CITY OF PALO ALTO

Green Stormwater Infrastructure

Maintenance and Assessment Manual

CITY OF PALO ALTO

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This manual was developed to maintain Green Stormwater Infrastructure (GSI) based on staff assessment and maintenance experience to-date and direction from similar GSI maintenance programs in the cities of San Francisco and San Jose to promote regional consistency. This manual was modeled after the City of San Jose Field Guide and modified for Palo Alto, which was originally inspired by the City of Seattle's standards and San Francisco's maintenance guidelines and document organization. We are grateful for the permission from the City of San Jose to use the content and their contribution as well as the contribution of their consultant, Lotus Water Engineering.

This manual was prepared by Larry Walker Associates, Inc. in collaboration with Geosyntec Consultants.

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engineering

CITY OF
SAN JOSE
CAPITAL OF SILICON VALLEY

GLOSSARY

Bioretention	Depressed, landscaped areas with an engineered media composed of sand and compost, underlain by drain rock designed to retain runoff, filter the runoff through soil media and plant roots, then infiltrate to the underlying soil and/or discharge to the storm drain system. When the area's underlying soil does not infiltrate water quickly, an overflow, a waterproof lining, and an underdrain (a perforated pipe which conveys flow along the base of the bioretention, are typically installed to connect the area to the storm drain system. They typically add multi-benefits that include traffic calming, decreased street widths and pedestrian crossing distance, community engagement, and street greening. The term "rain garden" is often used to describe bioretention-like areas; however, rain gardens are typically not designed and installed per the specifications required in the Municipal Regional Stormwater NPDES Permit (MRP) and often do not meet compliance requirements.
Bioretention Soil Media (BSM)	An engineered soil media meeting the requirements detailed in the BASMAA Biotreatment Soil Media specification as required by the Municipal Regional Stormwater NPDES Permit (MRP). The current specification is provided in Attachment G of the GSI Handbook (see link to GSI Handbook in References).
Cleanout Pipe	A solid vertical pipe capped at the surface that provides access to the subsurface underdrain.
Drawdown Time	The time required for a stormwater detention or infiltration measure to drain and return to the dry-weather condition.
Erosion	The wearing away of land surface by wind or water. In the context of this manual, erosion is the process by which runoff washes away soil.
Flow-Through Planters	Type of above-ground bioretention measure that is completely lined and surrounded with concrete or other structural planter box walls with waterproof membranes and an overflow and/or underdrain. Flow-through planters typically receive runoff via downspouts leading from the roofs of adjacent buildings.
Forebay	A pretreatment designed as a small pool to catch sediment located immediately down-gradient of a stormwater inflow point.
Green Stormwater Infrastructure (GSI)	A system using vegetation, soils, and/or natural processes (such as infiltration) to manage water and create healthier urban environments. It provides habitat, flood control, cleaner air, and cleaner water, and can mimic nature by soaking up, storing, and/or improving the quality of water.
Infiltration	Downward entry of runoff into the soil.
Infiltration GSI Measures	Practices designed to capture stormwater and infiltrate it into the underlying soil. Infiltration facilities are sited for areas with favorable soil conditions and adequate depth to groundwater. Common facilities include: • Subsurface infiltration systems, which may be used to infiltrate larger quantities of runoff. These systems are underground vaults or pipes that store and infiltrate stormwater to the subsurface while preserving the use of the land surface above (e.g., parking lots, playing fields). • Infiltration trenches, which collect and hold runoff in a linear trench filled with aggregate or other media and allows it to infiltrate into the underlying soil. • Infiltration basins, which are depressions that capture runoff and allow it to infiltrate to the subsurface. • Drywells, which are deep, relatively small diameter structures filled or surrounded by aggregate that are installed in the subsurface to infiltrate stormwater 15 to 40 or more feet below the surface. There are few opportunities for infiltration facilities in the City of Palo Alto due to high groundwater and low subsurface soil infiltration rates.

GLOSSARY CONTINUED

Personal Protective Equipment (PPE)	Protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection.
Pervious Pavement	Hardscape designed to allow surface water to pass through to the ground below by infiltrating through the paver (pervious) or through the joints/space between the pavers (permeable). Water that percolates through the pavement enters an underground storage area filled with various layers of compacted, open-graded aggregates before infiltrating into the underlying soils. Common pervious hardscape types include pervious concrete, porous asphalt, permeable pavers, interlocking concrete pavers with aggregate, and grid pavements.
Scour	The removal of the bioretention soil from side slopes and flow path. It is caused by fast-flowing and channelized runoff.
Splash Pad	A concrete pad placed at the inlet to provide a hard surface for stormwater entering a vegetated GSI measure to run across or splash against to prevent stormwater from eroding the soil surface. Applicable to driveways, walkways, parking lots, and compacted lawn areas.
Stormwater	Water that originates from precipitation falling on impervious surfaces such as roofs, roadways, and sidewalks that prevent water from infiltrating into the underlying soils. This term is often used interchangeably with the term runoff.
Stormwater Curb Extension	A GSI Measure consisting of a bioinfiltration or bioretention area typically at an intersection or mid-block and within the flexible zone of a street. Stormwater curb extensions may help achieve complete streets goals of improving pedestrian access and safety.
Suspended Pavement Systems	Cells that support the weight of paving or other surfaces while creating a subsurface void that contains biotreatment for capturing and infiltrating stormwater and space for urban tree roots to grow. They can be installed as open-bottom systems that promote infiltration or in closed-bottom systems where infiltration is undesirable or infeasible, such as sites with underlying soils that do not allow appreciable infiltration, groundwater contamination, or high groundwater levels. These are frequently constructed using modular proprietary suspended pavement system products that can withstand roadway structural loads.
Tree Well Filter	A type of bioretention system consisting of an excavated pit or vault that can be filled with biotreatment soil media, planted with a tree and other vegetation, and underlain with drain rock and an underdrain, if needed. Tree well filters can be constructed in series and linked via a subsurface trench or underdrain. They can be integrated with suspended pavement systems and pervious pavement.
Vegetated Swales	Open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff to downstream discharge points. In contrast to bioretention areas, which are designed such that stormwater percolates vertically, vegetated swales are designed to convey flow laterally along the length of the swale, and typically have a shallow biotreatment soil media layer and no underdrain. Vegetated swales can be used to convey flow to other facilities or as pretreatment.
Wearing Course	The upper layer in pavement sections. May consist of impervious pavements such as asphalt or concrete, or pervious pavements such as porous asphalt, pervious concrete or permeable unit pavers.

Chapter 1. Overview

CITY OF PALO ALTO

Regulatory Requirements

The City of Palo Alto (City) is responsible for ensuring compliance with federal and state laws that regulate how stormwater runoff is managed prior to its entry to the storm drain system and/or the San Francisco Bay.

Bioretention in Southgate neighborhood

Specifically, the City operates under the Regional Water Quality Control Board's Municipal Regional Stormwater Permit (MRP) which dictates how stormwater is managed in the urban areas of the San Francisco Bay Area. Provision C.3 of the MRP requires new development and redevelopment projects to include appropriate measures to treat stormwater runoff and to prevent increases in runoff flows.

Purpose

This manual provides instruction on assessment and maintenance of GSI in the City. Proper maintenance is critical to the long-term function and appearance of these measures, which in turn promotes regulatory compliance and community acceptance. The main purposes of the Manual are to provide: (1) assessment checklists, (2) maintenance standards, and (3) maintenance guidelines for different types of GSI measures. The guidance herein was developed based on staff assessment and maintenance experience to-date and direction from other municipalities' similar GSI maintenance programs. This Manual addresses various types of GSI, including:

- Bioretention, Flow-Through Planter, Vegetated Swales and Tree Well Filters
- Suspended Pavement Systems and Tree Well Filters
- Pervious Pavement
- Green Roofs
- Rainwater Capture
- Infiltration Measures

This Manual takes an assessment-based approach for maintenance and adaptive management. Each site visit begins with progressing through a checklist to visually assess the condition of various GSI measure components in order to determine the maintenance condition. Observations made during the assessment not only inform what maintenance activities are currently needed but also may be used as the basis to adjust the standard maintenance regimen for that GSI facility in terms of which tasks are performed and with what frequency.

While certain maintenance activities are performed during every visit (e.g., trash removal), others are performed in response to crew observations made during the initial assessment and available budget (e.g., plant replacement). Trained maintenance crews can remedy some deficiencies on the spot, while other deficiencies require that the crew document the materials needed to fix the problem on the ensuing visit and then discuss resolution with the City GSI Maintenance Lead.. If structural, irrigation, or subsurface drainage problems are found, then the field crew should document the deficient condition and report it to management so that specialized trades can be brought in to make the needed repairs.

Use of Manual

This Manual is intended to function as a quick reference guide for Maintenance Use Assessment and activities at City of Palo Alto GSI measures. An emphasis was placed on including photos, beyond the written metrics and guidance, to clearly demonstrate actions and expectations. The Manual is designed to function as a whole or separated into fact sheets organized by type of GSI for different types of users. Because understanding of GSI maintenance is evolving, the layout of the Manual was designed to be simple to allow for easier updates as the City's maintenance program matures. The City requires that all City-owned GSI be maintained at a "good" or "excellent" maintenance standard. These standards are established by regular maintenance activities, less frequent major improvements, and direction by the City GSI Maintenance Lead and other staff. The conditions are confirmed by City assessments, particularly by the GSI Maintenance Lead. At a minimum, the GSI measures will be inspected annually once a GSI measure is considered "good" or "excellent," with more frequent assessments conducted to improve the condition standard of a site. Because maintenance needs and available budget and staffing resources vary over time, specifics about maintenance and assessment frequencies are not provided in this Manual. The City's Stormwater Program staff should be contacted for more information.

This Manual provides maintenance assessment checklists, maintenance standards, and maintenance guidelines for the GSI measures listed in Table 1. These GSI types are either in existence in the City or are generally designed at a scale that would be feasible to construct in this geographic area.

GSI FACILITIES AND CHAPTERS

- Vegetated GSI: Bioretention, Flow-through Planters, Vegetated Swales and Tree Well Filters
- Pervious Pavement
- Infiltration Measures
- Green Roofs
- Rainwater Capture
- Suspended Pavement System

MAINTENANCE STAFF CAN FOLLOW THE MAINTENANCE PROCESS BY:

- Identifying the correct guidance for the GSI type being maintained;
- Preparing for the site visit with the necessary tools and materials;
- Reviewing Maintenance Standards for that GSI type;
- Conducting a facility assessment using the Maintenance Checklist for the GSI type;
- Determining the maintenance needs based on the results of the assessment;
- Performing needed maintenance activities, per guidelines for the respective GSI; and
- After maintenance is completed, check the final condition of the GSI against the Maintenance Standards for that GSI type. Consult with the GSI Maintenance Lead if an issue arises or more maintenance is needed than was anticipated.

Follow the steps below to assess each GSI type.

GSI Assessment Flowchart

ADAPTIVE MANAGEMENT

The City intends to promote adaptive management practices as GSI sites continue to be constructed and revitalized within the City. This Manual will evolve with the GSI Program and will be modified based on future conditions such as:

- Findings of GSI inspections;
- Costs of inspections and maintenance activities;
- Potential impacts of climate change, such as increased rainfall intensity;
- Changes to the Municipal Regional Stormwater NPDES Permit (MRP); and
- Availability of new information and data from sources other than the City's monitoring program that informs the effectiveness of the actions implemented by the City.

Chapter 2. Types of Green Stormwater Infrastructure

CITY OF PALO ALTO

SEE CHAPTER 4

GSI TYPE AND DESCRIPTION

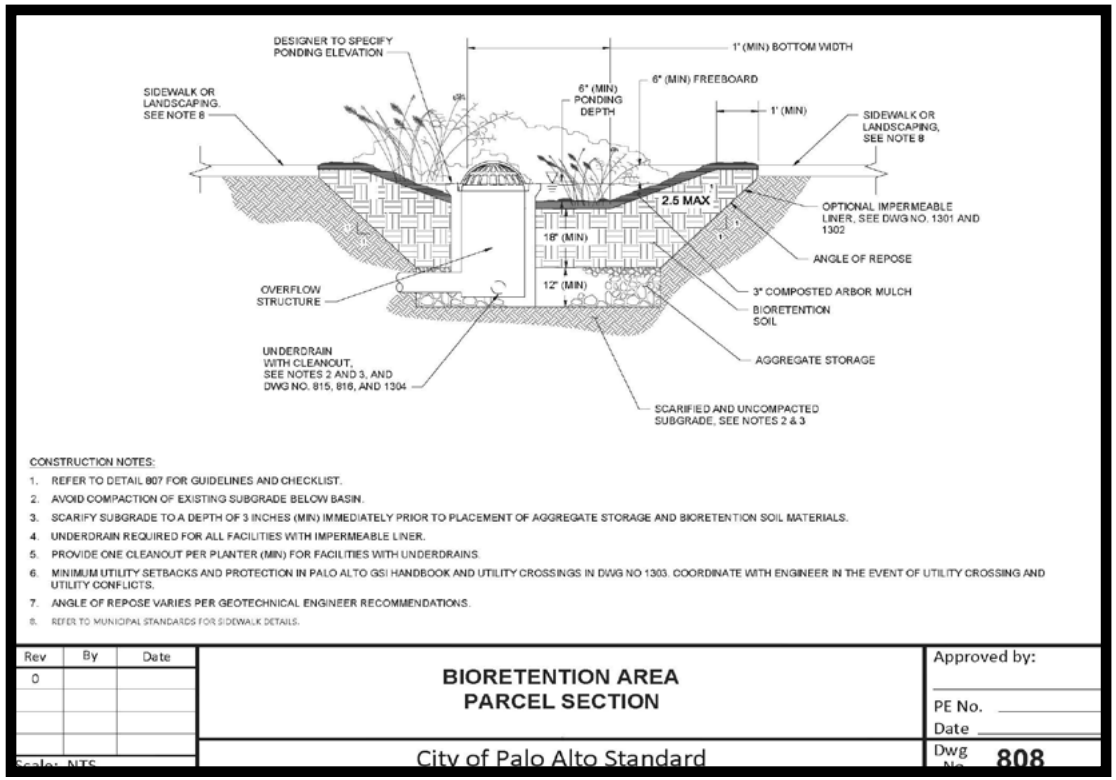
Bioretention – Bioretention areas are depressed, landscaped areas with an engineered soil media composed of sand and compost, underlain by drain rock. Bioretention areas are designed to retain runoff, filter the runoff through soil media and plant roots, then infiltrate to the underlying soil and/or discharge to the storm drain system. When the area's underlying soil does not infiltrate water quickly, an overflow and an underdrain (a perforated pipe which conveys flow along the base of the bioretention) can connect the bioretention area to the municipal storm drain system. These areas can be designed to infiltrate or prevent infiltration using waterproof lining.

Bioretention areas typically add multi-benefits that include traffic calming, decreased street widths and pedestrian crossing distance, community engagement, and street greening. The term "rain garden" is often used to describe bioretention-like areas; however, rain gardens are typically not designed and installed per the specifications required in the MRP and often do not meet compliance requirements.

EXAMPLES

Southgate Neighborhood Bioretention Area, City of Palo Alto

Fire Station #3 Bioretention Area, City of Palo Alto



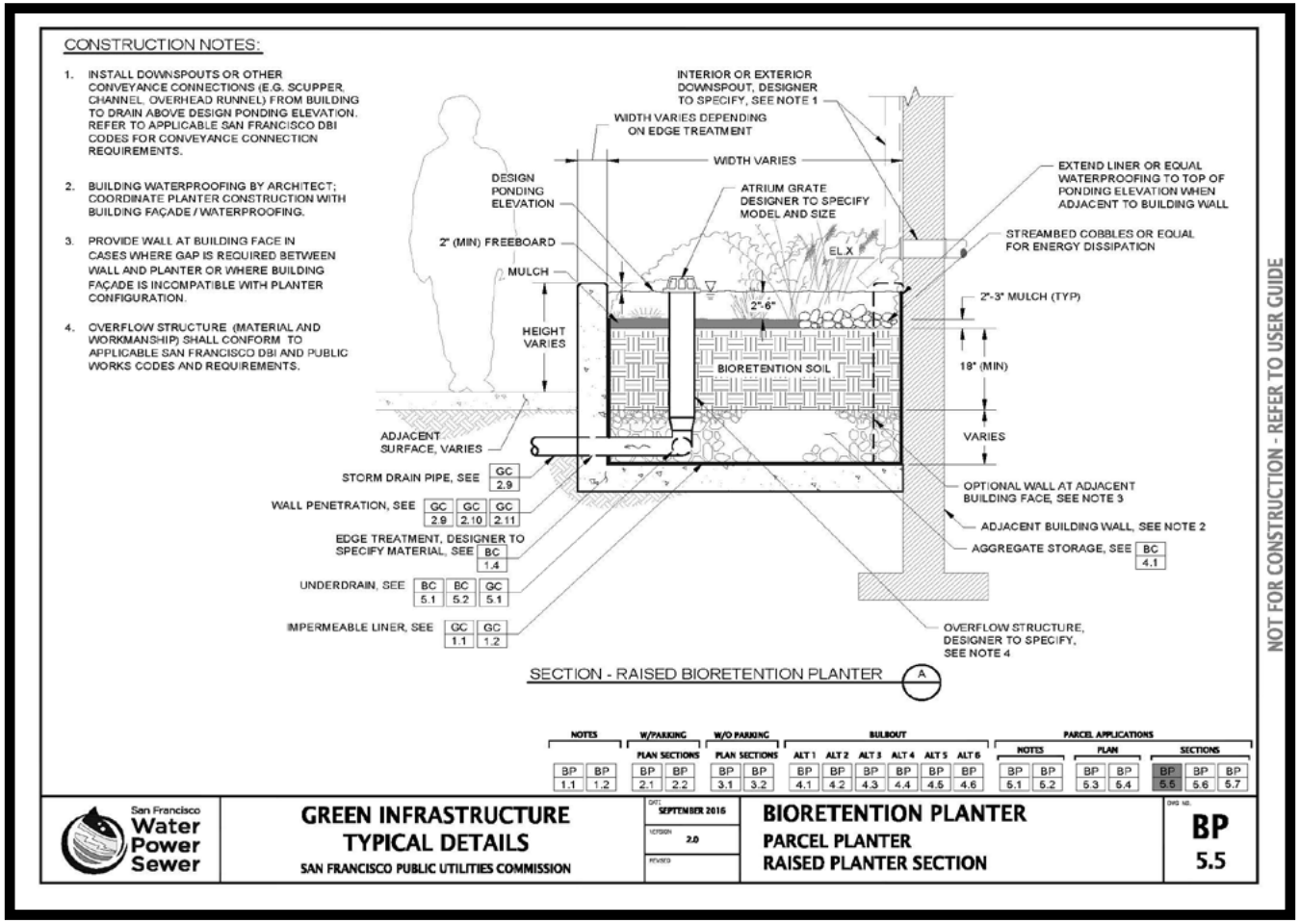
SEE CHAPTER 4

GSI TYPE AND DESCRIPTION

Flow-Through Planter – Flow-through planters are above ground GSI facilities designed to treat stormwater by intercepting runoff from a roof or other impervious surface and slowly draining it through biotreatment soil media into an underdrain without allowing seepage into the underlying soil. They can be used next to buildings and other locations where soil moisture is a potential concern.

