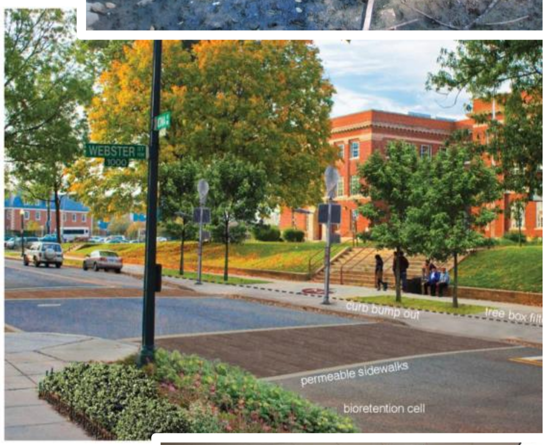

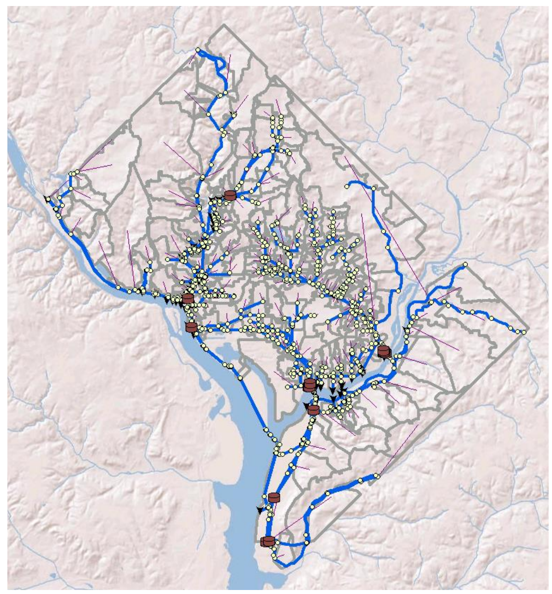

Quality Assurance Project Plan
Consolidated Total Maximum Daily Load (TMDL) Implementation Plan and Monitoring Program

Prepared for:
District Department of the Environment

FINAL

July 25, 2014

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APPROVAL LIST

Jonathan Champion District Department of the Environment, Government of District of Columbia	Date
Dan Herrema LimnoTech Project Manager	Date
Dave Dilks LimnoTech Technical Advisor for Modeling	Date

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List of Acronyms

B

BMP – Best Management Practice

C

CSO – Combined Sewer Overflow

D

DOC – Dissolved Organic Carbon

DQO – Data Quality Objective

DDOE – District Department of Environment

E

EPA – United States Environmental Protection Agency

M

MS4 – Municipal Separate Storm Sewer System

N

NHD – National Hydrography Dataset

P

PCB

Q

QA – Quality Assurance

QA/QC – Quality Assurance/Quality Control

QAPP – Quality Assurance Project Plan

QC – Quality Control

T

TMDL – Total Maximum Daily Loads

U

USGS – United States Geological Survey

W

WIP – Watershed Implementation Plan

WLA – Wasteload Allocation

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1. PROJECT MANAGEMENT

The Project Team (the Team) has developed this Quality Assurance Project Plan (QAPP) to guide all of the technical activities of team members engaged on the project. The purpose of the QAPP is to document the necessary procedures required to assure that the project is executed in a manner consistent with applicable guidance documents and with generally accepted and approved quality assurance objectives. As such, the QAPP integrates quality control policies and procedures with project-specific work tasks. While this project is not being done directly for EPA, EPA's guidance was used as a best practice for developing this QAPP. EPA QAPP Guidance requirements (i.e., the elements of Groups A through D; U.S. EPA, 2001) are addressed in this document. This section of the document specifically addresses EPA QAPP Guidance Group A Project Management elements.

1.1 Project Organization (A4)

LimnoTech has a contract to support the District Department of Environment (DDOE) in the development of a Consolidated Total Maximum Daily Load (TMDL) Implementation Plan (hereafter referred to as the IP) and Monitoring Program. TMDL implementation planning will be done using a TMDL Implementation Plan modeling tool (the IP Modeling Tool) to calculate land-based pollutant loads generated in the District of Columbia (the District) municipal separate storm sewer (MS4) area, and the load reductions that will be achieved through the implementation of various stormwater management strategies. The intended use of the IP Modeling Tool is to show progress towards attainment of the Wasteload Allocations (WLAs) for the District's MS4 area. The IP Modeling Tool results will also assist with prioritization to help determine the most efficient way to implement stormwater management strategies over time.

The Team consists of DDOE, which directs the overall work; LimnoTech, which will provide lead technical direction and technical support in the execution of this work, and will also manage subcontractors supporting specific elements of the work; and subcontractors including:

- Apex Companies for review of existing monitoring program, crosswalk comparison, and revised monitoring.
- Low Impact Development (LID) Center for advice on the implementation of stormwater best practices (BMPs).
- MDB, Inc. and Nspiregreen, LLC for stakeholder outreach and facilitation services and assist with public participation.
- PEER Consultants for environmental engineering services support.
- Stratus Consulting for economic analysis services.
- Dr. Tom Grizzard of Virginia Tech as Technical Advisor for wet and dry weather and BMP performance monitoring.

Each of the organizations included on the Team has established an organizational structure for providing technical direction and administrative control to accomplish quality-related activities for the project. The organizational structure of the Team for the study is shown in Figure 1-1.

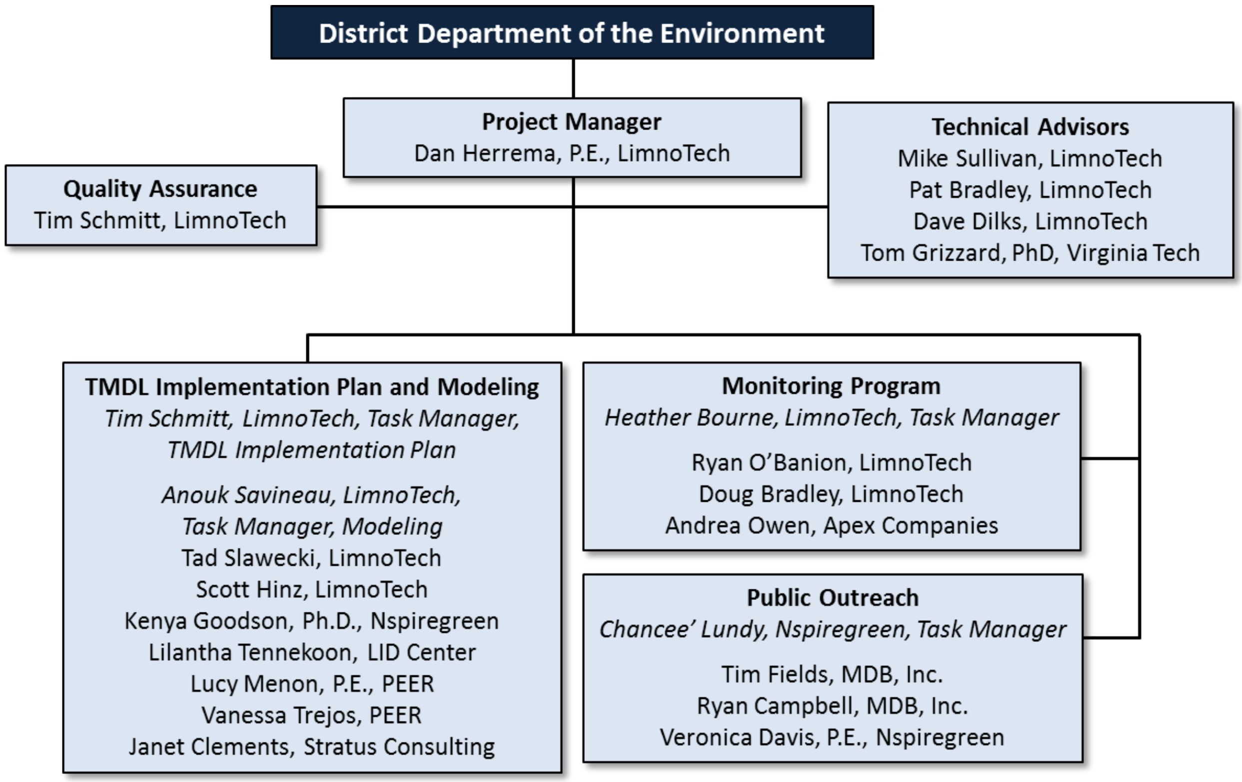

Figure 1-1. Project Team Organization and Responsibilities

The key personnel on the Team and their role in delivering the required services are summarized in Table 1-1.

Table 1-1. Key Personnel

Name	Organization	Role/Responsibilities
Dan Herrema, P.E.	LimnoTech	Project Manager. Point of contact for contractual matters. Will lead the delivery of technical services.
Mike Sullivan	LimnoTech	Technical Advisor on monitoring and modeling
Pat Bradley	LimnoTech	Technical Advisor on TMDL implementation and methods to assess compliance with TMDLs.
Dave Dilks, Ph.D.	LimnoTech	Technical Advisor for Modeling.
Tim Schmitt	LimnoTech	Task Manager for IP.
Anouk Savineau, P.E.	LimnoTech	Modeling Team Leader, Task Manager for modeling approach.
Heather Bourne	LimnoTech	Task Manager for Revised Monitoring Program.
Tad Slawecki	LimnoTech	Project Engineer. GIS support and modeling for watershed planning, baseline analysis, and WLA reduction tracking.
Scott Hinz	LimnoTech	Project Engineer. Water quality modeling, data collection review and management.

Table 1-1. Key Personnel		
Name	**Organization**	**Role/Responsibilities**
Ryan O'Banion	LimnoTech	Project Scientist. GIS support and modeling for watershed planning, baseline analysis, and WLA reduction tracking.
Doug Bradley	LimnoTech	Project Scientist. Support for integration of stream health, fisheries, biological, and physical indicators into revised monitoring plan.
Andrea Owen	Apex	Project Scientist. Support to development of a revised water quality monitoring plan.
Lilantha Tennekoon	LID Center	Project Engineer. Evaluation and planning for potential green infrastructure and other BMP technologies.
Tim Fields	MDB, Inc.	Task Manager, public participation process.
Ryan Campbell	MDB, Inc.	Outreach specialist. Support for the public participation process.
Chancee' Lundy	Nspiregreen	Project Engineer. Support for capital project and development forecasting and public outreach.
Veronica Davis, P.E.	Nspiregreen	Project Engineer. Support for capital project and development forecasting and public outreach.
Kenya Goodson, Ph.D.	Nspiregreen	Project Engineer. Supporting data collection and analysis for the IP.
Lucy Menon, P.E.	PEER Consultants	Project Engineer. Supporting data collection and analysis for Consolidated TMDL Implementation Plan.
Vanessa Trejos	PEER Consultants	Project Scientist. Supporting data collection and analysis for the IP.
Janet Clements	Stratus Consulting	Planner. Support for evaluation of environmental benefits of TMDL implementation plan and BMP strategies.
Thomas Grizzard, Ph.D, P.E.	Virginia Tech	Technical Advisor on monitoring and BMP performance.

1.2 Project Team Responsibilities

DDOE will provide overall direction, review, and funding for the project. LimnoTech will report to DDOE and manage the work contract activities. LimnoTech will assign and approve work products, maintain a repository for all final distributed work products, and facilitate coordination among the team members. LimnoTech will also manage all subcontractors on the team. General roles for each subcontractor were summarized in Section 1.1; however, LimnoTech will use a team approach to completing the necessary work and will assign individual tasks to subcontractors based on the nature of the task and the skill sets of each individual subcontractor. Subcontractors will be responsible for completing tasks and assignments as assigned by LimnoTech.

The roles of the DDOE and Team personnel that will work on this project are provided below.

- Mr. Jonathan Champion of DDOE is the Contracting Officer's Technical Representative (COTR) for Tasks Orders under the master project contract. Mr. Champion is the direct point of contact at

DDOE and is responsible for technical direction of all work under each Task Order. He will review and provide input on all project activities and deliverables.

- Mr. Jeff Seltzer of DDOE is the Associate Director, Stormwater Management Division. In this position, Mr. Seltzer serves as the District's Stormwater Administrator and is responsible for the administration of the District's MS4 permit. Mr. Seltzer will review and provide input on all project activities and deliverables.
- Mr. Marty Hurd of DDOE is an Environmental Protection Specialist with the Stormwater Management Division. He will provide technical support to the project.
- Ms. Kimberly Gray of the District's Department of General Services is the Manager of Goods and Services in the Contracts and Procurement Division. Ms. Gray is responsible for issuing and administering the contract and individual Task Orders, and for ensuring that the terms and conditions of the contract are met.
- Mr. Dan Herrema is the Project Manager and the Task Manager for Task 3.2 (Project Coordination.) He will coordinate all project activities and review all deliverables. He will also manage all subcontractors.
- Dr. Dave Dilks of LimnoTech is a Technical Advisor for Modeling. He will provide direction and technical advice regarding the development of the modeling tool. In addition, because modeling is so central to the completion of this project, Dr. Dilks will approve QAPP, oversee its implementation, and review technical activities performed by the Team to verify that they comply with the QAPP. He will sign the quality assurance (QA) Statements that must accompany all deliverables.
- Mr. Mike Sullivan of LimnoTech is a Technical Advisor. He will provide direction and technical advice regarding the use of data from existing TMDLs.
- Mr. Pat Bradley of LimnoTech is a Technical Advisor. He will provide direction and technical advice regarding regulatory and compliance issues.
- Dr. Tom Grizzard of Virginia Tech is a Technical Advisor. He will provide direction and technical advice regarding updates to the DDOE monitoring program.
- Mr. Tim Schmitt of LimnoTech is the Task Manager for Tasks 1.1 (Consolidated TMDL Implementation Plan Methodology) and 1.3 (Consolidated TMDL Implementation Plan.). Mr. Schmitt will be responsible for the day-to-day activities required to develop the IP Methodology document and the IP, including defining tasks and schedule, managing staff on technical work, communicating with the client regarding the task, and producing draft internal and external deliverables. Mr. Schmitt will coordinate with Mr. Herrema on staffing and submission of deliverables to the client.
- Ms. Anouk Savineau of LimnoTech is the Task Manager for Task 1.2 (Modeling) and the Modeling Team Leader. Ms. Savineau will be the Modeling Team leader and responsible for the day-to-day activities required to develop the IP Modeling Tool, including defining tasks and schedule, managing staff on technical work, communicating with the client regarding the task, and producing draft internal and external deliverables. Ms. Savineau will coordinate with Mr. Herrema on staffing and submission of deliverables to the client.
- Ms. Heather Bourne of LimnoTech is the Task Manager for Task 2 (Revised Monitoring Framework. Ms. Bourne will be responsible for the day-to-day activities required to develop the revised monitoring framework, including defining tasks and schedule, managing staff on

technical work, communicating with the client regarding the task, and producing draft internal and external deliverables. Ms. Bourne will coordinate with Mr. Herrema on staffing and submission of deliverables to the client.

