SAFE
CLEAN
WATER
PROGRAM

Safe, Clean Water Program

Post-Construction Monitoring Guidance

June 2026

Table of Contents

Introduction and Purpose

Multi-benefit stormwater best management practices (BMPs) constructed in Los Angeles (LA) County may be eligible to receive Safe, Clean Water Program (SCW Program) funding for the operations, maintenance, and monitoring of projects after construction. BMPs funded and constructed through the SCW Program's Regional Program are required to track post-construction BMP performance, specifically performance related to the Program Goals which the BMP was designed to address. Additionally, Municipal Program projects could also benefit from the concepts and suggestions in this guidance, since these suggestions can strengthen outcomes and support long-term performance for all projects. Post-construction monitoring and maintenance can help verify that BMPs continue to function as designed after construction is complete and for the useful life of the project. The feedback provided by specific, regular reporting and adaptive management can bolster the project's performance and commitment to community benefits, realigning project operations with intended benefits.

This guidance addresses post-construction monitoring and maintenance related to Water Quality Benefits, Water Supply Benefits, and Operations and Maintenance (O&M). Sections within this guidance document include activities that can be incorporated into a post-construction monitoring and maintenance plan to demonstrate that projects are functioning as intended and contributing to SCW Program Goals and other efforts as discussed below. Additionally, this guidance offers long-term adaptive management strategies and examples of actions to take to address near-term triggers noticed during monitoring (e.g., observations of diminishing BMP performance, notices from the community, etc.).

To provide proper context, it is important to understand the key elements of BMP monitoring to determine which activities are appropriate for a given project. The following presents foundational questions and considerations related to post construction BMP monitoring, which steered the development of this guidance and will be expanded on in greater detail later:

- ***Who is BMP monitoring useful for?***
  BMP monitoring is useful for project developers, the community of local stormwater practitioners, and the SCW Program. Collecting BMP performance data helps identify whether a BMP is functioning as intended, including its ability to treat and remove polluted runoff before downstream discharge, and whether the infrastructure is collectively contributing to overall Program goals.
- ***What should BMP monitoring measure?***
  Monitoring that BMPs capture runoff and contribute to the treatment of pollutants (such as those identified in the SCW Program funding applications) is the clearest way to be sure that they are functioning as intended. Deciphering the magnitude of runoff capture and pollutant reductions can offer even greater insight into performance and progress, though the absence of continuous monitoring presents challenges that are discussed further within.

- ***Where should monitoring take place?***
  The locations selected for BMP monitoring can greatly influence what the collected information can provide. Monitoring only the runoff and pollutants that are captured by the BMP (and not what may bypass) may help verify that the BMP is functioning but may not offer watershed area context needed to understand performance related to watershed-scale measures. Additionally, water passing through the BMP and returning to runoff flows is likely cleaner, but pollutant reduction is rarely complete, and discharges will have some loading associated with them. These nuances will differ from BMP to BMP depending on the specific types and configuration, but where monitoring occurs and what that information can indicate are important considerations for trying to get the most out of these data collection activities.
- ***When do BMPs need to be monitored?***
  Continuous BMP monitoring would offer the greatest amount of information, and while this is generally feasible for flow-based measures, it is challenging for water quality considerations. When, how, and how long monitoring occurs are all very important to consider as a BMP's performance is assessed through the course of its useful lifetime. This guidance offers options for when monitoring may occur; it is important to consider these options to prepare for mobilization efforts and how collected data may be used.
- ***Why is monitoring needed?***
  Monitoring to demonstrate that BMPs are functioning as intended is a requirement for projects funded by the SCW Program. Beyond that, monitoring is extremely important to make sure that BMPs are maintained in working order and that quick action can be taken if they become non-operational due to the variety of challenges that may be faced in urban watershed area settings.
- ***How do we monitor BMPs?***
  The mechanics of monitoring, physically collecting the data in situ once BMPs are constructed, is beyond the scope of this guidance. There are a range of national, local, and academic resources on these topics, ranging from best practices in the field to strict laboratory protocols to ensure collected samples are handled and tested correctly. This guidance points to some of the key local resources that can be used as a jumping off point as needed to guide the field collection efforts associated with these monitoring recommendations.

Monitoring provides insight at the BMP scale that can help make sure it contributes to watershed area improvements that align with the Program Goals, where progress is now being tracked through the Watershed Planning Initiative (WP).

Watershed Planning Initiative

The WP was initiated in 2023 to comprehensively and strategically enhance and track progress towards the SCW Program's 14 Goals. It uses data, collaboration, and community input to inform SCW Program decisions, reduce redundancies, and enhance accountability across the region. The WP produced nine Initial Watershed Plans (Plans) to accomplish this in each of the

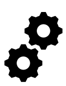
Watershed Areas (WAs); the Plans provide detailed information on Program-wide and WA-specific targets, needs, strategies, and opportunities within the scope of the SCW Program.

To track progress toward SCW Program Goals, the Plans use two distinct types of metrics, referred to as Performance Measures (PMs) and Indicators. PMs track progress at the project scale, whereas Indicators sum and track project benefits across large spatial scales, such as the SCW Program region or per WA. Each Indicator correlates to a specific target and aligns with one of the 14 SCW Program Goals.

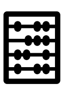
Explanation of Category and Tier Usage

There are a range of activities that could be included in a post-construction monitoring and maintenance program for any given BMP, and these may vary in cost, resource and personnel availability, level of effort, and level of complexity. The extent of information, feedback, and insight into project performance provided by various monitoring activity options differ accordingly. This guidance addresses this breadth of options by organizing post-construction monitoring and maintenance activities into ***Value Categories*** and ***Effort Tiers***. The intent is to provide a range of potential options for project developers and operators to choose from that will meet the specific needs and priorities of their project and its goals and provide the degree of information about the project and its performance that is warranted.

Value Categories group activities by the type of information they provide and thus contribute distinct benefits associated with incorporating the activity into a post-construction monitoring and maintenance program. As such, activities across different Value Categories are not meant to be compared. The three Value Categories used within this guidance are distinguished by which of the following questions they answer. The symbols included for each Value Category are used as identifiers throughout this guidance.



Value Category A: Is the BMP installed and operational?



Value Category B: How well is the BMP performing?

Value Category C: How is the BMP contributing to WA goals?

Value Category B activities may align closely with tracking progress toward project goals (i.e., PMs) while Value Category C activities may align closely with tracking progress toward WA goals.

Effort Tiers represent the relative levels of effort and/or cost associated with implementing an activity. Since projects vary in size and complexity, estimating absolute cost ranges is difficult. As project experience grows and cost estimates are refined for post-construction monitoring and maintenance activities, cost estimates can be used for planning future activities. For this guidance, the Effort Tiers provide a proxy for cost that is generally assumed to increase as monitoring activities increase in complexity. The Effort Tiers used in this guidance are as follows:

- **Effort Tier 1** includes activities that require *fewer* resources and/or *lower* financial commitment
- **Effort Tier 2** includes activities that require *intermediate* resources and/or financial commitment
- **Effort Tier 3** includes activities that require *more* resources and/or *higher* financial commitment

Value Categories and Effort Tiers offer flexible guidance and are not prescriptive or definitive categories. The distinctions between activities in different Value Categories and Effort Tiers are meant only to emphasize the difference in activities and outcomes achieved from implementing a post-construction monitoring and maintenance program with different levels of cost and effort. Agencies can incorporate activities from different Value Categories and Effort Tiers into a post-construction monitoring and maintenance program, customized to data needs, budgetary restrictions, personnel availability, etc. The corresponding findings from each activity can provide more information on BMP effectiveness, refine O&M scheduling, produce long-term cost savings, and help to adaptively manage the post-construction monitoring and maintenance program.

Examples of Value Category and Effort Tiers in Practice

Below are a few examples of how Value Categories and Effort Tiers may be used to select activities for a project. These three examples present projects with different resources and goals to demonstrate the flexibility of Value Category and Effort Tier application. These examples are not meant to be prescriptive of specific activities a project must select, and projects may choose to select activities within any Value Category or Effort Tier regardless of guidance.

Example Project 1: The project has limited budget for post-construction monitoring and maintenance but wants to develop a monitoring plan that is able to adequately assess if the BMP is consistently achieving the planned pollutant removal.

The goal of assessing the magnitude of the BMP's pollutant removal means this project may focus on selecting activities designated as Value Category B. Limited budget means that the project will likely prefer activities that fall into Effort Tiers 1 or 2. As contribution to overall WA goals was not mentioned as a goal for this BMP's monitoring plan, the information provided by activities in Value Category C may not be necessary.

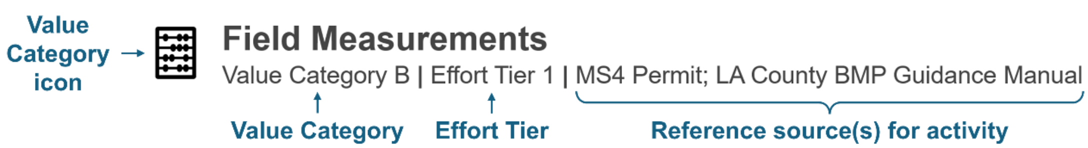
Example Project 2: The project has installed a BMP type that the project managers are familiar with and have installed before in the WA. This familiarity provides reasonable confidence that the BMP will be operating as intended, and since this type of BMP has been repeatedly installed in the area, the project operators intend to develop a monitoring plan that can provide insight into how this BMP type contributes to overall WA goals. This project does not have significant budget limitations.

The goal of assessing how the BMP contributes to meeting overall WA goals indicates that this project may benefit from focusing on including activities designated as Value Category C in the monitoring plan. Activities designated as Value Categories A and B may also be considered if the information they provide is needed to meet minimum reporting requirements. As the project does not have budget concerns, activities from all Effort Tiers may be considered.

Example Project 3: The project has installed a BMP type that is new to the project managers. They want the monitoring plan to collect as much information as possible about the BMP so that it can be determined if the BMP type works well for the area. The budget for this project is very limited.

As the budget for this project is very limited, activities that fall into Effort Tier 1 are most likely to be achievable. The goal of collecting as much information as possible indicates that activities from all Value Categories may be considered. If budget ultimately limits how many activities can be added to the monitoring plan, it may be useful to prioritize activities in Value Categories A and B to determine BMP performance before assessing how it contributes to greater WA goals.

Throughout this guidance, information on Value Categories, Effort Tiers, and references for each activity will be presented as follows:



Information on each activity will be included following their introduction.

Additionally, reference sources are cited throughout this guidance (see Reference Section at the end of this guidance). These sources provide more detail on the activities they reference in their corresponding sections. These sources can be used to assist decision-making for the activities to include in a post-construction monitoring and maintenance program.

Water Quality Benefits

Improving water quality is a primary goal of the SCW Program, which is largely accomplished through BMP implementation. Cleaner water safeguards the environment, fosters safer communities, supports regulatory compliance, and reduces pollution clean-up and human health costs. Tracking water quality changes before and after BMP treatment can help diagnose flawed or degrading systems and promote implementation of BMPs that reliably improve water quality. Creating a post-construction monitoring and maintenance program that monitors water quality is essential for meeting this Program Goal.

Water quality measurements (such as turbidity or concentrations of pollutants of interest) and stormwater flow data can be combined with water quality analysis methods (such as summation of loads, for example) to estimate BMP load reductions on a storm-by-storm or annual basis.

For more information on the PM pollutants specific to a BMP's WA refer to the corresponding Plans and Watershed Planning Tool, available at the SCW Program Watershed Planning webpage.

Refer to the corresponding Plans and Watershed Planning Tool to learn more about the "Improve Water Quality" Planning Theme, and the corresponding Indicators and PMs being tracked through the WP, which may include:

- Zinc load reduction (pounds/year)
- Total phosphorous load reduction (pounds/year)
- Bacteria load reduction (billion/year; may be assessed in future adaptive efforts)
- Trash load reduction (%; may be assessed in future adaptive efforts)
- Total dichloro-diphenyl-trichloroethane (DDT) load reduction (pounds/year; may be assessed in future adaptive efforts)
- Total polychlorinated biphenyls (PCBs) load reduction (pounds/year; may be assessed in future adaptive efforts)

Water Quality Sampling Frequency

The following is a list of water quality sampling frequencies that are described per the corresponding references:

- **SCW Program Transfer Agreement, Exhibit F (Operations and Maintenance Guidance Document)**: "Quarterly, unless justified otherwise"
  - This is a minimum requirement for projects funded through the SCW Program, for at least three years after the project begins operation. Sample collection may emphasize wet-season sample collection (i.e., three annual wet-season samples and one annual dry-season sample).
- **Los Angeles County Public Works' Best Management Practice Monitoring Guidance Manual (LA County BMP Guidance Manual; attached)**: "BMP performance monitoring frequency is based on BMP design and program requirements. If BMPs are

designed to treat wet/dry weather runoff, monitoring should occur during wet/dry weather conditions… A common number of events for dry weather monitoring is four events per year, with events occurring quarterly. The number of wet weather monitoring events… typically occurs during three to five events per year covering a wide range of storm sizes."

Where this guidance aims to provide options for activities to include within a post-construction monitoring and maintenance program for stormwater BMPs, LA County BMP Guidance Manual includes more detail on such activities (including sampling methods, equipment options, sampling locations, etc.). This resource is referenced throughout this guidance and is also included as an attachment.

- **LA County National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit (MS4 Permit)**, for receiving waters and outfalls: "…a minimum of three times per water year during wet weather for all parameters" and "…a minimum of two times per water year during dry weather for all parameters."
    - BMP sampling is not required to meet compliance with the MS4 Permit. However, the sampling frequencies required for receiving waters and outfalls per the MS4 Permit can serve as a reference for BMP sampling frequencies. Aligning sampling frequencies and dates of BMPs with MS4 Permit-compliant sampling can help assess how concentrations and loads at receiving waters and outfalls compare to BMPs for a given storm event. Comparing BMPs and data collected for MS4 Permit compliance may provide justification for adaptive management of the implementation program, and how BMP performance and pollutant reduction is contributing to the goals of the WA. Coordinating sampling events can also reduce costs via efficient mobilization.
- **Coordinated Integrated Monitoring Plan (CIMP)**: A CIMP is a regional framework developed to coordinate stormwater monitoring activities across multiple permittees under the MS4 Permit. Refer to the watershed area's corresponding CIMP for sampling frequencies per wet- and dry-weather conditions, constituent, etc.
    - As with MS4 Permit compliance, aligning sampling frequencies and dates of BMPs with CIMP sampling can help assess how concentrations and loads at receiving waters and outfalls compare to BMPs for a given storm event. Coordinating sampling events can also reduce costs via efficient mobilization.

Aside from the minimum requirement per the SCW Program Transfer Agreement, the frequencies referenced above are not meant to be prescriptive for a post-construction monitoring and maintenance program. Considerations for selecting the water sampling frequency for a post-construction monitoring and maintenance program include:

- Sampling more frequently to diagnose diminishing BMP performance

- Sampling during wet and dry season, based on BMP design and program requirements (i.e., emphasizing dry-season sampling for dry-weather projects and targeted storm event sampling for wet-weather projects)
- Sampling more frequently during the wet season for wet-weather projects (to obtain a more representative sample of BMP performance throughout the wet season)
- Sampling the “first flush” storm event for wet-weather projects (where “first flush” may be considered the first storm event of the wet season)
- Sampling multiple storm sizes and intensities for wet-weather projects, which would result in data that is more representative of dynamic storm events over the year
- Sampling during storm events/conditions when the BMP has shown to have decreased performance in the past
- Continuing sampling beyond the SCW Program-required three-year minimum period (per the SCW Program Transfer Agreement)
- Collecting individual samples throughout storm events (not just at storm peak, for example) to generate pollutographs (graphs of pollutant concentrations during a storm event)
- Sampling during as many storms as possible, to track concentrations and corresponding BMP performance by season/year

Increased water quality sampling incurs higher costs for equipment (purchase, repair, and calibration), personnel (labor hours), laboratory sample analysis, etc. However, an increase in water sampling frequency may also provide benefits:

- Improved understanding of BMP performance under varying conditions
- Early identification of maintenance needs based on declining pollutant removal
- Ability to correlate storm intensity with BMP effectiveness and corresponding operations and maintenance (O&M) needs
- Enhanced support for adaptive management strategies
- Improved understanding and accuracy of estimating progress toward project and WA goals

Especially after the first three years of sampling, frequencies can be adjusted if supported by data trends, predictable and consistent BMP performance, recommendations from experienced workers, and/or regulatory approval. Over time, improved data resolution and trend recognition may incite adaptive management of monitoring frequencies, leading to more efficient sampling events, better-informed O&M decisions, and long-term project cost savings.

Water Quality Sampling Mobilization

Carefully planning for water quality sampling based on forecasts can help to prevent lost time and costs associated with false starts. Refer to the corresponding CIMP for the project’s watershed area to review conditions that determine wet-weather sampling mobilization. In the absence of mobilization criteria, the following criteria (consistent with qualified storm event requirements per Section V.A.2.a.i. of Attachment E of the MS4 Permit) may be used to determine whether to mobilize for an impending storm event and wet-weather sampling (though alternative criteria specific to each watershed area may also be used):

- Storm forecasts must meet criteria at least 24 hours prior to the onset of rainfall
- A storm must be forecast to produce at least 0.25 inches of rainfall
- The probability of precipitation must be at least 70 percent
- A storm event must be preceded by at least 72 hours of dry conditions (less than 0.1 inch of precipitation in a 24-hour period)

Water Quality Sampling Locations

Water quality sampling of BMPs involves collecting and analyzing stormwater samples to measure pollutant concentrations, providing crucial information for evaluating how effectively a BMP reduces pollutants of concern on a concentration basis. Collecting samples from at least the BMP influent and effluent may help to characterize overall BMP performance of pollutant reduction. The influent and effluent sampling locations may look different for different BMP types but may be located downstream of the diversion point to the BMP (for the influent sample) and downstream of BMP treatment processes (for the effluent sample). Note that infiltration BMPs may not have the option to collect effluent samples.

Collecting water quality samples from additional locations throughout the BMP (e.g., downstream of pre-treatment devices, within storage galleries) can help to diagnose performance of individual components and can help isolate the location of diminishing BMP performance, and where corresponding O&M activities may be needed. Collecting water quality samples from conveyance points (e.g., downstream of treatment/upstream of return) may help to assess water quality goals for such conveyances.

Over time, water quality data may inform the need to update sample locations (i.e., adding sample locations if data gaps are recognized, updating sample locations if data indicates that trends become predictable, etc.). Such adaptive management strategies may lead to more efficient data collection, better-informed O&M decisions, and long-term project cost savings.

Refer to the LA County BMP Guidance Manual for more information on sampling locations by BMP.

Water Quality Sampling Methods

Water quality samples may be collected in a variety of ways:

- Grab sample
- Automated sampler (time- and flow-weighted composite sampling, pollutograph sampling)
- In situ parameter measurement

Refer to Section II.G. of Attachment E of the MS4 Permit, the corresponding CIMP, and/or the LA County BMP Guidance Manual for more information on sampling options and methods, including sampling methods specific to the watershed area and constituent(s) being sampled.

Water Quality Sampling Pollutants

The selection of water quality sampling pollutants is central to evaluating BMP performance and watershed area health, as it defines the parameters used to detect pollutant loading, treatment effectiveness, and potential O&M needs. In addition to watershed area-specific goals, pollutants may also align with those required for regulatory compliance to help verify that monitoring results are meaningful and actionable. The constituent list below is outlined by Value Category and Effort Tier and is derived from multiple references indicative of the range of possible pollutants.

Over time, water quality data may inform the need to update which pollutants are sampled (e.g., adding pollutants if data gaps are recognized, deprioritizing pollutants if data indicates that trends become predictable after the first three years of sampling, etc.). Such adaptive management strategies may lead to more efficient data collection, better-informed O&M decisions, and long-term project cost savings.

Flow

Value Category A **|** Effort Tier 1 **|** MS4 Permit; LA County BMP Guidance Manual

Flow measurements are critical for verifying that the BMP is functioning, and is therefore included in Value Category A. As flow meters are simple and inexpensive to install, the activity is included in Effort Tier 1.

Flow measurements are important for converting measured water quality concentrations to estimated loads. Since flow and volume measurements are crucial for water supply, flow measurements are explained in more detail in the Water Supply Benefits section.

Field Measurements

Value Category B **|** Effort Tier 1 **|** MS4 Permit; LA County BMP Guidance Manual

Field measurements are often collected as part of a water sampling program to quantify physical and chemical conditions of a water sample. Field measurements are collected with a handheld meter and may be taken instantaneously or continuously. Standard field measurements include:

- Dissolved oxygen (DO)
- pH
- Temperature
- Specific conductivity
- Total suspended solids (TSS)
- Total hardness

Measurements of these parameters may augment water quality analysis and understanding of changes in water quality conditions over time (and are thus categorized within Value Category B). Because these parameters may be collected with a handheld meter, the relative cost of collecting these parameters is low (Effort Tier 1).

Refer to the LA County BMP Guidance Manual for more information on sampling field measurements.

Turbidity

Value Category A | Effort Tier 1 | LA County BMP Guidance Manual

Turbidity measurements are included in Value Category A since turbidity can serve as a high-level gauge of BMP operation and performance. Monitoring turbidity over time can help inform whether BMP performance is diminishing; this can help inform O&M frequency requirements. Turbidity measurements are included in Effort Tier 1 due to the relatively low cost of purchasing, installing, and maintaining turbidity meters.

Turbidity meters are a practical option for addressing water quality performance in BMPs. Stormwater turbidity can be used as a proxy for suspended sediment and other pollutant concentrations, and properly collected turbidity data that has been calibrated with more rigorous water quality observations (including pollutants tracked through WP PMs) and/or modeling analysis can offer real-time insight into BMP performance and pollutant removal efficiency. If turbidity is deemed to be a reliable proxy for stormwater quality for a given BMP (if supported by, for example, multiple years of data and data-driven analysis, recommendations from developers, etc.), turbidity monitoring can be a cost-effective alternative which offers more continuous data, compared to more rigorous and expensive water quality monitoring and sample analysis, which provides discrete water quality data. Connecting a turbidity sensor to a data logger (which may log data in 15-minute intervals) can help with remote measurement, reducing costs associated with personnel and sample collection mobilization.

Turbidity meters installed at the influent and effluent points can help assess if the BMP is reducing turbidity and improving water quality. However, turbidity meters may also be installed at multiple locations throughout the BMP (e.g., influent and downstream of treatment components), which may help determine whether the BMP is operating to qualitatively improve water quality at each treatment component; this can help diagnose performance of certain components and trigger corresponding O&M for those components. Additional turbidity meters needed to collect this data would require greater budget during installation and upkeep.

While turbidity meters are more cost-effective than water quality sampling, they may be susceptible to fouling, degrading quickly, or requiring frequent re-calibration.

Primary/Secondary Pollutants

Value Category B | Effort Tier 2 | SCW Program Application

Through the SCW Program application module, a project applicant selects the primary and secondary water quality pollutants that their project is intended to treat and reduce once constructed. These pollutants often align with the limiting pollutants identified in the corresponding Watershed Management Program (WMP). Examples of primary and secondary pollutants that can be selected in the application module include:

- Metals (e.g., total copper, total lead, total zinc)

- Nutrients (e.g., total phosphorous, total nitrogen)
- Bacteria
- Trash
- Toxics
- Chloride

Projects in the post-construction phases must demonstrate progress in reducing the primary/secondary pollutants selected in the project applications. Once projects complete their first operational year and a total of three years after operation begins, project developers seeking future SCW Program funding for O&M may be required to demonstrate a reduction in the pollutants identified in the project application or provide justification for why the project is underperforming, along with a corrective action plan to ensure the project is operating as designed. Tracking a project's pollutant reduction performance is a measure of how well a project is performing (and therefore assigned Value Category B). Sampling of the primary and secondary pollutants requires mobilization, personnel, laboratory analysis, and more planning and financial effort than field measurement sampling; these pollutants are included in Effort Tier 2.

Performance Measure Pollutants

Value Category B **|** Effort Tier 2 **|** IWPs

PM pollutants (which may align with the above primary and secondary pollutants, the corresponding WMP, Indicator pollutants, etc.) that are being tracked through the WP measure performance at the project-scale and are assigned to Value Category B. Sampling of the PM pollutants requires mobilization, personnel, laboratory analysis, and more planning and financial effort than field measurement sampling; these pollutants are included in Effort Tier 2.

For more information on the PM pollutants specific to a BMP's WA refer to the corresponding Plans and Watershed Planning Tool, available at the SCW Program Watershed Planning webpage.

Indicator Pollutants

Value Category C **|** Effort Tier 2 **|** IWPs

Indicator pollutants (which may align with the above primary and secondary pollutants, the corresponding WMP, PM pollutants, etc.) that are being tracked through the WP measure performance at the SCW Program- and WA-scale and are assigned to Value Category C. Sampling of the Indicator pollutants requires mobilization, personnel, laboratory analysis, and more planning and financial effort than field measurement sampling; these pollutants are included in Effort Tier 2.

For more information on the Indicator pollutants specific to a BMP's WA, refer to the corresponding Plans and Watershed Planning Tool, available at the SCW Program Watershed Planning webpage. Note that there may be overlap between PM and Indicator pollutants, so coordinating sampling events may help to reduce redundancies.

WMP Category 1 Pollutants

Value Category C | Effort Tier 2 | MS4 Permit (TMDLs)

WMP Category 1 pollutants are those associated with TMDLS (i.e., pollutants identified in a WMP for which water quality-based effluent and/or receiving water limitations are established, per the MS4 Permit). These pollutants are often prioritized for assessing watershed area health and MS4 compliance; understanding how a BMP performs to reduce TMDL pollutants can help assess the BMP's utility as a project within its watershed area. As such, these pollutants are classified into Value Category C. Sampling these pollutants requires mobilization, personnel, laboratory analysis, and more planning and financial effort than field measurement sampling; these pollutants are included in Effort Tier 2.

Refer to the applicable WMP and/or CIMP for information on each BMP's WA, including associated Category 1 pollutants. Links to additional information on WMPs and CIMPs is included in the corresponding WA's Plan (see Table 1-1 and Appendix H).

WMP Category 2 Pollutants

Value Category C | Effort Tier 2 | MS4 Permit

WMP Category 2 pollutants are those identified in the corresponding WMP because data indicates water quality impairment per the 303(d) list (which lists impaired waterbodies as mandated by the Clean Water Act). Sampling for these pollutants (in coordination with MS4-compliant CIMP sampling) may help to identify patterns between waterbodies and BMP projects that may affect those waterbodies, thus informing BMP utility and contributions to watershed area health. Like Category 1 pollutants, Category 2 pollutants may help to assess watershed area health, and so are classified into Value Category C. Sampling these pollutants requires mobilization, personnel, laboratory analysis, and more planning and financial effort than field measurement sampling; these pollutants are included in Effort Tier 2.

Refer to the applicable WMP and/or CIMP for information on each BMP's WA, including associated Category 2 pollutants. Links to additional information on WMPs and CIMPs is included in Table 1-1 and Appendix H of the corresponding WA's Plan.

WMP Category 3 Pollutants

Value Category C | Effort Tier 2 | MS4 Permit

WMP Category 3 pollutants are those identified in the corresponding WMP for which there is insufficient data to indicate water quality impairment, but which exceed applicable limitations per the MS4 Permit. Sampling for these pollutants (in coordination with MS4-compliant CIMP sampling) may help to identify patterns between waterbodies and BMP projects that may affect those waterbodies, thus informing BMP utility and contributions to watershed area health. Like Category 1 and 2 pollutants, Category 3 pollutants may help to assess watershed area health, and so are classified into Value Category C. Sampling these pollutants requires mobilization, personnel, laboratory analysis, and more planning and financial effort than field measurement sampling; these pollutants are included in Effort Tier 2.Refer to the applicable WMP and/or CIMP for information on each BMP's WA, including associated Category 3 pollutants. Links to additional information on WMPs and CIMPs is included in Table 1-1 and Appendix H of the corresponding WA's Plan.

Other Pollutants

Value Category B **|** Effort Tier 3 **|** LA County BMP Guidance Manual

Miscellaneous pollutants may include those listed in the LA County BMP Guidance Manual that are not included in the WMP or the Plans (as PMs and/or Indicators). Collecting and analyzing certain pollutants may help inform BMP performance over time (Value Category B). One example may be sampling for particle size distribution (PSD). PSD can be used to help diagnose BMP filtration performance and effectiveness at capturing/removing sediment of certain particle sizes. Corresponding adjustments can be implemented, such as more frequent cleaning of filters if certain storm forecasts/intensities are correlated with PSDs that inhibit filtration effectiveness.

Furthermore, collecting BMP water quality data for these additional pollutants may be useful for comparing results with other projects within the watershed area, helping to evaluate project performance at the watershed area scale (Value Category C). The added costs associated with sampling these pollutants may be prohibitive for certain programs and are therefore grouped into Effort Tier 3.

Water Quality Sampling Pollutants Summary

Value Category A (Is the BMP installed and operational?)

- Flow (Effort Tier 1)
- Turbidity (Effort Tier 1)

Value Category B (How well is the BMP performing?)

- Field Measurements (Effort Tier 1)
- Primary/Secondary Pollutants (Effort Tier 2)
- Performance Measure Pollutants (Effort Tier 2)
- Other Pollutants (Effort Tier 3)

Value Category C (How is the BMP contributing to WA goals?)

- Indicator Pollutants (Effort Tier 2)
- WMP Category 1-3 Pollutants (Effort Tier 2)

Water Quality Analysis

Measuring only water quality parameters is not enough to assess load reductions; additional calculations and analysis are required to track progress toward WA Goals, and to gauge how well the BMP is performing over time. The list of analysis methods below is outlined by Value Category and Effort Tier and is derived from multiple references indicative of the range of possible analyses. As there is minimal difference in the effort required to conduct these analyses, Effort Tier designation primarily considers the amount of monitoring information that is required to conduct the analysis.

Over time, water quality data analysis may inform the need to update the monitoring plan (e.g., increasing sampling frequency to obtain a more robust dataset, adding sampling pollutants to obtain a more holistic understanding of BMP performance, etc.) and/or O&M plan (e.g., performing retrofits or maintenance to improve BMP performance, increasing O&M frequency to maintain performance regularity, etc.). Such adaptive management strategies may lead to a more holistic understanding of the BMP's performance, better-informed O&M decisions, and long-term project cost savings.

Efficiency Ratio Analysis

Value Category A **|** Effort Tier 1 **|** SCCWRP

Efficiency ratio analysis is classified as Value Category A because it provides high-level results indicating whether the BMP is operating to reduce pollutants (that is, if the BMP's effluent has a lower concentration of pollutants than the influent). Results are provided in the form of a removal percentage, which indicates whether the BMP is removing pollutants, but does not provide any additional information on performance. This analysis is assigned Effort Tier 1, as the data required is limited.

To calculate results, efficiency ratio analysis compares the pollutant concentration in the influent to the concentration in the effluent. **Equation 1** shows how to calculate percent removal.

Equation 1: Percent Removal Calculation

$$\frac{Influent\ concentration - Effluent\ concentration}{Influent\ concentration} \times 100\% = Percent\ Removal$$

Positive percent removal indicates that the BMP is successfully removing pollutants; negative percent removal indicates that the BMP is introducing pollutants, rather than removing them. Negative percent removals are an indication that a BMP requires maintenance, operational updates, or redesign.

This method does not incorporate flow data, meaning that it is only able to determine whether pollutant concentrations were lowered, and not quantify the amount of pollutant removed. Since flow is not considered, these results can be misleading when analyzing how a BMP performs with different influent loads or in comparison to other BMPs.

While efficiency ratio analysis has limited applications for assessing progress toward annual load reductions, comparing percent removal results over time can indicate whether BMP performance is diminishing, and can aid in adaptive management decisions.

Statistical Evaluation of Pollutant Removal

Value Category A **|** Effort Tier 1 **|** LA County BMP Guidance Manual

Paired t-testing can be used to determine if there is a statistically significant difference in the pollutant concentrations of a BMP's influent and effluent. This evaluation will provide information determining whether the BMP is functioning to remove pollutants, but does not provide any additional information on performance, placing it in Value Category A. This analysis is assigned Effort Tier 1, as the data required is limited.

When conducting a t-test, the hypothesis is that the pollutant concentrations measured in the effluent are higher than or equal to the pollutant concentrations measured in the influent. The null hypothesis is that the pollutant concentrations measured in the effluent are lower than the pollutant concentrations measured in the influent. A statistically significant difference in pollutant concentrations allows for the assumption to be made that the BMP is functioning to remove pollutants.

Refer to the LA County BMP Guidance Manual for more information on the statistical evaluation of pollutant removal and how to apply it to BMP water quality data.

Summation of Loads Analysis

Value Category B **|** Effort Tier 1 **|** LA County BMP Guidance Manual

Summation of loads analysis is classified as Value Category B because this analysis quantifies a BMP's performance by estimating the pollutant load reduction. This analysis is assigned Effort Tier 1, as the sampling needs are limited to flow and pollutant concentration at influent and effluent locations. The summation of loads analysis method can be used to estimate pollutant load reduction for each storm event (**Equation 2**).

Equation 2: Pollutant Mass Load Reduction Calculation

$$[Influent\ concentration \times Influent\ flow\ rate] -$$

$$[Effluent\ concentration \times Effluent\ flow\ rate]$$

$$*\ Storm\ event\ duration =$$

$$Pollutant\ mass\ load\ reduction\ rate\ by\ storm\ event$$

If the values in **Equation 2** are assumed to be average concentrations and average flow rates throughout the storm event, this will calculate pollutant load reduction for the storm event.

Alternatively, summation of loads can also be used to calculate average annual pollutant loads, aligning with corresponding annual load reduction PMs. Per the LA County BMP Guidance Manual, wet-weather pollutant loads can be calculated with influent and effluent water quality concentrations and total runoff estimates for each storm event. Total annual wet weather pollutant road reduction can then be calculated as the sum of load reduction from storm events; for storm events where data is not collected, the median pollutant load may be used as an estimate. Dry weather loads can be calculated by multiplying median dry weather pollutant concentrations by average daily runoff volumes. These calculated pollutant load reductions for wet- and dry-weather can be summed up to determine the average annual pollutant load reduction for the year. Note, the level of effort associated with an average annual pollutant load reduction estimate is higher than for sampling individual storm events.

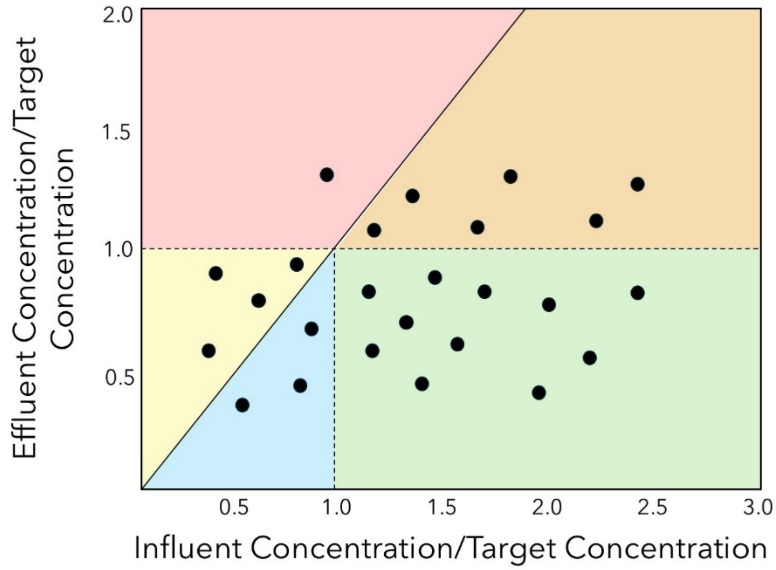
This analysis method is limited by the amount of data collected; limited, discrete sampling data may result in errors when extrapolating results to annual performance. Performing this analysis with continuous concentration (or turbidity by proxy) and continuous flow data would more easily allow for calculating annual mass load removals.

Performance Index Analysis

Value Category B **|** Effort Tier 2 **|** SCCWRP; LA County BMP Guidance Manual

To conduct Performance Index (PI) analysis, influent and effluent flow-weighted event mean concentration (EMCs) are calculated and plotted on a plot indicating five performance categories (success, excess, marginal, insufficient, and failure). PI scores provide a numerical interpretation of the data on the plot and can be correlated to suggested actions for maintaining proper BMP function (**Figure 1**).

By translating numerical scores into easily interpretable guidance, PI analysis decreases the subjectivity involved in determining whether a BMP is meeting water quality treatment goals. PI analysis can also be used to compare the effectiveness of different BMP types within a watershed area, as the numerical PI scores can be directly compared. Infrequent sampling must be considered as a limitation to this method, since fewer data points means that the accuracy of the resulting PI score and suggested action needs to be more critically considered.



		# of Occurrences	Proportion of Occurrences	Weighting	Weighted Total
Adequate	**Success**	11	0.44	0	0
	Excess	3	0.12	1	0.12
Inadequate	**Marginal**	4	0.16	3	0.48
	Insufficient	6	0.24	4	0.96
	Failure	1	0.04	10	0.4
				Weighted Average PI Value:	1.96

PI score of 1.96 indicates no action needed. A potential interpretation of this score is that the BMP is performing adequately often enough that it does not need immediate maintenance, but it performs inadequately often enough that it should be monitored for a declining trend.

***Figure 1**. Example of PI Analysis*

PI analysis is classified as Value Category B because it aims to assess the removal achieved by a BMP as progress toward the project's water quality benchmark. PI analysis is included in Effort Tier 2, as there is an increase in the necessary calculations. Sampling needs are limited to flow and pollutant concentrations at influent and effluent points.

The Southern California Coastal Water Research Project (SCCWRP) has publicly available web tools that use uploaded BMP monitoring data to graph and analyze BMP performance. One of these web tools plots and calculates PI values based on provided EMC data. This PI analysis web tool (including an explanation on its method, scoring, and instructions for use) is accessible here: https://sccwrp.shinyapps.io/bmp_wq_index_app/.

BMP Effectiveness Curves

Value Category B | Effort Tier 2 | LA County BMP Guidance Manual

Plotting log-transformed concentration data on a normal quantile distribution axis can help compare the pollutant concentrations of a BMP's influent and effluent (**Figure 2**). Higher separation distance between the influent and effluent curves indicates higher pollutant removal ability of the BMP. The examples shown in **Figure 2** are hypothetical and provided for the sake of understanding how this information would be presented. They do not depict all possible results.

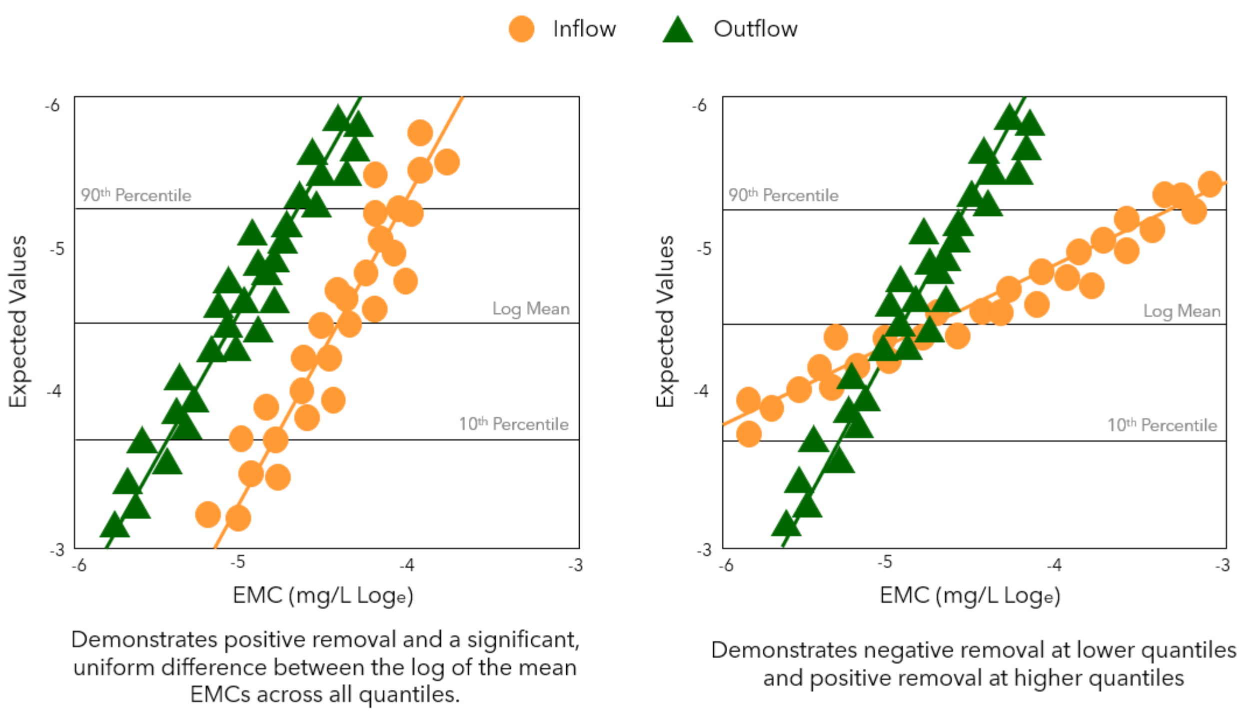


***Figure 2**. Examples of BMP Effectiveness Curve Plot and Interpretations*

As this information may help to provide results on how effectively the BMP functions to remove pollutants at different influent rates, it has been assigned Value Category B. The necessary data ranges in amount depending on how many pollutants are being plotted. For these reasons, this analysis method has been determined as Effort Tier 2.

Refer to the LA County BMP Guidance Manual for more information on BMP effectiveness curves and how to apply this method to BMP water quality data.

Multi-Pollutant Index Analysis

Value Category C | Effort Tier 3 | SCCWRP

Multi-Pollutant Index (MPI) analysis is classified as Value Category C because it aims to identify how a BMP functions within the water quality priorities of its WA. MPI analysis is included in Effort Tier 3 due to the increased analysis and sampling required; to conduct MPI analysis for multiple pollutants of concern within a watershed area, samples of each pollutant must be collected at influent and effluent points.

MPI analysis considers PI scores for multiple pollutants to give a numerical score that can represent how the BMP performs across the range of analyzed pollutants. During calculations, pollutants are weighted by order of concern within the watershed area, so that the MPI score calculated is accurate to the water quality priorities of the watershed areas. Like PI scores, MPI scores can be correlated to suggested actions for BMP maintenance. To use this method there must be data collected for multiple pollutants at the same sampling event.

Like with PI analysis, the results of MPI analysis translate data that may be difficult to understand into easily interpreted guidance. MPI analysis is useful for determining whether the type of BMP installed can meet the treatment needs of a specific watershed area. Repeated high MPI scores may indicate that even if a BMP is successful at removing select pollutants, it may be failing to treat those that are a priority within the given watershed area (indicating that the BMP may need operational changes, increased maintenance, a retrofit/redesign, or the installation of supplementary BMPs downstream to help meet the treatment needs). This knowledge is also helpful when looking to implement future BMP projects since it allows for the installation of BMP types that will maximize the benefits to the given watershed area.

Water Quality Analysis Summary

Value Category A (Is the BMP installed and operational?)

- Efficiency Ratio Analysis (Effort Tier 1)
- Statistical Evaluation of Pollutant Removal (Effort Tier 1)

Value Category B (How well is the BMP performing?)

- Summation of Loads Analysis (Effort Tier 1)
- Performance Index Analysis (Effort Tier 2)
- BMP Effectiveness Curves (Effort Tier 2)

Value Category C (How is the BMP contributing to WA goals?)

- Multi-Pollutant Index Analysis (Effort Tier 3)

Triggers and Actions

Table 1 highlights water quality improvement actions that can be taken if monitoring activities indicate that a BMP is not performing adequately. This list serves as guidance and is not exhaustive of all possible “triggers” related to water quality improvement. The “actions” can be modified based on BMP type and corresponding manufacturer recommendations, field experience, watershed area-specific regulations, community input, etc. While this list provides general recommendations, it is the responsibility of the Project Developer to ensure operation and performance of the BMP, which may address “triggers” and/or require “actions” not listed here. Documenting any actions and outcomes can help to inform future planning and adaptive management.

Table 1: Water Quality Benefits Adaptive Management Examples

Consideration	Triggers	Actions
Increased Turbidity/Fouling	• Elevated turbidity over time • Sensor fouling • Sediment buildup (especially after storm events)	• Increase frequency of sediment removal and/or turbidity sensor cleaning • Inspect post-storm to prevent long-term fouling
Sampling/Frequency Optimization	• High variability in water quality results between sampling events • Lack of trend clarity	• Increase sampling frequency during initial years or high-flow seasons • Reduce once performance trends stabilize (data-supported reduction)
Storm Event-Based Maintenance	• Evidence from autosampler or turbidity data showing pollutant spikes immediately following large storms	• Schedule targeted post-storm inspections and maintenance • Clean pretreatment units and sedimentation chambers promptly
Sampling Method Adjustments	• Sampling results inconsistent with expected pollutant loads • Time-weighted data not representative of actual flows	• Shift to flow-weighted composite sampling to better characterize pollutant mass loading and assess BMP efficiency
Particle Size Distribution Sampling	• Sedimentation cleaning shows evidence of fine particle bypass (potential source of sediment buildup)	• Use particle size distribution data to optimize pre-treatment screening design and determine appropriate screen replacement frequency

Consideration	Triggers	Actions
Decreasing Pollutant Load Removal	• Progressive decline in removal of pollutants over time	• Initiate maintenance activities • Establish scheduled performance-based maintenance
High Loads/Pollutant Exceedances	• Negative percent removals • Increased pollutant loads (from efficiency ratio or summation of loads analysis)	• Implement intermediate water quality sampling points to diagnose and isolate underperforming BMP components
High Loads/Pollutant of Concern Exceedances	• High MPI score (indicates potential failure to treat pollutants of concern effectively)	• Retrofit BMP • Redesign BMP (for implementation of future BMPs) • Supplement system with additional BMPs (watershed-scale adaptive management)
Flow Monitoring Integration	• Uncertain pollutant load removal efficiency due to missing or unreliable flow data	• Install and calibrate flow meters at influent/effluent points to enable accurate load-based performance analysis

Water Supply Benefits

As stormwater management control measures, BMPs are essential pieces of the constructed watershed area system that are relied on to capture, treat, infiltrate, store, reuse, and/or convey stormwater to other parts of the watershed area. Tracking water supply flow rates and volumes throughout a BMP is crucial for understanding water supply goals, as well as the BMP's operational efficiency. Therefore, a project's post-construction monitoring and maintenance program is benefitted by incorporating methods for tracking, reporting, and interpreting stormwater flows and volumes.

Water supply volumes can be estimated from continuous flow measurements using flow meters. Groundwater storage and recharge volumes can be estimated from continuous water level data (combined with BMP geometry, such as footprint area).

Similar to Water Quality Benefits, there are PMs specific to Water Supply Benefits that are being tracked at the project scale to ensure that projects are delivering on their intended water supply goals. Below are the PMs being monitored under the 'Increase Drought Preparedness' WP theme:

- Average annual stormwater captured (acre-feet/years (ac-ft/yr))
- Average annual stormwater captured and recharged (ac-ft/yr)

Additionally, a project's monitoring considerations depend on the stormwater's fate (where the managed water ends up) and the BMPs design. The following is a list of the fates that may contribute to achievement of a project's water supply goals:

- Infiltrated to managed useable aquifer
- Infiltrated over confined or unmanaged aquifer (with documentation to confirm infiltration and use)
- Stormwater capture treated discharged to a receiving water body or aquatic ecosystem
- Diverted to existing treatment and reuse plants
- Diverted to future planned treatment and reuse plants
- Used on-site for potable offset
- Other stormwater capture

For more information on the water supply PMs and Indicators specific to a BMP's WA and water fates, refer to the corresponding Plans and Watershed Planning Tool, available at the SCW Program Watershed Planning webpage.

Water Supply Measurements

Flow Meters

Value Category A | Effort Tier 1 | MS4 Permit; LA County BMP Guidance Manual; IWPs

Flow meters are cost-effective tools for helping to verify that water is flowing through the BMP, and for recording a BMP's flow and volumetric capture data. They have the capacity to record data continuously, providing estimates for volume capture that can be used to provide estimates for the PMs related to water supply. When combined with continuous water quality data (such as turbidity measurements from turbidity meters), flow meters can provide highly valuable information on water supply in addition to water quality. Even if water quality data is discrete, loading estimates can be extrapolated and estimated using flow meter data (see Water Quality Benefits section for methods and analyses that incorporate flow data). Additionally, pairing flow meters with a telemetry system reduces the effort required to collect data and allows data to be uploaded in real-time and continuously.

To estimate captured stormwater runoff (especially annual volumes related to PMs), flow meters must be placed at both the inlet and outlet locations. The flow meter at the inlet records the total runoff volume entering the BMP, while the flow meter at the outlet records the total volume that is discharged from the BMP via an outlet conveyance. For BMPs with infiltration components or that divert to the sewer, the difference between these values is the total amount water infiltrated or managed. Since the SCW Program's Feasibility Study Guidelines specify that the volume of stormwater captured for onsite reuse and augmenting other water supplies needs to be estimated, flow meters installed at the appropriate diversion point may be used to calculate average annual volumes for diverted stormwater.

Installing flow meters also provides important data for determining how well the BMP is operating. During storm events, diversion rates, storage capacity, flowthrough volumes, and infiltration rates may be limited by the BMP's design and operational efficiency. Flow meters allow for the tracking of flow through the BMP, and tracking flow rates is important for diagnosing flawed components and potential O&M needs.

In addition to typical flow meters, there are many varieties of devices that can be used to measure flow, such as:

- Automated sampler flow modules (connects to an automated sampler)
- Area-velocity (AV) sensors (can also measure water level; data reliability is affected by turbulent flow; combined with channel geometry to provide flow)
- Weirs (requires water level sensor to calculate flow rates, and data reliability may be affected by wet-weather flows)
- Flumes (unable to be used within pipe conveyance)

If flow measurement data gaps inhibit accurate estimates of the annual volumes related to the water supply PMs, an example strategy for extrapolating data may be by using median storm event flow volumes for wet-weather and median dry-weather flow volumes and then summing up wet- and dry-weather volumes to estimate flow volumes throughout the year. Conducting regular inspections and calibrations of the installed flow devices are important considerations for avoiding data gaps and verifying reliable data collection.

Over time, flow data may inform the need to update components of the monitoring plan (i.e., increasing recalibration frequency if data quality diminishes or goes offline, adding meters if data gaps are recognized, etc.). Such adaptive management strategies may lead to more efficient data collection, better-informed O&M decisions, and long-term project cost savings.

Refer to the CIMP of the project's corresponding watershed area for any flow meter guidelines and to the LA County BMP Guidance Manual for more information on flow measurement devices that may be better suited for the appropriate BMP type.

Flow meter installation is grouped into Value Category A, as flow meters can help verify that water is flowing through the BMP (i.e., that the BMP is operational). Installing flow meters is identified as Effort Tier 1, as flow meters are relatively cost-effective to install.

Flow Measurements Taken Between BMP Components

Value Category B **|** Effort Tier 2 **|** MS4 Permit; LA County BMP Guidance Manual; Plans

In addition to installing flow meters at only influent and effluent locations for a BMP, flow meters may also be installed between individual BMP components (such as after pre-treatment, before or after infiltration basins, etc.). These additional measurement locations may provide information on stormwater flows and volumes at each component, allowing for tracking water volume fate at each point in the BMP. Furthermore, tracking water supply can help provide a more localized diagnosis of BMP component performance and O&M needs. In contrast to flow meter installation at only the influent and effluent locations, these additional locations may provide more localized, quantifiable information on BMP functioning, aligning with Value Category B. This aligns with Effort Tier 2, as it requires installation, maintenance, recalibration, and monitoring of additional flow meters.

Refer to the CIMP for the project's corresponding watershed area for any flow meter guidelines and to the LA County BMP Guidance Manual for more information on flow measurement devices.

Water Level Measurements

Value Category A **|** Effort Tier 1 **|** LA County BMP Guidance Manual; Plans

Water level sensors can be installed to track water levels and infiltration rates, especially for BMPs with infiltration components. Verifying infiltration rates against modeled parameters can help adapt BMP performance expectations and modeling assumptions. In combination with BMP geometries (such as infiltration gallery footprint area, for example), infiltrative volumes can also be calculated, contributing to groundwater recharge for water supply benefit. As with flow meters, the logging of continuous water level data is key for understanding water supply benefits and BMP performance. Installing water level sensors at the influent and effluent of the infiltration/storage chambers of a BMP can help to estimate the water volume.

The data provided by water level sensors can also help determine whether a BMP is meeting its designed volume capacity and can help inform O&M needs. Analyzing water level data, flow data, and precipitation data during storm events (including the 48-96 hours beyond the initial event) can give an understanding of how measured hydrologic conditions compare to modeled and design conditions. If infiltration is not happening at the rate the BMP was designed for it is a sign that additional maintenance or design adjustments may be needed, or that modeling needs to be revisited. Infiltration rates over time can be tracked to diagnose degrading stormwater infiltration rates, which may require adjusting maintenance schedules and cleaning activities to keep the BMP operating at intended capacity.

There are many varieties of devices that can be used to measure water level, such as:

- Pressure transducers (provides continuous data, but requires calibration)
- Radar level sensors (can be used when submergence is undesirable)
- AV sensors (can also measure flow; data reliability is affected by turbulent flow)
- Staff gauges (requires manual measurement, and therefore not continuous)

If water level measurement data gaps inhibit accurate estimates of annual volumes related to water supply , an example strategy for extrapolating data may be by using median storm event infiltration volumes for wet-weather and median dry-weather infiltration volumes and then summing up wet- and dry-weather volumes to estimate infiltration volumes throughout the year. Conducting regular inspections and calibrations of water level sensors are important considerations for avoiding data gaps and verifying reliable data collection.

Over time, water level data may inform the need to update components of the monitoring plan (i.e., increasing recalibration frequency if data quality diminishes, replacing/repairing sensors if data gaps are recognized, etc.). Such adaptive management strategies may lead to more efficient data collection, better-informed O&M decisions, and long-term project cost savings.

Refer to the CIMP for the project's corresponding watershed area for any water level sensor guidelines and to the LA County BMP Guidance Manual for more information on types of water level measurement devices that may be better suited for the appropriate BMP type.

Water level sensor installation is grouped into Value Category A, as flow meters can help verify that water is infiltrating (i.e., that the BMP is operational). Installing water level sensors is identified as Effort Tier 1, as sensors are relatively cost-effective to install.

Water Supply Measurements Summary

Value Category A (Is the BMP installed and operational?)

- Flow Meters (Effort Tier 1)
- Water Level Measurements (Effort Tier 1)

Value Category B (How well is the BMP performing?)

- Flow Measurements Taken Between BMP Components (Effort Tier 2)

Water Supply Analysis

Analyzing water supply data helps assess whether a BMP is treating the intended amount of water. Collecting and analyzing detailed water supply data can facilitate maintenance strategies that are specific to how BMPs react to certain storm intensities, extended storm events, and corresponding water volumes. Ultimately, these activities can improve understanding of how a BMP's stormwater capture varies throughout a singular storm event, which can inform how certain components are reacting to certain storm conditions (e.g., being diversion-limited by capture), which can facilitate adaptive management practices to help capture more stormwater.

Over time, water supply data analysis may inform the need to update the monitoring plan (e.g., increasing sampling frequency to obtain a more robust dataset, etc.) and/or O&M plan (e.g., performing retrofits or maintenance to improve BMP performance, increasing regular O&M frequency to maintain regular performance, etc.). Such adaptive management strategies may lead to a more holistic understanding of the BMP's performance, better-informed O&M decisions, and long-term project cost savings.

Analysis of Water Supply Across Multiple Storms

Value Category B **|** Effort Tier 2 **|** LA County BMP Guidance Manual; SCCWRP

Los Angeles County's Hydrology Performance Plot (Performance Plot) can be used to assess a BMP's flow performance using data collected across multiple, distinct storms. The Performance Plot assesses BMP hydrologic performance for each storm assessed in the analysis by plotting measured volume retained/design volume against measured precipitation depth/design storm depth. The locations of these points on the plot classify the BMP's performance into four categories: success, failure, excess (manages more runoff than designed), and check data (e.g., more runoff captured than physically possible). Once data points for recorded storms are graphed, a hydrology performance index score can be calculated based on the number of occurrences in each category (**Figure 3**). This score correlates to a suggested action for managing the BMP.

This analysis method represents hydrological performance of the BMP in a way that provides a quantifiable metric for assessing BMP hydrologic performance, and whether it is meeting intended water supply benefits. A BMP that is failing to meet design expectations may require an updated maintenance schedule to assess shortcomings in the existing O&M program and apply adaptive management practices to optimize performance. For example, if analysis indicates that a BMP is not capturing the intended volumes during design storms, diversion point flows and conveyances might be assessed for performance and/or scheduled for more pre-storm O&M.

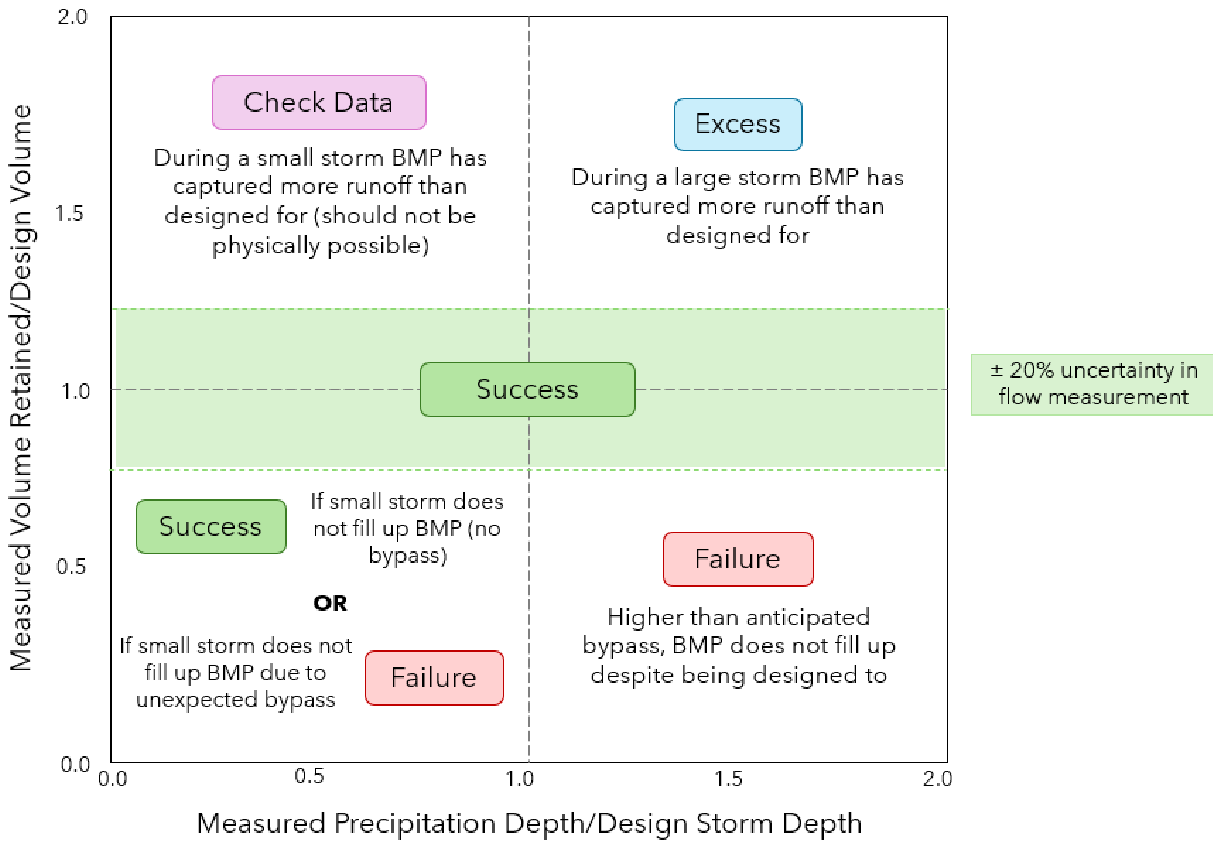


Figure 3*. Example of LA County's Hydrology Performance Plot*

Additionally, SCCWRP has a publicly available web tool that plots data and calculates a hydrology performance index score consistent with the Hydrology Performance Plot methodology. This web tool (including an explanation on its method, scoring, and instructions for use) is accessible here: https://sccwrp.shinyapps.io/bmp_wq_index_app/.

Conducting analysis on data collected across multiple storms provides information on how the BMP is performing for a given storm and how performance changes over time, which may help to anticipate potential O&M needs based on the weather forecast. This information may help to inform project needs, thus aligning with Value Category B. Due to the level of analysis required, this activity is classified as Effort Tier 2.

Analysis of Water Supply Within a Single Storm

Value Category B | Effort Tier 3 | LA County BMP Guidance Manual; SCCWRP

The Hydrology Performance Plot can also be used to analyze data points taken within a single storm event, instead of across multiple storms. Water flow and volume can be analyzed over the course of a storm to better understand water supply dynamics over time, how they might interact with precipitation, and how a BMP performs throughout the course of a single storm event.

A limitation to this analysis is the amount of data required; flow data must be recorded at multiple points throughout a single storm, and precipitation data must also be logged (or referenced from a site such as the National Weather Service). Flow meters and water level sensors may require more frequent recalibration so that they function properly for each recorded storm event.

SCCWRP has a publicly available web tool that can be used to sum rainfall depths, create hydrographs, and calculate infiltration rates during storm events. This web tool (including an explanation on its method, scoring, and instructions for use) is accessible here: https://sccwrp.shinyapps.io/bmp-hydrology-calculator/.

Comparing metrics and findings over the course of a single storm event can help diagnose BMP issues and whether performance diminishes over time. Conducting analysis on how a BMP's performance changes throughout a single storm event can provide detailed information on functioning and O&M needs. This information aligns with Value Category B. Due to the level of analysis required and the data collection needs, this activity is classified as Effort Tier 3.

Water Supply Analysis Summary

Value Category B (How well is the BMP performing?)
- Analysis of Water Supply Across Multiple Storms (Effort Tier 2)
- Analysis of Water Supply Within a Single Storm (Effort Tier 3)

Triggers and Actions

Table 2 highlights potential water supply actions that may be taken if monitoring activities determine a BMP is not performing adequately. This list serves as guidance and is not exhaustive of all possible "triggers" related to water supply. The "actions" can be modified based on BMP type and corresponding manufacturer recommendations, field experience, watershed area-specific regulations, community input, etc. While this list provides general recommendations, it is the responsibility of the Project Developer to ensure operation and performance of the BMP, which may address "triggers" and/or require "actions" not listed here. Documenting any actions and outcomes can help to inform future planning and adaptive management.

Table 2: Water Supply Benefits Adaptive Management Examples

Consideration	Triggers	Actions
Improper Flow Meter Calibration and Placement	• Inconsistent or implausible flow/volume data across BMP stages (e.g., influent flow volume is less than effluent flow volume)	• Recalibrate flow meters • Install additional sensors at key points to better quantify flow rates and volumes • Explore alternative flow devices
Infiltration Rate Decline	• Water level data shows slower drawdown, reduced infiltration rates, or standing water during/after storm events (can be calculated using SCCWRP web tool)	• Inspect for clogging, compaction, and over-sedimentation • Remove accumulated sediment • Replace subsurface media
Overflow Events	• BMP unable to retain design volume	• Investigate flow control/diversion devices • Verify design capacity and retrofit BMP as needed
Hydrology Performance Plot Failures	• BMP data plots as "failure" per Los Angeles County hydrology performance plot	• Conduct maintenance on infiltration/storage components • Verify constructed design • Reassess modeling assumptio
Need for Storm Event Remodeling/Recalibration	• Discrepancy between measured and modeled precipitation-runoff relationships (based on failing design storm capacity retention, overflow events)	• Update hydrologic modeling assumptions/parameters using site-specific data • Adjust monitoring frequency during storm events to help verify accurate data collection
Need for Continuous Monitoring Integration	• Manual sampling (of influent flows, water level, etc.) is insufficient to capture dynamic stormwater behavior and timing	• Install automated flow and water level sensors for continuous monitoring of storm event duration, storage, and infiltration performance
BMP Retrofit Required	• BMP consistently cannot capture the runoff volume it was designed to	• Redesign diversion structures, flow control structures, weirs, or other structural components that improve capture and flow • Identify features that optimize runoff capture to inform future projects

Operations and Maintenance

This section details O&M strategies for a BMP's functional components. Ensuring adequate O&M of a BMP's components is essential for optimizing its lifetime performance. Where measurable, findings from O&M activities may also provide supporting evidence of BMP performance and may support various benefit metrics, including progress toward relevant PMs and Indicators. The needs and costs associated with O&M activities are highly variable and are dependent on BMP type, weather conditions, level of adherence to post-construction monitoring and maintenance program, and more.

O&M reporting is crucial to understanding whether a project is delivering its intended benefits. Reporting documents a project's successes and lessons learned, and can steer adaptive O&M efforts to help verify that the related BMP's performance can be optimized for continued delivery of project benefits.

For a project's O&M, specific PMs are tracked at the project scale to ensure that projects are properly maintained and operated effectively, and therefore delivering their intended benefits. Below are the PMs being monitored under the 'Ensure Ongoing Operations & Maintenance for Projects' WP theme:

- Is there an O&M plan being implemented to sustain intended project benefits? (yes/no)
- O&M cost ratio (%)
- O&M and monitoring funding ratio (%)

Note that these Performance Measures may have already been reported prior to project construction. For more information on the O&M PMs specific to a BMP's WA, refer to the corresponding Plans and Watershed Planning Tool, available at the SCW Program Watershed Planning webpage.

O&M Activities

O&M activities will vary based on specific project BMP components (e.g., specific treatment components, hydraulic features, mechanical components, site conditions, etc.). As such, a comprehensive list of O&M activities applicable to every BMP type and condition is not provided in this guidance. Project-specific O&M activities (and other corresponding considerations for health and safety, frequency, personnel needs, etc.) should be implemented in accordance with a project's approved O&M plan.

O&M Frequency

The following is a list of example frequencies for O&M activities related to a BMP's operational components:

- As needed, based on observations/visual inspections and worsening performance
- Annually, prior to wet season (inspected for effective operation and public safety)
- Quarterly

- Semi-annually
- Before and/or after select storm events (e.g., based on learned patterns of storm size/intensity and required O&M)
- Before and/or after every storm event
- In coordination with water quality sampling events
- Per component-specific specifications in the project's O&M plan

These frequencies are meant as guidance and can be adapted and adjusted based on feedback from the community and tribal members, frequency and intensity of storm events, regulatory recommendations, budgetary/personnel restrictions, recommendations from experienced workers, etc. As much as possible, O&M activities can be scheduled to overlap with other sampling events (including water quality sampling events) for efficiency and cost savings. O&M activities can also be informed by the corresponding CIMP and manufacturer specifications; refer to the corresponding CIMP and approved project O&M plans for guidance on O&M practices specific to the watershed area and a project's BMP components.

Adaptively managing O&M frequency may help to maintain BMP performance over time. Maintaining BMPs more regularly may also extend a project's useful life. Additionally, documenting and reporting outcomes from activities (e.g., performance data, condition trends) can support adaptive management by enabling managing agencies to refine O&M schedules, accurately justify resource allocation, and adapt practices based on observed performance and evolving conditions.

Triggers and Actions

Table 3 highlights examples of triggers and actions related to ongoing O&M. This list serves as guidance and is not exhaustive of all possible "triggers" related to ongoing O&M. The "actions" can be modified based on BMP type and corresponding manufacturer recommendations, field experience, watershed area-specific regulations, community input, etc. While this list provides general recommendations, it is the responsibility of the Project Developer to ensure operation and performance of the BMP, which may address "triggers" and/or require "actions" not listed here. Documenting any actions and outcomes can help to inform future planning and adaptive management.

Table 3: Ongoing O&M Examples

Consideration	Triggers	Actions
Sediment or Trash Accumulation	• Observed/measured/weighed buildup in pretreatment units, sumps, or conveyance structures	• Increase cleaning frequency • Propose upstream trash capture units • Re-evaluate pretreatment sizing

Consideration	Triggers	Actions
Sensor Malfunction	• Unresponsive sensors • Sensors consistently malfunction or report poor data • Telemetry errors	• Clean and recalibrate sensors with higher frequency • Check telemetry settings • Schedule equipment replacement per manufacturer recommendations
Hydraulic Blockage or Reduced Flow Through BMP	• Flow bypassing treatment systems	• Conduct hydro jetting or pipe inspection with increased frequency (e.g., after storm events) • Clear debris and sediment • Confirm valve operation
Pump Station or Valve Vault Failure	• Pump not activating • Valve sticking	• Clean, lubricate, or replace pump/valve components • Inspect control panels and battery power sources
Filter or Cartridge Clogging	• Shortened maintenance intervals needed • Reduced flow through filtration units	• Evaluate upstream sediment control • Replace filter media per manufacturer specification • Consider retrofitting with backwashable units
Structural Damage or Degradation	• Cracking, settlement, or erosion observed during inspection	• Monitor and schedule repair as needed • Compare hydrology model results with actual/observed design storm tolerance • Restabilize with geotextile/vegetation as appropriate
Persistent Standing Water	• Reoccurring flooding or standing water at BMP sites	• Verify drainage capacity • Inspect flow control structures • Schedule maintenance for improved conveyance (or retrofitting, if necessary)

Long-Term Vision for Post-Construction Monitoring Guidance

As post-construction monitoring and maintenance programs are implemented throughout the region, this guidance will evolve in response to new findings and feedback from interested parties. As part of a long-term vision, future efforts will adapt accordingly to achieve the following:

1. **Refinement of O&M Guidance**: This guidance aims to provide flexibility for project developers to apply program practices as required for each BMP, and to adapt such practices per informed, data-driven findings. This guidance includes examples for such adaptive management (for sampling frequency, sampling locations, sampled pollutants, etc.). As adaptive management is implemented and project developers learn more about opportunities and limitations of program components (which may be applied generally to BMPs throughout the region, or only for nuanced conditions relevant to BMP type, for example), guidance may be updated accordingly.

2. **Integration of Monitoring into Watershed Planning**: As discussed in the Watershed Planning Initiative section of this guidance, certain data obtained during post-construction monitoring and maintenance programs may inform understanding of progress toward WP goals (e.g., PMs). Such data may not be able to quantify watershed-scale metrics directly; quantifying metrics may require modeling and introduce uncertainty. However, post-construction program strategies may implement parallel tracking strategies which separates project performance from watershed-scale assessment, maintaining alignment with WP goals at appropriate scales.

3. **Integration of Monitoring into Reporting Module**: Standardizing reporting via the Reporting Module will help to streamline data entry, improve consistency, and enable comparison across subsequent reporting years (as data "shall be collected and reported… for a period of three years," per the SCW Program Transfer Agreement). The Post-Construction Monitoring Reporting Outline/Wireframe can be used to help inform updates to the Reporting Module that support standardized reporting practices.

4. **Alignment and Integration with Regional Monitoring**: BMP data alone is not representative of watershed health. Assessing BMP data in tandem with regional monitoring data (e.g., MS4-compliant CIMP) can help contextualize BMP performance within watershed-scale conditions. When considered alongside BMP data, watershed-scale CIMP results can be used to evaluate whether observed changes in downstream water quality are consistent with anticipated pollutant load reductions associated with BMP implementation. Specifically, CIMP data can be used in coordination with BMP sampling data to:

    - Establish baseline and background concentrations for pollutants of interest within the watershed.

- Assess how concentrations and loads at CIMP stations that are downstream of BMPs compare to CIMP stations that are not downstream of BMPs.
- Support interpretation of BMP performance results, especially in cases where BMP influent concentrations are highly variable or influenced by regional hydrologic conditions.
- Identify storm conditions driving downstream loads (e.g., examining CIMP data for specific sampling events such as first flush or large storm events, as well as analyzing seasonal trends) to adaptively update a BMP sampling program.
- Assess whether load reductions attributable to BMP implementation are detectable and/or have a measurable impact on concentrations/loads of relevant pollutants as measured at downstream outfalls receiving waters and outfalls.
- Compare BMP data to CIMP data at downstream outfalls or receiving waters to provide justification for further adaptive management.

5. **Exploration of Integration with SCW Program Workforce Development Efforts**: Developing a workforce to support post-construction monitoring and maintenance programs will be key for long-term SCW Program success. Refer to the SCW Program's Workforce Development Program Update for guidance on staffing projects via creating new jobs and workforce development programs in addition to engaging the existing workforce. In part, the Workforce Development Program aims to:
    - Train a County workforce for SCW Program projects and programs.
    - Establish a pathway for those with barriers to employment.
    - Connect people and communities to tailored training, jobs, and careers.
    - Leverage local partnerships and training/certification programs.

6. **Monitoring for Nature-based Solutions (NbS), Community Investment Benefits (CIBs), and Engagement**: Additional updates to this guidance may be applied to address NbS, CIBs, and engagement, as these are key components to SCW Program development. Future efforts may include integration of existing metrics into project monitoring standards.

Conclusion

The post-construction monitoring guidance options presented throughout this document (especially those with Value Category and Effort Tier designations) can be used to customize monitoring and maintenance programs to ensure they include activities that best suit the needs and functional requirements of a project's BMP. The guidance herein provides details on BMP performance and is intended to support the continued delivery of a project's Water Quality and Water Supply Benefits, as well as its ongoing O&M.

In post-construction, it is important to consider the following items for effective BMP performance and monitoring:

- Sampling/monitoring frequency
- Mobilization efforts
- BMP sampling locations
- BMP sampling methods
- Pollutants to sample
- Measurements taken
- Analyses to conduct

These items will produce distinct types of data; it is important to consider the utility and intended use of this data when selecting the appropriate activities to implement in a monitoring plan and in practice. In the context of the activities conducted and the data produced, a well-informed post-construction monitoring and maintenance program can yield many benefits, including:

- Diagnosing short-term O&M needs
- Improving monitoring efficiencies (for sampling event mobilization, staffing, resource management, etc.)
- Managing the plan long-term by adapting to new insights
- Prolonging BMP lifetime
- Saving on long-term costs
- Quantifying BMP performance (e.g., PMs)
- Tracking contributions toward broader watershed-area goals (e.g., Indicators)
- Improving holistic understanding of BMP operations, the roles of BMPs in their respective watershed areas, and the roles of BMPs in the SCW Program overall

As more projects continue to adopt, implement, and optimize post-construction monitoring and maintenance programs, including incorporating information from this guidance and other resources, new understandings and information will assist the evolution of this guidance and associated best practices. Aligning with the long-term vision will continue to direct the SCW Program toward successful implementation of stormwater control measures in the Los Angeles region.

