Guidance for CAPTURE at Schools

California Practices To Use Runoff Effectively (School Capture Guidance)

California State Water Resources Control Board

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CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

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1.0 INTRODUCTION

1.1 Intent and Content

In October 2017, the Governor of the State of California signed into law Senate Bill 541 (SB 541), which amended the State Water Code and required the State Water Resources Control Board (State Water Board) to "provide recommendations of best design and use practices for storm water and dry weather runoff capture practices that can generally be applied to all new, reconstructed, or altered public schools, including school grounds." (California SB-541 2017). SB 541 defines the intent of such practices as follows: "…to control water pollutants, pollutant loads, and water runoff volume exiting a site to the maximum extent feasible by minimizing impervious surface area and controlling runoff from impervious surfaces..."

Figure 1-1. Example of a Bioretention Planter that Captures and Infiltrates Runoff

These guidelines fulfill that requirement by offering technical insights for selection, design, and implementation of practices that can prevent and reduce runoff volumes, flow rates, and pollutants discharged from school properties. These practices are referred to in this document as site design measures (SDMs) and stormwater control measures (SCMs), but are also known as low impact development (LID) or Best Management Practices (BMPs). These measures prevent and capture runoff by minimizing impervious surfaces and promoting infiltration, evapotranspiration, bioretention, treatment, and rainfall harvesting. These guidelines also encourage efforts to develop and implement sustainable management of stormwater runoff that afford schools opportunities to contribute to multiple benefits in their communities. School districts and schools can create or cooperate on projects that offer teachers and students opportunities in the STEM fields (and possibly other areas such as language arts, social studies, government, and arts) as well as educate the community about the beneficial uses of stormwater including improving water quality, increasing water supply, reducing flood risks, protecting the environment, and enhancing communities.

Additionally, these guidelines are intended to assist school districts in complying with future stormwater permit requirements. Such permits are issued by the State Water Board to protect beneficial uses of state, regional, and local water bodies. There is a body of literature documenting how beneficial uses such as drinking water supply, recreation, and habitat quality can be negatively impacted by runoff associated with urban development. These negative impacts occur when rain or snowmelt runs off impervious areas like rooftops, paved streets, highways or parking lots; picks up pollutants (pesticides, sediment, trash, bacteria, metals, etc.); and transports them into local water bodies. The construction of impervious areas also increases the flow rate and volume of runoff generated, resulting in further threats to beneficial uses. To protect beneficial uses, the State Water Board stormwater permits establish specific actions (including runoff capture practices) that municipalities, industrial facilities, universities, and others must take to prevent runoff from detrimentally impacting the beneficial uses. The permits are based on National Pollutant Discharge Elimination System (NPDES) regulations adopted by the US Environmental Protection

Agency (US EPA) under the Clean Water Act. In addition to preventing negative impacts from stormwater and dry weather runoff (collectively referred to as runoff), the actions required in NPDES permits can help reduce greenhouse gas emissions, augment water supply, protect against localized flooding, and enhance communities. In the face of climate change and the recent California drought, these concepts are particularly crucial in the name of sustainability — conserving current resources for future generations.

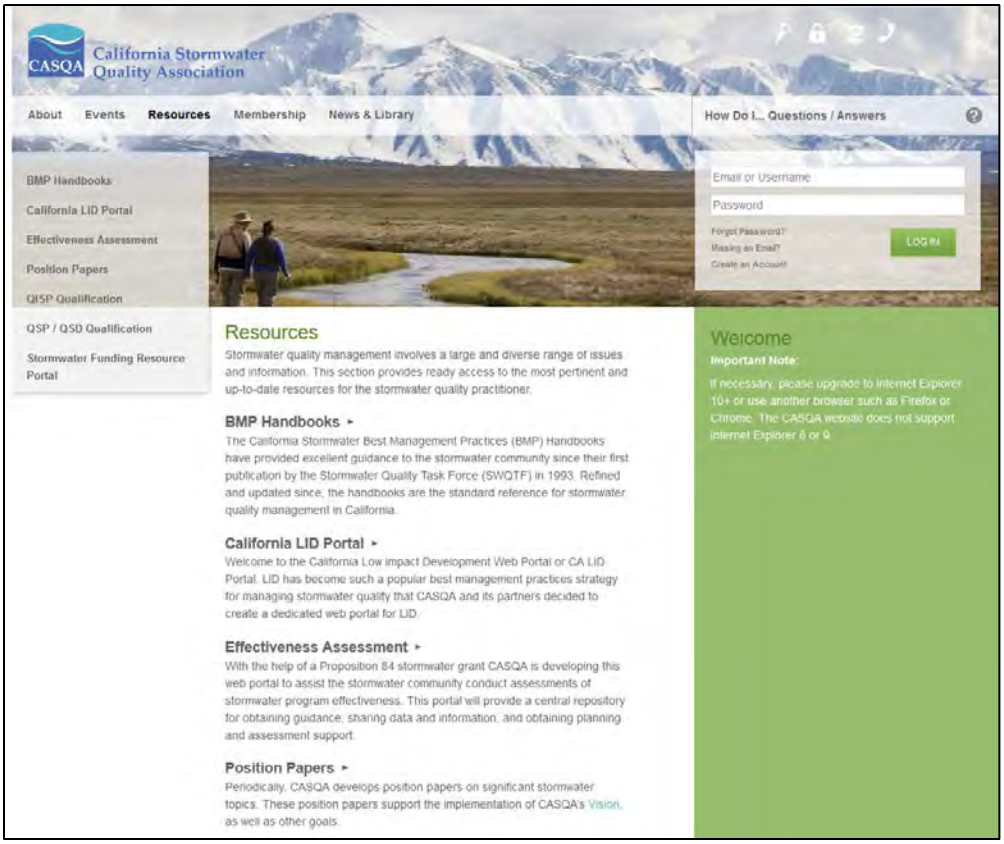

Figure 1-2. The California Stormwater Quality Association (CASQA) Website

The State Water Board is planning to include school districts and associated public and charter school properties in the next version of the small (Phase II) municipal separate stormwater sewer system (MS4) permit, which is expected to take effect in 2020. The Phase II permit was developed for small communities after the Phase I permits, which regulated municipalities with populations greater than 100,000. School districts fall under the definition of non-traditional small MS4s. Several school districts are listed in the 2013 small MS4 permit (State Water Board 2013). The guidelines in this document were developed in anticipation of school administrators' needs for resources to comply with the future versions of the permit. The resources provided in these guidelines include:

- Considerations for reducing runoff generated on school properties (Section 2.0)
- Regulations that impede runoff reduction practices and recommendations for addressing them (Section 3.0)
- Suggestions for maintaining runoff capture practices (Section 4.0)
- Considerations for collaborating with municipalities or others on regional projects (Section 5.0).

To better understand the context of the runoff prevention and capture material provided in these guidelines, Sections 1.2 through 1.4 summarize why runoff is of concern, how it can be captured and used as a resource, and the benefits of doing so. Section 1.5 discusses many resources relevant to these guidelines. Rather than "reinventing the wheel", these guidelines pull from these existing materials, provide informational summaries and considerations, and direct the reader to specific resources, such as the California Stormwater Quality Association's (CASQA's) web portals, that are occasionally updated to reflect changing technologies, regulations, and practices.

1.2 Natural Watershed Processes and Impacts of Development

The value and objectives of runoff capture are easier to understand within the context of natural watershed processes (Figure 1.1) and how urban and agricultural development affects those processes. To summarize:

> "An undeveloped watershed has many sophisticated components. Precipitation is dispersed through multiple processes, including infiltration, groundwater recharge, evapotranspiration, overland flow, interflow, or base flow. The distribution of water within these processes is determined by several factors specific to a watershed, including climate, land cover, topography, soil characteristics, and land use. These factors also influence the delivery of sediment and organic matter to receiving waters, as well as chemical and biological processes that affect water quality within the watershed's landscape." (OWP 2018a).

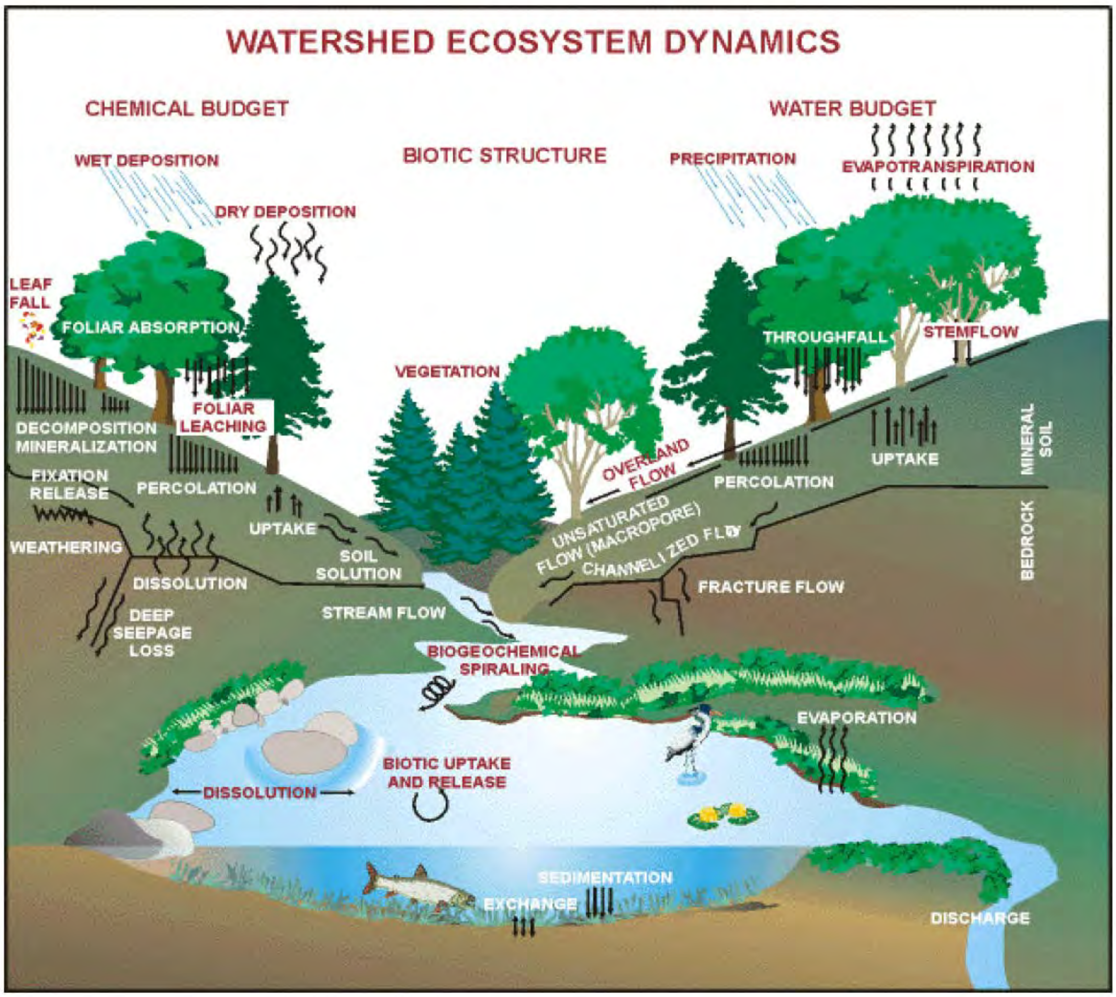

Figure 1-3. Natural Watershed Processes (USEPA 2017)

> **_Hydromodification_**
>
> *"…alterations in natural watershed hydrology associated with changes in land use or cover. Conversion of the open landscape to features such as roads, buildings, houses, sidewalks, parking lots, flood control channels, and agricultural fields modifies runoff patterns, causing rainfall to run off into streams more quickly with higher energy, and large flow events to occur more frequently." (SCCWRP 2013)*

However, urbanization, along with agricultural development and drainage, alter theses natural watershed processes as illustrated in Figure 1-4. Grasslands, forests, and other naturally-occurring, pervious landscapes become covered with buildings, roads, and parking lots. The resulting imperviousness reduces the amount of precipitation that is infiltrated into the soil (a process of permeating the soil and in some cases filtrating into groundwater basins), so instead it runs off over surfaces at increasing rates (Hollis 1975, Schueler 1994). Such hydromodification causes excess sediment transport into streams; downstream erosion; flooding; disruption of natural drainage patterns, stream flows, and riparian habitat; and elevated water temperatures (SSQP 2013). In addition, anthropogenic activities have introduced pollutants, which are transported through overland flow to downstream receiving waters (Brown and Peake 2006, Duncan 1995, Duncan 1999, Ellis 1986). This overland flow is comprised of stormwater runoff as well as dry-weather runoff (i.e., runoff from irrigation water and wash water). When the plastics, oils, greases, metals, and other contaminants used every day to support urban life are mobilized in runoff, they pose threats to a water body's beneficial uses, including loss of habitat and biotic integrity or poor water quality for consumption and recreation.

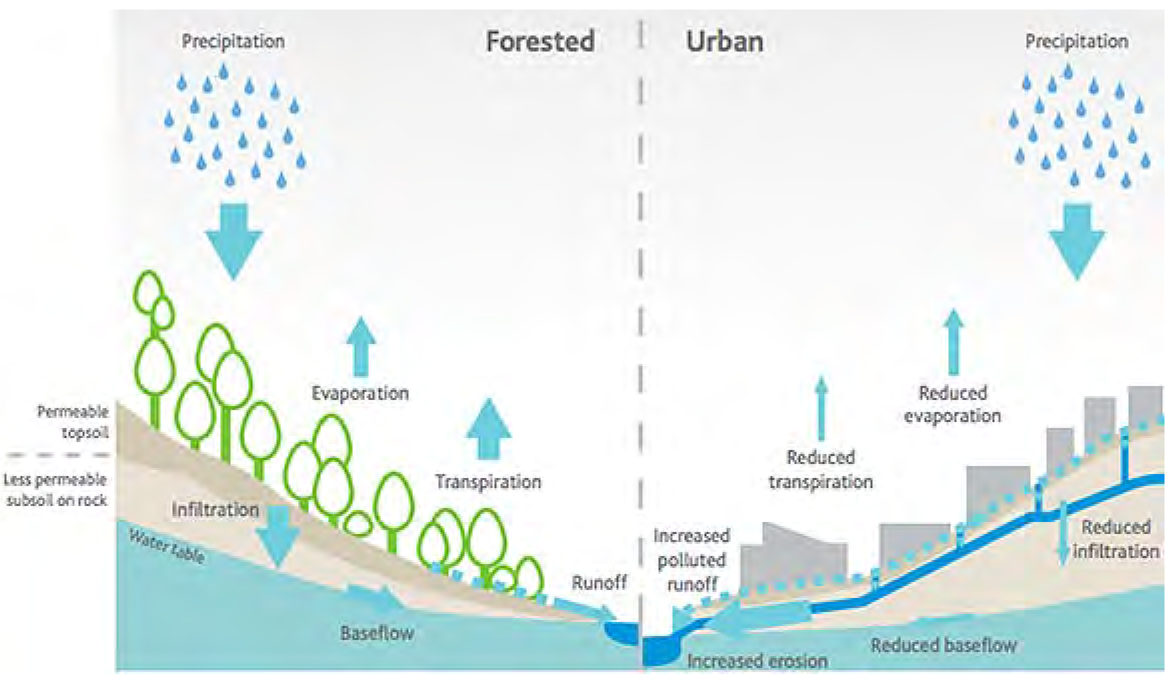

Figure 1-4. Impacts of Development on Natural Watershed Processes (Melbourne Water 2018)

1.3 The Evolution of Runoff Management

Historically, runoff from developed areas was managed solely to mitigate flooding. Runoff was captured and discharged directly to nearby water bodies. This practice increased runoff volumes and velocities, erosion, and sediment transport, degrading associated watersheds. Additionally, water quality was effected by increased pollutant transport from products and activities associated with urban development (transportation, landscaping, industry, etc.).

In recent decades, however, stormwater management has evolved to emphasize designs and infrastructure that reduce runoff volumes, flow rates, and pollutants discharged to receiving waters with the overall goal of reducing detrimental impacts. The practice of capturing runoff and retaining it on site or treating it before leaving the site can result in multiple benefits. These benefits include improving water quality, augmenting water supplies, supporting flood control, protecting environmental systems, and enhancing the quality of life in communities.

Practices that help to maintain or restore these processes, and achieve permit compliance, are presented in this guidance document. For example, minimizing impervious surfaces and other design practices avoid increasing the amount of runoff generated (compared to the pre-construction condition), which prevents pollutant transport and hydromodification effects. For runoff that is generated from impervious surfaces, mitigation is needed to restore these processes. Infiltration, for example, is an ideal mitigation because it helps return overland flow to a pre-development (pervious) condition. Enhanced infiltration (above pre-project conditions) could also improve the amount of recharge to underlying aquifers.

1.4 The Multiple Benefits of Managing Runoff

As previously stated, the runoff management practices presented in this guidance document provide many benefits. This section describes the benefits that can be achieved directly by and for schools, as well as their regional communities.

1.4.1 School Benefits

Benefits from runoff capture that apply directly to schools include those presented in Table 1-1. Appendix A describes how preventing and capturing runoff provides these benefits.

