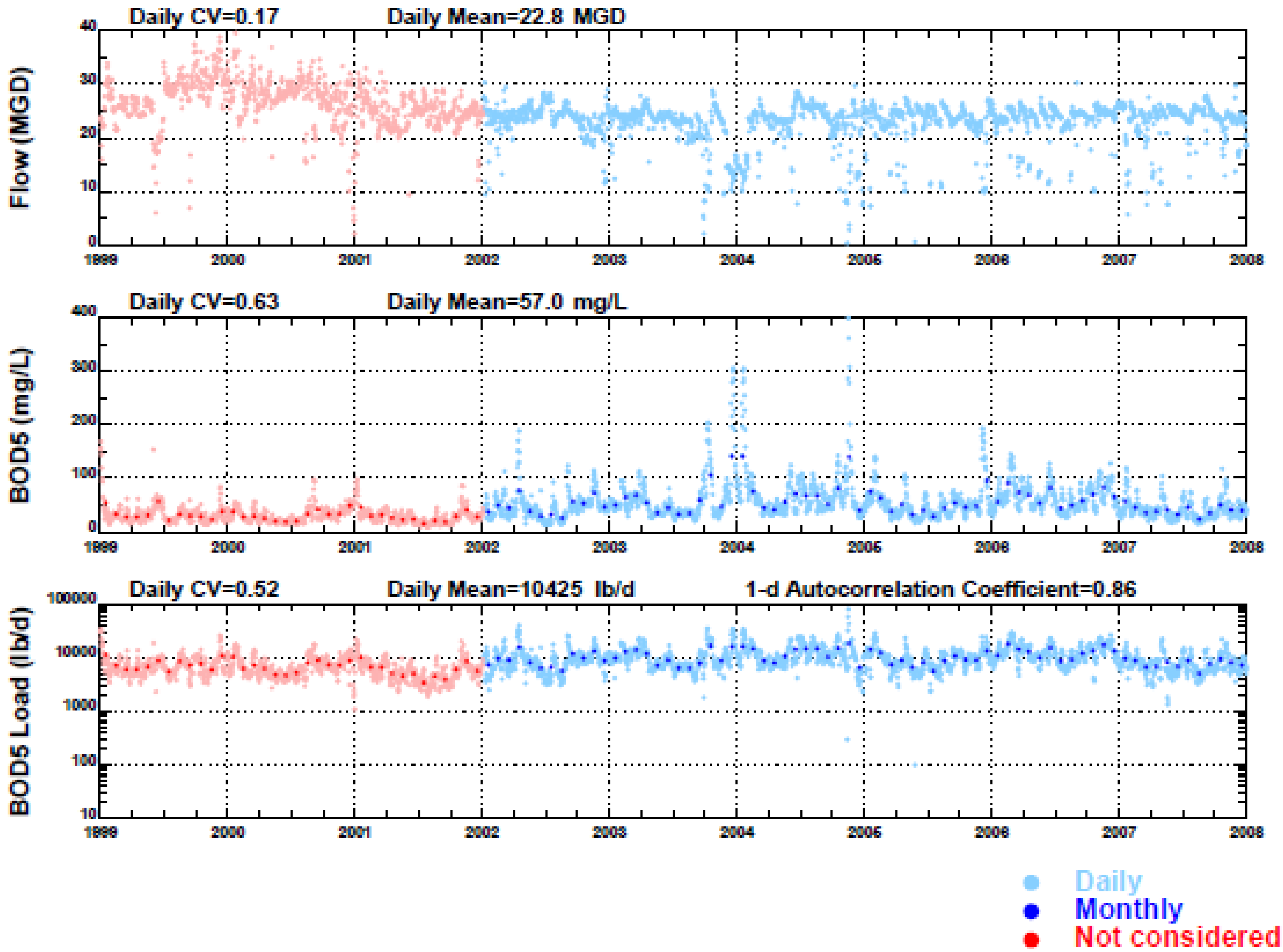


Figure 2-2a. International Paper at Savannah Flow and BOD5 Data (1999-2007)

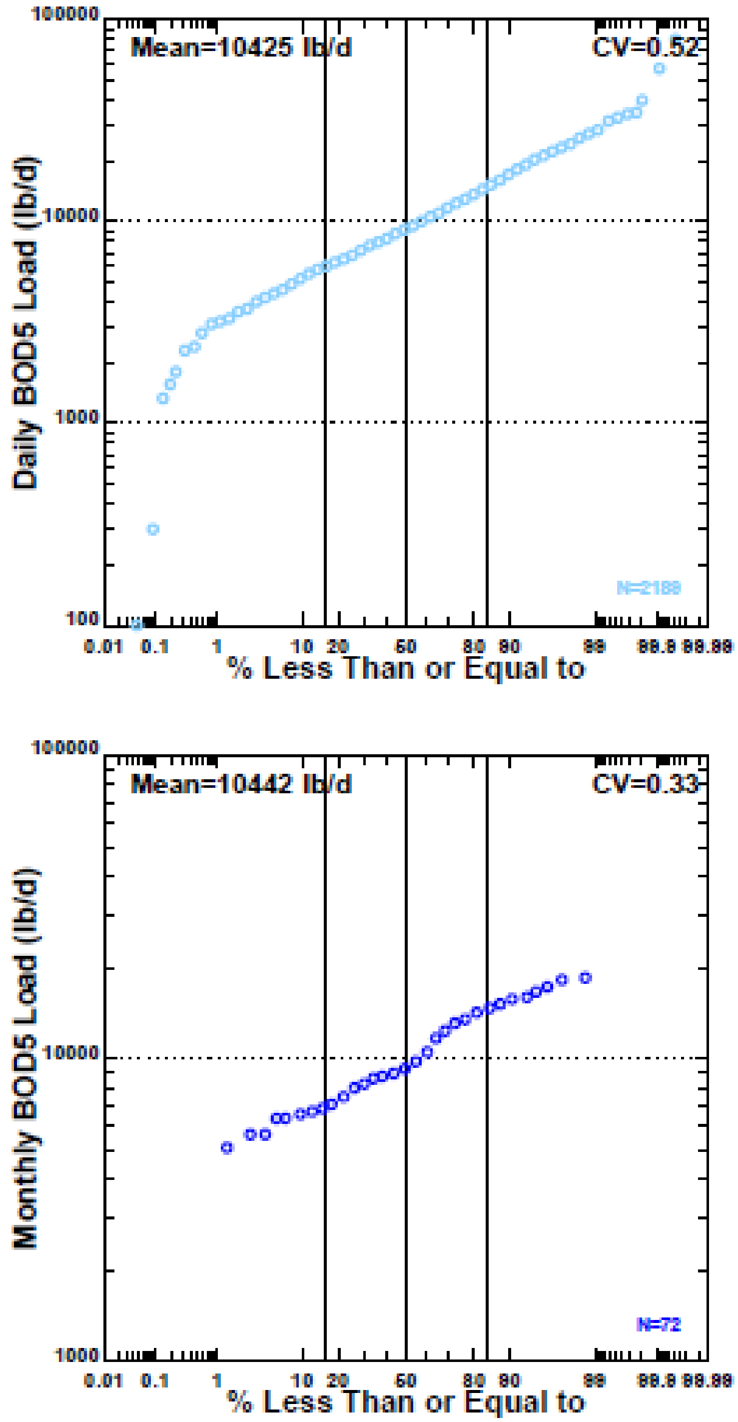


Figure 2-2b. International Paper at Savannah Flow and BOD5 Effluent Data (1999-2007)

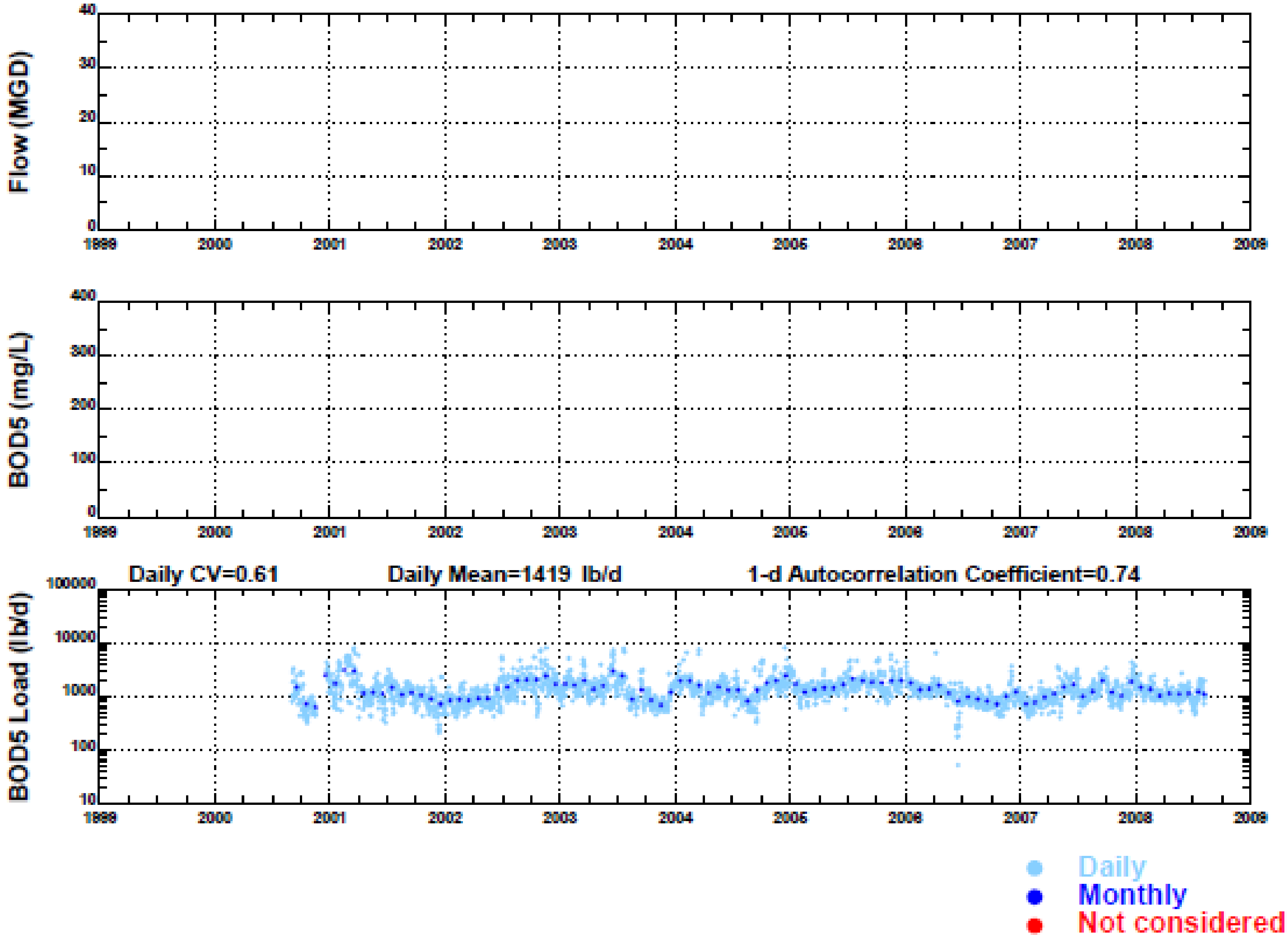


Figure 2-3a. Weyerhaeuser Flow and BOD5 Effluent Data (2000-2008)

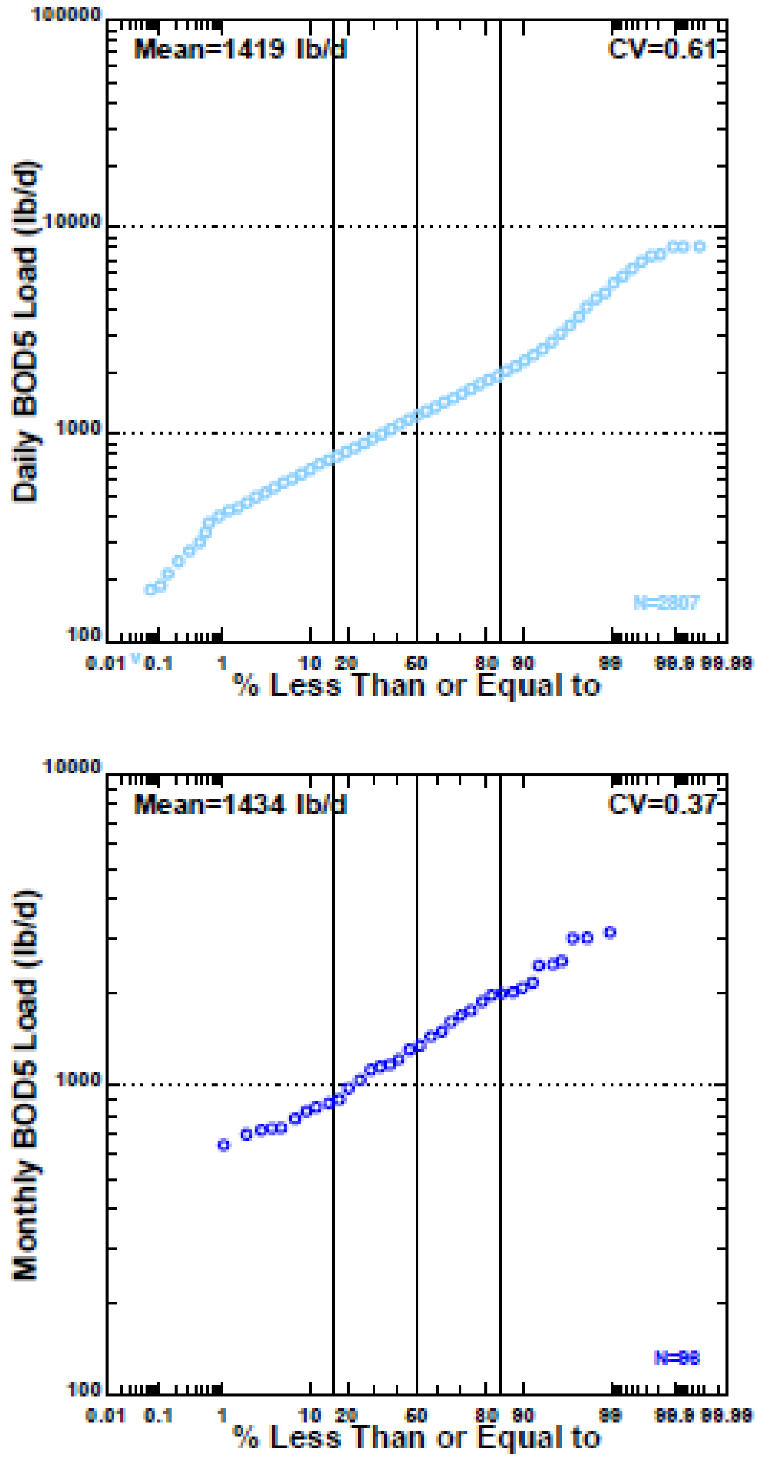


Figure 2-3b. Weyerhaeuser Flow and BOD5 Effluent Data (2000-2008)

