CHAPTER 5 | GREEN INFRASTRUCTURE

Green infrastructure, improves Oakland's watershed by cleaning and slowing runoff from impervious roadways, sidewalks, and building surfaces before it enters creeks and other waterways. Green infrastructure treatments help to restore pre-development drainage patterns and must be considered in most street reconstruction projects.

Planned San Pablo Avenue Retrofit - Rendering: Nevue Ngan Associates

Overview

Healthy watersheds are a vital component of a healthy urban environment. Oakland's watershed comprises 15 main creeks, over 30 tributaries, Lake Merritt and the Estuary. Sustainable stormwater management, such as green infrastructure, improves Oakland's watershed by cleaning and slowing runoff from impervious roadways, sidewalks, and building surfaces before it enters creeks and other waterways. Green Infrastructure treatments also help to restore pre-development drainage patterns and must be considered for medians, curb zones, and furniture zones in most street reconstruction projects. These Design Guidelines provide information on designing and implementing green infrastructure within street rights of way.

Complete Streets that include green infrastructure take advantage of landscape and other street design elements to manage and improve stormwater runoff quality. Green infrastructure design elements such as bioretention areas[1], tree wells and pervious pavement collect, absorb and clean water runoff from adjacent impervious surfaces. These design elements allow rain to soak into soil and/or vegetated areas. In addition to improving stormwater quality, green infrastructure can reduce localized flooding, minimize downstream creek bank erosion, expand green space, improve streetscape aesthetics, provide cleaner and cooler air, increase economic vitality, and enhance the pedestrian experience.

Streetscape projects that construct 10,000 square feet or more of new contiguous impervious area may qualify as "Regulated Projects" under section C.3 of the state's Municipal Regional Stormwater Permit (MRP).[2] C.3 Regulated Projects must follow the Alameda County C.3 Technical Guidelines[3] to comply with the MRP. Other streetscape projects with GI potential must incorporate GI measures to the maximum extent practicable. [4]

To document compliance, project managers (or project consultants) must complete the City's C.3 Stormwater Compliance Sign-off Form for Capital Improvement Program Projects.[5] For green infrastructure project site-specific design and engineering technical guidance see the City of Oakland's Green Infrastructure Guide.[6] See **Figure 5-9.** at the end of the chapter for examples of green infrastructure in the city of Oakland.

Figure 5-1. The Green Infrastructure in Streets Design Process, summarizes the process of how to integrate green infrastructure into street design.

1. Depending on their design, bioretention areas may be referred to as rain gardens, stormwater planters stormwater curb extensions, or flow-through planters. Other guidance documents may use different terminology.

2. The City of Oakland must comply with the San Francisco Bay Regional Water Quality Control Board's Municipal Regional Stormwater Permit, Order No. R2-2015-0049 (MRP). Section C.3 of the MRP includes stormwater treatment and control requirements for specific types of public and private development projects and requires the City to incorporate green infrastructure into all public infrastructure projects where practicable.

3. C.3 Stormwater Technical Guidance, Alameda Countywide Clean Water Program. Retrieved from http://contextsensitivesolutions.org/content/reading/alameda_county_c_3_stormwater_t_/resources/AlamedaCoTechnicalGuidance/

4. Maximum Extent Practicable is a standard for implementation of stormwater management actions to reduce pollutants in stormwater.

5. This form is available on the City of Oakland's Creeks, Watershed & Stormwater Program page at www.oaklandcreeks.org.

6. This guide is available on the City's Creeks, Watershed & Stormwater Program page at www.oaklandcreeks.org.

Figure 5-1. Green Infrastructure in Street Design Process

Step 1: Identify Environmental Context Factors

- Underlying soil and hydrology conditions (feasibility of infiltration, groundwater table recharge)
- Pollutant Management (surface and subsurface)
- Tree Canopy
- Localized Flooding
- Location within Watershed
- Others Conditions

Step 2: Identify Built Context Factors and Constraints

- Adjacent land use and built context
- On-street parking
- Drainage areas and patterns (including tributary drainage areas (e.g. flows from adjacent properties or cross streets) that may concentrate flows within the right-of-way)
- Location and capacity of existing stormwater utilities (lines and inlets)
- Longitudinal and cross-slopes
- Potential physical conflicts with underground and other utilities, drain inlets, fire hydrants, driveways, and existing well-established landscaping and street trees

Step 3: Select Green Infrastructure Elements in Context of Other Project Goals

- Set multimodal transportation (Complete Streets) and stormwater management goals for the project in question
- Select appropriate Complete Streets and Green Infrastructure Elements (along with complementing general landscape elements)
- Closely integrate Complete Streets and Green Infrastcruture Elements

Step 4: Detail Design of Green Infrastructure Elements

- Minimize project's impervious surfaces
- Maximize and design landscape based components as appropriate to project context
- Size and design Green Infrastructure Elements for local context and conditions following applicable design guidance and requirements*
- Define needed operations and maintenance procedures for selected Green Infrastructure Elements
- If unforeseen issues arise, return to Step 3 to (re)evaluate the use of other Green Infrastcrutue Elements

Use and Design

Green infrastructure elements are designed to capture, detain, and/or infiltrate stormwater runoff from roadway and sidewalk surfaces. This slows peak flow rates and removes sediments and other pollutants typically present in runoff. The following list describes green infrastructure functions that apply to varying degrees depending on the green infrastructure element:

Green Infrastructure Measures

INFILTRATION

The process or rate at which water percolates into the ground. The infiltration capacity of a green infrastructure element is dependent on the capacity of soils present under the feature to absorb water and must be verified on a site-by-site basis prior to finalizing green infrastructure element design. In most cases biotreatment will be required prior to infiltration into underlying native soil. Infiltration helps to reduce peak stormwater flows to the storm drain system and waterbodies and improves water quality.

