To:	Matt Fabry, San Mateo Countywide Water Pollution Prevention Program
From:	Stephen Carter, Paradigm Environmental
Date:	9/11/2018
Re:	Quantitative Relationship Between Green Infrastructure Implementation and PCBs/Mercury Load Reduction

1 INTRODUCTION

The Municipal Regional Stormwater Permit (MRP) (Order No. R2-2015-0049) requires San Francisco Bay Area cities and counties to develop Green Infrastructure (GI) Plans (Provision C.3) and Polychlorinated Biphenyls (PCBs) and Mercury Control Measure Implementation Plans (Provisions C.11 and C.12) that provide the necessary pollutant load reductions to meet Total Maximum Daily Load (TMDL) wasteload allocations (WLAs) over specified compliance periods. A key component of these plans is a Reasonable Assurance Analysis (RAA) that quantitatively demonstrates that proposed control measures will result in sufficient load reductions of PCBs and mercury to meet WLAs for municipal stormwater discharges to the Bay. The City/County Association of Governments (C/CAG) of San Mateo County, via its San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), initiated a county-wide effort to develop an RAA to estimate the baseline PCB and mercury loads to the Bay, determine load reductions to meet WLAs, and set goals for the amount of GI needed to meet the portion of PCB and mercury load reduction the MRP assigns to GI (SFBRWQCB 2015).

Per the MRP (Provision C.11.c.iii and C.12.c.iii), as part of the 2018 Annual Report SMCWPPP must provide a report on the approach to be used in the RAA to establish the quantitative relationship between GI implementation and PCBs and mercury load reductions. This submittal shall include all data used and a full description of models and model inputs relied on to establish this relationship. The purpose of this memorandum is to provide a preliminary report on the countywide RAA approach currently supporting GI planning efforts by Permittees in San Mateo County. As the 2018 Annual Report precedes the completion and documentation of the RAA, this memorandum provides a preliminary description of the models supporting the RAA, methods for using the model to determine stormwater improvement goals to be met with GI, and RAA output that will be used to demonstrate the relationship between GI implementation and pollutant load reduction and set goals for municipal GI planning. Based on further development of the RAA, the methods described in this memorandum may be revised to better align with MRP and/or TMDL assumptions, guidance documents intended to provide regional consistency, or the perspectives of Permittees, Regional Water Quality Control Board (Water Board) staff, or peer reviewers. Revisions to the methods and assumptions described in this memorandum will be documented in the RAA technical report that will be submitted as part of the Control Measures Implementation Plans.

1.1 MRP/TMDL Requirements for PCBs and Mercury Load Reduction from Municipal Stormwater Discharges

To address TMDLs for both PCBs (SFBRWQCB 2008) and mercury (SFBRWQCB 2006), the MRP (Provisions C.11 and C.12) requires the development of Control Measure Implementation Plans that outline the control measures that are expected to be implemented to meet interim and final pollutant reductions to address the WLAs assigned to municipal stormwater discharges. The MRP outlines schedules for phased pollutant load reductions over time, as summarized in Table 1-1. The PCBs TMDL assigns a total WLA of 2 kg/year to MRP Permittees, of which 0.2 kg/year is allocated to Permittees within San Mateo County (SFBRWQCB 2008). The mercury TMDL assigns an 82 kg/year WLA to all MRP Permittees (collectively), with 8.4 kg/year allocated to Permittees within San Mateo County (SFBRWQCB 2006).

Table 1-1. PCBs and Mercury TMDL Interim and Final Wasteload Allocation (WLA) Schedules

Year	Aggregate WLA for All Sources of Urban Runoff to San Francisco Bay	
	PCBs (kg/yr)	Mercury (kg/yr)
2003 (TMDL baseline)	20	160
2018 (MRP interim)	19.5[1]	120
2020 (MRP interim)	17[2]	--
2028 (TMDL final)	--	82[4]
2030 (TMDL final)	2[3]	--

[1] 0.5 kg/yr aggregate load reduction required via MRP (2.0) from all MRP Permittees, with 60 g/yr load reduction specific to San Mateo County Permittees.
[2] 3 kg/yr aggregate load reduction required via MRP (2.0) from all MRP Permittees, with 370 g/yr load reduction specific to San Mateo County Permittees.
[3] 18 kg/yr load reduction for all sources of urban runoff to the Bay, with 14.4 kg/yr aggregate load reduction from urban runoff sources within the boundaries of MRP Permittees. Urban runoff sources within San Mateo County are allocated 0.2 kg/yr of the total WLA of 2 kg/yr assigned sources within the boundaries of all MRP Permittees.
[4] Urban runoff sources within the boundaries of Permittees within San Mateo County are allocated 8.4 kg/yr of the total WLA of 82 kg/yr assigned to urban runoff sources within the boundaries of all MRP Permittees.

GI will play an integral role in the Control Measure Implementation Plans and reduction of mercury and PCBs to address TMDL load reduction goals and WLAs. The MRP outlines a specific PCBs and mercury load reduction schedule attributable to GI, as summarized in Table 1-2.

Table 1-2. PCBs and Mercury Load Reduction Schedules for Green Infrastructure (GI) Implementation Outlined in the MRP

Year	Aggregate Load Reduction Required Through Implementation of GI by all MRP Permittees	
	PCBs (kg/yr)	Mercury (kg/yr)
2020	0.120[1]	0.048[2]
2040	3	10

[1] 0.015 kg/yr load reduction specific to San Mateo County Permittees.
[2] 0.006 kg/yr load reduction specific to San Mateo County Permittees.

1.2 Purpose of the Reasonable Assurance Analysis

In 2017, the U.S. Environmental Protection Agency (EPA) Region 9 released *Developing Reasonable Assurance: A Guide to Performing Model-Based Analysis to Support Municipal Stormwater Program Planning* (EPA RAA Guide) (USEPA 2017), which provides guidance on the technical needs of the RAA and considerations for model selection. Building upon the EPA RAA Guide, the Bay Area Stormwater Management Agencies Association (BASMAA) prepared the *Bay Area Reasonable Assurance Analysis Guidance Document* (Bay Area RAA Guidance) (BASMAA 2017a), which provides specific guidance on modeling to support RAAs performed in the Bay Area to meet MRP requirements, address TMDLs for PCBs and mercury, and support GI planning. The EPA RAA Guide and Bay Area RAA Guidance both outline essential steps for performing an RAA, as depicted in Figure 1-1.

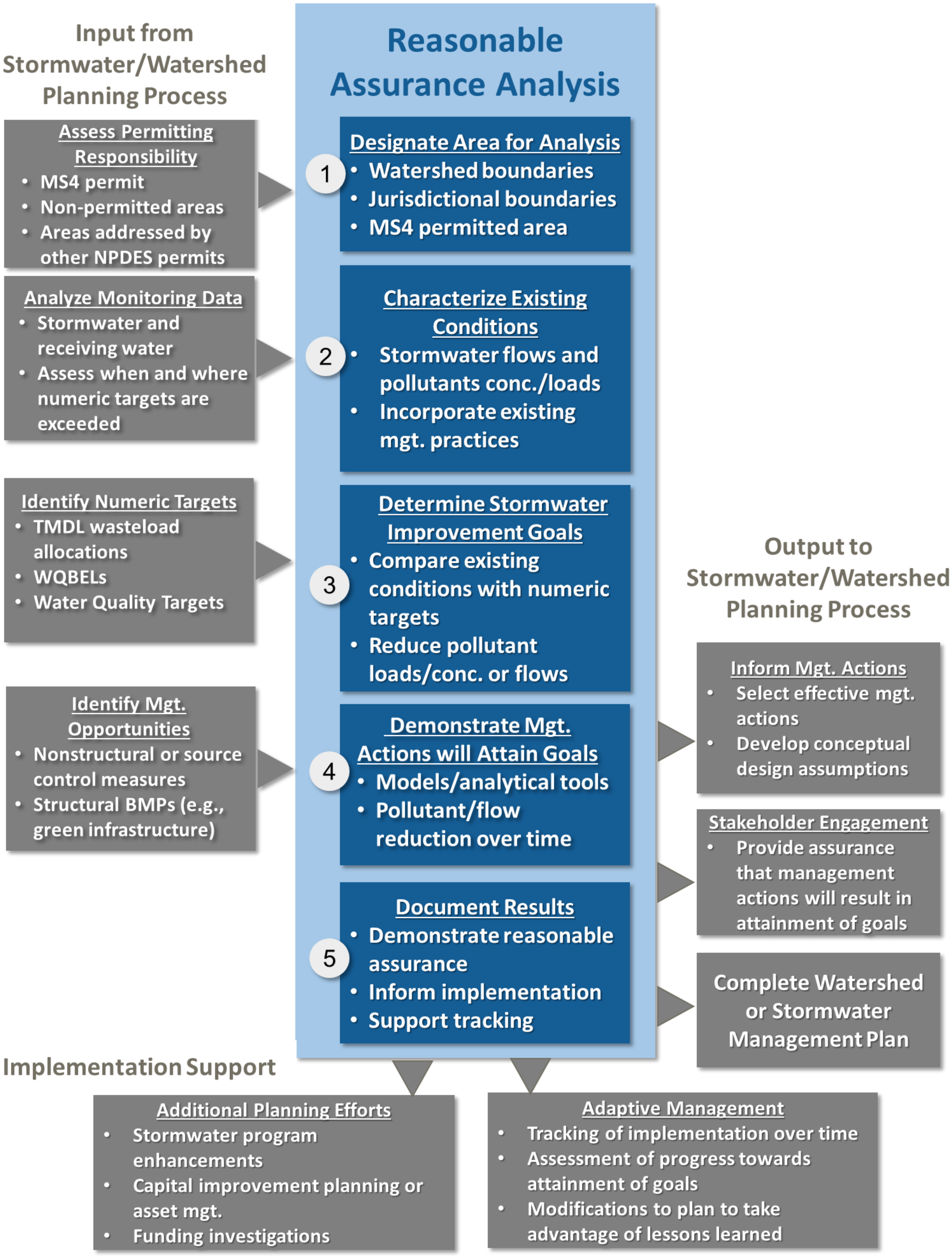


Figure 1-1. RAA Process Flow Chart (USEPA 2017).

Depending on the audience, the purpose of the RAA can vary in terms of what constitutes reasonable assurance. The EPA RAA Guide provides an example of three differing perspectives for defining reasonable assurance (USEPA 2017):

- **Regulator Perspective** - Reasonable assurance is a demonstration that the implementation of a GI Plan will result in sufficient pollutant reductions over time to meet TMDL WLAs or other targets specified in the MRP.
- **Stakeholder Perspective** - Reasonable assurance is a demonstration that specific management practices are identified with sufficient detail, and implemented on a schedule to ensure that necessary improvements in water quality will occur.
- **Permittee Perspective** - Reasonable assurance is based on a detailed analysis of the TMDL WLAs and associated MRP targets themselves, and a determination of the feasibility of those requirements. The RAA may also assist in evaluating the financial resources needed to meet pollutant reductions based on schedules identified in the MRP.

