ATTACHMENT 2

BMP Monitoring Plan Template

Project SPR - 335
Water Quality Facility Investigation

Response to Modified Task 4: Development of BMP Monitoring Plan Template

December 2002

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The following Monitoring Plan Template is designed for easy development of a site-specific BMP monitoring plan. In each section a brief description of the minimum informational requirements is provided. Text in red is for monitoring plan development information and should be removed in the final plan. Text in black should be modified as necessary. Also, some sections may be greatly reduced if other guidance documents or protocols are available, such as sample collection and QA/QC procedures. A simple reference and summary of what is included in the guidance document should be included in the section introduction. Section and page numbers from the four primary reference documents are included for finding specific guidance on each particular section topic. The four primary reference documents include:

- ASCE/EPA, 2002. "Urban Stormwater BMP Performance Monitoring – A Guidance Manual for Meeting the National Stormwater BMP Database Requirements"
- FHWA, 2001. "Guidance Manual for Monitoring Highway Runoff Water Quality"
- FHWA, 2000. "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring"
- Caltrans, 2000. "Guidance Manual: Stormwater Monitoring Protocols"

Introduction and Organization

Section

1

1.1 Introduction

This Stormwater BMP Monitoring Plan details the approach to be used for monitoring [Insert BMP Name], a [Insert type of BMP (structural or source control)] stormwater BMP located at [Insert location], which was installed in [Insert Year Installed] for the treatment of stormwater runoff.

[DISCUSS REGULATORY DRIVERS (e.g., NPDES, TMDL, etc.)]

Refer to:

- (FHWA, 2001) Section 2.4 Regulations as Drivers for Monitoring Programs pg 7

1.2 Monitoring Plan Organization

The plan covers event targeting, sample collection methods, analytical procedures, data analysis and reporting, and heath and safety. The monitoring plan is organized as follows:

Section 1	Introduction and monitoring plan organization
Section 2	Goals and objectives of the monitoring effort
Section 3	Stormwater monitoring requirements
Section 4	Sampling locations and types of sampling stations
Section 5	Monitoring frequency and event targeting
Section 6	Constituents of concern – monitoring parameters
Section 7	The sampling team
Section 8	Sample collection procedures
Section 9	Sample analysis methods and procedures
Section 10	Quality assurance and quality control
Section 11	Data management and reporting

The body of the report includes general descriptions of each of the above sections as well as specific policies and procedures. Provided in the appendices are the health and safety plan, mobilization checklists, and collection and reporting forms that should be taken into the field during event monitoring.

Appendix A	Standard Operating Procedures for Stormwater Monitoring
Appendix B	Site Specific Standard Operating Procedures

Goals and Objectives of the Monitoring Effort

Section

2

[IDENTIFY THE MONITORING GOALS AND OBJECTIVES]

BMP monitoring can be divided into four broad categories according to typical monitoring goals and levels of technical sophistication: base level effluent monitoring, treatment monitoring, systems monitoring, and drainage basin monitoring.

Base level effluent monitoring is the most basic and therefore the least expensive type of BMP monitoring. The purpose of effluent monitoring is to determine if the BMP meets a predetermined goal, such as effluent quality limitation or maximum flood attenuation.

Treatment monitoring requires more information than effluent monitoring. The purpose of this type of monitoring is to determine not only that the BMP is working, but also how well it works. Treatment monitoring traditionally refers to the pollutant removal effectiveness or efficiency of the BMP.

Systems monitoring is similar, but more comprehensive (and therefore more complicated) than treatment monitoring, in that it requires an engineering systems analysis or optimization approach. The purpose of systems monitoring is to determine how well a BMP meets a predetermined goal within stipulated constraints and objectives.

Drainage basin monitoring is not very complicated; however, it may require a substantial amount of information and sampled storm events to obtain meaningful data. There are three different methods for conducting a drainage basin monitoring study: upstream-downstream, before and after, and reference drainage area.

More information on defining goals can be found in:

- (FHWA, 2000) Section 4.3.1 Management Goals pg. 154-155; Section 4.3.4 Monitoring Objectives pp 163-165
- (ASCE/EPA) Section 3.1 Phase I – Determining Objectives and Scope of BMP Water Quality Monitoring Program, pp 46-56
- (FHWA, 2001) Section 2.5 Highway Stormwater Monitoring Goals pp 7-33
- (Caltrans, 2000) Appendix A Monitoring Approaches

Site Conditions and BMP Characteristics

Section

3

BMPs and sampling sites should be selected based on specific monitoring goals, data quality objectives, and other study resources or limitations.

3.1 Study Site Location

[INCLUDE DESCRIPTION OF SITE]

[INCLUDE A REGIONAL MAP]

For guidance on reporting site information refer to:

- (ASCE/EPA, 2002) Section 3.4.3.2 Standard Format Examples pp 156-163
- (Caltrans, 2000) Section 3 pp 3-13 to 16

3.2 Hydrology and Hydraulics

[INCLUDE A DRAINAGE MAP, LOCATION OF NEAREST RAIN GAGE, AND DESCRIPTIVE STATISTICS OF RAINFALL RECORD]

For guidance on the information to include with summarized precipitation data:

- (ASCE/EPA, 2002) Section 3.2.3.2 Standard Format Examples pg 201
- (FHWA, 2000) Section 4.3.2 Physical Site and BMP Characterization pp 155-157

For guidance on estimating runoff and/or rainfall:

- (ASCE/EPA, 2002) Section 3.2.1.8 Modeling Methods pp 67-68

If installing a site rain gage refer to the following:

- (ASCE/EPA, 2002) Section 3.2.1.4 Rainfall pp 61-62

3.3 Water Quality Issues

[IDENTIFY WATER QUALITY CHARACTERISTICS OF RECEIVING WATERS, INCLUDE SUMMARIZED WQ DATA IF AVAILBLE]

Visit ODEQ's Laboratory Analytical Storage and Retrieval Database for water quality data of receiving waters at http://www.deq.state.or.us/wq/lasar/LasarHome.htm

Also refer to:

- (FHWA, 2000) Section 4.3.2 Physical Site and BMP Characterization pp 157-160

3.4 BMP Characteristics

[INCLUDE DESCRIPTION OF THE BMP INCLUDING DIMENSIONS, STORAGE AND/OR FLOW CAPACITY, ETC.]

[IDENTIFY THE TYPE OF BMP ACCORDING TO DEFINABLE INLETS AND OUTLETS]

[INCLUDE PHOTO AND/OR DRAWING OF BMP HERE]

BMPs can be divided according to the following types:

- Type I BMPs with well-defined inlets and outlets (e.g., detention basins, vegetated swales, catch basin inserts).
- Type II BMPs with well-defined inlets, but not outlets (e.g., infiltration basins, infiltration trenches)
- Type III BMPs with well-defined outlets, but not inlets (e.g., grass swales where inflow is overland flow along the length of the swale, buffer strips where the overland flow can be funneled into a collection vessel).
- Type IV BMPs without any well-defined inlets or outlets and/or institutional BMPs (e.g., buffer strips, catch basin retrofits, education programs, source control programs).