BIORETENTION

The absorption, temporary storage and evapotranspiration[7] of stormwater in a green infrastructure feature composed of biotreatment soil media, vegetation, and permeable material. Stormwater flows into bioretention facilities, where natural processes, such as water uptake by plants, soil microbial action, and infiltration, work to remove pollutants from and detain and evaporate the water. The size, surface area, and depth of a bioretention area depends on the area of impervious surface draining to it. A bioretention area may incorporate an underdrain and overflow system to accommodate larger storms or low infiltration rates in underlying soils.

7. Evapotranspiration occurs when water evaporates from the soil and plants.

POLLUTANT REMOVAL:

The removal of solid (particulate) matter and other pollutants, such as oil and grease and pesticides, from runoff by means of chemical adsorption to soil particles and organic matter, microbial transformation, plant uptake, sedimentation, and filtration mechanisms. For example, where vegetation is present, some pollutants are also absorbed by plant roots and bound to plant surfaces.

INTERCEPTION:

The process of precipitation temporarily adhering to the leaves and other parts of trees and other plants before reaching the ground. This leads to a modest reduction and delay in the concentration and peaking of stormwater runoff flows.

Design Considerations

When designing green infrastructure elements of a given project, the designer should consider the environmental and built context as well as construction and ongoing operation and maintenance.

Environmental Context Factors

Environmental factors that may affect the feasibility, location, and design of an individual feature or a network of green infrastructure features include the following:

- Soil and hydrological conditions, specifically the infiltration rate of the underlying soil and the groundwater depth;
- Soil conditions that can affect plant health, such as high levels of salt or lime, or soil compaction.
- Surrounding watershed, including the relative location of the feature to nearby creeks and other bodies of water as well as to flood and/or tidal inundation zones, including areas that experience localized flooding;
- Slope[8]
- Pollutants present in the surface runoff that is to be treated; and,
- Pollutants that may already be present within soils or in water flowing in subsurface conditions.

8. Steeper topography can affect the feasibility of green infrastructure by increasing costs and reducing performance

Built Context Factors

For green infrastructure elements to best support the land use and urban context of the street along which they are placed, the following factors should be considered:

- Available right-of-way width;
- Adjacent buildings and uses;
- Drainage areas that determine the amount of runoff to be treated;
- Presence of transportation features such as on-street parking, bike lanes, or bus stops;
- Presence of right of way features such as utility boxes and lines, existing street trees, or public art;
- Access and circulation patterns in the vicinity and across the feature;
- Design characteristics of existing or proposed hardscape elements, such as planter walls (height, visual detailing, color), pavement (combination of types, materials, patterns, and color), or the need to accommodate street furniture; and,
- Plant selection (plant height relative to pedestrians, bicyclists, drivers, and signs, etc.)[9];
- Local street sweeping programs

Construction

Green infrastructure construction requires specific methodologies to achieve required performance standards. Construction drawings and specifications documents should provide clear instructions for building and maintaining green infrastructure facilities until they are accepted and transferred to the public or private owner. For example, contractors must avoid soil compaction on top of areas where green infrastructure will be constructed and must verify and ensure the proper level of planting soil compaction. In addition, grading and drainage plans must be followed to achieve desired performance. Even a 1/8-inch discrepancy in elevation can affect how water flows into a green infrastructure facility. In addition, actual site conditions may require design adjustments and plan set amendments during construction.

Operation and Maintenance

The type and design of green infrastructure features can have a significant effect on operation and maintenance (O&M) costs. Therefore, the expected levels of maintenance must be considered during green infrastructure design.

9. The City of Oakland's Green Infrastructure Guide includes a list of preferred plants for green infrastructure features. The Oakland Public Works Parks & Tree Services Division also provides a Master Street Tree List (April 2017 – April 2018). See Attachments XX and XX.

5.2 Green Infrastructure Measures

Green infrastructure measures that capture and treat runoff from impervious surfaces should be selected based on a site's land use and street type, and the various constraints each site presents. This section of the Design Guidelines lists the various types of green infrastructure measures and provides use and design information for each type.

A. Bioretention Areas

Bioretention Areas[10] can be designed in many forms and locations within a street. In general, bioretention areas slow, detain, and filter stormwater in a recessed landscaped area. They are designed to "fill up like a bathtub" so a specific amount of water can be temporarily stored before filtering through a layer of mulch, a layer of engineered biotreatment soil, and then a layer of clean drain rock.[11] An underdrain which connects to the municipal storm drain system is typically installed at the top of the rock layer to handle overflows while allowing water to slowly infiltrate into the underlying soil. Bioretention Areas may be designed as stormwater planters, flow-through planters, stormwater curb extensions, or rain Gardens. These areas may be of any shape, but they should be designed and built flat and level.

Stormwater Planters

Overview

Stormwater planters are typically narrow, linear landscape areas with vertical sidewalls. Stormwater planters are designed to treat water runoff that flows into the planter from adjacent sidewalk surfaces or is directed to it from the roadway through a curb inlet and/or covered drain channel. The use of vertical sidewalls creates runoff retention capacities using limited space and sidewalk width. Stormwater planters are called "Flow-through Planters" if lined by structural walls on the sides and the base to prevent seepage into the surrounding soil.

Use and Design

Stormwater planters can be used in constrained area and retrofit areas. In some locations they can be set level with the ground to receive sheet flow. Flow-through planters can be used next to buildings and other locations where soil moisture is a potential concern. Like stormwater planters, lined flow-through planters include mulch, biotreatment soil and drain rock, but they must include an underdrain that is connected to the municipal storm drain system. **Figure 5-2.** shows stormwater planters integrated into a sidewalk that also includes pervious or permeable pavers.

