Characterization of Combined Sewer Overflow Discharges to the Chesapeake Bay

Prepared for:

City of Alexandria, VA;

Alexandria Sanitation Authority;

District of Columbia Water & Sewer Authority;

City of Lynchburg, VA; and

City of Richmond, VA

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

ASA	Alexandria Sanitary Authority
BMP	Best Management Practices
CBP	U.S. EPA Chesapeake Bay Program
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
DC WASA	District of Columbia Water and Sewer Authority
ECF	Enhanced Clarification Facilities
EMC	Event Mean Concentration
LTCP	Long-Term Control Plan
MGD	Million Gallons per Day
MS4	Municipal Separate Storm Sewer
NMC	Nine Minimum Controls
NPDES	National Pollutant Discharge Elimination System
RDII	Rainfall-Derived Infiltration and Inflow
TN	Total Nitrogen
TMDLs	Total Maximum Daily Loads
TP	Total Phosphorous
TSS	Total Suspend Solids
WQSTM	Chesapeake Bay Water Quality Sediment Transport Model
WSM	Watershed Model
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This report was prepared to provide the U.S. EPA Chesapeake Bay Program (CBP) and jurisdictional regulatory agencies in the District of Columbia (District Department of the Environment) and Virginia (Department of Environmental Quality) with information on combined sewer system (CSS) pollutant loads for five municipal entities and utilities in the Chesapeake Bay Watershed. These entities and utilities, referred to as the *CSS Working Group*, are the City of Alexandria, VA; Alexandria Sanitation Authority (ASA), VA; District of Columbia Water and Sewer Authority (DC WASA), DC; City of Lynchburg, VA; and City of Richmond, VA. The CSS Working Group members own and operate CSSs and/or provide treatment of combined sewage at a wastewater treatment plant (WWTP). Each of the members owning and operating a CSS independently developed CSO Long Term Control Plans (LTCPs) per National Pollutant Discharge Elimination System (NPDES) requirements.

The CSS Working Group undertook a significant effort to develop information to be used by the CBP and the jurisdictional regulatory agencies to characterize CSS pollutant loads for the Chesapeake Bay Nutrient and Total Suspended Solids (TSS) Total Maximum Daily Loads (TMDLs) study. This work was done by the CSS Working Group in recognition that representative nutrient (nitrogen and phosphorus) and total suspended solids (TSS) loads from their CSSs are needed to support 1) calibration of the Chesapeake Bay Water Quality Sediment Transport Model (WQSTM), and 2) development of TMDLs.

As background, CSS Working Group members maintain and apply hydrologic and hydraulic models of their individual systems for planning, design and/or reporting purposes. These models and other estimation procedures are used to simulate the response of the CSS to wet weather events. The product of these simulations is quantification of CSS flows and volumes at permitted CSO discharge points and at the WWTPs serving the CSSs. In addition, CSS Working Group members conduct monitoring to characterize CSO end-of-pipe concentrations of water quality constituents. The available monitoring data is used to characterize and establish pollutant specific event mean concentrations (EMCs) for each CSS. CSO loads are calculated by multiplying simulated flow by the appropriate EMC and necessary conversion factors. Estimated CSO loads are available in the form of daily time series files in electronic format and annual summaries.

Historical data and load estimations based on modeling results were assembled and evaluated to characterize the CSS operations for each CSS Working Group member. This included model-based estimation of historical CSO discharge volumes and loads corresponding to the WQSTM TMDL model calibration period of 1985-2005. With the exception of the City of Alexandria, where an approved LTCP is in place, these loads generally represent existing discharges that reflect pre-LTCP conditions. That is, the loads are consistent with existing facilities and operations within the CSSs prior to complete implementation of the controls and operations described in approved LTCPs. The City of Alexandria CSO discharge volumes and loads contained in this report reflect their approved post-LTCP condition.

The CSS Working Group members plan to coordinate with the CBP and their respective jurisdictional regulatory agencies to provide CSO LTCP-based loads for development of CSS allocations for the nutrient and TSS TMDLs from the initial gross allocations provided by the CBP. The CSO LTCP-based loads will represent complete implementation of the controls and operations described in LTCPs. As such, they generally represent a substantial reduction in CSO loads linked to NPDES required LTCPs.

Summary tables of annual CSO discharge volumes and nutrient loads are provided in the report for comparative purposes. Daily time series of CSO volumes and loads based on model simulations will be made available in an electronic format for use in calibration and application of the Chesapeake Bay WQSTM. Division of the annual totals by 365 to create daily volumes and loads would be inappropriate because of the episodic nature of the precipitation events that cause CSOs to occur.

Key information provided in this report is summarized as:

- The CSS Working Group members deemed it necessary to provide the CBP and jurisdictional regulatory agencies with the specific information needed to accurately characterize CSS pollutant loads for the Chesapeake Bay Nutrient and TSS TMDL Study.
- The CSS Working Group members maintain and apply hydrologic and hydraulic models of their individual systems for planning, design and/or reporting purposes. These models are used in conjunction with end-of-pipe concentrations of water quality constituents to estimate CSO loads.
- CSO loads are highly variable on a year-to-year basis due to differences in precipitation. In addition, end-of-pipe concentrations of water quality constituents are also highly variable from outfall to outfall, storm to storm, and community to community due to system configuration, variations in precipitation and sewershed characteristics.
- Approved LTCPs developed by CSS Working Group members are based on national policy and EPA guidance that accounts for variability in rainfall.
- Except for City of Alexandria, CSO loads developed by the CSS Working Group for calibration of the Chesapeake Bay WQSTM reflect existing pre-LTCP conditions and do not include controls and operations described in LTCPs. The City of Alexandria CSO loads contained in this report include controls and operations described in its approved LTCP.
- LTCP-based CSO loads are to be provided to the CBP and jurisdictional regulatory agencies in the near future for use in developing CSS allocations for the nutrient and TSS TMDLs following provision of the initial gross load allocations to these agencies. These loads will include complete implementation of LTCPs. The City of Alexandria CSO loads provided with this report effectively represent the post-LTCP condition.
- The use of LTCP-based loads for development of allocations and the daily expression of CSO loads has precedent in the development of TMDLs for

nutrients and TSS in the Anacostia River Watershed where it was determined that complete implementation of DC WASA's LTCP represented an adequate level of control for WLA purposes (U.S. EPA 2007, 2008b).

- The CBP and jurisdictional regulatory agencies should ensure that there is consistency between the LTCPs developed by CSS Working Group members and CSS allocations proposed under the TMDL, and recognize the need to explicitly state this consistency should be expressly acknowledged in the discussion of CSOs and CSO allocations in the final TMDL report.

In summary, the information presented in this report is intended to be used by the CBP to inform the calibration and application of the Chesapeake Bay Program's WQSTM model. The report does not provide information on pollutant loads for the other 56 CSO communities in the Chesapeake Bay Watershed.

1. INTRODUCTION

This report was prepared to provide the U.S. EPA Chesapeake Bay Program (CBP) with information on combined sewer overflow (CSO) pollutant loads for five municipal agencies and/or wastewater treatment utilities in the Chesapeake Bay Watershed. These entities and utilities, referred to as the *Combined Sewer System (CSS) Working Group*, are the City of Alexandria, VA; Alexandria Sanitation Authority (ASA), VA; District of Columbia Water and Sewer Authority (DC WASA); City of Lynchburg, VA; and City of Richmond, VA. These utilities own and operate CSSs and/or provide treatment of combined sewage at wastewater treatment plants (WWTPs) serving the CSSs.

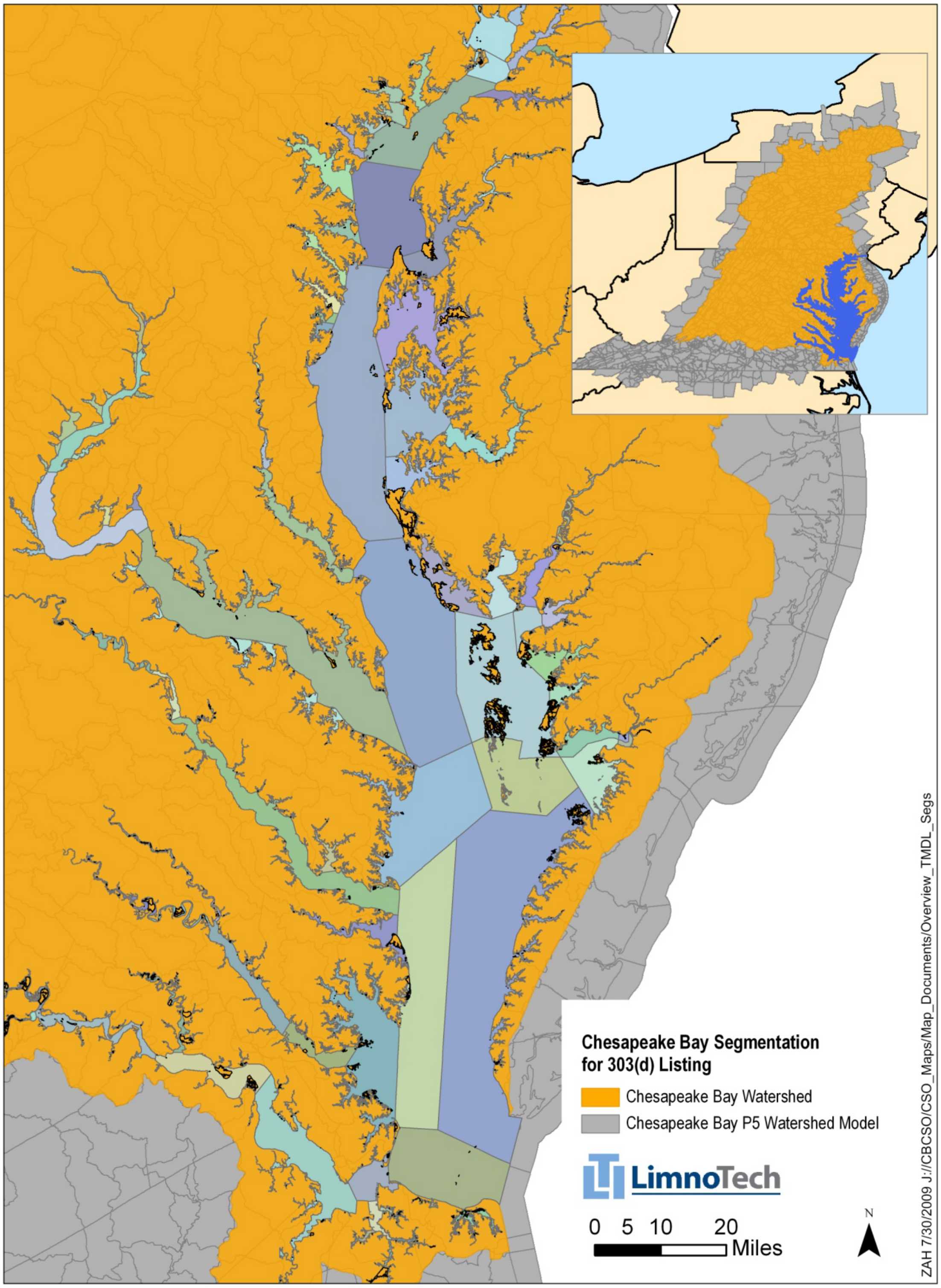
The information presented in this report is intended to be used by the CBP to inform the calibration of a Water Quality Sediment Transport Model (WQSTM) of the Bay and tidal tributaries. The information is provided to assist the CBP in working towards development of Total Maximum Daily Loads (TMDLs) for nitrogen, phosphorus, and sediment discharges to the Bay and tidal tributaries and subsequent development of Implementation Plans that will demonstrate how States and the District will achieve the pollutant load reductions required by the TMDLs. Once initial gross load allocations are provided to the States and the District, the CSS Working Group members will coordinate with their respective regulatory agencies to provide LTCP-based loads for use in developing allocations for the TMDLs. The report does not provide information on pollutant loads for the other 56 CSO communities in the Bay watershed.

1.1 CHESAPEAKE BAY TMDL BACKGROUND

Excess nitrogen, phosphorus, and sediment discharges to the Chesapeake Bay are contributing to low dissolved oxygen problems, loss of submerged aquatic vegetation, and decline of the Bay's living resources. EPA Region 3, working with the states and other partners, is developing 92 TMDLs for the Chesapeake Bay to meet water quality standards for dissolved oxygen, chlorophyll *a*, and clarity (Figure 1). These TMDLs will establish loading limits for point and nonpoint source discharges of total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) to the Bay and its tributaries. The EPA fact sheet for the TMDL states that

> *EPA is planning to work with its Bay Program partner states to develop implementation plans that will accompany the TMDL. These plans will identify specific actions needed to achieve the loading reductions in the TMDL. The states will also provide commitments every two years for actions to be taken to reduce nitrogen, phosphorus and sediments. Lastly, EPA is working with the states on measures that would be taken if a state did not achieve the two-year commitments.* (U.S. EPA 2008a)

Figure 1. The 92 Segments for the Chesapeake Bay TMDL



Under Executive Order 13508[1] (74 FR 23099, May 15, 2009), EPA and other federal agencies are overseeing development and coordination of the agencies' reporting, data management and other programs and activities to restore the Bay. This includes developing a strategy (draft by November 12, 2009; final by May 12, 2010) for coordinated implementation of existing programs and projects to guide efforts to protect and restore the Chesapeake Bay. EPA and the other federal agencies were also directed to develop an annual Chesapeake Bay Action Plan describing how Federal funding will be used for Bay restoration in the coming year, as well as to develop annual progress reports. The order specifies that the reports shall:

> *assess the impacts of a changing climate on the Chesapeake Bay and develop a strategy for adapting natural resource programs and public infrastructure to the impacts of a changing climate on water quality and living resources of the Chesapeake Bay watershed*

The order also states:

> *the Administrator of the EPA (Administrator) shall, after consulting with appropriate State agencies, examine how to make full use of its authorities under the Clean Water Act to protect and restore the Chesapeake Bay and its tributary waters and, as appropriate, shall consider revising any guidance and regulations.*

1.1.1 Data Sources for Point and Nonpoint Sources

To inform the TMDL, the Chesapeake Bay Program is refining their estimates of pollutant loads for point and nonpoint sources and atmospheric deposition. Point sources include WWTPs, urban and suburban storm water, confined animal feeding operations (CAFOs), and CSOs. Nonpoint sources include storm water runoff from rural, agricultural, and forested areas and septic systems.

Modeling of Point and Nonpoint Sources

Point source loads are handled two different ways in the Chesapeake Bay models. In general, point sources discharging directly to the Bay and the tidal tributaries are input to the WQSTM as monthly or daily loads. Point sources discharging to non-tidal tributaries are input to the Watershed Model (WSM[2]) which then calculates the amount of load that is removed by instream processes before the load reaches the tidal tributaries.

The WSM is used to calculate surface runoff from land segments in the entire watershed. As such, the WSM calculates loads for a mixture of points (CSO, MS4 and industrial storm water) and nonpoint (agriculture, rural storm water) sources

[1] Executive Order 13508, Chesapeake Bay Protection and Restoration, created a Federal Leadership Committee (FLC), chaired by EPA and with membership from Departments of Agriculture, Commerce, Defense, Homeland Security, the Interior, Transportation and other agencies as determined by the committee. The purpose of the FLC is to oversee development and coordination of agencies' reporting, data management and other programs and activities to restore the Bay.

[2] The Chesapeake Bay Program is continually updating the Watershed Model (WSM) and the Water Quality Sediment Transport Model (WQSTM) to reflect new information. One goal of this project is to ensure that the Bay Program has the data needed to separately account for loads associated with the CSS Working Group's systems.

based on land use segments. The WSM inherently estimates a portion of the loads in segments served by combined sewer systems (CSSs) by calculating runoff in the CSS land area and assuming this runoff is discharged to the adjacent waterway (as opposed to entering the CSS). If the Chesapeake Bay Program has information on a CSS's service area, this area can be masked out of the WSM. Masking out this area will ensure that the runoff associated with the CSS is not double-counted when CSO loads are directly input to the Chesapeake Bay models as point source loads.

Updating Point Source Loads

In previous water-quality efforts (Chesapeake Bay Tributary Strategies, 1999-2004, U.S. EPA 2003[3]), data were gathered to characterize loads from approximately 500 significant point sources. CSOs[3], smaller point sources, such as WWTPs that discharge less than 1 million gallons per day (MGD), and large animal feedlots were generally not assigned an individual load estimate.

For the TMDL, the Bay Program is assembling loads for 483 major (significant) facilities, 3,000 minor (non-significant facilities); 60 CSO communities; and municipal separate storm sewer systems (MS4s). These loads will be aggregated by county and for the 92 receiving water segments for which TMDLs will be specified. The States and EPA Region 3 (which issues permits for discharges in the District of Columbia) will use the allocations established in the TMDL to calculate NPDES permit limits for each affected point source.