Also for ideas of the type of information to report refer to:

- (FHWA, 2000) Section 4.3.2 Physical Site and BMP Characterization pg 160-163
- (ASCE/EPA, 2002) Section 3.4.3.1 National Stormwater BMP Database Requirements pp 147-155; Section 3.4.3.2 Standard Format Examples pp 162-197

Sampling Locations and Equipment

Section

4

4.1 Sampling Locations and Access

[INCLUDE AN ACCESS MAP FOR EACH SAMPLING LOCATION]
[DESCRIBE HOW THE CHOSEN SAMPLING SITES WILL PROVIDE DATA THAT IS REPRESENTATIVE OF WHAT IS BEING SAMPLED]

Refer to the following for guidance:

- (ASCE/EPA) Section 3.2.1 Recommendations and Discussion of Monitoring Locations pp 56-61
- (Caltrans, 2000) Section 3 Site Selection pp 3-1 to 3-16.
- (FHWA, 2000) Section 4.4.2 Sampling Design Plan pp 169-172
- (FHWA, 2001) Section 3.1 Monitoring Location pp 35-36

4.2 Sampling Stations and Equipment

[INCLUDE EQUIPMENT SPECIFICATIONS AND DRAWINGS AND/OR PHOTOS]

For guidance in deciding whether to do manual or automated sampling:

- (FHWA, 2001) Section 4.3.1 Introduction pg 61
- (Caltrans, 2000) Section 5 Selection of Monitoring Methods and Equip. pp5-1 to 4

For manual sampling guidance refer to:

- (FHWA, 2000) Section 4.4.2 Sampling Design Plan pp 178-179
- (FHWA, 2001) Section 4.3.1 Introduction pg 62-63
- (Caltrans, 2000) Section 10 Sample Collection pp 10-4 to 8
- (ASCE/EPA, 2002) Section 3.2.4 pp 111-114, pp 124-125

For automated equipment guidance refer to the following:

Data Loggers

- (FHWA, 2001) Section 4.1 Data Loggers pp 39-43

Sample Locations and Equipment

Flow Measurement Equipment and Methods

- (FHWA, 2001) Section 4.2 Flow Measurement Methods and Equipment pp 43-59
- (Caltrans, 2000) Section 5 pp 5-9 to 17
- (ASCE/EPA, 2002) Section 3.2.4 pp 89-111

Sampling Equipment

- (FHWA, 2001) Section 4.3 Sampler Equipment pp 63-71
- (FHWA, 2000) Section 4.4.2 Sampling Design Plan pp179-180
- (Caltrans, 2000) Section 5 Selection of Monitoring Methods and Equipment pp 5-5 to 8
- (ASCE/EPA, 2002) Section 3.2.4 pp 114-124

Installation and Maintenance

- (Caltrans, 2000) Section 7 Equipment Installation and Maintenance pp 7-1 to 11
- (FHWA, 2001) Section 5.1 Installation pp 75-79
- (ASCE/EPA, 2002) Section 3.3.2 Installation of Equipment pg 140

Monitoring Frequency and Event Targeting

Section

5

For general information refer to:

- (ASCE/EPA, 2002) Section 3.2.2 Recommendation and Discussion of Monitoring Frequency pp 68-76

5.1 Event Targeting

[INCLUDE THE DESIRED NUMBER OF EVENTS PER YEAR OR SAMPLING PERIOD AND THE MINIMUM SIZE RAINFALL EVENT]

For guidance on the typical target storm characteristics:

- (ASCE/EPA, 2002) Section 3.2.5 Recommendation and Discussion of Storm Criteria pp 127-128
- (Caltrans, 2000) Section 9 Preparation and Logistics pp 9-2 to 3
- (FHWA, 2001) Section 2.5.1.2 Develop Monitoring Plan pp 9-11

5.2 Weather Forecasting

[INCLUDE THE NAME OF THE WEATHER FORECASTING CONSULTANT AND DESCRIPTION OF RESPONSIBIITIES, MAY ALSO WANT TO INCLUDE WEBSITES OR PHONE NUMBERS OF WHERE FORECASTS WILL BE OBTAINED]

For guidance on tracking weather for target event prediction:

- (Caltrans, 2000) Section 9 pp 9-1 to 2, Appendix G
- (FHWA, 2001) Appendix C-4 Pre-Storm Mobilization pp C13

Selection of Analytical Parameters

Section

6

[REFER TO REGULATORY DRIVERS DISCUSSED IN INTRODUCTION, INCLUDE ANY SUMMARIZED WATER QUALITY DATA OF RECEIVING WATERS AND COMPARE TO APPLICABLE WATER QUALITY CRITERIA OR OBJECTIVES]

[INCLUDE A LIST OF CONSTITUENTS LIKELY TO BE PRESENT IN THE INFLUENT TO THE BMP]

[QUALITATIVELY DISCUSS EACH PARAMETER]

An example list of parameters is provided below. Modify as necessary.

Parameter	Method	Reporting Limit		Minimum Sample Volume/ Bottle/ Preservative	Holding Time
Bacteria					
Enterococci	SM 9221 F	<2 MPN		100 mL/ sterile P/[1]	6 hours
Fecal Coliform	SM 9221 E	<2 MPN		100 mL/ sterile P/[1]	6 hours
Total Coliform	SM 9221 B	<2 MPN		100 mL/ sterile P/[1]	6 hours
Conventional Parameters					
Total Hardness	EPA 130.2	2	mg/l	100 mL/ P/ HNO_3	6 months
Nitrate + Nitrite as Nitrogen	EPA 300.0	0.01	mg/l	200 mL/ P/ H_2SO_4 [1]	48 hours
Total Oil & Grease	EPA 1664	1	mg/l	2 L/ G A/ H_2SO_4 or HCl	28 days
Total Phosphorus	EPA 365	0.005	mg/l	1 L/ P/ H_2SO_4 [2,1]	28 days
Ortho-phosphate and Dissolved Phosphorus	EPA 365	0.002	mg/l	100 mL/ P/Filter immediately [1]	48 hours
Total Dissolved Solids	EPA 160.1	1	mg/l	100 mL/ P/[1]	7 days
Total Kjeldahl Nitrogen	EPA 351	0.1	mg/l	500 mL/ P/ H_2SO_4 [2, 4,1]	28 days
Total Suspended Solids	EPA 160.2	1	mg/l	100 mL/ P/[1]	7 days
Turbidity	EPA 180.1	0.05	mg/l	100 mL/ P/[1]	48 hours
Total and Dissolved Metals				400 mL[3] / P/ HNO_3[2,(1]	6 months if preserved
Antimony	EPA 200.8/7000	2	ug/l	””	“”
Arsenic	EPA 200.8/7000	0.5	ug/l	””	“”
Cadmium	EPA 200.8/7000	0.1	ug/l	””	“”
Chromium (all species)	EPA 200.8/7000	1	ug/l	””	“”

Selection of Analytical Parameters

Parameter	Method	Reporting Limit		Minimum Sample Volume/ Bottle/ Preservative	Holding Time
Copper	EPA 200.8/7000	1	ug/l	””	“”
Lead	EPA 200.8/7000	0.5	ug/l	””	“”
Nickel	EPA 200.8/7000	1	ug/l	””	“”
Selenium	EPA 200.8/7000	2	ug/l	””	“”
Silver	EPA 200.8/7000	0.1	ug/l	””	“”
Thallium	EPA 200.8/7000	1	ug/l	””	“”
Zinc	EPA 200.8/7000	5	ug/l	””	“”
Mercury	EPA 1631	0.0005	ug/l	500 ml/ Borosilicate G or fluoropolymer/ HNO_3 (2, 4,1)	
Chromium (VI)	EPA 7196A	2	ug/l	200 mL/ P/ HNO_3 (2,1)	24 hours/ *30 days if preserved with NaOH*
Organophosphorus Pesticides					
Diazinon, Chlorpyrifos	ELISA and 8141	50	ng/l	2 L/GA/(1)	7/40 days analysis
Petroleum Hydrocarbons					
TPH-Diesel	EPA 8015B	50	ug/l	2 L/ G A/(1)	7/40 days
TPH-Gasoline	EPA 8015B	50	ug/l	120 mL/ VOA/ HCl (1)	14 days