EXAMPLES

Flow Through Planter, California Ave. Garage, City of Palo Alto

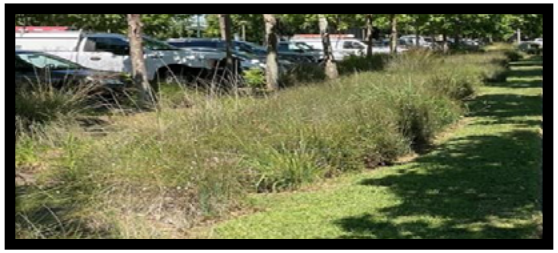


SEE CHAPTER 4

GSI TYPE AND DESCRIPTION

Vegetated Swales – Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff to downstream discharge points (SCVURPPP, 2024). In contrast to bioretention areas, which are designed such that stormwater percolates vertically, vegetated swales are designed to convey flow laterally along the length of the swale, and typically have a shallow bioretent soil media layer and no underdrain. Vegetated swales can be used to convey flow to other GSI measures or as pretreatment.

EXAMPLES



Stanford/Palo Alto Community Playing Fields Vegetated Swale, City of Palo Alto

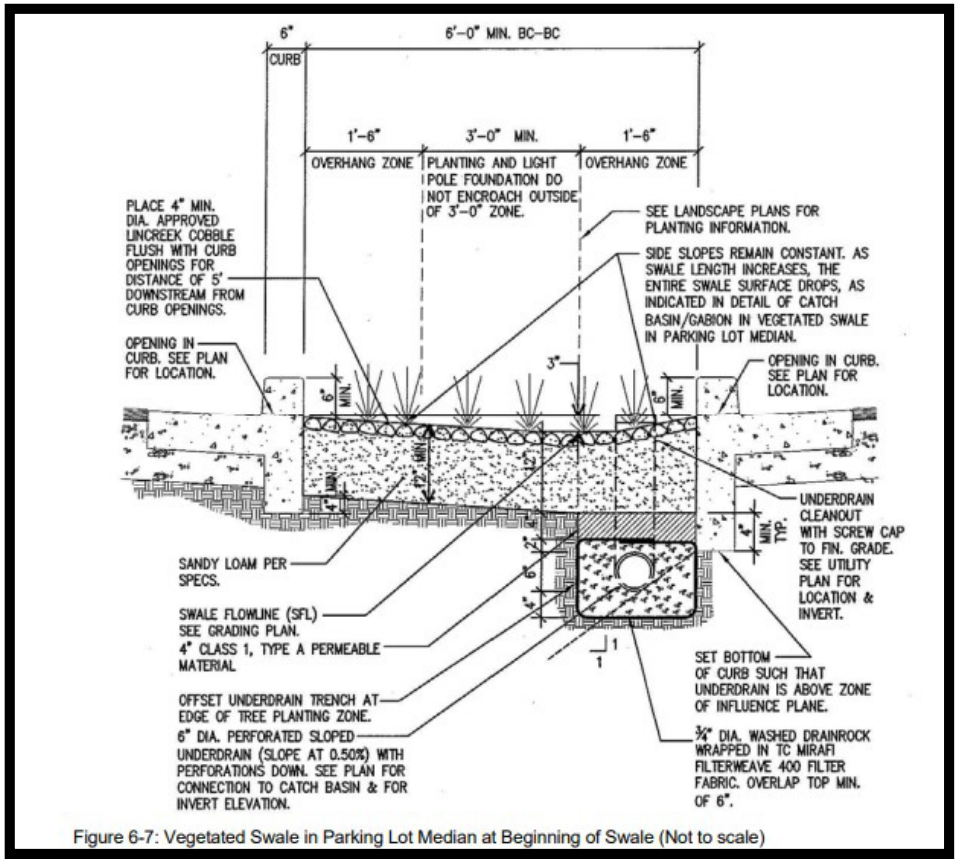


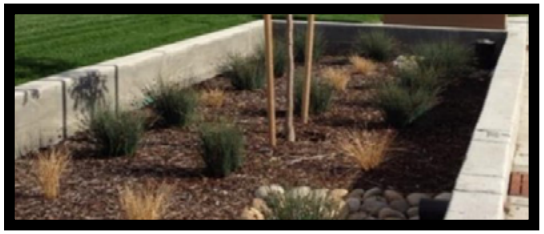
Figure 6-7: Vegetated Swale in Parking Lot Median at Beginning of Swale (Not to scale)

SEE CHAPTER 4

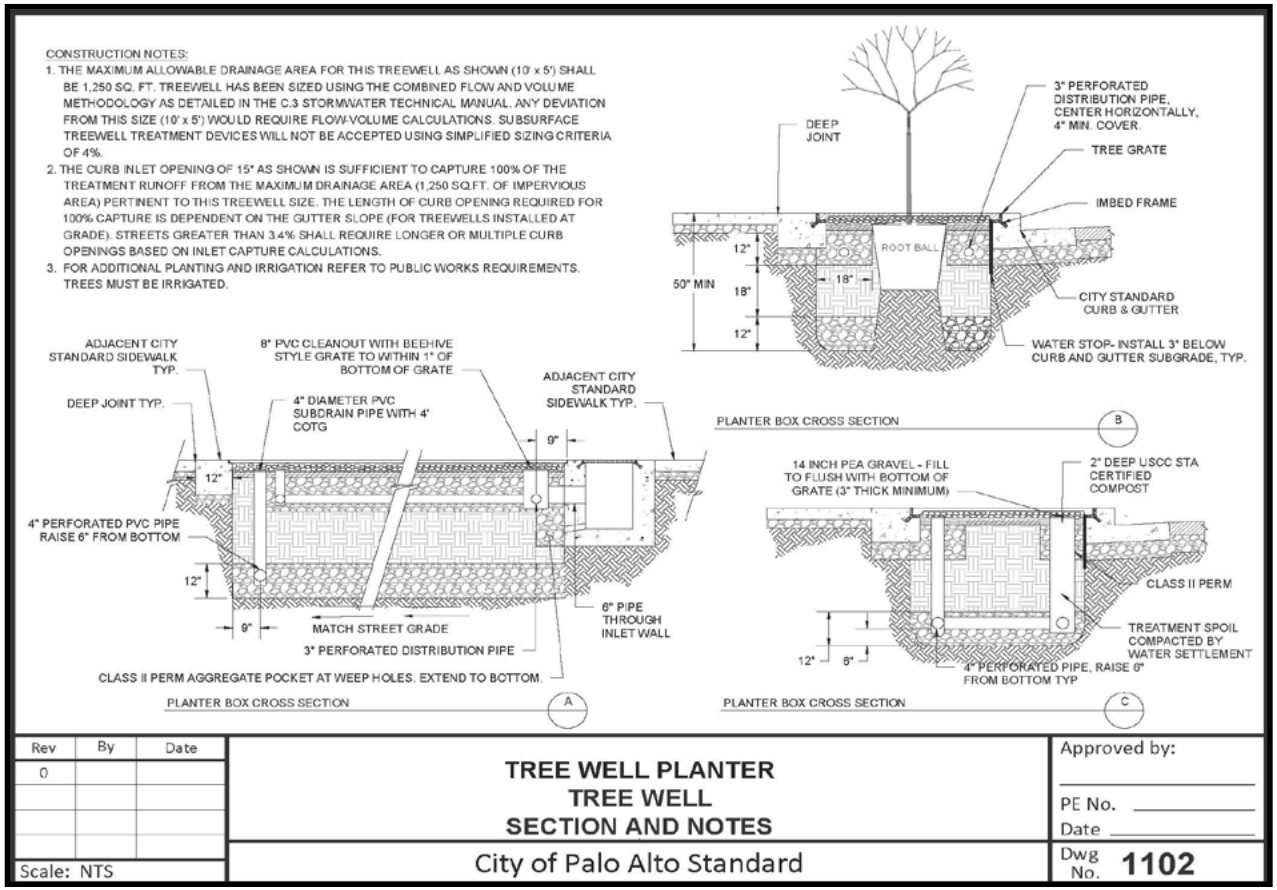
GSI TYPE AND DESCRIPTION

Tree Well Filters – A type of bioretention system consisting of an excavated pit or vault that can be filled with biotreatment soil media, planted with a tree and other vegetation, and underlain with drain rock and an underdrain, if needed. Tree well filters can be constructed in series and linked via a subsurface trench or underdrain. They can be integrated with suspended pavement systems and pervious pavement.

EXAMPLES



Fremont Tree Well Filter (Gilbreath, Hunt, and McKee, 2015)



SEE CHAPTER 5

GSI TYPE AND DESCRIPTION

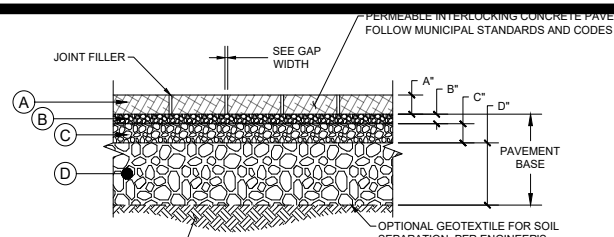
Pervious Pavement – Pervious pavement is hardscape designed to allow surface water to pass through to the ground below by infiltrating through the paver (pervious) or through the joints/space between the pavers (permeable). Water that percolates through the pavement enters an underground storage area filled with various layers of compacted, open-graded aggregates before infiltrating into the underlying soils. Common pervious hardscape types include pervious concrete, porous asphalt, permeable pavers, interlocking concrete pavers with aggregate, and grid pavements (SCVURPPP, 2024).

EXAMPLES

Junior Museum and Zoo Pervious Concrete, City of Palo Alto

CONSTRUCTION NOTES:

1. SEE PERMEABLE INTERLOCKING CONCRETE PAVER SPECIFICATIONS FOR WEARING COURSE, PAVEMENT BASE, SUBGRADE, AND OTHER REQUIREMENTS FOR PERMEABLE INTERLOCKING CONCRETE PAVER FACILITIES.
2. MINIMUM UTILITY SETBACKS AND PROTECTION IN PALO ALTO GSI HANDBOOK AND UTILITY CROSSINGS IN DWG NO 1303. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.
3. IF UNDERDRAIN IS REQUIRED, DESIGN AND PLACEMENT IS PER ENGINEER'S RECOMMENDATION. SEE DWG NO. 1011.
4. SEE DWG NO. 1007 - 1009 FOR EDGE TREATMENT.



PERMEABLE INTERLOCKING CONCRETE PAVERS (1)

MINIMUM MATERIAL THICKNESS (IN) GUIDANCE:

LAYER	MATERIAL TYPE*	MODERATE VEHICULAR		LIGHT VEHICULAR		PEDESTRIAN	
		GOOD SOILS**	POOR SOILS**	GOOD SOILS**	POOR SOILS**	GOOD SOILS**	POOR SOILS**
A	PERMEABLE INTERLOCKING CONCRETE PAVERS	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8
B	LEVELING COURSE ASTM NO. 8	2	2	2	2	2	2
C	BASE COURSE ASTM NO. 57	6	6	6	4	4	4
D	RESERVOIR COURSE ASTM NO. 2, 3, OR 57	22	28	-	10	-	-

* MATERIAL FINER THAN NO. 100 SIEVE SHALL NOT EXCEED 2 PERCENT FOR ANY AGGREGATE LAYER (LICENSED PROFESSIONAL TO SELECT AGGREGATE).

** "GOOD" AND "POOR" SOIL CLASSIFICATIONS BASED ON AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES. SEE DESIGNER NOTES FOR SUBGRADE ASSUMPTIONS. (LICENSED PROFESSIONAL MUST CALCULATE REQUIRED DEPTH BASED ON SITE CONDITIONS).

*** FOR HEAVY VEHICLE TRAFFIC, LICENSED PROFESSIONAL MUST CALCULATE REQUIRED DEPTH BASED ON EXPECTED LOADS AND SITE CONDITIONS.

TYPICAL JOINT FILLER AGGREGATE SIZE:

GAP WIDTH (IN)	JOINT FILLER AGGREGATE*
3/8 OR 1/2	ASTM NO. 8
1/4	ASTM NO. 9 OR 89
1/8	ASTM NO. 10 **

* PROVIDED FOR REFERENCE ONLY, FOLLOW MANUFACTURER'S RECOMMENDATIONS

** FOR PERMEABLE PAVERS ONLY, ASTM NO. 20 SAND NOT ALLOWED PER MANUFACTURER'S RECOMMENDATIONS. PERMEABLE PAVERS REFER TO PAVERS THAT ALLOW WATER TO FLOW THROUGH ACTUAL UNIT PAVER WHILE PERMEABLE INTERLOCKING CONCRETE PAVERS REFER TO PAVER SYSTEMS THAT ONLY ALLOW WATER TO PASS THROUGH JOINTS.

Rev	By	Date
0		

Scale: NTS

PERVIOUS PAVEMENT
MATERIAL SECTIONS PERMEABLE INTERLOCKING CONCRETE PAVERS

City of Palo Alto Standard

Approved by: _____
PE No. _____
Date _____

Dwg No. **1004**

SEE CHAPTER 6

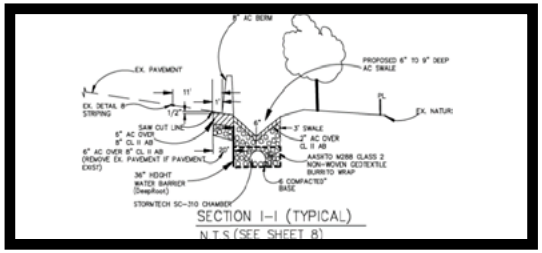
GSI TYPE AND DESCRIPTION

Infiltration GSI Measures – GSI measures designed to capture stormwater and infiltrate it into the underlying soil. Infiltration measures are sited for areas with favorable soil conditions and adequate depth to groundwater. Common types include:

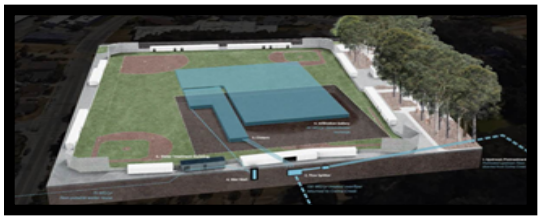
- Subsurface infiltration systems, which may be used to infiltrate larger quantities of runoff. These systems are underground vaults or pipes that store and infiltrate stormwater to the subsurface while preserving the use of the land surface above (e.g., parking lots, playing fields).
- Infiltration trenches, which collect and hold runoff in a linear trench filled with aggregate or other media and allows it to infiltrate into the underlying soil.
- Infiltration basins, which are depressions that capture runoff and allow it to infiltrate to the subsurface.
- Drywells, which are deep, relatively small diameter structures filled or surrounded by aggregate that are installed in the subsurface to infiltrate stormwater 15 to 40 or more feet below the surface.

There are few opportunities for infiltration measures in the City of Palo Alto due to high groundwater and low subsurface soil infiltration rates.