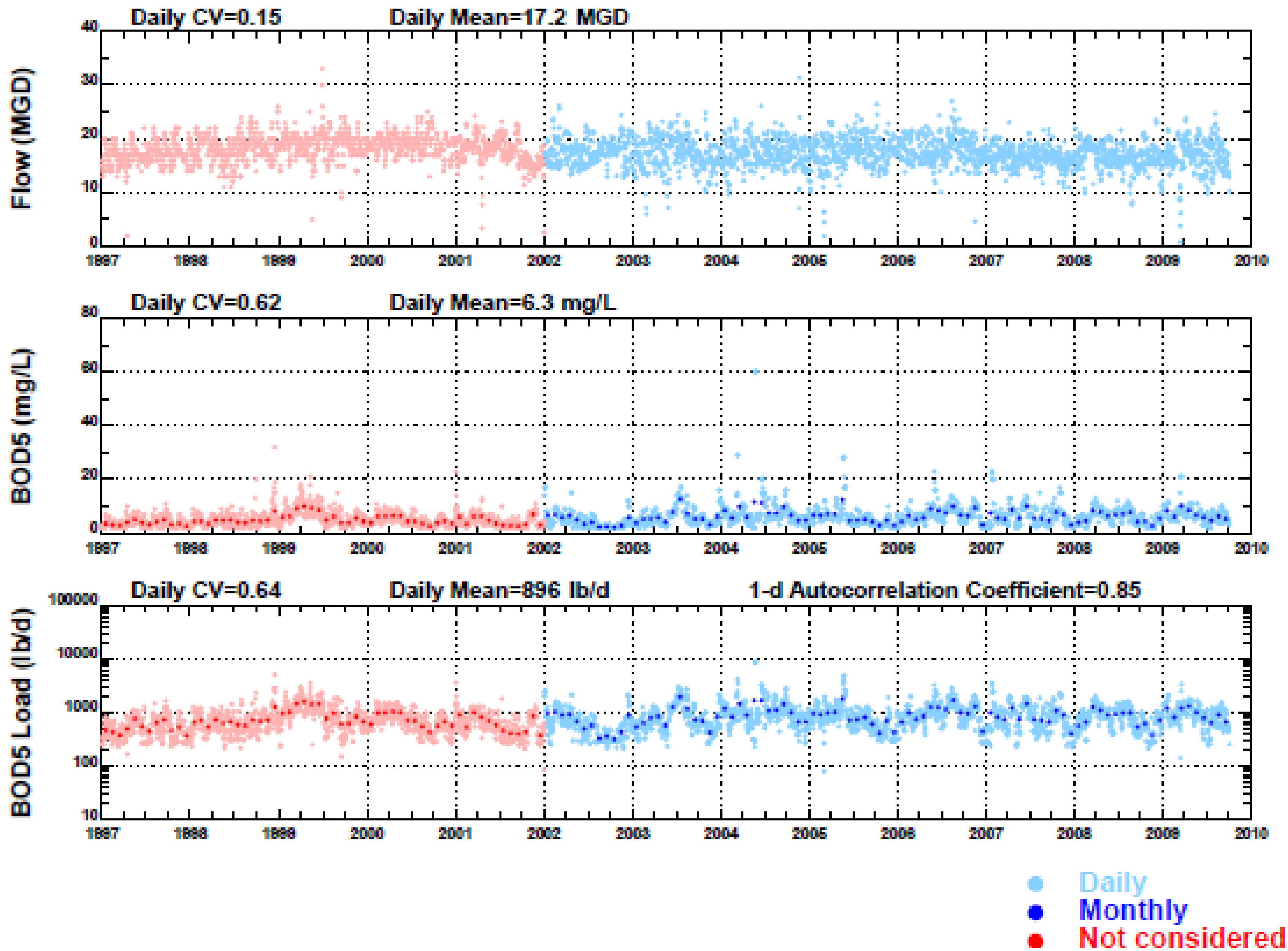
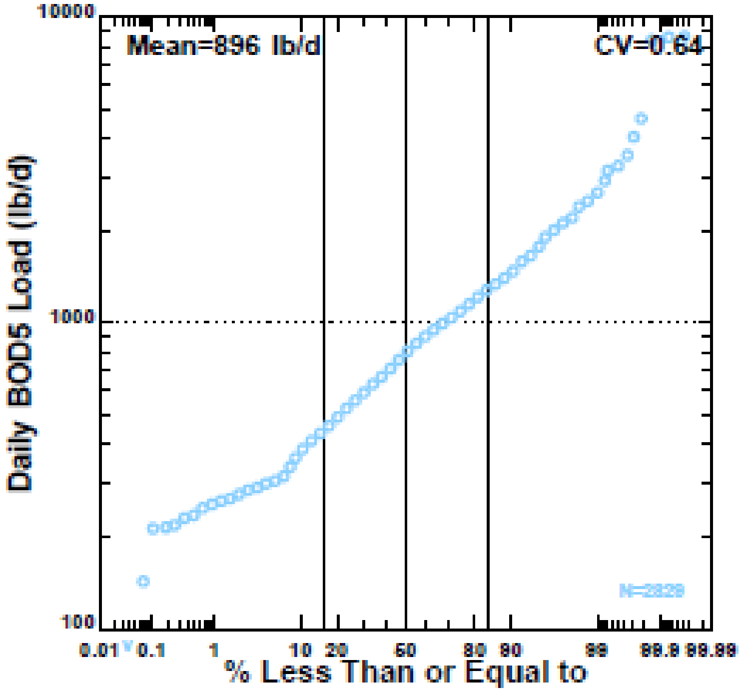


Figure 2-4a. Georgia Pacific Flow and BOD5 Effluent Data (1997-2009)



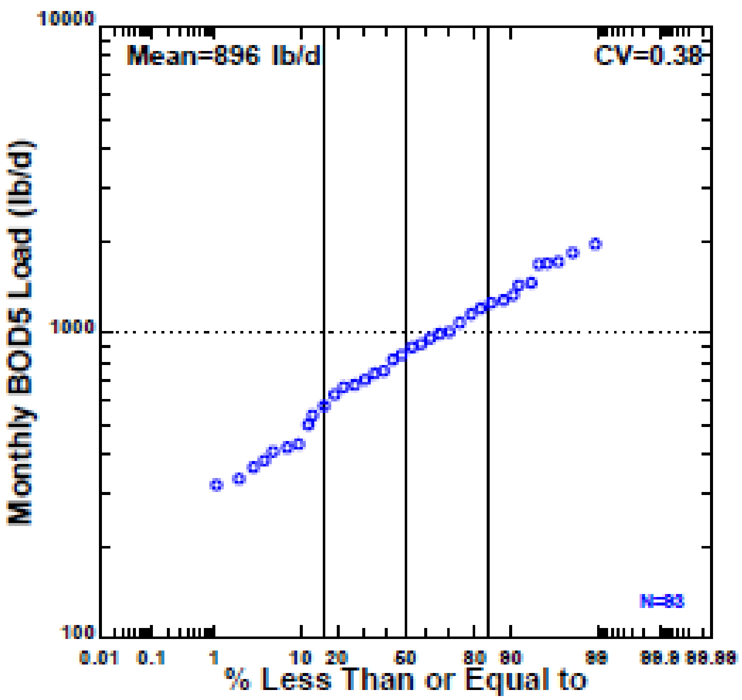


Figure 2-4b. Georgia Pacific Flow and BOD5 Effluent Data (1997-2009)

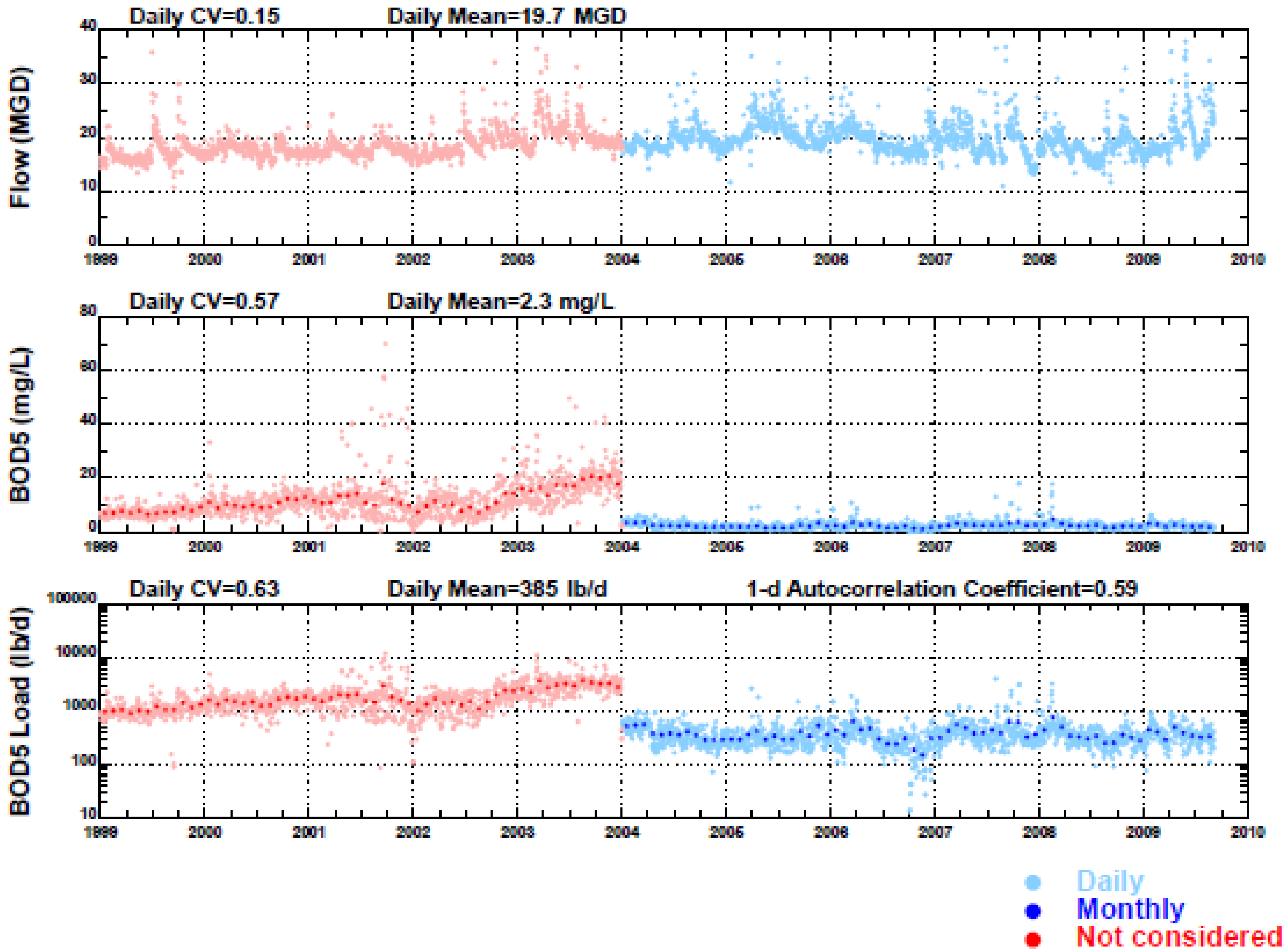


Figure 2-5a. President Street Plant Flow and BOD5 Effluent Data (1999-2009)

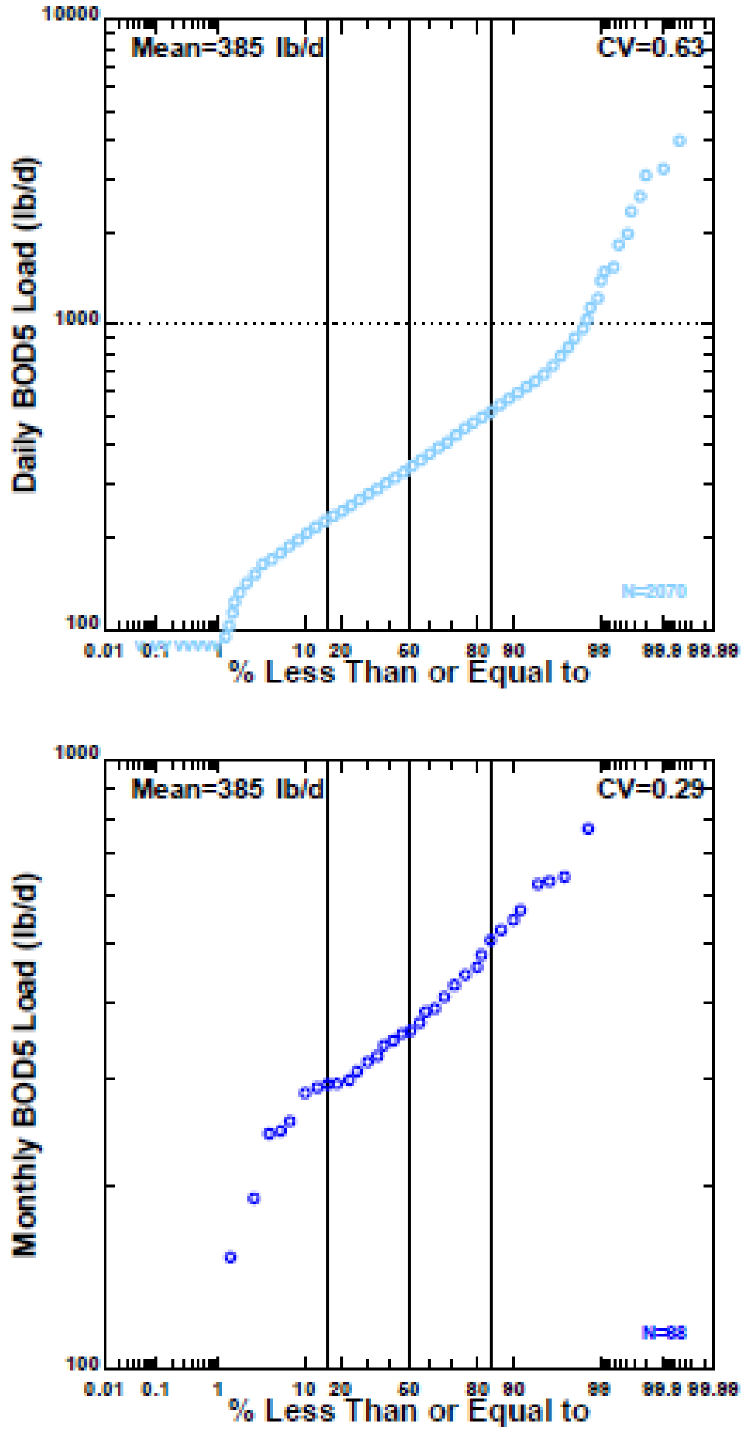


Figure 2-5b. President Street Plant Flow and BOD5 Effluent Data (1999-2009)

