City of Cambridge
Community Preservation Act
FY 2022 Project Funding Application

SUBMISSION INSTRUCTIONS

Completed forms and attachments may be emailed to jmathews@cambridgema.gov. **Deadline for submission is Wednesday, July 14, 2021.**

CPA CATEGORIES & ALLOWABLE USES

CPA funds can only be used for certain purposes:

- Affordable Housing (also called Community Housing)
- Historic Resources
- Open Space
- Recreational Land

For a description of the CPA categories and the allowable uses of CPA funds in each project category, please review the state Department of Revenue Allowable Uses Chart. Also note the following regarding potential **affordable housing** and **historic projects**:

- Cambridge Affordable Housing Trust (CAHT): Absent extraordinary circumstances, CPA funding for affordable housing flows through the CAHT. For more information, including on applying for funding, visit: https://www.cambridgema.gov/CDD/housing/housingtrust.

- Cambridge Historical Commission Preservation Grant Program: CPA funding for historic projects on private property is available through the Preservation Grant Program. If you are applying for historic funding for a private property, please explain why Preservation Grant funding is insufficient or unavailable. For more information, visit: https://www.cambridgema.gov/historic/permitsApplications/preservationgrants.

APPLICANT INFORMATION

Name(s): Andrew Putnam, David Lefcourt, Abigail Bentley

Applicant Organization, if applicable: Cambridge DPW - Urban Forestry Dept.

Phone: 617-349-4846

Email: abentley@cambridgema.gov

Address: 147 Hampshire St, Cambridge, MA 02139

PROJECT INFORMATION

- Applicants are encouraged to attach any maps, photographs, designs, renderings, budget documents, or other images or plans related to the project when submitting their application form.
- Letters of support from community members or organizations may also be attached.
- Actual quotes for project costs are strongly encouraged. Estimates may be used, so long as the basis for the estimate is explained in detail.

Project Title: Bare Root Tree Nursery

Project Address: 691 Huron Ave, Cambridge, MA, 02138

CPA Category:

- [ ] Affordable Housing
- [ ] Historic Resources
- [x] Open Space
- [ ] Recreation

Previous CPA Funding Received, if applicable: N/A

CPA Funding Amount Requested: $125,000

Project Description:

Please submit a separate word document or pdf with the following project details:

- Goals/Purpose
- Property Ownership/Site Control

  If you are not the property owner, please submit site control documentation, a memorandum of agreement (MOA), or a letter of support from the relevant public agency (e.g., the Massachusetts Department of Conservation and Recreation) as an attachment. Projects for City of Cambridge-owned property must be submitted by a City Department.
- Community Support
- Total Project Budget
- Other Funding Description (amount, source of funds, etc.)
- Project Timeline

Application for CPA Grant Funding to Expand and Upgrade Bare Root Tree Nursery at Thomas P. O'Neill Jr. Golf Course, Fresh Pond Reservation
City of Cambridge Department of Public Works Urban Forestry Division

Goals/Purpose

The City of Cambridge Department of Public Works Urban Forestry Division submits this request for CPA funding to be used to expand and upgrade the City's bare root tree nursery located within the Thomas P. O'Neill Jr. Golf Course at the Fresh Pond Reservation. Expanding the nursery would allow the City to implement recommendations provided by the Urban Forest Master Plan (UFMP) technical report document (Attachment A). The technical report provides data on the past and current state of the City's urban forest, as well as projections and recommendations for increasing the tree canopy and creating a more diverse and resilient urban forest. The key recommendations from the UFMP technical report we hope to achieve with this project are to:

- Establish a bare root tree nursery (UFMP Technical Report, pg 181)
- Establish a soils management program (UFMP Technical Report, pg 177)

One of the recommendations from the UFMP is for the City to plant over twelve hundred (1,200) trees per year to mitigate the effects of canopy loss on public and private land and to grow the urban forest. Bare root trees are faster and easier to plant, less expensive, and generally acclimate to their environment faster than B&B (balled and burlapped) trees. However, one downside of bare root trees is that many species are only seasonally available (usually in spring) and because of their exposed roots, they have a shorter planting window than B&B trees. To meet the planting requirements outlined in the UFMP, the City must increase the number of bare root trees planted each year. Using a gravel bed nursery, the bare root trees are stored or "heeled in" after delivery until they are ready for planting. The heeling in process allows the bare root trees increase their fibrous root growth which leads to increased survivability. Please see slide 7 in Attachment B for an example of fibrous root growth on a bare root tree after 6 months in the gravel bed nursery.

In fall 2020, 125 trees were heeled in at the existing nursery area. Almost all of these trees survived the winter and were planted along sidewalks, in parks, and around schools during the spring 2021 planting season. This first year has shown that the gravel bed nursery is successful at storing and increasing the survivability of bare root trees. The Division of Urban Forestry wishes to expand the capacity of our nursery to increase the number of trees that can be stored and planted each year. With the proposed expansion and reorganizing the current layout to maximize the available space, the capacity of the nursery would quadruple, from 125 trees to 500 trees.

Tree planting in the City has historically been completed by contractors but the City has recently posted for hiring 3 new planting positions to create an in-house planting crew. The in-house planting crew is expected to be hired during summer 2021 and will be available to assist in a portion of the fall 2021 tree planting program. The expanded nursery and in-house planting crew will help to ensure each planting season no longer relies on the availability of contracted planting crews or the unpredictable and weather-dependent delivery of the bare root trees; rather, City staff can begin planting trees that have been heeled in at the golf course nursery as soon as the ground thaws in the spring and planting can continue throughout the growing season.

With CPA funding, City staff will be able to use the upgrades at the bare root nursery to meet the soils management program recommendation from the UFMP Technical Report. A robust soils management

program will help increase the survivability of newly planted trees as well as maintain the health of young and mature trees. The City has a new Soils Management Field Guide (Attachment C) that will be used by City staff to assess and amend soils in growing locations around the city. The field guide recommends the application of compost tea as a Best Management Practice to improve soil texture and soil organic matter. The City currently has one compost tea brewer but a second brewer is recommended to meet the demand of the increasing number of trees planted each year. Compost tea improves soil texture and increases the beneficial microorganisms in the soil. Biochar is already included as part of our planting program but with increased holding capacity at the nursery, biochar and compost tea would be used to amend the soil around mature trees growing in poor soil.

Property Ownership/Site Control
The nursery is located within the Thomas P. O'Neill Jr. Golf Course at 691 Huron Ave, Cambridge, MA 02138. The golf course is within the Fresh Pond Reservation which is owned by the City of Cambridge. Attachment D details ownership of the golf course. The nursery area is maintained by the Urban Forestry Division.

Community Support
The installation of a gravel bed nursery and a soil management program are recommendations from the UFMP Technical Report. This report was developed in part by a Task Force made up of community members including residents, business owners, Committee on Public Planting members, university representatives, and other City departments.

Total Project Budget
Below is a table with estimated costs for upgrading and expanding the nursery area.

