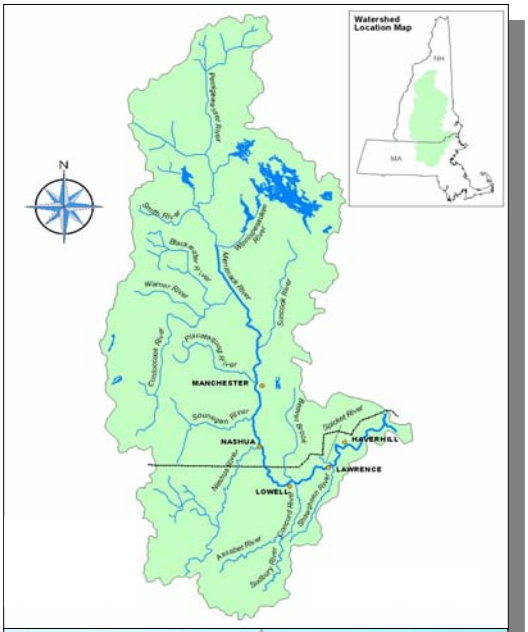
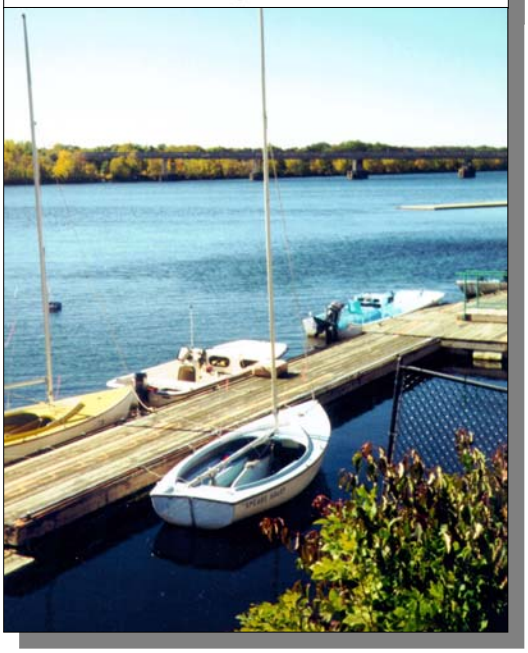




Merrimack River Watershed Assessment Study

Field Sampling Plan

Prepared for:

New England District
U.S. Army Corps of Engineers

Sponsor Communities:
Manchester, NH
Nashua, NH
Lowell, MA
GLSD, MA
Haverhill, MA

May 2003

The River Basin Community Coalition concept was conceived in June 1998 in response to regulatory requirements to mitigate Combined Sewer Overflows (CSO) discharges. Because the coalition communities faced an aggregate financial commitment of 0.5 to 1.0 billion dollars, the five founding technical managers and administrators from each community believed that such an investment should be made wisely. They believed that this wise investment should be founded on good science that holistically embraces the needs of the watershed. Generally speaking the mission is to "spend smart" by making wise science based investments in activities related to water quality improvements that are not solely focused on CSO mitigation.

Contents

Figures

Tables

Acronyms and Abbreviations

BOD	Biochemical Oxygen Demand
CSO	Combined Sewer Overflow
cfs	Cubic feet per second
DO	Dissolved Oxygen
DQO	Data Quality Objectives
Dup	Duplicate
D/S	Downstream
FSP	Field Sampling Plan
FPC	Field Program Coordinator
GLSD	Greater Lawrence Sanitary District
GPS	Global Positioning System
L	Liter
MADEP	Massachusetts Department of Environmental Protection
mL	Milliliter
NAI	Normandeau Associates, Inc.
NEA	Northern Ecological Associates, Inc.
NHDES	New Hampshire Department of Environmental Services
PFD's	Personal Floatation Devices
PIBS	Portable-Invertebrate-Box Sampler
PM	Project Manager
Poly	Polyethylene
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
SOP	Standard Operating Procedure
TBD	To be determined
TKN	Total Kjeldahl Nitrogen
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
U/S	Upstream
WWTP	Wastewater Treatment Plant

Section 1
Introduction

1.1 Study Overview

The Merrimack River Watershed Assessment Study is a jointly funded effort between the Federal Government, through the United States Army Corps of Engineers (USACE), and the five local community sponsors of Manchester and Nashua, New Hampshire; Lowell and Haverhill, Massachusetts; and the Greater Lawrence Sanitary District, Massachusetts.

The overall purpose of this Study is to develop a comprehensive Watershed Management Plan for the Merrimack River watershed. The plan will be used to guide investments in the environmental resources and infrastructure of the basin and will be aimed at achieving water quality and flow conditions that support designated uses, including drinking water supply, recreation, fisheries, and aquatic life support. Currently, according to the most recent water quality assessment reports for New Hampshire and Massachusetts (NHDES 2002; MADEP 2002), the majority of the mainstem Merrimack River downstream of Manchester, New Hampshire does not meet designated use requirements based on water quality standards for bacteria, nutrients, and/or metals.

1.2 Task Description

A comprehensive field sampling program has been developed as part of the Merrimack River Watershed Assessment Study. The overall goal of the program is to provide an accurate and representative picture of the current water quality and streamflow conditions at specific sampling stations in the Merrimack River mainstem, as well as at the mouth of major tributaries. The environmental data collected under this task will be used as input to water quality and hydrologic/hydraulic models to be developed under subsequent tasks of the Merrimack River Watershed Assessment Study. These models will serve as the basis for future investment decisions in the basin.

The field sampling program consists of the following four major subtasks:

- Dry-weather water quality surveys
- Wet-weather water quality surveys
- In-stream flow monitoring
- Continuous dissolved oxygen and temperature measurements

The surveys will be distributed throughout the spring, summer, and fall of 2003 (May-November 2003) as precipitation patterns allow; winter sampling will not be conducted. Additional details on each survey are presented in Sections 4.0 and 5.0.

This document presents a summary of the sampling and flow monitoring locations, sampling frequency, and water quality parameters to be measured/collected during the wet and dry-weather surveys. This Field Sampling Plan supports the Quality Assurance Project Plan (QAPP), submitted under separate cover, for the Merrimack River Watershed Assessment Study. A supporting compendium of Standard Operating Procedures (SOPs) for field and analytical methods is also bound separately.

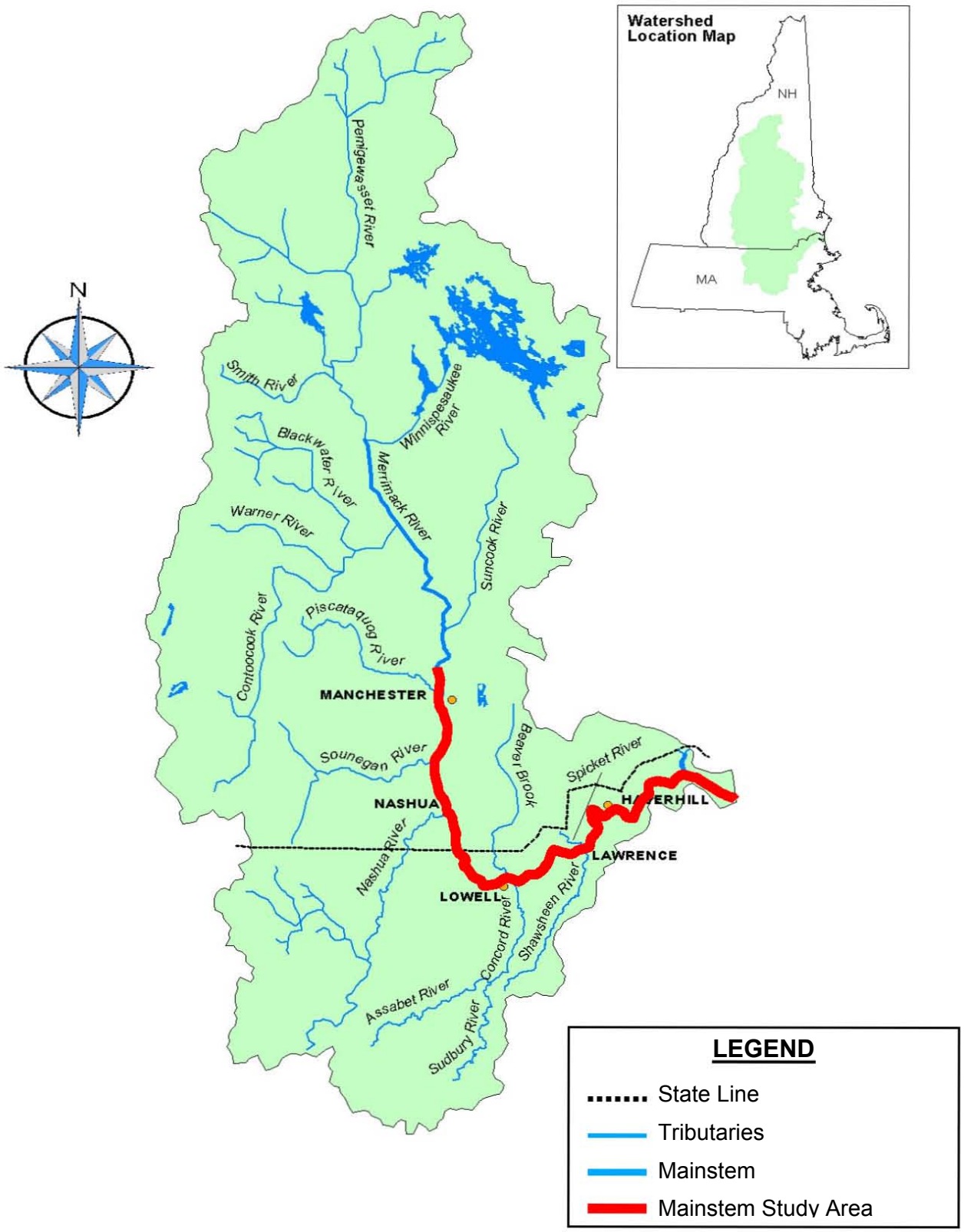
1.2.1 Study Area

For the purposes of the field sampling program, the Study Area has been identified as the mainstem Merrimack River south of Hooksett, New Hampshire to the confluence of the River with the Atlantic Ocean. This area includes the sponsor communities of Manchester and Nashua, New Hampshire, Lowell and Haverhill, Massachusetts, and the Greater Lawrence Sanitary District, Massachusetts. The final 22 miles of the mainstem Merrimack River in the Study Area downstream of Haverhill, Massachusetts are tidally influenced.

Four dams are located in the Study Area: the Hooksett Dam in Hooksett, New Hampshire; the Amoskeag Dam in Manchester, New Hampshire; the Pawtucket Dam in Lowell, Massachusetts; and the Essex Dam in Lawrence, Massachusetts. The Study Area also includes the confluence of 11 major tributaries with the mainstem, many of which contribute to the pollutant load in the Merrimack River.

Figure 1-1 shows the entire watershed, along with the portion of the mainstem Merrimack River that is targeted by this sampling program.

Figure 1-1: Merrimack River Watershed and Study Area



1.3 Sampling Parameters

Table 1-1 presents a summary of the water quality parameters to be included in the field and laboratory analyses. All parameters will be sampled during both wet and dry-weather events, except as noted. Sample matrices for each event are provided in Section 5.0.

Table 1-1: Summary of Sampling Parameters

Analytical Parameters	Field Measurements
Indicator Organisms • Fecal coliform • E. Coli • Enterococcus (marine waters only) Nutrients & Impacts • Total Phosphorus • Nitrate/ Nitrite • Total Kjeldahl Nitrogen (TKN) • Ammonia-N • Chlorophyll-a Oxygen & Oxygen Demand • Dissolved Oxygen (Winkler Titration) • BOD_5 • BOD_{20}	• *In situ* Measurements o Temperature o Dissolved Oxygen (DO) o Salinity o pH o Conductivity o Turbidity • Secchi Disk depth (dry-weather only) • Vertical Temperature and DO profiles (only upstream of dams during dry-weather) • Diurnal DO sweeps (select stations during dry-weather events only) • Streamflow (select stations only) • Continuous DO/Temperature measurements (select stations only)

As noted, only samples collected in tidally influenced portions of the mainstem Merrimack River, defined as downstream of Haverhill, Massachusetts for the purposes of this Study, will be analyzed for Enterococcus, as the United States Environmental Protection Agency (USEPA) has designated this organism as a better indicator of human health risk in marine waters.

Continuous dissolved oxygen and temperature measurements will be taken at two locations in the mainstem Merrimack River as part of the field sampling program. Monitoring will be performed over a one-month period from mid-July to mid-September. The exact timing of the monitoring will be based on prevailing streamflow and climatic conditions.

1.4 Roles and Responsibilities

Funding for the Merrimack River Watershed Assessment Study is managed by the USACE; Ms. Barbara Blumeris serves as the Study Manager. The USACE, in

conjunction with the five sponsor communities, serve as the project Study Management Team.

The CDM Project Team is comprised of CDM and its subcontractors:

- Normandeau Associates Inc. (NAI) of Bedford, New Hampshire
- Northern Ecological Associates (NEA) of Portland, Maine
- Aquatec Biological Sciences of Williston, Vermont
- AMRO Environmental Laboratories Corporation of Merrimack, New Hampshire

Mr. Gary Mercer (CDM) will serve as the Technical Project Manager for the overall Study. Mr. Mercer will be responsible for overseeing the mobilization of sampling crews from CDM, Normandeau, and NEA, as well as making final go/no-go decisions for dry and wet-weather sampling events. Ms. Beth Rudolph (CDM), Mr. Don Kretchmer (NAI), and Ms. Sarah Watts (NEA) will serve as the Field Program Coordinators. The Field Program Coordinators will be responsible for mobilizing and managing sampling crews from their respective companies. Ms. Jeniffer Oxford will serve as CDM's independent Quality Assurance Officer.

Mr. Phil Downey and Mr. Robert Kennedy are the Technical Managers for Aquatec and AMRO laboratories, respectively. Mr. John Williams and Mr. Samir Naguib are the respective laboratory QA Officers. Mr. Downey (Aquatec) and Ms. Marianne Steen (AMRO) will serve as the primary point of contact at each laboratory during event mobilization.

Additional information regarding Team mobilization, decision trees, and contact numbers is provided in Section 4.0 and Appendix A. A complete project organization chart is provided in the associated QAPP.

Section 2
Data Quality Objectives

Based on the sampling program objectives and proposed data usage requirements for the Merrimack River Watershed Assessment Study, the Data Quality Objectives (DQOs) for the sampling program are as follows:

- Collect water quality and streamflow data sufficient for the calibration and validation of water quality and hydrologic/hydraulic models to be developed under subsequent tasks of this Study

- Collect water quality data to determine the relative likelihood that segments of the mainstem Merrimack River meet state water quality standards

A detailed discussion of the field and laboratory Data Quality Objectives and measurement performance criteria is provided in the associated Quality Assurance Project Plan (QAPP), submitted under separate cover. Laboratory quality assurance (QA) objectives are not addressed in this Field Sampling Plan; however, it is necessary for all field crews to be aware of and adhere to the QA requirements for samples that will be submitted to the laboratories for analysis, as discussed in the QAPP.

2.1 Quality Assurance Objectives

Quality assurance objectives for measurement data are typically expressed in terms of data precision, accuracy, representativeness, completeness, and comparability. To achieve these objectives, data will be (1) of known quantitative statistical significance in terms of precision and accuracy, at levels appropriate for each stated data use for the project; (2) representative of actual site physical and chemical conditions; (3) complete to the extent that specified criteria are achieved; and (4) comparable to previous and subsequent data collected under this task.

Table 2-1 summarizes how the water quality and flow data will be collected during the field sampling program relative to these objectives and measurement performance criteria. A more detailed discussion of each element is provided in Section 1.4 of the associated QAPP.

Table 2-1: Quality Assurance Criteria

Type of Sampling	Precision	Accuracy	Representativeness	Completeness	Comparability
Spatial composite & grab samples during dry-weather events	Field duplicates (1 in 20)	Field blanks (1 in 20)	Proper site selection and sample collections procedures per Standard Operating Procedures (SOPs) Events meeting dry-weather event criteria Seasonal distribution	Samples collected according to Field Sampling Plan (FSP) over at least 90% of sampling locations	Field crew training & SOPs Documentation of field activities Use of standard analyses
Spatial composite & grab samples during wet weather events	Field duplicates (1 in 20)	Field blanks (1 in 20) Equipment blanks (all bacteria compositing stations)	Proper site selection and sample collections procedures per SOPs Meets wet-weather event criteria Seasonal distribution	Samples collected according to FSP over at least 90% of sampling locations	Field crew training & SOPs Documentation of field activities Use of standard analyses
Flow Measurement (Rating Curve development)	N/A	Comparison with USGS rating curves at nearby sites	Proper site selection and use of SOPs	"Valid" record at 90% of monitoring locations based on accuracy requirements	Field Crew training & SOPs Documentation of field activities Use of standard instrumentation

2.2 Quality Control Objectives

Quality Control (QC) is the system of technical activities that measures the performance of a process. Internal QC checks will be performed for sampling, field, and laboratory analyses to verify compliance with the data quality objectives and performance measurement criteria. This provides an overview of the field and sampling QC checks that will be used during the field sampling program, including the collection of field duplicates and field blanks; additional detail is provided in Section 1.4 and 2.5 of the QAPP. Laboratory QC checks are described in Section 2.4 and 2.5 of the QAPP and the respective laboratory Quality Assurance Plans.

Field Duplicates

Spatial composite and grab sample field duplicates will be collected concurrently with the original samples. They will be carried through all phases of the sampling and analytical procedures in an identical manner to provide overall precision information for each sampling event.

Field duplicates will be collected for all parameters analyzed in the field at a frequency of five percent, or one duplicate per 20 samples.

Field Blanks

Field blanks will consist of distilled, deionized water. The blanks will be prepared in the field and preserved as appropriate for each parameter. They will accompany the samples during transport to the laboratory and will be analyzed as per the specified water quality constituent. Samples will be submitted blindly to the laboratory at a rate of five-percent, or one blank per 20 samples.

Equipment blanks will be collected at all stations were spatial bacteria compositing is performed during the first wet-weather sampling event. Depending on the outcome of the first sampling round, a limited number of equipment blanks may be taken in subsequent events (*i.e.* one blank per 20 samples). The equipment blanks will consist of rinsate samples from the sample compositing equipment to determine if there is cross-contamination between sampling locations.

Field Analytical Control Check

Quality control (QC) checks on all instruments used to conduct field measurements, including continuous dissolved oxygen and temperature monitoring equipment, will be performed on a predetermined basis, as discussed in Sections 2.6 and 2.7 of the QAPP. QC checks will include scheduled equipment testing, inspection, maintenance, and calibration. *In situ* dissolved oxygen measurements will be further verified using laboratory DO Winkler Titration methods at select stations.

Section 3
Wet- and Dry-Weather Sampling Criteria

This section describes the criteria that will govern the selection of wet- and dry-weather sampling events during the field sampling program. For the purposes of this program, the following seasonal designations will apply:

- *Spring* - May through mid-June 2003
- *Summer* – Mid-June through mid-September 2003
- *Fall* - Mid-September through November 2003

Whenever possible, dry and wet-weather sampling events will be performed under streamflow conditions at or below the mean monthly flow, as defined by the historical flow records on the mainstem Merrimack River. However, flexibility in the scheduling of these surveys is required due to the potential for prevailing seasonal conditions to dictate higher streamflow conditions. Table 3-1 provides a summary of the monthly mean streamflow for the two active USGS gaging stations on the Merrimack River during the months of interest.

Table 3-1: Summary of Mean Monthly Streamflow for Active Gaging Stations on the mainstem Merrimack River

Month	Mean Monthly Streamflow (cfs)	
	Merrimack River near Goffs Falls, below Manchester, NH	*Merrimack River below Concord River at Lowell, MA*
May	8,632	11,590
June	4,520	6,360
July	2,459	3,408
August	1,958	2,802
September	2,106	2,978
October	3,037	4,160
November	4,702	6,592

Source: Published USGS monthly streamflow statistics (http://waterdata.usgs.gov/nwis)

3.1 Dry-Weather Sampling

Dry-weather sampling will be conducted three times during the course of the field program. Two of these events will occur between May and mid-September; the third event will be conducted during October or November. As noted above, dry-weather sampling will be targeted for flows at or below the mean monthly flow conditions.

Antecedent dry conditions required for the selection of dry-weather sampling events will be evaluated on a case-by-case basis with regards to the following three factors, each of which are discussed below in further detail:

- Expected travel time based on in-stream flow conditions
- Pollutant uptake and die-off in the system
- Prior event coverage across the Merrimack River watershed

Table 3-2 summarizes the travel times expected between the Hooksett Dam in Hooksett, New Hampshire and the mouth of the mainstem at the Atlantic Ocean in Newburyport, Massachusetts under various flow conditions. For example, if the Merrimack River is flowing at approximately 2000 cubic feet per second (cfs), 11 days of antecedent dry conditions would be required considering travel time only. Estimates provided in this table are based on time of travel studies conducted in the mainstem Merrimack River by the U.S. Department of Interior- Federal Water Pollution Control Administration in 1966. It is assumed that, although the streamflow characteristics of the River may have changed from the mid-1960's, the hydraulics of the River, and hence the travel times, has not been dramatically modified.

Table 3-2: Travel Time Between the Hooksett Dam, New Hampshire and Newburyport, Massachusetts

Streamflow (cfs)	Travel Time (days)
1500	15
2000	11
3000	9
6000	6

Source: US Department of Interior 1966.

However, time of travel is not the only factor affecting the pollutant load in the system resulting from previous storm events. Since the contaminants of concerns for this sampling program are not conservative (*i.e.* input rate ≠ output rate), the persistence of these contaminants is also affected by pollutant uptake and die-off processes. According to standard estimates, approximately 90-percent of indicator organisms die-off over approximately a two-day period. Thus, the attenuation of pollutants in the Merrimack River may greatly reduce the required antecedent dry conditions, as compared to travel times alone (Table 3-2). As such, dry-weather sampling events will be selected with a **maximum seven-day antecedent dry period** based on river flow conditions and expected pollutant uptake and die-off. For the purposes of this study, antecedent dry conditions are defined as a given period with less than **0.1 inch** of precipitation observed in the Study Area.

Finally, as previously noted, not all precipitation events may cover the entire Study Area. Thus, the spatial distribution of the previous storm event will be considered on a case-by-case basis when determining the required antecedent dry conditions. For example, an event extending only to the coastal reaches of the basin may only require one or two days to fully flush from the system.

The selection of dry-weather sampling events will be made so as to avoid periods when the Merrimack River mainstem may be influenced by snowmelt runoff from the immediate Study Area, particularly during the Spring and late Fall sampling seasons.

3.2 Wet-Weather Sampling Criteria

Three wet-weather sampling events will be performed as part of the field sampling program. These events will be distributed throughout the Spring, Summer, and Fall 2003 seasons as precipitation conditions allow. The criteria used to select wet-weather monitoring events are based on an effort to represent both short, intense events that may cover only a portion of the Study Area and larger events of extended duration that cover the entire Study Area. These latter events generally occur less frequently, but may represent a higher proportion of the hydraulic loading discharged to the receiving waters.

To assess the full range of precipitation conditions and patterns affecting the Study Area, the wet-weather events have been divided into the following two categories:

- *Full Coverage Events*: Events covering the entire Study Area
- *Partial Coverage Events*: Events affecting only a portion of the Study Area

Criteria for each precipitation event are provided in the following sections. At least one wet-weather event should meet the full-coverage event criteria; the remaining two events may cover only a portion of the Study Area. The selection of full and partial coverage wet-weather events will be made so as to avoid the influence of snowmelt from the immediate Study Area on streamflow conditions during the Spring and late Fall sampling seasons. Decisions regarding the additional wet-weather sampling if one full-coverage and two-partial coverage events are performed would be made based on budgetary constraints.

