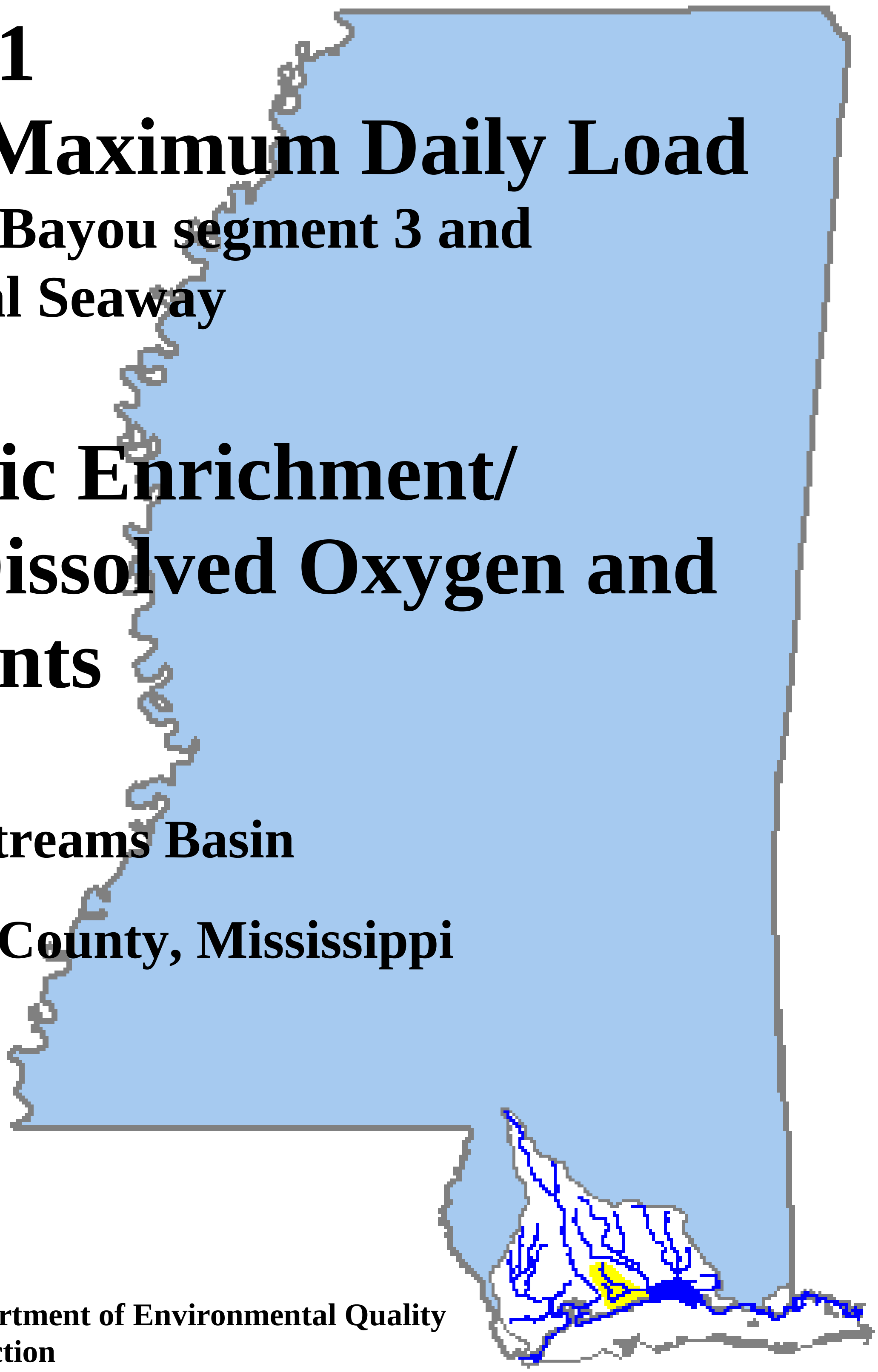
FINAL
November 2001

# Phase 1
# Total Maximum Daily Load
## Bernard Bayou segment 3 and Industrial Seaway

# Organic Enrichment/ Low Dissolved Oxygen and Nutrients

## Coastal Streams Basin

## Harrison County, Mississippi




**Prepared by**
**Mississippi Department of Environmental Quality**
**TMDL/WLA Section**
**P.O. Box 10385**
**Jackson, MS  39289-0385**
**(601) 961-5171**

# FOREWORD

The report contains one or more Total Maximum Daily Loads (TMDLs) for waterbody segments found on Mississippi's 1996 Section 303(d) List of Impaired Waterbodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

**Conversion Factors**

| To convert from | To | Multiply by | To Convert from | To | Multiply by |
|---|---|---|---|---|---|
| acres | sq. miles | 0.0015625 | days | seconds | 86400 |
| cubic feet | cu. meter | 0.028316847 | feet | meters | 0.3048 |
| cubic feet | gallons | 7.4805195 | gallons | cu. feet | 0.133680555 |
| cubic feet | liters | 28.316847 | hectares | acres | 2.4710538 |
| cfs | gal/min | 448.83117 | miles | meters | 1609.344 |
| cfs | MGD | 0.6463168 | mg/l | ppm | 1 |
| cubic meters | gallons | 264.17205 | µg/l * cfs | gm/day | 2.45 |
| cubic meters | liters | 1000 | µg/l * MGD | gm/day | 3.79 |

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# MONITORED SEGMENT IDENTIFICATION

| | |
|---|---|
| Name: | Bernard Bayou segment 3 |
| Waterbody ID: | MS118BBM3 |
| Location: | Near Gulfport: From Highway 49 to Industrial Seaway at Entrance to Bernard Bayou Natural Channel |
| County: | Harrison County, Mississippi |
| USGS HUC Code: | 03170009 |
| Length: | 4 miles |
| Use Impairment: | Aquatic Life Support |
| Cause Noted: | Organic Enrichment/Low Dissolved Oxygen |
| Priority Rank: | 21 |
| NPDES Permits: | There are 5 NPDES permits issued for facilities that potentially discharge oxidizable organic material in the watershed (Table 3.1). |
| Standards Variance: | None |
| Pollutant Standard: | Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in the top 5 feet. |
| Waste Load Allocation: | May – October: 4,532.4 lbs/day Total Biochemical Oxygen Demand<br>November – April: 16,814.2 lbs/day Total Biochemical Oxygen Demand |
| Load Allocation: | May – October: 9,938.1 lbs/day Total Biochemical Oxygen Demand<br>November – April: 9,938.1 lbs/day Total Biochemical Oxygen Demand |
| Margin of Safety: | Implicit modeling assumptions |
| Total Maximum Daily Load (TMDL): | May – October: 14,470.5 lbs/day Total Biochemical Oxygen Demand<br>November – April: 26,752.3 lbs/day Total Biochemical Oxygen Demand |

# MONITORED SEGMENT IDENTIFICATION

| | |
|---|---|
| Name: | Bernard Bayou segment 3 |
| Waterbody ID: | MS118BBM3 |
| Location: | Near Gulfport: From Highway 49 to Industrial Seaway at Entrance to Bernard Bayou Natural Channel |
| County: | Harrison County, Mississippi |
| USGS HUC Code: | 03170009 |
| Length: | 4 miles |
| Use Impairment: | Aquatic Life Support |
| Cause Noted: | Nutrients |
| Priority Rank: | 21 |
| NPDES Permits: | There are 5 NPDES permits issued for facilities that potentially discharge nutrients in the watershed (Table 3.1). |
| Standards Variance: | None |
| Pollutant Standard: | Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in the top 5 feet. |
| Waste Load Allocation: | May – October: 916.1 lbs/day $PO_4$, 340.5 lbs/day $NH_3$-N, and 575.6 lbs/day $NO_3$-N<br>November – April: 1031.9 lbs/day $PO_4$, 2,079.4 lbs/day $NH_3$-N, and 667.3 lbs/day $NO_3$-N |
| Load Allocation: | May – October: 37.0 lbs/day $PO_4$, 123.3 lbs/day $NH_3$-N, and 160.4 lbs day $NO_3$-N<br>November – April: 37.0 lbs/day $PO_4$, 123.3 lbs/day $NH_3$-N, and 160.4 lbs day $NO_3$-N |
| Margin of Safety: | Implicit modeling assumptions. |
| Total Maximum Daily Load (TMDL): | May – October: 953.1 lbs/day $PO_4$, 463.9 lbs/day $NH_3$-N, and 735.9 lbs/day $NO_3$-N<br>November – April: 1,068.9 lbs/day $PO_4$, 2,202.8 lbs/day $NH_3$-N, and 827.6 lbs/day $NO_3$-N |

# MONITORED SEGMENT IDENTIFICATION

| | |
|---|---|
| Name: | Industrial Seaway |
| Waterbody ID: | MS118BBM5 |
| Location: | Near Gulfport: From Gulfport Lake to Mouth at Big Lake |
| County: | Harrison County, Mississippi |
| USGS HUC Code: | 03170009 |
| Length: | 2 miles |
| Use Impairment: | Aquatic Life Support |
| Cause Noted: | Organic Enrichment/Low Dissolved Oxygen |
| Priority Rank: | 131 |
| NPDES Permits: | There are 5 NPDES permits issued for facilities that potentially discharge oxidizable organic material in the watershed (Table 3.1). |
| Standards Variance: | None |
| Pollutant Standard: | Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in the top 5 feet. |
| Waste Load Allocation: | May – October: 4,532.4 lbs/day Total Biochemical Oxygen Demand<br>November – April: 16,814.2 lbs/day Total Biochemical Oxygen Demand |
| Load Allocation: | May – October: 9,938.1 lbs/day Total Biochemical Oxygen Demand<br>November – April: 9,938.1 lbs/day Total Biochemical Oxygen Demand |
| Margin of Safety: | Implicit modeling assumptions |
| Total Maximum Daily Load (TMDL): | May – October: 14,470.5 lbs/day Total Biochemical Oxygen Demand<br>November – April: 26,752.3 lbs/day Total Biochemical Oxygen Demand |

# MONITORED SEGMENT IDENTIFICATION

| | |
|---|---|
| Name: | Industrial Seaway |
| Waterbody ID: | MS118BBM5 |
| Location: | Near Gulfport: From Gulfport Lake to Mouth at Big Lake |
| County: | Harrison County, Mississippi |
| USGS HUC Code: | 03170009 |
| Length: | 2 miles |
| Use Impairment: | Aquatic Life Support |
| Cause Noted: | Nutrients |
| Priority Rank: | 131 |
| NPDES Permits: | There are 5 NPDES permits issued for facilities that potentially discharge nutrients in the watershed (Table 3.1). |
| Standards Variance: | None |
| Pollutant Standard: | Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in the top 5 feet. |
| Waste Load Allocation: | May – October: 916.1 lbs/day $PO_4$, 340.5 lbs/day $NH_3$-N, and 575.6 lbs/day $NO_3$-N<br><br>November – April: 1031.9 lbs/day $PO_4$, 2,079.4 lbs/day $NH_3$-N, and 667.3 lbs/day $NO_3$-N |
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| Margin of Safety: | Implicit modeling assumptions. |
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# EXECUTIVE SUMMARY

Bernard Bayou segment 3 and Industrial Seaway have been placed on the Mississippi 1998 Section 303(d) List of Waterbodies as impaired due to organic enrichment/low dissolved oxygen and nutrients. The TMDL Report for these waterbodies has been developed as a Phase 1 TMDL. Following additional monitoring and modeling activities, the load and wasteload allocations developed in this Phase 1 TMDL will be refined, and a Phase 2 TMDL will be developed.

Figure ES.1 Industrial Seaway

The TMDLs for these waterbodies are based on a monitoring and modeling project that included the Back Bay of Biloxi and its major tributaries. The model, which used the DYNHYD and EUTRO5 components of the Water Quality Analysis Simulation Program-5 (WASP5), was developed by the Civil Engineering Department at Mississippi State University, based on water quality studies of the area which were conducted in September 1994 and April-May 1995. The dataset developed from monitoring data collected in 1994 was used for model calibration, and the dataset developed from monitoring data collected in 1995 was used for model verification. The area included in the Back Bay of Biloxi modeling project is located along the Mississippi Gulf Coast in Jackson and Harrison Counties. Also included in the study were the metropolitan areas of Biloxi, Gulfport, Ocean Springs, and D'Iberville. The Back Bay of Biloxi provides convenient and inexpensive navigation and transportation services to the economic activities of the area. The Back Bay of Biloxi and its major tributaries also provide recreational opportunities and stimulate industrial development within the region. This industrialization, in turn, tends to promote population growth and economic development within the adjoining communities and Jackson and Harrison Counties.

According to a study made in 1970 (Gulf Regional Planning Commission 1972), the 1970 population of the counties in and adjacent to Jackson, Harrison, and Hancock Counties was 240,000. The study also projected that by year 2015, the population of the counties in the region was expected to exceed 700,000. The 1990 census showed a combined population of 580,000. Since 1950, cheap water transportation, unlimited water supplies, natural gas, availability of refining products as raw materials, and extensive timber resources have provided the base for rapid industrial growth in this area. Growth has also been stimulated by resort casino facilities, by the presence of abundant fresh and saltwater marine life, and by the establishment or expansion of military installations.

Unfortunately, population growth and industrial development have been accompanied by an increased demand for water and wastewater disposal facilities. Over the past 25 years, a large number of pollution source studies (Gaines et al. 1987) revealed that in spite of the enormous improvements in physical wastewater treatment facilities, the rapid growth of residential, commercial, and industrial developments was still overwhelming the treatment systems. These studies also revealed that the estuary system was receiving tremendous amounts of seafood processing waste. Overall these comprehensive water quality surveys showed that the Biloxi Bay and Back Bay were receiving large volumes of pollution from a variety of point and nonpoint sources, and that the overall estuarine system was experiencing considerable environmental stress. It is also anticipated that the volume of wastewater generated by industry and surrounding municipalities, especially in Biloxi and Gulfport, will continue to increase in direct proportion to regional development.

The BASINS Nonpoint Source Model (NPSM) and the WASP5 Model were selected as the models for performing the TMDL calculations for this study. The NPSM was used as a watershed model for predicting the amount of runoff from each watershed draining into Bernard Bayou and Industrial Seaway. The WASP5 model was used as a receiving water model for simulating the water quality conditions in Bernard Bayou and Industrial Seaway in response to the point and nonpoint source pollutant loadings during critical, low-flow conditions.