1.1.2 Changes in Chesapeake Bay Allocations based on Updates to the WSM and WQSTM

EPA and the states plan to use updated data and modeling tools to develop the TMDL and the Implementation Plans. This has resulted in revised historical periods or timescales for CBP model calibration and application. In particular, the new timescale for the WSM calibration has resulted in changes in estimated loads, as discussed below. In past CBP model application, the 10-year average of 1985 through 1994 was used for development of the Tributary Strategies in 2003. The new timescale for model applications for the TMDL will be based on the 10-year period of 1991 to 2000.

As shown in Table 1, change in the calibration period of the WSM affects the calculated loads for TN, TP, and TSS. Phase 4.3 of the WSM, used for development of the tributary strategies, was calibrated to 1985 to 1994 hydrology. Phase 5.1 is a recent version of the WSM, which is being calibrated to 1991 to 2000 hydrology. This tabulation illustrates the difference in the calculated loads for the 1985 baseline scenario (which was used to calculate the percent reductions needed in different tributary loads); the 2002 progress scenario; the Tributary Strategy load (based on 2010 conditions); and a theoretical limit of technology "E3" scenario to bound what was potentially attainable. The "E3" scenario assumes maximum performance and

[3] The only combined sewer overflow (CSO) community represented in the tributary strategies was the District of Columbia. (Note: The tributary strategies included TN and TP concentration limits for wet weather flows treated at the Lynchburg and Richmond STPs.)

full implementation of BMPs or control technologies throughout the entire watershed. As can be seen, the load estimates under the more recent Phase 5.1 are higher, particularly for nitrogen.

The relative sources of nitrogen, phosphorus and suspended sediment to the Bay from different source categories are shown in Figure 2. CSO loads represent a small portion of the urban/suburban and wastewater load categories, but the relative contribution is unknown.

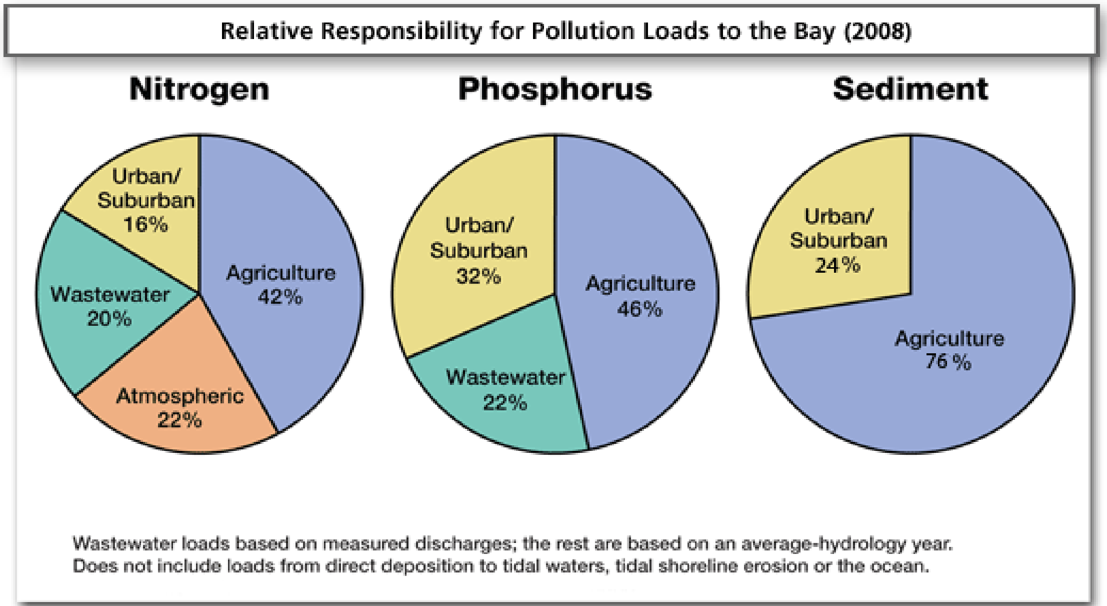
Table 1. Comparison of Loads Generated with the Chesapeake Bay Watershed Model, Phase 4.3 and 5.1

WSM Phase	1985 Baseline	2002 Progress	Tributary Strategies (2010)	E3 Scenario (2010)*
Total Nitrogen (Million Pounds)				
Ph. 4.3	337.5	277.7	181.6	116.4
Ph 5.1	419.8	333.3	235.7	142.9
Total Phosphorus (Million Pounds)				
Ph. 4.3	27.1	19.5	12.7	10.1
Ph 5.1	28.31	20.93	20.96	11.93
Total Suspended Solids (Million Pounds)				
Ph. 4.3	5.8	5.0	3.2	1.5
Ph 5.1	5.03	4.59	3.29	2.58

Source: Chesapeake Bay Modeling Subcommittee meeting of Jan. 6, 2009, Handout 1.

* The E3 scenario or 'Everything, Everywhere by Everyone" was developed to support selection of the tributary strategies by the representative regulatory authority. The E3 scenario represents an implausible scenario that cannot be attained.

Figure 2. Sources of Pollution to the Chesapeake Bay



Source: Chesapeake Bay Program 2009

Progress is generally being made in reducing nutrient loads based on load reductions established in the tributary strategies. The one exception is loads associated with urban and suburban storm water. CSSs are located in the older portions of CSO communities, and these types of sewer systems are no longer constructed. Therefore, loads from CSOs are not expected to increase and, in many cases, will decrease substantially based on permit requirements and the implementation of CSO controls as discussed in subsequent sections.

1.2 CSS AND LTCP BACKGROUND

EPA's CSO Control Policy, 59 FR 18688 (April 19, 1994), establishes a strategy for permitting authorities to require through permits or enforcement that each CSO community implement technology-based controls (the Nine Minimum Controls or NMCs) to reduce CSO pollution and, if necessary, develop long-term control plans (LTCPs) to ensure that water quality standards will be achieved.

The locations of the 60 CSO communities in the Chesapeake Bay Watershed and the locations of the WWTPs serving the CSS Working Group members are presented in Figure 3.

The remainder of this section discusses important concepts associated with CSS and LTCPs that could, if not properly considered with the TMDL development, be in direct conflict with decisions about the Chesapeake Bay TMDL.

1.2.1 Concept #1: The CSO Control Policy is used to establish the appropriate level of control for each community

CSSs were designed to collect and transport both storm water runoff and sanitary sewage. These systems were therefore designed to occasionally overflow during rain events to prevent flooding or basement backups. The CSO Control Policy and EPA guidance identify the requirements to ensure that the CSS is properly maintained and operated.

Under the policy, technology-based controls (the NMCs) are implemented and examined to determine if they are sufficient to meet water quality standards. The NMC are best management practices (BMPs) for CSSs. For example, the City of Alexandria, VA demonstrated that the NMC are sufficient to meet water quality standards in local receiving waters (Greeley and Hansen 2006a). The Commonwealth of Virginia recognized the City's NMC's as their CSO LTCP, approving it as such in February 1999.

1.2.2 Concept #2: The CSO Control Policy requires that CSOs comply with applicable water quality standards, but allows cost-effectiveness to be considered in identifying the level of control needed to comply with applicable standards

In general, CSO communities are expected to identify cost-effective controls by conducting "knee-of-the-curve" analysis and financial capability assessment. As shown in Figure 4, the "knee-of-the-curve" is defined as the point where the marginal increase in the cost of control (million dollars in this example) exceeds the marginal increase in benefit (reduction in number of overflows in a typical average year). This is considered to be a cost-effective breakpoint. EPA and state regulatory agencies often use this breakpoint as a starting point for establishing the appropriate level of control.

Figure 3. Communities with Combined Sewer Systems in the Chesapeake Bay Watershed

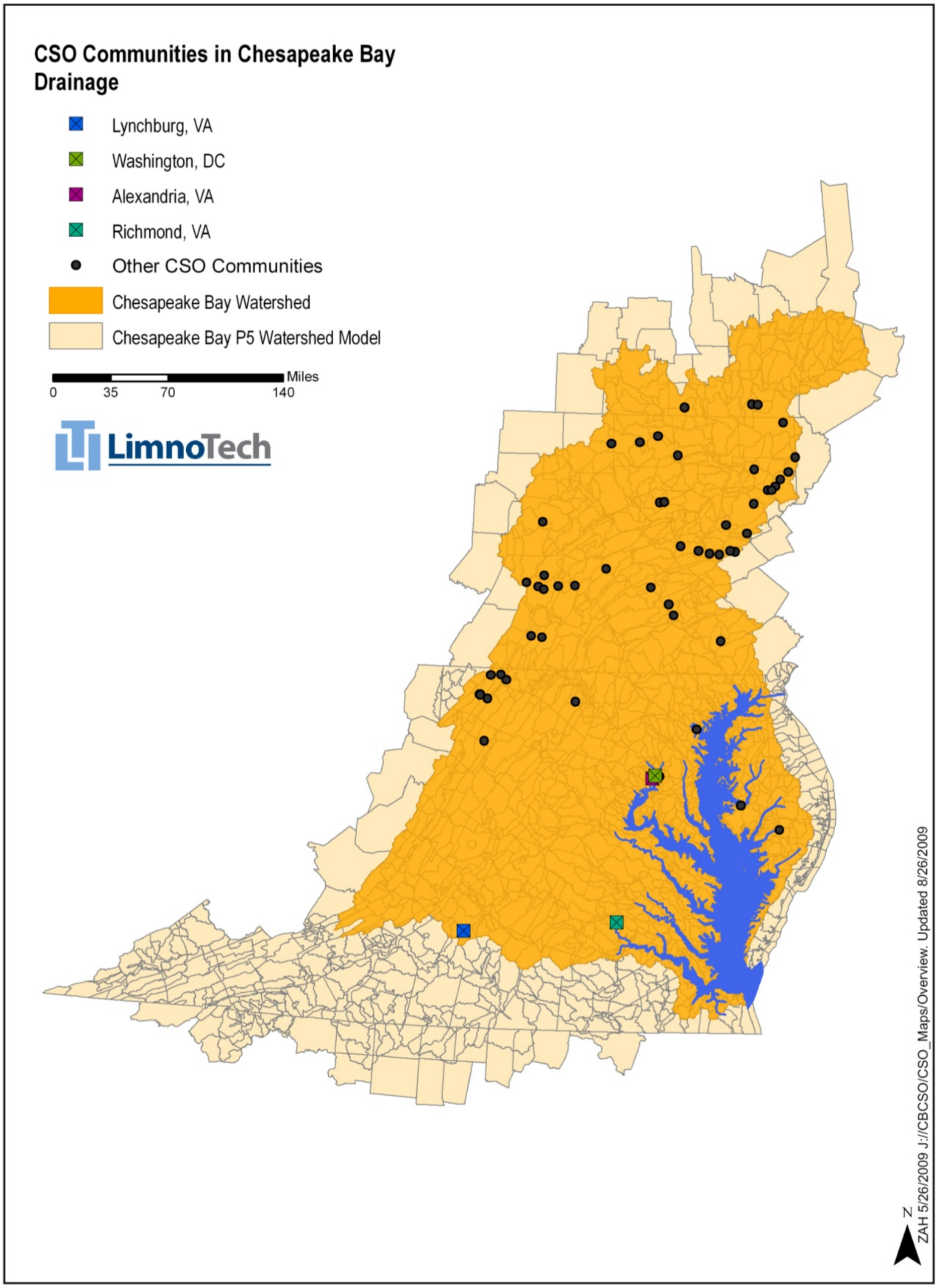
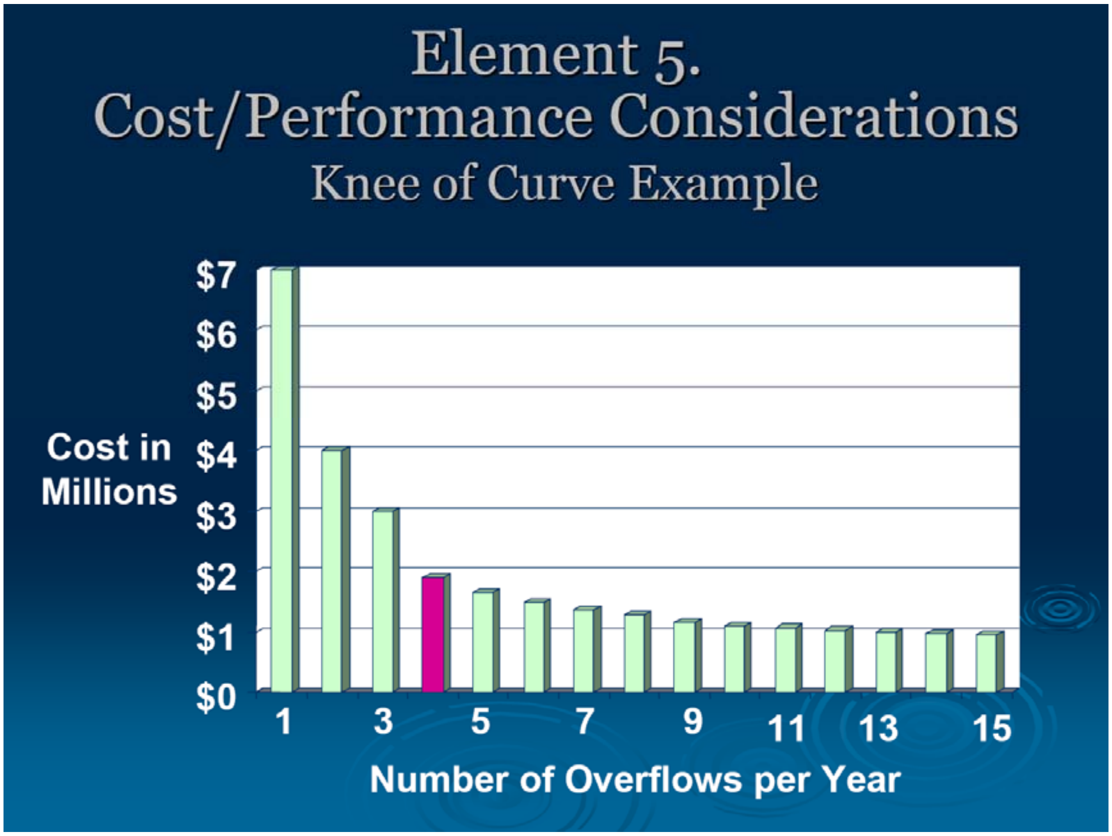


Figure 4. Example Knee-of-the-Curve Analysis for Selecting CSO Controls



Source: EPA 2008c.

Financial capability assessment is used to determine how much a CSO community can afford to spend on CSO control, and over what time period. The financial capability assessment can also be used to establish the appropriate level of control.

Under the CSO Control Policy, if the level of cost-effective CSO control exceeds what the community can afford to pay, or water quality standards cannot be met for other reasons identified in the Clean Water Act, communities can conduct a Use Attainability Analysis (UAA). The policy anticipates the permitting authority will take the lead for coordinating the review of the water quality standards with the development of the LTCP (U.S. EPA 2001). Potential outcomes of a UAA can result in a community receiving a variance or a temporary or permanent change in water quality standards for the events that CSO controls are determined to not be affordable (Moore and Nemura 2004).

1.2.3 Concept #3: The rainfall conditions used to size the CSO controls will differ from the rainfall conditions used to establish the TMDL

In developing LTCPs, EPA guidance recommends that CSO communities develop “average year” conditions based upon historic rainfall records and selection of a representative climate period to determine needed controls. A continuous simulation model of the CSS or other statistical methods can be used to establish the current

CSO discharge characteristics and the CSO discharge that is anticipated to remain (on average) after the LTCP is implemented (U.S. EPA 1995). Selection of a representative climate period involves an analysis of the number of different storm events, the duration and magnitude of those events, the number of back-to-back storm events, and concurrent hydrologic and water quality conditions in the local receiving waters. The average year conditions may be represented by a single “typical” year or by multiple year periods that, on average, are representative of the expected year-to-year variability in local climate conditions.

The concept of a representative climate period and use of an average year approach means that a CSO community is expected to achieve a level-of-control that will result in the targeted CSO reductions over an average period. That is, during some wet years the actual CSO discharge loads may not meet the average year performance target, whereas for other dry years the actual CSO discharge may be considerably less than the performance target. The selection of the representative climate period is based on local rainfall and stream flow conditions that are specific for CSO communities. It is likely that the representative years used by CSO communities will be different than the TMDL scenario simulation period selected by the CBP.

1.2.4 Concept #4: CSO communities are at different points in developing and implementing LTCPs

Some CSO communities such as the City of Alexandria, VA have already achieved the level of control required by the CSO Control Policy and their approved LTCP acknowledges this level of control. CSO communities such as the District of Columbia and the City of Richmond, VA have approved LTCPs that are currently being implemented. Other communities such as Lynchburg, VA are in the process of updating their LTCPs. Across the Chesapeake Bay Watershed and the nation, some CSO communities have not yet completed their LTCPs. EPA’s goal is to have all LTCPs completed by 2012 (WEF 2008).