Section 4.0 provides additional information on how the weather decisions will be communicated to the USACE and CDM Project Team and how they will be documented in the project files.

Full Coverage Events

Historical, hourly precipitation records from 1948 to 2000 were analyzed for two long-term gaging stations located within or adjacent to the watershed (Concord, New Hampshire and Worcester, Massachusetts) to develop the wet-weather sampling criteria for wet-weather events covering the entire Study Area. These precipitation stations were selected to provide a spatially representative view of precipitation patterns in the Merrimack River watershed. An analysis was performed to determine the number of storms during which a specified precipitation volume (greater than 0.5 inch) and antecedent dry condition (less than 0.1 inch) were met at both locations; the analysis was performed over varying storm event and antecedent dry condition durations. The minimum precipitation volume criterion was established based on the

amount of rainfall required to trigger the majority of the combined sewer overflows (CSOs) in the five communities.

The precipitation analysis indicated that an average of four events per year with the following storm volume, duration, and antecedent conditions met these criteria at both stations:

- *Expected storm volume and duration*: Greater than 0.5 inch over a 12-hour period
- *Antecedent dry days*: Three-days with less than 0.1 inch of precipitation

Such events are typically large frontal storms that occur most frequently during spring and fall.

The above-mentioned criteria should be sufficient to allow for a below-average year or missed events and still yield at least one full-coverage event meeting the criteria during the sampling season. It is important to note, however, that the minimum three day antecedent dry condition may not result in the full flushing of any prior storm events from the system based on the expected time-of-travel provided in Table 3-2. As such, the selection of each event will be evaluated on a case-by-case basis and the data collected in such events will be qualified accordingly. Real-time flow records for the USGS gaging stations at Manchester, New Hampshire and Lowell, Massachusetts (http://waterdata.usgs.gov/nwis) will be used to evaluate the progression of a previous storm event through the basin. Wet-weather events meeting the duration and volume requirements will not be sampled until the previous storm's hydrograph has receded by at least 75-percent.

Partial Coverage Events

Given the size of the Study Area and the inherent uncertainty in precipitation events, a maximum of two wet-weather events sampled by the CDM Project Team may affect only a portion of the Study Area. The criterion for such events are defined as follows:

- *Expected storm volume and duration*: Greater than 0.5 inch over at least one hour
- *Antecedent dry days*: Three days with less than 0.1 inch of precipitation
- *Study Area coverage*: Event will trigger CSOs in at least two of the five sponsor communities based on predicted storm tracking and volume

Such events would be expected during the summer and early fall seasons, when short, intense rainstorms dominate the precipitation patterns. The downstream impacts of partial coverage events will be sampled in accordance with the standard wet-weather sampling procedures. For example, if a rainstorm hits only the New Hampshire portion of the basin, sampling will be performed in the area directly affected by the precipitation, as well as the in all downstream portions of the mainstem River according to the sample matrices. If two partial coverage events are

sampled, efforts will be made to select two events covering distinct portions of the watershed, although sampling to determine the downstream impacts may overlap.

As previously noted for full-coverage events, antecedent dry-weather conditions will be evaluated on a case-by-case basis for each proposed event and the data qualified accordingly.

Section 4
Weather Tracking and Team Mobilization

This section describes the weather tracking and team mobilization procedures that will be employed during the field sampling program.

4.1 Dry-Weather Events

Potential dates for dry-weather sampling events will be identified approximately five days in advance based on predicted forecasts and prior antecedent dry conditions as required by the criteria specified in Table 3-2. Weather tracking and monitoring will be performed on a daily basis by CDM's in-house meteorologist, Mr. Marc Wallace, to identify potential dry-weather events.

Preliminary daily precipitation totals for Concord, New Hampshire and Worcester, Massachusetts will be obtained on-line at http://www.erh.noaa.gov/box/worksheet2.shtml. These records are based on preliminary monthly data worksheets for each station and have not been subject to quality control reviews by the National Climate Data Center (NCDC). The provisional on-line daily totals will be used to determine if the prescribed antecedent dry conditions have been met. Additionally, the stage of the Merrimack River will be evaluated in comparison to monthly average streamflow conditions by observing the real-time flow data available from the USGS on-line at http://waterdata.usgs.gov/nwis.

The CDM Field Program Coordinator, Ms. Beth Rudolph, will notify the Field Program Coordinators from Normandeau and NEA, as well as the laboratory contacts from Aquatec and AMRO, approximately five days in advance of the proposed dry-weather sampling event to schedule equipment and personnel. Ms. Rudolph will confirm the scheduled event with the CDM Project Team approximately 24 hours in advance. It is anticipated that each dry-weather event will be completed within one working day. Ms. Rudolph will prepare a memo for the project files and USACE Study Manager documenting the weather conditions approaching and the day of the dry-weather sampling event to confirm that the dry-weather sampling criteria specified in Section 3.0 were met.

4.2 Wet-Weather Events

CDM's in-house meteorologist, Mr. Marc Wallace, will notify Ms. Rudolph when a potential event expected to meet the specified wet-weather criteria is identified. Ms. Rudolph will then notify Mr. Gary Mercer, the Technical Project Manager, and the Field Program Coordinators from Normandeau (Mr. Don Kretchmer) and NEA (Ms. Sarah Watts), typically 48 hours prior to the event. Mr. Wallace and Ms. Rudolph will continue to monitor the event and keep key Team members informed of the potential event status.

After a potential monitoring event is identified, the respective Field Program Coordinators will issue a standby notice to all sampling crews and confirm their

availability for the anticipated sampling time frame. Back-up crews will be notified as necessary. Standby notice will also be issued to the laboratories at that time. Approximately one day (10 hours) is required for Aquatec to mobilize and set-up the Mobile Lab station, including travel time. A call-in number will be established with a taped message of the sampling status for Team members to call for further information.

As the storm is subsequently tracked, Mr. Wallace, Ms. Rudolph, and Mr. Mercer will issue a "go"/ "no-go" decision as to whether sampling will proceed; all crew members and other participants will be notified accordingly. If a "go" decision is made (*i.e.* a sampling event meeting the criteria is confirmed), the Field Program Coordinators will mobilize their respective sampling crews. Crews will meet at pre-arranged locations based on the guidelines established in Section 6.0. Depending on the anticipated track of the precipitation event, crews may begin sampling on a staggered schedule throughout the Study Area. If a "no go" decision is made, the Field Program Coordinators will be notified accordingly by Ms. Rudolph. Figure 4-1 presents the decision tree and notification procedures to be used in selecting wet-weather events. A list of contact numbers is provided in Appendix A.

For either a "go" and "no-go" decision, Ms. Rudolph will prepare a memo that will be added to the project file and provided to the USACE Study Manager detailing the available forecast information at the time of the decision and the outcome of the precipitation event (*i.e.* whether it fell within or outside of the designated event criteria).

4.3 Field Mobilization Efforts

Once a dry- or wet-weather sampling event has been identified, the respective Field Program Coordinators and sampling crews are responsible for ensuring that all sampling-preparation activities are completed. These activities include ensuring that all personnel have reviewed the Standard Operating Procedures (SOPs), procurement of field equipment, and confirmation of site access. Ms. Rudolph is responsible for obtaining and distributing the required bottles and coolers from the respective laboratories. Aquatec will be responsible for the coordination efforts required to establish their mobile laboratory.

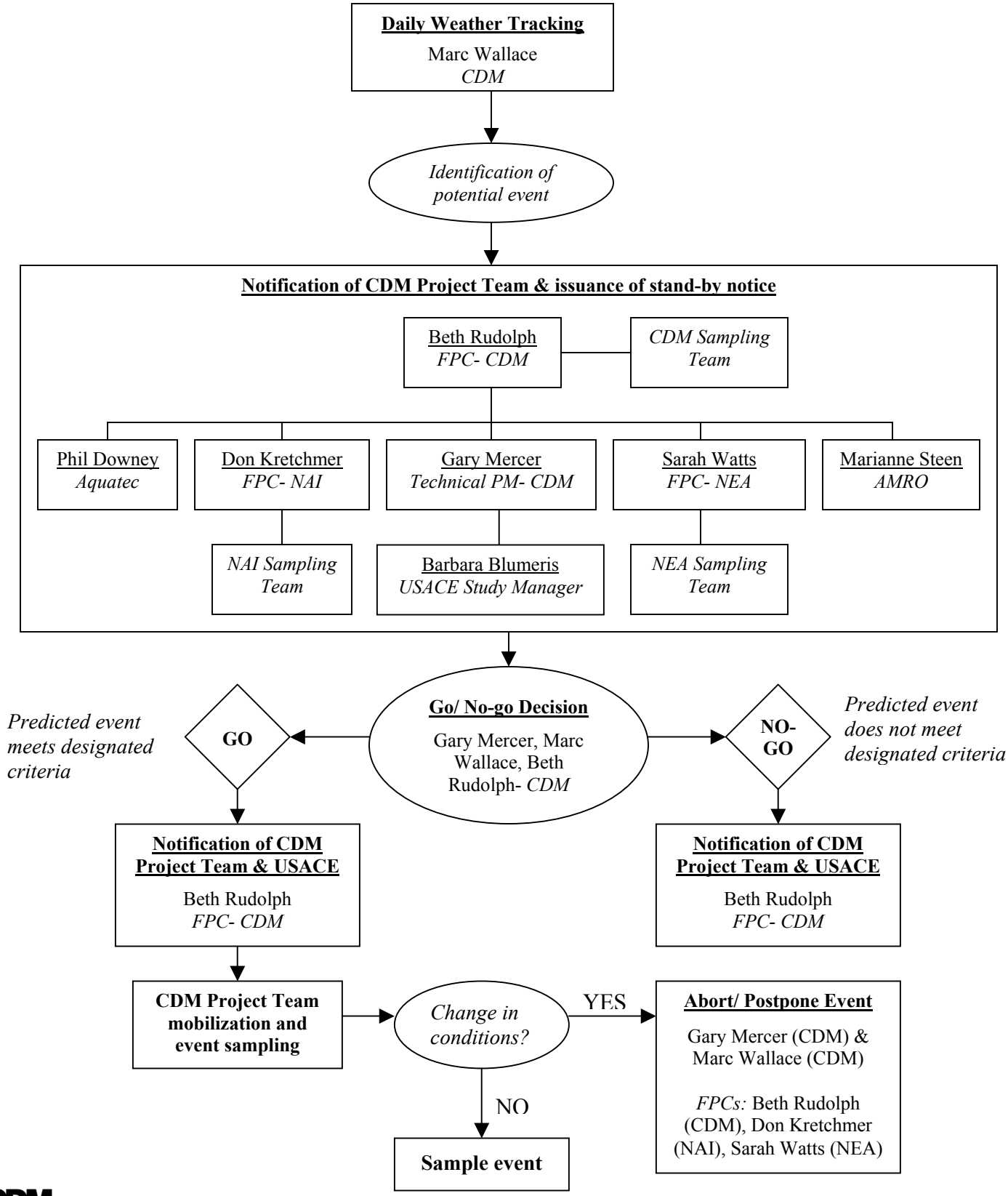
In the field, initial set-up procedures include the establishment of sample staging areas and the distribution of required equipment, bottles, and coolers. An Equipment Checklist is provided in Appendix B.

4.4 False Starts and Aborted Events

Given the unpredictable nature of wet-weather sampling, there is potential for false starts and aborted events as a result of changes in predicted precipitation patterns, volumes, and/or durations. In all cases, the Field Program Coordinators, in consultation with Mr. Mercer and Mr. Wallace, will be responsible for determining

whether an event will be aborted following the mobilization of sampling crews to the field. Sampling teams will be responsible for reporting weather conditions in their designated reach to the respective Field Program Coordinator. In some cases, the event may not be fully aborted, but rather postponed based on predicted storm event timing. The Field Program Coordinators will notify their respective sampling teams of the event termination or postponement. Ms. Rudolph will be responsible for preparing a memo for the project files and the USACE Study Manager documenting the conditions and sampling decision.

Figure 4-1: Wet-Weather Event Decision Tree and Team Notification Procedures



Section 5
Sampling Location and Frequency

This section of the Field Sampling Plan outlines the sampling locations and frequency at which water quality and streamflow measurements will be performed during dry- and wet-weather sampling events. Sampling stations were selected to meet the overall project and Data Quality Objectives, as discussed in Sections 1.0 and 2.0 and in the associated QAPP (submitted under separate cover).

5.1 Dry-Weather Sampling Events

Three dry-weather surveys will be conducted as part of the sampling program. Two events will be conducted between May and mid-September 2003; the third event will be conducted during October or November 2003.

The Study Area has been divided into three reaches for the dry-weather sampling program. Sampling crews will be assigned to each reach in accordance with the following general boundaries:

- *Dry Reach 1*: Hooksett Dam (Hooksett, New Hampshire) to downstream of Nashua, New Hampshire
- *Dry Reach 2*: Upstream of Lowell, Massachusetts to downstream of GLSD, Massachusetts
- *Dry Reach 3*: Upstream of Haverhill, Massachusetts to mouth of Merrimack River at Newburyport, Massachusetts

Dry-weather samples will be collected at the mouth of 11 major tributaries, downstream of WWTPs in the mainstem, at two recreational areas (public beach and boat launch), upstream and downstream of the five CSO communities and Concord, New Hampshire, and at two shellfishing beds in the tidally influenced portion of the basin. Samples will be collected in accordance with the procedures established in Section 7.0.

Samples collected at each station will generally be analyzed in the laboratory for indicator organisms, nutrients, and oxygen/oxygen demand, as per Table 1-1. Bacteria samples only will be collected at the Lowell Public Beach to compare concentrations with state water quality standards for primary contact recreation. Samples will be analyzed for BOD_{20} at select stations in the first dry-weather sampling event, as BOD_{20} approximates $BOD_{Ultimate}$ in New England waters.

In situ measurements for temperature, pH, conductivity, dissolved oxygen, and water clarity (using a Secchi Disk) will be performed at all sites. Additionally, diurnal dissolved oxygen measurements (*i.e.* "Diurnal Sweeps") will be taken at select stations during the two summer dry-weather sampling events (Dry Survey 2 and 3). One measurement will be taken at dawn when dissolved oxygen concentrations are at a minimum due to the loss of oxygen from night-time respiration and decomposition;

a second round of DO sampling will be performed in the mid to late afternoon when primary production and photosynthesis are maximized. Vertical temperature and dissolved oxygen profiles will be measured upstream of the Amoskeag, Pawtucket, and Essex Dams during all three surveys.

A detailed description of each sampling location is provided in Table 5-1; maps showing the location of each station are provided in Section 6.0. Sample matrices describing the frequency and type of samples to be collected during each dry-weather sampling event are provided in Table 5-2 (a-c). Specific procedures for sample collection, including where samples will be collected in-stream, are provided in Section 7.0. Sampling teams will be asked to note any wildlife in the immediate area of sample collection that may have an impact on contaminant concentration, such as pigeon roosting areas under bridges for samples collected on the downstream sides.

Sampling conducted at Stations M27, M28, M29, and M30 will be heavily influenced by tidal affects. As a result, dry-weather sampling performed at these four downstream stations must be collected on an outgoing tide. The sampling team for Dry Reach 3 will schedule their sampling run accordingly to meet the tidal requirements. Tide data will be obtained online from the National Oceanic and Atmospheric Administration (NOAA) at http://www.erh.noaa.gov/er/box/matides.html.

Table 5-1: Sampling Stations

Station No.			Description	Type		Location	Access		GPS Coordinates	
Main	*Trib*	*Pipe*		*Wet*	*Dry*		*Boat*	*Land*	*Latitude*	*Longitude*
C001			U/S Concord, NH	●	●	D/S of I-93 bridge north of Concord, NH		●	TBD	TBD
C002			D/S Concord, NH	●	●	D/S of bend to south of Concord		●	TBD	TBD
M001			D/S Hooksett Dam	●	●	200-300' D/S of power plant on east bank	●		43°06'03"	71°27'54"
M002			U/S Amoskeag Dam	●	●	Float line U/S of Amoskeag Dam	●		43°00'18"	71°28'11"
M003			D/S Amoskeag Dam	●	●	300' D/Ss of kayak course	●		43°00'07"	71°28'22"
	T001		Piscataquog River	●	●	Pinard St bridge (D/S side)*		●	42°58'40"	71°28'15"
M004			D/S Manchester	●		USGS Gaging station at Goffs Falls	●		42°56'53"	71°27'50"
M005			Manchester WWTP	●	●	300' D/S of Manchester WWTP outfall	●		42°56'20"	71°27'25"
	T002		Cohas Brook	●	●	Rte 3A Bridge (D/S side)*		●	42°55'19"	71°27'10"
M006			Derry WWTP outfall	●	●	300' D/S of pipeline outfall	●		TBD	TBD
	T003		Souhegan River	●	●	200-300' U/S of confluence*	●		42°51'43"	71°29'16"
M007			Merrimack WWTP	●	●	300' D/S of Merrimack WWTP outfall	●		42°48'07"	71°28'11"
M008			U/S Nashua	●		One mile D/S of Litchfield/Nashua Line	●		42°47'31"	71°27'28"
	T004		Nashua River	●	●	D/S of Route 3 bridge*		●	42°45'57"	71°26'52"
	T005		Salmon River	●	●	200-300' U/S of confluence*	●		42°44'56"	71°26'31"
M009			Nashua WWTP	●	●	300' D/S of Nashua WWTP outfall	●		42°43'33"	71°26'13"
M010			D/S Nashua	●		300' D/S of first bridge north of state line	●		42°43'26"	71°26'16"
M011			U/S Lowell	●	●	500' D/S of Tyngs Island	●		42°38'56"	71°23'16"
	T006		Stony Brook	●	●	Middlesex Road bridge (D/S side)*		●	42°38'16"	71°20'38"
M012			Lowell Public Beach	●	●	Adjacent to beach area	●		42°38'42"	71°20'16"
M013			U/S Pawtucket Dam	●	●	Float line U/S of Pawtucket Dam	●		42°38'56"	71°19'51"
M014			D/S Pawtucket Dam	●	●	500' D/S of dam's D/S terminus	●		42°39'03"	71°19'44"
	T007		Beaver Brook	●	●	Parker Ave bridge (D/S side)*		●	42°39'28"	71°19'4"
	T008		Concord River	●	●	Route 133 bridge (D/S side)*		●	42°38'49"	71°17'59"
M015			D/S Lowell	●	●	USGS Gaging Station at Lowell	●		42°38'45"	71°17'56"
M016			Lowell WWTP	●	●	300' D/S of Lowell WWTP outfall	●		TBD	TBD
M017			U/S Lawrence	●	●	County Line	●		42°40'12"	71°14'16"
M018			U/S Essex Dam	●	●	Float line U/S of Essex Dam	●		42°42'21"	71°08'34"
M019			D/S Essex Dam	●	●	100' U/S of Casey Bridge	●		42°42'25"	71°08'09"
	T009		Spicket River	●	●	Haverhill St bridge (D/S side)*		●	42°42'25"	71°08'20"
	T010		Shawsheen River	●	●	200-300' U/S of confluence*	●		42°42'25"	71°08'09"
M020			D/S Lawrence	●		1000' D/S of O'Reilly Bridge	●		42°42'39"	71°08'02"
M021			GLSD WWTP	●	●	300' D/S of GLSD WWTP outfall	●		TBD	TBD
M022			U/S Haverhill	●	●	Lawrence/Haverhill Town Line	●		42°43'19"	71°08'02"
M023			D/S Haverhill	●		200' U/S of Hales Island	●		42°46'01"	71°03'39"
M024			Haverhill WWTP	●	●	300' D/S of Haverhill WWTP outfall	●		42°45'32"	71°03'10"
M025			Merrimac WWTP	●	●	300' D/S of Merrimac WWTP outfall	●		TBD	TBD

Table 5-1 (continued)

Station No.			Description	Type		Location	Access		GPS Coordinates	
Main	*Trib*	*Pipe*		*Wet*	*Dry*		*Boat*	*Land*	*Latitude*	*Longitude*
M026			Amesbury WWTP	●	●	300' D/S of Amesbury WWTP outfall	●		42°50'27"	70°55'26"
	T011		Powwow River	●	●	200-300' U/S of confluence*	●		42°50'27"	70°55'29"
M027			Shellfish Bed	●	●	Newburyport Boat Ramp in Joppa Flats	●		42°48'28"	70°51'32"
M028			Salisbury WWTP	●	●	300' D/S of Salisbury WWTP	●		TBD	TBD
M029			Newburyport WWTP	●	●	300' D/S of Newburyport WWTP	●		42°48'46"	70°51'39"
M030			Shellfish Bed	●	●	TBD	●		TBD	TBD
		O001	CSO Outfall- Manchester, NH	●		TBD		●	TBD	TBD
		O002	CSO Outfall- Nashua, NH	●		TBD		●	TBD	TBD
		O003	CSO Outfall- Lowell, MA	●		TBD		●	TBD	TBD
		O004	CSO Outfall- Lawrence, MA	●		TBD		●	TBD	TBD
		O005	CSO Outfall- Haverhill, MA	●		TBD		●	TBD	TBD
		O006	Stormwater Outfall	●		TBD		●	TBD	TBD
		O007	Stormwater Outfall	●		TBD		●	TBD	TBD
		O008	Stormwater Outfall	●		TBD		●	TBD	TBD
		O009	Stormwater Outfall	●		TBD		●	TBD	TBD
		O010	Stormwater Outfall	●		TBD		●	TBD	TBD
		O011	Stormwater Outfall	●		TBD		●	TBD	TBD
		O012	Stormwater Outfall	●		TBD		●	TBD	TBD
		O013	Stormwater Outfall	●		TBD		●	TBD	TBD
		O014	Stormwater Outfall	●		TBD		●	TBD	TBD
		O015	Stormwater Outfall	●		TBD		●	TBD	TBD
		O016	Stormwater Outfall	●		TBD		●	TBD	TBD
		O017	Stormwater Outfall	●		TBD		●	TBD	TBD
		O018	Stormwater Outfall	●		TBD		●	TBD	TBD
		O019	Stormwater Outfall	●		TBD		●	TBD	TBD
		O020	Stormwater Outfall	●		TBD		●	TBD	TBD

*Tributary Sampling Stations- Flow must be in D/S direction toward the Merrimack River (no stagnant backwater); for tributaries with CSO discharges, sampling must be performed at least 100-feet U/S of CSO discharge