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Attachment

Los Angeles County Department of Public Works' *Best Management Practice Monitoring Guidance Manual*

Best Managment Practice
MONITORING GUIDANCE MANUAL

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Final - Version 1.0

Confidential and Privileged

Los Angeles County Public Works
Stormwater Quality Division
Environmental Planning Section

Public Works
LOS ANGELES COUNTY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Definition
µS/cm	Microsiemen(s) per Centimeter
AC	Alternating Current
AV	Area Velocity
BMP	Best Management Practices
Caltrans	California Department of Transportation
CEDEN	California Environmental Data Exchange Network
COC	Chain of Custody
County	County of Los Angeles
EMC	Event Mean Concentration
FPS	Feet per Second
IWQS	Integrated Water Quality System
LID	Low-impact Development
MS	Matrix Spike
MS4	Municipal Separate Storm Sewer System
MSD	Matrix Spike Duplicate
O&M	Operations and Maintenance
PEAP	Performance Assessment and Evaluation Plan
Public Works	Los Angeles County Public Works
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RPD	Relative Percent Difference
SCCWRP	Southern California Coastal Water Research Project
SCWP	Safe, Clean Water Program
SMC	Stormwater Monitoring Coalition
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey

GLOSSARY OF TERMS

Term	Definition
85^{th} percentile, 24-hour storm volume	This terminology refers to a storm size (i.e., rainfall depth) class where 85 percent of the storms that occur in the project area are smaller or deliver less rainfall. The total rainfall is constrained to a 24-hour period. For example, if the 85th percentile is 1.5 inches in 24 hours, this means 85 percent of storms are less than 1.5 inches and 15 percent are greater. The 85th percentile 24-hour storm is a common design metric for BMP design.
Analytical Method	Laboratory method for requested sample analyses. Approved methods are typically Standard Methods (e.g., SM2340C) or Environmental Protection Agency (EPA) methods (e.g., EPA300.0). In most cases, methods used for monitoring programs should be validated in 40 CFR Part 136.
Constituent	Refers to measured pollutant or compound. Term is often used interchangeably with “analyte” or “parameter”
Data sonde	Multi-parameter water quality meter. Typically has on-board power and data storage, allowing the data sonde to be deployed for extended periods.
Design storm	The design storm is typically the upper limit of storm size the BMP is designed to treat. In most cases the design storm is the 85^{th} percentile, 24-hour storm volume (see definition), but the design storm could be smaller or larger depending on site and watershed factors. The design storm sets the stage for performance expectations. BMP performance evaluations measure if the BMP is capturing the intended (or modeled) runoff volumes from the intended design storm.
Event mean concentration (EMC)	The average pollutant concentration for a given monitoring event, expressed in units of mass per volume (e.g., mg/L). A flow-weighted composite sample provides a single sample analysis result that represents the EMC. EMC can also be calculated from a series of pollutograph sample results and associated flow data.
Holding Time	The amount of time allowed between sample collection and analysis by the laboratory, as prescribed by the analytical method. Holding times can be a short as 8 hours (e.g., bacteria) up to many months, depending on constituent and sample preservation.
Hydromodification mitigation	Hydromodification is the alteration of the natural flow of water through a landscape, and often takes the form of channel modification or channelization. Hydromodification mitigation refers to steps taken to reduce the impacts from hydromodification. Some mitigation steps include installation of BMPs to slow down flow rates, reduce peak flow rates, or divert runoff to an infiltration gallery.

GLOSSARY OF TERMS (continued)

Term	Definition
Infiltration volumes and/or rates	This is the measure of the runoff volume that is captured by a BMP. Typically, captured volumes will be infiltrated into the ground via drywells or infiltration galleries. Infiltration rate refers to the rate or time it takes the water level to drop in the drywell or gallery. An infiltration rate that decreases over time may indicate clogging or sedimentation and O&M may be required.
In situ field measurements	"in situ" is defined as "in the natural or original position or place". In situ field measurements refers to making field water quality measurements directly in the discharge using a water quality meter or probe.
Laboratory Reporting Limit	The laboratory reporting limit is the lowest concentration at which an analyte can be detected in a sample and its concentration can be reported by the laboratory with a reasonable degree of accuracy and precision. The reporting limit is often approximately 3-5x the MDL, but is dependent on laboratory-specific studies and analyte being measured.
Method Detection Limit	The method detection limit (MDL) is lowest level reliably measured based on a given analytical method. EPA defines the MDL as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.
Peak flow attenuation	Reduction of peak flow rates compared with those measured prior to BMP implementation.
Pollutant load	The mass of a pollutant that passes the monitoring point. Load is calculated by multiplying the volume of water for a monitored event by the pollutant concentration (and necessary conversion factors).
Pollutant reduction	Pollutant reduction refers the BMP's ability to reduce measured pollutants. This can be evaluated in two ways: (1) pollutant concentration reduction, which compares the measured influent concentration to the effluent concentration; or (2) pollutant load reduction, which compares the influent pollutant load to the effluent pollutant load (see pollutant load definition). For full-capture or infiltration BMPs, pollutant load reduction is evaluated as the total influent pollutant load captured by the BMP.
Primary device	A device used to measure open channel flow using a structure like a flume, weir or dam that enables the measurement of flow by measuring the depth
Sample aliquot	A sample aliquot is a small sample volume that is collected as part of a composite sample. For example, a composite sample collected over a storm event may be

GLOSSARY OF TERMS (continued)

Term	Definition
	comprised of 20 500 mL sample aliquots resulting in a final composite sample volume of 10,000 mL (10 L).
Sample pacing	The pace at which an automated sampler collects sample aliquots. The pacing can be a time interval or a flow volume.
Stormwater conveyance	Refers to a constructed flow path for stormwater runoff. Some examples include stormdrain pipes, trapezoidal or rectangular channels, or box culverts.
Turbidity	Water quality measurement of relative clarity. High turbidity indicates cloudy or opaque water. Low turbidity indicates clear water, allowing light to pass through.

INFORMATION BOXES

Information boxes are included throughout the document to highlight tips, definitions, or examples. The information boxes are blue and include one of the three icons included in the example box below. The definition for each icon is included in the example box below.

Indicates an example of a topic or items discussed in the text.

Indicates a definition of terminology.

Indicates a tip related to the section discussion topic(s).

1.0 INTRODUCTION

A stormwater capture Best Management Practices (BMP) Project presents a unique opportunity for municipalities to improve the quality of life of the community they are serving. The projects may benefit the community by providing additional green space and amenities for residents, encouraging water reuse, and improving the local water supply. Implementing Stormwater BMPs is considered one of the effective solutions to improve watershed health. BMPs are generally classified into two categories: nonstructural BMPs and structural BMPs. Nonstructural BMPs are focused on behavioral changes, activities, and other measures that do not include constructing a physical structure to prevent contaminants from entering the water. Structural BMPs are constructed features designed to manage hydrology and improve water quality in a variety of ways. Some examples of structural BMPs include bioswales, infiltration galleries, drywells, media filters, and many others. The goal of this document is to assist in the development of a stormwater BMP performance monitoring program and provide a basic understanding of the monitoring components.

1.1 Significance of Performance Monitoring

BMPs are designed to achieve water quality regulatory goals, enhance community areas, reduce flood risk, and provide education and outreach to the public. Los Angeles County Public Works (Public Works) has invested considerable resources into structural and non-structural BMPs over the past 20 years, and investment will continue through the Safe, Clean Water Program (SCWP) and other funding mechanisms. Given this large investment, it is important to understand the funded projects are operating as intended. Structural control BMP performance monitoring provides an understanding of pollutant removal efficiency, hydrology and hydraulic impacts, maintenance needs, and project lifecycle costs.

BMP performance monitoring typically includes:

- Flow monitoring
- Water quality sampling
- In situ water quality field measurements
- Visual observations

Site-specific factors may impact how data are collected. Discussing these levels of detail is beyond the scope of this document. However, some monitoring issues may be overcome by evaluating lessons learned on previous projects and considering monitoring requirements during the design phase of the project. Examples of these considerations include:

- Physical access to desired monitoring points
- Conveyance conditions for measuring flow, such as pipe slope
- Surcharging
- Areas prone to clogging
- Instrumentation selection and placement

Careful consideration of monitoring needs and goals is required for successful BMP performance monitoring. Collecting and accurately reporting monitoring results from a given program provides valuable data for assessing performance and informing future project planning and design.

1.2 Purpose of the Guidance Document

This guidance document provides stormwater agencies with a consistent and standardized approach for developing a BMP performance monitoring program. BMP performance data is influenced by a variety of factors, including monitoring approaches. Standardizing the monitoring protocol for stormwater agencies BMP monitoring provides benefits including:

- Comparable and repeatable data across projects
- Consistent expectations of data collection, analysis, and reporting protocols
- Streamline monitoring program planning.
- Streamlined installation, instrumentation, and field activities.
- Efficient monitoring-based project design

Guidance in this manual is intended to provide the foundation to develop and complete a monitoring program. Monitoring can be a complicated task that varies from site to site and storm to storm. This manual will discuss monitoring program elements but does not cover the nuances of site-specific characteristics or issues. Monitoring nonstructural BMPs and privately owned BMPs is not within the scope of this document.

1.3 How to Use This Guidance Document

This guidance document is intended to be used by Public Works to develop and conduct BMP performance monitoring programs. Other stormwater agencies and research groups may also refer to this guidance document to develop their own monitoring programs. This document is organized around the planning and implementation phases of a typical BMP performance-monitoring project. Table 1 is a document map describing the phases and content this document will cover. There are several "industry" related terms used throughout that are defined in a glossary of terms at the beginning of this document.

Table 1. Document Map

Chapter	Study Phase	Content Summary
NA	NA	Acronyms and abbreviations table. Glossary of terms used in this guidance document.
1	NA	Introduction and use of this document.
2	Monitoring program development	Identification of objectives, study questions, drivers, and relevant information from similar projects. Monitoring plan development overview.
3	BMP performance evaluation framework	Study framework, including required data types and metrics.
4	Data type	Describes the two categories of data types for a BMP evaluation
5	Dynamic data collection methodology	Description of data collection methodologies for data types identified during evaluation framework development. Data management and remote access. Development of a field checklist, if necessary.
6	QA/QC	Discussion of the importance of data quality. Description of QA/QC sample types and use. Calibration requirements for instrumentation.
7	Reporting	Reporting requirements based on program drivers and funding.
8	Data Repository	Data management for completed project data. Incorporation of data into a BMP database.
9	References and Bibliography	Bibliography of relevant resources cited in this guidance document.
NA	Appendices	Resources including example monitoring plan, monitoring plan and QAPP template, and example report,

BMP = best management practices; NA = not applicable; QA = quality assurance; QC = quality control; QAPP = quality assurance project plan

2.0 MONITORING PROGRAM DEVELOPMENT

The considerations and components of monitoring program development drive programmatic success. Section 2.1 describes the importance of developing study objectives and questions. This section also includes common program drivers and funding mechanisms used to determine program objectives. Study goals, drivers, and requirements may vary among projects. Considering these components during this phase ensures the monitoring program will address project-specific goals and allow data to be compared among programs. Section 2.2 describes key components of monitoring plan development. Following the monitoring program development framework, Appendix A provides a monitoring plan example Public Works developed for the East Los Angeles Sustainable Median Stormwater Capture Project.

2.1 Identify the Monitoring Objectives and Study Questions

The most critical steps for a scientific investigation are identifying the objectives and the study questions that address those objectives. This key step drives the monitoring design, data types, and other study factors that provide results to answer study questions. Multiple factors may dictate project objectives or requirements that steer the study question development.

Public Works and other local agencies may apply for project funding through grants that are administrated by Federal, State, or local government. Funding may be provided for project implementation, which may include water quality improvement goals and volume capture or treatment goals. While each project may have specific goals due to the nature of the granting agency, this guidance manual provides the common components necessary to execute BMP performance monitoring project to meet the most typical grant requirements. There may be additional drivers that steer the monitoring objectives. For example, grant, regulatory, special investigation, and/or performance monitoring requirements. Sections 2.1.1 through 2.1.4 describe potential additional funding sources or programs that drive study question development.

2.1.1 Grant Requirements

Many structural BMPs are funded through single or multiple grant agencies. For example, some grants administered through the California Bureau of Reclamation’s WaterSMART program[1] include drought resiliency as a programmatic goal. Goals for drought resiliency may include requiring awarded programs to demonstrate water capture and reuse by monitoring the volume of water captured during dry and wet weather conditions. The metrics to address goals for a grant-funded program are often outlined in a Performance Assessment and Evaluation Plan

[1] https://www.usbr.gov/drought/

(PAEP). The PAEP may be used to determine monitoring objectives and study goals. Furthermore, grant programs have specific timelines to complete the project. The schedule may dictate the number of seasons or years to be monitored, the number and type of samples collected, and other monitoring program requirements.

The metrics to address goals for a grant-funded program are often outlined in a Performance Assessment and Evaluation Plan (PAEP).

- How much pollutants are reduced by the project?
- How much water is captured by the project annually?

Development of monitoring objectives and study questions for grant-funded projects should include a careful review of grant requirements to ensure that they are being met and the metrics can be properly evaluated through the monitoring program design.

2.1.2 Regulatory Drivers

BMPs are typically implemented to achieve primary goals such as pollutant reduction, hydromodification mitigation, or water capture. Regulatory mechanisms such as a regional municipal separate storm sewer system (MS4) permit or total maximum daily load (TMDL) may not specifically require installation of a BMP but include specific water quality objectives or pollutant load reduction requirements for the watershed. BMP implementation is a common approach to achieve regulatory water quality goals. During the BMP design phase, specific pollutant reduction performance is modeled to develop sizing and other BMP design features. Pollutant removal efficiency and watershed-specific regulatory objectives should be considered when developing BMP performance study questions to ensure that the monitoring program can adequately address anticipated performance.

BMP implementation is a common approach to achieve regulatory water quality goals. An example study question to address this objective is presented below:

- Can the effluent water quality after the treatment system meet downstream water quality objectives?

2.1.3 Special Study/Investigation Requirements

The goals of special studies should be considered during study question development and program design. BMP performance evaluations may also support a special study or contribute to a regional program. Although these types of studies may not have regulatory drivers or requirements that dictate funding, the goals of special studies should be considered during study question development and program design.

For example, the Southern California Stormwater Monitoring Coalition (SMC) has a regional BMP study that includes the installation of turbidity sensors to help address the program's study questions related to sediment accumulation and maintenance requirements. One of the example study questions is presented below.

- Do water turbidity levels correlate to decreased infiltration rates?

Other research question is presented below.

- How much stormwater has the project captured compared to the watershed model prediction?

2.1.4 Performance Monitoring

Evaluation of BMP performance should be based on the metrics that the BMP was designed to achieve. BMPs are typically designed to achieve water quality and/or hydraulic benefits such as volume capture, peak flow attenuation, and/or pollutant reduction. Understanding the design goals and limitations of the BMP are important when developing study questions. For example, a BMP that is designed to reduce zinc loading may not be effective for reducing nitrogen loading, and vice versa. The following are some common performance monitoring approaches and related study questions:

- Influent versus effluent monitoring – what is the pollutant concentration or load removal efficiency of the BMP?
- Flow diversion monitoring – what is the quantity of runoff diverted to storage or infiltration?
  - Coupled with water quality data, this approach also answers questions of pollutant load diversion (i.e., not reaching the receiving water).
- Preconstruction versus post-construction – does the BMP improve water quality discharging to the receiving water?

Performance monitoring considerations may include other drivers not discussed in the section. A clear understanding of the program drivers and goals at the early stage of monitoring plan development helps create an informative and effective performance evaluation that addresses the necessary objectives and answers study questions. The results from a well-designed performance evaluation provide a clear understanding of BMP performance and useful information for future BMP selection and design.

2.2 Monitoring Plan Development

The monitoring plan shall include the pertinent information to inform the monitoring team about the BMP and the monitoring requirements for the specific monitoring program. The monitoring plan shall include a brief description of the BMP location, treatment type, and function. This portion of the monitoring plan should include BMP design goals relevant to the study, which may include wet and/or dry weather volume capacity, design storm size, pre-construction versus post-construction water quality and/or quantity, and other project-water quality benefits. The BMP goals bracket the intended performance range and appropriate evaluation criteria used to assess performance. Understanding the BMP function and intended performance conditions sets the stage for developing the monitoring requirements described in the monitoring plan. For example, if the BMP is designed to only treat dry weather runoff, data collection and evaluation during wet weather events may not be included in the monitoring priority.

In addition to the BMP function and goals that drive the monitoring program, the monitoring plan shall include key elements of performance monitoring such as sampling locations, sample analysis requirements, monitoring approaches, and QA/QC requirements. The subsequent Sections in this guidance document describe data collection methodologies and QA/QC requirements. Appendix B provides a monitoring plan template that provides a common document layout of information; examples, definitions, and tips; common text that may be useful to include; and prompts for new text specific to the project.

3.0 STORMWATER BMP PERFORMANCE EVALUATION FRAMEWORK

3.1 Framework Overview

The Southern California Coastal Water Research Project (SCCWRP), along with Public Works and other regulatory and regulated agencies, developed a technical document titled Monitoring Guidance to Support Adaptive Watershed Management (Schiff et al., 2022). The document includes guidance to help managers understand quickly and clearly whether implemented BMPs are performing compared to planned expectations.

The BMP performance evaluation tool can be applied to nearly all BMPs that include water quality sampling at inlet and outlet monitoring points (water quality category). Based on the input data, the tool provides simple classification of performance into one of five categories: Success, Excess, Marginal, Insufficient, or Failure.

The BMP performance evaluation tool has been adapted to evaluate BMP volume capture performance (hydrology category), providing a similar simple classification into one of four categories: Success, Excess, Check Data, or Fail.

The BMP performance evaluation tool provides a consistent method to evaluate performance and allows for intra- and inter-project comparison. Section 3.0 provides an overview of the BMP performance evaluation tool. Further detail can be found in the Monitoring Guidance to Support Adaptive Watershed Management (Schiff et al., 2022).

3.2 Data Categories and Metrics

BMPs are designed to address a variety of water quality and quantity issues and a variety of data types can be used to understand performance. Metrics used to evaluate the performance of a BMP may be based on a regulatory limit or a design specification. In addition to understanding project objectives, it is important to understand data types needed to perform the evaluation, as discussed in the previous section, to produce a meaningful assessment. Data categories such as chemistry, microbiology, field water quality parameters, or maintenance logs may be used to assess whether the anticipated pollutant removal occurs and whether reductions achieve a water quality objective. The hydrology data category includes flow rates and volumes, rainfall rates, and infiltration rates, which may be used to evaluate whether diversion is occurring when anticipated, the BMP is treating the design volume, and infiltration is occurring at expected rates. Sections 3.2.1 through 3.2.4 discuss these categories in further detail.

3.2.1 Design Parameters and Field Measurements

During the design phase of a BMP, specific goals are developed to facilitate a proper design that will achieve desired outcomes. These static design parameters include data such as the 85^{th} percentile, 24-hour storm volume, which is the “maximum” storm runoff volume that the BMP can treat before bypass occurs. Other examples of design parameters include expected pollutant reduction, peak flow attenuation, and infiltration volumes and rates.

> What does the 85th percentile, 24-hour storm volume mean?
> This terminology refers to a storm size (i.e., rainfall depth) class where 85 percent of the storms that occur in the project area are smaller or deliver less rainfall. The total rainfall is constrained to a 24-hour period. For example, if the 85th percentile is 1.5 inches in 24 hours, this means 85 percent of storms are less than 1.5 inches and 15 percent are greater.
>
> The 85th percentile 24-hour storm is a common design metric for BMP design that ranges from 0.7 inches to 1.2 inches in Los Angeles County areas (Refer to: https://ladpw.org/wrd/publication/engineering/Final_Report-Probability_Analysis_of_85th_Percentile_24-hr_Rainfall1.pdf).

Field measurements and data collected during monitoring provide a dynamic data set used to evaluate design success and achievement of desired outcomes. Field data such as water samples, in situ field measurements, flow measurements, and field observations provide the data used to assess performance against predetermined metrics.

3.2.2 Water Quality Category

The water quality category for the BMP performance evaluation tool requires three key metrics: (1) influent pollutant concentration, (2) effluent pollutant concentration, and (3) desired water quality threshold concentration. Water quality samples may be collected at the influent and effluent points of the entire BMP or collected upstream and downstream of a pretreatment device. Using the threshold concentration, two ratios are calculated:

1. Influent concentration divided by the threshold concentration (plotted on the X-axis)
2. Effluent concentration divided by the threshold concentration (plotted on the Y-axis)

3.2.2.1 *Influent Pollutant Concentration*

Influent pollutant concentration is measured at a point where untreated water enters the BMP. The water quality or pollutant concentration at this point represents the existing water quality condition that would otherwise discharge into the receiving water. Typically, the influent pollutant concentration is monitored downstream from the BMP's diversion structure but upstream from the treatment unit. The influent pollutant concentration sampling point is discussed in Section 5.1.

3.2.2.2 *Effluent Pollutant Concentration*

Effluent pollutant concentration is measured at a point after treatment. Depending on the design of the BMP, this point may be downstream of a pretreatment device or downstream of the entire BMP. A bioswale BMP typically has an effluent monitoring point to evaluate the complete treatment effectiveness of the BMP. Infiltration BMPs typically do not have an effluent monitoring point but may include an effluent monitoring point following a pretreatment device to evaluate the effectiveness of the device or series of devices. The effluent pollutant concentration sampling point discussed in Section 5.1.

3.2.2.3 *Water Quality Threshold*

The BMP is designed to reduce pollutant loads or concentrations below a certain level known as the water quality threshold. Water quality thresholds are typically objectives set through a regulatory requirement or other design requirement (e.g., broader watershed-scale goals).

3.2.2.4 *Evaluation Categories*

The influent and effluent ratios are plotted on an x–y scatter plot. The water quality threshold is plotted as horizontal and vertical lines for influent and effluent axes. A diagonal line from the origin through the upper-right corner of the plot is the 1:1 line, at which influent and effluent pollutant concentrations (and resulting ratio calculations) are identical. This plot creates zones that indicate where BMP performance is categorized in terms of the categories described in Section 3.1. Figure 1 shows an example of this plot with the five categories identified.

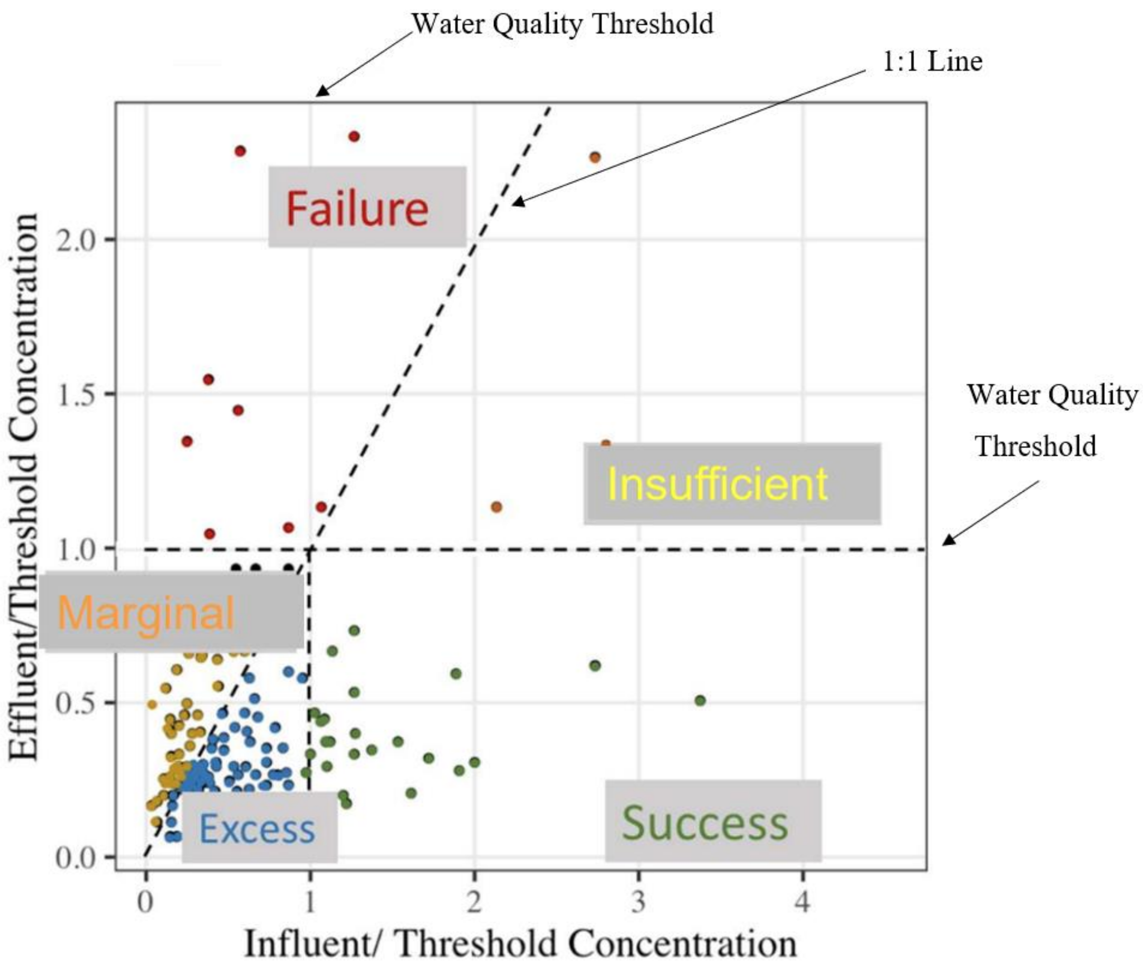


Figure 1. Water Quality Assessment Framework for BMP Effectiveness (Schiff et al., 2022)

A BMP is producing results which fall into one of five categories shown in Figure 1. The categories are defined as follows (Schiff et al., 2022):

- Success: influent pollutant concentrations are greater than the water quality threshold and effluent pollutant concentrations are less than the water quality threshold (lower right area of the plot).
- Failure: pollutant concentration in effluent is greater than the concentration in influent (i.e., higher than the 1:1 line) and is also greater than the water quality threshold (upper left area of the plot).
- Insufficient: influent pollutant concentrations are greater than the water quality threshold and the effluent pollutant concentrations are less than the influent pollutant concentrations (i.e., lower than the 1:1 line), but not less than the water quality threshold (upper right area of the plot).

- Marginal: influent pollutant concentration is below the water quality threshold and the effluent results are below the water quality threshold, but the effluent results are higher than the influent and higher than the 1:1 line (lower left area of the plot).
- Excess: influent and effluent pollutant concentrations are both below the water quality threshold as well as below the 1:1 line (central lower left area of the plot).

3.2.3 Hydrology Category

The hydrology category for the BMP performance evaluation tool is based on four metrics: (1) actual rainfall depth, (2) design storm depth, (3) actual volume captured, and (4) design volume capture. Similar to the water quality category, two ratios are calculated:

- Actual rainfall depth divided by the design storm depth (plotted on the X-axis)
- Actual volume captured divided by design volume capture (plotted on the Y-axis)

3.2.3.1 Design Storm Depth

The design storm depth is the maximum rainfall depth determined by design engineers. The 85th percentile, 24-hour storm event for the project area is a common design parameter; however, this parameter could be different depending on factors such as BMP size constraints and project budgets.

3.2.3.2 Actual Precipitation Depth

The actual precipitation depth is the rainfall depth measured during a monitored event at or near the location of the BMP. This depth is typically measured by an onsite rain gauge but could be data from publicly available sources.

3.2.3.3 Actual Volume Retained

The actual volume retained is the runoff volume measured entering the BMP during a monitored event. Measuring flow rate has inherent uncertainty based on sensor performance, flow characteristics, and other site-specific factors. An uncertainty range of ±20 percent is generally considered acceptable in the surface hydrology industry. Measurement uncertainty is discussed further in Section 4.3.3.

3.2.3.4 Design Capture Volume

The design capture volume is the total runoff volume that should be captured by the BMP, as determined by the design engineers. Factors such as drainage area, land use, and BMP size constraints affect the volume capacity of a BMP.

3.2.3.5 Evaluation Categories

Similar to the water quality category plot, the ratios are plotted on an x-y scatter plot. However, in the hydrology category, no water quality threshold or objective is used for comparison; only the design parameters are included in the ratio calculations. Given the uncertainty of flow measurement, an uncertainty band is included at ±20 percent of the 1.0 ratio line on the y-axis, at which measured volume and design volume are identical. This plot creates zones that indicate where a BMP is categorized in terms of the four categories described in Section 3.1. Figure 2 shows an example of this plot with the four categories identified.

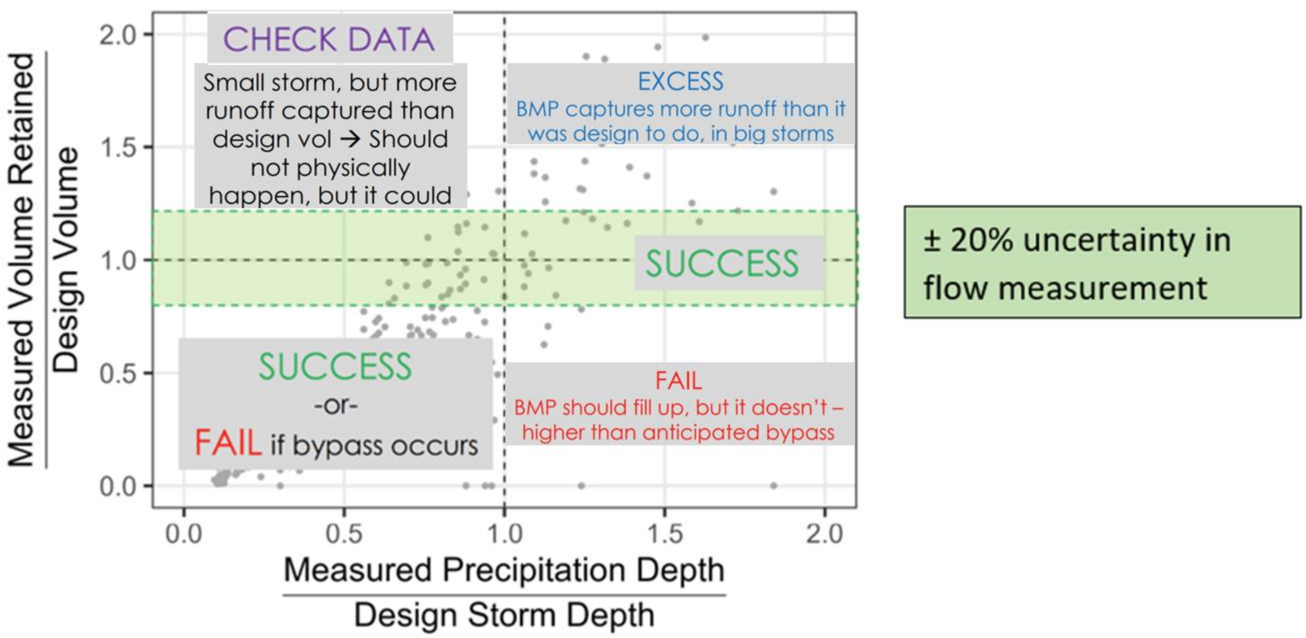


Figure 2. Hydrology Assessment Framework for BMP Effectiveness

A BMP is producing results which fall into one of four categories shown in Figure 2. The categories are defined as follows (Schiff et al., 2022):

- Success occurs during either of two conditions:
  - The BMP does not fill up during a small storm with one caveat – if bypass flow occurs during a small storm, the BMP is "failing" (lower left corner); or
  - The BMP is functioning as designed within the ±20 percent uncertainty band (center horizontal band).
- Failing occurs during either of two conditions:
  - Bypass flow occurs during a small storm, as previously described in the caveat to "Success" condition (lower left corner); or

    - The BMP does not fill up when it should during a large storm and anticipated bypass flow is greater than anticipated.
- Excess: During a large storm event the BMP captures a higher quantity of runoff than was initially anticipated which could indicate an overdesign of the BMP.
- Check Data: The BMP captured a higher volume than initially anticipated for a small- scale event. Data landing in this category could indicate a potential error in the flow data.

3.2.4 Operations and Maintenance Category

O&M is critical for the long-term success of a BMP. An adaptation of the assessment framework for O&M is under development. The goal of the tool for this category is to help managers determine quickly whether a BMP needs to maintain or restore proper function. This guidance manual may be revised in the future if the tool is developed successfully.

4.0 DATA TYPE

Project data typically fall into one of two categories: Project Static Data and Project Dynamic Data (Fassman-Beck, 2021). Sections 4.1 and 4.2 provide further descriptions of the two data types. Table 2 and Table 3 provide examples of the data types.

4.1 Project Static Data

The project static data is the type of data that describes the structural control stormwater BMP project's background information, treatment features, and design parameters. The project's static data, which seldomly change after construction, can usually be found from the project concept report, feasibility study, or design plan. The list of project static data that shall be documented at the beginning of the monitoring is presented in Table 2. Static data shall not change and do not need to be monitored nor collected in the field.

4.2 Project Dynamic Data

The project dynamic data is the type of data that describes the structural control stormwater BMP project's treatment performance. The project dynamic data may include pollutant concentration measured at the influent/effluent, flow rate, and precipitation depth for a sampling event. The list of project static data that shall be collected during each monitoring event is presented in Table 3. Project dynamic data are data that will be collected in the field during monitoring efforts and are discussed in Section 5.0.

Table 2. Project's static data

Field Name	Descriptions	Example
BMP Site Information		
Site Name	Site Name is a unique geographic location where the project is located	Roosevelt Park Multi-Benefit Stormwater Capture Project
City Name	City closest to the BMP project site	City of Los Angeles
County Name	County where the BMP project site is located	Los Angeles County
State	State where the BMP project site is located	California
Zip Code	Zip code where the BMP project site is located	90001
latitude	Latitude is the North-South coordinate that locates the project to the nearest second on the globe relative to the equator	
Longitude	Longitude is the East-West coordinate that locates the project to the nearest second on the globe relative to the selected principal meridian	
Watershed Information		
Watershed Name	Watershed Name is the name that the watershed is referred to locally. The watershed should contain the drainage area to the BMP	Los Angeles River; Rio Hondo River
Watershed HUC Code	Hydrologic Unit Code is the USGS 8-digit hydrologic unit code (HUC) which represents a geographic area containing part or all of a surface drainage basin or distinct hydrologic feature. The HUC can be looked up at the USGS Website: https://water.usgs.gov/wsc/map_index.html	18070105
BMP Design Information		
Site Name	Site Name is a unique geographic location where the treatment device is located	76th St.
BMP Type	The type of BMP being monitored	Bioretention; Infiltration Basin
Basis of Design	The design criteria the project is based on. For example 2-yr 24-hr design storm volume, design treatment flow rate, 85th percentile storm volume, other water quality design storm	85th percentile 24 hours design storm volume
Design Flow Rate	The peak flow rate the BMP is designed to be able to handle	6.5 cubic feet per second (cfs)
Design Capture Volume	The annual total capture volume the BMP is designed for	10 acre feet per year
Date of Installation	Construction finish date	1/1/2021
Monitoring Station Information		
Site Name	Site Name is a unique geographic location where the monitoring is conducted	Pre-treatment unit influence
Site ID	An unit ID to identify the monitoring station	RP01-BMP-INF
Station Type	The Station Type is to identify the function of each monitoring station in relation to each BMP	Inflow; Bypass; Rain Gauge
Measurement Type	The type of measurement being taken	Water Quality; Flow; Precipitation

Table 3. Project's dynamic data

Field Name	Descriptions	Example
Flow Data		
Site Name	Site Name is a unique geographic location where the monitoring is conducted	Pre-treatment unit influence
Site ID	An unit ID to identify the monitoring station	RP01-BMP-INF
Event ID	Event Number is the monitoring event associated with the collected flow data, as selected from the pick-list of previously identified monitoring stations	1
Start Date	The date that the flow is above the base flow	7/4/2022
End Date	The date that the flow return to the base flow	7/6/2022
Start Time	The time that the flow is above the base flow	01:45
End Time	The time that the flow return to the base flow	18:30
Runoff Volume	The total flow volume measured at the inflow(s) or outflow(s) from the BMP, excluding bypassed flow volumes	1.25 acre-feet
Peak Flow Rate	The greatest rate of runoff into or from the BMP treatment device	5.7 cubic feet per second (cfs)
Precipitation Data		
Site Name	Site Name is a unique geographic location where the monitoring is conducted	Pre-treatment unit influence
Site ID	An unit ID to identify the monitoring station	RP01-BMP-INF
Event ID	Event Number is the monitoring event associated with the collected flow data, as selected from the pick-list of previously identified monitoring stations	1
Start Date	The date that the storm started	7/4/2022
End Date	The date that the storm ended	7/6/2022
Start Time	The time that the storm started	00:45
End Time	The time that the storm ended	17:15
Total Precipitation Depth	Total depth is the total amount of precipitation that occurred during the storm event	2.0 inches
Water Quality Data		
Site Name	Site Name is a unique geographic location where the water quality is collected	Pre-treatment unit influence
Site ID	An unit ID to identify the water quality sample	RP01-BMP-INF
Event ID	Event Number is the monitoring event associated with the collected flow data, as selected from the pick-list of previously identified monitoring stations	1
Sample Start Date	The date that the first composite sample is collected in the field	7/4/2022
Sample End Date	The date that the last composite sample is collected in the field	7/6/2022
Sample Start Time	The time that the first composite sample is collected in the field	03:45
Sample End Time	The time that the last composite sample is collected in the field	18:00
Event Type	Event Type identifies whether the monitored event is associated with storm runoff, base flow/dry weather, or other event	Wet Weather
Analyte name	Name of the analyte or parameter for which the analysis is conducted and result is reported.	Copper; Lead; Zinc
Fraction Name	Specific descriptor of the Analyte. For example, metals are often expressed as total or dissolved and therefore this description should be used within the fraction field	Total
Results	Final numeric result of a given analyte	0.1 ppb

5.0 DYNAMIC DATA COLLECTION METHODOLOGY

Reliable, high-quality data are essential for meaningful BMP performance evaluations. The core data components of a BMP performance monitoring program are the following:

1. Representative monitoring locations
2. Water quality sampling
3. Flow measurements
4. Rainfall measurements
5. Field observations

Sections 5.1 through 5.5 provide further detail on these components.

5.1 Monitoring Locations

Identifying monitoring locations is the first step to ensure data collection will address project goals. Figure 3 and Figure 4 provide conceptual level monitoring points for common BMP configurations followed by descriptions of how data from those locations can be used to evaluate performance.

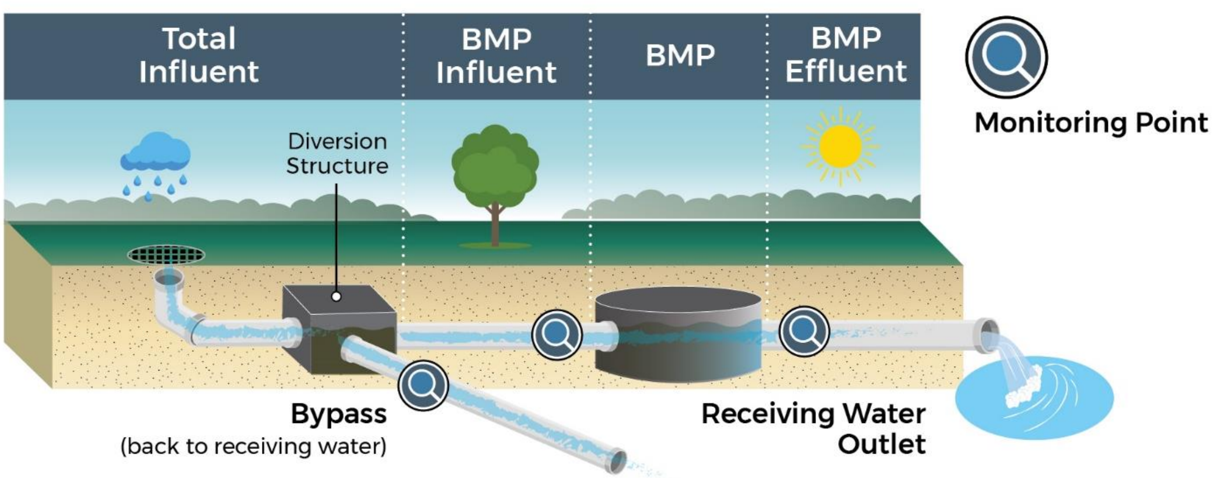


Figure 3. Conceptual Graphic of Influent-Effluent BMP monitoring

Figure 3 provides a conceptual-level graphic of monitoring locations for a "flow-through" BMP. Comparisons can be made with pollutant concentration, hydrology, and pollutant loading data. The BMP influent point will characterize conditions entering the BMP. Similarly, the BMP effluent point will characterize conditions exiting the BMP, ultimately discharging to the receiving water. Pollutant concentration and pollutant loading reduction performance are calculated by comparing BMP influent and effluent data. This type of BMP and data collection are suitable for the BMP evaluation tool described in Section 3.2.2.

> The bypass monitoring location is typically monitored for flow only, providing data on the volume of and when runoff is bypassing the BMP. Water quality is not monitored at the bypass location since the bypass water quality is similar to the untreated stormwater near the BMP influent monitoring location. Influent pollutant data can be used for loading calculations at the bypass, if desired.

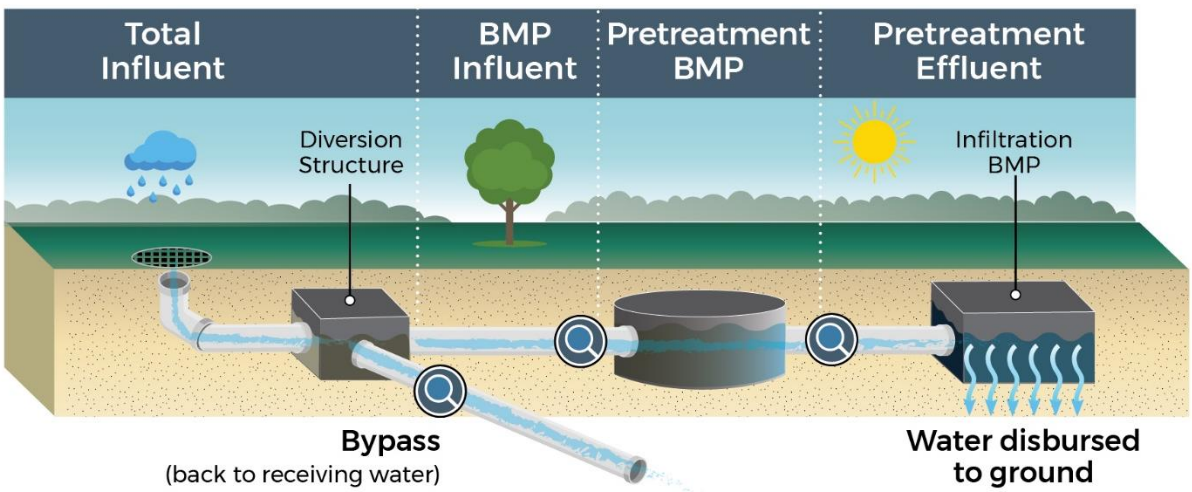


Figure 4. Conceptual Graphic of Infiltration BMP with Pretreatment Monitoring

Figure 4 shows a similar configuration as Figure 3 but includes a pretreatment BMP and an infiltration BMP. In many BMP projects, recharging the groundwater basin through infiltration is the primary goal. However, to improve the lifespan performance of the infiltration BMP, it is common practice to install a pretreatment BMP upstream. The pretreatment BMP filters large debris and sediment that may clog the infiltration BMP located downstream. With this type of configuration, influent and effluent performance can be evaluated for the pretreatment BMP. Pretreatment BMP monitoring (flow and water quality) also provides an understanding of water quality and volume captured and infiltrated by the BMP. Bypass monitoring provides the same information in both scenarios.

5.2 Monitoring Event Frequency

BMP performance monitoring frequency is based on BMP design and program requirements. If BMPs are designed to treat dry weather runoff, monitoring should occur during dry weather conditions. Dry weather is defined as a 24-hour period with less that 0.1-inch of rain and is preceded by at least 72 hours of dry weather (i.e., 3 days with less than 0.1-inch of rain). If a BMP is designed to treat wet weather runoff, monitoring should occur during wet weather conditions. Wet weather is commonly defined as ≥0.25-inch within a 24-hour period. It is common to have BMPs designed to treat both dry weather and wet weather runoff, in which case both conditions should be monitored.

A common number of events for dry weather monitoring is four events per year, with events occurring quarterly. The number of wet weather monitoring events varies between programs, but typically occurs during three to five events per year covering a wide range of storm sizes.

5.3 Water Quality Sampling

An array of sampling techniques are used for water quality sampling depending on analytical method requirements, study questions and goals, budget and time constraints, and other project-specific factors. Water quality sampling includes collection for chemical and microbiological parameters, and often includes in situ field measurement of physical parameters such as pH, conductivity, dissolved oxygen, turbidity, and/or temperature. The goal of this section is to provide practitioners with an understanding of common techniques to obtain samples for BMP performance monitoring.

5.3.1 Sampling Types and Procedures

Sample types and procedures are dictated by the analytical methods and monitoring program requirements. For example, oil and grease and microbiological samples are commonly collected as grab samples due to analytical method requirements. Many other parameters such as metals, nutrients, and total suspended solids (TSS) can be collected as composite samples. Sections 5.3.1.1 through 5.3.1.3 briefly describe collection protocols and procedures. The California Department of Transportation (Caltrans) Stormwater Monitoring Guidance Manual (Caltrans, 2020) and the Caltrans BMP Pilot Study Guidance Manual (Caltrans, 2021) are valuable resources for information on sample collection techniques, including advantages and disadvantages.

5.3.1.1 Grab Sample Collection

Grab samples are collected by submerging the sample container in the flow to fill the container. Samples may be collected manually or with the use of a grab pole if the conveyance is beyond reach. If samples cannot be collected manually or with a grab pole, an automated sampler can be used; however, this method should be considered a last resort because it introduces the potential for sample cross-contamination. Sample collection methodology should be recorded on the field data sheet. Common constituents requiring direct grab sample collection include bacteria and oil and grease. Figure 5 shows a field technician collecting a grab sample from an open stream.

Water quality samples collected for laboratory analysis must be accompanied by a chain of custody (COC). The COC is a record of the samples collected and serves as the work order of analyses that are required by the laboratory. Key fields on the COC form include sample ID, sample collection date and time, analysis requested for each sample, and signature blocks for sample custody transfer. Figure 6 show an example COC with a few key components called out.

Considerations for grab sample collection include the following:

- Place the bottle in the flow with the opening facing upstream to avoid potential contamination from the bottle, grab pole, or other items that flow might contact before entering the container.
- Submerge the opening below the water surface if possible to avoid potential surface scum or debris that does not represent the water column.
- Always use powder-free nitrile gloves when collecting samples of any type, especially grab samples for which direct contact with the water occurs.
- If an automated sampler is needed to collect the samples, allow the pump to run for a brief period prior to filling the bottle to completely flush the line with site water.
- If a sample preservative is included in the container, ensure that the bottle is not overfilled and causes the preservative to be lost.

Figure 5. Person collecting a Grab Sample

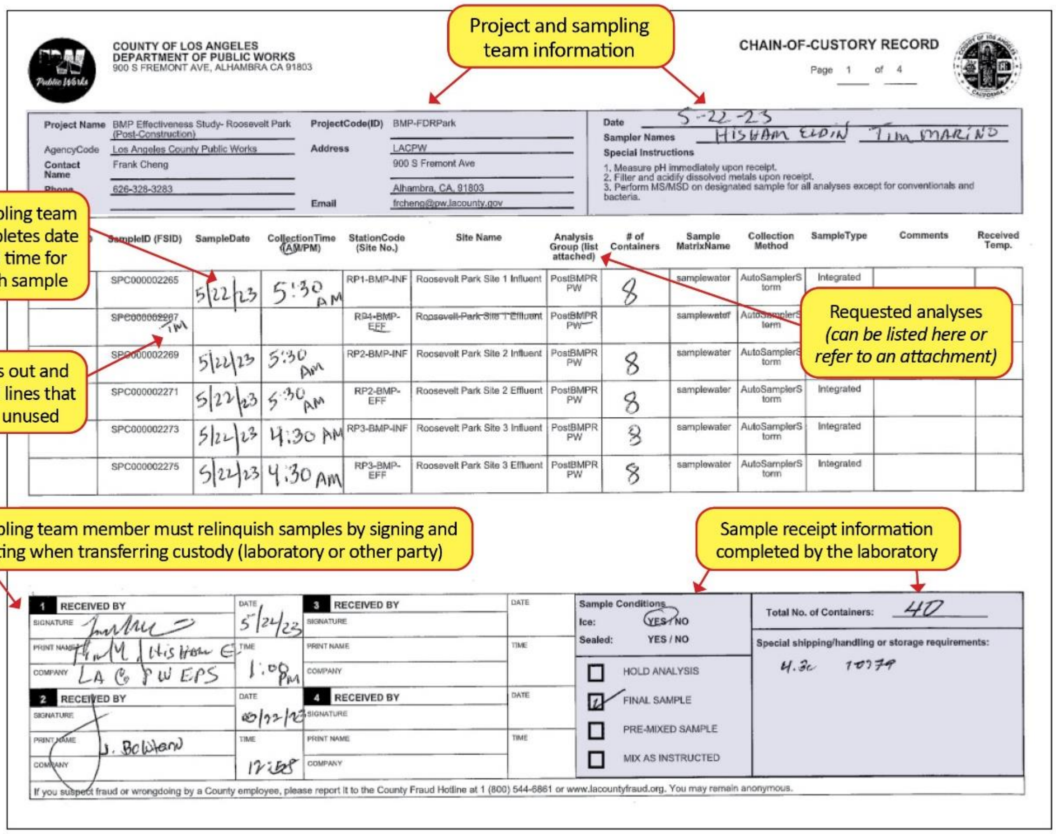


Figure 6. Example COC and Key Components

5.3.1.2 Automated Sample Collection

A sample collected using automated methods is typically either a time-weighted or flow-weighted composite sample, or as pollutograph sample (individual samples collected at specified intervals). These types are the most common for stormwater BMP monitoring, but other programming options are possible. Composite samples are comprised of multiple small sample aliquots. Sample aliquots are pumped into one large container to form a composite sample. Composite samples are typically collected using an automated sampler but can be collected manually. Figure 7 shows two automated samplers and other key components in a monitoring enclosure. Consult the user manual of the automated sampler for programming instructions.

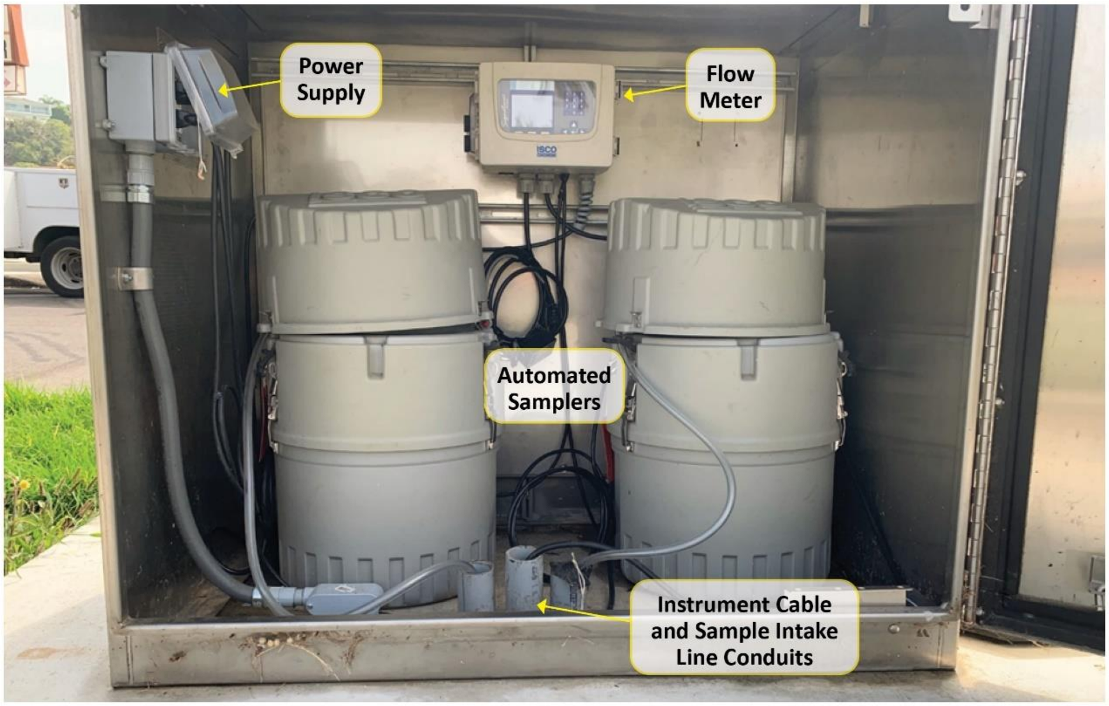


Figure 7. Monitoring Enclosure with Influent and Effluent Automated Samplers Installed

<u>Time-Weighted Composite Sample</u>

Time-weighted sampling occurs when an automated sampler is programmed to collect sample aliquots at specified time intervals. Figure 8 shows example hydrographs with time-weighted sampling intervals compared with flow-weighted sample intervals. The orange diamonds along the top show the different frequencies. With time-weighted composite sampling, the sample time interval is consistent throughout the event. The sample aliquot volume is also constant. This is referred to as "constant volume, constant interval" sampling.

The time interval is based on the project needs, sample volume needs, storm and/or flow duration, and other site- and event-specific factors. A time-weighted sampling program can be started manually, programmed to start at a specific date and time, or triggered based on a specific condition such as water level or flow rate if the sampler is connected to a flow meter.

<u>Flow-Weighted Composite Sample</u>

Flow-weighted sampling is similar to time-weighted sampling, but the interval is based on flow volume rather than a time interval. Figure 8 shows a comparison of time-weighted sampling versus flow-weighted sampling. The orange diamonds along the top show the sample collection frequency. With flow-weighted sampling, the sample time interval is variable throughout, becoming more frequent with increased flow rate and less frequent as flow rate decreases. As with time-weighted composite sampling, the sample aliquot volume is constant. Flow-weighted sampling is referred to as “constant volume, variable interval” sampling.

Flow-weighted composite sampling requires the sampler to be connected to a flow meter that collects accurate flow data throughout the sampling event. The flow-weighted composite sample is representative of the flow over the monitored duration because aliquots are collected proportionally based on the actual flow observed. The flow-weighted composite sample is considered to be the most representative sample type for stormwater monitoring because stormwater runoff can vary significantly in terms of flow rate and pollutant concentrations during a storm event. Collecting sample aliquots based on flow rate provides a more accurate representation of the pollutant concentration from a given storm event, allowing for improved assessment of water quality and BMP performance.

The composite sample collected using the flow-weighted composite sampling method represents the mean pollutant concentrations of the sampling event, namely the Event Mean Concentration (EMC). The time-weighted composite sample, on the other hand, includes samples aliquots collected at a set time interval throughout the storm event, resulting in a simple average concentration. While the time-weighted sample is not as representative as a flow-weighted sample, it provides reasonable representativeness when conditions do not allow for a flow-weighted sample.

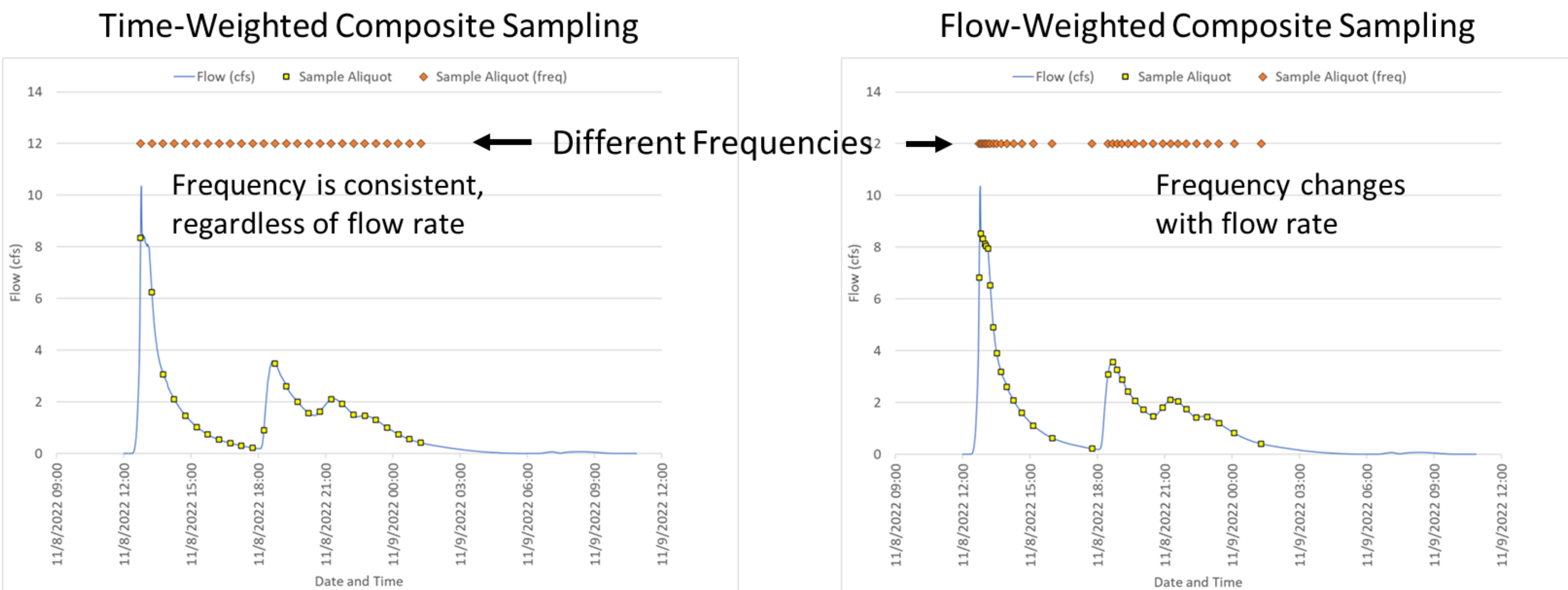


Figure 8. Example Hydrograph showing Time-Weighted versus Flow-Weighted Sample Aliquot Collection

Pollutograph Sample

Pollutograph sampling refers to individual samples that are typically collected at specified time intervals but may also be collected at flow intervals. This type of sample collection results in a series of discrete samples that can be analyzed individually. Data from this type of sampling can be used to evaluate changes in pollutant concentrations throughout a storm event or time period. These data can also be used in combination with recorded flow data to calculate a flow-weighted event mean concentration (EMC) (Equation 1), which is comparable to the flow-weighted composite sampling results. Pollutograph sampling can be cost-prohibitive because of the number of laboratory analyses required. Figure 9 shows a common configuration of pollutograph bottles in an automated sampler base. The automated sampler is configured with a distributor arm that fills each bottle individually based on programmed intervals.

Equation 1. Calculation of the EMC

$$EMC\ (mg/L) = \frac{\sum(V_i * C_i)}{\sum(V_i)}$$

where:

V_i represents stormwater volume received by the treatment system when a sample is taken;

C_i represents analyte concentration corresponding to the collected sample;

i is the sample number

Figure 9. Automated Sampler Base with Pollutograph Bottles

5.3.1.3 *In Situ Physical Parameter Measurement*

In situ physical parameters can be measured instantaneously or continuously. Instantaneous measurements are made using a handheld meter. Continuous measurements are made by installing a sensor to record continuous data. The need for an installed sensor is based on project objectives and requirements. For example, projects included in the SMC regional BMP monitoring program require continuously recorded turbidity data throughout the event to help answer specific study questions. Other programs may require a single instantaneous measurement to satisfy program requirements.

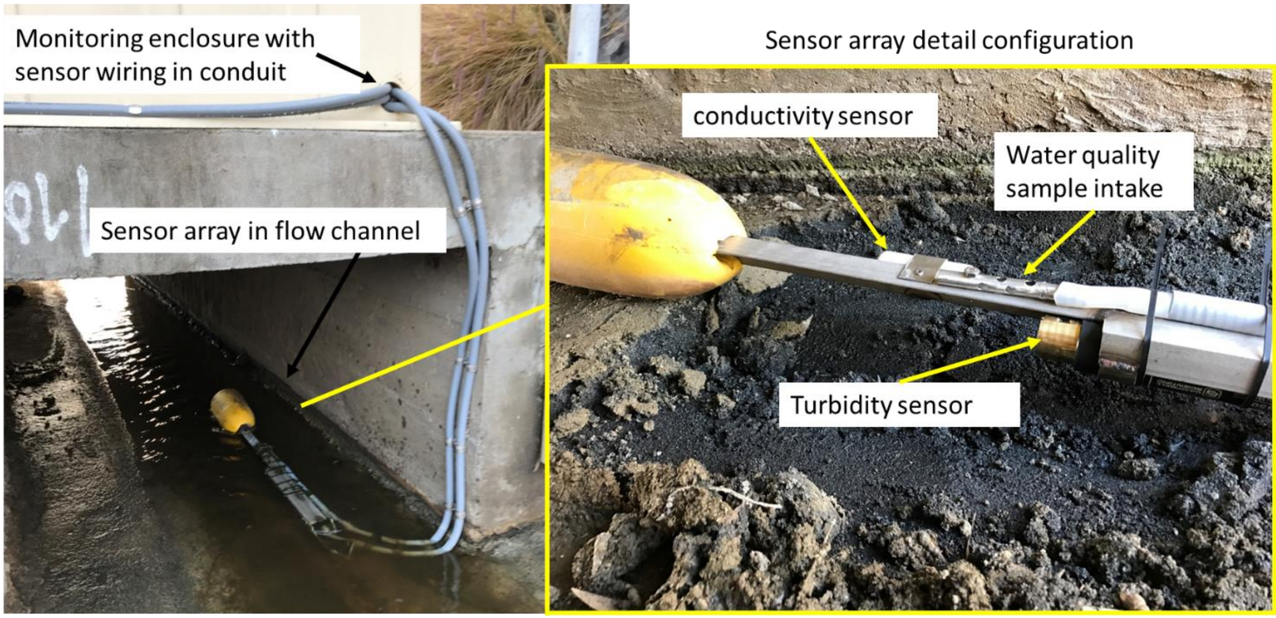
Instantaneous measurements are made by submerging the sensors in the flow directly or in a sample container pulled from the flow. Instantaneous measurement collection may have challenges similar to those for grab sample collection. If the water level is too shallow to submerge the sensor, water may need to be collected in a secondary container or pumped into a secondary container for the measurements. The water quality parameter measurements and measurement method should be recorded on the field data sheet.

Figure 10. Instantaneous Field Water Quality Measurement

Considerations for instantaneous water quality measurements include the following:

- Ensure that the sensor is fully submerged. If using a multi-parameter meter, ensure that all sensors are submerged. Some sensors may rely on data from another sensor. For example, a pH probe uses information from a temperature probe to produce a valid result. Similarly, specific conductance is measured using the conductivity sensor and the temperature sensor.
- If a secondary container and pump must be used, attempt to pump the water in the container as smoothly as possible to avoid aerating the sample. This aeration can affect dissolved oxygen measurements.
- If a secondary container must be used, the sample must be stirred continuously to ensure sample homogeneity when the measurements are collected.

Installed sensors for continuous measurements can be stand-alone (battery and memory housed within the unit) or wired to a data logger. Both types have advantages and disadvantages with respect to ease of installation and data access. If possible, it is preferable to use a sensor wired to the station datalogger, which allows easy review of the data, less concern for power failure, and early identification of data quality issues. Stand-alone sensors can be installed nearly anywhere, but data quality and/or completeness are unknown until the sensor unit is retrieved and data have been downloaded. In most cases with BMP projects, sensors will be installed in the storm drain conveyance and wired to the station datalogger. Figure 11 shows an example of long-term sensor installation in a storm drain conveyance. Figure 12 and Figure 13 show multi-parameter data sondes and common deployment in open water bodies.



Note: Sensors and intake strainer are installed on an arm in this example to keep out of sediment deposition. Sensors and intake strainers can be installed on the invert of the channel where sediment deposition is not an issue.

Figure 11. Long Term Turbidity and Conductivity Sensor Installation in a Storm Water Channel

Figure 12. Sensors Installed on Two Different Manufacturer Multi-Parameter Data Sondes

Figure 13. Common Installation of a Long-Term Data Sonde in an Open Water Body

5.3.2 Water Quality Parameters

Water quality is measured through laboratory analysis and in situ field measurements. Table 4 provides a core list of water quality parameters commonly monitored for a BMP performance evaluation project. This consistent list of water quality parameters allows for similar evaluations across BMP projects. Additional analytes may be included based on project-specific goals, such as a particular TMDL pollutant.

Table 5 provides common field water quality measurement parameters and their associated sensor specifications. The sensor specifications presented in Table 5 are based on a YSI ProDSS sensor. Other field water quality sensors can be used and may have slightly different specifications. These parameters are commonly measured as instantaneous in situ measurements, but some or all can also be made through deployed sensors, as discussed in Section 5.3.1.3.

Table 4. Common Storm Water Sample Analysis Requirements and Collection Methods for BMP Projects

Constituent [1]	Sample Volume*	Analytical Method [1]	Method Detection Limit [1]	Laboratory Reporting Limit [1]	Container (number, size, and type)	Preservation	Holding Time [1]	Collection Method
Bacteria								
E. coli	120 mL	SM9221F	1 MPN/100 mL	1 MPN/100 mL	1 x 120 mL sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C	8 hours	Grab Sample
Enterococci	120 mL	SM9230B	1 MPN/100 mL	1.8 MPN/100mL	1 x 120 mL Sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C	8 hours	Grab Sample
Fecal Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100mL	1 x 120 mL sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C or less	8 hours	Grab Sample
Total Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100mL	1 x 120 mL sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C	8 hours	Grab Sample
Metals								
Copper (Total and Dissolved)	500 mL	EPA 200.8	0.29 µg/L	1.0 µg/L	2 x 500 mL plastic bottle	HNO3, Store Cool at 6°C	28 days	Composite Sample
Lead (Total and Dissolved)	500 mL	EPA 200.8	0.052 µg/L	1.0 µg/L	2 x 500 mL plastic bottle	HNO3, Store Cool at 6°C	28 days	Composite Sample
Zinc (Total and Dissolved)	500 mL	EPA 200.8	1.3 µg/L	10 µg/L	2 x 500 mL plastic bottle	HNO3, Store Cool at 6°C	28 days	Composite Sample
Nutrients								
Total Kjehldahl Nitrogen	500 mL	SM 4500-NH3C	0.065 mg/L	0.1 mg/L	1 x 1000 mL plastic bottle	H2SO4, Store Cool at 6°C	28 days	Composite Sample
Ammonia-N	500 mL	SM 4500-NH3C	0.017 mg/L	0.1 mg/L	1 x 500 mL plastic bottle	H2SO4, Store Cool at 6°C	28 days	Composite Sample
Nitrate-N	500 mL	EPA 300.0	0.0095 mg/L	0.1 mg/L	1 x 500 mL plastic bottle	Store Cool at 6°C	48 hours	Composite Sample
Nitrite-N	500 mL	EPA 300.0	0.03 mg/L	0.1 mg/L	1 x 500 mL plastic bottle	Store Cool it 6°C	48 hours	Composite Sample
Total Nitrogen	500 mL	Calculation	0.1 mg/L	NA				
Total Phosphorus	500 mL	EPA 365.3	0.0062 mg/L	0.02 mg/L	1 x 500 mL plastic bottle	H2SO4, Store Cool at 6°C	28 days	Composite Sample
Ortho phosphorus	500 mL	EPA 300.0	0.003 mg/L	0.01 mg/L	1 x 500 mL plastic bottle	Store Cool it 6°C	48 hours	Composite Sample
Particulate Matter								

Table 4. Common Storm Water Sample Analysis Requirements and Collection Methods for BMP Projects (continued)

Constituent [1]	Sample Volume*	Analytical Method [1]	Method Detection Limit [1]	Laboratory Reporting Limit [1]	Container (number, size, and type)	Preservation	Holding Time [1]	Collection Method
Total Suspended Solids	1000 mL	SM 2540D	1.0 mg/L	1.0 mg/L	1 x 1000 mL plastic bottle	Store Cool at 6°C	7 days	Composite Sample
Conventional Chemistry								
Oil and Grease	1000 mL	EPA 1664	1.3 mg/L	5.0 mg/L	1 x 1000 mL Amber glass bottle	H2SO4, Store Cool at 6°C	28 days	Grab Sample
Total Organic Carbon	500 mL	SM5310B	0.14 mg/L	1.0 mg/L	1 x 500 mL plastic bottle	HCl, Store Cool at 6°C	28 days	Composite Sample
Total Hardness	500 mL	SM 2340C	1.0 mg/L	1.0 mg/L	1 x 500 mL plastic bottle	Store Cool at 6°C	6 months	Composite Sample

Notes:
Sample volume, method detection limit, and reporting limit may vary depending on the California ELAP contracted laboratory.
°C = degree(s) Celsius; µg/L = microgram(s) per liter; E. coli = Escherichia coli; ELAP = Environmental Laboratory Accreditation Program; EPA = United States Environmental Protection Agency; HCl = hydrochloric acid; HNO3 = nitric acid; H2SO4 = sulfuric acid; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not analyzed; SM = Standard Method

1. Term defined in Glossary of Terms at beginning of this manual.

Table 5. Common In Situ Field Water Quality Measurement Sensor Specifications

Constituent [1]	Equipment	Sensor Type	Measurement Range	Equipment Accuracy	Holding Time [1]
Field Parameters					
Conductivity	YSI ProDSS Handheld Multiparameter Meter	Four Nickel Electrode Cell	0–200 mS/cm	0 to 100 mS/cm (±0.5% of reading or 0.001 mS/cm, whichever is greater)	15 minutes
Dissolved Oxygen		Optical Luminescence	0–50 mg/L	0 to 20 mg/L (±0.1 mg/L or 1% of reading, whichever is greater)	15 minutes
pH		Glass Bulb Combination Electrode; Ag/AgCl Reference Gel	0–14 units	± 0.2 units	15 minutes
Temperature		Thermistor; Combination Sensor with Conductivity	-5 to 70°C (23 to 158°F)	± 0.2°C	15 minutes
Turbidity		Nephelometric Optical, 90° Scatter	0 to 4000 FNU	0 to 999 (0.3 or ±2% of reading, whichever is greater) 1000 to 4000 (±5% of reading)	15 minutes

Notes:
°C = degree(s) Celsius; °F = degree(s) Fahrenheit; Ag = silver; AgCl = silver chloride; mg/L = milligram(s) per liter; mS/cm = millisiemen(s) per centimeter
Specifications such as Equipment Accuracy and Measurement Range provide confidence in the measurement results.
1. Term defined in Glossary of Terms at beginning of this manual.

5.4 Hydrology Measurement

Hydrology measurement is essential for understanding BMP performance. BMPs are typically designed to reduce pollutant loading and/or capture runoff for infiltration or reuse (e.g., irrigation). Accurate flow measurement is critical for calculating pollutant loads and captured flow volume. This section describes some key considerations for installation and device selection to obtain high-quality hydrology data.

5.4.1 Instrumentation and Primary Devices

A variety of methods are used to measure flow and calculate volume capture. Flow data are recorded by a data logging flow meter. There are many different manufacturers and types of data logging flow meters that can be used for stormwater monitoring applications. Flow meters common to BMP projects are summarized in Table 6.

Table 6. Common Flow Meter and Data Logging Instrumentation

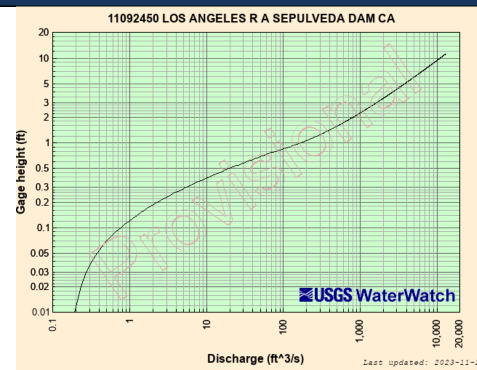
Hardware	Flow Measurements	Use with sampling	Example
Flow Meter	• Measure and log flow data independent of other devices. • Multiple primary device options and multiple inputs. • Telemetry capable, but limited control.	• When connected to a sampler or samplers, the flow meter can trigger a sampling program or send pulses to control sampling throughout an event. • Limited control via telemetry.	
Automated Sampler Flow Module	• Module connects directly on to the automated sampler to allow sampler to measure flow. • Single sensor input • Data are stored on the autosampler's memory.	• The flow module can trigger a sampling program or send pulses to control sampling throughout an event. • Limited control via telemetry.	
Data Logger	• May requires programming or coding. • Large array of capabilities based on the programming. • Can accept a variety of sensor inputs to calculate and/or log flow data.	• When connected to a sampler, the data logger can trigger a sampling program or send pulses to control sampling throughout an event. • Generally, provides more control via telemetry.	

Selection of the primary device to measure flow rates and volumes is largely based on the site conditions. Table 7 shows common primary devices used to measure flow in the stormwater industry, along with some constraints and benefits.

Table 7. Common Primary Devices with Benefits and Constraints

Primary Device	Benefit	Use Constraint	Examples
Area Velocity Sensor	Directly measure water depth and water velocity. Used with channel geometry, provides a direct output of flow rates and volumes	Data reliability affected by swift and/or turbulent flow.	 Area-Velocity Sensor
Weir	Can provide very accurate flow data. Large variety of weir types based on conveyance and expected flow ranges. Requires level sensor to calculate flow rates. Requires space to pond water behind weir without velocity impacts on flow over weir.	Can cause flow to back up. Depending on weir type, the spillway is subject to fouling or clogging. Swift water "pushing" through the spillway can result in data bias. May not be suitable for wet weather flows, depending on magnitude.	 V-notch weir
Flume	Can provide very accurate flow data. Large variety of flume types based on conveyance and expected flow ranges. Does not cause flow to back up. Generally considered one of the most accurate flow devices and can be more appropriate for stormflow compared with weirs.	Can be difficult to install because they must be perfectly level. Typically, will not work in a pipe conveyance. Requires ability for water to free fall out of the flume.	 Trapezoidal Flume

Table 7. Common Primary Devices with Benefits and Constraints (continued)

Primary Device	Benefit	Use Constraint	Examples
Stage Discharge Relationship	Requires only a level sensor, providing more options for long-term, robust installation.	Relies on a Manning equation or similarly modeled flow for output. Requires additional effort for field stream gauging to calibrate and validate the curve, which can be done only during safe conditions.	 USGS stage-discharge rating curve
Manning Equation (not an actual primary device)	Requires only a level sensor, but the sensor must be at the conveyance invert (or near the invert, in combination with a level offset). A Manning equation is suited for a large variety of conveyances, conditions, and construction types.	Flow based solely on level measurement and flow calculation. May not account for irregular or unforeseen high flow velocities.	Manning Equation: $Q = \frac{K*A*R^{2/3}*S^{1/2}}{n}$ where: Q = flow rate A = cross-sectional area of flow R = hydraulic radius (cross-section area divided by wetted perimeter) S = slope of the channel at the point of measurement N = surface roughness K = constant dependent upon units

5.5 Precipitation Measurement

BMP design is often based on anticipated runoff from a range of rain event sizes for the local area. A common design parameter is the 85th percentile storm event rainfall depth; however, BMPs may be designed to different design parameters. Precipitation data are important for understanding whether the BMP performs as expected for the range of design storms.

5.5.1 Device or Data Source Selection

A common rain gauge device for stormwater programs includes tipping-bucket rain gauges installed on site, which records 0.01 inch of rainfall with each bucket tip. The rain gauge is connected to the flow meter or datalogger and can be programmed to log data at desired intervals. Rainfall data can be used to calculate rainfall intensity and total rainfall. If it is not possible to install a rain gauge at the project site, nearby publicly available rain gauge data can be used in lieu of direct measurements. National Weather Service and Public Works rain gauges are suitable sources for rainfall data. Other online sources such as the Weather Underground or MesoWest network may have suitable rainfall data, but the data from a given location should be reviewed thoroughly for reliability. Precipitation data should be collected in the watershed draining to the BMP if possible.

> The Los Angeles County Public Works has real-time and historical rainfall data across the Los Angeles County areas. The information can be accessed from the following website: https://dpw.lacounty.gov/wrd/rainfall/

5.6 Field Observations

Field observations play an important role in documenting issues or site conditions that are not clear based on the flow and water quality data. Observations such as normal operation and flow through the BMP (if visible), clogging or surcharging, unusual discharge characteristics, notes regarding sample collection (e.g., bottle and pacing changes, missed samples, etc.), and other notes pertinent to BMP operation and performance monitoring must be recorded. Field observations should be made on every site visit and during every sampling event to document site conditions and identify any potential issues as early as possible.

> A digital field observation form helps streamline data collection and data management. Public Works has a Survey123 app designed to be completed during site visits to automate transfer of site observations. The app can be accessed at: https://arcg.is/1erCyG0

BMPs are subject to accumulation of debris, sedimentation, and high flows of stormwater. O&M is one of the most critical factors for successful BMP function. Sediment or debris clogging, failing slide gates, or other operational components may result in limited BMP function or "failing" status based the assessment framework tools described in Section 3.0. Field observations help detect issues early and have them addressed by O&M crews. Although field observations may seem to be a minor part of a BMP performance monitoring program, they are critical for overall program success.

