COLORADO
Department of Transportation

SAMPLING ANALYSIS PROJECT PLAN FOR CDOT WET WEATHER

Colorado Department of Transportation

Environmental Programs Branch

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SAMPLING ANALYSIS PROJECT PLAN FOR CDOT WET WEATHER MONITORING PROGRAM

Topical Report RSI-2774

by

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1.0 DISTRIBUTION LIST

The Sampling and Analysis Project Plan (SAPP) for monitoring of outfalls from priority development highway road surfaces with permanent water quality control measure was developed to support Colorado Department of Transportation's (CDOT) Wet Weather Monitoring (WWM) program. The SAPP has been distributed to the parties listed in Table 1-1. All parties who receive the original SAPP will be provided with any subsequent revised versions.

Table 1-1. Distribution Table

Name	Organization	Role	Address
Mr. Robert McDade	CDOT	MS4 WWM Manager	4201 E. Arkansas Ave., Shumate Bldg Denver, CO 80222
Ms. Jean Cordova	CDOT	Water Quality Manager	4201 E. Arkansas Ave., Shumate Bldg Denver, CO 80222
Ms. Jane Hann	CDOT	Environmental Programs Manager	4201 E. Arkansas Ave., Shumate Bldg Denver, CO 80222

2.0 PROJECT ORGANIZATION

The assigned responsibilities for each of the project leads are displayed in Table 2-1. The WWM Manager oversees the day-to-day operations of the program and monitoring staff, while the Water Quality Manager is tasked with ensuring that reporting requirements and permit compliance are being followed.

Table 2-1. Key Personnel and Responsibilities

Key Personnel	Responsibilities
WWM Manager	• Oversees permit compliance • Completes annual data reporting/storage • Maintains SAPP • Develops and monitors Quality Assurance (QA)/ Quality Control (QC) procedures • Ensures that monitoring staff are properly trained
Water Quality Manager	• Provides review of sampling report • Ensures sampling report is finalized annually • Evaluated compliance to CDOT WWM program • Ensures that QA/QC procedures are adhered to

3.0 INTRODUCTION

CDOT's municipal separate storm sewer system (MS4) is permitted under the Colorado Discharge Permit System (CDPS) Permit No. COS000005. Individual Permit Renewal for Discharges (MS4 permit) requires CDOT to implement seven program areas to reduce pollutants from entering state waters, including Construction Site, Permanent Water Quality, Illicit Discharges, Industrial Facilities, Public Outreach and Education, Pollution Prevention and Good Housekeeping, and Wet Weather Monitoring.

The WWM program is tasked with assessing wet weather impacts from highways and facilities and the performance of control measures used to control discharges. A Program Description Document (PDD) was developed for the WWM program that defines the requirements for administrating and implementing the program and integrates CDOT's Environmental Management System (EMS) elements for program consistency and continuity. The WWM PDD address the three project areas within the overall program that require monitoring, including: complex highway-maintenance facilities, outfalls from priority development highway road surfaces and permanent water quality (PWQ) control measures (CMs), and outfalls from priority development highway, road surfaces without control measures.

While the WWM PDD provides program guidance, this SAPP is developed for specific, finite stormwater sampling projects. The SAPP defines the procedural details and quality standards for project management, data generation and acquisition, assessment and oversight, and data validation. The SAPP is supplemented with Standard Operating Procedures (SOPs) for routine operations, which provide detailed sets of step-by-step instructions to ensure consistent and uniform outcomes.

3.1 PROBLEM STATEMENT

The purpose of the SAPP is to ensure that the project produces reliable, usable data according to identified data quality objectives. Because monitoring needs vary between the three WMM Program's project areas, a separate SAPP and corresponding set of SOPs are developed for each project area. This SAPP addresses the monitoring of outfalls from priority development highway road surfaces with PWQ CMs.

3.2 INTENDED USE OF DATA

Data collected for this project will allow pollutant concentrations and loads at the inlets and outfalls of permanent CMs to be determined along with the storm characteristics that generate these loads. These data will allow CDOT to determine removal efficiencies and the performance of current CMs and are intended to support CDOT's MS4 permit compliance.

4.0 PROJECT/TASK DESCRIPTION

4.1 GENERAL PROJECT OVERVIEW

The goal of CDOT's WWM program is to understand the impact on water quality from wet weather runoff from highways and facilities. The PWQ CM sampling project task is to assess the efficiency of CMs that control discharge after a storm event. The WWM program will follow requirements under MS4 Permit No. COS000005 to evaluate CM efficiencies after a storm event for highways and PWQ CMs.

4.2 SAMPLING PROJECT ANNUAL WORKFLOW AND MAJOR TASKS

The annual workflow for the PWQ CM project is displayed in Figure 4-1. The workflow contains three phases: planning, data collection/entry, and reporting. The data collection/entry phase will be a redundant loop until all of the required samples have been collected in a given calendar year to meet permit requirements.

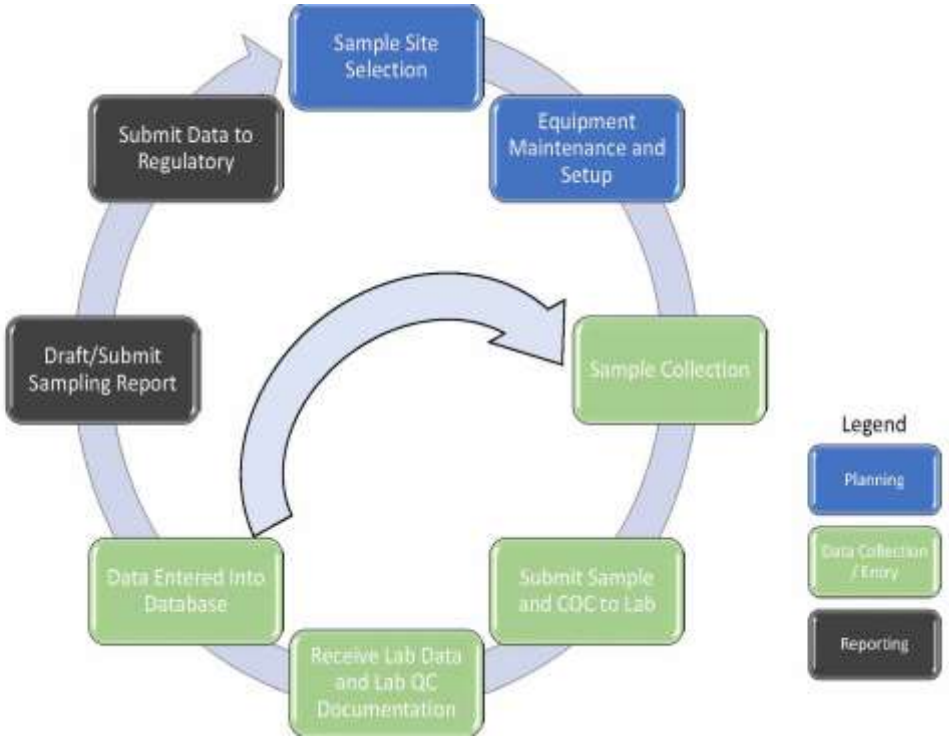

Figure 4-1. Annual Workflow for the Wet Weather Monitoring Program.

4.3 SAMPLE LOCATIONS

Previously sampled facilities and highways with PWQ CMs are shown in Tables 4-1 and 4-2 and Figures 4-2 and 4-3, respectively. The tables include the map ID, site name, site ID, location (latitude/longitude), outfall type (i.e., PWQ-Outfall, direct discharge from a maintenance facility outfall without a PWQ [M-Outfall], or direct discharge from a highway without a PWQ [Hwy-Outfall]), and dates monitored.

