CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE VERSION 1.1

City of Oakland Department of Public Works
Oakland, California

Lake Merritt Improvement Project, Bioretention Area, Oakland.
Photo Credit: Kevin Torres, Northgate

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1.0 INTRODUCTION

The City of Oakland (the City) Green Infrastructure Guide (the GI Guide) identifies stormwater treatment opportunities and provides design guidance for incorporating green infrastructure on City-owned properties. The intended audience for the GI Guide is City in-house (staff) including Capital Improvement Program (CIP) project managers, designers, and engineers as well as consultants contracted to work on City capital improvement projects.

The City is a highly urbanized area with a large percentage of impervious surfaces. Rain cannot soak into the ground when it falls on impervious surfaces and rain runoff moves rapidly without soil and vegetation slowing it down. Increased rates and volumes of runoff from rainfall events disrupt the natural water cycle, resulting in less infiltration of water into subsurface soil, increased stream channel erosion, and reduced groundwater recharge. In addition, parking lots and roadways provide a pathway for typical urban pollutants, such as pesticides and petroleum hydrocarbons, to flow with stormwater into streams and the San Francisco Bay through the City's storm drain infrastructure. The City is working to reverse some of these impacts by investing in green infrastructure, which is an approach to stormwater management that protects and restores the natural water cycle, providing habitat, flood protection, cleaner air and cleaner water (American Rivers 2017)[1]. Integrating green infrastructure into public projects will help protect Oakland's water resources and will lessen the negative impacts of climate change by reducing runoff from severe weather and by adding vegetation. More green infrastructure will benefit human health, San Francisco Bay fisheries and wildlife habitat, recreational resources, and the aesthetics of Oakland.

The GI Guide includes step by step instructions to evaluate treatment opportunity conditions at City-owned project sites, identify appropriate treatment options, choose suitable plants, and apply necessary treatment standard details. In addition to selecting a treatment option for a specific site, the GI Guide provides a series of maps showing locations of City-owned properties where various treatment options could potentially be installed based on results of a Geographic Information System (GIS) screening analysis. This guide also includes a worksheet for City staff to identify green infrastructure potential in municipal capital improvement program projects.

City-owned project site profiles considered in this Guide include streets with parallel parking; streets with diagonal parking; ground-level parking lots; ground-level areas including plazas, parks, roadsides or undeveloped land; and structures, such as municipal buildings, shelters, and garages, with storm drain access.

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[1] American Rivers National Non-Profit Conservation Organization. 2017. https://www.americanrivers.org/threats-solutions/clean-water/green-infrastructure/what-is-green-infrastructure/

As stormwater treatment projects are planned based on the GI Guide, they will contribute to achieving the important citywide goals of stormwater management and moderation of the urban effects of climate change.

2.0 TREATMENT OPTIONS

Based on the treatment requirements for green infrastructure in Provision C.3 *New Development and Redevelopment* and related Provisions C.11 *Mercury Controls* and C.12 *Polychlorinated Biphenyls (PCBs) Controls* of the National Pollutant Discharge Elimination System (NPDES) Municipal Regional Permit (MRP)[2], the City adopted treatment options that are consistent with measures and standards provided in the Alameda Countywide Clean Water Program[3] C.3 Stormwater Technical Guidance[4]. These treatment options include bioretention areas[5] (including rain gardens and flow-through planters), permeable pavements, green roofs, and tree wells. Project managers can select from the options described in the sections below to best manage stormwater at specific locations.

2.1 Bioretention Areas

2.1.1 Rain Gardens

Bioretention Area, Fire Station #1,Oakland. Source: City of Oakland

Rain gardens are shallow landscaped basins that utilize the natural physical, biological, and chemical processes of vegetation growth in soils to collect, detain, filter, and absorb stormwater runoff. Planted with a varied plant palette that can include trees, shrubs, grasses, and groundcovers, rain gardens are often promoted and designed as native or drought-tolerant landscapes that enhance the aesthetic appearance of properties, provide habitat, and lower ambient temperatures. As the category "bioretention" suggests, the primary purpose of rain gardens is retention and temporary storage of stormwater. By retaining and infiltrating stormwater runoff and/or delaying its discharge into the watershed system, rain gardens both improve the quality of stormwater runoff and reduce overall runoff volume.

Rain gardens improve water quality through:

- Reduction of runoff flow rates and volume;
- Detention and retention of stormwater;

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[2] The City is a permitee under the California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit Order No. R2-2015-0049 NPDES Permit No. CAS612008, November 19, 2015.
[3] The City is a member agency of the Alameda Countywide Clean Water Program (ACCWP).
[4] C.3 Stormwater Technical Guidance. Handbook for developers, builders and project applicants. Version 6. ACCWP C, October 31, 2017.
[5] A bioretention area may be considered a "bioinfiltration area" if it is unlined. For more information on bioinfiltration, see the C.3 Stormwater Technical Guidance.

- Infiltration and groundwater recharge;
- Evapotranspiration and biological uptake through native plants; and
- Filtration of pollutants through biological, chemical, and physical processes.

Rain gardens typically consist of a ponding area including a mulch layer, planting soil, plants, and an underlying layer of virgin rock. After water flows through the planting soil, it enters the rock layer and slowly infiltrates into the underlying native soil. An underdrain may be installed at the top of the underlying rock layer to handle overflow into the storm drain system. Rain gardens are typically designed to be flat-bottomed without any longitudinal slope to maximize storage potential. Rain gardens can share certain characteristics with swales and planters (they can be designed with vertical curbs or side slopes).

The primary advantage of rain gardens as a stormwater treatment option is their versatility in size and shape. They are often molded to fit in "leftover" spaces in parking lots, along street frontages, where they may be referred to as a "stormwater planter"[6], and in situations where streets intersect at odd angles. They are typically most effective in detaining, filtering and absorbing stormwater for a drainage area less than one acre, but multiple rain gardens can be used to collect runoff from a larger area. Because rain gardens are flexible in size, they can potentially adapt to retrofit opportunities more often than other stormwater treatment options. Rain gardens require native soils with a minimum infiltration capacity of 0.5 inches per hour. Native soils with low infiltration rates (infiltration less than 1.6-inches of water per hour) will typically require the sub-drains[5]. Bioretention systems of MRP regulated projects must be designed to infiltrate runoff through biotreatment soil media at a minimum of five inches per hour and maximize infiltration to the native soil. Simple rain garden applications that do not use extensive hardscape or pipe infrastructure can be very cost effective to install when infiltration capacity of native soils allow for natural infiltration, depending on the capacity of native soil.

2.1.2 Flow-through Planters

Flow-through planters are also considered bioretention facilities. They are typically narrow, flat-bottomed, rectangular, contained landscape areas designed to capture and detain stormwater runoff from roofs or other hardscape. These planters feature vertical side walls, which allows for more storage volume in less space. Pollutants settle and are filtered out as the runoff passes through the vegetation, soil layer, and underlying layer of clean gravel. The stormwater is then

At-grade Flow-through Planter, Alameda.
Source: City of Alameda.

[6] Stormwater planters are flow-through planters without a liner.

conveyed through a perforated pipe underdrain to a storm drain or other discharge point. An overflow inlet conveys flows that exceed the capacity of the planter.

Two types of planters are used for stormwater management: stormwater and flow-through planters. Stormwater planters depend on native soil conditions that allow runoff to soak into the underlying soil, and these planters may or may not include an underdrain depending on the infiltration rate of the underlying soil. Flow-through planters are completely contained systems designed to treat and detain runoff without allowing seepage into the underlying soil. Flow-through planters and stormwater planters improve water quality through:

- Temporary detention of stormwater runoff;
- Filtration of pollutants through biological, chemical, and physical processes;
- Reduction of runoff volume and flow rates; and
- Infiltration of runoff and groundwater recharge (stormwater planters only).

Stormwater planters allow for greater volume reduction and further ease the burden on local storm drain facilities; however, flow-through planters are ideal for use where native soil conditions are unfavorable to infiltration, or where infiltration to native soil is not physically possible. Examples where the use of flow-through planters would be ideal include: facilities on upper-story plazas or adjacent to building foundations (e.g., collecting runoff via downspouts leading from roofs of adjacent buildings), or on sites where seasonal high groundwater would be within 10 feet of the planter, mobilization of pollutants in soil or groundwater is a concern, and/or potential geotechnical hazards are associated with infiltration.

Flow-through planters can be built to fit between driveways, underground utilities, between or adjacent to buildings, trees, and other existing site elements. They can be planted with a wide variety of plants. Because planters have no side slopes and are contained by vertical curbs, it is best to use plants that will grow at least as tall as the planter’s walls to help “soften” the edges. Planters can be used in both relatively level conditions and in steep conditions if they are appropriately terraced.

2.2 Permeable Pavement

Permeable or pervious pavement describes a system comprised of a loadbearing, durable surface that is either permeable or interlocking, together with an underlying layered structure that allows for stormwater storage, transport, or infiltration into the underlying ground. The goal of these systems is to reduce the amount of stormwater runoff to the storm drain system by replacing an impervious area with a permeable surface.

As a stormwater management practice, permeable pavement improves water quality through:

- Reduction of the volume of stormwater runoff;
- Reduction of impervious areas; and

- Reduction of the need for stormwater conveyance and detention space.

Functionally, the distinguishing feature among the different pervious pavement systems is how the surface is made permeable. There are two main categories of permeable pavements:

- Pervious concrete and asphalt are formulated with pore spaces within the material itself and poured in place; and
- Permeable pavers are discrete units set in place, allowing rainwater to pass through evenly spaced gaps between the pavers' edges.[7]

Permeable pavers, Fire Station #1, Oakland
Source: City of Oakland

Pervious asphalt, pervious concrete and permeable pavers are well suited for practically all pedestrian areas, as well as residential driveways and commercial parking lots. Pervious paving can also be used on roadways with low-traffic speeds and volumes. Pervious paving should not be used in situations with known soil contamination or high groundwater tables. Generally, subgrade infiltration rates that exceed or meet the accepted standard of 0.5 inches per hour are suitable for pervious paving systems without underdrains. In less permeable soil conditions, a subdrain can be utilized and connected to a standard storm drain where accessible.

Pervious concrete in parking area.
Source: San Mateo County Green Streets

2.3 Green Roofs

A green roof is a roofing system composed of a waterproof layer, a drainage system, growing medium, and vegetation that filters, absorbs, and retains/detains the rain that falls upon it. Rainfall that infiltrates into the vegetated roof is subsequently lost through evaporation or transpiration by plants, or, once the soil has become saturated, percolates through to the drainage layer and is discharged through the roof downspouts. In unsaturated conditions, vegetated roofs provide high rates of rainfall retention for small storm events. Lower rates of retention are achieved for larger storm events, but the runoff volume and peak flow rate are reduced due to

[7] Some vendors offer permeable pavers that allow rainwater to pass through the pavers themselves.

temporary storage in the soil. Green roofs can retain 50% or more of the annual precipitation compared to impervious roofs[8].

Green Roof at Kaiser Center, Oakland.
Source: C.3 StormwaterTechnical Guidance

As a stormwater management practice, green roofs improve water quality through:

- Significant reduction of roof runoff volume;
- Filtration of pollutants through biological, chemical, and physical processes;
- Reduction of impervious area; and
- Biological uptake by plants and soil microorganisms.

There are two types of green roofs: extensive, with approximately 6 inches or less of lightweight soil layer, designed to support dense, low-profile, drought-tolerant vegetation; and intensive, with a thicker (greater than 6 inches) soil layer, more varied plant types, and a more garden-like appearance.

For retrofit projects, design professionals such as an architect, structural engineer, and/or roof consultant may be necessary to determine the condition of the existing building structure and roof and what might be needed to support a green roof. Alterations might include additional decking, roof trusses, joists, columns, and/or foundations. Generally, the building structure must be adequate to hold an additional 15 to 30 pounds per square-foot (psf) saturated weight, including the vegetation and growing medium that will be used. Green roofs may cover large sections of a roof while maintaining access for utilities, maintenance, or recreation. Green roofs are most often applied to buildings with flat roofs, but extensive green roofs can be installed on roofs with slopes up to 30 degrees with the use of mesh, stabilization panels, or battens. Slopes greater than 30 degrees require special design considerations.

2.4 Tree Wells

A stormwater detention tree well is an open- or closed-bottom vault filled with bioretention soil mix, planted with tree or tall bush species, and underlain with a subdrain. Tree wells are used to intercept, slow, and filter stormwater as it enters the conventional stormwater conveyance system. The vegetation grows in bioretention media through which runoff is filtered prior to entering the collection system. For low to moderate runoff events, stormwater enters through the

[8] Green Roofs for Stormwater Runoff Control. United States Environmental Protection Agency (EPA), Office of Research and Development National Risk Management Research Laboratory - Water Supply and Water Resources Division, February 2009. http://nepis.epa.gov/Adobe/PDF/P1003704.PDF.

tree well inlet, filters through the soil, and exits through an underdrain into the storm drain. For high flows, stormwater will bypass the tree well if it is full and flow directly to the downstream curb inlet. At a minimum, a tree well temporarily detains the stormwater runoff as it flows through the well prior to discharge into the storm drain system. If surrounding soils have adequate permeability, a tree well can also be designed to promote infiltration of the stormwater runoff. A tree well improves water quality through:

- Temporary detention of stormwater runoff;
- Filtration of pollutants through biological, chemical, and physical processes;
- Reduction of runoff volume and flow rates; and
- Infiltration of runoff and groundwater recharge (open-bottomed designs only).

Tree Wells.
Source: C.3 Stormwater Technical Guidance

Tree wells are especially useful in settings where available space is at a premium. They are most often installed along urban sidewalks or roadways with parallel parking but are highly adaptable and can be used in most development scenarios. They can be installed in closed-bottom chambers where infiltration is undesirable or not possible, such as tight clay soils, sites with high groundwater, or areas with soil contamination or highly contaminated runoff. Small trees and shrubs up to 15 or 20 feet tall that are tolerant of tree well conditions are suitable vegetation choices. Typically tree wells are 6 feet by 6 feet and treat runoff from ¼ acre of impervious surface. Larger and smaller sized tree boxes are available, including double tree boxes that can accommodate canopy trees.

2.5 Alternative Treatment Options

In addition to MRP and C.3 Stormwater Technical Guidance compliant treatment options, the following GI Guide sections describe other landscaping elements with stormwater management and green infrastructure benefits (alternative treatment options) such as bioswales and vegetated filter strips. These landscaping elements do not meet the MRP treatment requirements for bioretention and the City will not receive C.3 (if a regulated project) or green infrastructure implementation credit, or partial credit, for non-regulated projects. The Bay Area Stormwater Management Agencies Association (BASMAA) is currently developing an approach to obtain reduced stormwater treatment credit under the MRP for landscape elements as “undersized” green infrastructure. Although not credited under the MRP at the time of the GI Guide, these landscaping elements will contribute to achieving the important citywide goals of stormwater management and moderation of the urban effects of climate change.

2.5.1 Bioswales

Bioswale. Source: City of Oakland

Bioswales, also called vegetated swales, are long, shallow landscaped areas with a gentle longitudinal slope, designed to capture, slowly convey, filter, and potentially infiltrate stormwater runoff as it moves downstream. Suitable for a variety of grasses, groundcovers, and other plants, bioswales are an important treatment option retrofit for traditional pipe systems that convey roadway, parking lot and other site drainage underground. Bioswales are primarily used to convey stormwater runoff on the land's surface while also providing minor water quality treatment. As water flows through a vegetated swale, it is slowed by the interaction with plants and soil, allowing pollutants to settle, or adhere to vegetation. Some water soaks into the soil and is taken up by plants, and some may infiltrate further if native soils are well drained. Alternatively an under drain that connects to the storm drain system may be utilized. The remaining water that continues to flow through the bioswale travels more slowly than it would through pipes in a traditional stormwater conveyance system. Bioswales are typically built very shallow and contain runoff that is only a few inches in depth. Parking lots and certain street conditions that have a long, continuous space to support a functioning landscape system are candidate sites for vegetated swales. The longer a vegetated swale is, the greater the residence time for slowing and filtering stormwater runoff.

Although the primary function of bioswales is conveyance, not storage, of runoff, they are similar to rain gardens in that they both improve water quality and reduce peak runoff volumes through:

- Reduction of runoff flow rates passing through vegetation;
- Filtration of pollutants through biological, chemical, and physical processes;
- Groundwater recharge and detention of stormwater (dependent upon design); and
- Evapotranspiration and biological uptake through native plants.

Bioswales are a relatively low-cost, simple to construct, stormwater treatment option. For green street and parking lot applications, bioswales can be used in both nearly level conditions and in steeper conditions with up to a five percent longitudinal slope. When swales have a five percent slope or greater, check dams or terraces should be used to help slow the flow of water. Bioswales may be used in conjunction with other elements to form a "treatment train" to achieve compliance with the state's current clean water regulations.

2.5.2 Vegetated buffer strips

Vegetated buffer strip alongside roadway.
Source: C.3 StormwaterTechnical Guidance

Vegetated buffer strips are bands of dense, permanent vegetation with a uniform slope that are designed to treat sheet flow from adjacent hardscape. Vegetated buffer strips function by slowing runoff velocities and allowing sediment and other pollutants to settle. They may provide some infiltration into underlying soils. Vegetated buffer strips were originally used as an agricultural treatment practice and have more recently evolved into a stormwater treatment option. With proper design and maintenance, vegetated buffer strips can provide low to moderate pollutant removal. Because of their ability to decrease sediment loads, filter strips often serve as pretreatment for infiltration trenches or bioretention areas.

Buffer strips provide some water quality improvement primarily through vegetative filtering and infiltration; however, their greatest asset may be the amount of vegetation that they can accommodate. Reductions in runoff volume from small storms can be achieved if the soils are sufficiently pervious, sheet flow is maintained along the entire length and width of the strip, and contact time is long enough for infiltration to occur. Vegetated buffer strips improve water quality by:

- Settling and filtering pollutants (through reduced velocity of stormwater flows); and
- Reducing stormwater peak flows due to slowing stormwater runoff.

Reducing pollutant concentrations through microbial and plant-uptake processes vegetated buffer strips are typically linear facilities that run parallel to and receive the runoff from impervious surfaces such as roads, walkways, driveways, and parking lots. For a vegetated buffer strip to be effective, the stormwater has to enter and flow through the buffer in sheet flow. If stormwater enters the area as a concentrated flow i.e. a topographic depression or inlet, a flow spreader is needed to change the flow pattern to sheet flow. The ground slope needs to be between two and six percent. The vegetation can consist of a variety of native, deep rooted grasses, shrubs and trees. Depending on the desired aesthetics and maintenance availability, a vegetated buffer can be managed (cultivated and maintained) or unmanaged (left in a natural condition without maintenance).

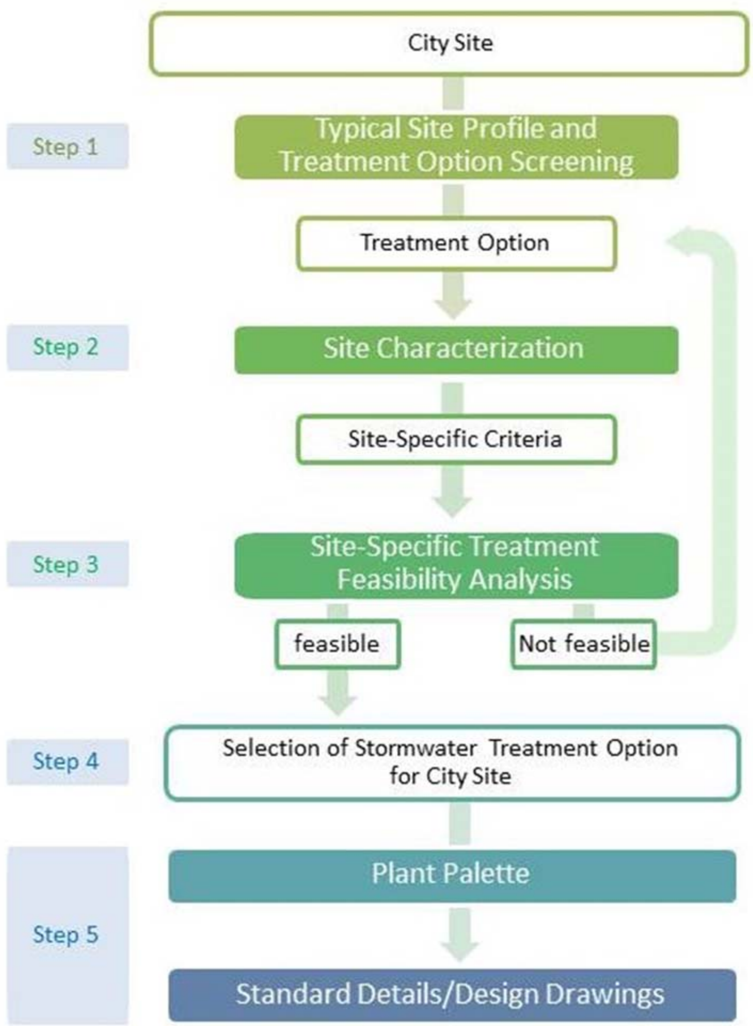
3.0 GREEN INFRASTRUCTURE PLANNING PROCESS

Project managers should follow the process outlined in this guide to select potential stormwater treatment options for City sites. The process explains how to characterize site conditions with respect to stormwater management criteria, to identify an appropriate treatment option, to choose suitable plants, and to apply necessary standard details.

3.1 Step by Step

Follow the five steps described below and illustrated in Figure 1 to identify and confirm feasibility of potential stormwater treatment options for a specific site and to verify that green infrastructure projects comply with regulatory requirements and align with the City's goals.

Figure 1
Treatment Options Decision Tree



Step 1 - *Site Profile and Treatment Opportunity Screening*

Follow this process to identify potential suitable treatment option(s) for a given site profile and rank them based on the rating system presented in Table 1. This process takes into consideration factors including budget, space, planned and existing infrastructure, intended site usage, and management considerations. First, categorize the site by its typical profile:

- City street with parallel parking;
- City street with diagonal parking;
- City ground-level parking lot;
- Other City ground-level area (e.g., plaza, park, roadside or undeveloped land); or
- City structure with storm drain access (e.g., a roof area on a high-rise building, house, shelter, or garage).

After identifying a specific site profile (i.e. a large structure occupies a specific site), refer to Table 1 to determine and rank the treatment options based on a match for that profile (i.e. based on technical, administrative and economic requirements, flow through planters are best suited to treat on-site stormwater and a green roof would also be suited for the City structure while other options are not suited).

The screening matrix in Table 1 uses site profiles typical for the City and information from existing literature to screen treatment options. Table 1 provides a pre-rated list of stormwater treatment options. The pre-rating system uses an alphabetic nomenclature (A, B, C) that is based on assessment of suitability, including A for best suited, B for moderate, and C for least suited, to satisfy the technical, administrative, and economic requirements of treatment options.

Typical requirements include:

- Technical: Capacity for stormwater detention, capacity for flow conveyance, and permeability for infiltration.
- Administrative: Access controls, permitting, assignment of responsibility for O&M, insurance, and ADA compliance.
- Economic: Capital, operating and maintenance costs[9].

The stormwater treatment option with the highest average rating (e.g., AAA) among the technical, administrative and economical requirements presents the best fit for the available City site and should be the preferred option for the next step in the planning process.

[9] For example, low installation and maintenance cost, in addition to minimal access control and water detention requirements result in a triple-A rating for vegetative strips in ground-level areas such as undeveloped land along parking or roadsides.

Step 2 - *Protocol for Stormwater Site Characterization*

After identifying the best suited stormwater treatment option for a typical site profile, the actual City site is characterized using the parameters described in Table 2 - Site Criteria and Stormwater Treatment Option Minimum Requirements. The result of the site characterization is a set of site-specific data that can be compared to requirements of the identified treatment option.

Table 2 organizes site-specific information into general site categories (e.g., topography), sub-categories (e.g., slope) and site-specific criteria (e.g., percent grade). Using the sources of information as indicated on the table, data can be obtained that describe a specific site (e.g., the topography of the specific site may include a slope of two percent grade). Table 2 refers to general sources of information including field surveys, plan, permits, and budget reviews.

Site characterization results in a set of site-specific data to be utilized for the next step in the planning process.

Step 3 - *Protocol for Site-Specific Feasibility Analysis*

Site-specific treatment feasibility analysis can be performed following site characterization to determine if the site-specific criteria meet the preferred stormwater treatment option's requirements. Minimum requirements are defined by qualitative and quantitative (e.g. numeric) minimum requirements necessary to ensure constructability and functionality of treatment options. Examples include minimum percent topographic grade and availability of irrigation. A complete set of minimum requirements is provided Table 2.

Using the Table 2 matrix, information gathered in the site characterization step is compared to the minimum requirements of the preferred treatment option. A site-specific criterion meets a treatment option minimum requirements when a quantitative value (e.g., slope is two percent grade) falls within a range required by the minimum requirements (e.g., rain gardens require a slope between 0.5 and four percent grade). A criterion also meets a minimum requirement when a qualitative site characterization (e.g., the geotechnical site-specific criteria describe the subsurface soil as stable) is inclusive of the minimum requirements (e.g., rain garden: subsurface barrier required if soils are unstable).

The rain garden example above illustrates that additional planning may be required if a site-specific condition (e.g., unstable soil) does not meet the stormwater treatment option's minimum requirements. The site-specific feasibility analysis is a set of site-specific criteria that meet requirements or require detailed planning to meet requirements. <u>A treatment option is suitable for a site if all site-specific criteria meet the minimum requirements,</u> otherwise it is not suitable unless detail planning is used to make the option feasible.

Step 4 - *Protocol for Selecting Stormwater Treatment Option*

Following the site characterization and feasibility analysis, the final selection of a screened treatment option should be confirmed for a specific site. A treatment option can be selected if it is feasible at the City site (i.e., site-specific criteria meet the minimum requirements) or can be satisfied with detail planning. A treatment option is excluded if a City site that does not meet the treatment option minimum requirements (e.g., a rain garden is excluded from a site with a native soil infiltration rate of less than 0.5 inches per hour)[10]. In this case, the GI Guide recommends returning to the screening process, considering a lower-ranking treatment option, reviewing the site characterization for additional information, and conducting a treatment feasibility analysis for the next preferred option. The result of the selection is a feasible stormwater treatment option and identification of potential planning requirements. Table 2 provides planning requirements based on literature review.

Step 5 - *Planning General Design of Stormwater Treatment Option*

Treatment design recommendations for use in Step 5, including plant selection, standard details and construction strategies, are summarized in Sections 4.0 and 5.0.

[10] If the native soil has a saturated hydraulic conductivity rate > 1.6 in/hr, a bioinfiltration area including a rain garden may be designed without an underdrain. Otherwise use of an underdrain is recommended per the C.3 Stormwater Technical Guidance.

4.0 PLANT PALETTE

Designers should select plants using the plant palette included in Attachment A. The palette utilizes plants with desirable characteristics for stormwater treatment that are suitable for Oakland microclimates and local conditions within the City. The plant list takes into consideration the range of soil and drainage conditions that occur in new stormwater facility locations.

The list also provides detailed information about each plant including, at minimum, form (e.g., tree, shrub, grass), light preference, mature size, irrigation needs, tolerance of extremes (e.g., heat, salt spray, flooding, wind, mowing), climate zones, and maintenance needs. Source materials reviewed for the development of the plant palette are tabulated in an annotated bibliography included in Attachment A.

5.0 TREATMENT STANDARD DETAILS

5.1 General

Designers should utilize the standard details provided in this guide for their green infrastructure design (Attachment B). These standard details are intended to assist with planning for the general design, construction, and Operations and Maintenance (O&M) of a selected treatment option. They include preferred materials, recommendation for coordinating with typical City infrastructure, strategies for handling existing utilities, infiltration rates, soil specifications, preferred layout, O&M requirements, specifications, and approximate cost estimates. Typical standard details for each type stormwater treatment are shown on the standard detail drawings, Figure 2 through 13.

5.2 Preferred Materials

5.2.1 Standard Landscape Requirements

5.2.1.1 <u>Piping</u>

Piping used for under-drain systems should meet SDR 35 PVC requirements (piping typically used for gravity drains). Minimum pipe diameter should be 4 inches or greater unless otherwise specified. Various lengths of pipe should be perforated/slotted or solid per specific treatment option design.

5.2.1.2 <u>Geotextiles</u>

Geotextiles used for drainage should be permeable filter fabrics that allow stormwater to pass. Where geotextiles are specified per standard details, Mirafi® 140N, FW 700 or equivalent filter fabrics should be used (i.e. geotextiles used on top of subbase in permeable pavement or protection of underlying waterproofing membranes on green roofs or flow-through planter boxes). **Underdrains must not be wrapped in filter fabric and must not be used in or around underdrain trench.**

5.2.1.3 <u>Impermeable Liner</u>

The integrity of the liner against damage during installation is one of the most important considerations when selecting an impermeable (waterproof) liner. The impermeable liner selected should have a minimum thickness of 30 mils. Generally, a thin layer of sand can be placed above and below the liner to protect it from damage as the treatment option is constructed. Refer to the specific design guidance for additional information.

5.2.1.4 <u>Vegetation (Plant Palette)</u>

Vegetation requirements will vary based on the treatment option selected. Refer to the plant palette (Section 6.0) for specific guidance on selecting appropriate plant types.

5.2.1.5 Mulch

Organic mulch or compost should be applied as an area cover to bare soil between plantings. Mulch should typically be applied in a 3-inch layer on flatter surfaces, or 4 to 6 inches in thickness on sloping areas. Considerations must be taken to prevent the mulch from eroding or floating; Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. Aged mulch can be obtained through soil suppliers or directly from commercial recycling yards. Washed and clean pea gravel, rock, cobble, or other mulches that resist floating may also be used. Bark and “gorilla hair” mulches are not recommended. Shredded redwood bark mulch should not be used, as it is easily ignitable and may present a fire hazard in public spaces.

5.2.2 Permeable Pavement

5.2.2.1 Native Soils

Native soils shall be free of debris, waste, vegetation, and other deleterious matter. Unsuitable materials include ASTM D 2487 Soil Classification Groups CH, OL, OH, and PT, or a combination of these group symbols. The subgrade soil permeability should be equal or greater than 0.5 incher per hour, or based on hydrologic analysis, an underdrain should be installed to remove detained flows within the pervious paving and base.

5.2.2.2 Sub-base

Sub-base consists of an open-graded base of crushed angular rock, with a 35 to 45 percent pore space; a minimum 90% with at least 2 fractured faces conforming to Caltrans test method CT 205; have Los Angeles Rattler no greater than 40% loss at 500 revolutions per Caltrans test method CT 211; and a minimum Cleanness value of 75 per Caltrans test method CT 211. Sieve analysis should conform to Caltrans test method CT 202. The recommended base thickness is 6 inches for pedestrian use and 10 inches for driveways to provide adequate structural strength. The sub-base should be suitable for design traffic loads and allow infiltration of stormwater.

5.2.2.3 Asphalt

Porous asphalt consists of open-graded coarse aggregate (reduced fines), bonded together by bituminous asphalt. Polymers can also be added to the mix to increase strength for heavy load applications. The thickness of porous asphalt ranges from three to four inches depending on the expected traffic loads. For adequate permeability, the porous asphalt should have a minimum of

16% air voids. The California Stormwater Quality Association (CASQA)[11] online guidance on LID Parking Lots provides design and construction details for permeable paving.

5.2.2.4 Concrete

Porous concrete should consist of Portland cement, open-graded coarse aggregate (typically 5/8 to 3/8 inch), and water. Admixtures can be added to the concrete mixture to enhance strength, increase setting time, or add other properties. The thickness of pervious concrete ranges from five to eight inches depending on the expected traffic loads. The reduced fines should leave stable air pockets in the concrete and a total void space of between 15 and 35 percent.

5.2.2.5 Pavers

Many types of pavers can create a pervious surface including impermeable-pervious pavers, which are only permeable between the spaces, and permeable pavers made from permeable material. The pavers should be set in sand or gravel and placed such that a 3/8 inch space is maintained between them. These spaces between pavers must be filled with open-graded aggregate that is free of fines. Interlocking concrete unit pavers that have been designed specifically for stormwater management applications are ideal. The selected paver must be able to withstand the anticipated traffic load without being damaged, with a minimum thickness of 3-1/8 inches for vehicle loads.

5.3 Recommendation for Coordinating with Typical City Infrastructure

Identifying existing infrastructure features and limitations is integral to selecting an appropriate stormwater treatment option for a specific site. Infrastructure dimensions, proximity to the proposed treatment location, access, and operation and maintenance conflicts present typical limitations that should be identified using the tool provided in the specific site characterization under Section 3.5. Potential conflicts can be mitigated though planning, design, and construction management. Review of existing plans, identifying responsible parties (e.g. City departments, other agencies) and communicating plans for stormwater treatment are critical for the success of stormwater treatment projects.

