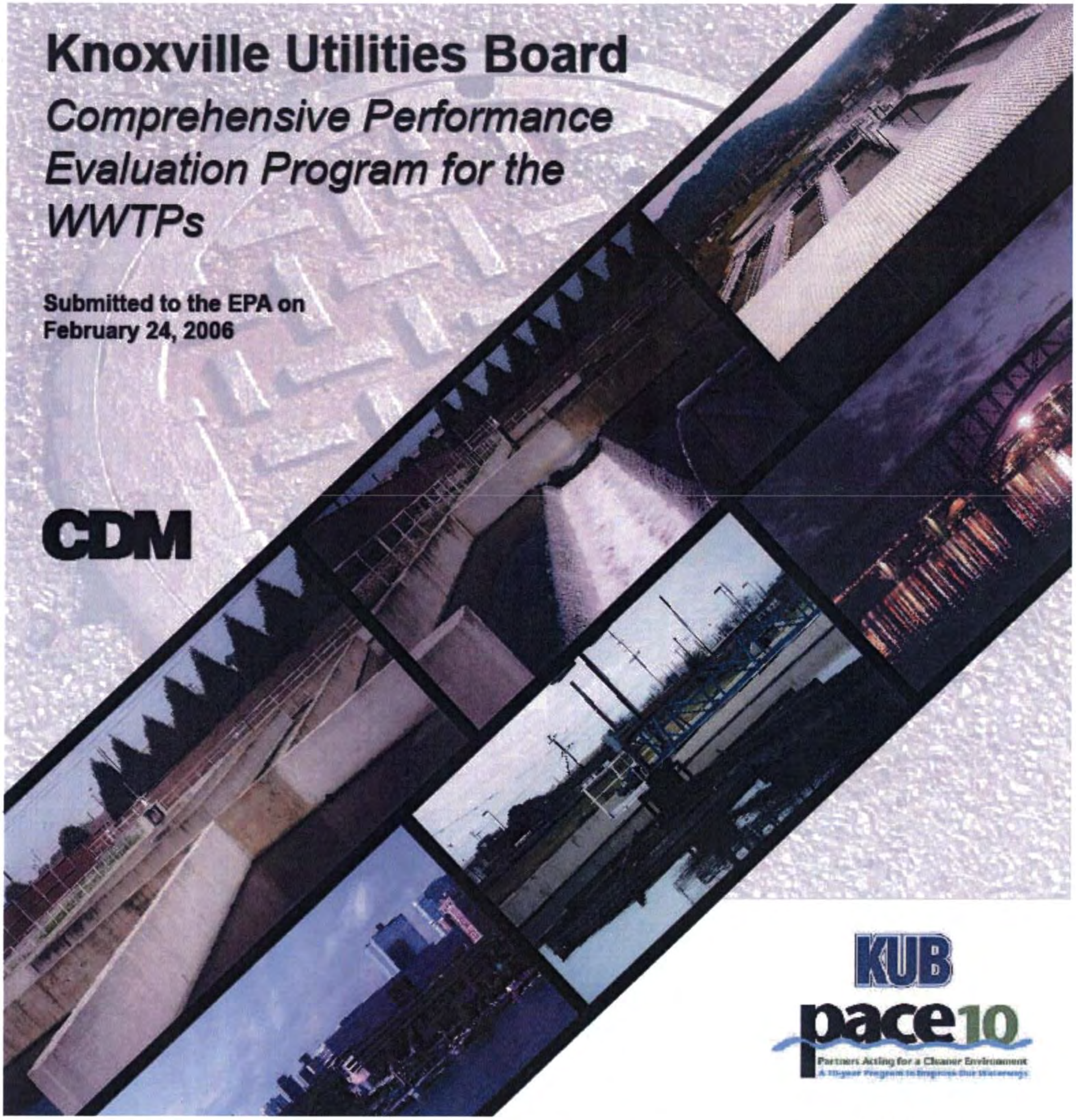
Knoxville Utilities Board

Comprehensive Performance Evaluation Program for the WWTPs

Submitted to the EPA on February 24, 2006

CDM



KUB

pace10

Partners Acting for a Cleaner Environment

A 10-year Program to Progress Our Waterways

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering such information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

2-24-06

D. Wayne Loveday — Date

BERNARD F. MALOY
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 101277
STATE OF TENNESSEE

2/20/06

0001433

Contents

Section 1 Introduction

1.1 Related Consent Decree Programs 1-1
1.2 Permit Compliance Issues 1-3
1.3 CPE Process Overview 1-5
1.4 CPE Report Overview 1-7

Section 2 Kuwahee WWTP Process Performance Evaluation & Data Analysis

2.1 KWWTP General Description 2-1
2.2 Operational Description 2-2
2.3 Treatment Requirements and Effluent Limitations 2-5
2.4 Treatment Process and Equipment Descriptions 2-6
2.5 WWTP Data Analysis and Performance Summary 2-14
2.5.1 Influent Flows and Loadings 2-14
2.5.2 Effluent Flow Rates, Effluent Loadings and NPDES Permit Compliance 2-30
2.5.3 Solids Accountability and Process Performance 2-46
2.6 Wet Weather Data Analysis and Performance Summary 2-51
2.6.1 Process Performance During Diversions 2-53

Section 3 Fourth Creek WWTP Performance Evaluation & Data Analysis

3.1 FCWWTP General Description 3-1
3.2 Operational Description 3-2
3.3 Treatment Requirements and Effluent Limitations 3-4
3.4 Treatment Process and Equipment Descriptions 3-5
3.5 WWTP Data Analysis and Performance Summary 3-10
3.5.1 Influent Flows and Loadings 3-10
3.5.2 Effluent Flow Rates, Effluent Loadings, and NPDES Permit Compliance 3-27
3.5.3 Solids Accountability Analysis 3-36
3.6 Wet Weather Data Analysis and Performance Summary 3-43

Section 4 Loves Creek WWTP Process Performance Evaluation & Data Analysis

4.1 LCWWTP General Description 4-1
4.2 Operational Description 4-2
4.3 Treatment Requirements and Effluent Limitations 4-2
4.4 Treatment Process and Equipment Descriptions 4-4
4.5 WWTP Data Analysis and Performance Summary 4-8
4.5.1 Influent Flows and Loadings 4-8
4.5.2 Effluent Flow Rates, Effluent Loadings, and NPDES Permit Compliance 4-21

4.5.3 Solids Accountability Analysis 4-33
4.6 Wet Weather Data Analysis and Performance Summary 4-41

Section 5 WWTP Flow and Hydraulic Analyses

5.1 Overview 5-1
5.2 Flow Projections 5-1
5.3 KWWTP - Hydraulic Analysis 5-2
5.3.1 Analysis Procedure/Approach 5-2
5.3.2 Pump Station Capacities 5-3
5.3.3 Analysis Results 5-4
5.3.4 Conclusions 5-7
5.4 FCWWTP - Hydraulic Analysis 5-9
5.4.1 Analysis Procedure and Approach 5-9
5.4.2 Pump Station Capacities 5-10
5.4.3 Analysis Results 5-11
5.4.4 Conclusions 5-14
5.5 LCWWTP - Hydraulic Analysis 5-15
5.5.1 Analysis Procedure and Approach 5-15
5.5.2 Influent Pump Station Capacity 5-16
5.5.3 Analysis Results 5-16
5.5.4 Conclusions 5-17

Section 6 Biological Process Evaluation

6.1 Overview 6-1
6.2 KWWTP Model Development and Results 6-1
6.2.1 Biological Treatment Capacity 6-2
6.2.2 Maximum Capacity of Biological Treatment 6-8
6.2.3 Aeration Capacity 6-8
6.2.4 Washout Analysis 6-11
6.2.5 Summary 6-15
6.3 FCWWTP Model Development and Results 6-15
6.3.1 Biological Treatment Capacity 6-18
6.3.2 Maximum Capacity of Biological Treatment 6-18
6.3.3 Aeration Capacity 6-21
6.3.4 Washout Analysis 6-23
6.3.5 Summary 6-24
6.4 LCWWTP Model Development and Results 6-27
6.4.1 Biological Treatment Capacity 6-27
6.4.2 Maximum Capacity of Biological Treatment 6-32
6.4.3 Aeration Capacity 6-32
6.4.4 Washout Analysis 6-35
6.4.5 Summary 6-36

0001435

Section 7 WWTP Administration, Operations and Maintenance

7.1 Overview – Performance Limiting Factors 7-1
7.2 Plant Administration 7-2
7.3 Plant Staff 7-3
7.3.1 Manpower 7-3
7.3.2 Morale 7-4
7.3.3 Staff Qualifications 7-4
7.3.4 Productivity 7-4
7.4 Financial 7-4
7.5 Maintenance 7-5
7.5.1 Maintenance Responsibilities 7-5
7.5.2 Preventive Maintenance 7-5
7.5.3 Corrective Maintenance 7-6
7.5.4 Operations and Maintenance Cross-Training 7-6
7.5.5 Summary 7-7
7.6 Operations 7-7
7.6.1 Process Monitoring and Testing 7-7
7.6.2 Process Control Adjustments 7-8
7.6.3 O&M Manuals/Procedures 7-9
7.7 Summary 7-10

Section 8 CPE Summary and Conclusions

8.1 Summary 8-1
8.2 Wet Weather Process Monitoring and Controls 8-2
8.3 Conclusions 8-5

Section 9 Composite Correction Program Plan

9.1 Overview 9-1
9.2 CCP Approach 9-2
9.3 CCP Schedule 9-3

0001436

Figures

1-1 Aeration MLSS and Washout Illustration 1-5
2-1 Kuwahee WWTP Process Schematic 2-3
2-2 1-Day Average Flow and Single Day Rainfall Data 2-15
2-3 7-Day Average Flow and 7-Day Cumulative Rainfall Data 2-16
2-4 30-Day Average Flow and Rainfall Data 2-17
2-5 1-Day Average Flow and BOD_5 Data 2-19
2-6 7-Day Average Flow and 7-Day Average BOD_5 Data 2-20
2-7 30-Day Average Flow and 30-Day Average BOD_5 Data 2-21
2-8 1-Day Average Flow and Total Suspended Solids (TSS) Data 2-23
2-9 7-Day Average Flow and 7-Day Average Total Suspended Solids (TSS) Data 2-24
2-10 30-Day Average Flow and 30-Day Average Total Suspended Solids (TSS) Data 2-25
2-11 1-Day Average Flow and Ammonia (NH_3) Data 2-27
2-12 7-Day Average Flow and 7-Day Average Ammonia (NH_3) Data 2-28
2-13 30-Day Average Flow and 30-Day Average Ammonia (NH_3) Data 2-29
2-14 Performance vs Daily BOD Effluent Limits 2-31
2-15 Performance vs Weekly BOD Effluent Limits 2-32
2-16 Performance vs Monthly BOD Effluent Limits 2-33
2-17 Performance vs Daily TSS Effluent Limits 2-34
2-18 Performance vs Weekly TSS Effluent Limits 2-35
2-19 Performance vs Monthly TSS Effluent Limits 2-36
2-20 Performance vs Daily Minimum Removal Requirements 2-38
2-21 Performance vs Monthly Minimum Removal Requirements 2-39
2-22 Performance vs Daily NH3-N Effluent Limits 2-40
2-23 Performance vs Weekly NH3-N Effluent Limits 2-41
2-24 Performance vs Monthly NH3-N Effluent Limits 2-42
2-25 Performance vs Daily Settleable Solids Effluent Limits 2-43
2-26 Performance vs Daily Fecal Coliform Effluent Limit 2-44
2-27 Performance vs Monthly Fecal Coliform Effluent Limit 2-45
2-28 Kuwahee WWTP Flow Schematic and Solids Balance at 36.7 mgd 2-47
3-1 Fourth Creek WWTP Process Schematic 3-3
3-2 1-Day Average Flow and Single Day Rainfall Data 3-12
3-3 7-Day Average Flow and 7-Day Cumulative Rainfall Data 3-13
3-4 30-Day Average Flow and 30-Day Cumulative Rainfall Data 3-14
3-5 1-Day Average Flow and BOD_5 Data 3-16
3-6 7-Day Average Flow and 7-Day Average BOD_5 Data 3-17
3-7 30-Day Average Flow and 30-Day Average BOD_5 Data 3-18
3-8 1-Day Average Flow and Total Suspended Solids (TSS) Data 3-20

0001437

3-9 7-Day Average Flow and 7-Day Average Total Suspended Solids (TSS) Data 3-21
3-10 30-Day Average Flow and 30-Day Average Total Suspended Solids (TSS) Data 3-22
3-11 1-Day Average Flow and Ammonia (NH_3-N) Data 3-24
3-12 7-Day Average Flow and 7-Day Average Ammonia as (NH_3-N) Data 3-25
3-13 30-Day Average Flow and 30-Day Average Ammonia as (NH_3-N) Data 3-26
3-14 Performance vs Daily BOD Effluent Limits 3-28
3-15 Performance vs Weekly BOD Effluent Limits 3-29
3-16 Performance vs Monthly BOD Effluent Limits 3-30
3-17 Performance vs Daily TSS Effluent Limits 3-31
3-18 Performance vs Weekly TSS Effluent Limits 3-32
3-19 Performance vs Monthly TSS Effluent Limits 3-33
3-20 Performance vs Daily Minimum Removal Requirements 3-34
3-21 Performance vs Monthly Minimum Removal Requirements 3-35
3-22 Performance vs Daily Settleable Solids Effluent Limits 3-37
3-23 Performance vs Daily Fecal Coliform Effluent Limit 3-38
3-24 Performance vs Monthly Fecal Coliform Effluent Limit 3-39
3-25 Fourth Creek WWTP Flow Schematic and Solids Balance at 7.1 mgd 3-40
4-1 Loves Creek WWTP Process Schematic 4-3
4-2 1-Day Average Flow and Single Day Rainfall Data 4-10
4-3 7-Day Average Flow and 7-Day Cumulative Rainfall Data 4-11
4-4 30-Day Average Flow and 30-Day Cumulative Rainfall Data 4-12
4-5 1-Day Average Flow and BOD_5 Data 4-14
4-6 7-Day Average Flow and 7-Day Average BOD_5 Data 4-15
4-7 30-Day Average Flow and 30-Day Average BOD_5 Data 4-16
4-8 1-Day Average Flow and Total Suspended Solids (TSS) Data 4-18
4-9 7-Day Average Flow and 7-Day Average Total Suspended Solids (TSS) Data 4-19
4-10 30-Day Average Flow and 30-Day Average Total Suspended Solids (TSS) Data 4-20
4-11 1-Day Average Flow and Ammonia (NH_3-N) Data 4-22
4-12 7-Day Average Flow and 7-Day Average Ammonia (NH_3-N) Data 4-23
4-13 30-Day Average Flow and 30-Day Average Ammonia (NH_3-N) Data 4-24
4-14 Performance vs Daily BOD Effluent Limits 4-25
4-15 Performance vs Weekly BOD Effluent Limits 4-26
4-16 Performance vs Monthly BOD Effluent Limits 4-27
4-17 Performance vs Daily TSS Effluent Limits 4-28
4-18 Performance vs Weekly TSS Effluent Limits 4-29
4-19 Performance vs Monthly TSS Effluent Limits 4-30
4-20 Performance vs Daily Minimum Removal Requirements 4-31
4-21 Performance vs Monthly Minimum Removal Requirements 4-32
4-22 Performance vs Daily NH3-N Effluent Limits 4-34

0001438

4-23 Performance vs Weekly NH3-N Effluent Limits 4-35
4-24 Performance vs Monthly NH3-N Effluent Limits 4-36
4-25 Performance vs Daily Settleable Solids Effluent Limits 4-37
4-26 Performance vs Daily Fecal Coliform Effluent Limit 4-38
4-27 Performance vs Monthly Fecal Coliform Effluent Limit 4-39
4-28 Loves Creek WWTP Flow Schematic and Solids Balance at 3.1 mgd 4-40
6-1 Normalized Diurnal Flows at KWWTP 6-2
6-2 Effluent Concentrations of TSS, $CBOD_5$, and NH_3-N at KWWTP (Influent Flow = 50 mgd, RAS = 15 mgd) 6-3
6-3 Effluent Concentrations of TSS, $CBOD_5$, and NH_3-N at KWWTP (Influent Flow = 55 mgd, RAS = 25-30 mgd) 6-5
6-4 Final Clarifier Sludge Blanket at KWWTP (Influent Flow = 50 mgd, RAS = 15 mgd) 6-6
6-5 Final Clarifier Sludge Blanket at KWWTP (Influent Flow= 55 mgd, RAS = 25-30 mgd) 6-7
6-6 Effluent Concentrations of TSS, $CBOD_5$, and NH_3-N at KWWTP (Influent Flow = 80 mgd, RAS = 15 mgd) 6-9
6-7 Final Clarifier Sludge Blanket at KWWTP (Influent Flow = 80 mgd, RAS = 15 mgd) 6-10
6-8 Hydrograph for 2-yr, 24-hr Storm at KWWTP 6-12
6-9 MLSS Concentrations during 2-yr, 24-hr Storm at KWWTP (90 mgd to Biological Treatment, RAS = 15 mgd) 6-14
6-10 Effluent Concentrations of TSS, $CBOD_5$, and NH_3-N during 2-yr, 24-hr Storm at KWWTP (90 mgd to Biological Treatment, RAS = 15 mgd) 6-16
6-11 Normalized Diurnal Flows at FCWWTP 6-17
6-12 Effluent TSS, BOD_5, and TKN at FCWWTP (Average Influent Flow = 7.1 mgd, RAS Flow = 2 mgd) 6-19
6-13 Effluent TSS, BOD_5, and TKN at FCWWTP (Average Influent Flow = 15 mgd, RAS Flow = 3 mgd) 6-20
6-14 Predicted Sludge Blanket Depth at FCWWTP (Average Influent Flow = 15 mgd, RAS Flow = 3 mgd) 6-20
6-15 Effluent TSS, BOD_5, and TKN at FCWWTP (Average Influent Flow = 18 mgd, RAS Flow = 3 mgd) 6-22
6-16 Diversion TSS, Clarifier TSS, and Effluent TSS at FCWWTP (Average Influent Flow = 18 mgd, RAS Flow = 3 mgd) 6-22
6-17 Summary of Flows at FCWWTP for 2-yr, 24-hr Storm (RAS Flow = 2 mgd) 6-25

6-18 Impact of Diversion on Final Effluent TSS during 2-yr, 24-hr Storm at FCWWTP 6-25
6-19 Effluent TSS, BOD_5, and TKN at FCWWTP (2-yr, 24-hr Storm, RAS Flow = 2 mgd) 6-26
6-20 Aeration Basin MLSS at FCWWTP (2-yr, 24-hr Storm, RAS Flow = 2 mgd) 6-26
6-21 Normalized Diurnal Flows at LCWWTP 6-28
6-22 Effluent TSS, $CBOD_5$, and NH3-N at LCWWTP (Average Influent Flow = 3.1 mgd, RAS Flow = 1.5 mgd) 6-29
6-23 Summary of Flows at LCWWTP (Average Influent Flow = 5 mgd, RAS Flow = 1.5-2 mgd) 6-30
6-24 Effluent TSS, $CBOD_5$, and NH3-N at LCWWTP (Average Influent Flow = 5 mgd, RAS Flow = 1.5-2 mgd) 6-30
6-25 MLSS Concentration at 5 mgd Average Influent Flow for LCWWTP (RAS Flow = 1.5-2 mgd) 6-31
6-26 Final Clarifier Sludge Blanket Depth at LCWWTP (Average Influent Flow = 5 mgd, RAS Flow = 1.5-2 mgd) 6-31
6-27 Summary of Flows at LCWWTP for Average Influent Flow = 10 mgd (RAS Flow = 2-3 mgd) 6-33
6-28 Aeration Basin MLSS at LCWWTP (Average Influent Flow = 10 mgd, RAS Flow = 2-3 mgd) 6-33
6-29 Effluent TSS, $CBOD_5$, and NH3-N at LCWWTP (Average Influent Flow = 10 mgd, RAS Flow = 2-3 mgd) 6-33
6-30 Summary of Flows at LCWWTP for Average Influent Flow = 15 mgd (10 mgd to Biological Treatment, RAS Flow = 3 mgd) 6-34
6-31 Effluent TSS, Final Clarifier TSS, and Peak Flow Clarifier TSS at LCWWTP (Average Influent Flow = 15 mgd, RAS Flow = 3 mgd, 10 mgd to Biological Treatment) 6-34
6-32 Flows at LCWWTP following 2-yr, 24-hr Storm (RAS Flow = 3 mgd, 10 mgd to Biological Treatment) 6-37
6-33 MLSS Concentration at LCWWTP (2-yr, 24-hr Storm RAS Flow = 3 mgd, 10 mgd to Biological Treatment) 6-37
6-34 Effluent TSS, $CBOD_5$, and NH3-N at LCWWTP (2-yr, 24-hr Storm, RAS Flow = 3 mgd) 6-38
6-35 Final Clarifier TSS, Peak Flow Clarifier TSS and Effluent TSS at LCWWTP (2-yr, 24-hr Storm, RAS Flow = 3 mgd) 6-38

Tables

1-1 CPE Summary 1-6
2-1 NPDES Effluent Limits for the KWWTP 2-6
2-2 Bar Screen Design Information and Tennessee Design Standards 2-7
2-3 Aerated Grit Chamber Design Information and Tennessee Design Standards 2-7
2-4 Primary Clarifier Design Information and Tennessee Design Standards 2-9
2-5 Aeration Basin Design Information and Tennessee Design Standards 2-10
2-6 Final Clarifier Design Information and Tennessee Design Standards 2-10
2-7 Chlorination Design Information and Tennessee Design Standards 2-11
2-8 Summary of Gravity Thickener Design Information and Tennessee Design Standards 2-12
2-9 Summary of DAF Design Information and Tennessee Design Standards 2-12
2-10 Summary of Anaerobic Digester Design Information and Tennessee Design Standards 2-12
2-11 Summary of Kuwahee WWTP Average Flow Rates 2-14
2-12 Summary of Kuwahee WWTP Average Influent $CBOD_5$ Concentrations 2-18
2-13 Summary of Kuwahee WWTP Average Influent $CBOD_5$ Loadings 2-18
2-14 Summary of Kuwahee WWTP Average Influent TSS Concentrations 2-22
2-15 Summary of Kuwahee WWTP Average Influent TSS Loadings 2-22
2-16 Summary of Kuwahee WWTP Average Influent NH_3-N Concentrations 2-26
2-17 Summary of Kuwahee WWTP Average Influent NH_3-N Loadings 2-26
2-18 Summary of TSS and TSS Removal Efficiencies 2-46
2-19 Solids Accountability for Advanced Wastewater Treatment System 2-49
2-20 Kuwahee WWTP Average Daily Process Performance 2-50
2-21 Kuwahee WWTP 2002 - 2004 Total, Dry Weather and Wet Weather Flow Rates 2-52
2-22 Kuwahee WWTP 2002 - 2004 Total, Dry Weather and Wet Weather $CBOD_5$ Removal Process Performance 2-52
2-23 Kuwahee WWTP 2002 - 2004 Total, Dry Weather and Wet Weather TSS Removal Process Performance 2-53
2-24 Kuwahee WWTP 2002 - 2004 Total, Dry Weather and Wet Weather NH_3 Removal Process Performance 2-53

0001441

2-25 Comparison of $CBOD_5$ and TSS Concentrations During Diversions 2-55
3-1 NPDES Effluent Limits for the FCWWTP 3-4
3-2 Bar Screen Design Information and Tennessee Design Standards 3-5
3-3 Aerated Grit Chamber Design Information and Tennessee Design Standards 3-6
3-4 Primary Clarifier Design Information and Tennessee Design Standards 3-6
3-5 Aeration Basin Design Information and Tennessee Design Standards 3-7
3-6 Final Clarifier Design Information and Tennessee Design Standards 3-8
3-7 Chlorination Design Information and Tennessee Design Standards 3-8
3-8 Summary of Gravity Thickener Design Information and Tennessee Design Standards 3-9
3-9 Summary of Fourth Creek WWTP Average Flow Rates 3-11
3-10 Summary of Fourth Creek WWTP Average Influent BOD_5 Concentrations 3-15
3-11 Summary of Fourth Creek WWTP Average Influent BOD_5 Loadings 3-15
3-12 Summary of Fourth Creek WWTP Average Influent TSS Concentrations 3-19
3-13 Summary of Fourth Creek WWTP Average Influent TSS Loadings 3-19
3-14 Summary of Fourth Creek WWTP Average Influent NH_3-N Concentrations 3-23
3-15 Summary of Fourth Creek WWTP Average Influent NH_3-N Loadings 3-23
3-16 Summary of TSS and TSS Removal Efficiencies 3-41
3-17 Solids Accountability for Advanced Wastewater Treatment System 3-42
3-18 Fourth Creek WWTP Average Daily Process Performance 3-43
3-19 Fourth Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather Flow Rates 3-44
3-20 Fourth Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather BOD_5 Removal Process Performance 3-44
3-21 Fourth Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather TSS Removal Process Performance 3-45
3-22 Fourth Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather NH_3 Removal Process Performance 3-45
4-1 NPDES Effluent Limits for the LCWWTP 4-4
4-2 Aeration Basin Design Information and Tennessee Design Standards 4-5
4-3 Final Clarifier Design Information and Tennessee Design Standards 4-6
4-4 Chlorination Design Information and Tennessee Design Standards 4-7
4-5 Summary of Loves Creek WWTP Average Flow Rates 4-8
4-6 Summary of Loves Creek WWTP Average Influent $CBOD_5$ Concentrations 4-9

4-7 Summary of Loves Creek WWTP Average Influent $CBOD_5$ Loadings 4-9
4-8 Summary of Loves Creek WWTP Average Influent TSS Concentrations 4-13
4-9 Summary of Loves Creek WWTP Average Influent TSS Loadings 4-13
4-10 Summary of Loves Creek WWTP Average Influent NH_3-N Concentrations 4-17
4-11 Summary of Loves Creek WWTP Average Influent NH_3-N Loadings 4-17
4-12 Fourth Creek WWTP Average Daily Process Performance 4-41
4-13 Loves Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather Flow Rates 4-41
4-14 Loves Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather $CBOD_5$ Removal Process Performance 4-42
4-15 Loves Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather TSS Removal Process Performance 4-42
4-16 Loves Creek WWTP 2002 - 2004 Total, Dry Weather and Wet Weather NH_3 Removal Process Performance 4-43
5-1 Comparison of Estimated WWTP Peak Wet Weather Flows 5-1
5-2 Comparison of WWTP Average Daily Influent Flows 5-2
5-3 Influent Pump Station Capacity 5-3
5-4 Intermediate Pump Station Capacity 5-4
5-5 Pump Station Capacities 5-1
6-1 Summary of Influent Wastewater Characteristics for KWWTP 6-2
6-2 Comparison of Amount of Biomass in Aeration Basin, Using Cell #6 MLSS vs. MLSS Concentration of Individual Aeration Basin Cells During Washout 6-13
6-3 Summary of Influent Wastewater Characteristics for FCWWTP 6-17
6-4 Summary of Influent Wastewater Characteristics for LCWWTP 6-27
8-1 CPE Summary of WWTP Performance Issues - KWWTP 8-9
8-2 CPE Summary of WWTP Performance Issues - FCWWTP 8-11
8-3 CPE Summary of WWTP Performance Issues - LCWWTP 8-13

Section 1
Introduction

Section VII.D.1.(a).(iv) of the Consent Decree (CD) requires KUB to complete a Comprehensive Performance Evaluation (CPE) Program for the Kuwahee WWTP (KWWTP), Fourth Creek WWTP (FCWWTP) and the Loves Creek WWTP (LCWWTP). The Eastbridge WWTP is not required to be included in the CPE, however the CD prohibits Diversions to occur at this facility. Pertinent CD language describing the CPE is provided below.

"The purpose of the CPE is to identify flow and/or loading rate restricted treatment process unit(s) at each WWTP. To the extent applicable, the CPE shall be consistent with the EPA publications Improving POTW Performance Using the Composite Correction Approach, EPA CERI, October 1984, and Retrofitting POTWs, EPA CERI, July 1989. The CPE shall require an in-depth diagnostic evaluation of the capacity and operation of each of the identified WWTPs and their ability to meet all terms of the NPDES Permits. The CPE shall establish a schedule and procedures that KUB will use to prepare a Composite Correction Plan (CCP), as set forth below, based on the results of the CPE. The CPE shall employ flow modeling and other appropriate techniques to evaluate WWTP capacity and operation, taking into account the net (cumulative) increase or decrease to the existing volume of wastewater introduced to the WWTP as a result of KUB's actual and anticipated increases in flow from the authorization of new sewer service connections and/or from existing sewer service connections pursuant to Section VII.D.1.(a).(iii), and the reduction of I/I into the WCTS. The CPE shall also identify the flow at which each of the identified WWTPs is designed to operate without experiencing a Bypass or a Diversion prohibited under the NPDES Permits."

Note: Section VII.D.1.(a).(iii) referenced above describes the requirements for the Capacity Assurance Program (CAP).

This CPE is consistent with the Comprehensive Performance Evaluation Program - Initial Scope which was previously approved by EPA on May 4, 2006.

1.1 Related Consent Decree Programs

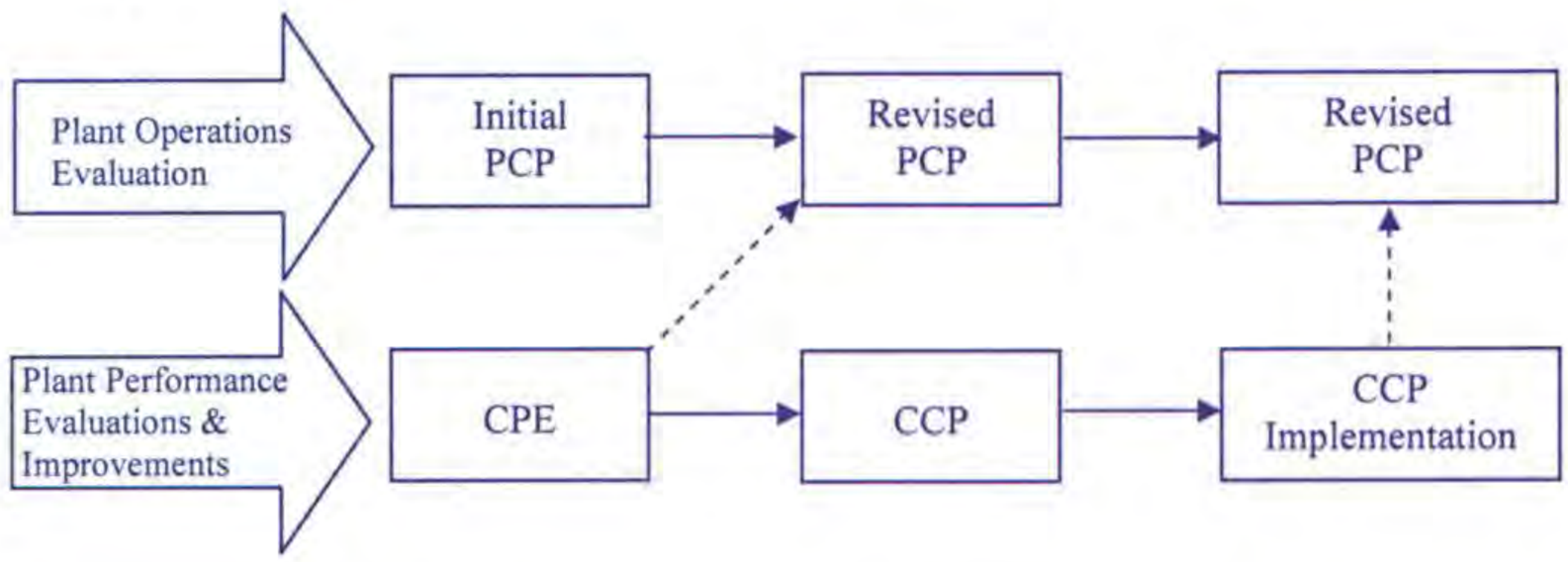
This CPE is consistent with other programs that are being developed to comply with the CD, specifically the Process Controls Program (PCP) and the Composite Correction Plan (CCP). These programs are described below:

Process Controls Program (PCP) - The Consent Decree (CD) requires development of a PCP for the Kuwahee, Fourth Creek, and Loves Creek wastewater treatment plants (WWTPs). The PCP consists of standard procedures for wet weather flow operating conditions, along with supporting documentation to optimize treatment of wastewater with existing facilities in order to achieve NPDES permit compliance. The standard procedures consist of checklists and flow charts and have been developed to base operational decision-making on parameters including plant flow, mixed liquor suspended solids (MLSS), clarifier sludge blanket levels, and other operational conditions including, but not limited to, status of on-site storage basins. Specifically,

the procedures address when to initiate and conclude Diversions in accordance with the requirements of the currently applicable NPDES permits. [Ref. CD Section VII.D.2.(b)]

Composite Correction Program (CCP) – The CCP is the performance improvement phase that follows the CPE. It is a systematic approach to implementing administrative, operational, and maintenance improvements as well as rehabilitation and/or upgrades to the WWTPs to address the problems, if any, identified in the CPE. The CCP will also be consistent with the EPA publications "Improving POTW Performance Using the Composite Correction Approach" - EPA CERI, October 1984 and "Retrofitting POTWs" - EPA CERI, July 1989; and the "Tennessee Design Criteria", to the extent applicable. The CCP will: (A) address all factors which limit or which could limit the WWTP's operating efficiency or the ability to achieve NPDES Permit compliance; (B) address the peak flow handling procedures and peak flow capacity of the WWTP; and (C) identify specific actions and schedules to correct each limiting factor, including capital improvements to the existing WWTP where appropriate. The CCP will evaluate all appropriate alternatives and provide schedules for achieving permit compliance. [Ref. CD Section VII.D.1.(a).(v)]

The graphic below illustrates the relationship between the CPE, PCP and CCP components of the CD.



Upon approval and implementation of this CPE, the initial PCP will be revised as appropriate to reflect the capacities of all unit processes, and action levels will be confirmed or revised.

Additionally, as stated above, the CPE must consider anticipated future changes in flows which are authorized under the CAP. This program requires KUB to certify that there is sufficient capacity (collection system, transmission system and treatment capacity) for all new building connections or increases in flow from existing connections, within the constraints defined in the CD. In the event capacity for additional flow cannot be certified, the additional flow can only be approved if KUB documents that a multiple of the new flow has been removed from the system. The CAP is being developed concurrently with the CPE. The CPE will establish the treatment capacities and current flow and loading conditions to be included in the

0001445

CAP. Current and future flow conditions were established by the Corrective Action Plan/Engineering Report (CAP/ER).

1.2 Permit Compliance Issues

In addition to addressing each WWTP's ability to meet effluent limits, the CPE specifically addresses the use of a Diversion and a Bypass, as defined by the currently applicable NPDES permits.

All three WWTPs were designed and permitted for Diversion of flows that exceed the capacity of the biological treatment system. However, diverted flows receive disinfection after being combined with effluent from the biological system. The CD requires compliance with the currently applicable NPDES permit Diversion provisions until new permits become effective.

Diversion language from the NPDES permits and the CD is provided below:

> **"Diversion**
>
> a. 'Diversion' is the intentional rerouting of wastewater within a treatment facility away from a biological portion of the treatment facility.
>
> b. A Diversion is permissible only when necessary to protect the active biomass from a wash-out due to peak flow events and when this action does not cause effluent limitations to be exceeded."

The definition of "Washout" in the permits (and the CD) is as follows:

> "For domestic wastewater plants only, a 'washout' shall be defined as loss of Mixed Liquor Suspended Solids (MLSS) of 30% or more. This refers to the MLSS in the aeration basin(s) only. This does not include MLSS decrease due to solids wasting to the sludge disposal system. A washout can be caused by improper operation or from peak flows due to infiltration and inflow.
>
> A washout is prohibited. If a washout occurs, the permittee must report the incident to the appropriate field office within 24 hours by telephone. A written submission must be provided within five days. The washout must be noted on the Discharge Monitoring Report (DMR). Each day of a washout is a separate exceedance."

In addition to Diversions, Bypasses are also an issue during peak wet weather flow conditions. Bypass language from the currently applicable KUB's NPDES permits is provided below:

> "a. *'Bypass'* means the discharge of wastes from any portion of the collection or treatment system other than through permitted outfalls. 'Severe property damage' means substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be

expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

b. Bypass is prohibited unless the following three (3) conditions are met:

   i. Bypass is unavoidable to prevent loss of life, personal injury, or severe property damage;

   ii. There are not feasible alternatives to bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment down-time. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment down-time or preventative maintenance;

   iii. The permittee submits notice of an unanticipated bypass to the appropriate field office of the Division of Water Pollution Control within 24 hours of becoming aware of the bypass (if this information is provided orally, a written submission must be provided within five days). When the need for the bypass is foreseeable, prior notification shall be submitted to the Director, if possible, at least 10 (10) days before the date of the bypass.

c. The permittee shall operate the collection system so as to avoid bypassing. The permittee shall actively pursue the goal of eliminating bypasses through its Collection System Inspection and Rehabilitation Program as outlined in Exhibit A."

The CD contains a new term for "Bypass" as defined below:

"Bypass" shall have "the meaning set forth at 40 C.F.R. § 122.41(m)." Under 40 C.F.R. 122.41(m)(l)(i), a "bypass" means "the intentional diversion of waste streams from any portion of a treatment facility. A bypass is prohibited unless:

(A) Bypass was *unavoidable to prevent* loss of life, personal injury or *severe property damage* ("severe property damage" is defined under 40 C.F.R. § 122.41(m)(l)(ii) as "substantial physical damage to property, *damage to treatment facilities which causes them to become inoperable,* or substantial and permanent loss of natural resources, which can reasonably be expected to occur in the absence of a bypass");

(B) There were *no feasible alternatives* to the bypass, such as use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred

during normal periods of equipment downtime or preventive maintenance; and

(C) The permittee submitted notices as required under paragraph (m)(3) of this section (Permittee must comply with the 24-hour reporting requirements of 122.41(1)(6).)"

Operation of the WWTPs during peak wet weather flows can result in Diversions, Unpermitted Discharges (as defined in the CD) and/or *Bypasses* as defined by the currently applicable NPDES Permits and/or Bypasses as defined in the CD. The PCP has been developed to minimize the possibility of these occurrences.

Diversions under KUB's currently applicable NPDES permit provisions can only be made when necessary to prevent washout (and effluent limits must not be violated), which is specifically defined to mean the specific result of an increased rate of solids transfer from the aeration basins to the final clarifiers (loss of 30 percent or more of MLSS in aeration basins, exclusive of wasted solids), as illustrated in **Figure 1-1**.

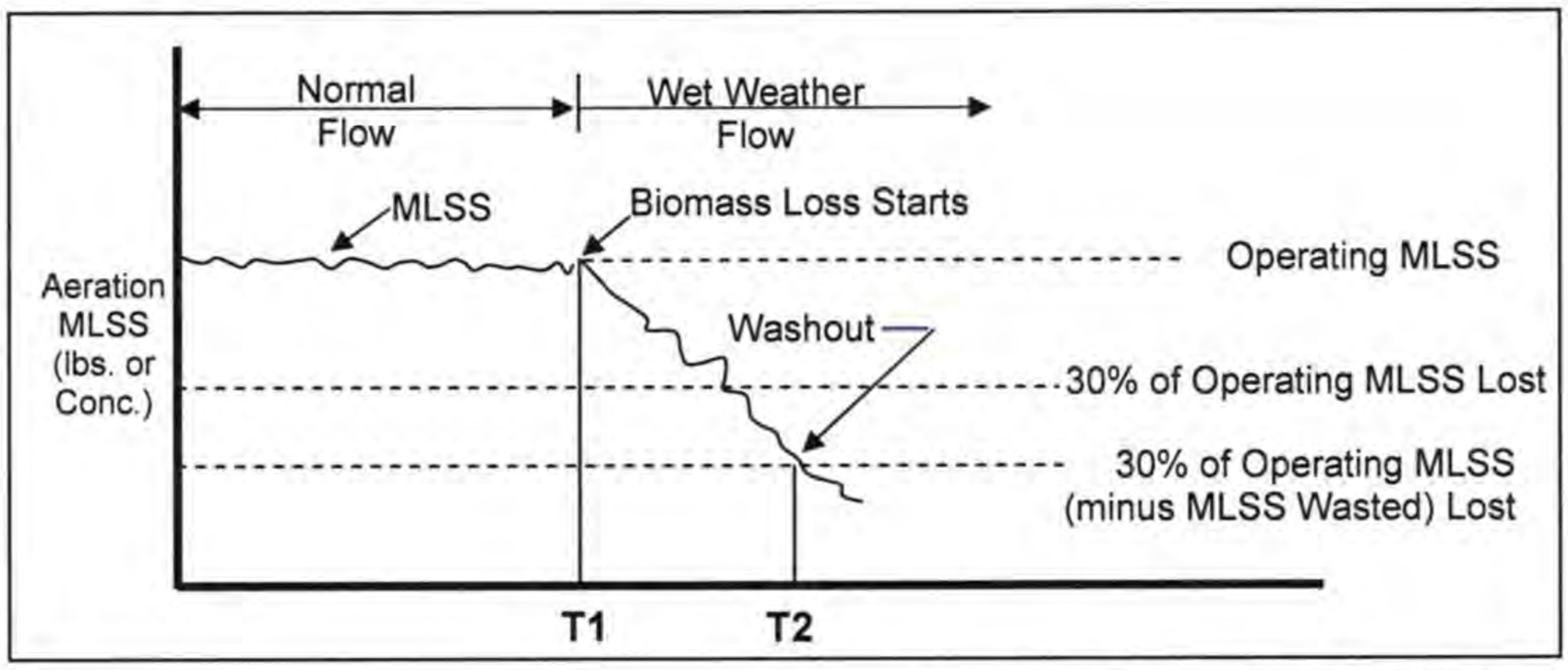


Figure 1-1: Aeration MLSS and Washout Illustration

1.3 CPE Process Overview

The CPE process is a detailed, systematic process for identifying current WWTP performance limiting factors that impact current NPDES Permit compliance. The process features several classification processes for rating plants based on major unit processes and for prioritizing performance-limiting factors (typically operations, maintenance, or administration factors). The CD requires the CPE to be completed in accordance with the EPA documents identified previously in this section. Key elements are summarized below:

Evaluation of Major Unit Processes

Type 1 WWTP - CPE indicates performance problems (or potential performance problems) are not a result of unit process capacities, but are related to operation,

maintenance, administration, or to facility problems that can be corrected with minor modifications.

Type 2 WWTP - CPE indicates performance problems may be related to marginal capacity of one or more major unit processes; major facility modifications are likely required.

Type 3 WWTP - CPE indicates one or more major unit processes does not have sufficient capacity; major modifications or facility replacement may be required.

Prioritization of Performance Limiting Factors

A Rating - CPE indicates major performance effect on long-term, repetitive basis

B Rating - CPE indicates minimum performance effect on routine basis, or major effect on a periodic basis

C Rating - CPE indicates minor performance effect

There is also a points allocation system for rating individual unit process capabilities (aeration, final clarifiers, and sludge handling). The process supports subsequent CCP activities and ultimately, any required major capital improvements. The process also supports the PCP, which will likely require revisions to wet weather operational practices as improvements are made.

Given the stated purpose of the CPE, the unique characteristics of the WWTPs (i.e., designed for Diversions, nitrification requirements for KWWTP and LCWWTP, etc.), and KUB's administration model (i.e., shared staff among plants, etc.), some aspects of the prescribed CPE process are not relevant.

A summary of CPE elements and KUB's approach to completing this CPE are provided in **Table 1-1**.

Table 1-1: CPE Summary

CPE Element	Comment	KUB Implementation Approach
1. Data Collection A. Kick-off Meeting B. Plant Tour C. Detailed Data Gathering	Completed generally in accordance with CPE guidelines	- Existing data, including record drawings, SOPs, recent flow and loading data, projected flows and loadings, and process performance data were reviewed and evaluated - Interviews were used to gather information on perceived plant performance issues and constraints
2. Evaluation of Major Unit Processes A. Wastewater Pumping B. Screening C. Grit Removal D. Primary Clarifiers (if applicable)	Point scoring system for aeration, final clarifiers, and sludge handling was replaced with a more detailed and comprehensive analysis featuring process modeling using	- Current and planning period flows and loadings were established - Flow and loading design criteria were compared to TDEC standards and other relevant design criteria - Process modeling was conducted to establish capacity constraints - Hydraulic analyses were performed to identify

Table 1-1: CPE Summary

CPE Element	Comment	KUB Implementation Approach
E. Biological Treatment F. Disinfection G. Residuals Management	a dynamic model (BioWin)	hydraulic constraints
3. Prioritization of Performance-Limiting Factors	Was limited to design and operations issues with focus on wet weather performance	– Administrative factors were only evaluated to extent necessary to identify operations (and/or maintenance) factors that adversely impact performance, and to address implementation of recommendations if necessary – Design factors included hydraulic capacity, process controls, level of automation, flow and measurement capabilities, and reliability criteria (per EPA guidelines) – Operations factors included staffing level, operator training, SOPs, laboratory analysis procedures (including QA/QC) and data management – Sludge accountability evaluations were completed

1.4 CPE Report Overview

The following sections of this report are briefly described below.