Table 4-1. Previously Sampled Facilities

Map ID	Site Name	Location (Latitude, Longitude)[a]	Outfall Type	Dates Monitored
1	11th Ave.	39.734613, –105.014085	M-Outfall	2010
2	Park Ave.	39.767299, –104.995436	M-Outfall	2010
3	R-1 Colfax	39.73634, –104.774026	M-Outfall	2010
4	I-70WBP&R	39.699225, –105.20556	Hwy-Outfall	2010
5	E470&I-70	39.736259, –104.716963	Hwy-Outfall	2010
6	West US 160	37.269941, –107.910044	M-Outfall	2011
7	East/South US 160	37.22152, –107.858077	M-Outfall	2011
8	Snow Dump	37.268104, –107.884413	PWQ-Outfall	2011
9	*PT#6813 Outfall	39.835468, –104.983125	M-Outfall	2012, 2013
10	*PT#6813 Separator	39.837065, –104.983248	M-PWQ-Outfall	2012, 2013
11	*PT#6822 Outfall	39.628812, –105.009762	M-PWQ-Outfall	2012, 2013
12	*PT#6898 Outfall	39.823923, –104.980325	M-Outfall	2012, 2013
13	ZANG Outfall	39.776013, –105.145537	M-Outfall	2014

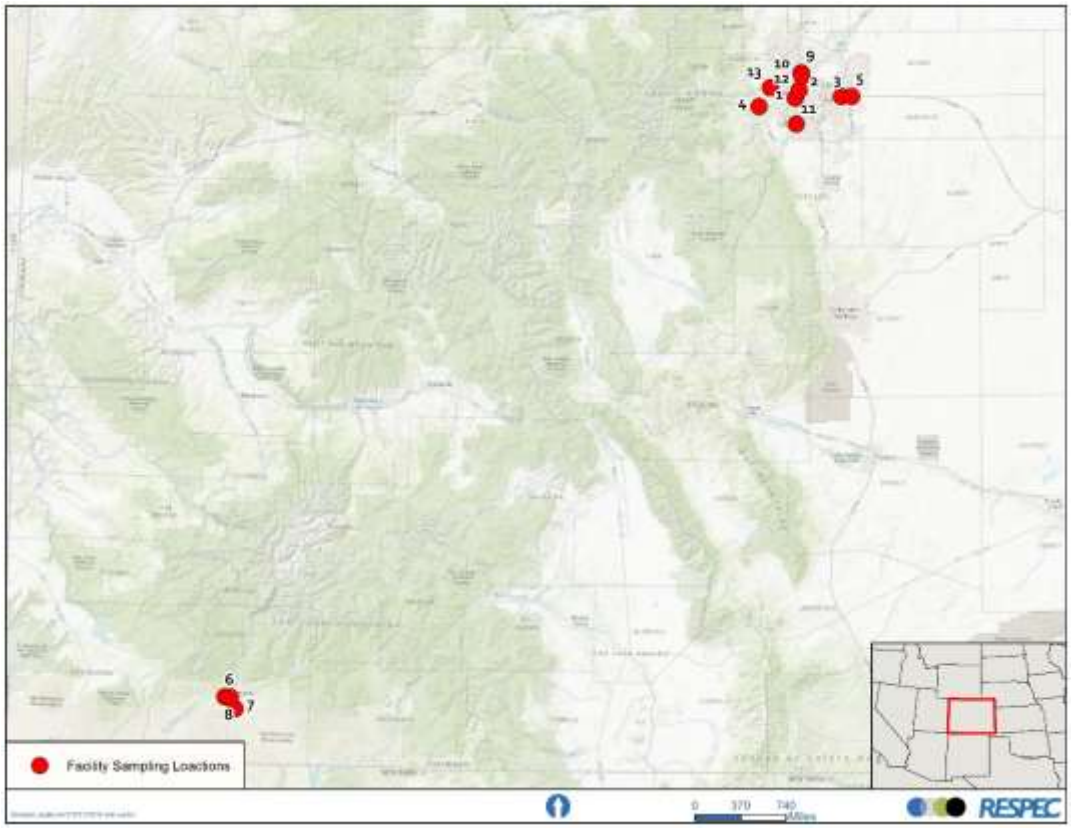

Figure 4-2. Previously Sampled Facilities With Permanent Watery Quality Control Measures.

Table 4-2. Previously Sampled Highways

Map ID	Site Name	Location (Latitude, Longitude)[a]	Outfall Type	Dates Monitored
1	Cherry Creek PWQ Structure	39.656, –104.837	PWQ-Outfall	2011
2	RTD I-225 Ballast	39.635332, –104.90084	PWQ-Outfall	2011, 2012
3	N-I-225&RTD Grassy Swale Drop Inlet	39.64, –104.877	PWQ-Outfall	2011
4	N-I-225&RTD Before Silt Berm #4	39.64, –104.877	Hwy-Outfall	2011
5	Hwy 58 & I-70 SW-PWQS Outfall	39.77487, –105.14694	PWQ-Outfall	2012
6	Hwy 58 & I-70 SW-PWQS Inlet 1A	39.774875, –105.14763	Hwy-Outfall-Inlet	2012
7	Hwy 58 & I-70 SW-PWQS Ditch	39.774875, –105.14763	Hwy-Outfall	2012
8	Detention Pond Inlet (ditch): ID# CO-058A-RS00010-EN002	39.775717, –105.145318	Hwy-Outfall	2014
9	Zang Facility Inlet to pond: ID# CO-058A-RS00010-EN002	39.776013, –105.145537	M-Outfall	2014
10	Detention Pond Wetland system main inlet: ID# CO-025A-RS00251-EN004	39.684167, –104.956389	Hwy-Outfall	2014, 2015
11	Detention Pond Wetland System Outfall: ID# CO-025A-RS00251-EN004	39.683333, –104.958889	PWQ-Outfall	2014, 2015
12	Detention Pond Wetland system Outfall: ID# CO-025A-RS00251-EN003	39.683889, –104.961389	PWQ-Outfall	2015

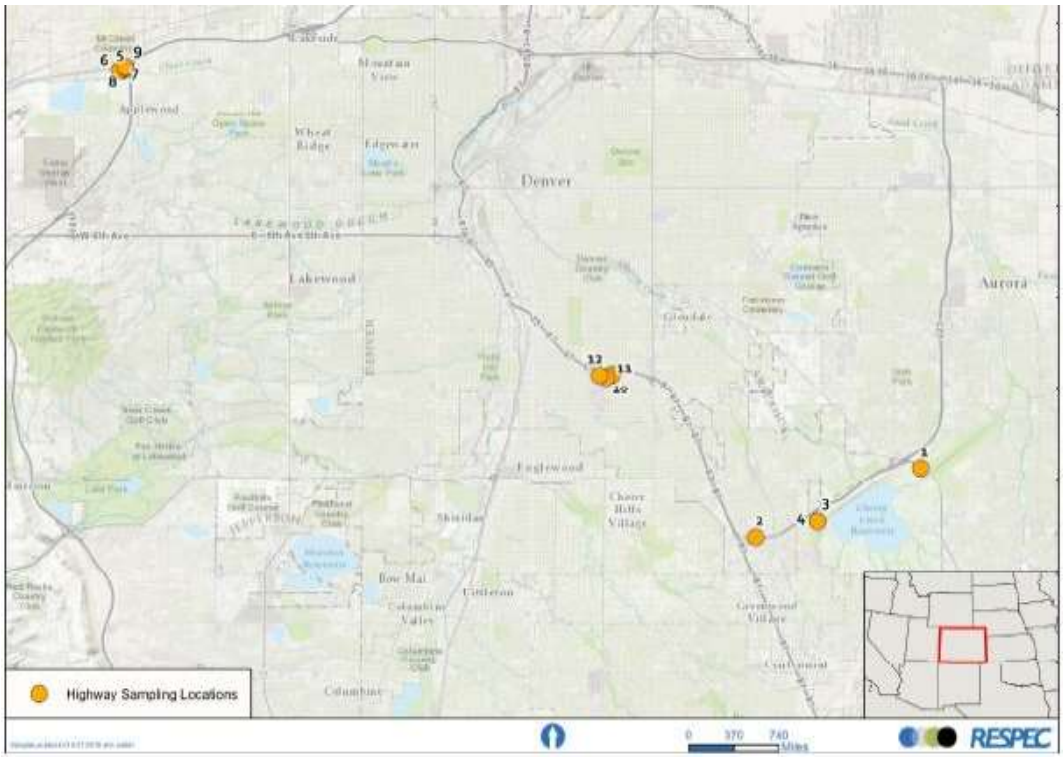

Figure 4-3. Previously Sampled Highways With Permanent Water Quality Control Measures.

