Annual Reporting for FY 2015-2016

Regional Supplement for New Development and Redevelopment

San Francisco Bay Area Municipal Regional Stormwater Permit

B A S M A A

Bay Area Stormwater Management Agencies Association

September 2016

Alameda Countywide
Clean Water Program

Contra Costa
Clean Water Program

Fairfield-Suisun
Urban Runoff
Management Program

Marin County
Stormwater Pollution
Prevention Program

Napa County
Stormwater Pollution
Prevention Program

San Mateo Countywide
Water Pollution
Prevention Program

Santa Clara Valley
Urban Runoff Pollution
Prevention Program

Sonoma County
Water Agency

Vallejo Sanitation
and Flood
Control District

BASMAA

To Whom It May Concern:

We certify under penalty of law that this document was prepared under our direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate, and complete. We are aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

James Scanlin, Alameda Countywide Clean Water Program

Tom Dalziel, Contra Costa Clean Water Program

Kevin Cullen, Fairfield-Suisun Urban Runoff Management Program

Matthew Fabry, San Mateo Countywide Water Pollution Prevention Program

Adam Olivieri, Santa Clara Valley Urban Runoff Pollution Prevention Program

Douglas Scott, Vallejo Sanitation and Flood Control District

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INTRODUCTION

This Regional Supplement has been prepared to report on regionally implemented activities complying with portions of the Municipal Regional Stormwater Permit (MRP), issued to 76 municipalities and special districts (Permittees) by the San Francisco Bay Regional Water Quality Control Board (Water Board). The Regional Supplement covers new development and redevelopment activities related to the following MRP provisions:

- C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications,
- C.3.j.ii. Early Implementation of Green Infrastructure Projects, and
- C.3.j.iii. Participate in Processes to Promote Green Infrastructure.

These regionally implemented activities are conducted under the auspices of the Bay Area Stormwater Management Agencies Association (BASMAA), a 501(c)(3) non-profit organization comprised of the municipal stormwater programs in the San Francisco Bay Area. Most of the 2016 annual reporting requirements of the specific MRP Provisions covered in this Supplement are completely met by BASMAA Regional Project activities, except where otherwise noted herein or by Permittees in their reports. Scopes, budgets and contracting or in-kind project implementation mechanisms for BASMAA Regional Projects follow BASMAA's Operational Policies and Procedures as approved by the BASMAA Board of Directors. MRP Permittees, through their program representatives on the Board of Directors and its committees, collaboratively authorize and participate in BASMAA Regional Projects or Regional Tasks. Depending on the Regional Project or Task, either all BASMAA members or Phase I programs that are subject to the MRP share regional costs.

Low Impact Development

C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications

This provision requires:

> *Biotreatment (or bioretention) systems shall be designed to have a surface area no smaller than what is required to accommodate a 5 inches/hour stormwater runoff surface loading rate, infiltrate runoff through biotreatment soil media at a minimum of 5 inches per hour, and maximize infiltration to the native soil during the life of the Regulated Project. The soil media for biotreatment (or bioretention) systems shall be designed to sustain healthy, vigorous plant growth and maximize stormwater runoff retention and pollutant removal.*
>
> *Permittees shall ensure that Regulated Projects use biotreatment soil media that meet the minimum specifications set forth in Attachment L of the previous permit (Order No. R2-2009-0074), dated November 28, 2011. Permittees may collectively (on an all-Permittee scale or countywide scale) develop and adopt revisions to the soil media minimum specifications, subject to the Executive Officer's approval.*

In 2015, the biotreatment soil media (BSM) specification had been in use Bay Area-wide for 5 years and in that time Permittees had identified several components of the soil

specification for which review was warranted, including:

- Compost gradation specifications, soluble Boron criteria, and pH limit;
- Potential effect on stormwater treatment / retention of additives recommended by soil suppliers to augment plant health;
- Locally appropriate and available mulch options to include in biotreatment systems, for both the bottom and side slopes;
- Appropriate plant palette and irrigation requirements for biotreatment systems in drought conditions;
- How to create a living soil to enhance the performance of the treatment systems, both for pollutant removal and plant vigor; and
- Typographical errors and missing or incorrectly identified units of measurement in the specification.

In August 2015, the BASMAA Development Committee formed a Work Group on behalf of the Permittees to re-evaluate the soil specification. The Work Group took a two-step approach: first, immediately propose minor modifications to the current soil specification to ensure suppliers can deliver material that complies with the specification, and second, convene a soil specification "roundtable" (similar to the 2010 roundtable used to reach consensus on the MRP 1.0 Attachment L specification). The newly convened soil specification roundtable would investigate the need for alternative specifications that might enhance the performance of bioretention facilities under varying microclimates and drought conditions and with diverse planting palettes, including trees.

Revisions to Attachment L Specification of Soils for Biotreatment or Bioretention Facilities

The Development Committee addressed the following issues in step one:

- Compost suppliers having difficulties meeting the gradation specifications, soluble Boron criteria, and occasionally the pH limit listed in the specification; and
- Typographical errors and missing or incorrectly identified units of measurement in the specification.

The BASMAA Soil Specifications Work Group met several times, reviewed the specification regarding the two issues above, researched and made proposed changes, and vetted the proposed changes with the Development Committee and Permittees. In its January 2016 meeting, the BASMAA Board of Directors approved the transmittal of Revised Model Biotreatment Soil Media Specifications to the Regional Water Board. The revised specifications were transmitted to the Regional Water Board on February 5, 2016 (see attached) and the Regional Water Board Executive Officer approved the revised specifications on April 18, 2016 (attached).

Biotreatment Soil Media Specifications Roundtable

The BASMAA Soil Specifications Work Group also initiated a Roundtable project to start to address the remaining issues identified above. BASMAA engaged consultant assistance in February 2016 to prepare research and design considerations for updating the BASMAA Biotreatment Soil Media Specifications to incorporate considerations

regarding trees in bioretention areas. The major project tasks included a literature review and the Roundtable, which was conducted in June 2016. The Roundtable agenda and attendance list are attached. The project also resulted in three products (attached):

- *Biotreatment Soil Media and Specification: Current Research on Trees and Water Quality Treatment; Literature Review* – This report: 1) examines potential changes to the BSM and to the design of bioretention systems for the benefit of trees, 2) examines concerns with the performance of the current Biotreatment Soil Media specification, 3) addresses changes to the mix and the design of bioretention that could reduce pollutant leaching and flushing and correct identified problems, 4) provides a review of the available literature and municipal specifications for BSM, and 5) incorporates numerous interviews of experts and stakeholders involved in BSM.

- *Biotreatment Soil and Tree Roundtable Summary; Improvements for the Health of Trees* – This report provides a summary of the discussion, identifies action items from the Roundtable and a summary of the Roundtable evaluation survey responses.

- *Bioretention Design for Tree Health: Literature Review* – This report focuses on how to enhance the soil volume for trees in bioretention – one of the most important factors effecting urban tree health and is relatively limited in bioretention systems as they are currently designed.

The last product is a direct result of a recommended action item from the June 2016 Roundtable. The Development Committee expects to continue to implement action items in FY 16-17.

Green Infrastructure Planning and Implementation

C.3.j.ii. Guidance for Identifying Green Infrastructure Potential in Municipal Capital Improvement Program Projects

This provision requires Permittees to:

> *(1) Prepare and maintain a list of green infrastructure projects, public and private, that are already planned for implementation during the permit term and infrastructure projects planned for implementation during the permit term that have potential for green infrastructure measures.*

The list must be submitted with each Annual Report, including:

> *(2) … a summary of how each public infrastructure project with green infrastructure potential will include green infrastructure measures to the maximum extent practical during the permit term. For any public infrastructure project where implementation of green infrastructure measures is not practicable, submit a brief description for the project and the reasons green infrastructure measures were impracticable to implement.*

The BASMAA Development Committee initiated and competed a regional project in FY 15-16 to address this provision. A Work Group of the Committee formed in February 2016 and met several times to scope the project, and develop and review the guidance. The Development Committee received regular updates from the Work Group, and recommended and the BASMAA Board of Directors approved as a final BASMAA product in May 2016 the document: *Guidance for Identifying Green Infrastructure Potential in Municipal Capital Improvement Program Projects* (attached). The document also provides guidance to Permittees on using the Annual Report Format to provide the required information on the projects.

Note that this guidance primarily addresses the review of proposed or planned public projects for green infrastructure opportunities. Permittees may also be aware of proposed or planned private projects, not subject to LID treatment requirements, that may have the opportunity to incorporate green infrastructure. The guidance recommends that planned private projects should be addressed in the same way as planned public projects.

C.3.j.iii. Participation in Processes to Promote Green Infrastructure

This provision requires:

> *(1) The Permittees shall, individually or collectively, track processes, assemble and submit information, and provide informational materials and presentations as needed to assist relevant regional, State, and federal agencies to plan, design, and fund incorporation of green infrastructure measures into local infrastructure projects, including transportation projects. Issues to be addressed include coordinating the timing of funding from different sources, changes to standard designs and design criteria, ranking and prioritizing projects for funding, and implementation of cooperative in-lieu programs.*

The BASMAA activities described in this section provide compliance for MRP Permittees with this provision.

Grant – Urban Greening Bay Area

Urban Greening Bay Area is a large-scale, grant-funded effort to re-envision Bay Area urban landscapes to develop stormwater-friendly dense, green urban infrastructure that addresses challenges associated with climate change, infiltrates or captures stormwater and pollutants near their sources, and in turn, promotes improved water quality in San Francisco Bay. *Urban Greening Bay Area* is funded by an EPA Water Quality Improvement Fund grant awarded to the Association of Bay Area Governments (ABAG), a joint powers agency acting on behalf of the San Francisco Estuary Partnership (SFEP), a program of ABAG. The term of the *Urban Greening Bay Area* grant project is July 1, 2015 to June 30, 2018.

BASMAA is one of the subrecipients of the grant and is taking the lead on two of the grant project tasks (see attached scope of work) – a Regional Green Infrastructure Roundtable process and a Design Charrette, both of which are scheduled to be

implemented between May 2016 and May 2018.

The Regional Roundtable will be a two year process, with work groups as needed, to identify and develop a list of recommendations for integrating green infrastructure and stormwater management funding and investments with future climate change and transportation investments within the region. The Roundtable will include convening meetings with local, regional, and state stakeholders, agencies, elected officials, and staff to produce draft and final task reports that will identify and recommend possible legislative fixes, agency agreements, consolidated funding mechanisms, and other means and actions as appropriate. The Roundtable is envisioned as using innovative participatory processes that will include key experts, regulators, decision-makers, and other stakeholders to share information, solicit and discuss ideas and solutions, and to identify next steps (i.e., a roadmap), which will be summarized in the draft and final task reports.

The Design Charrette task involves coordinating with the cities of Sunnyvale and San Mateo to conduct a Bay Area design charrette to develop cost-effective and innovative "typical" designs for integrating green infrastructure with bicycle and pedestrian improvements at roadway intersections. The overall goal of developing standardized, transferable designs is to make progress in addressing the high cost of design, implementation, operations, and maintenance that inhibits the widespread use of green infrastructure and LID features. The charrette will utilize actual intersection locations in San Mateo and Sunnyvale that are as representative as possible of the common features of road segments that make up intersections found throughout Bay Area cities. Charrette participants will be solicited by BASMAA and will include multiple representatives, including contractors, engineers, landscape architects, plant specialists, and city transportation engineers and planners, and design, construction management, and operations and maintenance staff. Final designs will be constructed at the San Mateo and Sunnyvale locations to verify costs and serve as demonstration projects for other agencies throughout the Bay Area.

During FY 15-16 and early FY 16-17, BASMAA's accomplishments on the *Urban Greening Bay Area* project included:

1. Finalizing the scope of work and development of contracts with EPA and ABAG;
2. Conducting an RFP process to obtain consultant services;
3. Building a task team of BASMAA, SFEP, EPA, Water Board, and municipal representatives to further identify goals, desired outcomes, meeting formats, schedule, and Roundtable participants;
4. Developing a strategy for conducting the Roundtable meetings;
5. Preparing a project briefing sheet to help introduce the task to key stakeholders and encourage participation; and
6. Conducting informational interviews with key stakeholders.

Presentations and Comments

Presentations

In addition to the *Urban Greening Bay Area* grant efforts described above, Matt Fabry (SMCWPPP Manager, BASMAA Board member and former Board Chair) made the following presentations and comments "…*to assist relevant regional, State, and federal agencies to plan, design, and fund incorporation of green infrastructure measures into local infrastructure projects*…" These presentations helped to lay the foundation for the *Urban Greening Bay Area* grant project by raising awareness of regional issues and securing commitments from various agencies to support and participate in the project, thus benefitting all Permittees.

a. CASQA 2014 Annual Conference; "Stormwater, Climate Change, and Complete Streets – The Transportation Connection" (September 2014)
b. C/CAG "Lobby Day" in Sacramento (presentations to local legislative delegation on stormwater, transportation, and green infrastructure issues (April 2015, June 2016)
c. State of the Estuary Conference/RMP Annual Meeting; "Green Infrastructure in San Mateo: A Vision for the Future" (September 2015)
d. San Francisco Bay Regional Monitoring Program Annual Meeting; "Green Infrastructure – Planning for the Future" (October 2015)
e. American Public Works Association, Silicon Valley Chapter; "Stormwater, Climate Change, and Complete Streets – The Transportation Connection" (October 2015)
f. State Coastal Conservancy staff; "Green Infrastructure – Planning for the Future" (October 2015)
g. SPUR Water Committee; "Green Infrastructure for Stormwater Management" (December 7, 2015)
h. U.S. Environmental Protection Agency, Region 9 staff; "Green Infrastructure – Planning for the Future" (January 2016)
i. Stanford's Water in the West Program, Dr. Newsha Ajami; "Green Infrastructure – Planning for the Future" (February 2016)
j. Alameda Countywide Pedestrian Bicycle Working Group; "Green Infrastructure – Planning for the Future" (February 2016)
k. SPUR Oakland; "Growing Sustainable Communities Through Green Infrastructure"; Matt Fabry and Kristin Hathaway, City of Oakland (February 2016)

The BASMAA Development Committee also helped strengthen the connection between green infrastructure and land development/transportation planning by partnering with the American Planning Association, Northern California section, to organize and conduct a field tour and panel discussion at the 2015 APA Conference in Oakland. The sessions included the following presentations:

a. Mobile Workshop: "Green Infrastructure Bay Area: Green Infrastructure Takes Root in the East Bay"; Kristin Hathaway, Josh Bradt and Peter Schultze-Allen, moderated by Laura Prickett (October 4, 2015);
b. Panel: "Trends, Opportunities, and Challenges for Integrating Green Infrastructure

with Urban Design in the San Francisco Bay Area"; Matt Fabry, Josh Bradt, Rosey Jencks, Laura Prickett, Brent Bucknum, and Peter Schultze-Allen, moderated by John Steere (October 5, 2015).

The attendees came from within and outside of California and represented various professions in addition to planners. The mobile workshop brought attendees into the streets of the East Bay to see green infrastructure projects in El Cerrito, Emeryville, and Oakland. Design, construction, maintenance and neighborhood outreach were discussed on the tour, with the hosts giving details and insights into the projects. The panel provided an interactive discussion with the audience on green infrastructure policies and programs, identifying the challenges and opportunities to implementation.

Comments

BASMAA submitted comments to the Air Resources Board on the Urban Greening and Green Infrastructure Section of the Natural and Working Lands Discussion Paper on May 3, 2016 (attached).

ATTACHMENT

C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications

Proposed Revised Model Biotreatment Soil Media Specifications (February 5, 2016)

Alameda Countywide Clean Water Program

Contra Costa Clean Water Program

Fairfield-Suisun Urban Runoff Management Program

Marin County Stormwater Pollution Prevention Program

Napa County Stormwater Pollution Prevention Program

San Mateo Countywide Water Pollution Prevention Program

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February 5, 2016

Bruce Wolfe, Executive Officer
California Regional Water Quality Control Board
San Francisco Bay Region

Subject: Model Biotreatment Soil Media Specifications–MRP 2.0 Provision C.3.c.i.(2)(c)(ii)

Dear Mr. Wolfe:

This letter and attachments are submitted on behalf of all 76 Permittees subject to the requirements of the Municipal Regional Stormwater NPDES Permit (MRP). In December 2010, the Permittees, per Provision C.3.c.iii.(3) of the MRP[1], submitted a biotreatment soil specification to the Regional Water Board and received approval to use the specification in low impact development (LID) treatment measures. The permit was amended on November 28, 2011 to include the biotreatment soil specification as Attachment L.

The recently adopted "MRP 2.0," which took effect on January 1, 2016, allows Permittees to collectively develop and adopt revisions to the biotreatment soil media minimum specifications, subject to the Executive Officer's approval[2]. The biotreatment soil mix is required to meet the performance criteria stated in the MRP, including a long-term minimum permeability of 5 inches-per-hour over the life of the facility, support healthy plant growth, and remove pollutants.

The current biotreatment soil specification has been in use Bay Area-wide for 5 years[3]. The following immediate issues with the specification have been identified:

- Compost suppliers are having difficulties meeting the gradation specifications, soluble Boron criteria, and occasionally the pH limit listed in the specification;
- There are typographical errors and missing or incorrectly identified units of measurement.

In August 2015, the BASMAA Development Committee formed a Work Group on behalf of the Permittees to re-evaluate the soil specification. The Work Group decided to take a two-prong approach: first, immediately propose minor modifications to the current soil specification to ensure suppliers can deliver

[1] Reference is to the "original" MRP, Order R2-2009-0074, NPDES Permit No. CAS612008, adopted October 14, 2009.
[2] Provision C.3.c.i.(2)(c)(ii), Order No. R2-2015-XXXX, NPDES Permit No. CAS612008, adopted November 19, 2015.
[3] The original very similar specification was developed by the Contra Costa Clean Water Program beginning in 2007, and has been in formal effect in Contra Costa County and its 19 cities and towns since March 2009.

material that complies with the specification, and second, concurrently convene a soil specification "roundtable" (similar to the 2010 roundtable used to reach consensus on the MRP 1.0 Attachment L specification). The newly convened soil specification roundtable will investigate the need for alternative specifications that might enhance the performance of bioretention facilities under varying microclimates and drought conditions and with diverse planting palettes, including trees.

The attachment to this letter includes the following revisions to the Attachment L specification:

For the compost fraction of the mix:

1. Reduce the minimum percent of the #200 sieve size gradation from 2% to 1%;
2. Change the allowable pH range from 6.5-8.0 to 6.2-8.2;
3. Remove the soluble Boron specification;
4. Fix typographical errors, and
5. Correct missing or erroneous units of measure.

There are no proposed changes to the sand fraction of the mix.

Your approval of these minor changes will make it possible for suppliers to meet the letter of the mix specification without compromising performance of the mix. Biotreatment soil mixes having those revised specification limits have in fact been used successfully in meeting the permit requirements. Using the alternative biotreatment soil mix option in Attachment L, the products were able to meet the specification.

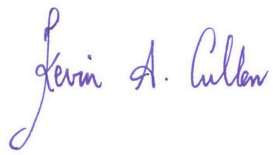
The Work Group plans to convene the stakeholder roundtable meeting during Spring 2016. We hope your staff will participate in this effort.

We thank you for your prompt consideration. If we do not hear from you by March 9, 2016, we will assume that the modified soil specification has been approved.

We certify under penalty of law that this document was prepared under our direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate, and complete. We are aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

James Scanlin, Alameda Countywide Clean Water Program

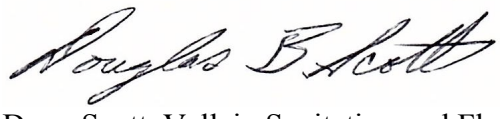
Tom Dalziel, Contra Costa Clean Water Program



Kevin Cullen, Fairfield-Suisun Urban Runoff Management Program

Matt Fabry, San Mateo Countywide Water Pollution Prevention Program

Adam Olivieri, Santa Clara Valley Urban Runoff Pollution Prevention Program



Doug Scott, Vallejo Sanitation and Flood Control District

Attachments:
Mark-up of Specification of Soils for Biotreatment or Bioretention Facilities
Proposed Revised Specification of Soils for Biotreatment or Bioretention Facilities

cc: Tom Mumley, Regional Water Board
Keith Lichten, Regional Water Board
Dale Bowyer, Regional Water Board
Sue Ma, Regional Water Board
BASMAA Board of Directors, Development Committee, and Soil Specifications Work Group

~~ATTACHMENT L~~

~~Provision C.3.c.i.(1)(b)(vi)~~

Specification of soils for Biotreatment or Bioretention Facilities

Soils for biotreatment or bioretention areas shall meet two objectives:

- Be sufficiently permeable to infiltrate runoff at a minimum rate of 5" per hour during the life of the facility, and
- Have sufficient moisture retention to support healthy vegetation.

Achieving both objectives with an engineered soil mix requires careful specification of soil gradations and a substantial component of organic material (typically compost).

Local soil products suppliers have expressed interest in developing 'brand-name' mixes that meet these specifications. At their sole discretion, municipal construction inspectors may choose to accept test results and certification for a 'brand-name' mix from a soil supplier.

Tests must be conducted within 120 days prior to the delivery date of the bioretention soil to the project site.

Batch-specific test results and certification shall be required for projects installing more than 100 cubic yards of bioretention soil.

SOIL SPECIFICATIONS

Bioretention soils shall meet the following criteria. "Applicant" refers to the entity proposing the soil mixture for approval by a Permittee.

1. General Requirements – Bioretention soil shall:
   a. Achieve a long-term, in-place infiltration rate of at least 5 inches per hour.
   b. Support vigorous plant growth.
   c. Consist of the following mixture of fine sand and compost, measured on a volume basis:
      60%-70% Sand
      30%-40% Compost
2. Submittal Requirements – The applicant shall submit to the Permittee for approval:
   a. A minimum one-gallon size sample of mixed bioretention soil.
   b. Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.
   c. Grain size analysis results of the fine sand component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils or Caltrans Test Method (CTM) C202.
   d. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in 4.
   e. Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".

f. Grain size analysis results of compost component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
g. A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
h. Provide the name of the testing laboratory(s) and the following information:

(1) Contact person(s)

(2) Address(s)

(3) Phone contact(s)

(4) E-mail address(s)

(5) Qualifications of laboratory(s), and personnel including date of current certification by USCC~~STA~~, ASTM, Caltrans, or approved equal

3. Sand for Bioretention Soil
   a. Sand shall be free of wood, waste, coating such as clay, stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be nonplastic.
   b. Sand for Bioretention Soils shall be analyzed by an accredited lab using #200, #100, #40 or #50, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422, CTM 202 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
3/8 inch	100	100
No. 4	90	100
No. 8	70	100
No. 16	40	95
No. 30	15	70
No. 40 or No.50	5	55
No. 100	0	15
No. 200	0	5

Note: all sands complying with ASTM C33 for fine aggregate comply with the above gradation requirements.

4. Composted Material

Compost shall be a well decomposed, stable, weed free organic matter source derived from waste materials including yard debris, wood wastes or other organic materials not including manure or biosolids meeting the standards developed by the US Composting Council (USCC). The product shall be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

a. Compost Quality Analysis by Laboratory – Before delivery of the soil, the supplier shall submit a copy of lab analysis performed by a laboratory that is enrolled in the US Composting Council's Compost Analysis Proficiency (CAP) program and using approved Test Methods for the Examination~~Evaluation~~ of Composting and Compost (TMECC). The lab report shall verify:
   ~~(1) Feedstock Materials shall be specified and include one or more of the following: landscape/yard trimmings, grass clippings, food scraps, and agricultural crop residues.~~
   ~~(2)~~(1) Organic Matter Content: 35% - 75% by dry wt.
   ~~(3)~~(2) Carbon and Nitrogen Ratio: C:N < 25:1 and C:N >15:1
   ~~(4)~~(3) Maturity/Stability: ~~shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable. In addition~~ Aany one of the following is required to indicate stability:
      (i) Oxygen Test < 1.3 O2 /unit TS /hr
      (ii) Specific oxy. Test < 1.5 O2 / unit BVS /hr
      (iii) Respiration test < 8 mg CO_2-C /g OM ~~unit VS~~ / day
      (iv) Dewar test < 20 Temp. rise (°C) e.
      (v) Solvita® > 5 Index value
   ~~(5)~~(4) Toxicity: Aany one of the following measures is sufficient to indicate non-toxicity.
      (i) ~~NH4- : NO3-N < 3~~ NH_4^+ : NO_3^--N < 3
      (ii) Ammonium < 500 ppm, dry basis
      (iii) Seed Germination > 80 % of control
      (iv) Plant Trials > 80% of control
      (v) Solvita® ~~=>~~ 5 Index value
   ~~(6)~~(5) Nutrient Content: provide analysis detailing nutrient content including N-P-K, Ca, Na, Mg, S, and B.
      (i) Total Nitrogen content 0.9% or above preferred.
      (ii) Boron: Total shall be <80 ppm; ~~Soluble shall be <2.5 ppm~~
   ~~(7)~~(6) Salinity: Must be reported; < 6.0 mmhos/cm
   ~~(8)~~(7) pH shall be between 6.2~~5~~ and 8.2 May vary with plant species.

b. Compost Quality Analysis by Compost Supplier – Before delivery of the compost to the soil supplier the Compost Supplier shall verify the following:
   (1) Feedstock materials shall be specified and include one or more of the following: landscaping/yard trimmings, grass clippings, food scraps, and agricultural crop residues.

(2) Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell or containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable.
(3) Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach min. 55C for 15 days with at least 5 turnings during that period.

~~b.~~c. Compost for Bioretention Soil Texture – Compost for bioretention soils shall be analyzed by an accredited lab using #200, 1/4 inch, 1/2 inch, and 1 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
1 inch	99	100
1/2 inch	90	100
1/4 inch	40	90
No. 200	1~~2~~	10

~~c.~~d. Bulk density shall be between 500 and 1100 dry lbs/cubic yard
~~d.~~e. Moisture content shall be between 30% - 55% of dry solids.
~~e.~~f. Inerts – compost shall be relatively free of inert ingredients, including glass, plastic and paper, < 1 % by weight or volume.
~~f. Weed seed/pathogen destruction – provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach min. 55C for 15 days with at least 5 turnings during that period.~~
~~f.~~g. Select Pathogens – Salmonella <3 MPN/4grams of TS, or Coliform Bacteria <10000 MPN/gram.
~~g.~~h. Trace Contaminants Metals (Lead, Mercury, Etc.) – Product must meet US EPA, 40 CFR 503 regulations.
~~h.~~i. Compost Testing – The compost supplier will test all compost products within 120 calendar days prior to application. Samples will be taken using the STA sample collection protocol. (The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: 631-737-4931, www.compostingcouncil.org). The sample shall be sent to an independent STA Program approved lab. The compost supplier will pay for the test.

VERIFICATION OF ALTERNATIVE BIORETENTION SOIL MIXES

Bioretention soils not meeting the above criteria shall be evaluated on a case by case basis. Alternative bioretention soil shall meet the following specification: "Soils for bioretention facilities shall be sufficiently permeable to infiltrate runoff at a minimum rate of 5 inches per hour during the life of the facility, and provide sufficient retention of moisture and nutrients to support healthy vegetation."

The following steps shall be followed by municipalities to verify that alternative soil mixes meet the specification:

1. General Requirements – Bioretention soil shall achieve a long-term, in-place infiltration rate of at least 5 inches per hour. Bioretention soil shall also support vigorous plant growth. The applicant refers to the entity proposing the soil mixture for approval.
   a. Submittals – The applicant must submit to the municipality for approval:
      (1) A minimum one-gallon size sample of mixed bioretention soil.
      (2) Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.
      (3) Certification from an accredited geotechnical testing laboratory that the Bioretention Soil has an infiltration rate between 5 and 12 inches per hour as tested according to Section 1.b.(2)(ii).
      (4) Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
      (5) Grain size analysis results of mixed bioretention soil performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
      (6) A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
      (7) The name of the testing laboratory(s) and the following information:
         (i) Contact person(s)
         (ii) Address(s)
         (iii) Phone contact(s)
         (iv) E-mail address(s)
         (v) Qualifications of laboratory(s), and personnel including date of current certification by STA, ASTM, or approved equal.
   b. Bioretention Soil
      (1) Bioretention Soil Texture: Bioretention Soils shall be analyzed by an accredited lab using #200, and 1/2" inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	Percent Passing (by weight) *Min* *Max*

1/2 inch	97	100
No. 200	2	5

(2) Bioretention Soil Permeability testing: Bioretention Soils shall be analyzed by an accredited geotechnical lab for the following tests:

(i) Moisture – density relationships (compaction tests) shall be conducted on bioretention soil. Bioretention soil for the permeability test shall be compacted to 85 to 90 percent of the maximum dry density (ASTM D1557).

(ii) Constant head permeability testing in accordance with ASTM D2434 shall be conducted on a minimum of two samples with a 6-inch mold and vacuum saturation.

MULCH FOR BIORETENTION FACILITIES

Three inches of m~~M~~ulch is recommended for the purpose of retaining moisture, preventing erosion and minimizing weed growth. Projects subject to the State's Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least three~~two~~ inches of mulch. 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. It is recommended to apply 1" to 2" of composted mulch, once a year, preferably in June following weeding.

Specification of Soils for Biotreatment or Bioretention Facilities

Soils for biotreatment or bioretention areas shall meet two objectives:

- Be sufficiently permeable to infiltrate runoff at a minimum rate of 5" per hour during the life of the facility, and
- Have sufficient moisture retention to support healthy vegetation.

Achieving both objectives with an engineered soil mix requires careful specification of soil gradations and a substantial component of organic material (typically compost).

Local soil products suppliers have expressed interest in developing 'brand-name' mixes that meet these specifications. At their sole discretion, municipal construction inspectors may choose to accept test results and certification for a 'brand-name' mix from a soil supplier.

Tests must be conducted within 120 days prior to the delivery date of the bioretention soil to the project site.

Batch-specific test results and certification shall be required for projects installing more than 100 cubic yards of bioretention soil.

SOIL SPECIFICATIONS

Bioretention soils shall meet the following criteria. "Applicant" refers to the entity proposing the soil mixture for approval by a Permittee.

1. General Requirements – Bioretention soil shall:
   a. Achieve a long-term, in-place infiltration rate of at least 5 inches per hour.
   b. Support vigorous plant growth.
   c. Consist of the following mixture of fine sand and compost, measured on a volume basis:
      60%-70% Sand
      30%-40% Compost
2. Submittal Requirements – The applicant shall submit to the Permittee for approval:
   a. A minimum one-gallon size sample of mixed bioretention soil.
   b. Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.
   c. Grain size analysis results of the fine sand component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils or Caltrans Test Method (CTM) C202.
   d. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in 4.
   e. Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
   f. Grain size analysis results of compost component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
   g. A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
   h. Provide the name of the testing laboratory(s) and the following information:

(1) Contact person(s)
(2) Address(s)
(3) Phone contact(s)
(4) E-mail address(s)
(5) Qualifications of laboratory(s), and personnel including date of current certification by USCC, ASTM, Caltrans, or approved equal

3. Sand for Bioretention Soil
   a. Sand shall be free of wood, waste, coating such as clay, stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be nonplastic.
   b. Sand for Bioretention Soils shall be analyzed by an accredited lab using #200, #100, #40 or #50, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422, CTM 202 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
3/8 inch	100	100
No. 4	90	100
No. 8	70	100
No. 16	40	95
No. 30	15	70
No. 40 or No.50	5	55
No. 100	0	15
No. 200	0	5

Note: all sands complying with ASTM C33 for fine aggregate comply with the above gradation requirements.

4. Composted Material

   Compost shall be a well decomposed, stable, weed free organic matter source derived from waste materials including yard debris, wood wastes or other organic materials not including manure or biosolids meeting the standards developed by the US Composting Council (USCC). The product shall be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

   a. Compost Quality Analysis by Laboratory – Before delivery of the soil, the supplier shall submit a copy of lab analysis performed by a laboratory that is enrolled in the US Composting Council's Compost Analysis Proficiency (CAP) program and using approved Test Methods for the Examination of Composting and Compost (TMECC). The lab report shall verify:
      (1) Organic Matter Content: 35% - 75% by dry wt.

(2) Carbon and Nitrogen Ratio: C:N < 25:1 and C:N >15:1
(3) Maturity/Stability: Any one of the following is required to indicate stability:
  (i) Oxygen Test < 1.3 O2 /unit TS /hr
  (ii) Specific oxy. Test < 1.5 O2 / unit BVS /hr
  (iii) Respiration test < 8 mg CO_2-C /g OM / day
  (iv) Dewar test < 20 Temp. rise (°C) e.
  (v) Solvita® > 5 Index value
(4) Toxicity: Any one of the following measures is sufficient to indicate non-toxicity.
  (i) NH_4^+ : NO_3^--N < 3
  (ii) Ammonium < 500 ppm, dry basis
  (iii) Seed Germination > 80 % of control
  (iv) Plant Trials > 80% of control
  (v) Solvita® = 5 Index value
(5) Nutrient Content: provide analysis detailing nutrient content including N-P-K, Ca, Na, Mg, S, and B.
  (i) Total Nitrogen content 0.9% or above preferred.
  (ii) Boron: Total shall be <80 ppm;
(6) Salinity: Must be reported; < 6.0 mmhos/cm
(7) pH shall be between 6.2 and 8.2 May vary with plant species.

b. Compost Quality Analysis by Compost Supplier – Before delivery of the compost to the soil supplier the Compost Supplier shall verify the following:
(1) Feedstock materials shall be specified and include one or more of the following: landscaping/yard trimmings, grass clippings, food scraps, and agricultural crop residues.
(2) Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell or containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable.
(3) Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach min. 55C for 15 days with at least 5 turnings during that period.

c. Compost for Bioretention Soil Texture – Compost for bioretention soils shall be analyzed by an accredited lab using #200, 1/4 inch, 1/2 inch, and 1 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
1 inch	99	100
1/2 inch	90	100
1/4 inch	40	90
No. 200	1	10

d. Bulk density shall be between 500 and 1100 dry lbs/cubic yard
e. Moisture content shall be between 30% - 55% of dry solids.
f. Inerts – compost shall be relatively free of inert ingredients, including glass, plastic and paper, < 1 % by weight or volume.
g. Select Pathogens – Salmonella <3 MPN/4grams of TS, or Coliform Bacteria <10000 MPN/gram.
h. Trace Contaminants Metals (Lead, Mercury, Etc.) – Product must meet US EPA, 40 CFR 503 regulations.
i. Compost Testing – The compost supplier will test all compost products within 120 calendar days prior to application. Samples will be taken using the STA sample collection protocol. (The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: 631-737-4931, www.compostingcouncil.org). The sample shall be sent to an independent STA Program approved lab. The compost supplier will pay for the test.

VERIFICATION OF ALTERNATIVE BIORETENTION SOIL MIXES

Bioretention soils not meeting the above criteria shall be evaluated on a case by case basis. Alternative bioretention soil shall meet the following specification: "Soils for bioretention facilities shall be sufficiently permeable to infiltrate runoff at a minimum rate of 5 inches per hour during the life of the facility, and provide sufficient retention of moisture and nutrients to support healthy vegetation."

The following steps shall be followed by municipalities to verify that alternative soil mixes meet the specification:

1. General Requirements – Bioretention soil shall achieve a long-term, in-place infiltration rate of at least 5 inches per hour. Bioretention soil shall also support vigorous plant growth. The applicant refers to the entity proposing the soil mixture for approval.
   a. Submittals – The applicant must submit to the municipality for approval:
      (1) A minimum one-gallon size sample of mixed bioretention soil.
      (2) Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.
      (3) Certification from an accredited geotechnical testing laboratory that the Bioretention Soil has an infiltration rate between 5 and 12 inches per hour as tested according to Section 1.b.(2)(ii).
      (4) Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
      (5) Grain size analysis results of mixed bioretention soil performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
      (6) A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
      (7) The name of the testing laboratory(s) and the following information:
         (i) Contact person(s)
         (ii) Address(s)
         (iii) Phone contact(s)

(iv) E-mail address(s)
(v) Qualifications of laboratory(s), and personnel including date of current certification by STA, ASTM, or approved equal.

b. Bioretention Soil
(1) Bioretention Soil Texture: Bioretention Soils shall be analyzed by an accredited lab using #200, and 1/2" inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
1/2 inch	97	100
No. 200	2	5

(2) Bioretention Soil Permeability testing: Bioretention Soils shall be analyzed by an accredited geotechnical lab for the following tests:
(i) Moisture – density relationships (compaction tests) shall be conducted on bioretention soil. Bioretention soil for the permeability test shall be compacted to 85 to 90 percent of the maximum dry density (ASTM D1557).
(ii) Constant head permeability testing in accordance with ASTM D2434 shall be conducted on a minimum of two samples with a 6-inch mold and vacuum saturation.

MULCH FOR BIORETENTION FACILITIES

Three inches of mulch is recommended for the purpose of retaining moisture, preventing erosion and minimizing weed growth. Projects subject to the State's Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least three inches of mulch. 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. It is recommended to apply 1" to 2" of composted mulch, once a year, preferably in June following weeding.

ATTACHMENT

C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications

Approval of Revisions to Biotreatment Soil Media Specifications in Water Board Order No. R2-2015-0049, Municipal Regional Stormwater NPDES Permit (April 18, 2016)

April 18, 2016
CIWQS Place No. 756972 (SKM)

To: Municipal Regional Stormwater NPDES Permit (Order No. R2-2015-0049) Permittees

Sent via email to:

Mr. James Scanlin, Alameda Countywide Clean Water Program: jimd@acpwa.org
Mr. Tom Dalziel, Contra Costa Clean Water Program: tdalz@pw.cccounty.us
Mr. Kevin Cullen, Fairfield-Suisun Urban Runoff Management Program: kcullen@fssd.com
Matt Fabry, San Mateo countywide Water Pollution Prevention Program: mfabry@smcgov.org
Adam Olivieri, Santa Clara Valley Urban Runoff Pollution Prevention Program: awo@eoainc.com
Doug Scott, Vallejo Sanitation and Flood Control District: dscott@vsfcd.com
Geoff Brosseau, Bay Area Stormwater Management Agencies Association: Geoff@brosseau.us

Subject: Approval of Revisions to Biotreatment Soil Media Specifications in Water Board Order No. R2-2015-0049, Municipal Regional Stormwater NPDES Permit

On February 5, 2016, the Bay Area Stormwater Management Agencies Association (BASMAA) submitted proposed revisions to the biotreatment soil media specifications referenced in Provision C.3.c.i.(2)(c)((ii) of Board Order No. R2-2015-0049, the Municipal Regional Stormwater NPDES Permit (MRP). The proposed revisions were submitted on behalf of the 76 Permittees regulated by the MRP and were submitted as allowed under and in accordance with the requirements of Provision C.3.c.i.(2)(c)((ii).

The proposed revisions address issues with the current soil media specifications that Permittees have identified, based on implementation of these soil media specifications for the last 5 years under the previous MRP. These identified issues are as follows:

- Compost suppliers are having difficulties meeting the gradation specifications, soluble boron criteria, and occasionally the pH limits listed in the specifications.
- The specifications contain typographical errors and missing or incorrectly identified units of measurement.

This letter approves the Permittees' proposed changes to the biotreatment soil media specifications referenced in Provision C.3.c.i.(2)(c)(ii) of the MRP. We understand that BASMAA intends to convene a soil specification roundtable in Spring 2016 to investigate the need for alternative specifications that might enhance the performance of bioretention facilities under varying microclimates and drought conditions and with diverse planting palettes, including trees.

If you have questions, please contact Sue Ma of my staff at (510) 622-2386 or via email to sma@waterboards.ca.gov.

Sincerely,

for Bruce H. Wolfe
Executive Officer

ATTACHMENT

C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications

Biotreatment Soil Media Specifications Roundtable Agenda and Attendance List

B A S M A A
Bay Area Stormwater Management Agencies Association

Biotreatment Soil and Tree Round Table
June 30, 2016
9:00 am – 3:00 pm
Elihu Harris State Office Building
Room #2 (Second Floor)
1515 Clay Street, Oakland, CA, 94612

9:00 – 9:15 am	Welcome/Goals for the Day/Logistics

Goals:

- Maximize the discussion of what we know now about these topics, what we do not know but want to know, and how we may go about increasing our knowledge moving forward.
- Include your voice, your concerns, and your knowledge in our consideration of whether and how to refine the current soil specification.
- Come to a consensus regarding improvements that may be made to improve the current soil specification.
- Be efficient with your time and input.

9:15 – 10:00 am	Recap of Literature Review
10:00 – 10:15 am	Break
10:15 – Noon	Breakouts – Discuss the questions provided and develop a scenario for how the soil specification might be modified or improved to ensure the long-term health of trees.

Breakout Conversation Rules:

- Note taker will write down what is said without censoring or changing it.
- Allow each participant an opportunity to speak.
- Share information and answer questions from your professional expertise. If you have practical considerations stemming from another participant's suggestion, please mention it.

Noon - 1:00 pm	Lunch (provided)
1:00 – 2:45 pm	Summary/Highlights/Group Discussion

Report out from the morning breakout session. Participants will engage in discussions to try to develop a consensus on an approach for an alternative or revised soil specification.

2:45 – 3:00 pm	Wrap-up/Next steps

- Overview of consensus points
- Further opportunities to participate
- Fill out evaluation forms

9/23 NO VISUAL TAKE

Attendance	First Name	Last Name	Email	Interested in follow-up information?
	Alex	McDonald	alex.mcdonald@dot.ca.gov	
	Alexander	Lopez		
	Allan	Laca	alaca@woodrodgers.com	yes
	Amber	Schat	Amber.Schat@sanjoseca.gov	
	Annmarie	Lucchesi	alucchesi@soilandplantlaboratory.com	yes alucchesi@waypoint analytical.com
	Ann-Marie	Benz	annmarie@bayfriendlycoalition.org	
	Bill	Sowa	bsowa@hmhca.com	YES
	Brian	Currier	dorothy.abeyta@sanjoseca.gov brian.currier@owp.csus.edu	yes.
	Christine	Boschen	cboschen@waterboards.ca.gov	
	Connie	Goldade	connie@community-design.com	yes
	Dale	Bowyer	dbowyer@waterboards.ca.gov	
	Dan	Cloak	dan@dancloak.com	
	David	Swartz	dswartz@fremont.gov	
	David	Haas	David.Haas@fire.ca.gov	
	Dorothy	Abeyta	dorothy.abeyta@sanjoseca.gov	
	Elizabeth	Lanham	elizabeth.lanham@davey.com	yes
	Glenn	Flamik	Glenn.Flamik@fire.ca.gov	
	Glenn	Bohling	GBohling@republicservices.com	
	Greg	Balzer	gregory.balzer@dot.ca.gov	YES
	hardeep	takhar	hardeep.takhar@dot.ca.gov	
	Igor	Lacan	ilacan@ucanr.edu	
	Jack	Broadbent	jack.broadbent@dot.ca.gov	
	Jeff	Sinclair	jeff.sinclair@sanjoseca.gov	Yes
	Jill	Bicknell	jcbicknell@eoainc.com	
	Jing	Wu	jingw@sfei.org	
	Katheryn	Kim	Kkim@woodrodgers.com	Yes
	Kelly	Schoonmaker	KSchoonmaker@stopwaste.org	Yes
	Kelly	Carroll	kcarroll@wvcwp.org	
	LeighAnna	Johnson		
	Matt	Moore	matt@tmtenterprises.net	Yes
	Meagan	Hynes	info@talussoil.com	YES
	Megan	Stromberg	stromberg@wra-ca.com	
	Mike	Adamow	MAdamow@sfwater.org	
	Nabiul	Afrooz	rnabiul@stanford.edu	yes
	Nelda	Matheny	nelda@hortscience.com	yes
	Norman	Gonsalves	norman.gonsalves@dot.ca.gov	

	Nyoka	Corley	Shannan.Young@dublin.ca.gov	Nyoka.corley@Gmail.com
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	Sarah	Sutton	ssutton@placeworks.com	
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	Shawn	Freedberg	shawn@deeproot.com	yes
	Sue	Ma	sma@waterboards.ca.gov	
	Teresa	Eade	teade@stopwaste.org	
	Tom	Dalziel	tom.dalziel@pw.cccounty.us	
	Walter	Passmore	walter.passmore@cityofpaloalto.org	
	Will	Bakx	willbakx@sonomacompost.com	Yes
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	Call-in Participants			
	Wilfung	Martono	wilfung.martono@dot.ca.gov	
	Terrence Bottomley		tbottomley@bottomleydp.com	
	Kevin Robert	Perry	kevin@urbanraindesign.com	
	Bhaskar	Joshi	bhaskar.joshi@dot.ca.gov	

NAMETAGS ON TABLE

RACHEL ROBERTS

BRIAN ROWLEY

ATTACHMENT

C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications

Biotreatment Soil Media and Specification: Current Research on Trees and Water Quality Treatment; Literature Review

Biotreatment Soil Media and Specification:

Current Research on Trees and Water Quality Treatment

Literature Review
San Francisco Bay Area, California

Prepared For:

BASMAA
Contact: Shannan Young
Shannan.young@dublin .ca.gov

WRA Contact:

Megan Stromberg
stromberg@wra-ca.com

Date:

September 14, 2016

WRA #20066

ENVIRONMENTAL CONSULTANTS

2169-G East Francisco Blvd., San Rafael, CA 94901 (415) 454-8868 tel (415) 454-0129 fax info@wra-ca.com www.wra-ca.com

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List of Appendices

1.0 INTRODUCTION

Provision C.3 of the Municipal Regional Permit (MRP) requires that biotreatment (or bioretention) systems use biotreatment soil media (BSM) that meets the minimum specifications of the BASMAA BSM Specification. Like other municipalities around the country, the BASMAA Specification requires the BSM to be a mixture of sand and compost (Appendix A):

60% - 70% Sand
30% - 40% Compost

The Bay Area Stormwater Management Agencies Association (BASMAA) and its associated members have identified items of concern with the current specifications for BSM. In particular, trees have failed to thrive in bioretention systems. Trees have a number of potential benefits when included in bioretention: increased nutrient uptake, reduced stormwater runoff through rainfall interception and evapotranspiration, enhanced soil infiltration, soil stabilization, increased aesthetic appeal, wildlife habitat, and shading. Trees have been shown to capture stormwater, reducing the runoff volume directly and potentially reducing peak flows. Tree roots can also directly enhance infiltration rates. Studies in collaboration between Cornell, Virginia Tech, and University of California at Davis showed that black oak and red maple tree roots can penetrate compacted subsoils and increase infiltration rates by an average of 153% (Day and Dickinson 2008).

This report examines potential changes to the BSM and to the design of bioretention systems for the benefit of trees. A variety of potential additives to the BSM have been studies and have the potential to increase water holding capacity and/or compensate for minimal soil volume available in bioretention systems.

Additional concerns with the performance of the current BSM mix are also examined. In particular, nutrient and other pollutant leaching and flushing from bioretention has emerged as a concern in many municipalities. This report addresses changes to the mix and the design of bioretention that could reduce pollutant leaching and flushing.

Lastly, within the current specification, there are a number of improvements that can be made to correct identified problems. These items include:

- Sand Analysis: A need to qualify the sand source due to potential for toxicity, high pH, or other contaminants.
- Compost particle size gradation changes:
- Provide corrections to the infiltration test methods for meeting the alternative specification

This report provides a review of the available literature and municipal specifications for (BSM). In addition, numerous interviews of experts and stakeholders involved in BSM were conducted and incorporated into the report. Experts and stakeholders include: municipal representatives, soil and compost testing laboratories, soil suppliers, urban foresters, and stormwater soil researchers.

This report was presented at Roundtable hosted by BASMAA on June 30, 2016 which is summarized in a separate report dated July 27, 2016 (BASMAA 2016).

2.0 POTENTIAL ADDITIVES OR CHANGES TO BIOTREATMENT SOIL MIX TO BENEFIT TREES AND WATER QUALITY

Biotreatment Soil Mix (BSM) is designed to balance the needs to sustain healthy soil and plant growth, to optimize water quality treatment, and provide an infiltration rate of between 5 – 12 inches per hour. BSM in the Bay Area and in many other regions is a mix of 60% - 70% Sand and 30% - 40% Compost. Most municipalities and researchers (SFEI, San Diego, Seattle, Redmond, Washington State) expressed concern that high levels of nutrients and other pollutants are leaching from bioretention BMPs using the compost/sand BSM (Gilbreath, et al. 2015, BES City of Portland, 2010, RICK Engineering 2014, Herrera 2015, Hinman, personal communication 2016). San Diego, San Francisco, and Seattle have adopted specifications within the last 12 months that adjusted their mix to reduce the proportion of compost to a maximum of 30% by volume in response to this concern.

These concerns are backed by recent studies. Herrera Environmental Consultants, in a study for the City of Redmond, Washington, reports that of 19 different BSM mixes tested, the 60% sand and 40% compost mix was the worst performer in terms of pollutant flushing and pollutant reduction. Curtis Hinman confirmed that after testing numerous different potential BSM mixes, all mixes that contain compost and sand flushed pollutants initially and continued to leach over time (Hinman, personal communication 2016). Most notably, the 60/40 mixes leached nitrogen, phosphorous, and copper.

Others, including Caltrans, are concerned that bioretention BMPs may flush solids when first installed (Penders, personal communication, 2016). BASMAA has identified additional concerns with tree survival and the need for heavy irrigation in the drought limited Bay Area. This section reviews alternative mixes and additives to address tree health and water quality improvements.

Overall, much research has been done in recent years to identify BSMs that improve water quality performance of bioretention BMPs. Emerging trends in municipal specifications point toward providing for recommended alternative mixes to target different goals such as nutrient reduction, or metals reduction, or supporting trees. In general, the standard sand and compost mix is broadly available in our region and the cheapest. Most of the additives will add considerable cost and may need to be shipped from other parts of the country or world (Butch Voss, personal communication, 2016). However, the additional cost may be warranted to meet water quality goals or tree/plant performance goals in some locations.

At this time, research regarding plant growth in various BSMs is much more limited. Some studies of plant performance in alternative mixes are being launched in coming months. Nonetheless, this section summarizes the available research on both the water quality treatment potential and the potential to benefit trees and plants of each additive below.

2.1 Alternative Mixes in Specifications

In general, most municipalities allow for the use of alternative BSM mixes with additional performance testing to ensure they meet the performance criteria. Curtis Hinman feels that the standard 60/40 sand compost mix may be “just fine” for many locations, namely those that are not sensitive to nutrients or copper, and those without underdrains (Personal communication 2016). However, he sees municipalities moving towards a range of alternative mixes.

This is taking place in California as well. The City of San Francisco allows the replacement of up to 15% of the sand volume with other media or soil admixtures to enhance moisture retention capacity of the soil, provided admixtures are low in fines (less than 5% passing the 200 sieve) and do not break down under normal handling and use. However, San Francisco bars the use of topsoil, peat, silts, or clays as admixtures and any materials deleterious to plant growth. San Diego recently adopted recommended alternative BSM mixes including a mix with coconut coir for certain areas sensitive to phosphorous (see below for more detail).

2.2 Topsoil in Biotreatment Soil Mixes

In the San Diego Region, concern for the leaching of nutrients lead the County to evaluate and ultimately revise their BSM specification. Based on input from a task force that included engineers, soil agronomists, landscape architects, and geotechnical engineers, it was deemed important to introduce a sandy loam topsoil component that would still allow good plant growth but reduce the potential leaching of nutrients associated with high levels of organics in the compost. The collective agreement resulted in a mixture (by volume) of 65% sand, 20% Sandy Loam, and 15% Compost. This mix results in approximately 1.5% to 5% organic matter (by weight), once mixed (RICK Engineering, 2014). This mix was adopted and incorporated into the County of San Diego LID Handbook in 2014.

In contrast, the City of San Diego in its most recent *Stormwater Guidebook* (2016), the adopted a standard BSM of sand and compost only, but they encourage use of an alternative mixes for improving plant growth and performance in some areas. The standard mix is 70% to 85% by volume washed sand and 15% to 30% by volume compost 'or alternative organic amendment'. In order to reduce the potential for leaching of nutrients, the City requires that the proportion of compost or alternative organic amendment in the mix is "held to a minimum level that will support the proposed vegetation in the system" (City of San Diego 2016). San Diego allows for 'natural soils' subject to approval by the City Engineer.

In areas where phosphorous is associated with water quality impairment or a Total Maximum Daily Load (TMDL) and underdrains are required, the City recommends replacing the compost component with coco coir pith (see below) or adding an activated alumina polishing layer below the standard BSM to control phosphorous leaching. These recommended alternatives were added per the advice of Geosyntec consultants (Talamayan, personal communication, 2016). According to Jonard Talamayan at the City of San Diego, not many projects were installed while the topsoil BSM was in place. Of primary concern in their region has been the availability of the mix components rather than tree performance but few installations have taken place with trees to date.

CalTrans recently undertook testing of BSM that was a mix of 50% sand, 25% compost, and 25% topsoil (by weight). The mix was designed to have a higher fines content to retain moisture and support grasses and forbs. After 5 years, the overall long-term average infiltration rate was 15 in/hr despite the inclusion of added fines in the mix. In addition, vegetation (grasses) density was healthy and the sites showed improved water quality. Specific water quality data is not yet avialable (CalTrans 2016).

The City of Portland also allows for the inclusion of topsoil in their stormwater facility mix. Their specification calls for "any material that is a blend of loamy soil, sand, and compost that is 30-40% compost (by volume) and meets the other criteria" (City of Portland 2014). Other criteria include a particle size gradation limiting fines in the overall mix, however, hydraulic conductivity or infiltration testing is not required.

In Washington State, numerous studies are on-going to find superior alternatives to the standard sand and compost BSM and reduce pollutant flushing and leaching (Hinman, personal communication, 2016). One study for the City of Redmond Washington, evaluated a mix of 50% Sand and 50% Loamy Sand Topsoil. They tested two mixes to compare two separate sources of loamy sand topsoil. Overall, they found that compared to other BSM mixes, the loamy sand mix exported fewer nutrients but had the poorest infiltration rates at between 1.3 and 5.1 in/hour, based on lab permeability testing (Herrerra Engineering 2015). Herrera Environmental Consultants recommends against the use of the loamy sand mix because of the inconsistency of hydraulic performance. As a part of the Herrera Environmental Consultants study, the 'Loamy Sand Mix' was also tested for its ability to support plant growth (primarily grasses). In comparison to the 60/40 sand and compost mix, the loamy sand mix plant community was not as robust; however, the plant community was still healthy, indicating that growing conditions are at least favorable in the loamy sand mix.

2.3 Biochar in Biotreatment Soil Mixes

Biochar is made from biomass via pyrolysis, a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen. Raw biochar has no nutrients but it serves as a structure or lattice that can hold nutrients and water to improve soil structure (MacDonagh 2016). This internal carbon architecture is so stable that microorganisms can flourish there, and the long-term stable symbiotic root/microorganism relationships build more sustainable soil environments for tree function. The outcome of enhancing the nutrient- and water-holding capacity and biotic community, is that biochar strengthens soil structure and arrests soil leaching (Fite 2015). When added to soil along with compost, or otherwise activated with fertilizer, the response of trees is greater than with either raw biochar or compost alone (Fite and Macdonagh 2016).

Biochar also has the potential to improve water quality treatment of stormwater in bioretention applications. According to a study out of Oregon State University, researcher Myles Gray found that filtration with biochar alone removed copper and zinc from runoff at a boatyard in Washington State. This study used rinsed biochar, which had the fines removed from the raw biochar material (Gray 2015).

Other studies have examined biochar as an additive to typical sand-compost BSM. Herrera Environmental Consultants tested a mix containing 60% sand, 15% Compost, 15% Biochar, and 10% shredded bark (Herrera Environmental Consultants 2015). As compared to the Bay Area BSM, this mix has less compost but the same quantity of sand. The results showed that the biochar mix had a lower infiltration rate (6.0 in/hr) and seemed to be a source of nutrients. According to the study, the systems with the standard sand-compost mix exported the highest levels of copper, while the systems with biochar exported the highest levels of nutrients. The reduction in infiltration rate with the biochar additive is most likely because the biochar used in this study contained fines (Herrera Environmental Consultants 2015). According to Macdonagh and Fite (2016), washed biochar could be specified to avoid reduction in hydraulic performance. However, according to Curtis Hinman, washed biochar has also been shown to export nutrients and reduce the infiltration rate (personal communication, 2016).

Other studies show biochar has a significant benefit to plants when added under certain conditions. Cao et. al. (2015) studied a biochar mix for use in greenroof soil media and found that biochar significantly increased water retention in green roof substrates. Additional water was plant available and wilting was delayed by 2 days. Kelby Fite, Arboriculture Researcher

with the Bartlett Tree Laboratory, conducted research on biochar amendments for street trees. Fite's research revealed that for trees, Biochar should be added to soil at a rate of no more than 5% by volume. When added at greater volumes, plant benefits level off or decline. He believes this may be because the biochar can hold too tightly to water and nutrients (Fite and MacDonagh 2016).

Fite's research and experience revealed a number of additional recommendations for soil amendment with biochar which he described in a recent presentation (Fite and MacDonagh 2016):

- Characteristics of biochar vary based on the feed source and how it is made.
- There are no known open-source specifications for biochar, however, the International Biochar Initiative provides standards for selecting a biochar.
- Biochar for trees is best from a hardwood feed source.
- According to MacDonagh, for low flow bioretention applications, biochar does not cause clogging; however, washed biochar may reduce compromises to hydraulic capacity.

2.4 Coconut Coir Pith in Biotreatment Soil Mixes

Coco coir pith, or coconut coir, is a byproduct of the coconut industry and has previously been used as an alternative to peat moss in soil-less media. This product is not produced in the US and must be shipped from Asia.

In terms of BSM, coco coir pith is recommended in City of San Diego's most recent guidebook as an alternative to compost in areas where phosphorous is associated with water quality impairment or a Total Maximum Daily Load (TMDL) and underdrains are required. No specification for the type or quality of the coco coir is provided.

Curtis Hinman (pers. Communication 2016) and Herrerra Engineering (2015) also identify coconut coir (or coco coir pith) as an additive with potential as an alternative to compost. In their study, they tested a number of BSMs with coco coir replacing the compost component (Herrera Environmental Consultants 2015). The mixes tested included:

- 80% sand, 20% coconut coir
- 70% sand, 20% coconut coir, 10% diatomaceous earth
- 70% sand, 20% coconut coir, 10% granular activated carbon
- 70% sand, 20% coconut coir, 10% high carbon wood ash

The coconut coir mixes outperformed the 60% sand/40% compost mixes in terms of pollutant flushing and pollutant leaching. Basic tests of plant germination and growth were conducted on these mixes with cucumber, barley and clover. All mixes germinated plants. Mixes with compost were the best performers.

Plant growth studies in the context of bioretention systems, beyond the basic germination test, haven't been conducted but Washington State is about to begin some studies in 2016. In general, coconut coir has been shown to promote plant growth and it has been used as an alternative to peat in many hydroponic products. Some negative results have been reported when no other soil is present. Bugbee (2005) indicates that media with more than 50% coir may have reduced growth because of nitrogen immobilization and a high C:N ratio in the coir. Other studies find that coir has a high potassium and low calcium content, and potentially high sodium

levels. Lastly, there are different types of coconut coir available on the market and one may be better than others in supporting plants.

2.5 Vermicompost in Biotreatment Soil Mixes

Vermicompost, also known as worm compost or worm castings, uses earthworms and microorganisms to turn organic wastes into high quality compost. The chemical secretions in the earthworm's digestive tract help break down soil and organic matter, so the castings contain more nutrients that are immediately available to plants. The level of nutrients in compost depends upon the source of the raw material and the species of earthworm; however, in general, vermicompost contains higher percentage of macro and micronutrients than traditional 'hot' compost (Nelson 2010). Vermicompost can also be produced at a faster rate than traditional compost. Vermicompost generally always has a high percentage of fines, whereas traditional compost can vary considerably depending on the feed source and processing. The "quality of the fines" is also an important consideration. Assaf Sadeh of Soil Control Lab, indicated that in his experience of testing BSM for permeability, worm castings are highly compressible such that if compacted, no water will infiltrate through a BSM containing a high proportion of vermicompost (Sadeh, personal communication, 2016).

Researchers at Cornell University Department of Plan Pathology and Plant Microbe Biology have shown that vermicompost has potential for plant nutrient management and suppression of plant disease especially for container plants without synthetic fertilizers (Nelson 2010). However, no other studies were identified to evaluate vermicompost over traditional compost for use in BSM. Anecdotally, in San Diego, prior the establishment of a BSM including topsoil, some soil suppliers were experimenting with alternative BSM mixes that included vermicompost (RICK Engineering 2014), but no data on its performance was available.

2.6 Perlite in Biotreatment Soil Mixes

Perlite is a mined material that is quickly heated to expand the mineral. Perlite has been utilized in stormwater treatment facilities and is comparable to sand. Perlite is also used in soil-less media in combination with peat or coco coir to grow plants. Perlite improves drainage and wicks water well much like sand but is more porous. It dries out quickly between rain events or watering. Perlite is not widely used in bioretention mixes although it is specified as part of the BSM in Montgomery County, Maryland. The planting media specified includes 1/3 perlite, 1/3 compost, and 1/3 topsoil (Montgomery County 2005). Studies of perlite for use in media filters have shown it to be superior in capturing fine particles and metals (Wigart 2011). Perlite could be considered as an alternative to the sand component but it appears to have minimal or no benefit for plants and is considerably costlier than sand meeting the current specification.

2.7 Volcanic Sands in Biotreatment Soil Mixes

Volcanic sand is an alternative to silica based sands such as those commonly used to meet the BASMAA Specification. Volcanic sands are more porous than sand specified in the current specification. Their pores can hold air and water and create favorable conditions for rich microbial life and strong root systems. Laboratory tests by researchers in Washington showed that volcanic sand and compost BSM reduce some pollutants in water more effectively that riverine sands mixed with compost (Gealogica 2015). Preliminary research by Gealogica has also shown volcanic sands surpass riverine sands in plant growth. As a pilot project in Washington, researchers installed identical planter boxes with either 60% volcanic sand and 40% compost or 60% riverine sand and 40% compost. After eight months, the planter boxes

with the volcanic sands grew to a height that was 140-160% greater than the sedges in the silica sand mix with the same compost component. Tests also revealed that the volcanic sand mixes held water for longer periods of time (Amy Waterman, personal communication 2016). Fassman-Beck et al. (2015) also found that pumice sand had greater than 2.5 times the plant available water as compared to marine sands.

Herrera Environmental Consultants (2015) also tested a number of BSM mixes containing volcanic sand. In all cases, the compost component was either reduced to 10% or replaced with coco coir pith. As described above, the alternative volcanic sand was tested because previous studies had indicated that C-33 sand (the sand commonly used for BASMAA specified bioretention in Seattle and our region) tend to have a higher copper content than other sands. In contrast, the volcanic sand does have a lower copper content and did not leach copper. Volcanic sands could be considered as an alternative to the sand component to reduce copper leaching or possibly improve water holding capacity. Volcanic sands are also being studied for their potential use in polishing layers as described in Section 6 below.

2.8 Diatomaceous Earth in Biotreatment Soil Mixes

Diatomaceous earth or diatomite is the fossilized skeletal remains of single celled aquatic plants called diatoms. Diatomaceous earth is harvested from sedimentary rock and has been widely used as a material for water treatment for over 100 years in the chemical, beverage industries, and potable water production (Marsh 2004). Diatomaceous earth is naturally porous mineral and has the potential to increase drainage, oxygen access, and cation exchange capacity in soil. The pores trap bacteria, clay particles, and other suspended solids. It is also commonly used to repel insects without use of pesticides. Manufacturers recommend an amendment rate of between 5-10% to improve infiltration, reduce compaction, and to increase water availability in the soil. Researchers have confirmed that it can improve soil physical properties including soil moisture content under laboratory conditions when incorporated at a rate of 10% to 30% (Aksakal 2012).

Herrera Environmental Consultants (2015) tested a number of BSM mixes containing diatomaceous earth. Mixes tested contained 70% volcanic sand, 10% diatomaceous earth, and either 20% iron-coated wood chips or 20% coconut coir pith. These mixes out-performed the standard 60/40 sand and compost mix for nutrient and copper reduction. Herrera Environmental Consultants performed basic tests of plant germination and growth on the mixes with cucumber, barley and clover plants. All mixes germinated plants; however, mixes with compost were the best performers for plant coverage and biomass.

2.9 Fines in Biotreatment Soil Mixes

Fines are the clay and silt fraction of soil. Fines are beneficial for bioretention because they increase soil water and nutrient holding capacity, they improve pollutant removal, and they improve soil structure (Shanstrom 2016). Conversely, they have been associated with clogging and are more likely to flush out of a facility.

BSM specifications typically greatly limit fines content in order to protect from failure due to clogging. The current BASMAA specification limits fines (those passing the 200 sieve size) to a maximum of 5% for the sand component and up to 10% in the compost. The lower limit of fines in the compost was recently reduced from 2% to 1%. While this ensures that suppliers are meeting the required permeability, it also likely reduces the water holding capacity of the mix.