Item	**Description**	**Cost Estimate**
Gravel sub-base for expanded area	Level, grade, and install crushed stone material	
	Labor	$ 10,000
	Material	$ 20,000
Fencing	-Install Jersey barrier fencing around perimeter of holding area to prevent expansion and provide protection to bare root trees. -Move existing fencing from parking area to edge of curb to create more space for receiving bare root trees and supplies. -Create cubby for dumpster -Create bins for mulch, sandy loam, and compost	
	Privacy fencing	$ 10,000
	Labor	$ 15,000
	Material	$ 25,000
Compost Tea Brewer		$ 10,000

Reeds Ferry Prefab Shed (10'x20')	-House compost tea brewer and supplies for compost tea application and soil amendments	$ 10,000
Full irrigation system with metered box, connected to DPW remote system	-Bare root trees must be watered daily during spring, summer, and fall. -Ability to control irrigation manually would ensure trees are watered more during drought periods and less during periods of rain	$ 25,000
Total		**$ 125,000**

Project Timeline

Once funding is secured, we would like to begin upgrading and expanding the nursery immediately. Below is a general timeline:

- September/October 2021:
    - Remove herbaceous material in expansion area
    - Install gravel sub-base in bare root holding area
    - Move existing chain-link fence to create receiving area for trees and supplies
    - Install Jersey barrier fence around perimeter of nursery
    - Install gravel base for dumpster to be moved from parking area to next to golf course bins
    - Purchase and install bins for mulch, sandy loam, and compost
    - Obtain compost tea brewer
- November 2021:
    - Heel in trees for Spring 2022 planting
    - Install irrigation

Attachment A

Cambridge Urban Forest Master Plan Technical Report

https://www.cambridgema.gov/~/media/Files/publicworksdepartment/urbanforestmasterplan/20191112cufmtechnicalreport.pdf

Attachment B

Presentation of Bare Root Nursery Upgrade Proposal to CPA Committee on June 9, 2021


Vertical
Mon Apr 9 2018
nearmap
Imagery © 2021 Nearmap, HERE
20 ft
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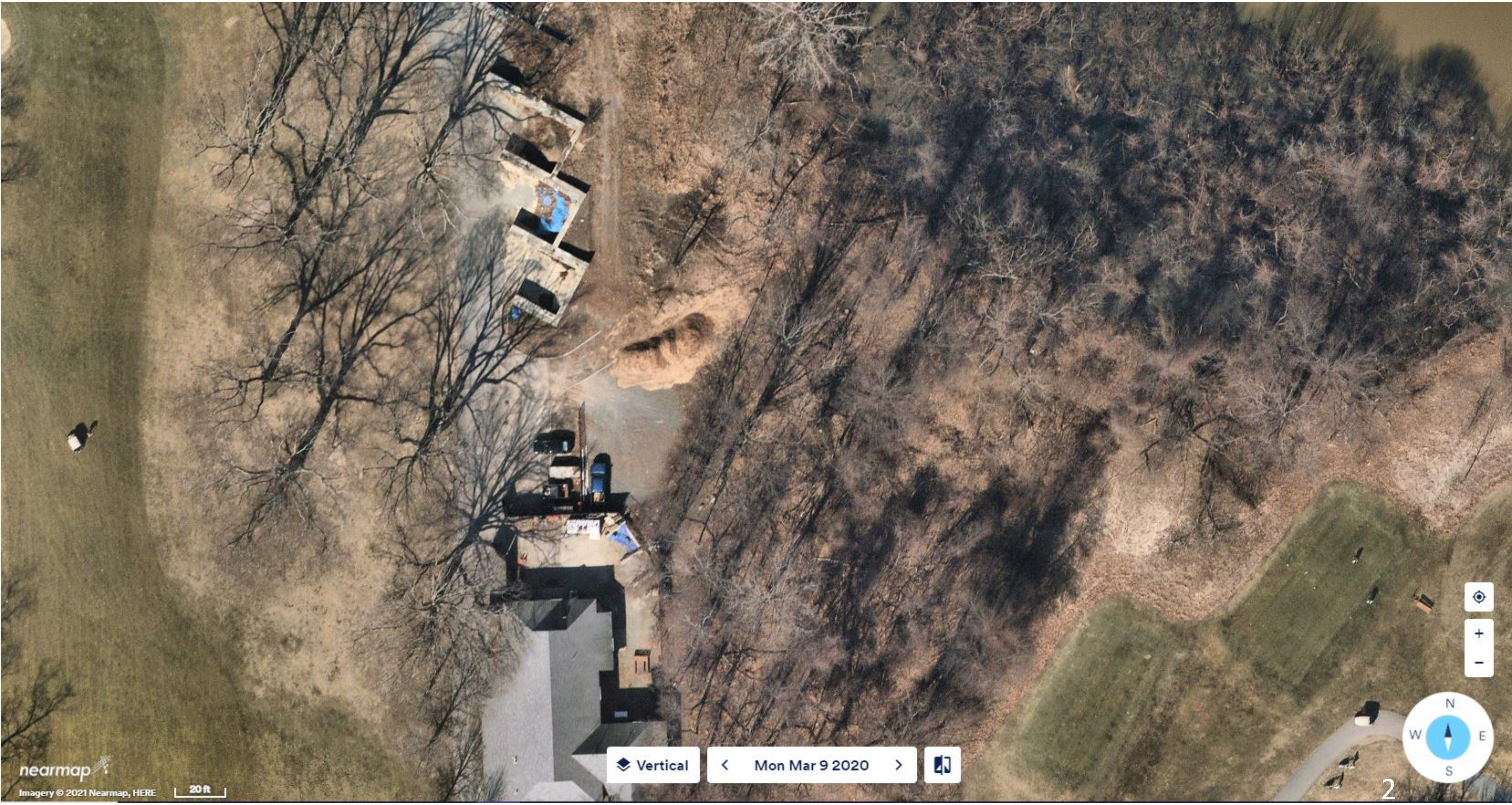
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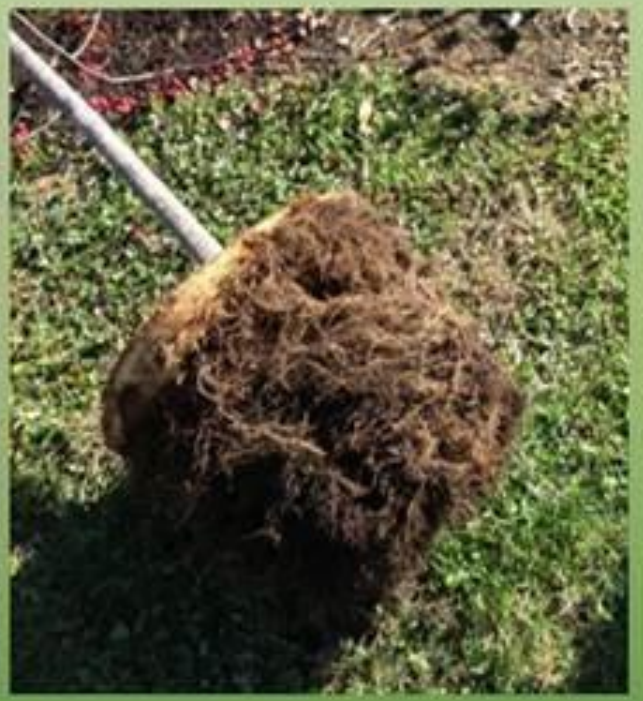
Existing Conditions – June 2021


Proposed Expansion and Upgrades – September 2021
New bins to consolidate planting operations in one location
mulch
sandy loam
compost
Proposed extent of new gravel subbase. Jersey Barrier fencing
Additional space for heeling in trees
Gravel road/parking to be installed by golf course
Existing tree planting areas to be reorganized to maximize space
Compost tea brewer & shed
Move fence to create receiving area
Golf maintenance building
Golf dumpster
Add gravel base, relocate dumpster into new fenced in area
5

Root Structure of Nursery Stock

Balled and Burlapped

Bare Root



Containerized


Bare root Horsechestnut (Aesculus hippocastanum) tree heeled in at Golf Course Nursery from Fall 2020 to Spring 2021
Fibrous roots grown while heeled in