Table 1-1. School Benefits

School Benefits*
Compliance with NPDES post-construction requirements for school development and redevelopment projects
Opportunities for education on sustainable water management
Improvements in academics and behavioral health
Prevent or mitigate on-site flooding
Create environmental benefits
Cost savings compared to traditional drainage and site layout practices
New funding opportunities
Improved community reputation
Enhanced community engagement and standing on issues concerning local infrastructure
Support regional sustainability (see Section 1.4.2)

** See Appendix A for descriptions*

1.4.2 Regional Benefits

Preventing and reducing runoff can contribute to regional goals of sustainability, including climate change adaptation and resiliency — specifically those related to water quality, water supply, flood control, the environment, and communities. Table 1-2 lists many of these benefits, and Appendix A summarizes how the practices presented in this document can support this regional sustainability.

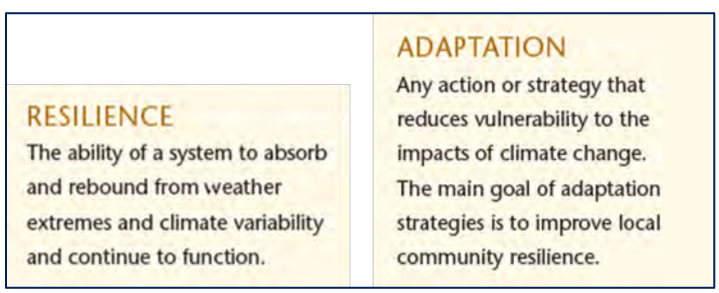

Figure 1-5. Climate Change Resilience and Adaptation
UNH 2018

Table 1-2. Regional Benefits

Benefit Category	Regional Benefit*
Improve Water Quality	• Prevent and reduce amount of pollutants discharged into local water bodies • Reduce impacts from hydromodification, particularly excess sediment transport to streams and downstream erosion and sedimentation
Augment Water Supply	• Recharge groundwater by capturing and infiltrating runoff • Offset local water demand by capturing and using runoff
Support Flood Control	• Reduce flood risks by preventing and reducing runoff flow volumes and rates • Reduce combined sewer overflows, which can also be considered water quality, community, and environmental benefits
Protect Environmental Systems	• Reduce and enhance wetlands, riparian zones, and habitat by reducing hydromodification impacts and pollutant transport • Reduce energy demand and greenhouse gas emissions • Improve instream water temperatures and oxygen levels to support aquatic habitat
Enhance Communities	• Provide education and involvement regarding sustainable watershed and runoff management • Improve property and neighborhood aesthetics • Increase property values • Reduce local costs related to water treatment, sewer overflows, and flood damage
Climate Change Adaptation and Resiliency	• Address increased precipitation volumes and intensities by increasing infiltration, reducing runoff volumes, and delaying peak runoff to prevent water quality and habitat degradation, and flood damage. • Prepare for more extreme and frequent drought conditions by capturing and using runoff to reduce demand on water supplies, as well as recharging groundwater to increase groundwater supplies • Reduce heat island effects by promoting incorporation of vegetated landscapes to the extent feasible • Provide redundancy through distributed, small-scale measures

** See Appendix A for descriptions*

1.5 Relevant Resources

This document was developed following decades of planning, research, and implementation conducted by others. Table 1-3 recognizes key literature documenting the many activities, findings, and lessons learned on which this document's materials were based.

Table 1-3. Relevant Resources

Key Resources for Runoff Management at School Properties
The State Water Board and Regional Water Boards stormwater programs, including MS4 permits (State Water Board 2018a)
Drought Response Outreach Program for Schools (DROPS) Guidance for Planning and Executing Vegetated LID Projects (CWH 2016)
California Stormwater Quality Association (CASQA) Stormwater BMP Handbook, New and Redevelopment (CASQA 2003 and 2018a)
Central Coast LID Initiative literature (LIDI 2018)
County of San Diego LID Handbook Stormwater Management Strategies (County of San Diego 2014)
Los Angeles Unified School District (LAUSD) Stormwater Technical Manual (LAUSD 2009)
Existing municipal stormwater design manuals and tools (Appendix F)
CA Phase II LID Sizing Tool (OWP 2018b)
Unlocking Collaborative Solutions to Water Challenges in the Los Angeles Region: The Power of Schools (TreePeople 2015)

2.0 MANAGING RUNOFF ON SCHOOL PROPERTY

2.1 Overview of Practices

The options for minimizing runoff generated and discharged from school properties can be categorized as either site design measures or structural installations. All options are intended to prevent or minimize runoff volumes, flow rates, and pollutants. The practices presented are based on those established by stormwater practitioners from across the US over the last few decades.

2.1.1 Site Design Measures

Site design measures (SDMs) are non-structural principles incorporated during the site design and planning stages of a project. They help prevent runoff from being generated and/or promote infiltration, evapotranspiration, and treatment of runoff. These measures and example strategies are listed in Table 2-1.

Table 2-1. Site Design Measures

Site Design Measure (SDM)	Strategies
Preserve natural areas and features	• Design around existing trees and vegetated landscapes to promote infiltration
Minimize impervious surfaces	• Replace impervious surfaces with pervious surfaces such as porous pavement or green roofs • Minimize building footprint with multi-story structures • Minimize parking areas by using parking structures or shared space (e.g., parking/basketball court)
Improve and maintain soil quality	• Use compost and mulch to amend soils, which will promote and enhance infiltration
Direct runoff to permeable surfaces	• Drain runoff from impervious surfaces to pervious surfaces like vegetated landscapes to allow infiltration
Incorporate water-wise irrigation and vegetation	• Select plants that require minimal watering • Operate and maintain irrigation systems to minimize generation of runoff
Design stormwater control measures	• See Section 2.1.2

2.1.2 Stormwater Control Measures

Stormwater control measures (SCMs) are structural devices that reduce runoff volumes, flow rates, and pollutants through infiltration, filtration, harvest and use, sedimentation, and/or floatation. Evapotranspiration also reduces runoff, but often to a lesser degree than these other mechanisms. Table 2-2 lists the various capture devices, their associated runoff management mechanisms, and common alternative names and variations. Appendix B provides factsheets for each capture device, with descriptions and schematics of the typical layout and function; advantages and limitations; siting, design, and construction considerations; and typical maintenance requirements. Note that any of the SCMs listed can be combined in series to create a "treatment train" that provides equivalent performance. This is especially useful when site layout is limited, but also allows creativity in site aesthetics related to SCM features.

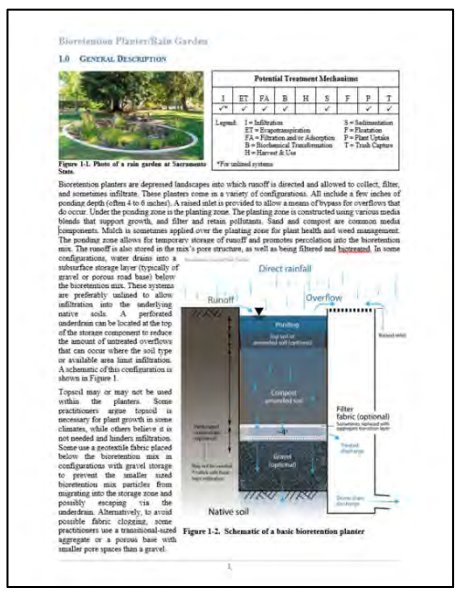

Figure 2-1. Example of SCM Factsheet in Appendix B

Table 2-2. Stormwater Control Measures and Associated Runoff Management Mechanisms

Stormwater Control Measure (SCM)	Runoff Management Mechanisms[1]	Variations and Alternative Names
Bioretention planter/rain garden	I[2], ET, FA, B, S, P, T	Rain gardens, lined bioretention planter, infiltrating stormwater planter, bioretention cell, vegetated filter, Biotreatment
Bioswale	I, ET, FA, B, S, P	Vegetated swale, swale
Biostrip	I, ET, FA, B, S, P	Vegetated buffer strip, strip, buffer
Constructed wetland	I, ET, FA, B, S, P	-
Detention basin	I, S, T	Detention pond, extended detention basin, dry extended detention basin/pond, dry pond
Drain inlet insert	FA	-
Dry well	I, FA, S, F	Underground injection control (UIC)
Green roof	ET, FA, B, S, P	Eco roof
Hydrodynamic separator	S, F	Vortex separator, swirl separator, gravity separator, flow-through separator
Infiltration basin	I, ET, FA, S, T	Retention basin, spreading ground
Infiltration gallery	I, H, S	-
Infiltration trench	I, FA, H, T	Rock swale
Media filter	FA, T	Sand filter, Austin sand filter, Delaware sand filter, DC sand filter, Canister filter, alternative media filter
Oil-water separator	S, F	Water quality inlet, trapping catch basin, oil-grit separator, flow-through separators
Porous/pervious pavement	I, ET, FA	Porous/permeable pavers, porous/permeable asphalt, porous/permeable concrete
Rain barrel and cistern	H, S	Harvest and (re)use (practices)
Wet pond	I, ET, S, P	Stormwater pond, retention pond, wet extended detention pond, detention pond
Wet vault	S	-

[1]I: infiltration; ET: evapotranspiration; FA: filtration and/or adsorption; B: biochemical transformation; H: harvest and use; S: sedimentation; F: floatation; P: plant uptake; T: trash capture
[2]for unlined systems only

2.1.3 Additional Runoff Management Practices

Ideal runoff management will include practices that prevent generation and discharge of runoff, as described in this manual, as well as other, on-going program elements that control discharge of pollutants and evaluate and refine runoff management activities. Such elements are listed in Table 2-3.

Table 2-3. Additional Runoff Management Practices

Runoff Management Practices	
Education and outreach	
Public involvement and participation	
Illicit discharge detection and elimination	
Construction site runoff control	
Water quality monitoring	
Program effectiveness assessment and improvement	
Pollution prevention/good housekeeping related to:	
o Outdoor storage of liquids and raw materials	o Sweeping and cleaning
o Parking/storage area maintenance	o Outdoor process equipment
o Vehicle/ equipment fueling and maintenance	o Landscape maintenance
o Outdoor loading and unloading of materials	o Trash storage

Although not the focus of this document, these elements are required by NPDES permits, and guidance on the related activities is provided from a variety of sources. The CASQA Post-Construction BMP Handbook (CASQA 2018) is an excellent resource. For publicly available material, the reader is referred to EPA's National Management Measures to Control Nonpoint Source Pollution from Urban Areas (Nov 2005).

2.2 Factors That Influence Design

Design of stormwater control devices follows a risk-based approach, intended to capture, retain, or treat a certain amount of runoff. Notably, SCMs are not designed to capture all runoff from all storm events. Instead, regulatory requirements stipulate a certain rate or volume that must be captured, in California often by specifying a design storm linked with historic hydrologic records. In general, the amount of runoff to be captured is estimated from historic precipitation (and sometimes evaporation) data, the area on which precipitation falls and drains to the device, and land cover characteristics that influence the amount of precipitation that becomes runoff. Selection and design of the proper type of device will also depend on the types of pollutants of concern, the desired performance (runoff volumes, flows, and pollutants discharged), the characteristics of existing soils, and the types and proximity to surrounding infrastructure. Additional considerations for SCM design include creating a proper vegetation plan, addressing safety concerns, outlining maintenance needs, and assessing permit requirements. A project owner could also enact small-scale voluntary measures such as disconnecting downspouts or other low-effort activities to mildly reduce runoff that reaches the SCM, at least for smaller storms. Ultimately, the volume to be captured determines the size of an SCM. Capturing more runoff from a larger contributing catchment will require regional SCMs of larger size, while capturing runoff from smaller catchments can be accomplished using smaller SCMs such as distributed LID devices. The following subsections discuss these factors.

2.2.1 Climate

As previously noted, SCM designs are based on historic precipitation and, sometimes, evaporation data. The frequency, duration, depths, and intensities (depths per time) of precipitation are all used to design projects. They result from climate patterns such as temperature, wind, atmospheric pressure, and humidity, but also by latitude, altitude, terrain, and nearby water bodies. Section 2.2 below describes how rainfall and evaporation are used in designing runoff capture devices.

California has diverse climate systems, ranging from rainforest conditions with average rainfall depths exceeding 170 inches per year to desert zones having average rainfall depths less than 1 inch per year (Figure 2-2). Using appropriate climate data, especially precipitation and evaporation data, for a particular project site is crucial.

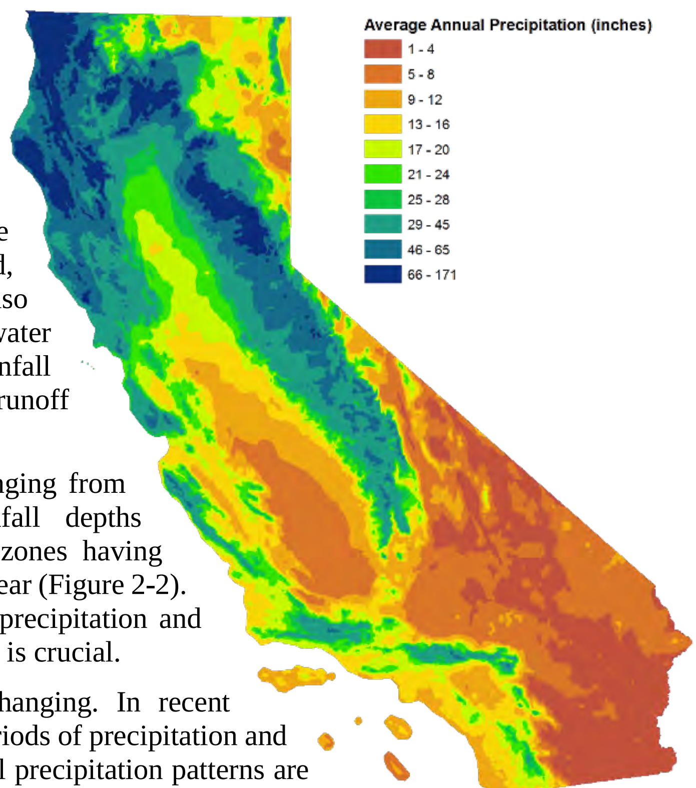

Figure 2-2. Annual Average Precipitation throughout California (USDA 2012)

However, historic climate patterns are changing. In recent decades, the state has seen more extreme periods of precipitation and drought. In many parts of the state, seasonal precipitation patterns are growing more acute, with the rainy and snowy periods condensed into fewer months with more extreme events. These considerations are important for designing, managing, and maintaining stormwater systems. Stormwater capture devices should be designed to accommodate larger flows during an event, while maintenance schedules should be revised to include regular maintenance before storms. Such measures will keep systems operating as planned.

A number of sources provide freely available hydrologic data. For instance, the National Centers for Environmental Information, an arm of the National Oceanic and Atmospheric Administration (NOAA), compiles a collection of databases across agencies for obtaining historic precipitation and evaporation data. One source of precipitation data is NOAA's Precipitation Frequency Data Server (PFDS), which supports visualization and download services for precipitation depth and intensity data across its stations. Other tools and manuals incorporate this data as part of design guidance and tools, so users do not need to obtain raw data. For example, the Office of Water Programs (OWP) at California State University, Sacramento, developed the Phase II Sizing Tool to support design of SCMs for Phase II small traditional and non-traditional permittees in California (OWP 2018b). This tool includes a database of NOAA-derived precipitation data throughout California. Municipal hydrology manuals, which are listed in Appendix D for reference, also adopt a method for sizing SCMs, with many providing compiled tables of precipitation and other data.

2.2.2 Drainage Area

The area, or catchment, on which precipitation falls significantly influences the amount of runoff volumes and flow rates generated during a precipitation event. Catchments are delineated based on topography, with runoff flowing down slopes and accumulating according to the grading of a site, either natural or altered.

For volume-based SCM design at the site-scale, the catchment area is simply multiplied by a specified precipitation depth and a volume reduction factor—a factor estimating the percent of precipitation that becomes runoff. For flow-based design, a runoff model will simulate routing of flows through a single catchment (site-scale design) or multiple catchments (watershed-scale). As runoff moves through a site or watershed, it increases in volume and velocity. The travel time required for runoff to move through a site or watershed can be estimated through a number of methods. For instance, the rational method and modified rational method are typical, straightforward means of estimating the travel time. While estimating large-scale flows across watersheds requires significant data, estimating flows and routing in a small catchment contributing to an SCM is usually less intensive and uses simpler methods.

2.2.3 Land Cover and Use

Land Cover and Use Influence

- *Types of potential pollutants*
- *Volume and rate of runoff generated and discharged*

Land cover contributes to the percentage of precipitation that becomes runoff, as well as the flow rates of runoff. A major factor influencing runoff flow rates is the amount and location of impervious surfaces in a watershed or catchment (Hollis 1975, Shuster 2005). Areas with more impervious surfaces generally create more runoff because less precipitation is stored and infiltrated in soils, plants, and other pervious materials. Additionally, when impervious areas are directly connected or interconnected by "grey" infrastructure, such as pipes and gutters, runoff volumes and velocities increase as runoff accumulates and moves towards outlets. SDMs such as those discussed in Section 2.1.1 help prevent the generation of runoff, while contemporary practices for SCMs are increasingly emphasizing distributed infrastructure that incorporates temporary storage and pervious surfaces to reduce the discharge of runoff water bodies.

Many runoff management design procedures utilize a factor, or coefficient, to estimate the percentage of precipitation that becomes runoff. Impervious surfaces typically have a relatively high coefficient (0.7-1.0), while more pervious surfaces have varying amounts. Although all pervious surfaces can help promote infiltration and reduce runoff, not all pervious cover is alike. The effectiveness of pervious surfaces to retain and infiltrate water vary. Surfaces with more and/or larger pore spaces or voids between soil particles allow more flow. Many soils on developed properties are disturbed and have been compacted, reducing the spaces in soil material and increasing the percentage of precipitation that turns to runoff. The design manuals identified in Appendix D will typically provide guidance for estimating coefficients of various surfaces.