Sections 2, 3 and 4 provide overviews of the KWWTP, FCWWTP and LCWWTP respectively. These sections provide a general description of wastewater treatment unit processes, operational description, treatment requirements and effluent limitations, treatment process and equipment descriptions and comparison to TDEC design criteria, influent flows and loadings, and treatment performance summaries. A mass balance is also included for each WWTP. For the KWWTP, an analysis of wet weather sampling data obtained during Diversion events on the Diversion flow and biological effluent flow prior to blending is presented. This data is not currently available for the other plants, however sampling equipment has recently been installed at the FCWWTP.

Section 5 presents the results of hydraulic analyses of each facility. Also presented are estimated existing and future influent hydrographs for a representative 2-year 24-hour storm based on collection and transmission system hydraulic modeling.

Section 6 presents the results of dynamic process modeling analyses. The primary purpose of this modeling was to determine the average annual and peak flow capacity of each WWTP. Specifically, each plant was analyzed to determine the peak flow that could be treated without experiencing a Bypass or Diversion prohibited by currently applicable NPDES permits.

Section 7 presents the results of a review of WWTP administration, operations and maintenance. The objective of this review was to determine if these factors adversely

impact performance of existing facilities, and to present recommendations for addressing any identified performance limiting factors.

Section 8 presents a summary of CPE findings and conclusions.

Section 9 presents a recommended CCP implementation plan, including procedures to address identified deficiencies and a schedule.

Section 2
Kuwahee WWTP Process Performance Evaluation & Data Analysis

The purpose of this section of the CPE is to summarize the process performance of the existing wastewater treatment facilities at the Kuwahee Wastewater Treatment Plant (KWWTP). This section is divided into the following subsections:

2.1 KWWTP General Description

2.2 Operational Description

2.3 Treatment Requirements and Effluent Limitations

2.4 Treatment Process and Equipment Descriptions

2.5 WWTP Data Analysis and Performance Summary

2.6 Wet Weather Data Analysis and Performance Summary

This evaluation compares the capacity of each major treatment process to Tennessee Department of Environment and Conservation (TDEC) Design Standards. In addition, this evaluation describes the performance of each major process, including removal efficiencies for various pollutants, and currently applicable NPDES permit compliance. Finally, the evaluation examines the impact of wet weather on flows, loadings, and process performance at the KWWTP.

The analysis consisted of a detailed evaluation of the wastewater treatment plant operational data, including flow and loading data, for January 2002 through August 2005.

2.1 KWWTP General Description

The KWWTP is an advanced wastewater treatment facility that was originally constructed in the 1950's to serve residential, commercial, and industrial customers. The facility underwent a major expansion and upgrade in the late 1970's when the existing secondary and tertiary facilities, digesters, and dewatering system were constructed. The KWWTP is designed to provide advanced secondary treatment to an average daily flow of 40 mgd with a maximum daily flow of 70 mgd. The bar screens, raw sewage pumps/wetwell, aerated grit chamber, and chlorination/dechlorination facilities are designed to handle a peak flow of 120 mgd. However, after the aerated grit chamber, flows greater than 70 mgd must be routed through the preaeration basin in order to fully utilize the wet weather treatment provisions designed and built into the plant and to avoid overloading the primary clarifiers and the remainder of the biological treatment processes, which are designed for 70 mgd, and thereby avoiding a potential Washout. The effluent from the preaeration basin flows into the secondary aeration basins. All or part of the effluent from the primary

clarifiers is also routed to the secondary aeration basins where it combines with the flow from preaeration (if any), for a maximum flow of 70 mgd, to be treated by the remainder of the plant. The remainder of the 70 mgd flow treated by primary clarifiers (combined with secondary effluent) is disinfected with chlorine, dechlorinated with sodium bisulfite, and discharged into the Tennessee River.

The advanced wastewater treatment plant includes preliminary, primary, advanced secondary, and disinfection treatment. Secondary treatment originally included a high purity oxygen activated sludge system (UNOX) with secondary aeration basins and clarifiers; however, the cryogenic oxygen generator and liquid oxygen facilities were no longer needed following the closure of a local paper mill with high BOD wastes and have been removed. An Intermediate Pump Station pumps flows to "tertiary" treatment (i.e., advanced secondary treatment); which is accomplished by an activated sludge nitrification system. Effluent from the advanced secondary facilities is disinfected in chlorine contact tanks and then dechlorinated by use of sodium bisulfite prior to discharge into the Tennessee River.

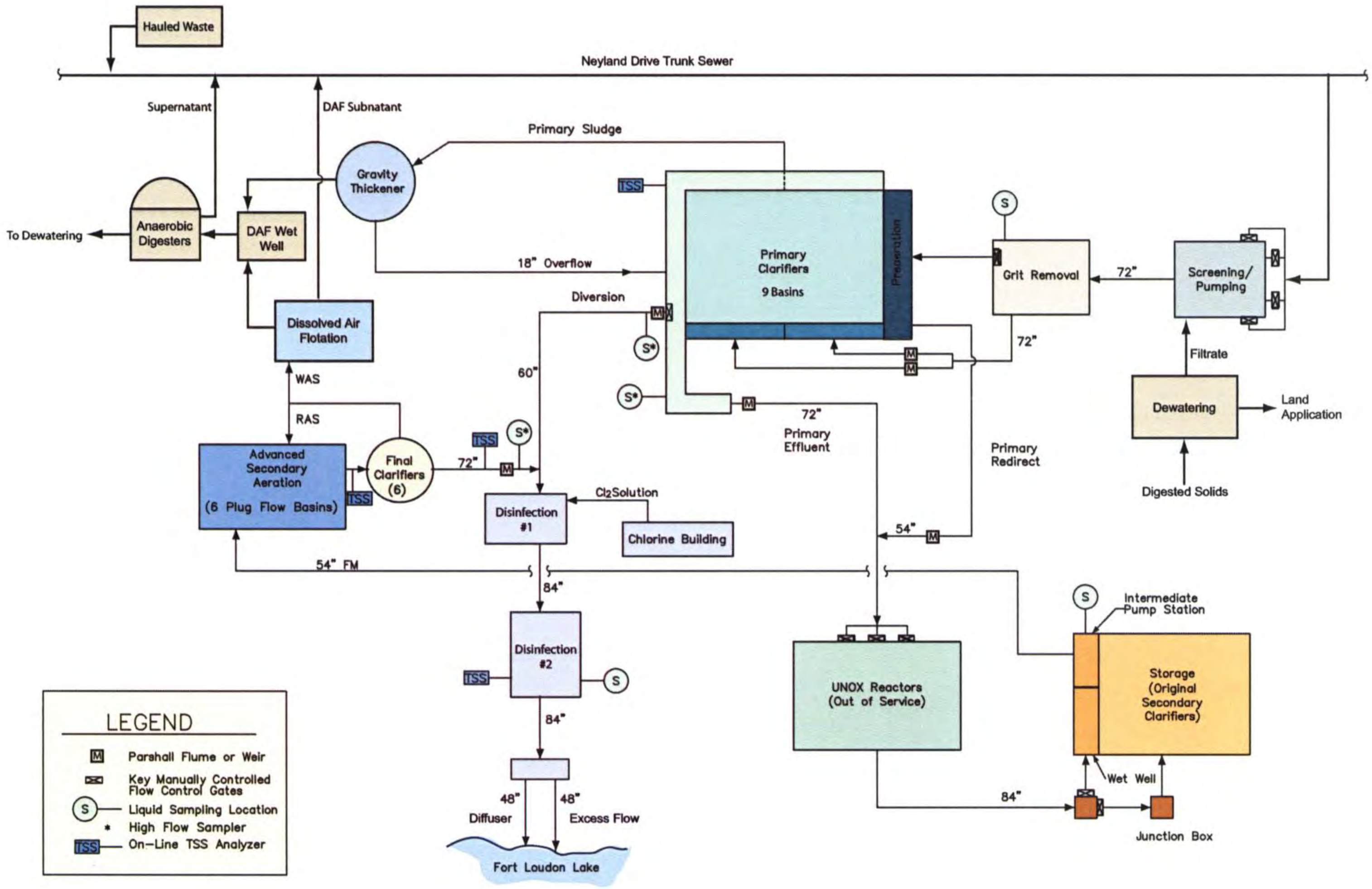
Solids processing is achieved through several different mechanisms. Sludge from primary treatment is thickened by a gravity sludge thickener, and sludges from advanced secondary treatment are thickened by dissolved air flotation (DAF) units. The thickened sludge from both sludge thickening processes is then digested using anaerobic sludge digesters. Until August 2005, the digested sludge was dewatered by two high pressure plate and frame filter presses. That equipment is currently being replaced with a centrifuge dewatering system. The dewatered sludge is currently land applied by a private contractor. Methane produced by sludge digestion is used to run the sludge heat exchanger boilers. Excess methane is flared. A schematic of the KWWTP is shown in **Figure 2-1**.

2.2 Operational Description

At flows up to 70 mgd, all but 1 to 2 mgd receive primary treatment, prior to secondary treatment. The plant features a preaeration basin that receives 1 to 2 mgd which is routed around primary treatment, but receives full secondary treatment. Flows in excess of 70 mgd must pass through the preaeration basin to avoid overloading the primary clarifiers. The basin is kept full with 1 to 2 mgd flow at all times to avoid damaging the diffusers by routing high flows into an empty basin.

As influent flows increase above 70 mgd, flow to the preaeration basin is increased to maintain 70 mgd through primary clarification. Flows above 70 mgd through the primary clarifiers cause flooding of the effluent launders.

Primary and preaeration effluents cannot be routed around the original high purity oxygen process tanks. Primary effluent (up to 70 mgd) and preaeration effluent (up to 50 mgd) flows pass through the high purity oxygen aeration basins and enter the intermediate pump station for pumping to biological treatment. The original intermediate clarifiers provide up to approximately 6.5 million gallons of storage for



0001454

CDM

Figure 2-1: Kuwahee WWTP Process Schematic

flows that exceed the capacity of the intermediate pump station. Use of the intermediate clarifiers for storage results in operation of the intermediate pump station with a wetwell level that is up to 5 feet higher than normal. This appears to result in a capacity of more than 70 mgd with all five pumps in service. The pumping capacity is further evaluated in Section 5.

Although the original design provided for Diversion to automatically occur whenever plant flows exceeded 70 mgd, KUB has found that the use of the intermediate clarifiers for storage and performance monitoring of the biological system results in minimizing Diversion volume and sometimes eliminates the need for Diversion, even at flows in excess of 70 mgd.

The biological system consists of six plug flow aeration basins with fine bubble ceramic diffusers that are also designed to be operated in the complete mix mode. Effluent is distributed to the six final clarifiers through a channel with a weir to control flow to each clarifier. Sludge in each clarifier is collected by a rotating hydraulic removal system which discharges through an adjustable telescopic valve. All of the sludge flows by gravity to the sludge pump station where it is returned to the aeration basin influent stream, or wasted. An on-line total suspended solids meter in the aeration basin effluent channel continuously measures mixed liquor suspended solids (MLSS).

Process control of the biological system is influenced by the hydraulics of the clarifier feed channel which make it difficult to achieve uniform flow and solids loadings to each clarifier. As a result, the telescope valves must be set at different levels to maintain similar sludge blanket levels in each clarifier. This aspect of the system makes it difficult to adjust sludge removal rates as flows change, even though sludge blanket levels are checked frequently during high flow conditions, and the telescopic valves are adjusted to maintain uniform low blanket levels. The difficulty in increasing the return sludge rate can result in a washout under sustained high flow conditions.

The on-line total suspended solids (TSS) meter recently installed at the aeration basin effluent channel is used to monitor for a Washout condition.

With plug flow aeration basins, use of effluent MLSS to monitor for Washout conditions does not accurately reflect the solids levels within the tank because of the variability of MLSS concentration from the influent to effluent end of the basin.

The procedure for completing Diversion process preparation activities is included in the PCP, and is described as follows:

1. Establish pre-event MLSS concentration – this is the MLSS concentration that will be used to calculate the percentage of biomass lost from aeration.

2. The pre-Diversion approval threshold is the MLSS concentration at which supervisory approval is obtained for a possible Diversion. It is set at 10 percent

of the pre-event MLSS value. (There is also a pre-Diversion approval threshold for storage tank level as described below).

3. The Diversion threshold is the MLSS concentration at which the Diversion gate is opened to avoid a washout condition. It is set at 15 percent of the pre-event MLSS value.

The pre-event MLSS concentration is the average concentration determined by TSS meter readings for the 12 hours preceding the time the second influent pump comes on. The pre-Diversion approval and Diversion thresholds described above are used as guidelines to take the indicated actions. Due to the typically rapid changes in flows and process performance characteristic of wet weather operations and manual operation required to adjust gates, these actions may be taken when TSS measurements are within two percent of the action levels.

In addition to monitoring MLSS for Washout conditions, the operator must concurrently monitor the storage basin level to ensure maximum use of available plant storage while not exceeding the capacity of the junction box. When flows to the intermediate pump station exceed the biological treatment capacity of 70 mgd, the storage basins begin to fill. Once the storage basins are full and plant flows are at or exceeding biological system capacity, the Diversion gate must be opened if the additional wet weather design capacity of the plant is to be utilized. The pre-Diversion notification level (elevation) for the storage tanks is approximately 823.00 and the Diversion threshold is approximately 824.00. If the Diversion gate is open as a result of reaching the MLSS threshold, the operator must continue to monitor the storage basin level. If the level reaches approximately 823.00, it is necessary to adjust the influent gates.

2.3 Treatment Requirements and Effluent Limitations

The KWWTP was designed to treat an average daily flow of 40 mgd with a maximum daily flow of 70 mgd and a peak hydraulic flow of 120 mgd. The KWWTP is permitted to meet the following maximum monthly average, maximum weekly average and daily maximum effluent requirements for an average annual flow of 40 mgd as imposed under NPDES Permit No. TN0023582 (issued on September 30, 1994). The plant was re-rated in 2001 at a flow of 44 mgd, however this rerating has not yet been reflected in a revised NPDES permit. The permit limits for conventional pollutants are shown in **Table 2-1**.

Table 2-1: NPDES Effluent Limits for the KWWTP

	Monthly Average	Weekly Average	Daily Maximum
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)[1]	25 mg/L 8,340 lb/day	35 mg/L 11,676 lb/day	40 mg/L
Total Suspended Solids (TSS)[(1)]	30 mg/L 10,008 lb/day	40 mg/L 13,344 lb/day	45 mg/L
Ammonia, as Nitrogen (NH_3-N)			
- May 1 to October 31	5 mg/L 1668 lb/day	7.5 mg/L 2,502 lb/day	10 mg/L
- November 1 to April 30	15 mg/L 5,004 lb/day	20 mg/L 6,672 lb/day	25 mg/L
Fecal Coliforms	200 colonies per 100 ml	--	1,000 colonies per 100 ml
Total Residual Chlorine	--	--	0.6 mg/L (instantaneous)
Settleable Solids	--	--	1.0 ml/L
Dissolved Oxygen	--	--	1.0 mg/L (instantaneous)

[(1)] 85 percent monthly average removal and 40 percent minimum daily removal are also required.

Additionally, the daily effluent pH shall not be less than 6.0 or greater than 9.0 standard units. The existing permit also contains limits for numerous other chemical constituents.

2.4 Treatment Process and Equipment Descriptions

The following paragraphs give a brief description of the treatment processes and corresponding equipment. Comparisons to Tennessee design standards (Design Criteria for Sewage Works, State of Tennessee, Department of Health and Environment, Division of Water Pollution Control, April 1989) are provided where appropriate. The evaluation addresses average design flows as well as a revised average design flow of 44 mgd which was determined to be feasible in a previous study.

Preliminary Treatment (Screening, Pumping, Grit Removal, and Preaeration)
As wastewater enters the plant, the flow is split into two channels that contain 7 feet wide mechanically cleaned bar screens with ½ inch openings. Prior to reaching the 7 feet wide bar screens, the flow can be diverted into two interior channels. Each of the two interior channels contains a 4 feet, 10 inch wide mechanically cleaned bar screen with ¾ inch screen openings. All four bar screens are rated at 60 mgd; thus, two screens provide the rated maximum capacity of 120 mgd. Under normal conditions

all flow is routed through the exterior bar screens; while, the interior bar screens are used as backup. Flow is controlled and directed to selected screens by four hydraulically operated sluice gates. Debris removed by bar screens are mechanically lifted up to ground level and placed in individual dumpsters prior to disposal at a sanitary landfill. **Table 2-2** provides a summary of design information.

Table 2-2: Bar Screen Design Information and Tennessee Design Standards

	Screen Size Openings (in)	Approach Velocity (fps)		
		Average Flow (40 mgd)	Average Flow (44 mgd)	Peak Flow (120 mgd)
Inner Bar Screens	0.75	1.29	1.42	3.87
Outer Bar Screens	0.5	1.03	1.13	3.08
Tennessee Design Standard	.675 (minimum)	1.25 (minimum)	1.25 (minimum)	3.0 (maximum)

Note: Velocities shown are for full flow passing through two of the screens

After screening, the raw wastewater enters a wetwell with a volume of approximately 83,400 gallons (55 feet long by 11.7 feet wide by 20.5 feet deep) and variable speed centrifugal pumps pump the wastewater to the aerated grit chamber.

The aerated grit chamber consists of four channels, each 45 feet in length by 15 feet in width with a side water depth of 16.5 feet. Air diffusers are located along the sides and bottom of each channel. High pressure blowers currently provide air to the aerated grit chamber. Heavy inorganic solids/particles are removed from the raw wastewater and settle in each of the four channels. One chain driven bucket collector per channel, capable of handling 48 cubic feet of grit per hour, is utilized to remove the collected grit from the aerated grit chamber. The grit is then placed on a conveyor which transports it to a dumpster in the Sludge Dewatering Building where it awaits off site disposal at a sanitary landfill. **Table 2-3** provides a summary of design information.

Table 2-3: Aerated Grit Chamber Design Information and Tennessee Design Standards

	Peak Flow (120 mgd)	Average Flow (44 mgd)	Average Flow (40 mgd)	Tennessee Design Standards
Detention Time, minutes	3.6	9.9	10.9	2-5 minutes at peak flow
Surface Overflow Rate, gpd/ft^2	44,500	16,300	14,800	46,300 gpd/ft^2 at peak flow

As mentioned above, all equipment and processes up to this point were designed to handle 120 mgd (with one of the largest units out of service). Flows greater than 70 mgd are routed to the preaeration basin. Effluent from the preaeration basin is then directed into the secondary aeration basins. A portion or all of the 70 mgd flow receiving primary treatment will then be diverted and combined with the flow (if any)

0001458

from the preaeration basin to achieve a combined maximum flow of 70 mgd to be treated by the remainder of the plant. The remainder of the 70 mgd flow from primary treatment goes on to receive disinfection with chlorine and then is dechlorinated and discharged into the Tennessee River.

The preaeration tank is 155 feet long by 20 feet wide with a side water depth of 15 feet (approximately 374,820 gallons). It contains 600 dome type ceramic diffusers along the bottom of the basin that aerate the wastewater for the first 100 feet. The remainder of the tank acts as a quiescent zone allowing heavy suspended solids to settle and scum and grease to float to the top. The scum and grease are collected by a hydraulically operated scum collector (skimmer) and then pumped along with scum from primary settling tanks to the DAF units. Sludge is removed from the bottom of the tank by a motor driven conveyor type sludge collector. The sludge is then pumped along with the sludge from the primary settling tanks over to the gravity sludge thickener. Effluent from the preaeration basin flows through a 72 inch Parshall flume (nominal flow capacity of 50 mgd) before combining with a portion of the 70 mgd flow treated by the primary settling tanks and moving on to the secondary aeration basins.

Under normal operating conditions, the preaeration basin is operational and receives approximately 1 to 2 mgd of flow at all times.

Primary Treatment

As mentioned above, flows less than or equal to 70 mgd pass from the aerated grit chamber to the primary settling tanks. Prior to entering the primary settling tanks, the flow passes through a double Parshall flume. One flume is 48 inches with a nominal flow capacity of 30 mgd, and the other is 60 inches with a nominal flow capacity of 40 mgd. Primary treatment consists of nine rectangular double bay settling tanks that are 144 feet long by 40 feet wide with a side water depth of 12.5 feet. The length of the weir is 458 feet per settling tank. A primary effluent Parshall flume (96 inches), with a nominal capacity of 70 mgd, measures the primary effluent being transported to the secondary aeration basins. A Diversion Parshall flume (96 inches wide), measures flows above the 70 mgd that go directly to the chlorine contact basin.

Each settling tank contains a chain and flight type sludge collector that carries sludge to the south end of each tank where the sludge hoppers are located. The sludge is then transferred by two vortex type centrifugal pumps to the gravity sludge thickener along with sludge from the preaeration tank.

Scum is removed from the primary settling tanks by gravity flow to the five scum boxes located at the south end of the tanks. The scum is then pumped, along with scum from the preaeration basin, to the DAF units for thickening or to the DAF wetwell prior to being transferred to the anaerobic sludge digesters. **Table 2-4** provides the primary clarifier design information as well as TDEC design standards.

Table 2-4: Primary Clarifier Design Information and Tennessee Design Standards

	Influent Flow (mgd)								Tennessee Design Standards
	20	**30**	**40**	**44**	**44**	**50**	**60**	**70**	
Number of Units	4	6	8	8	9	9	9	9	N/A
Detention Time, hours	2.6	2.6	2.6	2.4	2.6	2.3	1.9	1.7	2.5 (maximum recommended)
Surface Overflow Rate, gpd/ft^2 Average design flow Peak design flow	868	868	868	955	849	965	1,157	1,350	 800-1,200 2,000-3,000
Weir Loading Rate, gpd/ft^2	10,917	10,917	10,917	12,000	10,700	12,130	14,556	16,982	15,000 (maximum)

Secondary Treatment
Depending on the influent flow to the plant, all or a portion of the primary effluent flows to the secondary aeration basins. Flows from primary treatment and/or preaeration currently pass through the secondary aeration basins and into the intermediate pump station. Minimal aeration is provided by mechanical aerators as the wastewater passes through the secondary aeration basins for the purposes of mixing only.

Intermediate Pump Station
As described above, the effluent from the secondary aeration basins presently enters the intermediate pump station, except during high flow conditions when the secondary clarifiers are used for storage (approximately 6.5 million gallons). The intermediate pump station consists of a wetwell that is 134 feet long by 36 feet wide with a depth of 5.5 to 11 feet and contains five pumps. Each pump is a vertical turbine type pump with a variable speed drive that consists of a level control bubbler and adjustable frequency convertors. Nominal capacity of each pump is approximately 17 mgd. Secondary effluent within the intermediate pump station is pumped to advanced secondary treatment.

Advanced Secondary Treatment
Advanced secondary treatment consists of nitrification aeration tanks and clarifiers. Flow is distributed among six nitrification activated sludge basins by the influent channel. Each basin is 183 feet long by 32 feet wide with a side water depth of 33 feet. Each basin is also divided up into five compartments with 2,940 ceramic fine bubble diffusers per basin (17,640 total diffusers) installed on the floors of the basins. Currently, the nitrification activated sludge basins are being used for advanced secondary activated sludge treatment since the secondary treatment system is not being operated. **Table 2-5** provides a summary of design information.

Table 2-5: Aeration Basin Design Information and Tennessee Design Standards

	Average Flow (40 mgd)	Average Flow (44 mgd)	Peak Flow (70 mgd)	Tennessee Design Standards [1]
Detention Time, hours	5.2	4.7	3	4-8 hrs (average)
Basin Loading lbs $CBOD_5$/1000 ft^3 $CBOD_5$ = 98 mg/L (Avg. 2002-2005)	27	29	N/A	20-40 (average)
F:M (MLSS = 3200 mg/L)	0.17	0.18	N/A	0.2 – 0.4

(1) Plug flow conventional activated sludge.

Air is supplied to the nitrification system by two blowers (one on duty, one on standby), each rated at 22,000 scfm.

Effluent from the nitrification activated sludge basins flows by gravity to six final clarifiers. Each clarifier is circular with a diameter of 135 feet and a sidewater depth of 12 feet, except one which has a sidewater depth of 14 feet. Five clarifiers feature suction headers for sludge removal. One is equipped with scrapers and a hopper. The effluent weir length is 800 feet for each clarifier. Effluent from the final clarifiers flows into the nitrification diversion box where a nitrification treatment bypass line also enters. Flow then passes through a 72 inch wide Parshall flume (with a nominal flow capacity of 70 mgd) and goes on to Chlorine Contact Basin No. 1 to receive disinfection. **Table 2-6** provides a summary of design information.

Table 2-6: Final Clarifier Design Information and Tennessee Design Standards

	Peak Flow (70 mgd)	Average Flow (44 mgd)	Average Flow (40 mgd)	Tennessee Design Standards
Detention Time, hours	2.64	4.20	4.63	2.5 recommended maximum
Surface Overflow Rate, gpd/ft^2 Average design flow Peak design flow	815	512	466	 400 800
Solids Loading Rate, lbs/day/ft^2 @ MLSS Average design flow Peak design flow	 24 @ 3500 mg/L 17 @ 2500 mg/L	 15 @ 3500 mg/L 11 @ 2500 mg/L	 14 @ 3500 mg/L 10 @ 2500 mg/L	 25 35
Weir loading Rate, gpd/ft	14,314	8,842	8,038	15,000
Side Water Depth, ft Diameter 101 – 140 feet	12	12	12	14 minimum

Sludge from within the clarifiers flows by gravity through telescopic valves into a nitrification return sludge wetwell, 35.5 feet by 15 feet with a usable volume of 13,700 cubic feet. Sludge is returned to the nitrification activated sludge basins using two 30 mgd and one 40 mgd centrifugal return activated sludge pumps with variable speed drives. The returned sludge intersects the 54 inch secondary effluent line and then flows through a 72 inch line back into the distribution channel for the nitrification activated sludge basins.

Sludge is wasted by two variable speed centrifugal waste activated sludge pumps. Waste sludge is pumped to the DAF facility for thickening.

Disinfection

Disinfection is achieved by injecting chlorine solution into the wastewater and allowing enough contact time within the two chlorine contact tanks to reduce pathogen organisms to below NPDES permit limits. Chlorine Contact Basin No. 1 is 87 feet long by 59 feet wide with a side water depth of 14 feet (approximately 537,500 gallons), and Chlorine Contact Basin No. 2 is 140 feet long by 84 feet wide with a side water depth of 7.75 feet (approximately 681,700 gallons). Together, the two contact tanks and the 84 inch pipe that connects them provide a theoretical contact time of approximately 15.6 minutes at a flow of 120 mgd. The chlorine feed equipment consists of three 8,000 lbs./day and one 2,000 lbs./day chlorine gas feeders (chlorinators) and three 8,000 lbs./day and one 2,000 lbs./day liquid chlorine evaporators. **Table 2-7** provides a summary of design information.

Table 2-7: Chlorination Design Information and Tennessee Design Standards

Operating Conditions	Detention Time (minutes)	
	Actual	Tennessee Design Standards
Average Flow, 40 mgd	47	30
Average Flow, 44 mgd	40	30
Peak Flow, 120 mgd	15.6	15

Dechlorination is accomplished by the injection of sodium bisulfite (NaHSO3) solution into the wastewater at the effluent end of Chlorine Contact Basin No. 2. Dechlorination is performed to reduce the chlorine levels in the wastewater to below NPDES limits (0.6 mg/L residual chlorine). The sodium bisulfite contact tank is a common wall tank with Chlorine Contact Basin No. 2, and is 64 feet in length by 48 feet in width with a side water depth of 7.75 feet. Effluent from the dechlorination treatment is discharged by gravity flow through a 48 inch effluent diffuser into the Tennessee River. There is also a 48 inch overflow line that discharges directly into the Tennessee River.

Solids Processing

Solids processing and disposal is accomplished by utilizing the following treatment processes/equipment:

1. Gravity thickening of sludges from primary clarifiers and preaeration tank.
2. DAF thickening of sludges from secondary treatment and scum from the secondary clarifiers, primary settling tanks, and preaeration tank.
3. Anaerobic sludge digestion of thickened sludge from the gravity sludge thickener and the DAF.
4. Dewatering of digested sludge was by high pressure plate and frame sludge filter presses until August 2005. The presses are currently being replaced by a centrifuge dewatering system.
5. Dewatered biosolids are disposed of by land application by a private contractor.

An anaerobic sludge digester supernatant/sludge filter press filtrate treatment system exists but is no longer in use. **Table 2-8, Table 2-9 and Table 2-10** summarize the different sludge handling and disposal processes and equipment.

Table 2-8: Summary of Gravity Thickener Design Information and Tennessee Design Standards

	Average Flow (40 mgd)	Average Flow (44 mgd)	Tennessee Design Standards
Solids Loading, lbs/day/ft^2	30	31	20 to 30
Hydraulic Loading, gpd/ft^2	657	724	500 to 800

Table 2-9: Summary of DAF Design Information and Tennessee Design Standards

	Average Flow (40 mgd, 1 unit)	Average Flow (44 mgd, 3 units)	Tennessee Design Standards
Hydraulic Loading, gpm/ft^2	<2.0	<2.0	2.5
Solids Loading, lb/ft^2/hr	<0.4	0.76	0.42

Table 2-10: Summary of Anaerobic Digester Design Information and Tennessee Design Standards

	Average Flow (40 mgd)	Average Flow (44 mgd)	Tennessee Design Standards
Volatile Solids Loading, lb/day/ft^3	<0.2	<0.2	0.1-0.2
Hydraulic Detention Time, days	>15	14	15-25

The centrifuge dewatering system consists of two centrifuges, each with a capacity of 5,500 lb/hr dry solids.

TDEC Reliability Criteria

For components included in the design of Reliability Class I works, the following backup requirements apply.

- **Mechanically Cleaned Bar Screens or Equivalent Devices** - A backup bar screen shall be provided. It is permissible for the backup bar screen to be designed for manual cleaning only. Works with only two bar screens shall have at least one bar screen designed to permit manual cleaning.

- **Pumps** - A backup pump shall be provided for each set of pumps which performs the same function. The capacity of the pumps shall be such that, with any one pump out of service, the remaining pumps will have the capacity to handle the peak flow. It is permissible for one pump to serve as backup to more than one set of pumps.

- **Primary Sedimentation Basins** - There shall be a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a design flow capacity of at least 50 percent of the total design flow to that unit operation.

- **Final and Chemical Sedimentation Basins, Trickling Filters, Filters and Activated Carbon Columns** - There shall be a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a design flow capacity of at least 75 percent of the total design flow to that unit operation.

- **Activated Sludge Process Components** -

  Aeration Basin - A backup basin shall not be required; however, at least two equal volume basins shall be provided. (For the purpose of this criterion, the two zones of a contact stabilization process are considered as only one basin.)

  Air Diffusers - The air diffusion system for each aeration basin shall be designed such that the largest section of diffusers can be isolated without measurably impairing the oxygen transfer capability of the system.

- **Disinfectant Contact Basins** - There shall be a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a design flow capacity of at least 50 percent of the total design flow to that unit operation.

The installed facilities at the Kuwahee WWTP meet Reliability Class I requirements for flows up to 120 mgd, however the capacity of the pump stations and the biological treatment system are addressed in later sections of this report.

2.5 WWTP Data Analysis and Performance Summary

The data included in this analysis consist of daily SCADA measurements from January 2002 through July 2005. In addition to numerous significant industrial discharges, the KWWTP receives hauled waste discharges on site. Sludges from FCWWTP, LCWWTP and the water treatment plant reach the KWWTP via the trunk sewers.

2.5.1 Influent Flows and Loadings

Influent Flow Rates

From the years 2002-2005, the daily average influent flow rate to the Kuwahee WWTP was 36.32 mgd, the average daily maximum influent flow rate was 54.63 mgd, and the average daily minimum influent flow rate was 24.04 mgd. The maximum daily average influent flow rate during this period was 100 mgd. The maximum instantaneous influent flow rate from 2002 through 2005 has been recorded at 120 mgd.

Table 2-11 shows the average daily flow rate, the maximum daily flow rate, the average weekly flow rate, maximum weekly flow rate, average monthly flow rate, and maximum monthly flow rate for the years 2002 through 2005. Table 2-11 presents this data for the entire period, as well as broken down by calendar year.

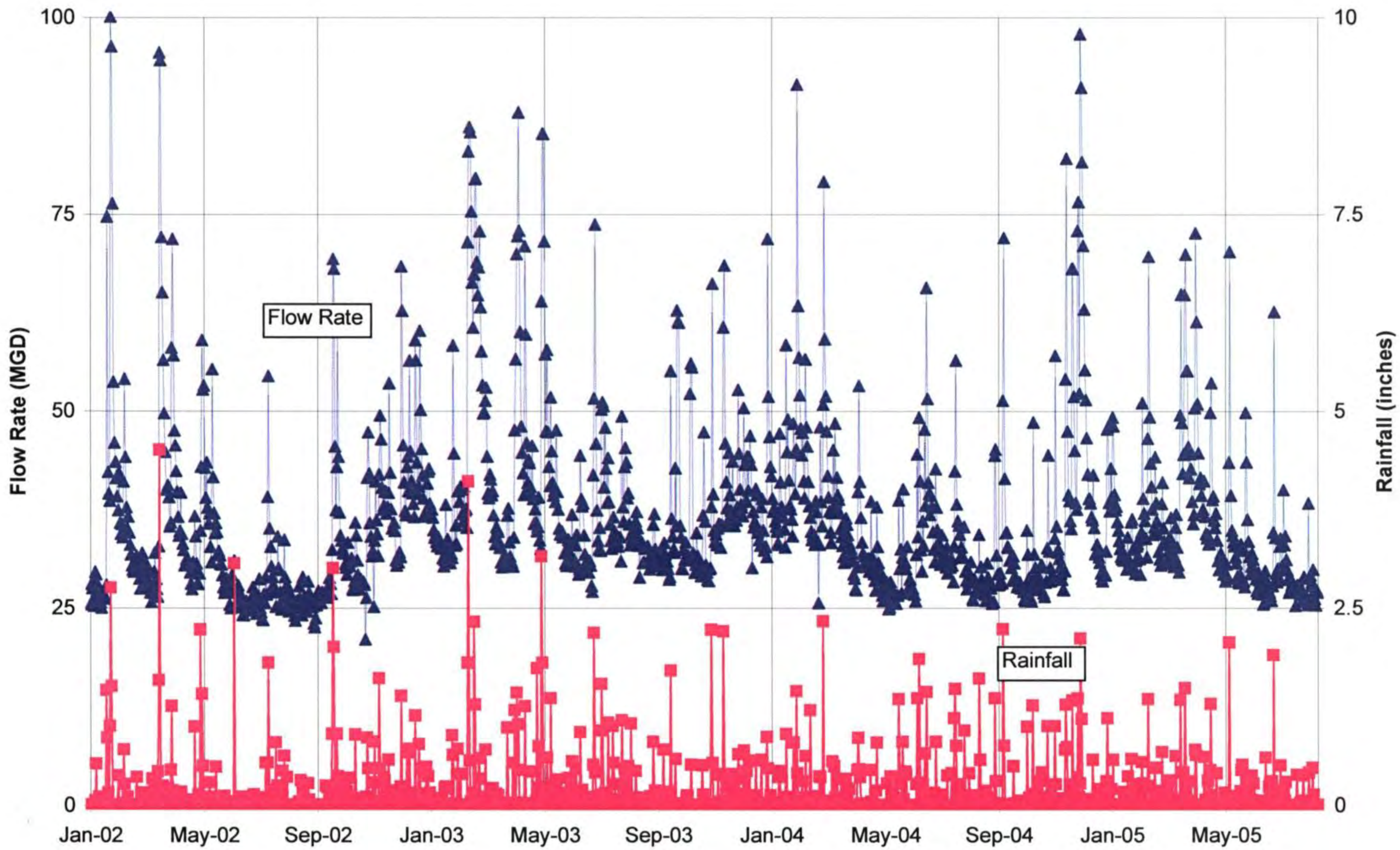
Table 2-11: Summary of Kuwahee WWTP Average Flow Rates

Data Period (Year)	Average Daily Flow Rate (mgd)	Maximum Daily Flow Rate (mgd)	Average Weekly Flow Rate (mgd)	Maximum Weekly Flow Rate (mgd)	Average Monthly Flow Rate (mgd)	Maximum Monthly Flow Rate (mgd)
2002	34.30	100.00	34.34	68.24	34.00	46.93
2003	39.71	87.85	39.73	75.39	39.93	58.78
2004	35.50	97.80	35.54	77.55	35.73	54.33
2005[1]	34.73	72.54	34.79	55.61	35.60	47.87
2002 - 2005	36.32	100.00	36.37	77.55	36.47	58.78

[1] 2005 data includes January - July

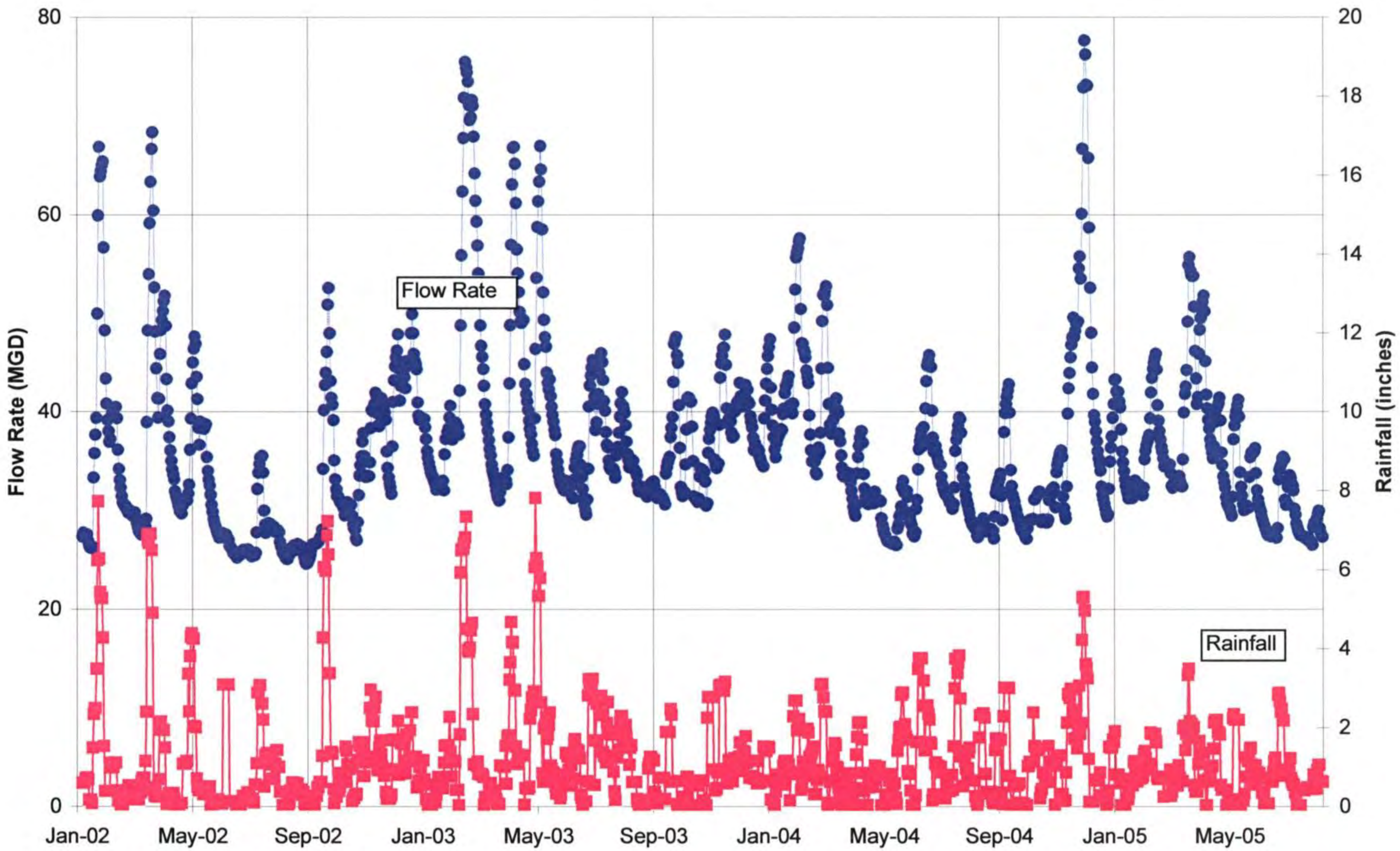
Figure 2-2, Figure 2-3, and Figure 2-4 graphically show the daily average, weekly moving average, and monthly moving average flow rates. As can be seen in these figures, flow rates are directly proportional to rainfall amounts, indicating infiltration and inflow in the collection system.

FIGURE 2-2: 1-Day Average Flow and Single Day Rainfall Data



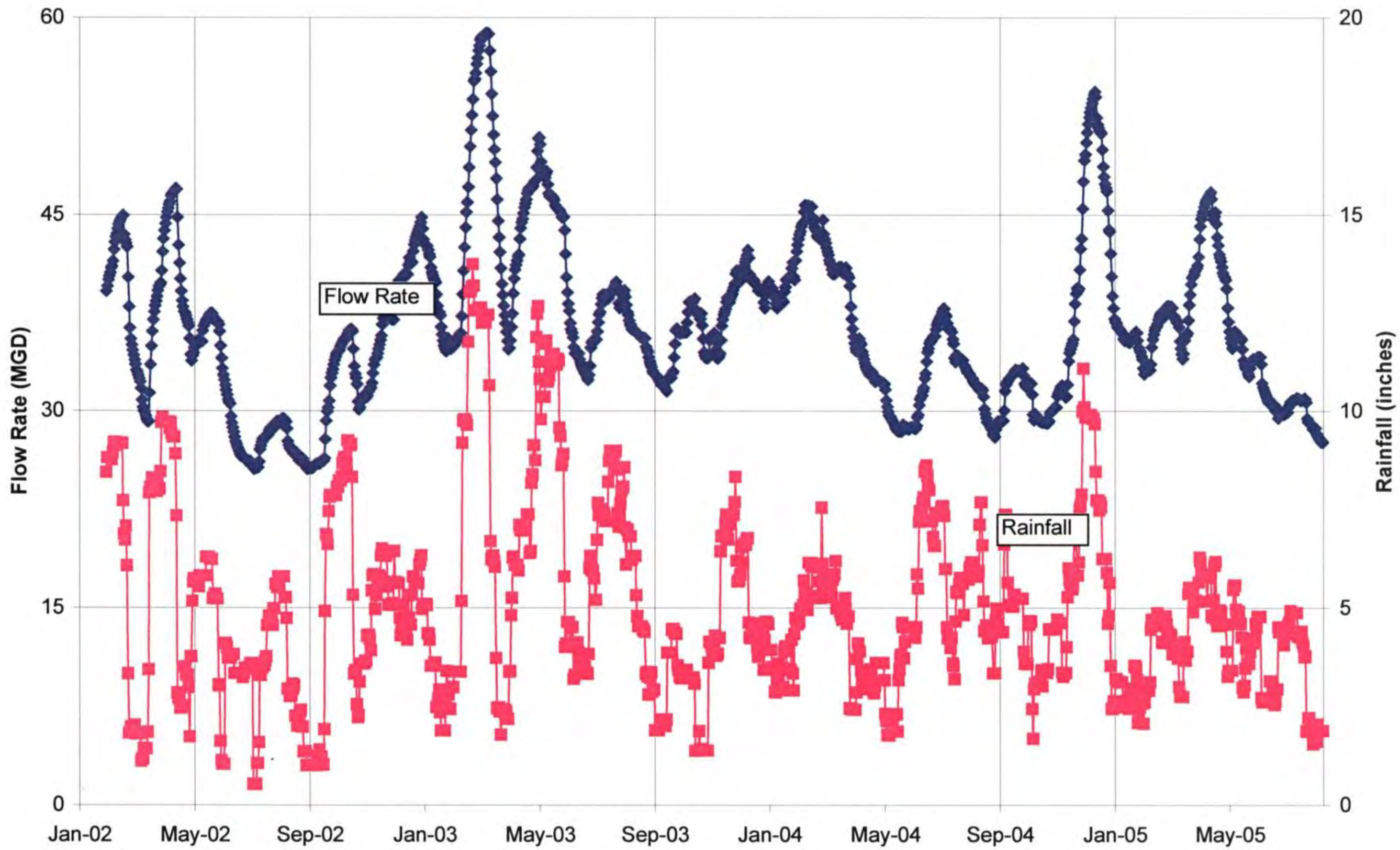
0001466

FIGURE 2-3: 7-Day Average Flow and 7-Day Cumulative Rainfall Data



0001467

FIGURE 2-4: 30-Day Average Flow and Rainfall Data



0001468

Influent Pollutant Loadings - Five Day Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)

From the years 2002-2005, the daily average influent $CBOD_5$ concentration at the Kuwahee WWTP was 240 mg/L, the daily maximum influent $CBOD_5$ concentration was 1,100 mg/L, and the daily minimum influent $CBOD_5$ concentration was 28 mg/L.