As a result, each of the steps of the RAA shown in Figure 1-1 may have varying levels of interest for different audiences in terms of providing reasonable assurance. To streamline RAAs performed in the Bay Area and to standardize expectations of each of the RAA steps, the Bay Area RAA Guidance sought to provide greater details regarding the methods and goals for each of the RAA steps. A summary of the outcomes of the Bay Area RAA Guidance are summarized below (BASMAA 2017a):

1. **Identifying the Area of Analysis** - The area of analysis should be consistent with the regulatory area covered by the TMDL and the MRP. The MRP defines areas contributing permitted discharges as Permittee areas (i.e., within the boundaries of the Permittee's jurisdiction) that discharge stormwater runoff from storm drains and watercourses within their jurisdictions. Federal, State, and regional entities within Permittees' boundaries that are not subject to the MRP are not the responsibility of the Permittees. Non-urban land areas also do not need to be incorporated into the area of analysis. Areas that are hydrologically connected to regulated areas that may not be subject to the TMDL and/or the MRP should be included in the area of analysis to adequately calibrate the model. Areas that are not subject to the TMDL and/or the MRP should be accounted for in RAA models, but do not require control measure implementation or load reduction calculations.
2. **Calculating the Baseline Pollutant Loading (Characterizing Existing Conditions)** - The baseline pollutant loading for use in the RAA can be selected or calculated using one of the following three methods: (1) utilize the baseline loading presented in the TMDL Staff Reports (SFBRWQCB 2006; SFBRWQCB 2008); (2) utilize the baseline loading produced by the Regional Watershed Spreadsheet Model (RWSM) output; or (3) recalculate the baseline loading using a calibrated model of the baseline period for the area of analysis.
3. **Identifying Stormwater Improvement Goals** - The pollutant load reduction goals are the loads that must be reduced to achieve the MRP load reduction requirements (Provisions C.11.c/C.12.c) and demonstrate quantitatively that planned control measures will result in load reductions sufficient to attain the TMDL WLAs (Provisions C.11.d/C.12.d). The MRP load reductions required to be achieved through GI (C.11.c/C.12.c) are interpreted as a total mass required to be reduced as a proportion of the required load reduction. The required total load reduction for MRP permittees for mercury is 62 kg/yr and for PCBs is 14.4 kg/yr. In the case that a new baseline load has been computed using a calibrated model (method #3 in Step 2 above) and a new load reduction goal has been calculated, the percent of the permittee load reduction can be used as the stormwater improvement goal for guiding planning and implementation of GI measures. Table 1-3 provides a summary of the MRP required PCB and

mercury load reductions and the interpretation of the percent of Permittee load reductions to be attained through GI implementation, as reported by the Bay Area RAA Guidance.

Table 1-3. MRP Required Pollutant Load Reductions Achieved through GI

Pollutant	MRP Required Load Reduction (kg/yr)	Percent of Permittee Load Reduction Achieved through GI
PCBs	3.0	20.8%
Mercury	10.0	16.1%

4. **Estimating Load Reduction Achieved by Controls (Demonstrating Management Actions Will Attain Goals)** – The RAA will include methods for estimating pollutant load reductions associated with source controls and GI. Load reductions associated with source controls will be based on methods provided in the approved refinement of the Interim Accounting Methodology (BASMAA 2017b). The source control component of the RAA will be discussed through a separate coordinated effort and regional discussion on acceptable methods and assumptions for the accounting methodology. The focus of this memorandum is to provide early documentation of the approach to be used to address the RAA for GI. Load reductions from GI can include: (1) land use change associated with redevelopment, (2) low impact development (LID) and non-LID treatment controls on land development projects as required by MRP Provision C.3, and (3) retrofit of existing streets and developed sites with GI features and LID treatment controls (e.g., green streets and regional projects). The Bay Area RAA Guidance states that "GI performance should be simulated directly using a process-based model, or simulated using a combination of continuous simulation-based volume performance and empirically based concentration performance to estimate load reductions."
5. **Documentation** – Documentation of RAA results is critical to the demonstration that GI Plans and Control Measure Implementation Plans will result in attainment of pollutant load reduction goals. The documentation can serve various purposes, including providing: (1) reasonable assurance to stakeholders and regulators that the plans will lead to effective implementation, (2) information to support next steps for implementation (e.g., capital improvement planning, investigation of funding options), and (3) quantitative results to support an adaptive management process, tracking of implementation over time, and/or assessment of progress towards attainment of pollutant reduction goals (USEPA 2017). The 2020 Annual Report will include all documentation associated with the RAA. The Bay Area RAA Guidance provides recommendations for minimum requirements for RAA documentation, including summaries of model input (e.g., model parameters, data sources, or other assumptions), calibration results, model processes and procedures, key model outputs (e.g., baseline loads, load reduction goals), modeled GI and source control measures, and modeled load reductions by control measure category.

1.3 Preliminary Identification of Opportunities for GI Projects

To support the RAA and GI Plans, C/CAG has initiated a number of planning efforts that identify opportunities for GI implementation. The following is a summary of those efforts:

- **LID for New Development and Redevelopment** – The MRP includes a Provision (C.3) for the integration of LID within new development and redevelopment. As LID techniques are implemented as new development and redevelopment occurs throughout the County, the benefits of such practices in terms of reducing urban runoff flows and associated pollutant loads can be considered as part of the pollutant load reductions attributed to implementation of GI. C/CAG has been working with San Mateo County Permittees to compile information on LID practices that have been implemented within new development and redevelopment since water year 2003 (baseline year for the TMDL). C/CAG has also performed analysis to project the number of acres of future new development and redevelopment to be addressed by the Provision C.3 regulated development by 2040. The RAA will consider existing LID practices and projections of LID in future new development and redevelopment areas to estimate anticipated PCBs and mercury load reductions from 2003 to 2040.

- **Countywide Stormwater Resource Plan (SRP)** – The SRP is a comprehensive plan that identifies and prioritizes 1000's of GI project opportunities throughout San Mateo County and within each municipal jurisdiction. Prioritized project opportunities include: (1) large regional projects within publicly owned parcels (e.g., public parks) that infiltrate or treat stormwater runoff generated from surrounding areas (e.g., diversion from neighborhood storm drain system; diversions from creeks draining large urban areas); (2) retrofit of publicly owned parcels with GI that provide demonstration of onsite LID designs; and (3) retrofit of public street rights-of-way with GI, or "green streets." The SRP included a multi-benefit scoring and prioritization process that ranks GI project opportunities based on multiple factors beyond pollutant load reduction (e.g., proximity to flood prone channels, potential groundwater basin recharge). Figure 1-2 provides an example of green street opportunities identified, scored, and prioritized by the SRP throughout San Mateo County (SMCWPPP 2017).

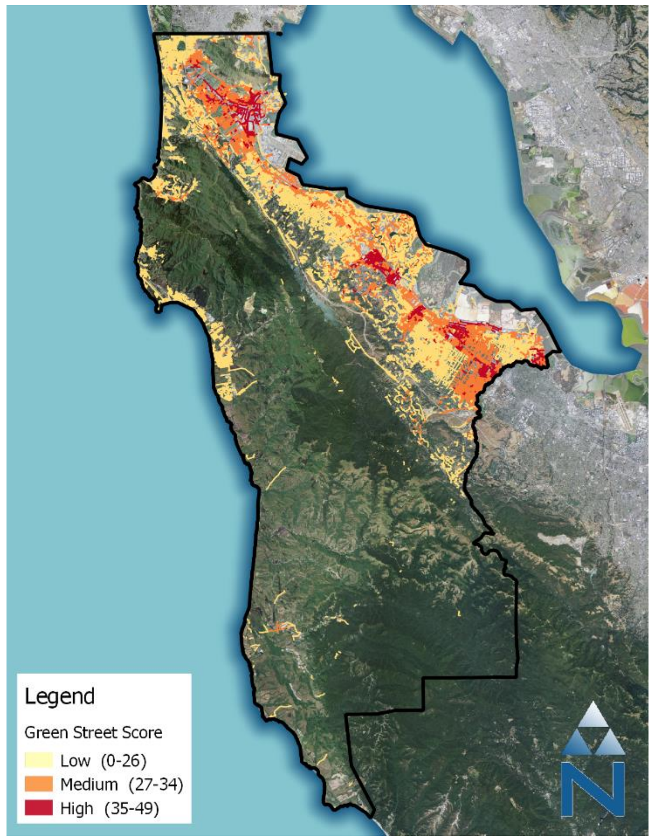


Figure 1-2. SRP Prioritized Green Street Opportunities.

The above efforts and resulting technical products provide preliminary identification of opportunities for GI projects. These GI project opportunities serve as the foundation for the RAA and GI Plans as strategies are developed for implementation plans to meet the PCBs and mercury load reduction goals.

2 DESCRIPTION OF THE RAA MODEL

C/CAG has initiated a comprehensive, countywide modeling effort to provide: (1) simulation of baseline loads of PCBs and mercury for each of the County's watersheds and municipal jurisdictions discharging to San Francisco Bay; (2) estimation of necessary GI implementation that is needed to meet load reduction goals and TMDL WLAs; and (3) determination of the amount of GI needed to meet load reduction goals based on project opportunities identified Section 1.3. The RAA will also provide analysis of alternative implementation scenarios through cost-benefit optimization that can inform cost-effective GI implementation within each municipal jurisdiction. Results can be used to set goals for GI Plans developed by each Permittee.

2.1 RAA Model Overview

The analytical framework selected to support the San Mateo Countywide RAA is based on a linked system of models (Figure 2-1). Component models of the linked system include:

- **Loading Simulation Program C++ (LSPC)** – The hydrologic and water quality model selected for the baseline model of San Mateo County watersheds was the Loading Simulation Program in C++ (LSPC) (Shen et al., 2004), a watershed modeling system that includes Hydrologic Simulation Program – FORTRAN (HSPF) (Bicknell et al. 1997) algorithms for simulating watershed hydrology, erosion, water quality, and in-stream fate and transport processes. The model can simulate upland loading and transport of sediment, mercury, and PCBs. LSPC is built upon a relational database platform, making it easier to collate diverse datasets to produce robust representations of natural systems. LSPC integrates GIS outputs, comprehensive data storage and management capabilities, the original HSPF algorithms, and a data analysis/post-processing system into a convenient PC-based Windows environment. The algorithms of LSPC are identical to a subset of those in the HSPF model with selected additions, such as algorithms to address land use change over time. LSPC is an open-source public-domain watershed model available from EPA.
- **System of Urban Stormwater Treatment & Analysis Integration (SUSTAIN)** – Developed by EPA's Office of Research and Development, SUSTAIN was primarily designed as a decision-support system for selection and placement of GI projects at strategic locations in urban watersheds. It includes a process-based continuous project simulation module for representing flow and pollutant transport routing through various types of GI projects. A distinguishing feature of SUSTAIN is a robust cost-benefit optimization model that incorporates dynamic, user-specified project unit-cost functions to quantify the costs associated with project construction, operation, and maintenance. The cost-benefit optimization model runs iteratively to generate a cost-effectiveness curve that is sometimes comprised of millions of GI project scenarios representing different combinations of projects throughout a watershed. Those results are used to make cost-effective management recommendations by evaluating the trade-offs between different scenarios. The "benefit" component can be represented in several ways: (1) reduction in flow volume (2) reduction in load of a specific pollutant or (3) other conditions including numeric water quality targets, frequency of exceedances of numeric water quality targets, or minimizing the difference between developed and pre-developed flow-duration curves (USEPA 2009, Riverson et al. 2014).