Notes:

G = glass
A = Amber
P = Polyethylene, polycarbonate or polypropylene
VOA = 40 mL glass vial for volatile organic compounds
HCl = Hydrochloric acid
NaOH = Sodium hydroxide

H_2SO_4 = Sulfuric Acid
HNO_3 = Nitric acid (high purity for metals)
7/40 days = extraction/ analysis holding time
(1) Samples will be maintained at 4°C
(2) Samples aliquots will be filter for dissolved constituents immediately upon arrival at the laboratory and preserved as appropriate for the analytical method.
(3) Sample volume is sufficient for all metals analyzed by 200.8/7000
(4) Reporting Limit for Chlordane 1 ug/l and Toxaphene 2 ug/l

Also refer to:

- (FHWA, 2000) Section 4.3.2 Physical Site and BMP Characterization pp157-160
- (ASCE/EPA, 2002) Section 3.2.3.1 Selecting Parameters pp 76-83
- (Caltrans, 2000) Section 4 Constituent Selection 4-4 to 7, Section 12 pp 12-6 to 12-15, Appendix B
- (FHWA, 2001) Section 2.5.1.2 Develop Monitoring Plan pp 9-10

The Sampling Team

Section 7

The Sampling Team refers to all personnel who are involved in logistical support, sample collection, traffic control, and safety during the actual storm event being monitored. There may be backup personnel to cover for employees that have other obligations when a monitoring event is scheduled, but at a minimum the Sampling Team should include:

- Storm Event Coordinator (1 person, can be remote)
- Monitoring Team (2-4 persons)

1.1 Storm Event Coordinator

[INSERT NAME AND TITLE OF STORM EVENT COORDINATOR] will be the Storm Event Coordinator for monitoring. The Storm Event Coordinator (Coordinator) is responsible for observing weather patterns and selecting the events to be monitored. The Coordinator will work directly with the Weather Consultant to obtain the latest weather updates and forecasts and relay them to the Monitoring Team Leader. The Coordinator directs monitoring activities from a base station equipped with necessary equipment to track weather conditions, recalculate sampler pacing as conditions change, and access dependable two-way communication with weather consultant and field crews (via cell phone or radio). The Coordinator makes the decision of which storms to monitor, when to initiate sampling, and calculates the runoff intervals to be used for automated sampler pacing. The Coordinator should notify the Monitoring Team 72-hours in advance of a potential monitoring event.

1.2 Monitoring Team

The Monitoring Team consists of [INSERT NAMES AND TITLES OF TEAM MEMEBERS]. They are responsible for ensuring that all required equipment is ready for field operation. They are also responsible for performing the entire field monitoring activities and most of the monitoring preparation. Any member of the Monitoring Team may recommend canceling monitoring if the predicted conditions do not materialize or if health or safety of the team could be imperiled due to site conditions or extreme weather. The Monitoring Team's other duties include contacting the analytical lab to arrange for delivery of sample bottles and drop-off of the samples at the lab once monitoring is completed. Specific duties of the Storm Event Coordinator and Monitoring Team members are detailed in Appendix A: Standard Operating Procedures (SOPs) for Stormwater Sampling and Appendix B: Site Specific Operating Procedures (SSOPs) for Stormwater Monitoring.

Sample Collection Procedures

Section

8

Three types of sampling collection procedures and field measurement methods are incorporated into this monitoring plan: 1) field measurements, 2) automated flow-weighted compositing, and 3) grab sampling. There are general procedures for safety, cleanliness, documentation, and transport that apply to all of these types of sampling. Additionally, there are more specific procedures that must be followed for the different types of sampling as well as for individual parameters sampled by similar methods. Stormwater monitoring generally takes place under difficult operating conditions, which can increase safety risks or sample collection problems for the sampling team. There also exists the potential for sample contamination during collection or transport. Adherence to the procedures outlined in this section and the Standard Operating Procedures (SOPs) can help to minimize these risks and problems as well as reduce the likelihood of errors in sampling results. Topics covered in this section include:

- Personal Safety
- Sampling Equipment and Bottles
- Clean Sampling Techniques
- Field Measurement Collection
- Grab Sample Collection
- Automated Sampling and Flow Monitoring
- Transport and Chain of Custody

[IF THERE IS A SAMPLE COLLECTION PROTOCOL TO BE FOLLOWED BY ALL EMPLOYEES OF YOUR ORGANIZATION REFER TO IT HERE]

8.1 Personal Safety

The Health and Safety Plan approved by [INSERT NAME AND TITLE OF ACTIVE HEALTH AND SAFETY OFFICER] should be reviewed by the all field personnel before the sampling operations covered in this monitoring plan begin. Personal safety should be of primary concern while conducting all stormwater sampling related activities. All persons involved in the sampling operation should be made aware of the hazards associated with monitoring and should freely voice any concerns if potential hazards become apparent. The Occupational Safety and Health Administration (OSHA) provides regulations and guidance on occupational safety, many of which are directly applicable to the types of activities involved in stormwater monitoring. It is the direct responsibility of each person involved in the monitoring program to read the Health and Safety Plan and adhere to its requirements. The following list provides a few basic health and safety procedures that can help to create a safer sampling environment.

- Do not sample alone, a minimum of two person field crews will be used for stormwater sampling.
- Do not enter a confined space without proper training, equipment, and surface support.
- Never remove or replace manhole covers with your bare hands or feet.
- Never leave an open manhole unattended.
- Do not start staging or sampling until traffic control has been established.

When sampling near open water it is important to be aware of and avoid drowning hazards. High stormwater flows often carry branches and other debris that can entangle a person or pin them beneath submerged obstacles. Creek banks can be unstable or slippery during wet weather and caution should be observed when walking on wet unstable surfaces.

8.2 Clean Sampling Techniques

Clean sample collection techniques should be followed to minimize the potential for contamination of stormwater runoff samples. Care must be taken during all sampling operations to avoid contamination of the water samples by human, atmospheric, or other potential sources of contamination. The monitoring team should prevent contamination of any of the following items: composite bottles, lids, sample, tubing, and strainers. Whenever possible, samples should be collected upstream, and upwind of sampling personnel to minimize contamination.

Refer to:

(Caltrans, 2000) Section 10 Sample Collection pp 10-3 to 4

8.3 Sampling Equipment

Portable Field Equipment

The parameters that will be monitored in the field using portable measurement equipment include:

1. Temperature
2. pH
3. Conductivity
4. Dissolved Oxygen
5. Salinity

Measurements of these parameters will be accomplished using a multi-probe monitoring system.

Refer to:

- (ASCE/EPA, 2002) Section 3.2.4.2 Water Quality Sample Collection Techniques pp 111-112

Grab Sampling Methods and Equipment

[INCLUDE NAME OF EACH MONITORED PARAMETER THAT WILL REQUIRE GRAB SAMPLING] Note: grab sampling is required for oil and grease, petroleum hydrocarbons, volatile organics, and bacteria.