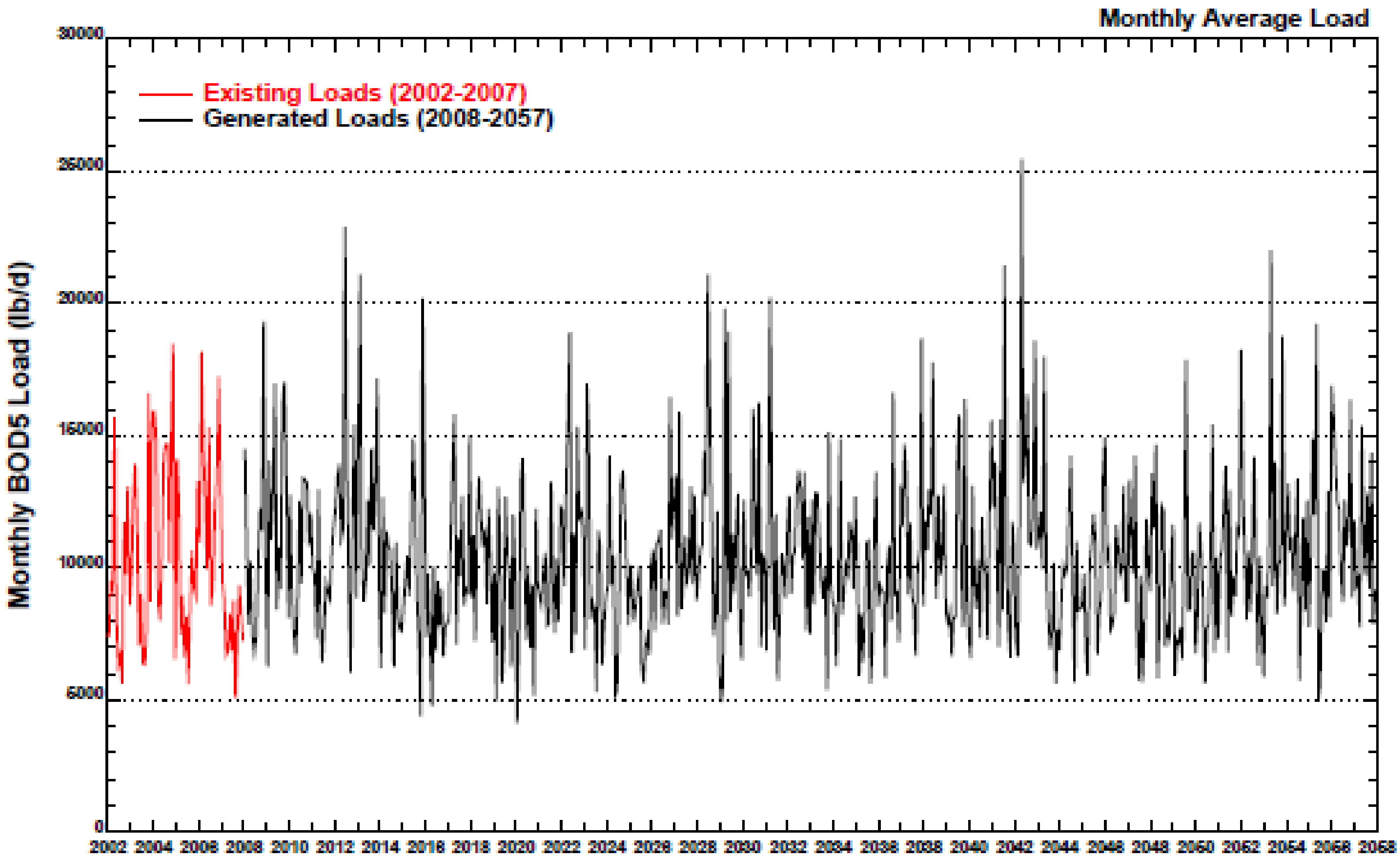


Figure 2-6. International Paper - Savannah Mill Existing and Generated BOD5 Loads

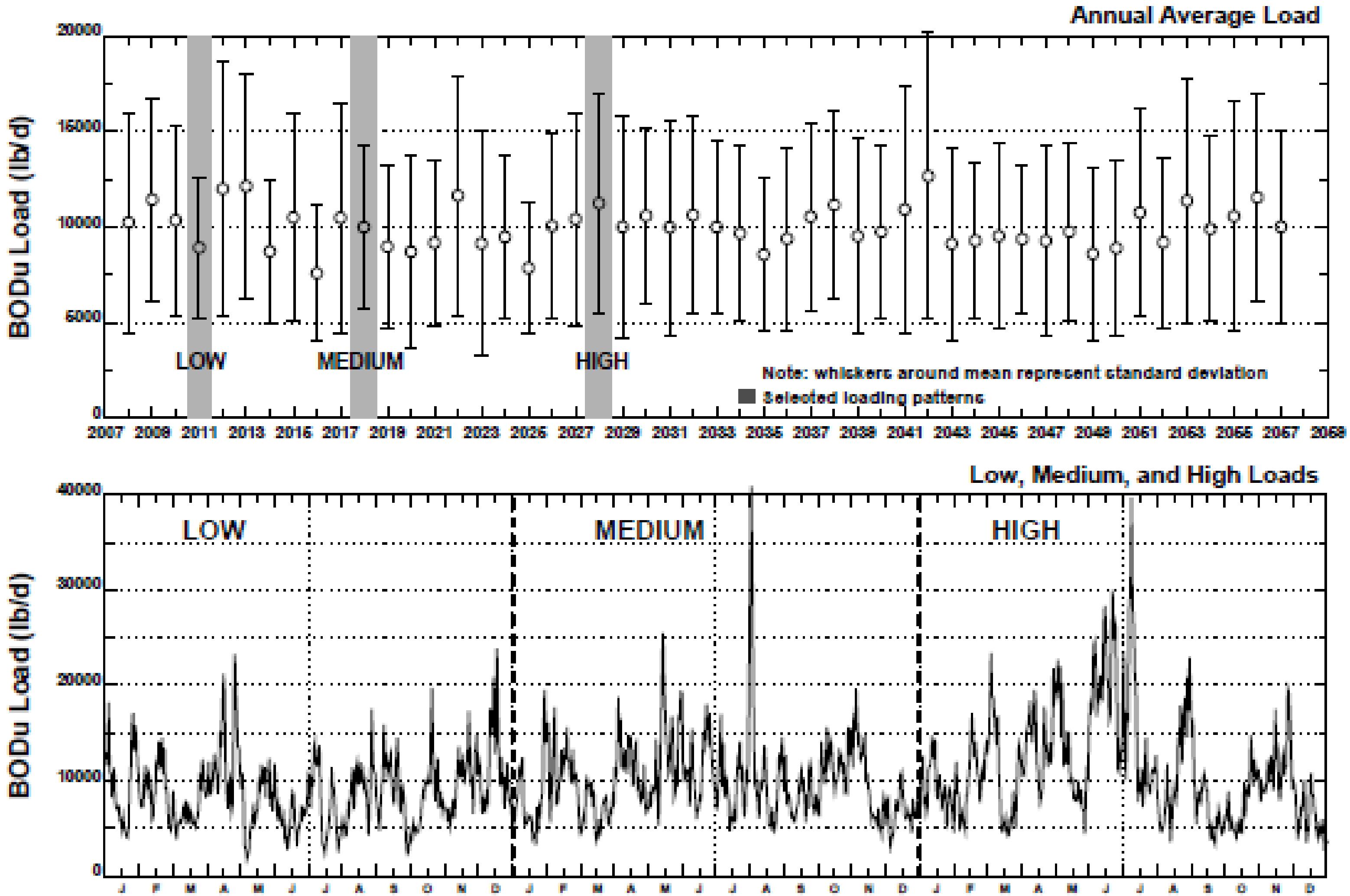


Figure 4-1. International Paper - Savannah Mill BODu generated load (2008-2057)

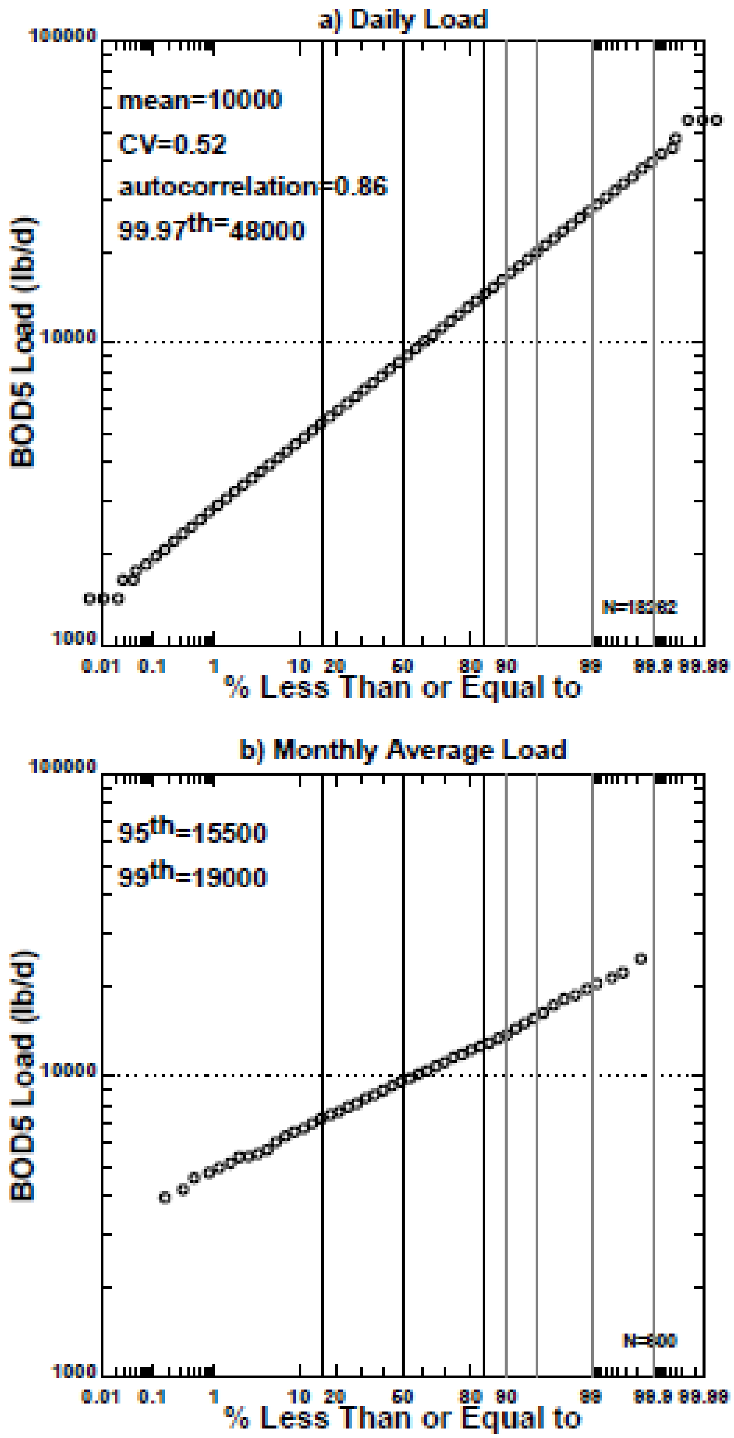
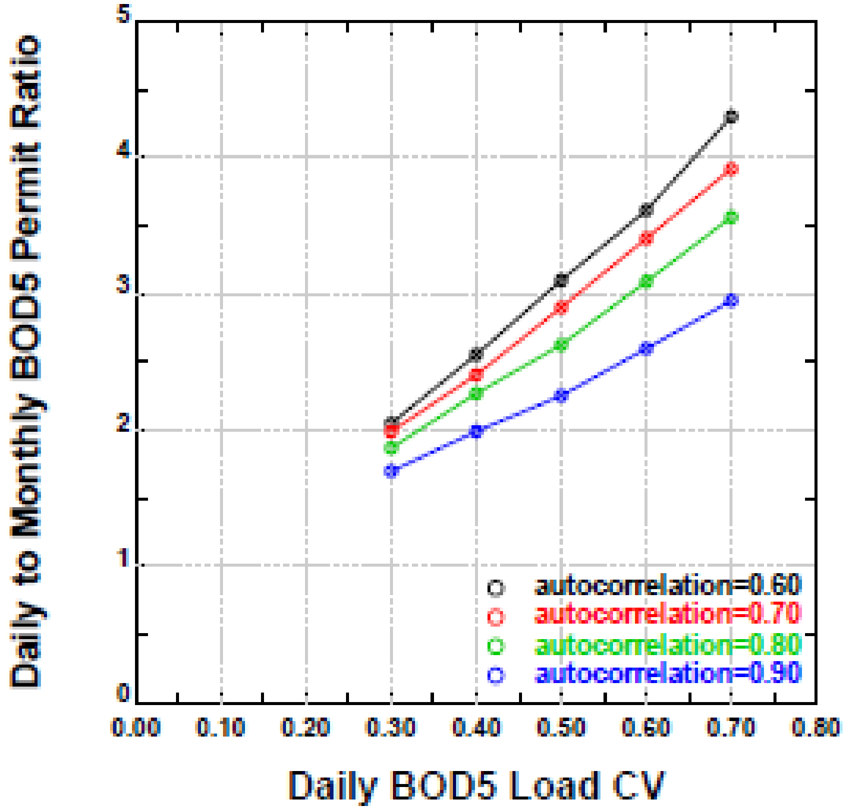