Table 2-12 shows the average daily $CBOD_5$ concentration, the maximum daily $CBOD_5$ concentration, the average weekly $CBOD_5$ concentration, maximum weekly $CBOD_5$ concentration, average monthly $CBOD_5$ concentration, and maximum monthly $CBOD_5$ concentration for the years 2002 through 2005. Table 2-12 presents this data for the entire period, as well as broken down by calendar year. **Table 2-13** presents the $CBOD_5$ loading data in pounds per day.

Table 2-12: Summary of Kuwahee WWTP Average Influent $CBOD_5$ Concentrations

Data Period (Year)	Average Daily $CBOD_5$ Concentration (mg/L)	Maximum Daily $CBOD_5$ Concentration (mg/L)	Average Weekly $CBOD_5$ Concentration (mg/L)	Maximum Weekly $CBOD_5$ Concentration (mg/L)	Average Monthly $CBOD_5$ Concentration (mg/L)	Maximum Monthly $CBOD_5$ Concentration (mg/L)
2002	286	970	286	633	288	402
2003	251	1,100	250	599	252	417
2004	223	780	223	457	226	311
2005[1]	177	780	177	285	171	234
2002 - 2005	240	1,100	239	633	239	417

[1] 2005 data includes January - July

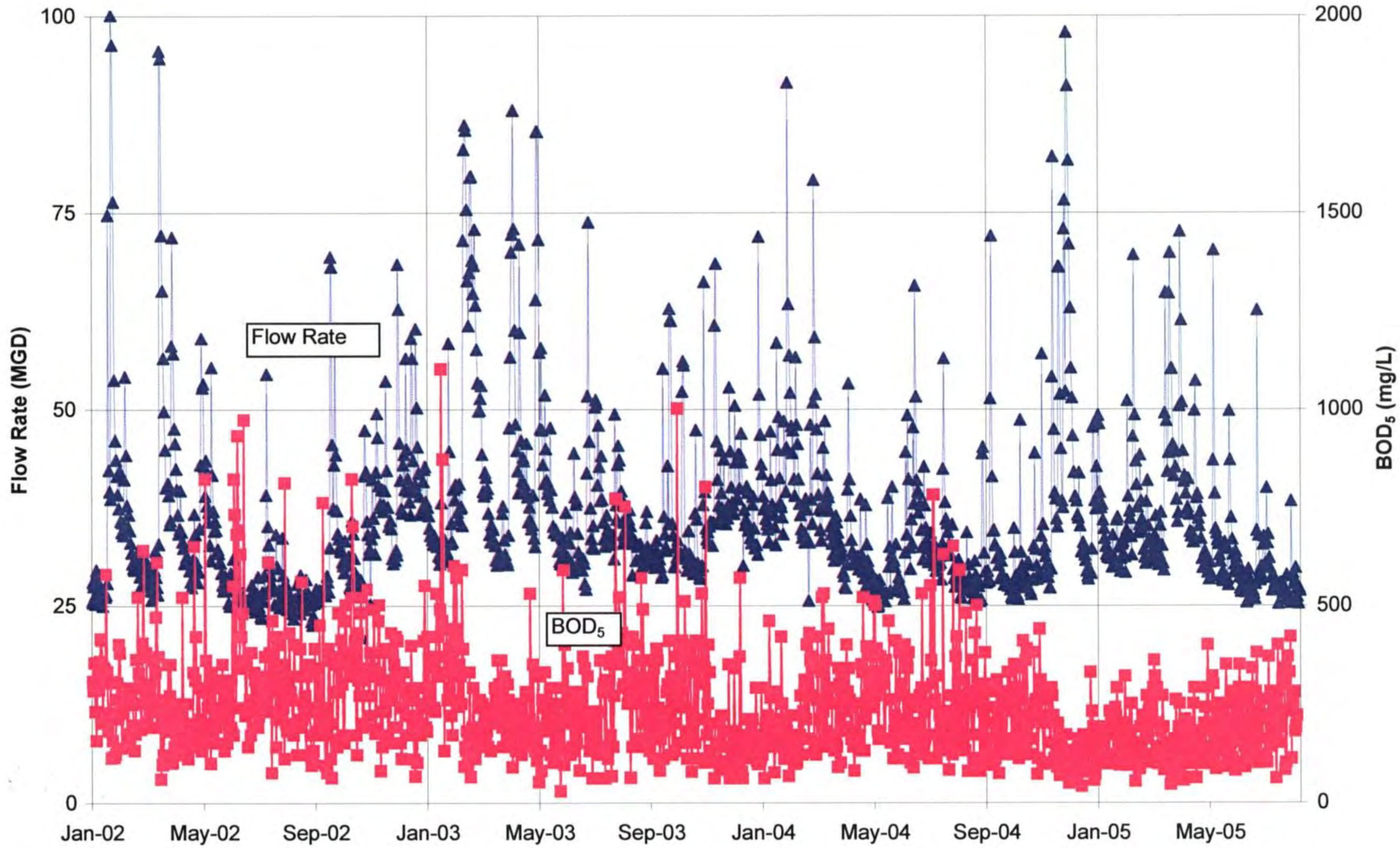
Table 2-13: Summary of Kuwahee WWTP Average Influent $CBOD_5$ Loadings

Data Period (Year)	Average Daily $CBOD_5$ Loading (lbs/day)	Maximum Daily $CBOD_5$ Loading (lbs/day)	Average Weekly $CBOD_5$ Loading (lbs/day)	Maximum Weekly $CBOD_5$ Loading (lbs/day)	Average Monthly $CBOD_5$ Loading (lbs/day)	Maximum Monthly $CBOD_5$ Loading (lbs/day)
2002	78,800	266,100	79,600	138,700	80,500	105,800
2003	80,200	349,000	80,300	163,700	82,800	137,400
2004	64,100	222,300	64,400	121,500	65,900	97,800
2005[1]	49,700	109,400	49,900	68,100	49,800	56,100
2002 - 2005	70,000	349,000	70,400	163,700	71,500	137,400

[1] 2005 data includes January - July

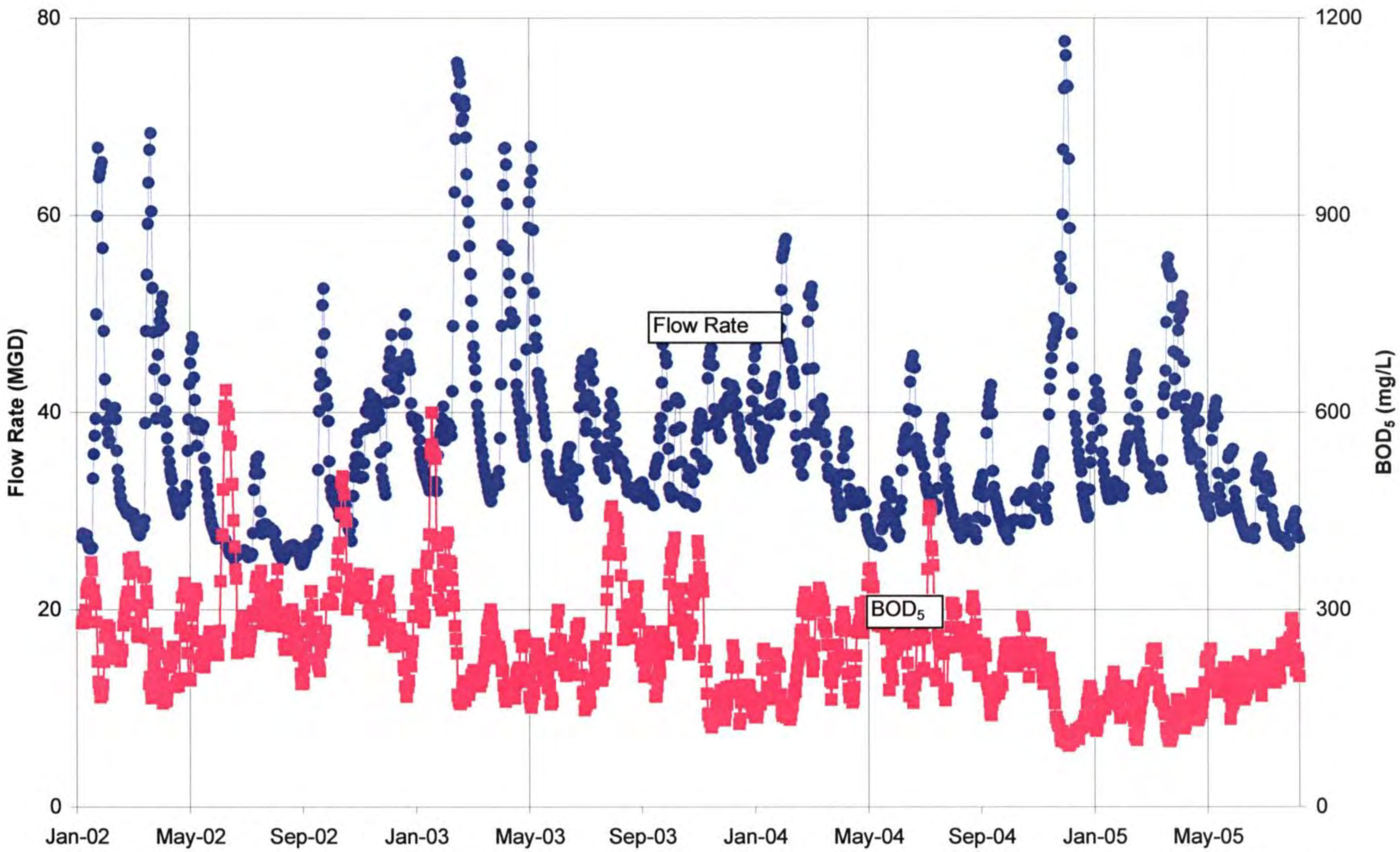
Figure 2-5, Figure 2-6, and Figure 2-7 graphically show the daily average, weekly moving average, and monthly moving average $CBOD_5$ concentration. As can be seen in these figures, $CBOD_5$ concentrations are generally inversely proportional to influent flow rates, indicating storm water and groundwater infiltration and inflow in the collection system.

FIGURE 2-5: 1-Day Average Flow and BOD_5 Data



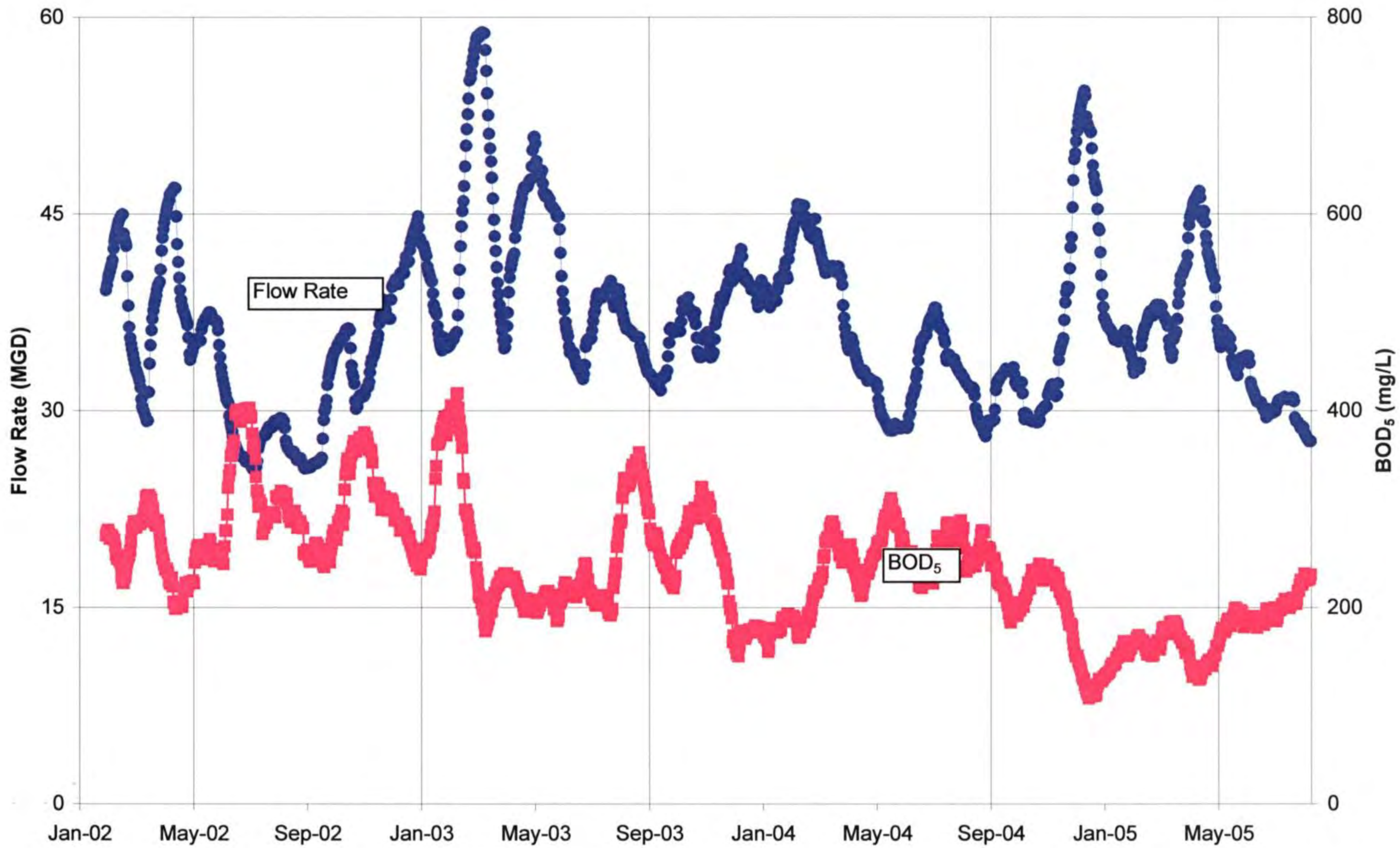
0001470

FIGURE 2-6: 7-Day Average Flow and 7-Day Average BOD_5 Data



0001471

FIGURE 2-7: 30-Day Average Flow and 30-Day Average BOD_5 Data



0001472

Influent Pollutant Loadings - Total Suspended Solids (TSS)
From the years 2002-2005, the daily average influent TSS concentration at the Kuwahee WWTP was 413 mg/L, the daily maximum influent TSS concentration was 1,910 mg/L, and the daily minimum influent TSS concentration was 35 mg/L.

Table 2-14 shows the average daily TSS concentration, the maximum daily TSS concentration, the average weekly TSS concentration, maximum weekly TSS concentration, average monthly TSS concentration, and maximum monthly TSS concentration for the years 2002 through 2005. Table 2-14 presents this data for the entire period, as well as broken down by calendar year. **Table 2-15** presents the TSS loading data in pounds per day.

Table 2-14: Summary of Kuwahee WWTP Average Influent TSS Concentrations

Data Period (Year)	Average Daily TSS Concentration (mg/L)	Maximum Daily TSS Concentration (mg/L)	Average Weekly TSS Concentration (mg/L)	Maximum Weekly TSS Concentration (mg/L)	Average Monthly TSS Concentration (mg/L)	Maximum Monthly TSS Concentration (mg/L)
2002	457	1,690	457	1,191	460	802
2003	423	1,910	425	858	427	692
2004	411	1,485	409	835	410	637
2005[1]	332	1,100	332	477	327	394
2002 - 2005	413	1,910	413	1,191	413	802

[1] 2005 data includes January – July

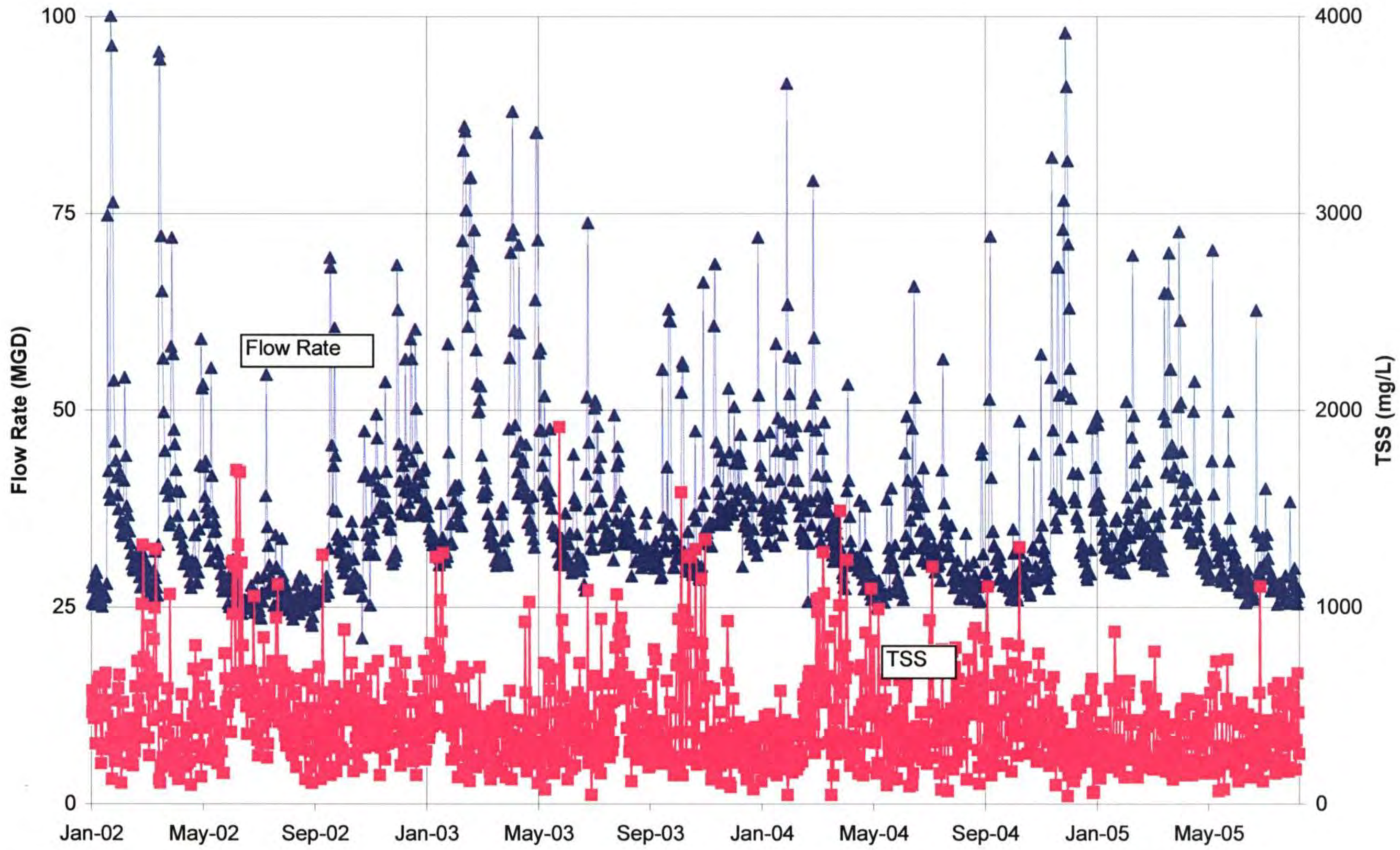
Table 2-15: Summary of Kuwahee WWTP Average Influent TSS Loadings

Data Period (Year)	Average Daily TSS Loading (lbs/day)	Maximum Daily TSS Loading (lbs/day)	Average Weekly TSS Loading (lbs/day)	Maximum Weekly TSS Loading (lbs/day)	Average Monthly TSS Loading (lbs/day)	Maximum Monthly TSS Loading (lbs/day)
2002	124,500	392,000	126,000	262,600	127,700	187,100
2003	138,000	687,200	137,200	287,600	140,100	206,100
2004	120,400	526,200	119,400	274,600	120,100	212,100
2005[1]	94,000	274,900	95,400	145,100	96,400	117,700
2002 - 2005	121,700	687,200	121,800	287,600	123,400	212,100

[1] 2005 data includes January - July

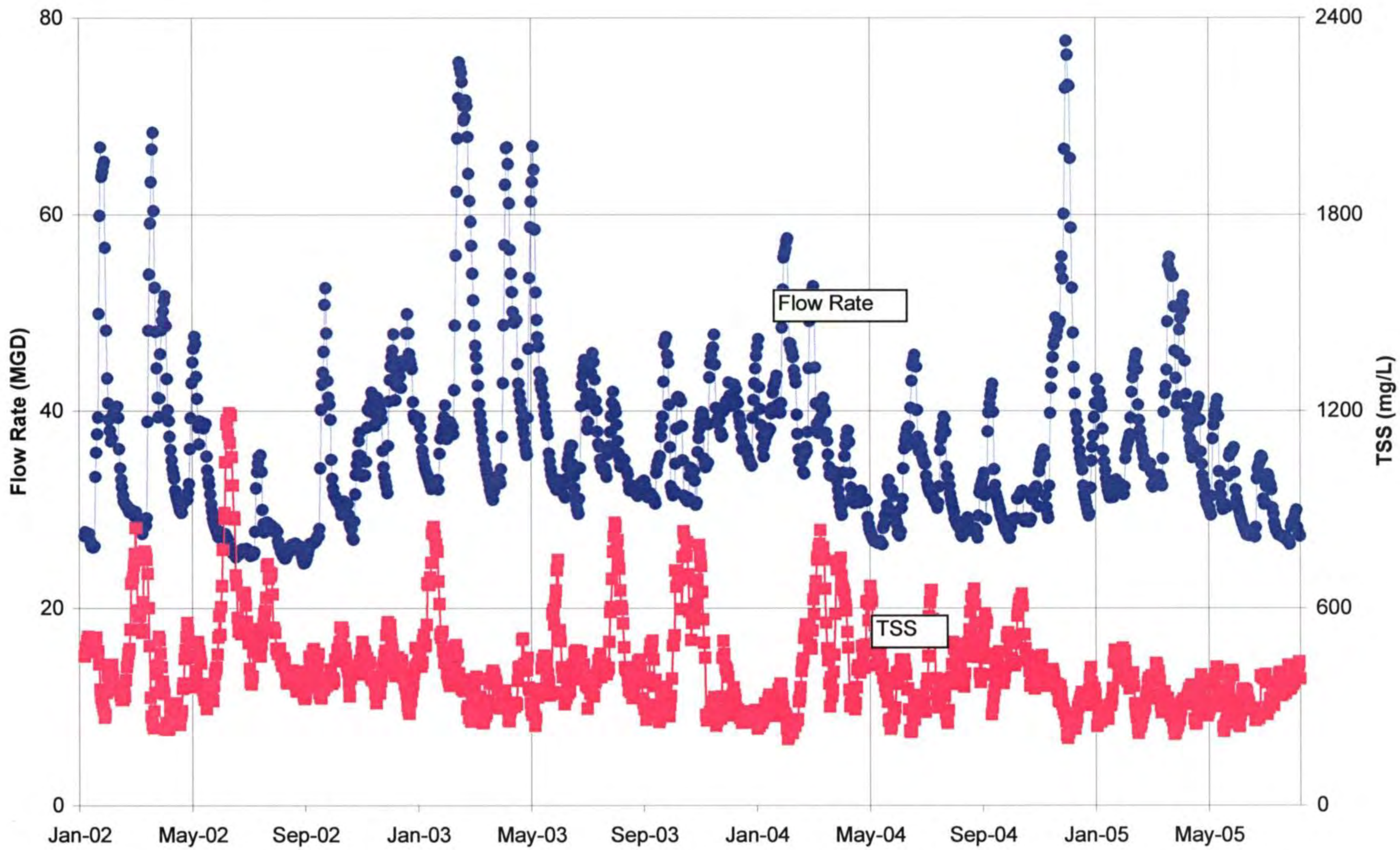
Figure 2-8, Figure 2-9, and Figure 2-10 graphically show the daily average, weekly moving average, and monthly moving average TSS concentration. As can be seen in these figures, TSS concentrations are generally inversely proportional to influent flow rates, indicating storm water and groundwater infiltration and inflow in the collection system.

FIGURE 2-8: 1-Day Average Flow and Total Suspended Solids (TSS) Data



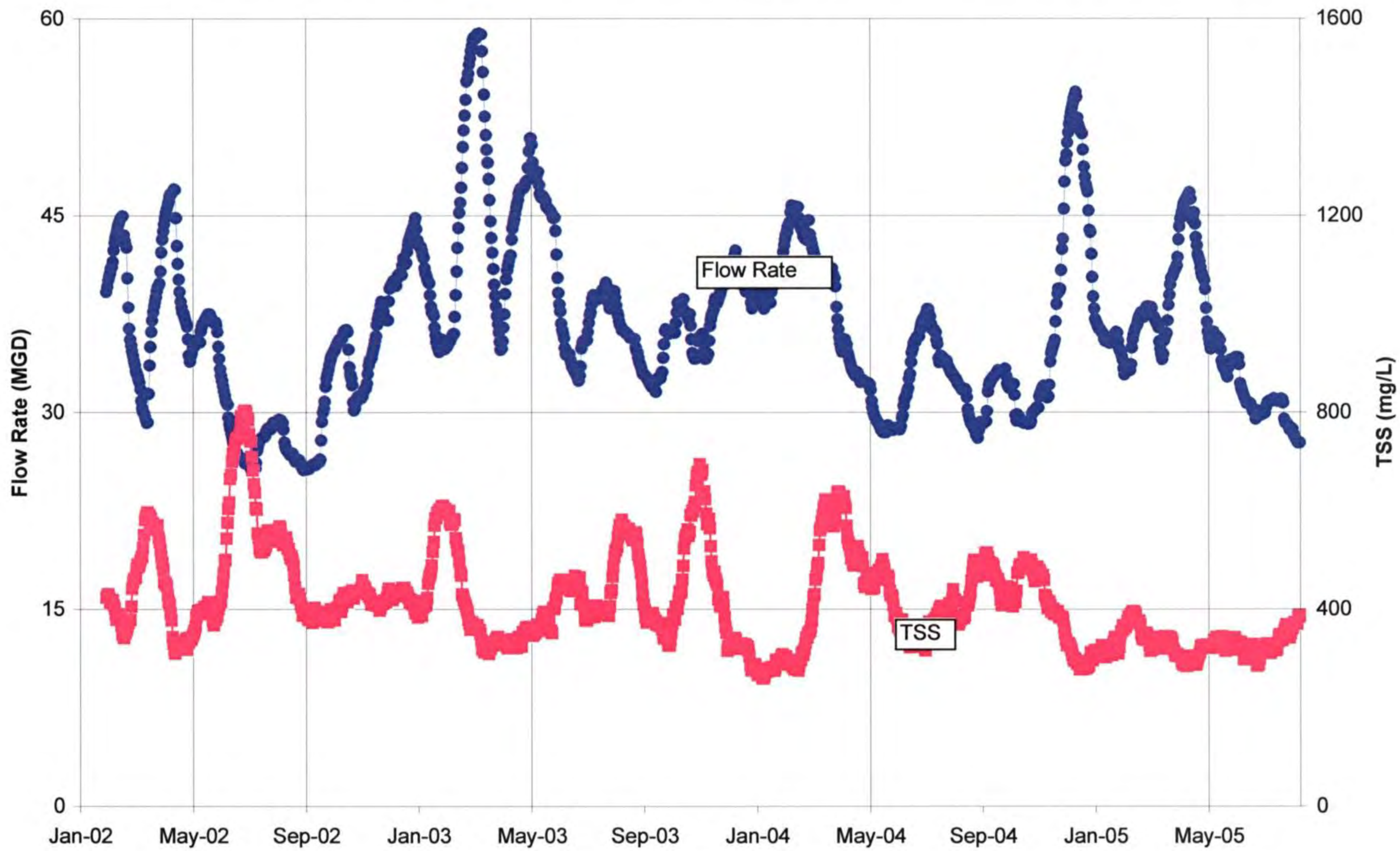
0001474

FIGURE 2-9: 7-Day Average Flow and 7-Day Average Total Suspended Solids (TSS) Data



0001475

FIGURE 2-10: 30-Day Average Flow and 30-Day Average Total Suspended Solids (TSS) Data



0001476

Influent Pollutant Loadings - Ammonia as Nitrogen (NH_3- N)
From the years 2002-2005, the daily average influent NH_3-N concentration at the Kuwahee WWTP was 12.3 mg/L, the daily maximum influent NH_3-N concentration was 32.2 mg/L, and the daily minimum influent NH_3-N concentration was 0.2 mg/L.

Table 2-16 shows the average daily NH_3-N concentration, the maximum daily NH_3-N concentration, the average weekly NH_3-N concentration, maximum weekly NH_3-N concentration, average monthly NH_3-N concentration, and maximum monthly NH_3-N concentration for the years 2002 through 2005. Table 2-16 presents this data for the entire period, as well as broken down by calendar year. **Table 2-17** presents the NH_3-N loading data in pounds per day.

Table 2-16: Summary of Kuwahee WWTP Average Influent NH_3-N Concentrations

Data Period (Year)	Average Daily NH_3-N Concentration (mg/L)	Maximum Daily NH_3-N Concentration (mg/L)	Average Weekly NH_3-N Concentration (mg/L)	Maximum Weekly NH_3-N Concentration (mg/L)	Average Monthly NH_3-N Concentration (mg/L)	Maximum Monthly NH_3-N Concentration (mg/L)
2002	12.3	24.3	12.3	20.2	12.4	16.9
2003	11.2	22.4	11.2	17.6	11.1	15.6
2004	12.9	28.7	12.9	22.5	12.9	17.8
2005[1]	13.2	32.2	13.2	19.2	13.0	16.6
2002 - 2005	12.3	32.2	12.3	22.5	12.3	17.8

[1] 2005 data includes January – July

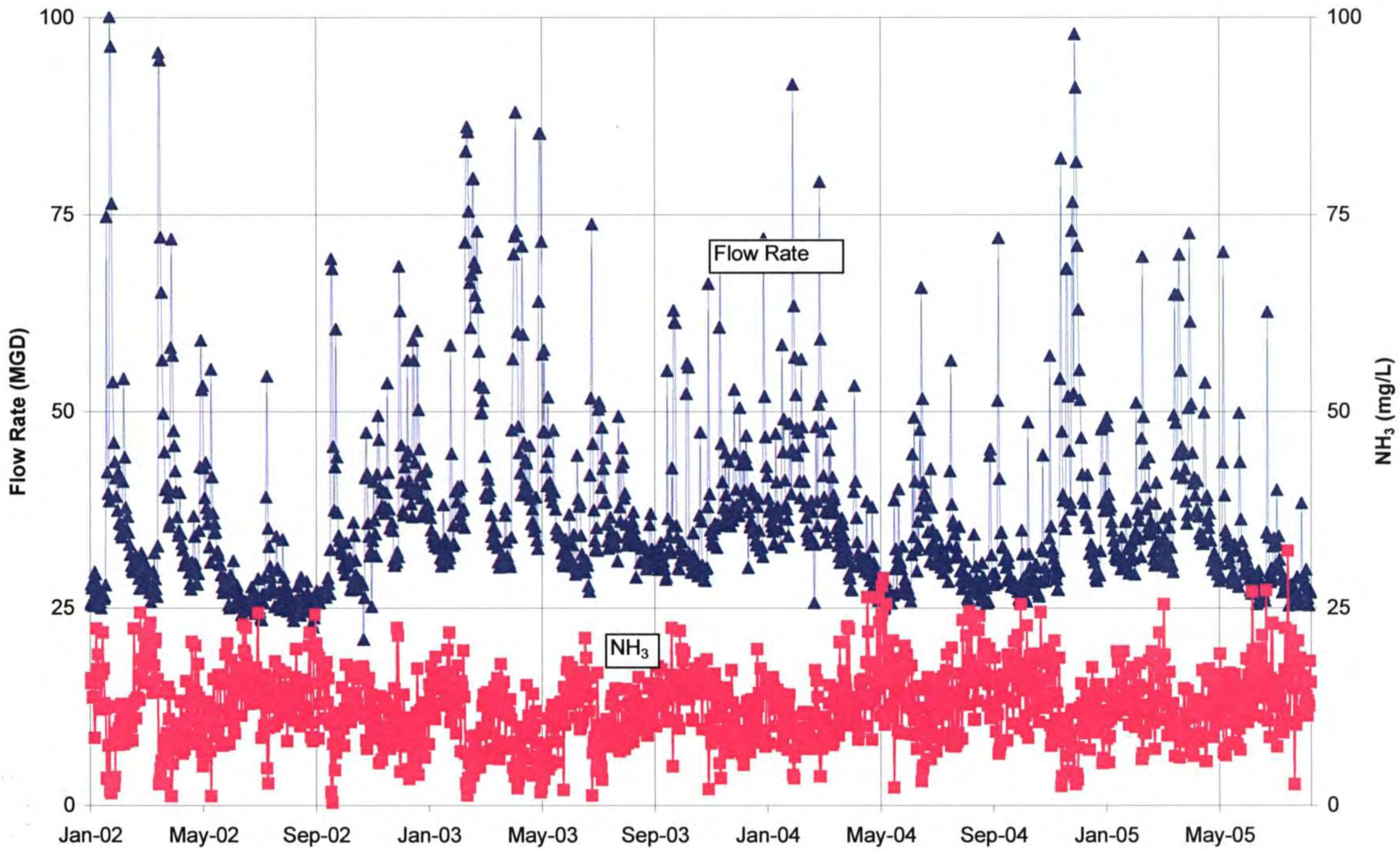
Table 2-17: Summary of Kuwahee WWTP Average Influent NH_3-N Loadings

Data Period (Year)	Average Daily NH_3-N Loading (lbs/day)	Maximum Daily NH_3-N Loading (lbs/day)	Average Weekly NH_3-N Loading (lbs/day)	Maximum Weekly NH_3-N Loading (lbs/day)	Average Monthly NH_3-N Loading (lbs/day)	Maximum Monthly NH_3-N Loading (lbs/day)
2002	3,220	8,630	3,300	5,440	3,410	4,780
2003	3,480	8,580	3,530	5,800	3,620	4,750
2004	3,610	7,310	3,680	5,100	3,740	4,270
2005[1]	3,680	7,310	3,720	4,940	3,790	4,250
2002 - 2005	3,480	8,630	3,550	5,800	3,630	4,780

[1] 2005 data includes January - July

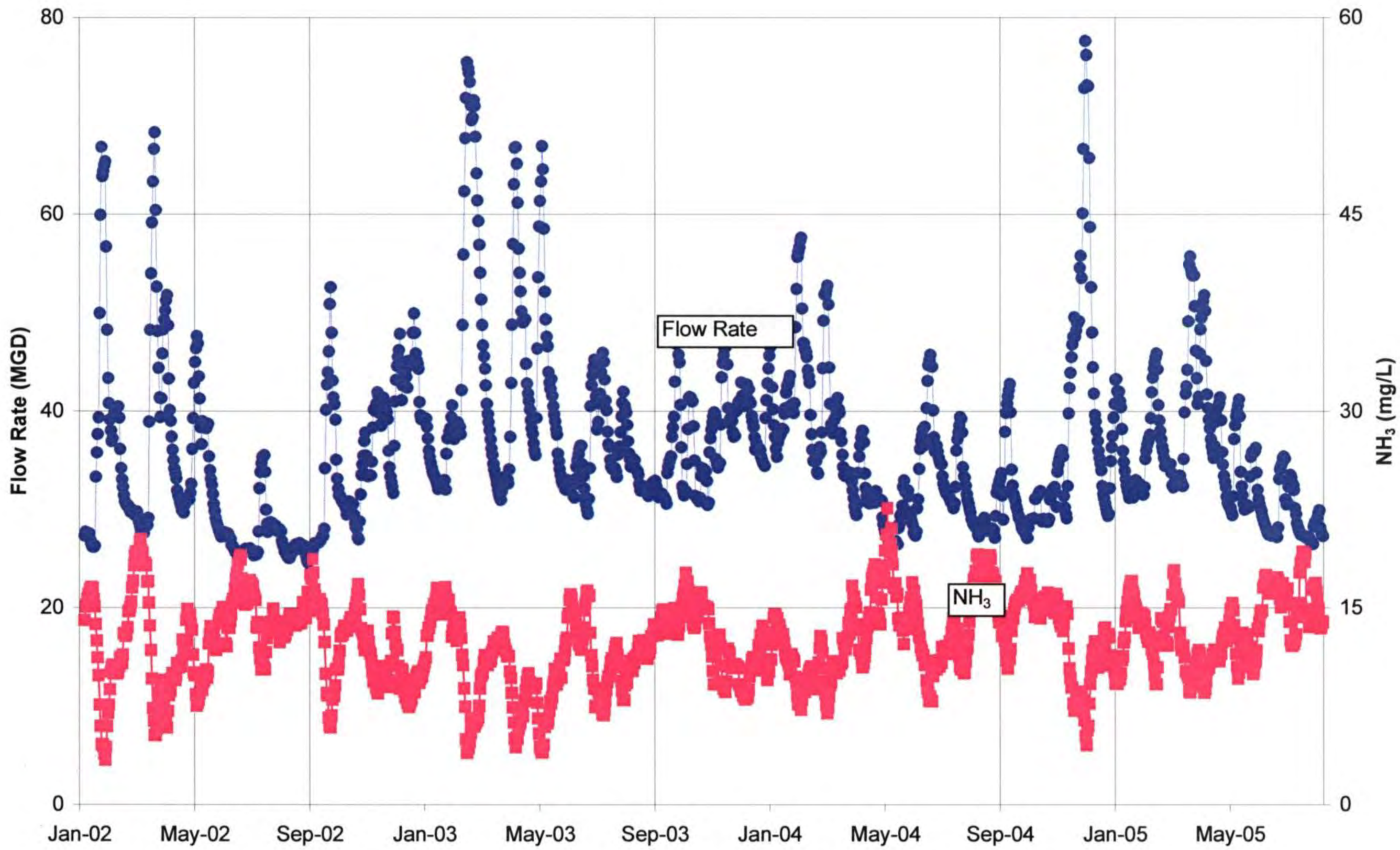
Figure 2-11, Figure 2-12, and Figure 2-13 graphically show the daily average, weekly moving average, and monthly moving average NH_3-N concentration. As can be seen in these figures, NH_3-N concentrations are generally inversely proportional to influent flow rates, indicating storm water and groundwater infiltration and inflow in the collection system.

FIGURE 2-11: 1-Day Average Flow and Ammonia (NH_3) Data



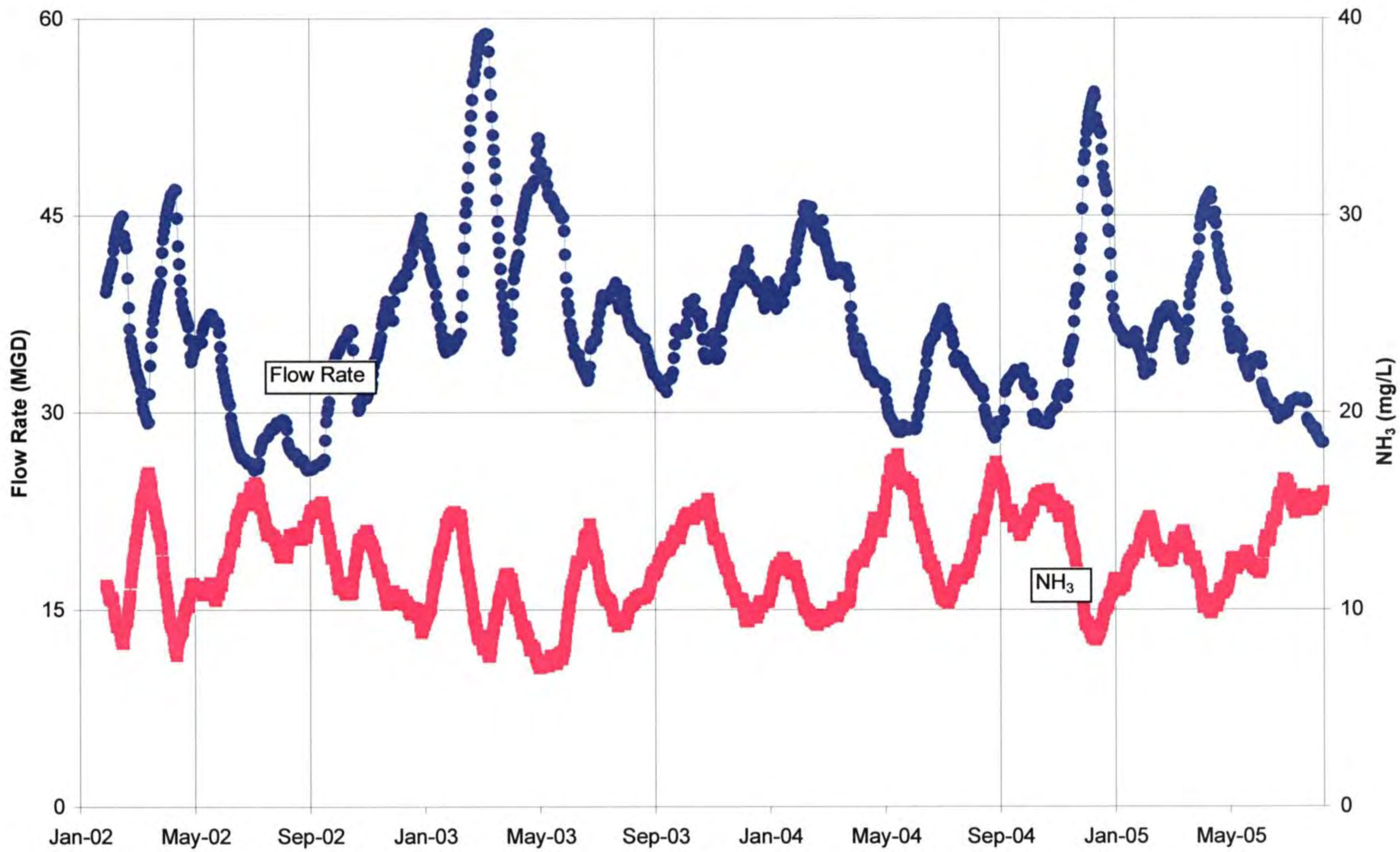
00014478

FIGURE 2-12: 7-Day Average Flow and 7-Day Average Ammonia (NH_3) Data



0001479

FIGURE 2-13: 30-Day Average Flow and 30-Day Average Ammonia (NH_3) Data



00001480

2.5.2 Effluent Flow Rates, Effluent Loadings and NPDES Permit Compliance

Effluent Flow Rates

From the years 2002-2005, the daily average effluent flow rate at the KWWTP was 32.37 mgd, the average daily maximum effluent flow rate was 46.05 mgd, and the average daily minimum effluent flow rate was 20.74 mgd. The maximum daily average effluent flow rate during this period was 120 mgd. The maximum instantaneous effluent flow rate from 2002 through 2005 has been recorded at 120 mgd, however, it is likely that flow rates exceeded this value, but due to equipment limitations, were not recorded properly.

It is likely that the effluent flow rates differ from the influent flow rates due to internal recycle flows within the system. In addition, influent flow is calculated as the sum of flows through three Parshall flumes (two Primary Clarifier influent flumes and the Preaeration Basin effluent flume). Effluent flow is calculated from the sum of flows through two Parshall flumes (the Diversion flume when in use and the final clarifier effluent flume). Influent flow rates were used to determine KWWTP influent loadings and effluent flow rates were used to determine effluent loadings for the purposes of this analysis.

Effluent $CBOD_5$

The effluent limits imposed by the NPDES permit include maximum $CBOD_5$ concentrations of 40 mg/L (daily), 35 mg/L (weekly), and 25 mg/L (monthly). **Figures 2-14, 2-15, and 2-16** indicate compliance with these limits, except for infrequent exceedances over the period January 2002 through August 2005.