Additionally, different land uses have varying levels of risk related to the associated contaminants typically found on site. For projects only serving a single school site, this is only potentially relevant to areas such as workshops with hazardous chemicals. However, differentiations in contaminant risk across properties is especially important when designing school SCM projects that include runoff from multiple sources, such as joint-use projects at regional scales. Basic considerations for land use and contaminant risks are described later in Section 5.0. As a basic guideline, for runoff capture projects on school sites, any sources of hazardous contaminants should be identified and treated separately from other runoff. Runoff can induce erosion in catchments and channels. The degree of erosion that can occur during precipitation events depends on many factors, including soil types, land slope and gradient, and the energy associated with runoff velocities. Generally, higher runoff flow rates can yield more erosion in channels and waterways, typically referred to as one type of hydromodification. Such effects can significantly damage stream habitat. Hydromodification mitigation efforts work to slow runoff velocities by retaining more runoff upstream to reduce peak flow rates, spreading flows over larger surface areas, and redeveloping rivers and streams to include meandering rather than straight flow paths. In cases of significant runoff, however, soils can become liquefied after sufficient saturation, causing erosion and loss of bearing capacity. Liquefaction risks are incorporated into watershed and flood management planning by identifying areas of soil and geologic composition that are susceptible to damaging erosion after significant rainfall.

2.2.4 Soil Type

For infiltrating SCMs, soil type is an important design consideration. California has significant diversity in geology and soil type, which both influence infiltration rates that must be included in designs. Soils with significant amounts of sand and gravel will have higher rates of infiltration, while less porous soils such as clay and silts have lower infiltration rates. Some parts of California, such as the southern coastal region, have more consistent soil types, while in other parts of the state, including the Central Valley, soil type can significantly change in a short distance. Infiltrating SCMs that are implemented in areas with better infiltrating soils have the potential to have a smaller footprint than those implemented in areas with soils having poor infiltration rates.

The soils throughout the subsurface are comprised of many horizons, or layers. When considering infiltration, the upper layers that are unsaturated are considered the vadose zone, which can consist of a number of different soil types that were deposited over time. Below the unsaturated zone, groundwater aquifers or bedrock can exist. Varyingly connected saturated zones of aquifers constitute a groundwater basin. The depth of the vadose zones to groundwater varies significantly and can change from human actions such as groundwater pumping. Additionally, a relatively impervious layer such as clay can slow infiltration rates significantly, serving as a limiting layer that may need to be modified to better allow infiltration. Designs for SCM with distributed LID or other infiltration-dependent devices should be based on a soil survey with a core that samples soil layers through horizons for a site.

The soil infiltration rate for a given soil type also changes with environmental conditions. In particular, the infiltration rate changes throughout a precipitation event and between events. Initially, when precipitation hits dry hardened soils, runoff rates will be higher. As soils quickly absorb water, infiltration rates increase and runoff is reduced. Over time, soils become saturated. The hydraulic conductivity metric represents an infiltration rate for design calculations. Saturated hydraulic conductivity is the rate at which water passes through saturated soil media and this is often used in hydrologic modeling for stormwater designs.

Areas with similar soil types are classified by several existing data sets. The US Geologic Survey's original soil profile classification systems divided soil types into hydrologic groups with similar properties, labeled A, B, C, and D (Table 2-4). Soils of type A and B are more advantageous for infiltration, while C and D less so. These soil type groups were surveyed and estimated prior to most urban development and do not incorporate compacting or imperviousness.

Table 2-4. Soils Hydrologic Groups Indicating Infiltration Potential

Hydrologic Soil Group	Description
A	Sandy and loamy soils with low runoff potential and high infiltration rates
B	Silty and loamy soils with some infiltration potential but can reduce with saturation
C	Sandy clay loam soils that are less advantageous for infiltration
D	Clay loam, silty clay loam, sandy clay, or clay soils with limited infiltration capacity

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) hosts a web map that depicts hydrologic soils groups throughout the country. Figure 2-3 shows the diversity throughout California. The soils groups depicted represent multiple soils groups that exist within various depths of the subsurface below any particular point. As an alternative, NRCS publishes its Soil Survey Geographic Database (SSURGO) dataset with more detailed spatial estimates of soil types and hydraulic conductivities based on extensive soil sampling (Figure 2-3, right). This data is growing increasingly important in California with statewide interest in infiltration and groundwater recharge, but has been difficult to obtain due to formatting issues. However, several products, including the University of California, Davis, Soil Agricultural Groundwater Banking Index (SAGBI, UC Davis 2018; O'Geen et al. 2015) and the American River Basin Stormwater Resource Plan Webmap (OWP 2018c), make this data much easier to obtain.

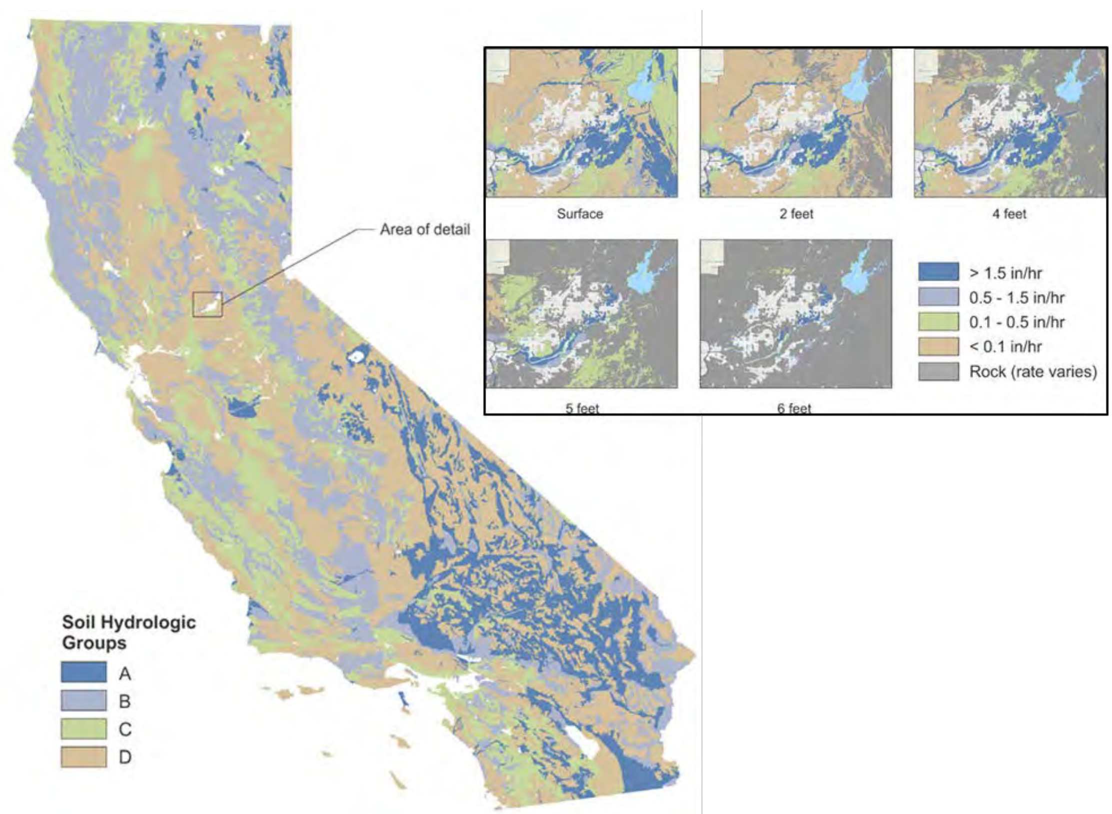

Figure 2-3. Hydrologic Soil Groups throughout California (left) and Variations with Depth (right)
NRCS 2018. Detail shows example from Sacramento, CA of saturated conductivities varying by depth.
Not to be used for design; shown for demonstration purposes only

2.2.5 Pollutants of Concern

Stormwater permits specify pollutants of concern that permittees must control. There are several decades of research studying the types of pollutants found in runoff. Such studies are integrated into water quality targets stipulated in permits. Generally, the pollutants of concern include suspended solids, metals, organic pollutants, nutrients, and bacteria. Regions can also have specific contaminants of concern because of increased levels of hazardous metals or other pollutants. Table 2-5 below lists and describes some typical pollutants in urban runoff and associated impacts on water quality. Targets for reducing these contaminants can be of several types, and are referred to as water quality standards (WQS). Total maximum daily loads (TMDLs), which are specified by the Clean Water Act, are WQS that stipulate the maximum amount of contaminant discharges to water bodies from municipal systems. They include a waste load allocation from point sources (i.e., outfalls) and an additional load allocation from non-point sources (sheet flow discharges), which are interpreted or translated through permits as targets for regional permittees. Other pollutants can be listed as contaminants of concern for impaired or threatened waters in a state as part of the EPA's 303(D) program, assigning priority for development of a TMDL.

Some regions have moved towards installing long-term planning targets with stipulated infrastructure upgrades to meet those targets. This alternative compliance pathway within stormwater permits, called reasonable assurance analysis (RAA), supports the development of regional plans that outline infrastructure spending strategies based on modeling that demonstrates long-term reductions in pollutant loads.

Table 2-5: Typical pollutants of concern in urban runoff (adapted from CASQA 2003)

Pollutant	Description
Sediments	Sediment comes from dirt, grit, and building materials in cities. It is typically measured as total suspended solids (TSS). Solids in runoff are mitigated by capturing flows and allowing time for solids to deposit into the basin of an SCM for later removal.
Nutrients	Nutrients typically include nitrogen and phosphates that are components of fertilizers used in urban areas. They can stimulate algae growth in receiving waters.
Bacteria and viruses	Bacteria and nutrients originate from animal and human feces, trash, and sewage (in combined sewer systems). Bacteria are particularly difficult to model as part of SCM designs.
Oils and greases	Oils and greases originate from many sources, including automobiles and associated shops, gas stations, restaurants, and disposal facilities. The components of oils and greases can be hazardous to aquatic life.
Organic pollutants	Organics are carbon-based products, which can be found in synthetic cleaners and may be dumped directly to storm drains and waterways.
Metals	Urban runoff contains many types of metals such as lead, zinc, copper, chromium, and nickel. Both municipal and natural sources of metals can contribute to concentrations in runoff.
Pesticides	Many types of pesticides are commercially available and often used in excess by professionals and homeowners. Pesticides include hazardous contaminants such as pyrethroids, chlorpyrifos, fipronil, and diazinon.
Trash and particulates	Tash is a current issue of significance in California stormwater management. Current regulations are considering full control of trash through installation of screens and other devices.

2.2.6 SCM Performance

During design, a modeling program or hand calculations may be used to determine size requirements. Some models may include available commercial programs such as the Hydrologic Simulation Program-Fortran (HSPF), WinSLAMM, the Stormwater Management Model (SWMM), and tailored California-specific programs such as the Phase II Sizing Tool. Other models such as GreenPlanIT from the San Francisco

Estuary Institute or the Tool to Estimate Load Reductions (TELR) are also available for regional planning but may not include necessary capabilities for modeling small-scale SCMs. Some models include means for assessing concentration and/or load reductions achievable for various SCMs.

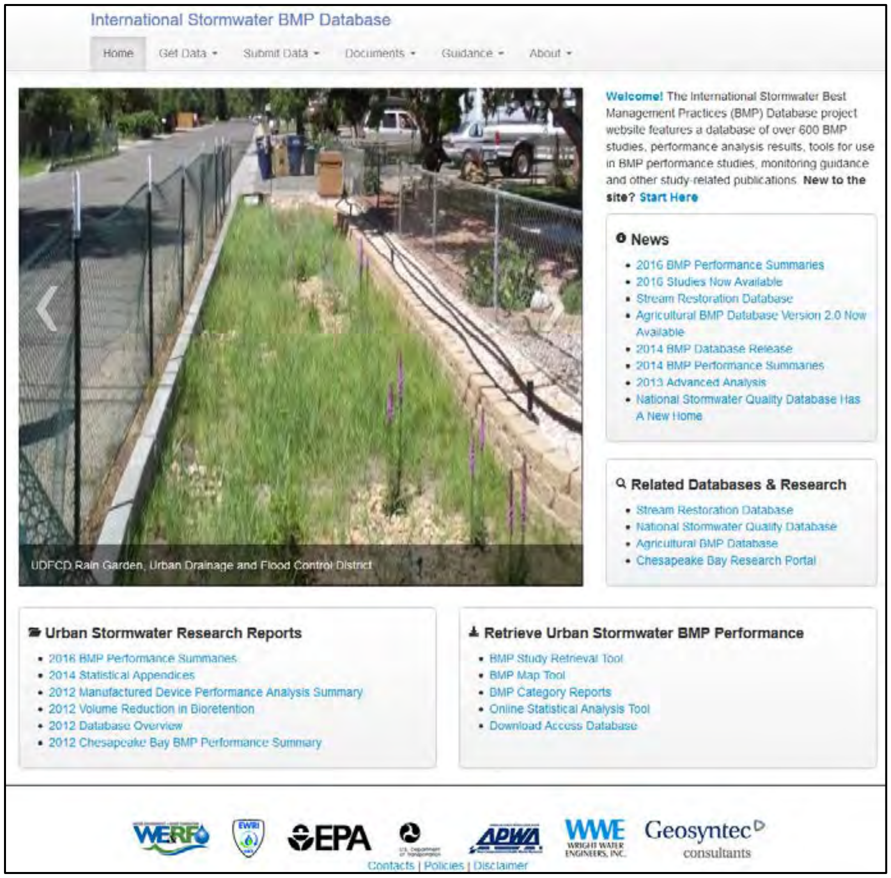

Figure 2-4. Screenshot of the International Stormwater BMP Database

The performance type will be determined during project planning with the objective being either water quality treatment and volume reduction or water quality treatment only (CWH 2016). SCMs listed in Table 2-2 having infiltration (I) as the primary treatment mechanism will provide water quality treatment and volume reduction. SCMs having primary mechanisms other than infiltration will mostly provide water quality treatment only.

Quantifying the runoff volume reduction by an SCM will be determined through modeling or hand calculations. Quantifying water quality reduction for an SCM (or merely the quality of the effluent being discharged) can be estimated from CASQA's BMP New and Redevelopment Handbook (CASQA 2003; 2018a) or the International Stormwater BMP Database (http://www.bmpdatabase.org/).

2.2.7 Surrounding Infrastructure

An important aspect of design is considering the infrastructure surrounding an SCM. In particular, site designs should consider the proximity of SCMs to buildings, runoff drainage systems, and underground utilities. The proximity to buildings is important for projects that involve infiltration; moisture damage to foundations and basements must be prevented. Guidance for SCMs often identifies setbacks of 10 feet between buildings and infiltrating devices. Alternatively, a geotechnical engineer can be consulted. Additional measures, such as the use of a vertical moisture barrier, underdrains, or trench drains, can help route water away from buildings and structures to ensure that moisture does not cause long-term damage.

Figure 2-5. A Lined Bioretention Planter
Prevents infiltration impacts to building foundation

The location of underground utilities, too, must be considered when siting and building projects. Sub-surface electric, natural gas, phone, and cable infrastructure must all be identified to prevent damage from excavations or long-term corrosion from habitual saturation. Utilities all provide services to identify sub-surface lines on construction sites. Upon request, utilities staff will come to the site to delineate utility lines.

Figure 2-6. Tying a Bioretention Planter into Existing Drainage Infrastructure

For redevelopment or retrofit projects, and even some new development projects, tapping into existing drainage infrastructure may be a good cost-savings approach. Runoff capture measures could be connected to or built around existing drain inlets, grading, surface conveyance (e.g., valley gutters), and subsurface conveyance piping to avoid costs associated with excavation and materials.

2.2.8 Vegetation Plan

A vegetation plan must include specifications for trees and/or plants, soils, and mulch or other ground cover. As part of the design process, SCMs with surface vegetation should follow existing guidance in the selection of the types and locations for plants. Important considerations include water needs and irrigation requirements, sun exposure, capacity for surviving saturated soils in SCMs such as rain gardens, and weeding and upkeep requirements. SCMs with slopes and vegetation have at minimum two separate zones of soil moisture: dry and seasonally wet or inundated.

A number of resources exist that provide guidance in selecting and siting plants within green infrastructure. For instance, the LID handbook developed by the County of San Diego (County of San Diego 2014) and available to San Diego County School Districts with stormwater programs includes an appendix with detailed, species-specific information on plant water needs, sun requirements, climate zones, and, uniquely, ideal locations within SCM landscapes where inundation varies. Some plants, such as Pacific wax myrtle or California rose, are suitable for areas of sustained inundation (up to 48 hours) during events along with longer term wet soils, while others such as toyon do better in areas of SCMs that experience more drying, such as the upper slope of a raingarden. Similar considerations should govern the species of trees that are chosen for planting. Smaller trees may establish faster and be hardier, easing landscaping and maintenance needs. Most contemporary landscape guidance documents emphasize the use of native plants for their drought adaptive traits and contributions to local habitat such as supporting pollinators.

Even if native plants are planted in a rain garden or other feature that sounds quite wet, in California's seasonal climate, plants located in SCMs may need seasonal irrigation, especially when not protected by tree canopy cover, as well as during vegetation establishment. This is especially true in the Central Valley and many parts of inland Southern California. Irrigation systems should be installed and calibrated during construction, and maintained over time similar to irrigation in other landscaping features.