5.0 DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

Any monitoring program can be expected to have some level of error associated with both sample collection and sample analysis. Performance criteria, also called data quality objectives (DQOs), are developed to specify acceptable levels of error. DQOs for measurement data or data quality indicators are precision, accuracy, representativeness, completeness, comparability, and measurement range.

5.1 DATA PRECISION, ACCURACY, AND MEASUREMENT RANGE

5.1.1 Precision

Precision is the degree of agreement among repeated measurements of the same characteristic, or parameter and is a measure of reproducibility of test results. Precision is estimated by means of duplicate/replicate samples and analyses and is best expressed in terms of the standard deviation or the relative percent difference (RPD) between field duplicate measurements. The following equation is provided from the US Environmental Protection Agency (EPA) [1996]:

$$RPD = [(x1 - x2) / \{(x1 + x2)/2\}] \times 100$$

RPD = relative percent difference (%)
x1 and x2 = duplicate measurements of the same parameter

The smaller the RPD, the more precise the measurements. The usability of duplicate measurements is assessed during data validation. The Colorado Department of Public Health and Environment (CDPHE) recommends that if the RPD is greater than 30 percent, data from that site will be either discarded or interpreted with caution. If the RPD from the measurement of the same parameter from duplicate samples is greater than 30 percent, the data will be flagged and brought to the attention of the WWM Manager.

5.1.2 Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value.
This measurement is derived during laboratory analysis by comparing a measured value to an accepted reference value in a sample of known concentration or by determining the recovery of a known concentration spiked into a sample [EPA, 1996]. Each project needs to define accuracy or percent recovery (%R) according to the laboratory that will be used for the project's data analyzes.

$$\%R = \{100 (xs - xu) / K$$

%R = percent recovery or accuracy
xs = measured value for spiked sample
xu = measured value for unspiked sample
K = known value of the spike in the sample

The EPA-certified laboratory decides which constituents are appropriate for spiking and for other measurements and also defines the %R required for proper QA/QC to meet method requirements.

Acceptable %R is evidence of accuracy in laboratory data measurements. CDOT's DQOs for precision and accuracy are addressed in EPA-approved analytical methods and the contracted laboratory's quality assurance plan. Figure 5-1 shows an example of low, average, and high %R for Method 200.7 (used for analyzing metals).

TABLE 6: PRECISION AND RECOVERY DATA IN AQUEOUS MATRICES (Cont'd)

INDUSTRIAL EFFLUENT

Analyte	Sample Conc. mg/L	Low Spike mg/L	Average Recovery R (%)	S (R)	RPD	High Spike mg/L	Average Recovery R (%)	S (R)	RPD
Ag	<0.0003	0.05	88	0.0	0.0	0.2	84	0.9	3.0
Al	0.054	0.05	88	11.7	12.2	0.2	90	3.9	8.1
As	<0.02	0.05	82	2.8	9.8	0.2	88	0.5	1.7
B	0.17	0.1	162	17.6	13.9	0.4	92	4.7	9.3
Ba	0.083	0.05	86	8.2	1.6	0.2	85	2.3	2.4
Be	<0.0006	0.01	94	0.4	1.1	0.1	82	1.4	4.9
Ca	500	5.0	*	*	2.8	20.0	*	*	2.3
Cd	0.008	0.01	85	4.7	6.1	0.1	82	1.4	4.4
Co	<0.004	0.02	93	1.8	5.4	0.2	83	0.4	1.2
Cr	0.165	0.01	*	*	4.5	0.1	106	6.6	5.6
Cu	0.095	0.02	93	23.3	0.9	0.2	95	2.7	2.8
Fe	0.315	0.1	88	16.4	1.0	0.4	99	6.5	8.0
Hg	<0.01	0.05	87	0.7	2.3	0.2	86	0.4	1.2
K	2.87	5.0	101	3.4	2.4	20.0	100	0.8	0.4
Li	0.069	0.02	103	24.7	5.6	0.2	104	2.5	2.2
Mg	6.84	5.0	87	3.1	0.0	20.0	87	0.9	1.2
Mn	0.141	0.01	*	*	1.2	0.1	89	6.6	4.8
Mo	1.27	0.02	*	*	0.0	0.2	100	15.0	2.7
Na	1500	5.0	*	*	2.7	20.0	*	*	2.0
Ni	0.014	0.02	98	4.4	3.0	0.2	87	0.5	1.1
P	0.326	0.1	105	16.0	4.7	0.4	97	3.9	1.4
Pb	0.251	0.05	80	19.9	1.4	0.2	88	5.0	0.9
Sb	2.81	0.05	*	*	0.4	0.2	*	*	2.0
Se	0.021	0.1	106	2.6	3.2	0.4	105	1.9	4.6
SiO_2	6.83	5.0	99	6.8	1.7	20.0	100	2.2	3.0
Sn	<0.01	0.05	87	0.7	2.3	0.2	86	0.4	1.2
Sr	6.54	0.1	*	*	2.0	0.4	*	*	2.7
Tl	<0.03	0.1	87	1.8	5.8	0.4	84	1.1	3.6
V	<0.005	0.05	90	1.4	4.4	0.2	84	1.1	3.6
Zn	0.024	0.05	89	6.0	4.4	0.2	91	3.5	8.9

S (R) Standard deviation of percent recovery.
RPD Relative percent difference between duplicate spike determinations.
< Sample concentration below established method detection limit.
* Spike concentration <10% of sample background concentration.

Figure 5-1. Example of Low, Average, and High Percent Recovery From US Environmental Protection Agency Method 200.7.

5.1.3 Measurement Range

Measurement range is the range of reliable readings of an instrument or measuring device, as specified by the manufacturer. Each standard analytical method has a specified measurement range that corresponds to the laboratory equipment used to take the measurement. EPA-approved analytical methods used by CDOT's contracted laboratory are provided in supplementary folders.

In cases where measurements are detected above the range specified in the EPA-approved analytical method, the sample is diluted and then reanalyzed. If not enough of the sample remains to be diluted and reanalyzed, the sample will be recorded as ">X," where X is the upper limit of the measurement range. When laboratory measurements are below the Method Detection Limits (MDLs), they are reported as "non-detect." If the laboratory reports results that are below the Practical Quantification Limits (PQLs, also known as reporting limits), the sample is noted as "below PQL" when it is entered into the Ambient Water Quality Monitoring System (AWQMS) database.

5.2 DATA REPRESENTATIVENESS

Representativeness is the extent to which measurements actually represent the true environmental condition and expresses the degree for which data accurately and precisely represent the true condition of the investigation. Evaluating representativeness is a qualitative procedure that addresses the overall design of a sampling program. Representativeness is improved by selecting and using appropriate numbers of samples, sampling stations, and techniques that have been proven to obtain samples reflective of the actual quality of the water being sampled.