5.7 Data Management and Remote Access

BMP performance monitoring programs generate a large amount of data from a single project. Data include discrete and continuous types that vary depending on the number of monitoring locations within the monitored BMP. Table 8 shows a few examples of each data type. Both data types should be maintained in a project database. Finalized data should be stored in specified formats for data receptacles such as the California Environmental Data Exchange Network (CEDEN).

Table 8. Examples of Discrete and Continuous Data Types

Discrete Data	Continuous Data
Laboratory sample analysis results	Flow data
Field water quality measurements	Rainfall data
Field observations	Water level data
Instantaneous flow measurement	Long-term water quality sensor (e.g., turbidity)

BMP performance monitoring projects may require water quality data be submitted in CEDEN format. Monitoring teams may require their contract laboratories to provide analytical results in CEDEN-Excel format.

Continuous data sets need to be managed differently from discrete data. Managing large amounts of continuous data can be challenging. Data collection and compilation require downloading data, compiling into the project database, and reviewing for data quality and anomalies. Data loggers with remote access (also referred to as "telemetry") can streamline these processes and can potentially be automated. There are two types of remote access data categories: "push" data and on-demand (or "push/pull") data. Figure 14 shows the primary difference between the two types of telemetry and are further described below.

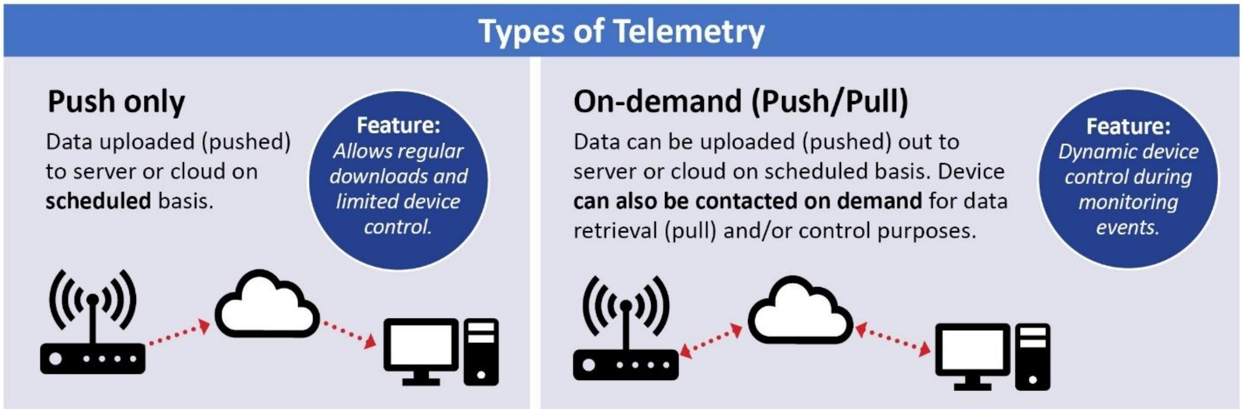


Figure 14. Push-Only versus On-Demand (Push/Pull) Telemetry

Push versus pull telemetry options offer different levels of data access and instrument control, which require different quantities of power. The method of data retrieval should be determined based off the individual BMP's capabilities and monitoring program requirements.

Either type of remote access can accommodate automated data download and compilation. Program scripting can be used to manage data, append data to databases, and display data on desired platforms, depending on the need for and level of effort required to write the code to automate these processes. In some cases, Microsoft Power Platform applications can be used to automate data management steps so data can be displayed and reviewed in applications such as Power BI. The level of automation and visualization is based on project needs, but automation can provide an efficient method to manage project data from download through QA/QC review.

5.8 Health and Safety

A health and safety training program ensures that field employees receive the appropriate level of training to conduct their work in a safe manner. The work that the field employees conduct will comply with the regulatory requirements, if applicable. Field employees are required to maintain the training qualifications necessary to perform their assigned duties and job functions. Training programs provided to LACPW field employees will be administered by the LACPW Stormwater Quality Division and coordinated by the Stormwater Quality Division’s Safety Coordinator with LACPW Risk Management Office. Additional training necessary to conduct water quality sampling for the project will be managed by the project’s field team leader (or designee). Additional trainings include, but are not limited to, the following:

- First Aid
- Cardio-Pulmonary Resuscitation (CPR)
- Confined Space Competent Person Training
- Gas Detector

- Hazardous Waste Operations and Emergency Response (HAZWOPER)
- 8 Hour Fall Protection: Worker at Heights
- Hazard Communication Program (HAZCOM)

Training sessions will be documented. Documentation and certifications verifying completion will be maintained by the Stormwater Quality Division safety coordinator, LACPW Risk Management Office, and if applicable, the Consultant PM for records pertaining to their consultant staff. Copies of the training documentation will be submitted to the PM. Training documentation will be made available for review at all times. This section does not substitute for training programs. Topics discussed in this section are common health and safety training requirements for storm water monitoring programs.

5.8.1 Fall Protection

There is a potential for slips, trips, and falls, due to the slippery surfaces during a sampling event and uneven terrain at some sampling sites. While collecting samples with a bucket at the edge of a waterbody or open manhole, it's possible to get pulled into the river/creek by turbulent flows or fall into the manhole due to slippery or uneven surfaces. A fall protection system, including a full body harness and lifeline, would prevent falling during monitoring events.

5.8.2 Confined Space Entry

Storm drains are classified as "confined spaces" under OSHA regulations. Regulations for entry into confined spaces are contained in 29 Code of Federal Regulations 1910.146 and 8 California Code of Regulations, Article 108, confined spaces, which states no person will enter a confined space without proper training and equipment. The risks associated with confined spaces include dangerous atmospheres, engulfment, falls, falling objects, and bodily harm due to explosion.

No confined space entry is required during storm events. Any maintenance or work needed to be conducted within the storm drain must be done during dry weather conditions. Any work that must be conducted within the storm drain will be conducted under the confined space entry procedures. The storm drain will be ventilated before and throughout the duration of the work being conducted within the confined space. A calibrated gas meter will be used to determine the oxygen level and the concentration of toxic gases. After the gas meter indicates the oxygen content in the catch basin is within safe levels and no hazardous atmosphere is present, maintenance staff may enter the space to conduct the work. The gas meter must monitor the air quality within the confined space constantly while work is being conducted. Another staff will remain outside of the confined space and constant communication will be maintained between the team members throughout the maintenance activity.

5.8.3 Personal Protective Equipment

During all site visits, personal protective equipment (PPE) must be worn at all times. This equipment protects the wearer from on-site related injuries such as slipping on wet surfaces, falling objects, oncoming traffic, and other potential injuries to sensitive areas on the body such as eyes, ears, mouth, and other extremities. PPE will consist of a high visibility vest, steel toe boots and safety glasses at a minimum but can also include but is not limited to:

- Full body harness for confined space entry
- Flashlight/head torch
- Gloves
- Ear Plugs
- Face mask/ respirator
- High visibility rain suit

PPE will be provided by LACPW for Public Works staff. Consultant teams will provide their own PPE. It is the responsibility of the person utilizing the PPE to contact the Storm Water Quality Division Safety Coordinator to receive replacement PPE as needed.

5.9 Checklists (Optional)

Checklists ensure sets of tasks are completed. Checklists are useful for event preparation tasks, data collection or monitoring event tasks, data compilation and review tasks, and many other activities that include a routine set of tasks. Storm monitoring can be exhausting, and simple checklists can help tired field teams be confident that they have completed the required tasks before, during, and after the event.

Checklists can also be designed to ensure that O&M occurs at the desired frequency and all steps are conducted. O&M requirements are specific to each type of BMP and often are specified by the BMP manufacturer. O&M procedures are described in the project monitoring plan and/or quality assurance project plan (QAPP) and may reference Public Works standard operating procedures.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Meaningful and reliable BMP performance assessments require high-quality data. The quality of the performance assessment is only as good as the quality of data collected for the assessment. QA/QC requirements and metrics assess project data quality and usability. Data that meet or exceed QA/QC metrics provide confidence in the data used for data analysis results and overall outcomes of the performance evaluation. This section describes the different types of QA/QC types for laboratory and field data. Sections 6.1 through 6.5 describe common measurement quality objectives (MQOs) and their calculation steps where applicable. A QAPP is often developed for monitoring programs. A QAPP includes the target MQOs and corrective actions if the MQOs are not met. Appendix B provides a QAPP template with a common document layout of information; examples, definitions, and tips; common analytes and MQOs; common text that may be useful to include; and prompts for new text specific to the project.

6.1 Data Quality

Data quality is typically broken down into two categories: precision and accuracy. Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Analysis of field duplicates will serve to measure the precision of samplers' techniques and methods. Analysis of laboratory duplicates will measure the precision of laboratory procedures. The precision of a duplicate measurements can be expressed as the relative percent difference (RPD). The mathematical equation to calculate the RPD is presented in Equation 2:

Equation 2. Calculation of the RPD

$$\mathrm{RPD} = \left\{ \frac{|\mathrm{X}_1 - \mathrm{X}_2|}{\frac{(\mathrm{X}_1 + \mathrm{X}_2)}{2}} \right\} \times 100$$

where

X_1 = native sample

X_2 = duplicate sample

Accuracy helps determine how close the analytical results are to the true value. In the laboratory, the accuracy of the analytical results will be checked with a matrix spike sample. A matrix spike sample will be prepared by the laboratory analyst by introducing a known concentration of a target analyte to a sample or a blank sample. Results of sample analysis will be used to determine how close the measured concentration is to the known concentration. The results will be expressed as percent recovery. For example, a common percent recovery range MQO will be set at 80-120%.

Precision measures how close repeated measurements are to each other. Accuracy measures how close the measurement is to the true or accepted value.

Measurement error is broken down into two components: random error and systematic error.

Random Error: Indicated by low precision.

Systematic Error: Indicated by low accuracy.

High precision and high accuracy reflect control of both systematic and random errors within the program. Figure 15 is commonly used to illustrate precision and accuracy.

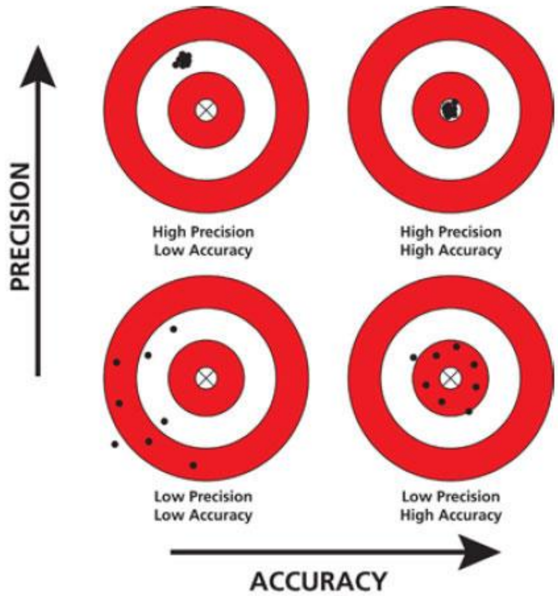


Figure 15. Conceptual Comparison of Precision and Accuracy

6.2 Laboratory QA/QC Types

Laboratory QA/QC sample analyses are common steps used by analytical laboratories. QA/QC requirements are often dictated by the analytical method and the laboratory QA manual. Furthermore, QA/QC requirements can be dictated by monitoring program requirements and statewide guidance such as the Surface Water Ambient Monitoring Program (SWAMP). SWAMP provides QA/QC requirements based on analytical group (e.g., conventional, organics, etc.). SWAMP QA/QC guidance serves as a good set of metrics for monitoring programs, but not always required. However, following SWAMP requirements is typically required for BMP projects funded by State Water Resources Control Board grants. Sections 6.2.1 through 6.2.4 describe common laboratory QA/QC requirements. Acceptable criteria limits for each measurement are prescribed in the project monitoring plan or QAPP. Limits are project-specific and determined based on project requirements. References such as SWAMP may be used for guidance when setting limits. Table 9 shows common MQOs for storm water monitoring programs.

6.2.1 Method Blank

Method blanks are prepared and analyzed by the laboratory as closely as possible in time to the original and QC samples to detect any sample contamination introduced in the laboratory. The results from the method blanks estimate any variability or bias by the analytical method.

6.2.2 Laboratory Duplicate

A laboratory duplicate is a portion of a sample taken from an original sample and then prepared and analyzed using the same process used for the original sample to quantify the precision of laboratory procedures.

6.2.3 Matrix Spikes and Matrix Spike Duplicates

A matrix spike (MS) is a sample prepared by the laboratory by spiking a known concentration of a target analyte to a specific amount of sample. A matrix spike duplicate (MSD) is similar to the MS and shows the effect of the sample matrix on the accuracy of the analytical results. MS/MSD sample recovery analyses are both measures of accuracy. The relative percent difference (RPD) between the MS and MSD is a measure of precision.

6.2.4 Laboratory Control Sample and Laboratory Control Sample Duplicate

The laboratory control sample (LCS)/laboratory control sample duplicate (LCSD; also often referred to as a blank spike/blank spike duplicate) is created in the laboratory using contaminant-free reagent water that is spiked with a known concentration of a target analyte for analysis using the same preparation and procedures used for the other project samples. Similar to MS/MSD analyses, the LCS/LCSD sample recovery analyses are both measures of accuracy and the RPD between the LCS and LCSD is a measure of precision.

Table 9. Data Quality and Measurement Quality Objectives

Constituent	Analytical Method	Reporting Limit	Accuracy (Percent Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Bacteria									
E. coli	SM 9223B	1 MPN/100 mL	NA	NA	No growth	NA	NA	Negative response	NA
Enterococci	SM 9230D	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Fecal Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Total Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Metals									
Copper (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7440-50-8
Lead (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7439-92-1
Zinc (Total and Dissolved)	EPA 200.8	10 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7440-66-6
Nutrients									
Total Kjehldahl Nitrogen	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7727-37-9
Ammonia-N	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7664-41-7
Nitrate-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Nitrite-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Nitrogen	Calculation	NA							
Total Phosphorus	EPA 365.3	0.02 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7723-14-0
Orthophosphate (as P)	EPA 300.0	0.01 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	14265-44-2

Table 9. Data Quality and Measurement Quality Objectives (continued)

Constituent	Analytical Method	Reporting Limit	Accuracy (Percent Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Particulate Matter									
Total Suspended Solids	SM 2540D	1.0 mg/L	NA	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Conventional Chemistry									
Oil and Grease	EPA 1664	5.0 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Total Organic Carbon	SM 5310B	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Hardness as $CaCO_3$	SM 2340C	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA

Notes:
µg/L = microgram(s) per liter; $CaCO_3$ = calcium carbonate; CAS = Chemical Abstracts Service; E. coli = Escherichia coli; EPA = United States Environmental Protection Agency; mg/L = milligram(s) per liter; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not applicable; RL = reporting limit; SM = Standard Method

6.3 Field QA/QC Types

Field QA/QC sample types are collected during sampling to assess field sampling techniques for contamination and repeatability. Field QA/QC frequency and sample type requirements and acceptable criteria limits for each sample type are prescribed in the project monitoring plan or QAPP. These requirements are often based on those recommended by SWAMP but may be project specific. The QAPP for Evaluating the East Los Angeles Sustainable Median Stormwater Capture Effectiveness Monitoring (Public Works, 2023) is an example of common field QA/QC criteria limits for sample types and corrective actions when exceeded. Sections 6.3.1 through 6.3.4 describe common field calibration and field QA/QC requirements.

6.3.1 Field Equipment Calibration

A multi-parameter water quality meter is used to measure in situ physical water quality parameters such as dissolved oxygen, temperature, pH, turbidity, and conductivity. The probe must be calibrated according to the manufacturer's specifications prior to each sampling event.

Water level measurements by a pressure transducer or AV sensor should be checked against a known level prior to installation and water level offsets applied if necessary. Once the equipment is installed, visual assessments will be made if possible without confined space entry. If data are questionable, a maintenance visit may be required for confined space entry to test and replace sensors if needed. Velocity is calibrated by the manufacturer and the equipment cannot be calibrated or adjusted. Table 10 provides an example of calibration frequencies for common water quality probes.

Table 10. Examples of Instrument Calibration Frequency

Equipment Type	Calibration Frequency	Standard or Calibration Instrument
pH	Each sampling day	pH 4.0, 7.0, and 10.0 buffer solutions according to manufacturer's recommendations
Conductivity	Each sampling day	1,000 microsiemens per centimeter (µS/cm) calibration standard solution according to manufacturer's recommendations
Dissolved Oxygen	Each sampling day	At a minimum, water-saturated air, according to manufacturer's recommendations

6.3.2 Field Blank

Field blank samples are collected by pouring contaminant-free reagent water into sample containers for analyses as grab samples. Field blank samples are prepared and tested with the actual samples collected during sampling events. Potential contamination from field handling procedures is assessed through analysis of the field blanks. Per SWAMP guidance, field blanks should occur at a rate of 5 percent of total project samples. This often results in field blank collection once or twice per monitoring year.

6.3.3 Sample Duplicate

Sample duplicates are collected into separate, clean, laboratory-certified bottles and analyzed as independent samples, in the same manner as the original environmental samples. These duplicates are used to document the precision of the sampling process. Per SWAMP guidance, field sample duplicates should occur at a rate of 5 percent of total project samples. This often results in field sample duplicates collection once or twice per monitoring year.

6.3.4 Equipment Blank

Equipment blank samples are collected and analyzed after auto-sampler installation to detect contaminants in the intake tubing, auto-sampler pump tubing, and auto-sampler bottles. Laboratory-grade deionized water is pumped through the autosampler tubing with the peristaltic pump into a clean sample container. The equipment blank sample is packaged and delivered to the laboratory for analysis. Equipment blank samples are typically collected once per monitoring year, preferably at the beginning of the monitoring year.

6.4 Hydrology Data Accuracy and Precision Needs

Hydrology data are critical for BMP performance monitoring. Accurate flow data are needed to evaluate BMP performance in terms of capturing the expected amount of flow and calculating pollutant load removal. Flow measurement accuracy and precision are based on primary device selection and conveyance characteristics. Factors described in Section 5.4 should be considered to obtain the highest data quality possible based on site factors. Measuring flow accurately is challenging even in ideal conditions. Flow measurements within an accuracy range of ±20 percent are generally considered acceptable in the surface hydrology industry, but that range can expand based on flow characteristics and suitable measurement points. If possible, using manual flow measurements to check against sensor measurements provide increased confidence in data outputs.

Manual flow can be measured using volumetric methods or stream gauging techniques such as those used by the United States Geological Survey (USGS). Manual flow measurements increase confidence in data collection but can typically be taken only during lower flows because of safety concerns.

Volumetric Method

The volumetric method involves collecting discharge in a bucket while measuring the time it takes to collect water. This provides a volume of water over time, equaling a flow rate. It is important to ensure that the entire discharge is collected during the test period. This method often requires a point where the flow spills out from an outfall or over a weir to allow for bucket or collection device placement. Figure 16 shows field crew collecting a volumetric flow measurement from a weir.

Figure 16. Field Crew Collecting Volumetric Flow Measurement

Stream Gauging

Stream gauging can be conducted in larger conveyances or streams. A common method for stream gauging is the 0.6-depth method, where velocity is measured at multiple points across the channel at 0.6 of the depth at each point. Stream gauging methods are described in detail in the USGS document titled Measurement and Computation of Streamflow (Rantz, 1982). The USGS document also describes the volumetric method and many other flow measurement techniques. A staff gauge can be installed on site to use as a consistent visual water level measurement point. Figure 17 shows an example of a staff gauge installed in a water body.

Figure 17. Photo of Staff Gauge Measuring Water Depth

6.5 Rainfall Data Accuracy and Precision Needs

Rainfall data accuracy is typically 0.01 inch based on common industry use of 0.01-inch tipping bucket rain gauges. These gauges provide sufficiently accurate and precise rainfall data for BMP performance evaluation purposes. Clogging, incorrect installation, or other physical factors can affect instrument performance, but when installed and maintained correctly (see Section 5.5), rain gauges are considered reliable.

7.0 REPORTING

BMP performance evaluation reporting is the final critical step to complete a project. Reporting is how the measured performance of the BMP is communicated to stormwater managers, stakeholders, grant managers, and other interested parties.

7.1 Reporting Requirements

Reporting requirements vary based on project requirements. For example, requirements for a grant program may include elements not required for annual watershed reporting programs. Although specific reporting requirements may vary, some elements are common to all reports. Common elements include descriptions of the BMP; monitoring objectives or study goals, including pollutant reduction and/or volume diversion goals; methods for monitoring and data analysis; results of data analysis; and a discussion of results and conclusions. Section 7.2 describes common sections to use as a guideline for BMP performance monitoring report development. Appendix D provides an example BMP performance monitoring report for the East Los Angeles Sustainable Median Stormwater Capture Project.

7.2 Report Sections

The following report outline provides a guideline for sections to include in a BMP performance evaluation report; however, specific sections may or may not be included depending on the monitoring program (e.g., if no dry weather monitoring is conducted, the dry weather monitoring sections shall be removed from the report).

1. Introduction
    - 1.1. Project Description
    - 1.2. Project Benefits
    - 1.3. Monitoring Objectives
    - 1.4. Study Questions
    - 1.5. Reporting Period
    - 1.6. Accomplished Monitoring Activities
2. Monitoring Approach
    - 2.1. Monitoring Location
    - 2.2. Monitoring Frequency
    - 2.3. Sampling Methodology
        - 2.3.1. Dry Weather Sampling Method (if applicable)
        - 2.3.2. Wet Weather Sampling Method
    - 2.4. Sample Handling
    - 2.5. Chain-of-Custody Form

   2.6. Field Observation
   2.7. Field Measurements
   2.8. Flow Monitoring
3. Results
   3.1. Water Chemistry
   3.2. Quality Control/Quality Assurance
   3.3. Runoff Volume Calculation
   3.4. Pollutant Loading Calculation
   3.5. Pollutant Removal Evaluation
   3.6. BMP Effectiveness
4. Discussions
   4.1. BMP Performance
   4.2. Further Investigation
5. Conclusion
6. References

8.0 DATA REPOSITORY

Equally important for project reporting is project data management. Data must be stored in an organized, methodical fashion for integration into the Public Works internal database and grant-required databases and for efficient data parsing, compilation, and analysis.

8.1 BMP Databases

As part of the stormwater BMP effectiveness monitoring, tremendous amounts of data will be collected and compiled. Based on program requirements, BMP database requirements may include multiple databases, each with specific requirements. A single open-source data repository shall be prepared to store and retrieve the monitoring data so that performance information can be shared, harvested, and assessed. Not only does the data repository store dynamic data from routine monitoring, but it should also capture static data of various types of BMP projects. Programs funded by the State Water Resources Control Board may require data storage in CEDEN. The CEDEN database currently includes only discrete data such as chemistry or field measurements. CEDEN does not have the capability to upload continuous data such as flow data. CEDEN guidance requirements are provided at http://www.ceden.org.

The data repository may be hosted on the cloud (such as Amazon Web Services or Microsoft Azure) or on premise. Ideally, the data repository should make data easy to upload and download, allow for direct connections to sensor technology, incorporate measurements of data quality, and have automated QA/QC checks to ensure data uploads are complete and compliant with data quality objectives. While the development of a successful online platform is predicated upon skilled data scientists and programmers working collaboratively with stormwater technical experts, the data upload and download routines should be simple and intuitive, based on the needs of the end-users. A strategic goal will be to make the system compatible and inviting to local co-permittees and others, incentivizing their contribution to, and use of, the system. Thus, the platform can become a county-wide (or state-wide) system helping all parties increase the total amount of data available to assess BMP performance and inform improved future decision making about BMP selection, design, and maintenance by stormwater managers.

8.1.1 Urban Stormwater BMP Database

The Urban Stormwater BMP Database project is a voluntary, collaborative effort focused on providing science-based information to advance the state of the practice for urban stormwater management. The front page of the Urban Stormwater BMP Database is presented in Figure 18 The project’s long-term purpose is to provide scientifically sound information that informs improved design, selection, implementation, cost-effectiveness and ultimately performance of BMPs, also known as stormwater control measures. The Urban Stormwater BMP Database includes voluntarily shared performance monitoring data and study site metadata in a consolidated, publicly accessible repository that can be used to support selection of BMPs appropriate to achieve stormwater management goals. Performance data, data entry spreadsheets, performance summary reports and monitoring guidance can be accessed through the website (https://bmpdatabase.org/urban).

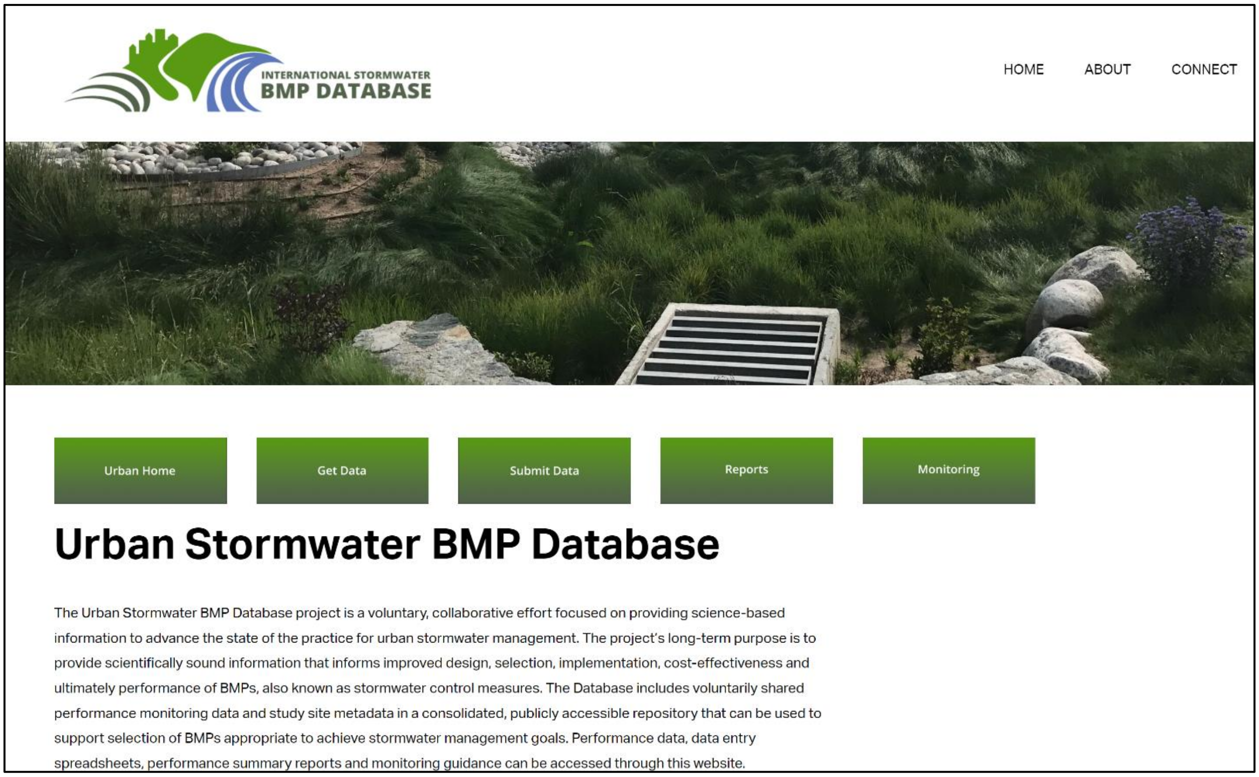


Figure 18.Urban Stormwater BMP Database

8.1.2 BMP Performance Application

The BMP Performance Application (https://sccwrp.shinyapps.io/alternative-compliance-pathways-/) was developed by SCCWRP and SFEI. The front page of the application is presented in Figure 19. The application allows watershed managers to upload their stormwater BMP performance monitoring data and analyze it in two different ways. The first evaluates if the local BMP is achieving water quality targets specified in the BMP design. The second evaluates how the local BMP is performing relative to similar BMPs in the International Stormwater BMP Database (https://bmpdatabase.org). This information will help watershed managers decide if they are achieving water quality goals, if the BMPs might need maintenance to improve performance, or if BMP design specifications might need to be upgraded.

The application supports monitoring designs that collect BMP influent and effluent sampling during the same storm event. The application will provide an answer for a single storm, but multiple storm events are preferred. The BMP app will accommodate chemical, bacteria, trash, or volume data, but it requires a threshold to work properly. The BMP application can be used for a variety of BMPs including bioretention, biofilter, dry wells, detention basins, baffle boxes, and infiltration galleries, but is designed to be used one location at a time.

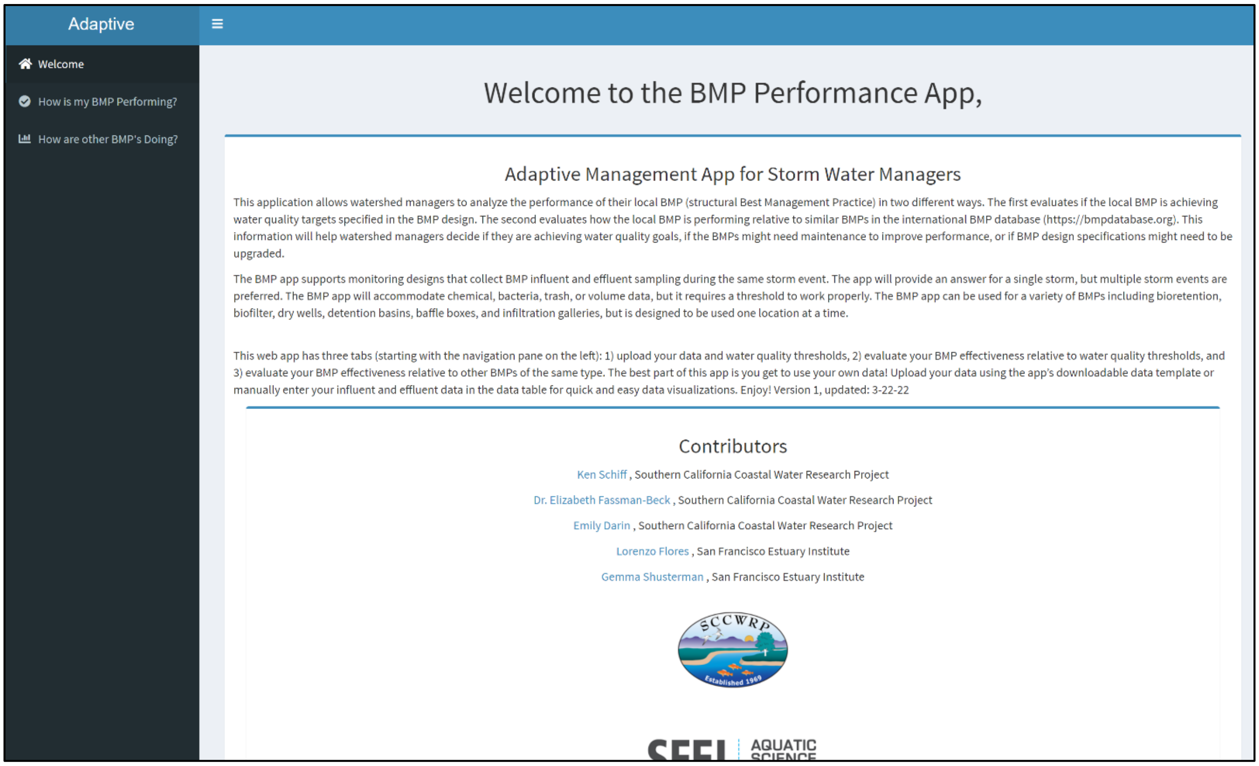


Figure 19. BMP Performance Application

8.2 Metadata Interface

Metadata refers to information or data about data. It is used to provide information such as the source of the data, the collection method, the name of the person who collected those data, and any manipulation of the data. Metadata for BMP performance evaluations can also include field observations recorded on the Survey123 app. Information recorded on the app can assist in data management and analysis by increasing understanding of any issues during data collection, verification of primary device and channel characteristics for flow measurement, and any necessary data corrections based on field observations.

8.3 BMP Performance Application

The BMP performance evaluation tool described in Section 3.0 is publicly available. The tool can be accessed via the following link: https://sccwrp.shinyapps.io/alternative-compliance-pathways-/. From this website, data can be uploaded in the tool's specific data format to output performance assessment results based on the categories described in Section 3.0. This tool also allows the performance of other BMPs to be researched. The online version of this tool currently allows only assessment of the water quality category.

9.0 REFERENCES AND BIBLIOGRAPHY

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APPENDIX A

Example Monitoring Plan:

East Los Angeles Sustainable Median Stormwater BMP Project

DRAFT

East Los Angeles Sustainable Media Stormwater Capture Project Post-Construction Monitoring Plan

Created: 06/15/2018

Updated: 07/08/2020

Confidential and Privilege

Los Angeles County Public Works

Stormwater Quality Division

Environmental Planning Section

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The East Los Angeles Sustainable Median Stormwater Capture Project (Project) aims to provide water quality improvement to the downstream Rio Hondo and Los Angeles River receiving water bodies. The Project was first proposed in the Upper Los Angeles Enhanced Watershed Management Plan (EWMP). In subsequent determinations, it was recommended that four storm water treatment systems would be used to capture and filter pollutants from an upstream 3,000-acre sub-drainage area. In this Project, two types of storm water treatment configurations will be used to complete the tasks. The first type of the storm water treatment configuration will utilize a nutrient separating baffle box to physically filter out pollutants from water; while the second type of the treatment system will utilize biochar and sand mixture to trap pollutants in the water through adsorption, absorption, and filtration. In addition to improving water quality, the Project will help promote water conservation by reducing irrigation water usage and will provide additional recreational areas benefit to the local community.

This monitoring program has been developed to evaluate the effectiveness of the storm water treatment systems in terms of volume capture and pollutant removal ability. Monitoring has been identified at each of the treatment system's influent, effluent, and bypass locations, for a total of 14 locations across the four treatment systems. Using the pre-construction monitoring data, the post-construction monitoring strategy is refined that sampling requirements will be divided based on dry and wet weather conditions. Dry weather water quality samples and flow measurement will be conducted only at the treatment system 1, while wet weather water quality samples and flow measurement will be conducted at all the monitoring locations. Water quality samples will be analyzed for bacteria, metals, nutrients, oil and grease, total organic carbon, particulate matters, and conventional chemistry compounds. Flow rate will be measured with the assistance of the circular weir, where necessary.

Data will be evaluated to ensure the data quality fulfills the established objectives. The data quality objectives describe requirements for the analytical methods, the detection limit, the accuracy and precision for the quality control samples, and the completeness of the dataset. As part of data analysis, total runoff volume and pollutant loading will be calculated. Hypothesis testing approach will be used to determine if pollutants are significantly removed by the treatment systems and treatment effectiveness will be evaluated using the effluent probability method.

Routine inspection and maintenance will help optimize the performance and extend the useable life of the treatment system. The inspection and maintenance schedules are proposed based on engineers' recommendations. An adaptive management process will be utilized for this monitoring program and adjustments to the program may be implemented if unforeseen challenges are encountered.

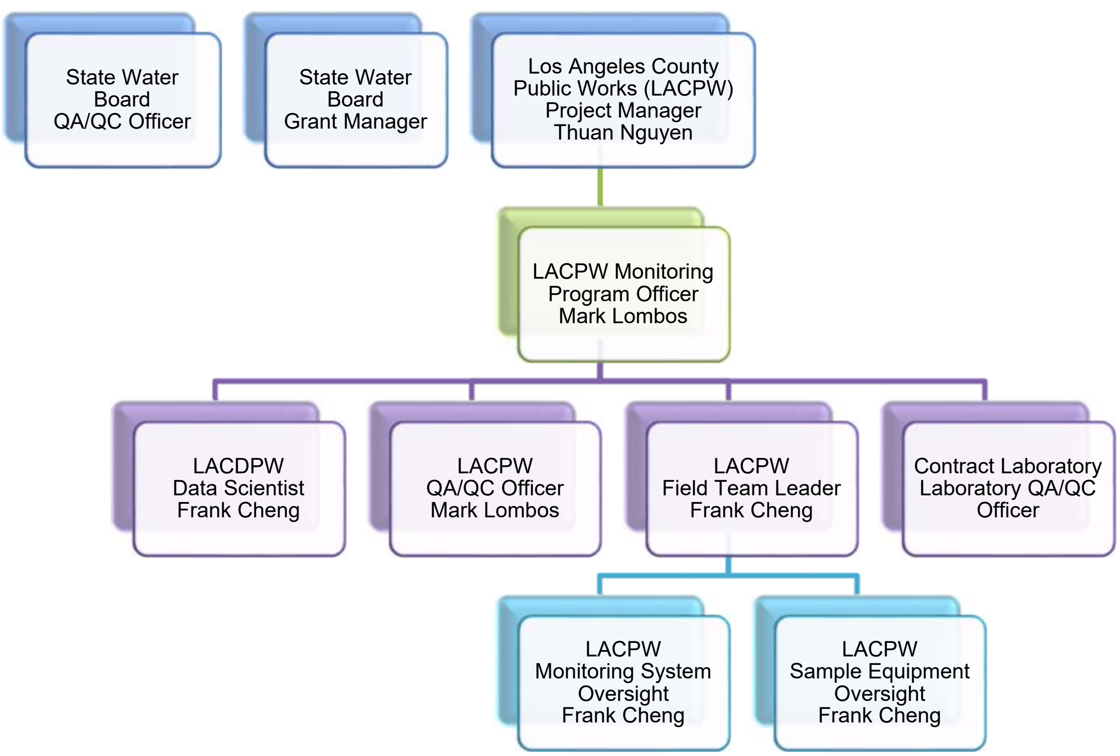
1.0 INTRODUCTION

Landscape Maintenance District Zone 35 – Montebello contains large medians along the Northside Drive, Southside Drive, Concourse Avenue, and Montebello Park Way. In the past few years, over 100 trees within the area were removed because they were determined to be a potential safety risk due to ailing health issues. These trees were experienced several factors, such as prolonged drought and disease. To address the issue, the East Los Angeles Sustainable Median Stormwater Capture Project (Project) is proposed. The Project emphasizes on multi-benefits focusing on redesigning the surface landscape, providing extra recreational areas to the community, and promoting storm water reuse at the project site. In addition, a series of underground storm water treatment systems will be used to capture stormwater run-off pollutants. In this monitoring plan, the storm water quality components will be discussed in detail.

1.1. Project Organization

The functional groups that will be responsible for conducting the post-construction monitoring are illustrated in Figure 1.

Figure 1 Project organization in conducting the monitoring



2.0 PROJECT DESCRIPTIONS

2.1. Objective

There are multiple objectives that the Project will be achieving. The Project will increase urban green spaces by planting native and drought tolerant plants at the center medians. The surface landscape will be enhanced. Water efficient irrigation system, decomposed granite walkways, par course exercise stations, picnic tables, and benches will be provided in the median. In addition, multiple storm water treatment devices will be constructed to enhance the water quality downstream from the Project's site. The overall drainage area map for the Project is presented in Figure 2. In addition, the existing land use in the Project area consists of 80% high density single family residential development, eight percent multi-family residential development, seven percent undeveloped areas, and five percentage commercial development. The project will offer a unique opportunity for education by demonstrating the concept of sustainable development to the local community. The Project benefits are briefly described in the below sections.

2.1.1 Water Conservation

The Project will be located above the Central Basin unconfined aquifers, utilizing more than 100 infiltration wells to infiltrate treated storm water into the ground. It is estimated that the Project will be able to capture and provide approximately 21 acre-feet of treated storm water to recharge the aquifers every year. In addition, drought tolerant plants and native trees will be planted in the road medians to enhance the surface landscape. A high efficient watering system will be used to further reduce the water usage for irrigation.

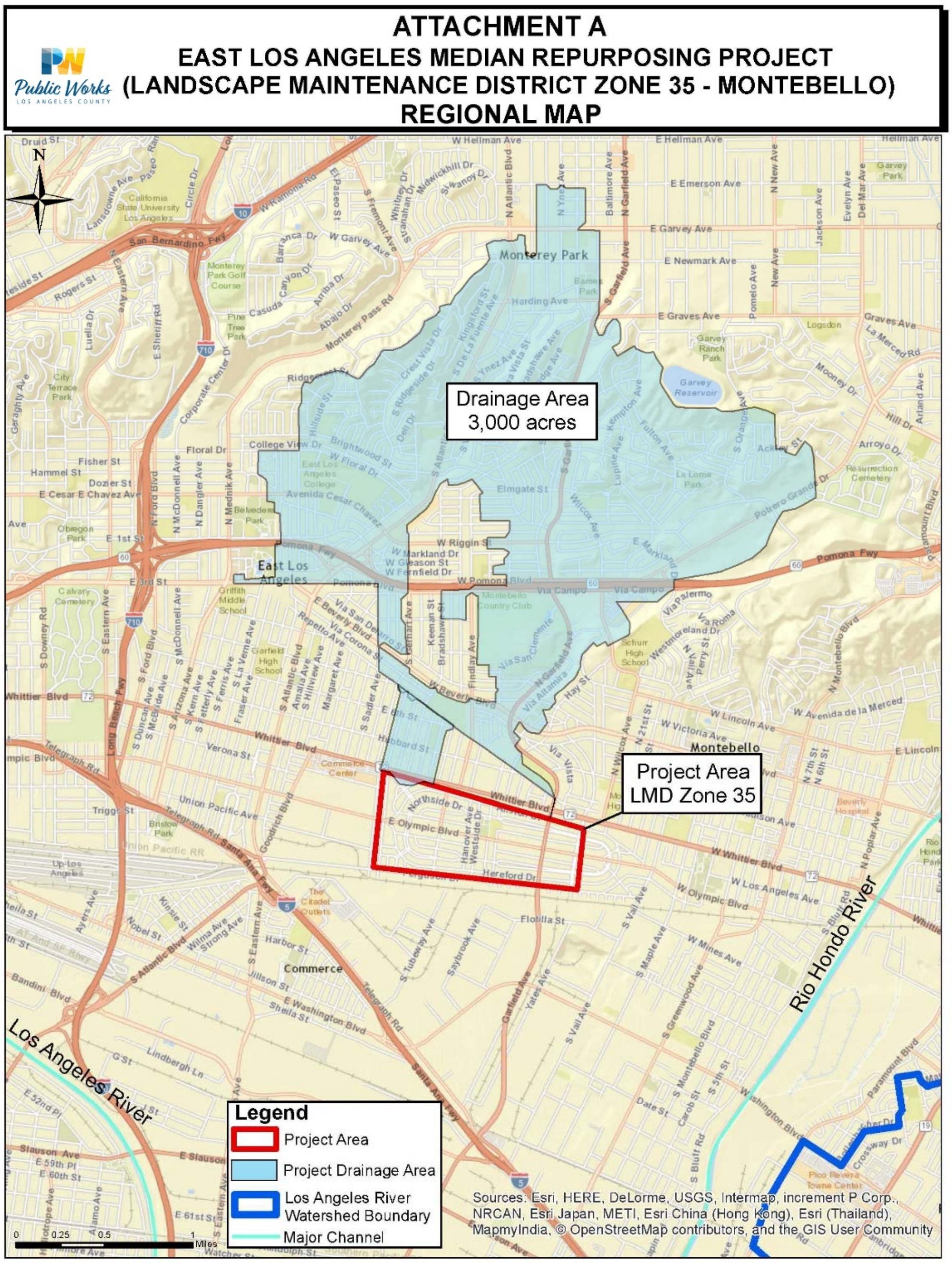
2.1.2 Recreation and Education/Outreach

The Project will provide active-passive recreational improvements and potential educational opportunities to the local communities, especially to the nearby Montebello Park Elementary School. The recreational improvements include construction of the interpretive educational signs to promote sustainable development and water conservation, and will provide exercise outdoor fitness equipment that meet the Americans with Disabilities Act (ADA) requirements. Teachers from the Montebello Park Elementary School may also use the Project to educate the students about water conservation concepts.

2.1.3 Improving Water Quality

The lower Los Angeles River watershed was identified on the Clean Water Act Section 303(d) list as one of the impaired water bodies. The water quality exceeded the desired nutrients, metals, and bacteria concentrations. The Total Maximum Daily Loads (TMDL) were developed to regulate the water quality discharge from the surrounding sub-watershed areas and help meet water quality standards. One of the project objectives is to address the water quality challenges and reduce pollutants discharging into the Los Angeles River. Several storm water treatment devices will be installed for this project. The storm water treatment devices are designed to contain and remove floatable trash, suspended sediments, nutrients, metals, and hydrocarbon pollutants from the runoff. The goal is to reduce the targeted pollutants entering the Los Angeles River and thus, fulfill the TMDL water quality requirements.

Figure 2 Project's drainage area map



2.2. Water Quality Regulation

The Project will be situated in the upper Los Angeles River watershed region. Water coming from the Project's upstream sub-drainage area will discharge into the Rio Hondo River. Water in the Rio Hondo River travels approximately 6.5 miles before becoming confluent with the Los Angeles River. Water discharged into the Rio Hondo River (Reach 1) and Los Angeles River (Reach 2) is subjected to comply with the Los Angeles River Bacteria and Los Angeles River Metals TMDL requirements.

The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit Order No. R4-2012-0175 (Permit) became effective December 28, 2012. The MS4 Permit provides permittees an option to develop an Enhanced Watershed Management Program (EWMP) to demonstrate compliance with water quality standards. The Upper Los Angeles River Watershed EWMP was developed by the County of Los Angeles and various cities to address the water quality issue within the Los Angeles River Watershed area. The vision for development of the EWMP was to utilize a multi-pollutant approach that maximizes the retention and urban runoff usages as resources for groundwater recharge and irrigation, while also creating additional benefits for the surrounding communities. One of the key elements in the EWMP is to determine and identify the network of control measures [also known as best management practices (BMPs)] that will help achieve the pollutant reduction goal required by the Permit. The identification of the BMP needs is based on the water quality priorities and the results obtained from the reasonable assurance analysis. A wide range of control measures were proposed in the EWMP including low-impact development, green streets, institutional control measures, and regional BMPs. The Project was identified as one of the high priority-regional BMP projects. The Project's goal is to help reduce the amount of pollutants discharging into the Los Angeles River.

3.0 MONITORING STRATEGY

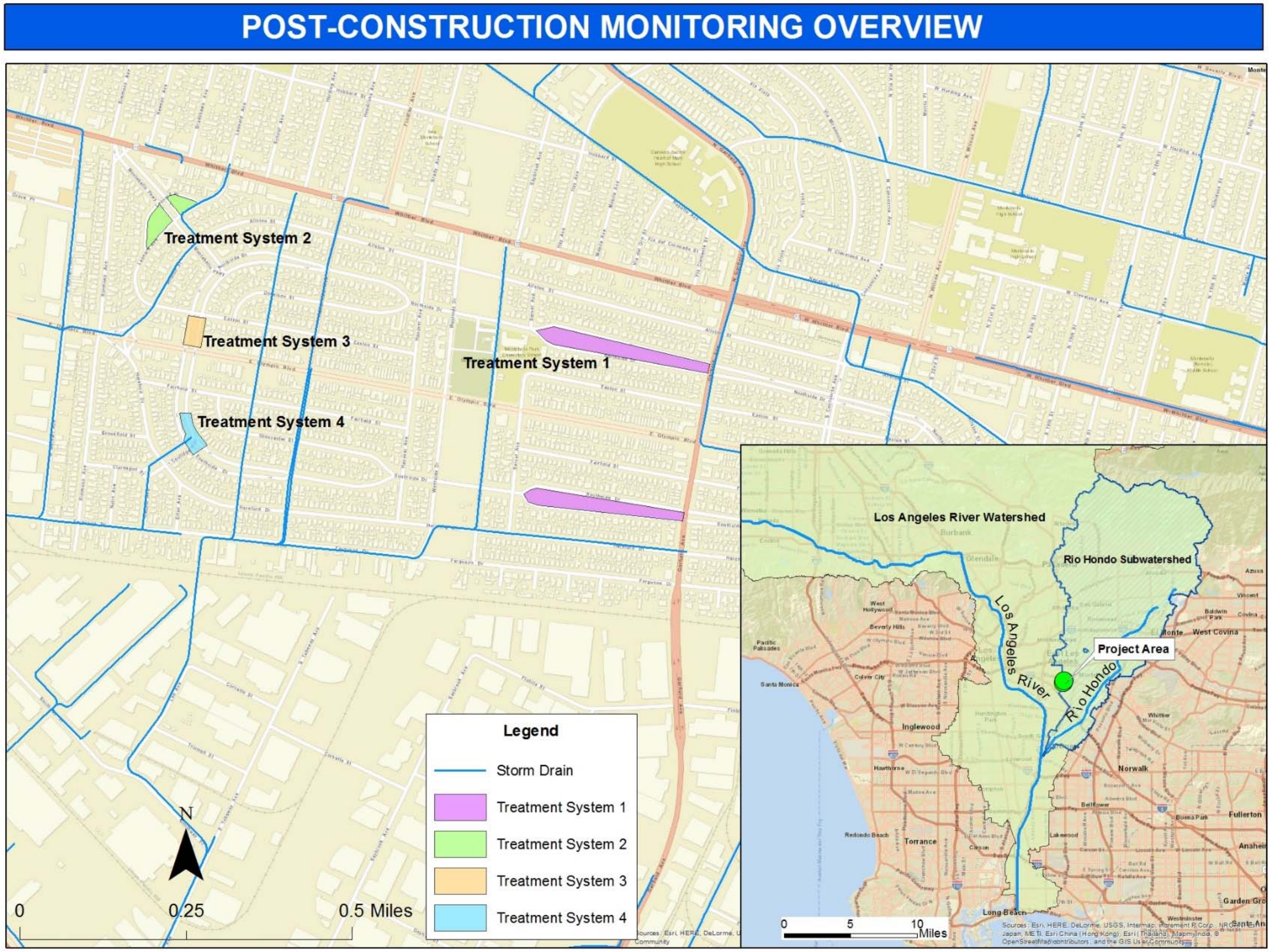
3.1. Monitoring Purpose

The purpose of the monitoring is to evaluate the effectiveness of the storm water treatment systems in terms of volume capture and pollutant load reduction. Monitoring focuses on quantifying the amount of the TMDL-specified pollutants that will be captured by the treatment systems. Paired samples collected from the treatment systems' influents and effluents will be evaluated for water chemistry characteristics. The results will reveal whether pollutants can effectively be removed by the treatment systems. Water quality data collected from multiple sampling events may be pooled together to create a larger data set for analysis purpose. The information gathered from the study may assist with selecting and implementation of more regional BMP projects in the future.

3.2. Location

The monitoring will focus on quantifying the pollutant removal effectiveness of the four treatment systems. Treatment system 1 will be located at the intersection between the Northside Drive and Garfield Avenue and the Southside Drive and Garfield Avenue; treatment system 2 will be located between the Montebello Parkway and Leonard Avenue; treatment system 3 will be located between the Northside Drive and Olympic Boulevard; and treatment system 4 will be located between the Southside Drive and Coolidge way. The locations of the treatment systems are presented in Figure 3.

Figure 3 Treatment system location map



3.3. Storm Water Treatment System Design

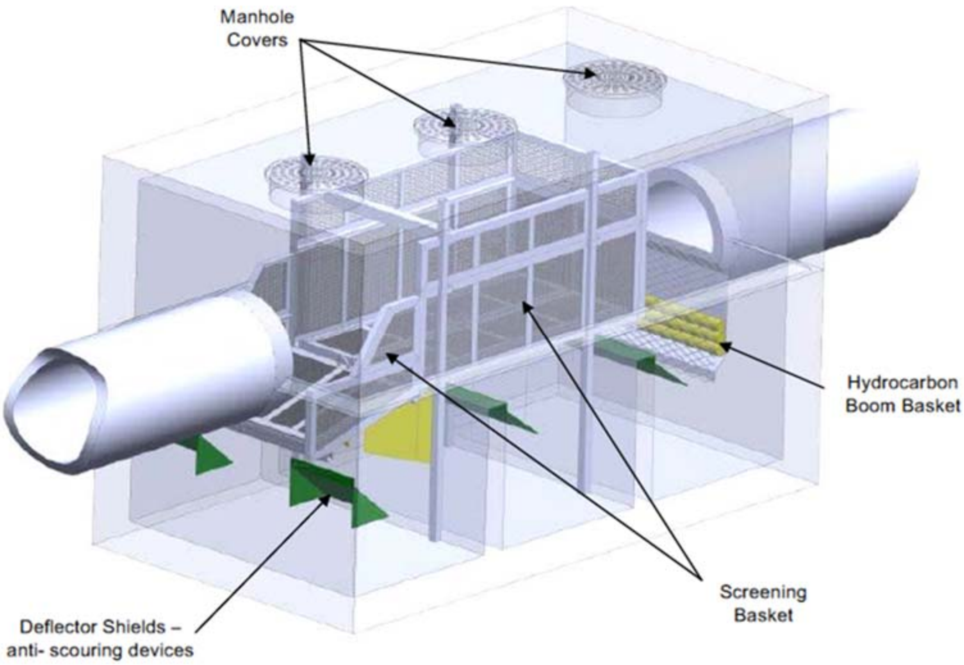
Two different types of storm water treatment configurations will be used in this Project. The first configuration will utilize a diversion structure, a nutrient separating baffle box (NSBB), and a series of infiltration wells to capture storm water pollutants. The configuration features a three-step treatment process that involves diversion, filtration, and infiltration. This type of treatment configuration will be found in the treatment system 1, 2, and 4. The second type of treatment configuration consists of a pre-treatment chamber, a structural cell module system, and an infiltration well. The configuration features a four-step treatment process that involves diversion, adsorption, absorption, and infiltration. This type of treatment configuration will be found in the treatment system 3. The treatment processes are further elaborated below.

3.3.1 Treatment System Configuration #1

Step 1 - Diversion: Storm water flow will be diverted from the existing storm drain into a NSBB through a diversion structure. Water will flow continuously into the treatment system until the flow rate in the existing storm drain exceeds the design specification. When this happens, water will bypass the treatment system and continue to travel inside the existing storm drain.

Step 2 - Filtration: The NSBB is a concrete box that is designed to filter storm water pollutants in dry and wet weather conditions. Inside the NSBB is a screening system, a skimmer system, and three sediment removal chambers. When water enters the NSBB, solid debris will be captured by the screening system, floating pollutants will be captured by the skimmer system, and suspended sediment will settle from the water column in the sediment removal chambers. A hydrocarbon boom is used to capture any remaining oil and grease from the water before it leaves the NSBB. The NSBB is presented in Figure 4. Water treated by the NSBB will discharge into a series of interconnected infiltration wells for infiltration.

Figure 4: Nutrient separating baffle box



In addition to the NSBB, surface runoff may be captured by the renew catch basins located along the curbsides of the streets. The renew catch basin will be able to capture more water than the existing one by extending the depth of the basin. An overflow feature will also be incorporated in the catch basin design. When flow rate exceeds the catch basin's design capacity, excess water will be diverted into the existing storm drain. Water from the renew catch basin will be routed into a series of interconnected infiltration wells for infiltration.

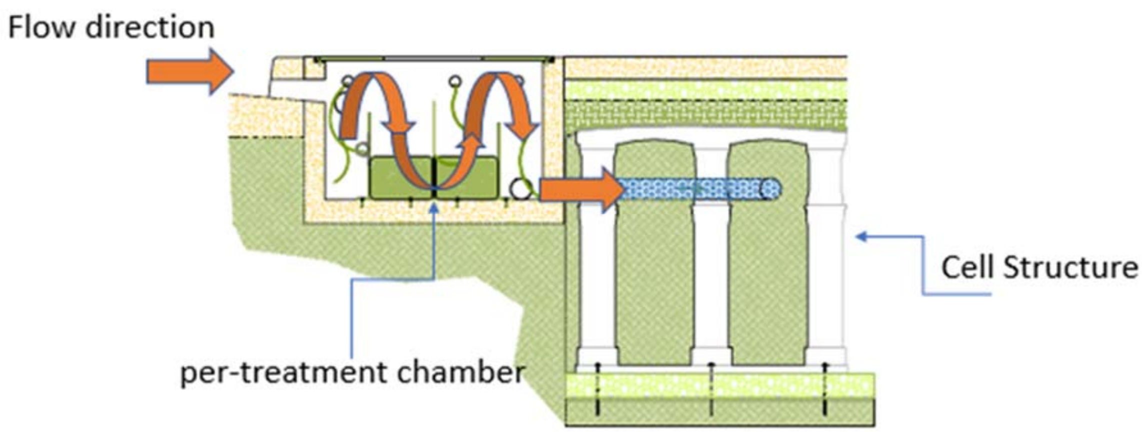
Step 3 - Infiltration: A series of interconnected infiltration wells will be constructed to infiltrate the treated storm water. Inside the infiltration well, water will slowly percolate through the soil to recharge the groundwater basin. During the percolation process, pollutants may be further removed from the water column through the natural filtration property of the soil particles.

3.3.2 Treatment System Configuration #2

Step 1 - Diversion: Surface runoff will be captured by the pre-treatment chamber located along the curbsides of the streets. A pre-treatment chamber will be constructed upstream from the structural cell module system to remove additional pollutants from the surface runoff.

Step 2 – Absorption and Filtration: Inside the pre-treatment chamber, a series of filter cartridges will be found to filter out pollutants from the water column. The filter cartridges will be filled up with biochar and sand mixture. The filter cartridges will consist of 30% biochar and 70% sand wrapped in fibric. Openings will be available on top of the pre-treatment chamber for easy access and replacement of the filter cartridges. Baffles will be installed in-between the filter cartridges so that water will flow from one filter cartridge to another. Filtered water will continue to flow downstream from the pre-treatment chamber to the structural cell module system via the underdrains. The pre-treatment chamber and the structural cell module system are presented in Figure 5.

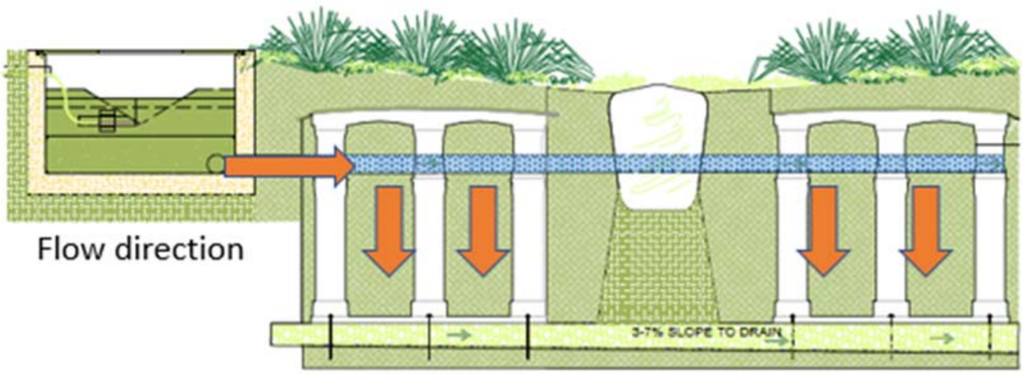
Figure 5 Pre-treatment chamber for the structural cell module system



Step 3 – Absorption, Filtration and Uptake: The structural cell module system located downstream from the pre-treatment chamber will contain additional biochar and soil mixture to further clean up the storm water. Nutrient and metal compounds retained by the biochar acts as a food source to enrich the soil microbial community and support the plant growth. Since the pre-treatment chamber is the first line of defense to remove pollutants from the storm water, the filtration property of the biochar in the structural cell module system can be preserved, thus extending the usable life of the materials.

Two zones with different biochar-to-sand ratios will be assigned for each of structural cell module systems. The first zone will be located near the tree root where a lower biochar-to-sand ratio will be applied. The second zone will be located away from the tree root where a higher biochar-to-sand ratio will be applied. At the same time, because of the moisture retaining property of the biochar, the frequency of watering the tree planted on top of the structural cell module system may be reduced. The treated water inside the structural cell module system will be collected in a network of perforated pipes located at the bottom of the structure. Water leaving structural cell module system will be discharged into the infiltration well for infiltration. The structural cell module system is presented in Figure 6.

Figure 6 Structural cell module system



Step 4 - Infiltration: An infiltration well will be constructed to infiltrate the treated storm water. Inside the infiltration well, water will slowly percolate through the soil to recharge the groundwater basin. During the percolation process, pollutants may be further removed from the water column through the natural filtration property of the soil particles.

3.4. Pre-construction Monitoring Results

Pre-construction monitoring was conducted by Los Angeles Department of Public Works (LACPW) in 2016 and 2017. The purpose of pre-construction monitoring was to establish the baseline dry weather and wet weather water quality and flow conditions before project construction. The pre-construction monitoring results were used to refine the design of the BMP to be suitable for the Project's site-specific needs.

Two monitoring locations were selected downstream from the treatment system 1 and 2. The monitoring location map is presented in Figure 7. The first monitoring site (station ID# ELA-01) was located on Hay Avenue between Garfield Avenue and Whittier Boulevard (latitude: 34.018398 longitude: -118.133686) inside the DDI 23 storm drain. Water from the DDI 23 storm drain will be diverted into the treatment system 1 after construction. The second monitoring site (station ID# ELA-02) was located on the intersection between Leonard Avenue/Easton Street/Allston Street (latitude: 34.014470 longitude: -118.145112) downstream from the treatment system 2 inside the storm drain. At the two monitoring locations, from September 2016 through October 2016, four dry weather water quality samples and one dry weather water quality sample were collected at ELA-01 and ELA-02 respectively. Five wet weather samples were collected at both locations (ELA-01 and ELA-02) from November through February 2017. Flow rate was measured continuously in the storm drains during the study period and was used to calculate the daily average runoff volume.

Figure 7 Pre-construction monitoring location map

The pre-construction monitoring results showed that, on average, 0.17 and 0.02 acre feet of annual dry weather runoff may be captured by the treatment system 1 and 2, respectively. For wet weather, the capture volume depends on the rainfall amount and intensity. Total rainfall amount of 20.0 inches was observed during the 2016-2017 storm season and the corresponding storm water runoff volume was approximately 390 acre feet and 30.8 acre feet measured at ELA-01 and ELA-02, respectively. Although the Project is not designed to capture the storm size up to 85th percentile recorded from the past 10 years, up to a total of 228 acre feet of storm water may be diverted into the treatment system after construction every year.

3.5. BMP Performance Expectations

The Watershed Management Modeling System estimated that the Project would capture approximately 13.11 kilogram (kg) of total zinc, 1.38 kg of total copper, and 1.27 kg of total lead annually for an average rainfall amount. After construction of the BMP, the performance will be evaluated by measuring how much pollutant load is diverted annually into each treatment system.

In addition to zinc removal, the treatment system may also filter others pollutant in the water such as copper, lead, suspended solids, hydrocarbons, and nutrients pollutants. Since reduction targets are not identified for these pollutants, the pollutant reduction will be evaluated using the hypothesis testing approach. Paired water quality samples will be collected at the NSBB's and structural cell module system's influent and effluent to measure if pollutant reductions are statistically significant. An additional pilot study may be conducted to enhance the understanding of the biochar's pollutant removal ability.

The monitoring approaches and evaluation methods are further discussed in the Section 4.0 and Section 6.0, respectively.

3.6. Study Questions

The following five study questions will be examined in the post-construction monitoring:

1. How much water is captured by the storm water treatment systems annually?
2. How much pollutant loads are captured by the storm water treatment systems annually?
3. What is the pollutant removal efficiency of the nutrient separating baffle box?
4. What is the pollutant removal efficiency of the structural cell module system pre-treatment chamber?
5. What is the overall pollutant load reduction achieved by the Project?

4.0 MONITORING APPROACH

The goal of the monitoring is to evaluate how much storm water runoff and pollutant loads will be captured by the treatment systems. LACPW will monitor water quality and flow at the treatment systems during dry and wet weather. The monitoring location, frequency, water sampling methodology, and flow monitoring methodology are described in the following sections.

The pre-construction monitoring results revealed that, in dry weather condition, approximately 2,600 square feet of water passed through the DDI 23 storm drain every day. It is anticipated that a majority of the runoff will be diverted into the treatment system 1 from the existing DDI 23 storm drain. On the other hand, little dry weather runoff was found in the storm drain that will be connected to the treatment system 2. It is anticipated that no dry weather runoff will be diverted to the treatment system 2 after the project is built. Similarly, treatment systems 3 and 4 will be designed to capture surface runoff only. It is anticipated that no dry weather surface runoff will be diverted to the treatment system 3 and 4. Therefore, dry weather water quality and flow monitoring will not be evaluated at the treatment system 2, 3, and 4.

The monitoring methodology will remain adaptive. Data collection method may be evaluated to determine if high quality of data is collected. Such evaluation may be based on completeness, precision, and accuracy of the quality control samples. Additional consideration may be taken to determine if the data effectively answers the study questions. The monitoring methodology may be adjusted if the proposed methods encounter unforeseen challenges, but any adjustments will ensure data quality is not compromised. The adaptive monitoring approaches/strategies are further discussed in Section 7.0.

4.1. Monitoring Location

Fourteen monitoring locations are identified in the Project. The monitoring locations are strategically selected to measure the pollutant removal performance of the NSBB and the biochar. Influent and effluent water quality samples will be collected from the NSBB and the pre-treatment chamber of the structural cell module system. The differences between the influent and effluent water quality will reveals the pollutant removal effectiveness of the treatment system. The monitoring locations will also quantify the amount of storm water that will be diverted into the treatment systems and, thus, the overall pollutant removal ability contributed by the Project can be calculated. An overview of the monitoring locations at each treatment system are presented in Appendix A.

For treatment system 1, 2, and 4, water quality and flow rate will be measured at the NSBB's influent and effluent. An additional monitoring location will be placed at the existing storm drain downstream from the diversion pipe to quantify the runoff volume that bypasses each treatment system. For treatment system 3, where biochar and sand mixture will be in place, water quality will be measured at the influent and effluent of structural cell module system pre-treatment chambers. Another effluent water quality sample will be taken inside the perforated pipe of the structural cell module system before water enters the infiltration well. The storm water treatment system, monitoring station ID, and monitoring parameters are summarized in Table 1.

Table 1: Storm water treatment system monitoring locations, sources, and parameters

Stormwater Treatment System	Monitoring Station ID	Latitude	Longitude	Dry Weather Monitoring Parameter		Wet Weather Monitoring Parameter	
				Flow	Water Quality	Flow	Water Quality
#1	ELA-1N-INF	34.0131	-118.1305	•	•	•	•
	ELA-1N-EFF	34.01314	-118.1307		•		•
	ELA-1S-INF	34.00992	-118.1314	•	•	•	•
	ELA-1S-EFF	34.00994	-118.1305		•		•
	ELA-01-BYP	34.01138	-118.1316	•		•	
#2	ELA-02-INF	34.0164	-118.1445			•	•
	ELA-02-EFF	34.01639	-118.1446				•
	ELA-02-BYP	34.01631	-118.1444			•	
#3	ELA-3A-INF	34.01416	-118.1438				•
	ELA-3A-BIO-EFF	34.01414	-118.1438			•	•
	ELA-3A-EFF	34.01408	-118.1438				•
#4	ELA-04-INF	34.01167	-118.1442			•	•
	ELA-04-EFF	34.01174	-118.1442				•
	ELA-04-BYP	34.01143	-118.1444			•	

4.2. Monitoring Frequency

The monitoring frequency is justified by the nature of the sample. Dry weather pollutant concentrations typically exhibit a relatively consistent pattern, and thus four sets of dry weather samples are proposed for each monitoring year. Dry weather sampling events will be scheduled quarterly to account for any seasonal variations in dry weather runoff.

Wet weather pollutant concentrations generally exhibit greater temporal variation due to storm size, rainfall intensity, and flow volume. To account for the variability, up to eight sets of wet weather samples will be targeted for each monitoring year (minimum of four samples). Every effort will be made to target for various storm size occurred throughout the monitoring period. Neither small storms nor large storms contribute significant fractions of the total annual flow in the Southern California Region. Intermediate flows are considered the most significant (Andrew J. Erickson, 2013) and thus more sampling events from an intermediate sized storm will be targeted, if feasible. The proposed wet weather sampling events are summarized in Table 2.

Table 2: Number of Proposed Wet Weather Sampling Events by Storm Size

Storm Size[1]	Predicted Rainfall Amount[2] (inches)	Proposed Sampling Event for Each Year (up to)[3]
Small	0.19	2
Intermediate	0.34	4
Large	0.71	2

The water quality results will be evaluated annually by the approach described in Section 6.0. If the data indicates a high degree of fluctuation, then additional sampling events may be conducted that year to overcome the result's uncertainty. However, if the data is consistent, then sampling will be concluded for the post-construction monitoring that year.

4.3. Water Chemistry Sampling Methodology

Dry and wet weather samples will be analyzed for constituents listed in the Los Angeles River Watershed TMDL programs. Additional pollutants will be analyzed to inform the maintenance schedule needed. These constituents include fecal indicator bacteria, metals, nutrients, oil and grease, total organic carbon, particulate matters, and conventional chemistry compounds. Analytical Methods are selected in accordance with the 40 Code of Federal Regulations Part 136.3

[1] Storm size is based on the inter-quartile range of the rainfall measured at the LACDPW headquarter rain gage from 10/01/2012 to 11/09/2017.

[2] Predicted rainfall amount is the amount of rainfall predicted from the weather forecast at a 70% probability at least 24 hours prior to the rain event.

[3] The feasibility of the proposed sampling events will be based on the weather conditions of that year.

requirements. The reporting limits will be set at appropriate levels so the results could be comparable to other studies, if available. The sample volume, analytical methods, detection limits, reporting limits, sample containers, and preservations are provided in Table 3 and further discussed in Section 5.0.

Table 3: Water Chemistry Analysis Parameter Summary Table

Constituents	Sample Volume	Analytical Method [1]	Method Detection Limits	Reporting Limits	Containers (#, size and type)	Preservation	Holding Time
Bacteria							
E. coli	250 mL	SM9223B	10 MPN/100mL	10 MPN/100mL	1 X 250 mL Sterilized Bottle	Sodium Thiosulfate, Store Cool at 10ºC	8 hours
Enterococci	250 mL	SM9230D	10 MPN/100mL	10 MPN/100mL	1 X 250 mL Sterilized Bottle	Sodium Thiosulfate, Store Cool at 10ºC	8 hours
Metals							
Cadmium (Total & Dissolved)	500 mL	EPA 200.8	0.1 ug/L	0.25 ug/L	2 X 500 mL Plastic Bottle	HNO3, Store Cool at 6ºC	28 days
Copper (Total & Dissolved)	500 mL	EPA 200.8	0.5 ug/L	0.5 ug/L	2 X 500 mL Plastic Bottle		28 days
Lead (Total & Dissolved)	500 mL	EPA 200.8	0.2 ug/L	0.5 ug/L	2 X 500 mL Plastic Bottle		28 days
Zinc (Total & Dissolved)	500 mL	EPA 200.8	1.0 ug/L	1.0 ug/L	2 X 500 mL Plastic Bottle		28 days
Nutrients							
Total Kjehldahl Nitrogen	500 mL	SM 4500-NH3 C	0.1 mg/L	0.1 mg/L	1 X 1000 mL Plastic Bottle	H2SO4, Store Cool at 6ºC	28 days
Ammonia as Nitrogen	500 mL	SM 4500-NH3 C	0.1 mg/L	0.1 mg/L	1 X 500 mL Plastic Bottle	H2SO4, Store Cool at 6ºC	28 days
Nitrate as Nitrogen	500 mL	EPA 300.0	0.05 mg/L	0.1 mg/L	1 X 500 mL Plastic Bottle	Store Cool at 6ºC	48 hours
Nitrite as Nitrogen	500 mL	EPA 300.0	0.02 mg/L	0.1 mg/L	1 X 500 mL Plastic Bottle	Store Cool at 6ºC	48 hours
Total Nitrogen	Calculation		0.07 mg/L	0.1 mg/L			
Particulate Matter							
Total Suspended Solids	1000 mL	SM 2540D	1.0 mg/L	2.0 mg/L	1 X 1000 mL Plastic Bottle	Store Cool at 6ºC	7 days
Conventional Chemistry							
Oil and Grease	1000 mL	EPA 1664	1.44 mg/L	5.0 mg/L	1 X 1000 mL Amber Glass Bottle	H2SO4, Store Cool at 6ºC	28 days
Total Organic Carbon	500 mL	SM 5310B	0.02 mg/L	1.0 mg/L	1 X 500 mL Plastic Bottle	HCl, Store Cool at 6ºC	28 days
Total Hardness	500 mL	SM 2340C	2.0 mg/L	2.0 mg/L	1 X 500 mL Plastic Bottle	Store Cool at 6ºC	6 months

[1] = Methods may be substituted by an equivalent method that is lower than or meets the project reporting limits requirements

Constituents	Equipment	Sensor Type	Measurement Range	Equipment Accuracy	Holding Time
Field Parameters					
Conductivity	YSI ProDSS Handheld Multiparameter Meter	Four Nickel Electrode Cell	0 - 200 mS/cm	0 to 100 mS/cm (±0.5% of reading or 0.001 mS/cm, whichever is greater)	15 mins
Dissolved Oxygen		Optical Luminescence	0 to 50 mg/L	0 to 20 mg/L (±0.1 mg/L or 1% of reading, whichever is greater)	15 mins
pH		Glass Bulb Combination Electrode; Ag/AgCl Reference Gel	0 to 14 units	± 0.2 units	15 mins
Temperature		Thermistor; Combination Sensor with Conductivity	-5 to 70°C (23 to 158°F)	± 0.2°C	15 mins

4.3.1 Sampling Method

Flow-weighted composite sampling method will be used in this study (except for oil and grease, fecal indicator bacteria, and field parameters). The flow-weighted composite method is more accurate than the time-weighted sampling method because the capture volume passing through the sampling location is constant for each collected sample. The analytical results from the flow-weighted samples may simplify the event mean concentration (EMC) calculation. The pollutants' EMC changes over time can be determined (Andrew J. Erickson, 2013). Therefore, a flow-weighted composite sampling method will be the first sampling strategy utilized whenever possible.

4.3.1.1 Dry Weather Sampling Method

Dry weather samples will be collected at the influents and effluents of the treatment system 1 by flow-weighted composite sampling method using the autosampler. At each location, an automated sampler will be programmed to collect a total of 24 samples in each event. When the autosampler is triggered, a water quality sample will be collected in a composite bottle inside the automated sampler. Water quality samples inside the automated sampler will be refrigerated, if possible, until retrieved by the field crew. Sample retrieval will typically occur within 24-hours after the event. During sample retrieval, the sample bottle will be tightly capped, cooled down to below 6 °C inside a cooler filled with ice, and delivered to an approved Environmental Laboratory Approval Program (ELAP) certified Laboratory (Laboratory) under chain of custody (COC) protocol. Discrete samples may be collected instead of a composite sample if understanding the temporal variation in pollutant concentrations throughout a sampling event is desired. Due to the nature of the analyte, fecal indicator bacteria and oil and grease samples will be collected using grab sampling technique. Grab samples will be collected when the field crew retrieves the composite sample from the monitoring sites.

When the automated sampler fails to collect water quality samples (i.e. due to a low flow condition), the grab sampling technique will be used. Following the grab sample technique, field staff will descend into the diversion pipe following safety protocols to collect water quality samples for the dry weather event. When collecting the water samples, sample bottles will be inserted under the surface of the flow with the container opening facing upstream. After the bottles are filled, the bottles will be tightly capped, cooled down to below 6 °C inside a cooler filled with ice, and delivered to the Laboratory under COC protocol.

4.3.1.2 Wet Weather Sampling Method

Similar to dry weather sampling, wet weather samples will be collected using flow-weighted composite sampling method by the automated sampler. Depending on the storm size and duration, the autosampler will be programmed to collect between a total of 24 to 48 flow-weighted samples in a composite bottle during each event. The program pacing will be adjusted before each storm event in order to collect a batch of representative samples. If it is determined the autosampler was falsely triggered, the sample will be discarded. Discrete sampling method may be used instead of composite if understanding the temporal variation in pollutant concentrations throughout a storm event is desired. After the storm event, effort will be made to retrieve the composite samples from the sampling locations within 24-hours. Sample bottles will be tightly capped, cooled down to below 6 °C inside a cooler filled with ice, and delivered under COC protocol to the Laboratory.