Loading estimates of organic substances and nutrients from nonpoint sources in the watershed were based upon background concentrations measured during the model calibration/verification studies of the Back Bay of Biloxi watershed and the daily average flow due to runoff from the watershed as predicted by the NPSM model. The estimated loadings were incorporated into the WASP5 model. There are 5 NPDES permitted discharges included as point sources in the WASP5 model. Under existing, or baseline, conditions, output from the model indicated that there were no violations of the dissolved oxygen standard in Bernard Bayou segment 3 and Industrial Seaway. In addition, numeric criteria developed for toxicity due to unionized ammonia nitrogen were not exceeded. Thus no reductions of the current loadings will be recommended by this TMDL. New NPDES permitted dischargers or proposed expansions of current dischargers will be evaluated on a case-by-case basis following the development of this Phase 1 TMDL.

# 1.0 INTRODUCTION

## 1.1 Background

The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those waterbodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired waterbodies through the establishment of pollutant specific allowable loads. The pollutants of concern for this TMDL are oxidizable organic matter and nutrients, as represented by total, ultimate biochemical oxygen demand ($TBOD_U$) and the inorganic species of phosphorous and nitrogen: orthophosphate, ammonia nitrogen, and nitrate nitrogen.

Organic enrichment is measured in terms of total ultimate biochemical oxygen demand ($TBOD_U$). $TBOD_U$ is the oxygen consumed by microorganisms while stabilizing or degrading carbonaceous and nitrogenous compounds under aerobic conditions over an extended time period. The carbonaceous compounds are referred to as $CBOD_U$, and the nitrogenous compounds are referred to as $NBOD_U$. $TBOD_U$ is equal to the sum of $CBOD_U$ and $NBOD_U$, Equation 1.

$$\mathbf{CBOD_U + NBOD_U = TBOD_U} \qquad \text{Equation 1}$$

Elevated levels of nutrients, as well as oxidizable material will cause a decrease in the level of dissolved oxygen in a waterbody due to the acceleration of eutrophication. Eutrophication, or nutrient enrichment of a waterbody, results in an undesirable abundance of plant growth, particularly phytoplankton and macrophytes. Excessive plant growth can cause impairment to aquatic life and fisheries when dead plant material is broken down by microorganisms, via an oxygen demanding process. Eventually the level of oxygen in a waterbody can be depleted to the extent that desirable aquatic life are stressed or eliminated. Microbial breakdown of dead plant matter can also produce unionized ammonia, through a process called ammonification, which can adversely affect aquatic life. Nuisance plant growth in many lakes and rivers can be limited by the availability of phosphorus and nitrogen. For this reason, this Phase 1 TMDL includes phosphorus concentrations as well as nitrogen concentrations as indicators.

Phosphorus can be measured in several ways, including total phosphorus (TP) or as orthophosphorous ($PO_4$). However, orthophosphorous is more often used for setting criteria in rivers and streams because it is more representative of the form of phosphorus directly available to plants. Orphophosphorous is the most significant form of phosphorus in terms of plant growth, but because of the ability of bacteria to convert organic phosphorus to a bioavailable form, TP loading is also important (USEPA 1999).

Nitrogen in the aquatic environment can exist in several forms; dissolved nitrogen gas ($N_2$), ammonia ($NH_4^+$ and $NH_3$), nitrite ($NO_2^-$), nitrate ($NO_3^-$), and organic nitrogen as proteinaceous matter or in dissolved or particulate phases. The most important forms of nitrogen in terms of its immediate impact on water quality are the readily available, dissolved ammonia ions, nitrites, and nitrates. Particulate and organic nitrogen, because they must be converted to a usable form, are less important indicators of water quality in the short term (USEPA 1999).

In order to develop a TMDL, it is necessary to use a target value or indicator as a quantitative value for evaluating the relationship between pollutant sources and water quality. MDEQ regulations do not specify water quality targets for phosphorous and nitrogen species. The maximum nutrient loads specified in this TMDL are based on MDEQ standards for dissolved oxygen, considering the effect of these nutrients on the dissolved oxygen levels in waterbodies. According to EPA guidance, the wasteload allocations for nutrients can be expressed in terms of the inorganic forms of phosphorous and nitrogen, orthophosphorous, ammonia nitrogen, and nitrate nitrogen.

The listed segments of Bernard Bayou and Industrial Seaway are in the Coastal Streams Basin Hydrologic Unit Code (HUC) 03170009 in south Mississippi. The drainage area of the listed segments is approximately 51,000 acres; and lies within Harrison County. Figure 1.2 shows the location of the waterbody segments.

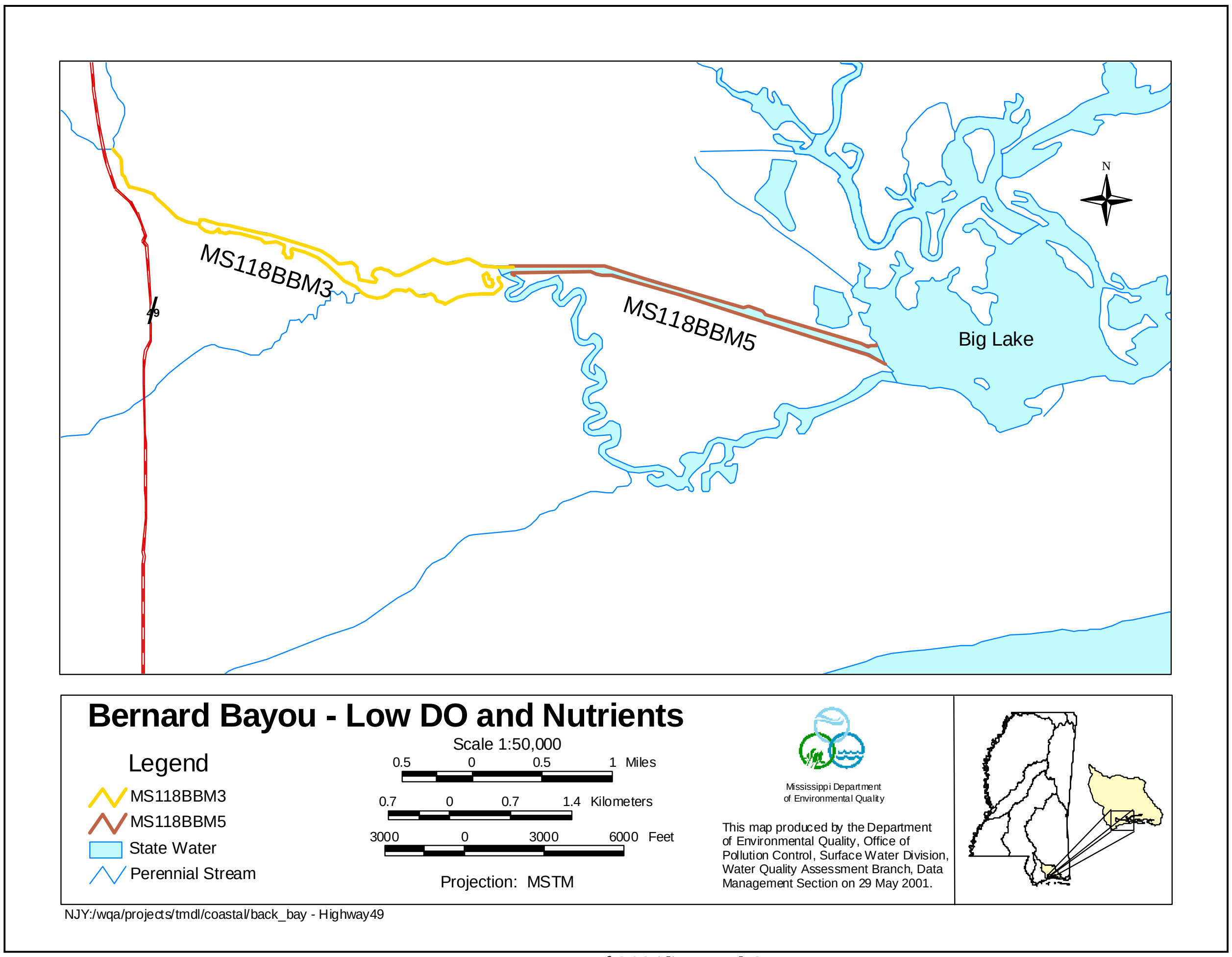


Figure 1.2 Location of 303(d) Listed Segments

## 1.2 Applicable Waterbody Segment Use

The water use classification for Bernard Bayou segment 3 and Industrial Seaway, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. Waters with this classification are intended for fishing and propagation of fish, aquatic life, and wildlife. Waters that meet the Fish and Wildlife Support criteria should also be suitable for secondary contact recreation, which is defined as incidental contact with water including wading and occasional swimming.

## 1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the waterbody and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The state standard for dissolved oxygen specifies that the dissolved oxygen shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in estuaries and in the tidally affected portions of streams. This water quality standard will be used as the targeted endpoint to evaluate impairments and to establish this TMDL for organic enrichment/low dissolved oxygen and nutrients.

# 2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

## 2.1 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by meeting the load and waste load allocations specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream target used for this TMDL is a daily average dissolved oxygen concentration of not less than 5.0 mg/l, with an instantaneous minimum dissolved oxygen concentration of not less than 4.0 mg/l. This instream dissolved oxygen target will be used to calculate allowable loads of organic material and nutrients in the waterbody. MDEQ regulations do not specify the maximum instream concentrations of organic substances and nutrients. However, the dissolved oxygen target will be used to quantify the maximum allowable loads of these substances by quantifying the maximum oxygen depletion allowed due to eutrophication caused by these substances.

Low dissolved oxygen typically occurs during seasonal low-flow periods of late summer and early fall. Elevated oxygen demand can be a primary concern during dry periods because the effects of low-flow, minimum dilution, and high temperatures combine to produce the worst case potential effect on water quality (USEPA 1997). The low-flow, high-temperature period is referred to as the critical condition for this Phase 1 TMDL. The dissolved oxygen standard applicable for Bernard Bayou and Industrial Seaway will be maintained during critical conditions when it receives the loads of oxidizable organic material and nutrients allowed in this TMDL.

Ammonia must not only be considered due to its effect on the level of dissolved oxygen in the receiving water, but also its toxicity potential. According to *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ 1994), allowable ammonia nitrogen concentrations should meet the water quality criteria given in *Quality Criteria for Water, 1986* (EPA 440/5-86-001) for a pH of 7.0 and a temperature of 25°C. The maximum allowable instream ammonia nitrogen concentration under these conditions is a 4 day average of less than 1.20 mg/l. This ammonia nitrogen concentration will be used as a water quality target for this TMDL. Model output will be analyzed to ensure that the ammonia nitrogen concentrations do not exceed the target level under the loads allowed in this TMDL.

## 2.2 Discussion and Inventory of Instream Water Quality Data

There are several monitoring stations within the listed segments where MDEQ collected water quality monitoring data. Data from these stations were used to determine the impaired status of the segments. MDEQ recently assessed the data available for Bernard Bayou and Industrial Seaway and determined that the waterbodies are fully supporting but threatened for their designated use. Previous assessments of the waterbody were based on all available dissolved oxygen data, regardless of the depth at which the data were collected. However, a revised assessment methodology has been developed by MDEQ. This new methodology was developed during the assessment year 2000. According to the new methodology, the state standard for dissolved oxygen must be maintained within the top five feet in tidally influenced portions of streams. Considering only the data that were collected at a depth of five feet and above, the state standard for DO is consistently met in Bernard Bayou segment 3 and Industrial Seaway.

The TMDL and water quality modeling are based on data collected during several intensive studies of the Back Bay of Biloxi performed by the Water Quality Assessment Branch of MDEQ and EPA Region 4. In order to investigate the impact of pollutant sources during both low-flow and high-flow conditions and provide two sets of data for calibration and verification of the model, the water quality studies were conducted during a low-flow, high-temperature period in September1994 and a higher flow period in April-May 1995. Data collected during these studies consisted of water chemistry sampling, and continuous in-situ monitoring of water quality parameters. In addition, flow, water velocity, and freshwater inflow were measured. Water quality data were collected from four monitoring stations within Bernard Bayou segment 3 and Industrial Seaway during these studies. Station S18 was located in Bernard Bayou segment 3 at Three Rivers Road. Stations S17 and S16 were located within the portion of Bernard Bayou segment 3 known as Gulfport Lake. S17 was located on the western end of the lake, while S16 was located on the eastern end, near the entrance to Industrial Seaway. Station S15 was located approximately half way between the beginning of Industrial Seaway and its entrance into Big Lake. Additional details of the sampling activities, as well as much of the data are available in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume II – Calibration/Verification, 1994/1995 Data* (Shindala et al. 1996).

# 3.0 SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential sources of organic substances and nutrients in Bernard Bayou and Industrial Seaway. The source assessment was used as the basis of development for the model and ultimate analysis of the TMDL allocation options. Sources were characterized with the best available information, monitoring data, literature values, and local management activities. This section documents the available information.

## 3.1 Assessment of Point Sources

Figure 3.1 Point Source Discharger in Gulfport Lake

There are 5 facilities permitted to discharge organic substances and nutrients included in Bernard Bayou segment 3. These facilities serve a variety of activities including residential trailer parks, industries, and municipalities. Marinas and shipyards located in the study area were considered to be discharging into the POTWs. MDEQ collected effluent samples at the point sources in the Bernard Bayou watershed in conjunction with the Back Bay of Biloxi model calibration study, in July – September 1994. The samples were analyzed for concentrations of several consistuents, including $CBOD_5$, TKN, organic nitrogen, ammonia nitrogen, nitrate nitrogen, organic phosphorous, and inorganic phosphorous. In addition, the $CBOD_U$ to $CBOD_5$ ratios were determined based on the type of wastewater treatment used at each facility. The flow from these facilities was also measured at the time that the samples were collected. Flow and water chemistry values from the September 1994 study were used as input into the Back Bay model for calibration of the water quality model. For subsequent application runs of the model, including model runs used to develop this TMDL, the maximum permitted flow and concentrations were used for each facility. Facilities included in the model are listed in Table 3.1. The concentrations and loads are given in Tables 3.2, 3.3, and 3.4. Because some of the NPDES permits for these facilities have seasonal permit limits, the loads are specified on a seasonal basis. These tables are based on permit limits of the facilities. Parameter concentrations which are not specified in NPDES permits, such as organic nitrogen, nitrate nitrogen, and organic phosphorous, are based on the data collected during MDEQ's effluent sampling. Concentrations of ammonia nitrogen were converted into an oxygen demand, $NBOD_U$. A conversion factor of 4.57 pounds of oxygen per pound of ammonia nitrogen oxidized to nitrate nitrogen was used for this calculation. The use of this factor is a conservative modeling assumption because it assumes that all of the ammonia nitrogen in the effluents is converted to nitrate nitrogen through nitrification after reaching the receiving stream.