The LSPC model will provide a characterization of existing conditions and determination of necessary pollutant load reductions to meet requirements of TMDLs and the MRP. SUSTAIN will be used to provide analysis of the amount of GI needed to provide the portion of the load reduction assigned to GI by the MRP (Table 1-2). The models, as planned, will not account for pollutant load reductions associated with source/institutional controls such as source property referrals, enhanced operation and maintenance, etc. This accounting approach will be developed as part of a BASMAA regional project, with results incorporated into a Control Measures Implementation Plan that includes both the RAA modeling of GI and methods for accounting for load reductions associated with sources/institutional controls.

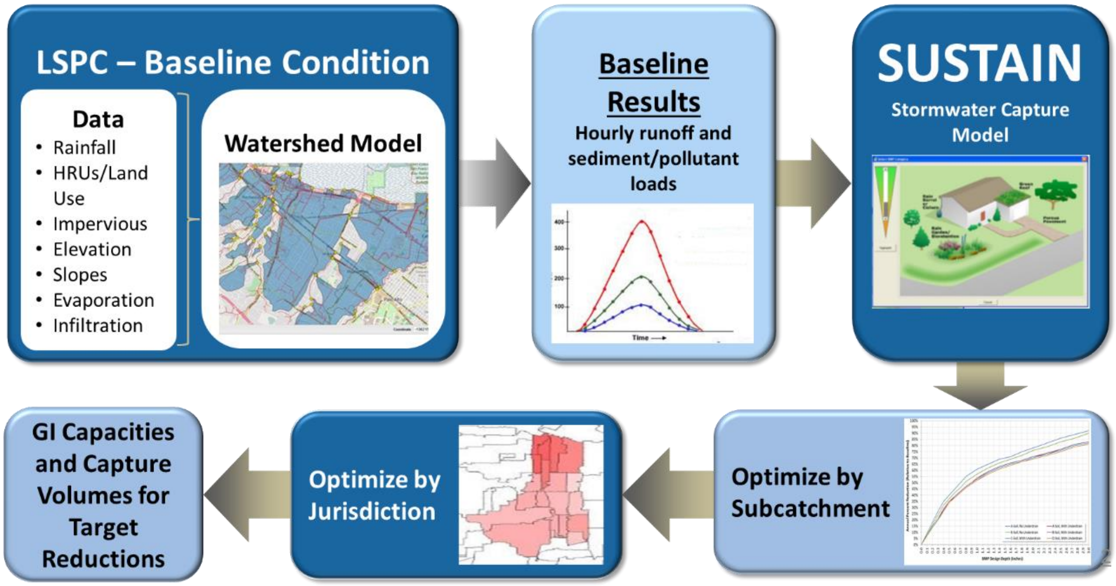


Figure 2-1. Modeling System Supporting the RAA.

2.2 Baseline Model

A draft LSPC model has been developed for San Mateo County watersheds to represent the baseline condition and determine the PCBs and mercury load reduction goal associated with the implementation of GI. As stated in the Bay Area RAA Guidance, if such a model is used to recalculate the baseline loading, the model should be calibrated for hydrology and water quality using local data, to the extent data are available, to ensure the model reliably captures the characteristics and conditions of the watersheds (BASMAA 2017). The following sections provide an overview of the approach used to develop the LSPC hydrology and water quality model and the use of the model for determining stormwater improvement goals for GI.

2.2.1 Hydrologic Model

The LSPC hydrology model includes a comprehensive method for representing the various processes associated with the various pathways of water through a watershed. Figure 2-2 is a generalized schematic of the underlying hydrology model (Stanford Watershed Model) used in HSPF and LSPC. The schematic represents land-based processes for a single land unit in the model. Meteorological data are the driver for modeled hydrologic processes. As shown in the schematic, precipitation is the primary input, while total actual evapotranspiration (TAET) and streamflow are the primary outputs in the water budget. Potential evapotranspiration (PEVT; not explicitly shown in the schematic) is another key meteorological boundary condition for the model. The interaction of model parameters shown below in Figure 2-2 will ultimately determine how much PEVT becomes TAET. There are several pathways that water can take as it makes its way through the network. For each land unit, process-based parameters that reflect differences in geology, soils, vegetation, and land cover will govern the rates and volumes of water at each stage throughout the schematic.

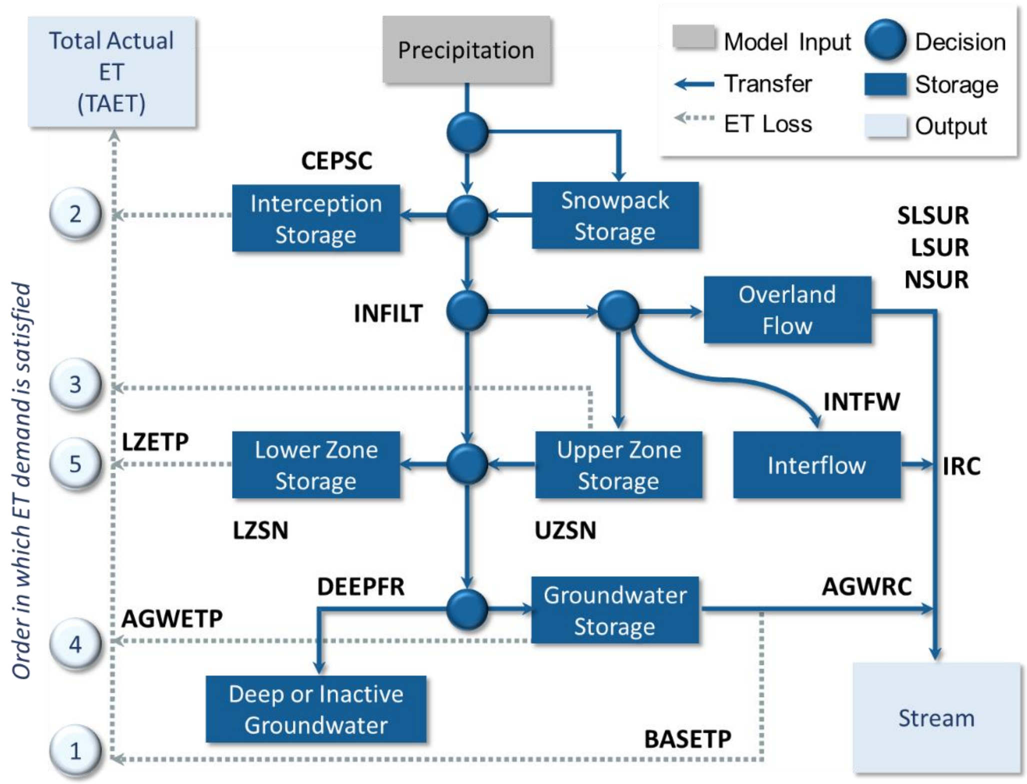


Figure 2-2. Hydrologic Model Schematic (based on the Stanford Watershed Model).

2.2.1.1 Model Subwatershed Delineation

Subwatershed delineation was based primarily on the National Hydrography Dataset (NHD) Plus v2 catchments. This layer provided a good starting point because the subwatersheds were at a relatively fine resolution that captured orographic changes and stream connectivity. For segments where orographic variability was relatively small and stream connectivity was minimally impacted, smaller subwatersheds were aggregated into larger ones. Where necessary, subwatersheds were also adjusted to reflect the locations of streamflow monitoring gages used for calibration. Figure 2-3 shows delineated subwatersheds for all San Mateo County watersheds and those used for model calibration. The Guadalupe River watershed in nearby Santa Clara County was included in the model development due to the amount of flow and water quality data available for model calibration and validation. Much of these data also served as the basis for extrapolating total sediment and pollutant loads for the Bay TMDLs (SFBRWQCB 2006 and 2008). Therefore, modeling the Guadalupe River watershed alongside San Mateo County watersheds allows for comparison of modeled results with assumptions used in the TMDLs for the calculation of WLAs.

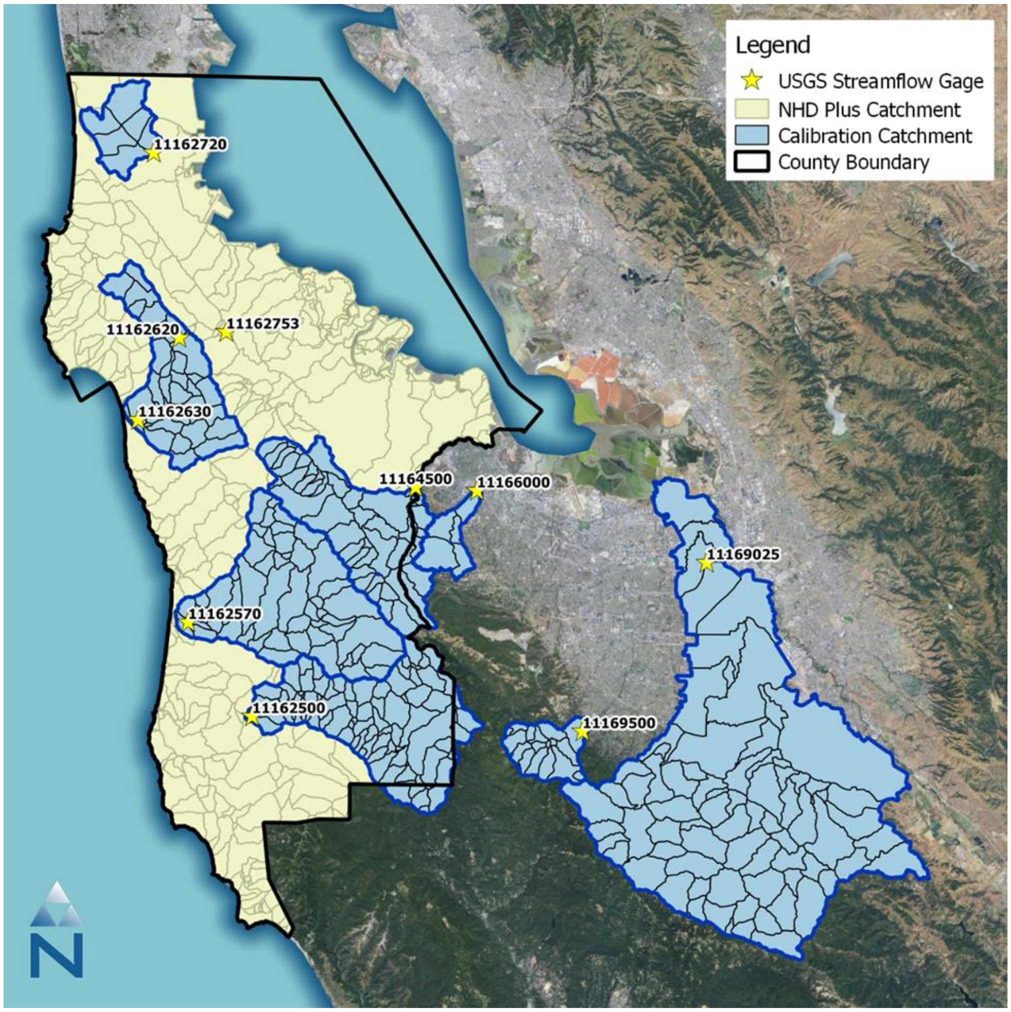


Figure 2-3. LSPC Model Subwatershed Delineation.