Due to the nature of the analyte, fecal indicator bacteria and oil and grease samples will be collected using grab sampling technique. Grab samples will be collected at the beginning of each storm event. Under no circumstances will field crew enter the diversion pipe during a wet weather sampling event.

4.3.1.3 Field Measurements

A multiparameter probe will be used to measure dissolved oxygen (DO), temperature, pH, and conductivity in the field during dry and wet weather sampling events. Field parameters such as DO, temperature, and pH have a shorter sample holding time, thus collecting in-situ measurements of these field parameters will provide a more accurate measurement. In addition, DO analysis requires extra precaution in the laboratory to prevent contamination by introducing extra oxygen into the sample. Thus, it may be more accurate to measure DO in the field. Before each sampling event, the multiparameter probes will be calibrated to manufacturers' specifications. Field measurements will be collected by submerging the sensors in sample water. The sample will be stirred continuously to ensure sample homogeneity when the measurements are collected. Field measurements will be collected in duplicate to ensure data precision.

4.3.1.4 Field Observation

A field data observation sheet will be completed by the field crew during each dry and wet sampling event. At minimum, the observation sheet will document the sampling date and time, monitoring location ID, sampler names, and additional comments about the field activities. The observation sheet will also note the weather, flow conditions, water column position where samples or measurements were collected, and a description of the sample when it is collected including color, clarity, turbidity, oil and/or grease, floating or suspended materials, and odors. Additional observations about the surrounding environment, including algae, trash, foam, or wildlife observations will also be noted. Photographs will be taken during each sampling event, if feasible. A copy of the field observation form is provided in Appendix B - Field Observation Sheet.

4.3.2 Sample Handling

General sample handling practices should be followed by field sampling personnel during both dry and wet sampling to ensure the samples will be collected in a manner that prevents and reduces contamination of the samples.

Sampling personnel should wear clean and powder-free nitrile gloves to collect each round of samples to prevent cross-contamination. Care should be exercised to reduce potential of contaminating sample bottles or sampling equipment (i.e., do not touch the bottle or cap interior, do not put the bottle lid on the floor, do not sample near a running vehicle, etc.). After sample collection, bottles should be tightly capped and sample labels should be applied to the side of the bottles. If a 2.5-gallon bottle is used in the automated sampler to collect the sample, a label should be applied to both the upper side of the lid and the side of the bottle. The sample label should be printed on blank waterproof labels and at minimum should include the Project name, monitoring location ID, collection date and time, and sampler's initials. Chemical preservatives will be added to the samples, where applicable, to extend the sample holding time. The appropriate sample containers and preservatives will be prepared and provided by the Laboratory

4.3.3 Chain of Custody Form

A COC form provides record and documentation regarding sample collection and handling. A COC form must be completed and submitted to the Laboratory with each sample. The COC form must contain the same information as the sample labels and include: Project name, monitoring location ID (sample ID), collection date and time, sampler's initials. In addition, the COC should indicate the sample matrix, number of sample containers, and type of requested analyses.

4.4. Flow Monitoring Methodology

Dry weather flows will be measured at the influent and bypass of the treatment system 1 (ELA-1N-INF, ELA-1S-INF, ELA-01-BYP). During dry weather condition, it is anticipated that majority of the flow will be measured at the treatment system 1 influents where runoff will be diverted from the existing DDI 23 storm drain. Since the treatment system 2, 3, and 4 are designed to capture wet weather surface runoff, dry weather flows at these monitoring locations are assumed to be insignificant and will not be evaluated. Wet weather flow will be measured at the influent and the bypass of all the treatment systems (ELA-1N-INF, ELA-1S-INF, ELA-01-BYP, ELA-02-INF, ELA-02-BYP, ELA-3A-INF, ELA-04-INF, and ELA-04-BYP).

At the eight monitoring locations, water depth (feet) readings will be recorded every 15 minutes. Three types of flow sensors will be used in this project, include the area velocity sensor, the pressure transducer, and the radar level sensor. An area velocity sensor will be installed with the automated sampler at the influent of each of the NSBBs (ELA-1N-INF, ELA-1S-INF, ELA-02-INF, and ELA-04-INF) to measure the capture volume by the treatment system. When the area velocity sensor is connected to the autosampler, the sensor will also function as a trigger to initialize the sampling sequence when water levels are above the trigger values.

To improve the flow measurement accuracy, it is recommended that weirs be used to measure the dry and wet weather flows. Circular weirs (or compound weirs) may be installed at the five monitoring locations (ELA-1N-INF, ELA-1S-INF, ELA-02-INF, ELA-3A-INF, and ELA-04-INF) to assist with the flow measurement. The circular weir provides a good combination of small discharge accuracy in dry weather condition and large discharge capacity in wet weather condition (Andrew J. Erickson, 2013). The flow rate will be calculated using Equation 1 Circular weir flow equation which takes the circular orifice diameter, water depth, and discharge coefficient into account.

Equation 1 Circular weir flow equation

$$Q = C_d \left[10.12 \left(\frac{h}{d} \right)^{1.975} - 2.66 \left(\frac{h}{d} \right)^{3.78} \right] (d)^{5/2}$$

where

Q = discharge (L/s)
d = circular orifice diameter (m)
h = height over the weir (m)
Cd = discharge coefficient is presented in Equation 2 Discharge coefficient for circular weir

Equation 2 Discharge coefficient for circular weir

$$C_d = 0.555 + \frac{1}{110\left({}^{h}/_{d} \right)} + 0.041 \left(\frac{h}{d} \right)$$

The second type of sensor is a pressure transducer. A pressure transducer will be installed inside the structural cell module system pre-treatment chamber's influent (ELA-3A-INF) to measure the capture volume by the treatment system. Data gathered by the sensors will be transmitted to the automated sampler for storage.

The third type of sensor is a radar level sensor. The radar level sensor will be installed at each bypass location (ELA-01-BYP, ELA-02-BYP, and ELA-04-BYP) downstream from the diversion pipe. The sensors will measure the runoff volume that bypasses the treatment system. Data gathered by the sensors will be transmitted to data loggers for storage.

Water level readings collected by the pressure transducer and radar level sensors will be converted into flow rate. Manning's equation will be used to perform the conversation. The slope of the channel bottom, the cross-sectional area of the flow, and the empirical roughness coefficient will be obtained from the storm drain as-built drawings and will be used to compute the flow rates. The Manning's Equation is presented in Equation 3.

Equation 3 Manning's Equation

$$Q = \left(\frac{1.486}{n}\right) \times A \times R^{\frac{2}{3}} \times \sqrt{S}$$

where:

Q = flow rate in cubic feet

n = Empirical roughness coefficient of the pipe

A = Cross-sectional area of the channel in foot

R = Wetted perimeter in foot

S = Channel slope in foot/foot

Due to the channel geometry inside the DDI-23 storm drain at the monitoring location Site ID# ELA-01-BYP, the cross section from 0 - 0.3 feet of water depth will be considered as a triangular shape. When the water level is above 0.3 feet, the channel cross section transitions into rectangular shape. Two Manning's equations will be used to account for the transition in geometry when performing flow rate calculation. For the other locations, the storm drains will be a circular pipe. One Manning's equation will be used to calculate the flow rate.

5.0 QUALITY ASSESSMENT PROGRAM

To assure the data set contains useful information and of adequate quality, any data collected must meet the data quality objectives (DQOs) established within this monitoring plan and the quality assurance project plan (QAPP). The DQOs consists of field monitoring and laboratory quality assessment under the guidance of *Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan* (California State Water Resources Control Board, 2008). The objective of the quality assurance program is to produce data of known and acceptable quality by measuring the accuracy, bias, precision, recovery, and completeness of sample data collected during field monitoring and from laboratory analysis quality control. The DQOs and the quality control requirements for this project are described below and shown in Table 4. Quality control and quality assurance requirements for this project are further discussed in the *Quality Assurance Program Plan For Evaluating the East Los Angeles Sustainable Median Stormwater Capture Effectiveness*.

Table 4 Data quality and measurement quality objectives

Constituent	Analytical Method	Units	Method Detection Limit	Reporting Limit	Accuracy (% Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Bacteria											
E. *coli*	SM9223B	MPN/100mL	10	10 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Enterococci	SM9230D	MPN/100mL	10	10 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Metals											
Cadmium (Total & Dissolved)	EPA 200.8	ug/L	0.1	0.1 ug/L	75-125%	0-25%	< RL	RPD < 25%	5% of total project sample count	< RL	7440-43-9
Copper (Total & Dissolved)	EPA 200.8	ug/L	0.5	0.5 ug/L	75-125%	0-25%	< RL	RPD < 25%		< RL	7440-50-8
Lead (Total & Dissolved)	EPA 200.8	ug/L	0.2	0.2 ug/L	75-125%	0-25%	< RL	RPD < 25%		< RL	7439-92-1
Zinc (Total & Dissolved)	EPA 200.8	ug/L	1	1.0 ug/L	75-125%	0-25%	< RL	RPD < 25%		< RL	7440-66-6
Nutrients											
Total Kjehldahl Nitrogen	SM 4500-NH3C	mg/L	0.1	0.1 mg/L	80-120%	0-25%	< RL	RPD < 25%	5% of total project sample count	< RL	7727-37-9
Ammonia-N	SM 4500-NH3C	mg/L	0.1	0.1 mg/L	80-120%	0-25%	< RL	RPD < 25%		< RL	7664-41-7
Nitrate-N	EPA 300.0	mg/L	0.05	0.1 mg/L	80-120%	0-25%	< RL	RPD < 25%		< RL	NA
Nitrite-N	EPA 300.0	mg/L	0.02	0.1 mg/L	80-120%	0-25%	< RL	RPD < 25%		< RL	NA
Total Nitrogen	Calculation	mg/L	NA							NA	
Particulate Matter											
Total Suspended Solids	SM 2540D	mg/L	1	2.0 mg/L	80-120%	0-25%	< RL	RPD < 25%	5% of total project sample count	< RL	NA
Conventional Chemistry											
Oil and Grease	EPA 1664	mg/L	1.44	5.0 mg/L	80-120%	0-25%	< RL	RPD < 25%	5% of total project sample count	< RL	NA
Total Organic Carbon	SM 5310B	mg/L	0.02	1.0 mg/L	80-120%	0-25%	< RL	RPD < 25%		< RL	NA
Total Hardness as $CaC0_3$	SM 2340C	mg/L	2	2.0 mg/L	80-120%	0-25%	< RL	RPD < 25%		< RL	NA

Notes:

Measurement quality objectives are from the SWAMP 2013 Quality Assurance Program Plan tables.

< - less than

NA - Not applicable

RPD - relative percent difference

RL - reporting limit

5.1. Data Quality Objectives

The level of data quality is dependent upon the objective use of the results supported by the data. DQOs are qualitative and quantitative statements that define the type, quality, and quantity of data necessary to support project decisions. To meet the DQO criteria for this project, the analytical performance requirements are expressed in terms of precision, accuracy and bias, representativeness, comparability, completeness, and sensitivity. Summarized below are definitions for each parameter and calculation equations, if applicable.

5.1.1 Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Analysis of field duplicates will serve to measure the precision of samplers' techniques and methods. Analysis of laboratory duplicates will measure the precision of laboratory procedures. The precision of a duplicate measurements can be expressed as the relative percent difference (RPD). The mathematical equation to calculate the RPD is presented in Equation 4:

Equation 4 Calculate the relative percent difference

$$RPD = \left\{ \frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}} \right\} \times 100$$

where

X_1 = native sample
X_2 = duplicate sample

5.1.2 Accuracy and Bias

Accuracy helps determine the level of certainty in data and how close the results are to the true value. Bias may be present during data collection, calibration, or limitations in analytical methods by the laboratory. In the field and laboratory, accuracy and bias will be checked with calibration solution or a matrix spike by introducing a known concentration of a target analyte to a sample or a blank sample, and then analyzing the sample to determine how close the result is to the known concentration. Values consistently higher or lower than the true value are considered a high bias.

5.1.3 Representativeness

Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic environmental condition. Representativeness is a subjective parameter and is used to evaluate the efficacy of the sampling plan design. Representativeness is demonstrated by providing full descriptions of the sampling techniques and the rationale used for selecting sampling locations in the project planning documents.

There cannot be a target goal for a qualitative parameter such as representativeness or comparability. Therefore, this criterion is evaluated subjectively rather than quantitatively. The question of the measurement of representativeness is answered during the preparation of the sampling and analysis approach and rationale and then reassessed during the data usability process. For example, an integral part of developing the sampling and analysis approach is to answer the question, “How many samples are needed to fully evaluate *x*?” and then during the data usability process, “Was enough data collected to answer the original question?”

5.1.4 Completeness

Completeness is defined as the percentage of measurements judged to be valid compared to the total number of measurements made for a specific sample matrix and analysis. The mathematical equation to calculate the completeness is presented in Equation 5. An overall completeness goal of 95 % has been set for this project.

Equation 5 Calculate completeness

$$Completeness = \frac{Valid\ Measurements}{Total\ Measurements} \times 100\%$$

5.1.5 Comparability

Comparability is another qualitative measure designed to express the confidence with which one data set may be compared to another. Sample collection and handling techniques, sample matrix type, and analytical method all affect comparability. Comparability is limited by the other parameters because data sets can be compared with confidence only when precision and accuracy are known. Data from one phase of an investigation can be compared to others when similar methods are used and similar data packages are obtained.

5.1.6 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method is commonly referred to as the detection limit as shown in Table 4 and described in Section 5.1.7.

5.1.7 Detection Limit

The method detection limit (MDL) is the lowest concentration that a sample can be analyzed with 99% confidence. The MDL is a lab-specific and method-specific value, so there may be variation between labs. The reporting limit (RL) is set for each analyte at a value greater than the MDL. For this project, an RL are selected with consideration for comparability to other studies in the Los Angeles River Watershed. The target RLs are provided in Table 4.

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5.2. Quality Control Requirements

Quality control (QC) samples will be collected in the field. These activities provide a mechanism for ongoing control and evaluation of data quality measurements. QC samples consist of sample duplicates, field blanks, and equipment blanks. The QC requirements for this Project are listed below.

5.2.1 Requirements

For this project, one set of sample duplicates and one set of field blanks will be collected during dry weather monitoring annually. For wet weather monitoring, one set of sample duplicates, one set of field blanks, and one set of equipment blanks will be collected annually.

5.2.2 Sample Duplicates

Sample duplicates will be collected in the same manner as the environmental samples into separate, clean, laboratory-certified bottles and analyzed as independent samples. These duplicates are used to document the precision of the sampling process. If the relative percent difference between the sample and sample duplicate is greater than 20%, then the sample collected during that sampling event will be discarded. The sampling procedure will be re-evaluated and improved procedure will be implemented for the next scheduled sampling event.

5.2.3 Field Blanks

Field blanks will be prepared and tested with the actual samples collected during one sampling event. Potential contamination from field handling procedures will be assessed through the analyses of the field blanks. If contamination is found in the field blanks, then the sample collected during that sampling event will be discarded. The sampling procedure will be re-evaluated and improved procedure will be implemented for the next scheduled sampling event.

5.2.4 Equipment Blanks

Equipment blank samples will be collected and analyzed after auto-sampler installation to determine if any contaminants are detected in the auto-sampler pump tubing, sampling equipment, and auto-sampler bottles. Laboratory-grade deionized water will be pumped through the auto-samplers' Teflon tubing with the peristaltic pump into a clean sample container. The equipment blank sample will be packaged and delivered to the laboratory for analysis in the same manner as non-quality control samples. In order to meet the quality control criteria for this project, the results shall be lower than the reporting limits of the associated constituents. If the equipment blank concentrations are detected higher than the reporting limits, then the pump tubing will be replaced and the sampling procedure will be re-evaluated. Once the issue is identified and resolved, another equipment blank will be collected to ensure the sampling equipment is free of contaminants.

5.3. Laboratory Quality Assessment

Water samples will be analyzed by a state certified analytical laboratory under the guidance of their Quality Assurance Manual. Prior to sampling, the analytical methods and reporting limits (Table 3) will be verified with the laboratory ensure they can be achieved. The DQOs and measurement quality objectives (MQO) will apply to bacteria (E. *coli*), metals (total and dissolved cadmium, copper, lead, zinc, and total mercury), and nutrient (TKN, ammonia as nitrogen, nitrate as N, and nitrite as N) samples.

The laboratory analyzes multiple water quality samples as a batch, and one set of QC samples will be analyzed with each batch. Every 10 or 20 water quality samples will have one associated set of QC samples. The following QC sample types are analyzed as part of the QC batch: method blank, laboratory duplicate, matrix spike (MS), matrix spike duplicate (MSD), laboratory control sample (LCS), and laboratory control sample duplicate (LCSD).

5.3.1 Method Blanks

Method blanks are prepared and analyzed by the laboratory as closely as possible to the original and QC samples to determine if there is any contamination present in the lab. The results of the method blanks provide an estimate of any variability or bias by the analysis. Any detection in the method blank will be investigated and a qualifier will be used to indicate the potential presence of contamination.

5.3.2 Laboratory Duplicates

A laboratory duplicate is portion of a sample taken from an original sample and then prepared and analyzed through the same process as the original sample to quantify the precision of laboratory procedures. The RPD is calculated using the same formula in Section 5.1.1. If the RPD between the laboratory duplicates is greater than 25% of the native concentration, then the laboratory should investigate the potential presence of laboratory bias.

5.3.3 Matrix Spike and Matrix Spike Duplicates

A matrix spike is a sample prepared by the laboratory by spiking a known concentration of a target analyte to a specific amount of sample. The MSD is similar to the MS and shows the effect of the sample matrix on the accuracy of the analytical results. The MS/MSD sample should have between 80% to 120% recovery (accuracy) and the RPD between the MS and MSD should be below 25% (precision). If the accuracy or precision does not meet the acceptable limits, then the laboratory should investigate the potential presence of laboratory or matrix bias.

5.3.4 Laboratory Control Sample (LCS) and LCS Duplicates

The LCS is created in the lab using contaminant-free reagent water that is spiked with a known concentration of a target analyte for analysis following the same preparation and procedures as the other project samples. The LCSD is used as quality control for accuracy and precision of the

LCS sample. The LCS/LCSD sample should have between 80% to 120% recovery and the RPD between the LCS and LCSD should be below 25%. If the accuracy or precision does not meet the acceptable limits, then the laboratory should investigate the potential presence of laboratory or matrix contamination.

6.0 DATA ANALYSIS APPROACH

Data analysis will be completed through the following five steps:

6.1. Exploratory Data Analysis

First, exploratory analysis will be performed to check for data quality and data integrity. Chemistry results that are below the MDL are reported as non-detect (ND) will be replaced with a numerical value of zero (0) for calculations. Flow data will be sorted and separated into sub-datasets based on dry and wet weather conditions. Outliers and abnormal values will be inspected before any analyses are completed in the next step.

6.2. Runoff Volume Calculation

Second, the total runoff volume will be estimated using the data collected by the flow sensor installed at the monitoring locations. Daily dry weather runoff volume will be calculated by using the average daily flow. Wet weather runoff volume will be calculated by summing the runoff volume measured at each storm event.

6.3. Pollutant Loading Calculation

Third, dry weather pollutant loads will be calculated by multiplying the dry weather pollutant median concentrations with the average daily runoff volume. Wet weather pollutant loads will be calculated by multiplying the pollutant concentrations with the total runoff volume measured at each storm event. For storm event that samples are not collected, the pollutant median concentrations measured during the storm season will be used to estimate the pollutant loads.

6.4. Pollutant Removal Evaluation

Fourth, hypothesis testing approach will be used to determine if pollutants are removed by the NSBBs and biochar. Paired t-test will be performed and the results will determine whether there is a statistically significant difference in pollutant concentrations between influent and effluent samples. The hypothesis (H_o) and null hypothesis (H_a) for evaluating the NSBB pollutant removal ability are listed below:

> H_a: The pollutant concentrations measured at the NSBB's effluent are higher than or equal to the pollutant concentrations measured at the influent
>
> H_o: The pollutant concentrations measured at the NSBB's effluent are lower than the pollutant concentrations measured at the influent.

The hypothesis (H_o) and null hypothesis (H_a) for evaluating the biochar (in the structural cell module system pre-treatment chamber) pollutant removal ability are listed below:

H_a: The pollutant concentrations measured at the structural cell module system's pre-treatment chamber effluent are higher than or equal to the pollutant concentrations measured at the influent

H_o: The pollutant concentrations measured at the structural cell module system's pre-treatment chamber effluent are lower than the pollutant concentrations measured at the influent.

6.5. BMP Effectiveness

Fifth, the effluent probability method will be used to evaluate the pollutant removal effectiveness by the treatment system. The effluent probability method provides easy comparison of the pollutant concentrations between influent and effluent samples by plotting the log-transformed concentration data on a normal quantile distribution axis (Geosyntec Consultants and Wright Water Engineers, Inc., 2009). The interpretation is based on the assumption that the influent and effluent concentrations are correlated (California Stormwater Quality Association, 2003). This relationship was evaluated using Spearman's rank correlation coefficient. The separation between the influent and effluent curves indicates the pollutant removal ability of the treatment unit. The greater the separation between the curves, the more effective the treatment unit is in removing pollutants. The results from the effluent probability plot evaluate the pollutant removal ability of the treatment unit across the entire range of the influent concentrations. This method will be applied to certain constituents when statistical significances are identified in step four.

7.0 DATA MANAGEMENT AND REPORTING

7.1. Field Data

Field measurements and field observations during monitoring activities will be documented on a field observation sheet, provided in Appendix B - Field Observation Sheet. Upon completion of the field monitoring activities, a hardcopy and/or an electronic copy of the field observation sheet will be saved to a project specific file and the field measurements and observations will be stored on the Integrated Water Quality System (IWQS) database.

7.2. Chemistry Analytical Data

The water quality analytical data will be provided by the laboratory as final reports in PDF and as California Environmental Data Exchange Network (CEDEN) formatted electronic data deliverable files. The data will be prepared in accordance with CEDEN guidance for submission. The field measurement data will also be managed in a method allowing integration with the CEDEN website. CEDEN guidance requirements can be found at http://www.ceden.org. After the data has been verified and validated by County of Los Angeles Stormwater Quality Division's QA/QC officer, the data will be stored in the IWQ database.

7.3. Flow Data

The flow data will be downloaded from the flow sensors onto hand held units at regular intervals during the monitoring period. After the flow data is retrieved, the data will be uploaded and saved to a County of Los Angeles Stormwater Compliance Division's computer for data quality review and storage. The flow data will be saved on the local computer hard drive and a backup copy will be saved on the County's internal server. Any irregularities in the flow data will be reviewed and qualified, if necessary. Once the data has been reviewed, the file will be managed in a method allowing integration with CEDEN.

7.4. Reporting

The results of the Project water quality monitoring will be described in accordance with Proposition 1 Stormwater Grant Program requirements, if available.

8.0 MAINTENANCE

The performance of the stormwater treatment system may decline over time. Routine inspections and maintenance will help optimize the performance of the BMP and extend the useable life of the treatment system. In this Project, maintenance will primarily be conducted on the pre-treatment chamber of the structural cell module system and the nutrient separating baffle box. The infiltration wells require no consumable materials for daily operation, and thus do not require routine maintenance.

8.1. Maintenance Procedures

Maintenance and inspections will be conducted or overseen by LACDPW. Any changes or improvements to the maintenance and inspection procedures may be evaluated in accordance with the adaptive management strategy described in Section 9.0.

8.1.1 Structural Cell Module System

Structural cell module system's pre-treatment chamber consists of a series of filter cartridges that will be filled up with biochar and sand mixture. The filter cartridges will require periodical maintenance that the filtra materials will need to be replaced. The replacement frequency depends on serval factors, such as the influent water quality, the flow rate, and the desired hydrologic conductivity of the materials.

8.1.1.1 Pre-treatment Chamber

It is recommended that the pre-treatment chamber shall be inspected at least every six months and be cleaned at least every 12 months depending on the sediment loadings. The cleaning procedure includes removal of the solid material (e.g., sediment, trash or debris) and can be performed manually or with a vacuum truck from the hatch (vault covers) located on top of the chamber. A pressure washer may be needed to remove heavy debris stuck to the side wall of the chamber.

8.1.1.2 Filter Cartridge

The filter cartridges shall be visually inspected every six months and may be replaced every 12 months, depending on the pollutant loading. If the filter cartridges appear to be significantly discolored, worn, and torn, the old filter cartridges may be replaced prior to the annual replacement date.

8.1.2 Nutrient Separating Baffle Box

The nutrient separating baffle box consists of three components that may require periodical maintenance: screening basket, sedimentation chambers, and hydrocarbon booms (see Figure 4). The inspections and maintenance should be performed regularly to prevent the system from clogging following the procedures below. It is highly recommended that all maintenance work be completed from the ground surface. If entry into the underground vault is required, the work will be conducted under confined space protocols by trained and certified staff.

8.1.2.1 Screening Basket

Screening is provided by a rectangular basket suspended above the standing water level of the sedimentation chambers. The screening basket captures and filters large solid materials coming in from the storm drain. The manufacturer recommends that the screening basket shall be inspected at least every six months and be cleaned at least every 12 months depending on the loading. The cleaning procedure includes removal of the solid material (e.g., trash or debris) and can be performed manually or with a vacuum truck from the hatch (manhole covers) located on top of each chamber. A pressure washer may be needed to remove heavy debris stuck to the basket.

8.1.2.2 Sedimentation Chamber

Pollutants such as suspended particles, particulate metals, and nutrients, are separated from the water column in the sedimentation chambers. The manufacturer recommends chambers shall be inspected every six months and be cleared every 12 months, depending on the loading. The sedimentation chamber cleaning should be conducted after the screening baskets have been cleaned. The procedure should be performed with a vacuum truck from the hatches (manhole covers) located on top of the chambers, and a pressure washer may be needed to remove compacted sediments that are stuck to the walls or the floor of the sedimentation chambers.

8.1.2.3 Hydrocarbon Booms

The hydrocarbon boom located inside the third sedimentation chamber (near the outflow end of the system) removes free floating and emulsified hydrocarbon from the water. The manufacturer recommends the hydrocarbon booms shall be visually inspected every six months and may be replaced every 12 months, depending on the loading. If the hydrocarbon boom appears to be significantly discolored, the old hydrocarbon boom may be replaced prior to the annual replacement date in accordance with manufacturer's instructions. The hydrocarbon boom should be completed after maintenance of the screening basket and separation chambers.

8.2. Maintenance Schedule

Routine inspections and maintenance should be performed at the per-treatment chamber of the structural cell module system, as well as the NSBB's screening basket, the sedimentation chamber, and the hydrocarbon booms. The replacement schedule of the pre-treatment chamber of the structural cell module system will be determined in the first or second year(s) after construction after the monitoring data has been reviewed. The recommended maintenance schedule for the NSBB is summarized in Table 5. However, based on the loading, weather, and other site conditions, the inspection and maintenance schedule may be adjusted to increase optimization of the BMP.

Table 5: Maintenance schedule for the structural cell module system and nutrient separating baffle box

Service At The Indicated Time Or Whenever Is Needed	≤ Every 6 months after construction	≤ Every 12 months after construction
Structural Cell Module System		
Inspect pre-treatment chamber	•	•
Clean pre-treatment chamber		•
Inspect filter cartridge	•	•
Replace filter cartridge		•
Nutrient Seperating Baffle Box		
Inspect screening basket	•	•
Clean screening basket		•
Inspect sedimentation chambers	•	•
Clean sedimentation chambers		•
Inspect hydrocarbon booms	•	•
Replace hydrocarbon booms		•

8.3. Maintenance and Inspection Form

Following the maintenance or inspection, field staff should document the activities performed. This record should include the maintenance or inspection date and weather condition, describe any maintenance performed, the condition of the treatment system, the amount and description of debris collected, and other observations or comments. An example of an inspection and maintenance report is provided in Appendix C – Maintenance and Inspection Form. The records will be retained in accordance with LACDPW retention policy.

9.0 ADAPTIVE MANAGEMENT STRATEGY

Adaptive management is an important component of the BMP effectiveness monitoring since new monitoring methods, maintenance methods, and stormwater science and technologies may change during the span of the Project. The monitoring plan provides a standard framework to measure the effectiveness of the treatment system, and over time the monitoring plan may be revised or modified based on implementation findings to become more effective through the adaptive management strategy.

9.1. Adaptive Management Framework

A review of the monitoring data may be used to justify the effectiveness of the monitoring and maintenance activities. Monitoring and maintenance activities will be evaluated through an iterative process every two years and updates to the plan will be made as necessary. The adaptive management framework will integrate data collected through implementation of the BMP, new knowledge and experience learned from the monitoring and maintenance activities, and may take into consideration the changes and improvements in stormwater science and technology.

The adaptive management process will continue to evolve, identify, and prioritize the best locations, frequency, and constituent lists for water quality monitoring. The process will also review and identify maintenance needs in order to optimize the performance of the treatment system. Key components to be considered during the adaptive management process are described below.

9.1.1 Based on field experience

Field experience and knowledge of the monitoring program will continue to develop during implementation of the BMP. Any field challenges that are encountered during routine monitoring will be reviewed on a regular basis with the field crews. Alternative site-specific solutions may be proposed to resolve the challenges based on the experience, site conditions, and understanding of the monitoring program. Proposed solutions will be presented to the project managers and reviewed to obtain consensus before implementing the change.

9.1.2 Based on manufacturer recommendation

Other challenges that may be encountered during routine inspection and maintenance of the BMP may be discussed and resolved by contacting the BMP manufacturer or vendor. As part of evaluating the maintenance procedures, alternate options to help reduce maintenance efforts for the existing BMP may be suggested. Any manufacturer recommendations will be fully evaluated to determine if it is necessary or feasible and discussed with project managers to obtain consensus before implementing a change.

9.1.3 Based on monitoring data

Review of the data collected from the monitoring is a vital component to the adaptive management process. Analysis of the water quality data will help determine the representativeness of the selected monitoring locations, frequency of the monitoring, and whether the pollutants analyzed are best suited to evaluate the effectiveness of the BMP treatment performance. Based on the analysis, the water quality data may be used as justification to modify or revise certain components of the monitoring plan. Other types of monitoring data that may be used to support monitoring plan revisions may include annual rainfall amount, total runoff volume, the amount of sediment captured in the sedimentation chamber, etc.

The components of the adaptive management strategy described above provide only a few examples of how the adaptive management process would lead to revision of the monitoring plan. It is anticipated that during BMP implementation, the water quality monitoring procedures will continue to evolve, the sampling location(s) and frequency will be optimized based on analytical findings, and the maintenance and inspection schedule will continue to be adjusted based on the varying conditions. Tracking progress during the BMP implementation will provide valuable information for improvements and adjustments towards achieving the expected pollutant reduction outcomes.

10.0 BIBLIOGRAPHY

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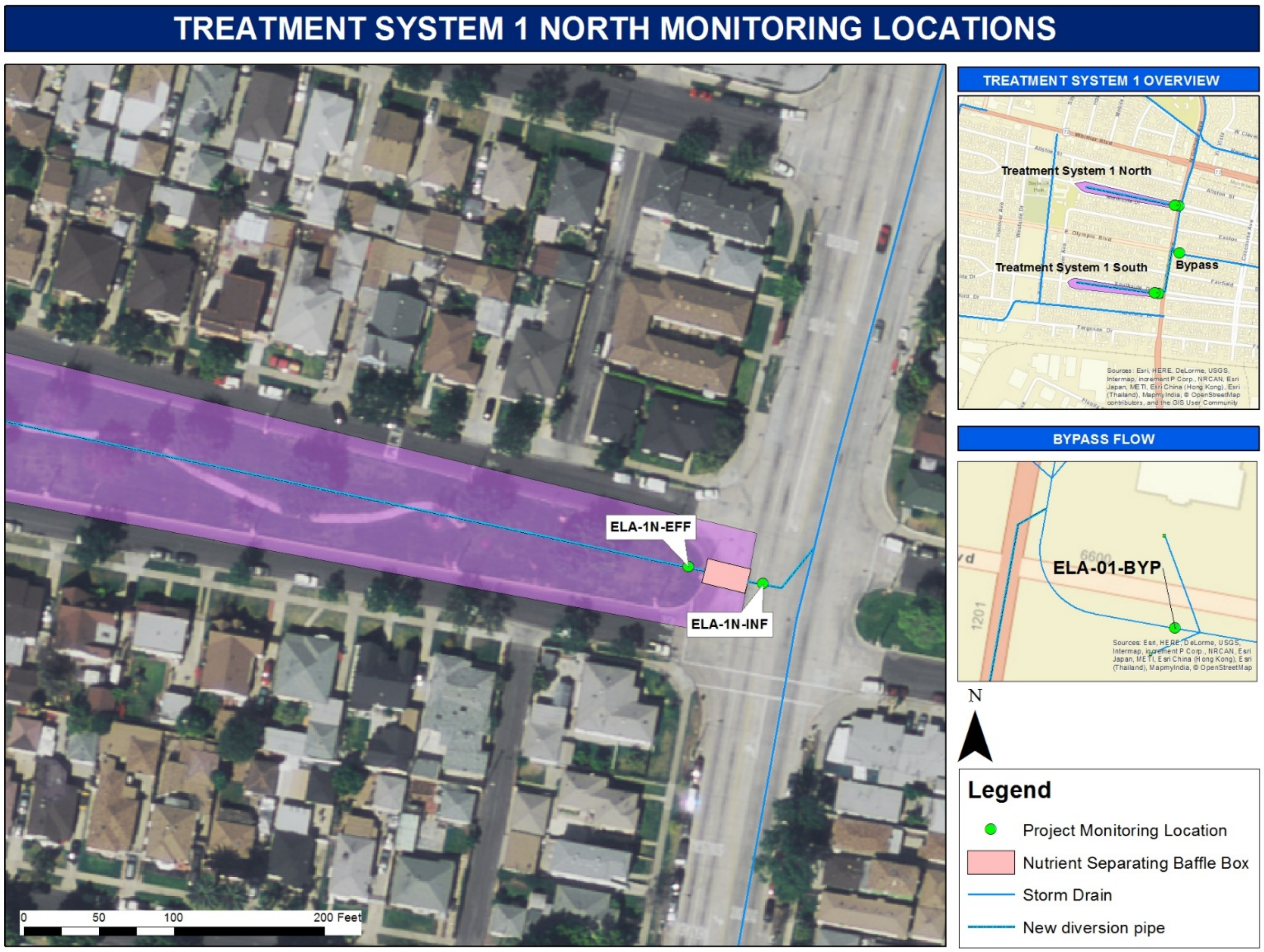
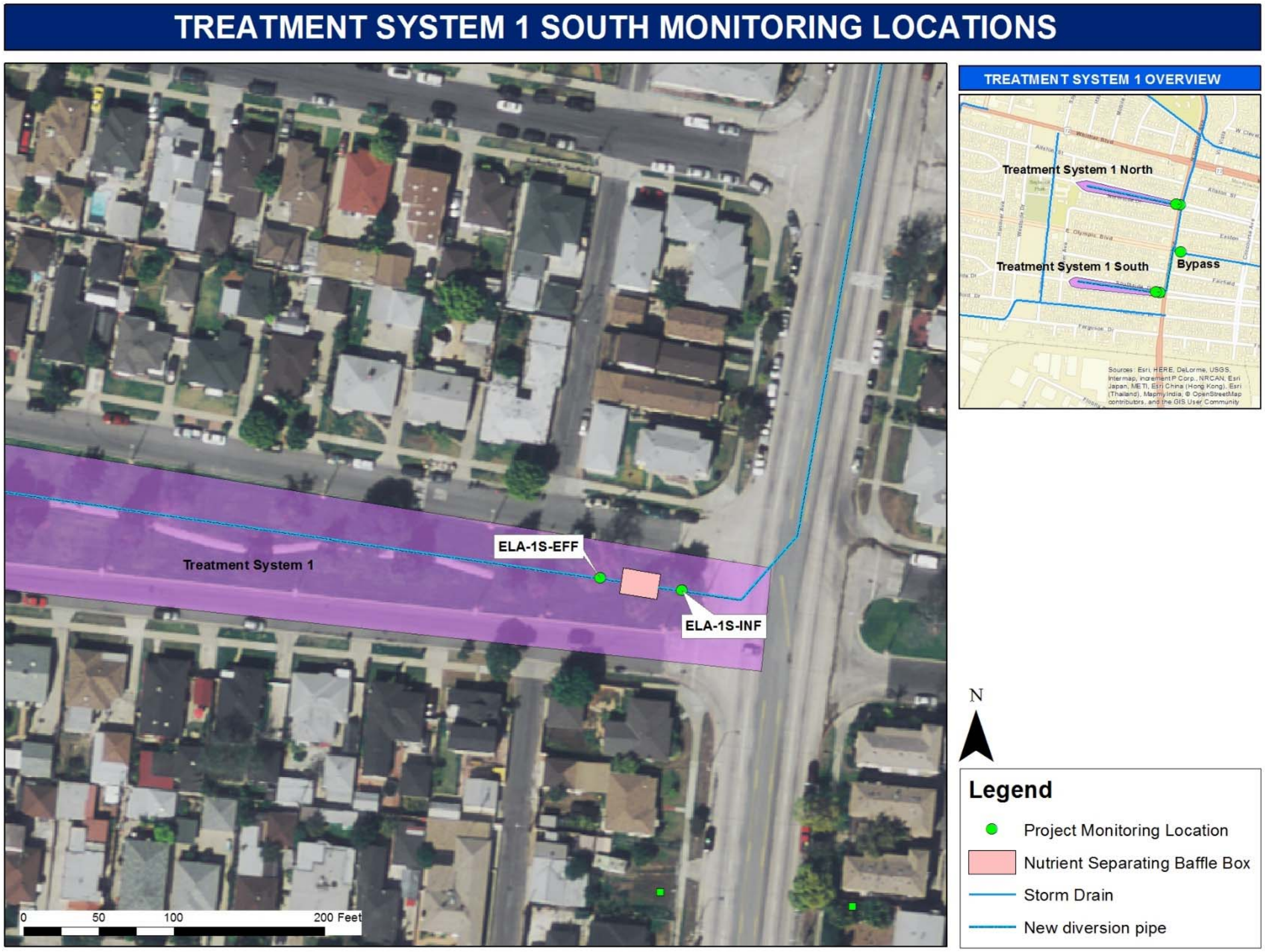
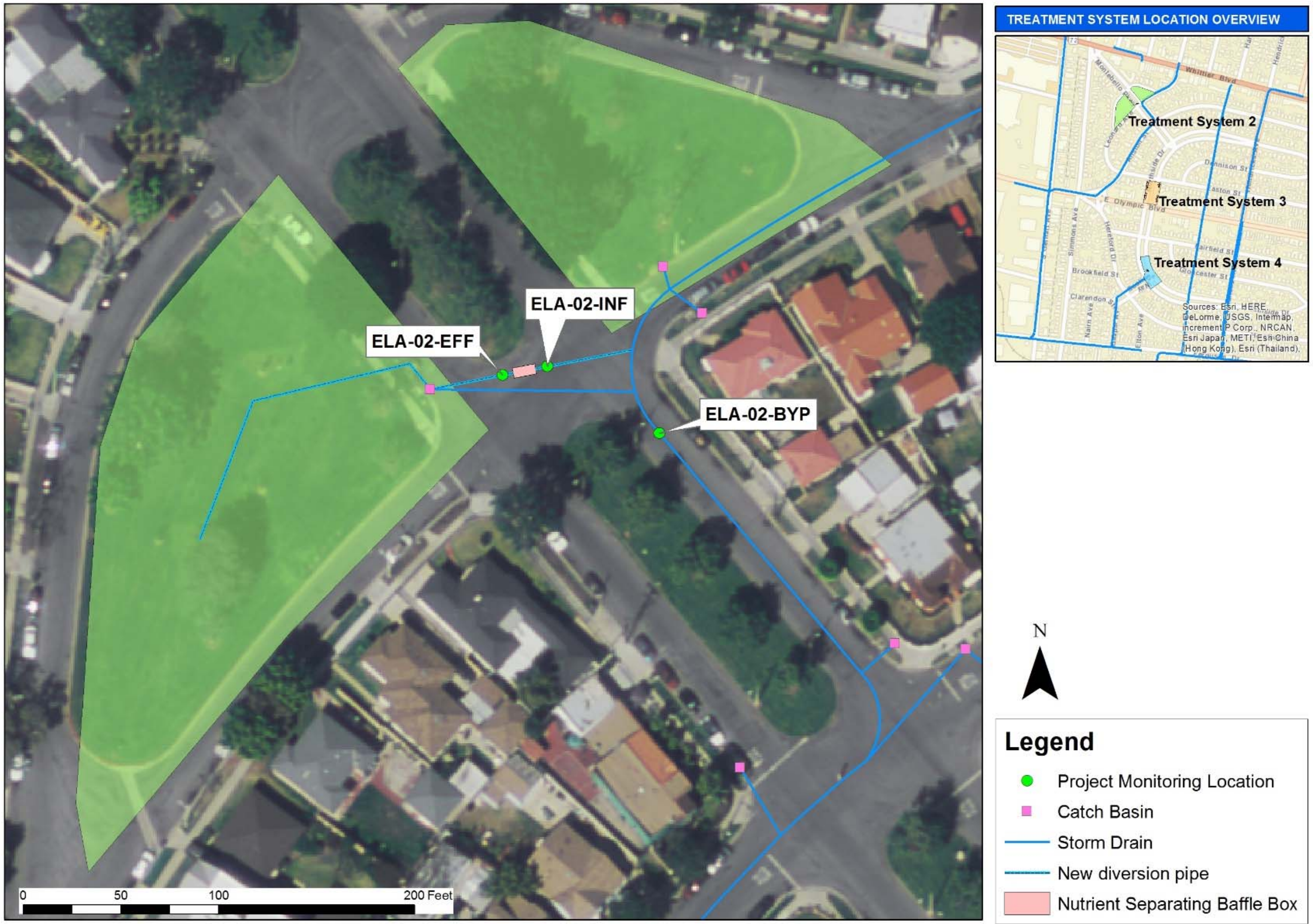
11.0 APPENDIX

11.1. Appendix A – Water quality and flow monitoring locations



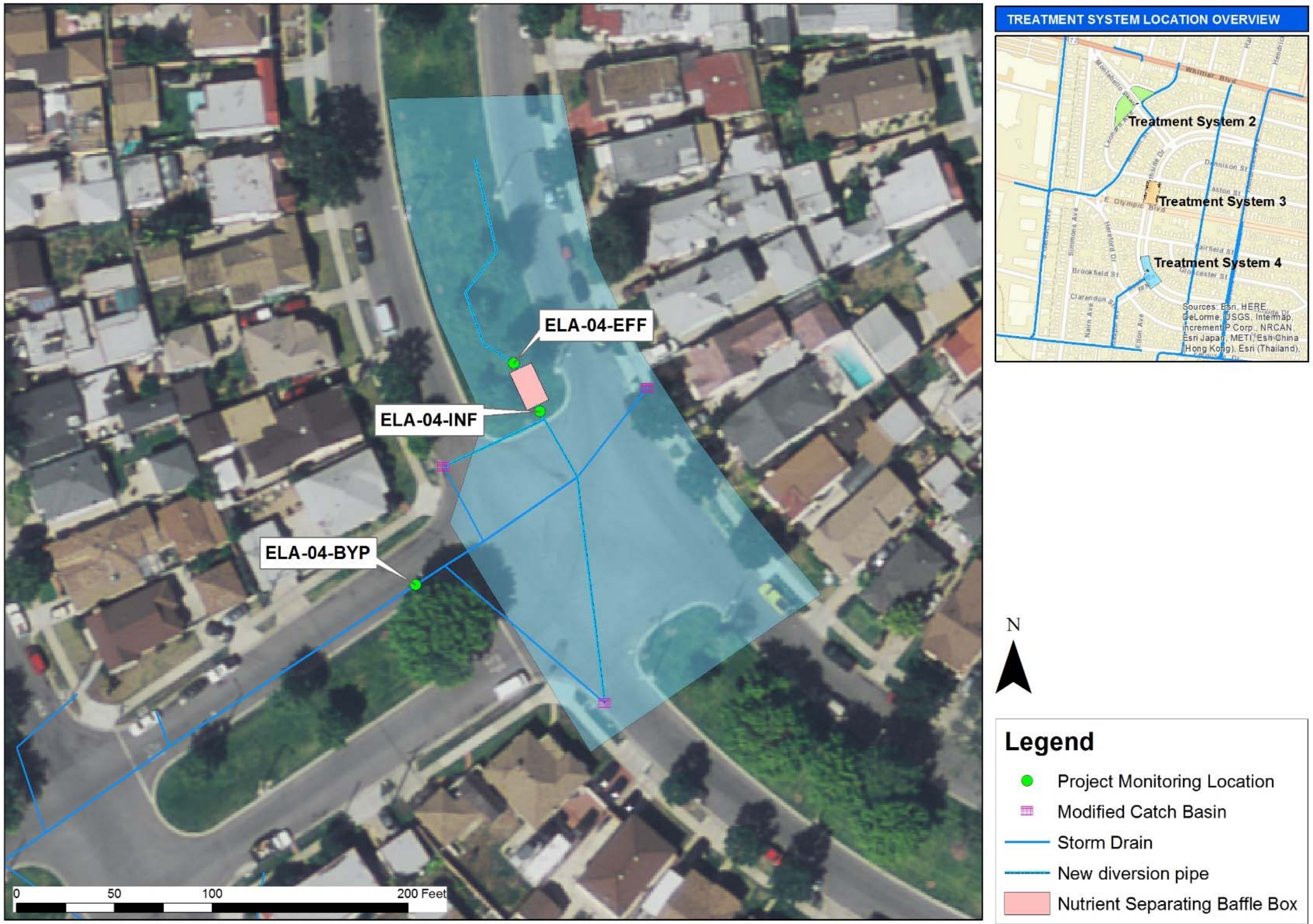

TREATMENT SYSTEM 1 SOUTH MONITORING LOCATIONS
TREATMENT SYSTEM 1 OVERVIEW
Treatment System 1 North
Treatment System 1 South
Bypass
Treatment System 1
ELA-1S-EFF
ELA-1S-INF
0
50
100
200 Feet
N
Legend
Project Monitoring Location
Nutrient Separating Baffle Box
Storm Drain
New diversion pipe

TREATMENT SYSTEM 2 MONITORING LOCATIONS



TREATMENT SYSTEM 3 MONITORING LOCATIONS

TREATMENT SYSTEM 4 MONITORING LOCATIONS



11.2. Appendix B - Field Observation Sheet

FIELD OBSERVATION SHEET
*Fill out all applicable information

PROJECT NAME ____________ STATION ID ____________
SAMPLER NAME ____________ STATION NAME ____________
SAMPLER NAME ____________ COORDINATES N ____________
DATE ____________ TIME ____________ W ____________

MONITORING TYPE
☐ DRY WEATHER ☐ WET WEATHER ☐ BLANK

WEATHER CONDITION
☐ CLEAR ☐ HAZE ☐ RAIN
☐ DRIZZLE ☐ OVERCAST ☐ THUNDERSTORM
☐ FOG ☐ PARTLY CLOUDY

SAMPLE ID (FSID) ____________
YSI UNIT NO. ____________

SAMPLE COLLECTED? ☐ YES ☐ NO
If no, observations only
DUPLICATE SAMPLE COLLECTED? ☐ YES ☐ NO
If yes, duplicate sample ID (FSID) ____________

FIELD MEASUREMENTS IN DUPLICATE

TEMPERATURE	____ °C	____ °C
pH	____	____
DISSOLVED OXYGEN	____ mg/L	____ mg/L
SP. CONDUCTIVITY	____ µS/cm	____ µS/cm
SALINITY	____ ppt	____ ppt
TURBIDITY	N/A NTU	N/A NTU

FLOW CONDITION
☐ DRY
☐ PONDED
☐ TRICKLING
☐ STEADY FLOW
☐ HIGH/FLOODED

SAMPLE SOURCE
☐ GROUNDWATER ☐ OCEAN
☐ LAKE/RESERVOIR ☐ NON-STORM
☐ MARINA ☐ STORM

SAMPLE DEPTH
☐ BOTTOM ☐ MIDDLE ☐ SURFACE

SAMPLE COLLECTION METHOD
☐ AUTOMATIC ☐ MANUAL

IS SURFACE FLOW REACHING THE OCEAN? ☐ YES ☐ NO ☐ DON'T KNOW (see comments)

FIELD OBSERVATIONS

ODOR
☐ NONE
☐ AMMONIA
☐ CHEMICAL
☐ CHLORINE
☐ FISH/DECAY
☐ MUSTY
☐ PETROLEUM
☐ ROTTEN EGG
☐ SEWAGE

COLOR
☐ COLORLESS
☐ BLUISH
☐ BROWNISH
☐ GREENISH
☐ REDDISH
☐ YELLOWISH
☐ GREYISH

TURBIDITY
☐ CLEAR
☐ CLOUDY
☐ MURKY

ALGAE NEAR DRAIN? ☐ YES ☐ NO
TRASH COMING FROM DRAIN? ☐ YES ☐ NO
If yes, type of trash ☐ PLASTICS ☐ STYROFOAM ☐ VEGETATION ☐ WOOD ☐ OTHER ____________ (e.g. DEAD ANIMAL, ETC.)
SOAP OR FOAM IN DISCHARGE? ☐ YES ☐ NO
WILDLIFE WITHIN 50 YARDS? ☐ YES ☐ NO
If yes, type and number ____________ TYPE (e.g. DUCKS, ETC.) ____________ NUMBER (e.g. 2)
REDTIDE (OCEAN)? ☐ YES ☐ NO

COMMENTS ____________

Page 1 P:\wmpub\DATA MANAGEMENT\Monitoring Programs Unit\Forms\Field observation sheet\Field Observation Sheet (2015)

11.3. Appendix C – Maintenance and Inspection Form

BMP MAINTENANCE AND INSPECTION FORM

Project Name ______________________ **Inspector Name** ______________________

Project Location ______________________ **Inspection Date** ______________________

Weather ______________________ **Inspection Start Time** ______________ **AM / PM**

Storm in last 72-hrs? Yes No **Type of Inspection (circle one)**

Routine Followup Complaint

BMP Treatment ID	BMP System Component	Condition (Good, Fair, Bad)	Cleanout performed? If yes, how much removed? (lbs)	Maintenance conducted (Yes/No)	Follow-up needed (Yes/No)	Other observations/ comments
1	Screen Basket					
	Sediment Accumulation Chamber 1					
	Sediment Accumulation Chamber 2					
	Sediment Accumulation Chamber 3					
	BMP System Component	**Condition Full (25, 50, 75, or 100%)**	**Was boom changed?**	**Boom Change date**	**Follow-up needed (Yes/No)**	**Other observations/ comments**
	Hydrocarbon Booms					
Treatment ID	**BMP System Component**	**Condition (Good, Fair, Bad)**	**Cleanout performed? If yes, how much removed? (lbs)**	**Maintenance conducted (Yes/No)**	**Follow-up needed (Yes/No)**	**Other observations/ comments**
2	Screen Basket					
	Sediment Accumulation Chamber 1					
	Sediment Accumulation Chamber 2					
	Sediment Accumulation Chamber 3					
	BMP System Component	**Condition Full (25, 50, 75, or 100%)**	**Was boom changed?**	**Boom Change date**	**Follow-up needed (Yes/No)**	**Other observations/ comments**
	Hydrocarbon Booms					
BMP Treatment ID	**BMP System Component**	**Condition (Good, Fair, Bad)**	**Cleanout performed? If yes, how much removed? (lbs)**	**Maintenance conducted (Yes/No)**	**Follow-up needed (Yes/No)**	**Other observations/ comments**
3	Screen Basket					
	Sediment Accumulation Chamber 1					
	Sediment Accumulation Chamber 2					
	Sediment Accumulation Chamber 3					
	BMP System Component	**Condition Full (25, 50, 75, or 100%)**	**Was boom changed?**	**Boom Change date**	**Follow-up needed (Yes/No)**	**Other observations/ comments**
	Hydrocarbon Booms					

P:\wmpub\Environmental Analysis\Projects\BMP Monitoring\Roosevelt Park\Post-Construction Monitoring\Documents\Inspection forms 5/4/2017

Appendix D – Biochar performance study

Biochar demonstrates exceptional pollutant removal ability that is documented in literatures but is seldom tested in the field. A column experiment was conducted in the laboratory to determine the biochar pollutant removal ability. In the experiment, stormwater was collected in the field and fed into the biochar and biomediaGREEN filter columns respectively. Water quality samples were taken before water entering the filter columns and after it came out from the two columns. The experiment was conducted three times using water collected from storm events occurred on 01/09/2018, 01/25/2018, and 02/23/2018. After each experiment was completed, water was not emptied out from the filter columns. For the subsequent experiments, the same testing columns were re-used. The testing columns simulated the dry period and repeated hydraulic loading scenario for a field scale system. Samples were analyzed for 21 constituents in three categories. The results revealed that the biochar filter material significantly removed Total Nitrate, Cadmium, Copper, Zinc, Total Coliform, and E. coli from the water column. The pollutant removal ability observed from the biochar is somewhat similar to the biomediaGREEN filter media. The experiment results in boxplot were presented below.

Figure 1 Pollutant removal for nitrogen pollutants

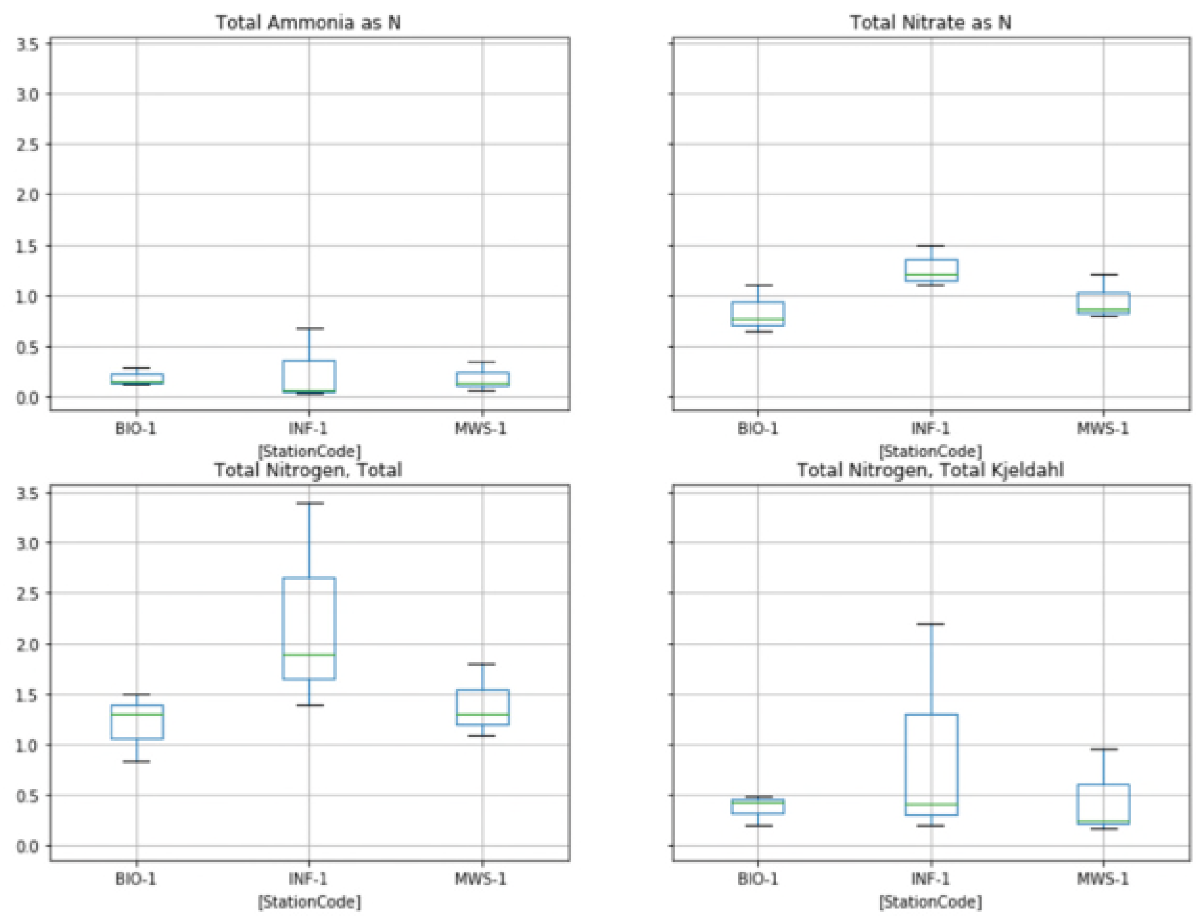


Figure 2 Pollutant removal for total metals pollutants

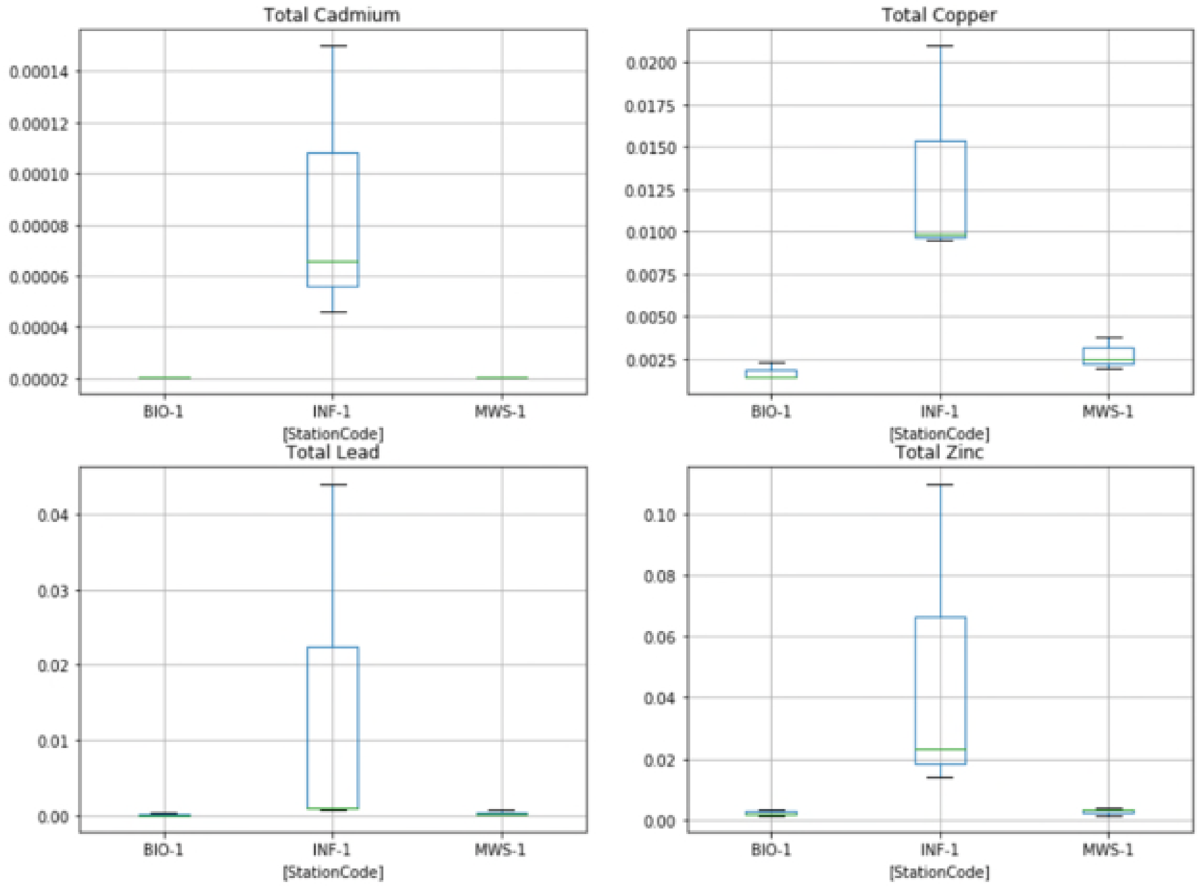


Figure 3 Pollutant removal for dissolved metals pollutants

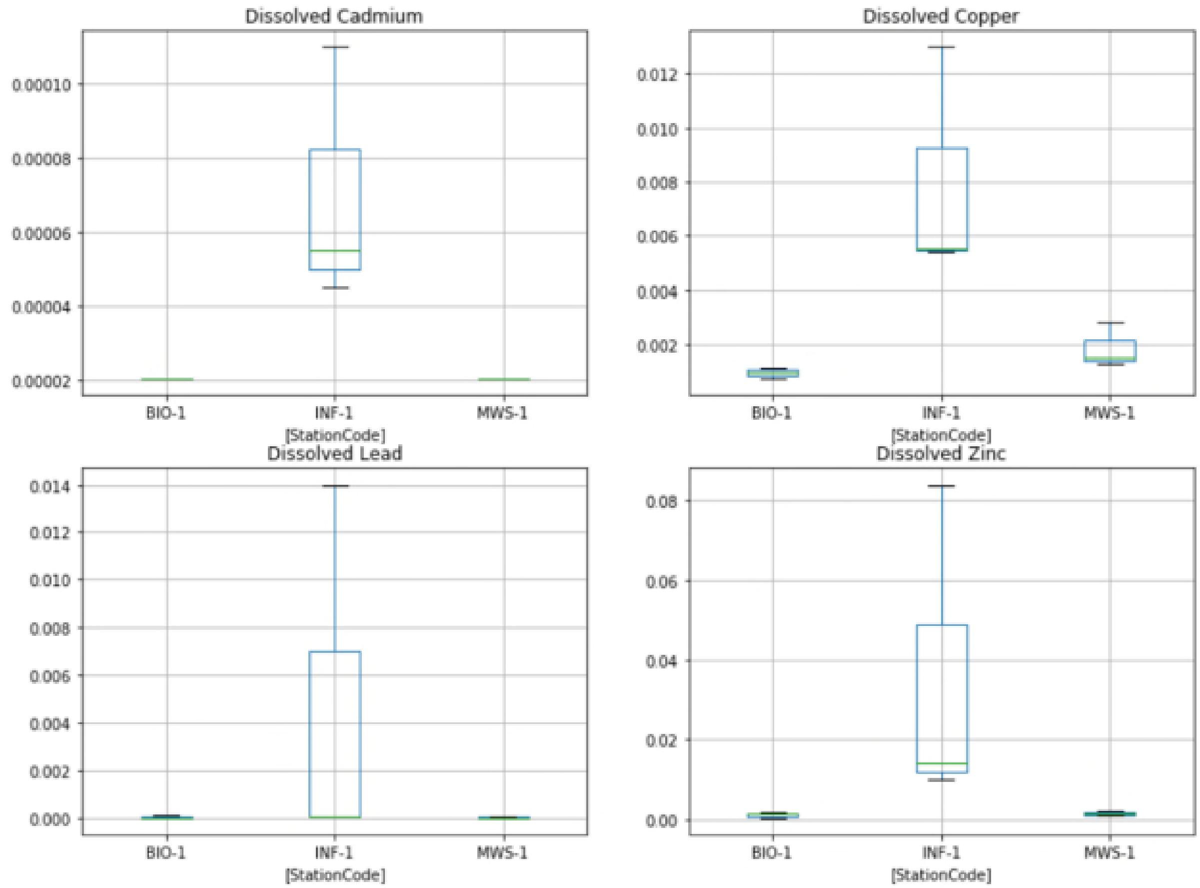
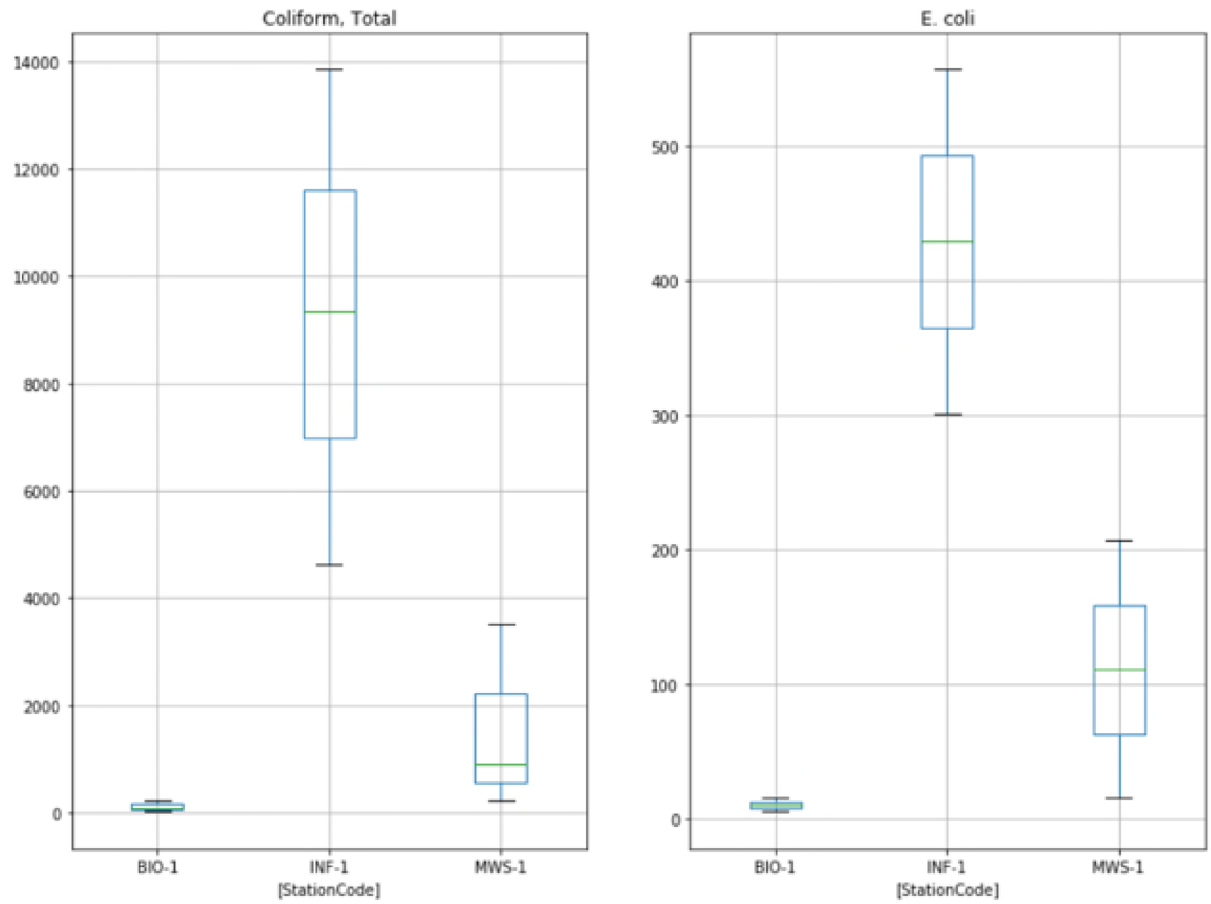


Figure 4 Pollutant removal for bacteria species



The goal of the biochar performance study (performance study) is to determine whether biochar can significantly removal pollutants from storm water runoff. The specific objectives of the study are to (1) determine whether biochar can remove pollutants in storm water, (2) determine what is biochar's pollutant removal degradation rate, (3) understand how flow rate may affect biochar's pollutant removal efficiency, and (4) find out what biochar-to-sand ratio will provide the optimum treatment conditions. This performance study will be conducted in a short duration of time. The results will not be used in the performance report to fulfill the Proposition 1 grant reporting requirements.

Monitoring Locations

Treatment system #3 is selected to conduct the biochar performance study. Treatment system #3, that consists of the four separate treatment chambers, provides a unique opportunity to apply biochar-to-sand in different ratios. In addition, the four treatment chambers are designed to receive different flow rates. In each of the four treatment chambers, two sets of filter cartridges will be in place. Storm water will be filtered through each of the cartridges before entering the Structural cell module system structures. The first filter cartridge in each of the treatment chambers will be filled with sand. The cartridge will be used as the control in the experiment. The second cartridge in each of the per-treatment chambers will be used as the "treatment" where it will be filled with biochar and sand mixture. Different biochar-to-sand ratios will be applied to the second cartridges across the four treatment chambers. In the Structural cell module system structure, different biochar-to-sand ratios will also be applied to study how tree growth will be affected by the biochar. The study design schematic is presented in Figure 5.

Figure 5 Study design schematic

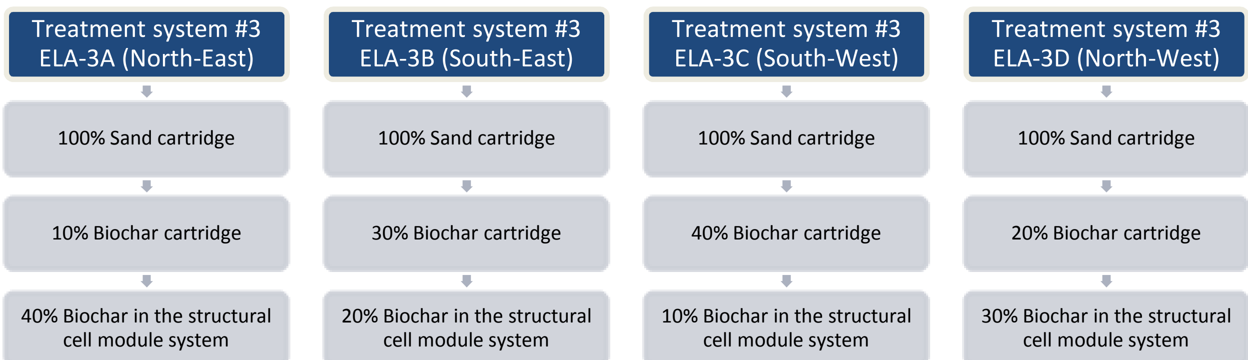
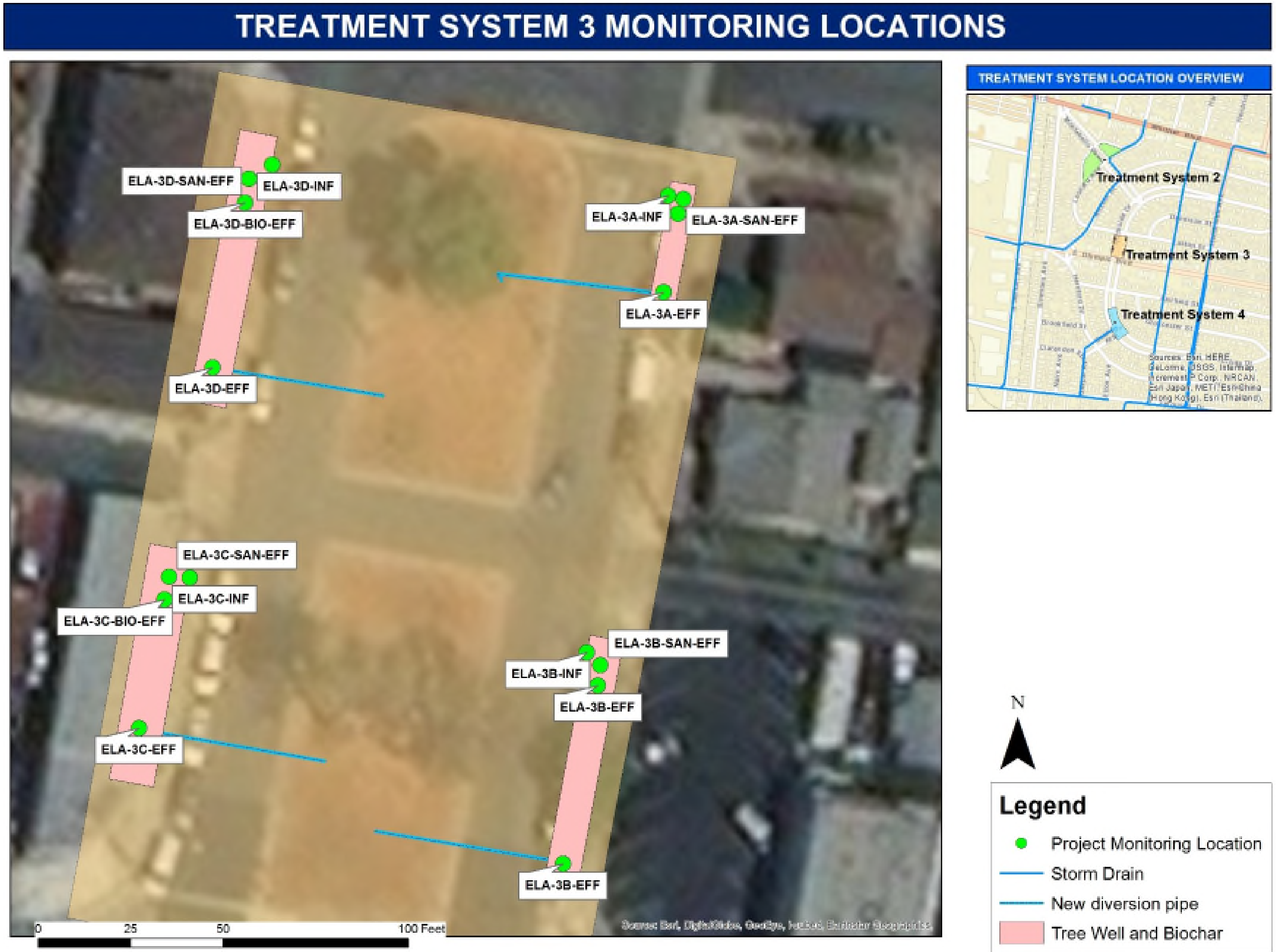


Figure 6 Treatment System #3 Monitoring Locations



Monitoring Method

Water level sensors will be installed at the influent of each of the pre-treatment chambers to measure the incoming flow rate and runoff volume. Paired water quality samples will be taken from the influent and the effluents of the first and second filter cartridges and at the Structural cell module system structure's effluent. In other words, at each of the monitoring locations, one influent sample will be taken before water enters the sand filter cartridge; one effluent sample[1] will be taken after water passes through the sand filter cartridge; one effluent sample will be taken after water passes through the biochar cartridge; and one effluent samples will be taken from the perforated pipe at the end of the Structural cell module system structure. A total of sixteen sampling points is assigned in the experiment (four samples at each of the Structural cell module system structure x four Structural cell module system Structures = 16 sampling points).

Manual grab sampling technique will be used to collect water quality samples in the field for a three-hour duration taken at 30-minute intervals. Sampling will be conducted at the beginning of a storm event, whenever possible. One bacteria grab sample will be collected first. Then, a total of 12 manual grab samples will be collected every 30 minutes, for up to three hours at each of the structural cell module system structures. For each round of manual grab sampling, approximately 1.5-L of sample will be collected. Sample collected at each of the monitoring locations will be emptied into a composite bottle to make up a total of 9-L composite sample. When a grab sample is taken, an instantaneous flow measurement should also be taken. The flow data will be used to estimate the total runoff volume for the storm event and, thus, pollutant load can be calculated. It is estimated that up to six sampling events will be conducted for the performance study.

Hypothesis testing will be applied to the water quality sample results to determine whether biochar can removal storm water pollutants from the runoff. The goal is to determine the optimum biochar-to-sand mixture ratios that can provide the best pollutant removal ability. It is assuming that the biochar cartridges in the pre-treatment chambers will not be replaced during the study period. The degradation rate of the biochar in terms of pollutant removal ability will be evaluated. It is estimated that the experiment will be carried for two storm seasons. Such long-team testing of biochar will provide insights into the design life of biochar-amended filters for storm water treatment.

Meanwhile, quarterly field observation will be conducted to monitor the overall healthiness of the trees. During the observations, eight different categories will be evaluated including tree

[1] The sample will also represent the influent water quality before water enters the biochar filter cartridge.

height, canopy size, canopy density, branching density, trunk diameter at the chest height, size of the root flare zone, leave coloration, and overall health. Furthermore, additional constituents collected from the effluents of the Structural cell module system structures will be analyzed to evaluate the overall soil condition.