5.4 Strategies for Handling Existing Utilities

Each City owned site needs to be checked for possible existing utility conflicts prior to choosing a stormwater treatment option for the location. The presence of existing utilities does not necessarily preclude the development of a stormwater treatment project, however they can present design and siting challenges. In some situations, the depth to, size of, or risk level working around or near an existing utility may require the use of a treatment option without

[11] Stormwater Best Management Practice Handbook – New Development and Redevelopment. California Stormwater Quality Association (CASQA), Menlo Park, California. January 2003.

subsurface work. Prior to any design choice, the City infrastructure maps should be cross-checked for possible existing utility conflicts. Utility companies such as Pacific Gas & Electric (PG&E), East Bay Municipal Utility District (EBMUD), Comcast & AT&T should also be contacted for information on the location of their utility lines near the proposed project. Utility line locations must be incorporated into the design to the extent feasible so that conflicts can be resolved prior to construction.

Prior to constructing a retrofit that requires subsurface excavation utilities within the work area underground utilities must be identified, via an Underground Service Alert (USA) ticket submitted at least 48 hours prior to the start of work. The boundaries of work area must be marked out in advance, typically using white, chalk-based "mark-out" paint. The utility owners are then responsible for marking out their existing lines. Prior to and during construction, private companies offer onsite services for locating underground utilities such as gas, water, sewer, and telecommunication lines; and subsurface obstruction including documented and undocumented underground storage tanks.

If any unknown piping or conduits are encountered during work, stop excavation activities and if possible, identify and contact the owner of that utility by contacting USA. The relocation of any existing lines must be considered on a case-by-case basis, and coordinated with their owner. It is better to avoid the need to relocate lines during construction through careful and thorough investigation of utility issues during the design of the selected treatment option.

Potential overhead utilities should also be identified during plan review and site visits prior construction. The United States Department of Labor Occupational Safety and Health Administration (OSHA) provide guidelines for construction work near overhead power lines. Safety requires a minimum clearance of 15 feet between any existing overhead utility (e.g. a power line and the proposed treatment). The design and construction of the treatment (e.g. height of tree and operation of excavator) must satisfy this safety requirement.

5.5 Strategies for Identifying Potential Subsurface Contamination

Contaminated sites are not suitable for stormwater infiltration. The presence of chemicals at the ground surface or in the subsurface at a site may pose a risk of mobilizing contamination that could enter the stormwater treatment option and allow contamination to spread deeper into the subsurface. The California State Water Resources Control Board maintains a database of registered contaminated sites through their 'Geotracker' Program. In addition, the City maintains some information on known contaminated site within the City. If no information is available, and the City would like to investigate further, a Phase I Environmental Site Assessment could be performed to assess if there is a reason to suspect contamination is present.

5.6 Infiltration Rates

Infiltration rate requirements vary by treatment option and site-specific conditions. The infiltration rate of native soil at a specific site has a large impact on the final design of the selected treatment option. Native soils with low infiltration rates (infiltrate less than 1.6-inches of water per hour) will typically require the sub-drains. Infiltration rates for native soils can be obtained online at usda.gov but these may not be specific enough for a given site. Specific infiltration rate of a site can be obtained by testing in a soil laboratory, or performing a standard percolation test. The American Society for Testing Materials (ASTM) provides standard methods for testing infiltration rates. All treatment options should completely drain within 72 hours for mosquito abatement purposes.

5.7 Soil Specifications

5.7.1 Site Preparation and Grading

Site preparation often involves clearing the work site of existing vegetation or paved surfaces. Ideally, the selected treatment option will fit closely to existing site grades, reducing the need to excavate, backfill, or off-haul large amounts of soil. Minimizing off haul and imported fill will help reduce project costs. Existing native vegetation should be retained if it can be incorporated into the project design. Subsequent construction of the treatment option should follow shortly after preparation and grading to reduce risks for surface contamination especially if the project is part of a much larger development.

5.7.2 Drain Material

Generally, drain material is an aggregate that should meet requirements for Caltrans class II permeable material. Additional aggregate sizing requirements or allowances may apply to specific treatment options per the design guidelines. The CalTrans Standard Specifications[12] provide construction details for subsurface drains and related materials including plastic, concrete and corrugated metal pipe.

5.7.3 Thickness

The thickness of gravel and soil layers will vary depending on the specific treatment option and site characteristics. Refer to the design guidelines for specific construction requirements.

[12] Standard Specifications, State of California, Department of Transportation, 1900 Royal Oaks Drive, Sacramento, California, 2015.

5.8 Preferred Layout

5.8.1 Irrigation

The layout of irrigation varies by treatment type, design and site-specific conditions. A typical irrigation layout for appropriate type of stormwater treatment is shown on the standard detail drawings. The treatment option irrigation requirements depend on plant selection and establishment following construction. Table 2 and the attached Plant Palette provide details for irrigation by treatment option and plant selection. If a treatment option project exceeds a landscaping area of 22,500 square feet, the irrigation design and operation must comply with the State of California's Model Water Efficient Landscape Ordinance (WELO).

5.8.2 Drainage

The layout of drainage varies by treatment type, design and site-specific conditions. A typical drainage layout for stormwater treatment is shown on the standard detail drawings.

5.9 Operation and Maintenance Requirements

5.9.1 Maintenance Planning

The long-term effectiveness of stormwater treatment depends on inspection and maintenance of the treatment system. Maintenance can be performed by City personnel or through a contract with a service provider. An Operations and Maintenance (O&M) Plan should be prepared to provide guidance and requirements for maintenance and troubleshooting. The O&M Plan should at a minimum address schedule, contain site maps as needed pending on the size of the area; describe inspection and cleaning activities, specify equipment and resource requirements, and identify responsible parties.

5.9.2 Bioretention Areas

5.9.2.1 Rain Gardens

Maintenance should limit the vegetation height, allow for a neat appearance, provide for adequate surface flow capacity, and be in keeping with generally acceptable landscape maintenance practices. The use of herbicides, fertilizers and pesticides is not allowed on City Property. Visual inspections for weeds, trash, and plant health should be conducted regularly (at least biannually). It is advisable to perform inspections following any heavy rain event to ensure the garden can fully drain within 72 hours. Once the vegetation has been established, annual inspections should be made to replenish any mulch and address any areas of poor vegetation growth.

5.9.2.2 Flow-through Planters

Inspect planters annually, and after periods of heavy precipitation for rot, cracks, or any visible failure in the planter structure. Repair or replace any damaged planters. Inspect drainage piping for clogs or damage, and clear or repair as needed. All plant replacement materials should be able to tolerate saturated soil conditions for the length of time anticipated in the design storm event (one hour), as well as other anticipated runoff constituents. The planters need to be planted with vegetation having low water/fertilizer requirements. In addition, all plants should be native where possible, drought-tolerant, and look attractive year round rather than being subject to a distinct dormant period.

5.9.3 Permeable Pavement

Conduct annual inspections of the surface to maintain infiltration capacity. Over time, all types of permeable pavement are susceptible to clogging with sediment and debris, which greatly reduces the effectiveness of the treatment option. Conducting a percolation test at the completion of construction allows for continued monitoring of changes in infiltration rates over time. If test results indicate decreasing infiltration rates the use of a vacuum truck to remove clogging sediment and debris is recommended to maintain effective infiltration. Inspect the driving surface for signs of wear, excessive settlement, or other types of physical damage and, if found, repair as soon as possible. Annual inspections of drainage piping should look for clogs or damage, and be repaired or replaced, when needed. If the adjacent land use generates dust or sediment that may affect the site, inspections may be required at a higher frequency.

5.9.4 Green Roofs

Annually inspect to ensure that water is permeating through the growth media. The media should be aerated or replaced as needed. Remove fallen leaves and other debris biannually, and inspect the area for signs of erosion or excessive scouring of the soil. Inspect and maintain vegetation bi-annually, replacing any dead or poorly-performing vegetation and removing weeds (use of herbicides or pesticides is prohibited). During annual inspections, inspect drainage lines for damage, and confirm the integrity of the impermeable liner. If damage to the membrane is noted, the membrane may be repaired or replaced as appropriate.

5.9.5 Tree Wells

Inspect tree wells annually, or during periods of heavy precipitation. The condition of the tree should be inspected at least monthly, as they are susceptible to damage from vehicles, vandalism and insects. Repair any damage to the tree well-box to ensure proper drainage from the street. Inspect the drainage piping and overflow for clogs or damage, and clear or repair as needed.

5.9.6 Alternative Treatment Options

5.9.6.1 ***Bioswales***

Monitor bioswales several times a year for the accumulation of weeds, and monthly for trash/debris, or any signs of chemical pollution from outside sources (paint, oil, etc.). After vegetation is established, grass should be kept between three and six inches in height. Conduct biannual inspections for evidence of excessive erosion– if erosion is evident, check dams can be installed to reduce flow speeds or a liner appropriate for the expected velocities can be added.

5.9.6.2 ***Vegetated Buffer Strips***

Similar to bioswales, vegetated buffer strips should be inspected regularly (three to four times a year) for weeds, accumulated trash/debris, and any signs of chemical pollution from outside sources. After vegetation is established, inspect biannually for excessive overgrowth (grasses exceeding 10 inches in height) or poor growth due to limited sunlight or other factors. Inspect biannually for evidence of erosion or flow channelizing (areas where runoff no longer enters the strip as sheet flow).

5.10 Typical Treatment Option Costs

Table 3 of the GI Guide includes a summary of typical treatment costs, based on a literature review, for use in the planning process.

6.0 GEOGRAPHIC INFORMATION SYSTEM SCREENING APPLICATION

The GI Guide provides a series of maps showing locations of City-owned properties where various treatment options could potentially be installed based on results of a Geographic Information System (GIS) screening analysis. City-owned properties and Rights-of-Way (City Sites) were screened using a GIS database to identify potential stormwater treatment opportunities at City Sites. The screening analysis applied criteria set forth in the GI Guide (Table 1 and 2). Project managers should use the GIS screening application or the maps to identify stormwater treatment opportunities for City Sites. A technical memorandum summarizing the development and outlining the organization of the GIS data is included in Attachment C. Access to the electronic data can be provided by the City's GIS support staff.

7.0 CAPITAL IMPROVEMENT PROGRAM WORK SHEET

The GI Guide also includes a worksheet[13] for City staff for identifying green infrastructure potential in municipal capital improvement program projects. City of Oakland developed this worksheet that provides a series of checklists to walk member agency staff through the process of reviewing capital improvement program projects for green infrastructure. The work sheet is included in Attachment D and is based on worksheets developed by the Bay Area Stormwater Management Agencies Association (BASMAA) and the Alameda County Clean Water Program.

[13] Worksheet for Identifying Green Infrastructure Potential in Municipal Capital Improvement Program Projects. Bay Area Stormwater Management Agencies Association (BAASMA), California, May 6, 2016.

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TABLES

TABLE 1
Site Profile and Stormwater Treatment Option Screening

Site Profile/ Treatment Screening		Stormwater Treatment Options					Alternative Treatment Options[7]	
		Bioretention[6]		Permeable Pavement	Green Roofs	Stormwater Detention Tree Wells	Bio-swales	Vegetated Buffer Strips
		Rain Gardens	Flow-through Planters					
Typical City Sites	Streets with parallel parking [1]	BBB	BBB	BCC	--	ABB	--	--
	Streets with diagonal parking [2]	BBB	ABB	BCC	--	ABB	--	--
	Ground level parking lot [3]	BAB	AAB	ABC	--	AAB	BBA	AAA
	Ground level areas [4]	AAB	AAB	AAC	--	AAB	ABA	AAA
	Structures with storm drain access [5]	--	AAB	--	CBC	--	--	--

Stormwater Treatment Options Rating System:

Rating	Category	Best Suited	Moderate	Least Suited
1st Rating	Technical Requirements	A	B	C
2nd Rating	Administrative Requirements	A	B	C
3rd Rating	Economic Requirements	A	B	C

Notes:

-- not recommended based on literature review

Low technical, administrative and economic requirements result in AAA rating

Site characteristics assumed for ratings:

1. Narrow streets/sidewalks, residential, parallel parking both sides, less room to work with than diagonal
2. Wider streets, possibly more commercial, room to work with in sidewalk/replacing parking w/ rain garden corners etc.
3. Commercial/office parking lot
4. Plazas, parks, roadsides and undeveloped land
5. Roofs, dense-urban areas (high-rise buildings, houses, shelters, and garages)
6. A bioretention area may be considered a “bioinfiltration area” if it is unlined per the 2017 Alameda County Clean Water Program C.3 Stormwater Technical Guidance.
7. Alternative treatment options are landscaping elements with stormwater management and green infrastructure benefits that do not meet the 2015 Municipal Regional Stormwater Permit treatment requirements for bioinfiltration and the City will not receive C.3 (if a regulated project) or green infrastructure implementation credit, or partial credit, for non-regulated projects.

TABLE 2
Site Criteria and Stormwater Treatment Option Standards

Site Criteria and Source of Information					Stormwater Treatment Option Standards					Alternative Treatment Option Standards[1]	
					Bioretention[2]						
					Rain Gardens[3]	Flow-through Planters[3,6]	Permeable Pavement[4]	Green Roofs[4,5]	Stormwater Detention Tree Wells[3]	Bio-swales[4]	Vegetated Buffer Strips[5]
Type	**Site Characteristic**	**Sub-Category**	**Site Specific Criteria**	**Source of Information**	**Feasibility Requirements**						
Technical Requirement	Topography	Slope	………………… Percent grade	Plan review, field survey	Between 0.5% and 4% slopes recommended. Can be terraced to accommodate slopes steeper than 4%.	--	Slopes flatter than 4% recommended. Sites with slopes greater than 25% should be excluded, and a geotechnical analysis of slope stability should be conducted if located on slopes greater than 15%[1]	Intensive roofs should be generally flat, while extensive roofs can have steeper slopes up to 25%	--	Check dams required if steeper than 2%, underdrains required if shallower than 0.5%, with a minimum slope of 0.2% in the direction of flow.	Slopes in the direction of flow should be between 2 and 4%. Lateral slopes (perpendicular to flow) should also not exceed 4%. Both the top and toe of the buffer slope should be as flat as possible to prevent channeling. The slope of the impervious tributary area should not exceed 5%.
	GW	Depth to groundwater	………………… Depth below the ground surface (feet)	Field survey, literature, piezometer/well	The depth to groundwater (or low permeability soil) should be 5 vertical feet from the bottom of the garden	The depth to groundwater should be at least 2 ft. below the bottom of the planter box.	The depth to groundwater (or low permeability soil) should be 5 vertical feet from the bottom of aggregate base	--	--	Minimum 1' above seasonal high GW	Minimum 1' above seasonal high GW at lowest elevation.
		Setbacks to GW-wells	………………… Distance (feet)	Plan review, field survey	Min 100 feet between infiltration and potable wells, non-potable wells, drain fields, and springs	--	--	--	Minimum 100 feet between infiltration and potable wells, non-potable wells, drain fields, and springs	--	--
	Soil type	Soil type	………………… Clayey (yes / no)	Report, literature, field survey	--	--	--	--	--	--	--
	Permeability	Infiltration rate	………………… Infiltration (inches per hour)	Field test, estimate based on soil type	Native soil minimum infiltration rate of 0.5 inches per hour	--	Native soil minimum infiltration rate of 0.5 inches per hour	--	--	Native soil minimum infiltration rate of 0.5 inches per hour	--
	Structures	Setbacks to structures	………………… Distance (feet)	Plan review, field survey	Min 8 ft. offset from building foundations or as specified by a geotechnical expert.	No offset restriction for lined planters	Min 8 ft. offset from building foundations or as specified by a geotechnical expert.	--	Minimum 10 offset from building foundation. May be greater depending on size of mature tree[2]	Min 25ft offset from building foundations	Min 10' offset from building foundations
	Space availability	Flexibility of placement of treatment option	………………… Area (square feet)	Plan review, field survey	Requires a minimum area of approximately 4% of contributing impervious surface area.	--	--	--	Generally installed in place of a standard storm-drain	Usually not feasible in dense urban area[1]	Min 4ft buffer length in direction of flow if sized for pretreatment. Lengths greater than 15 ft. are otherwise acceptable, with 25 ft. or greater being preferred.
	Irrigation availability	--	………………… Available (yes / no)	Plan review, field survey	May require irrigation until plants establish[8]	May require irrigation until plants establish[8]	--	Irrigation is required if seeds are planted in spring or summer. The need for permanent irrigation systems will vary depending on plant selection.[7,8]	May require irrigation until plants establish[7]	May require irrigation until plants establish[7]	May require irrigation until plants establish[7]
	Utility/infrastructure conflicts	Extent of excavation, flexibility to accommodate existing utility lines, ability to relocate existing utility lines	………………… Conflict (yes / no)	Plan review	--	Chance of underground utility conflicts depending on installation depth	Chance of underground utility conflicts depending on installation depth	--	Chance of underground/overhead utility conflicts[2]	--	--
	Tributary Areas	Size physical characteristics	………………… Area (acres)	Map review	Contributing impervious area should not exceed 2 acres	Can accept runoff from impervious areas up to 25x the area of the planter	Should not accept runoff from additional surfaces	Should not accept runoff from additional surfaces	Varies by well box design[1]	Contributing impervious area should not exceed 0.5 acres[1]	Accepts flow from lengths up to 4-times that of the buffer (max 150' impervious length, parallel to flow).
	Proximity to other pervious/impervious areas	Stormwater flow behavior considerations	………………… Pervious / impervious source area	Plan review, field survey	--	Design considerations depending on inflow type[1]	--	--	Design considerations depending on inflow type[1]	Design considerations depending on inflow type[1]	Inflow must be "sheet flow" not a point source
	Drainage availability	Discharge to existing stormwater system	………………… Available (yes / no)	Plan review, field survey	Requires a discharge of overflow	Requires a discharge of flowthrough	Requires a discharge of runoff	Requires a discharge of overflow	Requires a discharge of overflow	Requires a discharge of flowthrough	Requires a discharge of runoff
	Stormwater runoff reduction	Level of stormwater reduction high / medium / low	………………… Cubic feet per hour. Volume (cubic feet)	Permit review, hydrologic analysis	High	Medium	High	High	Medium	High	Low
	Stormwater runoff reduction	High flow situations (e.g. 10-year storm)	………………… High flow conditions (yes / no), access to storm drain (yes / no)	Permit, plan review, field survey	Medium	Low	Low	Low to Medium[1]	Low	Medium	Low
	Geotechnical	Soil stability	………………… Stable (yes / no)	Plan review, geotechnical analysis	Subsurface barrier required if soils are unstable	--	Must sustain traffic load	--	--	Subsurface barrier required if soils are unstable	Subsurface barrier required if soils are unstable

TABLE 2
Site Criteria and Stormwater Treatment Option Standards

Site Criteria and Source of Information					Stormwater Treatment Option Standards					Alternative Treatment Option Standards[1]	
					Bioretention[2]						
					Rain Gardens[3]	Flow-through Planters[3,6]	Permeable Pavement[4]	Green Roofs[4,5]	Stormwater Detention Tree Wells[3]	Bio-swales[4]	Vegetated Buffer Strips[5]
Type	**Site Characteristic**	**Sub-Category**	**Site Specific Criteria**	**Source of Information**	**Feasibility Requirements**						
	Geotechnical	Setbacks to slopes	.... Distance (feet)	Plan review, field survey	Min 50 feet between infiltration and slopes steeper than 15 percent or an alternative setback established by the geotechnical expert	--	--	--	Minimum 50 feet between infiltration and slopes steeper than 15 percent or an alternative setback established by the geotechnical expert	--	--
	Environmental	Pollutant removal effectiveness	.... Chemicals, sediment, bacteria, nutrients, trash present (yes / no)	Permit review, environmental study, database research e.g. Geotracker	High	Medium	High, except for bacteria and oil/grease	Low to Medium¹	Medium	Low to Medium	Low to Medium
	Environmental	Existing contamination mobilization concerns from infiltration	.... Soluble chemicals present (yes / no)	Plan review, database quarry	Subsurface barrier required unless a site-specific analysis determines that infiltration would be beneficial.	Subsurface barrier required.	Subsurface barrier required unless a site-specific analysis determines that infiltration would be beneficial.	--	Subsurface barrier required unless a site-specific analysis determines that infiltration would be beneficial.	Subsurface barrier required unless a site-specific analysis determines that infiltration would be beneficial.	Subsurface barrier required unless a site-specific analysis determines that infiltration would be beneficial.
	Landscaping	Design requirements	.... Area and aesthetic considerations	Plan review	Landscape design	Landscape design	--	Landscape design for roof gardens	--	Landscape design	Landscape design
	Infrastructure	Infrastructure Impacts	.... Infrastructure impact (yes / no), can design be modified	Plan review, field survey	Low likelihood of impacts	--	--	High, special structural design requirements	Mature tree size must not conflict with existing infrastructure[6]	May not be useable in areas where curb and gutter are legally required	--
Administrative Requirement	Site Usage	Foot/vehicle traffic	.... None / low / medium / high	Plan review	Foot traffic should be limited	--	Unsuitable for high vehicle traffic	foot traffic unsuitable on extensive roof	--	Foot traffic should be limited	Foot traffic should be limited
	Community concerns	Impact on public safety	.... Impact acceptable (yes / no)	Plan review	--	--	Potential safety concerns for high-heels and disability access	--	--	--	--
	Community concerns	Impact on traffic/pedestrians	.... Impact acceptable (yes / no)	Plan review	--	May reduce width of available sidewalk or roadway	Low traffic and speeds under 30 mph	--	May reduce width of available sidewalk or roadway	--	--
	Public involvement/stewardship	Community role in maintenance	.... Public involvement (yes / no)	Design review	Public involvement possible	Public involvement possible	--	--	--	Public involvement possible	Public involvement possible
	Geographical	Type of development/ locations best suited	.... Residential / commercial / industrial / infrastructure	Plan review, field survey	Undeveloped or low-density areas.	Urban spaces, new development, close to structures, limited development space	In place of existing/planned pervious paved areas	Urban public space, new development	Best suited for urban areas, any location with an existing or planned curb and gutter system	Undeveloped or low-density areas	Next to impervious roadways or other linear paved areas
Economic Requirement	Funding availability	Installation costs	.... No / low / medium / high funding availability	Grant review, city budget	Medium	Medium	Medium[7]	High	Medium	Low	Low
	Funding availability	Maintenance costs	.... No / low / medium / high funding availability	Grant review, city budget	Low	Low	Medium to High[7]	Low to Medium	Low	Low	Low

Notes:

-- no feasibility requirements based on literature review

1. Alternative treatment options are landscaping elements with stormwater management and green infrastructure benefits that do not meet the 2015 Municipal Regional Stormwater Permit treatment requirements forbioinfiltration and the City will not receive C.3 (if a regulated project) or green infrastructure implementation credit, or partial credit, for non-regulated projects.
2. A bioretention area may be considered a "bioinfiltration area" if it is unlined per the 2017 Alameda County Clean Water Program C.3 Stormwater Technical Guidance.
3. Detention and infiltration of stormwater
4. Conveyance and some infiltration of stormwater
5. Collect and absorb stormwater
6. Conveyance and filtration of stormwater
7. See Site-Specific Feasibility Analysis (SSFA) for details
8. See Plant Palette (PP) for plant selection details

TABLE 3
Typical StormwaterTreatment Option Costs

Stormwater Treatment Option	Relative Expense (cost/ac-ft[1] or cost/cfs[2])	Construction Costs	Typical Cost[3]		Maintenance Cost	Notes
			($/BMP)	Type of Application		
Rain Garden	$[4,5]	$3-5.30/cuft[3], residential $3-4 & commercial $10-40 (incl. undertrain)[4], $8/sqft[6]	$60k	5-acre Commercial Site (65% Impervious)	5%- 7% of Construction[3,4], $[5], 12.5% of Construction[6]	Cost of plants varies. Maintenance costs comparable to cost of typical landscaping.
Flow-Through Planters	$$[5]	planter $32.70/sqft, or impervious surface area $2.10/sqft[6]	NIA	NIA	$[5], 5-10% of Construction/year[6]	The costs of installing and maintaining a bioretention planter vary depending on size, materials, and maintenance requirements of selected plantings[6]
Permeable Pavement	$$ - $$$$[5]	$3.54-15.53/sqft[3], materials $2-8/sqft & construction $10k/acre[6]	NIA	$$ - $$$$[5]	$$ - $$$$[5], $4k/acre/year[6]	Permeable pavement can be up to 25% cheaper than traditional pavement when all construction and drainage costs are included[6]
Green Roof	$$$$[5]	new roof $10-20/sqft or re-roof $6-40/sqft[6]	NIA	NIA	$$$[5], $1.25-5.49/sqft/year[6]	NIA
Tree Well	$$ [5]	$8-10k/prefabricated system & construction $1,5-6k[7]	NIA	NIA	$[5], $100-500/year[7]	NIA
Bio-Swales	$ - $$[5]	$0.25-0.50/sqft'[4]	$3.5k	5-acre Residential Site (35% Impervious)	5%- 7% of Construction[3,4], $ [5], 6% of Construction[6]	Construction of vegetated swales[6] can be less expensive than other more traditional conveyance systems such as concrete ditches or sewers.
Vegetative Buffer Strips	$$[4], $ - $$[5]	$0.00-1.30/sqft, $13k-30k/acre, $0.30-0.70/sqft3 or $13k-17k/acre[6]	$0-$9k	5-acre Residential Site (35% Impervious)	$350/ acre/ year (about $0.01/ sqft/ year)[4], $[5]	Costs depends upon the dimensions and location of the strip[6]

Notes:

1 Volume-based Best Management Practice (BMPs)
2 Flow-based BMPs
3 Preliminary Data Summary of Urban Storm Water Best Management Practices. Part D, Cost and Benefits Analysis, United States Environmental Protection Agency, 1999, http://water.epa.gov/scitech/wastetech/guide/stormwater/index.cfm#report
4 California Stormwater Quality Association, 2003. New Development and Redevelopment Handbook
5 Green Infrastructure Design Manual, 2011. Louisville and Jefferson County Metropolitan Sewer District.
6 San Francisco Stormwater Design Guidelines, San Francisco Public Utilities Commission & Port of San Francisco, November 2009
7 Charles River Watershed Association, Low Impact Best Management Practice (BMP) Information Sheet, August 2008

$ Relatively low
$$ Moderate
$$$ Moderately High
$$$$ High

NIA = no information available
sqft = square foot
cuft = cubic foot
k = 1,000

CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE

ATTACHMENT A
OAKLAND PLANT PALETTE FOR GI SYSTEMS
AND ANNOTATED BIBLIOGRAPHY

ATTACHMENT A

Plant Palette for Stormwater Treatment

PLANT			Size	STORMWATER TREATMENT OPTION								SOIL TYPE			IRRIGATION NEEDS				LIGHT REQUIREMENTS						
Scientific Name	Common Name	Plant Type	Mature H x W (feet)	Bioretention Area	Flow-Through Planter	Green Roof-Extensive	Green Roof-Intensive	Tree Well Filter	Buffer Strip	Swale	Turf Blocks	Clay	Loam	Sand	Regular	Moderate	Low	Drought Tolerant	Full Sun	Partial Shade	Shade	Bloom Time:Color	Native Status	Zones	Notes
Acer circinatum	vine maple	tree	15 x 10	●			●	●	●			●	●		●	●	●			●	●	n/a	CA	16; 17	not vigorous, best in shade
Acer macrophyllum	big leaf maple	tree	30 x 30	●					●			●	●	●		●	●		●	●		n/a	CA	16; 17	
Achillea millefolium	common yarrow	perennial	1.5 x 1.5	●	●	●	●		●		●	●	●	●	●	●	●	●	●	●	●	Spring; white	CA	16; 17	easy, full sun near bay, part shade inland
Achillea millefolium var. lanulosa	mountain yarrow	perennial	1 x 1.5	●	●	●			●			●	●	●	●	●	●		●	●		Spring; white	CA	16; 17	tolerates foot traffic
Agave 'blue flame'	blue flame agave	perennial	2 x 1			●							●	●			●	●	●	●		rare; green	N	16; 17	
Allium schoenoprasum	Allium	perennial	1 x 0.5			●	●						●	●			●	●	●	●	●	Spring; pink	N	16; 17	winter dormant
Aloe x nobilis	gold tooth aloe	perennial	2 x 1			●							●	●			●		●	●		Summer; orange	N	16; 17	
Alnus rhombifolia	white alder	tree	40 x 30	●					●			●	●	●	●	●			●	●		n/a	CA	16; 17	
Anemopsis californica	yerba mansa	perennial	1 x 2	●	●				●			●	●	●	●	●		●	●	●		Spring; white	CA	16; 17	winter dormant
Arbutus x 'marina'	strawberry tree	tree	20 x 15						●			●	●	●			●		●	●		Year-round; pink	N	16; 17	plant on mound if not well-drained soil
Arctostaphylos uva-ursi 'Point Reyes' or 'San Bruno'	bearberry manzanita, kinnick kinnick	perennial	0.5 x 6	●	●		●		●			●	●	●	●	●	●			●		Summer; white	C	16; 17	full sun near bay
Aristida purpurea	purple three-awm	grass	2 x 2	●	●		●		●					●			●	●	●			Summer; purple	CA	16; 17	
Armeria maritime	California sea pink	perennial	1 x 1	●	●	●	●						●	●	●	●	●			●	●	Summer; pink	CA	17	
Artemisia douglasiana	mugwort	shrub	3 x 3	●	●				●	●		●	●	●	●	●	●	●	●	●		Summer; grey	CA	16; 17	
Artemisia pycnocephala	beach sagewort	shrub	2 x 3	●	●				●				●	●	●	●	●	●	●			n/a	CA	16; 17	nice foliage, easy in sand
Aquilegia formosa	scarlet columbine	perennial	2 x 1	●	●				●			●	●	●	●	●	●	●		●	●	Summer; red	CA	16; 17	deer proof, prune annually
Baccharis pilularis var. consanguinea	coyote brush	shrub	4 x 6	●					●			●	●	●	●	●	●	●	●	●		Summer; white	CA	16; 17	Full size variety, good for tough sites, not showy
Baccharis pilularis 'twin peaks' or or 'pigeon point'	prostrate coyote brush	sub-shrub	1 x 6	●	●		●		●			●	●	●	●	●	●	●	●	●		Summer; white	CA	16; 17	Easy groundcover, deer proof
Betula occidentalis	water birch	tree	15 x 8	●				●	●				●	●	●	●			●	●	●	n/a	CA	16; 17	
Bromus carinatus	California Brome	grass	2 x 1	●	●				●	●		●	●	●				●	●			n/a	CA	16; 17	
Calystegia macrostegia	California morning glory	vine	10 x 10	●	●				●			●	●	●	●	●	●		●	●		Spring; pink	CA	16; 17	good for covering a fence
Carex divulsa	Berkeley sedge, European grey sedge	grass	1 x 2	●	●				●	●		●	●	●	●	●	●		●	●	●	Summer; brown	N	16; 17	
Carex pansa	dune sedge	grass	1 x 1	●	●								●	●	●	●		●	●	●		n/a	CA	16; 17	intolerant to foot traffic
Carex barbarae	Santa Barbara sedge	grass	1 x 1	●		●	●					●	●	●	●	●		●	●			n/a	CA	16; 17	
Cercis canadensis	eastern redbud	tree	25 x 25	●				●	●				●	●	●	●	●	●	●	●		Spring; pink	N	16; 17	deciduous, low maintenance
Clarkia spp.	clarkia	annual	1 x 1	●		●	●		●			●	●	●	●	●	●	●	●	●		Spring; varies	CA	16; 17	use in seed mix
Cornus stolonifera	red twig dogwood	shrub	3 x 3	●	●				●			●	●	●	●	●			●	●	●	Summer; white	CA	16; 17	red bark
Delosperma 'Lavendar Ice'	lavendar ice delosperma	perennial	0.5 x 1.5			●							●	●			●	●	●			Spring; lavender	N	16; 17	rapid cover, long blooming
Deschampsia cespitosa	tufted hairgrass	grass	2 x 1	●	●		●		●	●		●	●	●		●	●	●	●			Spring, Summer; greenish gold	CA	16; 17	
Deschampsia cespitosa ssp. Holciformis	Pacific hairgrass	grass	1 x 2	●	●		●		●	●		●	●			●	●	●	●			Spring, Summer; yellow	CA	17	
Dudleya virens spp.hassei	Bright green dudleya	perennial	0.5 x 0.5			●							●	●			●		●	●		Summer; yellow	CA	16; 17	
Dudleya farinose	live forever	perennial	0.5 x 0.5			●							●	●			●		●			Summer; yellow	CA	16; 17	
Eleocharis palustris	creeping spikerush	grass	1 x 1	●	●				●	●		●	●		●	●			●			n/a	CA	16; 17	
Elymus glaucus	blue wildrye	grass	2 x 2	●	●	●	●		●	●		●	●	●								Spring;	CA	16; 17	difficult to mow
Epilobium canum	California fuchsia and varieties	perennial	1 x 4	●	●	●			●			●	●	●	●	●	●	●	●	●		Spring, Summer, Fall; varies	C	16; 17	Variable tolerances by variety, check with nursery
Eriogonum fasciculatum	flattop buckwheat	perennial	3 x 4	●					●			●	●	●			●	●	●			Summer; white	CA	16; 17	do not water in summer; plant where flooding is minimal,
Eriogonum umbellatum	sulfur buckwheat	perennial	1 x 3	●					●			●	●	●			●	●	●	●		Summer; yellow	CA	16; 17	plant where flooding is minimal, very drought tolerant
Erigeron glaucus	seaside daisy	perennial	1 x 2	●	●				●			●	●	●	●	●	●	●	●	●		Spring; pink	CA	16; 17	sun and drought tolerant at the bay, part-shade and regular water inland
Erigeron foliosus	leafy fleabane	perennial	1 x 2	●	●				●			●	●	●	●	●	●	●	●	●		Spring; pink	CA	16; 18	easy
Eschscholzia californica	California poppy	annual	1 x 1	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●			Summer; orange	CA	16; 17	use in seed mix
Festuca californica	California fescue	grass	2 x 2	●	●		●		●		●	●	●	●	●	●		●		●	●	n/a		16; 17	
Festuca idahoensis	idaho fescue; blue bunchgrass	grass	1 x 1	●	●		●		●	●	●	●	●	●	●	●			●	●		Summer; yellow	CA	16; 17	intolerant to shade; good slope stabilizer
Festuca rubra	red fescue	grass	1 x 2	●	●		●		●	●	●		●	●	●				●	●			CA	16; 17	Mowing optional, can be mixed with other species to cover shaded areas
Festuca rubra 'molate'	molate fescue	grass	1 x sp	●	●		●		●		●	●	●	●	●	●	●			●	●	Spring; white	C	16;17	prefers part shade, regular water in hot areas, lawn alternative
Fragaria chiloensis	coastal strawberry; beach strawberry	perennial	1 x sp	●	●	●			●	●				●	●				●	●		Spring; white	CA	17	ground cover