2.2.1.2 Hydrologic Response Units

In a watershed model, land unit representation should be sensitive to the features of the landscape that most affect hydrology. In urban areas, land is divided into pervious and impervious components; in less developed areas, vegetative cover and soil type are the most influential factors. Irrigation can also be an important factor in some portions of the County. Hydrologic soil groups are rarely homogeneous in a watershed; therefore, pervious land cover will typically be further subdivided into soil hydrologic groups so that infiltration processes are better represented. Slope is also an important factor in portions of the County where steep slopes are prevalent; runoff and moisture-storage vary between low and high sloped areas. The combination of land use, soil hydrologic group, and slope was used to define hydrologic response units (HRUs).

Table 2-1 provides a summary of HRU component data layers and approximate dates for each source, which are representative of the period between 2010 to 2016. The HRU provides a physical basis for parameterizing and representing hydrologic processes in the model. Figure 2-4 shows an example spatial distribution of land cover for the study area.

Table 2-1. Summary of Hydrologic Response Unit (HRU) Components and Source Datasets

HRU Characteristic	Data Source	Approximate Source Date
Impervious Cover	National Land Cover Dataset (NLCD)	2011
Hydrologic Soil Group	National Resource Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO)	2016 [1]
Percent Slope	Derived from San Mateo County LiDAR Digital Elevation Model (DEM)	2010
Land Cover	National Land Cover Dataset (NLCD)	2011

1: NRCS SSURGO dataset was downloaded in March 2016

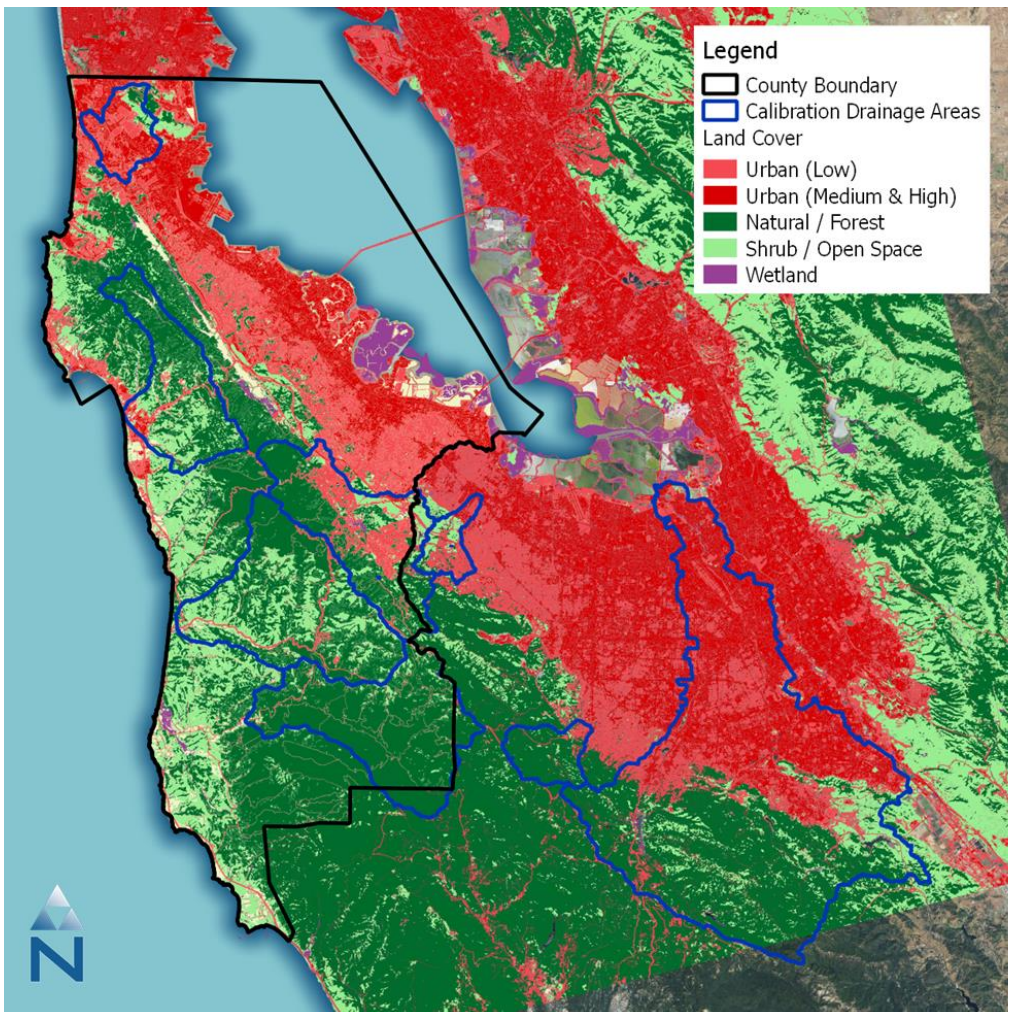


Figure 2-4. Land cover (NLDC).

2.2.1.3 Meteorological Boundary Condition

Meteorological data such as precipitation, evapotranspiration, temperature, and other climate time series are the primary forcing functions of the model—analytical considerations include data quantity and quality. Primary meteorological data products compiled and reviewed for this effort included two observed precipitation data products from the National Climatic Dataset Center (Global Historical Climatology Network – GHCN Daily and Local Climatic Data). Secondary meteorological data, which are derived or interpolated from primary sources, included monthly precipitation totals from the Parameter-elevation Regressions on Independent Slopes Model (PRISM), hourly precipitation distributions and potential evapotranspiration (ET) estimates from the North American Land Data Assimilation System (NLDAS2), a quality-controlled spatiotemporal dataset supported by the National Aeronautics and Space Administration (NASA), and reference ET rates from the California Irrigation Management Information System (CIMIS).

Table 2-2 is a summary of available meteorological data by source that were reviewed as part of model development. Table icons indicate the temporal resolution of the data by source. NLDAS2 also includes the full suite of hourly meteorological timeseries that the model uses, except for dewpoint temperature, which is a function of air temperature, station pressure, and specific humidity and was computed from those NLDAS2 timeseries. The recommended approach was to intersect NLDAS2 and PRISM and scale the NLDAS2 hourly rainfall timeseries distributions with PRISM timeseries. The resulting intersect is an hourly 4-km spatial distribution of PRISM timeseries (based on NLDAS2 rainfall distributions) for the San Mateo County watersheds—there are 94 unique sets of meteorological timeseries available for assignment to the modeled subwatersheds.

Table 2-2. Summary of the Climate Parameters Evaluated During the Initial Inventory

Meteorological Data	Temporal Resolution of Meteorological Data by Source (Timestep: ● Hourly, ○ Daily, ☐ Monthly)			
	(a) GHCN	(b) LCD	(c) PRISM-M	(d) NLDAS2
Precipitation	○	●	☐	●
Potential Evapotranspiration	--	--	--	●
Daily Air Temperature (Min/Max)	○	--	☐	--
Hourly Air Temperature	--	●	--	●
Solar Radiation	--	●	--	●
Cloud Cover	--	●	--	●
Wind Speed	--	●	--	●
Wind Direction	--	●	--	●
Station Pressure	--	--	--	●
Specific Humidity	--	--	--	●[1]
Dewpoint Temperature	--	●	--	●[2]

Acronyms: (a) Global Historical Climatology Network, (b) Local Climatic Data, (c) Parameter-elevation Regressions on Independent Slopes Model-Monthly aggregated timeseries, (d) North American Land Data Assimilation System.
1: *Specific Humidity* converted to *Relative Humidity* as a function of *Air Temperature* and *Station Pressure*
2: *Dewpoint Temperature* calculated as a function of *Air Temperature* and *Relative Humidity*

In the LSPC model, one set of meteorological timeseries are assigned to each of the delineated model subwatersheds—it is also assumed that the associated precipitation falls uniformly within each subwatershed. Figure 2-5 shows long-term historical average distribution of annual average PRISM rainfall for the region overlaid with modeled subwatersheds, PRISM, and NLDAS2 data centroids. Meteorological boundary conditions were associated with subwatersheds by assigning the grid that covered most of the subwatershed area.

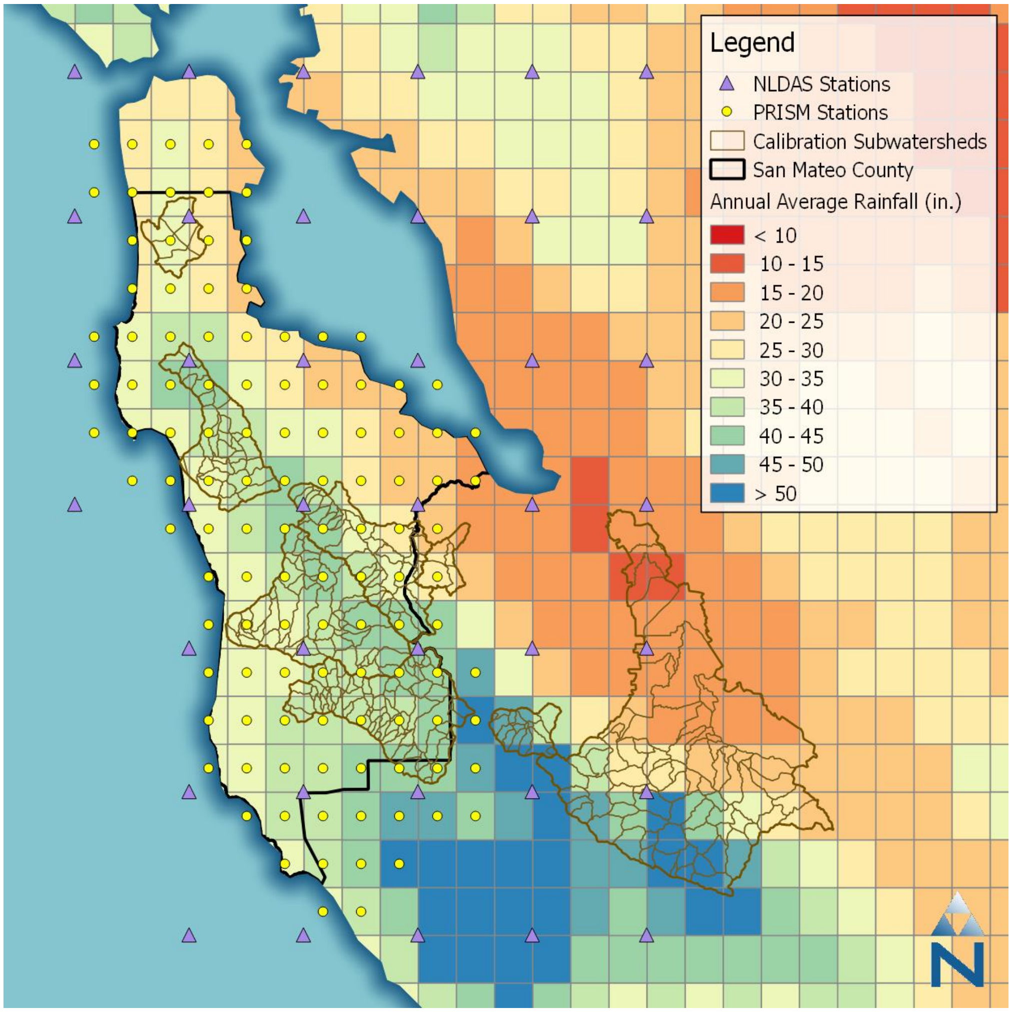


Figure 2-5. Annual Average PRISM Rainfall Depths with Associated PRISM and NLDAS2 Data Centroids.