Data representativeness is addressed in this sampling design. Automated samplers are installed at the inlet and outfall of each permanent control structure; proper functioning of the inlets and outfalls is assured by adhering to cleaning and maintenance procedures that are defined by the SOPs. CDOT Stormwater Permit No. COS000005 requires that concentration and loads be determined for three representative storms at each location, which will be achieved best by collecting flow-weighted composite samples to analyze for the Event Mean Concentration (EMC). Periodic field blanks will be collected at each location to control for background concentrations and/or equipment contamination.

5.3 DATA COMPARABILITY

Comparability is the degree of confidence that datasets are comparable with each other. The QA/QC standards that are necessary to ensure data comparability are critical because water quality investigations can involve different contractors and personnel and may also include new and currently evolving analytical techniques. This confidence is ensured by (1) using SOPs, (2) only using EPA-accepted or comparable methods of all analyses, and (3) reporting data using a standardized format. Strict adherence to the SOPs and periodic training of sampling personnel will be employed by CDOT to achieve comparability.

5.4 DATA COMPLETENESS

Completeness is the percentage of all of the collected data that are acceptable. For example, data may become unusable because of laboratory error, holding time violations, or errors in field collection procedures. To be considered complete, the dataset must contain all of the water quality parameters required by CDOT Stormwater Permit No. COS000005 and pass all of the QC check analyses performed by both the laboratory and the WWM Manager to verify precision, accuracy, comparability, and representativeness for the analytical protocol.

6.0 TRAINING REQUIREMENTS

All field personnel, CDOT professionals, contractors, students, and volunteers must be familiar with the requirements of the WWM PDD, SAPP, SOPs, and equipment user's manuals before they are deployed into the field. All sampling team members should receive training from the WWM Manager, including a classroom session, field training session, on-the job training, and an annual refresher. Because stormwater sampling events are difficult to predict and monitoring often run for at least 1 year, one or more trained members of the sampling team should be involved to ensure that monitoring is performed consistently.

6.1 DOCUMENT REVIEW

Document review should occur shortly before the monitoring phase begins in which the participants will review the following documents: WWM PDD, this SAPP, SOPs, and equipment user's manuals. This review can either be done in a classroom setting or individually under the guidance of the WWM program manager or a sampling team leader.

6.2 FIELD TRAINING SESSION

When the document review is complete, all participants should participate in a field simulation under the supervision of the WWM program manager or a sampling team leader. During the field training, sampling team members travel to their assigned monitoring locations and run through the procedures specified in the Sampling Methods section of the SAPP (Chapter 9 of this document) and associated SOPs, including: Equipment Lists, Cleaning, Configuration and Calibrations (SOP Chapter 3); Sampling Procedures for Surface-Water Point Source Collection (SOP Chapter 4); Operational Guidelines For Conducting Field Monitoring Activities (SOP Chapter 5); and Standard Procedures For Field Safety (SOP Chapter 9). The trainer should emphasize health and safety considerations during the field sampling simulation.

6.3 ON-THE-JOB TRAINING

In addition to document review and field training, inexperienced monitoring personnel must complete their first actual sampling event under supervision of an experienced team member before being allowed to conduct monitoring without supervision. Upon completion of on-the-job training, every field technician should be able to explain the methods and procedures associated with all aspects of sampling and monitoring.

6.4 ANNUAL REFRESHER

A refresher training session will be held annually, before the onset of each subsequent monitoring season. During this session, team members should review the responsibilities of individual team members, QA/QC protocol, and data submission procedures. The WWM Manager or sampling team leader shall provide more detailed instructions during the annual refresher for any new team members, including the document review and field training sessions. The names of all employees who have completed training shall be recorded and retained by the WWM Manager.

7.0 DOCUMENTATION AND RECORDS

Several forms and templates must be completed by CDOT field professionals, contractors, or students/ volunteers who are involved in sample collection, sample processing, data input, sample analysis, and reporting. Once completed, the forms and templates are stored by the year they were completed. The form name along with specific information, format, individual(s) responsible for populating, and individual(s) responsible for QA/QC are displayed in Table 7-1.

Table 7-1. Data Record Maintenance Table

Template	Project Phase	Format	Individual Responsible for Populating	Individual Responsible for QA/QC
Training Checklist	Project Initiation	PDF	Field Staff, Subcontractor, and Student/Volunteer	WWM Manager
Chain of Custody (COC)	Sample Collection	PDF	Field Staff, Subcontractor, and Student/Volunteer	WWM Manager
Field Log Book	Sample Collection	MS Word, MS, Excel, and PDF	Field Staff, Subcontractor, and Student/Volunteer	WWM Manager
Flow and Precipitation Records	Sample Collection	MS Word, MS, Excel, and PDF	Field Staff, Subcontractor, and Student/Volunteer	WWM Manager
Equipment Calibration/ Maintenance Records	Sample Collection	MS Word, MS, Excel, and PDF	Field Staff, Subcontractor, and Student/Volunteer	WWM Manager
Laboratory Results	Sample Processing	MS Word, MS, Excel, and PDF	Field Staff, Subcontractor, and Student/Volunteer	WWM Manager
Summarized Laboratory Results	Sample Analysis	MS Word, MS, Excel, and PDF	WWM Manager	Water Quality Manager
Final Report	Final Deliverable	MS Word	WWM Manager	Water Quality Manager

Part I.F.6 of the CDOT Stormwater Permit No. COS000005 establishes that the following records are required to be maintained for each sample collected:

- Date, type, exact location, and time of sampling or measurements
- Type of location being monitored (PWQ CM or roadway)
- Location information (i.e., CM outfall or CM inlet)
- Individual(s) who performed the sampling or measurements
- Date(s) that the analyses were performed
- Individual(s) or entity who performed the analyses

- Analytical techniques or methods used
- Results of such analyses.

Additionally, the WWM program maintains all of the COC forms for water quality samples, pH strip/meter recordings or digitally logged flow data, and equipment calibration/maintenance records within the database. Part I.K.2 of the CDOT Stormwater Permit No. COS000005 states that these data and any reports generated from the event must be retained "for a period of at least 3 years from the date that the specific item is no longer being actively used for stormwater management." This period of retention also needs to be extended in the case of any unresolved litigation that pertains to the discharge of pollutants by CDOT or when directly requested by the CDPHE or EPA. To ensure that this requirement is met, all of the data generated are uploaded into AWQMS. The monitoring results and other contents within the database must be discussed at least annually with CDOT's Water Quality representatives to potentially improve water quality management practices.

8.0 SAMPLING PROCESS DESIGN

8.1 RATIONALE FOR SAMPLE SITE SELECTION

The CDOT Sampling Program is focused on assessing the performance of PWQ CMs that reduce pollutant mass loads from wet weather impacts off highways. Two types of locations may be sampled to determine CM efficiencies. Specific sampling locations will depend on individual site variabilities; however, all possible inlets and the CM outfall will need to be identified. Sampling inlets will be necessary in order to assess the CM performance, even though only the outfall is required under CDOT Stormwater Permit No. COS000005.

For a simplistic efficiency calculation, an ideal PWQ CM will have one inlet and one outfall to monitor. However, PWQ CMs are typically more complex. A single site location may have multiple inlets from maintenance facilities and from highway runoff. Sites with multiple inlets may complicate computations for efficiency; however, they do offer the advantage of providing a combination of site characteristics of discharge. Data from one site may apply to other required characteristics under the WWM program.

EPA regulations require MS4 discharges to monitor EMCs and mass pollutant loads for each of their sampled storm events. According to the National Research Council [2009], "An EMC is intended to represent the average concentration for a single monitored event, usually based on flow-weighted composite sampling. It can also be calculated from discrete samples taken during an event if flow data are also available."

Because of the flashy nature of stormwater that originates from predominantly impervious areas, the sites must be located where it is feasible to record flow measurements using an automated device and/or structure. Equipment inventory will play a role in the site selection process, and equipment should be paired with the most applicable location. For example, area/velocity (AV) sensors work well in pipes or culverts, where the channel geometry is fixed and easy to calculate flow with measured velocity; flumes should be paired with a stage recording device in small- to medium-sized channels where water can smoothly enter and exit the flume.