More “mature and stable” compost typically has more fines because the material has spent more time decomposing. More mature compost, is typically higher in nutrients – particularly nitrogen. Medium-coarse composts, produced from green waste material, typically more woody, less mature, together with a higher C:N ratio, seem to release less nitrogen than the finer, more mature products. (Greg Balzer, Caltrans, personal communication 2016)

Fines have been documented to contribute to clogging but other factors may mitigate their importance in hydraulic conductivity. Natural soils have better soil structure and therefore higher infiltration rates than an engineered soil with the same particle size profile. Some studies of infiltration rates in bioretention basins show that rather than decreasing over time due to clogging, many bioretention cells exhibit an increase in infiltration rates (Shanstrom 2016).. Lucas (2010) observed 21 bioretention systems in Australia. In systems with initial infiltration rates of over 7 in/hr, rates declined towards an average infiltration rate of 4 in/hr. In contrast, in systems with an initial rate of 0.4 in/hr, these systems increased over time to average nearly 0.8 in/hr, presumably due to the development of macropores (Le Coustumer et al. 2007). Other studies in the US also showed an increase in infiltration rates over time in rain gardens with sand and clay soils (Selbig and Baster 2010, Jenkins et al. 2010). Numerous basins have been documented to have infiltration rates above 1” per hour and up to 6” per hour with greater than 12% fines (Shanstrom 2016, Wardynski et al 2012). Possible explanations for this phenomenon are the presence and development of macropores in healthy soils. Growth and death of plants, earthworms, and other soil organisms can create soil structure than enhances permeability (Shanstrom 2016).

Besides clogging, variable compaction is another possible explanation for the variability seen in BSM that allow for natural soils and fines. Compaction has been shown to decrease infiltration by up to an order of magnitude (Pitt et al. 2008).

2.10 Granular Activated Carbon in Biotreatment Soil Mixes

Granular activated carbon (GAC), like biochar, is a form of stable carbon processed to have small pores that increase the surface area available for adsorption. It has been used for a number of years in water treatment and deodorizing systems. GAC can be specified at various sizes similar to sand. Infiltration rates are typically comparable or faster than sand depending on the specification of the granule size. GAC is one of the costliest additives available and is not made in California.

Pitt and Clarke (2010) in a comparison of filter media including local sand, rhyolite sand, peat moss, surface modified zeolite, and combinations of these materials, found that GAC provided the best reductions in pollutants including copper, lead, and dioxins. GAC was also shown to provide superior performance for removal of metals in the studies by Herrera Environmental Consultants (2015, 2016).

GAC alone does not provide any nutrients to plants. In water treatment studies, GAC was observed to provide sorption of dissolved organic nitrogen but was ineffective for phosphorous attenuation (Wendling 2013). GAC is not locally available and is the most expensive potential additive reviewed in this report.

2.11 High Carbon Wood Ash in Biotreatment Soil Mixes

High carbon wood ash is a waste product from electricity generation wood-fired boilers. Wood ash contains high concentrations of carbon and exhibits some of the properties of GAC and

biochar, like high surface area and cation exchange capacity, but is generally cheaper.

Andrew Carpenter of Northern Tilth prepared a study of high carbon wood ash as a soil amendment. He found that the benefits of wood ash include: neutralization of soil acidity, reduction of aluminum toxicity, increased phosphorous availability, provides a source of some micronutrients but is not a source of nitrogen. In his study of germination and growth, wood ash amended soils showed increased cucumber and tomato plant growth after five weeks. When amended at 10% by volume with wood ash, the soil also had greater porosity and water holding capacity (Carpenter 2013). Another recent study in boreal peatland forests showed that amendment with granulated wood ash increased microbial activity and tree growth over two years (Maljanen et al. 2014).

Herrera Environmental Consultants (2015, 2016) tested this product in combination with sand and coconut coir in a mix that contained 70% sand, 20% coconut coir and 10% high carbon wood ash. Hinman believes this mix has the most potential to avoid nutrient and metals flushing after installation and leaching over the long-term for bioretention basins (personal communication, 2016). Basic tests of plant germination and growth were conducted on this mix with cucumber, barley and clover. While this mix did germinate plants, the mixes containing compost outperformed this mix for plant germination and growth.

2.12 Availability and Cost of Additives

We reached out to local suppliers to provide some insight to the costs and feasibility of obtaining additives locally in the Bay Area. Some items were not readily available locally and would require further research to establish a supply chain. In their similar study of costs, Herrera Engineers concluded that the use of additives improves water quality but adds cost to the BSM.

Table 6. Relative Cost of Bioretention Soil Components

Additive	**Potential % in mix by volume**	**Cost per yard (delivered to Bay Area)**	**Nearest Origin (bulk)**
BASMAA Compost	10% - 40%	$15 - 25	Bay Area
BASMAA Sand	50% - 90%	$40 - 45	Bay Area
Biochar, washed	Up to 5%	$350.00[1]	unknown
Coconut Coir Pith	20%	$176.7[1]	India, SE Asia, South Pacific
Vermicompost	15% to 40%	Bulk source not identified	unknown
Perlite	Up to 5%	$50 - 75	Bay Area
Volcanic Sand (Scoria, Pumice)	50% - 70%	$55 - 60	Bay Area
Diatomaceous earth	10%	$300.00[1]	unknown
Clay (clean, non-dredge)	1% - 5%	$15 - 40	Bay Area
Granular Activated Carbon	10%	$718[1]	Nebraska
High Carbon Wood Ash	5-10%	$300[1]	unknown

[1]Local costing not available. Costs based on Seattle sources provided by Herrera Environmental Consultants (2016)

3.0 MODIFICATIONS TO THE CURRENT SPECIFICATION

This section reviews the potential changes to the current BSM Specification. Through working with the current specification BASMAA identified the following problems that warrant consideration:
These items include:

- Sand Analysis: A need to qualify the sand source due to potential for toxicity, high pH, copper, or other contaminants.
- Does the compost particle size gradation provide adequate balance between hydraulic conductivity and treatment?
- Provide corrections to the infiltration test methods for meeting the alternative specification

3.1 Sand Analysis and Qualification

BASMAA identified concerns that the sand component has the potential to contain toxins, high or low pH, or other contaminants. Anecdotally, at least one submitted BSM contained dredge sand material. Caltrans and Washington State also identified issues with potential contamination of the sand component.

Sean Penders, Senior Engineer at Caltrans, describes instances when the sand source was not uniform. Qualifying tests were conducted on the top of the sand pile, while the bottom of the sand pile contained significantly higher proportion of fines resulting in the export of solids from the built bioretention basin.

Herrera Consultants undertook synthetic precipitation leaching protocol (SPLP) testing of the sand component of the BSM mix for the City of Redmond, Washington. The Herrera results indicate that C-33 sands tend to have a higher copper content than other sands. They found that volcanic sands exhibit lower leachable copper levels (Herrera 2015). However, C-33 sand is inexpensive and locally available. Herrera recommends adding a requirement to test for copper in the C-33 sand for default and custom blends. The synthetic precipitation leaching protocol testing is relatively cheap whereas, requiring volcanic or other washed sand sources may add considerable cost to the BSM mix. Anecdotally, Curtis Hinman of Herrera Consultants tested several sands from the Puget Sound region and only found two sands that passed the synthetic precipitation leaching protocol testing (personal communication 2016).

The City of San Diego now specifies chemical suitability testing of the mixed BSM for systems with underdrains. Suitability criteria were established for Nitrate, Phosphorous, Zinc, Copper, Lead, Arsenic, Cadmium, Mercury and Selenium. San Diego requires either the Saturated Media Extract Method or the SPLP test to confirm BSM has limited potential to leach pollutants (Appendix D). It should be noted that Saturation Extract and SPLP tests are expected to result in somewhat more leaching than would be experienced with real storm water; therefore, a direct comparison to water quality standards or effluent limitations is not relevant (City of San Diego 2016).

Caltrans also has developed a sand specification to ensure the sand is clean and will not export solids (Appendix E).

3.2 Compost Particle Size Gradation

Fines, particles passing the 200 sieve, are the clay and silt fraction of soil. Fines are beneficial for bioretention because they increase soil water and nutrient holding capacity, they improve pollutant removal, and they improve soil structure (Shanstrom 2016). Conversely, they have been associated with clogging and are more likely to flush out of a facility. BSM specifications typically greatly limit fines content in order to protect from failure due to clogging.

Across municipalities, the sand gradation is relatively consistent and conforms to ASTM C33 sand. On the other hand, the compost gradation varies considerably more. In the Bay Area, the compost gradation was recently adjusted for the BASMAA specification as well as the City of San Francisco specification to allow a minimum of 1 percent passing the 200 sieve versus the previously required minimum of 2 percent passing. Reducing the allowable minimum fines component may allow soil suppliers to ensure they are meeting the hydraulic conductivity needed in the BSM but could reduce water holding capacity or result in permeability that far exceeds the upper target of 12" per hour.

Below Tables 1 through 4 provide a comparison of allowable compost gradation in bioretention soil mixes from different municipalities.

Table 1. Bay Area Compost Required Gradation (BASMAA, 2016 and San Francisco, 2016):

Sieve Size	Percent Passing (by weight)	
	Min	Max
1 inch	99	100
½ inch	90	100
¼ inch	40	90
No. 200 (0.0029")	1	10

Note: Sand gradation allows 0 – 5% passing 200 sieve.

Table 2. Los Angeles Compost Gradation (Los Angeles County, 2012):

Sieve Size	Percent Passing (by weight)	
	Min	Max
1 inch	99	100
½ inch	90	100
¼ inch	40	90
No. 200 (0.0029")	2	10

Note: This gradation is equivalent to the previously adopted BASMAA guidance. Sand gradation allows 0 – 5% passing 200 sieve.

Table 3. San Diego Compost Gradation (San Diego, 2016)

Sieve Size	Percent Passing (by weight)	
	Min	Max
5/8 inch	99	100
¼ inch	40	95
2 mm (0.079")	40	90
No. 200 (0.0029")	Not specified	

Note: Sand gradation allows 0 – 5% passing 200 sieve. Mixed BSM must have hydraulic conductivity of between 8 – 20 inches per hour.

Table 4. Seattle Compost Gradation (City of Seattle, 2016)

Sieve Size	Percent Passing (by weight)	
	Min	Max
2 inch	100	100
1 inch	99	100
5/8 inch	90	100
¼ inch	75	100

Note: Mixed BSM must have infiltration rate of at least 6"/hour

In addition to these examples, the City of Portland requires gradation of the blended soil to be tested. They allow for fines to be between 5 and 15% passing the 200 sieve size but do not require testing of the compost component and do not test the hydraulic conductivity. Los Angeles also has requirements for alternative BSM. They require the particles passing the 200 sieve size in alternative mixes to be between 2 and 5% by weight (Los Angeles, 2012). For municipalities that do not specify a gradation of fines in either the compost or the mixed BSM, they require hydraulic conductivity testing which may effectively limit the proportion of fines in the mix.

Fines have been documented to contribute to clogging but other factors may mitigate their importance in hydraulic conductivity. Natural soils have better soil structure and therefore higher infiltration rates than an engineered soil with the same particle size profile. Some studies of infiltration rates in bioretention basins show that rather than decreasing over time due to clogging, many bioretention cells exhibit an increase in infiltration rates (Shanstrom 2016). Lucas (2010) observed 21 bioretention systems in Australia. In systems with initial infiltration rates of over 7 in/hr, rates declined towards an average infiltration rate of 4 in/hr. In contrast, in systems with an initial rate of 0.4 in/hr, these systems increased over time to average nearly 0.8 in/hr, presumably due to the development of macropores (Le Coustumer et al. 2007). Other studies in the US also showed an increase in infiltration rates over time in rain gardens with sand and clay soils (Selbig and Baster 2010, Jenkins et al. 2010). Numerous basins have been documented to have infiltration rates above 1" per hour and up to 6" per hour with greater than 12% fines (Shanstrom 2016, Wardynski et al 2012). Possible explanations for this phenomenon are the presence and development of macropores in healthy soils. Growth and death of plants, earthworms, and other soil organisms can create soil structure than enhances permeability (Shanstrom 2016); however, in soils with a high sand content like the BASMAA BSM, soil structure is slow to develop, or may never develop.

Besides clogging, inconsistent compaction is another possible explanation for the variability seen in BSM that allow for natural soils and fines. Compaction has been shown to decrease infiltration by up to an order of magnitude (Pitt et al. 2008). Hinman (2009) showed that at constant relative compaction of 85 percent of maximum dry density), the percent fines is a strong controlling factor in the permeability test. However, variable compaction will result in variable infiltration across equivalent soils.

In contrast to the focus on fines, Assaf Sadeh, of Soil Control Lab, feels that the controlling particle size gradient does not always translate to passing the hydraulic conductivity performance criteria. Sadeh feels that the quality of the fine particles, i.e. are they angular, round, or humus-like, can play a major role in the hydraulic conductivity. In his experience, he has seen compost that meet the gradation but don't pass the permeability testing (Personal communication 2016). He emphasized the need for hydraulic conductivity or permeability testing of all BSM. The allowable gradation may also be linked to the permeability testing

methods described in the next section.

3.3 Permeability Test Methods

The BASMAA Specification requires permeability testing of the BSM standard mix every 120 days and on a project basis for large scale projects. Mixed BSM must have a permability of at least 5" per hour with no upper limit. However, a provision for meeting the performance standard of between 5 and 12 inches per hour for a custom BSM that deviates from the standard mix is provided. The current specification calls for compaction to 85 to 90% of the maximum dry density (ASTM D1557) and testing of hydraulic conductivity via the constant head permeability test ASTM D2434. According to Assaf Sadeh of Soil Control Laboratories, the specified testing method requires compaction to a degree that is above and beyond what is required in field installations. The method then produces a much reduced rate of permeability and is not representative of field conditions for alternative BSM mixes. Sadeh recommends using an alternative testing method that he believes to be more similar to actual installations of BSM: the Proctor Compaction Test or ASTM D698.

Other municipalities have modified the ASTM D2434 to make it more compatible with the goals of the BSM specification. The Cities of San Francisco and Seattle issued modifications to ASTM D2434 to make it more compatible with bioretention performance goals (SFPUC 2016 and Aspect Consulting, 2011).

In Washington State, the City of Redmond undertook a Bioretention Performance Study to evaluate alternatives to the standard sand and compost BSM (Herrera Environmental Consultants 2015). As a part of this study, eight types of different BSM mixes were tested including the Bay Area equivalent BSM mix of 60% sand and 40% compost. For this mix, researchers found that the permeability testing done with method ASTM D2434 at the lab resulted in a slightly higher but fairly comparable rate to field infiltration tests. The column falling head test, however, resulted in a much lower value than found in the field. The table below summarizes the results:

Table 5. Results from 60% Sand/40% Compost BSM Infiltration Rate Testing for Five Studies in Washington (Herrera Environmental Consultants 2015)

Infiltration Test	Rate (In/Hour)
Tacoma Field Test	20.9
Redmond Field Test Site 1	2.9
Redmond Field Test Site 2	11.8
Field Infiltration Average	**11.9**
WSU Column Falling Head Test	41.7
Redmond Column Falling Head Test	49.0
Kitsap Column Falling Head Test	84.0
Column Falling Head Average	**58.2**
Redmond Permeability ASTM 2434	11.9
Kitsap Permeability ASTM 2434	210
Permeability ASTM 2434 Average	**112.6**

4.0 EVALUATION OF MULCH OPTIONS

Many bioretention design guides specify placement of a mulch layer over the surface of bioretention devices. Mulch is specified to protect the medium from erosion, suppress weed growth, and increase water availability for plants during establishment. However, some organic mulches are prone to floating. Floating mulch can expose and erode the underlying growing medium, block overflows, and contaminate receiving waters.

Interviews with California municipal representatives revealed that few had tackled the issue of mulch. Most reported they leave the decision up to the designer and recommend inorganic mulches like stone mulches in areas of direct flow. The City of Seattle recommends 'coarse compost' for which they provide a specific gradation that contains larger particle sizes and limited fines.

A literature search revealed few resources; however, the City of Auckland, New Zealand did undertake a detailed study of mulch options for bioretention to minimize mulch movement into the storm system. Simcock and Dando (2013) evaluated several different mulch types in the field and through lab testing of floatability. The resulting recommendation is to use primarily inorganic mulch: stone and crushed shell mulches. This study also found that some organic mulches (shredded wood waste, shredded bark, arborist pruning and green waste) have reduced floatability when moisture contents and wet bulk density are higher. Here in California, shredded wood products are often barred from use by fire codes. Simcock and Dando found that the most floatable mulches were decorative bark or bark nuggets.

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Appendix A.
BASMAA Regional Biotreatment Soil Specification

Specification of Soils for Biotreatment or Bioretention Facilities

Soils for biotreatment or bioretention areas shall meet two objectives:

- Be sufficiently permeable to infiltrate runoff at a minimum rate of 5" per hour during the life of the facility, and
- Have sufficient moisture retention to support healthy vegetation.

Achieving both objectives with an engineered soil mix requires careful specification of soil gradations and a substantial component of organic material (typically compost).

Local soil products suppliers have expressed interest in developing 'brand-name' mixes that meet these specifications. At their sole discretion, municipal construction inspectors may choose to accept test results and certification for a 'brand-name' mix from a soil supplier.

Tests must be conducted within 120 days prior to the delivery date of the bioretention soil to the project site.

Batch-specific test results and certification shall be required for projects installing more than 100 cubic yards of bioretention soil.

SOIL SPECIFICATIONS

Bioretention soils shall meet the following criteria. "Applicant" refers to the entity proposing the soil mixture for approval by a Permittee.

1. General Requirements – Bioretention soil shall:
   a. Achieve a long-term, in-place infiltration rate of at least 5 inches per hour.
   b. Support vigorous plant growth.
   c. Consist of the following mixture of fine sand and compost, measured on a volume basis:
      60%-70% Sand
      30%-40% Compost
2. Submittal Requirements – The applicant shall submit to the Permittee for approval:
   a. A minimum one-gallon size sample of mixed bioretention soil.
   b. Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.
   c. Grain size analysis results of the fine sand component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils or Caltrans Test Method (CTM) C202.
   d. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in 4.
   e. Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
   f. Grain size analysis results of compost component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
   g. A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.

h. Provide the name of the testing laboratory(s) and the following information:

(1) Contact person(s)

(2) Address(s)

(3) Phone contact(s)

(4) E-mail address(s)

(5) Qualifications of laboratory(s), and personnel including date of current certification by USCC, ASTM, Caltrans, or approved equal

3. Sand for Bioretention Soil
   a. Sand shall be free of wood, waste, coating such as clay, stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be nonplastic.
   b. Sand for Bioretention Soils shall be analyzed by an accredited lab using #200, #100, #40 or #50, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422, CTM 202 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
3/8 inch	100	100
No. 4	90	100
No. 8	70	100
No. 16	40	95
No. 30	15	70
No. 40 or No.50	5	55
No. 100	0	15
No. 200	0	5

Note: all sands complying with ASTM C33 for fine aggregate comply with the above gradation requirements.

4. Composted Material

Compost shall be a well decomposed, stable, weed free organic matter source derived from waste materials including yard debris, wood wastes or other organic materials not including manure or biosolids meeting the standards developed by the US Composting Council (USCC). The product shall be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

a. Compost Quality Analysis by Laboratory – Before delivery of the soil, the supplier shall submit a copy of lab analysis performed by a laboratory that is enrolled in the US Composting Council's Compost Analysis Proficiency (CAP) program and using approved Test Methods for the Examination of Composting and Compost (TMECC). The lab report shall verify:
   (1) Organic Matter Content: 35% - 75% by dry wt.
   (2) Carbon and Nitrogen Ratio: C:N < 25:1 and C:N >15:1
   (3) Maturity/Stability: Any one of the following is required to indicate stability:
      (i) Oxygen Test < 1.3 O2 /unit TS /hr
      (ii) Specific oxy. Test < 1.5 O2 / unit BVS /hr
      (iii) Respiration test < 8 mg CO_2-C /g OM / day
      (iv) Dewar test < 20 Temp. rise (°C) e.
      (v) Solvita® > 5 Index value
   (4) Toxicity: Any one of the following measures is sufficient to indicate non-toxicity.
      (i) NH_4^+ : NO_3^--N < 3
      (ii) Ammonium < 500 ppm, dry basis
      (iii) Seed Germination > 80 % of control
      (iv) Plant Trials > 80% of control
      (v) Solvita® = 5 Index value
   (5) Nutrient Content: provide analysis detailing nutrient content including N-P-K, Ca, Na, Mg, S, and B.
      (i) Total Nitrogen content 0.9% or above preferred.
      (ii) Boron: Total shall be <80 ppm;
   (6) Salinity: Must be reported; < 6.0 mmhos/cm
   (7) pH shall be between 6.2 and 8.2 May vary with plant species.

b. Compost Quality Analysis by Compost Supplier – Before delivery of the compost to the soil supplier the Compost Supplier shall verify the following:
   (1) Feedstock materials shall be specified and include one or more of the following: landscaping/yard trimmings, grass clippings, food scraps, and agricultural crop residues.
   (2) Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell or containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable.
   (3) Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach min. 55C for 15 days with at least 5 turnings during that period.

c. Compost for Bioretention Soil Texture – Compost for bioretention soils shall be analyzed by an accredited lab using #200, 1/4 inch, 1/2 inch, and 1 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***

1 inch	99	100
1/2 inch	90	100
1/4 inch	40	90
No. 200	1	10

d. Bulk density shall be between 500 and 1100 dry lbs/cubic yard
e. Moisture content shall be between 30% - 55% of dry solids.
f. Inerts – compost shall be relatively free of inert ingredients, including glass, plastic and paper, < 1 % by weight or volume.

g. Select Pathogens – Salmonella <3 MPN/4grams of TS, or Coliform Bacteria <10000 MPN/gram.
h. Trace Contaminants Metals (Lead, Mercury, Etc.) – Product must meet US EPA, 40 CFR 503 regulations.
i. Compost Testing – The compost supplier will test all compost products within 120 calendar days prior to application. Samples will be taken using the STA sample collection protocol. (The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: 631-737-4931, www.compostingcouncil.org). The sample shall be sent to an independent STA Program approved lab. The compost supplier will pay for the test.

VERIFICATION OF ALTERNATIVE BIORETENTION SOIL MIXES

Bioretention soils not meeting the above criteria shall be evaluated on a case by case basis. Alternative bioretention soil shall meet the following specification: “Soils for bioretention facilities shall be sufficiently permeable to infiltrate runoff at a minimum rate of 5 inches per hour during the life of the facility, and provide sufficient retention of moisture and nutrients to support healthy vegetation.”

The following steps shall be followed by municipalities to verify that alternative soil mixes meet the specification:

1. General Requirements – Bioretention soil shall achieve a long-term, in-place infiltration rate of at least 5 inches per hour. Bioretention soil shall also support vigorous plant growth. The applicant refers to the entity proposing the soil mixture for approval.
   a. Submittals – The applicant must submit to the municipality for approval:
      (1) A minimum one-gallon size sample of mixed bioretention soil.
      (2) Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.

(3) Certification from an accredited geotechnical testing laboratory that the Bioretention Soil has an infiltration rate between 5 and 12 inches per hour as tested according to Section 1.b.(2)(ii).
(4) Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
(5) Grain size analysis results of mixed bioretention soil performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
(6) A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
(7) The name of the testing laboratory(s) and the following information:
  (i) Contact person(s)
  (ii) Address(s)
  (iii) Phone contact(s)
  (iv) E-mail address(s)
  (v) Qualifications of laboratory(s), and personnel including date of current certification by STA, ASTM, or approved equal.

b. Bioretention Soil
(1) Bioretention Soil Texture: Bioretention Soils shall be analyzed by an accredited lab using #200, and 1/2" inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
1/2 inch	97	100
No. 200	2	5

(2) Bioretention Soil Permeability testing: Bioretention Soils shall be analyzed by an accredited geotechnical lab for the following tests:
  (i) Moisture – density relationships (compaction tests) shall be conducted on bioretention soil. Bioretention soil for the permeability test shall be compacted to 85 to 90 percent of the maximum dry density (ASTM D1557).
  (ii) Constant head permeability testing in accordance with ASTM D2434 shall be conducted on a minimum of two samples with a 6-inch mold and vacuum saturation.

MULCH FOR BIORETENTION FACILITIES

Three inches of mulch is recommended for the purpose of retaining moisture, preventing erosion and minimizing weed growth. Projects subject to the State's Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least three inches of mulch. 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. It is recommended to apply 1" to 2" of composted mulch, once a year, preferably in June following weeding.

Appendix B.
Caltrans Sand Specificaiton

Add to section 68-2.02F:

68-2.02F(6) Class 5 Permeable Material

Class 5 permeable material for use in media filters must consist of hard, durable, clean sand, and must be free from organic material, clay balls, or other deleterious substances.

The percentage composition by weight of Class 5 permeable material in place must comply with the grading requirements shown in the following table:

Class 5 Permeable Material
Grading Requirements

Sieve sizes	Percentage passing
3/8"	100
No. 4	95–100
No. 8	80–100
No. 16	45–85
No. 30	15–60
No. 50	3–15
No. 100	0–4
No. 200	0

Standard ASTM 6913	Range
Effective Particle size (ES)=(D_{10})	0.0098”-0.0197”
Uniformity Coefficient Uc = (D_{60}/D_{10})	< 4

Class 5 permeable material must have a durability index of not less than 40.

At least 5 days before placing Class 5 permeable material, submit a certificate of compliance for gradation of the material.

No more than 5 days after placing Class 5 permeable material, submit:

1. At least one ASTM D 6913 test on the permeable material at an authorized location.
2. Verification that the placed permeable material complies with the grading requirements

Prior to placement, wash Class 5 permeable material:

1. To remove silt and clay particles.
2. With potable water equal to at least four times the volume of the material to be placed.

After placement, wash Class 5 permeable material:

1. With potable water.
2. Until the discharged water has a turbidity reading of:
   a. 30 NTU or less for jobs within the Tahoe Hydrologic Unit
   b. 200 NTU or less for jobs outside of the Tahoe Hydrologic Unit

You must capture and dispose of the wash water, and

1. Dispose of outside the state right of way.
2. Use as dust control.
3. Disperse onsite in an authorized location other than the BMP.

Place Class 5 permeable material:

1. In a manner that will not damage or cause permanent displacement of the filter fabric.
2. Using methods that will produce a finished surface as shown.

Appendix C.
City of San Diego Bioretention Soil Media (BSM) Specificaiton

F.4. Bioretention Soil Media (BSM)

F.4.1 General

Bioretention Soil Media (BSM) is a formulated soil mixture that is intended to filter storm water and support plant growth while minimizing the leaching of chemicals found in the BSM itself. BSM consists of 70% to 85% by volume washed sand and 15% to 30% by volume compost or alternative organic amendment. Alternative proportions may be justified under certain conditions. BSM shall be mixed thoroughly using a mechanical mixing system at the plant site prior to delivery. In order to reduce the potential for leaching of nutrients, the proportion of compost or alternative organic amendment shall be held to a minimum level that will support the proposed vegetation in the system.

F.4.1.1 Sand for Bioretention Soil Media.

The sand shall conform to ASTM C33 "fine aggregate concrete sand" requirements. A sieve analysis shall be performed in accordance with ASTM C 136, ASTM D 422, or approved equivalent method to demonstrate compliance with the gradation limits shown in Table F.4-1. The sand shall be thoroughly washed to remove fines, dust, and deleterious materials prior to delivery. Fines passing the No. 200 sieve shall be non-plastic.

Table F.4-1 Sand Gradation Limits

Sieve Size (ASTM D422)	Percent Passing (by weight)	
	Minimum	Maximum
3/8 inch	100	100
#4	95	100
#8	80	100
#16	50	85
#30	25	60
#50	5	30
#100	0	10
#200	0	5

Note: Coefficient of Uniformity (Cu = D60/D10) equal to or greater than 4.

F.4.1.2 Compost.

Compost shall be certified by the U.S. Composting Council's Seal of Testing Assurance Program or an approved equivalent program. Compost shall comply with the following requirements:

1. Organic Material Content shall be 35% to 75% by dry weight.

2. Carbon to nitrogen (C:N) ratio shall be between 15:1 and 40:1, preferably above 20:1 to reduce the potential for nitrogen leaching/washout.
3. Physical contaminants (manmade inert materials) shall not exceed 1% by dry weight.
4. pH shall be between 6.0 and 7.5.
5. Soluble Salt Concentration shall be less than 10 dS/m (Method TMECC 4.10-A, USDA and U.S. Composting Council).
6. Maturity (seed emergence and seedling vigor) shall be greater than 80% relative to positive control (Method TMECC 5.05-A, USDA and U.S. Composting Council)
7. Stability (Carbon Dioxide evolution rate) shall be less than 2.5 mg CO_2-C per g compost organic matter (OM) per day or less than 5 mg CO_2-C per g compost carbon per day, whichever unit is reported. (Method TMECC 5.08-B, USDA and U.S. Composting Council). Alternatively a Solvita rating of 6 or higher is acceptable.
8. Moisture shall be 25%-55% wet weight basis.
9. Select Pathogens shall pass US EPA Class A standard, 40 CFR Section 503.32(a).
10. Trace Metals shall pass US EPA Class A standard, 40 CFR Section 503.13, Tables 1 and 3.
11. Shall be within gradation limits in Table F.4-2 (ASTM D 422 sieve analysis or approved equivalent).

Table F.4-2 Compost Gradation Limits

Sieve Size	Percent Passing (by weight)
16 mm (5/8")	99 to 100
6.3 mm (1/4")	40 to 95
2 mm	40 to 90

F.4.1.3 Alternative Mix Components and Proportions.

Alternative mix components and proportions may be utilized, provided that the whole blended mix (F.4.2) conforms to agricultural, chemical, and hydraulic suitability criteria, as applicable. Alternative mix designs may include alternative proportions, alternative organic amendments and/or the use of natural soils. Alternative mixes are subject to approval by the City Engineer.

Alternative mixtures may be particularly applicable for systems with underdrains in areas where phosphorus is associated with a water quality impairment or a Total Maximum Daily Load (TMDL) in a downstream receiving water. BSM with 15% to 30% compost by volume (as specified in F.4.1.3) will likely contribute to increased phosphorus in effluent. Alternative organic amendments, such as

coco coir pith, in place of compost should be considered in these areas. A sand or soil substrate with low plant available phosphorus (< 5 mg/kg) should also be considered. The use of compost in these mixes should be limited to the top three to six inches of soil and limited to the minimum level needed to augment fertility. Additionally, an activated alumina polishing layer can be considered to control phosphorus leaching.

Additional mix components, such as granular activated carbon, zeolite, and biochar may be considered to improve performance for other parameters.

F.4.2 Whole BSM Testing Requirements and Criteria.

The Contractor shall submit the following information to the City Engineer at least 30 days prior to ordering materials:

- Source/supplier of BSM,
- Location of source/supplier,
- A physical sample,
- Available supplier testing information,
- Whole BSM test results from a third party independent laboratory,
- Description of proposed methods and schedule for mixing, delivery, and placement of BSM.

Test results shall be no older than 120 days and shall accurately represent the materials and feed stocks that are currently available from the supplier.

Test results shall demonstrate conformance to agricultural suitability criteria (F.4.2.1), chemical suitability criteria (F.4.2.2), and hydraulic suitability criteria (F.4.2.3). No delivery, placement, or planting of BSM shall begin until test results confirm the suitability of the BSM. The Contractor shall submit a written request for approval which shall be accompanied by written analysis results from a written report of a testing agency. The testing agency must be registered by the State for agricultural soil evaluation which indicates compliance stating that the tested material proposed source complies with these specifications. Third party independent laboratory tests shall be paid for by the Contractor.

F.4.2.1 BSM Agricultural Suitability

The BSM shall be suitable to sustain the growth of the plants specified and shall conform to the following requirements:

a) pH range shall be between 6.0-7.5

b) Salinity shall be less than 3.0 millimho/cm (as measured by electrical conductivity)

c) Sodium adsorption ration (SAR) shall be less than 3.0

d) Chloride shall be less than 150 ppm

The test results shall show the following information:

a) Date of Testing

b) Project Name

c) The Contractor's Name

d) Source of Materials and Supplier's Name

e) pH

f) E_C

g) Total and plant available elements (mg/kg particle concentration): phosphorus, potassium, iron, manganese, zinc, copper, boron, calcium, magnesium, sodium, sulfur, molybdenum, nickel, aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, mercury, selenium, silver, strontium, tin, and vanadium. Plant available concentration shall be assessed based on weak acid extraction(ammonium Bicarbonate/DTPA soil analysis or similar)

h) Soil adsorption ratio

i) Carbon/nitrogen ratio

j) Cation exchange capacity

k) Moisture content

l) Organic content

m) An assessment of agricultural suitability based on test results

n) Recommendations for adding amendments, chemical corrections, or both.

BSM which requires amending to comply with these specifications shall be uniformly blended and tested in its blended state prior to testing and delivery.

F.4.2.2 BSM Chemical Suitability

For systems with underdrains, the BSM shall exhibit limited potential for leaching of pollutants that are at levels of concern. Potential for pollutant leaching shall be assessed using either the Saturated Media Extract Method (aka, Saturation Extract) that is commonly performed by agricultural laboratories or the Synthetic Precipitation Leaching Procedure (SPLP) (EPA SW-846, Method 1312). The referenced tests express the criteria in terms of the pollutant concentration in water that is in contact with the media. In areas in which a pollutant or pollutants are associated with a water quality impairment or a TMDL, BSM in systems with underdrains shall conform to the following Saturation Extract or SPLP criteria for applicable pollutant(s):

a) Nitrate < 3 mg/L

b) Phosphorus < 1 mg/L[10]

c) Zinc < 0.1 mg/L

d) Copper < 0.025 mg/L

10 Alternative mixtures should be considered for systems with underdrains in areas where phosphorus is associated with a water quality impairment or a TMDL or where the BSM does not achieve the Saturation Extract or SPLP criteria of < 1 mg/L total phosphorus as specified in 800-4.2.2. Details regarding alternative mixtures requirements and potential components are included in F.4.1.3.

e) Lead < 0.025 mg/L

f) Arsenic < 0.02 mg/L

g) Cadmium < 0.01 mg/L

h) Mercury < 0.01 mg/L

i) Selenium < 0.01 mg/L

Criteria shall be met as stated where a pollutant is associated with a water quality impairment or Total Maximum Daily Load (TMDL) in any downstream receiving water. Criteria may be waived or modified, at the discretion of the City Engineer, where a pollutant does not have a nexus to a water quality impairment or TMDL of downstream receiving water(s). Criteria may also be modified at the discretion of the City Engineer if the Contractor demonstrates that suitable BSM materials cannot be feasibly sourced within a 50-mile radius of the project site and a good faith effort has been undertaken to investigate available materials.

Note that Saturation Extract and SPLP tests are expected to result in somewhat more leaching than would be experienced with real storm water; therefore, a direct comparison to water quality standards or effluent limitations is not relevant.

The chemical suitability criteria listed in this section do not apply to systems without underdrains, unless groundwater is impaired or susceptible to nutrients contamination.

F.4.2.3 BSM Hydraulic Suitability

The saturated hydraulic conductivity or infiltration rate of the whole BSM shall be measured by one of the following methods:

a. Measurement of hydraulic conductivity (USDA Handbook 60, method 34b) (commonly available as part of standard agronomic soil evaluation), or

b. ASTM D2434 Permeability of Granular Soils (at approximately 85% relative compaction Standard Proctor, ASTM D698)

BSM shall conform to hydraulic criteria associated with the BMP design configuration that best applies to the facility where the BSM will be installed (options describe below).

Systems with unrestricted underdrain system (i.e., media control). For systems with underdrains that are not restricted, the BSM shall have a minimum measured hydraulic conductivity of 8 inches per hour to ensure adequate flow rate through the BMP and longevity of the system. The BSM should have a maximum measured hydraulic conductivity of no more than 20 inches per hour. BSM with higher measured hydraulic conductivity may be accepted at the discretion of the City Engineer. In all cases, an upturned elbow system on the underdrain, measuring 9 to 12 inches above the invert of the underdrain, should be used to control velocities in the underdrain pipe and reduce potential for solid migration through the system.

Systems with restricted underdrain system (i.e., outlet control). For systems in which the flowrate of water through the media is controlled via an outlet control device (e.g., orifice or valve) affixed to the outlet of the underdrain system, the hydraulic conductivity of the media should be at least 15 inches per hour and not more than 40 inches per hour. The outlet control device should control the flowrate to between 5 and 12 inches per hour. This configuration reduces the sensitivity of system performance to the hydraulic conductivity of the material, reduces the likelihood of

preferential flow through media, and allows more precise design and control of system flow rates. For these reasons, outlet control should be considered the preferred design option.

Systems without underdrains. For systems without underdrains, the BSM shall have a hydraulic conductivity at least 4 times higher than the underlying soil infiltration rate, but shall not exceed 12 inches per hour.

F.4.3 Delivery, Storage and Handling

The Contractor shall not deliver or place soils in frozen, wet, or muddy conditions. The Contractor shall protect soils and mixes from absorbing excess water and from erosion at all times. The Contractor shall not store materials unprotected during large rainfall events (>0.25 inches). If water is introduced into the material while it is stockpiled, the Contractor shall allow the material to drain to the acceptance of the City Engineer before placement.

BSM shall be thoroughly mixed prior to delivery using mechanical mixing methods such as a drum mixer. BSM shall be lightly compacted and placed in loose lifts approximately 12 inches (300 mm) to ensure reasonable settlement without excessive compaction. Compaction within the BSM area should not exceed 75 to 85% standard proctor within the designed depth of the BSM. Machinery shall not be used in the bioretention facility to place the BSM. A conveyor or spray system shall be used for media placement in large facilities. Low ground pressure equipment may be authorized for large facilities at the discretion of the City Engineer.

Placement methods and BSM quantities shall account for approximately 10% loss of volume due to settling. Planting methods and timing shall account for settling of media without exposing plant root systems.

The Engineer may request up to three double ring infiltrometer tests (ASTM D3385) or approved alternative tests to confirm that the placed material meets applicable hydraulic suitability criteria (800-4.2.3). In the event that the infiltration rate of placed material does not meet applicable criteria, the City Engineer may require replacement and/or decompaction of materials.

F.4.4 Quality Control and Acceptance

Close adherence to the material quality controls herein are necessary in order to support healthy vegetation, minimize pollutant leaching, and assure sufficient permeability to infiltrate/filter runoff during the life of the facility. Amendments may be included to adjust agronomic properties. Acceptance of the material will be based on test results certified to be representative. Test results shall be conducted no more than 120 days prior to delivery of the blended BSM to the project site. For projects installing more than 100 cubic yards of BSM, batch-specific tests of the blended mix shall be provided to the City Engineer for every 100 cubic yards of BSM along with a site plan showing the placement locations of each BSM batch within the facility.

F.4.5 Integration with Other Specifications

This specification includes is related to, and may depend or have dependency on other specifications, including but not limited to:

- Plantings and Hydroseed
- Mulch
- Aggregate (choking stone, drainage stone, energy dissipation)
- Geotextiles
- Underdrains
- Outlet control structures
- Excavation

Execution of this specification requires review and understanding of related specifications. Where conflicts with other specifications exist or appear to exist, the Contractor shall consult with the City Engineer to determine which specifications prevail.

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F.5. Aggregate Materials for BSM Drainage Layers

Drainage of BSM requires the use of specific aggregate materials for filter course (aka choking layer) materials and for an underlying drainage and storage layer.

F.5.1 Rock and Sand Products for Use in BSM Drainage

Size classifications detailed in Tables F.5-1 and F.5-2 shall apply with respect to BSM drainage materials. All sand and stone products used in BSM drainage layers shall be clean and thoroughly washed.

Table F.5-1 Crushed Rock and Stone Gradation Limits

Sieve Size	Percent Passing Sieves	
	AASHTO No. 57	ASTM No. 8
3 in	-	-
2.5 in	-	-
2 in	-	-
1.5 in	100	-
1 in	95 – 100	-
0.75 in	-	-
0.5 in	25 – 60	100
0.375 in	-	85 – 100
No. 4	10 max.	10 – 30
No. 8	5 max.	0 – 10
No. 16		0 – 5
No. 50		-

Table F.5-2 Sand Gradation Limits

Sieve Size	Percent Passing Sieves
	Choker Sand - ASTM C33
0.375 in	100
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	5 – 30
No. 100	0 – 10
No. 200	0 – 3

F.5.2 Graded Aggregate Choker Stone

Graded aggregate choker material is installed as a filter course to separate BSM from the drainage rock reservoir layer. This ensures that no migration of sand or other fines occurs. The filter course consists of two layers of choking material increasing in particle size. The top layer of the filter course shall be constructed of thoroughly washed ASTM C33 fine aggregate sand material conforming to gradation limits contained in Table F.5-2. The bottom layer of the filter course shall be constructed of thoroughly washed ASTM No. 8 aggregate material conforming to gradation limits contained in Table F.5-1.

F.5.3 Open-Graded Aggregate Stone

Open-graded aggregate material is installed to provide drainage for overlying BSM and filter course layers, provide additional storm water storage capacity, and contain the underdrain pipe(s). This layer shall be constructed of thoroughly washed AASHTO No. 57 open graded aggregate material conforming to gradation limits contained in Table F.5-1.

F.5.4 Spreading

Imported BSM drainage material shall be delivered to the BMP system installation site as uniform mixtures and each layer shall be spread in one operation. Segregation within each aggregate layer shall be avoided and the layers shall be free from pockets of coarse or fine material.

Aggregate shall be deposited on underlying layers at a uniform quantity per linear foot (meter), which quantity will provide the required compacted thickness within the tolerances specified herein without resorting to spotting, picking up, or otherwise shifting the aggregate material.

The thickness of the aggregate storage layer (AASHTO No. 57) will depend on site specific design and shall be detailed in contract documents.

The bottom layer of the filter course (ASTM No.8) shall be installed to a thickness of 3 inches (75 mm). The layer shall be spread in one layer. The top layer of the filter course (ASTM C33) shall be installed to a thickness of 3 inches (75 mm). The layer shall be spread in one layer. Marker stakes should be used to ensure uniform lift thickness.

F.5.5 Compacting

Filter course material and aggregate storage material shall be lightly compacted to approximately 80% standard proctor without the use of vibratory compaction.

F.5.6 Measurement and Payment

Quantities of graded aggregate choker material and open-graded aggregate storage material will be measured as shown in the Bid. The volumetric quantities of graded aggregate choker stone material and open-graded storage material shall be those placed within the limits of the dimensions shown on the Plans.

The weight of material to be paid for will be determined by deducting (from the weight of material delivered to the Work) the weight of water in the material (at the time of weighing) in excess of 1% more than the optimum moisture content. No payment will be made for the weight of water deducted as provided in this subsection.

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Appendix D.
San Francisco Bioretention Specification 33 47 27

DIVISION 33 – UTILITIES

Section 33 47 27 – Bioretention

DESIGNER NOTE: Green text corresponds to notes to the designer. Remove prior to use.

DESIGNER NOTE: Replace "Engineer/Landscape Architect" with person in responsible charge for the project (e.g., Owner, Engineer, Landscape Architect).

PART 1 GENERAL

1.01 SUMMARY

A. This section includes:

1. Bioretention Soil Mix

2. Aggregate Storage

3. Mulch [To be completed by designer.]

4. Streambed Gravel [To be completed by designer.]

B. Related Sections:

1. Section 01 57 29 – Temporary Protection of Green Infrastructure Facilities

DESIGNER NOTE: The designer should list any additional specification sections which relate to the bioretention work (i.e., clean outs and underdrains, overflow structures, planting, temporary erosion control, utilities, irrigation, earthwork, other appurtenances, etc.).

1.02 STANDARDS AND CODES

A. Reference Standards: This section incorporates by reference the latest versions of the following documents. These references are a part of this section as specified and modified.

Reference	Title
Caltrans	Standard Specifications
San Francisco DPW	Engineering Standard Specifications
ASTM	Annual Book of ASTM Standards, American Society for Testing and Materials, Philadelphia, PA, 1997 or latest edition.

1.03 DEFINITIONS

A. Bioretention Soil Mix (BSM): A soil mix that has been specially blended and tested for use in bioretention facilities with the intent to meet the following objectives:

1. Infiltrate runoff at a minimum rate of 5 inches per hour throughout the life of the facility, and

2. By nature of its components be capable of the removal of certain suspended and dissolved stormwater pollutants, and

3. Have sufficient moisture retention and other agronomic properties to support healthy vegetation.

1.04 REFERENCES

DESIGNER NOTE: Designer to provide references to all project specific documents (e.g., geotechnical report).

1.05 SUBMITTALS

A. Pre-Installation Submittals: The Contractor shall submit to the Engineer/Landscape Architect the following a minimum of 20 calendar days (or as directed by the Engineer/Landscape Architect) prior to the construction of bioretention facilities:

1. BSM Submittals

a. Two one (1) gallon samples of the BSM.

b. Source certificates for all BSM materials.

c. Sieve analysis of BSM per ASTM D422 performed within two (2) months of product delivery to site

d. Certification from the soil supplier or an accredited testing agency that the BSM, including sand and compost components, conforms to all industry or technical society reference standards specified in Sections 2.01.A, 2.01.B, and 2.01C.

e. A description of the equipment and methods used to mix the sand and compost to produce BSM.

f. Organic content test results of the BSM, performed in accordance with Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, “Loss-On-Ignition Organic Matter Method.”

g. Permeability test results for BSM per ASTM D2434 (Modified). See SFPUC Modified ASTM D2434 Procedures for required modifications to test.

DESIGNER NOTE: On larger projects, it may be appropriate to require that the above testing be performed on samples taken at the supplier’s yard from the stockpile to be used for the project; see designer note in Section 1.06.C.2.

2. Sand Submittals

a. Sieve analysis of sand per ASTM D422 performed within two (2) months of product delivery to site.

DESIGNER NOTE: Consider revising acceptable age of sieve tests depending on scale of project. On a larger project it may be appropriate to require testing on samples taken at the supplier’s yard from the stockpile to be used for the project.

3. Compost Submittals

a. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in Section 2.01.C, and performed within two (2) months of product delivery to site.

b. Sieve analysis of compost per TMECC 02.02-B performed within two (2) months of product delivery to site.

4. Other Submittals

a. Cut sheets of any media or soil admixes to enhance moisture retention properties, if used.

b. Testing agency qualifications as specified in Section 1.06.B.

DESIGNER NOTE: Designer should include relevant submittal requirements for mulch and streambed gravel (e.g., sieve analysis), to ensure quality of delivered products.

1.06 QUALITY CONTROL AND QUALITY ASSURANCE

A. General: Test and inspect bioretention materials and operations as Work progresses as described in this section. Failure to detect defective Work or materials at any time will not prevent rejection if a defect is discovered after installation, nor shall it constitute final acceptance.

B. Testing Agency Qualification:

1. General: Agencies that perform testing on bioretention materials, including permeability testing, shall be accredited by STA, ASTM, AASHTO, or other designated recognized standards organization. All certifications shall be current. Testing agency shall be capable of performing all tests to the designated and recognized standards specified and shall provide test results with an accompanying Manufacturer's Certificate of Compliance. The following information shall be provided for all testing laboratories used:

a. Name of lab(s) and contact person(s)

b. Address(es) and phone number(s)

c. Email address(es)

d. Qualifications of laboratory and personnel including the date of current certification by STA, ASTM, AASHTO, or approved equal.

2. Compost: Laboratory that performs testing shall be independent, enrolled in the US Composting Council's (USCC) Compost Analysis Proficiency (CAP) program, and perform testing in accordance with USCC Test Method for The Examination of Composting and Compost (TMECC). The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway,

Suite 275, Holbrook, NY 11741, 631-737-4931, www.compostingcouncil.org.

C. Responsibilities of Contractor

1. Submittals: Some of the tests required for this specification are unique, and BSM shall be considered a long-lead-time item. Under no circumstance shall failure to comply with all specification requirements be an excuse for a delay or for expedient substitution of unacceptable material(s). The requirements of Division 0 apply in their entirety.

Pre-Placement Conference: A mandatory pre-placement conference will take place, including at a minimum the Engineer/Landscape Architect, the Resident Engineer, the Owner/Client Representative, Installer, and general Contractor, to review schedule, products, soil testing, permeability testing, and installation. The Contractor shall notify the Engineer/Landscape Architect a minimum of 2 working days prior to conference.

DESIGNER NOTE: Pre-placement conference is mandatory for all projects within the public right-of-way, or on other public property, and is strongly recommended for privately-owned parcel projects.

2. Testing: All testing specified herein is the responsibility of the Contractor and shall be conducted by an independent testing agency, retained by the Contractor. The Owner reserves the right to conduct additional testing on all materials submitted, delivered, or in-place to ensure compliance with Specifications.

DESIGNER NOTE: Batch-specific test results and certifications shall be required for projects installing more than 500 cubic yards of BSM.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect the BSM and mulch from contamination and all sources of additional moisture at supplier site, during transport, and at the project site, until incorporated into the Work.

B. The Contractor is required to coordinate delivery of BSM and aggregates with bioretention facility excavation and soil installation. A written schedule shall be submitted for review as part of the submittal package. BSM should not be stockpiled onsite for any length of time. In no case shall BSM be stockpiled onsite for more than 24 hours without prior written approval by the Engineer/Landscape Architect. If stockpiling onsite for any length of time, BSM stockpiles shall meet the following requirements:

1. Locate stockpiles away from drainage courses, inlets, sewer cleanout vents, and concentrated stormwater flows

2. Place stockpiles on geotextile fabric

3. Cover stockpiles with plastic or comparable material

4. Contain stockpiles (and prevent contamination from adjacent stockpiles) with temporary perimeter barrier (e.g., sand bags, wattles, silt fence)

PART 2 PRODUCTS

2.01 BIORETENTION SOIL MIX (BSM)

A. General: BSM shall be a well-blended mixture of sand and compost, shall have sufficient moisture retention to support healthy plant growth, and shall meet the following criteria:

1. Mixture proportions: 30 to 40 percent Compost by volume and 60 to 70 percent Sand by volume

DESIGNER NOTE: Up to 15 percent of the sand fraction may be replaced with other media or soil admixtures (e.g., scoria, coconut coir, perlite, expanded shale, gypsum, vermiculite, pumice, biochar, etc.) to enhance moisture retention capacity of soil, provided admixtures are low in fines (less than 5 percent passing the 200 sieve) and do not break down under normal handling and use. No topsoil, peat, silts, or clays are permitted to be used as admixtures. Admixtures shall be free of sediments and other materials deleterious to plant growth.

2. Organic matter content: 4 to 8 percent as determined by TMECC 05.07-A, Loss on Ignition Method.

3. Extraneous materials: BSM shall be free of all roots, plants, weeds, sod, stones, clods, pockets of coarse sand, construction debris, or other extraneous materials harmful to plant growth.

4. Permeability/Saturated Hydraulic Conductivity: 10 inches per hour (minimum) tested in accordance with ASTM D2434 (Modified). See SFPUC Modified ASTM D2434 Procedures for required modifications to test.

DESIGNER NOTE: 10-inch-per-hour minimum rate assumes a design rate of 5 inches per hour and a correction factor of 2 to account for reduction in performance from initially measured rates.

5. Acceptance of BSM quality and performance may be based on samples taken from stockpiles at supplier's yard, submitted test results, and/or onsite and laboratory testing of installed material at the discretion of the Engineer/Landscape Architect. The point of acceptance will be determined in the field by the Engineer/Landscape Architect.

DESIGNER NOTE: Designer to consider non-compost based BSM specification if facility is serviced by an underdrain and if it is draining to phosphorus sensitive water body.

B. Sand: Sand in the BSM shall conform to the requirements for Sand, Type [specify type from table below] specified herein, unless otherwise approved by the Engineer/Landscape Architect.

DESIGNER NOTE: Designer to specify sand type based on project specific requirements. If bioretention facilities will be subjected to heavy sediment loads (e.g., arterial runoff), consider specifying Sand, Type B (low fines sand) in an effort to reduce clogging risk (pending local availability). Additionally, projects anticipating heavy sediment loads should incorporate pre-settling measures at the upstream end of the facility to allow for more efficient maintenance of facilities.

1. Sand shall be free of wood, waste, coating, or any other deleterious material.

2. Sand material shall meet the following specifications for gradation.

Sieve Size[1]	Percent Passing by Weight	
	Type A[2]	Type B (low fines)[3]
3/8 inch	100	100
No. 4	90 to 100	90 to 100
No. 8	70 to 100	70 to 100
No. 16	40 to 95	40 to 85
No. 30	15 to 70	15 to 60
No. 50	5 to 55	8 to 15
No. 100	0 to 15	0 to 4
No. 200	0 to 5	0 to 2

[1] Sieve provided in nominal size square openings or United States Standard Sieve Series sizes.

[2] Sand conforming to ASTM C33 for Fine Aggregate satisfies the requirements of this specification for Sand, Type A.

[3] Type B (low fines) sand gradation pending local availability.

3. Coefficient of Uniformity: $C_u = \frac{D_{60}}{D_{10}}$: 4 or less for Sand, Type B.

4. Effective Particle Size (D_{10}): 0.3 to 0.5 mm for Sand, Type B.

5. All aggregate passing the No. 200 sieve shall be non-plastic.

6. Acceptance of grading and quality of the sand may be based on samples taken from stockpiles at supplier's yard or a submitted gradation report at the discretion of the Engineer/Landscape Architect. The point of acceptance will be determined in the field by the Engineer/Landscape Architect.

C. Compost: Compost in the BSM shall be well decomposed, stable, weed free organic matter sourced from waste materials including yard debris, wood wastes or other organic materials, not including biosolids or manure feedstock. Compost shall conform to California Code of Regulations

Title 14, Division 7, Chapter 3.1 requirements, be certified through the USCC Seal of Testing Assurance (STA) Program, and meeting the criteria specified herein.

1. Feedstock: Feedstock materials shall be specified and include one or more of the following: landscape/yard trimmings, grass clippings, food scraps, and agricultural crop residues. Feedstock shall not include biosolids or manure.

2. Organic Matter Content: 35 to 75 percent by dry weight tested in accordance with TMECC 05.07-A (Loss on Ignition Organic Matter Method).

3. Carbon to Nitrogen Ratio: C:N between 15:1 and 25:1 when tested in accordance with TMECC 05.02-A.

4. Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120°F) upon delivery or rewetting is not acceptable. In addition any one of the following is required to indicate stability:

a. Specific Oxygen Uptake Rate (SOUR): 1.5 milligrams O_2 per gram biodegradable volatile solids per hour (maximum) per TMECC 05.08-A.

b. Carbon Dioxide Evolution Rate: 8 milligrams CO_2 per gram volatile solids per day per TMECC 05.08-B.

c. Dewar Self Heating Test: 20°C temperature rise (maximum) per TMECC 05.08-D (Class IV or V).

d. Solvita®: Index value greater than 6 per TMECC 05.08-E.

5. Toxicity: Seed Germination: greater than 80 percent of control AND Vigor: greater than 80 percent of control per TMECC 05.05-A.

6. Nutrient Content: provide analysis detailing nutrient content including N-P-K, Ca, Na, Mg, S, and B.

a. Total Nitrogen: 0.9 percent (minimum).

b. Boron: Total shall be < 80 ppm

7. Salinity/Electrical Conductivity: less than 6.0 deciSiemen per meter (dS/m or mmhos/cm) per TMECC 04.10-A (1:5 Slurry Method, Mass Basis).

8. pH: 6.5 to 8 per TMECC 04.11-A (1:5 Slurry pH).

9. Gradation: Compost for BSM shall meet the following size gradation per TMECC 02.02-B (test shall be run on dry compost sample):

Sieve Size	Percent Passing by Weight

	Min	***Max***
1 inch	99	100
1/2 inch	90	100
1/4 inch	40	90
No. 200	1	10

10. Bulk density: 500 to 1,100 dry pounds per cubic yard.

11. Moisture content: 30 to 55 percent of dry solids.

12. Inerts: compost shall be relatively free of inert ingredients, including glass, plastic and paper, less than 1 percent by weight or volume per TMECC 03.08A.

13. Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach minimum 55°C for 15 days with at least 5 turnings during that period.

14. Select Pathogens

a. Salmonella: less than 3 Most Probable Number per 4 grams of total solids, dry weight per TMECC 07.02.

b. Coliform Bacteria: fecal coliform less than 1,000 Most Probable Number per gram of total solids, dry weight per TMECC 07.01.

15. Trace Contaminants Metals (lead, mercury, etc.): Product must meet US EPA, 40 CFR 503 regulations.

D. Soil Admixtures: [Specify admixtures, if used]

2.02 AGGREGATE STORAGE

DESIGNER NOTE: Aggregate storage layer requirements are dependent on location of project (i.e., MS4 areas vs. combined sewer areas), site specific conditions (e.g., native soil infiltration rates, storage volume needs of project). The designer should update this specification based on the aggregate storage materials required for the project.

DESIGNER NOTE: Aggregate storage is optional in combined sewer areas for facilities without underdrains. BSM depth may also be increased for additional storage capacity (in lieu of an aggregate storage layer), provided the facility is within a combined sewer area and not serviced by an underdrain.

A. Aggregate Storage shall consist of hard, durable, and clean, sand, gravel, or mechanically crushed stone, substantially free from adherent coatings. Materials shall be washed thoroughly to remove fines, organic matter, extraneous debris, or objectionable materials. Recycled materials are not permitted. The material shall be obtained only from a source(s) approved by the Engineer/Landscape Architect. Written requests for source approval shall be submitted to the Engineer/Landscape Architect not less than ten (10) working days prior to the intended use of the Material. Should the proposed source be one that the Engineer/Landscape Architect has no

history of Material performance with, the Engineer/Landscape Architect reserves the right to take preliminary samples at the proposed source, and make preliminary tests, to first determine acceptability of the new source and then perform the applicable Material approval testing. Continued approval of a source is contingent upon the Materials from that source continuing to meet Contract requirements. Materials shall meet the Standard Specifications for grading and quality for use in the Work; however, allowable exceptions may be specified in the Contract.

B. Aggregate storage shall meet the following specifications for grading and quality.

1. Aggregate gradation testing in accordance with ASTM C136 at least once per 500 cubic yards.

Sieve[1]	Percent Passing by Weight		
	Choking Course ASTM No. 9 (Modified)[3]	**Reservoir Course ASTM No. 7 (Modified)[4]**	**Caltrans Class 2 Permeable Aggregate (MS4 Areas Only)**
1 inch	–	–	100
3/4 inch	–	100	90 to 100
1/2 inch	100	90 to 100	–
3/8 inch	100	40 to 70	40 to 100
No. 4	85 to 100	0 to 15	25 to 40
No. 8	10 to 40	0 to 5	18 to 33
No. 16	0 to 10	–	–
No. 30	–	–	5 to 15
No. 50	–	–	0 to 7
No. 200[2]	0 to 2	0 to 2	0 to 3

[1] Sieve provided in nominal size square openings or United States Standard Sieve Series sizes.

[2] Gradation modified from ASTM for portion passing the No. 200 sieve.

[3] Materials likely to meet this specification are available locally as Graniterock 1/4” premium screenings (Wilson 1/4" x #10 Premium Screenings).

[4] Materials likely to meet this specification are available locally as Graniterock 1/2” premium screenings (Wilson 1/2" x #4 Roofing Aggregate).

2. Crushed Particles: 90 percent (minimum) fractured faces tested in accordance with California Test 205. Do not use rounded river gravel.

3. L.A. Abrasion: 40 percent (maximum) tested in accordance with ASTM C 131.

DESIGNER NOTE: If the designer chooses to specify materials that differ from those provided herein, the designer should check their filter criteria to evaluate the likelihood of finer-graded material migration into underlying coarser graded materials or reduction in permeability relative to the underlying material. Refer to the SFPUC Aggregate Filter Criteria Guidance document for information on selecting appropriate alternate materials.

DESIGNER NOTE: Designer should verify that underdrain slot dimensions for project are compatible with aggregate gradation specified. Refer to the SFPUC Aggregate Filter Criteria Guidance document for information on selecting appropriate underdrain materials.

2.03 MULCH

DESIGNER NOTE: This section intentionally left blank. Designer to specify mulch requirements for bioretention facilities. Mulch may be wood, compost, or rock mulch. Mulch shall be free of dyes, recycled dimensional lumber, and bark. Materials selected shall be sufficiently permeable to allow water to pass through at a rate equal to or greater than the underlying BSM. Typical mulch recommended for this application includes tree trimming mulch per Caltrans Standard Specification Section 20-7.02D(6)(a) and (e), or other comparable material (e.g., arbor mulch).

2.04 STREAMBED GRAVEL

DESIGNER NOTE: This section intentionally left blank. Designer to specify gravel requirements, including gradation, for bioretention facilities. Streambed Gravel shall be sized to provide energy dissipation and to minimize erosion at facility inlets and outlets. The following text is a sample/template specification for cobbles within a bioretention facility:

Streambed Cobbles shall be clean, naturally occurring water rounded gravel material. Streambed Cobbles shall have a well-graded distribution of cobble sizes and conform to the following gradation [Designer to specify]:

Streambed Cobbles	
Approximate Size[1]	**Percent Passing by Weight**

[1] Approximate size can be determined by taking the average dimension of the three axes of the rock, Length, Width, and Thickness, by use of the following calculation: (Length + Width + Thickness)/3 = Approximate Size Length is the longest axis, width is the second longest axis, and thickness is the shortest axis.

The grading of the cobbles shall be determined by the Engineer/Landscape Architect by visual inspection of the load before it is dumped into place, or, if so ordered by the Engineer/Landscape Architect, by dumping individual loads on a flat surface and sorting and measuring the individual rocks contained in the load. Cobbles must be washed before placement.

PART 3 EXECUTION

3.01 GENERAL

A. Prevent runoff from adjacent pervious and impervious surfaces from entering the bioretention facility (e.g., sand bag inlet curb cuts, stabilize adjacent areas, flow diversion) until authorization is given by the

Engineer/Landscape Architect. Refer to SFPUC Specification Section 01 57 29 Temporary Protection of Green Infrastructure Facilities.

B. Exclude equipment from bioretention facilities. No equipment shall operate within the facility once bioretention facility excavation has begun, including during and after excavation, backfilling, mulching, or planting.

C. Prevent foreign materials and substances, such as silt laden run-off, construction debris, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid from entering or being stored in the facility at any point during construction.

3.02 GRADING

A. The Contractor shall not start bioretention facility grading until all areas draining to the facility are stabilized and authorization has been given by the Engineer/Landscape Architect.

B. Construct bioretention facility subgrade to +/- 3/4 inch of the grades and slopes specified on the Plans.

C. Excavation within 6 inches of final native soil grade shall not be permitted if facility soils have standing water, or have been subjected to more than 1/2 inch of precipitation within the previous 48 hours.

3.03 SUBGRADE PREPARATION AND PROTECTION

A. Protect the bioretention excavation from over compaction and/or contamination.

1. Areas which have been over compacted by equipment or vehicle traffic or by other means and which need to be ripped, over excavated, receive additional scarification, or other restorative means shall be done at the Contractor's expense and at the direction of the Engineer/Landscape Architect.

2. Excavated areas contaminated by sediment laden runoff prior to placement of BSM or Aggregate Storage material shall be remediated at the Contractor's expense by removing the contaminated soil (top 3 inches minimum) and replacing with a suitable material, as determined by the Engineer/Landscape Architect.

B. Remove all trash, debris, construction waste, cement dust and/or slurry, or any other materials that may impede infiltration into prepared subgrade.

C. The subgrade shall be inspected and accepted by the Engineer/Landscape Architect prior to placement of any materials or final subgrade scarification.

D. Scarify the surface of the subgrade to a minimum depth of 3 inches immediately prior to placement of BSM or aggregate storage material. Acceptable methods of scarification include use of excavator bucket teeth or a rototiller to loosen the surface of the subgrade.

E. Place aggregate storage material, where shown on drawings with conveyor belt or with an excavator or loader from a height no higher than 6 feet unless otherwise approved by the Engineer/Landscape Architect (i.e., do not dump material directly from truck into cell).

F. Aggregate Storage areas contaminated by sediment-laden runoff prior to placement of BSM shall be remediated at the Contractor's expense by removing the contaminated aggregate storage material (top 3 inches minimum or as directed by the Engineer/Landscape Architect) and replacing with clean aggregate storage material per Section 2.03, to the lines and grades on the Plans.

G. Aggregate Storage material shall be inspected and accepted for placement and finish grade by the Engineer/Landscape Architect prior to the installation of BSM. Any material that does not conform to this Specification shall be removed and replaced with acceptable material or remediated to the satisfaction of the Engineer/Landscape Architect, at the Contractor's expense.

3.04 BIORETENTION SOIL MIX PLACEMENT

A. The Contractor shall not place BSM until the Engineer/Landscape Architect has reviewed and confirmed the following:

1. BSM delivery ticket(s): Delivery tickets shall show that the full delivered amount of BSM matches the product type, volume and manufacturer named in the submittals. Each delivered batch of BSM shall be accompanied by a certification letter from the supplier verifying that the material meets specifications and is supplied from the approved BSM stockpile.

2. Visual match with submitted samples: Delivered product will be compared to the submitted 1-gallon sample, to verify that it matches the submitted sample. The Engineer/Landscape Architect may inspect any loads of BSM on delivery and stop placement if the soil does not appear to match the submittals; and require sampling and testing of the delivered soil to determine if the soil meets the requirements of Section 2.01 before authorizing soil placement.

3. Inspection of the aggregate storage layer, underdrain, cleanout, and overflow structure installation, where included on the plans.

DESIGNER NOTE: On larger projects, it may be appropriate to require that the testing specified in Section 2.01 be performed on samples taken at the supplier's yard from the stockpile to be used for the project; see designer note in Section 1.06.C.2.

B. BSM placement, grading and consolidation shall not occur when the BSM is excessively wet, or has been subjected to more than 1/2 inch of precipitation within 48 hours prior to placement. Excessively wet is defined as being at or above 22 percent soil moisture by a General Tools &

Instruments DSMM500 Precision Digital Soil Moisture Meter with Probe (or equivalent). A minimum of three readings with the soil moisture probe will be used to determine the average percent soil moisture reading per each truck load. There should be no visible free water in the material.