- Ms. Chancee Lundy of Nspiregreen is the Task Manager for Task 3.1 (Public Participation Process.) Ms. Lundy will be responsible for the day-to-day activities required to implement the public participation process, including defining tasks and schedule, managing staff on technical work, communicating with the client regarding the task, and producing draft internal and external deliverables. Ms. Lundy will coordinate with Mr. Herrema on staffing and submission of deliverables to the client.

1.3 Problem Definition/Background (A5)

The District's MS4 NPDES permit requires DDOE to develop a Consolidated Total Maximum Daily Load Implementation Plan (the IP). The IP will define and organize a multi-year process centered on reducing pollutant loads originating within the District MS4. Section 4.10.3 of the permit includes instructions for the content of the IP and provides direction on how to demonstrate compliance with the permit requirements. Specifically, the IP must include:

1. A schedule for attainment of the WLAs (final date and interim milestones as necessary).
2. Demonstration using models for how each applicable WLA will be attained.
3. Narrative explaining schedules and controls used in the IP.
4. Requirement to follow elements 1-3 above until the TMDL is withdrawn, reissued or water body is de-listed.
5. Requirement to post the IP on the District website.

The IP will include a summary of the regulatory compliance strategy to satisfy TMDL-related permit requirements, a summary of data and methods used to develop the IP, specific prioritized recommendations for storm water control measures, a schedule for implementation, and a method for tracking progress. Substantial public involvement will be sought in the development of the IP.

A total of 26 TMDL studies have been developed for impaired waters in the District – fourteen (14) for waterbodies in the Anacostia watershed, seven (7) for waterbodies in the Potomac watershed, three (3) for waterbodies in the Rock Creek watershed, and two (2) that encompass impaired waters in both the Anacostia and the Potomac watersheds. Altogether, these TMDL studies provide allocations for 23 different pollutants in 45 different water body segments. The TMDL studies include over 380 individual MS4 WLAs. A summary of these TMDL studies is provided in Appendix 1.

These TMDL studies were completed over a 12 year period (from 1998 to 2010) by multiple agencies using different available datasets, modeling approaches, and documentation. In addition, most of the District's TMDLs were developed between 2003 and 2004, during the timeframe when U.S. EPA was clarifying its regulatory requirements for establishing WLAs for storm water discharges in TMDLs[1]. Consequently, many of the TMDL studies do not differentiate between stormwater loads from the MS4 system and areas that drained directly to the waterbodies (direct drainage areas). As a result, many of the TMDL study documents have combined allocations for point source MS4 and nonpoint source direct drainage areas. This adds a large amount of complexity to the development of the IP for MS4 WLAs. In addition, refinements over time in mapping the MS4 system have led to improved MS4 coverage and sewershed

[1]Memorandum *Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs*, from Robert H. Wayland, III, Director, Office of Wetlands, Oceans and Watersheds, and James A. Hanlon, Director, Office of Wastewater Management, to Water Division Directors, Regions 1 - 10, dated November 22, 2002.

delineations than what may have been used in earlier TMDL studies. Finally, in some cases, more than one TMDL was developed for the same pollutant(s) in the same waterbody. Overlaps need to be reconciled in order to effectively consolidate implementation planning. All of these issues must be reconciled to ensure that the IP meets regulatory requirements to address all applicable MS4 WLAs, and also that the IP is supported by stakeholders.

1.4 Project/Task Description and Schedule (A6)

This section describes the Team's approach to provide the services and project deliverables. The Project/Task Description provided below breaks the project into three major tasks: the Consolidated TMDL Implementation Plan; the Revised Monitoring Framework; and the TMDL Monitoring Program Supporting Requirements. Each of the major tasks also includes subtasks. A summary of the deliverables for each task can be found in the project schedule.

1.4.1 Task 1: Consolidated TMDL Implementation Plan

The Team will develop an IP that summarizes how DDOE will meet all applicable MS4 WLAs. The IP will include a schedule for attainment of the WLAs and a narrative explaining schedules and controls used in the IP. It will also describe and discuss the development and use of a modeling approach that will demonstrate how each applicable WLA will be attained.

Development of the IP is broken into three subtasks, including the development of the consolidated TMDL IP methodology; the development and implementation of a model to estimate baseline loads and required pollutant load reductions; and the development of the IP.

1.4.1.a *Task 1.1 Consolidated TMDL IP Methodology*

The Team will develop a methodology and plan that will describe the activities and procedures for data collection, management and synthesis; methods for developing and using the necessary models and evaluation tools; and assumptions to be used for developing the required IP for MS4 discharges.

Specific steps that will directly assist in preparing the Methodology document include:

- Review of existing TMDL information including MS4 WLAs, existing loads, existing BMPs, implementation strategies, and other relevant information. Also review impairment listings data.

  Review of existing TMDL information will also include developing a TMDL/MS4 WLA inventory and a summary of event mean concentration (EMC) data used in the original TMDLs. It also requires delineation of the TMDL watersheds. Specific data quality objectives for these data sets will be discussed in Section 1.5, Data Quality Objectives.

- Review of other existing information supporting the IP. This will include reviewing existing BMPs and developing a BMP database; collecting watershed and pollutant data such as information on land ownership, parcels, land use, impervious cover, slopes, soil types, wetlands, watersheds, infrastructure, and sewer systems; reviewing existing water quality and stream biological conditions data; and reviewing existing TMDL or Watershed Implementation Plans. Specific data quality objectives for these data sets will be discussed in Section 1.5, Data Quality Objectives.

- Conduct literature review. Evaluate data, literature and other materials that can provide information necessary to develop the IP, such as information on BMP pollutant removal efficiencies, BMP cost-effectiveness, BMP pollutant reduction estimates, and target load estimation methods.

The literature review will also include compiling land use-based EMCs, and compiling BMP pollutant removal efficiencies. Specific data quality objectives for these data sets will be discussed in Section 1.5, Data Quality Objectives.

- Prepare Draft and Final IP Methodology documents describing activities and technical methods for determining the District's baseline pollutant loads; developing and estimating credits for pollutant reductions through structural and nonstructural BMPs; modeling and forecasting the impact of development and re-development in the District on pollutant loads and load reductions; conducting public outreach; and monitoring and tracking progress towards milestones and benchmarks.
- Develop a Quality Assurance Project Plan (QAPP) to implement quality procedures to ensure that the project produces high quality deliverables that meet the project needs.

1.4.1.b *Task 1.2 Model for Load Estimation*

An IP Modeling Tool will also be developed to assist in the successful development and tracking of the IP, and to ensure that pollutant load targets will be met within the pre-defined regulatory time frame. Developing the modeling tool includes:

- Identifying the modeling tool requirements.
- Selecting the modeling framework.
- Developing dry-and wet-weather flow calculation methods.
- Developing a pollutant load calculation method.
- Developing a pollutant load reduction method.
- Conducting a baseline condition analysis.
- Conducting a current condition analysis.
- Developing a future management scenario analysis and method for prioritization.
- Developing the methodology for growth scenario.
- Evaluating and comparing management scenarios.

1.4.1.c *Task 1.3 Consolidated TMDL IP*

The Team will use the IP Methodology document and the results of the modeling task to develop an IP that includes a schedule for attainment of WLAs with final attainment dates and interim milestones (where final attainment of applicable WLAs requires more than five years) and numeric benchmarks (where applicable).

1.4.2 Task 2 Revised Monitoring Framework

The development of a Revised Monitoring Framework will include:

- Review of Monitoring Needs and Requirements.
- Review of Existing Monitoring Programs and Associated Components.
- Crosswalk Comparison of Monitoring Needs and DDOE's Existing Monitoring Components.

As a first step for this task, the Team will review of the District's current monitoring needs and requirements. The Team will begin this process by identifying readily available information from published reports, documents, internet sources, and interviewing District staff to identify any additional monitoring efforts and available materials. The Team will review MS4 monitoring programs, as well as ambient monitoring of biological and physical indicators such as macroinvertebrates and geomorphological factors. The Team will also review MS4 permit-related monitoring related to stormwater pollution control from industrial facilities, as well as programs to monitor trash. The Team will identify any monitoring efforts that may continue to occur despite changes to its requirements. The Team will prepare a report "Review of Monitoring Needs and Requirements" as well as an "Existing Monitoring Programs and Components" report for review and comment by DDOE. Next, the Team will compare the two reports to perform a gap analysis for MS4 permit monitoring requirements and prepare a "Crosswalk Comparison of Monitoring Needs and Existing Monitoring Components."

The Team will then develop a Revised Monitoring Framework to comply with the requirements of the MS4 permit.

1.4.3 Task 3 TMDL and Monitoring Program Supporting Requirements

The Team will also conduct several tasks intended to support the overall project and DDOE's project goals. These tasks are outlined below.

1.4.3.a *Task 3.1 Public Participation Process*

This task involves inclusion of the public in the development of the IP. The participation strategy will focus on engaging two distinct groups: stakeholders (regulatory agencies, sister agencies, environmental groups, and industry groups) and the general public. DDOE has identified selected stakeholders and has created a stakeholder group. The goal for the stakeholder group is to involve them directly in the IP development process to ensure that the IP is developed in an open and transparent fashion. DDOE will also engage the general public at certain points throughout the process to provide updates on the development of the IP. The Team will work with DDOE to develop and implement the stakeholder involvement and public participation strategies and will conduct activities such as handling meeting logistics, preparing meeting materials, writing meeting minutes; developing a project website, and other conducting other related public participation process support activities.

1.4.3.b *Task 3.2 Project Coordination*

The Team will manage the project to support completion of project goals. Project management will include ensuring adequate staffing, overseeing the completion of deliverables on time and on budget, and reporting and communicating with DDOE on a regular basis.

1.4.4 Schedule of Benchmarks and Deliverables

The proposed project duration is for the period of June 2013 through June 2016, which reflects that base period of the project contract. The contract also includes two options which could extend the period of performance for an additional two years.

The project is administered through the issuance of Task Orders against the contract. Each of the Task Orders includes a specific scope reflective of a subset of the tasks of the entire contract, a set of deliverables, a schedule, and a budget. Therefore, the schedule for the project and for specific deliverables is directly tied to the issuance of Task Orders, and while an overall project schedule has been proposed, the schedule is ultimately dependent on the timing of Task Orders.

This project is also being performed under a regulatory deadline. The District's MS4 permit requires the IP and revised monitoring framework to be completed by May 2015. This deadline is within the contract period for the project.

Major anticipated deadlines based on the proposed schedule are presented in Table 1-2 and a proposed schedule is shown in Figure 1-2. As of the writing of this QAPP, not all of the required work has been currently authorized through issuance of Task Orders.

Table 1-2. Proposed Project Schedule and Delivery Dates		
Task	**Deliverable**	**Due Date**
1.1	Draft Methodology document	December 2013
1.1	Final Methodology document	June 2014
1.1	Draft QAPP	February 2014
1.1	Final QAPP	July 2014
1.2	Draft Baseline Analysis Report	March 2014
1.2	Draft Comprehensive Baseline Analysis Report	June 2014
1.2	Final Comprehensive Baseline Analysis Report	August 2014
1.2	Draft Implementation Scenarios Report	October 2014
1.2	Final Implementation Scenarios Report	December 2014
1.2	Draft Modeling User Guide and Manual	February 2015
1.2	Final Modeling User Guide and Manual	March 2015
1.3	Draft Consolidated TMDL Implementation Plan	March 2015
1.3	Final Consolidated TMDL Implementation Plan	May 2015
2	Draft Report on Monitoring Needs and Requirements and Review of Existing Monitoring Programs	January 2014
2	Final Report on Monitoring Needs and Requirements and Review of Existing Monitoring Programs	March 2014
2	Draft Report on Crosswalk Comparison	May 2014
2	Final Report on Crosswalk Comparison	July 2014
2	Draft Revised Monitoring Framework	November 2014
2	Final Revised Monitoring Framework	February 2015

ID	Task Name
1	Draft Methodology Document
2	Final Methodology Document
3	Draft Quality Assurance Project Plan
4	Final Quality Assurance Project Plan
5	Draft Baseline Analysis Report
6	Final Baseline Analysis Report
7	Draft Comprehensive Baseline Analysis Report
8	Final Comprehensive Baseline Analysis Report
9	Draft Implementation Scenarios Report
10	Final Implementation Scenarios Report
11	Draft Modeling Report
12	Final Modeling Report
13	Draft Consolidated TMDL Implementation Plan
14	Draft Final Consolidated TMDL Implementation Plan
15	Final Consolidated TMDL Implementation Plan
16	Draft Report on Monitoring Needs and Requirements and Review of Existing Monitoring Programs
17	Final Report on Monitoring Needs and Requirements and Review of Existing Monitoring Programs
18	Draft Report on Crosswalk Comparison
19	Final Report on Crosswalk Comparison
20	Draft Revised Monitoring Program
21	Final Revised Monitoring Framework