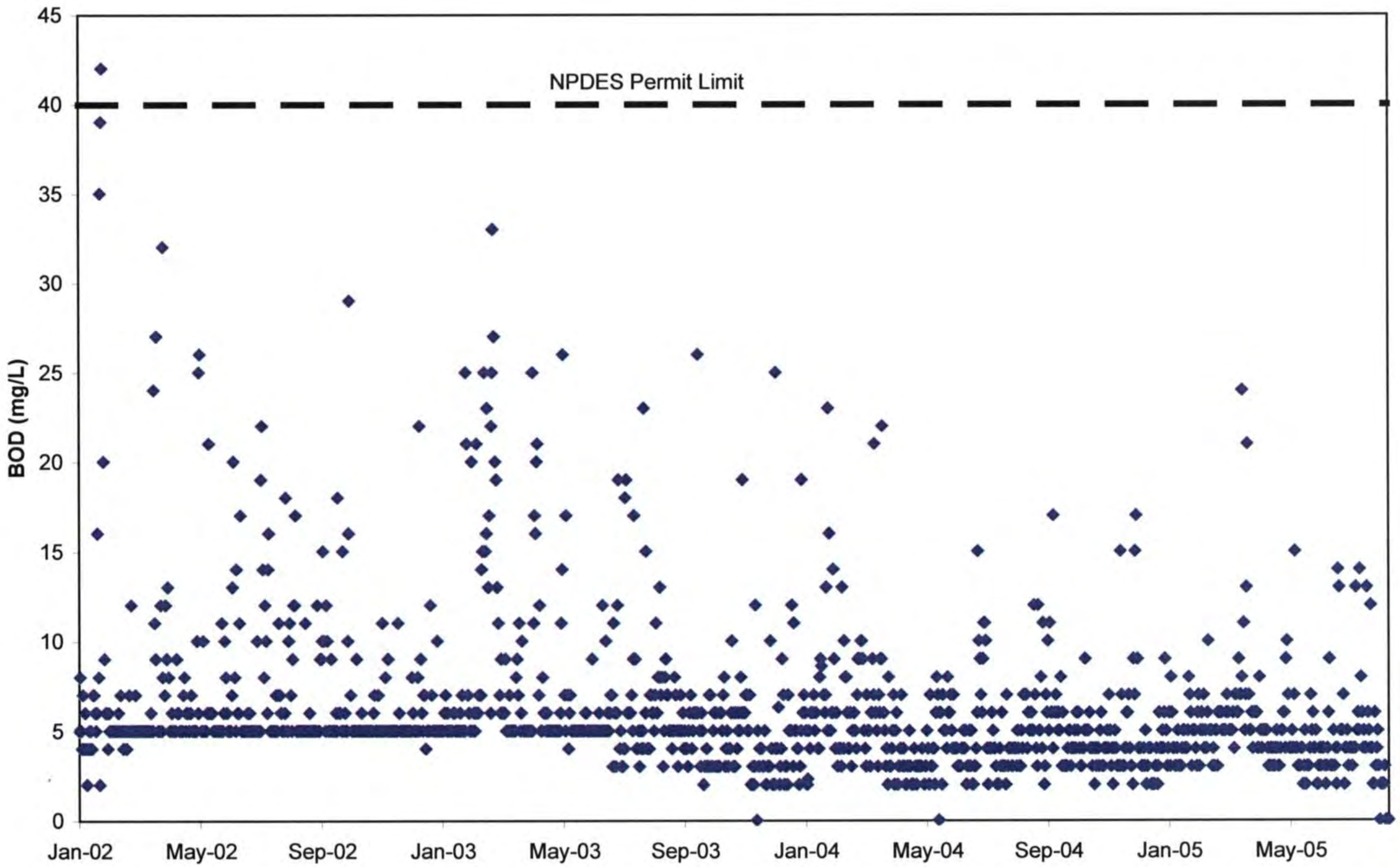
Effluent TSS

The effluent limits imposed by the NPDES permit include maximum TSS concentrations of 45 mg/L (daily), 40 mg/L (weekly), and 30 mg/L (monthly). **Figures 2-17, 2-18, and 2-19** indicate compliance with these limits over the period January 2002 through August 2005, except for periodic exceedances of the daily and weekly permit limits as illustrated on Figures 2-17 and 2-18. In February 2003, the monthly average TSS effluent limit was exceeded (as shown in Figure 2-19).

$CBOD_5$ and TSS Removal Efficiency

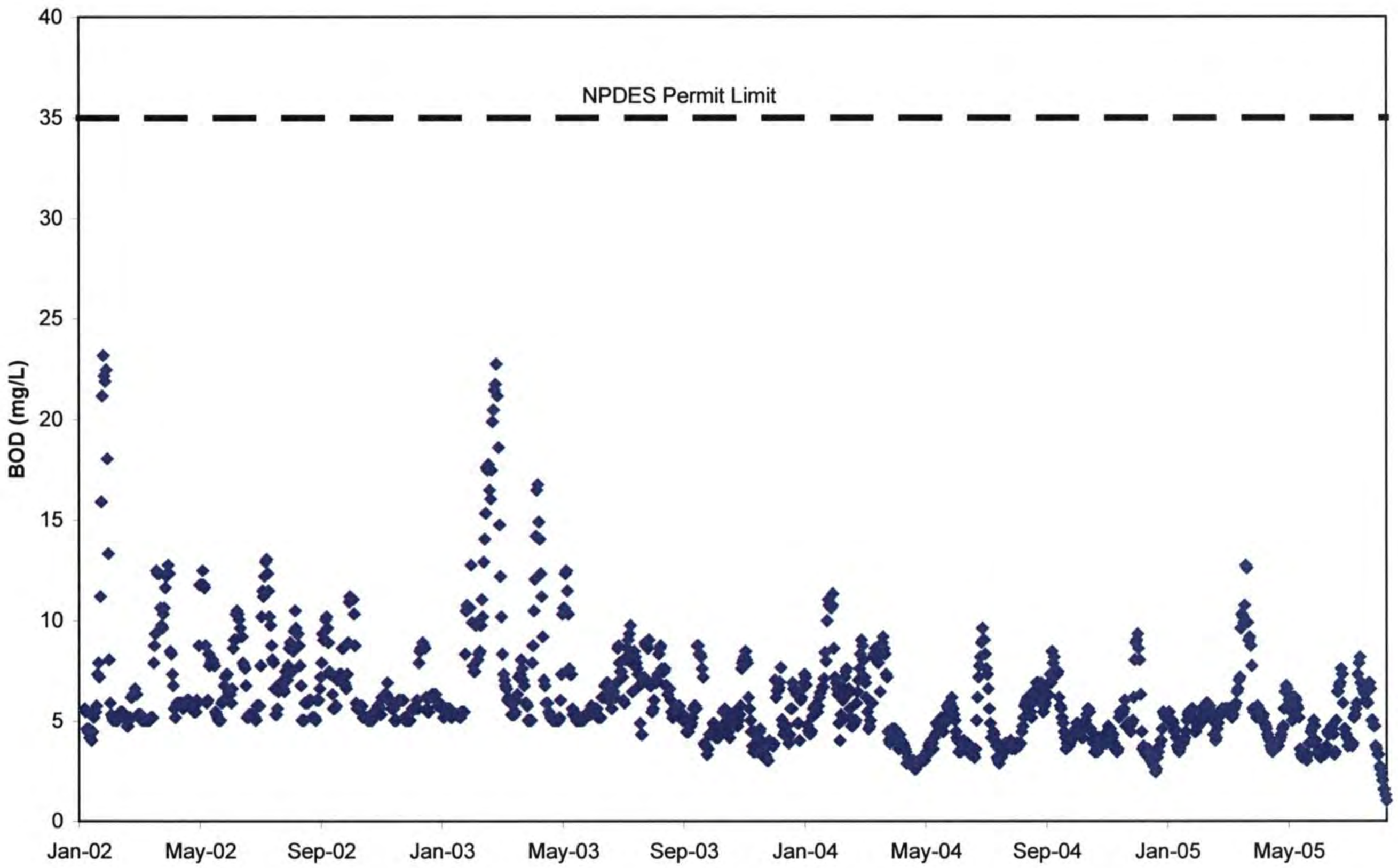
In addition to maximum limits on the concentration of $CBOD_5$ and TSS, the effluent from the KWWTP must also meet minimum removal efficiencies for these two parameters. The minimum daily removal efficiency is 40 percent and the minimum monthly removal efficiency is 85 percent. Removal efficiency is calculated as 1 - influent concentration/effluent concentration.

FIGURE 2-14: Performance vs Daily BOD Effluent Limits



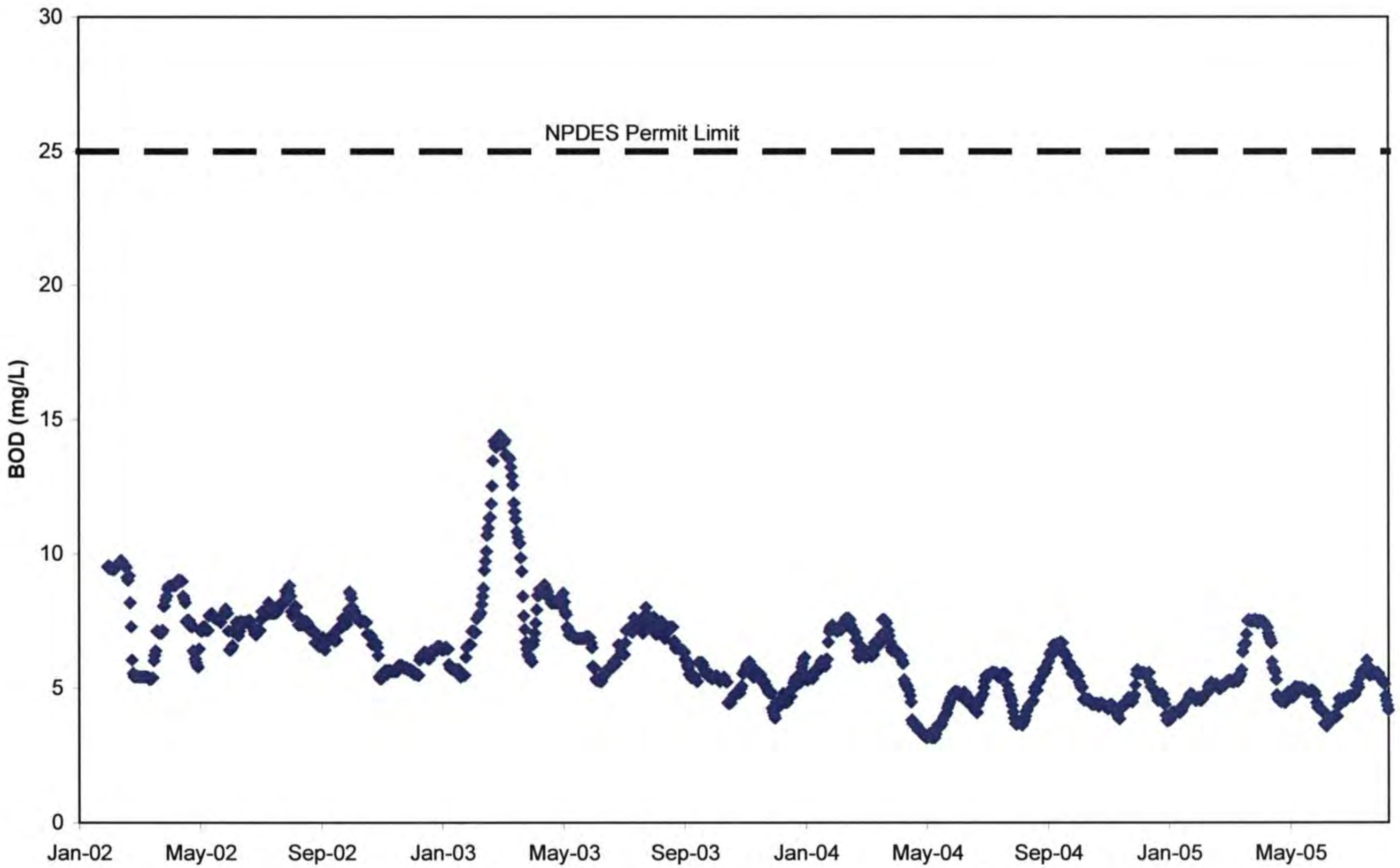
0001482

FIGURE 2-15: Performance vs Weekly BOD Effluent Limits



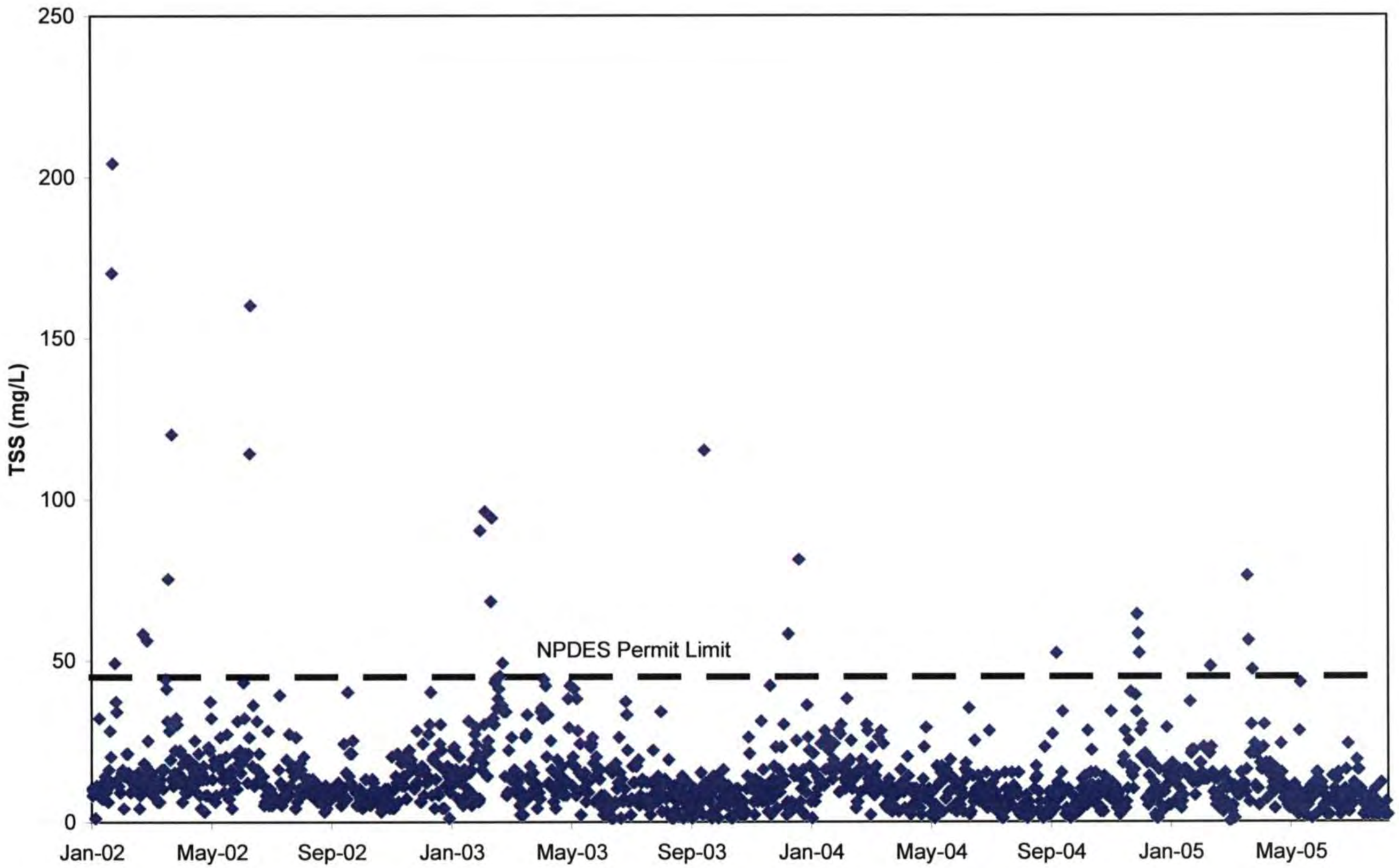
0001483

FIGURE 2-16: Performance vs Monthly BOD Effluent Limits



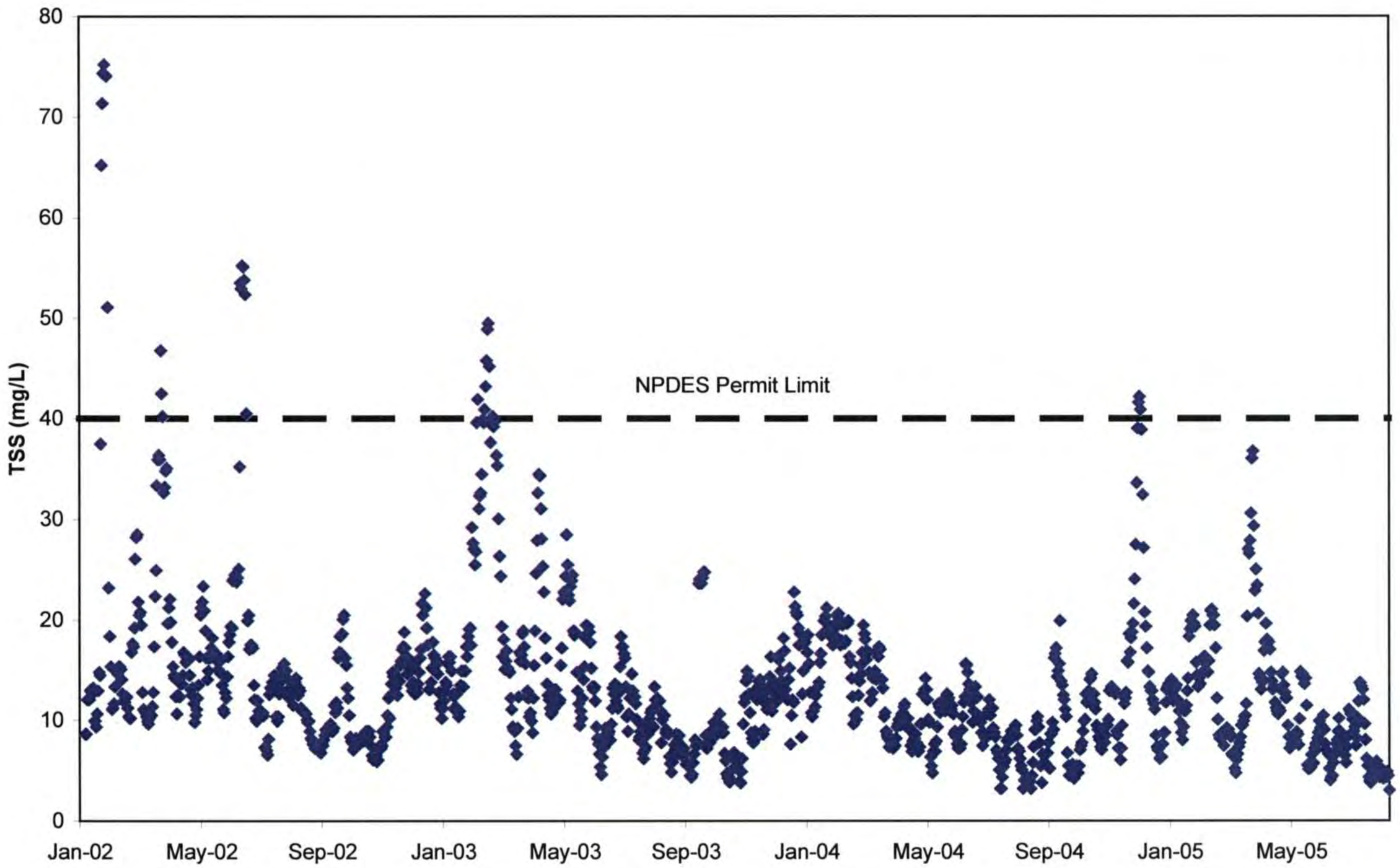
0001484

FIGURE 2-17: Performance vs Daily TSS Effluent Limits



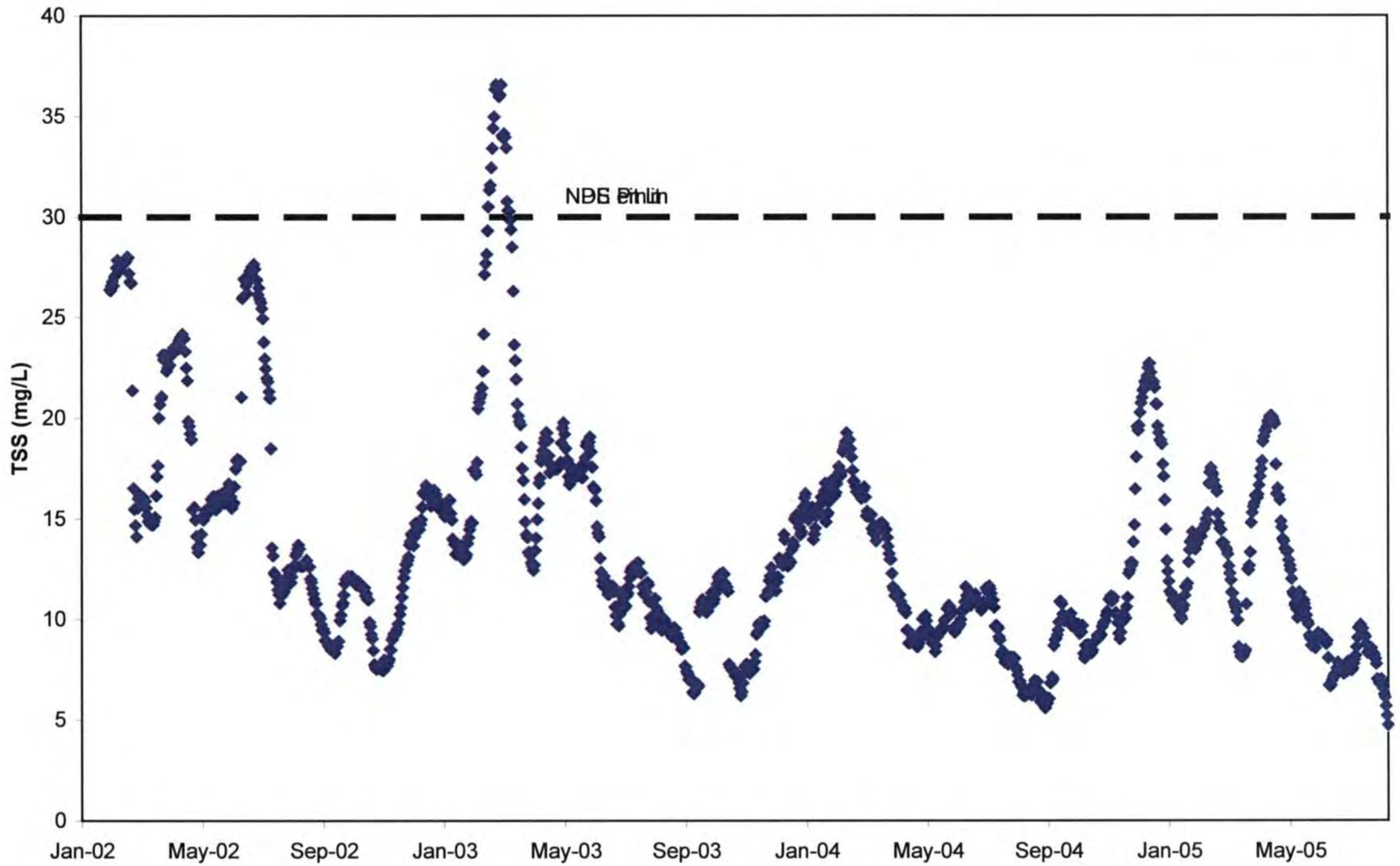
0001485

FIGURE 2-18: Performance vs Weekly TSS Effluent Limits



0001486

FIGURE 2-19: Performance vs Monthly TSS Effluent Limits



0001487

Figures 2-20 and 2-21 indicate compliance with the minimum removal efficiencies, except that on three occasions, the daily TSS removal efficiency was below 40 percent. In two of those instances, the TSS removal efficiency was less than 0 percent, indicating the effluent TSS concentration was greater than the influent TSS concentration.

Effluent NH_3-N

The effluent limits imposed by the NPDES permit include seasonal maximum NH_3-N concentrations. During the period May 1 - October 31, lower limits for NH_3-N concentrations apply. These limits are: 10 mg/L (daily), 7.5 mg/L (weekly), and 5 mg/L (monthly). During the period November 1 through April 30, NH_3-N limits are 25 mg/L (daily), 20 mg/L (weekly), and 15 mg/L (monthly). **Figures 2-22, 2-23, and 2-24** indicate compliance with these limits over the period January 2002 through August 2005, except for infrequent exceedances.

Effluent Settleable Solids

The effluent limit imposed by the NPDES permit for settleable solids includes maximum daily volume of 1 mL/L. **Figure 2-25** indicates compliance with the permit limit; except for periodic exceedances that are shown.

Effluent Fecal Coliforms

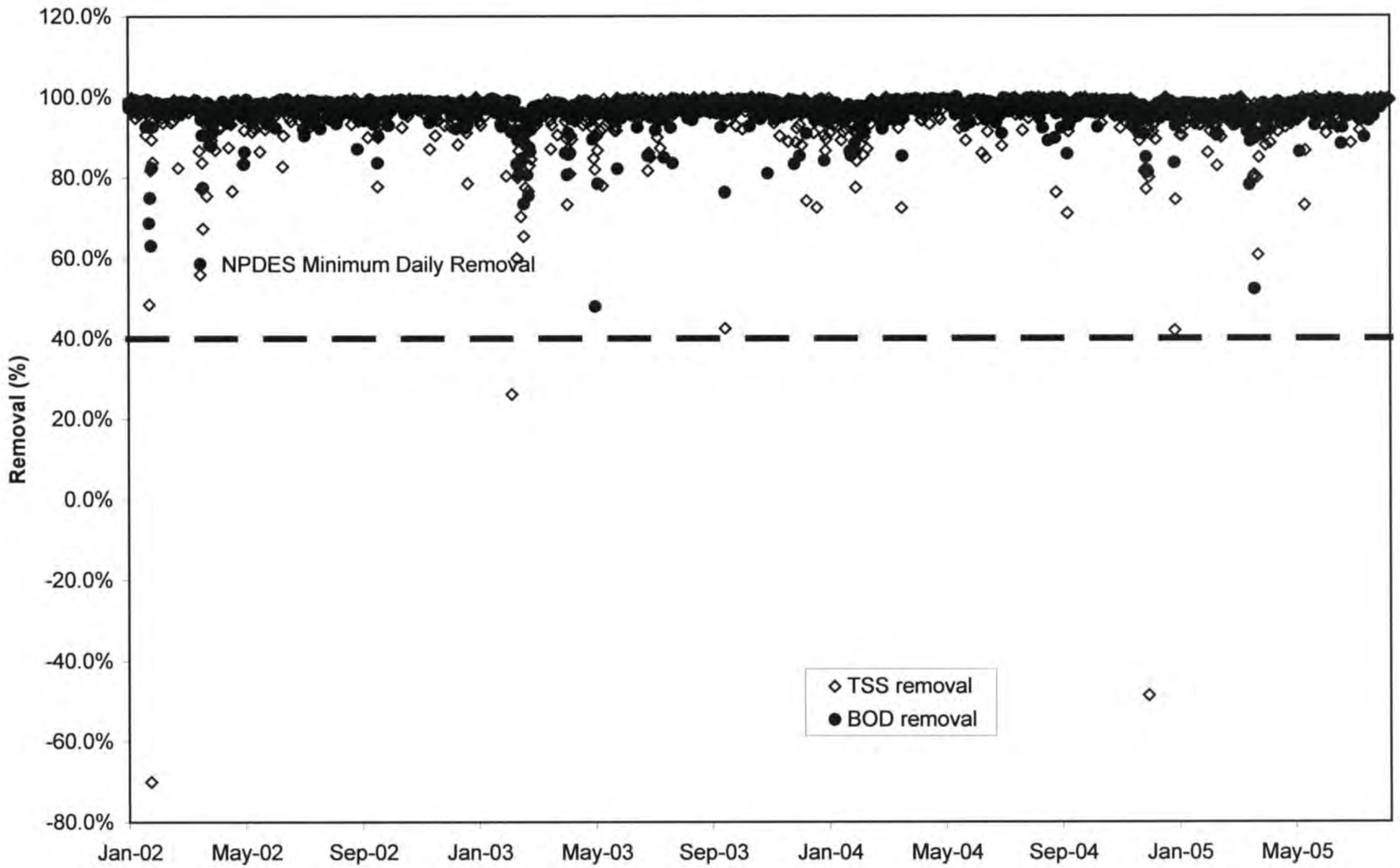
The effluent limits imposed by the NPDES permit for fecal coliforms include maximum daily value of 1,000 per 100 mL sample and maximum monthly value of 200 per 100 mL sample. The monthly value is calculated as the geometric mean of the daily values within a calendar month. **Figures 2-26 and 2-27** show compliance with the permit limit, except for a few exceedances as shown in Figure 2-26.

NPDES Permit Compliance

During the period January 2002 - August 2005, in addition to the infrequent exceedances shown above, KUB reported pursuant to the currently applicable NPDES permits, 126 Diversion events and 16 Bypass events. Of these infrequent numeric permit effluent limit exceedances, only 39 can be associated with Diversion events.

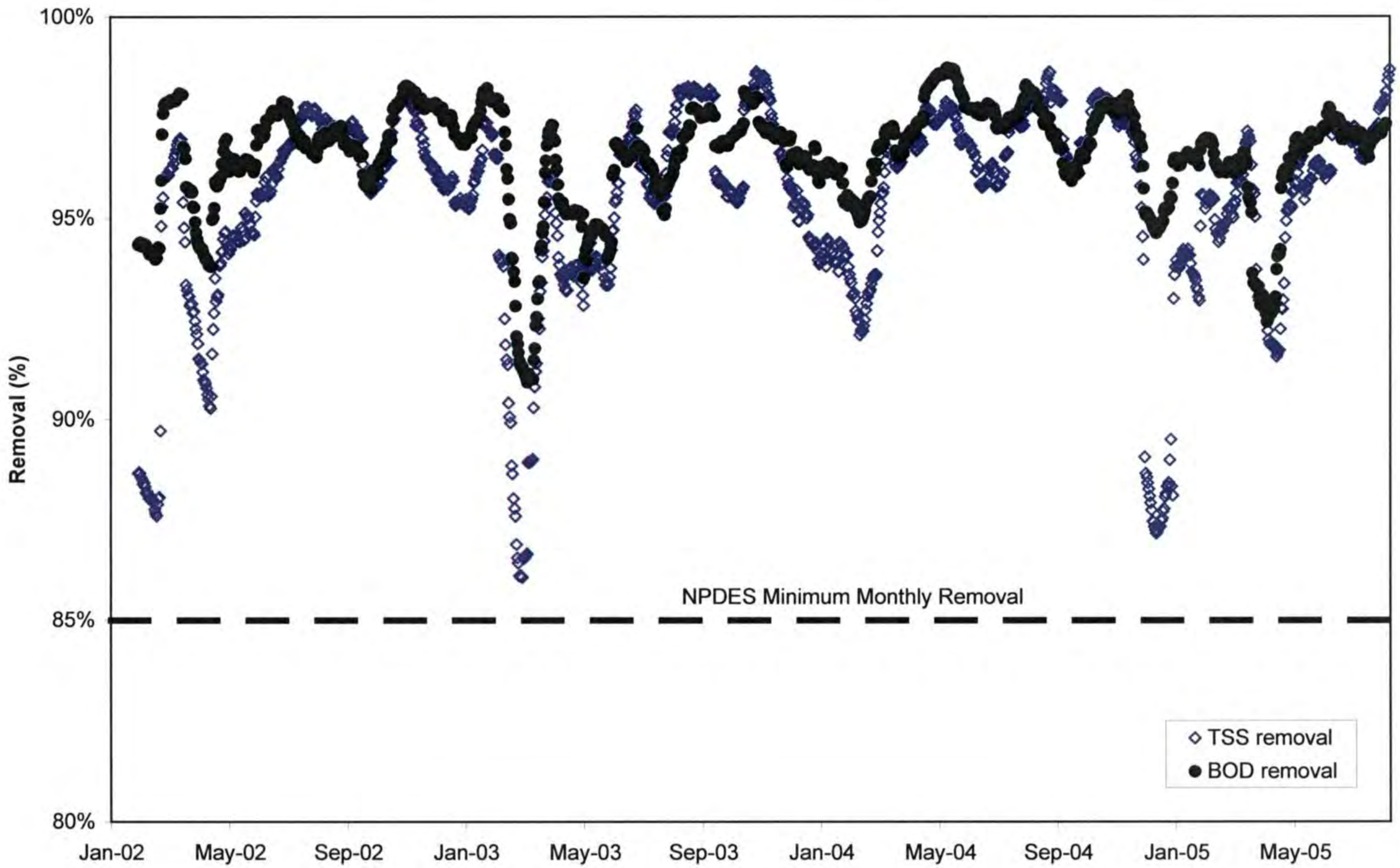
In early 2004, as the result of discussions with EPA and TDEC representatives, revised operational procedures were implemented to increase flows to biological treatment to more fully assure that Diversions are only made to avoid a Washout. This was intended to reduce the occurrence and volume of Diversions.