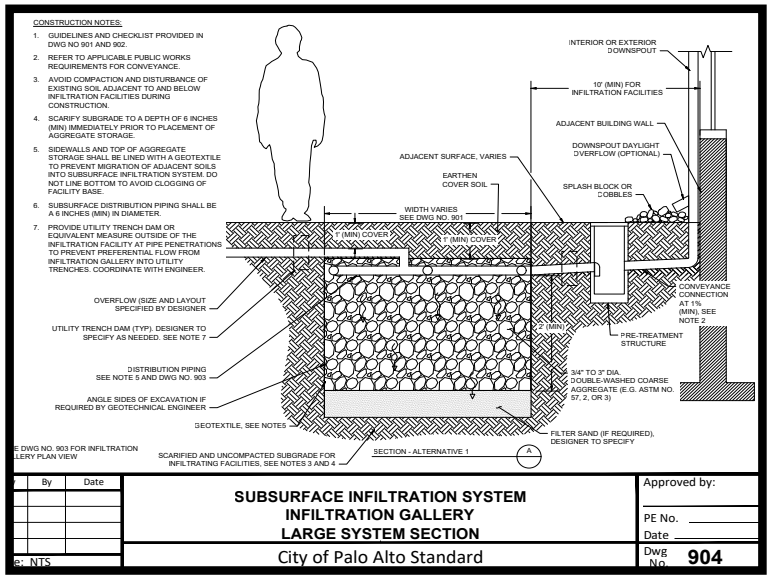
EXAMPLES



Orange Memorial Park Project, City of South San Francisco



Example of Subsurface Infiltration Measure (Lotus Water)



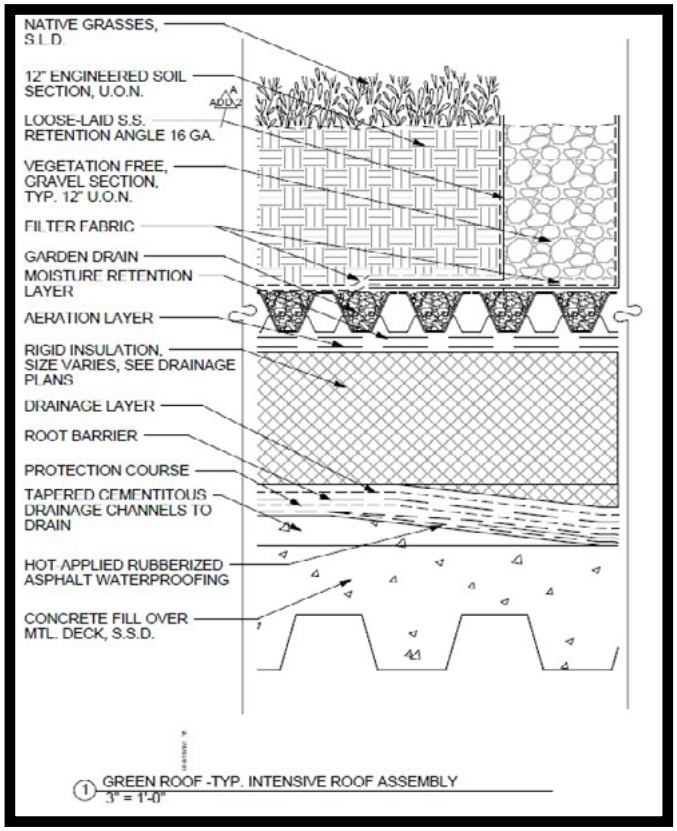
SEE CHAPTER 7

GSI TYPE AND DESCRIPTION

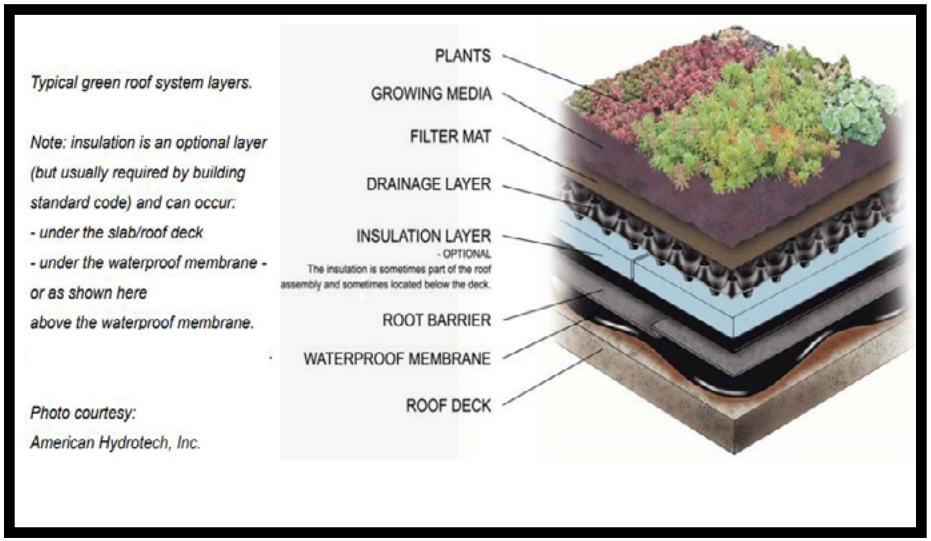
Green Roofs – Green roofs are vegetated roof GSI measures that filter, absorb, and retain or detain the rain that falls on them. Green roof systems are comprised of a layer of planting media planted with vegetation, underlain by other structural components including waterproof membranes, synthetic insulation and geofabrics (SCVURPPP, 2024).

EXAMPLES

Mitchell Park Library Green Roof, City of Palo Alto



Standard Detail, Mitchell Park Library Green Roof, City of Palo Alto



Design Guidelines and Maintenance Manual For Green Roofs in the Semi-Arid and Arid Desert Tolderlund, University of Colorado

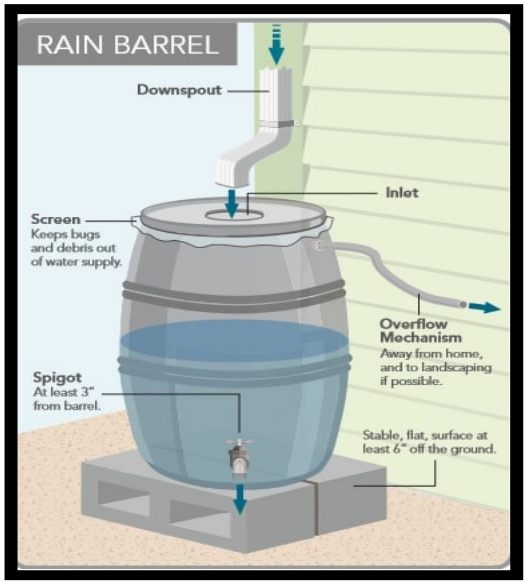
SEE CHAPTER 8

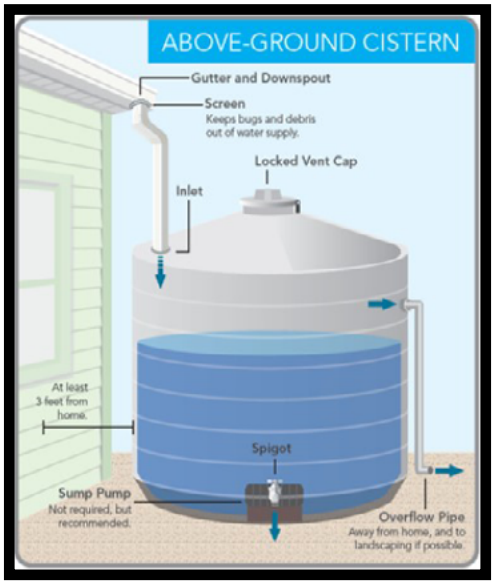
GSI TYPE AND DESCRIPTION

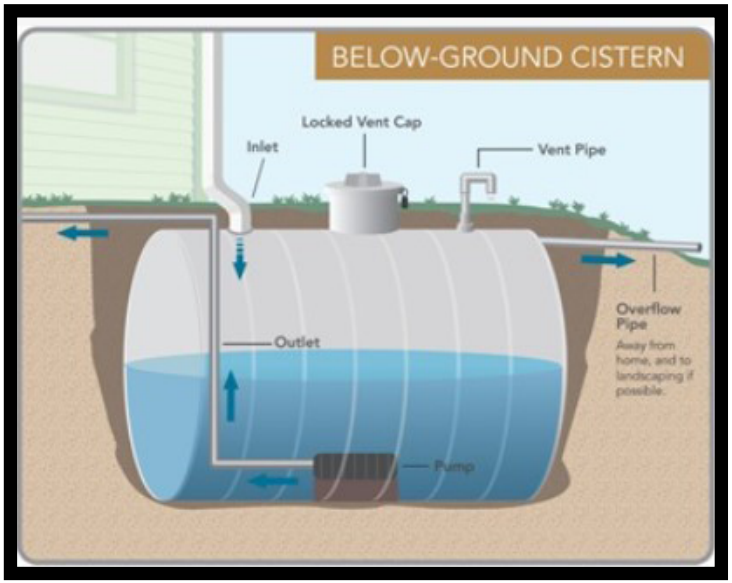
Rainwater Harvesting – Rainwater harvesting is the process of collecting rainwater from impervious surfaces (roofs, pathways, walkways, etc.) and storing it for later use. Rainwater capture systems are designed to store a specified volume of water with no discharge until this volume is exceeded. Storage facilities that can be used to harvest rainwater include rain barrels, above-ground or below-ground cisterns, open storage reservoirs (e.g., ponds), and various underground storage devices (tanks, vaults, pipes, and proprietary storage systems). The harvested water is then fed into irrigation systems or non potable water plumbing systems, either by pumping or by gravity flow (SCVURPPP, 2024).

EXAMPLES

Heron's Head Eco Center Rainwater Capture, San Francisco Recreation and Parks







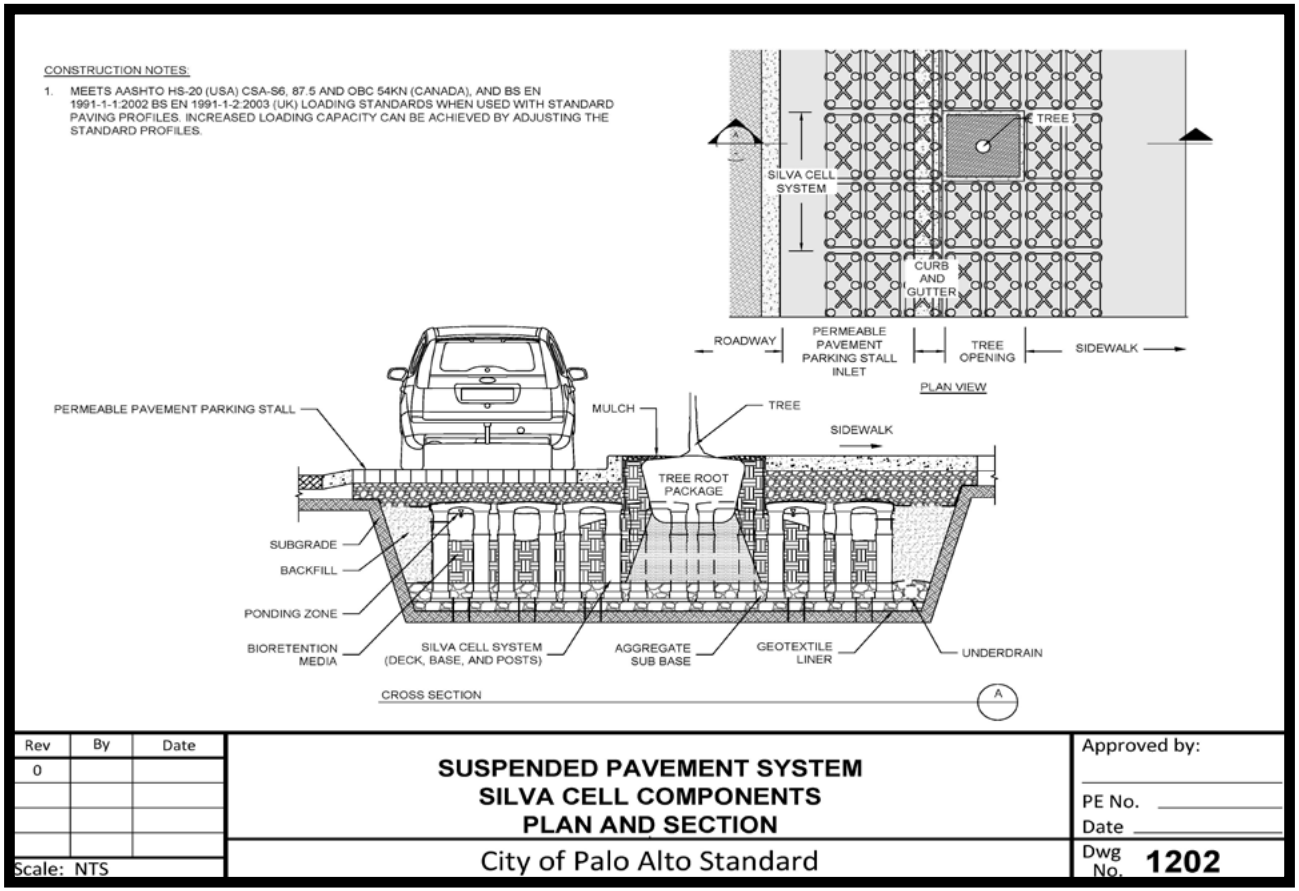
SEE CHAPTER 9

GSI TYPE AND DESCRIPTION

Suspended Pavement Systems – Cells that support the weight of paving or other surfaces while creating a subsurface void that contains biotreatment for capturing and infiltrating stormwater and provides space for urban tree roots to grow. They can be installed as open-bottom systems that promote infiltration or in closed-bottom systems where infiltration is undesirable or infeasible, such as sites with underlying soils that do not allow appreciable infiltration, groundwater contamination, or high groundwater levels. These are frequently constructed using modular proprietary suspended pavement system products, such as DeepRoot's Silva Cell, that can withstand roadway structural loads (adapted from SCVURPPP, 2024).

EXAMPLES

Junior Museum and Zoo Suspended Pavement System, City of Palo Alto



Chapter 3. Site Visit Preparation

CITY OF PALO ALTO

General Safety Considerations

As with all tasks, City staff and contractors are responsible for maintaining safe and healthy working conditions as part of their daily activities. Careful preparation prior to the site visit and safe conduct during such visits are of utmost importance for successful field operations.

TRAFFIC SAFETY

- Become familiar with the project and working location (e.g., traffic patterns, access points).
- Conduct all activities during daylight hours, and avoid peak traffic times on busy streets.
- Determine a traffic safety plan ahead of time, and implement it once onsite. Contact the GSI Maintenance Lead for assistance with the plan.
- Set up a safety perimeter, and be aware of passing pedestrians, bicycles, and vehicles.
- Do not stand in the street when performing maintenance activities unless traffic control has been implemented per the traffic safety plan. Utilize proper traffic safety methods.
- Always be aware of work site hazards above and around and utilize proper safety precautions to minimize work site risks.
- Make yourself visible. Wear brightly colored clothing and a safety vest.
- Do not leave tools unattended. Keep them out of the street and off the sidewalk so that they do not pose a hazard for pedestrians and passing vehicles.

HEALTH AND SAFETY CONSIDERATIONS

- Wear sunblock and a hat or sunglasses.
- Maintain hydration.
- Wear a hard hat (when conditions warrant it), protective clothing, thick gloves, and sturdy work boots.

Removing trash from a GSI measure area in public right-of-way

For complete safety measures refer to Cal/OSHA Title 8 regulations in the California Code of Regulations.

- Wear eye and ear protection as needed.
- Be aware of broken glass, sharp objects, construction debris, and other hazardous items.
- Be aware of needles and other biohazards that can be found in a GSI measure. Use grabbers and thick gloves to remove needles and dispose of them in a needle waste disposal container (i.e., sharps disposal container).
- Be aware of loose soil, standing water, tripping hazards, uneven ground, and other obstructions that might cause you to lose your footing.

Tools & Equipment

- Wear personal protective equipment (PPE): high-visibility clothes/vest, thick gloves, and sturdy/steel toe work boots; hard hats and safety glasses as needed. Wear appropriate rain gear, including jackets, boots, and hats in inclement weather.
- Print and compile applicable Maintenance Assessment Checklists.
- Bring a mobile device to complete checklist and to document activities and issues.
- Pack tarps, trash bags, and compostable bags. Coordinate proper disposal for trash, recyclables, and green waste (vegetative waste).
- Pack traffic control equipment such as traffic cones, delineators, and signs if working in or around traffic lanes or parking lots.

Spreading mulch in bioretention planter with proper tools

RECOMMENDED TOOLS AND EQUIPMENT FOR MAINTENANCE OF GSI FACILITIES

VEGETATED GSI MEASURES AND TREE WELL FILTERS	SUSPENDED PAVEMENT SYSTEMS	PERVIOUS PAVEMENT
• Plant and weed photo ID sheet • Hand weeding tools • Hand trowel • Leaf rake and bow rake • Flat shovel and rounded shovel • Pruners and loppers • Push broom • Tarp/buckets/trash cans (to remove leaf litter/ debris) • Wheelbarrow • Manhole cover hook or lifter (for opening grates) • Vacuum excavator for underdrain cleanout	• Leaf rake and bow rake • Pruners and loppers • Flat shovel and rounded shovel • Hand weeding tools • Manhole cover hook or lifter (for opening grates) • Tarp/buckets/trash cans (to remove leaf litter/ debris) • Wheelbarrow • Vacuum excavator for underdrain cleanout	• Flat shovel and broom • Garbage bags • Walk-behind vacuum • Pressure washer or power washer with rotating brushes • Regenerative air sweeper • Tarp/buckets/trash cans (to remove leaf litter/ debris)
GREEN ROOFS	**RAINWATER CAPTURE**	**INFILTRATION MEASURES**
• Plant and weed photo ID sheet • Hand weeding tools • Hand trowel • Leaf rake and bow rake • Flat shovel and rounded shovel • Pruners and loppers • Push broom • Tarp/buckets/trash cans (to remove leaf litter/ debris)	• Hand trowel • Flashlight • Tarp/buckets/trash cans (to remove leaf litter/ debris)	• Flat and rounded shovel • Tarp/buckets/trash cans (to remove leaf litter/ debris)

Chapter 4. Vegetated GSI: Bioretention, Flow-through Planters, Vegetated Swales, and Tree Well Filters

Maintenance Checklist, Standards, & Guidelines

CITY OF PALO ALTO

Vegetated GSI: Maintenance Condition Checklist

Bioretention, Flow-through Planters, Vegetated Swales and Tree Well Filters

How to Use This Form: Before conducting maintenance activities, Maintenance Staff should perform assessments (Step 4) by following the checklist below. Use the maintenance standard visuals on the following pages to rate each condition.

Date & Time: _____ Project Name or Address: _____ Last Serviced: _____

Name: _____ Agency/Department of Entity/Contractor Performing Assessment: _____

Latest Rainfall 0-24 hrs ☐24-48 hrs ☐ 1-2 days ☐ >3 days Can you access the measure? ☐ Yes ☐ No If not, why?_____

CONDITIONS ASSESSMENT

Trash & Debris Observe levels of trash and debris (including excessive leaf litter), degree of cleanup necessary, and/or obstruction of inlets, outlets, or overflows.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Cobble & Flow Dissipation** Look for signs of erosion or channelization and/ or silt deposition in or adjacent to the vegetated area, inlets, outlets, or splash pads. Check for signs of channelization and scour or loss of soil (moderate/poor).	☐ Excellent ☐ Good ☐ Moderate ☐ Poor
Weeds Observe presence of weeds and/or invasive plants. Note whether weeds are seeding. Check that an abatement plan is in place.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**CONTACT GSI LEAD** If any of the following conditions are **present**, contact the GSI Maintenance Lead.	
Plant & Tree Health Note overall plant and tree health. If thriving/aesthetically pleasing (excellent/good). If distressed/dead and in need or pruning, dead heading, etc.(moderate/poor).	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Standing Water & Vector Control** Note if ponding water is present for 3 days (72 hours) after rain event. Look for evidence of mosquito or mosquito larvae or rodent activity in the GSI measure.	☐ Present ☐ Absent
Plant Density Observe if vegetation is over overcrowded or if bare spots are present and if vegetation is obstructing one or more inlets, overflows, or irrigation emitters/sprinklers.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Irrigation Malfunction** Look for signs of issues with irrigation system (i.e., leaks or breaks, large patches of dead or dying vegetation, etc.).	☐ Present ☐ Absent
Pruning Observe if vegetation is well-manicured and properly pruned (excellent/good) or if over-pruned or overgrown (moderate/poor).	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Structural Damage** Note any evidence of apparent structural damage.	☐ Present ☐ Absent
Mulch Observe coverage and overall appearance of mulch. Mulch should be at least 3" deep and free of sediment and not clumped together.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Vandalism & Graffiti** Observe any vandalism and graffiti and potential problems to appearance, function, and safety.	☐ Present ☐ Absent
Cobble & Flow Dissipation Check that cobbles are appropriately sized and placed at all inlets, outlets, and splash pads. Look for signs of erosion. Check that locations are free of sediment, debris, and clogging.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Contamination & Spills** Contaminants can clog the pavement surface and reduce infiltration capacity. Contaminants and pollution can also negatively impact environmental and human health.	☐ Present ☐ Absent

Follow-Up Recommendations/Notes:

_____

_____

Maintenance Standards for Vegetated GSI: Bioretention, Flow-through Planters, Vegetated Swales and Tree Well Filters

The following series of visual aids are designed to help in the assessments of bioretention areas, flow-through planters, tree well filters, and vegetated swales. They should be used to evaluate the GSI type being assessed and to fill out the corresponding Maintenance Assessment Checklist.