Because of differences in LTCP development and LTCP implementation plans, it is important that the TMDLs and the Implementation Plans for TMDLs reflect the level of CSO control specified in the LTCP or currently attained for CSO communities not required to develop LTCPs. It is also important that the TMDL specifically acknowledge allocations can be met, on average, as long as the CSS is operating in accordance with the NMC and /or LTCP.

1.2.5 Concept #5: The Allocations must account for wet weather data variability similar to how this variability is accounted for in CSO LTCPs

As described earlier under Concept #3, there are many challenges inherent in evaluating measured and simulated wet weather data associated with CSO communities. The natural variability of wet weather requires that flow and concentration data be evaluated alongside rainfall conditions for both specific rain events and for annual and long-term averages. Rain event durations and intensities, antecedent conditions, inter-event durations, seasonal patterns, and shifts in long-term averages and individual event characteristics are all factors that should be considered during evaluation. The nature of combined sewer collection systems means that overflow dilution rates and concentrations often vary between sewersheds, and within a single sewershed, based on rainfall conditions, population density, land use, vegetation, and soil type. Differences in design and operational parameters for CSO regulator structures can lead to uneven CSO response across a single CSO community; there may be many small, frequent CSO locations alongside larger CSO points that discharge infrequently. WWTP capacity and operation often changes based on wet weather conditions; a plant's peak treatment capacity during wet weather often decreases over time during large events to protect biological treatment processes.

LTCPs developed by CSO communities account for wet weather variability. LTCP performance is evaluated for the average year, but simulated CSO frequency, duration, and volume are evaluated during LTCP development for specific LTCP forecast periods that often include wetter-than-average and drier-than-average years. LTCPs can and do change in response to the availability or feasibility of new treatment technology, to changes in permit requirements, and to consent decrees and other legal and regulatory requirements.

It is important that TMDLs and TMDL Implementation Plans take wet weather variability and the potential dynamic nature of CSSs and LTCPs into account.

2. CSS WORKING GROUP – BASIC FACILITY INFORMATION

This section describes the basic information associated with the CSS facilities owned and operated by the CSS Working Group. This information consists of detailed geographic locations of CSO outfalls and WWTPs, service areas, and general fcility information. Information on CSO and WWTP discharges is discussed later.

2.1 CITY OF ALEXANDRIA, VA

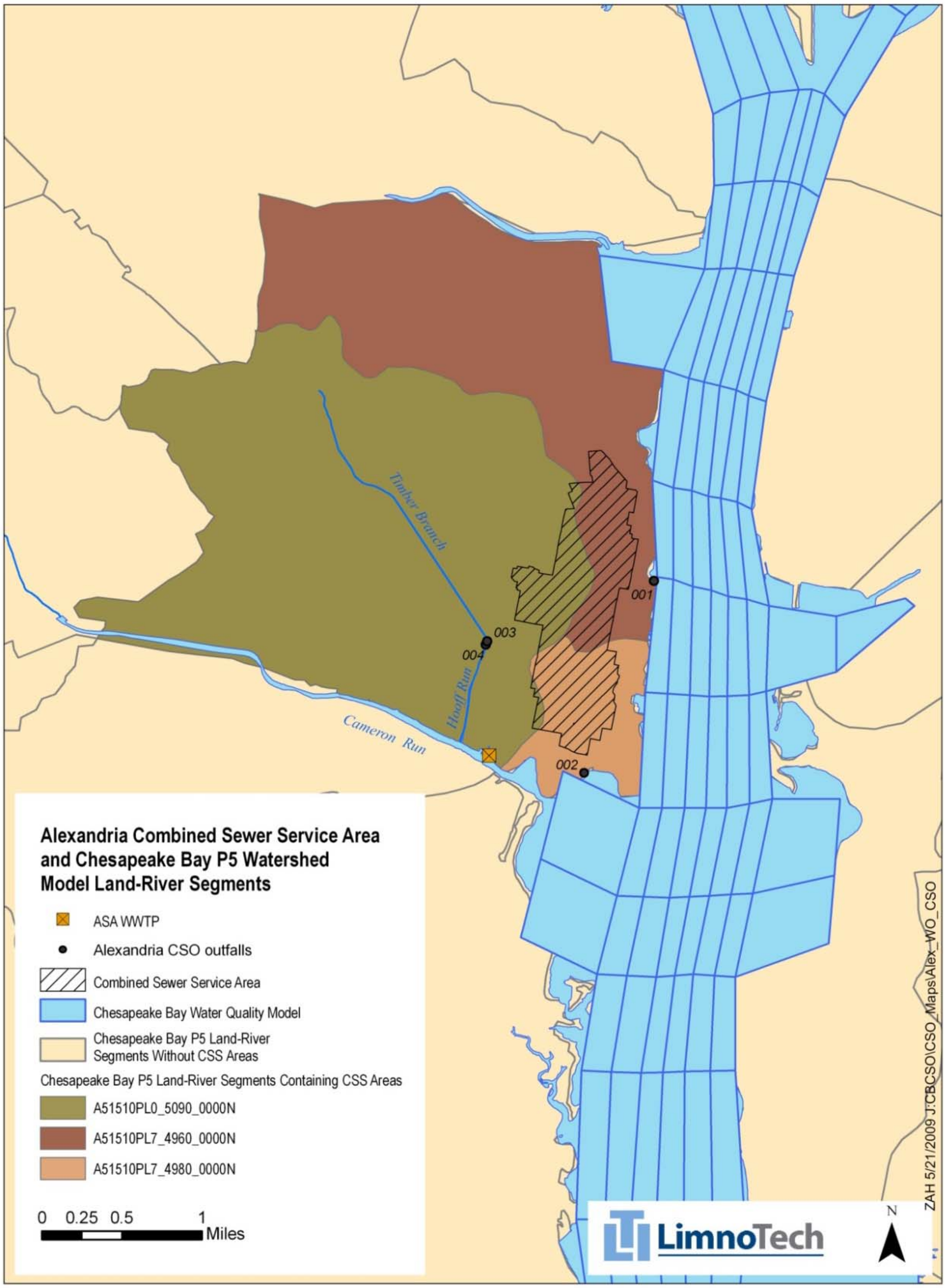
The City of Alexandria owns and operates a CSS and the Alexandria Sanitation Authority (ASA) owns and operates the ASA WWTP. The ASA WWTP is a regional plant serving the City of Alexandria and Fairfax County. The VPDES permit number for the ASA WWTP is VA0025160. The VPDES permit for the City's CSOs is VA0087068. As shown in Figure 5 and listed in Table 2, the City of Alexandria's CSS covers 540 acres e and includes four permitted CSO outfalls. The amount of CSO that is discharged depends on the system configuration, weather and tidal conditions, storm intensity, frequency and duration, and the capacity of the sewer interceptor.

Table 2. Location of the City of Alexandria, VA CSOs

CSO	Description	Stream	Latitude	Longitude
001	Pendleton Street CSO	Potomac River	N 38 48 35	W 77 02 19
002	Royal Street CSO	Hunting Creek	N 38 47 03	W 77 02 49
003	Duke Street CSO	Hooff's Run	N 38 48 15	W 77 03 33
004	Hooff's Run CSO	Hooff's Run	N 38 48 13	W 77 03 34

The City of Alexandria has had an approved LTCP since February 1999 (Greeley and Hansen 1999). As discussed in the City of Alexandria's recent permit application summary report, previous studies showed that the CSO discharges did not preclude attainment of existing water quality standards. The City's VPDES permit has gone through three permit cycles of VDEQ review and approval since 1995 and its current operating status is that of post-construction compliance monitoring. As required, the City of Alexandria continues to implement the NMC (including maximizing CSS flow through the ASA advanced wastewater treatment plant) and conduct post construction monitoring to verify compliance with water quality standards and ascertain the effectiveness of CSO controls (Greeley and Hansen 2006b).

Figure 5. Combined Sewer System for the City of Alexandria, Virginia



The design capacity of the ASA WWTP is 54 MGD with a peak capacity of 108 MGD. As shown in Table 3, ASA's WWTP has two discharge points, Outfalls 001 and 002. Outfall 001 discharges to Hunting Creek and receives tertiary treatment. Outfall 002 is only used in the event that the UV disinfection system fails.

Table 3. Location of the ASA WWTP Outfalls

Outfall	Stream	Latitude[1]	Longitude[1]
001	Hunting Creek	N 38 47 37	W 77 03 06
002[2]	Hooff's Run	N 38 47 49	W 77 03 06

[1] Location coordinates correspond to NPDES permit and do not necessarily reflect points of entry to receiving waters.
[2] Outfall 002 is a back-up outfall if UV disinfection system fails. Effluent would receive chlorination and de-chlorination.

2.2 DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY

DC WASA operates the Blue Plains Advanced Wastewater Treatment Plant (Blue Plains) and a CSS and is authorized to discharge under NPDES permit DC0021199. Blue Plains is a regional plant serving the District of Columbia, Montgomery and Prince Georges Counties in Maryland, and Fairfax and Loudoun Counties in Virginia. The service area for Blue Plains includes 12,478 acres that comprises the CSS in the District of Columbia. The remainder of the service area in the District of Columbia and in the suburban jurisdictions is comprised of separate sanitary sewer systems.

Blue Plains provides treatment for dry weather flows (DWF) and wet weather flows (WWF) from the service area. In its current configuration, Blue Plains provides complete treatment at all times. During wet weather or combined sewer system flow (CSSF) conditions, Blue Plains provides complete treatment and excess flow treatment. Treatment capacities at Blue Plains are presented in Table 4.

Table 4. Existing Treatment Capacity for Blue Plains

Condition	Treatment Capacity (MGD)		
	Complete	Excess Flow	Total
DWF (Annual Average)	370	--	370
CSSF - Conditions			
• First 4 hours	740	336	1,076
• After 4 hours	511	336	847

The Complete Treatment facilities comprise preliminary, secondary and nitrification/denitrification followed by effluent filtration and disinfection (chlorination and dechlorination). Excess Flow Treatment comprises primary clarification followed by chlorination and dechlorination.

Blue Plains has two outfalls. Outfall 001 serves the Excess Flow Treatment facilities and is classified as a CSO-Related Bypass. Outfall 002 serves the Complete Treatment facilities. The locations of these outfalls are listed in Table 5.

Table 5. Location of the Blue Plains Outfalls

Outfall	Latitude	Longitude
001	N 38 49 00	W 77 01 59
002	N 38 48 49	W 77 01 39

Blue Plains will be required to meet total nitrogen limits under a reissuance of its NPDES permit. A supplement to the LTCP provides for combining nitrogen removal and wet weather treatment at Blue Plains. Under the LTCP supplement plan, the wet weather or CSSF conditions peak flow rate to Complete Treatment will be reduced by providing equalization storage in the LTCP tunnel system, the Excess Flow Treatment facilities will be replaced by new Enhanced Clarification Facilities (ECF), and the tunnel system will be emptied employing an operating routine that provides for maintaining a rate of 511 MGD through Complete Treatment while optimizing conditions for maintaining the availability of tunnel system storage such that the occurrence of CSOs is minimized. The new ECF comprises enhanced clarification followed by disinfection (chlorination and dechlorination). Following completion of the nitrogen removal facilities and the ECF, treatment capacity at Blue Plains will be modified as shown in Table 6.

Table 6. Post-LTCP Capacities for Blue Plains

<table>
<tr><th rowspan="2">Condition</th><th colspan="4">Treatment and Diversion Capacities (MGD)</th></tr>
<tr><th>Complete Treatment</th><th>ECF</th><th>Tunnel System Diversion</th><th>Total</th></tr>
<tr><td>DWF (Annual Average)</td><td>370</td><td>n/a</td><td>n/a</td><td>370</td></tr>
<tr><td>CSSF - Conditions</td><td></td><td></td><td></td><td></td></tr>
<tr><td>• First 4 hours</td><td>555</td><td>225</td><td>521</td><td>1301</td></tr>
<tr><td>• After 4 hours</td><td>511</td><td>225</td><td>521</td><td>1257</td></tr>
</table>

Complete Treatment effluent will continue to be discharged from Outfall 002 and ECF effluent will be discharged from Outfall 001. The new ECF will provide a higher quality effluent than the existing Excess Flow Treatment facilities, and the overall water quality condition under the supplemented LTCP is predicted to equal that predicted for the original LTCP.

Figure 6 depicts the area served by the DC WASA CSS in relation to the Chesapeake Bay watershed model segmentation. The CSS has 53 active CSO outfalls, four abandoned outfalls, and four emergency relief points at pump stations[4]. As shown in Table 5, the Anacostia River has 15 CSOs, while 10 CSOs discharge to the Potomac River, and 28 CSOs discharge to Rock Creek.

DC WASA has an approved LTCP (Greeley and Hansen 2002a).

[4] DC WASA outfalls 004, 008, 061 and 062 are emergency relief points at pumping stations. They are not authorized to discharge.

Figure 6. Combined Sewer System for the District of Columbia Water and Sewer Authority

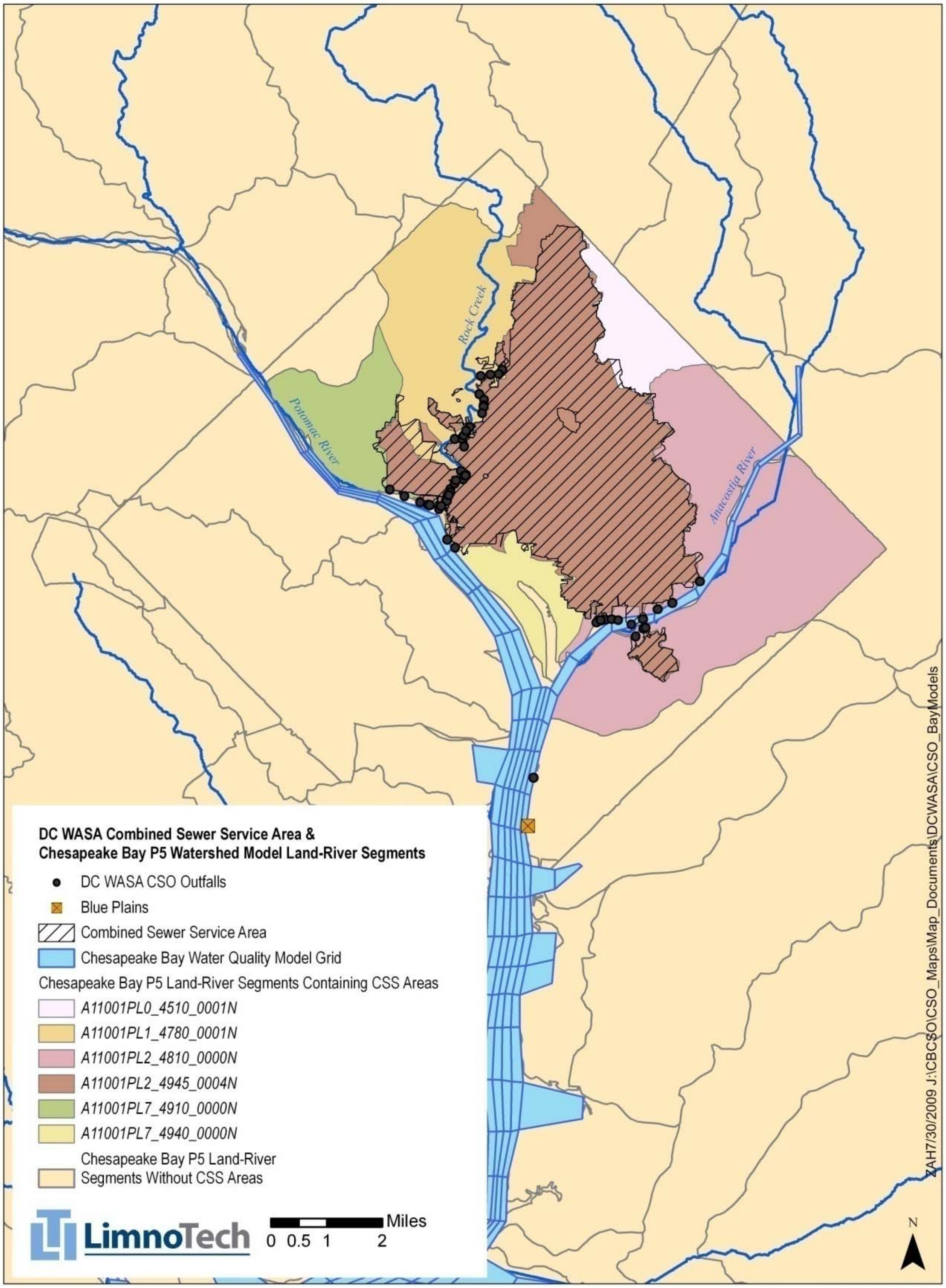


Table 7. District of Columbia Water And Sewer Authority Combined Sewer System Outfall Locations