Figure 6-1. Sample Effluent BOD5 Distribution


Daily to Monthly BOD5 Permit Ratio
Daily BOD5 Load CV
0
1
2
3
4
5
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
autocorrelation=0.60
autocorrelation=0.70
autocorrelation=0.80
autocorrelation=0.90

APPENDIX A

This document summarizes the development and implementation of a tool for facilitating the evaluation of multiple loading scenarios (BOD, NH3 and DO) on the Savannah River and Harbor system based on the water quality model developed by USEPA (USEPA, 2010). This effort is part of the Savannah Harbor Expansion Project (USACE, 2010) effort for developing a Total Maximum Daily Load (TMDL) for dissolved oxygen (DO) in the Savannah Harbor and Savannah River Estuary. The objective of this tool is the quantification of DO levels resulting from a specified loading condition from a set of unit responses (response matrix) as developed by USEPA. In order to estimate DO levels associated with loading conditions for which actual unit responses were not obtained, this tool (TMDL calculator) employs the principles of response linearity and response linear superposition. In contrast with the traditional application of these principles in TMDL applications represented by a steady-state response matrix, this particular TMDL calculator deals with time-variable modeling results as well as time-variable loading conditions. Additional complexity was added by the existence of up to three possible BOD oxidation rates per point source BOD loading.

1. UNIT RESPONSES

The generation of unit responses for each point source and each water quality component (BOD, NH3 and DO) required the configuration and execution of multiple model scenarios. USEPA implemented approximately 100 model scenarios with the actual three-dimensional water quality model application for the Savannah River and Harbor. This amount of model configurations were necessary given the number of point sources included in the model, three loading systems available for each point source and multiple oxidation rates per point source BOD loading. Unit responses were obtained for 21 point sources, 18 included BOD loadings, 19 included NH3 loadings, and 4 included DO (DO injection) loadings. For each point source BOD loading, at least two or three possible oxidation rates were considered (0.02, 0.04 or 0.06/d in the Harbor area, 0.02 and 0.15/d in the river section). Five point sources included time-variable BOD loadings and as such were represented by three different annual loading patterns. This resulted in three separate model configurations per point source per oxidation rate for each point source represented by time-variable BOD loadings.

For compliance evaluations the Savannah River and Harbor was divided into 27 zones. For each model scenario configured and executed, the volume-weighted daily average DO for each zone was stored. All point source loadings were applied to the representative hydrodynamic year 1999 as defined in previous sections of this report. Therefore, each unit response included 365 DO values per compliance zone. Unit response data was stored in CSV format files (comma-separated values).

2. METHODOLOGY

2.1 General Approach

As mentioned before, the methodology of the TMDL calculator is based on the principle of linear superposition. As such, the general approach assumes that the sum of individual responses of each point source loading (as computed individually) approximates the response of the system when all point sources are applied simultaneously. In this particular application, the actual unit response is defined by the delta dissolved oxygen (delta DO) resultant of the application of point source A-2 loadings to a natural conditions (base case) model configuration of the system (no point source loads). This principle allows the estimation of DO levels for scenarios that were not included in the set of runs performed by USEPA with the relatively time consuming three-dimensional model. The individual point source responses (delta DO values), given the responses linearity, can be scaled to represent any desired point source loading level; the scaling process is based on the actual point source loading level associated with the unit response. Once the individual point source unit responses are scaled, the sum of all point source unit responses can be appropriately performed.

2.2 Unit Responses Loading Levels

The loading levels corresponding to the model scenario runs were categorized in constant loads and time-variable loads. Thirteen point source BOD loads were characterized with a constant daily value applied every day during the model simulation. Five point source BOD loads were characterized by time-variable loads (i.e., 3 annual sets of different loading patterns) associated with a specific long term monthly-average 99th percentile. Nineteen point source NH3 loads and 4 point source DO loads were characterized with a constant daily value applied every day during the model simulation. Therefore, the loading levels associated with the model scenario runs per point source per water quality component (BOD, NH3, and DO) were characterized by a constant load value or by a long

term monthly-average 99th percentile load value. In the case where point source BOD loads were defined by more than one oxidation rate, an independent unit response was obtained for each BOD group. The inclusion of independent unit responses per BOD oxidation rate was performed to allow the option to specify any splitting between BOD groups for a specific point source BOD load.

2.3 Scaling Process and Total Response Calculation

The initial step consisted in the calculation of the delta DO values associated with each loading scenario executed by USEPA. The DO levels computed for the base case scenario (no point source loads) were subtracted from all sets of DO levels computed for all other scenarios. The resulting datasets (i.e., sets of delta DO values) represent the actual unit responses for all scenario loading conditions. Assuming a set of desired loading levels for each point source (BOD5, NH3, and DO), the scaling process consists of scaling the unit response (delta DO values) for each point source to reflect the desired loading levels. This process is slightly different for each water quality component as well as for constant loads versus time-variable loads. Briefly, for each point source the process is as follows:

- For constant DO and NH3 loads: The delta DO values are scaled by the ratio of the desired loading level to the unit response loading level.

- For constant BOD loads: Because the desired BOD loading levels are in terms of BOD5 while the BOD unit responses were developed in terms of ultimate BOD (BODu) and because a point source BOD load can be characterized by more than one BOD oxidation rate; a translation and splitting process is required before any scaling is actually performed. The desired total BOD5 loading is split into one or two desired BOD5 loading groups (different oxidations rates) according to specified ratios (splitting factors). Next, each desired BOD5 loading group is expressed in terms of BODu by the application of their respective BODu to BOD5 ratios. Subsequently, the delta DO values associated with each BOD oxidation rate is then scaled by the ratio of the corresponding resultant desired BODu level A-3 for each BOD oxidation rate and the corresponding unit response loading level. Finally, a summation of each set of scaled delta DO values for each BOD group is performed to reflect the response of the desired total BOD5 loading.

- For time-variable BOD loads: The process described for the constant BOD loads case fully applies to time-variable BOD loads with one additional consideration. As mentioned before, a time-variable BOD loading is defined by 3 annual loading patterns, each one applied to the same hydrodynamic year (1999). Therefore, in this loading case, the set of three loading patterns (1,095 days) is treated as one unit response. The final set of scaled delta DO values represents 1,095 days of modeling results per compliance zone.

Once all the unit responses for each water quality component for each point source are appropriately scaled, a summation of all delta DO values per zone per day can be performed. Conceptually, the three sets of BOD loadings that define a point source time-variable BOD loading level represent a high, medium, and low annual loading pattern that statistically characterize the long term loading behavior for that particular point source and desired loading level. Theoretically, the summation of the scaled delta DO values would be comprised of two stages. During the first stage, applicable to time-variable BOD loadings, a summation of each 3-year unit response per point source for all point sources should be performed. In the second stage, applicable to constant loadings, the 1-year unit responses for all water quality components (BOD, NH3, and DO) for all point sources should be added to each year of the resulting 3-year total response previously computed. A caveat in this approach is the order of each point source BOD loading pattern (high, medium, and low) to be prescribed into the corresponding 3-year scaled unit response. Arranging a pre-determined order to all point source 3-year scaled unit responses could result in overstating or understating of the upper and lower percentiles of the total delta DO values for each compliance zone. For example, the latter could be the case when prescribing high loading patterns to be summed up with high loading patterns only or, conversely, low loading patterns to be summed up with low loading patterns only. A more realistic approach would be to consider all possible combinations of the BOD loading patterns for all point sources that involve time-variable BOD loadings. This approach was implemented as it was considered to be more representative of the actual likelihood of multiple point source loading patterns occurring at once. Therefore, a combination algorithm was implemented where all combinations between point source BOD loading patterns were established before the summation of the scaled time-variable BOD unit responses. This application includes 5 time-variable BOD loadings (3-year unit response per point source) so that after performing the combination process, 243 years of total delta DO values per compliance zone were obtained. The 1-year total response for all water quality components (BOD, NH3, and DO) for all point sources with constant loadings was then added to each year of the resulting 243-year total response previously computed. The total response generated for the desired loadings levels is then defined by 243 years of delta DO values per compliance zone. The next sections provides a brief description of the implementation of the TMDL calculator, a tool capable of automating all the processes required to obtain the total response of the Savannah River/Harbor system for a desired loading condition.

3. TMDL CALCULATOR IMPLEMENTATION

Excel was selected as the platform for the TMDL calculator user interface. The Excel VBA capabilities (Visual Basic for Applications for Excel) provided enough resources to satisfy the A-4 calculator interface needs as well as presented a familiar input method for a user with a basic familiarity with this database program. All model scenario results provided by USEPA (CSV files) were integrated into one ASCII database to be used as the source of all unit response retrievals. Unique codes were included into this database to differentiate DO values per day, per zone, per water quality component and per loading scenario. Three main sheets were included in the calculator Excel interface: two of them for input parameters and one for output display. A summary of the input sections present in both input sheets is presented below.

- Section 1 (input sheet): This section contains a list of the point sources included in the Savannah River/Harbor water quality model and the user desired loading levels (lbs/day). The first five point sources are represented by time-variable BOD loadings, therefore, the input BOD5 values represent the long term monthly-average 99th percentile value associated with the desired loading level. All other input values for this section represent the user desired loading levels when constant daily loads are applied during the model simulation. For any input section, the -99 flag represents a situation where that type of loading is not applicable for a specific point source or such model scenario results are inexistent.

- Section 2 (input sheet): This section provides user defined scale factors to easily scale the input values in section 1

- Section 3 (input sheet): This section defines the splitting of the user defined BOD5 loading levels (section 1) among each applicable BOD oxidation rate. These splitting factors are expressed as a fraction of the unity.

- Section 4 (input sheet): This section defines the time period (start and end Julian day) for the statistical calculations performed on the total response per compliance zone. It also contains an additional user defined percentile for output display purposes.

- Section 5 (hidden sheet): This section is to be modified by the calculator developers only and represents the loading levels associated with the unit responses developed by USEPA. The units are lbs/day to be consistent with the user desired loading levels specified in Section 1 on the interface.

- Section 6 (hidden sheet): This section is also to be modified for the calculator developers only and contains scale factors that adjust the desired point source loading levels defined in section 1 for point sources represented as constant loads. This adjustment is done to account for the actual effluent variability of all constant point sources.

- Section 7 (hidden sheet): This section contains the BODu to BOD5 ratios for each BOD oxidation group. The “output” sheet of the calculator interface displays the computed delta DO’s corresponding to the loading scenario defined in all input sections of the calculator. Total delta DO statistics are shown for each one of the 27 compliance zones as well as approximate contributions to the total delta DO for each point source included in the loading scenario. The contribution of each point source to the total delta DO at each compliance zone is an approximation only as the delta DO criterion is defined by the 90th percentile and the individual 90th percentiles per point source cannot A-5 be directly added to obtain the total response. Additionally, the “input sheet” of the calculator interface computes and display a table that summarizes the ultimate oxygen demand (UOD), sum of carbonaceous (BODu) and nitrogenous organic matter (NBODu – 4.57*NH3), per each point source included in the loading scenario.

Appendix B: Technical Basis of Wasteload Allocation Proposal (Savannah River/Harbor Discharge Group)

MALCOLM PIRNIE | ARCADIS

The Water Division of ARCADIS

Imagine the result

Savannah River/Harbor Discharger Group

Technical Basis of Wasteload Allocation Proposal

Savannah Harbor TMDL

July 1, 2011

Technical Basis of WLA Proposal

Prepared for:
Savannah River /Harbor Discharger Group

Prepared by:
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Our Ref.:
06907001.0000

Date:
July 1, 2011

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EXECUTIVE SUMMARY

In 2010, the major dischargers to the Savannah River and Harbor initiated a facilitated process to derive equitable wasteload allocations (WLAs) to achieve the Savannah Harbor total maximum daily load (TMDL). The year-long process was designed to progress from the agreement on broad equity concepts to the exploration of alternatives, and finally to an agreement on specific WLAs. This report describes the major elements of the process, and also describes the technical basis of the group's WLA proposal.

After a series of discussion and technical analyses, the discharger group reached consensus to allocate WLA using a method entitled "load reductions proportional to baseline impact". It was generally agreed that this approach was an effective means of addressing the equity concepts that everyone contribute to the solution but that high-impacting dischargers do more. The allocation method also includes provisions such as load reduction caps and technology-based concentration floors that prevent dischargers from being assigned WLAs that are technologically or economically unachievable.

Through this process, the group made tremendous progress in agreeing to load reductions that greatly reduced the non-attainment of DO criteria in the Savannah Harbor. However, a relatively small but challenging amount of non-attainment remained due to a combination of factors including treatability limits. The group explored various options for bridging the attainment gap including the use of DO injection and higher reductions from specific facilities. Although some of these options were considered to be potentially viable, the group also identified several key uncertainties that could have a strong influence on exactly how the final attainment gap was bridged. These included technical and regulatory aspects of DO injection, how the cost/responsibility of DO injection would be shared, the details of credit trading/offset program, and implications of harbor deepening and DO injection by the Corps of Engineers.