The purpose of the assessment (to be conducted before maintenance activities) is to determine a maintenance condition for each maintenance standard category (see the list to the right for the categories assessed for this GSI type). Under each category, refer to the descriptions and example pictures to determine the condition for the GSI type being assessed. If the condition is identified as "moderate" or "poor," regular maintenance may need to be increased or additional maintenance tasks may be needed. If rated "excellent" or "good," planned maintenance is likely adequate but should continue unless maintenance staff is directed otherwise. Maintenance staff should seek advice from the Maintenance Lead if planned maintenance does not improve the assessment results, or if new tasks are essential for improvement.

MAINTENANCE STANDARD CATEGORIES

- Trash & Debris
- Weeds
- Plant & Tree Health
- Plant Density
- Pruning
- Mulch
- Cobble & Flow Dissipation
- Erosion & Sedimentation
- Contamination
- Standing Water & Vector Control
- Irrigation Malfunction
- Structural Damage
- Vandalism & Graffiti

TRASH & DEBRIS

Observe levels of trash and debris (including excessive leaf litter), degree of cleanup necessary, and/or obstruction of inlets, outlets, or overflows.

EXCELLENT CONDITION

- No trash or debris
- Unobstructed inlets, outlets, and overflow structures
- Regular trash and debris removal maintenance scheduled

GOOD CONDITION

- Minor trash or debris
- Unobstructed inlets, outlets, and overflow structures
- Regular trash and debris removal maintenance scheduled

MODERATE CONDITION

- Moderate trash or debris
- Frequency of existing trash removal schedule is inadequate
- One or more partially obstructed inlets, outlets, and/or overflow structures

POOR CONDITION

- Significant trash or debris, requires immediate trash removal
- Frequency of existing trash removal schedule is inadequate
- One or more fully obstructed inlets, outlets, and/or overflow structures

WEEDS

Observe presence of weeds and/or invasive plants. Note whether weeds are seeding. Check that an abatement plan is in place.

EXCELLENT CONDITION

- No weeds
- Weed abatement plan in place

GOOD CONDITION

- Sporadic weeds (under 5% coverage) with no present
- Weeds have not gone to seed
- Weed abatement plan in place

MODERATE CONDITION

- Moderate weed infestation (5-25% weed coverage)
- Weeds have gone to seed
- Lacking weed abatement plan (Refer to Section 10 Additional Resources for photos of common weeds)

POOR CONDITION

- Weed infestation covering 25% or more of the vegetated area and other plants ('volunteers') not part of the original planting plan are
- Weeds have gone to seed, and new weeds have become established
- Lacking weed abatement plan

PLANT & TREE HEALTH

Note overall plant and tree health. If thriving/aesthetically pleasing - excellent/good. If distressed/dead and in need of pruning, dead heading, etc. - moderate/poor.

EXCELLENT CONDITION

- All plants are healthy, thriving, and aesthetically pleasing

GOOD CONDITION

- Fewer than 10% of plants are showing signs of distress
- No dead plants

MODERATE CONDITION

- 10-25% of plants are distressed or dead

POOR CONDITION

- More than 25% of plants are distressed or dead

PLANT DENSITY

Observe if vegetation is over overcrowded or if bare spots are present and if vegetation is obstructing one or more inlets, overflows, or irrigation emitters/sprinklers.

EXCELLENT CONDITION

- 100% plant coverage at plant maturity*
- Plants are appropriately spaced
- No obstruction of inlets, overflow, or irrigation infrastructure
- *Newly planted vegetated areas may not have full coverage, but they must have full coverage after plant establishment and maturity

GOOD CONDITION

- At least 90% plant coverage at maturity*
- Some sporadic bare spots present (0-10%)
- Most plants are appropriately spaced

MODERATE CONDITION

- At least 50% plant coverage at maturity*
- Moderate number of small bare spots with no large, continuous bare spots (10-20%)
- Significant obstruction of one or more inlets, overflow, or irrigation system

POOR CONDITION

- Less than 50% plant coverage at maturity*
- Significant number of bare spots or large, continuous bare spots (more than 20%)
- Full obstruction of one or more inlets, overflow, or irrigation system

PRUNING

Observe if vegetation is well-manicured and properly pruned (excellent/good) or if over-pruned or overgrown (moderate/poor).

EXCELLENT CONDITION

- All plants are well manicured, and properly pruned

GOOD CONDITION

- Approximately 75% of plants or more are properly pruned and not overgrown to the point that they obstruct inlets/outlets/ water flow/line of sight

MODERATE CONDITION

- 25–50% of plants are overpruned or overgrown

POOR CONDITION

- More than 50% of plants are overpruned or overgrown

MULCH

Observe coverage and overall appearance of mulch. Mulch should be at least 3" deep and free of sediment and not clumped together.

EXCELLENT CONDITION

- Full coverage at a minimum of 3" of wood mulch across the vegetated area
- No mulch needed if there is no exposed soil

GOOD CONDITION

- 2-3" of wood mulch across the vegetated area
- Some small bare spots

MODERATE CONDITION

- Less than 2" of mulch across the treatment vegetated area
- Large bare spots
- Mulch has degraded/decomposed or is heavily compacted across the vegetated area

POOR CONDITION

- Little to no mulch applied to the vegetated area
- Significant amounts of exposed soil

COBBLE & FLOW DISSIPATION

Check that streambed-sized cobbles are appropriately sized and placed at all inlets, outlets, and splash pads. Look for signs of erosion. Check that locations are free of sediment, debris, and clogging.

EXCELLENT CONDITION

- Appropriately sized and placed clean cobble, splash pads, and flow dissipaters

GOOD CONDITION

- Still fully functional but showing signs of impacts, sedimentation, and clogging

MODERATE CONDITION

- Functioning poorly and showing signs of impacts, sedimentation, and clogging

POOR CONDITION

- Not functioning at all and clogged or heavily impacted by sediment/debris
- Incorrectly sized or missing cobble, broken splash pad, or flow dissipaters

EROSION & SEDIMENTATION

Look for signs of erosion or channelization and/ or silt deposition in or adjacent to the vegetated area, inlets, outlets, or splash pads. Check for signs of channelization and scour or loss of soil (moderate/poor).

EXCELLENT CONDITION

- No erosion or sedimentation present

GOOD CONDITION

- Minor erosion occurring but restricted to the inlet and not affecting functionality
- Erosion not present at a majority of inlets
- Minor sedimentation but no obstruction to flow

MODERATE CONDITION

- Moderate erosion with some evidence of channelization and scour or loss of biotreatment soil mix
- Moderate erosion at a majority of inlets
- Moderate sedimentation in stormwater treatment system

POOR CONDITION

- Significant erosion, sedimentation, or loss of biotreatment soil mix
- Erosion resulting in sediment and soil getting into the overflow structure
- Significant erosion at a majority of inlets

CONTAMINATION

Contaminants can clog the pavement surface and reduce infiltration capacity. Contaminants and pollution can also negatively impact environmental and human health.

PLANTERS CAN BECOME CONTAMINATED WITH

- Masonry, plaster, or concrete washout
- Roadway saw cutting slurry and residue
- Petroleum-based substances
- Unknown foreign residue

STANDING WATER & VECTOR CONTROL

Note if ponding water is present 3 days (72 hours) after rain event. Look for evidence of mosquito or mosquito larvae or rodent activity in the GSI measure.

ABSENT

- Adequate infiltration throughout the vegetated measure and no standing water present 48 hours after the last rain event
- No signs of soil compaction and soil is well-aerated
- Appropriate irrigation regime in place

PRESENT

- Evidence of little to no infiltration and significant standing water present more than 72 hours after the last rain event
- Clear signs that soil is compacted throughout entire vegetated measure
- Evidence of mosquito larvae present
- Presence of species that grow in saturated conditions such as cattails, umbrella sedge, mosses, and algae
- Irrigation regime may be causing standing water

IRRIGATION MALFUNCTION

Look for signs of issues with irrigation system (i.e., leaks or breaks, large patches of dead or dying vegetation, etc.)

ABSENT

- No signs of irrigation system malfunctions
- No water waste (sidewalk runoff, ponded water)
- Plants appear healthy throughout (no dead spots where irrigation does not reach)

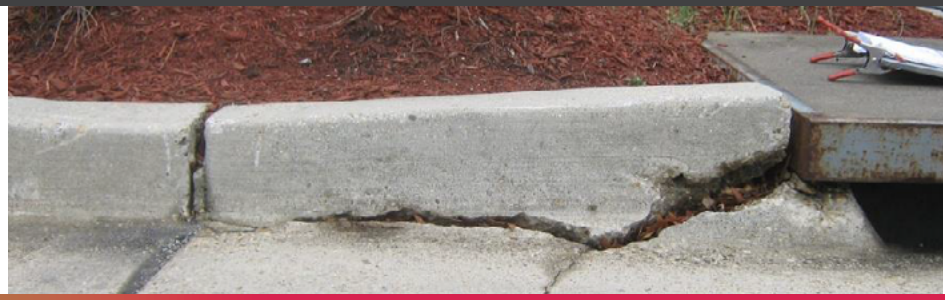
PRESENT

- Large patches of browning and/or wilting plants
- Areas with ponded water
- Evidence of waste of water (runoff outside of the facility perimeter)
- Damage to the irrigation system like leaky valves or couplings, broken popes, missing sprinklers, etc.

STRUCTURAL DAMAGE Note any evidence of apparent structural damage.

ABSENT

- No signs of structural damage
- No risk to public safety and property damage



PRESENT

- Evidence of damage to structural components, including curbs, perimeter fencing, sidewalls, outlet structures, and trench drains
- Potential risk to public safety and property damage

VANDALISM & GRAFFITI Observe any vandalism and graffiti and potential problems to appearance, function, and safety.

ABSENT

- No vandalism or graffiti observed

PRESENT

- Graffiti or vandalism present with potential impacts to appearance and safety, like a damaged irrigation system, broken fences, etc.

Maintenance Guidelines for Vegetated GSI: Bioretention, Flow-through Planters, Vegetated Swales and Tree Well Filters

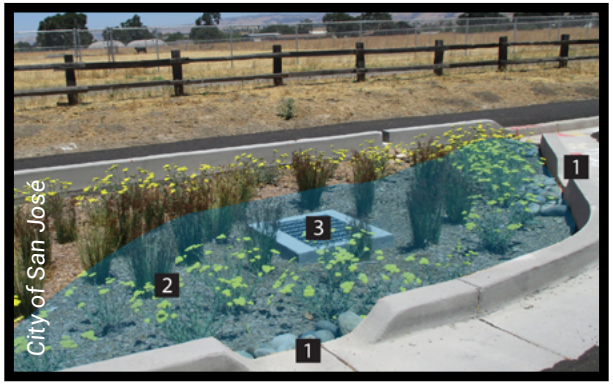
The following series of DOs and DON'Ts are intended to help in performing the most common maintenance tasks for bioretention areas, flow-through planters, vegetated swales and tree well filters.

Vegetated GSIs, such as bioretention areas, flow-through planters, vegetated swales and tree well filters are living systems that are designed to slow, filter, and infiltrate stormwater on site. These facilities utilize an engineered soil mix and selective plant palette that allow the soil matrix and root zone to provide storage and treatment of rainwater runoff. Proper maintenance of these systems is critical to ensure long-term function and appearance.

Maintenance of bioretention filters focuses on the removal of trash and debris, plant maintenance, as well as the upkeep of structures such inlets, outlets, overflows, and underdrains (see photo). Mulching, sediment removal, and erosion control and repairs may also be needed.

MAINTENANCE TASKS

At each visit, check the findings of the maintenance checklist and perform the needed maintenance to bring all facility conditions under the “excellent” and “good” ratings. Once maintenance tasks are complete, compare the final conditions against the maintenance standard visuals. Additional resources on vegetation maintenance can be found in the SCVURPPP GSI Vegetation Guide.



1 *Curb Cut Inlet where stormwater enters the planter*

2 *Capture and Treatment sunken area that holds stormwater and allows it to soak in*

3 *Overflow Structure where stormwater leaves the planter when flows exceed the infiltration capacity (i.e., the rate at which water can soak in)*

EVERY SITE VISIT

- Initial site assessment
- Trash and debris removal
- Weeding

AS-NEEDED, DOCUMENT AND REPORT

- Standing water (> 48 hours after most recent rainfall)
- Structural damage to concrete/wood/metal elements
- Severe erosion or sedimentation inthe planter or drainage system
- Oversized trash or debris that cannot be removed by hand
- Vandalism
- Contamination

AS-NEEDED MAINTENANCE

- Inlets, outlets, and overflow structures cleared of obstructions
- Erosion control and repair
- Sediment removal
- Mulching
- Pruning or trimming vegetation
- Plant replacement

Maintenance Guidelines for Trash & Debris

WHY IS REMOVING TRASH AND DEBRIS IMPORTANT?

Trash and debris can inhibit the functionality of the vegetated GSI measure and diminish treatment, aesthetics, and performance. Clogging of the surface will reduce infiltration and cause more water to bypass. Debris can also obstruct the inlets and outlet of the GSI measure, potentially causing flooding of the measure and/or upstream areas.

MAINTENANCE TASKS

- Remove trash or debris by gloved hand, with a litter stick, or with a rake and a shovel during every site visit.
- Be aware of sharp objects like needles and glass and wear appropriate personal protective equipment (PPE) when handling hazardous objects.
- Place trash in designated receptacle. Use tarps to collect trash and debris to collect significant amounts.
- Place vegetative debris in a compostable bag, tarp, bucket, or other receptacle and dispose of properly as green waste.
- Rake leaves from around the facility, especially in the fall when leaves can quickly clog inlets, outlets, and overflow structures.
- If site has excessive trash, Maintenance staff should refer to the Lead to determine if receptacles are needed.
- In accordance with SB 1383, effective January 1, 2022, and local Recycling and Composting Ordinance, appropriately sort recycling, organics, and landfill.

SUGGESTED TOOLS

- Dustpan and brush
- Compostable garbage bags
- Gloves
- Manhole cover hook or lifter (for opening grates)
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Spade
- Tarps/buckets/ trash cans (to remove leaf litter/ debris)
- Litter stick
- Wheelbarrow or push cart

WHAT TO DO

Manually remove trash

Properly store collected debris

Remove trash in the public right-of-way

Bioretention area with no trash or debris

WHAT NOT TO DO

- Do not attempt to remove trash and debris with a vactor or excavator.
- Do not dispose of leaf and plant litter in the GSI measure. Compost all organic debris.
- Do not remove waste without PPE.
- Limit walking within the vegetated area to prevent overcompacting soil media.
- Do not trample vegetation during routine maintenance activities.

WHAT NOT TO DO

Leaf debris blocking curb inlet

Significant trash in vegetated GSI

Leaf debris blocking overflow structure

Leaf debris in curb inlet

Maintenance Guidelines for Weeds

WHY IS REMOVING WEEDS IMPORTANT?

Weeds can smother the selected plants and inhibit their development, causing reduced infiltration rates. Weeds also reduce the aesthetics of designed vegetated GSI measure.

MAINTENANCE TASKS

- Pull plants upward at the base to remove roots entirely.
- Dig out stubborn root systems with a trowel. Move mulch from the surface to identify roots, and avoid irrigation tubing prior to applying the trowel.
- Remove leaves and stems that break apart from the roots.
- Dispose of weed debris outside the planter in an appropriate container. Weed debris may need to be taken off-site for proper disposal.
- Smooth and pat down the soil to prevent air pockets and fill any holes. Loose soils can encourage new weed growth.
- Cover any bare soil with a minimum of 3" of arbor mulch or other no-float or float resistant mulch approved by the city, such as organic bioretention mulch.
- Remove weeds and invasive plants prior to them going to seed. See GSI Vegetation Guide Attachment 1. for photos of common weeds gone to seed.
- Follow the City of Palo Alto Integrated Pest Management policies to eliminate the use of chemical pesticides. Organic herbicides should only be used in rare circumstances if other strategies have not helped. Approval must be provided by the GSI Maintenance Lead.

SUGGESTED TOOLS

- Gardening hoe
- Gloves
- Hori hori/knife/ trowel/spade
- Weed photo ID sheet
- Pruners/loppers/ shears/saw
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Tarp/buckets/ trash cans
- Wheelbarrow or push cart

WHAT TO DO

Remove weed taproot with a tool

Hand weed

Properly store removed weeds

Apply arbor mulch

Vegetated GSI measure with no weeds

WHAT NOT TO DO

- Do not apply herbicides, fungicides, or insecticides unless special approval is provided.
- Do not dispose of weed debris within the vegetated area.
- Do not leave exposed soil after weed removal (be sure to replace with mulch).
- Do not attempt to pull out weeds without removing the root system.

WHAT NOT TO DO

Pesticide, insecticide, herbicide

Invasive ivy

Invasive pampas grass

Allow weeds to displace GSI plants

Bioretention area with significant weeds

Maintenance Guidelines for Plant Health

WHY IS MAINTAINING PLANT HEALTH IMPORTANT?

Plants provide a critical function within the vegetated GSI measures. Plant roots create pathways for water to percolate through the soil. Plants also provide evapotranspiration of water and uptake of nutrients. They can also provide additional benefits such as habitat and aesthetic value.