TBD= To be determined

Merrimack River Watershed Assessment Study
Dry-Weather Sampling Matrix

Table 5-2a: Dry Survey #1

River Reach	Station ID	Station Description	Required Constituents: Grab Samples or Composites for Laboratory Analysis — Notes: Yellow Cells: QA samples (Blue=Field Blank, Reg = Dup); Grey Cells: Quarterpoint spatial composites; White Cells: Single point samples (from center of river); Red Text: Three discreet samples from quarterpoints. Numbers listed are *Total Samples* at each station.	Fecal Coliform	Fecal Coliform (QA)	E-coli	E-coli (QA)	Enterococcus	Enterococcus (QA)	Total Phosphorus	Total Phosphorus (QA)	Nitrate/Nitrite	Nitrate/Nitrite (QA)	Ammonia N	Ammonia N (QA)	TKN	TKN (QA)	Chlorophyll-a	Chlorophyll-a (QA)	BOD_5	BOD_5 (QA)	BOD_{20}	BOD_{20} (QA)	DO (Winkler Titration)	In-Situ Measurements — Notes: White Cells: Single point samples (from center of river); Red Text: Three discreet samples from quarterpoints. Numbers listed are *Total Samples* at each station.	DO, Temp, pH, Cond.	Turbidity	Secchi Disk Depth	Vertical Temp/DO Profile	Flow
Dry Reach 1	**M001**	D/S Hooksett Dam		1		1				1		1		1		1		1		1		1				3	1	1		
	M002	U/S Amoskeag Dam		1		1				1		1		1		1		1		1						3		1		
	M003	D/S Amoskeag Dam		1		1				1		1		1		1		1		1						3		1		
	T001	Piscataquog River		1		1				1		1		1		1		1		1						1		1		1
	M004	D/S Manch, U/S WWTP																												
	M005	D/S Manch WWTP		1		1				1		1		1		1		1		1				1		3		1		
	T002	Cohas Brook		1		1				1		1		1		1		1								1		1		1
	M006	D/S Derry WWTP outfall		1		1				1		1		1		1		1		1				1		3		1		
	T003	Souhegan River		1		1				1		1		1		1		1								1		1		1
	M007	D/S Merrimack WWTP		1	1	1	1			1	1	1	1	1	1	1	1	1	1	1		1		1		3	1	1		
	M008	U/S Nashua																												
	T004	Nashua River		1		1				1		1		1		1		1		1						1		1		1
	T005	Salmon River		1		1				1		1		1		1		1								1		1		1
	M009	D/S Nashua WWTP		1		1				1		1		1		1		1		1				1		3		1		
	M010	D/S Nashua																												1
Dry Reach 2	**M011**	U/S Lowell		1		1				1		1		1		1		1		1		1				3	1	1		
	T006	Stony Brook		1		1				1		1		1		1		1								1		1		1
	M012	Lowell Public Beach		1		1																								
	M013	U/S Pawtucket Dam		1		1				1		1		1		1		1		1						3		1		
	M014	D/S Pawtucket Dam		1		1				1		1		1		1		1		1						3		1		
	T007	Beaver Brook		1		1				1		1		1		1		1								1		1		1
	T008	Concord River		1		1				1		1		1		1		1		1						1		1		1
	M015	D/S Lowell (@ USGS)		1		1				1		1		1		1		1		1						3		1		
	M016	D/S Lowell WWTP		1		1				1		1		1		1		1		1				1		3		1		
	M017	U/ S Lawrence		1		1				1		1		1		1		1		1		1				3	1	1		
	M018	U/S Essex Dam		1		1				1		1		1		1		1		1						3		1		
	M019	D/S Essex Dam		1		1				1		1		1		1		1		1						3		1		
	T009	Spicket River		1		1				1		1		1		1		1								1		1		1
	T010	Shawsheen River		1	1	1	1			1	1	1	1	1	1	1	1	1	1	1	1					1		1		1
	M020	D/S Law, U/S GLSD																												1
	M021	D/S GLSD WWTP		1		1				1		1		1		1		1		1				1		3		1		
Dry Reach 3	**M022**	U/S Haverhill		1		1				1		1		1		1		1		1		1				3	1	1		
	M023	D/S Hav, U/S WWTP																												
	M024	D/S Hav WWTP		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1		1		1	*In situ* salinity measurements required for marine waters	3	1	1		
	M025	D/S Merrimac WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity measurements required for marine waters	3		1		
	M026	D/S Amesbury WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity measurements required for marine waters	3		1		
	T011	Powwow River		1		1				1		1		1		1		1							*In situ* salinity measurements required for marine waters	1		1		1
	M027	Shellfish Bed/Newb. boat ramp		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1				*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M028	D/S Salis WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M029	D/S Newburyport WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M030	Shellfish Bed, north bank		1		1		1		1		1		1		1		1		1					*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
			TOTALS	**36**	**4**	**36**	**4**	**7**	**0**	**35**	**4**	**35**	**4**	**35**	**4**	**35**	**4**	**35**	**4**	**28**	**2**	**6**	**0**	**11**		**83**	**6**	**35**	**0**	**13**
			REF: QA Requirements (5% Blanks)		*1.8*		*1.8*		*0.4*		*1.8*		*1.8*		*1.8*		*1.8*		*1.8*		*1*		*0*							
			REF: QA Requirements (5% Duplicates)		*1.8*		*1.8*		*0.4*		*1.8*		*1.8*		*1.8*		*1.8*		*1.8*		*1.4*		*0*							

[1]Samples will be analyzed for total metals at the tributary stations and dissolved metals in the mainstem Merrimack River. Separate QA samples will be conducted for the total and dissolved analyses.

Merrimack River Watershed Assessment Study
Dry-Weather Sampling Matrix

Table 5-2b: Dry Survey #2

River Reach	Station ID	Station Description	Required Constituents: Grab Samples or Composites for Laboratory Analysis — Notes: Yellow Cells: QA samples (Blue=Field Blank, Reg = Dup); Grey Cells: Quarterpoint spatial composites; White Cells: Single point samples (from center of river); Red Text: Three discreet samples from quarterpoints; Numbers listed are *Total Samples* at each station.	Fecal Coliform		E-coli		Enterococcus		Total Phosphorus		Nitrate/Nitrite		Ammonia N		TKN		Chlorophyll-a		BOD_5		BOD_{20}		DO (Winkler Titration)	In-Situ Measurements — Notes: Blue Cells: Diurnal Sweeps - Dawn/ mid-afternoon; White Cells: Single point samples (from center of river); Red Text: Three discreet samples from quarterpoints; Numbers listed are *Total Samples* at each station.	DO, Temp, pH, Cond.	Turbidity	Secchi Disk Depth	Vertical Temp/DO Profile	Flow
Dry Reach 1	**M001**	D/S Hooksett Dam		1		1				1		1		1		1		1					3	1	1		
	M002	U/S Amoskeag Dam		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1	1	
	M003	D/S Amoskeag Dam		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1		1
	T001	Piscataquog River		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	1		1		1
	M004	D/S Manch, U/S WWTP																										
	M005	D/S Manch WWTP		1		1				1		1		1		1		1				1	Diurnal Sweep for DO & Temp Only	3		1		
	T002	Cohas Brook		1		1				1		1		1		1							Diurnal Sweep for DO & Temp Only	1		1		1
	M006	D/S Derry WWTP outfall		1		1				1		1		1		1		1				1	Diurnal Sweep for DO & Temp Only	3		1		
	T003	Souhegan River		1		1				1		1		1		1								1		1		1
	M007	D/S Merrimack WWTP		1	1	1	1			1	1	1	1	1	1	1	1	1				1		3	1	1		
	M008	U/S Nashua																										
	T004	Nashua River		1		1				1		1		1		1		1						1		1		1
	T005	Salmon River		1		1				1		1		1		1								1		1		1
	M009	D/S Nashua WWTP		1		1				1		1		1		1		1				1		3		1		
	M010	D/S Nashua																										1
Dry Reach 2	**M011**	U/S Lowell		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3	1	1		
	T006	Stony Brook		1		1				1		1		1		1							Diurnal Sweep for DO & Temp Only	1		1		1
	M012	Lowell Public Beach		1		1																						
	M013	U/S Pawtucket Dam		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1	1	
	M014	D/S Pawtucket Dam		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1		1
	T007	Beaver Brook		1		1				1		1		1		1							Diurnal Sweep for DO & Temp Only	1		1		1
	T008	Concord River		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	1		1		1
	M015	D/S Lowell (@ USGS)		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1		
	M016	D/S Lowell WWTP		1		1				1		1		1		1		1				1	Diurnal Sweep for DO & Temp Only	3		1		
	M017	U/ S Lawrence		1		1				1		1		1		1		1						3	1	1		
	M018	U/S Essex Dam		1		1				1		1		1		1		1						3		1	1	
	M019	D/S Essex Dam		1		1				1		1		1		1		1						3		1		1
	T009	Spicket River		1		1				1		1		1		1								1		1		1
	T010	Shawsheen River		1	1	1	1			1	1	1	1	1	1	1	1	1	1	1	1			1		1		1
	M020	D/S Law, U/S GLSD																										1
	M021	D/S GLSD WWTP		1		1				1		1		1		1		1				1		3		1		
Dry Reach 3	**M022**	U/S Haverhill		1		1				1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3	1	1		
	M023	D/S Hav, U/S WWTP																										
	M024	D/S Hav WWTP		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1			1	Diurnal Sweep for DO & Temp Only, *in situ* salinity for marine	3	1	1		
	M025	D/S Merrimac WWTP		1		1		1		1		1		1		1		1				1	*In situ* salinity measurements required for marine waters	3		1		
	M026	D/S Amesbury WWTP		1		1		1		1		1		1		1		1				1	*In situ* salinity measurements required for marine waters	3		1		
	T011	Powwow River		1	1	1	1			1	1	1	1	1	1	1	1	1	1		1			*In situ* salinity measurements required for marine waters	1		1		1
	M027	Shellfish Bed/Newb. boat ramp		1		1		1		1		1		1		1		1						*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M028	D/S Salis WWTP		1		1		1		1		1		1		1		1				1		*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M029	D/S Newburyport WWTP		1		1		1		1		1		1		1		1				1		*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M030	Shellfish Bed, north bank		1		1		1		1		1		1		1		1						*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
			TOTALS	**36**	**4**	**36**	**4**	**7**	**0**	**35**	**4**	**35**	**4**	**35**	**4**	**35**	**4**	**35**	**4**	**28**	**2**	**0**	**0**	**11**		**83**	**6**	**35**	**3**	**16**
			REF: QA Requirements (5% Blanks)		*1.8*		*1.8*		*0.4*		*1.8*		*1.8*		*1.8*		*1.8*		*1.8*		*1.4*		*0*						
			REF: QA Requirements (5% Duplicates)		*1.8*		*1.8*		*0.4*		*1.8*		*1.8*		*1.8*		*1.8*		*1.8*		*1.4*		*0*						

[1]Samples will be analyzed for total metals at the tributary stations and dissolved metals in the mainstem Merrimack River. Separate QA samples will be conducted for the total and dissolved analyses.

Merrimack River Watershed Assessment Study
Dry-Weather Sampling Matrix

Table 5-2c: Dry Survey #3

River Reach	Station ID	Station Description	Required Constituents																											
			Grab Samples or Composites for Laboratory Analysis																						In-Situ Measurements					
			Notes: Yellow Cells: QA samples (**Blue**=Field Blank, Reg = Dup) Grey Cells: Quarterpoint spatial composites White Cells: Single point samples (from center of river) Red Text: Three discreet samples from quarterpoints Numbers listed are *Total Samples* at each station.	Fecal Coliform		E-coli		Enterococcus		Total Phosphorus		Nitrate/Nitrite		Ammonia N		TKN		Chlorophyll-a		BOD_5		BOD_{20}		DO (Winkler Titration)	**Notes:** Blue Cells: Diurnal Sweeps - Dawn/ mid-afternoon White Cells: Single point samples (from center of river) Red Text: Three discreet samples from quarterpoints Numbers listed are *Total Samples* at each station.	DO, Temp, pH, Cond.	Turbidity	Secchi Disk Depth	Vertical Temp/DO Profile	Flow
Dry Reach 1	**M001**	D/S Hooksett Dam		1		1				1		1		1		1		1		1						3	1	1		
	M002	U/S Amoskeag Dam		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1	1	
	M003	D/S Amoskeag Dam		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1		
	T001	Piscataquog River		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	1		1		1
	M004	D/S Manch, U/S WWTP																												
	M005	D/S Manch WWTP		1		1				1		1		1		1		1		1				1	Diurnal Sweep for DO & Temp Only	3		1		
	T002	Cohas Brook		1		1				1		1		1		1		1							Diurnal Sweep for DO & Temp Only	1		1		1
	M006	D/S Derry WWTP outfall		1		1				1		1		1		1		1		1				1	Diurnal Sweep for DO & Temp Only	3		1		
	T003	Souhegan River		1		1				1		1		1		1		1								1		1		1
	M007	D/S Merrimack WWTP		1	1	1	1			1	1	1	1	1	1	1	1	1	1	1				1		3	1	1		
	M008	U/S Nashua																												
	T004	Nashua River		1		1				1		1		1		1		1		1						1		1		1
	T005	Salmon River		1		1				1		1		1		1		1								1		1		1
	M009	D/S Nashua WWTP		1		1				1		1		1		1		1		1				1		3		1		
	M010	D/S Nashua																												1
Dry Reach 2	**M011**	U/S Lowell		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3	1	1		
	T006	Stony Brook		1		1				1		1		1		1		1							Diurnal Sweep for DO & Temp Only	1		1		1
	M012	Lowell Public Beach		1		1																								
	M013	U/S Pawtucket Dam		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1	1	
	M014	D/S Pawtucket Dam		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1		
	T007	Beaver Brook		1		1				1		1		1		1		1							Diurnal Sweep for DO & Temp Only	1		1		1
	T008	Concord River		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	1		1		1
	M015	D/S Lowell (@ USGS)		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3		1		
	M016	D/S Lowell WWTP		1		1				1		1		1		1		1		1				1	Diurnal Sweep for DO & Temp Only	3		1		
	M017	U/ S Lawrence		1		1				1		1		1		1		1		1						3	1	1		
	M018	U/S Essex Dam		1		1				1		1		1		1		1		1						3		1	1	
	M019	D/S Essex Dam		1		1				1		1		1		1		1		1						3		1		
	T009	Spicket River		1		1				1		1		1		1		1								1		1		1
	T010	Shawsheen River		1	1	1	1			1	1	1	1	1	1	1	1	1	1	1	1					1		1		1
	M020	D/S Law, U/S GLSD																												1
	M021	D/S GLSD WWTP		1		1				1		1		1		1		1		1				1		3		1		
Dry Reach 3	**M022**	U/S Haverhill		1		1				1		1		1		1		1		1					Diurnal Sweep for DO & Temp Only	3	1	1		
	M023	D/S Hav, U/S WWTP																												
	M024	D/S Hav WWTP		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	Diurnal Sweep for DO & Temp Only, *in situ* salinity for marine	3	1	1		
	M025	D/S Merrimac WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity measurements required for marine waters	3		1		
	M026	D/S Amesbury WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity measurements required for marine waters	3		1		
	T011	Powwow River		1		1				1		1		1		1		1							*In situ* salinity measurements required for marine waters	1		1		1
	M027	Shellfish Bed/Newb. boat ramp		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1				*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M028	D/S Salis WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M029	D/S Newburyport WWTP		1		1		1		1		1		1		1		1		1				1	*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
	M030	Shellfish Bed, north bank		1		1		1		1		1		1		1		1		1					*In situ* salinity meas req'd. All sampling to be at outgoing tide	3		1		
			TOTALS	**36**	**4**	**36**	**4**	**7**	**0**	**35**	**4**	**35**	**4**	**35**	**4**	**35**	**4**	**35**	**4**	**28**	**2**	**0**	**0**	**11**		**83**	**6**	**35**	**3**	**13**
			REF: QA Requirements (5% Blanks)		*1.8*		*1.8*		*0.4*		*1.8*		*1.8*		*1.8*		*1.8*		*1.8*		*1.4*		*0*							
			REF: QA Requirements (5% Duplicates)		*1.8*		*1.8*		*0.4*		*1.8*		*1.8*		*1.8*		*1.8*		*1.8*		*1.4*		*0*							

5.2 Wet-Weather Sampling Events

Three wet-weather surveys will be conducted as part of this sampling program during Spring, Summer, and Fall 2003. The Study Area has been divided into five reaches for the purposes of conducting wet-weather sampling events, in accordance with the following reach boundaries:

- *Wet Reach 1*: Hooksett Dam in Hooksett, New Hampshire to the Souhegan River confluence in Merrimack, New Hampshire
- *Wet Reach 2*: Downstream of Merrimack, New Hampshire WWTP outfall to downstream of Nashua, New Hampshire
- *Wet Reach 3*: Upstream of Lowell, Massachusetts to upstream of Lawrence, Massachusetts
- *Wet Reach 4*: Upstream of Essex Dam in Lawrence, Massachusetts to upstream of Haverhill, Massachusetts
- *Wet Reach 5*: Downstream of Haverhill, Massachusetts to mouth of Merrimack River at Newburyport, Massachusetts

Wet-weather samples will be collected at locations similar to those discussed above for dry-weather sampling events, as well as at select combined sewer outfalls and stormdrain outfalls throughout the Study Area. Five CSOs will be sampled during each wet-weather event- one per sponsor community; the same outfall will be sampled during each of the three events. One stormdrain outfall will also be sampled in each community during each wet-weather event. Unlike the CSO outfalls, a different stormdrain outfall will be sampled during each of the three wet-weather events, for a total of three outfalls per community over the course of the sampling program.

Specific locations for CSO and stormdrain monitoring are not provided in Table 5-1. CSO sampling locations will be determined based on a review of available data provided in the Long-Term Control Plans (LTCP's) developed for each of the five sponsor communities. One CSO outfall will be sampled per community. The selected CSO's will represent the outfall with the largest overflow volume and most frequent discharge in each community. Safety concerns and ease of access for sampling will also be considered in the selection of stations. Stormdrain sampling locations will be selected based on a review of available stormdrain information from each community, as well as field surveys. Outfalls with known or suspected illicit connections will be avoided.

High-frequency bacteria monitoring (approximately one sample per hour, over a 12-hour period) will be performed at one station downstream of Lowell, Massachusetts to develop a detailed pollutograph (*i.e.* plot of constituent concentration versus time) of the contaminant plume. Sampling at this station only will commence at or near the beginning of the precipitation event to characterize the pollutant plume as it passes downstream.

Additionally, the wet-weather stormwater impacts from Concord, New Hampshire, which has a fully separated sanitary/ stormdrain system, will be assessed by measuring the in-stream water quality upstream and downstream of the City. Sampling downstream of WWTP's will only be performed during the first wet-weather sampling event, as it is anticipated that the WWTP's will not have a significant impact on wet-weather water quality in relation to other pollution sources. This generally accounts for the difference in the number of water quality sample being collected during the three surveys. Additionally, only samples collected from select locations in the Study Area will be analyzed for BOD_{20} during the first two wet-weather sampling events.

Sampling teams will be divided into "boat", "land", and "outfall" crews to sample the respective in-stream and outfall locations. Additional information on sampling logistics is provided in Section 6.0. Each boat, land, and outfall crew will perform several "sweeps" (*i.e.* sample collection rounds) across their designated sampling locations to determine the temporal variability of the water quality parameters. Sampling crews will begin the sweep at the most upstream location and continue downstream through their entire reach. Once complete, they will return to the upstream station and proceed through the stations again from upstream to downstream location. A total of five sweeps will be conducted, though not all water quality parameters will be collected during all of the sweeps. In general, samples for indicator organisms will be collected on all five sweeps; nutrients will sampled on the second sweep. Both spatial composite and grab samples will be collected in accordance with the procedures established in Section 7.0.

Samples collected at each station will be analyzed for indicator organisms, nutrients and impacts, and oxygen/oxygen demand, as per Table 1-1. *In situ* measurements for temperature, pH, conductivity, and dissolved oxygen will be performed at all sites.

A description of each sampling location is provided in Table 5-1; maps locating each sampling station are provided in Section 6.0. It should be noted that the sampling station locations may differ between wet and dry-weather surveys. Sample matrices describing the frequency and type of samples to be collected during each wet-weather sampling event are provided in Table 5-3 (a-d). Additional detail describing the sample collection procedures and in-stream sampling locations for each station is provided in Section 7.0.

As with the dry-weather sampling, Stations M27, M28, M29, and M30 may be heavily influenced by tidal affects during wet-weather events. Thus, in-stream sampling during the first four sampling sweeps will be conducted regardless of the tidal conditions. However, the last sampling sweep must be conducted on an out-going tide, even if this sampling round is performed after the 24-hour mark from the commencement of the sampling event.

Merrimack River Watershed Assessment Study
Wet-Weather Sampling Matrix

Table 5-3a: Wet Survey #1

River Reach	Station ID	Station Description	Required Constituents: Grab Samples or Composites for Laboratory Analysis — Notes: Yellow Cells: QA samples (Blue=Field Blank, Pink= Equipment Blank, Reg = Dup); Grey Cells: Quarterpoint spatial composites; White Cells: Single point samples (from center of river); Red Text: One grab at centerpoint & one composite; Numbers listed are *Total Samples* at each station.	Fecal Coliform		E-coli		Enterococcus		Total Phosphorus		Nitrate/Nitrite		Ammonia N		TKN		Chlorophyll-a		BOD_5		BOD_{20}		DO (Winkler Titration)	Required Constituents: In-Situ Measurements — Notes: White Cells: Single point samples (from center of river); Green Cells: One measurement performed on outfall grab samples; Red Text: Three discreet samples from quarterpoints; Numbers listed are *Total Samples* at each station.	DO, Temp, pH, Cond.	Turbidity	Secchi Disk Depth	Vertical Temp/DO Profile	Flow
Wet Reach 1	M001	D/S Hooksett Dam	All stations: if 1 sweep listed, sample 2nd sweep	5		5	1			1		1		1		1				1					Turbidity during Sweep #3	15	1			
	M002	U/S Amoskeag Dam		5		5	1			1		1		1		1				1						15				
	M003	D/S Amoskeag Dam		5	1	5	1			1		1		1		1				1						15				
	T001	Piscataquog River		5	1	5	1			1	1	1	1	1	1	1	1			1	1					5				5
	M004	D/S Manch, U/S WWTP	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1		1				15				
	M005	D/S Manch WWTP		5	1	5	1			1		1		1		1				1				1		15				
	T002	Cohas Brook		5	1	5	1			1		1		1		1				1						5				5
	M006	D/S Derry WWTP outfall		5	1	5	1			1		1		1		1				1				1		15				
	T003	Souhegan River		5	1	5	1			1		1		1		1				1						5				5
Wet Reach 2	M007	D/S Merrimack WWTP	All stations: if 1 sweep listed, sample 2nd sweep	5		5				1		1		1		1				1				1	Turbidity during Sweep #3	15	1			
	M008	U/S Nashua		5	1	5	1			1	1	1	1	1	1	1	1			1	1					15				
	T004	Nashua River		5		5				1		1		1		1				1						5				5
	T005	Salmon River		5	1	5	1			1		1		1		1				1						5				5
	M009	D/S Nashua WWTP		5	1	5	1			1		1		1		1				1				1		15				
	M010	D/S Nashua	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1		1				15				
Wet Reach 3	M011	U/S Lowell	All stations: if 1 sweep listed, sample 2nd sweep	5		5				1		1		1		1				1					Turbidity during Sweep #3	15	1			
	T006	Stony Brook		5		5				1		1		1		1				1						5				5
	M012	Lowell Public Beach	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1						15				
	M013	U/S Pawtucket Dam		5	1	5	1			1		1		1		1				1						15				
	M014	D/S Pawtucket Dam		5	1	5	1			1	1	1	1	1	1	1	1			1	1					15				
	T007	Beaver Brook		5	1	5	1			1		1		1		1				1						5				5
	T008	Concord River		5	1	5	1			1		1		1		1				1						5				5
	M015	D/S Lowell (@ USGS)	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1		1				15				
	M015	D/S Lowell (@ USGS) - Cont.	Continuous E. Coli sampling- one sample per hour for 12hrs			12																								
	M016	D/S Lowell WWTP		5	1	5	1			1		1		1		1				1				1		15				
	M017	U/ S Lawrence		5	1	5	1			1		1		1		1				1					Turbidity during Sweep #3	15	1			
Wet Reach 4	M018	U/S Essex Dam	All stations: if 1 sweep listed, sample 2nd sweep	5	1	5	1			1		1		1		1				1						15				
	M019	D/S Essex Dam		5	1	5	1			1		1		1		1				1						15				
	T009	Spicket River		5	1	5	1			1		1		1		1				1						5				5
	T010	Shawsheen River		5	1	5	1			1	1	1	1	1	1	1	1			1	1					5				5
	M020	D/S Law, U/S GLSD	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1		1				15				5
	M021	D/S GLSD WWTP		5	1	5	1			1		1		1		1				1				1		15				
	M022	U/S Haverhill		5	1	5	1			1		1		1		1				1					Turbidity during Sweep #3	15	1			
Wet Reach 5	M023	D/S Hav, U/S WWTP	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5	10	5	1		1		1		1				1		1				15				
	M024	D/S Hav WWTP	All stations: if 1 sweep listed, sample 2nd sweep	5	1	5	1	5	1	1	1	1	1	1	1	1	1			1	1			1	Turbidity during Sweep #3; *in situ* salinity for marine waters	15	1			
	M025	D/S Merrimac WWTP		5	1	5	1	5	1	1		1		1		1				1				1	*In situ* salinity measurements required for marine waters	15				
	M026	D/S Amesbury WWTP		5		5		5		1		1		1		1				1				1	*In situ* salinity measurements required for marine waters	15				
	T011	Powwow River		5	1	5	1		1	1		1		1		1				1					*In situ* salinity measurements required for marine waters	5				5
	M027	Shellfish Bed/Newb. boat ramp	Sample near south shore only	5		5		5	1	1		1		1		1				1					*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
	M028	D/S Salis WWTP		5		5		5		1		1		1		1				1				1	*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
	M029	D/S Newburyport WWTP		5		5		5		1		1		1		1				1				1	*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
	M030	Shellfish Bed, north bank	Sample near north shore only	5		5		5		1		1		1		1				1					*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
Outfalls	O001	CSO outfall - Manchester	All stations: if 1 sweep listed, sample 2nd sweep	5	1	5	1			1		1		1		1				1						1				
	O002	CSO outfall - Nashua		5	1	5	1			1		1		1		1				1						1				
	O003	CSO outfall - Lowell		5	1	5	1			1		1		1		1				1						1				
	O004	CSO outfall - Lawrence		5		5	1			1	1	1	1	1	1	1	1			1	1					1				
	O005	CSO outfall - Haverhill		5		5				1		1		1		1				1						1				
	O006	Stormdrain outfall #1		5		5				1		1		1		1				1						1				
	O007	Stormdrain outfall #2		5		5				1		1		1		1				1						1				
	O008	Stormdrain outfall #3		5		5	1			1		1		1		1				1						1				
	O009	Stormdrain outfall #4		5		5	1			1		1		1		1				1						1				
	O010	Stormdrain outfall #5		5		5				1		1		1		1				1						1				
			TOTALS	**285**	**57**	**297**	**62**	**45**	**9**	**51**	**6**	**51**	**6**	**51**	**6**	**51**	**6**	**0**	**0**	**51**	**6**	**5**	**0**	**11**		515	6	0	0	65
			REF: QA Requirements (5% Blanks)		*14*		*14.9*		*2.3*		*2.6*		*2.6*		*2.6*		*2.6*		*0*		*2.6*		*0.3*							
			REF: QA Requirements (5% Duplicates)		*14*		*14.9*		*2.3*		*2.6*		*2.6*		*2.6*		*2.6*		*0*		*2.6*		*0.3*							

[1]Samples will be analyzed for total metals at the tributary and outfall stations and dissolved metals in the mainstem Merrimack River. Separate QA samples will be conducted for the total and dissolved analyses.