ATTACHMENT A

Plant Palette for Stormwater Treatment

PLANT			Size	STORMWATER TREATMENT OPTION								SOIL TYPE			IRRIGATION NEEDS				LIGHT REQUIREMENTS						
Scientific Name	Common Name	Plant Type	Mature H x W (feet)	Bioretention Area	Flow-Through Planter	Green Roof-Extensive	Green Roof-Intensive	Tree Well Filter	Buffer Strip	Swale	Turf Blocks	Clay	Loam	Sand	Regular	Moderate	Low	Drought Tolerant	Full Sun	Partial Shade	Shade	Bloom Time:Color	Native Status	Zones	Notes
Fragaria vesca	mountain strawberry; woodland strawberry	perennial	1 x sp	•					•	•				•	•				•	•		Spring; white	CA	16; 17	ground cover
Fraxinus latifolia	Oregon ash	tree	25 x 25	•					•	•		•	•	•	•	•		•	•	•		Spring; green	CA	16; 17	deciduous, fall color, tolerates bayside conditions
Fraxinus oxycarpa 'Raywood'	Raywood Ash	tree	40 x 25	•				•	•			•	•	•	•	•	•	•	•			Spring; green	N	16; 17	intolerant of wind and fog, min 5'x5' tree well
Fremontodendron 'California Glory'	flannel bush	shrub	14 x 12	•					•					•			•	•	•			Spring; yellow	C	16; 17	requires good drainage; no water once established; no salinity tolerance
Gambelia speciosa	Island snapdragon	vine	10 x 10	•	•				•			•	•	•	•	•	•	•	•			Summer; pink	CA	16; 17	evergreen, climbs fences
Garrya elliptica	coast silktassel; wavyleaf silktassel	shrub; tree	8 x 8	•				•	•							•		•	•	•		Winter; yellow-green	CA	16; 17	requires good drainage; good screen
Gaultheria shallon	salal	shrub	3 x 6	•					•	•		•	•	•	•				•	•	•	Spring; white	CA	17	best in summer fog
Gilia capitata ssp. chamissonis	blue coast gilia; dune gilia; chamisso's gilia; bluehead gilia	annual	3 x 1			•				•			•	•		•	•		•			Spring, Summer; Blue	CA	16; 17	requires well-drained soils
Gleditsia triacanthos	honey locust	tree	70 x 35	•	•				•				•		•	•			•			Spring; yellow	CA	16	intolerant to shade
Pseudognaphalium californicum	California everlasting	perennial	2 x 2	•	•				•			•	•	•	•	•		•	•			Winter - Summer; white	CA	16; 17	long blooming, lives only 2-3 years, will self seed in frequently disturbed areas
Grevillea lanigera 'Coastal Gem'	wooly grevillea	shrub	1 x 4	•					•			•	•	•		•	•	•	•	•		Winter; pink	N	16; 17	plant where flooding is minimal, tough, deer resistant
Grevillea robusta	silk oak	tree	60 x 35					•				•	•	•		•	•	•	•			Summer; yellow	CA	16; 17	intolerant to shade
Grindelia camporum	gumplant	shrub	2 x 2	•	•				•			•	•	•		•	•	•	•			Summer; yellow	CA	17	tolerates salty soil
Heteromeles arbutifolia	toyon	shrub	20 x 15	•					•			•	•	•			•	•	•	•		Summer; white	CA	16; 17	evergreen, red winter berries
Hordeum brachyantherum	meadow barley	grass	1.5 x 1	•	•				•	•		•	•		•	•	•	•	•			n/a	CA	16; 17	will not outcompete weeds
Heuchera micrantha	coral bells	perennial	1 x 1	•	•				•			•	•	•	•	•	•	•		•	•	Summer; pink	CA, C	16; 17	cultivars ok too
Iris douglasiana	Douglas iris	perennial	1.5 x 2	•	•				•			•	•	•	•	•	•	•	•	•	•	Spring; purple	CA	16; 17	summer dormant, short blooming, prefer no summer water
Juncus patens	blue rush	grass	2 x 1	•	•					•		•	•	•	•	•			•	•		Summer; yellow	CA	16; 17	Use in seed mix for green roof
Laurus nobilis 'saratoga'	Saratoga bay laurel	tree, shrub	30 x 30	•				•	•			•	•	•	•	•	•	•	•	•		Spring; yellow	N	16; 17	evergreen, prune for tree form
Layia platyglossa	tidy tips	annual	1 x 1			•	•					•	•	•	•	•	•		•			Summer; yellow	CA	16; 17	
Lessingia 'silver carpet'	silver carpet	perennial	1 x 2	•	•				•			•	•	•	•	•	•	•	•			Summer; purple	CA	16; 17	
Leymus triticoides	creeping wildrye, beardless wildrye	grass	3 x 1	•	•				•	•		•	•	•		•	•	•	•			n/a	CA	16; 17	Best grass for swales. Lawn alternative if irrigated and mown
Lolium spp.	perennial ryegrass	grass	1 x sp						•		•	•	•	•	•	•	•		•	•		n/a	N	16; 17	preferred, requires mowing
Lupinus variicolor	many colored lupine	perennial	1 x 2	•	•				•			•	•	•			•	•	•			Summer; blue	CA	16; 17	best with no summer water after established
Lupinus nanus	sky lupine, dwarf lupine	annual	1 x 1			•			•			•	•	•			•		•			Summer; blue	CA	16; 17	can be planted as seed
Magnolia grandiflora 'Saint Marys'	magnolia	tree	25 x 25	•				•	•			•	•	•	•	•	•	•	•			Summer; pink	N	16; 17	Minimum tree well 4' by 4' or 3' by 6'
Mahonia repens	creeping Oregon grape	shrub	2 x 3	•	•		•		•			•	•	•	•	•	•	•		•	•	Summer; yellow	CA	16; 17	deer proof
Mahonia pinnata	California holly grape	shrub	4 x 4	•	•				•			•	•	•	•	•	•	•		•	•	Summer; yellow	CA	16; 17	deer proof, slow
Mimulus aurantiacus	common monkeyflower	perennial	4 x 4	•	•		•		•			•	•	•	•	•	•	•	•	•	•	All year; orange	CA	16; 17	best in part shade
Mimulus cardinalis	scarlet monkeyflower	perennial	2.5 x 2.5	•	•		•			•		•	•	•	•	•	•		•	•		All year; red	CA	16; 17	
Muhlenbergia rigens	deergrass	grass	3 x 3	•	•		•		•	•		•	•	•	•	•	•	•	•			n/a	CA	16; 17	quick to establish
Nasella pulchra	purple needlegrass	grass	2 x 1	•	•		•		•	•		•	•	•		•	•	•	•			n/a	CA	16; 17	
Platanus racemosa	California sycamore	tree	60 x 60					•	•			•	•	•	•	•	•	•	•			n/a	CA	16; 17	Min. 5'x5' tree well, requires root barrier
Polystichum munitum	sword fern	perennial	3 x 3	•	•				•			•	•	•	•	•	•	•		•	•	n/a	CA	16; 17	easy in shade
Potentilla anserina ssp. Pacifica	Pacific silver cinquefoil	perennial	1 x sp	•	•				•			•	•	•	•	•		•	•			Summer; yellow	CA	16; 17	spreads like strawberry
Prunella vulgaris	selfheal	perennial	0.5 x sp	•	•	•			•	•			•	•	•	•	•	•	•	•		Summer; violet	CA	16; 17	tolerates mowing
Prunus cerasifera 'Thundercloud'	purple leaf plum	tree	15 x 15	•				•	•				•	•	•	•	•		•	•		Spring; pink	N	16; 17	short-lived, evergreen
Prunus ilicifolia	holly leaf cherry	tree	15 x 15	•				•	•			•	•	•		•	•	•	•	•		Spring; white	CA	16; 17	showy fall berries
Pyrus kawakamii	evergreen pear	tree	20 x 12					•	•			•	•	•	•				•			Spring; white	N	16; 17	short-lived, evergreen, tolerates bayside conditions
Quercus agrifolia	coast live oak	tree	70 x 70	•				•	•			•	•	•			•	•	•	•		Spring; green	CA	16; 17	evergreen, no summer irrigation after established
Rhamnus crocea	redberry	shrub	2 x 5	•	•				•				•	•	•	•	•	•	•						sun at bay, part shade inland
Rhus lancea	African sumac, karee	tree	20 x 20	•				•	•			•	•	•	•	•	•	•	•			Spring; green	N	16; 17	evergreen

ATTACHMENT A
Plant Palette for Stormwater Treatment

PLANT			Size	STORMWATER TREATMENT OPTION								SOIL TYPE			IRRIGATION NEEDS				LIGHT REQUIREMENTS						
Scientific Name	Common Name	Plant Type	Mature H x W (feet)	Bioretention Area	Flow-Through Planter	Green Roof-Extensive	Green Roof-Intensive	Tree Well Filter	Buffer Strip	Swale	Turf Blocks	Clay	Loam	Sand	Regular	Moderate	Low	Drought Tolerant	Full Sun	Partial Shade	Shade	Bloom Time:Color	Native Status	Zones	Notes
Ribes sanguineum	flowering currant	shrub	8 x 8	•	•				•			•	•	•	•	•	•	•	•	•	•	Winter; pink	CA	16; 17	easy and adaptable, attracts hummingbirds
Ribes sanguineum cultivars	flowering currant	shrub	8 x 8	•	•				•			•	•	•	•	•	•	•	•	•	•	Winter; pink	CA	16; 17	easy and adaptable, attracts hummingbirds
Ribes speciosum	fuchsia-flowered gooseberry	shrub	5 x 5	•	•				•			•	•	•	•	•	•	•	•	•	•	Winter; pink	CA	16; 17	thorny
Rosa californica	California wild rose	shrub	3 x 4	•					•			•	•	•	•	•	•	•	•	•	•	Spring; pink	CA	16; 17	sun at bay, shade interior, hooked thorns
Rubus ursinus	California blackberry	shrub	3 x 5	•	•				•			•	•	•	•	•		•		•	•	Spring; white	CA	16; 17	edible fruit
Sambucus nigra ssp. Caerulea	blue elderberry	shrub, tree	12 x 12	•				•	•			•	•	•	•	•	•	•	•	•		Spring; yellow	CA	16; 17	
Clinopodium douglasii	yerba buena	perennial	1 x 3			•							•	•	•	•	•			•	•	Spring; white	CA	17	shaded roofs
Sidalcea malviflora	checkerbloom	perennial	3 x 3	•	•				•			•	•	•	•	•	•	•	•	•		Spring; pink	CA	16; 17	easy, summer dormant if not watered, butterflies
Sisyrinchium bellum	blue-eyed grass	perennial	1 x 1	•	•	•			•			•	•	•	•	•	•	•	•			Winter; blue	CA	16; 17	grass-like
Sedum spathulifolium	stone crop	perennial	0.5 x 1.5			•	•						•	•			•	•	•	•		Winter: yellow	CA	16; 17	needs well drained soil
Sedum acre aureum	stone crop	perennial	0.5 x 1.5			•	•						•	•			•	•	•	•	•	Summer; yellow	N	16; 17	Best with some shade, needs well drained soil, won't out compete bigger sedums
Sedum floriferum 'Weihenstephaner'	stone crop	perennial	0.5 x 1			•	•						•	•			•	•	•			Summer; yellow	N	16; 17	needs well drained soil, occasional water on roof
Sedum reflexum	blue spruce stone crop	perennial	0.5 x sp			•	•						•	•			•	•	•			Summer; yellow	N	16; 17	needs well drained soil, occasional water on roof
Sedum 'Sea Gold'	stone crop	perennial	0.5 x 1.5			•	•						•	•			•	•	•			Summer; yellow	N	16; 17	needs well drained soil, occasional water on roof
Sedum sexangulare	tasteless stone crop	perennial	0.5 x 0.5			•	•						•	•			•	•	•	•	•	Summer; yellow	N	16; 17	Easy, needs well drained soil, occasional water on roof
Sedum specible 'Autumn Joy'	showy stone crop	perennial	2 x 2			•	•						•	•			•	•	•			Summer; pink	N	16; 17	Needs well drained soil, occasional water on roof
Sedum spurium 'John Creech'	John Creech stone crop	perennial	0.5 x 0.5			•	•						•	•			•	•	•			Summer; pink	N	16; 17	Easy, needs well drained soil, occasional water on roof
Solidago velutina ssp. Californica	California goldenrod	perennial	3 x 2	•	•		•		•			•	•	•	•	•	•	•	•	•	•	Fall; yellow	CA	16; 17	Easy, winter dormant
Stachys albens	cobwebby hedgenettle	perennial	2 x 2	•	•					•		•	•	•	•	•	•		•	•	•	Summer; white	CA	16; 17	Easy, fuzzy foliage, hummingbirds
Stachys byzantina	lamb's ear	perennial	1 x 3	•	•	•	•		•			•	•	•		•	•	•	•	•	•	Summer; pink	N	16; 17	silver carpet' is non-flowering
Stachys chamissonis	magenta butterfly flower	perennial	3 x 2	•	•							•	•	•	•	•		•	•	•		Spring; purple	CA	16; 17	best in wettest areas, attracts butterflies
Symphoricarpos albus	common snowberry	shrub	4 x 4	•	•				•			•	•	•	•	•	•	•	•	•		Spring; pink	CA	16; 17	adaptible, thicket forming
Tristania laurina 'Elegant'	water gum	tree	25 x 15	•				•	•	•		•	•	•	•	•	•	•	•	•	•	Spring; yellow	N	16; 17	evergreen, adaptable low-maintenance
Vitis californica	california grape	vine	10 x 10	•	•				•			•	•	•	•	•	•	•	•	•		Spring; white	CA	16; 17	great covering for fences; edible grapes

Definitions:

Plant Type: *Annual* = Herbaceous plant that germinates, grows shoots and leaves, flowers, sets seed, and dies within a single year or less. An annual plant may seem to be perennial if it self-sows in place, coming up with new plants year after year.

Grass = Perennial or annual tufted herbaceous plant, usually growing from rhizomes or stolons, with linear and often showy plumes of small, inconspicious flowers.

Perennial = Herbaceous or partially woody plant that lives for more than two and often for many years. Some perennials are treated as annuals because they look their best for only one year or do not survive cold winters.

Shrub = Woody plant that lives for many years, usually multi-trunked and often with foliage almost to the ground, typically but not always smaller than a tree.

Tree = Woody plant that lives for many years, often but not always single-trunked, typically but not always larger than a shrub. Shrubbiness can be a maintenance issue: the search for small trees for urban yards has led many shrubs to be grown as "standards" with a single trunk, but stems growing from the base must be regularly removed to maintain this form.

vine = Flexible woody or semi-woody shrub that sprawls, climbs, clings, or twines.

H x W: Mature Height and Width in feet; sp = spreading; if site conditions are harsh or less than optimal for the species it may not reach the mature size.

Native Status: CA - California Native; C - Native Cultivar; N - non-native, regionally adapted

Zones: Adopted from Sunset Western Garden Book. Oakland contains Zone 16 (thermal belts and hillsides in the coastal climate area; more summer heat than Zone 17; afternoon wind in summer; Lows range from 32 to 19 degrees F.) and Zone 17 (Mild, wet, almost frostless winters and cool summers with typical highs from 60 to 75 degrees F.; frequent fog or wind; heat loving plants may not flower or fruit reliably; mild winters support many plants that cannot tolerate cold; Lows range from 36 to 23 degrees F.)

CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE

ATTACHMENT A
Annotated Bibliography for Plant Palette

Introduction

The purpose of this annotated bibliography is to provide a brief review of resources utilized to develop the Stormwater Treatment Options Plant Palette. Resources were chosen because they offered some aspect of data that was included in the plant palette or offered scientific or field knowledge of plants in a typical stormwater BMP or similar growing situation. Targeted information included the following:

- Stormwater treatment BMP design guidelines
- Recommended drought tolerant plants
- Recommended Bay Area adapted plants
- Recommended plants for various BMPs
- Plant characteristics including water needs, soil adaptability, light needs, and climate/hardiness.

Bibliography

Bornstein, Carol, David Fross, and Bart O'Brien. *California Native Plants for the Garden*. Los Olivos, CA: Cachuma, 2005.

Summary: Plant recommendations for California, plant care, nursery resources.

CalTrans District Five. “Advisory Guide to Plant Species Selection for Erosion Control.” Cal Trans, District 5, 2001

Summary: Hardcopy format of a geographic information system (GIS) that combines state and district-level climatological, geological, topographical, and plant biogeographical data to define ecologically meaningful subdistrict Plant climate Zones. These climate zones form the foundation for rapid access to lists of plant species for revegetation that is both ecologically appropriate for a project site and useful in minimizing erosion.

City of Portland. “Appendix F.4 Plant Lists” *Portland Stormwater Management Manual*. Portland, OR: City of Portland, 2008.

Summary: Provides lists of plant appropriate for various stormwater BMPs in Portland, OR and plant characteristics. Hydro-zones for each plant also provided.

City of Portland. “Chapter 2 Facility Design” *Portland Stormwater Management Manual*. Portland, OR: City of Portland, 2008.

Summary: Detailed information on site design and facility design criteria for each BMP type.

City of San Francisco. “Appendix D: Vegetation Palette.” San Francisco Stormwater Design Guidelines. San Francisco, CA: City of San Francisco, 2009.

Summary: plant palettes for recommended BMPs commonly used in San Francisco. Provides plant characteristics including bloom time, soil, water, sun, native status, and habitat value.

Clean Water Program Alameda County. “Appendix B: Plant List and Planting Guidance for Landscape-Based Stormwater Measures” *C.3 Stormwater Technical Guidance: A handbook for developers, builders and project applicants.* Hayward, CA: Alameda County, 2012

Summary: Guidance for planting techniques and selection of appropriate plant materials for stormwater measures in Alameda County.

Clean Water Program Alameda County. “Chapter 6: Technical Guidance for Specific Treatment Measures” *C.3 Stormwater Technical Guidance: A handbook for developers, builders and project applicants.* Hayward, CA: Alameda County, 2012

Summary: Technical guidance for stormwater treatment measures commonly used in Alameda County. Used as the basis for understanding the characteristics of different BMPs for plant selection.

El Nativo Growers, Inc. “What California Natives are Easy to Grow?” Azusa, CA: El Nativo Growers, 2010.

Summary: Trusted grower of native plants in Southern California. Lists of California native plants that are (1) easy, adaptable, and low maintenance, (2) moderate maintenance, and (3) high maintenance or challenging to grow.

Harlow, Nora, and Barrie D. Coate. *Plants and Landscapes for Summer-dry Climates of the San Francisco Bay Region*. Oakland, CA: East Bay Municipal Utility District, 2004.

Summary: Selected plants for Bay Area landscapes that conserve water. Provides detailed information about each species including physical tolerances and suitability to various locations.

Houdeshal, C.D. and Pomeroy, C.A. “Plant Selection for Bioretention in the Arid West” *Low Impact Development 2012: Redefining Water in the City*. Salt Lake City, UT: University of Utah. 2010

Summary: Examines plant species for use in Bioretention facilities including C:N ratio, rooting depth, salt tolerance, soil preferences, season of growth, and water needs. Recommendations for native plants for bioretention facilities for urban centers in the arid west including Anaheim, California.

LA County Dept. of Public Works. "LA River Masterplan: Landscaping Guidelines and Plant Palettes." Los Angeles, CA: Los Angeles County, 2004.

Summary: Landscape design guidelines for the LA River corridor. Includes plant list of plants that should never be planted along the river and suggested plant lists, plants by plant communities and info about each plant such as estimated water needs, height, spread, and frequency of occurrence.

Perry, Bob. *Landscape Plants for Western Regions: An Illustrated Guide to Plants for Water Conservation*. Claremont, CA: Land Design Pub., 1992.

Summary: Provides detailed information about each species including physical tolerances and suitability to various locations.

Santa Clara Valley Urban Runoff Pollution Prevention Program. "Appendix D: Plant List and Planting Guidance for Landscape-Based Stormwater Measures" *San Mateo Countywide Water Pollution Prevention Program: C.3 Technical Guidance*. 2012

Summary: Guidance for planting techniques and selection of appropriate plant materials for stormwater measures in Santa Clara County.

Snodgrass, Edmund C., and Lucie L. Snodgrass. *Green Roof Plants: A Resource and Planting Guide*. Portland, Or.: Timber, 2006.

Summary: Plant selection and guidance for green roofs.

SVR Design Company. "High Point Community Site Drainage Technical Standards" Seattle, WA: Seattle Public Utilities, 2006.

Summary: Includes a suggested plant list for various common stormwater BMPs.

University of California Cooperative Extension. "A guide to Estimating Irrigation Water Needs of Landscape Plantings in California: Landscape Coefficient Method and WUCOLS III." Sacramento, CA: California Dept. of Water Resources. 2000.

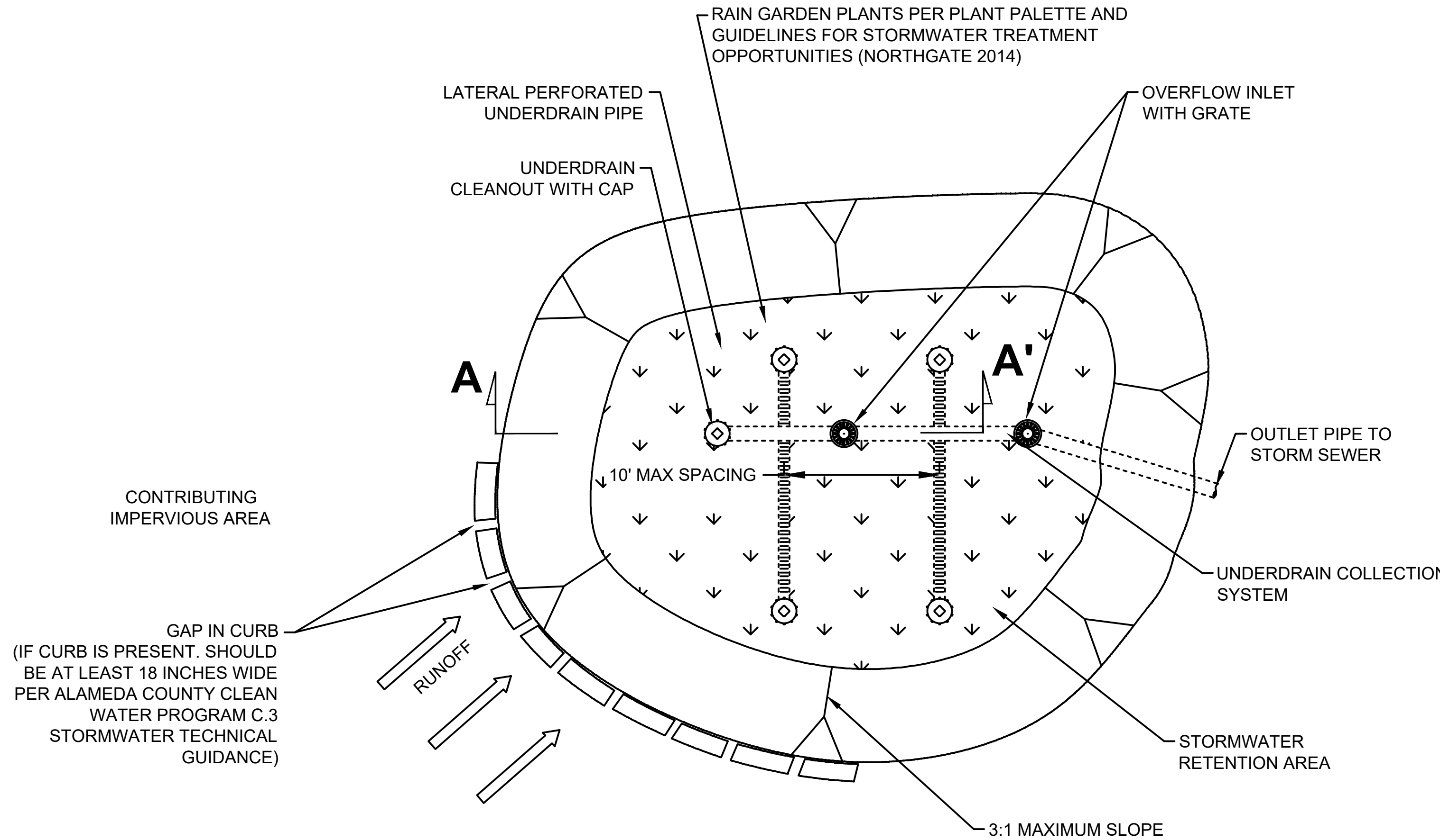
Summary: Includes irrigation needs for many landscape plants typical in California.

Wilson, Bert. "Complete List of California Native Plants." *California Native Plants for Your Garden, Butterflies and Birds.* Las Pilitas Nursery, 26 Oct. 2012. Web. 08 Nov. 2012. <http://www.laspilitas.com/plants/plants.htm>.

Summary: Provides plant characteristics and field experience notes on many California native plants.

CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE

ATTACHMENT B
STANDARD DETAILS



PLAN
NTS

NOTES:

1. DIMENSIONS OF RAIN GARDEN ARE VARIABLE AND DEPENDENT UPON AVAILABLE SPACE AND REQUIRED DESIGN STORAGE CAPACITY. SURFACE AREA OF THE BIOTREATMENT SOIL SHALL EQUAL 4% OF THE AREA OF THE SITE THAT DRAINS TO THE RAIN GARDEN PER ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE, UNLESS SIZING CALCULATIONS ARE SUBMITTED DEMONSTRATING THAT PROVISION SAN FRANCISCO BAY MUNICIPAL REGIONAL STORMWATER PERMIT C.3, INCLUDING C.3.J., REQUIREMENTS ARE MET USING A SMALLER SURFACE AREA.

2. AN OVERFLOW WEIR MAY BE INSTALLED IN PLACE OF OVERFLOW INLET RISERS WITH GRATES.

3. RUNOFF ENTERING THE RAIN GARDEN MAY ENTER AS SHEET AS SHOWN ON FIGURE 1A OR CONCENTRATED FLOW AS SHOWN ON FIGURE 1B.

4. FOR PLANT SELECTION SEE GREEN INFRASTRUCTURE GUIDE ATTACHMENT A PLANT PALETTE (NORTHGATE 2018).

5. SEE CITY OF OAKLAND DESIGN AND CONSTRUCTION SERVICE DEPARTMENT STANDARD DETAILS FOR PUBLIC WORK CONSTRUCTION DRAWING NO. D-2□ FOR STORM CONDUIT CONNECTION DETAIL.

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TYPICAL LAYOUT FOR RAIN GARDEN

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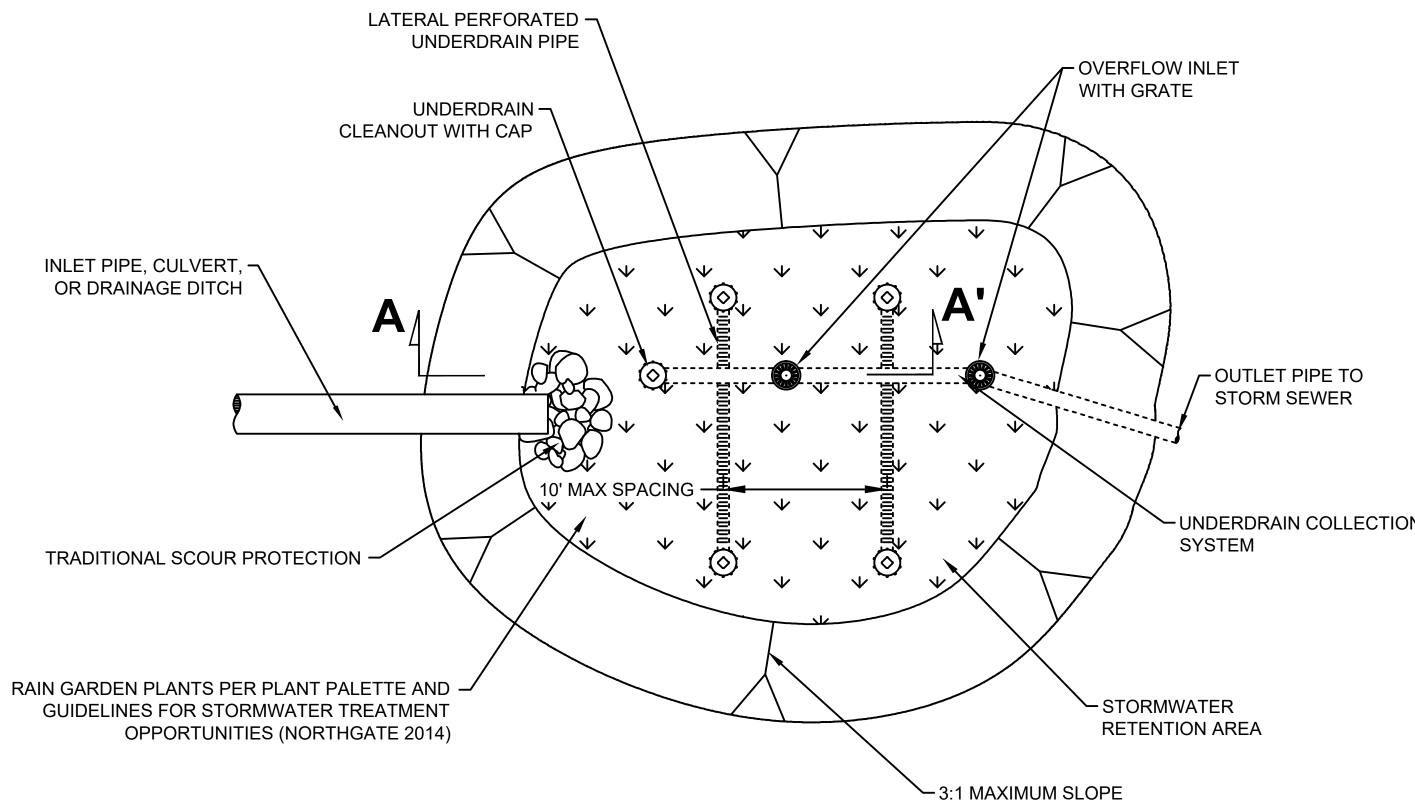

PLAN
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NOTES:

1. DIMENSIONS OF RAIN GARDEN ARE VARIABLE AND DEPENDENT UPON AVAILABLE SPACE AND REQUIRED DESIGN STORAGE CAPACITY. REQUIRES A MINIMUM RETENTION AREA OF APPROXIMATELY 4% OF CONTRIBUTING AREA. PER ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE.