Table 3.1. Inventory of Point Source Dischargers

| Facility Name | NPDES Permit | Receiving Waterbody |
|---|---|---|
| Harrison County WWM District/Gulfport South | MS0023345 | Bernard Bayou |
| Bernard Bayou Industrial Park | MS0027537 | Bernard Bayou |
| Harrison County/Gulport POTW – North #2 | MS0051756 | Bernard Bayou (Gulfport Lake) |
| Homestead Trailer Village | MS0051373 | Flat Branch thence Bernard Bayou |
| Walters Trailer Park | MS0046086 | Bernard Bayou |

Table 3.2. Parameter Concentrations for Point Source Dischargers

| Facility Name | Flow (MGD) | $NH_3$-N (mg/l) | $NO_3$-N (mg/l) | $PO_4$ (mg/l) | $BOD_5$ (mg/l) | $CBOD_U$/ $CBOD_5$ Ratio | $CBOD_U$ (mg/l) | DO (mg/l) | ON (mg/l) | OP (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| Harrison County WWM District/Gulfport South | 10.50 **(summer)*** **16.0** **(winter)*** | 3 **(summer)*** **15** **(winter)*** | 2 | 7 | 12 **(summer)*** **22** **(winter)*** | 2.3 | 27.60 **(summer)** **51.26** **(winter)** | 6* | 3 | 3 |
| Bernard Bayou Industrial Park | 0.60* | 6* | 2 | 2.7 | 16* | 1.5 | 24.00 | 6* | 0.75 | 0.1 |
| Harrison County/Gulfport POTW – North #2 | 5.50* | 1* | 8.5 | 1.8 | 4* | 2.3 | 9.20 | 6* | 0.1 | 0.3 |
| Homestead Trailer Village | 0.029* | 7 | 2 | 7 | 45* | 1.5 | 67.50 | 6* | 3 | 3 |
| Walters Trailer Park | 0.0015* | 7 | 2 | 7 | 45* | 1.5 | 67.50 | 6* | 3 | 3 |

*These values are specified in the NPDES Permit for the Facility.

Table 3.3. Parameter Loads for Point Source Dischargers (May – October)

| Facility Name | Flow (MGD) | $NH_3$-N (lbs/day) | $NO_3$-N (lbs/day) | $PO_4$ (lbs/day) | $BOD_5$ (lbs/day) | $CBOD_U$/ $CBOD_5$ Ratio | $CBOD_U$ (lbs/day) | DO (lbs/day) | ON (lbs/day) | OP (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| Harrison County WWM District/Gulfport South | 10.5000 | 262.71 | 175.14 | 612.99 | 1050.84 | 2.3 | 2416.93 | 525.42 | 262.71 | 262.71 |
| Bernard Bayou Industrial Park | 0.6000 | 30.02 | 10.01 | 13.51 | 80.06 | 1.5 | 120.10 | 30.02 | 3.75 | 0.50 |
| Harrison County/Gulfport POTW – North #2 | 5.5 | 46.00 | 389.90 | 82.57 | 183.48 | 2.3 | 422.00 | 275.22 | 4.59 | 13.76 |
| Homestead Trailer Village | 0.029 | 1.69 | 0.48 | 1.69 | 10.88 | 1.5 | 16.33 | 1.45 | 0.73 | 0.73 |
| Walters Trailer Park | 0.0015 | 0.09 | 0.03 | 0.09 | 0.56 | 1.5 | 0.84 | 0.08 | 0.04 | 0.04 |
| **All Facilities** | **16.6305** | **340.51** | **575.56** | **710.85** | **1325.82** | **-** | **2976.20** | **832.19** | **271.82** | **277.74** |

Table 3.4. Parameter Loads for Point Source Dischargers (November - April)

| Facility Name | Flow (MGD) | $NH_3$-N (lbs/day) | $NO_3$-N (lbs/day) | $PO_4$ (lbs/day) | $BOD_5$ (lbs/day) | $CBOD_U$/ $CBOD_5$ Ratio | $CBOD_U$ (lbs/day) | DO (lbs/day) | ON (lbs/day) | OP (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| Harrison County WWM District/Gulfport South | 16.0000 | 2001.60 | 266.88 | 934.08 | **2935.68** | 2.3 | **6752.06** | 800.64 | 400.32 | 400.32 |
| Bernard Bayou Industrial Park | 0.6000 | 30.02 | 10.01 | 13.51 | 80.06 | 1.5 | 120.10 | 30.02 | 3.75 | 0.50 |
| Harrison County/Gulfport POTW – North #2 | 5.5 | 46.00 | 389.90 | 82.57 | 183.48 | 2.3 | 422.00 | 275.22 | 4.59 | 13.76 |
| Homestead Trailer Village | 0.029 | 1.69 | 0.48 | 1.69 | 10.88 | 1.5 | 16.33 | 1.45 | 0.73 | 0.73 |
| Walters Trailer Park | 0.0015 | 0.09 | 0.03 | 0.09 | 0.56 | 1.5 | 0.84 | 0.08 | 0.04 | 0.04 |
| **All Facilities** | **22.1305** | **2079.4** | **667.3** | **1031.94** | **3210.67** | **-** | **7311.33** | **1107.41** | **409.43** | **415.35** |

The $CBOD_U$ concentrations and loads given in the previous tables are based on the assumption that $BOD_5$ is equal to $CBOD_5$. Effluent limits for oxygen-demanding, organic material in NPDES permits are generally expressed in terms of $BOD_5$, which is a measure of both carbonaceous ($CBOD_5$) and nitrogenous ($NBOD_5$) material over a 5-day incubation period. $BOD_5$ is equal to the sum of $CBOD_5$ and $NBOD_5$. Oxidation of nitrogenous material, called nitrification, usually does not take place within the first 5 days of $TBOD_U$ exertion because *Nitrosomonas* and *Nitrobacter*, the two types of bacteria that are responsible for nitrification, are normally not present in large numbers. A measurable oxygen demand due to nitrification is usually not exerted for six to ten days because the reproductive rates of these bacteria are extremely slow (Metcalf and Eddy 1991). Thus, $NBOD_5$ is negligible, and the assumption that $BOD_5$ is equal to $CBOD_5$ is valid.

## 3.2 Assessment of Nonpoint Sources

Nonpoint loading of organic material in a waterbody results from the transport of the material into receiving waters by overland surface runoff and groundwater infiltration. Landuse activities within the drainage basin, such as agriculture, silvaculture, and urbanization contribute to nonpoint source loading. Other nonpoint pollution sources include atmospheric deposition and natural weathering of rocks, soil, and fallen leaves.

As described in *Protocol for Developing Nutrient TMDLs*, using site-specific data collected at monitoring stations upstream of the area of concern can be used to estimate boundary conditions and nonpoint source loads. Load estimates at the upstream monitoring station can typically be derived from measurements of flow and concentrations of organic materials and nutrients. These relationships can be used to estimate the loads. In the EUTRO5 model, constant concentrations were specified for each water quality constituent at each upstream boundary. A freshwater inflow study conducted during the period of May 1993 to August 1994, in conjunction with the Back Bay of Biloxi model study, was used as the main source of data for the model boundary conditions. Table 3.4 shows the boundary concentrations established for Bernard Bayou.

Table 3.5. Boundary Conditions for Bernard Bayou

| $NH_3$-N (mg/l) | $NO_3$-N (mg/l) | $PO_4$ (mg/l) | $CBOD_U$ (mg/l) | DO (mg/l) | ON (mg/l) | OP (mg/l) |
|---|---|---|---|---|---|---|
| 0.1 | 0.13 | 0.03 | 7.6 | 5.0 | 0.5 | 0.02 |

Using these boundary conditions, nonpoint source loads were estimated on a subwatershed basis by using yearly average runoff for each subwatershed. Yearly average runoff was calculated from output from the NPSM for 1995. The year 1995 was chosen because it was a wet-year, and thus would give a greater average daily flow. The estimated nonpoint source loads are given in Table 3.5. The drainage area of Bernard Bayou segment 3 and Industrial Seaway was divided into 5 subwatersheds for determination of the subwatershed size and estimation of the nonpoint source loads. The locations of the subwatersheds are shown in Figure 3.2.

Table 3.6 Calculation of Nonpoint Source Loads

| Watershed | Yearly Average Flow (cfs) | $NH_3$-N (lbs/day) | $NO_3$-N (lbs/day) | $PO_4$ (lbs/day) | $CBOD_U$ (lbs/day) | ON (lbs/day) | OP (lbs/day) |
|---|---|---|---|---|---|---|---|
| W1 | 6.2 | 3.34 | 4.35 | 1.00 | 254.07 | 16.72 | 0.67 |
| W9 | 8.95 | 4.83 | 6.27 | 1.45 | 366.76 | 24.13 | 0.97 |
| W11 | 10.54 | 5.68 | 7.39 | 1.70 | 431.92 | 28.42 | 1.14 |
| W36 | 107.55 | 57.99 | 75.39 | 17.40 | 4407.31 | 289.95 | 11.60 |
| W37 | 95.52 | 51.50 | 66.96 | 15.45 | 3914.33 | 257.52 | 5.15 |

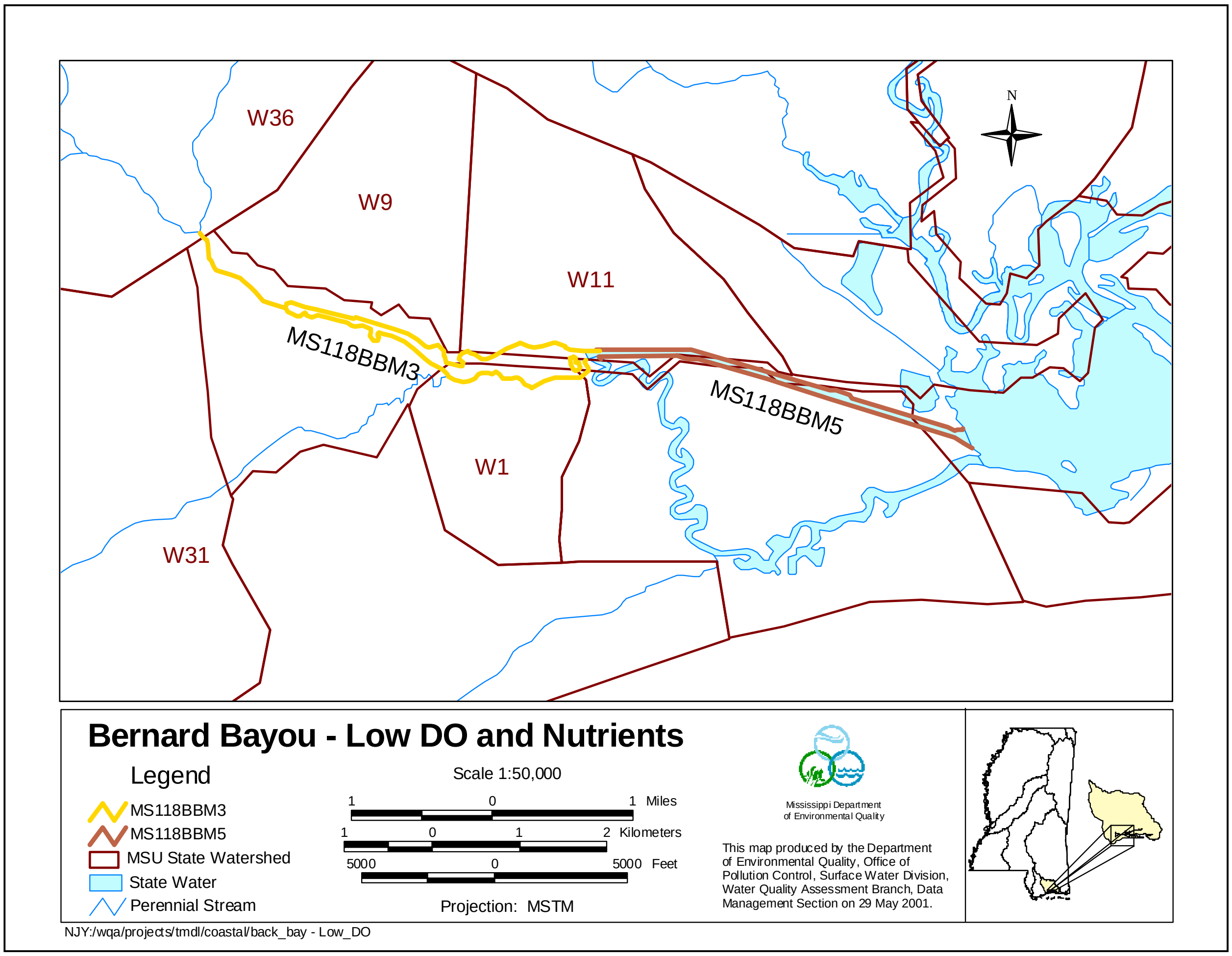


Figure 3.2. Subwatershed Locations

The 51,000 acre drainage area of Bernard Bayou and Industrial Seaway contains many different landuse types, including urban, forest, cropland, pasture, barren, and wetlands. The landuse information for the entire watershed is based on the State of Mississippi's Automated Resource Information System (MARIS 1997). This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. Figure 3.1 shows the landuse distribution for the watershed. The land use distribution is shown in Table 3.6. Forest and wetland areas represent the largest percentage of landuses within the watershed. The watershed includes the metropolitan area of Gulfport and Biloxi. Gulfport's major industries include fishing, seafood processing, glass making, chemicals, pharmaceuticals, steel products, iron and machine works, and aluminum extrusions. Waterborne commerce includes fertilizers, chemicals, seafood, and pulpwood products.