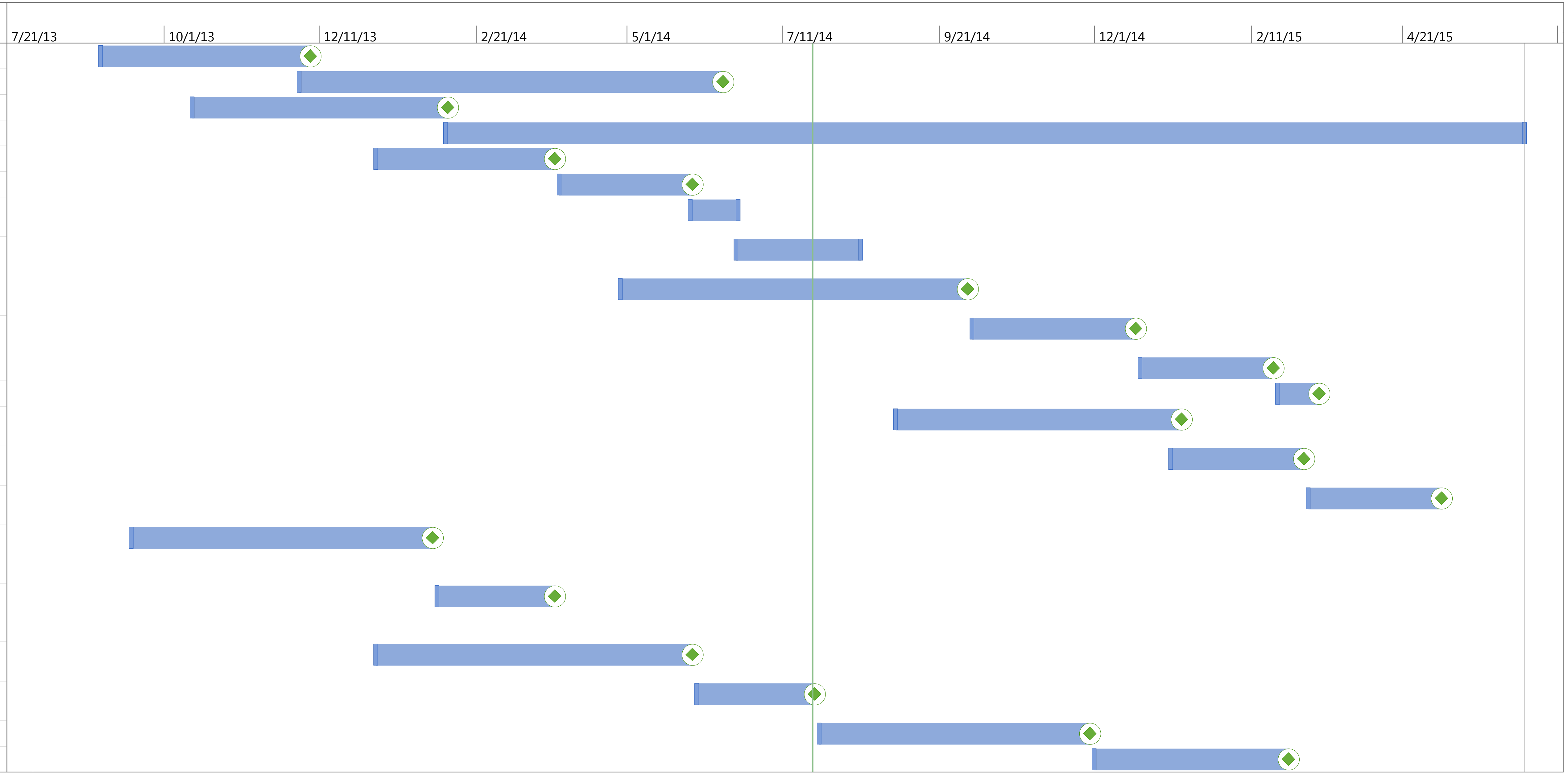

Figure 1 2. Proposed Schedule

1.5 Data Quality Objectives and Criteria (A7)

The traditional data quality criteria (accuracy, precision, representativeness, completeness, comparability, and sensitivity) do not apply in the usual sense to the work being performed for this project because minimal new data will be generated under this project. However, previously collected, reported, or synthesized data will be used to compile the MS4 WLA and EMC inventories and the BMP database, as well as for watershed delineations and modeling activities. The data quality requirements for this project are to assess the adequacy of the data for use in the assigned tasks and to ensure that the work associated with the data and models has been documented.

Data quality and reliability is primarily determined during the measurement phase of data acquisition. Data quality cannot be improved beyond what was measured and/or reported by the data sources. Most of the data to be used in this project will be obtained from databases maintained by government agencies such as the District of Columbia Office of the Chief Technology Officer (OCTO), the Natural Resources Conservation Service (NRCS), and the United States Geological Survey (USGS), or from original source documents, such as the original TMDL studies or supporting documents, such as modeling studies. In order to document the quality of the data used in this project, including data from these government databases and original source documents, the existence of publicly-accessible, quality-related metadata will be documented as part of the quality assurance (QA) procedures outlined in this QAPP.

Accurate and precise data are an important foundation of the MS4 WLA and EMC inventories and the BMP database, as well as of the watershed delineations and modeling activities required to be developed and conducted under this project. The data quality objectives (DQOs) and associated criteria for the data used for this project are as follows:

1) Data are from a known and reliable source. The data sources and rationale for data source selection will be documented. Data will be compiled primarily from original source documents and/or reliable local, state, federal and peer-reviewed sources.
2) Data are of known quality. The quality of secondary data will be evaluated using the following criteria:
    a) Data were used for development of original source documents (e.g., data compiled and used for original TMDL studies).
    b) Data were generated under an approved QAPP or other sampling document (references will be documented).
    c) Data that include QA statements/descriptions/qualifiers and/or associated quality control (QC) data that allows evaluation for precision, bias, representativeness, completeness, comparability, and/or sensitivity.
    d) Data from peer-reviewed publications.
    e) Data quality is limited or unknown, but comes from a reliable source (data limitations and the rationale for data source reliability will be documented).
3) Data are appropriate for the intended use in the project. This will be evaluated using the following criteria:
    a) Data generated using appropriate methods.
    b) Data satisfy project objectives.
    c) Data satisfy evaluation and modeling requirements.
    d) Data exhibit appropriate characteristics (e.g., quality, quantity, temporal, spatial).

Data available from various source documents and databases will be evaluated to determine if data meets DQOs. In order to determine if data meets DQOs, a number of data quality indicators, including data quantity, spatial distribution, representativeness, and completeness, will be used to determine if data sets meet DQOs. These indicators are discussed in more detail below for each individual data type.

Data quantity will be evaluated based on whether there is sufficient data to meet project objectives. With respect to this project, data quantity primarily impacts load modeling, and the adequacy of data quantity for modeling will be determined based on whether there is sufficient data to complete the model inputs.

The spatial distribution of the data will be evaluated based on whether it can provide sufficient data to model loading throughout study area. For example, the Team will evaluate the available data on soils and impervious surfaces to determine whether these data capture the spatial variations in the District.

The Team will review all data sets to be used in the project for representativeness and completeness. "Representativeness" of the data is generally interpreted as the ability of the data to adequately describe the source from which they are generated. Criteria for representativeness include:

- Data were collected and managed according to an approved QAPP.
- Data were evaluated for outliers and outliers were managed appropriately.

Data completeness will also be evaluated to ensure that there are sufficient usable data available to conduct the planned modeling and BMP site identification. The Team will first identify data gaps in the data set required for model application. If possible, the data gaps will be filled using other available data. If the data gaps cannot be addressed, then the data completeness issue will be documented.

Data sets will fit into one of the following:

- Accepted for use if they conform to the data quality indicators.
- Qualified if they are found to be deficient but the discrepancy is within the range of uncertainty for a given data set.
- Rejected.

Ultimately, the Team will use best professional judgment to evaluate each data set against these data quality indicators and determine if the data will be accepted, qualified, or rejected.

1.5.1 Quality Objectives and Criteria for MS4 WLA Inventory

The project requires a complete an accurate inventory of MS4 WLAs that must be included in the IP. The requirements laid out in Section 1.4.2 of the NPDES permit require the attainment of "applicable wasteload allocations (WLAs) for each established or approved Total Maximum Daily Load (TMDL) for each receiving water body." Section 4.10.3 of the permit further states that "For all TMDL waste load allocations assigned to District MS4 discharges, the permittee shall develop, public notice and submit to EPA for review and approval a consolidated TMDL Implementation Plan." The QC steps that will be taken to ensure a complete and accurate inventory of all applicable MS4 WLAs for each receiving water body are summarized below.

DDOE compiled an initial draft spreadsheet summarizing TMDL data relevant to Washington, DC (including MS4 WLAs) in July, 2013. This spreadsheet is referred to as the "draft TMDL tracking spreadsheet." The draft TMDL tracking spreadsheet contained basic tracking information such as the waterbody name, pollutant name, MS4 WLA, and other relevant information. DDOE also compiled a draft list of TMDL documents that was included in the Request for Proposal (RFP) for the project. The process to confirm each MS4 WLA will be as follows. As a first step, each individual MS4 WLA from DDOE's draft spreadsheet will be confirmed by correlating it with the specific TMDL document that establishes that

WLA. To do this, the individual TMDL documents will be reviewed and a cross check of the MS4 WLA will be made between the draft TMDL tracking spreadsheet and the original source TMDL document. As part of this cross-check, information on the table or other source of the MS4 WLA from the TMDL document will be identified and updated into the draft TMDL tracking spreadsheet. The following information will also be cross-checked with the original document and updated into the draft TMDL tracking spreadsheet:

- Name of TMDL study document
- Major basin
- Water body
- Drainage area
- Pollutant
- MS4 baseline load
- MS4 WLA
- Percent reduction of MS4 baseline load required to meet MS4 WLA
- Stormwater/direct drainage baseline load
- Stormwater/direct drainage LA
- Percent reduction of stormwater/direct drainage baseline load required to meet stormwater/direct drainage LA
- CSO baseline load
- CSO WLA
- Baseline year for modeling
- Pollutant sources
- Table number or other documentation of WLA
- Comments

It should be noted that not all of this information may be available for each MS4 WLA or TMDL study document. However, much of this information is supplementary and will be used for informational purposes only. The minimum data requirement to meet the data quality objectives is to identify and confirm each MS4 WLA.

Next, the original source documentation for each MS4 WLA entry in the draft TMDL tracking spreadsheet (i.e., the TMDL study documents and other supporting documentation) will be checked to ensure that the MS4 WLA entry in the spreadsheet is actually a MS4 WLA and not a stormwater or direct drainage LA. This is important because the regulatory requirements only extend to MS4 WLAs, and in the cases of many older TMDLs (particularly TMDLs developed before EPA's guidance clarifying EPA regulatory requirements for establishing WLAs for storm water discharges in TMDLs), stormwater loads were often expressed as LAs and were not assigned MS4 WLAs. In the case of the District of Columbia, stormwater loads can include both point source discharges from the MS4 system and direct drainage from areas not served by the MS4 system. Therefore, each TMDL document will be checked and specific language regarding stormwater allocations will be reviewed to ensure that loads identified as MS4 WLAs are indeed MS4 WLAs.

There are also individual TMDLs where confirmation of MS4 WLAs is not straightforward. Preliminary evaluation of the MS4 inventory indicates the following potential issues regarding confirmation of individual MS4 WLAs:

- TMDLs with no WLAs. There are two general categories of TMDLs that do not include WLAs. These include:

- TMDLs where an impairment exists, and no discharge of that pollutant is allowed, so no WLA is established for that pollutant. An example of this type of TMDL is the TMDL for PCBs and oil and grease in Hickey Run. In these cases, the pollutant reduction is expected to be achieved through a pollutant management plan, and not through achievement of a numeric WLA. The Consolidated TMDL Implementation Plan does include a process for implementing pollutant management/source reduction activities to achieve MS4 WLAs. Therefore, implementation of these types of TMDLs can be accommodated in the IP. These types of TMDLs will be tracked separately in the IP since they have no MS4 WLAs.
- TMDLs where monitoring data was used to demonstrate that an impairment no longer existed. An example of this type of TMDL is the 2003 BOD TMDL for Fort Davis. In cases where a water body is demonstrated to be no longer impaired, the water body can be de-listed from the 303(d) list and the WLA can be considered to be achieved. However, DDOE does not currently have a policy in place to de-list water bodies from the 303(d) list. As with the TMDLs cited above, these types of TMDLs will be tracked separately in the IP since they have no MS4 WLAs.

- TMDLs that may be superseded or replaced – the 2007 and 2008 Anacostia TMDLs for TSS and nutrients and BOD include language indicating that these TMDLs supersede the 2001 TSS TMDL for the Anacostia and the 2002 Nutrients and BOD TMDL for the Anacostia, respectively. However, DDOE does not currently have a policy in place to allow TMDLs to be replaced or superseded. These types of TMDLs and MS4 WLAs will be acknowledged in the Consolidated TMDL Implementation Plan, but depending on the ultimate disposition of the WLAs, there may be no specific implementation activities developed for these WLAs.
- TMDLs with aggregated allocations – these are TMDLs where the MS4 loads have been aggregated with other loads and have not been broken out into specific MS4 WLAs. For example, the 2003 Bacteria TMDL for the Anacostia and its tributaries; the 2001 TSS TMDL for the Anacostia; and the 2002 Nutrients and BOD TMDL for the Anacostia all aggregate load for direct drainage and MS4 into one allocation. Based on conversations with DDOE, aggregated loads (such as a Load Allocation [LA] consisting of MS4 and direct drainage) will be considered targets for the IP, and implementation strategies will be developed to meet these types of targets. In the example of a LA consisting of MS4 and direct drainage, the area on which BMPs can be placed to take load reduction credit towards the LA will include both the MS4 area and the direct drainage area that were included in generating the LA. However, because the implementation strategy to achieve a LA is not required by the MS4 permit (the MS4 permit requires strategies to meet MS4 WLAs only), the implementation activities for LAs will receive lower priority relative to implementation activities for MS4 WLAs.
- "Overlapping" TMDLs – the Anacostia TSS and Anacostia Nutrients and BOD TMDLs include WLAs for nutrients and sediment for certain water body segments of the Anacostia River. Likewise, the Chesapeake Bay TMDL also has WLAs for land river segments that include the Anacostia River. Thus, the Anacostia River is subject to two different sets of requirements for the same pollutants that must be achieved within different parts of the river. Because the Bay TMDL requirements do not "supersede" the Anacostia TSS and Anacostia Nutrients and BOD TMDLs, all of the individual MS4 WLAs must be achieved for each TMDL. Thus the individual WLAs will be tracked and mapped to the parts of the water body where they apply, and separate (but coordinated) implementation activities will be developed for each individual WLA.
- New or in process TMDLs - DDOE is currently in the process of developing or updating a number of TMDLs, including developing new TMDLs for total residual chlorine for Hickey Run, and for dissolved oxygen TMDL for Foundry Branch. In addition, DDOE is planning on revising the

bacteria TMDLs for Rock Creek. However, none of these TMDLs will be completed within the timeframe of the Consolidated TMDL Implementation Plan, which is due in May 2015. Thus, none of these TMDLs or MS4 WLAs will be included in this Plan.