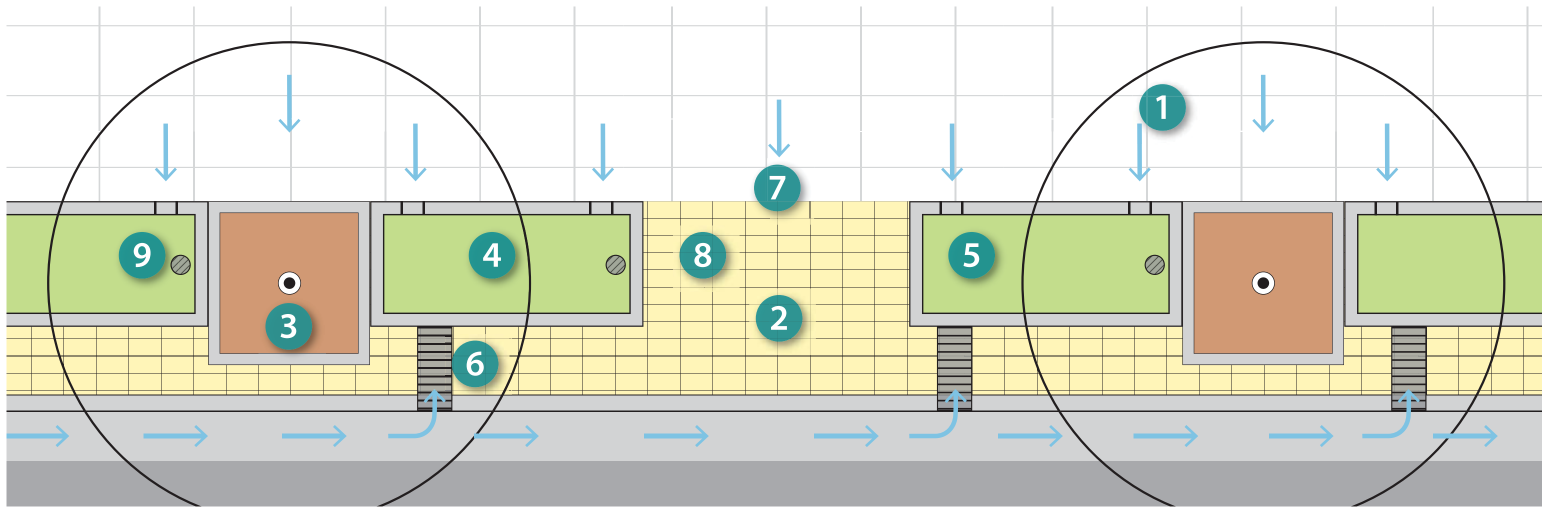
Additional Considerations

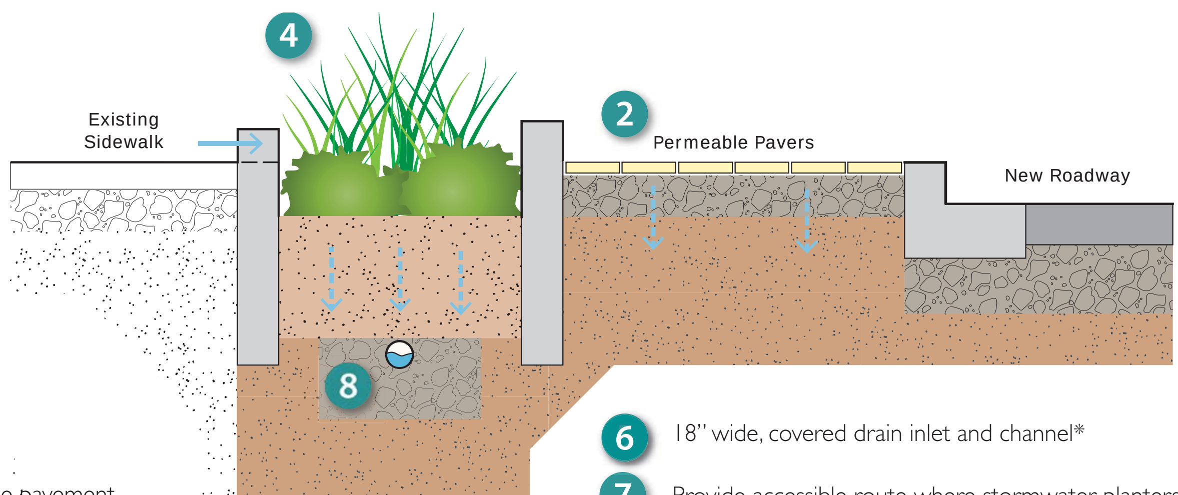
- Where stormwater planters are located next to parking, consider accessibility of parking spaces for persons with disabilities. Also see **Section 3.4 Q** Accessible Parking and **Section 3.5 Universal Design.**
- Stormwater planters should be located and designed in close coordination with other elements located in the Curb and Furniture Zones of sidewalks. Also see **Sections 3.3 Sidewalks Furniture Zone** and **3.4 Sidewalks Curb Zone and Curb Lane.**

10. A bioretention area may be considered a "bioinfiltration area" if it is unlined and if the underlying soils have a saturated hydraulic conductivity rate of 1.6" per hour or greater. For more information on bioinfiltration, see the C.3 Stormwater Technical Guidance, Alameda Countywide Clean Water Program.

11. The California Department of Health (2010) has identified a four-day maximum allowable water retention time for stormwater treatment facilities. All green infrastructure measures and general landscaping measures described in these design guidelines must be designed to drain completely within four days to effectively suppress vector production.

Figure 5-2. Stormwater Planters





1. Adjacent Sidewalk
2. Pervious or permeable pavement
3. Trees may be constructed as Green Infrastructure Tree Wells, Stormwater Trees or regular street trees with decomposed granite or tree grate, flush with adjacent grade (shown).
4. Stormwater planter. Minimum width between planter walls: 3 feet.
5. Planter may include inlets to capture runoff from sidewalk.
6. 18" wide, covered drain inlet and channel*
7. Provide accessible route where stormwater planters are installed along on-street parking
8. Provide clear circulation space between on-street parking and sidewalk.
9. Install overflow connected to subdrain and storm drain system as necessary.