Given these uncertainties, the discharger group ultimately reached consensus to pursue a two-stage TMDL process with regulators. The first stage would include the majority of the implementation progress and would provide both time for resolution of the key issues needed to bridge the final attainment gap. As proposed, Stage 1 represents a 396,281 lbs/day reduction in UOD from existing permitted conditions and a 72 percent total UOD load reduction and would make approximately 98 percent of the progress needed to eliminate the excess DO deficit in the Savannah Harbor. In parallel with Stage 1 load reductions, the dischargers would pursue a process resolving key uncertainties and identifying specific responsibilities for attaining the Stage 2 reductions. During stage 2, the final load reductions would be achieved if monitoring indicates they are necessary.

1.0 INTRODUCTION

In 2010, the U.S. Environmental Protection Agency (USEPA) released a revised draft Total Maximum Daily Load (TMDL) to address dissolved oxygen (DO) impairments in the Savannah Harbor. This document did not assign individual wasteload allocations (WLAs) to affected dischargers. Rather, USEPA and the states (Georgia and South Carolina) agreed to allow the dischargers to develop a mutually agreeable set of individual WLAs, which would then be incorporated into the final TMDL. This report provides an overview of the facilitated process that was undertaken to derive the WLAs, and describes the technical basis of the WLA proposal itself. It is intended to accompany a memorandum of understanding (MOU) that documents the discharger's agreement to the proposal.

2.0 OVERVIEW OF FACILITATED PROCESS

In the late summer of 2010, the combined discharger group retained Malcolm Pirnie, Inc. to facilitate the process of deriving WLAs. In October of 2010, the group embarked on a series of meetings, communications, and technical analyses to support the discussions. The process was designed to progress from the discussion of broad equity concepts (phase 1), to the exploration of alternatives (phase 2), to the agreement on specific WLAs (phase 3). Major elements of these activities are described in subsections below.

2.1 Phase 1 – Agreement on Equity Concepts and Process

The purpose of the phase 1 activities was to achieve consensus on the goals, process, schedule, and major equity concepts that would be pursued by the combined discharger group. The combined discharger group held their phase 1 meeting on October 12, 2010, and agreed on the common goal of achieving a WLA distribution that was approvable by regulators, implementable, fair, scientifically sound, and supportive of regional economic growth. The group compiled a list of major equity concepts, including the following:

- All dischargers should "do their share".
- Expectation of more effort from higher-impacting facilities than lower-impacting facilities.
- Dischargers should receive credit for past/present achievements.
- WLA should be equitably distributed between Georgia and South Carolina.
- WLA should be distributed based on actual needs of existing facilities.
- Economic hardship on industries or communities should be considered.

It was recognized that some of the equity concepts were in tension with each other and that the ultimate solution would likely represent a balance between multiple equity concepts. During the phase 1 meeting, the group reviewed various families of WLA distributions methods, and agreed to explore several including:

- Equal percent load reduction.
- Equal impact on DO in critical segment(s).
- Different splits of WLA between Georgia and South Carolina dischargers.
- Different splits of impact on DO between Georgia and South Carolina dischargers.
- Tiered reductions (i.e., more impacting facilities to achieve higher percent load reduction).
- Load reductions proportional to baseline impact.

As part of phase 1 activities, it was also agreed to perform a survey of facility-specific flow, concentration, and load information for the most recent three years. The survey also requested information needed to confirm existing permit limits and determine best practicable technology (BPT) limits as defined in federal effluent guidelines. The facilitator prepared and distributed a survey form, and individual dischargers responded in November 2010.

2.2 Phase 2—Exploration of WLA Distribution Alternatives

The purpose of phase 2 was to explore a range of WLA distribution scenarios and narrow the list of viable scenarios. The combined discharger group held two phase 2 meetings: the first on December 12, 2010, and the second on February 17, 2011. Both meetings involved detailed discussion of a range of WLA distribution scenario results, as documented in technical memoranda prepared by the facilitator. Specific scenarios were discussed with respect to the major equity concepts and implications for specific dischargers.

The group explored reductions from two different baselines: one representing existing permitted loading, and the other representing a technology baseline. Both baselines were compiled using information reported on the November 2010 survey. The technology baseline was intended to represent BPT for industrial dischargers and secondary treatment for municipal facilities. Not all industrial dischargers had federal categorical standards for defining BPT, and the technology baseline was set equal to the existing permitted baseline for these dischargers.

Over the course of the phase 2 communications, the discharger group narrowed the list of preferred WLA distribution scenarios and ultimately reached consensus on the scenario family entitled "load reductions proportional to baseline impact". In general, it was felt that this approach was an effective means of addressing the equity concepts that "everyone do their share" but that high-impacting dischargers do more. It was also found that this scenario tended to provide South Carolina with a slightly higher share of the total DO impact than under existing permitted conditions, which was considered a desirable outcome by some dischargers.

During phase 2, dischargers also reached consensus on the need to include certain provisions in the allocation method to prevent some dischargers from receiving WLAs that were technologically or economically unattainable. These provisions included caps on the maximum percent load reduction that any facility would be expected to bear and technology-based concentration floors for both 5-day carbonaceous biological oxygen demand (CBOD5) and ammonia nitrogen (NH_3-N). It was recognized that the WLA distribution method could produce very different results from some dischargers, depending on at what level the maximum load reductions caps were set.

2.3 Phase 3 – Agreement on WLA Distribution

The purpose of phase 3 was to achieve consensus of a specific set of WLAs. The facilitators conducted additional runs of the "load reductions proportional to baseline impact" scenario, primarily to explore differences in the maximum load reduction caps. The facilitator also held interviews with individual dischargers to discuss facility-specific limitations (e.g., documentable treatability limits) and load reduction opportunities. Information from these communications was used to create a "May 2011 scenario" for discussion at the phase 3 multi-discharger meeting, held on May 18, 2011.

In the May 2011 meeting, it was clear that the group had made tremendous progress in agreeing to load reductions that greatly reduced the non-attainment of DO criteria in the Savannah Harbor. However, the scenario also showed a relatively small amount of remaining non-attainment that resulted from a combination of factors including treatability limits and allocation rules aimed at producing equity. Although small when expressed as a percentage of the total progress needed, the attainability gap was very challenging from a load reduction and equity standpoint. Bridging of the gap had the potential to push some dischargers beyond treatability limits, or conversely, could cause some lower impacting dischargers to make much higher reductions from baseline loading levels.

A major focus of the phase 3 meeting was discussion of various options for bridging the attainment gap such as lower technology-based concentrations floors, use of DO injection, and higher reductions from specific facilities. Although some of these options (or combinations thereof) were considered to e potentially viable, the group also identified several key uncertainties that could have a strong influence on exactly how the final attainment gap was bridged. These included technical and regulatory aspects of DO injection, how the cost/responsibility of DO injection would be shared, and the details of credit trading/offset program.

Given these uncertainties, the discharger group ultimately reached consensus to pursue a two-stage TMDL process with regulators. The first stage would include the majority of the implementation progress and would also provide time for resolution of the key issues needed to bridge the final attainment gap. During Stage 2, the final load reductions would be achieved, if needed. The remainder of this report presents the technical basis for the two-stage proposal.

3.0 ALLOCATION METHOD

The allocation method presented herein is based on a method called “load reductions proportional to baseline impact”. By this method, each facility’s percent load reduction is calculated as a multiplier of the facility’s percent impact on the DO deficit under the baseline loading level. However, the load reductions so calculated are subject to adjustments based on:

- Caps on the maximum percent load reduction
- Technology-based concentration floors

- Antibacksliding (equal or less than current permit)

All scenarios were performed using the TMDL Calculator version 4.0, with no adjustments other than the CBOD5 and NH4-N load inputs themselves. The TMDL

Calculator output of interest was the 90th percentile of the DO deficit, which should be no higher than 0.1 mg/L (or as specifically evaluated, 0.149 mg/L) for TMDL attainment. Pre-processing of Calculator input was performed in Microsoft Excel. The basic approach involved the following steps:

1. Set the baseline loading level.
2. Calculate the percent of the total DO deficit in the critical cell (FR17 under baseline conditions) for which each facility is responsible.
3. Multiply each facility's percent of the DO deficit by a constant factor, and reduce each facility's baseline loading by the resulting percentage.
4. Adjusting the loadings to account for load reduction caps, concentration floors, and antibacksliding.
5. Enter the loads into the Calculator and evaluate whether the DO deficit in all model cells is equal to or less than 0.149 mg/L.
6. If not, increase the multiplier of step 3 and repeat steps 4-6 until the TMDL is achieved or the multiplier reaches a pre-defined maximum level (discussed further in section 3.5 below).

The TMDL Calculator includes discharges from several facilities that did not participate in the facilitated WLA distribution process. These facilities were included in the load reduction calculations and handled according to the same allocation rules as applied to all other dischargers. Various other details of the allocation method are discussed in subsections below.

3.1 Baseline loads

Under the proposed allocation method, load reductions are calculated from a baseline loading level. The proposed method uses a technology baseline (Table 1) that was derived from information submitted by dischargers on the November 2010 survey. This selection was based on the concept that the technology baseline is superior to an existing permitted baseline for addressing one of the major equity concepts to which the discharger group has agreed: that facilities are rewarded for past achievements.

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Technical Basis of WLA Proposal

TABLE 1
Technology Baseline

Facility Name	Receiving Water	Flow (MGD)	Monthly Average CBOD5 (mg/L)	Monthly Average Ammonia-N (mg/L)	Monthly Average CBOD5 (lbs/day)	Monthly Average Ammonia-N (lbs/day)	Notes
BASF	Harbor	1.2	--	87.9	--	880.0	Based on current permit.
Garden City WPCP	Harbor	2.0	30.0	17.4	500.4	290.2	Calculated from definition of secondary treatment.
Georgia Pacific - Savannah River Mill	Harbor	18.0	72.3	2.0	10,850.0	300.2	Based on production data provided by facility; identical to permit limits.
Hardeeville	Harbor	4.00	30.0	17.4	1,000.8	580.5	Calculated from definition of secondary treatment.
International Paper Company - Savannah Mill	Harbor	27.3	106.1	2.0	24,155.0	455.4	Based on production data provided by facility.
PCS Nitrogen Fertilizer Sav	Harbor	4.0	--	30.0	--	1,000.0	Based on current permit.
Savannah - President Street WPCP	Harbor	27.0	30.0	17.4	6,755.4	3,918.1	Calculated from definition of secondary treatment.
Savannah - Travis Field WPCP	Harbor	2.0	30.0	17.4	500.4	290.2	Calculated from definition of secondary treatment.
Savannah - Wilshire WPCP	Harbor	4.5	30.0	17.4	1,125.9	653.0	Calculated from definition of secondary treatment.
US Army - Hunter Airfield	Harbor	1.3	30.0	17.4	312.8	181.4	Calculated from definition of secondary treatment.
Weyerhaeuser Company - Port Wentworth	Harbor	13.0	208.0	2.0	22,547.0	216.8	Based on production data provided by facility. Includes BPT/BAT of sugar and pulp/paper wastewater.
Aiken PSA/Horse Creek WWTF	Rive r	26.0	30.0	17.4	6,505.2	3,773.0	Calculated from definition of secondary treatment.
Allendale	River	4.0	30.0	17.4	1,000.8	580.5	Calculated from definition of secondary treatment.
Augusta - James B. Messerly WPCP	Rive r	46.1	30.0	17.4	11,534.2	6,689.8	Calculated from definition of secondary treatment.
Clariant Corp/Martin Plant	River	1.63	45.0	147.1	611.7	2,000.0	CBOD5 load limit calculated from BPT concentration limit and flow. Ammonia load same as existing permitted.
Columbia County - Crawford Creek WPCP	River	1.5	30.0	17.4	375.3	217.7	Calculated from definition of secondary treatment.
Columbia County - Little River WPCP	River	6.0	30.0	17.4	1,501.2	870.7	Calculated from definition of secondary treatment.
Columbia County - Reed Creek WPCP	Rive r	4.6	30.0	17.4	1,150.9	667.5	Calculated from definition of secondary treatment.
Columbia County - Kiokee Creek WPCP	River	0.30	30.0	17.4	75.1	43.5	Calculated from definition of secondary treatment.
DSM Chemicals Augusta Inc	River	3.01	34.0	--	853.5	--	Based on production data provided by facility.
International Paper Company - Augusta Mill	River	42.0	127.0	2.0	44,478.0	700.6	Based on production data provided by facility.
Kimberly-Clark/Beech Island	River	11.0	43.9	N/A	4,031.0	--	Based on current permit.
PCS Nitrogen Fertilizer Aug	River	1.4	--	104.4	--	1,219.1	Based on production data provided by facility.
Savannah River Site (SRS) Discharges (50% red.)	Watershed	6.0	7.2	0.5	361.0	23.0	Based on current permit.

Some dischargers have significantly more stringent permit limits than others, and so equal reductions from the existed permitted baseline would not necessarily recognize past investments. The technology baseline was defined as follows:

- For municipal facilities, the technology baseline was secondary treatment (30 mg/L CBOD5 and 17.4 mg/L ammonia).
- For industrial facilities that reported a BPT or best available technology (BAT) load, that load was used as the baseline, but only if it corresponded to actual (not maximum theoretical) production levels as documented in a National Pollutant Discharge Elimination System (NPDES) permit or related application materials.
- For other facilities and parameters, the technology baseline was set equal to the existing permitted load.

3.2 Concentration-Based Technology Floors

The purpose of the concentration-based technology floors was to prevent any discharger being pushed beyond a pre-defined level of advanced treatment. Not only does this prevent dischargers from being assigned unattainable reductions, it also promotes equity by required greater reductions from facilities that have not yet hit the floors.

The general floors applied were 10 mg/L CBOD5 for industrial facilities and small publicly owned treatment works (POTWs), 5 mg/L CBOD5 for larger and midsize POTWs, and 2 mg/L NH3-N for all facilities. Several industrial dischargers have performed studies to document facility-specific treatability limits that would be encountered even with advanced treatment (Table 2). For the two International Paper facilities, these limits were not directly applied in the scenario; rather, an 85 percent load reduction cap was used that brings these facilities close to (but slightly lower than) the cited concentration floors. The facility-specific technology floors were applied directly for Clariant Corporation. Not all facilities hit the technology floors in the proposed WLA distribution scenario.