Outfall (1)	Structure Location	Stream	Latitude (approximate)	Longitude (approximate)
003	Bolling AFB	Potomac River	N 38 49 51	W 77 01 32
004	Emergency relief for Poplar Point Sewage Pumping Station, SE	Anacostia River, East Side	N 38 51 57	W 77 00 18
005	Chicago Street and Railroad Station, SE	Anacostia River, East Side	N 38 52 08	W 76 59 36
006	Good Hope Road, West of Nichols Ave, SE	Anacostia River, East Side	N 38 52 16	W 76 59 28
007	13th Street and Ridge Place,SE	Anacostia River, East Side	N 38 52 16	W 76 59 19
008 (2)	Anacostia Ave. west of Blaine St. NE – relief for Anacostia Main Interceptor	Anacostia River, East Side	N 38 53 29	W 76 57 46
009	2nd Street, 300 feet North of N Place, SE	Anacostia River, West Side	N 38 52 21	W 77 00 15
010	O Street Sewage Pumping Station, SE	Anacostia River, West Side	N 38 52 23	W 77 00 14
011	South of Main Sewage Pumping Station, SE (pumped overflow)	Anacostia River, West Side	N 38 52 22	W 77 00 17
011a	South of Main Sewage Pumping Station, SE (gravity overflow)	Anacostia River, West Side	N 38 52 22	W 77 00 17
012	North of Main Sewage Pumping Station, SE	Anacostia River, West Side	N 38 52 22	W 77 00 09
013	4th and N Streets, SE	Anacostia River, West Side	N 38 52 22	W 77 00 09
014	6th and M Streets, SE	Anacostia River, West Side	N 38 52 23	W 76 59 09
015	9th and M Streets, SE	Anacostia River	N 38 52 18	W 76 59 38
016	12th and M Streets, SE	Anacostia River, West Side	N 38 52 20	W 76 59 28
017	14th and M Streets, SE	Anacostia River	N 38 52 31	W 76 59 28
018	Barney Circle and Pennsylvania Ave, SE	Anacostia River	N 38 52 39	W 76 58 57
019	NE Boundary Trunk, Vic.Of 25th and E Sts., SE	Anacostia River, West Side	N 38 52 21	W 77 00 09
020	23rd Street, North of Constitution Ave, NW	Potomac River, East Side	N 38 53 10	W 77 03 03
021	Northeast of Roosevelt Bridge, NW	Potomac River, East Side	N 38 53 19	W 77 03 11
022	27th and K Streets, NW	Potomac River, East Side	N 38 53 52	W 77 03 27
023	Abandoned (Formerly 29th and K Streets, NW)	Potomac River, East Side	Not Available	
024	30th and K Streets, NW	Potomac River, East Side	N 38 54 05	W 77 03 31
025	31st and K Streets, NW	Potomac River East Side	N 38 54 03	W 77 03 44
026	Wisconsin Avenue and K St., NW	Potomac River, East Side	N 38 54 06	W 77 03 47

Table 7. District of Columbia Water And Sewer Authority Combined Sewer System Outfall Locations

Outfall (1)	Structure Location	Stream	Latitude (approximate)	Longitude (approximate)
027	Water Street West of Street, NW	Potomac River, East Side	N 38 54 13	W 77 03 57
028	36th and M Streets, NW	Potomac River, East Side	N 38 54 13	W 77 04 18
029	Canal Road 1000 feet east of Rock Creek, NW	Potomac River, East Side	N 38 49 00	W 77 01 40
030	Abandoned (Formerly Foxhall and Canal Roads, NW)	Potomac River, East Side	Not Available	
031	Pennsylvania Avenue, East Rock Creek, NW	Rock Creek, East Side	N 38 54 23	W 77 03 22
032	26th and M Streets, NW	Rock Creek, East Side	N 38 54 22	W 77 03 17
033	N Street extended west of 25th Street,NW	Rock Creek, East Side	N 38 54 26	W 77 03 18
034	23rd and O Streets, SW	Rock Creek, East Side	N 38 54 36	W 77 03 05
035	22nd Street south of Q Street, NW	Rock Creek, East Side	N 38 54 33	W 77 03 00
036	22nd Street South of Q Street, NW	Rock Creek, East Side	N 38 54 38	W 77 03 06
037	Northwest of Belmont and Rock Creek and Potomac Parkway	Rock Creek, East Side	N 38 55 02	W 77 03 04
038	North of Belmont Road, East of Kalorama Circle, NW	Rock Creek, East Side	N 38 55 08	W 77 03 05
039	Connecticut Avenue east of Creek, NW	Rock Creek, East Side	N 38 55 18	W 77 02 56
040	Biltmore Street extended east of Rock Creek, NW	Rock Creek, East Side	N 38 55 40	W 77 02 43
041	Ontario extended and Rock Creek Parkway	Rock Creek, East Side	N 38 55 40	W 77 02 43
042	Harvard Street and Rock Creek Parkway, NW	Rock Creek	N 38 55 42	W 77 02 43
043	Adams Mill Road South of Irving Street, NW	Rock Creek, East Side	N 38 55 42	W 77 02 42
044	Kenyon Street and Adams Mill Road, NW	Rock Creek East Side	N 38 55 44	W 77 02 44
045	Adams Mill Road and Lamont Street, NW	Rock Creek, East Side	N 38 55 50	W 77 02 49
046	Park Road south of Piney Branch Parkway, NW	Rock Creek, East Side	N 38 56 06	W 77 02 45

Table 7. District of Columbia Water And Sewer Authority Combined Sewer System Outfall Locations

Outfall (1)	Structure Location	Stream	Latitude (approximate)	Longitude (approximate)
047	Ingleside Terrace extended and Piney Branch Parkway	Rock Creek, East Side	N 38 56 10	W 77 02 36
048	Mt. Pleasant Street extended and Piney Branch Parkway	Rock Creek, East Side	N 38 56 15	W 77 02 23
049	Piney Branch and Lamont Street, NW	Rock Creek, East Side	N 38 56 12	W 77 02 19
050	28th Street west of 16th Street, NW	Rock Creek, East Side	N 38 54 14	W 77 03 23
051	Olive Street extended and Rock Creek Parkway, NW	Rock Creek, East Side	N 38 54 32	W 77 03 11
052	O Street extended and Rock Creek Parkway, NW	Rock Creek, West Side	N 38 54 31	W 77 03 16
053	O Street west of Rock Creek Parkway, NW	Rock Creek, West Side	N 38 55 18	W 77 01 40
054	West Side of Rock Creek 300 ft. south of Mass. Ave, NW	Rock Creek, West Side	N 38 54 34	W 77 03 02
055	Abandoned		Not Available	
056	Normanstone Drive extended west of Rock Creek, NW	Rock Creek, West Side	N 38 55 02	W 77 03 04
057	28th Street extended west of Rock Creek, NW	Rock Creek, West Side	N 38 55 18	W 77 03 09
058	Connecticut Avenue and Rock Creek Parkway, NW	Rock Creek, West Side	N 38 55 16	W 77 03 02
059	Abandoned (Formerly16th and Rittenhouse Streets, NW)	Rock Creek, West Side	N 38 57 54	W 77 02 13
060	P St and 26th St, NW	Rock Creek, West Side	Not Available	
061 (2)	Hayes St. & Anacostia Ave NE – Emergency relief for Upper Anacostia Sewage Pumping Station	Tributary to Anacostia – East Side	Not Available	
062 (2)	Earl Place, NE - Emergency relief for Earl Place Sewage Pumping Station	Tributary to Anacostia – West Side	Not Available	

(1) All outfalls are CSO outfalls unless noted otherwise.
(2) These outfalls are recognized in the permit as emergency relief locations; they are not CSO Outfalls. Discharges are prohibited under Part III.B.1.e (i) and are reportable under Part III.B.1.e (iii) and Part II.D.2 and 7.

2.3 CITY OF RICHMOND, VA

The City of Richmond owns and operates a CSS and a WWTP. The VPDES permit number for the WWTP and the CSOs is VA0063177.

The design capacity of the Richmond WWTP is 45 MGD with a peak capacity of 90 MGD. Effluent from Outfall 001, which discharges to the James River, receives tertiary treatment. The location of Outfall 001, the only discharge point for the WWTP, is described in Table 8.

Table 8. Location of the Richmond WWTP Outfalls

Outfall	Stream	Latitude	Longitude
001	James River	N 37 31 01	W 77 25 06

The service area for the CSS includes about 12,000 acres served by combined sewers, as shown in Figure 7. The CSS has 32 remaining outfalls (other outfalls have been eliminated through sewer separation) and two retention systems, the 50 million gallon Shockoe Retention System and the 7.2 million gallon Hampton/McCloy Retention System. There are 24 outfalls that discharge to the James River and 8 that discharge to Gillies Creek as described in Table 9.

Richmond operates the WWTP to provide treatment to flow rates up to 90 MGD, in accordance with its VPDES permit. CSO treatment conditions prevail on any day where the flow entering the WWTP exceeds the permitted dry weather flow of 45 MGD by more than 30 MGD, and on the day after any day when the flow exceeds the permitted dry weather flow by more than 40 MGD.

When wastewater is stored in the Shockoe Retention System, the WWTP treats at least 75 MGD until the system is empty. When wastewater is stored only in the Hampton/McCloy Retention System, the system is dewatered at a rate no less than 3.6 MGD until the system is empty.

The City of Richmond has an approved LTCP (Greeley and Hansen 2002b) and is implementing the LTCP under a Special Order (VA DEQ 2005).

Figure 7. Combined Sewer System for the City of Richmond, Virginia

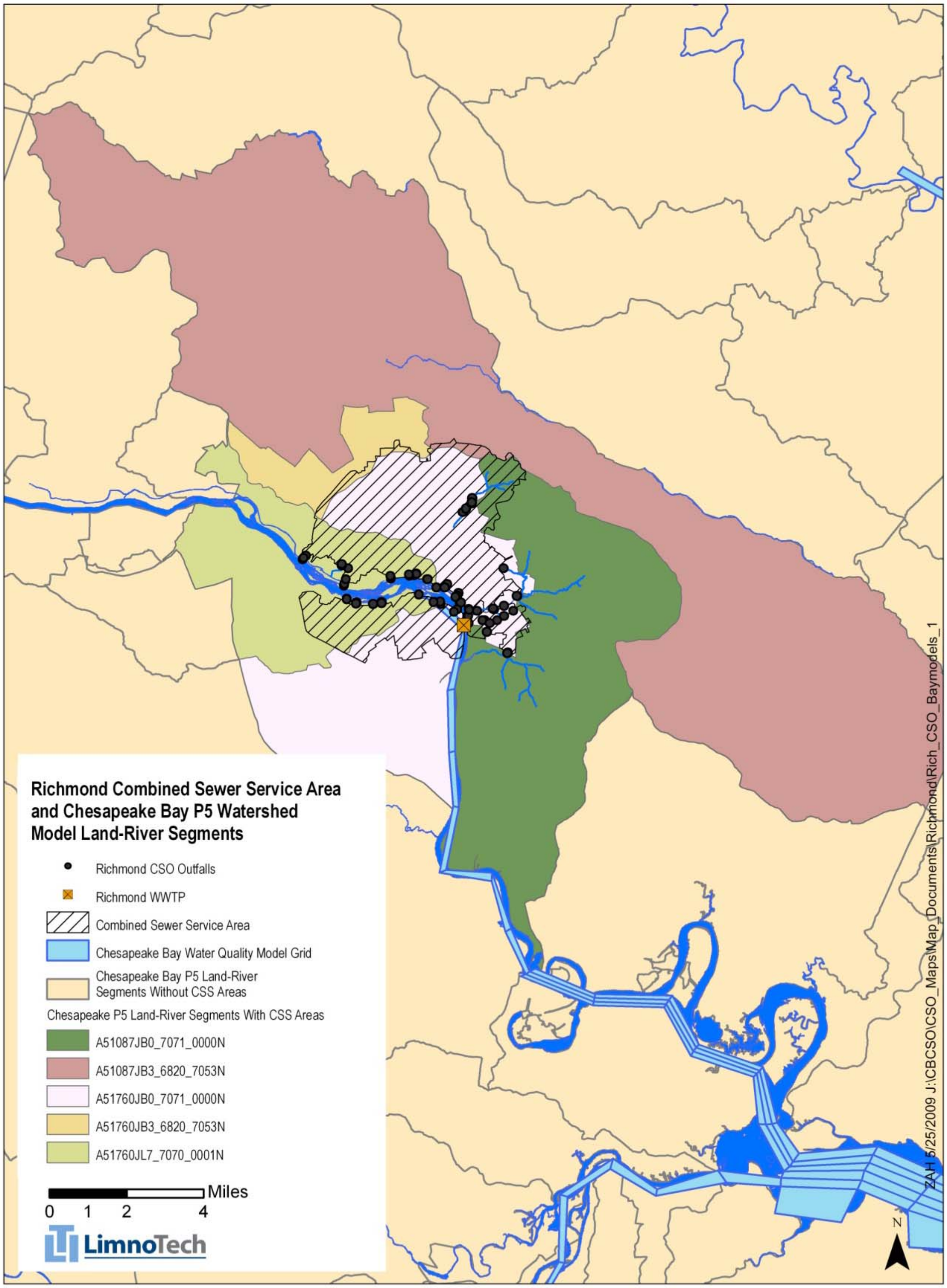


Table 9. Location of the Richmond, VA CSOs

CSO	Description	Stream	Latitude	Longitude
002	Orleans Street Regulator – Orleans & Main Streets	James River	N 37 31 05	W 77 25 00
003	Nicholson Street Regulator – Nicholson and Main Streets	James River	N 37 31 14	W 77 25 01
004	Bloody Run Regulator – Main Street, southeast of 32nd Street	Gillies Creek	N 37 31 23	W 77 25 00
005	Peach Street Regulator – South of Intersection of Peach and Dock Streets	James River	N 37 31 32	W 77 25 15
006	Shockoe Creek Regulator – Between Mayo's Bridge and 17th Street	James River	N 37 31 53	W 77 25 56
007	Byrd Street Regulator – Byrd Street, between 12th and 13th Streets	James River	N 37 32 03	W 77 26 12
008*	6th Street Regulator	Haxall Canal		
009	7th Street Regulator – 7th and Bragg Streets	Haxall Canal	N 37 32 07	W 77 26 35
010	Gambles Hill System – Off of Tredegar Street, west of 7th	Haxall Canal	N 37 32 08	W 77 26 41
011	Park Hydro Station Regulator – Tredegar Street, west of Lee Bridge	James River	N 37 32 02	W 77 27 15
012	Hilton Street Regulator – Southwest of Intersection of Hilton and Salem Streets	Almond Creek	N 37 30 25	W 77 23 54
013	Maury Street Regulator – Maury and Brander Streets	Manchester Canal (Cotton Mill Creek)	N 37 31 31	W 77 25 45
014	Stockton Street Regulator – Stockton and Bedford Streets	Manchester Canal (Cotton Mill Creek)	N 37 31 32	W 77 26 00
015	Canoe Run Regulator – Next to Southern Railway Line, north of Riverside Drive and 22nd Streets	James River	N 37 31 30	W 77 27 27
016	Woodland Heights Regulator – Next to Southern Railway Line, north of Riverside Drive and 26th Street	James River	N 37 31 28	W 77 27 42
017	Reedy Creek Regulator – Next to Southern Railway Line, approx. north of Riverside Drive and 30th Street	James River	N 37 31 39	W 77 28 12
018	42nd Street Regulator	James River	N 37 31 33	W 77 28 25
019 019b	Hampton Regulator	James River	N 37 31 51	W 77 28 29
020	McCloy Street Regulator	James River	N 37 32 24	W 77 29 42
021	Gordon Avenue Regulator	James River	N 37 31 21	W 77 25 18
023*	Old Ful Street Bridge Regulator	Gillies Creek	N 37 31 41	W 77 23 18
024	Gillies & Varina Streets Regulator	Gillies Creek	N 37 31 23	W 77 24 13
025	Briel Street & Gillies Creek Regulator	Gillies Creek	N 37 31 42	W 77 23 38
026	Government Road & NSSR Regulator	Gillies Creek	N 37 31 28	W 77 23 58

Table 9. Location of the Richmond, VA CSOs

CSO	Description	Stream	Latitude	Longitude
027*	New Westburg Road Regulator	Gillies Creek	N 37 31 41	W 77 23 18
028	Westburg Road Regulator	Gillies Creek	N 37 31 20	W 77 24 44
031	Oakwood Cemetery Regulator	Gillies Creek	N 37 32 21	W 77 24 01
033	Shields Lake Regulator	Shields Lake	N 37 32 18	W 77 28 34
034	19th & Dock Streets Regulator	City Dock	N 37 31 52	W 77 25 40
035	29th & Dock Streets Regulator	City Dock	N 37 31 39	W 77 25 22
039	Gov't Road & Gillies Regulator	Gillies Creek	N 37 31 23	W 77 24 18
040	Diff. User (CSO1-Outlet)		N 37 31 41	W 77 26 23

2.4 CITY OF LYNCHBURG, VA

The City of Lynchburg owns and operates a CSS and the Lynchburg Regional WWTP. The Lynchburg Regional WWTP serves the City of Lynchburg and portions of Amherst, Bedford, and Campbell counties. The VPDES permit for the WWTP and the CSOs is VA0024970.