Refer to:

- (Caltrans, 2000) Section 10 Sample Collection pp10-4 to 5
- (ASCE/EPA, 2002) Section 3.2.4.2 Water Quality Sample Collection Techniques pp 111-112, 125, 132

8.4 Automated Sampling

[INCLUDE NAME OF EACH MONITORED PARAMETER THAT WILL SAMPLED USING AUTOMATED EQUIPMENT]

Refer to:

- (Caltrans, 2000) Section 10 Sample Collection pp10-6

8.5 Sample Packing and Shipping

Monitoring personnel will deliver the samples to the laboratory. Sample bottles will be placed in coolers or some other package that is rigid enough to provide protection of the samples and has insulative properties to keep samples cold. During packing, the sample from one monitoring location should not be separated into separate shipping containers unless bottles of one size need to be shipped together because of container size. If samples from a location are separated a copy of the field-sampling sheet pertaining to the bottles will be enclosed in each shipping container. Prior to shipping all sample bottles will be recorded on the packing lists, which will include the shipping date and the method of transporting the samples. Samples must be delivered to the analytical laboratory within 4 hours of sampling to ensure the maximum holding time for bacteria of 6 hours is not exceeded.

8.6 Chain of Custody

After samples have been obtained and the collection procedures properly documented, a written record of the chain of custody of each sample will be made. This record ensures that samples have not been tampered with or inadvertently compromised in any way, and it also tracks the requested analysis for the analytical laboratory. “Chain of Custody” (COC) refers to the documented account of changes in possession that occur for samples. The Chain of Custody record tracks the sampling path from origin through laboratory analysis. Information necessary in the chain of custody include:

- Name of the persons collecting the sample(s)
- Date and time of sample collection
- Location of sample collection

- Names and signatures of all persons handling the samples in the field and in the laboratory
- Laboratory analysis requested and control information (e.g., duplicate or spiked samples etc.) and any special instructions (e.g., time sensitive analyses)

To ensure that all necessary information is documented a COC form will accompany each sample or set of samples. COC forms will be printed on multipart carbonless paper so that all personnel handling the samples may obtain a copy. A COC record should accompany all sample shipments and the sample originator should retain a copy of the forms. When transferring custody of samples the transferee should sign and record the date and time of each transfer. Each person who takes custody should complete the appropriate portion of the chain of custody documentation.

Refer to:

(Caltrans, 2000) Section 10 Sample Collection pp 10-15 to 16

Quality Assurance and Quality Control

Section 9

9.1 Data Quality Objectives

The quality assurance/quality control (QA/QC) program will be implemented to satisfy the data quality objectives of the monitoring program. The primary data quality objectives are to obtain defensible data of acceptable sensitivity and quality to:

- evaluate the stormwater management program, and
- evaluate stormwater quality
- evaluate the performance of the BMP

Analytical accuracy and precision are two parameters typically used to evaluate data quality. Accuracy is defined as the closeness of agreement between an observed value and an accepted reference value. Accuracy is expressed as percent recovery:

$$\%R = \frac{X}{T} x100 \qquad (9\text{-}1)$$

where:

% R	=	Percent recovery
X	=	Observed value of the measurement
T	=	True value of the measurement

The analytical laboratory selected for this study will evaluate the accuracy of its sample extraction and/or analytical procedures using spike samples, which may include matrix spikes (MS), laboratory control samples (LCS) and surrogate spikes. Acceptable spike recoveries must fall within statistically derived laboratory “control limits”.

Precision is the agreement among a set a replicate measurements of the same parameter. Precision is quantified by calculating the relative percent difference (RPD) between duplicate measurements:

$$RPD(\%) = \left(\frac{(C_1 - C_2)}{\left[\frac{C_1 + C_2}{2} \right]} \right) x100 \qquad (10\text{-}2)$$

where:

C1	=	First sample result
C2	=	Second sample result

The analytical laboratory will evaluate precision by performing matrix spike duplicate (MSD), laboratory control sample duplicate (LCSD) and duplicate stormwater sample analyses (typically performed for inorganic parameters only). Acceptable RPDs must meet the precision criteria established by the laboratory.

The data quality objectives also include obtaining data that are comparable and representative of the water quality conditions at each monitoring location. Comparable data will be collected if comparable sampling, analysis, QA/QC and reporting procedures are implemented throughout the monitoring program. Representative samples will be collected by performing sampling activities compliant with the procedures described in this monitoring plan. Duplicate samples will be collected and the results will be used to evaluate representativeness.

Comparability expresses the confidence with which one data set can be compared to another. Data are comparable if collection techniques, measurement procedures, methods, and reporting are equivalent for the samples within a sample set.

9.2 Field Quality Assurance/Quality Control

This section summarizes the QA/QC procedures that will be implemented by field personnel to evaluate sample contamination, sampling precision and matrix interference.

Equipment Blanks

After the intermediate sample container or scoop is cleaned using the procedures described in Appendix A (SOPs), an equipment blank will be collected by pouring reagent-grade water into the apparatus. The water will be transferred into sample bottles and analyzed for the full analytical suite.

Automated Samplers

Automated samplers will be cleaned using the rinse and purge-pump-purge cycle. Prior to each storm event, an equipment blank will be collected to evaluate potential carryover from the previous storm event. The blank will be collected by pumping reagent-grade water through the intake tubing into the intermediate sample container. The water is then transferred from the intermediate sample container into the sample bottles. The volume of reagent grade water pumped through the sampler for the equipment blank will be similar to the volume of water collected during a storm event.

Field Duplicate Samples

Field duplicate samples will be collected to evaluate the precision and representativeness of the sample collection procedures as well as sample homogeneity. One duplicate composite sample will be collected for each storm event. The duplicate sample will be collected using the specified manual grab and automated sampling techniques. Twice the volume required for the analytical suite will be collected with each duplicate sample. For grab samples, intermediate sample containers will be used, and the volume collected will be apportioned equally between the intermediate containers. The water in each intermediate container will be poured into a discrete set of sample bottles. One set of bottles will be labeled with fictitious sample identification and submitted “blind” to the laboratory.

Matrix Spike Samples

Matrix spike (MS) and matrix spike duplicate (MSD) analyses will be performed by the laboratory using project samples. MS/MSDs are described in more detail in the Laboratory QA/QC section. One MS/MSD sample will be analyzed for each storm event for all the full analytical suite. Additional sample volume is required to performed MS/MSD analyses. Field crews will submit twice the required sample volume for the sample selected as the matrix spike sample. Field personnel will identify the MS/MSD sample on the chain-of-custody form.

9.3 Laboratory Quality Control

This section summarizes the QC procedures the laboratory must perform and report with the analytical data packages. These procedures are not inclusive of the QA/QC that is required for compliance with the analytical method. The laboratory will be required to implement all procedures required by the analytical methods listed in Section 6, and to implement the Standard Operating Procedures documented in its Quality Assurance Plan. The required frequency for QC procedures and evaluation criteria are summarized in Table 10.1.

Method Blanks

A method blank is prepared using reagent-grade water, and is extracted and analyzed with each sample batch (typically 20 samples extracted and/or analyzed on a given day). Method blank results are used to identify potential sources of sample contamination resulting from laboratory procedures. Target analytes should not be detected in the method blank above the practical quantitative limit.

Bottle Blanks

Bottle blanks are required for trace-level metals analysis to verify the effectiveness of the cleaning procedures. After undergoing the cleaning procedures summarized in Section 9, a representative set of sample bottles will be filled with reagent-grade water acidified to pH <2 and allowed to stand for a minimum of 24 hours. Ideally, the time the bottles are allowed to stand should be as close as possible to the actual time the sample will be in contact with the bottle. After standing, the water should be analyzed for metals. If a metal is detected at or above its practical quantitative limit, the contamination source will be identified, the cleaning procedures corrected or cleaning solutions changed, and all affected bottles recleaned. Bottle blanks will be performed and the results obtained before the bottles are provided to field personnel.