*Size all trench drains, pipes, overflows and subdrains to be compatible with Public Works maintenance equipment

Stormwater Curb Extensions

Overview

A typical curb extension is used to increase pedestrian visibility, shorten the crossing distance, or to help calm traffic. Stormwater curb extensions fulfill these transportation functions and are designed to capture, treat, and manage stormwater runoff. Like stormwater planters, the primary function of stormwater curb extensions is to detain, clean, evapotranspire, and, if possible, infiltrate stormwater through bioretention.

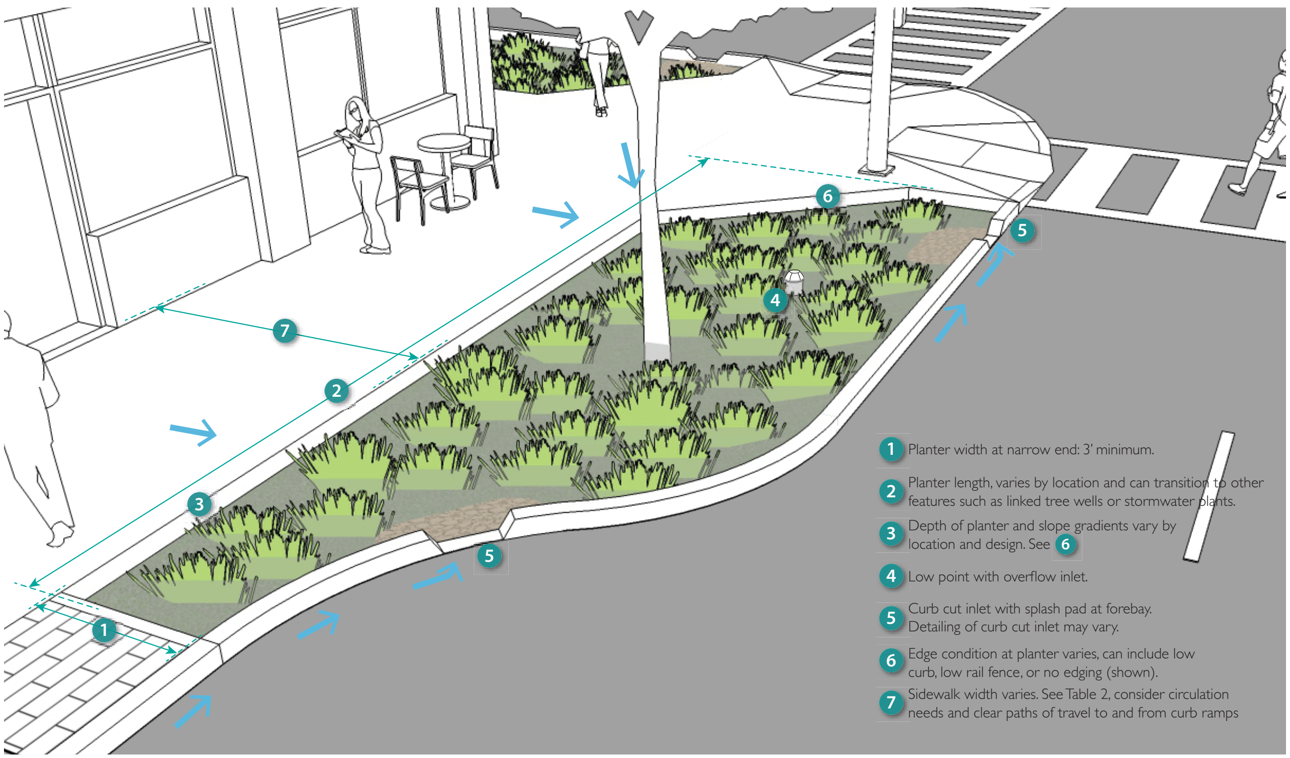
Use and Design

Water at curb extensions is directed to flow from the gutter and the flow line around and then into a depressed landscaped area contained within the extension. Stormwater curb extensions can be also be designed as the end points of subsurface trenches along a section of linked tree wells, stormwater planters, or bioswales the end of a stormwater "treatment train". **Figure 5-3.** Shows a typical stormwater curb extension.

Additional Considerations

- The use of a curb extension as stormwater curb extension should be balanced with potential other needs in a given area, such as spatial needs for pedestrian circulation near crosswalks, cafe seating, bicycle parking, or transit stops. See **Chapter 3 | Sidewalks, Curbs, and Curb Lane** and **Section 4.2 Intersections | Pedestrians.**

Figure 5-3. Stormwater extension



Rain Gardens

Overview

The term "rain garden" is often synonymous with "bioretention area" or "stormwater planter". Like any bioretention area, rain gardens may vary in size and shape. Where space allows, rain gardens are often built with sloped sides and may have the visual appearance of a garden in the urban landscape. They can be integrated with adjacent sidewalk, roadway and/or private property edge conditions.