Merrimack River Watershed Assessment Study
Wet-Weather Sampling Matrix

Table 5-3b: Wet Survey #2

River Reach	Station ID	Station Description	Required Constituents: Grab Samples or Composites for Laboratory Analysis — Notes: Yellow Cells: QA samples (Blue=Field Blank, Pink= Equipment Blank, Reg = Dup); Grey Cells: Quarterpoint spatial composites; White Cells: Single point samples (from center of river); Red Text: 1 grab at centerpoint & 1 composite; Numbers listed are *Total Samples* at each station.	Fecal Coliform		E-coli		Enterococcus		Total Phosphorus		Nitrate/Nitrite		Ammonia N		TKN		Chlorophyll-a		BOD_5		BOD_{20}		DO (Winkler Titration)	In-Situ Measurements — Notes: White Cells: Single point samples (from center of river); Green Cells: One measurement performed on outfall grab sample; Red Text: Three discreet samples from quarterpoints; Numbers listed are *Total Samples* at each station.	DO, Temp, pH/Cond.	Turbidity	Secchi Disk Depth	Vertical Temp/DO Profile	Flow
Wet Reach 1	M001	D/S Hooksett Dam	All stations: if 1 sweep listed, sample 2nd sweep	5		5	1			1		1		1		1				1					Turbidity during Sweep #3	15	1			
	M002	U/S Amoskeag Dam		5		5	1			1		1		1		1				1						15				
	M003	D/S Amoskeag Dam		5	1	5	1			1		1		1		1				1						15				
	T001	Piscataquog River		5	1	5	1			1	1	1	1	1	1	1	1			1	1					5				5
	M004	D/S Manch, U/S WWTP	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1						15				
	M005	D/S Manch WWTP																												
	T002	Cohas Brook		5	1	5	1			1		1		1		1				1						5				5
	M006	D/S Derry WWTP outfall		5	1	5	1			1		1		1		1				1				1		15				
	T003	Souhegan River		5	1	5	1			1		1		1		1				1						5				5
Wet Reach 2	M007	D/S Merrimack WWTP	All stations: if 1 sweep listed, sample 2nd sweep																											
	M08	U/S Nashua		5	1	5	1			1		1		1		1				1						15				
	T004	Nashua River		5	1	5	1			1		1		1		1				1						5				5
	T005	Salmon River		5	1	5	1			1	1	1	1	1	1	1	1			1	1					5				5
	M009	D/S Nashua WWTP																												
	M010	D/S Nashua	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1		1				15				5
Wet Reach 3	M011	U/S Lowell	All stations: if 1 sweep listed, sample 2nd sweep	5		5				1		1		1		1				1					Turbidity during Sweep #3	15	1			
	T006	Stony Brook		5		5				1		1		1		1				1						5				5
	M012	Lowell Public Beach	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1	1	1	1	1	1	1	1			1	1					15				
	M013	U/S Pawtucket Dam		5	1	5	1			1		1		1		1				1						15				
	M014	D/S Pawtucket Dam		5	1	5	1			1		1		1		1				1						15				
	T007	Beaver Brook		5	1	5	1			1		1		1		1				1						5				5
	T008	Concord River		5	1	5	1			1		1		1		1				1						5				5
	M015	D/S Lowell (@ USGS)	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1		1				15				
	M015	D/S Lowell (@ USGS) - Cont.	Continuous E. Coli sampling- one sample per hour for 12hrs			12																								
	M016	D/S Lowell WWTP																												
	M017	U/ S Lawrence		5	1	5	1			1		1		1		1				1					Turbidity during Sweep #3	15	1			
Wet Reach 4	M018	U/S Essex Dam	All stations: if 1 sweep listed, sample 2nd sweep	5	1	5	1			1		1		1		1				1						15				
	M019	D/S Essex Dam		5	1	5	1			1		1		1		1				1						15				
	T009	Spicket River		5	1	5	1			1		1		1		1				1						5				5
	T010	Shawsheen River		5	1	5	1			1	1	1	1	1	1	1	1			1	1					5				5
	M020	D/S Law, U/S GLSD	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1		1				15				5
	M021	D/S GLSD WWTP																												
	M022	U/S Haverhill		5	1	5	1			1		1		1		1				1					Turbidity during Sweep #3	15	1			
Wet Reach 5	M023	D/S Hav, U/S WWTP	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5	10	5	1		1		1		1				1		1				15				
	M024	D/S Hav WWTP																												
	M025	D/S Merrimac WWTP																												
	M026	D/S Amesbury WWTP																												
	T011	Powwow River		5	1	5	1		1	1		1		1		1				1					*In situ* salinity measurements required for marine waters	5				5
	M027	Shellfish Bed/Newb. boat ramp	Sample near south shore only	5		5		5	1	1		1		1		1				1					*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
	M028	D/S Salis WWTP																												
	M029	D/S Newburyport WWTP																												
	M030	Shellfish Bed, north bank	Sample near north shore only	5		5		5		1		1		1		1				1					*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
Outfalls	O001	CSO outfall - Manchester	All stations: if 1 sweep listed, sample 2nd sweep	5	1	5	1			1		1		1		1				1						1				
	O002	CSO outfall - Nashua		5	1	5	1			1		1		1		1				1						1				
	O003	CSO outfall - Lowell		5	1	5	1			1		1		1		1				1						1				
	O004	CSO outfall - Lawrence		5	1	5	1			1		1		1		1				1						1				
	O005	CSO outfall - Haverhill		5		5				1		1		1		1				1						1				
	O011	Stormdrain outfall #1		5		5				1		1		1		1				1						1				
	O012	Stormdrain outfall #2		5		5				1		1		1		1				1						1				
	O013	Stormdrain outfall #3		5	1	5	1			1		1		1		1				1						1				
	O014	Stormdrain outfall #4		5	1	5	1			1		1		1		1				1						1				
	O015	Stormdrain outfall #5		5	1	5	1			1		1		1		1				1						1				
			TOTALS	**235**	**56**	**247**	**58**	**20**	**7**	**41**	**4**	**41**	**4**	**41**	**4**	**41**	**4**	**0**	**0**	**41**	**4**	**4**	**0**	**1**		365	4	0	0	65
			REF: QA Requirements (5% Blanks)		*12*		*12*		*1*		*2.1*		*2.1*		*2.1*		*2.1*		*0*		*2.1*		*0.2*							
			REF: QA Requirements (5% Duplicates)		*12*		*12*		*1*		*2.1*		*2.1*		*2.1*		*2.1*		*0*		*2.1*		*0.2*							

Merrimack River Watershed Assessment Study
Wet-Weather Sampling Matrix

Table 5-3c: Wet Survey #3

River Reach	Station ID	Station Description	Required Constituents: Grab Samples or Composites for Laboratory Analysis — Notes: Yellow Cells: QA samples (Blue=Field Blank, Reg = Dup); Grey Cells: Quarterpoint spatial composites; White Cells: Single point samples (from center of river); Red Text: Three discreet samples from quarterpoints; Numbers listed are *Total Samples* at each station.	Fecal Coliform		E-coli		Enterococcus		Total Phosphorus		Nitrate/Nitrite		Ammonia N		TKN		Chlorophyll-a		BOD_5		BOD_{20}		DO (Winkler Titration)	Required Constituents: In-Situ Measurements — Notes: White Cells: Single point samples (from center of river); Green Cells: One measurement performed on outfall grab samples; Red Text: Three discreet samples from quarterpoints; Numbers listed are *Total Samples* at each station.	DO, Temp, pH, Cond.	Turbidity	Secchi Disk Depth	Vertical Temp/DO Profile	Flow
Wet Reach 1	M001	D/S Hooksett Dam	All stations: if 1 sweep listed, sample 2nd sweep	5		5	1			1		1		1		1				1				Turbidity during Sweep #3	15	1			
	M002	U/S Amoskeag Dam		5		5	1			1		1		1		1				1					15				
	M003	D/S Amoskeag Dam		5	1	5	1			1		1		1		1				1					15				
	T001	Piscataquog River		5	1	5	1			1	1	1	1	1	1	1	1			1	1				5				5
	M004	D/S Manch, U/S WWTP	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1					15				
	M005	D/S Manch WWTP																											
	T002	Cohas Brook		5	1	5	1			1		1		1		1				1					5				5
	M006	D/S Derry WWTP outfall		5	1	5	1			1		1		1		1				1				1	15				
	T003	Souhegan River		5	1	5	1			1		1		1		1				1					5				5
Wet Reach 2	M007	D/S Merrimack WWTP	All stations: if 1 sweep listed, sample 2nd sweep																										
	M008	U/S Nashua		5	1	5	1			1		1		1		1				1					15				
	T004	Nashua River		5	1	5	1			1		1		1		1				1					5				5
	T005	Salmon River		5	1	5	1			1	1	1	1	1	1	1	1			1	1				5				5
	M009	D/S Nashua WWTP																											
	M010	D/S Nashua	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1					15				5
Wet Reach 3	M011	U/S Lowell	All stations: if 1 sweep listed, sample 2nd sweep	5		5				1		1		1		1				1				Turbidity during Sweep #3	15	1			
	T006	Stony Brook		5		5				1		1		1		1				1					5				5
	M012	Lowell Public Beach	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1	1	1	1	1	1	1	1			1	1				15				
	M013	U/S Pawtucket Dam		5	1	5	1			1		1		1		1				1					15				
	M014	D/S Pawtucket Dam		5	1	5	1			1		1		1		1				1					15				
	T007	Beaver Brook		5	1	5	1			1		1		1		1				1					5				5
	T008	Concord River		5	1	5	1			1		1		1		1				1					5				5
	M015	D/S Lowell (@ USGS)	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1					15				
	M015	D/S Lowell (@ USGS) - Cont.	Continuous E. Coli sampling- one sample per hour for 12hrs			12																							
	M016	D/S Lowell WWTP																											
	M017	U/ S Lawrence		5	1	5	1			1		1		1		1				1				Turbidity during Sweep #3	15	1			
Wet Reach 4	M018	U/S Essex Dam	All stations: if 1 sweep listed, sample 2nd sweep	5	1	5	1			1		1		1		1				1					15				
	M019	D/S Essex Dam		5	1	5	1			1		1		1		1				1					15				
	T009	Spicket River		5	1	5	1			1		1		1		1				1					5				5
	T010	Shawsheen River		5	1	5	1			1	1	1	1	1	1	1	1			1	1				5				5
	M020	D/S Law, U/S GLSD	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5			1		1		1		1				1					15				5
	M021	D/S GLSD WWTP																											
	M022	U/S Haverhill		5	1	5	1			1		1		1		1				1				Turbidity during Sweep #3	15	1			
Wet Reach 5	M023	D/S Hav, U/S WWTP	Fecal Col/E-Coli: 5 Sweeps, 1 grab at center & 1 composite	10	5	10	5	10	5	1		1		1		1				1					15				
	M024	D/S Hav WWTP																											
	M025	D/S Merrimac WWTP																											
	M026	D/S Amesbury WWTP																											
	T011	Powwow River		5	1	5	1		1	1		1		1		1				1				*In situ* salinity measurements required for marine waters	5				5
	M027	Shellfish Bed/Newb. boat ramp	Sample near south shore only	5		5		5	1	1		1		1		1				1				*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
	M028	D/S Salis WWTP																											
	M029	D/S Newburyport WWTP																											
	M030	Shellfish Bed, north bank	Sample near north shore only	5		5		5		1		1		1		1				1				*In situ* salinity meas req'd. All sampling to be at outgoing tide	15				
Outfalls	O001	CSO outfall - Manchester	All stations: if 1 sweep listed, sample 2nd sweep	5	1	5	1			1		1		1		1				1					1				
	O002	CSO outfall - Nashua		5	1	5	1			1		1		1		1				1					1				
	O003	CSO outfall - Lowell		5	1	5	1			1		1		1		1				1					1				
	O004	CSO outfall - Lawrence		5	1	5	1			1		1		1		1				1					1				
	O005	CSO outfall - Haverhill		5		5				1		1		1		1				1					1				
	O016	Stormdrain outfall #1		5		5				1		1		1		1				1					1				
	O017	Stormdrain outfall #2		5		5				1		1		1		1				1					1				
	O018	Stormdrain outfall #3		5	1	5	1			1		1		1		1				1					1				
	O019	Stormdrain outfall #4		5	1	5	1			1		1		1		1				1					1				
	O020	Stormdrain outfall #5		5	1	5	1			1		1		1		1				1					1				
			TOTALS	**235**	**56**	**247**	**58**	**20**	**7**	**41**	**4**	**41**	**4**	**41**	**4**	**41**	**4**	**0**	**0**	**41**	**4**	**0**	**0**	**1**		**365**	**4**	**0**	**0**	**65**
			REF: QA Requirements (5% Blanks)		*12*		*12*		*1*		*2.1*		*2.1*		*2.1*		*2.1*		*0*		*2.1*		*0*							
			REF: QA Requirements (5% Duplicates)		*12*		*12*		*1*		*2.1*		*2.1*		*2.1*		*2.1*		*0*		*2.1*		*0*							

Merrimack River Watershed Assessment Study
Wet-Weather Sampling Matrix

Table 5-3d: Wet and Dry Surveys 1, 2, & 3 for Concord, NH Only

River Reach	Station ID	Station Description	Required Constituents: Grab Samples or Composites for Laboratory Analysis — Notes: Yellow Cells: QA samples (**Blue**=Field Blank, **Pink**= Equipment Blank, Reg = Dup); Grey Cells: Quaterpoint spatial composites; White Cells: Single point samples (from center of river); **Red** Text: One grab at centerpoint & one composite; Numbers listed are *Total Samples* at each station.	Fecal Coliform			E-coli			Enterococcus		Total Phosphorus		Nitrate/Nitrite		Ammonia N		TKN		Chlorophyll-a		BOD_5		BOD_{20}		DO (Winkler Titration)	In-Situ Measurements — Notes: White Cells: Single point samples (from center of river); Red Text: Three discreet samples from quarterpoints; Numbers listed are *Total Samples* at each station.	DO, Temp, pH, Cond.	Turbidity	Secchi Disk Depth	Vertical Temp/DO Profile	Flow
Concord NH	**C001**	WET WEATHER: U/S Concord	3 storms: Bacteria: 4 sweeps- 1 grab & 1 composite sample	**24**	**12**	2	**24**	**12**	2																3 storms, 5 sweeps	**45**				
	C002	WET WEATHER: D/S Concord	3 storms: Bacteria: 4 sweeps- 1 grab & 1 composite sample	**24**	**12**	**2**	**24**	**12**	**2**																3 storms, 5 sweeps	**45**				
Concord NH	**C001**	DRY WEATHER: D/S Concord	3 surveys: Bacteria: 1 sweep, 1 grab sample	3		1	3		1																4 surveys, 1 sweep	**12**				
	C002	DRY WEATHER: D/S Concord	3 surveys: Bacteria: 1 sweep, 1 grab sample	3		**1**	3		**1**																4 surveys, 1 sweep	**12**				
			TOTALS	54	24	6	54	24	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		90	0	0	0	0
			REF: QA Requirements (5% Blanks)			*3*			*3*		*0*		*0*		*0*		*0*		*0*		*0*		*0*							
			REF: QA Requirements (5% Duplicates)			*3*			*3*		*0*		*0*		*0*		*0*		*0*		*0*		*0*							

5.3 Instream Flow Measurements

Flow measurements are required to estimate pollutant loadings from measured parameter concentrations. In this study, streamflow data from the following sources will be used: (1) two active USGS gaging stations on the mainstem Merrimack River in Manchester, New Hampshire and Lowell, Massachusetts, and (2) rating curves developed at select locations in the mainstem Merrimack River and at the mouth of the major tributaries. A summary of these station locations is provided in Table 5-4. Due to the close proximity of the USGS gaging station on the Concord River in Lowell, Massachusetts to the mouth of the river, flow measurements recorded at this station will be used in lieu of establishing a rating-curve.

Table 5-4: Streamflow Monitoring Stations

	Station ID	Location	GPS Coordinates	
			Latitude	*Longitude*
Mainstem	M10	D/S Nashua, NH	42°43'26"	71°26'16"
	M20	D/S Lawrence, MA	42°42'39"	71°08'02"
	---	Merrimack River near Goffs Falls, below Manchester, NH (USGS)	42°56'53"	71°27'50"
	---	Merrimack River below Concord River at Lowell, MA (USGS)	42°38'45"	71°17'56"
Tributary	T01	Piscataquog River	42°58'40"	71°28'15"
	T02	Cohas Brook	42°55'19"	71°27'10"
	T03	Souhegan River	42°51'43"	71°29'16"
	T04	Nashua River	42°45'57"	71°26'52"
	T05	Salmon River	42°44'56"	71°26'31"
	T06	Stony Brook	42°38'16"	71°20'38"
	T07	Beaver Brook	42°39'28"	71°19'4"
	---	Concord River below R. Meadow Brook at Lowell, MA (USGS)	42°38'12"	71°18'09"
	T09	Spicket River	42°42'25"	71°08'20"
	T10	Shawsheen River	42°42'25"	71°08'09"
	T11	Powwow River	42°50'27"	70°55'29"

For the development of the rating curves, streamflow measurements will be made at each location over five different flow conditions ranging from approximately 2000 to 6000 cfs, between May and November 2003. These measurements will be made independent of the wet and dry-weather sampling events. Each sampling team will be required to assess the accuracy of their measurements by measuring streamflow at one of the two active USGS gaging stations on the mainstem Merrimack River (Table 5-4). Field streamflow measurements will be compared to the real-time USGS streamflow data to perform a quality assurance check on the sampling equipment and flow measurement techniques.

Staff gages will be installed at each of the non-USGS flow monitoring stations. Stage measurements will be read from the staff gages once during dry-weather sampling events and once per sampling sweep (*i.e.* up to five times) during wet-weather events. The stage will be recorded on the field data collection forms; rating curves will then be used to determine the corresponding discharge. Additional detail on how the flow measurements will be made and how the rating curves will be developed is provided in Section 7.0.

In addition to the in-stream flow measurements, sampling teams will record the flow depth in each outfall pipe during wet-weather events at the time of sample collection. Flow in the pipe will be estimated using Manning's equation.

5.4 Continuous Dissolved Oxygen and Temperature Measurements

Continuous dissolved oxygen and temperature measurements will be made at the following two locations in the mainstem Merrimack River:

- Upstream of the Amoskeag Dam in Manchester, New Hampshire
- Upstream of the Pawtucket Dam in Lowell, Massachusetts

Measurements will be logged at 15-minute intervals between mid-July and mid-September 2003 and downloaded weekly by members of the CDM Project Team. Additional information on installation and maintenance of the continuous monitors is provided in Section 7.0.

Section 6
Sampling Program Logistics

This section of the Field Sampling Plan outlines the sample collection and delivery logistics that will be implemented by the CDM Project Team during wet- and dry-weather sampling events.

6.1 Centralized Sampling Coordination

One centralized coordination point will be established at the WWTP in Nashua, New Hampshire during wet and dry-weather sampling events. This location will serve as the centralized drop-off location for samples from sample runners and sampling teams. Aquatec will establish a mobile laboratory facility at the WWTP during wet and dry-weather sample events to meet the six-hour holding time for bacteria samples. This collection point will be staffed by at least one Field Program Coordinator, who will serve as the primary point of contact between the sampling teams and the other Coordinators.

Prior to event mobilization, sample runners will be given a list of all sample containers provided to the sampling teams. The runners will be responsible for checking items off the list as they are received. Runners will deliver the samples to the centralized collection point and double check their list prior to transferring custody of the samples at the centralized collection point.

The Field Program Coordinator located at the Nashua WWTP will be responsible for confirming that all items on the runners' lists have been delivered to the central collection point and will confirm with the deliverer that the labeling is correct. The designated Field Program Coordinator will enter the receipt of the samples into a master log as they are received at the central collection point and will coordinate the transfer of sample custody to the appropriate laboratory.

Directions to the Nashua WWTP from major highways are provided in Appendix A.

6.2 Dry-Weather Sampling Logistics

The following section describes the dry-weather sampling logistics for sampling teams and sample runners. Dry-weather sampling station locations are provided in Figures 6-1 through 6-3.

6.2.1 In-stream Sampling by Boat and Land Crews

As discussed in Section 5.0, the Study Area has been divided into three reaches for the dry-weather sampling program: Dry Reach 1, 2, and 3. Boat crews will sample all mainstem and tributary sampling stations along their assigned reach that are accessible from in-stream locations. Three, one person "land" crews will be assigned to sample from the following locations:

- Land Crew 1: Upstream and downstream of Concord, New Hampshire (C01 and C02)

- Land Crew 2: Piscataquog River (T01), Cohas Brook (T02), and Nashua River (T03)
- Land Crew 3: Stony Brook (T06), Beaver Brook (T07), Concord River (T08), and Spicket River (T09)

All Boat Crews will be equipped with Global Positioning Systems (GPS) to field-locate the sampling stations in accordance with the coordinates provided in Table 5-1. All sampling teams (boat and land crews) and sample runners will be equipped with hand-held radio/cellular communication devices. Sampling teams will be required to check-in with their respective Field Program Coordinators when they are in place and prepared to start sampling.