2. AN OVERFLOW WEIR MAY BE INSTALLED IN PLACE OF OVERFLOW INLET RISERS WITH GRATES.

3. RUNOFF ENTERING THE RAIN GARDEN MAY ENTER AS SHEET AS SHOWN ON FIGURE 1A OR CONCENTRATED FLOW AS SHOWN ON FIGURE 1B.

4. FOR PLANT SELECTION SEE GREEN INFRASTRUCTURE GUIDE ATTACHMENT A PLANT PALETTE (NORTHGATE 2018).

5. SEE CITY OF OAKLAND DESIGN AND CONSTRUCTION SERVICE DEPARTMENT STANDARD DETAILS FOR PUBLIC WORK CONSTRUCTION DRAWING NO. D-2□ FOR STORM CONDUIT CONNECTION DETAIL.

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TYPICAL LAYOUT FOR RAIN GARDEN, CONCENTRATED FLOW

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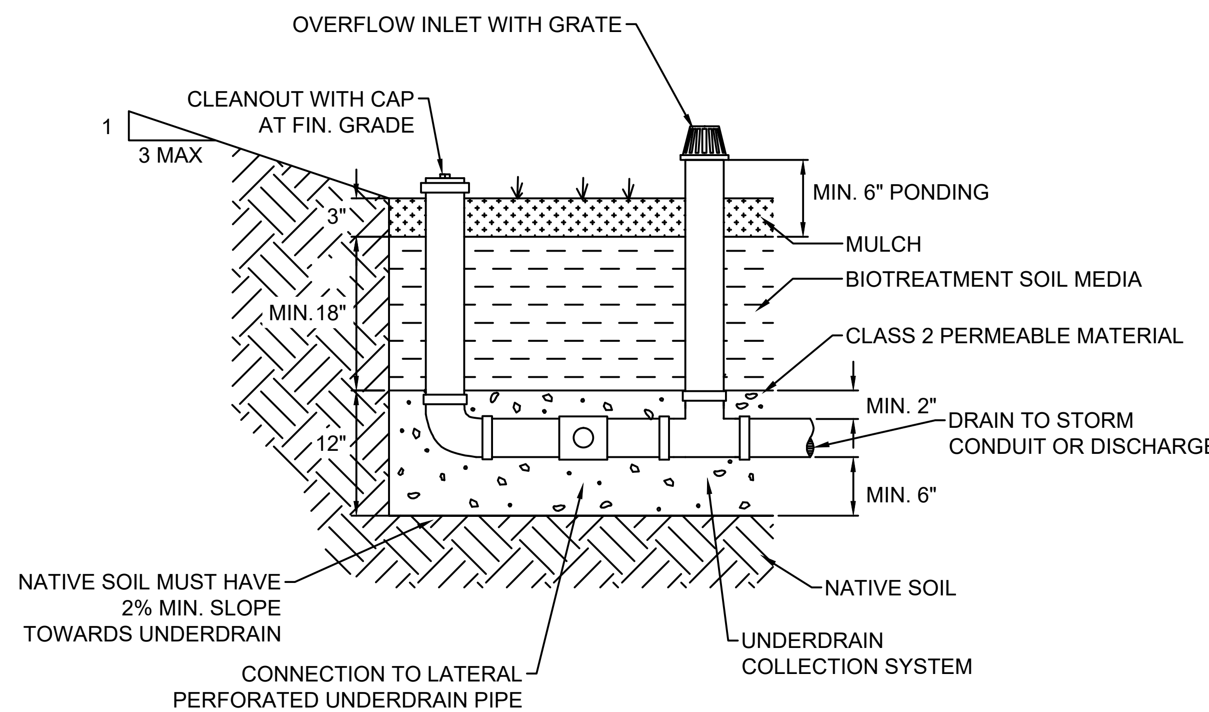

SECTION A-A'
NTS

NOTES:

1. DO NOT COMPACT NATIVE SOIL. INFILTRATION RATES FOR NATIVE SOILS CAN BE OBTAINED AT USDA.GOV OR PER ASTM STANDARD PERCOLATION TESTING.

2. 4"-DIAMETER PERFORATED OR SLOTTED UNDERDRAIN SHOULD HAVE A MINIMUM SLOPE OF 0.5% TOWARDS DRAINAGE.

3. SETBACKS MUST BE 8' FROM BUILDING FOUNDATIONS.

4. UNDERDRAIN SHOULD INCLUDE A MINIMUM 4-INCH DIAMETER, SCHEDULE 40 PERFORATED HDPE PIPE (PERFORATIONS FACING DOWNWARD) WITH CLEANOUTS AND CONNECTION TO A STORM DRAIN OR DISCHARGE POINT. CLEAN-OUT SHOULD CONSIST OF A VERTICAL, RIGID, NON-PERFORATED PVC PIPE, WITH A MINIMUM DIAMETER OF 4 INCHES AND A WATERTIGHT CAP FIT FLUSH WITH THE GROUND. PIPING MUST HAVE 0.5% MINIMUM GRADE AND FOLLOW THE UNIFORM PLUMBING CODE. DO NOT USE FILTER FABRIC IN OR AROUND UNDERDRAIN TRENCH.

5. PERMEABLE AGGREGATE SHALL BE CLASS 2 PERMEABLE MATERIAL (VIRGIN ROCK) PER CALTRANS SPECIFICATIONS, 3/4" MAX.

6. BIOTREATMENT SOIL MEDIA (BSM) SHALL BE ENGINEERED MIX WITH AN INFILTRATION RATE O F5 INCHES PER HOUR MIN. PER MUNICIPAL REGIONAL STORMWATER PERMIT (MRP) ORDER NO. R2-2015-004, AND INCLUDE 60-□0% SAND, 30-40% COMPOST BY WEIGHT PER MRP ORDER NO. R2-200□-011 ATTACHMENT L AND ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE APPENDIX K.

□. MULCH SHALL BE "ARBOR", "AGED" OR "COMPOSTED" MULCH. WASHED AND CLEAN PEA GRAVEL, ROCK, COBBLE, OR OTHER MULCHES THAT RESIST FLOATING AWAY MAY ALSO BE USED. BARK AND "GORILLA HAIR" MULCHES ARE NOT RECOMMENDED.

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RAIN GARDEN, TYPICAL SECTION A-A'

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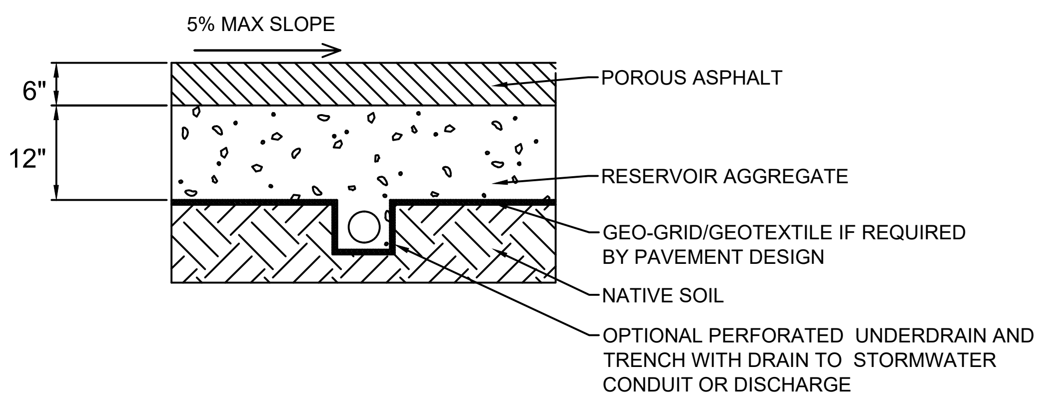

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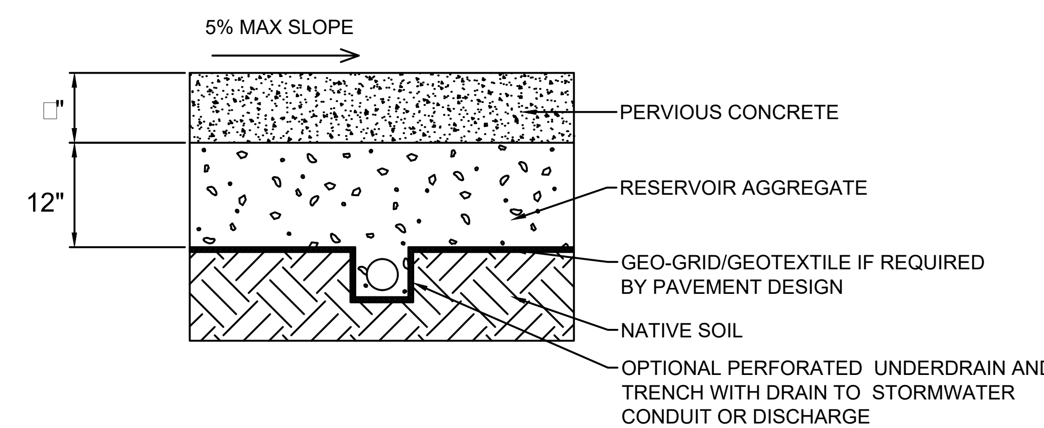

SECTION
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NOTES:

1. PIPING: SHALL BE PVC SCH. 40. 4" TO 8" DIAMETER. PIPING MUST HAVE 1% GRADE.

2. RESERVOIR AGGREGATE SHALL BE STONE SIZE NO. 8□OR NO. □PER ASTM D 448".

3. SEE CITY OF OAKLAND DESIGN AND CONSTRUCTION SERVICE DEPARTMENT STANDARD DETAIL FOR PUBLIC WORK CONSTRUCTION DRAWING NO. D-2□FOR STORM CONDUIT CONNECTION DETAIL.

4. THE SUBGRADE SHOULD BE UNGRADED IN-SITU MATERIAL WITH A MINIMUM INFILTRATION RATE OF 0.5-INCHES PER HOUR, OR BASED ON HYDROLOGIC ANALYSIS, AN UNDERDRAIN SHOULD BE INSTALLED TO REMOVE DETAINED FLOWS WITHIN THE PERVIOUS PAVING AND BASE, OR CALTRANS GUIDANCE FOR BASE LAYER SIZING MAY BE FOLLOWED (SEE, "BASE LAYER") PER ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE.

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PERMEABLE PAVEMENT, TYPICAL SECTIONS

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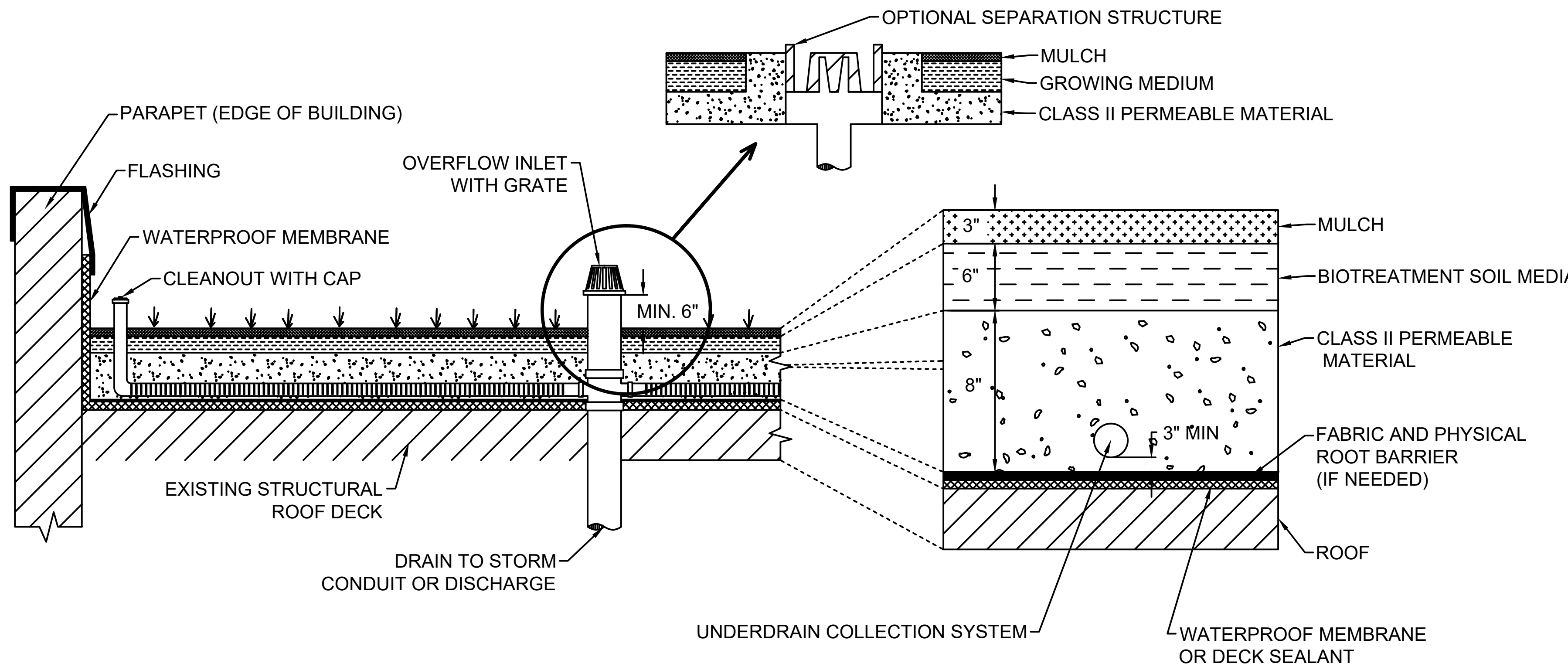

SECTION
NTS

NOTES:

1. PERFORATED OR SLOTTED UNDERDRAIN MUST BE SLOPED AT 0.50% MINIMUM TOWARDS DISCHARGE.
2. PIPE SHALL BE PVC SCH. 40 AND PERFORATED 6" DIAMETER HDPE.
3. ADDITIONAL WATERPROOFING SYSTEM ON BUILDING SHOULD BE INSTALLED AS NEEDED.
4. BIOTREATMENT SOIL MEDIA SHALL BE GREEN ROOF SOIL MIX INCLUDING: 50% PUMILE PERLITE, 25% ORGANIC COMPOST, 25% TOPSOIL.
5. FILTER FABRIC SHALL BE MIRAFI 140 N OR EQUIVALENT.
6. PERMEABLE AGGREGATE SHALL BE CLASS II PERMEABLE MATERIAL PER CALTRANS SPECIFICATIONS 3/4" INCH MAXIMUM.

□. WATERPROOF MEMBRANE SHALL BE 30 MIL PVC LINER OR EQUIVALENT, INSTALLED AND INSPECTED IN ACCORDANCE WITH MANUFACTURE'S SPECIFICATIONS.

8. FOR PLANT SELECTION SEE GREEN INFRASTRUCTURE GUIDE ATTACHMENT A PLANT PALETTE (NORTHGATE 2018).

□. SEE CITY OF OAKLAND DEISGN AND CONSTRUCTION SERVICE DEPARTMENT STANDARD DETAIL FOR PUBLIC WORK CONSTRUCTION DRAWING NO. D-2□ FOR STORM CONDUIT CONNECTION DETAIL.

10. STRUCTURAL ANALYSIS MAY BE REQUIRED.

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GREEN ROOF, TYPICAL SECTION

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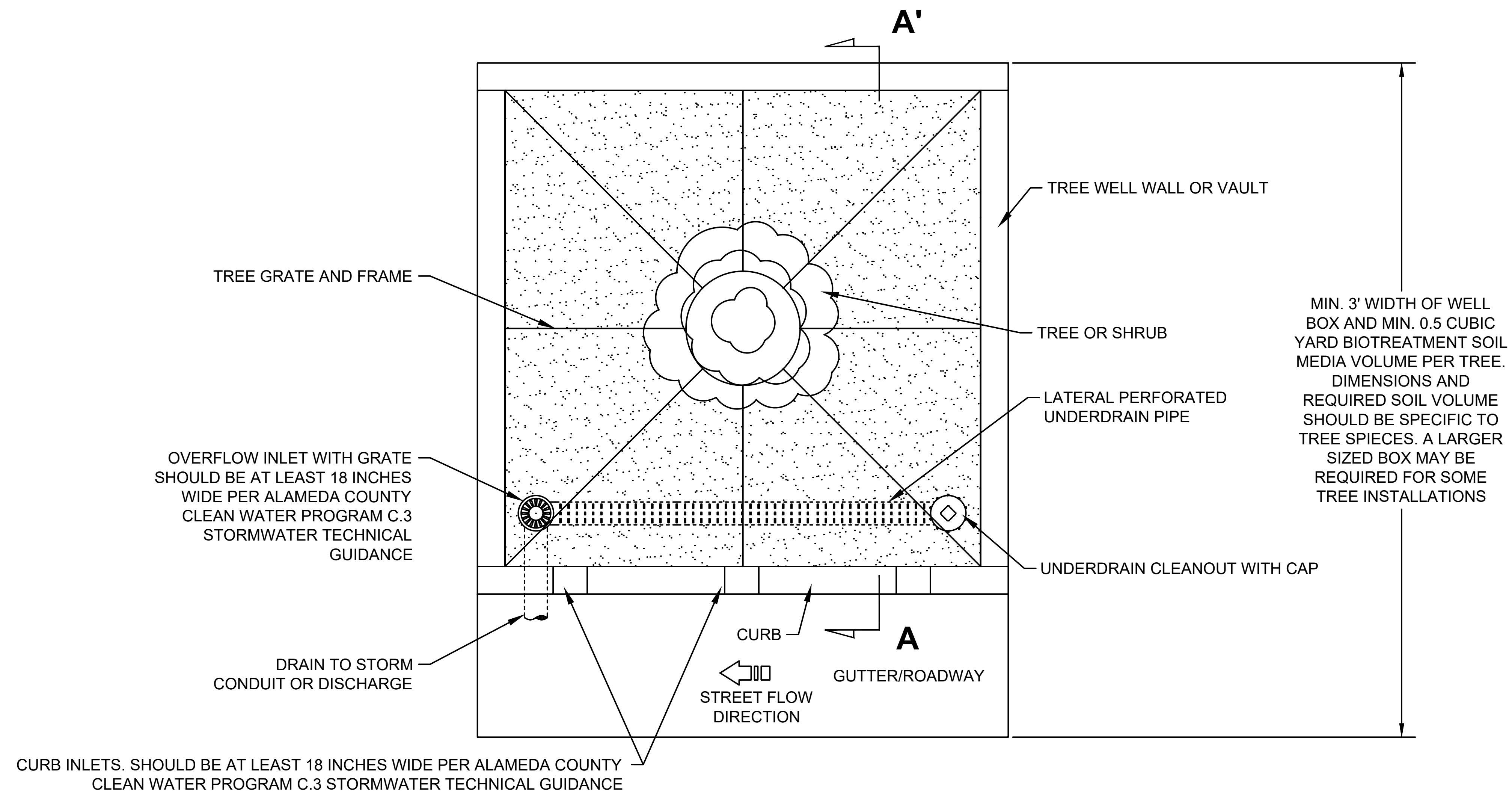

PLAN
NTS

NOTES:

1. PERFORATED OR SLOTTED UNDERDRAIN MUST BE SLOPED AT 0.50% MINIMUM TOWARDS DISCHARGE.
2. SETBACKS: MUST BE 10' FROM BUILDING FOUNDATION. STANDARD SETBACKS FOR INFILTRATION BMP PER 2010 SAN FRANCISCO STORMWATER DESIGN GUIDELINES.
3. DISTANCE BETWEEN TREES VARIES: 20-30 FT ON CENTER.
4. TREE WELLS MAY BE SIZED USING EITHER THE 4% METHOD, OR, WHERE ALLOWED BY THE CITY, THE COMBINATION FLOW-AND VOLUME-BASED METHOD PER THE ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE.

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TREE WELL, TYPICAL LAYOUT

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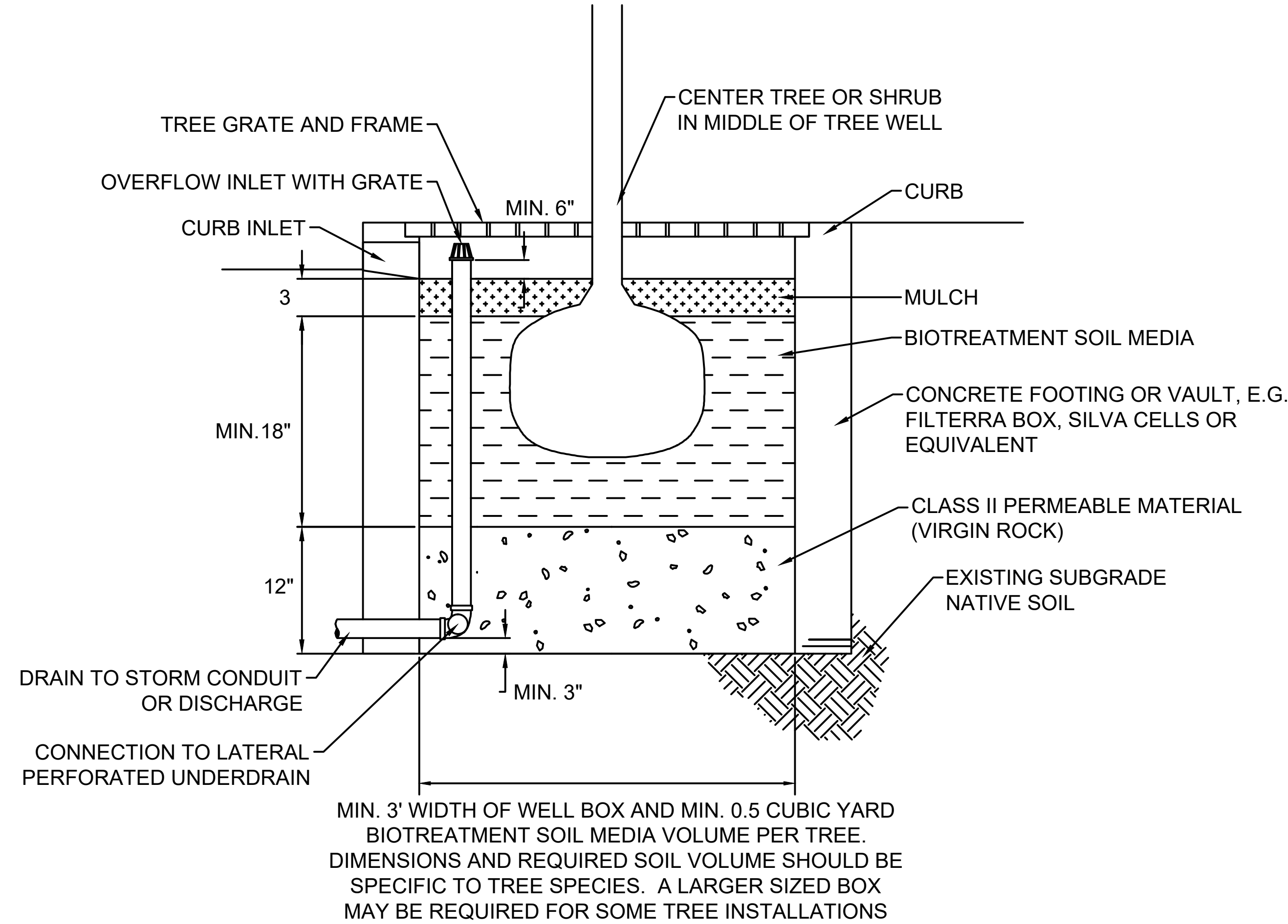

SECTION A-A'
NTS

NOTES:

1. PROVIDE PROTECTION FROM ALL VEHICLE TRAFFIC, EQUIPMENT STAGING, AND FOOT TRAFFIC IN PROPOSED INFILTRATION AREAS PRIOR TO, DURING, AND AFTER CONSTRUCTION. DO NOT COMPACT NATIVE SOIL.

2. OVERFLOW:
   □. INLET ELEVATION MUST ALL FOR 2" OF FREEBOARD, MINIMUM.
   □. PROTECT FROM DEBRIS AND SEDIMENT WITH STRAINER OR GRATE.

3. UNDERDRAIN SHOULD INCLUDE A MINIMUM 4-INCH DIAMETER, SCHEDULE 40 PERFORATED PVC PIPE (PERFORATIONS FACING DOWNWARD) WITH CLEANOUTS AND CONNECTION TO A STORM DRAIN OR DISCHARGE POINT. CLEAN-OUT SHOULD CONSIST OF A VERTICAL, RIGID, NON-PERFORATED PVC PIPE, WITH A MINIMUM DIAMETER OF 4 INCHES AND A WATERTIGHT CAP FIT FLUSH WITH THE GROUND. PIPING MUST HAVE 1% MINIMUM GRADE AND FOLLOW THE UNIFORM PLUMBING CODE. DO NOT USE FILTER FABRIC IN OR AROUND UNDERDRAIN TRENCH.

4. GROWING MEDIUM:
   □. 18" MINIMUM.

□. BIOTREATMENT SOIL MEDIA (BSM) SHALL BE ENGINEERED MIX WITH AN INFILTRATION RATE OF 5 INCHES PER HOUR MIN. PER MUNICIPAL REGIONAL STORMWATER PERMIT (MRP) ORDER NO. R2-2015-004, AND INCLUDE 60-□0% SAND, 30-40% COMPOST BY WEIGHT PER MRP ORDER NO. R2-200□-011 ATTACHMENT L AND ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE APPENDIX K. USE OF A HIGH FLOW RATE TREE WELLS, FOR WHICH THE LONG TERM INFILTRATION RATE OF THE MEDIA EXCEEDS 10 INCHES PER HOUR, IS ONLY ALLOWED FOR SPECIAL PROJECTS PER MRP.Z

5. MULCH SHALL BE "ARBOR", "AGED", OR "COMPOSTED" MULCH. WASHED AND CLEAN PEA GRAVEL, ROCK, COBBLE, OR OTHER MULCHES THAT RESIST FLOATING MAY ALSO BE USED. BARK AND "GORILLA HAIR" MULCHES ARE NOT RECOMMENDED.

6. SEE CITY OF OAKLAND DESIGN AND CONSTRUCTION SERVICE DEPARTMENT STANDARD DETAIL FOR PUBLIC WORK CONSTRUCTION DRAWING NO. D-2□ FOR STORM CONDUIT CONNECTION DETAIL.

□. FOR PLANT SELECTION SEE GREEN INFRASTRUCTURE GUIDE ATTACHMENT A PLANT PALETTE (NORTHGATE 2018), AND CITY TREE PLANTING GUIDELINES (OAKLAND PUBLIC WORKS AGENCY - TREE SERVICES, AUGUST 2010).

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TREE WELL, TYPICAL SECTION A-A'

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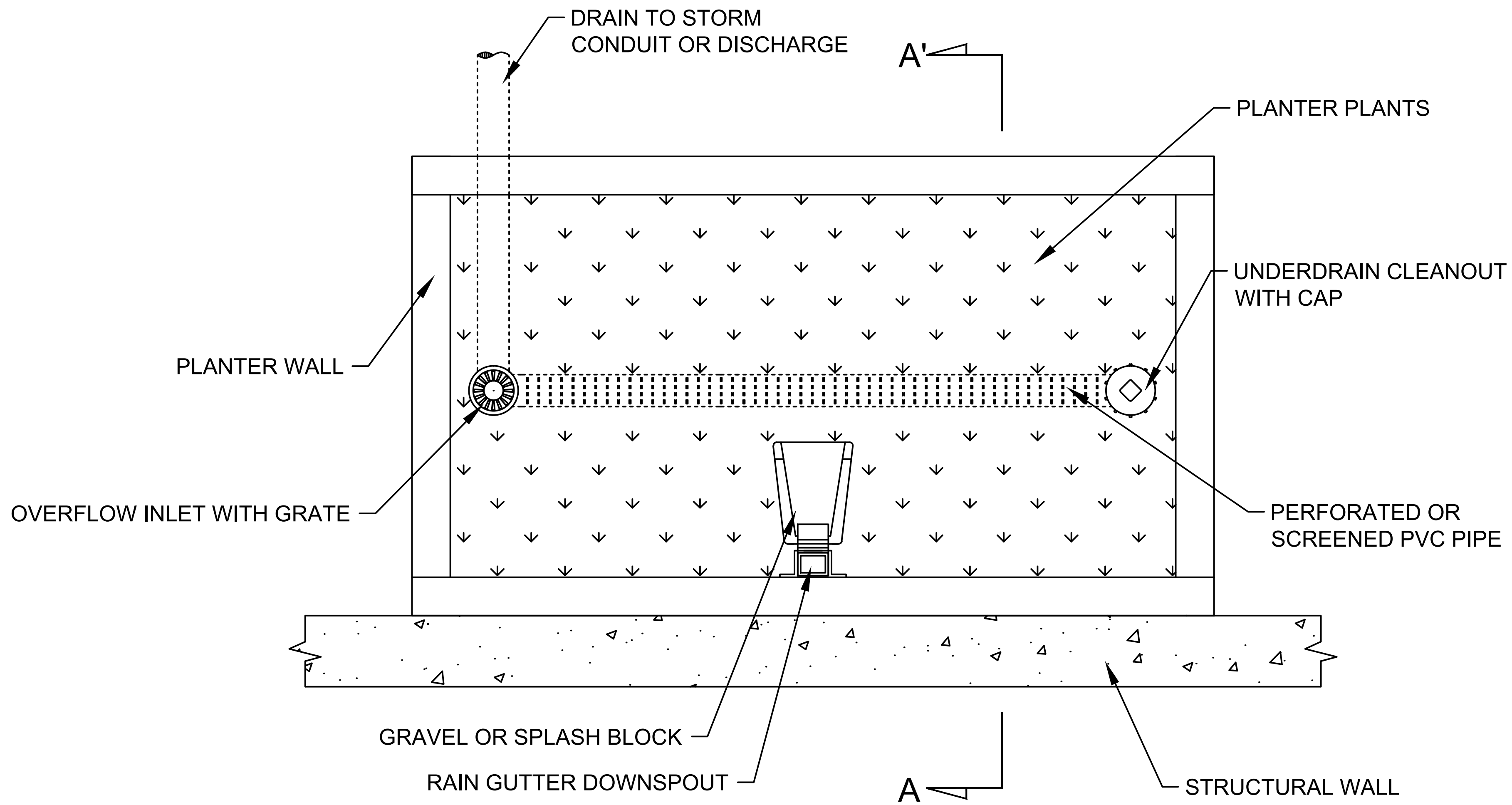

PLAN
NTS

NOTES:

1. PERFORATED OR SLOTTED UNDERDRAIN MUST BE SLOPED AT 0.50% MINIMUM TOWARDS DISCHARGE.

2. ADDITIONAL WATERPROOFING ON BUILDING SHOULD BE INSTALLED AND INSPECTED IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATIONS.

3. FLOW-THROUGH PLANTERS MAY BE SIZED USING EITHER THE 4% METHOD, OR, WHERE ALLOWED BY THE CITY, THE COMBINATION FLOW-AND VOLUME-BASED METHOD PER THE ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE.

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FLOW THROUGH PLANTER, TYPICAL LAYOUT

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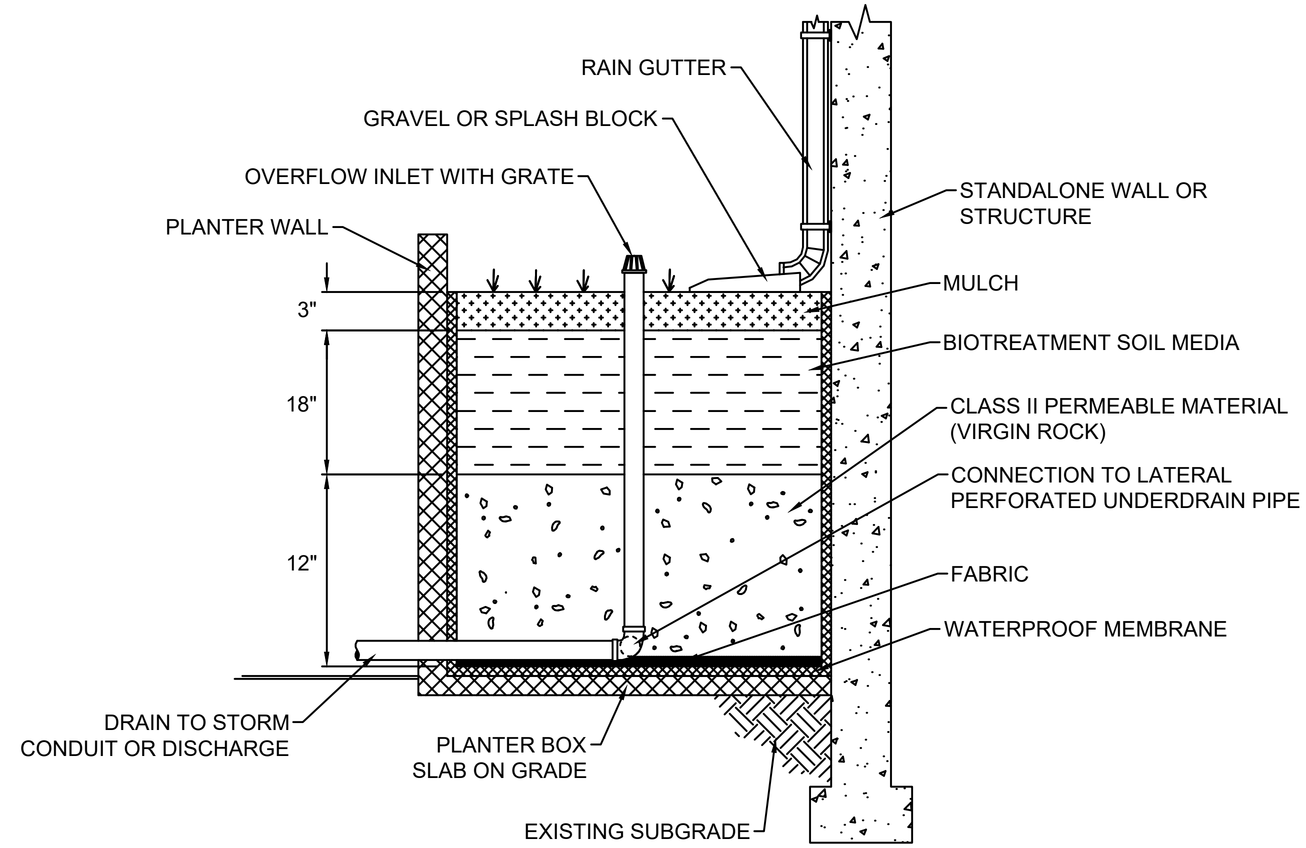

SECTION A-A'
NTS

NOTES:

1. DIMENSIONS:
   □. WIDTH OF FLOW-THROUGH PLANTER: 18" MINIMUM'
   □. WIDTH OF INFILTRATION PLANTER: 30" MINIMUM.
   □. SLOPE OF PLANTER: 0.5% OR LESS.