- Alternate expressions of WLAs – In some cases, TMDLs include expressions of MS4 WLAs in addition to the typical expression of the WLA as an annual average. For example, the Potomac and Anacostia PCB TMDL; the sediment/TSS TMDL for the Anacostia; the nutrients/BOD TMDL for the Anacostia; and the trash TMDL for the Anacostia include both annual and daily expressions for WLAs. Other TMDLs include WLAs for the growing season. Every individual expression of the WLA will be tracked for every individual MS4 WLA, and the load model will be able to calculate loads for comparison to every expression of a WLA.

Methods for resolving these TMDLs and MS4 WLAs will be determined through further discussion with DDOE. The resolution of these WLAs will be discussed in the IP document.

Once all of the MS4 WLAs in the draft TMDL tracking spreadsheet have been identified with a specific TMDL document and cross-checked, the entire TMDL inventory will be checked versus the EPA Watershed Assessment, Tracking Results System website at:

http://ofmpub.epa.gov/waters10/text_search.tmdl_search_form

By choosing "DC" under the "State Abbreviation" criterion and leaving all other criteria blank, a list of all unique water body/pollutant TMDLs done for the District can be generated. It should be noted that this search generates a record for water body/pollutant combination for each individual TMDL document in the underlying database. Thus each water body/pollutant combination for each individual TMDL could be listed several times if the underlying database contains multiple documents for that TMDL (e.g., individual documents could include the original TMDL report, a modeling document, the EPA Decision Rationale document, etc.). However, by exporting the data from the webpage into MS Excel, sorting by water body and pollutant, and then checking the date that the TMDL was established, duplicate records for the same water body/pollutant combination from the same TMDL document will be identified and deleted. The processed data will provide a list of all of the unique water body/pollutant TMDL combinations completed for the District. This list will be compared against the TMDL list from draft TMDL tracking spreadsheet. In a preliminary analysis of these data, several discrepancies were identified, but these discrepancies were cross-checked against the original TMDL documents and resolved. As a last check, the ATTAINS database data sent by DDOE on August 2, 2013 will be checked to ensure that all of the TMDLs identified in ATTAINS are included in the draft TMDL tracking spreadsheet. During a preliminary run of this exercise, the same discrepancies that were found with the Watershed Assessment, Tracking Results System data were identified again.

In addition to checking the TMDL inventory for completeness, the modeling documentation will be reviewed to ensure that the WLAs for the tributaries and the mainstems are assigned correctly (i.e., that the tributary WLAs are correctly assigned to the open channel portions of the tributaries, and that the mainstem WLAs are assigned to the entire MS4 area within the mainstem). This QA/QC check will involve reviewing the modeling documentation to determine how the modeling was done (i.e., to determine how the mainstem and tributary WLAs were developed and how they relate to each other) and developing a summary Technical Memorandum describing the modeling and the development of mainstem and tributary WLAs.

Once these processes and QA/QC activities have been completed, the WLA inventory will be finalized. The data will then be compiled in the project database to be used for the remainder of the project.

1.5.2 Quality Objectives and Criteria for TMDL Watershed Delineation

The watersheds that have been assigned MS4 WLAs must be delineated so that the boundaries of the watershed are known and so that any BMPs that reduce load are assigned to provide credit towards the correct WLAs (e.g., it must be known whether BMP X, which controls a certain area on the ground, controls area in subwatershed A or subwatershed B, because subwatersheds A and B have different WLAs that must be achieved in those subwaterheds, and so it must be known whether to assign the credit achieved by BMP X to the WLA for subwatershed A or subwatershed B).

Delineation of TMDL watersheds was accomplished in a step-wise process. The first step was identifying all of the watersheds and subwatersheds with MS4 WLAs. This was accomplished by evaluating the draft TMDL tracking spreadsheet described in Section 1.5.1 above. The draft TMDL tracking spreadsheet identifies MS4 WLAs by pollutant/waterbody segment. A summary table of all unique waterbodies in the draft TMDL Tracking spreadsheet was developed as the basis for the TMDL watershed delineation. This list of unique waterbodies included individual tributaries, as well as multiple designations of the mainstem segments of the Anacostia, and Potomac Rivers and of Rock Creek (for example, Upper and Lower Rock Creek; Upper, Middle, and Lower Potomac; and Tidal Upper and Lower Anacostia.)

DDOE used the list of unique waterbodies with MS4 WLAs in conjunction with an updated MS4 sewershed GIS data layer to delineate most of the TMDL watersheds. First, DDOE delineated all MS4 sewersheds. Next, each MS4 sewershed was assigned either to a tributary (sewers discharged to tributary) or to the mainstem (sewers discharged directly to the mainstem). Any area that was not assigned in this way to a tributary or to a mainstem was assigned as direct drainage, which represented overland flow directly into the mainstem (i.e., flow that was not piped). However, because segmentation of the mainstems (i.e., Upper and Lower Anacostia, Upper and Lower Rock Creek, etc.) was not dependent on the sewershed data, DDOE referred to the original maps and GIS files used to develop the TMDLs to delineate the segmentation of the mainstem Anacostia and Potomac Rivers or on Rock Creek.

As an independent QA check of the TMDL watershed delineations, the Team compared data from the TMDLs to the GIS shapefiles supplied by DDOE. For example, some of the TMDL studies and other supporting documents include tables of watershed areas of the tributaries. By comparing the watershed areas in these tables to the areas of the GIS shapefiles, the accuracy of the watershed delineations were checked. If the two areas were close in size, then it was likely that the delineation was accurate. However, if the areas from the TMDL tables and those calculated from the shapefiles were very different, then further investigation was done to determine if the watershed delineation was in error, or if there was some other reason for the discrepancy.

In order to check the mainstem delineations, base maps of the entire District were used as a starting point, and GIS data of the CSO and MS4 areas, as well as the MS4 tributary sewersheds updated by DDOE, were overlain on the map. Then the CSO and MS4 tributary areas were subtracted out. The remaining MS4 area represents the mainstem MS4 area of the Anacostia and Potomac Rivers and Rock Creek. Segmentation of the mainstems (for example, Upper and Lower Rock Creek; Upper, Middle, and Lower Potomac; and Tidal Upper and Lower Anacostia) were made by referring to maps and descriptions in the original TMDL documents. For example, the 2007 Anacostia sediment TMDL states that "The lower Anacostia is identified as that portion of the river extending from the mouth of the river to the John Philip Sousa Bridge and Pennsylvania Avenue and the upper Anacostia as that portion from the bridge to the MD border," and thus this segmentation can be made in the GIS shapefiles.

Comparison of the initial delineation to the MS4 tributary sewersheds used in the modeling revealed that the initial delineation required further refinement. In order to model the watersheds appropriately, the delineation needed to differentiate between open and closed channel (i.e., piped) streams. It also needed to separate direct drainage from sewered flow at the subwatershed scale.

To delineate the closed channel and open channel areas, a combination of aerial imagery, topography, pipe networks, and stream lines were used. Each subwatershed was reviewed to identify the furthest downstream point where a stream is day lighted. The final inlet to the piped system was then used as a pour point for delineation purposes.

Next, it was necessary to distinguish between the direct drainage and sewered areas of the open channel stream segments. To accomplish this task, MS4 catchment areas were intersected with the TMDL subwatershed level. The direct drainage to an open channel stream was then hand delineated.

1.5.3 Quality Objectives and Criteria for EMCs

A combination of the existing EMCs used in the original TMDLs and updated EMCs from the MS4 monitoring data will be used in the IP Modeling Tool. Therefore, these EMCs must be calculated (in the case of updated EMCs derived from the MS4 monitoring data), inventoried and stored in a database for subsequent use. The inventory of existing EMCs must be comprehensive and accurate and the updated EMCs derived from the MS4 monitoring data must be representative, accurate, and comparable to the TMDL EMCs to allow a comparison of TMDL versus MS4 monitoring data-derived EMCs and a subsequent evaluation of which EMCs to use in the IP Modeling Tool. Together, these quality objectives will help to ensure that the load data generated by the IP Modeling Tool is representative of watershed loads.

The EMC values from the MS4 monitoring data will also be used to help determine if water quality has improved or deteriorated since the TMDLs were developed. EMCs need to meet the same quality objectives for this analysis as for the determination of which EMCs to use in the IP Modeling Tool – they must be comprehensive, accurate, and representative of the respective watersheds for which they are used.

Because the objective of EMC use in both analyses was to make the best representation of current conditions, it was determined that EMCs derived from MS4 monitoring data should be used whenever these data were of sufficient quality to do so. This decision was made because MS4 monitoring data sets (and EMCs derived from these data sets) could be tailored to specific watersheds/basins and because there is more than 10 years of MS4 monitoring data to draw from to develop the EMCs. In contrast, the TMDL EMCs were derived from sampling data that was not as extensive, nor was it always specific to the District. It should also be noted that the MS4 monitoring program came into existence because the TMDL modeling done in the late 1990s and early 2000s demonstrated that there was very limited data to calculate EMCs and to calibrate the TMDL models. Thus, the MS4 monitoring program was designed to provide better estimates of EMCs and pollutant concentration trends over time. Therefore, the quality assurance steps described in the following subsections were initiated with the objective of determining where MS4 monitoring data could be used to derive EMCs, what specificity could be achieved with those EMCs (e.g., could watershed-specific EMCs be derived, or could only District-wide EMCs be derived?), and what specific values should be used for those EMCs.

In order to determine when MS4 monitoring data could be used and which sub-sets of MS4 monitoring data could be used to represent different parameters (i.e., could basin-specific EMCs be developed, or could only District-wide EMCs be developed), the following steps were taken:

- Compile aggregated data sets of individual parameters from all MS4 monitoring data. Remove outliers.
- Determine if there is sufficient MS4 monitoring data for an individual parameter to develop MS4 monitoring –based EMCs

- **DECISION** – if there is not enough data to calculate updated EMC based on MS4 monitoring data, use EMC from original TMDL. If there is enough data to calculate an updated EMC based on MS4 monitoring data, go to step below.
- Use ANOVA analysis to evaluate differences in MS4 monitoring data for each pollutant (with outliers already removed in Step 1 above) between Rock Creek, Potomac, and Anacostia. Conduct evaluation at 0.05 significance level.
- If there is no significant difference between the data sets at a 0.05 significance level, use aggregated EMC from MS4 monitoring (i.e., mean of all data from Anacostia, Rock Creek, Potomac).
- If there is a significant difference between the data sets at a 0.05 significance level, use watershed-based EMC from MS4 monitoring (i.e., mean of all data from individual basins [Anacostia, Rock Creek, Potomac]).

The specific QA procedures for the various steps in this process are described individually below.

1.5.3.a *Specific QA Procedures for Identifying EMCs Used in Original TMDLs*

In order to identify the EMCs used in the original TMDLs, the original TMDLs and TMDL support documents (modeling studies, etc.) were reviewed and EMC data was extracted. Data tables were set up to track the EMC data. To ensure accuracy and completeness of the data collection, EMC data were tracked by TMDL study. An Excel spreadsheet was set up with tables by pollutant type (for example, metals, nutrients, sediment, organics, bacteria, trash and other pollutants.) In each pollutant worksheet, a row was created for each TMDL study document which included that pollutant. Then data columns were completed with EMC and related data for that pollutant from each particular TMDL study. Data included the name of the TMDL study, the waterbodies addressed (for some TMDL studies, different EMCs were used for different waterbodies covered in the same TMDL study.) the EMCs by pollutant type, the units for the EMC, a summary of the source data and methods by which the EMC was developed (e.g., "Storm flow concentrations were obtained by averaging the DC WASA LTCP separate sewer system EMCs (DC WASA, 2000) with means of the recent DC MS4 monitoring results except arsenic, which was based on MS4 monitoring data."), and a summary of the source identifying the EMC (e.g., "Section 5.2 of TMDL report states Small Tributaries Model was used. EMCs are presented in Table 2b, p. 11, Small Tributaries Model Report, ICPRB July 2003.")

By creating a row for each relevant TMDL study within each pollutant tab, the completeness of the inventory could be checked. QA checks included ensuring that all pollutants within all TMDL study documents were included in the table, and that all TMDL documents were included at least once in the table (TMDL studies with multiple pollutant types were included multiple times in the table.) This EMC table was also cross-checked against the draft TMDL tracking spreadsheet described in Section 1.5.1 to ensure completeness.

Identifying some of the EMC data was challenging because EMCs were often not well documented. However, identification of EMCs was aided by the fact that, for the most part, EMCs used for TMDLs in the District were developed on a watershed basis (as opposed to being based on land use type), and EMCs developed for one watershed were often used in other watersheds. In addition, because many of the same many of the same monitoring studies (e.g., separate storm sewer monitoring conducted during development of the DC Water Long Term Control Plan for Combined Sewer Overflows) were used to develop EMCs and many of the same models (e.g., the Small Tributaries Model) were used to develop TMDLs, there were actually a small number of individual EMCs used for the various TMDLs in the District. As described above, this information was document as part of the QA process in developing the EMC tables.

1.5.3.b *Specific QA Procedures for Deriving EMCs from MS4 Monitoring Data*

Updated EMCs were also derived from the MS4 monitoring data. As part of its MS4 permit, the District has been monitoring selected outfalls for wet weather discharges. In order to develop updated EMCs from the MS4 monitoring data, data from various documents and spreadsheets provided by DDOE were consolidated into a database of all available MS4 monitoring data from 2002-2013. The following quality control actions were taken with the data before analysis. First, all dry weather data and fecal coliform samples qualified with ">" were removed. When units of the minimum detection limit (MDL) and the result did not match, both units were checked against the original sources and corrected. Those samples marked as non-detects ("ND") or below quantification limit ("BQL") were estimated to be one half the detection limit for analysis. Lastly, the PAH data was processed in order to compare to WLAs for the summed parameters "PAH1", "PAH2", and "PAH3" in the TMDLs. These are groups of 4-6 individual PAHs. If one or more PAH was missing from a given site/date, all the data were removed since a reliable estimate of the sum could not be computed without all data.