APPENDIX B

Monitoring Plan Template

Document Template | USAGE GUIDE

Public Works LOS ANGELES COUNTY

This document template is intended to help efficiently develop a **BMP Performance Evaluation Monitoring Plan.** The template contains chapters and subchapters, standard text, and prompts and examples for new text, tables, and/or figures commonly found in standard Monitoring Plans which need to be added or revised based on project requirements. Whether using standard text or incorporating new text, the entire monitoring plan template must be reviewed to ensure the content pertains to the users specific project. Below are two example pages noting the different components of the template.

General Notes

1. **Standard language, table fields, and other existing text should be reviewed and revised as appropriate to the project.**
2. **Boxes containing hints should be replaced with final content. When complete, there should be no remaining boxes or hints.**
3. **[Bolded, bracketed text] should be replaced. When complete, there should be no remaining bolded, bracketed text.**

Example 1

2 PROJECT DESCRIPTIONS

2.1 Objective

Hints for this section: Describe general project objectives such as water quality benefits, recreational benefits, aesthetic benefits, etc.

2.1.1 Improving Water Quality

Hints for this section: Describe planned water quality benefits such as pollutant load reductions, annual volume capture, etc. these should be based on the project design plans.

2.1.2 Water Conservation

Hints for this section: Describe water conservation benefits (if applicable) such as native vegetation or turf replacement.

2.1.3 Recreation and Education/Outreach

Hints for this section: Describe recreational and educational aspects of the project.

2.2 Water Quality Regulation

Hints for this section: Describe monitoring program regulations applicable to project area/watershed. Include brief description of related TMDL or other water quality objectives within the watershed, and how the project will contribute to achieving those objectives. Table 1 is an example table of project-specific water quality objectives – revise based on project requirements.

The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit Order No. R4-2021-0105 NPDES PERMIT NO. CAS004004 (Permit) became effective July 23, 2021. The MS4 Permit provides permittees an option to develop an Enhanced Watershed Management Program (EWMP) to demonstrate compliance with water quality standards. The **[watershed name]** Watershed EWMP was developed by the County of Los Angeles and various cities to address the water quality issue within the **[watershed name]** Watershed area. The vision for development of the EWMP was to utilize a multi-pollutant approach that maximizes the retention and urban runoff usages as resources for groundwater recharge and irrigation, while also creating additional benefits for the surrounding communities.

❶ ***Unbolded, unbracketed text*** *is standard language. Review for accuracy but typically modifications won't be needed.*

❷ ***Boxed text, figures, and tables*** *provide hints or direction for required information, examples where appropriate, and other guidance to complete this portion of the document. When complete, there should be no remaining boxes or hints.*

❸ ***Bolded, bracketed text*** *is project-specific information and must be modified.*

Example 2

One of the key elements in the EWMP is to determine and identify the network of control measures also known as best management practices (BMPs) that will help achieve the pollutant reduction goal required by the Permit. The identification of the BMP needs is based on the water quality priorities and the results obtained from the reasonable assurance analysis. A wide range of control measures were proposed in the EWMP including low-impact development, green streets, institutional control measures, and regional BMPs. The Project was identified as one of the high priority-regional BMP projects. The Project's goal is to help reduce the amount of pollutants discharging into the **[Receiving Water].**

Hints for this table: Replace with project-specific table.

Table 1. Harbor Toxics TMDL Wet Weather Numeric Targets for Metals

Pollutant of Concern	Source	Final Freshwater Water Column Numeric Target (wet weather)[2]	Interim Freshwater Water Column Numeric Target (wet weather)[2]
Total Copper	Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water Toxic Pollutants TMDL[1]	9.7 µg/L or 1,485.1 g/day	207.51 µg/L
Total Lead		42.7 µg/L or 6548.8 g/day	122.88 µg/L
Total Zinc		69.6 µg/L or 10,685.5g/day	898.87 µg/L
Dissolved Copper		6.99 µg/L	–
Dissolved Lead		30.14 µg/L	–
Dissolved Zinc		65.13 µg/L	–

Notes:

1. The final numeric target is listed on the Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water Toxic Pollutants TMDL Attachment A to Resolution No. R11-008 (dated May 5, 2011).
2. Numeric targets are applicable to discharge above Vermont Avenue to the Dominguez Channel in wet weather conditions.

[Project Name]
Monitoring Plan

FINAL

Created: **[Date]**

Version 1.0

Confidential and Privileged

Los Angeles County Public Works

Stormwater Quality Division

Environmental Planning Section

Public Works
LOS ANGELES COUNTY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

°C	degree(s) Celsius
µg/L	microgram(s) per liter
AF	acre-foot (feet)
Ag	silver
AgCl	silver chloride
BMP	best management practice
BS	blank spike
BSD	blank spike duplicate
CaCO2	calcium carbonate
CEDEN	California Environmental Data Exchange Network
cfs	cubic foot (feet) per second
COC	chain of custody
DCWMA	Dominguez Channel Watershed Management Area
DO	dissolved oxygen
DQO	data quality objective
E. coli	Escherichia coli
ELAP	Environmental Laboratory Accreditation Program
EMC	event mean concentration
EPA	United States Environmental Protection Agency
EWMP	Enhanced Watershed Management Plan
HCl	hydrochloric acid
HNO3	nitric acid
H2SO4	sulfuric acid
ID	identifier
IWQS	Integrated Water Quality System
LACFCD	Los Angeles County Flood Control District
LACPW	Los Angeles County Public Works
LACSD	Los Angeles County Sanitation District
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LID	low-impact development
MDL	method detection limit
mg/L	milligram(s) per liter
mL	milliliter(s)
MPN	most probable number
MS	matrix spike
MS4	Municipal Separate Storm Sewer System
mS/cm	millisiemen(s) per centimeter
MSD	matrix spike duplicate

N	nitrogen
NA	not analyzed
ND	non-detect
NPDES	National Pollutant Discharge Elimination System
NSBB	nutrient-separating baffle box
P	phosphorus
Permit	National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit Order No. R4-2021-0105
Project	**[Full project name]**
QA	quality assurance
QC	quality control
RCB	reinforced concrete box
RL	reporting limit
RMC	Rivers & Mountains Conservancy
RPD	relative percent difference
SCWP	Safe, Clean Water Program
SM	Standard Method
SWAMP	Surface Water Ambient Monitoring Program
SWQD	LACPW Stormwater Quality Division
TBD	to be determined
TMDL	total maximum daily load
WMA	watershed management area
WMMS	Watershed Management Modeling System
	[Add/remove rows as needed]

EXECUTIVE SUMMARY

Hints for this section: Brief summary (1-2 pages) describing project purpose/benefits, treatment system function, and monitoring goals and expected outcomes.

1 INTRODUCTION

1.1 Background

Hints for this section: Describe the project background, general drivers for the project, previous monitoring such as preconstruction monitoring, land uses, and other pertinent background information.

1.2 Project Organization

The proposed **[Project name]** effectiveness monitoring program will be executed by **[indicate team]** staff.

Hints for this section: Describe the party(ies) involved in the project implementation, brief description of location (e.g., cities/county jurisdictions), and other pertinent information regarding project owners and implementation. This org chart should correspond with the Project's QAPP.

Figure 1 shows the Project team organization responsible for conducting the post-construction monitoring.

Hints for this figure: Insert project-specific organization chart corresponding to Project QAPP.

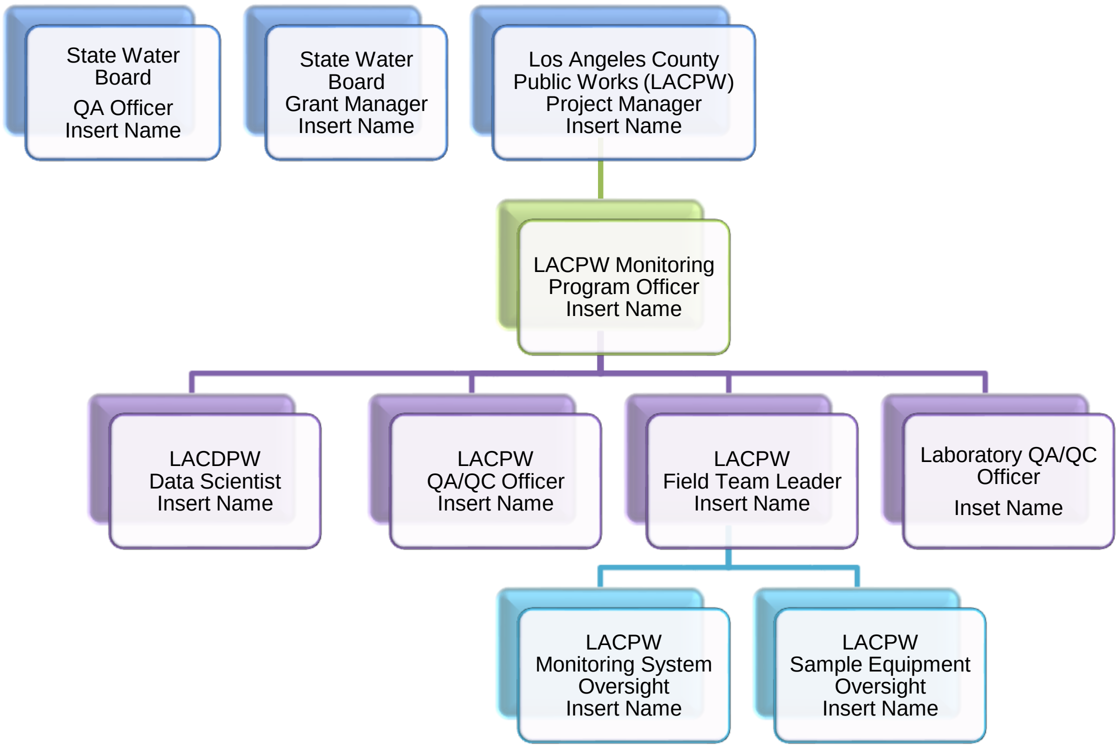


Figure 1. Project Organization for Post-Construction Monitoring

2 PROJECT DESCRIPTIONS

2.1 Objective

Hints for this section: Describe general project objectives such as water quality benefits, recreational benefits, aesthetic benefits, etc.

2.1.1 Improving Water Quality

Hints for this section: Describe planned water quality benefits such as pollutant load reductions, annual volume capture, etc. these should be based on the project design plans.

2.1.2 Water Conservation

Hints for this section: Describe water conservation benefits (if applicable) such as native vegetation or turf replacement.

2.1.3 Recreation and Education/Outreach

Hints for this section: Describe recreational and educational aspects of the project.

2.2 Water Quality Regulation

Hints for this section: Describe monitoring program regulations applicable to project area/watershed. Include brief description of related TMDL or other water quality objectives within the watershed, and how the project will contribute to achieving those objectives. Table 1 is an example table of project-specific water quality objectives – revise based on project requirements.

The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit Order No. R4-2021-0105 NPDES PERMIT NO. CAS004004 (Permit) became effective July 23, 2021. The MS4 Permit provides permittees an option to develop an Enhanced Watershed Management Program (EWMP) to demonstrate compliance with water quality standards. The **[watershed name]** Watershed EWMP was developed by the County of Los Angeles and various cities to address the water quality issue within the **[watershed name]** Watershed area. The vision for development of the EWMP was to utilize a multi-pollutant approach that maximizes the retention and urban runoff usages as resources for groundwater recharge and irrigation, while also creating additional benefits for the surrounding communities.

One of the key elements in the EWMP is to determine and identify the network of control measures also known as best management practices (BMPs) that will help achieve the pollutant reduction goal required by the Permit. The identification of the BMP needs is based on the water quality priorities and the results obtained from the reasonable assurance analysis. A wide range of control measures were proposed in the EWMP including low-impact development, green streets, institutional control measures, and regional BMPs. The Project was identified as one of the high priority-regional BMP projects. The Project's goal is to help reduce the amount of pollutants discharging into the **[Receiving Water]**.

Hints for this table: Replace with project-specific table.

Table 1. Harbor Toxics TMDL Wet Weather Numeric Targets for Metals

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Notes:

1. The final numeric target is listed on the Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water Toxic Pollutants TMDL Attachment A to Resolution No. R11-008 (dated May 5, 2011).
2. Numeric targets are applicable to discharge above Vermont Avenue to the Dominguez Channel in wet weather conditions.

3 MONITORING STRATEGY

3.1 Monitoring Purpose

The purpose of this monitoring program is to evaluate the effectiveness of the stormwater treatment systems in terms of volume capture and pollutant load reduction. Post-construction monitoring will focus on quantifying the specified pollutants that will be captured by the treatment systems. Paired samples collected from the treatment systems' influent and effluent points will be evaluated for water chemistry characteristics. The results will indicate whether the treatment systems can remove/reduce pollutants effectively. Water quality data collected from multiple sampling events may be pooled together to create a larger data set for analysis and performance assessment. The information gathered from the Project may assist with selection and implementation of future regional stormwater BMP projects.

3.2 Stormwater Treatment System Locations

Hints for this section: Describe project locations (i.e., cities/county jurisdiction, street intersections), conveyance types, and land uses and respective areas. **Figure 2 is a map of the Project location area, and Figure 3 is a map of the Project's overall drainage area and land uses.**

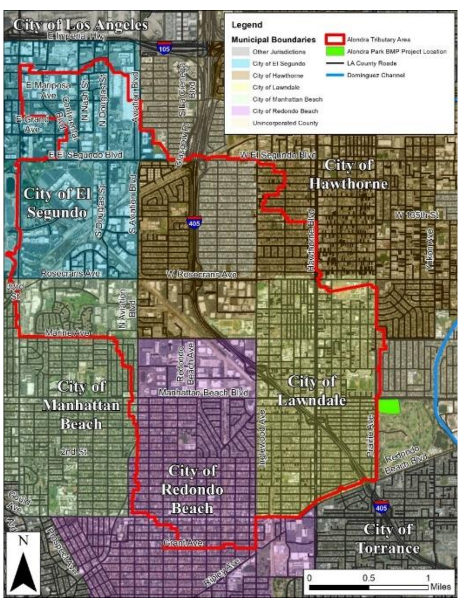

Figure 2. Project Location Map [Example – replace with project-specific map]

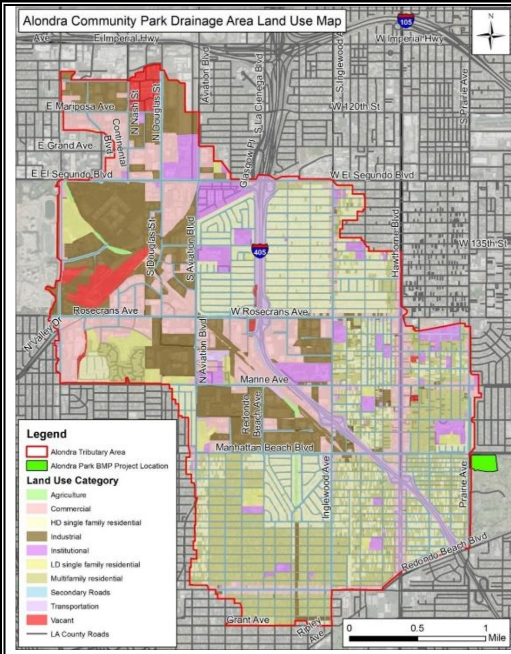

Figure 3. Project Drainage Area and Land Use Map [Example – replace with project-specific map]

3.3 Stormwater Treatment System Design

Hints for this section: Provide a brief summary of the project treatment system configurations and function. Include images or graphics where possible.

3.3.1 Treatment System Processes [Add subsections as needed for each treatment system configuration]

Hints for this section: Provide a brief step by step summary of the function of each component of the system (e.g., diversion structure, baffle box, etc.) and their pollutant removal processes. Include graphics or images when possible.

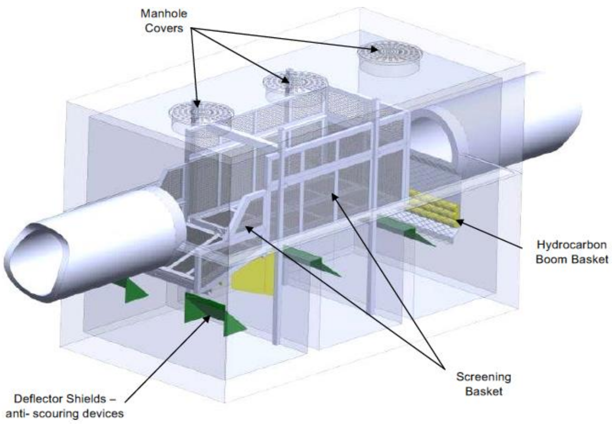

Figure 4. Nutrient-Separating Baffle Box [Example – replace with project-specific figure]

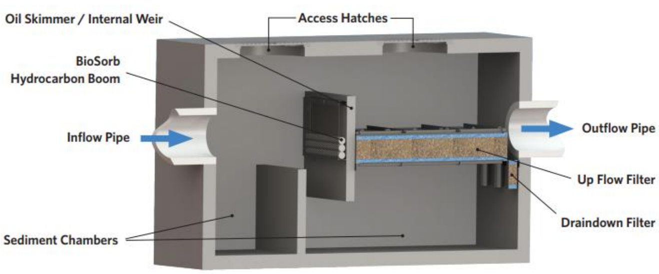

Figure 5. Water Polisher Stormwater Treatment System [Example – replace with project-specific figure]

3.4 Preconstruction Monitoring

Pre-construction monitoring was conducted by Los Angeles Department of Public Works (LACPW) in **[insert years when preconstruction monitoring occurred]**. The purpose of pre-construction monitoring was to establish the baseline dry weather and wet weather water quality and flow conditions before project construction. The pre-construction monitoring results were used to refine the design of the BMPs to be suitable for the Project's site-specific needs.

[The project preconstruction monitoring location map is presented in Figure 6. Describe preconstruction monitoring locations and outcomes, if applicable.]

Hints for this section: Replace with project-specific map.

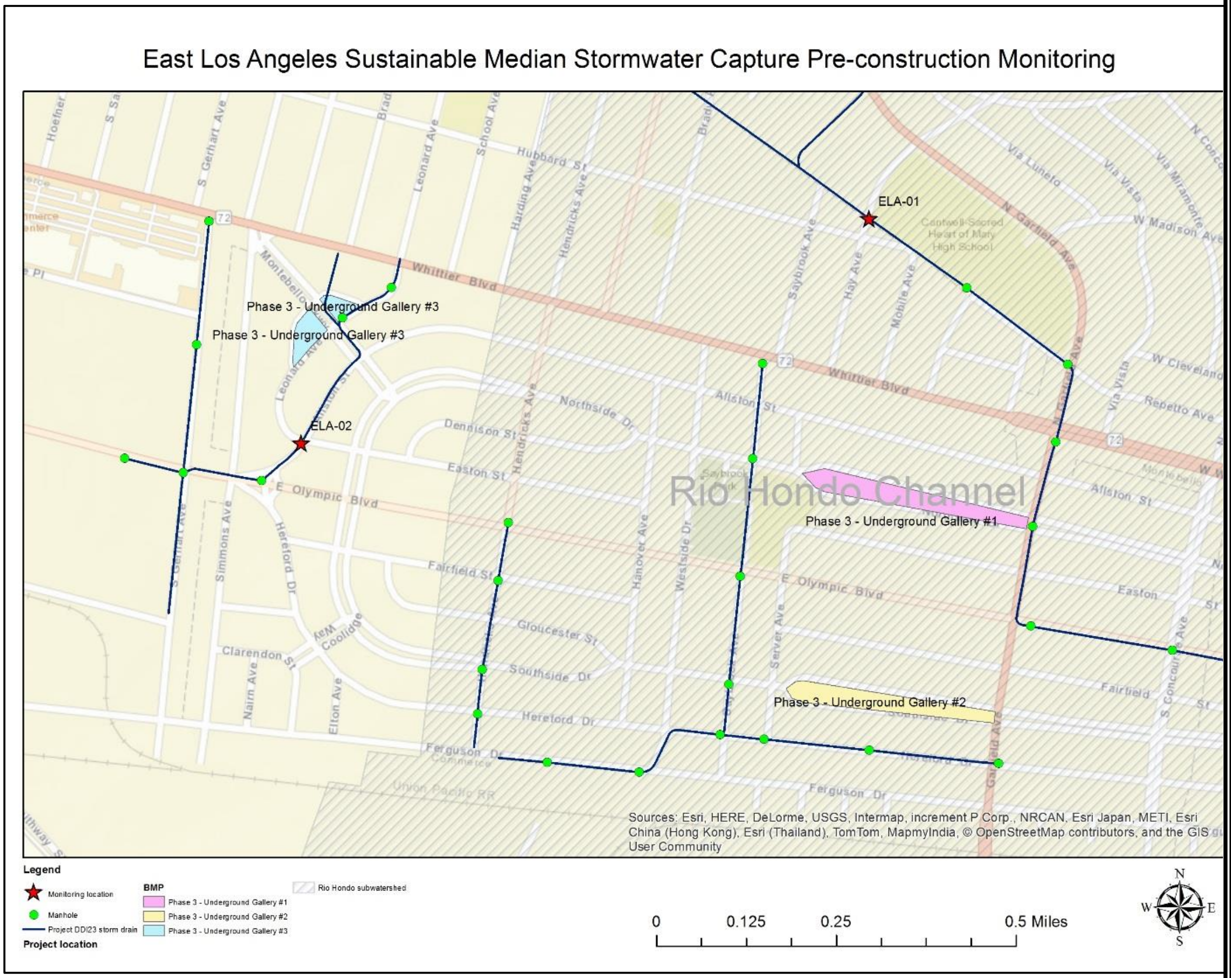

Figure 6. Preconstruction monitoring locations map [Example – replace with project-specific map]

3.5 BMP Performance Expectations

The expected average pollutant capture amount was calculated using the Watershed Management Modeling System (WMMS) during Project planning. The modeling results indicate that approximately **[X]** pounds of **[pollutant(s)]** will be captured annually by the Project.

3.6 Project Questions

Hints for this section: List study questions. These questions are the basis of study design such that the data collected during monitoring described in this Monitoring Plan can be used to directly answer the listed questions.

Example Study Questions:

The following study questions will be examined in the post-construction monitoring:

1. How much water is captured by the selected storm water treatment systems annually?
2. What are the pollutant loads captured by the BMP annually?
3. What is the pollutant removal efficiency of the BMP unit during the monitoring period?
4. What is the pollutant removal efficiency of the pretreatment device during the monitoring period?

4 MONITORING APPROACH

The goal of the monitoring is to evaluate the amounts of stormwater runoff and pollutant loads treated by the Project. The influent-effluent monitoring approach will be used to monitor water quality and flow during dry and wet weather. The typical monitoring layout strategy for the influent-effluent approach is illustrated on Figure 7.

Selection of the monitoring approach was based on the Project questions, the type of BMP, the Project constraints, and the current and the historical conditions of the Project area. The influent-effluent assessment will provide pollutant removal rates for the system and flow volumes and pollutant loads treated by the system.

The monitoring locations, monitoring frequency, water sampling methodology, and flow monitoring methodology are described in Sections 4.1 through 4.4.

The monitoring methodology will remain adaptive, and the data collection method may be evaluated for the quality of data collected. The data quality evaluation will be based on completeness, precision, and accuracy of the quality control (QC) samples. In addition, the effectiveness of the data for addressing the Project questions may be evaluated. The monitoring methodology may be adjusted if unforeseen challenges are encountered, and any adjustments will be verified by the County of Los Angeles project manager to maintain data quality. The adaptive monitoring approaches are discussed further in Section 9.0.

Hints for this figure: Insert project-specific influent-effluent configuration.

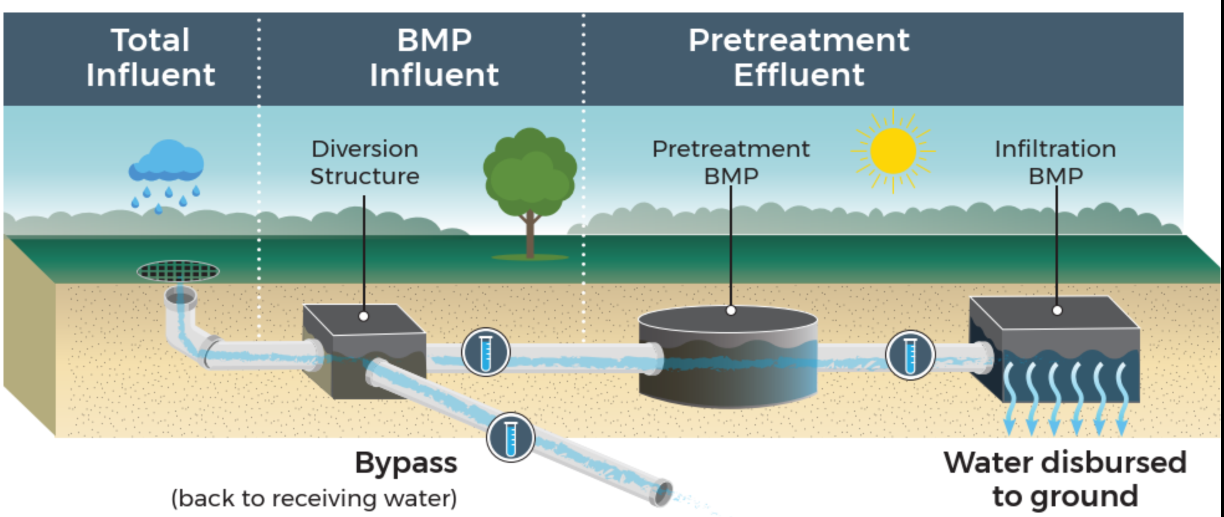

Figure 7. Influent-Effluent Monitoring Schematic [Example – replace with project-specific configuration]

4.1 Monitoring Location

Hints for this section: Describe monitoring locations and type of monitoring occurring at each location. Complete the fields in Table 2.

The stormwater treatment systems, monitoring station identifiers (IDs), and monitoring parameters are summarized in Table 2.

Hints for this table: Fill out table with stormwater treatment system monitoring locations, IDs, and parameters. Insert project-specific influent-effluent configuration figure

Table 2. Stormwater Treatment System Monitoring Locations, IDs, and Parameters

Monitoring Station ID	Monitoring Station Description	Latitude	Longitude	Monitoring Parameter		
				Flow	Water Quality	Continuous Turbidity

Notes:
ID = identifier;
1. Latitude and longitude of monitoring points will be determined after construction is complete.

4.2 Monitoring Frequency

The project post-construction monitoring will be carried out for **[X]** years after project completion. **[Dry and wet]** weather water quality samples will be collected at the monitoring frequency for dry and wet weather sampling described in this section.

The monitoring frequency is based on the sample type. Dry weather pollutant concentrations typically exhibit a relatively consistent pattern, so **[four]** dry weather sampling events are proposed for each monitoring year. Dry weather sampling events will be scheduled **[quarterly]** to account for seasonal variations in dry weather runoff.

Wet weather pollutant concentrations generally exhibit greater temporal variation due to storm size, rainfall intensity, and flow volume. Wet weather sampling will be triggered when the rainfall amount is forecast to be at least **[0.1 inch within a 24-hour period].** Up to **[X]** wet weather sampling events will be targeted for each monitoring year.

The water quality results will be evaluated annually. If the data indicate a high degree of fluctuation, then additional sampling events may be conducted during that year to overcome uncertainty in the results. However, if the data are consistent, then sampling will be concluded for the post-construction monitoring for that year.

4.3 Water Chemistry Sampling Methodology

Dry and wet weather samples will be analyzed for constituents listed in the **[List TMDL Program(s)]** TMDL programs. Additional pollutants will be analyzed as indicated. Additional monitored constituents include **[list additional monitored pollutants]**. Analytical methods are selected in accordance with 40 Code of Federal Regulations Part 136.3 requirements. The reporting limits (RLs) will be set at appropriate levels so the results can be compared with results from other studies, if available. The sample volume, analytical methods, method detection limits, RLs, sample containers, and preservation methods are listed in Table 3 and discussed further in Section 5. Table 4 summarizes the specifications for collection and analysis of field water quality parameters.

Hints for this table: Add or remove parameters as needed.

Table 3. Water Chemistry Analysis Parameter Summary Table [Add or remove parameters as needed]

Constituent	Sample Volume*	Analytical Method	Method Detection Limit	Laboratory Reporting Limit	Container (number, size, and type)	Preservation	Holding Time
Bacteria							
E. coli	120 mL	SM9223B	1 MPN/100 mL	1 MPN/100 mL	1 x 120-mL sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C	8 hours
Enterococci	120 mL	SM9230B	1 MPN/100 mL	1.8 MPN/100mL	1 x 120-mL Sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C	8 hours
Fecal Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100mL	1 x 120-mL sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C or less	8 hours
Total Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100mL	1 x 120-mL sterilized bottle	Sodium Thiosulfate, Store Cool at 10°C	8 hours
Metals							
Copper (Total and Dissolved)	500 mL	EPA 200.8	0.29 µg/L	1.0 µg/L	2 x 500-mL plastic bottle		28 days
Lead (Total and Dissolved)	500 mL	EPA 200.8	0.052 µg/L	1.0 µg/L	2 x 500-mL plastic bottle	HNO3, Store Cool at 6°C	28 days
Zinc (Total and Dissolved)	500 mL	EPA 200.8	1.3 µg/L	10 µg/L	2 x 500-mL plastic bottle		28 days
Nutrients							
Total Kjehldahl Nitrogen	500 mL	SM 4500-NH3C	0.065 mg/L	0.1 mg/L	1 x 1000-mL plastic bottle	H2SO4, Store Cool at 6°C	28 days
Ammonia-N	500 mL	SM 4500-NH3C	0.017 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	H2SO4, Store Cool at 6°C	28 days
Nitrate-N	500 mL	EPA 300.0	0.0095 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	Store Cool at 6°C	48 hours
Nitrite-N	500 mL	EPA 300.0	0.03 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	Store Cool it 6°C	48 hours
Total Nitrogen	500 mL	Calculation	0.1 mg/L	NA			
Total Phosphorus	500 mL	EPA 365.3	0.0062 mg/L	0.02 mg/L	1 x 500-mL plastic bottle	H2SO4, Store Cool at 6°C	28 days
Ortho phosphorus	500 mL	EPA 300.0	0.003 mg/L	0.01 mg/L	1 x 500-mL plastic bottle	Store Cool it 6°C	48 hours
Particulate Matter							
Total Suspended Solids	1000 mL	SM 2540D	1.0 mg/L	1.0 mg/L	1 x 1000-mL plastic bottle	Store Cool at 6°C	7 days
Conventional Chemistry							
Oil and Grease	1000 mL	EPA 1664	1.3 mg/L	5.0 mg/L	1 x 1000-mL Amber glass bottle	H2SO4, Store Cool at 6°C	28 days
Total Organic Carbon	500 mL	SM5310B	0.14 mg/L	1.0 mg/L	1 x 500 mL plastic bottle	HCl, Store Cool at 6°C	28 days
Total Hardness	500 mL	SM 2340C	1.0 mg/L	1.0 mg/L	1 x 500 mL plastic bottle	Store Cool at 6°C	6 months

Notes:
Sample volume, method detection limit, and reporting limit may vary depending on the California ELAP contracted laboratory.

°C = degree(s) Celsius; µg/L = microgram(s) per liter; E. coli = Escherichia coli; ELAP = Environmental Laboratory Accreditation Program; EPA = United States Environmental Protection Agency; HCl = hydrochloric acid; HNO3 = nitric acid; H2SO4 = sulfuric acid; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not analyzed; SM = Standard Method

Hints for this table: Add or remove parameters as needed.

Table 4. Field Water Quality Parameter Summary [Add or remove parameters as needed]

Constituent	Equipment	Sensor Type	Measurement Range	Equipment Accuracy	Holding Time
Field Parameters					
Conductivity	YSI ProDSS Handheld Multiparameter Meter	Four Nickel Electrode Cell	0–200 mS/cm	0 to 100 mS/cm (±0.5% of reading or 0.001 mS/cm, whichever is greater)	15 minutes
Dissolved Oxygen		Optical Luminescence	0–50 mg/L	0 to 20 mg/L (±0.1 mg/L or 1% of reading, whichever is greater)	15 minutes
pH		Glass Bulb Combination Electrode; Ag/AgCl Reference Gel	0–14 units	± 0.2 unit	15 minutes
Temperature		Thermistor; Combination Sensor with Conductivity	-5 to 70°C (23 to 158°F)	± 0.2°C	15 minutes

Notes:
°C = degree(s) Celsius; Ag = silver; AgCl = silver chloride; mg/L = milligram(s) per liter; mS/cm = millisiemen(s) per centimeter)

4.3.1 Sampling Method

The flow-weighted composite sampling method will be used in the Project (except for collection of samples for analysis of oil and grease, fecal indicator bacteria, and field parameters). The flow-weighted composite method is more accurate than the time-weighted sampling method because the capture volume passing through the monitoring location is constant for each collected sample. The analytical results from the flow-weighted samples may simplify calculation of the event mean concentration (EMC). Although the flow-weighted composite sampling method will be the first sampling strategy used whenever possible, time-weighted composite sampling may be used if flow-weighted sampling is not possible.

[Remove the following if not monitoring turbidity] Continuous measurements for turbidity will be made at ***[X]*** points within the treatment system: (1) **[list locations or delete if continuous turbidity monitoring not occurring]**. Turbidity measurements will be made using a Campbell Scientific ClariVUE10 turbidity sensor connected to a Campbell Scientific CR1000X data logger. Data will be logged at 15-minute intervals.**]**

4.3.1.1 Dry Weather Sampling Method

Dry weather samples will be collected at the influent and effluent points of the treatment system(s) using the flow-weighted composite sampling method with an autosampler. At each monitoring location, an automated sampler will be programmed to collect approximately 24 samples over a 24-hour period. When the autosampler is triggered, a water quality sample will be collected in a composite bottle placed inside the automated sampler. Water quality samples inside the automated sampler will be refrigerated, if possible, until retrieved by the field crew. Sample retrieval will typically occur within 24 hours after the sampling event. During sample retrieval, the sample bottle will be tightly capped, cooled to below 6 degrees Celsius (°C) inside a cooler filled with ice, and delivered to a laboratory certified by the California Environmental Laboratory Approval Program (ELAP) under chain-of-custody (COC) protocol (See Section 4.3.3).

Multiple discrete samples (i.e., pollutograph samples) may be collected instead of a composite sample if it is important to understand the temporal variation in pollutant concentrations throughout a sampling event. Results from pollutograph samples can provide valuable insight into variability; however, increased analytical laboratory fees apply as the samples are analyzed individually.

Due to analytical method requirement holding times of 8 hours, samples for analysis of fecal indicator bacteria and oil and grease will be collected using the grab sampling technique. Grab samples will be collected when the field crew retrieves the composite sample from the monitoring locations. When the automated sampler fails to collect water quality samples (e.g., because of low-flow conditions), the grab sampling technique will be used to collect samples for the other constituents. When collecting the water samples, field crews will insert sample bottles under the surface of the flow with the container opening facing upstream. After the bottles are filled, they will be tightly capped, cooled to below 6 °C inside a cooler filled with ice, and delivered to the laboratory under COC protocol. If the grab sampling technique is required, one set of samples will be collected at a single point in time rather than a flow-weighted composite collected over a 24-hour period.

4.3.1.2 Wet Weather Sampling Method

Similar to dry weather sampling, wet weather samples will be collected by the automated sampler using the flow-weighted composite sampling method. The autosampler will be **[programmed to collect approximately 24 to 48 flow-weighted sample aliquots in a composite bottle during each sampling event]**. However, actual sample aliquot counts may vary depending on storm characteristics. The program pacing will be adjusted before each storm event to collect representative samples that span the full hydrograph. If it is determined that the autosampler was falsely triggered, the sample will be discarded. The discrete sampling method may be used instead of composite sampling if it is important to understand the temporal variation in pollutant concentrations throughout a storm event. After the storm event, field crews will attempt to retrieve the composite samples from the monitoring locations within 24 hours. Sample bottles will be tightly capped, cooled to below 6°C inside a cooler filled with ice, and delivered under COC protocol to the laboratory.

Because of analytical method requirements, samples for analysis of fecal indicator bacteria and oil and grease will be collected using the grab sampling technique. Grab samples will be collected while storm sampling is underway. Under no circumstances will field crew enter the diversion pipe during a wet weather sampling event.

4.3.1.3 Field Measurements

A multi-parameter probe will be used to measure dissolved oxygen (DO), temperature, pH, and conductivity in the field during dry and wet weather sampling events. Field parameters such as DO, temperature, and pH have shorter sample holding times; therefore, collecting in situ measurements of these field parameters will provide more accurate measurements. In addition, DO analysis requires extra precautions in the laboratory to prevent contamination by introducing extra oxygen into the sample. Thus, it may be more accurate to measure DO in the field. Before each sampling event, the multi-parameter probes will be calibrated to manufacturers' specifications. Field measurements will be collected by submerging the sensors in sample water. The sample will be stirred continuously to ensure sample homogeneity when the measurements are collected. Field measurements will be collected in duplicate to ensure data precision.

4.3.1.4 Field Observation

A field data observation sheet in paper or electronic form will be completed by the field crew during each dry and wet weather sampling event. At a minimum, the observation sheet will document the sampling date and time, monitoring location ID, sampler names, and additional comments about the field activities. The observation sheet will also note the weather, flow conditions, and water column position where samples or measurements were collected, and will describe the sample when it is collected, including color, clarity, turbidity, oil and/or grease, floating or suspended materials, and odors. Additional observations about the surrounding environment, including algae, trash, foam, or wildlife, will also be noted. Photographs will be taken during each sampling event, if feasible. A copy of the field observation form is provided in Appendix A. A digital version of the field observation form can also be accessed in the field via https://arcg.is/TCLyK website.

4.3.2 Sample Handling

Field sampling personnel will follow general sample handling practices during both dry and wet weather sampling to ensure that samples are collected in a manner that prevents and reduces contamination of the samples.

Sampling personnel will wear clean, powder-free nitrile gloves to collect each round of samples to prevent cross-contamination. Field crews will be careful to reduce potential contamination of sample bottles or sampling equipment (i.e., they will not touch the bottle or cap interior, put the bottle lid on the floor, collect samples near a running vehicle, etc.). After sample collection, bottles will be capped tightly, and sample labels will be applied to the sides of the bottles. If a **[2.5-gallon bottle]** is used in the automated sampler to collect the sample, a label will be applied to both the upper side of the lid and the side of the bottle. The sample label will be printed on waterproof labels, and at minimum will include the Project name, monitoring location ID, collection date and time, and sampler's initials. The appropriate sample containers and preservatives will be prepared and provided by the laboratory. Chemical preservatives will be added to the sample containers, where applicable, to extend the sample holding time.

4.3.3 Chain-of-Custody Form

A COC form provides records and documentation regarding sample collection and handling. A COC form will be completed and submitted to the laboratory with each sample. The COC form will contain the same information as the sample labels: Project name, monitoring location ID (sample ID), collection date and time, sampler's initials. In addition, the COC form will indicate the sample matrix, number of sample containers, and type of requested analyses.

4.4 Flow Monitoring Methodology

Hints for this section: Continuous flow will be recorded at the following [X] monitoring locations: Site ID# (list site IDs). List flow measurement sensors and site IDs they will be used at. Flow data will be recorded every [X] minutes.

Manning's Equation (Equation 1) will be used to calculate dry weather and wet weather flow rates where an area-velocity sensor is not used. The slope of the storm drain, the cross-sectional area of the flow, and the empirical roughness coefficient will be obtained from the storm drain as-built drawings and will be used to compute the flow rates.

Equation 1: Manning's Equation

$$Q = \left(\frac{1.486}{n}\right) \times A \times R^{\frac{2}{3}} \times \sqrt{S}$$

where:

Q = flow rate in cubic feet

n = Empirical roughness coefficient of the pipe

A = Cross-sectional area of the channel in foot

R = Wetted perimeter in feet

S = Channel slope in foot per foot

5 QUALITY ASSESSMENT PROGRAM

To ensure that the data set contains information that is useful and of adequate quality, any data collected must meet the data quality objectives (DQOs) established in this monitoring plan. The DQOs consist of field monitoring and laboratory quality assessment under the guidance of *Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan* (California State Water Resources Control Board, 2008). The purpose of the DQOs is to produce data of known and acceptable quality by measuring the accuracy, bias, precision, recovery, and completeness of sample data collected during field monitoring and from laboratory analysis QC. The laboratory analysis DQOs and the QC requirements for this Project are described in this section and listed in Table 5.

Hints for this table: Add or remove parameters as needed.

Table 5. Laboratory Analysis Data Quality Objectives and QA/QC Requirements [Add or remove parameters as needed]

Constituent	Analytical Method	Reporting Limit	Accuracy (% Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Bacteria									
E. coli	SM9223B	1 MPN/100 mL	NA	NA	No growth	NA	NA	Negative response	NA
Enterococci	SM9230D	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Fecal Coliform	SM9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Total Coliform	SM9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Metals									
Copper (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7440-50-8
Lead (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7439-92-1
Zinc (Total and Dissolved)	EPA 200.8	10 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7440-66-6
Nutrients									
Total Kjehldahl Nitrogen	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7727-37-9
Ammonia-N	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7664-41-7
Nitrate-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Nitrite-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Nitrogen	Calculation	NA						NA	
Total Phosphorus	EPA 365.3	0.02 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7723-14-0
Orthophosphate (as P)	EPA 300.0	0.01 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	14265-44-2
Particulate Matter									
Total Suspended Solids	SM 2540D	1.0 mg/L	NA	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Conventional Chemistry									
Oil and Grease	EPA 1664	5.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Organic Carbon	SM 5310B	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Total Hardness as $CaC0_3$	SM 2340C	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA

Notes:
µg/L = microgram(s) per liter; CaCO2 = calcium carbonate; E. coli = Escherichia coli; EPA = United States Environmental Protection Agency; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not analyzed; P = phosphorus; RL = reporting limit; SM = Standard Method

5.1 Data Quality Objectives

Data quality depends on the objective use of the results supported by the data. DQOs are qualitative and quantitative statements that define the type, quality, and quantity of data necessary to support project decisions. To meet the DQO criteria for this Project, the analytical performance requirements are expressed in terms of precision, accuracy and bias, representativeness, comparability, completeness, and sensitivity. This section provides definitions for each parameter and calculation equations, if applicable.

5.1.1 Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Field duplicates will be collected to assess the precision of the field sampling. Analysis of field duplicates will measure the precision of samplers' techniques and methods and will also be used to measure laboratory precision. Analysis of laboratory duplicates will measure the precision of laboratory procedures. The precision of a duplicate measurements can be expressed as the relative percent difference (RPD). The mathematical equation to calculate the RPD is presented in Equation 2: Calculate the relative percent difference:

Equation 2: Calculate the relative percent difference

$$RPD = \left\{ \frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}} \right\} \times 100$$

where

X_1 = native sample
X_2 = duplicate sample

5.1.2 Accuracy and Bias

Accuracy helps determine the level of certainty in data and the closeness of the results to the true value. Bias may occur during data collection or calibration, or because of limitations in analytical methods by the laboratory. In the field and laboratory, accuracy and bias will be checked with calibration solution or a matrix spike by introducing a known concentration of a target analyte to a sample or a blank sample and then analyzing the sample to assess the closeness of the result to the known concentration. Values consistently higher or lower than the true value will be considered a bias.

5.1.3 Representativeness

Representativeness is a qualitative assessment used to evaluate data based on the sampling design's ability to meet the project objectives. If the sampling design specifies that samples must be collected from a certain location, at a certain time of day, during certain conditions (determined through a systematic planning process), then any sample collected outside of those design parameters may be determined to be "not representative," and any data from those samples may not be considered quality data.

The measurement of representativeness is addressed during preparation of the sampling and analysis approach and rationale, then reassessed during the data usability process. For example, an integral part of developing the sampling and analysis approach is to answer the question, "How many samples are needed to fully evaluate *x*?" and then during the data usability process, "Were enough data collected to answer the original question?"

5.1.4 Completeness

Completeness is defined as the percentage of measurements judged to be valid compared with the total number of measurements made for a specific sample matrix and analysis. The mathematical equation to calculate the completeness is presented in Equation 3. An overall completeness goal of 95 percent has been set for this Project.

Equation 3: Calculate completeness

$$Completeness = \frac{Valid\ Measurements}{Total\ Measurements} \times 100\%$$

5.1.5 Comparability

Comparability is another qualitative measure to express the confidence with which one data set may be compared with another. Sample collection and handling techniques, sample matrix types, and analytical methods all affect comparability. Comparability is limited by the other parameters because data sets can be compared with confidence only when precision and accuracy are known. Data from one phase of an investigation can be compared with data from other phases when similar methods are used and similar data packages are obtained. All policies and procedures implemented during the Project will be consistent and standardized across all phases, supporting data comparability.

5.1.6 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method is commonly referred to as the detection limit, as shown in Table 3 and described in Section 5.1.7.

5.1.7 Detection Limit

The method detection limit (MDL) is the lowest concentration with which a sample can be analyzed with 99 percent confidence. The MDL is a laboratory-specific and method-specific value, so variation may exist among laboratories. The RL is set for each analyte at a value greater than the MDL. For the Project, RLs have been selected with consideration for comparability with other studies in the Los Angeles River watershed. The target RLs are listed in Table 5.

5.2 Quality Control Requirements

QC samples will be collected in the field to provide a mechanism for ongoing control and evaluation of data quality measurements. QC samples consist of sample duplicates, field blanks, and equipment blanks. The QC requirements for this Project are listed in this section.

5.2.1 Requirements

For this Project, one set of sample duplicates and one set of field blanks will be collected annually during dry weather monitoring. For wet weather monitoring, one set of sample duplicates, one set of field blanks, and one set of equipment blanks will be collected annually**.**

5.2.2 Sample Duplicates

Sample duplicates will be collected in the same manner as the environmental samples into separate, clean, laboratory-certified bottles and analyzed as independent samples. These duplicates will be used to document the precision of the sampling process. If the RPD between the sample and sample duplicate is greater than 20 percent, then the sample collected during that sampling event may be discarded or qualified. The sampling procedure will be re-evaluated, and an improved procedure will be implemented for the next scheduled sampling event.

5.2.3 Field Blanks

Field blanks will be prepared and tested with the actual samples collected during one sampling event. Potential contamination from field handling procedures will be assessed using field blanks. If contamination is found in the field blanks, then the sample collected during that sampling event may be discarded or qualified. The sampling procedure will be re-evaluated, and an improved procedure will be implemented for the next scheduled sampling event.

5.2.4 Equipment Blanks

Equipment blank samples will be collected and analyzed after auto-sampler installation to detect any contaminants in the auto-sampler pump tubing, sampling equipment, and auto-sampler bottles. Laboratory-grade deionized water will be pumped through the auto-samplers' tubing with the peristaltic pump into a clean sample container. The equipment blank sample will be packaged and delivered to the laboratory for analysis in the same manner used for non-quality-control samples. To meet the QC criteria for the Project, the results must be lower than the RLs of the associated constituents. If the detected equipment blank concentrations are higher than the RLs, then the pump tubing will be replaced, and the sampling procedure will be re-evaluated. Once the issue is identified and resolved, another equipment blank will be collected to ensure that the sampling equipment is free of contaminants.

5.3 Laboratory Quality Assessment

Water samples will be analyzed by a California ELAP-accredited analytical laboratory under the guidance of the laboratory quality assurance manual. Prior to sampling, the analytical methods and RLs (Table 5) will be verified with the laboratory to ensure that they can be achieved. The DQOs and measurement quality objectives will apply to laboratory analyses listed in Table 5.

The laboratory will analyze multiple water quality samples as a batch, and one set of QC samples will be analyzed with each batch. An analytical batch contains up to 20 field samples. When applicable, the following QC sample types will be analyzed as part of the QC batch: method blank, laboratory duplicate, matrix spike (MS), matrix spike duplicate (MSD), laboratory control sample (LCS), and laboratory control sample duplicate (LCSD). These QC sample types are discussed in Sections 5.3.1 through 5.3.4.

5.3.1 Method Blanks

Method blanks will be prepared and analyzed by the laboratory as close as possible in time to the original and QC samples to assess the presence of contamination in the laboratory. The results from the method blanks provide an estimate of bias. Detections in the method blanks will be investigated, and qualifiers will be used to indicate the potential presence of contamination.

5.3.2 Laboratory Duplicates

A laboratory duplicate uses a portion of a sample taken from the original sample and then prepares and analyzes it through the same process as the original sample to quantify the precision of laboratory procedures. The RPD is calculated using Equation 2 in Section 5.1.1. If the RPD between the laboratory duplicates is greater than 25 percent of the original concentration, then the laboratory should investigate the potential presence of laboratory bias.

5.3.3 Matrix Spike and Matrix Spike Duplicates

An MS is a sample prepared by the laboratory by spiking a known concentration of a target analyte to a specific amount of sample. The MSD is similar to the MS and shows the effect of the sample matrix on the accuracy of the analytical results. MS/MSD sample recovery (accuracy) values are based on the analyte, and thus must be referenced from the DQO table (Table 5), and the RPD between the MS and MSD should be below 25 percent (precision). If the accuracy or precision does not meet the acceptable limits, then the laboratory will investigate the potential presence of laboratory or matrix bias.

5.3.4 Laboratory Control Samples and Laboratory Control Sample Duplicates

The LCS/LCSD, also often referred to as a blank spike (BS)/blank spike duplicate (BSD), is created in the laboratory using contaminant-free reagent water that is spiked with a known concentration of a target analyte for analysis using the same preparation and procedures used for the other project samples. The LCSD is used as a QC measure for the accuracy and precision of the LCS sample. The LCS/LCSD sample recovery (accuracy) DQOs are based on the analyte (Table 5), and the RPD between the LCS and LCSD should be below 25 percent. If the accuracy or precision does not meet the acceptable limits, then the laboratory will investigate the potential presence of laboratory or matrix contamination.

6 DATA ANALYSIS APPROACH

Data analysis will be completed through the five steps described in this section.

6.1 Exploratory Data Analysis

First, exploratory analysis will be used to check for data quality and data integrity. Chemistry results that are below the MDL will be reported as non-detect (ND) and will be replaced with a numerical value of zero (0) for calculations. Flow data will be sorted and separated into sub-data sets based on dry and wet weather conditions. Outliers and abnormal values will be inspected before any analyses are completed in the next step.

6.2 Runoff Volume Calculation

Second, the total runoff volume will be estimated using the data collected by the flow sensor installed at the monitoring locations. Daily dry weather runoff volume will be calculated using the average daily flow. Wet weather runoff volume will be calculated by summing the runoff volume measured during each storm event.

6.3 Pollutant Loading Calculation

Third, dry weather pollutant loads will be calculated by multiplying the dry weather pollutant median concentrations with the average daily runoff volume. Wet weather pollutant loads will be calculated by multiplying the pollutant concentrations by the total runoff volume measured during each storm event. For storm events in which samples are not collected, the pollutant median concentrations measured during the wet season will be used with measured flow data from those events to estimate the pollutant loads.

6.4 Pollutant Removal Evaluation

Fourth, hypothesis testing approach will be used to assess the effectiveness of the pretreatment systems in removing pollutants from discharge. Paired t-tests will be performed, and the results will determine whether there is a statistically significant difference in pollutant concentrations between influent and effluent samples. The hypothesis (H_o) and null hypothesis (H_a) for evaluating the pretreatment system pollutant removal ability are as follows:

> H_a: The pollutant concentrations measured at the pretreatment system's effluent are higher than or equal to the pollutant concentrations measured at the influent.
>
> H_o: The pollutant concentrations measured at the pretreatment system's effluent are lower than the pollutant concentrations measured at the influent.

6.5 BMP Effectiveness

Fifth, the effluent probability method will be used to evaluate the pollutant removal effectiveness by the pretreatment system. The effluent probability method compares the pollutant concentrations of influent and effluent samples by plotting the log-transformed concentration data on a normal quantile distribution axis (Geosyntec Consultants and Wright Water Engineers, Inc., 2009). The interpretation is based on the assumption that the influent and effluent concentrations are correlated (California Stormwater Quality Association, 2003). This relationship will be evaluated using Spearman's rank correlation coefficient. The separation between the influent and effluent curves indicates the pollutant removal ability of the treatment unit. The greater the separation between the curves, the more effective the treatment unit is in removing pollutants. The results from the effluent probability plot will be used to evaluate the pollutant removal ability of the treatment unit across the entire range of the influent concentrations. This method will be applied to certain constituents when statistical significances are identified in the pollutant removal evaluation.

In addition, BMP effectiveness will be evaluated using the Stormwater Performance Evaluation Framework developed by Los Angeles County Public Works and Southern California Costal Water Research Project. Influent and effluent pollutant concentrations will be compared against the water quality threshold to determine if the pollutants are removed from the water column. The assessment results will be concluded by assigning the BMP into one of the following performance categories: performing-well, performing, underperforming, or failing.

7 DATA MANAGEMENT AND REPORTING

7.1 Field Data

Field measurements and field observations during monitoring activities will be documented on a field observation sheet, provided in Appendix A. Observations can be made on an electronic form if available. Upon completion of the field monitoring activities, a hardcopy and/or electronic copy of the field observation sheet will be saved to a Project-specific file. After the data have been verified and validated by the Los Angeles County Stormwater Quality Division Quality Assurance/Quality Control Officer, the data will be stored in the Integrated Water Quality System (IWQS) database.

7.2 Chemistry Analytical Data

The water quality analytical data will be provided by the laboratory as final reports in PDF and as California Environmental Data Exchange Network (CEDEN)-formatted electronic data deliverable files. The data will be prepared in accordance with CEDEN guidance for submission. The field measurement data will also be managed using a method that allows integration with CEDEN. CEDEN guidance requirements are provided at http://www.ceden.org. After the data have been verified and validated by the Los Angeles County Stormwater Quality Division Quality Assurance/Quality Control Officer, the data will be stored in the IWQS database.

7.3 Flow Data

Flow data will be downloaded from the flow sensors onto laptop computers or downloaded remotely at regular intervals during the monitoring period. After the flow data are retrieved, the data will be uploaded and saved to a Los Angeles County Stormwater Quality Division computer for data quality review and storage. The flow data will be saved on the local computer hard drive, and a backup copy will be saved on the County of Los Angeles internal server. Any irregularities in the flow data will be reviewed and qualified, if necessary.

7.4 Reporting

Data collected under this monitoring program and results of the Project performance assessment will be described in accordance with the requirements for **[Indicate grant programs or other programs such as SCWP that may have specific reporting requirements]**. The Final Project Report may include the following components:

- Summary of flow condition during dry weather,
- Summary of sampling events (rainfall amount, storm duration, etc.),
- Runoff volume captured by the Project,

- Pollutant loads removed by the Project,
- Overall percentage of stormwater volume that bypassed the Project,
- Overall stormwater BMP performance achieved by the Project,
- Comparison of the hydrographs generated by the WMMS model with the actual flow measurements in the field,
- Copy of field observation sheets, and
- Water quality data in CEDEN format.
- **[Add additional reporting components as needed]**

8 MAINTENANCE

The performance of the stormwater treatment systems may decline over time. Routine inspections and maintenance will help optimize the performance of the BMPs and extend the usable life of the treatment systems. In the Project, maintenance will be conducted primarily on **[list structure(s) maintenance will be conducted on].**

8.1 Maintenance Procedures

Maintenance and inspections will be conducted or overseen by the LACPW Stormwater Maintenance Division. Any changes or improvements to the maintenance and inspection procedures may be evaluated in accordance with the adaptive management strategy described in Section 9.

Using the procedures described in this section, the components should be inspected and maintained regularly to prevent the system from clogging. It is highly recommended that maintenance work be completed from the ground surface. If entry into the underground vault is required, the work will be conducted under confined space protocols by trained and certified staff.

Hints for the following subsections 8.1.1, 8.1.2, 8.1.3, 8.1.4: Provide a brief description of maintenance needs for each component of the treatment system. The components and text included below are examples. Revise to project-specific components, procedures, and frequencies.

8.1.1 Underground Storage Vault and Forebay [Example – update to project specific component]

The underground storage vaults (cisterns) require no consumable materials for daily operation and thus do not require routine maintenance. However, the forebays within the cisterns will require regular maintenance. Forebays provide retention for a portion of the first-flush stormwater runoff and allow sediment to settle out from the incoming flows. They also help isolate sediment deposition and facilitate maintenance and effectiveness of the larger BMPs. Sediments and associated pollutants are removed only when sediment forebays are cleaned out, so regular maintenance is essential. Frequent removal of sediments will prevent accumulation over time, which can lead to resuspension of settle particles. At a minimum, sediment forebays should be inspected monthly and cleaned out at least four times per year when sediment depth is from 3 to 6 feet.

8.1.2 Nutrient-Separating Baffle Box [Example – update to project specific component]

The NSBB consists of three components that may require periodic maintenance: a screening basket, a sedimentation chamber, and a hydrocarbon boom (see **Error! Reference source not found.**).

Hints for the following subsections 8.1.2.1, 8.1.2.2, 8.1.2.3: The components and text included below are examples. Revise to project-specific components.

8.1.2.1 Screening Basket

A rectangular screening basket suspended above the standing water level of the sedimentation chambers captures and filters large solid materials entering the chambers from the storm drain. The manufacturer recommends the screening basket be inspected at least every 6 months and cleaned at least every 12 months, depending on the loading. The cleaning procedure includes removal of the solid material (e.g., trash or debris) and can be performed manually or with a vacuum truck from the hatch (manhole covers) on top of each chamber. A pressure washer may be needed to remove heavy debris stuck to the basket.

8.1.2.2 Sedimentation Chamber

Pollutants such as suspended particles, particulate metals, and nutrients are separated from the water column in the sedimentation chambers. The manufacturer recommends that chambers be inspected every 6 months and cleared every 12 months, depending on the loading. The sedimentation chamber should be cleaned after the screening baskets have been cleaned. The procedure should be performed with a vacuum truck from the hatches (manhole covers) on top of the chambers; a pressure washer may be needed to remove compacted sediments that are stuck to the walls or the floor of the sedimentation chambers.

8.1.2.3 Hydrocarbon Booms

The hydrocarbon boom inside the third sedimentation chamber (near the outflow end of the system) removes free-floating and emulsified hydrocarbon from the water. The hydrocarbon boom shall be inspected monthly, before and after storm season, and after any major storm events. Replace the booms as-needed based on inspection. The booms should be inspected/replaced after maintenance of the screening basket and separation chambers.

8.1.3 Water Polisher [Example – update to project specific component]

The water polisher consists of three components that may require periodic maintenance: a hydrocarbon boom, sedimentation chamber, and up-flow filter (see **Error! Reference source not**

found.). The same maintenance procedures apply to the sedimentation chambers of both the NSBB and water polisher.

Hints for the following subsections 8.1.3.1, 8.1.3.2: The components and text included below are examples. Revise to project-specific components.

8.1.3.1 Hydrocarbon Boom

The hydrocarbon boom inside the third sedimentation chamber (near the outflow end of the system) removes free-floating and emulsified hydrocarbon from the water. The manufacturer recommends that the hydrocarbon booms be visually inspected every 6 months and replaced every 12 months, depending on the loading. If the hydrocarbon boom appears to be significantly discolored, the old hydrocarbon boom may be replaced prior to the annual replacement date in accordance with manufacturer's instructions. The hydrocarbon boom should be inspected/replaced after maintenance of the screening basket and separation chambers.

8.1.3.2 Up Flow Filter

The frequency of inspection and maintenance can be determined in the field after installation. Based on site characteristics such as contributing area, types of surfaces (e.g., paved and/or landscaped), site activities (e.g., short-term or long-term parking), and site maintenance (e.g., sanding and sweeping), inspection and maintenance should be conducted at intervals of no more than 6 months during the first year of operation. Typically, maintenance is recommended once per year thereafter. Maintenance activities include inspection, removal of floating debris, oil removal, sediment removal, up-flow filter replacement, and draindown filter replacement. The following signs indicate that it is time to replace an up-flow filter and/or draindown filter:

Sediment Buildup – The function of the filter is to separate sediments from the runoff. However, over time, sediments are likely to accumulate, rendering the filter ineffective. When this occurs, it is advisable to replace the filter as soon as possible.

Debris Buildup – The buildup of dirt and debris on the walls of the filter is another telltale sign that the filter requires thorough cleaning. However, cleaning the filter is just a short-term solution, and replacing the entire filter for enhanced filtration may be required.

Visible Froth – A visible line of froth or scum around the drain is a sign of stagnant water, meaning that the filters are blocked, and they require thorough cleaning or replacement.

Standing Water – Under normal circumstances, the storm drains should absorb water within 24 hours after a heavy downpour. However, if there's standing water around the drains after this period has elapsed, then filters must be replaced.

8.1.4 Structural Cell Module System [Example – update to project specific component]

The structural cell module system's pre-treatment chamber consists of a series of filter cartridges that will be filled up with biochar and sand mixture. The filter cartridges will require periodic maintenance because the filter materials will need to be replaced. The replacement frequency depends on serval factors, such as the influent water quality, the flow rate, and the desired hydrologic conductivity of the materials.

Hints for the following subsections 8.1.4.1, 8.1.4.2: The components and text included below are examples. Revise to project-specific components.

8.1.4.1 Pre-treatment Chamber

It is recommended that the pre-treatment chamber shall be inspected at least every six months and be cleaned at least every 12 months depending on the sediment loadings. The cleaning procedure includes removal of the solid material (e.g., sediment, trash or debris) and can be performed manually or with a vacuum truck from the hatch (vault covers) located on top of the chamber. A pressure washer may be needed to remove heavy debris stuck to the side wall of the chamber.

8.1.4.2 Filter Cartridge

The filter cartridges shall be visually inspected every six months and may be replaced every 12 months, depending on the pollutant loading. If the filter cartridges appear to be significantly discolored, worn, and torn, the old filter cartridges may be replaced prior to the annual replacement date.

8.2 Maintenance Schedule

Routine inspections and maintenance should be performed at the pretreatment systems Inspections should occur **[insert frequency]**. Maintenance should occur as needed based on inspection results and the following. If either the screened basket or sediment chambers require cleaning based on the thresholds described below, clean out the entire pre-treatment system.

Hints for the following table: Update with project-specific treatment system components maintenance schedule. Add rows as needed.

Maintenance schedule Nutrient Separating Baffle Box	Service At The Indicated Time Or Whenever Is Needed	At A Minimum Every Six Months After Construction	At A Minimum Every 12 Months After Construction
	Inspect screening basket	•	•
	Clean screening basket		•
	Inspect sedimentation chambers	•	•
	Clean sedimentation chambers		•
	Inspect hydrocarbon booms	•	•
	Replace hydrocarbon booms		•

Table 6. Maintenance Schedule for Nutrient Separating Baffle Box [Example – Add rows as needed]

8.3 Maintenance and Inspection Form

Following maintenance or inspection, field crews will document the activities. This record will include the maintenance or inspection date and weather conditions, and will describe any maintenance performed, the condition of the treatment systems, the amount and description of debris collected, and other observations or comments. An example of an inspection and maintenance report is provided in Appendix B – Maintenance and Inspection Form. The records will be retained in accordance with the LACPW retention policy.

9 ADAPTIVE MANAGEMENT STRATEGY

Adaptive management is an important component of the BMP effectiveness monitoring because new monitoring methods, maintenance methods, and stormwater science and technologies may change during the span of the Project. The monitoring plan provides a standard framework for measuring the effectiveness of the treatment systems, and over time the monitoring plan may be revised or modified based on implementation findings to become more effective through the adaptive management strategy.

9.1 Adaptive Management Framework

The monitoring data may be reviewed to justify the effectiveness of the monitoring and maintenance activities. Monitoring and maintenance activities will be evaluated annually, and updates to the monitoring plan will be made as necessary. The adaptive management framework will integrate data collected through implementation of the BMPs. New knowledge and experience gained from the monitoring and maintenance activities may constitute changes to and improve storm water science and technology.

The adaptive management process will continue to evolve to identify and prioritize the optimum locations, frequencies, and constituent lists for water quality monitoring. The process also includes review and identification of maintenance needs to optimize the performance of the treatment systems. Key components to be considered during the adaptive management process are described in this section.

9.1.1 Based on Field Experience

Field experience and knowledge of the monitoring program will continue to develop during implementation of the BMPs. Any field challenges encountered during routine monitoring will be reviewed on a regular basis with the field crews. Alternative site-specific solutions may be proposed to resolve the challenges based on experience, site conditions, and understanding of the monitoring program. Proposed solutions will be presented to the project managers and reviewed to obtain consensus before implementing the change.

9.1.2 Based on Manufacturer Recommendations

Other challenges encountered during routine inspection and maintenance of the BMPs may be discussed and resolved by contacting the BMP manufacturer or vendor. As part of maintenance procedure evaluation, alternative options to help reduce maintenance efforts for the existing BMPs may be recommended. Manufacturer recommendations will be evaluated fully to assess the necessity and/or feasibility and will be discussed with project managers to obtain consensus before implementing a change.

9.1.3 Based on Monitoring Data

Another vital component of the adaptive management process is review of the data collected from the monitoring program. Analysis of the water quality data will help determine the representativeness of the selected monitoring locations, frequency of the monitoring, and suitability of the pollutants analyzed to evaluate the effectiveness of the BMP treatment performance. Based on the analysis, the water quality data may be used as justification to modify or revise certain components of the monitoring plan. Other types of monitoring data that may be used to support monitoring plan revisions include annual rainfall amount, total runoff volume, amount of sediment captured in the sedimentation chamber, etc.

This section provides only a few examples of how the adaptive management process might lead to revision of the monitoring plan. It is anticipated that during BMP implementation, the water quality monitoring procedures will continue to evolve, the monitoring locations and frequency will be optimized based on analytical findings, and the maintenance and inspection schedule will continue to be adjusted to address the varying conditions. Tracking progress during the BMP implementation will provide valuable information for improvements and adjustments toward achieving the expected pollutant reduction outcomes.

10 REFERENCES

[add/remove references as needed]

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APPENDICES

Appendix A – Field Observation Sheet

FIELD OBSERVATION SHEET

***Fill out all applicable information**

PROJECT NAME ______ STATION ID ______

SAMPLER NAME ______ STATION NAME ______

SAMPLER NAME ______ COORDINATES N ______

DATE ______ TIME ______ W ______

MONITORING TYPE

☐ DRY WEATHER ☐ WET WEATHER ☐ BLANK

WEATHER CONDITION

☐ CLEAR ☐ HAZE ☐ RAIN

☐ DRIZZLE ☐ OVERCAST ☐ THUNDERSTORM

☐ FOG ☐ PARTLY CLOUDY

SAMPLE ID (FSID) ______

YSI UNIT NO. ______

SAMPLE COLLECTED? ☐ YES ☐ NO

If no, observations only

DUPLICATE SAMPLE COLLECTED? ☐ YES ☐ NO

If yes, duplicate sample ID (FSID) ______

FIELD MEASUREMENTS IN DUPLICATE

TEMPERATURE	______ °C	______ °C
pH	______	______
DISSOLVED OXYGEN	______ mg/L	______ mg/L
SP. CONDUCTIVITY	______ µS/cm	______ µS/cm
SALINITY	______ ppt	______ ppt
TURBIDITY	N/A NTU	N/A NTU

FLOW CONDITION

☐ DRY
☐ PONDED
☐ TRICKLING
☐ STEADY FLOW
☐ HIGH/FLOODED

SAMPLE SOURCE

☐ GROUNDWATER ☐ OCEAN
☐ LAKE/RESERVOIR ☐ NON-STORM
☐ MARINA ☐ STORM

SAMPLE DEPTH

☐ BOTTOM ☐ MIDDLE ☐ SURFACE

SAMPLE COLLECTION METHOD

☐ AUTOMATIC ☐ MANUAL

IS SURFACE FLOW REACHING THE OCEAN? ☐ YES ☐ NO ☐ DON'T KNOW (see comments)

FIELD OBSERVATIONS

ODOR

☐ NONE
☐ AMMONIA
☐ CHEMICAL
☐ CHLORINE
☐ FISH/DECAY
☐ MUSTY
☐ PETROLEUM
☐ ROTTEN EGG
☐ SEWAGE

COLOR

☐ COLORLESS
☐ BLUISH
☐ BROWNISH
☐ GREENISH
☐ REDDISH
☐ YELLOWISH
☐ GREYISH

TURBIDITY

☐ CLEAR
☐ CLOUDY
☐ MURKY

ALGAE NEAR DRAIN? ☐ YES ☐ NO

TRASH COMING FROM DRAIN? ☐ YES ☐ NO

If yes, type of trash ☐ PLASTICS ☐ STYROFOAM ☐ VEGETATION ☐ WOOD ☐ OTHER ______ (e.g. DEAD ANIMAL, ETC.)

SOAP OR FOAM IN DISCHARGE? ☐ YES ☐ NO

WILDLIFE WITHIN 50 YARDS? ☐ YES ☐ NO

If yes, type and number ______ TYPE (e.g. DUCKS, ETC.) ______ NUMBER (e.g. 2)

REDTIDE (OCEAN)? ☐ YES ☐ NO

COMMENTS ______

Page 1 P:\wmpub\DATA MANAGEMENT\Monitoring Programs Unit\Forms\Field observation sheet\Field Observation Sheet (2015)

Appendix B – Maintenance and Inspection Form

BMP MAINTENANCE AND INSPECTION FORM

Project Name ______________________ **Inspector Name** ______________________

Project Location ______________________ **Inspection Date** ______________________

Weather ______________________ **Inspection Start Time** ______________ **AM / PM**

Storm in last 72-hrs? Yes No **Type of Inspection (circle one)**

Routine Followup Complaint

BMP Treatment ID	*BMP System Component*	*Condition (Good, Fair, Bad)*	*Cleanout performed? If yes, how much removed? (lbs)*	*Maintenance conducted (Yes/No)*	*Follow-up needed (Yes/No)*	*Other observations/ comments*
1	Screen Basket					
	Sediment Accumulation Chamber 1					
	Sediment Accumulation Chamber 2					
	Sediment Accumulation Chamber 3					
	BMP System Component	*Condition Full (25, 50, 75, or 100%)*	*Was boom changed?*	*Boom Change date*	*Follow-up needed (Yes/No)*	*Other observations/ comments*
	Hydrocarbon Booms					

Treatment ID	*BMP System Component*	*Condition (Good, Fair, Bad)*	*Cleanout performed? If yes, how much removed? (lbs)*	*Maintenance conducted (Yes/No)*	*Follow-up needed (Yes/No)*	*Other observations/ comments*
2	Screen Basket					
	Sediment Accumulation Chamber 1					
	Sediment Accumulation Chamber 2					
	Sediment Accumulation Chamber 3					
	BMP System Component	*Condition Full (25, 50, 75, or 100%)*	*Was boom changed?*	*Boom Change date*	*Follow-up needed (Yes/No)*	*Other observations/ comments*
	Hydrocarbon Booms					

BMP Treatment ID	*BMP System Component*	*Condition (Good, Fair, Bad)*	*Cleanout performed? If yes, how much removed? (lbs)*	*Maintenance conducted (Yes/No)*	*Follow-up needed (Yes/No)*	*Other observations/ comments*
3	Screen Basket					
	Sediment Accumulation Chamber 1					
	Sediment Accumulation Chamber 2					
	Sediment Accumulation Chamber 3					
	BMP System Component	*Condition Full (25, 50, 75, or 100%)*	*Was boom changed?*	*Boom Change date*	*Follow-up needed (Yes/No)*	*Other observations/ comments*
	Hydrocarbon Booms					

P:\wmpub\Environmental Analysis\Projects\BMP Monitoring\Roosevelt Park\Post-Construction Monitoring\Documents\Inspection forms 5/4/2017

APPENDIX C

Quality Assurance Project Plan Template

Document Template | USAGE GUIDE

Public Works
LOS ANGELES COUNTY

This document template is intended to help efficiently develop a **BMP Performance Evaluation QAPP**. The template contains chapters and subchapters, standard text, and prompts and examples for new text, tables, and/or figures commonly found in standard QAPPs which need to be added or revised based on project requirements. Whether using standard text or incorporating new text, the entire monitoring plan template must be reviewed to ensure the content pertains to the users specific project. Below are two example pages noting the different components of the template.

General Notes

1. **Standard language, table fields, and other existing text should be reviewed and revised as appropriate to the project.**
2. **Boxes containing hints should be replaced with final content. When complete, there should be no remaining boxes or hints.**
3. **[Bolded, bracketed text] should be replaced. When complete, there should be no remaining bolded, bracketed text.**

Example 1

2 PROJECT DESCRIPTIONS

2.1 Objective

Hints for this section: Describe general project objectives such as water quality benefits, recreational benefits, aesthetic benefits, etc.

2.1.1 Improving Water Quality

Hints for this section: Describe planned water quality benefits such as pollutant load reductions, annual volume capture, etc. these should be based on the project design plans.

2.1.2 Water Conservation

Hints for this section: Describe water conservation benefits (if applicable) such as native vegetation or turf replacement.

2.1.3 Recreation and Education/Outreach

Hints for this section: Describe recreational and educational aspects of the project.

2.2 Water Quality Regulation

Hints for this section: Describe monitoring program regulations applicable to project area/watershed. Include brief description of related TMDL or other water quality objectives within the watershed, and how the project will contribute to achieving those objectives. Table 1 is an example table of project-specific water quality objectives – revise based on project requirements.

The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit Order No. R4-2021-0105 NPDES PERMIT NO. CAS004004 (Permit) became effective July 23, 2021. The MS4 Permit provides permittees an option to develop an Enhanced Watershed Management Program (EWMP) to demonstrate compliance with water quality standards. The **[watershed name]** Watershed EWMP was developed by the County of Los Angeles and various cities to address the water quality issue within the **[watershed name]** Watershed area. The vision for development of the EWMP was to utilize a multi-pollutant approach that maximizes the retention and urban runoff usages as resources for groundwater recharge and irrigation, while also creating additional benefits for the surrounding communities.

❶ ***Unbolded, unbracketed text*** *is standard language. Review for accuracy but typically modifications won't be needed.*

❷ ***Boxed text, figures, and tables*** *provide hints or direction for required information, examples where appropriate, and other guidance to complete this portion of the document. When complete, there should be no remaining boxes or hints.*

❸ ***Bolded, bracketed text*** *is project-specific information and must be modified.*

Example 2

One of the key elements in the EWMP is to determine and identify the network of control measures also known as best management practices (BMPs) that will help achieve the pollutant reduction goal required by the Permit. The identification of the BMP needs is based on the water quality priorities and the results obtained from the reasonable assurance analysis. A wide range of control measures were proposed in the EWMP including low-impact development, green streets, institutional control measures, and regional BMPs. The Project was identified as one of the high priority-regional BMP projects. The Project's goal is to help reduce the amount of pollutants discharging into the **[Receiving Water]**.

Hints for this table: Replace with project-specific table.

Table 1. Harbor Toxics TMDL Wet Weather Numeric Targets for Metals

Pollutant of Concern	Source	Final Freshwater Water Column Numeric Target (wet weather)[2]	Interim Freshwater Water Column Numeric Target (wet weather)[2]
Total Copper	Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water Toxic Pollutants TMDL[1]	9.7 µg/L or 1,485.1 g/day	207.51 µg/L
Total Lead		42.7 µg/L or 6548.8 g/day	122.88 µg/L
Total Zinc		69.6 µg/L or 10,685.5g/day	898.87 µg/L
Dissolved Copper		6.99 µg/L	–
Dissolved Lead		30.14 µg/L	–
Dissolved Zinc		65.13 µg/L	–

Notes:
1. The final numeric target is listed on the Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water Toxic Pollutants TMDL Attachment A to Resolution No. R11-008 (dated May 5, 2011).
2. Numeric targets are applicable to discharge above Vermont Avenue to the Dominguez Channel in wet weather conditions.