2. FLOW-THROUGH PLANTERS MUST BE LESS THAN 30" IN HEIGHT ABOVE SURROUNDING AREA IF WITHIN 5 FEET OF PROPERTY LINE.

3. OVERFLOW:
   □. ALLOW A MINIMUM OF 6 INCHES AND A MAXIMUM OF 12 INCHES OF WATER SURFACE STORAGE BETWEEN THE PLANTING SURFACE AND THE TOP OF THE OVERFLOW RISER.
   □. PROTECT FROM DEBRIS AND SEDIMENT WITH STRAINER OR GRATE.

4. UNDERDRAIN SHOULD INCLUDE A MINIMUM 4-INCH DIAMETER, SCHEDULE 40 PERFORATED PVC PIPE (PERFORATIONS FACING DOWNWARD) WITH CLEANOUTS AND CONNECTION TO A STORM DRAIN OR DISCHARGE POINT. CLEAN-OUT SHOULD CONSIST OF A VERTICAL, RIGID, NON-PERFORATED PVC PIPE, WITH A MINIMUM DIAMETER OF 4 INCHES AND A WATERTIGHT CAP FIT FLUSH WITH THE GROUND. PIPING MUST HAVE 0.5% MINIMUM GRADE AND FOLLOW THE UNIFORM PLUMBING CODE. DO NOT USE FILTER FABRIC IN OR AROUND UNDERDRAIN TRENCH EXCEPT FOR PROTECTION OF WATERPROOFING MEMBRANE.

5. MULCH SHALL BE "ARBOR", "AGED", OR "COMPOSTED" MULCH. WASHED AND CLEAN PEA GRAVEL, ROCK, COBBLE, OR OTHER MULCHES THAT RESIST FLOATING MAY ALSO BE USED. BARK AND "GORILLA HAIR" MULCHES ARE NOT RECOMMENDED.

6. GROWING MEDIUM:
   □. 18" MINIMUM
   □. BIOTREATMENT SOIL MEDIA (BSM) SHALL BE ENGINEERED MIX WITH AN INFILTRATION RATE OF 5 INCHES PER HOUR MIN. PER MUNICIPAL REGIONAL STORMWATER PERMIT (MRP) ORDER NO. R2-2015-004, AND INCLUDE 60-□0% SAND, 30-40% COMPOST BY WEIGHT PER MRP ORDER NO. R2-200□-011 ATTACHMENT L AND ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE APPENDIX K.

□. PLANTER WALLS:
   □. MATERIAL SHALL BE STONE BRICK, CONCRETE, WOOD, OR OTHER DURABLE MATERIAL (NO CHEMICALLY TREATED WOOD).
   □. CONCRETE, BRICK, OR STONE WALLS SHALL BE INCLUDED ON FOUNDATION PLANS.

8. WATERPROOF MEMBRANE: SHALL BE 30 MIL PVC LINER OR EQUIVALENT, INSTALLED AND INSPECTED IN ACCORDANCE WITH MANUFACTURERS SPECIFICATIONS, FOR FLOW-THROUGH FACILITIES.

□. INSTALL WASHED RIVER ROCK TO TRANSITION FROM INLET OR SPLASH PAD TO GROWING MEDIUM, UNDERLAY WITH FILTER FABRIC.

10. SEE CITY OF OAKLAND DESIGN AND CONSTRUCTION SERVICE DEPARTMENT STANDARD DETAIL FOR PUBLIC WORK CONSTRUCTION DRAWING NO. D-2□ FOR STORM CONDUIT CONNECTION DETAIL.

11. FOR PLANT SELECTION SEE GREEN INFRASTRUCTURE GUIDE ATTACHMENT A PLANT PALETTE (NORTHGATE 2018). PLANT SELECTION MAY VARY IF IRRIGATION IS POSSIBLE.

12. DRAINAGE DETAIL NEXT TO WALL IS SPECIFIC TO LANDSCAPE ELEMENT ONLY.

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FLOW THROUGH PLANTER, TYPICAL SECTION A-A'

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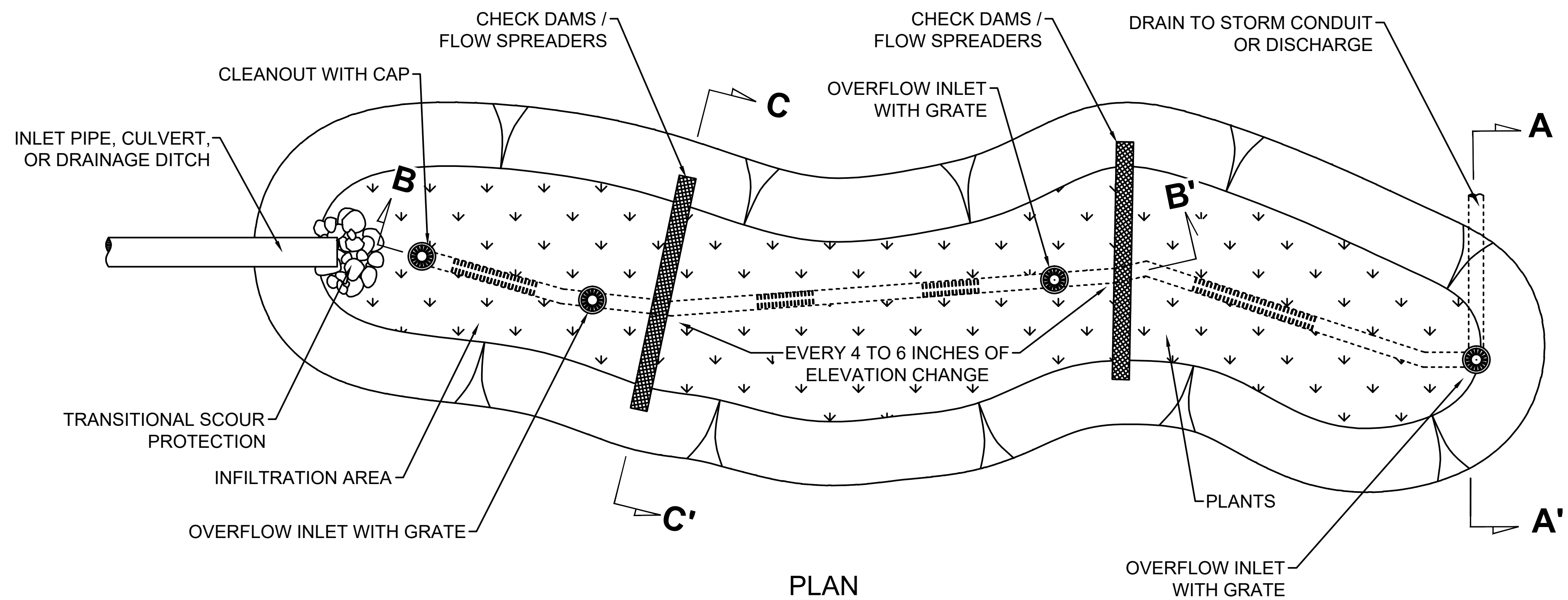
PROJECT TITLE



PLAN
NTS

NOTES:

1. PROVIDE PROTECTION FROM ALL VEHICLE TRAFFIC, EQUIPMENT STAGING, AND FOOT TRAFFIC IN PROPOSED INFILTRATION AREAS PRIOR TO, DURING, AND AFTER CONSTRUCTION. DO NOT COMPACT NATIVE SOIL.

2. DIMENSIONS:
   □. WIDTH OF SWALE: 5' - 12'.
   □. DESIGN SHALL INCORPORATE 3" MIN. FREEBOARD BETWEEN TOP OF OVERFLOW INLET AND TOP OF BANK.
   □. LONGITUDINAL SLOPE OF SWALE: 6.0% OR LESS.
   d. FLAT BOTTOM WIDTH: 2'.
   □. SIDE SLOPES OF SWALE: 3:1 MAXIMUM.

3. SETBACKS (FROM CENTERLINE OF FACILITY):
   □. INFILTRATION SWALES MUST BE 10' FROM FOUNDATIONS AND 5' FROM PROPERTY LINES.

4. OVERFLOW:
   □. INLET ELEVATION MUST ALLOW FOR 2" OF FREEBOARD, MINIMUM.
   □. PROTECT FROM DEBRIS AND SEDIMENT WITH STRAINER OR GRATE.

5. PIPING: SHALL BE PVC SCH. 40 3" DIAMETER PIPE REQUIRED FOR UP TO 1,500 SQ FT OF CONTRIBUTING IMPERVIOUS AREA, OTHERWISE 4" MIN. PIPING MUST HAVE 1% GRADE AND FOLLOW THE UNIFORM PLUMBING CODE.

6. INSTALL WASHED RIVER ROCK TO TRANSITION FROM INLETS TO GROWING MEDIUM, UNDERLAY WITH FILTER FABRIC.

□. FOR PLANT SELECTION SEE GREEN INFRASTRUCTURE GUIDE ATTACHMENT A PLANT PALETTE (NORTHGATE 2018).

8. CHECK DAMS: SHALL BE PLACED ACCORDING TO THE FOLLOWING:
   □. 3" TO 5" IN HEIGHT ABOVE GROUND SURFACE.
   □. EVERY 4 TO 6 INCHES OF ELEVATION CHANGE.

□. SEE CITY OF OAKLAND DESIGN AND CONSTRUCTION SERVICE DEPARTMENT STANDARD DETAIL FOR PUBLIC WORK CONSTRUCTION DRAWING NO. D-2□ FOR STORM CONDUIT CONNECTION.

10. BIOSWALES ARE LANDSCAPE ELEMENTS WITH STORMWATER MANAGEMENT BENEFITS. DESIGN IS NOT APPROVED BY THE WATER BOARD AND THE CITY WILL NOT CURRENTLY RECEIVE MRP C.3 (IF A REGULATED PROJECT) OR C.3.□GREEN INFRASTRUCTURE IMPLEMENTATION CREDIT, OR EVEN PARTIAL CREDIT, FOR NON-REGULATED PROJECTS.

CITY OF OAKLAND
DEPARTMENT OF ENGINEERING AND CONSTRUCTION
250 FRANK H. OGAWA PLAZA, SUITE 4314 * OAKLAND CA, 94612
(510) 238-3437 * FAX (510) 238-7227

BIO SWALE, TYPICAL LAYOUT

CIVIL ENGINEER
RCE NO. ________ EXP. ________
CHECKED BY — CHECK BY
DESIGNED BY — DESIGN BY
DRAWN BY — DRAWN BY

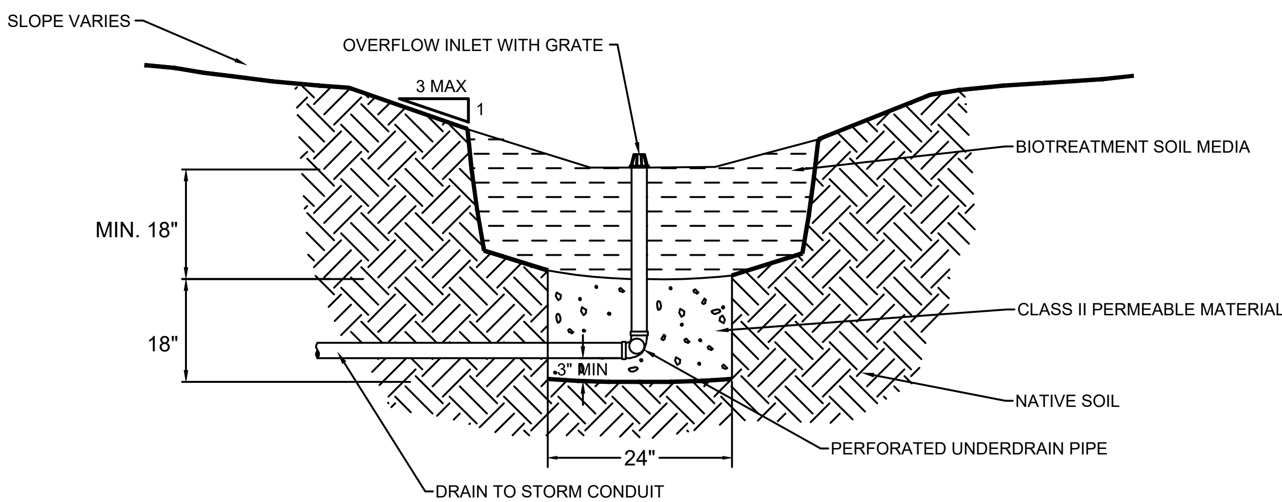
No.	DATE	BY	REFERENCE

FINAL DRAFT-SUBJECT TO REVISION
STANDARD DETAILS
NOT FOR CONSTRUCTION

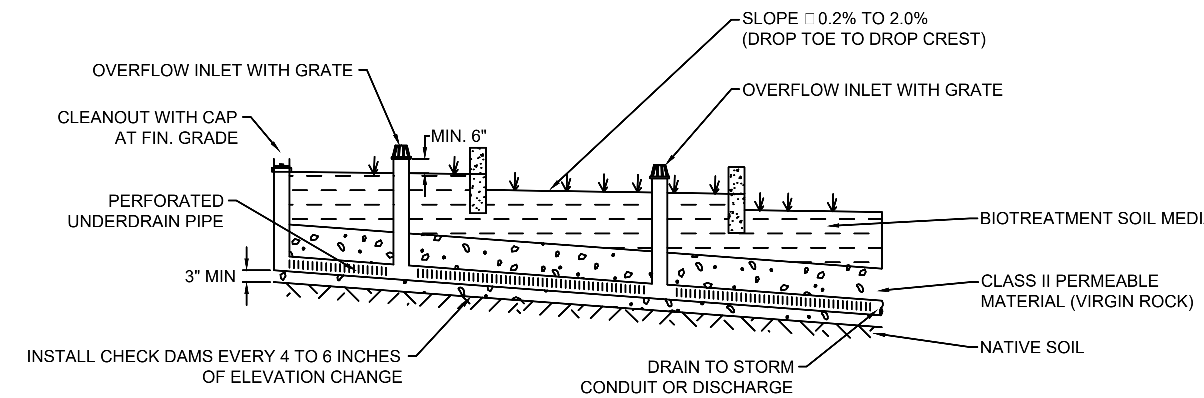
PROJECT NO.
FEDERAL AID PROJECT NO. ________
SCALE: NTS
HOR.
VERT.
DATE: 05/22/17
SHEET NO.
6A
____ OF ____

PROJECT TITLE

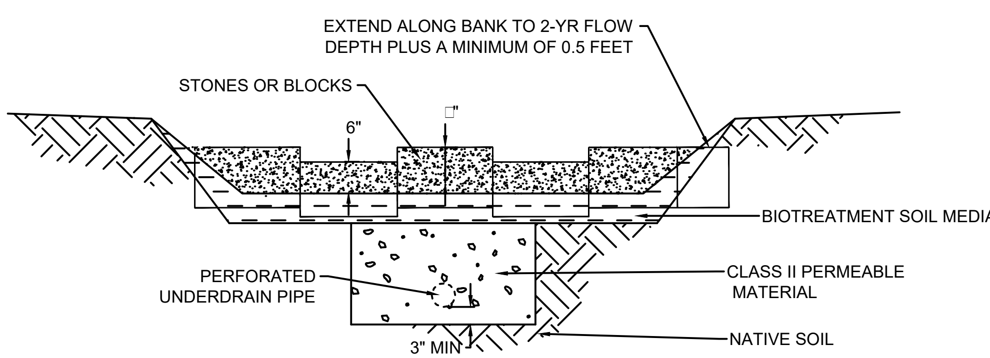
PROJECT TITLE



SECTION A-A'
NTS



SECTION B-B'
NTS



SECTION C-C'
NTS

NOTES:

1. PERMEABLE AGGREGATE SHALL BE CLASS 2 PERMEABLE MATERIAL PER CALTRANS SPECIFICATIONS, 3/4" MAXIMUM.

2. GROWING MEDIUM:
   □. 18" MINIMUM.
   □. BIOTREATMENT SOIL MEDIA (BSM) SHALL BE ENGINEERED MUX WITH AN INFILTRATION RATE OF 5 INCHES PER HOUR MIN. PER MUNICIPAL REGIONAL STORMWATER PERMIT (MRP) ORDER NO. R2-2015004, AND INCLUDE 60-□0% SAND, 30-40% COMPOST BY WEIGHT PER MRP ORDER NO. R2-200□-011 ATTACHMENT L AND ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE APPENDIX K.

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BIO SWALE, TYPICAL SECTION

CIVIL ENGINEER
RCE NO. ________ EXP. ________
CHECKED BY | CHECK BY
DESIGNED BY | DESIGN BY
DRAWN BY | DRAWN BY

No.	DATE	BY	REFERENCE

FINAL DRAFT-SUBJECT TO REVISION
STANDARD DETAILS
NOT FOR CONSTRUCTION

PROJECT NO.
FEDERAL AID PROJECT NO. ________
SCALE: NTS
HOR.
VERT.
DATE: 05/22/17
SHEET NO.
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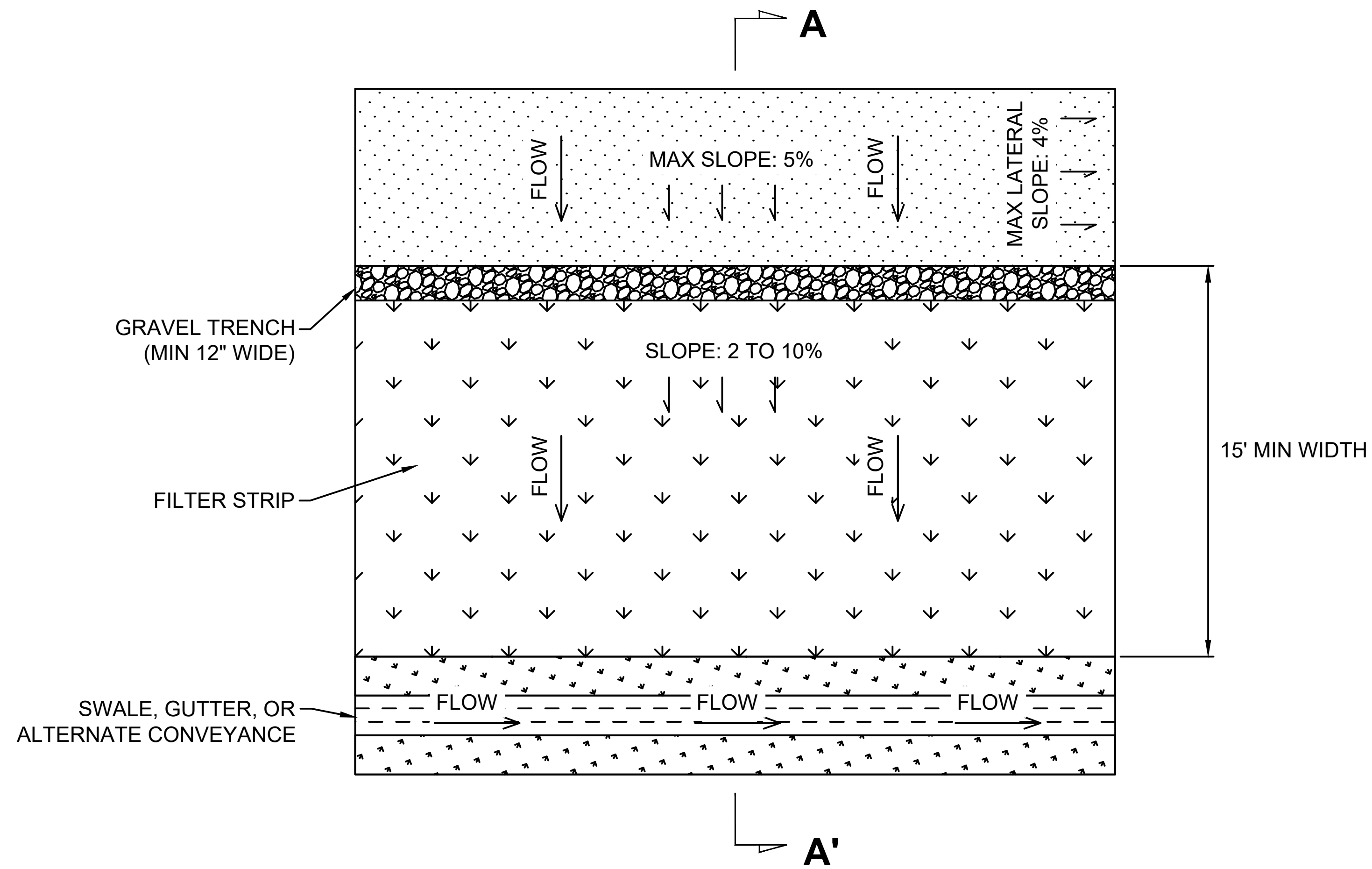
_____ OF _____



PLAN
NTS

NOTES:

1. FOR PLANT SELECTION SEE PLANT PALETTE AND GUIDANCE FOR STORMWATER TREATMENT OPPORTUNITIES (NORTHGATE, 2014)

2. VEGETATED BUFFER STRIPS ARE LANDSCAPE ELEMENTS WITH STORMWATER MANAGEMENT BENEFITS. DESIGN IS NOT APPROVED BY THE WATER BOARD AND THE CITY WILL NOT CURRENTLY RECEIVE MRP C.3 (IF A REGULATED PROJECT) OR GREEN INFRASTRUCTURE IMPLEMENTATION CREDIT, OR EVEN PARTIAL CREDIT, FOR NON-REGULATED PROJECTS.

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DEPARTMENT OF ENGINEERING AND CONSTRUCTION
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(510) 238-3437 * FAX (510) 238-7227

VEGETATED BUFFER STRIP, TYPICAL LAYOUT

CIVIL ENGINEER	
RCE NO. ________	EXP. ________
CHECKED BY	CHECK BY
DESIGNED BY	DESIGN BY
DRAWN BY	DRAWN BY

No.	DATE	BY	REFERENCE

FINAL DRAFT-SUBJECT TO REVISION
STANDARD DETAILS
NOT FOR CONSTRUCTION

PROJECT NO.

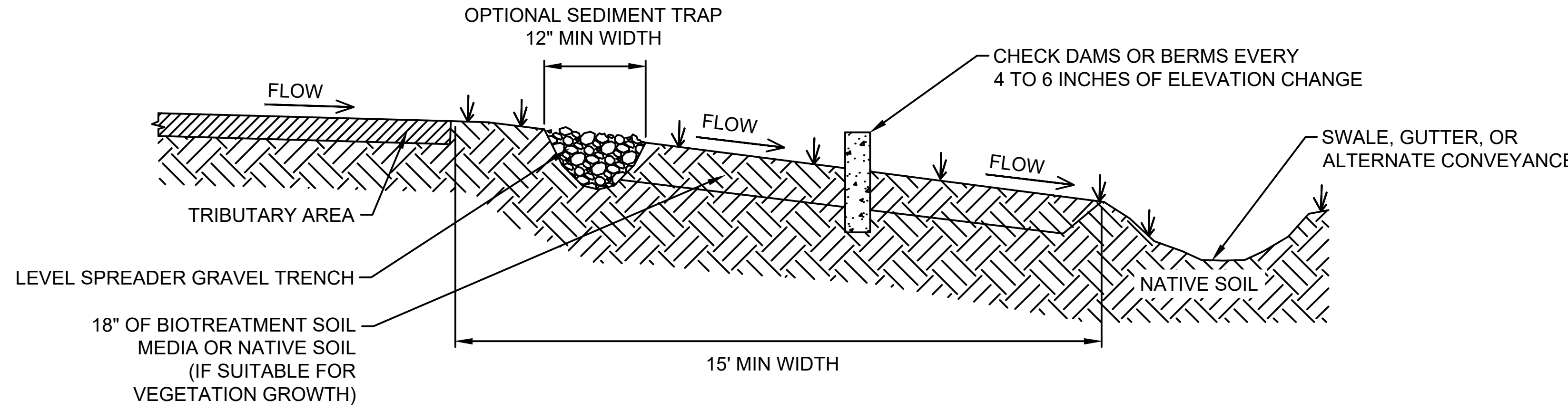
FEDERAL AID PROJECT NO. ________

SCALE: NTS
HOR.
VERT.

DATE: 05/22/17

SHEET NO.
7A
______ OF ______

PROJECT TITLE



SECTION A-A'
NTS

NOTES:

1. PROVIDE PROTECTION FROM ALL VEHICLE TRAFFIC, EQUIPMENT STAGING, AS WELL AS FOOT TRAFFIC FOR PROPOSED INFILTRATION AREA PRIOR TO AND DURING CONSTRUCTION. DO NOT COMPACT NATIVE SOIL.

2. DIMENSIONS:
   - FLOW LINE LENGTH: 15 FT MINIMUM, PER ALAMEDA COUNTY CLEAN WATER PROGRAM C.3 STORMWATER TECHNICAL GUIDANCE.
   - SLOPES: 0.5 TO 10%.

3. SETBACKS (FROM BEGINNING OF FACILITY):
   - 5 FT FROM PROPERTY LINE.
   - 10 FT FROM BUILDINGS.
   - 50 FT FROM WETLANDS, RIVERS, STREAMS, AND CREEKS WHERE REQUIRED.

4. OVERFLOW: COLLECTION FROM FILTER STRIP SHALL BE SPECIFIED ON PLANS TO APPROVED DISCHARGE POINT.

5. BIOTREATMENT SOIL MEDIA: NO BIOTREATMENT SOIL MEDIA REQUIRED IF VEGETATED AREAS ARE PRESENT. OTHERWISE BIOTREATMENT SOIL MEDIA SHALL BE USED WITHIN THE TOP 18".

6. VEGETATION: THE FILTER STRIP MUST HAVE 100% VEGETATION COVERAGE EXCEPT IN GRAVEL TRENCH.

□ LEVEL SPREADERS: A GRAVEL TRENCH MAY BE REQUIRED TO DISPERSE THE RUNOFF EVENLY ACROSS THE FILTER STRIP TO PREVENT A POINT OF DISCHARGE. THE TOP OF THE LEVEL SPREADER MUST BE HORIZONTAL AND AT AN APPROPRIATE HEIGHT TO PROVIDE SHEETFLOW DIRECTLY TO THE SOIL WITHOUT SCOUR. LEVEL SPREADERS SHALL NOT HOLD A PERMANENT VOLUME OF RUNOFF. GRADE BOARDS CAN BE USED INSTEAD OF THE GRAVEL TRENCH AND BE MADE OF ANY MATERIAL THAT WILL WITHSTAND WEATHER AND SOLAR DEGRADATION. TRENCHES USED AS LEVEL SPREADERS CAN BE FILLED WITH CRUSHED ROCK, OR PEA GRAVEL.

8. CHECK DAMS: SHALL BE PLACED ACCORDING TO THE FOLLOWING.
   - 3" TO 5" IN HEIGHT ABOVE GROUND LEVEL.
   - EVERY 10' WHERE SLOPE EXCEEDS 5%.

□ FOR PLANT SELECTION SEE GREEN INFRASTRUCTURE GUIDE ATTACHMENT A PLANT PALETTE (NORTHGATE 2018).

PROJECT TITLE

CITY OF OAKLAND DEPARTMENT OF ENGINEERING AND CONSTRUCTION 250 FRANK H. OGAWA PLAZA, SUITE 4314 * OAKLAND CA, 94612 (510) 238-3437 * FAX (510) 238-7227	VEGETATED BUFFER STRIP, TYPICAL SECTION A-A'	CIVIL ENGINEER RCE NO. ______ EXP. ______ CHECKED BY — CHECK BY DESIGNED BY — DESIGN BY DRAWN BY — DRAWN BY	No.	DATE	BY	REFERENCE	FINAL DRAFT-SUBJECT TO REVISION STANDARD DETAILS NOT FOR CONSTRUCTION	PROJECT NO. FEDERAL AID PROJECT NO. ______ SCALE: NTS HOR. VERT. DATE: 05/22/17	SHEET NO. 7B ____ OF ____

CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE

ATTACHMENT C
GIS SCREENING APPLICATION MEMORANDUM

TECHNICAL MEMORANDUM

April 18, 2018

Ms. Terri Fashing
Watershed Program Specialist
Watershed and Stormwater Management
City of Oakland, Public Works Agency
250 Frank H. Ogawa Plaza, Suite 4314
Oakland, California 94612

RE: Geographic Information System Screening Application
Green Infrastructure Guide
Oakland, California

Dear Ms. Fashing:

This Technical Memorandum summarizes the development and outlines the organization of the draft Geographic Information System (GIS) data set for the City of Oakland (the City). The purpose of the GIS data set is to provide a screening application to identify stormwater treatment opportunities for City-owned properties and Rights-of-Way (City Sites). The GIS screening application is based on the Green Infrastructure Guide (the GI Guide)[1] that summarizes standards for treating stormwater at City Sites. The following sections describe the organization of the available information and functions of the current data set.

GIS DATA SET

The City contracted with Northgate Environmental Management, Inc. (Northgate) to develop the GIS data set. Screening criteria were assigned to GIS layers for facilities, right-of-way areas, and other parcels that present City Sites potentially suitable for stormwater treatment. Figure 1 shows an overview map of all City Site. Table 1 provides a listing of the data layers and data sources for the City Sites layers.

[1] *Green Infrastructure Guide Version 1.0*, Northgate Environmental Management, Inc. document prepared for the City of Oakland, California, April 18, 2018

City Facilities

The facility layer combines a total of 330 buildings and service centers including:

- Libraries,
- Recreation centers,
- Fire stations,
- Senior centers,
- Municipal buildings, and
- Parking lots (21 parking lots and associated structures).

City Parks

The City Parks layer represents the City-owned parcels associated with City parks. Some City parks include property not owned by the City, and these parcels are not included in the assessment.

City Right-of-Way Areas

The City Right-of-Way layer includes sidewalks with widths greater or equal to 10 feet, street medians, and City streets.

Other City-Owned Properties

The layer for other properties includes City-owned parcels that are not identified as being associated with a specific City building, facility, or park.

SITE PROFILE SCREENING

The GI Guide introduces five typical City-Site profile categories with respect to stormwater treatment. Table 1 of the GI Guide in Appendix B presents the site profiles including City streets with parallel parking; City streets with diagonal parking; City ground-level parking lots; ground-level areas including plazas, parks, roadsides or undeveloped land; and City structures, such as municipal buildings, shelters, and garages, with storm drain access. A preliminary screening of treatment options was applied to the City Sites based on the above Site profile categories. This provides an initial screening of potential treatment options that do not use Site-specific criteria, but rather is based on the broad category of Site, such as “ground level area”, “streets”, “structures”, etc. Assigning Site profiles like “structures with storm drain access” to typical City Sites such as buildings allows for pre-screening of stormwater treatment options including green roofs. Figure 2 through Figure 8 illustrate the results of the Site profile screening.

ASSIGNMENT OF SITE-SPECIFC CRITERIA

Each of the City Sites layers were populated with Site-specific criteria based on stormwater treatment standards identified in Table 2 of the GI Guide. Qualitative Site criteria presented in the guidance (e.g., community concerns) are not included in the current GIS application. Site-specific criteria in the GIS application are currently limited to quantitative, numerically ascertainable site characteristics and include:

- Topography (slope);
- Hydrogeology (depth to shallowest groundwater);
- Soil type;
- Permeability (infiltration rate, based on dominant soil hydrologic group);
- Space (available area);
- Impervious tributary area (contributing area; assumes all properties are internally draining); and
- Drainage availability (distance to storm drain).