Available wet weather data for the years 2002-2013 were analyzed for minimum, maximum, average, median, number of samples and number of non-detects (NDs). Mercury, PAHs, PCBs, chlordane, dieldrin, DDT isomers, and heptachlor epoxide had such a large number of non-detects (more than 2/3 of all data) that they were excluded from this analysis due to lack of meaningful data. For the pollutants where sufficient data existed to calculate updated EMCs, this was done. First, each data set was scrubbed to remove outliers. To do this, the interquartile range (IQR) was first established as the difference between the upper (Q3) and lower (Q1) values for each parameter, where:

$$IQR = Q3 - Q1$$

Using the Interquartile Rule for the determination of outliers, outliers were identified as data values that are greater than Q3 + (3.0 * IQR). This analysis was applied to conventional pollutants and most metals to identify outliers.

After outliers were removed from the data sets, the data sets were divided by basin (Anacostia, Rock Creek, Potomac) and an ANOVA analysis was run at a 0.05 significance level to determine if there were differences between the basins. If there were differences between the basins, separate EMCs were derived per basin. If there were no differences between the basins, an aggregate, District-wide EMC was derived.

1.5.3.c *Determination of EMCs for Use in Further Analysis*

The TMDL EMCs and updated EMCs derived from MS4 monitoring data were then used in the decision analysis described above to determine which EMCs to use in the IP Modeling Tool and in the trend analysis to determine if water quality was improving or deteriorating in TMDL watersheds.

1.5.4 Quality Objectives and Criteria for Database of Existing BMPs

The Team will develop a comprehensive BMP database for use during the project. The purpose of the BMP database is to provide information on BMPs (BMP type, spatial locations, ownership, information on area treated and/or volume managed, and other data) that can be used to calculate load reductions or inform future implementation scenarios. The BMP database will provide input data for the loading model and will support calculations of load reductions. Data on existing BMPs will be used to calculate existing load reductions to help determine current status relative to achieving WLAs.

Data quality objectives for the BMP database are to maintain a complete and accurate accounting of existing BMP information. The QC steps that will be taken to ensure a complete and accurate BMP database are summarized below.

Existing BMP data will be compiled from multiple sources that DDOE uses for internal and external tracking and reporting, including:

- DDOE BMP Tracking Database – this is DDOE's primary database for BMP information. It is based on BMP installations that require permitting and plan reviews, and so it does not contain data on any BMPs that are not permitted. BMP information in the BMP Tracking Database comes from three main tables, including:
  - Construction Details. This table consists of 2,811BMP records compiled from 2000-2013.
  - General. This table consists of 1,589 BMP records compiled from 2000-2007.
  - Storm Water Facility Information. This table consists of 666 undated BMP records.

  These tables provide information from different phases of DDOE's plan and project review process, but records for individual BMPs are not consistent or comprehensive from table to table. Therefore, records from all three tables must be combined to produce a comprehensive set of BMP records. However, inclusion of all BMP records from these three tables will introduce some duplication of data (i.e., a subset of BMPs will be represented more than once). Because unique IDs are not included in the records to help determine duplicate records created by combining these tables, this database must be scrubbed to remove duplicates. Records will be deemed to be duplicates if data originated from different tables but the spatial location, WPD Plan No, BMP type, and drainage area all match exactly. This scrubbing process is described in more detail below.
- RiverSmart Communities spreadsheets – this data source consists of BMP installation data compiled for the RiverSmart Communities program. It consists of 21 records compiled from 2012-2013.
- RiverSmart Homes spreadsheets – this data source consists of BMP installation data compiled for the RiverSmart Homes program. It consists of 3,183 records compiled from 2009-2013.
- Green Roofs spreadsheet – this data source compiles information on green roofs and is considered by DDOE to be the definitive source of information on green roofs relative to any other data source. It contains 235 records compiled from 1975-2014.

After compiling data from the sources above, unique IDs will be assigned to each existing BMP. Next, database fields for the following standard information will be created and populated based on existing data in the database if it is available:

- BMP_ID
- BMP_Type
- BMP_Area
- DrainArea
- Retention_Volume
- NumberPractices
- BuiltDate
- SewershedType
- Description
- Facility_Name
- Address_Full
- Parcel #
- LotNo
- SquareNo
- Lat
- Lon
- PlanNo
- FileNumber
- Bldg_Permit
- WPDNo

Next, preliminary data cleanup will be performed on the existing BMP data. This will consist of:

- Modifying data to eliminate spelling mistakes or slight data entry discrepancies
- Modifying data to use common terms (e.g., "MS4" versus "separated")
- Modifying data to use common format (e.g., address, dates, lat/long, etc.)

Next, the database will be reviewed and scrubbed to identify and remove potential duplicate records introduced by combining multiple tables from the DDOE BMP Tracking Database. As noted above, potential duplicate records will be identified based on records with a common address and/or WPD Plan number, plus common BMP type and drainage area information. Any records that are determined to be duplicates in this way will be removed from the database. Following an initial analysis of the compiled data, 1,622 records were deemed to be duplicates, leaving 7,088 remaining BMP records.

The next step will be to confirm or identify the spatial location of each BMP. This will be done by first attempting to geocode BMP addresses using DC OCTO's Master Address Repository (MAR) batch geocoding tool, and then utilizing DDOE's internal research on BMPs to further resolve incomplete spatial locations. For BMPs with multiple spatial data attributes (e.g., address, lat./long., square/lot), the spatial location will be confirmed by checking that at least two data attributes match spatially (e.g., the address and the lot number correspond to the same spatial location). Preliminary review of the data reveals that 469 of the records have a populated latitude and longitude; 5,659 additional records are able to be geocoded with MAR and manual searching; and 389 additional records can be identified with internal DDOE research. In sum, a total of 6,517 records currently appear to have usable spatial data. This leaves 571 records with missing spatial data. For these BMPs with missing spatial data or conflicting data per the step above, plans and/or As-built records will be reviewed to populate or confirm spatial data. Once spatial locations are confirmed, BMP records known to be within combined sewer drainage areas will be removed from the database.

The last step will be to confirm or populate the drainage area data. Per consultation with DDOE, drainage areas for BMPs installed under the RiverSmart Homes program will be assumed based on the BMP type. Bayscaping and rain gardens will be assigned a drainage area of 0.01 acres per BMP. Rain barrels and permeable pavement will be assigned a drainage area of 0.005 acres per BMP. Following assignment of assumed drainage areas, a preliminary review of the data shows that 6,411 records have drainage areas and 677 records do not. For BMPs with missing drainage area data, plans and As-built records will be reviewed to identify this information. For those BMPs without plans or As-built records, simplifying assumptions will be employed to populate a drainage area.

- BMPs that are only applied to certain land covers (e.g., green roofs, rooftop disconnections) will be assigned the area of that associated land cover that exists on the BMP parcel (e.g., a green roof will be assigned the area associated with building footprints on the parcel)
- All other BMPs without drainage areas will be assigned the area of the associated BMP parcel

In many cases within the DDOE BMP Tracking Database, multiple BMPs were reported for a single drainage area. When this occurs, the reported drainage area will be split equally among all BMPs for the address, unless other data are available from plan reviews to allocate drainage areas individually,

For the remaining fields in the compiled database, if data is missing, it will be populated only if that data is encountered during the course of plan or As-built record research in the steps above.

For records with null or zero values for drainage area, several approaches will be used to populate this field. These include:

1.) Single BMP on a property with a drainage area. For this condition the drainage area is known and no additional steps were necessary.

2.) Multiple BMPs on a property with the same drainage area. For this condition, the drainage area needs to be divided amongst the BMPs. The drainage area for these BMPs was divided as follows: the first BMP ("1") was assigned 2/3 of the BMP drainage area and the remaining 1/3 area was divided evenly amongst the other BMPs (2, 3, etc.). This "2/3 Rule" was only applicable to BMPs originating from the General and Construction Details tables from the DDOE BMP Tracking Database.

   For all other BMPs where a single drainage area was reported for multiple BMPs at an address, the drainage area was divided evenly among the BMPs.

3.) BMPs with no drainage area recorded. For this condition there are two scenarios:

   a. BMP is spatially located. The BMP point is intersected with DC OCTO's Owner Polygon layer. The Owner Polygon layer holds the area of the parcel and this value was used as the drainage area. The "2/3 rule" and drainage area divide was then applied to this value.

   b. BMP is not spatially located. The BMP is discarded and not used.

This overall BMP review process is shown graphically in Figure 1-3.

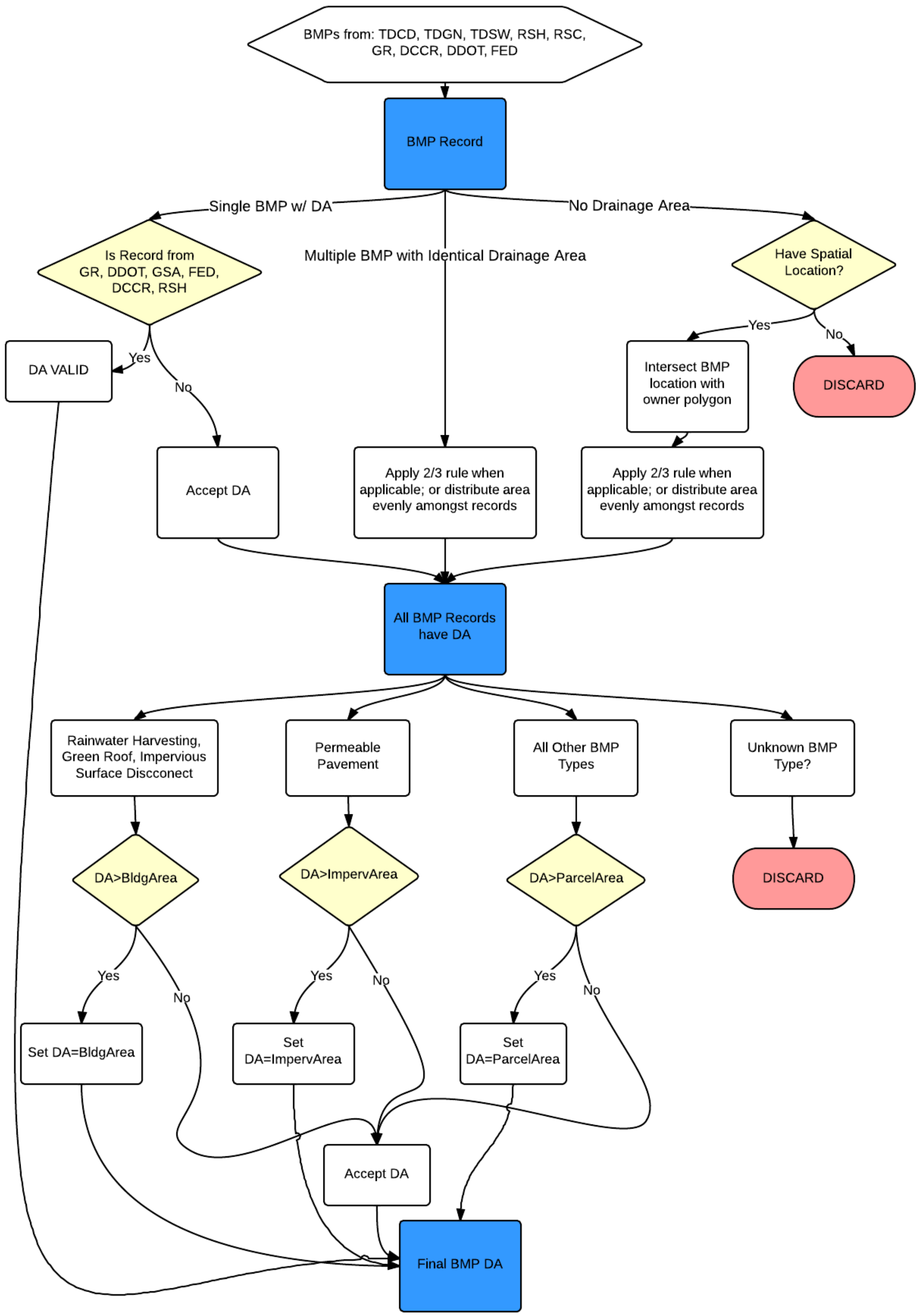

Figure 1-3 BMP Review Process

All additions or modifications made to existing data will be tracked in the BMP database to understand the reason for the modification and the source of the new information.

1.5.5 Quality Objectives and Criteria for GIS Data

The Team will compile a large amount of GIS data for use during the project. The GIS data will be used for modeling activities and the identification of potential BMP locations.

GIS data available from the various databases will be evaluated to determine if data meets DQOs. In order to determine if data meets DQOs, a number of data quality indicators, including data quantity, spatial distribution, representativeness, and completeness, will be used to determine if data sets meet DQOs.

The development of loading estimates for the District requires multiple geospatial data sets. The majority of these data sets have been provided by DDOE through OCTO. Datasets from OCTO include:

- Land Use – Existing
- Impervious Areas are represented by multiple OCTO datasets
    - Roads
    - Sidewalks
    - Buildings
    - Bridges
- Parcel Boundaries
- Hydrography

The geospatial data sets have already gone through quality control by OCTO before being posted for download. However, for an additional quality check before it is used for this project, the OCTO data will be reviewed for general completeness and accuracy. For impervious areas, spot checking of accuracy when compared to recent aerial imagery will be conducted. It is expected that some areas will have impervious type overlaps. In these instances, overlapping areas will be removed as needed.

Hydrology layers from OCTO will also be compared to the National Hydrography Dataset (NHD) provided by the USGS. The Team will download the high resolution NHD dataset for the District. These data will be used to identify any inconsistencies or missing stream segments in the OCTO hydrology dataset.