FIGURE 2-20: Performance vs Daily Minimum Removal Requirements



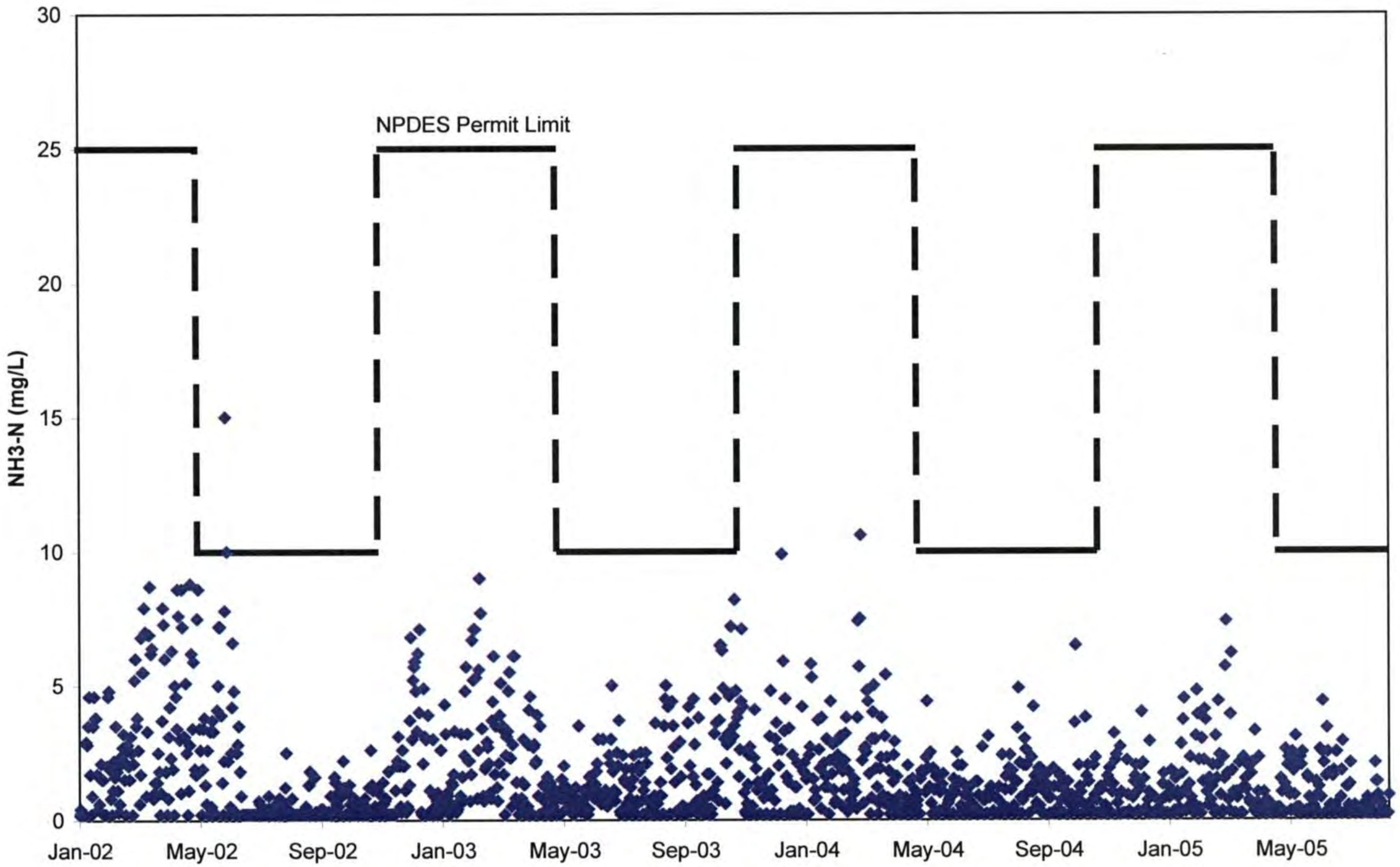
0001489

FIGURE 2-21: Performance vs Monthly Minimum Removal Requirements



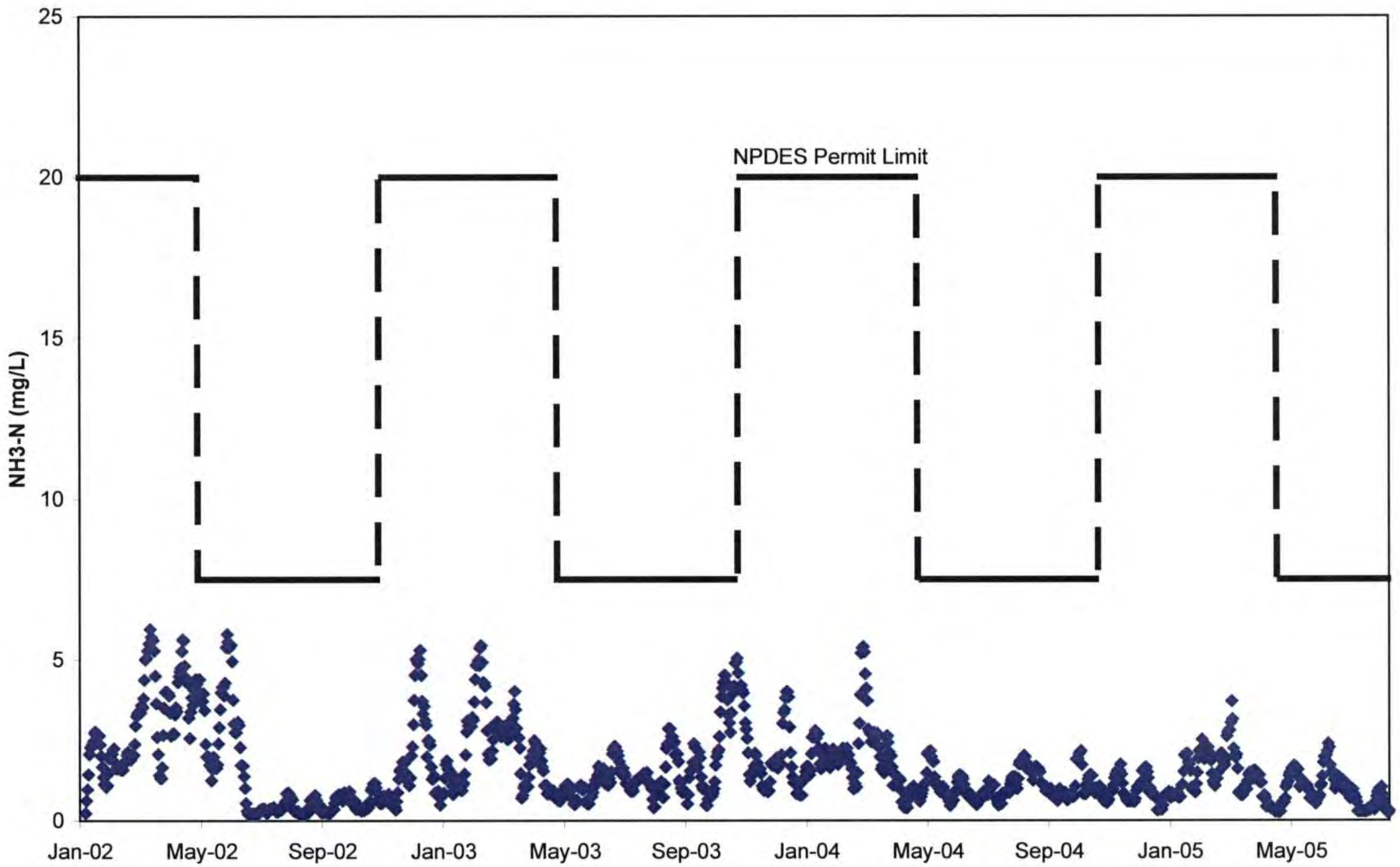
0001490

FIGURE 2-22: Performance vs Daily NH3-N Effluent Limits



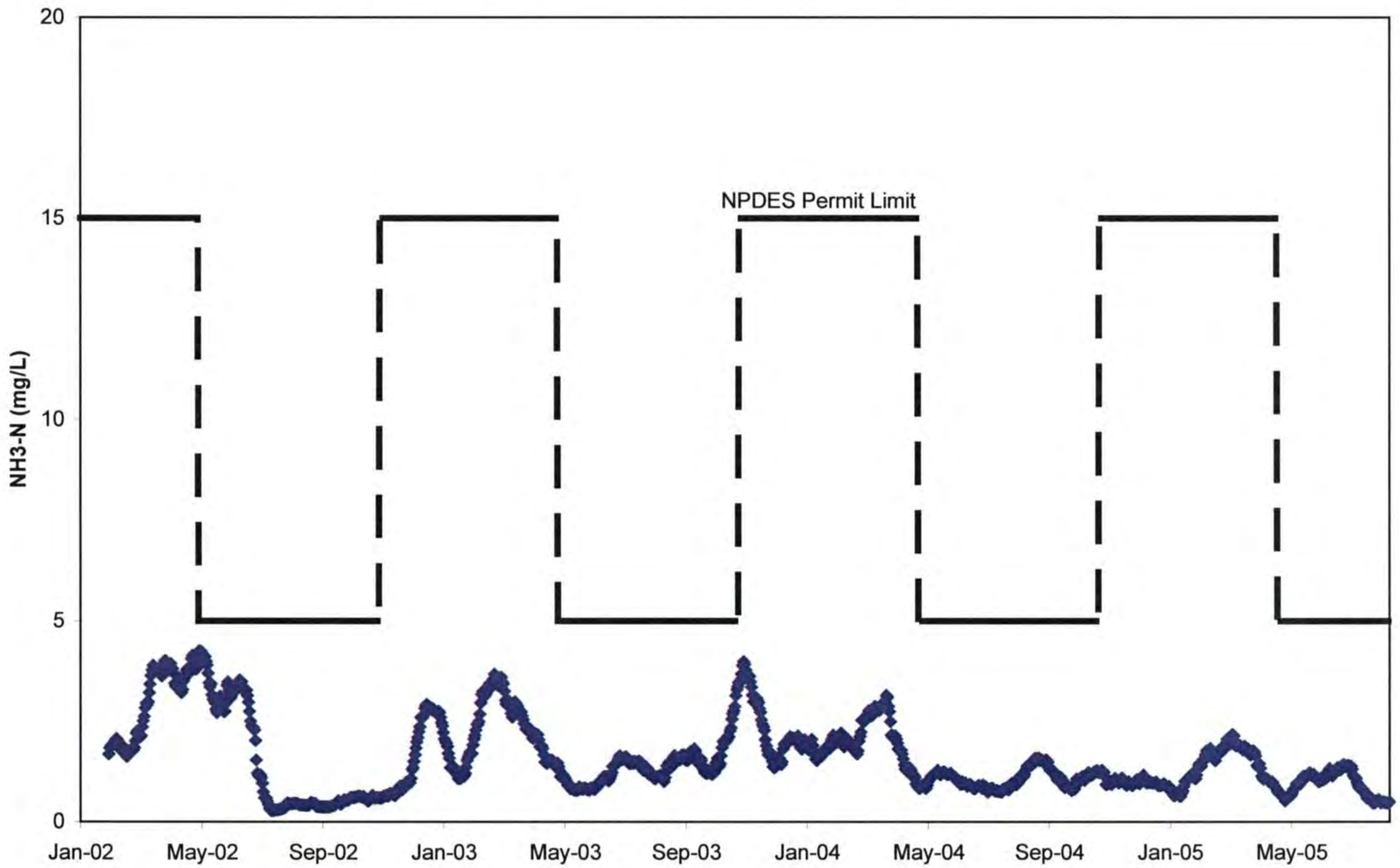
0001491

FIGURE 2-23: Performance vs Weekly NH3-N Effluent Limits



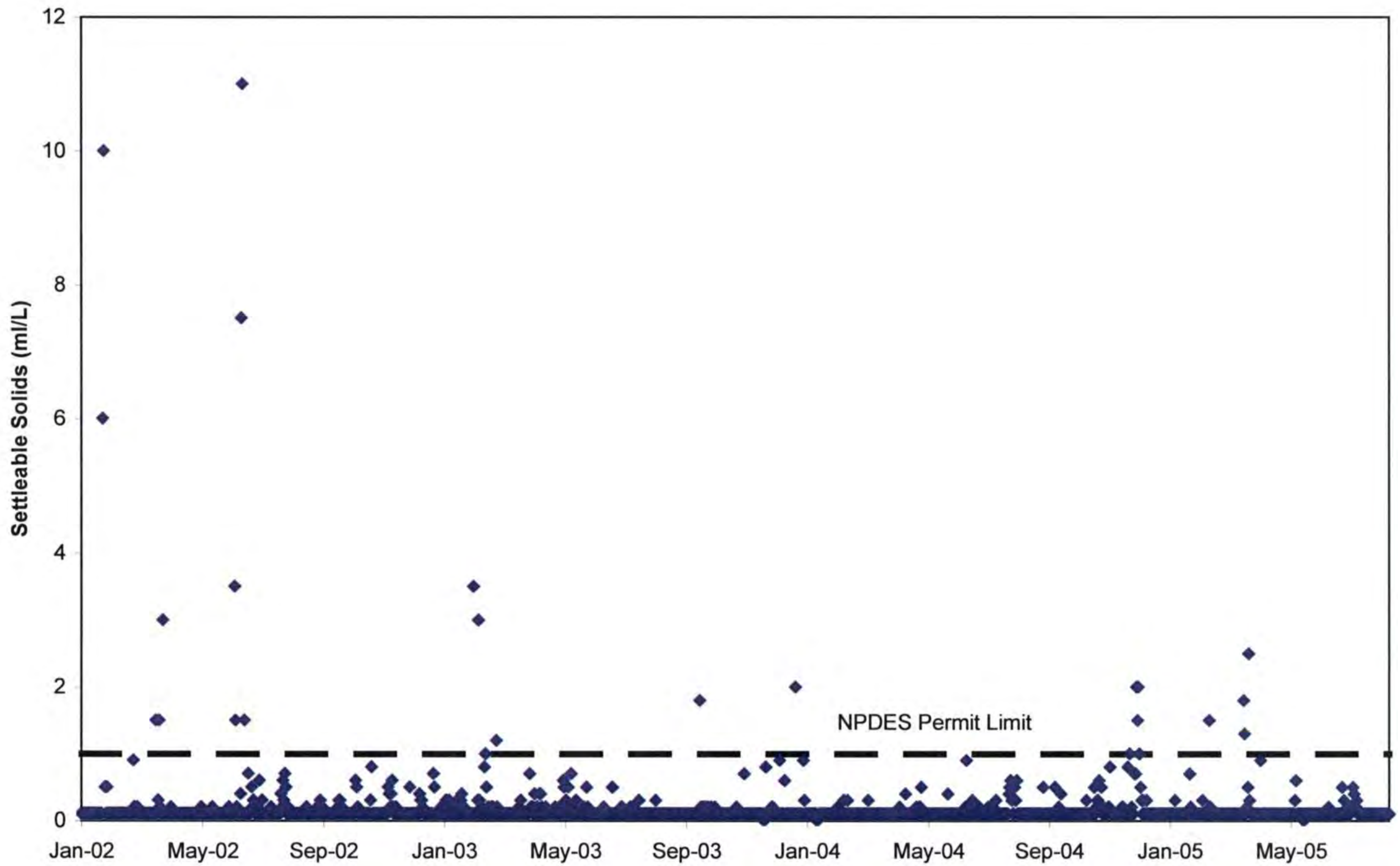
0001492

FIGURE 2-24: Performance vs Monthly NH3-N Effluent Limits



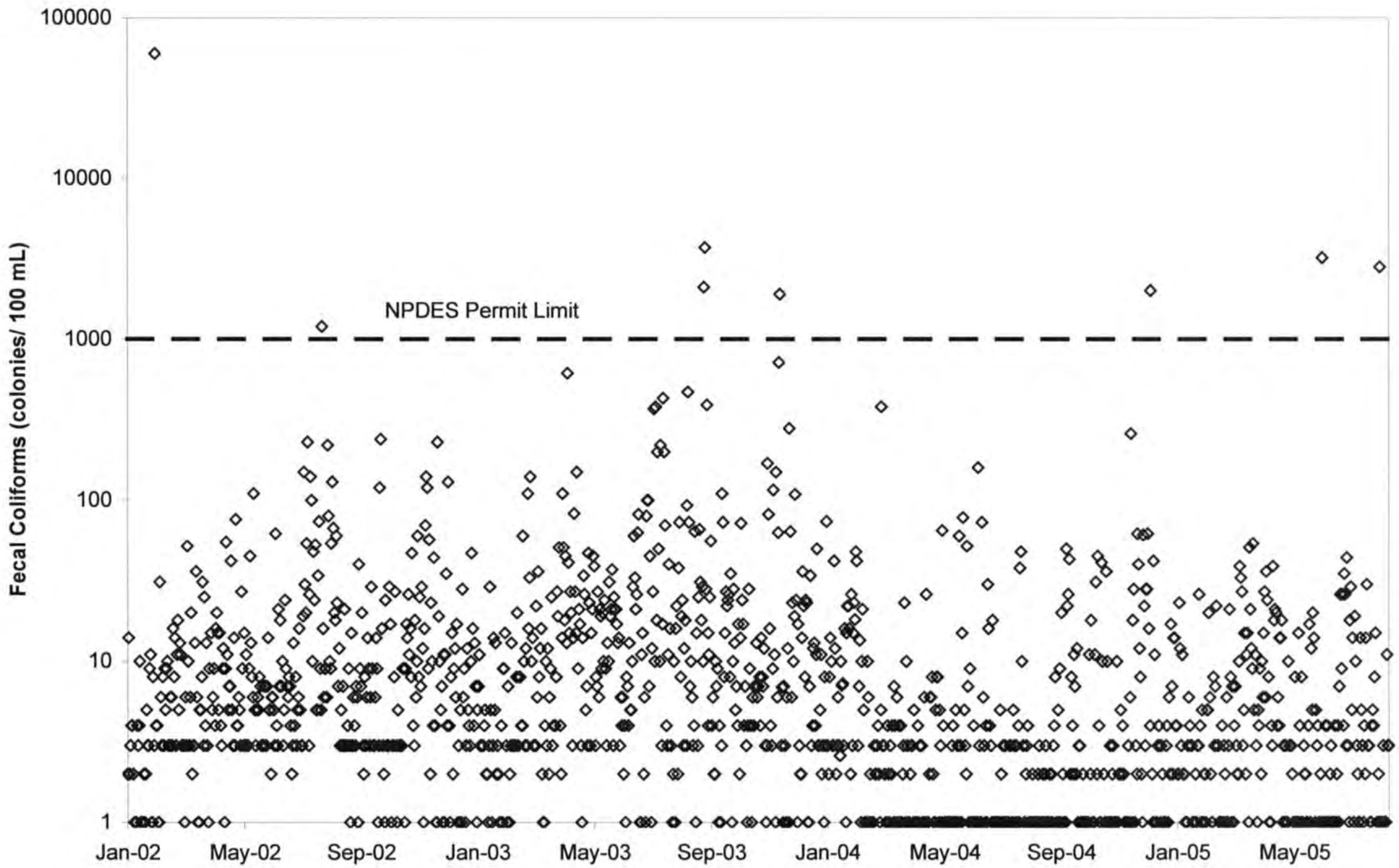
0001493

FIGURE 2-25: Performance vs Daily Settleable Solids Effluent Limits



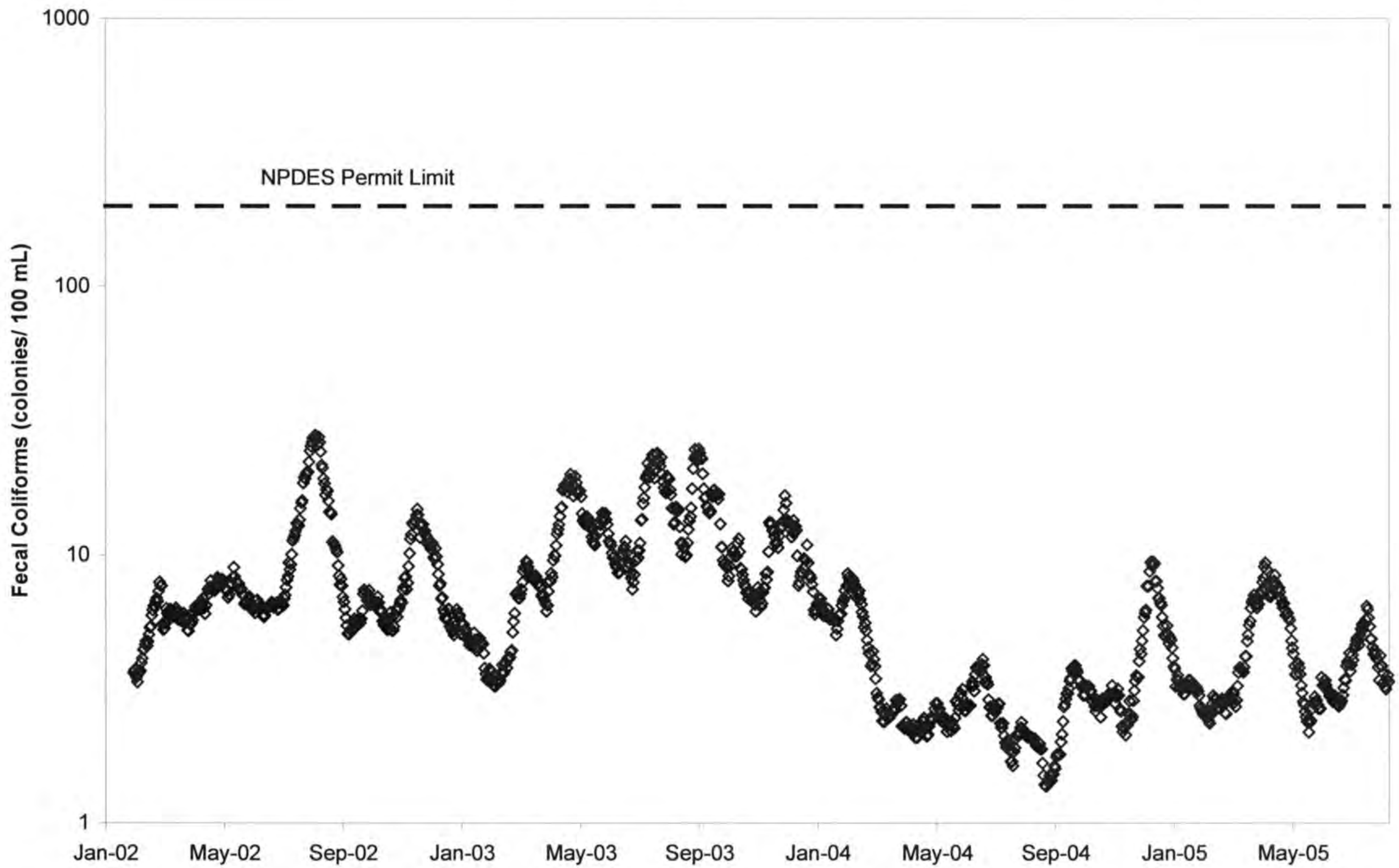
0001494

FIGURE 2-26: Performance vs Daily Fecal Coliform Effluent Limit



0001495

FIGURE 2-27: Performance vs Monthly Fecal Coliform Effluent Limit



0001496

2.5.3 Solids Accountability and Process Performance

Figure 2-28 is a solids balance for the Kuwahee WWTP based on the overall average of data collected for the period January 2002 through August 2005.

As shown in Figure 2-1, the average influent flow at the Kuwahee WWTP was 36.3 mgd over the period analyzed. The average TSS of the influent was 413 mg/L. The average effluent flow over the period was 32.4 mgd and the average effluent TSS was 14 mg/L. **Table 2-18** is a summary of TSS and removal efficiencies of TSS at the influent, primary effluent, and final effluent.

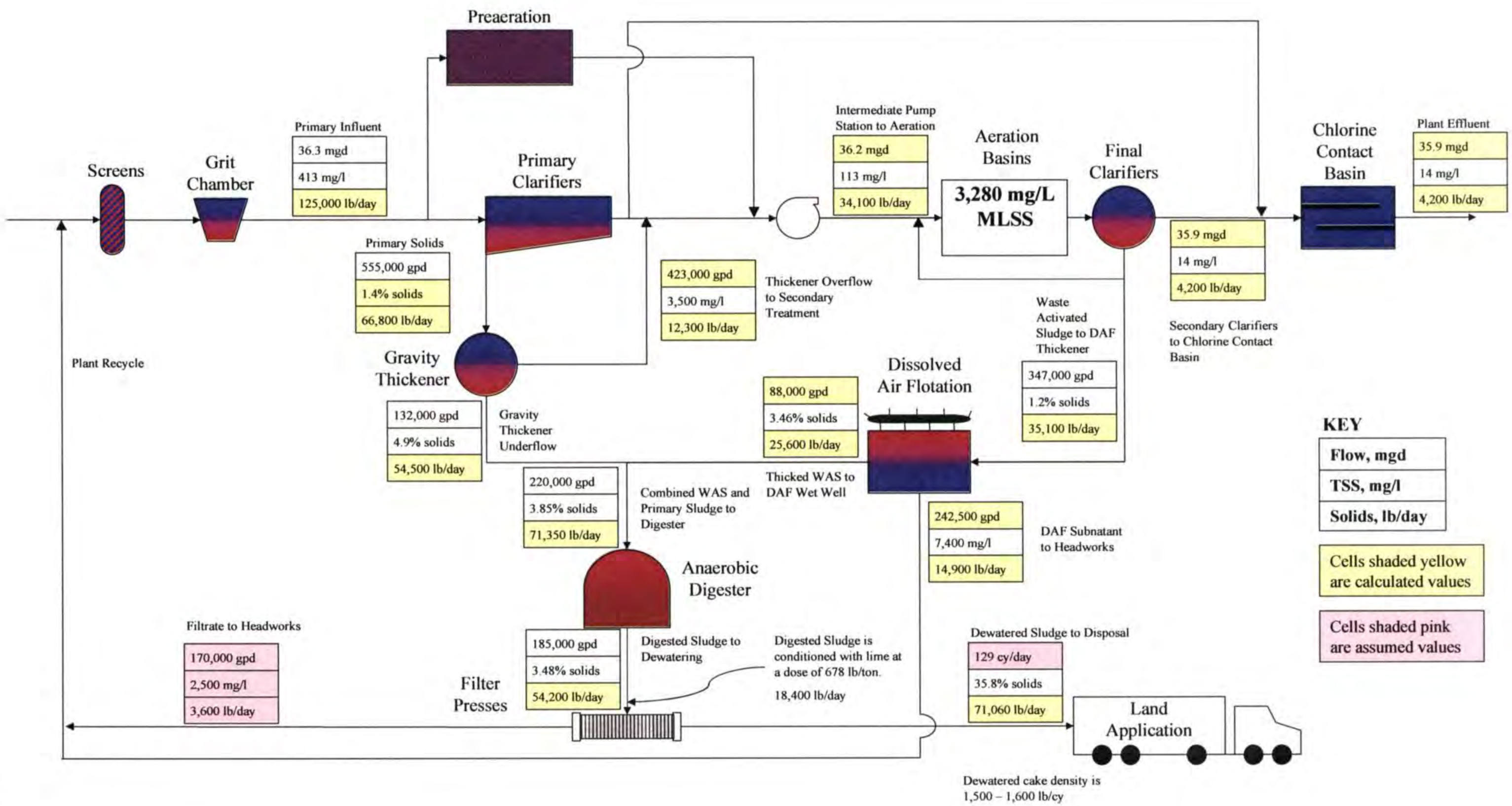
Table 2-18: Summary of TSS and TSS Removal Efficiencies

	Influent Flow (mgd)	Influent TSS (mg/L)	Secondary Influent TSS (mg/L)	Estimated Primary Clarifier TSS Removal (%)	Final TSS (mg/L)	Secondary Treatment TSS Removal (%)	Overall TSS Removal (%)
2002	34.3	457	127	72.2	16	87.4	96.5
2003	39.7	423	126	70.2	14	88.9	96.7
2004	35.5	380	97	74.5	11	88.7	97.1
2005	34.7	332	88	73.4	11	87.5	96.7
2002 – 2005	36.3	413	113	72.6	14	87.6	96.6

Primary Clarifier and Gravity Thickener Solids Balance

On average, approximately 125,000 lb/day of TSS enters the primary clarifiers; this includes both influent solids from the collection system and solids recycled from the digester supernatant, dissolved air flotation thickener subnatant and the plate and frame press filtrate. The collected primary clarifier solids are thickened in a gravity thickener to an average volume of 130,000 gpd and an average concentration of approximately 4.9% solids. This corresponds to 54,500 lb/day of solids removed by the primary clarifiers and gravity thickener. The overflow from the gravity thickeners is returned to the main process flow prior to the intermediate pump station.

A discrepancy exists for the recorded amount of primary influent solids and the recorded primary clarifier/ gravity thickener underflow solids. Based on the reported solids in the gravity thickener underflow, the combination of primary clarifiers and gravity thickeners remove only 40% of the influent TSS. By comparison with the values in Table 2-18, the estimated TSS removal by the primary clarifier and gravity thickener is 72.6%. The removal efficiency shown in Table 2-18 is calculated from the reported influent TSS concentration and the reported TSS concentration in the secondary influent. Both removal percentages are within reported ranges of TSS removal efficiencies by primary clarifiers; however, with the detention time exceeding 2 hours, greater than 50% removal of TSS would be expected.



CDM

Figure 2-28
Kuwahee WWTP Flow Schematic and Solids Balance at 36.7 mgd

0001498

Advanced Secondary Treatment Solids Balance

The influent to the advanced secondary treatment process contains the combined flows from the primary clarifier overflow, gravity thickener overflow, and preaeration system flow. Over the years 2002 - 2005, the estimated average flow through the advanced secondary treatment system was 36.2 mgd. The average influent TSS concentration was 113 mg/L and the average $CBOD_5$ concentration was 93 mg/L. Over the same period, the average effluent flow was 32.4 mgd with an average TSS concentration of 14 mg/L and an average $CBOD_5$ concentration of 6.2 mg/L. This corresponds to an average 87.6% removal for TSS and 93.3% removal for $CBOD_5$ for the advanced secondary treatment system.

Operation of the advanced secondary treatment system includes an internal recycle stream from the final clarifier underflows to the aeration basins (return activated sludge or RAS) and waste activated sludge (WAS) between the final clarifier underflows and the DAF thickeners. On average, 345,000 gpd of WAS is pumped from the final clarifiers underflow to the DAF thickener influent. At an average solids concentration of 1.2%, it is estimated that 35,100 lb/day of solids is wasted from the advanced secondary treatment system at the Kuwahee WWTP.

One fraction of the solids from the advanced secondary treatment system is the influent TSS. As shown in Figure 2-14, 34,100 lb/day TSS enters the advanced secondary treatment system. Based on samples collected in June - July 2005, 76% (25,900 lb/day) of the TSS in the advanced secondary system influent is volatile suspended solids (VSS). The remaining 24% (8,180 lb/day) is non-volatile. It is assumed that all of the non-volatile solids (8,180 lb/day) are removed with the WAS. Based on Manual of Practice 8 (WEF, 1992), it is assumed that 40% of the VSS are also nonbiodegradable and are removed in the WAS. For the Kuwahee WWTP, this is approximately 10,400 lb/day. It is assumed the remaining 60% of the VSS are absorbed into the biomass and solubilized.

A second source of solids from the advanced secondary treatment system is the biological growth that occurs as the influent $CBOD_5$ is converted. The average influent $CBOD_5$ concentration is 93 mg/L. By assuming 0.65 lb of TSS created for every 1 lb of $CBOD_5$ consumed in the aeration basins, approximately 17,000 lb/day of TSS is created and removed in the WAS.

Table 2-19 summarizes the solids accountability analysis for the advanced wastewater treatment system. In general, the influent solids and solids generated in the advanced secondary treatment total 35,600 lb/day. The effluent solids and waste activated sludge total 39,300 lb/day.

Table 2-19: Solids Accountability for Advanced Wastewater Treatment System

Solids Into System	Measured Data/Assumption	Calculated Value
Influent TSS	From TSS data = 34,100 lb/day	
Non-volatile TSS	24% of influent TSS	8,180 lb/day
Influent VSS	76% of influent TSS = 25,920 lb/day	
Nonbiodegradable VSS	40% of VSS	10,400 lb/day
Influent $CBOD_5$	From $CBOD_5$ data = 28,100 lb/day	
Effluent $CBOD_5$	From $CBOD_5$ data = 1,900 lb/day	
$CBOD_5$ Consumed	26,200 lb/day	
Biological Growth	Assume 0.65 lb TSS / 1 lb $CBOD_5$ consumed	17,000 lb/day
	Sum of Solids Into System	35,600 lb/day
Solids Out of System		
Final Effluent Solids	From TSS data	4,200 lb/day
WAS		35,100 lb/day
	Sum of Solids Out of System	39,300 lb/day

Dissolved Air Flotation Solids Balance

WAS is thickened by dissolved air flotation at the Kuwahee WWTP. As shown in Figure 2-28, 347,000 gpd at a concentration of 1.2% solids of WAS is conveyed to the DAF influent. The average percent solids in the DAF thickened WAS is 3.46%.

There is no data available about the volume of thickened WAS. Instead, the daily volume of thickened WAS is calculated by subtracting the daily volume of primary sludge pumped from the gravity thickener (132,000 gpd) from the daily volume of digester influent flow (220,000 gpd). It is estimated that 25,600 lb/day (88,000 gpd at 3.46% solids) of thickened WAS solids are pumped from the DAF wetwell to the anaerobic digester.

Samples are collected and analyzed to determine the solids concentration of the DAF subnatant. The data is widely scattered ranging from 0.01% to 4.6% solids.

Anaerobic Digestion Solids Balance

The thickened WAS and gravity thickener underflow combine to become the anaerobic digester influent. Over the years 2002 - 2005, the average influent flow to the digester was 220,000 gpd. The average measured digester influent solids concentration was 3.85% solids. The calculated mass of solids into the anaerobic digesters is 73,500 lb/day.

Previously in this section, it was estimated that 54,500 lb/day of thickened primary solids and 25,600 lb/day of thickened WAS were combined. This equates to 80,100 lb/day of digester influent solids, an 12% increase over the mass of solids calculated from digester influent measurements.

Solids were pumped from the anaerobic digester to the plate and frame presses for dewatering (this equipment has been replaced with centrifuges which should be

0001500

operational in January 2006). The average measured digester effluent flow was 185,000 gpd at 3.48% solids. This corresponds to 54,200 lb/day solids in the digester effluent. By comparing the influent and effluent mass of solids, it is estimated that approximately 17,100 lb/day of solids are destroyed in the anaerobic digester.

Plate and Frame Press Solids Balance

Up until August 2005, digested sludge was conditioned with lime and dewatered using plate and frame presses prior to being hauled off-site for disposal. Lime was dosed at approximately 678 lb lime/dry ton of solids. On average, 54,200 lb/day of solids were pumped from the anaerobic digester and 18,400 lb/day of lime was added to the solids. Approximately 133 cubic yards/day of dewatered product was produced at 35.8 percent solids.

No data are available regarding the quantity and quality of filtrate from the plate and frame press. To complete the mass balance, it is assumed that 95% of the solids are retained on the plate and frame press and 5% of the solids are returned with the filtrate. The filtrate and DAF subnatant are returned to the headworks of the Kuwahee WWTP.

The plate and frame presses are currently being replaced with centrifuges.

Overall Average Process Performance

The average daily influent pollutant parameters for 2002–2005 stated in the previous section are summarized in **Table 2-20**. Also shown in Table 2-20 are the average daily effluent pollutant parameters and the average daily activated sludge influent parameters for 2002-2005. Finally, Table 2-20 includes the average daily pollutant percent removals by the primary clarifiers and the activated sludge system for 2002 - 2005.

Table 2-20: Kuwahee WWTP Average Daily Process Performance

	$CBOD_5$	TSS	NH_3-N
Average Daily Influent Concentration (mg/L)	240	413	12.3
Average Daily Secondary Influent Concentration (mg/L)	93	113	11.8
Average Daily Primary Clarifier Percent Removal (%)	61.2	72.6	4.1
Average Daily Effluent Concentration (mg/L)	6.2	13.5	1.6
Average Daily Activated Sludge Percent Removal (%)	93.3	88.1	86.4

Because of flow and pollutant data limitations during high flow situations, the following assumptions were made for the purposes of this analysis:

- The average daily activated sludge influent parameters were used as the primary clarifier effluent parameters. During high flow situations, this is not completely accurate, because a portion of the activated sludge influent flow does not pass through the primary clarifiers. Therefore when the percent removals for the primary clarifiers are calculated, they are conservatively low.
- The average daily effluent parameters were used as the activated sludge effluent parameters. During high flow situations, this is not completely accurate, because a portion of the total effluent flow is treated by the primary clarifiers, but not the activated sludge system. Therefore, when the percent removals for the activated sludge system are calculated, they are conservatively low.

Summary of Solids Accountability
On average, the TSS loading to the KUB primary clarifiers is 125,000 lb/day TSS. In addition, it is estimated that on average 18,400 lb/day of lime are added to the dewatered solids. The total solids input at the KWWTP is 143,400 lb/day.

Solids leave the KWWTP over the effluent weir (4,200 lb/day) and via land use (71,100 lb/day). In addition, some solids are returned to the KWWTP influent from dewatering filtrate (3,600 lb/day) and DAF subnatant (14,900 lb/day). The total amount of solids exiting the KWWTP is estimated to be 93,800 lb/day.

The remaining 49,600 lb/day TSS are either destroyed or unaccounted for. Within the KWWTP solids balance, there are several areas with discrepancies among recorded data and calculated values. The primary clarifiers, the anaerobic digester influent, and to some degree the advanced secondary treatment system report either conflicting data or data that is outside normal wastewater treatment plant operating conditions.

2.6 Wet Weather Data Analysis and Performance Summary

As shown previously, rainfall greatly impacts flow rates at the KWWTP. The following analysis is intended to demonstrate how it affects WWTP process performance.

Table 2-21 shows the average flow rates for the entire period of 2002 –2004, during dry weather when daily rainfall was 0 inches, and during wet weather when daily rainfall amounts exceeded 0.1 inches, 0.5 inches, and 1.0 inches.

Table 2-21: Kuwahee WWTP 2002 – 2004 Total, Dry Weather and Wet Weather Flow Rates

	2002 – 2004 All Days	2002 – 2004 Days Rainfall =0 inches	2002 – 2004 Days Rainfall >0 inches	2002 – 2004 Days Rainfall >0.1 inches	2002 – 2004 Days Rainfall >0.5 inches	2002 – 2004 Days Rainfall >1.0 inches
Average Daily Influent Flow Rate (mgd)	36.67	33.61	41.40	43.40	49.74	57.32
Maximum Daily Influent Flow Rate (mgd)	100	76.29	100	100	100	100

Because flow is diverted from the primary clarifiers and activated sludge systems during wet weather events, the performance of these processes does not significantly suffer during rain events. The following percent removals incorporate the assumptions listed above. The assumptions cause the percent removal values to decrease as process bypasses increase.

Table 2-22 shows the average $CBOD_5$ percent removals of the primary clarifiers and the activated sludge system for the entire period of 2002 - 2004, during dry weather, when daily rainfall was 0 inches, and during wet weather, when daily rainfall amounts exceeded 0 inches, 0.1 inches, 0.5 inches, and 1.0 inches.

Table 2-22: Kuwahee WWTP 2002 – 2004 Total, Dry Weather and Wet Weather $CBOD_5$ Removal Process Performance

	2002 – 2004 All Days	2002 – 2004 Days Rainfall =0 inches	2002 – 2004 Days Rainfall >0 inches	2002 – 2004 Days Rainfall >0.1 inches	2002 – 2004 Days Rainfall >0.5 inches	2002 – 2004 Days Rainfall >1.0 inches
Average Daily Primary Clarifier Percent Removal (%)	54.4	54.9	53.7	54.8	54.2	49.8
Average Daily Activated Sludge Percent Removal (%)	92.7	93.3	91.9	91.4	89.4	89.3

Table 2-23 shows the average TSS percent removals of the primary clarifiers and the activated sludge system for the entire period of 2002 - 2004, during dry weather, when daily rainfall was 0 inches, and during wet weather, when daily rainfall amounts exceeded 0 inches, 0.1 inches, 0.5 inches, and 1.0 inches.

Table 2-23: Kuwahee WWTP 2002 – 2004 Total, Dry Weather and Wet Weather TSS Removal Process Performance

	2002 – 2004 All Days	2002 – 2004 Days Rainfall =0 inches	2002 – 2004 Days Rainfall >0 inches	2002 – 2004 Days Rainfall >0.1 inches	2002 – 2004 Days Rainfall >0.5 inches	2002 – 2004 Days Rainfall >1.0 inches
Average Daily Primary Clarifier Percent Removal (%)	66.3	68.8	62.4	63.2	63.0	57.4
Average Daily Activated Sludge Percent Removal (%)	91.3	86.3	85.5	84.1	80.8	73.9

Table 2-24 shows the average NH_3 percent removals of the activated sludge system for the entire period of 2002 - 2004, during dry weather, when daily rainfall was 0 inches, and during wet weather, when daily rainfall amounts exceeded 0 inches, 0.1 inches, 0.5 inches, and 1.0 inches.

Table 2-24: Kuwahee WWTP 2002 – 2004 Total, Dry Weather and Wet Weather NH_3 Removal Process Performance

	2002 – 2004 All Days	2002 – 2004 Days Rainfall =0 inches	2002 – 2004 Days Rainfall >0 inches	2002 – 2004 Days Rainfall >0.1 inches	2002 – 2004 Days Rainfall >0.5 inches	2002 – 2004 Days Rainfall >1.0 inches
Average Daily Activated Sludge Percent Removal (%)	83.3	86.4	78.6	77.8	73.4	71.7

2.6.1 Process Performance During Diversions

Additional analyses of wet weather sampling results were performed to gain a better understanding of primary treatment and biological treatment performance. The principle source of data for the analyses are the results of analyzing samples collected by the high flow samplers during high flow wet weather events at the KWWTP. These samplers are located at the Diversion Parshall flume and the biological system effluent Parshall flume (ref. Figure 2-1). Therefore, they provide effluent quality data of the two streams prior to blending at the chlorine contact basin.

The average influent flow at the KWWTP over the period January 2002 - July 2005 was 36.3 mgd. Over the same period the average influent $CBOD_5$ and TSS concentrations were 240 mg/L and 413 mg/L, respectively.

From January 2004 to July 2005, data was collected from high flow samplers at the KWWTP during high flow events. A total of 37 high flow events were sampled over that period. The average influent flow on days with Diversion sampling data collected was 61.4 mgd. The average influent $CBOD_5$ and TSS on those same days was 160 mg/L and 357 mg/L, respectively. The average rainfall reported on those days was 0.57 inches.

The higher flow reported during the Diversion events is associated with lower influent concentrations of $CBOD_5$ and TSS. This relationship is expected since the higher flows are most likely associated with increased inflow and infiltration with low concentrations of $CBOD_5$ and TSS.

The following analysis indicates the impact of primary redirect flows (flows directed to the preaeration basin that do not receive primary treatment) has on the influent of the biological treatment system. In general, blending of the primary clarifier redirect flows with the primary clarifier effluent increases the concentration of $CBOD_5$ and TSS. The $CBOD_5$ and TSS concentration of the primary clarifier effluent averaged 57 mg/L and 96 mg/L, respectively, when collected from the high flow samplers. After blending with the primary clarifier redirect flow, the $CBOD_5$ and TSS concentrations increased to 69 mg/L and 118 mg/L, respectively. The blended values are the loadings to the biological system.

Even though the blending of primary clarifier effluent with primary clarifier redirect flows increases the concentration of TSS and $CBOD_5$, the impact of the diluted plant influent is actually a lower concentration of $CBOD_5$ and TSS to the biological system during high flows when compared to the overall average. The average biological influent concentration of $CBOD_5$ during the 37 high flow events was 69 mg/L, slightly lower than the overall average of 93 mg/L. TSS data indicate nearly the same concentration (113 mg/L overall, 118 mg/L during high flows) of TSS entering the biological system.

The impact of a Diversion of the biological system on the final effluent quality can be related to the amount of flow in the Diversion. **Table 2-25** provides a summary of the influent and final effluent quality for each process stream, as an average of the 37 Diversion sampling events, and as an average of Diversion sampling events when the influent flow is greater than 70 mgd. Also shown in Table 2-25 is the average flow and duration of a Diversion at each condition.

In summary, the impact of the primary redirect flow on biological treatment is minimal at the KWWTP. Even though the blending of the primary redirect flow with primary clarifier effluent does increase the $CBOD_5$ and TSS of the influent to the biological treatment system, the increase is only marginal.

Table 2-25: Comparison of $CBOD_5$ and TSS Concentrations During Diversions

Parameter		Influent (mg/L)	Primary Effluent (mg/L)	Biological Influent (mg/L)	Biological Effluent (mg/L)	Final Effluent (mg/L)	Diversion (mgd) Volume	Diversion Duration (hr/day)
Overall	$CBOD_5$	240	N/A	93	N/A	6.2	2.0	1.4
	TSS	413	N/A	113	N/A	13.5		
37 Diversion Sampling Events	$CBOD_5$	160	57	69	14	8.0	9.2	6.9
	TSS	357	96	118	46	23.8		
Diversion Sampling Events when Average Daily Flow > 70 mgd	$CBOD_5$	114	63	50	14	10.5	24.4	16.9
	TSS	281	110	103	61	35.0		

Based on these averages, the primary clarifier effluent does not meet the NPDES maximum day final effluent limits for $CBOD_5$ (40 mg/L) or TSS (45 mg/L). Also based on these averages, biological effluent meets the maximum day limits for $CBOD_5$, and exceeds the maximum day limits for TSS, though for all Diversion events it is very close to the limit. Note that in all cases, these averages indicate the final effluent is lower in $CBOD_5$ and TSS than both of the blended streams. This is likely due to the final effluent samples being 24 hour composites, while the high flow samples (primary effluent and biological effluent) are typically for shorter periods. As shown in Table 2-25, the impact of the Diversion on the final effluent quality is an increase in average effluent TSS from 13.5 mg/L up to 35.0 mg/L.

The conclusion from these analyses is that Diversion flows are the likely cause of NPDES permit TSS effluent limit exceedances during high flow wet weather events, however further analyses are warranted.

Section 3
Fourth Creek WWTP Performance Evaluation & Data Analysis

The purpose of this section of the CPE is to summarize the process performance of the existing wastewater treatment facilities at the Fourth Creek Wastewater Treatment Plant (FCWWTP). This section is divided into the following major subsections:

3.1 FCWWTP General Description

3.2 Operational Description

3.3 Treatment Requirements and Effluent Limitations

3.4 Treatment Process and Equipment Descriptions

3.5 WWTP Data Analysis and Performance Summary

3.6 Wet Weather Data Analysis and Performance Summary (not yet completed)

The analysis consisted of a detailed evaluation of the wastewater treatment plant operational data, including flow and loading data, for January 2002 through August 2005. The capacity of each major treatment process is compared to TDEC Design Standards. In addition, this evaluation describes the performance of each major process, including removal efficiencies for various pollutants, and currently applicable NPDES permit compliance. Finally, the evaluation examines the impact of wet weather on flows, loadings, and process performance at the FCWWTP.

3.1 FCWWTP General Description

The FCWWTP is an advanced wastewater treatment facility that was originally constructed to serve primarily residential and commercial customers. The FCWWTP is designed to provide secondary treatment to an average daily flow of 10.8 mgd. The maximum daily design flow is not known, but is estimated to be 24 mgd, based upon the size and slope of the influent piping, as noted in the CTI report of June, 2002 (Study of Improvements to Fourth Creek Wastewater Treatment Plant). The maximum daily average flow reported during the period evaluated was approximately 40 mgd (however this data is not correct since this exceeds influent pumping capacity and is likely due to flooding of the Parshall flume).

The facility underwent a major expansion and upgrade in the mid-1980's when the screening, grit removal, primary clarifiers, secondary activated sludge system, and disinfection facilities were expanded. In 1995, new chlorination and dechlorination facilities were constructed. The effluent from the FCWWTP is discharged into the Tennessee River.

The wastewater treatment plant includes preliminary, primary, secondary, and disinfection treatment. Effluent from the secondary facilities is disinfected in chlorine contact tanks and then dechlorinated by use of sodium bisulfite prior to discharge into the Tennessee River.

Sludge from primary treatment and the activated sludge process is thickened in a gravity sludge thickener. The sludge is then pumped from the sludge thickening processes to a gravity sewer that flows to the KWWTP. A flow schematic of the FCWWTP is shown in **Figure 3-1**.

3.2 Operational Description

Flows up to 11 mgd receive full primary and secondary treatment, along with disinfection. As flow increases above 11 mgd, the empty primary clarifiers (typically 3 or 4 of the 8 clarifiers are in service) are put into service initially for storage, then as primary clarifiers when full. At this point, an on-line TSS meter in the aeration basin effluent is monitored to detect loss of solids, though this doesn't typically occur until flows through the biological process exceed 15 mgd.

The procedure for completing Diversion process preparation activities is included in the PCP and is described as follows:

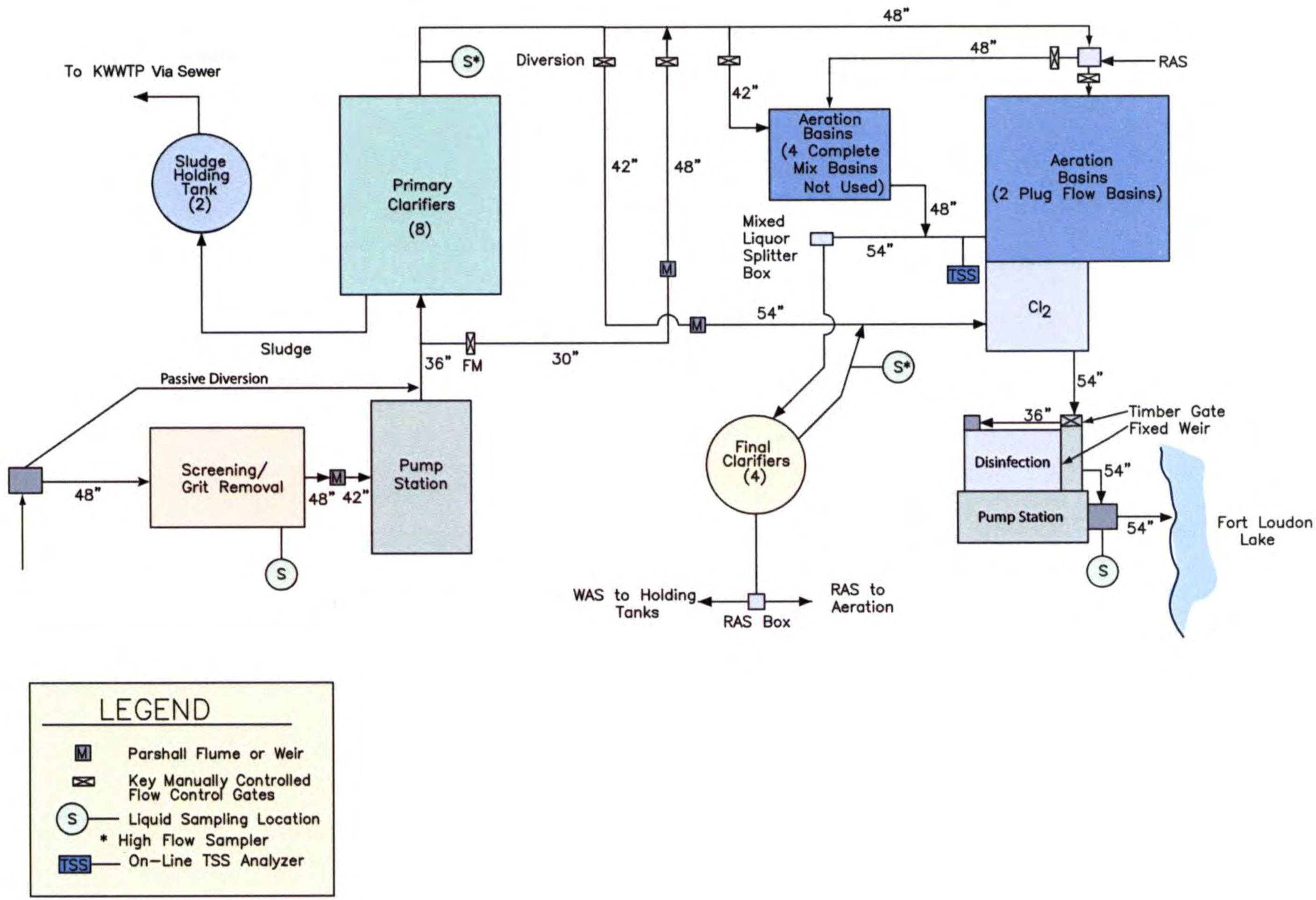
1. Establish pre-event MLSS concentration - this is the MLSS concentration that will be used to calculate the percentage of biomass lost from aeration.

2. The pre-Diversion approval threshold is the MLSS concentration at which supervisory approval is obtained for a possible Diversion. It is set at 10 percent of the pre-event MLSS value.

3. The Diversion threshold is the MLSS concentration at which the diversion gate is opened to avoid a washout condition. It is set at 15 percent of the pre-event MLSS value.

The pre-event MLSS concentration is the average concentration as determined by TSS meter readings for the 12 hours preceding the time when influent flow reaches 8 mgd. The pre-Diversion approval and Diversion thresholds described above are used as guidelines to take the indicated actions. Due to the typically rapid changes in flows and process performance characteristic of wet weather operations, and manual operation required to adjust gates, these actions may be taken when TSS measurements are within 2 percent of the action levels.

Note that it is up to the discretion of the operator to actually open the diversion gate once the Diversion threshold is reached. If plant flows are decreasing and/or final clarifier performance is satisfactory (sludge blanket levels are controlled in all clarifiers and excessive solids are not being lost), the operator may decide not to open



00001509

CDM

Figure 3-1: Fourth Creek WWTP Process Schematic

the Diversion gate. In fact, even if a Washout has occurred, the operator may exercise discretion and not open the Diversion gate based on the conditions described above.

When flows reach about 30 mgd, the mixed liquor splitter box at the final clarifiers is subject to overflowing resulting in an Unpermitted Discharge.

The chlorination/dechlorination basin is furnished with a timber gate that enables effluent flow from the first chlorine contact basin to be routed away from the downstream chlorination/dechlorination basin and enter the effluent box, downstream of the effluent weir. At flows exceeding 15 mgd, this gate must be partially opened to avoid flows from backing up over the final clarifier weirs.

3.3 Treatment Requirements and Effluent Limitations

The FCWWTP was designed to treat an average daily flow of 10.8 mgd. The FCWWTP is permitted to meet the following maximum monthly average, maximum weekly average, and daily maximum effluent requirements for an average annual flow of 10.8 mgd as imposed under NPDES Permit No. TN0023574. **Table 3-1** shows the permit limits for conventional pollutants.

Table 3-1: NPDES Effluent Limits for the FCWWTP

	Monthly Average	Weekly Average	Daily Maximum
Biochemical Oxygen Demand (BOD_5)*	30 mg/L 2,702 lb/day	40 mg/L 3,603 lb/day	45 mg/L
Total Suspended Solids (TSS)*	30 mg/L 2,702 lb/day	40 mg/L 3,603 lb/day	45 mg/L
Fecal Coliforms	200 colonies per 100 ml		1,000 colonies/ per 100 ml
Total Residual Chlorine			1.0 mg/L (instantaneous)
Settleable Solids			1.0 mg/L
Dissolved Oxygen			1.0 mg/L Minimum (instantaneous)

* 85 percent monthly average removal and 40 percent minimum daily removal are also required.

Additionally, the daily effluent pH shall not be less than 6.0 or greater than 9.0 standard units. The existing permit also contains limits for numerous other chemical constituents.

3.4 Treatment Process and Equipment Descriptions

The following paragraphs give a brief description of the treatment processes and corresponding equipment. Comparisons to Tennessee design standards (*Design Criteria for Sewage Works, State of Tennessee, Department of Health and Environment, Division of Water Pollution Control,* April 1989) are provided where appropriate.