Quality Assurance Project Plan

For

[Project Name]

Prepared by

Los Angeles County Public Works
Stormwater Quality Division

V 1.0

Created: **[Date]**

[Project Name] Quality Assurance Project Plan

Los Angeles County Public Works

[Date]

Approval Signatures

______________________________ ______________

[Name and project role of required signatory] Date
[Agency/organization]

______________________________ ______________

[Name and project role of required signatory] Date
[Agency/organization]

______________________________ ______________

[Name and project role of required signatory] Date
[Agency/organization]

______________________________ ______________

[Name and project role of required signatory] Date
[Agency/organization]

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYM LIST

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
µS/cm	microsiemen(s) per centimeter
µg/L	microgram(s) per liter
Ag	silver
AgCl	silver chloride
Basin Plan Amendment	Amendment to the Water Quality Control Plan for the Los Angeles Region to incorporate a TMDL for Toxic Pollutants in Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Resolution No. R11-008. May 5, 2011
BMP	best management practices
cfs	cubic foot (feet) per second
$CaC0_3$	calcium carbonate
CAS	Chemical Abstracts Service
CEDEN	California Environmental Data Exchange Network
COC	chain of custody
CPR	cardiopulmonary resuscitation
DO	dissolved oxygen
DQO	data quality objective
E. coli	Escherichia coli
ELAP	Environmental Laboratory Accreditation Program
EMC	event mean concentration
EPA	United States Environmental Protection Agency
EWMP	Enhanced Watershed Management Plan
FNU	Formazin Nephlometric Units
GIS	geographic information system
Harbor Toxics TMDL	Amendment to the Water Quality Control Plan for the Los Angeles Region (Basin Plan Amendment) to incorporate a TMDL for Toxic Pollutants in Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Resolution No. R11-008. May 5, 2011.
HAZCOM	Hazard Communication
ID	identification
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCl	hydrochloric acid
HNO3	nitric acid
H2SO4	sulfuric acid
kHz	kilohertz
LACFCD	County of Los Angeles Flood Control District
LACPW	County of Los Angeles Public Works
LACSD	County of Los Angeles Sanitation District
LCS	laboratory control sample
LCSD	laboratory control sample duplicate

LID	low-impact development
MDL	method detection limit
mg/L	milligram(s) per liter
mL	milliliter(s)
mm	millimeter(s)
MPN	most probable number
MQO	measurement quality objective
MS	matrix spike
mS/cm	millisiemen(s) per centimeter
MSD	matrix spike duplicate
mV	millivolt(s)
N	nitrogen
NA	not applicable
NSBB	nutrient-separating baffle box
NTU	nephelometric turbidity unit(s)
OSHA	Occupational Safety and Health Administration
Q	quarter
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCB	reinforced concrete box
RPD	relative percent difference
RL	reporting limit
SM	Standard Method
SOP	standard operating procedure
SWAMP	Surface Water Ambient Monitoring Program
SWGP	Stormwater Grant Program
State Water Board	State Water Resources Control Board
SWQB	Stormwater Quality Division (LACPW)
TBD	to be determined
TMDL	Total Maximum Daily Load
WMA	watershed management area
WMMS	Watershed Management Modeling System
	[Add/remove rows as needed]

1 DISTRIBUTION LIST

All appropriate staff working on the **[grant and/or other funding agencies]**, consultants, and technical advisors will receive copies of this Quality Assurance Project Plan (QAPP), and any approved revisions of this plan. The QAPP distribution list is presented in

Hints for this table: Fill in the table below with project-specific contacts.

Table 1. Quality Assurance Plan Distribution List

Number	Title	Agency	Name	Email
1	QA Officer			
2	Grant Manager			
3	Project Manager			
4	Monitoring Program Officer			
5	Field Team Leader			
6	Data Scientist			
7	QA/QC Officer			
8	Laboratory QA/QC Officer			
9	Safety Coordinator			
10	Monitoring System Oversight			
11	Sampling Equipment Oversight			

Notes:
QA = quality assurance
QC = quality control

. Once approved, this QAPP will be available to any interested party by requesting a copy at the address listed for the contact person on the title page of this document.

Hints for this table: Fill in the table below with project-specific contacts.

Table 1. Quality Assurance Plan Distribution List

Number	Title	Agency	Name	Email
1	QA Officer			
2	Grant Manager			
3	Project Manager			
4	Monitoring Program Officer			
5	Field Team Leader			
6	Data Scientist			
7	QA/QC Officer			
8	Laboratory QA/QC Officer			
9	Safety Coordinator			
10	Monitoring System Oversight			
11	Sampling Equipment Oversight			

Notes:
QA = quality assurance
QC = quality control

2 PROJECT ORGANIZATION

The proposed **[Project name]** effectiveness monitoring program will be executed by **[indicate team]** staff. Individuals who will assist with any monitoring station setup or analytical work are included in Table 2, and their affiliation.

Hints for this table: Fill in the table below with project-specific contacts.

Table 2. Project Organization and Contacts

Title/Task	Contact Name	Phone	E-mail
Project Manager			
Monitoring Program Officer			
Data Scientist			
QA/QC Officer			
Field Team Leader			
Laboratory QA/QC Officer			
Monitoring System Oversight			
Sample Equipment Oversight			

Notes:
QA = quality assurance
QC = quality control

All work, including contract execution, will be performed under the supervision of the project manager. The roles and responsibilities of each project team member are broken down as follows:

1. **[First, last name – Project role. Brief description of project duties.]**

2. **[Example:** Timothy Marino – Safety Coordinator. Mr. Marino will be responsible for providing safety trainings, maintaining safety documentation, and ensuring safety certification for the field crews.**]**

3. **[Repeat same format for all parties listed in Table 1]**

Figure 1 shows the project organization.

Hints for this table: Fill in the table below with project-specific contacts.

Table 2. Project Organization and Contacts

Title/Task	Contact Name	Phone	E-mail
Project Manager			
Monitoring Program Officer			
Data Scientist			
QA/QC Officer			
Field Team Leader			
Laboratory QA/QC Officer			
Monitoring System Oversight			
Sample Equipment Oversight			

Notes:
QA = quality assurance
QC = quality control

Hints for this figure: Insert project-specific organization chart.

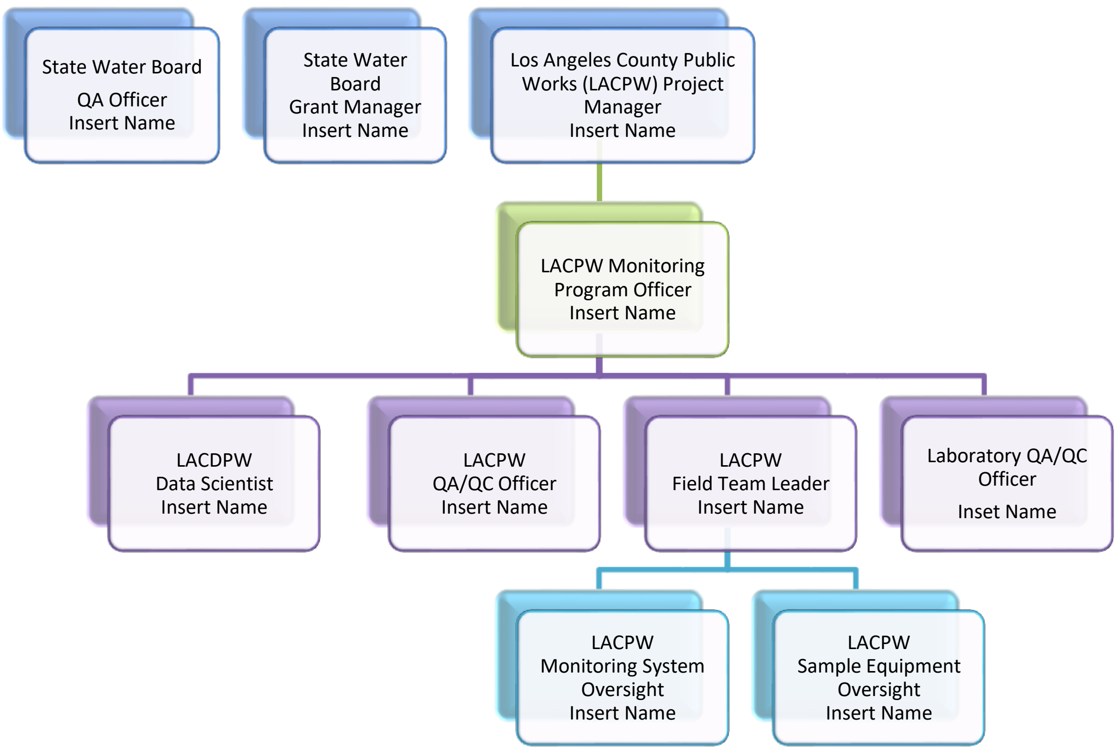

Figure 1. Organization Chart

3 PROBLEM DEFINITION/BACKGROUND

3.1 Project Background

Hints for this section: Describe the project background, general drivers for the project, previous monitoring such as preconstruction monitoring, and other pertinent background information.

3.2 Objective

Hints for this section: Describe project objectives such as water quality benefits, recreational benefits, aesthetic benefits, etc.

3.2.1 Improving Water Quality

Hints for this section: Describe planned water quality benefits such as pollutant load reductions, annual volume capture, etc.

3.2.2 Water Conservation

Hints for this section: Describe water conservation benefits (if applicable) such as native vegetation or turf replacement.

3.2.3 Recreation and Education/Outreach

Hints for this section: Describe recreational and educational aspects of the project.

3.3 Monitoring Program Goals

Hints for this section: Describe monitoring program goals. Include brief description of related TMDL or other water quality objectives within the watershed, and how the project will contribute to achieving those objectives. Table 3 is an example table of project-specific water quality objectives – revise based on project requirements.

Hints for this table: Replace the table below with project specific TMDL targets.

Table 3. Harbor Toxics TMDL Wet Weather Numeric Targets for Metals [Example – replace with project-specific table]

Pollutant of Concern	Source	Final Freshwater Water Column Numeric Target (wet weather)[2]	Interim Freshwater Water Column Numeric Target (wet weather)[2]
Total Copper	Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water Toxic Pollutants TMDL [1]	9.7 µg/L or 1,485.1 g/day	207.51 µg/L
Total Lead		42.7 µg/L or 6548.8 g/day	122.88 µg/L
Total Zinc		69.6 µg/L or 10,685.5g/day	898.87 µg/L
Dissolved Copper		6.99 µg/L	–
Dissolved Lead		30.14 µg/L	–
Dissolved Zinc		65.13 µg/L	–

Notes:

1. The final numeric target is listed on the Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water Toxic Pollutants TMDL Attachment A to Resolution No. R11-008 (dated May 5, 2011).
2. Numeric targets are applicable to discharge above Vermont Avenue to the Dominguez Channel in wet weather conditions.

3.4 Monitoring Outcomes and Benefits

The information gathered from the study may increase our understanding of the pollutant removal efficiency of the specific treatment systems. The data may allow the optimum range of the treatment conditions to be determined. The performance data may also help determine the maintenance frequency for the treatment systems. The information may help the designer to select the best suitable stormwater treatment systems for future projects. Specific groups that will benefit from the outcomes of the project include:

- State Water Board staff –Track the effectiveness of the TMDL and EWMP management actions.
- Stormwater manager – Understand the overall effectiveness of EWMP efforts in terms of meeting the TMDL targets in the receiving water body.
- Design engineer – Understand the effectiveness of the stormwater treatment system.

3.5 Stormwater Treatment System Design

Hints for this section: Provide a brief summary of the project design and function. Include images or graphics where possible.

3.6 Project Questions

Hints for this section: List study questions. These questions are the basis of study design such that the data collected during monitoring described in this QAPP can be used to directly answer the listed questions.

Example Study Questions:

The following study questions will be examined in the post-construction monitoring:

1. How much water is captured by the selected storm water treatment systems annually?
2. What are the pollutant loads captured by the BMP annually?
3. What is the pollutant removal efficiency of the BMP unit during the monitoring period?
4. What is the pollutant removal efficiency of the pretreatment device during the monitoring period?

4 PROJECT/TASK DESCRIPTION

This section summarizes the work to be performed and provides a brief description of the geographic location of the project. Section 8 through Section 11 provide detailed descriptions of the monitoring approach, sampling techniques, and laboratory analysis requirements.

4.1 Monitoring Purpose

The purpose of the monitoring program is to evaluate the effectiveness of the stormwater treatment systems in terms of volume capture and pollutant load reduction. Post-construction monitoring will focus on quantifying the amounts of the specified pollutants that will be captured by the treatment systems. Paired samples collected from the treatment systems' influent and effluent points will be evaluated for water chemistry characteristics. The results will indicate whether the treatment systems can remove/reduce pollutants effectively. Water quality data collected from multiple sampling events may be combined to create a larger data set for data analysis and performance assessment. The information gathered from the project may assist with selection and implementation of future regional stormwater best management practice (BMP) projects.

4.2 Stormwater Treatment System Locations

Hints for this section: Describe the location where the treatment system is located and project information such as drainage area and receiving water or watershed. **Describe land uses and respective areas. Replace Figures 2 and 3 with project-specific maps.**

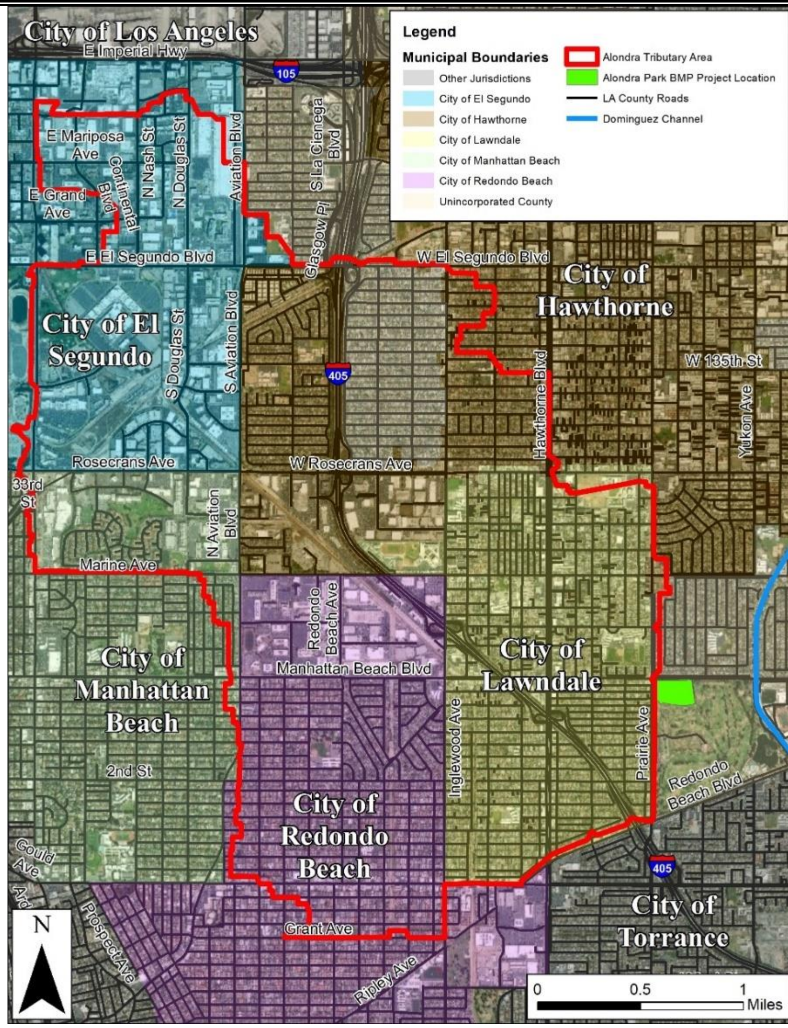

Figure 2. Project Location Map [Example – replace with project-specific map]

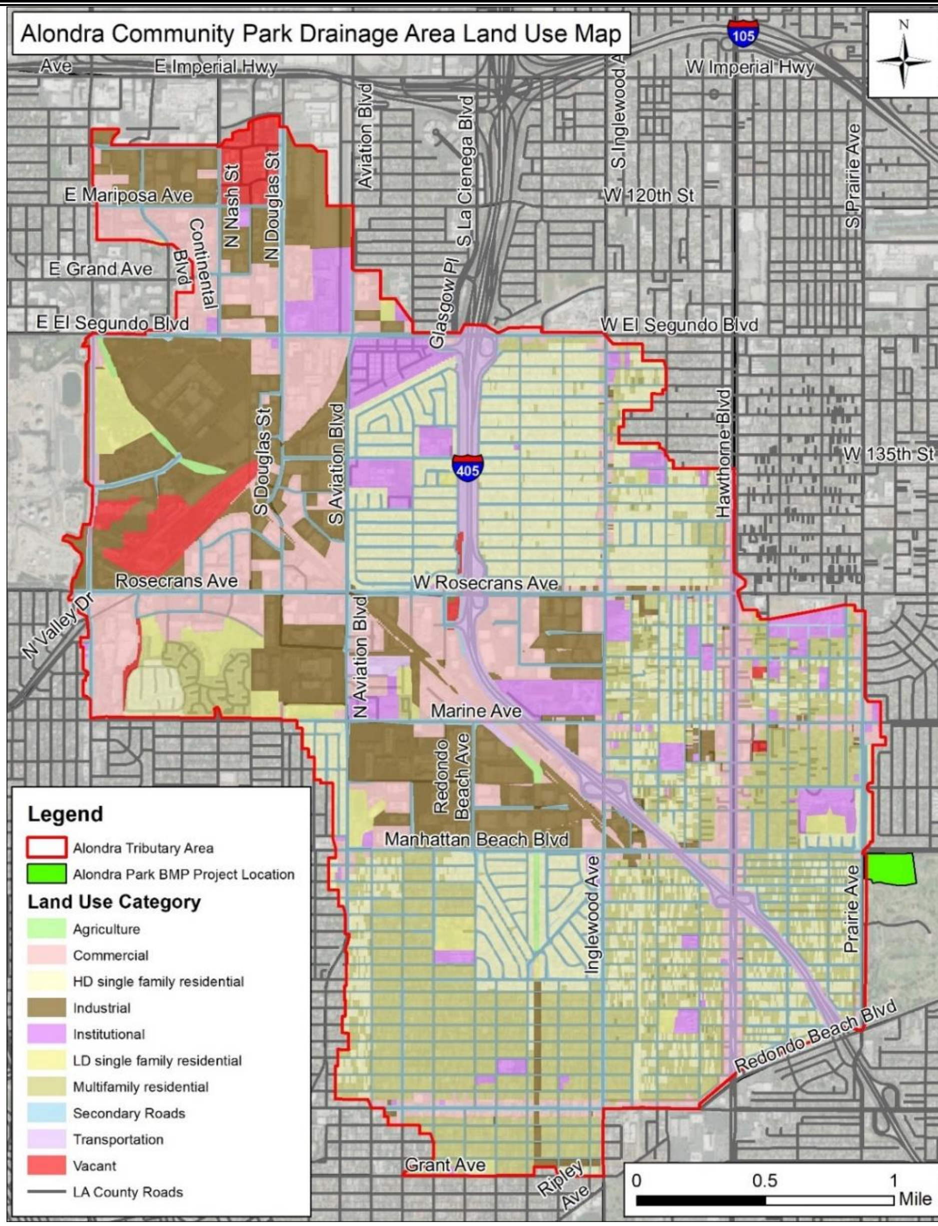

Figure 3. Project Drainage Area and Land Use Map [Example – replace with project-specific map]

4.3 Project Schedule and Deliverable

The tentative project schedule and the associated deliverables are presented in **Error! Reference source not found.**. The monitoring methodology will remain adaptive. The data collection method may be evaluated for the quality of the data collected. Such an evaluation may be based on completeness, precision, and accuracy of the QC samples. Additional consideration will be given for the adequacy of the data to effectively answer the study questions. The monitoring methodology may be adjusted for unforeseen challenges, but any adjustments will ensure data quality is not compromised. Appendix A provides a detailed schedule.

Hints for this table: Fill in the table below with project-specific schedule and deliverables.

Table 3. Tentative Project Schedule and the Corresponding Deliverables

Activity	Date (Quarter, Year)		Deliverable
	Initiation	Completion	
Conduct Field Training			
Monitoring Equipment Installation			
Monitoring Equipment Calibration			
Water Quality Sampling			
Dry Weather Sampling			
Wet Weather Sampling			
Data Analysis			
Reporting			
Monitoring Equipment Maintenance			

Notes:
Q = quarter

4.4 Constraints

Hints for this section: Provide a brief summary constraints that can impact the project schedule or ability meet other project objectives.

Example constraint:

Construction for the project has not begun. The final construction schedule and any potential delays may affect the planned schedule of effectiveness monitoring and assessments.

5 QUALITY OBJECTIVES AND CRITERIA

To ensure that the data set contains useful, high-quality information, any data collected must meet the data quality objectives (DQOs) established in this monitoring plan. The DQOs consist of field monitoring and laboratory quality assessment under the guidance of *Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan: 2008 to 2013 Appendix Revision Summary* (California State Water Resources Control Board, 2013). The purpose of the DQOs is to produce data of known and acceptable quality by measuring the accuracy, bias, precision, recovery, and completeness of sample data collected during field monitoring and from laboratory analysis QC. The laboratory analysis DQOs and the QC requirements for this project are described in this section and listed in

Hints for this table: Update table with project specific field parameters measurement quality objectives. Add or remove parameters as needed.

Table 5. Field Parameters Measurement Quality Objectives

Parameter	Sensor Type/ Measurement Method	Units	Range	Accuracy	Detection Limit	Completeness
Water Quality Field Parameters						
pH	Combination glass bulb electrode	pH, pH mV	0 to 14 pH units	±0.2 pH units	0.01 pH units	90%
Temperature	Thermistor, installed on conductivity sensor	°C	-5 to 70 °C (Temperature compensation range for DO mg/L measurement: -5 to 50 °C)	± 0.2 °C	0.1 °C or 0.1 °F (user selectable)	90%
Dissolved Oxygen	Optical luminescence - lifetime method	ppm	0 to 500%, 0 to 50 mg/L	0 to 200%: ±1% of reading or 1% saturation, whichever is greater.	0.01 mg/L and 0.1%	90%

				200 to 500%: ±8% of reading 0 to 20 mg/L: ±0.1 mg/L or 1% of reading, whichever is greater. 20 to 50 mg/L: ±8% of reading.		
Conductivity	Four nickel electrode cells	µS/cm, mS/cm	0 to 200 mS/cm	0 to 20 mg/L: ±0.1 mg/L or 1% of reading, whichever is greater	0.001, 0.01, 0.1 µS/cm	90%
Specific Conductance	Calculated from conductivity and temperature	µS/cm, mS/cm	0 to 200 mS/cm	0–100 mS/cm: ±0.5% of reading or .001 mS/cm, whichever is greater. 100–200 mS/cm: ±1.0% of reading.	0.001, 0.01, 0.1 mS/cm	90%
Turbidity	Nephelometric - Optical, 90-degree scatter	FNU, NTU	0 to 4,000 FNU	0 to 999 FNU: 0.3 FNU or ±2% of reading, whichever is greater. 1,000–4,000 FNU: ±5% of reading	0.1 FNU	90%
Flow Measurements						
Rainfall Amount	Tipping bucket/potted magnetic momentary contact reed switch	inch	4.73 mL/tip	1.0% up to 2 inches/hour (50 mm/hour)	0.01 per tip	90%
Water Level	K band radar frequency	feet, mm	1.6 to 114.8 feet	± 0.0065 foot	0.0033 foot	90%
Water Level	Pressure transducer	feet	0.033 to 10 feet (0.01 to 3.05 meters); max	Depths from 0.033 to 5.0 feet (0.01 to 1.52 meters): ±0.008	0.0033 foot	90%

			allowable level 20 feet (6.1 meter)	foot/foot (±0.008 meters/meter). Depth >5.0 feet (>1.52 m): ±0.012 foot/foot (±0.012 meter/meter). Accuracy per foot of change from calibrated depth @ 77°F (25°C). Includes nonlinearity and hysteresis.		
Water Velocity	500 kHz doppler ultrasonic	feet/second	-5 to +20 feet/second (-1.5 to 6.1 meters/second)	± 0.1 foot/second for velocity between -5 to +5 feet/second	0.08 foot (25 mm), typical	90%

Notes:
°C = degree(s) Celsius; °F = degree(s) Fahrenheit; µS/cm = microsiemen(s) per centimeter: DO = dissolved oxygen; FNU = Formazin Nephlometric Units (indicates different turbidity sensor characteritics but considered analgous to NTU); kHz = kilohertz; mg/L = milligram(s) per liter; mL = milliliter(s); mm = millimeter(s); mS/cm = millimeter(s) per centimeter; mV = millivolt(s); NTU = nephelometric turbidity unit(s);

and

Hints for this table: **Update table with project specific data quality and measurement quality objectives. Add or remove parameters as needed.**

Table 6. Data Quality and Measurement Quality Objectives

Constituent	Analytical Method	Reporting Limit	Accuracy (Percent Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Bacteria									
E. coli	SM 9223B	1 MPN/100 mL	NA	NA	No growth	NA	NA	Negative response	NA
Enterococci	SM 9230D	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Fecal Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Total Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Metals									
Copper (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7440-50-8
Lead (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7439-92-1
Zinc (Total and Dissolved)	EPA 200.8	10 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7440-66-6
Nutrients									
Total Kjehldahl Nitrogen	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7727-37-9
Ammonia-N	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7664-41-7
Nitrate-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Nitrite-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Nitrogen	Calculation	NA							

Total Phosphorus	EPA 365.3	0.02 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7723-14-0
Orthophosphate (as P)	EPA 300.0	0.01 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	14265-44-2
Particulate Matter									
Total Suspended Solids	SM 2540D	1.0 mg/L	NA	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Conventional Chemistry									
Oil and Grease	EPA 1664	5.0 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Total Organic Carbon	SM 5310B	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Hardness as CaC03	SM 2340C	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA

Notes:
µg/L = microgram(s) per liter; CaC03 = calcium carbonate; CAS = Chemical Abstracts Service; E. coli = Escherichia coli; EPA = United States Environmental Protection Agency; mg/L = milligram(s) per liter; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not applicable; RL = reporting limit; SM = Standard Method

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DQOs were derived by reviewing the QA plans and performance tables provided on the SWAMP website:

http://www.waterboards.ca.gov/water_issues/programs/swamp/mqo.shtml

DQOs applicable to field measurements are summarized in

Hints for this table: Update table with project specific field parameters measurement quality objectives. Add or remove parameters as needed.

Table 5. Field Parameters Measurement Quality Objectives

Parameter	Sensor Type/ Measurement Method	Units	Range	Accuracy	Detection Limit	Completeness
Water Quality Field Parameters						
pH	Combination glass bulb electrode	pH, pH mV	0 to 14 pH units	±0.2 pH units	0.01 pH units	90%
Temperature	Thermistor, installed on conductivity sensor	°C	-5 to 70 °C (Temperature compensation range for DO mg/L measurement: -5 to 50 °C)	± 0.2 °C	0.1 °C or 0.1 °F (user selectable)	90%
Dissolved Oxygen	Optical luminescence - lifetime method	ppm	0 to 500%, 0 to 50 mg/L	0 to 200%: ±1% of reading or 1% saturation, whichever is greater. 200 to 500%: ±8% of reading 0 to 20 mg/L: ±0.1 mg/L or 1% of reading, whichever is greater. 20 to 50 mg/L: ±8% of reading.	0.01 mg/L and 0.1%	90%
Conductivity	Four nickel electrode cells	µS/cm, mS/cm	0 to 200 mS/cm	0 to 20 mg/L: ±0.1 mg/L or 1% of reading, whichever is greater	0.001, 0.01, 0.1 µS/cm	90%

Specific Conductance	Calculated from conductivity and temperature	µS/cm, mS/cm	0 to 200 mS/cm	0–100 mS/cm: ±0.5% of reading or .001 mS/cm, whichever is greater. 100–200 mS/cm: ±1.0% of reading.	0.001, 0.01, 0.1 mS/cm	90%
Turbidity	Nephelometric - Optical, 90-degree scatter	FNU, NTU	0 to 4,000 FNU	0 to 999 FNU: 0.3 FNU or ±2% of reading, whichever is greater. 1,000–4,000 FNU: ±5% of reading	0.1 FNU	90%
Flow Measurements						
Rainfall Amount	Tipping bucket/potted magnetic momentary contact reed switch	inch	4.73 mL/tip	1.0% up to 2 inches/hour (50 mm/hour)	0.01 per tip	90%
Water Level	K band radar frequency	feet, mm	1.6 to 114.8 feet	± 0.0065 foot	0.0033 foot	90%
Water Level	Pressure transducer	feet	0.033 to 10 feet (0.01 to 3.05 meters); max allowable level 20 feet (6.1 meter)	Depths from 0.033 to 5.0 feet (0.01 to 1.52 meters): ±0.008 foot/foot (±0.008 meters/meter). Depth >5.0 feet (>1.52 m): ±0.012 foot/foot (±0.012 meter/meter). Accuracy per foot of change from calibrated depth @ 77°F (25°C). Includes nonlinearity and hysteresis.	0.0033 foot	90%

Water Velocity	500 kHz doppler ultrasonic	feet/second	-5 to +20 feet/second (-1.5 to 6.1 meters/second)	± 0.1 foot/second for velocity between -5 to +5 feet/second	0.08 foot (25 mm), typical	90%

Notes:
°C = degree(s) Celsius; °F = degree(s) Fahrenheit; µS/cm = microsiemen(s) per centimeter: DO = dissolved oxygen; FNU = Formazin Nephlometric Units (indicates different turbidity sensor characteritics but considered analgous to NTU); kHz = kilohertz; mg/L = milligram(s) per liter; mL = milliliter(s); mm = millimeter(s); mS/cm = millimeter(s) per centimeter; mV = millivolt(s); NTU = nephelometric turbidity unit(s);

, and DQOs applicable to laboratory analyses are summarized in

Hints for this table: **Update table with project specific data quality and measurement quality objectives. Add or remove parameters as needed.**

Table 6. Data Quality and Measurement Quality Objectives

Constituent	Analytical Method	Reporting Limit	Accuracy (Percent Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Bacteria									
E. coli	SM 9223B	1 MPN/100 mL	NA	NA	No growth	NA	NA	Negative response	NA
Enterococci	SM 9230D	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Fecal Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Total Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Metals									

Copper (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7440-50-8
Lead (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7439-92-1
Zinc (Total and Dissolved)	EPA 200.8	10 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7440-66-6
Nutrients									
Total Kjehldahl Nitrogen	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7727-37-9
Ammonia-N	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7664-41-7
Nitrate-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Nitrite-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Nitrogen	Calculation	NA							
Total Phosphorus	EPA 365.3	0.02 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7723-14-0
Orthophosphate (as P)	EPA 300.0	0.01 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	14265-44-2
Particulate Matter									
Total Suspended Solids	SM 2540D	1.0 mg/L	NA	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Conventional Chemistry									
Oil and Grease	EPA 1664	5.0 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Total Organic Carbon	SM 5310B	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Hardness as CaC03	SM 2340C	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA

Notes:

µg/L = microgram(s) per liter; CaC03 = calcium carbonate; CAS = Chemical Abstracts Service; E. coli = Escherichia coli; EPA = United States Environmental Protection Agency; mg/L = milligram(s) per liter; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not applicable; RL = reporting limit; SM = Standard Method

. Data validation and verification methods are discussed in Section 21.

5.1 Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Field duplicates will be collected to assess the precision of the field sampling. Field duplicates will be analyzed to measure the precision of samplers' techniques and methods and will also be used to measure laboratory precision. Laboratory duplicates will be used measure the precision of laboratory procedures. The precision of a duplicate measurements can be expressed as the relative percent difference (RPD). The mathematical equation to calculate the RPD is presented in Equation 1:

Equation 1: Calculate the RPD

$$RPD = \left\{ \frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}} \right\} \times 100$$

Where:

X_1 = native sample

X_2 = duplicate sample

5.2 Accuracy and Bias

Accuracy helps determine the level of certainty in data and the closeness of the results to the true value. Bias may occur during data collection, calibration, or limitations in analytical methods by the laboratory. In the field and laboratory, accuracy and bias will be checked with calibration solution or a matrix spike (MS) by introducing a known concentration of a target analyte to a sample or a blank sample and then analyzing the closeness of the result to the known concentration. Values consistently higher or lower than the true value will be considered a bias.

5.3 Representativeness

Representativeness is a qualitative assessment of the data used to assess data based on the ability of the sampling design to meet the project objectives. If the sampling design specifies that samples must be collected from a certain location, at a certain time of day, and during certain conditions (determined through a systematic planning process), then any sample taken outside of those design parameters would be determined to be "not representative," and therefore any data from those samples would not be considered quality data.

The question of the measure for representativeness is addressed during preparation of the sampling and analysis approach and rationale and then reassessed during the data usability process. For example, an integral part of developing the sampling and analysis approach is to answer the question, "How many samples are needed to fully evaluate x?" and then during the data usability process, "Were enough data collected to answer the original question?"

5.4 Completeness

Completeness is defined as the percentage of measurements judged to be valid compared with the total number of measurements for a specific sample matrix and analysis. The mathematical equation to calculate the completeness is presented in Equation 2. An overall completeness goal of 90 percent has been set for this project.

Equation 2 Completeness Calculation

$$Completeness = \frac{Valid\ Measurements}{Total\ Measurements} \times 100\%$$

5.5 Comparability

Comparability is another qualitative measure designed to express the confidence with which one data set may be compared with another. Sample collection and handling techniques, sample matrix type, and analytical method all affect comparability. Comparability is limited by the other parameters because data sets can be compared with confidence only when precision and accuracy are known. Data from one phase of an investigation can be compared with other data when similar methods are used, and similar data packages are obtained. All policies and procedures implemented during the project will be consistent and standardized across all phases to support data comparability.

5.6 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method is commonly referred to as the method detection limit (MDL), defined as the lowest concentration that a sample can be analyzed with 99 percent confidence. The MDL is a laboratory-specific and method-specific value, so results may vary between laboratories even if the same analytical methods are used. The reporting limit (RL) is set for each analyte at a value greater than or equal to the MDL. For this project, RLs are selected to consider comparability with other studies in the South Santa Monica Bay watershed. The target sample analysis RLs are provided in

Hints for this table: **Update table with project specific data quality and measurement quality objectives. Add or remove parameters as needed.**

Table 6. Data Quality and Measurement Quality Objectives

Constituent	Analytical Method	Reporting Limit	Accuracy (Percent Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Bacteria									
E. coli	SM 9223B	1 MPN/100 mL	NA	NA	No growth	NA	NA	Negative response	NA
Enterococci	SM 9230D	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Fecal Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Total Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Metals									
Copper (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%	5% of total project	< RL	7440-50-8

Lead (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%	sample count	< RL	7439-92-1
Zinc (Total and Dissolved)	EPA 200.8	10 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7440-66-6
Nutrients									
Total Kjehldahl Nitrogen	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7727-37-9
Ammonia-N	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7664-41-7
Nitrate-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Nitrite-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Nitrogen	Calculation	NA							
Total Phosphorus	EPA 365.3	0.02 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7723-14-0
Orthophosphate (as P)	EPA 300.0	0.01 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	14265-44-2
Particulate Matter									
Total Suspended Solids	SM 2540D	1.0 mg/L	NA	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Conventional Chemistry									
Oil and Grease	EPA 1664	5.0 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Total Organic Carbon	SM 5310B	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Hardness as CaC03	SM 2340C	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA

Notes:
µg/L = microgram(s) per liter; CaC03 = calcium carbonate; CAS = Chemical Abstracts Service; E. coli = Escherichia coli; EPA = United States Environmental Protection Agency; mg/L = milligram(s) per liter; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not applicable; RL = reporting limit; SM = Standard Method

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Hints for this table: Update table with project specific field parameters measurement quality objectives. Add or remove parameters as needed.

Table 5. Field Parameters Measurement Quality Objectives

Parameter	Sensor Type/ Measurement Method	Units	Range	Accuracy	Detection Limit	Completeness
Water Quality Field Parameters						
pH	Combination glass bulb electrode	pH, pH mV	0 to 14 pH units	±0.2 pH units	0.01 pH units	90%
Temperature	Thermistor, installed on conductivity sensor	°C	-5 to 70 °C (Temperature compensation range for DO mg/L measurement: -5 to 50 °C)	± 0.2 °C	0.1 °C or 0.1 °F (user selectable)	90%
Dissolved Oxygen	Optical luminescence - lifetime method	ppm	0 to 500%, 0 to 50 mg/L	0 to 200%: ±1% of reading or 1% saturation, whichever is greater. 200 to 500%: ±8% of reading 0 to 20 mg/L: ±0.1 mg/L or 1% of reading, whichever is greater. 20 to 50 mg/L: ±8% of reading.	0.01 mg/L and 0.1%	90%
Conductivity	Four nickel electrode cells	µS/cm, mS/cm	0 to 200 mS/cm	0 to 20 mg/L: ±0.1 mg/L or 1% of	0.001, 0.01, 0.1 µS/cm	90%

Table 5. Field Parameters Measurement Quality Objectives (continued)

				reading, whichever is greater		
Specific Conductance	Calculated from conductivity and temperature	µS/cm, mS/cm	0 to 200 mS/cm	0–100 mS/cm: ±0.5% of reading or .001 mS/cm, whichever is greater. 100–200 mS/cm: ±1.0% of reading.	0.001, 0.01, 0.1 mS/cm	90%
Turbidity	Nephelometric - Optical, 90-degree scatter	FNU, NTU	0 to 4,000 FNU	0 to 999 FNU: 0.3 FNU or ±2% of reading, whichever is greater. 1,000–4,000 FNU: ±5% of reading	0.1 FNU	90%
Flow Measurements						
Rainfall Amount	Tipping bucket/potted magnetic momentary contact reed switch	inch	4.73 mL/tip	1.0% up to 2 inches/hour (50 mm/hour)	0.01 per tip	90%
Water Level	K band radar frequency	feet, mm	1.6 to 114.8 feet	± 0.0065 foot	0.0033 foot	90%
Water Level	Pressure transducer	feet	0.033 to 10 feet (0.01 to 3.05 meters); max allowable level 20 feet (6.1 meter)	Depths from 0.033 to 5.0 feet (0.01 to 1.52 meters): ±0.008 foot/foot (±0.008 meters/meter). Depth >5.0 feet (>1.52 m): ±0.012 foot/foot (±0.012 meter/meter). Accuracy per foot of change from calibrated depth @	0.0033 foot	90%

Table 5. Field Parameters Measurement Quality Objectives (continued)

				77°F (25°C). Includes nonlinearity and hysteresis.		
Water Velocity	500 kHz doppler ultrasonic	feet/second	-5 to +20 feet/second (-1.5 to 6.1 meters/second)	± 0.1 foot/second for velocity between -5 to +5 feet/second	0.08 foot (25 mm), typical	90%

Notes:
°C = degree(s) Celsius; °F = degree(s) Fahrenheit; µS/cm = microsiemen(s) per centimeter: DO = dissolved oxygen; FNU = Formazin Nephlometric Units (indicates different turbidity sensor characteritics but considered analgous to NTU); kHz = kilohertz; mg/L = milligram(s) per liter; mL = milliliter(s); mm = millimeter(s); mS/cm = millimeter(s) per centimeter; mV = millivolt(s); NTU = nephelometric turbidity unit(s);

Hints for this table: **Update table with project specific data quality and measurement quality objectives. Add or remove parameters as needed.**

Table 6. Data Quality and Measurement Quality Objectives

Constituent	Analytical Method	Reporting Limit	Accuracy (Percent Recovery)	Precision (RPD)	Method Blank	Field Duplicate (RPD)	Field Duplicate Collection Frequency	Field Blank	CAS#
Bacteria									
E. coli	SM 9223B	1 MPN/100 mL	NA	NA	No growth	NA	NA	Negative response	NA
Enterococci	SM 9230D	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Fecal Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Total Coliform	SM 9221B	1.8 MPN/100mL	NA	NA	No growth	NA	NA	Negative response	NA
Metals									

Table 6. Data Quality and Measurement Quality Objectives (continued…)

Copper (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7440-50-8
Lead (Total and Dissolved)	EPA 200.8	1.0 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7439-92-1
Zinc (Total and Dissolved)	EPA 200.8	10 µg/L	75–125%	≤25%	< RL	≤ 25%		< RL	7440-66-6
Nutrients									
Total Kjehldahl Nitrogen	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	7727-37-9
Ammonia-N	SM 4500-NH3C	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7664-41-7
Nitrate-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Nitrite-N	EPA 300.0	0.1 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Nitrogen	Calculation	NA							
Total Phosphorus	EPA 365.3	0.02 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	7723-14-0
Orthophosphate (as P)	EPA 300.0	0.01 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	14265-44-2
Particulate Matter									
Total Suspended Solids	SM 2540D	1.0 mg/L	NA	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Conventional Chemistry									
Oil and Grease	EPA 1664	5.0 mg/L	80–120%	≤25%	< RL	≤ 25%	5% of total project sample count	< RL	NA
Total Organic Carbon	SM 5310B	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA
Total Hardness as $CaC0_3$	SM 2340C	1.0 mg/L	80–120%	≤25%	< RL	≤ 25%		< RL	NA

Notes:

Table 6. Data Quality and Measurement Quality Objectives (continued…)

µg/L = microgram(s) per liter; $CaC0_3$ = calcium carbonate; CAS = Chemical Abstracts Service; E. coli = Escherichia coli; EPA = United States Environmental Protection Agency; mg/L = milligram(s) per liter; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not applicable; RL = reporting limit; SM = Standard Method

6 SPECIAL TRAINING/CERTIFICATION

A safety training program is in place to ensure that field employees receive the appropriate level of training to conduct their work in a safe manner. The work that the field employees conduct will comply with the regulatory requirements, if applicable. Field employees are required to maintain the training qualification necessary to perform their assigned duties and job functions. Training programs provided to LACPW field employees will be administered by the LACPW Stormwater Quality Division and coordinated by the Stormwater Quality Division Safety Coordinator with the LACPW Risk Management Office. Additional training necessary to conduct water quality sampling for the project will be managed by the project field team leader (or designee). Additional trainings include, but are not limited to, the following:

1. First Aid
2. Cardiopulmonary Resuscitation (CPR)
3. Confined Space Competent Person Training
4. Gas Detector
5. Hazardous Waste Operations and Emergency Response (HAZWOPER)
6. 8-Hour Fall Protection: Worker at Heights
7. Traffic Control Training – Coning and Flagging
8. Hazard Communication (HAZCOM)

All training will be documented. Documentation and certifications verifying completion will be maintained by the field team leader, Stormwater Quality Division safety coordinator, and LACPW Risk Management Office. Copies of the training documentation will be submitted to the project manager. Training documentation will be made available for review at all times.

All contracted commercial laboratories must be certified by the California Environmental Laboratory Accreditation Program and will provide adequate training to their staff as part of their standard operating procedures (SOPs). All contracting laboratories will maintain their own records of training that comply with Occupational Safety and Health Administration (OSHA) requirements. These records can be obtained, if needed, from each contract laboratory through their QA/QC officer.

7 DOCUMENTATION AND RECORDS

All field results will be recorded at the time of completion using the field observation forms. An example of the field observation form is in Appendix B. A digital version of the field observation form can also be accessed in the field via https://arcg.is/TCLyK website. Field observation forms will be completed using permanent ink, with any corrections made by drawing a single line through the error, making corrections initialed by the corrector, and entering the correct value. Each sampling team will have one individual responsible for recording data. Data forms will be reviewed for outliers and omissions by field employees before leaving the sampling sites. The following items should be recorded on the field observation sheet for each sampling event at each sample location:

1. Date and time of sampling
2. Names of sampling team members
3. Project name, sampling location name, and sample identification (ID) numbers
4. Unique IDs for any replicate or blank samples collected from the site
5. Sample characteristics (color and turbidity)
6. Presence of any sheen or odor
7. Weather conditions
8. Field parameters, including temperature, dissolved oxygen, pH, and conductivity
9. Notation whether field duplicate and/or equipment blank samples were collected and from which sampling location
10. Description of any unusual occurrences associated with the sampling event, particularly those that may affect sample or data quality.

Chain-of-custody (COC) forms will be used to accompany samples being sent to the laboratory. Sample handing and custody procedures are discussed in Section 10. The field team leader will collect records for sample collection, field analyses, and chemical testing, including field data sheets and COC forms. The laboratory will generate records for sample receipt and storage, analyses, and reporting, and will store records pertinent to this project. Copies of all records held by the laboratory will be provided to the project manager and stored in a project file.

All records generated by this project will be stored at LACPW Headquarters, 900 South Fremont Avenue, Alhambra, California 91803. Field data forms will be archived for 10 years from the time they are collected. The project manager will maintain the information collected by this project for a period of at least 5 years following the end of the grant agreement term. Documents and records that may be produced and updated throughout the project are briefly summarized in

Hints for this table: Update this table with types of documents and records to be stored and their formats.

Table 4. Types of Documents and Records That Will Be Produced and Stored, and Their Formats

Document/Record	Location	Retention (years)	Format
Project Plans			
Project QAPP, amendments, and appendices	LACPW Headquarters	>= 5	Electronic
Project QAPP distribution documentations	LACPW Headquarters	>= 5	Electronic
Project's monitoring plan	LACPW Headquarters	>= 5	Electronic
Field Documents			
Field staff training records	LACPW Headquarters	>= 5	Electronic
Field equipment calibration/maintenance logs	LACPW Headquarters	>= 5	Electronic
Field notebooks or data sheets	LACPW Headquarters	>= 5	Electronic
Field observation forms	LACPW Headquarters	35	Paper and electronic
Flow data	LACPW Headquarters	35	Electronic
Rainfall data	LACPW Headquarters	35	Electronic
Laboratory Documents			
Laboratory analytical results and reports	LACPW Headquarters and contract laboratory	>= 5	Electronic
Laboratory chain of custody forms	LACPW Headquarters	>= 5	Paper and electronic
Laboratory calibration records	Contract laboratory	>= 5	Electronic
Laboratory equipment maintenance logs	Contract laboratory	>= 5	Electronic
Laboratory quality control manuals	Contract laboratory	>= 5	Electronic
Laboratory SOPs	Contract laboratory	>= 5	Electronic

Notes:
LACPW = County of Los Angeles Public Works; SOP = standard operating procedure

. Electronic data will be stored on the LACPW servers. Electronic data will be backed up weekly. The backup images will be kept on the servers for 3 months.

Copies of the most updated monitoring plan and QAPP will be held by the project manager and will be distributed to all parties involved with the project, including the contract laboratory and/or consulting field staff. Any future amendments will be distributed in the same fashion.

Hints for this table: Update this table with types of documents and records to be stored and their formats.

Table 4. Types of Documents and Records That Will Be Produced and Stored, and Their Formats

Document/Record	Location	Retention (years)	Format
Project Plans			
Project QAPP, amendments, and appendices	LACPW Headquarters	>= 5	Electronic
Project QAPP distribution documentations	LACPW Headquarters	>= 5	Electronic
Project's monitoring plan	LACPW Headquarters	>= 5	Electronic
Field Documents			
Field staff training records	LACPW Headquarters	>= 5	Electronic
Field equipment calibration/maintenance logs	LACPW Headquarters	>= 5	Electronic
Field notebooks or data sheets	LACPW Headquarters	>= 5	Electronic
Field observation forms	LACPW Headquarters	35	Paper and electronic
Flow data	LACPW Headquarters	35	Electronic
Rainfall data	LACPW Headquarters	35	Electronic
Laboratory Documents			
Laboratory analytical results and reports	LACPW Headquarters and contract laboratory	>= 5	Electronic
Laboratory chain of custody forms	LACPW Headquarters	>= 5	Paper and electronic
Laboratory calibration records	Contract laboratory	>= 5	Electronic
Laboratory equipment maintenance logs	Contract laboratory	>= 5	Electronic
Laboratory quality control manuals	Contract laboratory	>= 5	Electronic
Laboratory SOPs	Contract laboratory	>= 5	Electronic

Notes:
LACPW = County of Los Angeles Public Works; SOP = standard operating procedure

8 SAMPLING PROCESS DESIGN

Monitoring will focus on measuring stormwater runoff volume and pollutant load captured by the treatment systems. LACPW will monitor water quality and flow at the treatment systems during dry and wet weather.

8.1 Monitoring Locations

Hints for this section: Describe monitoring locations. Complete the fields in Table 8.

The constituents, collection methods, and the number of samples expected are summarized in Table 8. Monitoring locations have been selected during the project design phase. Monitoring equipment, such as automated samples, flow sensor, level sensor, rain gauge, datalogger, modem, and cabinet, have been specified in the design plan. The general sampling design is shown in Figure 4.

Hints for this table and figure: Fill out table with stormwater treatment system monitoring locations, IDs, and parameters. Insert project-specific influent-effluent configuration figure.

Table 5. Stormwater Treatment System Monitoring Locations, IDs, and Parameters

Monitoring Station ID	Monitoring Station Description	Latitude	Longitude	Monitoring Parameter		
				Flow	Water Quality	Continuous Turbidity

Notes:
ID = identifier;
1. Latitude and longitude of monitoring points will be determined after construction is complete.

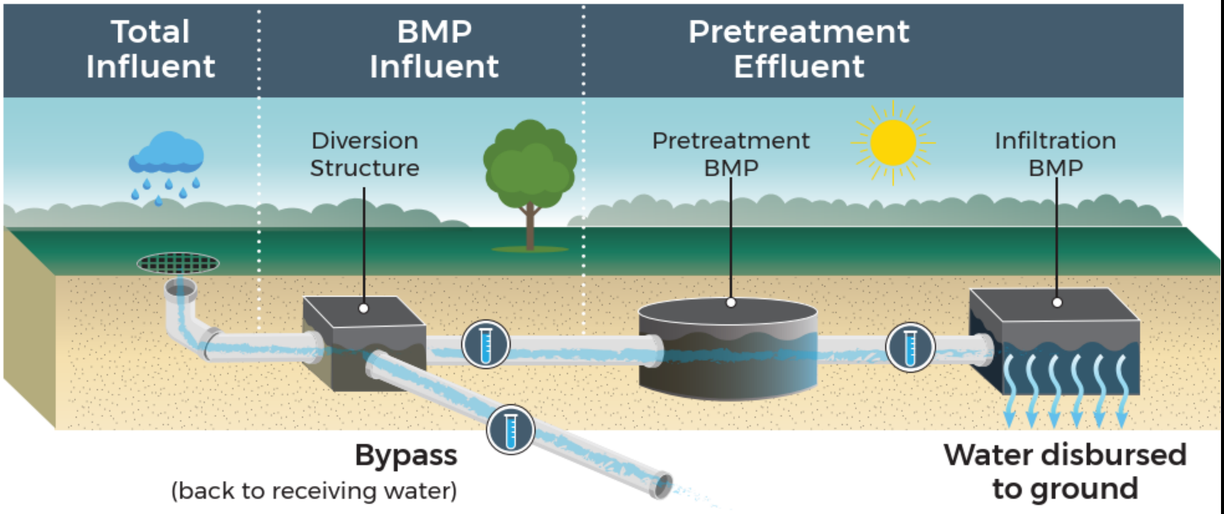

Figure 4. Influent-Effluent Monitoring Schematic [Example – replace with project-specific configuration]

Hints for this table: Fill out table below with the type and total number of samples, matrices, and samples expected. Add or remove parameters as needed.

Table 6. Type and Total Number of Samples, Matrices, and Samples Expected

Constituent	Type of Collection	Number of Dry Weather Events Per Year [1]	Number of Storm Events Per Wet Season [2]
Bacteria			
E. coli	Grab		
Enterococci			
Fecal Coliform			
Total Coliform			
Metals			
	Composite		
Copper (Total and Dissolved)			
Lead (Total and Dissolved)			
Zinc (Total and Dissolved)			
Nutrients			
Total Kjehldahl Nitrogen	Composite		
Ammonia-N			
Nitrate-N			
Nitrite-N			
Total Nitrogen	Calculation		
Total Phosphorus	Composite		
Orthophosphorus			
Particulate Matter			
Total Suspended Solids	Composite		
Conventional Chemistry			
Oil and Grease	Grab		
Total Organic Carbon	Composite		
Total Hardness as $CaC0_3$			
Field Parameters			
pH	In Situ		
Temperature			
Conductivity			
Dissolved Oxygen			
Hydraulic and Weather			
Water Level	In Situ		
Rainfall Intensity			

Notes:

1. Dry weather conditions are defined as <0.1 .in a 24-hour period and a minimum of 72 hours after a rain event.
2. Wet season is the period between November 1 and April 15. Wet weather sampling will be triggered when the rainfall amount is forecast to be at least 0.1 inch within a 24-hour period.

$CaC0_3$ = calcium carbonate; E. coli = Escherichia coli; N = nitrogen

8.2 Monitoring Frequency

The project post-construction monitoring will be carried out for **[X]** years after project completion. **[Dry and wet]** weather water quality samples will be collected at the monitoring frequency for dry and wet weather sampling described in this section.

The monitoring frequency is based on the sample type. Dry weather pollutant concentrations typically exhibit a relatively consistent pattern, so four dry weather sampling events are proposed for each monitoring year. Dry weather sampling events will be scheduled quarterly to account for seasonal variations in dry weather runoff.

Wet weather sampling will be triggered when the rainfall amount is forecast to be at least 0.1 inch within a 24-hour period. Up to **[X]** wet weather sampling events will be targeted for each monitoring year.

The water quality results will be evaluated annually. If the data indicate a high degree of fluctuation, then additional sampling events may be conducted during that year to overcome uncertainty in the results. However, if the data are consistent, then sampling will be concluded for the post-construction monitoring for that year.

8.3 Water Quality

Hints for this section: Describe how water quality data will be used to evaluate the project effectiveness. Include focused studies such as turbidity, etc. that may be used to evaluate effectiveness or maintenance needs.

8.4 Flow

Hints for this section: Describe how flow monitoring data will be used to evaluate function based on engineering design. Indicate how flow will be measured and duration of monitoring for specific sites. Describe anticipated diversion relative to the 85th percentile 24-hour runoff volume for the project drainage area.

The monitoring locations for flow measurements are presented in Appendix D.

9 SAMPLING METHODS

This section describes the sampling methodology for **[wet and dry]** weather sampling, including composite and grab sample collection. This section also discusses collection of field water quality data and continuous flow measurements. Table 10 lists the project water chemistry parameters, and Table 11 lists the project field parameters.

Hints for these tables: Update Table 10 with water chemistry parameters. Update Table 11 with field water quality parameters. Add or remove parameters as needed.

Table 10. Water Chemistry Analysis Parameter Summary Table

Constituent	Sample Volume*	Analytical Method	Method Detection Limit	Laboratory Reporting Limit	Container (number, size, and type)	Preservation	Holding Time
Bacteria							
E. coli	120 mL	SM9223B	1 MPN/100 mL	1 MPN/100 mL	1 x 120-mL sterilized bottle	Sodium thiosulfate, store cool at 10°C	8 hours
Enterococci	120 mL	SM9230B	1 MPN/100 mL	1.8 MPN/100 mL	1 x 120-mL Sterilized bottle	Sodium thiosulfate, store cool at 10°C	8 hours
Fecal Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100 mL	1 x 120-mL sterilized bottle	Sodium thiosulfate, store cool at 10°C or less	8 hours
Total Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100 mL	1 x 120-mL sterilized bottle	Sodium thiosulfate, store cool at 10°C	8 hours
Metals							
Copper (Total and Dissolved)	500 mL	EPA 200.8	0.29 µg/L	1.0 µg/L	2 x 500-mL plastic bottle	HNO3, store cool at 6°C	28 days
Lead (Total and Dissolved)	500 mL	EPA 200.8	0.052 µg/L	1.0 µg/L	2 x 500-mL plastic bottle		28 days
Zinc (Total and Dissolved)	500 mL	EPA 200.8	1.3 µg/L	10 µg/L	2 x 500-mL plastic bottle		28 days

Nutrients							
Total Kjehldahl Nitrogen	500 mL	SM 4500-NH3C	0.065 mg/L	0.1 mg/L	1 x 1,000-mL plastic bottle	H2SO4, store cool at 6°C	28 days
Ammonia-N	500 mL	SM 4500-NH3C	0.017 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	H2SO4, store cool at 6°C	28 days
Nitrate-N	500 mL	EPA 300.0	0.0095 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	Store cool at 6°C	48 hours
Nitrite-N	500 mL	EPA 300.0	0.03 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	Store cool it 6°C	48 hours
Total Nitrogen	500 mL	Calculation	0.1 mg/L	NA			
Total Phosphorus	500 mL	EPA 365.3	0.0062 mg/L	0.02 mg/L	1 x 500-mL plastic bottle	H2SO4, store cool at 6°C	28 days
Ortho phosphorus	500 mL	EPA 300.0	0.003 mg/L	0.01 mg/L	1 x 500-mL plastic bottle	Store cool at 6°C	48 hours
Particulate Matter							
Total Suspended Solids	1000 mL	SM 2540D	1.0 mg/L	1.0 mg/L	1 x 1,000-mL plastic bottle	Store cool at 6°C	7 days
Conventional Chemistry							
Oil and Grease	1000 mL	EPA 1664	1.3 mg/L	5.0 mg/L	1 x 1,000-mL amber glass bottle	H2SO4, store cool at 6°C	28 days
Total Organic Carbon	500 mL	SM 5310B	0.14 mg/L	1.0 mg/L	1 x 500-mL plastic bottle	HCl, store cool at 6°C	28 days
Total Hardness	500 mL	SM 2340C	1.0 mg/L	1.0 mg/L	1 x 500-mL plastic bottle	Store cool at 6°C	6 months

Notes:
Sample volume, method detection limit, and reporting limit may vary depending on the California ELAP contracted laboratory.
°C = degree(s) Celsius; µg/L = microgram(s) per liter; E. coli = Escherichia coli; ELAP = Environmental Laboratory Accreditation Program; EPA = United States Environmental Protection Agency; HCl = hydrochloric acid; HNO3 = nitric acid; H2SO4 = sulfuric acid; mg/L = milligram(s) per liter; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not analyzed; SM = Standard Method

Table 11. Field Water Quality Parameter Summary

Constituent	Equipment	Sensor Type	Measurement Range	Equipment Accuracy	Holding Time
Field Parameters					
Conductivity	YSI ProDSS Handheld Multiparameter Meter	Four Nickel Electrode Cell	0–200 mS/cm	0 to 100 mS/cm (±0.5% of reading or 0.001 mS/cm, whichever is greater)	15 minutes
Dissolved Oxygen		Optical Luminescence	0–50 mg/L	0 to 20 mg/L (±0.1 mg/L or 1% of reading, whichever is greater)	15 minutes
pH		Glass Bulb Combination Electrode; Ag/AgCl Reference Gel	0–14 units	± 0.2 units	15 minutes
Temperature		Thermistor; Combination Sensor with Conductivity	-5 to 70°C (23 to 158°F)	± 0.2°C	15 minutes

Notes:
°C = degree(s) Celsius; Ag = silver; AgCl = silver chloride; mg/L = milligram(s) per liter; mS/cm = millisiemen(s) per centimeter)

9.1 Sampling Method

The flow-weighted composite sampling method will be used in the project (except for collection of samples for analysis of oil and grease, fecal indicator bacteria, and field parameters). The flow-weighted composite method is more accurate than the time-weighted sampling method because the capture volume passing through the monitoring location is constant for each collected sample. The analytical results from the flow-weighted samples may simplify the event mean concentration (EMC) calculation. Although the flow-weighted composite sampling method will be the first sampling strategy used whenever possible, time-weighted composite sampling may be used if flow-weighted sampling is not possible.

Continuous measurements for turbidity will be made at **[X]** points within the treatment system: (1) **[list locations or delete if continuous turbidity monitoring not occurring]**. Turbidity measurements will be made using a Campbell Scientific ClariVUE10 turbidity sensor connected to a Campbell Scientific CR1000X data logger. Data will be logged at 15-minute intervals.

9.1.1 Dry Weather Sampling Method

Dry weather samples will be collected at the influent and effluent points of both treatment systems using the flow-weighted composite sampling method with an autosampler. At each monitoring location, an automated sampler will be programmed to collect approximately 24 samples over a 24-hour period. When the autosampler is triggered, a water quality sample will be collected in a composite bottle placed inside the automated sampler. Water quality samples inside the automated sampler will be refrigerated, if possible, until retrieved by the field crew. Sample retrieval will typically occur within 24 hours after the sampling event. During sample retrieval, the sample bottle will be tightly capped, cooled to below 6 degrees Celsius (°C) inside a cooler filled with ice, and delivered to a laboratory certified by the California Environmental Laboratory Approval Program (ELAP) under COC protocol.

Multiple discrete samples (i.e., pollutograph samples) may be collected instead of a composite sample if it is important to understand the temporal variation in pollutant concentrations throughout a sampling event. Results from pollutograph samples can provide valuable insight into variability, but increased analytical laboratory fees apply because samples are analyzed individually.

Because of the analytical method requirements, samples for analysis of fecal indicator bacteria and oil and grease will be collected using the grab sampling technique. Grab samples will be collected when the field crew retrieves the composite sample from the monitoring locations. When the automated sampler fails to collect water quality samples (e.g., because of low-flow conditions), the grab sampling technique will be used to collect samples for the other constituents. When collecting the water samples, field crews will insert sample bottles under the surface of the flow with the container opening facing upstream. After the bottles are filled, they will be tightly capped, cooled to below 6°C inside a cooler filled with ice, and delivered to the laboratory under COC protocol. If the grab sampling technique is required, one set of samples will be collected at a single point in time rather than a flow-weighted composite collected over a 24-hour period.

9.1.2 Wet Weather Sampling Method

Similar to dry weather sampling, wet weather samples will be collected by the automated sampler using the flow-weighted composite sampling method. The autosampler will be **[programmed to collect approximately 24 to 48 flow-weighted sample aliquots in a composite bottle during each sampling event].** However, actual sample aliquot counts may vary depending on storm characteristics. The program pacing will be adjusted before each storm event to collect representative samples that span the full hydrograph. If it is determined that the autosampler was falsely triggered, the sample will be discarded. The discrete sampling method may be used instead of composite sampling if it is important to understand the temporal variation in pollutant concentrations throughout a storm event. After the storm event, field crews will attempt to retrieve the composite samples from the monitoring locations within 24 hours. Sample bottles will be tightly capped, cooled to below 6°C inside a cooler filled with ice, and delivered under COC protocol to the laboratory.

Because of analytical method requirements, samples for analysis of fecal indicator bacteria and oil and grease will be collected using the grab sampling technique. Grab samples will be collected while storm sampling is underway. Under no circumstances will field crew enter the diversion pipe during a wet weather sampling event.

9.1.3 Field Measurements

A multi-parameter probe will be used to measure dissolved oxygen (DO), temperature, pH, and conductivity in the field during dry and wet weather sampling events. Field parameters such as DO, temperature, and pH have shorter sample holding times; therefore, collecting in situ measurements of these field parameters will provide more accurate measurements. In addition, DO analysis requires extra precautions in the laboratory to prevent contamination by introducing extra oxygen into the sample. Thus, it may be more accurate to measure DO in the field. Before each sampling event, the multi-parameter probes will be calibrated to manufacturers' specifications. Field measurements will be collected by submerging the sensors in sample water. The sample will be stirred continuously to ensure sample homogeneity when the measurements are collected. Field measurements will be collected in duplicate to ensure data precision.

9.1.4 Field Observation

A field data observation sheet in paper or electronic form will be completed by the field crew during each dry and wet weather sampling event. At a minimum, the observation sheet will document the sampling date and time, monitoring location ID, sampler names, and additional comments about the field activities. The observation sheet will also note the weather, flow conditions, and water column position where samples or measurements were collected, and will describe the sample when it is collected, including color, clarity, turbidity, oil and/or grease, floating or suspended materials, and odors. Additional observations about the surrounding environment, including algae, trash, foam, or wildlife, will also be noted. Photographs will be taken during each sampling event, if feasible. A copy of the field observation form is provided in Appendix B. A digital version of the field observation form can also be accessed in the field via https://arcg.is/TCLyK website.

9.2 Flow Monitoring Methodology

Hints for this section: Describe how flow will be measured. Example text:

Continuous flow will be recorded at the following (X) monitoring locations: Site ID# (list site IDs). An ISCO Signature 350 area-velocity sensor will be used to measure flow rate at Site ID# (list site IDs). A Campbell Scientific CS451 pressure transducer will be installed at Site ID# (list site IDs) to calculate the flow rate of influent flows from the (drain name/source) drain and bypass flows at the diversion. Flow data will be recorded every 15 minutes.

Manning's Equation (Equation 3) will be used to calculate dry weather and wet weather flow rates where an area-velocity sensor is not used. The slope of the storm drain, the cross-section area of the flow, and the empirical roughness coefficient will be obtained from the storm drain as-built drawings and will be used to compute the flow rates.

Equation 3: Manning's Equation

$$Q = \left(\frac{1.486}{n}\right) \times A \times R^{\frac{2}{3}} \times \sqrt{S}$$

where:

Q = flow rate in cubic feet
n = Empirical roughness coefficient of the pipe
A = Cross-sectional area of the channel in foot
R = Wetted perimeter in foot
S = Channel slope in foot per foot

10 SAMPLING HANDLING AND CUSTODY PROCEDURES

Field sampling personnel will follow general sample handling practices during both dry and wet weather sampling to ensure that samples are collected in a manner that prevents and reduces contamination of the samples.

Sampling personnel will wear clean, powder-free nitrile gloves to collect each round of samples to prevent cross-contamination. Field crews will be careful to reduce potential contamination of sample bottles or sampling equipment (i.e., they will not touch the bottle or cap interior, put the bottle lid on the floor, collect samples near a running vehicle, etc.). After sample collection, bottles will be capped tightly, and sample labels will be applied to the sides of the bottles. If a **[2.5-gallon bottle]** is used in the automated sampler to collect the sample, a label will be applied to both the upper side of the lid and the side of the bottle. The sample label will be printed on waterproof labels, and at minimum will include the project name, monitoring location ID, collection date and time, and sampler's initials. The appropriate sample containers and preservatives will be prepared and provided by the laboratory. Chemical preservatives will be added to the sample containers, where applicable, to extend the sample holding time.

Every sample delivery or shipment must contain a complete COC form that lists all samples taken and the analyses to be performed on the samples. The following items should be recorded on the COC for each sampling event at each sample location:

1. Sample date and time
2. Preservation used
3. Sampler name
4. Number of containers per sample
5. Analytical testing method requested
6. Parameter to be analyzed
7. Field QA/QC sample collection – such as duplicates, field blanks, equipment blanks, etc.
8. Date, time, name, and signature of the person relinquishing and the person receiving the samples.

COC forms must be completed each time samples are transported to a laboratory and should include any special instructions to the laboratory.

The receiving laboratory has a sample custodian who examines the samples for correct documentation, proper preservation, and holding times. The laboratory will follow the sample custody procedures in their laboratory SOP and QA/QC plans. COC procedures require that possession of samples be traceable from the time the samples are collected until completion of analyses and submittal of analytical results.

All samples remaining after successful completion of analyses will be disposed of properly by the laboratory in accordance with their laboratory retention schedule (e.g., 90 days or as agreed upon for the specific project). It is the responsibility of laboratory personnel to ensure that all applicable regulations are followed in the disposal of samples or related chemicals.

11 ANALYTICAL METHOD REQUIREMENTS

Only California ELAP- certified laboratories will be used for sample analysis. Water chemistry will be monitored using protocols determined during laboratory certification and QA/QC procedures at the laboratory. The analytical methods used should follow 40 Code of Federal Regulations Part 136 requirements.

Hints for these tables: Update Table 10 with water chemistry parameters. Update Table 11 with field water quality parameters. Add or remove parameters as needed.

Table 10. Water Chemistry Analysis Parameter Summary Table

Constituent	Sample Volume*	Analytical Method	Method Detection Limit	Laboratory Reporting Limit	Container (number, size, and type)	Preservation	Holding Time
Bacteria							
E. coli	120 mL	SM9223B	1 MPN/100 mL	1 MPN/100 mL	1 x 120-mL sterilized bottle	Sodium thiosulfate, store cool at 10°C	8 hours
Enterococci	120 mL	SM9230B	1 MPN/100 mL	1.8 MPN/100 mL	1 x 120-mL Sterilized bottle	Sodium thiosulfate, store cool at 10°C	8 hours
Fecal Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100 mL	1 x 120-mL sterilized bottle	Sodium thiosulfate, store cool at 10°C or less	8 hours
Total Coliform	120 mL	SM9221B	1.8 MPN/100mL	1.8 MPN/100 mL	1 x 120-mL sterilized bottle	Sodium thiosulfate, store cool at 10°C	8 hours
Metals							
Copper (Total and Dissolved)	500 mL	EPA 200.8	0.29 µg/L	1.0 µg/L	2 x 500-mL plastic bottle	HNO3, store cool at 6°C	28 days
Lead (Total and Dissolved)	500 mL	EPA 200.8	0.052 µg/L	1.0 µg/L	2 x 500-mL plastic bottle		28 days
Zinc (Total and Dissolved)	500 mL	EPA 200.8	1.3 µg/L	10 µg/L	2 x 500-mL plastic bottle		28 days
Nutrients							

Total Kjehldahl Nitrogen	500 mL	SM 4500-NH3C	0.065 mg/L	0.1 mg/L	1 x 1,000-mL plastic bottle	H2SO4, store cool at 6°C	28 days
Ammonia-N	500 mL	SM 4500-NH3C	0.017 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	H2SO4, store cool at 6°C	28 days
Nitrate-N	500 mL	EPA 300.0	0.0095 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	Store cool at 6°C	48 hours
Nitrite-N	500 mL	EPA 300.0	0.03 mg/L	0.1 mg/L	1 x 500-mL plastic bottle	Store cool it 6°C	48 hours
Total Nitrogen	500 mL	Calculation	0.1 mg/L	NA			
Total Phosphorus	500 mL	EPA 365.3	0.0062 mg/L	0.02 mg/L	1 x 500-mL plastic bottle	H2SO4, store cool at 6°C	28 days
Ortho phosphorus	500 mL	EPA 300.0	0.003 mg/L	0.01 mg/L	1 x 500-mL plastic bottle	Store cool at 6°C	48 hours
Particulate Matter							
Total Suspended Solids	1000 mL	SM 2540D	1.0 mg/L	1.0 mg/L	1 x 1,000-mL plastic bottle	Store cool at 6°C	7 days
Conventional Chemistry							
Oil and Grease	1000 mL	EPA 1664	1.3 mg/L	5.0 mg/L	1 x 1,000-mL amber glass bottle	H2SO4, store cool at 6°C	28 days
Total Organic Carbon	500 mL	SM 5310B	0.14 mg/L	1.0 mg/L	1 x 500-mL plastic bottle	HCl, store cool at 6°C	28 days
Total Hardness	500 mL	SM 2340C	1.0 mg/L	1.0 mg/L	1 x 500-mL plastic bottle	Store cool at 6°C	6 months

Notes:
Sample volume, method detection limit, and reporting limit may vary depending on the California ELAP contracted laboratory.
°C = degree(s) Celsius; µg/L = microgram(s) per liter; E. coli = Escherichia coli; ELAP = Environmental Laboratory Accreditation Program; EPA = United States Environmental Protection Agency; HCl = hydrochloric acid; HNO3 = nitric acid; H2SO4 = sulfuric acid; mg/L = milligram(s) per liter; mL = milliliter(s); MPN = most probable number; N = nitrogen; NA = not analyzed; SM = Standard Method

Table 11. Field Water Quality Parameter Summary

Constituent	Equipment	Sensor Type	Measurement Range	Equipment Accuracy	Holding Time
Field Parameters					
Conductivity	YSI ProDSS Handheld Multiparameter Meter	Four Nickel Electrode Cell	0–200 mS/cm	0 to 100 mS/cm (±0.5% of reading or 0.001 mS/cm, whichever is greater)	15 minutes
Dissolved Oxygen		Optical Luminescence	0–50 mg/L	0 to 20 mg/L (±0.1 mg/L or 1% of reading, whichever is greater)	15 minutes
pH		Glass Bulb Combination Electrode; Ag/AgCl Reference Gel	0–14 units	± 0.2 units	15 minutes
Temperature		Thermistor; Combination Sensor with Conductivity	-5 to 70°C (23 to 158°F)	± 0.2°C	15 minutes

Notes:
°C = degree(s) Celsius; Ag = silver; AgCl = silver chloride; mg/L = milligram(s) per liter; mS/cm = millisiemen(s) per centimeter)

provides the analytical method requirements, detection and reporting limits, container information, and holding times.

12 QUALITY CONTROL REQUIREMENTS

QC for water quality sample collection and analysis is discussed in Sections 12.1 and 12.2, respectively. QC samples are composed of field QA/QC samples and laboratory QA/QC samples. Analysis of these types of samples provides a mechanism for ongoing control and evaluation of data quality measurements. QC samples consist of sample duplicates, field blanks, and equipment blanks. The frequency of QC samples for this project is summarized in **Error! Reference source not found.**.

Hints for this table: Update table below with project-specific quality control field sampling and laboratory analysis frequency. Add or remove parameters as needed.

Table 12. Quality Control Field Sampling and Laboratory Analysis Frequency

Constituent	Field Blank	Sample Duplicate	Equipment Blank	QC Session # (Laboratory)
Bacteria				
E. coli	Minimum of one for dry weather and one for wet weather annually		Not applicable	Perform one set of method blanks and sample duplicates for each batch
Enterococci				
Fecal Coliform				
Total Coliform				
Metals				
Copper (Total and Dissolved)	Minimum of one for dry weather and one for wet weather annually		Minimum of once a year collected from the automated sampler	Perform one set of method blanks, sample duplicates, and MSs/MSDs for every 10 samples
Lead (Total and Dissolved)				
Zinc (Total and Dissolved)				
Nutrients				
Total Kjehldahl Nitrogen	Minimum of one for dry weather and one for wet weather annually		Minimum of once a year collected from the automated sampler	Perform one set of method blanks, sample duplicates, and MSs/MSDs for every 10 samples
Ammonia-N				
Nitrate-N				
Nitrite-N				
Total Phosphorus				
Ortho phosphorus				
Total Nitrogen	Not applicable			
Particulate Matter				

Table 12. Quality Control Field Sampling and Laboratory Analysis Frequency (continued)

Total Suspended Solids	Minimum of one for dry weather and one for wet weather annually	Minimum of once a year collected from the automated sampler	Perform one set of method blanks, sample duplicates, and MSs/MSDs for every 10 samples
Conventional Chemistry			
Oil and Grease	Minimum of one for dry weather and one for wet weather annually	Minimum of once a year collected from the automated sampler	Perform one set of method blanks, sample duplicates, and MSs/MSDs for every 10 samples
Total Organic Carbon			
Total Hardness as $CaC0_3$			
Field Parameters			
pH	Calibration will be conducted each time before use		
Temperature			
Conductivity			
Dissolved Oxygen			
Turbidity Sensor	Calibration prior to installation and as needed based on data review		
Flow sensors	Water level check against known level prior to installation		

Notes:
# – Perform LCS and LCSD immediately after initial calibration. Continuous calibration verification will be performed for every 10 samples.
CaC03 = calcium carbonate; LCS = laboratory control sample; LCSD = laboratory control sample duplicate; MS = matrix spike; MSD = matrix spike duplicate; QC = quality control

12.1 Field Requirements

For this project, one set of sample duplicates and one set of field blanks will be collected annually during dry weather monitoring. For wet weather monitoring, one set of sample duplicates, one set of field blanks, and one set of equipment blanks will be collected annually.

12.1.1 Field Blanks

Field blanks will be prepared and tested with the actual samples collected during one sampling event. Potential contamination from field handling procedures will be assessed through the analysis of the field blanks.

Corrective Action

If contamination is found in the field blanks, then the sample collected during that sampling event will be discarded or qualified. The sampling procedure will be re-evaluated, and an improved procedure will be implemented for the next scheduled sampling event.

12.1.2 Sample Duplicates

Sample duplicates will be collected in the same manner as the environmental samples into separate, clean, laboratory-certified bottles and analyzed as independent samples. These duplicates will be used to document the precision of the sampling process.

Corrective Action

If the RPD between the sample and sample duplicate is greater than 20 percent, then the sample collected during that sampling event will be discarded. The sampling procedure will be re-evaluated, and an improved procedure will be implemented for the next scheduled sampling event.