Attachment C

Soils Management Field Guide

Soils Management Field Guide

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Contents

2.1 Introduction

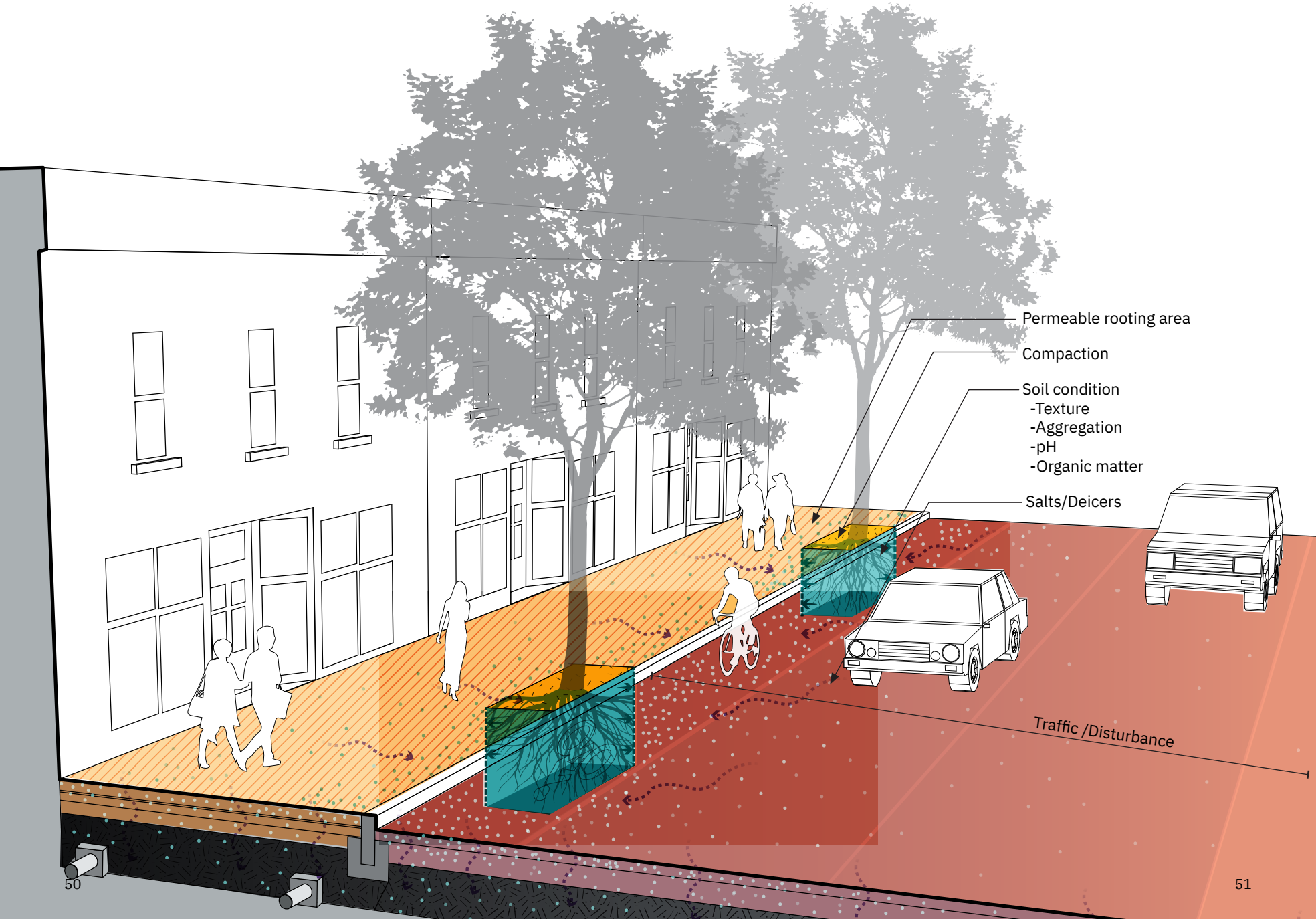
The intent of this guide is to provide instruction on how to perform the CUSI assessment, how to understand the CUSI scoring, and how to identify best management practices to address specific soil deficiencies identified through the scoring.

As noted in the “Soils Assessment Report”, the results of that study suggest the main driving factors of health for the assessed trees were salts (EC) and estimated root area (ERA). Other factors were also found to be correlated at a lower level of significance: traffic, texture, aggregate stability, pH, and organic matter. Compaction is also known to be a common issue, so it has been included in the attribute list as well. Focusing urban soil management efforts on these specific attributes rather than on a wider range of soil issues will more efficiently direct resources to optimize tree health.

The best management practices for addressing poor scoring attributes are summarized in tables in section 3.1 and detailed in sections 3.2 and 3.3. An annual calendar in section 3.4 compiles basic mantenance practices that are season specific.

Lastly, it is important to select tree species that are appropriate for existing soil and urban conditions as this is much more efficient than trying to modify soil properties.

CUSI Soil Health Indicators



Primary Best Management Practices

ERA Estimated Rooting Area

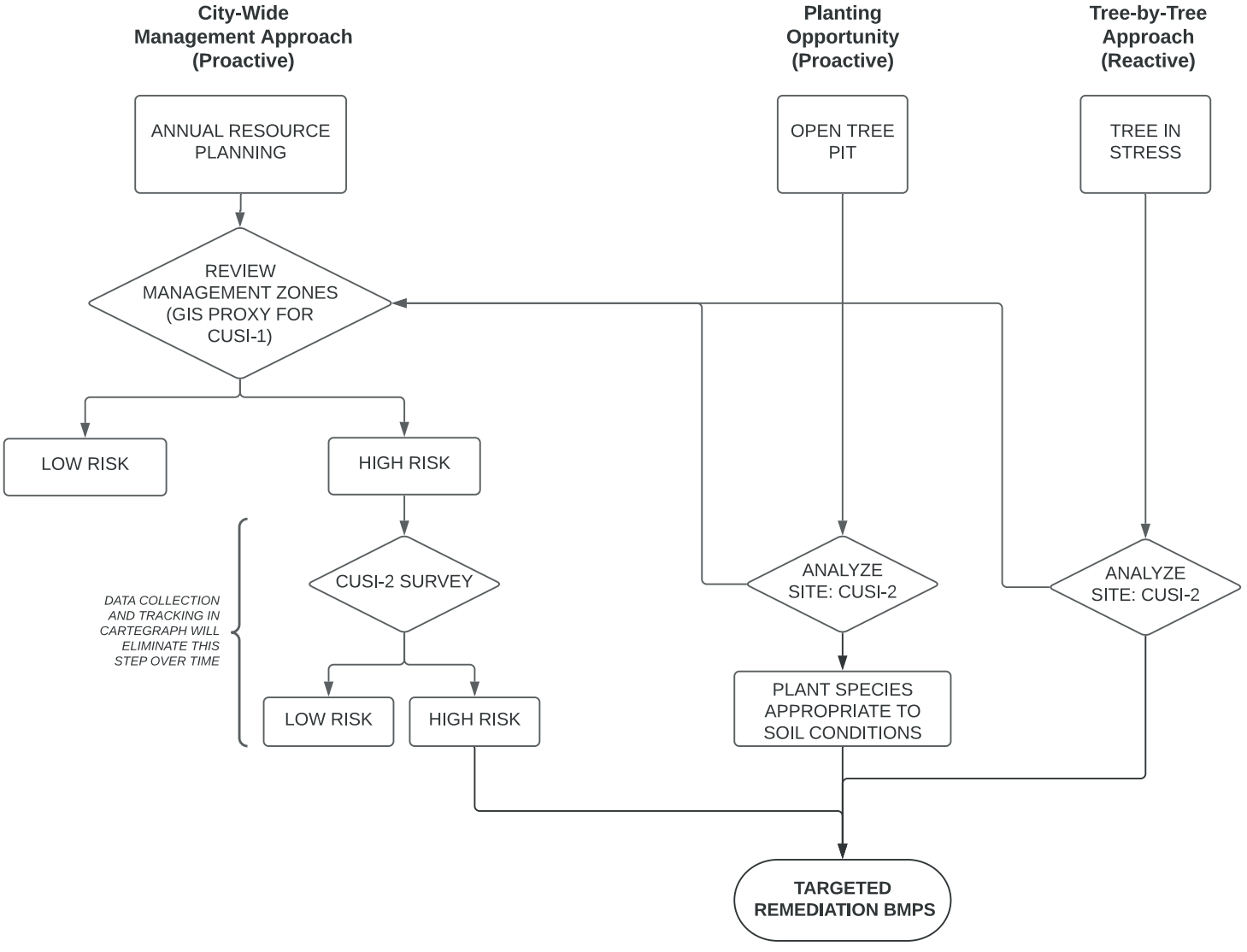
CUSI SCORE	0	1	2	3	4	5
	< 1m²	1 – 3m²	4 – 6 m²	7 – 9 m²	10-12m²	>12m²
	WORSE		BETTER			
TIME OF PLANTING	Available space is too limited for tree planting Increase tree pit opening to 4 m2 (44 sf) min. Connect soil volume to nearby pervious areas if possible See ERA Soil Management Actions pg 44		Do not plant tree(s) if insufficient soil depth (>30 inches) Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives			
TREE UNDER STRESS / AT RISK	Increase permeable rooting area by removing paved surface and installing new soil See ERA Soil Management Actions pg 54		Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives			