MAINTENANCE TASKS

- Provide adequate irrigation of newly planted vegetation until it is well-established.Newly planted installations will take two years to establish themselves.
- Replace dead plants and report major plant die-off (Note: Some CA native plants go through a dormant period in the warm, summer months and may appear dead or dying during this time). Newly planted installations will take up to two years to establish themselves.
- Remove dead and dying plants and record possible cause (e.g., soil compaction, standing water, evidence of disease/fungus, animal burrowing, contanimation) in the maintenance checklist.
- Replace dead or unhealthy plants using an appropriate plant palette or plants from the original design. Appendix D of the SCVURPPP C.3 handbook provides guidance on plant selection for stormwater treatment measures, GSI Maintenance Lead shall approve selection of plants.

SUGGESTED TOOLS

- Dibble bar (for plug planting)
- Gardening hoe
- Gloves
- Hand pick
- Hori hori or similar gardening knife/ trowel
- Post hole digger (for quart or gallon size plantings)
- Pruners, loppers, and shears
- Pruning saw
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Spade
- Tarp/buckets/trash cans (to remove leaf litter/debris)
- Wheelbarrow or push cart

WHAT TO DO

Healthy deer grass

Giant wild rye

Healthy grey rush and sedges

Healthy plants within vegetated GSI

Vegetated GSI measure with healthy and thriving plants

WHAT NOT TO DO

- Do not apply chemical fertilizers. Applying natural nutrients as compost and organic fertilizers is encouraged.
- Do not leave exposed soil after plant removal.
- Avoid planting new plants in the dry season (May - September).
- Do not overprune vegetation, which can cause distress and mortality.
- Do not overcrowd or underplant the GSI measure. In general, it should reach full coverage at plant maturity.
- Do not store maintenance materials or debris in any vegetated areas, and avoid trampling plants.
- Bunch and native grasses are only to be pruned in the late fall/early winter.

WHAT NOT TO DO

Dead and stressed deer grass

Dead ceanothus in a bioretention area

Dying and stressed vegetation

Bioretention area with distressed and dead plants

Maintenance Guidelines for Plant Density

WHY IS MAINTAINING PLANT DENSITY IMPORTANT?

Having dense plantings is important to ensure proper treatment of stormwater runoff and to reduce the risk of erosion and sedimentation. Plants provide a critical function within the vegetated measure. Plant roots create pathways for water to percolate through the soil and help stabilize soil to prevent erosion and catch sediment and debris to prevent it from entering the storm drain system. Plants also provide evapotranspiration of water and uptake of nutrients. They can also provide additional benefits such as habitat and aesthetic value.

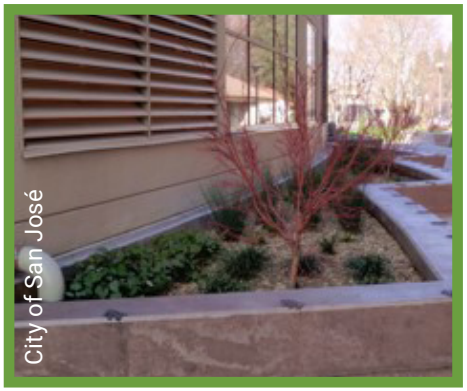
MAINTENANCE TASKS

- Replant bare areas to ensure full coverage at maturity of the plants without crowding.
- Remove dead or dying plants to prevent disease spread.
- Staggering plantings to prevent concentrated flow paths, thus preventing channelization and erosion.
- Ensure plants are properly trimmed and maintained to prevent overgrowth.
- Plant diverse groups of plants to mimic the natural environment.
- Dense plant material can help with weed suppression/control.
- Prune at the appropriate time of year for each species. Pruning when the plant is dormant (typically late summer/fall for CA natives) ensures the healthiest plants.

SUGGESTED TOOLS

- Dibble bar (for plug planting)
- Gardening hoe
- Gloves
- Hand picks
- Hand weeding tools
- Hori hori or similar gardening knife/trowel
- Post hole digger (for quart or gallon size plantings)
- Plant and weed photo ID sheet
- Pruners, loppers, and shears
- Pruning saw
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Spade
- Shovels (drain, edging, flat, rounded, scoop)
- Tarp/buckets/ trash cans (to remove leaf litter/debris)
- Wheelbarrow or push cart
- Wheelbarrow or push cart

WHAT TO DO



Properly planted flow-through planter

Proper plant density at maturity

Newly planted bioretention

Adequately planted bioretention

Bioretention area with proper plant density

WHAT NOT TO DO

- Do not leave dead or dying plants.
- Do not allow bare areas to form.
- Do not plant in rows, as this may encourage channelization and erosion.
- Do not plant monocultures of plants.
- When using overhead irrigation, do not plant directly in front of sprinkler head and place larger (at maturity) towards the center of coverage.
- Do not plant adjacent to valve boxes and overflow inlets. Leave space for plants to reach full size without covering valve boxes.

WHAT NOT TO DO

Incorrect plant density

Incorrect plant density

Plant die-back

Incorrect stagger of plantings

Vegetated GSI measure with poor plant density

Maintenance Guidelines for Pruning

WHY IS PRUNING IMPORTANT?

Pruning plants will ensure that the facility performs properly. Overgrown plants can obstruct facilities' inlets, outlets, irrigation systems, and infiltration pathways. Poorly maintained plants can also make other maintenance activities difficult. Field staff should be trained to conduct pruning, thinning, and transplanting per established horticultural practices and standards.

MAINTENANCE TASKS

- Prune vegetation that clogs inlets and outlets to ensure that stormwater can flow freely into and out of the vegetated areas.
- Prune vegetation that obstructs the irrigation system's function.
- Prune overhanging vegetation that inhibits sidewalks or line of sight at intersections.
- Maintain appropriate height for sight clearance.
- Remove pruning debris from the facility and dispose of properly.
- Remove deadheaded flowers.
- Prune at the appropriate time of year for each species. Pruning when the plant is dormant (typically late summer/fall for CA natives) ensures the healthiest plants.

SUGGESTED TOOLS

- Gloves
- Hedge trimmer
- Hori hori or similar gardening knife/ trowel
- Pruners, loppers, and shears
- Pruning saw
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)

WHAT TO DO

Cut back overcrowding of plants at overflow

Proper pruning technique for bunch grasses

Remove all clippings during routine maintenance

Well-manicured vegetated GSI

Bioretention area with well-manicured and properly pruned plants

WHAT NOT TO DO

- Do not apply herbicides, fungicides, or insecticides.
- Do not dispose of pruning material within the vegetated area.
- Do not prune vegetation too severely, which will diminish plant aesthetics (natural plant form, shape, and habitat).
- Do not trim wildflower mixes before mature seeds have set. Refer to GSI Vegetation Guide on maintenance for common flowering species.
- Do not prune perennials or ornamental grasses during their growth periods unless they are creating an obstruction.

WHAT NOT TO DO

Treatment area in need of pruning

Stressed and over-pruned deer grass

Overpruned giant cape rush

Overgrown grasses blocking overflow

Vegetated GSI area with overpruned plants

Maintenance Guidelines for Mulching

WHY IS MULCHING IMPORTANT?

Mulch provides several critical functions vegetated GSI measures. It provides the initial capture and removal of sediment and debris. It also protects bioretention soil from compaction and erosion, inhibits weed growth, promotes water conservation, media, and promotes healthier plant growth by adding critical nutrients to the soil as it decomposes.

MAINTENANCE TASKS

- Clear blockages so that water can flow freely in and out of the facility.
- Ensure entire vegetated area is covered with a minimum of 3" of composted arbor mulch or other mulch approved by the city.
- Remove sediments, trash, and debris.
- Remove “plated” or “crusted” mulch with a rake or pitchfork and replace with new mulch.
- Rake and loosen mulch to distribute evenly when needed.
- Re-mulch any bare spots or eroded areas on the surface where the soil is visible.
- Note locations of erosion or washout, replace mulch, and consider installing energy dissipation, such as cobbles.

SUGGESTED TOOLS

- Gloves
- Pitchfork
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop, snow)
- Tarp/buckets/trash cans (to remove leaf litter/debris and of sufficient size and strength to support hauling and moving of plant clippings and mulch)
- Trowel
- Wheelbarrow or push cart

WHAT TO DO

3" of composted arbor mulch

Composted arbor mulch

Evenly spread mulch

Install 3" of fresh arbor mulch with plantings

Vegetated GSI measure with good coverage of mulch

WHAT NOT TO DO

- Do not leave exposed soil.
- Do not use a mulch with high fines content or containing recycled materials or softwoods (e.g., gorilla hair, microbark, and bark mulch) which can easily float and be displaced.
- Do not allow mulch to cover tree trunks, shrub stems, leaves, or small plants. Don't place mulch higher than the splash pad/inlet elevation.
- Do not add leaves, grass clippings, or other organic debris to the mulch as these items can clog the bioretention soil.
- Do not use rock or gravel mulch.
- Do not allow mulch to cover cleanouts, cobble, overflows, or observation wells.

Vegetated GSI measure with no mulch coverage

WHAT NOT TO DO

Bark mulch floating into overflow of treatment area

Inappropriate bark mulch

Inappropriate gorilla hair mulch

Inappropriate, matted gorilla hair mulch

Rock mulch in flowthrough planter

Maintenance Guidelines for Cobble & Flow Dissipation

WHY IS MAINTAINING COBBLE AND FLOW DISSIPATION IMPORTANT?

Cobbles and flow dissipation slow turbulent water entering the facility in order to prevent erosion, channelization, and scour of the soil. They also help spread incoming water evenly across the facility, prolonging the lifespan of the soil.

MAINTENANCE TASKS

- Document and report signs of scour, channelization, or erosion, especially around inlets, outlets, structures, and walls.
- Replace any eroded or missing soil, mulch, or cobbles.
- Stabilize loose cobbles.
- Where erosion is observed, install cobbles or flow dissipation as needed to prevent repeated erosion. Size of cobbles should be approved by GSI Maintenance Lead.
- Remove any obstructions preventing adequate flow dissipation.
- Remove accumulated sediment from cobbles by vacuuming or periodically moving cobbles or replacing with clean cobbles.

SUGGESTED TOOLS

- Gloves
- Hammer and gardening staples
- Hand picks
- Hand tamper
- Landscape fabric
- Manhole cover hook or lifter (for opening grates)
- Push broom
- Shovels (drain, edging, flat, rounded, scoop, snow)
- Tarp/buckets/ trash cans
- Trowel
- Utility blade
- Wheelbarrow or push cart

WHAT TO DO

Good cobble splash pad

Clean and well placed cobble at a curb inlet

Properly sized cobble

Well-placed cobble for flow dissipation

Vegetated GSI measure with adequate and clean cobble at inlets

WHAT NOT TO DO

- Do not remove cobbles or flow dissipation.
- Do not place cobble so high that it impedes water from entering the facility through the inlets.
- Do not wash sediment trapped within cobble back into vegetated area. Dispose of sediment in a trash bin.

WHAT NOT TO DO

Cobble impacted by leaves and debris

Severe erosion at the inlet of bioretention area

Cobble severely impacted by sediment

Bioretention area installed without cobble

Maintenance Guidelines for Erosion & Sedimentation

WHY IS ADDRESSING EROSION AND SEDIMENTATION IMPORTANT?

Erosion and sedimentation can cause short-circuiting of flow through the vegetated area, resulting in less contact time with the soil media, and therefore, reduced treatment. Sedimentation can clog the inlet, resulting in bypass of flow, and can clog the soil media resulting in reduced infiltration through the soil.

MAINTENANCE TASKS

- Identify, eliminate, and correct what is causing erosion. Remove accumulated sediment from inlet forebay and low points.
- Scrape any excess sediment created by erosion and dispose of it properly.
- Inspect facility after heavy rain and before and after the wet season.
- Stabilize damaged areas by filling in ruts and gullies, smoothing the soil, and adding erosion control measures such as rock cobble at the inlet. For areas of major erosion, consider using an erosion blanket.
- If plantings are sparse, provide additional plantings to match the originally designed plant density.
- If severe erosion is found, document and report the issue on the assessment checklist. Attempt to identify the source of the problem.
- Locate the splashpad and remove excess sediment and silt by scraping up sediment with a shovel or removing and cleaning cobbles.
- For cobble forebays, remove cobbles, clean the debris from the cobbles, and replace the cobbles as designed.
- Replant vegetation damaged by sediment accumulation and removal process.
- If sediment buildup or hard “caking” of silt is found within the vegetated area, remove accumulated sediment and silt while being careful not to damage plants or remove a significant amount of soil, to the extent feasible. Replace any soil media that might have been removed during the process of removing sediment.

WHAT TO DO

Erosion control Best Management Practices installed adjacent to a vegetated GSI measure

Properly protected soil stockpile

Sediment manually removed from vegetated measure

SUGGESTED TOOLS

- Gloves
- Hammer and gardening staples
- Hand picks
- Hand tamper
- Landscape fabric
- Manhole cover hook or lifter (for opening grates)
- Plastic sheeting or jute netting to cover stockpiles
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Sand and gravel bags to secure wattle and plastic sheeting
- Shovels (drain, edging, flat, rounded, scoop, snow)
- Sledgehammer/mallet
- Straw wattle and stakes
- Tarp/buckets/trash cans (to remove leaf litter/debris and of sufficient size and strength to support hauling and moving of plant clippings and mulch)
- Trowel
- Utility blade
- Wheelbarrow or push cart

WHAT NOT TO DO

- Do not remove significant amounts of soil while removing sediment.
- Do not remove sediment overlaying soil with a vactor or excavator.
- Do not allow small amounts of erosion to go unchecked. Fix any erosion problems immediately to prevent much larger issues in the future.

WHAT NOT TO DO

Unprotected material stockpiles

Partially covered material stockpile

Sediment within vegetated area

Uncovered stockpile adjacent to vegetated GSI measure

Vegetated GSI measure with significant deposited sediment

Evidence of erosion and channelization

Maintenance Guidelines for Standing Water & Vector Control

WHY IS ADDRESSING STANDING WATER AND VECTOR CONTROL IMPORTANT?

Standing water can be a sign of failed drainage that needs to be corrected. It can create habitat for mosquitoes, which are vectors of disease. Vegetated GSI measures can also harbor other vectors such as pocket gophers, ground squirrels, and other rodents.

In order to prevent mosquitoes from becoming established, water should not stand within a treatment area for more than 24 hours after the last rain event. **If water remains for more than 72 hours, notify the City GSI Maintenance Lead so that they may contact the Santa Clara County Vector Control District.**

MAINTENANCE TASKS

- Document and report signs of standing water to the property manager, supervisor, or owner.
- Identify and eliminate causes of standing water within and around bioretention planters.
- Scarify soil mix or aerate to increase infiltration, remove sediment, and debris using rakes or mechanical tools, when needed.
- Inspect the outlet, cleanouts and downstream inlet for possible blockages.
- Remove all blockages, if possible.
- Maintain underdrains by hydro-jetting/snaking as needed.
- Perform a shovel test to determine if soil is compacted. Soil that is hard and difficult to penetrate or break up is exhibiting compaction.
- Implement sediment controls upstream as needed to prevent clogging of soil mix.

WHAT TO DO

Standing water during rainfall event

Vegetated GSI measure with minimal standing water and optimal infiltration

SUGGESTED TOOLS

- Gloves
- Hand picks
- Hoses
- Manhole cover hook or lifter (for opening grates)
- Mosquito dunks
- Pitchfork
- Rakes (bow, hand, leaf, shrub, weed)
- Sand and gravel bags to secure wattle and plastic sheeting
- Scarifier
- Shovels (drain, edging, flat, rounded, scoop, snow)
- Soil aerating tool
- Squirrel and rodent traps (containing no rodenticides)
- Sump pump
- Tarp/buckets/trash cans (to remove leaf litter/debris and of sufficient size and strength to support hauling and moving of plant clippings and mulch)
- Trowel
- Wheelbarrow or push cart

WHAT NOT TO DO

- Do not apply chemical insecticides unless directed by the City.
- Do not allow sediment to accumulate within the system, leading to reduced infiltration rates and standing water.
- Do not wait to address vector control issues, notify the GSI Maintenance Lead.

WHAT NOT TO DO

Do not apply chemical insecticides unless directed by the City

Standing water leading to cattail growth

Bioretention planter with standing water 24 hours after rainfall

Maintenance Guidelines for Irrigation Malfunction

WHY IS ADDRESSING IRRIGATION MALFUNCTION IMPORTANT?

Irrigation malfunctions can be problematic for vegetated GSI measures. Having uneven watering patterns or not watering at all can cause premature plant mortality. Conversely, broken irrigation lines can cause standing water to inundate the measure and kill plants that are not adapted to continuous water contact. Broken irrigation lines or overwatering can also lead to standing water and vector control issues.

MAINTENANCE TASKS

- If irrigation malfunction is suspected, inspect and run the system. Notify the GSI Maintenance Lead of any issue so that City staff may conduct the repair.
- City staff will repair any irrigation breaks as soon as it is feasible to protect plant health and prevent erosion and structural damage.

WHAT TO DO

Irrigation system in good working condition

SUGGESTED TOOLS

- Gloves
- Hand picks
- Irrigation components (drip lines, emitters, spray nozzles, valves, etc.)
- Manhole cover hook or lifter (for opening grates)
- Post hole digger (for quart or gallon size plantings)
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Spade
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Wheelbarrow or push cart

WHAT NOT TO DO

- Do not allow irrigation breaks to go unrepaired for extended periods of time.
- Do not allow heavy equipment to work in or around unprotected infrastructure. In no case should heavy equipment or vehicles be allowed in a treatment area.

WHAT NOT TO DO

Damaged irrigation line

Damaged sprinkler head

Damaged popup emitter

Maintenance Guidelines for Structural Damage

WHY IS ADDRESSING STRUCTURAL DAMAGE IMPORTANT?

Structural damage can occur from everyday wear and tear on treatment area systems. Systems installed in high traffic areas such as parking lots, along streets, and in public spaces can also show signs of structural damage. This can result in runoff bypassing the system and concentrating flows, causing erosion and undercutting infrastructure.

MAINTENANCE TASKS

- Document and report signs of structural damage to the property manager, supervisor, or owner and determine causes of damage if possible.
- Determine if structural damage can be corrected or if replacement is necessary.

WHAT TO DO

Treatment area with structural barrier in good condition

SUGGESTED TOOLS

- Gloves
- Hand picks
- Irrigation system components (drip lines, emitters, spray nozzles, valves, etc.)
- Manhole cover hook or lifter (for opening grates)
- Post hole digger (for quart or gallon size plantings)
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Spade
- Tarp/buckets/trash cans (to remove leaf litter/debris)
- Wheelbarrow or push cart

WHAT NOT TO DO

- Do not allow heavy equipment to work in or around unprotected infrastructure. In no case should heavy equipment or vehicles be allowed in a treatment area.
- Do not leave structural damage unreported. If structural damage presents a danger to the public, install temporary protections until the repair can be implemented.