In regions of the state with hot summer months, new plantings are best done in the fall or early winter to provide plants time to establish root systems that are critical for drought tolerance. Most newly-planted vegetation, even native species, benefit from watering during the first 1–2 months as they acclimate and establish root systems. However, new plantings may also be susceptible to inundation from storm events in SCMs that pool water for up to 48 hours for later infiltration. In those areas, early fall or late spring planting supplemented by additional irrigation may be beneficial.

2.2.9 Safety and Permitting

Safety considerations must be included in SCM designs. For instance, SCMs with depressed planting areas are typically designed to comply with municipal codes that reduce trip hazards. School planning requirements have specific code stipulations that specify that a drop of more than 4 inches from a sidewalk requires additional safety installations such as a curb. Design features such as curb cutouts may feed rain gardens, swales, and other structures that promote temporary ponding while meeting code requirements.

For some types of SCMs with surface or sub-surface features such as a constructed wetland or infiltration gallery, enclosures may be necessary to promote both safety and security. Designs should incorporate considerations for ease of access, as some facilities may require regular inspections. Fences or other enclosures may also be required by school building codes for areas with standing or open waters. The California Division of the State Architect (DSA) provides information on requirements for enclosures related to various SCMs.

Projects will require several types of permits. All projects in California that propose new development and structures are subject to a review of codes and regulations from the California Environmental Quality Act (CEQA). The requirements, identified in California Code of Regulations, Chapter 3 of Title 14, stipulate guidelines for performing an Environmental Impact Report (EIR) for projects before construction. A certified environmental planner will review the project and determine EIR requirements. Local and state agencies are subject to CEQA review. The California Natural Resources Agency provides introductory material for understanding basic guidelines and procedures related to CEQA requirements (http://resources.ca.gov/ceqa/).

For any construction project that disturbs more than one acre of soil, approval for a Construction General Permit (CGP) from the State Water Board is required to mitigate the effects of construction on runoff (State Water Board 2018b). To fulfill the requirements, a Stormwater Pollution Prevention Plan (SWPPP) must be developed that outlines measures to be taken for preventing debris, trash, and dirt from entering runoff. The plan must be developed by a Qualified SWPPP Developer (QSD). More information in QSD certification and a lookup tool to find QSDs is available at https://www.owp.csus.edu/stormwater-training/cgp/.

Plans meeting certain minimum thresholds for scope and cost must also be reviewed by DSA. These considerations are reviewed in Section 3.0.

2.2.10 Operations and Maintenance Needs

Operations and maintenance needs should be considered in designs. Accessibility for maintenance can be improved through site designs and orientations. Operations and maintenance considerations and requirements are discussed in detail in Section 4.0.

2.2.11 Small-Scale Landscape Features

The design considerations described above apply to projects implemented to comply with permit requirements. However, some SDMs and SCMs can be implemented as small-scale landscape features intended not necessarily to meet permit requirements, but as part of general efforts in green infrastructure and sustainability. Such measures include:

- Water wise vegetation and irrigation—using low-water plants, especially native plants, can help reduce the water needs of revamped landscapes that promote more infiltration. California's Model Water Efficient Landscape Ordinance (MWELO, CBSC 2014) is a good resource as it specifies design, installation, and maintenance practices for certain sized landscapes, with the intent of meeting an irrigation water budget that is based on landscaped area and climatological parameters.
- Curb cuts—these features allow runoff to flow from sidewalks or roads into swales and other infiltrating areas.

- Disconnected downspouts—disconnected downspouts are roof drains that direct runoff to cisterns, rain barrels, porous pavement or vegetated SCMs in lieu of discharging to grey infrastructure.
- Rain gardens—Rain gardens are depressed landscapes that capture runoff and allow it to pond and slowly infiltrate over time. Rain gardens are a simplified version of a bioretention planter, having limited infrastructure (e.g., no underdrain, overflow riser, or gravel storage).

Many online tools and guidebooks exist for such features. The requirements for design and construction are often quite accessible, making them excellent candidates for low-cost features that can include educational opportunities for schools, such as engaging students in project designs or construction.

2.3 Planning Activities

Planning activities are essential to implementing a project that meets its intended objectives and is sensitive to cost and other feasibility constraints. For purposes of this document, planning activities have been broken out into the four categories: 1) Preliminary Planning Activities; 2) Development of Project Concept; 3) Coordination with School Activities; and 4) Implementation Planning.

The Council for Watershed Health, as part of the State Water Board's Drought Response Outreach Program for Schools (DROPS), developed a resource for school administrators and other practitioners interested in having SCMs installed on school properties: Guidance for Design and Construction of Vegetated Low Impact Development Projects (CWH 2016). In addition to design and construction guidance, the document provides recommendations for project planning. The DROPS guidance is included as Appendix C of this document, for ease of reference, and the reader is directed to this appendix for recommendations on preliminary planning activities such as establishing a project team, reviewing existing information, and selecting the performance design type. Planning activities related to development of the project concept, coordination with school activities, and implementation planning are discussed in the following subsections. Planning activities and typical planning tasks are listed in Table 2-6.

Table 2-6. Planning Activities

Planning Activities	Discussion Location
Preliminary Planning Activities	Appendix C*
• Establish project team • Review existing information • Select the performance design type	
Development of Project Concept	Section 2.3.1
• Estimate existing metrics • Quantify desired performance • Conduct preliminary sizing • Identify long term maintenance needs • Document final concept	
Coordination with School Activities	Section 2.3.2
• Incorporate runoff management into CIP planning • Evaluate traffic routing • Coordinate construction staging	
Implementation Planning	Section 2.3.3
• Identify reporting requirements • Secure funding • Identify permitting requirements • Develop plan for vegetation establishment and maintenance • Develop plan for waste disposal • Develop monitoring plan • Document final plan	

** DROPS Guidance (CWH 2016)*

2.3.1 Development of Project Concept

The steps below describe the process for developing an appropriate project concept, which will be later carried forward into the design process.

Estimate Existing Metrics

The first step in developing the SCM project concept is to estimate the runoff volumes and flow rates that are to be managed. The school's topography should be assessed to evaluate surface drainage, to identify topographic high and low points, and to identify the presence of steep slopes that qualify as hillside locations. All these have an impact on what type of SCM will be most beneficial for a given project site. Runoff infiltration is more effective on level or gently sloping sites. On hillsides, infiltrated runoff may daylight a short distance down the slope, which could cause slope instability depending on the soil or geologic conditions or result in nuisance seepage. The analysis should also evaluate the pollutant types and concentrations that will be expected at the project site. This will help inform selection of SCMs.

Quantify Desired Performance

The next step in project concept development is to establish the desired performance of the SCM in terms of both the flow reduction and pollutant reduction. This analysis should consider the area available, funding constraints, site hydrology, and the environmental threat of discharged runoff. In addition, human health concerns should be prioritized, particularly with regards to vector control issues arising from the addition of standing water on site. Site constraints such as endangered species habitat, protected vegetation, and archaeological resources should be considered in site selection. Opportunities for site selection might include low areas, oddly configured areas, or otherwise unbuildable locations.

Conduct Preliminary Sizing

While the design process determines the final sizing and dimensions of the SCM project, it is generally necessary to determine a rough estimate of the dimensions of the project elements during the planning process. This preliminary sizing provides an estimate of the area of the project, i.e., the project footprint, and the dimensions of project elements. This information is required to perform planning tasks such as permitting, project location determination, traffic routing, and design type selection. The design methods presented in Section 2.4 can be used for preliminary sizing, but with a less rigorous estimation of the variables. Alternatively, the project manager can estimate the preliminary size based on previous experience with similar projects or general knowledge of SCM project performance.

Identify Long-Term Maintenance Needs

"Design with maintenance in mind" is a valuable strategy for managing costs and feasibility of a project. DeepRoot Green Infrastructure, a San Francisco-based company, posted an insightful blog breaking down maintenance aspects to be considered during project design and planning, as summarized in Table 2-7 (DeepRoot 2018). In many cases, incorporating features that lessen long-term maintenance efforts and costs may be well worth any additional capital cost investments.

Maintenance agreements should be developed between the SCM owner and the group in charge of maintenance to designate the parties responsible for each activity. A copy of the operations and maintenance plan should be included in the agreement. See Section 4.0 for information regarding maintenance activities and documented plans

Table 2-7. Design with Maintenance in Mind

Maintenance Considerations
Funding: *"The most important first step is to establish a maintenance budget that is tailored to the specific BMPs that need to be maintained. There are resources available that outline the level and intensity of maintenance required for various installations. Communities that have working GI [green infrastructure] systems can also be a valued resource with a budget set to identify long term sources of funding like a stormwater utility fund or a local improvement district. The source of funding for labor, equipment, and materials should be in place prior to selecting and designing a GI system. Failure to establish funding sources can result in failed systems with costly and sometimes dangerous impacts."*
Equipment: *"Designers should verify early in the design process what equipment is available for the care of infrastructure systems. This can include commonly-owned equipment from lawn mowers and power washers to specialty items such as weed burners or vacuum sweepers. Designers should not include types of facilities for which proper maintenance equipment is not or will not be available. Additionally, designers should strive to design systems that "fit" the equipment. A simple example of this approach can be found in the design of a roadway curb cut. A roadway curb cut is a depression in a roadside curb that allows for stormwater to flow from the roadway pavement surface, across the top of the depressed curb, and into an adjacent landscaped zone or bioretention facility. Curb cuts come in all shapes and sizes and designers must consider surface conditions, flow rates, and slopes. By also considering O&M, a designer may elect to widen the opening to fit a shovel or shape the curb to permit effective street sweeping. By speaking with maintenance personnel and familiarizing themselves with equipment, engineers can design more cost-effective GI solutions."*
Materials: *"The availability of appropriate materials will have a significant impact on the function and lifecycle of GI facilities. Maintenance protocols will include the repair and replacement of materials impacted by utility cuts, damage, die-off, etc., so designers should verify early in the design process the material sources available for the construction and care of infrastructure systems. These materials can include familiar supplies like bark mulch or specialty materials like bioretention soil or pervious concrete. Establishing material availability will ensure that maintenance personnel can perform their tasks to keep stormwater facilities in top shape."*
Appropriate Staff: *"GI facilities perform multiple functions beyond those related to simply stormwater. These include serving as a landscaped buffer, a habitat, a transportation surface, a roof surface, or even a play or educational feature. Where traditional maintenance functions have included street sweeping by the roadway crews, catch basin cleaning by utility personnel, and planting maintenance by landscape crews, GI systems can overlap traditional trades. Determine early on which personnel have the authority and capability to maintain the proposed GI. There may be a need to hire additional staff in order to meet maintenance needs. This can include seasonal staff during the spring growing season or in the fall when leaf debris increases."*
Aesthetic vs Function: *"When selecting GI facilities, designers must establish with owners the desired aesthetic and discuss the level of effort and maintenance protocol to maintain that aesthetic. Owners should be made aware of what the facility will look like when mature and what level of maintenance effort will be required to keep the facility looking that way. Part of maintenance protocols includes establishing a level of effort. This should be done with the owner early in the project as part of the vetting process to ensure that there are sufficient staff and funding."*

(DeepRoot 2018)

Document Final Concept

The development of the SCM project concept is an iterative process. As information is developed and costs are evaluated throughout the planning period, the concept may be adjusted to meet project constraints. Stakeholder input should be gathered during the planning period to adjust and focus the concept. The final concept should be documented, along with the rationale and estimated project cost.

2.3.2 Coordination with School Activities

The activities below summarize coordination with school activities that should occur when planning for the SCM project.

Incorporate Runoff Management into CIP Planning

The implementation of SCM projects will likely alter the flow patterns of runoff on the school campus. While most SCM projects will reduce the volume of runoff from the campus (more runoff will be infiltrated, as opposed to discharged to surface water), portions of the campus may experience increased runoff flow if water is diverted towards SCMs. In any case, the school should consider the changes in runoff patterns and possibly put measures in place to manage these changes in flow. Any infrastructure projects needed to manage flow changes should be incorporated into the overall capital improvement plan (CIP) for the school.

Evaluate Traffic Routing

Implementation of SCM projects have the potential to disrupt traffic patterns if the footprint of the project impinges on walkways, bike lanes, roads, or other transportation corridors on the school campus. A plan should be established to ensure that foot, bike, and car traffic loads can be maintained after the SCM project is constructed. This could involve rerouting of traffic or development of alternative routes to maintain traffic flow. If porous pavement is an element of a proposed SCM and the porous pavement is replacing impervious pavement that is used for vehicle traffic, the ability of the porous pavement to manage the previous vehicle traffic load needs to be considered.

Coordinate Construction Staging

The timing of the construction activities should consider both the school schedule and seasonal time of year. It may be less disruptive to students if construction activities occur in the summer or at other times when school is not in session. If the project involves work below grade (e.g., detention basins or bioretention planters), work will be more difficult in the rainy season, when run-on to the construction site must be managed. If the SCM involves planting of vegetation, the planting schedule should be coordinated with the planting season and weather to ensure that plants have an optimal chance for establishing healthy growth.

2.3.3 Implementation Planning

The following considerations relate to planning for project implementation activities.

Identify Reporting Requirements

Reporting requirements are typically driven by the permits and regulatory requirements that applied to the SCM project during project construction. Local and state agencies may require annual reporting of monitoring and operational information. The State Water Resources Control Board (State Water Board) obtains information on runoff projects through their Stormwater Multiple Application and Report Tracking System (SMARTS). This is a platform where dischargers, regulators, and the public can enter, manage, and view storm water data including permit registration documents, compliance, and monitoring data associated with California's Storm Water General Permits. The schools that are required to use this reporting method will be required to log onto the SMARTS system and enter information on SCM projects.

Secure Funding

It is critical that sources of funding for the SCM be identified early on to ensure successful project implementation. Funding must be identified for the initial planning, design, and construction activities as well as for future operation and maintenance (O&M) activities. Establishing funding for ongoing O&M activities is particularly important. A number of SCMs require ongoing maintenance, e.g., maintaining healthy vegetation, removing weeds, excavation of deposited materials in basins, and cleaning out of drains. These activities often require skills outside of the normal work of school maintenance staff. If these O&M tasks are not budgeted for, the value of the initial SCM construction project will be negated, as continuous, on-going O&M is necessary to ensure effective long performance of the SCM. Specific recommendations for O&M of SCMs is provided in Section 4.0 of this document.

Identify Permitting Requirements

Permitting requirements can vary widely depending on the type of SCM project and location within the state. It is important to identify permitting requirements early as the process to obtain applicable permits can be time consuming. In California, some SCM projects will be regulated under the California Environmental Quality Act (CEQA), and so must comply with all applicable CEQA requirements. Under CEQA, projects are subject to review for any adverse impacts the projects may have on the environment, including those impacts from runoff discharges. The CEQA compliance process begins with the preparation of an Initial Study and Checklist. If no significant effect upon the environment is found, a Negative Declaration will be issued for the project. If mitigation measures are needed, a Mitigated Negative Declaration (MND) is issued for the project, or an Environmental Impact Report (EIR) may be required. Additional permitting requirements could include zone variances, conditional use permits, planning permits, building permits, and grading permits.

In addition to these activities, project planners should also be aware of requirements of Section 404 of the Clean Water Act and California's Porter Cologne Water Quality Control Act, which protect wetlands from development. Actively managed runoff detention facilities, small and large, are generally not subject to these development and permitting requirements, as they are not naturally-occurring wetlands. To qualify for exemptions, they must be actively managed with record-keeping detailing regular trash removal, inspections, erosion control, and mowing and weeding. One exception is if sites contain endangered species, which should be assessed during the planning and design phase. In these cases, much stricter management and protection requirements would apply to the site (WRA 2015).

Develop Plan for Vegetation Establishment and Maintenance

A number of SDMs and SCMs (e.g., tree planting, bioswales, bioretention planters, and wetlands) involve the establishment and maintenance of vegetation. Maintaining the health of this vegetation throughout the life of the SCM is essential for adequate performance of the SCM. Upfront planning should occur to ensure both the successful establishment of the vegetation as well as the long-term maintenance of the vegetation. Resources must be identified up front so that both these processes are successful. Resources include both the identification of the staff responsible for the establishment and maintenance of vegetation, as well as a demonstrated commitment of these staff, and access to water and nutrients to ensure plant establishment and health.

Develop Plan for Waste Disposal

Installation and maintenance of some SCMs have the potential to generate waste materials for which disposal procedures must be developed. For example, plant material must be periodically removed from some SCMs, such as biostrips, bioswales, and bioretention planters. Additionally, dry wells, infiltration basins, and detention basins must be periodically cleaned of soils and settled solids. Grates and drains must be cleaned of debris and material that can impact optimum performance. These waste materials will generally be inert, non-hazardous waste materials, but plans should be put in place to characterize any waste streams that could possibly be defined as hazardous under California regulations. Hazardous wastes require more stringent storage and disposal procedures that must be followed to maintain compliance with these laws. A plan for waste disposal should be put in place before SCM construction.

Develop Monitoring Plan

Once the SCM is constructed, monitoring activities must be performed both to assess SCM performance and to ensure any permit monitoring requirements are met. This monitoring can take the form of visual inspections, runoff sampling, flow measurements, and assessments of operational performance. These monitoring activities must be planned for before SCM operation. For more complex operations, a monitoring plan can be prepared and template monitoring forms developed. Staff to perform the monitoring must be identified and procedures documented to record and analyze monitoring results.