Matrix Spike and Laboratory Control Samples

Matrix spikes (MS), matrix spike duplicates (MSD), laboratory control samples (LCS) and laboratory control sample duplicates (LCSDs) are performed by the laboratory to evaluate the accuracy of the sample extraction and analysis procedures. MS/MSDs are also performed to evaluate matrix interference. Matrix interference is the effect of the sample matrix on the analysis, which may partially or completely mask the response of the analytical instrumentation to the target analyte(s). Matrix interference may affect the accuracy of the extraction and/or analysis procedures to varying degrees, and may bias the sample results high or low.

The MS/MSD is prepared by adding known quantities of target analytes to a sample. The sample is then extracted and/or analyzed as a typical environmental sample, and the results are reported as percent recovery. The percent recovery for the MS/MSD analysis is expressed as:

$$\%R = \left(\frac{C_{obs} - C_{org}}{C_s} \right) x100 \qquad (10\text{-}3)$$

where:

% R	=	Percent recovery
Cobs	=	Concentration measured in MS analysis
Corg	=	Concentration measured in un-spiked sample analysis
Cs	=	MS concentration

The LCS/LCSD is prepared exactly like a MS/MSD, except a clean control matrix such as reagent-grade water is used. The LCS recoveries are used to evaluate the accuracy of the analytical procedures, independent of matrix effects (see Equation 10-1).

Surrogate Spikes

Surrogate spikes are performed for organic analysis method only. Surrogates are organic compounds that are similar to the target analytes in terms of their chemical structures and response to the analytical instrumentation, but are not usually detected in environmental samples. Surrogates will be added to each environmental sample and laboratory QC sample per the analytical method to monitor the effect of the matrix on the accuracy of the extraction and/or analysis. Surrogate analysis results are reported as percent recovery (Equation 10-1).

Duplicate Analysis

The laboratory will perform duplicate analyses that may include LCSD, MSD and replicate stormwater sample analyses (for inorganic methods only). The laboratory will evaluate the precision of the duplicate analyses by calculating RPDs (Equation 10-2).

Reporting of Petroleum Hydrocarbon Results

To avoid potential reporting of false-positive results for TPH-gasoline and TPH-diesel, the analytical laboratory will be required to flag results that do not match the laboratory standard for gasoline or diesel fuel. The laboratory will also submit sample and standard chromatograms with the analytical data packages.

9.4 Data Reduction and Validation Requirements and Methods

Laboratory Requirements

Laboratory data reduction and validation requirements will be consistent with the procedures documented in the laboratory Quality Assurance Plan and Standard Operating Procedures (SOPs). Data review will be performed by the project manager and the laboratory QA officer. Generally, the review will determine whether or not the:

- Sample preparation information is correct and complete.
- Analysis information is correct and complete.
- The appropriate SOPs have been followed.
- Analytical results are correct and complete.
- QC samples are within established control limits.
- Special sample preparation and analytical requirements have been met.
- Documentation is complete.
- Data reduction and validation steps are documented, signed, and dated by the analyst.

Independent Data Review Process

The analytical data received from the laboratory will be independently reviewed by the Project chemist to evaluate if the data are of acceptable quality to satisfy the project data quality objectives. The data quality evaluation will be performed following USEPA guidelines. Guidance is provided in the following documents:

- USEPA Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring (April 1995).
- USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (October 1999).
- USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (February 1994).

A summary of the evaluation criteria that will be used for the independent data review process is provided in Table 10.1. The data qualifiers that will be used to flag analytical results associated with QC parameters outside the evaluation criteria are defined below. All qualifiers are defined by USEPA, with the exception of the “H” qualifier.

UJ – The analyte was not detected above the reporting limit. However, the non-detect concentration is considered an estimated value.

U – The analyte was detected, however due to potential sample contamination from laboratory procedures, sampling equipment, sample handling or transportation to the laboratory, the sample reporting limit was raised to the concentration detected in the sample.

J – The analyte was positively identified. However the result should be considered an estimated value.

R – The sample result is rejected due to serious deficiencies in the ability to analyze the sample in compliance with the QC criteria or other laboratory protocols.

H – The reported petroleum hydrocarbon concentration is not representative of the fuel specified for analysis.

Table 10.1 : Summary of Quality Control Evaluation Criteria and Data Usability

QC Parameter	**Applicable Method**	**Frequency**	**Conditions Under Which Data May be Qualified**	**Reanalysis Required?**	**Use of Qualified Data**	**Reference**
Method Blank	Organic and Inorganic Methods	One per sample batch (i.e., 20 samples of a similar matrix analyzed within a 12-hour period)	Detection of Common Laboratory Contaminants in Blank* If the sample concentration is less than 10 times the associated method blank concentration, the sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 10 times the method blank concentration, no qualification is necessary. Detection of Other Analytes in Blank: If the sample concentration is less than 5 times the associated method blank concentration, the associated sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 5 times the method blank concentration, no qualification is necessary.	Yes	Qualified results should be reported as non-detect	USEPA 1994, 1995, 1999
Equipment Blank	Organic and Inorganic	One per storm event	Detection of Common Laboratory Contaminants in Blank* If the sample concentration is less than 10 times the associated equipment blank concentration, the sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 10 times the equipment blank concentration, no qualification is necessary. Detection of Other Analytes in Blank: If the sample concentration is less than 5 times the associated equipment blank concentration, the associated sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 5 times the equipment blank concentration, no qualification is necessary.	No	Qualified results should be reported as non-detect	USEPA 1994, 1995, 1999
Field Duplicate	Organic and	One per storm	Concentrations at least 5 times the quantitative limit: if the	No	Results qualified as **J** and	USEPA 1994,

Table 10.1 : Summary of Quality Control Evaluation Criteria and Data Usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
Samples	Inorganic	event	relative percent difference between the original and duplicate sample result exceeds 25 percent, sample results are qualified as **J.** Concentrations less than 5 times the quantitative limit: if the relative percent difference between the original and duplicate sample result is greater than the quantitative limit, detected sample results are qualified as **J.** If one result is below the quantitative limit, the quantitative limit shall be used to calculate the relative percent difference. If the relative percent difference between the original and duplicate sample is greater than the quantitative limit, the non-detect result is qualified as **UJ** and the detected result is qualified as **J.** Exceedingly high relative percent differences (e.g., 100%) will be qualified based on professional judgment. These data may be qualified as **R** (rejected).		**UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** can not be used to fulfill the project data quality objectives	1995
Matrix Spike/ Matrix Spike Duplicate	Organic and Inorganic	One per sample batch (i.e., 20 samples of a similar matrix analyzed within a 12-hour period)	Organic analyses are not qualified based on matrix spike data alone. Inorganics: Data are qualified only if the original sample concentration does not exceed the matrix spike concentration by greater than 4 times. If MS recovery is above the upper laboratory control limit, detected results are qualified a **J**, and non-detect results are not qualified. If the MS recovery is below the lower laboratory control limit, but is greater than 30%, detected results are qualified as **J**, non-detect results are qualified as **UJ.**	No	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** can not be used to fulfill the project data quality objectives	USEPA 1994, 1995, 1999