Figure 9 through Figure 13 illustrate a number of these physical criteria data sets, and provide a listing for the source of these data layers.

SITE-CRITERIA SCREENING MODEL

Once all the City-Site layers were populated with Site criteria, a quantitative screening model was developed for each Treatment Option and applied to the City Sites layers. For each stormwater treatment option, the screening model runs through all the potential City Sites, and identifies (with True/False criteria) whether the Site is a suitable candidate ("True") for the specific treatment opportunity or not ("False"). The results of the screening model are summarized through additional attribute fields added to each City Site GIS layer. The screening criteria used are based on Table 2 of the Guide and expressed in numeric values where quantitative requirements are available. The screening model was built using the ArcGIS Model Builder tool, and is configured so that it can be easily updated and re-applied if criteria are modified or added.

APPLICATION OF SCREENING MODEL

The GIS inputs and results of the treatment option screening process have been compiled and visualized in a GIS screening application consisting of an ArcGIS map document (MXD). Through this application, City Sites can be queried individually or by treatment option to identify potential treatment options by generalized Site profile or by application of the treatment standards to Site-specific criteria. The application can be used to generate map and tabular views of City Sites that are suitable or for any of the seven treatment options, based on either the generalized Site-profile screening, or Site-specific criteria screening.

Figure 14 through Figure 20 show examples of citywide maps of potential City Sites suitable for each of the seven different treatment options, based on application of the Site-specific criteria screening model.

SEA LEVEL RISE

Although not yet incorporated into the screening criteria model, all City Sites areas were also populated with information regarding their proximity to areas potentially impacted by sea level rise, including increased groundwater elevations. This information is recorded as the shortest distance (in feet) from the edge of the City Site to areas identified as being inundated by a 50 centimeter (1.6 feet) mean sea level (MSL) rise and by a 150 centimeter (4.9 feet) MSL rise. These two scenarios can be considered representative of currently predicted mid-century and end-of-century sea level rise scenarios. Groundwater elevations in coastal areas will also rise contemporaneously and therefore impact the selection for treatment options that have restrictions on the minimum depth to groundwater. Figure 21 illustrates these potential inundation areas (shown as filled areas in light blue (50 cm MSL rise), and dark blue (150 cm MSL rise) and also indicates regions (hatched pattern) where water table elevations could potentially rise over the next century and impact stormwater treatment options with minimum depth to water restrictions. It should be noted that the region of potential groundwater level impacts shown on Figure 21 is based on a very simplified approximation that assumes the magnitude of groundwater levels rise is equivalent to the magnitude of sea level rise. These data can be used as a basis for queries to further refine the selection of treatment options for the City Sites.

SCREENING MODEL LIMITATIONS & SENSITIVITY ANALYSIS

It should be understood that the Site-criteria based screening model is meant to be a planning tool and that it has certain limitations based on the following:

- The structure and makeup of the City-Sites and Rights-of-Way GIS layers that define what is considered a candidate Site,
- The spatial resolution, accuracy, and completeness of the GIS data sets that define the physical Site-criteria, and
- The need to make certain simplifying assumptions and/or generalizations to apply the Site-criteria standards through a semi-automated GIS process.

A preliminary sensitivity analysis was conducted to determine to which parameters and or data sets the model is most sensitive to in terms of excluding a specific treatment option for potential use at City Site. The sensitivity analysis of the screening model indicates the following:

- Rain Gardens – screening model results are most sensitive to the tributary area (contributing impervious area ≤ 2 acres) and to the infiltration rate of the native soil (infiltration rate ≥ 0.5 in/hr). For example, when considering the 159 parcels associated with City Facilities, only three parcels are returned as being potentially suitable for rain gardens using the above criteria. By relaxing the contributing impervious area restriction to 3 acres, 15 parcels are eligible; at 4 acres, 19 parcels are eligible.

- Bioswales – screening model results are most sensitive to tributary area (contributing impervious area ≤ 0.5 acres) and to the infiltration rate of the native soil (infiltration rate ≥ 0.5 in/hr). *It should be noted that the standards specify a minimum depth to groundwater of 1 foot, but the regional depth-to-groundwater GIS data set only has information at 5-foot depth intervals so does not have sufficient resolution to exclude sites based on these criteria in areas where the depth to water is in the 0-5-foot range.*

- Permeable Pavement – screening model results are most sensitive to slope restrictions (Slope ≤ 4%) and to the infiltration rate of the native soil (infiltration rate ≥ 0.5 in/hr).

- Green Roofs – screening model results sensitive only to distance from nearest storm drain (Distance ≤ 100 feet).

- Tree-Wells – screening model results sensitive only to distance from nearest storm drain (Distance ≤ 100 feet).

- Flow Through Planters – screening model results most sensitive to distance from nearest storm drain (Distance ≤ 100 feet). *It should be noted that the standards specify a minimum depth to groundwater of 2 feet below the planter bottom, but the regional depth-to-groundwater GIS data set only has information at 5-foot depth intervals so does not have sufficient resolution to exclude sites based on these criteria in areas where the depth to water is in the 0-5 foot range.*

- Vegetated Buffer Strips – screening model results most sensitive to slope restrictions (2% ≤ Slope ≤ 4%). *It should be noted that the standards specify a minimum depth to groundwater of 1 foot, but the regional depth-to-groundwater GIS dataset only has information at 5-foot depth intervals so does not have sufficient resolution to exclude sites based on these criteria in areas where the depth to water is in the 0-5 foot range.*

It should be noted that the exclusion of Sites based on the minimum native soil infiltration rate criteria is based on treatment option designs that use native soil conditions, with no use of under-drains along with import of and/or mixing with non-native soil. Removing the native soil infiltration rate restrictions used in the screening model substantially increases the number of Sites potentially suitable for many of the treatment options.

A closer review of several sample City Sites indicates that very important to the screening process is how the potential project areas are defined. For example, Frank Ogawa Plaza is defined by the entire property parcel in the City's GIS data layer. The calculation of average slope is very sensitive to the inclusion of the areas of the Plaza that include the amphitheater and the large steps around the lawn area. Including those areas gives higher average slope values than if one were just considering the grassy area or other level areas. Similarly, when considering the tributary areas, the model assumes that every parcel is self-draining (e.g. the entire impervious area of the parcel drains internally). As such for Frank Ogawa Plaza, the model is using the entire impervious area of the parcel to define the tributary area. But this would be different if the raised grassy area is considered separately, since it does not actually receive water from the entire Plaza. Each of these is sufficient to exclude the Site from consideration for a range of treatment options. For example, the model currently shows the Plaza as being not suitable for Vegetated Buffer Strips because of slope restrictions.

This all suggests that there can be some adjustments made on either removing certain criteria that are difficult to estimate accurately without more detailed Site study, such as the tributary area, as well as refining what is defined as a potential project Site so that parameters are not averaged over areas so large as to affect the average Site properties.

The GIS screening tool is meant for general planning purposes and is intended to exclude sites that are likely not suitable for each of the treatment options based on the available GIS data. However, this does not mean that sites that are not excluded by the screening tool are necessarily suitable for a given treatment option. Rather, it means that they cannot be excluded alone based on available data, and further site-specific studies would need to be conducted to verify that they are suitable for a given treatment option.

CLOSING

We appreciate the opportunity to provide service to you on this project and look forward to reviewing this information directly with you in person. Should you have any questions or require additional information, please do not hesitate to call.

Sincerely,
Northgate Environmental Management, Inc.

Pascual Benito, PhD	Axel Rieke, P.E., QSD/P	Nancy Hendrickson, P.E.
Associate Engineer	Associate Engineer	Principal Engineer

Enclosures:	Table 1	City Sites Data Layers and Data Sources
	Table 2	Layers Used for Assigning Site-Specific Physical Criteria
	Figure 1	All City Facilities, Properties, Parks, and Rights-of-Way
	Figure 2	Potential for Rain Gardens (Site Profile Screening)
	Figure 3	Potential for Bio-Swales (Site Profile Screening)
	Figure 4	Potential for Permeable Pavement (Site Profile Screening)
	Figure 5	Potential for Green Roofs (Site Profile Screening)
	Figure 6	Potential for Stormwater Detention Tree Wells (Site Profile Screening)
	Figure 7	Potential for Flow-Through Planters (Site Profile Screening)
	Figure 8	Potential for Vegetated Buffer Strips (Site Profile Screening)
	Figure 9	Physical Characteristics: Depth to Groundwater
	Figure 10	Physical Characteristics: Soil Type
	Figure 11	Physical Characteristics: Soil Type – Hydrologic Soil Groups
	Figure 12	Physical Characteristic: Slope (green = shallow, red = steep)
	Figure 13	Physical Characteristic: Percent Impervious
	Figure 14	Potential for Rain Gardens (Site Criteria Screening Applied
	Figure 15	Potential for Bio-Swales (Site Criteria Screening Applied)
	Figure 16	Potential for Permeable Pavement (Site Criteria Screening Applied)
	Figure 17	Potential for Green Roofs (Site Criteria Screening Applied
	Figure 18	Potential for Stormwater Detention Tree Wells (Site Criteria Screening Applied)
	Figure 19	Potential for Flow-Through Planters (Site Criteria Screening Applied)
	Figure 20	Potential for Vegetated Buffer Strips (Site Criteria Screening Applied)
	Figure 21	Potential Impacts of Sea Level Rise

CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE ATTACHMENT C
GIS SCREENING APPLICATION MEMORANDUM

TABLES

ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

TABLE 1
City Sites GIS Data Layers and Data Sources

City Sites	GIS Layer/Notes	Data Source
City Facilities	Building Footprints (Includes some parking garages)	City of Oakland
City Facilities Parcels	Parcels intersected by City Facilities	City of Oakland
City Owned Property	Provided by City of Oakland	City of Oakland
Medians	Street Medians	City of Oakland
Oakland Parks Parcel Based	Oakland Parks layer using parcel boundaries	City of Oakland Parcels intersected with GreenInfo CA Protected Areas Database
Parking Facilities	Parking Lots and Garages	City of Oakland
Sidewalks	Sidewalks over 10 feet wide considered	City of Oakland
Streets	Street centerlines have been buffered to 20 feet	City of Oakland

TABLE 2

GIS Layers Used for Assigning Site-Specific Physical Criteria

Screening Criteria Dataset	Screening Criteria	Data Source
Depth To Groundwater	Depth To Groundwater	California Geological Survey (CGS), Seismic Hazard Zone Report, 2003
NRCS SSURGO Soil Survey	Soil Type, Hydrologic Group	U.S. Dept. of Agriculture, Natural Resources Conservation Service (NRCS), 2010
Surficial Geology	Surficial Geology	U.S. Geological Survey (USGS), Geologic Map and map database of the Oakland metropolitan area, Alameda, Contra Costa, and San Francisco Counties, 2000
Impervious Surface	Percent Impervious Surface (averaged for each feature)	U.S. Geological Survey (USGS), National Land Cover Database (NLCD), 2006
Slope Grid	Percent Slope (averaged for each feature)	Alameda County DEM derivative, 2013
Storm System Pipes	Distance from City Site boundary to closest Storm Drain	City of Oakland
Mean Sea Level Rise	Sea Level Rise Inundation Scenarios	U.S. Geological Survey (USGS), Potential Inundation Due to Rising Sea Levels in the San Francisco Bay Region, 2010

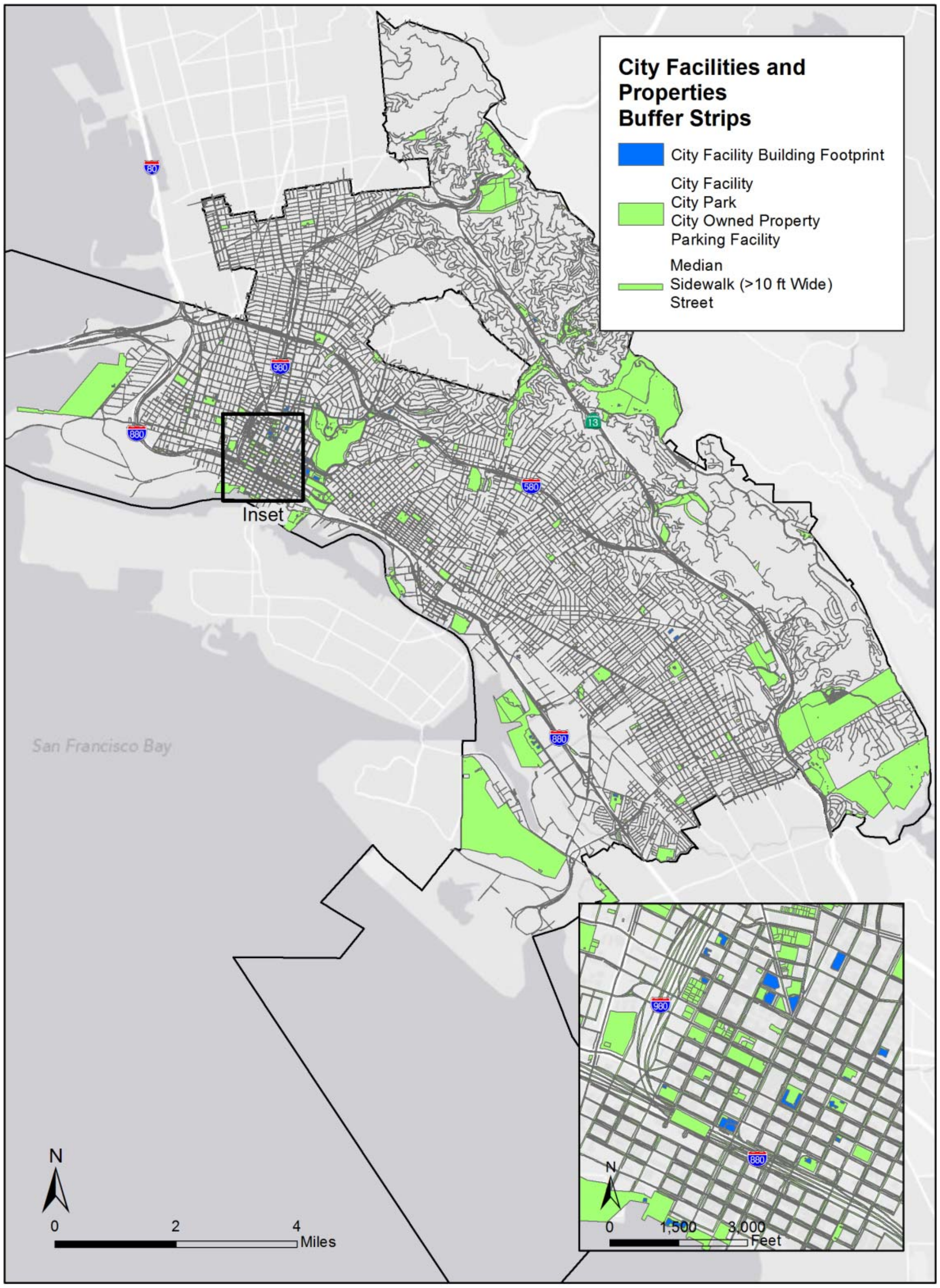
CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE ATTACHMENT C
GIS SCREENING APPLICATION MEMORANDUM

FIGURES

ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

<u>FIGURE 1</u>

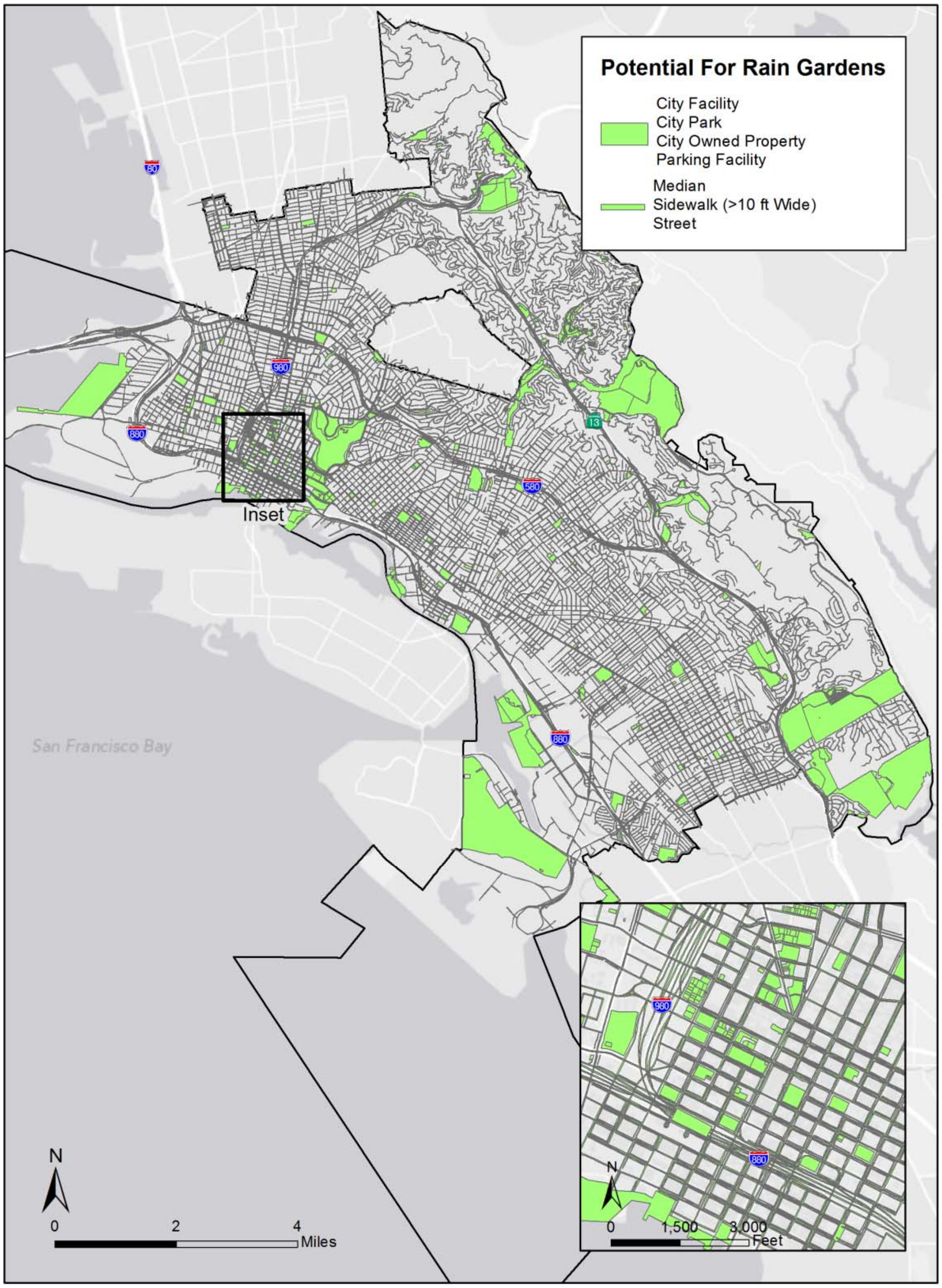
All City Facilities, Properties, Parks, and Rights-of-Way



ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

FIGURE 2

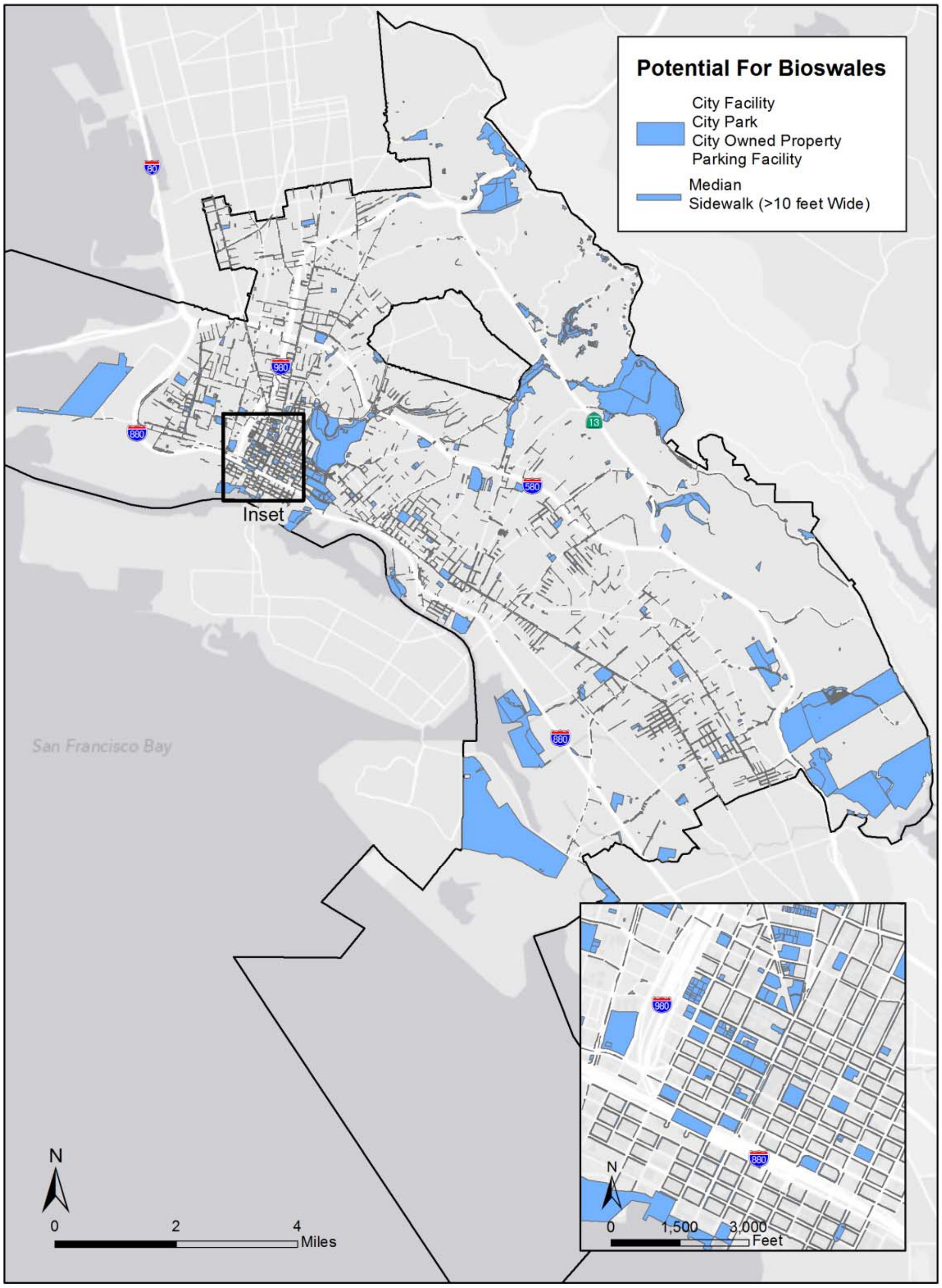
Potential for Rain Gardens (Site Profile Screening)



ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

FIGURE 3

Potential for Bio-Swales (Site Profile Screening)



ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

FIGURE 4

Potential for Permeable Pavement (Site Profile Screening)

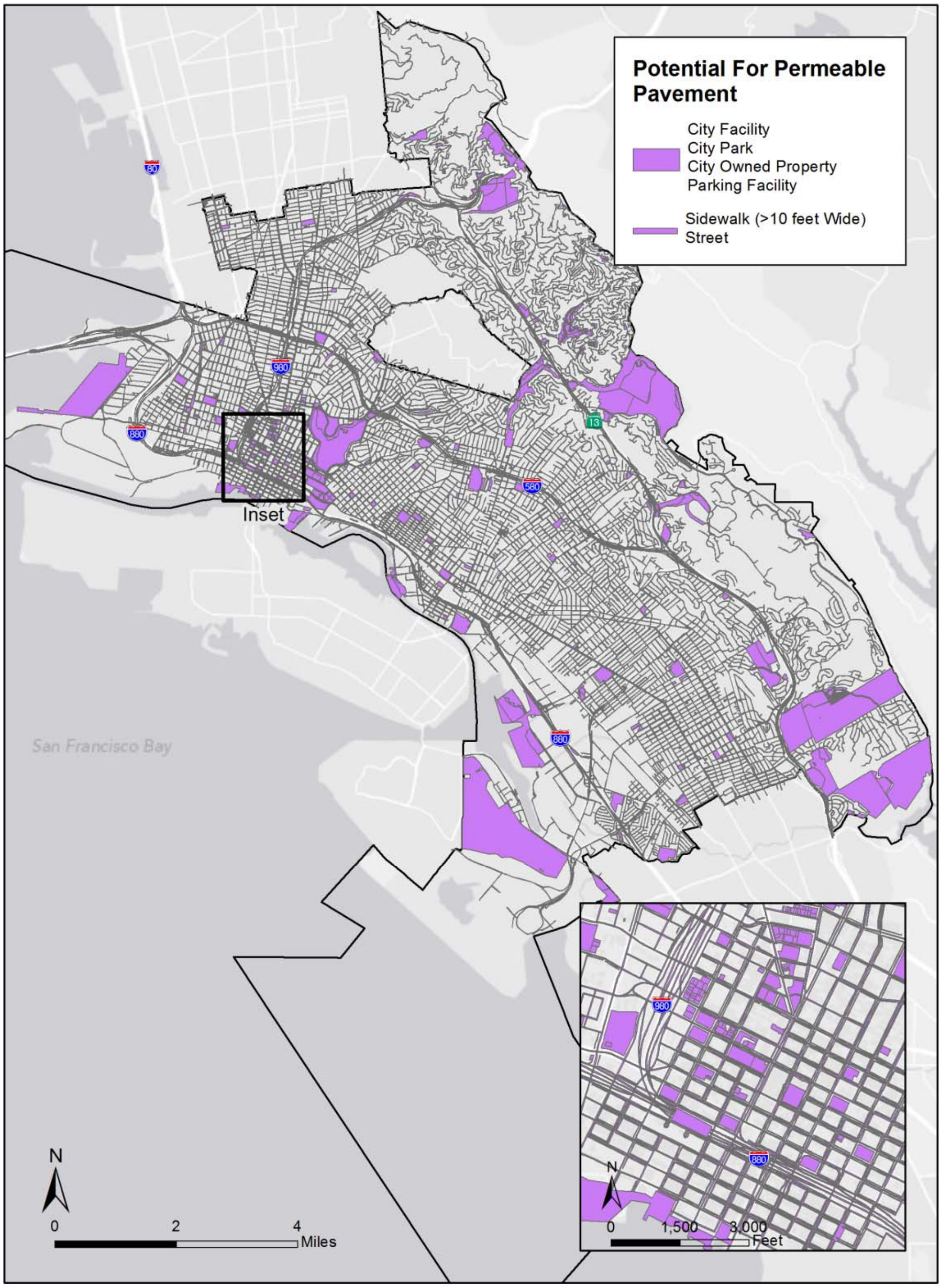


FIGURE 5

Potential for Green Roofs (Site Profile Screening)

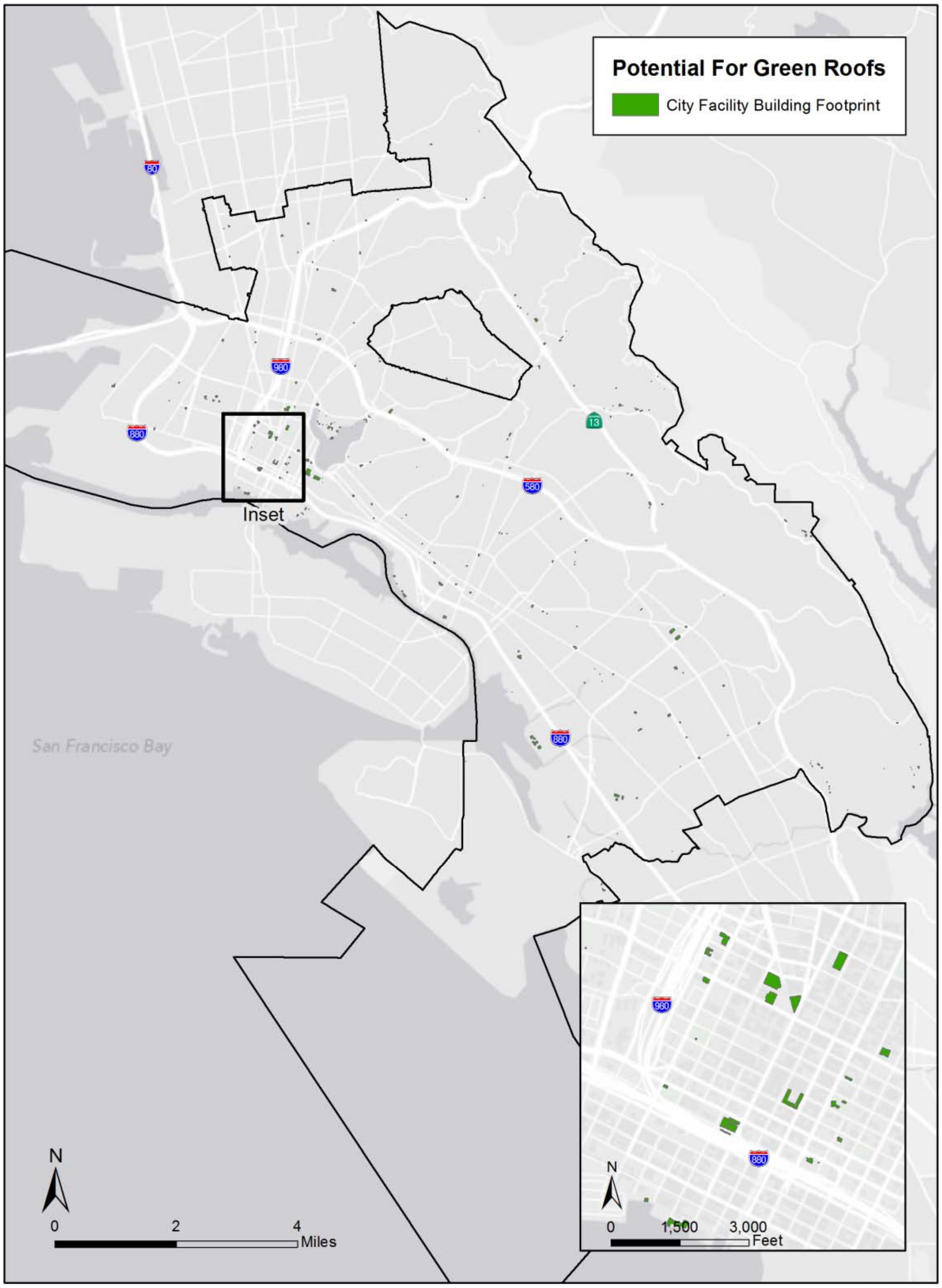
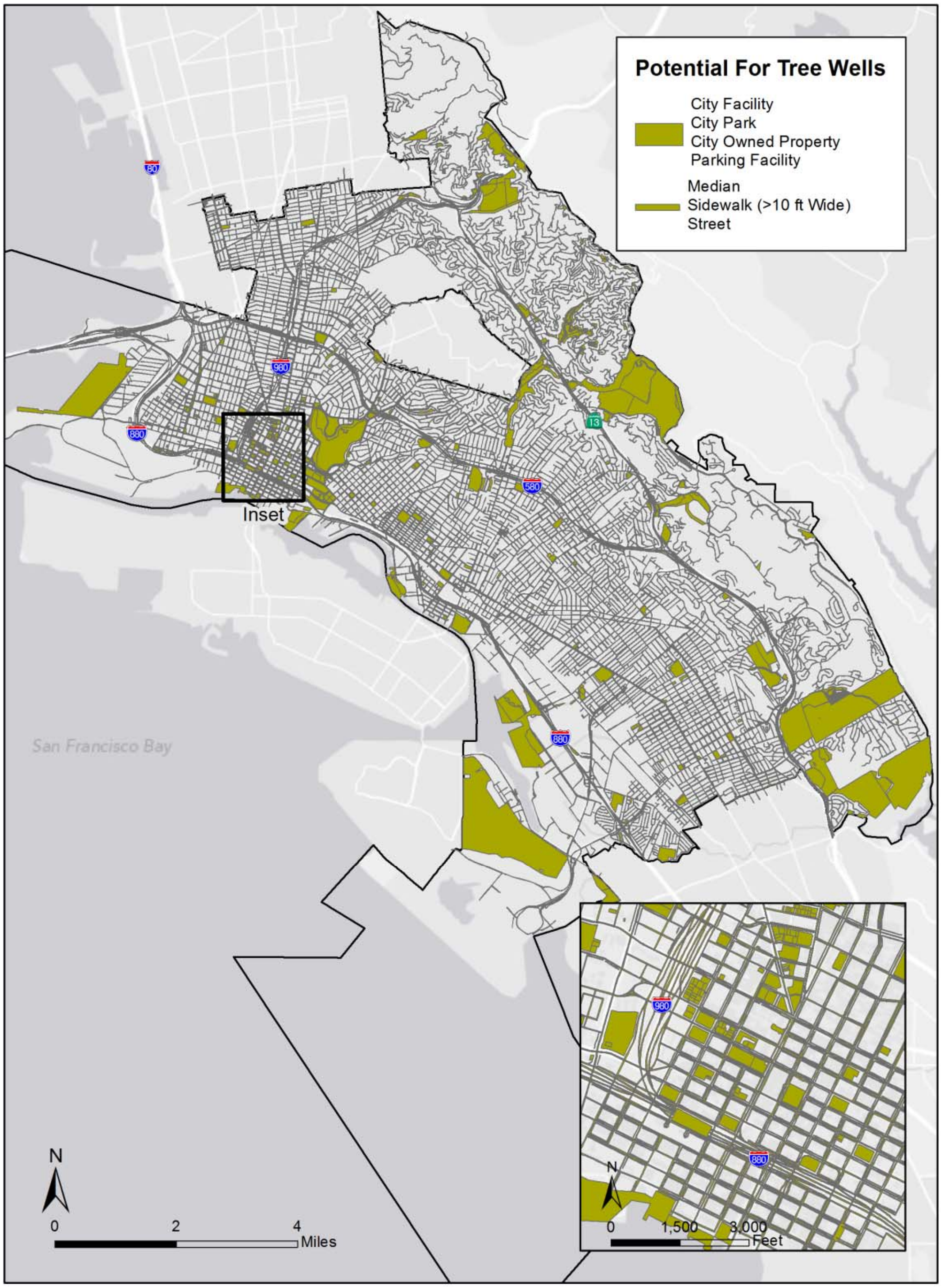