1.5.6 Quality Objectives for Modeling Tool Development

One of the primary goals of the project is to calculate land-based pollutant loads generated in the District's MS4 area, and the load reductions that will be achieved through the implementation of various storm water management strategies. These loads and load reductions will be used to show progress towards attainment of MS4 WLAs in the District. A custom runoff and pollutant load model (referred to as the IP Modeling Tool) will be developed to perform these load generation and reduction calculations. The intended use of the modeling tool is to develop and evaluate different BMP implementation scenarios to project progress towards attainment of the WLAs. Results from the IP Modeling Tool will be used to prioritize the most efficient implementation of storm water management strategies over time.

The objectives for the modeling task were defined through discussions with DDOE and include the following:

- Calculate and track pollutant loads and reductions spatially and temporally by watershed, catchment, pollutant, or other specification.
- Account for site-specific characteristics of watersheds and catchments such as land use, land cover, soil type, slope, and proximity to waterbodies and storm drains.

- Quantify pollutant load reductions associated with various implementation plan scenarios, including the implementation of the District stormwater management regulations over defined time periods.
- Incorporate spatial changes over time to the District's land use/land cover and BMP implementation and their effect on pollutant loads and reductions.
- Quantify the cost of various implementation scenarios.
- Evaluate progress towards WLA compliance by comparing current and future condition pollutant loads with benchmarks and milestones.
- Screen, rank, and prioritize catchments suitable for specific BMP implementation ("opportunity areas").
- Screen and rank potential BMPs to address pollutants in the opportunity areas.
- Utilize a GIS component to allow spatial visualization of modeling scenarios.
- Ensure that the tool is user-friendly and does not require expert knowledge of modeling concepts to run the modeling tool and understand the output.
- Ensure that the tool is adaptive so that future information can be incorporated into the tool as knowledge and data sources improve.
- Ensure that the tool is linked directly with original data sources to allow for continuous or periodic updates as sources are updated.

To satisfy identified management objectives for the study, a custom runoff and pollutant load modeling tool (the IP Modeling Tool) will be constructed by the Modeling Team. The IP Modeling Tool will consist of several different interconnected pieces, as shown in Figure 1-4 below.

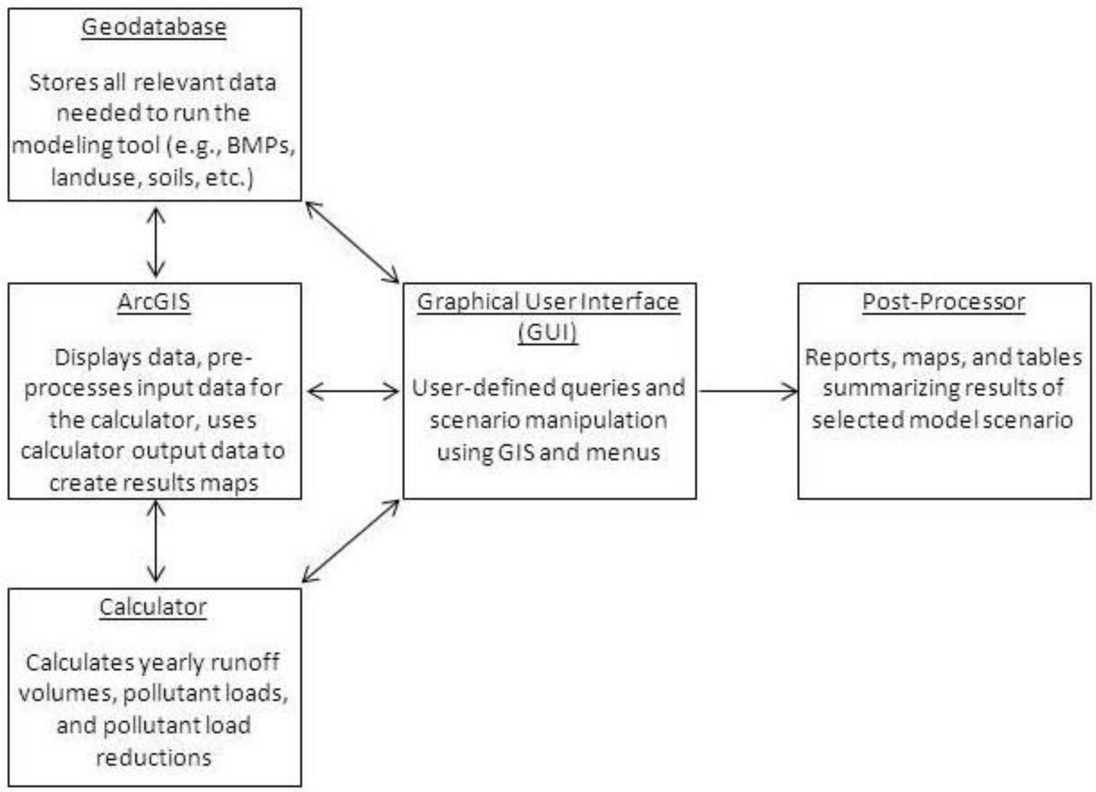

Figure 1-4. IP Modeling Tool Concept Diagram

This section discusses the DQOs and criteria that will be used to evaluate the model inputs and outputs. The quality objectives and criteria will be used to judge the adequacy of information generated within the project and data used that are generated outside the project.

The development of the IP Modeling Tool will follow three major steps: 1) development of the modeling tool; 2) comparison of results from the modeling tool to results from the original TMDLs; and 3) application of the modeling tool to simulate future conditions and stormwater management scenarios.

The DQO of step 1, the development of the IP Modeling Tool, is that the IP Modeling Tool will be constructed using scientifically acceptable and defendable hydrologic principles and data. The criteria are that data used to construct or populate the IP Modeling Tool will be checked for precision, accuracy, bias, completeness, and representativeness. If the data does not meet one or more of these criteria, the data will be flagged and further analyzed to determine if the data could still be used for qualitative purposes rather than quantitative purposes. If further analysis shows that the data cannot be used even in a qualitative way, then the data will be rejected. Data obtained from government agencies will be assumed to meet DQOs based on the QA/QC program of the agency providing the data, unless otherwise indicated by those agencies. Whenever appropriate, a scientific literature review will be conducted to determine the validity and accuracy of data.

The DQO for step 2, the comparison of results from the modeling tool to results from the original TMDLs, is that the modeling tool can estimate storm water loads and load reduction in a consistent manner across the District.. Review of TMDL documentation confirmed that a variety of modeling approaches, drainage areas, precipitation data and EMCs were used within and between the multiple TMDLs in the District. Newer monitoring datasets and land-use GIS coverages are also presently available and relevant to a quality IP modeling effort moving forward. The application of this consistent modeling approach to all

TMDLs as part of the Consolidated TMDL IP makes the tracking of pollutant loads consistent, reflective of current conditions, transparent, and easy to understand. .

The DQO for step 3, the application of the model, is that the model should only be used for its intended purpose, which is to calculate pollutant load and load reductions for the District's MS4 area. A key component of the modeling tool is to define the relationship between stormwater management activities in the MS4 area and the resulting reductions in pollutant loads. The quality criterion is that projected load generation and reduction should fall within generally observed values as documented by scientific literature.

1.5.7 Quality Objectives for Future BMP Placement

Future BMP scenarios will depend on much of the same data described in the Quality Objectives for Modeling Tool Development. These data include land use, imperviousness, and parcel boundary geospatial representations. However, additional data will be required to create feasible future scenarios. This data will also undergo the same quality checks as described in the previous section.

An important component in the selection of future BMP scenarios is the delineation of soil groups. The NRCS Soil Survey Spatial and Tabular Data (SSURGO) for the District. From this data set, soil infiltration capacity (represented by hydrologic soil group) and soil erodibility will be identified in the MS4 areas.

1.5.8 Quality Objectives for BMP Load Reduction Estimates and Tracking

Developing load reduction estimates from BMPs is a critical part of the project, because load reductions will be required to meet MS4 WLAs. The modeling tool will depend on load reduction information as an integral part of scenario modeling and compliance tracking. Load reduction information will be necessary for all of the BMPs (structural and non-structural) that will be used in load reduction scenarios, as well as for all of the different pollutant types for which MS4 WLAs exist. This pollutant reduction information will be used to project the effectiveness of individual BMP installations in reducing pollutant loads to meet individual WLAs. This information will also be used to track compliance by projecting pollutant load reduction after specific levels of actual BMP installation in the future.

Quality objectives for BMP load estimates include representativeness, completeness, comparability, and transparency. The importance of each of these quality objectives is discussed below:

- The planning level estimates of load reduction from projected/proposed BMP implementation must be generally representative of what will be expected to happen when the BMPs are actually implemented.
- Different data sets used to develop BMP load reduction estimates must be comparable so that they can be combined together to yield a larger data set from which to draw conclusions.
- The data must be complete so that BMP load reduction estimates can be made for all of the BMPs (structural and non-structural) that will be used to reduce loads in the District, as well as for all of the pollutant types for which there are MS4 WLAs.
- The data must be transparent so that all interested parties (e.g., DDOE, EPA, stakeholders) will understand how the load reduction estimates were derived and can agree on their use.

1.5.8.a *Use of Literature-Based Pollutant Removal Efficiency Rates to Calculate Load Reductions*

The Team will perform a comprehensive literature search for data and methods employed by others to determine BMP load reductions. This work will be a part of the larger Literature Review subtask under Task 1.1, Development of the IP Methodology document.

The literature search will focus on collecting data that can be utilized to develop load reduction "efficiencies" for all pollutants and classes of BMPs to be modeled. In addition, the Team will also utilize this data to help develop load reduction efficiency curves for various sizes of retention-based BMPs.

Load reduction "efficiency" is a commonly used measure of BMP load reduction. This measure is typically expressed as a percent reduction from baseline. For example, the "efficiency" of a BMP for a certain pollutant could be specified as a 30 percent reduction. In other words, the pollutant load into a BMP is reduced by 30 percent. So if 100 pounds of a certain pollutant was captured by a BMP, 70 pounds of that pollutant would be discharged out of the BMP, and 30 pounds of the pollutant would be reduced.

As stated above, measuring and reporting pollutant removal "efficiency" is a common method for reporting calculating BMP load reductions. Much of the literature reports BMP load reduction in this manner, and many previous plans have used this method for projecting load reductions from certain levels of BMP implementation. For example, the Chesapeake Bay TMDL WIP planning uses load reduction efficiencies for BMP reporting. Therefore, there is a great deal of literature containing BMP efficiency data for certain common pollutants (e.g., nutrients, sediment, and certain metals). Other less common pollutants (e.g., some metals, PAHs, persistent organic compounds, etc.) have very little data. In these cases, partition coefficients will be used (see Section 1.5.8.b for a discussion of the use of partition coefficients to calculate load reductions.

1.5.8.b *Use of Partition Coefficients to Calculate Load Reduction*

As noted above, there is scarce data on the BMP pollutant removal efficiency for some pollutants. In these cases, Partition Coefficients will be used to help calculate pollutant load reductions. Partition coefficients are the ratios of the concentrations of two separate components in a mixture – in this case, the concentration of organic carbon versus the concentration of the specific pollutant in question. Partition coefficients for organic pollutants depend on the organic carbon content of the solids. For use in the TMDL IP Modeling Tool, it was assumed that total suspended solids in stormwater runoff are comprised of 2.4% organic carbon, based upon work for District stormwater (Hwang and Foster, 2006). Partition coefficients of specific pollutants versus TSS were then taken from the literature. The partition coefficients were then used in a standard formula to calculate the fraction of total pollutant concentration in particulate form

$$f_p = (m^*K_p) / (1 + m^*K_p) \qquad (1)$$

where

f_p = the fraction of total pollutant concentration in particulate from,
m = the suspended solids concentration
K_p = the partition coefficient

The fraction of total pollutant removed by a given BMP is calculated as a function of the fraction of pollutant in particle-bound form and the assumed removal efficiency of the BMP for suspended solids, i.e.

$$f_r = r_{TSS} \text{ x } f_p \qquad (2)$$

where

f_r = fraction of total pollutant removed
r_{TSS} = the assumed removal efficiency of the BMP for suspended solids
f_p = fraction of total pollutant concentration in particulate form (determined from Equation 1)

1.5.8.c *Use of Runoff retention to Calculate Load Reduction*

In contrast to load reduction efficiency methods, some researchers relate BMP runoff retention to BMP load reduction. The concept behind this approach is that achieving runoff retention is an effective way to capture pollutants, and focusing on projecting and tracking runoff reduction is a good surrogate for load reduction. In this case, tracking and calculating load reduction based on runoff retention is done by developing curves that relate the amount of runoff captured to the percent of an individual pollutant removed.

Before developing and implementing a protocol to calculate volume-based efficiencies, LimnoTech performed a limited literature review of other methods that seek to establish volume reduction curves. The CBP's Expert Panel on Stormwater BMP Performance Standards recently released its "Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards" report (Chesapeake Stormwater Network, October 2012), which includes a protocol whereby the removal rate for each individual development project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The Chesapeake Stormwater Network lumps BMP types into two categories: stormwater treatment practices (e.g., wet ponds, constructed wetlands, filtering practices) or runoff reduction practices (e.g., bioretention, infiltration practices, permeable pavement). The approach developed nutrient and sediment removal rates for these composite categories of BMPs based on the amount of runoff treated or reduced. The removal rates are presented as BMP removal rate adjustor curves based on runoff depth managed (i.e., treated or reduced) per impervious acre. Since the Chesapeake Bay Program curves were only created for total nitrogen, total phosphorus, and total suspended solids, LimnoTech will develop a continuous simulation modeling approach to develop retention volume curves for all pollutants. The modeling will be completed using EPA's SWMM hydrologic model to simulate rainfall, runoff, and BMP runoff reduction.

1.5.8.d *Load Reduction for Non-Structural BMPs*

Non-structural BMPs and programmatic activities will also be investigated and reviewed for pollutant removal credit. The Literature Review will determine appropriate removal efficiencies or other means of establishing pollutant removal credit for these types of BMPs.