WHAT NOT TO DO

Damaged popup emitter

Broken curb

Curb damaged by heavy equipment

Treatment area damaged by vehicular traffic

Maintenance Guidelines for Vandalism

WHY IS ADDRESSING VANDALISM IMPORTANT?

In high traffic areas, vandalism such as removal of plants, cobbles, soil, and mulch can adversely affect the performance of the facility.

MAINTENANCE TASKS

- Install protective measures to ensure sensitive infrastructure, such as irrigation controls and weirs, cannot be vandalized.
- Repair infrastructure that has been damaged or vandalized as soon as possible.
- Remove graffiti or other signs of vandalism as soon as possible.

WHAT TO DO

Flow-through planter free of vandalism

SUGGESTED TOOLS

- Gloves
- Plant safe, biodegradable paint removers
- Power washer
- Hand picks
- Manhole cover hook or lifter (for opening grates)
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Wheelbarrow or push cart

Maintenance Guidelines for Contamination

WHY IS ADDRESSING CONTAMINATION IMPORTANT?

Contamination is a problem where dumping or spills can occur and enter the bioretention. Removal of contaminants is critical to ensure proper operation of bioretention and prevent pollution of downstream drainage systems and receiving waters.

MAINTENANCE TASKS

- Clean up spills as soon as possible to prevent contamination of the measure and stormwater.
- Implement source control Best Management Practices such as covering stockpiles of landscape material, cleaning spills on parking lots, etc.
- If hazardous substances are observed, do not remove or touch. Document and report immediately to your supervisor for proper handling and disposal.
- For nonhazardous materials, remove the contaminated layer of mulch and soil to expose clean soil, roughen clean soil surface with a rake, add new soil (if required), and apply a new layer of mulch.

SUGGESTED TOOLS

- Gloves
- Hand picks
- Manhole cover hook or lifter (for opening grates)
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Spade
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Wheelbarrow or push cart

WHAT TO DO

Field staff removing contamination with appropriate protective measures

Bioretention plants with no contamination or vandalism

WHAT NOT TO DO

- Do not encourage pedestrian or pet access to treatment area.
- Do not wash out concrete, stucco, paint or food waste or allow anything other than rainwater to enter the treatment system.

WHAT NOT TO DO

Gap in fencing that promotes pedestrian accesses through bioretention area

Do not allow contamination to remain in bioretention area

Do not allow vandalism to remain in bioretention area

Chapter 5. Pervious Pavement

Maintenance Checklist, Standards, & Guidelines

CITY OF PALO ALTO

Pervious Pavement: Maintenance Condition Checklist

How to Use This Form: Before conducting maintenance activities, Maintenance Staff should perform assessments (Step 4) by following the checklist below. Use the maintenance standard visuals on the following pages to rate each condition.

Date & Time: _____ Project Name or Address: _____ Last Serviced: _____

Name: _____ Agency/Department of Entity/Contractor Performing Assessment: _____

Latest Rainfall 0-24 hrs ☐24-48 hrs ☐ 1-2 days ☐ >3 days Can you access the Measure? ☐ Yes ☐ No If not, why?_____

CONDITIONS ASSESSMENT			
Trash & Debris Observe levels of trash and debris (including excessive leaf litter), and determine degree of cleanup necessary.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**CONTACT GSI LEAD** If any of the following conditions are **present**, contact the GSI Maintenance Lead.	
Plant Growth Note extent of vegetative growth (moss/ creeping plants/ weeds) between pavers or in pavement cracks.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Structural Damage** Observe cracks of pavement deformation or broken pavers.	☐ Present ☐ Absent
Sedimentation Observe area for sedimentation and ensure area is free of infiltration blockage and all joints are filled with appropriate filler material.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Oil Staining and Contamination** Contaminants can clog the pavement surface and reduce infiltration capacity. Contaminants and pollution can also negatively impact environmental and human health.	☐ Present ☐ Absent
Standing Water Look for signs of ponding water 2-3 dats (48-72 hours) after the rain event	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Utility Repairs** If proper maintenance and repair procedures are not in place, damaged pervious pavement may be replaced with a quick fix of asphalt or other binder. Photograph and report conditions to your supervisor or facility owner.	☐ Present ☐ Absent

Follow-Up Recommendations/Notes:

_____

_____

_____

_____

Maintenance Standards for Pervious Pavement

The following series of visual aides are designed to help in the assessments of Pervious Pavement.

The purpose of the assessment is to determine a maintenance standard for each category. Refer to the description and example picture to determine the standard condition for the GSI at that time. If identified as "moderate" or "poor," regular maintenance may need to be increased or additional maintenance tasks may be needed. If rated "excellent" or "good," planned maintenance is likely adequate but should continue unless Maintenance staff is directed otherwise. Maintenance staff should seek advice from Lead if planned maintenance does not improve the assessment results, or if new tasks are essential for improvement.

Maintenance Standard Categories listed in the table on the right-hand side need to be rated based on the conditions provided below.

MAINTENANCE STANDARD CATEGORIES

- Trash & Debris
- Plant Growth
- Standing Water & Vector Control
- Structural Damage
- Sedimentation
- Oil Staining & Contamination
- Utility Repairs

TRASH & DEBRIS

Observe levels of trash and debris (including excessive leaf litter), degree of cleanup necessary, and/or obstruction of inlets, outlets, or overflows.

EXCELLENT CONDITION

- No trash or debris
- Regular trash and debris removal maintenance scheduled

GOOD CONDITION

- Minor trash or debris
- Regular trash and debris removal maintenance scheduled

MODERATE CONDITION

- Moderate trash or debris
- Frequency of existing trash removal schedule is inadequate

POOR CONDITION

- Significant trash or debris, requires immediate trash removal
- Frequency of existing trash removal schedule is inadequate

PLANT GROWTH

Note extent of vegetative growth (moss/ creeping plants/ weeds) between pavers or in pavement cracks.

EXCELLENT CONDITION

- No vegetative growth (moss/ creeping plants) adjacent or within pavers

GOOD CONDITION

- Vegetative growth beginning to appear between 10-25% of pavers

MODERATE CONDITION

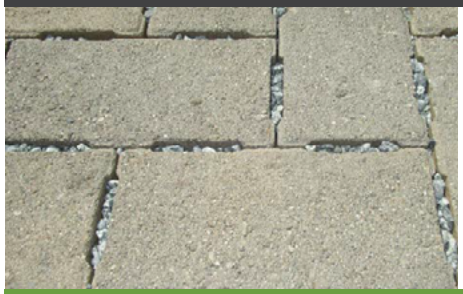
- Moderate vegetative growth between 25-50% of pavers

POOR CONDITION

- Significant vegetative growth is overtaking at least 50% of the pavers

SEDIMENTATION

Look for signs of sediment/silt or debris deposition that may impact ability of pervious pavement to infiltrate at 10-20 inches per hour.



EXCELLENT CONDITION

- No sedimentation or debris present

GOOD CONDITION

- Minor (<10%) sedimentation or debris but no obstruction to infiltration

MODERATE CONDITION

- Moderate sedimentation (10-30%) that is impacting infiltration

POOR CONDITION

- Significant sediment (>30%) accumulation decreasing infiltration

STANDING WATER

Look for signs of ponding water 3 days (72 hours) after rain event. Look for evidence of mosquito or mosquito larvae or rodent activity in the GSI measure.

ABSENT

- Infiltration rate of 20+ inches per hour
- No standing water after 24 hours

PRESENT

- Infiltration rate of < 3 inches per hour
- Long-term ponding (48-72 hours)
- Ponding in over 20% of the surface area

STRUCTURAL DAMAGE

Note evidence of any apparent structural damage.

ABSENT

- Minimal wear of pavement
- None or minimal chipped / cracked pavers

PRESENT

- Significant wear / cracks in pavement
- Significant number of broken or cracked pavers
- Areas of settling and shifting

OIL STAINING & CONTAMINATION

Oil leaks from vehicles can stain the pavement surface. Contaminants can clog the pavement surface and reduce infiltration capacity. Contaminants and pollution can also negatively impact environmental and human health.

ABSENT

- Pavement is clean and free of stains or other contamination

PRESENT

- Oil / vehicle fluids or other chemical staining
- Plaster or concrete "washout"
- Masonry or roadway saw-cutting slurry and residue
- Pesticides and herbicides
- Stockpiled materials stored on unprotected pervious pavement

UTILITY REPAIRS

If proper maintenance and repair procedures are not in place, damaged pervious pavement may be treated with a quick fix of asphalt or other binder. Photograph and report conditions to your supervisor or facility owner.

UTILITY REPAIRS MAY INCLUDE:

- Inappropriate patching or repairs using non-porous materials (e.g., asphalt over pervious pavers)

Maintenance Guidelines for Pervious Pavement

The following series of DOs and DON'Ts are intended to help in performing the most common maintenance tasks. Pervious pavement, such as permeable pavers, porous concrete, and porous asphalt, are a type of pavement that allow stormwater to infiltrate through the paving surface into a storage layer below. Proper maintenance is critical to ensure long-term function and appearance.

Maintenance of pervious pavement is most commonly performed by vacuuming the pavement surface to prevent clogging and to maintain the pervious pavement's designed infiltration rates. Vacuuming is very effective for porous concrete or asphalt, but is likely to remove the in-fill rocks between pavers. This material will need to be replaced following cleanings of pavers. Refer to design plans for information about in-fill material that was used. Materials shall be approved by the GSI Maintenance Lead.

If installed in areas with potential for high sediment, trash, or leaf debris, the pervious pavement facilities may require frequent maintenance, especially in the fall or in seasons with high vegetation debris (like seeds or pollen).

1 Capture and Treatment Area where stormwater is managed and allowed to infiltrate to the subsurface.

2 Colored Pavers - pervious pavement comes in a variety of styles and colors that can be used to distinguish different aspects of the street (crosswalks, parking, etc.).

Maintenance Tasks

At each visit, check the findings of the maintenance checklist, and perform the needed maintenance to bring all facility conditions under the “excellent” and “good” ratings. Once maintenance tasks are complete, compare the final conditions against the maintenance standard visuals.

EVERY SITE VISIT

- Initial site inspection
- Trash and debris removal
- Weeding

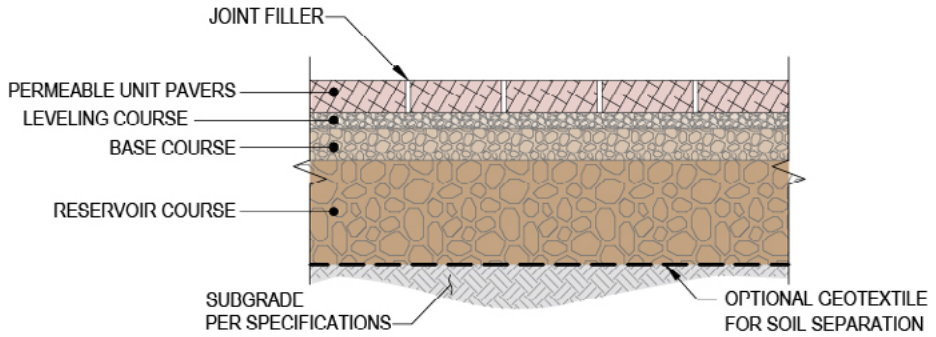
DOCUMENT AND REPORT, AS NEEDED

- Standing water (> 48 hours after most recent rainfall)
- Structural damage to concrete/wood/metal elements
- Oversized trash or debris that cannot be removed by hand
- Vandalism
- Contamination
- Spills

AS-NEEDED MAINTENANCE

- Clear inlets, outlets and overflow structures of obstructions
- Sediment Removal

Typical Pervious Paver Section



Maintenance Guidelines For Trash & Debris

WHY IS REMOVING TRASH AND DEBRIS IMPORTANT?

Trash and debris can clog pervious pavement, which can reduce performance and increase flooding.

MAINTENANCE TASKS

- Remove smaller trash and debris with vacuuming and sweeping.
- Remove leaves using rakes and leaf blowers. Dispose of organic material in a compost bin.
- Manually remove all large trash and debris that cannot be removed by routine vacuuming from the pervious pavement surface and upstream areas. Dispose of this trash and debris at an appropriate facility.

SUGGESTED TOOLS

- Dustpan and brush
- Compostable garbage bags
- Gloves
- Manhole cover hook or lifter (for opening grates)
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Spade

WHAT TO DO

Martha Gardens Green Alleys in San Jose

Pervious pavement free of trash and debris

Cleaned pervious concrete sidewalk

Cleaned pervious concrete

Pervious pavement parking with no trash or debris

WHAT NOT TO DO

- Do not stage or stockpile mulch, sand, dirt, or yard waste on the pervious pavement.
- Do not allow garbage bins in adjacent areas to leak leachate onto any type of pervious pavement.

WHAT NOT TO DO

Contaminants dumped on pervious pavement surface

Dumpsters leaking leachate onto pervious pavement surface

Pervious pavement with landscape debris stockpiled on surface

Maintenance Guidelines for Plant Growth

WHY IS ADDRESSING PLANT GROWTH IMPORTANT?

Some pervious pavements are designed to grow plants within the void space of pavers. It is important to maintain the plants in these pavers to prevent overgrowth and clogging. Pervious pavement that is not designed to have plants can grow moss and creeping plants that can reduce the infiltration rate and overall performance. Moss and any type of vegetation should be immediately removed.

MAINTENANCE TASKS

- Remove unwanted plant growth manually or with a power washer, vacuum, or weed burner.

Note: Some practices, such as power washing or vacuuming, can remove grout material that will require replacement.

SUGGESTED TOOLS

- Bristle broom
- Dustpan and brush
- Garbage bags
- Gloves
- Manhole cover hook or lifter (for opening grates)
- Litter stick
- Power washer/ pressure washer (do not use detergents)
- Push broom
- Rakes (bow, hand, leaf, shrub)
- Shovels (drain, edging, flat, rounded, scoop)
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Walk-behind vacuum (wet/dry vacuum; regenerative air sweeper)
- Wheelbarrow or push cart

WHAT TO DO

Weed burner to restore pervious pavement surface performance

Power washing pervious pavement surface

Pervious pavement free of plant growth

WHAT NOT TO DO

- Do not apply herbicides, fungicides, or insecticides to pervious pavement.

WHAT NOT TO DO

Unwanted chemicals that should never be applied (unless directed by City)

Weed growth between pavers

Weed growth between pavers

Pervious pavement with nuisance plant growth

Maintenance Guidelines for Sedimentation

WHY IS CONTROLLING SEDIMENTATION IMPORTANT?

Sedimentation can clog pervious pavement and cause weed growth.

MAINTENANCE TASKS

- Vacuum sediment and debris from the entire surface area of the pervious pavement installation using a dry vacuum.
- Give extra attention to pavement edges and areas where sediment has accumulated.
- Sweep sediment and debris from surrounding surface areas, especially those that slope toward the pervious pavement.
- Keep joints filled and replace aggregate if gaps are apparent.
- Implement stockpile management and landscape materials storage Best Management Practices. For example, store stockpiles away from pervious pavement systems and storm drains, cover with plastic, and add perimeter controls such as straw wattle.
- Use a wet/dry shop vacuum to clean loose sediment.
- When using a walk-behind vacuum, use a screen over the intake to prevent removing joint aggregate.
- Caution: Power washing can displace joint aggregate and sediment rather than removing it.
- Prevent contamination from routine landscape maintenance such as mowing grass, trimming hedges, and mulching plant beds.
- Mechanically sweep paved surfaces and dispose of debris properly.

Pervious pavement with no sedimentation

WHAT TO DO

Installed pervious concrete sidewalk

Pervious interlocking concrete pavement

Pervious concrete free of sediment

Power wash pervious pavement surface

SUGGESTED TOOLS

- Dustpan and brush
- Garbage bags
- Gloves
- Electric leaf blowers
- Manhole cover hook or lifter (for opening grates)
- Litter stick
- Power washer/pressure washer (do not use detergents)
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Tarp/buckets/trash cans (to remove leaf litter/debris)
- Walk behind vacuum (regenerative air sweeper)
- Wheelbarrow or push cart

WHAT NOT TO DO

- Do not apply salt or sand to the pervious pavement.
- Do not store landscaped materials directly on treatment system.
- Do not allow sediment to accumulate.
- Do not stockpile mulch, topsoil, or other materials that could cause clogging on or near pervious pavement.
- Do not leave exposed soil on slopes adjacent to pervious pavement.
- Do not leave debris piles in areas that may transplant seeds in joints.
- Do not manually sweep pervious surfaces.

WHAT NOT TO DO

Clogged pavers with ponding

Pervious pavement surface clogged with sediment

Pervious pavement with sedimentation blocking drainage

Maintenance Guidelines for Standing Water

WHY IS ADDRESSING STANDING WATER IMPORTANT?

Standing water is an indication that the pervious pavement is not draining adequately. Standing water can lead to damage to the pavement, create habitat for mosquitoes, and cause slipping hazards.

MAINTENANCE TASKS

- Inspect and report to the GSI Maintenance Lead any signs of standing water such as moss or algae growth.
- Inspect and report any signs of high groundwater or seepage.
- Sweep or vacuum the surface and test infiltration afterward.
- If there are signs of standing water or reduced infiltration rates, perform infiltration tests utilizing ASTM Testing Method C1781 to ensure the pervious pavement is functioning properly.

SUGGESTED TOOLS

- Bristle broom
- Dustpan and brush
- Garbage bags
- Gloves
- Manhole cover hook or lifter (for opening grates)
- Power washer/ pressure washer (do not use detergents)
- Push broom
- Rakes (bow, hand, leaf, shrub)
- Shovels (drain, edging, flat, rounded, scoop)
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Litter stick
- Walk-behind vacuum (wet/dry vacuum; regenerative air sweeper)
- Wheelbarrow or push cart

WHAT TO DO

Standing water infiltration test

Pervious pavement with no standing water

WHAT NOT TO DO

- Do not allow water to pond for more than 2-3 days (48-72 hours).
- If standing water is observed, do not delay performing maintenance, as the problem will only get worse.
- Do not apply dry spill cleanup methods such as kitty litter to absorb small ponding, as it could result in clogging.