2.2.1.4 Hydrologic Model Calibration

The model calibration process follows recommendations from both the EPA RAA Guide and the Bay Area RAA Guidance. Table 2-3 presents recommended model performance metrics for hydrology and sediment (BASMAA 2017). The Bay Area RAA Guidance specifies annual percent difference calibration metrics, which align with the spatial and temporal scales of the Bay TMDLs. For additional resolution regarding the timing of flow and pollutant loads, monthly and seasonal model hydrology performance were also evaluated as part of the calibration effort.

Table 2-3. Hydrologic Model Calibration Performance Targets (Bay Area RAA Guidance, Table 4-2).

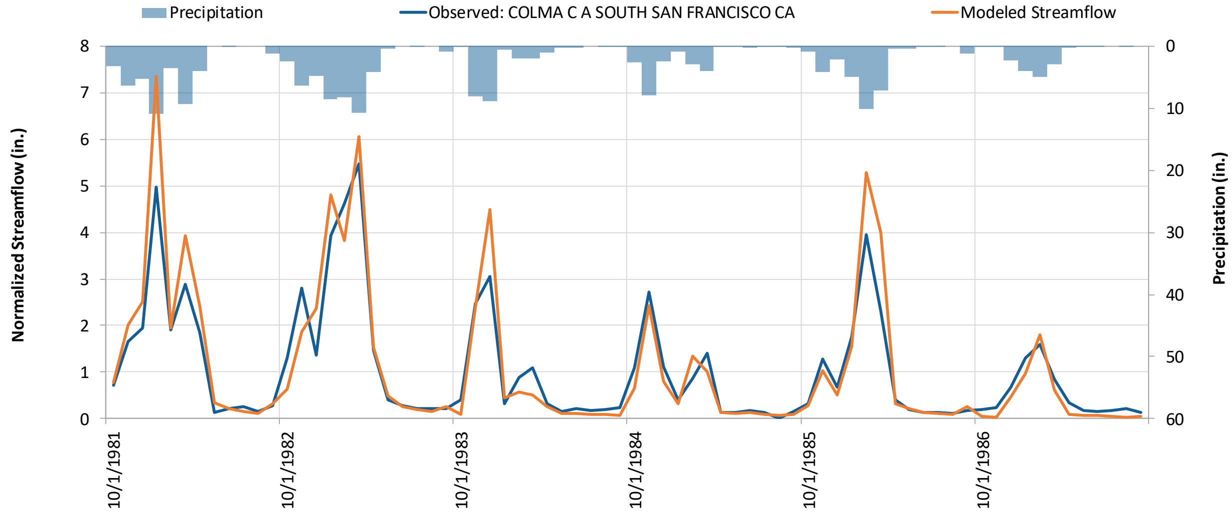
Model Parameters	%-Difference (Annual Simulated vs. Observed)		
	Very Good	Good	Fair
Hydrology/Flow[1]	< 10%	10-15%	15-25%

1: Reference: Donigian 2000 as cited in LARWQCB 2014.

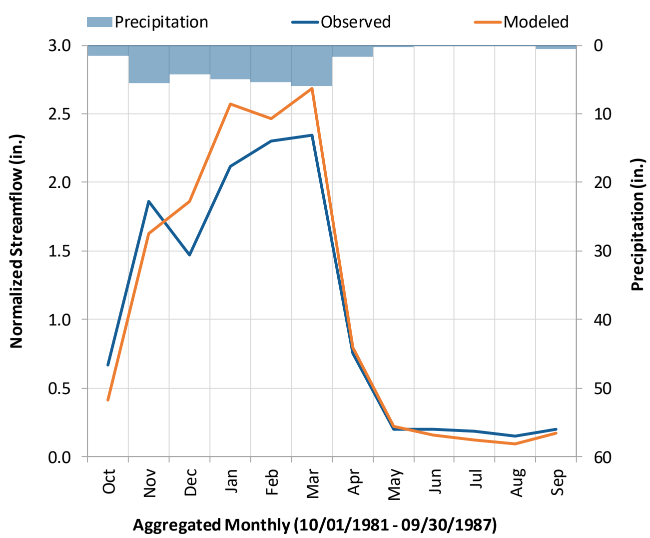
A phased weight-of-evidence approach was used for hydrology calibration. First, an initial set of model parameters were selected from the Bay Area Hydrologic Model (BAHM) (Clear Creek Solutions 2014) and refined and stratified by HRU with guidance from the BASINS Technical Note 6: *Estimating Hydrology and Hydraulic Runoff Parameters* (USEPA 2000). The goal was to characterize the relative hydrologic response of the various HRU combinations of land cover, soil type, and slope such that the routed aggregate response of the model was representative of observed trends at the flow monitoring gages. When model results diverged from observed data, Google Earth was used to further investigate and identify unrepresented features such as impoundments, concrete-lined channels, or other hydraulic features that may be attributable to the divergent model results. Finally, wherever it was possible to represent those notable features, model parameters were fine-tuned so that the calculated error statistics fell within the targeted model performance ranges.

Figure 2-6 shows example calibration results for USGS gage 11162720 at Colma Creek. The figure shows a comparison of monthly observed vs. modeled flow in the top panel, calibration statistics in the middle panel, and a seasonal aggregate comparison in the lower panel. The model captures year-to-year variability as well as seasonal hydrograph swings. The Bay Area RAA Guidance performance metric of ≤10% error in total annual volume (Table 2-3) corresponds to the first row in the calibration statistics shown in the middle panel. Results show that model performance of 5.9% relative error in annual volume is well within the recommended performance metric. Three additional metrics that are commonly evaluated for hydrology (highest 10% flows, lowest 50% flows, annual storm volume) were also assessed to test the robustness of model predictions during varying hydrologic regimes and to better understand periods and hydrologic processes that may cause model error.

Similar analyses were performed for each of the nine USGS gages utilized for model calibration and validation. Final documentation of the RAA will provide a full discussion of the model hydrologic calibration and validation process and demonstration of results at each location, providing reasonable assurance that the model is sufficient for representing baseline conditions.



Calibration Metrics (10/01/1981 - 09/30/1987)	Relative Mean Error	Recommended Error Criteria			
		Very Good	Good	Fair	Poor
Total Annual Volume	5.9%	≤ 5%	5 - 10%	10 - 15%	>15%
Highest 10% of Flows	8.6%	≤ 10%	10 - 15%	15 - 25%	>25%
Lowest 50% of Flows	9.2%	≤ 10%	10 - 15%	15 - 25%	>25%
Annual Storm Volume	12.2%	≤ 10%	10 - 15%	15 - 25%	>25%



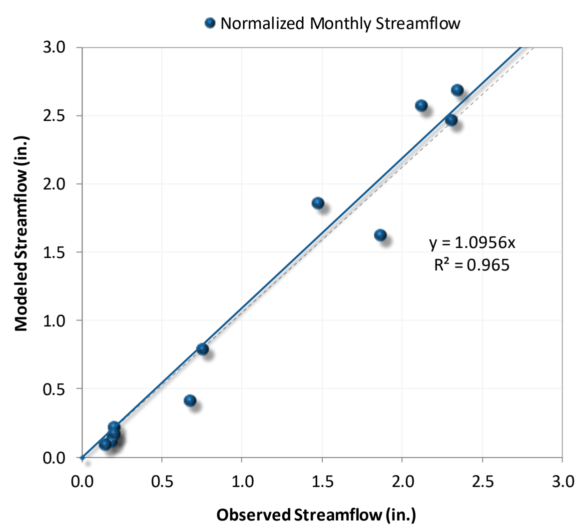


Figure 2-6. Hydrology Calibration Summary for Colma Creek.

2.2.2 Water Quality Model

During development of the Bay Area RAA Guidance, it was acknowledged through multiple discussions between Permittees, EPA and Water Board staff, and researchers (e.g., SFEI) that limited local water quality data may impact the robustness of any new computational method developed by an individual Bay Area Permittee or stormwater program to represent PCB or mercury loading.

Although Bay-wide tools such as RWSM are deemed acceptable through model calibration utilizing monitoring data collected throughout Bay watersheds, there is often not enough data within a single County jurisdiction to provide the same level of resolution needed to calibrate a model within that jurisdiction. As demonstrated in the previous sections, sufficient data are available to calibrate a model for simulating the hydrology of San Mateo County watersheds. Similar efforts were performed to configure, calibrate, and validate the LSPC model to simulate sediment transport, which will be fully documented later. The modeling approach used for the RAA combines this LSPC hydrology and sediment loading model with the RWSM, using RWSM values for pollutant concentrations representative of various land use and PCB source categories. The Bay Area RAA Guidance states that "if RWSM is used to represent pollutant concentrations or loads, this calibration is assumed to be conducted as part of the RWSM process," and "if sufficient concentration and loading data are available, these data should be used as part of model validation."

An example validation combining LSPC and RWSM for simulating PCBs is shown in Figure 2-7. As part of the Small Tributaries Loading Strategy (STLS) conducted by SFEI, nine storm events were sampled for PCBs at the Pulgas Creek Pump Station North and South Gages between 2011 and 2014. Figure 2-7 presents a summary of observed versus modeled PCB concentrations at the Pulgas Creek South station, where most of the data were collected. Matching concentrations during storms can be challenging because of factors including: (1) the flashiness of the system, (2) a mismatch in the timing of a localized storm event that was not reflected in the rainfall gage used in the model, or (3) obstructions or inefficiencies in the collection system upstream of the sampling location. For this reason, modeled concentrations that coincided with ±1 day of the sampling date were summarized and paired for comparison with the samples. Figure 2-7 shows five summaries for comparison: (1) all observed samples, (2) observed samples excluding 2 potential outliers, (3) modeled results using runoff concentrations for ±1 day of the sampling date, (4) modeled results using sediment concentrations for ±1 day of the sampling date, and (5) modeled results using sediment concentrations for the 2011-2014 simulation period.