The design capacity of the Lynchburg Regional WWTP is 22 MGD with a peak capacity of 44 MGD to pass flow through the facility before a bypass is required due to pump station capacity limitations (Scarano, 2009). The location of the WWTP discharge is presented in Table 10.

Table 10. Location of the Lynchburg Regional WWTP Outfall

Outfall	Stream	Latitude	Longitude
001	James River	N 37 23 53	W 79 06 50

The City of Lynchburg originally had 132 CSO outfalls and has steadily reduced the number of CSOs through sewer separation projects (Lynchburg 1989 and 2000; Mitchell 2008). The service area for the CSS of six square miles (approximately 3,000 acres) and the locations of the 31 remaining CSOs are shown in Figure 8. Detailed information on the locations of the active outfalls is presented in Table 11.

The City of Lynchburg continues to address its CSOs under a Special Order of Consent with the State of Virginia signed in 1994. The City of Lynchburg has also recently initiated a study to review and update the CSO LTCP and anticipates that this update will be completed by the end of 2010.

Figure 8. Combined Sewer System for the City of Lynchburg, Virginia

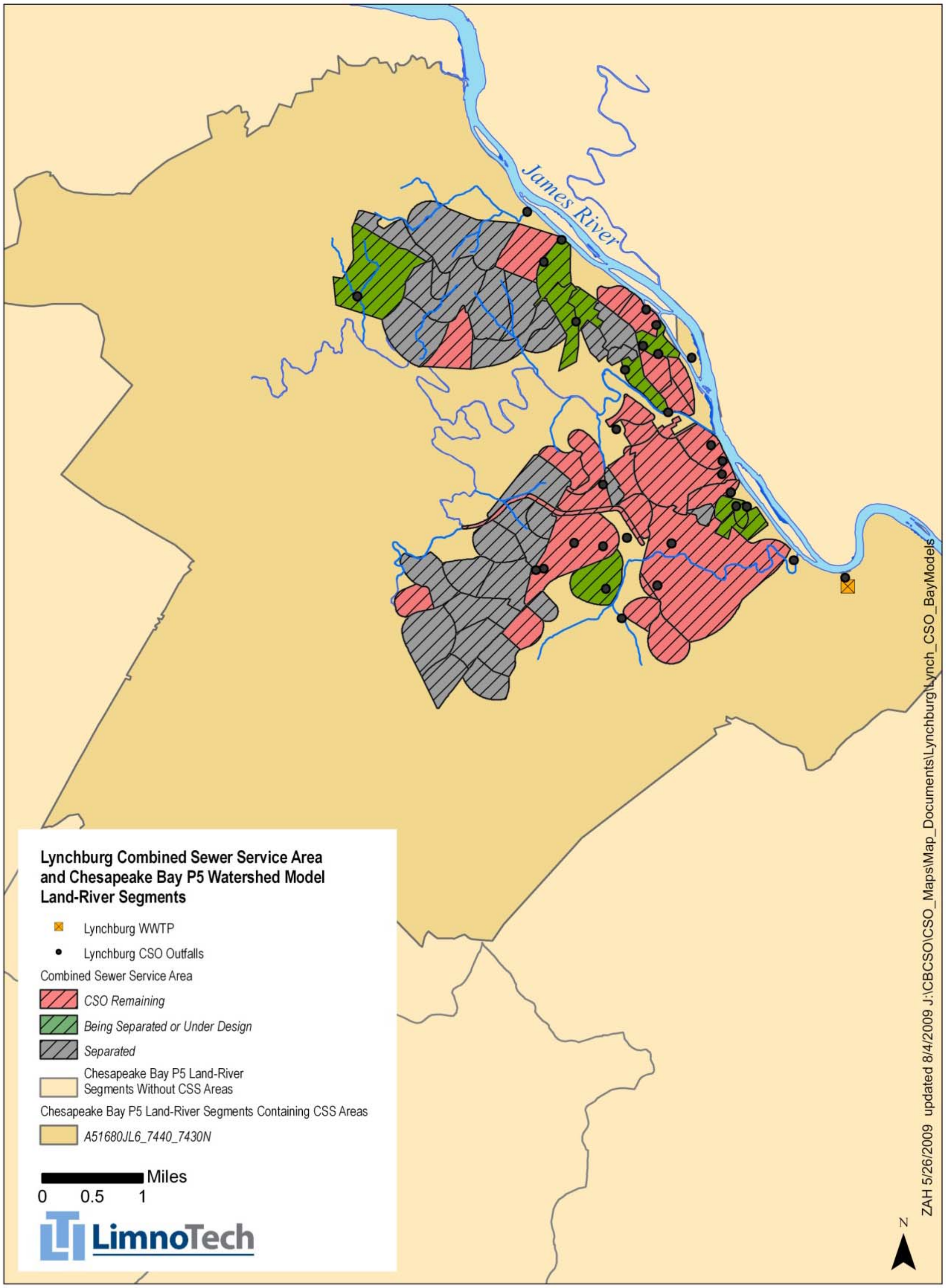


Table 11. CSO Outfalls for the City of Lynchburg

CSO	Description	Stream	Latitude	Longitude
9	Dead end off Byrd and Belmont Streets	Tributary to Blackwater Creek	N 37 25 31	W 79 09 21
11	Monroe and 1st Streets	Tributary to Blackwater Creek	N 37 25 00	W 79 09 25
14	Between Brook Street and Centerdale Street	Fishing Creek	N 37 34 00	W 79 09 49
15	Between Kemper Street and 15th Street	Tributary to Fishing Creek	N 37 24 04	W 79 09 15
17	Tiden Avenue and 14th Street	Tributary to Fishing Creek	N 37 23 59	W 79 09 30
23	Kindley Avenue and Newberne Street	Tributary to Blackwater Creek	N 37 23 37	W 79 10 53
33	Mansfield Avenue between Eldon Street and Oakley Avenue	Tributary to Fishing Creek	N 37 23 46	W 79 10 08
34	Euclid Avenue and Eldon Street	Tributary to Fishing Creek	N 37 23 45	W 79 10 13
44	Hollins Mill Road at Cleveland Avenue	Tributary to Blackwater Creek	N 37 25 55	W 79 09 54
48	Pansy Street between Amherst Street and Botetourt Street	Tributary to James River	N 37 25 44	W 79 09 10
52	Beneath Rivermont Bridge at Blackwater Creek Trail	Blackwater Creek	N 37 25 10	W 79 08 52
55	Dead end of Pansy Street at Norwood Street	Tributary to James River	N 37 25 40	W 79 09 00
56	Horseford Road at Commerce Street	James River	N 37 24 39	W 79 08 15
57	13th Street and Jefferson Street	James River	N 37 24 46	W 79 08 15
59	10th Street and Jefferson Street	James River	N 37 24 54	W 79 08 23
60	9th Street and Jefferson Street (CLOSED)	James River	N 37 24 57	W 79 08 25
61	Main Street and Elm Street	Tributary to James River	N 37 24 23	W 79 08 05
62	Between Holiday Street and Tazewell Street	Tributary to Fishing Creek	N 37 23 40	W 79 08 54
66	19th Street and Floyd Street	Tributary to Fishing Creek	N 37 24 02	W 79 08 46

Table 11. CSO Outfalls for the City of Lynchburg

CSO	Description	Stream	Latitude	Longitude
68	Gordon Street and Carroll Avenue	Fishing Creek	N 37 23 37	W 79 09 27
70	Off Greene Street at Cobbs Street	Tributary to Fishing Creek	N 37 23 22	W 79 09 16
74	Dumas Street and Midvale Street (CLOSED)	Tributary to Blackwater Creek	N 37 23 17	W 79 10 53
78	Wingfield Avenue near Warren Avenue (CLOSED)	Tributary to Blackwater Creek	N 37 23 33	W 79 10 36
80	Edgar Street and McCausland Street (CLOSED)	Tributary to Blackwater Creek	N 37 23 30	W 79 10 58
81	Sussex Street and McCausland Street (CLOSED)	Tributary to Blackwater Creek	N 37 23 27	W 79 10 54
92	Dead end Quarry Street and Woodcrest Drive	Tributary to Ivy Creek	N 37 26 03	W 79 12 17
97	Access Road off Hydro Street at CSX Railroad	James River	N 37 26 51	W 79 10 29
98	Behind Randolph Macon Woman's College at athletic field	Tributary to James River	N 37 26 38	W 79 10 17
100	Garnet Street at CSX Railroad	James River	N 37 24 23	W 79 07 58
102	Dead end of McKinney Avenue (CLOSED)	Tributary to Fishing Creek	N 37 22 40	W 79 10 31
109	Concord Turnpike at Wastewater Treatment Plant	James River	N 37 23 48	W 79 06 52
113	Pigeon Creek behind Orphanage (CLOSED)	Pigeon Creek	N 37 26 46	W 79 11 32
116	Meeting House Branch at 7th Street Extended	Meeting House Branch	N 37 24 31	W 79 09 32
121	James River and Cedar Drive	James River	N 37 26 37	W 79 10 06
122	James River and Denver Avenue	James River	N 37 26 03	W 79 09 09
123	James River and Willow Street Extended	James River	N 37 25 55	W 79 09 02
124	James River and I Street Extended	James River	N 37 25 39	W 79 08 38
125	Carter Glass Bridge and Concord Turnpike	James River	N 37 24 30	W 79 08 09
133	Concord Turnpike and Fishing Creek	Fishing Creek	N 37 23 56	W 79 07 26

3. CSS WORKING GROUP – CSS DATA

The data gathering process for the CSS Working Group centered on the collection of rainfall amounts, WWTP and CSO flows, nutrient and sediment concentrations, and collection system hydrologic and hydraulic (H&H) model simulations of CSSs.

3.1 RAINFALL DATA

A summary of the average annual rainfall recorded for the airports used as the bases for development of LTCPs for the CSS Working Group members is presented in Table 12. The summary presented in Table 12 also uses shading to denote the representative years used by the CBP and Working Group members for model simulation purposes. This includes:

- The representative period of 1974 to 1978 used by the City of Richmond for evaluation of CSO control alternatives.
- The representative period of 1988 to 1990 used by the City of Alexandria and DC WASA for evaluation of CSO and/or CSO control alternatives.
- The twenty-one year period of 1985 to 2005 used by the CBP for calibration of the WQSTM.
- The ten-year period of 1991 to 2000 used by the CBP for application of the WSM and WQSTM models to assess TMDLs (the TMDL Period).

The City of Lynchburg has pursued full separation of the CSS, but is currently re-evaluating the targeted level of control. A representative rainfall period has not yet been selected for the review and update of the City of Lynchburg LTCP.

Interpretation of the rainfall data reveals that the annual average rainfall for the representative periods used to evaluate CSO controls and for LTCP development by the City of Alexandria, DC WASA, and the City of Richmond is greater than the annual average rainfall used by the CBP for the TMDL period. Therefore, it is important to recognize that the CSO loads that will be included in the TMDL are consistent with the LTCPs, and that the allocations expressed in the TMDL can be different than those in the LTCP because of the different timeframes. In addition, future NPDES permits should reflect that the appropriate levels of control are specified in the CSO LTCPs, and that these controls are consistent with the allocations in the TMDL.

Table 12. Average Annual Rainfall for the CSS Working Group LTCPs and the Chesapeake Bay TMDL

			Year	Richmond International Airport	Reagan National Airport[1] (DC WASA)	Reagan National Airport[1] (Alexandria)	Lynchburg Regional Airport
		Richmond LTCP	1974	35.70	NA	NA	NA
			1975	61.31	NA	NA	NA
			1976	34.76	NA	NA	NA
			1977	44.08	NA	NA	NA
			1978	47.62	NA	NA	NA
			1979	57.12	47.33	47.33	NA
			1980	41.13	29.32	29.32	NA
			1981	35.87	30.67	30.67	NA
			1982	46.48	35.77	35.77	NA
			1983	43.43	51.87	51.87	NA
			1984	46.04	37.73	37.73	NA
20-year Chesapeake Bay Model Calibration			1985	49.08	35.86	35.86	54.22
			1986	36.56	32.57	32.57	32.07
			1987	40.27	36.63	36.63	41.15
		ALX and DC WASA LTCP	1988	37.26	31.74	31.74	31.50
			1989	49.74	50.32	50.32	45.77
			1990	41.93	40.84	40.84	35.71
	Chesapeake Bay TMDL		1991	35.78	29.62	29.62	28.33
			1992	41.55	36.38	36.38	33.77
			1993	42.25	41.41	41.41	38.23
			1994	43.81	37.57	37.56	36.85
			1995	34.44	39.85	39.85	37.34
			1996	54.13	50.24	50.24	43.77
			1997	34.13	32.22	32.21	27.52
			1998	46.75	33.32	33.31	35.38
			1999	48.20	40.02	40.02	35.24
			2000	43.15	39.28	39.28	31.29
			2001	31.52	29.95	29.90	26.79
			2002	37.77	33.43	33.38	31.82
			2003	63.29	59.19	59.12	49.58
			2004	58.50	41.37	42.36	27.02
			2005	41.54	41.67	41.63	29.14
			2006	52.12	47.77	47.77	NA
			2007	37.90	32.93	32.93	NA
			2008	49.55	46.49	46.49	NA
Average (20 year calibration)				*43.41*	*38.74*	*38.77*	*35.83*
Average (TMDL period)				*42.42*	*37.99*	*37.99*	*34.77*
Average (LTCP periods)				*44.69*	*40.97*	*40.97*	

NOTES:

[1] Ronald Reagan Airport applies to both DC WASA and Alexandria, VA

3.2 WWTP AND CSO FLOWS

CSS Working Group members maintain and apply hydrologic and hydraulic models of their individual systems for planning, design, and/or reporting purposes. These models and other estimation procedures are used to simulate the response of the CSS to rainfall events. The product of these simulations is quantification of CSO flows and volumes at permitted CSO discharge points and at WWTPs. The models were calibrated using local rainfall data and measured flows within the CSS. Following calibration, the models were applied in a forecast mode to simulate CSO discharges associated with various CSO control alternatives for the purpose of CSO control planning, LTCP development, and reporting.

City of Alexandria, VA

The City of Alexandria maintains an EPA SWMM-based collection system model that uses the built-in RUNOFF module for hydrologic modeling and the TRANSPORT and EXTRAN modules for hydraulic modeling. The model represents the combined sewer area in detail, and it also includes flow contributions (sanitary and RDII) from sanitary sewersheds throughout the City of Alexandria and the greater ASA service area. The SWMM model was developed in 2004 based on an existing somewhat more simplistic model of the CSS, the Sewer Overflow Model (SOM), that was previously used to assist the City in managing its' CSO control program. The SWMM model accounts for dry and wet weather boundary flows from the ASA service area based on results of earlier flow studies and adjustment factors based on measured ASA WWTP inflows. The model was calibrated for the time period of October 2002 through December 2003, a period during which metered wet and dry weather flow information was available.

For purposes of this report, simulated CSO and ASA WWTP flows and volumes were produced for 1985 to 2005 to establish the existing or baseline condition. The results of these simulations are summarized in Table 13. No future design scenarios were modeled for the CSOs, since the City of Alexandria already has an approved LTCP. As shown in Table 13, the ASA WWTP flow volumes were split to identify the CSO source as 1) the "Modeled City CSS to WWTP" volumes that include all of the flows from the separate (non-CSO) area of the service area, and 2) the "Modeled Total City CSO" volumes contributed from the CSS.

Table 13. ASA WWTP and City of Alexandria CSO Annual Volumes, Modeled

Year	Rain (in.)	Modeled ASA to WWTP (MG)	Modeled City CSS to WWTP (MG)	Modeled Total City CSO (MG)
1985	35.86	10,879	1,142	125
1986	32.57	10,792	1,144	80
1987	36.63	10,908	1,157	112
1988	31.74	11.539	1,189	85
1989	50.32	12,002	1,279	159
1990	40.84	11,793	1,234	125
1991	29.62	11,737	1,210	63
1992	36.38	11,959	1,247	86
1993	41.41	12,052	1,262	131
1994	37.57	11,959	1,269	82
1995	39.85	12,028	1,257	140
1996	50.24	12,346	1,325	156
1997	32.22	11,806	1,244	79
1998	33.32	11,849	1,256	67
1999	40.02	12,018	1,262	139
2000	39.28	12,486	1,293	121
2001	29.95	12,191	1,257	71
2002	33.43	12,293	1,282	76
2003	59.19	13,745	1,468	210
2004	41.37	13,266	1,378	153
2005	41.67	13,209	1,366	183

District of Columbia Water And Sewer Authority

DC WASA maintains a Mike Urban H&H model for its collection system that uses the MOUSE hydrologic and hydraulic model engines. The model represents the combined sewer area in detail, and also includes contributions from the District's separate sanitary sewersheds and suburban jurisdictions. The model was initially developed and calibrated in 1999-2000 for the LTCP, and was recalibrated in 2003-2004.