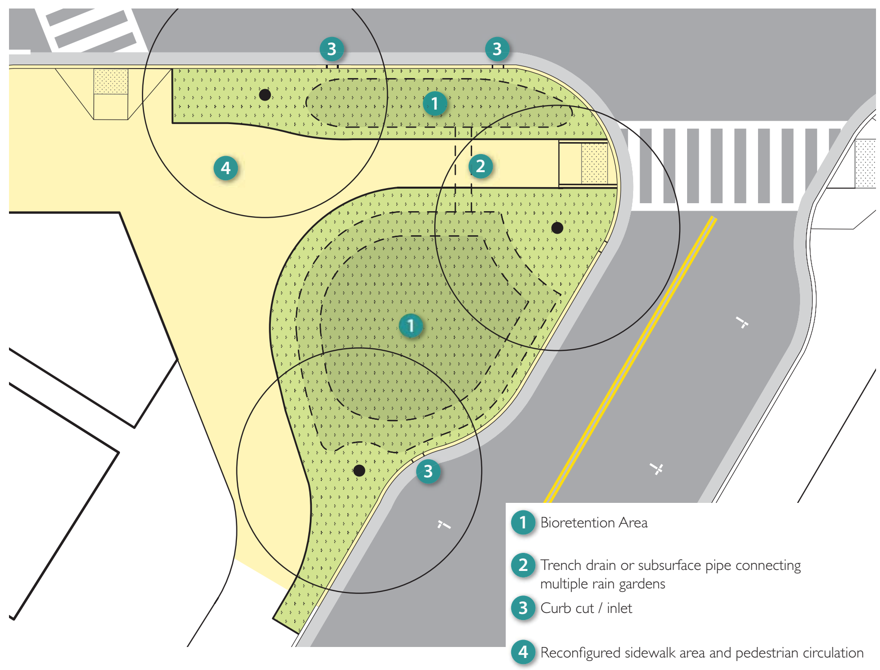
Use and Design

Consider building rain gardens into the public right-of-way in areas that are "left over", where streets intersect at odd angles or street grids are offset from one another. In some cases, a portion of a public park may be transformed into a rain garden where the feature's detention function can be enhanced. The conceptual before and after conditions in **Figure 5-4.** illustrate a small traffic island transformed into a modestly sized rain garden that stores and treats runoff from the remaining paved surfaces by eliminating unnecessary roadway surfaces.

Additional Considerations

- Rain gardens can be designed in a broad range of ways. Striking the right balance between landscaped and hardscaped surfaces as well as the appropriate selection of amenities, such as seating, largely depends on the built context, adjacent uses, and community needs.
- Rain gardens can be integrated into the redesign of locations where slip lanes are

Figure 5-4. Example of Opportunity Site and configureation of Rain Garden



B. Tree Wells

Overview

A tree well's basic design is a vault filled with bioretention soil mix, planted with vegetation, and underlain with an subdrain. The top of the soil is set low enough to take in water from surrounding sidewalks or from the flowline of the curb. **Figure 5-5.** illustrates different configurations of green infrastructure Tree Wells. **Section A** shows a Tree Well covered with an ADA-Compliant tree grate. **Section B** illustrates a Tree Well that includes planting and a low fence.

Use and Design

Tree wells are typically located within the Furniture Zone of the sidewalk like other street trees. The tree well can appear to be a standard street tree planting with a tree grate or if the well is open the lower level of the soil and any groundcover that is planted in it can make its stormwater function more apparent.

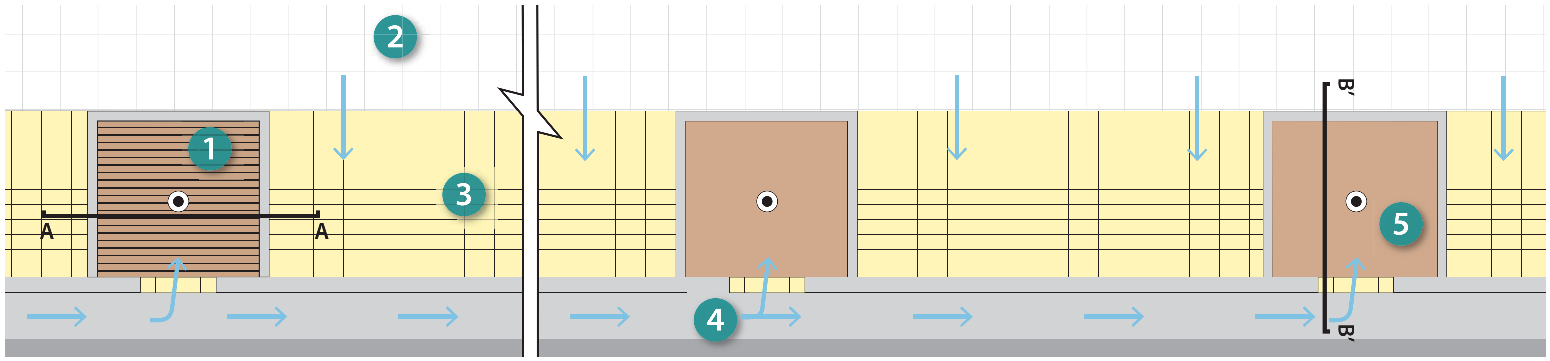
Multiple Tree Wells can be connected with a sub-drain to form a linked row of Tree Wells. At the surface level, such an array of tree wells may take the form of a continuous planting area or appear as individual tree wells with standard or permeable paving between them.

Additional Considerations

- **Use of pavement support systems:** The stormwater volume of an individual or array of Tree Wells can be enhanced using structural soils or a structural pavement support system.[12] Structural soils and structural support systems support the sidewalk and/or adjacent curb lane and allow the soil to be compacted at a low enough level to provide a biotreatment function. The lower compaction of the soil can also support improved tree health.
- **Use of permeable or pervious pavement:** The surface of the sidewalk or adjacent curb lane can be paved with permeable or pervious pavement to allow a more dispersed flow of stormwater into the soil of the Tree Well or linked row of Tree Wells which can provide for better tree health and functioning of the biotreatment soil. **Section B** in **Figure 5-8.** illustrates a linked tree well application under sidewalk pavement that also includes permeable or pervious unit pavers.
- Tree wells designed for stormwater treatment can be used in combination with standard tree wells as may be needed based on local conditions. The sizing of tree wells should be based on both stormwater treatment needs and the recommendations for the width of adjacent sidewalk zones. For more information see **Chapter 3 Sidewalks, Curbs, and Curb Lanes** and **Sections 3.3 D Street Trees and Landscaping**. Consider low fencing around the edges of open tree wells where deeper wells are needed to meet stormwater treatment capacities.

12. Structural soil is a planting medium that consists of a stone skeleton structure for strength and clay soil for water retention, which allows urban trees to grow under pavement. Structural support systems include load-bearing modular grid products that are commercially available.