WHAT NOT TO DO

Clogged pavers with ponding

Pervious pavement surface clogged with sediment

Pervious pavement with standing water

Maintenance Guidelines for Structural Damage

WHY IS ADDRESSING STRUCTURAL DAMAGE IMPORTANT?

Structural damage can create preferential flow paths in the pervious pavement, resulting in erosion of the subgrade, failure of the pavement, and reduced stormwater management.

MAINTENANCE TASKS

- Inspect and report any structural damage, especially along pavement edges and heavy use areas to the GSI Maintenance Lead.
- City staff will identify and address sources of structural damage when feasible.
- Refill joints and bedding with aggregate 0.25" ASTM Stone Size No. 8 or 9 to address paver settling.

WHAT TO DO

Newly installed pervious interlocking concrete pavers

Pervious interlocking concrete pavers

Pervious pavement with no structural damage

WHAT NOT TO DO

- Do not allow vehicles to drive, park, or turn around on the pervious pavement if it is not designed for vehicular loads.
- Do not allow heavy equipment to operate on any type of pervious pavement.

WHAT NOT TO DO

Interlocking paver with minor chipping

Pervious pavers showing signs of deterioration

Pervious concrete with structural damage caused by concrete slurry

Pervious pavement sidewalk with structural damage

Maintenance Guidelines for Routine Vacuuming & Sweeping

WHY IS ROUTINE VACUUMING & SWEEPING IMPORTANT?

Vacuuming and sweeping can remove sedimentation and improve infiltration through the pervious pavement.

MAINTENANCE TASKS

- Prior to vacuuming or sweeping, remove bulky debris and waste materials from pavement surfaces that are too large to be picked up by vacuum hose (e.g., litter, tree branches, wire or car parts).
- Vacuum or sweep sediment and debris from the entire surface area of the pervious pavement installation using a dry vacuum.
- Give extra attention to pavement edges and areas where sediment has accumulated.
- Sweep up sediment and debris from surrounding surface areas, especially those that slope toward the pervious pavement.
- Note and report damage in pavement, including holes, cracks, excessive scuffing, settlement and areas of standing water. Notify the GSI Maintenance Lead so that it can be repaired when feasible.

SUGGESTED TOOLS

- Bristle/Push broom
- Dustpan and brush
- Garbage bags
- Gloves
- Manhole cover hook or lifter (for opening grates)
- Power washer/ pressure washer (no detergents)
- Tarp/buckets/ trash cans
- Litter stick
- Walk-behind vacuum (wet/dry vacuum; regenerative air sweeper)

WHAT TO DO

Sweep up sediment and debris from surrounding surface areas

Clean pervious pavement

WHAT NOT TO DO

- Avoid sweeping and vacuuming from downstream (lowest point) to upstream (highest point) to prevent any sediment from being carried back onto the already cleaned surface.

WHAT NOT TO DO

Trash and debris on pervious pavement surface

Pervious pavement in need of vacuuming

Maintenance Guidelines for Power Washing and Restorative Vacuuming

WHY ARE POWER WASHING AND RESTORATIVE VACUUMING IMPORTANT?

Power washing and restorative vacuuming are done to maintain the aesthetic appearance of pervious pavement as well as provide deep cleaning to remove plugs and restore percolation.

MAINTENANCE TASKS

- Prior to vacuuming or power washing, remove bulky debris and waste materials from pavement surfaces that may be too large to be picked up by the vacuum hose (e.g., litter, tree branches, wire, car parts).
- Vacuum and power wash impacted areas of the pervious pavement.
- Note and report to your supervisor or facility owner any damage in pavement, including holes, cracks, excessive scuffing, settlement, dislodged aggregate, and areas of standing water.
- After vacuuming and power washing permeable pavers, rejoin the pavers with the appropriate aggregate based on the original design or the paver manufacturer's recommendation. If hazardous substances are observed, do not remove or touch them. Document and report them immediately for proper disposal.

WHAT TO DO

Pressure washing pervious pavement surface

Pervious Pavement free of oil staining

SUGGESTED TOOLS

- Bristle broom
- Dustpan and brush
- Gloves
- Manhole cover hook or lifter (for opening grates)
- Power washer/ pressure washer (do not use detergents)
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Litter stick
- Walk-behind vacuum (wet/dry vacuum; regenerative air sweeper)

WHAT NOT TO DO

- Do not use extremely high pressures with a power washer. Doing so can dislodge joint aggregate in unit pavers or damage pervious concrete and porous asphalt surfaces.
- Do not use a vacuum that will remove the gravel in between the joints of pavers.

WHAT NOT TO DO

Pervious pavement surface clogged with sediment

Pervious pavement in need of power washing

Maintenance Guidelines for Oil Staining & Contamination

WHY IS ADDRESSING OIL STAINING AND CONTAMINATION IMPORTANT?

Removal of oil and contamination is done to reduce pollutants, prevent clogging, maintain the aesthetic appearance of the pervious pavement, and eliminate slip hazards.

MAINTENANCE TASKS

- If oil or grease is freshly deposited, lightly blot (not rub) the areas with a clean rag or paper towels. Liquid dish soap or laundry detergent will remove most oil stains. Directly apply the soap to the stain, and allow to sit for 20-30 minutes. Then, scrub with a nylon bristle brush and rinse with hot water. Repeat as needed.
- If removing oil stains after the material has dried and absorbed, soak up as much oil on pavers as possible. Leave granular materials on areas for approximately 6 hours. Sweep up the material. Follow the instructions above for freshly deposited stains.
- If non-hazardous contaminants are observed, scrape them off, and vacuum and power wash the pavement. Then, discard the contaminated material keeping in mind to use an appropriate facility if suspected hazardous waste was removed. Replace any dislodged filler material.

WHAT TO DO

Removing oil from permeable brick pavers

Pervious Pavement free of oil staining

SUGGESTED TOOLS

- Bristle broom
- Dustpan and brush
- Garbage bags
- Gloves
- Manhole cover hook or lifter (for opening grates)
- Power washer/ pressure washer (do not use detergents)
- Push broom
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Litter stick
- Walk-behind vacuum (wet/dry vacuum; regenerative air sweeper)
- Wheelbarrow or push cart

WHAT NOT TO DO

- Do not delay in cleaning a stain. The longer the stain sits on the pervious pavement, the harder it will be to remove.
- If possible, avoid power washing in the direction of storm drains and plants. If unavoidable, try to dilute the solution with as much water as possible.
- Do not use hard bristled brushes that may scratch the pervious pavement.

WHAT NOT TO DO

Contaminant staining on Pervious Pavement surface

Paint staining on Pervious Pavement surface

Pervious Pavement with oil staining

Chapter 6. Infiltration Measures

Maintenance Checklist, Standards, & Guidelines

CITY OF PALO ALTO

Infiltration Measures: Maintenance Condition Checklist

How to Use This Form: Before conducting maintenance activities, Maintenance Staff should perform assessments (Step 4) by following the checklist below. Use the maintenance standard visuals on the following pages to rate each condition.

Date & Time: _____ Project Name or Address: _____ Last Serviced: _____

Name: _____ Agency/Department of Entity/Contractor Performing Assessment: _____

Latest Rainfall 0-24 hrs ☐24-48 hrs ☐ 1-2 days ☐ >3 days Can you access the Measure? ☐ Yes ☐ No If not, why?_____

CONDITIONS ASSESSMENT			
Trash & Debris Observe levels of trash and debris (including excessive leaf litter), degree of cleanup necessary, and/or obstruction of inlets, outlets, or overflows.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**CONTACT GSI LEAD** If any of the following conditions are **present**, contact the GSI Maintenance Lead.	
Weeds Observe presence of weeds and/or invasive plants. Note whether weeds are seeding. Check that an abatement plan is in place.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Standing Water and Vector Control** Note if ponding water is present 3 days (72 hours) after rain event. Look for evidence of mosquito or mosquito larvae or rodent activity in the GSI measure.	☐ Present ☐ Absent
Erosion & Sedimentation Look for signs of erosion or channelization and/ or silt deposition in or adjacent to the vegetated area, inlets, outlets, or splash pads. Check for signs of channelization and scour or loss of soil (moderate/poor).	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Structural Damage** Note evidence of any apparent structural damage.	☐ Present ☐ Absent
		Vandalism & Graffiti Observe any vandalism and graffiti and potential problems to appearance, function, and safety.	☐ Present ☐ Absent

Follow-Up Recommendations/Notes:

_____

_____

_____

_____

Maintenance Standards for Infiltration Measures

An infiltration trench in good condition should have little to no trash and debris accumulation, few weeds, no erosion, and light to no sediment accumulation. Flow through the infiltration trench should show no signs of poor infiltration or clogging. An infiltration trench in poor condition will have standing water, low infiltration rates, heavy sedimentation, structural damage, erosion, or heavy weed growth, and should be maintained.

The purpose of the assessment is to determine a maintenance standard for each category. Maintenance Standard Categories listed in the table on the right-hand side need to be rated based on the conditions listed in the vegetated GSI section. An example for Trash and Debris is provided below. If rated "excellent" or "good," planned maintenance is likely adequate but should continue unless Maintenance staff is directed otherwise. If identified as "moderate" or "poor," regular maintenance may need to be increased or additional maintenance tasks may be needed. Maintenance staff should seek advice from Lead if planned maintenance does not improve the assessment results, or if new tasks are essential for improvement.

MAINTENANCE STANDARD CATEGORIES

- Trash & Debris
- Weeds
- Erosion & Sedimentation
- Standing Water & Vector Control
- Structural Damage
- Vandalism & Graffiti

TRASH & DEBRIS

Observe levels of trash and debris (including excessive leaf litter), degree of cleanup necessary, and/or obstruction of inlets, outlets, or overflows.

EXCELLENT CONDITION

- No trash or debris
- Regular trash and debris removal maintenance scheduled

GOOD CONDITION

- Minor trash or debris
- Regular trash and debris removal maintenance scheduled

MODERATE CONDITION

- Moderate trash or debris
- Existing trash removal schedule but increased frequency needed

POOR CONDITION

- Significant trash or debris, requires immediate trash removal
- Ineffective or nonexistent trash removal program

Maintenance Guidelines for Infiltration Measures

The following series of DOs and DON'Ts are intended to help in performing the most common maintenance tasks for infiltration GSI measures. Infiltration GSI measures are designed to capture stormwater and infiltrate it into native soils. They are sited in areas with favorable soil conditions and adequate depth to groundwater. Common facilities include subsurface infiltration systems, which may be used to infiltrate large quantities of runoff while preserving the use of the land surface above (e.g., parking lots, playing fields), infiltration trenches, infiltration basins, and drywells. Some, but not all infiltration systems include vegetation to provide filtration, prevent erosion, and enhance aesthetics.

Infiltration GSI measures are susceptible to clogging with sediment and typically utilize buffer strips or swales as pretreatment. Regular maintenance involves sediment, trash, and debris removal and cleaning of inlets and pretreatment systems. Infiltration basins that include vegetation will also need weeding and other vegetation care.

MAINTENANCE TASKS

At each visit, check the findings of the assessment checklist and perform the needed maintenance to bring all facility conditions under the “excellent” and “good” ratings. Once maintenance tasks are complete, you may find it helpful to compare the facility’s final conditions against the maintenance standard visuals.

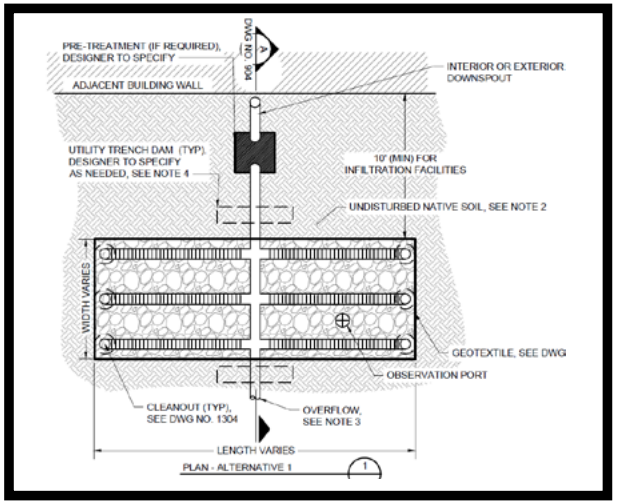
EVERY SITE VISIT

- Initial site assessment
- Trash and debris removal
- Weeding

AS-NEEDED MAINTENANCE

- Inlets, outlets, and overflow structures cleared of obstructions
- Erosion control and repair
- Sediment removal
- Mulching
- Pruning or trimming vegetation

Well-maintained infiltration trench



Infiltration Gallery

MAINTENANCE TASKS

- Inspect and clear debris, trash, and sediment from inlets, outlets, and overflow structures.
- Inspect and report any structural damage, especially along the infiltration trench edges and outlet structure.
- Inspect for erosion and sedimentation
- Note any signs of standing water or extended drawdown time (ponded water over 48 hours).

WHAT NOT TO DO

- Do not create ruts in backfill while performing maintenance.
- Do not damage filter fabric during maintenance.
- Do not allow water to pond within trench for longer than three days.
- Do not replace trench backfill with smaller aggregate or aggregate mixed with fines. Refer to design specifications if available.

WHAT TO DO

Properly maintained infiltration trench

WHAT NOT TO DO

Unkempt cobble infiltration trench

SUGGESTED TOOLS

- Gardening hoe
- Gloves
- Hand picks
- Hand weeding tools
- Pruners/loppers/ shears/saw
- Push broom
- Rakes (bow, hand, leaf, shrub, weed)
- Shovels (drain, edging, flat, rounded, scoop)
- Tarp/buckets/ trash cans
- Wheelbarrow or push cart

Chapter 7. Green Roofs

Maintenance Checklist, Standards, & Guidelines

CITY OF PALO ALTO

GREEN ROOFS: MAINTENANCE CONDITION CHECKLIST

How to Use This Form: Before conducting maintenance activities, Maintenance Staff should perform assessments (Step 4) by following the checklist below. Use the maintenance standard visuals on the following pages to rate each condition.

Date & Time: _____ Project Name or Address: _____ Last Serviced: _____

Name: _____ Agency/Department of Entity/Contractor Performing Assessment: _____

Latest Rainfall 0-24 hrs ☐24-48 hrs ☐ 1-2 days ☐ >3 days Can you access the Measure? ☐ Yes ☐ No If not, why?_____

CONDITIONS ASSESSMENT

Trash & Debris Trash or debris present? Are one or more drains, outlets or overflows, obstructed with sediment, vegetation, or debris?	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**CONTACT GSI LEAD** If any of the following conditions are **present**, contact the GSI Maintenance Lead.	
Weeds Observe presence of weeds and/or invasive plants. Note whether weeds are seeding. Check that an abatement plan is in place.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Standing Water & Vector Control** Note if ponding water is present 3 days (72 hours) after rain event. Look for evidence of mosquito or mosquito larvae or rodent activity in the GSI measure.	☐ Present ☐ Absent
Plant Density Observe if vegetation is over overcrowded or if bare spots are present and if vegetation is obstructing one or more inlets, overflows, or irrigation emitters/sprinklers.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Irrigation Malfunction** Look for signs of issues with irrigation system (i.e., leaks or breaks, large patches of dead or dying vegetation, etc.)	☐ Present ☐ Absent
Plant Health Note overall plant and tree health. If thriving/aesthetically pleasing (excellent/good). If distressed/dead and in need or pruning, dead heading, etc.(moderate/poor).	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Structural Damage** Note any evidence of apparent structural damage to the green roof, its membranes, geofabrics, and other waterproofing.	☐ Present ☐ Absent
Pruning Observe if vegetation is well-manicured and properly pruned (excellent/good) or if over-pruned or overgrown (moderate/poor). Observe that vegetation is not encroaching on HVAC or other roof top equipment, exposed roof membranes, or penetrations.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Debris** Are one or more drains, outlets or overflows, obstructed with sediment, vegetation, or debris?	☐ Present ☐ Absent
Mulch Observe coverage and overall appearance of mulch. Mulch should be at least 3" deep and free of sediment and not clumped together.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**Follow-Up Recommendations/Notes:** --- --- ---	
Erosion Look for signs of erosion or channelization treatment area, inlets, outlets, or splash pads. Check for signs of channelization and scour or loss of soil (moderate/poor).	☐ Excellent ☐ Good ☐ Moderate ☐ Poor		

Maintenance Standards for Green Roofs

Green roofs are roofs that are partially or completely covered with vegetation planted in a growing medium that is underlain by an impermeable barrier. Green roofs typically consist of a series of layers (waterproof membrane, growing medium, vegetation,etc) that create an environment suitable for plant growth without damaging the underlying roof system.

A roof's planting media depth determines, in part, the species and characteristics of selected vegetation, which guides maintenance needs. Media depth typically ranges between 3 inches, for low profile green roofs, and 48 inches, for intensive planted green roofs.

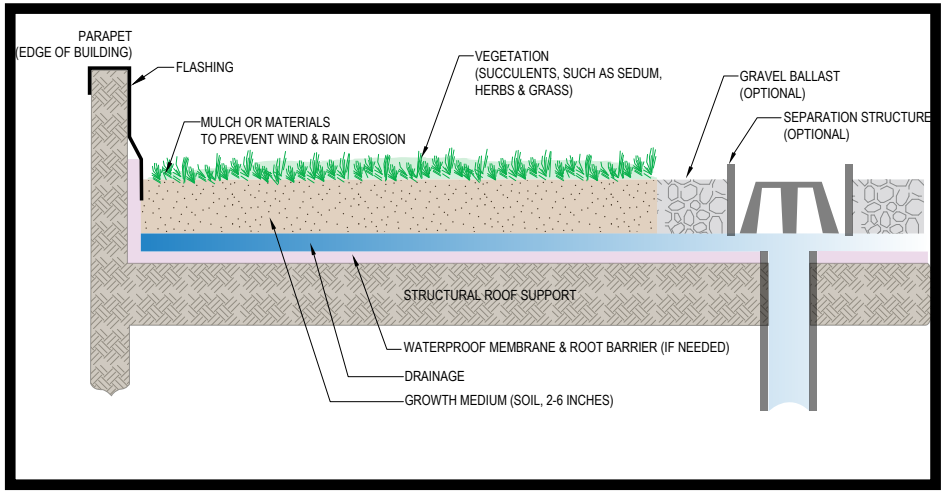
For vegetation maintenance standards, refer to the vegetation-related standards in Chapter 4 Vegetated GSI.