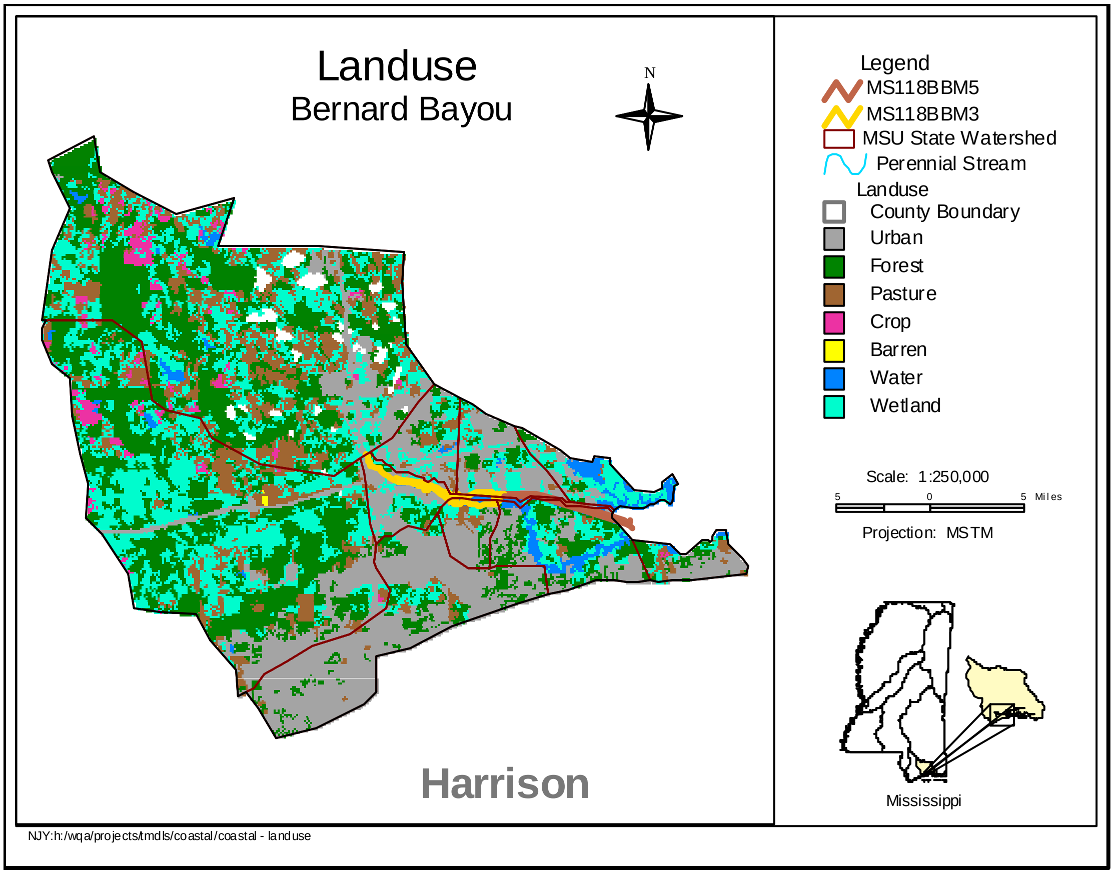


Figure 3.3 Landuse Distribution within the Bernard Bayou segment 3 and Industrial Seaway Watershed

Table 3.7. Landuse Distribution in Acres for the Bernard Bayou segment 3 and Industrial Seaway Watershed

| | Urban | Forest | Cropland | Pasture | Barren | Water | Wetland | Total |
|---|---|---|---|---|---|---|---|---|
| **Area (acres)** | 11,955.97 | 16,474.43 | 1,037.88 | 6,811.05 | 16.01 | 1,373.68 | 13,340.10 | 51,009.12 |
| **% Area** | 23.44 | 32.30 | 2.03 | 13.35 | 0.03 | 2.69 | 26.15 | 100.00 |

# 4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source loads. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

## 4.1 Modeling Framework Selection

The Phase 1 TMDL for Bernard Bayou and Industrial Seaway was developed using two computer simulation models. The NPSM model, which simulated the hydrology of the watershed, was used to calculate the yearly average runoff and nonpoint source pollutant loadings from the watershed. The loads were input into the Water Quality Analysis Simulation Program 5 (WASP5). WASP5 was used to simulate hydrodynamics, salinity, and water quality conditions within Bernard Bayou and Industrial Seaway. The WASP5 model consists of three stand-alone computer programs, DYNHYD, EUTRO5, and TOXI5. These programs can be run in conjunction with the others or separately. The hydrodynamics program, DYNHYD, was used to simulate the movement of water, while the water quality program, EUTRO5, was used to simulate the movement and interaction of the pollutants within the water. This TMDL report gives a brief description of the model setup and application of the models used for developing this Phase 1 TMDL. Detailed information about the NPSM is available in *Better Assessment Science Integrating Point and Nonpoint Sources, BASINS, Version 2.0 User's Manual* (USEPA 1998). Additional details of the model setup and calibration of the WASP5 model are available in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume I – Model Documentation* (Shindala et al. 1996).

## 4.2 Model Setup

The BASINS model platform and the NPSM model were used to model the watershed hydrology and load washoff from the watersheds of Bernard Bayou and Industrial Seaway. BASINS is a multipurpose environmental analysis system for use in performing watershed and water quality-based studies. A geographic information system (GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landuses, monitoring stations, and stream descriptions. The calibrated NPSM model simulated nonpoint source runoff from selected subwatersheds in order to isolate the major stream reaches and to allow for the relative contribution of nonpoint sources to be addressed within each subwatershed. The weather data used for the NPSM were collected at several locations in the study area. The representative hydrologic period used for the NPSM was a wet year, 1995, as determined by an analysis of mean annual rainfall distributions at several weather stations including Biloxi, Gulfport Naval Center, Merril, Ocean Springs, Saucier Experimental Forest Station, Vancleave, and Wiggins Ranger Station.

WASP5 is a dynamic model that can be used to simulate water quality processes in aquatic systems. The model incorporates the time-varying processes of advection, dispersion, and boundary exchange in simulating both the water column and benthic systems. In order to set up the water quality portion of the model, the Back Bay of Biloxi and its major tributaries were divided into 641 segments. Figure 4.1 shows the segment locations and numbers within Bernard Bayou and Industrial Seaway. The representative hydrologic period used for the WASP5 Model was a low-flow, high-temperature period in August – September 1994. Both point and nonpoint sources were represented in the model. Pollutant loadings from point and nonpoint sources were added as a direct input into the appropriate segment of the EUTRO model. Loads were represented as a constant source, and input into the model in units of lbs/day.

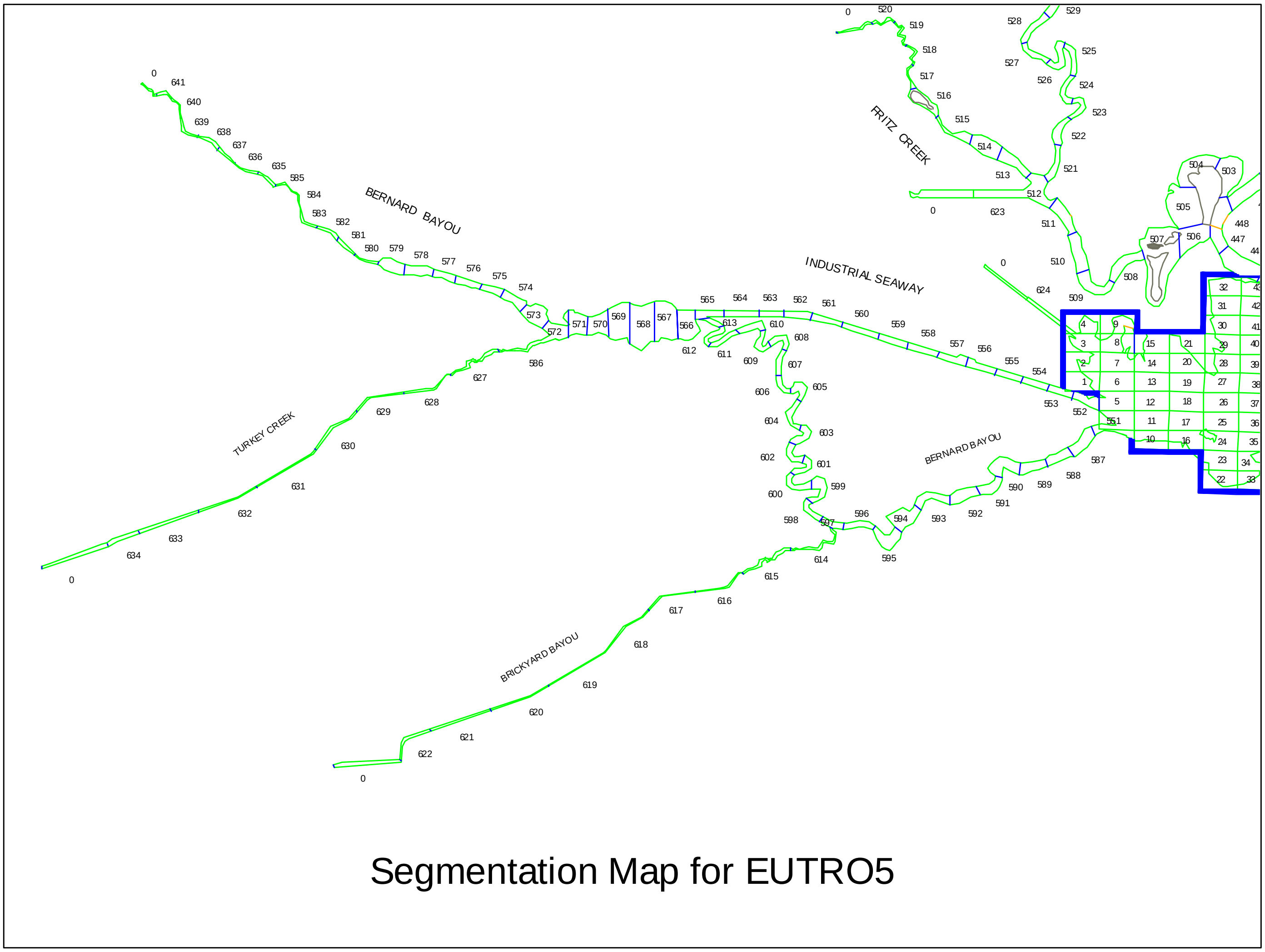


Figure 4.1: EUTRO Segmentation Map

## 4.3 Model Calibration Process

The first step in calibrating a water quality model is to calibrate the hydrodynamics of the model. During the calibration process, several important hydrodynamic parameters were adjusted, and output from trial model runs was analyzed. After the adjustments were completed, output from the hydrodynamic model was compared to observed data by producing temporal profiles of observed and predicted measurements of tide level and flow velocity. The profiles are available in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume II – Calibration/Verification, 1994/1995 Data* (Shindala et al. 1996). The profiles show that the predicted tide levels and flow velocity reasonably match the observed data at several points within the Back Bay of Biloxi system.

Calibration of the water quality model began after completion of the hydrodynamic calibration. In order to conduct the calibration, organic material and nutrient contributions from all sources were estimated or measured, hydrologic transport processes were superimposed, and then water quality modeling was performed to allow adjustments in parameters and sources as part of the calibration process. Water quality calibration is an iterative process; the model predictions are the integrated results of all the assumptions used in developing the model input and in representing the physical and chemical processes occurring in the waterbody. Difference in model predictions and the observations require the model user to reevaluate these assumptions, in terms of both the estimated model input and model parameters, and consider the accuracy and uncertainty in the observations. Graphs which show comparisons between monitoring data and model output are shown in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume II – Calibration/Verification, 1994/1995 Data* (Shindala et al. 1996). Examination of the graphs in this document shows that the model, in general, reproduces most of the observed water quality data but does not predict every data point.

## 4.4 Selection of Representative Modeling Period

The NPSM model was run for a period representing a wet year, January through December 1995. A wet year was chosen for the representative modeling period, because it would predict a higher than usual amount of runoff from the watersheds, which would increase the estimated nonpoint source loads. Using the higher estimates of nonpoint source loads for the TMDL ensures that water quality standards will be attained during all seasons of the year.

The WASP5 model was run for a 10-day period, simulating low-flow, critical conditions. The first two days of the model run allowed the model to stabilize, and output data from days three through ten were used to evaluate the water quality response to the pollutant loadings. The boundary flow condition for the most upstream modeled segment of Bernard Bayou was set at the 7Q10 flow, 4.23 cfs. The 7Q10 is the minimum flow expected for seven consecutive days during a period of ten years. The 7Q10 was calculated according to a method provided by the USGS in *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics on Ungaged Sites on Streams in MS*. Since the nonpoint source loads are based on a yearly average flow for a wet-year, they would not be expected to occur during 7Q10 flow conditions. However, placing these loads in the model at low flow conditions adds an additional margin of safety to the Phase 1 TMDL.

## 4.5 Model Results

Appendix A includes graphs of the model results showing the instream water quality conditions of the waterbodies included in this TMDL. The graphs show the daily average dissolved oxygen concentration in Bernard Bayou segment 3 and Industrial Seaway on days 3 through 10 of the WASP5 model simulation. The straight line at 5.0 mg/l indicates the water quality standard for the stream, a daily average dissolved oxygen concentration of 5.0 mg/l. Additional graphs show the diurnal variation in dissolved oxygen in selected model segments. The straight line at 4.0 mg/l indicates the instantaneous water quality standard for the waterbody, an instantaneous dissolved oxygen level of not less than 4.0 mg/l. An additional set of graphs shows the ammonia nitrogen concentrations in selected segments of Bernard Bayou segment 3 and Industrial Seaway. The graphs show the daily average ammonia nitrogen concentrations compared to the ammonia nitrogen standard for toxicity.  As shown, the ammonia nitrogen concentrations do not exceed the chronic criteria of a 4-day average of 1.2 mg/l ammonia nitrogen.

# 5.0 ALLOCATION

The allocation for this TMDL involves a wasteload allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources, and an implicit margin of safety (MOS) which will result in continued attainment of water quality standards in Bernard Bayou segment 3 and Industrial Seaway. The wasteload allocation specified in this TMDL is based on the existing loads from point source dischargers and estimated loads from nonpoint sources. At the current loads, water quality standards are attained and no reductions are necessary. However, it is recognized that the models used in this TMDL are limited, because collection of additional data and refinement of the models are necessary in order to better represent the physical and chemical processes occurring in the waterbody. Due to the limitations of the model, it is also recognized that the actual assimilative capacity of the waterbody may be greater than the loads specified in this TMDL. Thus, as further development occurs in the watershed, and new point source discharges are proposed, the wasteload allocations will continue to be evaluated on an individual basis. This TMDL will be modified in response to new NPDES permit requests. Increases in the wasteload allocation for Bernard Bayou segment 3 and Industrial Seaway will not result in commensurate reductions to the load allocation.