Document Final Plan

For simpler projects with fewer stakeholders involved and fewer planning tasks, the planning activities discussed above can be documented through informal communication amongst the project team. For more complex projects, it may be useful to prepare a written document describing all planning activities. This written report, which could be entitled a "Feasibility Study" or "Project Planning Report" provides the overall identification and coordination strategy of planning tasks. This approach will also inform project stakeholders of all planning activities so that they can provide input and understand all planning elements. The documented plan will identify an overall approach to managing and scheduling planning tasks to ensure efficient management of planning tasks and identification of critical paths. The plan also provides written documentation of project decisions and a record of actions that may be useful for development of other SCM projects.

2.4 Design Methods

The primary objective for the runoff capture devices featured in this document is to improve water quality. In regards to design, this is accomplished by retaining and/or treating a specified runoff volume or flow rate to reduce pollutant discharge as well as matching preconstruction flow rates to reduce hydromodification impacts. The following subsections summarize the methods typically used for retaining and treating runoff and reducing hydromodification. Resources for detailed design standards that have been developed throughout California are also provided.

The Council for Watershed Health's DROPs guidance (CWH 2016), previously mentioned in Section 2.3, serves as an excellent resource for design guidance, with topics ranging from selection and siting, to plant selection, to considering pedestrian walkways that preserve newly implemented SCMs. It also has an extensive appendix with pictures of good design practices, as well as poorly implemented SCMs. This guidance appears in Appendix C for convenient reference. The DROPS guidance includes a discussion on sizing aspects of design, focusing on a simple and appropriate volumetric design storm method. There are, however, other methods allowed by the Phase II permit as well as other methods used by Phase I permittees. To supplement the guidance provided by DROPS, the subsections below summarize the following topics related to sizing and other design approaches: retention and treatment design, hydromodification design, and existing design standards. Particular topics are listed in Table 2-8.

Table 2-8. Design Topics

Design Topics	Discussion Location
Retention and treatment design	Section 2.4.1
Hydromodification design	Section 2.4.2
Existing design standards	Section 2.4.3
Ensuring runoff can enter and exit the project	Appendix C*
Protecting adjacent structures from runoff intrusion	Appendix C*
Using ponding depth and check dams to enhance infiltration	Appendix C*
Using appropriate plants and landscaping materials	Appendix C*
Determining the irrigation approach	Appendix C*
Avoiding sediment and erosion problems	Appendix C*
Considering pedestrian circulation and use	Appendix C*

** DROPS Guidance (CWH 2016)*

2.4.1 Retention and Treatment Design

Retention and treatment design evaluates the size devices need to be to prevent or reduce pollutant discharge, while recognizing cost and other feasibility limitations. To balance water quality and costs, practitioners have generally accepted a handful of sizing methods, which fall into either volume-based or flow-based categories. These are described in the following subsections.

Volumetric Design Storm Method

The volumetric design storm method is an algebraic water balance in which the device must be able to capture the volume of runoff generated from a specific rain depth that falls onto a specific area. The depth is approximated by ranking several years of 24-hour rainfall data and calculating the depth at which a certain percent of the storms are smaller. The 85th percentile is a common a rule of thumb based on research showing that more frequent, smaller storms have the greatest amount of pollutants. The design storm depth is multiplied by the drainage area and a runoff coefficient, the latter of which represents a fraction of the rainfall that becomes runoff (often 0.9 for impervious surfaces). The storage within the SCM—including within the void space of the media, ponding zone, or open space—must be large enough to hold this design storm volume.

Volumetric Percent Capture Method

The volumetric percent capture method models many rain events and the resulting runoff from a drainage area, as well as the infiltration, evapotranspiration, storage, and discharge from runoff management devices. The models use many years of historic rainfall and evaporation data (often in hourly time-steps), runoff coefficients appropriate for the drainage area land cover (representing the fraction of rainfall that becomes runoff), on-site soil properties (for infiltration estimates), and capture device characteristics such as depths and media porosities to calculate and record volumes of runoff that is evapotranspirated, infiltrated, and discharged from SCMs across each time step. The cumulative volume is then divided by the total simulation period to determine an annual average volume. This annual average volume is targeted as a specified percent of the total annual average volume of runoff generated. A common target based on the idea of a point-of-diminishing returns at which the costs for capturing larger volumes begins to increase is 80%.

Baseline Bioretention Method

For the baseline bioretention method, the size and other characteristics of a bioretention planter are pre-established without regard to local precipitation data. A common example is a planter that is 4% of the drainage area, with 18 inches of bioretention soil mix, 12 inches of gravel storage, an elevated underdrain, and other specified components. These standards are based on research indicating that such designs result in roughly 80% capture of the runoff generated, and is therefore a simplification of the percent capture method.

Flow-Based Method

The flow-based method sizes an SCM to retain and treat the flow of runoff produced from a rain event of a specified intensity. Common intensities are 0.02 inches per hour or 2 times the 85th percentile rainfall intensity based on historic rainfall data.

2.4.2 Hydromodification Design

Hydromodification design is intended to minimize impacts from higher runoff volumes and flow rates. The objective is to closely match post-construction flow rate discharge to that which occurred pre-construction. For this design, models are run to simulate pre-and post-construction flow rates for a specified return interval such as the 2-yr or 10-yr 24-hour storm; it is generally accepted that the greatest effects of hydromodification occur from these (or between these) recurrence intervals. Other methods are more sophisticated, using statistical analysis to evaluate probability of exceedance for the post-construction condition.

2.4.3 Existing Design Standards

Many municipalities throughout California have been subject to MS4 permit requirements for several years, and so have already established design standards for preventing and minimizing runoff. The standards provide specifications for the technical aspects of runoff management, including types of materials to be used; numerical retention, treatment, and hydromodification design criteria and tools; and required maintenance activities. These standards were developed with specific regional interests in mind, and can serve as resources for design specifications for schools in the interest of regional sustainability and consistency. Appendix D lists MS4 permittees and their design manuals. The Phase II LID Sizing Tool (OWP 2018) includes a map of school properties and MS4 permittee boundaries to assist in identifying design standards that may be useful for schools (based on proximity).

2.5 Construction Considerations

Activities required for SCM installation include those typical for most construction projects: staging, surface and infrastructure preparation, excavation, infrastructure placement, regrading, planting and vegetation establishment. The following subsections highlight topics related to construction of SCMs on school properties. The reader is also referred to the Guidance for Design and Construction of Vegetated Low Impact Development Projects (CWH 2016, included as Appendix C of this document) developed for the State Water Board's DROPS, which provides additional suggestions, as listed in Table 2-9.

Table 2-9. Construction Considerations

Construction Considerations	Discussion Location
Construction general permit compliance	Section 2.5.1
Scheduling	Section 2.5.2
Nuances of SCM construction	Section 2.5.3
SCM specific considerations	Section 2.5.4
Reviewing the project design with the construction team	Appendix C*
Preparing for different construction techniques and material requirements	Appendix C*
Making sure proper protections are in place and checking the native soil condition	Appendix C*
Conducting excavation, placing materials, and setting elevations	Appendix C*
Completing construction	Appendix C*

** DROPS Guidance (CWH 2016)*

2.5.1 Construction General Permit

Construction activities that disturb a specified area of land (i.e., clearing, grading, excavating, and stockpiling—including installation of structural capture practices) are subject to requirements in California's General Permit for Discharges of Storm Water Associated with Construction Activity. The requirements include development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP must be created by a Qualified SWPPP Developer (QSD) and implemented by a Qualified SWPPP Practitioner (QSP). The SWPPP must include potential pollutant sources; pollution prevention practices; inspections, maintenance, and repair of pollution prevention equipment; spill response; and other elements. The State Water Board's construction general permit webpage provides specific information.

2.5.2 Scheduling

As cornerstones of communities, schools are busy places that often host activities during non-classroom hours, such as after-school camps, scout meetings, parent-teacher conferences, festivals, or recreational soccer games. Scheduling when and where various construction activities can occur so as to minimize activity disruptions can be challenging. For some schools, summer may be an ideal time for construction if school is not in session, although the long, dry summers typical of much of California can be difficult for plant establishment, even if irrigation is provided. These examples demonstrate that sequencing and staging of construction activities should be considered during the planning stages of the project and confirmed during design and at the start of construction.

2.5.3 Nuances of SCM Construction

Compared to conventional drainage infrastructure, the runoff management practices featured in this document focus on capture, retention, and treatment of small storms. This is a relatively new concept to many contractors and developers. The Central Coast LID Initiative developed a useful and concise Technical Assistance Memo (TAM) that informs practitioners on the nuances of LID implementation. The pointers in the TAM are directly applicable to the runoff practices covered in this document, such as avoiding compaction of soils to allow runoff to infiltrate. A copy of the TAM is provided as Appendix E of this document.

Pitfalls of SCM Construction

- *Installing inlets flush to ground in lieu of raising them*
- *Swapping specified bioretention soil mix with a mix not designed for water quality treatment*
- *Allowing heavy equipment and compaction on areas intended for infiltration*
- *Actual on-site soils having lower infiltration potential than intended design*
- *Sloping curb cuts away from SCMs*
- *Planting when weather is too hot*

2.5.4 SCM Specific Considerations

The factsheets in Appendix B note construction considerations specific to each SCM. Examples include:

- Following proper confined space entry practices
- Conducting leak detection
- Preventing sediment from entering SCM
- Scheduling vegetation establishment to minimize irrigation needs and plant loss/damage
- Mitigating plant damage
- Field verifying soil characteristics
- Following manufacturer guidelines

2.6 Costs

While runoff prevention and capture practices have numerous benefits, there is a monetary expense, as indicated by the extensive discussion on planning, design, and construction activities provided above. Beyond those costs, materials, labor, and fees required for installing and maintaining the devices need to be accounted for to ensure the desired benefits are achieved. Planning, design, capital, and maintenance costs for runoff management practices vary according to region, types of practices, design features, and industry demand.

2.6.1 Cost Resources

Cost estimates can be definitive based on final or near-final design specifications or an order-of-magnitude level needed during the planning stage to secure project funding. Estimates will also need to include a contingency amount intended to account for unknown occurrences such as increased labor or materials rates or unexpected field conditions requiring design alternations.

There is a variety of literature summarizing costs for various types of runoff management projects. Table 2-10 lists several and Appendix F provides an annotation of each.

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1 **Table 2-10. Resources for Developing Costs of Runoff Management Projects**

Resource	Type of Cost		SCMs Evaluated	Cost Information Type	Associated References
	Capital	O&M			
USEPA National Stormwater Calculator[1]	X	X	• Downspout disconnect • Rain Barrel/Cistern • Bioretention/Rain Garden • Green Roof • Street Planter • Infiltration Basin • Porous Pavement	• Regression Equations • Software Application	• Rossman and Bernagros (2014) • Clary and Piza (2017)
University of Minnesota/Weiss BMP Cost Estimation Algorithm[1]	X	X	• Detention Basin • Wet Basin • Sand Filter • Constructed Wetland • Bioretention/Rain Garden • Infiltration Trench	• Literature Review • Regression Equations	• Weiss et al. (2007) • EPA (1999) • Clary and Piza (2017)
University of New Hampshire Maintenance Expenditure Study [1]		X	• Wet/Dry Pond • Swale • Bioretention/Rain Garden • Sand Filter • Subsurface Wetland • Porous Pavement	• Physical models at field facility	• Houle et al. (2013) • Clary and Piza (2017)
WE&RF-AWWA-UKWIR Whole-Life Costs Tool[1]	X	X	• Retention Pond • Detention Basin • Vegetated Swale • Bioretention/Rain Garden • Porous Pavement • Green Roof • Infiltration Practices	• Surveys/Site Visits • Spreadsheet Tool	• Andrews and Lampe (2005) • Clary and Piza (2017)
The National Cooperative Research Program (NCHRP) Whole-Life Cost Models[1]		X	• Swale • Bioretention	• Literature Review • Surveys	• Taylor (2014)

Resource	Type of Cost		SCMs Evaluated	Cost Information Type	Associated References
	Capital	O&M			
ASCE EWRI Survey of BMP O&M Costs[1]	X	X	• Permeable Pavement • Bioretention/Rain Garden • Infiltration Basins/Trench • Rainwater Harvesting	• National Survey • Tabular Data Tool	• EPA (1999) • Clary and Piza (2017)
Urban Drainage and Flood Control District's BMP-REALCOST Tool[1]	X	X	• Detention Basin • Retention Pond • Constructed Wetland • Bioretention • Permeable Concrete Paver • Sand Filter Basin	• Informational Interviews • Engineering Judgment • Spreadsheet Tool	• Clary and Piza (2017) • Urban Drainage and Flood Control District (2018)
Wossink and Hunt (2003) Empirical Cost Evaluation of SCMs in North Carolina	X	X	• Stormwater Wetlands • Wet Pond • Sand Filter • Bioretention	• Phone Surveys • Site Contacts • Regression Equations	• Wossink and Hunt (2003) • Clary and Piza (2017)
USEPA Water Financing Clearinghouse LID and GI Case Study Inventory	X	X	• Varies by Study	• Varies by Study	• EPA (2013)
Green Values National (GVN) Stormwater Management Calculator	X	X	• Green Roof • Disconnect Downspout • Cisterns/Rain Barrel • Swale • Vegetated Filter Strip	• Literature Review • Regression Equations • Online Assessment Tool	• Center for Neighborhood Technology (2009)
SCM Databases for Generating Capital and O&M Cost Equations	X	X	• Bioretention • Dry Pond/Detention Basin • Bio-Filtration • Infiltration Basin • Infiltration Trench • Porous Pavement • Sand Filter • Gravel Wetland System	• Databases • Regression Equations • Tabular Data Tool	• Urbonas (2002) • Brown and Schueler (1997) • SWRPC (1991) • Torno (1984) • Knight et al. (1994) • RS Means Company (2018)

[1]*Resource summarized in ASCE EWRI 2017*

2.6.2 Balancing Capital and Maintenance Costs

The "design with maintenance in mind" concepts presented in Section 2.3.1 can support feasibility and help manage costs of SCM O&M activities. As discussed, during the planning and design stages, alternative project details should be evaluated in the interest of minimizing maintenance and repair costs. Given the ongoing limitations of funding for schools, investing in higher, upfront costs for capital infrastructure and features that may reduce the maintenance burden may be more cost-effective over the life of the SCM.

2.6.3 Cost-Benefit Considerations

The SDMs and SCMs presented in this document, as a subset of green infrastructure practices, are often claimed to be cost-effective with lots of opportunity for savings. A number of studies comparing the costs of green and grey infrastructure were tallied by USEPA. The studies and USEPA's descriptions of them are provide in Table 2-11.

Table 2-11. Studies Comparing Costs of Green and Grey Infrastructure (USEPA 2018)

Cost Analyses
Low Impact Design vs. Conventional Development *
"This report compares the construction costs of conventional and low impact development (LID) approaches for nine subdivisions in the United States and Auckland, New Zealand."
Pembroke Woods: Lessons Learned in the Design and Construction of an LID *
"This case study of a 43-acre residential subdivision in Frederick County, Maryland, documents the cost savings achieved by adopting a green infrastructure approach. Cost savings were realized by: • *Eliminating the need for stormwater management ponds;* • *Reducing the extent of clearing, grubbing, and paving; and* • *Adding two additional lots."*
Changing Cost Perceptions: An Analysis of Conservation Development *
"This report prepared for the Illinois Conservation Foundation and Chicago Wilderness compares the stormwater management costs of conservation development with those of conventional development. It defines conservation development as an approach that "addresses stormwater on-site by distributing water across the landscape."
Low Impact Development at the Local Level: Developers' Experiences and City and County Support *
"This report by ECONorthwest focuses on two aspects of LID adoption at the local level: the experiences that developers have had with LID, and actions that local jurisdictions can take to increase LID use. "
Forging the Link, Chapter 3: Economics and LID *
"This report by the University of New Hampshire Stormwater Center documents case studies demonstrating how adopting a green infrastructure approach can lead to more cost-effective site designs and stormwater management systems."
Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*
"This EPA report summarizes 17 case studies of developments that include LID practices and compares project costs to typical costs for conventional development."
The Economics of Low Impact Stormwater Management in Practice—Glencourt Place*
"This paper compares the life cycle costs of a green infrastructure approach with those of a conventional approach to a retrofit of a residential subdivision."

** Documents and references available at USEPA 2018.*

However, evaluating costs alone do not fully represent their economic feasibility or potential. Cost analyses alone "… ignore the differences in performance between green infrastructure and gray infrastructure. As a result, they provide an incomplete basis for decision-making," according to the USEPA (2018). As an alternative, cost-benefit analysis "…provides a more complete basis for decision-making. It considers costs as well as environmental, social, and public health outcomes of alternative management approaches. The result is more complete information on the benefits associated with different stormwater control options."

(USEPA 2018). Table 2-12 lists cost-benefit studies cited by USEPA and their descriptions. Table 2-13 lists tools recommended by USEPA for gathering information sufficient to initiate conversations with stakeholders regarding the benefits and costs of green infrastructure, such as SCMs.