C. The Contractor shall place BSM loosely with a conveyor belt or with an excavator or loader from a height no higher than 6 feet, unless otherwise approved by the Engineer/Landscape Architect (i.e., do not dump material directly from truck into cell). Soil shall be placed upon a prepared subgrade in accordance with these Specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the Drawings or as established by the Engineer/Landscape Architect.

D. Excessively dry BSM may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.

E. Compact BSM using non-mechanical compaction methods (e.g., boot packing, hand tamping, or water consolidation) to 83 percent (+/- 2 percent) of the maximum dry density per modified Proctor test (ASTM D1557), or as directed by the Geotechnical Engineer. Determination of in-place density shall be made using a nuclear gauge per ASTM D6938. Moisture content determination shall be conducted on a soil sample taken at the location of the nuclear gage reading per ASTM D2216.

DESIGNER NOTE: BSM compaction target density will be updated as more data from installed projects becomes available on the optimal compaction to minimize settlement while maintaining the infiltration capacity of the media. Designers are encouraged to report field density measurements, observed infiltration rates (if available), and anecdotal field observations (e.g., soil appears well draining, settlement observed minimal).

F. Grade BSM to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.

G. Final soil depth shall be measured and verified only after the soil has been compacted. If after consolidation, the soil is not within +/- 3/4 inch of the grades and slopes specified on the Plans, add material to bring it up to final grade and raked.

H. The BSM shall be inspected and accepted for placement and finish grade by the Engineer/Landscape Architect prior to the installation of planting and mulch. Any BSM that does not conform to this Specification shall be remediated to the satisfaction of the Engineer/Landscape Architect, or removed and replaced with acceptable BSM, at the Contractor's expense.

3.05 PLANTING AND MULCHING

A. Bioretention facilities shall be planted and mulched as shown on the Plans.

B. Bioretention facilities shall not be planted or mulched when soils are excessively wet as defined in Section 3.04.

C. Bioretention facility areas contaminated by sediment laden runoff prior to planting or placement of mulch shall be remediated at the Contractor's expense by removing the contaminated BSM (top 3 inches minimum) and replacing with BSM per Section 2.01, to the lines and grades on the Plans.

D. All mulch shall be inspected and accepted by the Engineer/Landscape Architect to ensure appropriate depth and material prior to facility commissioning (e.g., unblocking of inlets).

DESIGNER NOTE: Planting and mulching requirements shall be determined by the designer and included or referenced herein.

3.06 FLOOD TESTING

A. Inlets shall be constructed per the Plans and free from all obstructions prior to commencing flow testing.

B. Testing shall be conducted at the conclusion of the 90-day plant grow-in period. Protection and flow diversion measures installed to comply with Section 01 57 29 Temp Protection of GI Facilities shall be removed in their entirety prior to commencing flow testing.

C. Underdrains shall be plugged at the outlet structure to minimize water consumption during testing.

D. Prior to testing, broom sweep gutter and other impervious surfaces within the test area to remove sediments and other objectionable materials.

E. The Engineer/Landscape Architect shall be present during the demonstration. The Contractor shall notify the Engineer/Landscape Architect a minimum of 2 working days prior to testing.

F. The Contractor shall water test each facility to demonstrate that all inlet curb openings are capturing and diverting all water in the gutter to the facility, outlet structures are engaging at the elevation specified, and the designed ponding depth is achieved. Testing shall include application of water from a hydrant or water truck per Section 00 73 73, Article 3.04 (Requirements for Using Water For Construction), at a minimum rate of 10 gallons per minute, into the gutter a minimum of 15 feet upstream of the inlet curb opening being tested. Each inlet shall be tested individually. If erosion occurs during testing, restore soils, plants, and other affected materials.

DESIGNER NOTE: Designer should update test flow rate for inlets to reflect project-specific design, as needed.

G. Engineer/Landscape Architect will identify deficiencies and required corrections, including but not limited to relocating misplaced plants, adjusting streambed gravel, adjusting mulch, adjusting inlets, splash aprons, and forebays, removing and replacing inlets, and removing debris.

H. Once adjustments are made, the Contractor shall re-test to confirm all test water flows into the facility from the gutter and correct any remaining deficiencies identified by Engineer/Landscape Architect.

I. Inlets, outlets, and other bioretention facility appurtenances shall not be accepted until testing and any required correction and retesting is complete and accepted by the Engineer/Landscape Architect.

DESIGNER NOTE: The Owner may, at any time, conduct additional testing on all materials submitted, delivered, or in-place, to ensure compliance with the Specifications. Testing may include permeability testing per ASTM D2434 (Modified), density testing per ASTM D6938, etc., if the Engineer/Landscape Architect suspects the facility does not conform to these specifications (e.g., as evidenced by lower than anticipated infiltration capacity).

DESIGNER NOTE: Designer should consider adding a similar requirement to the Concrete Paving and Sanitary Sewerage Utilities sections of the Specifications, as needed.

END OF SECTION

ATTACHMENT

C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications

Biotreatment Soil and Tree Roundtable Summary; Improvements for the Health of Trees

Biotreatment Soil and Tree Roundtable Summary

Improvements for the Health of Trees

Held on June 30, 2016

Prepared For:

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Date of Summary:

July 27, 2016

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1.0 INTRODUCTION

The Municipal Regional Stormwater NPDES Permit Order No. R2-2015- 0049 (MRP) Provision C.3 mandates that Regulated Projects meeting certain impervious surface area thresholds include low impact development (LID) stormwater treatment measures in the project design. The current MRP biotreatment soil specification (biotreatment soil) required to be used in LID stormwater treatment measures (e.g. bioretention areas, tree well filters, etc.) consists of a 60-70% sand/30-40% compost mix. This mix was specified to: 1) ensure long-term biotreatment soil permeability of 5 inches per hour; 2) sustain healthy, vigorous plant life; and 3) maximize stormwater runoff retention and pollutant removal. The complete specification may be viewed at http://basmaa.org/

On June 30, BASMAA convened a biotreatment soil and tree round table to review the current soil specifications to determine if improvements to the specification can be made to positively impact the health of trees planted in biotreatment areas. Participants at the Roundtable included numerous stakeholders: Municipal representatives, compost providers, soil suppliers, soil laboratory technicians, civil engineers, landscape architects, soil scientists, construction inspectors, and Water Board representatives.

Round Table participants broke into small discussion groups to address common questions and foster smaller discussions. The group then came together to share the results of these small discussions, highlight common themes, find areas of consensus, and identify areas that require more research or discussion. This Report provides a summary of the discussion, identifies action items from the Round Table anda summary of the survey responses.

2.0 DISCUSSION SUMMARY

Participants were broken into five smaller discussion groups with experts from as many disciplines as possible in each group. Team leaders and note takers provided the attached notes from the small group discussion (Appendix A). Team leaders then shared main talking points with the larger group. The following provides a summary of the comments organized into the ten most common points that emerged from the small and large group discussions.

1. **Provide trees with access to native soil via design changes**
    - Remove barriers to roots including tall curbs, liners, aggregate, compaction, moving trees to edge
    - Engineers/designers prefer liners and tall curbs to limit risk of water damage to adjacent road, building, utilities, etc. Education of engineers will be needed for further understanding of why these elements are included and how they can be changed to accommodate trees.
    - Explore alternative designs: “Window trees in” to basins, “Tree pockets”, Vertical and Horizontal “potholes” for roots, treatment train, silva cells, forebays and structural soil
    - 90% of tree roots are in the top 18” of soil. Provide lateral access to native soil.
    - Roots grow deeper in sandy soils when water is available. Provide a deeper soil profile in addition to lateral access to native soil, increase the overall soil volume or access to native soil.
    - Soil volume is important for tree health but research from Cornell is not accurate for California. The “maximize soil volume” guideline still applies but not the quantities given.
    - Raising the underdrain on the system might provide a longer-term reservoir of water

- Aggregate layer: may be too porous, too dry and plant roots can't access water stored in aggregate; Make longer/deeper where there are no trees, remove from under trees and replace with structural soil under trees.
- Trees not appropriate in all basins
- Some sites have poor/no/compacted soil adjacent. Improve/evaluate adjacent soil to support trees
- Structural soil may be an alternative in tight spaces adjacent to basins
- Water Board is open to design changes to "window trees in" to bioretention in lieu of or in addition to changing the soil spec

2. **Conflict between water holding capacity vs. permeability rate; irrigation vs. pathogens & drought**
   - The permeability rate of 5" is based on a sizing design constraint developed by Dan Cloak based on rainfall patterns; lowering the rate would make basins larger.
   - The current spec results in a permeability well above 5" per hour in most cases. Based on moisture sensor data, basins become very dry, very quickly.
   - Achieving a mix closer to 5" per hour that is repeatable is very challenging.
   - Irrigation may help to overcome soil volume constraint and water holding capacity
   - Over irrigation leads to increase in pathogens, especially phytopthera
   - Over irrigation is unlikely in a fast draining soil like BSM
   - Using irrigation as a solution is not sustainable due to drought
   - Trees without irrigation are not practical because of the summer dry climate
   - It is difficult to provide even coverage Irrigation in a fast draining soil
   - Plants often die due to lack of water
   - There is a misconception that basins are always wet and that trees should withstand flooding. They drain incredibly fast.

3. **Topsoil in the BSM is both beneficial for plants and challenging to specify**
   - Trees need healthy soil biota, soil structure, and better water holding capacity: all provided by soil.
   - Topsoil must be a loamy sand which is not a sustainable locally sourced product (strip mining).
   - Topsoil supplies are variable with inconsistent gradation and permeability.
   - Topsoil specifications exist for landscapes, street trees, structural soils, etc. that have gradation included.
   - Handling soil degrades the structure and leads to loss of permeability

4. **More study is needed to understand what is out there, what is working and what is not working.**
   - On-going tree study by UC Cooperative Extension open to enroll more trees. Results not yet available.
   - Need to look at long-term soil conductivity and soil/plant health. Trees only beginning to mature after 10+ years. Does BSM change over time, develop into soil? What tests do we perform on existing BSM?
   - Look at soil/natural systems to find something that will sustain plants over time.
   - Are micro-organisms, soil structure, organic matter, increasing or decreasing overtime in existing BSM?
   - Are existing BSM soils getting more or less permeable over time?

- We need more data, who has the data?
- The problem is not well defined. What are the underlying issues?
- Do we have a problem with effluent water quality?

5. **Trees can fail for many variable reasons. Successful trees all have: a) adequate soil volume, b) healthy soil, c) adequate water and drainage, d) nutrients, e) quality nursery stock.**
    - Reasons for failure: Shade, not draining, compaction, barriers to soil, shallow soil, draining too fast, wrong tree, poor nursery stock
    - Changes to the soil mix may only solve some of these issues. Need to look at design as well.

6. **The soil specification should meet performance goals but also be realistic, feasible, repeatable, available and sustainably- and locally- sourced and not too expensive.**
    - Submittals for meeting current soil standard specification almost always fail.
    - Change the compaction test per lab recommendations to reduce compaction and match field conditions better. Changing the compaction test won't fix the problem because the mixes are generally way over the lower threshold as it is now.
    - Permeability testing is very expensive. Repeat testing is a challenge.
    - Involve more compost suppliers to address compost specification issues
    - Add pH requirement for sand and maybe whole mix
    - Add chemical analysis for sand, maybe whole mix
    - Give a permeability performance spec and leave the mix up to the supplier

7. **Additives to BSM**
    - Need locally sourced sustainable options**.**
    - Topsoil: improves plant/tree health but challenging to engineer and may inhibit permeability
    - Biochar lowers permeability but adds microbial activity. In its infancy and is inconsistent. No viable data.

8. **Education for city staff, designers/engineers, and soil providers needed.**
    - Provide decision tree to give clear easy way of choosing designs, soil mix, trees, etc.

9. **Revisit the specification**

10. **Compost**
    - Revisit compost gradation with compost providers
    - Consider soil to replace some or all of compost
    - Revisit testing methods

3.0 ACTION ITEMS

The following action items were identified during the large group discussion.

1. Convene a work group of compost suppliers, soil suppliers, soil labs to consider adding topsoil and/or more fines to the BSM mix. Some representatives of plants and soil health should also be present to ensure tree health needs are considered.

- Involve more compost suppliers.
- Address issues with compost and inability to meet current specification
- Address potential to include topsoil and resolve challenges in specifying and sourcing topsoil.
- Address potential to add topsoil/fines without reducing permeability below performance threshold.

2. Workgroup needed to look specifically at design of bioretention for tree health.
    - Remove barriers to roots accessing native soil.
    - "Windows" for trees, "pot holes", treatment trains, forebay, tree pockets, silva cells, structural soils
    - Increase vertical and horizontal soil volume
    - Reconfigure the aggregate layer

3. Evaluate trees in bioretention that are currently built.
    - Enroll trees in Igor Lancan (UCCE) research project
    - More clearly define the problem
    - Understand how BSM changes over time: permeability, organic matter, soil structure

4. Change the compaction test method to the Standard Proctor test (ASTM D698).
    - BASMAA to consider changing the test method in the specification. Potential to try both methods side by side for comparison prior to adoption.

4.0 SUMMARY OF SURVEY EVALUATION RESPONSES

Thirty eight participants completed the evaluation survey at the end of the Bioretention Soil and Tree Round Table. Overall 94% of participants felt the round table met their expectations and 83% were satisfied with the consensus reached. The following provides a summary of the ratings and paraphrases the comments provided.

Question	**% agree or highly agree**	**Comments**
1. The goals for the meeting and logistics were clearly expressed at the beginning of the round table	84%	• Well organized & managed • Allowed for free expression of ideas & flexibility • Goals unclear • More history would be useful
2. The literature review was sufficiently recapped	89%	• Additional topics reduced clarity • Look at more regions with similar climate • Good job/communication for time allowed • Distilled a lot of information into useful summary
3. Breakouts - the questions were helpful	58%	• Questions helpful and provided guidance, but we didn't use them • Discussion flowed freely and covered the topics without answering specific questions • Conversation lead more to design than soil • Survey and material should have focused

		on plant interplay
4. Breakouts - this exercise allowed for adequate input to develop scenarios for modified/improved soil for tree health.	89%	• Discussion was engaged, robust, productive • I learned a lot • More questions than answers • What is the goal of the Water Board relative to biotetention, trees and soil
5. The outcomes of the breakout sessions were adequately summarized.	89%	• By necessity, they were condensed • Summary raised significant areas of discussion
6. The group discussion sufficiently addressed concerns, opinions, and agreements.	89%	• Soil testing would be helpful • Subcommittees a good outcome • Would have preferred less summary or more time for group discussion • Not all issues discussed • Useful discourse but didn't resolve much
7. The facilitator managed the discussion well and provided an opportunity for all participants' voices to be heard.	97%	• Well done, effective facilitator • Great ability to synthesize and summarize
8. The right mixes of professionals were included in the round table.	91%	• Developers, contractors/installers, and more composters, more civil engineers should have been included • Fantastic/healthy mix of participants
Did this round table meet your expectations?	94%	(Limited comments)
Were you satisfied with the consensus reached?	83%	• Somewhat/no: best that could be achieved; to be expected due to complexity of the issue, varied perspectives, and difficulty to reconcile goals. •
What parts of the round table meeting were most useful to you?	Not rated	• Small group breakout session & summary • Open discussions were informative • Mix of disciplines, expertise, and different opinions
What would have made this round table meeting more useful?	Not rated	• Better management of discussion • Case studies showing successes/failures • More time needed • Send fewer papers beforehand • Give better understanding of end goal • Provide soil providers/mixers education on the spec and goals • Hard to follow the group consensus. Find consensus in small group and build from there
General comments?	Not rated	• More time needed • No real consensus • Address design outside of soil mix; design influences the success of the mix • Good work towards a difficult goal; Action items provide a path forward • Important topic to continue discussing with all disciplines

Appendix A.
Complete Round Table Notes

BASMAA Bioretention Break out group notes

6-30-2016

Blue group participants:

1. **Paul Truyts**- lyngso: goal- help make spec more realistic
   Cost is a big factor
2. **Walter Passmore**- Urban forester Palo Alto- goal: creating new standard designs for the configuration and soil volume- more relevant for tree and plant health
3. **Dan Cloak**- stormwater compliance and LID expansion- Contra Costa Clean Water Program's 2007 interest in fixing failed soil mixes (no filtration), hired Megan Stromberg to help guide creation of a spec. In 2010, Megan assisted BASMAA adopting current spec. Goal: want to see investigation and data on quality of soil for supporting plant life and infiltration after the 3 year. 5-year, 10-year mark for LID facilities.
4. **Kelly Schoonmaker**-stop waste program manager- regional public agency- rep city of Alameda. Lead compost and mulch market development education programs. Bay Friendly original trainings. Water efficient Landscape Ordinance enforcement, and lawn conversion. Goal: don't fix spec at cost of sustainably sourced material and entire materials management cycle.
5. **Sarah Sutton**- Placeworks landscape architect- Also on BoD of Rescape California. Goal: wholistic approach, 7 principles, protect water quality, conserve water, conserve energy, landscape locally, habitat creation. Need rooting volume, healthy soils, sequester carbon, microbe populations. Project example: multi benefit rain garden Ohlone green way Bart station. Treats road runoff.
6. **Sue Ma**- waterboard, engineering background. Goal: to learn about bioretention. Seen both good and poor examples. Need to focus on trees.
7. **Alan Laca**- sacramento- private consulting firm (development and transport)- meeting post construction requirements. Example Caltrans job in Colusa- designed planters for trees and treatment but species did not do well in planters.
8. **Nabiul Afrooz**- Stanford university. Design new soil media to treat stormwater and improve water quality. Recently concluded some studies with foci on pathogens, nutrients, etc. using BIOCHAR. Looking for testing locations!
9. **Brian Currier**- sac state office of water programs. Bench scale and some field scale testing. Proprietary side of mixes in recent past, but looking to share info. Goal: Identify research gaps, keep implementation moving forward.
10. **Amber Schat**- City of San Jose- stormwater management. Tree and plant health and ability to sequester/remove pollutants. Long term health of systems, maintenance requirements. Edu and training of engineers, contractors and landscaping companies

Team Leader- Dan Cloak

1. Soil Spec
    - Challenges
        - Blender perspective: spec is relatively new (2002), different spec introduced and refined and they kept changing, blenders can't control how it is used off site by contractors. What is the life span of product? Want to see someone checking it to make sure there is not experiencing over-compaction issues. Maintenance is needed to make sure weeds and imported fines are not affecting the system in the long term.
        - Reasons to keep bioretention facilities open with living soil that is renewing, as opposed to a non organic filter or drain
        - Long term soil conductivity and health viable over longer periods? Might still be draining even after 10 years, but supporting plant life? Mixed results.
        - Useful to highlight failures and find opportunities for developing criteria
        - Like creating a recipe without knowing how the cake turned out
        - Find research students and look at long term trends
        - View recent landscape installations (even non stormwater) and see what similar issues are happening (irrigation, not enough soil volume). Separate stormwater from general (general landscaping issues vs. bioretention-specific issues).
        - Lack of tree and root structure (spokes on a wheel) is not encouraging plant vigor
        - Introduce bacteria to create biofilm, increase conductivity. With biochar, lots of microbe activity but reduces conductivity.
        - Tree health issues- 10 years investigations are not long enough to really determine tree health, but after 10 is really when you start to see how that tree will perform in the long term. Conflict between infiltration and water holding capacity. Trees are survivors, but almost no trees perform well in such extremes (inundation vs drought).
        - Augment with irrigation? Tree stand chance of getting to native soil and improving beyond the bioretention, water storage potential is limited in tree, vs. if it can access below the retention line.
        - Tradeoffs in design to focus on water quality benefits vs. plant health and increases conductivity and can penetrate biofilm
        - Sand performs ok with pollutant removal, but can get clogged at surface..
        - Bioretention with healthy plants can process fines and pollutants because of soil organisms and health. What happens to soils after 5-10 years? Dead or alive?
        - Reason for 5 inch/hr is a sizing design constraint to the goal of managing big storms in small urban environments. 4% sizing factor.

- Trying to hit a lower specified infiltration rate is more difficult than appears, so 5 inches/hour is not really the issue
- Configuration: Raising underdrains on systems
    - Porous spec is leaving plants dry too often and have trouble penetrating to area below bioretention areas (true for plants and trees?)
    - Modern config any better? Dead water stored for plants, available?
    - Tree roots cant access the water if the surface tension is not present

2. Structural/Design Configuration
    - Challenges

        - Tree Pocket solution? Placement on sides instead of over drain?
        - Structural Soils? Allows trees to penetrate and has good water holding capacity that you can develop fine roots in medium.
        - Engineered soils too complex for most buyers-
        - 90% of adsorbing tree roots are in top 18" of soil
        - The transitions from soil mix to gravel and gravel to native soils may create barriers to root penetration
        - Horizontal component more important than vertical- the width of tree wells is much more important. Create paths of least resistance.
        - Structural soils are used in parking lots, streets, tree cells, etc…
        - Urban constraints really dictate the ability to include trees
        - Determine where trees are appropriate
        - Success and failure observed in many scenarios, sometimes issues are obvious.
        - Need to include bioretention in foundation plans- train city staff and engineers to include tree space- have to work with old thinking to show geo tech engineers that it can work.
        - Tree health guidance is related to wind, light, exposure, water, and appropriate tree species selection given the specific location constraints.
        - Select subspecies/cultivars from climates with no summer rain.

    - Supplemental Irrigation:

        - Issues with plants trying to access adjacent water sources during no irrigation, or outside episodic events?
        - Temporary? For how long?
        - Establishment periods for tree is minimum of 3 years, and then remove it and trees will have to seek out their own long term sources.
        - Can configuration changes account for this need?
        - Trees find its way to get to where it needs to get water and soil, but need to design so that trees can access these areas (path of least resistance)

- Vic Cluasen- UC davis- insert tubes down to 1 meter for plants to get established quicker, and get away from temp irrigation reqs
- Roots will move where the available soil, water, nutrients are, but still have majority of fine roots in top 18"
- Training trees inappropriately to live within confines of bioretention and creating major failures? BSM to sand or clay outside retention area?
    - **Natural barriers to root growth** (gravel layers in bottom of profile)
- Alleviating compaction created during construction? In the spec already (rip bottom)
- Vertical and Horizontal potholes included in design to allow root movement (pockets within the BSM mix that have ability to support trees).

3. Soil Additive:

o Challenges

- Gel polymer (Cornell university) that is supposed to have better water holding capacity is added to structural soils, but tree roots just move through to native soils (only acts as a conduit) so water holding capacity of the structural soil not as important in long run.
- Biochar does hold water well, but creates low permeability (6 " with 15% biochar and sand)
- Using biochar and compost does not remove much pollutants
- Compost tea instead of compost- requires repeated applications. But helps inoculate soil. Most results with trees are favorable, but not a silver bullet
- Inoculating with Michorizal fungi? Variability with injection studies
- Inoculation process/method makes a difference and use broadsprectum because of uncertainty in which will take hold.
- Reserve small quantity of "native" or topsoil that has some resident microbes still present.
- Treatment train to deal with nutrient export issues with compost? Secondary containment? Complex and more expensive? Another area for failure.
- No current reqs on nutrient export. How does it perform after 3+ years?
- Some sensitive areas require special approaches: e.g. Tahoe needed to work with supplier to get extra rinse of additives in retention areas (primary issues are with Phosphorus and nitrogen).
- Compost suppliers (finished and unfinished)- making and selling it like crazy.
- Sheer volume of material that is used and moved every day. Reality is tough to please all players with test results, price point, and availability. Commercial scale needs are different than designers, engineers, planners, etc…
- **Tree pathogens**: phytophera- more irrigation, the more vigorous the pathogen is

- Many nurseries have issue with this pathogen and spreading it to projects
- Plans to test coconut fiber/pith and biochar-Nabuil Afrooz- issues with it coming compacted and hard to break apart
- Wood fiber is perhaps easier to obtain, locally sourced, byproduct of sustainable forest practices?
- Activated alumina- does not look plant friendly, any research on how plants respond to it?

BMP Database- contains info on effluent quality (import vs export of pollutants and pathogens)

Enforceability of compost spec? suppliers provide test every few month of material not older than 120 days. Almost always immature. Space is expensive. Testing on site not feasible. Ask for the last six sheets to determine if there is a trend in product quality.

Cal Recycle allows 0.5% by weight for inert materials (glass and plastic)- because of feedstock (foodwaste, green waste, safeway)

RED GROUP

Dale Bowyer (Water Board), Jill Bicknell (SCVURPP), David Haas (CalFire), Robert Schott (CalTrans), Will Bakx (Sonoma Compost), Annamarie Lucchesi (Waypoint Analytical), Shawn Freedberg (Deep Root), Peter Schultze-Allen (SMCWPPP/SCVVURPPP), Katheryne Kim (Wood Rodgers)

Dale's main goal: window trees through to the underlying soil, and there's no way to make bioretention soil suitable for growing trees

Dale Bowyer: Bay bridge Caltrans project used a little more topsoil. Infiltrometer testing found it was averaging 15 in/hour (really high permeability). Probably grew saltgrass on it, but permeability was much higher than anyone expected

Katheryn Kim, Wood Rodgers (landscape architecture dept.): Wants to stay on top of what's new in the industry. Not much in the way of input; mostly has knowledge of what trees need. Interested in learning about solutions for this problem

Peter Schultze-Allen: It's hard to find a solution based on what everyone else is doing due to soil conditions, climate differences (even within the Bay Area). Thinking a lot about this particular test to compact the mix (ASTM D1557 test). This was a conservative approach (worst case scenario), but now we're learning that we're not compacting it that much during construction so hopefully we can use less conservative testing (ASTM D698 test). Would like to hear more about what this group thinks about changing the spec to make a huge difference in the amount of finds in these tests.

Worst case scenario for failure: puddles/standing water form due to clogging/compaction

Found a green street project that wasn't infiltrating quickly enough; compaction is usually the culprit. The problem is having good records about what they installed, except without any soil mix records. We should be keeping track of this now

DB: Guessing contractors think it's cheaper to get surrounding (clay) soil or whatever is cheaper

Jill Bicknell: mostly here to listen and understand all the issue. Whatever proposal comes out, she wants to become educated.

Robert Schott, Caltrans: big fan of case studies, and the science of proving/disproving something after the fact. Interested in hearing this/similar soil blend in different applications and how well it performed in bioretention, water retention, how much washed away, etc. Doesn't think bay bridge is a good study because they pumped water up, and it's a different thing when it comes to rain gardens. (He recognized that he and Dale might be talking about two different parts of the bay bridge treatment system.)

David Haas: pretty new to all this, coming from a plant based background, increasing volume to promote tree establishment/growth. Some ideas have already been discussed in slides from earlier, esp. in regards to soil depth. You need to increase depth and not just lateral soil space. Agrees a small gravel layer would seriously deteriorate root growth in that area.

KK: Soil with lots of cobble tend to result in roots sticking near the surface

DH: When that happens, that's when you have tree failure

Annemarie Lucchesi: Also results in soil pH of 9-10

RS: When it gets rinsed, the pH issue disappears. But a well-drained layer results in trees having a hard time going down to where it's dry.

DH: restricting root to size of a certain hole

AML: seen failed testing on fawning setups due to improper installations. Can we adjust the specs to have some mineral fines that won't clog the system and not have the copper and issues from defined compost? A lot of times they're dealing with a really coarse compost that's not providing an adequate nutrient source in loamy soils, in particular. Small plants tend to be a common installation.

PSA: Haven't gotten much information back from small plant installation

Shawn Freedberg: We are at the end of the line in terms of what we're dealing with. Involved in development driven projects. Since we're putting such a high volume of water into a small surface area of bioretention, the soil has been developed to accommodate that. But if we want to plant trees, then it seems that the relationship of surface area to treatment area needs to be looked at. If we were able to make that space larger, we could use more topsoil and less fabricated soil to provide SW treatment AND plant trees. The fact of the matter is they're testing a lot of products and highly specific mixes that will be very hard to find, supply, and install in the precise mixes that they're producing in the lab. We're trying to bring things back to a pre-developed condition. Bioretention needs to be bigger, and surface area needs to increase.

DB: Shawn F is up against California real estate.

JB: Retrofitting urban environment. Things need to be balanced.

SF: If you go from 4 to 6%, could we see impacts to these issues? Because of the demand and return on development, I see how willing those developments are to pay for more regulatory enforcement because the return is so great. When the city/staff pushes back on them, they just want to get it over with.

JB: AS we move forward, the cities are going to be the developers. It's not just private sector. This needs to work for a city street as well.

SF: In Palo Alto, they want a quick turnaround to get things built as quickly as possible.

PSA: Problems with street trees in very tiny holes. Start with giving trees root space. IF you want a bigger tree, give them a bigger area. Maybe what the tree needs, the permit requires can find a happy medium.

DB: Trees and bioretention systems need to both be happy and both be able to function. I think there are ways to do that. Bioretention systems around the tree – we need to figure out a standard design for this, and I think this has already been done in OR and WA.

JB: motion to generate consensus that trees and bioretention systems are compatible? Not promoting either one, but it might be interesting to think about.

SF: Not only are they compatible (debatable), but what role do trees have when we're trying to do with bioretention? WE need to find a role for trees in treating the stormwater. Some people in this room don't think they're compatible due to difference in soil necessities, but trees in open bioretention are going to do a lot better than standard street trees. From my view, bioretention is a golden opportunity for a strong tree to grow vs. the alternative surrounded by concrete and asphalt. Once you have that open space, you have a lot of potential to grow a healthy tree. Cites a U of Chicago study where trees are taking that water up. We need to find a way to make these compatible.

PSA: One of the things I've learned over the years is people think you can just plant a tree in a bioretention area. We also need to think of the design from the tree's perspective – what does the tree need. We can't do one without the other and we need to start thinking about that. Perhaps a hybrid design/treatment train with a forebay with soil w/ high flow rate, small plants and then downstream a tree with a different soil mixture. There's also trash (esp. in street environment) and leaves from other trees. How can we prevent clogging from this trash? There are several different factors that go into a street environment design. Silva cells can also be used in the design.

When it gets narrow you need to spread out the water, but otherwise it's pretty flexible.

RS: Look at how much water you have and size accordingly

PSA: Know how many square feet you need, but be flexible.

DB: Old timey swales used to require water to traverse over certain distance. Now, as long as it moves through it's fair play.

SF: Is it true that we have the soil spec we have today because we know it starts out at 15-20 in/hr with the anticipation that it'll eventually get to 5 in/hr?

DB: actually you might get more permeability over time.

SF: I've seen studies that trees/woody perennials would increase porosity over time. If we can create a soil that provides more permeability after time.

PSA: The 12 in/hr max is only in the alternative spec. The regular spec has no maximum. If you mix the specified compost and specified sand it should be about 20 in/hr.

JB: But we design it for 5 in/hr

DH: Tree care is always the first to go in financial troubles

JB: but there is a long term commitment to these bioretention areas. And it's the landowner's responsibility.

DB: unless they leave the responsibility to the homeowners.

PSA: I think it would be good if we could write down all the ways tree-based systems are from small plant-based systems. Size change over time is an obvious one. If you design a system that will allow a tree to grow to 50 years old, that would be better. How the roots grow through the soil, root size, root uptake, needs of tree later in life (increased irrigation) are all possible problems to consider. If we could use our clay soil, that would help a lot (if it's not compacted).

Will Bakx: Trees are in a claustrophobic environment. If you allow it to grow deep, that can affect irrigation growth as well. When you take that and apply it to the soil itself, you get soils that are well aggregated/structured. Sandy soils are not well structured. That over time increases permeability. Well managed soils w/ OM are very permeable. Don't just apply compost at one time. Sandy soils decompose compost very quickly. Compost is in essence the kickstarter. Mulch: fungi try to break down mulch, which breaks into soil for nutrients. Look more in the whole ecosystem of what's in the soil instead of just the plants and soil.

RS: Yes, take natural systems into account.

WB: Assist the ecosystem to get a natural aggregation going. Also, when materials are being imported, I don't like it. Look at resources that exist in my community that people perceive as waste. What can we make use out of with it? Taking these materials and making them a beneficial use (diatomaceous earth). Winery waste is expensive to dispose of. I've included it in my compost (5-10%), so now I'm going after big wineries and working with them to tell them how to divert the waste to compost operations.

DH: Why is mulch such a concern?

PSA: It's not a contained system. Water can overflow and follow the same line it always follows. IN line systems – anytime it fills up, it moves around.

KK: Water fish and landscape ordinance requires 3 in of mulch

WB: Mulch is lacking nutrients (pretty much C). Fungi (hyphae) see this as a good thing to break down, but needs to dig down into soil to actually get nutrients. Hyphae makes a very stable aggregate. This is the best way to do it.

PSA: Doesn't biochar do this as well?

WB: Yes, but biochar is in its infancy. Not all biochar performs. High absorption rate will attract heavy metals, but other biochar won't do so. Industry needs regulation in order to standardize conditions. Low temp is good, but high temp is bad. (There is no scientific literature to prove this, and the makers don't know.) Right now biochar is on a case by case basis.

PSA: JB and I know of a system with 25% biochar in Richmond that was built about 1-2 years ago. We'll see how the monitoring turns out for that one.

WB: That's a lot. Biochar is expensive – about $350/cu. yard. The price point should be $75/cu. yd., and right now its way higher. You have to think about what you are getting and what you want. The compost that's being mentioned out here is the same way too. These are most likely native plants that don't need high nutrient compost, so what you're looking for is low N compost. That's not being talked about. (low N for native plants, high N for ag). You design what you need, and bring it to the table. That nutrient budget needs to be taken into account.

PSA: The BASMAA spec has a minimum Total N content of 0.9%. Is that high or low?

WB: That sounds low, but they need to specify wet or dry.

PSA: There's no top limit.

WB: They need a top limit. You need to actually calculate the N budget needed. You need to have a mature compost but a ratio of 25/1 is robbing N out of the soil. You'll mobilize it, which goes straight to microbes and none to plants. 20/1 should be the max. Above 20/1 is robbing N from the plants. 12/1 is equilibrium. Now how can we get thrown off there? 12/1 isn't necessarily mature.

PSA: So what do you think is a good upper limit?

WB: Invite Assaf from Control Lab (Not here today), look at how much compost is being added.

RS: When it comes to compaction I'd like to see the closest conditions to the field.

WB: Assaf has some ideas about how to achieve that. I think he'd be good at getting us results.

PSA: N in this product was 1.9%, C/N ratio 17/1.

WB: The particle size distribution does not reflect the size we use

PSA: 200 sieve

AL: I think that's 0.5 mm

PSA: We require the 200 sieve in our standards. It's not typically asked for in the STA compost test. It's seen as a good at pollutant removal/cation removal. But it's better when it's dry. The #200 does seem to get finer as the compost matures too. That's another thing that could be a variable over time.

WB: They thought it deteriorates to humus but surprise! Humus doesn't really exist!

PSA: Any other questions we haven't addressed?

KK: Curiosity: it seems like there's a lot of focus on the soil, but is that the only thing that's going to be actually perfected out of this or are we also going to talk about design?

JB: We do need to keep exploring overall design but I don't think we can talk about all those components today.

WB: I think the problem is if you look at system design but you are myopic with your approach. You solve one problem and create another one. You have to look at how everything behaves in the whole system and if it answers the whole problem

JB: Our basic premise is: "What is the best bioretention soil for the tree?" but there are a lot of factors in this.

PSA: And the soil we came up with is best for small plants - not trees.

JB: Basic goal of these things is to remove pollutants. We don't even need 18 in. The nutrients are usually trapped in the first 6-12 in.

WB: Also trees are huge water pumps. That is a huge benefit.

JB: They're also intercepting rain water before it hits the ground.

SF: Seattle/VA rainy seasons are way different than the bay area too. It's something we should be thoughtful of as we move forward.

PSA: What particular trees would be the best?

RS: The soil you proposed is good for wetland species but also bad for growing trees because the soil depth is inadequate and because the soil mix of fines/aggregates is inappropriate.

JB: Depth is a design issue

RS: But it's a system

JB: What if you had a 4 foot deep system?

RS: I'd still like more native soil. It's a more natural habitat. If you're doing this in isolation and add fines then the system may fail. But getting the fines in the soil will promote the aggregation of the soil.

JB: Best way to introduce fines? Artificial or native soils from the site?

WB: If you have an adobe soil and blend it with sand, you get a dry brick. There has to be some specifications about what you have to do.

JB: Maybe its better to find a way to get the tree to go down to the native soil like what DB said

RS: also, are the native soils down there truly native soils? CalTrans is developing soils like this artificially. It's a big different problem. Brining in your soil is impractical. What depth do you need? What compaction are we looking at?

PSA: We've also been thinking about trees that are dormant in the winter. How do they absorb water in the wet winter? Deciduous vs Evergreen. We need to find an evergreen tree that works well in a street environment (not that many), but the Brisbane box (non-native) seems to do the job and is popular. What works well with environment and street environment?

WB: is Brisbane box deep rooted or surface tree?

PSA: I think it's a surface tree since it does well in the street.

AL: Would it work with our compost? Not a lot of Australian trees take up phosphorus.

PSA: Seems to be a hardy tree, not a lot of pest problems

DH: for now.

PSA: it would be better to have multiple species, but we don't have that many species.

WB: also, how does it interact with other trees around it? Also, what are other plants that grow around the trees and make a community?

PSA: This hybrid concept about forward bay w/ small plants and a tree further downstream would be something to explore.

RS: your highland/wetland analysis works well here. Wetland plants want sunshine and so do trees.

PSA: Any other questions?

PSA: Diatomaceous earth: some of our suppliers are experimenting with different things.

WB; if he's using virgin earth, lets' talk to the guy who's here.

PSA: are there any human health issues?

WB: depends if DE is wet or dry. At 25% moisture content human health shouldn't be an issue. Recycled DE comes as a wet clay.

PSA: Allowable MC is 30-55% (AL agrees)

WB: I think that's a reasonable amount. 65% is the upper limit. Below 35 creates a dust problem.

PSA: sandy usually gets dry.

PSA: Drought – trees need lots of water. That's why people went to smaller plants. What can we do to minimize irrigation requirements, esp. with street trees?

RS: I don't think it's practical to not have irrigation system due to dry summers.

DB and PSA: exit

SF: if a tree is successful in 5 years, wouldn't it be self-sustaining?

RS: however, wetland species at a certain depth need supplemental water

WB: if you have drain rock underneath it, I don't think that tree will be dependent on irrigation water.

RS; but tree won't live past 5 years

WB: true. But a shallow tree would be independent

JB: I wish Dale was here to answer questions about design of reservoir that goes through the soil but includes gravel to retain water.

WB: soil would also be more permeable at a lower level

SF: there's a difference between systems with and without an underdrain. From what I've heard, the 12 inches of gravel may need different designs depending on whether or not they have one.

JB: 90% of our systems do include an underdrain though since we don't want clay retention. Maybe the systems that are not lined…

RS: gravel systems used as a reservoir hold the water in the gravel reservoir so it can infiltrate over a longer period of time. That's a good basin design, but it's not good for trees.

SF: another thing that's challenging is looking at small bioretention spaces and variability.

PSA returns: recent change in impervious paving?

JB: I don't know if that's relevant. Everyone complains about the rock underneath

SF: all that rock needs to be brought in. It's not very sustainable.

JB: requirements vary across the state. Bay area can treat and release so that's why you see more underdrains here

PSA: Dan Cloak has talked about systems with adjustable openings in the outflow.

JB: we do have flow reduction/retention standards, but I don't think that would benefit the tree.

SF: I think the issue of the water and the tree is not that significant of a problem in general. It's not a species issue. Water flow of 5 in/hour + rain in the bay area = not gonna be a significant problem in terms of oversaturation.

PSA: when I talked about what tree to use, I was thinking of reducing irrigation.

SF: I think the experts would agree irrigation is necessary and there will never be too much water for the tree.

WB: Well it might not need irrigation after 5 years. It'll be out of the sandy soil in no time.

SF: once its past 5 years, it's finding water, oxygen and nutrients on its own and won't need outside help.

PSA: but once you get to the native soil you can't turn it off.

RS: with native soil, you need to provide all its inputs. You need to make sure the roots drain, tree gets nutrients.

PSA: we should anticipate that there might not be native soil beneath

SF: but there's middle ground in ultra-urban developments and bioretention is being implemented. Only native soils are underneath parking structures, are compacted. Irrigation and long term success of the tree are nuanced.

PSA: It's the same in Emeryville as well.

SF: Facebook didn't want bay high water coming into their system. There's goals and then there's practicality.

PSA: Does soil with more volume eventually make a difference? Water retention?

RS: I don't think they'll make significant difference and I don't think it'll be cost effective. I see green roofs that don't have this

AL: some of these have hybrid layers though.

SF: I feel like this group is going towards a movement away from additives and towards topsoil in the system. Engineers want to make sure that hydrology of the system continues to function.

RS: I think you need a different structural design for bioretention and a different for trees. I think they can be next to each other, but they're very different systems.

PSA: Forebay could be sized for 10 in/hr, and tree system for 2.5 in/hr, and you combine them to equal 5

SF: If the goal is 5, can we start out at something that starts out at 5 instead of something at 25 that will eventually clog to 5? Pull back so we can actually get some retention and account for failure.

JB: I'm not sure how much scientific footing 5 in/hr has.

RS: Caltrans has filters that do 100 in/hr and we're trying to get up to 4. We're looking at what water treatment plans are using. Soil: maybe less would be a better number.

SF: isn't 5 in/hr driving the 4%?

JB: It's the 5 in/hr and the design of rainfall intensity for a flow-based system. Designing for frequent storms. It's a very simplistic method. Soil mix as a filter drains through and you have to have a minimum of filtration to the soil. Bioretention should be a combination system. NO one wants to go above 4%.

What you're proposing is radical. But if we're talking about a 2 stage system, we can do 4% first and something else later.

SF: we see a lot of designs that are missing the intent. I'd rather have them get more credit in the development process if they can make the system bigger and allow trees.

JB: Green infrastructure is trying to get street trees etc. in the big picture.

SF: Some people can't plant these trees because the 4% will increase to 4.5%

Takeaways:

- design differently for different situations and take natural systems into account. Look at overall designs, and redefining specs for compost would be a good idea. It deserves extra attention.
- Bioretention should also find a way to incorporate without massively retrofitting the urban environment
- Look at systems approach and not just fixing the soil itself. This includes access to native soils, which go back to soil volume.
- Don't force trees down places where they can't grow.
- Think about why we integrate trees with stormwater/bioretention facilities in the first place? Why does it increase the function of the facility?
    - Improves efficiency of the bioretention facility due to water uptake (but is it necessarily true here in California?)
    - Also, are there any native plants that aren't dormant in the wet winter that can do the job?

6/30/16

Green Breakout Group

Tom Bonnell (Pleasant Trucking), Nelda Matheny (Hortscience), Greg Balzer (Caltrans), Robert Campos (Wood Rodgers), Jing Wu (SFEI), Teresa Eade (StopWaste), Nyoka Corley (LH Voss), Joshi Bhaskar (CalTrans, phone), Shannan Young (City of Dublin)

What brought participants to the Round Table:

Nelda: Soil volume for trees. Doesn't think the ratio of soil volume to trees canopy that is commonly quoted is appropriate for CA. Climate based model developed by Nina Bassuck at Cornell. Her formula was based on the soil volume required for adequate water for a 10 day supply, in sandy loam soil, in Ithaca NY. Stop using as a guideline. Instead, concentrate on growing the biggest root system possible into landscape/native soil.

Greg: Lots of different functions for bioretention areas (i.e water quality vs trees/building an ecology). Try to verify what the goal is. You aren't going to grow plants/trees in a 60-70% sand mix. Need more of a sandy-loam mix and research/testing of any new mix.

Robert: Need to pick the right tree in the correct location within the treatment area, and have appropriate irrigation.

Jing W: We will be planting trees in urban landscapes and it is beneficial to have stormwater systems with trees. Maybe have a tree specific mix. Do future research/monitoring.

Teresa E: Create sustainable landscapes, compost is the cornerstone of sustainable landscapes because of water holding and biological component. The biological component is missing in the current mix, and these are high demand systems. Additives mentioned in lit review don't have any of the biological metric. It is difficult to get bioretention areas to perform multiple functions. Maybe just have shrubs/small plants in bioretention areas.

Tom B: He's not seeing many trees in bioretention areas. He thinks it makes more sense to have only shrubs/small plants in bioretention areas. His interest is in having a specification that they can meet. They are still missing a couple of components on the compost side (i.e. Not passing the spec). Additives: everything costs, and most are not local. He thinks the top soil is good and we should go back to using that. He takes samples from different portions of the pile in order to get samples that pass the requirements.

Nyoka: Confusing regarding the quarter inch (1/4") screen. Spec indicates 40-90 % passing is required, but the compost is coming in finer than that (typically 95% passing). Alternative mix specifications indicate that only 2-5 % fines are allowed, but the sand component is already at 5% max so you can't add compost.

Greg: Are we looking at a performance spec or materials and methods?

Tom B: Cost is an issue. It's costing them $800/permeability test. Go through two different labs.

Phone (Joshi): Mostly been concerned with stormwater pollutant removal. Need a mix that shouldn't be compacted too much for stormwater pollutant removal, but that can be used in roadway conditions; it's difficult to do that. Also trying to work in narrow roadway conditions, creating environments that work for stormwater treatment and also not creating unsafe environments for vehicles and pedistrians.

Nelda: If you have 30% compost in the specification, when it degrades, you've lost 30% volume.

Teresa: Add mulch on a regular basis to help with that (compost) problem. (Not everyone wants mulch because of floating issues).

Jing: Does the biological activity of compost decrease over time as the tree uptakes/uses the compost? Nelda: plants are constantly adding organic matter (to assist with biological component). Benefit of grasses is that they add the most root mass to the soil.

Nyoka: Planted trees in Gateway Safeway in Pleasanton. They are doing well in LH Voss soil. They have been installed for three years. What is the sizing of BRAs? Some seem really small.

Shannan: Sizing is either 4% of the impervious surface drainage area, or based on the combo flow-volume sizing (as small as 2% with more surface ponding).

Teresa: Crazy idea: Hydroponic trees. Happiest trees are the ones that have broken through sewer pipes.

Nelda: It's like the Green Machine. Take the black water from the building to irrigate the landscape.

Greg: In his experience, bioretention doesn't work because it's shady, not draining, or because of compaction issues. Caltrans doesn't have a soil mix, only compost spec; no topsoil standard. They use whatever the locals want them to use. They would love a regional or state mix.

Jing: Monitored the Ceaser Chavez project in San Francisco. BRA sizing for that project: 4%. She has seen that there is no problem with standing water with 4% sizing, but with smaller BRAs, you may see problems.

Nelda: How do you irrigate in a soil that is designed to drain? Getting uniform soil moisture is difficult when you have a fast draining soil.

Nelda: What is magic about the 5-10 inches per hour? At what point are we supposed to reach the 5-10 inches per hour? At installation?

Jing: If we get failure during large storms, then we shouldn't consider it a failure because the BRAs are not designed for large storms.

Nelda: Are there maintenance standards? Are municipalities testing infiltration rates after some period of time? Haz waste issues? Teresa: we don't know yet. She thinks San Jose did a study and didn't find anything, but we still don't know. She will try to find the study.

Nyoka: Add more compost and if it's really working the way it should, then it shouldn't be hazardous waste.

Tom: The theory was that BRAs would last 7-10 years at the beginning of this. The facilities that were installed 7-10 years ago look good now. However, did it with gorilla hair to back then.

Jing: Sediment will be added over time and maintenance will be needed to maintain permeability.

Nelda: How do we encourage infiltration into native soils? Add organic matter to the native soil? Scarification?

People don't like the gravel layer. Prefer to have the gravel layer go deeper (i.e. long, narrow), or on the side? Is it really true that tree roots won't grow in the gravel?

Maintenance is huge. In order for the trees to be successful, you need to have a good maintenance program.

Nelda: We need a statement opposing lining. Edges made of concrete. Why? One landscape architect (not in the breakout group) thinks it is to keep moisture out of the adjacent landscape.

Change the soil type depending on the design of the bioretention area (more urban vs. rural) (parking lot or street trees).

Nelda: tree roots don't really go deeper than 18 inches in clay soils because they need the oxygen. In sandy soils, they can go deeper because oxygen is available. However, she thinks that we don't need to increase the depth of bioretention mix.

Big ideas:

Can't separate BRA design from materials (i.e. soil).

1) Look at the gravel layer. Will the tree roots really not penetrate into gravel layer? If they do penetrate, will they utilize the gravel layer in preference to native soil since it is less work? If so, then we would need to irrigate in warm months to keep the gravel layer wet; not a sustainable system. Think vertically instead of laterally. Jing: have to be sure that it is designed such that you are not causing more storm bypass.

Nelda, Teresa, Robert: goal is to get the tree roots into native soil as quick as possible.

2) 18 inches for the treatment soil layer seems to be working, you go deeper = dryer at the surface = more irrigation.

Materials:

3) Would having some larger woody material (composted mulch) included in the compost mix help address some of the coarseness? Tom expressed frustration that the specification has mixed goals: want it coarse at the top end for infiltration and want it fine at the bottom end for

pollutant removal. Teresa: use the same mix as in compost socks. Greg: it's difficult to get the compost socks mix because they have to compost it again. Teresa thought it is more widely available in Nor Cal than So Cal. Teresa: Why are we using such finely screened compost?

4) The group is not feeling most additives (unless you are focusing on a particular pollutant problem), except for compost and top soil (but top soil is not consistent). Focus on local sources.
5) Need to require a spec for chemical component of sand. Need threshold for salinity.
6) Maintenance standards are needed and training for landscapers.

If we are going to change the standards, we need lab testing standards.

WDOT studies on Compost amended vegetated filter systems. First flush, pollutants are exported, after that: net removal.

Group participants:
Megan Stromberg (WRA), Jeff Sinclair (City of San Jose), Alex McDonald (Caltrans), Elizabeth Lanham (Davey Resource Group), Igor Lancan (UCCE), David Swartz (City of Fremont), Meagan Hynes (Talus Soil Consulting), Connie Goldade (Community Design and Architecture).

From: Megan Stromberg
To: Shannan Young
Subject: Notes from my discussion group
Date: Sunday, July 03, 2016 11:24:31 AM

Hi Shannan,

Well done. I get that you were hoping for more concrete direction but I think it was significant forward progress.

My group had the following main points in no particular order:
-Change the compaction test to reflect the field conditions better.
-The mix needs to be slower, closer to 5"/hour. The max flow rate is too high. It needs more fines. The interim spec moved in the wrong direction.
-When mulch floats it indicates a design problem, not a problem with mulch. if basin is designed correctly, mulch won't float.
-Need to educate everyone on terminology of permeability/infiltration/hydraulic conductivity testing. Meagan Hynes to provide summary.
- pH range of sand acceptance should be up to 7.8 (7.5 at the very least). Would be good to add a pH range for the mixed BSM.
-Chemical suitability testing seems like a good idea. Especially in watersheds with TMDL
Could test for target pollutants. Do we need to test sand for metals? Look at local sands to determine if there are problems.
-Would like to have a decision tree to aid designers and reviewers. Help determine which design and/or soil mix is best to meet different goals.
-Trees need access to native soil. Tree roots grow mostly laterally not down below 18". Side barriers are most important to remove, not the aggregate layer. Engineers commonly want deepened curb and liner (concern for water moving into utility aggregate layer or building impacts.)
-We don't want to require any additives that aren't locally available. Consider the sustainability of changing mix.
-Most submittals fail to meet standard and have to get treated like the alternative mix almost always. Alternative mix spec may be too lenient.
-Look at adding Silva cells outside bioretention
-Look at work by Geofortis on diatomaceous earth

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BASMAA Meeting notes 6/30/16

Biotreatment Soil and Tree: Yellow Group

Participants: Paul Niemuth (City of Fremont), Glenn Flamik (Cal Fire), Matt Moore (TMT), Bill Sowa (HMH engineers), Dorothy Abeyta (City of San Jose), Anne –Marie Benz (BFLGC), LeighAnna Johnson (WB, note taker).

Beginning concerns/comments

What is trying to be accomplished with the soil compositions itself? Is this because of reduced space? – Glenn

Too micro of a view, wants to look at the big picture – Ann-Marie

Biotreatment cells are replacing the space in the urban environment where trees should be. How can we make biocells accommodate trees? – Dorothy

We've gotten away from our professional experience, solutions are diminishing. Wants to open the dialogue and open solutions to water quality treatment. Has concern for risk management for his clients, wants less risk at the agency level, less risk at construction level where materials are available. Find the benefit for natural reasons compared to engineering solutions, we're becoming less creative. Get away from cite and look at the regional outlook to support the Water Board. - Bill Sowa

Treatment areas need to be confined to a certain area, you can't grow plants, trees, or irrigate- isn't there a zone for alternative treatment? Engineers just want the numbers to work, not if the treatment or soil health is actually beneficial. -Paul

Can we keep a consistent amount of topsoil? Finding soil for a decent price.

The import compost material for soil may contain pollutants, or excessive nutrient content that leach in the beginning. Do we really need something to filter it if it's a short term problem?

How do we reassess something if we don't know it's broken?

Group Discussion Questions: Bioretention facility experience

What has been your experience using the current bioretention soil mix specification? What are the biggest advantages, drawbacks, most vexing difficulties?

- Inspector looks at the soil mix, they test to make sure the plant material is it alive and functioning. Results are soil sluffing; dead plants that need replacement; plants, splash blocks or cobblestone getting buried in the biotreatment soil.

Have you experienced any failures (inadequate percolation through the soil mix?) What did you discern was the cause?

- An alternative mix of soil based media (worm castings) making up 3 ft tested great in the lab, but out in the field locked up in the wood spaces and turned into clay in the rain. The cause- Bad combination of sandy loam based soil 20% fines, 10% worm casting, coco is supposed to keep soil loose but it bounded everything up even more.
- In consistent test results: Over-compaction during installation or soil design can be tested at a certain percolation rate but you can't duplicate that percolation rate during lab tests or in the field. Even with a duplicate procedure, you obtain completely different results.
- Consultant came in to tell the team how to do sheet mulching and it made it completely anaerobic, water doesn't go through it.
- Plant establishment with biotreatment is difficult, percolation ability, different areas of the cell performing in different ways.
- Failure- dead plants because we can't water them enough or failing/absent percolation. Biotreatment soil sluffing down and covering the plants.
- Loose soils

<u>Have you noted large quantities of water were needed for plant establishment in comparison to a similar typical landscape setting, and or for long term maintenance? Are you able to meet WELO water budget with this soil? If so, how did this problem relate to selection of the plant palette? To irrigation system features and design? Could Changes to either address the water issue?</u>

- Large quantities of water are needed and irrigation is needed much more frequently. To keep Juncus from looking like rags, you need to water much more heavily.
- Excess irrigation is affecting plant palette, it's really narrow depending on irrigation.
- Water holding capability of the soil needs to be addressed. It needs to be increased.
- Weeds are an issue because they do not want to use pesticides. Discerning and educating maintanance on weeds vs plants that are supposed to be there.
- Mulch is producing weeds. Recommendation-

<u>Are you familiar with any bioretention facilities that have been installed for 5 years or longer? 10 yrs? What changes if any in characteristics or performance have you noted?</u>

<u>What aspects of bioretention design and construction stand out as factors affecting long-term performance?</u>

- Do milk crates under soil affect long term?
- Must be patient with soil structure

Have you had experience with trees in bioretention facilities? What features of design and construction were innovated to support tree survival and health? Did any problems of failures occur?

- Trees were getting irrigated by a bubbler in a 3 ft deep PVC tube. It was not an effective method to deliver water to the tree roots. How do we get out of an established narrowed option solution? It took so long to create a solution. How do you beat a long term accepted plan that isn't best for planting design?

- Recommendation -Do not plant trees in concrete boxes, and get rid of Filteras.

- Plumb irrigation to where we're planting and water with truck water until the trees are established.

Do you have any ideas or recommendations for design, installation, soil characteristics, or other features for supporting trees in bioretention facilities?

- Liners are not recommended unless you cut open a hole in the liner. Use native soil to establish roots beyond the biotreatment wall.
- Recommendation -put the liners to the side from the trees. Mechanical treatment opposed to liners because they are not sustainable and chemicals leach out of liners.
- Open bottom planters is another recommendation.

Soil Testing

- It's easy to get soil approved/accepted in Fremont. - Matt
- Problem- A separate City department approves soils even though they have no experience interpreting data. – Dorothy
- There is significant inconsistency and variability with soil testing (due to environmental conditions, availability of fully compliant material, availability to aged compost)
- Batch specific is highly impractical and no one in the Bay area can do it because of needed real estate.
- Quarterly or monthly testing is much more practical.
- Lack of testing might be because of inconsistency.

Compost specification

- If compost has never met spec, what needs to change?
- It's difficult to get a sieve test on compost.
- pH is a good marker for effective composition

- You need to test the finished blended components and test for soil chemistry, not the individual components.

Question 4-

- There is no aged compost in this region, it moves faster than it should. Composted mulch works. Compost from ZBest works in sheet mulching.
- Gorilla hair or shredded wood-concerning from the fire standpoint or it matted too much yet it's effective and locks into place. It needs to be replenished because it mats down but doesn't move away.
- Subsurfaced load exceeded surface load.

Additives

- It's hard to justify the extra costs. It's better to use local resources – for environment and cost.
- Biochar has no viable data and results are hard to duplicate.
- Volcanic sand is not as costly
- Perlite and vermiculite are an environmental disaster.
- What works? engineered soil to mimic native soil. The challenge is getting consistent long term product.

Concensus and Summary:

- We need a bigger broader solution to the problem.
- We need to treat areas before they drain to sites, not once they reach every certain site.
- "More tools for the toolbox"
- High alkalinity compost or sand is a concern. Yet when you buffer sand or compost it changes the composition, stability, and effect.
- Plants are dying – wash the roots and examine and the result of the plants dying is almost every time lack of water.
- We need education on soil placement
- Educate irrigation maintenance and inspectors.
- Testing methods for the component need to be improved, need more local testing on local sites.
- Do we have enough sites and come up with funding to improve more consistent testing.
- If we can't compare what's working with the soil and water quality we need more data, but who has the data?
- Collaborate and come up with sites that are three years old and maybe apply for a grant to test and see what's working and what's not working because that is the underlying issue.

- No one is identifying the problem at hand.

Notes from Christine. Big picture comments from large group discussion are listed below.

Paul report out

- Need more data to see if we have a problem that we need to fix.

Dan (blue group)

- Knowns: locally sourced, sustained materials. WE have a process for getting the spec. Problems: age and maturity due to supply/demand. Food waste as a source, so inerts will continue to be a problem.
- Unknowns: effluent quality and if that is a concern. How does the export of ss and nutrients change over time? More research is needed.
- Configuration and volume. In the design of BRAs, need to look at the path of least resistance for tree roots. Sandwich effect of layer maybe causing problems with root expansion.
- Trees: relationship between irrigation and plant pathogens.

Megan (red group)

- Design of BRAs, in particular barriers. How do you design BRAs without barriers.
- Options. Developing a matrix/process for alternatives. Decision tree the big item.
- Add pH testing to the whole mix.

Nelda (green group)

- Tree roots into native soil. Modify the gravel layer so that it's not a flat pancake into a deeper layer.
- Improve the native soil to encourage roots to grow into it.
- 2:1 tree canopy ratio is an east coast specification
-
- BRA soil is integral to the type of design that is used
- Avoid using additives that are not locally sourced
- Chemical analysis for sand
- Consider including medium and large size compost in the specified compost mix.
- Maintenance guidelines and training for the landscape maintenance professionals.

Peter (red group)

- Integrated system design and how it evolves over time.
- How does the size of the tree over time impact the design
- How did we get to this point of today? Where did the 5" per hour come from? Dan: what is an infiltration rate that could reasonably be used in the urban landscape? Dan imported the Portland standard of 5" per hour.

- More complex, hybrid design
- Maybe there are some instances in which trees shouldn't be used.
- What do trees bring to the discussion? There are a lot of advantages to big trees (i.e. uptake of water and increase performance of BRAs)
- Access to native soil
- Maybe 18 inches of BSM isn't enough
- Workgroup of compost suppliers (maybe an action item that could come out of today)

Compost

¼ compost people can't meet it. Request is to change to 95%. Someone else thinks that is not the right approach. Need bigger particle size. ½ minus. Most trees are low nitrogen requiring plants. Look at nutrient loading of the trees and then look at the compost needs. Moving forward suggestion: compost suppliers and soil labs to develop a good spec.

Why 30% compost? Include soil instead of as much sand/compost. Include more fines to slow the infiltration rate. Fines are mostly clay, depending on your component gradations (i.e sand), then you may have plugging. But from a blenders perspective, each soil batch is different.

Define the most appropriate testing methodology. Maybe methods that are used in lab don't reflect what is happening in situ

Dan. We need to evaluate trees that have been in the ground. Igor offered to evaluate trees.

Other ideas for additives. Biochar (will slow down infiltration rate).

Soil – specification to limit variability? Suppliers say it's a natural product that is all variable, supplies variable. Horticultural people say there are specifications for landscape soils.

When we start adding sand, there is a high probability of locking up. The less you handle the soil, the better. Over time, the soil will improve.

Evaluate topsoil so we know what we are getting. Suppliers: Where are you going to get the soil (strip mining)?

What about adding about 5-10% of the compost as the compost sock variety? Available carbon is higher, then more nitrogen is immediately available.

Need to look at systems that sustain themselves over time in regard to nitrogen renewal.

Question from Dan: when the trees have been in the ground for some time, does the soil develop into a more complete soil? Is there a lab test? Maybe (ask) Can you visually look at the soil (Igor says yes, to some extent, but soils don't really form in such a short time frame (i.e. ten years).) Dorothy thinks that

soil can actually form (via the topsoil SJ specification) in a couple of years. But the BSM mix does not form soil.

Want a carbon mix that doesn't create bioavailable nitrogen so the biological breakdown doesn't starve the plants.

Focus:

Dale: treeable bioretention soil is not attainable. What we really need is a bioretention design that can accommodate trees to help them grow.

Supplier: performance spec, but don't give ingredients. Soil lab would need to be able to test performance and have it be repeatable.

How does the BSM mix function as a soil

Supplier: can't meet the ¼ inch spec. Need to change it.

Jill: two working groups: 1) to look at compost/fines, and one to look at design.

Idea of degrading infiltratin rate over time may not be accurate. Tree and plant roots will increase/maintain permeability. Design for a healthy environment and infiltration rate will follow.

What is the target initial infiltration rate? From where did the 12 inches per hour come?

Constrained right-of-way

Peter: Try out the use a different test with less compaction which supposedly mimics more in the ground conditions. Thumbs up on that from the group. Dale, we WB will allow it. Labs: maybe try out both methods side-by-side to see how it impacts infiltration.

Ron Alexander: helped CalTrans, Washington DOT spec, (include on subcommittee).

Compost suppliers are not involved. Need to involve more of them.

ATTACHMENT

C.3.c.i.(2)(c)(ii) Model Biotreatment Soil Media Specifications

Bioretention Design for Tree Health: Literature Review

Bioretention Design for Tree Health:

Literature Review
San Francisco Bay Area, California

Prepared For:

BASMAA
Contact: Shannan Young
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Date:

September 15, 2016

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1.0 INTRODUCTION

On June 30, the Bay Area Stormwater Management Agencies Association (BASMAA) convened over 40 experts at a biotreatment soil and tree round table to review the current soil specifications to determine if improvements to the specification can be made to positively impact the health of trees planted in bioretention areas. Participants at the Roundtable included numerous stakeholders: Municipal representatives, compost providers, soil suppliers, soil laboratory technicians, civil engineers, landscape architects, soil scientists, construction inspectors, and Water Board representatives. One outcome of the Round Table was the consensus that the standard design of bioretention areas should be evaluated to promote improved tree health. A complete summary of the Roundtable hosted by BASMAA on June 30, 2016 is summarized in a separate report dated July 27, 2016 (BASMAA 2016).

To begin to improve bioretention basins for trees it is important to first understand the basic needs of urban trees. James Urban, one of the contributing designers of silva cells and structural planting soils, describes the six critical requirements to grow a successful tree paraphrased below (Urban 2013):

1. Sufficient soil volume
2. Room for growth at the base of the tree
3. Water flow in to the soil
4. Water draining out of the soil
5. Room for canopy growth
6. Quality nursery root stock

Bioretention generally adequately provides for items two through five. This report will focus on how to enhance the soil volume for trees in bioretention.

2.0 DESIGNING BIORETENTION FOR TREES

2.1 Soil Volume Guidelines

Soil volume is one of the most important factors effecting urban tree health and is relatively limited in bioretention systems as they are currently designed. While there have been studies of urban tree soil volume requirements on the east coast of the US, these studies don't apply in California where irrigation is the norm. Limited research on the minimum soil volume required for urban trees in summer dry climates has been conducted. In general, researchers suggest that irrigation can compensate for limited soil volume. We were not able to locate any research based guidelines applicable to the Bay Area for soil volume for trees. However, researchers recommended that soil volume should be maximized, especially considering the fast-draining engineered soils in bioretention. While general guidelines don't exist for the arid west, some cities have issued guidelines. The City of Emeryville has adopted minimum urban tree soil volume standards in Table 1.