Selected sites must produce sufficient runoff and measurable discharge in order to fulfill the analytical sample volume for the required list of pollutants. A hydrologic study of potential sites will help determine priority locations for sampling, including the likely measurable discharge for various storm intensities and durations.

For more detailed specifics of the site selection process for monitoring CDOT's permanent water quality CMs, reference the Site Selection SOP (SOP Chapter 1.0).

8.2 SAMPLE DESIGN LOGISTICS

A measurable event is defined as either (1) a rainfall event that results in measurable discharge from the roadway or PWQ CM and follows the preceding event by a minimum of 72 hours or (2) a snow event where measurable discharge occurs from the roadway or PWQ CM and results from melting snow. Site

locations will need to be sampled three to five times annually, with at least one rainfall and one snowmelt event. Priority locations will include sites that will produce enough runoff during a measurable event to fill all of the required analytical sample bottles (9 liters) multiple times a year.

If not already available, the drainage area and percent of impervious area to each potential site location must be determined. Impervious areas are made up of roadways; roofs; pavement; and other man-made, non-permeable surfaces that allow water to run off quickly. The percent of impervious area will dictate how quickly a storm event will create measurable discharge into a proposed site locations and if collecting enough water for a composite sample is feasible to fill the required sample bottles.

All of the samples are recommended to be taken as flow-weighted, composite samples. However, given the flashy nature of impervious surfaces, flow-weighted composite sampling is not always feasible and a composite of the first flush is a possibility. In this scenario, only the first portion of the storm is composited. Regardless of sample method, automated samplers are necessary to trigger sampling when measurable discharge is detected.

To trigger sampling events, samplers will need to be paired with an appropriate automated flow-measuring device or structure. The primary measurement devices to measure flow are AV sensors and flumes. AV sensors are recommended to be placed in a pipe or culvert. With a fixed geometry, instrumentation can be mounted to the bottom of the structure to measure water depth and velocity. Stormwater samples will be collected by a sampler suction line placed inside the pipe or culvert near the sensor, within the main part of the flow stream.

Flumes in conjunction with an automated depth sensor can provide highly accurate flow volume measurements. Flumes should be installed in small- to medium-sized channels, often set in concrete or bolted to other structures. Water is forced through a narrow channel of the flume but requires smooth flow with minimal turbulence. Frequent maintenance is necessary to keep the entrance and exit of the flume clear for accurate flow calculations. The most common type of flume is the Parshall flume, which uses equations for calculating flow based on fixed, specific geometric shapes of the flume. Flume geometry may vary in the width of the throat, and the equations for flow calculations depend on the depth of water in the converging section of the flume. Cutthroat flumes are another geometric flume structure. These structures differ from Parshall flumes in that there is no parallel throat section of the flume. Cutthroat flumes can be collapsible and, therefore, do not have to be permanently installed for field applications.

Sites will be prioritized by assessing the extent to which they are conducive to placing AV sensors or flumes and whether these structures and instrumentation will be able to detect enough discharge to fill sample bottles. The Site Selection Requirements SOP (SOP Chapter 1.0) provides detailed instructions on how to prioritize and select site locations.

9.0 SAMPLING METHODS REQUIREMENTS

9.1 SAMPLING NEEDS

The CDOT stormwater permit requires analysis of roadway and PWQ CMs (1) pollutants of concern, (2) conductivity, and (3) hardness. The WWM Manager will also need to identify if any additional parameters have been determined to have a reasonable impact to beneficial uses of receiving waters. A full list of pollutants of concern for roadways and PWQ CMs with additional sampled parameters are provide in Table 9-1 and further discussed in the data requirements, Field Measurements, and Water Chemistry Samples SOP.

Table 9-1. Pollutants of Concern Required by Municipal Separate Storm Sewer System Permit and Supplemental Parameters Sampled

Parameter	Required by MS4 Permit	Supplemental Parameters
Ammonia Nitrogen		X
Arsenic/Arsenic Dissolved		X
Cadmium/Cadmium Dissolved	X	
Calcium Dissolved		X
Chloride	X	
Chromium/Chromium Dissolved	X	
Conductivity/Specific Conductance	X	
Copper/Copper Dissolved	X	
Hardness	X	
Iron/Iron Dissolved	X	
Lead Dissolved	X	
Magnesium/Magnesium Dissolved	X	
Manganese/Manganese Dissolved	X	
Nickel/Nickel Dissolved	X	
Nitrate-Nitrite		X
Oil and Grease (hexane)	X	
pH		X
Phosphorus	X	
Selenium/Selenium Dissolved	X	
Sodium	X	
Total Inorganic Nitrogen	X	
Total Kjeldahl Nitrogen (TKN)		X
Total Suspended Solids	X	
Zinc/Zinc Dissolved	X	

Samplers will also need to monitor flow to determine the EMC of each pollutant of concern and pollutant loads from each event and rainfall data to determine the storm characteristics that generated the corresponding runoff event.

A flow-weighted composite sampling method is necessary for determining the EMC and pollutant mass loads. This sample method allows one to represent each portion of the hydrograph proportionally to flow volume. The resulting concentrations of pollutants provide an average concentration of the event and a more representative value of the storm's water quality. Using the entire measurable volume during the event, one can calculate the event mass load of each pollutant. The pollutant mass loads will be used to evaluate the efficiency of each monitored PWQ CM. A discussion on how to collect and composite samples is discussed in the **Sampling Procedures for Surface-Water Point Source Collection SOP**.

Using automated sampling equipment to measure and collect samples will improve the efficiency of monitoring each event. A list of equipment that are necessary to conduct sampling is listed in the **Equipment Lists, Cleaning, Configuration, and Calibrations SOP (SOP Chapter 3.0)**.

9.2 LOGGING EQUIPMENT NEEDS

Automated equipment for stormwater sampling will undergo annual maintenance and calibration procedures and may require frequent upgrades and/or part replacements. The Equipment Lists, Cleaning, Configuration, and Calibrations SOP also discusses specific maintenance and calibration requirements to maintain accuracy for each monitored event. Documentation of equipment calibrations, cleaning, and/or other needs are necessary for data validation. These processes should also be referenced when installing new sites or during equipment replacement. Monitoring setup procedures can be easily replicated by applying documentation of past equipment configurations and calibrations.

10.0 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

10.1 HANDLING PROCEDURES

The CDOT WWM program does not operate an analytical laboratory and must contract an EPA-certified laboratory to perform sample analyses. CDOT should contact the laboratory well before an expected sample event. The laboratory will provide the necessary sampling equipment, including ready-to-use sample bottles, preservatives, labels, and COC forms.

CDOT also collaborates with the laboratory to make sure that they can meet the needs and provide information on sampling procedures, shipping requirements, analyses, and reporting. This collaboration allows the laboratories to be well aware of the pollutants of concern and any holding time requirements. Samples must be collected and delivered to the lab before exceeding the holding time; otherwise samples will be deemed invalid. Data results should be reported in CDOT's database format, as discussed in the AWQMS SOP. In addition, required reporting to EPA's Network Discharge Monitoring Report (NetDMR).

If samples are not hand-delivered to the laboratory, they should be placed in a shipping container, or cooler, with the COC, sampling records, and any analysis request forms. Any glass bottles should be securely wrapped with bubble wrap or foam to prevent bottles from breaking during shipment. Samples should be shipped on ice or with ice packs if required in the cooler to maintain the sample temperature at 39 degrees Fahrenheit (°F) (4 degrees Celsius [°C]).

10.2 LABELING INSTRUCTIONS

After completing the composite sampling methods, bottles will be filled and labeled appropriately. Labeling provided from the laboratory will include the following information:

- Project name
- Sample ID
- Site name and ID
- Date and time of collection
- Analysis/preservative/container.