## 5.1 Wasteload Allocations

The contribution of load from point sources was included in the model, based on the facilities' current NPDES permit limits and available discharge monitoring data. No reduction in the current wasteload allocation was necessary to establish this TMDL.

## 5.2 Load Allocations

The load allocation developed for this Phase 1 TMDL is an estimation of the contribution of all nonpoint sources in the watershed. Measurements of the relative contribution of actual sources in the watershed were not considered due to the difficulty of obtaining such data. Estimates of nonpoint sources were estimated based on data collected at the headwaters of Bernard Bayou during the intensive studies of the waterbody. Because landuses are similar, the assumption was made that the concentrations of organic substances and nutrients found in runoff in the headwater watershed of Bernard Bayou would be the same as the concentrations resulting from runoff in the remainder of the watershed.

## 5.3 Incorporation of a Margin of Safety (MOS)

The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. Running the model simulations with no violations of the water standard throughout the critical condition period provides the primary component of the MOS. Another component of the MOS is the conservative assumption that the yearly average runoff and nonpoint source loads reach the stream during the 7Q10 flow.

## 5.4 Calculation of the TMDL

As shown below, the wasteload allocation incorporates the contribution of organic material and nutrients from identified NPDES permitted facilities. The load allocation includes the contributions from surface runoff. The margin of safety for this TMDL is implicit and derived from the conservative loading assumptions used in setting up the model. Because they are continuous waterbodies, Bernard Bayou segment 3 and Industrial Seaway were considered one waterbody for the purposes of developing this TMDL. This Phase 1 TMDL was calculated based on the following equation:

$$\mathbf{TMDL = WLA + LA + MOS} \quad \text{Equation 2}$$

**WLA** = NPDES Permitted Facilities
**LA** = Surface Runoff
**MOS** = Implicit

Table 5.1 Calculation of the TMDL, Summer Conditions (May – October)

| Parameter | WLA | LA | MOS | TMDL |
|---|---|---|---|---|
| $TBOD_U$ (lbs/day) | 4,532.4 | 9,938.1 | implicit | **14,470.5** |
| $PO_4$ (lbs/day) | 916.1 | 37.0 | implicit | **953.1** |
| $NH_3$-N (lbs/day) | 340.5 | 123.3 | implicit | **463.9** |
| $NO_3$-N (lbs/day) | 575.6 | 160.4 | implicit | **735.9** |

Table 5.2 Calculation of the TMDL, Winter Conditions (November – April)

| Parameter | WLA | LA | MOS | TMDL |
|---|---|---|---|---|
| $TBOD_U$ (lbs/day) | **16,814.2** | 9,938.1 | Implicit | **26,752.3** |
| $PO_4$ (lbs/day) | 1,031.9 | 37.0 | Implicit | **1,068.9** |
| $NH_3$-N (lbs/day) | 2,079.4 | 123.3 | Implicit | **2,202.8** |
| $NO_3$-N (lbs/day) | 667.3 | 160.4 | Implicit | **827.6** |

## 5.5 Seasonality

Summer and winter loads were calculated to account for seasonality in the Phase 1 TMDL. The NPSM model was run for a representative wet year, and took into account all of the seasons within the calendar year. This time period allowed the simulation of many different atmospheric conditions such as rainy and dry periods and high and low temperatures. It also allowed seasonal critical conditions to be simulated. In order to ensure that water quality conditions will be met during all atmospheric conditions, the WASP5 model was run during the critical condition period. Some of the NPDES permitted facilities have permit limits that vary seasonally. Gulfport South has permit limits for summer (May – October) and winter (November – April). This was accounted for when calculating the TMDL.

# 6.0 CONCLUSION

MDEQ's current assessment methodology indicates that Bernard Bayou segment 3 and Industrial Seaway are fully supporting but threatened for their designated use. Concern that the continued stress placed on the waterbody by the rapid growth and development in the region necessitated the development of this TMDL for organic enrichment/low dissolved oxygen and nutrients. The TMDL was developed by setting the existing permitted loads as the waste load allocation. MDEQ recognizes that future expansion and additional loads requested for this area may modify this TMDL approach, requiring additional data collection and modeling. The TMDL calculations may also be modified, in necessary, at that time.

## 6.1 Future Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each yearlong cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Coastal Streams Basin, the Biloxi Bay Watershed will receive additional monitoring to identify any changes or improvements in water quality. Any request for modification of this TMDL will require additional monitoring to validate the modeling results.

## 6.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public meeting.

All comments received during the public notice period and at any public meeting become a part of the record of this TMDL. All comments will be considered in the ultimate completion of this TMDL for submission of this TMDL to EPA Region 4 for final approval.

# DEFINITIONS

**Aerobic**: Environmental conditions characterized by the presence of dissolved oxygen; used to describe biological or chemical processes that occur in the presence of oxygen.

**Algal growth**: Algal growth is related to temperature, available light, and the available abundance of inorganic nutrients (N, P, Si). Algal species groups (e.g., diatoms, greens, etc.) are typically characterized by different maximum growth rates.

**Algal respiration**: Process of endogenous respiration of algae in which organic carbon biomass is oxidized to carbon dioxide.

**Algae**: Any organisms of a group of chiefly aquatic microscopic nonvascular plants; most algae have chlorophyll as the primary pigment for carbon fixation. As primary producers, algae serve as the base of the aquatic food web, providing food for zooplankton and fish resources. An overabundance of algae in natural waters is known as eutrophication.

**Ambient stations**: a network of fixed monitoring stations established for systematic water quality sampling at regular intervals, and for uniform parametric coverage over a long-term period.

**Ammonia**: Inorganic form of nitrogen; product of hydrolysis of organic nitrogen and denitrification. Ammonia is preferentially used by phytoplankton over nitrate for uptake of inorganic nitrogen.

**Ammonia toxicity**: Under specific conditions of temperature and pH, the un-ionized component of ammonia can be toxic to aquatic life. The unionized component of ammonia increases with pH and temperature.

**Assimilative capacity**: The capacity of a body of water or soil-plant system to receive wastewater effluents or sludge without violating the provisions of the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality regulations.

**Background**: The condition of waters in the absence of man-induced alterations based on the best scientific information available to MDEQ. The establishment of natural background for an altered waterbody may be based upon a similar, unaltered or least impaired, waterbody or on historical pre-alteration data.

**Biochemical oxygen demand (BOD)**: The amount of oxygen per unit volume of water required to bacterially or chemically oxidize (stabilize) the oxidizable matter in water. Biochemical oxygen demand measurements are usually conducted over specific time intervals (5, 10, 20, 30 days). The term BOD generally refers to a standard 5-day BOD test. BOD = CBOD + NBOD.

**Calibrated model**: a model in which reaction rates and inputs are significantly based on actual measurements using data from surveys on the receiving waterbody.

**Calibration**: The process of adjusting model parameters within physically defensible ranges until the resulting predictions give a best possible good fit to observed data.

**Carbonaceous Biological Oxygen Demand (CBOD)**: Refers to the oxygen demand associated with the oxidation of organic carbon

**Chlorophyll**: A group of green photosynthetic pigments that occur primarily in the chloroplast of plant cells. The amount of chlorophyll *a*, a specific pigment, is frequently used as a measure of algal biomass in natural waters.

**Chronic toxicity**: Toxicity impact that lingers or continues for a relatively long period of time, often one-tenth of an organism's life span or longer. Chronic effects could include mortality, reduced growth, or reduced reproduction.

**Critical Condition**: Hydrologic and atmospheric conditions in which the pollutants causing impairment of a waterbody have their greatest potential for adverse effects.

**Daily discharge**: The "discharge of a pollutant" measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily average" is calculated as the average.

**Decay**: The gradual decrease in the amount of a given substance in a given system due to various sink processes including chemical and biological transformation, dissipation to other environmental media, or deposition into storage areas.

**Decomposition**: Metabolic breakdown of organic materials; the formation of by-products of decomposition releases energy and simple organic and inorganic compounds.

**Denitrification**: The process of decomposition of nitrites and nitrates (by bacteria) that results in the eventual release of nitrogen gas into the atmosphere.

**Designated Use**: Use specified in water quality standards for each waterbody or segment regardless of actual attainment.

**Discharge monitoring report**: Report of effluent characteristics submitted by a NPDES permitted facility.

**Diurnal**: Actions or processes that have a period or a cycle of approximately one tidal-day or are completed within a 24-hour period and that recur every 24 hours.

**Dynamic model**: A mathematical formulation describing and simulating the physical behavior of a system or a process and its temporal variability.

**Effluent**: Treated wastewater flowing out of the treatment facilities.

**Effluent standards and limitations**: All State or Federal effluent standards and limitations on quantities, rates, and concentrations of chemical, physical, biological, and other constituents to which a waste or wastewater discharge may be subject under the Federal Act or the State law. This includes, but is not limited to, effluent limitations, standards of performance, toxic effluent standards and prohibitions, pretreatment standards, and schedules of compliance.

**Eutrophication**: The natural aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the waterbody is choked by abundant plant life as the result of increased amounts of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process of nutrient enrichment in waterbodies, resulting in accelerated biological productivity (growth of algae and weeds) and an undesirable accumulation of algal biomass.

**Impaired Waterbody**: Any waterbody that does not attain water quality standards due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.

**Land Surface Runoff**: Water that flows into the receiving stream after application by rainfall or irrigation. It is a transport method for nonpoint source pollution from the land surface to the receiving stream.

**Load allocation (LA)**: The portion of a receiving water's loading capacity attributed to or assigned to nonpoint sources (NPS) or background sources of a pollutant. The load allocation is the value assigned to the summation of all direct sources and land applied fecal coliform that enter a receiving waterbody.

**Loading**: The total amount of pollutants entering a stream from one or multiple sources.

**Macrophytes**: The larger aquatic plants of all types. They are sometimes attached to the waterbody bottom, sometimes free-floating, sometimes totally submersed, and sometimes partially emergent. Complex types usually have true roots, stems, and leaves; the macroalgae are simpler but may have stem- and leaf-like structures.

**Nitrate ($NO_3$) and Nitrite ($NO_2$)**: Oxidized nitrogen species. Nitrate is the form of nitrogen preferred by aquatic plants.

**Nitrification**: The oxidation of ammonium salts to nitrites (via *Nitrosomonas* bacteria) and the further oxidation of nitrite to nitrate (via *Nitrobacter* bacteria).

**Nitrifier organisms**: Bacterial organisms that mediate the biochemical oxidative processes of nitrification.

**Nitrogen**: A nutrient assimilated by plants which promotes growth. The most bioavailable forms of nitrogen are nitrate ($NO_3$), nitrite ($NO_2$), and ammonia ($NH_3$).

**Nitrogenous biochemical oxygen demand (NBOD)**: The oxygen demand associated with the oxidation of ammonia.

**Nonpoint Source**: Pollution that is in runoff from the land. Rainfall, snowmelt, and other water that does not evaporate become surface runoff and either drains into surface waters or soaks into the soil and finds its way into groundwater. This surface water may contain pollutants that come from land use activities such as agriculture, construction, silviculture, surface mining, disposal of wastewater, hydrologic modifications, and urban development.

**NPDES permit**: An individual or general permit issued by the Mississippi Environmental Quality Permit Board pursuant to regulations adopted by the Mississippi Commission on Environmental Quality under Mississippi Code Annotated (as amended) §§ 49-17-17 and 49-17-29 for discharges into State waters.

**Nutrient**: A primary element necessary for the growth of living organisms. Carbon dioxide, nitrogen, and phosphorus, for example, are required nutrients for phytoplankton growth

**Organic matter**: The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.

**Organic nitrogen**: Nitrogen in a form that is bound to an organic compound.

**Organic phosphorous**: Phosphorus in a form that is bound to an organic compound.

**Orthophosphate**: Phosphorus in a form that is most readily available to plants. It consists of the species $H_2PO_4^{2-}$, $HPO_4^{2-}$, and $PO_4^{3-}$. (Also known as soluble reactive phosphorus (SRP).)

**Oxygen depletion**: A deficit of dissolved oxygen in a water system due to oxidation of organic matter.

**Phased approach**: Under the phased approach to TMDL development, load allocations and wasteload allocations are calculated using the best available data and information recognizing the need for additional monitoring data to accurately characterize sources and loadings. The phased approach is typically employed when nonpoint sources dominate. It provides for the implementation of load reduction strategies while collecting additional data.

**Phosphorus**: A nutrient assimilated by plants which promotes growth. The most bioavailable form of phosphorus is soluble reactive phosphorus (SRP), also known as orthophosphate.

**Photosynthesis**: The biochemical synthesis of carbohydrate-based organic compounds from water and carbon dioxide using light energy in the presence of chlorophyll. Photosynthesis occurs in all plants, including aquatic organisms such as algae and macrophytes. Photosynthesis also occurs in primitive bacteria such as blue-green algae.

**Plankton.** Group of generally microscopic plants and animals passively floating, drifting, or swimming weakly. Plankton include the phytoplankton (plants) and zooplankton (animals).

**Point Source**: Pollution loads discharged at a specific location from pipes, outfalls, and conveyance channels from either wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream.

**Pollution**: Contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the State, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance, or leak into any waters of the State, unless in compliance with a valid permit issued by the Permit Board.

**Publicly Owned Treatment Works (POTW)**: A waste treatment facility owned and/or operated by a public body or a privately owned treatment works which accepts discharges which would otherwise be subject to Federal Pretreatment Requirements.

**Regression Coefficient**: An expression of the functional relationship between two correlated variables that is often empirically determined from data, and is used to predict values of one variable when given values of the other variable.

**Soluble reactive phosphorus**: Form of phosphorus that is most readily available to plants. It consists of the species $H_2PO_4^{2-}$, $HPO_4^{2-}$, and $PO_4^{3-}$. (Also known as orthophosphate.)

**Total Kjeldahl nitrogen (TKN)**: The total of organic and ammonia nitrogen in a sample, determined by the Kjeldahl method

**Total Maximum Daily Load or TMDL**: The calculated maximum permissible pollutant loading to a waterbody at which water quality standards can be maintained.

**Total nitrogen (TN)**: The total amount of nitrogen in a sample, including organic nitrogen, nitrate ($NO_3$), nitrite ($NO_2$), and ammonia ($NH_4$).

**Total phosphorus (TP)**: The total amount of phosphorus in a sample, including both organic and inorganic forms. In most lakes, the organic forms of phosphorus make up a large majority of the total phosphorus.

**Waste**: Sewage, industrial wastes, oil field wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the State.

**Wasteload allocation (WLA)**: The portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant.

**Water Quality Standards**: The criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

**Water quality criteria**: Elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports the present and future most beneficial uses.