Table 1. City of Emeryville Minimum Soil Volume Standards[1]

Size	**Volume (cubic feet)**	**SF needed in 18" deep soil**
Large Tree	1200	800
Medium	900	600
Small	600	400

1 Water Efficient Landscape Requirements referred to in Section 9-4.602 of the Emeryville Municipal Code. Found at: http://emeryville.org/DocumentCenter/View/1754

2.2 Increase Access to Native Soil

BASMAA bioretention standard designs require a minimum soil depth of 18" which is widely used as the standard depth. The biotreatment soil media (BSM) is underlain with a 12" aggregate layer (Figure 1). Loren Oki, Landscape Horticultural Specialist at UC Davis, indicates that trees roots are unlikely to utilize the drainage aggregate layer below the BSM for rooting because it does not contain soil and the roots are unable to access the water that may be stored there below the underdrain (Personal communication, 2016). Changes in soil texture (actually changes in soil pore space) create a texture interface that impedes water and air movement across the texture change. This impedes the movement of roots into the aggregate layer as well. Furthermore, the change in soil texture between the soil in the nursery grown root ball and the BSM can have the same effect. It is imperative that the root ball come to the soil surface with no BSM soil covering the root ball soil. The interface between the root ball and the BSM will impede water and air movement into the root ball.

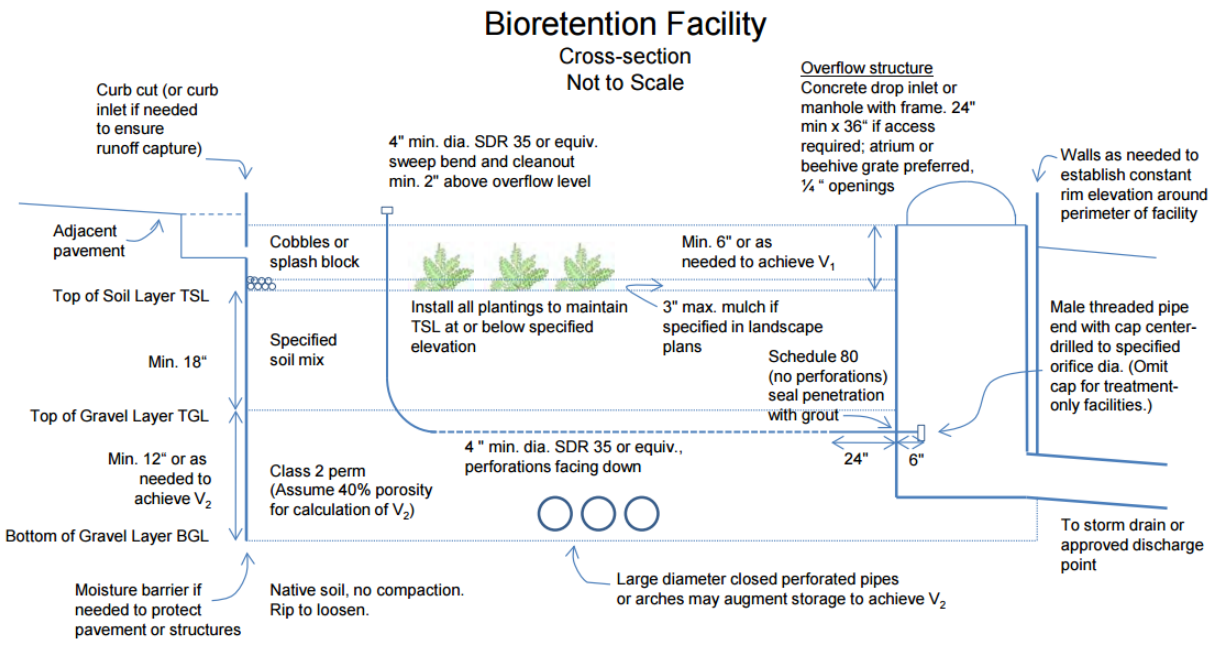

Figure 1. Contra Costa County (2012) Bioretention Facility Cross-section

In a traditional landscape planting, trees should be planted in a wide saucer-shaped planting hole with broadly sloped sides (Colorado Master Gardener 2016). This is because, if the roots have a hard time penetrating compacted site soil (due to low oxygen) sloped sides direct roots upward and outward toward higher oxygen soil near the surface. Roots that do not penetrate site soil begin to circle in the hole leading to trunk girdling roots.

Bioretention basins which are surrounded by increased height vertical curbs, retaining walls, adjacent to compacted soil, road base, pavement, utility corridors, and structures do not provide trees with access to native soil and promote circling roots (Colorado Master Gardener 2016). They are further limited by the aggregate layer that underlays the root ball. The urban Horticulture Institute at Cornell University suggests that limited volume planters can be designed with sleeves through the planter box walls to allow tree roots to access the structural or native soil adjacent to a bioretention area with vertical walls (Figure 2). Structural soil is discussed in more detail in Section 3.0.

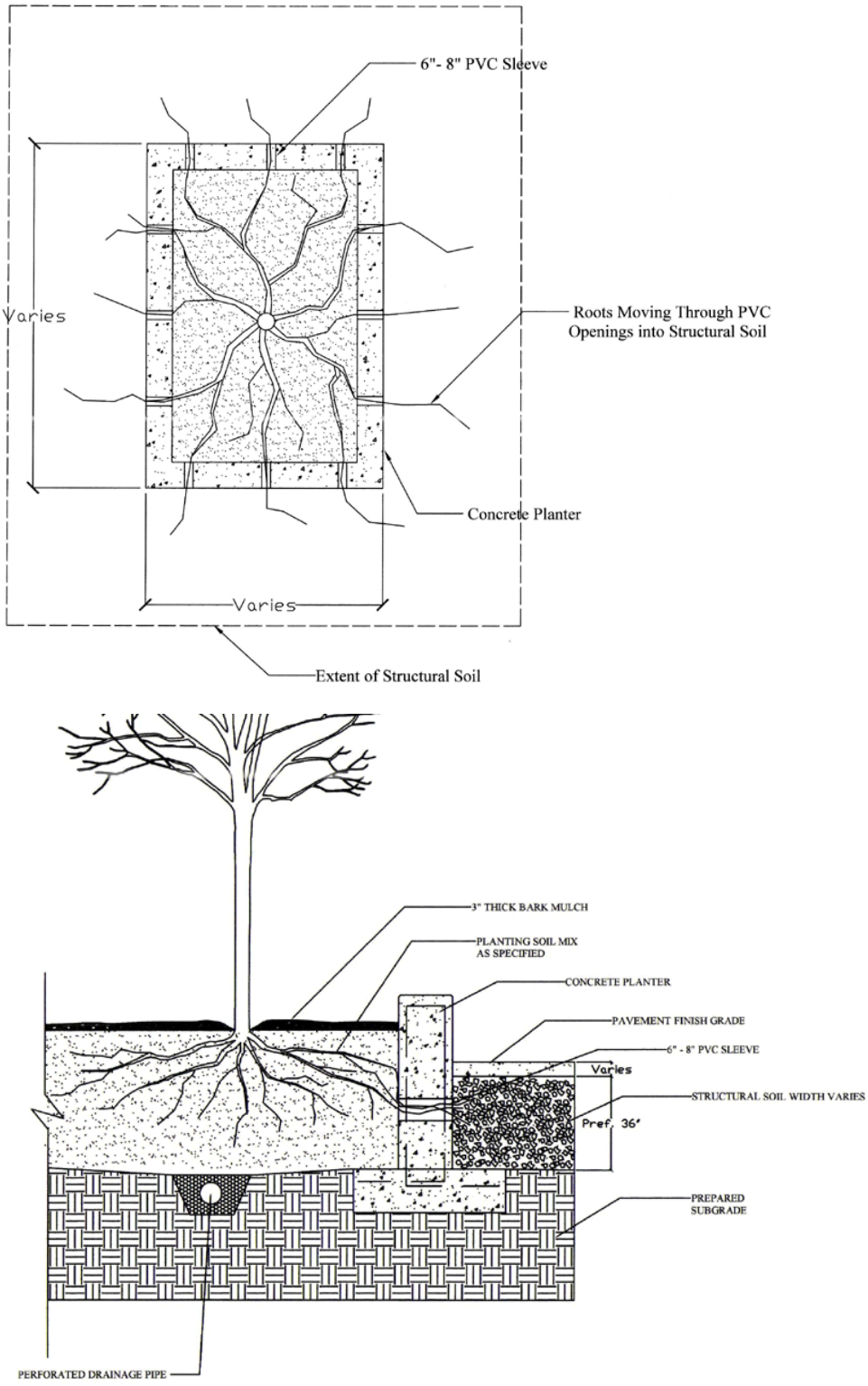

Figure 2. Roots move through PVC openings in concrete planter box wall into structural soil under pavement (Urban Horticulture Institute 2007).

Curtis Hinman, of Herrera Environmental Consultants, also reports that trees and plants, in

general, have thrived in bioretention systems around the Puget Sound (Hinman, personal communication 2016). Potentially, this could be a result of the different rainfall pattern with a much reduced drought period as compared to the Bay Area. However, it may also be significant to note that, according to Hinman, Portland also reports problems with tree survival. Portland and the Bay Area are similar in their design of bioretention systems in that both require a full width aggregate drain layer beneath the BSM layer. Seattle systems are designed such that the aggregate layer is only 12" wide and deep around the perforated drain (See Figure 3 below). The remaining areas of the basin bottom are in contact with the native soil, greatly expanding the available soil volume for trees. In the Bay Area systems, the drain rock provides added storage volume for infiltration but limits the tree's access to native soil. However, healthy trees have the potential to capture a significant volume of stormwater.

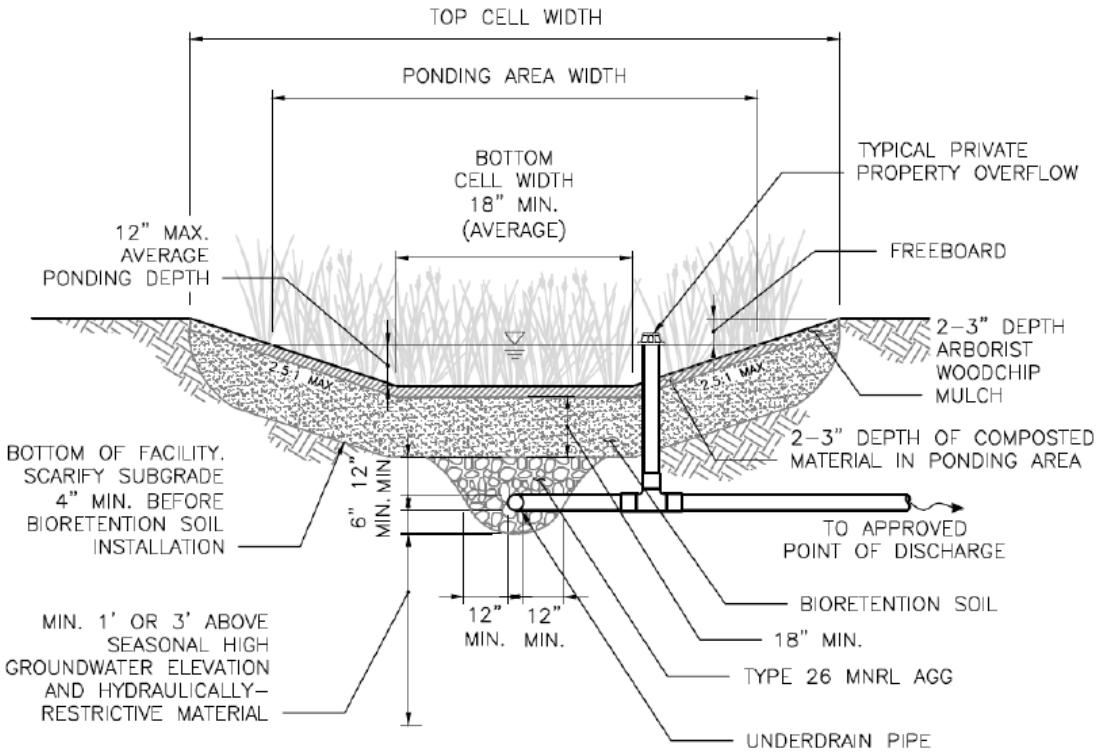

Figure 3. City of Seattle (2016) Infiltrating Bioretention Facility with Underdrain Standard Detail

2.3 Increase Soil Depth

Increasing the soil depth may also aid tree health. It is widely accepted that most tree roots grow near the surface, within the top 18" of the top of the soil. This is because tree roots require air, which is most plentiful near the surface. (Colorado Master Gardener Program 2016) However, engineered soils and structural soils may promote deeper root growth. In sandier and loamy soils that have oxygen and water moving freely through the soil column, similar to BSM, tree roots will move freely downward as long as they are not under drought stress (Urban 2010). Other municipalities around the country recommend deeper soil planting for trees in bioretention. The City of Arlington, Virginia recommends 4 feet deep planting holes for trees in bioretention.

2.4 Additional Example Cross Sections for Trees in Bioretention

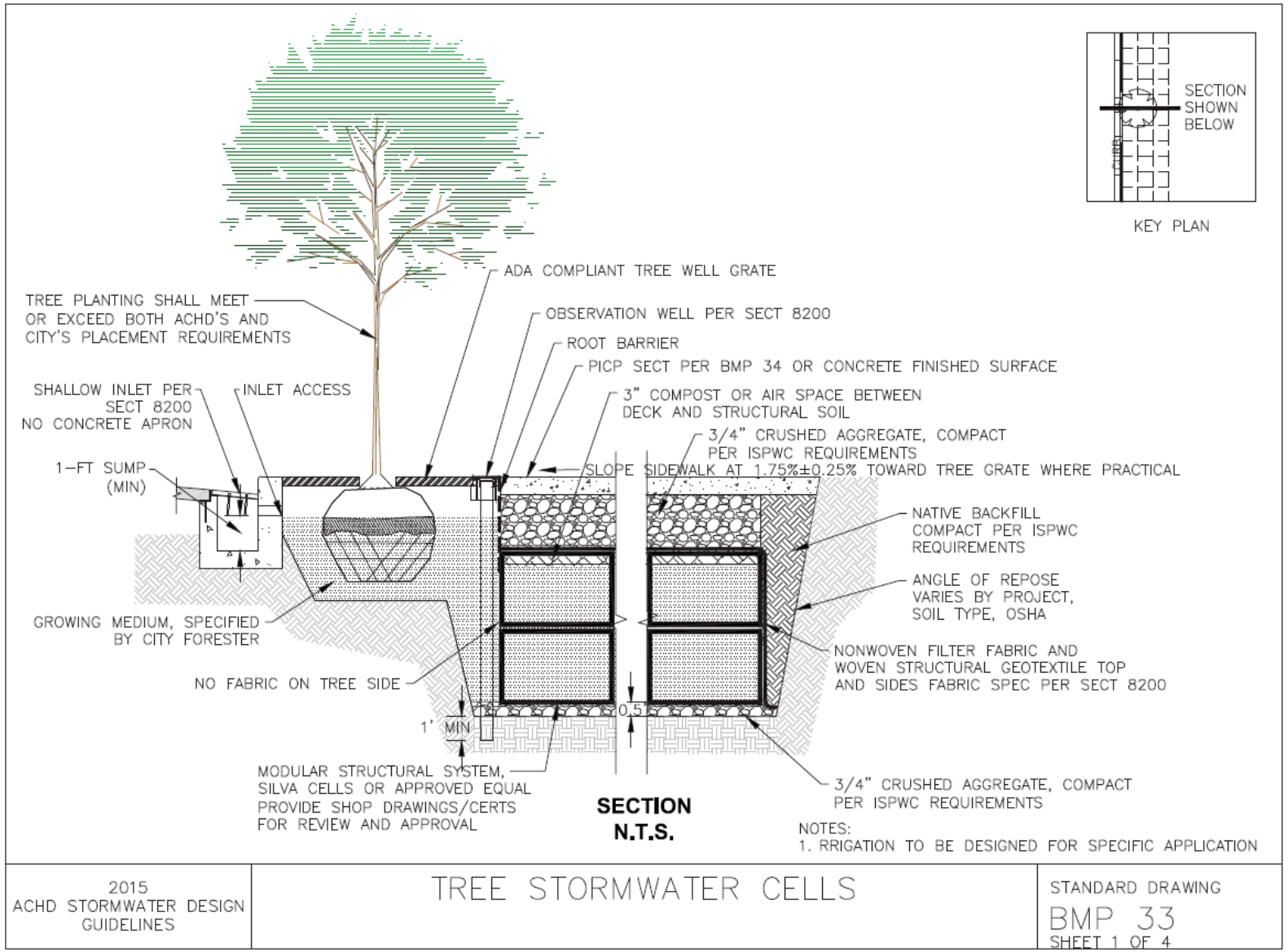

Figure 4. Ada County Highway District Tree Stormwater Cell Detail 1 of 3. (ACHD 2015)

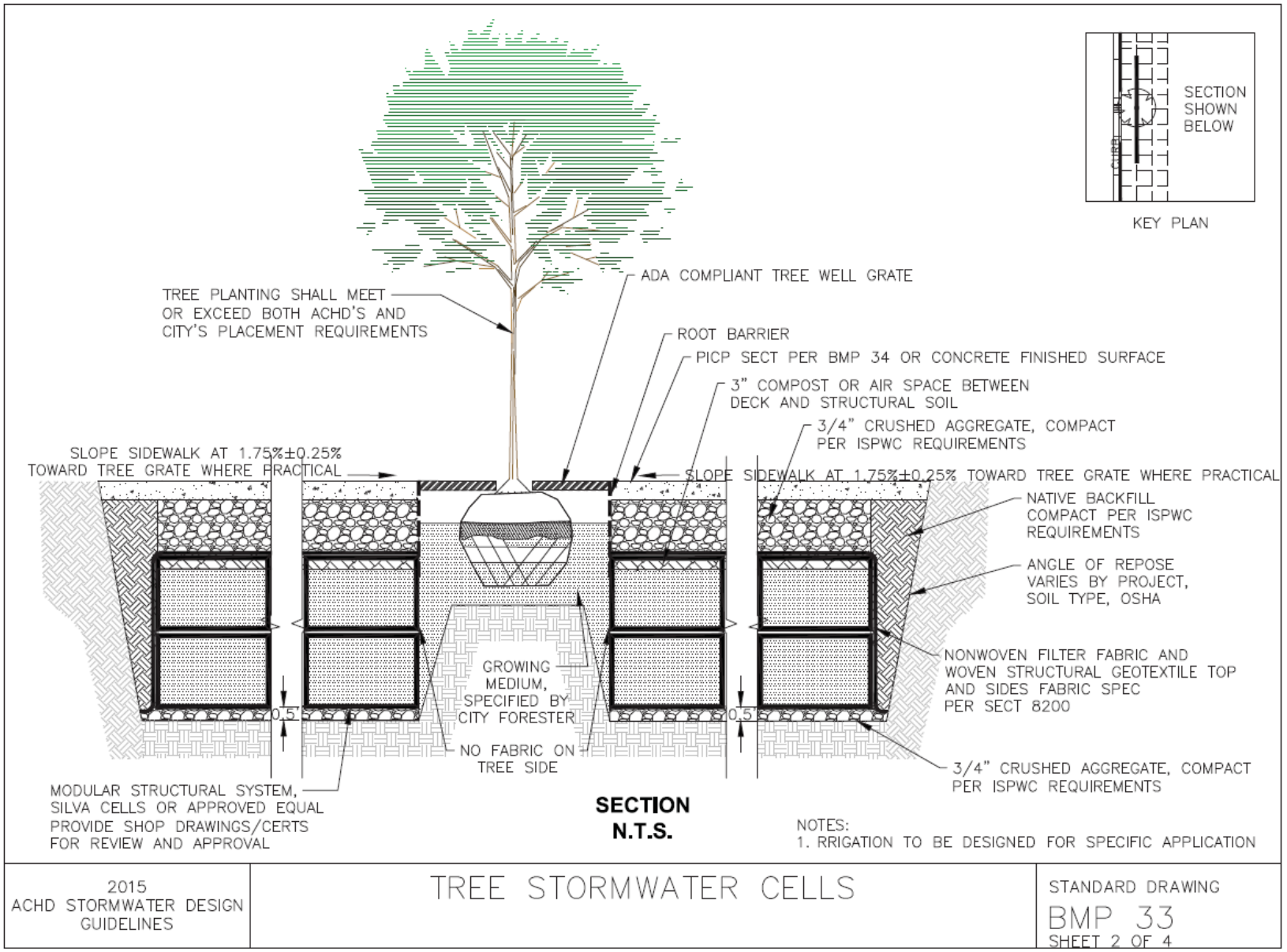

Figure 5. Ada County Highway District Tree Stormwater Cell Detail 2 of 3. (ACHD 2015)

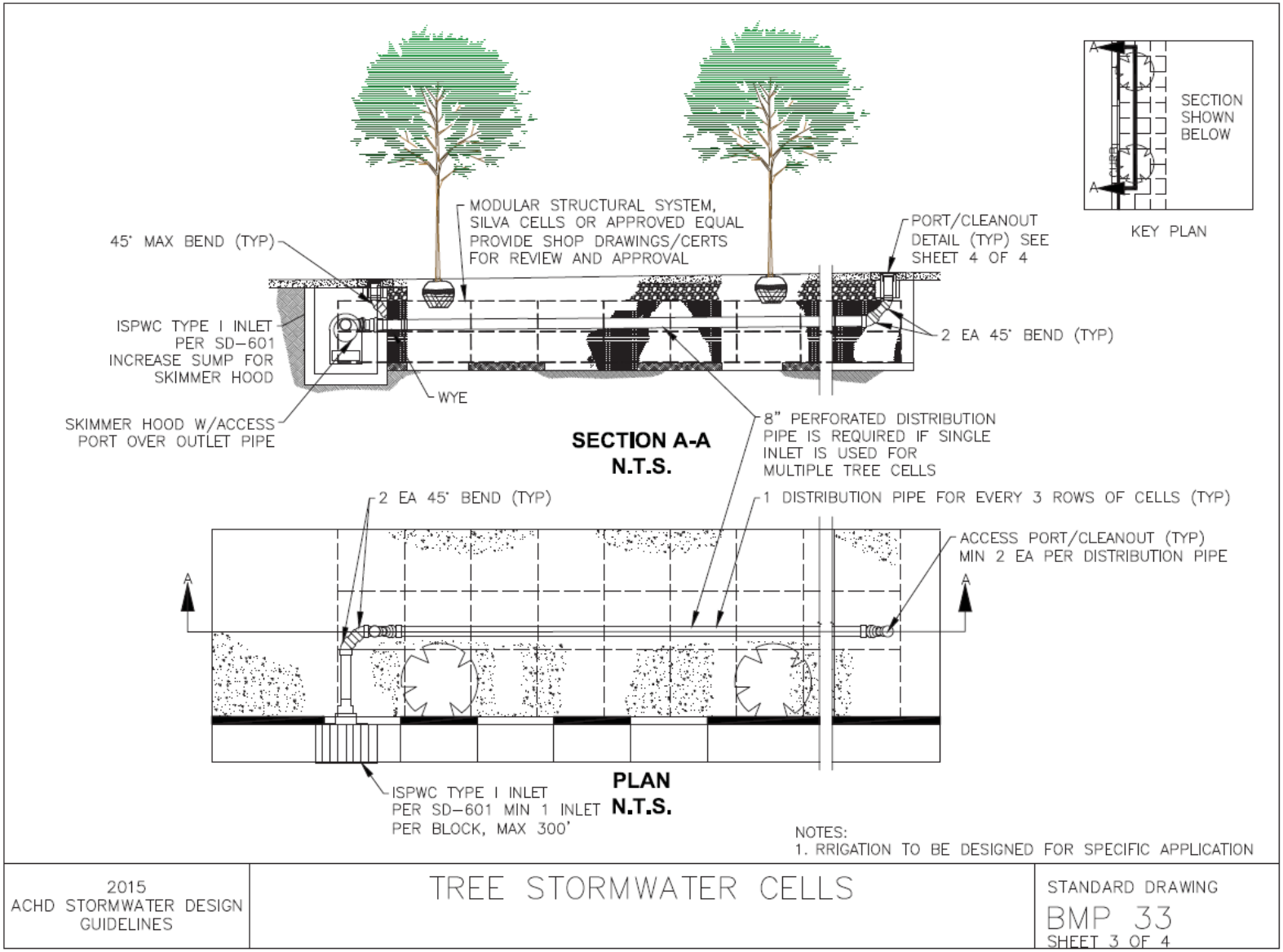

Figure 6. Ada County Highway District Tree Stormwater Cell Detail 3 of 3. (ACHD 2015)

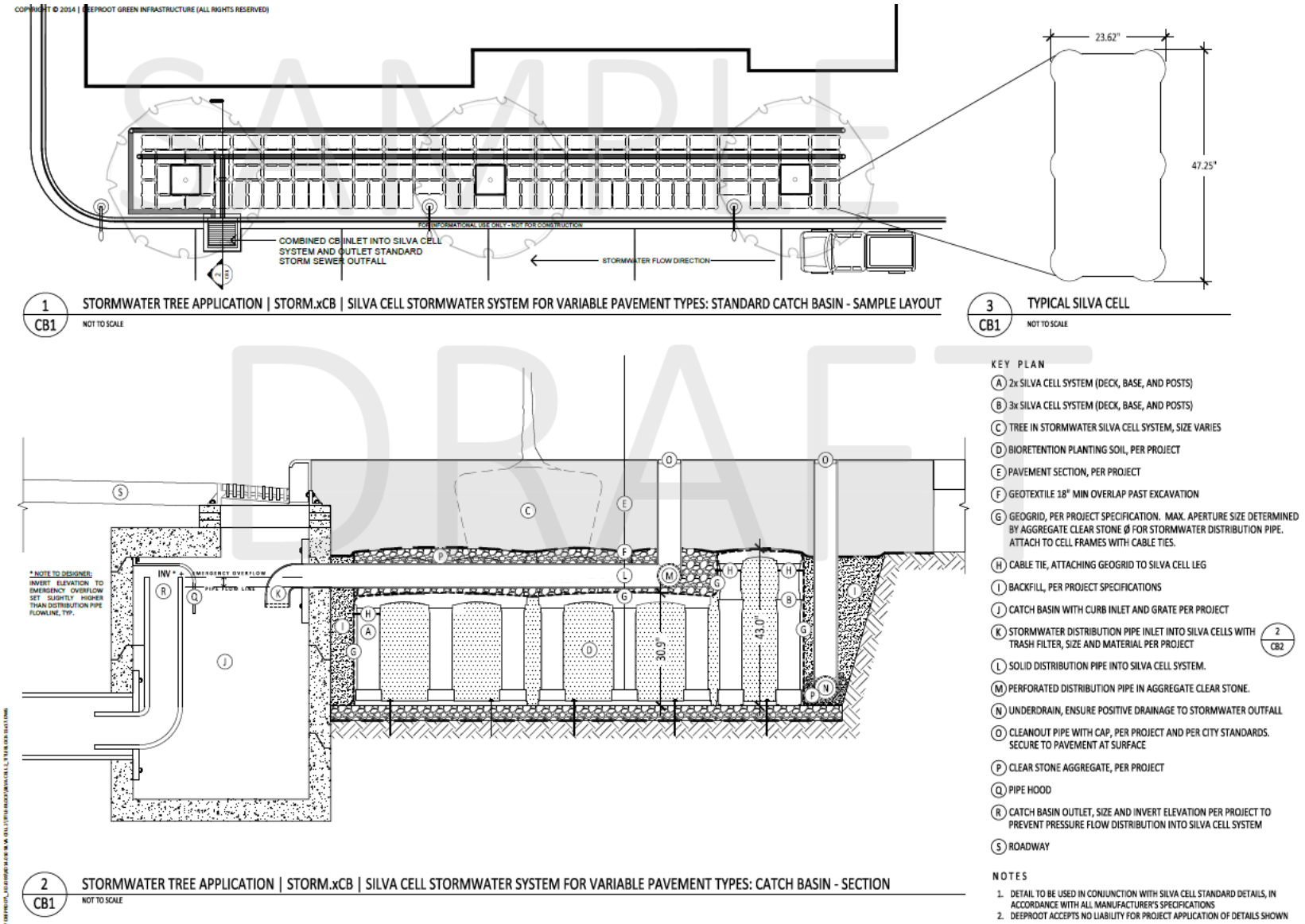

Figure 7. Draft Silva Cells for Stormwater Tree Applications. (Deeproot 2014)

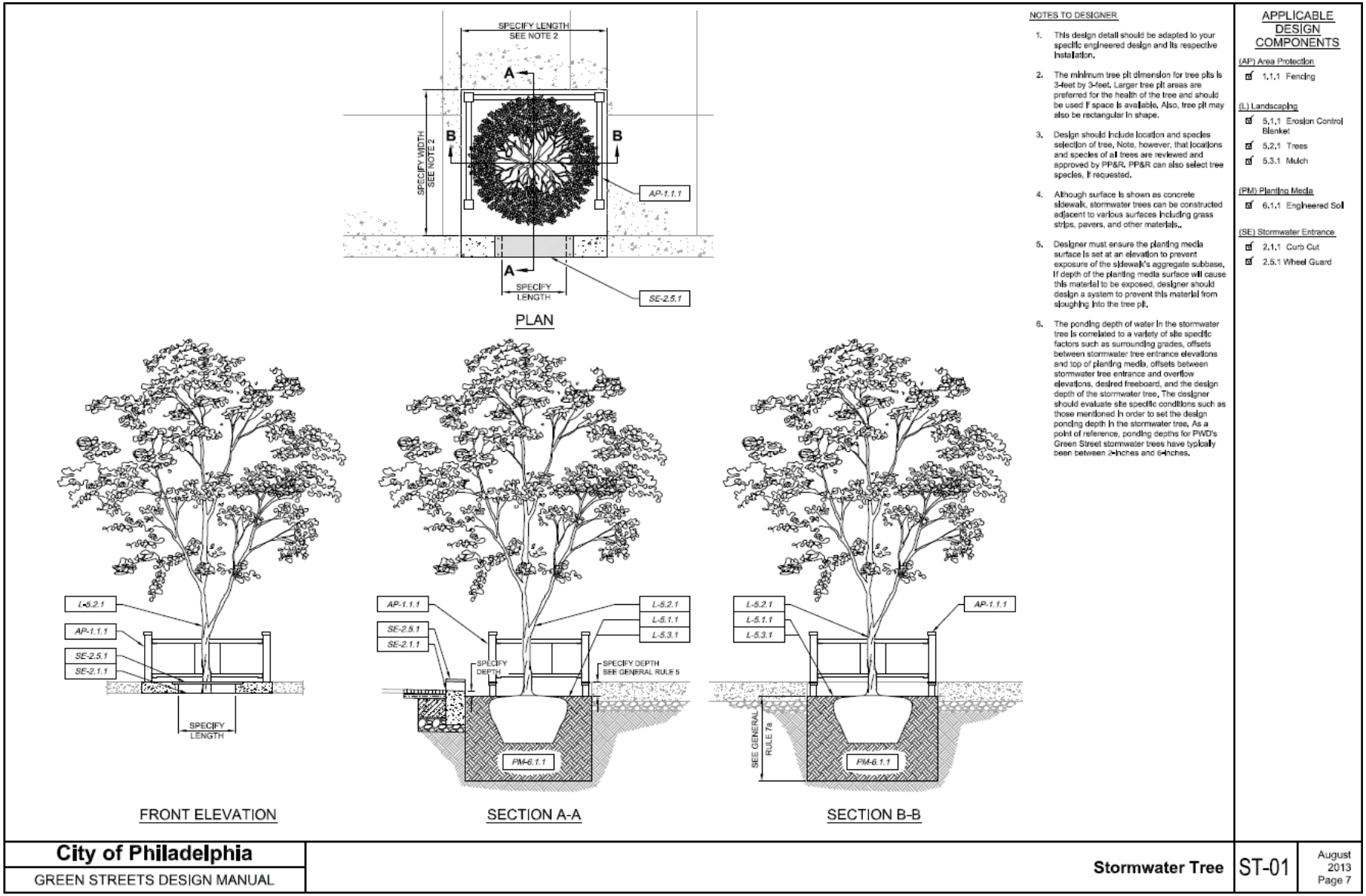

Figure 8. Stormwater Tree Standard Detail, City of Philadelphia. (City of Philadelphia 2013)

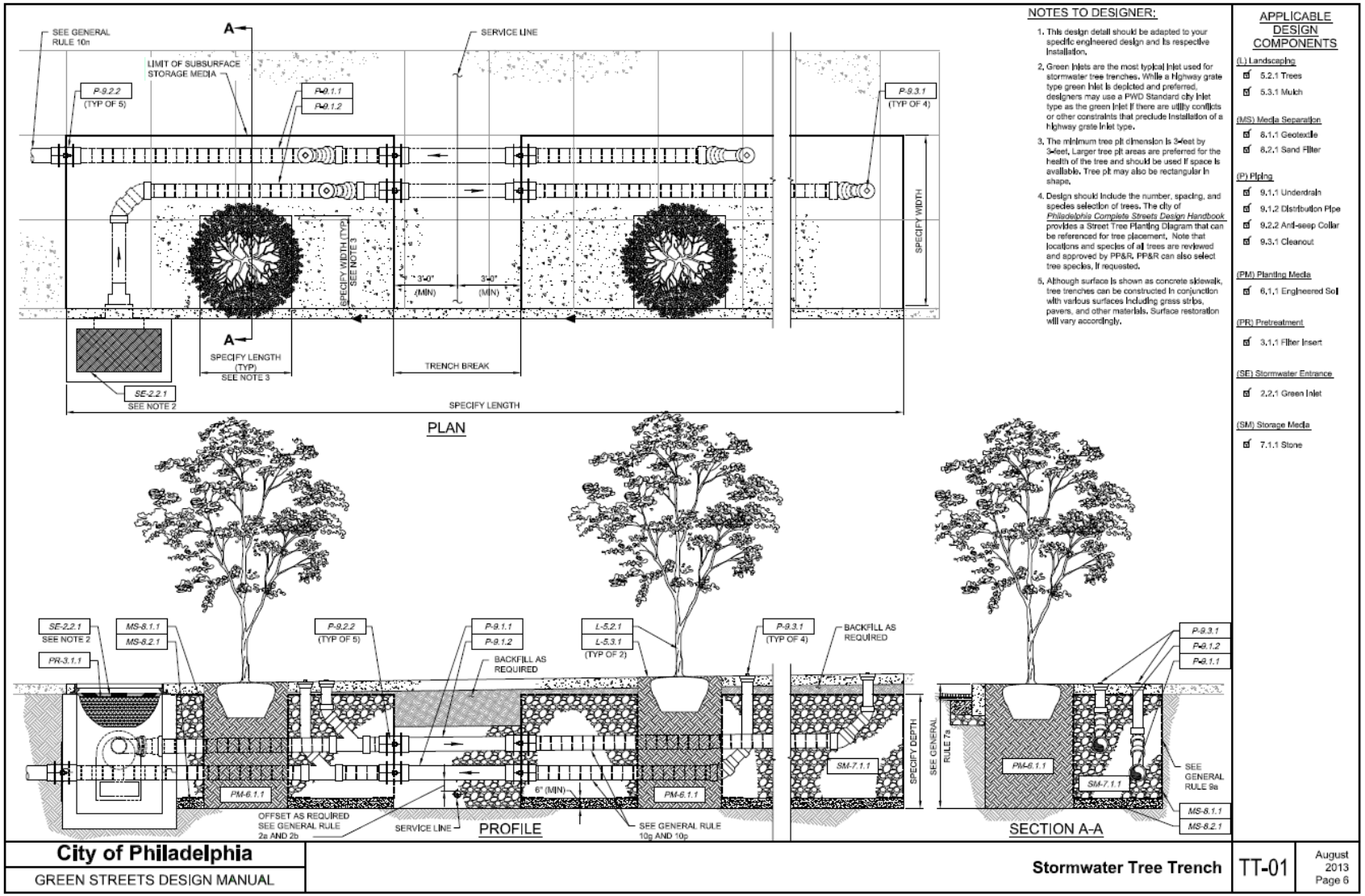

Figure 9. Stormwater Tree Trench Standard Detail, City of Philadelphia. (City of Philadelphia 2013)

2.5 Additional Design Recommendations for Trees in Bioretention

The following recommendations are compiled from a number of sources including the Center for Watershed Protection 2012, Colorado Master Gardener Program 2016, and Deeproot 2013 – 2016.

- **Compacted soils:** On extremely compacted soils, rototill a rind around the backfill area to a width of four, five, or more times the root ball diameter.
- **Select species** that do not provide excessive litter, particularly when planting near impervious surfaces.
- **Select species** that are tolerant of bioretention conditions
- **Root Ball Uncovered:** Do not cover the root ball soil with BSM soil as the texture change will impede the movement of air and water into the root ball.
- **Location:** Plant trees along the bioretention edge on side slopes and where there is no aggregate drainage layer below

3.0 OTHER TREE BMPS

Outside of bioretention, the benefits of trees for capturing and treating stormwater are well recognized. Best practices for urban trees in general have been developed by others as well. While they are not specific to stormwater or bioretention applications, there are numerous best practices that could improve the trajectory of trees in bioretention basins. Specifications for growing urban trees were developed by tree experts, Dr. Ed Gilman, Brian Kempf, and Jim Urban with the Urban Tree Foundation. The best practices guidelines are open source and include planting details and written specifications for planting, staking, soil modifications, irrigation and tree protection. These are included in Appendix A.

A variety of other stormwater BMPs have been developed specifically to support trees and manage stormwater as well. Tree BMPs can mimic certain physical, chemical, and biological processes that occur in the natural environment. Depending upon the design of a facility, different processes can be maximized or minimized depending on the type of pollutant loading expected. Tree BMPs may be able to be linked with bioretention in a treatment train, placed adjacent to a bioretention to share hydrology, or aspects of their design may inform bioretention basin design to enhance tree health.

Suspended Pavement Systems: In areas that do not have enough open space to grow large trees, techniques like structural cells or suspended pavement systems can be used to extend tree rooting volume under load-bearing surfaces and create favorable conditions to grow large trees in urban areas. This rooting volume can also be used for bioretention. While suspended pavement has been built in several different ways, all suspended pavement is held slightly above the soil by a structure that “suspends” the pavement above the soil so that the soil is protected from the weight of the pavement and the compaction generated from its traffic. Another option is modular pre-constructed soil cells that support pavement while allowing the soil below to be tailored to the desired functions like tree growth and stormwater management. Silvacells, Stratacell and Stratavault are three examples of this type of product. Examples are shown in Figures 7 and 10.

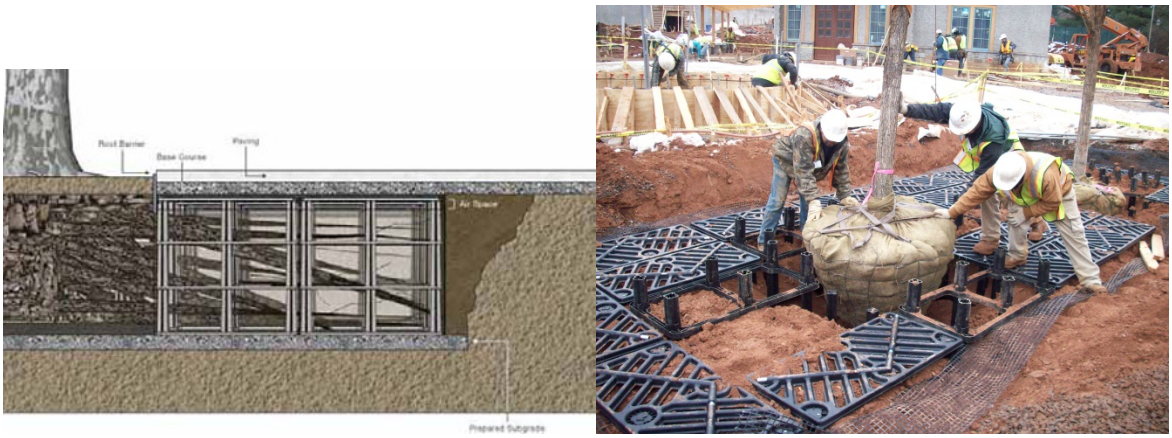

Figure 10. Silva Cell diagram (left), and installation (right)

Rock Based Structural Soil: Rock based structural soils are typically engineered to be able to be compacted to 95 percent Proctor density without impeding root growth. Rock based structural soils are typically gap graded engineered soils with the following components:

- Stones to provide load bearing capacity and protect soil in its void spaces from compaction. The stones should be uniformly graded and crushed or angular for maximum porosity, compaction, and structural interface (Bassuk et al,, 2005). Mean pore size should be large enough to accommodate root growth (Lindsey, 1994). Significant crushing of stone should not occur during compaction (Lindsey 1994).
- Soil in rock void spaces for tree root growth. Soil needs to have adequate nutrient and water holding capacity to provide for the tree's needs. Although rock-based structural soils consist primarily of rock, with perhaps about 20 percent of the volume consisting of soil, a study by Grabowsky et al. (2009) showed the available water holding capacity of a Cornell University structural soil ranged from 7 to 11 percent. This compares to a typical water holding capacity of about 15 to 20 percent for a loam soil. The structural soil appears to retain water on the aggregate surfaces, meaning a structural soil with only 20 percent soil behaves more like a system with about 50 percent soil in terms of water holding capacity.
- Tackifier to keep the soil uniformly distributed in the rock void spaces (tackifier is only found in some kinds of rock based structural soil). Two (2) inch stones would be able to support most tree roots. The tackifier, if used, should be non-toxic and non-phototoxic.
- Tree species tolerant of extremely well drained soils (Bassuk 2010) because rock based structural soils drain quickly (greater than 24 inches per hour).
- Tree species tolerant of structural soil pH. If limestone-based structural soil is used, trees tolerant of alkaline pH must be selected, as limestone can raise the pH of soil to 8.0 or higher (Bassuk, 2010 soil debate; Urban, 2008).

4.0 REFERENCES

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Appendix A
Urban Tree Foundation Open Source Specifications

32 9100 Planting Soil

DISCLAIMER AND RESPONSIBILITY OF THE USER

Use of this document: The following specification has been prepared by the Urban Tree Foundation and is copyrighted 2014. Permission is granted for use of this material for individual use or use by your organization to prepare specifications. It may not be reproduced in part or in its entirety for sale or profit; however it can be used as part of a package of services you provide for specific landscape projects. This document, when used as the basis of a specification, has significant legal and financial ramifications on the outcome of a construction project. By adopting this specification, in part or in its entirety, the user accepts all liability related to its use.

INSTRUCTIONS TO THE SPECIFICATION WRITER:

The following document is intended as a general specification to guide the writing of a project-specific specification. Each project is unique and it is required that the specification be developed accordingly. DO NOT USE THE FOLLOWING SPECIFICATION WITHOUT MAKING IMPORTANT ADJUSTMENTS to reflect local conditions, regulations, market standards, project schedules and local and regional practices. The following are specific items that need to be addressed.

1. General instructions for using this specification: *These instructions are intended to guide the specification writer (the specifier) through the process of editing this document into a Planting Soil specification. Be sure to delete these instructions (i.e. all the text in red displayed above the paragraph) before issuing the specifications.*

2. General Requirements - Division 01 (Construction Specification Institute) specifications and other contract elements: *This specification is designed to be used in conjunction with standard Division 01 specifications, which cover project general conditions and project wide contract elements. THIS IS NOT A STAND-ALONE SPECIFICATION and should not be used as a contract for the modification, purchase of and installation of planting soil. Important issues of project ownership, liability, insurance, contract language, project controls, Instructions to bidders, change orders and review and approval of the work are normally in the Division 01 specifications.*

3. The construction team: *A construction project is a team effort where the Owner, in effect, creates a partnership with all the Contractors to build a project. As with any good contract there are protections for all parties that the Owner will get the quality of project that they desire within the time limits and budget available; and the Contractor will be paid for the work satisfactorily completed. In between the initial bidding and the final completion there will be many places where parts of the construction do not work out as originally intended. This is normal and a good contract should allow for these changes in a manner that is equitable to both the Owner and the Contractor. To get there, a team approach and spirit must prevail. All parties must assume that each is operating in the best interest of the project goals. The clearer the goals and description of the project, the smoother the flow of a successful project.* ***The more each of the team members can trust the other members, the better the project****. This should be a critical principle in approaching interpretation of the specification.*

4. Other project documents: *This specification is intended to be used in conjunction with other project documents including the bid forms, the construction contract, Division 1 specifications, other specifications directly related to this section; other specifications that are not directly related to this work and most critically the Project construction drawings. It is very critical that all these documents be prepared with consistent terminology and that they be coordinated. The terms used for the parts of trees and other plants, different soil types, drainage features, irrigation features and structures such as paving, walls and planters must be consistent across disciplines. A very common mistake is the use of different terms and details for soil and the extent of soil work. The terms and details for planting, planting soil, subsoil and other materials must be well coordinated.*

5. Related specification sections: *This specification requires an additional specification section to describe several important related parts of the planting process.*

> ***Tree Protection:*** *This specification assumes that there is a separate specification section and construction drawings and details for tree protection; remove this section if there are no existing trees to be protected on the project.*
>
> ***Planting:*** *This specification assumes that there is a separate specification section and construction*

drawings for installation of plants.

Irrigation: *This specification assumes that there might be a separate specification section for irrigation associated with the project planting.*

6. Reviewing and approval authority: *Each specification identifies a certain entity as responsible for the review and approval of the work, project submittals, changes to the work and final acceptance of the work The entity is normally identified in Division 1. For the purposes of this specification, the term the "Owner's Representative" has been used as a placeholder for this entity. Once the proper term is defined (for example Contracting Officer, The Architect, The Landscape Architect, The Engineer etc.) this term should replace the words "Owner's Representative" wherever it appears in this specification.*

7. Header and footer requirements: *Change the header/footer language to meet the project requirements.*

8. Note to specifier: *Before issuing the document, be sure to remove all "**Note to specifier**" incorporated into this document in red text after you have read them and responded to the recommendations.*

9. Submittals: *Submittals are a critical part of any construction contract. This is where all products and materials are reviewed and approved in advance of the work. Planting Soil quality control is in this section. Including very specific requirements for approval of submittals, while a good practice, assumes that the reviewing authority has the skills needed to make these reviews and interpret the results. A common practice is to make very specific requirements but not have the time or expertise to enforce them. Lack of review of submittals does not automatically transfer quality control to the Contractor. In fact, lack of review or inappropriate review can make the reviewing authority responsible for having accepted the submittal even if it was not acceptable.* ***Do not put into the specification submittal requirements that you do not have the time, resources or knowledge, which you knew or should have known, to enforce.***

10. Specification modifications: *There are locations in this specification where additional information is required to reflect project region or contract conditions. Please insert the requested information.*

SECTION 32 9100

PLANTING SOIL

PART 1 – GENERAL

1.1 SUMMARY

Note to specifier: *Remove parts of this work description that do not apply.*

A. The scope of work includes all labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of Planting Soil and /or the modification of existing site soil for use as Planting Soil, complete as shown on the drawings and as specified herein.

B. The scope of work in this section includes, but is not limited to, the following:

1. Locate, purchase, deliver and install Imported Planting Soil and soil amendments.
2. Harvest and stockpile existing site soils suitable for Planting Soil.
3. Modify existing stockpiled site soil.
   a. Modify existing site soil in place for use as Planting Soil.
   b. Install existing or modified existing soil for use as Planting Soil.
4. Locate, purchase, deliver and install subsurface Drain Lines.
5. Fine grade Planting Soil.
6. Install Compost into Planting Soil.
7. Clean up and disposal of all excess and surplus material.

1.2 CONTRACT DOCUMENTS

A. Shall consist of specifications, general conditions, and the drawings. The intent of these documents is to include all labor, materials, and services necessary for the proper execution of the work. The documents are to be considered as one. Whatever is called for by any parts shall be as binding as if called for in all parts.

1.3 RELATED DOCUMENTS AND REFERENCES

A. Related Documents:

Note to specifier: *Coordinate this list with the other related specification sections. Add or delete sections as appropriate.*

1. Drawings and general provisions of contract, including general and supplementary conditions and Division I specifications, apply to work of this section.
2. Related Specification Section
   a. Section - Planting
   b. Section - Irrigation
   c. Section – Lawn
   d. Section – Tree and Plant Protection

B. References: The following specifications and standards of the organizations and documents listed in this paragraph form a part of the Specification to the extent required by the references thereto. In the event that the requirements of the following referenced standards and specification conflict with this specification section the requirements of this specification shall prevail. In the event that the requirements of any of the following referenced standards and specifications conflict with each other the more stringent requirement shall prevail.

1. ASTM: American Society of Testing Materials cited section numbers.
2. U.S. Department of Agriculture, Natural Resources Conservation Service, 2003. National Soil

Survey Handbook, title 430-VI. Available Online.

3. US Composting Council *www.compostingcouncil.org and* http://compostingcouncil.org/admin/wp-content/plugins/wp-*pdfupload/pdf/191/LandscapeArch_Specs.pdf.*
4. *Methods of Soil Analysis*, as published by the Soil Science Society of America (http://www.soils.org/).
5. Up by Roots: healthy soils and trees in the built environment. 2008. J. Urban. International Society of Arboriculture, Champaign, IL.

1.4 VERIFICATION

A. All scaled dimensions on the drawings are approximate. Before proceeding with any work, the Contractor shall carefully check and verify all dimensions and quantities, and shall immediately inform the Owner's Representative of any discrepancies between the information on the drawings and the actual conditions, refraining from doing any work in said areas until given approval to do so by the Owner's Representative.

1.5 PERMITS AND REGULATIONS

A. The Contractor shall obtain and pay for all permits related to this section of the work unless previously excluded under provision of the contract or general conditions. The Contractor shall comply with all laws and ordinances bearing on the operation or conduct of the work as drawn and specified. If the Contractor observes that a conflict exists between permit requirements and the work outlined in the contract documents, the Contractor shall promptly notify the Owner's Representative in writing including a description of any necessary changes and changes to the contract price resulting from changes in the work.

B. Wherever references are made to standards or codes in accordance with which work is to be performed or tested, the edition or revision of the standards and codes current on the effective date of this contract shall apply, unless otherwise expressly set forth.

C. In case of conflict among any referenced standards or codes or among any referenced standards and codes and the specifications, the more restrictive standard shall apply or Owner's Representative shall determine which shall govern.

Note to specifier: *Remove the paragraph below if the project is not in California.*

D. Comply with the requirements of the California code of regulation title 23 waters, division 2 department of water resources chapter 2.7 model water efficient landscape ordinance, 492.5 soil management report.

1. Where requirements of specification section Planting Soil are more stringent than the California code, the more stringent requirements shall prevail.

1.6 PROTECTION OF WORK, PROPERTY AND PERSON

A. The Contractor shall adequately protect the work, adjacent property, and the public, and shall be responsible for any damages or injury due to the Contractor's actions.

1.7 CHANGES IN WORK

A. The Owner's Representative may order changes in the work, and the contract sum adjusted accordingly. All such orders and adjustments plus claims by the Contractor for extra compensation must be made and approved in writing before executing the work involved.

B. All changes in the work, notifications and contractor's request for information (RFI) shall conform to the contract general condition requirements.

1.8 CORRECTION OF WORK

A. The Contractor shall re-execute any work that fails to conform to the requirements of the contract and shall remedy defects due to faulty materials or workmanship upon written notice from the Owner's Representative, at the soonest possible time that can be coordinated with other work and seasonal

weather demands but not more than 180 (one hundred and eighty) days after notification.

1.9 DEFINITIONS

Note to specifier: *Use the following definitions as needed to define words used in this specification. Delete and words that are not used.*

A. Acceptable drainage: Drainage rate is sufficient for the plants to be grown. Not too fast and not too slow. Typical rates for installed Planting Soil are between 1 - 5 inches per hour. Turf soils are often higher, but drainage rates above 2 - 3 inches per hour will dry out very fast. In natural undisturbed soil a much lower drainage rate, as low as 1/8th inch per hour can still support good plant growth. Wetland plants can grow on top of perched water layers or even within seasonal perched water layers, but could become unstable in high wind events.

B. Amendment: material added to Topsoil to produce Planting Soil Mix. Amendments are classified as general soil amendments, fertilizers, biological, and pH amendments.

C. Biological Amendment: Amendments such as Mycorrhizal additives, compost tea or other products intended to change the soil biology.

D. Compacted soil: soil where the density of the soil is greater that the threshold for root limiting, and further defined in this specification.

E. Compost: well decomposed stable organic material as defined by the US Composting Council and further defined in this specification.

F. Drainage: The rate at which soil water moves through the soil transitioning the soil from saturated condition to field capacity. Most often expressed as saturated hydraulic conductivity (Ksat; units are inches per hour).

Note to specifier: *The following is a general introduction to soil drainage terminology and is intended for the benefit of the specifier only. Do not include the following information in the completed specifications.*

The drainage rate of any soil is also influenced by the drainage rate of the soil lower in the profile. A compacted hard pan or Cliché layer below a free drainage soil can create poor drainage in the upper soil profile. To understand soil drainage one must investigate the total profile. Measured drainage rates are also highly influenced by soil compaction particularly in installed soil. A soil that drains at 1 inch per hour at 200 psi might become anaerobic if compacted to 350 psi. The amount of organic matter also influences drainage particularly if the organic matter is the result of adding Compost to the soil. A little Compost (10% by volume) will almost always increase drainage, but at higher amounts of Compost above 20% by volume will begin to slow drainage in the lower level of the profile because the Compost also holds water. In general it is not advisable to add much Compost to Planting Soil Mixes that are to be placed deeper than 12 inches but lots of Compost can be added to the upper 6 inches of the soil profile.

G. End of Warranty Acceptance: The date when the Owner's Representative accepts that the plants and work in this section meet all the requirements of the warranty. It is intended that the materials and workmanship warranty for Planting, Planting Soil, and Irrigation (if applicable) work run concurrent with each other, and further defined in this specification.

H. Existing Soil: Mineral soil existing at the locations of proposed planting after the majority of the construction within and around the planting site is completed and just prior to the start of work to prepare the planting area for soil modification and/or planting, and further defined in this specification.

I. Fertilizer: amendment used for the purpose of adjusting soil nutrient composition and balance.

J. Fine grading: The final grading of the soil to achieve exact contours and positive drainage, often accomplished by hand rakes or drag rakes other suitable devices, and further defined in this specification, and further defined in this specification.

K. Finished grade: surface or elevation of Planting Soil after final grading and 12 months of settlement of the soil, and further defined in this specification.

L. Graded soil: Soil where the A horizon has been stripped and relocated or re-spread; cuts and fills deeper than 12 inches, and further defined in this specification.

M. Installed soil: Planting soil and existing site soil that is spread and or graded to form a planting soil, and further defined in this specification.

N. Minor disturbance: Minor grading as part of agricultural work that only adjusts the A horizon soil, minor surface compaction in the top 6 inches of the soil, applications of fertilizers, installation of utility pipes smaller than 18 inches in diameter thru the soil zone.

O. Owner's Representative: The person or entity, appointed by the Owner to represent their interest in the review and approval of the work and to serve as the contracting authority with the Contractor. The Owner's Representative may appoint other persons to review and approve any aspects of the work.

P. Ped: a clump or clod of soil held together by a combination of clay, organic matter, and fungal hyphae, retaining the original structure of the harvested soil.

Q. Planting Soil: Topsoil, or Planting Soil Mixes which are imported or existing at the site, or made from components that exist at the site, or are imported to the site; and further defined in this specification.

R. *Poor drainage: Soil drainage that is slower than that to which the plants can adapt. This is a wide range of metrics, but generally if the soil is turning grey in color it is reasonable preferable to either to plant moisture adaptive plants at smaller sizes that are young in age with shallow root balls or look at options to improve the drainage*

S. Scarify: Loosening and roughening the surface of soil and sub soil prior to adding additional soil on top, and further defined in this specification.

T. Soil Fracturing: Deep loosening the soil to the depths specified by using a back hoe, and further defined in this specification.

Note to specifier: *The following paragraph is a general introduction to soil fracturing terminology and is intended for the benefit of the specifier only. Do not include the following information in the completed specifications.*

The back hoe method of soil fracturing is more practical in small spaces and can be more selective in areas and depths loosened when constrained by utility lines and structures such as walks, curbing or walls. The back hoe digs into the soil lifting and then dropping the soil immediately back into the hole. The bucket then moves to the adjacent soil and repeats. Optimally, a layer of Compost is spread over the soil before fracturing is begun and the Compost falls into the spaces between the soil chunks created by the effort. The deeper the fracturing and the more compact and dryer the soil the more difficult the operation becomes, but is generally less limited by built objects than soil ripping. Fracturing is not practical when soil moisture is close to or above field capacity. Fracturing leaves the soil surface quite rough with large soil clods. These must be broken by additional tilling. Tilling in more Compost to the surface after fracturing will help create an A horizon soil and/or imported or reused Topsoil can be added on top of the fractured soil.

U. Soil Horizons: as defined in the USDA National Soil Survey Handbook

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242.

V. Soil Ripping: Loosening the soil by dragging a ripping shank or chisel thru the soil to the depths and spacing specified, and further defined in this specification.

Note to specifier: *The following is a general introduction to soil ripping terminology and is intended for the benefit of the specifier only. Do not include the following paragraph in the completed specifications.*

Soil ripping requires large heavy equipment to be able to operate in the space. The deeper the ripping and the more compact and dryer the soil the more difficult the operation becomes. Ripping is not practical when soil moisture is close to or above field capacity. Existing shallow utilities such as electric and particularly irrigation lines make ripping near these lines difficult if not impossible.

W. Soil Tilling: Loosening the surface of the soil to the depths specified with a **rotary tine tilling machine, roto tiller, (or spade tiller)**, and further defined in this specification**.**

Note to specifier: *The following is a general introduction to soil tilling terminology and is intended for the benefit of the specifier only. Do not include the following information in the completed specifications.*

Compost can be added at the time of tilling. Tilling has the advantage of using more compact equipment that can work in small spaces. The great disadvantage is that even large commercial tillers are limited to about 8 inches maximum tilling depth. Garden tillers typically have a maximum depth of 6 inches. The second disadvantage is that the tines create additional compaction below the tilled soil and drainage will be reduced between the tilled soil and the undisturbed subsoil.

A new tiller called a ***spade tiller*** *is becoming available that does a better job at breaking the interface between the tilled soil and the subsoil as well as retaining some of the original soil structure. This type of tiller, originally developed for the wine industry, is preferred if one is available.*

As with all soil modification techniques, Soil Tilling is more difficult the more compact and dryer the soil. Soil Tilling is not practical when soil moisture is close to or above field capacity.

X. Soil trenching: Cutting narrow trenches thru the soil at the depths and spacing specified to loosen the soil profile, and further defined in this specification.

Note to specifier: *The following is a general introduction to soil trenching terminology and is intended for the benefit of the specifier only. Do not include the following paragraph in the completed specifications.*

Where space is limited and soil fracturing is not practical, the soil can be trenched using a standard chain trenching machine. This can cut trenches easily in compacted soil to depths of 30 inches or more. The trenches are dug about 3 feet on center and backfilled with Compost. This improves drainage and over time loosens the soil between the trenches. Trenching is usually combined with additional Compost and surface soil tilling to create a new A horizon. Soil trenching is not practical when soil moisture is close to or above field capacity but not very limited by dry soil conditions.

Y. Subgrade: surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing Planting Soil.

Z. Substantial Completion Acceptance: The date at the end of the Planting, Planting Soil, and Irrigation installation (if applicable) where the Owner's Representative accepts that all work in these sections is complete and the Warranty period has begun. This date may be different than the date of substantial completion for the other sections of the project, and further defined in this specification.

AA. Topsoil: naturally produced and harvested soil from the A horizon or upper layers or the soil as further defined in this specification.

BB. Undisturbed soil: Soils with the original A horizon intact that have not been graded or compacted. Soils that have been farmed, subjected to fire or logged but not graded, and natural forested land will be considered as undisturbed.

1.10 SUBMITTALS

A. See the contract General Conditions for policy and procedures related to submittals.

B. Submit all product submittals eight weeks prior to the start of the soil work.

Note to specifier: *Confirm submittal time above is appropriate for project schedule.*

C. Product data and certificates: For each type of manufactured product, submit data and certificates that the product meets the specification requirements, signed by the product manufacturer, and complying with the following:

1. Submit manufacturers or supplier's product data and literature certified analysis for standard products and bulk materials, complying with testing requirements and referenced standards and

specific requested testing.

a. For each Compost product submit the following analysis by a recognized laboratory:
   1.) pH
   2.) Salt concentration (electrical conductivity)
   3.) Moisture content %, wet weight basis
   4.) Particle size % passing a selected mesh size, dry weight basis
   5.) Stability carbon dioxide evolution rate mg CO2-C per g OM per day
   6.) Solvita maturity test
   7.) Physical contaminants (inerts) %, dry weight basis
   8.) US EPA Class A standard, 40CFR § 503.13, Tables 1 and 3 levels Chemical Contaminants mg/kg (ppm)

b. For Coarse Sand product submit the following analysis by a recognized laboratory:
   1.) pH
   2.) Particle size distribution (percent passing the following sieve sizes):
   3/8 inch (9.5 mm)
   No 4 (4.75 mm)
   No 8 (2.36 mm)
   No 16(1.18 mm)
   No 30 (.60 mm)
   No 50 (.30 mm)
   No 100 (.15 mm)
   No 200 (.075 mm)

D. Samples: Submit samples of each product and material, where required by Part 2 of the specification, to the Owner's Representative for approval. Label samples to indicate product, characteristics, and locations in the work. Samples will be reviewed for appearance only.

1. Submit samples a minimum of 8 weeks prior to the anticipated date of the start of soil installation.
2. Samples of all Topsoil, Coarse Sand, Compost and Planting Soil shall be submitted at the same time as the particle size and physical analysis of that material.

E. Soil testing for Imported and Existing Topsoil, existing site soil to be modified as Planting Soil and Planting Soil Mixes.

1. Topsoil, existing site soil and Planting Soil Mix testing: Submit soil test analysis report for each sample of Topsoil, existing site soil and Planting Soil from an approved soil-testing laboratory and where indicated in Part 2 of the specification as follows:
   a. Submit Topsoil, Planting Soil, Compost, and Coarse Sand for testing at least 8 weeks before scheduled installation of Planting Soil Mixes. Submit Planting Soil Mix test no more than 2 weeks after the approval of the Topsoil, Compost and Coarse Sand. Do not submit to the testing laboratory, Planting Soil Mixes, for testing until all Topsoil, Compost and Coarse Sand have been approved.
   b. If tests fail to meet the specifications, obtain other sources of material, retest and resubmit until accepted by the Owner's Representative.
   c. All soil testing will be at the expense of the Contractor.
2. Submit all testing required by California Code of regulation Title 23 waters, Division 2 Department of Water resources Chapter 2.7 Model Water Efficient Landscape Ordinance, 492.5 Soil Management Report.
   Note to specifier: *Delete the above paragraph if the project is not in California.*
3. Provide a particle size analysis (% dry weight) and USDA soil texture analysis. Soil testing of Planting Soil Mixes shall also include USDA gradation (percentage) of gravel, coarse sand, medium sand, and fine sand in addition to silt and clay.
4. Provide the following other soil properties:
   a. pH and buffer pH.

b. Percent organic content by oven dried weight.
c. Nutrient levels by parts per million including: phosphorus, potassium, magnesium, manganese, iron, zinc and calcium. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the soil for optimum growth of the plantings specified.
d. Soluble salt by electrical conductivity of a 1:2 soil water sample measured in Milliohm per cm.
e. Cation Exchange Capacity (CEC).

1.11 SOIL INSTALLATION MOCKUP

Note to specifier: *This section is designed to provide the construction team an opportunity to test means and methods and to record expectations on the finished soil installation. The Owner's Representative must understand enough about soil installation to make an assessment of the mockup and have sufficient observation fee budget to review the work. Mockups add to the cost of the project and this section should be evaluated for its critical nature to the soil installation scope.*

A. Prior to installation or modification of Topsoil, site soil, Planting Soil, or Planting Soil Mixes, construct at the site, a mockup of each soil type using the means and methods and equipment proposed by the Contractor to complete the work. Installation of the mockup shall be in the presence of the Owner's Representative. The purpose of the mockup is to test the methods of installation and compaction of the soil and to serve as a benchmark for completed soil compaction and serve to calibrate penetrometer readings to the known proctor density of the mockup. The mockup shall be as follows:

1. Following acceptance of the soil submittals, in areas that can be protected from disturbance and further compaction, install mockups of each soil type and soil modification, 20 foot X 20 foot X the full depth of the deepest installation, using the requirements of these specifications. Compaction methods, including the type of compaction equipment and number of passes required to achieve the required compaction, shall be evaluated and results measured.

2. Compaction in the mockup soil shall be tested using the penetrometer. A minimum of four penetrometer readings from each Planting Soil shall be taken at the specified depths of the soil profile. Record the soil moisture at each penetrometer test site. In the event that the penetrometer readings exceed the specified densities, reconstruct the mockup, adjusting the soil density to achieve the desired results. Where the modification requires ripping, tilling or fracturing soils that are over compacted, start the procedure in a new location so that the process is working on soil that is similar to the density of the expected soil.

3. Submit a report of the final methods of soil installation, the penetrometer and soil moisture readings to the Owner's Representative.

4. The mockup area may remain as part of the installed work at the end of the project if protected from further compaction, contamination or other disturbance.

5. Provide a protective 4 foot high fence on metal posts around each mockup to keep all work and equipment from entering the surface of the mockup area.

1.12 OBSERVATION OF THE WORK

A. The Owner's Representative may observe the work at any time. They may remove samples of materials for conformity to specifications. Rejected materials shall be immediately removed from the site and replaced at the Contractor's expense. The cost of testing materials not meeting specifications shall be paid by the Contractor.

1. The Owner's Representative may utilize the Contractor's penetrometer and moisture meter at any time to check soil compaction and moisture.

B. The Owner's Representative shall be informed of the progress of the work so the work may be observed at the following key times in the construction process. The Owner's Representative shall be afforded sufficient time to schedule visit to the site. Failure of the Owner's Representative to make field observations shall not relieve the Contractor from meeting all the requirements of this specification.