Table 2-12. Studies Evaluating Costs and Benefits of Green Infrastructure (USEPA 2018)

Cost-Benefit Analyses
The Economic Benefits of Green Infrastructure: A Case Study of Lancaster, PA*
"This case study estimates the value of several of the cost benefits of Lancaster's Green Infrastructure Plan. It highlights the importance of including the multiple benefits of green infrastructure in cost-benefit assessments and adding green infrastructure into planned improvement projects."
Case Studies Analyzing the Economic Benefits of LID and Green Infrastructure Programs*
"This EPA report summarizes 13 economic benefit analyses conducted by public entities across the country to assess the effectiveness of their green infrastructure programs. The case studies represent a range of methodologies, geographic contexts, and municipal program types."
The Economics of Low Impact Development: A Literature Review*
"This literature review summarizes the benefits of LID, methodologies for assessing the economic impact of LID, and results of more than 50 studies."
NYC Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways*
"In this plan released by New York City, the modeling results indicate that a combined sewer overflow (CSO) reduction strategy that combines green and gray infrastructure can yield greater reductions in CSO volumes at a lower cost than an all-gray strategy while providing more community benefits."
A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds*
"This report compares the benefits of a green infrastructure approach to CSO control to the benefits of a traditional tunnel approach. It monetizes a range of environmental, social, and public health benefits."
Fresh Coast Green Solutions: Weaving Milwaukee's Green & Grey Infrastructure for a Sustainable Future*
"This presentation by the Milwaukee Metropolitan Sewerage District explains Milwaukee's goal of achieving zero sewer overflows with combined green and gray systems. It compares capital costs for different green infrastructure measures and provides a detailed summary of the multiple environmental, social, and economic benefits associated with the measures."
Municipal Forest Benefits and Costs in Five US Cities*
"This article describes the structure, function, and value of street and park tree populations in: • *Fort Collins, Colorado;* • *Cheyenne, Wyoming;* • *Bismarck, North Dakota;* • *Berkeley, California; and* • *Glendale, Arizona.* *Although these cities spent $13 to $65 annually per tree, benefits ranged from $31 to $89 per tree. For every dollar invested in management, benefits returned annually ranged from $1.37 to $3.09."*
Cost Benefit Evaluation of Ecoroofs 2008*
"This report attempts to quantify the private and public costs and benefits of green roofs—or "ecoroofs"—in Portland, Oregon. Ecoroofs are expected to be an important part of the city's urban strategy as it grows and density increases in the decades to come."

** Documents and references available at USEPA 2018*

Table 2-13. Tools Evaluating Costs and Benefits of Green Infrastructure (USEPA 2018)

Cost-Benefit Tools
Green Infrastructure Opportunities that Arise During Municipal Operations*
"This report provides approaches that local government officials and municipal program managers in small to midsize communities can use to incorporate green infrastructure components into work they are doing in public spaces. The document presents examples and case studies of how integrating green infrastructure methods can enhance retrofits and maintenance projects and provide other multiple community benefits."
The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental, and Social Benefits*
"This guide describes the steps to quantifying and valuing many of the environmental, social, and public health benefits of green infrastructure. It includes simple, illustrative examples to assist decision-makers, planners, and communities in performing their own calculations."
Green Values National Stormwater Management Calculator*
"This screening-level tool developed by the Center for Neighborhood Technology allows site designers to quickly compare the performance, costs, and benefits of green infrastructure practices to conventional stormwater practices."
National Oceanic and Atmospheric Administration's Office of Coastal Management*
"NOAA's programs and data tools for analyzing costs and benefits of green infrastructure for coastal areas".

** Tool references available at USEPA 2018*

3.0 CODES INFLUENCING RUNOFF CAPTURE PRACTICES AT SCHOOLS

3.1 How Codes Can Impact Runoff Capture

California code, both directly by the legislature as statute or by promulgation by a state agency as regulation, can impact the runoff minimization (SDMs) and runoff capture measures (SCMs).

California statutes and regulations impact the placement of vehicle-bearing surfaces. However, they do not always specify that impervious surfaces must be used. These requirements and how they impact SDMs and SCMs are presented in this section, along with a discussion of whether the requirements are a hard barrier to runoff prevention and capture measures or merely a design consideration. This section also recommends improvements or changes to existing requirements or policy to improve implementation of SDMs and SCMs. Guidelines that could be improved toward better stormwater planning are also listed

3.2 Relevant Requirements and Potential Barriers

Table 3-1 contains analysis of regulations for relevance to minimizing impervious surfaces via SDMs or incorporation of SCMs into the facility infrastructure. As noted in the table, no modifications for supporting compliance with stormwater regulations, without compromising safety or learning objectives, were identified.

The following areas were thought to have regulations affecting SDM and SCM implementation, however, no impact was found:

- Minimum shade
- Covered lunch areas
- Security or barriers around standing water

Finally, some policies support consideration of SCMs and regional projects. For example, Education Code §35275 requires meeting with appropriate local government, recreation, and park authorities to consider possible joint use of the grounds and buildings and to coordinate the design to benefit the intended users. Such collaboration could also provide a platform for regional urban runoff projects.

3.1 Recommended Changes in Policy or Regulation

Table 3-2 lists recommendations for modifying policies, law, regulations, and guidance in order to better promote implementation of SDMs and SCMs at school properties.

Table 3-1. Review of Potential Regulatory Barriers to SDMs and SCMs

Requirement	Authority/Regulation	Imperviousness Required	Recommended Change[1]
Site layout: parking, loading, drop off	Title 5 §14030	No (but could impact SCM placement)	None
Americans with Disabilities Act (ADA) as incorporated into Title 25 (California Building Standards Code) for sidewalk widths and parking stall widths	CBC Title 24 Part 2, Chapt 11B	No (Impacts minimum widths and turning radii, but allows pervious surfaces are allowed)	None
Overall minimum facility size: • For kindergarten and grades one through six: 59 square feet per pupil • For grades seven and eight: 80 square feet per pupil • For grades nine through twelve: varies from 91.5 square feet per pupil for an enrollment of 2,400 to 127 square feet per pupil for an enrollment of 400	Title 5 §14001 (and forward)	Yes	None[1]
Playground and Field Areas: adequate physical education teaching stations (including hardcourts)	Title 5 §14030	Yes (hardcourt minimums vary by grade and number of pupils)	None[1]
Classroom size: grades one through twelve may not be less than 960 square feet	Title 5 §14030	Yes	None[1]
Kindergarten classroom size for permanent structures may not be less than 1350 square feet	Title 5 §14030	Yes	None[1]
New school resource specialist program: at least 240 sq ft for the resource specialist program	Title 5 §14030 Education Code §17747(a)	Yes	None[1]
New school speech and language program : at least 200 sq ft.	Title 5 §14030	Yes	None[1]
Science and home economic labs: at least 1300 sq ft	Title 5 §14030	Yes	None[1]
Library space: proportional to the maximum planned school enrollment; at least 960 sq ft	Title 5 §14030	Yes	None[1]
Computer laboratory: at least 960 sq ft	Title 5 §14030	Yes	None[1]
Fire Access: all-weather hard-surfaced at least 20 feet in width	CCR Title 19 §3.05(a)	No	None
All Parking: faculty, staff, students, visitors	CFC §503.4 CCR Title 19 §3.05(a)	No	None

Requirement	Authority/Regulation	Imperviousness Required	Recommended Change[1]
Bus drive aisles serving as the required fire apparatus emergency vehicle access, must be maintained free and clear or obstruction at all times. Stopping for short periods the purposes of unloading, where the bus driver remains in the vehicle, would be permitted. Stopping/parking where the driver shuts the bus off and leaves the vehicle, would not be permitted (additional area would be required to accommodate bus parking).	CFC §503.4 CCR Title 19 §3.05(a) CA Vehicle Code §22500 (i), 22500.1, and 22500.5	No	None
Minimum 30-foot width when student drop-off/loading zones are incorporated with required fire apparatus access roadways (fire lanes)	DSA Policy PL 07-03	No	None
Requires 42" high guards[2] along open-sided walking surfaces that are located more than 30 inches measured vertically to the grade below at any point within 36 inches horizontally to the edge of the open side	CBC §1015	No (but impacts SCM Design Feature)	None
Shade Material	CCR. Title 19	No specific restriction on use of pervious materials, but other restrictions apply for fire safety	None

[1]Assumes that modifications to regulations that require minimum impervious surface areas but would compromise safety or learning objectives; so no modifications are recommended.

[2] Design Detail: Guards shall not have openings which allow passage of a sphere 4 inches in diameter from the walking surface to the required guard height

Table 3-2. Recommended Action to Promote Use of SDMs and SCMs at School Properties

Entity to Take Action	Recommendation
CDE	Include SCM and SDM as objectives for strengthening relationships between schools and communities, with those previously identified in DOE's Re-Visioning School Facility Planning and Design for the 21st Century Roundtable Report (CDE 2008)
DSA	If DSA is to provide review to ensure adequate post-construction SCMs are used, then the DSA project review thresholds per Education Code §17280 (K-12) and 81133 (post-secondary) (these are currently based on project cost estimate greater than $100,000) should match the Phase II thresholds for post-construction SCMs/BMPs: 2,500 sq ft for SDMs and 5,000 sq ft for SDMs and catchment-sized SCMs/BMPs
CDE	Expand Education Code §35275 to require consultation specifically on local water capture projects that could be collocated with joint recreation facilities.
CDE	Update the Schools of the Future Report (CDE 2011) to include GI for stormwater runoff management (CDE 2011)
CDE	Update Item 9 in Vision for California School Facilities (CDE 2015) to include "limit runoff"
CDE	Update CDE Sample Form 1.02b - Plot Plan of Site and Buildings (from Guide to Development of Long Range Facilities Plan, CDE 1986) to include SCMs
DSA	Add stormwater management information to the DSA/s Water Resources page for Sustainable Schools (DSA 2018) or where elsewhere appropriate
CDE	Update the Guide for Planning Educational Facilities (COEFP 1991) to include SDM and SCM information. Although this document states to consult state and local "Water Pollution Control" codes, Phase II stormwater regulations were only promulgated in 1990, so detailed information should not be expected. Consequently, the guidance needs updating or this document could also be listed within CCR Title 5, §14034 (Planning Guides).
CDE	CCR Title 5, §14031, Plan Approval Procedures for State-Funded School Districts, part b. states "Each state-funded school district shall submit final plans including grading, site utilization, elevation, floor, lighting, and mechanical working drawings and any alterations to the educational specifications to the California Department of Education for approval." The regulation could be updated so that grading plans are required to include post-construction SCMs (compliant with current CGP and future Phase II requirements).
CDE	Update Healthy Children Ready to Learn: Facilities Best Practices" (CDE 2006) to reference these SB 541 guidelines.
CDE	Update Guide to School Site Analysis and Development (CDE 2000) to incorporate SCM footprint requirements for impervious roofs, hard courts, and other impervious surfaces (that do not use pervious alternatives).
USEPA	Update School Siting Guidelines (EPA 2011) to address concerns with co-location of regional stormwater projects that would manage offsite urban runoff. Also expand list of tools for water quality mitigation provided on page 51 of those guidelines.

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4.0 MAINTAINING RUNOFF CAPTURE PRACTICES TO EXTEND BENEFITS

4.1 The Value of Maintenance

Implementation of SCMs involves a good amount of investment for planning, design, and construction. To ensure the expected performance throughout the effective life of these systems (and thereby maximize on their investments) maintenance activities must be performed. Most activities involve fairly simple inspections or preventive measures, with occasional corrective actions needed. Conducting inspections and preventative or corrective maintenance will help reduce the risk of premature failures. Consequences of ineffective maintenance or neglect can include clogging or short circuiting of the systems, often well before they reach their intended effective life. Developing an operations maintenance (O&M) plan, then, can help ensure that maintenance activities and any follow up actions get completed.

4.2 Developing an O&M Plan

The subsections below provide summaries of the maintenance, training, record keeping, and safety considerations that will need to be included in and O&M Plan. A template for O&M Plan, which includes these elements, is provided in Appendix G. The template provides standard language that can be used to instruct and document inspection and preventive and corrective maintenance activities that are typical for SCMs. Recommended activities, including tables citing frequency for each activity, are provided for each SCM listed in Table 2-2 of this guidance document. SCMs that are not applicable can simply be deleted. The template uses a color highlighting system to indicate fields where information needs to be added or deleted, or other instructions.

Inspection form templates are provided for each SCM as an attachment to the O&M Plan template. The O&M Plan template also suggests attaching vegetation plans or preferred species lists, and well as material specifications used for SCM design and construction. The intent of attaching this information is to provide a starting point for making decisions regarding what is an intended plant versus and weed, and what type of fill material could be used for replacements, if needed.

4.3 Operation and Maintenance Activities

Operation and maintenance activities required for SCMs are categorized below as typical activities (i.e., those that do not differ too much from traditional landscaping or drainage infrastructure maintenance practices) and specialized activities. Table 4-1 activities conducted for each SCM.

4.3.1 Typical Activities

All but one activity in Table 4-1 (replace fill material) are activities that are fairly typical for any landscape and drainage infrastructure system. The O&M Plan template in Appendix G provides narrative descriptions of each, and tabulates the activities for each SCM according to recommended frequencies, with the intent to assist in schedule developments. Replace of fill materials is a specialized activities for SCMs, and is discussed in below in Section 4.3.2.

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Table 4-1. Inspection and Maintenance Activities for SCMs

	Inspection/Maintenance Activity																			
SCM	*Inspect Adjacent Landscaping and Pavement*	*Inspect for Erosion*	*Inspect Inlet Conveyance Infrastructure*	*Inspect Irrigation System*	*Inspect Outlet Conveyance Infrastructure*	*Inspect Overflow System*	*Inspect for Permanent Pool*	*Inspect for Ponding*	*Inspect Porous/Pervious Pavement Structure*	*Inspect Pumps[1]*	*Inspect SCM Structure*	*Inspect Vegetative Health*	*Clean/Vactor Sediment*	*Perform Integrated Pest Management*	*Prune Vegetation*	*Remove Accumulated Debris*	*Replace Fill Material*	*Replace Mulch*	*Replace Signage[1]*	*Weed*
Bioretention Planters/Rain Gardens	X	X	X	X	X	X		X			X	X		X	X	X	X	X		X
Biostrips	X	X	X	X	X						X	X		X	X	X				X
Bioswales	X	X	X	X	X			X			X	X		X	X	X		X		X
Constructed Wetland	X	X	X		X	X	X				X	X				X				
Detention Basins	X	X	X		X			X			X					X				
Drain Inlet Inserts	X		X		X			X			X					X				
Dry Wells	X		X		X	X		X			X		X			X	X			
Green Roofs	X	X	X	X	X	X		X			X	X		X	X	X	X	X		X
Hydrodynamic Separators	X		X		X						X		X			X				
Infiltration Basins	X	X	X	X	X			X			X	X		X	X	X				X

	Inspection/Maintenance Activity																			
SCM	*Inspect Adjacent Landscaping and Pavement*	*Inspect for Erosion*	*Inspect Inlet Conveyance Infrastructure*	*Inspect Irrigation System*	*Inspect Outlet Conveyance Infrastructure*	*Inspect Overflow System*	*Inspect for Permanent Pool*	*Inspect for Ponding*	*Inspect Porous/Pervious Pavement Structure*	*Inspect Pumps[1]*	*Inspect SCM Structure*	*Inspect Vegetative Health*	*Clean/Vactor Sediment*	*Perform Integrated Pest Management*	*Prune Vegetation*	*Remove Accumulated Debris*	*Replace Fill Material*	*Replace Mulch*	*Replace Signage[1]*	*Weed*
Infiltration Galleries	X		X		X			X			X					X				
Infiltration Trenches	X		X		X			X			X					X	X			
Media Filters	X	X	X		X	X		X			X					X	X			
Porous/Pervious Pavement	X		X		X				X		X		X			X				
Rain Barrels and Cisterns	X		X		X	X		X			X		X			X				
Oil/Water Separators	X		X		X						X		X			X				
Wet Ponds	X	X	X		X	X	X				X	X		X	X	X				X
Wet Vaults	X		X		X	X					X		X			X				

4.3.2 Specialized Activities

Depending on the SCM type and the associated permitting program, there may be some maintenance activities that are not typical for traditional drainage systems or even landscaping. The activities include:

- Replace fill material
- Monitoring

Many SCMs contain some sort of fill material. Media filters contain some sort of filter media, such as limestone, activated alumina, perlite, zeolites, sand, peat, biochar, granular activated carbon, or mixes thereof. Bioretention planters and rain gardens may contain layers of top soil and gravel in addition to the bioretention soil mix. Dry wells may be filled with sand or aggregate, and infiltration trenches are comprised of aggregate materials. Over time, filtration and adsorption within these fill materials can cause clogging and loss of adsorption sites, resulting in reduced pollutant reduction. The fill material will then need to be replaced. Vendor of such materials often provide an expected life, although this is subject to project-specific conditions, particularly the amount of pollutant loading. The engineer or designer of the SCM system should provide an effective life based on site specific conditions, and around this time, the fill material should be planned for replaced. Note that several of the inspections included as typical activities above (Section 4.3.1) will help evaluate the fill material for premature failure.

Monitoring of runoff volumes, flow rates, and water quality may need to be included as a "maintenance activity", if permit conditions, grant funding, or other circumstances require it. Either runoff entering or discharging from the SCM (influent and effluent, respectively), or both, may need to be monitored, depending on the objective of the monitoring program. If monitoring is required, a separate monitoring plan (or sampling and analysis plan, SAP) should be developed to provide instructions of what is to be monitoring (flow volumes, flow rates, and specific water quality constituents); where, when, and how samples should be collected and analyzed; how data will be reviewed and reported; and who is responsible for various tasks. Sometime a Quality Assurance Project Plan (QAPP) will also need to be developed to described processes for ensuring good quality data.