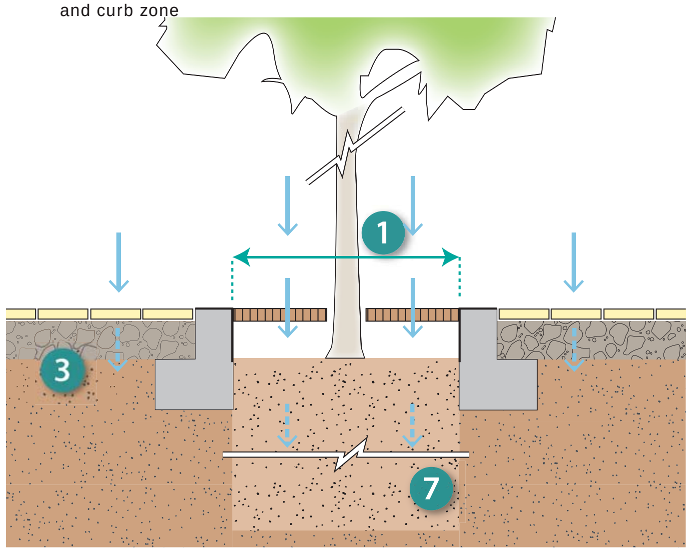
Figure 5-5. Tree Wells



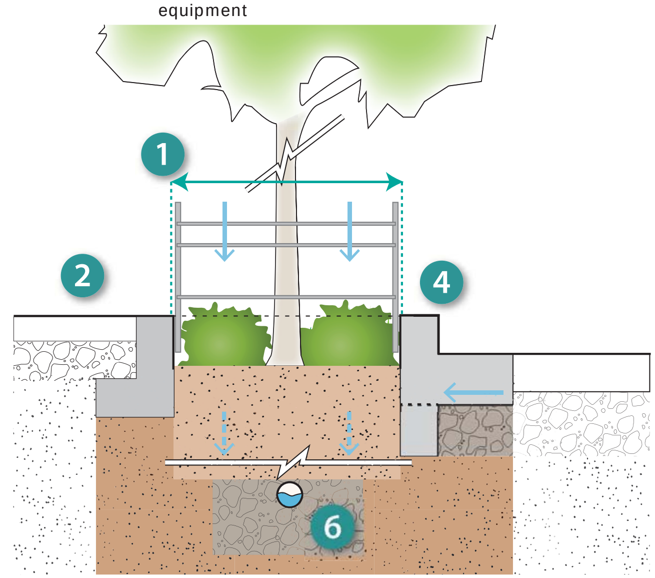
Plan

1. Size stormwater tree linked/tree wells according to stormwater management goals and per section 5.3D Street Trees
2. Adjacent sidewalk
3. Match width of pervious or permeable pavement to width of tree wells or width of street furniture and curb zone
4. 18" wide stormwater tree curb inlet, with wheel guard as needed*
5. Minimum planter depth varies
6. Subdrain, if needed.* Use Class II virgin permeable material for gravel layer.
7. To maximize tree health, consider the use of structural soils and load-bearing modular grid products.

*Size all trench drains, pipes, overflows and subdrains to be compatible with Public Works maintenance equipment



Section 'A'



Section 'B'

C. Pervious, Permeable and Porous Pavement

Overview

Pervious, permeable and porous paving materials are designed to allow stormwater runoff to pass directly through or around the paving material into a permeable subgrade engineered to receive and temporarily store the collected runoff. From the permeable subgrade the runoff either infiltrates into the existing underlying soils or is directed to the stormwater system through a sub-drain. While permeable paving provides water quality benefits limited to the filtering of larger debris and some sediments and other solids, pervious paving has more filtering capacity. The primary function of all pervious, permeable and porous paving installations is to detain and/or infiltrate stormwater. **Figure 5-6.** illustrates applications of pervious, permeable and porous pavement.

Additional Considerations

- Coordinate the use of pervious, permeable, or porous pavement materials within the overall street design. Porous paving materials are typically better suited for application in the parking lane whereas more expensive permeable or pervious pavers lend themselves to application in the different sidewalk zones.
- Also see **Chapter 3 Sidewalks, Curbs, and Curb Lanes.**

Figure 5-6. Examples of pervious, permeable and porous pavement applications.

Bus stop with pervious pavers and tree well

Permeable paver installation in a crosswalk

Parking lane constructed of porous concrete (beyond stormwater curb extensions in foreground)

Use and Design

Table 5-1. provides an overview of the different types of paving materials and for which street design elements they may be appropriate. The different paving types are defined as:

- Permeable pavers are separated by joints filled with a crushed aggregate. Permeable pavers are different from pervious pavers in that rainwater passes through the joints only and not the paver itself.
- Pervious pavers allow stormwater to percolate through the paver rather than through the permeable joints around the pavers. As water runs through the pavers some urban pollutants get filtered out.
- Pervious concrete is a concrete pavement with a large volume (about 20%) of interconnected voids. Like conventional concrete, pervious concrete is made from a mixture of cement, coarse aggregates, and water. However, it contains little or no sand, which results in a porous open-cell structure that allows water to pass through.
- Porous asphalt is the same as regular asphalt except that it is manufactured without the fine material, which leaves voids throughout the pavement allowing water to filter through and into a drainage bed of aggregate.

Table 5-1. Permeable, Pervious, and Porous Paving Locations with the Street

PAVING MATERIAL	AREA OF THE STREET								
	Frontage Zone and Pedestrian Through Zone	Street Furniture and Curb Zone	Curb Extension	Bicycle Lane	Curb Lane	Travel Lane	Raised Median	Alley	Roundabout
Permeable Pavers	■	■	■	▯	o	o	■	o	[2]
Pervious Pavers	■[1]	■[1]	■[1]	▯	o	o	■	o	[2]
Pervious Concrete	■	■	■	■	o	o	■	o	[2]
Porous Asphalt	▯	▯	▯	■	o	o	▯	o	[2]

■ Generally appropriate

o Appropriate if load and wear requirements can be met

▯ Not appropriate

NOTES:

1. Pervious pavers with a butt joint of 1/8" or less sand joint are appropriate for a pedestrian, an ADA compliant, surface.