1. SOIL MOCKUP REVIEW: At the time of construction of all soil mockups.
2. EXISTING SOIL CONDITIONS REVIEW: Prior to the start of any soil modification that will utilize or modify the existing soil.
3. EXCAVATION REVIEW: Observe each area of excavation prior to the installation of any Planting Soil.
4. DRAIN LINE INSTALLATION REVIEW: Upon completion of the installation of drain lines and prior to the installation of any Planting Soil
5. COMPLETION of SOIL MODIFICATIONS REVIEW: Upon completion of all soil modification and installation of planting soil.
6. COMPLETION OF FINE GRADING AND SURFACE SOIL MODIFICATIONS REVIEW: Upon completion of all surface soil modifications and fine grading but prior to the installation of shrubs, ground covers, or lawns.

1.13 PRE-CONSTRUCTION CONFERENCE

A. Schedule a pre-construction meeting with the Owner's Representative at least seven (7) days before beginning work to review any questions the Contractor may have regarding the work, administrative procedures during construction and project work schedule.

1.14 QUALITY ASSURANCE

A. Installer Qualifications: The installer shall be a firm having at least 5 years of experience of a scope similar to that required for the work, including the preparation, mixing and installation of soil mixes to support planting. The installer of the work in Section: Planting, shall be the same firm installing the work in this section.
   1. The bidders list for work under this section shall be approved by the Owner's Representative.
   2. Installer Field Supervision: When any Planting Soil work is in progress, installer shall maintain, on site, an experienced full-time supervisor who can communicate in English with the Owner's Representative.
   3. Installer's field supervisor shall have a minimum of five years experience as a field supervisor installing soil, shall be trained and proficient in the use of field surveying equipment to establish grades and can communicate in English with the Owner's Representative.
   4. The installer's crew shall be experienced in the installation of Planting Soil, plantings, and irrigation (where applicable) and interpretation of planting plans, soil installation plans, and irrigation plans (where applicable).
   5. Submit references of past projects and employee training certifications that support that the Contractors meet all of the above installer qualifications and applicable licensures.

B. Soil testing laboratory qualifications: an independent laboratory, with the experience and capability to conduct the testing indicated and that specializes in USDA agricultural soil testing, Planting Soil Mixes, and the types of tests to be performed. Geotechnical engineering testing labs shall not be used.

C. All delivered and installed Planting Soil shall conform to the approved submittals sample color, texture and approved test analysis.
   1. The Owner's Representative may request samples of the delivered or installed soil be tested for analysis to confirm the Planting Soil conforms to the approved material.
   2. All testing shall be performed by the same soil lab that performed the original Planting Soil testing.
   3. Testing results shall be within 10% plus or minus of the values measured in the approved Planting Soil Mixes.

4. Any Planting Soil that fails to meet the above criteria, if requested by the Owner's Representative, shall be removed and new soil installed.

D. Soil compaction testing: following installation or modification of soil, test soil compaction with a penetrometer.

1. Maintain at the site at all times a soil cone penetrometer with pressure dial and a soil moisture meter to check soil compaction and soil moisture.
   a. Penetrometer shall be AgraTronix Soil Compaction Meter distributed by Ben Meadows, www.benmeadows.com or approved equal.
   b. Moisture meter shall be "general digital soil moisture meter" distributed by Ben Meadows, www.benmeadows.com or approved equal.

2. Prior to testing the soil with the penetrometer check the soil moisture and penetrometer readings in the mockup soils. Penetrometer readings are impacted by soil moisture and excessively wet or dry soils will read significantly lower or higher than soils at optimum moisture.

3. The penetrometer readings shall be within 20% plus or minus of the readings in the approved mockup when at similar moisture levels.

1.15 SITE CONDITIONS

A. It is the responsibility of the Contractor to be aware of all surface and subsurface conditions, and to notify the Owner's Representative, in writing, of any circumstances that would negatively impact the health of plantings. Do not proceed with work until unsatisfactory conditions have been corrected.

1. Should subsurface drainage or soil conditions be encountered which would be detrimental to growth or survival of plant material, the Contractor shall notify the Owner's Representative in writing, stating the conditions and submit a proposal covering cost of corrections. If the Contractor fails to notify the Owner's Representative of such conditions, they shall remain responsible for plant material under the warrantee clause of the specifications.

2. This specification requires that all Planting Soil and Irrigation (if applicable) work be completed and accepted prior to the installation of any plants.

1.16 SOIL COMPACTION – GENERAL REQUIREMENTS

A. Except where more stringent requirements are defined in this specification. The following parameters shall define the general description of the threshold points of soil compaction in existing, modified or installed soil and subsoil.

Note to specifier: *All soil has some level of compaction and subsoil is naturally more compacted than Topsoil simply from the static weight of the upper level soil. There are three common ways to measure, quantify and assess levels of compaction that may be used to determine compaction levels.*

1. *Bulk Density Method*
   Units - Bulk density lb./cf or g/cc dry weight. Threshold results that determine critical bulk density are different for each soil texture.
   Measurement tool - Bulk density cores.
   Pro/cons - Requires one day or more per test, accurate, somewhat expensive. Landscape architect can own and operate equipment or hire a soil testing service.

2. *Standard Proctor Method ASTM D 698*
   Units - % maximum dry bulk density as tested by the standard proctor method. Threshold results that determine critical bulk density are the same for each soil texture. A proctor test will typically also provide results as Bulk density lb./cf dry weight.
   Measurement Tool - Densitrometer
   Pro/cons - Moderately slow 10 minutes per test, accurate, expensive, lab test required to determine every specific soil texture's Proctor density curve, readings are impacted by soil organic matter, must hire a soil testing service.

3. *Penetration Resistance Method*

Units – PSI (lb. pressure per sq. in.) Threshold results that determine critical bulk density are somewhat the same for each soil texture.
Measurement tool - Penetrometer
*Pro/cons - Fast less than one minute per test, **not very accurate**. The Owner's representative may interpret the results and require different limits based on soil type, and moisture content at the time the soil is tested.*
Inexpensive, limited by soil moisture and gravel, landscape architect can own and operate equipment, no soil testing service required.

B. The following are threshold levels of compaction as determined by each method.

1. Acceptable Compaction: Good rooting anticipated, but increasing settlement expected as compaction is reduced and/or in soil with a high organic matter content.
   a. Bulk Density Method – Varies by soil type see Chart on page 32 in Up By Roots.
   b. Standard Proctor Method – 75-85%; soil below 75% is unstable and will settle excessively.
   c. Penetration Resistance Method – about 75-250 psi, below 75 psi soil becomes increasingly unstable and will settle excessively.

2. Root limiting Compaction: Root growth is limited with fewer, shorter and slower growing roots.
   a. Bulk Density Method – Varies by soil type see Chart on page 32 in Up By Roots.
   b. Standard Proctor Method – above approximately 85%.
   c. Penetration Resistance Method – about 300 psi.

3. Excessive Compaction: Roots not likely to grow but can penetrate soil when soil is above field capacity.
   a. Bulk Density Method – Varies by soil type see Chart on page 32 in Up By Roots.
   b. Standard Proctor Method – Above 90%.
   c. Penetration Resistance Method – Approximately above 400 psi

1.17 DELIVERY, STORAGE, AND HANDLING

A. Weather: Do not mix, deliver, place or grade soils when frozen or with moisture above field capacity.

B. Protect soil and soil stockpiles, including the stockpiles at the soil blender's yard, from wind, rain and washing that can erode soil or separate fines and coarse material, and contamination by chemicals, dust and debris that may be detrimental to plants or soil drainage. Cover stockpiles with plastic sheeting or fabric at the end of each workday.

C. All manufactured packaged products and material shall be delivered to the site in unopened containers and stored in a dry enclosed space suitable for the material and meeting all environmental regulations. Biological additives shall be protected from extreme cold and heat. All products shall be freshly manufactured and dated for the year in which the products are to be used.

D. Deliver all chemical amendments in original, unopened containers with original labels intact and legible, which state the guaranteed chemical analysis. Store all chemicals in a weather protected enclosure.

E. Bulk material: Coordinate delivery and storage with Owner's Representative and confine materials to neat piles in areas acceptable to Owner's Representative.

1.18 EXCAVATING AND GRADING AROUND UTILITIES

A. Contractor shall carefully examine the civil, record, and survey drawings to become familiar with the existing underground conditions before digging.

B. Determine location of underground utilities and perform work in a manner that will avoid damage. Hand excavate as required. Maintain grade stakes set by others until parties concerned mutually agree upon removal.

C. Notification of the *local utility locator service*, *Insert PHONE NUMBER*, is required for all planting areas. The Contractor is responsible for knowing the location and avoiding utilities that are not covered by the *local utility locator service*.

Note to specifier: *Insert the telephone number and correct name of the local utility locator service to the paragraph above if available.*

PART 2 – PRODUCTS

Note to specifier: *Delete all products not applicable to this specific project. Local conditions for the harvested materials will vary and these specifications may need to be revised to reflect local source requirements, availability, budgets and plants to be grown.*

2.1 IMPORTED TOPSOIL

A. Imported Topsoil definition: Fertile, friable soil containing less than 5% total volume of the combination of subsoil, refuse, roots larger than 1 inch diameter, heavy, sticky or stiff clay, stones larger than 2 inches in diameter, noxious seeds, sticks, brush, litter, or any substances deleterious to plant growth. The percent (%) of the above objects shall be controlled by source selection not by screening the soil. Topsoil shall be suitable for the germination of seeds and the support of vegetative growth. Imported Topsoil shall not contain weed seeds in quantities that cause noticeable weed infestations in the final planting beds. Imported Topsoil shall meet the following physical and chemical criteria:

Note to specifier: Make adjustments in the following to account for the fact that these idea soils may not be available in your area.

1. Soil texture: USDA loam, sandy clay loam or sandy loam with clay content between 15 and 25%. And a combined clay/silt content of no more than 55%.
2. pH value shall be between 5.5 and 7.0.
3. Percent organic matter (OM): 2.0-5.0%, by dry weight.
4. Soluble salt level: Less than 2 mmho/cm.
5. Soil chemistry suitable for growing the plants specified.

B. Imported Topsoil shall be a harvested soil from fields or development sites. The organic content and particle size distribution shall be the result of natural soil formation. Manufactured soils where Coarse Sand, Composted organic material or chemical additives has been added to the soil to meet the requirements of this specification section shall not be acceptable. Retained soil peds shall be the same color on the inside as is visible on the outside.

Note to specifier: *Make adjustments to the above to account for the fact that these idea soils may not be available in your area. Soil peds may not normally occur, especially where soils have a high sand content.*

C. Imported Topsoil for Planting Soil shall NOT have been screened and shall retain soil peds or clods larger than 2 inches in diameter throughout the stockpile after harvesting.

D. Stockpiled Existing Topsoil at the site meeting the above criteria may be acceptable.

E. Provide a two gallon sample from each Imported Topsoil source with required soil testing results. The sample shall be a mixture of the random samples taken around the source stockpile or field. The soil sample shall be delivered with soil peds intact that represent the size and quantity of expected peds in the final delivered soil.

2.2 COMPOST

A. Compost: Blended and ground leaf, wood and other plant based material, composted for a minimum of 9 months and at temperatures sufficient to break down all woody fibers, seeds and leaf structures, free of toxic material at levels that are harmful to plants or humans. Source material shall be yard waste trimmings blended with other plant or manure based material designed to produce Compost high in fungal material.

1. Compost shall be commercially prepared Compost and meet US Compost Council STA/TMECC criteria or as modified in this section for “Compost as a Landscape Backfill Mix Component”.

http://compostingcouncil.org/admin/wp-content/plugins/wp-pdfupload/pdf/191/LandscapeArch_Specs.pdf

2. Compost shall comply with the following parameters:
   a. pH: 5.5 - 8.0.
   b. Soil salt (electrical conductivity): maximum 5 dS/m (mmhos/cm).
   c. Moisture content %, wet weight basis: 30 – 60.
   d. Particle size, dry weight basis: 98% pass through 3/4 inch screen or smear.
   e. Stability carbon dioxide evolution rate: mg CO_2-C/ g OM/ day < 2.
   f. Solvita maturity test: > 6.
   g. Physical contaminants (inerts), %, dry weight basis: <1%.
   h. Chemical contaminants, mg/kg (ppm): meet or exceed US EPA Class A standard, 40CFR § 503.13, Tables 1 and 3 levels.
   i. Biological contaminants select pathogens fecal coliform bacteria, or salmonella, meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) level requirements.

B. Provide a two gallon sample with manufacturer's literature and material certification that the product meets the requirements.

2.3 COARSE SAND

A. Clean, washed, sand, free of toxic materials

1. Coarse concrete sand, ASTM C-33 Fine Aggregate, with a Fines Modulus Index of 2.8 and 3.2.

2. Coarse Sands shall be clean, sharp, natural Coarse Sands free of limestone, shale and slate particles. Manufactured Coarse Sand shall not be permitted.

3. pH shall be lower than 7.0.

4. Provide Coarse Sand with the following particle size distribution:

Sieve	Percent passing
3/8 inch (9.5 mm)	100
No 4 (4.75 mm)	95-100
No 8 (2.36 mm)	80-100
No 16 (1.18 mm)	50-85
No 30 (.60 mm)	25-60
No 50 (.30 mm)	10-30
No 100 (.15 mm)	2-10
No 200 (0.75 mm	2-5

B. Provide a two gallon sample with manufacturer's literature and material certification that the product meets the requirements.

2.4 FERTILIZER, BIOLOGICAL AND OTHER AMENDMENTS

Note to specifier: *Fertilizers and specialty biological amendment products such as* Mycorrhizal amendments *or Compost Tea are not generally required or recommended at planting and are not included in this specification. If the project team would like to add any of these amendments, add the product descriptions here. These types of amendments, if used at all, should never be applied without a soil test that documents their need and application rate.*

2.5 LIME

A. ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:

1. Class: Class T, with a minimum 99 percent passing through No. 8 (2.36-mm) sieve and a minimum 75 percent passing through No. 60 (0.25-mm) sieve.

2. Provide lime in form of dolomitic limestone.

B. Provide manufacturer's literature and material certification that the product meets the requirements.

2.6 EXISTING SOIL (Acceptable for planting with minimum modifications)

Note to specifier: *If existing soil is to be retained and reused, it is prudent to document the condition of this soil prior to the start of construction. Documentation (called a soil report) should include standard agricultural chemical soil testing, soil profile condition, as well as documenting soil penetration resistance to anticipated rooting depth. Such testing is typically already needed in order to make the decision of reusing this resource and the testing and observations can easily be inserted into this section of the specification.*

Undisturbed soil or soil with minor disturbance to soil profiles (e.g. farming) has at least two of the following attributes:

A. Site soils not excessively graded or not compacted at root limiting or above.
B. Soils previously disturbed have a restored A horizon (min 2.5% organic matter dry weight) at least 6 inches deep and B and/or C horizons that drain and have acceptable compaction.
C. Soils are currently supporting mature tree and or large shrub growth with high vitality.
D. Sufficient soil volumes meeting the above criteria above rock or other limiting structures to support the proposed plants.

In addition to the above, the soil organic matter, pH, and chemistry in the A horizon should be suitable for the proposed plants, or may need to be modified if required. In dry climates and sandy soils plants are often adapted to grow in soil with very low organic matter and high pH. Raising the organic matter too high or lowering the pH may negatively impact native or adapted plant performance.

A. General definition of existing soil: Surface soil in the areas designated on the soils plan as existing soil, that is not altered, compacted to root limiting density, graded or contaminated before or during the construction process and considered acceptable for planting and long term health of the plants specified either as it exists or with only minor modification.

   1. The Owner's Representative shall verify that the soil in the designated areas is suitable at the beginning of planting bed preparation work in that area. In the event that the work of this project construction has damaged the existing soil in areas designated for use as Planting Soil to the point where the soil is no longer suitable to support the plants specified, the Owner's Representative may require modification of the damaged soil up to and including removal and replacement with soil of equal quality to the soil that existed prior to construction. Examples of damage include further compaction, contamination, grading, creation of hard pan or drainage problems, and loss of the O, and or A horizon.
      a. Do not begin work on additional modifications until changes to the contract price are approved by Owner's Representative.
   2. Soil testing results and soil observation notes that describe the pre-construction soil conditions in the existing soil areas are included as an appendix to this specification:

      Note to specifier: *Delete the above sentence if no soil test are included.*

B. Protect existing soil from compaction, contamination, and degradation during the construction process.

C. Unless otherwise instructed, remove all existing plants, root thatch, and non-soil debris from the surface of the soil using equipment that does not increase compaction of soil to root limiting levels.

D. Modifications:

   1. When results of soil tests recommend chemical adjustments, till surface soil to six inches or greater after chemical adjustments have been are applied.
   2. Remove existing turf thatch, ground cover plants and weeds.
   3. Provide pre-emergent weed control if indicated.
   4. Make chemical adjustment as recommended by the soil test.

2.7 MODIFIED EXISTING SOIL (SOIL SUITABLE FOR PLANTING WITH INDICATED MODIFICATION)

Note to specifier: *SOILS PLANS: This specification assumes that there will be separate set of drawings in the construction documents titled Soils Plans. These plans and details will define the areas on the site where different type of soil modification practices will occur. The plan should be a simple diagram with each type of soil modification keyed to a detail. Details of different modifications are included in the set of details that accompany this set of specifications. Using this method allows a wide range of different modifications to be required such that the modifications can easily fix the existing soil conditions, the expectations for plant performance, the project budget and schedule.*

In the event that there is not a separate Soils Plan, this information can be added to the Planting Plan. On simple sites where one soil modification may be appropriate, the specification could be used without having a plan. If no Soils Plan is included, be sure to remove reference to a Soils Plan from these specifications and replace it with the appropriate reference that defines the limits of soil modification.

A. General definition: Surface soil in the areas designated on the soils plan as Modified Existing Soil has been altered and or graded before or during the construction process but is still considered acceptable for planting and long term health of the plants specified with the proposed modifications. Modifications respond to the soil problems expected or encountered. The Owner's Representative shall verify that the soil in the designated areas is suitable for modification at the beginning of planting bed preparation work in that area.

1. The Owner's Representative shall verify that the soil in the designated areas is suitable for the specified modification at the beginning of planting bed preparation work in that area. In the event that the work of this project construction has damaged the existing soil in areas designated for modification to the point where the soil is no longer suitable to support the plants specified with the specified modification, the Owner's Representative may require further modification of the damaged soil up to an including removal and replacement with soil of equal quality to the soil that would have resulted from the modification. Damage may include further compaction, contamination, grading, creation of hard pan or drainage problem, and loss of the O, and or A horizon.

2. General requirements for all soil modifications:
   a. Take soil samples, test for chemical properties, and make appropriate adjustments.
   b. Unless otherwise instructed, remove all existing plants, root thatch, and non-soil debris from the surface of the soil using equipment that does not add to the compaction in the soil.
   c. All soil grading, tilling and loosening must be completed at times when the soil moisture is below field capacity. Allow soil to drain for at least two days after any rain event more than 1 inch in 24 hours, or long enough so that the soil does not make the hand muddy when squeezed.
   d. Provide pre-emergent weed control after the soil work is complete and plants planted but prior to adding mulch to the surface, if indicated by weed type and degree of threat.

B. Modified existing soil – soil removed, stockpiled, and spread

1. Description of condition to be modified: Existing soil that is suitable for reuse as Planting Soil but is in the wrong place of elevation, or cannot be adequately protected during construction. Soil is to be harvested, stockpiled and re-spread with or without further modifications as indicated.

   Note to specifier; *If existing soils are to be harvested and reused, the areas where soil may be reused and the depths of soil harvesting must be described on the drawings and the specifications. This requires that the specifier has site and soil knowledge sufficient to make these decisions. Additionally, one of the greatest limitations on reuse of soil at many projects is finding a suitable place to store the soil during construction. This coordination must be resolved during the design process with the project manager.*

2. Modifications:
   a. Excavate existing soil from the areas and to depths designated on the drawings. Stockpile in

zones noted on the drawings or in areas proposed by the Contractor.
1.) Prepare a soil stock pile plan for approval.

b. Excavate soil using equipment and methods to preserve the clumps and peds in the soil. Generally this means using the largest piece of equipment that is practical for the project size and scope.
c. Protect stock piles from erosion by compacting or tracking the soil surface, covering with breathable fabric or planting with annual grasses as appropriate for the season, location, and length of expected time of storage.
d. Re-spread soil as required in Part 3 of this specification.

C. Modified existing soil – compacted surface soil (Tilling Option)

Note to specifier: *If the soil problem is limited to surface compaction, one of two options should be considered: Tilling option or Radial Trenching option. Tilling prepares an entire root zone for trees and other plants but is relatively shallow. The radial trenching goes deeper. As the level of compaction increases, these two methods become less effective. Select one of these options based on the project requirements and delete the other or use both options to treat the upper (Tilling) and lower (Trenching) portions of the soil profile..*

1. Description of condition to be modified: Surface soil compaction to a maximum of 6 inches deep from traffic or light grading. Original A horizon may be previously removed or graded but lower profile intact with acceptable compaction levels and limited grading. The soil organic matter, pH and chemistry in the A horizon may not be suitable for the proposed plants and may need to be modified as required.

2. Modifications:
Note to specifier: *A spade tiller is a superior tiller than the standard roto tiller. A spade tiller leaves a soil with larger peds and less glazing between the loose soil and the subsoil. However these tillers are limited in availability and may be more costly than the conventional tiller. Check with local Contractors before requiring a spade tiller over roto tiller.*

a. Till top 6 inches or deeper of the soil surface, with a *roto tiller, spade tiller,* ripper or agricultural plow. Spread 2 - 3 inches of Compost on the surface of the tilled soil and make any chemical adjustment as recommended by the soil test.
1.) If spade tillers are to be required, add a paragraph to that effect here.
b. Till or disk the Compost into the loosened soil. Smooth out grades with a drag rake or drag slip.

D. Modified existing soil – compacted surface soil (Radial Trenching Option)

1. Description of condition to be modified: Surface soil compaction to a maximum of 24 inches deep from traffic or light grading. Original A horizon may be previously removed or graded but lower profile below 24 inches intact with acceptable compaction levels and limited grading. The soil organic matter, pH and chemistry in the A horizon may not be suitable for the proposed plants and may need to be modified as required.

2. Modifications:
a. Using a trenching machine, dig trenches to the extent and depth shown on the plans and details.
b. Backfill the trench with the soil removed from the trench. Add additional site soil if needed to fill the trench to be flush to the existing grade after the soil settlement.

E. Modified existing soil – compacted subsoil

1. Description of condition to be modified: Deep soil compaction the result of previous grading, filling and dynamic or static compaction forces. Original A horizon likely removed or buried. The soil organic matter, pH and chemistry in the A horizon is likely not suitable for the proposed plants and should be modified as required.
Note to specifier: *Select one of the following options as appropriate to the constraints at the site, and the project budget. Do not give the contractor the option to select any of the below alternative*

as they are not equal treatments. Soil fracturing is the most effective and may be the most cost effective in small to medium size spaces. Soil ripping is usually the cheapest option but only appropriate in large spaces, approximately ¼ acre or greater, accessible by large size grading machines, and where there are no underground utilities or where limited utility locations can be avoided. Soil trenching is only suitable for spaces where only small sized equipment such as a walk-behind chain trencher can access the area. If different treatments are appropriate for different locations on the same project be clear on the drawings the extent of each treatment.

The Trenching modification below is for compacted soil that is NOT within the root zone of existing trees and is substantially different from the modification "Radial Trenching" described above. The practice of radial trenching within the root zone of an existing tree is not described in this specification.

2. Soil Ripping:
   a. Step one: After grading and removing all plants and debris from the surface, using a tracked dozer or similar large grading equipment, loosen the soil by dragging a ripping shank or chisel thru the soil to depths of 24 inches with ripping shanks spaced 18 inches or less apart in two directions. The number of shanks per pull is dependent on the degree of soil compaction and the size of the dozer.
   b. Step 2: Spread 3-4 inches of Compost over the ripped area and till into the top 6 inches of the soil surface.
3. Soil Fracturing:
   a. Step one: After grading and removing all plants and debris from the surface, spread 2 – 3 inches of Compost over the surface of the soil. Loosen the soil to depth of 18 - 24 inches, using a backhoe to dig into the soil through the Compost. Lift and then drop the loosened soil immediately back into the hole. The bucket then moves to the adjacent soil and repeats the process until the entire area indicated has been loosened.
   b. Step 2: Spread 3-4 inches of Compost over the ripped area and till into the top 6 inches of the soil surface.
4. Trenching:
   a. Step one: After grading and removing all plants and debris from the surface using a chain trenching machine, dig 24 inch deep trenches, 24 inches apart across the entire area. Maintain an 18-inch standoff from the edges of all curbs, paving and structures. Backfill the trenches with Compost.
   b. Step 2: Spread 3-4 inches of Compost over the trenches area and till into the top 6 inches of the soil surface. Compost tilling treatment shall extend to the edges of curbs, paving and structures.
5. Following soil ripping or fracturing the average penetration resistance should be less than 250 psi to the depth of the ripping or fracturing.
6. Do not start planting into ripped or fractured soil until soil has been settled or leave grades sufficiently high to anticipate settlement of 10 – 15% of ripped soil depth.

F. Modified existing soil – low organic matter

1. Description of condition to be modified: Low soil organic matter and/or missing A horizon but soil is not compacted except for some minor surface compaction. The soil organic matter, pH and/or chemistry are likely not suitable for the proposed plants and should be modified as required.
2. Modifications:
   a. Spread 3 - 4 inches of Compost over the surface of the soil and make chemical adjustment as recommended by the soil test.
   b. Till Compost into the top 6 inches of the soil.

G. Modified existing soil – soil within the root zone of existing established trees

Note to specifier: *Any of the above soil conditions may be present within the root zone areas of*

large existing trees to remain but these must be dealt with in a different manner in order to preserve the root system of the tree. Options are limited. On the other hand, usually problems with soil within the root zone of mature trees are limited to the surface 6 - 12 inches of soil. These are most often excess surface soil compaction, chemical changes from applied material, added soil over an existing soil, severed roots, and drainage problems caused by adjacent work that changed drainage patterns. Deep compaction and other deep soil disturbances would likely already have killed the tree or the tree has adapted to the condition.

Modifications to consider:

Surface compaction - *There are several methods to remediate excess surface soil compaction within a root zone. The preferred method is to use a pneumatic digging device such as an Air Knife or Air Spade that can loosen soil without significant damage to roots. Compost is added to the soil as part of the loosening process. A specification section on this process is included. Other methods include vertical mulching, radial trenching, surface applications of Compost or mulch, Compost Tea injections into soil, and soil-injected air combined with added material. Each of these has demonstrated limited success depending on the level of compaction and many variables in the process. Due to the complexity of each of these options they will not be included in the specification. Consult a local soils and / or arboricultural expert to develop a specification.*

Chemical changes - *Changes in soil chemistry due to applications intentional and inadvertent are too complex to determine and remediate to be part of this specification. Consult a local soils and / or arboricultural expert to develop a specification.*

Soil added over the root zone - *Small amounts of soil added over the root zone may not be a problem for the tree, and leaving it there or mixing with an air knife may be the best option. Often the greatest damage to the tree is caused not by the soil, even at relatively deep layers of soil, but the damage caused by the equipment that brought in the soil or is used to remove the soil. Setting requirements to remediate soil added over the root zone are too complex to be part of this specification. Consult a local soils and / or arboricultural expert to develop a specification.*

Drainage problems - *The different types of conditions that cause drainage problems and how to remediate them around existing trees are too complex to be part of this specification. Consult a local soils and / or arboricultural expert to develop a specification.*

1. Description of condition to be modified: Surface compaction near or above root limited levels in the upper soil horizon the result of traffic or other mechanical compaction.
2. Modifications:
   a. Remove the tops of all plants to be removed from the root zone. Remove sod with a walk behind sod cutter. Do not grub out the roots of plats to be removed.
   b. Use a pneumatic air knife to loosen the top 9 – 12 inches of the soil. Surface roots may move and separate from soil during this process but the bark on roots should not be broken
      1.) Pneumatic air knife shall be as manufactured by:
      Concept Engineering Group, Inc., Verona, PA (412) 826-8800
      or
      Supersonic Air Knife, Inc., Allison Park, PA (866) 328 5723
   c. Make chemical adjustment as recommended by the soil test and add 2 - 3 inches of Compost over the soil.
   d. Using the pneumatic air knife, mix the Compost into the top 6 – 8 inches of the loosened soil.
   e. Work in sections such that the entire process - including irrigation - can be completed in one day. Apply approximately one inch of water over the loosened soil at the completion of each day's work. Apply mulch or turf as indicated on the drawings within one week of the completion of work.

2.8 PLANTING SOIL MIXES

Note to specifier: *The subject of Planting Soil Mixes is quite complex and requires significant*

information about the goals of the planting. Mixes can include free draining high use turf planting soil mixes, bio-retention mixes, specialty mixes for palm planting or slow draining mixes designed to reduce water use and maintenance. The specifier will need to design the Planting Soil Mix that is best for each part of the project. The following specification is for a moderately slow draining Mix that would be good for trees and shrubs and can serve as a template for other mixes. The key adjustment for most applications is to change the proportion Topsoil/Coarse Sand and Compost. Local suppliers may also have their own specification or Mix design. These can be inserted into this specification.

Note that the topsoil and planting mix is not to be screened or mixed in a sol blending machine. Screening and blending breaks down important topsoil peds and reduces drainage in the soil. Machine blended and screened mixes typically will require more sand

A. General definition: Mixes of Existing Soil or Imported Topsoil, Coarse Sand, and or Compost to make a new soil that meets the project goals for the indicated planting area. These may be mixed off site or onsite, and will vary in Mix components and proportions as indicated.

B. Planting Mix - moderately slow draining soil for trees and shrub beds

1. A Mix of Imported Topsoil, Coarse Sand and Compost. The approximate Mix ratio shall be:

Mix component	% by moist volume
Imported Topsoil unscreened	45-50%
Coarse sand	40-45%
Compost	10%

2. Final tested organic matter between 2.75 and 4% (by dry weight).

3. Mix the Coarse Sand and Compost together first and then add to the Topsoil. Mix with a loader bucket to loosely incorporate the Topsoil into the Coarse Sand/Compost Mix. DO NOT OVER MIX! Do not mix with a soil blending machine. Do not screen the soil. Clumps of Soil, Compost and Coarse Sand will be permitted in the overall Mix.

4. At the time of final grading, add fertilizer if required to the Planting Soil at rates recommended by the testing results for the plants to be grown.

5. Provide a two gallon sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time.

2.9 PRE-EMERGENT HERBICIDES

***Note to specifier**: Pre-emergent herbicides have known environmental impacts. The project team must evaluate the risks and rewards of using chemical treatments to control weeds and consider specifying hand weed removal.*

A. Chemical herbicides are designed to prevent seeds of selective plants from germinating. Exact type of herbicide shall be based on the specific plants to be controlled and the most effective date of application.

B. Submit report of expected weed problems and the recommendation of the most effective control for approval by Owner's Representative. Provide manufacturer's literature and material certification that the product meets the requirements.

***Note to specifier:** Insert additional products as needed for the specific project requirements.*

***Note to specifier:** If soil drainage rates or subsurface conditions indicate that additional drainage beyond modification in needed subsurface drain lines may need to be added.*

There are many pipe options available from heavy duty Schedule 40 PVC pipes to lightweight ABS corrugated flexible pipes. This specification will provide three pipe options. The specifier must select the appropriate pipe from the below list that meets the budget and operational needs of the project and delete the other options. It is advised not to use the corrugated pipe as it is too easily crushed and tends to silt up faster than the other alternatives.

Note that filter fabric socks and other filter cloth applications around the pipe or the pipe bedding material is not include in this specification and is not recommended due to tendency of the filter cloth to clog.

2.10 HEAVY DUTY PIPE DRAIN PIPE

A. Drain pipe shall be 4 inch diameter, perforated, PVC, Schedule 40 pipe. Holes in the pipe shall only be on the bottom quadrant. All fittings, elbows, unions, T's and screw caps shall be the same material and from the same manufacturer as the pipe. "T" and elbow joints shall be sanitary type connections. All joints shall be solvent welded. Submit manufacturers product literature for approval by the Owner's Representative.

1. When pipe has perforations on all quadrants, drape a 12 inch wide 4 mil plastic sheet over the length of the pipe to force water to the bottom of the pipe.

B. Clean out: Clean out risers shall be 4 inch diameter Schedule 40 PVC solid pipe compatible with the bottom fitting and clean out screw cap. Elbow fitting at the bottom of the clean out riser. When the cleanout is in the middle of a pipe run the fitting shall be a sanitary T fitting. Screw cap FITTING shall be PVC Schedule 40.

2.11 MEDIUM DUTY PIPE DRAIN PIPE

A. Drain pipe shall be 4 inch diameter, perforated, PVC, double wall (smooth interior wall / corrugated exterior wall) pipe. Holes in the pipe shall only be on the bottom quadrant. All fittings, elbows, unions, T's and screw caps shall be the same material and from the same manufacturer as the pipe. "T" and elbow joints shall be sanitary type connections. All joints shall be gasketed bell and spigot. Example source A -2000 by Contech Construction Products or approved equal. Submit manufacturers product literature for approval by the Owner's Representative.

1. When pipe has perforations on all quadrants, drape a 12 inch wide 4 mil plastic sheet over the length of the pipe to force water to the bottom of the pipe.

B. Clean out: Clean out risers shall be 4 inch diameter Schedule 40 PVC solid pipe compatible with the bottom fitting and clean out screw cap. Elbow fitting at the bottom of the clean out riser. When the cleanout is in the middle of a pipe run the fitting shall be a sanitary T fitting. Screw cap FITTING shall be PVC Schedule 40.

2.12 LIGHT DUTY PIPE DRAIN PIPE

A. Drain pipe shall be 4 inch diameter, perforated, HDPE, single wall corrugated exterior pipe. ASTM F405. All fittings, elbows, unions, T's and screw caps shall be the same material and from the same manufacturer as the pipe. All joints shall be gasketed bell and spigot. Example source ADS Single Wall Pipe by Advance Drainage Systems or approved equal. Submit manufacturers product literature for approval by the Owner's Representative.

1. When pipe has perforations on all quadrants, drape a 12 inch wide 4 mil plastic sheet over the length of the pipe to force water to the bottom of the pipe.

B. Clean out: Clean out risers shall be 4 inch diameter Schedule 40 PVC solid pipe compatible with the bottom fitting and clean out screw cap. Elbow fitting at the bottom of the clean out riser. When the cleanout is in the middle of a pipe run the fitting shall be a sanitary T fitting. Screw cap FITTING shall be PVC Schedule 40.

PART 3 – EXECUTION

3.1 SITE EXAMINATION

A. Prior to installation of Planting Soil, examine site to confirm that existing conditions are satisfactory for the work of this section to proceed.

1. Confirm that the subgrade is at the proper elevation and compacted as required. Subgrade elevations shall slope toward the under drain lines as shown on the drawings.
2. Confirm that surface all areas to be filled with Planting Soil are free of construction debris, refuse, compressible or biodegradable materials, stones greater than 2 inches diameter, soil crusting films of silt or clay that reduces or stops drainage from the Planting Soil into the subsoil; and/or standing water. Remove unsuitable material from the site.
3. Confirm that no adverse drainage conditions are present.
4. Confirm that no conditions are present which are detrimental to plant growth.
5. Confirm that utility work has been completed per the drawings.
6. Confirm that irrigation work, which is shown to be installed below prepared soil levels, has been completed.

B. If unsatisfactory conditions are encountered, notify the Owner's Representative immediately to determine corrective action before proceeding.

3.2 COORDINATION WITH PROJECT WORK

A. The Contractor shall coordinate with all other work that may impact the completion of the work.

B. Prior to the start of work, prepare a detailed schedule of the work for coordination with other trades.

C. Coordinate the relocation of any irrigation lines, heads or the conduits of other utility lines that are in conflict with tree locations. Root balls shall not be altered to fit around lines. Notify the Owner's Representative of any conflicts encountered.

3.3 GRADE AND ELEVATION CONTROL

A. Provide grade and elevation control during installation of Planting Soil. Utilize grade stakes, surveying equipment, and other means and methods to assure that grades and contours conform to the grades indicated on the plans.

3.4 SITE PREPARATION

A. Excavate to the proposed subgrade. Maintain all required angles of repose of the adjacent materials as shown on the drawings or as required by this specification. Do not over excavate compacted subgrades of adjacent pavement or structures. Maintain a supporting 1:1 side slope of compacted subgrade material along the edges of all paving and structures where the bottom of the paving or structure is above the bottom elevation of the excavated planting area.

B. Remove all construction debris and material including any construction materials from the subgrade.

C. Confirm that the subgrade is at the proper elevation and compacted as required. Subgrade elevations shall slope approximately parallel to the finished grade and/or toward the subsurface drain lines as shown on the drawings.

D. In areas where Planting Soil is to be spread, confirm subgrade has been scarified.

E. Protect adjacent walls, walks and utilities from damage or staining by the soil. Use 1/2 inch plywood and or plastic sheeting as directed to cover existing concrete, metal and masonry work and other items as directed during the progress of the work.

1. At the end of each working day, clean up any soil or dirt spilled on any paved surface.
2. Any damage to the paving or site features or work shall be repaired at the Contractor's expense.

3.5 SOIL MOISTURE

A. Volumetric soil moisture level, in both the Planting Soil and the root balls of all plants, prior to, during and after planting shall be above permanent wilt point and below field capacity for each type of soil texture within the following ranges.

Soil texture	Permanent wilting point	Field capacity
Sand, Loamy sand, Sandy loam	5-8%	12-18%
Loam, Sandy clay, Sandy clay loam	14-25%	27-36%
Clay loam, Silt loam	11-22%	31-36%
Silty clay, Silty clay loam	22-27%	38-41%

B. The Contractor shall confirm the soil moisture levels with a moisture meter (Digital Soil Moisture Meter, DSMM500 by General Specialty Tools and Instruments, or approved equivalent). If moisture is found to be too low, the planting holes shall be filled with water and allowed to drain before starting any planting operations. If the moisture is too high, suspend planting operations until the soil moisture drains to below field capacity.

3.6 EXISTING SOIL MODIFICATION

A. Follow the requirements for modifying existing soil as indicated in Part 2 for the different types of soil modifications. The extent of the areas of different soil modification types are indicated on the Soils Plan or as directed by the Owner's Representative.

Note to specifier: *Note above that it is critical for the contract documents to define the extent of all soil improvement work on a Soil Plan and detail drawing that is part of the contract documents.*

3.7 DRAIN PIPE INSTALLATION

1. Trench lines to depths and widths shown on plans.
2. Place 2 – 3 inches Coarse Sand as bedding for pipes.
3. Place pipe (holes facing down) to invert elevations shown on the plan.
   a. If pipe with holes on all sides is used drape a piece of 4 mil plastic 12 inches wide over top of pipe.
   b. Cover sides and top of pipe with Coarse Sand with min 4 inches of Coarse Sand cover above top of pipe.
   c. Backfill trench with Planting Soil compacted to same level as Planting Soil requirements.
4. Add cleanout pipe reaching the surface at the uphill end of each pipe run as shown on drawings.
5. Connect pipes to manhole or daylight outfall as shown on the drawings.

3.8 PLANTING SOIL AND PLANTING SOIL MIX INSTALLATION

Note to specifier: *These specifications are not intended to include Planting Soils over architectural structures that are waterproofed. If this condition exists, add special installation instructions in this paragraph.*

A. Prior to installing any Planting Soil from stockpiles or Planting Soil Mixes blended off site, the Owner's Representative shall approve the condition of the subgrade and the previously installed subgrade preparation and the installation of subsurface drainage.

B. All equipment utilized to install or grade Planting Soils shall be wide track or balloon tire machines rated with a ground pressure of 4 psi or less. All grading and soil delivery equipment shall have buckets equipped with 6 inch long teeth to scarify any soil that becomes compacted.

C. In areas of soil installation above existing subsoil, scarify the subgrade material prior to installing Planting Soil.

1. Scarify the subsoil of the subgrade to a depth of 3 – 6 inches with the teeth of the back hoe or loader bucket, tiller or other suitable device.

2. Immediately install the Planting Soil. Protect the loosened area from traffic. DO NOT allow the loosened subgrade to become compacted.

3. In the event that the loosened area becomes overly compacted, loosen the area again prior to installing the Planting Soil.

D. Install the Planting Soil in 12 - 18 inch lifts to the required depths. Apply compacting forces to each lift as required to attain the required compaction. Scarify the top of each lift prior to adding more Planting Soil by dragging the teeth of a loader bucket or backhoe across the soil surface to roughen the surface.

E. Phase work such that equipment to deliver or grade soil does not have to operate over previously installed Planting Soil. Work in rows of lifts the width of the extension of the bucket on the loader. Install all lifts in one row before proceeding to the next. Work out from the furthest part of each bed from the soil delivery point to the edge of the each bed area.

Note to specifier: *The following 4 paragraphs are not normal to most soil installation specifications but are deemed critical to the process.* Be sure that the Owner's Representative is familiar with these requirements during construction observation.

F. Where possible place large trees first and fill Planting Soil around the root ball.

G. Installing soil with soil or mulch blowers or soil slingers shall not be permitted due to the over mixing and soil ped breakdown cause by this type of equipment.

H. Where travel over installed soil is unavoidable, limit paths of traffic to reduce the impact of compaction in Planting Soil. Each time equipment passes over the installed soil it shall reverse out of the area along the same path with the teeth of the bucket dropped to scarify the soil. Comply with the paragraph "Compaction Reduction" (section 3.9) in the event that soil becomes over compacted.

I. The depths and grades shown on the drawings are the final grades after settlement and shrinkage of the compost material. The Contractor shall install the Planting Soil at a higher level to anticipate this reduction of Planting Soil volume. A minimum settlement of approximately 10 - 15% of the soil depth is expected. All grade increases are assumed to be as measured prior to addition of surface Compost till layer, mulch, or sod.

3.9 COMPACTION REQUIREMENTS FOR INSTALLED OR MODIFIED PLANTING SOIL

A. Compact installed Planting Soil to the compaction rates indicated and using the methods approved for the soil mockup. Compact each soil lift as the soil is installed.

B. Existing soil that is modified by tilling, ripping or fracturing shall have a density to the depth of the modification, after completion of the loosening, such that the penetrometer reads approximately 75 to 250 psi at soil moisture approximately the mid-point between wilting point and field capacity. This will be approximately between 75 and 82% of maximum dry density standard proctor.

C. Installed Planting Soil Mix and re-spread existing soil shall have a soil density through the required depth of the installed layers of soil, such that the penetrometer reads approximately 75 to 250 psi at soil moisture approximately the mid-point between wilt point and field capacity. This will be approximately between 75 and 82% of maximum dry density standard proctor.

D. Planting Soil compaction shall be tested at each lift using a penetrometer calibrated to the mockup soil and its moisture level. The same penetrometer and moisture meter used for the testing of the mockup shall be used to test installed soil throughout the work.

E. Maintain moisture conditions within the Planting Soil during installation or modification to allow for satisfactory compaction. Suspend operations if the Planting Soil becomes wet. Apply water if the soil is overly dry.

F. Provide adequate equipment to achieve consistent and uniform compaction of the Planting Soils. Use the smallest equipment that can reasonably perform the task of spreading and compaction. Use the same equipment and methods of compaction used to construct the Planting Soil mockup.

G. Do not pass motorized equipment over previously installed and compacted soil except as authorized below.

1. Light weight equipment such as trenching machines or motorized wheel barrows is permitted to pass over finished soil work.

2. If work after the installation and compaction of soil compacts the soil to levels greater than the above requirements, follow the requirements of the paragraph "Over Compaction Reduction" below.

3.10 OVER COMPACTION REDUCTION

A. Any soil that becomes compacted to a density greater than the specified density and/or the density in the approved mockup shall be dug up and reinstalled. This requirement includes compaction caused by other sub-contractors after the Planting Soil is installed and approved.

B. Surface roto tilling shall not be considered adequate to reduce over compaction at levels 6 inches or greater below finished grade.

3.11 INSTALLATION OF CHEMICAL ADDITIVES

A. Following the installation of each soil and prior to fine grading and installation of the Compost till layer, apply chemical additives as recommended by the soil test, and appropriate to the soil and specific plants to be installed.

B. Types, application rates and methods of application shall be approved by the Owner's Representative prior to any applications.

3.12 FINE GRADING

A. The Owner's Representative shall approve all rough grading prior to the installation of Compost, fine grading, planting, and mulching.

B. Grade the finish surface of all planted areas to meet the grades shown on the drawings, allowing the finished grades to remain higher (10 – 15% of depth of soil modification) than the grades on the grading plan, as defined in paragraph Planting Soil Installation, to anticipate settlement over the first year.

C. Utilize hand equipment, small garden tractors with rakes, or small garden tractors with buckets with teeth for fine grading to keep surface rough without further compaction. Do not use the flat bottom of a loader bucket to fine grade, as it will cause the finished grade to become overly smooth and or slightly compressed.

D. Provide for positive drainage from all areas toward the existing inlets, drainage structures and or the edges of planting beds. Adjust grades as directed to reflect actual constructed field conditions of paving, wall and inlet elevations. Notify the Owner's Representative in the event that conditions make it impossible to achieve positive drainage.

E. Provide smooth, rounded transitions between slopes of different gradients and direction. Modify the grade so that the finish grade before adding mulch and after settlement is one or two inches below all paving surfaces or as directed by the drawings.

F. Fill all dips and remove any bumps in the overall plane of the slope. The tolerance for dips and bumps in shrub and ground cover planting areas shall be a 2 inch deviation from the plane in 10 feet. The tolerance for dips and bumps in lawn areas shall be a 1 inch deviation from the plane in 10 feet.

3.13 INSTALLATION OF COMPOST TILL LAYER

Note to specifier: *The following paragraph is critical to building a proper A/O horizon in installed Planting Soil Mixes. This added layer of Compost must be shown on the soil details in the drawings.*

A. After Planting Soil Mixes are installed in planting bed areas and just prior to the installation of shrub or groundcover plantings, spread 3 – 4 inches of Compost over the beds and roto till into the top 4 - 6 inches of the Planting Soil. This step will raise grades slightly above the grades required in paragraph

"Fine Grading". This specification anticipates that the raise in grade due to this tilling will settle within a few months after installation as Compost breaks down. Additional settlement as defined in paragraph "Planting Soil and Planting Soil Mix installation" must still be accounted for in the setting of final grades.

3.14 CLEAN-UP

A. During installation, keep the site free of trash, pavements reasonably clean and work area in an orderly condition at the end of each day. Remove trash and debris in containers from the site no less than once a week.

1. Immediately clean up any spilled or tracked soil, fuel, oil, trash or debris deposited by the Contractor from all surfaces within the project or on public right of ways and neighboring property.

B. Once installation is complete, wash all soil from pavements and other structures. Ensure that mulch is confined to planting beds and that all tags and flagging tape are removed from the site. The Owner's Representative seals are to remain on the trees and removed at the end of the warranty period.

1. Make all repairs to grades, ruts, and damage to the work or other work at the site.

2. Remove and dispose of all excess Planting Soil, subsoil, mulch, plants, packaging, and other material brought to the site by the Contractor.

3.15 PLANTING SOIL AND MODIFIED EXISTING SOIL PROTECTION

A. The Contractor shall protect installed and/or modified Planting Soil from damage including contamination and over compaction due to other soil installation, planting operations, and operations by other Contractors or trespassers. Maintain protection during installation until acceptance. Utilize fencing and matting as required or directed to protect the finished soil work. Treat, repair or replace damaged Planting Soil immediately.

B. Loosen compacted Planting Soil and replace Planting Soil that has become contaminated as determined by the Owner's Representative. Planting Soil shall be loosened or replaced at no expense to the Owner.
   a. Till and restore grades to all soil that has been driven over or compacted during the installation of plants.
   b. Where modified existing soil has become contaminated and needs to be replaced, provide imported soil that is of similar composition, depth and density as the soil that was removed.

3.16 PROTECTION DURING CONSTRUCTION

A. The Contractor shall protect planting and related work and other site work from damage due to planting operations, operations by other Contractors or trespassers.

1. Maintain protection during installation until the date of plant acceptance (see specifications section – Planting). Treat, repair or replace damaged work immediately.

2. Provide temporary erosion control as needed to stop soil erosion until the site is stabilized with mulch, plantings or turf.

B. Damage done by the Contractor, or any of their sub-contractors to existing or installed plants, or any other parts of the work or existing features to remain, including large existing trees, soil, paving, utilities, lighting, irrigation, other finished work and surfaces including those on adjacent property, shall be cleaned, repaired or replaced by the Contractor at no expense to the Owner. The Owner's Representative shall determine when such cleaning, replacement or repair is satisfactory. Damage to existing trees shall be assessed by a certified arborist.

3.17 SUBSTANTIAL COMPLETION ACCEPTANCE

A. Upon written notice from the Contractor, the Owners Representative shall review the work and make a determination if the work is substantially complete.

B. The date of substantial completion of the planting soil shall be the date when the Owner's

Representative accepts that all work in Planting, Planting Soil, and Irrigation installation sections is complete.

3.18 FINAL ACCEPTANCE / SOIL SETTLEMENT

A. At the end of the plant warrantee and maintenance period, (see Specification section - Planting) the Owner's Representative shall observe the soil installation work and establish that all provisions of the contract are complete and the work is satisfactory.

1. Restore any soil settlement and or erosion areas to the grades shown on the drawings. When restoring soil grades remove plants and mulch and add soil before restoring the planting. Do not add soil over the root balls of plants or on top of mulch.

B. Failure to pass acceptance: If the work fails to pass final acceptance, any subsequent observations must be rescheduled as per above. The cost to the Owner for additional observations will be charged to the Contractor at the prevailing hourly rate of the Owner's Representative.

APPENDIX TO 32 9100 PLANTING SOIL

Existing Soil Test Data

Note to specifier: *If existing soil test data is available, add such testing reports in this location. Include a plan of the site designating the extent of the different soil types identified and the location of all soil test pits. If no testing was completed, remove the appendix.*

END OF SECTION 32 9100

32 8400 Irrigation

DISCLAIMER AND RESPONSIBILITY OF THE USER

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INSTRUCTIONS TO THE SPECIFICATION WRITER:

The following document is intended as a general specification to guide the writing of a project-specific specification. Each project is unique and it is required that the specification be developed accordingly. DO NOT USE THE FOLLOWING SPECIFICATION WITHOUT MAKING IMPORTANT ADJUSTMENTS to reflect local conditions, regulations, market standards, project schedules and local and regional practices. The following are specific items that need to be addressed.

1. General instructions to use this specification: *These instructions are intended to guide the specification writer (the specifier) through the process of editing this document into an Irrigation specification. Be sure to delete these instructions (i.e. all the text in red displayed above the paragraph) before issuing the specifications.*

2. General Requirements - Division 01 (Construction Specification Institute) specifications and other contract elements: *This specification is designed to be used in conjunction with standard Division 01 specifications, which cover project general conditions and project wide contract elements. THIS IS NOT A STAND-ALONE SPECIFICATION and should not be used as a contract for the purchase of and installation of an irrigation system. Important issue of project ownership, liability, insurance, contract language, project controls, Instructions to bidders, change orders and review and approval of the work are normally in the Division 01 specifications.*

3. The construction team: *A construction project is a team effort where the owner, in effect, creates a partnership with all the Contractors to build a project. As with any good contract there are protections for both sides; that the Owner will get the quality of project that they desire within the time limits and budget available; and the Contractor will be paid for the work satisfactorily completed. In between the initial bidding and the final completion there will be many places where parts of the construction do not work out as originally intended. This is normal and a good contract should allow for these changes in a manner that is equitable to both the Owner and the Contractor. To get there, a team approach and spirit must prevail. Both sides must assume that each is operating in the best interest of the project goals. The clearer the goals and description of the project, the smoother the flow of a successful project.* ***The more each of the team members can trust the other members, the better the project.*** *This should be a critical principle in approaching the interpretation of the specification.*

4. Other project documents: *This specification is intended to be used in conjunction with other project documents including the bid forms, the construction contract, Division 1 specifications, other specifications directly related to this section; other specifications that are not directly related to this work, and most critically the Project construction drawings. It is very critical that all these documents be prepared with consistent terminology and that they be coordinated. The terms used for the parts of trees and other plants, different soil types, drainage features, irrigation features and structures such as paving, walls and planters must be consistent across disciplines. A very common mistake is the use of different terms and details for soil and the extent of soil work. The terms and details for Planting Soil, subsoil and other materials must be well coordinated.*

5. Relate specification sections: *This specification requires additional specification sections to describe several important related parts of the planting process.*

> ***Tree Protection:*** *This specification assumes that there is a separate specification section and construction drawings and details for tree protection; remove this section if there are no existing trees to be protected on the project.*
>
> ***Planting:*** *This specification assumes that there is a separate specification section and separate plans and details for installation of Planting.*

Planting Soil: *This specification assumes that there may be a separate specification section for Planting Soil associated with the project planting.*

6. Reviewing and approval authority: *Each specification identifies a certain entity as responsible for the review and approval of the work, project submittals, changes to the work and final acceptance of the work. The entity is normally identified in Division 1. For the purposes of this specification, the term the "Owner's Representative" has been used as a placeholder for this entity. Once the proper term is defined, for example another term such as; Contracting Officer, The Architect, The Landscape Architect, The Engineer etc.; this term should replace the words "Owner's Representative" wherever it appears in this specification.*

7. Header and footer requirements: *Change the header/footer language to meet the project requirements.*

8. Notes to specifiers: *Before issuing the document, be sure to remove all "**Notes to specifiers**" incorporated into this document after you have read them and responded to the recommendations.*

9. Submittals: *Submittals are a critical part of any construction contract. This is where all products and materials are reviewed and approved in advance of the work. Including very specific requirements for approval of submittals, while a good practice, assumes that the reviewing authority has the skills needed to make these reviews and interpret the results. A common practice is to make very specific requirements but not have the time or expertise to enforce them. Lack of review of submittals does not automatically transfer quality control to the Contractor. In fact, lack of review or inappropriate review can make the reviewing authority responsible for having accepted the submittal even if it was not acceptable.* ***Do not put into the specification submittal requirements that you do not have the time, resources or knowledge, which you knew or should have known, to enforce.***

10. Specification modifications: *There are locations in this specification where additional information is required to reflect project region or contract conditions. Please insert the requested information.*

11. SPECIAL REQUIREMENTS OF THIS SPECIFICATION:

Product specification: *This specification offers three approaches to product quality. The first is a generic quality non-proprietary product specification. The second option is to peg the generic product quality to a specific manufacture or several or equal manufactures product lines (inserted by the specifier) without specifying specific products. The third option is to allow the specifier to specify specific products where that product exactly fits the design premise of the system design and quality. If the specifier desires to specify specific products a schedule including the product descriptions and model numbers needs to be added either to the drawings or to the specification. DO NOT add a schedule to both documents.*

Irrigation system design assumptions: *This specification assumes that the specifier and the system designer understand the system design assumptions such as the supply pipe size and water pressure. This information must be incorporated onto the drawing. Other design features on the plan such as head type and spacing are a function of water pressure, requirements of completeness of water cover, topography and wind factors. This makes substitutions of head type, for example, have impact on the layout and spacing of heads and even the number of heads on a specific zone. Given the integration of design considerations, drawings and specifications, it is critical for the specifier to work closely with the system design team during the preparation of this document and the resulting construction observation and submittal process.*

SECTION 32 8400

IRRIGATION

PART 1 – GENERAL

1.1 SUMMARY

Note to specifier: *Remove any parts of this work description that does not apply.*

A. Irrigation system required for this work includes but is not limited to the furnishing of all labor, tools, materials, appliances, tests, permits, taxes, etc., necessary for the installation of a landscape irrigation system as herein specified and shown on the drawings, and the removal of all debris from the site.

Note to specifier: *Confirm if the installing Contractor or the general Contractor or the owner is paying for water and electric use fees and hook up charges. Amend the above paragraph if the installing Contractor is required to pay any of these fees.*

1. Locate, purchase, deliver and install piping, conduit, sleeves, 120 volt and low voltage electrical and water connections, valves, backflow preventer devices, controllers, rain sensors, spray and bubbler heads, drip irrigation lines, and associated accessories for a fully operational automatic irrigation system.
2. Trenching and water settling of backfill material.
3. Testing and startup of the irrigation system.
4. Prepare an as built record set of drawings.
5. Training of the Owner's maintenance personnel in the operational requirements of the Irrigation system.
6. Clean up and disposal of all excess and surplus material.
7. Maintenance of the irrigation system during the proscribed maintenance period.

B. The system shall efficiently and evenly irrigate all areas and be complete in every respect and shall be left ready for operation to the satisfaction of the Owner's Representative.

C. Coordinate with other trades, as needed to complete work, including but not limited to Water Meter, Point of Connection (POC) and Backflow Preventer Device (BFPD) location and electrical hookups.

1.2 CONTRACT DOCUMENTS

A. Shall consist of specifications and its general conditions and the drawings. The intent of these documents is to include all labor, materials, and services necessary for the proper execution of the work. The documents are to be considered as one. Whatever is called for by any part shall be as binding as if called for in all parts.

1.3 RELATED DOCUMENTS AND REFERENCES

A. Related Documents:

Note to specifier: *Coordinate this list with the other related specification sections. Add or delete sections as appropriate.*

1. Drawings and general provisions of contract, including general and supplementary conditions and Division I specifications, apply to work of this section.
2. Related Specification Sections
   a. Section - Planting
   b. Section - Planting Soil
   c. Section – Lawn
   d. Sections - Mechanical/Plumbing
   e. Section – Tree and Plant Protection

f. Sections - Electrical

B. References:

1. American Society of Testing Materials (ASTM): cited section numbers.
2. National Sanitation Foundation (NSF): rating system.
3. Irrigation Association: Turf & Landscape Irrigation Best Management Practices

1.4 VERIFICATION

A. Irrigation piping and related equipment are drawn diagrammatically. Scaled dimensions are approximate only. Before proceeding with work, carefully check and verify dimensions and immediately notify the Owner's Representative of discrepancies between the drawings or specifications and the actual conditions. Although sizes and locations of plants and or irrigation equipment are drawn to scale wherever possible, it is not within the scope of the drawings to show all necessary offsets, obstructions, or site conditions. The Contractor shall be responsible to install the work in such a manner that it will be in conformance to site conditions, complete, and in good working order.

B. Piping and equipment is to be located within the designated planting areas wherever possible unless specifically defined or dimensioned otherwise.

1.5 PERMITS AND REGULATIONS

A. The Contractor shall obtain and pay for all permits related to this section of the work unless previously excluded under provision of the contract or general conditions. The Contractor shall comply with all laws and ordinances bearing on the operation or conduct of the work as drawn and specified. If the Contractor observes that a conflict exists between permit requirements and the work outlined in the contract documents, the Contractor shall promptly notify the Owner's Representative in writing including a description of any necessary changes and changes to the contract price resulting from changes in the work.

B. Wherever references are made to standards or codes in accordance with which work is to be performed or tested, the edition or revision of the standards and codes current on the effective date of this contract shall apply, unless otherwise expressly set forth.

C. In case of conflict among any referenced standards or codes or between any referenced standards and codes and the specifications, the more restrictive standard shall apply or Owner's Representative shall determine which shall govern.

1.6 PROTECTION OF WORK, PROPERTY AND PERSON

A. The Contractor shall adequately protect the work, adjacent property, and the public, and shall be responsible for any damages or injury due to the Contractor's actions.

1.7 CHANGES IN THE WORK

A. The Owner's Representative may order changes in the work, and the contract sum being adjusted accordingly. All such orders and adjustments plus claims by the Contractor for extra compensation must be made and approved in writing before executing the work involved.

B. All changes in the work, notifications and Contractor's request for information (RFI) shall conform to the contract general condition requirements.

1.8 CORRECTION OF WORK

A. The Contractor shall re-execute any work that fails to conform to the requirements of the contract and shall remedy defects due to faulty materials or workmanship upon written notice from the Owner's Representative, at the soonest as possible time that can be coordinated with other work, and seasonal weather demands, but not more than 90 (ninety) days after notification**.**

1.9 DEFINITIONS

A. Owner's Representative: The person appointed by the Owner to represent their interest in the review

and approval of the work and to serve as the contracting authority with the Contractor. The Owner's Representative may appoint other persons to review and approve any aspects of the work.

B. Substantial Completion Acceptance: The date at the end of the Planting, Planting Soil, and Irrigation installation where the Owner's Representative accepts that all work in these sections is complete and the Warranty period has begun. This date may be different that the date of substantial completion for the other sections of the project.

C. Final Acceptance: The date when the Owner's Representative accepts that the plants and work in this section meet all the requirements of specification. It is intended that the materials and workmanship warranty for Planting, Planting Soil, and Irrigation work run concurrently.

1.10 SUBMITTALS

A. See the contract General Conditions for policy and procedures related to submittals.

B. Product data

1. Submit a minimum of (3) complete lists of all irrigation equipment to be used, manufacturer's brochures, maintenance manuals, warrantees and operating instructions, within 15 days after the notice to proceed.
    a. This submission may be done digitally and all documents shall be submitted in one PDF document.
2. The submittals shall be packaged and presented in an organized manner, in the quantity described in Division 1 of the specifications. Provide a table of contents of all submitted items.
3. Clearly identify on each submitted sheet by underlining or highlighting (on each copy) the specific product being submitted for approval. Failure to clearly identify the specific product being submitted will result in a rejection for the entire submittal. No substitutions of material or procedures shall be made concerning these documents without the written consent of an accepted equivalent by the Owner's Representative.
4. Equipment or materials installed or furnished without prior approval of the Owner's Representative, may be rejected by the Owner's Representative and the Contractor shall be required to remove such materials from the site at their own expense.
5. Approval of substitution of material and/or products, other than those specified shall not relieve the Contractor from complying with the requirements of the contract documents and specifications. The Contractor shall be responsible, at their own expense, for all changes that may result from the approved substitutions, which affect the installation or operations other items of their own work and/or the work of other Contractors.

C. Samples: Samples of the equipment may be required at the request of the Owner's Representative if the equipment is other than that specified.

D. Other Submittals: Submit for approval:

1. Documentation of the installer's qualifications.
2. As built record set of drawings.
3. Testing data from all required pressure testing.
4. Backflow prevention device certification: Certification from the manufacturer or their representative that the back flow prevention device has been installed correctly according to the manufactures requirements.
5. Booster pump certification: Certification from the manufacturer or their representative that the booster pump has been installed correctly according to the manufacturer's requirements.
6. Irrigation controller certification: Certification from the manufacturer or an authorized distributor that the Controller has been installed correctly according to the manufactures requirements.

1.11 OBSERVATION OF THE WORK

A. The Owner’s Representative may inspect the work at any time. They may remove samples of materials for conformity to specifications. Rejected materials shall be immediately removed from the site and replaced at the Contractor's expense. The cost of testing materials not meeting specifications shall be paid by the Contractor.

B. The Owner’s Representative shall be informed of the progress of the work so the work may be observed at the following key times in the construction process. The Owner’s Representative shall be afforded sufficient time to schedule visit to the site. Failure of the Owner’s Representative to make field observations shall not relieve the Contractor from meeting all the requirements of this specification.

1. Trenching, directional boring, and sleeving review.
2. Hydrostatic pressure testing.
3. Adjustment and coverage test.
4. Pre-maintenance observation.
5. Final acceptance / system malfunction corrections.

1.12 PRE-CONSTRUCTION CONFERENCE

A. Schedule a pre-construction meeting with the Owner’s Representative at least seven (7) days before beginning work to review any questions the Contractor may have regarding the work, administrative procedures during construction and project work schedule.

1.13 QUALITY ASSURANCE

A. It is the intention of this specification to accomplish the work of installing an automatic irrigation system, which will operate in an efficient and satisfactory manner. The irrigation system shall be installed and made operational according to the workmanlike standards established for landscape installation and sprinkler irrigation operation as set forth by the most recent Best Management Practices (BMP) of the Irrigation Association.

B. The specification can only indicate the intent of the work to be performed rather than a detailed description of the performance of the work. It shall be the responsibility of the Contractor to install said materials and equipment in such a manner that they shall operate efficiently and evenly and support optimum plant growth and health.

C. The Owner’s Representative shall be the sole judge of the true intent of the drawings and specifications and of the quality of all materials furnished in performance of the contract.

D. The Contractor shall keep one copy of all drawings and specifications on the work site, in good order. The Contractor shall make these documents available to the Owner’s Representative when requested.

E. In the event of any discrepancies between the drawings and the specification, the final decision as to which shall be followed, shall be made by the Owner’s Representative.

F. In the event the installation is contradictory to the direction of the Owner’s Representative, the installation shall be rectified by the Contractor at no additional cost to the Owner. The Contractor shall immediately bring any such discrepancies to the attention of the Owner’s Representative.

G. It shall be distinctly understood that no oral statement of any person shall be allowed in any manner to modify any of the contract provisions. Changes shall be made only on written authorization of the Owner’s Representative.

H. Installer Qualifications: The installer shall be a firm having at least 5 years of successful experience of a scope similar to that required for the work.

a. Installer Field Supervision: The installer shall maintain on site an experienced full-time supervisor who can communicate in English with the Owner’s Representative.
b. Submit the installer’s qualifications for approval.

1.14 IRRIGATION SYSTEM WARRANTY:

A. The Contractor shall Warrantee all workmanship and materials for a period of X year (s) following the acceptance of the work.

Note to specifier: *Insert above the length of time for the system warrantee period. It is advised to make the irrigation system and the plants have the same length of warrantee.*

1. Any parts of the irrigation work that fails or is defective shall be replaced or reconstructed at no expense to the Owner including but not limited to: restoring grades that have settled in trenches and excavations related to the work. Reconstruction shall include any plantings, soil, mulch or other parts of the constructed landscape that may be damaged during the repair or that results from soil settlement.