6.2.2 Sampler Runners

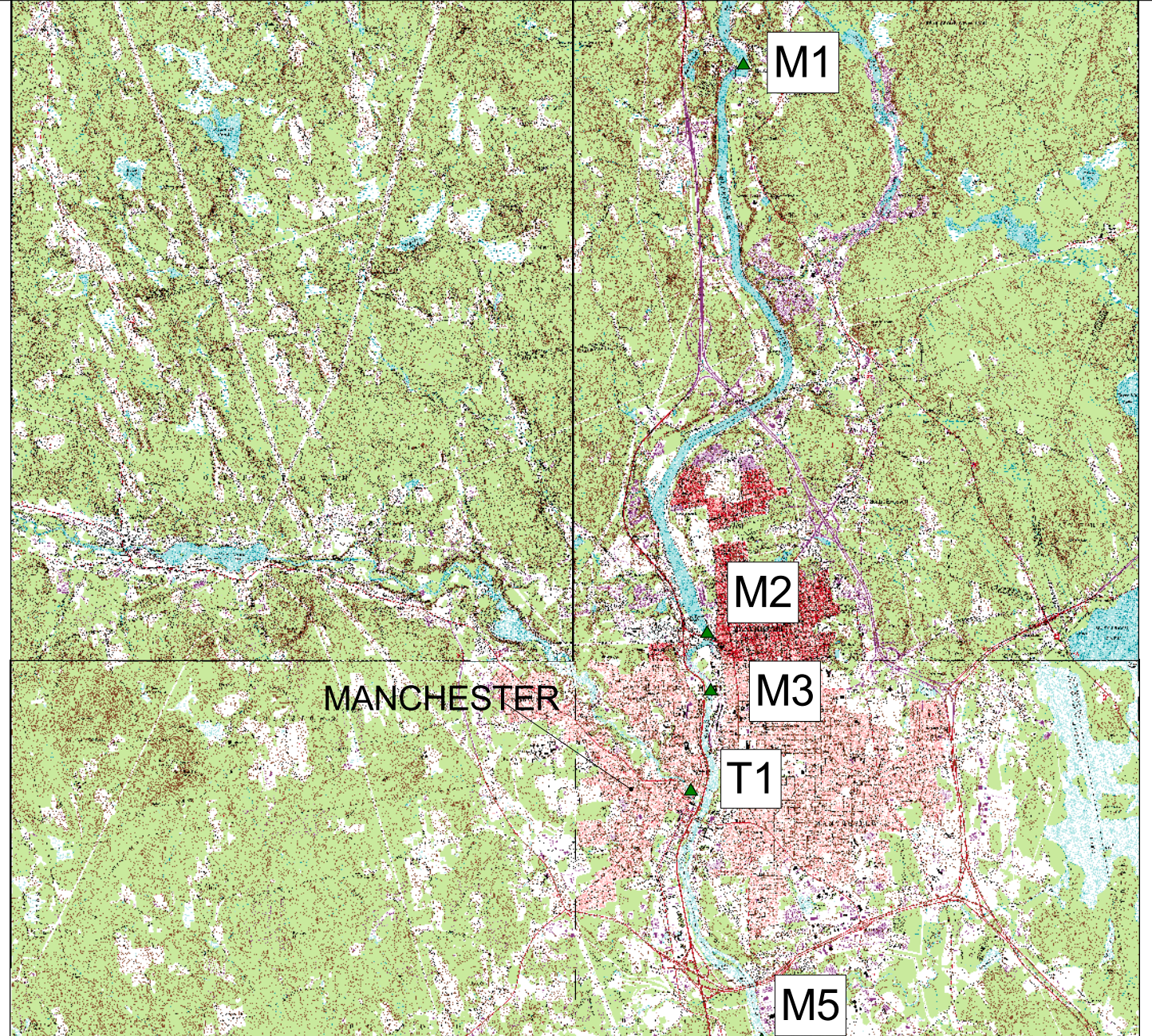
Two sample runners will coordinate sample pick-up/drop-off and transportation logistics for the boat and land crews, as needed. The runners will be responsible for delivering the boat trailer to the end of the reach and for collecting samples from the crews following the event. The runner will also be responsible for picking up samples from the sampling teams as necessary to meet required holding times, transporting samples to the designated central collection points, and either transporting samples to the laboratory or transferring sample custody to designated laboratory couriers. Bacteria samples must be provided to the Aquatec mobile laboratory within four-hours of sample collection to provide adequate time for sample preparation and analysis within the required holding time. Table 6-1 provides a summary of the approximate travel times between the end of the three Dry Reaches and the Nashua WWTP.

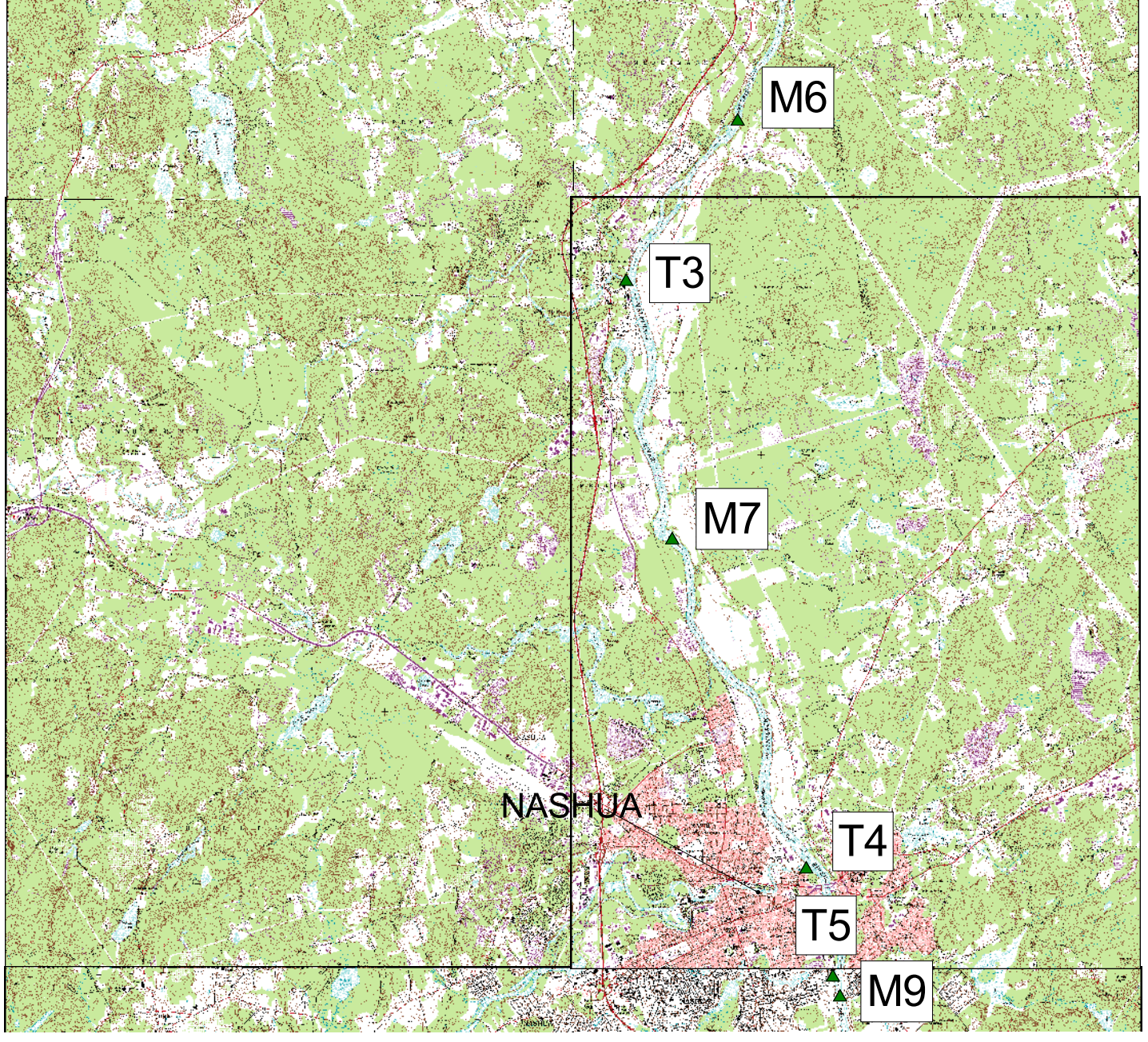
Table 6-1: Approximate Travel Times from each Dry Reach to the Nashua WWTP

Reach	Reach End	Approximate Travel Time to Nashua WWTP[1]
Dry Reach 1	Nashua, NH	15 minutes
Dry Reach 2	Lawrence, MA	40 minutes
Dry Reach 3	Newburyport, MA	60 minutes

[1]Note: Travel times may be longer based on traffic conditions

Sampling teams will be responsible for notifying their respective runners when they have reached a designated location to provide adequate time for runners to meet them at assigned drop-off locations.





LEGEND

▲ Dry Sampling Locations

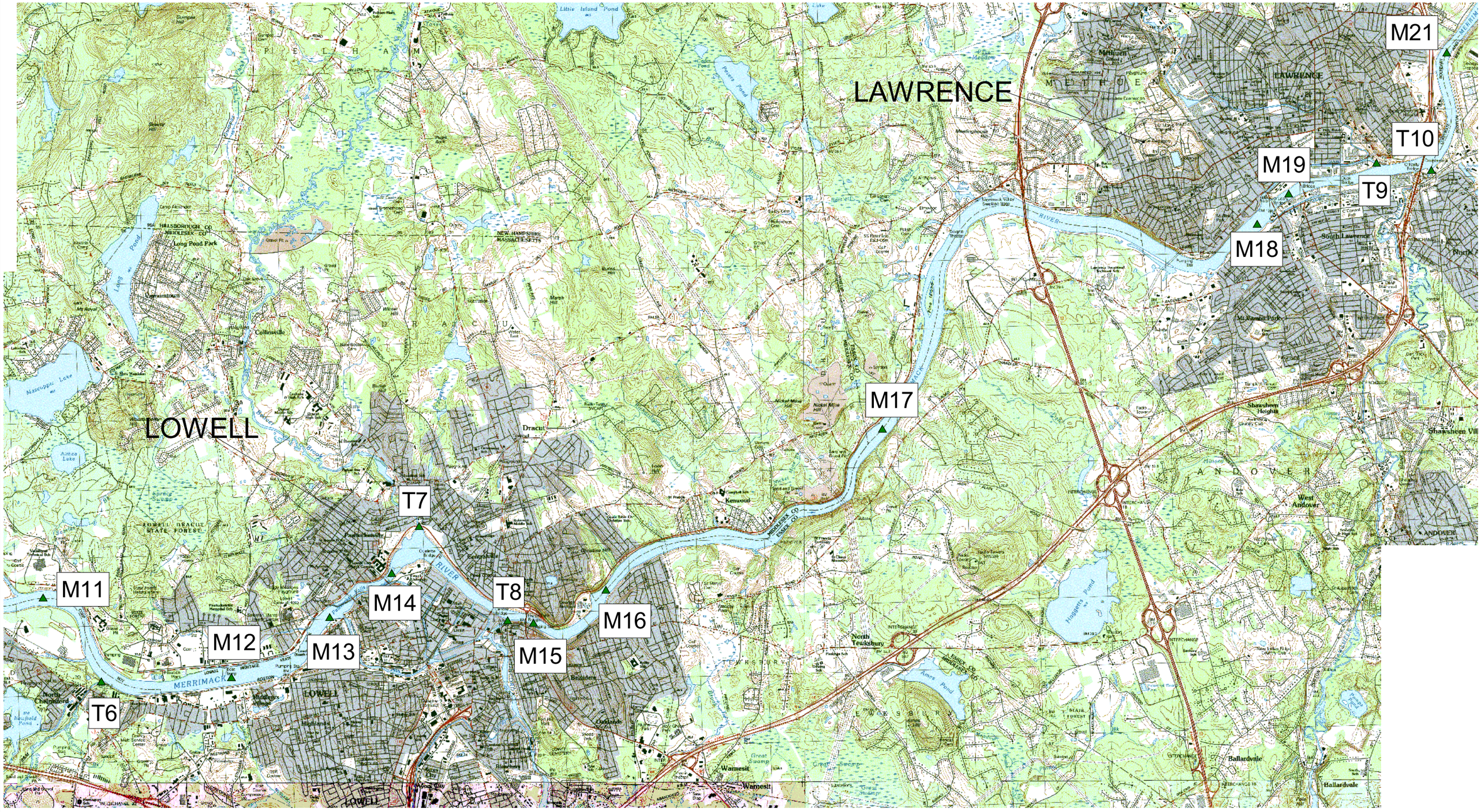
Basemap Source: USGS

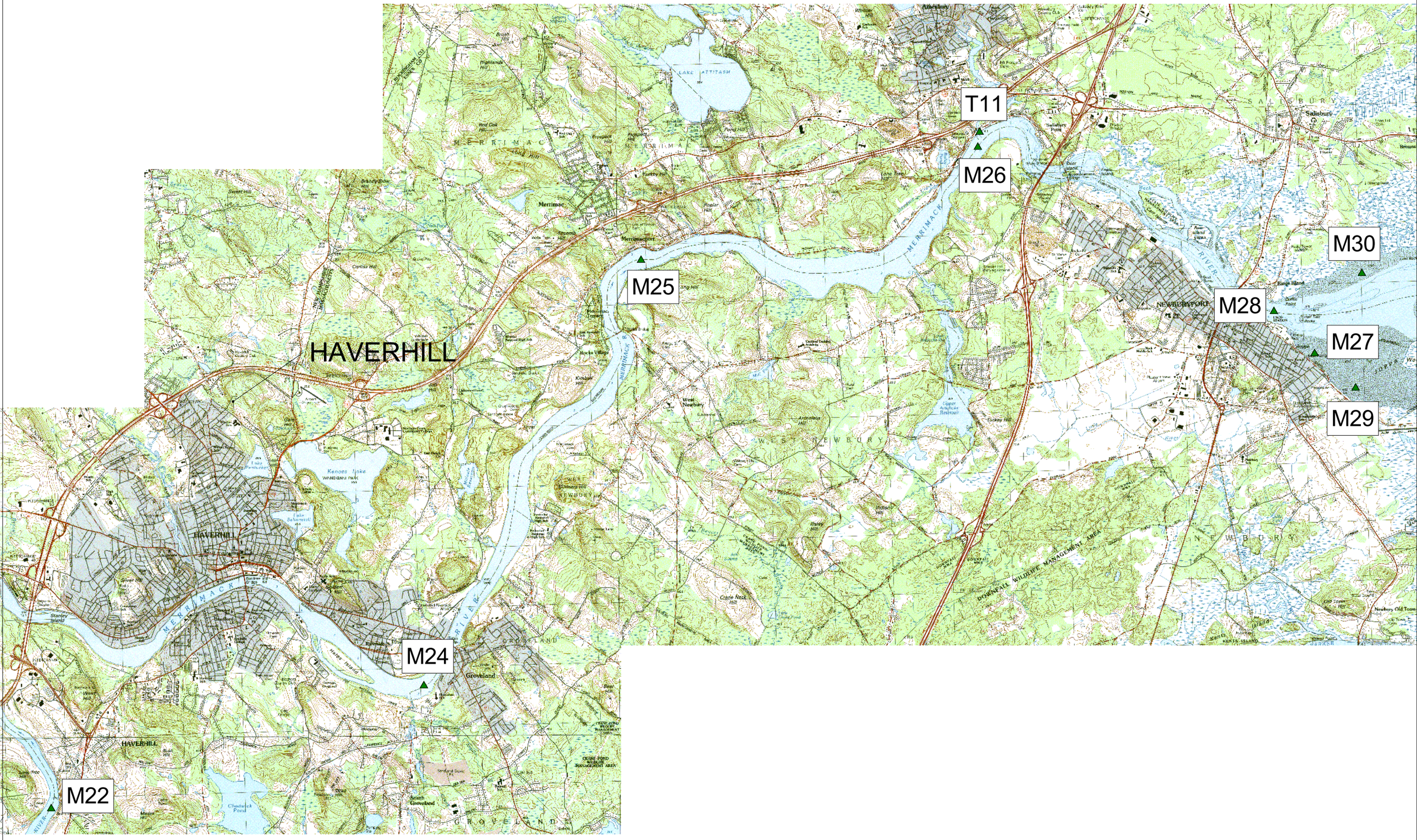
4000 0 4000 8000 Feet

CDM

Merrimack River Watershed Assessment Study

Figure 6-1: Dry Weather Sampling Locations-Dry Reach 1


LAWRENCE
LOWELL
M21
T10
M19
T9
M18
M17
T7
M14
T8
M16
M11
M12
M13
M15
T6
LEGEND
Dry Sampling Locations
Basemap Source: USGS
CDM
900 0 900 Feet
N
Merrimack River Watershed
Assessment Study
Figure 6-2: Dry Weather Sampling Locations-Dry Reach 2



LEGEND

▲ Dry Sampling Locations

Basemap Source: USGS

CDM

2000 0 2000 Feet

N

Merrimack River Watershed
Assessment Study

Figure 6-3: Dry Weather Sampling Locations-Dry Reach 3

6.3 Wet-Weather Sampling Logistics

As discussed in Section 5.0, the Study Area has been divided into five reaches for the purposes of conducting wet-weather sampling events. Wet-weather sampling stations for each Wet Reach are presented in Figures 6.4 through 6.8. Boat, land, and outfall crews will be assigned to each wet reach, in accordance with the following guidance. All boat and land crews will be equipped with GPS units to field locate the in-stream sampling stations, per Table 5-1.

6.3.1 Boat Crews: In-stream Monitoring

One two-person Boat Crew will be assigned to each wet reach; they will be responsible for sampling all mainstem and tributary stations that are accessible instream along their designated reaches. All Boat Crews will be equipped with hand-held radio/cellular communication devices. Each team will check-in with the Field Program Coordinator when the boat is successfully launched in the River, when they arrive at their first sampling location, and when they reach a designated point in the River to provide adequate time for a runner to pick-up samples at a predetermined location. Two boat handlers will transport the boat trailers from the upstream to downstream portion of each wet reach.

In-stream samples will be collected along each reach from upstream to downstream. In-stream sampling will not commence until CSO outfalls in the designated Wet Reach have begun discharging. For storms with an expected duration of approximately 12-hours, sampling teams will perform five sweeps of the sampling stations, such that samples taken at the most upstream location are collected three, six, 12, and 24-hours after the first sample is taken. For shorter duration events, the sample collection schedule will be evaluated on a case-by-case basis; in most cases in-stream sampling will still be performed over a period of 24-hours. Boat Crews may be relieved after two or three sweeps depending on the timing of the storm for a total of five sweeps. The team transfer point will be located at the upper station of each reach.

One, two-person Boat Crew will be stationed downstream of Lowell, Massachusetts (Station M15) to conduct high-frequency bacteria monitoring at a frequency of approximately one sample per hour over a 12-hour period.

6.3.2 Land Crews: Bridge and Shore Sample Collection

Five one-person "land" crews will be assigned to sample the seven tributary stations that are not accessible by boat, as indicated in Table 5-1, as well as stations upstream and downstream of Concord, New Hampshire. Land Crews will be assigned based on the following station division:

- Land Crew 1: Upstream and downstream of Concord, New Hampshire (C01 and C02)

- Land Crew 2: Piscataquog River (T01) and Cohas Brook (T02)
- Land Crew 3: Nashua River (T03)
- Land Crew 4: Stony Brook (T06), Beaver Brook (T07), and Concord River (T08)
- Land Crew 5: Spicket River (T09)

Each Land Crew will be equipped with a hand-held radio/cellular communication device. The teams will notify their respective Field Program Coordinators when they are in place at the first sampling location and ready to begin. Sampling will not commence until the CSO outfalls in the respective Wet Reach have begun discharging. The Land Crews will coordinate their sample collection efforts with the Boat Crews on their respective wet reaches and their Field Program Coordinator to ensure that they are on the same collection schedule, *i.e.* samples will be collected after the boat crew has finished sampling at the next upstream location.

Each crew will be equipped with the required number of laboratory bottles prior to mobilization. Sample runners will collect samples at predetermined locations for transport to the mobile laboratory or central drop-off location for transfer of custody to the laboratory.

6.3.3 Outfall Crews: CSO and Stormdrain Outfall Monitoring

For wet-weather events, one-person outfall crews will be assigned to each CSO and stormdrain outfall that will be sampled. All Outfall Crews will be equipped with hand-held radio/cellular communication devices. Each team will check in with their respective Field Program Coordinators when they are in place and prepared to start sampling. Outfall crews will notify their Field Program Coordinator when their outfall begins discharging for sample collection and runner scheduling. In-stream sampling by Land and Boat Crews will not commence until the CSO outfall in the respective Wet Reach has begun discharging. In general, it is assumed that the stormdrains will begin discharging earlier than the CSOs. Thus, sampling at the stormdrains may commence early than that in the remainder of the reach.

Up to five samples will be collected at each CSO and stormdrain outfall sampling station in accordance with Table 5-3. For events with an expected duration of approximately 12-hours, the first sample will be collected 0.5-hour after discharge is observed in the respective stormdrain and CSO outfalls. Subsequent samples will be collected approximately one, two, three, and five hours after the outfall triggers. For shorter duration events, the Field Program Coordinators, in coordination with the Technical Project Manager, will determine the required sample collection intensity for a total of five samples.

6.3.4 Sample Runners

One sample runner will be assigned to each Wet Reach to collect samples from the Boat and Land Crews. At a minimum, runners will retrieve samples from each Boat Crew at the end of their respective reaches; however, additional pick-up points along the Wet Reaches may be required to meet holding times. Land Crew members will be responsible for coordinating sample pick-up locations in the field. The runners will then transport the samples to the central coordination point/mobile laboratory at the Nashua WWTP. The Land Crew stationed in Concord, NH will be responsible for transporting samples to the Nashua WWTP.