Table 2 Facility-Specific Treatability Limits or Concentration-Based Technology Floors

Facility or Facility Type	Treatability Limitation or Technology Floor	
	CBOD5 (mg/L)	NH3-N (mg/L)
IP-Savannah	23	2
Clariant	25	25
IP-Augusta	23	2
Other industrial	10	2
Large & mid-size POTWs (≥ 2 million gallons per day [MGD])	5	2
Small POTWs (< 2 MGD)	10	2

3.3 Load Reduction Caps

Similar to the technology-based concentration floors, the purpose of the load reduction caps was to prevent any single facility from being pushed to load reductions that are technologically or economically unattainable. The proposed WLA distribution scenario uses a generally-applicable load reduction cap of 86.5 percent. The exception is for the two International Paper facilities, to which a load reduction cap of 85 percent was applied to partially address their facility-specific treatability limits.

3.4 Antibacksliding

To account for anti-backsliding, no final WLA was set at levels higher than the existing permitted level. If a facility encountered the antibacksliding provision for one parameter (e.g. ammonia nitrogen) but not the other, the load of ultimate oxygen demand (UOD) that would have been lost to the anti-backsliding provision was shifted to the other parameter, unless such a shift would cause that facility to be assigned loads lower than merited by the proportional reduction calculation. Similarly, if a facility's existing permitted concentration for a parameter was lower than the technology-based floor, the UOD associated with the difference between the existing permitted concentration and the technology floor was assigned to the other parameter, up to the extent allowed by antibacksliding for the second parameter.

3.5 Maximum Multiplier

In the proportional reduction scenarios, each facility's percent load reduction is calculated as a multiple of the baseline DO impact. The "multiplier" is defined as the ratio of the percent load reduction to the percent of the DO deficit in cell FR17 for which that facility is responsible under baseline loading conditions. The scenario is executed by increasing the multiplier until the TMDL is achieved.

For any scenario, the effective multiplier is different for different facilities. The reason is that as some facilities hit the load reduction cap or technology floors, other facilities must have a higher multiplier in order to achieve the TMDL. Similarly, triggering of an antibacksliding provision would cause a facility to have a higher multiplier than derived from the proportional reduction calculation alone. Under some scenarios, the TMDL can be achieved only if some facilities' effective multipliers are much higher (20x) than others, which could be perceived as inequitable. On the other hand, some differential in the multipliers is necessary to achieve the TMDL and acknowledge technical/economic restraints on the larger facilities.

For the proposed scenario, the maximum multiplier differential (i.e., the ratio between the largest effective multiplier of any facility and the smallest effective multiplier of any facility) was set to 10. This was done to balance the concepts of equitable proportional reductions and technical/economic restraints on the higher-impacting facilities. The calculation of the maximum multiplier differential excluded facilities whose allocation was based on the antibacksliding provision, because this provision resulted in extremely high multipliers for selected facilities, and anti-backsliding-based allocations were not considered to be inequitable regardless of multiplier differentials.

3.6 Combined Load Allocation

The proposed scenario also reflects a "bubbling" of load allocations for the two PCS Nitrogen facilities. The NH_3-N load allocation for PCS Nitrogen-Augusta was increased by 167.1 lbs/day, and the NH_3-N load allocation for PCS Nitrogen-Savannah was decreased by 500.7 lbs/day, resulting in no net increase in the total DO deficit caused by the two facilities combined.

3.7 Additional Reductions from Individual Facilities

As discussed in section 2, the combination of treatability limits and other allocation results resulted in a scenario that greatly reduced but did not eliminate the DO deficit in the Savannah Harbor. During the phase 3 discussions, some facilities made offers to make additional load reductions as documented in Table 3. These additional reductions are incorporated into the stage 1 WLAs, but they represent efforts of these specific facilities to bridge the attainment gap and achieve Stage 2 WLAs. The group reached consensus that, in any future efforts to close the remaining attainment gap, these facilities should be credited with these additional load reductions already offered.

Table 3 Additional Load Reductions Offered

Facility	Additional Load Reduction Offered
Clariant Corp.	200 lbs/day NH3-N
Kimberly-Clark	100 lbs/day CBOD5
PCS-Nitrogen-Savannah	100 lbs/day NH3-N
Weyerhaeuser	544 lbs/day CBOD5
Savannah River Site	25 lbs/day CBOD5

4.0 ALLOCATION RESULTS

Table 4 presents the results of the allocation method described in section 3. This scenario, hereafter called the "proposed stage 1 allocation", represents a 396,212 lbs/day reduction in UOD from existing permitted conditions and a 72 percent total UOD load reduction. This level of reduction would make the great majority of progress needed to eliminate the excess DO deficit in the Savannah Harbor. Compared with existing permitted loads, the proposed Stage 1 scenario would reduce the DO deficit in excess of the allowable level specified in DO standard by 98 percent or more in the critical segments (Table 5). However, a small amount of excess DO deficit was predicted to remain in the critical cells. Elimination of this excess DO deficit is predicted to require an additional ~6,300 to ~16,200 lbs/day reduction in UOD loads, depending on where the Stage 1 reductions were made.

As discussed in section 2.3, the combined discharger group explored various options for eliminating the remaining DO deficit. Because some facilities are already allocated at treatability limits, a simple proportional sharing of the gap would take some facilities

TABLE 4
Results of Allocation Method

Facility Name	Receiving Water	Flow (MGD)	CBOD5 Load Under Scenario (lbs/day)	NH4 Load Under Scenario (lbs/day)	CBOD5 % Reduction from Technology Baseline	NH4-N % Reduction from Technology Baseline Under Scenario	CBOD5 % Reduction from Existing Permit Under Scenario	NH4-N % Reduction from Existing Permit Under Scenario	CBOD5 Conc. Under Scenario (mg/L)	NH4-N Conc. Under Scenario (mg/L)	Control on CBOD Load Under Scenario	Control on NH4-N Load Under Scenario	Effective Multiplier CBOD5	Effective Multiplier NH4-N	% Impact Baseline FR17	% Impact Under Scenario FR17	Technology Baseline Rank of Impact FR17	Scenario Rank of Impact FR17
BASF	Harbor	1.2	--	840.5	--	4.5%	--	4.5%	--	84.0	--	Proportional reduction	--	34.0	0.13%	0.70%	23	21
Garden City WPCP	Harbor	2.0	428.4	248.4	14.4%	14.4%	14.4%	14.4%	25.7	14.9	Proportional reduction	Proportional reduction	34.0	34.0	0.42%	1.99%	17	13
Georgia Pacific - Savannah River Mill	Harbor	18.0	1501.2	300.2	86.2%	0.0%	86.2%	--	10.0	2.0	Technology floor	Technology floor	7.4	0.0	11.66%	9.34%	4	4
Hardeeville	Harbor	4.0	253.0	183.0	74.7%	68.5%	0.0%	0.0%	7.6	5.5	Antibacksliding	Antibacksliding	55.4	50.8	1.35%	1.94%	10	15
International Paper Company - Savannah Mill	Harbor	27.3	3623.3	455.4	85.0%	0.0%	85.5%	--	15.9	2.0	Reduction cap	Technology floor	6.2	0.0	13.61%	11.52%	3	3
PCS Nitrogen Fertilizer Sav	Harbor	4.0	--	313.0	--	68.7%	--	68.7%	--	9.4	--	Manual Trading and additional reduction	--	270.6	0.25%	0.43%	20	22
Savannah - President Street WPCP	Harbor	27.0	1125.9	528.9	83.3%	86.5%	73.0%	81.4%	5.0	2.3	Technology floor	Reduction cap	19.5	20.3	4.26%	3.80%	7	7
Savannah - Travis Field WPCP	Harbor	2.0	250.0	145.0	50.0%	50.0%	0.0%	0.0%	15.0	8.7	Antibacksliding	Antibacksliding	129.3	129.3	0.39%	1.06%	18	18
Savannah - Wilshire WPCP	Harbor	4.5	792.1	459.4	29.6%	29.6%	29.6%	29.6%	21.1	12.2	Proportional reduction	Proportional reduction	34.0	34.0	0.87%	3.36%	13	10
US Army - Hunter Airfield	Harbor	1.3	208.5	181.4	33.3%	0.0%	0.0%	0.0%	20.0	17.4	Antibacksliding	Antibacksliding	126.1	0.0	0.26%	1.05%	19	19
Weyerhaeuser Company - Port Wentworth	Harbor	13.0	2500.0	216.8	88.9%	0.0%	62.7%	--	23.1	2.0	Reduction cap	Antibacksliding	4.3	0.0	20.80%	12.93%	2	2
Aiken PSA/Horse Creek WWTF	River	26.0	1084.2	509.4	83.3%	86.5%	84.8%	78.6%	5.0	2.3	Technology floor	Reduction cap	18.6	19.3	4.47%	3.87%	6	6
Allendale	River	4.0	630.5	365.7	37.0%	37.0%	24.4%	45.2%	18.9	11.0	Proportional reduction	Proportional reduction	34.0	34.0	1.09%	3.76%	11	8
Augusta - James B. Messerly WPCP	River	46.1	2165.1	576.0	81.2%	91.4%	43.7%	0.0%	5.6	1.5	Technology floor + NH4	Antibacksliding	9.6	10.8	8.44%	7.02%	5	5
Clariant Corp/Martin Plant	River	1.6	339.9	622.0	44.4%	68.9%	39.8%	68.9%	25.0	45.8	Technology floor	Proportional reduction and additional reduction	25.7	39.8	1.73%	3.48%	9	9
Columbia County - Crawford Creek WPCP	River	1.5	150.1	12.4	60.0%	94.3%	0.0%	0.0%	12.0	1.0	Antibacksliding	Antibacksliding	244.2	383.9	0.25%	0.36%	21	23
Columbia County - Little River WPCP	River	6.0	375.3	215.2	75.0%	75.3%	0.0%	0.0%	7.5	4.3	Antibacksliding	Antibacksliding	76.3	76.6	0.98%	1.39%	12	16
Columbia County - Reed Creek WPCP	River	4.6	383.6	76.7	66.7%	88.5%	0.0%	0.0%	10.0	2.0	Antibacksliding	Antibacksliding	88.5	117.5	0.75%	1.03%	14	20
Columbia County - Kiokee Creek WPCP	River	0.3	50.0	17.5	33.3%	59.8%	0.0%	0.0%	20.0	7.0	Antibacksliding	Antibacksliding	678.4	1216.7	0.05%	0.16%	24	24
DSM Chemicals Augusta Inc	River	3.0	727.0	--	14.8%	--	0.0%	--	29.0	--	Antibacksliding	--	34.8	--	0.43%	1.98%	16	14
International Paper Company - Augusta Mill	River	42.0	6671.7	700.6	85.0%	0.0%	80.1%	--	19.0	2.0	Reduction cap	Technology floor	3.4	0.0	24.88%	21.78%	1	1
Kimberly-Clark/Beech Island	River	11.0	1007.9	--	75.0%	--	75.0%	--	11.0	--	Proportional reduction and additional reduction	--	35.2	--	2.13%	2.92%	8	11
PCS Nitrogen Fertilizer Aug	River	1.4	--	1162.0	--	4.7%	--	0.0%	--	99.5	--	Manual trading	--	8.7	0.54%	2.83%	15	12
Savannah River Site (SRS) Discharges (50% red.)	Watershed	6.0	342.0	23.0	5.3%	0.0%	5.3%	0.0%	6.8	0.5	Technology floor	Antibacksliding	22.0	0.0	0.24%	1.31%	22	17

Note: CBOD5 and NH3-N concentrations and loads are shown for information purposes, and that the allocations are proposed as UOD loads only.

Table 5 Summary of DO Attainment (90th Percentile) under Proposed Stage 1 WLAs

Segment	Maximum Allowable DO Deficit (mg/L)	Existing Permitted DO Deficit (mg/L)	Phase 1 TMDL Predicted DO Deficit (mg/L)	Phase 1 Excess DO Deficit (mg/L)	Phase 1 Progress Toward Attainment
FR15	0.149	0.579	0.154	0.005	98.8
FR17	0.149	0.589	0.157	0.008	98.2
FR19	0.149	0.584	0.157	0.008	98.2

beyond treatability limits or concentration floors, which is obviously problematic for those facilities. However, most of the other facilities are relatively low-impacting dischargers that would need to make significantly higher load reductions from baseline in order to bridge the attainment gap. Reducing the ammonia floor from 2 mg/L to 1 mg/L was shown to have the capability to address less than 20 percent of the gap, and was considered to be technologically problematic at some facilities.

Exploration of DO injection in the Calculator demonstrated that this technology had the potential to not only eliminate the remaining DO deficit, but also provided a margin of safety for compliance and room for future growth. The consensus of the discharger group was that DO injection is likely to have a role in long-term compliance. However, there are several important questions that would affect that ability of specific dischargers to commit to a specific DO injection-based solution for eliminating the attainment gap. These questions include those related to:

- Regulatory acceptance of DO injection.
- Differing water quality benefits and costs, depending on where it is installed.
- Which facilities would actually install DO injection.
- How the capital and operation and maintenance costs of DO injection might be shared.
- Details of how DO injection credits might be generated, exchanged, or guaranteed.
- Implications of harbor deepening and DO injection by the Corps of Engineers.

The allocation method presented herein is based on the needs and capabilities of existing facilities and includes no reserve for future growth other than that represented by the 0.001 mg/L reserve for future *de minimis* dischargers. Similarly, the allocation method did not include intentional, explicit shifts of WLA between states. However, the proposed Stage 1 allocations are predicted to cause a small (<3%) shift in the total

FR17 DO deficit from Georgia to South Carolina (Table 6). Due to the importance of allowing economic development in both states, another potential topic of future discussion is how DO injection and pollutant reading credits might be distributed between the states.

5.0 PROPOSAL FOR A TWO-STAGE TMDL

The facilitated process has resulted in the agreement to very large load reductions from existing permitting levels, representing most of the progress needed, but has also highlighted the need to resolve important questions in determining how the remaining DO deficit should be eliminated. The group consensus is that that these questions can be resolved in a reasonable amount of time by a continued, focused effort and communications.