B. The date of acceptance of the work and start of the Guarantee period shall be determined by the Owner's Representative, upon the finding that the entire irrigation system is installed as designed and specified, and found to be operating correctly, supplying water evenly to all planting and/or lawn areas.

C. The system controller shall be warranted by the equipment manufacturer against equipment malfunction and defects for a period of X years, following the acceptance of the work.

Note to specifier: *Insert the length of time that the selected controller is warrantied.* ***Verify material warranty with the controller manufacturer.*** *If a specific controller is not specified, delete the above paragraph.*

D. Neither the final acceptance nor any provision in the contract documents shall relieve the Contractor of responsibility for faulty materials or workmanship. The Contractor shall remedy any defects within a period of 7 days (s) from the date of notification of a defect.

1.15 SITE CONDITIONS

A. It is the responsibility of the Contractor to be aware of all surface and sub-surface conditions, and to notify the Owner's Representative, in writing, of any circumstances that would negatively impact the installation of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

1.16 DELIVERY, STORAGE, AND HANDLING

A. All materials and equipment shall be stored properly and protected as required by the Contractor. The Contractor shall be entirely responsible for damages or loss by weather or other cause to work under the contract. Materials shall be furnished in ample quantities and at such times as to ensure uninterrupted progress of the work.

B. Deliver the products to the job site in their original unopened container with labels intact and legible at time of use.

C. Store in accordance with the manufacturers' recommendations.

1.17 PROTECTION

A. The Contractor shall continuously maintain adequate protection of all their work from damage, destruction, or loss, and shall protect the owner's property from damage arising in connection with this contract. Contractor shall make good any such damage, destruction, loss or injury. Contractor shall adequately protect adjacent property as provided by law and the contract documents.

B. The Contractor shall maintain sufficient safeguards, such as railings, temporary walks, lights, etc., against the occurrence of accidents, injuries or damage to any person or property resulting from their work, and shall alone be responsible for the same if such occurs.

C. All existing paving, structures, equipment or plant material shall be protected at all times, including the irrigation system related to plants, from damage by workers and equipment. The Contractor shall follow all protection requirements including plant protection provision of the general contract documents. All damages shall be repaired or replaced at the Contractor's expense. Repairs and or

replacement shall be to the satisfaction of the Owner's Representative, including the selection of a Contractor to undertake the repair or maintenance. Repairs shall be at no cost to the owner.

1. For trees damaged to the point where they will not be expected to survive or which are severely disfigured and that are too large to replace, the cost of damages shall be as determined by the Owner's arborist using accepted tree value evaluation methods.

D. The Contractor shall refrain from trenching within the drip line of any existing tree to remain. The Owner's Representative may require the Contractor to relocate proposed irrigation work, bore lines beneath roots or use air spade technology to dig trenches through and under the root system to avoid damage to existing tree root areas.

1.18 EXCAVATING AROUND UTILITIES

A. Contractor shall carefully examine the civil, record, and survey drawings to become familiar with the existing underground conditions before digging.

1. Do not begin any excavation until all underground utilities have been located and marked.

Determine location of underground utilities and perform work in a manner that will avoid possible damage. Hand excavate, as required. Maintain stakes and or markings set by others until parties concerned mutually agree to their removal.

Note to specifier: *Insert the telephone number and correct name of the Local Utility Locator Service if available to the paragraph below.*

B. Notification of *Local Utility Locator Service*, *Insert PHONE NUMBER*, is required for all excavation around utilities. The Contractor is responsible for knowing the location and avoiding utilities that are not covered by the *Local Utility Locator Service*.

Note to specifier: *If the project is not in California remove the following paragraph.*

C. Section 4216/4217 of the government code requires a dig-alert identification number be issued before a "permit to excavate" will be valid. For your dig-alert identification number call underground service alert toll free 1-800-422-4133 two working days before beginning construction.

1.19 POINT OF CONNECTION

Note to specifier: *Confirm exactly where the irrigation Contractor is to connect to the water and high voltage electrical supply. Often the General Contractor and their plumber and electrician are to provide the connections, including the electrical junction box or plug receptacle, back flow preventer, main shutoff valve and other items. Where non-potable water is used another Contractor may provide some of the required equipment and connections. This specification provides two options, which may also need further modification by the specifier. The specifier must confirm assumptions and pick one of the following options.*

Point of connection option 1 - Irrigation Contractor provided

A. The point of connection of the irrigation system to its electrical power sources shall be provided by the irrigation installer. All connections shall be made by a licensed electrical Contractor per governing codes at the location shown on the drawings.

B. The point of connection of the irrigation system to its potable and or non-potable water sources, including the main shutoff valve and backflow preventer shall be provided by the irrigation installer. All connections shall be made by a licensed Contractor per governing codes, at the location shown on the drawings.

Point of connection option 2 – General Contractor provided

A. The point of connection of the irrigation system to its electrical power sources shall be provided by the General Contractor's licensed electrical Contractor per governing codes at the location shown on the drawings. The irrigation Contractor will connect the power to provided junction box or grounded plug receptacle.

B. The point of connection of the irrigation system to its potable and or non-potable water sources, including the main shutoff valve and backflow preventer shall be provided by the General Contractor's licensed plumbing Contractor per governing codes at the location shown on the drawings. The minimum size and water pressure of the pressurized line will be as noted on the irrigation drawing.

1.20 TEMPORARY UTILITIES

A. All temporary piping, wiring, meters, panels and other related appurtenances required between source of supply and point of use shall be provided by the Contractor and coordinated with the Owner's Representative. Existing utilities may be used with the written permission of the owner.

1.21 CUTTING, PATCHING, TRENCHING AND DIGGING

A. The Contractor shall do all cutting, fitting, trenching or patching of their work that may be required to make its several parts come together as shown upon, or implied by, the drawings and specifications for the completed project.

B. Digging and trenching operations shall be suspended when the soil moisture is above field capacity.

1.22 USE OF PREMISES

A. The Contractor shall confine their apparatus; the storage of materials, and the operations of their workers to limits indicated by the law, ordinances, or permits and shall not unreasonably encumber the premises with their materials.

B. Contractor parking, and material and equipment storage shall in areas approved by the Owner's Representative.

1.23 AS BUILT RECORD SET OF DRAWINGS

A. Immediately upon the installation of any buried pipe or equipment, the Contractor shall indicate on the progress record drawings the locations of said pipe or equipment. The progress record drawings shall be made available at any time for review by the Owner's Representative.

B. Before final acceptance of work, the Contractor shall provide an as built record set of drawings showing the irrigation system work as built. The drawings shall be transmitted to the Owner's Representative in paper format and as a pdf file of each document on compact disk or flash drive. The drawings shall include all information shown on the original contract document and revised to reflect all changes in the work. The drawings shall include the following additional information

1. All valves shall be numbered by station and corresponding numbers shall be shown on the as built record set of drawings.

2. All main line pipe or irrigation equipment including sleeves, valves, controllers, irrigation wire runs which deviate from the mainline location, backflow preventers, remote control valves, grounding rods, shut-off valves, rain sensors, wire splice locations, and quick coupling valves shall be located by two (2) measured dimensions, to the nearest one-half foot. Dimensions shall be given from permanent objects such as buildings, sidewalks, curbs, walls, structures and driveways. All changes in direction and depth of main line pipe shall be noted exactly as installed. Dimensions for pipes shall be shown at no greater than a 50 ft. maximum interval.

3. As built record set of drawings shall be signed and dated by the Contractor attesting to and certifying the accuracy of the as built record set of drawings. As built record set of drawings shall have "As Built Record Set of Drawings", company name, address, phone number and the name of the person who created the drawing and the contact name (if different).

C. The Owner shall make the original contract drawing files available to the Contractor.

1.24 CONTROLLER CHARTS:

A. Provide one controller chart for each automatic controller installed.

1. On the inside surface of the cover of each automatic controller, prepare and mount a color-coded chart showing the valves, main line, and systems serviced by that particular controller. All valves shall be numbered to match the operation schedule and the drawings. Only those areas controlled by that controller shall be shown. This chart shall be a plot plan, entire or partial, showing building, walks, roads and walls. The plan, reduced as necessary and legible in all details, shall be made to a size that will fit into the controller cover. This print shall be approved by the Owner's Representative and shall be protected in laminated in a plastic cover and be secured to the inside back of the controller cabinet door.
2. The controller chart shall be completed and approved prior to acceptance of the work.

1.25 TESTING

A. Provide all required system testing with written reports as described in part 3.

1.26 OPERATION AND MAINTENANCE MANUALS AND GUARANTEES

A. Prepare and deliver to the Owner's Representative within ten calendar days prior to completion of construction, two 3-ring hard cover binders containing the following information:
   1. Index sheet stating Contractor's address and telephone number, list of equipment with name and addresses of local manufacturers' representatives.
   2. Catalog and parts sheets on all material and equipment.
   3. Guarantee statement. The start of the guarantee period shall be the date the irrigation system is accepted by the Owner.
   4. Complete operating and maintenance instruction for all major equipment.
   5. Irrigation product manufacturers warrantees.
B. In addition to the above-mentioned maintenance manuals, provide the Owner's maintenance personnel with instructions for maintaining major equipment and show evidence in writing to the Owner's Representative at the conclusion of the project that this has been rendered.

PART 2 – PRODUCTS

2.1 MATERIALS GENERAL

A. All materials shall be of standard, approved and first grade quality and shall be new and in perfect condition when installed and accepted.

***Note to specifier**: The following are three options for the use of specific manufacturer's product to set quality and capability of the installation. Confirm the desired approach and select only one of the following options, Modify the text as needed.*

***Option 1** – Use of a manufacturer's name on the drawing only as a general guide.*

B. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and configuration desired only. Other manufacturer's equipment may be submitted for approval with written approval by the Owner's Representative. Substituted equipment shall not substantially alter the operations of the system.

***Option 2** – Use of a manufacturer's name or names in the specification as a specific requirement to use their products but where no specific products are required.*

B. All controllers, valves, and heads *(add other product categories if needed)* shall be manufactured by the following manufacturer(s) *(or approved equal).*
1. Insert manufacturer's name(s) and contact information.

Option 3 *- Use of a specific manufacturer's name and product model for critical products. If this option is selected modify the product specific specifications that follow so that the text is consistent with the product required.*

B. See the parts schedule on the drawings *(or below)* for specific components and manufacturers.
1. Insert schedule of required parts with manufactures name(s) and contact information or add to the various product specifications below.

C. Approval of any items or substitutions indicates only that the product(s) apparently meet the requirements of the drawings and specifications on the basis of the information or samples submitted. The Contractor shall be responsible for the performance of substituted items. If the substitution proves to be unsatisfactory or not compatible with other parts of the system, the Contractor shall replace said items with the originally specified items, including all necessary work and modifications to replace the items, at no cost to the owner.

Note to specifier: *Some of the following product specifications have a clause that say that further product descriptions are on the drawings. Confirm that this is the case. If this is the desired option for the specification, select Option 3 above. If this is not the case remove reference to the product being described on the drawings. Add additional specifications as needed to strengthen the product requirements as needed by the project goals and tolerance for tightening industry product options.*

Delete all products in the following paragraphs not applicable to this specific project.

2.2 RECLAIMED WATER SYSTEM DESIGNATION

A. Where irrigation systems use reclaimed water, all products including valve boxes, lateral and main line pipe, etc. where applicable and/or required by local code shall have the reclaimed water purple color designation.

2.3 PIPING MATERIAL

A. Individual types of pipe and fittings supplied are to be of compatible manufacturer unless otherwise approved. Pipe sizes shown are nominal inside diameter unless otherwise noted.

B. Plastic pipe:

1. All pipe shall be free of blisters, internal striations, cracks, or any other defects or imperfections. The pipe shall be continuously and permanently marked with the following information: manufacturer's name or trade mark, size, class and type of pipe pressure rating, quality control identifications, date of extrusion, and National Sanitation Foundation (NSF) rating.

2. Pressure main line for piping upstream of remote control valves and quick coupling valves:
   a. Pipe smaller than 2 inch diameter shall be plastic pipe for use with solvent weld or threaded fittings. Shall be manufactured rigid virgin polyvinyl chloride (PVC) 1220, Type 1, Grade 2 conforming to ASTM D 1785, designated as Schedule 40.
   b. Pipe 2 - 3 inch diameter shall be manufactured rigid virgin polyvinyl chloride (PVC), Type 1, Grade 2 conforming to ASTM D 1785, designated as bell gasket Class 315.
   c. Pipe larger than 3 inch diameter shall be manufactured rigid virgin polyvinyl chloride (PVC), Type 1, Grade 2 conforming to ASTM D 1785, designated as bell gasket Class 200 PVC.

3. Non-pressure lateral line for piping downstream of remote control valves: plastic pipe for use with solvent weld or threaded fittings. Shall be manufactured rigid virgin polyvinyl chloride PVC 1220 (type 1, grade 2) conforming to ASTM d 1785, designated as Class 200, 3/4″ minimum size.

C. Galvanized pipe shall be used for above ground connections to, backflow prevention device assemblies, hose bibs, and booster pumps and as shown on the plans and details.

1. Pipe shall be hot dip galvanized continuous welded, seamless, Schedule 40 conforming to applicable current ASTM standards.

2.4 FITTINGS AND CONNECTIONS:

A. Polyvinyl chloride pipe fittings and connections: Type II, Grade 1, Schedule 40, high impact molded fittings, manufactured from virgin compounds as specified for piping tapered socket or molded thread type, suitable for either solvent weld or screwed connections. Machine threaded fittings and plastic saddle and flange fittings are not acceptable. Furnish fittings permanently marked with following information: nominal pipe size, type and schedule of material, and National Sanitation Foundation (NSF) seal of approval. PVC fittings shall conform to ASTM D2464 and D2466.

B. Brass pipe fittings, unions and connections: standard 125 pound class 85% red brass fittings and connections, IPS threaded.

C. PVC Schedule 80 threaded risers and nipples: Type I, grade 1, Schedule 80, high impact molded, manufactured from virgin compounds as specified for piping and conforming to ASTM D-2464. Threaded ends shall be molded threads only. Machined threads are not acceptable.

D. Galvanized pipe fittings shall be galvanized malleable iron ground joint Schedule 40 conforming to applicable current ASTM standards.

2.5 SOLVENT CEMENTS AND THREAD LUBRICANT

A. Solvent cements shall comply with ASTM D2564. Socket joints shall be made per recommended procedures for joining PVC plastic pipe and fittings with PVC solvent cement and primer by the pipe and fitting manufacturer and procedures outlined in the appendix of ASTM D2564.

B. Thread lubricant shall be Teflon ribbon-type, or approved equal, suitable for threaded installations as per manufacturer's recommendations.

C. Pipe Joint Compound (Pipe dope) shall be used on all galvanized threaded connections. Pipe Joint Compound is a white colored, non-separating thread sealant compound designed to seal threaded connections against leakage due to internal pressure. It shall contain PTFE (Polytetrafluoroethylene) to permit a tighter assembly with lower torque, secure permanent sealing of all threaded connections and allow for easy disassembly without stripping or damaging threads.

2.6 BACKFLOW PREVENTION DEVICES

A. The backflow prevention device shall be certified to NSF/ANSI 372 shall be ASSE Listed 1013, rated to 180 degree F, and supplied with full port ball valves.

B. The main body and access covers shall be low lead bronze (ASTM B 584)

C. The seat ring and all internal polymers shall be NSF Listed Noryl and the seat disc elastomers shall be silicone.

D. Backflow Preventer shall be as indicated on the drawings.

2.7 PRESSURE REGULATOR

A. Pressure regulator shall certified to NSF/ANSI 372, consisting of low lead bronze body bell housing, a separate access cap shall be threaded to the body and shall not require the use of ferrous screws.

B. The main valve body shall be cast bronze (ASTM B 584).

C. The access covers shall be bronze (ASTM B 584 or Brass ASTM B 16)

D. The assembly shall be of the balanced piston design and shall reduce the pressure in both flow and no flow conditions.

E. Pressure regulator shall be as indicated on the drawings.

2.7. Wye Strainer

A. Strainer shall conform to MIL –S-16293, and be ANSI 3rd party certified to comply with the states lead plumbing law 0.25% maximum weighted average lead content.

B. The main body shall be low lead bronze (ASTM B 584)

C. The access covers shall be yellow brass or cast bronze (ASTM B 16 or ASTM B 584)

D. Strainer screen shall be 300 series stainless steel available in 20, 40, 60, 80, or 100 mesh.

F. Wye strainer shall be as indicated on the plans.

2.8 BACKFLOW PREVENTER CAGE

A. A heavy-duty steel mesh cage with rust proof finish. The caging shall be sized to allow space for the entire piping assembly associated with the Backflow Preventer unit, and all associated equipment.

B. The cage shall include the manufacturers' standard tamper proof locking mechanism.

C. Provide a concrete base as detailed on the drawings.

D. Backflow Preventer Cage type, manufacturer and color shall be as indicated on the plans.

2.9 BOOSTER PUMP

Note to specifier: *Booster pumps are used when available static pressure is too low for the system to operate, demand is high requiring multiple stations to operate at once, future expansion of the system of the water window is very small due to maintenance practices or site use (such as in the case of parks, sports fields, or schools). It is the responsibility of the specifier to consider all such factors in determining whether or not a booster pump is required. IN many cases booster pumps are specified when they are not needed due to all of the variables not being taken into consideration.*

A. Booster pump shall be housed in a sturdy, locking, weather-resistant case, furnished for maximum exterior protection.

B. Booster pump shall be as indicated on the drawings. .

2.10 BALL VALVES

A. Ball valves for 3/4 inch through 2-1/2 inch shall be of PVC, block, tru-union design with EDPDM seals and o-ring.

B. Ball valves for 3 inch and larger shall be gate design and shall be iron body, brass or bronze mounted AWWA gate valves, and shall have a clear waterway equal to the full nominal diameter of the valve, and shall be rubber gasket, flanged or mechanical joint only, and shall be able to withstand a continuous working pressure of 150 PSI. Valve shall be equipped with a square-operating nut.

C. All ball valves located in a valve manifold shall be the same size as the main line (1-1/2 inch size minimum). Provide pipe-reducing adapters down stream of valves, as required. All ball valves in line shall be the same size as the pipe.

D. Ball valves shall be as indicated on the drawings.

2.11 CHECK VALVES

A. Swing check valves 2 inch and smaller shall be 200 lbs., W.O.G., bronze construction with replaceable composition, neoprene or rubber disc and shall meet or exceed federal specification WW-V- 5ld, class a, type iv.

B. Anti-drain valves shall be of heavy-duty virgin PVC construction with female iron pipe thread inlet and outlet. Internal parts shall be stainless steel and neoprene. Anti-drain valves shall be field adjustable against draw out from 5 to 40 feet of head.

C. Check valves shall be as indicated on the drawings.

2.12 REMOTE CONTROL VALVES

A. Remote control valves shall be electrically operated, single seat, normally closed configuration, equipped with flow control adjustment and capability for manual operation.

B. Valves shall be actuated by a normally closed low wattage solenoid using 24 volts, 50/60 cycle solenoid power requirement. Solenoid shall be epoxy encased. A union shall be installed on the discharge end.

C. Remote control valves shall be wired to controller in same numerical sequence as indicated on drawings.

D. Remote control valves shall be as indicated on the drawings.

2.13 MASTER CONTROL VALVES

Note to specifier: *The master valve and flow sensor specifications must meet the requirements or recommendations of the controller manufacturer. Additional specifications are required for this product.*

A. Master Control Valve shall be compatible with the irrigation controller.

B. Master control valves shall be as indicated on the drawings.

2.14 FLOW SENSOR

A. Flow sensor shall be compatible with the irrigation controller.

B. Flow sensor shall be as indicated on the drawings.

2.15 HYDROMETER

Note to specifier: *The hydrometer specifications must meet the requirements or recommendations of the controller manufacture. The Hydrometer can be either Reed Switch or Photo Diode Register, specifier needs to verify with the controller manufacturer. Additional specifications are required for this product.*

A. Hydrometer shall be compatible with the irrigation controller.

B. Hydrometer shall be as indicated on the drawings.

2.16 QUICK COUPLER VALVES

A. Quick coupler valves shall be a one or two piece, heavy-duty brass construction with a working pressure of 150 PSI with a built in flow control and a self-closing valve.

B. Quick coupler shall be equipped with locking red brass cap covered with durable yellow thermo-plastic rubber cover. Key size shall be compatible with quick coupler and of same manufacturer.

C. Quick coupler valves shall be as indicated on the drawings.

2.17 SPRINKLER HEADS

Note to specifier: *The selection of irrigation heads is a complex decision and needs far stronger specifications than are listed here. Confirm the approach to selecting heads and revise the text.*

A. All sprinkler heads shall have check valves installed.

B. All sprinkler heads shall be as indicated on the drawings.

C. Riser nipples for all sprinkler heads shall be the same size as the riser opening in the sprinkler body and fabricated as shown on the drawings.

2.18 AUTOMATIC CONTROLLER

Note to specifier: *Irrigation controllers vary upon the designer's preferences, users needs, and education of the owner/maintenance personal. The specifier shall develop these specifications based upon those factors.*

A. Controller shall be housed in a sturdy, locking, weather-resistant case, furnished for maximum exterior protection.

B. Controller shall be equipped with evapo-transpiration (ET) sensor, which adjusts the controller programming based on local climatic conditions. The sensor shall also have a rain sensing shut-off switch, wind sensing shut off switch, and freeze sensing shut-off of switch.

1. If a moisture sensor is used in lieu of an evapo-transpiration sensor an additional sensor, which has a rain-sensing shut-off switch, wind sensing shut-off switch, and freeze sensing shut-off switch shall be provided.

C. Automatic controller shall be as indicated on the drawings.

2.19 CONTROLLER DECODERS

Note to specifier: *Controller decoders for 2-wire systems are specific to each controller manufacturer. In addition the installation warranty can be connected to the purchase of the 2-wire controller and decoders from the same distributor. The specifier shall develop these specifications based upon those factors.*

A. All decoders shall be per the controller manufacturer's specifications.

B. Decoder model number shall be as shown on the drawings.

2.20 ELECTRICAL CONTROL WIRING

A. Low voltage

1. The electrical control wire shall be direct burial type UF, no. 14 AWG, solid, single conductor, copper wire UL approved or larger, if required to operate system as designed.
2. For 2-Wire controllers all irrigation wire for the controller, flow sensor, master valve, hydrometer, remote control valves and moisture sensors shall be per the controller manufacturer's specifications and recommendations.
3. Color code wires to each valve. Common wire shall be white.
4. If multiple controllers are being utilized, and wire paths of different controllers cross each other, both common and control wires from each controller to be of different colors.
5. Control wire splices: Splices are when required shall be placed in splice boxes.
6. Wire connections shall be per the controller manufacturer's specifications and recommendations.

B. High voltage

1. Shall be of type as required by local codes and ordinances.
2. Shall be of proper size to accommodate needs of equipment it is to serve.

2.21 VALVE BOXES AND MATERIALS

Note to specifier: *Valve box color shall differentiate depending on the specifier's preference or the irrigation system is using non potable water.*

A. Valve boxes: valve boxes shall be constructed of ABS (acrylonitrile butadiene styrene) plastic, green in color, with rigid base and sides and shall be supplied with bolt lock cover secured with stainless steel bolts. Cover shall be identified as shown on drawings. Provide box extensions as required.

1. Master valves, flow sensors, remote control irrigation valves, gate valves, and ball valves 3 inch or less in size shall use a 14 inch x 19 inch x 12 inch rectangular box.
2. Quick coupler valves, wire splices, and grounding rods shall use a 10 inch circular box.

2.22 CONCRETE THRUST BLOCKS

A. Concrete thrust blocks shall be sized per the pipe manufactures requirement or as indicated on the drawings.

2.23 VALVE IDENTIFICATION TAGS

A. Valve Identification Tags shall be 2.25 inch x 2.65 inch polyurethane. Color: potable water; yellow / Non-potable water; purple. Tags shall be permanently attached to each remote control valve with

tamper proof seals as indicated on the drawings.

2.24 EQUIPMENT TO BE FURNISHED TO OWNER

A. Two (2) sets of keys for each automatic controller.

B. Two (2) 48 inch tee wrenches for operating the gate valves.

C. Three (3) sets of special tools required for removing, disassembling and adjusting each type of sprinkler and valve supplied on this project.

D. Five (5) Extra sprinkler heads, nozzles, shrub adapters, nozzle filter screens, for each type used on the project.

E. Two (2) quick coupler keys to match manufacturer type of quick coupler.

2.25 INCIDENTAL MATERIALS AND EQUIPMENT

A. Furnish all materials and equipment not specified above, but which are necessary for completion of the work as intended.

2.26 MAIN LINE LOCATOR TAPE

A. 3 - inch wide plastic detectable locator tape.

2.27 MAIN LINE AND LATERAL LINE BEDDING SAND

A. Sand shall consist of natural or manufactured granular material, free of organic material, mica, loam, clay or other substances not suitable for the intended purpose.

B. Sand shall be masonry sand ASTM C 144 or coarse concrete sand, ASTM C 33.

PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS

A. Code requirements shall be those of state and municipal codes and regulations locally governing this work, providing that any requirements of the drawings and specifications, not conflicting therewith, but exceeding the code requirements, shall govern unless written permission to the contrary is granted by the Owner's Representative.

B. Extreme care shall be exercised at all times by the Contractor in excavating and working in the project area due to existing utilities and irrigation systems to remain. Contractor shall be fully responsible for expenses incurred in the repair of damages caused by their operation.

1. The Contractor is responsible for identifying and maintaining existing irrigation main lines that supply water to areas on the site as noted on the drawings and outside of the proposed limit of work. The Contractor shall relocate or replace existing irrigation main line piping as required to provide a continuous supply of water to all areas of existing irrigation on site.
    a. Providing continuous water supply shall include hand watering and or the use of watering trucks to provide adequate water.

C. Plan locations of backflow preventers, valves, controllers, irrigation lines, sleeves, spray heads and other equipment are diagrammatic and indicate the spacing and relative locations of all installations. Final site conditions and existing and proposed plantings shall determine final locations and adjusted as necessary and as directed to meet existing and proposed conditions and obtain complete water coverage. Minor changes in locations of the above from locations shown shall be made as necessary to avoid existing and proposed trees, piping, utilities, structures, etc. at the Contractor's expense or when directed by the Owner's Representative.

1. The Contractor shall be held responsible for relocation of any items without first obtaining the Owner's Representative's approval. The Contractor shall remove and relocate such items at their expense if so directed by the Owner's Representative.

D. Prior to any work the Contractor shall stake out locations of all pipe, valves, equipment and irrigation heads and emitters using an approved staking method and maintain the staking of the approved layout in accordance with the drawings and any required modifications. Verify all horizontal and vertical site dimensions prior to staking of heads. Do not exceed spacing shown on drawings for any given area. If such modified spacing demand additional or less material than shown on the drawings, notify the Owner's Representative before beginning any work in the adjacent area.

E. Stub out main line at all end runs and as shown on drawings. Stub out wires for future connection where indicated on plan and as directed.

F. Point of connection shall be approximately as shown on drawings. Connect new underground piping and valves and provide all flanges, adapters or other necessary fittings for connection.

G. Permission to shut off any existing in-use water line must be obtained 48 hours in advance, in writing from the Owner. The Contractor shall receive instructions from the Owner's Representative as to the exact length of time of each shut-off.

H. No fittings shall be installed on pipe underneath pavement or walls.

I. Prior to starting any work, Contractor shall obtain a reading of existing static water pressure (no flow condition) at the designated point of connection and immediately submit written verification of pressure with date and time of recording to Owner's Representative.

3.2 TRENCHING, DIRECTIONAL BORING AND SLEEVING

A. Perform all trenching, directional boring, sleeving and excavations as required for the installation of the work included under this section, including shoring of earth banks to prevent cave-ins.

B. The Contractor may directional bore lines where it is practical or where required on the plans.

1. Extend the bore 1' past the edge of pavement unless noted differently on the plans
2. Cap ends of each bore and locate ends at finished grade using metal stakes.
3. All boring and sleeving shall have detectable locator tape placed at the ends of the pipe.

C. Make trenches for mains, laterals and control wiring straight and true to grade and free of protruding stones, roots or other material that would prevent proper bedding of pipe or wire.

D. Excavate trenches wide enough to allow a minimum of 4 - inch between parallel pipelines and 8 inch from lines of other trades. Maintain 3 - inch vertical clearance between irrigation lines. Minimum transverse angle is 45 degrees. All pipes shall be able to be serviced or replaced without disturbing the other pipes.

E. Trenches for pipelines shall be made of sufficient depth to provide the minimum cover from finished grade as follows:

Note to specifier: *Mainline depths shall vary based on geography and climate conditions. For colder climates mainline depths shall be deeper. Specifier shall verify local and or state requirements.*

1. Pressure main line: 18 inches below finish grade and 24-30 inches below paved areas in Schedule 40 PVC sleeves.
2. Reclaimed water constant pressure main lines shall cross at least twelve (12) inches below potable water lines.
   a. If a constant pressure reclaimed water main line must be installed above a potable water line or less than twelve (12) inches below a potable water line, then reclaimed water line shall be installed within an approved protective sleeve. The sleeve shall extend ten (10) feet from each side of the center of the potable line, for a total of twenty (20) feet. The sleeve shall be color-coded (purple) for use with reclaimed water.
3. Lateral lines: 12 inches below finish grade and 18 inches below paved areas in Schedule 40 PVC sleeves.

4. Control wiring: to the side of pressure main line and 24 inches below paved areas in Schedule 40 PVC sleeves.

F. On new on-site systems (post-meter), the required horizontal separation between potable water lines, reclaimed water constant pressure main lines and sewer lines shall be a minimum of four (4) feet apart as directed by the project engineer and/ or regulatory agency. Measurements shall be between facing surfaces, not pipe centerlines.

G. When trenching through areas of imported or modified soil, deposit imported or modified soils on one side of trench and subsoil on opposite side.

H. Backfill the trench per the requirements in paragraphs “Backfilling and Compacting” below.

3.3 PIPE INSTALLATION

A. General Pipe Installation

1. Exercise caution in handling, loading and storing, of plastic pipe and fittings to avoid damage.
   a. The pipe and fittings shall be stored under cover until using, and shall be transported in a vehicle with a bed long enough to allow the length of pipe to lay flat so as not to be subjected to undue bending or concentrated external load at any point.
   b. All pipe that has been dented or damaged shall be discarded unless such dent or damaged section is cut out and pipe rejoined with a coupling.
2. Trench depth shall be as specified above from the finish grade to the top of the pipe.
3. Install a detectable pipe locator tape 6 to 8 inches above all main line pipes.

B. Polyvinyl Chloride Pipe (PVC) Installation

1. Under no circumstance is pipe to rest on concrete, rock, wood blocks, construction debris or similar items.
2. No water shall be permitted in the pipe until a period of at least 24 hours has elapsed for solvent weld setting and curing.
3. Install assemblies and pipe to conform to respective details and where shown diagrammatically on drawings, using first class workmanship and best standard practices as approved. All fittings that are necessary for proper connections such as swing joints, offsets, and reducing bushings that are not shown on details shall be installed as necessary and directed as part of the work.
4. Dielectric bushings shall be used in any connections of dissimilar metals.
5. Gasketed plastic pipe: pipe-to-pipe joints or pipe to fittings shall be made in accordance with manufacturer’s specifications.
6. Solvent weld or threaded plastic pipe:
   a. Installation of all pipe and fittings shall be in strict accordance with manufacturer’s specifications.
   b. Pipe shall be cut using approved PVC pipe cutters only. Sawed joints are disallowed. All field cuts shall be beveled to remove burrs and excess before gluing.
   c. Welded joints shall be given a minimum of 15 minutes to set before moving or handling. Excess solvent on the exterior of the joint shall be wiped clean immediately after assembly.
   d. Plastic to metal connections shall be made with plastic adapters and if necessary, short (not close) brass threaded-nipples. Connection shall be made with two (2) wraps of Teflon tape and hand tightened plus one turn with a strap wrench.
   e. Snake pipe horizontally in trench to allow one (1) foot of expansion and contraction per 100 feet of straight run.
   f. Threaded pipe joints shall be made using Teflon tape. Solvent shall not be used with threaded joints. Pipe shall be protected from tool damage during assembly. All damaged pipe shall be removed and replaced. Take up threaded joints with light wrench pressure.
   g. No close nipples or risers are allowed. Cross connections in piping is disallowed.

h. Center load pipe at 10 feet on center intervals with small amount of backfill to prevent arching and slipping under pressure. Other than this preliminary backfill all pipe joints, fittings and connections are to remain uncovered until successful completion of hydrostatic testing and written approval of the testing report.
i. Concrete thrust blocks shall be constructed behind all pipe fittings 1-1/2 inch diameter and larger at all changes of direction of 45 degrees or more.

C. Galvanized Pipe Installation

1. All joints shall be threaded with pipe joint compound used on all threads.
2. Dielectric bushings shall be used in any connections of dissimilar metals.

3.4 TRENCHING, DIRECTIONAL BORING, AND SLEEVING REVIEW:

A. Upon completion and installation of all trenching, directional boring, and sleeving, all installed irrigation control wiring, lines and fittings shall be visually observed by the Owner's Representative unless otherwise authorized. Do not cover any wires, lines or fittings until they have been tested and observed by the Owner's Representative.

3.5 FLUSHING

A. Openings in piping system during installation are to be capped or plugged to prevent dirt and debris from entering pipe and equipment. Remove plugs when necessary to flush or complete system.

B. After completion and prior to the installation of any terminal fittings, the entire pipeline system shall be thoroughly flushed to remove dirt, debris or other material.

3.6 HYDROSTATIC PRESSURE TESTING

A. After flushing, and the installation of valves the following tests shall be conducted in the sequence listed below. The Contractor shall furnish all equipment; materials and labor necessary to perform the tests and all tests shall be conducted in the presence of the Owner's Representative.

B. Water pressure tests shall be performed on all pressure main lines before any couplings, fittings, valves and the like are concealed.

C. Immediately prior to testing, all irrigation lines shall be purged of all entrapped air or debris by adjusting control valves and installing temporary caps forcing water and debris to be discharged from a single outlet.

D. Test all pressure main line at 150 PSI. For a minimum of four (4) hours with an allowable loss of 5 PSI. Pressure and gauges shall be read in PSI, and calibrated such that accurate determination of potential pressure loss can be ascertained.

E. Re-test as required until the system meets the requirements. Any leaks, which occur during test period, will be repaired immediately following the test. All pipe shall be re-tested until final written acceptance.

F. The Contractor is responsible for proving documentation stating the weather conditions, date, the start time and initial water pressure readings, the finish time and final water pressure readings and the type of equipment used to perform the test. The documentation must be signed by a witness acceptable to the Owner, verifying all of the above-mentioned conditions.

G. Submit a written report of the pressure testing results with the other above required information to the Owner's Representative for approval.

3.7 BACKFLOW PREVENTER TESTING

A. The backflow preventer shall be tested according to procedures and results per the requirements of the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California or American Water Works Association whichever is more stringent.

B. Testing shall be performed by a Backflow Prevention Assembly Tester with a current certification

from the American Backflow Preventer Association.

3.8 CONTROLLER AND BOOSTER PUMP TESTING AND CERTFICIATION

Note to specifier: *Testing and certification of the installation of the controller and the booster pump (if installed) is sometimes preferred by the specifier for a third party verification that the equipment was installed and working in accordance with the manufacturer's specifications. The specifiers knowledge of the manufacturer's installation requirements, along with their level of construction observation and administration on the project, should be taken into consideration on whether or not to proceed with certification. Not having the installation certified does not relieve the Contractor of any responsibility for installation but does provide the specifier with an additional mechanism so that the equipment is installed correct and technical support, if a non-manufacturing issue were to arise with the equipment, is available. Remove this section if certification is not required.*

A. Controller and booster Pump shall be certified by xxxxx of (name the company). Contact xxxxxxxx at xxx.xxx.xxxx.

3.9 BACKFILLING AND COMPACTING

A. Irrigation trenches shall be carefully backfilled with material approved for backfilling and free of rocks and debris one (1) inch in diameter and larger. When back filling trenches in areas of imported or modified planting soil, replace any excavated subsoil at the bottom and the imported soil or modified planting soil at the top of the trench.

B. Backfill shall be compacted with approved equipment to the following densities

1. Backfill under pavement and within 2 feet of the edge of pavement: Compact to 95% or greater of maximum dry density standard proctor.
2. Backfill of subsoil under imported planting mixes or modified existing planting soil: Between 85 and 90% of maximum dry density standard proctor.
3. Backfill of imported planting mixes or modified existing planting soil: Compact to the requirements of the adjacent planting mix or planting soil as specified in section "Planting Soil".

C. Finish grade of all trenches shall conform to adjacent grades without dips or other irregularities. Dispose of excess soil or debris off site at Contractor's expense.

D. Any settling of backfill material during the maintenance or warranty period shall be repaired at the Contractor's expense, including any replacement or repair of soil, lawn, and plant material or paving surface.

3.10 RESURFACING PAVING OVER TRENCHES

Note to specifier: *In some projects paving restoration may be the responsibility of the General Contractor. Coordinate with other specification sections and amend this paragraph as needed.*

A. Restore all surfaces and repair existing underground installations damaged or cut as a result of the excavation to their original condition, satisfactory to the Owner's Representative.

B. Trenches through paved areas shall be resurfaced with same materials quality and thickness as existing material. Paving restoration shall be performed by the project paving Sub-contractor or an approved Contractor skilled in paving work.

C. The cost of all paving restoration work shall be the responsibility of the irrigation Contractor unless the trenching thru the paving was, by previous agreement, part of the general project related construction.

3.11 INSTALLATION OF EQUIPMENT

A. General:

1. All equipment shall be installed to meet all installation requirements of the product manufacturer. In the event that the manufactures requirements cannot be implemented due to particular condition at the site or with other parts of the design, obtain the Owner's Representative's written authorization and approval for any modifications.

2. Install all equipment at the approximately at the location(s) and as designated and detailed on the drawings. Verify all locations with the Owner's Representative.
3. Install all valves within a valve box of sufficient size to accommodate the installation and servicing of the equipment. Group valves together where practical and locate in shrub planting areas.
4. All sprinkler irrigation systems that are using water from potable water systems shall require backflow prevention. All backflow prevention devices shall meet and be installed in accordance with requirements set forth by local codes and the health department.

B. Pressure regulator:
1. Set regulator for required PSI per manufacturer's specifications.

C. Check Valve:
1. Install check valves approximately at the locations necessary to prevent low head run off.

D. Remote control valves:
1. Install one remote control valve per valve box.
2. Remote control valve manifolds and quick coupler valves shall be separate allowing use of a quick coupler with all remote control valves shut off.
3. Install boxes no farther than 12 inches from edge of paving and perpendicular to edge of paving and parallel to each other. Allow 12 inches clearance between adjacent valve boxes.

E. Quick coupler valve:
1. Install each quick coupler valve in its own valve box.
2. Install thrust blocks on quick couplers.
3. Place no closer than 12 inches to adjacent paving.
4. Install 18 inches off set from main line.

F. Sprinkler heads:
1. All main lines and lateral lines, including risers, shall be flushed and pressure tested before installing sprinkler heads.
2. Install specified sprinkler heads as shown in details at locations shown on the drawings. Adjust layout for full coverage, spacing of heads shall not exceed the maximum spacing recommended by the manufacturer.
3. All sprinkler heads shall be set perpendicular to finish grade unless otherwise designated on the drawings or details.

G. Irrigation controllers:
1. Remote control valves shall be connected to controller in numerical sequence as shown on the drawings.
2. Controller shall be tested with complete electrical connections. The Contractor shall be responsible for temporary power to the controller for operation and testing purposes.
3. Connections to control wiring shall be made within the pedestal of the controller. All wire shall follow the pressure main insofar as possible.
4. Electrical wiring shall be in a rigid gray PVC plastic conduit from controller to electrical outlet. The electrical Contractor shall be responsible for installing all wiring to the controller, in order to complete this installation. A disconnect switch shall be included.

H. Wiring:
1. Low Voltage
   a. Control wiring between controller and electrical valves shall be installed in the same trench as

the main line where practical. The wire shall be bundled and secured to the lower quadrant of the trench at 10 foot intervals with plastic electrical tape.

b. When the control wiring cannot be installed in the same main line trench it shall be installed a minimum of 18 inches below finish grade and a bright colored plastic ribbon with suitable markings shall be installed in the trench 6 inches below grade directly over the wire.

c. An expansion loop shall be provided every 500 feet in a box and inside each valve box. Expansion loop shall be formed by wrapping wire at least eight (8) times around a ¾ inch pipe and withdrawing pipe.

d. Provide one control wire to service each valve in system.

Note to specifier: *A majority of the newer irrigation controllers have more than one port for common wire allowing for multiple directional runs. Depending on the controller location within the irrigation system it might be more efficient to have more than one common wire in the system. The specifier must confirm the number of common wires and fill in below.*

e. Provide XX common wire(s) per controller.

f. Run two (2) spare #14-1 wires from controller along entire main line to last electric remote control valve on each and every leg of main line. Label spare wires at controller and wire stub to be located in a box.

g. All control wire splices not occurring at control valve shall be installed in a separate splice valve box.

h. Wire markers (sealed, 1 inch to 3 inch square) are to identify control wires at valves and at terminal strips of controller. At the terminal strip mark each wire clearly indicting valve circuit number.

2. High Voltage

a. All electrical work shall conform to local codes, ordinances and any authorities having jurisdiction. All high voltage electrical work to be performed by licensed electrician.

b. The Contractor shall provide 120-volt power connection to the automatic controller unless noted otherwise on drawings.

I. Valve boxes:

1. Install one valve box for each type of valve installed as per the details.

2. Gravel sump shall be installed after compaction of all trenches. Final portion of gravel shall be placed inside valve box after valve is backfilled and compacted.

3. Permanently label valve number and or controller letter on top of valve box lid using a method approved by the Owners Representative.

J. Tracer wire:

1. Tracer wire shall be installed with non-metallic plastic irrigation main lines where controller wires are not buried in the same trench as the main line.

2. The tracer wire shall be placed on the bottom of the trench under the vertical projection of the pipe with spliced joints soldered and covered with insulation type tape.

3. Tracer wire shall be of a color not used for valve wiring. Terminate wire in a valve box. Provide enough length of wire to make a loop and attach wire marker with the designation "tracer wire".

K. Drip Installation:

1. Clamp fittings with Oetiker clamps or approved equal when operating pressure exceeds specific drip tubing fitting requirements.

2. When installing drip tubing, install soil staples as listed below:

a. Sandy Soil - One staple every three (3') feet and two (2) staples on each change of direction (tee, elbow, or cross).

b. Loam Soil - One staple every four (4') feet and two (2) staples on each change of direction (tee, elbow, or cross).

c. Clay Soil - One staple every five (5') feet and two (2) staples on each change of direction (tee, elbow, or cross).

3. Cap or plug all openings as soon as lines have been installed to prevent the intrusion of materials that would obstruct the pipe. Leave in place until removal is necessary for completion of installation.

4. Thoroughly flush all water lines before installing valves and other hydrants.

3.12 ADJUSTMENT AND COVERAGE TEST

A. Adjustment:

1. The Contractor shall flush and adjust all sprinkler heads, valves and all other equipment to ascertain that they function according to the manufacturer's data.

2. Adjust all sprinkler heads not to overspray onto walks, roadways and buildings when under maximum operating pressure and during times of normal prevailing winds.

B. Coverage test:

1. The Contractor shall perform the coverage test in the presence of the Owner's Representative after all sprinkler heads have been installed, flushed and adjusted. Each section is tested to demonstrate uniform and adequate coverage of the planting areas serviced.

2. Any systems that require adjustments for full and even coverage shall be done by the Contractor prior to final acceptance at the direction of the Owner's Representative at no additional cost. Adjustments may also include realignment of pipes, addition of extra heads, and changes in nozzle type or size.

3. The Contractor at no additional cost shall immediately correct all unauthorized changes or improper installation practices.

4. The entire irrigation system shall be operating properly with written approval of the installation by the Owner's representative prior to beginning any planting operations.

3.13 REPAIR OF PLANTING SOIL

A. Any areas of planting soil including imported or existing soils or modified planting soil which become compacted or disturbed or degraded as a result of the installation of the irrigation system shall be restored to the specified quality and compaction prior to beginning planting operations at no additional expense to the Owner. Restoration methods and depth of compaction remediation shall be approved by the Owner's Representative.

3.14 CLEAN-UP

A. During installation, keep the site free of trash, pavements reasonably clean and work area in an orderly condition at the end of each day. Remove trash and debris in containers from the site no less than once a week.

a. Immediately clean up any spilled or tracked soil, fuel, oil, trash or debris deposited by the Contractor from all surfaces within the project or on public right of ways and neighboring property.

B. Once installation is complete, wash all soil from pavements and other structures.

1. Make all repairs to grades ruts, and damage to the work or other work at the site.

2. Remove and dispose of all excess soil, packaging, and other material brought to the site by the Contractor.

3.15 PROTECTION

A. The Contractor shall protect installed irrigation work from damage due to operations by other Contractors or trespassers.

1. Maintain protection during installation until Acceptance. Treat, repair or replace damaged work immediately. The Owner's Representative shall determine when such treatment, replacement or repair is satisfactory.

3.16 PRE-MAINTENANCE OBSERVATION:

A. Once the entire system shall be completely installed and operational and all planting is installed, the Owner's Representative shall observe the system and prepare a written punch list indicating all items to be corrected and the beginning date of the maintenance period.

B. This is not final acceptance and does not relieve the Contractor from any of the responsibilities in the contract documents.

3.17 GENERAL MAINTENANCE AND THE MAINTENANCE PERIOD

A. General maintenance shall begin immediately after installation of irrigation system. The general maintenance and the maintenance period shall include the following:

1. On a weekly basis the Contractor shall keep the irrigation system in good running order and make observations on the entire system for proper operation and coverage. Repair and cleaning shall be done to keep the system in full operation.

2. Records of all timing changes to control valves from initial installation to time of final acceptance shall be kept and turned over to the Owner's Representative at the time of final acceptance.

3. During the last week of the maintenance period, provide equipment familiarization and instruction on the total operations of the system to the personnel who will assume responsibility for running the irrigation system.

4. At the end of the maintenance period, turn over all operations logs, manuals, instructions, schedules, keys and any other equipment necessary for operation of the irrigation system to the Owner's Representative who will assume responsibility for the operations and maintenance of the irrigation system.

B. The maintenance period for the irrigation system shall coincide with the maintenance period for the Planting. (See specification section "Planting"

3.18 SUBSTANTIAL COMPLETION ACCEPTANCE

A. Upon written notice from the Contractor, the Owners Representative shall review the work and make a determination if the work is substantially complete.

B. The date of substantial completion of the irrigation shall be the date when the Owner's Representative accepts that all work in Planting, Planting Soil, and Irrigation installation sections is complete.

3.19 FINAL ACCEPTANCE / SYSTEM MALFUNCTION CORRECTIONS

A. At the end of the Plant Warrantee and Maintenance period, (See specification section "Planting") the Owner's Representative shall inspect the irrigation work and establish that all provisions of the irrigation system are complete and the system is working correctly.

1. Restore any soil settlement over trenches and other parts of the irrigation system.

2. Replace, repair or reset any malfunctioning parts of the irrigation system.

B. The Contractor shall show all corrections made from punch list. Any items deemed not acceptable shall be reworked and the maintenance period will be extended.

C. The Contractor shall show evidence that the Owner's Representative has received all charts, records, drawings, and extra equipment as required before final acceptance.

D. Failure to pass review: If the work fails to pass final review, any subsequent observations must be rescheduled as per above. The cost to the Owner for additional observations will be charged to the Contractor at the prevailing hourly rate of the reviewer.

END OF SECTION 32 8400

32 9300 Planting

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INSTRUCTIONS TO THE SPECIFICATION WRITER:

The following document is intended as a general specification to guide the writing of a project-specific specification. Each project is unique and it is required that the specification be developed accordingly. DO NOT USE THE FOLLOWING SPECIFICATION WITHOUT MAKING IMPORTANT ADJUSTMENTS to reflect local conditions, regulations, market standards, project schedules and local and regional practices. The following are specific items that need to be addressed.

1. General instructions for using this specification: *These instructions are intended to guide the specification writer (the specifier) through the process of editing this document into a Planting specification. Be sure to delete these instructions (i.e. all the text in red displayed above the paragraph) before issuing the specifications.*

2. General Requirements - Division 01 (Construction Specification Institute) specifications and other contract elements: *This specification is designed to be used in conjunction with standard Division 01 specifications, which cover project general conditions and project-wide contract elements. THIS IS NOT A STAND-ALONE SPECIFICATION and should not be used as a contract for the purchase of and installation of plants. Important issues of project ownership, liability, insurance, contract language, project controls, instructions to bidders, change orders and review and approval of the work are normally in the Division 01 specifications.*

3. The construction team: *A construction project is a team effort where the Owner, in effect, creates a partnership with all the Contractors to build a project. As with any good contract there are protections for all parties; that the Owner will get the quality of project that they desire within the time limits and budget available; and the Contractor will be paid for the work satisfactorily completed. In between the initial bidding and the final completion there will be many places where parts of the construction do not work out as originally intended. This is normal and a good contract should allow for these changes in a manner that is equitable to both the Owner and the Contractor. To get there, a team approach and spirit must prevail. All parties must assume that each is operating in the best interest of the project goals. The clearer the goals and description of the project, the smoother the flow of a successful project.* ***The more each of the team members can trust the other members, the better the project.*** *This should be a critical principle in approaching interpretation of the specification.*

4. Other project documents: *This specification is intended to be used in conjunction with other project documents including the bid forms, the construction contract, Division 1 specifications, other specifications directly related to this section; other specifications that are not directly related to this work and most critically the project construction drawings. It is very critical that all these documents be prepared with consistent terminology and that they be coordinated. The terms used for the parts of trees and other plants, different soil types, drainage features, irrigation features and structures such as paving, walls and planters must be consistent across disciplines. A very common mistake is the use of different terms and details for soil and the extent of soil work. The terms and details for planting soil, subsoil and other materials must be well coordinated.*

5. Related specification sections: *This specification requires an additional specification section to describe several important related parts of the planting process.*

> ***Tree Protection:*** *This specification assumes that there is a separate specification section and construction drawings and details for tree protection; remove this section if there are no existing trees to be protected on the project.*
>
> ***Planting Soil:*** *This specification assumes that there is a separate specification section and construction*

drawings and details for installation of planting soils.

Irrigation: *This specification assumes that there might be a separate specification section for irrigation associated with the project planting.*

6. Reviewing and approval authority: *Each specification identifies a certain entity as responsible for the review and approval of the work, project submittals, changes to the work, and acceptance of the work The entity is normally identified in Division 1. For the purposes of this specification, the term the "Owner's Representative" has been used as a placeholder for this entity. Once the proper term is defined (for example Contracting Officer, The Architect, The Landscape Architect, The Engineer etc); this term should replace the words "Owner's Representative" wherever it appears in this specification.*

7. Header and footer requirements: *Change the header/footer language to meet the project requirements.*

8. Notes to specifiers: *Before issuing the document, be sure to remove all "**Notes to specifiers**" incorporated into this document in red text after you have read them and responded to the recommendations.*

9. Submittals: *Submittals are a critical part of any construction contract. This is where all products and materials are reviewed and approved in advance of the work. Planting soil quality control is in this section. Including very specific requirements for approval of submittals while a good practice assumes that the reviewing authority has the skills needed to make these reviews and interpret the results. A common practice is to make very specific requirements but not have the time or expertise to enforce them. Lack of review of submittals does not automatically transfer quality control to the Contractor. In fact, lack of review or inappropriate review can make the reviewing authority responsible for having accepted the submittal even if it was not acceptable.* ***Do not put into the specification submittal requirements that you do not have the time, resources or knowledge, which you knew or should have known, to enforce.***

10. Specification modifications: *There are locations in this specification where additional information is required to reflect project region or contract conditions. Please insert the requested information.*

11. SPECIAL REQUIREMENTS OF THIS SPECIFICATION:

Plant observations: *The area of plant observations is one of the most critical points in the planting process. Ideally this should take place at the growing nursery prior to digging and or shipping the plant. This is very time consuming but its importance cannot be over stated. This is the only time where meaningful alterations can be made to find and correct many of the most common root quality issues found in nurseries. If you cannot make these observations do not require them. Failure of the Owner or their representative to* make observations where *they are required can result in the Contractor being able to defend the use of poor quality plants. Once a plant is shipped from the nursery, it is very difficult to reject. The defects must be very severe and visible. Often root defects and buried root collars are quite difficult to identify within the root ball package.*

Many plants are purchased from re-wholesale yards. These plants are more difficult to observe than in the field but if observed prior to purchase by the Contractor there is a better chance of rejecting them. Re-wholesale plants may have other problems such as having been held too long without adequate water, and loss of the ability to make corrections in root collar depth in the root ball package.

Root ball package options: *There are many root ball packages available in the industry in certain regions. That is, the methods used to contain the roots and the type of system used to grow or manage the roots of the plant. It is critical that the specifications herein be amended to reflect allowable root ball packages. All projects do not have to accept all types of root ball packages. Since this can have a huge impact on the ultimate success of the plant, careful consideration must be made in selecting the type of packages permitted. Do not leave in references to root ball packages you do not want to use on the project in the specification (i.e. B&B, container, bare root, etc.).*

Warranty: *This specification assumes or implies a 1-year warranty. Modify the warranty to meet the project requirements.*

Maintenance: *This specification includes an option for no maintenance during the warranty period and optional language for maintenance during the warranty period.*

PART 1 – GENERAL

1.1 SUMMARY

Note to specifier: Remove parts of this work description that do not apply. *This specification section is only for the planting and maintenance of trees, shrubs and ground covers. If construction and maintenance of lawn areas are included in the project, the provisions for construction and maintenance of lawns must be covered under a separate specification section.*

A. The scope of work includes all labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of plant (also known as "landscaping") complete as shown on the drawings and as specified herein.

B. The scope of work in this section includes, but is not limited to, the following:

1. Locate, purchase, deliver and install all specified plants.
2. Water all specified plants.
3. Mulch, fertilize, stake, and prune all specified plants.
4. Maintenance of all specified plants until the beginning of the warranty period.
5. Plant warranty.
6. Clean up and disposal of all excess and surplus material.
7. Maintenance of all specified plants during the warranty period.

1.2 CONTRACT DOCUMENTS

A. Shall consist of specifications and general conditions and the construction drawings. The intent of these documents is to include all labor, materials, and services necessary for the proper execution of the work. The documents are to be considered as one. Whatever is called for by any parts shall be as binding as if called for in all parts.

1.3 RELATED DOCUMENTS AND REFERENCES

A. Related Documents:

Note to specifier: *Coordinate this list with the other related specification sections. Add, delete or modify sections as appropriate.*

1. Drawings and general provisions of contract including general and supplementary conditions and Division I specifications apply to work of this section
2. Related Specification Sections
   a. Section - Planting Soil
   b. Section - Irrigation
   c. Section - Lawn
   d. Section - Tree Protection and Plant Protection

B. References: The following specifications and standards of the organizations and documents listed in this paragraph form a part of the specification to the extent required by the references thereto. In the event that the requirements of the following referenced standards and specification conflict with this specification section the requirements of this specification shall prevail. In the event that the requirements of any of the following referenced standards and specifications conflict with each other the more stringent requirement shall prevail or as determined by the Owners Representative.

Note to specifier: *Remove any references that do not apply in the project region.*

1. State of California, Department of Food and Agriculture, Regulations for Nursery Inspections, Rules and Grading.

2. ANSI Z60.1 American Standard for Nursery Stock, most current edition.
3. ANSI A 300 – Standard Practices for Tree, Shrub and other Woody Plant Maintenance, most current edition and parts.
4. Florida Grades and Standards for Nursery Stock, current edition (Florida Department of Agriculture, Tallahassee FL).
5. Interpretation of plant names and descriptions shall reference the following documents. Where the names or plant descriptions disagree between the several documents, the most current document shall prevail.
   a. USDA - The Germplasm Resources Information Network (GRIN) http://www.ars-grin.gov/npgs/searchgrin.html
   b. Manual of Woody Landscape Plants; Michael Dirr; Stipes Publishing, Champaign, Illinois; Most Current Edition.
   c. The New Sunset Western Garden Book, Oxmoor House, most current edition.
6. Pruning practices shall conform to recommendations “Structural Pruning: A Guide For The Green Industry” most current edition; published by Urban Tree Foundation, Visalia, California.
7. Glossary of Arboricultural Terms, International Society of Arboriculture, Champaign IL, most current edition.

1.4 VERIFICATION

A. All scaled dimensions on the drawings are approximate. Before proceeding with any work, the Contractor shall carefully check and verify all dimensions and quantities, and shall immediately inform the Owner’s Representative of any discrepancies between the information on the drawings and the actual conditions, refraining from doing any work in said areas until given approval to do so by the Owner’s Representative.

B. In the case of a discrepancy in the plant quantities between the plan drawings and the plant call outs, list or plant schedule, the number of plants or square footage of the planting bed actually drawn on the plan drawings shall be deemed correct and prevail.

1.5 PERMITS AND REGULATIONS

A. The Contractor shall obtain and pay for all permits related to this section of the work unless previously excluded under provision of the contract or general conditions. The Contractor shall comply with all laws and ordinances bearing on the operation or conduct of the work as drawn and specified. If the Contractor observes that a conflict exists between permit requirements and the work outlined in the contract documents, the Contractor shall promptly notify the Owner’s Representative in writing including a description of any necessary changes and changes to the contract price resulting from changes in the work.

B. Wherever references are made to standards or codes in accordance with which work is to be performed or tested, the edition or revision of the standards and codes current on the effective date of this contract shall apply, unless otherwise expressly set forth.

C. In case of conflict among any referenced standards or codes or between any referenced standards and codes and the specifications, the more restrictive standard shall apply or Owner’s Representative shall determine which shall govern.

1.6 PROTECTION OF WORK, PROPERTY AND PERSON

A. The Contractor shall adequately protect the work, adjacent property, and the public, and shall be responsible for any damages or injury due to his/her actions.

1.7 CHANGES IN THE WORK

A. The Owner’s Representative may order changes in the work, and the contract sum should be adjusted accordingly. All such orders and adjustments plus claims by the Contractor for extra compensation must be made and approved in writing before executing the work involved.

B. All changes in the work, notifications and contractor's request for information (RFI) shall conform to the contract general condition requirements.

1.8 CORRECTION OF WORK

A. The Contractor, at their own cost, shall re-execute any work that fails to conform to the requirements of the contract and shall remedy defects due to faulty materials or workmanship upon written notice from the Owner's Representative, at the soonest as possible time that can be coordinated with other work and seasonal weather demands**.**

1.9 DEFINITIONS

Note to specifier: *Delete any words below that are not used in the final specification.*

All terms in this specification shall be as defined in the "Glossary of Arboricultural Terms" or as modified below.

A. Boxed trees: A container root ball package made of wood in the shape of a four-sided box.

B. Container plant: Plants that are grown in and/or are currently in a container including boxed trees.

C. Defective plant: Any plant that fails to meet the plant quality requirement of this specification.

D. End of Warranty Final Acceptance: The date when the Owner's Representative accepts that the plants and work in this section meet all the requirements of the warranty. It is intended that the materials and workmanship warranty for Planting, Planting Soil, and Irrigation work run concurrent with each other.

E. Field grown trees (B&B): Trees growing in field soil for at least 12 months prior to harvest.

F. Healthy: Plants that are growing in a condition that expresses leaf size, crown density, color; and with annual growth rates typical of the species and cultivar's horticultural description, adjusted for the planting site soil, drainage and weather conditions.

G. Kinked root: A root within the root package that bends more than 90 degrees.

H. Maintenance: Actions that preserve the health of plants after installation and as defined in this specification.

I. Maintenance period: The time period, as defined in this specification, which the Contractor is to provide maintenance.

J. Normal: the prevailing protocol of industry standard(s).

K. Owner's Representative: The person appointed by the Owner to represent their interest in the review and approval of the work and to serve as the contracting authority with the Contractor. The Owner's Representative may appoint other persons to review and approve any aspects of the work.

L. Reasonable and reasonably: When used in this specification relative to plant quality, it is intended to mean that the conditions cited will not affect the establishment or long term stability, health or growth of the plant. This specification recognizes that it is not possible to produce plants free of all defects, but that some accepted industry protocols and standards result in plants unacceptable to this project.

When reasonable or reasonably is used in relation to other issues such as weeds, diseased, insects, it shall mean at levels low enough that no treatment would be required when applying recognized Integrated Plant Management practices.

This specification recognizes that some decisions cannot be totally based on measured findings and that professional judgment is required. In cases of differing opinion, the Owner's Representative's expert shall determine when conditions are judged as reasonable.

M. Root ball: The mass of roots including any soil or substrate that is shipped with the tree within the root ball package.

N. Root ball package. The material that surrounds the root ball during shipping. The root package may include the material in which the plant was grown, or new packaging placed around the root ball for

shipping.

O. Root collar (root crown, root flare, trunk flare, flare): The region at the base of the trunk where the majority of the structural roots join the plant stem, usually at or near ground level.

P. Shrub: Woody plants with mature height approximately less than 15 feet.

Q. Spade harvested and transplanted: Field grown trees that are mechanically harvested and immediately transplanted to the final growing site without being removed from the digging machine.

R. Stem: The trunk of the tree.

S. Substantial Completion Acceptance: The date at the end of the Planting, Planting Soil, and Irrigation installation where the Owner's Representative accepts that all work in these sections is complete and the Warranty period has begun. This date may be different than the date of substantial completion for the other sections of the project.

T. Stem girdling root: Any root more than ¼ inch diameter currently touching the trunk, or with the potential to touch the trunk, above the root collar approximately tangent to the trunk circumference or circling the trunk. Roots shall be considered as Stem Girdling that have, or are likely to have in the future, root to trunk bark contact.
Note to specifier regarding the Stem Girdling Root specification: *1/4 inch min. root diameter is in debate. Check most recent opinions from trusted researchers and practitioners. Insert the diameter standard that may be attainable from regional or selected growers.*

U. Structural root: One of the largest roots emerging from the root collar.

V. Tree: Single and multi-stemmed plants with mature height approximately greater than 15 feet.

1.10 SUBMITTALS

A. See contract general conditions for policy and procedure related to submittals.

B. Submit all product submittals 8 weeks prior to installation of plantings.

Note to specifier**:** *Confirm submittal time above is appropriate for project schedule.*

C. Product data: Submit manufacturer product data and literature describing all products required by this section to the Owner's Representative for approval. Provide submittal eight weeks before the installation of plants.

D. Plant growers' certificates: Submit plant growers' certificates for all plants indicating that each meets the requirements of the specification, including the requirements of tree quality, to the Owner's Representative for approval. Provide submittal eight weeks before the installation of plants.

E. Samples: Submit samples of each product and material where required by the specification to the Owner's Representative for approval. Label samples to indicate product, characteristics, and locations in the work. Samples will be reviewed for appearance only. Compliance with all other requirements is the exclusive responsibility of the Contractor.

F. Plant sources: Submit sources of all plants as required by Article – "Selection of Plants" to the Owner's Representative for approval.

G. Close out submittals: Submit to the Owner's Representative for approval.

1. Plant maintenance data and requirements.

H. Warranty period site visit record: If there is no maintenance during the warranty period, after each site visit during the warranty period, by the Contractor, as required by this specification, submit a written record of the visit, including any problems, potential problems, and any recommended corrective action to the Owner's Representative for approval.

Note to specifier: *The paragraph above is only required if maintenance during the warranty period is not required.*

I. Installation plan submitted a minimum of 14 days prior to the scheduled installation. Plan should describe the methods, activities, materials and schedule to achieve installation of plants.

Note to specifier: *The paragraph above is only required if a contractor submitted Plant Installation Plan is required.*

1.11 OBSERVATION OF THE WORK

A. The Owner's Representative may observe the work at any time. They may remove samples of materials for conformity to specifications. Rejected materials shall be immediately removed from the site and replaced at the Contractor's expense. The cost of testing materials not meeting specifications shall be paid by the Contractor.

B. The Owner's Representative shall be informed of the progress of the work so the work may be observed at the following key times in the construction process. The Owner's Representative shall be afforded sufficient time to schedule visit to the site. Failure of the Owner's Representative to make field observations shall not relieve the Contractor from meeting all the requirements of this specification.

1. SITE CONDITIONS PRIOR TO THE START OF PLANTING: review the soil and drainage conditions.
2. COMPLETION OF THE PLANT LAYOUT STAKING: Review of the plant layout.
3. PLANT QUALITY: Review of plant quality at the time of delivery and prior to installation. Review tree quality prior to unloading where possible, but in all cases prior to planting.
4. COMPLETION OF THE PLANTING: Review the completed planting.

1.12 PRE-CONSTRUCTION CONFERENCE

A. Schedule a pre-construction meeting with the Owner's Representative at least seven (7) days before beginning work to review any questions the Contractor may have regarding the work, administrative procedures during construction and project work schedule.

Note to specifier: *Confirm time frame above is appropriate for project schedule.*

1.13 QUALITY ASSURANCE

A. Substantial Completion Acceptance - Acceptance of the work prior to the start of the warranty period:

1. Once the Contractor completes the installation of all items in this section, the Owner's Representative will observe all work for Substantial Completion Acceptance upon written request of the Contractor. The request shall be received at least ten calendar days before the anticipated date of the observation.
2. Substantial Completion Acceptance by the Owner's Representative shall be for general conformance to specified size, character and quality and not relieve the Contractor of responsibility for full conformance to the contract documents, including correct species.
3. Any plants that are deemed defective as defined under the provisions below shall not be accepted.