Mitchell Park Library Green Roof - Vegetated section in good condition

Mitchell Park Library Green Roof - Vegetated section in poor condition

MAINTENANCE STANDARD CATEGORIES

- Weeds
- Plant Health
- Plant Density
- Pruning
- Mulch
- Erosion
- Standing Water & Vector Control
- Irrigation Malfunction
- Structural Damage



Typical green roof section

Maintenance Guidelines for Green Roofs

Green roofs require dedicated and regular maintenance to ensure proper and long-lasting operation and ecosystem services. The most frequently cited O&M concerns for green roofs include poorly drained green roofs and standing water due to poor design or drain blockage, roof leaks from perforated membranes, accumulation of trash and debris, and growth and proliferation of weeds or other non-native species that threaten the function and/or the structural integrity of underlying green roof layers.

The waterproofing roof membrane is a vital aspect of green roof longevity and success. Regular inspections of all joints and borders, vertical walls, roof vent pipes, outlets, air conditioning units and perimeter areas are advised. Vegetation should not encroach on HVAC equipment, roof vent pipes, or similar vegetation-free roofing elements.

Regular maintenance of green roofs involves maintaining healthy vegetation, weeding and pest management, and maintaining the irrigation system. Roofs need to also be checked for erosion in the planting media and compromising of the underlaying waterproof layers. The waterproofing roof membrane is a vital aspect of green roof longevity and success. Regular inspections of all joints and borders, vertical walls, roof vent pipes, outlets, air conditioning units and perimeter areas are advised.

MAINTENANCE TASKS

At each visit, check the findings of the assessment checklist and perform the needed maintenance to bring all facility conditions under the “excellent” and “good” ratings. Once maintenance tasks are complete, you may find it helpful to compare the facility’s final conditions against the maintenance standard visuals.

EVERY SITE VISIT

- Initial site assessment
- Debris removal
- Weeding

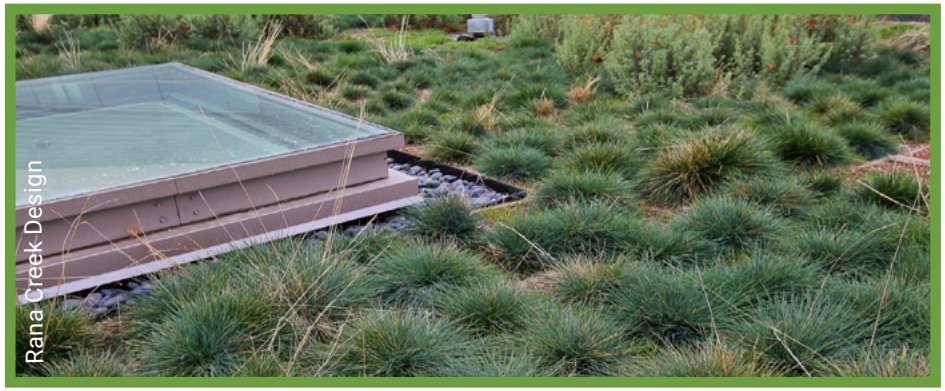
AS-NEEDED, DOCUMENT AND REPORT

- Standing water
- Irrigation malfunction
- Damage to waterproofing membranes, geofabrics, or other structural elements

AS-NEEDED MAINTENANCE

- Inlets, outlets, and overflow structures cleared of obstructions
- Erosion control and repair
- Sediment removal
- Mulching
- Pruning or trimming vegetation
- Plant replacement

WHAT TO DO



Well-established green roof

WHAT NOT TO DO

Do not allow damaged membranes to go unrepaired

Chapter 8. Rainwater Harvesting

Maintenance Checklist, Standards, & Guidelines

CITY OF PALO ALTO

Rainwater Harvesting: Maintenance Condition Checklist

How to Use This Form: Before conducting maintenance activities, Maintenance Staff should perform assessments (Step 4) by following the checklist below. Use the maintenance standard visuals on the following pages to rate each condition.

Date & Time: _____ Project Name or Address: _____ Last Serviced: _____

Name: _____ Agency/Department of Entity/Contractor Performing Assessment: _____

Latest Rainfall 0-24 hrs ☐24-48 hrs ☐ 1-2 days ☐ >3 days Can you access the Measure? ☐ Yes ☐ No If not, why?_____

CONDITIONS ASSESSMENT		
Trash & Debris Observe if trash or debris present on or in the systems. Observe if one or more inlets, outlets, or overflow structures are obstructed.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	**CONTACT GSI LEAD** If any of the conditions are noted for Standing Water & Vector Control, Structural Damage, or Vandalism & Graffiti, contact the GSI Maintenance Lead.
Standing Water and Vector Control Observe to ensure all of the rainwater drained from the harvest system within 5 days from last rain. Observe system to determine if there is evidence of mosquitoes in the cisterns or other systems.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	Field Measurement/Materials Used: Amount of material (trash, debris, sediment) collection: Number of bags, pounds, or gallons/bag: _____ _____ _____ _____
Structural Damage Note any structural damage or leaks on the storage or conveyance systems. Note that filters, screens, conveyances, and storage systems are free from damage.	☐ Excellent ☐ Good ☐ Moderate ☐ Poor	NOTES: _____ _____ _____
Vandalism & Graffiti Note any signs of vandalism or graffiti.	☐ Present ☐ Absent	

Maintenance Standards for Rainwater Harvesting

Rainwater capture is the process of collecting rainwater from impervious surfaces, such as roofs and pavement systems, and storing it for later use. Storage facilities that can be used to store rainwater include rain barrels, above ground cisterns, below ground cisterns, and open storage reservoirs.

Uses of harvested rainwater can include irrigation, vehicle washing, and indoor nonpotable use. Rainwater harvesting systems typically include conveyance for inflow to the storage system, overflow conveyance for when the storage is full, treatment and/or filtration systems, and a distribution system to convey water for use.

To function properly, it is essential that the components of rainwater harvesting systems are free of clogs that may be caused by debris such as foliage, algae, sediment, or other kinds of contamination. The systems should also be free of leaks, loose fittings, or any other structural damage.

Rainwater Harvesting at Alameda County Turner Court Demonstration Program

MAINTENANCE STANDARD CATEGORIES

- Conveyance Connections and Structural Damage
- Vector Control
- Contamination & Vandalism

Rainwater Harvesting at Mills College (SCVURPPP, 2024)

Maintenance Guidelines for Rainwater Harvesting

WHY IS RAINWATER HARVESTING IMPORTANT?

Regular maintenance of rainwater harvesting systems involves contanimant and debris removal and cleaning of intake screens and pretreatment devices. Tanks and cisterns may need to be emptied and cleaned occasionally and lines inspected for clogs or damage.

MAINTENANCE TASKS

It is essential to keep systems free of clogs that may be caused by algae or other debris. As such, typical maintenance tasks include removal of any accumulated debris, algae growth, or any other obstruction from the inlets, outlets, or surface of the containment system. Periodical cleaning of roofs, gutters, or other areas that convey rain into the system are also essential for preventing clogs and ensuring proper system functioning.

EVERY SITE VISIT

- Initial site assessment
- Trash and debris removal
- Cleaning intake screens and pretreatment devices

AS-NEEDED MAINTENANCE

- Tank cleaning, with special attention to algae removal
- Pipe assessment and line flushing
- Address structural damage such as holes or loose, leaking fittings

DOCUMENT AND REPORT

- Leaks or other structural damage
- Vector presence
- Contamination

Hoover Park, City of Palo Alto

Heron's Head Eco Center Rainwater Harvesting, San Francisco Recreation and Parks

MAINTENANCE TASKS

- Inspect and clear debris and trash from roof outlets, conveyance, and cistern (where accessible).
- Check the condition of pretreatment device and first flush diversion if they are present. If components are damaged, take steps to correct problems and restore function.
- Inspect and note sediment accumulation and structural condition of the storage tank.
- Note presence of mosquitoes and eliminate causes such as standing water.
- Inspect piping, valves, vents, drains, and baffles for damage, blockages, and leaks.
- Check for visible contaminants and pollution in the tank and catchment area. Take appropriate cleanup action.

WHAT NOT TO DO

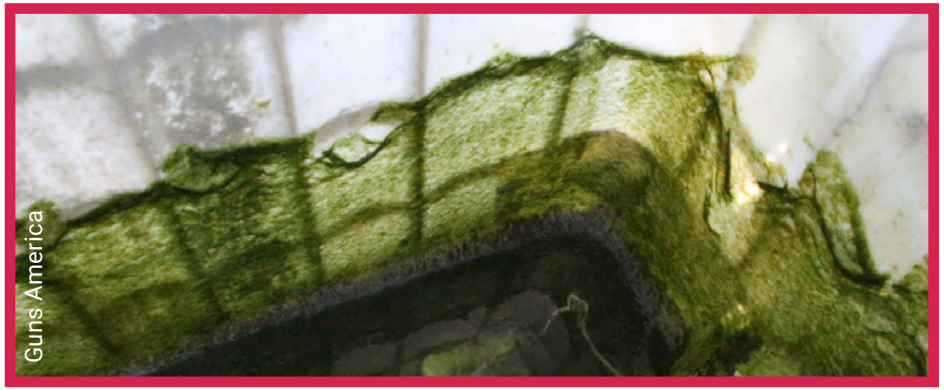
- Do not allow conditions that promote algae or other organisms to grow inside the storage reservoir.
- Do not store contaminants on or near the collection surface.
- Do not allow trees or other vegetation to overhang the collection surface. Prune vegetation to avoid overhang.
- Do not enter storage reservoir without proper applicable training, e.g., confined space entry and personal protective equipment.
- Do not leave cleaning product residue on surface of storage or collection areas. Flush with clean water.

WHAT TO DO

Inspect and note sediment accumulation

Inspect piping and valves

WHAT NOT TO DO



Do not allow conditions that promote algae growth

SUGGESTED TOOLS

- Compostable trash bags
- Gloves
- Pruners/loppers/ shears/saw
- Tarp/buckets/ trash cans (to remove leaf litter/ debris)
- Vacuum
- Wheelbarrow or push cart

Chapter 9. Suspended Pavement Systems

Maintenance Standards & Guidelines

CITY OF PALO ALTO

Maintenance Standards for Suspended Pavement Systems

Suspended Pavement Systems are cells that support the weight of paving or other surfaces while creating a subsurface void that contains biotreatment for capturing and infiltrating stormwater and space for urban tree roots to grow. These are frequently constructed using modular proprietary suspended pavement system products, such as DeepRoot's Silva Cell, that can withstand roadway structural loads.

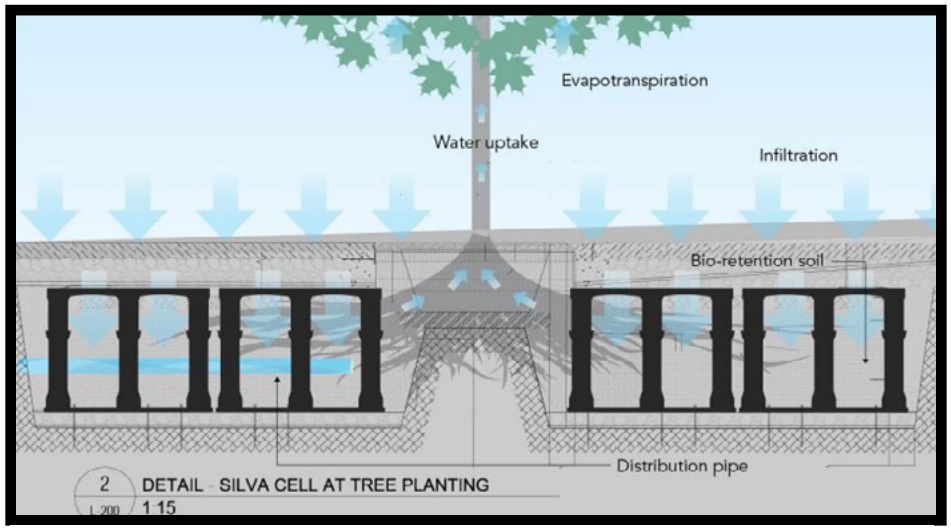
Suspended pavement systems are often used in combination with pervious pavement and/or tree wells filters. As such, maintenance standards for suspended pavement systems are similar to those for pervious pavement (Chapter 5) and tree well filters (Chapter 4). At a minimum, inlets, outlets, and pretreatment systems, if present, need to be free of debris and sediment to ensure proper functioning of the system.

For Condition Assessments, use the appropriate Maintenance Checklist for Vegetated GSI or Pervious Pavement Systems.

MAINTENANCE STANDARD CATEGORIES

- Trash & Debris
- Weeds
- Tree Health
- Mulch
- Cobble & Flow Dissipation
- Erosion & Sedimentation
- Standing Water & Vector Control
- Irrigation Malfunction
- Structural Damage
- Vandalism & Graffiti

Suspended Pavement System Junior Museum & Zoo, City of Palo Alto



Example suspended pavement system and a tree well filter (Deeproot Green Infrastructure, LLC.)

Maintenance Guidelines for Suspended Pavement Systems

In and of themselves, suspended pavement systems such as DeepRoot Silva Cells, require minimal maintenance. The inlet/outlet structures, distribution pipes, underdrain pipes, pretreatment systems, and catch basins require periodic cleanout. Typically, the pipes have a cleanout to be accessed for maintenance purposes.

If the systems have trees or are designed with pervious pavement, then additional maintenance tasks typical for those GSI need to be conducted (refer to Chapter 4 and Chapter 5, respectively). Additionally, the corresponding tool lists should be referenced.

AS-NEEDED, DOCUMENT & REPORT

- Standing water (> 48 hours after most recent rainfall)
- Structural damage to concrete/wood/metal elements
- Oversized trash or debris that cannot be removed by hand
- Vandalism
- Contamination
- Spills

EVERY SITE VISIT

- Initial site assessment
- Trash and debris removal
- Weeding

AS-NEEDED MAINTENANCE

- Inlets, outlets, and overflow structures cleared of obstructions
- Erosion control and repair
- Sediment removal
- Mulching
- Pruning or trimming vegetation
- Weeds Management

Chapter 10. Additional Resources

CITY OF PALO ALTO

Common Weeds

Bur Clover

Description: Stems grow to 2 feet long and tend to trail along the ground but may grow upright. Leaves divide into three round leaflets, resembling those of a clover. Leaflets have serrated edges.

Removal: Grab at base and hand pull or use a trowel to get tap root completely (easy to remove, especially in soft soils).

Catchweed Bedstraw

Description: Seed leaves are oblong with slightly notched tips. Mature bedstraw has 6-foot-long square stems. Forms dense mats that sprawl on the ground or over other vegetation. Leaves are whorled and have small hair-like structures. Small, four-parted, white or greenish-white flowers.

Removal: Pull gently from base if accessible to get entire root out (easy to remove, especially in soft soils).

Cutleaf Geranium

Description: Remains prostrate in turf. Rosette with long-stalked leaves. Has a beak where flowers are growing.

Removal: Grab at base and hand pull or use a trowel to get tap root completely (easy to remove, especially in soft soils).

Dandelion

Description: Seed leaves are oval and hairless. The first and next few leaves are football-shaped to oblong, taper at the base, and have weakly toothed edges.

Removal: Push leaves aside to get at base of plant, remove taproot completely (moderately easy to remove in soft soils but will regrow if any part of taproot remains).


Field Bindweed

Description: Mature plants have arrowhead-shaped leaves that can be 0.5-2 inches long. Leaves at the base of the stem are larger than the young leaves at the stem terminal. Flowers are trumpet-shaped, white to pink, and 1-1.5 inches wide.

Removal: Move vines away from base and dig deep for the whole taproot with a weed pick or flathead screwdriver (difficult to remove).


Milk Thistle

Description: Mature plants are stiff and have prickly, white-marked leaves. Stem branches are thick, hollow, sparsely hairy, lack wings or spines, and grow 2-6.5 feet tall.

Removal: Knock leaves aside with spade and dig deep under base of stem to get taproot completely (difficult to remove, use leather gloves and long pants/ sleeves).


Little Mallow

Description: Seed leaves are distinctly heart-shaped, hairless, and have long stalks.

Removal: When young, pull from base to get taproot. Older plants require a trenching or pointed shovel to dig out completely (difficult to remove).


Redstem Filaree

Description: Seed leaves and first true leaves are deeply lobed and occur on long petioles that are hairy (look like a carrot top).

Removal: Grab at base and hand pull or use a trowel to get tap root completely (easy to remove, especially in soft soils).

Reference Documents

Santa Clara Valley Urban Runoff Pollution Prevention Program Handbook
https://scvurppp.org/2016/06/20/c-3-stormwater-handbook-june-2016/

Santa Clara Valley Urban Runoff Pollution Prevention Program Green Stormwater Infrastructure Vegetation Guide
https://scvurppp.org/2023/06/30/green-stormwater-infrastructure-vegetation-guide/

City of Palo Alto Green Stormwater Infrastructure Plan
cityofpaloalto.org/gsi

City of Palo Alto GSI Design Specifications
Placeholder

City of San José Green Stormwater Infrastructure Maintenance Field Guide
https://www.sanjoseca.gov/home/showpublisheddocument/40709/637072498623830000

City of San Francisco Green Infrastructure Maintenance Guide
https://sfpuc.sharefile.com/share/view/sb83923c24cb4298a

City of Seattle Green Stormwater Operations and Maintenance Manual
https://owl.cwp.org/mdocs-posts/green-stormwater-operations-and-maintenance-manual/

City of Philadelphia Green Stormwater Infrastructure Maintenance Manual
http://phillywatersheds.org/doc/GSI%20Maintenance%20Manual_v1.pdf

City of Austin Green Stormwater Infrastructure Maintenance Manual
http://www.austintexas.gov/sites/default/files/files/Watershed/stormwater/GSI_Maintenance_Manual_web.pdf

Resources

Bay Friendly Landscape Guidelines
https://rescapeca.org

California Invasive Plant Council
https://www.cal-ipc.org

California Native Plant Society CalScape
https://calscape.org

City of San José Environmental Services Department
www.sjenvironment.org

National Green Infrastructure Certification Program
http://ngicp.org/

San José Integrated Pest Management
https://www.sanjoseca.gov/your-government/departments-offices/environmental-services/homes-green-tips-resources/gardening-composting/pesticides-and-integrated-pest-management-ipm

South Bay Green Gardens
https://www.southbaygreengardens.org/