An annual summary of DC WASA reported and model simulated annual discharge volumes for Blue Plains and CSOs is presented in Table 14. The summarized information in this table corresponds to the CBP WQSTM model calibration period of 1985 to 2005. As previously noted, the WQSTM calibration period encompasses the DC WASA CSO LTCP forecast period of 1988 to 1990. Reported volumes from the Blue Plains Outfall 001 (excess flow treatment) and Outfall 002 (complete treatment) are included for periods where this information is available. Flow records for Outfall 001 for 1985 to 1995 were not available and modeled Outfall 001 values are used to fill this gap. The modeled baseline tabulation for CSO outfalls within the collection system for 1985 to 2001 are represented by the baseline or pre-LTCP condition described in DC WASA's C1calibration configuration of the CSS. This configuration represents the collection system with several inflatable dam CSO control structures out of service, and with the Eastside Interceptor partially obstructed. The baseline pre-LTCP conditions for CSO outfalls within the collection system for 2002-2005 are described in DC WASA's C2 configuration of the CSS. This configuration represents the inflatable dams in service and the Eastside Interceptor at full capacity. The baseline total CSOs tabulation sums up the volumes presented for the Baseline Outfall 001 and Baseline CSO outfalls.

Table 14. DC WASA Blue Plains and Annual Baseline Volumes, Reported and Modeled

Year	Rain (in.)	Reported: Blue Plains Outfall 002, complete treatment (MG)	Reported: Blue Plains Outfall 001 (CSO bypass), excess flow treatment (MG)	Modeled Baseline: Blue Plains Outfall 001 (CSO bypass), excess flow treatment (MG)	Modeled Baseline: CSO outfalls on collection system (MG)	Baseline: total CSOs (MG)
1985	35.86	108,941	not available	118	2,407	2,525
1986	32.57	104,607	not available	25	1,610	1,635
1987	36.63	108,345	not available	188	2,239	2,427
1988	31.74	109,035	not available	4	1,633	1,637
1989	50.32	115,724	not available	223	3,359	3,582
1990	40.84	115,593	not available	56	2,769	2,825
1991	29.62	109,390	not available	27	1,233	1,260
1992	36.38	112,412	not available	60	1,782	1,842
1993	41.41	121,073	not available	152	2,541	2,693
1994	37.57	112,695	not available	126	1,969	2,095
1995	39.85	111,718	not available	83	2,913	2,996
1996	50.24	122,166	519	-	3,537	4,056
1997	32.22	118,990	230	-	1,875	2,105
1998	33.32	117,634	496	-	1,304	1,800
1999	40.02	111,472	272	-	2,825	3,097
2000	39.28	107,454	152	-	2,310	2,462
2001	29.95	115,737	156	-	1,188	1,344
2002	33.43	113,601	558	-	1,365	1,923
2003	59.19	135,008	2,377	-	5,541	7,918
2004	41.37	122,348	834	-	2,281	3,115
2005	41.67	118,679	1,165	-	6,105	7,271

City of Richmond, VA

The City of Richmond maintains an EPA SWMM-based collection system model that uses the built-in RUNOFF module for hydrologic modeling and the TRANSPORT module for hydraulic modeling. The model represents the combined sewer area in detail and incorporates all major intercepting sewers and CSO regulators. The model was initially developed between 1999 and 2001 for the LTCP, and was calibrated using six months of metered flow data monitor for 1999.

A summary of City of Richmond reported and model simulated annual discharge volumes for the WWTP and CSOs is presented in Table 15. These volumes represent the existing or pre-LTCP condition.

Table 15. Annual Richmond Reported WWTP and Modeled CSO Volumes for 1985-2005 Baseline Existing Conditions

Year	Rain (in.)	Reported WWTP Discharge Volume (MG)	Modeled CSO Discharge Volume (MG)
1985	49.08	24,161	5,181
1986	36.56	26,695	3,304
1987	40.27	27,705	3,416
1988	37.26	28,553	3,135
1989	49.74	29,201	3,751
1990	41.93	20,242	3,408
1991	35.78	17,383	2,982
1992	41.55	18,785	3,153
1993	42.25	20,064	3,140
1994	43.81	21,110	3,546
1995	34.44	18,770	2,356
1996	54.13	20,892	3,972
1997	34.13	18,078	2,099
1998	46.75	19,067	3,819
1999	48.2	16,371	3,715
2000	43.15	17,517	2,343
2001	31.52	13,762	1,709
2002	37.77	15,416	1,434
2003	63.29	22,722	4,296
2004	58.5	22,866	3,830
2005	41.54	20,073	2,826

City of Lynchburg, VA

The City of Lynchburg maintains an EPA SWMM-based collection system model of its combined sewer system that was originally constructed to represent 1989 conditions in the CSS. The model is not operated in a continuous simulation fashion, but instead was calibrated to simulate conditions for individual storm events. A regression approach, based upon SWMM simulation results for a range of typical storm events, is utilized to estimate overflows at each outfall in response to daily rainfall conditions for annual overflow reporting needs. The SWMM model was updated in 1995, 1998, 2000, 2002, and 2007 to reflect changes in the CSS including sewer separation and other upgrades.

In order to develop CSO discharge volumes and loads covering the entire 1985-2005 WQSTM calibration period, gaps in the available City records of the model-based data were filled based upon a linear regression of daily total CSO volume versus rainfall from the periods during which model-based overflow predictions were available. Separate overflow-rainfall regressions were produced for the periods of 1989-1994 and 2000-2005, to account for the 1995 model update. These two regressions allowed estimates of CSO discharge volume to be generated for the 1985-1988 period prior to when model-based estimates were available, and for gaps in the existing records of the model-based data for other periods. This approach was used in conjunction with reported WWTP volumes to develop flows and volumes consistent with the WQSTM model calibration time period. Lynchburg WWTP flows were estimated by using operations data and rolling-average rainfall to distinguish and estimate wet and dry weather treatment plant flows. The annual volumes of observed WWTP discharge, model-based CSO predictions, and estimated treated wet weather for the City of Lynchburg are presented in Table 16.

Table 16. Lynchburg Regional WWTP and CSO Annual Volumes

Year	Rain (in.)	Model-based Total CSO (MG)	Estimated Treated Wet Weather (MG)	Observed Total WWTP Discharge (MG)
1985	54.2	369	660	5,018
1986	32.1	219	538	4,704
1987	41.2	280	497	4,883
1988	31.5	215	424	4,131
1989	49.5	289	664	5,385
1990	35.7	211	601	5,345
1991	28.3	150	641	4,942
1992	33.8	175	592	4,194
1993	38.2	217	628	4,963
1994	36.9	176	573	5,040
1995	37.3	207	629	4,524
1996	43.8	185	821	5,007
1997	27.5	107	538	4,493
1998	35.4	218	352	4,967
1999	35.2	190	229	4,749
2000	31.3	137	499	4,837
2001	26.8	126	568	4,153
2002	31.8	109	660	4,279
2003	49.6	226	885	5,847
2004	27.0	97	662	4,637
2005	29.1	85	588	4,548

4. CSS WORKING GROUP – CSS CONCENTRATION DATA AND LOAD ESTIMATION

The CSS Working Group monitoring data for nutrients and TSS available to characterize concentrations for CSO water quality constituents from CSS areas varies widely in terms of both the type of monitoring that has been carried out and the amount of data collected. This data is summarized in Table 17.

Table 17. CSS Working Group data available to characterize CSO water quality constituents

CSO Data				WWTP Influent Data		
Years	Sample Count	Parameters	CSO Outfalls	Years	Sample Count	Parameters
DC WASA				*DC WASA*		
2000	14 events (1-5 samples each)	NH_3, NO_2+NO_3, TKN, TP, PO_4, TSS	010, 012, 019, 021			
City of Alexandria				*ASA WWTP*		
2002-2003	17 events (1-6 samples each)	NH_3, NO_3, NO_2, TKN, TP, TSS	001, 002, 003, 004	1991-2000; 2004-2008	2184	TKN, TN, TP
Richmond				*Richmond*		
				1992-2007	3492 dry; 973 wet[1]	NH_3, NO_3N, NO_2, Org-N, TKN
Lynchburg				*Lynchburg*		
				1986-1992, 2005	84	NH_3, NO_3, NO_2, Org-N, TKN, PO_4

[1] Wet weather assumed when flow >70 mgd; dry weather assumed with flow <45 mgd.

Direct sampling of CSO water quality during wet weather overflow events has only been conducted by DC WASA and the City of Alexandria. The City of Richmond has conducted intensive sampling of WWTP influent and uses this information to effectively distinguish water quality conditions in the CSS.

4.1 CSS WATER QUALITY SAMPLING ASSESSMENT

The data for each CSS Working Group member was reviewed, evaluated and summarized in order to inform the CSS Working Group regarding the range of observed water quality concentrations in CSO discharges. This information forms the basis for recommended event mean concentrations (EMCs) proposed for use by EPA and the states for characterizing CSO loads in the calibration of the WQSTM. The remainder of this section first presents an overview of CSS water quality sampling in each of the CSO communities in the CSS Working Group, and then describes the recommended EMCs and an annual summarization of CSO loads for the CBP model calibration period.

The water quality monitoring data provided by each public agency (as noted above in Table 17) was tabulated, reviewed, and assessed with respect to its potential use for estimating CSO EMCs, and subsequent TMDL allocations, for each CSS Working Group member and across the group as a whole. This section summarizes the CSO and WWTP influent data for each municipal agency and utility, and the constituents for which data were available that could be used to inform the nutrient TMDL.

City of Alexandria, VA

In recent years the City of Alexandria has conducted VPDES permit monitoring of CSO outfalls to support its CSO control program and provide information to VA DEQ on the water quality characteristics of discharges from these outfalls. These data have been used by the City of Alexandria to evaluate the effectiveness of the NMC implementation with respect to meeting the regulatory requirements of its approved CSO LTCP (Greeley and Hansen 2006b).

Available data:

CSO water quality constituent concentration data were available from storm events sampled during 2002 and 2003. Each permitted outfall (CSO 001, 002,003, and 004) was sampled over 3 to 4 events, depending on location (City of Alexandria 2006). A range of 1 to 6 sequential samples per event were collected with NH3, NO3, NO2, TKN, TP and TSS concentrations being measured and reported.

EMC development for CSOs:

The City of Alexandria previously (Greeley and Hansen 2006b) determined composite EMCs for each CSO that had been monitored by flow-weighting aggregated individual storm event EMCs (i.e., for each CSO the total mass/ total volume for all sampled events). These EMCs are summarized in Table 18.

Table 18. Water quality constituent EMCs previously developed for the City of Alexandria CSOs (Greeley and Hansen 2006b)

Water Quality Constituent	*EMC (mg/l)*			
	CSO 001	CSO 002	CSO 003	CSO 004
TKN (mg/L)	4.28	4.12	5.82	16.29
NH_3-N (mg/L)	1.11	1.27	1.65	3.26
NO_3-N (mg/L)	0.53	0.66	0.86	1.00
NO_2-N (mg/L)	0.06	0.03	0.06	0.15
TP (mg/L)	1.04	0.66	0.72	2.38
TSS (mg/L)	128.3	66.4	57.6	157.2

Further evaluation of the CSO monitoring data was undertaken to characterize the range of possible storm event-specific and CSO-specific EMCs for each water quality constituent. While the four storm events that were monitored for the City of Alexandria CSOs were relatively small, it is important to understand and recognize that there is significant variability in observation-based water quality constituent EMCs, both spatially and with respect to individual storm events. The range of the variability in the individual storm event EMCs and median values for each of the permitted Alexandria CSOs are presented in Table 19.

Table 19. Distribution of City of Alexandria CSO water quality constituent EMCs across storm events

Water Quality Constituent	Metric	CSO 001	CSO 002	CSO 003	CSO 004
Number of Events Sampled		*4*	*4*	*4/3***	*3*
TN* (mg/L)	Min	2.36	2.86	4.89	10.53
	Median	*4.89*	*5.72*	*5.85*	*15.41*
	Max	5.92	6.54	11.18	19.92
TKN (mg/L)	Min	1.49	2.41	4.29	9.70
	Median	*4.27*	*4.96*	*5.77*	*13.50*
	Max	5.32	5.73	9.24	18.79
NH_3-N (mg/L)	Min	0.35	0.54	1.13	2.21
	Median	*1.06*	*1.12*	*1.72*	*2.78*
	Max	1.79	1.72	2.30	3.58
NO_3-N (mg/L)	Min	0.49	0.43	0.54	0.34
	Median	*0.60*	*0.65*	*1.02*	*1.07*
	Max	0.86	0.78	1.85	1.84
NO_2-N (mg/L)	Min	0.01	0.02	0.06	0.05
	Median	*0.04*	*0.03*	*0.06*	*0.07*
	Max	0.07	0.06	0.09	0.49
NO_2+ NO_3-N* (mg/L)	Min	0.56	0.45	0.60	0.83
	Median	*0.64*	*0.77*	*1.08*	*1.13*
	Max	0.87	0.81	1.94	1.91
TP (mg/L)	Min	0.29	0.34	0.65	1.55
	Median	0.73	0.65	0.75	2.06
	Max	1.21	1.26	1.26	12.68
TSS (mg/L)	Min	5.32	10.59	30.01	53.67
	Median	*79.00*	*49.60*	*58.90*	*73.54*
	Max	160.90	102.74	75.22	202.79

** TN and NO_2+NO_3-N are derived and calculated from constituents.*
*** NH_3-N and $N0_3$-N available for 3 of 4 events sampled at CSO 003.*

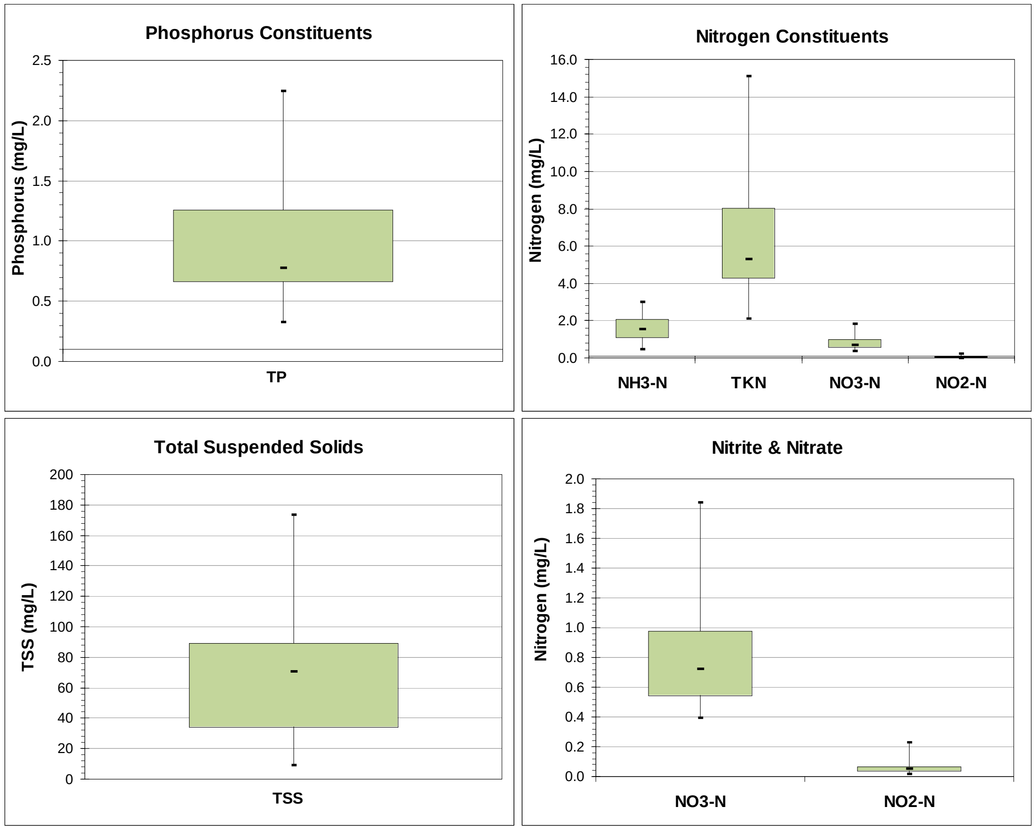
Table 20 describes the distribution of the EMCs across the City of Alexandria CSOs, in aggregate and for the storm events that were sampled, while Figure 9 provides a visual depiction of the distributions.