**Waters of the State**: All waters within the jurisdiction of this State, including all streams, lakes, ponds, wetlands, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, situated wholly or partly within or bordering upon the State, and such coastal waters as are within the jurisdiction of the State, except lakes, ponds, or other surface waters which are wholly landlocked and privately owned, and which are not regulated under the Federal Clean Water Act (33 U.S.C.1251 et seq.).

**Watershed**: The area of land draining into a stream at a given location.

# ABBREVIATIONS

7Q10 ........................... Seven-Day Average Low Stream Flow with a Ten-Year Occurrence Period

BASINS .................................. Better Assessment Science Integrating Point and Nonpoint Sources

BMP ........................................................................................ Best Management Practice

CWA ....................................................................................................... Clean Water Act

DMR ............................................................................................ Discharge Monitoring Report

DYNHYD5 ........................................................................................ Hydrodynamic Model - 5

EPA ........................................................................................ Environmental Protection Agency

GIS ........................................................................................ Geographic Information System

HUC ........................................................................................ Hydrologic Unit Code

LA ....................................................................................................... Load Allocation

MARIS ........................................................ State of Mississippi Automated Information System

MDEQ ........................................................... Mississippi Department of Environmental Quality

MOS ....................................................................................................... Margin of Safety

NPDES ........................................................... National Pollution Discharge Elimination System

NPSM ........................................................................................ Nonpoint Source Model

RF3 ....................................................................................................... Reach File 3

USGS ........................................................................................ United States Geological Survey

WASP5 ........................................................ Water Quality Analysis Simulation Program - 5

WLA ........................................................................................ Waste Load Allocation

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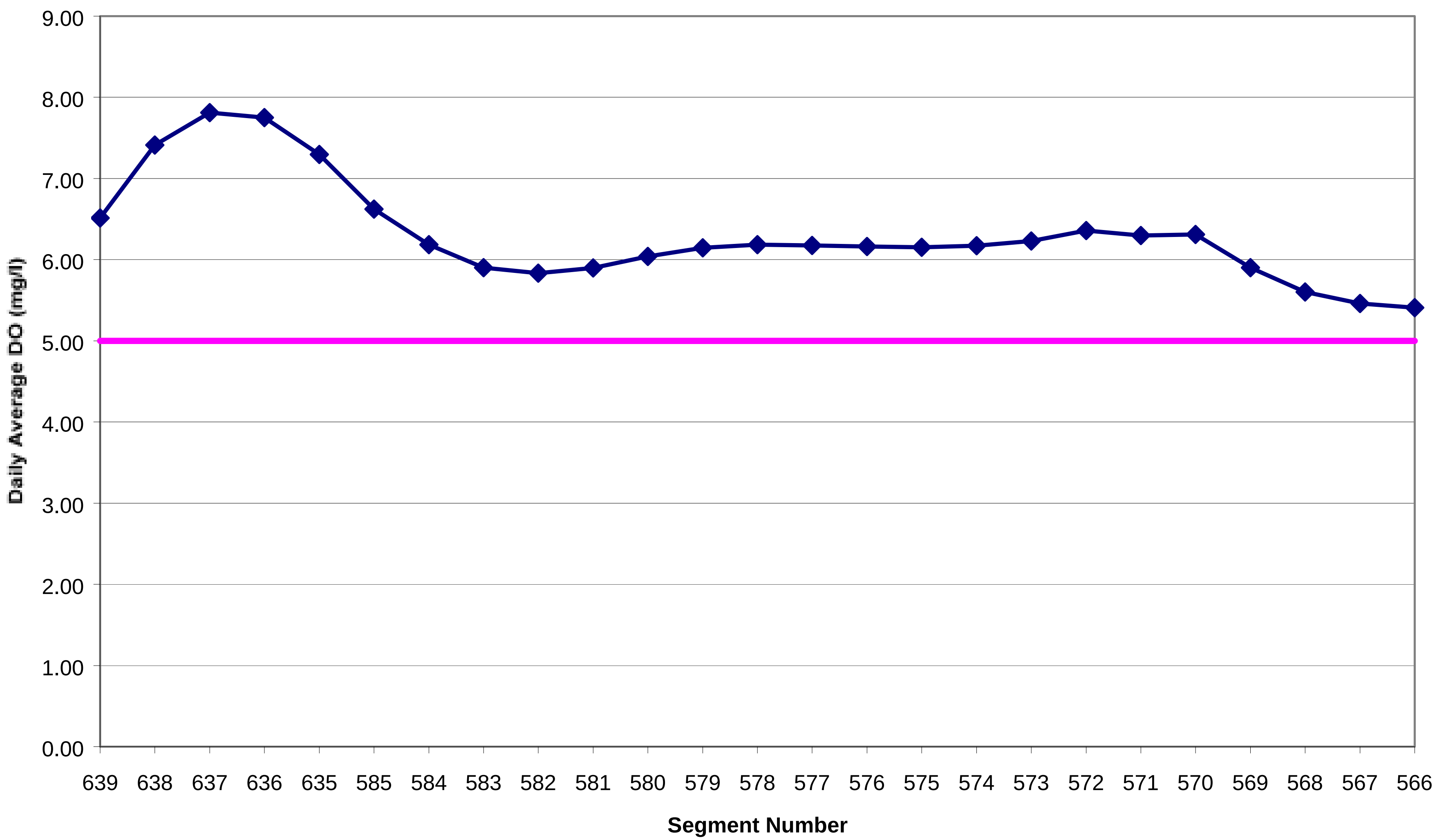
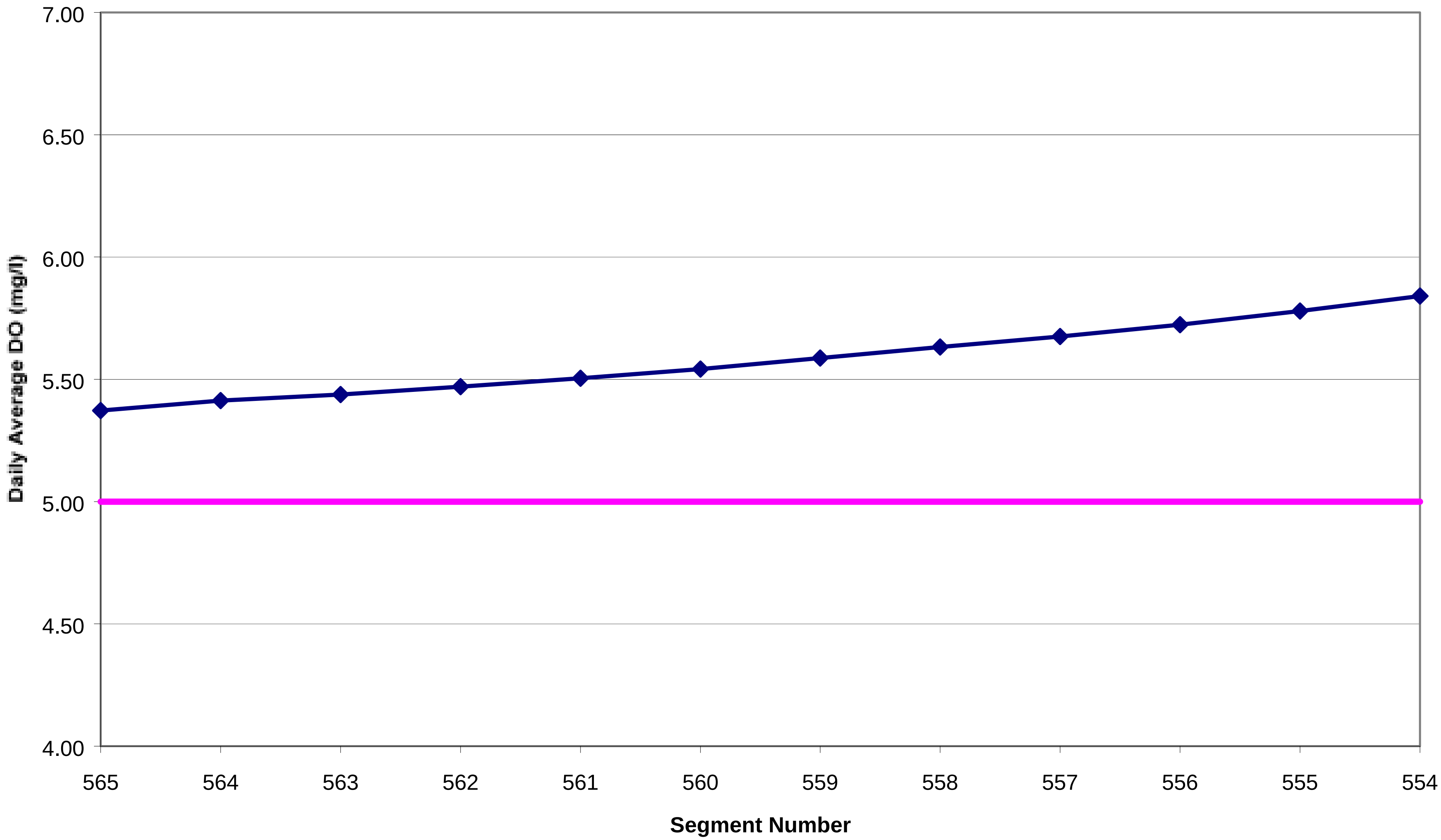
# APPENDIX A

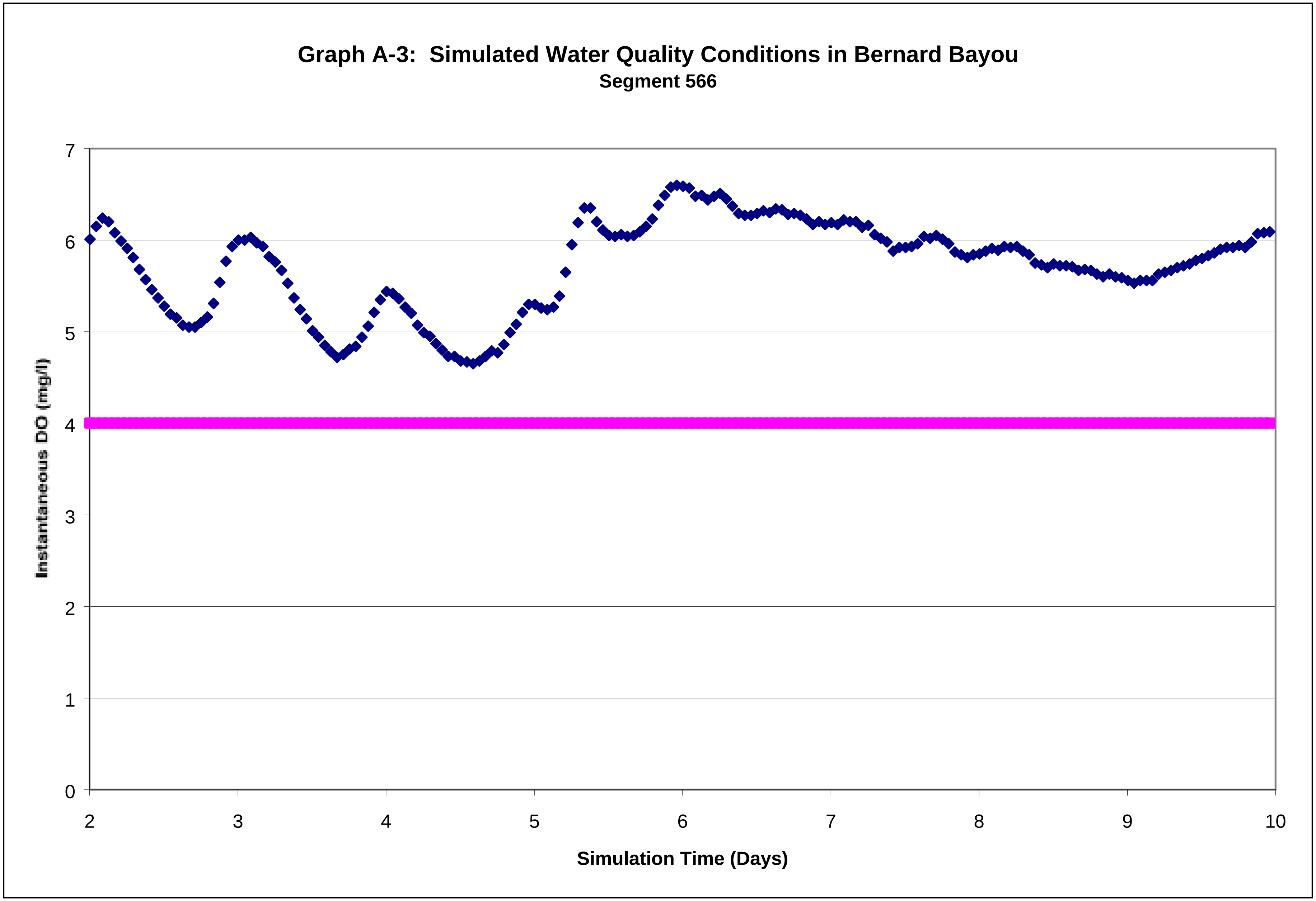
Appendix A includes graphs of the model results showing the water quality condition of the waterbodies included in this TMDL. The graphs shown in this section are based on model output for low-flow conditions for the summer and winter seasons. Graphs A-1 through A-10 show model output for the summer season. Graphs A-1 and A-2 show the daily average dissolved oxygen concentrations in Bernard Bayou segment 3 and Industrial Seaway. The daily average dissolved oxygen concentrations were calculated by using output from the WASP5 model for days 3 through 10 of the simulation. The straight line at 5.0 mg/l represents the water quality target for this TMDL, a daily average dissolved oxygen concentration of not less than 5.0 mg/l. Graphs A-3 through A-6 show the diurnal variation of the dissolved oxygen in several segments within Bernard Bayou segment 3 and Industrial Seaway. The locations of the selected segments are shown on Figure 4.1: EUTRO Segmentation Map. Model output from the EUTRO model is output every fifteen minutes. It can be seen from the graphs that diurnal variations of up to 1.5 mg/l dissolved oxygen occur. Graphs A-7 through A-10 show the daily average ammonia nitrogen concentrations in Bernard Bayou segment 3 and Industrial Seaway. The straight line at 1.2 mg/l represents the maximum target level for ammonia nitrogen toxicity. As shown in the graphs, the modeled ammonia nitrogen concentrations are significantly less than the target level. Model output for winter conditions is shown in Graph A-11. The model representing the winter season had the temperature set at 20°C and the point source inputs set at the maximum permitted loads for November – April. Graph A-11 shows the daily average dissolved oxygen concentrations in Bernard Bayou segment 3. As shown in the graph, the dissolved oxygen standard of 5.0 mg/l is not violated during winter conditions.