EC Electrical Conductivity or Soluble Salts

CUSI SCORE	0	1	2	3	4	5
	>1000 µS cm^{-1}	501-1000 µS cm^{-1}	251-500 µS cm^{-1}	101-250 µS cm^{-1}	50-100 µS cm^{-1}	<50 µS cm^{-1}
			WORSE	BETTER		
TIME OF PLANTING	Excavate tree pit. Irrigate open pit with 2.5 gallons of water per sq. ft. of area and let drain prior to tree planting If EC >3,000 µS cm-1, blend compost into excavated soil (1 cf compost per 4 cf of soil) before replacing Advise nearby residents and businesses to reduce de-icer applications in winter See EC Soil Management Actions pg 45				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	
TREE UNDER STRESS / AT RISK	If EC >1,000 µS cm-1, immediately irrigate soil with 2.5 gal of water per sq ft of area daily until EC <1 µS cm-1 For EC >1,000 µS cm-1, that won't drain, loosen soil (refer to PEN actions) and irrigate as above Blend 1" of compost into the top inch of soil. Place 2" of compost as mulch Advise nearby residents and businesses to reduce de-icer applications in winter See EC Soil Management Actions pg 54		Irrigate soil with 2.5 gal of water per sq ft of area weekly Place 2" of compost as mulch	Irrigate weekly with 1.5 gal water per sq ft of area Place 2" of compost as mulch Measure EC 2 times per year	Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	

Soils Management Approaches

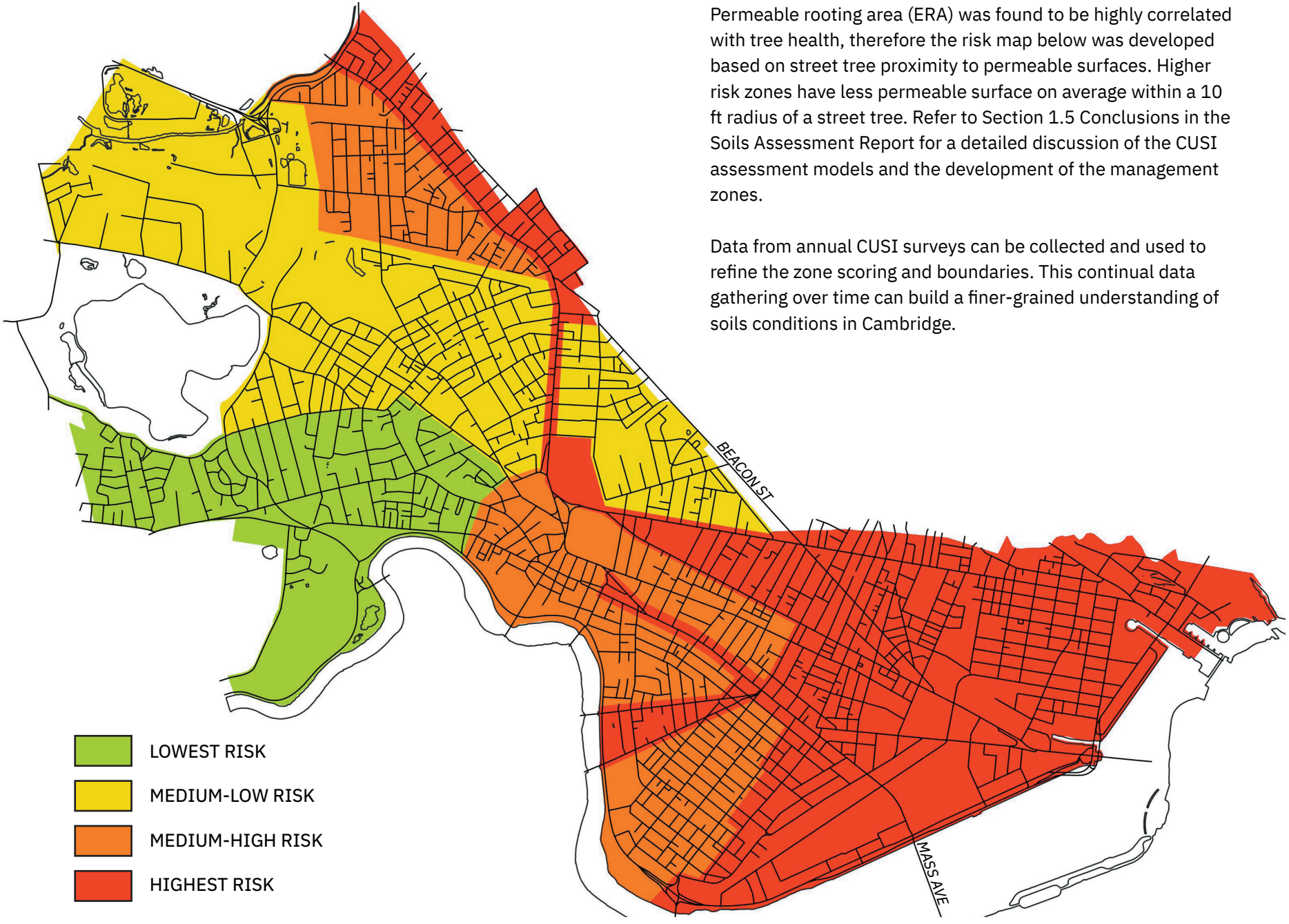
This guide builds upon three distinct needs. First, to help determin efficient resource management, a city-wide analysis of existing conditions, based on GIS data, is developed and reviewed yearly. This articulates a series of risk zones. Second, when planting a new tree, this guide provides recommendations for targeted soils improvements based on the analysis of the site using this Cambridge-specific tool. And finally, when a tree shows signs of stress, this guide recommends soils amendments in response.