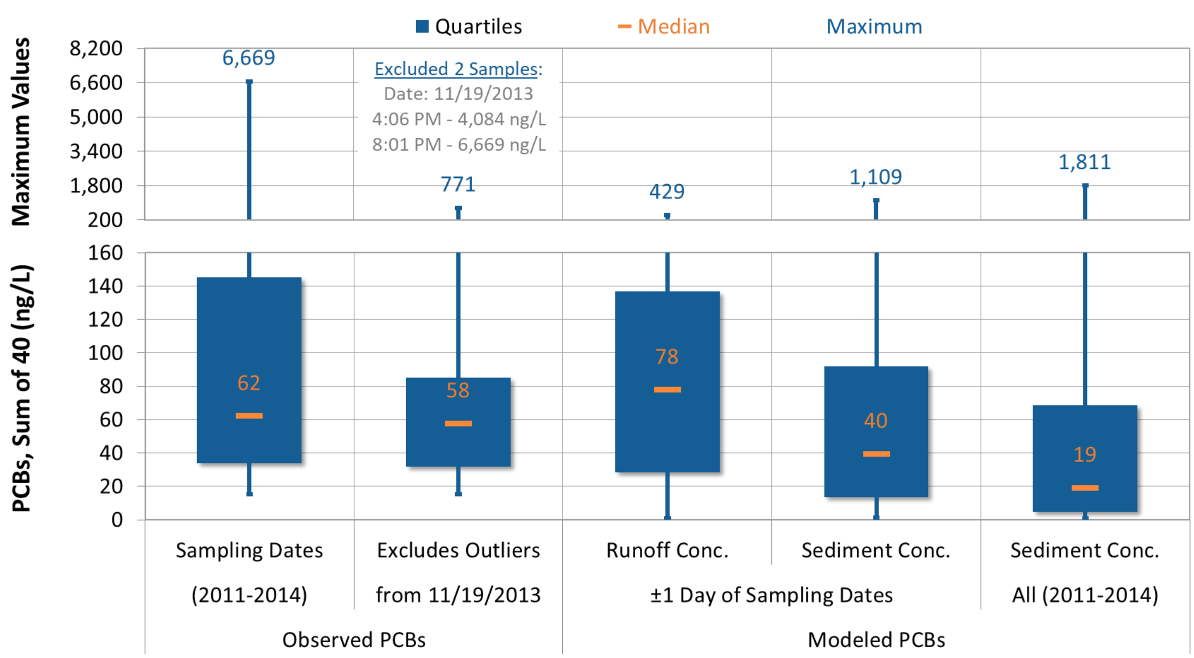


Figure 2-7. Observed vs. modeled PCB concentrations at the Pulgas Creek monitoring stations.

2.2.3 Determination of Overall and GI Stormwater Improvement Goals

The baseline model reported in the previous sections was developed for all areas within County watersheds and provides a complete estimate of all PCBs and mercury loads delivered to the Bay via stormwater, including loads from urban and non-urban sources. However, for the determination of stormwater improvement goals and those associated with GI, the RAA is performed to provide direct comparison to TMDL WLAs assigned to permitted municipal stormwater discharges addressed by the MRP. The Bay Area RAA Guidance states that "consistent with TMDL accounting, areas within the boundaries of the Permittee's jurisdiction that do not need to be incorporated into the area of analysis include non-urban land areas, including non-urban areas upstream from dams, which are not needed for calibration or validation of the RAA model." The EPA RAA Guide and Bay Area RAA Guidance also both outline the following factors for consideration in defining the area for analysis:

- If multiple municipal jurisdictions are addressed by the RAA, the analysis should be capable of distinguishing among jurisdictions in terms of relative contributions of wet weather flow and pollutant loads.
- If areas not subject to municipal jurisdiction are included, their flows and loads should be distinguishable.
- The area of analysis should make sense in terms of hydrologic function and connectivity, and for some approaches flows and loads may require routing through the modeled area of analysis.

To provide direct comparison to WLAs assigned to municipal stormwater discharges to the Bay, the pollutant loadings associated with non-urban areas or areas addressed by other NPDES permits were separated from loads addressed by the MRP. Table 2-4 summarizes the MRP and non-MRP land areas and their pollutant loads. The MRP pollutant loads in Table 2-4 can be directly compared to respective TMDL WLAs to determine stormwater improvement goals.

Table 2-4. Summary of Total Area and Baseline Pollutant Loading for MRP-Associated Land Areas and Non-MRP Areas

Permitted and Other Areas		Area (acres)	PCBs[1] (g/year)	Mercury[1] (g/year)
MRP		56,943	1,373	1,686
Non-MRP	*Open Space*	44,958	3	1,025
	Caltrans	2,992	95	100
	Industrial (NPDES)	1,796	215	77
	Industrial (General)	828	91	23

1 Per the Bay Area RAA Guidance, the baseline period used for model simulation is Water Year 2002 (BASMAA 2017).

As an example, Table 2-5 provides a summary of the calculation of stormwater improvement goals, or pollutant load reductions, to meet WLAs for PCBs. The table summarizes values reported in the TMDL for existing pollutant and sediment loads for all stormwater sources to the Bay, the sediment target, and the WLA and PCBs reduction assigned to all urban stormwater discharges to the Bay; the San Mateo County portion of the WLA associated with stormwater sources; and the existing PCBs and sediment loads and load reductions estimated by the RAA model for MRP areas designated in Table 2-4. An 84.6% reduction in annual loads is estimated for municipal discharges within San Mateo County to meet the San Mateo County portion of the PCBs WLA.

Table 2-5. Calculation of Stormwater Improvement Goals to Address PCBs TMDL

TMDL Component		Area Addressed		
		Bay-wide (based on TMDL)	San Mateo Co. (based on TMDL)	San Mateo Co. (based on RAA model)[3]
1	Existing PCB Load (kg/year)	20[1]	n/a	1.37
2	Existing Sediment Load (t/year)	2,000,000[1]	n/a	8,107
3	Target Sediment Concentration (µg/kg)	1[1]	n/a	n/a
4	WLA for Urban Stormwater Discharges(kg/year)	2[1]	0.2[1]	n/a
5 = 1 - 4	Load Reduction for Urban Stormwater Discharges (kg/year)	18[1]	n/a	1.17[2]
6 = 5 / 1	Percent Reduction	90[1]%	n/a	85.4[2]%

1 Reference: SFBRWQCB 2008
2 Calculated based on the difference between the RAA modeled Existing PCB Load (blue = 1.37 kg/yr) and the WLA (green = 0.2 kg/yr)
3 Per the Bay Area RAA Guidance, the baseline period used for model simulation is Water Year 2002 (BASMAA 2017).

The MRP outlines PCBs (3 kg/yr) and mercury (10 kg/yr) load reduction goals to be achieved through the implementation of GI by all MRP Permittees by 2040. When the Bay Area RAA Guidance was developed, it was agreed that if a new baseline model is developed and it results in a revised calculation of the baseline load and the load reduction required to meet WLAs, the percent of the Permittee load reduction can be used as the stormwater improvement goal to guide GI planning. Table 1-3 provided a summary of the MRP required PCBs and mercury load reductions and the interpretation of percent of Permittee load reductions to be achieved through GI implementation. Based on the total load reductions calculated for PCBs (Table 2-5), and the percentage of the load reductions to be achieved through GI (Table 1-3), the PCBs load reduction target can be calculated for GI implementation. Summarized in Table 2-6, this load reduction serves as a goal for GI Plans to be achieved by 2040.

Table 2-6. PCB Load Reduction by 2040 Based on GI Implementation

Achieved Through GI Implementation by 2040	San Mateo County (Based on RAA Model)
Load Reduction (kg/yr)	0.24[1]
Percent Reduction	17.8[2]%

1: Bay Area RAA Guidance reports 20.8% of the permittee load reduction associated with the MRP GI requirements. Calculated based on 20.8% of the PCB Load Reduction (1.17 kg/yr).
2: Calculated based on difference of Load Reduction reported above (0.24 kg/yr) and Existing PCB Load (1.37 kg/yr).

2.3 GI Performance Model

The SUSTAIN model will be used to establish relationships between the overall amount of GI implementation and the quantity of stormwater runoff volume captured, infiltrated, and/or treated to achieve incremental reductions of mercury and PCBs loadings. The SUSTAIN model establishes a robust quantitative linkage between the level of GI implementation, runoff volumes managed, and associated mercury and PCBs loads to demonstrate phased reductions to meet TMDL WLAs. SUSTAIN includes a process-based continuous project simulation module for representing flow and pollutant transport routing through various types of GI projects.

2.3.1 GI Modeling Assumptions

Due to the requirements outlined by the MRP that affect the design of LID for new and redevelopment (Provision C.3), the modeling assumptions used in the SUSTAIN model will reflect the minimum requirements of the permit. The MRP outlines several methods for sizing GI projects that will be used in the RAA. The SMCWPPP (2016) has also developed a technical guidance document tailored for San Mateo County that aids developers of stormwater projects in their efforts to address Provision C.3 requirements. This guidance document specifies preferred methods and design criteria for stormwater treatment systems that fulfill MRP requirements while addressing local standards. The methods suggested by the SMCWPPP technical guidance document are proposed as the basis for SUSTAIN modeling assumptions. Modeling assumptions are organized into subsequent sections according to the three project types identified in the SRP: Regional Projects, Green Streets (bioretention, permeable pavement), and LID.

2.3.1.1 Regional Stormwater Capture Projects

Regional stormwater capture projects (regional projects) are assumed to be subsurface infiltration systems. These types of projects are typically implemented on publicly owned parcels within parks, open space, and/or recreational facilities. Depending on specific site constraints, these facilities can capture stormwater diverted from adjacent channels or storm drains, which often results in increased captured drainage area. These situations require inclusion of a diversion structure and may require pumping at additional cost. Modeling assumptions regarding diversion will be determined on a case-by-case basis for each regional project. Based on the SMCWPPP technical guidance, these facilities will be represented using a storage depth that facilitates a 72-hour drain-down time. The modeling assumptions for regional projects are listed in Table 2-7.

Table 2-7. Modeling Assumptions for Regional Projects

Groups	Item Description	Value	Units	Source
Storage	Design Drainage Area	*Sized for capture of 80% of the annual runoff volume*		[1] C.3.d.i.(1).(b) pg.22
	Structure Footprint			
	Storage Depth	3	ft	[2] Section 6.11 pg.6-55
	Minimum Infiltration	0.5	in/hr	[2] Section 6.11 pg.6-55
Diversion	*Diversion assumptions will be made on a case-by-case basis for each regional project*			

[1] Reference: SFBRWQCB 2015
[2] Reference: SMCWPPP 2016

2.3.1.2 Green Streets

Green streets are implemented in public rights-of-way and typically capture runoff contributed from the street and adjacent parcels. Suitable green street locations were identified through a screening process during the development of the SRP (Figure 1-2). Green streets will be represented using primarily bioretention, however on a case-by-case basis some projects may include a combination of bioretention and permeable pavement. These two components are conceptually implemented in unison, although permeable pavement can be limited or removed in areas where implementation is not feasible or determined too costly. The modeling assumptions for both the bioretention and permeable pavement components of green streets are listed in Table 2-8.