12.1.3 Equipment Blanks

Equipment blank samples will be collected and analyzed after auto-sampler installation to detect any contaminants in the auto-sampler pump tubing, sampling equipment, and auto-sampler bottles. Laboratory-grade deionized water will be pumped through the auto-sampler tubing with the peristaltic pump into a clean sample container. The equipment blank sample will be packaged and delivered to the laboratory for analysis in the same manner as non-quality control samples. To meet the QC criteria for this project, the results must be lower than the RLs of the associated constituents or not detected when RLs and detection levels are the same.

Corrective Action

If the equipment blank concentrations detected are higher than the reporting limits, then the pump tubing will be replaced and the sampling procedure will be re-evaluated. Once the issue is identified and resolved, another equipment blank will be collected to ensure the sampling equipment is free of contaminants.

12.2 Laboratory Quality Control Assessment

Water samples will be analyzed by a California ELAP-certified laboratory under the guidance of their QA Manual. Prior to sampling, the analytical methods and reporting limits will be verified with the laboratory to ensure they can be achieved. The DQOs and measurement quality objectives (MQOs) will apply to all laboratory analyses.

The laboratory will analyze multiple water quality samples as a batch, and one set of QC samples will be analyzed with each batch. An analytical batch will contain up to 20 field samples. When applicable, the following QC sample types are analyzed as part of the QC batch: method blank, laboratory duplicate, matrix spike (MS), matrix spike duplicate (MSD), laboratory control sample (LCS), and laboratory control sample duplicate (LCSD). These QC sample types are discussed in Sections 12.2.1 through 12.2.4.

12.2.1 Method Blanks

Method blanks are prepared and analyzed by the laboratory as closely as possible to the original and QC samples to detect any contamination in the laboratory. The results of the method blanks provide an estimate of any variability or bias by the analysis.

Corrective Action

Any detection in the method blank will be investigated, and a qualifier will be used to indicate the potential presence of contamination. Once the source of contamination has been identified and eliminated, another set of method blank samples will be collected to confirm the results.

12.2.2 Laboratory Duplicates

A laboratory duplicate is a portion of a sample taken from an original sample and then prepared and analyzed through the same process as the original sample to quantify the precision of laboratory procedures. The RPD is calculated using the same formula in Section 5.1.

Corrective Action

If the RPD between the laboratory duplicates is greater than 25 percent of the native concentration, then the laboratory should investigate the potential presence of laboratory bias.

12.2.3 Matrix Spikes and Matrix Spike Duplicates

An MS is a sample prepared by the laboratory by spiking a known concentration of a target analyte to a specific amount of sample. The MSD is similar to the MS and shows the effect of the sample matrix on the accuracy of the analytical results. MS/MSD sample recovery (accuracy) values are based on the analyte, and thus must be referenced from the DQO Table (Table 6), and the RPD between the MS and MSD should be below 25 percent (precision).

Corrective Action

If the accuracy or precision does not meet the acceptable limits, then the laboratory should investigate the potential presence of laboratory or matrix bias. Sample results associated with a MS/MSD result outside the limits will be flagged as potentially biased (high or low).

12.2.4 Laboratory Control Samples and LCS Duplicates

The LCS/LCSD (also often referred to as a blank spike/blank spike duplicate) is created in the laboratory using contaminant-free reagent water that is spiked with a known concentration of a target analyte for analysis using the same preparation and procedures used for the other project samples. The LCSD is used as a QC measure for the accuracy and precision of the LCS sample. The LCS/LCSD sample recovery (accuracy) DQOs are based on the analyte (Table 6), and the RPD between the LCS and LCSD should be below 25 percent.

Corrective Action

If the accuracy or precision does not meet the acceptable limits, then the laboratory should investigate the potential presence of laboratory or matrix contamination.

13 INSTRUMENT AND EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

Multi-parameter sensors, such as the YSI ProDSS, will be used to measure pH, conductivity, DO, and temperature in the field. The instruments will be tested prior to the start of field sampling to verify that the instrument is operating appropriately. The instrument will be calibrated according to the manufacturer recommended procedures. The calibration process is discussed in Section 14. Table 13 summarizes equipment maintenance requirements.

Routine maintenance of the sensors (e.g., ProDSS sensors, flow sensors, or turbidity sensors) may prolong the usable life of the equipment and maintain high accuracy during measurement. Maintenance will be performed on the installed flow sensors and turbidity sensors approximately every 6 months, or as needed based on review of data. Water quality sensors, such as the ProDSS, should be stored properly and clean so ongoing maintenance is not required.

If equipment is identified as defective, it will be sent back to the manufacturer for repair. All maintenance activities will be documented. Maintenance records will be reviewed by the QC officer for final approval.

Hints for this table: Update this table with project-specific supplies and their recommended inspection.

Table 7. Recommended Inspection for Supplies

Supplies	Inspection Frequency	Type of Inspection	Available Parts	Maintenance
Sampling Equipment				
Reagent	Before each sampling date	Visual inspection of quantity and expiration date	Spare, fresh reagents	Annual replacement at the beginning of sampling season
Sample bottle	Before each sampling date	Before each sampling date	One set of spare bottles	Replace as needed
Cooler	Before each sampling date	Before each sampling date	Spare cooler	Replace as needed
Electronic Equipment				
Multiparameter water quality sensor	Before each sampling date	Calibration	Spare sensors	Calibrate and replace as needed. Logbook notation
Automated sampler	Before each sampling season	Visual and program diagnostic	Portable automated samplers	Calibrate and replace as needed. Logbook notation
Datalogger	Before each sampling date	Visual and program diagnostic	Spare datalogger	Replace as needed. Logbook notation
Onsite rain gauge	Before each wet season	Visual diagnostic	Spare rain gauge	Replace as needed. Logbook notation
Radar level logger	Before each sampling season	Calibration	Spare pressure transducer	Calibrate and replace as needed. Logbook notation
Pressure transducer	Before each sampling season	Calibration	Spare pressure transducer	Calibrate and replace as needed. Logbook notation
Modem	Before each sampling season	Program diagnostic	Spare modem	Replace as needed. Logbook notation

14 INSTRUMENT CALIBRATION AND FREQUENCY

A multi-parameter water quality meter (such as YSI ProDSS water quality meter) will be used to measure DO, temperature, pH, and conductivity in the field during dry and wet weather sampling. The probe will be calibrated according to the manufacturer's specifications prior to each sampling event (see Appendix E – YSI ProDSS Calibration Sheet). Field measurements will be taken by submerging the sensors in sample water. The water will be stirred continuously to ensure sample homogeneity be attended when the measurements are taken.

Water level measurements by the pressure transducer or area velocity sensor will be checked against a known level prior to installation, and water level offsets will be applied if necessary. Once the equipment is installed, visual assessments will be made if/when possible without confined space entry. If data are questionable, a maintenance visit may be required for confined space entry to test and potential replace sensors. Velocity is calibrated by the manufacturer and the equipment cannot be calibrated or adjusted.

Sensor accuracy and calibration will be verified by immersing the sensor into a secondary standard solution (i.e., YSI Confidence Solution or equivalent). The readings measured by the instrument will be compared with the true values given by the manufacturer. If the readings deviate from the accuracy specification of the sensor, equipment calibration will be re-performed.

Table 14 lists the calibration frequencies for the instruments to be used.

Hints for this table: Update table below with project-specific equipment and their calibration frequency.

Table 8. Instrument Calibration Frequency

Equipment Type	Calibration Frequency	Calibration Verification	Standard or Calibration Instrument
pH	Every sampling day	Using a secondary standard solution, confidence solution, or equivalent	pH 4.0, 7.0, and 10.0 buffer solutions according to manufacturer's recommendations
Temperature	Not Applicable (ProDSS temperature sensor does not require calibration)		
Conductivity	Every sampling day	Using a secondary standard solution, confidence solution, or equivalent	1,000 microsiemens per centimeter (µS/cm) calibration standard solution according to manufacturer's recommendations
Dissolved Oxygen	Every sampling day		At a minimum, water saturated air, according to manufacturer's recommendations

15 INSPECTION/ACCEPTANCE REQUIREMENTS

The laboratory will supply all the sample containers necessary for the monitoring program. Other consumable supplies necessary for the monitoring program, such as gloves, sample labels, waterproof pens, and pH standards, will be provided by the project manager. Consumable supplies will be obtained from vendors. The recommended inspections for consumables and supplies are presented in **Error! Reference source not found.**.

Hints for this table: Update table below with project specific consumable supplies and their recommended inspections.

Table 9. Recommended Inspection for Consumables and Supplies

Project-Related Supplies/ Consumables	Inspection/Testing Specifications	Acceptance Criteria	Frequency	Responsible Individual
Sample bottles	Check bottles integrity; check for preservatives	No cracks, intact bottle caps; preservative present	Upon receipt of bottles and prior to sampling	Sampling team
Gloves	Look for tears/holes	Intact, no tears	Prior to use	Each sampler
Sample labels and pens	Check presence/absence of supplies	Supplies in field bin	Prior to going to field	Sampling team
Lab glassware and supplies	Check integrity and cleanness	Clean, no damage	Prior to use	Laboratory

16 NON-DIRECT MEASUREMENTS

Although most environmental projects involve generation of a new data set, projects based solely on the use of existing data is becoming common (United States Environmental Protection Agency (EPA) New England Quality Assurance Unit Office of Environmental Measurement and Evaluation, 2009). The existing data are sometimes considered secondary data. In this project, use of secondary data includes pre-construction monitoring results, storm drain network locations, catch basin locations, drainage area, local rainfall data, and weather forecast information. Information and/or data generated/collected outside of the project activity that will be used to make environmental decisions for the project is summarized in

Hints for this table: Update table below with project specific secondary data used to support project monitoring activities.

Table 16. Secondary Data Will Be Used to Support the Project Monitoring Activities

Non-Direct Measurement	Secondary Data Source	Hyperlink	Data Generator(s) (Originating Organization, Data Types, Data Generation/ Collection Dates)	How Data Will Be Used	Limitations on Data Use
[Pre-construction Water Quality and Flow Monitoring Data]	Los Angeles County Public Works	***[If Applicable]***	***[If Applicable]***	Compare the pre-construction and post-construction monitoring results	***[If Applicable]***
Los Angeles County Storm Drain System (includes channels, gravity mains, and catch basins)	Los Angeles County Geographic Information System (GIS) Data Portal	https://egis3.lacounty.gov/dataportal/category/data_source/la-county/public_works/	Los Angeles County, Los Angeles County Storm Drain System, August 8th 2013	Assess the storm drain network and catch basin locations	1. Unvalidated data used to generate report
Sub-drainage Area Map	Los Angeles County GIS Data Portal	https://egis3.lacounty.gov/dataportal/category/data_source/la-county/public_works/	Los Angeles County, Los Angeles County Sub Watersheds, January 11th 2011	Calculate the sub-drainage area for the project	1. Unvalidated data used to generate report
Forecast Rainfall Data	National Oceanic and Atmospheric Administration	http://noaa.gov/	National Oceanic and Atmospheric Administration, Real-Time	Assess weather forecast information	1. Unvalidated data used to generate report 2. Rainfall data collected from the rain gauge nearby the project site

Real-time and Historical Rainfall Data	Los Angeles County Public Works	http://www.ladpw.org/wrd/precip/	National Oceanic and Atmospheric Administration, Real-Time	Assess historical weather information	

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Hints for this table: Update table below with project specific secondary data used to support project monitoring activities.

Table 16. Secondary Data Will Be Used to Support the Project Monitoring Activities

Non-Direct Measurement	Secondary Data Source	Hyperlink	Data Generator(s) (Originating Organization, Data Types, Data Generation/ Collection Dates)	How Data Will Be Used	Limitations on Data Use
[Pre-construction Water Quality and Flow Monitoring Data]	Los Angeles County Public Works	***[If Applicable]***	***[If Applicable]***	Compare the pre-construction and post-construction monitoring results	***[If Applicable]***
Los Angeles County Storm Drain System (includes channels, gravity mains, and catch basins)	Los Angeles County Geographic Information System (GIS) Data Portal	https://egis3.lacounty.gov/dataportal/category/data_source/la-county/public_works/	Los Angeles County, Los Angeles County Storm Drain System, August 8th 2013	Assess the storm drain network and catch basin locations	1. Unvalidated data used to generate report
Sub-drainage Area Map	Los Angeles County GIS Data Portal	https://egis3.lacounty.gov/dataportal/category/data_source/la-county/public_works/	Los Angeles County, Los Angeles County Sub Watersheds, January 11th 2011	Calculate the sub-drainage area for the project	1. Unvalidated data used to generate report
Forecast Rainfall Data	National Oceanic and Atmospheric Administration	http://noaa.gov/	National Oceanic and Atmospheric Administration, Real-Time	Assess weather forecast information	1. Unvalidated data used to generate report 2. Rainfall data collected from the rain

Table 16. Secondary Data Will Be Used to Support the Project Monitoring Activities (continued…)

					gauge nearby the project site
Real-time and Historical Rainfall Data	Los Angeles County Public Works	http://www.ladpw.org/wrd/precip/	National Oceanic and Atmospheric Administration, Real-Time	Assess historical weather information	

17 DATA MANAGEMENT

Results of analyses, as well as field notes, will be entered into LACPW Integrated Water Quality System database. Data will be maintained by various project team members, as described in Section 2. All laboratory and field measurement data submitted for inclusion in the project database will follow the guidelines and formats established by the California Environmental Data Exchange Network (CEDEN) and the State Water Board (http://www.ceden.org/).

Prior to uploading the data, the project QA officer will conduct a QA/QC review to check the data against existing data in the database for completeness, validity of analytical methods, validity of sampling locations, and validity of sampling dates. The sampling location information will be checked to ensure that sites are correctly referenced, and that identifiers and descriptions match corresponding records from the existing database. Data not passing QA/QC review will be returned to the laboratory or generator for clarification and/or correction. When all data within a batch set have passed QA/QC requirements, the data will be uploaded. A unique batch number, date loaded, and the name of the person who loaded the data will be recorded so that data can be identified and removed in the future if necessary. LACPW QA/QC officers will be responsible for submitting the data for processing into the CEDEN database per grant requirements.

Electronic and handwritten data will be managed using standard techniques such as computers, external hard drives, and LACPW servers. Data will be managed and backed up at a minimum of four locations, at each consultant's office (if applicable), and at the LACPW.

Hand-written data such as field sheets and logs will be filed and kept at the LACPW Headquarters. Field data, including data from loggers, will be maintained in original form (raw data) throughout the duration of the project. Data will be entered into or transferred to Integrated Water Quality System database. Data entries will be double checked. Files will be backed up onto the server every night. LACPW QA/QC officers are the project staff directly responsible for data management. Completed data will be submitted to the Grant Manager. All analytical reports from consultants and laboratories will be submitted, unedited, to the Grant Manager.

18 ASSESSMENT AND RESPONSE ACTIONS

All reviews will be made by the project QA/QC officer as described in Section 2. Reviews may include the following:

- Audits of laboratories
- Audits and field observations of all field sampling teams
- Review of the LACPW Integrated Water Quality System database for accuracy and completeness

The QA/QC officer will conduct reviews of sampling procedures on an annual basis for the entire sampling period. Reviews consist of auditing practices in the field and comparing them with the protocols outlined in this QAPP.

The QA/QC officer will conduct reviews of the database for accuracy and completeness on a quarterly basis once sampling begins. The QA/QC officer will check that the inventory of monitoring activities adequately matches the number of sampling events.

If an audit uncovers any discrepancy, the QA/QC officer will discuss the observed discrepancy with the appropriate person responsible for the activity (see organization chart) and issue a stop-work order if deemed necessary. The discussion will begin with the accuracy of the data collected, the cause(s) leading to the deviation, the potential effect of the deviation data quality, and the corrective actions considered. Reports will be developed by the QA/QC officer to document the results of audits.

The QA/QC officer has the authority to halt all sampling and analytical work by the laboratory if the deviation(s) noted are considered detrimental to data quality. Alternatively, the QA/QC officer may require that certain corrective actions be made within a defined time schedule.

19 REPORTS

The results of the project water quality monitoring will be described in accordance with **[Indicate grant programs or other programs such as SCWP that may have specific reporting requirements]**. Laboratory and field measurements will follow the procedures in the monitoring plan and the QAPP. Laboratory personnel will be responsible for internal QA/QC processes, data verification, data transfer, and reporting to the project data scientist. Sampling logistics and sampling team mobilization dates, times, and activities will be summarized in the post-sampling event memorandum (example provided in Appendix F). The deliverables for the project are presented in Table 17.

Hints for this section: List primary items to be included in the report. These questions are the basis of study design such that the data collected during monitoring described in this Monitoring Plan can be used to directly answer the listed questions.

Example Report Items:

The post-construction monitoring report may include the following items:

1. A summary of pollutant concentrations at the influent and effluent of each sampled treatment system
2. A summary of flows for qualified storm events at the influent and effluent monitoring locations
3. A discussion of treatment effectiveness based on data analysis and study questions
4. A section discussing QA/QC for the data
5. An appendix including all the raw water chemistry data with laboratory qualifiers

Hints for this table: Update table with project deliverables and dates.

Table 17. Project Deliverables

Type of Report	Frequency	Project Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Post-sampling Event Summary Memoranda	After each field sampling event	Within 7 business days after sampling	LACPW Field Team Leader	LACPW Project Manager and LACDPW QA/QC Officer
Draft Post-construction Monitoring Report	Annually	Within six months after the last sampling event have been conducted	LACPW Data Scientist and QA/QC Officer	LACPW Project Manager
Final Post-construction Monitoring Report	At the end of the project	Within one month after the draft monitoring reporting has been submitted	LACPW Data Scientist and QA/QC Officer	LACPW Project Manager and State Water Board Grant Manager

Notes:
LACPW = County of Los Angeles Public Works; QA = quality assurance; QC = quality control;
State Water Board = California State Water Resources Control Board

20 DATA REVIEW, VALIDATION, AND VERIFICATION

Data generated by project activities will be reviewed by the project QA/QC officer against the DQOs in this QAPP. A “peer review” consists of a second analyst or individual proficient with the methods reviewing the data set. A checklist will be provided to guide the reviewer through the process. Furthermore, the data set may be sent to an independent third party, such as Southern California Coastal Water Research Project, for review and comments.

Data will be separated into three categories: (1) data meeting all data quality objectives, (2) data failing precision criteria, and (3) data failing to meet recovery (accuracy) criteria. Data meeting all data quality objectives but with failures of QA/QC practices will be qualified and set aside until the impact of the failure on data quality is determined. Once the impact is determined, the data will be moved into either the first category (data meets all DQOs) or the third category (data failing to meet accuracy criteria).

Data in the first category will be considered usable by the project. Data in the third category will be considered unusable. Data in the second category will have all aspects assessed to determine the usability of the data. If sufficient evidence is found supporting data quality for use in this project, the data will be moved to the first category, but will be flagged with a “J” per EPA data validation specifications.

21 VALIDATION AND VERIFICATION METHODS

Data recorded in the field, including field measurements, observation forms, and COC forms, must pass a review process before final results are released. Field data will be checked by the project field team leader to ensure that all necessary data and activities were completed, including collection of all water samples, field blanks, and field replicates; correct unit measurements were reported; and values fall within expected ranges. The validation will also check to ensure that samples were delivered to the laboratory within the required holding times and that all sample handling and custody procedures were followed. The project data scientist will perform a subsequent check on 10 percent of the reports.

In addition to field data validation, laboratory results will be validated. The laboratory QA/QC officer will check all laboratory records. The review will involve verifying that all required parameters listed on the COC form were measured, analyzed, and reported in the correct units, and that results fall within expected ranges. All checks by the laboratory will be reviewed by the QA officer.

Issues, including missing data, incomplete site visits, reporting errors (such as incorrect units of measure or incorrect date/time information, etc.), or data management errors will be communicated to the responsible party immediately and documented in the QA/QC reports for either field sampling, laboratory activities, or database management. A committee composed of the project QA/QC officer and project manager will reconcile and correct issues. Any corrections will require a unanimous agreement that the correction is appropriate.

Flow data collected in association with this monitoring will be reviewed for QA purposes. These data will be checked for inconsistencies, gaps, and anomalies between the rain gauge data and water level. If QA issues are identified based on these reviews, a site visit will be performed to troubleshoot the issue and any possible corrective actions may be implemented (King County Department of Natural Resources and Parks Water and Land Resources Division, 2015).

During verification of the water level readings, a stream gauge will be used to verify the readings recorded from the level sensor. RPDs will be compared with accuracy and precision specifications of the installed equipment. If deviations are beyond the equipment specifications, those data may be “J” flagged as estimated or “R” flagged as rejected. Data qualification will be determined with the field team leader, project manager, and the QA/QC officer. The field team leader will coordinate with the field crew to troubleshoot the issue. Corrective actions will be determined and implemented after obtaining the approval from the project manager and project QA/QC officer.

Rainfall data will be measured by the onsite rain gauge. Other rain gauges surrounding the project site will be used to verify the accuracy of the on-site rain gauge. These additional gauges are maintained by Los Angeles County Stormwater Engineering Division.

Onsite rainfall will be measured by a tipping bucket rain gauge recording rainfall in 0.01-inch increments. The time of each 0.01-hour tip will be recorded by a data logger. A weekly rainfall amount summary report will be generated by the data logger. The field team leader will examine the report weekly to verify gauge function and data plausibility. Routine site visits will be made to clean and maintain the equipment. Periods of missing records will be filled with data from a separate, nearby rain gauge maintained by the County of Los Angeles. Data for periods when the gauge is more than 20 percent out of calibration may be adjusted.

Data logger time will be checked monthly by the data logger communication software. The time will be adjusted if off by more than 30 seconds.

22 REFERENCES

[add/remove references as needed]

California State Water Resources Control Board. (2013). *Surface Water Ambient Monitoring Program Quality Assurance Program Plan: 2008 to 2013 Appendix Revision Summary, Revised MQO Tables.* Sacramento: California State Water Resources Control Board, Office of Information Management and Analysis, Surface Water Ambient Monitoring Program Unit.

King County Department of Natural Resources and Parks Water and Land Resources Division. (2015). *Quality Assurance Project Plan For Monitoring Stormwater Retrofit in the Echo Lake Drainage Basin - RSMP Effectiveness Study.* Seattle: Science and Technical Support Section.

United States Environmental Protection Agency (EPA) New England Quality Assurance Unit Office of Environmental Measurement and Evaluation. (2009, October 10). *EPA New England Quality Assurance Project Plan Guidance For Environmental Projects Using Only Existing (Secondary) Data.* Retrieved from Secondary Data QAPPs: https://www.epa.gov/sites/production/files/2015-06/documents/EPANESecondaryDataGuidance.pdf

23 APPENDIX A

23.1 Appendix A – Project Schedule

Revised schedule TBD

23.2 Appendix B – Field Observation Sheet

FIELD OBSERVATION SHEET
*Fill out all applicable information

PROJECT NAME ____________________ STATION ID ____________________

SAMPLER NAME ____________________ STATION NAME ____________________

SAMPLER NAME ____________________ COORDINATES N ____________________

DATE __________ TIME __________ W ____________________

MONITORING TYPE

☐ DRY WEATHER ☐ WET WEATHER ☐ BLANK

WEATHER CONDITION

☐ CLEAR ☐ HAZE ☐ RAIN
☐ DRIZZLE ☐ OVERCAST ☐ THUNDERSTORM
☐ FOG ☐ PARTLY CLOUDY

SAMPLE ID (FSID) ____________________

YSI UNIT NO. ____________________

SAMPLE COLLECTED? ☐ YES ☐ NO
If no, observations only

DUPLICATE SAMPLE COLLECTED? ☐ YES ☐ NO
If yes, duplicate sample ID (FSID) __________

FIELD MEASUREMENTS IN DUPLICATE

TEMPERATURE	______ °C	______ °C
pH	______	______
DISSOLVED OXYGEN	______ mg/L	______ mg/L
SP. CONDUCTIVITY	______ µS/cm	______ µS/cm
SALINITY	______ ppt	______ ppt
TURBIDITY	N/A ______ NTU	N/A ______ NTU

FLOW CONDITION

☐ DRY
☐ PONDED
☐ TRICKLING
☐ STEADY FLOW
☐ HIGH/FLOODED

SAMPLE SOURCE

☐ GROUNDWATER ☐ OCEAN
☐ LAKE/RESERVOIR ☐ NON-STORM
☐ MARINA ☐ STORM

SAMPLE DEPTH

☐ BOTTOM ☐ MIDDLE ☐ SURFACE

SAMPLE COLLECTION METHOD

☐ AUTOMATIC ☐ MANUAL

IS SURFACE FLOW REACHING THE OCEAN? ☐ YES ☐ NO ☐ DON'T KNOW (see comments)

FIELD OBSERVATIONS

ODOR

☐ NONE
☐ AMMONIA
☐ CHEMICAL
☐ CHLORINE
☐ FISH/DECAY
☐ MUSTY
☐ PETROLEUM
☐ ROTTEN EGG
☐ SEWAGE

COLOR

☐ COLORLESS
☐ BLUISH
☐ BROWNISH
☐ GREENISH
☐ REDDISH
☐ YELLOWISH
☐ GREYISH

TURBIDITY

☐ CLEAR
☐ CLOUDY
☐ MURKY

ALGAE NEAR DRAIN? ☐ YES ☐ NO

TRASH COMING FROM DRAIN? ☐ YES ☐ NO
If yes, type of trash
☐ PLASTICS ☐ STYROFOAM
☐ VEGETATION ☐ WOOD
☐ OTHER __________ (e.g. DEAD ANIMAL, ETC.)

SOAP OR FOAM IN DISCHARGE? ☐ YES ☐ NO

WILDLIFE WITHIN 50 YARDS? ☐ YES ☐ NO
If yes, type and number __________ TYPE (e.g. DUCKS, ETC.) __________ NUMBER (e.g. 1)

REDTIDE (OCEAN)? ☐ YES ☐ NO

COMMENTS ____________________

Page 1

P:\wmpub\DATA MANAGEMENT\Monitoring Programs Unit\Forms\Field observation sheet\Field Observation Sheet (2015)

23.3 Appendix C – Monitoring Location Maps

23.4 Appendix D – Flow Monitoring Location Maps

23.5 Appendix E – YSI ProDSS Calibration Sheet

ProDSS Calibration Worksheet

YSI a xylem brand

When the Environment Demands It

This calibration worksheet can help document your calibration and track the performance of your sensors. Please follow the detailed calibration procedures in the ProDSS manual or your facility's standard operating procedure (SOP) to ensure all calibrations are as accurate and as consistent as possible.

Refer to the YSI Solution Expiration Dates document to ensure your calibration solutions are fresh. In addition to using fresh standards, never accept an out-of-range or questionable calibration results.

Calibration Date__________________ **Technician:**_______________

Handheld Serial Number:__________ **Handheld Software Version:**________

Cable Serial Number:_____________

Temperature

*Reading when sensor is dry and in room temp air:*________ *Accurate?* ***Y N***

Conductivity

*Reading when sensor is dry and in room temp air:*________ *Acceptable value is less than* ***1 µS/cm***

*Actual Reading in solution before calibration is accepted:*________

*Reading in calibration solution after calibration is completed:*_________

Conductivity Cell Constant in GLP record after calibration:*________

Acceptable range for ProDSS conductivity/temperature sensors (626902) is ***4.5*** *to* ***6.5***

Acceptable range for integral (i.e. built-in) sensors on ODO/CT assemblies is ***4.4*** *to* ***6.4***

Optical Dissolved Oxygen

*Barometric pressure:*_________

*Actual Reading before DO% calibration is accepted:*__________

*Reading in DO% calibration environment after calibration is completed:*__________

*ODO gain in GLP record after calibration:*________ *Acceptable range is* ***0.75*** *to* ***1.50***

pH

		Actual Readings during calibration		
Buffer	Calibration Value	pH	pH mV**	Acceptable pH mV in buffer
7				-50 mV to 50 mV
4				+165 to +180 from pH 7 buffer mV value
10				-165 to -180 from pH 7 buffer mV value

*pH slope in GLP record after calibration:*_________ *Acceptable range is ~* ***55*** *to* ***60*** *pH/mV (Ideal is 59.16 mV/pH)*

*GLP stands for Good Laboratory Practice file. This calibration record contains important information about the calibration result.

**The pH mV at the time of calibration (Sensor Value) can also be seen in the final pH GLP record.

23.6 Appendix F – An Example of the Post-Sampling Event Summary Memo

INTER-OFFICE CORRESPONDENCE
Stormwater Quality Division

TO:	Ka Lun Cheng, Grace Komjakraphan, Hoan Tang, Orlando Almader, Yao Kouwonou, Fernando Villaluna	**DATE:** March 28, 2018
FROM:	Leslie Levy	
SUBJECT:	Post-Storm Sampling Report - 3/21/2018 Storm	

Dear Team,

This is the summary report for the wet weather event which occurred from Wednesday, March 21 to Friday, March 23, 2018. The teams were activated on Wednesday (3/21) during normal work day hours and Friday (3/23) at 08:15-08:30 for sampling activities for the following projects:

1. **Viewridge Super Green Streets**
2. **Hasley Canyon Park**
3. **Rory M. Shaw Wetlands Park**

Wednesday, March 21st – Team assignments for the grab sampling were as follows:

1. Frank Cheng and Grace Komjakraphan travelled to **Viewridge Super Green Streets** project sites to check the autosampler program, conduct any necessary autosampler program adjustments, and collect the grab samples.
2. Leslie Levy and Orlando Almader travelled to **Hasley Canyon Park** project sites to check the autosampler program, conduct any necessary autosampler program adjustments, and collect the grab samples.

The grab sampling activities at Hasley and Viewridge were successfully conducted. The grab samples were dropped off at Weck Laboratory in the City of Industry, then sampling teams returned to HQ during normal work day hours. All samples were delivered to Weck Lab within the holding times.

Friday, March 23rd - Team assignments for the after-storm composite sample pick-up were as follows:

1. Frank Cheng and Orlando Almader travelled to **Viewridge Super Green Streets**, **Hasley Canyon Park,** and **Rory M. Shaw Wetlands Park** project sites to pick up the composite samples. Grace Komjakraphan was on stand-by during sampling activities.

The composite samples for all project sites successfully collected full composite samples. All samples were delivered to Weck Lab within the holding times. Team 1 returned to HQ at 15:45 and Frank Cheng with Leslie Levy continued coordination with Weck Lab until 16:15.

Total rainfall amounts (March 21-23):

1. Viewridge had 2.03" at Topanga Canyon
2. Hasley had 2.44" at Castaic Junction
3. Rory had 1.72" at Tujunga SG

APPENDIX D

Example Monitoring Report:

East Los Angeles Sustainable Median Stormwater BMP Project

2022-23 Year 1

East Los Angeles Sustainable Median Stormwater Capture BMP Monitoring Annual Report

Created on: 08/04/2023

Updated on:

Version:1.0

Los Angeles County Public Works

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 Project Description

The East Los Angeles Sustainable Median Stormwater Capture Project is in the unincorporated area of East Los Angeles within Landscape Maintenance District Zone 35 – Montebello along Northside Drive, Southside Drive, Concourse Avenue, and Montebello Park Way (see Appendix 6.8). The construction of the East Los Angeles Sustainable Median Stormwater (Project) was proposed to reduce pollutants discharged into the Upper Los Angeles River watershed, which is identified on the Clean Water Act Section 303(d) list as an impaired waterbody. Four stormwater treatment systems were constructed to reduce and remove floatable trash, suspended sediments, nutrients, metals, and hydrocarbons from runoff leading to Rio Hondo Reach 1 and Los Angeles River Watershed Reach 2 waterbodies.

For this Project, two types of stormwater treatment configurations were installed. The first configuration utilizes a nutrient separating baffle box (NSBB) and a series of infiltration wells to capture stormwater pollutants. The NSBB system features a three-step treatment process involving diversion, filtration, and infiltration which consists of a screening system, skimmer system, and three sediment removal systems. This configuration is found in treatment systems 1, 2, and 4. The second configuration consists of a pre-treatment chamber, a structural cell module system, and an infiltration well. The structural cell module system features a four-step treatment process involving diversion, adsorption, absorption, and infiltration. This system consists of a series of sand and biochar filter cartridges with a structural cell module system located downstream which contains additional filter media for further treatment of stormwater. This type of treatment configuration is found in treatment system 3.

The construction of the Project was completed in late 2021 and inaugurated by Los Angeles County Public Works on May 18, 2022. Following the construction of the Project, the first year of a three-year post-construction performance monitoring period began in April 2022 to evaluate the effectiveness of the stormwater treatment systems in terms of volume capture and pollutant removal ability.

1.2 Project Benefits

The Project benefits include improving stormwater quality, promoting water conservation, and providing recreational and educational/outreach to the surrounding neighborhoods. The stormwater quality improvement benefit has been achieved by constructing four underground treatment units, spatially separated to treat stormwater from different sub-drainage areas. The stormwater treatment units are designed to remove floatable trash, suspended sediment, nutrients, metals, and hydrocarbons from the captured runoff. The treatment units will actively treat stormwater runoff to help reduce the targeted pollutants from entering the Upper Los Angeles River Watershed. The project is also structured to be full capture; any pollutants which enter the treatment systems but bypass the pretreatment units will be captured by the downstream drywells. Pollutants which enter as runoff into the pretreatment unit will not flow to the Los Angeles River Watershed.

To promote water conservation benefits, the Project utilized drought-tolerant plants and native trees as well as an installation of a high efficiency watering system to reduce regular irrigation. In addition, the Project was designed to capture and infiltrate 22 AF of stormwater per storm event. More than 100 infiltration wells have been constructed to allow treated stormwater to recharge groundwater through percolation.

Furthermore, the Project includes interpretive educational signs to promote sustainable development and water conservation, and outdoor exercise equipment that meets the American with Disabilities Act (ADA) requirement. Teachers from the nearby Montebello Park Elementary School have also used the Project to educate students about water conservation and climate resilience.

1.3 Monitoring Objectives

The monitoring objectives of the Project are to understand the amount of stormwater that can be captured and the amount of priority pollutants that can be removed. The monitoring objectives were converted into a series of study questions, presented in Section 1.4 below.

1.4 Study Questions

The post-construction monitoring seeks to answer the following study questions:

1. How much water is captured by the Project annually?
2. What are the pollutant loads captured by the Project annually?
3. What is the pollutant removal efficiency of the nutrient separating baffle box?
4. What is the pollutant removal efficiency of the structural cell module system pre-treatment chamber?
5. What is the overall pollutant load reduction achieved by the Project?

1.5 Reporting Period

This report represents the first year of monitoring conducted during the 2022 – 2023 monitoring season (between April 1, 2022 and March 31, 2023).

1.6 Accomplished Monitoring Activities

A total of four dry weather and four wet weather samples were collected between April 2022 and March 2023. Continuous flow monitoring was conducted to quantify the amount of stormwater captured and bypassed at the treatment system. An on-site rain gauge was used to measure the total rainfall amount during each storm event.

2.0 MONITORING APPROACH

The monitoring approach followed the descriptions in the Project monitoring plan (see Appendix 6.7). One change to the monitoring plan was that a time-based schedule was used instead of the described flow-based sampling. To answer the study questions listed in Section 1.4, water quality and flow rate were measured during dry and wet weather conditions at the monitoring station locations indicated in Table 1. Water quality samples were collected at the influent and effluent of each NSBB and biofiltration planter box. The monitoring approach is presented in Sections 2.1 through Section 2.8.

2.1 Monitoring Location

A total of 14 monitoring locations were identified in this Project. The monitoring locations are summarized in Table 1. The automatic ISCO samplers installed at each of the treatment systems measured flow from the influent monitoring locations. Dry weather flows were measured continuously at the influents and bypass to Treatment System #1 (located at Northside Dr. and Garfield Avenue) and wet weather flows were measured continuously at the influents and bypasses of all treatment systems. Bypass flow data from the flow sensors was recorded in the Campbell Scientific datalogger in 5- to 15-minute increments. A map of the monitoring locations can be found in Appendix 6.9.

Table 1. Stormwater treatment system monitoring locations, IDs, and parameters

Stormwater Treatment System	Monitoring Station ID	Latitude	Longitude	Dry Weather Monitoring Parameter		Wet Weather Monitoring Parameter	
				Flow	Water Quality	Flow	Water Quality
#1	ELA-1N-INF	34.0131	-118.1305	•	•	•	•
	ELA-1N-EFF	34.01314	-118.1307		•		•
	ELA-1S-INF	34.00992	-118.1314	•	•	•	•
	ELA-1S-EFF	34.00994	-118.1305		•		•
	ELA-01-BYP	34.01138	-118.1316	•		•	
#2	ELA-02-INF	34.0164	-118.1445			•	•
	ELA-02-EFF	34.01639	-118.1446				•
	ELA-02-BYP	34.01631	-118.1444			•	
#3	ELA-3A-INF	34.01416	-118.1438				•
	ELA-3A-BIO-EFF	34.01414	-118.1438			•	•
	ELA-3A-EFF	34.01408	-118.1438				•
#4	ELA-04-INF	34.01167	-118.1442			•	•
	ELA-04-EFF	34.01174	-118.1442				•
	ELA-04-BYP	34.01143	-118.1444			•	

2.2 Monitoring Frequency

A total of four dry weather sampling events were conducted throughout the reporting period. Dry weather samples were collected quarterly on 4/20/2022, 07/26/2022, 10/28/2022, and

01/25/2023. In the 2022-23 storm season, four qualified[1] storm events were sampled. Wet weather samples were collected on 11/08/2022, 12/10/2022, 01/09/2023, and 02/27/2023, respectively.

2.3 Sampling Methodology

Time-weighted water quality composite samples were collected (except for oil and grease, fecal indicator bacteria, and field parameters) at each of the monitoring locations. Grab sampling techniques were used for the samples where composite sampling was not appropriate at each of the monitoring locations. The sampling methods are presented in Sections 2.3.1 and 2.3.2.

2.3.1 Dry Weather Sampling Method

Dry weather samples were collected at the influent and effluent of treatment system Site ID#ELA-1N and Site ID#ELA-1S by time-weighted composite sampling method using the Teledyne ISCO autosamplers. The Teledyne ISCO samplers were programmed to collect 48 samples totaling 9.6 Liters in 24 hours. Water quality samples were pumped into a composite bottle stored inside each automated sampler when a pre-set program was triggered. Collected samples were retrieved by the field crew within 24 hours after the sampling event. During the 2022-23 monitoring year, all dry weather runoff was intercepted by the upstream treatment system Site ID# ELA-1N and little flow was received by the downstream treatment system Site ID#ELA-1S. Thus, dry weather sample was not collected at the treatment system Site ID# ELA-1S.

Bacteria and oil and grease samples were collected using a grab sampling technique at each of the monitoring locations due to the short holding time and nature of the analytes. Grab samples were collected simultaneously to the field crew retrieving the composite samples from the automated samplers. To collect the grab samples, a sample bucket attached to a rope was lowered inverted from the monitoring manholes into the storm drain and water that flowed into the bucket was used as the grab samples. The collected samples were transferred into the laboratory-provided sample bottles, stored in iced cooler to be cooled down to below 6 °C and delivered to an Environmental Laboratory Approval Program (ELAP) approved laboratory with the completed chain of custody (COC) document.

2.3.2 Wet Weather Sampling Method

Similar to the dry weather sampling method, wet weather samples were collected by the Teledyne ISCO automated sampler using the time-weighted composite sampling method. Before the sampling event, the automated samplers were programmed to start collection at the beginning of the storm event and the first sample was collected when the incoming flow rate was above the base flow condition. Depending on the storm's size and duration, the automated

[1] *A qualified storm event is a storm event that has the predicted rainfall of at least 0.25 inch at a seventy percent probability of rainfall at least 24 hours prior to the event start time.*

samplers were programmed to collect 48 time-weighted samples totaling 9.6 Liters in a composite bottle at various intervals during each sampling event. After the storm event, the composite samples were retrieved from the sampling locations within 24-hours. Sample bottles were tightly capped, stored in iced coolers, and chilled to less than 6 °C before being delivered under COC protocol to the ELAP approved laboratory.

Bacteria and oil and grease samples were collected using a grab sampling technique due to short holding times. Grab samples were collected at the beginning of each storm event.

2.4 Sample Handling

During sample retrieval, samples in the composite bottles were transferred into laboratory-provided sample bottles and stored in coolers filled with ice at 6˚C or lower. The samples were delivered to ASSET Laboratories, Inc (1110 Artesia Blvd, Ste. B Cerritos, CA 90703) and Weck Laboratories, Inc (14859 Clark Ave, City of Industry, CA 91745).

2.5 Chain of Custody Form

A COC form was completed by the sampling team in the field when collecting water quality samples. Completed COC forms were submitted to ASSET Laboratories, Inc or Weck Laboratories, Inc with the collected samples. Scanned copies of the COC forms are included in Appendix 6.6 of this report.

2.6 Field Observation

Field observations were conducted during each sampling event in dry and wet weather conditions. Data was input into the electronic field observation forms using ESRI Survey123 mobile application (https://arcg.is/TCLyK).

2.7 Field Measurements

A YSI ProDSS handheld multiparameter water quality meter was used in the field during dry and wet events to measure the physical parameters; dissolved oxygen (DO), temperature, pH, and conductivity. Calibration of the water quality meter occurred within 24 hours prior to the collection of grab samples. Water was collected using the grab sample method to measure the physical parameters; water in the bucket was swirled continuously to achieve homogeneity before field measurements were taken. Duplicate measurements were taken for quality control purposes. YSI ProDSS water quality meter was used for the first dry weather event; however, no data was collected for that event due to dry conditions.

2.8 Flow Monitoring

Dry weather flows were measured at the influent of treatment system 1 (Site ID#ELA-1N-INF and ELA-1S-INF). During dry weather conditions, it was anticipated that most of the flow would be measured at treatment system 1 influent where runoff was diverted from the existing DDI 23 storm drain. Since treatment systems 2, 3, and 4 are designed to capture wet weather surface runoff, dry weather flows at these monitoring locations were assumed to be insignificant and were not evaluated. Wet weather flow was measured at the following monitoring stations: Site ID# ELA-1N-INF, ELA-1S-INF, ELA-01-BYP, ELA-02-INF, ELA-02-BYP, ELA-3A-INF, ELA,-04-INF, and ELA-04-BYP. At the five monitoring locations where wet weather flow was measured, water depth (feet) readings were recorded every 5 to 15 minutes.

There were two types of flow sensors used in this project, area velocity sensors and radar level sensors. Area velocity sensors were installed with the automated samplers at the influent of the monitoring stations Site ID# ELA-1N-INF, ELA-1S-INF, ELA-02-INF, ELA-3A-INF, and ELA-04-INF to measure the capture volume. It was noticed that the area velocity sensor installed at Site ID# ELA-1N-INF was not able to measure flow rate with water depth less than 2 inches in storm drains. To quantify the dry weather runoff volume, Manning's equation was used. Details are further discussed in Section 3.3. Radar level sensors were installed downstream from the diversion structures to measure the bypass stormwater volume. The bypass stormwater volume was calculated using Manning's equation. The slopes of the storm drain inverts, the cross-sectional areas of the flow, and the empirical roughness coefficients were obtained from the Project as-built drawings. Manning's Equation is presented in Equation 1.

Equation 1: Manning's Equation

$$Q = \left(\frac{1.486}{n\, P^{\frac{2}{3}}}\right) \times\ A^{\frac{5}{3}} \times \sqrt{S}$$

where:

Q = flow rate in cubic feet
n = Empirical roughness coefficient of the pipe
P = Perimeter of the channel in feet
R = Wetted perimeter in feet
S = Channel slope in foot/feet

3.0 RESULTS

3.1 Water Chemistry

To assess the effectiveness of the treatment system, influent and effluent pollutant median concentrations were calculated to determine the effectiveness of the NSBBs and the biofiltration planter boxes in dry and wet weather conditions. The dry and wet weather median pollutant concentration values are summarized in Table 2 and Table 3 respectively. The water quality analytical data was provided by the laboratory as final reports in PDF and CEDEN format electronic data deliverable files. The data was prepared in accordance with CEDEN guidance for submission. Field measurement results are summarized in Appendix 6.4. The calculated influent and effluent median values are also depicted in boxplot form in the Appendix, Section 6.10, to provide a visual comparison for the pollutant removal ability of the NSBBs.

Table 2: Dry Weather Pollutant Median Concentrations

2022-2023 Median Pollutant Concentrations in Dry Weather Conditions				
Parameter	**Units**	**MDL**	**ELA-1N-INF (N=4)**	**ELA-1N-EFF (N=4)**
Bacteria				
E. coli	MPN/100mL	1	565	195
Enterococci	MPN/100mL	18	4150	1900
Fecal Coliform	MPN/100mL	18	310	330
Total Coliform	MPN/100mL	18	16000	16000
Metals				
Cadmium (Total)	ug/L	0.2	0.0	0.0
Copper (Total)	ug/L	0.5	16.0	14.5
Lead (Total)	ug/L	0.2	1.0	0.4
Zinc (Total)	ug/L	10	59.5	30.5
Cadmium (Dissolved)	ug/L	0.2	0	0
Copper (Dissolved)	ug/L	0.5	10.3	9.45
Lead (Dissolved)	ug/L	0.4	0.35	0.24
Zinc (Dissolved)	ug/L	10	50.0	24.5
Nutrients				
Total Kjehldahl Nitrogen	mg/L	0.1	1.2	0.5
Ammonia as Nitrogen	mg/L	0.1	0.1	0.0
Nitrate as Nitrogen	mg/L	0.5	6.2	5.9
Nitrite as Nitrogen	mg/L	0.5	0.0	0.0
Total Nitrogen	mg/L	0.1	7.1	6.8
Total Phosphorus	mg/L	0.02	0.2	0.1
Particulate Matter				
Total Suspended Solids	mg/L	5	5.4	3.0
Conventional Chemistry				
Oil and Grease	mg/L	4.7	0	0
Total Organic Carbon	mg/L	5	13.5	8.3
Total Hardness	mg/L	1	555	570

Note:
"N" indicates the number of sample collected.

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Table 3. Wet weather pollutant concentrations

Parameter	Units	MDL	2022-2023 Median Pollutant Concentrations in Wet Weather Conditions										
			ELA-1N-INF	ELA-1N-EFF	ELA-02-INF	ELA-02-EFF	ELA-1S-INF	ELA-1S-EFF	ELA-3A-INF	LA-3A-BIO-EF	ELA-3A-EFF	ELA-04-INF	ELA-04-EFF
Bacteria													
E. coli	MPN/100mL	1	5200	6900	12000	24000	14000	10000	20000	15000	13000	46500	40000
Enterococci	MPN/100mL	18	24000	17000	34000	28000	24000	24000	23000	36000	19000	84000	121500
Fecal Coliform	MPN/100mL	18	12600	2950	31550	9200	10100	5400	8200	24000	19500	54500	13750
Total Coliform	MPN/100mL	18	175000	50000	920000	920000	37500	63500	495000	1600000	107000	580000	54000
Metals													
Cadmium (Total)	ug/L	0.2	0.0	0.0	0.27	0.16	0.073	0.05600	0.3500	0.082	0.3300	0.170	0.220
Copper (Total)	ug/L	0.5	11.0	11.0	22.5	16.0	12.0	13.0	18.55	10.0	18.6	12.95	13.0
Lead (Total)	ug/L	0.2	4.1	2.7	9.9	7.2	4.8	4.5	17.6	3.7	24.3	5.35	4.0
Zinc (Total)	ug/L	10	64.5	54.5	245.0	145.0	73.5	63.5	90.5	51.0	97.0	86.5	227.0
Cadmium (Dissolved)	ug/L	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0745	0.13
Copper (Dissolved)	ug/L	0.5	7.5	6.6	6.1	3.8	8.1	8.0	9.0	6.6	4.9	10.0	10.5
Lead (Dissolved)	ug/L	0.2	0.37	0.4	1.6	0.9	0.3	0.5	0.365	0.18	0.275	0.85	1.4
Zinc (Dissolved)	ug/L	10	46.0	43.0	165.0	70.0	50.5	40.0	30.5	17.0	24.5	57.5	198.5
Nutrients													
Total Kjehldahl Nitrogen	mg/L	0.1	1.6	1.3	6.45	4.00	1.3	1.1	2.4	1.6	2.2	3.8000	3.85000
Ammonia as Nitrogen	mg/L	0.1	0.1	0.17	0.49	0.3	0.0950	0.17500	0.375	0.4	0.325	0.575	0.7
Nitrate as Nitrogen	mg/L	0.5	1.4	1.4	0.1	0.07	1.0	0.9	1.12	0.14	0.8	0.585	0.865
Nitrite as Nitrogen	mg/L	0.5	0.0190	0.1	0.03	0.0	0.061	0.054	0.0750	0.060	0.071	0.268	0.075
Total Nitrogen	mg/L	0.1	2.9	2.6	6.6	3.8	2.6	2.3	3.4	2.4	3.1	4.6500	4.800
Total Phosphorus	mg/L	0.02	0.28	0.25	1.1	0.49	0.24	0.26	0.8000	0.965	0.8900	0.42	0.52
Particulate Matter													
Total Suspended Solids	mg/L	5	23.0	16.5	75.5	47.0	28.5	15.5	158.0	334.5	171.0	29.0	13.0
Conventional Chemistry													
Oil and Grease	mg/L	4.7	2.3	2.5	2.85	4.1	3.1	1.9	2.400	2.35	1.5000	2.9	2.6
Total Organic Carbon	mg/L	5	29	23	97.5	60	21	11	17.5	20.5	15	17.5	20.5
Total Hardness	mg/L	1	117.8	113.45	70.7	43.1	41.25	38.55	88.15	109.75	115	50.45	30.2

Note:

The median pollutant concentrations were calculated based on five sampling events conducted in 2022-23 monitoring period.

3.2 Quality Control/Quality Assurance

Quality Assurance/Quality Control (QA/QC) procedures were performed to fully document the field and laboratory data collected. The procedures ensured data integrity from the time of field collection through the analytical processes to produce the highest quality data possible. Data was assessed by the following parameters: Precision, Accuracy, Comparability, Representativeness, and Completeness. Analytical chemistry QC was formalized by procedures outlined in the Standard Methods For The Examination of Water and Wastewater and involved internal laboratory QC checks such as method blanks, matrix spike/spike duplicates (MS/MSDs) and laboratory control sample/laboratory control sample duplicates (LCS/LCSDs). QC in the field included the analysis of equipment blanks, field blanks and duplicate samples, maintaining proper sample documentation, and adherence to the Monitoring Plan.

Equipment blanks were analyzed to assess potential contamination from the new or pre-cleaned equipment installed at all stations. Prior to the collection of equipment blank samples, all tubing was flushed well with de-ionized water. On October 5, 2022, one equipment blank sample was collected from each station and analyzed for all composite sample parameters. A summary of the equipment blank detections found above the reporting levels (RLs) is summarized in Table 20-Appendix 6.3. The source of equipment blank detections may be due to possible laboratory contamination (e.g., contamination from preservatives, lab water, or cross contamination), contamination that may occur during the blanking process in the field, or directly from the equipment. Field corrective actions were taken; de-ionized water was used to back flush the sampling lines prior to sample collection. Pollutants were sample strainers without introducing additional cleaning agents. The procedure was assumed to be effective, and equipment blank samples were not re-collected.

3.3 Runoff Volume Captured

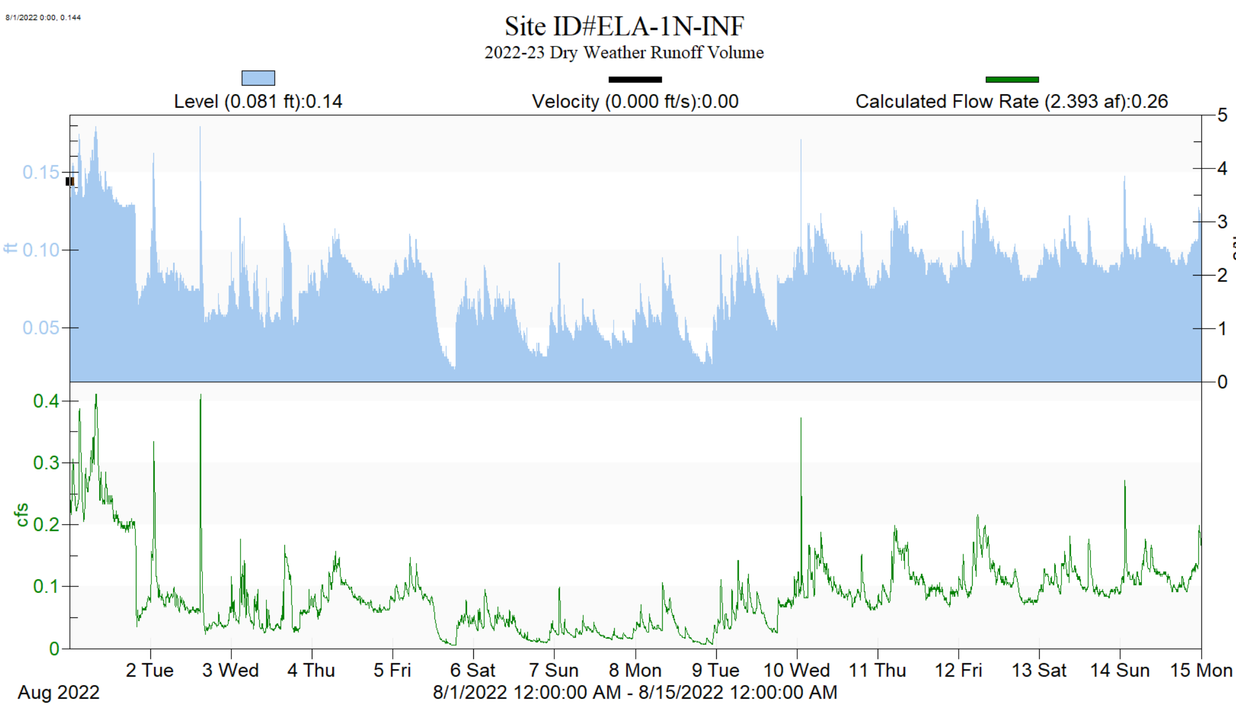
Dry and wet weather stormwater capture volumes were calculated using data from the flow sensors installed at each treatment system. During the monitoring period, the total dry and wet weather stormwater capture volume by the Project was approximately 298 AF. In dry weather conditions, surface runoff was either not observed or not significant, except for treatment system Site ID# ELA-1N. The dry weather stormwater capture volume at Site ID# ELA-1N was calculated during the driest month of the year, August. A total of 2.39 AF of dry weather runoff was recorded between 08/01/2023 and 08/15/2023. The value was scaled to obtain the total dry weather runoff volume captured that was 58.23 AF for the entire annual runoff capture volume. The results are summarized in Table 4. The hydrograph is presented in Figure 1. When analyzing flow data, it was noticed that the area-velocity sensor was not able to measure water velocity when water depth was less than 2 inches (0.17 feet). The technological challenge was unavoidable as the area-velocity sensor needs to be fully submerged to allow the ultrasonic signal travel in the water column that water velocity can be measured. Instead of using the area-velocity sensor to measure flow rate directly, Manning's equation was used to convert water level into flow rate and, thus, the total dry weather runoff capture volume could be calculated.

Table 4. Dry Weather runoff capture volume

Site ID	Date	15-Day Runoff Capture Volume (Acre Feet)	Annual Runoff Capture Volume (Acre Feet)
ELA-1N	08/01/2022 - 08/15/2022	2.39	58.23

Note:
The velocity meter installed at the treatment system Site ID# ELA-1N was unable to detect sheet flow in dry weather conditions. Manning's equation was used to calculate flow rates from water levels.

Figure 1 Hydrograph for treatment system Site ID# ELA-1N in dry weather conditions



In wet weather conditions, stormwater captured volume was quantified for each qualified storm event. It was observed that the area-velocity flow sensors installed at Site ID# ELA-02-INF, ELA-3A-INF, and ELA-04-INF malfunctioned occasionally during storm events and flow data was not recorded. The missing data was filled using a regression analysis by establishing the relationships between stormwater capture volume and rainfall amount. Site specific regression curves were used to estimate the total capture volume when flow data was not available. The regression equations and the corresponding coefficient of determination (R^2) are presented below. The wet weather stormwater capture volume at each treatment system is presented in Table 5.

- For the treatment system site ID# ELA-1N, the estimated stormwater capture volume (AF) = 1.7034 x total rainfall amount (inches); R^2 = 0.84.

- For the treatment system site ID# ELA-1S, the estimated stormwater capture volume (AF = 2.7161 x total rainfall amount (inches); R^2 = 0.76.

- For the treatment system site ID# ELA-02, the estimated stormwater capture volume (AF) = 2.0847 x total rainfall amount (inches); R^2 = 0.92.

- For the treatment system site ID# ELA-3A, the estimated stormwater capture volume (AF) = 0.3025 x total rainfall amount (inches); R^2 = 0.80.

- For the treatment system site ID# ELA-04, the estimated stormwater capture volume (AF) = 2.3547 x total rainfall amount (inches); R^2 = 0.96.

Stormwater bypassed the treatment system Site ID# ELA-01, ELA-02, and ELA-04 were measured downstream from the diversion structures. The solar-powered datalogger installed at Site ID# ELA-01-BYP and Site ID# ELA-04-BYP shut down multiple times during storm events due power shortage in cloudy and rainy days. Bypassed stormwater volume was not recorded in several of the storm events. Regression analyses were used to fill the data gaps. The regression equations that estimated the bypass stormwater volume at Site ID# ELA-01-BYP and ELA-04-BYP are presented below. Table 5 provides a summary of stormwater bypass volume.

- The estimated stormwater bypass volume (AF) at Site ID# ELA-01-BYP = 41.53 x total rainfall amount (inches); R^2 = 0.91.

- The estimated stormwater bypass volume (AF) at Site ID# ELA-04-BYP = 0.0506 x total rainfall amount (inches); R^2 = 0.83.

During the monitoring period, approximately 240 AF of stormwater was captured by the project as a result of 21.9 inches of total rainfall amount. Therefore, the total stormwater capture volume in 2022-23 monitoring period was 298 AF (58 AF in dry weather + 240 A in wet weather = 298 AF). The total amount of stormwater bypassed the project was approximately 1,106 AF. Ultimately, the project successfully captured about 27% of stormwater from upstream drainage areas.

Table 5 Summary of rain events, rainfall amount, runoff and bypass volume

					Total Runoff Capture Volume By Treatment System (Acre Feet)								
Qualified Storm Event	**Water Quality Sample Collected**	**Start Date**	**End Date**	**Total Rainfall (inches)**	**ELA-1N**	**ELA-1S**	**ELA-01-BYP~**	**ELA-02#**	**ELA-02-BYP**	**ELA-3A^**	**ELA-04***	**ELA-04-BYP****
1	Yes	11/7/2022	11/9/2022	1.26	3.55	8.92	130.23	2.63	1.05	0.38	2.04	0.12
2	Yes	12/11/2022	12/13/2022	1.42	2.73	11.96	58.97	1.73	0.08	0.05	1.84	0.05
3	No	12/28/2022	1/3/2023	1.48	2.64	13.12	111.01	2.62	1.67	0.45	3.02	0.07
4	Yes	1/9/2023	1/11/2023	3.28	7.04	10.50	136.22	6.73	4.53	1.62	9.00	0.17
5	No	1/15/2023	1/17/2023	1.64	2.09	2.44	93.58	5.45	1.82	0.17	3.75	0.16
6	No	1/30/2023	1/31/2023	0.38	0.95	4.88	70.19	1.52	0.09	0.12	0.93	0.00
7	Yes	2/24/2023	3/2/2023	8.45	11.83	19.41	323.24	16.18	3.99	2.15	20.58	0.38
8	No	3/14/2023	3/15/2023	1.54	6.47	4.83	63.96	7.50	0.77	1.42	3.75	0.26
9	No	3/20/2023	3/23/2023	1.61	7.42	0.45	66.86	5.03	2.02	1.07	3.92	0.08
10	No	3/29/2023	3/31/2023	0.84	3.99	2.23	34.89	4.14	0.34	0.25	2.05	0.04
			Total:	21.90	48.70	78.73	1089.14	53.52	16.35	7.69	50.86	1.33
			Total Stormwater Capture Volume:	239.50			Total Stormwater Bypassed Volume:			1106.82		

Notes:

Yellow and green highlighted cells are estimated values.

~ Missing values in green highlight were calculated using a site-specific regression curve, where the Estimated Bypass Volume (Acre-feet) = 41.53 x Total Rainfall Amount (inches).

The velocity meter installed at the treatment system Site ID# ELA-02 was malfunctioned. Manning's equation was used to calculate flow rates from the water level. The missing value in the yellow highlighted was calculated using a site-specific regression curve, where the Estimated Capture Volume (Acre-feet) = 2.0847 x Total Rainfall Amount (inches).

^ Missing values in yellow highlights were calculated using a site-specific regression curve, where the Estimated Capture Volume (Acre-feet) = 0.3025 x Total Rainfall Amount (inches).

* Missing values in yellow highlights were calculated using a site-specific regression curve, where the Estimated Capture Volume (Acre-feet) = 2.3547 x Total Rainfall Amount (inches).

** Missing values in green highlights were calculated using a site-specific regression curve, where the Estimated Capture Volume (Acre-feet) = 0.0506 x Total Rainfall Amount (inches).

3.4 Pollutant Loading Calculation

The flow monitoring data revealed that dry weather flows were fully captured and contained within the treatment system Site ID# ELA-1N. Dry weather pollutant load was calculated by multiplying the pollutant median concentration with the average daily runoff volume measured at the monitoring station, Site ID# ELA-1N-INF. The pollutant loading for dry weather is shown in Table 6.

Table 6 Dry weather pollutant load captured in 2022-23 monitoring period

Parameter	Units	Pollutant Load Captured ELA-01
Metals		
Cadmium (Total)	Kg	Not Detected
Copper (Total)	Kg	1.15
Lead (Total)	Kg	0.07
Zinc (Total)	Kg	4.27
Cadmium (Dissolved)	Kg	Not Detected
Copper (Dissolved)	Kg	0.74
Lead (Dissolved)	Kg	0.03
Zinc (Dissolved)	Kg	3.59
Nutrients		
Total Kjehldahl Nitrogen	Kg	86.2
Ammonia as Nitrogen	Kg	7.2
Nitrate as Nitrogen	Kg	445.3
Nitrite as Nitrogen	Kg	Not Detected
Total Nitrogen	Kg	510.0
Total Phosphorus	Kg	14.4
Particulate Matter		
Total Suspended Solids	Kg	387.9
Conventional Chemistry		
Oil and Grease	Kg	Not Detected
Total Organic Carbon	Kg	969.6
Total Hardness as Calcium	Kg	39863.2

Note:
The total dry weather runoff volume is approximately 58.23 acre-feet during the 2022-23 monitoring period.

For wet weather pollutant loading calculation, the pollutant loading was determined based on the runoff volume and the pollutant median concentrations. Once the pollutant load captured at each of the treatment system was calculated, the total pollutant captured by the Project could be obtained. The wet weather pollutant load that was captured by the treatment system is presented in Table 7. The total pollutant load captured by the Project is presented in Table 8.

Table 7 Wet weather total pollutant loads captured in 2022-2023

Pollutant Load Captured in Wet Weather Condition							
Parameter	Units	Pollutant Load Captured ELA-1N-INF	Pollutant Load Captured ELA-1S-INF	Pollutant Load Captured ELA-02-INF	Pollutant Load Captured ELA-03-INF	Pollutant Load Captured ELA-04-INF	Total Pollutant Captured
Metals							
Cadmium (Total)	Kg	0.00	0.01	0.02	0.00	0.01	0.04
Copper (Total)	Kg	0.66	1.17	1.49	0.18	0.81	4.30
Lead (Total)	Kg	0.25	0.47	0.65	0.17	0.34	1.87
Zinc (Total)	Kg	3.87	7.14	16.17	0.86	5.43	33.47
Cadmium (Dissolved)	Kg	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Dissolved)	Kg	0.45	0.79	0.40	0.09	0.63	2.35
Lead (Dissolved)	Kg	0.02	0.03	0.11	0.00	0.05	0.21
Zinc (Dissolved)	Kg	2.76	4.90	10.89	0.29	3.61	22.46
Nutrients							
Total Kjehldahl Nitrogen	Kg	96.11	126.25	425.80	22.77	238.39	909.32
Ammonia as Nitrogen	Kg	7.24	9.23	32.35	3.56	36.07	88.44
Nitrate as Nitrogen	Kg	84.10	97.11	7.26	10.62	36.70	235.80
Nitrite as Nitrogen	Kg	1.14	5.92	1.98	0.71	16.81	26.57
Total Nitrogen	Kg	174.20	252.49	435.71	32.25	291.72	1186.37
Total Phosphorus	Kg	16.82	23.31	72.62	7.59	26.35	146.68
Particulate Matter							
Total Suspended Solids	Kg	1381.62	2767.69	4984.20	1498.71	1819.31	12451.54
Conventional Chemistry							
Oil and Grease	Kg	138.16	301.05	188.15	22.77	181.93	832.05
Total Organic Carbon	Kg	1742.05	2039.35	6436.55	166.00	1097.86	11481.81
Total Hardness as Calcium	Kg	7076.31	4005.87	4667.33	836.14	3164.98	19750.63

Notes:
The median pollutant concentrations were calculated based on five sampling events conducted in 2022-23 monitoring period.
Pollutant loads were calculated using the median pollutant concentration times the total captured volume in wet weather conditions.

Table 8 Total pollutant loads captured in 2022-2023

Total Pollutant Loads Captured in 2022-2023				
Parameter	**Units**	**Total Pollutant Captured In Wet Weather**	**Total Pollutant Captured In Dry Weather**	**Total Pollutant Captured**
Metals				
Cadmium (Total)	Kg	0.04	0.00	0.04
Copper (Total)	Kg	4.30	1.15	5.45
Lead (Total)	Kg	1.87	0.07	1.94
Zinc (Total)	Kg	33.47	4.27	37.74
Cadmium (Dissolved)	Kg	0.00	0.00	0.00
Copper (Dissolved)	Kg	2.35	0.74	3.09
Lead (Dissolved)	Kg	0.21	0.03	0.24
Zinc (Dissolved)	Kg	22.46	3.59	26.05
Nutrients				
Total Kjehldahl Nitrogen	Kg	909.32	86.19	995.51
Ammonia as Nitrogen	Kg	88.44	7.18	95.62
Nitrate as Nitrogen	Kg	235.80	445.32	681.12
Nitrite as Nitrogen	Kg	26.57	0.00	26.57
Total Nitrogen	Kg	1186.37	509.96	1696.33
Total Phosphorus	Kg	146.68	14.37	161.05
Particulate Matter				
Total Suspended Solids	Kg	12451.54	387.86	12839.40
Conventional Chemistry				
Oil and Grease	Kg	832.05	0.00	832.05
Total Organic Carbon	Kg	11481.81	969.65	12451.46
Total Hardness as Calcium	Kg	19750.63	39863.23	59613.87

Note:
The median pollutant concentrations were calculated based on five sampling events conducted in 2022-23 monitoring period.

3.5 Pollutant Removal Evaluation

Two differing structures of treatment units were implemented in this project: nutrient separating baffle boxes, and a biofiltration planter box. The nutrient separation baffle box captures large-scale pollutants such as floating trash, sediment, and debris by physically intercepting pollutants from stormwater. Other pollutants attached to trash and sediment are also removed and may include heavy metals, nutrients, bacteria, and oil and grease. Alternatively, the biofiltration planter box utilizes physical and biological processes to contain and absorb pollutants from stormwater. The planter box consists of vegetation, native soil, sand, and biochar to achieve the pollutant removal capability.

The pollutant removal ability of the nutrient separation baffle box was evaluated in several ways. First, an initial evaluation was conducted to determine if the nutrient separation baffle boxes were removing or exporting pollutants in dry and wet weather conditions. The effluent concentration to influent concentration ratio was calculated for each of the pollutants. When the effluent-to-Influent concentration ratio is less than one, the pollutant is removed from the water by the nutrient separation baffle box. The pollutant is exported from the baffle box if the ratio is greater than one. The comparison results are presented in Table 9, Table 10, and Table 11 The results suggest that pollutants are likely to be removed by the baffle boxes in dry weather conditions. In wet weather conditions, pollutants exported from the baffle boxes are noticeable but lack consistent patterns to demonstrate definitive results. Among all the baffle boxes, a majority of the pollutants were exported from the baffle box at Site ID# ELA-04 where a trash rack and slide gate were absent. Due to a degree of uncertainty which occurs because of the slim determinations between several of the Removing vs. Exporting ratios, the removal efficiency of the baffle box is also determined with a Mann-Whitney Test and an Effluent Probability Plot.

Table 9 Pollutant removal and export from the nutrient separation baffle box (Site ID# ELA-1N) in dry weather conditions

Parameter	Units	MDL	Median Concentration		Removing/Exporting Pollutant
			ELA-1N-INF (N=4)	ELA-1N-EFF (N=4)	
Bacteria					
E. coli	MPN/100mL	1	565	195	Removing
Enterococci	MPN/100mL	18	4150	1900	Removing
Fecal Coliform	MPN/100mL	18	310	330	Exporting
Total Coliform	MPN/100mL	18	16000	16000	---
Metals					
Cadmium (Total)	ug/L	0.2	0	0	---
Copper (Total)	ug/L	0.5	16	14.5	Removing
Lead (Total)	ug/L	0.2	1	0.4	Removing
Zinc (Total)	ug/L	10	59.5	30.5	Removing
Cadmium (Dissolved)	ug/L	0.2	0	0	---
Copper (Dissolved)	ug/L	0.5	10.3	9.45	Removing
Lead (Dissolved)	ug/L	0.4	0.35	0.24	Removing
Zinc (Dissolved)	ug/L	10	50	24.5	Removing
Nutrients					
Total Kjehldahl Nitrogen	mg/L	0.1	1.2	0.5	Removing
Ammonia as Nitrogen	mg/L	0.1	0.1	0	Removing
Nitrate as Nitrogen	mg/L	0.5	6.2	5.9	Removing
Nitrite as Nitrogen	mg/L	0.5	0	0	---
Total Nitrogen	mg/L	0.1	7.1	6.8	Removing
Total Phosphorus	mg/L	0.02	0.2	0.1	Removing
Particulate Matter					
Total Suspended Solids	mg/L	5	5.4	3	Removing
Conventional Chemistry					
Oil and Grease	mg/L	4.7	0	0	---
Total Organic Carbon	mg/L	5	13.5	8.3	Removing
Total Hardness	mg/L	1	555	570	Exporting

Notes:

"N" indicates the number of sample collected.

The highlighted cells indicate that pollutants left the nutrient separating baffle boxes and went to the downstream treatment system.

Table 10 Pollutant removal and exporting from the nutrient separation baffle boxes (Site ID# ELA-1N and ELA-1S) in wet weather conditions

Parameter	Units	MDL	Median Concentration		Removing/Exporting Pollutant	Median Concentration		Removing/Exporting Pollutant
			ELA-1N-INF	ELA-1N-EFF		ELA-1S-INF	ELA-1S-EFF	
Bacteria								
E. coli	MPN/100mL	1	5200	6900	Exporting	14000	10000	Removing
Enterococci	MPN/100mL	18	24000	17000	Removing	24000	24000	---
Fecal Coliform	MPN/100mL	18	12600	2950	Removing	10100	5400	Removing
Total Coliform	MPN/100mL	18	175000	50000	Removing	37500	63500	Exporting
Metals								
Cadmium (Total)	ug/L	0.2	0	0	---	0.073	0.056	Removing
Copper (Total)	ug/L	0.5	10.95	11	Removing	12	13	Exporting
Lead (Total)	ug/L	0.2	4.1	2.7	Removing	4.8	4.5	Removing
Zinc (Total)	ug/L	10	64.5	54.5	Removing	73.5	63.5	Removing
Cadmium (Dissolved)	ug/L	0.2	0	0	---	0	0	---
Copper (Dissolved)	ug/L	0.5	7.5	6.6	Removing	8.1	8	Removing
Lead (Dissolved)	ug/L	0.4	0.37	0.4	Exporting	0.3	0.5	Exporting
Zinc (Dissolved)	ug/L	10	46	43	Removing	50.5	40	Removing
Nutrients								
Total Kjehldahl Nitrogen	mg/L	0.1	1.6	1.3	Removing	1.3	1.1	Removing
Ammonia as Nitrogen	mg/L	0.1	0.1205	0.17	Exporting	0.095	0.175	Exporting
Nitrate as Nitrogen	mg/L	0.5	1.4	1.4	---	1	0.9	Removing
Nitrite as Nitrogen	mg/L	0.5	0.019	0.1	Exporting	0.061	0.054	Removing
Total Nitrogen	mg/L	0.1	2.9	2.6	Removing	2.6	2.3	Removing
Total Phosphorus	mg/L	0.02	0.28	0.25	Removing	0.24	0.26	Exporting
Particulate Matter								
Total Suspended Solids	mg/L	5	23	16.5	Removing	28.5	15.5	Removing
Conventional Chemistry								
Oil and Grease	mg/L	4.7	2.3	2.5	Exporting	3.1	1.9	Removing
Total Organic Carbon	mg/L	5	29	23	Removing	21	11	Removing
Total Hardness	mg/L	1	117.8	113.45	Exporting	41.25	38.55	Removing

Notes:

The median pollutant concentrations were calculated based on five sampling events conducted in 2022-23 monitoring period.

The highlighted cells indicate that pollutants left the nutrient separating baffle boxes and went to the downstream treatment system.

Table 11 Pollutant removal and exporting from the nutrient separation baffle boxes (Site ID# ELA-02 and ELA-04) in wet weather conditions

Parameter	Units	MDL	Median Concentration		Removing/Exporting Pollutant	Median Concentration		Removing/Exporting Pollutant
			ELA-02-INF	ELA-02-EFF		ELA-04-INF	ELA-04-EFF	
Bacteria								
E. coli	MPN/100mL	1	12000	24000	Exporting	46500	40000	Removing
Enterococci	MPN/100mL	18	34000	28000	Removing	84000	121500	Exporting
Fecal Coliform	MPN/100mL	18	31550	9200	Removing	54500	13750	Removing
Total Coliform	MPN/100mL	18	920000	920000	---	580000	54000	Removing
Metals								
Cadmium (Total)	ug/L	0.2	0.27	0.16	Removing	0.17	0.22	Exporting
Copper (Total)	ug/L	0.5	22.5	16	Removing	12.95	13	Exporting
Lead (Total)	ug/L	0.2	9.9	7.2	Removing	5.35	4	Removing
Zinc (Total)	ug/L	10	245	145	Removing	86.5	227	Exporting
Cadmium (Dissolved)	ug/L	0.2	0	0	---	0.0745	0.13	Exporting
Copper (Dissolved)	ug/L	0.5	6.1	3.8	Removing	10	10.5	Exporting
Lead (Dissolved)	ug/L	0.4	1.6	0.9	Removing	0.85	1.4	Exporting
Zinc (Dissolved)	ug/L	10	165	70	Removing	57.5	198.5	Exporting
Nutrients								
Total Kjehldahl Nitrogen	mg/L	0.1	6.45	4	Removing	3.8	3.85	Exporting
Ammonia as Nitrogen	mg/L	0.1	0.49	0.3	Removing	0.575	0.7	Exporting
Nitrate as Nitrogen	mg/L	0.5	0.11	0.07	Removing	0.585	0.865	Exporting
Nitrite as Nitrogen	mg/L	0.5	0.03	0	Removing	0.268	0.075	Removing
Total Nitrogen	mg/L	0.1	6.6	3.8	Removing	4.65	4.8	Exporting
Total Phosphorus	mg/L	0.02	1.1	0.49	Removing	0.42	0.52	Exporting
Particulate Matter								
Total Suspended Solids	mg/L	5	75.5	47	Removing	29	13	Removing
Conventional Chemistry								
Oil and Grease	mg/L	4.7	2.85	4.1	Exporting	2.9	2.6	Removing
Total Organic Carbon	mg/L	5	97.5	60	Removing	17.5	20.5	Exporting
Total Hardness	mg/L	1	70.7	43.1	Removing	50.45	30.2	Removing

Notes:

The median pollutant concentrations were calculated based on five sampling events conducted in 2022-23 monitoring period.