4.4 Training & Education of Maintenance Staff

To ensure maintenance activities are properly conducted and performed as scheduled, maintenance crews should receive training. It is recommended that training occur in summer to adequately prepare them for wet season maintenance activities, including leaf removal. All new maintenance personnel should receive training prior to conducting activities. Training should include the following:

- Knowledge of the location, components, and intended operation of each SCM
- Understanding of the methods, including frequency and required equipment, for each SCM's required maintenance activities
- Understanding of specifications for materials used during SCM installation, as provided in an attachment of the O&M Plan. Crews and managers should check with the SCM design engineer in case specifications are out of date
- Record keeping procedures
- Safety precautions

4.5 Record Keeping

Inspections form templates for each SCM are provided as Attachment A of the O&M Plan template (Appendix G). Forms should be completed during each maintenance activity for each SCM. The facility or maintenance manager, operator, or other designated, responsible party should identify where all records, including inspections forms and purchase orders for necessary repairs, are stored, as well as the protocols for scheduling and completing correction actions identified during inspections.

4.6 Safety Considerations

As with most field maintenance or construction activities, safety of crews and passers-by must be addressed. A health and safety plan (HASP) should be developed to identify possible safety hazards; measures to prevent injury, damage, or other undesired incidents; and practices to respond to and address such events if they occur. Table 4-2 lists typical components of a HASP for SCM O&M activities.

Table 4-2. Components of a Health and Safety Plan for SCM O&M

Relevant Topics
Safety Training
Training Providers
Required Attendants
Frequency
Goals and Topics
Project/Site/SCM Descriptions
Project Organization and Responsibilities
Project Location
Field Activities[1]
General Safety Concerns and Practices
Prohibited On-Site Activities
General Safety Practices
Driving Safety
Establishment of Safe Work Zones and Traffic Control
Personal Protective Equipment (PPE)
Project-Specific Safety Concerns and Practices
Traffic Safety
Chemical Hazards
Biological Hazards
Physical Hazards
Other Hazards
Emergency Procedures
Medical Emergencies
Hazardous Spills
Other Emergencies
Incident Reporting
Definition of an Incident
Reporting Procedures

[1] *Field activities will include those listed in Table 4-1.*

Note that some of these safety considerations (e.g., driving safety) may already incorporated in existing maintenance program protocols, and the HASP should be acknowledge the relevant procedures.

5.0 BENEFITTING FROM REGIONAL COLLABORATION

5.1 Introduction

Although undertaking runoff management activities can seem daunting for schools given the constantly increasing demands on resources, engaging with local and regional entities can ease the burden, achieving permit compliance and other benefits as summarized in Section 1.4 and Appendix A. To date, motivations for schools to conduct runoff prevention and capture activities vary across California, with only a small number of school districts actively engaged as of issuance of this guidance document (2018). The few districts named in stormwater permits are all non-traditional Phase II Small MS4 permittees, identified most recently in the 2013 Phase II MS4 permit (State Water Board 2013). These districts have clear motivation to manage runoff from school sites as a resource and are already realizing the multiple benefits. Other schools throughout the state (who are not currently permittees) have voluntarily implemented runoff management features. Several science-focused or charter schools have used on-site runoff capture and use measures such as LID as demonstration projects that support education and outreach. Some newly constructed or retrofitted schools in California have pursued certification through the Collaborative for High Performance Schools (CHPS) standards program. This criteria-based scoring system includes points for LID features as part of broader energy efficiency and green design practices. The Los Angeles Unified School District, for instance, adopted CHPS standards for school designs in 2009. Yet, for the majority of schools and school districts throughout the state, runoff prevention and capture and the potential benefits have not been fully addressed.

This section describes how schools can benefit from regional collaborations on runoff management.

5.2 Incentives for Joint Use Projects

Many incentives exist for school districts to engage in jointly managing runoff with other local entities. However, successful engagement requires communication, planning, and clear delineation of roles and responsibilities among parties. Such agreements, which can take many forms, should be formalized through accepted documentation, such as the descriptions and examples presented in Section 5.6. Generally, school districts can work with local runoff managers and permittees in several capacities:

- Joint compliance activities—Local entities and school districts can merge permit compliance functions such as monitoring, education and outreach, or documenting best practice manuals.
- Joint use projects—School districts and other entities can manage runoff together. It may involve collecting runoff from several sites spanning jurisdictions at a downstream point or moving runoff across jurisdictional boundaries.
- Delegation of responsibilities between entities—In these agreements, one regulated entity delegates management activities to another entity as specified through an agreed-upon arrangement. For example, in the case of school districts, they might assign responsibilities to a local government permittee with capacity for managing the runoff program.

In addition to the benefits identified in Section 1.4, schools can benefit from regional collaboration efforts as follows:

- Leverage resources and expertise—Schools can leverage the expertise and existing resources of local permittees with on-going program activities and trained personnel. Current school utility managers could learn from these professionals through joint workshops and planning, or school managers could directly engage local runoff managers in helping scope and plan projects and compliance activities. Additionally, local municipalities that are permittees will all have existing stormwater management design manuals, which specify local development regulations for new and existing properties. These include runoff management requirements, hydrologic design approaches, best practices, LID requirements, and others. For schools that cross jurisdictions, too, collaborating with municipal runoff managers can assist in identifying overlap or differences between jurisdictional management requirements.

- Share costs of compliance—Rather than starting a new program, schools could work with a local permittee on monitoring, outreach, or administrative requirements, helping streamline the resources needed to initiate runoff management activities. Additionally, schools can share costs of building infrastructure to manage runoff. If a school district's contributing area funnels into a downstream, large-scale existing piece of municipal runoff infrastructure, it could use that to demonstrate compliance. Alternatively, school districts could partner with local permittees and land-owners to build new infrastructure that manages runoff from multiple contributing areas. Example projects in the Los Angeles area have allocated the costs of new projects between entities based on the relative percentage of contributing runoff area that each entity owns. Such agreements are worked out on a project-by-project basis.
- Delegate requirements of managing runoff—Schools could benefit from working with local permittees by entering into agreements that delegate requirements of managing runoff on-site. As noted above, existing MS4 permits allow for regulated entities to delegate an SIE as the permittee responsible for compliance, monitoring, system maintenance, and other program activities. In this arrangement, a school district that designates a local municipality as an SIE would devise an arrangement to compensate the local entity for managing runoff, perhaps through monetary or in-kind services such as volunteer trash cleanup and monitoring. Permittees identify SIEs in the permit compliance paperwork. Such arrangements can be highly beneficial by leveraging efficiencies of scale.

5.3 Regional Project Types

Regional projects that involve multiple agencies tend to capture and retain or treat runoff from larger catchment areas. No clear classifications of project sizes exist, but regional projects generally involve capturing runoff from catchments larger than a property or site, which could generally translate to catchment areas larger than an acre, but could also involve thousands of acres. Generally speaking, the volume of runoff that must be managed or mitigated through a regional project will increase as the contributing catchment area increases.

For regional projects involving schools, two types of general configurations are possible. First, schools could accept runoff from catchment areas that are not school property. In these configurations, the municipality would benefit by demonstrating compliance with runoff mitigation requirements, while the school district could benefit in receiving new infrastructure or compensation. Second, schools can work with local agencies to send runoff generated on school property to an offsite SCM for capture and treatment or use. In these arrangements, the school would benefit by demonstrating permit compliance in that its runoff is mitigated at a downstream site, while other agencies might benefit by augmenting runoff that could flow to a capture and infiltration basin that supports groundwater recharge.

A number of runoff capture measures can satisfy the design requirements for larger regional projects. These include large detention basins, infiltration galleries, and sub-surface cisterns. Examples of some projects are shown in Figure 5-1. Several of these devices could be placed in series to improve removal of contaminants, configurations sometimes called "trains." For each type of project, a description of advantages; limitations; and considerations for siting, design, and construction are available in Appendix B.

Alternatively, rather than moving runoff to school grounds from off-site, runoff from schools can be diverted off-site or mixed with runoff from other sources en route to capture and use or treatment. In these cases, runoff would likely still be diverted to larger runoff capture measures such as those listed above, but additional large-scale options might be available that do not emphasize quick drawdown times or underground storage. For instance, constructed wetlands would be densely vegetated basins with a shallow pool of water that persists throughout the wet season or even the entire year. These sorts of measures could accept a large volume of runoff from municipal and school sources, while potentially reducing some construction costs by alleviating requirements for digging and sub-surface installations.

Left: A detention basin for retaining and infiltrating runoff on the surface (WRA 2018). Right: A sub-surface infiltration gallery for infiltrating diverted runoff via underground, perforated pipes (Migliore 2014).

Figure 5-1. Examples of Large Regional Stormwater Control Measures (SCMs)

When connecting to city or county runoff systems, schools will have to meet associated code requirements. These are generally found in city or county runoff design manuals, which are developed to standardize system designs that meet stormwater permit requirements. However, combining runoff from schools and other sources provides an opportunity to go beyond baseline design standards, such as combining educational and recreation opportunities in runoff management features. As part of its Green Solutions Project, Los Angeles-based Community Conservation Solutions developed conceptual plans (Figure 5-2) for redeveloping a regional park for improved runoff management, including the incorporation of runoff from an adjacent magnet charter high school site. The proposal uses treatment wetlands as pre-treatment facilities to remove trash and pollutants, and bioswales to treat and infiltrate runoff that would otherwise flow to the L.A. River. The incorporated runoff capture measures for the adjacent magnet school site include treating parking lot runoff and roadway drainage in a bioswale with infiltration capacity.

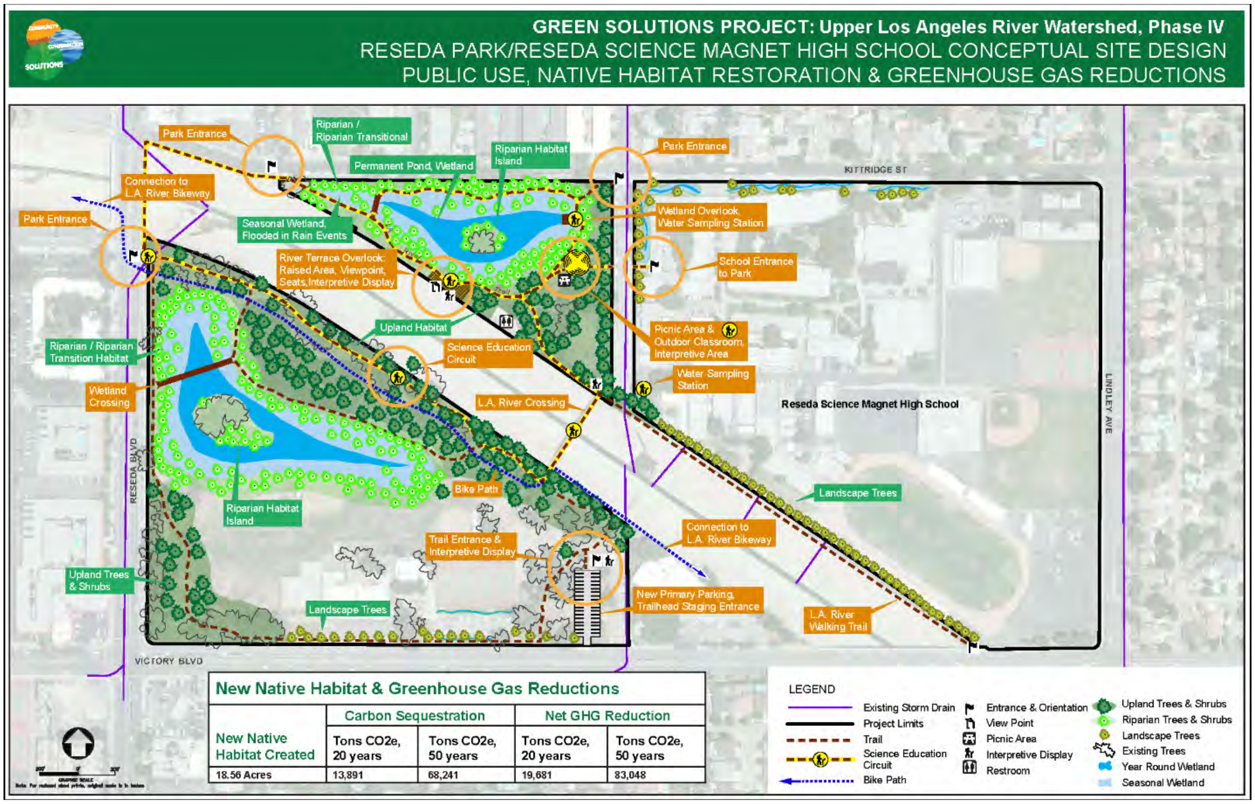

Figure 5-2. A Regional Project Diverting Runoff through a School Site to Offsite Infrastructure
Reprinted with the permission of Community Conservation Solutions 2016.

5.4 Maximizing Benefits for Schools

Schools entering into agreements to jointly manage runoff with local agencies and municipalities must protect their interests, while also identifying clear benefits that will accrue from the partnerships. Ideally, collaboration creates unforeseen benefits for all parties, but outlining expectations as part of the planning process yields a greater likelihood of long-term success for multi-agency regional projects.

Other parts of the water sector offer examples of such integrated planning. For over a decade, California has incentivized, and required, regional collaboration among agencies as part of Integrated Regional Water Management (IRWM) planning efforts, bringing together agencies and stakeholders to discuss regional planning issues of importance. Because agencies were not used to working closely together, they had to identify the motivations for and benefits from working together and identify codified mechanisms for sharing duties and costs. Similarly, schools engaging with regional agencies on runoff planning projects must build capacity to manage runoff on-site and to work with local agencies in joint projects. They must also understand how to identify and quantify the resulting benefits, both monetary and non-monetary.

For regional joint use runoff projects, the project initiators will likely be other runoff management entities such as a municipality or transportation agency. School districts and their utility managers and planning departments will be working with local municipalities, consultants, and regulators in devising designs and plans. Schools will need to assess the potential value of proposed collaborative projects, as well as protect school district interests as part of agreements. To promote more productive working agreements, reduce uncertainties, and outline risks and design considerations for planning regional runoff projects, the sections below outline activities that must be considered for projects and methods for sharing costs and responsibilities.

5.4.1 Design Considerations

In designing joint use projects, many of the same considerations described in Section 2.3 apply. In particular, the amount of runoff to be captured should be quantified to properly design the SCM. The sources and quality of runoff as well as local conditions that influence the SCM performance (e.g., soil conditions) are also critical design factors. Section 2.0 provides information and references regarding SCM designs.

Quantity of Runoff

SCMs that manage runoff from a single catchment are designed to capture a specified flow rate or volume of runoff. Section 2.4 describes the various methods used for calculating the runoff quantity. Large SCMs for joint use projects, however, may collect runoff from several catchments, and various methods may be used to evaluate the cumulative flow rates or volumes. As runoff moves through a watershed consisting of several catchments, it tends to collect volume and velocity. As runoff flows through a watershed and collects in urbanized areas, it can increase in intensity and velocity. As the left image in Figure 5-3 shows, the location in the watershed influences the arrival and duration of peak flows. In urban areas, overland flow moves to runoff infrastructure, including surface-based treatment measures such as LID, as well as more traditional sub-surface infrastructure such as pipes and gutters (Figure 5-3, right). Routing methods must incorporate both modes of conveyance.

Several methods can be used to estimate the travel time required for runoff to move through the watershed. For instance, the rational method and modified rational method are typical, straightforward methods of estimating the amount of time required for runoff to move through a watershed. The methods estimate flow over surfaces and in pipes, gutters, and channels. The runoff generated over time at a particular location is plotted as a hydrograph, and its shape is driven by the intensity and duration of precipitation, as well as the characteristics of the watershed. For instance, a watershed may have a runoff rate that varies from 0 to 1,500 cubic feet per second following the onset of precipitation. A peak outflow rate will occur sometime after the precipitation event starts and then dwindle until the drainage channel returns to dry-weather flow stages. Local runoff design manuals published by communities often provide guidance and templates for performing hydrograph and routing calculations to design downstream mitigation systems, including SCMs. Typical data needs for routing calculations include the size (area), topography, land cover, runoff coefficient, soil types, and infiltration rates.

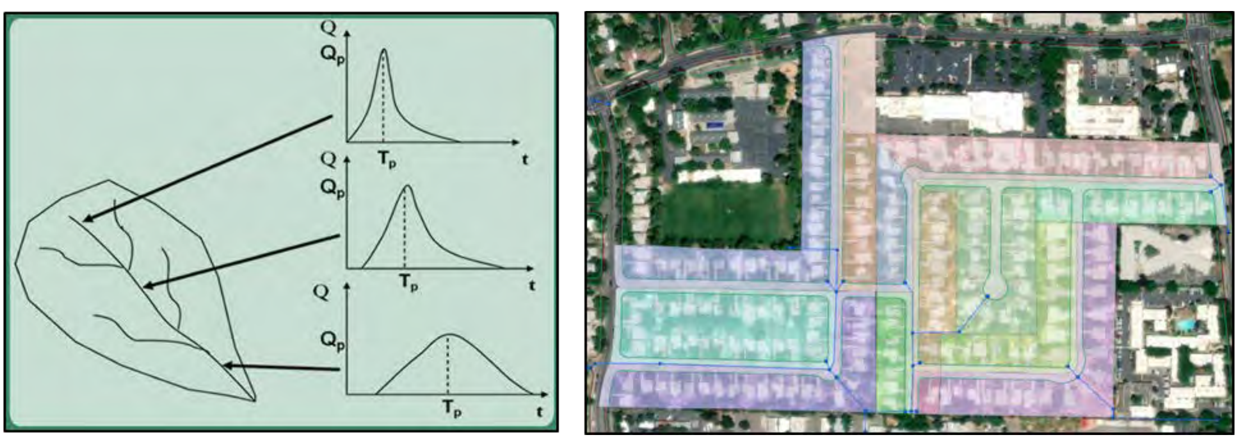

Figure 5-3. Watershed Routing Concepts

Sources and Quality of Runoff

The quality of runoff and contaminants it contains will likely differ depending on the source. Common school site contaminants are sediment, food waste, and trash. Runoff from off-site sources will likely have all these contaminants, but potentially in different concentrations. In addition, runoff from certain sources may also contain other contaminants such as oils and metals. See Section 2.2.5for further discussion on pollutants of concern. As such, understanding the characteristics of the contributing catchment is an important step in designing joint use projects.