Table 10.1 : Summary of Quality Control Evaluation Criteria and Data Usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
			If the MS recovery is below 30%, detected results are qualified as **J** and non-detected results are qualified as **R** (rejected).			
Laboratory Control Sample/ Laboratory Control Sample Duplicate	Organic	One per sample batch (i.e., 20 samples of a similar matrix analyzed within a 12-hour period)	If the LCS recovery is above the upper laboratory control limit, associated detected analytes are qualified as **J**. Non-detect associated analytes are not qualified. If the mass spectral criteria are met but the LCS recovery is below the lower control limit, associated detected analytes are qualified as **J** and associated non-detect analytes are qualified as **R** (rejected). If more than half the compounds in the LCS are not within the laboratory control limits, all associated detected analytes are qualified as **J** and all associated non-detect analytes are qualified as **R** (rejected). *Professional judgment will be used to qualify sample data for the specific compounds that are not included in the LCS solution.*	Yes, to verify recoveries outside laboratory control limits	Results qualified as **J** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** can not be used to fulfill the project data quality objectives	USEPA 1999
	Inorganic		If the LCS recovery is above the laboratory control limits, detected results are qualified as **J**. Non-detect results are not qualified. If the LCS recovery is below the laboratory control limits but greater than 50%, detected results are qualified as **J** and non-detect results are qualified as **UJ**. If the LCS recovery is below 50%, detected results are qualified as **J** and non-detect results are qualified as **R**	Yes, to verify recoveries outside laboratory control limits	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** can not be used to fulfill the project data quality objectives	USEPA 1994, 1995

Table 10.1 : Summary of Quality Control Evaluation Criteria and Data Usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
			(rejected).			
Surrogates	Organic	Added to every environmental and batch QC sample	Volatile Organic Compounds *If a surrogate recovery is above the upper laboratory control limit, detected sample results are qualified as **J**. Non-detect results are not qualified.* If a surrogate recovery is below the lower laboratory control limit but above 10%, detected results are qualified as **J** and non-detect results are qualified as **UJ**. If a surrogate recovery is less than 10%, detected results are qualified as **J** and non-detect results are qualified as **R** (rejected). Pesticides The guidance above for volatile organic compounds will be used but professional judgment will be used in applying these criteria as surrogate recovery problems may not directly apply to target analytes. Semi-Volatile Organic Compounds The above criteria for volatile organic compounds applies, but sample results are qualified only if two surrogates within each fraction (i.e., acid, base/neutral) are outside control limits.	Yes, to confirm non-compliance is due to sample matrix effects rather than laboratory deficiencies	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** can not be used to fulfill the project data quality objectives	USEPA 1999
Laboratory Replicate Analysis	Inorganic	One per sample batch (i.e., 20 samples of a similar matrix analyzed	<u>Concentrations at least 5 times the quantitative limit</u>: if the relative percent difference between the original and duplicate sample result exceeds the laboratory control limit, sample results are qualified as **J.**	Yes	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality	USEPA 1994

Table 10.1 : Summary of Quality Control Evaluation Criteria and Data Usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
		within a 12-hour period)	Concentrations less than 5 times the quantitative limit: if the relative percent difference between the original and duplicate sample result is greater than the quantitative limit, detected sample results are qualified as **J.** If one result is below the quantitative limit, the quantitative limit shall be used to calculate the relative percent difference. If the relative percent difference between the original and duplicate sample is greater than the quantitative limit, the non-detect result is qualified as **UJ** and the detected result is qualified as **J.** Exceedingly high relative percent differences (e.g., 100%) will be qualified based on professional judgment. These data may be qualified as **R** (rejected).		objectives Results qualified as **R** can not be used to fulfill the project data quality objectives	
False-Positive Petroleum Hydrocarbon Result	TPH-Gasoline TPH-Diesel	NA	Based on the review of the chromatograms, sample results that do not match the laboratory standard are qualified as **H**. Chromatograms should be reviewed to evaluate if the detection is due to the presence of a different petroleum hydrocarbon, or a volatile organic compound (in the case of TPH-gasoline analysis).	Yes	Use of data qualified as H depends on the information obtained from the review of chromatograms	None. This is not a standard USEPA qualifier.

9.5 Laboratory Audits

Prequalification Laboratory Audits

Prior to selecting the analytical laboratory for this project, a prequalification laboratory audit will be performed to evaluate the acceptability of laboratory conditions, practices and procedures. The laboratory audit may consist of:

- inspection of the laboratory by a qualified individual, using an audit checklist
- review of laboratory Quality Assurance Plan and Standard Operating Procedures
- evaluation of laboratory accuracy and precision criteria
- review of laboratory certifications
- evaluation of performance evaluation results.

The candidate laboratory will be required to review the Crystal Cove Monitoring Plan and authorize that analytical, QA/QC and reporting procedures will be consistent with those requirements documented herein.

Performance Audits

Performance audits are used to quantitatively assess the accuracy of measurement data through the use of performance evaluation samples. The laboratory selected for this project will participate in performance evaluation programs administered by USEPA and in other programs as mandated for State of California certification. The results of performance audit samples will be reviewed before the laboratory is selected. A performance audit may be performed any time during the project at the discretion of the project chemist and the project manager.

Technical Systems Audits

The laboratory will be required to conduct quarterly technical system audits to evaluate:

- compliance with analytical method protocols,
- data validation, reduction, reporting and management procedures
- QA requirements- e.g., method detection limit studies, documentation requirements, employee training

Data Management and Reporting

Section

10

Results will be reported by the laboratory as hard copy and as electronic files. Hard copy data will be entered into an electronic format, and checked at least once by a different person. Electronic submittal of results will be discussed with the analytical lab in advance of delivery and its format arranged. A separate record will be generated for each sample analysis.

In addition the key information such as; station ID, sample date and time, name of sampler, name of constituent), all results, units, detection limits, EPA methods used, name of the laboratory, and any field notes will be entered into the database. Additional information, such as compositing of multiple samples, or the use of grab or automatic samples, will also be included.

When reporting the laboratory results for each stormwater sample the following information will be provided:

- Sample site
- Sample date and time
- Sample number (or identification)
- Sampling technician(s)
- Detection Limit and Reliability Limit of analytical procedure(s)
- Sample Results with clearly specified units

For more guidance on data management refer to:

- (ASCE/EPA, 2002) Section 3.2.7 Recommendations for Data Management pp 137-139
- (Caltrans, 2000) Section 6 pg 6-8

For general guidance on evaluating and reporting data:

- (ASCE/EPA, 2002) Section 3.4 Phase IV – Evaluation and Reporting of Results pp 144-149
- (Caltrans, 2000) Section 13 pp 13-3 to 10, Section 14 Data Reporting Protocols pp 14-1 to 14-3, Appendix H

For specific guidance on reporting data from a particular BMP:

- (ASCE/EPA, 2002) Section 3.4 Phase IV – Evaluation and Reporting of Results pp 150-206

Data Management and Reporting

- (Caltrans, 2000) Appendix H

General Standard Operating Procedures for Stormwater Monitoring (SOPs)

Appendix

A

SOP A-1 Weather Tracking and Monitoring Preparation

The Storm Event Coordinator will review the daily National Weather Service forecasts (www.nws.noaa.gov) and track all potential rainfall events.

If an event being tracked has a 75% or greater probability of generating 0.4” of rainfall within a 24 hour period, the Storm Event Coordinator will inform the Monitoring Team 72 hours before its predicted arrival and a the Team will be placed in a “Prepare Mode”.

Monitoring Team “Prepare Mode”

- Order bottles from lab and alert lab of possible monitoring activities (may want to keep a supply on hand during monitoring season)
- Assemble field equipment
- Arrange team members schedule for field activities
- Arrange vehicle for monitoring activities
- For 1st event of each season, check and flag all sample locations and assess site conditions, report any potential problems to Storm Event Coordinator

The Storm Event Coordinator will maintain frequent contact with the Weather Consultant and if the forecast still predicts a target magnitude event at 48 hours before its arrival, the Monitoring Team will be placed in a “Stand-By Mode”.