The highlighted cells indicate that pollutants left the nutrient separating baffle boxes and went to the downstream treatment system.

The second method used to determine the nutrient separation baffle box's ability to remove pollutants was evaluated using the Mann-Whitney Test to determine if the baffle box could have a statistically significant reduction on quantities of pollutants. Data collected from nutrient separation baffle boxes (including Treatment System Site ID# ELA-01, ELA-02, and ELA-04) were pooled together to increase the number of data points. The statistical testing results revealed that stormwater pollutants were not significantly removed by the NSBB in dry weather conditions. In wet weather conditions, fecal bacteria removal by the baffle box was statistically significant. The statistical testing results are summarized in Table 12.

Table 12 Test for statistical difference

Parameter	2022-23 Dry Weather Dataset Mann-Whitney Test P-Value	2022-23 Wet Weather Dataset Mann-Whitney Test P-Value
Nutrients		
Total Nitrogen^	0.49	0.12
Total Phosphorus as P	0.82	0.73
Total Orthophosphate as P	1.00	0.45
Metals		
Total Copper	0.49	0.84
Dissolved Copper	0.49	0.75
Total Lead	0.11	0.19
Dissolved Lead	0.25	0.89
Total Zinc	0.69	0.70
Dissolved Zn	0.66	0.55
Total Cadmium	1.00	0.50
Dissolved Cadmium	1.00	0.94
Conventional Chemistry		
Oil and Grease	0.20	0.82
Total Organic Carbon	0.38	0.23
Bacteria		
E. Coli#	0.89	1.00
Total Coliform#	1.00	0.29
Fecal Coliform#	1.00	0.02
Enterococcus#	0.49	0.92
Particulate Matter		
Total Suspended Solids	0.77	0.19

Notes:
^ = Total Khejdahl+ Nitrite+ Nitrate.
# = Tested with log-transformation.
Null Hypothesis: The pollutant concentrations measured at the influent and effluent are similar.
The hightlighted cell represent the pollutant concentration was significantly removed (p-value <0.05).

Similar analyses were conducted to evaluate the pollutant removal ability of the biofiltration planter boxes installed at treatment system Site ID# ELA-03. Since dry weather flow was not observed at the monitoring locations, dry weather samples were not collected and the performance of the biofiltration planter box in dry weather conditions could not be evaluated. In wet weather conditions, the performance of the biofiltration planter boxes is presented in Table 13.

Table 13: Pollutant removal and export from the biofiltration planter box (Site ID# ELA-03) in wet weather conditions

Parameter	Units	MDL	Median Concentration		Removing/Exporting Pollutant
			ELA-3A-INF	ELA-3A-EFF	
Bacteria					
E. coli	MPN/100mL	1	20000	13000	Removing
Enterococci	MPN/100mL	18	23000	19000	Removing
Fecal Coliform	MPN/100mL	18	8200	19500	Exporting
Total Coliform	MPN/100mL	18	495000	107000	Removing
Metals					
Cadmium (Total)	ug/L	0.2	0.35	0.33	Removing
Copper (Total)	ug/L	0.5	18.55	18.6	Exporting
Lead (Total)	ug/L	0.2	17.6	24.3	Exporting
Zinc (Total)	ug/L	10	90.5	97	Exporting
Cadmium (Dissolved)	ug/L	0.2	0	0	---
Copper (Dissolved)	ug/L	0.5	9	4.9	Removing
Lead (Dissolved)	ug/L	0.4	0.365	0.275	Removing
Zinc (Dissolved)	ug/L	10	30.5	24.5	Removing
Nutrients					
Total Kjehldahl Nitrogen	mg/L	0.1	2.4	2.2	Removing
Ammonia as Nitrogen	mg/L	0.1	0.375	0.325	Removing
Nitrate as Nitrogen	mg/L	0.5	1.12	0.8	Removing
Nitrite as Nitrogen	mg/L	0.5	0.075	0.071	Removing
Total Nitrogen	mg/L	0.1	3.4	3.1	Removing
Total Phosphorus	mg/L	0.02	0.8	0.89	Removing
Particulate Matter					
Total Suspended Solids	mg/L	5	158	171	Removing
Conventional Chemistry					
Oil and Grease	mg/L	4.7	2.4	2.35	Exporting
Total Organic Carbon	mg/L	5	17.5	15	Removing
Total Hardness	mg/L	1	88.15	115	Exporting

Notes:
The median pollutant concentrations were calculated based on five sampling events conducted in 2022-23 monitoring period.
The highlighted cells indicate that pollutants left the nutrient separating baffle boxes and went to the downstream treatment system.

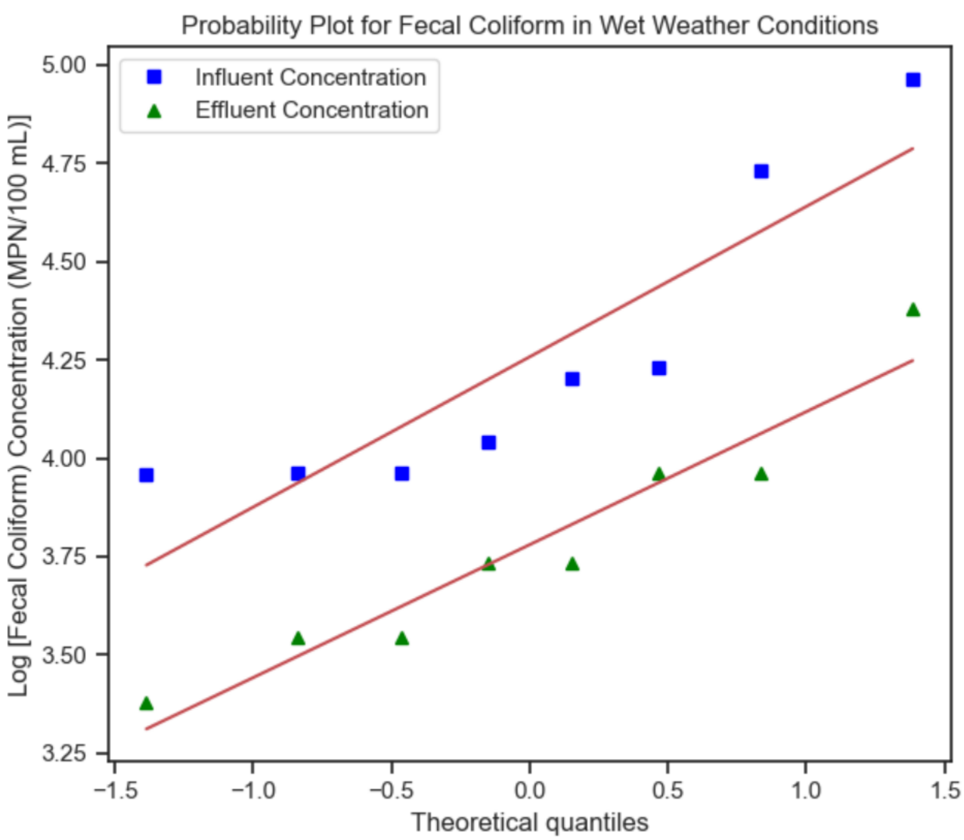
The results indicated that slight amounts of total metals and oil and grease were being exported from the biofiltration planter boxes. The magnitude differences of pollutant concentrations before and after treatment were not significant. However, Fecal Coliform was found approximately two times higher in water when leaving the biofiltration planter box.

Unlike the nutrient separation baffle boxes, the biofiltration planter box's pollutant removal ability was not further evaluated using the Mann-Whitney Test due to only five data points being obtained during monitoring period. The relatively small sample size may introduce a significant error or bias in the statistical analysis. With an increase in data points during Year 2 and 3 monitoring, the pollutant removal ability of the biofiltration planter box can be assessed.

3.6 Best Management Practice (BMP) Effectiveness

The pollutant removal evaluation results in Section 3.5 indicated that the nutrient separating baffle box could remove fecal coliform in urban runoff during wet weather conditions. The effluent probability plot evaluates the consistency of the removal during the five sampling events in 2022-23. The effluent probability plot for fecal coliform in wet weather conditions is presented in Figure 2. The effluent probability plot indicated that fecal coliform was effectively removed by the NSBB showing approximately 68% (half-log) to 90% (one-log) reduction. The separation between the two best-fit lines in Figure 2 becomes wider at higher concentrations. The phenomenon suggested that the removal of bacteria inside the NSBB was relatively effective when the influent fecal coliform concentrations were high. The results concluded that the NSBB was most efficient in removing fecal coliform bacteria at a high concentration during wet weather conditions.

Figure 2 Effluent probability plot for fecal coliform in wet weather conditions



4.0 DISCUSSION

4.1 Pre-Treatment Unit Performance

The pollutant removal ability of the NSBB was studied in this project. The results in Table 9 indicates that, in dry weather condition, stormwater pollutants are likely to be contained and removed by the baffle box. Dry weather flow data showed that water flow into the baffle box in dry weather conditions was relatively slower than in wet weather conditions. Slow water flow allows trash and sediment to settle within the treatment system and, thus, less likely to be washed off to downstream of the treatment train. On the other hand, during wet weather conditions, fast flowing water prevented pollutants from being settled in the treatment system. The fast-moving water may stir up the settled pollutants from the baffle box and carry them downstream of the treatment system.

Not only does flow rate affect the NSBB performance, the presence of a slide gate and trash rack upstream from the baffle box seem to increase the baffle box performance. The results in Table 11 demonstrated that, for treatment system at Site ID#ELA-04, majority of the pollutants were washed off from the baffle box into the downstream dry wells in a storm event. During the Project design phase, the slide gate and trash rack were not included for the treatment system at Site ID#ELA-04. In a rain event, stormwater carrying pollutants would not be slowed down by the slide gate when entering the treatment system. Trash and debris would not be intercepted by the trash rack neither. As a result, the NSBB might have been overwhelmed. Unfiltered stormwater might have bypassed the treatment system that pollutants were found in the effluent water samples. The finding underscores the importance of the using a slide gate to control and slow down the incoming flow rate. More importantly, the presence of the trash rack will help filter out trash and debris before stormwater enters into the baffle box and, thus, prolong the service life and performance of the NSBB.

A significant amount of fecal coliform bacteria was removed by the NSBB during wet weather conditions. This unexpected result is not observed with other fecal indicator bacteria testing like total coliform and *E. coli*. It is our understanding that the baffle box treatment was not intended to target the removal of fecal indicator bacteria specifically. Performance data collected from similar treatment devices installed at LA County's Roosevelt Park Stormwater BMP Project indicated that fecal indicator bacteria was not removed by the baffle box. It is speculated that insufficient data points from five sampling events conducted in 2022-23 monitoring year might negatively impact the robustness of Mann-Whitney Testing and, thus, increase the chance of committing an inferential error, or Type 1, error during analysis. Inferential error occurs when pollutant removal ability of the nutrient separation baffle box is in fact not statistically significant. The analysis outcome is interfered by noise in the dataset due to small sample size and a large degree of variance. To overcome the challenge, additional data will be collected to increase the confidence in the data sets to produce continued statistically significant results for the nutrient separating baffle box for all parameters.

4.2 Year 2 Monitoring

Year 2 of the Project will continue from April 1, 2023, and March 31, 2024. The same monitoring locations, analytes, and methods are recommended to be utilized for the 2023-24 monitoring season.

5.0 CONCLUSION

The project’s post-construction monitoring was carried out from April 1, 2022 to March 31, 2023 with a total of four dry weather and four wet weather samples collected within the monitoring period. There are two types of treatment systems studied in this project. The nutrient separating baffle box and the structural cell module system.

The nutrient separating baffle box was found able to contain most of the stormwater pollutants in dry weather conditions, as well as demonstrate a significant removal of fecal coliform in wet weather conditions. The presence of the slide gate and trash rack were found having a positive impact to the baffle box performance by slowing down the incoming water and removing trash and debris from the water column. The monitoring activities in the next two years will allow additional data to be collected. The statistical analyses can be re-run with a larger dataset to confirm which type of pollutants can be significantly removed by the baffle box.

The overall sample results from the structural cell module demonstrated a slight decrease of fecal indicator bacteria and dissolved metals. These results did not demonstrate a statistically significant decrease in pollutant load, and more data will have to be collected to increase the confidence in the median quantity of the pollutants between the influent, effluent, and biochar effluent. Although the results were not significant, the samples collected from biofiltration planter box tend to have lower concentrations of pollutants, which indicates the media is successful in filtering bacteria and metals.

Overall, both the baffle box and the structural cell module were highly capable of removing pollutants from storm water in dry and wet weather conditions. Large pollutant loads were collected over the course of the monitoring year, preventing them from making their way into the Los Angeles River.

6.0 APPENDIX

6.1 Dry Weather Event Pollutant Concentration

Table 14 Pollutant concentrations collected from dry weather sampling events

			Dry Weather #1		Dry Weather #2		Dry Weather #3		Dry Weather #4	
Parameter	Units	MDL	4/20/2022 ELA-1N-INF	4/20/2022 ELA-1N-EFF	7/27/2022 ELA-1N-INF	7/27/2022 ELA-1N-EFF	10/27/2022 ELA-1N-INF	10/27/2022 ELA-1N-EFF	1/25/2023 ELA-1N-INF	1/25/2023 ELA-1N-EFF
Bacteria										
E. coli	MPN/100mL	1	86	88	150	210	20000J	930J	980	180
Enterococci	MPN/100mL	18	2800	5400	130	170	14000J	1300J	5500	2500
Fecal Coliform	MPN/100mL	18	78	170	310	700	---	---	790	330
Total Coliform	MPN/100mL	18	>=16000	>=16000	5400	16000	---	---	540000	54000
Metals										
Cadmium (Total)	ug/L	0.2	0ND	0ND	0ND	0ND	0ND	0ND	0ND	0ND
Copper (Total)	ug/L	0.5	14	13	29	18	17	16	15	12
Lead (Total)	ug/L	0.2	0.7	0.8	2.0	0.4	0.48J	0.39J	1.2	0.4
Zinc (Total)	ug/L	10	71	81	140	27	18	20	48	34
Cadmium (Dissolved)	ug/L	0.2	0ND	0ND	0ND	0ND	0ND	0ND	0ND	0ND
Copper (Dissolved)	ug/L	0.5	9.6	9.5	16	8.7	11.0	12.0	9.1	9.4
Lead (Dissolved)	ug/L	0.2	0.4	0.4	0.6	0.2	0.24J	0.28J	0.3	0.2
Zinc (Dissolved)	ug/L	10	68	78	95	18	15J	18J	32	31
Nutrients										
Total Kjehldahl Nitrogen	mg/L	0.1	1.1	1.6	2.0	0.7	0ND	0ND	1.3	0.31
Ammonia as Nitrogen	mg/L	0.1	0ND	0ND	0.1	0	0.24	0.26	0ND	0ND
Nitrate as Nitrogen	mg/L	0.5	5.5	4.9	1.5	2.7	7.5	7.2	6.8	6.8
Nitrite as Nitrogen	mg/L	0.5	0ND	0ND	0ND	0ND	0ND	0ND	0s	46J
Total Nitrogen	mg/L	0.1	6.6	6.5	3.5	3.4	7.5	7.2	8.1	7.1
OrthoPhosphate	mg/L	0.01	---	---	---	---	---	---	0.17	0.17
Total Phosphorus	mg/L	0.02	0.2	0.1	0ND	0ND	---	---	0.3	0.27
Particulate Matter										
Total Suspended Solids	mg/L	5	0	12	20	0	3.7	3	7J	0s
Conventional Chemistry										
Oil and Grease	mg/L	4.7	0ND	0ND	0ND	0ND	0ND	0ND	0ND	0ND
Total Organic Carbon	mg/L	5	6.4	30	60	3.6	13	3.3	14	13
Total Hardness	mg/L	1	520	510	460	480	590	630	651	633

0 Signifies ND (Non-Detect) For calculation Purposes

0ND Signifies that the system never had traces of the pollutant. These values are excluded from data analysis

J signifies an estimated concentration

6.2 Wet Weather Event Pollutant Concentration

Table 15 Pollutant concentrations collected from the wet weather sampling events at ELA-1N

Parameter	Units	MDL	Wet Weather #1		Wet Weather #2		Wet Weather #3		Wet Weather #4	
			11/8/2022	11/8/2023	12/10/2022	12/10/2022	1/9/2023	1/9/2023	2/27/2023	2/27/2023
			ELA-1N-INF	ELA-1N-EFF	ELA-1N-INF	ELA-1N-EFF	ELA-1N-INF	ELA-1N-EFF	ELA-1N-INF	ELA-1N-EFF
Bacteria										
E. *coli*	MPN/100mL	1	17000	14000	5200	6900	3000	3400	---	---
Enterococci	MPN/100mL	18	12000	13000	24000	17000	33000	26000	---	---
Fecal Coliform	MPN/100mL	18	---	---	16000	2400	9200	3500	---	---
Total Coliform	MPN/100mL	18	---	---	240000	46000	110000	54000	---	---
Metals										
Cadmium (Total)	ug/L	0.2	0ND	0ND	0ND	0ND	0.079J	0.063J	0.053J	0.062J
Copper (Total)	ug/L	0.5	13	12	12	10	8.1	6.5	9.9	21
Lead (Total)	ug/L	0.2	4.2J	4.4J	2.6	2.5	4.7	2.7	3.9	3.7
Zinc (Total)	ug/L	10	79	82	56	44	60	47	69	62
Cadmium (Dissolved)	ug/L	0.2	0ND	0ND	0ND	0ND	0ND	0ND	0ND	0ND
Copper (Dissolved)	ug/L	0.5	11.0	8.7	8.4	7.6	4.9	4.8	6.5	5.6
Lead (Dissolved)	ug/L	0.2	0.62J	0.56J	0.41	0.46	0.3	0.34	0.33	0.37
Zinc (Dissolved)	ug/L	10	62	50	41	34	37	38	51	48
Nutrients										
Total Kjehldahl Nitrogen	mg/L	0.1	2.3	2.0	1.1	1.2	1.7	0.77	1.4	1.4
Ammonia as Nitrogen	mg/L	0.1	0.16	0.17	0.16	0.17	0.081J	0.086J	0.033J	0.029J
Nitrate as Nitrogen	mg/L	0.5	0.15J	0.19J	2.1	2	1.4	1.4	1.4	0.18
Nitrite as Nitrogen	mg/L	0.5	0s	0.27J	0ND	0ND	.019J	.020J	.076J	.085J
Total Nitrogen	mg/L	0.1	2.4	2.5	2.9	2.6	3.1	2.1	2.9	3.3
Orthophosphate as P	mg/L	0.01	---	---	0.22J	0.18J	0.057	0.086	0	0.018
Total Phosphorus	mg/L	0.02	---	---	0.33	0.28	0.28	0.25	0.14	0.16
Particulate Matter										
Total Suspended Solids	mg/L	5	21.0	15.0	16	21	28	13	25	18
Conventional Chemistry										
Oil and Grease	mg/L	4.7	0ND	0ND	---	---	2.3J	2.5J	---	---
Total Organic Carbon	mg/L	5	45	36	35	22	23	21	22	24
Total Hardness	mg/L	1	52	48	183	170	62.6	56.9	173	194

0 Signifies ND (Non-Detect) For calculation Purposes

0ND Signifies that the system never had traces of the pollutant. These values are excluded from data analysis

J Signifies an estimated concentration

Table 16 Pollutant concentrations collected from the wet weather sampling event at ELA-1S

Parameter	Units	MDL	Wet Weather #1 11/8/2022 ELA-1S-INF	Wet Weather #1 11/8/2022 ELA-1S-EFF	Wet Weather #2 12/10/2022 ELA-1S-INF	Wet Weather #2 12/10/2022 ELA-1S-EFF	Wet Weather #3 1/9/2023 ELA-1S-INF	Wet Weather #3 1/9/2023 ELA-1S-EFF	Wet Weather #4 2/27/2023 ELA-1S-INF	Wet Weather #4 2/27/2023 ELA-1S-EFF
Bacteria										
E. coli	MPN/100mL	1	24000	17000	14000	7700	5800	10000	---	---
Enterococci	MPN/100mL	18	23000	23000	24000	24000	87000	49000	---	---
Fecal Coliform	MPN/100mL	18	---	---	11000	5400	9200	5400	---	---
Total Coliform	MPN/100mL	18	---	---	54000	35000	21000	92000	---	---
Metals										
Cadmium (Total)	ug/L	0.2	0ND	0ND	0.16J	0.065J	0.073J	0.056J	0.048J	0.051J
Copper (Total)	ug/L	0.5	14	14	22	14	7.6	7.3	10	12
Lead (Total)	ug/L	0.2	3.9J	4.4J	13	5.5	4.9	3.2	4.7	4.6
Zinc (Total)	ug/L	10	80	86	130	68	52	45	67	59
Cadmium (Dissolved)	ug/L	0.2	0ND	0ND	0ND	0ND	0ND	0ND	0ND	0ND
Copper (Dissolved)	ug/L	0.5	12.0	13.0	9.1	7.9	4.5	5.6	7	8
Lead (Dissolved)	ug/L	0.2	0.62J	0.75J	0.38	0.44	0.23	0.31	0.31	0.53
Zinc (Dissolved)	ug/L	10	59	65	54	37	30	31	47	43
Nutrients										
Total Kjehldahl Nitrogen	mg/L	0.1	1.3	1.2	2.3	1	0.72	0.94	1.3	1.3
Ammonia as Nitrogen	mg/L	0.1	0	0.18	0.31	0.3	0.1	0.14	.090J	0.17
Nitrate as Nitrogen	mg/L	0.5	8.6	1.0	0.83	0.83	1.2	1.2	0.76	0.81
Nitrite as Nitrogen	mg/L	0.5	0.12J	0.13J	.046J	.043J	.017J	.017J	.076J	.065J
Total Nitrogen	mg/L	0.1	10.0	2.3	3	1.8	1.9	2.6	2.2	2.2
Orthophosphate as P	mg/L	0.01	---	---	0.17J*	0.19J*	0.095	0.2	0	0.059
Total Phosphorus	mg/L	0.02	---	---	0.39	0.26	0.24	0.29	0.15	0.15
Particulate Matter										
Total Suspended Solids	mg/L	5	12.0	0	130	49	29	13	28	18
Conventional Chemistry										
Oil and Grease	mg/L	4.7	0.98J	0.93J	3.1J	1.9J	3.4J	6.1s	---	---
Total Organic Carbon	mg/L	5	17	14	27	11	14	8.3	25	11
Total Hardness	mg/L	1	39	34	33.7	35.5	44.7	62.5	43.5	41.6

* Analyzed outside of holding time

0 Signifies ND (Non-Detect) For calculation Purposes

J Signifies an estimated concentration

0ND Signifies that the system never had traces of the pollutant. These values are excluded from data analysis

Table 17 Pollutant concentrations collected from the wet weather sampling events from ELA-02

Parameter	Units	MDL	Wet Weather #1 11/8/2022 ELA-02-INF	Wet Weather #1 11/8/2022 ELA-02-EFF	Wet Weather #2 12/10/2022 ELA-02-INF	Wet Weather #2 12/10/2022 ELA-02-EFF	Wet Weather #3 1/9/2023 ELA-02-INF	Wet Weather #3 1/9/2023 ELA-02-EFF	Wet Weather #4 2/27/2023 ELA-02-INF	Wet Weather #4 2/27/2023 ELA-02-EFF
Bacteria										
E. coli	MPN/100mL	1	52000	55000	12000	24000	11000	11000	---	---
Enterococci	MPN/100mL	18	55000	26000	20000	28000	34000	37000	---	---
Fecal Coliform	MPN/100mL	18	---	---	54000	9200	9100	9200	---	---
Total Coliform	MPN/100mL	18	---	---	240000	920000	1600000	920000	---	---
Metals										
Cadmium (Total)	ug/L	0.2	0ND	0ND	0.6	0.7	0.17J	0.16J	0.27	0.12J
Copper (Total)	ug/L	0.5	18	16	54	77	16	13	27	16
Lead (Total)	ug/L	0.2	5.9	5.1	23	37	9.7	9.3	10	4.6
Zinc (Total)	ug/L	10	180	130	790	570	150	130	310	160
Cadmium (Dissolved)	ug/L	0.2	0s	0.065J	0ND	0ND	0ND	0ND	0.052J	0s
Copper (Dissolved)	ug/L	0.5	6.1	7.0	6.1	2.5	1.6	2.2	6.3	5.1
Lead (Dissolved)	ug/L	0.2	1.4	1.4	3	0.39	0.46	0.22	1.7	1.4
Zinc (Dissolved)	ug/L	10	130	73	500	17	62	67	200	120
Nutrients										
Total Kjehldahl Nitrogen	mg/L	0.1	4.2	0	19	7.5	4.4	3.2	8.5	3.9
Ammonia as Nitrogen	mg/L	0.1	0ND	0ND	2.8	2.6	0.75	0.22	0.22	0.38
Nitrate as Nitrogen	mg/L	0.5	0.11J	0.14J	.011J	0	0.22	0.5	0ND	0
Nitrite as Nitrogen	mg/L	0.5	0ND	0ND	0.15	0	.055J	.019J	0ND	0ND
Total Nitrogen	mg/L	0.1	4.3	0.1	20	8.1	4.7	3.7	8.5	3.9
Orthophosphate as P	mg/L	0.01	---	---	1.4J*	0.28J*	0.42	0	0.39	0.013
Total Phosphorus	mg/L	0.02	---	---	3.7	1.6	1	0.35	1.1	0.49
Particulate Matter										
Total Suspended Solids	mg/L	5	21.0	25.0	200	250	75	64	76	30
Conventional Chemistry										
Oil and Grease	mg/L	4.7	0ND	0ND	3.9J	5.1	1.8J	3.1J	---	---
Total Organic Carbon	mg/L	5	25	25	890	67	100	67	95	53
Total Hardness	mg/L	1	45	36	122	78.9	55.1	25.1	86.3	50.2

* Analyzed outside of holding time

0 Signifies ND (Non-Detect) For calculation Purposes

J Signifies an estimated concentration

0ND Signifies that the system never had traces of the pollutant. These values are excluded from data analysis

Table 18 Pollutant concentrations collected from the wet weather sampling events from ELA-3A

Parameter	Units	MDL	Wet Weather #1 11/8/2022 ELA-3A-INF	Wet Weather #1 11/8/2022 ELA-3A-BIO-EFF	Wet Weather #1 11/8/2022 ELA-3A-EFF	Wet Weather #2 12/10/2022 ELA-3A-INF	Wet Weather #2 12/10/2022 ELA-3A-BIO-EFF	Wet Weather #2 12/10/2022 ELA-3A-EFF	Wet Weather #3 1/9/2023 ELA-3A-INF	Wet Weather #3 1/9/2023 ELA-3A-BIO-EFF	Wet Weather #3 1/9/2023 ELA-3A-EFF	Wet Weather #4 2/27/2023 ELA-3A-INF	Wet Weather #4 2/27/2023 ELA-3A-BIO-EFF	Wet Weather #4 2/27/2023 ELA-3A-EFF
Bacteria														
E. coli	MPN/100mL	1	17000	13000	13000	24000	---	20000	20000	17000	5800	---	---	---
Enterococci	MPN/100mL	18	23000	26000	28000	18000	---	19000	61000	46000	11000	---	---	---
Fecal Coliform	MPN/100mL	18	---	---	---	11000	---	22000	5400	24000	17000	---	---	---
Total Coliform	MPN/100mL	18	---	---	---	70000	---	54000	920000	1600000	160000	---	---	---
Metals														
Cadmium (Total)	ug/L	0.2	0ND	0ND	0ND	0.76	1	0.33	0.4	---	0.5	0.047J	0.082J	0.058J
Copper (Total)	ug/L	0.5	6.6	3.8J	2.4J	61	78	28	22	---	34.0	15	10	9.1
Lead (Total)	ug/L	0.2	4.1J	2.7J	1.2J	100	170	50	31	---	46.0	2.3	3.7	2.6
Zinc (Total)	ug/L	10	46J	24J	26J	320	450	150	130	---	190	51	51	44
Cadmium (Dissolved)	ug/L	0.2	0ND	0ND	0ND	0.062J	0ND	0ND	0ND	---	0ND	0ND	0ND	0ND
Copper (Dissolved)	ug/L	0.5	5.0	1.5	3.4	14	6.6	5.4	3.8	---	4.4	13	6.7	7.5
Lead (Dissolved)	ug/L	0.2	0.22J	0.1	0.052J	0.48	0.27	0.26	0.64	---	0.34	0.25	0.18J	0.29
Zinc (Dissolved)	ug/L	10	27	4.7J	19	34	17	16	19	---	30	42	32	35
Nutrients														
Total Kjehldahl Nitrogen	mg/L	0.1	1.5	1.5	0.74	4.5	5.2	2.9	3.3	---	4	1.4	1.6	1.4
Ammonia as Nitrogen	mg/L	0.1	0.16	0	0.16	0.53	0.37	0.43	0.5	---	0.32	0.25	0.59	0.33
Nitrate as Nitrogen	mg/L	0.5	1.5	0.14J	2.0	1.5	1.2	0.46	0.44	---	0.87	0.74	0.72	0.73
Nitrite as Nitrogen	mg/L	0.5	0ND	0ND	0ND	0.39	0.2	.13J	.056J	---	.047J	.075J	.060J	.071J
Total Nitrogen	mg/L	0.1	3.0	1.6	2.7	5.9	6.4	3.4	3.8	---	4.9	2.3	2.4	2.2
Orthophosphate as P	mg/L	0.01	---	---	---	0.38J*	0.36J*	0.32J*	0.24	---	0.16	0.16	0.092	0.17
Total Phosphorus	mg/L	0.02	---	---	---	1.4	1.7	0.92	0.8	---	0.89	0.25	0.23	0.26
Particulate Matter														
Total Suspended Solids	mg/L	5	10.0	39.0	0	770	1200	330	300	630	590.0	16	29	12
Conventional Chemistry														
Oil and Grease	mg/L	4.7	0ND	0ND	0ND	3.8J	---	1.5J	1.0J	3.4J	3.2J	---	---	---
Total Organic Carbon	mg/L	5	12	17	6.4	36	35	20	21	24	24.0	14	11	10
Total Hardness	mg/L	1	110	160	190	186	164	170	66.3	59.5	59.9	30.8	19.6	27.8

* Analyzed outside of holding time

0 Signifies ND (Non-Detect) For calculation Purposes

J Signifies an estimated concentration

0ND Signifies that the system never had traces of the pollutant. These values are excluded from data analysis

Table 19 Pollutant concentrations collected from the wet weather sampling events from ELA-04

Parameter	Units	MDL	Wet Weather #1		Wet Weather #2		Wet Weather #3		Wet Weather #4	
			11/8/2022	11/8/2022	12/10/2022	12/10/2022	1/9/2023	1/9/2023	2/27/2023	2/27/2023
			ELA-04-INF	ELA-04-EFF	ELA-04-INF	ELA-04-EFF	ELA-04-INF	ELA-04-EFF	ELA-04-INF	ELA-04-EFF
Bacteria										
E. coli	MPN/100mL	1	---	---	65000	61000	28000	19000	---	---
Enterococci	MPN/100mL	18	---	---	28000	73000	140000	170000	---	---
Fecal Coliform	MPN/100mL	18	---	---	92000	24000	17000	3500	---	---
Total Coliform	MPN/100mL	18	---	---	240000	54000	920000	54000	---	---
Metals										
Cadmium (Total)	ug/L	0.2	0ND	0ND	---	---	---	---	0.17J	0.22
Copper (Total)	ug/L	0.5	9.9	12	---	---	---	---	16	14
Lead (Total)	ug/L	0.2	4.3J	3.5J	---	---	---	---	6.4	4.5
Zinc (Total)	ug/L	10	76	94	---	---	---	---	97	360
Cadmium (Dissolved)	ug/L	0.2	0.064J	0.11J	---	---	---	---	0.085J	0.15J
Copper (Dissolved)	ug/L	0.5	9.0	11.0	---	---	---	---	11	10
Lead (Dissolved)	ug/L	0.2	0.8J	1.7	---	---	---	---	0.9	1.1
Zinc (Dissolved)	ug/L	10	49	77	---	---	---	---	66	320
Nutrients										
Total Kjehldahl Nitrogen	mg/L	0.1	3.4	3.1	---	---	---	---	4.2	4.6
Ammonia as Nitrogen	mg/L	0.1	0.28	0	---	---	---	---	0.87	1.4
Nitrate as Nitrogen	mg/L	0.5	0.21J	0.9	---	---	---	---	0.96	0.86
Nitrite as Nitrogen	mg/L	0.5	0.45J	0	---	---	---	---	.086J	0.15
Total Nitrogen	mg/L	0.1	4.1	4.0	---	---	---	---	5.2	5.6
Orthophosphate as P	mg/L	0.01	---	---	---	---	---	---	0.2	0.35
Total Phosphorus	mg/L	0.02	---	---	---	---	---	---	0.42	0.52
Particulate Matter										
Total Suspended Solids	mg/L	5	0ND	0ND	---	---	---	---	29	13
Conventional Chemistry										
Oil and Grease	mg/L	4.7	---	---	3.6J	2.4J	2.2J	2.8J	---	---
Total Organic Carbon	mg/L	5	21	21	---	---	---	---	14	20
Total Hardness	mg/L	1	68	25	---	---	---	---	32.9	35.4

J Signifies an estimated concentration

0ND signifies that the system never had traces of the pollutant. These values are excluded from data analysis

6.3 QA/QC Results

Table 20 Equipment blank sample concentrations

Parameter	Units	MDL	10/5/2022 ELA-1N-INF	10/5/2022 ELA-1N-EFF	10/6/2022 ELA-1S-INF	10/5/2022 ELA-02-INF	10/5/2022 ELA-02-EFF	10/5/2022 ELA-3A-INF	10/5/2022 ELA-3A-BIO-EFF	10/6/2022 ELA-04-INF	10/6/2022 ELA-04-EFF
Metals											
Cadmium (Total)	ug/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Total)	ug/L	0.5	0.93J	1.3	0.56J	0.71J	ND	ND	0.86J	ND	0.68J
Lead (Total)	ug/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	NA
Zinc (Total)	ug/L	10	17.0	11.0	13.0	10.0	ND	ND	18.0	33.0	55.0
Cadmium (Dissolved)	ug/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Dissolved)	ug/L	0.5	0.54J	1.0J	ND	ND	ND	ND	ND	ND	ND
Lead (Dissolved)	ug/L	0.2	ND	0.24J	ND	ND	ND	ND	ND	ND	ND
Zinc (Dissolved)	ug/L	10	14.0	14.0	14.0	11.0	10.0	33.0	25.0	110.0	30.0
Nutrients											
Total Kjehldahl Nitrogen	mg/L	0.1	NS	0.1	ND	0.2	ND	ND	0.2	ND	ND
Ammonia as Nitrogen	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate as Nitrogen	mg/L	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrite as Nitrogen	mg/L	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Nitrogen	mg/L	0.1	ND	0.2	ND	0.3	ND	ND	0.3	ND	ND
Particulate Matter											
Total Suspended Solids	mg/L	5	ND	3.0	ND	2.1	ND	ND	6.9	ND	ND
Conventional Chemistry											
Total Organic Carbon	mg/L	5	1.7	2.8	ND	1.2	ND	ND	13	ND	ND
Total Hardness	mg/L	1	ND	0.98	ND	1.7	1.1	ND	5.8	ND	ND

Note:
ND = Non-Detect
J = Results may be considered estimated due to QA/QC related issues

6.4 Field Measurement Results

Table 21 Dry and wet weather field measurement results

Parameter	Units	2022-2023 Pollutant Median Concentration in Wet Weather Conditions										
		ELA-1N-INF	ELA-1N-EFF	ELA-02-INF	ELA-02-EFF	ELA-1S-INF	ELA-1S-EFF	ELA-3A-INF	A-3A-BIO-E	ELA-3A-EFF	ELA-04-INF	ELA-04-EFF
4/20/2022 (DWE #1)												
pH	No unit	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Temperature	C	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Specific Conductivity	us/cm	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Oxygen	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/27/2022 (DWE #2)												
pH	No unit	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Temperature	C	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Specific Conductivity	us/cm	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Oxygen	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/27/2022 (DWE #3)												
pH	No unit	8.21	7.77	ND	ND	ND	ND	ND	ND	ND	ND	ND
Temperature	C	23.1	23.13	ND	ND	ND	ND	ND	ND	ND	ND	ND
Specific Conductivity	us/cm	1.52	1.49	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Oxygen	mg/L	5.74	5.8	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/25/2023 (DWE #1)												
pH	No unit	8.355	8.42	ND	ND	ND	ND	ND	ND	ND	ND	ND
Temperature	C	16.25	16.26	ND	ND	ND	ND	ND	ND	ND	ND	ND
Specific Conductivity	us/cm	1.4255	1.54	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Oxygen	mg/L	7.685	7.6	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/08/2022 (WWE #1)												
pH	No unit	6.93	7.09	7.12	7.15	7.67	7.62	7.03	7.35	7.29	NS	NS
Temperature	C	14.49	14.81	16.22	15.92	17.15	17.50	17.77	18.00	17.96	NS	NS
Specific Conductivity	us/cm	0.05	0.06	0.08	0.07	0.17	0.17	0.32	0.35	0.33	NS	NS
Dissolved Oxygen	mg/L	9.80	9.70	7.58	7.39	9.31	6.92	6.19	4.43	5.47	NS	NS
12/10/2022 (WWE #2)												
pH	No unit	6.10	6.35	6.49	6.57	6.54	6.77	7.80	8.03	7.93	6.45	6.45
Temperature	C	13.69	13.67	13.87	13.98	13.82	13.90	13.64	13.83	13.60	13.77	13.78
Specific Conductivity	us/cm	0.04	0.04	0.04	0.04	0.06	0.06	0.04	0.06	0.03	0.05	0.05
Dissolved Oxygen	mg/L	10.29	10.10	0.02	7.98	10.07	0.03	9.80	9.70	9.70	9.66	7.00
1/9/2023 (WWE #3)												
pH	No unit	7.87	7.83	8.21	7.95	7.92	8.15	7.62	7.54	7.51	8.08	7.92
Temperature	C	13.78	13.72	14.24	14.43	14.68	14.74	14.30	14.33	14.16	15.79	15.38
Specific Conductivity	us/cm	0.32	0.28	0.05	0.06	0.27	0.24	0.12	0.10	0.09	0.07	0.06
Dissolved Oxygen	mg/L	8.71	9.53	6.48	6.15	9.17	8.60	10.43	8.90	9.91	8.29	5.95
2/27/2023 (WWE #4)												
pH	No unit	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Temperature	C	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Specific Conductivity	us/cm	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Oxygen	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
ND= No Data DWE = Dry Weather Event WWE = Wet Weather Event

6.5 Calibration Logs

6.6 Water Chemistry Laboratory Reports

6.7 Site-Specific Regression Curves to Estimate Stormwater Capture/Bypass Volume

Figure 3 Rainfall-to-Capture Volume regression curve for treatment system Site ID#ELA-1N

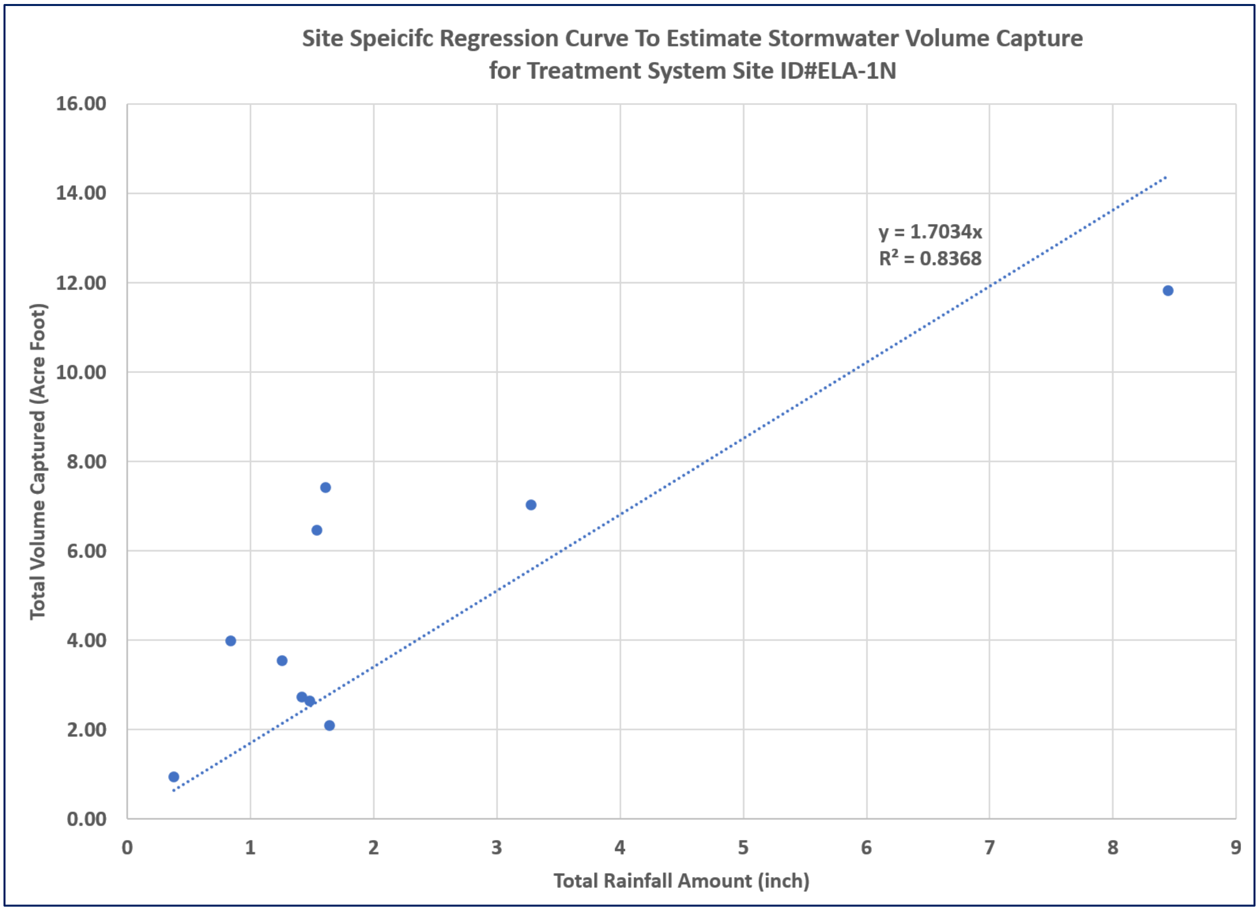


Figure 4 Rainfall-to-Capture Volume regression curve for treatment system Site ID#ELA-1S

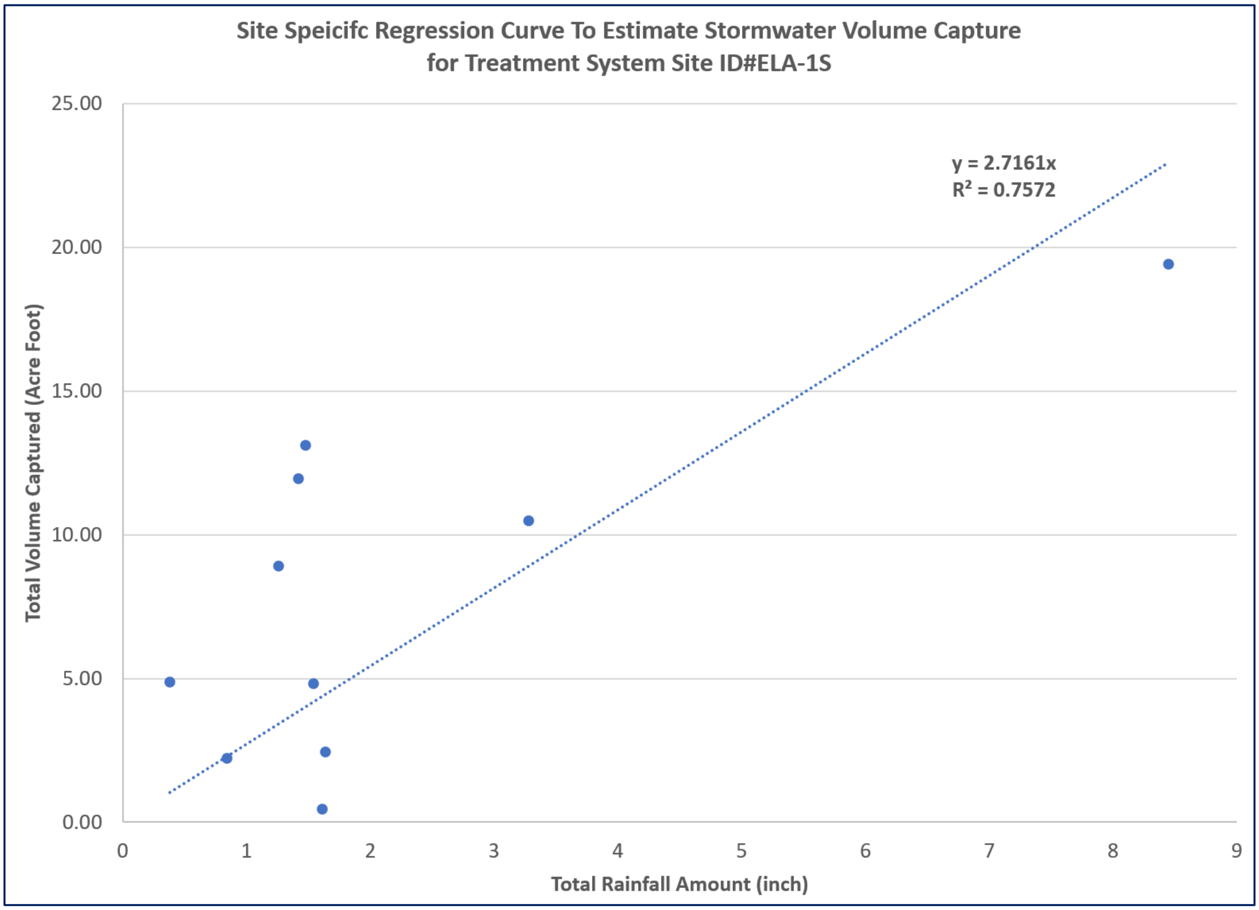


Figure 5 Rainfall-to-Bypass Volume regression curve for treatment system Site ID#ELA-01-BYP

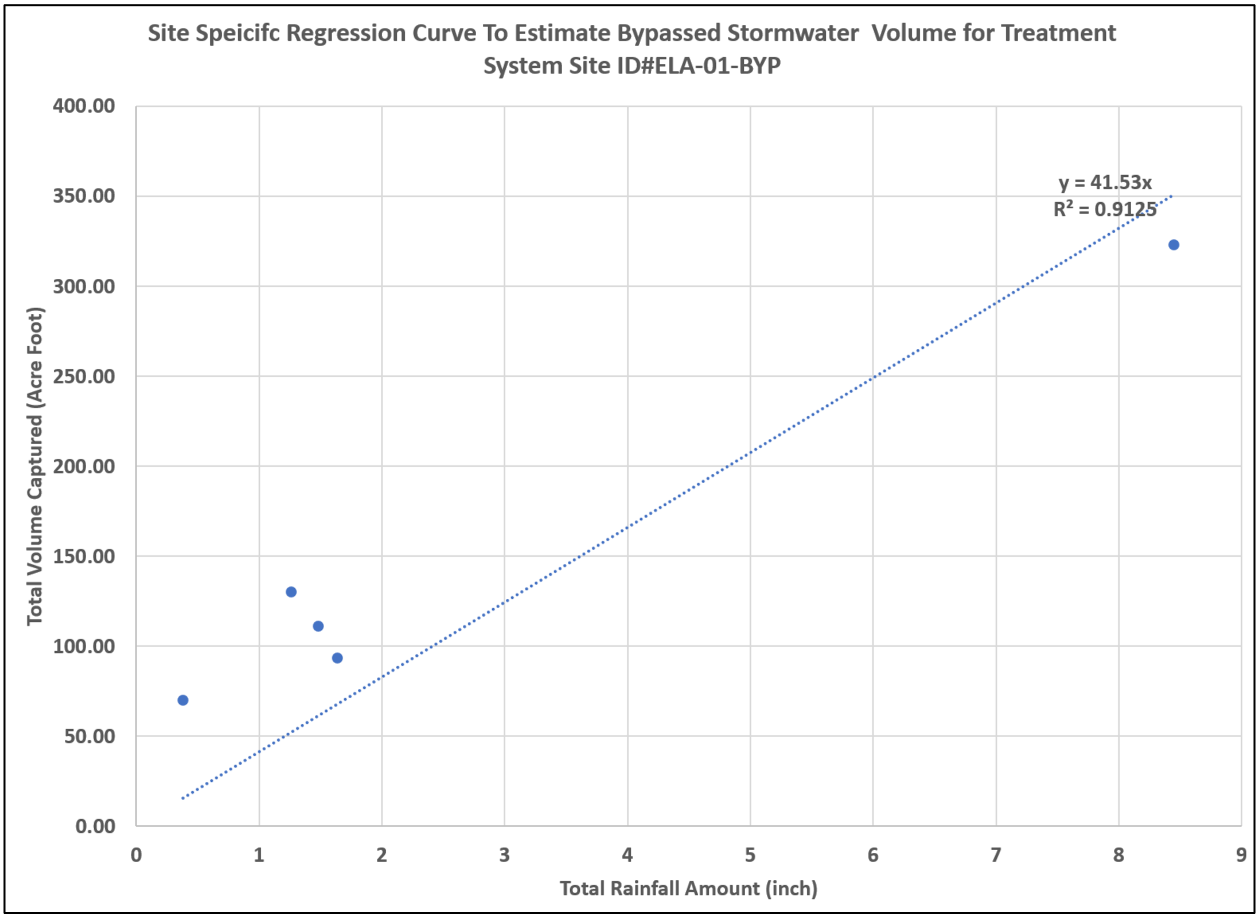


Figure 6 Rainfall-to-Capture Volume regression curve for treatment system Site ID#ELA-2A

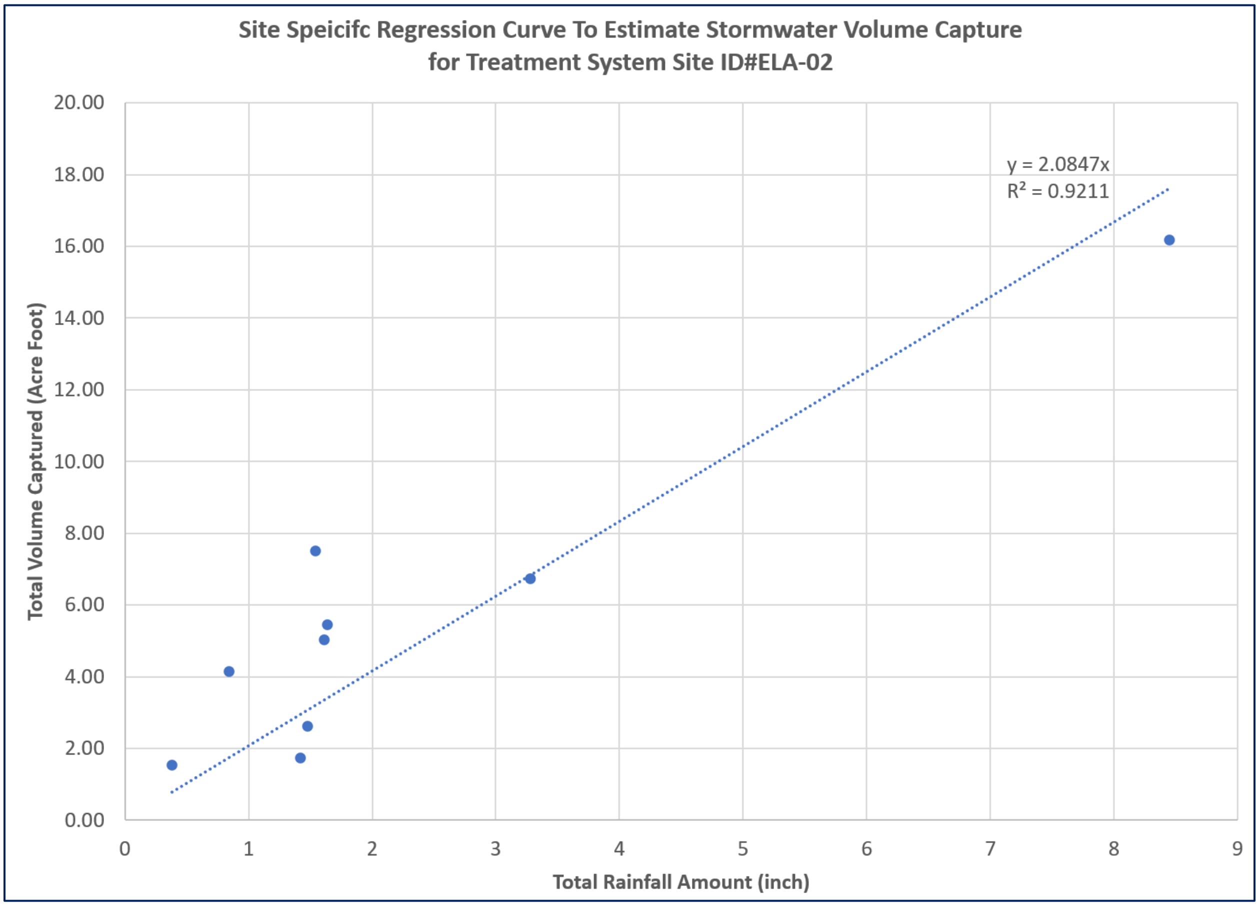


Figure 7 Rainfall-to-Capture Volume regression curve for treatment system Site ID#ELA-3A

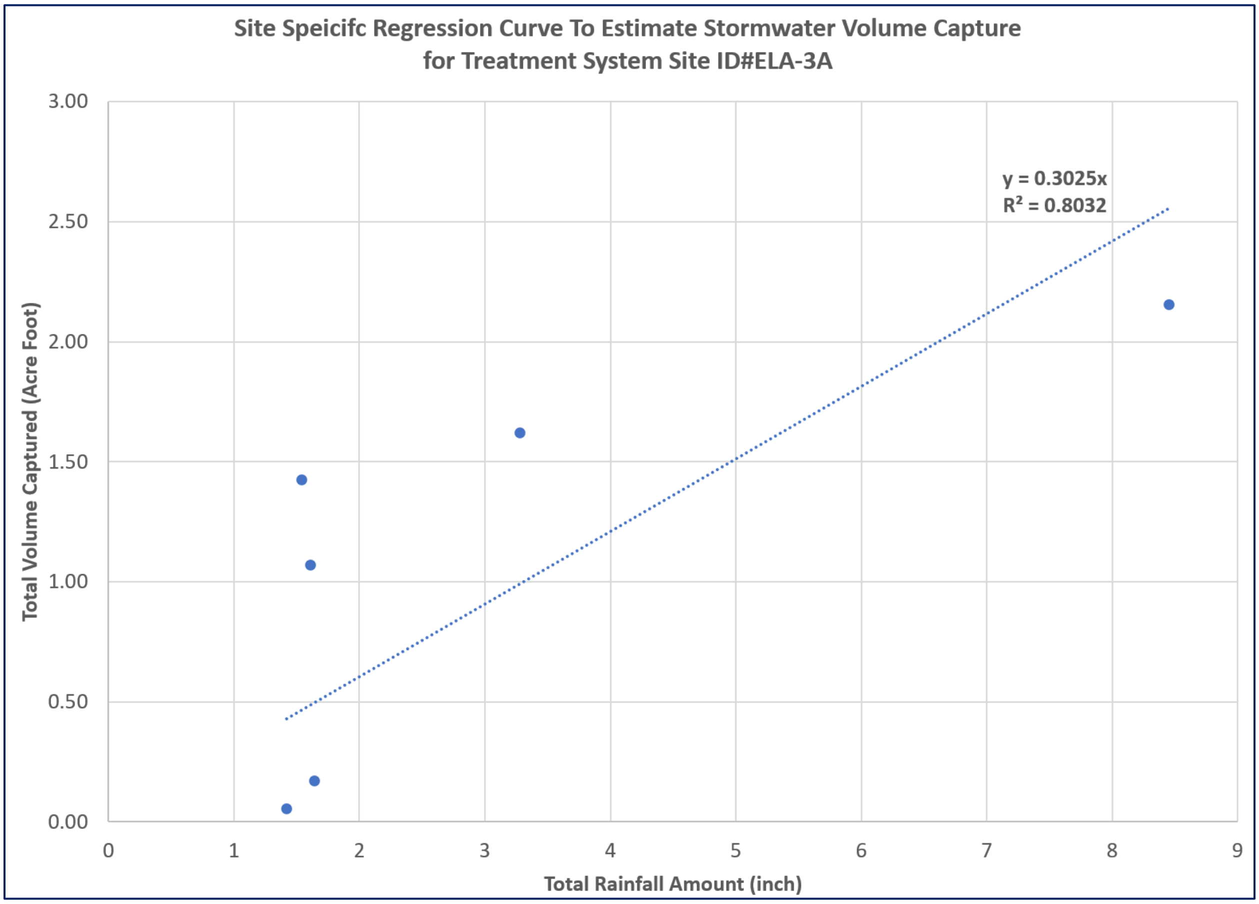


Figure 8 Rainfall-to-Capture Volume regression curve for treatment system Site ID#ELA-04

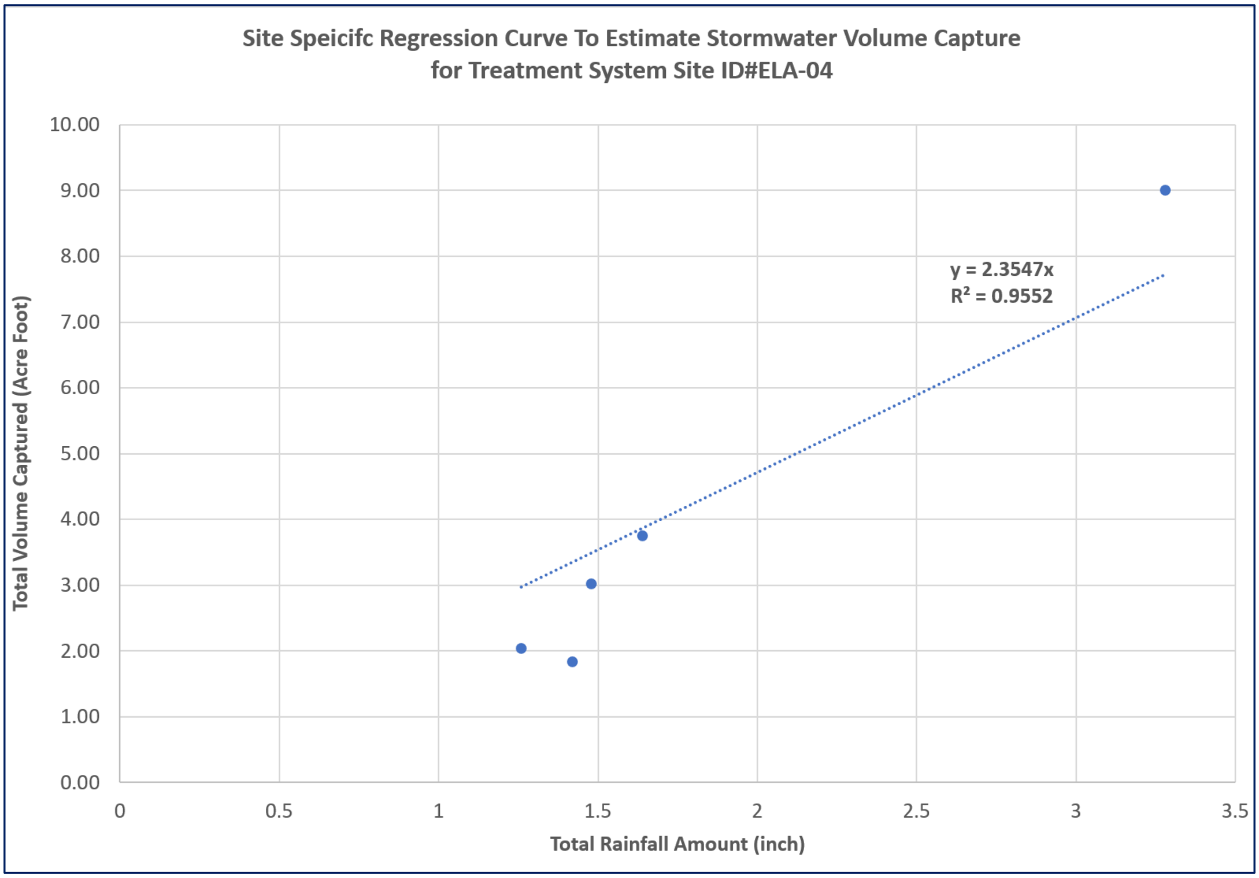
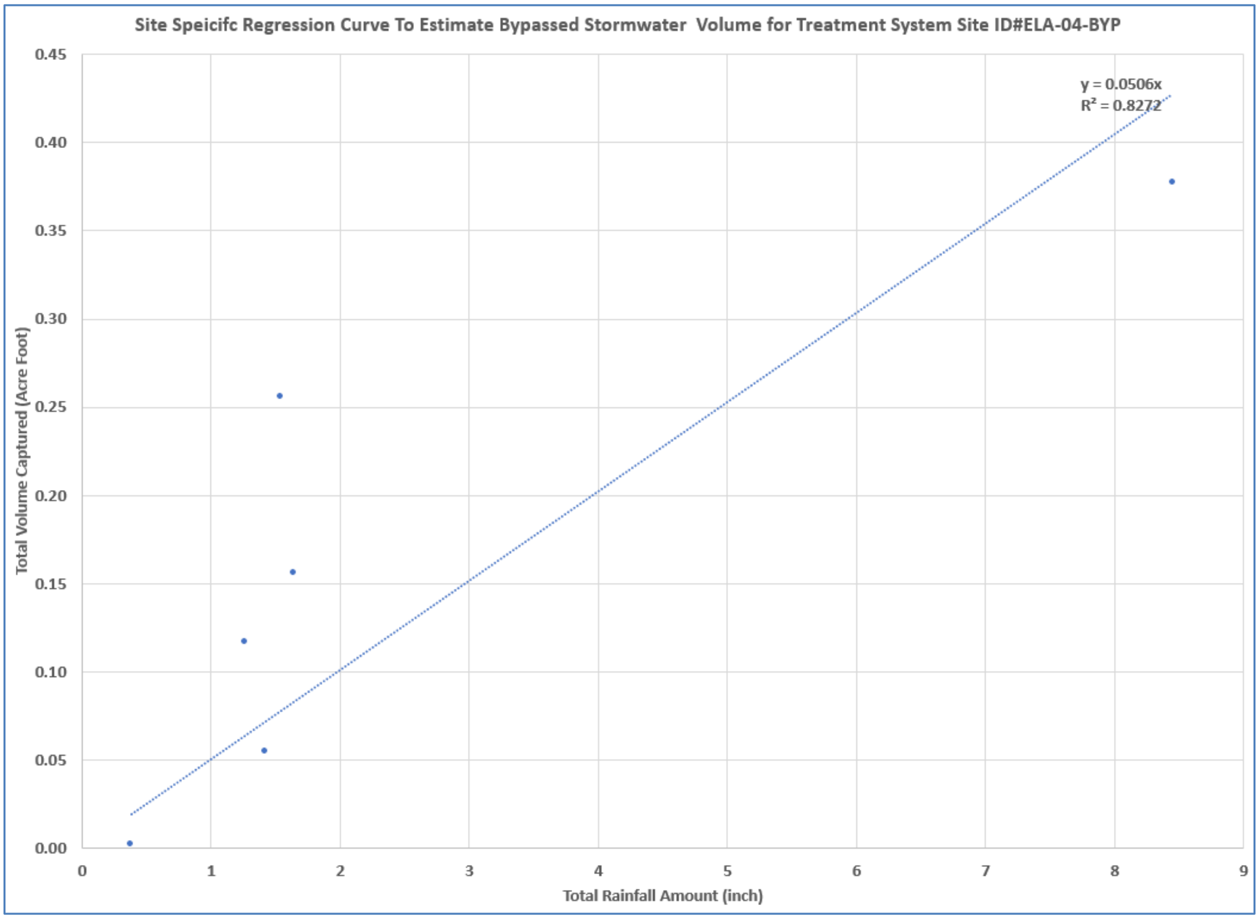
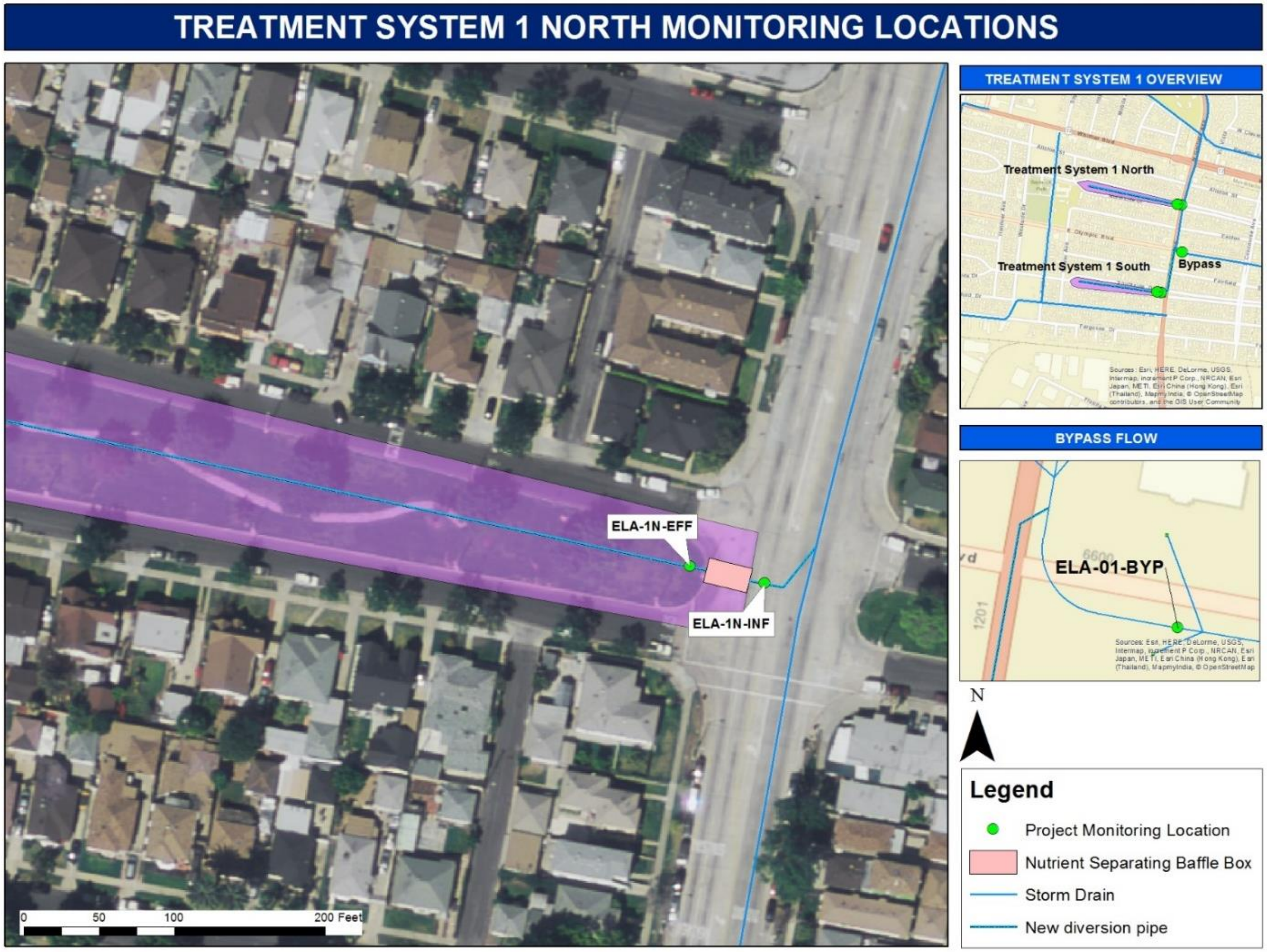


Figure 9 Rainfall-to-Bypass Volume regression curve for treatment system Site ID#ELA-04-BYP

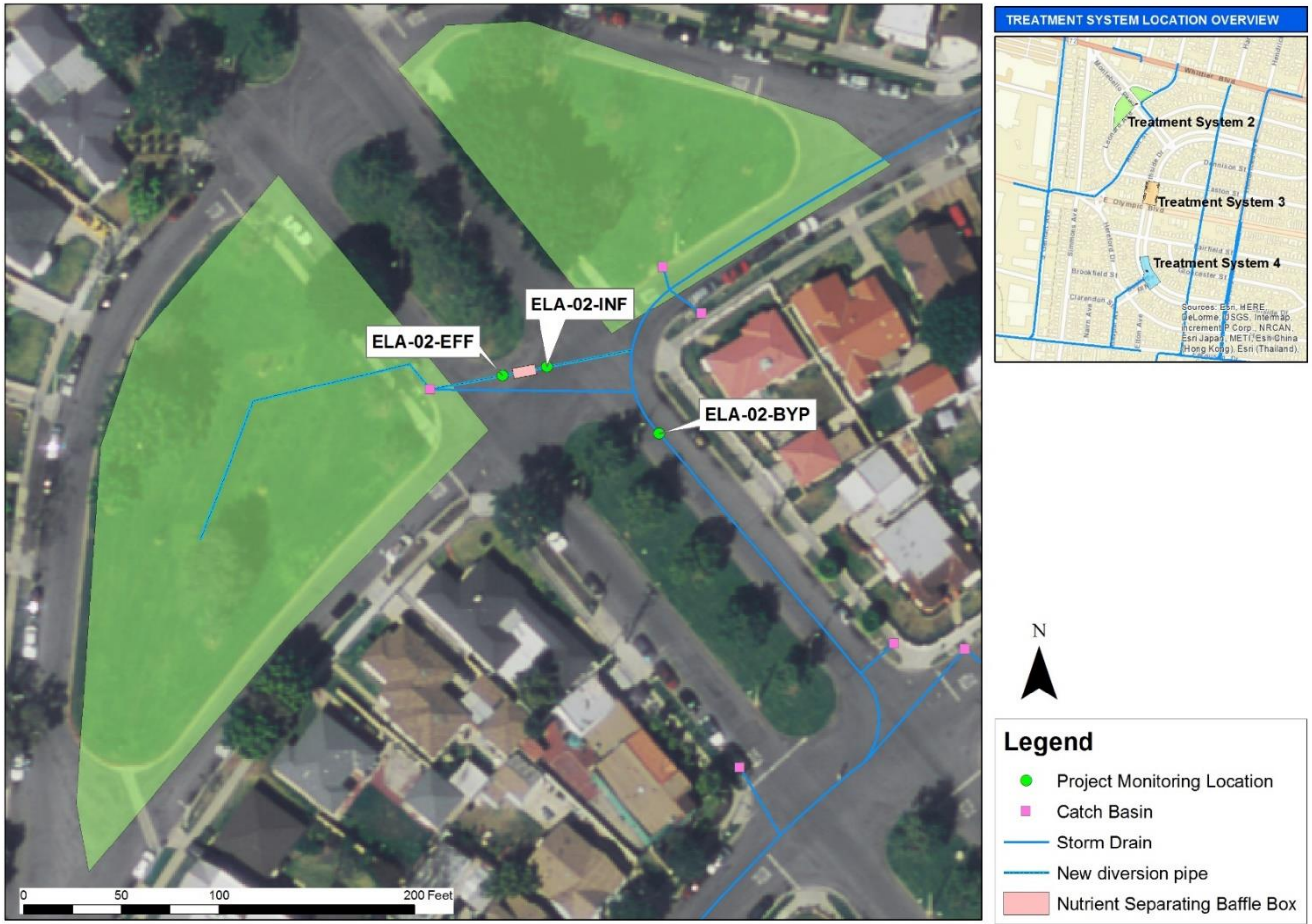


6.8 Monitoring Plan

6.9 Maps - Monitoring Locations

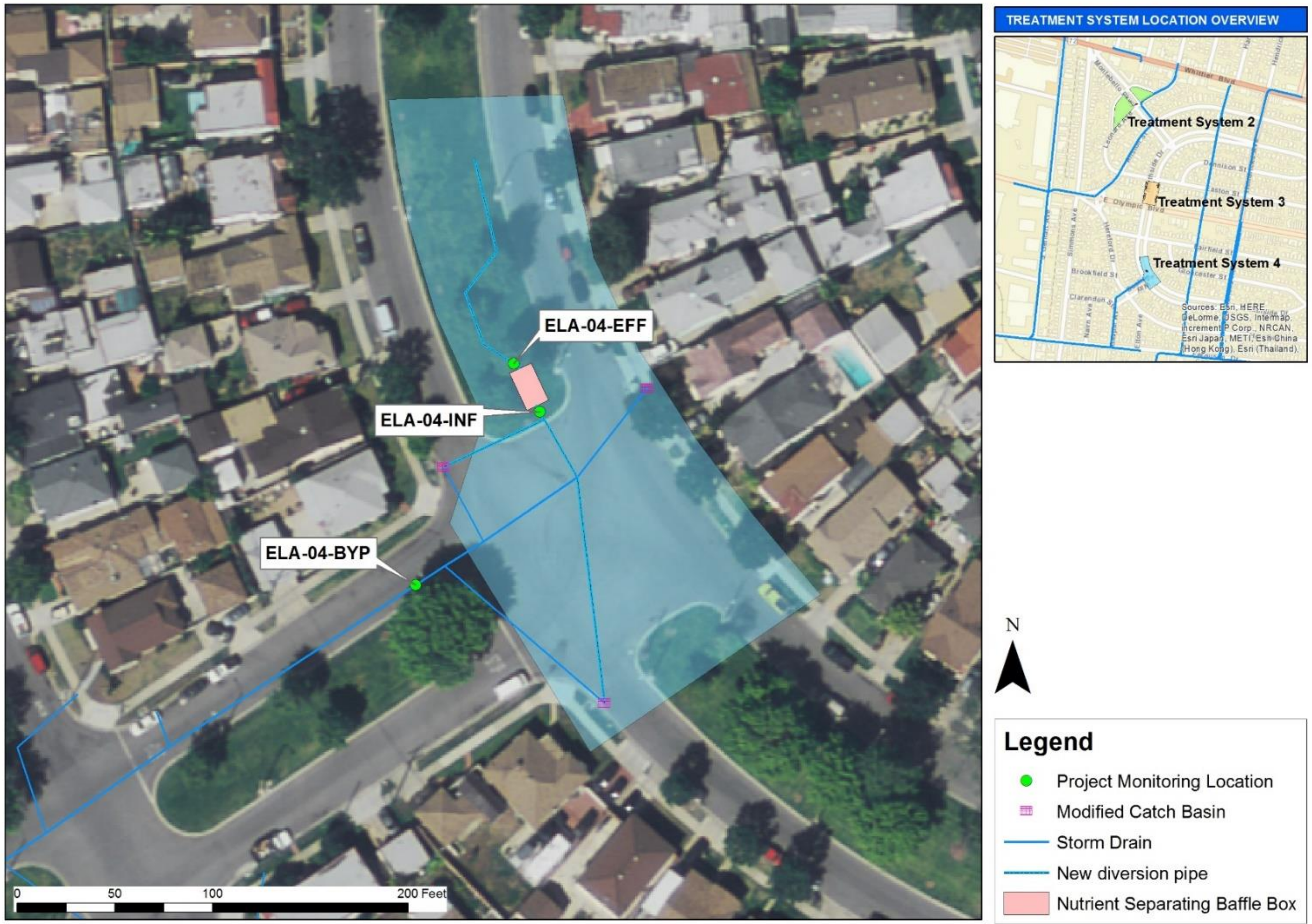


TREATMENT SYSTEM 2 MONITORING LOCATIONS



TREATMENT SYSTEM 3 MONITORING LOCATIONS

TREATMENT SYSTEM 4 MONITORING LOCATIONS



6.10 Boxplots – Nutrient Separation Baffle Boxes’ Pollutant Removal Ability