1.5.8.e *QA/QC Procedures for Calculating BMP Load Reduction*

QA procedures for BMP load reduction estimates will include documenting the source of the load reduction estimate, evaluating any QA/QC metadata provided in the original source literature, and evaluating the data to determine whether it meets the project's DQOs. As described above, DQOs for load reduction estimates include representativeness, completeness, comparability, and transparency. Data comparability will be evaluated based on whether or not the original studies reported the data in a similar way (e.g., mass-based versus concentration-based). Data comparability will also be ensured by only including studies (1) that contain land uses that are comparable to those found in the District. Compiling comparable data will be necessary to evaluate the representativeness of individual data sets. The representativeness of the data will be evaluated by compiling summary statistics (for example, minimum, maximum, median, 25th, and 75th percentile.) Evaluating different data sets and reviewing where the load reduction estimate results fall along the distribution of different data sets will help to ensure that any load reduction estimates chosen for use in the modeling will be representative of the universe of comparable data.

Load reduction estimate data will be considered complete when load reduction estimates can be made for all relevant pollutants BMPs for all relevant BMPs.

Finally, transparency will be ensured by following all of the QA/QC procedures in this QAPP and documenting all of the steps described above.

1.5.9 Quality Objectives and Criteria for the Developing a Revised Monitoring Program

As part of the NPDES permit requirement to develop a Revised Monitoring Program, the Team will be collecting information on the District's current monitoring programs. The goal of this data collection effort is to allow an evaluation of DDOE's current monitoring programs to determine if they address existing and new requirements, including making wet weather loading estimates for select parameters, evaluating the health of the District's receiving waters, assisting with pollutant source identification, and facilitating the tracking of progress toward meeting MS4 WLAs. A crosswalk comparison between the District's needs and requirements and existing activities and programmatic data will identify monitoring programs that are sufficient or need modification, new programs that will be required or that are no longer necessary, and efficiencies that may be identified through streamlining various monitoring efforts.

Programmatic data and information on existing monitoring programs will be collected through the review of publically available documentation (e.g., MS4 Annual Reports) as well as through direct communication with staff from DDOE and other city agencies and relevant contractors, through an interview process. Communication will occur with staff in DDOE's Stormwater Management, Watershed Protection, Water Quality, and Fisheries and Wildlife Divisions, and other DDOE Divisions as appropriate. Communication will also occur with DDOE contractors and grantees collecting monitoring data, as well as with non-DDOE entities collecting similar data within and outside the District's boundaries (e.g., USGS flow gauging in the Anacostia and Potomac Rivers; water quality and biological monitoring by the Maryland Department of the Environment or Maryland Counties).

MS4 program-related monitoring data and information to be compiled includes:

- Wet weather discharge monitoring
- Dry weather monitoring
- Area /Source Identification program
- Flow measurements
- Trash monitoring
- Specialized studies, such as Hickey Run oil and grease monitoring
- Others as identified through the course of the assessment

Non-MS4 monitoring data to be compiled includes:

- Fixed station monitoring
- Benthic macroinvertebrate and habitat assessments
- Fish assessment
- Morphological assessments
- Others as identified through the course of the assessment

No new data will be generated in association with the development of the revised monitoring program; only previously collected, reported, or synthesized data will be used. In addition, the actual monitoring data results will not be used to develop the revised monitoring program. Therefore, the data quality objectives for the data used to assist with the development of the revised monitoring program will focus on ensuring a complete and accurate accounting of monitoring efforts within the District through evaluation of programmatic data. This accounting will serve as the basis for determining whether DDOE has the existing monitoring programs and resources in place to meet its monitoring needs and requirements, if additional monitoring programs are required, or if efficiencies can be identified to streamline the monitoring programs to improve cost effectiveness.

The data quality review process will assess the adequacy of the programmatic data for use in the development of the Revised Monitoring Program and to ensure these data have been thoroughly documented. Data used in this task is anticipated to be compiled from DDOE databases and spreadsheets as well as from non-DDOE entities (e.g., MDE, USGS). Sources of information, names of individuals providing the information and data collected, including publicly-accessible data (such as that from the USGS website), will be documented.

To ensure a complete and accurate accounting of monitoring program data and information has been compiled, the Team will hold a “round table” discussion presenting this information. Attendees at the round table will include DDOE staff involved in monitoring activities as well as individuals from outside of DDOE as deemed appropriate. Attendees will have the opportunity to review monitoring program information compiled to date, identify any omissions or needed modifications, and convey monitoring objectives not yet addressed.

1.6 Special Training Requirements/Certification (A8)

While no specific special training or certifications are required for this work, staff engineers and scientists comprising the Team are trained professionals with appropriate technical degrees and the skills necessary to successfully conduct the necessary research and data compilation and develop and apply the modeling tool for the project.

1.7 Documentation and Records (A9)

This section includes the plan for long-term documentation, which is important in a multi-year project such as this one.

The primary deliverable products from this work are reports and memos, databases, a modeling tool, and load reduction scenarios. Major deliverables are summarized in Section 1.4.4. The IP Methodology document will document all of the data and methods that will be used to develop the IP. All of the databases will contain metadata and will be developed according to this QAPP. The modeling tool will be documented as described in the paragraph below and will follow the QAPP as well. Load reduction scenarios and the final project data will be summarized in the final IP document.

Because modeling is so central to this project, additional documentation will be done for the modeling task. Four memoranda are required under the scope of the modeling task, including draft and final memos for the baseline and the management scenarios. Additionally, a modeling tool user guide and manual will be provided at the conclusion of the modeling task. All these memoranda and reports will exist as stand-alone documents separate from the IP. Records pertaining to the modeling task will be maintained on a project directory. These records will include documentation of model testing, validation, and evaluation, as well as pertinent literature, relevant internal and external meeting notes, and sources of data.

1.7.1 Electronic File Storage Procedures

All project files will be maintained in a project folder on the Team’s computer network. No files will be maintained on individual personal computers unless they are temporary working files. All data and work products will be saved to their respective network files daily. As part of its information technology systems, the Team creates a daily back up of all computer files. This daily backup will ensure that copies of all project files exist in the event that electronic files are lost or corrupted.

1.7.2 Project Documents and Records

Documents to be generated by this project include this QAPP, meeting minutes, e-mail messages, technical memoranda, and the draft and final IP Methodology and IP reports.

Records that will be generated during this project include an databases, GIS layers, hardware/ software configuration test reports, model inputs and output files, internal notes in the modeling code, model confirmation results, code verification records and model post-processing files (e.g., those produced using Microsoft Excel, databases, or other data analysis software programs). With respect to the modeling tool, modification to the model code will be documented and the model will be attributed a different version name to track modifications. Incremental changes made to different model versions to arrive at the final model version will be documented. A detailed run log will be maintained associating each simulation to a model version. These records will be complete and detailed enough to allow the models to be re-loaded and re-run independently with the same data sets and producing the same results. The final project report will describe model application to support the IP.

At the conclusion of the project, all relevant information from the project files and computer disks will be turned over to the DDOE COTR to be archived. Documents will be retained in accordance with the DDOE Quality Management Plan (i.e., 10 years for data and 20 years for deliverables). In addition, Team will be responsible for maintaining technical records for at least 10 years.

1.7.3 Metadata for Spatial Data Layers

Metadata will be recorded for each new GIS data layer that is produced during the project and that provides inputs to the load reduction modeling tool. The metadata will include the following:

1. An explanation of the intended use of the new data layer and an explanation of its name.
2. The projection/coordinate system and units of measurement of the location information.
3. A description of the spatial extent of the data layer.
4. A list of sources and dates of original data used as inputs to the creation of the new data layer.
5. An outline of procedures used in ArcGIS (and other software programs, such as Microsoft Access or Excel) to create the data layer.
6. An outline of manipulations used to edit and improve the newly created data layer, including QA/QC procedures.
7. A list of attribute fields, including names, descriptions, domains, and units of measurement.

2. Measurement and Data Acquisition

The ten Group B elements that address measurement and data acquisition are presented in "EPA Requirements for Quality Assurance Project Plans" (EPA, 2001). U.S. EPA draft guidance for modeling QAPPs (EPA, 2002) identifies the following three Group B elements as relevant for modeling:

- Model Calibration (B7)
- Non-direct measurements (data acquisition requirements) (B9)
- Data management and hardware/software configuration (B10)

This section addresses various aspects of data acquisition, the calibration of the model, and the software/hardware configuration needed for data processing.

2.1 Model Calibration (B7)

Model calibration will not occur for this project, since no data exist with which to calibrate the model. Instead, as described in section 1.5.6, results from the IP Modeling Tool will be compared to results from the original TMDLs to ensure that IP Modeling Tool can estimate storm water loads and load reduction in a consistent manner across the District. The Baseline Report will describe the comparison and evaluation of the runoff and load calculation methods.

2.2 Non-Direct Measurements (Data Acquisition Requirements) (B9)

The non-direct measurements for this project include the data described in Table 2-1 required for the IP Modeling Tool. Data needs for the site-specific application include, but are not necessarily limited to: information such as watershed characteristics (topography, soil properties, land use and cover); precipitation data; pollutant-specific EMCs; and BMP characteristics (location, drainage area, treatment volume, removal efficiency).

Table 2-1. Data Requirements for the TMDL Implementation Plan Modeling Tool	
Data Type	**Sponsoring Agency**
Land use and land cover	DC OCTO
Topography	USGS Digital Elevation Model
Soils	National Resource Conservation Service
MS4 watersheds	DDOE
Subsheds	Delineated by DDOE and LimnoTech from sewer data and DEM data
Precipitation Data	National Climatic Data Center
Stream network	U.S. EPA reach files
EMCs	From DDOE wet-weather monitoring data or from original TMDLs
BMP Type/Location/drainage area	DDOE and LimnoTech
BMP efficiencies	From scientific literature

The project data quality standards measured by indicators include features of data quality such as precision, accuracy, bias, completeness, and representativeness. DQOs for existing data obtained from federal and state agencies such as NRCS and DDOE will be assumed to be met based on the QA/QC program of the agency providing the data, unless otherwise indicated by those agencies.

This QAPP is designed to ensure the quality of the predictive capacity of the model framework for predicting pollutant loads and load reduction in the MS4 area. According to U.S. EPA guidance, the following QA procedures will be adopted:

- Maintaining written records of data needs for modeling
- Keeping written rationale for model selection, model development, and linkages of models
- Keeping records of model assumptions
- Providing written documentation of code development and modifications
- Keeping records of all data used for model development and validation, including information on data quality and performance evaluation and acceptance criteria
- Documenting all model updates and revisions
- Maintaining a log book of model runs and listing all the model run conditions
- Providing a description of the limitations of the modeling framework

Results of model application will provide comprehensive assessment of all pollutant loads and load sources within a watershed, as well as pollutant load reductions achieved through management practices. The application will help assess the watershed pollutant loads and also rank the sub-catchments by load to help guide future management decisions.

Model input data will be verified for quality from its sources. To determine whether the data sources meet the acceptance criteria for the project, separate checks on each data source will be conducted. Data will be checked to determine whether to accept, reject, or qualify each individual data set based on requirements for the project. Validation and verification criteria will be applied to determine if the available data meet the project needs and if data are sufficient to draw conclusions. Data will also be tested for its usability to meet required spatial and temporal scales. Therefore, limitations in non-direct measurements identified through application of the acceptance criteria will be resolved either by using the data but identifying the implications of its limitations on the study results or, for non-critical non-direct measurements that do not pass acceptance criteria, applying the models without the use of those non-direct measurements. Any limitation on the use of data and subsequent interpretation of study results will be reported in the final model report. Data quality objectives for representativeness, bias, completeness, and comparability to expected input data will be evaluated for use of data in the model.

As previously described, data used for model inputs and corroboration will be obtained from different sources. The QAPP includes checks on data from different sources to ensure achievement of the data compatibility requirements.

2.3 Data Management and Hardware/Software Configuration (B10)

Data management and the hardware/software configuration for the project are described in this section.

2.3.1 Data Management

Data used during the project will be maintained in either hard copy or electronic format, depending on its nature. Manipulation (e.g., transcription/copying, formatting) of the downloaded data is identified as one of the major preventable error sources in the project effort. Original copies of all data will be kept in the project file and the original source of the data will be documented in the database; thereby, allowing all data to be traced to its original source. Formatting of data to ensure usability and comparability (e.g., normalization of units, referencing or georeferencing of datapoints, etc.) will be done by the Modeling Team, who will then document their formatting to ensure all data manipulations can be tracked to ensure quality.

User-induced error can be identified and corrected under an appropriate level of QA/QC. Multiple steps will be taken to ensure errors are minimized. Data formatting will be reviewed, including the data element type, format, allowable values and ranges, and other parameters. Any manually entered parameter values from paper sources will be evaluated by reviewing hard copy printouts. The review will include a comparison of the original data sources and paper documentation. Any record identified as having issues will be reviewed to determine whether corrected data can be acquired or the record omitted.

Data from various sources will be combined in a database designed in MS Access. The Modeling Team will coordinate data efforts including identifying data sources, collecting and compiling the data in one location, and maintaining the required data formats. The final model report and the final IP will document how data from various sources were utilized in the project. Project documentation as identified in Section 1.8 will report the sources of data, the procedure adopted to obtain the data in required format, the record-keeping procedure, and the process of compiling and combining the data to meet spatial and temporal scales of the model. Any pre- and/or post-processing required to meet the needs of the IP Modeling Tool will be described in the final modeling report. The data will be checked for any inconsistencies in the records. Data in the forms of charts, plots and tables will be included in the model memoranda or reports wherever appropriate.

The performance of data will be evaluated by performing simple tests; e.g., a simple graphical representation in MS Excel program will show if there is any inconsistency in data. The QA procedure for data sets includes:

- Review data from different sources
- Summarize data handling procedure
- Maintain database with information of sources
- Check for data inconsistencies
- Check data for representativeness

- Perform and check data analysis
- Document the procedure for data analysis
- List the details on use of data
- Report any manipulations/transformations performed on data
- Document the appropriateness and completeness of data for required application
- Maintain information on QA/QC performed on data
- Archive original data and analyzed data

2.3.2 Hardware/Software Configuration

The IP Modeling Tool will be a tabular accounting tool designed using Microsoft Excel but ultimately converted into a database, most likely using or Microsoft Access. Pre-processing and Post-processing will be accomplished through use of ESRI's ArcGIS 10.x software, including the Spatial Analyst extension. The IP Modeling Tool will be linked to a database containing the input data sets, and this database will be prepared in MS Access.