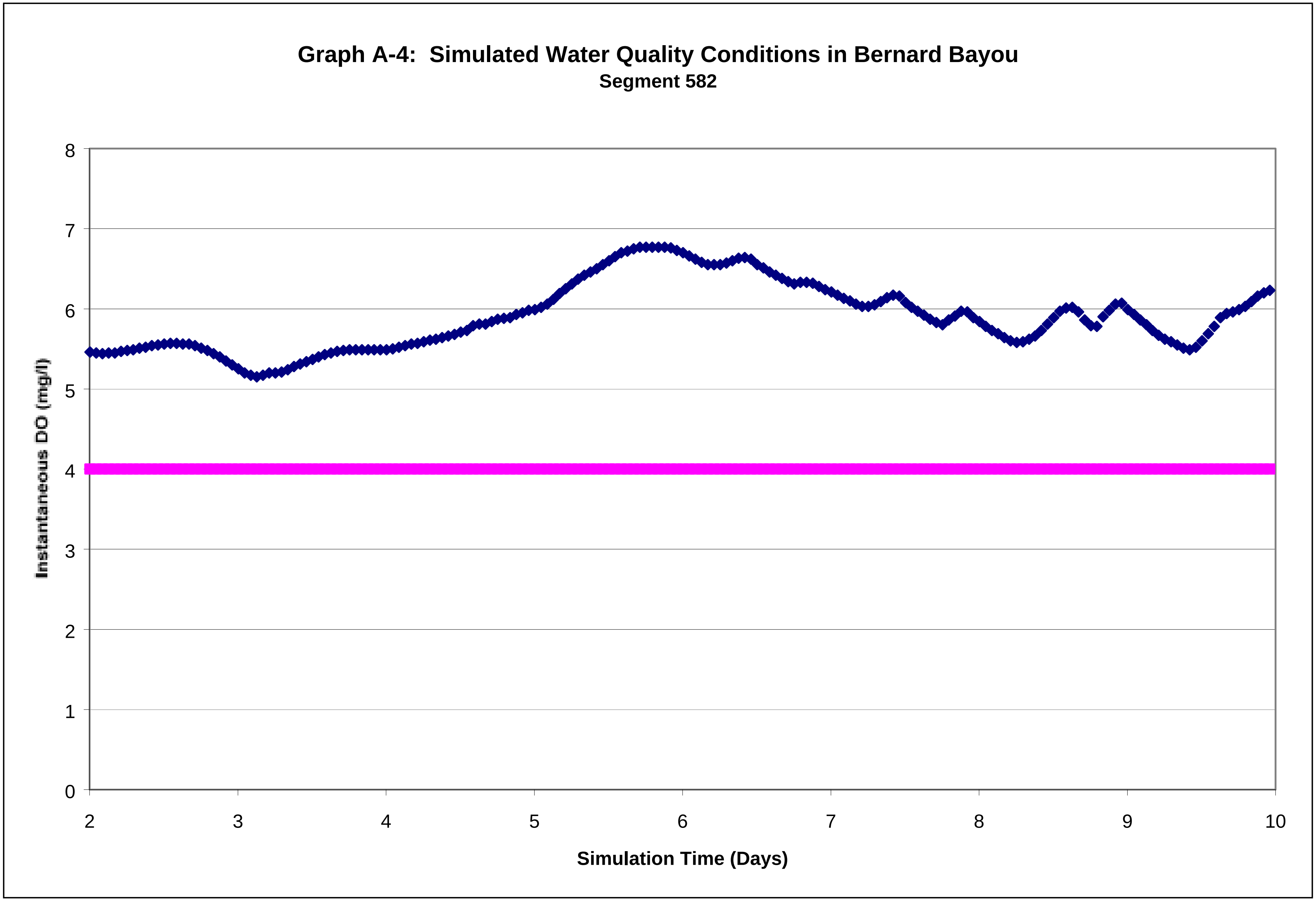
**Graph A-1: Daily Average Dissolved Oxygen in Bernard Bayou segment 3**
**from WASP5 Model**

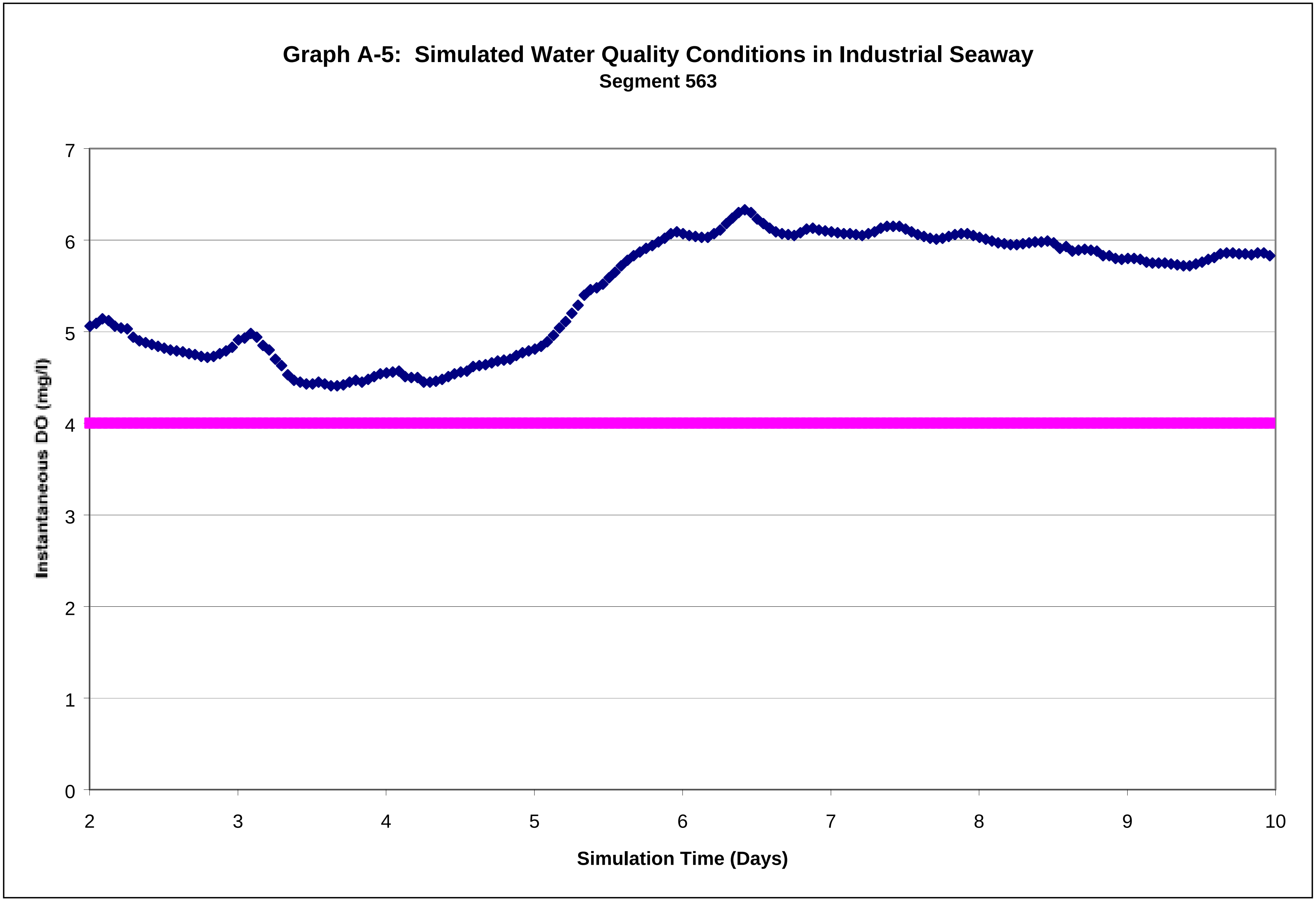


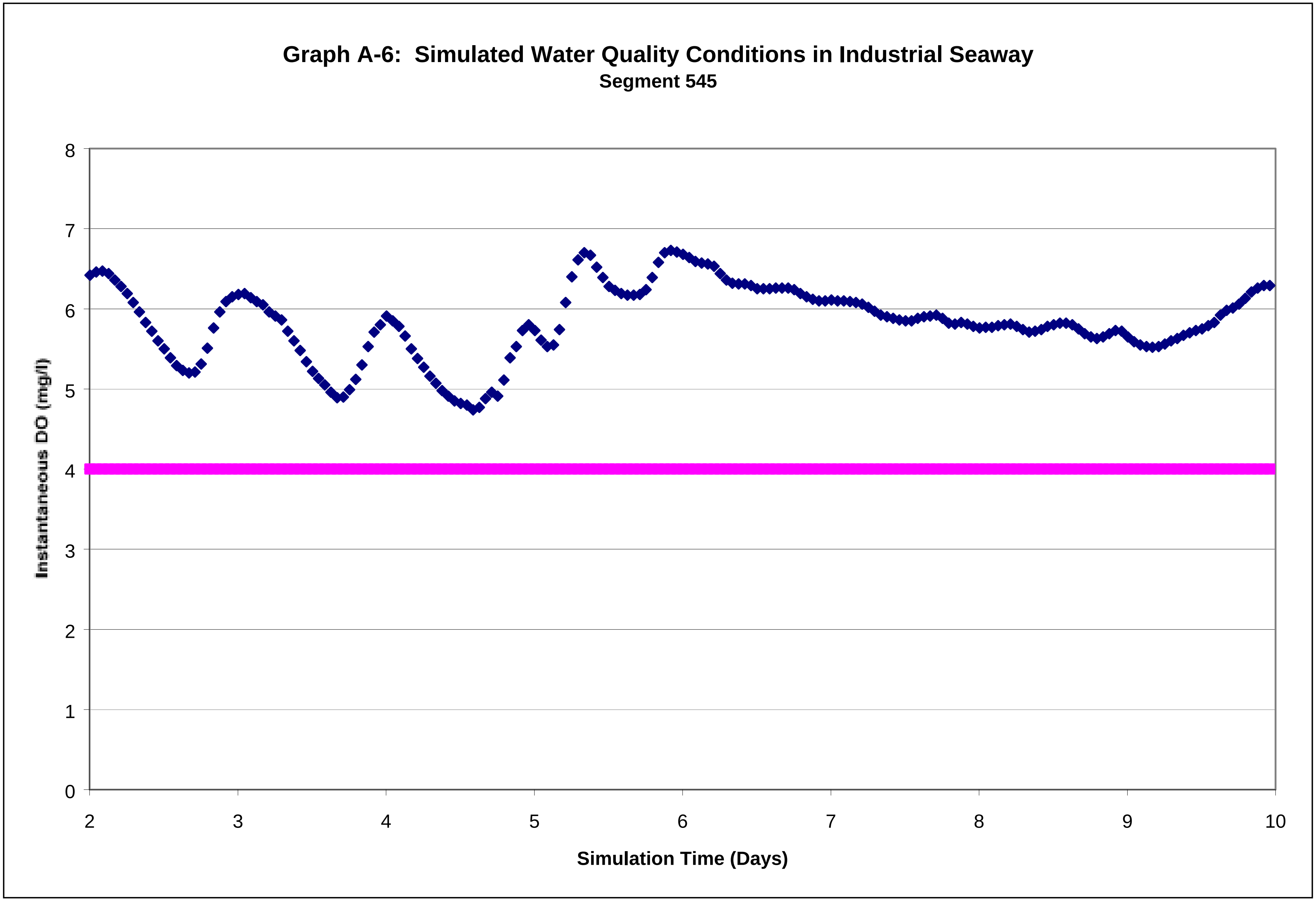
**Graph A-2: Simulated Daily Average Dissolved Oxygen in Industrial Seaway**
**from WASP5 Model**