FIGURE 6
Potential for Stormwater Detention Tree Wells (Site Profile Screening)



ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

FIGURE 7

Potential for Flow-Through Planters (Site Profile Screening)

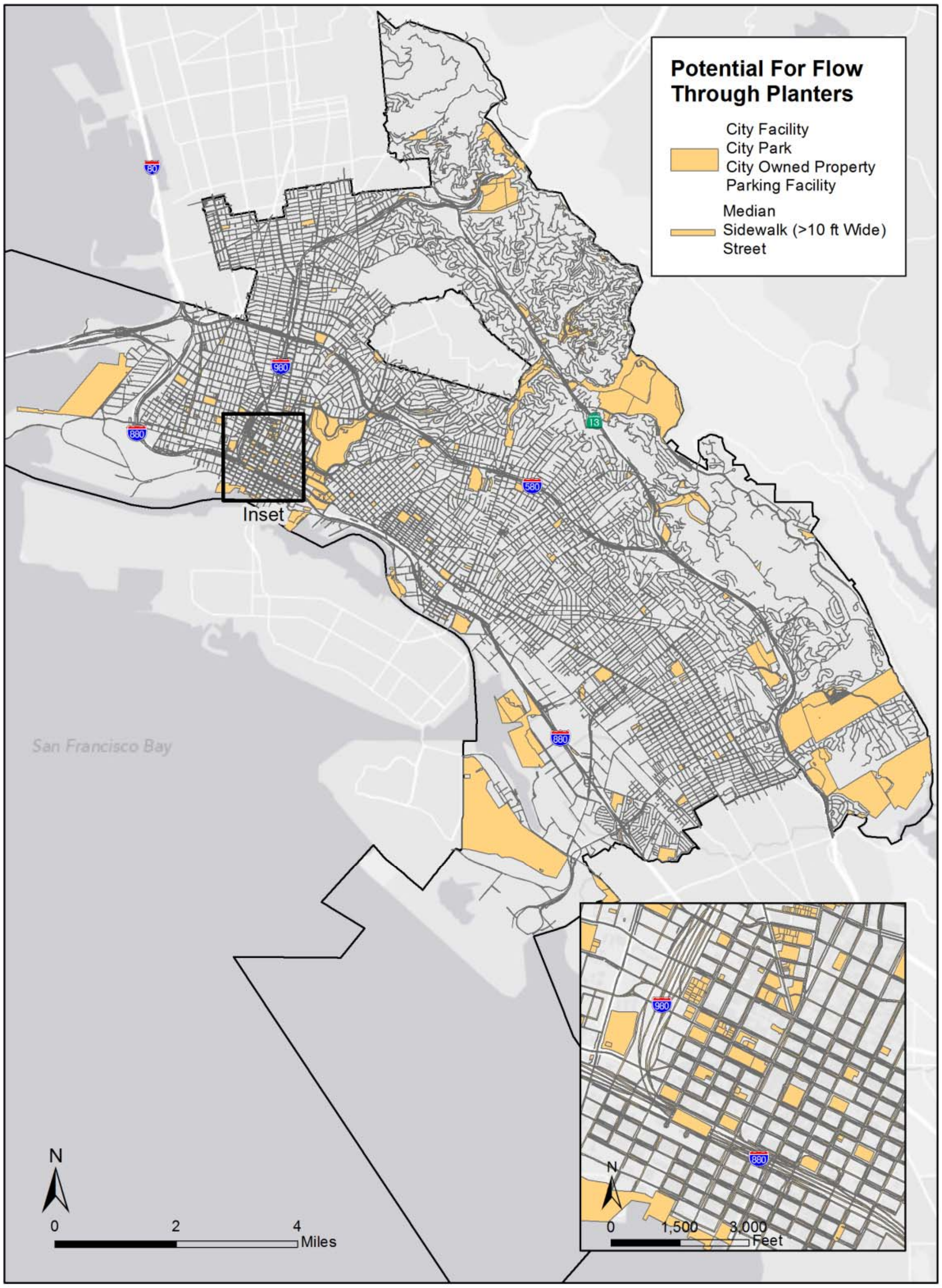


FIGURE 8

Potential for Vegetated Buffer Strips (Site Profile Screening)

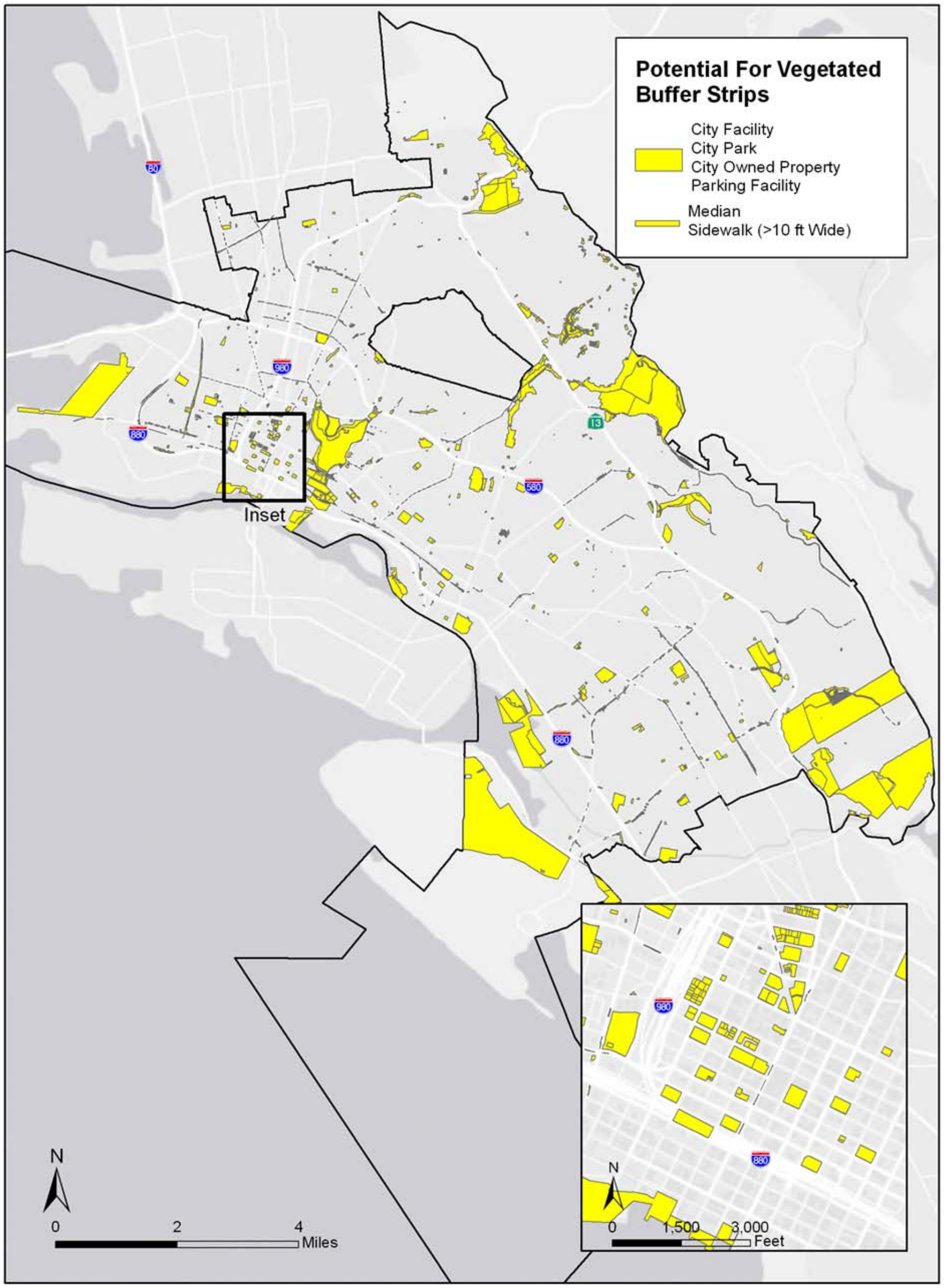


FIGURE 9
Physical Characteristics: Depth to Groundwater

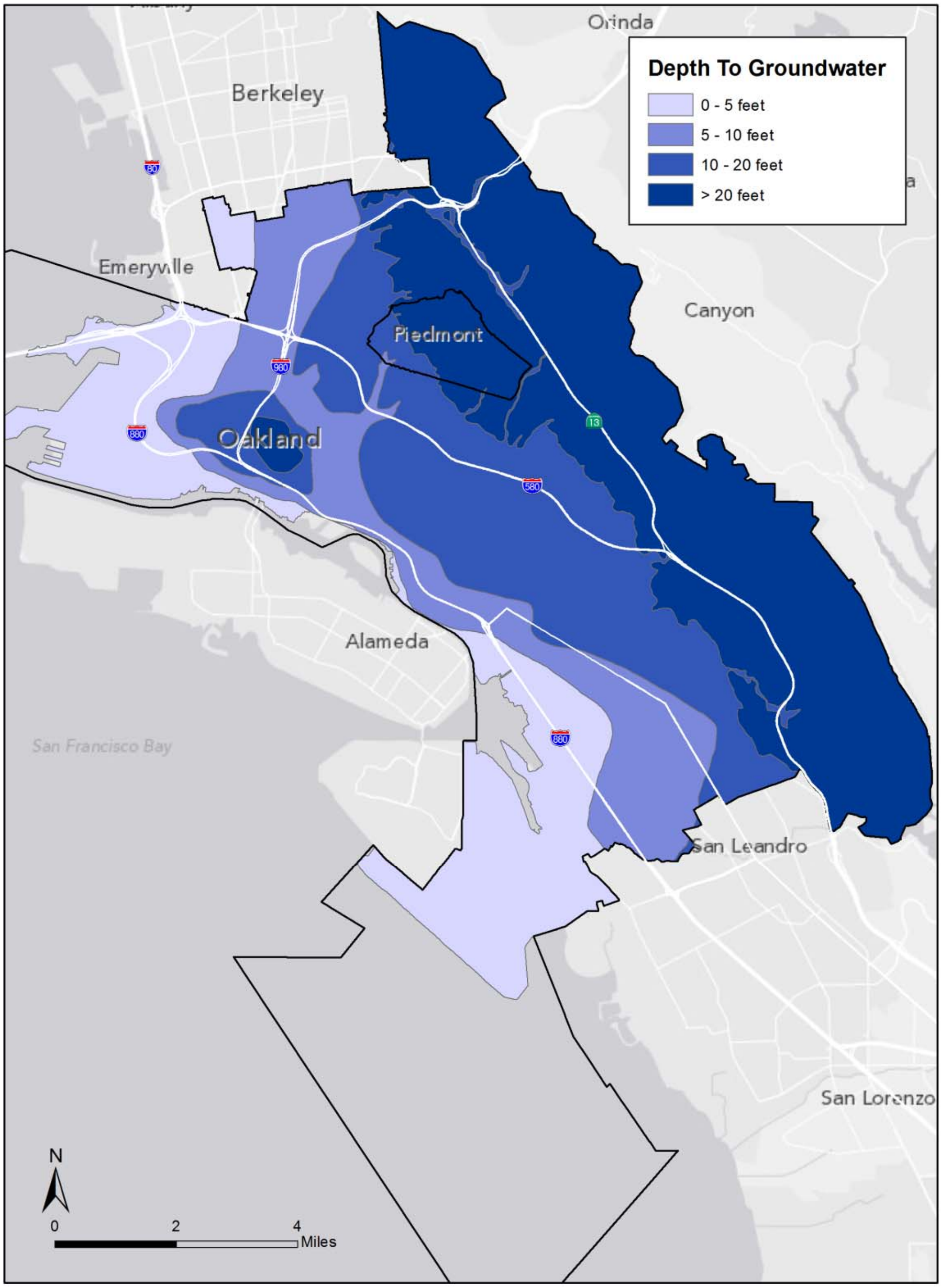
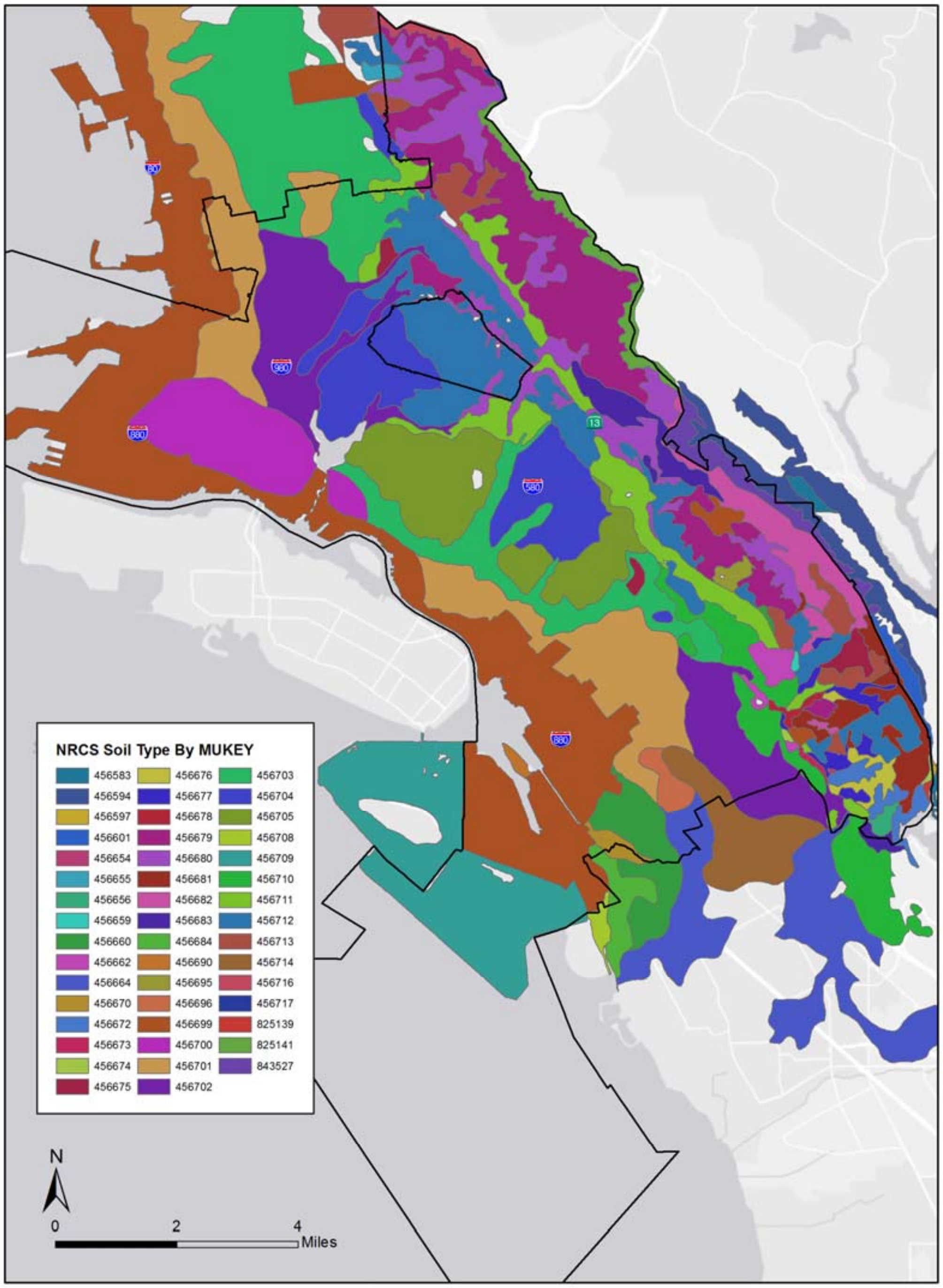


FIGURE 10

Physical Characteristics: Soil Type. MUKEY = NRCS soil database map unit ID (e.g. MUKEY 456714 = “Yolo silt loam, 0 to 2 percent slopes”)



ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

FIGURE 11

Physical Characteristics: Soil Type – NRCS Hydrologic Soil Groups (based on estimates of runoff potential. Group A- high infiltration rate, B – moderate infiltration rate, C– slow infiltration rate, D – very slow infiltration rate)

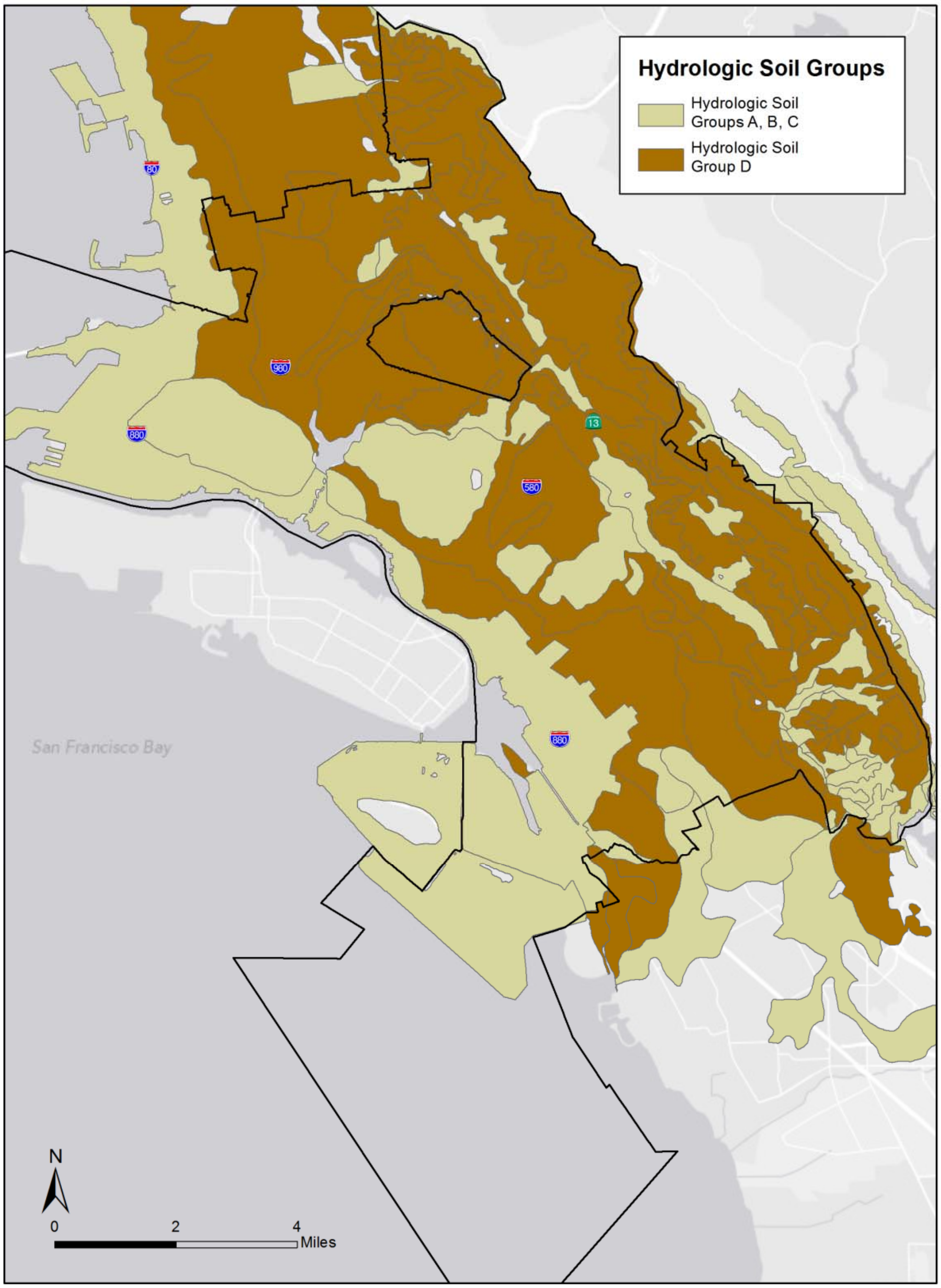


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FIGURE 12

Physical Characteristic: Slope (green = shallow, red = steep)

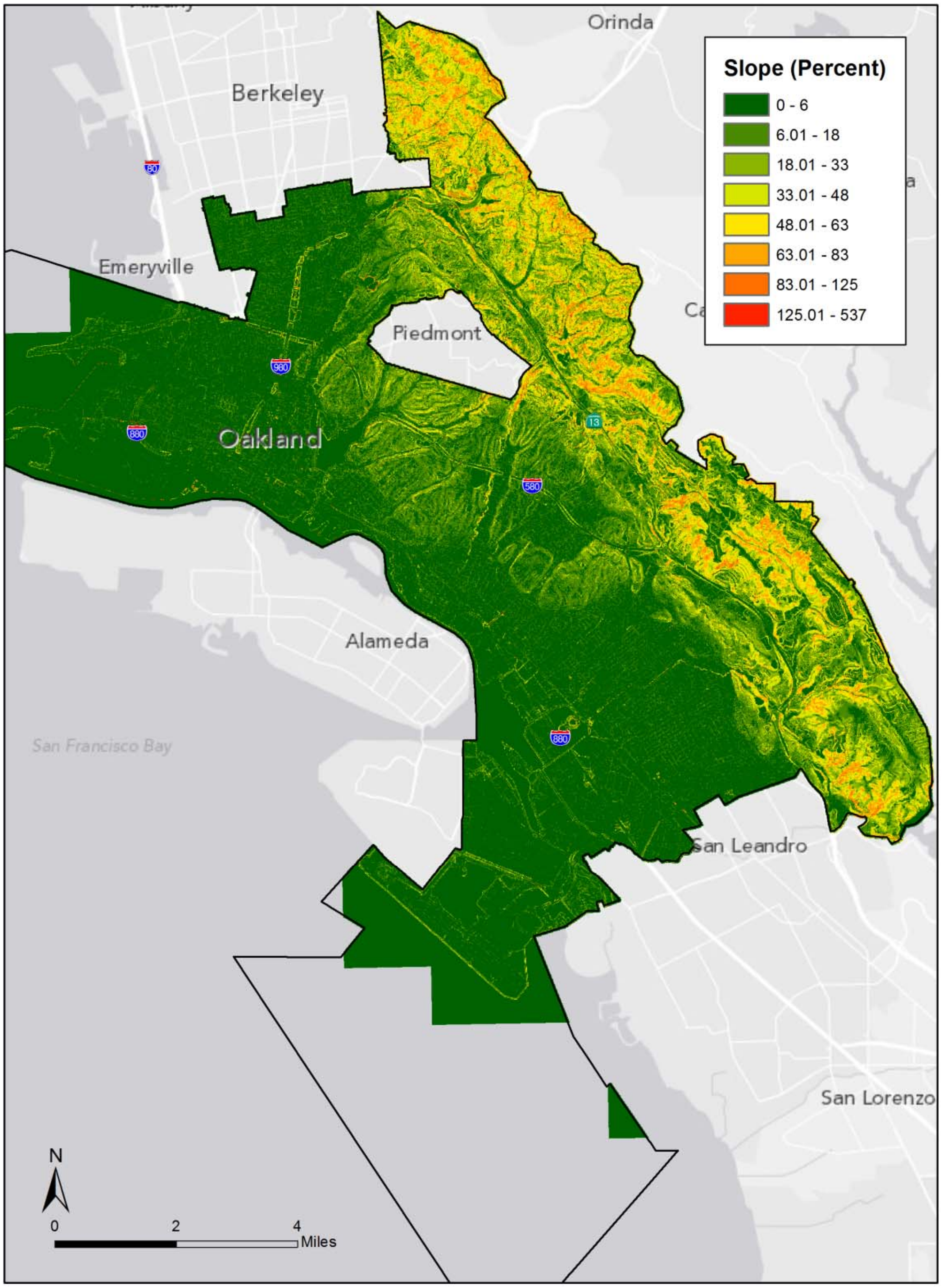

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FIGURE 13

Physical Characteristic: Percent Impervious

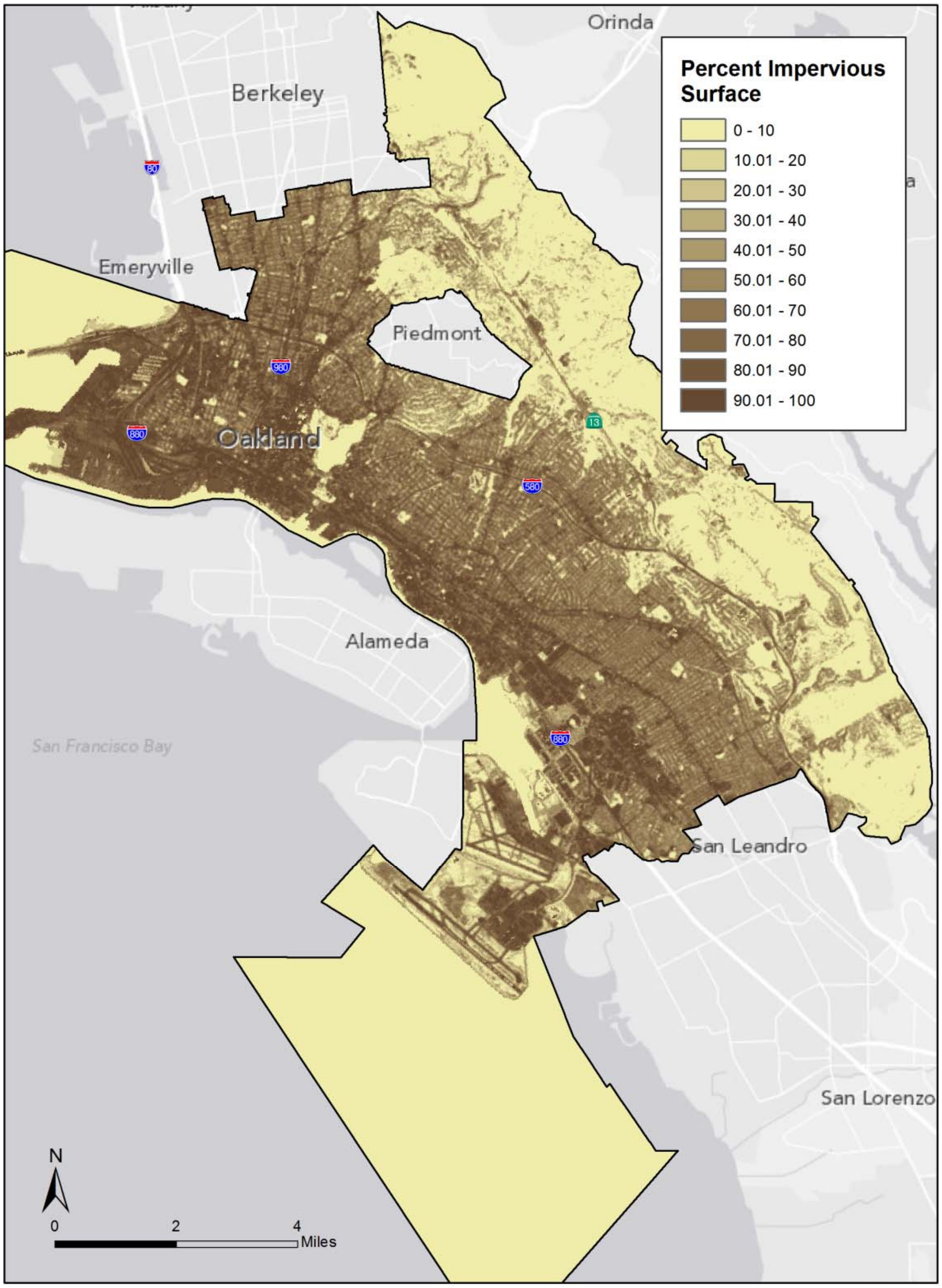


FIGURE 14

Potential for Rain Gardens (Site Criteria Screening Applied)

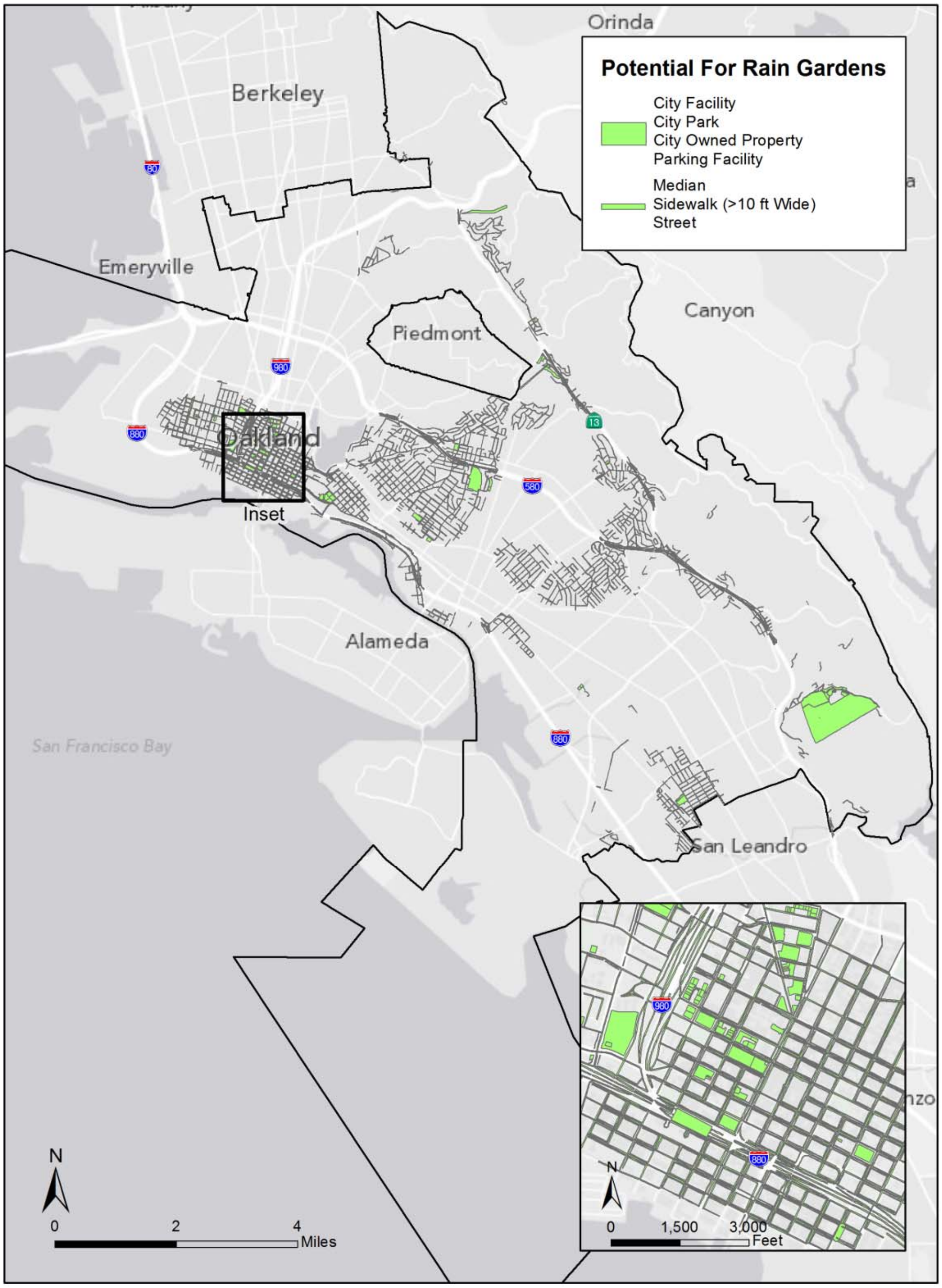


FIGURE 15

Potential for Bio-Swales (Site Criteria Screening Applied)