Hardware required to run the modeling tool is a standard personal computer (PC) and a hard disk drive. Software requirements are Microsoft Excel, Access, and Word, as well as ESRI ArcGIS 10.x, including the Spatial Analyst extension. A printer will be needed to print hardcopies of the results files. The database containing input and output data sets will be prepared in MS Access.

3. Assessment and Oversight Elements (Group C)

The Group C Assessment and Oversight elements presented in "EPA Requirements for Quality Assurance Project Plans" (EPA, 2001) are addressed in this section of the QAPP.

3.1 Assessment and Response Actions (C1)

Models represent reality through the use of theoretical equations designed to approximate the natural system. The ability of the IP Modeling Tool to correctly represent model theory will be assessed continually during the duration of the project by the Modeling Team. The Modeling Team will evaluate and assess data to be used in model development and validation per criteria discussed in previous sections. This evaluation will ensure reasonable behavior of the model output when compared with available data and will help in understanding system behavior. In cases where data are sparse or available data have different spatial and temporal scales, judgments will be made to check data applicability for field testing of model results. Information gained from the sensitivity analyses will be used to guide the ultimate modeling approach and help assess its utility in helping meet the goals of the project.

Performing QC calculations to validate the information utilized by the modeling effort and the results produced by the models are major components of the QA framework. Data entries, hand calculations, and other actions will be used to check model performance. Any corrective actions required will be performed by the Modeling Team in consultation with DDOE. The Modeling Team Leader is responsible for ensuring that identified corrective actions are implemented. The Modeling Team will document these activities as they occur, and the information will be maintained by the Team. This documentation will be included in the project records, and maintained on a project directory as explained in section 1.8.

The Technical Advisor for Modeling will review the modeling work conducted for this project, including the modeling approach and assumptions, and all documentation of the modeling effort to ensure that a scientifically credible product is produced. The Modeling Team will address any technical issues identified from these reviews.

3.1.1 Assessment of Model Input/Output

During Task 1.2, model inputs for the IP Modeling Tool will be carefully reviewed by the Modeling Team prior to each model run to ensure the inputs are consistent with the modeling approach. Any model inputs that are questionable or not fully documented will not be used to generate final results. Additional QA/QC will include performing control calculations and post-simulation validation of predictions.

All modifications and assumptions to the model inputs will be documented in a separate file that lists the date, run ID, and inputs that were modified. All model inputs will be stored in the same folder as the corresponding model output to keep a complete record of each simulation used for model comparison.

Model results will be reviewed by the Modeling Team as a final quality check to ensure the model results are within reasonable ranges (see Section 1.5.6). Processed model outputs will always be stored in a folder with the run ID and the unprocessed model output.

3.1.2 Review and Corrective Action

The corrective actions required to address any future potential QA issues will be performed by the Modeling Team. The Modeling Team will document these activities as they occur, and the information will be maintained by the Team. This documentation will be included in the project records.

The Technical Advisor for Modeling will review the modeling work conducted for this project, including model results and all documentation of the modeling effort, to ensure that a scientifically credible product is produced. The review will include analysis and comment on parameter evaluation, and model application. The Technical Advisor for Modeling will meet with the Modeling Team to facilitate interaction with the models and to explore certain aspects in detail. The Modeling Team will address any technical issues identified from these reviews.

If the review results in detection of unacceptable conditions or data, the Technical Advisor for Modeling will be responsible for developing and initiating corrective action. The Project Manager and Modeling Team will be notified in writing if the nonconformance relates to their work. Corrective response actions may include review or validation of data, performing additional model runs, or editing and modifying report deliverables. Determination of the appropriate corrective response will be coordinated by the Technical Advisor for Modeling. Depending on the nature of the issues, the Technical Advisor for Modeling may determine that it is necessary to notify and/or engage the DDOE COTR in the discussion and resolution of the issues. The decision on the need to engage DDOE will be made on a case-by-case basis. All decisions will be documented in the project reports (final modeling report and or final IP).

The Team will meet all QA requirements prior to approval of the final deliverables.

3.2 Reports to Management (C2)

The Modeling Team will provide independent reporting to the Technical Advisor for Modeling and DDOE on an as needed basis. The communication is facilitated through the use of electronic mail, which provides ready access. Pertinent model documentation will be included in the various report deliverables shown in Table 1-2.

4. Data Validation and Usability Elements (Group D)

The Group D Data Validation and Usability elements presented in "EPA Requirements for Quality Assurance Project Plans" (EPA, 2001) are addressed in this section of the QAPP.

4.1 Data Review, Validation, and Verification Requirements (D1)

To achieve the objectives of project, including developing and performing the modeling, developing the IP, and developing the revised monitoring framework, attainment of quality procedures adopted for the project must be evaluated. The performance evaluation criteria will determine the quality and usability of the project and model results. This section describes the process to assess usability of the project and model results.

Criteria must be established to decide whether to accept, reject, or qualify the data collected for the project and generated by the model. This is accomplished by adopting validation and verification criteria. Validation criteria specifies whether data satisfy user requirements, and verification criteria determine if data are sufficient for drawing data quality conclusions and project objectives. The data review and compilation tasks completed to compile these data and support the development and implementation of the modeling, the development of the IP, and the development of the revised monitoring framework will be performed by experienced personnel.

The acceptance criteria for data used to develop the IP and the revised monitoring framework are conformance with the DQOs. The acceptance criteria for the modeling process include evaluation of the model at various stages of the process, including development, validation, and application. Evaluations of model performance will be made by comparing plots of reference data and model predictions. These plots will provide both quantitative estimates and qualitative assessments. As information is passed from one step to another, different assessments will be made to determine if it is acceptable to move to the next phase of assessment.

4.2 Validation and Verification Methods (D2)

Different procedures for data validation (i.e., the process of determining whether the data satisfy user requirements), and data verification (i.e., the process of ensuring that data are sufficient for drawing conclusions related to the data quality objectives) will be adopted. The data used to develop the IP and the revised monitoring framework, as well as model input data and IP Modeling Tool results, will undergo extensive review and will be assessed for quality. Data will be evaluated for adequacy in terms of the common data quality indicators, such as precision, accuracy, comparability, representativeness, and completeness, as appropriate. Specifically for the modeling, the accuracy of the IP Modeling Tool output data will be checked by comparing the data trends and by comparing data with any historical data available. Each data set will be categorized into different group by its usability. The categories will include:

- Acceptable (data may be used without any restrictions).
- Acceptable under certain conditions (data may be used under certain conditions, which must be specified).
- Not acceptable (data cannot be used; the problems and reasons for unsuitability will be identified).

The project team will discuss all the issues identified pertaining to available data, alert the appropriate team leader about any identified issues (who will at their discretion alert the DDOE COTR), and will document procedures used to resolve them. Information on data sources, validation and verification will be included in the IP and/or IP Modeling Tool report, as appropriate.

4.3 Reconciliation with User Requirements (D3)

Overall project data will be acceptable to meet user requirements if the data supports development of the IP, the IP Modeling Tool, and the revised monitoring framework. With respect to the modeling, the Modeling Team will review the model results, incorporating the uncertainty in IP Modeling Tool predictions, and check predictions for reasonableness and relevance based on observed data. The development and validation of the modeling tool are intended to ensure that if the third step of the modeling protocol (i.e., applying the model for future scenario management) meets its own internal quality standards, the output of this step (i.e., the output of the modeling tool framework) will meet the requirement for the entire project. Therefore, if the outputs meet the internal criteria for the IP Modeling Tool development and validation, as described in this QAPP, requirements for the overall modeling framework will be met.

5. References

Hwang, H.M., and G. D. Foster. 2006. *Characterization of Polycyclic Aromatic Hydrocarbons in Urban Stormwater Runoff Fowing into the Tidal Anacostia River, Washington, DC, USA*. Environmental Pollution (140): 416-426.

United States Environmental Protection Agency (EPA). 2001. *EPA Requirements for Quality Assurance Project Plans*. EPA QA/R-5. EPA, Office of Environmental Information: Washington, DC. EPA/240/B-01/003.

United States Environmental Protection Agency (EPA). 2002. *Guidance for Quality Assurance Project Plans for Modeling* EPA QA/G-5M. EPA, Office of Environmental Information: Washington, DC. EPA/240/R-02/007.

Appendix 1

Summary of TMDLs and MS4 WLAs in Washington, DC											
				Pollutant Category							
Major Basin	**TMDL Name**	**Year Approved**	**Number of MS4 WLAS**	**Metals**	**Organics**	**Nutrients**	**Sediment**	**Bacteria**	**Pesticides**	**PCBs**	**Other (Oil and Grease, BOD, Trash)**
Anacostia	District of Columbia Final TMDL for Fecal Coliform Bacteria in Upper Anacostia River, Lower Anacostia River, Watts Branch, Fort Dupont Creek, Fort Chaplin Tributary, Fort Davis Tributary, Fort Stanton Tributary, Hickey Run, Nash Run, Popes Branch, Texas Avenue Tributary	2003	12					X			
Anacostia	DC TMDL for Organics and Metals in the Anacostia River and Tributaries	2003	125	X	X				X	X	
Anacostia	TMDL Upper Anacostia River Lower Anacostia River District of Columbia BOD	2001	0			X					X

Summary of TMDLs and MS4 WLAs in Washington, DC											
				Pollutant Category							
Major Basin	**TMDL Name**	**Year Approved**	**Number of MS4 WLAS**	**Metals**	**Organics**	**Nutrients**	**Sediment**	**Bacteria**	**Pesticides**	**PCBs**	**Other (Oil and Grease, BOD, Trash)**
Anacostia	TMDL of Nutrients/BOD for the Anacostia River Basin, Montgomery and Prince George's Counties, MD and the District of Columbia	2008	6			X					X
Anacostia	DC Final TMDL for Oil and Grease in the Anacostia River	2003	2								X
Anacostia	TMDL of Sediment/Total Suspended Solids for the Anacostia River Basin, Montgomery and Prince George's Counties, MD and the District of Columbia	2007	5				X				
Anacostia	TMDL of Trash for the Anacostia River Watershed, Montgomery and Prince George's Counties, MD and the District of Columbia	2010	2								X

Summary of TMDLs and MS4 WLAs in Washington, DC											
				Pollutant Category							
Major Basin	**TMDL Name**	**Year Approved**	**Number of MS4 WLAS**	**Metals**	**Organics**	**Nutrients**	**Sediment**	**Bacteria**	**Pesticides**	**PCBs**	**Other (Oil and Grease, BOD, Trash)**
Anacostia	Total Maximum Daily Loads: Upper Anacostia River, Lower Anacostia River, District of Columbia; Total Suspended Solids	2002	2				X				
Anacostia	District of Columbia Draft TMDL for Biochemical Oxygen Demand in Fort Davis Tributary	2003	1								X
Anacostia	DC Final Hickey Run TMDL Water Quality Management Plan to Control Oil and Grease, PCB, and Chlordane	1998	3		X						X
Anacostia	District of Columbia Final TMDL for Fecal Coliform Bacteria in Kingman Lake	2003	1					X			
Anacostia	District of Columbia Final TMDL for Organics and Metals in Kingman Lake	2003	14	X	X				X	X	
Anacostia	District of Columbia Final TMDL for TSS, Oil &Grease, BOD in Kingman Lake	2003	3				X				X

Summary of TMDLs and MS4 WLAs in Washington, DC

				Pollutant Category							
Major Basin	**TMDL Name**	**Year Approved**	**Number of MS4 WLAS**	**Metals**	**Organics**	**Nutrients**	**Sediment**	**Bacteria**	**Pesticides**	**PCBs**	**Other (Oil and Grease, BOD, Trash)**
Anacostia	District of Columbia Final TMDL for Total Suspended Solids in Watts Branch	2003	2				X				
Potomac	DC TMDL for Organics, Metals and Bacteria in Oxon Run	2004	13	X	X			X	X	X	
Potomac	District of Columbia Final TMDL for Bacteria in the Chesapeake and Ohio Canal	2004	1					X			
Potomac	DC Final TMDL for Fecal Coliform Bacteria in Upper Potomac River, Middle Potomac River, Lower Potomac River, Battery Kemble Creek, Foundry Branch, and Dalecarlia Tributary	2004	6					X			
Potomac	District of Columbia Final TMDL for Organics and Metals in Battery Kemble Creek, Foundry Branch, and the Dalecarlia Tributary	2004	18	X	X				X	X	
Potomac	DC Final TMDL for pH in the Washington Ship Channel	2004	1			X					

Summary of TMDLs and MS4 WLAs in Washington, DC											
				Pollutant Category							
Major Basin	**TMDL Name**	**Year Approved**	**Number of MS4 WLAS**	**Metals**	**Organics**	**Nutrients**	**Sediment**	**Bacteria**	**Pesticides**	**PCBs**	**Other (Oil and Grease, BOD, Trash)**
Potomac	District of Columbia Final TMDL for Bacteria in the Tidal Basin and the Washington Ship Channel	2004	2					X			
Potomac	DC Final TMDL for Organics in Tidal Basin and Washington Ship Channel	2004	20		X				X	X	
Potomac, Anacostia	Chesapeake Bay TMDL for Nitrogen, Phosphorus, and Sediment	2010	12	X							
Potomac, Anacostia	TMDL for PCBs for Tidal Portions of the Potomac and Anacostia Rivers in DC, MD, and VA	2007	7							X	
Rock Creek	District of Columbia Final TMDL for Fecal Coliform Bacteria in Rock Creek	2004	2					X			
Rock Creek	DC Final TMDL for Metals in Rock Creek	2004	8	X							

Summary of TMDLs and MS4 WLAs in Washington, DC											
				Pollutant Category							
Major Basin	**TMDL Name**	**Year Approved**	**Number of MS4 WLAS**	**Metals**	**Organics**	**Nutrients**	**Sediment**	**Bacteria**	**Pesticides**	**PCBs**	**Other (Oil and Grease, BOD, Trash)**
Rock Creek	DC Final TMDL for Organics and Metals in Broad Branch, Dumbarton Oaks, Fenwick Branch, Klingle Valley Creek, Luzon Branch, Melvin Hazen Valley Branch, Normanstone Creek, Pinehurst Branch, Piney Branch, Portal Branch, and Soapstone Creek	2004	114	X	X				X	X	
Totals			**381**								