Proper labeling will ensure that analyses are performed on the appropriate bottle and will prevent sample analysis delay or lost items. Details on how to label sample bottles are discussed in the **Field Documentation and Supporting Documents SOP**.

10.3 CHAIN OF CUSTODY

The EPA-certified laboratory will provide CDOT with a COC form, which will be delivered to the laboratory with the labeled sample bottles. The COC is a written record of any changes in possession that occur for a set of samples. Every lab has a unique COC form, but the following information is always required:

- Sampler's name and signature
- Name and signature of all personnel who handled the samples

- Project name
- Project description
- Site name and site ID (site location)
- Sample ID
- Date and time that the samples were collected
- Sample type (i.e., composite or grab sample)
- Sample volume, container type, and preservation
- Number of containers
- Sample analyses
- Laboratory delivery date
- Sample temperature and condition.

This document is essential for sample integrity in case any issues result from QC checks. COC forms are typically printed on 3- or 4-ply carbon-copy paper, so all personnel who handle the sample set receive a copy. Each person who takes custody of the samples must fill out the appropriate information on the COC. When transferring possession of samples, the transferee will sign, date, and include the time they released possession of the samples. The **Field Documentation and Supporting Documents SOP (SOP Chapter 6.0)** also provides an example COC and areas that must be filled in before shipping samples to the laboratory.

11.0 ANALYTICAL METHODS REQUIREMENTS

11.1 ANALYTICAL METHODS

CDOT Stormwater Permit No. COS000005 requires all of the samples to be analyzed with methods according to 40 CFR Part 136 requirements. To ensure that analytical methods are in accordance to the permit and EPA regulations, samples are shipped to an EPA-certified laboratory. The laboratory will provide the permittee with a list of the analytical methods that were used and sample volumes required to fulfill the EPA requirements. Table 11-1 displays the standard analytical methods, along with the MDLs and report units, sample container size and preservation requirements, and sample holding times for the pollutant of concern for CDOT's roadways and PWQ CMs. Supplemental documentation of the analytical methods that were used can be found in the **Data Requirements SOP**.

11.2 LABORATORY TEST

CDOT Stormwater Permit No. COS000005 requires that the PQL and analytical method chosen to be as described below:

- Measured at or below the lowest surface/groundwater quality standard listed (in the permit) where that standard is greater than or equal to the PQL
- Measured at or below the PQL listed below where the lowest surface/groundwater quality standard is less than the PQL
- If neither an applicable receiving water standard nor PQL listed in the table (in the permit) exists for a parameter sampled at a specific outfall, the permittee is not subject to permit requirements associated with the PQL for the method selected.

Table 11-1 also includes the PQL for parameters that are currently sampled by CDOT from ESC Laboratories and is further discussed in the Data Requirements SOP.

Table 11-1. Water Chemistry Parameters; Analytical Method Information; and Container, Preservative, and Hold Time Requirements (Page 1 of 2)

Water Chemistry Parameter	Analytical Method	MDL	PQL	Unit	Container	Preservative	Hold Time
Total Recoverable Metals					**500 ml HDPE**	**HNO_3**	**6 months**
Arsenic	EPA 200.7	6.5	10	µg/l			
Cadmium	EPA 200.7	0.7	2.0	µg/l			
Chromium	EPA 200.7	1.4	10	µg/l			
Copper	EPA 200.7	5.3	10	µg/l			
Iron	EPA 200.7	14.1	100	µg/l			
Lead	EPA 200.7	1.9	5	µg/l			
Magnesium	EPA 200.7	11.1	1,000	µg/l			
Manganese	EPA 200.7	1.2	10	µg/l			
Nickel	EPA 200.7	4.9	10	µg/l			
Selenium	EPA 200.7	7.4	10	µg/l			
Zinc	EPA 200.7	5.9	50	µg/l			
Dissolved Metals					**500 ml HDPE**	**N/A**	**6 months**
Arsenic	EPA 200.7	6.5	10	µg/l			
Cadmium	EPA 200.7	0.70	2.0	µg/l			
Calcium	EPA 200.7	46.3	1,000	µg/l			
Chromium	EPA 200.7	1.4	10	µg/l			
Copper	EPA 200.7	5.3	10	µg/l			
Iron	EPA 200.7			µg/l			
Lead	EPA 200.7	1.9	5	µg/l			
Magnesium	EPA 200.7	11.1	1,000	µg/l			
Manganese	EPA 200.7	1.2	10	µg/l			
Nickel	EPA 200.7	4.9	10	µg/l			
Selenium	EPA 200.7	7.4	10	µg/l			
Sodium	EPA 200.7	98.8	1,000	µg/l			
Zinc	EPA 200.7	5.9	50	µg/l			

Table 11-1. Water Chemistry Parameters; Analytical Method Information; and Container, Preservative, and Hold Time Requirements (Page 2 of 2)

Water Chemistry Parameter	Analytical Method	MDL	PQL	Unit	Container	Preservative	Hold Time
Total Phosphorus					**250 ml HDPE**	**$H2SO_4$**	**28 days**
Total Phosphorus	EPA 365.1/ SM4500PE	0.035	0.10	mg/l			
Ammonia, NO_2/NO_3, TKN					**500 ml HDPE**	**$H2SO_4$**	**28 days**
Ammonia Nitrogen	EPA 350.1	0.0317	0.10	mg/l			
Nitrite-Nitrate (NO_2/NO_3)	EPA 353.2	0.0197	0.10	mg/l			
Total Kjeldahl Nitrogen (TKN)	EPA 351.2/ SM4500NH3C	0.0350	0.25	mg/l			
Chloride, SPCON					**250 ml HDPE**	**N/A**	**48 hours**
Chloride - Dissolved	EPA 300.0 (Ion Chromatography)	0.051	1.0	mg/l			
Specific Conductance (SPCON)	EPA 120.1/ SM 2510 B	10	10	µmhos/cm			
Hardness	SM2340B	0.50	1.0				
TSS					**1000 ml HDPE**	**N/A**	**48 hours**
Total Suspended Solids	SM 2540 D	0.35	2.5	mg/l			
OGHEX					**1000 ml Glass**	**HCl**	**28 days**
Oil and Grease	EPA 1664 A	1.16	5.0	mg/l			
pH	Measure in field with pH strip/ approved meter	**N/A**	**N/A**		**N/A**	**N/A**	**N/A**

12.0 QUALITY CONTROL REQUIREMENT

12.1 FIELD QUALITY ASSURANCE

Field duplicate analyses on the same composite sample serve as QA/QC for the methods, equipment, and calibrations used. The EPA's Volunteer Monitor's Guide To Quality Assurance Project Plans states that the general rule for field quality control is that 10 percent of samples should be QC samples. The permit requires three events per year at each of the six outfalls monitored. If the minimum number of storm events were sampled each year, 10 percent of this would yield 1.8 or 2 duplicate samples collected each year. Duplicate samples are a set of similar samples collected from the same site, at approximately the same time and in the same manner, which entails duplicate samples be collected as a composite sample, which should be taken from the same sample composite bucket as the original sample.

Equipment blanks are collected to assess and validate the decontamination process. Collecting blanks involves pulling deionized water through the suction lines and into the automated sampler to mimic the compositing process, as well as running one purge and rinse cycle, Blanks are recommended to be collected twice a year: once at the beginning of the season and once midway through the sampling season. These samples should be analyzed as a regular sample with all of the appropriate QC performed. A blank should represent the same volume of stormwater that would be collected during a typical event. The **Data Requirements SOP** includes more information on field duplicates/replicates and field blanks.