Preliminary Treatment (Screening, Grit Removal and Pumping)

As wastewater enters the plant, it flows through a channel that contains a 6 feet wide mechanically cleaned bar screen with 1.2 inch openings. Prior to reaching the 6 feet wide bar screen, the flow can be diverted into a side channel that contains 4 feet, 6 inch wide manually cleaned bar screen with 1 inch screen openings. **Table 3-2** provides a summary of design information.

Table 3-2: Bar Screen Design Information and Tennessee Design Standards

	Screen Size Openings (in)	Approach Velocity (fps)	
		Average Flow (10.8 mgd)	Peak Day Flow (24 mgd)
Mechanical Bar Screens	1.2	2.37	3.1
Manual Bar Screens	1.0	1.56	1.9
Tennessee Design Standard	.675 (minimum)	1.25 (minimum)	3.0 (maximum)

After screening, the raw wastewater enters the aerated grit chamber.

The aerated grit chamber consists of two channels, each 66 feet in length by 5 feet - 10 inches in width with a side water depth of 11.61 feet. Air diffusers are located along bottom of each channel. Blowers currently provide air to the aerated grit chamber. Heavy inorganic solids/particles are removed from the raw wastewater and settle in each of the two channels. One traveling bridge is utilized to guide pumps to remove the collected grit from the aerated grit chamber. The grit is pumped to a grit channel where it flows by gravity to a classifier that transports it to a dumpster in the screen building where it awaits off site disposal at a sanitary landfill. With the grit chambers are two grease removal channels. Because of the nature of the baffling between the aerated grit chambers and the grease channels, grease does not readily enter the grease removal channels, limiting their effectiveness. **Table 3-3** provides a summary of design information.

Table 3-3: Aerated Grit Chamber Design Information and Tennessee Design Standards

	Average Flow (10.8 mgd)	Peak Day Flow (24 mgd)	Tennessee Design Standards
Detention Time, minutes	8.9	4.0	2-5 minutes at peak flow

From the grit channels, wastewater flows through a 48-inch Parshall flume that measures the influent wastewater flow rates. From the flume, the wastewater flows to a 42-inch sewer that leads to a raw wastewater pump station.

The raw wastewater pump station contains three pumps rated at 10.8 mgd at 30 feet of total discharge head. The discharge head is actually less, allowing the pumps to pump approximately 12.9 mgd. These pumps deliver wastewater to the primary clarifiers.

Primary Treatment
Primary treatment consists of eight rectangular settling tanks that are 135 feet long by 20 feet wide with a side water depth of 10 feet. The length of the weir is 120 feet per settling tank. During low flow periods, three or four clarifiers remain in operation. The weir lengths of the clarifiers limit the efficient operation at high flow rates. Wastewater can be directed around the primary clarifiers to the secondary activated sludge system through a Parshall flume. Additionally, a primary effluent Diversion directly to the chlorine contact basin through another Parshall flume can be used for flows that exceed biological treatment capacity.

Each settling tank contains a chain and flight type sludge collector that carries sludge to the east end of each tank where the sludge hoppers are located. The sludge is then pumped to the gravity sludge thickener.

Scum is removed from the primary settling tanks by gravity flow to the two scum boxes located at the east and west ends of the tanks. The scum is then pumped to the gravity sludge thickener. **Table 3-4** provides the primary clarifier design information as well as TDEC design standards.

Table 3-4: Primary Clarifier Design Information and Tennessee Design Standards

	Influent Flow (mgd)			Tennessee Design Standards
	10.8	10.8	24	
Number of Units	4	8	8	N/A
Detention Time, hours	1.8	3.6	1.7	2.5 (maximum recommended)
Surface Overflow Rate, gpd/ft^2 Average design flow Peak design flow	1000	500	1111	 800-1200 2000-3000
Weir Loading Rate, gpd/ft	22,500	11,250	25,000	15,000 (maximum)

Secondary Treatment

Secondary treatment consists of complete mix activated sludge aeration tanks and clarifiers. Flow can be distributed among six activated sludge basins. There are four older basins that are each 55 feet square with an approximate depth of 12 feet, each with a 40 horsepower mechanical surface aerator, that are not currently used. There are two newer basins in service, one 90-feet by 93-feet and one 83.5-feet by 93-feet, both with side water depth of approximately 12 feet, and with four 30 horsepower mechanical surface aerators each. Currently, the flow splitting devices do not deliver wastewater proportionally to all six aeration basins. **Table 3-5** provides a summary of design information.

Table 3-5: Aeration Basin Design Information and Tennessee Design Standards

	Average Flow (10.8 mgd) Newer Basins Only	Average Flow (10.8 mgd) All Basins	Peak Day Flow (24 mgd) All Basins	Tennessee Design Standards (1)
Detention Time, hours	3.2	5.6	2.5	3-5 hrs (average)
Basin Loading lbs BOD_5/1000 ft^3 BOD_5 = 108 mg/L (Avg. 2002-2005)	50	29	N/A	20-80 (average)
F:M (MLSS = 2300 mg/L, Avg. 2002-2005) BOD_5 = 108 mg/L (Avg. 2002-2005) Assume 80% Volatile MLSS	0.24	0.16	0.16	0.15

(1) Complete Mix Conventional Activated Sludge

Effluent from the activated sludge aeration basins flows by gravity to a junction box which distributes the flow to four secondary clarifiers. Each clarifier is circular with a diameter of 76 feet and a sidewater depth of 12 feet. Each is equipped with scrapers and a hopper. The effluent weir length is 239 feet for each clarifier. Effluent from the clarifiers flows to the chlorine contact basin adjacent to the large aeration basins to receive disinfection. **Table 3-6** provides a summary of design information.

Table 3-6: Final Clarifier Design Information and Tennessee Design Standards

	Average Flow (10.8 mgd) All Basins	Peak Day Flow (24 mgd) All Basins	Tennessee Design Standards
Detention Time, hours	3.62	1.63	2.5 recommended maximum
Surface Overflow Rate, gpd/ft^2 Average design flow Peak design flow	595	1,322	 800 1,200
Solids Loading Rate, lbs/day/ft^2 @ MLSS Average design flow Peak design flow	12 @ 2,300 mg/L	27 @ 2,300 mg/L	 30 50
Weir loading Rate, gpd/ft	11,308	25,130	15,000
Side Water Depth, ft Diameter 71 – 100 feet	12	12	13 minimum

Sludge from within the clarifiers' flows by gravity through telescopic valves into a return sludge wetwell. Sludge is returned to the activated sludge basins splitter box by the return activated sludge pumps. There are two pumps with variable frequency drives, each rated at 2500 to 7600 gpm. Because flow splitting is not proportional when all aeration basins are in service, sludge return is also not proportional.

Sludge is wasted from the return sludge wetwell by two waste activated sludge pumps. Waste sludge is pumped to the sludge thickening tanks.

Disinfection

Disinfection is achieved by injecting chlorine solution into the wastewater and allowing enough contact time within the two chlorine contact tanks to reduce pathogen organisms to below NPDES permit limits. Chlorine Contact Basin No. 1 is 83 feet 6 inches long by 40 feet 10 inches wide with a side water depth of 8 feet 3 inches (approximately 201,350 gallons), and Chlorine Contact Basin No. 2 is approximately 41 feet 6 inches long by 33 feet 3 inches wide with a side water depth of 7 feet 10 inches (approximately 70,000 gallons). The chlorine feed equipment consists of chlorine gas feeders (chlorinators). **Table 3-7** provides a summary of design information.

Table 3-7: Chlorination Design Information and Tennessee Design Standards

Operating Conditions	Detention Time (minutes)	
	Actual	Tennessee Design Standards
Average Flow, 10.8 mgd	49	30
Peak Day Flow, 24 mgd	22	15

Dechlorination is accomplished by the injection of sodium bisulfite (NaHSO3) solution into the wastewater at the effluent end of Chlorine Contact Basin No. 2. Dechlorination is performed to reduce the chlorine levels in the wastewater to below NPDES limits. Effluent from the dechlorination treatment is pumped to the Tennessee River using three 10.1 mgd pumps. Effluent can be discharged by gravity to the Tennessee River when it is at low level.

There is a hydraulic limitation at the second chlorine contact basin which causes flow to back up and flood the final clarifier effluent weirs. To avoid this situation the second chlorine contact basin must be bypassed for flows above 24 mgd.

Solids Processing

Solids processing and disposal is accomplished by utilizing the following treatment processes/equipment:

1. Gravity thickening of sludges from primary clarifiers and secondary treatment and scum from the secondary clarifiers and primary settling tanks.

2. Pump to gravity sewer leading to KWWTP.

Table 3-8 summarizes the sludge handling and disposal processes and equipment.

Table 3-8: Summary of Gravity Thickener Design Information and Tennessee Design Standards

	Average Flow (10.8 mgd)	Tennessee Design Standards
Solids Loading, lbs/day/ft^2	30	20 to 30
Hydraulic Loading, gpd/ft^2	657	500 to 800

TDEC Reliability Criteria

For components included in the design of Reliability Class I works, the following backup requirements apply.

- **Mechanically Cleaned Bar Screens or Equivalent Devices** - A backup bar screen shall be provided. It is permissible for the backup bar screen to be designed for manual cleaning only. Works with only two bar screens shall have at least one bar screen designed to permit manual cleaning.

- **Pumps** - A backup pump shall be provided for each set of pumps which performs the same function. The capacity of the pumps shall be such that, with any one pump out of service, the remaining pumps will have the capacity to handle the peak flow. It is permissible for one pump to serve as backup to more than one set of pumps.

- **Primary Sedimentation Basins** - There shall be a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a design flow capacity of at least 50 percent of the total design flow to that unit operation.

- **Final and Chemical Sedimentation Basins, Trickling Filters, Filters, and Activated Carbon Columns** - There shall be a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a design flow capacity of at least 75 percent of the total design flow to that unit operation.

- **Activated Sludge Process Components** -

  Aeration Basin - A backup basin shall not be required; however, at least two equal volume basins shall be provided. (For the purpose of this criterion, the two zones of a contact stabilization process are considered as only one basin.)

  Aeration Blowers or Mechanical Aerators - There shall be a sufficient number of blowers or mechanical aerators to enable the design oxygen transfer to be maintained with the largest capacity unit out of service. It is permissible for the backup unit to be an uninstalled unit, provided that the installed unit can be easily removed and replaced. However, at least two units shall be installed.

- **Disinfectant Contact Basins** - There shall be a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a design flow capacity of at least 50 percent of the total design flow to that unit operation

The installed facilities at the FCWWTP meet Reliability Class I Requirements. The capacity of the pump stations and biological treatment system are addressed in later sections of this report.

3.5 WWTP Data Analysis and Performance Summary

3.5.1 Influent Flows and Loadings

Influent Flow Rates

From the years 2002-2005, the daily average influent flow rate to FCWWTP was 6.95 mgd, the average daily maximum influent flow rate was 11.35 mgd, and the average daily minimum influent flow rate was 3.86 mgd.

The maximum daily average influent flow rate during this period was reported to be 39.8 mgd. The maximum instantaneous influent flow rate from 2002 through 2005 has been recorded at 50 mgd. However, it is likely that these high flow rates were due to the flow back-up in the raw wastewater flume causing the flow rates to not be recorded properly. These values exceed influent pumping capacity.

0001516

Table 3-9 shows the average daily flow rate, the maximum daily flow rate, the average weekly flow rate, maximum weekly flow rate, average monthly flow rate, and maximum monthly flow rate for the years 2002 through 2005. Table 3-9 presents this data for the entire period, as well as broken down by calendar year.

Table 3-9: Summary of Fourth Creek WWTP Average Flow Rates

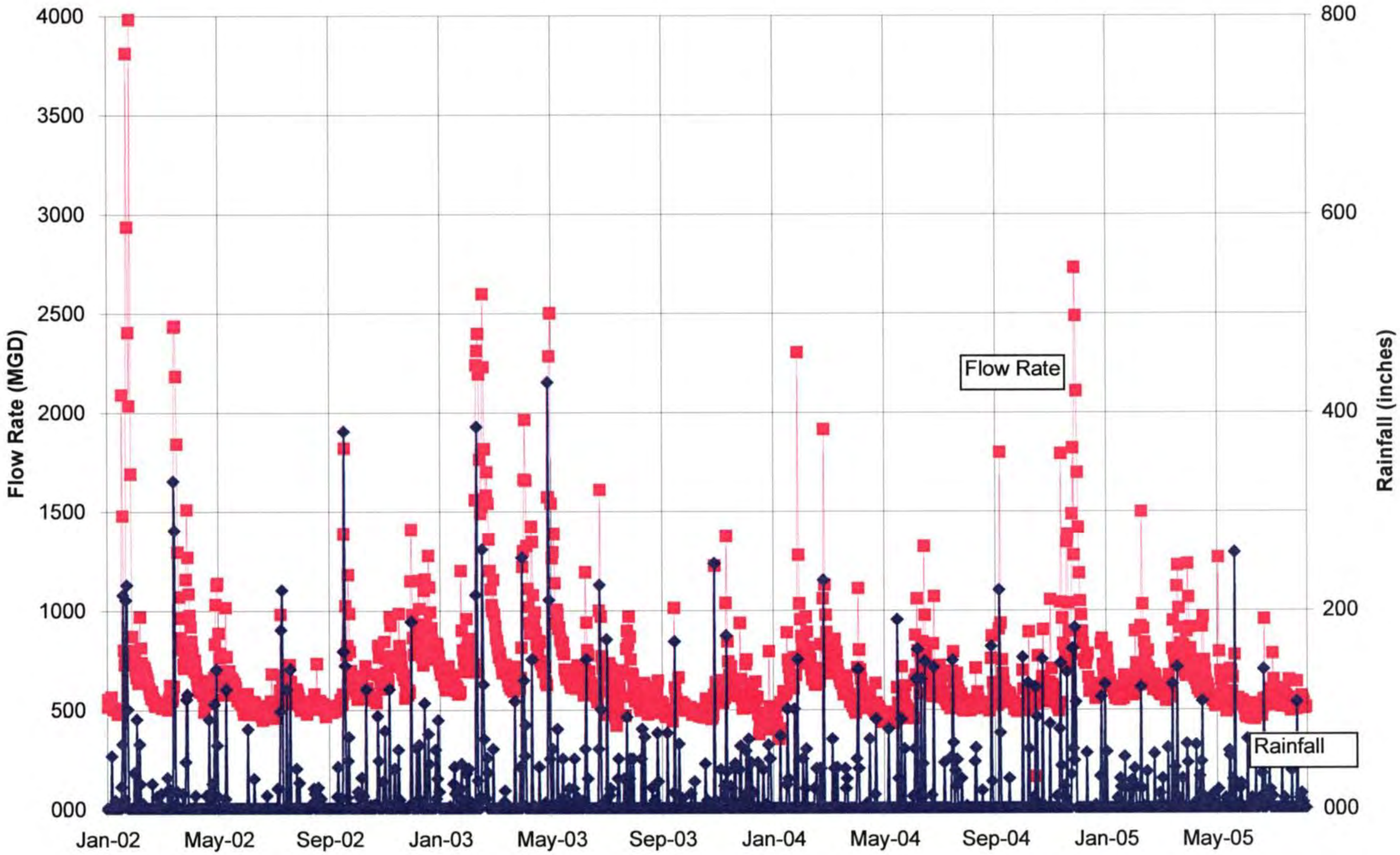
Data Period (Year)	Average Daily Flow Rate (mgd)	Maximum Daily Flow Rate (mgd)	Average Weekly Flow Rate (mgd)	Maximum Weekly Flow Rate (mgd)	Average Monthly Flow Rate (mgd)	Maximum Monthly Flow Rate (mgd)
2002	7.13	39.78	7.14	25.28	7.03	12.15
2003	7.47	25.93	7.50	20.35	7.63	14.22
2004	6.68	27.25	6.66	19.39	6.53	12.00
2005[1]	6.30	14.94	6.31	9.56	6.51	10.52
2002 - 2005	6.95	39.78	6.96	25.28	6.69	14.22

[1] 2005 data includes January - July

Figure 3-2, Figure 3-3, and Figure 3-4 graphically show the daily average, weekly moving average, and monthly moving average flow rates. As can be seen in these figures, flow rates are directly proportional to rainfall amounts, indicating infiltration and inflow in the collection system.

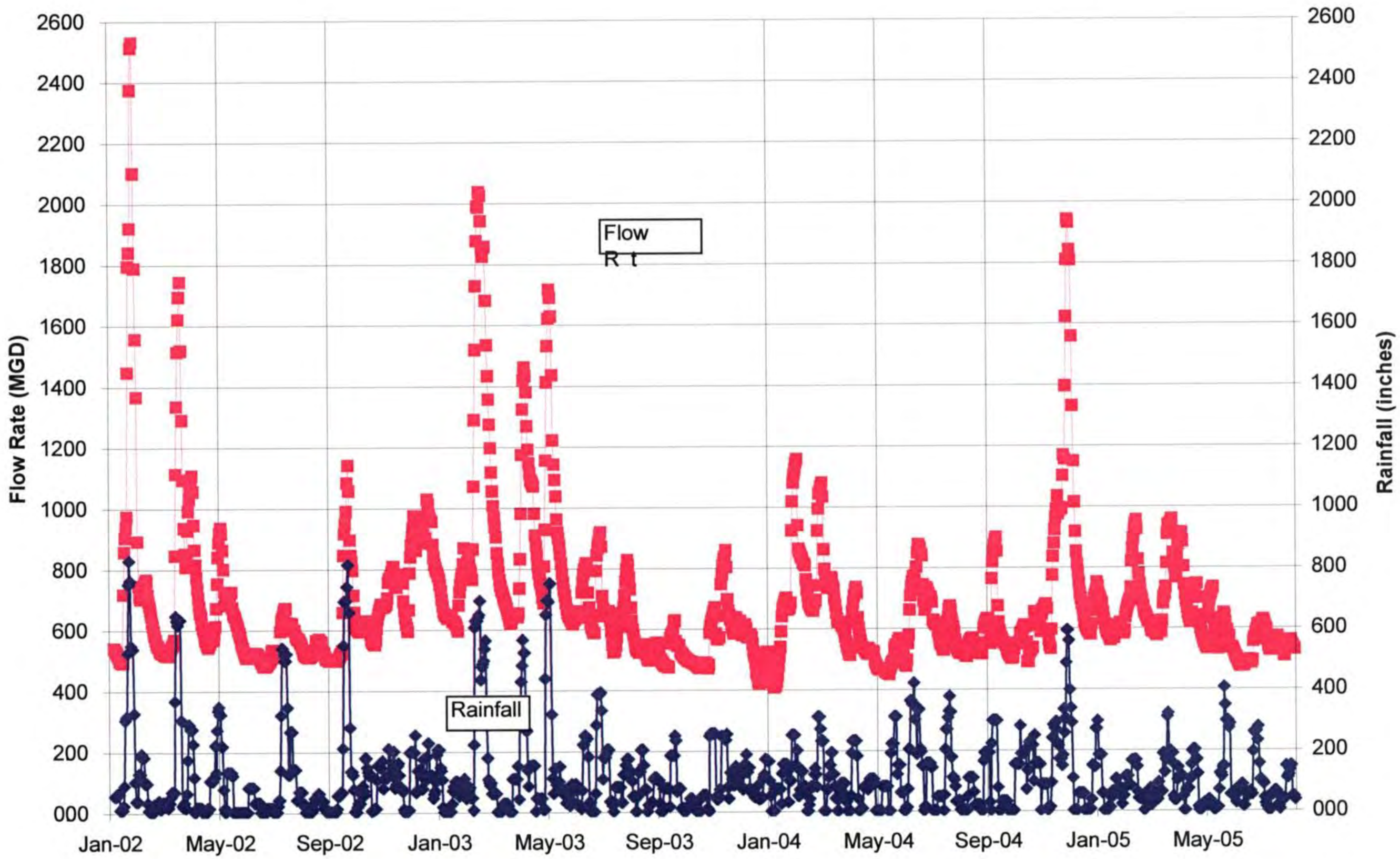
Influent Pollutant Loadings – Five Day Biochemical Oxygen Demand (BOD_5)
From the years 2002-2005, the daily average influent BOD_5 concentration at the FCWWTP was 187 mg/L, the daily maximum influent BOD_5 concentration was 750 mg/L, and the daily minimum influent BOD_5 concentration was 30 mg/L.

FIGURE 3-2: 1-Day Average Flow and Single Day Rainfall Data



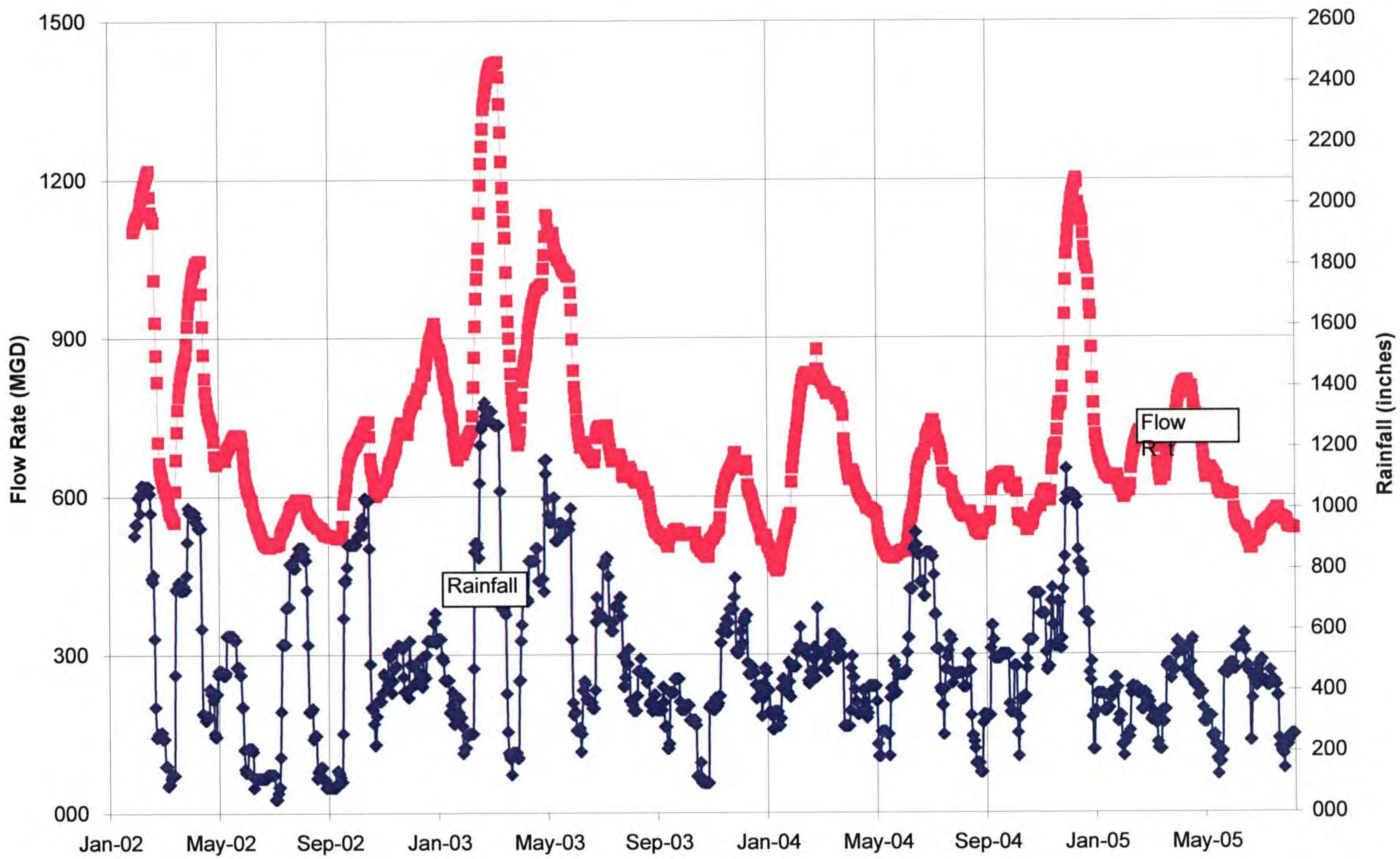
0001518

FIGURE 3-3: 7-Day Average Flow and 7-Day Cumulative Rainfall Data



00001519

FIGURE 3-4: 30-Day Average Flow and 30-Day Cumulative Rainfall Data



0001520

Table 3-10 shows the average daily BOD_5 concentration, the maximum daily BOD_5 concentration, the average weekly BOD_5 concentration, maximum weekly BOD_5 concentration, average monthly BOD_5 concentration, and maximum monthly BOD_5 concentration for the years 2002 through 2005. Table 3-10 presents this data for the entire three year period, as well as broken down by calendar year. **Table 3-11** presents the BOD_5 loading data in pounds per day.

Table 3-10: Summary of Fourth Creek WWTP Average Influent BOD_5 Concentrations

Data Period (Year)	Average Daily BOD_5 Concentration (mg/L)	Maximum Daily BOD_5 Concentration (mg/L)	Average Weekly BOD_5 Concentration (mg/L)	Maximum Weekly BOD_5 Concentration (mg/L)	Average Monthly BOD_5 Concentration (mg/L)	Maximum Monthly BOD_5 Concentration (mg/L)
2002	193	450	192	281	193	249
2003	176	520	175	350	176	245
2004	187	750	187	312	188	236
2005[1]	193	510	193	330	186	285
2002 - 2005	187	750	186	350	185	285

[1] 2005 data includes January – July

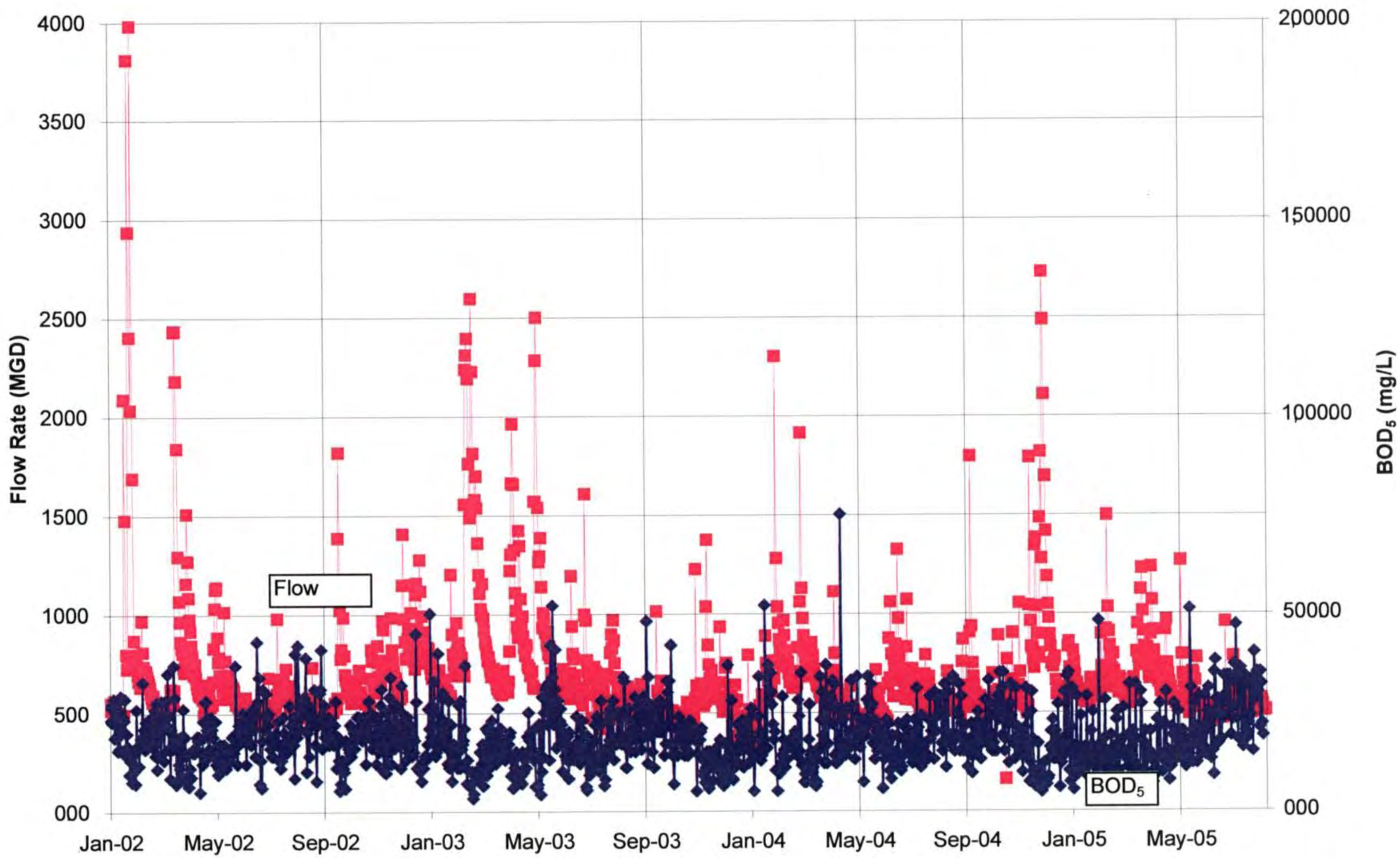
Table 3-11: Summary of Fourth Creek WWTP Average Influent BOD_5 Loadings

Data Period (Year)	Average Daily BOD_5 Loading (lbs/day)	Maximum Daily BOD_5 Loading (lbs/day)	Average Weekly BOD_5 Loading (lbs/day)	Maximum Weekly BOD_5 Loading (lbs/day)	Average Monthly BOD_5 Loading (lbs/day)	Maximum Monthly BOD_5 Loading (lbs/day)
2002	10,700	49,700	10,900	26,800	11,100	17,600
2003	10,000	32,200	10,300	22,900	10,800	19,800
2004	9,800	34,000	9,900	18,100	9,900	13,600
2005[1]	9,800	25,200	9,800	15,600	9,800	13,400
2002 - 2005	10,100	49,700	10,300	26,800	10,500	19,800

[1] 2005 data includes January - August

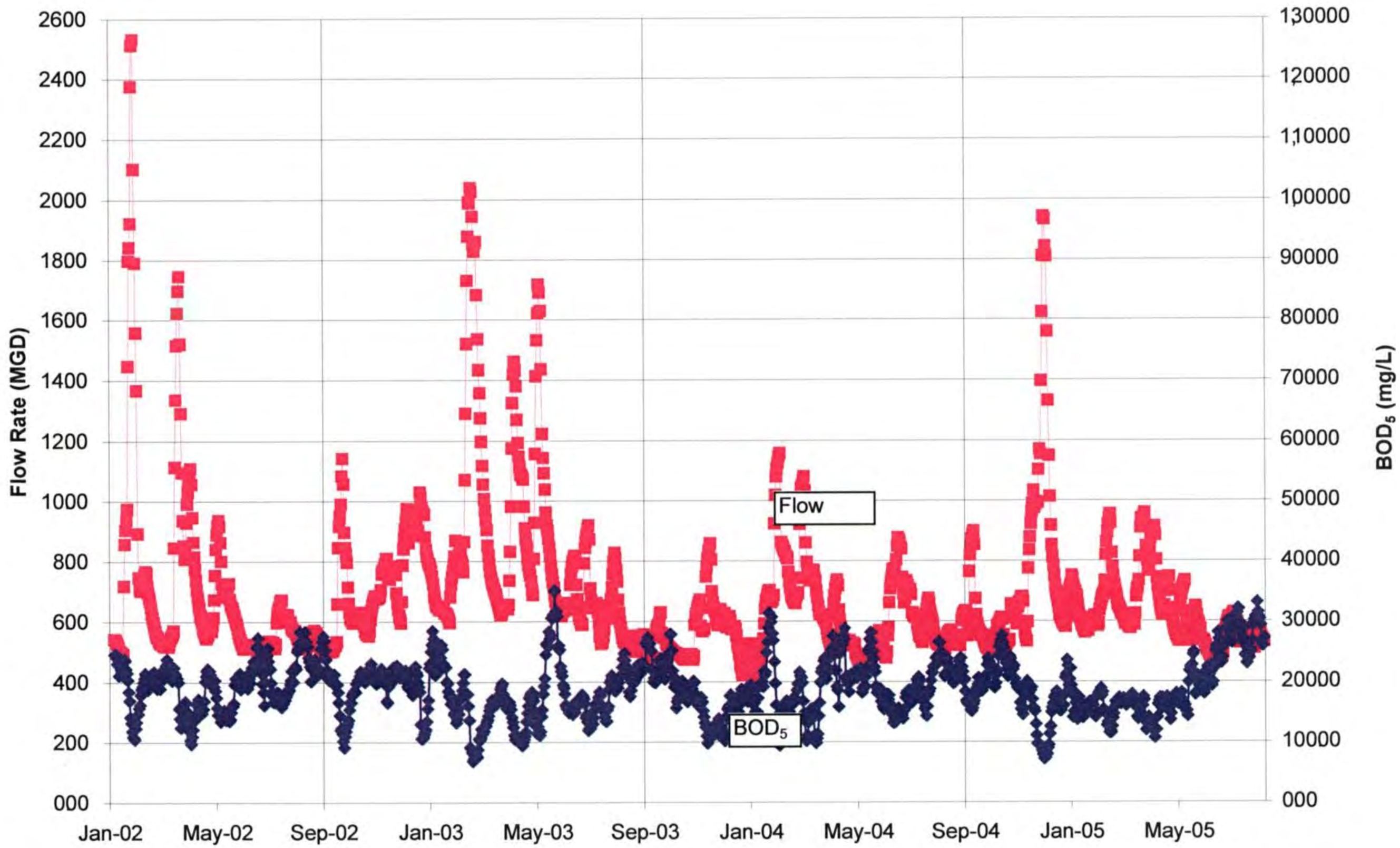
Figure 3-5, Figure 3-6, and Figure 3-7 graphically show the daily average, weekly moving average, and monthly moving average BOD_5 concentration. As can be seen in these figures, BOD_5 concentrations are generally inversely proportional to influent flow rates, indicating storm water and groundwater infiltration and inflow in the collection system.

FIGURE 3-5: 1-Day Average Flow and BOD_5 Data



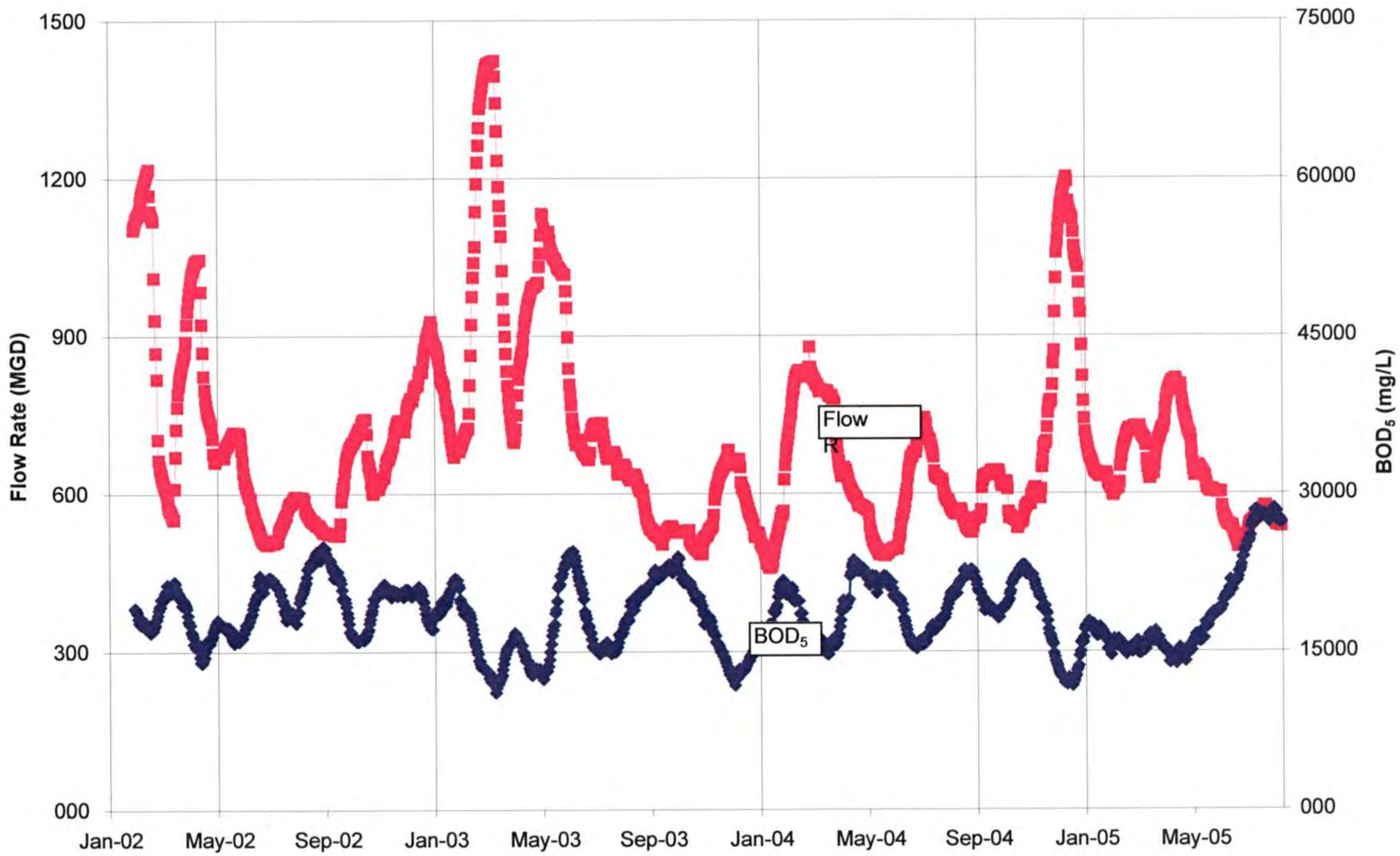
0001522

FIGURE 3-6: 7-Day Average Flow and 7-Day Average BOD_5 Data



0001523

FIGURE 3-7: 30-Day Average Flow and 30-Day Average BOD_5 Data



0001524

Influent Pollutant Loadings - Total Suspended Solids (TSS)
From the years 2002-2005, the daily average influent TSS concentration at the FCWWTP was 219 mg/L, the daily maximum influent TSS concentration was 1,440 mg/L, and the daily minimum influent TSS concentration was 20 mg/L.

Table 3-12 shows the average daily TSS concentration, the maximum daily TSS concentration, the average weekly TSS concentration, maximum weekly TSS concentration, average monthly TSS concentration, and maximum monthly TSS concentration for the years 2002 through 2005. Table 3-12 presents this data for the entire period, as well as broken down by calendar year. **Table 3-13** presents the TSS loading data in pounds per day.

Table 3-12: Summary of Fourth Creek WWTP Average Influent TSS Concentrations

Data Period (Year)	Average Daily TSS Concentration (mg/L)	Maximum Daily TSS Concentration (mg/L)	Average Weekly TSS Concentration (mg/L)	Maximum Weekly TSS Concentration (mg/L)	Average Monthly TSS Concentration (mg/L)	Maximum Monthly TSS Concentration (mg/L)
2002	228	1,080	228	439	230	332
2003	192	1,440	193	586	194	402
2004	223	1,000	222	444	222	375
2005[1]	240	930	239	527	228	441
2002 - 2005	219	1,440	219	586	217	441

[1] 2005 data includes January - July

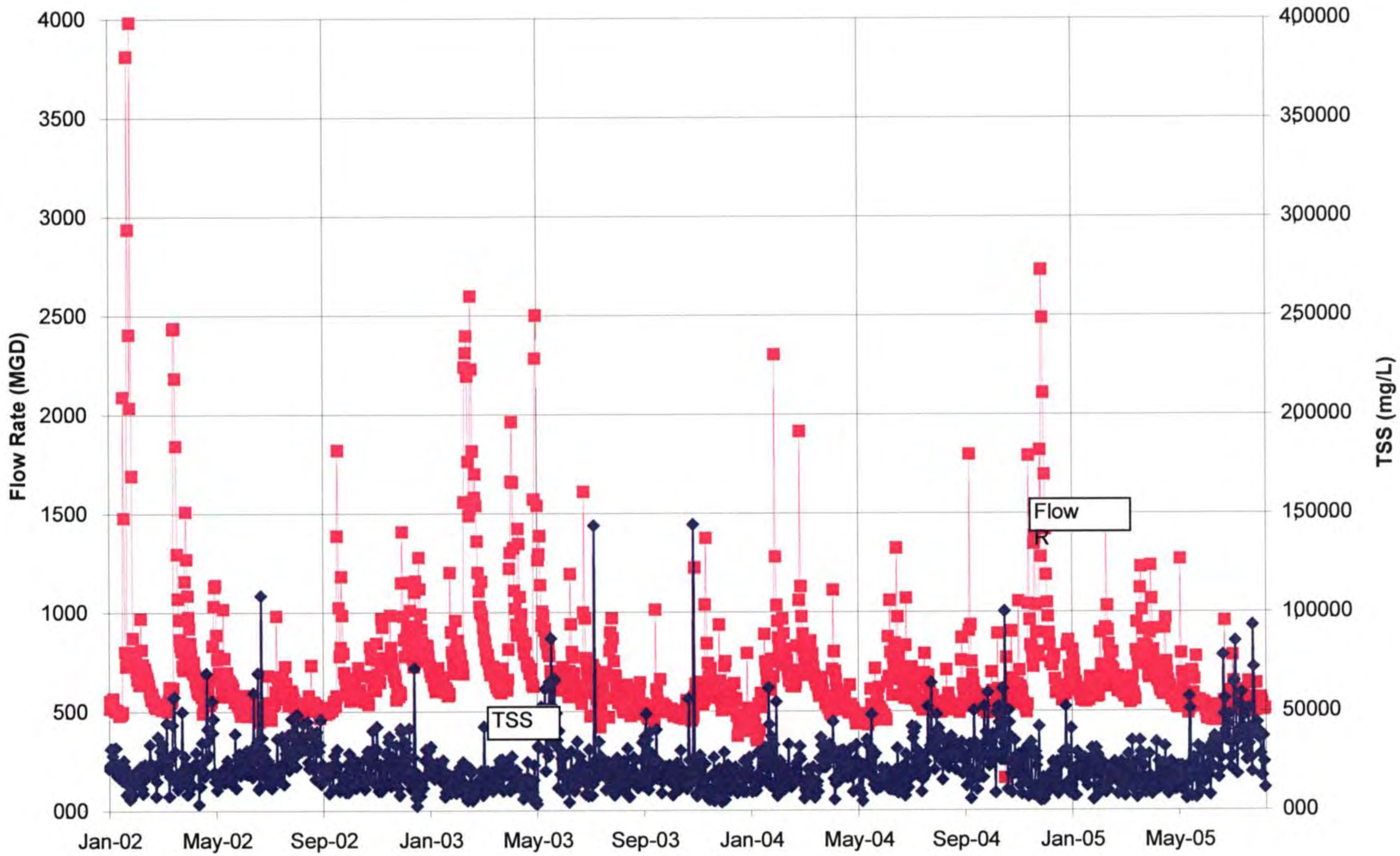
Table 3-13: Summary of Fourth Creek WWTP Average Influent TSS Loadings

Data Period (Year)	Average Daily TSS Loading (lbs/day)	Maximum Daily TSS Loading (lbs/day)	Average Weekly TSS Loading (lbs/day)	Maximum Weekly TSS Loading (lbs/day)	Average Monthly TSS Loading (lbs/day)	Maximum Monthly TSS Loading (lbs/day)
2002	12,900	115,400	13,000	43,300	13,100	19,700
2003	11,500	84,700	11,700	42,600	12,100	32,700
2004	11,700	58,000	11,800	23,300	11,800	17,000
2005[1]	12,100	44,500	12,200	23,800	11,900	20,600
2002 - 2005	12,000	115,400	12,100	43,300	12,300	32,700

[1] 2005 data includes January - July

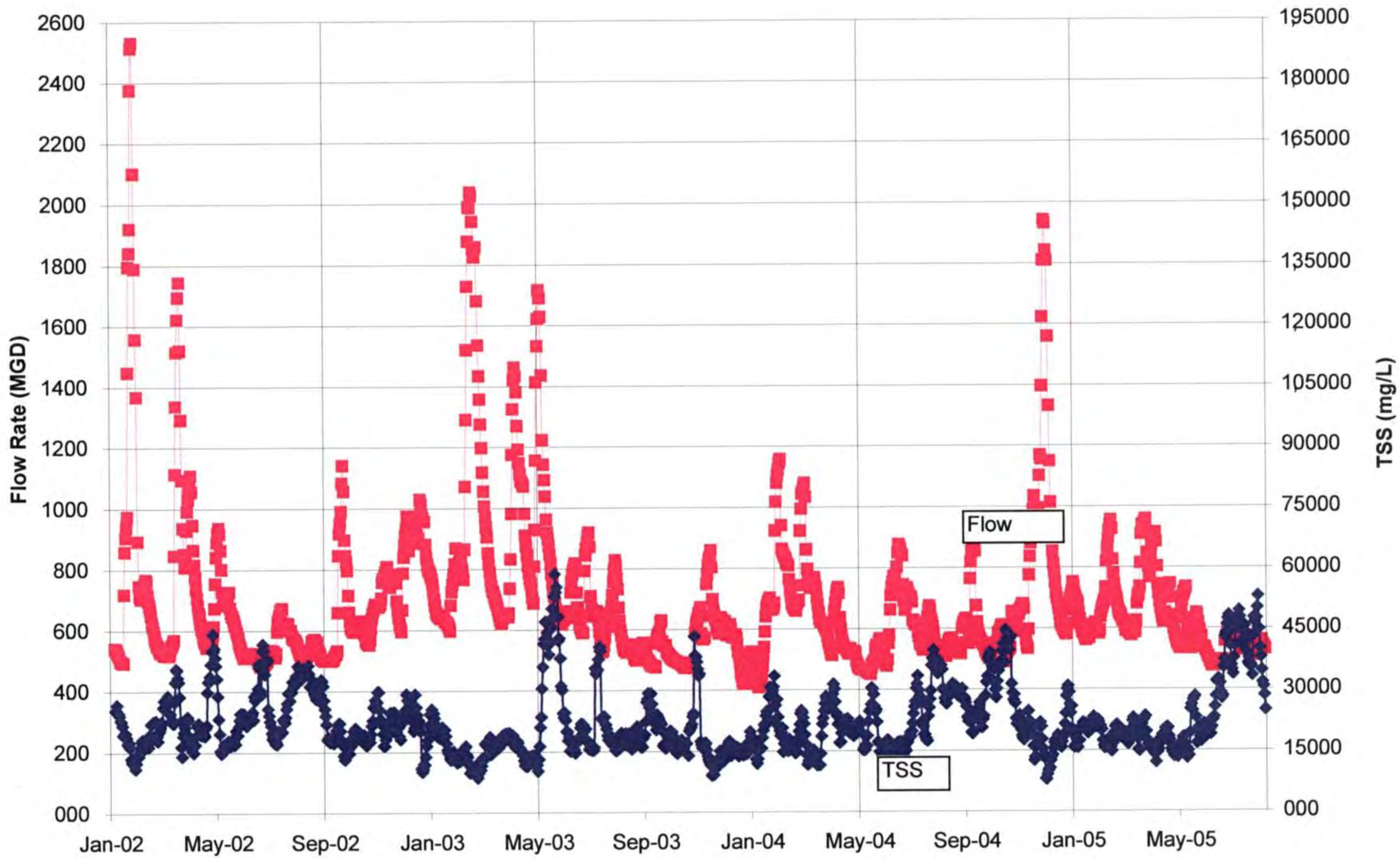
Figure 3-8, Figure 3-9, and Figure 3-10 graphically show the daily average, weekly moving average, and monthly moving average TSS concentration. As can be seen in these figures, TSS concentrations are generally inversely proportional to influent flow rates, indicating storm water and groundwater infiltration and inflow in the collection system.