B. The Owner's Representative will provide the Contractor with written acknowledgment of the date of Substantial Completion Acceptance and the beginning of the warranty period and plant maintenance period (if plant maintenance is included).

C. Contractor's Quality Assurance Responsibilities: The Contractor is solely responsible for quality control of the work.

D. Installer Qualifications: The installer shall be a firm having at least 5 years of successful experience of a scope similar to that required for the work, including the handling and planting of large specimen trees in urban areas. The same firm shall install planting soil (where applicable) and plant material.

1. The bidders list for work under this section shall be approved by the Owner's Representative.
2. Installer Field Supervision: When any planting work is in progress, installer shall maintain, on site, a full-time supervisor who can communicate in English with the Owner's Representative.
3. Installer's field supervisor shall have a minimum of five years experience as a field supervisor installing plants and trees of the quality and scale of the proposed project, and can communicate in English with the Owner's Representative.
4. The installer's crew shall have a minimum of 3 years experienced in the installation of Planting Soil, Plantings, and Irrigation (where applicable) and interpretation of soil plans, planting plans and irrigation plans.
5. Submit references of past projects, employee training certifications that support that the Contractors meets all of the above installer qualifications and applicable licensures.

1.14 PLANT WARRANTY

A. Plant Warranty:

1. The Contractor agrees to replace defective work and defective plants. The Owner's Representative shall make the final determination if plants meet these specifications or that plants are defective.

   Plants warranty shall begin on the date of Substantial Completion Acceptance and continue for the following periods, classed by plant type:

   Note to specifier: *Modify below to state the number of years of the warranty.*
   a. Trees – XX Year(s).
   b. Shrubs – XX Year(s).
   c. Ground cover and perennial flower plants – XX Year(s).
   d. Bulbs, annual flower and seasonal color plants – for the period of expected bloom or primary display.
2. When the work is accepted in parts, the warranty periods shall extend from each of the partial Substantial Completion Acceptances to the terminal date of the last warranty period. Thus, all warranty periods for each class of plant warranty, shall terminate at one time.
3. All plants shall be warrantied to meet all the requirements for plant quality at installation in this specification. Defective plants shall be defined as plants not meeting these requirements. The Owner's representative shall make the final determination that plants are defective.
4. Plants determined to be defective shall be removed immediately upon notification by the Owner's Representative and replaced without cost to the Owner, as soon as weather conditions permit and within the specified planting period.
5. Any work required by this specification or the Owner's Representative during the progress of the work, to correct plant defects including the removal of roots or branches, or planting plants that have been bare rooted during installation to observe for or correct root defects shall not be considered as grounds to void any conditions of the warranty. In the event that the Contractor decides that such remediation work may compromise the future health of the plant, the plant or plants in question shall be rejected and replaced with plants that do not contain defects that require remediation or correction.
6. The Contractor is exempt from replacing plants, after Substantial Completion Acceptance and during the warranty period, that are removed by others, lost or damaged due to occupancy of project, lost or damaged by a third party, vandalism, or any natural disaster.
7. Replacements shall closely match adjacent specimens of the same species. Replacements shall be subject to all requirements stated in this specification. Make all necessary repairs due to plant replacements. Such repairs shall be done at no extra cost to the Owner.
8. The warranty of all replacement plants shall extend for an additional one-year period from the

date of their acceptance after replacement. In the event that a replacement plant is not acceptable during or at the end of the said extended warranty period, the Owner's Representative may elect one more replacement items or credit for each item. These tertiary replacement items are not protected under a warranty period.

9. During and by the end of the warranty period, remove all tree wrap, ties, and guying unless agreed to by the Owner's Representative to remain in place. All trees that do not have sufficient caliper to remain upright, or those requiring additional anchorage in windy locations, shall be staked or remain staked, if required by the Owner's Representative.

B. End of Warranty Final Acceptance - Acceptance of plants at the end of the warranty period.

1. At the end of the warranty period, the Owner's Representative shall observe all warranted work, upon written request of the Contractor. The request shall be received at least ten calendar days before the anticipated date for final observation.

2. End of Warranty Final Acceptance will be given only when all the requirements of the work under this specification and in specification sections Planting Soil and Irrigation have been met.

1.15 SELECTION AND OBSERVATION OF PLANTS

A. The Owner's Representative may review all plants subject to approval of size, health, quality, character, etc. Review or approval of any plant during the process of selection, delivery, installation and establishment period shall not prevent that plant from later rejection in the event that the plant quality changes or previously existing defects become apparent that were not observed.

B. Plant Selection: The Owner's Representative reserves the right to select and observe all plants at the nursery prior to delivery and to reject plants that do not meet specifications as set forth in this specification. If a particular defect or substandard element can be corrected at the nursery, as determined by the Owner's Representative, the agreed upon remedy may be applied by the nursery or the Contractor provided that the correction allows the plant to meet the requirements set forth in this specification. Any work to correct plant defects shall be at the contractor's expense.
1. The Owner's Representative may make invasive observation of the plant's root system in the area of the root collar and the top of the root ball in general in order to determine that the plant meets the quality requirements for depth of the root collar and presence of roots above the root collar. Such observations will not harm the plant.
2. Corrections are to be undertaken at the nursery prior to shipping.

C. The Contractor shall bear all cost related to plant corrections.

D. All plants that are rejected shall be immediately removed from the site and acceptable replacement plants provided at no cost to the Owner.

E. Submit to the Owner's Representative, for approval, plant sources including the names and locations of nurseries proposed as sources of acceptable plants, and a list of the plants they will provide. The plant list shall include the botanical and common name and the size at the time of selection. Observe all nursery materials to determine that the materials meet the requirements of this section.

1. The following nurseries are pre-approved to supply plants for this project:
XXXXXX

Note to specifier: *Insert pre-approved growers. If pre-approved growers are not to be required, eliminate the above paragraph. If specific nurseries are going to be REQUIRED for specific plants this is the place to insert that language.*

F. Trees shall be purchased from the growing nursery. Re-wholesale plant suppliers shall not be used as sources unless the Contractor can certify that the required trees are not directly available from a growing nursery. When Re-wholesale suppliers are utilized, the Contractor shall submit the name and location of the growing nursery from where the trees were obtained by the re-wholesale seller. The re-wholesale nursery shall be responsible for any required plant quality certifications.

G. The Contractor shall require the grower or re-wholesale supplier to permit the Owner's Representative to observe the root system of all plants at the nursery or job site prior to planting including random removal of soil or substrate around the base of the plant. Observation may be as frequent and as extensive as needed to verify that the plants meet the requirements of the specifications and conform to requirements.

H. Each tree shall have a numbered seal applied by the Contractor. The seal shall be placed on a lateral branch on the north side of the tree. The seal shall be a tamper proof plastic seal bearing the Contractors name and a unique seven-digit number embossed on the seal.
   1. Do not place seals on branches that are so large that there is not sufficient room for the branch growth over the period of the warranty.

I. The Owner's Representative may choose to attach their seal to each plant, or a representative sample. Viewing and/or sealing of plants by the Owner's Representative at the nursery does not preclude the Owner's Representative's right to reject material while on site. The Contractor is responsible for paying any up charge for the Owner's Representative to attach their seal to specific plants.

J. Where requested by the Owner's Representative, submit photographs of plants or representative samples of plants. Photographs shall be legible and clearly depict the plant specimen. Each submitted image shall contain a height reference, such as a measuring stick. The approval of plants by the Owner's Representative via photograph does not preclude the Owner's Representative's right to reject material while on site.

1.16 PLANT SUBSTITUTIONS FOR PLANTS NOT AVAILABLE

A. Submit all requests for substitutions of plant species, or size to the Owner's Representative, for approval, prior to purchasing the proposed substitution. Request for substitution shall be accompanied with a list of nurseries contacted in the search for the required plant and a record of other attempts to locate the required material. Requests shall also include sources of plants found that may be of a smaller or larger size, or a different shape or habit than specified, or plants of the same genus and species but different cultivar origin, or which may otherwise not meet the requirements of the specifications, but which may be available for substitution.

1.17 SITE CONDITIONS

A. It is the responsibility of the Contractor to be aware of all surface and sub-surface conditions, and to notify the Owner's Representative, in writing, of any circumstances that would negatively impact the health of plantings. Do not proceed with work until unsatisfactory conditions have been corrected.

   1. Should subsurface drainage or soil conditions be encountered which would be detrimental to growth or survival of plant material, the Contractor shall notify the Owner's Representative in writing, stating the conditions and submit a proposal covering cost of corrections. If the Contractor fails to notify the Owner's Representative of such conditions, he/she shall remain responsible for plant material under the warranty clause of the specifications.

B. It is the responsibility of the Contractor to be familiar with the local growing conditions, and if any specified plants will be in conflict with these conditions. Report any potential conflicts, in writing, to the Owner's Representative.

C. This specification requires that all Planting Soil and Irrigation (if applicable) work be completed and accepted prior to the installation of any plants.

   1. Planting operations shall not begin until such time that the irrigation system is completely operational for the area(s) to be planted, and the irrigation system for that area has been preliminarily observed and approved by the Owner's Representative.

D. Actual planting shall be performed during those periods when weather and soil conditions are suitable in accordance with locally accepted horticultural practices.

1. Do not install plants into saturated or frozen soils. Do not install plants during inclement weather, such as rain or snow or during extremely hot, cold or windy conditions.

1.18 PLANTING AROUND UTILITIES

A. Contractor shall carefully examine the civil, record, and survey drawings to become familiar with the existing underground conditions before digging.

B. Determine location of underground utilities and perform work in a manner that will avoid possible damage. Hand excavate, as required. Maintain grade stakes set by others until parties concerned mutually agree upon removal.

C. Notification of *Local Utility Locator Service*, *Insert PHONE NUMBER*, is required for all planting areas: The Contractor is responsible for knowing the location and avoiding utilities that are not covered by the *Local Utility Locator Service*.

Note to specifier: *Insert the telephone number and correct name of the Local Utility Locator Service if available.*

PART 2 – PRODUCTS

2.1 PLANTS: GENERAL

A. Standards and measurement: Provide plants of quantity, size, genus, species, and variety or cultivars as shown and scheduled in contract documents.

1. All plants including the root ball dimensions or container size to trunk caliper ratio shall conform to ANSI Z60.1 “American Standard for Nursery Stock” latest edition, unless modified by provisions in this specification. When there is a conflict between this specification and ANSI Z60.1, this specification section shall be considered correct.

2. Plants larger than specified may be used if acceptable to the Owner’s Representative. Use of such plants shall not increase the contract price. If larger plants are accepted the root ball size shall be in accordance with ANSI Z-60.1. Larger plants may not be acceptable if the resulting root ball cannot be fit into the required planting space.

3. If a range of size is given, no plant shall be less than the minimum size and not less than 50 percent of the plants shall be as large as the maximum size specified. The measurements specified are the minimum and maximum size acceptable and are the measurements after pruning, where pruning is required.

B. Proper Identification: All trees shall be true to name as ordered or shown on planting plans and shall be labeled individually or in groups by genus, species, variety and cultivar.

C. Compliance: All trees shall comply with federal and state laws and regulations requiring observation for plant disease, pests, and weeds. Observation certificates required by law shall accompany each shipment of plants.

1. Clearance from the local county agricultural commissioner, if required, shall be obtained before planting trees originating outside the county in which they are to be planted.
Note to specifier: *Confirm that the above sentence is applicable to the region of the project.*

D. Plant Quality:
Note to specifier: *The following paragraphs are necessary to assure that quality plant material is installed. With a few exceptions such as the Florida Grades and Standards for Nursery Plants and the Guideline Specifications for Nursery Tree Quality, current nursery standards for root systems do not exist. It is critical that the purchaser of plants have sufficient resources to enforce these quality standards through* observation*s and well-conceived plans, details, specifications, and contracts.*

1. **General**: Provide healthy stock, grown in a nursery and reasonably free of die-back, disease, insects, eggs, bores, and larvae. At the time of planting all plants shall have a root system, stem, and branch form that will not restrict normal growth, stability and health for the expected life of the plant

2. **Plant quality above the soil line:** ***Note to specifier:*** *Determining acceptability of crown quality is subjective. These specifications are designed to have the Crown Acceptance details included with the other planting details. An alternative is to use the Florida Grades and Standards for Nursery Plants and specify tree grades as either Florida #1 or Florida Fancy Grades. If the project does not want to use the Florida Grades and Standards or does not include the Crown Acceptance details on the drawings delete these references in the following paragraph*.

   a. Plants shall be healthy with the color, shape, size and distribution of trunk, stems, branches, buds and leaves normal to the plant type specified. Tree quality above the soil line shall comply with the project Crown Acceptance details (or Florida Grades and Standards, tree grade Florida Fancy or Florida #1) and the following:
      1.) Crown: The form and density of the crown shall be typical for a young specimen of the species or cultivar pruned to a central and dominant leader.
         a.) Crown specifications do not apply to plants that have been specifically trained in the nursery as topiary, espalier, multi-stem, clump, or unique selections such as contorted or weeping cultivars.
      2.) Leaves: The size, color, and appearance of leaves shall be typical for the time of year and stage of growth of the species or cultivar. Trees shall not show signs of prolonged moisture stress or over watering as indicated by wilted, shriveled, or dead leaves.
      3.) Branches: Shoot growth (length and diameter) throughout the crown should be appropriate for the age and size of the species or cultivar. Trees shall not have dead, diseased, broken, distorted, or otherwise injured branches.
         a.) Main branches shall be distributed along the central leader not clustered together. They shall form a balanced crown appropriate for the cultivar/species.
         b.) Branch diameter shall be no larger than two-thirds (one-half is preferred) the diameter of the central leader measured 1 inch above the branch union.
         c.) The attachment of the largest branches (scaffold branches) shall be free of included bark.
      4.) Trunk: The tree trunk shall be relatively straight, vertical, and free of wounds that penetrate to the wood (properly made pruning cuts, closed or not, are acceptable and are not considered wounds), sunburned areas, conks (fungal fruiting bodies), wood cracks, sap leakage, signs of boring insects, galls, cankers, girdling ties, or lesions (mechanical injury).
      5.) Temporary branches, unless otherwise specified, can be present along the lower trunk below the lowest main (scaffold) branch, particularly for trees less than 1 inch in caliper. These branches should be no greater than 3/8-inch diameter. Clear trunk should be no more than 40% of the total height of the tree.
         Note to specifier*: Delete the last sentence above if more clearance is needed.*

   b. Trees shall have one central leader. If the leader was headed, a new leader (with a live terminal bud) at least one-half the diameter of the pruning cut shall be present.
      1.) All trees are assumed to have one central leader trees unless a different form is specified in the plant list or drawings.
   c. All graft unions, where applicable, shall be completely closed without visible sign of graft rejection. All grafts shall be visible above the soil line.
   d. Trunk caliper and taper shall be sufficient so that the lower five feet of the trunk remains vertical without a stake. Auxiliary stake may be used to maintain a straight leader in the upper half of the tree.

3. **Plant quality at or below the soil line:**
   a. Plant roots shall be normal to the plant type specified. Root observations shall take place without impacting tree health. Root quality at or below the soil line shall comply with the project Root Acceptance details and the following:

      1.) The roots shall be reasonably free of scrapes, broken or split wood.
      2.) The root system shall be reasonably free of injury from biotic (e.g., insects and

pathogens) and abiotic (e.g., herbicide toxicity and salt injury) agents. Wounds resulting from root pruning used to produce a high quality root system are not considered injuries.

3.) A minimum of three structural roots reasonably distributed around the trunk (not clustered on one side) shall be found in each plant. Root distribution shall be uniform throughout the root ball, and growth shall be appropriate for the species.
    a.) Plants with structural roots on only one side of the trunk (J roots) shall be rejected.

4.) The root collar shall be within the upper 2 inches of the substrate/soil. Two structural roots shall reach the side of the root ball near the top surface of the root ball. The grower may request a modification to this requirement for species with roots that rapidly descend, provided that the grower removes all stem girdling roots above the structural roots across the top of the root ball.

5.) The root system shall be reasonably free of stem girdling roots over the root collar or kinked roots from nursery production practices.
    a.) Plant Grower Certification: The final plant grower shall be responsible to have determined that the plants have been root pruned at each step in the plant production process to remove stem girdling roots and kinked roots, or that the previous production system used practices that produce a root system throughout the root ball that meets these specifications. Regardless of the work of previous growers, the plant's root system shall be modified at the final production stage, if needed, to produce the required plant root quality. The final grower shall certify in writing that all plants are reasonably free of stem girdling and kinked roots as defined in this specification, and that the tree has been grown and harvested to produce a plant that meets these specifications.

Note to specifier: *The above certification requirement is not an industry standard and will require that the project team is willing to enforce the process.*

6.) At time of observations and delivery, the root ball shall be moist throughout. Roots shall not show signs of excess soil moisture conditions as indicated by stunted, discolored, distorted, or dead roots.

E. Submittals: Submit for approval the required plant quality certifications from the grower where plants are to be purchased, for each plant type. The certification must state that each plant meets all the above plant quality requirements.
    1. The grower's certification of plant quality does not prohibit the Owner's Representative from observing any plant or rejecting the plant if it is found to not meet the specification requirements.

2.2 ROOT BALL PACKAGE OPTIONS: The following root ball packages are permitted. Specific root ball packages shall be required where indicated on the plant list or in this specification. Any type of root ball packages that is not specifically defined in this specification shall not be permitted.

Note to specifier: *It is critical to* ***remove*** *any of the following root ball package descriptions and requirement paragraphs that are not to be permitted for the project. Assure that the plants and root ball packages specified are available from regional growers as not all plant types are available in all root ball package types. Consider specifying preapproved growers to obtain higher quality root ball package types and overall tree quality.*

Each of these final root ball package types has advantages and disadvantages. Not all root ball package types are available in every market region and for every tree species. Some species may only be available in a few root ball package types. To complicate the decision of which to specify, trees may be grown in more than one type of root ball system during the production phase and normally the final grower may have purchased seedlings or liners from another nursery. The methods used at the different stages in the nursery production process can affect the root system of a plant, leaving root problems and difficult root architecture that the plant may struggle with for many years after planting. These root system problems may cause premature decline and even kill the tree well after the end of the warranty period.

The quality control and root ball package type in the initial production nursery may not be known or

apparent to the final grower. It can be quite difficult for the purchaser to determine the quality of the trees root system. The current American Nursery and Landscape Association (ANLA) "American Standards for Nursery Stock (ANSI Z60.1)" does not adequately address these issues, set acceptable standards for root architecture, or offer solutions to the problems. It is up to the purchaser to set their own quality standards, recommend solutions, and to enforce those standards with appropriate observations. Simply stating "Trees shall meet the ANSI Z60.1 standard" does NOT address nor guarantee quality.

It is NEVER REQUIRED for any specification to accept all products available from an industry or to use the ANLA "American Standards for Nursery Stock" as the only requirement that a grower must comply with. The specifier has a choice of what to accept as long as they can verify that the products that meet the specification are available. Until significant changes are made in the nursery industry, it may be difficult, in many regions and for many species, to specify large numbers of trees with an optimum root system. Check your local suppliers to specify the best quality root ball package prior to making specification edits in this section.

It is critical that the specifications be amended to reflect the root ball packages that will be allowable on the project. Since this has a huge impact on the ultimate success of the tree, careful consideration must be made in selecting the type of packages permitted. It is not required that a project accept all types of root ball packages. Some root ball package types can be strictly prohibited in the specification.
Do not leave references to any of the root ball packages you do not want to permit for the project in the specification. Remove the paragraphs related to both the package option descriptions in Part 2 and the special planting requirements in Part 3 of all root ball packages that will not be permitted.

A. BALLED AND BURLAPPED PLANTS

Note to specifier: *Remove this paragraph if Balled and Burlapped plants are not to be permitted.*

1. All Balled and Burlapped Plants shall be field grown, and the root ball packaged in a burlap and twine and/or burlap and wire basket package.
2. Plants shall be harvested with the following modifications to standard nursery practices.
    a. Prior to digging any tree that fails to meet the requirement for maximum soil and roots above the root collar, carefully removed the soil from the top of the root ball of each plant, using hand tools, water or an air spade, to locate the root collar and attain the soil depth over the structural roots requirements. Remove all stem girdling roots above the root collar. Care must be exercised not to damage the surface of the root collar and the top of the structural roots.

    Note to specifier: *Modify paragraph below to reflect climatic differences.*

    b. Trees shall be dug for a minimum of 4 weeks and a maximum of 52 weeks prior to shipping. Trees dug 4 to 52 weeks prior to shipping are defined as hardened-off. Digging is defined as cutting all roots and lifting the tree out of the ground and either moving it to a new location in the nursery or placing it back into the same hole. Tress that are stored out of the ground shall be placed in a holding area protected from extremes of wind and sun with the root ball protected by covering with mulch or straw and irrigated sufficiently to keep moisture in the root ball above wilt point and below saturation
    c. If wire baskets are used to support the root ball, a "low profile" basket shall be used. A low profile basket is defined as having the top of the highest loops on the basket no less than 4 inches and no greater than 8 inches below the shoulder of the root ball package.
        1.) At nurseries where sandy soils prevent the use of "low profile baskets", baskets that support the entire root ball, including the top, are allowable.

    Note to specifier: *Where removal of all or a portion of the wire basket is desirable, insert language to that effect in the above paragraph.*

    d. Twine and burlap used for wrapping the root ball package shall be natural, biodegradable material. If the burlap decomposes after digging the tree then the root ball shall be re-wrapped prior to shipping if roots have not yet grown to keep root ball intact during shipping.

3. The following tree species when harvested at a size greater than X inches in caliper shall be root-pruned a minimum of XX months before digging in the nursery. All root pruning and hardening off procedures shall be accomplished utilizing accepted horticultural practices.

   Note to specifier: *Remove the paragraph above if root pruning is not required. Add the minimum caliper size and time needed for root pruning and/or hardening off. Add required species as considered by local knowledge as benefitting from hardening off and/or root pruning.*

B. SPADE HARVESTED AND TRANSPLANTED

Note to specifier: *Remove the paragraph below if Spade Harvested and Transplanted plants are not to be permitted.*

1. Spade Harvested and Transplanted Plants shall meet all the requirements for field grown trees. Root ball diameters shall be of similar size as the ANSI Z60.1 requirements for Balled and Burlapped plants.
2. Trees shall be harvested prior to leafing out (bud break) in the spring or during the fall planting period except for plants know to be considered as fall planting hazards. Plants that are fall planting hazards shall only be harvested prior to leafing out in the spring.
3. Trees shall be moved and planted within 48 hours of the initial harvesting and shall remain in the spade machine until planted.

C. CONTAINER (INCLUDING ABOVE-GROUND FABRIC CONTAINERS AND BOXES) PLANTS

Note to specifier: *Remove the paragraph below if Container plants are not to be permitted.*

1. Container plants may be permitted only when indicated on the drawing, in this specification, or approved by the Owner's Representative.
2. Provide plants shall be established and well rooted in removable containers.
3. Container class size shall conform to ANSI Z60.1 for container plants for each size and type of plant.

D. BARE ROOT PLANTS

Note to specifier: *Remove the paragraph below if Bare Root plants are not to be permitted.*

1. Harvest bare root plants while the plant is dormant and a minimum of 4 weeks prior to leaf out (bud break).
2. The root spread dimensions of the harvested plants shall conform to ANSI Z60.1 for nursery grown bare root plants for each size and type of plant. Just prior to shipping to the job site, dip the root system into a slurry of hydrogel (cross linked polyacrylamide) and water mixed at a rate of 15 oz. of hydrogel in 25 gallons of water. Do not shake off the excess hydrogel. Place the root system in a pleated black plastic bag and tie the bag snugly around the trunk. Bundle and tie the upper branches together.
3. Keep the trees in a cool dark space for storage and delivery. If daytime outside temperatures exceeds 70 degrees F, utilize a refrigerated storage area with temperature between 35 and 50 degrees.
4. Where possible, plan time of planting to be before bud break. For trees to be planted after bud break, place the trees before bud break in an irrigated bed of pea gravel.
   a. The pea gravel bed shall be 18 inches deep over a sheet of plastic.
   b. Space trees to allow the unbundled branches to grow without shading each other.
   c. Once stored in pea gravel, allow the trees sufficient time for the new root system to flush and spring growth of leaves to fully develop before planting.
   d. Pea gravel stored trees may be kept for up to one growing season.
   e. Pea gravel stored trees shall be dipped, packaged and shipped similar to the requirements for freshly dug bare root trees above.

E. IN-GROUND FABRIC BAG-GROWN

Note to specifier: *Remove this paragraph if trees grown in In-ground fabric containers are not to be permitted.*

1. In-ground fabric container plants may be permitted only when indicated on the drawing, in this specification, or approved by the Owner's Representative.
2. Provide plants established and well rooted.

2.3 ANNUAL FLOWERING AND SEASONAL COLOR PLANTS

Note to specifier: *Annual and Seasonal color plants may require project specific requirements. Add special plant requirements here as needed.*

A. Container or flat-grown plants should be sized as noted in the planting plan. Plants shall be well-rooted and healthy.

2.4 PALMS

Note to specifier: *If palms are included in this planting add any special requirements for this classification of plant here. The following is a general product specification. If Palms are not to be included, delete this section.*

A. Except as modified below or where the requirements are not appropriate to the specification of palms, palms shall meet all the requirements of the plant quality section above.

B. Defronding, tying, and hedging:
   1. In preparing palm trees for relocation, all dead fronds shall be removed.
   2. All remaining fronds above horizontal shall be lifted up and tied together around the crown in an upright position. Up to 2/3 of the oldest live fronds can be removed; all fronds can be removed on Sabal palms. Do not tie too tightly, bind or injure the bud. Jute binder twine shall be used in tying up the fronds; wire will not be permitted. Fronds shall be untied immediately after planting.

C. Digging the root ball:
   1. When digging out the root ball, no evacuation shall be done closer than XX Inches to the trunk at ground level and the excavation shall extend below the major root system to a minimum depth of 3.5 feet. The bottom of the root ball shall be cut off square and perpendicular to the trunk below the major root system.

D. The Contractor shall not free-fall, drag, roll or abuse the tree or put a strain on the crown (bud area) at any time. A protective device shall be used around the trunk of the tree while lifting and relocating so as not to injure the bud, or scar or skin the trunk in any way.

2.5 PLANTING SOIL

Note to specifier: *It is critical to this planting specification that a separate specification section Planting Soil be included. If no such section is included the specifier MUST add in any needed soil requirements to the Planting specification; however, this alternative is NOT recommended.*

A. Planting Soil as used in this specification means the soil at the planting site, or imported as modified and defined in specification Section Planting Soil. If there is no Planting Soil specification, the term Planting Soil shall mean the soil at the planting site within the planting hole.

2.6 MULCH

Note to specifier: *Revise this paragraph to reflect regionally available mulch materials or project specific mulch quality or type requirements where appropriate. The coarse grade mulch specified here is considered superior for its water retention and soil building properties in areas of tree and shrub roots when irrigation is drip, bubblers or flood methods. The term "Walk on Mulch" is a California regional term. Use regional terminology.*

Add additional requirements as needed to more tightly define tree species source, % bark if desired

and size.

A. Mulch shall be "Walk on" grade, coarse, ground, from tree and woody brush sources. The size range shall be a minimum (less than 25% or less of volume) fine particles 3/8 inch or less in size, and a maximum size of individual pieces (largest 20% or less of volume) shall be approximately 1 to 1-1/2 inch in diameter and maximum length approximately 4 to 8". Pieces larger than 8 inch long that are visible on the surface of the mulch after installation shall be removed.

1. It is understood that mulch quality will vary significantly from supplier to supplier and region to region. The above requirements may be modified to conform to the source material from locally reliable suppliers as approved by the Owner's Representative.

B. Submit supplier's product specification data sheet and a one gallon sample for approval.

2.7 TREE STAKING AND GUYING MATERIAL

***Note to specifier**: Do not leave references to any of the staking and guying types you do not want to permit for the project in the specification. Remove the paragraphs below of the types that will not be permitted. Add specifications for other types of staking and guying.*

A. Tree guying to be flat woven polypropylene material, 3/4 inch wide, and 900 lb. break strength. Color to be Green. Product to be ArborTie manufactured by Deep Root Partners, L.P. or approved equal.

B. Stakes shall be lodge pole stakes free of knots and of diameters and lengths appropriate to the size of plant as required to adequately support the plant.

C. Below ground anchorage systems to be constructed of 2 x 2 dimensional untreated wood securing (using 3 inch long screws) horizontal portions to 4 feet long vertical stakes driven straight into the ground outside the root ball.

D. Submit manufacturer's product data for approval.

2.8 TREE BARK PROTECTOR

***Note to specifier:** This is a specialty application generally only used in locations such as streetscapes and parks where tree trunks may be subject to mechanical abuse. Remove these paragraphs if this is not applicable.*

A. Tree Bark Protectors shall be black extruded resin mesh, 4 inches in diameter, 5 feet long. As manufactured by Industrial Netting, Minneapolis, MN, USA or approved equal.

B. Fasten the split side of the Tree Bark Protector together in three places with black plastic tape.

C. Submit manufacturers' product data for approval.

2.9 WATERING BAGS

***Note to specifier:** Remove this paragraph it this is not applicable*.

A. Plastic tree watering bags holding a minimum of 15 gallons of water and with a slow drip hole(s) water release system, specifically designed to water establishing trees. Water should release over a several day period, not within a few hours

B. Watering bags shall be:
1. Treegator Irrigation Bags sized to the appropriate model for the requirements of the plant, manufactured by Spectrum Products, Inc., Youngsville, NC 27596.
2. Ooze Tube sized to the appropriate model for the requirements of the plant, manufactured by Engineered Water Solutions, Atlanta, GA.
3. Or approved equal.

C. Submit manufacturer's product data for approval.

2.10 CHEMICAL OR BIOLOGICAL ADDITIVES

***Note to specifier:** Insert additives, as desired for the specific project requirements.*

PART 3 – EXECUTION

3.1 SITE EXAMINATION

A. Examine the surface grades and soil conditions to confirm that the requirements of the Specification Section – Planting Soil - and the soil and drainage modifications indicated on the Planting Soil Plan and Details (if applicable) have been completed. Notify the Owner's Representative in writing of any unsatisfactory conditions.

3.2 DELIVERY, STORAGE AND HANDLING

A. Protect materials from deterioration during delivery and storage. Adequately protect plants from drying out, exposure of roots to sun, wind or extremes of heat and cold temperatures. If planting is delayed more than 24 hours after delivery, set plants in a location protected from sun and wind. Provide adequate water to the root ball package during the shipping and storage period.

1. All plant materials must be available for observation prior to planting.

2. Using a soil moisture meter, periodically check the soil moisture in the root balls of all plants to assure that the plants are being adequately watered. Volumetric soil moisture shall be maintained above wilting point and below field capacity for the root ball substrate or soil.

B. Do not deliver more plants to the site than there is space with adequate storage conditions. Provide a suitable remote staging area for plants and other supplies.

1. The Owner's Representative or Contractor shall approve the duration, method and location of storage of plants.

C. Provide protective covering over all plants during transporting.

3.3 PLANTING SEASON

A. Planting shall only be performed when weather and soil conditions are suitable for planting the materials specified in accordance with locally accepted practice. Install plants during the planting time as described below unless otherwise approved in writing by the Owner's Representative. In the event that the Contractor request planting outside the dates of the planting season, approval of the request does not change the requirements of the warranty.

Note to specifier: *Insert required regional appropriate planting date limitations including limitations if any for fall planting hazard plants.*

1. Deciduous trees and shrubs XXX to XXX and YYY to YYY

2. Evergreen trees and shrubs XXX to XXX and YYY to YYY

3.4 ADVERSE WEATHER CONDITIONS

A. No planting shall take place during extremely hot, dry, windy or freezing weather.

3.5 COORDINATION WITH PROJECT WORK

A. The Contractor shall coordinate with all other work that may impact the completion of the work.

B. Prior to the start of work, prepare a detailed schedule of the work for coordination with other trades.

C. Coordinate the relocation of any irrigation lines, heads or the conduits of other utility lines that are in conflict with tree locations. Root balls shall not be altered to fit around lines. Notify the Owner's Representative of any conflicts encountered.

3.6 LAYOUT AND PLANTING SEQUENCE

A. Relative positions of all plants and trees are subject to approval of the Owner's Representative.

B. Notify the Owner's Representative, one (1) week prior to layout. Layout all individual tree and shrub locations. Place plants above surface at planting location or place a labeled stake at planting location. Layout bed lines with paint for the Owner's Representative's approval. Secure the Owner's Representative's acceptance before digging and start of planting work.

C. When applicable, plant trees before other plants are installed.

D. It is understood that plants are not precise objects and that minor adjustments in the layout will be required as the planting plan is constructed. These adjustments may not be apparent until some or all of the plants are installed. Make adjustments as required by the Owner's Representative including relocating previously installed plants.

3.7 SOIL PROTECTION DURING PLANT DELIVERY AND INSTALLATION

A. Protect soil from compaction during the delivery of plants to the planting locations, digging of planting holes and installing plants.

1. Where possible deliver and plant trees that require the use of heavy mechanized equipment prior to final soil preparation and tilling. Where possible, restrict the driving lanes to one area instead of driving over and compacting a large area of soil.

2. Till to a depth of 6 inches, all soil that has been driven over during the installation of plants.

3.8 SOIL MOISTURE

A. Volumetric soil moisture level, in both the planting soil and the root balls of all plants, prior to, during and after planting shall be above permanent wilting point and below field capacity for each type of soil texture within the following ranges.

Soil type	**Permanent wilting point**	**Field capacity**
Sand, Loamy sand, Sandy loam	5-8%	12-18%
Loam, Sandy clay, Sandy clay loam	14-25%	27-36%
Clay loam, Silt loam	11-22%	31-36%
Silty clay, Silty clay loam	22-27%	38-41%

1. Volumetric soil moisture shall be measured with a digital moisture meter. The meter shall be the Digital Soil Moisture Meter, DSMM500 by General Specialty Tools and Instruments, or approved equivalent.

B. The Contractor shall confirm the soil moisture levels with a moisture meter. If the moisture is too high, suspend planting operations until the soil moisture drains to below field capacity.

3.9 INSTALLATION OF PLANTS: GENERAL

A. Installation plan shall be submitted a minimum of 14 days prior to the scheduled installation. Plan should describe the methods, activities, materials and schedule to achieve installation of plants.

***Note to specifier**: Remove the above paragraph if no Installation Plan is required. Also remove the submittal requirement in Part One – Submittals.*

B. Observe each plant after delivery and prior to installation for damage of other characteristics that may cause rejection of the plant. Notify the Owner's Representative of any condition observed.

C. No more plants shall be distributed about the planting bed area than can be planted and watered on the same day.

D. The root system of each plant, regardless of root ball package type, shall be observed by the Contractor, at the time of planting to confirm that the roots meet the requirements for plant root quality in Part 2 Products: Plants General: Plant Quality. The Contractor shall undertake at the time of planting, all modifications to the root system required by the Owner's Representative to meet these quality standards.

1. Modifications, at the time of planting, to meet the specifications for the depth of the root collar and removal of stem girdling roots and circling roots may make the plant unstable or stress the plant to the point that the Owner's Representative may choose to reject the plant rather than permitting

the modification.

2. Any modifications required by the Owner's Representative to make the root system conform to the plant quality standards outlined in Part 2 Products: Plants General: Quality, or other requirements related to the permitted root ball package, shall not be considered as grounds to modify or void the plant warranty.
3. The resulting root ball may need additional staking and water after planting. The Owner's Representative may reject the plant if the root modification process makes the tree unstable or if the tree is not healthy at the end of the warranty period. Such plants shall still be covered under the warranty
4. The Contractor remains responsible to confirm that the grower has made all required root modifications noted during any nursery observations.

E. Container and Boxed Root Ball Shaving: The outer surfaces of ALL plants in containers and boxes, including the top, sides and bottom of the root ball shall be shaved to remove all circling, descending, and matted roots. Shaving shall be performed using saws, knives, sharp shovels or other suitable equipment that is capable of making clean cuts on the roots. Shaving shall remove a minimum of one inch of root mat or up to 2 inches as required to remove all root segments that are not growing reasonably radial to the trunk.

F. Exposed Stem Tissue after Modification: The required root ball modifications may result in stem tissue that has not formed trunk bark being exposed above the soil line. If such condition occurs, wrap the exposed portion of the stem in a protective wrapping with a white filter fabric. Secure the fabric with biodegradable masking tape. DO NOT USE string, twine, green nursery ties or any other material that may girdle the trunk if not removed.

G. Excavation of the Planting Space: Using hand tools or tracked mini-excavator, excavate the planting hole into the Planting Soil to the depth of the root ball measured after any root ball modification to correct root problems, and wide enough for working room around the root ball or to the size indicated on the drawing or as noted below.
   1. For trees and shrubs planted in soil areas that are NOT tilled or otherwise modified to a depth of at least 12 inches over a distance of more than 10 feet radius from each tree, or 5 feet radius from each shrub, the soil around the root ball shall be loosened as defined below or as indicated on the drawings.
      a. The area of loosening shall be a minimum of 3 times the diameter of the root ball at the surface sloping to 2 times the diameter of the root ball at the depth of the root ball.
      b. Loosening is defined as digging into the soil and turning the soil to reduce the compaction. The soil does not have to be removed from the hole, just dug, lifted and turned. Lifting and turning may be accomplished with a tracked mini excavator, or hand shovels.
   2. If an auger is used to dig the initial planting hole, the soil around the auger hole shall be loosened as defined above for trees and shrubs planted in soil areas that are NOT tilled or otherwise modified.
   3. The measuring point for root ball depth shall be the average height of the outer edge of the root ball after any required root ball modification.
   4. If motorized equipment is used to deliver plants to the planting area over exposed planting beds, or used to loosen the soil or dig the planting holes, all soil that has been driven over shall be tilled to a depth of 6 inches.

Note to specifier: *Most other planting specifications set a minimum planting hole size, often 2 or 3 times the root ball diameter. This specification assumes that all soil preparation and the preparation of the planting hole is specified in the specification section Planting Soil and the Contractor needs to dig the hole in the already prepared soil only as large as is required to accomplish the planting process; the smaller the planting hole the better. Revise the paragraph Installation of Plants, above to reflect other project requirements if needed.*

In some circumstance (soil type or budget) it may be reasonable or necessary to allow the use of an auger to dig planting holes. While augers are not recommended, if they are allowed, the soil around the top and sides of the holes must be loosened as defined for holes that are dug with other equipment.
Motorized equipment used to dig planting holes or deliver plants to the planting location will compact the soil surface. Tilling of the surface soil that has been compacted, as noted in this specification, is critical to the health of the soil after planting.

H. For trees to be planted in prepared Planting Soil that is deeper than the root ball depth, compact the soil under the root ball using a mechanical tamper to assure a firm bedding for the root ball. If there is more than 12 inches of planting soil under the root ball excavate and tamp the planting soil in lifts not to exceed 12 inches.

I. Set top outer edge of the root ball at the average elevation of the proposed finish. Set the plant plumb and upright in the center of the planting hole. The tree graft, if applicable, shall be visible above the grade. Do not place soil on top of the root ball.

J. The Owner's Representative may request that plants orientation be rotated when planted based on the form of the plant.

K. Backfill the space around the root ball with the same planting soil or existing soil that was excavated for the planting space. See Specification Section Planting Soil, for requirements to modify the soil within the planting bed.

L. Brace root ball by tamping Planting Soil around the lower portion of the root ball. Place additional Planting Soil around base and sides of ball in six-inch (6") lifts. Lightly tamp each lift using foot pressure or hand tools to settle backfill, support the tree and eliminate voids. DO NOT over compact the backfill or use mechanical or pneumatic tamping equipment. Over compaction shall be defined as greater than 85% of maximum dry density, standard proctor or greater than 250 psi as measured by a cone penetrometer when the volumetric soil moisture is lower than field capacity.

1. When the planting hole has been backfilled to three quarters of its depth, water shall be poured around the root ball and allowed to soak into the soil to settle the soil. Do not flood the planting space. If the soil is above field capacity, allow the soil to drain to below field capacity before finishing the planting. Air pockets shall be eliminated and backfill continued until the planting soil is brought to grade level.

M. Where indicated on the drawings, build a 4 inch high, level berm of Planting Soil around the outside of the root ball to retain water. Tamp the berm to reduce leaking and erosion of the saucer.

N. Thoroughly water the Planting Soil and root ball immediately after planting.

O. Remove all nursery plant identification tags and ribbons as per Owner's Representative instructions. The Owner's Representative's seals are to remain on plants until the end of the warranty period.

P. Remove corrugated cardboard trunk protection after planting.

Q. Follow additional requirements for the permitted root ball packages.

3.10 PERMITTED ROOT BALL PACKAGES AND SPECIAL PLANTING REQUIREMENTS

A. The following are permitted root ball packages and special planting requirements that shall be followed during the planting process in addition to the above General planting requirements.

B. BALLED AND BURLAPPED PLANTS

Note to specifier: *Remove this paragraph if BALLED AND BURLAPPED PLANTS are not permitted. Removing some or all of the wire of a wire basket after the plant is positioned in the planting hole is controversial. Despite the scientific evidence showing that roots grow to engulf the wire, and lack of documented cases of wire impacting tree health, some professionals insist that some or all wire be removed. Delete, accept, or modify sections B.1 and 2 below as you feel necessary.*

1. After the root ball has been backfilled, remove all twine and burlap from the top of the root ball. Cut the burlap away; do not fold down onto the Planting Soil.
2. If the plant is shipped with a wire basket that does not meet the requirements of a “Low Rise” basket, remove the top 6 - 8 inches of the basket wires just before the final backfilling of the tree.
3. Earth root balls shall be kept intact except for any modifications required by the Owner’s Representative to make root package comply with the requirement in Part 2 Products.

C. SPADE HARVESTED AND TRANSPLANTED PLANTS

Note to specifier: *Remove this paragraph if Tree Spade Harvested and Transplanted Plants are not to be permitted.*

1. After installing the tree, loosen the soil along the seam between the root ball and the surrounding soil out to a radius from the root ball edge equal to the diameter of the root ball to a depth of 8 - 10 inches by hand digging to disturb the soil interface.
2. Fill any gaps below this level with loose soil.

D. CONTAINER (INCLUDES BOXED AND ABOVE-GROUND FABRIC CONTAINERS) PLANTS

Note to specifier: *Remove this paragraph if CONTAINER PLANTS are not permitted. All of the items below can be included if the following details are included in the contract: 1) root ball shaving, 2) root observations, 3) root correction. Remove sections below that will not be required.*

1. This specification assumes that most container plants have significant stem girdling and circling roots, and that the root collar is too low in the root ball.
2. Remove the container.
3. Perform root ball shaving as defined in Installation of Plants: General above.
4. Remove all roots and substrate above the root collar and the main structural roots according to root correction details so root system conforms to root observations detail.
5. Remove all substrate at the bottom of the root ball that does not contain roots.
6. Using a hose, power washer or air excavation device, wash out the substrate from around the trunk and top of the remaining root ball and find and remove all stem girdling roots within the root ball above the top of the structural roots.

E. BARE ROOT PLANTS

Note to specifier: *Remove this paragraph if BARE ROOT PLANTS are not permitted.*

1. Dig the planting hole to the diameter of the spread of the roots to a depth in the center that maintains the root collar at the elevation of the surrounding finished grade and slightly deeper along the edges of the hole.
2. Spread all roots out radial to the trunk in the prepared hole making the hole wider where needed to accommodate long roots. Root tips shall be directed away from the trunk. Prune any broken roots removing the least amount of tissue possible.
3. Maintain the trunk plumb while backfilling soil around the roots.
4. Lightly tamp the soil around the roots to eliminate voids and reduce settlement.

F. IN-GROUND FABRIC CONTAINERS

Note to specifier: *Remove this paragraph if FABRIC CONTAINERS are not permitted.*

1. Remove the fabric container from the root ball. Cut roots at the edge of the container as needed to extract the fabric from the roots. Make clean cuts with sharp tools; do not tear roots away from the fabric.
2. Observe the root system after the container is removed to confirm that the root system meets the quality standards.

3.11 GROUND COVER, PERENNIAL AND ANNUAL PLANTS

A. Assure that soil moisture is within the required levels prior to planting. Irrigation, if required, shall be applied at least 12 hours prior to planting to avoid planting in muddy soils.

B. Assure that soil grades in the beds are smooth and as shown on the plans.

C. Plants shall be planted in even, triangularly spaced rows, at the intervals called out for on the drawings, unless otherwise noted. The first row of Annual flower plants shall be 6 inches from the bed edge unless otherwise directed.

D. Dig planting holes sufficiently large enough to insert the root system without deforming the roots. Set the top of the root system at the grade of the soil.

E. Schedule the planting to occur prior to application of the mulch. If the bed is already mulched, pull the mulch from around the hole and plant into the soil. Do not plant the root system in the mulch. Pull mulch back so it is not on the root ball surface.

F. Press soil to bring the root system in contact with the soil.

G. Spread any excess soil around in the spaces between plants.

H. Apply mulch to the bed being sure not to cover the tops of the plants with or the tops of the root ball with mulch.

I. Water each planting area as soon as the planting is completed. Apply additional water to keep the soil moisture at the required levels. Do not over water.

3.12 PALM PLANTING

A. Palm trees shall be placed at grade making sure not to plant the tree any deeper in the ground than the palm trees originally stood.

B. The trees shall be placed with their vertical axis in a plumb position.

C. All backfill shall be native soil except in cases where planting in rock. Water-settle the back fill.

D. Do not cover root ball with mulch or topsoil.

E. Provide a watering berm at each palm. Berms shall extend a minimum of 18 inches out from the trunk all around and shall be a minimum of (6) inches high.

F. Remove twine which ties fronds together after placing palm in planting hole and securing it in the upright position.

3.13 STAKING AND GUYING

Note to specifier: *There are many staking systems available in the market. Special project requirements and regional or designer preferences may indicate different approach. Modify the following paragraphs to reflect project requirements.*

If palms are include then add palm bracing detail.

A. Do not stake or guy trees unless specifically required by the Contract Documents, or in the event that the Contractor feels that staking is the only alternative way to keep particular trees plumb.

1. The Owner's Representative shall have the authority to require that trees are staked or to reject staking as an alternative way to stabilize the tree.

2. Trees that required heavily modified root balls to meet the root quality standards may become unstable. The Owner's Representative may choose to reject these trees rather than utilize staking to temporarily support the tree.

B. Trees that are guyed shall have their guys and stakes removed after one full growing season or at other times as required by the Owner's Representative.

C. Tree guying shall utilize the tree staking and guying materials specified. Guying to be tied in such a

manner as to create a minimum 12-inch loop to prevent girdling. Refer to manufacturer's recommendations and the planting detail for installation.
1. Plants shall stand plumb after staking or guying.
2. Stakes shall be driven to sufficient depth to hold the tree rigid.

D. For trees planted in planting mix over waterproofed membrane, use dead men buried 24 inches to the top of the dead man, in the soil. Tie the guy to the dead man with a double wrap of line around the dead man followed by a double half hitch. When guys are removed, leave the dead men in place and cut the guy tape 12 inches above the ground, leaving the tape end covered in mulch.

3.14 TREE BARK PROTECTION

Note to specifier: *This is a specialty application generally only used in location such as streetscapes where tree trunks may be subject to mechanical abuse. Remove this paragraph it this is not applicable.*

A. For all street trees in commercial areas where indicted on the drawings, apply a Tree Bark Protector to each tree.

3.15 STRAIGHTENING PLANTS

A. Maintain all plants in a plumb position throughout the warranty period. Straighten all trees that move out of plumb including those not staked. Plants to be straightened shall be excavated and the root ball moved to a plumb position, and then re-backfilled.

B. Do not straighten plants by pulling the trunk with guys.

3.16 INSTALLATION OF FERTILIZER AND OTHER CHEMICAL ADDITIVES

A. Do not apply any soluble fertilizer to plantings during the first year after transplanting unless soil test determines that fertilizer or other chemical additives is required. Apply chemical additives only upon the approval of the Owner's Representative.

B. Controlled release fertilizers shall be applied according to the manufacturer's instructions and standard horticultural practices.

3.17 PRUNING OF TREES AND SHRUBS

A. Prune plants as directed by the Owner's Representative. Pruning trees shall be limited to addressing structural defects as shown in details; follow recommendations in "Structural Pruning: A Guide For The Green Industry" published by Urban Tree Foundation, Visalia CA.

B. All pruning shall be performed by a person experienced in structural tree pruning.

C. Except for plants specified as multi-stemmed or as otherwise instructed by the Owner's Representative, preserve or create a central leader.

D. Pruning of large trees shall be done using pole pruners or if needed, from a ladder or hydraulic lift to gain access to the top of the tree. Do not climb in newly planted trees. Small trees can be structurally pruned by laying them over before planting. Pruning may also be performed at the nursery prior to shipping.

E. Remove and replace excessively pruned or malformed stock resulting from improper pruning that occurred in the nursery or after.

F. Pruning shall be done with clean, sharp tools.

G. No tree paint or sealants shall be used.

3.18 MULCHING OF PLANTS

A. Apply 4 inches of mulch before settlement, covering the entire planting bed area. Install no more than 1 inch of mulch over the top of the root balls of all plants. Taper to 2 inches when abutting pavement. ***Note to specifier:*** *Mulch thickness varies by mulch type, project location, and project requirements. Four inches of coarse mulch is for dry climates. In wet climates 4 inches of shredded bark mulch would be far too much mulch and have detrimental effect to the plants. Adjust the mulch thickness in*

both the specifications and details.

B. For trees planted in lawn areas the mulch shall extend to a 5 foot radius around the tree or to the extent indicated on the plans.

C. Lift all leaves, low hanging stems and other green portions of small plants out of the mulch if covered.

3.19 PLANTING BED FINISHING

A. After planting, smooth out all grades between plants before mulching.

B. Separate the edges of planting beds and lawn areas with a smooth, formed edge cut into the turf with the bed mulch level slightly lower, 1 and 2 inches, than the adjacent turf sod or as directed by the Owner's Representative. Bed edge lines shall be a depicted on the drawings.

3.20 WATERING

A. The Contractor shall be fully responsible to ensure that adequate water is provided to all plants from the point of installation until the date of Substantial Completion Acceptance. The Contractor shall adjust the automatic irrigation system, if available, and apply additional or adjust for less water using hoses as required.

B. Hand water root balls of all plants to assure that the root balls have moisture above wilt point and below field capacity. Test the moisture content in each root ball and the soil outside the root ball to determine the water content.

C. The Contractor shall install 25 gallon watering bag for each tree to be maintained and used for tree watering during the warranty period.

Note to specifier: *Watering bags come in various sizes from 15 to 25 gallons. Confirm bag size needed and adjust the above paragraph. Confirm if the watering bags are to be given to the Owner or remain the property of the Contractor. Adjust the below paragraph as required.*

1. The watering bags shall remain the property of the Owner at the completion of the work.

3.21 CLEAN-UP

A. During installation, keep the site free of trash, pavements reasonably clean and work area in an orderly condition at the end of each day. Remove trash and debris in containers from the site no less than once a week.
   1. Immediately clean up any spilled or tracked soil, fuel, oil, trash or debris deposited by the Contractor from all surfaces within the project or on public right of ways and neighboring property.

B. Once installation is complete, wash all soil from pavements and other structures. Ensure that mulch is confined to planting beds and that all tags and flagging tape are removed from the site. The Owner's Representative's seals are to remain on the trees and removed at the end of the warranty period.

C. Make all repairs to grades, ruts, and damage by the plant installer to the work or other work at the site.

D. Remove and dispose of all excess planting soil, subsoil, mulch, plants, packaging, and other material brought to the site by the Contractor.

3.22 PROTECTION DURING CONSTRUCTION

A. The Contractor shall protect planting and related work and other site work from damage due to planting operations, operations by other Contractors or trespassers. Maintain protection during installation until Substantial Completion Acceptance. Treat, repair or replace damaged work immediately.

B. Damage done by the Contractor, or any of their sub-contractors to existing or installed plants, or any other parts of the work or existing features to remain, including roots, trunk or branches of large existing trees, soil, paving, utilities, lighting, irrigation, other finished work and surfaces including those on adjacent property, shall be cleaned, repaired or replaced by the Contractor at no expense to

the Owner. The Owner's Representative shall determine when such cleaning, replacement or repair is satisfactory.

3.23 PLANT MAINTENANCE PRIOR TO SUBSTANTIAL COMPLETION ACCEPTANCE

A. During the project work period and prior to Substantial Completion Acceptance, the Contractor shall maintain all plants.

B. Maintenance during the period prior to Substantial Completion Acceptance shall consist of pruning, watering, cultivating, weeding, mulching, removal of dead material, repairing and replacing of tree stakes, tightening and repairing of guys, repairing and replacing of damaged tree wrap material, resetting plants to proper grades and upright position, and furnishing and applying such sprays as are necessary to keep plantings reasonably free of damaging insects and disease, and in healthy condition. The threshold for applying insecticides and herbicide shall follow established Integrated Pest Management (IPM) procedures. Mulch areas shall be kept reasonably free of weeds, grass.

3.24 SUBSTANTIAL COMPLETION ACCEPTANCE

A. Upon written notice from the Contractor, the Owners Representative shall review the work and make a determination if the work is substantially complete.
   1. Notification shall be at least 7 days prior to the date the contractor is requesting the review.

B. The date of substantial completion of the planting shall be the date when the Owner's Representative accepts that all work in Planting, Planting Soil, and Irrigation installation sections is complete.

C. The Plant Warranty period begins at date of written notification of substantial completion from the Owner's Representative. The date of substantial completion may be different than the date of substantial completion for the other sections of the project.

Note to specifier: *The following two sections are options for maintenance during the warranty period: Maintenance During the Warranty Period by Others" and "Maintenance During the Warranty Period by the Plant Installer". Confirm the approach that is appropriate to the project and delete the other option. These options may also need to be modified to meet the project requirements.*

Confirm that the lengths and timing of beginning and end of maintenance periods are suitable to the project owner's requirements. If the owner does not want to purchase plant maintenance during warranty period, use option one below. If plant maintenance is to be included the extent of the maintenance must be defined.

The maintenance specification assumes that maintenance of lawn grass areas, if required, would be covered under a separate specification for lawn installation.

3.25 MAINTENANCE DURING THE WARRANTY PERIOD BY OTHERS

A. After Substantial Completion Acceptance, the Contractor shall make sufficient site visits to observe the Owner's maintenance and become aware of problems with the maintenance in time to request changes, until the date of End of Warranty Final Acceptance.

   1. Notify the Owner's Representative in writing if maintenance, including watering, is not sufficient to maintain plants in a healthy condition. Such notification must be made in a timely period so that the Owner's Representative may take corrective action.

      a. Notification must define the maintenance needs and describe any corrective action required.

   2. In the event that the Contractor fails to visit the site and or notify, in writing, the Owner's Representative of maintenance needs, lack of maintenance shall not be used as grounds for voiding or modifying the provisions of the warranty.

3.26 MAINTENANCE DURING THE WARRANTY PERIOD BY THE PLANT INSTALLER

A. During the warranty period, provide all maintenance for all plantings to keep the plants in a healthy state and the planting areas clean and neat.

B. General requirements:
   1. All work shall be undertaken by trained planting crews under the supervision of a foreman with a minimum of 5 years experience supervising commercial plant maintenance crews.
   2. All chemical and fertilizer applications shall be made by licensed applicators for the type of chemicals to be used. All work and chemical use shall comply with all applicable local, provincial and federal requirements.
   3. Assure that hoses and watering equipment and other maintenance equipment does not block paths or be placed in a manner that may create tripping hazards. Use standard safety warning barriers and other procedures to maintain the site in a safe manner for visitors at all times.
   4. All workers shall wear required safety equipment and apparel appropriate for the tasks being undertaken.
   5. The Contractor shall not store maintenance equipment at the site at times when they are not in use unless authorized in writing by the Owner's Representative.
   6. Maintenance vehicles shall not park on the site including walks and lawn areas at any time without the Owner's Representative's written permission.
   7. Maintain a detailed log of all maintenance activities including types of tasks, date of task, types and quantities of materials and products used, watering times and amounts, and number of each crew. Periodically review the logs with the Owner's Representative, and submit a copy of the logs at the end of each year of the maintenance agreement.
   8. Meet with the Owner's Representative a minimum of three times a year to review the progress and discuss any changes that are needed in the maintenance program. At the end of the warranty period attend a hand over meeting to formally transfer the responsibilities of maintenance to the Owner's Representative. Provide all information on past maintenance activities and provide a list of critical tasks that will be needed over the next 12 months. Provide all maintenance logs and soil test data. Make the Contractor's supervisor available for a minimum of one year after the end of the warranty period to answer questions about past maintenance.

C. Provide the following maintenance tasks:
   1. Watering; Provide all water required to keep soil within and around the root balls at optimum moisture content for plant growth.
      a. Maintain all watering systems and equipment and keep them operational.
      b. Monitor soil moisture to provide sufficient water. Check soil moisture and root ball moisture with a soil moisture meter on a regular basis and record moisture readings. Do not over water.
   2. Soil nutrient levels: Take a minimum of 4 soil samples from around the site in the spring and fall and have them tested by an accredited agricultural soil testing lab for chemical composition of plant required nutrients, pH, salt and % organic matter. Test results shall include laboratory recommendations for nutrient applications. Apply fertilizers at rates recommended by the soil test.
      a. Make any other soil test and/or plant tissue test that may be indicated by plant conditions that may not be related to soil nutrient levels such as soil contaminated by other chemicals or lack of chemical uptake by the plant.
   3. Plant pruning: Remove cross over branching, shorten or remove developing co dominant leaders, dead wood and winter-damaged branches. Unless directed by the Owner's Representative, do not shear plants or make heading cuts.
   4. Restore plants: Reset any plants that have settled or are leaning as soon as the condition is noticed.
   5. Guying and staking: Maintain plant guys in a taught position. Remove tree guys and staking after the first full growing season unless directed by Owner's Representative.
   6. Weed control: Keep all beds free of weeds. Hand-remove all weeds and any plants that do not appear on the planting plan. Chemical weed control is permitted only with the approval of the Owner's Representative. Schedule weeding as needed but not less *12 times per year*.
      Note to specifier: *Insert the frequency of weed control above based on the project budget and need to keep the plantings weed free.*
   7. Trash removal: Remove all trash and debris from all planting beds and maintain the beds in a neat and tidy appearance. The number of trash and debris removal visits shall be no less than 12 times per year and may coincide with other maintenance visits.

Note to specifier: *Insert the frequency of trash removal based on the project budget and need to keep the site trash free.*

8. Plant pest control: Maintain disease, insects and other pests at manageable levels. Manageable levels shall be defined as damage to plants that may be noticeable to a professional but not to the average person. Use least invasive methods to control plant disease and insect outbreaks.
   a. The Owner's Representative must approve in advance the use of all chemical pesticide applications.
9. Plant replacement: Replace all plants that are defective as defined in the warranty provisions, as soon as the plant decline is obvious and in suitable weather and season for planting as outlined in above sections. Plants that become defective during the maintenance period shall be covered and replaced under the warranty provisions.
10. Mulch: Refresh mulch once a year to maintain complete coverage but do not over mulch. At no time shall the overall mulch thickness be greater that 4 inches. Do not apply mulch within 6 inches of the trunks or stems of any plants. Replacement mulch shall meet the requirements of the original approved material. Mulch shall be no more than one inch on top of the root ball surface.

    Note to specifier: *Insert the maximum depth of mulch based on the project budget and need to keep the mulch in the beds. Often after bed foliage completely fills in, no or little additional mulch is needed.*
11. Bed edging: Check and maintain edges between mulch and lawn areas in smooth neat lines as originally shown on the drawings.
12. Leaf, fruit and other plant debris removal: Remove fall leaf, spent flowers, fruit and plant part accumulations from beds and paved surfaces. Maintain all surface water drains free of debris. Debris removal shall be undertaken at each visit to weed or pick up trash in beds.
13. Damage from site use: Repair of damage by site visitors and events, beyond normal wear, are not part of this maintenance. The Owner's Representative may request that the Contractor repair damage beds or plantings for an additional cost. All additional work shall be approved in advance by the Owner's Representative.

3.27 END OF WARRANTY FINAL ACCEPTANCE / MAINTENANCE OBSERVATION

A. At the end of the Warranty and Maintenance period the Owner's Representative shall observe the work and establish that all provisions of the contract are complete and the work is satisfactory.
   1. If the work is satisfactory, the maintenance period will end on the date of the final observation.
   2. If the work is deemed unsatisfactory, the maintenance period will continue at no additional expense to the Owner until the work has been completed, observed, and approved by the Owner's Representative.

B. FAILURE TO PASS OBSERVATION: If the work fails to pass final observation, any subsequent observations must be rescheduled as per above. The cost to the Owner for additional observations will be charged to the Contractor at the prevailing hourly rate of the Owners Representative.

END OF SECTION 32 9300

015639 Tree and Plant Protection

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INSTRUCTIONS TO THE SPECIFICATION WRITER:

The following document is intended as a general specification to guide the writing of a project-specific specification. Each project is unique and it is required that the specification be developed accordingly. DO NOT USE THE FOLLOWING SPECIFICATION WITHOUT MAKING IMPORTANT ADJUSTMENTS to reflect local conditions, regulations, market standards, project schedules and local and regional practices. The following are specific items that need to be addressed.

1. General instructions for using this specification: *These instructions are intended to guide the specification writer (the specifier) through the process of editing this document into a Tree and Plant Protection specification. Be sure to delete these instructions (i.e. all the text in red displayed above the paragraph) before issuing the specifications.*

2. General Requirements - Division 01 (Construction Specification Institute) specifications and other contract elements: *This specification is designed to be used in conjunction with standard Division 01 specifications, which cover project general conditions and project wide contract elements. THIS IS NOT A STAND-ALONE SPECIFICATION and should not be used as a contract for the protection of plants. Important issue of project ownership, liability, insurance, contract language, project controls, Instructions to bidders, change orders and review and approval of the work are normally in the Division 01 specifications.*

3. The construction team: *A construction project is a team effort where the Owner, in effect, creates an agreement with all the Contractors to build a project. As with any good contract there are protections for both sides; that the Owner will get the quality of project that they desire within the time limits and budget available; and the Contractor will be paid for the work satisfactorily completed. In between the initial bidding and the final completion there will be many places where parts of the construction do not work out as originally intended. This is normal and a good contract should allow for these changes in a manner that is equitable to both the Owner and the Contractor. To get there, a team approach and spirit must prevail. Both sides must assume that each is operating in the best interest of the project goals. The clearer the goals and description of the project, the smoother the flow of a successful project.* ***The more each of the team members can trust the other members, the better the project.*** *This should be a critical principle in approaching interpretation of the specification.*

4. Unique aspects of Tree and Plant Protection: *Most specification sections describe how a particular trade or sub contractor should proceed to accomplish certain tasks to construct a specific part of the project. There is an assumption in almost all specifications that if the subcontractor damages the work of another they must provide a remedy to fix the damage. With plants, particularly large trees, there is not effective remedy if significant damage occurs to the plant. Often the damage particularly to the root system of a tree may not be readily apparent and may not express itself as decline in the tree till after the construction project is finished. For this reason Tree and Plant Protection specification is as much about preventing damage as it is instructions to the subcontractor related to what to build. It is also unique specification section in that it applies to all Contractors working on the site effecting where they can park, store equipment and perform excavations by making certain areas off limits except for the activities permitted by the specification. Conflicts between this specification and other requirements must be resolved prior to the start of work. The Tree and Plant Protection requirements begin at the very beginning of construction and are enforce for the entire construction contract period.*

5. Other project documents: *This specification is intended to be used in conjunction with other project documents including the bid forms, the construction contract, Division 1 specifications, other specifications directly related to this section; other specifications that are not directly related to this work and most critically the Project*

construction drawings. It is very critical that all these documents be prepared with consistent terminology and that they be coordinated. The terms used for the parts of trees and other plants, different soil types, drainage features, irrigation features and structures such as paving, walls and planters must be consistent across disciplines.

6. Related specification sections: *This specification requires additional specification sections to describe several important related parts of the Tree and Plant Protection process.*

> ***Planting:*** *This specification assumes that there is a separate specification section and separate plans and details for installation of plants.*
>
> ***Planting Soil:*** *This specification assumes that there is a separate specification section and separate plans and details for installation of planting soils.*
>
> ***Irrigation:*** *This specification assumes that there is a separate specification section for Irrigation that might be associated with the project planting.*
>
> ***Other sections:*** *such as plumbing, electric, excavation, paving site structures.*

7. Reviewing and approval authority: *Each specification identifies a certain entity as responsible for the review and approval of the work, project submittals, changes to the work and acceptance of the work. The entity with this authority is normally identified in Division 1. For the purposes of this specification, the term the "Owner's Representative" has been used as a placeholder for this entity. Once the proper term is defined for example another term such as; Contracting Officer, The Architect, The Landscape Architect, The Engineer etc.; this term should replace the words "Owner's Representative" wherever it appears in this specification.*

8. Header and footer requirements: *Change the header/footer language to meet the project requirements.*

9. Notes to specifier: *Before issuing the document, be sure to remove all "**Notes to specifier**" incorporated into this document after you have read them and responded to the recommendations.*

10. Submittals: *Submittals are a critical part of any construction contract. This is where all products and materials are reviewed and approved in advance of the work. Tree and Plant Protection quality control is in this section. Including very specific requirements for approval of submittals while a good practice assumes that the reviewing authority has the skills needed to make these reviews and interpret the results. A common practice is to make very specific requirements but not have the time or expertise to enforce them. Lack of review of submittals does not automatically transfer quality control to the Contractor. In fact, lack of review or inappropriate review can make the reviewing authority responsible for having accepted the submittal even if it was not acceptable. Take great care in putting into the specification submittal requirements that you do not have the time or knowledge to enforce.*

11. Specification modifications: *There are locations in this specification where additional information is required to reflect project region or contract conditions. Please insert the requested information.*

PART 1 – GENERAL

1.1 SUMMARY

Note to specifier: *Remove parts of this work description that do not apply.*

A. The scope of work includes all labor, materials, tools, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with protection of existing trees and other plants as shown on the drawings and as specified herein.