With these considerations in mind, the group proposes a two-stage TMDL corresponding to two permit cycles. Stage 1 would involve commitment of the signatory discharges to the UOD load allocations of Table 7, to be achieved at the end of the first permit cycle. Stage 1 would also include specific activities for determining how the remaining non-attainment will be addressed. Likely activities would include:

- Agreement on a specific schedule for Stage 1 activities.
- Identification of specific opportunities, costs, and regulatory approaches for DO injection.
- Evaluation of the impact of harbor deepening and DO injection by the Corps of Engineers.
- Exploration of additional reduction capabilities at individual facilities.
- Creation of specific regulatory and/or legal mechanisms for trading/offsets.
- Consideration of how the trading/offset mechanism will affect state equity.

If needed, Stage 2 would involve attainment of the final UOD loads, currently represented as aggregate loads in Table 7.

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Technical Basis of WLA Proposal

TABLE 6
Proposed Stage 1 Allocation
Summary of Split in UOD and Delta DO
Allocation by State and Discharger Type

Facility Name	State	Type	UOD under Scenario: EP Baseline	UOD under Scenario: Proposed Stage 1 Allocation	Delta DO in FR17: EP Baseline	Delta DO in FR17: Proposed Stage 1 Allocation
BASF	GA	Ind	4,022	3,841	1.27E-03	1.22E-03
Garden City WPCP	GA	Mun	4,089	3,500	4.07E-03	3.49E-03
Georgia Pacific - Savannah River Mill	GA	Ind	60,372	9,659	1.11E-01	1.64E-02
Hardeeville	SC	Mun	2,233	2,233	3.41E-03	3.41E-03
International Paper Company - Savannah Mill	GA	Ind	147,474	23,284	1.35E-01	2.02E-02
PCS Nitrogen Fertilizer Sav	GA	Ind	4,570	1,430	3.30E-03	2.23E-03
Savannah - President Street WPCP	GA	Mun	35,965	8,632	2.59E-02	6.67E-03
Savannah - Travis Field WPCP	GA	Mun	2,043	2,043	1.86E-03	1.86E-03
Savannah - Wilshire WPCP	GA	Mun	9,200	6,472	8.38E-03	5.89E-03
US Army - Hunter Airfield	GA	Mun	1,980	1,980	1.84E-03	1.84E-03
Weyerhaeuser Company - Port Wentworth	GA	Ind	55,325	21,265	5.98E-02	2.27E-02
Aiken PSA/Horse Creek WWTF	SC	Mun	36,804	6,253	4.16E-02	6.79E-03
Allendale	SC	Mun	6,068	3,954	9.99E-03	6.59E-03
Augusta - James B. Messerly WPCP	GA	Mun	16,544	10,470	2.00E-02	1.23E-02
Clariant Corp/Martin Plant	SC	Ind	11,182	4,073	1.64E-02	7.36E-03
Columbia County - Crawford Creek WPCP	GA	Mun	600	600	5.15E-03	5.15E-03
Columbia County - Little River WPCP	GA	Mun	2,342	2,342	5.15E-03	5.15E-03
Columbia County - Reed Creek WPCP	GA	Mun	1,739	1,739	5.15E-03	5.15E-03
Columbia County - Kiokee Creek WPCP	GA	Mun	261	261	5.15E-03	5.15E-03
DSM Chemicals Augusta Inc	GA	Ind	2,632	2,632	3.48E-03	3.48E-03
International Paper Company - Augusta Mill	GA	Ind	122,290	27,353	1.79E-01	3.82E-02
Kimberly-Clark/Beech Island	SC	Ind	14,592	3,649	2.05E-02	5.63E-03
PCS Nitrogen Fertilizer Aug	GA	Ind	5,310	5,310	4.96E-03	4.24E-03
Savannah River Site (SRS) Discharges (50% red.)	SC	Ind	1,412	1,343	2.30E-03	2.30E-03

Sum	476,758	132,814	5.81E-01	1.61E-01
Georgia Sum	72,292	21,504	9.41E-02	3.21E-02
South Carolina Sum	86.8%	86.1%	86.1%	83.4%
% Georgia	13.2%	13.9%	13.9%	16.6%
% South Carolina				

Sum	429,182	103,839	5.38E-01	1.24E-01
Industrial Sum	119,868	50,478	1.38E-01	6.95E-02
Municipal	78.2%	67.3%	79.6%	64.1%
% Industrial	21.8%	32.7%	20.4%	35.9%
% Municipal				

TABLE 7
Summary of Two-Stage TMDL Proposal

Facility Name	Receiving Water	Stage 1 UOD (lbs/day)	Stage 2 UOD (lbs/day)
BASF	Harbor	3,841	An additional 6,700 -16,200 lbs/day reduction (depending on location) in UOD
Garden City WPCP	Harbor	3,500	
Georgia Pacific - Savannah River Mill	Harbor	9,659	
Hardeeville	Harbor	2,233	
International Paper Company - Savannah Mill	Harbor	23,284	
PCS Nitrogen Fertilizer Sav	Harbor	1,430	
Savannah - President Street WPCP	Harbor	8,632	
Savannah - Travis Field WPCP	Harbor	2,043	
Savannah - Wilshire WPCP	Harbor	6,472	
US Army - Hunter Airfield	Harbor	1,980	
Weyerhaeuser Company - Port Wentworth	Harbor	21,265	
Aiken PSA/Horse Creek WWTF	River	6,253	
Allendale	River	3,954	
Augusta - James B. Messerly WPCP	River	10,470	
Clariant Corp/Martin Plant	River	4,073	
Columbia County - Crawford Creek WPCP	River	600	
Columbia County - Little River WPCP	River	2,342	
Columbia County - Reed Creek WPCP	River	1,739	
Columbia County - Kiokee Creek WPCP	River	261	
DSM Chemicals Augusta Inc	River	2,632	
International Paper Company - Augusta Mill	River	27,353	
Kimberly-Clark/Beech Island	River	3,649	
PCS Nitrogen Fertilizer Aug	River	5,310	
Savannah River Site (SRS) Discharges (50% red.)	Watershed	1,343	

Appendix C: Memorandum of Understanding Between Dischargers to the Savannah River and Harbor

MEMORANDUM OF UNDERSTANDING
BETWEEN
DISCHARGERS TO THE SAVANNAH RIVER AND HARBOR

I. PURPOSE

In 2010, the U.S. Environmental Protection Agency (EPA) published a draft revised total maximum daily load (TMDL) to address dissolved oxygen impairments of the Savannah Harbor. The TMDL will require major reductions in the permitted loads of oxygen-demanding substances to the Savannah River and Harbor. EPA and the states of Georgia and South Carolina have allowed the affected dischargers to develop a mutually agreeable set of individual wasteload allocations (WLAs), to be incorporated into the final TMDL. EPA also developed a TMDL Calculator to be used to evaluate potential allocation scenarios.

This memorandum of understanding (MOU) reflects the consensus of the signatory dischargers to a specific set of WLAs for the first component of the TMDL implementation. The consensus was achieved through a facilitated process that sought compromise between various equity concepts.

This MOU does not represent the agreement of any discharger to an individual WLA independent of the larger agreement of the signatories. In addition, this MOU is dependent upon the technical and regulatory assumptions set forth in section III below. By entering into this MOU, the signatory dischargers do not waive any rights that they may have to contest the TMDL or its underlying technical basis.

II. WASTELOAD ALLOCATIONS

The specific set of WLAs set forth in Table 1 reflects the consensus of the signatory dischargers. The technical basis of the WLA is provided in the attached document entitled *Technical Basis of Wasteload Allocation Proposal*, which is hereby incorporated by reference. The distribution of individual WLAs was derived using the TMDL Calculator version 4.0 which predicts that the distribution will achieve approximately 98% of the reductions necessary to achieve the TMDL.

TABLE 1

Component 1 Wasteload Allocations

Facility Name	Receiving Water	Constituents Upon Which UOD WLA Is Based	Component 1 UOD WLA (lb/d) (see Note 1)
BASF	Harbor	NH4-N	3,841
Garden City WPCP	Harbor	CBOD5 & NH4-N	3,500
Georgia Pacific - Savannah River Mill	Harbor	CBOD5 & NH4-N	9,659
Hardeeville	Harbor	CBOD5 & NH4-N	2,233
International Paper Company - Savannah Mill	Harbor	CBOD5 & NH4-N	23,284
PCS Nitrogen Fertilizer Savannah	Harbor	NH4-N	1,430
Savannah - President Street WPCP	Harbor	CBOD5 & NH4-N	8,632
Savannah - Travis Field WPCP	Harbor	CBOD5 & NH4-N	2,043
Savannah - Wilshire WPCP	Harbor	CBOD5 & NH4-N	6,472
US Army - Hunter Airfield	Harbor	CBOD5 & NH4-N	1,980
Weyerhaeuser Company - Port Wentworth	Harbor	CBOD5 & NH4-N	21,265
Aiken PSA/Horse Creek WWTF	River	CBOD5 & NH4-N	6,253
Allendale	River	CBOD5 & NH4-N	3,954
Augusta - James B. Messerly WPCP	River	CBOD5 & NH4-N	10,470
Clariant Corp/Martin Plant	River	CBOD5 & NH4-N	4,073
Columbia County - Crawford Creek WPCP	River	CBOD5 & NH4-N	600
Columbia County - Little River WPCP	River	CBOD5 & NH4-N	2,342
Columbia County - Reed Creek WPCP	River	CBOD5 & NH4-N	1,739
Columbia County - Kiokee Creek WPCP	River	CBOD5 & NH4-N	261
DSM Chemicals Augusta Inc	River	CBOD5 & NH4-N	2,632
International Paper Company - Augusta Mill	River	CBOD5 & NH4-N	27,353
Kimberly-Clark/Beech Island	River	CBOD5	3,649
PCS Nitrogen Fertilizer Augusta	River	NH4-N	5,310
Savannah River Site (SRS) Discharges (50% red.)	Watershed	CBOD5 & NH4-N	1,343

Note 1. As described in the *Technical Basis of Wasteload Allocation Proposal*, the component 1 WLAs of some facilities reflect larger reductions than would be required by the consensus-based allocations rules agreed upon by the signatories. The signatories agree that in component 2 of implementation, these facilities should be credited with these additional load reductions already offered. Expressed as UOD, the component 2 credits are as follows: 457 lb/day (PCS Nitrogen-Savannah), 4,412 lb/day (Weyerhaeuser), 914 lbs/day (Clariant Corp.), 362 lb/day (Kimberly –Clark), and 91 lb/day (Savannah River Site), as set forth in section 3.7 of the accompanying technical document.

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III. ASSUMPTIONS

The MOU is contingent upon the following assumptions:

A. While Table 1 is expressed in terms of ultimate oxygen demand (UOD), it is assumed that the agencies will provide flexibility in how the UOD is partitioned between effluent parameters such as carbonaceous biochemical oxygen demand (CBOD5) and ammonia nitrogen in individual NPDES permits. Where a facility is identified in the TMDL for only one of these parameters (i.e., ammonia), the entire UOD will be applied to that parameter. Similarly, for entities with multiple permitted discharges, the agencies will provide flexibility in how the collective WLA is distributed between permits, using the TMDL Calculator to demonstrate that the collective deficit caused by the trading partners achieves the collective TMDL WLA for those discharges.

B. It is assumed that federal and state regulators will allow a phased compliance schedule that includes a "component 2" process to resolve certain uncertainties regarding issues such as DO injection, pollutant credit trading/offsets, "up to 10%" demonstration, prior to assigning individual WLAs that close the 2% attainment gap.

C. It is assumed that the WLAs will be implemented through limits on parameters that already have limits at specific outfalls in existing NPDES permits. The MOU does not represent an agreement to any limits on parameters that may be present in existing discharges, but for which reasonable potential determinations have not previously indicated the need for limits.

D. It is assumed that non-signatory dischargers to the Savannah River and Harbor will receive limits that are at least as stringent as with those represented in Table 1.

E. Except as may be set forth in Note 1 of Table 1above or in Section 3.7 of the *Technical Basis of Wasteload Allocation Proposal*, nothing in this MOU creates any right or obligations to a future component 2 WLA.

IV. EFFECT OF MOU

This MOU is intended solely to memorialize the WLAs and the assumptions on which they are based so that they can then be incorporated into the final TMDL. This MOU does not create any rights, either substantive or procedural, that are enforceable by any signatory discharger. Nothing in this MOU is intended to diminish, modify, or otherwise affect the legal rights or obligations of any of the signatory dischargers.