Monitoring Team “ Stand-By Mode”

- Identify Monitoring Team and arrange schedules for field activities
- Check bottle inventory against station check list
- Initiate chain of custody procedure
- Bench test and calibrate all field equipment
- Confirm team members schedules for field activities
- Arrange for vehicle to conduct monitoring activities

At 24 hours before the event is predicted to arrive if there is still a 75% probability that the storm will generate 0.4” of rainfall within 24 hours the Storm Event Coordinator will receive QPFs every 6 hours from the Weather Consultant and a monitoring “Alert” will be issued.

Monitoring Team “Alert Mode”

- Label bottles
- Check field boxes for supplies
- Ensure a sufficient amount of ice for sampling and sample transport
- Set up sampling equipment at sites (preferably during daylight hours)

At 12 hours before a target event is scheduled to arrive, a Go/No-Go decision on monitoring will be made by the Storm Event Coordinator. The latest QPF will be obtained from the Weather Consultant and sampler programming calculations will be done for each site and this information will be relayed to the Monitoring Team.

Monitoring Team “Go”

- Mobilize Monitoring Team

- Install fully charged batteries in samplers
- Program automated samplers
- Install clean bottles in samplers
- Check all tubing, connections, and strainer placement

Monitoring Team “No-Go”

- Retrieve sampling equipment
- Inventory, clean, organize, and prepare sampling equipment for next event.

Once precipitation has begun the Monitoring Team will go into “Sample Mode”

Monitoring Team “Sample Mode”

- Contact Storm Event Coordinator and confirm “Go” decision
- Place ice in automated samplers
- (See Site Specific Standard Operating Procedures (SSOPs))

SOP A-2 Field Equipment Preparation

Two field boxes will be prepared that will contain tools, spare parts, operation manuals for equipment, copies of the Monitoring Plan and Monitoring Checklist, safety equipment, and other supplies that might be useful during sample collection and transport. Minimum field equipment should include:

Table A.1: Stormwater monitoring field equipment checklist

Documentation	Safety
Health and Safety Plan	Portable gas monitor (in one box only)
Stormwater Monitoring Plan	Safety line
Monitoring Plan Check Lists and Field Notebooks	Tripod, winch, and safety harness (1 per vehicle)
Equipment Manuals	Flashing lights for vehicle
Chain of Custody Forms/Bottle Labels/Permanent markers/pen/pencils	Traffic cones
Sampler	Cell phone (two way radios)
Graduated cylinder for sampler calibration	Flashlights (1 per person)
Spare suction line (0.24-in to 0.375-in diameter)	Gloves (protective leather and nitrile)
Spare strainer	Hard hat (1 per person)
Spare battery	Goggles (1 set per person)
Masonry anchors & screws	**Miscellaneous**
Masonry drill bits	Battery powered drill
Tubing anchors or galvanized steel strapping	Hand tools (hammer, screwdriver, pliers, knife, hacksaw, wire strippers, measuring tape)
Flowmeter	Manhole hook
Depth-measuring rod	Buckets
Data interrogator or laptop computer	Ropes
Spare Batteries	Duct tape
	Distilled water
Area velocity sensor	Watch or stopwatch
Cable ties	Digital camera
Calibration equipment (see flowmeter manual)	Heavy duty hand truck

When the Monitoring Team is placed in "Alert Mode" (approximately 24 hrs. prior to sampling) the field equipment checklist in should be gone through to ensure the equipment is available for monitoring.

SOP A-3 Bottle Organization

- Bottles of proper size and material and sufficient quantity should be prepared by the analytical lab and delivered to the Monitoring Team at least 48 hours prior to the sampling event (see sample bottle order form). Bottles should be inventoried and checked against the SSOPs for each monitoring station.
- A separate 80-quart Rubbermaid Environmental Cooler should be prepared and clearly labeled for each set of samples at each monitoring station. The cooler should include the required bottles for sampling at that site as well as bottles for blanks and duplicates as required by QA/QC plan.
- All sample bottles should be labeled prior to placement in sampler and as much information as possible should be filled out on the labels when bottles are dry. A second label or corresponding Sample ID No. should be place on sample bottle lid.
- One set of clean beakers in Ziploc bags (1-250 ml and 1-500 ml.) should be placed in coolers with bottles.
- Powder free nitrile gloves should be worn whenever handling clean bottles.

Table A.2: Sample Site Identification Information

Site Name	Site ID Number	Grab Sample Bottles	Automated Sample Bottles

SOP A-4 Clean Sampling Techniques

Sample collection personnel should adhere to the following rules while collecting stormwater samples to reduce potential contamination.

General

- No Smoking
- Do not park vehicles in immediate sample collection area, do not sample near a running vehicle.
- Always wear clean powder-free nitrile gloves when handling composite bottles, lids, sterile grab sample bottles, tubing, or strainers.
- Never touch the inside surface of a sample bottle, lid, or sampling tube (even with gloved hands) to be contacted by any material other than the sample water.
- Never touch the exposed end of a sampling tube.
- Never allow any object or material to fall into or contact the collected sample water.
- Avoid allowing rainwater to drip from rain gear or other surfaces into sample bottles.
- Do not eat or drink during sample collection.
- Do not breathe, sneeze, or cough in the direction of an open sample bottle.

Equipment Decontamination Procedures

Non-dedicated sampling equipment will be properly cleaned before sample collection Non-dedicated equipment may include:

- Teflon or fluoropolymer scoops [note- your can't use stainless steel for trace metals analysis], buckets used to collect manual grab samples
- Water quality probe for field parameter measurements

Scoops and buckets used to transfer samples into the sample bottles required for will be cleaned as follows:

- Clean with tap water and phosphate-free laboratory detergent such as Liquinox®
- Rinse thoroughly with tap water
- Rinse thoroughly with analyte-free water
- Air dry

Before the water quality probe is used at each site, the probe will be double-rinsed with analyte-free water.

SOP A-5 Grab Sampling

Grab samples will be taken for the following parameters:

- Oil and Grease
- Bacteria
- Ammonia
- Mercury
- TSS

Grab sample technique is described as follows:

- Put on sterile nitrile gloves
- Adhere to clean sampling techniques in SOP-A3
- Remove lid of sample bottle
- Place lid top down on a clean surface out of the rain or hold in hand while taking sample, do not allow inside of lid to contact any objects.
- Fill sample bottle directly from flowing stream with bottle opening facing upstream (do not take samples from pooled areas). For Oil and Grease, the sample should be taken at the air/water interface. For other samples, the collection point should be a mid-depth.
- Replace lid on sample bottle
- Fill out label on sample bottle and place in cooler

For locations where surface collection is not possible (e.g., manholes), sample bottles may be filled using the sampler pump.

Bacteria samples should be taken just prior to completion of monitoring due to the short holding time requirements for their analysis.

SOP A-6 Sampling of Field Parameters

Field parameters will be measured at each sampling location once per event. Parameters to be measured include:

- Temperature
- pH
- Dissolved oxygen
- Conductivity
- Salinity

These measurements will be taken with a portable water quality probe according to the following procedures:

- Calibrate equipment according to manufacturers instructions.
- Rinse a clean 500 ml beaker twice with runoff to be sampled, dump rinsate downstream of sampling point.
- Fill beaker with sample using grab sample techniques in SOP-A4 and submerge probe in sample.
- *Follow manufacturers instructions for sample analysis*

Note: Detailed SOPs will be developed once sampling equipment is purchased and operations manuals are reviewed.