Table 20. Distribution individual CSO constituent EMCs for the City of Alexandria CSOs

Water Quality Constituent (mg/L)								
	TN*	TKN	NH_3-N	NO_3-N	NO_2-N	NO_2+ NO_3-N*	TP	TSS
N (sample count)	15	15	15	15	15	15	15	15
Min	2.36	1.49	0.35	0.34	0.01	0.45	0.29	5.3
5th %tile	*2.68*	*2.13*	*0.49*	*0.4*	*0.02*	*0.52*	*0.33*	*9.0*
25th %tile	*4.92*	*4.29*	*1.06*	*0.54*	*0.04*	*0.62*	*0.66*	*34.0*
Median	*5.88*	*5.32*	*1.53*	*0.72*	*0.05*	*0.79*	*0.78*	*70.5*
75th %tile	*9.53*	*8.01*	*2.06*	*0.98*	*0.07*	*1.02*	*1.26*	*89.0*
85th %tile	*11.39*	*9.65*	*2.29*	*1.11*	*0.07*	*1.16*	*1.52*	*118.3*
95th %tile	*16.98*	*15.09*	*3.02*	*1.84*	*0.23*	*1.92*	*2.25*	*173.5*
Max	19.92	18.79	3.58	1.85	0.49	1.94	*2.68*	202.8

* Derived and calculated from constituents

Figure 9. Distribution* of individual CSO constituent EMCs for the City of Alexandria CSOs



Box represents 25th-75th percentile; whiskers represent 5th and 95th.

District of Columbia Water and Sewer Authority

DC WASA conducted extensive monitoring of discharge water quality conditions at several of its CSO outfalls in support of the development of its LTCP. These data were utilized in conjunction with modeled flows from the CSS to develop CSO loads. The CSO loads in turn supported the calibration and application of receiving water quality models used to inform the evaluation and selection of CSO control management scenarios for the LTCP development effort (DC WASA 2001).

Available data:

CSO water quality constituent data from storm events was collected during the EMPC-IIIs sampling program in 1999 and 2000. Measured constituents include PO4, TP, NH3, TKN, NO2+NO3, TN, and TSS. Samples were collected for a total of 16 storm events. Each CSO overflow was sampled at least four times; however, not all parameters were sampled during each event (DC WASA 2001).

Inflatable dams (CSO diversion & in-system storage) are located at some of the sampled/reported outfalls, but the only operational dams during the sampling period were the dams at outfall 019. The inflatable dam operation in the 019 sewershed (the largest combined sewershed in the system) may have contributed to higher-than-expected dilution.

EMC development for CSOs:
The DC WASA LTCP provided CSO water quality constituent data as composite EMC's for each outfall that was sampled as shown in Table 21. These EMCs were determined by flow-weighting aggregated individual storm event EMCs (total mass measured during all sampling events/total volume of overflow during all sampling events). Note that the Outfall 001 discharges at Blue Plains and is classified as a CSO-Related Bypass, as described previously in Section 2.2. The Outfall 001 data were not evaluated with respect to characterizing CSS-wide CSO water quality conditions, but they are appropriate to characterize water quality for the outfall itself for baseline (pre-LTCP) existing conditions.

Table 21. CSO water quality constituent EMCs developed by DC WASA (2001)

Water Quality Constituent	EMCs (mg/L)					
	CSO 10	CSO 021	CSO 12	CSO 19 (Location 1)	*CSO 19 (Location 2)*	Outfall 001 (CSO Bypass)
TKN	6	3.8	4	4	2.4	17
NH_3-N	2.9	0.96	0.66	0.69	0.46	8.7
NO_3+NO_2-N	0.6	0.85	0.81	0.79	0.78	0.7
TP	1.31	1.00	0.98	0.85	0.83	2.4
DIP (PO_4)	0.37	1.04	0.11	0.23	0.15	0.8
TSS	147	130	186	96	182	130.1

Note: CSO 19 was monitored at two locations.

Further evaluation of the CSO monitoring data was undertaken to characterize the range of possible storm-event specific and CSO-specific EMCs for each water quality constituent. Depending on location, each parameter was sampled two to eight times during storm events. There is significant variability in the observation-based water quality constituent EMCs, both spatially and with respect to individual storm events. It is important to recognize this variability even if a single set of EMCs are used in the nutrient TMDL modeling effort. Table 22 describes the range of the variability in the individual storm event EMCs for the DC WASA CSOs. The variability in EMCs through the sampled storm events can be significant across the CSO locations. For example TN EMCs range from 2 mg/L to as high as 13 mg/L, while the TP EMCs show an order of magnitude in variability from 0.3 mg/L (CSO 12) to 3.3 mg/L.

Table 22. Distribution of individual storm event water quality constituent EMCs for each DC WASA CSO outfall

Water Quality Constituent	Metric	CSO 10	CSO 12	CSO 19 (1)	CSO 19 (2)	CSO 21
Number of Events Sampled		*2/4***	*4*	*8*	*4*	*6*
TN* (mg/L)	Min	6.6	2.6	3.6	2	3.7
	Median	*6.7*	*5.4*	*4.8*	*3.5*	*5.2*
	Max	6.7	7.0	5.9	5.4	13
TKN (mg/L)	Min	5.9	1.7	2.8	1	3.2
	Median	*6*	*4.7*	*4*	*2.8*	*3.9*
	Max	6.1	6	5	4.6	12
NH_3-N (mg/L)	Min	1.7	0	0.6	0.1	0.1
	Median	*2.9*	*0.7*	*0.7*	*0.8*	*0.9*
	Max	4	1.2	1.2	1.2	1.4
NO_2+ NO_3-N (mg/L)	Min	0.5	0.5	0.8	0.7	0.5
	Median	*0.6*	*0.9*	*0.9*	*0.8*	*0.9*
	Max	0.8	1	1	1	2.1
TP (mg/L)	Min	1.3	0.3	0.7	0.4	0.7
	Median	*1.3*	*1*	*0.9*	*1*	*1*
	Max	1.3	1.9	1.6	1.2	3.3
DIP (mg/L)	Min	0.2	0	0.2	0.1	0.1
	Median	*0.3*	*0.2*	*0.2*	*0.2*	*0.3*
	Max	0.5	0.3	0.3	0.2	0.3
TSS (mg/L)	Min	0	48	78	118	53
	Median	*125.5*	*235*	*110.5*	*180.5*	*102*
	Max	180	294	276	293	540

** TN is reported, as calculated from constituents*
*** TSS sampled during 4 events at CSO 10*
Note: CSO 19 was monitored at two locations.

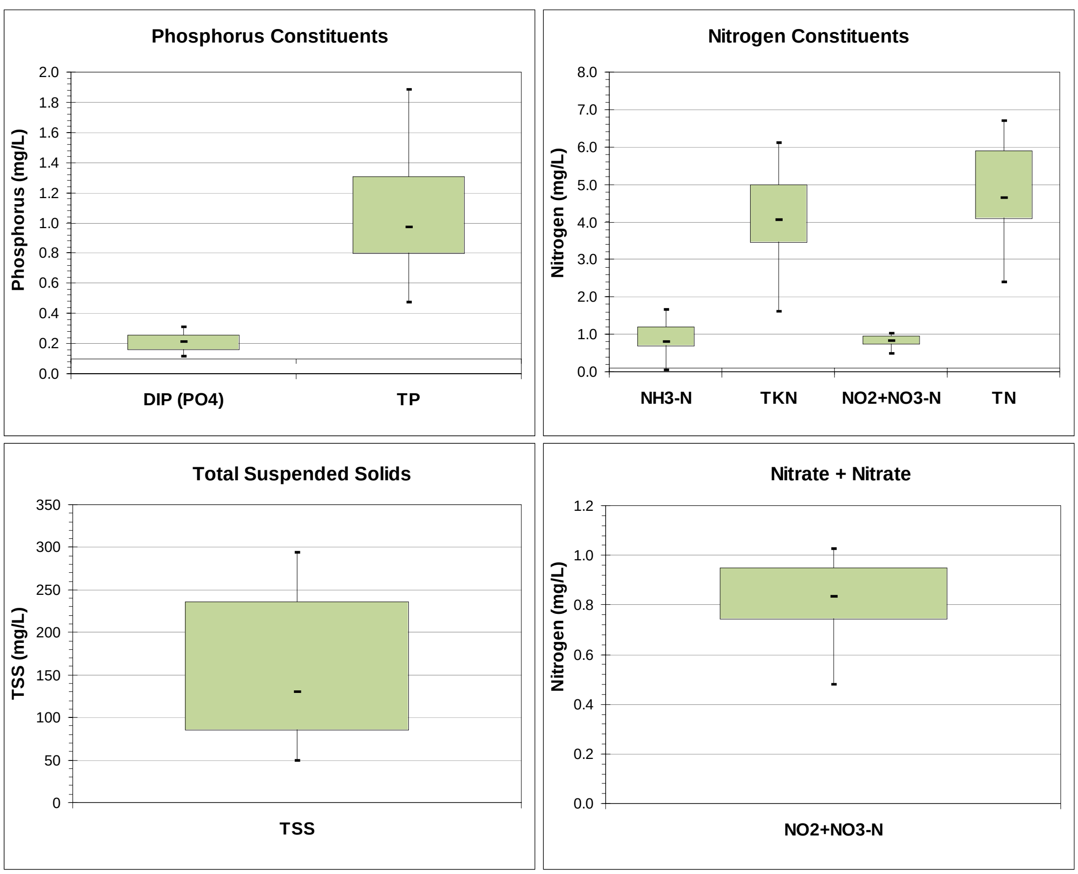
Table 23 describes the distribution of the EMCs across the DC WASA CSOs, in aggregate, for the storm events that were sampled, while Figure 10 provides a visual depiction of the distributions.

Table 23. Distribution of individual storm water quality constituent EMCs for DC WASA CSOs

	Water Quality Constituent (mg/L)						
Metric	TN*	TKN	NH_3-N	NO_2+ NO_3-N	TP	DIP (PO_4)	TSS
N	23	24	24	24	24	24	26
Min	2.0	1.0	0.0	0.5	0.3	0.0	0.0
5th Percentile	*2.4*	*1.6*	*0.1*	*0.5*	*0.5*	*0.1*	*49.3*
25th Percentile	*4.1*	*3.4*	*0.7*	*0.7*	*0.8*	*0.2*	*84.8*
Median	*4.7*	*4.1*	*0.8*	*0.8*	*1.0*	*0.2*	*130.0*
75th Percentile	*5.9*	*5.0*	*1.2*	*0.9*	*1.3*	*0.3*	*235.8*
95th Percentile	*6.7*	*6.1*	*1.7*	*1.0*	*1.9*	*0.3*	*293.8*
Max	13.0	12.0	4.0	2.1	3.3	0.5	540.0

* Calculated from constituents

Figure 10. Distribution* of individual storm water quality constituent EMCs for DC WASA CSOs



**Box represents 25th-75th percentile; whiskers represent 5th and 95th.*

City of Richmond, VA

The City of Richmond has conducted long-term, intensive (i.e., frequently daily to near-daily) monitoring of incoming water quality conditions to its WWTP since 1992. This information in combination with the operating characteristics of its wet weather storage facilities provides a basis on which CSO water quality is distinguished from normal dry weather flow influent conditions.

Available data:

No recent water quality data from direct sampling of CSO discharges is available for the City of Richmond. However, intensive WWTP influent sampling data for both wet weather inflow (>70 mgd) and dry weather inflow (<45 mgd) conditions including NH3, NO3, NO2, Org-N, TKN and TN is available for the period of January 1992 to October 2007 (Greeley and Hansen 2009). During periods of high inflow to the WWTP, the primary source of the flow besides sanitary is from the CSS wet weather retention facilities (i.e., Shockoe Basin). The frequency of the available water quality measurements combined with the operational characteristics of the CSS and the WWTP provides a basis for generating data-based estimates of CSO water quality conditions. In essence, the available data allows CSO loads to be estimated by evaluating the difference between wet and dry weather inflows to the WWTP.

EMC development for CSOs:

The City of Richmond developed a spreadsheet-based analysis in which the difference between loads for various sampled water quality constituents during wet weather and dry weather inflows are considered to be surrogates for CSO conditions (Greeley and Hansen 2009). WWTP inflow and water quality data collected from January 1992 through October 2007 were used for the analysis. A comparison of available WWTP wet weather and dry weather data showed the total nitrogen loads were about 34% higher on wet weather days. However, there was no similar wet/dry weather relationship in the phosphorous data because sufficient total phosphorus data were not collected over the same long-term period. The median, 75th and 80th percentile estimates of the CSO water quality constituent concentrations for these wet weather loads are presented in Table 24. The results indicate that these estimates of Richmond CSO water quality conditions are similar to the observed range of EMCs for the City of Alexandria (see Table 20) and DC WASA (see Table 23) CSOs. However, because there are no direct measurements for the CSO discharges and the range estimate includes the 8 mg/l concentration for TN assigned to the City of Richmond WWTP via Virginia DEQ guidance and the tributary strategy, it is recommended that the 8 mg/l value be used as the EMC. (See – VA DEQ Guidance Memo No. 07-2008; VA DEQ Guidance Memo No. 04-2017). Table 24 presents the TN from the tributary strategy permitting and shows estimated concentrations for nitrogen components based on linear scaling from the median TN value.

Table 24. Estimated water quality constituent EMCs for Richmond CSOs based on differentiation between wet weather and dry weather inflows to the WWTP

Water Quality Constituent (mg/L)						
Metric	TN	TKN	NH_3-N	NO_3-N	NO_2-N	NO_2+ NO_3-N
Median	6.7	5.8	1.2	0.7	0.2	0.9
75th percentile	10.9	10.3	3.9	1.3	0.3	1.6
80th percentile	12.3	11.5	4.8	1.5	0.3	1.8
Tributary Strategy	8	6.9	1.4	0.84	0.24	1.1

City of Lynchburg, VA

The City of Lynchburg has not conducted monitoring of CSO discharge water quality constituents in the past because its current LTCP calls for complete separation. The existing LTCP is now being reevaluated because the cost for separation of some portions of the CSS may now be prohibitive relative to other CSO management options that would remain consistent with the EPA CSO Policy. The update to the CSO LTCP is expected to be completed by the end of 2010, and the study will likely generate at least some data for characterizing water quality constituents discharging from the City's remaining CSOs. The timeframe for completion of the LTCP update is not consistent with the CBP nutrient TMDL schedule, so characterization of the City of Lynchburg CSO water quality to meet the CBP TMDL needs must rely on the available data from other CSO communities.

Available data:

There is no CSO overflow pollutant data for Lynchburg. There is limited WWTP influent nutrient concentrations for wet weather flow, including NH3, NO3, NO2, Org-N, TKN, TN, PO4 and Total P for the period of January 1987 to February 1992 (with a few additional data points 2005) for a total of 84 samples. Wet weather flow was characterized with this data for CSO occurrence days. However, an analysis of these data is not presented in this report, since they do not relate directly to characterizing CSO water quality conditions for the City's CSOs.

EMC development for CSOs:

The City of Lynchburg currently must rely on data from other locales to estimate water quality constituent EMCs for their active CSOs, since direct CSO monitoring data are not available. Both Lynchburg and Richmond are located on the James River and are subject to Virginia's tributary strategy for nutrient loads to the river. For these reasons, the use of the Richmond CSO EMCs for the Lynchburg CSOs is currently the most appropriate option for representing these loads in the WQSTM calibration.

4.2 CSO WATER QUALITY EMC AND LOAD SUMMARY

The previous section described the water quality data available to characterize CSO and wet weather conditions for Alexandria, DC WASA, and Richmond. The data were evaluated in various ways to examine the spatial and storm-event variability in EMCs. Review of this data reveals significant spatial variability across CSOs. However, specific focus on individual CSO water quality concentrations may be unwarranted with respect to characterizing CSS-wide conditions and provision of a set of recommended EMCs for use by the CBP and states for instances where addressing data gaps is necessary. It remains important to make sure recommended EMCs adequately characterize the CSS-wide conditions so that total CSO loads are realistically represented in the final calibrated WQSTM, as this model will be used to inform the nutrient TMDL effort through simulation of load reduction scenarios. For CSO communities, it is expected that their CSS wet weather-related discharges will correspond to their CSO LTCPs.