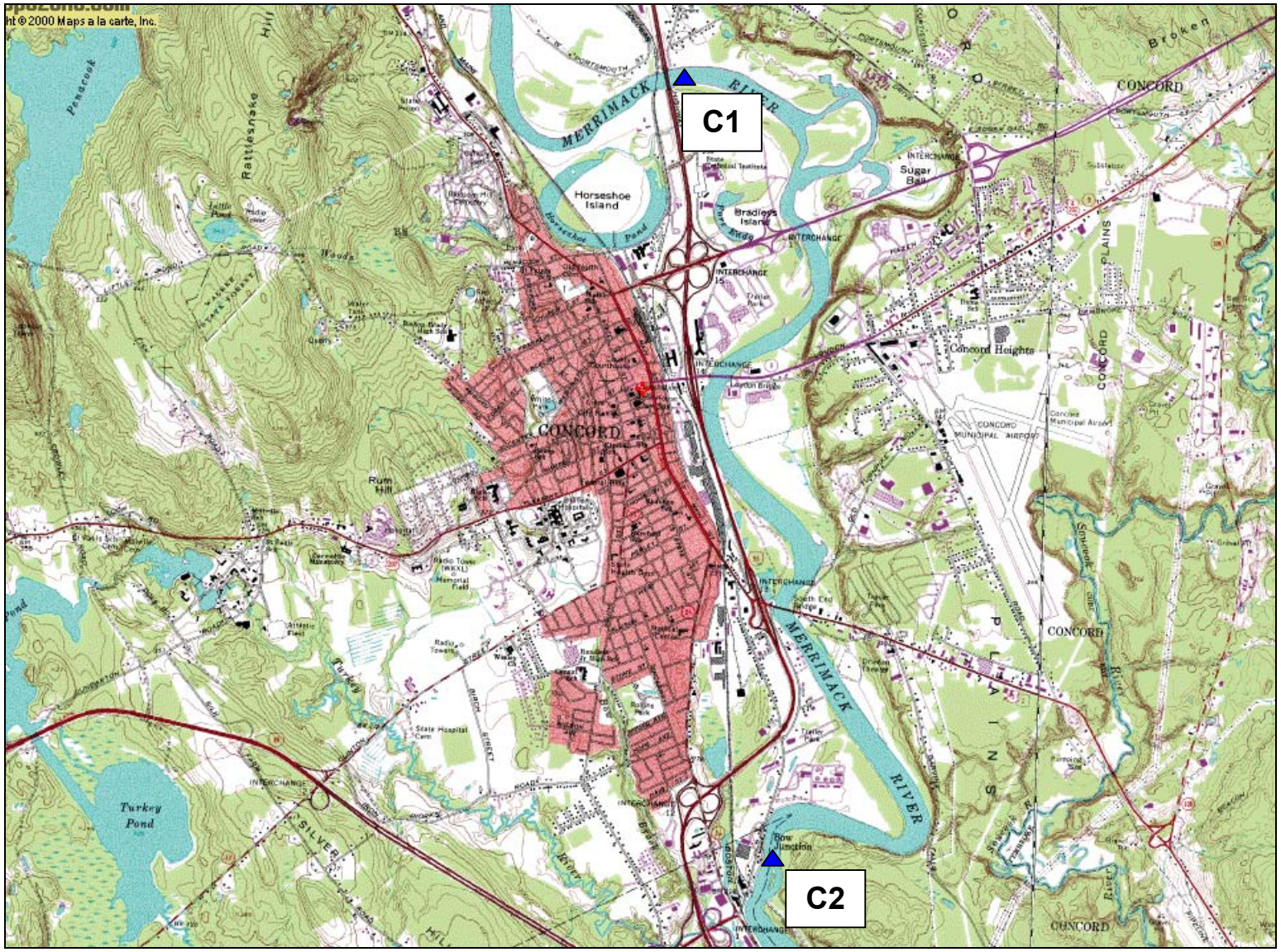
One additional sample runner will be stationed in each of the five sponsor communities of Manchester and Nashua, New Hampshire, Lowell, Lawrence, and Haverhill, Massachusetts to collect samples from the respective Outfall Crews in each community. During shorter events (*i.e.* less than six hours), Outfall Crews may be responsible for transferring custody of their samples to the Nashua WWTP.

All sample pick-up/drop-off will be scheduled to ensure that bacteria samples are delivered to the mobile laboratory within **four-hours** of their collection to allow adequate time for sample preparation and analysis. Table 6-2 provides a summary of the approximate travel times required between the downstream extent of each Wet Reach, the sponsor communities, and the Nashua WWTP.

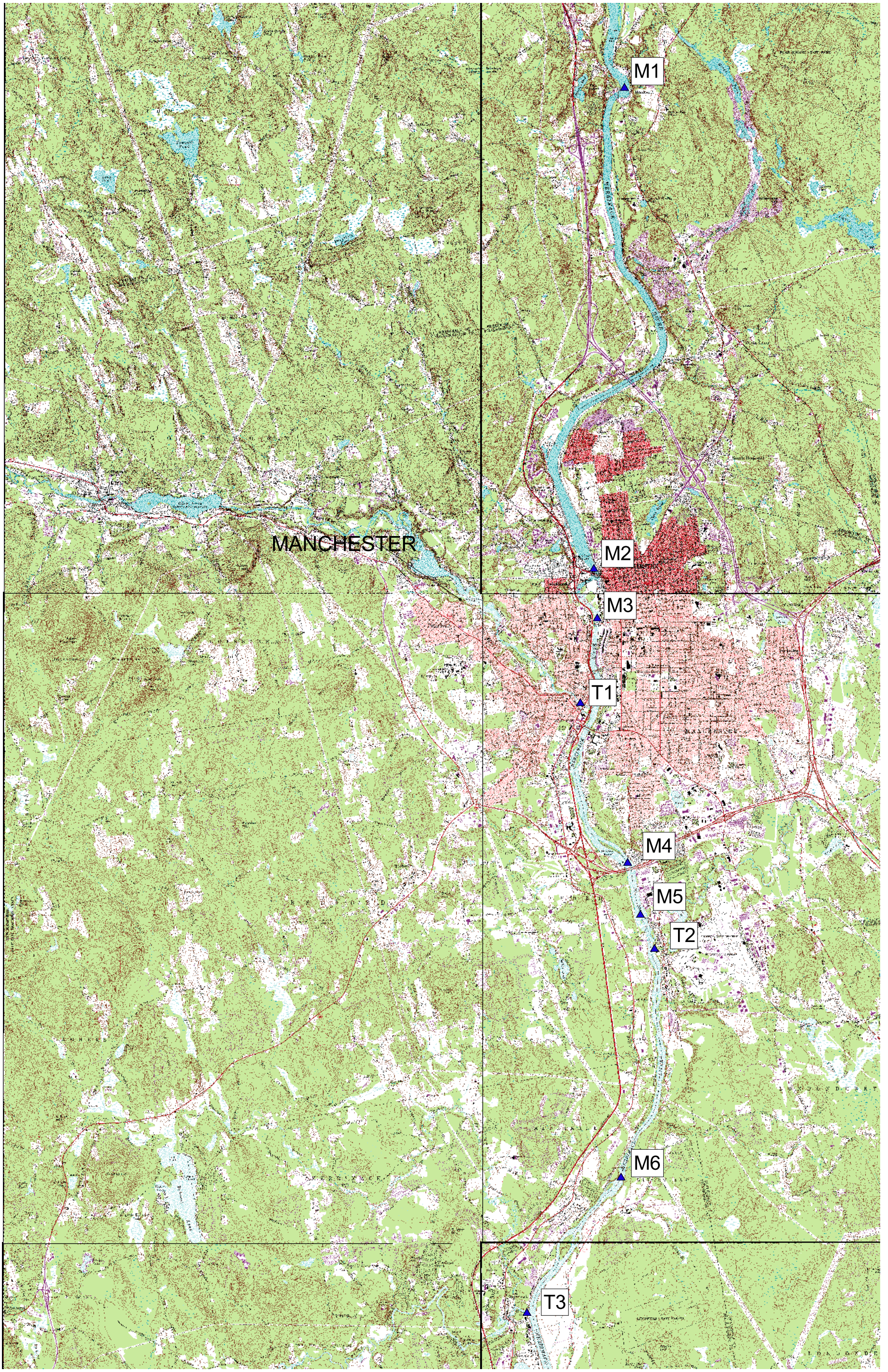
Table 6-2: Approximate Travel Times to the Nashua WWTP

Reach/Community	Reach End	Approximate Travel Time[1]
Wet Reach 1	Merrimack, NH	20 minutes
Wet Reach 2	Nashua, NH	15 minutes
Wet Reach 3	Lawrence, MA	40 minutes
Wet Reach 4	Haverhill, MA	45 minutes
Wet Reach 5	Newburyport, MA	60 minutes
Concord, NH	N/A	45 minutes
Manchester, NH	N/A	30 minutes
Nashua, NH	N/A	15 minutes
Lowell, MA	N/A	25 minutes
Lawrence, MA	N/A	40 minutes
Haverhill, MA	N/A	45 minutes

[1]Note: Travel times may be longer based on traffic/weather conditions



Merrimack River Watershed Assessment Study
Figure 6-4: Wet Weather Sampling- Concord, NH



LEGEND

▲ Wet Sampling Locations

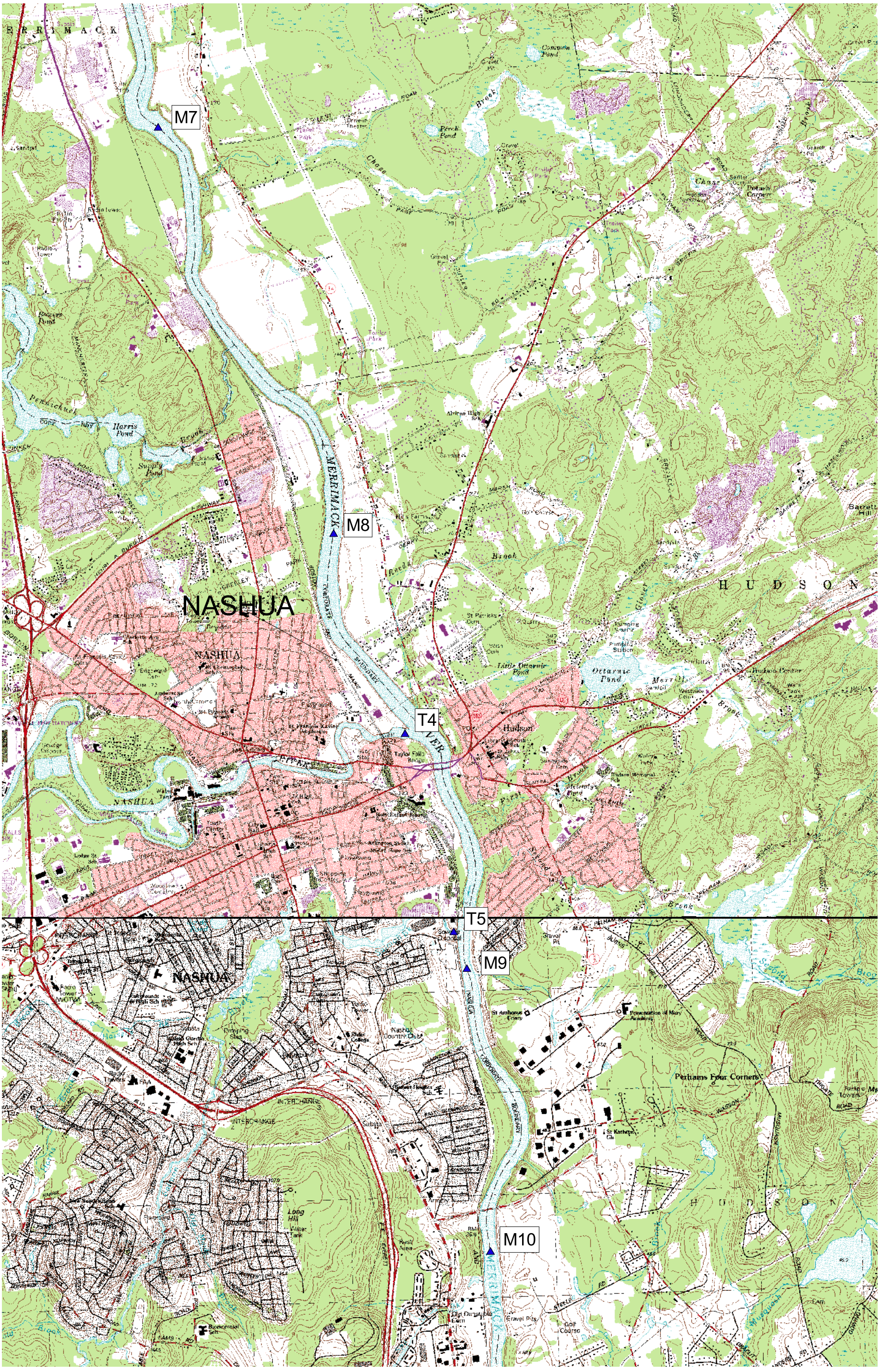
Basemap Source: USGS

600 0 600 1200 Feet

N

Merrimack River Watershed Assessment Study

Figure 6-5: Wet Weather Sampling Locations-Wet Reach 1



LEGEND

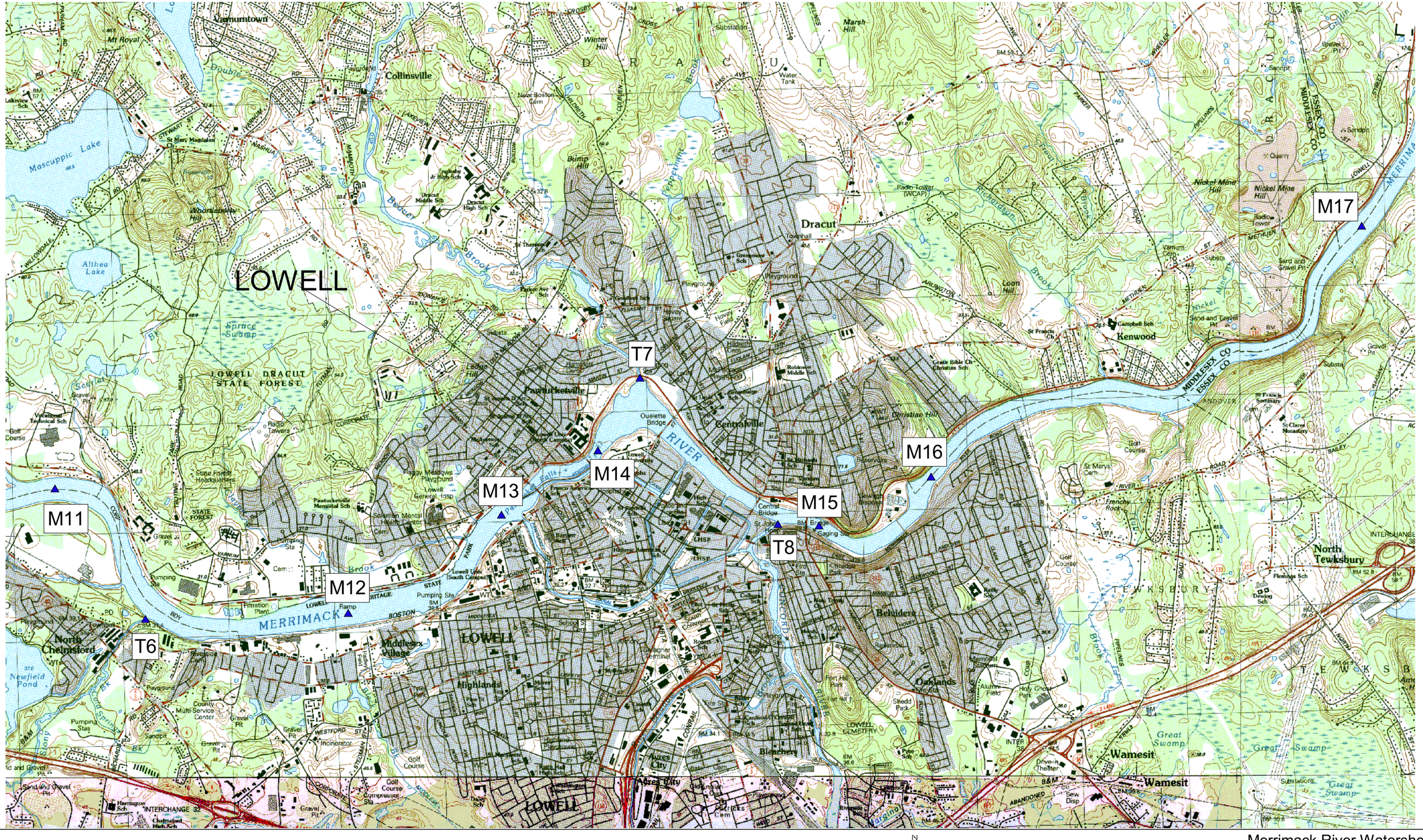
▲ Wet Sampling Locations

Basemap Source: USGS

1000 0 1000 Feet

Merrimack River Watershed Assessment Study

Figure 6-6: Wet Weather Sampling Locations-Wet Reach 2



LEGEND

▲ Wet Sampling Locations

Basemap Source: USGS

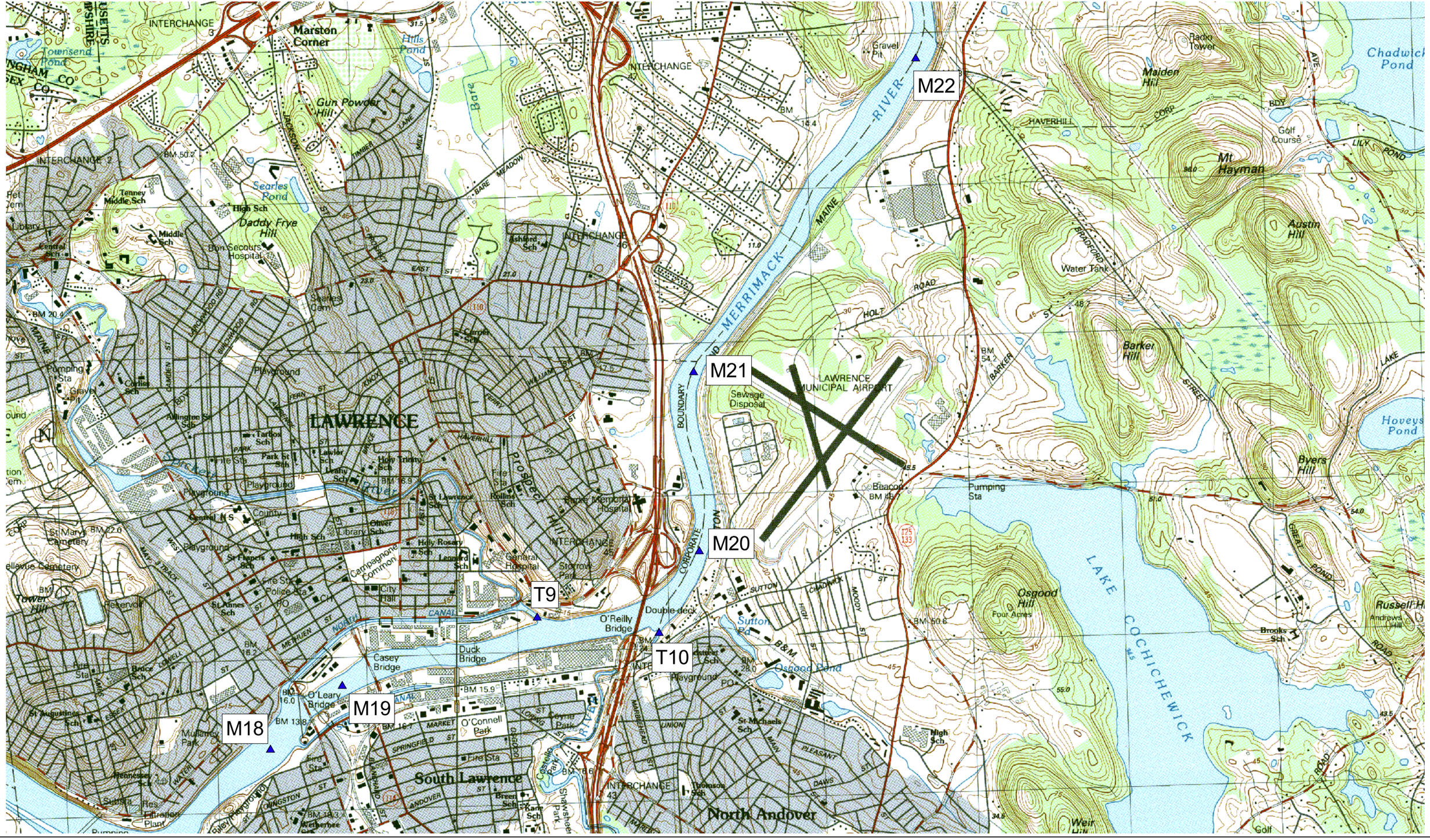
CDM

500 0 500 1000 1500 2000 Feet

N

Merrimack River Watershed Assessment Study

Figure 6-7: Wet Weather Sampling Locations-Wet Reach 3



LEGEND

▲ Wet Sampling Locations

Basemap Source: USGS

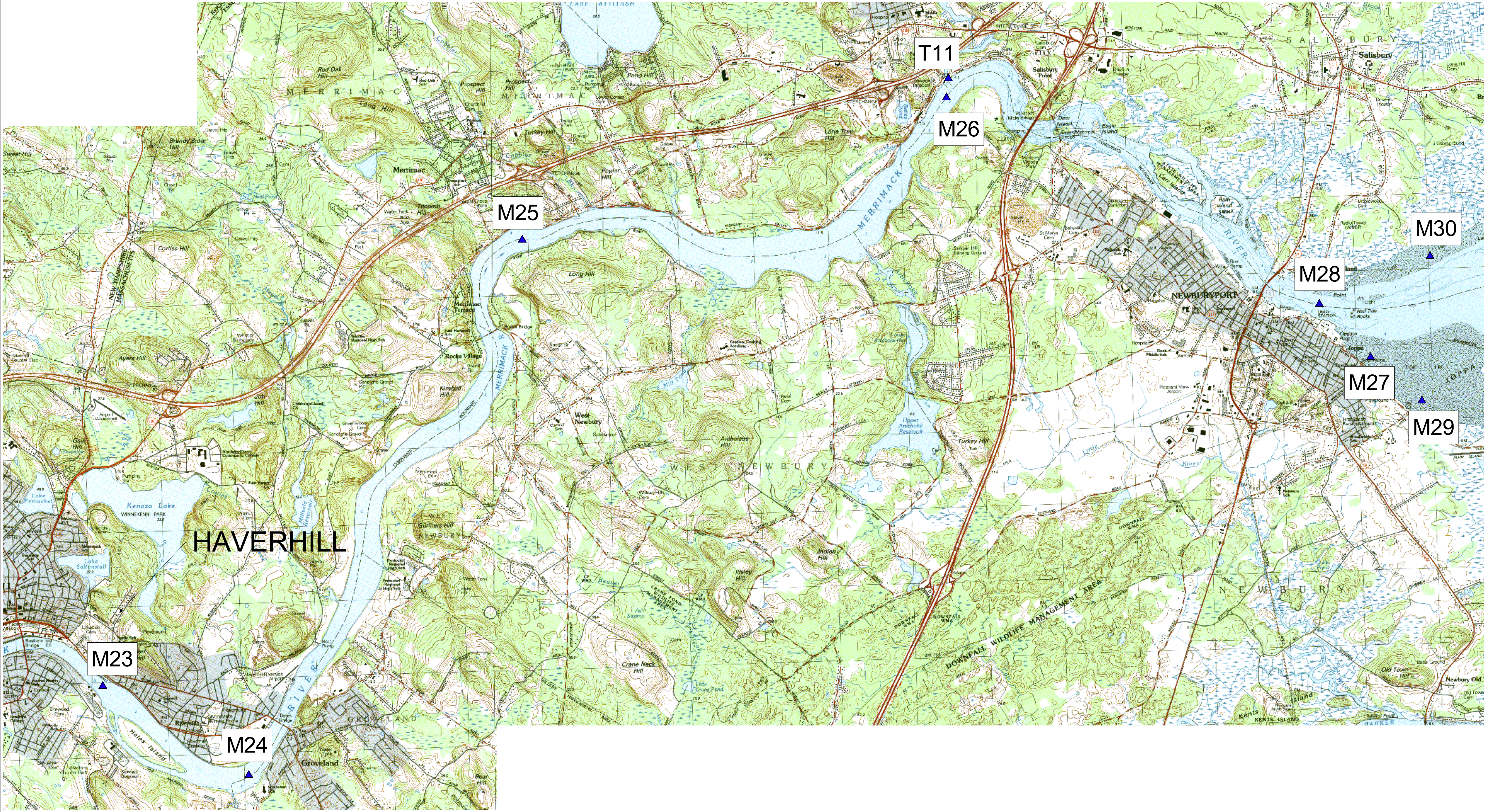
CDM

500 0 500 1000 Feet

N

Merrimack River Watershed Assessment Study

Figure 6-8: Wet Weather Sampling Locations-Wet Reach 4



LEGEND

▲ Wet Sampling Locations

Basemap Source: USGS

CDM

3000 0 3000 6000 Feet

N

Merrimack River Watershed
Assessment Study

Figure 6-9: Wet Weather Sampling Locations-Wet Reach 5

Section 7
Sampling Methods

The following section describes the sampling and measurement methods that will be used during the wet- and dry-weather sampling events to be completed under this field sampling program.