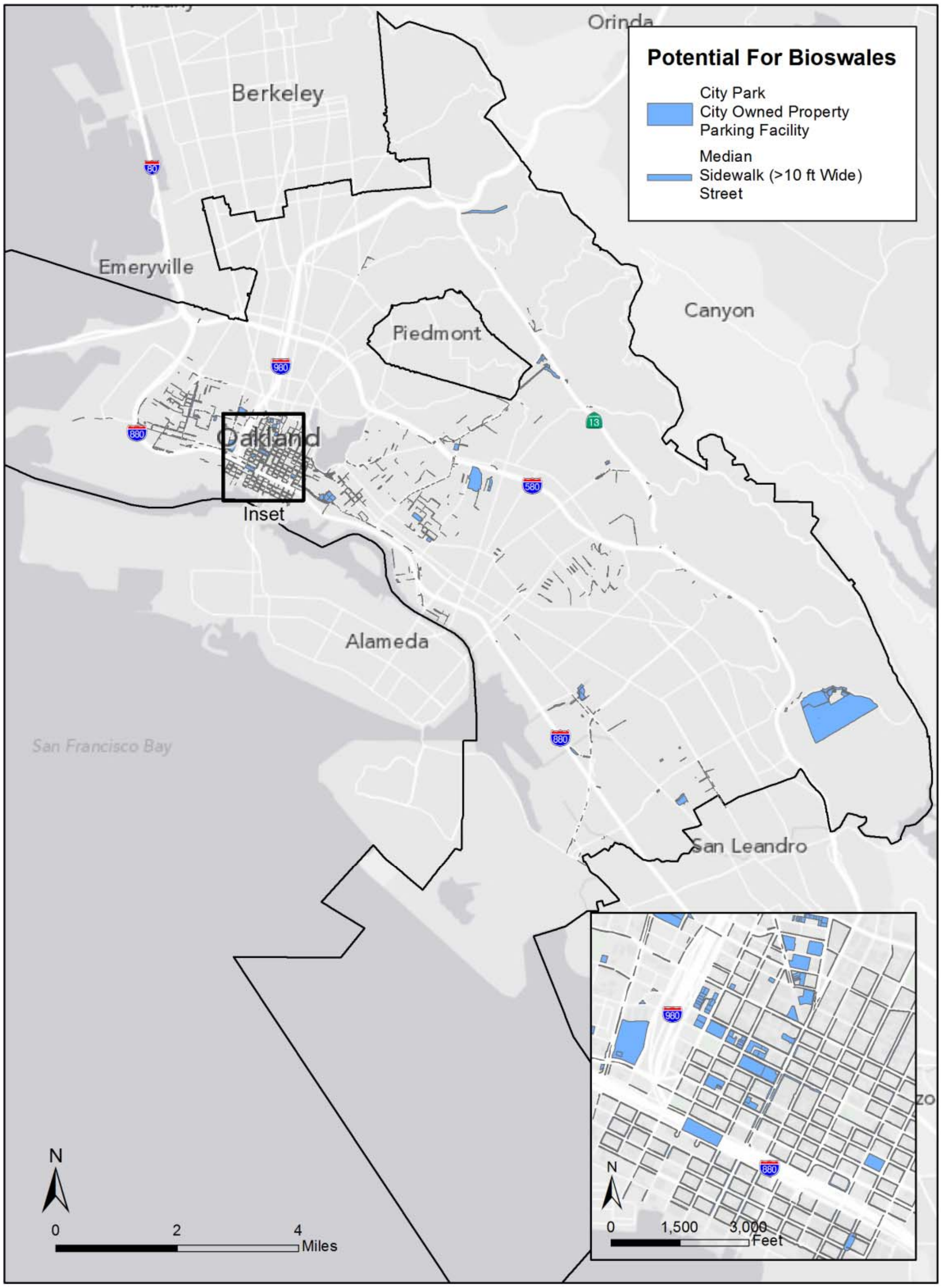


FIGURE 16

Potential for Permeable Pavement (Site Criteria Screening Applied)

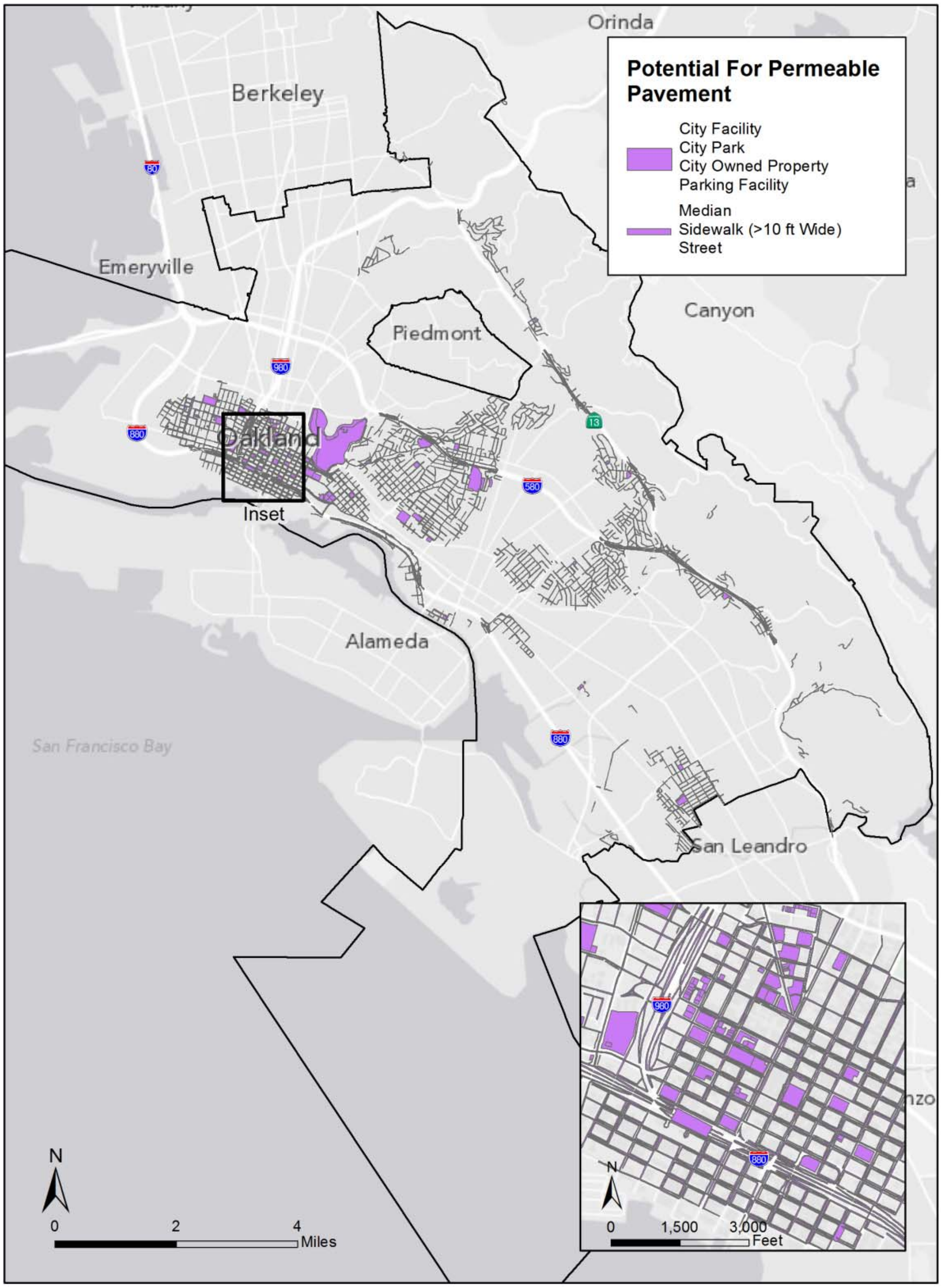


FIGURE 17

Potential for Green Roofs (Site Criteria Screening Applied)

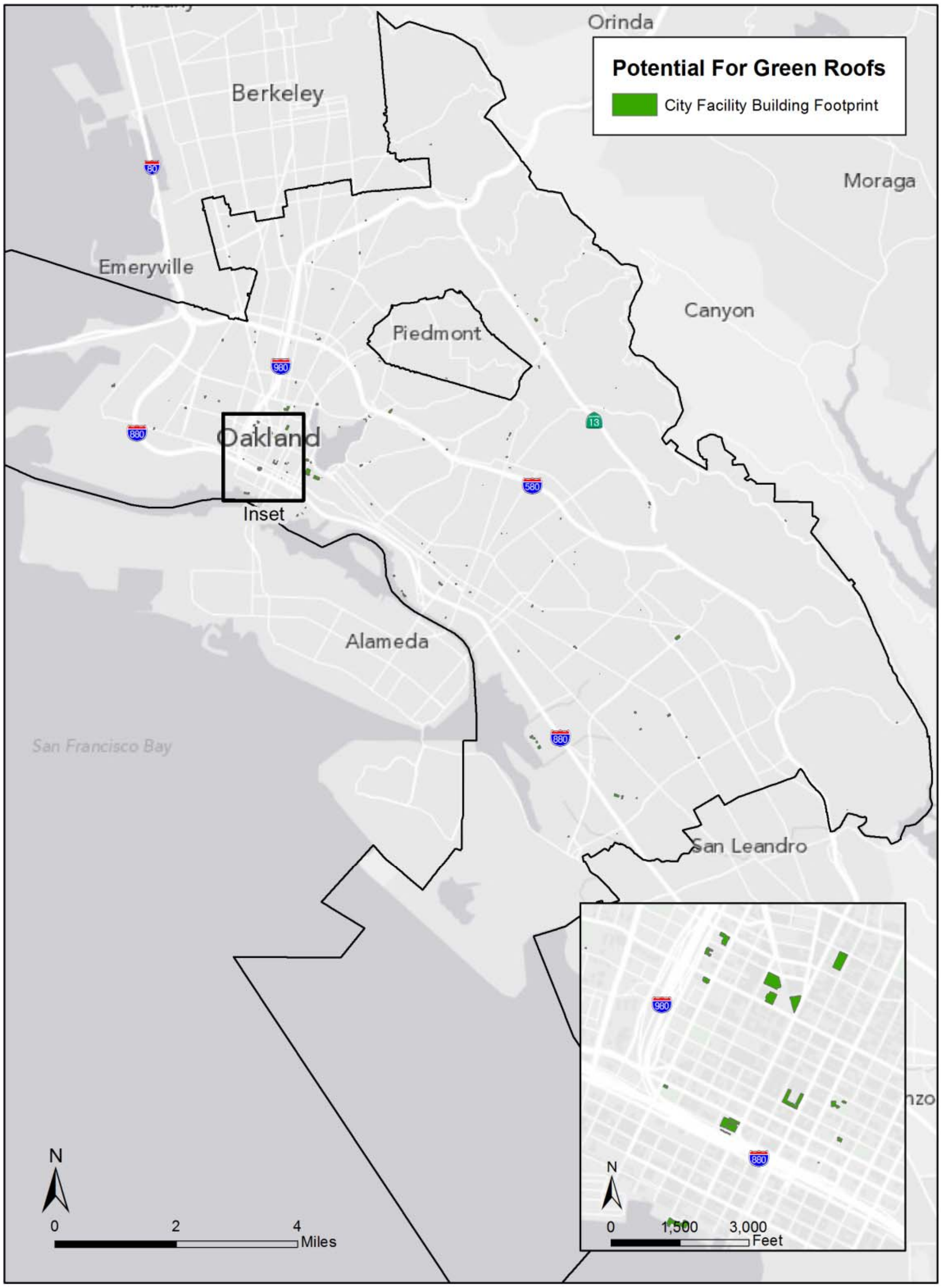


FIGURE 18

Potential for Stormwater Detention Tree Wells (Site Criteria Screening Applied)

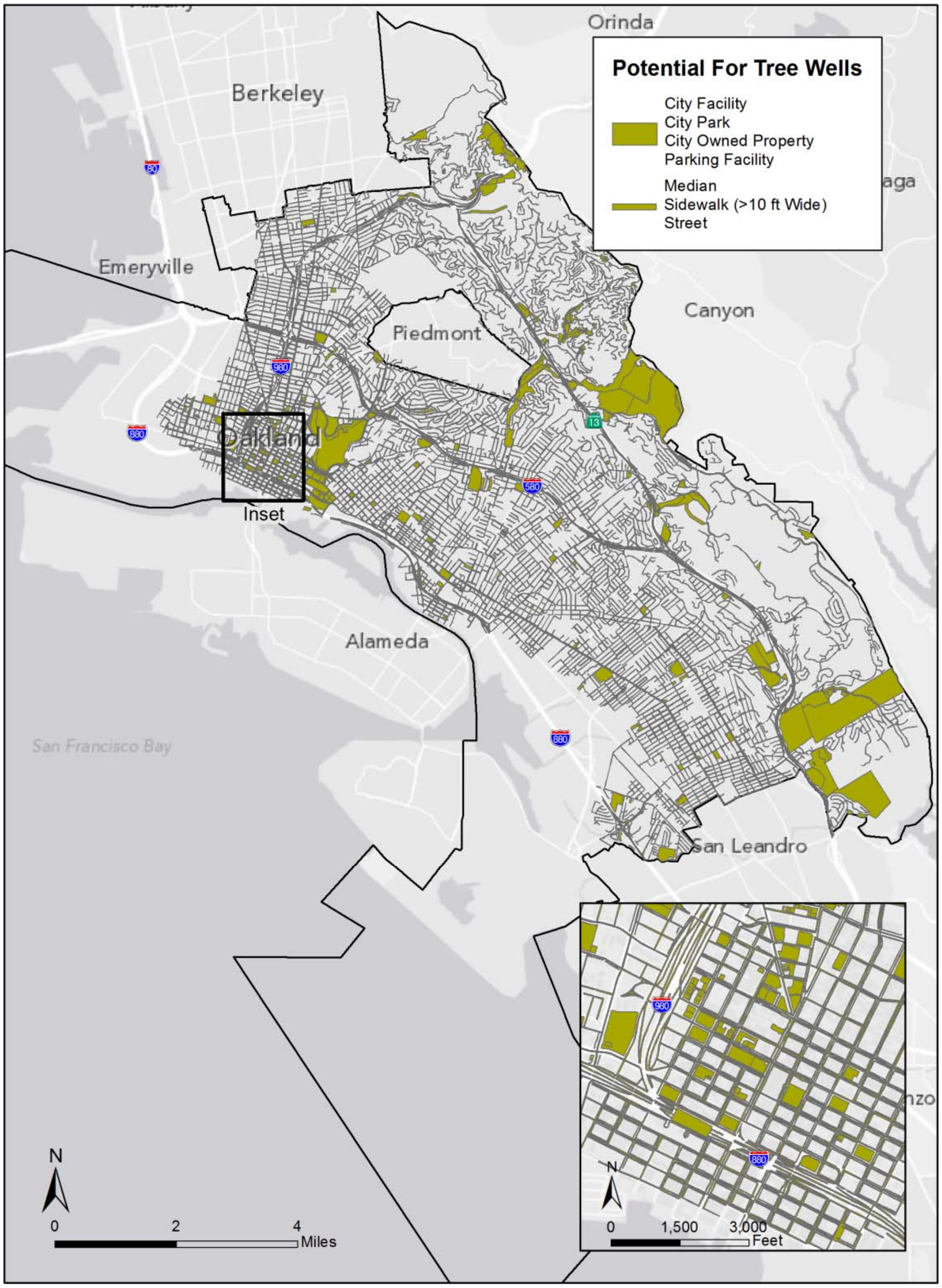
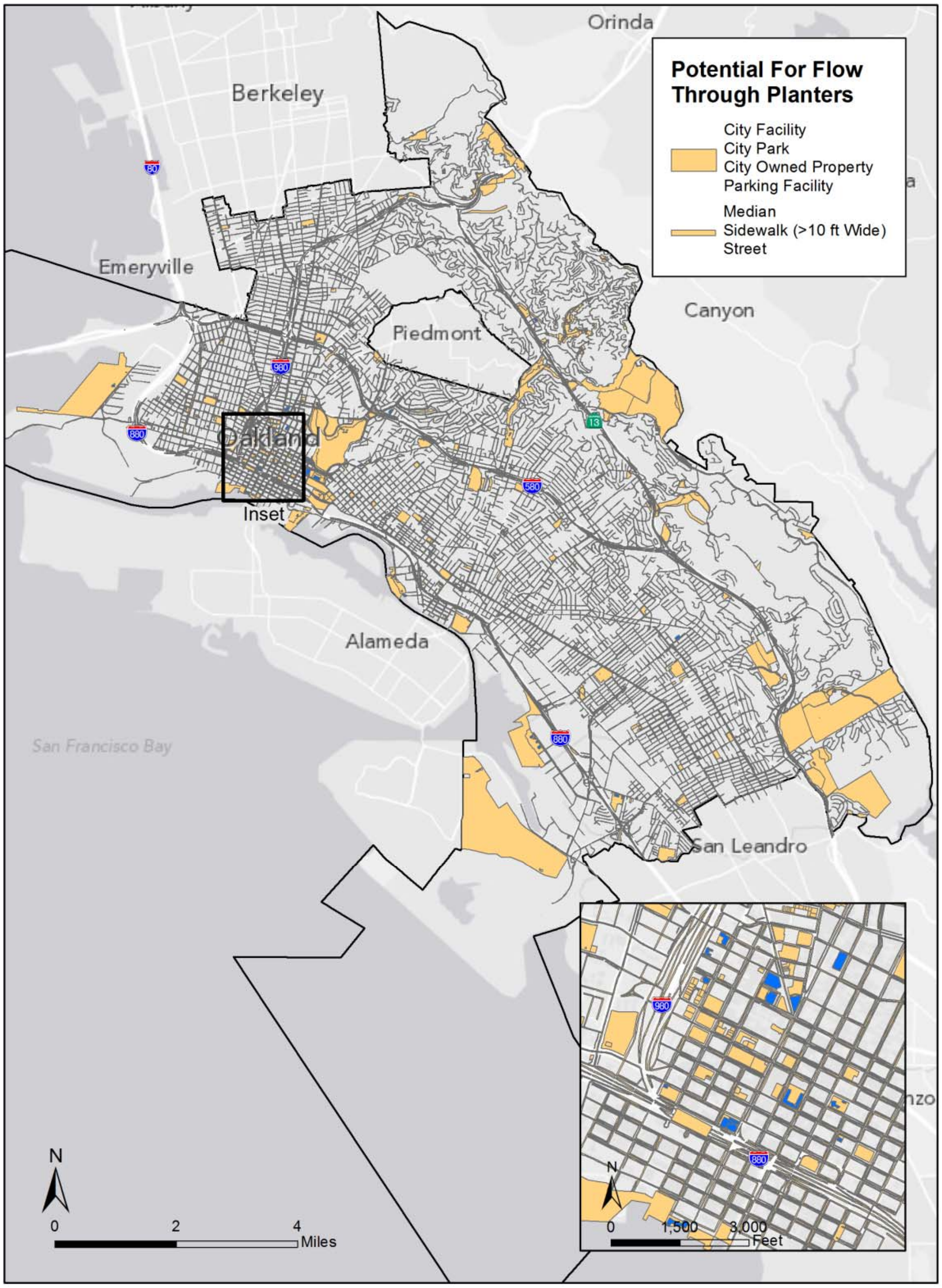


FIGURE 19

Potential for Flow-Through Planters (Site Criteria Screening Applied)



ATTACHMENT C GIS SCREENING APPLICATION MEMORANDUM

FIGURE 20

Potential for Vegetated Buffer Strips (Site Criteria Screening Applied)

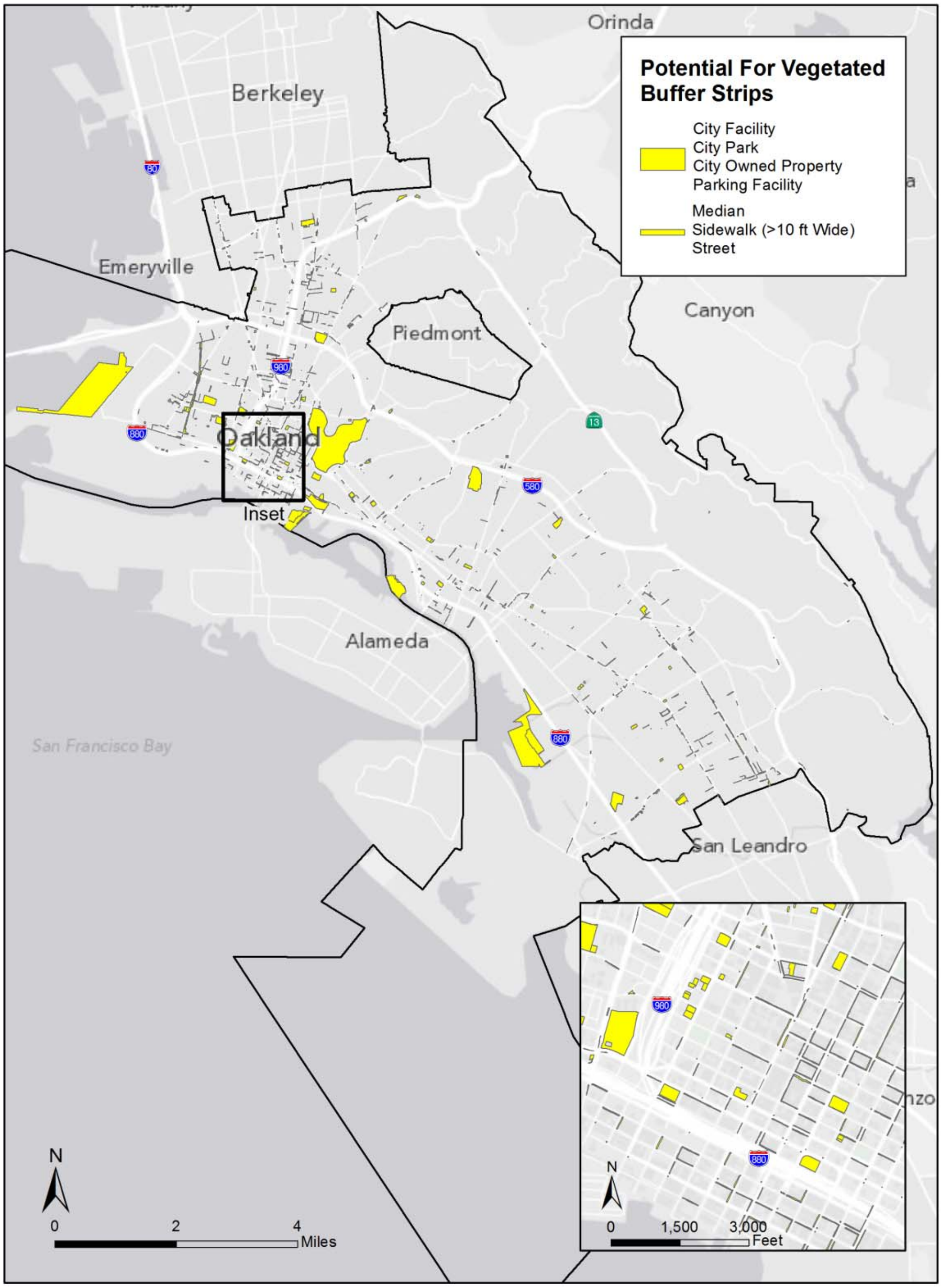
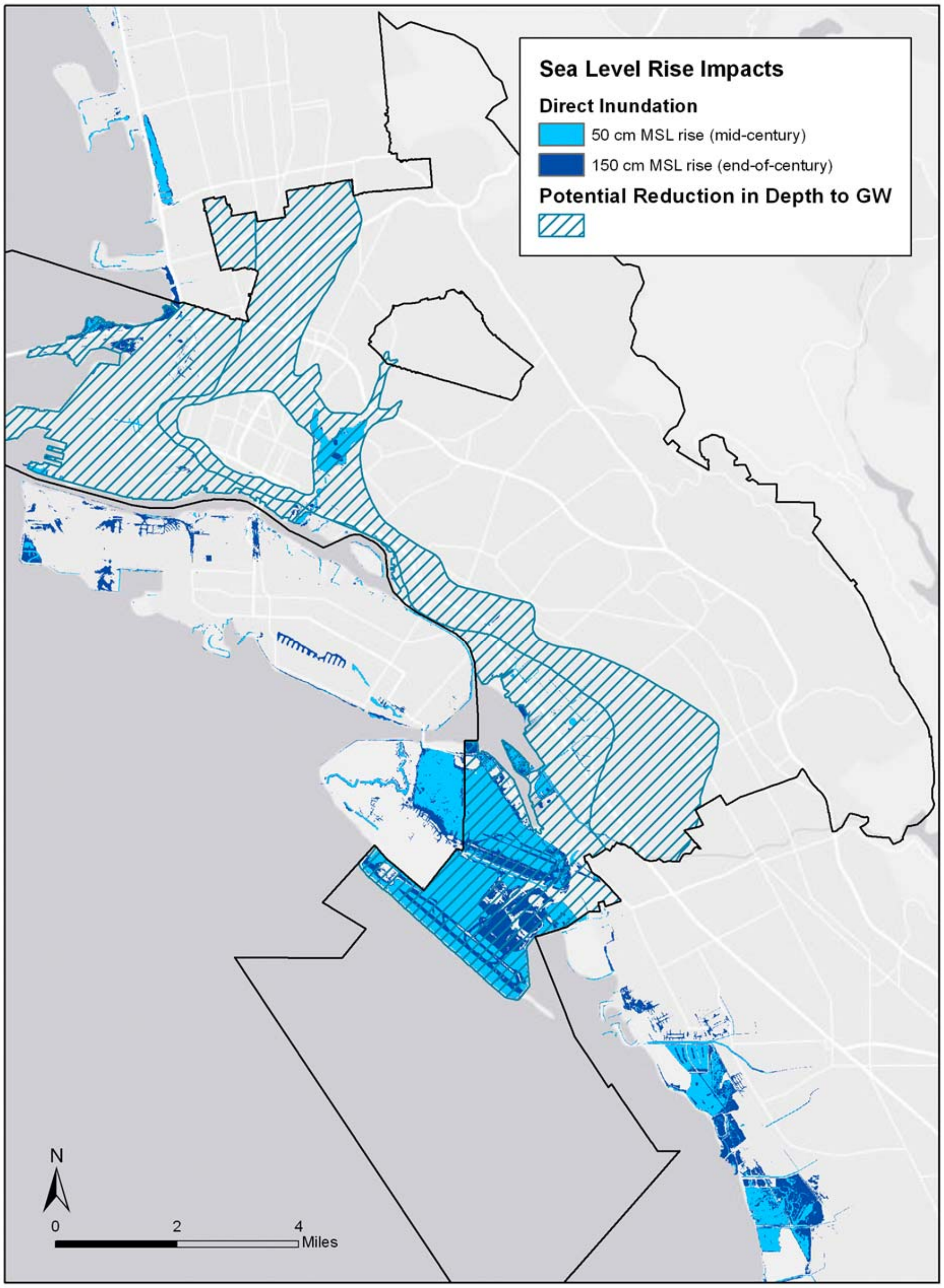


FIGURE 21

Potential Impacts from Sea Level Rise: Direct inundation areas for 50 cm mean sea level (MSL) rise (mid-century scenario) shown in light blue fill and150 cm MSL rise (end-of century scenario) shown in dark blue. Hatched area indicates potential areas with shallower depth to groundwater.



CITY OF OAKLAND GREEN INFRASTRUCTURE GUIDE

ATTACHMENT D
CAPITAL IMPROVEMENT PROGRAM WORK SHEET

City of Oakland Capital Improvement Program (CIP) Project
MRP C.3 Sign-off & GI Potential Worksheet

Use this worksheet to document:

- ***Is the CIP project a "Regulated Project" under the state's Municipal Regional Stormwater Permit (MRP) C.3 requirements?***
- ***If not, to comply with C.3.j. of the MRP, identify the project's Green Infrastructure (GI) Potential***

Project Name:

Project Address: APN:

Contact Person:

Contact Phone: Contact Email:

C.3 "Regulated Project" Review - Please check the applicable box(es):

☐ Project would create and/or replace less than 5,000 square feet of impervious area.

☐ Project would create and/or replace less than 10,000 square feet of impervious area **AND** project does not include auto service/maintenance facilities, restaurants, uncovered parking areas (stand-alone or as part of a larger project), or structures with rooftop parking.

☐ Project is a Road Project **AND** project would construct less than 10,000 square feet of new contiguous impervious area when the following are excluded from the calculation:[1]

- Sidewalks built as part of new streets or roads that direct stormwater runoff to adjacent vegetated areas.
- Bicycle lanes built as part of new streets or roads that are not hydraulically connected to the new streets or roads and that direct stormwater runoff to adjacent impervious areas.
- Impervious trails that are:
  - A. less than 10 feet wide and more than 50 feet away from the top of a creek bank.

  OR

  - B. designed to direct stormwater runoff to adjacent vegetated areas or other non-erodible permeable areas (preferably away from creeks or towards the outboard side of levees).
- Sidewalks, bicycle lanes, or trails constructed with permeable surfaces (pervious concrete, porous asphalt, unit pavers, or granular materials).
- Caltrans highway projects and associated facilities.

☐ Project consists of interior remodel.

☐ Project consists of routine maintenance and repairs (e.g., roof replacement, replacement of exterior wall surface, and/or pavement resurfacing) within the existing footprint.

☐ **The Project IS a C.3 "Regulated Project" because none of the boxes above were checked. The Project will be designed and built to comply with MRP section C.3.**

☐ **The Project is NOT a C.3 "Regulated Project" as indicated above (see checked box above).**

[1] *When calculating the impervious area of a Road Project, include all roadway surfaces related to creation of additional traffic lanes (including, for example, passing lanes and turning pockets). Shoulders and widened portion of existing lanes may be excluded from the calculation.*

If the Project is not a C.3 "Regulated Project", use worksheet to evaluate Green Infrastructure (GI) potential.[2]

The City must 1) Evaluate "non-regulated" infrastructure projects (CIP projects) to determine GI potential; 2) Briefly describe reasons green infrastructure measures were not practicable; and, 3) Maintain a list of planned and completed GI projects and CIP projects with GI potential.

☐ **YES, the project has GI potential. The project's GI design is/will be consistent with the *City of Oakland Green Infrastructure Guide* or the *Alameda County C.3 Technical Guidelines*. Stop here and sign below.**

☐ **No, the project does not have GI potential based on the following (check applicable box(es))**:

- ☐ Project includes no exterior work (for example, it is an interior remodel)
- ☐ Project involves exterior building upgrades or equipment, such as HVAC, solar panels, window replacement, roof repairs and maintenance
- ☐ Construction of new streetlights, traffic signals or communication facilities
- ☐ Minor bridge and culvert repairs/replacement
- ☐ Non-stormwater utility project (e.g., sewer or water main repairs/replacement, utility undergrounding, treatment plant upgrades)
- ☐ Irrigation system installation, upgrades or repairs
- ☐ Too early in planning process to assess the project for GI potential
- ☐ Not scheduled to begin design before December 2020
- ☐ Planned and designed before January 2016
- ☐ The project has moved to a stage of design in which changes cannot be made
- ☐ Maintenance/minor construction
- ☐ The project does not include alterations to building drainage
- ☐ Roof leaders and downspouts are up gradient from landscaped areas and paved surfaces, however, pervious pavement and or landscaped green infrastructure facilities cannot be incorporated due to ____.
- ☐ The project is a landscape or street project but after locating drainage pathways and structures, it was determined that there is not potential to substitute pervious or grid pavements for impervious paving because ____.
- ☐ After reviewing the City of Oakland Green Infrastructure Guide[3] or the other appropriate GI guidance, it was determined that the Project has no GI potential because of confirmed conflicts with subsurface utilities, very constrained site, property ownership issues, lack of water supply for irrigation, severe budget constraints, including for ongoing maintenance, project schedule constraints due to mandates or grant requirements, or: ______________________________.

Signature	Date
Name	Title

[2] *If more analysis is needed to explore a project's GI potential, see Alameda County Clean Water Program (ACCWP) Worksheet for Identifying Green Infrastructure (GI) Potential in Municipal Capital Improvement Program Projects.*

[3] See the City of Oakland Green Infrastructure Guide in Appendix B of the City of Oakland Urban Greening Plan and Grant Report: https://s3-us-west-1.amazonaws.com/beta.oaklandca.gov/pdfs/UGPGR-4-30-18-FINAL.PDF