FIGURE 3-8: 1-Day Average Flow and Total Suspended Solids (TSS) Data



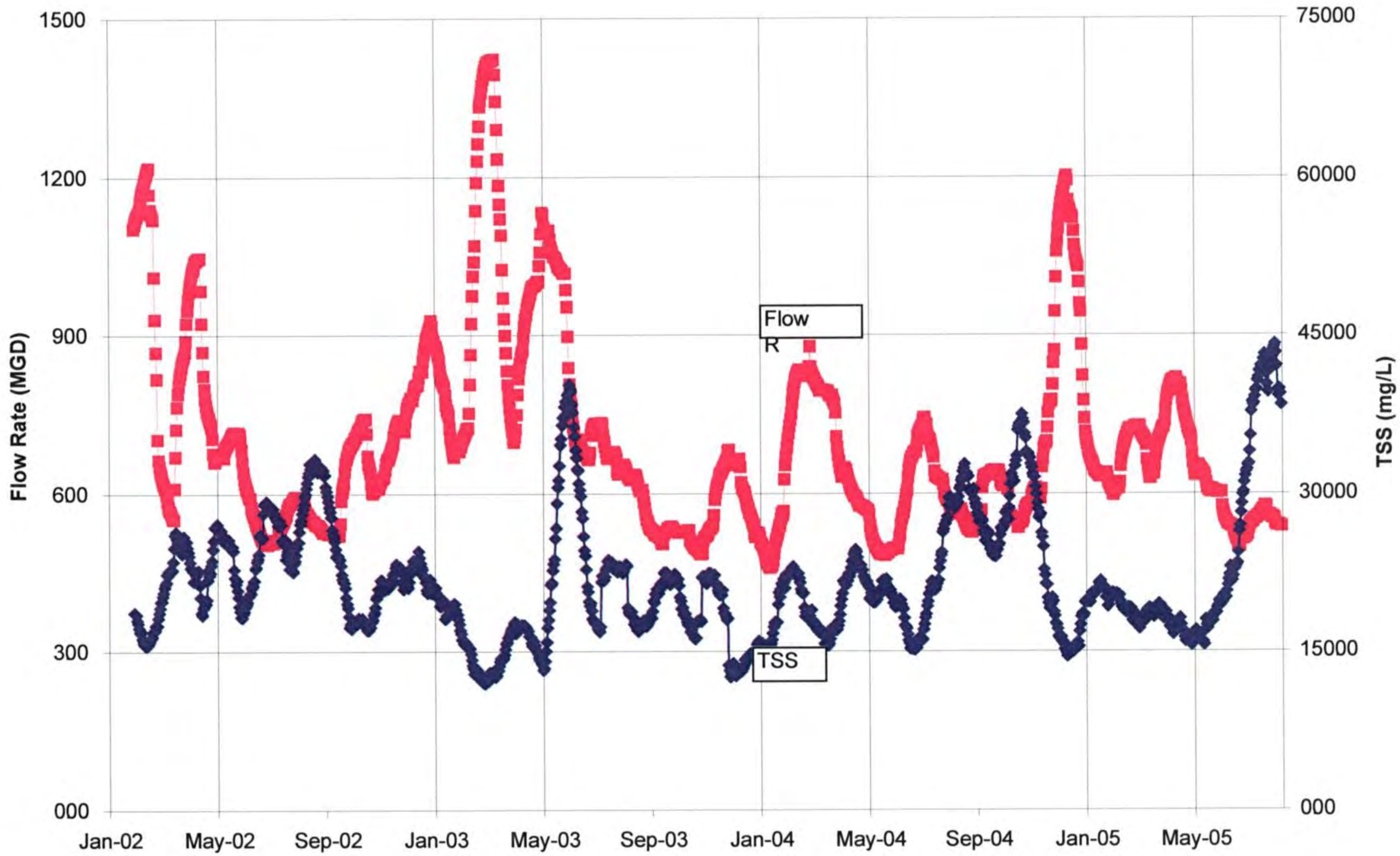
00001526

FIGURE 3-9: 7-Day Average Flow and 7-Day Average Total Suspended Solids (TSS) Data



00015227

FIGURE 3-10: 30-Day Average Flow and 30-Day Average Total Suspended Solids (TSS) Data



0001528

Influent Pollutant Loadings - Ammonia as Nitrogen (NH_3- N)

From the years 2002-2005 the daily average influent NH_3-N concentration at the Fourth Creek WWTP was 13.3 mg/L, the daily maximum influent NH_3-N concentration was 28.7 mg/L, and the daily minimum influent NH_3-N concentration was 0.6 mg/L.

Table 3-14 shows the average daily NH_3-N concentration, the maximum daily NH_3-N concentration, the average weekly NH_3-N concentration, maximum weekly NH_3-N concentration, average monthly NH_3-N concentration, and maximum monthly NH_3-N concentration for the years 2002 through 2005. Table 3-14 presents this data for the entire period, as well as broken down by calendar year. **Table 3-15** presents the NH_3-N loading data in pounds per day.

Table 3-14: Summary of Fourth Creek WWTP Average Influent NH_3-N Concentrations

Data Period (Year)	Average Daily NH_3-N Concentration (mg/L)	Maximum Daily NH_3-N Concentration (mg/L)	Average Weekly NH_3-N Concentration (mg/L)	Maximum Weekly NH_3-N Concentration (mg/L)	Average Monthly NH_3-N Concentration (mg/L)	Maximum Monthly NH_3-N Concentration (mg/L)
2002	12.3	22.4	12.4	19.4	12.3	15.8
2003	11.7	23.6	11.8	22.1	11.6	19.9
2004	15.1	44.0	15.2	24.7	15.4	19.6
2005[1]	14.5	35.0	14.4	22.6	14.0	18.3
2002 - 2005	13.3	44.0	13.3	24.7	13.3	19.9

[1] 2005 data includes January – July

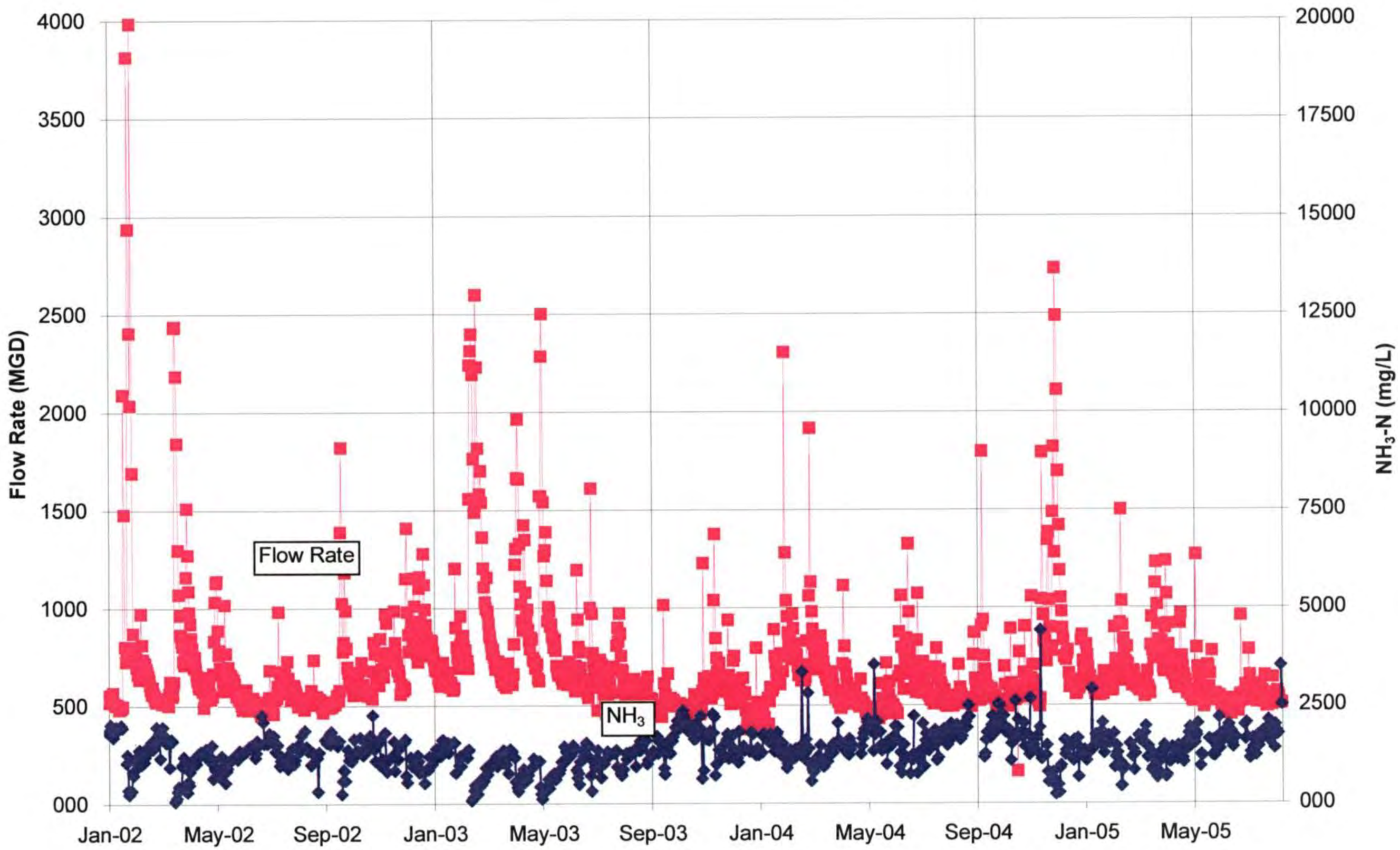
Table 3-15: Summary of Fourth Creek WWTP Average Influent NH_3-N Loadings

Data Period (Year)	Average Daily NH_3-N Loading (lbs/day)	Maximum Daily NH_3-N Loading (lbs/day)	Average Weekly NH_3-N Loading (lbs/day)	Maximum Weekly NH_3-N Loading (lbs/day)	Average Monthly NH_3-N Loading (lbs/day)	Maximum Monthly NH_3-N Loading (lbs/day)
2002	650	1,110	680	1,460	700	1,290
2003	640	1,890	650	1,140	680	900
2004	770	1,940	790	1,900	810	1,130
2005[1]	730	1,870	740	1,020	750	880
2002 - 2005	690	1,940	710	1,900	740	1,290

[1] 2005 data includes January – July

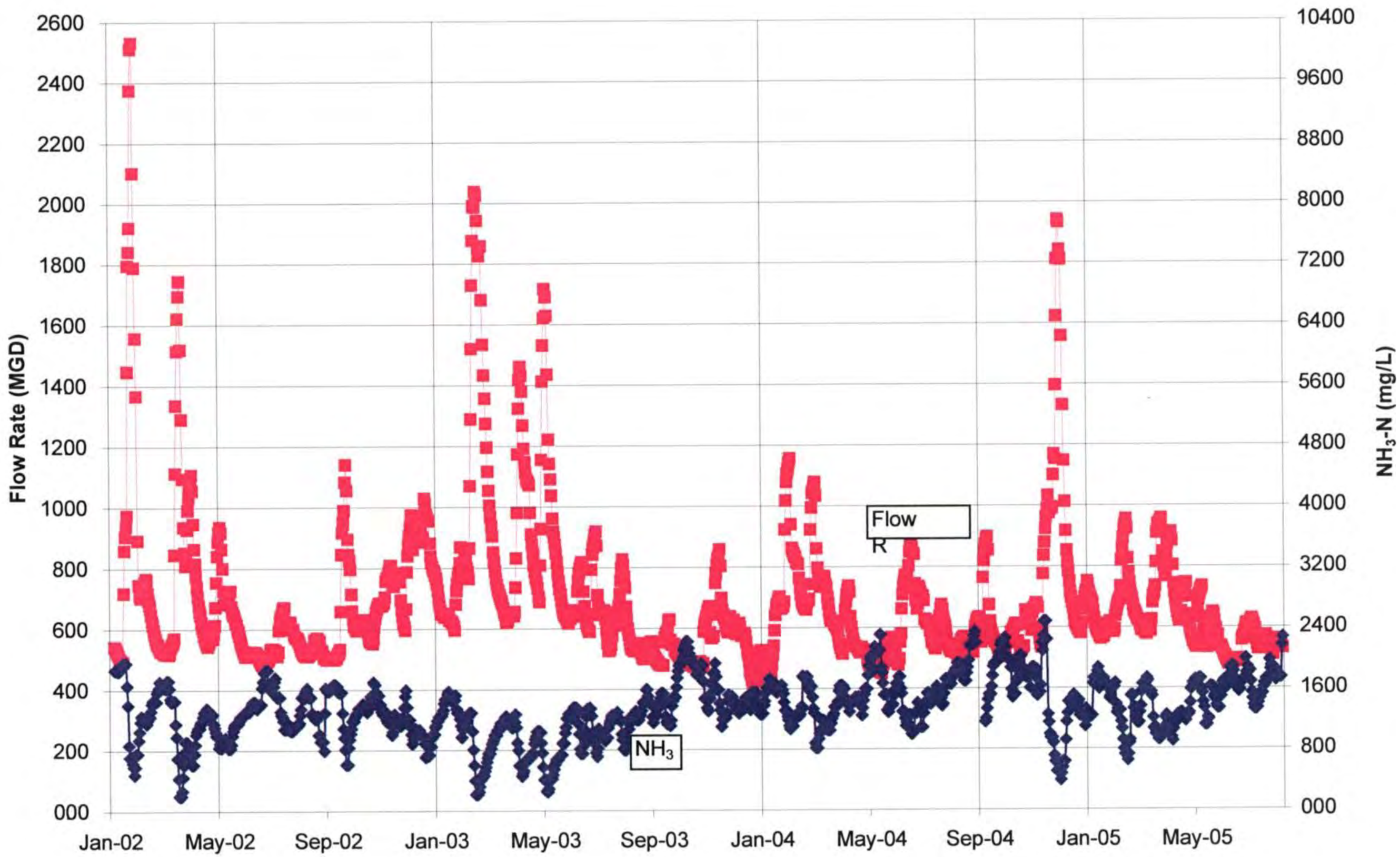
Figure 3-11, Figure 3-12, and Figure 3-13 graphically show the daily average, weekly moving average, and monthly moving average NH_3-N concentration. As can be seen in these figures, NH_3-N concentrations are generally inversely proportional to influent flow rates, indicating storm water and groundwater infiltration and inflow in the collection system.

FIGURE 3-11: 1-Day Average Flow and Ammonia (NH_3-N) Data



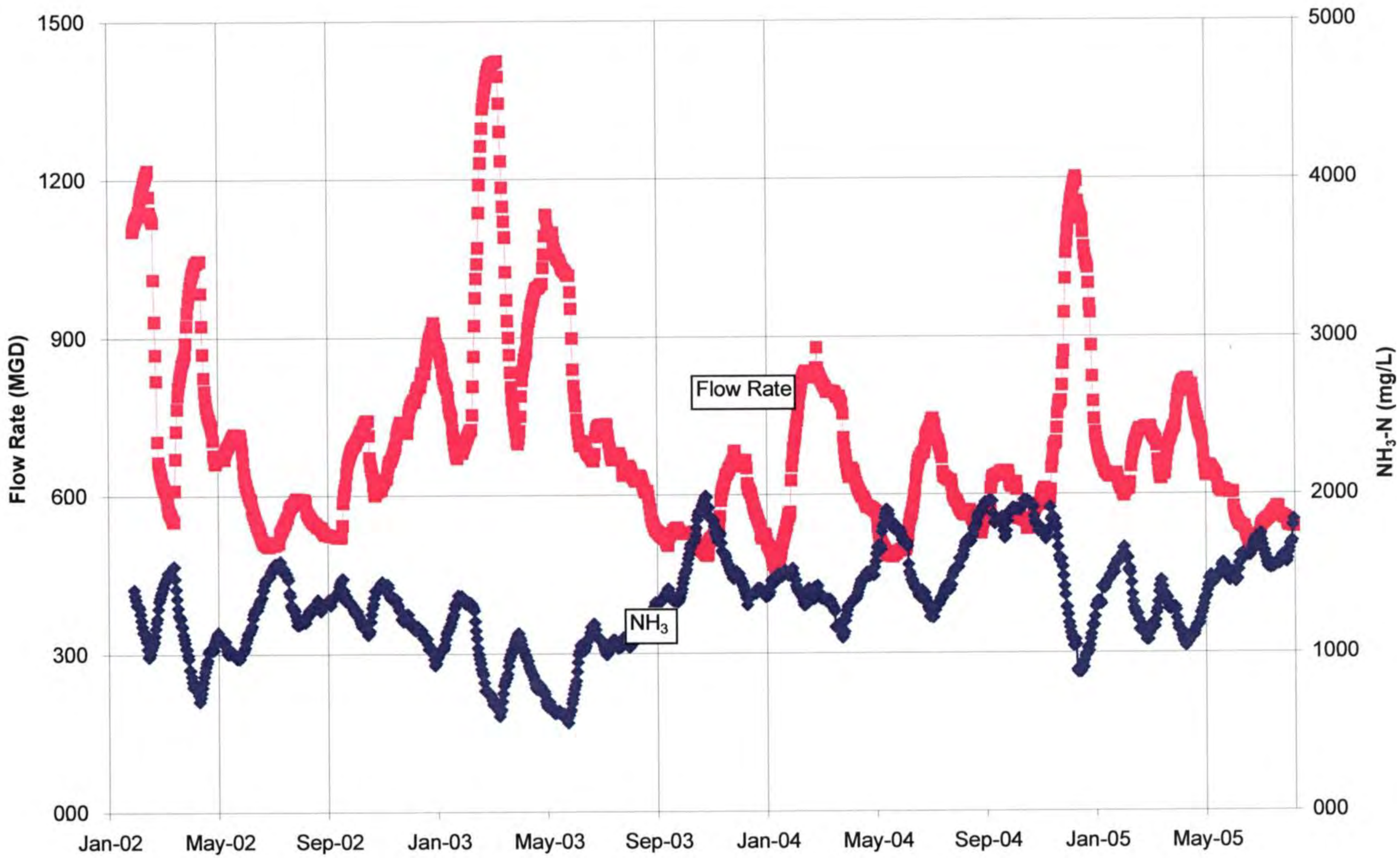
0001530

FIGURE 3-12: 7-Day Average Flow and 7-Day Average Ammonia as (NH_3-N) Data



0001531

FIGURE 3-13: 30-Day Average Flow and 30-Day Average Ammonia as (NH_3-N) Data



00001532

3.5.2 Effluent Flow Rates, Effluent Loadings, and NPDES Permit Compliance

Effluent Flow Rates

From the years 2002-2005, the daily average effluent flow rate from the Fourth Creek WWTP was 7.30 mgd. The maximum daily average effluent flow rate during this period was 29.20 mgd. Influent flows rates were used to determine FCWWTP influent loadings and effluent flow rates were used to determine effluent loadings for the purposes of this analysis.

Effluent BOD_5

The effluent limits imposed by the NPDES permit includes maximum BOD_5 concentrations of 45 mg/L (daily), 40 mg/L (weekly), and 30 mg/L (monthly). **Figures 3-14, 3-15, and 3-16** indicate compliance with these limits over the period January 2002 through August 2005, except for the Daily exceedances in January, February, and December 2003 which are indicated on Figure 3-14. Omitted from Figure 3-14 is the December 10, 2003 daily effluent BOD_5 exceedance of 280 mg/L and the resulting weekly BOD_5 exceedance. The December 2003 BOD_5 exceedance is accompanied by an effluent TSS exceedance (see below).

Effluent TSS

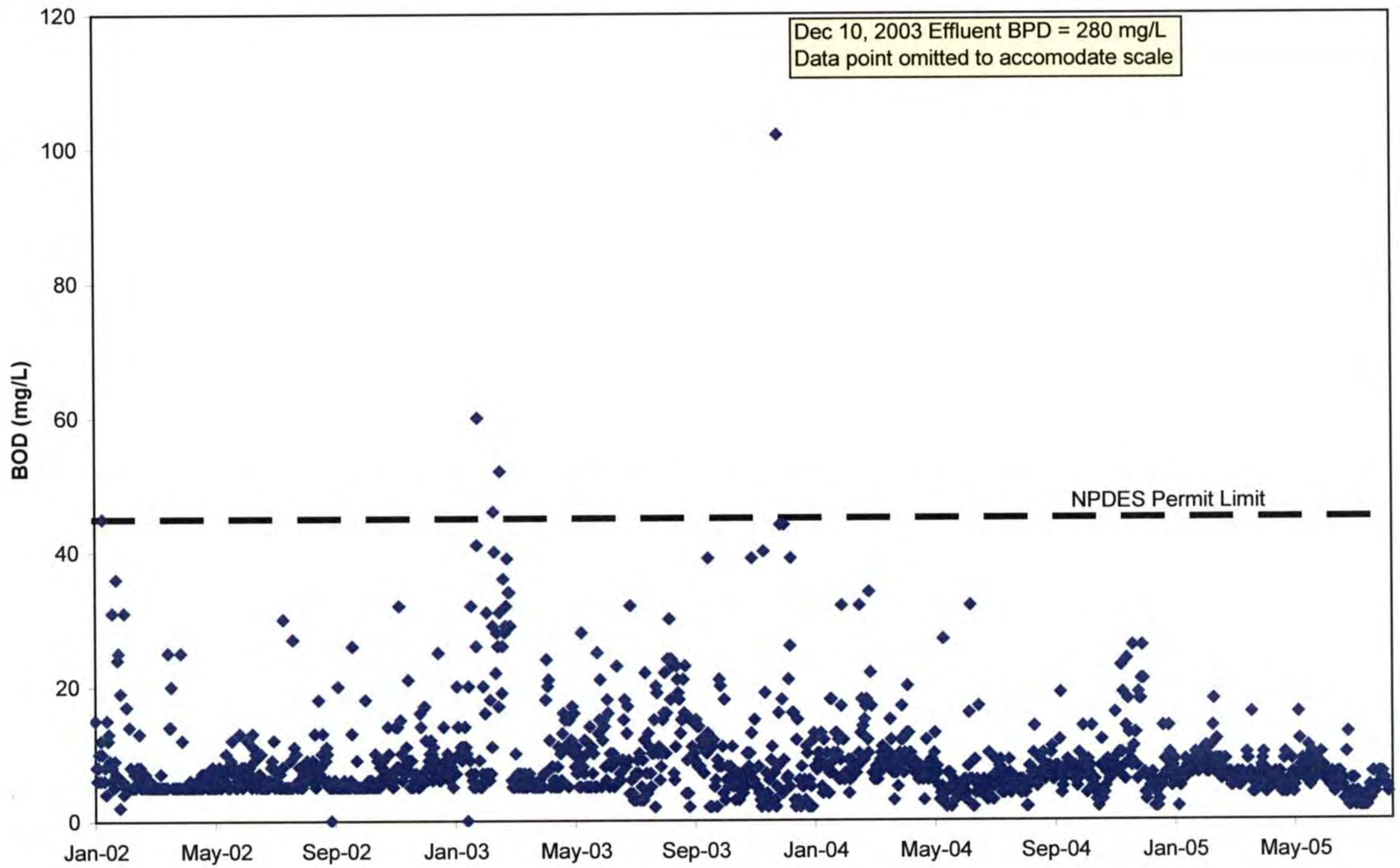
The effluent limits imposed by the NPDES permit includes maximum TSS concentrations of 45 mg/L (daily), 40 mg/L (weekly), and 30 mg/L (monthly). **Figures 3-17, 3-18, and 3-19** indicate compliance with these limits over the period January 2002 through August 2005, except for the infrequent exceedances of the daily and weekly permit limits are illustrated on Figures 3-17 and 3-18. On one occasion (December 10, 2003), the reported effluent TSS concentration was 890 mg/L due to a process upset (Nocardia and H. Hydrossis problem). This single point results in the December 2003 exceedance of the monthly average TSS effluent limit shown in Figure 3-19.

BOD_5 and TSS Removal Efficiency

In addition to maximum limits on the concentration of BOD_5 and TSS, the effluent from the FCWWTP must also meet minimum removal efficiencies for these two parameters. The minimum daily removal efficiency is 40 percent and the minimum monthly removal efficiency is 85 percent. Removal efficiency is calculated as 1 - influent concentration/effluent concentration.

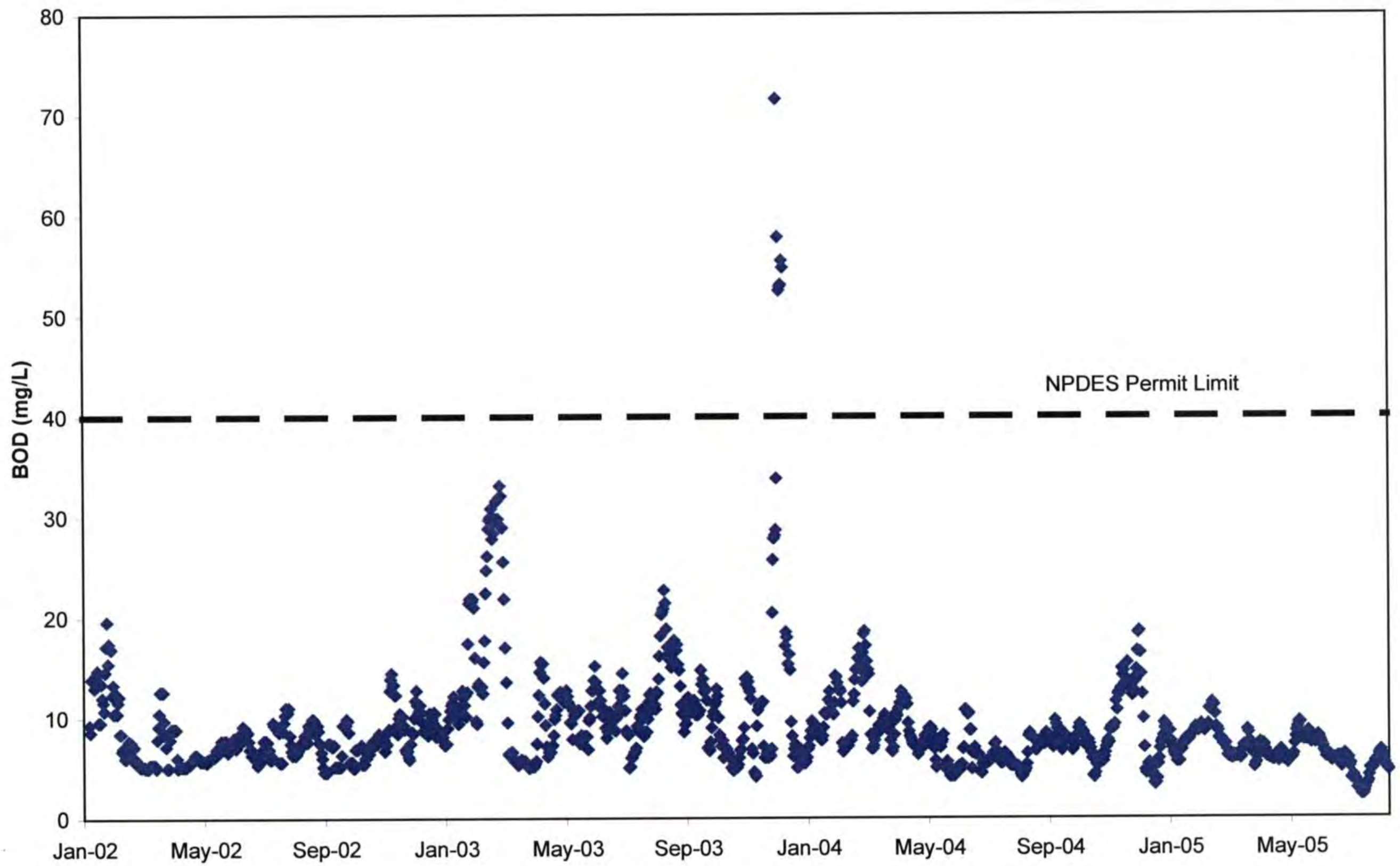
Figures 3-20 and 3-21 indicate compliance with the minimum removal efficiencies, except that on several occasions, the daily BOD_5 removal and/or TSS removal was below 40 percent. On three occasions, the monthly minimum removal efficiency of 85 percent was not achieved. The December 10, 2003 TSS removal data point is omitted from the graph.