7.1 Flow Measurements, Staff Gage Installation, and Rating Curve Development

Flow Measurements

As previously noted in Table 5-4, flow measurements will be collected by the CDM Project Team at 11 stations within the Study Area over five different flow conditions to develop a rating curve at each site. Instream velocity measurements will be made in accordance with SOP-FLD-007: *Determination of Water Velocity and Stream Discharge* using either the Marsh-McBirney Model 2000 or 201. All equipment will be provided by members of the CDM Project Team or leased from an approved distributor. Recorded velocity measurements will be used to compute the stream discharge at each station in accordance with standard protocols outlined in "Measurements and Computation of Streamflow: Volume 2. Computation of Discharge" (USGS 1982). Each flow monitoring team will be required to conduct streamflow measurements at one of the real-time USGS gaging stations in the Merrimack River watershed to verify the accuracy and precision of their streamflow monitoring techniques.

Staff Gage Installation and Maintenance

Staff gages will be installed at flow measurement stations so that stage measurements can be recorded during wet- and dry-weather sampling events by the respective boat or land crews. Wherever possible, the gages will be affixed to a permanent landmark (*i.e.* bridge abutment) that is readily visible to all sampling crews in the vicinity of the sampling/flow monitoring station. The final location of each gage will be determined in the field during the first flow-monitoring event. At stations where a fixed location is not available, the gage will be attached to a length of pipe or rebar and driven into the river bottom. The gage will be of sufficient length to span the anticipated range in water levels at the gaging site. A photograph of the installed gage will be taken and a detailed description explaining the exact location of each staff gage will be developed at the time of installation and distributed to each respective sampling team. Wherever possible, the staff gage location will be referenced to another fixed object (*i.e.* 21-feet below bridge railing on northwest pier). The location of the gage will be verified during each subsequent flow monitoring event prior to taking readings. Additionally, a quality assurance check of each gage will be performed approximately one-day prior to each wet and dry-weather sampling event to confirm that the gages have not been damaged or shifted.

Wet and dry-weather sampling teams will record the stage of the river based on the staff gage reading. If water levels are above or below the gage, the distance from the gage top or bottom to the water level will be recorded.

Rating Curve Development

Rating curves will be developed at each site in accordance with standard procedures (*i.e.* Gupta 1989 or Mosely and McKerchar 1993) to establish a relationship between the observed stage and the estimated stream discharge.

7.2 Water Quality Sample Collection

This section describes the analytical laboratory requirements for each water quality parameter, the procedures that will be used to manually collect spatial composite and grab samples during wet- and dry-weather events, and the procedures for performing *in situ* measurements. Additional information regarding the procedures is outlined in the appropriate SOPs as noted in Table 7-1. The SOPs are intended to serve as a fairly generic description of sampling procedures, with additional details provided in this section of the Field Sampling Plan. All sampling procedures will be discussed in-depth at a preliminary field training meeting to be held prior to initiation of the sampling program.

Table 7-1: Summary of SOPs for Sample Collection

SOP	Title
SOP-FLD-001	Collection and Handling of Water Samples for Water Quality Analyses
SOP-FLD-002	Determination of Dissolved Oxygen (Modified Winkler, Full Bottle Technique)
SOP-FLD-003	Determination of Dissolved Oxygen (Membrane Electrode Technique)
SOP-FLD-004	Field Determination of Specific Conductance in Water
SOP-FLD-005	Calibration of Thermometers and Thermistors and Determination of Temperature
SOP-FLD-006	Field Determination of pH in Water (Electrometric Method)
SOP-FLD-007	Determination of Light Transparency (Secchi Disk Transparency)
SOP-FLD-008	Determination of Turbidity in Water
SOP-FLD-009	Operation of Global Positioning Systems (GPS)
SOP-FLD-007	Determination of Water Velocity and Stream Discharge

Analytical Laboratory Requirements

All water quality samples to be submitted for analysis will be collected in clean, preserved bottles supplied by the respective analytical laboratories. Table 7-2 provides a summary of the required sample volumes, collection containers, holding times, and preservatives for each water quality parameter.

Table 7-2: Summary of Analyte Collection Container, Holding Time, and Preservative

Parameter	Container		Holding Time	Method of Preservation	Analytical Laboratory
	Volume	*Type*			
Fecal Coliform (freshwater)	125-mL	Sterile Poly or Glass	6 hours	4°C	Aquatec
Fecal Coliform (marine water)	125-mL	Sterile Poly or Glass	6 hours	4°C	Aquatec
E. Coli	125-mL	Sterile Poly or Glass	6 hours	4°C	Aquatec
Enterococcus	125-mL	Sterile Poly or Glass	6 hours	4°C	Aquatec
Total Phosphorus	250-mL	Poly	28 days	H_2SO_4 to pH<2, 4°C	AMRO
Nitrate/Nitrite	250-mL	Poly	28 days	H_2SO_4 to pH<2, 4°C	AMRO
TKN	500-mL	Poly	28 days	H_2SO_4 to pH<2, 4°C	AMRO
Ammonia-N	500-mL	Poly	28 days	H_2SO_4 to pH<2, 4°C	AMRO
Chlorophyll-a	500-mL	Amber Poly or Glass	24 hours	4°C	Aquatec
Dissolved Oxygen (Winkler Titration)	300-mL	BOD bottle	8 hours	Manganous sulfate & alkali-iodide azide (added in the field); 4°C	Aquatec
BOD_5	1-L	Poly or Glass	48 hours	4°C	AMRO
BOD_{20}	1-L	Poly or Glass	48 hours	4°C	AMRO

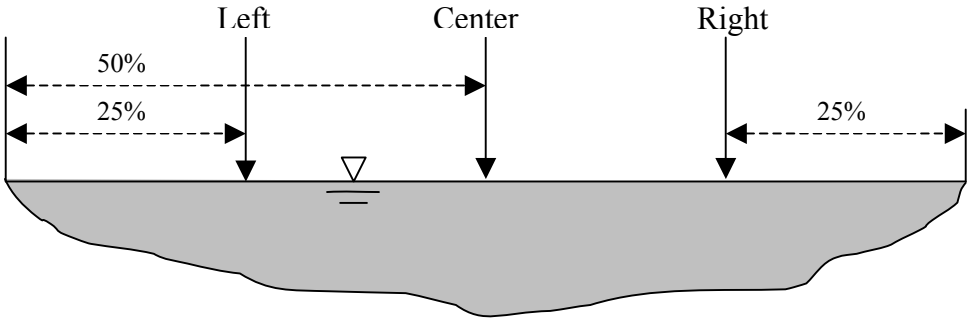
Poly= Polyethylene

Merrimack River Mainstem: Spatial Composite Sample Collection

Spatial composite samples will be manually developed at each sampling station in the Merrimack River mainstem during both wet- and dry-weather surveys, except for indicator organisms at stations that are assumed to be well-mixed. During wet-weather events, one spatial composite and one grab sample will be collected for bacteria at stations that are assumed to be poorly-mixed, such as those directly downstream of the sponsor communities.

Spatial composite samples will be developed from three vertically integrated samples collected at the quarterpoints (Figure 7-1) of the river for all constituents (see section below). The left, center, and right quarterpoint locations are defined as looking downstream.

Figure 7-1: Quarterpoint Sample Collection Stations (looking downstream)



Three vertically integrated samples will be collected at each station quarterpoint using a peristaltic pump and discharged into a compositing container (carboy) at stations with water depths greater than three-feet, or approximately one-meter. Samples will be pumped from the midpoint of the water depth at all stations with shallower depths and used to develop the spatial composite samples. In some cases, water depths may only permit the collection of integrated samples at the centerpoint and grab samples one or both of the left and right quarterpoints. In such cases, a spatial composite sample will be developed from a combination of grab and vertically-integrated samples.

Pre-label bottles will be provided to each sampling team for each station and sampling run. Samples will be collected in accordance with SOP-FLD-001: *Collection and Handling of Water Samples for Water Quality Analysis* and the following procedures:

- All samples should be collected from the upstream side of the boat to prevent contamination from the boat or disturbed sediments.
- Rinse the compositing container (carboy) three times with river water.
- Purge the pump and hose with at least three volumes of water at each station prior to collecting samples.
- At each quarterpoint with depths greater than three-feet (or approximately one-meter), lower the pump to within 0.5 meters of the channel bottom; insert the sample intake line following the pump. For locations with a shallower depth, collect a sample from the middle of the depth using the pump.
- Where water depth is greater than three-feet (approximately one-meter), collect one 1.5-gallon sample (at each quarterpoint station) as the pump is raised through the water column at a steady rate; pump into carboy. For stations with shallower depths, pump one 1.5-gallon sample from the midpoint of the water depth.
- Mix the carboy thoroughly by gently swirling the collection container.

- Record the date, time, location, volume and other pertinent information about each sub-sample in the field logbook.

- Fill laboratory bottles with spatially composited sample in accordance with the following procedures:

  o For pre-preserved bottles (*i.e.* nutrients):

    - Pour the sample in the laboratory bottle taking care not to overflow the container.

    - Simultaneously squeeze and cap the bottle.

  o For BOD_5 and BOD_{20}:

    - Rinse the bottle and cap three times with water from the composite container, emptying the rinse water over the side of the boat. Be sure not to put your fingers inside the bottle or the cap.

    - Cap bottle leaving no headspace. Tape glass stopper on bottle using electrical tape.

- Complete sample labels with sample collection time (labels will be applied to sample bottle prior to sample collection).

- Place sample in cooler with ice.

- Fill out field data collection worksheet.

It is critically important not to disturb the bottom sediments when collecting the vertically integrated samples at each site. If this occurs, the sample should be collected at the other end of the boat to avoid entraining sediment in the water sample. A note should be made in the field logbook describing the problem and corrective action taken; the sampling team should notify their respective Field Program Coordinator following the sampling event.

During the first wet-weather sampling event, equipment blanks will be collected at all stations assumed to be poorly-mixed where spatial composite bacteria samples are collected to assess cross-contamination between sampling stations. The frequency of equipment blank collection will most likely drop to five-percent, or one in 20 samples, for the remaining two wet-weather events.

Merrimack River Mainstem: Bacteria Grab Sample Collection

Bacteria grab samples will be collected from the centerpoint of all stations during both wet and dry-weather. During dry-weather and at well-mixed stations during wet-weather, the grab samples are assumed to be representative of the pollutant

concentrations at the respective stations at the time of sampling. At poorly mixed stations during wet-weather, the grab samples are collected for comparison purposes to the spatially composited bacteria samples. In addition, they will be used in lieu of the spatial composite samples if significant contaminant is found in the equipment blanks.

Specific collection procedures are provided in SOP-FLD-001*: Collection and Handling of Water Samples for Water Quality Analysis*. General sampling procedures are as follows:

- Wash hands before starting run. If you are sampling in an area that may have high bacteria levels, rinse hands before handling the next sample.
- Be careful not to touch your hands to yourself before you have cleaned them to avoid coming in contact with pathogens. If you are sampling from waters with potential sewage contamination, wear latex gloves.
- Collect sample in the sterile container just below the water surface at the center of the river or at the quarterpoints, as discussed above.
- Label bottle with appropriate information.
- Place sample in cooler with ice.
- Complete field data collection worksheet.

Tributary Sample Collection

One vertically integrated sample will be collected from the center of each major tributary station during wet- and dry-weather sampling events for all constituents except indicator organisms. Samples will be collected using a peristalitc pump, as discussed above. Open both ends of the sample tube and thoroughly rinse the sampler with water from the tributary. The sample will be transferred directly to the appropriate bottles for laboratory analysis.

For indicator organisms, one grab sample will be collected at the center of the river in accordance with the procedures discussed above and SOP-FLD-001*: Collection and Handling of Water Samples for Water Quality Analyses*.

Outfall Grab Sample Collection

Grab samples will be collected at all stormdrain and CSO outfalls. Each sample will be collected in a clean container (*i.e.* five-gallon bucket) and transferred to the proper laboratory bottles as identified in Table 7-1. Sufficient volume should be collected to ensure that all sample volume requirements listed in Table 7-1 are met.

Grab samples collected at the outfalls for bacteriological analysis will be collected directly into the sampling bottles in accordance with SOP-FLD-001: *Collection and*

Handling of Water Samples for Water Quality Analyses. Bottle holders may be used when transferring the sample to the analytical bottles to avoid contact with the effluent.

Outfall sampling teams will record the depth of water flow in the respective outfall pipes when each sample is collected. These measurements will be used to determine the approximate flow at the time of sampling using Manning's equation.

In situ Measurements

The following section describes the procedures that will be used to perform the various *in situ* measurements that will be required during the field sampling program; these include:

- *In situ* temperature, pH, dissolved oxygen, conductivity, salinity (select stations), and turbidity (select stations) measurements
- Vertical temperature and dissolved oxygen profiles upstream of the dams
- Diurnal dissolved oxygen measurements
- Secchi Disk depth measurements

Temperature, pH, dissolved oxygen, conductivity, salinity (select stations) and turbidity (select stations) measurements. During wet- and dry-weather events, *in situ* dissolved oxygen, specific conductance, pH, and temperature measurements will be made instream at the quarterpoint sampling stations in the mainstem and the centerpoint sampling stations in the major tributaries. Salinity measurements will be made at all stations downstream of Haverhill, Massachusetts in the tidally-influenced portion of the basin. Readings will be taken approximately at the midpoint of the river depth (*i.e.* 50-percent of the water depth).

For CSO and stormdrain outfall stations, *in situ* measurements will be taken in the effluent stream where sufficient depth allows. In all other cases, the *in situ* measurements will be performed in the metal collection container (*i.e.* five-gallon bucket) after the required laboratory sample bottles have been filled to avoid contamination. Sampling teams will be required to note how the *in situ* measurements where made.

Vertical temperature and dissolved oxygen profiles. Vertical profiles of temperature and dissolved oxygen will be developed upstream of the four dams during dry-weather sampling events in accordance with the following guidelines:

- If possible, one instrument will be used to simultaneously record both temperature and dissolved oxygen. If more than one probe is required, then they will be taped together so that all sensors are located at the same elevation

- The cord will be marked off in 0.5-meter increments to ensure that measurements are taken at the correct intervals
- Sufficient time will be allowed at each depth in order for each parameter value to stabilize
- The probe(s) will not be allowed to touch the bottom sediments

All data will be recorded on the appropriate field data collection sheet (Appendix C).

Diurnal dissolved oxygen measurements. Diurnal dissolved oxygen measurements will be collected during two dry-weather sampling events at select stations. The first round of measurements will be made at approximately dawn when it is anticipated that dissolved oxygen concentrations will be at their lowest; the second round of sampling will be performed in the mid- to late-afternoon (*i.e.* between 1 p.m. and 4 p.m.) when dissolved oxygen concentrations will be at a maximum.

Measurements will be made instream using a portable water quality unit at the quarterpoints of the river cross-section for each sampling station on the mainstem and at the center of the river for all tributary stations. The general procedures discussed in SOP-FLD-003: *Determination of Dissolved Oxygen (Membrane Electrode Technique)* will be used. Measurements will be made at approximately the midpoint of the river depth (*i.e.* 50 percent of the water depth), since it is assumed that all instream stations will be sufficiently mixed vertically to prevent stratification (except immediately upstream of the dams).

The three measurements for each station will be recorded on the appropriate field data collection sheet (Appendix C); the averaged value will be considered representative of the dissolved oxygen concentrations at each water quality monitoring station.

Secchi Disk depth measurements. Secchi disk depth measurements will be made during dry-weather events only at stations with water depths greater than two feet. The standard 25-centimeter black and white weighted disk will be lowered into the water column until it cannot be seen and then raised until it appears. The Secchi depth is the average of the disappearance and reappearance depths. To help quantify the variability in depth measurements, two members of the sampling teams should read the Secchi depth and both measurements should be recorded on the appropriate field data collection sheet (Appendix C). The sampling conditions (*i.e.* cloudy, windy, etc.) and collection time should also be noted, as both items may affect the depth measurements.

7.3 Continuous Dissolved Oxygen and Temperature Monitoring

Continuous dissolved oxygen and temperature monitors will be deployed at two locations in the mainstem Merrimack River over an approximately one-month period between mid-July and mid-September. The exact period of deployment will be governed by prevailing streamflow and climatic conditions. Each meter will be anchored and secured to a buoy to ensure that the probes remain submersed. The meters will be "tied to the surface" to so that readings are taken at a constant depth below the water surface as the levels change in response to streamflow conditions. Each meter will be housed in a length of PVC piping with holes and secured to the mooring apparatus with a padlock to avoid theft.

A quality assurance check will be performed for the first three days following installation of the probes and then weekly thereafter. Meters will be recalibrated and probe membranes either cleaned or replaced during each check. Calibrations will be performed in accordance with SOP-FLD-003 and SOP-FLD-005. The batteries in each unit will be replaced weekly. The logged data will also be downloaded during the weekly visit.

Section 8
Field Documentation

Proper documentation of all field activities is essential to ensure that the prescribed Data Quality Objectives are achieved. Sample crews should document any unusual or anomalous conditions that may later be useful for data interpretation and analysis.

8.1 Field Data Collection Forms

The data for this project will include field measurements and analytical sampling. Most field data recording and record keeping will be made on standard forms to ensure consistency across sampling teams. The following sections describe the standard forms that have been developed for this project; examples of each are provided in Appendix C.

Field Program Coordinators are responsible for ensuring that all of their respective sampling teams have sufficient data collection forms for each wet- and dry-weather sampling event.

Event Procedure Forms

These forms will be used to document sample collection activities, flow measurements, and sample compositing. They include:

- Dry-/Wet-Weather Sample Collection Sheets
    - Includes sample compositing and grab sampling forms, *in situ* temperature, pH, DO, conductivity, and Secchi disk measurements, stage height, and QA samples collected
- Wet-Weather Outfall Sample Collection Sheet
    - Includes sample *in situ* temperature, pH, DO, conductivity and QA samples collected
- Vertical Temperature/DO Profile Measurement Sheet
- Diurnal Dissolved Oxygen Measurement Sheet
- Streamflow Measurement Forms

Equipment Inspection, Servicing, Calibration Forms

These forms will be used to document routine inspection and maintenance of sampling equipment and calibration of probes. They include:

- Equipment Inspection, Testing, and Maintenance Sheet
- Equipment Calibration Sheet

- Equipment Problem Report Sheet

Laboratory Forms

Standard forms will be used for coordination with the laboratories. These include a bottle request form to be submitted to each laboratory by the CDM Project Team and chain-of-custody forms supplied by each laboratory to ensure proper handling of samples.

- AMRO Bottle Request Form
- Aquatec Bottle Request Form
- AMRO Chain-of-Custody Form
- Aquatec Chain-of-Custody Form

8.2 Field Logbooks

Field logbooks will provide a means for documenting all investigation and data collection activities performed at a site that are not covered by the standard data collection forms. Logbooks should be filled out in accordance with the following procedures and SOP-DOC-001: *Field Logbook Content and Control*.

Field logbooks will be bound, hardcover, waterproof books. The pages of the logbooks shall be consecutively numbered prior to the initial entry to ensure that missing pages may be identified after completion. The logbooks shall be permanently assigned to field personnel, but will be stored in a master project file at the respective CDM Project Team member's office.

The cover of each notebook must contain the following information:

- Project name
- Field logbook document control number
- Name of the CDM Project Team member and contact number
- Start date

If a logbook is transferred to another staff person, notation should be made of the transfer, date, and signatures.

Entries into the logbook may contain a variety of information, including:

- Date and purpose of site visit (*i.e.* wet- or dry-weather sampling)
- Sampling team's responsibilities (*i.e.* sampling station locations, etc.)

- Summary of sampling activities performed at each location, including number of samples collected and data collection forms completed
- Summary of problems encountered and corrective actions

Section 9
Sample Designation

Sample labels will be attached to individual sample aliquots for each investigation or quality control sample. Sample labels will be provided by the laboratories along with the sample bottles. Field Program Coordinators will be responsible for ensuring that all labels are affixed to the bottles prior to event mobilization. Sample labels will include the following information:

- Name of the investigation
- Sample identification number
- Sample collection location
- Date and time (military) of collection
- Number of dry-/wet-weather sampling event
- Number of sampling sweep
- Analysis requested
- Preservative

The unique sample identification numbers will be specified in accordance with the following guidance:

MR-XXXX-ABCDE

MR - denotes Merrimack River survey and will be the same for all the samples

XXXX - four letter/digit Station ID, as per Table 5-1 (*i.e.* M001)

A - "D" or "W" for dry- or wet-weather sampling events, respectively

B - Number of sampling event, 1 to 3

C - Number of sampling sweep: 1 to 5 for wet-weather; 0 for dry-weather

D - Analysis requested (abbreviated), see Table 9-1

E - Type of sample -- "C" for Merrimack River spatial composite samples, "G" for Merrimack River and tributary bacteria grab samples, "T" for tributary centerpoint samples, "O" for CSO or stormdrain outfall samples

Fictitious station numbers will be developed for to identify the blanks and duplicate samples in accordance with the following designations:

Series 000- regular water quality samples

Series 100- field blanks

Series 200- duplicates

Series 300- equipment blanks

For example, M101 is a field blank collected at station M001.

Table 9-1 presents a summary of the abbreviations to be used for each of the water quality parameters on the sample labels.

Table 9-1: Water Quality Parameter Abbreviations for Sample Labels

Parameter	Abbreviation
Fecal Coliform	FC
E. Coli	EC
Enterococcus	ENT
Total Phosphorus	TP
Nitrate/Nitrite	NO23
Total Kjeldahl Nitrogen	TKN
Ammonia-Nitrogen	NH3
Chlorophyll-a	Chla
Dissolved Oxygen (Winkler Titration)	DO
BOD_5	BOD5
BOD_{20}	BOD20

An example label is provided in Figure 9-2, for a wet weather fecal coliform sample collected during at outfall station O001 during the first sweep:

Figure 9-2: Example Sample Label

CDM Merrimack River WQ Survey

Date: 10/25/02 Time: 1200
MR-O001-W11FCO
Station: O001 Preservative: N/A
Wet Event 1/Sweep 1 Analysis: Fecal Coliform

Section 10
Sampling Handling and Custody

This section describes the sample handling and custody procedures that will be used during the wet- and dry-weather sampling events.

10.1 Sample Handling

All spatial composite and grab samples will be provided to the laboratories in clean, pre-preserved (as needed) bottles supplied directly by either Aquatec or AMRO in accordance with the applicable collection SOPs. Sampling crews will be supplied with extra bottles during each event in case of breakage. All samples will be preserved in accordance with the requirements provided in Table 7-2. Samples will be placed in laboratory-supplied coolers with sufficient ice to meet holding requirements. A return name and address for the sample cooler will be written on the inside of the lid in permanent ink to ensure that the cooler is returned to its owner.

10.2 Sample Custody and Documentation

Sample chain-of-custody protocols shall be maintained through receipt of the sample containers, sample collection, transfer between personnel, transport to the laboratories, and final disposal of the sample. The purpose of the protocols and procedures established herein is to ensure that the integrity of the samples is maintained throughout collection and analysis. The sample custody shall be properly documented to provide a mechanism for tracking each sample submitted for laboratory analysis.