Soils Management Zones

Permeable rooting area (ERA) was found to be highly correlated with tree health, therefore the risk map below was developed based on street tree proximity to permeable surfaces. Higher risk zones have less permeable surface on average within a 10 ft radius of a street tree. Refer to Section 1.5 Conclusions in the Soils Assessment Report for a detailed discussion of the CUSI assessment models and the development of the management zones.

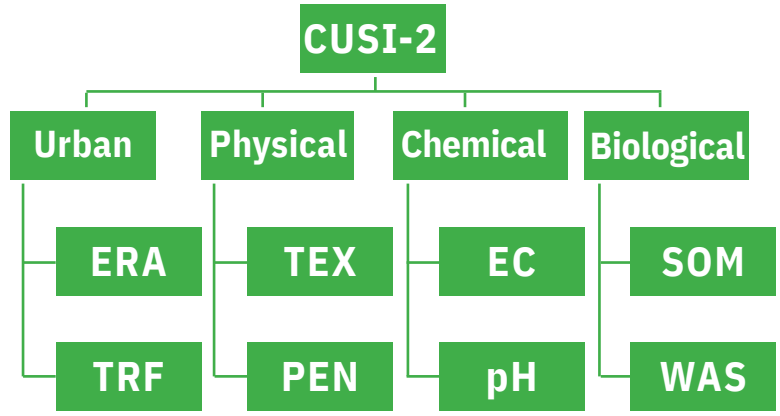
Data from annual CUSI surveys can be collected and used to refine the zone scoring and boundaries. This continual data gathering over time can build a finer-grained understanding of soils conditions in Cambridge.



2.2 CUSI Assessment

The modified Cambridge Urban Site Index (CUSI-2) evaluates 8 site attributes most correlated with tree health in Cambridge (see table below) in order to focus specific BMPs for greatest impact. The top two attributes, permable rooting area and salinity, were found to be the most correlated with tree health and should be the primary concerns when evaluating soils health.

Urban Site Attribute	**Effect on Urban Trees**
ERA Permeable rooting area	Low soil permeability limits the amount of high quality rooting area
EC Salinity	High soil salinity can lead to infrastructure damage, plant toxicity, and the loss of soil structure
TRF Traffic	Traffic and street disturbance can add deleterious substances and physically damage roots and soils
TEX Texture	Water retention and nutrient availability is limited in coarse textures. Fine textured soils are highly compactible
PEN Compaction	Compaction can lead to the loss of macropores, low aeration, poor drainage, physical root restricting layers, erosion, and other negative impacts
WAS Aggregation	Poorly aggregated soils may also indicate relatively poor physical, chemical, and biological condition
pH	Nutrients can be less available in more alkaline soils and these soils are often impacted by salts while more acidic soils can also be nutrient poor
SOM Organic matter	Low organic matter content can limit nutrient and water availability and also indicates low biological activity



STEPS TO COMPUTE THE CUSI-2 SCORE:

1. Assess the each of the eight attributes below following instructions described for each.

2. Determine the score for each attribute.

3. Compute the CUSI-2 score by summing up each the scores for each of the eight attributes.

4. Determine the maximum possible score by multiplying the total attributes assessed by 5. If the user can not measure a specific attribute or that attribute is not useful for the assessment, the attribute can be omitted. Likewise, additional attributes can be added to the approach if needed. The maximum score must be adjusted to the total number of attributes assessed.

5.Divide the total by the maximum score. If using all eight attributes, the maximum will be 40.

6.Multiply the number by 100 to return a CUSI-2 score of 0-100 for relative comparisons.

EXAMPLE

Property	Value	Score
ERA	5 m2	2
TRAF	<4 lanes and no recent and no disturbance	3
TEX	LS (with irrigation)	3
PEN	>50 cm and no evidence of compaction	4
EC	3,000 µS cm-1	0
pH	7.7	2
SOM	A horizon ≥5 cm depth and medium organic matter	4
WAS	PL with weak or strong aggregates	1
Sum of the scores [= 2 + 3 + 3 + 4 + 0 + 2 + 4 + 1]		19
Maximum possible [= 8 x 5]		40
CUSI-2 [= (19 / 40) x 100]		47.5

EQUIPMENT NEEDED:

- Soil core sampler
  E.G. Classic Soil Probe by Oakfield Apparatus
- Bucket
- Measuring tape
- Water (deionized)
- pH/EC meter
  E.G. ExStik EC500 by Extech
- Plastic vials and scoop
- Munsell color book or SOM chart in the appendix
- Screen
- Dish with water
- Data sheets
- Sample collection bags if you wish to also conduct a laboratory assessment

ERA (ESTIMATED ROOT AREA)

Estimated root area is an estimate of the space for root growth. The area must be permeable surface and determined to be a substrate that tree roots can grow in. Measure or estimate the estimated root area. Add 1 to ERA score break out area of at least 10 m^2 present. A break-out area is a space that is connected to the ERA that roots might grow into. Determine the ERA score with the scoring function below:

Scores:

- 0 = <1 m2
- 1 = 1-3
- 2 = 4-6
- 3 = 7-9
- 4 = 10-12
- 5 = >12

TRF (TRAFFIC)

Traffic is number of lanes and parking on either side of street. More lanes and less parking indicate more traffic and a site with more problems associated with contaminants and disturbance. Count the number of traffic lanes and assess the parking on the street. Determine the TRF score with the scoring function below:

Scores:

- 0 = >4 lanes and disturbance
- 1 = 2-4 lanes and no parking and disturbance
- 2 = 2-4 lanes and parking on either side and disturbance
- 3 = <4 lanes and no parking and no recent disturbance
- 4 = 2-4 lanes and parking on either side and no disturbance
- 5 = <2 lanes and no disturbance

TEX (TEXTURE)

Texture is the relative particle size distribution. Assessment includes the volume of coarse fragments (>2 mm in diameter). Assessment is made via feel method (see Appendix). Moisten a handful of soil and break up soil until it feels like moist playdough. Remove rocks and roots as you do this. Try to form a ball. If no ball can be formed = sand (S). Next, try to form a soil ribbon by pushing the soil with your thumb and forefinger. If a ribbon forms measure how long that ribbon before it breaks under its own weight. If a ball formed, but no ribbon and/or ball falls apart when dropped = loamy sand (LS). Form the soil back into a ball, push a dimple in the ball, and squirt some water in the dimple. Feel for stickiness, smoothness, or grittiness. Use the ribbon size and dimple feel to assign a texture lass. Ribbons <1" and feels gritty = sandy loam (SL), sticky = loam (L), smooth = silt loam (SiL). Ribbons <1-2" and feels gritty = sandy clay loam (SCL), sticky = clay loam (CL), smooth = silty clay loam (SiCL). Ribbons >2" and feels gritty = sandy clay (SC), sticky = clay (C), smooth = silty clay (SiC). Assess whether the site has irrigation.

Determine the TEX score with the scoring function below:

Scores:

- 0 = no soil and/or coarse fragments are >75% of volume
- 1 = C, SC, SiC, or Si textures, or S (without irrigation)
- 2 = CL, SiCL, SCL textures, S (with irrigation), or LS (without irrigation)
- 3 = LS (with irrigation)
- 4 = SL (without irrigation)
- 5 = L or SiL texture or SL (with irrigation)

PEN (PENETRATION RESISTANCE)

Penetration is depth/ease of penetration with a soil core sampler, tile probe, or a shovel. Effort will need to be calibrated by experience. This is relative assessment that is sensitive to moisture conditions. It is important to conduct all your PEN assessments when soils are near the same moisture conditions. . Push the soil core sampler, tile probe, or shovel into the ground and assess how deep it goes and the relative effort to push into the ground. Repeat this assessment at least 5 times throughout the planting site. If the site appears to be heterogeneous, repeat for a total of 10 times. Collect each core in a bucket. This soil will be used to assess TEX, EC, pH, SOM, WAS, and any other measurements you may wish to conduct.