FIGURE 3-14: Performance vs Daily BOD Effluent Limits



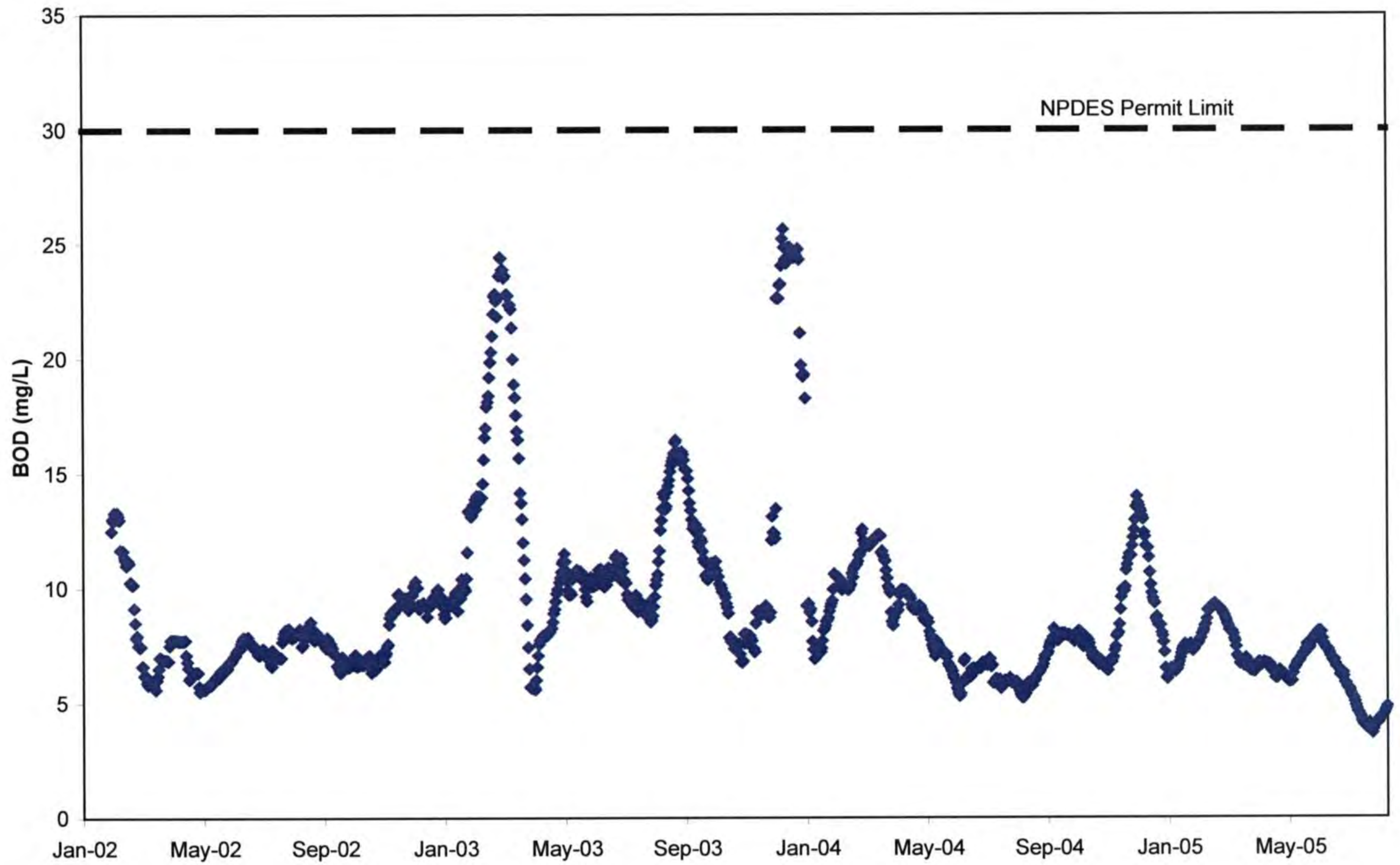
0001534

FIGURE 3-15: Performance vs Weekly BOD Effluent Limits



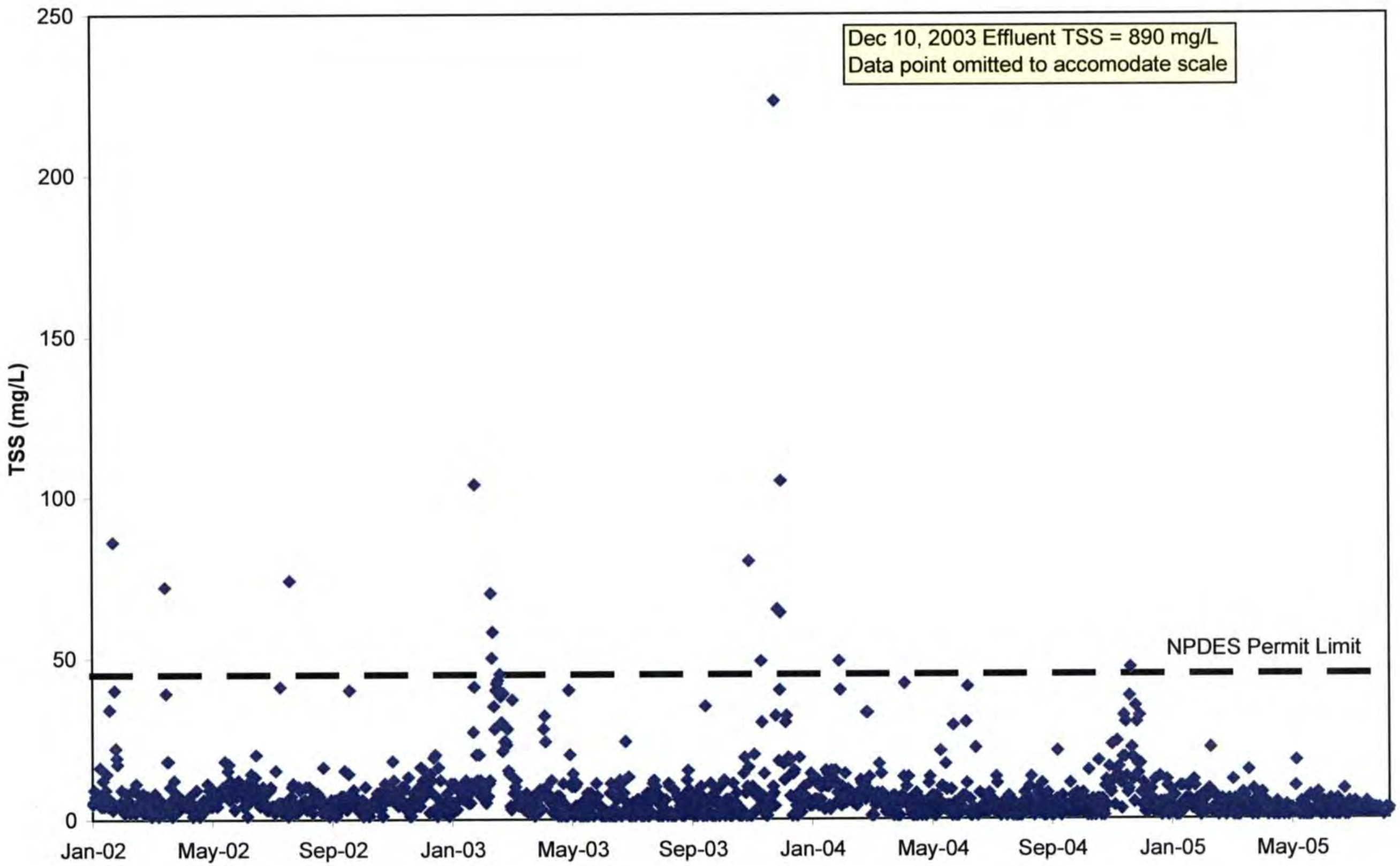
0001535

FIGURE 3-16: Performance vs Monthly BOD Effluent Limits



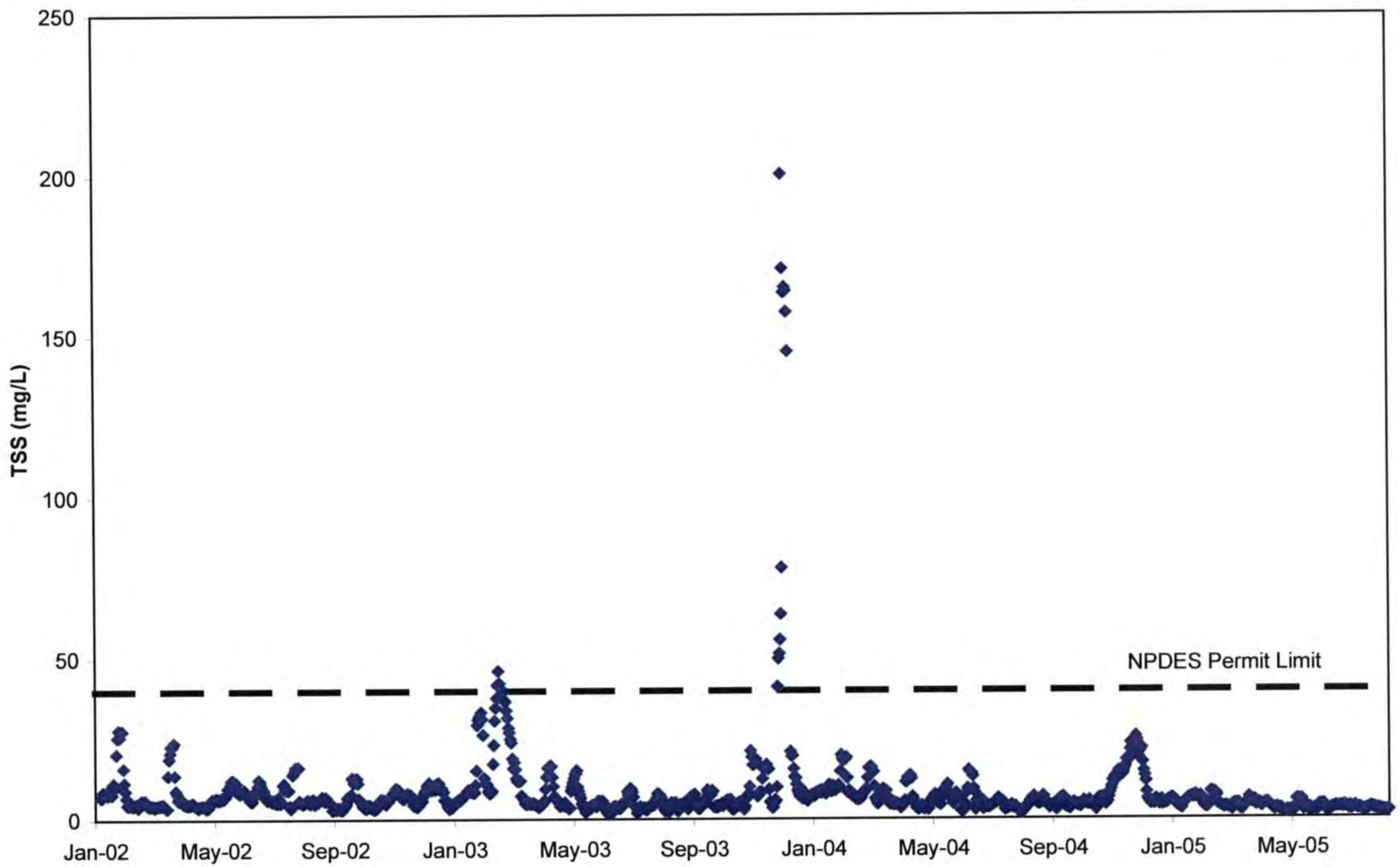
00001536

FIGURE 3-17: Performance vs Daily TSS Effluent Limits



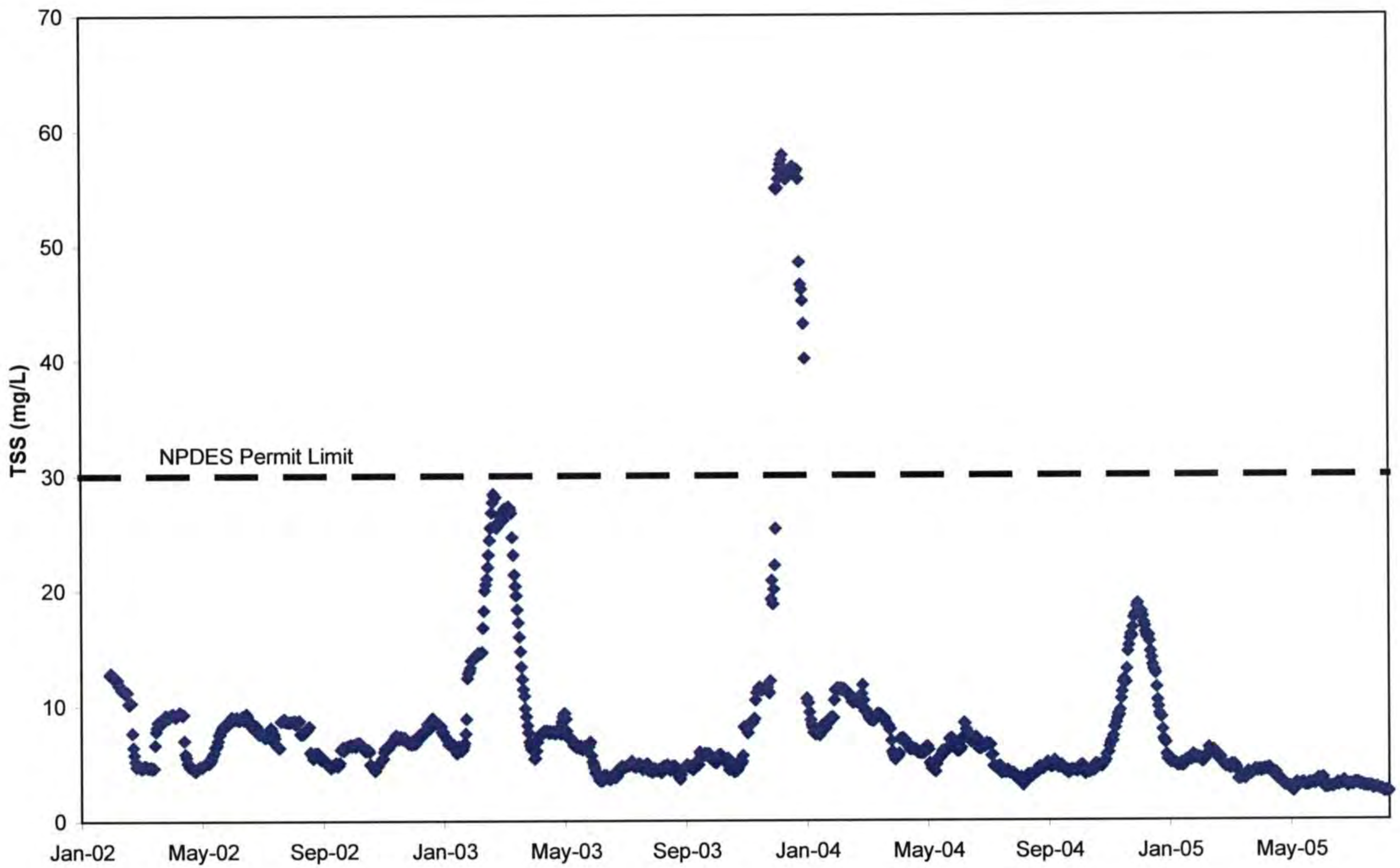
00015537

FIGURE 3-18: Performance vs Weekly TSS Effluent Limits



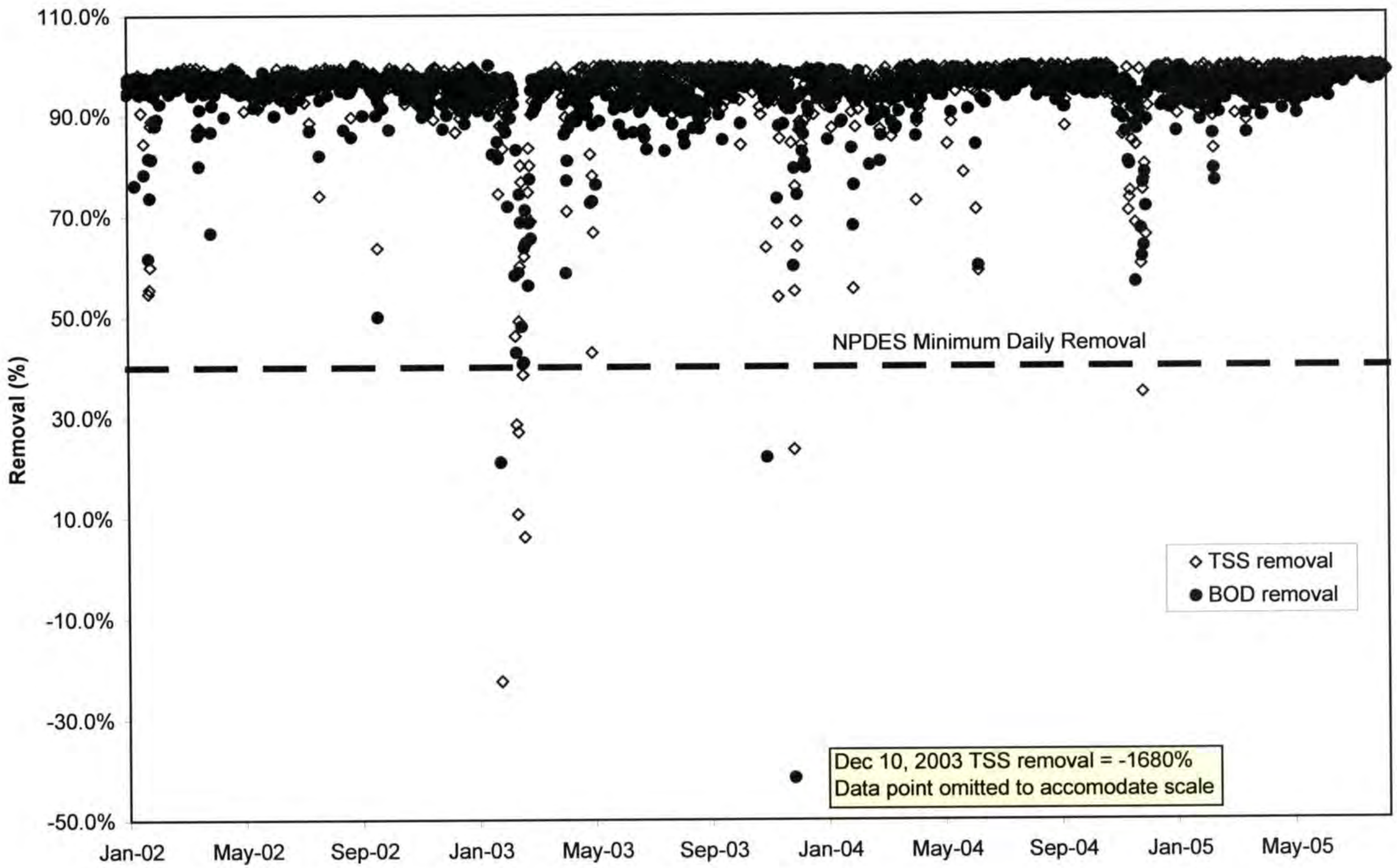
00001538

FIGURE 3-19: Performance vs Monthly TSS Effluent Limits



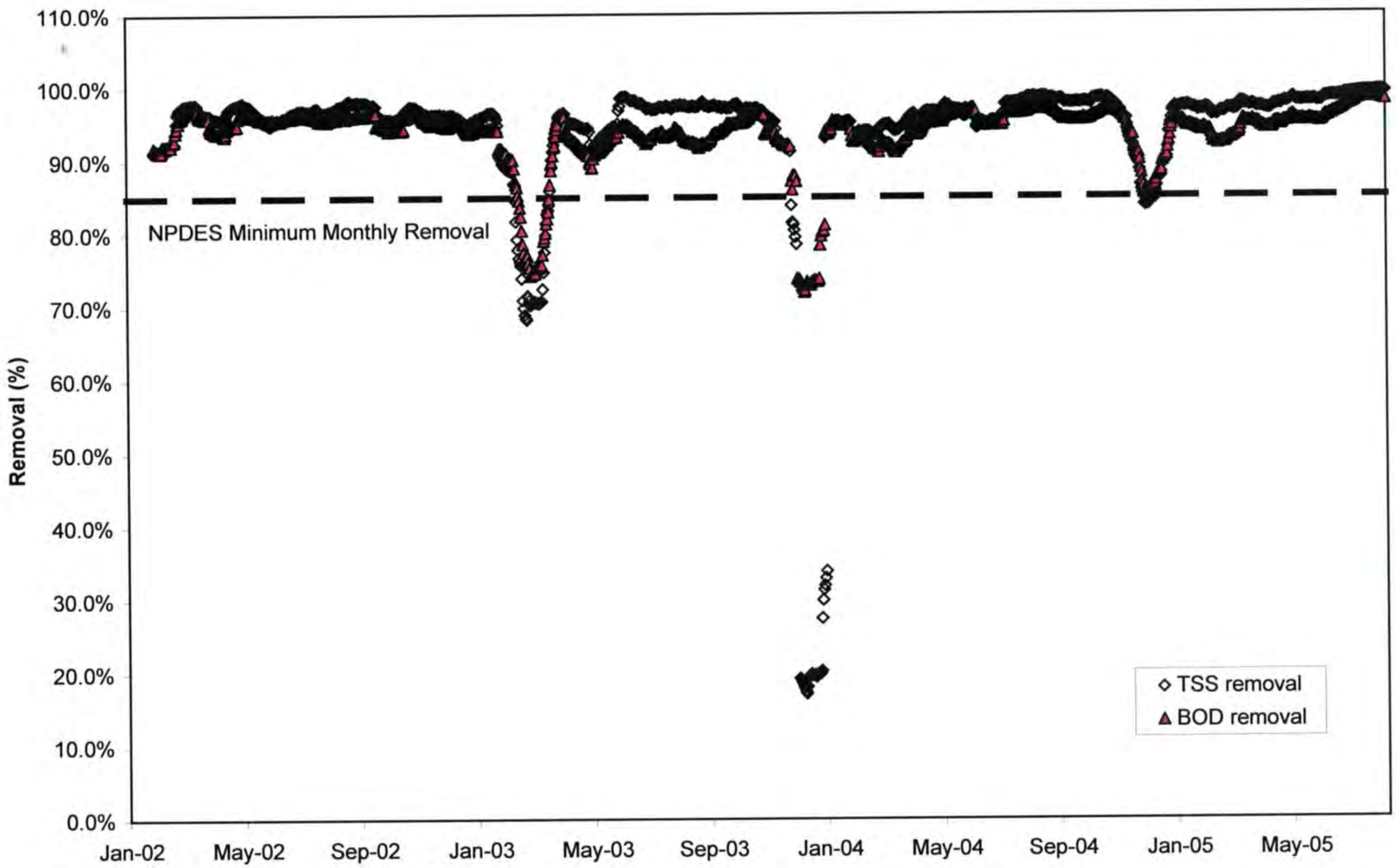
00001539

FIGURE 3-20: Performance vs Daily Minimum Removal Requirements



0001540

FIGURE 3-21: Performance vs Monthly Minimum Removal Requirements



0001541

Effluent Settleable Solids
The effluent limit imposed by the NPDES permit for settleable solids includes maximum daily volume of 1 mL/L. **Figure 3-22** indicates compliance with the permit limit; except that 8 exceedances are shown, including a settleable solids value of 250 ml/L on December 10, 2003 which resulted from a process upset described previously (under Effluent TSS).

Effluent Fecal Coliforms
The effluent limits imposed by the NPDES permit for fecal coliforms include maximum daily value of 1,000 per 100 mL sample and maximum monthly value of 200 per 100 mL sample. The monthly value is calculated as the geometric mean of the daily values within a calendar month. **Figures 3-23 and 3-24** indicate compliance with the permit limit. On one occasion (December 5, 2003) the daily fecal coliform limit was exceeded as shown in Figure 3-23.

NPDES Permit Compliance
The data included in this analysis consist of daily SCADA measurements from January 2002 through July 2005. During this period there were 45 NPDES permit exceedances. These exceedances included twenty-eight (28) TSS exceedances, eight (8) settleable solids (SS) exceedances (all associated with TSS exceedances), one (1) fecal coliform exceedance, and eight (8) BOD_5 exceedances (all associated with TSS exceedances). Additionally there were 92 Diversion events and 12 Bypass events. Of these 45 numeric permit exceedances, all occurred during Diversion events.

In early 2004, revised operational procedures were implemented to increase flows to biological treatment to better comply with the permit conditions regarding Diversions (i.e. Diversions are only made to avoid a Washout). This is intended to reduce the occurrence and volume of Diversions.

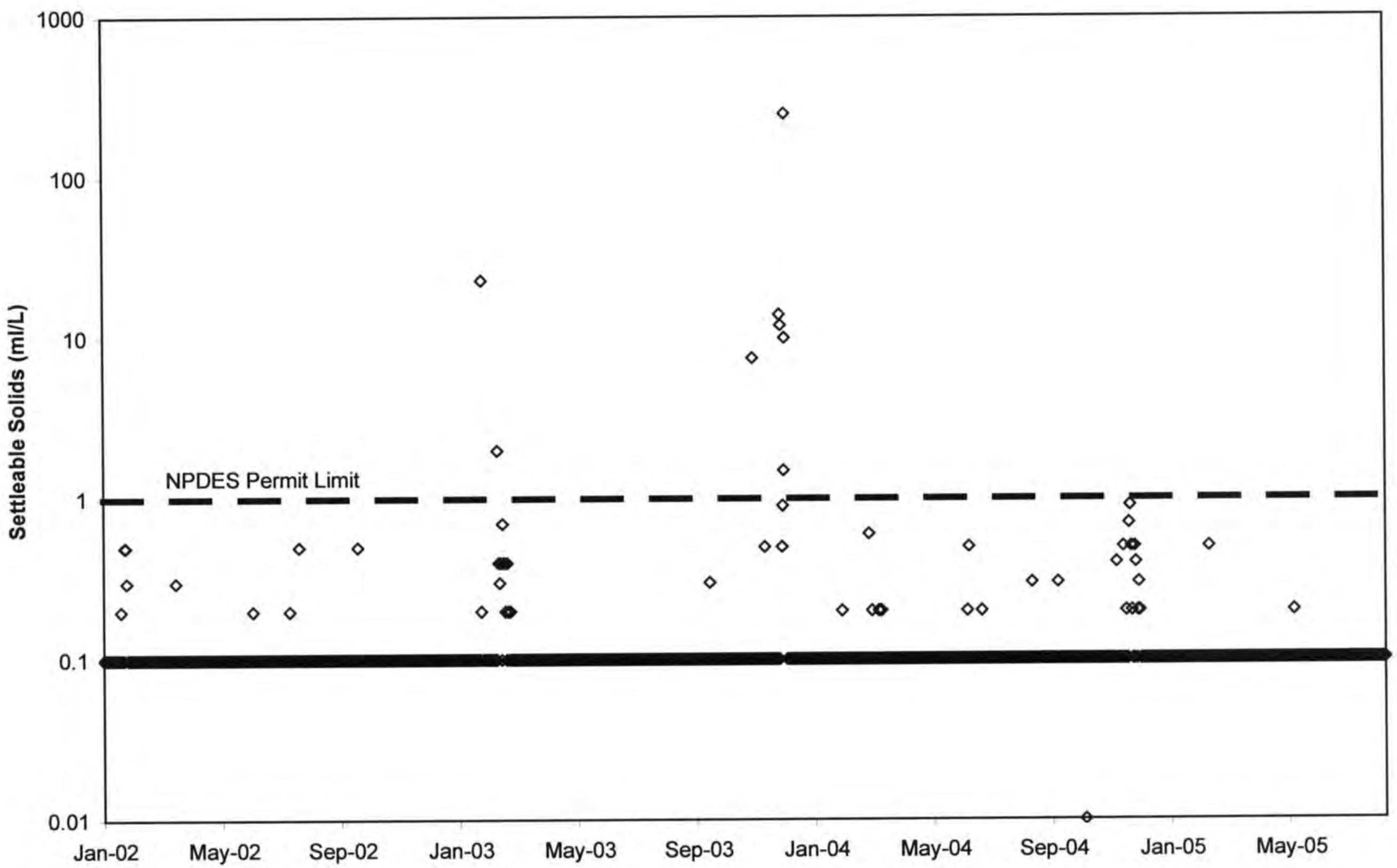
3.5.3 Solids Accountability Analysis

Figure 3-25 is a solids balance for the Fourth Creek WWTP based on the overall average of data collected January 2002 to August 2005.

As shown in Figure 3-25, the average influent flow at the Fourth Creek WWTP was 7.0 mgd over the period analyzed. The average TSS of the influent was 219 mg/L. The average effluent flow over the period was 6.9 mgd and the average effluent TSS was 9 mg/L. **Table 3-16** is a summary of TSS and removal efficiencies of TSS at the influent, primary effluent, and final effluent.

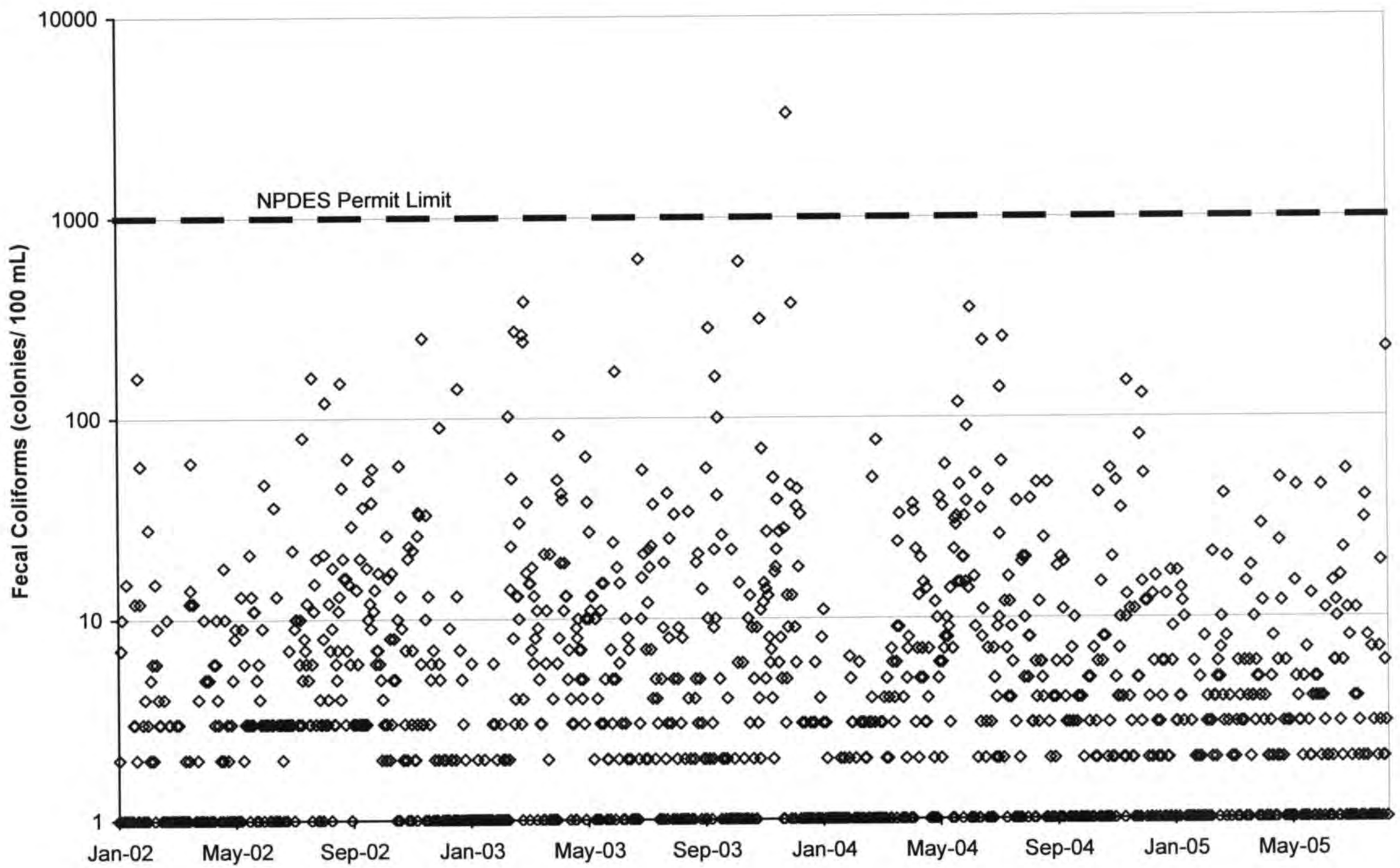
0001542

FIGURE 3-22: Performance vs Daily Settleable Solids Effluent Limits



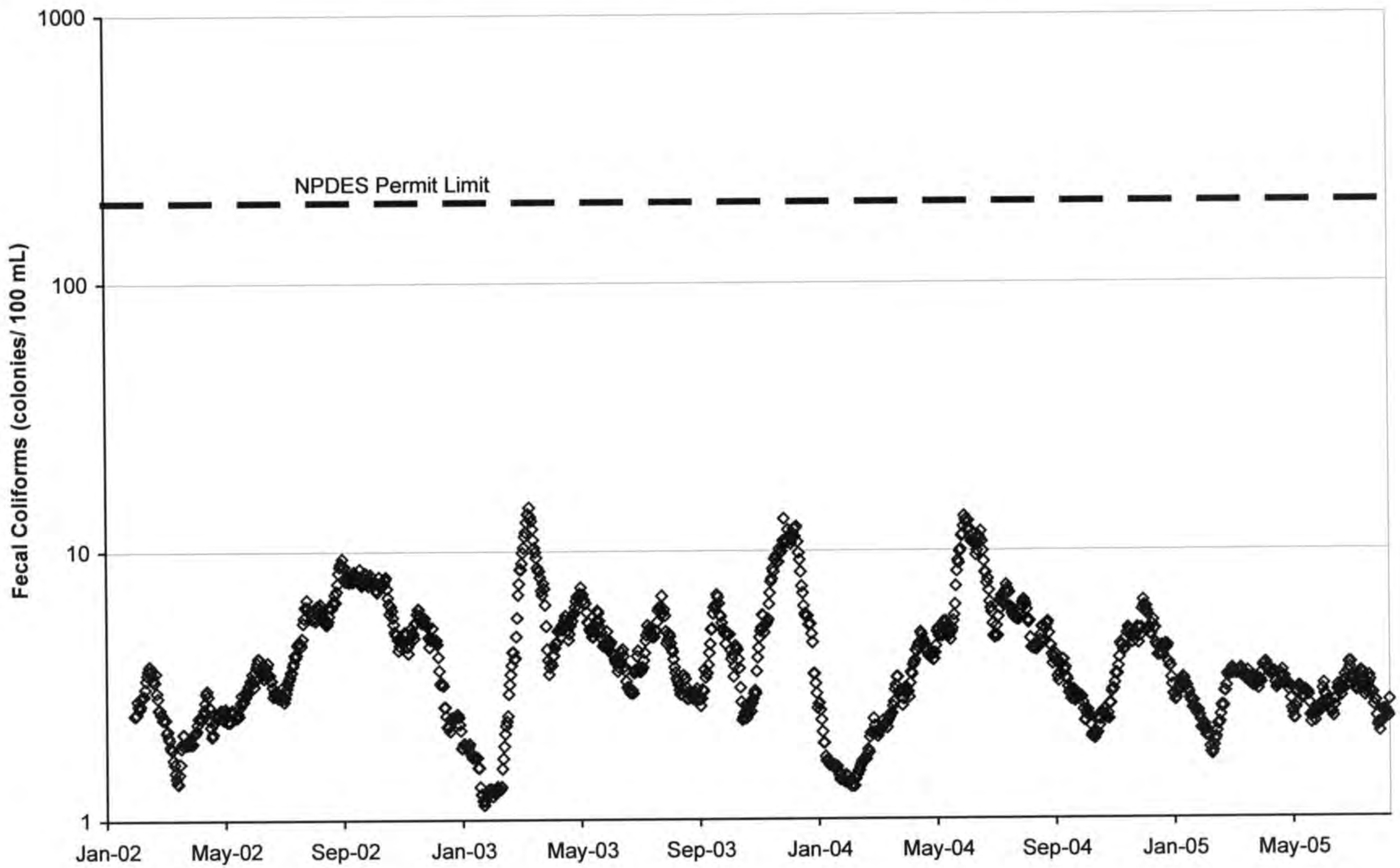
0001543

FIGURE 3-23: Performance vs Daily Fecal Coliform Effluent Limit

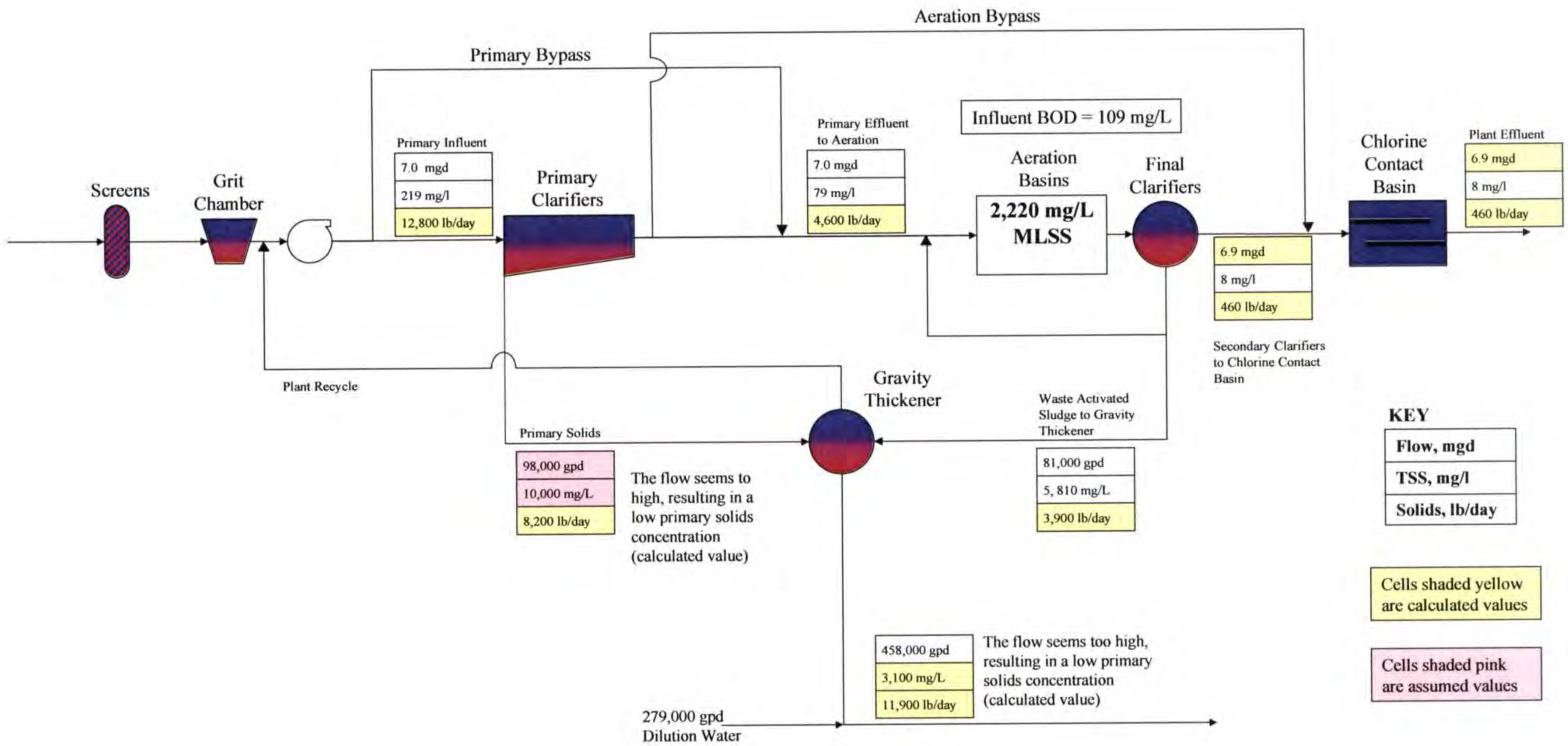


00001544

FIGURE 3-24: Performance vs Monthly Fecal Coliform Effluent Limit



0001545



0001546

CDM.

Figure 3-25

Fourth Creek WWTP Flow Schematic and Solids Balance at 7.1 mgd

Table 3-16: Summary of TSS and TSS Removal Efficiencies

	Influent Flow (mgd)	Influent TSS (mg/L)	Secondary Influent TSS (mg/L)	Estimated Primary Clarifier TSS Removal (%)	Final TSS (mg/L)	Secondary Treatment TSS Removal (%)	Overall TSS Removal (%)
2002	7.1	228	73	68.0	7	90.4	96.9
2003	7.5	192	87	54.7	13	85.1	93.2
2004	6.7	223	78	65.0	7	91.0	96.9
2005[1]	6.3	240	77	67.9	4	94.8	98.3
2002 – 2005[1]	7.0	219	79	63.9	8	89.9	96.3

[1] 2005 data includes January - July

Primary Clarifier Solids Balance

On average, approximately 12,800 lb/day of TSS enters the primary clarifiers. The solids from the primary clarifier underflow are combined with WAS at the gravity thickeners. The overflow from the primary clarifiers flows to secondary treatment.

It is estimated that 8,200 lb/day of TSS is removed in the primary clarifier underflow for a removal efficiency of 64 percent. This is based on the average influent TSS loading of 12,800 mg/L and the average effluent TSS loading of 4,600 mg/L.

Secondary Treatment Solids Balance

The influent to the secondary treatment process contains the primary clarifier overflow and any primary bypass flow. Over the period January 2002 - August 2005, the estimated average flow through the advanced secondary treatment system was 7.0 mgd. The reported influent TSS concentration was 79 mg/L and the reported BOD_5 concentration was 109 mg/L. Over the same period, the average effluent flow was 6.9 mgd with an average TSS concentration of 8 mg/L and an average BOD_5 concentration of 9 mg/L. This corresponds to an average 92 percent removal for TSS and 90 percent removal for BOD_5 for the secondary treatment system.

Operation of the advanced secondary treatment system includes an internal recycle stream from the final clarifier underflows to the aeration basins (return activated sludge or RAS) and WAS between the final clarifier underflows and the gravity thickeners. On average 81,000 gpd of WAS is pumped from the final clarifiers underflow to the gravity thickener. At an average solids concentration of 5,810 mg/L, it is estimated that 3,900 lb/day of solids is wasted from the secondary treatment system at the FCWWTP.

The first source of solids from the secondary treatment system is the influent TSS. As shown in Figure 3-25, 4,600 lb/day TSS enters the advanced secondary treatment system. Based on samples collected in June 2005 and July 2005, 85 percent (3,900 lb/day) of the TSS in the secondary treatment influent is volatile suspended solids

(VSS). The remaining 15 percent (700 lb/day) is non-volatile. It is assumed that all of the non-volatile solids (700 lb/day) is removed with the WAS. Based on Manual of Practice 8 (WEF, 1992), it is assumed that 40 percent of the VSS is also nonbiodegradable and is removed in the WAS. For the Fourth Creek WWTP, this is approximately 1,600 lb/day. It is assumed the remaining 60 percent of the VSS is absorbed into the biomass and solubilized.

A second source of solids from the advanced secondary treatment system is the biological growth that occurs as the influent BOD_5 is converted. By assuming 0.5 lb of TSS created for every 1 lb of BOD_5 consumed in the aeration basins, approximately 2,900 lb/day TSS is created and removed in the WAS.

Table 3-17 summarizes the solids accountability analysis for the advanced wastewater treatment system.

Table 3-17: Solids Accountability for Advanced Wastewater Treatment System

Solids Into System	Measured Data/Assumption	Calculated Value
Influent TSS	From TSS data = 4,600 lb/day	
Non-volatile TSS	15% of influent TSS	700 lb/day
Influent VSS	85% of influent TSS = 3,900 lb/day	
Nonbiodegradable VSS	40% of VSS	1,600 lb/day
Influent BOD_5	From BOD_5 data = 6,400 lb/day	
Effluent BOD_5	From BOD_5 data = 600 lb/day	
BOD_5 Consumed	5,800 lb/day	
Biological Growth	Assume 0.5 lb TSS / 1 lb BOD_5 consumed	2,900 lb/day
	Sum of Solids Into System	5,200 lb/day
Solids Out of System		
Solids over Final Clarifier Weir	From TSS data	500 lb/day
WAS	From RAS and WAS data	3,900 lb/day
	Sum of Solids Out of System	4,300 lb/day

Gravity Thickener Solids Balance

Solids from the primary clarifier underflow and WAS solids are combined at the gravity thickener at FCWWTP. No information is collected about the influent to the gravity thickener.

The reported volume of thickened sludge pumped from the gravity thickeners to the KWWTP averaged 458,000 gpd from 2002-2005. It is estimated that on average 11,900 lb/day (8,100 lb/day of primary solids and 3,800 lb/day WAS) are pumped each day. The average concentration of solids pumped is 3,100 mg/L.

It is expected that a large volume of dilution water is added to the combined sludges prior to pumping. There is no available information about the volume or concentration of primary solids. Conservatively estimating 1 percent solids in the primary clarifier underflow, the corresponding flow of primary solids is 98,000 gpd.

The reported flow of WAS is 81,000 gpd. The combined influent to the gravity thickeners is 179,000 gpd. The reported amount pumped to Kuwahee WWTP is 458,000 gpd. This result implies that 279,000 gpd (~194 gpm) of dilution water is added to the gravity thickener solids at the FCWWTP.

3.6 Wet Weather Data Analysis and Performance Summary

Overall Average Process Performance

The average daily influent pollutant parameters for 2002 - 2004 stated in the previous section are summarized in **Table 3-18**. Also shown in Table 3-18 are the average daily effluent pollutant parameters and the average daily activated sludge influent parameters for 2002 - 2004. Table 3-18 also includes the average daily pollutant percent removals by the primary clarifiers and the activated sludge system for 2002 - 2004.

Table 3-18: Fourth Creek WWTP Average Daily Process Performance

	BOD_5	TSS	NH_3-N
Average Daily Influent Concentration (mg/L)	185.36	214.19	13.04
Average Daily Secondary Influent Concentration (mg/L)	108.51	79.45	12.14
Average Daily Primary Clarifier Percent Removal (%)	32.9	54.4	3.1
Average Daily Effluent Concentration (mg/L)	9.61	9.09	6.03
Average Daily Activated Sludge Percent Removal (%)	90.12	83.24	48.05

Dry and Wet Weather Process Performance

As shown previously, rainfall greatly impacts flow rates at the FCWWTP. The following analysis is intended to demonstrate how it affects WWTP process performance.

Table 3-19 shows the average flow rates for the entire period of 2002 - 2004, during dry weather when daily rainfall was 0 inches, and during wet weather when daily rainfall amounts exceeded 0.1 inches, 0.5 inches, and 1.0 inches.

Table 3-19: Fourth Creek WWTP 2002 – 2004 Total, Dry Weather and Wet Weather Flow Rates

	2002 – 2004 All Days	2002 – 2004 Days Rainfall =0 inches	2002 – 2004 Days Rainfall >0 inches	2002 – 2004 Days Rainfall >0.1 inches	2002 – 2004 Days Rainfall >0.5 inches	2002 – 2004 Days Rainfall >1.0 inches
Average Daily Influent Flow Rate (mgd)	7.09	6.54	8.45	8.74	10.32	11.58
Maximum Daily Influent Flow Rate (mgd)	39.78	39.78	38.07	38.07	38.07	38.07

Table 3-20 shows the average BOD_5 percent removals of the primary clarifiers and the activated sludge system for the entire period of 2002 - 2004, during dry weather when daily rainfall was 0 inches, and during wet weather when daily rainfall amounts exceeded 0 inches, 0.1 inches, 0.5 inches, and 1.0 inches.

Table 3-20: Fourth Creek WWTP 2002 – 2004 Total, Dry Weather and Wet Weather BOD_5 Removal Process Performance

	2002 – 2004 All Days	2002 – 2004 Days Rainfall =0 inches	2002 – 2004 Days Rainfall >0 inches	2002 – 2004 Days Rainfall >0.1 inches	2002 – 2004 Days Rainfall >0.5 inches	2002 – 2004 Days Rainfall >1.0 inches
Average Daily Primary Clarifier Percent Removal (%)	32.9	32.8	33.0	32.3	29.7	32.6
Average Daily Activated Sludge Percent Removal (%)	90.1	92.5	84.3	83.2	78.8	81.3

Table 3-21 shows the average TSS percent removals of the primary clarifiers and the activated sludge system for the entire period of 2002 - 2004, during dry weather when daily rainfall was 0 inches, and during wet weather when daily rainfall amounts exceeded 0 inches, 0.1 inches, 0.5 inches, and 1.0 inches.

Table 3-21: Fourth Creek WWTP 2002 – 2004 Total, Dry Weather and Wet Weather TSS Removal Process Performance

	2002 – 2004 All Days	**2002 – 2004 Days Rainfall =0 inches**	**2002 – 2004 Days Rainfall >0 inches**	**2002 – 2004 Days Rainfall >0.1 inches**	**2002 – 2004 Days Rainfall >0.5 inches**	**2002 – 2004 Days Rainfall >1.0 inches**
Average Daily Primary Clarifier Percent Removal (%)	54.4	55.6	51.4	50.7	48.4	52.3
Average Daily Activated Sludge Percent Removal (%)	83.2	90.6	65.5	61.0	38.6	76.3

Table 3-22 shows the average NH_3 percent removals of the activated sludge system for the entire period of 2002 - 2004, during dry weather when daily rainfall was 0 inches, and during wet weather when daily rainfall amounts exceeded 0 inches, 0.1 inches, 0.5 inches, and 1.0 inches.

Table 3-22: Fourth Creek WWTP 2002 – 2004 Total, Dry Weather and Wet Weather NH_3 Removal Process Performance

	2002 – 2004 All Days	**2002 – 2004 Days Rainfall =0 inches**	**2002 – 2004 Days Rainfall >0 inches**	**2002 – 2004 Days Rainfall >0.1 inches**	**2002 – 2004 Days Rainfall >0.5 inches**	**2002 – 2004 Days Rainfall >1.0 inches**
Average Daily Activated Sludge Percent Removal (%)	48.1	50.1	43.3	42.4	41.7	37.6

Section 4
Loves Creek WWTP Process Performance Evaluation & Data Analysis

The purpose of this section of the CPE is to summarize the process performance of the existing wastewater treatment facilities at the Loves Creek Wastewater Treatment Plant (LCWWTP). This section is divided into the following subsections:

4.1 LCWWTP General Description

4.2 Operational Description

4.3 Treatment Requirements and Effluent Limitations

4.4 Treatment Process and Equipment Descriptions

4.5 WWTP Data Analysis and Performance Summary

4.6 Wet Weather Data Analysis and Performance Summary

The analysis consisted of a detailed evaluation of the wastewater treatment plant operational data, including flow and loading data, for January 2002 - July 2005. The capacity of each major treatment process is compared to TDEC Design Standards. In addition, the evaluation consists of an overall performance summary, including a solids accountability analysis. Finally, the impact of wet weather on flows, loadings, and process performance at the LCWWTP is presented.

4.1 LCWWTP General Description

The LCWWTP is an advanced wastewater treatment facility that was originally constructed to serve primarily residential and commercial customers. The facility underwent a major expansion in 1990 when the screening, grit removal, activated sludge system, and disinfection facilities were expanded. The waste sludge at the LCWWTP is pumped through a force main to the KWWTP.

The LCWWTP is designed to provide secondary treatment to an average daily flow of 5 mgd. The maximum daily design flow is 10 mgd for the activated sludge system with additional peak flow clarification of 5 mgd. The disinfection system is designed for a maximum flow of 15 mgd.

The wastewater treatment plant includes preliminary, peak flow primary, secondary, and disinfection treatment. Effluent from the secondary facilities is disinfected in

chlorine contact tanks and then dechlorinated using sodium bisulfite prior to discharge into the Holston River.

Sludge from peak flow primary treatment and the activated sludge process is pumped to the KWWTP. A flow schematic of the LCWWTP is shown in **Figure 4-1**.

4.2 Operational Description

Since average daily flows are typically less than 3.5 mgd, two aeration basins are kept off-line and empty. During wet weather events, flows up to 10 mgd pass through the biological treatment process and are disinfected prior to discharge. As flows exceed 10 mgd, excess flows are directed to the peak flow clarifiers which provide approximately 0.52 million gallons of storage prior to operating as primary clarifiers. A Diversion does not occur until the peak flow clarifiers overflow the weirs and operate as clarifiers. The drains on the peak flow clarifiers are left open resulting in recycling of flows to the influent pump station.

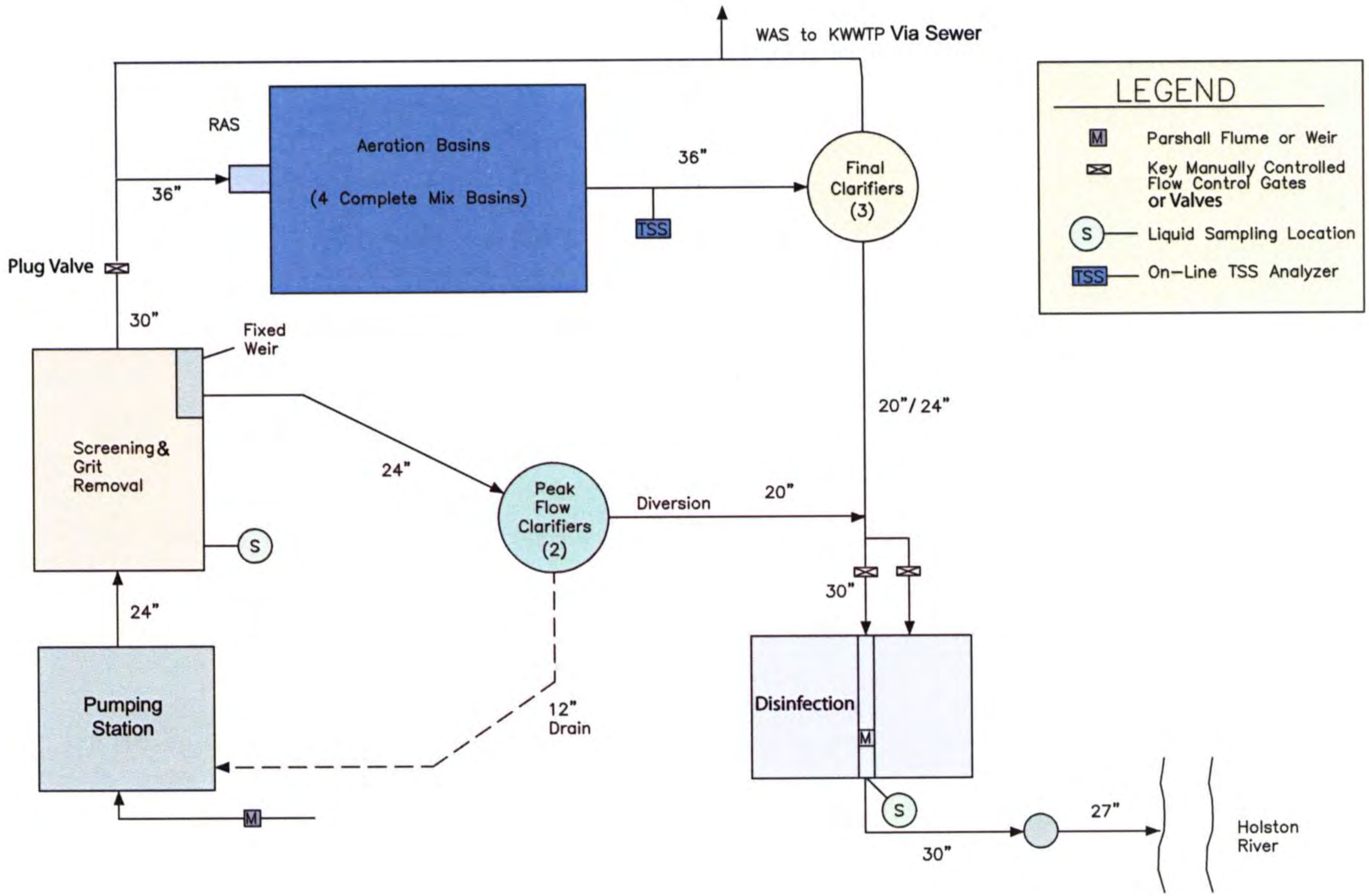
Once the flows overflow the weir in the grit basin, approximately 11 mgd is being routed to the secondary treatment system. As flows increase above 11 mgd, some excess flow overflows to the peak flow clarifiers. The rest of the excess flow is sent to the out of service aeration basins for storage, so that a maximum of 11 mgd continues through full secondary treatment. The routing of flow to the out of service aeration basins is accomplished by manually controlled gates.

To summarize, a Diversion at the LCWWTP is not currently initiated by an operator decision, but by hydraulic conditions. The level of the Diversion weir was originally set to prevent peak flows from causing a Washout. The out-of-service aeration basins are used for storage to minimize flow to the peak flow clarifiers, which only results in a Diversion if they become full.

At flows above about 11 mgd, the launders in the final clarifiers flood unless the second line feeding the chlorine contact basin is used. It has been found that use of this second line does not adversely impact the process.

4.3 Treatment Requirements and Effluent Limitations

The LCWWTP was designed to treat an average daily flow of 5.0 mgd, and is permitted to meet the following maximum monthly average, maximum weekly average, and daily maximum effluent requirements as imposed under NPDES Permit No. TN0021822. **Table 4-1** shows the permit limits for conventional pollutants. Note that the mass loadings are based on an average daily flow of 10.0 mgd instead of 5.0 mgd.



00001554

CDM

Figure 4-1: Loves Creek WWTP Process Schematic