Table 2-8. Modeling Assumptions for Green Streets

Groups	Item Description	Value	Units	Source
Bioretention				
Surface	Design Drainage Area	*Sized for runoff from 0.2 inches per hour intensity rainfall event*		[1] C.3.d.i.(2).(c) pg.22
	Project Footprint	*4% of drainage area*		[2] Section 5.1 pg.5-6
	Ponding Depth	6	in	[2] Section 6.1 pg.6-4
Media	Depth	1.5	ft	[2] Section 6.1 pg.6-5
	Soil Porosity	0.35	-	[3] Appendix A
	Soil Infiltration Rate	5	in/hr	[1] C.3.c.i.(2).(c).(ii) pg.20
Underdrain	Use if soil infiltration rate is less than	0.5	in/hr	
	Depth	1	ft	[2] Section 6.1 pg.6-5, [3]
	Media Porosity	0.4	-	[3] Appendix A
	Pollutant Filtration	*98% PCBs / 45% Hg Reductions*		[4] Table 4-2, pg.36
	Background Infiltration	*Match underlying soils*		
Permeable Pavement				
Surface	Design Drainage Area	*Sized for capture of 80% of the annual runoff volume*		[1] C.3.d.i.(1).(b) pg.22
	Project Footprint	*1/3 of the drainage area*		[2] Section 6.6 pg.6-33
	Ponding Depth	0.12	in	
Underdrain	Use if soil infiltration rate is less than	0.5	in/hr	
	Depth	1	ft	[2] Section 6.6 pg.6-33
	Media Porosity	0.4	-	[3] Appendix A
	Pollutant Filtration	*No significant filtration through underdrain*		
Media	Depth	2	ft	[5] Appendix B
	Media Porosity	0.4	-	[3] Appendix A
	Media Infiltration Rate	10	in/hr	[1] C.3.c.i.(2).(c).(ii) pg.20
	Background Infiltration	*Match underlying soils*		

[1] Reference: SFBRWQCB 2015
[2] Reference: SMCWPPP 2016
[3] Reference: ULAR WMG 2016
[4] Reference: BASMAA 2015
[5] Reference: SFPUC 2016

Both bioretention and permeable pavement consist of three components: a surface layer, media layer, and underdrain layer. The surface layer consists of captured runoff that can pond above the treatment surface and is treated as storage. The media layer is the primary component of treatment and storage. The media layer must be a minimum of 18 inches for bioretention (SMCWPPP 2016). For permeable pavement, the media layer depth is dependent on expected traffic load, runoff depth, and soil conditions (Caltrans 2014). According to design guidance in San Francisco, a minimum depth between 18 and 28 inches is required for the media layer, depending on soil conditions and expected traffic load (SFPUC 2016). A depth of 2 feet will be used for permeable pavement as an intermediate assumption to account for a variety of street usage and expected runoff depths. The media infiltration rate should not be a limiting factor for permeable pavement and a rate of 10 inches per hour will be assumed, compared to the minimum of 5 inches per hour specified by the MRP. Underdrains are typically required for either component when the underlying soils have low infiltration capacity below a specific threshold. In most of San Mateo County, underdrains will generally be required unless exempted by the local jurisdiction on a case-by-case basis depending on soil permeability (SMCWPP 2016). According to several regional design resources across the United States, underdrains should be included when underlying soils have an infiltration rate below 0.5 inches per hour (DOEE 2013; VA DEQ 2011; SF DPW Order No. 178,493) and will be used in the model to determine which projects include underdrains. For bioretention, the underdrain layer can be a minimum of 12 inches (SMCWPPP 2016; SFPUC 2016). For permeable pavement, an underdrain can have a diameter of at least 4 inches with a minimum 4 inches of aggregate on all sides (SMCWPPP 2016), resulting in an underdrain layer of 12 inches. Underdrains in permeable pavements are typically placed above the media layer (the primary component of storage) to maximize infiltration (BASMAA 2015; SMCWPPP 2016). Pollutant removal estimates for PCBs and mercury are from influent and underdrain concentration summary statistics reported by BASMAA (2015).

2.3.1.3 Low Impact Development

Assumptions for LID will be incorporated in the model and linked to future projections of new and re-development to represent implementation of Provision C.3. LID may also be considered on public parcels, as identified in the SRP. LID typically treats runoff generated onsite. This means that the drainage area for LID is typically no larger than the parcel size. In SUSTAIN, these features will be represented as bioretention, though implementation will vary with individual site constraints. The components for bioretention are discussed in Section 2.3.1.2. The modeling assumptions for LID are listed in Table 2-9. Underdrains are typically required for bioretention when the underlying soils have low infiltration capacity below a specific threshold. According to several regional design resources across the United States, underdrains should be included when underlying soils have an infiltration rate below 0.5 inches per hour (DOEE 2013; VA DEQ 2011; SF DPW Order No. 178,493). Using infiltration estimates for the proposed GI locations, the 0.5 inches/hour threshold will be used to determine which projects include underdrains. Pollutant removal estimates for PCBs and mercury are from influent and underdrain concentration statistics reported by BASMAA (2015).

Table 2-9. Modeling Assumptions for Low Impact Development

Groups	Item Description	Value	Units	Source
Bioretention				
Surface	Design Drainage Area	*Sized for runoff from 0.2 inches per hour intensity rainfall event*		[1] C.3.d.i.(2).(c) pg.22
	Project Footprint	*4% of drainage area*		[2] Section 5.1 pg.5-6
	Ponding Depth	6	in	[2] Section 6.1 pg.6-4
Media	Depth	1.5	ft	[2] Section 6.1 pg.6-5
	Soil Porosity	0.35	-	[3] Appendix A
	Soil Infiltration Rate	5	in/hr	[1] C.3.c.i.(2).(c).(ii) pg.20
Underdrain	Use if soil infiltration rate is less than	0.5	in/hr	
	Depth	1	ft	[2] Section 6.1 pg.6-5
	Media Porosity	0.4	-	[3] Appendix A
	Pollutant Filtration	*98% PCBs / 45% Hg Reductions*		[4] Table 4-2, pg.36
	Background Infiltration	*Match underlying soils*		

[1] Reference: SFBRWQCB 2015
[2] Reference: SMCWPPP 2016
[3] Reference: ULAR WMG 2016
[4] Reference: BASMAA 2015

2.4 Model Considerations to Inform GI Plans

As discussed in Section 1.3, C/CAG has initiated preliminary planning efforts to: (1) identify LID practices that have been implemented within new development and redevelopment since 2003 (baseline year for the TMDL; (2) develop estimates of future new development and redevelopment and the number of acres that will be addressed by the Provision C.3 regulated development by 2040; and (3) identify and prioritize GI retrofit opportunities on public parcels and within street rights-of-way through the development of SRP (SMCWPPP 2017). An important consideration for the RAA was the ability to track costs and benefits of different categories of GI projects within the model. This tracking can be performed for GI project categories within each model subwatershed and municipal jurisdiction, and can aid in the selection of the most cost-effective implementation strategy to attain pollutant reduction goals. The RAA builds upon the previous planning efforts and utilizes the following categories of GI projects for model representation:

1. **Existing Projects**: Stormwater treatment and GI projects that have been implemented since FY-2004/05. This primarily consists of all of the regulated projects that were mandated to treat runoff via Provision C.3 of the MRP, but also includes any public green street or other demonstration projects that were not subject to Provision C.3 requirements. For regulated projects in the early years of C.3 implementation, stormwater treatment may have been achieved through non-GI means, such as underground vault systems or media filters.
2. **Future New and Redevelopment:** All the regulated projects that will be subject to Provision C.3 requirements to treat runoff via LID and is based on spatial projections of future new and redevelopment tied to regional models for population and employment growth.
3. **Regional Projects (identified)**: The SRP identified three projects within public parks to provide regional capture and infiltration/treatment of stormwater, and included conceptual

designs to support further planning and designs. C/CAG is currently working with agencies to identify additional regional project opportunities for conceptual design and inclusion in the RAA.

4. **Green Streets**: The SRP identified and prioritized opportunities throughout San Mateo County for retrofitting existing streets with GI in public rights-of-way. Green streets were ranked as high, medium, and low priority based on a multiple-benefit prioritization process developed for the SRP.
5. **Other GI Projects (to be determined)**: Other types of GI projects on publicly owned parcels, representing a combination of either additional parcel-based GI or other Regional Projects. The SRP screened and prioritized public parcels for opportunities for onsite LID and Regional Projects. These opportunities need further investigation to determine the best potential projects.

GI Plans prepared for each Permittee will need to consider the numerous GI project opportunities that exist within their respective jurisdiction, and select a suite or "recipe" of projects that can most cost-effectively result in attainment of the pollutant load reductions. The amount and combination of those GI projects can be determined through analysis of estimated load reductions and implementation costs. Figure 2-8 presents an example GI recipe showing the distribution of selected GI project categories versus incremental reductions in pollutant loading and increasing cost. To build upon preliminary C/CAG planning efforts above, and to properly inform and set meaningful goals for GI Plans, it was determined to be beneficial for the countywide RAA approach to include the capability of performing cost-benefit optimization of GI project opportunities. For multiple combinations of GI projects, SUSTAIN provides an estimate of pollutant load reduction and implementation costs, allowing for the comparison of various GI implementation scenarios and the selection of the most cost-effective implementation plan to meet the pollutant reduction goals.

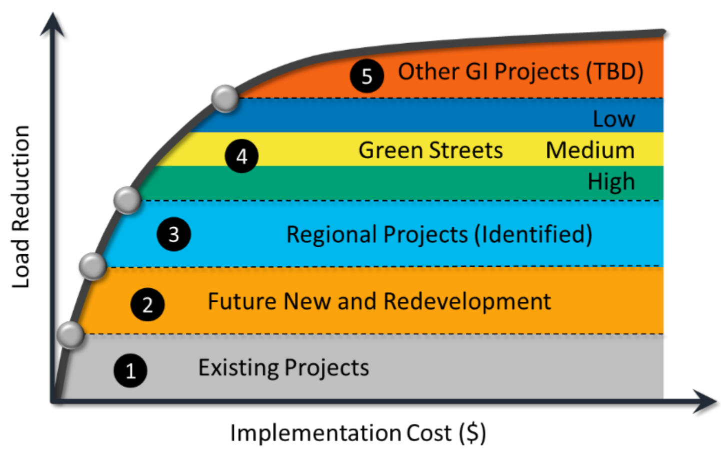


Figure 2-8. Example Implementation Recipe Showing General Sequencing of GI Projects.