Determine the PEN score with the scoring function below:

Scores:

- 0 = <5 cm and/or evidence of severe compaction
- 1 = 5-25 cm and/or evidence of moderate compaction
- 2 = 26-50 cm and/or evidence of minor compaction
- 3 = >50 cm or no evidence of compaction
- 4 = >50 cm and no evidence of compaction
- 5 = >100 cm and no evidence of compaction

CHEMICAL

EC (ELECTRICAL CONDUCTIVITY)

Electrical conductivity is an estimate of the soil salinity. It is measured with a field meter and soil:water paste (1:1). Using a soil core sampler, collect at least five cores from the site to at least 25 cm depth or to the limiting PEN depth. Place all the cores in a bucket and mix for a composite sample. Place a scoop of soil in the plastic vial. Add a scoop of deionized water. Mix the sample thoroughly. Place the EC probe in the sample and measure the EC according to the instrument instructions. Determine the EC score with scoring function below:

Scores:

- 0 = >1000 µS cm-1
- 1 = 501-1000
- 2 = 251-500
- 3 = 101-250
- 4 = 50-100
- 5 = <50

PH

pH is a measure of the soil's acidity and alkalinity, which affects nutrient availability and microbial activity, and other factors. It is measured with a field meter using a 1:1 soil and DI water mixture. Using a soil core sampler, collect at least five cores from the site to at least 25 cm depth or to the limiting PEN depth. Place all the cores in a bucket and mix for a composite sample. Place a scoop of soil in the plastic vial. Add a scoop of deionized water. Mix the sample thoroughly. Place the pH probe in the sample and measure the pH according to the instrument instructions. Determine the pH score with scoring function below:

Scores:

- 0 = <4.5 or >8.5
- 1 = 4.5-5.0 or 8.1-8.5
- 2 = 5.1-5.4 or 7.6-8.0
- 3 = 5.5-5.9 or 7.1-7.5
- 4 = 6.0-6.3 or 6.8-7.0
- 5 = 6.4-6.7

SOM (SOIL ORGANIC MATTER)

Soil organic matter is estimated based on color or with a laboratory analysis. Using a soil core sampler, collect at least five cores from the site to at least 25 cm depth or to the limiting PEN depth. Place all the cores in a bucket and mix for a composite sample. Soil color is assessed in the field under moist conditions, so dry soils should be wetted. The values in the Munsell Soil color book can be used to estimate organic matter into high (Munsell value of <3), medium (Munsell value of 3-4), or low (Munsell value >4). Alternatively, the chart in the appendix may be used to estimate OM by color. Laboratory analyses can be used in place of color estimates. Rate the SOM by color or laboratory data into high (>6), medium (2-6%), and low (<2%) categories. The depth of the organic horizon is also very important. The depth of the A horizon is determined by visual inspection. This can be done at the same time as doing the PEN assessment and soil core collection. The A horizon can be distinguished by darker color, a more well-developed structure and a greater abundance of fine roots. Determine the SOM score with the scoring function below:

Scores:

- 0 = A horizon <5 cm depth and low organic matter
- 1 = A horizon <5 cm depth and medium organic matter
- 2 = A horizon <5 cm depth and high organic matter
- 3 = A horizon ≥5 cm depth and low organic matter
- 4 = A horizon ≥5 cm depth and medium organic matter
- 5 = A horizon ≥5 cm depth and high organic matter

WAS (WET-AGGREGATE STABILITY)

Wet-aggregate stability is an estimate of the strength of the aggregates to resist degradation. Using a soil core sampler, collect at least five cores from the site to at least 25 cm depth or to the limiting PEN depth. Place all the cores in a bucket and mix for a composite sample. Aggregates 2-5 mm in diameter are placed on a screen (1 mm). The aggregates are soaked in water for 30 s. After 30 s the screen is agitated (swirl) for another 30 s. The swirl should be violent, but not so violent that water is splashed out of container. The amount of aggregates left after the soak and swirl are volumetrically estimated relative to the aggregate volume at the start of the assessment. If >50% of the aggregates are intact after this test, the aggregates are considered strong. If most of the aggregates fall apart, the aggregates are considered weak. Structure is the shape of the aggregates. Massive (M) is no shape and compacted block. Single-grained (SG) is no aggregates and sandy. Platy (PL) is flat and horizontal. Blocky (BK) is equi-dimensional. Granular (GR) is spherical and generally smaller in size (<5 mm) compared to ABK and SBK. Images of structure types can be found in the appendix.

Determine the WAS score with the scoring function below:

Scores:

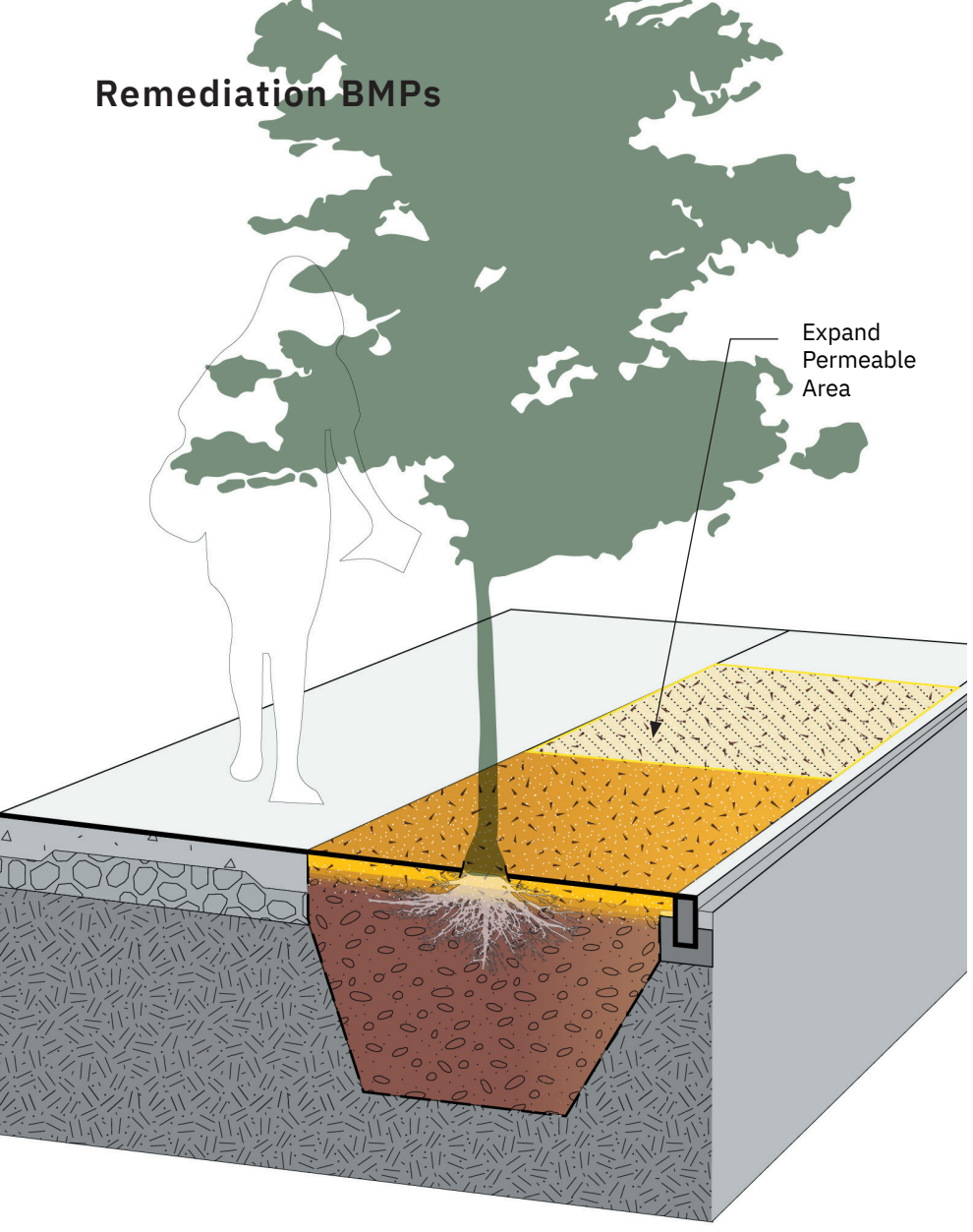
- 0 = M or SG or PL
- 1 = PL with weak or strong aggregates
- 2 = BK with weak aggregates
- 3 = GR with weak aggregates
- 4 = BK with strong aggregates
- 5 = GR with strong aggregates