12.2 LABORATORY QUALITY CONTROL

CDOT contracts an EPA-certified laboratory to perform all of the water chemistry measurements by using EPA-approved analytical methods. The certified laboratory is required to complete their own quality control checks and report on their precision and accuracy of analytical results based on EPA guidelines. Contact the laboratory for any questions or concerns regarding their methods or reporting of QC check on final results. The laboratory QA/QC methods are provided by the contracted laboratory, which document their procedures to address any QC errors that may arise.

12.3 DATA ANALYSIS QUALITY CONTROL

The permit requires CDOT to electronically report using EPA's Net-DMR service. This data reporting requires that CDOT complete a quality check of all the data collected before reporting. Quality checks will include an evaluation of the precision, accuracy, and data validation from laboratory reports and results from all of the quality controlled samples to determine if data should be rejected or accepted in part or as a whole. The final representable data will be checked by the WWM Manager and approved for electronically reporting.

13.0 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

13.1 DECONTAMINATION

Before the start of each season and following every event sampled, equipment and instrumentation will need to be decontaminated. Decontamination methods must follow procedures specified in 40 CFR Part 136. The cleaning process is imperative following every storm event and before the start of each season to ensure no threats of contamination to the containers during the sample compositing procedure.

The CDOT WWM program uses an Auto-Clave Glassware Washer to clean and decontaminate all of the sample bottles. The **Equipment Lists, Cleaning, Configuration, and Calibrations SOP** includes an overview on how to program and run the Auto-Clave Washer. Additionally, the *SteamScrubber & FlaskScrubber Glassware Washers User's Manual* [Labconco Corporation, 2011] also provides detailed instructions on how to operate and program the Glass Washer for different bottle sets, temperatures, and wash cycles.

The laboratory will provide clean sample bottles prepared for field sampling, following EPA guidance and as set forth in 40 CFR Part 136. Arrangements should be made before a sampling event, as discussed earlier, so that the laboratory can provide CDOT field personnel with prepared and cleaned sample containers, ready for collection.

13.2 MAINTENANCE

General maintenance will be necessary for all automated equipment and instrumentation to validate the parameter values that are recorded. Lack of equipment maintenance will decrease the accuracy and precision of measurements collected. All cable connections should be checked routinely to verify no signs of damage or interference that may cause inaccurate readings. The Equipment Lists, Cleaning, Configuration and Calibrations SOP lists the instrumentation and equipment used for CDOT's Permanent CM Sampling and methods or instructions for maintaining accuracy of all equipment.

13.3 RECORDS

Documentation of equipment cleaning, decontamination, and maintenance is required by the CDOT monitoring staff. Procedures and methods used to decontaminate and maintain equipment must be documented and kept on file. Field personnel will document the date and time of maintenance performed and include their signature in field log book or in additional equipment maintenance spreadsheets. These records are essential to trace if the integrity of samples results is ever disputed.

14.0 INSTRUMENT CALIBRATION AND FREQUENCY

14.1 CALIBRATION METHODS AND FREQUENCY

All field instrumentation must be calibrated seasonally and checked on a weekly schedule, or at minimum, before a storm event. Sensors will need to be calibrated at the beginning of each season following the manufacturer's directions. Submerged AV sensors and pressure transducers must be checked and calibrated, if necessary, before each event to verify that depth readings are consistent with independent measurements (i.e., staff gauge). Storm event composite sampling will depend on accurate flow measurements.

Automated samplers will also need to be calibrated annually to verify that the sampler is pumping the correct volume as set by the program. Calibration procedures will need to follow manufacturer's directions. The Equipment Lists, Cleaning, Configuration, and Calibrations SOP provides step-by-step instructions on the manufacturer's recommended calibration procedures.

14.2 MAINTAINING CALIBRATION RECORDS

Calibration documentation must be logged in the field logbook or in a separate calibration spreadsheet. The records must include the following:

- Time and date of calibration
- Value recording pre- and post-calibration
- Calibration standard value
- The name and signature of field personnel completing the calibration.

Documentation of equipment and instrumentation calibration provide validity of the recorded measurements. An example calibration worksheet for AV sensors and automated samplers are included in the CDOT WWM SOP 2017 RSI-2772.

15.0 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES

Annual equipment inventory will be performed at the beginning of each monitoring season. Sample bottles will be checked for cracks or other damage that might contaminate sample results. All other equipment that is required for automated stormwater monitoring will be inspected annually. If any damage on equipment is detected that might disrupt the sampling procedure or impact measurements collected, the equipment will not be used for the monitoring season until parts are fixed or replaced. The WWM Manager will be in charge of ordering new equipment if damage cannot be repaired.

16.0 DATA ACQUISITION REQUIREMENTS

16.1 SUPPLEMENTAL DATA

Beyond monitoring data requirements, additional information about the site location and monitoring history will be beneficial for field personnel to perform QC checks on data results. This information includes but is not limited to watershed hydrologic studies, topographic maps, aerial imagery, traffic information, climatological data, and historical monitoring data.

Before selecting sample site locations, a hydrologic study must be completed of the proposed watershed. If already delineated, the drainage area must be validated with field visits and topographic analyses. Historic studies should be stored within CDOT's database and available for review. Any additional surveys that are necessary will be documented and kept on record. Studies should include the amount of impervious area and an estimate of hydrologic response time for multiple rainfall events. Topographic maps and aerial photographs of the site location should also be included, because they will be useful for monitoring personnel.

Traffic information will also be noted for each site location. Field personnel will be provided with the appropriate safety wear and equipment, such as reflective vests, as discussed in the **Standard Procedures for Field Safety SOP**.

Climatological studies will help monitoring staff identify seasonal trends for required storm events, including probable storm intensities, duration, and frequency throughout the year. Knowledge of a site's historical hydrologic response to a variety of storms will help staff identify ideal sampling events. Additionally, potential flooding, storm runoff volume, and duration data are useful for maintaining safety protocols. The **Sampling Procedures for Surface-Water Point Source Collection SOP (SOP Chapter 4.0)** identifies a variety of websites of weather-related references.

Sites that have been previously monitored are listed in Table 4-1 and 4-2. Referencing historical data of parameter value ranges and sampling dates could be useful for field personnel to use as a QC check of data collected. Historical data will help identify the likely range of measurements recorded and identify the constituents that frequently appear in runoff and those that are rarely or never detected from various site locations.

16.2 LIMITATIONS AND UNCERTAINTY

When accessing supplemental data, field personnel must be aware of the limitations and credibility of outside data sources. For example, processing meteorological data, such as event precipitation totals, should be quality controlled to verify that the totals are realistic and represent the sampled storm. The limitations of volunteer weather stations compared to government, automated sites must be kept in mind.

17.0 DATA MANAGEMENT

17.1 DOWNLOAD/UPLOAD PROCEDURE

Data collected from field equipment and composite sampling procedures must be documented, downloaded, and saved in the AWQMS database. The **Field Documentation and Supporting Documents SOP (SOP Chapter 6.0)** provides a step-by-step procedure for how to download field data from CDOT's samplers. Flow measurements, water level, rainfall totals, and sample information will be collected from the sampler for every event.

These records will be uploaded into AWQMS for future reference and available in case of possible disputes on methods and procedures. The AWQMS SOP includes detailed instructions for uploading data into the official database, which also includes a quality check process before uploading data to ensure practical results and to avoid errors during the upload process. CDOT now requires data to be uploaded through AWQMS for consistent data logging methods and for its accessibility to share data. Once loaded into AWQMS, data can be automatically pushed to other required database entities, such as eDMR and EPA's STORET, if applicable. As of 11/30/2017 this eDMR process is still pending.

17.2 CALCULATIONS

Raw data collected from each sampler will be used for completing the composite. Resulting EMCs will be applied to calculate an event mass load for each pollutant of concern. The WWM Manager will perform QC checks to verify that the data entered and calculations are complete and correct, including a data validity check in which "bad data" are removed and documented before load calculations are made. These calculations will determine the PWQ CM efficiency and will be included in the reporting process.