SOP A-7 Automated Sampling

Sampler Pre-Event Inspection and Bench Test

(See SSOPs and Users Manuals for Equipment)

Sampler System Set Up and Calibration

(See SSOPs and Users Manuals for Equipment)

Sampler Programming

(See SSOPs and Users Manuals for Equipment)

Installing Bottles in Samplers

- Unlatch and remove top portion of retaining ring so that the bottom of the tub is open.
- Wearing clean nitrile gloves, place bottles in rack (see SSOPs and Bottle Checklist)
- Line Bottles up with numbers on outside of tub
- Fill sampler with ice
- **Remove lids from sample bottles and place in lids in plastic bags**
- Replace top portion of sampler, aligning the distributor arm with bottle number one.
- Latch top of sampler to tub

Sample Compositing

- The automated sampling equipment is placed in pause mode prior to the initiation of a composite bottle change. This action is accomplished in the field or by remote monitoring personnel if the monitoring station is equipped with telemetry.
- Composite bottle changing requires two field crew members – "clean hands" (operations involving contact with the sample: bottle, lid, tubing and sample transfer) "dirty hands" (sampler operation, operation of machinery, and other activities that do not involve handling items that directly contact the sample). Both team members wear clean, powder-free nitrile gloves. "Clean hands" only touches suction tubing and Teflon composite bottle lids. Keep extra gloves within easy reach.
- Prior to putting on clean gloves, the clean empty sample bottle is placed near the automated sampling unit, and the sampler is opened.
- Wearing clean powder-free nitirle gloves, "dirty hands" removes the lid clamps from both the full sample bottle and the clean sample bottle.
- "Clean hands" switches the bottle lids, putting the solid lid on the full bottle and dirt hands" places a clean ziplock bag over the end of the tubing securing it with a rubber band. The inside of the bag should never be touched by sampling personnel.
- "Clean hands" removes the bottle lids, putting the solid lid on the full bottle and the perforated lid on the clean empty bottle.
- "Dirty hands" installs the lid clamps on both bottles, removes the full bottle from the sampler, replacing it with the clean empty bottle.

- "Clean hands" holds the tubing while "Dirty hands" removes the Ziploc bag from the end of the pump tubing, being careful not to touch the tubing.
- "Clean hands" inserts the tubing through the lid of the clean bottle.
- The sampler is closed and sampling equipment is placed in sample mode. Remote operation personnel are notified as soon as the bottle change is complete.
- The sampling team fills out the appropriate information on the label of the full sample bottle.
- The full bottle is surrounded with fresh ice or frozen refreezable ice packets, and secured inside the vehicle for transport.

Disassembly, Cleaning, and Storage of Automated Samplers

(See SSOPs and Users Manuals for Equipment)

SOP A-8 Chain of Custody Records

A chain of custody record (COC) is a legal document designed to track samples and persons who are responsible for them during preparation of the sample container, sample collection, sample delivery, and sample analysis. These form are supplied by the analytical laboratory that performing the sample analysis. The procedures for filling out these forms are as follows:

Prior to sampling

After bottles are labeled placed in coolers, fill out general information on COC form including:

- Company information and Client Code
- Project Name
- Sample Site ID
- Matrix
- Date
- Sample Numbers (unique to each bottle, see SSOPs for labeling instructions)
- Type of sample

Place COC in a Ziploc bag and tape to the lid of the cooler

After Sampling is complete

After sampling has been completed, fill out remainder of the COC including:

- Time sampling was initiated
- Number of containers
- Comments or special instructions (see SSOPs)
- Disposal requirements

Replace in Ziploc bag and tape to lid of cooler

At Laboratory or Transfer to Another Person

Whenever custody of the samples is relinquished:

- Sign and date
- Have new custodian sign and date
- Relay any special instructions
- Take one copy of COC for your records

SOP A-9 Automated Sampler Programming

Automated samplers will be programmed to collect composite samples that represent the entire storm event (to the extent possible) based on predicted rainfall depth and the estimated runoff volume or the predicted duration of runoff at from areas tributary to the sampling stations. For flow-weighted composite samples, the sampler will be programmed to collect an aliquot of sample after a predetermined volume of flow has been measured at the sampling location

Flow-Weighted Composites

The Runoff Coefficient Method will be used to estimate total runoff volume for sampler programming at each location. The method provides an estimate of total runoff volume based on the predicted depth of rainfall, the total watershed area, and the estimated runoff coefficient according to the following relationship.

$$V=QPF*(C_1*A_1+C_2*A_2.....C_n*A_n)$$

Where:

V=Estimate total runoff volume for an event in cubic feet

QPF=Quantitative Precipitation Forecast for an event in feet

C=Runoff Coefficient

A=Tributary area in square feet

The runoff coefficient is a unitless value between 0 and 1 and is estimated based on watershed characteristics. These values are published in most hydrology books. For this project, the runoff coefficients that will be used are as follows:

Table A.3: Runoff coefficients to be used in flow-weighted composite volume estimation.

Description of Area	Runoff Coefficient	
	Lower Estimate	Upper estimate
Retail	0.7	0.95
Single Family Residential	0.3	0.5
Suburban Residential	0.25	0.4
Parks	0.1	0.25
Unimproved Areas	0.1	0.3
Streets	0.7	0.95
Lawns	0.1	0.35

If a watershed has a relatively homogenous land use, the runoff coefficient can be selected directly for the above table. If the watershed has multiple types of land uses, a weighted average coefficient is used.

After the first storm event, the total volume measured by the sample is compared to the volume estimated by the equation. If the difference between the two values is greater than 10% the various parameters in the volume equation are examined and adjusted as necessary to obtain the measured volume value. This calibration is repeated after subsequent events until the volume equation and the measured volume for an event can be made to agree.

The total volume of sample required is calculated by summing the required volume for each laboratory analysis to be performed.

An aliquot volume for compositing is chosen. For stormwater monitoring, a minimum of 8 samples throughout the storm event is recommended to achieve a representative composite. The aliquot volume is calculated by dividing the total required sample volume by the number of samples per event.

$$v = V/n$$

Where:

v = Aliquot volume

V = Total required sample volume

n = Number of aliquots to be collected per event

The flow pacing for the sampler is calculated by dividing the total predicted runoff volume by the number of aliquots to be collected.

SOP A-10 Transporting, Packaging, and Shipping Samples from the Field to the Laboratory

- Clearly mark the analyses to be performed for each sample.
- Fold the field-sampling sheets and chain of custody record form and place them in plastic bags to protect the sheets during transport. Tape COCs to the lid of the cooler.
- Pack samples well to prevent breakage or leakage (samples should already be labeled) and provide additional protection for glass sample bottles (e.g. foam or bubble wrapping).
- Sample should be packed in ice or an ice substitute to maintain a sample temperature of 4°C during shipping. Ice (or substitute) should be placed in double wrapped watertight bags to prevent leaking during shipping.
- Using duct tape or packing tape, wrap the cooler twice to seal the opening.
- On the sealing tape, write the date and time the sample container was sealed
- Affix destination, identification, and FRAGILE labels to each shipping container.
- Samples must be delivered to the analytical laboratory within 4 hours of sampling to ensure the maximum holding time for bacteria of 6 hours is not exceeded.

Site-Specific Standard Operating Procedures (SSOPs)

Appendix

B

SOP B-1 Seasonal Site Inspection and Preparation

[INCLUDE SPECIFIC INFORMATION ON EACH SAMPLING SITE]

SOP B-2 Grab Sample Collection

[INCLUDE SPECIFIC INFORMATION ON EACH SAMPLING SITE]

SOP B-3 Automated Sample Collection

[INCLUDE SPECIFIC INFORMATION ON EACH SAMPLING SITE]