NEXT STEPS

Once the attributes are scored, consult the tables on the following pages for BMPs related to each attribute score.

2.3 Best Management Practices

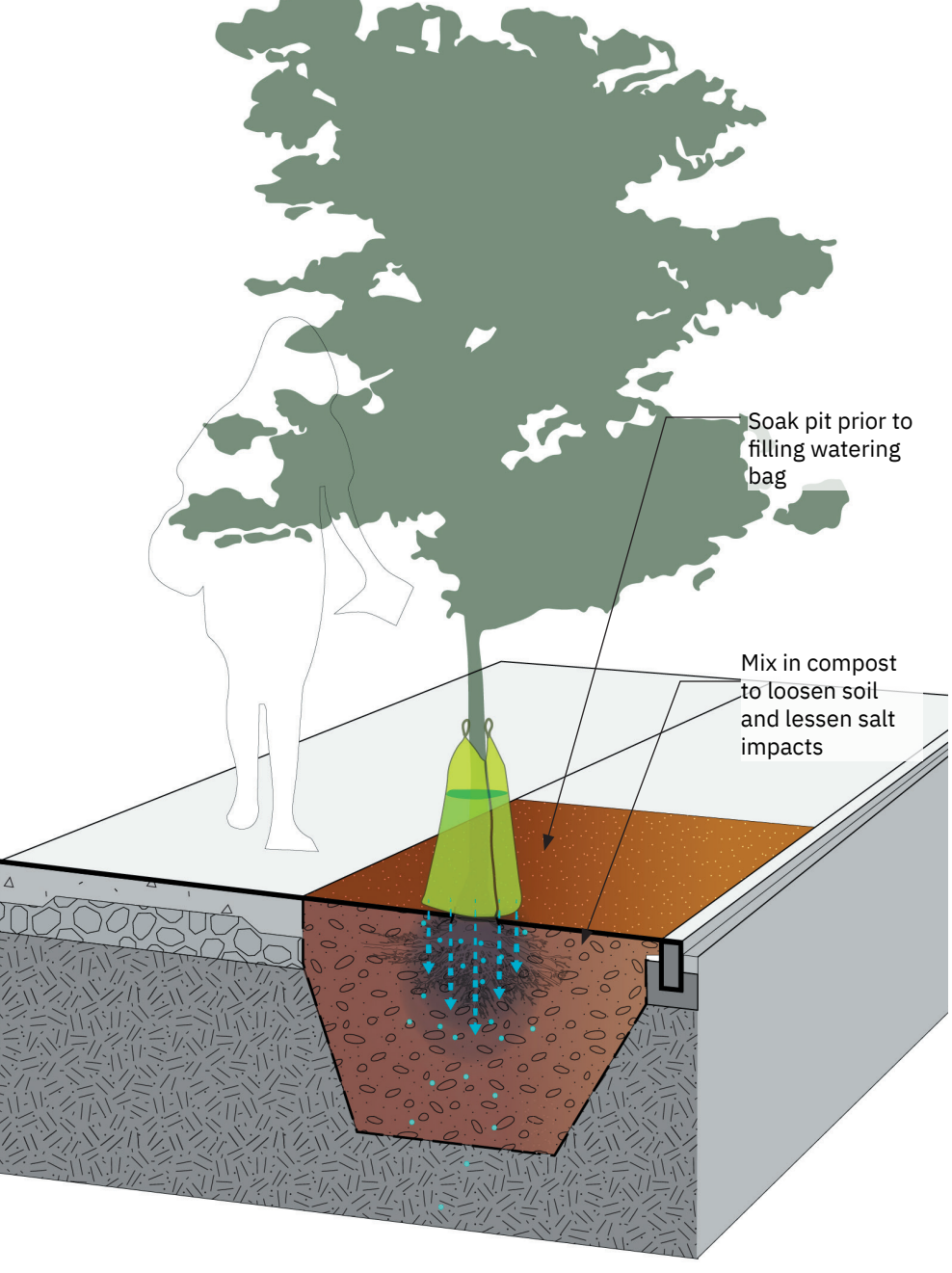
This section describes the Best Management Practices (BMPs) for addressing specific soil deficiencies identified through CUSI scoring. The BMPs are summarized in the tables in section 3.1 and detailed in sections 3.2 and 3.3. An annual calendar in section 3.4 compiles basic mantenance practices that are season-specific.



Low soil permeability (Low ERA) limits the amount of high quality rooting area. Improving ERA can be done relatively quickly by increasing tree pit area.