2. Center of roundabout: see Raised Median; Apron: see Travel Lane; and Travel Lane: see Travel Lane.

Figures 5-2. and **5-5.** illustrate pervious, permeable or porous paving materials integrated with other green infrastructure elements located in the sidewalk area or parking lane. Where local conditions limit landscaped green infrastructure features, the sole use of pervious, permeable or porous paving materials is a valid option for still advancing the goal reducing stormwater flows and improving water quality through the reduction of impervious surfaces in urban environments.

5.3 Other Landscaping Elements with Stormwater Management Benefits

The green infrastructure measures, such as bioretention features, described in these Design Guidelines should be incorporated into the streetscape, and where feasible, designed to meet clean water standards set by the California Regional Water Quality Control Board. When this is not possible, some general landscape elements, such as landscaped medians, planting strips, individual planters, and street trees, do provide urban greening and stormwater management benefit. Street trees and planted areas can be designed to enhance these benefits and will contribute to the City's green infrastructure planning goals.

D. Street Trees

Overview

While the Tree Wells described in **Section 5.2 B** of this chapter can be designed to meet the state's C.3 and green infrastructure stormwater management requirements, regular street trees planted in a tree well cannot. At a relatively low cost, however, street trees can be designed to provide some stormwater benefit.[13]

Additional Considerations

- See Section **5.2 B - Tree Wells.**
- See Section **3.3 D Street Trees and Landscaping.**

13. The Bay Area Stormwater Management Agencies Association (BASMAA) is currently developing an approach to obtain reduced stormwater treatment credit under the state's Municipal Regional Permit for "undersized" green infrastructure elements (i.e.; alternative treatment measures).

Use and Design

Street trees are generally planted in the Furnishing and Curb Zones. Where possible, the soil in the tree planter should be at or slightly below the flow line of the adjacent gutter line, and a cut out should be provided to allow water into the street tree planter. **Figure 5-10.** illustrates a stormwater-enhanced Street Tree installation.

Figure 5-7. stormwater-enhanced Street Tree installation.

City of Philadelphia

E. Bioswales

Overview

Bioswales, also known as vegetated swales, are shallow, linear, recessed landscaped areas with a central drainage course and gently sloped sides. The entire width of the swale is typically planted with vegetation. Water flowing through a bioswale is slowed by the plants, allowing sediments and some pollutants to settle out and some of the water to soak into the soil. The remaining water in the bioswale moves more slowly than it would through pipes in a traditional stormwater conveyance system and the resulting ponding, if it occurs, is typically only a few inches deep and temporary. A bioswale may be used in conjunction with other elements to form a "treatment train" to achieve compliance with the state's current clean water regulations.