Chain-of-Custody Protocols

Chain-of-custody procedures are established to provide sample integrity, to ensure the timely analysis of all parameters, and to track the progress of samples in the laboratory. Sample custody procedures will be based on procedures described in this Field Sampling Plan and the associated QAPP.

AMRO and Aquatec will provide chain-of-custody forms (Appendix C) to be used for all samples collected during wet- and dry-weather sampling events. The forms will be filled out by each boat, land, and outfall crew prior to relinquishing custody to the sample runners; the chain-of-custody forms will be placed in a plastic, waterproof bag and affixed to the top inside cover of the cooler. Sample runners, or outfall crews where necessary, will transfer custody of the sample to either the Aquatec mobile laboratory personnel or a courier from AMRO depending on the required analysis. When transferring sample custody, the individuals relinquishing and receiving the samples will sign, date, and note the time of transfer on the record. Representatives from both the CDM Project Team and the laboratories will retain a copy of the forms.

Section 11
Health and Safety Procedures

11.1 Health and Safety Plans

All members of the CDM Project Team will be responsible for reviewing and following the most recent Health and Safety Plan approved by their respective employer.

Field personnel must observe common field and water safety procedures when working on the water. Boat crews must wear personal floatation devices (PFD's) while on the water, must operate the sampling vessel in a safe manner, and should never work alone on the water.

All CDM Project Team members will be outfitted with a full set of raingear, including waterproof pants and jackets, during wet-weather sampling events. Steel-toed boots and reflective safety vests must be worn at all times during wet- and dry-weather surveys to prevent injury. As necessary, land and outfall crews will be equipped with traffic cones to prevent accidental injury from traffic.

Rubber gloves must be worn by all boat, land, and outfall crews sampling at stations suspected of being contaminated with sewage.

11.2 Emergency Procedures and Contacts

In case of an accident or emergency, the land, boat, or outfall sampling crew should call 911 (if necessary) and/or notify their respective Field Program Coordinator immediately via hand-held communication devices. Maps showing the location of the major hospitals in the Study Area are provided in Appendix D.

Section 12
References

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Appendix A: Contact List and Directions to Nashua WWTP

Table A.1: Project Team Contacts

Organization	Contact(s)	Title	Business Phone/ Fax	Home/ Cellular Phone
USACE 696 Virginia Road Concord, MA 01742-2751	Barbara Blumeris	Study Manager	978-318-8737 978-318-8080 (Fax)	
	Townsend Barker	Technical Advisor		
Nashua WWTP Sawmill Road Nashua, NH 03060	Rick Seymour	WWTP Superintendent	603-589-3560	
CDM One Cambridge Place 50 Hampshire Street Cambridge, MA 02139	Gary Mercer	Technical Project Manager	617-452-6238 617-452-8238 (Fax)	978-658-5085 (home) 978-509-3335 (cell)
	Beth Rudolph	Field Program Coordinator	617-452-6356 617-452-8356 (Fax)	781-395-8150 (home)
	Kirk Westphal	Project Engineer	617-452-6440 617-452-8440 (Fax)	508-357-6332 (home)
	Mark Wallace	Meteorologist	617-452-6363 617-452-8363 (Fax)	
Normandeau Assoc. 25 Nashua Road Bedford, NH 03110	Don Kretchmer	Field Program Coordinator	603-472-5191 603-472-7052 (Fax)	
NEA 451 Presumpscot Street Portland, ME 04103	Sarah Watts	Field Program Coordinator	207-879-9496 207-879-9481 (Fax)	
Aquatec 273 Commerce Street Williston, VT 05495	Phil Downey	Contact/ Technical Manager	802-860-1638	
	John Williams	QA Officer	802-860-1638	
AMRO 111 Herrick Street Merrimack, NH 03054	Marianne Steen	Contact	508-405-0232	
	Robert Kennedy	Technical Manager	508-405-0232	
	Samir Naguib	QA Officer	508-405-0232	

Directions to Nashua Wastewater Treatment Plant:

From the Southeast (*i.e.* Newburyport, Haverhill, & Lawrence, Massachusetts):

(1) Take I-495 South

(2) Take the Route 3/ Lowell Connector exit (Exit 35BA/36) towards Nashua, NH

(3) Merge onto Route 3 North towards Nashua, NH

(4) Take Exit 4- East Dunstable Road/ FAA Center

(5) Keep right off exit onto East Dunstable Road

(6) At end of East Dunstable Road, turn left onto Main Street

(7) Take fourth right off of Main Street onto Taylor Street

(8) Bear left onto Lynn Street

(9) Turn left onto Sawmill Road

From Lowell, Massachusetts:

(1) Take Route 3 North towards Nashua, NH/ Tyngsboro

(2) Follow direction (4) through (9) above

From the North (*i.e.* Concord and Manchester, New Hampshire):

(1) Take I-293 South/ Route 3A South towards Boston/ Nashua

(2) Continue on Fredrick E. Everett Turnpike towards Merrimack/ Nashua

(3) Continue on Route 3 South

(4) Follow directions (4) thru (9) above

Appendix B: Equipment Checklist

Table B.1: Equipment Checklist

Type	Equipment	Number
Boat-related	Boat	One per boat crew
	Life vests	One per boat crew member
	Anchor	One per boat
	Paddles (if needed)	One set per boat
Sampling Equipment	In situ temperature, pH, dissolved oxygen, conductivity meter	One per sampling team
	Salinity meter	One per boat and land crews downstream of Haverhill
	Water column pump sampler	One per boat and land crew
	Secchi disk with marked cord	One per boat and land crew (dry-weather only)
	Turbidity meter	One per boat and land crew, as needed
	Weighted measuring tape	One per boat and land crew
Sampling Support	Pre-labeled sample bottles	Boat, land and outfall crews (required plus extras)
	Sample cooler with ice	One per sampling team
	Extendible rod for sample collection	Land and outfall crews
	Clean 5-gallon bucket	One per outfall crew
	5-gallon container of deionized water	One per sampling team
	Plastic or glass Funnel	One per sampling team
	Carboy sample compositor	One per boat and land crew
	Cellular/ Radio Communication Device	One per sampling team and sample runner
	GPS Unit	One per boat and land crew
Tools & Miscellaneous	Paper towels (1 roll in ziplock bag)	Two per sampling team
	Scissors	One per sampling team
	Extra batteries	Four per sampling team
	Duct tape	One per sampling team
	Extra cord/ rope	One per sampling team
	Ziploc bags	50 per sampling team
	Camera and film (optional)	One per sampling team
	Hand-held communication system	One per sampling team
	Trash bags	10 per sampling team
Administrative	Field notebook	One per sampling team
	Data collection forms (Appendix C)	As need per team (plus extras)
	Chain of custody forms	As need per team (plus extras)
	Extra sample labels	50 per sampling team and sample runner

Type	Equipment	Number
Administrative (cont'd)	Indelible ink markers (*i.e.* Sharpies)	Five per sampling team and sample runner
	Pens and Pencils	Five each per sampling team and sample runner
	Metal/ Plastic clipboard	One per sampling team and sample runner
	MA-NH map and applicable street maps	One per sampling team and sample runner
	Calculator	One per sampling team
	Field Sampling Plan and SOP Compendium	One copy per sampling team and sample runner
Personal Safety	First aid kit	One per sampling team
	Disposable gloves	One box per sampling team
	Safety vest	One per team member
	Rain gear (wet weather)	Per team member
	Flashlight	One per sampling team
	Traffic cones	Five per sampling team

Appendix C: Standard Data Collection Forms

Merrimack River Watershed Assessment Study
Dry-weather Composite Sample Collection- Mainstem

Note: Form to be used during the collection of dry-weather composite samples on the mainstem for all analytical parameters except indicator organisms

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____

_____

Composite Sample Collection Record:

Quaterpoint[1]	Time	Sample Volume
Left		
Middle		
Right		
Total		

[1]"Left" and "Right" determined as looking downstream

Samples Collected- Record Sample IDs:

Parameter	Sample ID
Total Phosphorus	
Nitrate/ Nitrite	
Ammonia-N	
TKN	
Chlorophyll-a	
BOD_5	
BOD_{20}	
DO (Winkler titration)	

Merrimack River Watershed Assessment Study
Dry-weather Microbiological Grab Samples- Mainstem

Note: Form to be used during the collection of dry-weather microbiological grab samples at all mainstem river segments during dry-weather events.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____

_____

Grab Sample Collection:

Sample Collection Time: _____

--One sterile 250-mL bottle will be filled at the centerpoint of each station

Samples Collected- Record Sample IDs:

Parameter	Sample ID
Fecal Coliform[1]	
E. Coli	
Enterococcus[2]	

[1]Note if MF (freshwater) or MPN (marine waters)

[2]Marine waters only

Merrimack River Watershed Assessment Study
Dry-weather Sample Collection- Tributaries

Note: Form to be used during the collection of dry-weather vertically integrated and grab microbiological samples at all tributary stations.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____

_____

Vertically Integrated and Grab Samples:

Sample Type	Time	Sample Volume
Vertically integrated		
Grab for Bacteria Samples[1]		N/A

[1]One sterile 250-mL bottle will be filled at each station for fecal coliform, E. Coli, and enterococcus (3 total)

Samples Collected- Record Sample ID:

Parameter	Sample ID
Fecal Coliform	
E. Coli	
Enterococcus	
Total Phosphorus	
Nitrate/ Nitrite	
Ammonia-N	
TKN	
BOD_5	
BOD_{20}	
DO (Winkler titration)	

Merrimack River Watershed Assessment Study
Dry-weather Field Measurement Worksheet

Note: Form to be used to record dry-weather field measurement data at all stations on the mainstem and tributaries.

Sampling Team: Land Crew 1 Samplers: _____

Date/Time: _____ Sampling Event: _____

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Station ID	Water Depth (m)	Secchi Disk Depth (m)	In Situ[2]			
			Temp (°C)	*DO (mg/L)*	*pH*	*Conductivity*
C001						
C002						

[1]All measurements taken at quarterpoints of each channel cross-section, except secchi disk- one measurement at centerpoint

[2]Measurements taken at a approximately the mid-point of the depth

Merrimack River Watershed Assessment Study
Dry-weather Field Measurement Worksheet

Note: Form to be used to record dry-weather field measurement data at all stations on the mainstem and tributaries.

Sampling Team: _Land Crew 2_____ Samplers: _____

Date/Time: _____ Sampling Event: _____

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Station ID	Water Depth (m)	River Stage (m)	Secchi Disk Depth (m)	In Situ[2]			
				Temp (°C)	*DO (mg/L)*	*pH*	*Conductivity*
T001							
T002							
T004							

[1]All measurements taken at center of each channel cross-section

[2]Measurements taken at a depth 50-percent of the total water column depth

Merrimack River Watershed Assessment Study
Dry-weather Field Measurement Worksheet

Note: Form to be used to record dry-weather field measurement data at all stations on the mainstem and tributaries.

Sampling Team: Land Crew 3 Samplers: _____

Date/Time: _____ Sampling Event: _____

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Station ID	Water Depth (m)	River Stage (m)	Secchi Disk Depth (m)	In Situ[2]			
				Temp (°C)	*DO (mg/L)*	*pH*	*Conductivity*
T006							
T007							
T008							
T009							

[1]All measurements taken at center of each channel cross-section

[2]Measurements taken at a depth 50-percent of the total water column depth

Merrimack River Watershed Assessment Study
Dry-weather Field Measurement Worksheet

Note: Form to be used to record dry-weather field measurement data at all stations on the mainstem and tributaries.

Sampling Team: _Boat Crew 1_____ Samplers: _____

Date/Time: _____ Sampling Event: _____

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Station ID	Water Depth (m)	River Stage (m)	Secchi Disk Depth (m)	In Situ[3]			
				Temp (°C)	*DO (mg/L)*	*pH*	*Conductivity*
M001[1]		N/A					
M002[1]		N/A					
M003[1]		N/A					
M005[1]		N/A					
M006[1]		N/A					
T003[2]							
M007[1]		N/A					
T005[2]							
M009[1]		N/A					

[1]Measurements collected at quarterpoints of each channel cross-section, except secchi disk- one measurement at centerpoint

[2]Measurements taken at center of each channel cross-section

[3]Measurements taken at a depth 50-percent of the total water column depth

Merrimack River Watershed Assessment Study
Dry-weather Field Measurement Worksheet

Note: Form to be used to record dry-weather field measurement data at all stations on the mainstem and tributaries.

Sampling Team: _Boat Crew 2_____ Samplers: _____

Date/Time: _____ Sampling Event: _____

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Station ID	Water Depth (m)	River Stage (m)	Secchi Disk Depth (m)	In Situ[3]			
				Temp (°C)	*DO (mg/L)*	*pH*	*Conductivity*
M011[1]		N/A					
M012[1]		N/A					
M013[1]		N/A					
M014[1]		N/A					
M015[1]		N/A					
M016[1]		N/A					
M017[1]		N/A					
M018[1]		N/A					
M019[1]		N/A					
T010[2]							
M021[1]		N/A					

[1]Measurements collected at quarterpoints of each channel cross-section, except secchi disk- one measurement at centerpoint

[2]Measurements taken at center of each channel cross-section

[3]Measurements taken at a depth 50-percent of the total water column depth

Merrimack River Watershed Assessment Study
Dry-weather Field Measurement Worksheet

Note: Form to be used to record dry-weather field measurement data at all stations on the mainstem and tributaries.

Sampling Team: Boat Crew 3 Samplers: _____

Date/Time: _____ Sampling Event: _____

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Station ID	Water Depth (m)	River Stage (m)	Secchi Disk Depth (m)	In Situ[3]				
				Temp (°C)	*DO (mg/L)*	*Salinity*	*pH*	*Conductivity*
M022[1]		N/A						
M024[1]		N/A						
M025[1]		N/A						
M026[1]		N/A						
T011[2]								
M027[1]		N/A						
M028[1]		N/A						
M029[1]		N/A						
M030[1]		N/A						

[1]Measurements collected at quarterpoints of each channel cross-section, except secchi disk- one measurement at centerpoint

[2]Measurements taken at center of each channel cross-section

[3]Measurements taken at a depth 50-percent of the total water column depth

Merrimack River Watershed Assessment Study
Dry-weather Diurnal Dissolved Oxygen Measurements

Sampling Team: __Dry Reach 1_____ Samplers: _____

Date: _____ Sampling Event (circle one): 1 2 3

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Dissolved Oxygen Data: Circle one: Morning Afternoon

Station ID	Time	Quarterpoint 1- Left		Quarterpoint 2- Center		Quarterpoint 3- Right		Average	
		DO (mg/L)	*Temp (°C)*	*DO (mg/L)*	*Temp (°C)*	*DO (mg/L)*	*Temp (°C)*	*DO (mg/L)*	*Temp (°C)*
M2									
M3									
T1		N/A	N/A			N/A	N/A		
M4									
M5									
T2		N/A	N/A			N/A	N/A		
M6									

"Left" and "Right" Quarterpoints determined as looking downstream
Measurements made at 50-percent of depth

Merrimack River Watershed Assessment Study
Dry-weather Diurnal Dissolved Oxygen Measurements

Sampling Team: __Dry Reach 2_____ Samplers: _____

Date: _____ Sampling Event (circle one): 1 2 3

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Dissolved Oxygen Data: Circle one: Morning Afternoon

Station ID	Time	Quarterpoint 1- Left		Quarterpoint 2- Center		Quarterpoint 3- Right		Average	
		DO (mg/L)	*Temp (°C)*	*DO (mg/L)*	*Temp (°C)*	*DO (mg/L)*	*Temp (°C)*	*DO (mg/L)*	*Temp (°C)*
M11									
T6		N/A	N/A			N/A	N/A		
M12									
M13									
M14									
T7		N/A	N/A			N/A	N/A		
T8		N/A	N/A			N/A	N/A		
M15									
M16									

"Left" and "Right" Quarterpoints determined as looking downstream
Measurements made at 50-percent of depth

Merrimack River Watershed Assessment Study
Dry-weather Diurnal Dissolved Oxygen Measurements

Sampling Team: __Dry Reach 3_____ Samplers: _____

Date: _____ Sampling Event (circle one): 1 2 3

Comments: _____

Equipment Make/ Model:_____ Serial Number: _____

Dissolved Oxygen Data: Circle one: Morning Afternoon

Station ID	Time	Quarterpoint 1- Left			Quarterpoint 2- Center			Quarterpoint 3- Right		
		DO (mg/L)	*Temp (°C)*	*Salinity*	*DO (mg/L)*	*Temp (°C)*	*Salinity*	*DO (mg/L)*	*Temp (°C)*	*Salinity*
M22										
M24										

"Left" and "Right" Quarterpoints determined as looking downstream
Measurements made at 50-percent of depth

Merrimack River Watershed Assessment Study
Wet-weather Composite Sample Collection Sheet- Mainstem

Note : Form to be used during composite sample collection in the mainstem Merrimack River for all parameters, including indicator organisms.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____

_____

Composite Sample Collection Record:

Sweep	Quarterpoint 1- Left		Quarterpoint 2- Center		Quarterpoint 3- Right	
	Time	*Sample Vol.*	*Time*	*Sample Vol.*	*Time*	*Sample Vol.*
2						

Quaterpoint locations determined as looking downstream

Samples Collected- Record Sample ID:

Parameter	Sample ID- Sweep 2
Fecal Coliform	
E. coli	
Enterococcus	
Total Phosphorus	
Nitrate/ Nitrite	
Ammonia-N	
TKN	
BOD_5	
DO (Winkler titration)	

Merrimack River Watershed Assessment Study
Wet-weather Microbiological Grab Samples- Mainstem

Note : Form to be used during the collection of microbiological grab samples at the centerpoint of the mainstem Merrimack River during all wet-weather events.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____

_____

Grab Sample Collection:

Sweep	Quaterpoint 2- Center
	Time
1	
2	
3	
4	
5	

-- One sterile 250-mL sample bottle to be filled at each station

-- For well-mixed stations (noted in the FSP) only one sample will be collected at Quaterpoint 2

Samples Collected- Record Sample IDs:

Sweep	Fecal Coliform[1]	E. Coli	Enterococcus[2]
1			
2			
3			
4			
5			

[1]Note if MF (freshwater) or MPN (marine water)

[2]Marine waters only

Merrimack River Watershed Assessment Study
Wet-weather Sample Collection- Tributary Stations

Note : Form to be used during the collection of all vertically integrated samples at the tributary sampling stations.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____
_____

Vertically Integrated Samples:

Sweep	Centerpoint	
	Time	*Sample Vol.*
2		

Vertically Integrated Samples Collected- Record Sample ID:

Parameter	Sweep 2- Sample ID
Total Phosphorus	
Nitrate/ Nitrite	
Ammonia-N	
TKN	
BOD_5	
DO (Winkler Titration)	

Merrimack River Watershed Assessment Study
Wet-weather Sample Collection- Tributary Stations

Note : Form to be used during the collection of all grab microbiological samples at the tributary sampling stations.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____
_____

Microbiological Grab Samples:

Sweep	Centerpoint *Time*
1	
2	
3	
4	
5	

--One sterile 250-mL container to be filled at each station

Samples Collected- Record Sample IDs:

Sweep	Fecal Coliform	E. Coli	Enterococcus
1			
2			
3			
4			
5			

Merrimack River Watershed Assessment Study
Wet-weather Outfall Data Collection Sheet

Note : Form to be used during the collection of all grab samples at outfall stations.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Samples Collected- Record Sample ID:

Parameters	Sweep 1	Sweep 2	Sweep 3	Sweep 4	Sweep 5
Fecal Coliform					
E. Coli					
Enterococcus					
Total Phosphorus	N/A		N/A	N/A	N/A
Nitrate/ Nitrite	N/A		N/A	N/A	N/A
Ammonia-N	N/A		N/A	N/A	N/A
TKN	N/A		N/A	N/A	N/A
BOD_5	N/A		N/A	N/A	N/A

Merrimack River Watershed Assessment Study
Wet-weather Outfall Data Collection Sheet- *In Situ* Measurements

Note : Form to be used during the collection of in situ measurement at all outfall sampling locaitons.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____

_____

Grab Sample Collection & *In Situ* Measurements:

Sweep	Time	*In Situ*			
		Temp (°C)	*DO (mg/L)*	*pH*	*Conductivity*
1					
2					
3					
4					
5					

Equipment Information:

Make/ Model:_____

Serial Number:_____

Merrimack River Watershed Assessment Study
Wet-weater Field Measurement Data Sheet

Note: Form to be used to record field measurements at all mainstem and tributary stations during all wet-weather sampling events.

Station Name:_____ Station ID:_____

Sampling Team: _____ Samplers: _____

Date/Time: _____ Sampling Event (circle one): 1 2 3

Comments: _____

_____

Sweep	Water Depth at Centerpoint (m)	River Stage (m)	*In Situ* [1]				
			Temp (°C)	*DO (mg/L)*	*pH*	*Conductivity*	*Salinity*
1							
2							
3							
4							
5							

[1]Measurements to be made at center of channel, at a depth 50-percent of the total water depth

Equipment Information:

Make/ Model: _____

Serial Number: _____

Merrimack River Watershed Assessment Study
Equipment Calibration Sheet

Equipment Type	Serial #	Owner[1]	Date	Calibration Procedure	Calibration Solution Lot # (if applicable)	Performed by

[1]Owner: CDM, NAI, NEA

Sheet _____ of _____

MR-EQUIP-01

Merrimack River Watershed Assessment Study
Equipment Problem Report Sheet

Equipment: _____

Date: _____ Time: _____

Problem Reported by: _____

Sampling Event (if applicable): _____

Define the Problem: _____

_____

_____

_____

_____

Proposed Corrective Action: _____

_____

_____

_____

_____

Corrective Action Implemented? YES NO

If No, why not? _____

_____

_____

Follow-up: If problem was not corrected in the field, what was done as follow-up corrective action?_____

_____

_____

_____

Date: _____ Time: _____

Name: _____ Signature: _____

Merrimack River Watershed Assessment Study
Equipment Inspection, Testing, and Maintenance Sheet

Equipment	Owner	Maintenance/ Inspection/ Testing (choose one)	Date	Activity	Performed by

Merrimack River Watershed Assessment Study
Equipment Tracking Log Sheet

Equipment Type: _____

Equipment Owner: _____

Date	Action	Action by

Sheet ____ of _____

MR-EQUIP-04

Appendix D: Hospital Locations and Emergency Contacts

CDM

Table D.1: Emergency Contacts

Town	Emergency Responder	Telephone Number
Concord, NH	Police Fire/ EMS	603-225-8600 603-225-8650
Manchester, NH	Police Fire/ EMS	603-668-8711 603-669-2256
Nashua, NH	Police Fire/ EMS	603-594-3500 603-594-3651
Lowell, MA	Police Fire/ EMS	978-937-3200 978-458-4588
Lawrence, MA	Police Fire/ EMS	978-794-5940 978-794-1204
Haverhill, MA	Police Fire/ EMS	978-374-2403 978-373-8460

ALL EMERGENCIES SHOULD BE REPORTED IMMEDIATELY BY CALLING 911

Merrimack Valley Hospital
140 Lincoln Street
Haverhill, MA
978-374-2000

Lawrence General Hospital
One Garden Street
Lawrence, MA
978-686-3896

Lowell General Hospital
295 Varnum Avenue
Lowell, MA
978-937-6000

Saints Memorial Medical Center
One Hospital Drive
Lowell, MA
978-458-1411

Saint Joseph Health Care Center
220 Pawtucket Street
Lowell, MA
978-453-1761

Southern New Hampshire Medical

8 Prospect Street
Nashua, NH
603-577-2000

Elliot Hospital
410 Cypress Street
Manchester, NH
603-668-4111

Concord Hospital
250 Pleasant Street
Concord, NH
603-227-7122

New Hampshire Hospital
36 Clinton Street
Concord, NH
603-271-5300