A summarization of the CSS-wide median CSO water quality EMCs extracted from the storm event variability evaluation for each CSO community (i.e., from Tables 20, 23, and 24) is presented in Table 25. Among these medians, the recommendation is that the highest medians be the selected EMCs for use by CSO communities that do not have data to fill gaps and characterize CSO water quality conditions. This recommendation is made to provide a degree of assurance that CSO loads for any individual CSO community are not underrepresented in the TMDL modeling effort. For nutrients the recommended EMCs are based on total nutrient concentrations. The inorganic and organic components for each nutrient should be specified using data consistent with the recommended available total nutrient EMCs (i.e., use data from the same utility for a given series of nutrient EMCs). The City of Richmond median EMCs are presented for comparative purposes. Although these data are representative of CSS water quality conditions and indicate a higher TN concentration, they do not represent direct measurements of CSO discharge. Therefore the City of Alexandria EMCs are recommended for nitrogen forms, while DC WASA EMCs are recommended for the phosphorus forms and total suspended solids (TSS). For utilities which have data gaps for characterizing inorganic and/or organic nutrient forms, the recommendation is to apply the fractions of these from the recommended EMCs to estimate concentrations for missing constituents. Regulatory factors, such as the Virginia tributary strategy take precedent, where applicable, in selection of the specific EMCs that a CSO community desires to use for representing their loads for the baseline existing condition period.

Table 25. Summary of Median EMC for City of Alexandria, DC WASA, and City of Richmond CSOs

Water Quality Constituent (mg/L)[1]						
	TN	NH_3-N	NO_2-N + NO_3-N	PO_4-P	TP	TSS
Alexandria median[2]	5.88	1.53	0.79	-	0.78	70.5
DC WASA median[2]	4.7	0.8	0.8	0.2	1.0	130.0
Richmond tributary strategy[3]	8	1.4	1.1	-	-	-

[1]Total organic nutrient forms can be derived by subtracting the inorganic forms from the total nutrient concentrations.
[2]EMCs are based on analysis of CSO samples collected from the CSO Outfalls.
[3]EMCs for Richmond adjusted based on Virginia tributary strategy limits provided for comparative purposes and use in similarly affected locales.

Table 26 summarizes the CSO EMCs that are utilized to determine baseline pre-LTCP existing condition (1985-2005) loads for each CSO community based upon the available site-specific EMCs, regulatory considerations (i.e., tributary strategy), and application of recommended EMCs (or constituent fractions) to fill data gaps. As described in Section 2.2, the supplement to the CSO LTCP for DC WASA incorporates enhanced clarification facilities (ECF) that will discharge through Outfall 001. The water quality conditions associated with Outfall 001, which is classified as a CSO-Related Bypass, for the existing baseline conditions and after implementation of the CSO LTCP conditions are documented in the LTCP (Greeley and Hansen 2007) and previously described in Table 21. The selected nitrogen EMCs for both Richmond and Lynchburg represent the regulatory requirements of the Virginia tributary strategy for the James River, while the phosphorus and TSS EMCs are based upon the Table 25 recommended concentrations for filling CSO data gaps.

Table 26. Summary of Selected Existing Conditions CSO EMCs for Each CSO Working Group Utility

Water Quality Constituent (mg/L)[1]						
Member	TN	NH_3-N	NO_2-N + NO_3-N	PO_4-P	TP	TSS
City of Alexandria CSO	5.88	1.53	0.79	0.16[2]	0.78	70.5
DC WASA CSOs	4.7	0.8	0.8	0.2	1.0	130.0
DC WASA CSO Bypass (Outfall 001 only)	17	8.7	0.7	0.8	2.4	130.1
City of Richmond CSOs (VA Tributary Strategy)	8	1.4	1.1	0.2	1.0	130.0
City of Lynchburg[3] (VA Tributary Strategy)	8	1.4	1.1	0.2	1.0	130.0

[1]Total organic nutrient forms can be derived by subtracting the inorganic forms from the total nutrient concentrations.
[2]The Alexandria EMC for orthophosphate-P is estimated as 20% of TP as per the recommendations for filling these types of data gaps.
[3]The Lynchburg EMCs correspond to the selected Richmond EMCs and the Virginia tributary strategy.

CSS Working Group Wet Weather Load Summary: A summary of the 1985 through 2005 annual CSS-related loads for each CSS Work Group member is provided in Tables 27 through 30. Daily time series files for the individual loading sources arranged by CBP WQSTM model segments will be made available to the CBP in an electronic format. In a general sense, daily loads are developed by multiplying daily flow values by the recommended EMC and appropriate conversion factors. The annual loads presented herein are a summation of daily loads for the given years.

The annual summary of loads provided in this report and the daily times series files of loads to be delivered in electronic format are strictly intended to meet the needs of the CBP for calibration of the WQSTM for the historical 1985-2005 period. Both DC WASA and Richmond have CSS model configurations capable of characterizing CSS discharges for conditions after complete implementation of their approved LTCPs. Alexandria’s current approved LTCP is represented by continued and compliant NMC implementation, and Lynchburg is currently in the process of reevaluating and updating its CSO LCTP with the possibility that complete sewer separation may no longer represent the best option for managing its CSS towards attaining compliance with water quality standards. As noted previously, the CSS Working Group members will provide the LTCP-based loads to the CBP following coordination with their respective regulatory agencies once initial gross allocations are provided by EPA to the states and the District of Columbia.

Table 27. Annual Alexandria Modeled CSO Loads (lbs) for 1985-2005 Baseline Existing Conditions

Year	TN CSO load	NH_3 CSO load	NO_2+NO_3 CSO load	DIP (PO_4) CSO load	TP CSO load	TSS CSO load
1985	6,113	1,591	821	166	811	73,288
1986	3,927	1,022	528	107	521	47,081
1987	5,474	1,424	735	149	726	65,635
1988	4,185	1,089	562	114	555	50,180
1989	7,808	2,032	1,049	212	1,036	93,622
1990	6,113	1,591	821	166	811	73,297
1991	3,090	804	415	84	410	37,045
1992	4,197	1,092	564	114	557	50,323
1993	6,439	1,676	865	175	854	77,208
1994	4,005	1,042	538	109	531	48,023
1995	6,855	1,784	921	187	909	82,189
1996	7,640	1,988	1,027	208	1,014	91,607
1997	3,867	1,006	520	105	513	46,367
1998	3,309	861	445	90	439	39,676
1999	6,810	1,772	915	185	903	81,656
2000	5,928	1,542	796	161	786	71,073
2001	3,460	900	465	94	459	41,489
2002	3,734	972	502	102	495	44,766
2003	10,287	2,677	1,382	280	1,365	123,340
2004	7,489	1,949	1,006	204	993	89,788
2005	8,971	2,334	1,205	244	1,190	107,563

Table 28. Annual DC WASA Reported and Modeled CSO Loads (lbs) for 1985-2005 Baseline Existing Conditions

Year	TN			NH_3			NO_2+NO_3		
	Baseline Load: Blue Plains 001	Baseline Load: CSOs on collection system	Baseline Load: total CSOs	Baseline Load: Blue Plains 001	Baseline Load: CSOs on collection system	Baseline Load: total CSOs	Baseline Load: Blue Plains 001	Baseline Load: CSOs on collection system	Baseline Load: total CSOs
1985	16,708	94,403	111,111	8,551	16,069	24,619	688	16,069	16,757
1986	3,579	63,147	66,727	1,832	10,748	12,580	147	10,748	10,896
1987	26,615	87,815	114,431	13,621	14,947	28,568	1,096	14,947	16,043
1988	609	64,049	64,658	312	10,902	11,214	25	10,902	10,927
1989	31,601	131,753	163,354	16,172	22,426	38,598	1,301	22,426	23,727
1990	7,898	108,615	116,513	4,042	18,488	22,530	325	18,488	18,813
1991	3,846	48,376	52,223	1,968	8,234	10,203	158	8,234	8,393
1992	8,465	69,907	78,372	4,332	11,899	16,231	349	11,899	12,248
1993	21,541	99,657	121,198	11,024	16,963	27,987	887	16,963	17,850
1994	17,807	77,233	95,040	9,113	13,146	22,259	733	13,146	13,879
1995	11,764	114,273	126,037	6,020	19,451	25,471	484	19,451	19,935
1996	73,646	138,716	212,362	37,689	23,611	61,301	3,032	23,611	26,644
1997	32,616	73,536	106,152	16,692	12,517	29,209	1,343	12,517	13,860
1998	70,340	51,157	121,497	35,998	8,707	44,705	2,896	8,707	11,604
1999	38,646	110,795	149,441	19,778	18,859	38,636	1,591	18,859	20,450
2000	21,593	90,609	112,202	11,050	15,423	26,473	889	15,423	16,312
2001	22,089	46,594	68,684	11,305	7,931	19,236	910	7,931	8,840
2002	79,210	53,536	132,746	40,537	9,113	49,649	3,262	9,113	12,374
2003	337,232	217,342	554,575	172,584	36,994	209,578	13,886	36,994	50,880
2004	118,335	89,453	207,789	60,560	15,226	75,786	4,873	15,226	20,099
2005	165,339	239,470	404,809	84,615	40,761	125,376	6,808	40,761	47,569

Note: These loads and the daily time series load to be delivered in electronic format are DC WASA's best estimate of actual discharges for the period 1985-2005. They are suitable for us in calibration only. They do not account for growth in the Blue Plains service area, and it is not appropriate to apply reductions to these loads.

Table 28. Annual DC WASA Reported and Modeled CSO Loads (lbs) for 1985-2005 Baseline Existing Conditions (cont'd)

Year	DIP (PO_4)			TP			TSS		
	Baseline Load: Blue Plains 001	Baseline Load: CSOs on collection system	Baseline Load: total CSOs	Baseline Load: Blue Plains 001	Baseline Load: CSOs on collection system	Baseline Load: total CSOs	Baseline Load: Blue Plains 001	Baseline Load: CSOs on collection system	Baseline Load: total CSOs
1985	786	4,017	4,803	2,359	20,086	22,445	127,868	2,611,140	2,739,008
1986	168	2,687	2,856	505	13,436	13,941	27,392	1,746,629	1,774,021
1987	1,252	3,737	4,989	3,757	18,684	22,442	203,686	2,428,938	2,632,624
1988	29	2,725	2,754	86	13,627	13,713	4,659	1,771,574	1,776,233
1989	1,487	5,607	7,094	4,461	28,033	32,494	241,840	3,644,240	3,886,081
1990	372	4,622	4,994	1,115	23,110	24,225	60,445	3,004,250	3,064,694
1991	181	2,059	2,240	543	10,293	10,836	29,437	1,338,072	1,367,508
1992	398	2,975	3,373	1,195	14,874	16,069	64,782	1,933,607	1,998,389
1993	1,014	4,241	5,254	3,041	21,204	24,245	164,849	2,756,474	2,921,324
1994	838	3,287	4,124	2,514	16,433	18,946	136,276	2,136,231	2,272,507
1995	554	4,863	5,416	1,661	24,313	25,974	90,026	3,160,752	3,250,778
1996	3,466	5,903	9,369	10,397	29,514	39,911	563,606	3,836,837	4,400,443
1997	1,535	3,129	4,664	4,605	15,646	20,251	249,611	2,033,963	2,283,574
1998	3,310	2,177	5,487	9,930	10,884	20,815	538,308	1,414,967	1,953,276
1999	1,819	4,715	6,533	5,456	23,573	29,029	295,755	3,064,542	3,360,297
2000	1,016	3,856	4,872	3,048	19,278	22,327	165,249	2,506,201	2,671,450
2001	1,040	1,983	3,022	3,119	9,914	13,032	169,049	1,288,775	1,457,824
2002	3,728	2,278	6,006	11,183	11,391	22,573	606,189	1,480,786	2,086,974
2003	15,870	9,249	25,118	47,609	46,243	93,852	2,580,818	6,011,596	8,592,414
2004	5,569	3,807	9,375	16,706	19,033	35,739	905,613	2,474,237	3,379,851
2005	7,781	10,190	17,971	23,342	50,951	74,293	1,265,329	6,623,651	7,888,979

Note: These loads and the daily time series load to be delivered in electronic format are DC WASA's best estimate of actual discharges for the period 1985-2005. They are suitable for us in calibration only. They do not account for growth in the Blue Plains service area, and it is not appropriate to apply reductions to these loads

Table 29. Annual Richmond Reported WWTP and Modeled CSO Loads (lbs) for 1985-2005 Baseline Existing Conditions

Year	TN		NH_3		NO_2+NO_3		DIP (PO_4)		TP		TSS	
	Reported WWTP load	Baseline CSO load	Reported WWTP load	Baseline CSO load	Reported WWTP load	Baseline CSO load	Reported WWTP load	Baseline CSO load	Reported WWTP load	Baseline CSO load	Reported WWTP load	Baseline CSO load
1985	3,460,964	345,932	2,391,805	60,538	203,716	47,566	775,775	8,648	1,172,730	43,241	3,828,499	5,621,389
1986	3,599,050	220,582	3,083,106	38,602	213,555	30,330	906,586	5,515	1,201,361	27,573	2,894,308	3,584,451
1987	3,475,641	228,072	3,000,075	39,913	308,095	31,360	680,239	5,702	1,307,796	28,509	4,390,128	3,706,174
1988	4,255,849	209,273	2,952,805	36,623	1,204,935	28,775	428,633	5,232	581,036	26,159	4,286,330	3,400,689
1989	4,368,083	250,460	3,063,698	43,831	1,116,374	34,438	276,658	6,262	410,117	31,308	3,653,058	4,069,978
1990	2,575,179	227,529	1,528,833	39,818	904,537	31,285	84,410	5,688	185,027	28,441	2,025,839	3,697,343
1991	2,360,815	199,078	1,058,337	34,839	977,149	27,373	173,973	4,977	260,960	24,885	579,910	3,235,024
1992	1,834,320	210,517	950,387	36,840	596,215	28,946	119,819	5,263	171,057	26,315	439,843	3,420,901
1993	1,738,438	209,611	845,646	36,682	704,834	28,822	98,812	5,240	158,208	26,201	717,728	3,406,183
1994	1,873,989	236,721	1,212,586	41,426	383,409	32,549	51,296	5,918	101,527	29,590	1,028,357	3,846,721
1995	1,898,437	157,325	1,243,127	27,532	404,752	21,632	92,557	3,933	141,110	19,666	943,735	2,556,537
1996	1,609,269	265,217	561,510	46,413	869,287	36,467	72,960	6,630	142,017	33,152	1,346,312	4,309,773
1997	1,124,654	140,158	274,621	24,528	727,303	19,272	90,178	3,504	133,863	17,520	577,587	2,277,571
1998	1,441,533	254,975	214,887	44,621	1,061,433	35,059	72,357	6,374	116,767	31,872	493,938	4,143,341
1999	1,500,943	248,007	139,267	43,401	1,204,441	34,101	53,180	6,200	85,184	31,001	370,340	4,030,108
2000	1,620,399	156,421	158,885	27,374	1,350,249	21,508	76,932	3,911	109,376	19,553	529,440	2,541,843
2001	1,457,819	114,111	111,042	19,969	1,216,898	15,690	36,887	2,853	74,289	14,264	277,980	1,854,307
2002	1,575,272	95,761	85,094	16,758	1,348,752	13,167	51,208	2,394	82,390	11,970	250,819	1,556,114
2003	2,231,421	286,845	341,893	50,198	1,643,105	39,441	57,044	7,171	94,223	35,856	700,756	4,661,228
2004	2,180,799	255,711	287,738	44,749	1,589,370	35,160	107,992	6,393	150,881	31,964	912,441	4,155,298
2005	2,115,625	188,682	548,971	33,019	1,234,214	25,944	149,962	4,717	218,548	23,585	886,337	3,066,090

Table 30. Annual Lynchburg Model-based Estimates of CSO Loads (lbs) for 1985-2005 Baseline Existing Conditions

Year	TN CSO load	NH_3 CSO load	NO_2+NO_3 CSO load	DIP (PO_4) CSO load	TP CSO load	TSS CSO load
1985	24,636	4,311	3,387	616	3,079	400,329
1986	14,621	2,559	2,010	366	1,828	237,594
1987	18,694	3,271	2,570	467	2,337	303,773
1988	14,354	2,512	1,974	359	1,794	233,254
1989	19,295	3,377	2,653	482	2,412	313,537
1990	14,087	2,465	1,937	352	1,761	228,914
1991	10,014	1,753	1,377	250	1,252	162,735
1992	11,684	2,045	1,606	292	1,460	189,858
1993	14,488	2,535	1,992	362	1,811	235,424
1994	11,750	2,056	1,616	294	1,469	190,943
1995	13,820	2,418	1,900	345	1,727	224,575
1996	12,351	2,161	1,698	309	1,544	200,707
1997	7,144	1,250	982	179	893	116,085
1998	14,554	2,547	2,001	364	1,819	236,509
1999	12,685	2,220	1,744	317	1,586	206,131
2000	9,147	1,601	1,258	229	1,143	148,632
2001	8,412	1,472	1,157	210	1,052	136,698
2002	7,277	1,274	1,001	182	910	118,254
2003	15,088	2,640	2,075	377	1,886	245,188
2004	6,476	1,133	890	162	810	105,236
2005	5,675	993	780	142	709	92,217

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