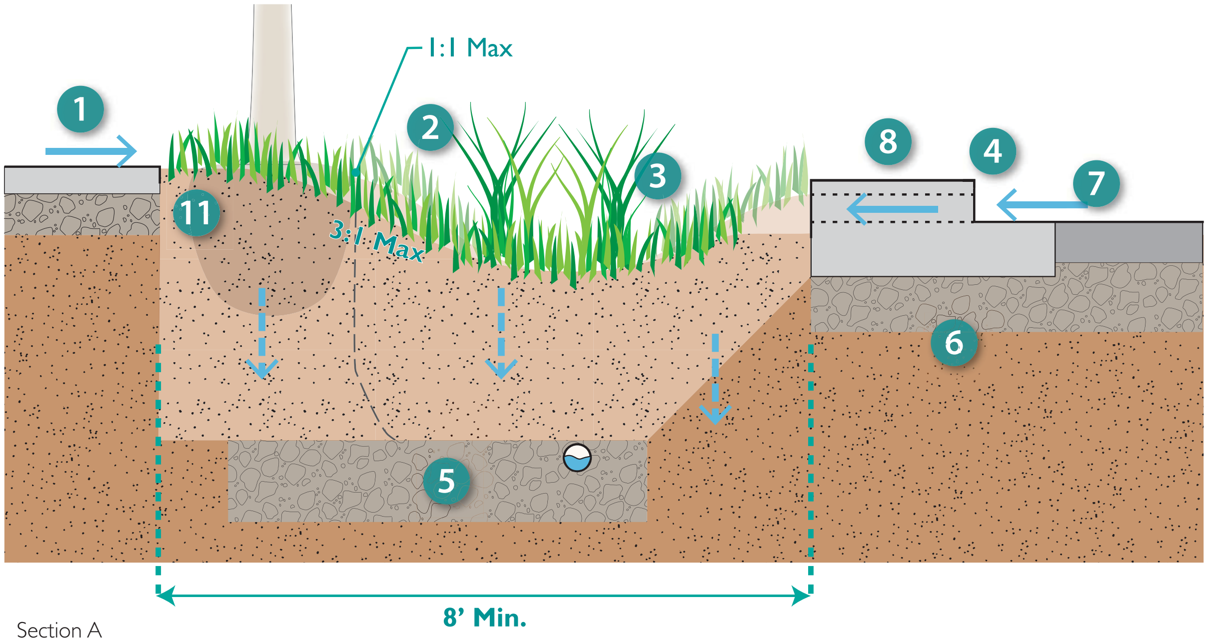
Use and Design

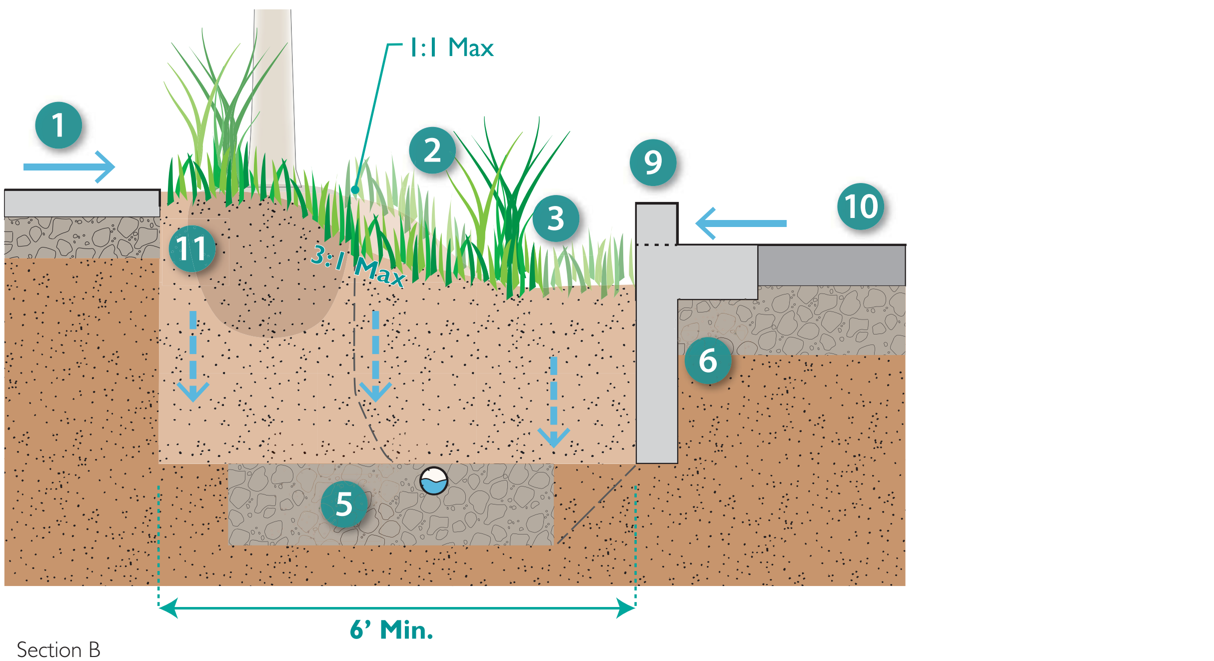
Use bioswales in the furniture zone of residential or low-volume streets to both ecologically and aesthetically enhance the streetscape, as they are generally wider than stormwater planters or other green infrastructure elements. **Figure 5-8. Section A** illustrates a bioswale design option for streets with wider sidewalks and on-street parking where a swale with two sloping sides and a curbside "step-out space" along parked cars can be accommodated. **Figure 5-8. Section B**, shows a design option for bioswales in locations where less space is available and no step-out space is required.

Additional Considerations

- Where bioswales are located next to parking, consider accessibility of parking spaces for persons with disabilities. Also see **Section 3.4 Q Accessible Parking.**

Figure 5-8. Bioswales





1 Sidewalk

2 Landscape with tree*

3 Bioswale

4 Curb with curb-cut inlet with trench drain grate**

5 Subdrain, if needed. Use Class II virgin permeable material for gravel layer

6 Retaining curb as required for depth of facility

7 Adjacent roadway with on-street parking

8 Provide a "Step-Out" area along parking

9 Curb with curb-cut inlet, and splash pad and/or rock dissipater, as needed

10 Adjacent roadway without on-street parking

11 Tree rootball, watering ring, and native soil beyond

*Per City of Oakland Plant Palette for Stormwater Treatment (April 2016)

**Size all trench drains, pipes, overflows and subdrains to be compatible with Public Works maintenance equipment

5.4 Locating Green Infrastructure within the Street Right of Way

Overview

Specific green infrastructure elements are best suited to particular locations within the street. For example, Tree Wells and standard Street Trees are best located within the sidewalk, in planters in the curb lane, within landscaped medians, or in the center of roundabouts.

Use and Design

Pervious or Permeable Paving can be appropriate in most locations within a street but must be designed properly. **Table 5-2.** provides guidance on appropriate green infrastructure and other landscaping features given land use context and location within the street.

Table 5-2. Green Infrastructure Locations within the Street Right of Way

	STREET ZONE	Sidewalk		Curb Lane	Roadway		Intersection
	ELEMENTS / LAND USE CONTEXT	Dntn / MX / Com	Emp / Neigh / Parks	All Contexts[6]	Dntn	All Other Contexts	All Contexts
GREEN INFRASTRUCTURE MEASURES[4]	Stormwater Planter[7]	●	●[1]				
	Stormwater Curb Extension			●			●
	Rain Garden	●	●[1]	●			●[2,3]
	Tree Well	●	●	●			●
	Pervious / Permeable Paving	●	●	●	●	●[5]	●
OTHER LANDSCAPING[5]	Street Tree	●	●	●	●[1]	●[1]	●[2]
	Bioswale		●[1]				
	Understory Planting	●		●	●[1]	●[1]	●[2]
	Container Planter	●	●	●	●[1]	●[1]	●[2]

Dntn= Downtown, MX= Mixed Use, Com= Commercial, Emp= Employment, Neigh= Neighborhood

NOTES:

1. Can be located on medians within the roadway

2. Can be located within landscaped areas of traffic circles or roundabouts within intersections

3. "Left-over" spaces, i.e. triangular spaces where streets meet at an angle

4. These green infrastructure elements can be designed to meet the state's C.3 clean water requirements

5. These landscaping elements provide some stormwater benefit but do not currently meet the state's C.3 requirements

6. Designer must evaluate whether a given green infrastructure feature is appropriate within the curb lane

7. Where necessary, a stormwater planter may be designed as a "flow-through planter". Flow-through planters are lined on the sides and bottom with structural planter walls to prevent seepage into the underlying soil

Figure 5-9. Examples of public and private green infrastructure in the City of Oakland

Rain garden adjacent to a bike lane

Bioretention areas and regular landscaping combined in a single median

Stormwater curb extension

Rain garden adjacent to driveway

Rain garden connected to the gutter by a trench drain

Pervious pavers