1. Provide preconstruction evaluations
2. Provide tree and plant protection fencing.
3. Provide protection of root zones and above ground tree and plants
4. Provide pruning of existing trees and plants.
5. Coordinate with the requirements of Section Planting Soil for modifications to the soil within the root zone of existing trees and plants.
6. Provide all insect and disease control.
7. Provide maintenance of existing trees and plants including irrigation during the construction period as recommended by the arborist report.
8. Provide maintenance of existing trees and plants including irrigation during the post construction plant maintenance period.
9. Remove tree protection fencing and other protection from around and under trees and plants.
10. Clean up and disposal of all excess and surplus material.

1.2 CONTRACT DOCUMENTS

A. Shall consist of specifications and general conditions and the drawings. The intent of these documents is to include all labor, materials, and services necessary for the proper execution of the work. The documents are to be considered as one. Whatever is called for by any parts shall be as binding as if called for in all parts.

B. It is the intent of this section that the requirements apply to all sections of the project specification such that any subcontractor must comply with the restrictions on work within designated Tree and Plant Protection Areas.

1.3 RELATED DOCUMENTS AND REFERENCES

A. Related Documents:

Note to specifier: *Coordinate this list with the other related specification sections. Add or delete sections as appropriate.*

1. Drawings and general provisions of contract including general and supplementary conditions and Division I specifications apply to work of this section.
2. Section - Planting Soil
3. Section - Irrigation
4. Section - Planting
5. Section - Lawn

B. References: The following specifications and standards of the organizations and documents listed in this paragraph form a part of the specification to the extent required by the references thereto. In the event that the requirements of the following referenced standards and specification conflict with this specification section the requirements of this specification shall prevail. In the event that the

requirements of any of the following referenced standards and specifications conflict with each other the more stringent requirement shall prevail.

1. ANSI A 300 (Part 5) – Standard Practices for Tree, Shrub and other Woody Plant Maintenance, most current editions.
2. Pruning practices shall conform with recommendations “Structural Pruning: A Guide For The Green Industry”; Published by Urban Tree Foundation, Visalia, California; most current edition.
3. Glossary of Arboricultural Terms, International Society of Arboriculture, Champaign Il, most current edition.

1.4 VERIFICATION

A. All scaled dimensions on the drawings are approximate. Before proceeding with any work, the Contractor shall carefully check and verify all dimensions and quantities, and shall immediately inform the Owner’s Representative of any discrepancies between the information on the drawings and the actual conditions, refraining from doing any work in said areas until given approval to do so by the Owner’s Representative.

1.5 PERMITS AND REGULATIONS

A. The Contractor shall obtain and pay for all permits related to this section of the work unless previously excluded under provision of the contract or general conditions. The Contractor shall comply with all laws and ordinances bearing on the operation or conduct of the work as drawn and specified. If the Contractor observes that a conflict exists between permit requirements and the work outlined in the contract documents, the Contractor shall promptly notify the Owner’s Representative in writing including a description of any necessary changes and changes to the contract price resulting from changes in the work.

B. Wherever references are made to standards or codes in accordance with which work is to be performed or tested, the edition or revision of the standards and codes current on the effective date of this contract shall apply, unless otherwise expressly set forth.

C. In case of conflict among any referenced standards or codes or between any referenced standards and codes and the specifications, the more restrictive standard shall apply or Owner’s Representative shall determine which shall govern.

1.6 PROTECTION OF WORK, PROPERTY AND PERSON

A. The Contractor shall protect the work, adjacent property, and the public, and shall be responsible for any damages or injury due to his/her actions.

1.7 CHANGES IN THE WORK

A. The Owner’s Representative may order changes in the work, and the contract sum should be adjusted accordingly. All such orders and adjustments plus claims by the Contractor for extra compensation must be made and approved in writing before executing the work involved.

1.8 CORRECTION OF WORK

A. The Contractor shall re-execute any work that fails to conform to the requirements of the contract and shall remedy defects due to faulty materials or workmanship upon written notice from the Owner’s Representative, at the soonest possible time that can be coordinated with other work and seasonal weather demands**.**

1.9 DEFINITIONS

Note to specifier: *Delete any words below that are not used in the final specification.*

All terms in this specification shall be as defined in the “Glossary of Arboricultural Terms” or as modified below.

A. Owner’s Representative: The person appointed by the Owner to represent their interest in the review

and approval of the work and to serve as the contracting authority with the Contractor. The Owner's Representative may appoint other persons to review and approve any aspects of the work.

B. Reasonable and reasonably: When used in this specification is intended to mean that the conditions cited will not affect the establishment or long term stability, health or growth of the plant. This specification recognizes that plants are not free of defects, and that plant conditions change with time. This specification also recognizes that some decisions cannot be totally based on measured findings and that profession judgment is required. In cases of differing opinion, the Owner's Representative expert shall determine when conditions within the plant are judged as reasonable.

C. Shrub: Woody plants with mature height approximately less than 25 feet.

D. Tree and Plant Protection Area: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and defined by a circle centered on the trunk with each tree with a radius equal to the clown dripline unless otherwise indicated by the owner's representative.

E. Tree: Single and multi-stemmed plants, including palms with anticipated mature height approximately greater than 25 feet or any plant identified on the plans as a tree.

1.10 SUBMITTALS

Note to specifier: *The arborist report, described below is to provide a current assessment of all trees to remain and serve as the basis for determining if trees are damaged. The Contractor is made responsible for the preparation of this report with the Owner's Representative responsible for approval of the report so that both sides of the contract are satisfied that the condition of these trees is accurately reported before any work has started. Add or delete any portions that do not apply.*

A. ARBORIST REPORT: Prior to the start of construction, submit, for approval by the Owner's Representative, the report of a consulting arborist who is a registered Consulting Arborist® (RCA) with American Society of Consulting Arborists or an ISA Board Certified Master Arborist, which details the following information for all trees to remain within the area designated on the drawings as the Tree and Plant Protection Area. The report shall include the following:
   1. A description of each tree to remain indicating its genus and species, condition including any visible damage to the root system or soil within the root zone, tree diameter at breast height (dbh) and approximate height, size and any visible disease, insect infestations and or branch and trunk structural deficiencies.
   2. The report shall note all trees or parts of trees, which are considered a hazard or significant or extreme risk level. Include the International Society of Arboriculture hazard evaluation sheet for each tree, which may reasonably be identified as a potential hazard tree.
   3. Recommendations as to treatment of all insect, disease and structural problems encountered.
   4. Recommendations for fertilizer treatments, if any.
   5. A plan of the site showing the location of all trees included in the report.

B. PRODUCT DATA: Submit manufacturer product data and literature describing all products required by this section to the Owner's Representative for approval. Provide submittal four weeks before the start of any work at the site.

   Note to specifier: *Confirm submittal time is appropriate for project schedule.*

C. QUALIFICATIONS SUBMITTAL: For each applicable person expected to work on the project, provide copies of the qualifications and experience of the Consulting arborist, proof of either the registered Consulting Arborist® (RCA) with American Society of Consulting Arborists or an ISA Board Certified Master Arborist and any required Herbicide/Pesticide license to the Owner's Representative, for review prior to the start of work.

1.11 OBSERVATION OF THE WORK

A. The Owner's Representative may inspect the work at any time.

1.12 PRE-CONSTRUCTION CONFERENCE

A. Schedule a pre - construction meeting with the Owner's Representative at least seven (7) days before beginning work to review any questions the Contractor may have regarding the work, administrative procedures during construction and project work schedule.
   1. The following Contractors shall attend the preconstruction conference:
      a. General Contractor.
      b. Consulting Arborist.
      c. Subcontractor assigned to install Tree and Plant Protection measures.
      d. Earthwork Contractor.
      e. All site utility Contractors that may be required to dig or trench into the soil.
      f. Landscape subcontractor.
      g. Irrigation subcontractor

B. Prior to this meeting, mark all trees and plants to remain and or be removed as described in this specification for review and approval by the Owner's Representative.

1.13 QUALITY ASSURANCE

A. Contractor qualifications:
   1. All pruning, branch tie back, tree removal, root pruning, and fertilizing required by this section shall be performed by or under the direct supervision of ISA Certified Arborist Submit aforementioned individual's qualifications for approval by the Owner's Representative.
   2. All applications of pesticide or herbicide shall be performed by a person maintaining a current state license to apply chemical pesticides valid in the jurisdiction of the project. Submit copies of all required state licensing certificates including applicable chemical applicator licenses.

PART 2 – PRODUCTS

2.1 MULCH

Note to specifier: *Revise this paragraph to reflect regionally available mulch materials or project specific mulch quality or type requirements where appropriate. The coarse grade Mulch specified here is considered superior for its water retention and soil building properties in areas of tree and shrub roots when irrigation is drip, bubblers or flood methods.*

A. Mulch shall be coarse, ground, from tree and woody brush sources. The minimum range of fine particles shall be 3/8 inch or less in size and a maximum size of individual pieces shall be approximately 1 to 1-1/2 inch in diameter and maximum length of approximately 4 to 8 inches. No more that 25% of the total volume shall be fine particles and no more than 20% of total volume be large pieces.
   1. It is understood that Mulch quality will vary significantly from supplier to supplier and region to region. The above requirements may be modified to conform to the source material from locally reliable suppliers as approved by the Owner's Representative.

B. Submit suppliers product data that product meets the requirements and two gallon sample for approval.

2.2 WOOD CHIPS:

Note to specifier**:** *Woodchips if available may be a suitable and more sustainable alternative to other types of Mulch. Consider permitting Mulch or Wood Chips; however be sure to coordinate requirements with the drawings. Remove this paragraph if Wood Chips are not to be permitted.*

A. Wood Chips from an arborist chipping operation with less than 20% by volume green leaves. Chips stockpiled from the tree removal process may be used.

2.3 TREE PROTECTION FENCING:

Note to specifier: *Two fencing options are provided. The more robust chain link fencing is often*

required at urban sites where there are significant conflicts between tree preservation and other work tasks. Amend this specification and the tree protection details to be clear as to the required fencing. Remove the paragraph of the fence type that is not to be used. If both types are to be permitted coordinate with the drawings so that use is correctly identified.

A. PLASTIC MESH FENCE: Heavy - duty orange plastic mesh fencing fabric 48 inches wide. Fencing shall be attached to metal “U” or “T” post driven into the ground of sufficient depth to hold the fabric solidly in place with out sagging. The fabric shall be attached to the post using attachment ties of sufficient number and strength to hold up the fabric without sagging. The Owner’s Representative may request, at any time, additional post, deeper post depths and or additional fabric attachments if the fabric begins to sag, lean or otherwise not present a sufficient barrier to access.

B. CHAIN LINK FENCE: 6 feet tall metal chain link fence set in metal frame panels on movable core drilled concrete blocks of sufficient size to hold the fence erect in areas of existing paving to remain.

C. GATES: For each fence type and in each separate fenced area, provide a minimum of one 3 foot wide gate. Gates shall be lockable. The location of the gates shall be approved by the Owner's Representative.

D. Submit suppliers product data that product meets the requirements for approval.

2.4 TREE PROTECTION SIGN:

A. Heavy-duty cardboard signs, 8.5 inches x 11 inches, white colored background with black 2 inch high or larger letters block letters. The signs shall be attached to the tree protection fence every 50 feet o.c. The tree protection sign shall read “Tree and Plant Protection Area- Keep Out”.

2.5 TREE GROWTH REGULATOR (TGR)

A. Cambistat 25C.

B. Submit suppliers product data that product meets the requirements for approval.

2.6 MATTING

A. Matting for vehicle and work protection shall be heavy duty matting designed for vehicle loading over tree roots, Alturnamats as manufactured by Alturnamats, Inc. Franklin, PA 16323 or approved equal.

B. Submit suppliers product data that product meets the requirements for approval.

2.7 GEOGRID

A. Geogrid shall be woven polyester fabric with PVC coating, Uni-axial or biaxial geogrid, inert to biological degradation, resistant to naturally occurring chemicals, alkalis, acids.
   1. Geogrid shall be Miragrid 2XT as manufactured by Ten Cate Nicolon, Norcross, GA. http://www.tencate.com or approved equal.

B. Submit suppliers product data that product meets the requirements for approval.

2.8 FILTER FABRIC

A. Filter Fabric shall be nonwoven polypropylene fibers, inert to biological degradation and resistant of naturally occurring chemicals, alkalis and acids.
   1. Mirafi 135 N as manufactured by Ten Cate Nicolon, Norcross, GA. http://www.tencate.com or approved equal.

B. Submit suppliers product data that product meets the requirements for approval.

PART 3 – EXECUTION

3.1 SITE EXAMINATION

A. Examine the site, tree, plant and soil conditions. Notify the Owner’s Representative in writing of any conditions that may impact the successful Tree and Plant Protections that is the intent of this section.

3.2 COORDINATION WITH PROJECT WORK

A. The Contractor shall coordinate with all other work that may impact the completion of the work.

B. Prior to the start of Work, prepare a detailed schedule of the work for coordination with other trades.

C. Coordinate the relocation of any irrigation lines currently present on the irrigation plan, heads or the conduits of other utility lines or structures that are in conflict with tree locations. Root balls shall not be altered to fit around lines. Notify the Owner's Representative of any conflicts encountered.

3.3 TREE AND PLANT PROTECTION AREA: The Tree and Plant Protection Area is defined as all areas indicated on the tree protection plan. Where no limit of the Tree and Plant Protection area is defined on the drawings, the limit shall be the drip line (outer edge of the branch crown) of each tree.

3.4 PREPARATION:

A. Prior to the preconstruction meeting, layout the limits of the Tree and Plant Protection Area and then alignments of required Tree and Plant Protection Fencing and root pruning. Obtain the Owner's Representative's approval of the limits of the protection area and the alignment of all fencing and root pruning.

B. Flag all trees and shrubs to be removed by wrapping orange plastic ribbon around the trunk and obtain the Owner's Representative's approval of all trees and shrubs to be removed prior to the start of tree and shrub removal. After approval, mark all trees and shrubs to be removed with orange paint in a band completely around the base of the tree or shrub 4.5 feet above the ground.

C. Flag all trees and shrubs to remain with white plastic ribbon tied completely around the trunk or each tree and on a prominent branch for each shrub. Obtain the Owner's Representative's approval of all trees and shrubs to be remain prior to the start of tree and shrub removal.

D. Prior to any construction activity at the site including utility work, grading, storage of materials, or installation of temporary construction facilities, install all tree protection fencing, Filter Fabric, silt fence, tree protection signs, Geogrid, Mulch and or Wood Chips as shown on the drawings.

3.5 SOIL MOISTURE

A. Volumetric soil moisture level, in all soils within the Tree and Plant Protection Area shall be maintained above permanent wilt point to a depth of at least 8 inches. No soil work or other activity shall be permitted within the Tree and Plant Protection Area when the volumetric soil moisture is above field capacity. The permanent wilt point and field capacity for each type of soil texture shall be defined as follows (numbers indicate percentage volumetric soil moisture).

Soil type	**Permanent wilt point v/v**	**Field capacity v/v**
Sand, Loamy sand, Sandy loam	5-8%	12-18%
Loam, Sandy clay, Sandy clay loam	14-25%	27-36%
Clay loam, Silt loam	11-22%	31-36%
Silty clay, Silty clay loam	22-27%	38-41%

1. Volumetric soil moisture shall be measured with a digital, electric conductivity meter. The meter shall be the Digital Soil Moisture Meter, DSMM500 by General Specialty Tools and Instruments, or approved equivalent meter.

B. The Contractor shall confirm the soil moisture levels with a moisture meter. If the moisture is too high, suspend operations until the soil moisture drains to below field capacity.

3.6 ROOT PRUNING:

A. Prior to any excavating into the existing soil grade within 25 feet of the limit of the Tree and Plant Protection Area or trees to remain, root prune all existing trees to a depth of 24 inches below existing grade in alignments following the edges of the Tree and Plant Protection Area or as directed by the

Owner’s Representative. Root pruning shall be in conformance with ANSI A300 (part 8) latest edition.

1. Using a rock saw, chain trencher or similar trenching device, make a vertical cut within 2 feet of the limit of grading.
2. After completion of the cut, make clean cuts with a lopper, saw or pruner to remove all torn root ends on the tree side of the excavation, and backfill the trench immediately with existing soil, filling all voids.

3.7 INSTALLATION OF GEOGRIDS, FILTER FABRIC, MATTING, WOOD CHIPS AND OR MULCH

A. Install Geogrids, Filter Fabric, matting, Wood Chips and or Mulch in areas and depths shown on the plans and details or as directed by the Owner's representative. In general it is the intent of this specification to provide the following levels of protection:
   1. All areas within the Tree and Plant Protection area provide a minimum of 5 inches of Wood Chips or Mulch.
   2. Areas where foot traffic or storage of lightweight materials is anticipated to be unavoidable provide a layer of Filter Fabric under the 5 inches of Wood Chips or Mulch.
   3. Areas where occasional light vehicle traffic is anticipated to be unavoidable provide a layer of Geogrids under 8 inches of Wood Chips or Mulch.
   4. Areas where heavy vehicle traffic is unavoidable provide a layer of Geogrids under 8 - 12 inches of Wood Chips or Mulch and a layer of matting over the Wood Chips or Mulch.

B. The Owner's Representative shall approve the appropriate level of protection.

C. In the above requirements, light vehicle is defined as a track skid steer with a ground pressure of 4 psi or lighter. A heavy vehicle is any vehicle with a tire or track pressure of greater than 4 psi. Lightweight materials are any packaged materials that can be physically moved by hand into the location. Bulk materials such as soil, or aggregate shall never be stored within the Tree and Plant Protection Area.

3.8 PROTECTION:

A. Protect the Tree and Plant Protection Area at all times from compaction of the soil; damage of any kind to trunks, bark, branches, leaves and roots of all plants; and contamination of the soil, bark or leaves with construction materials, debris, silt, fuels, oils, and any chemicals substance. Notify the Owner’s Representative of any spills, compaction or damage and take corrective action immediately using methods approved by the Owner’s Representative.

3.9 GENERAL REQUIREMENTS AND LIMITATIONS FOR OPERATIONS WITHIN THE TREE AND PLANT PROTECTION AREA:

A. The Contractor shall not engage in any construction activity within the Tree and Plant Protection Area without the approval of the Owner's Representative including: operating, moving or storing equipment; storing supplies or materials; locating temporary facilities including trailers or portable toilets and shall not permit employees to traverse the area to access adjacent areas of the project or use the area for lunch or any other work breaks. Permitted activity, if any, within the Tree and Plant Protection Area maybe indicated on the drawings along with any required remedial activity as listed below.

B. In the event that construction activity is unavoidable within the Tree and Plant Protection Area, notify the Owner’s Representative and submit a detailed written plan of action for approval. The plan shall include: a statement detailing the reason for the activity including why other areas are not suited; a description of the proposed activity; the time period for the activity, and a list of remedial actions that will reduce the impact on the Tree and Plant Protection Area from the activity. Remedial actions shall include but shall not be limited to the following:
   1. In general, demolition and excavation within the drip line of trees and shrubs shall proceed with extreme care either by the use of hand tools, directional boring and or Air Knife excavation where indicated or with other low impact equipment that will not cause damage to the tree, roots or soil.
   2. When encountered, exposed roots, 1 inches and larger in diameter shall be worked around in a manner that does not break the outer layer of the root surface (bark). These roots shall be

covered in Wood Chips and shall be maintained above permanent wilt point at all times. Roots one inch and larger in diameter shall not be cut with out the approval of the owners representative. Excavation shall be tunneled under these roots without cutting them. In the areas where roots are encountered, work shall be performed and scheduled to close excavations as quickly as possible over exposed roots.

3. Tree branches that interfere with the construction may be tied back or pruned to clear only to the point necessary to complete the work. Other branches shall only be removed when specifically indicated by the Owner's Representative. Tying back or trimming of all branches and the cutting of roots shall be in accordance with accepted arboricultural practices (ANSI A300, part 8) and be performed under supervision of the arborist.
4. Matting: Install temporary matting over the Wood Chips or Mulch to the extent indicated. Do not permit foot traffic, scaffolding or the storage of materials within the Tree and Plant Protection Area to occur off of the temporary matting.
5. Trunk Protection: Protect the trunk of each tree to remain by covering it with a ring of 8 foot long 2 inch x 6 - inch planks loosely banded onto the tree with 3 steel bands. Staple the bands to the planks as necessary to hold them securely in place. Trunk protection must by kept in place no longer than 12 months. If construction requires work near a particular tree to continue longer than 12 months, the steel bands shall be inspected every six months and loosened if they are found to have become tight.
6. Air Excavation Tool: If excavation for footings or utilities is required within the Tree and Plant Protection Area, air excavation tool techniques shall be used where practical or as designed on the drawings.
    a. Remove the Wood Chips from an area approximately 18 inches beyond the limits of the hole or trench to be excavated. Cover the Wood Chips for a distance of not less than 15 feet around the limit of the excavation area with Filter Fabric or plastic sheeting to protect the Wood Chips from silt. Mound the Wood Chips so that the plastic slopes towards the excavation.
    b. Using a sprinkler or soaker hose, apply water slowly to the area of the excavation for a period of at least 4 hours, approximately 12 hours prior to the work so that the ground water level is at or near field capacity at the beginning of the work. For excavations that go beyond the damp soil, rewet the soil as necessary to keep soil moisture near field capacity.
    c. Using an air excavation tool specifically designed and manufactured for the intended purpose, and at pressures recommended by the manufacturer of the equipment, fracture the existing soil to the shape and the depths required. Work at rates and using techniques that do not harm tree roots. Air pressure shall be a maximum of 90-100 psi.
        1.) The air excavation tool shall be "Air-Spade" as manufactured by Concept Engineering Group, Inc., Verona, PA (412) 826-8800, or Air Knife as manufactured by Easy Use Air Tools, Inc. Allison Park, Pa (866) 328-5723 or approved equal.
    d. Using a commercial, high-powered vacuum truck if required, remove the soil from the excavation produced by the Air Knife excavation. The vacuum truck should generally operate simultaneously with the hose operator, such that the soil produced is picked up from the excavation hole, and the exposed roots can be observed and not damaged by the ongoing operation. Do not drive the vacuum truck into the Tree and Plant Protection Area unless the area is protected from compaction as approved in advance by the Owner's Representative.
    e. Remove all excavated soil and excavated Wood Chips, and contaminated soil at the end of the excavation.
    f. Schedule the work so that foundations or utility work is completed immediately after the excavation. Do not let the roots dry out. Mist the roots several times during the day. If the excavated area must remain open over night, mist the roots and cover the excavation with black plastic.
    g. Dispose of all soil in a manner that meets local laws and regulations.
    h. Restore soil within the trench as soon as the work is completed. Utilize soil of similar texture to the removed soil and lightly compact with hand tools. Leave soil mounded over the trench to a height of approximately 10% of the trench depth to account for settlement.
    i. Restore any Geogrids, Filter Fabric, Wood Chips or Mulch and or matting that was previously

required for the area.

3.10 TREE REMOVAL:

A. Remove all trees indicated by the drawings and specifications, as requiring removal, in a manner that will not damage adjacent trees or structures or compacts the soil.

B. Remove trees that are adjacent to trees or structures to remain, in sections, to limit the opportunity of damage to adjacent crowns, trunks, ground plane elements and structures.

C. Do not drop trees with a single cut unless the tree will fall in an area not included in the Tree and Plant Protection Area. No tree to be removed within 50 feet of the Tree and Plant Protection Area shall be pushed over or up-rooted using a piece of grading equipment.

D. Protect adjacent paving, soil, trees, shrubs, ground cover plantings and understory plants to remain from damage during all tree removal operations, and from construction operations. Protection shall include the root system, trunk, limbs, and crown from breakage or scarring, and the soil from compaction.

E. Remove stumps and immediate root plate from existing trees to be removed. Grind trunk bases and large buttress roots to a depth of the largest buttress root or at least 18 inches below the top most roots which ever is less and over the area of three times the diameter of the trunk (DBH).
   1. For trees where the stump will fall under new paved areas, grind roots to a total depth of 18 inches below the existing grade. If the sides of the stump hole still have greater than approximately 20% wood visible, continue grinding operation deeper and or wider until the resulting hole has less than 20% wood. Remove all wood chips produced by the grinding operation and back fill in 8 inch layers with controlled fill of a quality acceptable to the site engineer for fill material under structures, compacted to 95% of the maximum dry density standard proctor. The Owner's Representative shall approve each hole at the end of the grinding operation.
   2. In areas where the tree location is to be a planting bed or lawn, remove all woodchips and backfill stump holes with planting soil as defined in Specification Section Planting Soil, in maximum of 12 inch layers and compact to 80 - 85% of the maximum dry density standard proctor.

3.11 PRUNING:

A. Within six months of the estimated date of substantial completion, prune all dead or hazardous branches larger than 2 inch in diameter from all trees to remain.

B. Implement all pruning recommendations found in the arborist report.

C. Prune any low, hanging branches and vines from existing trees and shrubs that overhang walks, streets and drives, or parking areas as follows:
   1. Walks - within 8 feet vertically of the proposed walk elevation.
   2. Parking areas - within 12 feet vertically of the proposed parking surface elevation.
   3. Streets and drives - within 14 feet vertically of the proposed driving surface elevation.

D. All pruning shall be done in accordance with ANSI A300 (part 1), ISA BMP Tree Pruning (latest edition, and the "Structural Pruning: A Guide for the Green Industry", Edward Gilman, Brian Kempf, Nelda Matheny and Jim Clark, 2013 Urban Tree Foundation, Visalia CA.

E. Perform other pruning task as indicated on the drawings or requested by the Owner's Representative.

F. Where tree specific disease vectors require, sterilize all pruning tools between the work in individual trees.

3.12 TREE GROWTH REGULATOR INJECTION (TGR)

Note to specifier: *Confirm that Tree Growth Regulator is appropriate for the project. If not remove this paragraph and the TGR product in Part 2. If appropriate, be sure that the specific trees to be treated are labeled on the Tree and Plant Protection Plan. There is little data on the effectiveness of*

TGR treatments. Use you own judgment on including it in the requirements.

A. At the start of the construction contract period, treat all trees, indicated on the Plan, with Tree Growth Regulator at recommended rates, time of year and methods indicated by the product distributor.

3.13 WATERING

A. The Contractor shall be fully responsible to ensure that adequate water is provided to all plants to be preserved during the entire construction period. Adequate water is defined to be maintaining soil moisture above the permanent wilt point to a depth of 8 inches or greater.

B. The Contractor shall adjust the automatic irrigation system, if available, and apply additional water, using hoses or water tanks as required.

C. Periodically test the moisture content in the soil within the root zone to determine the water content.

3.14 WEED REMOVAL

A. During the construction period, control any plants that seed in and around the fenced Tree and Plant Protection area at least three times a year.
   1. All plants that are not shown on the planting plan or on the Tree and Plant Protection Plan to remain shall be considered as weeds.

B. At the end of the construction period provide one final weeding of the Tree and Plant Protection Area.

3.15 INSECT AND DISEASE CONTROL

A. Monitor all plants to remain for disease and insect infestations during the entire construction period. Provide all disease and insect control required to keep the plants in a healthy state using the principles of Integrated Plant Management (IPM). All pesticides shall be applied by a certified pesticide applicator.

3.16 CLEAN-UP

A. During tree and plant protection work, keep the site free of trash, pavements reasonably clean and work area in an orderly condition at the end of each day. Remove trash and debris in containers from the site no less than once a week.
   1. Immediately clean up any spilled or tracked soil, fuel, oil, trash or debris deposited by the Contractor from all surfaces within the project or on public right of ways and neighboring property.

B. Once tree protection work is complete, wash all soil from pavements and other structures. Ensure that Mulch is confined to planting beds.

C. Make all repairs to grades, ruts, and damage to the work or other work at the site.

D. Remove and dispose of all excess Mulch, Wood Chips, packaging, and other material brought to the site by the Contractor.

3.17 REMOVAL OF FENCING AND OTHER TREE AND PLANT PROTECTION

A. At the end of the construction period or when requested by the Owner's Representative remove all fencing, Wood Chips or Mulch, Geogrids and Filter Fabric, trunk protection and or any other Tree and Plant Protection material.

3.18 DAMAGE OR LOSS TO EXISTING PLANTS TO REMAIN

Note to specifier: *This clause is not written to cover high value heritage trees. A specification to address high value heritage trees should be added here if any exist on the project.*

A. Any trees or plants designated to remain and which are damaged by the Contractor shall be replaced in kind by the Contractor at their own expense. Trees shall be replaced with a tree of similar species and of equal size or 6 inch caliper which ever is less. Shrubs shall be replaced with a plant of similar species and equal size or the largest size plants reasonably available which ever is less. Where replacement plants are to be less than the size of the plant that is damaged, the Owner's

Representative shall approve the size and quality of the replacement plant.

1. All trees and plants shall be installed per the requirements of Specification Section Planting.

B. Plants that are damaged shall be considered as requiring replacement or appraisal in the event that the damage affects more than 25 % of the crown, 25% of the trunk circumference, or root protection area, or the tree is damaged in such a manner that the tree could develop into a potential hazard. Trees and shrubs to be replaced shall be removed by the Contractor at his own expense.

1. The Owner's Representative may engage an independent arborist to assess any tree or plant that appears to have been damaged to determine their health or condition.

C. Any tree that is determined to be dead, damaged or potentially hazardous by the Owner's arborist and upon the request of the Owner's Representative shall be immediately removed by the Contractor at no additional expense to the owner. Tree removal shall include all clean up of all wood parts and grinding of the stump to a depth sufficient to plant the replacement tree or plant, removal of all chips from the stump site and filling the resulting hole with topsoil.

D. Any remedial work on damaged existing plants recommended by the consulting arborist shall be completed by the Contractor at no cost to the owner. Remedial work shall include but is not limited to: soil compaction remediation and vertical mulching, pruning and or cabling, insect and disease control including injections, compensatory watering, additional mulching, and could include application tree growth regulators (TGR).

E. Remedial work may extend up to two years following the completion of construction to allow for any requirements of multiple applications or the need to undertake applications at required seasons of the year.

END OF SECTION 015639

ATTACHMENT

C.3.j.ii. Early Implementation of Green Infrastructure Projects

Guidance for Identifying Green Infrastructure Potential in Municipal Capital Improvement Program Projects

BASMAA Development Committee

Guidance for Identifying Green Infrastructure Potential
in Municipal Capital Improvement Program Projects
May 6, 2016

Background

In the recently reissued Municipal Regional Stormwater Permit ("MRP 2.0"), Provision C.3.j. requires Permittees to develop and implement Green Infrastructure Plans to reduce the adverse water quality impacts of urbanization on receiving waters over the long term. Provisions C.11 and C.12 require the Permittees to reduce discharges of Mercury and PCBs, and portion of these load reductions must be achieved by implementing Green Infrastructure. Specifically, Permittees collectively must implement Green Infrastructure to reduce mercury loading by 48 grams/year and PCB loading by 120 grams/year by 2020, and plan for substantially larger reductions in the following decades. Green Infrastructure on both public and private land will help to meet these load reduction requirements, improve water quality, and provide multiple other benefits as well. Implementation on private land is achieved by implementing stormwater requirements for new development and redevelopment (Provision C.3.a. through Provision C.3.i.). These requirements were carried forward, largely unchanged, from MRP 1.0.

MRP 2.0 defines Green Infrastructure as:

> Infrastructure that uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water.

In practical terms, most green infrastructure will take the form of diverting runoff from existing streets, roofs, and parking lots to one of two stormwater management strategies:

1. Dispersal to vegetated areas, where sufficient landscaped area is available and slopes are not too steep.
2. LID (bioretention and infiltration) facilities, built according to criteria similar to those currently required for regulated private development and redevelopment projects under Provision C.3.

In some cases, the use of tree-box-type biofilters may be appropriate[1]. In other cases, where conditions are appropriate, existing impervious pavements may be removed and replaced with pervious pavements.

In MRP 2.0, Provision C.3.j. includes requirements for Green Infrastructure planning and implementation. Provision C.3.j. has two main elements to be implemented by municipalities:

1. Preparation of a Green Infrastructure Plan for the inclusion of LID drainage design into storm drain infrastructure on public and private land, including streets, roads, storm drains, etc.
2. Early implementation of green infrastructure projects ("no missed opportunities"),

This guidance addresses the second of these requirements. The intent of the "no missed opportunities" requirement is to ensure that no major infrastructure project is built without assessing the opportunity for incorporation of green infrastructure features.

Provision C.3.j.ii. requires that each Permittee prepare and maintain a list of green infrastructure projects, public and private, that are already planned for implementation during the permit term (not including C.3-regulated projects), and infrastructure projects planned for

[1] Standard proprietary tree-box-type biofilters are considered to be non-LID treatment and will only be allowed under certain circumstances. Guidance on use and sizing of these facilities will be provided in a separate document.

implementation during the permit term that have potential for green infrastructure measures. The list must be submitted with each Annual Report, including:

> "… a summary of how each public infrastructure project with green infrastructure potential will include green infrastructure measures to the maximum extent practical during the permit term. For any public infrastructure project where implementation of green infrastructure measures is not practicable, submit a brief description for the project and the reasons green infrastructure measures were impracticable to implement".

This requirement has no specified start date; "during the permit term" means beginning January 1, 2016 and before December 31, 2020. The first Annual Report submittal date will be September 30, 2016.

Note that this guidance primarily addresses the review of proposed or planned public projects for green infrastructure opportunities. The Permittee may also be aware of proposed or planned private projects, not subject to LID treatment requirements, that may have the opportunity to incorporate green infrastructure. These should be addressed in the same way as planned public projects, as described below.

Procedure for Review of Planned Public Projects and Annual Reporting

The municipality's Capital Improvement Program (CIP) project list provides a good starting point for review of proposed public infrastructure projects. Review of other lists of public infrastructure projects, such as those proposed within separately funded special districts (e.g., lighting and landscape districts, maintenance districts, and community facilities districts), may also be appropriate. This section describes a two-part procedure for conducting the review.

Part 1 – Initial Screening

The first step in reviewing a CIP or other public project list is to screen out certain types of projects from further consideration. For example, some projects (e.g., interior remodels, traffic signal replacement) can be readily identified as having no green infrastructure potential. Other projects may appear on the list with only a title, and it may be too early to identify whether green infrastructure could be included. Still others have already progressed past the point where the design can reasonably be changed (this will vary from project to project, depending on available budget and schedule).

Some "projects" listed in a CIP may provide budget for multiple maintenance or minor construction projects throughout the jurisdiction or a portion of the jurisdiction, such as a tree planting program, curb and sidewalk repair/upgrade, or ADA curb/ramp compliance. It is recommended that these types of projects not be included in the review process described herein. The priority for incorporating green infrastructure into these types of projects needs to be assessed as part of the Permittees' development of Green Infrastructure Plans, and standard details and specifications need to be developed and adopted. During this permit term, Permittees will evaluate select projects, project types, and/or groups of projects as case studies and develop an approach as part of Green Infrastructure planning.

The projects removed through the initial screening process do not need to be reported to the Water Board in the Permittee's Annual Report. However, the process should be documented and records kept as to the reason the project was removed from further consideration. Note that projects that were determined to be too early to assess will need to be reassessed during the next fiscal year's review.

The following categories of projects may be screened out of the review process in a given fiscal year:

1. **Projects with No Potential -** The project is identified in initial screening as having no green infrastructure potential based on the type of project. For example, the project does not include any exterior work. Attachment 1 provides a suggested list of such projects that Permittees may use as a model for their own internal process.

2. **Projects Too Early to Assess –** There is not yet enough information to assess the project for green infrastructure potential, or the project is not scheduled to begin design within the permit term (January 2016 – December 2020). If the project is scheduled to begin within the permit term, an assessment will be conducted if and when the project moves forward to conceptual design.
3. **Projects Too Late to Change –** The project is under construction or has moved to a stage of design in which changes cannot be made. The stage of design at which it is too late to incorporate green infrastructure measures varies with each project, so a "percent-complete" threshold has not been defined. Some projects may have funding tied to a particular conceptual design and changes cannot be made even early in the design process, while others may have adequate budget and time within the construction schedule to make changes late in the design process. Agencies will need to make judgments on a case-by-case basis.
4. **Projects Consisting of Maintenance or Minor Construction Work Orders –** The "project" includes budgets for multiple maintenance or minor construction work orders throughout the jurisdiction or a portion of the jurisdiction. These types of projects will not be individually reviewed for green infrastructure opportunity but will be considered as part of a municipality's Green Infrastructure Plan.

Part 2 – Assessment of Green Infrastructure Potential

After the initial screening, the remaining projects either already include green infrastructure or will need to go through an assessment process to determine whether or not there is potential to incorporate green infrastructure. A recommended process for conducting the assessment is provided later in this guidance. As a result of the assessment, the project will fall into one of the following categories with associated annual reporting requirements. Attachment 2 provides the relevant pages of the FY 15-16 Annual Report template for reference.

- **Project is a C.3-regulated project and will include LID treatment.**

  Reporting: Follow current C.3 guidance and report the project in Table C.3.b.iv.(2) of the Annual Report for the fiscal year in which the project is approved.

- **Project already includes green infrastructure and is funded**.

  Reporting: List the project in "Table B-Planned Green Infrastructure Projects" in the Annual Report, indicate the planning or implementation status, and describe the green infrastructure measures to be included.

- **Project may have green infrastructure potential** pending further assessment of feasibility, incremental cost, and availability of funding.

  Reporting: If the feasibility assessment is not complete and/or funding has not been identified, list the project in "Table A-Public Projects Reviewed for Green Infrastructure" in the Annual Report. In the "GI Included?" column, state either "TBD" (to be determined) if the assessment is not complete, or "Yes" if it has been determined that green infrastructure is feasible. In the rightmost column, describe the green infrastructure measures considered and/or proposed, and note the funding and other contingencies for inclusion of green infrastructure in the project. Once funding for the project has been identified, the project should be moved to "Table B-Planned Green Infrastructure Projects" in future Annual Reports.

- **Project does not have green infrastructure potential.** A project-specific assessment has been completed, and Green Infrastructure is impracticable.

  Reporting: In the Annual Report, list the project in "Table A-Public Projects Reviewed for Green Infrastructure". In the "GI Included?" column, state "No." Briefly state the reasons for the determination in the rightmost column. Prepare more detailed documentation of the reasons for the determination and keep it in the project files.

Process for Assessing Green Infrastructure Potential of a Public Infrastructure Project

Initial Assessment of Green Infrastructure Potential

Consider opportunities that may be associated with:

- Alterations to roof drainage from existing buildings
- New or replaced pavement or drainage structures (including gutters, inlets, or pipes)
- Concrete work
- Landscaping, including tree planting
- Streetscape improvements and intersection improvements (other than signals)

Step 1: Information Collection/Reconnaissance

For projects that include alterations to building drainage, identify the locations of roof leaders and downspouts, and where they discharge or where they are connected to storm drains.

For street and landscape projects:

- Evaluate potential opportunities to substitute pervious pavements for impervious pavements.
- Identify and locate drainage structures, including storm drain inlets or catch basins.
- Identify and locate drainage pathways, including curb and gutter.

Identify landscaped areas and paved areas that are adjacent to, or down gradient from, roofs or pavement. These are potential facility locations. *If there are any such locations, continue to the next step.* Note that the project area boundaries may be, but are not required to be, expanded to include potential green infrastructure facilities.

Step 2: Preliminary Sizing and Drainage Analysis

Beginning with the potential LID facility locations that seem most feasible, identify possible pathways to direct drainage from roofs and/or pavement to potential LID facility locations—by sheet flow, valley gutters, trench drains, or (where gradients are steeper) via pipes, based on existing grades and drainage patterns. Where existing grades constrain natural drainage to potential facilities, the use of pumps may be considered (as a less preferable option).

Delineate (roughly) the drainage area tributary to each potential LID facility location. Typically, this requires site reconnaissance, which may or may not include the use of a level to measure relative elevations.

Use the following preliminary sizing factor (facility area/tributary area) for the potential facility location and determine which of the following could be constructed within the existing right-of-way or adjacent vacant land. Note that these sizing factors are guidelines (not strict rules, but targets):

- Sizing factor ≥ 0.5 for dispersal to landscape or pervious pavement[2] (i.e., a maximum 2:1 ratio of impervious area to pervious area)
- Sizing factor ≥ 0.04 for bioretention
- Sizing factor ≥ 0.004 (or less) for tree-box-type biofilters

For bioretention facilities requiring underdrains and tree-box-type biofilters, note if there are potential connections from the underdrain to the storm drain system (typically 2.0 feet below soil surface for bioretention facilities, and 3.5 feet below surface for tree-box-type biofilters).

[2] Note that pervious pavement systems are typically designed to infiltrate only the rain falling on the pervious pavement itself, with the allowance for small quantities of runoff from adjacent impervious areas. If significant runoff from adjacent areas is anticipated, preliminary sizing considerations should include evaluation of the depth of drain rock layer needed based on permeability of site soils.

If, in this step, you have confirmed there may be feasible potential facility locations, *continue to the next step*.

Step 3: Barriers and Conflicts

Note that barriers and conflicts do not necessarily mean implementation is infeasible; however, they need to be identified and taken into account in future decision-making, as they may affect cost or public acceptance of the project.

Note issues such as:

- Confirmed or potential conflicts with subsurface utilities
- Known or unknown issues with property ownership, or need for acquisition or easements
- Availability of water supply for irrigation, or lack thereof
- Extent to which green infrastructure is an "add on" vs. integrated with the rest of the project

Step 4: Project Budget and Schedule

Consider sources of funding that may be available for green infrastructure. It is recognized that lack of budget may be a serious constraint for the addition of green infrastructure in public projects. For example, acquisition of additional right-of-way or easements for roadway projects is not always possible. Short and long term maintenance costs also need to be considered, and jurisdictions may not have a funding source for landscape maintenance, especially along roadways. The objective of this process is to identify opportunities for green infrastructure, so that if and when funding becomes available, implementation may be possible.

Note any constraints on the project schedule, such as a regulatory mandate to complete the project by a specific date, grant requirements, etc., that could complicate aligning a separate funding stream for the green infrastructure element. Consider whether cost savings could be achieved by integrating the project with other planned projects, such as pedestrian or bicycle safety improvement projects, street beautification, etc., if the schedule allows.

Step 5: Assessment—Does the Project Have Green Infrastructure Potential?

Consider the ancillary benefits of green infrastructure, including opportunities for improving the quality of public spaces, providing parks and play areas, providing habitat, urban forestry, mitigating heat island effects, aesthetics, and other valuable enhancements to quality of life.

Based on the information above, would it make sense to include green infrastructure into this project—*if funding were available for the potential incremental costs of including green infrastructure in the project?* Identify any additional conditions that would have to be met for green infrastructure elements to be constructed consequent with the project.

Attachment 1

Examples of Projects with No Potential for Green Infrastructure

- ☐ Projects with no exterior work (e.g., interior remodels)
- ☐ Projects involving exterior building upgrades or equipment (e.g., HVAC, solar panels, window replacement, roof repairs and maintenance)
- ☐ Projects related to development and/or continued funding of municipal programs or related organizations
- ☐ Projects related to technical studies, mapping, aerial photography, surveying, database development/upgrades, monitoring, training, or update of standard specs and details
- ☐ Construction of new streetlights, traffic signals or communication facilities
- ☐ Minor bridge and culvert repairs/replacement
- ☐ Non-stormwater utility projects (e.g., sewer or water main repairs/replacement, utility undergrounding, treatment plant upgrades)
- ☐ Equipment purchase or maintenance (including vehicles, street or park furniture, equipment for sports fields and golf courses, etc.)
- ☐ Irrigation system installation, upgrades or repairs

Attachment 2

Excerpts from the C.3 Section of the FY 15-16 Annual Report Template:
Tables for Reporting C.3-Regulated Projects and Green Infrastructure Projects

C.3.b.iv.(2) ►Regulated Projects Reporting Table (part 1) – Projects Approved During the Fiscal Year Reporting Period

Project Name Project No.	Project Location[9], Street Address	Name of Developer	Project Phase No.[10]	Project Type & Description[11]	Project Watershed[12]	Total Site Area (Acres)	Total Area of Land Disturbed (Acres)	Total New Impervious Surface Area (ft^2)[13]	Total Replaced Impervious Surface Area (ft^2)[14]	Total Pre-Project Impervious Surface Area[15](ft^2)	Total Post-Project Impervious Surface Area[16](ft^2)
Private Projects											
Public Projects											

Comments:

Guidance: If necessary, provide any additional details or clarifications needed about listed projects in this box. Do not leave any cells blank.

[9]Include cross streets
[10]If a project is being constructed in phases, indicate the phase number and use a separate row entry for each phase. If not, enter "NA".
[11]Project Type is the type of development (i.e., new and/or redevelopment). Example descriptions of development are: 5-story office building, residential with 160 single-family homes with five 4-story buildings to contain 200 condominiums, 100 unit 2-story shopping mall, mixed use retail and residential development (apartments), industrial warehouse.
[12]State the watershed(s) in which the Regulated Project is located. Downstream watershed(s) may be included, but this is optional.
[13]All impervious surfaces added to any area of the site that was previously existing pervious surface.
[14]All impervious surfaces added to any area of the site that was previously existing impervious surface.
[15]For redevelopment projects, state the pre-project impervious surface area.
[16]For redevelopment projects, state the post-project impervious surface area.

C.3.b.iv.(2) ►Regulated Projects Reporting Table (part 2) – Projects Approved During the Fiscal Year Reporting Period (public projects)

Project Name Project No.	Approval Date[29]	Date Construction Scheduled to Begin	Source Control Measures[30]	Site Design Measures[31]	Treatment Systems Approved[32]	Operation & Maintenance Responsibility Mechanism[33]	Hydraulic Sizing Criteria[34]	Alternative Compliance Measures[35/36]	Alternative Certification[37]	HM Controls[38/39]
Public Projects										

Comments:

Guidance: If necessary, provide any additional details or clarifications needed about listed projects in this box. Note that MRP Provision C.3.c. contains specific requirements for LID site design and source control measures, as well as treatment measures, for all Regulated Projects. Entries in these columns should not be "None" or "NA". Do not leave any cells blank.

[29]For public projects, enter the plans and specifications approval date.
[30]List source control measures approved for the project. Examples include: properly designed trash storage areas; storm drain stenciling or signage; efficient landscape irrigation systems; etc.
[31]List site design measures approved for the project. Examples include: minimize impervious surfaces; conserve natural areas, including existing trees or other vegetation, and soils; construct sidewalks, walkways, and/or patios with permeable surfaces, etc.
[32]List all approved stormwater treatment system(s) to be installed onsite or at a joint stormwater treatment facility (e.g., flow through planter, bioretention facility, infiltration basin, etc.).
[33]List the legal mechanism(s) (e.g., maintenance plan for O&M by public entity, etc…) that have been or will be used to assign responsibility for the maintenance of the post-construction stormwater treatment systems.
[34]See Provision C.3.d.i. "Numeric Sizing Criteria for Stormwater Treatment Systems" for list of hydraulic sizing design criteria. Enter the corresponding provision number of the appropriate criterion (i.e., 1.a., 1.b., 2.a., 2.b., 2.c., or 3).
[35]For Alternative Compliance at an offsite location in accordance with Provision C.3.e.i.(1), on a separate page, give a discussion of the alternative compliance site including the information specified in Provision C.3.b.v.(1)(m)(i) for the offsite project.
[36]For Alternative Compliance by paying in-lieu fees in accordance with Provision C.3.e.i.(2), on a separate page, provide the information specified in Provision C.3.b.v.(1)(m)(ii) for the Regional Project.
[37]Note whether a third party was used to certify the project design complies with Provision C.3.d.
[38]If HM control is not required, state why not.
[39]If HM control is required, state control method used (e.g., method to design and size device(s) or method(s) used to meet the HM Standard, and description of device(s) or method(s) used, such as detention basin(s), biodetention unit(s), regional detention basin, or in-stream control).

C.3.j.ii.(2) ► Table A - Public Projects Reviewed for Green Infrastructure

Project Name and Location[43]	Project Description	Status[44]	GI Included?[45]	Description of GI Measures Considered and/or Proposed or Why GI is Impracticable to Implement[46]
EXAMPLE: Storm drain retrofit, Stockton and Taylor	Installation of new storm drain to accommodate the 10-yr storm event	Beginning planning and design phase	TBD	Bioretention cells (i.e., linear bulb-outs) will be considered when street modification designs are incorporated

C.3.j.ii.(2) ► Table B - Planned Green Infrastructure Projects

Project Name and Location[47]	Project Description	Planning or Implementation Status	Green Infrastructure Measures Included
EXAMPLE: Martha Gardens Green Alleys Project	Retrofit of degraded pavement in urban alleyways lacking good drainage	Construction completed October 17, 2015	The project drains replaced concrete pavement and existing adjacent structures to a center strip of pervious pavement and underlying infiltration trench.

[43] List each public project that is going through your agency's process for identifying projects with green infrastructure potential.
[44] Indicate status of project, such as: beginning design, under design (or X% design), projected completion date, completed final design date, etc.
[45] Enter "Yes" if project will include GI measures, "No" if GI measures are impracticable to implement, or "TBD" if this has not yet been determined.
[46] Provide a summary of how each public infrastructure project with green infrastructure potential will include green infrastructure measures to the maximum extent practicable during the permit term. If review of the project indicates that implementation of green infrastructure measures is not practicable, provide the reasons why green infrastructure measures are impracticable to implement.
[47] List each planned (and expected to be funded) public and private green infrastructure project that is not also a Regulated Project as defined in Provision C.3.b.ii. Note that funding for green infrastructure components may be anticipated but is not guaranteed to be available or sufficient.

ATTACHMENT

C.3.j.iii. Participate in Processes to Promote Green Infrastructure

Scope of Work – *Urban Greening Bay Area*

B A S M A A

Urban Greening Bay Area
Scope of Work

Introduction: The Bay Area Stormwater Management Agencies Association (BASMAA) is contracting with the Association of Bay Area Governments (ABAG)/San Francisco Estuary Partnership (SFEP) to manage and execute the Green Infrastructure Roundtable and Design Charrette elements of the Urban Greening Bay Area project funded by the US EPA's San Francisco Bay Water Quality Improvement Fund 2015 grant program.

Task 1 – Task Management
Subcontract with qualified consultants to assist with the performance of the listed tasks. Coordinate with SFEP, consultants, and partner cities (San Mateo and Sunnyvale) to ensure the tasks are completed on time and on budget. Submit quarterly reports and invoices, information for administrative and financial reports prepared by SFEP (e.g., FFR, MBE/WBE utilization, progress reports, final report), and deliverables as completed.

Task 1. Deliverables
A. Quarterly Reports and Invoices
B. Information for administrative and financial reports

Task 2 – Regional Roundtable
Organize and staff a two year Green Infrastructure Roundtable process, with work groups as needed, to identify and develop a list of recommendations for integrating green infrastructure and stormwater management funding and investments with future climate change and transportation investments within the region. The Roundtable will include convening up to 12 meetings with local, regional, and state stakeholders, agencies, elected officials, and staff to produce draft and final task reports that will identify and recommend possible legislative fixes, agency agreements, consolidated funding mechanisms, and other means and actions as appropriate. The Roundtable is envisioned as a two year effort using innovative participatory processes that will include key experts, regulators, decision-makers, and other stakeholders to share information, solicit and discuss ideas and solutions, and to identify next steps (i.e., a roadmap), which will be summarized in the draft and final task reports.

Task 2a: Planning. Build a task team of BASMAA, SFEP, US EPA, the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), and municipal representatives, as appropriate, to further identify goals, desired outcomes, meeting formats, schedule, and Roundtable participants. Prepare a project briefing sheet, including statement of purpose and summary of tasks and schedule, fact sheets, or other outreach information to help introduce the task to key stakeholders and encourage participation. Conduct informational interviews as an initial step to assist in designing the Roundtable process, and prepare interview summaries. Prepare a Draft and Final Roundtable Strategy that describes the approach and plan for conducting Task 2.

In addition to the task team, an advisory team may be established of high-level stakeholders that may be key to achieving task goals (see Task 2c). Schedule meeting locations and dates. Identify and subcontract with partners and technical experts, as appropriate. Develop a list of key experts, regulators, decision-makers, and other stakeholders to invite to the various Roundtable meetings and send out invitations.

Task 2b: Roundtable Meetings. Convene up to 12 meetings with key agency stakeholders, interested environmental/policy organizations, and technical experts. The meeting presentations and discussions will be summarized in the draft and final task reports that will serve as a roadmap for needed next steps to integrate green infrastructure and stormwater management funding and programs with future climate change and transportation investments in the Bay Area. The goals of the meetings are to:

- Educate participants on the drivers for a long-term distributed green infrastructure approach for meeting stormwater regulatory requirements;
- Illustrate the challenges in funding such an approach strictly from a stormwater perspective; with a particular emphasis to:
    - Quantify the numerous green infrastructure benefits beyond water quality improvement;
    - Demonstrate the ways green infrastructure can be effectively integrated with active transportation investments intended to achieve greenhouse gas emission reductions and climate change adaptation;
    - Highlight the current barriers and challenges to such an integrated approach from the perspective of planning, design and implementation; and,
    - Develop recommendations on how to effectively integrate green infrastructure with these future transportation and stormwater management infrastructure investments.

Task 2c: Expert Input. Identify key experts knowledgeable about green infrastructure, stormwater management, and climate change and transportation funding and investments. Work with experts on quantification of benefits and innovative finance, including identification of tools. Solicit experts to participate in appropriate Roundtable meetings/forums to apply their expertise and help problem solve particular issues key to achieving task goals.

Task 2d: Roundtable Report. Draft a comprehensive report on Task 2, including a roadmap for integrating green infrastructure and stormwater management funding and programs with future climate change and transportation investments in the Bay Area. The roadmap will identify key policies, documents, legislation, agencies, and specific actions needed to effectively integrate and fund green infrastructure and stormwater management with transportation programs and funding mechanisms. The intended audience includes entities that play a role in implementing solutions, and is expected to include the State legislature, the Metropolitan Transportation Commission, ABAG, the Strategic Growth Council, the Department of Water Resources, the State Water Resources Control Board and SFBRWQCB, county congestion management agencies, and municipal stormwater management agencies and associations.

Task 2. Deliverables

A. Outreach Information
B. Interview Summaries
C. Draft and Final Roundtable Strategy
    - Outline
    - Draft Strategy
    - Final Strategy
D. Meeting Agendas, Meeting Summaries, and Lists of Meeting Attendees
E. Draft and Final Roundtable Report (i.e., roadmap)
    - Outline
    - 1st Draft Report
    - 2nd Draft Report
    - Final Report

Task 3 – Design Charrette

Coordinate with the cities of Sunnyvale and San Mateo to conduct a Bay Area design charrette to develop cost-effective and innovative "standard" designs for integrating green infrastructure with bicycle and pedestrian improvements at roadway intersections. The overall goal of developing standardized, transferable designs is to make progress in addressing the high cost of design, implementation, operations, and maintenance that inhibits the widespread use of green infrastructure and LID features. The charrette will utilize actual intersection locations in San Mateo and Sunnyvale that are as representative as possible of the common features of road segments that make up intersections found throughout Bay Area cities. Charrette participants will be solicited by BASMAA and will include multiple representatives, including contractors, engineers, landscape architects, plant specialists, and city transportation engineers and planners, and design, construction management, and operations and maintenance staff. Final designs will be constructed at the San Mateo and Sunnyvale locations to verify costs and serve as demonstration projects for other agencies throughout the Bay Area.

Task 3a: Charrette Pre-Coordination. Convene advisory committee of SFEP, BASMAA, US EPA, and San Mateo/Sunnyvale representatives. Purpose of the committee will be to provide advice on design of the charrette. The grant Project Team may serve as the advisory committee on this task.

Task 3b: Site Identification. Coordinate with San Mateo and Sunnyvale staffs to identify intersections in those cities with common features of road segments with a focus on characterizing typical stormwater management and active transportation scenarios, such as parallel vs. angled parking, pedestrian bulbouts, storm drain inlet locations, presence or absence of bike lanes, etc. Estimate the relative frequency of occurrence of the road segment features in Bay Area cities. Summarize the results of this task in a technical memorandum.

Task 3c: Call for Charrette Participants. Issue a Request for Qualifications (RFQ) from contractors and engineering/landscape architecture design firms identifying individuals interested in participating in the design charrette and providing statements of qualifications (SOQs).

Task 3d: Select Charrette Panel. Grantee representatives will perform an SOQ review process that may include interviews to select a diverse design panel that will participate in the design charrette, with the goal to have representation from individuals throughout the design, construction, and operations and maintenance phases of projects.

Task 3e: Site Visits/Information Compilation. Convene charrette participants to tour the San Mateo and Sunnyvale site locations and identify necessary design information to be provided by cities to enable the charrette to proceed. Cities will then compile the necessary information.

Task 3f: Design Charrette. Host a design charrette event, at which participants will be educated on the overall goals and desired outcomes of the process, the group will develop, discuss, and evaluate various design alternatives to identify the most cost-effective integrated solution. Outputs will be transferable design details that can be used by all agencies.

Task 3g: Final Designs Support. Provide outputs and relevant related information from Task 3f to San Mateo and Sunnyvale. Cities will work with the design charrette team to finalize the designs to 100% designs with necessary plans, specifications, and cost estimates in preparation for bidding.

Task 3h: Bidding and Construction. San Mateo and Sunnyvale will initiate and manage bid processes for the final designs, award contracts to winning bidders, issue notices-to-proceed, and manage construction.

Task 3i: Charrette Summary. BASMAA and SFEP will develop an electronic summary for web posting of the charrette results, final designs, photos of constructed projects, and lessons learned. Package and distribute designs and standard details to Bay Area municipal and regional governments to support future planning and implementation efforts.

Task 3j: Outreach. BASMAA and SFEP will perform outreach to generate interest and participation in the charrette, generate press coverage of the process, final designs, and constructed projects, as well as post-charrette debriefs, potentially through conference or other meeting presentations.

Task 3. Deliverables

A. Site Identification Technical Memorandum
B. Information Compilations
C. Design Details
D. Charrette Summary
    - Draft Summary
    - Final Summary
E. Outreach Presentation

ATTACHMENT

C.3.j.iii. Participate in Processes to Promote Green Infrastructure

BASMAA comments to the Air Resources Board on the Urban Greening and Green Infrastructure Section of the Natural and Working Lands Discussion Paper

Alameda Countywide Clean Water Program

Contra Costa Clean Water Program

Fairfield-Suisun Urban Runoff Management Program

Marin County Stormwater Pollution Prevention Program

Napa County Stormwater Pollution Prevention Program

San Mateo Countywide Water Pollution Prevention Program

Santa Clara Valley Urban Runoff Pollution Prevention Program

Sonoma County Water Agency

Vallejo Sanitation and Flood Control District

B A S M A A

May 3, 2016

Mary Nichols, Chair
Air Resources Board
1001 I St.
Sacramento, CA 95814

Subject: Comments on the Urban Greening and Green Infrastructure Section of the Natural and Working Lands Discussion Paper

Dear Ms. Nichols:

On behalf of the Bay Area Stormwater Management Agencies Association (BASMAA)[1] thank you for the opportunity to provide comments on the Urban Greening and Green Infrastructure Section of the Natural and Working Lands Discussion Paper. Below are some general comments followed by comments on the discussion topics and questions at the end of the Discussion Paper. The main purpose for our commenting is to point out the many natural linkages between stormwater quality management, transportation planning, greenhouse gas reductions, and climate change mitigation strategies. And having recognized those linkages, to suggest actions that would take advantage of those linkages to effect the goals of California's Climate Change Scoping Plan.

General Comments:

Green infrastructure (GI) has a direct connection with water, both through stormwater capture, treatment, and infiltration, and recharging groundwater and stream flows. GI is also directly connected to transportation as a means of treating polluted runoff from roadways, which are the primary surface conveyance system for stormwater runoff. Transportation infrastructure and vehicles have two primary environmental impacts: 1) air quality impacts through vehicle emissions, and 2) water quality impacts from stormwater runoff. As such, GI should be directly incorporated into both the water and transportation sectors, with sector-specific goals and objectives adopted in regard to GI's connection with both.

Quantitative Targets Questions:

Stormwater management is likely the primary driver for implementing green infrastructure in California in response to municipal stormwater permit mandates adopted by the State and Regional Water Boards. As such, it may be most appropriate to establish targets connected to stormwater management requirements, with secondary targets related to issues such as urban heat island reduction or carbon sequestration. It may be appropriate to establish specific targets for pollutant removal, greened acreage, treated acres of roadway, and/or stormwater volumes captured.

Bay Area

Stormwater Management

Agencies Association

P.O. Box 2385

Menlo Park, CA 94026

510.622.2326

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[1] BASMAA is a 501(c)(3) non-profit organization comprised of the municipal stormwater programs in the San Francisco Bay Area representing 100 agencies, including 85 cities and towns, 8 counties, and 7 special districts. BASMAA focuses on regional challenges and opportunities to improve the quality of stormwater flowing to our local creeks, the Delta, San Francisco Bay, and the Pacific Ocean.

Stormwater management via green infrastructure is already being mandated throughout the state via municipal stormwater permits. Green infrastructure, in the form of Low Impact Development, is mandated for most new and redevelopment projects throughout the state. Municipalities are required to achieve pollutant load reductions, in the form of Total Maximum Daily Loads, via management measures that are frequently GI-based.

For example, municipalities regulated under the San Francisco Bay Regional Water Board's Municipal Regional Permit are required to develop GI Plans designed to achieve 3 kg/year reduction in PCBs discharging to San Francisco Bay by 2040. Local agencies are also mandated to develop Stormwater Resource Plans that identify and prioritize stormwater capture projects in order to compete for voter-approved bond funding. Quantitative targets for stormwater treatment could be developed in coordination with the State and Regional Water Boards to reflect the mandates already in place related to GI. Targets for pollutant reduction, greened acreage, and/or stormwater volumes captured can be connected to funding programs for implementing GI Plans, Stormwater Resource Plans, or Watershed Management Plans.

Targets will likely need to be regional based on the stormwater management mandates set by the State and Regional Water Boards. Regional targets also make more sense for issues like urban heat island reduction, which is likely different region to region.

The appropriate timescale is likely decades, given that it will require costly retrofit of urban infrastructure developed over the past century or more to achieve the targets.

Regarding implementation mechanisms, municipal stormwater mandates are likely the most significant existing mechanism pushing GI implementation; however, stormwater management is also the most under-resourced utility throughout the state due to the constitutional restrictions imposed by Proposition 218 on generating new or increased stormwater fees. As such, programs that support municipal implementation of GI to achieve water quality mandates are key for widespread deployment of GI. One of the most important changes that could be made to support GI implementation is to integrate water and transportation funding streams. Beyond GI implementation on private parcels via new and redevelopment, the primary location in which GI will be implemented is in roadways in the form of green streets. Therefore, funding programs that readily support integrated transportation/GI projects would greatly expedite the rate of GI implementation. The state needs to move beyond "Complete Streets" to "Sustainable Streets." Flexible funding is needed to implement integrated projects – transportation funds won't pay for GI and water quality funds won't pay for bike lanes. If all of the funding the state is directing toward active transportation could include a GI "add-on" from water quality or other sustainability funding sources, it would enable more rapid retrofit of urbanized areas and speed the transition to more sustainable, resilient, walkable, livable communities.

Incentive-based programs or mandates for private development to expand GI implementation into adjacent public rights-of-way may be appropriate. This would encourage more public/private partnerships on stormwater management and blur the lines between public and private stormwater.

Engaging Local Communities through Innovation Question

As stated above, moving communities from the current focus on Complete Streets that address active transportation issues to Sustainable Streets that also incorporate green infrastructure for

stormwater management, urban heat island reduction, improved aesthetics, reduced flooding, etc., would be a significant improvement. Engaging the MPOs in incentivizing the move toward Sustainable Streets with funding awards would help shift the dial. Working with Caltrans to integrate its active transportation programs with its own water quality requirements could lead to more integrated funding opportunities for local agencies. Incorporating GI into Climate Action Planning is another approach. Agencies that already have to implement GI for stormwater permit requirements should include it in their CAPs to show how related climate action benefits.

Land Use Valuation and Co-Benefits

There are several tools available for quantifying the multiple benefits of green infrastructure. The US EPA Green Infrastructure website has a list of cost-benefit analysis tools: (https://www.epa.gov/green-infrastructure/green-infrastructure-cost-benefit-resources).

In particular, the Center for Neighborhood Technology's "The Value of Green Infrastructure" tool (http://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf) provides means of quantifying various benefits of GI, but does also highlight that additional research is needed for quantifying things like air pollution uptake of GI. This is an area for which that the Agencies may want to direct resources for additional studies.

Philadelphia also did a triple-bottom line assessment of GI approaches in comparison to traditional grey infrastructure which provides useful information in quantifying the multiple benefits (https://www.epa.gov/sites/production/files/2015-10/documents/gi_philadelphia_bottomline.pdf).

Thank you again for the opportunity to comment. If you have any questions, please contact me at 650-599-1419 or our Executive Director, Geoff Brosseau at 650-365-8620.

Sincerely,

Matt Fabry, Immediate Past Chair
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