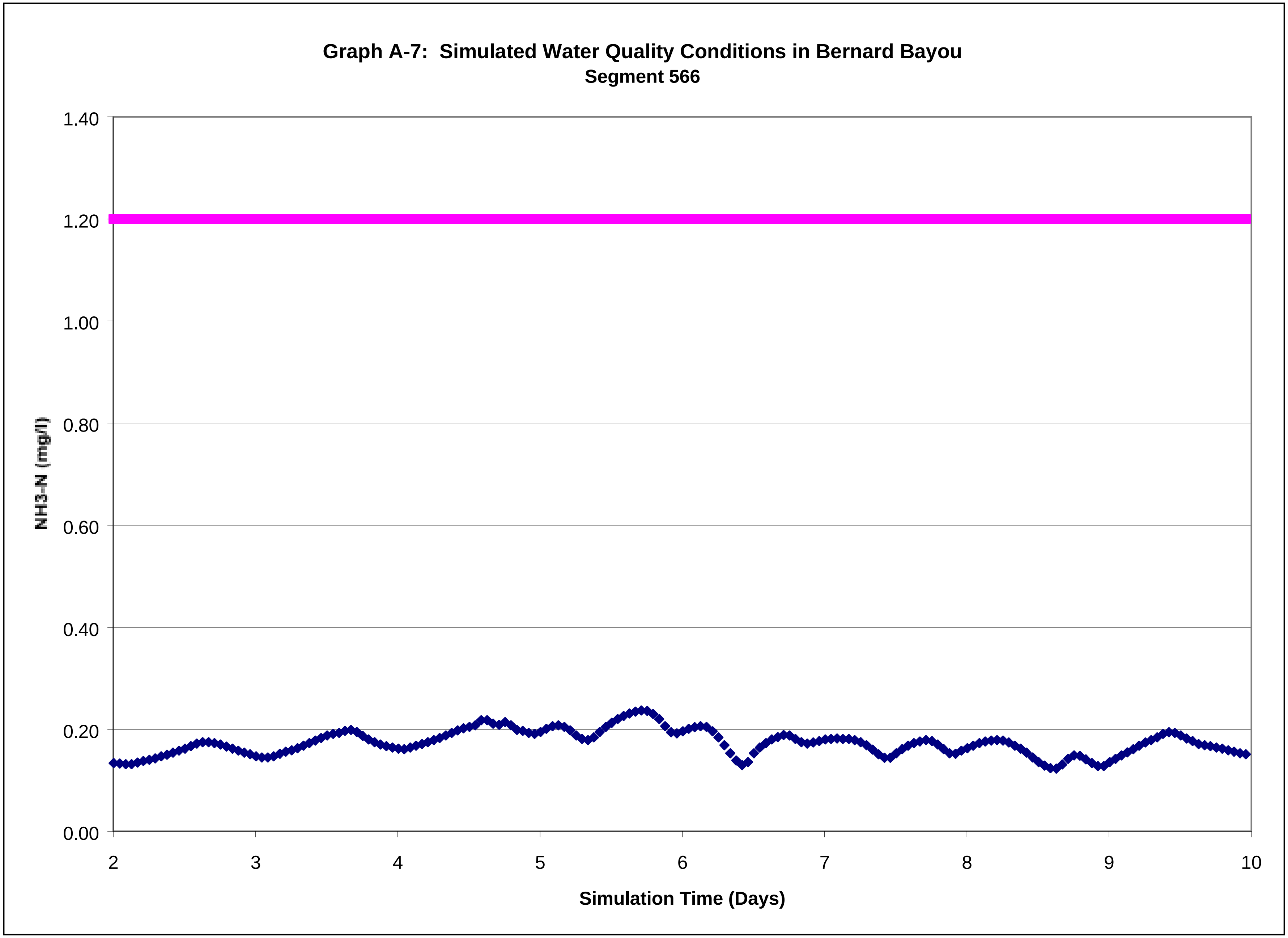


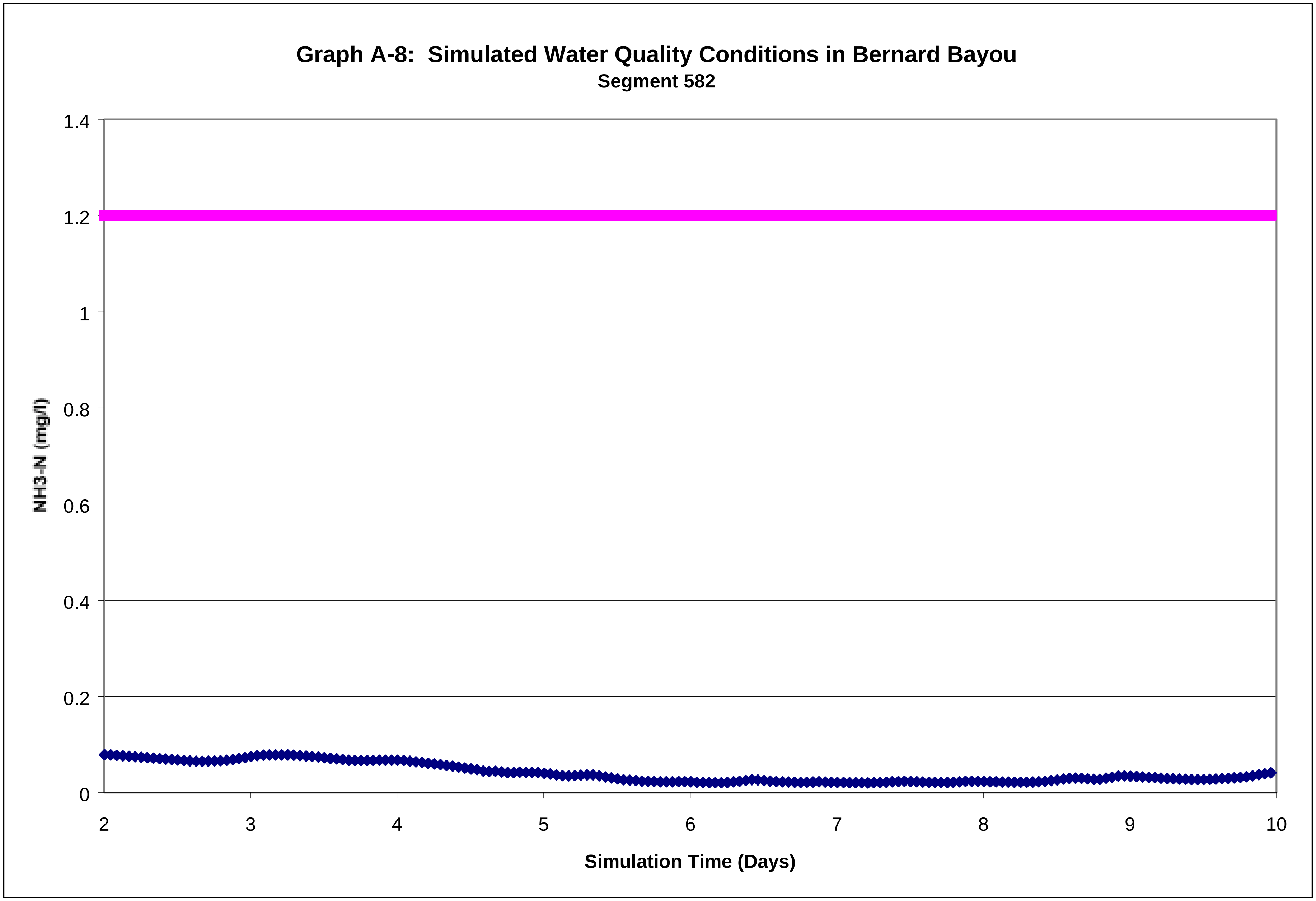

Graph A-3: Simulated Water Quality Conditions in Bernard Bayou
Segment 566
Instantaneous DO (mg/l)
0
1
2
3
4
5
6
7
2
3
4
5
6
7
8
9
10
Simulation Time (Days)


Graph A-4: Simulated Water Quality Conditions in Bernard Bayou
Segment 582
Instantaneous DO (mg/l)
0
1
2
3
4
5
6
7
8
2
3
4
5
6
7
8
9
10
Simulation Time (Days)

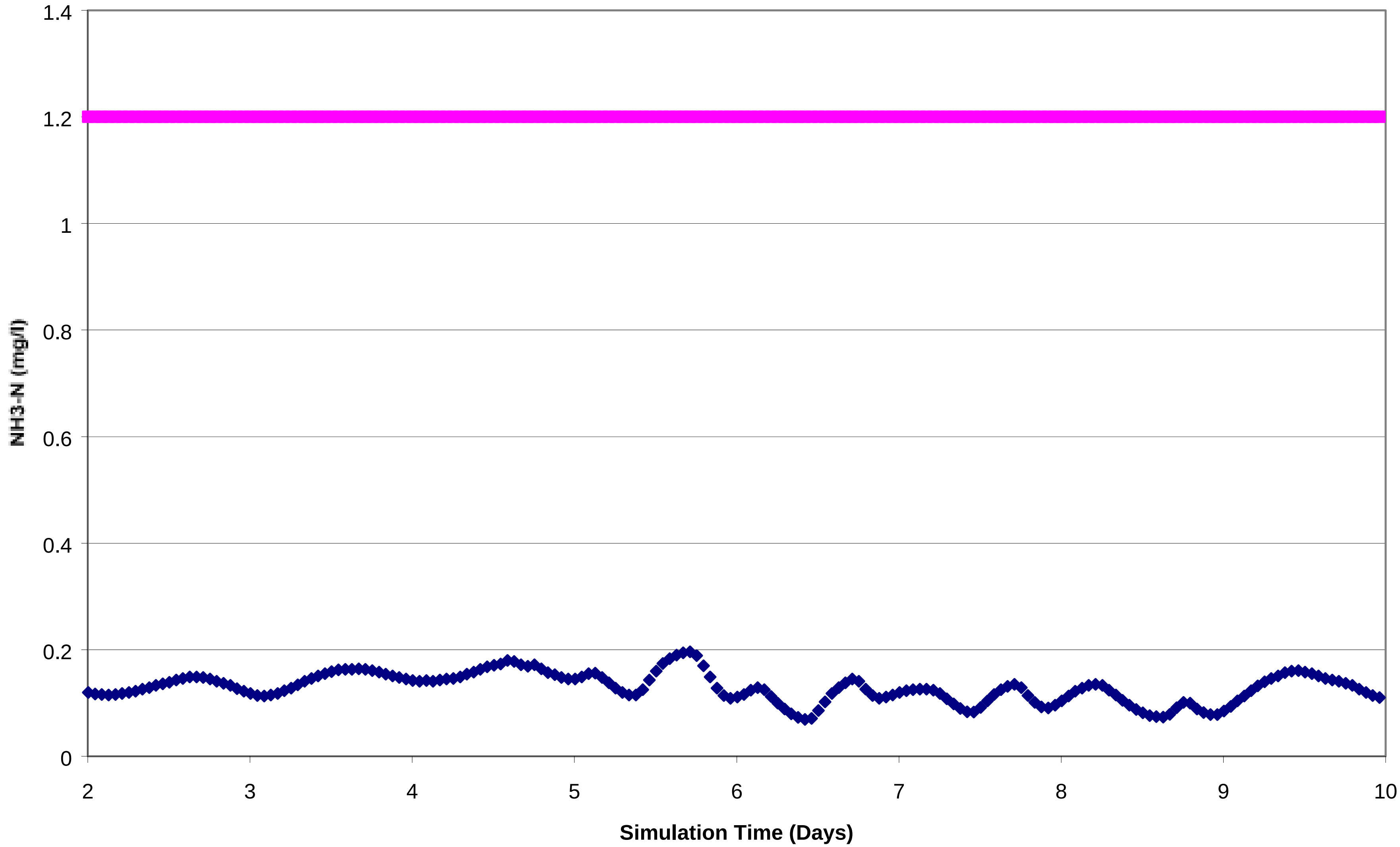

Graph A-5: Simulated Water Quality Conditions in Industrial Seaway
Segment 563
Instantaneous DO (mg/l)
0
1
2
3
4
5
6
7
2
3
4
5
6
7
8
9
10
Simulation Time (Days)

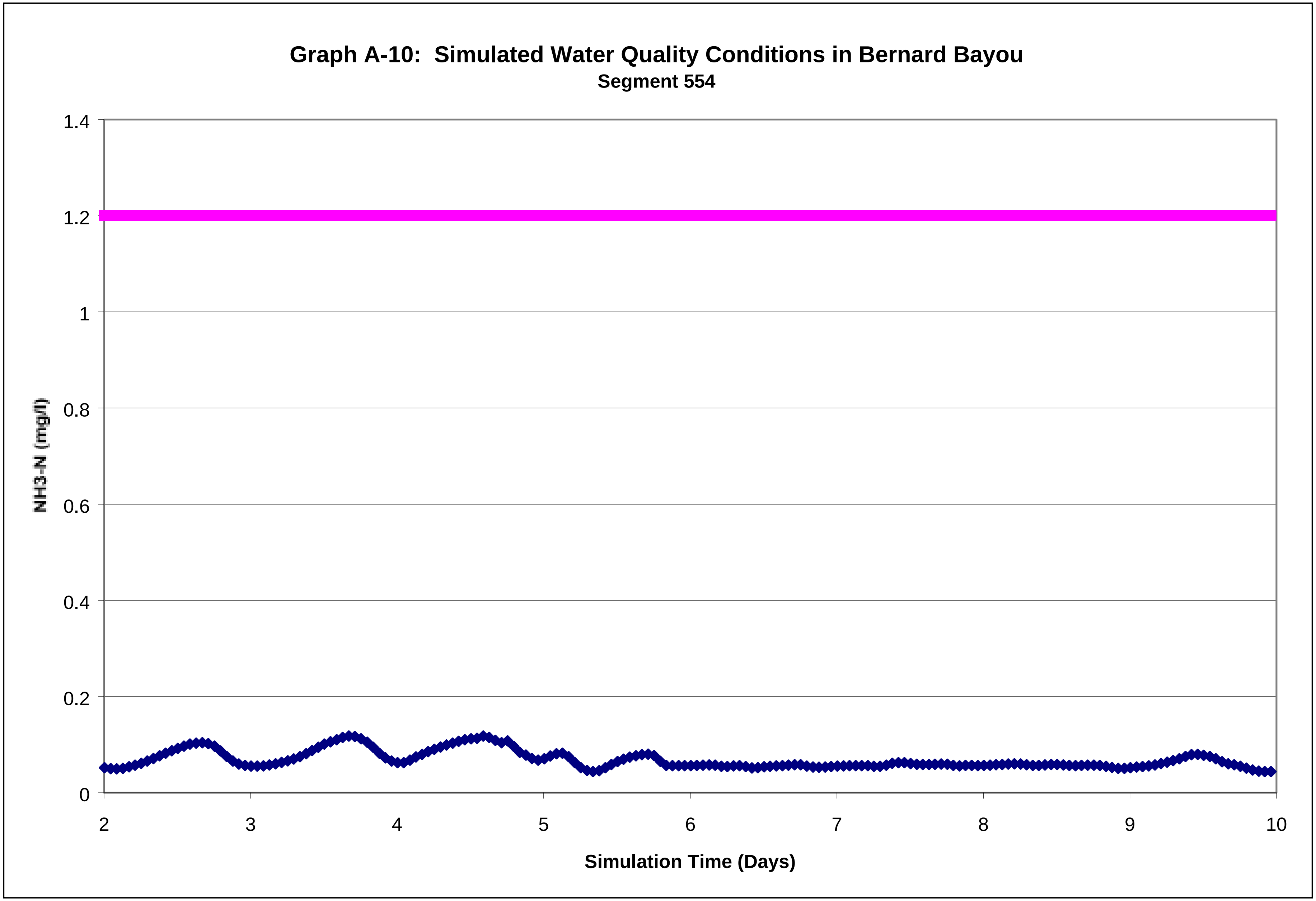

Graph A-6: Simulated Water Quality Conditions in Industrial Seaway
Segment 545
Instantaneous DO (mg/l)
0
1
2
3
4
5
6
7
8
2
3
4
5
6
7
8
9
10
Simulation Time (Days)


Graph A-7: Simulated Water Quality Conditions in Bernard Bayou
Segment 566
NH3-N (mg/l)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2
3
4
5
6
7
8
9
10
Simulation Time (Days)


Graph A-8: Simulated Water Quality Conditions in Bernard Bayou
Segment 582
NH3-N (mg/l)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
6
7
8
9
10
Simulation Time (Days)

**Graph A-9: Simulated Water Quality Conditions in Bernard Bayou**
**Segment 563**




Graph A-10: Simulated Water Quality Conditions in Bernard Bayou
Segment 554
NH3-N (mg/l)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
6
7
8
9
10
Simulation Time (Days)

**Graph A-11: Daily Average Dissolved Oxygen in Bernard Bayou segment 3, Winter Conditions for WASP5 Model**