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	Weyerhaeuser NR Port Wentworth
Name (printed):	Robert W. Williams
Title:	VP / Mill Manager
Signature:	[signature]
Date:	1/30/2012
Phone number:	912 964 1271
Mailing address:	PO Box 668 Savannah, GA 31402

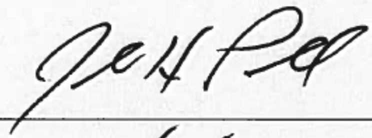
This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	International Paper - Savannah Mill and Augusta Mill
Name (printed):	Tommy S. Joseph
Title:	Senior Vice President
Signature:	[signature] 9/12/2011
Date:	
Phone number:	901-419-4775
Mailing address:	6400 Poplar Ave Memphis, TN 38197 attn: Brian Heim, Chief Counsel, Environmental Law

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	Augusta Utilities
Name (printed):	Tom Wiedmeier
Title:	Director
Signature:	Tom D. Wiedmeier
Date:	January 4, 2012
Phone number:	(706) 312-4160
Mailing address:	360 Bay St. Ste. 180 Augusta, GA 30901

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	KIMBERLY-CLARK BEECH ISLAND MILL
Name (printed):	JOHN POWNALL
Title:	MILL MANAGER
Signature:	
Date:	08/16/2011
Phone number:	(803) 827-1100
Mailing address:	246 OLD JACKSON HWY BEECH ISLAND, SC 29842

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	Georgia-Pacific Consumer Products LP - Savannah River Mill
Name (printed):	Kelly L Wolff
Title:	VP Manufacturing
Signature:	[signature]
Date:	8.23.11
Phone number:	912.826.9209
Mailing address:	P.O. Box 828 Rincon, GA 31326-0828

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	Beaufort Jasper Water and Sewer Authority
Name (printed):	Ed Saxon
Title:	Deputy General Manager/Ops & Eng
Signature:	
Date:	
Phone number:	843-987-9249
Mailing address:	6 Snake Road Okatie, SC 29909

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	Clariant Corporation
Name (printed):	Victor B. Ethridge
Title:	ESHA Manager
Signature:	Victor B. Ethridge
Date:	August 18, 2011
Phone number:	803-584-4321
Mailing address:	788 Chert Quarry Road Martin, SC 29836

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	Aiken County PUblic Service Authority
Name (printed):	Mr. Clay Killian
Title:	Aiken County Administrator
Signature:	[signature]
Date:	August 18, 2011
Phone number:	(803) 278-1911
Mailing address:	Post Office Box 6548 North Augusta, SC 29861

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	(ESH+Q) Savannah River Nuclear Solutions
Name (printed):	Alice C. Doswell
Title:	Vice President
Signature:	Alice C. Doswell
Date:	8/15/11
Phone number:	803.952.7198
Mailing address:	Savannah River Nuclear Solutions LLC 730-1B Aiken, SC 29808

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	Columbia County Board of Commissioners
Name (printed):	Ron C. Cross
Title:	Chairman
Signature:	[signature]
Date:	September 6, 2011
Phone number:	706 868 3379
Mailing address:	630 Ronald Reagan Dr. Bldg B PO Box 498 Evans, GA 30809

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	City of Savannah
Name (printed):	Rochelle Small-Toney
Title:	City Manager
Signature:	Rochelle D. Small-Toney
Date:	2/23/12
Phone number:	912.651.6415
Mailing address:	P. O. Box 1027 Savannah GA 31402

This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	BASF Corporation
Name (printed):	Dustin G. Allen
Title:	Site Manager
Signature:	Dustin Allen
Date:	August 16, 2011
Phone number:	912-644-3838
Mailing address:	BASF Corporation 1800 East President Street Savannah, Georgia 31404

Savannah River/Harbor Dischargers Group

As the duly authorized representative of the organization identified below, I agree to the terms of the Participation Agreement.

Dated: November 11, 2011

Organization Name: DSM Chemicals North America, Inc.

By: Beth Connell
(Name of authorized representative)

SHE & Security Manager
(Title)

Signature: Beth Connell

Designated Contact for Receipt of Invoices and Notices:

Name: Beth Connell

Address: P.O. Box 2451
Augusta, GA 30903

Telephone Number: (706) 849-6395

Facsimile Number: (706) 849-6487

E-mail Address: beth.connell@dsm.com

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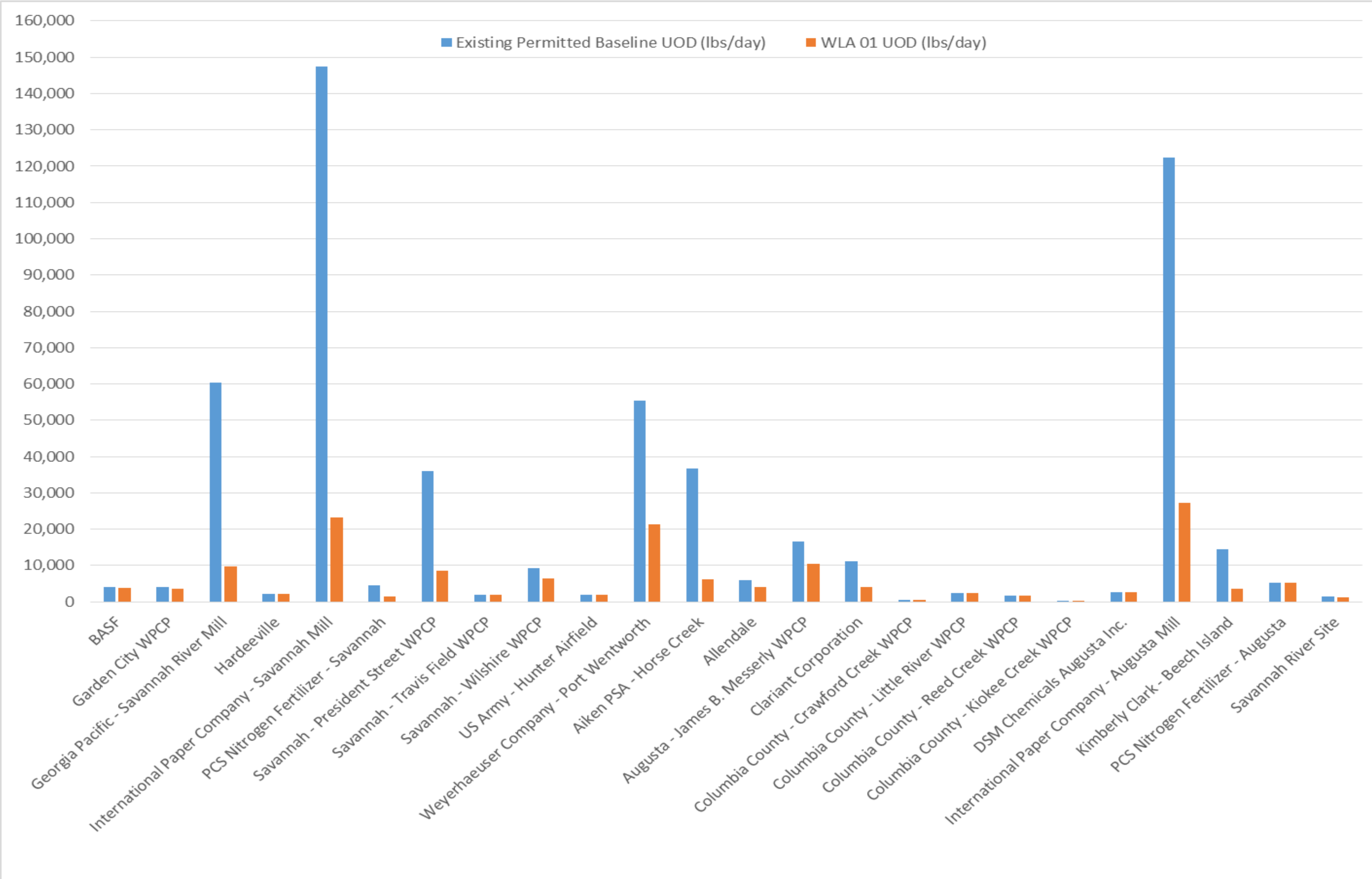
This signature on this page indicates agreement by the indicated organization to the memorandum of understanding between dischargers to the Savannah River and Harbor.

Organization:	PCS Nitrogen Fertilizer, L.P. By PCS Nitrogen Fertilizer Operations, Inc., Its General Partner
Name (printed):	Raef Sully
Title:	President
Signature:	
Date:	1 DEC 2014
Phone number:	847-849-4200
Mailing address:	1101 Skokie Blvd., Suite 400 Northbrook, IL 60062

Appendix D: Savannah River and Harbor DO Calculator Run

Facility Name	Receiving Water	NPDES Permit Number	Existing Permitted Baseline UOD (lbs/day)	WLA 01 UOD (lbs/day)	Percent Reduction in UOD from Existing Permitted Baseline to WLA 01 (%)
BASF	Harbor	GA0048330	4022	3841	4.50%
Garden City WPCP	Harbor	GA0031038	4089	3500	14.40%
Georgia Pacific - Savannah River Mill	Harbor	GA0046973	60372	9659	84.00%
Hardeeville	Harbor	SC0034584	2233	2233	0.00%
International Paper Company - Savannah Mill	Harbor	GA0001988	147474	23285	84.21%
PCS Nitrogen Fertilizer - Savannah	Harbor	GA0002356	4570	1430	68.71%
Savannah - President Street WPCP	Harbor	GA0025348	35965	8632	76.00%
Savannah - Travis Field WPCP	Harbor	GA0020427	2043	2043	0.00%
Savannah - Wilshire WPCP	Harbor	GA0020443	9200	6472	29.65%
US Army - Hunter Airfield	Harbor	GA0027588	1980	1980	0.00%
Weyerhaeuser Company - Port Wentworth	Harbor	GA0002798	55325	21265	61.56%
Aiken PSA - Horse Creek	River	SC0024457	36804	6253	83.01%
Allendale	River	SC0039918	6068	3954	34.84%
Augusta - James B. Messerly WPCP	River	GA0037621	16544	10470	36.71%
Clariant Corporation	River	SC0042803	11182	4073	63.58%
Columbia County - Crawford Creek WPCP	River	GA0031984	600	600	0.00%
Columbia County - Little River WPCP	River	GA0047775	2342	2342	0.00%
Columbia County - Reed Creek WPCP	River	GA0031992	1739	1739	0.00%
Columbia County - Kiokee Creek WPCP	River	GA0038342	261	261	0.00%
DSM Chemicals Augusta Inc.	River	GA0002160	2632	2632	0.00%
International Paper Company - Augusta Mill	River	GA0002801	122290	27353	77.63%
Kimberly Clark - Beech Island	River	SC0000582	14592	3649	74.99%
PCS Nitrogen Fertilizer - Augusta	River	GA0002071	5310	5310	0.00%
Savannah River Site	River	SC0000175	1412	1343	4.89%


Existing Permitted Baseline UOD (lbs/day)
WLA 01 UOD (lbs/day)
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
BASF
Garden City WPCP
Georgia Pacific - Savannah River Mill
Hardeeville
International Paper Company - Savannah Mill
PCS Nitrogen Fertilizer - Savannah
Savannah - President Street WPCP
Savannah - Travis Field WPCP
Savannah - Wilshire WPCP
US Army - Hunter Airfield
Weyerhaeuser Company - Port Wentworth
Aiken PSA - Horse Creek
Allendale
Augusta - James B. Messerly WPCP
Clariant Corporation
Columbia County - Crawford Creek WPCP
Columbia County - Little River WPCP
Columbia County - Reed Creek WPCP
Columbia County - Kiokee Creek WPCP
DSM Chemicals Augusta Inc.
International Paper Company - Augusta Mill
Kimberly Clark - Beech Island
PCS Nitrogen Fertilizer - Augusta
Savannah River Site

Dissolved Oxygen Deficit Calculations for the Savannah Harbor

Savannah Harbor Delta DO Target: 0.149 mg/L

Existing Conditions				Background Data and Available Information					WLA for Savannah Harbor				
Zone ID	Zone #	Delta DO 90th Percentile (mg/L)	Delta DO Target Excess (mg/L)	Zone ID	Zone #	Delta DO 90th Percentile (mg/L)	Delta DO Target Excess (mg/L)	Percent Delta DO Excess Remaining	Zone ID	Zone #	Delta DO 90th Percentile (mg/L)	Delta DO Target Excess (mg/L)	Percent Delta DO Excess Remaining
FR27	5	0.3619	0.2129	FR27	5	0.3595	0.21051	98.9%	FR27	5	0.1089	0.00000	0.0%
FR25	6	0.4112	0.2622	FR25	6	0.3982	0.24923	95.0%	FR25	6	0.1099	0.00000	0.0%
FR23	7	0.4719	0.3229	FR23	7	0.4519	0.30287	93.8%	FR23	7	0.1164	0.00000	0.0%
FR21	8	0.5245	0.3755	FR21	8	0.4993	0.35025	93.3%	FR21	8	0.1226	0.00000	0.0%
FR19	9	0.5663	0.4173	FR19	9	0.5433	0.39433	94.5%	FR19	9	0.1329	0.00000	0.0%
FR17	10	0.5726	0.4236	FR17	10	0.5502	0.40120	94.7%	FR17	10	0.1340	0.00000	0.0%
FR15	11	0.5637	0.4147	FR15	11	0.5436	0.39458	95.2%	FR15	11	0.1331	0.00000	0.0%
FR13	12	0.5379	0.3889	FR13	12	0.5206	0.37158	95.6%	FR13	12	0.1280	0.00000	0.0%
FR11	13	0.5049	0.3559	FR11	13	0.4902	0.34120	95.9%	FR11	13	0.1215	0.00000	0.0%
FR09	14	0.4556	0.3066	FR09	14	0.4434	0.29438	96.0%	FR09	14	0.1105	0.00000	0.0%
FR07	15	0.3811	0.2321	FR07	15	0.3719	0.22289	96.0%	FR07	15	0.0931	0.00000	0.0%
FR05	16	0.3141	0.1651	FR05	16	0.3070	0.15797	95.7%	FR05	16	0.0768	0.00000	0.0%
FR03	17	0.2494	0.1004	FR03	17	0.2443	0.09534	94.9%	FR03	17	0.0614	0.00000	0.0%
FR01	18	0.1888	0.0398	FR01	18	0.1855	0.03652	91.7%	FR01	18	0.0465	0.00000	0.0%
OCE1	19	0.0871	-0.0619	OCE1	19	0.0865	0.00000	0.0%	OCE1	19	0.0223	0.00000	0.0%
OCE2	20	0.0192	-0.1299	OCE2	20	0.0191	0.00000	0.0%	OCE2	20	0.0054	0.00000	0.0%
LBR	21	0.3040	0.1550	LBR	21	0.3016	0.15261	98.5%	LBR	21	0.0892	0.00000	0.0%
BR2	22	0.2222	0.0732	BR2	22	0.2199	0.07088	96.9%	BR2	22	0.0598	0.00000	0.0%
BR1	23	0.3088	0.1598	BR1	23	0.3023	0.15330	95.9%	BR1	23	0.0783	0.00000	0.0%
SEDB	24	0.5094	0.3604	SEDB	24	0.4951	0.34607	96.0%	SEDB	24	0.1233	0.00000	0.0%
STCH	25	0.3382	0.1892	STCH	25	0.3311	0.18208	96.2%	STCH	25	0.0822	0.00000	0.0%
MR2	26	0.3054	0.1564	MR2	26	0.3003	0.15129	96.7%	MR2	26	0.0829	0.00000	0.0%
MR1	27	0.4212	0.2722	MR1	27	0.4071	0.25811	94.8%	MR1	27	0.1047	0.00000	0.0%