17.3 HARDWARE/SOFTWARE

Hardware that is required for data collection are specific to Sigma and ISCO samplers. Data downloads from Sigma samplers will require a Data Transfer Unit (DTU-II) and an RS232 connecter cable. Hach Flow provides a free download link for their communication software: InSight, which will be required for collecting and saving data from the DTU-II to a CDOT computer.

Direct downloads from an ISCO sampler will require a Rapid Transfer Device (RTD). The RTD will transfer all of the data from the ISCO into a program called Flowlink. Flowlink software can export data as a comma-delimited file (csv), which can be opened for data manipulation and calculations in Excel.

Manual documentation of sampler data is another available method in the case of hardware or software malfunction or missing equipment.

The **Field Documentation and Supporting SOP** discusses the specific hardware and software that are required to retrieve data from each device and how to load these data onto a CDOT computer.

18.0 ASSESSMENT AND RESPONSE ACTIONS

To ensure that the PWQ CM is meeting its objectives and that the SAPP is implemented as described, periodical assessments will be conducted, At a minimum, assessments will be conducted on an annual basis at the close of the monitoring season, but may be conducted more frequently if the need arises. Assessments will consist of audits of field, laboratory, and data management activities as well as audits of data quality.

The WWM Manager will conduct audits of field staff (technicians, students, volunteers, and contractors), lab, and data management activities including, but not limited to: annual refresher training sessions, field and instrumentation site inspections, and SOP review. If problems are identified through these assessments, corrective actions will be taken. Corrective actions may include but are not limited to increasing the number of regularly scheduled training sessions, calibrating equipment more frequently, or repairing worn or broken equipment, rescheduling field or lab activities, revising SOPs to meet changing monitoring needs. In addition, an assessment of any permit modification that may be needed if compliance with the current term or condition may not be practicable.

The Water Quality Manager will perform periodic audits of data quality by comparing the collected data with DQOs. If data quality concerns are detected through these audits, the Water Quality Manager will work with the WWM Manager to determine the appropriate corrective action. These actions can include but are not limited to increasing training, replacing equipment, revising monitoring site design, and selecting a different analytical laboratory.

19.0 REPORTS

Part I.I.1 of the CDOT Stormwater Permit No. COS000005 outlines the annual system-wide reporting requirements that need to be submitted annually by CDOT by April 1. The report covers activities from January 1 to December 31 of the previous year. The WWM program will be responsible for helping to develop several portions of the final report as outlined below:

- Part I.I.1.d provides a list of compliance schedule items that need to be completed, which include the completion date and any associated information required in Part I.H.
- Part I.H specifies that the WWM program is required to ensure that the permit requirements are being met and that implementation and documentation procedures are being revised as necessary.
- Part I.I.1.e provides the assessment results of the CM effectiveness.
- Part I.I.1.f specifies the results of the permit-modification assessment and whether or not any part of this permit needs to be modified or if a condition of the permit may not be practicable.

Specifically, reporting on Part I.I.1.e will require the WWM program to follow protocols and QA/QC procedures outlined in this SAPP to ensure compliance with the permit. All information necessary to complete this reporting requirement should be readily accessible from the database in a folder labeled for the respective year that the monitoring was completed.

If extenuating circumstances, such as budget, availability of trained staff, or weather anomalies, prevent the WWM program from completing its permit responsibilities, the reasons will be thoroughly documented in the final CDPHE Annual Report. Additionally, WWM program staff will coordinate directly with the CDPHE and identify any measures that could help alleviate future challenges. Each year, the WWM program's team members should review the requirements of the permit and provide recommendations on whether or not modifications should be considered, as specified in Part I.I.1.f of the reporting requirements. This review could include any suggested modifications to specified locations, frequency of monitoring, or pollutants being monitored.

In addition to the regulatory requirements, a WWM Annual Report will be developed by the WWM Manager and delivered to the Water Quality Manager. This annual report will summarize the findings and recommendations based on stormwater quality concentration, loadings, pollutant-removal percentages, concentration trends, and pollutant identifications based on SAPP sampling objectives, among other details. The report will evaluate and discuss whether or not permit conditions have been met and what (if any) corrective actions are necessary and will also be distributed to interested CDOT regions for reference and potential action.

20.0 DATA REVIEW, VALIDATION, AND VERIFICATION REQUIREMENTS

The WWM Manager will oversee all exercises completed by field personnel. As the direct supervisor to the staff that collect composite samples, the WWM Manager will need to verify that the samples were collected in accordance to 40 CFR 122.26 and properly shipped to the EPA-certified laboratory. Additionally, the WWM Manger will need to review all of the analytical results from the laboratory before data are entered into AWQMS and eDMR. An event summary will suffice to report the results, procedures, and methods that were used for every sampling event. The Water Quality Manager will review all of the data periodically and review the final report to verify data collected meet the permit's requirements.

21.0 VALIDATION AND VERIFICATION METHODS

DQOs, as discussed in Chapter 5.0 of this SAPP, include the criteria developed for validating data and verifying errors that were detected by using the data quality indicators, such as precision, accuracy, representativeness, completeness, and measurement range. These indicators are used as rationale for discarding data, error detection, and correction.

21.1 RATIONALE FOR DISCARDING DATA

Data precision and accuracy calculations are completed by the EPA-certified laboratory by using duplicates and blanks collected from the field and spikes performed by the laboratory. CDPHE recommends discarding or interpreting data with an relative percent difference (RPD) greater than 30 percent.

Acceptable field data must lie within the measurement range, which is the reliable reading of an instrument or measuring device. The EPA-approved analytical methods that are used also have a specified measurement range that corresponds to the laboratory equipment used. If measurements exceed the measurement range, the sample is diluted and reanalyzed. Results that are below the measurement range should be identified and reported as "below detection limit."

Data must be representative of the Permanent Control Measure Sampling Program, which uses the appropriate equipment and techniques proven to reflect the water quality and CM efficiency. This process requires EMCs and pollutant loads to be calculated from the inlet(s) and outfall of each site location. If an event is missing results from any PWQ CM source (inlet or outfall), data will not be considered representative to calculate efficiency and will not fulfill permit requirements. The following are examples of invalid data that will result in discarding data:

- Sample contamination
- Exceeding holding limits
- Laboratory errors.

21.2 DESCRIPTION OF ERROR DETECTION AND CORRECTION

To avoid incomplete datasets, data QC checks will be completed by field personnel and managers. Personnel will perform spot checks of data after performing analyses and looking for outliers, unit conversion errors, and calculations before data are transferred. These results will be compared to measurement ranges and historical data values for validation.

When errors or exceedances are detected, adjustments such as dilution methods will be performed and then reanalyzed. If errors or exceedances are still reported after adjustments, then no change in the database is required. If exceedances are eliminated after adjustment methods are used, data points may be interpreted with caution and resampling at the site is recommended.

22.0 RECONCILIATION WITH DATA QUALITY OBJECTIVES

22.1 PROCESS FOR DETERMINING WHETHER THE DATA MEET PROJECT OBJECTIVES

Determining the PWQ CM efficiency is the objective of Permanent Control Measure Sampling Program. All EMCs and pollutant loads must be validated and verified through the QA/QC process to be used for final efficiency calculations. The QA/QC process includes meeting all of the DQOs as described in Chapter 5.0. Additionally, objectives will be complete when the efficiency is determined for the required storm events per location as stated in CDOT Stormwater Permit No. COS000005.

Missing measurements for load calculations and/or failure to meet permit requirements will be considered an incomplete dataset.

22.2 DATA USAGE LIMITATIONS

Data that have met the PWQ CM objectives will be loaded into AWQMS and eDMR. PWQ CM efficiencies and pollutant concentrations are publicly available upon request. These data are intended to support CDOT's compliance with its MS4 Stormwater Permit No. COS00005.

23.0 REFERENCES

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