Municipalities classify land use types to meet zoning requirements and support property taxes. However, land use characteristics influence the types and toxicity of contaminant runoff. Common land use types include single- and multi-family residential, commercial, light and heavy industrial, and governments and schools. Within these general categories, some land uses are of particular concern for managing risks associated with runoff contaminants. As part of developing guidance for implementing dry wells within the American River Basin Stormwater Resource Plan (ARB SWRP), general guidelines were developed to associate land uses and runoff contaminant risks (Table 5-1). These were used to guide the requirements for pre-treatment facilities associated with dry wells.

According to the ARB SWRP dry well framework, residential properties, office parks, small retail areas with limited parking, and streets with low-levels of traffic are all lower risk sources of runoff contamination. Medium and high-density residential areas, institutional and commercial land uses, large retail and office complexes, and roads with more traffic are all medium-risk areas due to sediments, chemicals, fertilizers, trash, and metals that may be associated with automobile traffic. Several types of properties are considered high risk sites for runoff contamination, including industrial land uses, gas stations, wholesale and retail plant nurseries, automobile repair shops and car washes, and heavily-travelled streets. These categories are intended to be general guidelines to assist in associating pollutant risks with land uses, not a definitive matrix of correlations.

Table 5-1: General Runoff Pollution Risk Categories Associated with Land Use Types

Risk Category	Description	Example Land Uses
Insignificant	Little to no risk of contaminated runoff that would not be mitigated through normal treatment measures.	Residential rooftops
Low	Low risk of contaminated runoff that would not be mitigated through normal treatment measures. Sites should be assessed for any specific sources of contamination that would increase risk.	Residential properties Office parks Small retail shops with limited parking Streets with <15,000 AADT[1]
Medium	Increased risk of some contaminants, such as higher concentrations of trash, fertilizers, oils, greases, and metals from automobiles, and increased sediment associated with greater impervious surfaces.	Medium- and high-density residential Institutional and commercial land uses Major retail and offices Large parking lots Roads with 15,000 – 30,000 AADT[1]
High	High risk of contaminated runoff that would not be mitigated through normal treatment measures.	Industrial land uses Gas stations, plant nurseries, car washes Automobile repair stations and shops Streets with >30,000 AADT[1]

OWP 2018a

[1] Annual Average Daily Traffic (AADT)

In addition to these general categorizations, some properties require special considerations. Brownfields and properties with hazardous contaminants from past activities should have special mitigation plans in place for runoff management. Searchable databases of identified brownfield sites are available through the State Water Board's Geotracker website (State Water Board 2018d), along with the California Department of Toxic Substances Control EnviroStor website (DTSC 2018). These databases can be used to identify any potential properties of concern in the contributing watershed for a joint use project.

Data collection and analysis can help characterize the quality of runoff flowing from a watershed of interest. During project planning, schools can work with project partners to identify existing sources of water quality monitoring data that may contain relevant information, or plan for new water quality sampling. Many permittees such as municipalities and transportation agencies are required to conduct regular water quality monitoring at stormwater system outfall locations or in receiving waters where runoff discharges. The samples, usually collected by agency employees or contract consultants, are sent to laboratories for analysis of basic water quality constituents (total suspended solids, pH) or more advanced analysis for constituents such as metals or pesticides. Some larger municipal agencies may have in-house water quality testing capacity, but this is rare. While monitoring data can be valuable for project planning, limited resources and intermittent precipitation events in California mean that data is often limited, inconsistent, or too generalized to pinpoint runoff quality in specific catchments. The International BMP Database is a good source for obtaining estimates of pollutant concentrations in runoff (WERF et al. 2018).

Resources exist for analyzing and interpreting data from monitoring, which can help understand system sizing and pretreatment options. An SCM should be designed to meet flow or volume targets and provide sufficient treatment capacity to reduce contaminants, such as suspended solids, metals, or others. Often, this is performed by slowing the velocity of runoff or temporarily storing it, allowing sediment to settle out for later removal and disposal. To assist in designing and assessing performance, the modeled BMP effluent quality estimates can be compared to existing water quality compliance requirements. These are located in local or regional stormwater permits as load or concentration amounts at a runoff discharge point or in receiving waters. The State Water Board's Stormwater Multiple Application and Report Tracking System (SMARTS) website includes resources and information on the state's construction, industrial, and municipal stormwater permit programs. Modeled values may also be compared to EPA water quality benchmarks. These are located at the EPA's Water Quality Criteria webpage, which provides guidelines for safe levels of constituents for human health and aquatic habitat (USEPA 2018b). The EPA's Water Quality Standards Regulations webpage includes a repository of stormwater permit documents, amendments, and reports for the state's management regions (USEPA 2018c).

SCM Performance

The characteristics of the installation site for an SCM are important to consider in designing SCMs. For instance, when diverting regional runoff to a school with an SCM, the existing drainage infrastructure, on-site soils, sub-surface geology, and proximity to sites of increased pollutants can all affect performance. Runoff from an external source is diverted to a school site mixes with some volume of on-site runoff, increasing the total flow to be mitigated. Joint use planning projects should characterize both the contributing catchment characteristics as well as the land cover and drainage systems on the school grounds. Greater impervious surface cover will increase on-site runoff, which combined with off-site runoff could overwhelm poorly designed systems.

Many on-site SCMs that are appropriate for school use—both surface and sub-surface installations—would infiltrate some volume of water to soils. Soil infiltration rates can vary widely depending on the soil material, compaction from construction and landscape, plant and tree cover, and subsurface layers that slow infiltration. After a period of continual inundation, infiltration rates slow, and initial precipitation after dry periods can also have increased runoff before soils saturate and soften. These considerations are particularly important across California with its seasonal precipitation, long periods of dryness, and highly diverse soil and geologic characteristics. While several tools are available to help estimate soil characteristics for planning purposes (e.g., National Resource Conservation Survey's Soil Survey, NRCS 2018), conducting on-site soil investigations is crucial for achieving the desired performance. Ultimately, for any project, site characteristics should be assessed prior to construction and inform designs.

Schools should also consider proximity to areas of higher contaminant and trash concentrations in designing SCMs. For instance, at schools, cafeteria areas would have increased food waste and trash, which should be mitigated. Alternatively, runoff from construction areas or hazardous sites should be properly treated before releasing runoff to an SCM for infiltration or discharge.

A number of straightforward actions can be taken to improve the quality of runoff being considered as part of a joint use project. For instance, through pollution prevention and good housekeeping measures, regulated permittees are required to undertake several types of activities to reduce pollutants. The CASQA

BMP Handbooks (CASQA 2003 and 2018a) and USEPA publications (USEPA 2005a and b) serve as excellent resources on these activities. Example activities include:

- An implemented operations and maintenance program with schedules of activities, which promotes more reliably performing systems
- Employee training on pollution prevention and SCMs for municipal facilities and fleets,
- Stormwater controls in key areas such as parking lots and roads
- Waste disposal and trash management

Pretreatment measures can help to improve the performance of runoff mitigation infrastructure by removing pollutants prior to capturing the runoff for treatment and discharge. Such measures include filters, screens, vegetated swales, and detention basins. Such devices can be used as part of a multi-stage runoff management train that seeks to improve the effluent water quality discharging to watersheds. In planning joint use projects, if the modeled effluent quality does not meet desired levels, project designers can test the effects of using various pretreatment measures to improve outcomes. For joint use projects with schools and other permittees, pretreatment could take place on the same site as the primary runoff collector or another site away from the SCM, with pretreated effluent routed to the destination SCM through a pipe or other device that preserves its improved quality before ultimately being captured for infiltration, use, or discharge.

Trash management, in particular, is an increasing topic of discussion in California that relates to pretreatment infrastructure. In 2017, the State Water Board sent orders (Water Code Section 13383) to small MS4 permittees containing specific requirements for trash abatement measures. The provisions stipulated control systems to achieve "full capture" of trash from runoff systems in an effort to reduce or eliminate the volume of waste that reaches watersheds. As part of this policy, schools working with local partners on joint use projects may undertake infrastructure planning to address the regulated trash management requirements.

The actual performance of a constructed module can differ from the intended design outcomes, sometimes significantly. A number of factors can cause this disparity. First, the SCM may be improperly sized due to incorrect assumptions as part of the design process. Second, SCM performance can degrade over time. A measure may operate properly soon after construction, but its performance may degrade if it becomes clogged with sediment or its components and features are not properly maintained. This often happens with weeds in surface-based SCMs, which require regular weeding and soil management to maintain performance. Third, actual influent characteristics used to design an SCM may differ from the influent characteristics assumed during design. The presence of unpredicted or increased concentrations of constituents could overload the treatment capacity of the runoff mitigation device. For these and other reasons, post-construction monitoring during storms is helpful to ensure proper operation, including visual inspections during events and water quality testing. Guidelines for post-construction operation and maintenance activities are provided in Section 4.0.

5.4.2 Responsibilities and Costs

Successful joint use projects must devise an approach to allocating responsibilities and costs for project planning, design, construction, and long-term operations and maintenance. Failing to outline these considerations early in discussions can lead to miscommunication and misaligned expectations, potentially stalling projects under development or leading to long-term collaboration issues. This subsection outlines important concepts that schools should consider in identifying responsibilities and costs among parties involved in joint use projects. It covers topics that should be outlined in joint use agreements, including conceptual planning and permitting, financial planning, design and construction activities, and operations and maintenance.

Planning for Joint Use Projects

The project planning activities described in Section 2.3 also apply to joint use projects. Collaborating parties in a joint use project will need to designate who is in charge of the various tasks and determine how and when they will be performed.

As discussed in Section 2.3, project planning should also include financing considerations. In particular, how will the new infrastructure be paid for and by whom? Will parties share costs equally through an agreed-upon arrangement, or will one party provide the majority of funding? How will various parties alternatively support capital and long-term maintenance costs?

In joint use projects to date, various financing options have been proposed, including:

- Joint grant applications—all project participants apply together. These grants can pay for some or all of the project costs. Funding programs through the California Department of Transportation General Obligation Bonds are potential sources for joint grants.
- Catchment-based funding allocations— the percentages of funding contributions closely match the assessed runoff contributions of all parties to the device. For instance, if a new joint use project will capture runoff from a 100-acre catchment and the participating parties own 75 and 25 acres, respectively, a 75/25 funding scheme could be appropriate. Alternatively, funding amounts could be adjusted if some land uses in the catchment are higher risk.
- Mutually-agreed upon allocations—each of the parties agrees to contribute according to the value it expects to gain. In many cases, local and regional runoff quality control agencies may contribute a large percentage of the capital costs, while school districts agree to fund long-term maintenance and upkeep as part of regular activities.

Funding arrangements can include the monetary value of cash contributions for design and construction together with the assessed value of land in determining cost-sharing. Ultimately, the proper funding scheme for a project will involve detailed negotiations among parties and could be part of broader capital improvement projects on school grounds.

The State Water Board published a staff report that surveys available funding resources for runoff management (State Water Board 2018c). CASQA’s Stormwater Financing web portal (CASQA 2018b) also provides stormwater funding resources.

Design and Construction of Joint Use Projects

As with all new infrastructure development, after a conceptual project design and financing plan are established, the design and construction phases implement the plan according to local conditions and regulations within the allowable budget. In building a joint use runoff control project, many design and construction steps will be similar to other types of runoff control infrastructure, including on-site features. Sections 2.4 and 2.5 present different design and construction activities and the methods involved. All these will need to be delegated among parties coordinating on joint use projects.

Operating and Maintaining Joint Use Projects

Operating and maintaining joint use projects is a critical component of successful infrastructure development. A long-term plan must be devised and followed that ensures continued operation of the SCM as designed. Without proper maintenance, SCM performance can significantly decrease, potentially affecting core functions that mitigate runoff for permit compliance.

As noted throughout this document, an important component of successful long-term operations is developing detailed maintenance plans that describe relevant activities for various SCMs. Guidelines and templates for maintenance plans that for joint use projects relevant to schools are presented in Section 4.0 and Appendix G of this document. In addition to the information provided in the guidance and templates, joint use project maintenance plans must allocate maintenance responsibilities among participating parties, specifically identifying the responsible party for each activity.

Municipalities regularly use maintenance agreements to assign maintenance responsibilities to parties other than the named stormwater permittee. For instance, a municipality might develop a standard maintenance agreement for private landowners who agree to build and maintain an SCM as part of a development agreement. Maintenance agreements would outline:

- Routine performance activities
- Maintenance schedules
- Inspection requirements
- Personnel access to SCMs for maintenance
- Consequences of failing to maintain SCMs
- Recordkeeping requirements for operations and maintenance

These activities are identified and outlined in the CASQA New and Re-Development BMP Handbook (CASQA 2003 and 2018a). In addition, maintenance agreements should include a description of the system and a map of assets so that all involved parties understand what needs maintained or inspected. Many examples of maintenance agreements are available on the web, such as the template available at the Stormwater Equipment Manufacturers Association website (SEMA 2018).

5.5 Potential Barriers

A number of potential barriers to joint use projects where schools accept runoff from offsite sources have been identified through collaborative processes. These potential barriers are important considerations in planning and should not be overlooked by schools or collaborating agencies. These barriers can be overcome through collaboration and creativity in the planning process. Runoff management at schools to date in California provide an indication of benefits that can accrue to schools from adopting green infrastructure and runoff management activities and the creativity used to attain those benefits. Such creativity can be harnessed for future projects.

In Los Angeles, the LA Unified School District (LAUSD) has worked with interested parties and regional stakeholders in considering potential projects that utilize the open spaces of school grounds to capture and infiltrate runoff within the otherwise built-out urban fabric of Los Angeles. In 2015, the non-profit TreePeople published a summary of a collaborative fact-finding workshops that identified barriers for school districts in working with regional agencies on joint use projects. TreePeople then worked with regional experts to explore these barriers and identify potential solutions. The barriers and solutions are summarized below in Table 5-2. Not all school districts will face these barriers or questions, but they provide examples of the regional discussions that may be needed to spur projects with multiple regional stakeholders.

Table 5-2: Potential Barriers and Solutions for Implementing Joint use Projects

Potential Barrier	Description	Potential Solution
Health risks	Accepting off-site runoff could expose students and faculty to health risks from contaminates	Use monitoring to demonstrate risk exposure and work with local public health officials to assess potential exposure risks.
Regulatory issues	Schools may not be allowed to accept off-site runoff due to environmental and water quality standards	While California state agencies (e.g., Department of Toxic Health and Safety) could prohibit such transfers, no current regulations exist that prohibit the transfer of runoff to schools from another site.
Land-use limitations	Developing runoff facilities, such as sub-surface infiltration, could inhibit future development of those areas	Runoff planning and design processes on school sites should include school district and site-specific master plans to ensure that SCMs do not conflict with long-term infrastructure upgrades.

Potential Barrier	Description	Potential Solution
Training and labor agreements	Implementing and managing green infrastructure on public school grounds will require additional training for facilities personnel and faculty, and may conflict with existing labor agreements if personnel from other municipal agencies or water districts are engaged to maintain SCMs	Existing programs in LA, supported through the DROPS program, have devised training programs on runoff management with separate components for faculty, students, facility managers, and the broader community. Agreements can be organized to allocate duties for maintenance among school district staff and other personnel.
Additional maintenance requirements	Green infrastructure for managing runoff requires more maintenance than existing ground cover, such as asphalt	Long-term funding and worker training should incorporate the requirements of maintenance plans. State and local funding streams that promote green infrastructure should be adapted to allow for such expenses as well as long-term, life-cycle considerations. Emerging research indicates the benefits of more diverse school grounds that are not just hardscape. School maintenance activities, and associated funding, must be adjusted to promote better student experiences.
Liability	School districts could be vulnerable to lawsuits concerning the risks of health exposure, personal injury, subsidence from saturated soils, soil contamination, or other long-term environmental consequences of infiltrating runoff on-site	Liability considerations can be discussed as part of negotiations. Mechanisms such as indemnification agreements exist that could protect schools from such lawsuits. Notably, in surveying stakeholders and existing research for this report, liability concerns arose in examples of larger school districts, but were not raised in discussions about site-level projects. Statewide legislation could alleviate such concerns, which would support the regulatory efforts to include school districts in the Phase II MS4 permits by offering an avenue for schools to meet permit requirements through regional collaboration.

Adapted and augmented from a study in Los Angeles by TreePeople (2015).

Notably, for all these cases, smart designs can alleviate concerns. For instance, at a school site, off-site runoff could be captured, retained, and infiltrated and/or released only on peripheral areas where students and faculty are not exposed. This would pose exposure similar to any retention and infiltration-based SCM implemented within a municipality, which is increasingly common. Additionally, designs can emphasize sub-surface SCMs, where no captured runoff is exposed at the surface. While more expensive, such projects have been proposed in California with no associated safety or liability risks raised during design discussions.

5.6 Developing Joint Use Agreements

<Provide recommendations for agreement contents and development, as well as template for use>

<Seeking examples of existing agreements>

6.0 DCOUMENT REFERENCES

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