3 RAA OUTPUT THAT DEMONSTRATES THE RELATIONSHIP BETWEEN GI IMPLEMENTATION AND POLLUTANT REDUCTION

As discussed in Section 1.2, depending on the perspective of the regulators, stakeholders, or Permittees, the purpose and expectations of the RAA can vary in terms of how reasonable assurance is demonstrated. As a result, the output from the RAA must consider multiple perspectives and strike the right balance between detail and specificity while still leaving ample opportunity to allow for future adaptive management. The following are key considerations for the RAA output:

- **Demonstrate PCBs and Mercury Load Reductions** – The primary goal of the RAA is to quantitatively demonstrate that GI Plans and Control Measure Implementation Plans will result in load reductions of PCBs and mercury sufficient to attain their respective TMDL WLAs and stormwater improvement goals associated with GI. Ongoing regional discussions between Permittees and Water Board staff are further defining Water Board expectations for the RAA and methods to demonstrate reasonable assurance that pollutant load reductions are met. For example, preliminary results of the RAA were recently presented to key Water Board staff at the MRP 2.0 Pollutants of Concern (POC) Steering Committee, in conjunction with separate presentations also provided by other countywide programs on the status and methods used for their RAAs.
- **Develop Metrics to Support Implementation Tracking** – The MRP (Provision C.3.j) also requires tracking methods to provide reasonable assurance that TMDL WLAs are being met. Provision C.3.j states that the GI Plan "shall include means and methods to track the area within each Permittee's jurisdiction that is treated by green infrastructure controls and the amount of directly connected impervious area", and a "process for tracking and mapping completed projects, public and private, and making the information publicly available (e.g., SFEI's GreenPlanIT tool)." Preliminary RAA results presented at the POC Steering Committee introduced concepts for discussion on quantifiable metrics to be reported by the RAA and potentially tracked in the future.
- **Support Adaptive Management** – Given the relatively small scale of most GI projects (e.g., LID on an individual parcel, a single street block converted to green street), the number of GI projects needed countywide to meet the pollutant reduction goals will be in the thousands. All the GI projects will require site investigations to assess feasibility and costs. As a result, the RAA provides a preliminary investigation of the amount of GI needed spatially (e.g., by subwatershed and municipal jurisdiction) to achieve the countywide pollutant load reduction target. The RAA sets the "goals" in terms of the amount of GI implementation, which can be incorporated within each Permittee's GI Plan. As GI Plans are implemented and more comprehensive municipal engineering analyses (e.g., masterplans, capital improvement plans) are performed, the adaptive management process will be key to ensuring that goals are met. In summary, the RAA inform GI implementation goals, but the pathway to meeting those goals is subject to adaptive management and can potentially change based on new information or engineering analyses performed over time.

C/CAG has invested much effort into preliminary modeling and preparation of example RAA output in an attempt to identify the appropriate balance in terms of detail and specificity needed to address the above considerations. As mentioned above, example output has been presented to key Water Board staff, and further meetings and discussions are expected to reach final agreement on the expectations of the reported RAA output. Figure 3-1 provides a summary of preliminary RAA results for the City of South San Francisco that was presented at the POC Steering Committee for discussion. The following provides an explanation of each of the steps corresponding to those depicted in the figure.

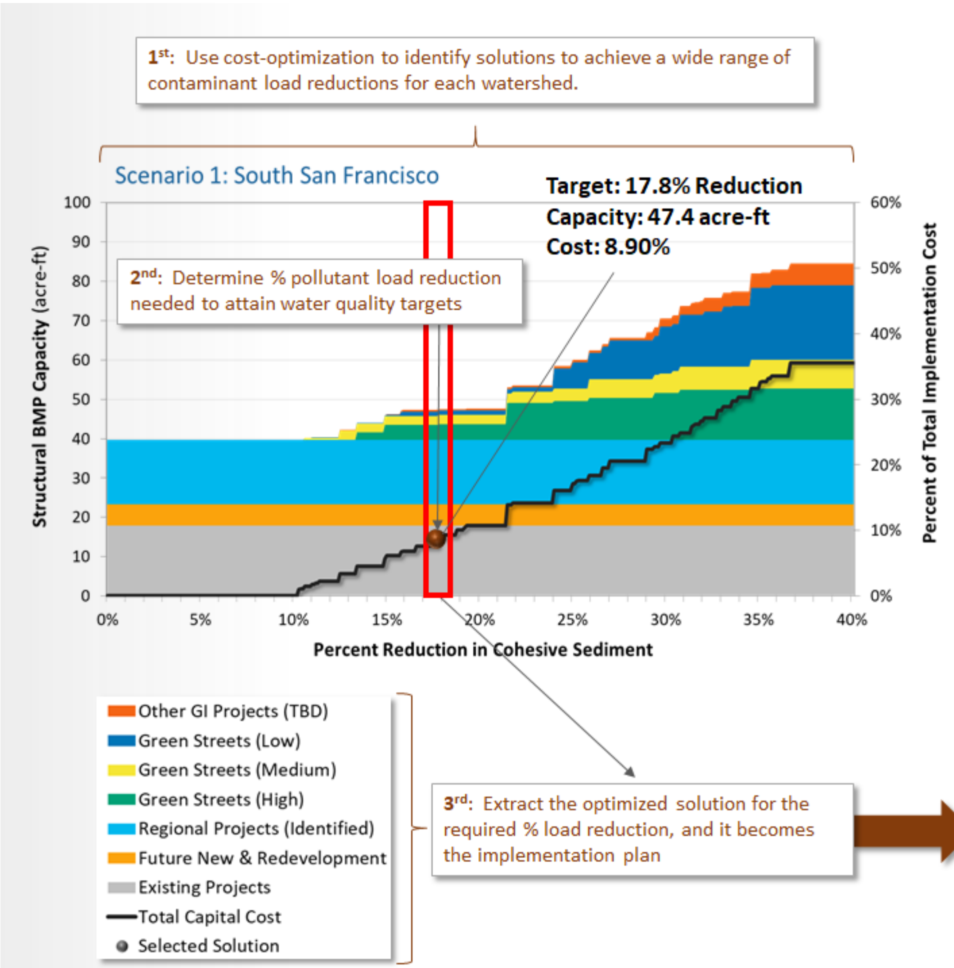
First: Based on GI project categories defined in Section 2.4, SUSTAIN is used to simulate effectiveness/load reductions and estimate planning-level costs for various combinations of GI projects within the City's jurisdiction (along the x-axis, from low pollutant reduction/effectiveness to high reduction/effectiveness). "Existing Projects" were locked in the model and included those GI projects included in the FY 2016-17 MRP Annual Report to the Water Board. "Future New & Redevelopment" is an estimation of the LID that will likely be implemented in the future in redevelopment areas (based on Provision C.3). "Green Streets" were based on prioritized and ranked (High, Medium, and Low) street retrofit opportunities reported in the SRP. For South San Francisco, the "Regional Project (Identified)" refers to the regional project located within Orange Memorial Park that is currently funded by Caltrans for design and construction. "Other GI Projects" refer to additional GI projects needed, but specific locations for project opportunities within certain subwatersheds yet to be determined.

Second: As discussed in Section 2.2.3 and depicted in Figure 3-1, a 17.8% reduction of PCBs was was identified as the target reduction to be attained through the implementation of GI (for this scenario, cohesive sediment reduction is used as a surrogate to represent load reduction of PCBs).

Third: SUSTAIN is used to provide cost-optimization and selection of the most cost-effective combination of GI projects to attain the target reduction. This solution is depicted in the plot as the vertical slice that intersects the point on the x-axis at 17.8% reduction. The combination of GI structural capacities in that slice at the 17.8% load reduction represents the proposed GI implementation plan for South San Francisco. The table to the right provides details on that implementation plan for the 10 subwatersheds within the City's jurisdiction (represented by each row in table). Optimization results recommend that varying amounts of GI capacity in different subwatersheds (different rows) are needed to achieve the most cost-effective solution, but the overall PCBs load reduction equals 17.8% (bottom row of table).

As can be seen in the results in Figure 3-1, the cost-optimization favored implementation of different combinations of GI projects within each subwatershed. These combinations were based on: (1) number and type of GI project opportunities identified within each subwatershed, and (2) cost-effectiveness given various characteristics associated with GI control measure efficiency (typically governed by infiltration rates), higher sediment (or PCBs) generation in upstream areas, etc. During implementation, it is almost certain that the actual implementation of GI will not follow the RAA output exactly. Dimensions and location of GI projects will vary based on on-the-ground feasibility and site-specific constraints. At the same time, all GI project capacity is not created equal in terms of effectiveness. For these reasons, tracking implementation using implemented *GI capacity* is not recommended.

Instead of relying on GI capacity as the metric for implementation tracking and reporting, the effective PCBs load reduction and stormwater volume managed are proposed as tracking metrics. At the left side of the table in Figure 3-1 are columns under the header "Management Metrics for GI," which include performance metrics for "% Load Reduction PCBs (Annual)" or "Annual Volume Managed (acre-ft)." Both metrics are based on annualized results represented in the RAA modeling system that are directly comparable to TMDL WLAs. The "% Load Reduction PCBs (Annual)" provides a relative comparison of the load reduction to be achieved within each subwatershed. The "Annual Volume Managed (acre-ft)" shows the acre-feet of water captured and infiltrated and/or treated within each subwatershed, resulting in a total annual volume of 792.0 acre-feet of stormwater managed in South San Francisco for an average year. This 792.0 acre-feet of stormwater managed could serve as the primary metric to be tracked for GI implementation. In other words, stormwater volume managed is being used as a unifying metric to evaluate GI effectiveness. As a result of adaptive management, the implementation plan may change over time and alternative GI projects can be substituted without having to re-run the RAA, as long as the volume managed remains on track. This same stormwater volume managed could be correlated with other multiple benefits related to flood control and water supply, among others.



Subwatershed ID	Management Metrics for GI		Green Infrastructure Capacity to Achieve 17.6% Reduction Target (Capacity expressed in units of acre-feet)							
			Existing/Planned			Green Streets				
	% Load Reduction PCBs (Annual)	Annual Volume Managed (acre-ft)	Existing Projects	Future New & Redevelopment	Regional Projects (Identified)	High	Medium	Low	Other GI Projects (TBD)	Total BMP Capacity (acre-ft)
232519	42%	6.9	0.15	0.05	--	0.08	0.01	0.10	0.01	**0.4**
232619	55%	0.42	--	0.00	--	--	0.01	0.01	0.01	**0.0**
240119	15%	338	10.40	2.60	--	3.70	--	--	--	**16.7**
240219	10%	34	0.18	0.60	3.93	--	--	--	--	**4.7**
240319	19%	149	0.74	0.74	7.89	0.20	--	--	--	**9.6**
240419	16%	15.6	0.05	0.11	0.99	--	--	--	--	**1.1**
240519	16%	56	0.14	0.28	3.56	--	--	--	--	**4.0**
250119	33%	166	5.91	0.66	--	0.02	1.85	0.98	0.11	**9.5**
250219	31%	19.5	0.30	0.32	--	0.00	0.47	0.01	0.06	**1.2**
250319	31%	5.4	--	0.04	--	--	--	0.02	0.15	**0.2**
Total	**17.8%**	**792.0**	**17.9**	**5.4**	**16.4**	**4.0**	**2.3**	**1.1**	**0.3**	**47.4**

RED = Subwatersheds with highest required % load reductions
BLUE = Subwatersheds with highest BMP capacities within a BMP category

Figure 3-1. Preliminary RAA Output Introducing Concepts for Trackable Metrics.

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