ERA Estimated Rooting Area

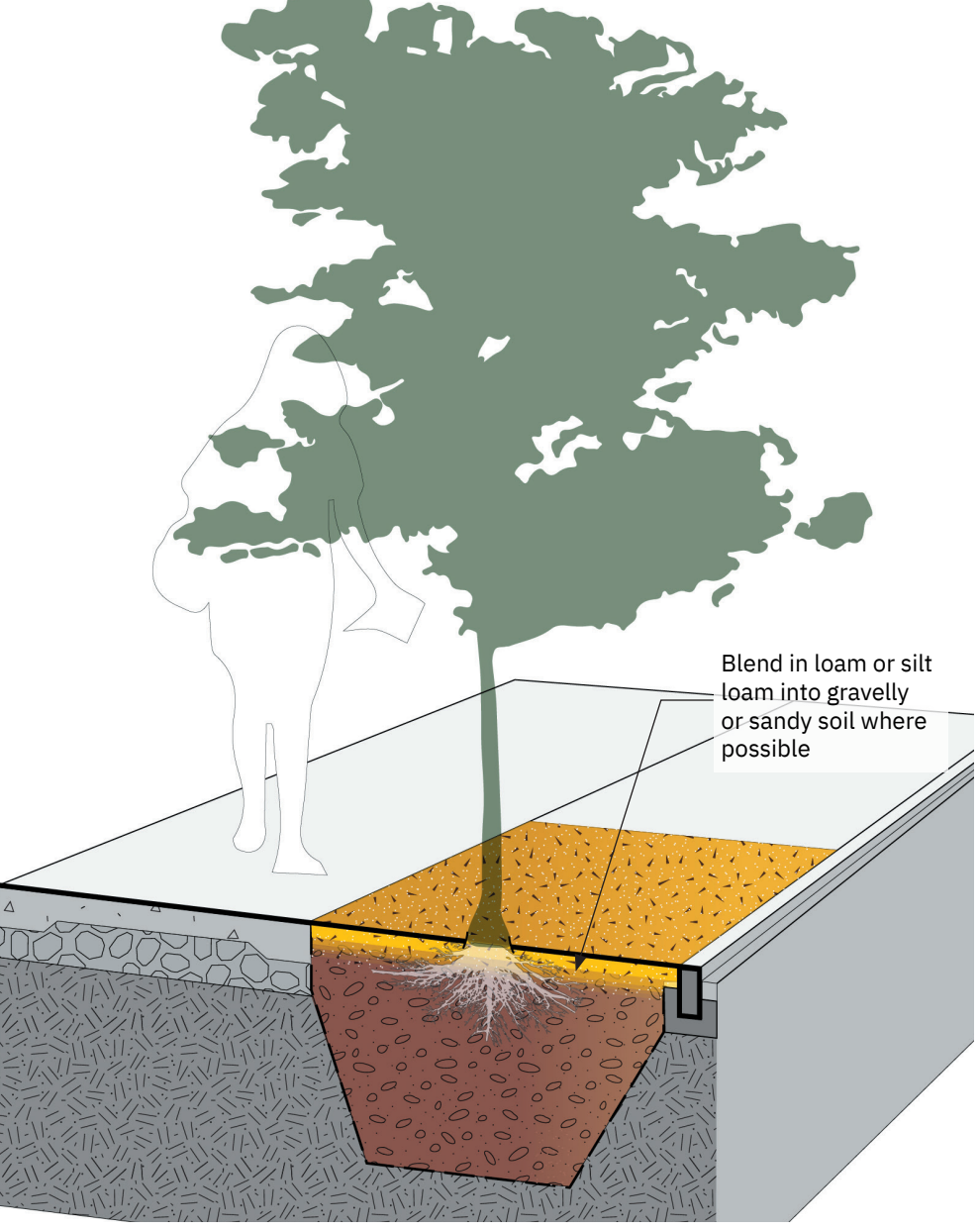
CUSI SCORE	0	1	WORSE 2	BETTER 3	4	5
	< 1 m^2	1 – 3 m^2	4 – 6 m^2	7 – 9 m^2	10-12 m^2	>12 m^2
TIME OF PLANTING	Available space is too limited for tree planting Increase tree pit opening to 4 m2 (44 sf) min. Connect soil volume to nearby pervious areas if possible See ERA Soil Management Actions pg 44		Do not plant tree(s) if insufficient soil depth (>30 inches) Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives			
TREE UNDER STRESS / AT RISK	Increase permeable rooting area by removing paved surface and installing new soil See ERA Soil Management Actions pg 54		Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives			



High salt content (low EC) can hinder tree growth. Irrigating the soil flushes out salts.

EC Electrical Conductivity or Soluble Salts

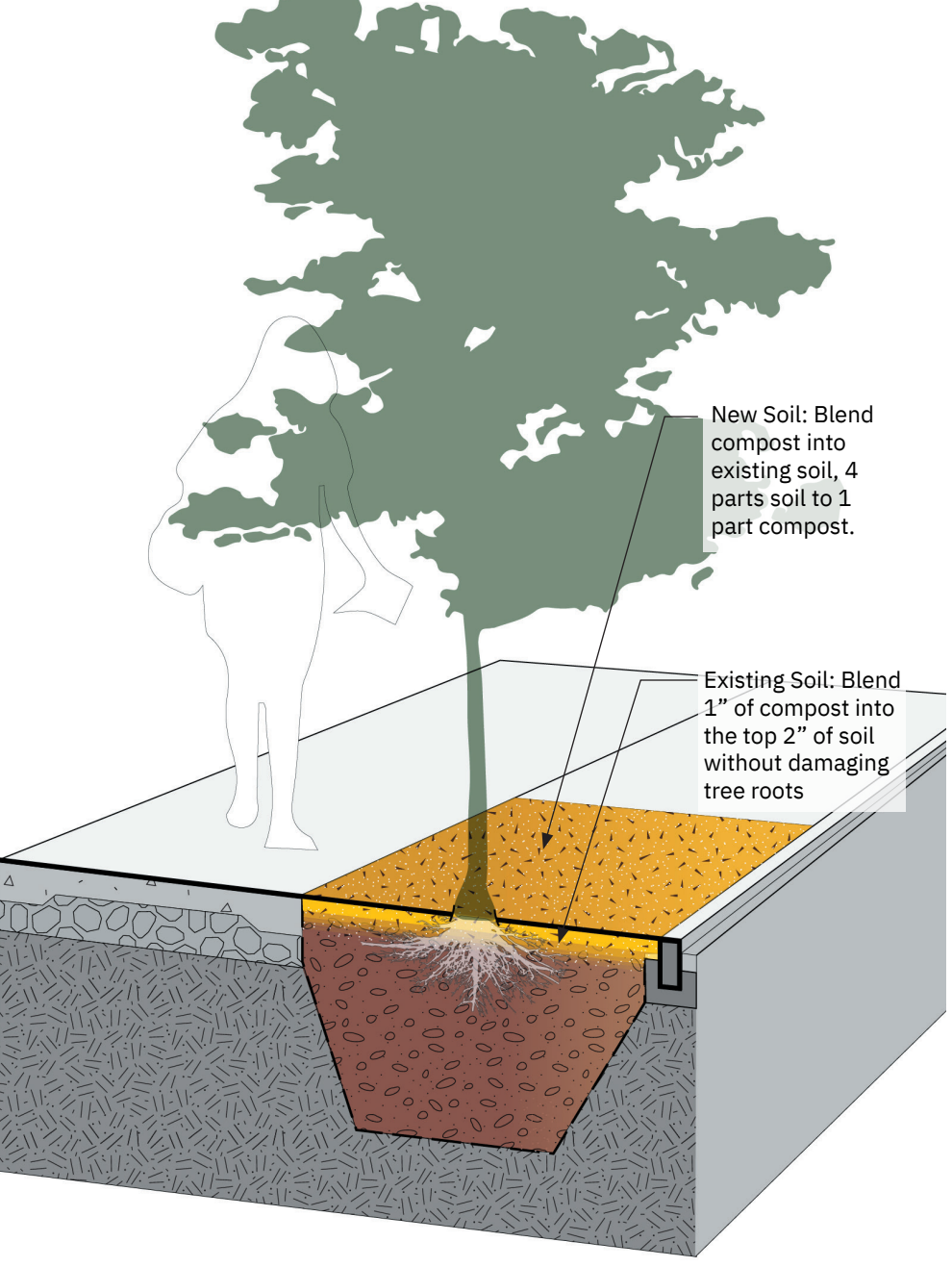
CUSI SCORE	0	1	2	3	4	5
	>1000 µS cm^{-1}	501-1000 µS cm^{-1}	WORSE ◁ 251-500 µS cm^{-1}	BETTER ▷ 101-250 µS cm^{-1}	50-100 µS cm^{-1}	<50 µS cm^{-1}
TIME OF PLANTING	Excavate tree pit. Irrigate open pit with 2.5 gallons of water per sq. ft. of area and let drain prior to tree planting If EC >3,000 µS cm-1, blend compost into excavated soil (1 cf compost per 4 cf of soil) before replacing Advise nearby residents and businesses to reduce de-icer applications in winter See EC Soil Management Actions pg 45				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	
TREE UNDER STRESS / AT RISK	If EC >1,000 µS cm-1, immediately irrigate soil with 2.5 gal of water per sq ft of area daily until EC <1 µS cm-1 For EC >1,000 µS cm-1, that won't drain, loosen soil (refer to PEN actions) and irrigate as above Blend 1" of compost into the top inch of soil. Place 2" of compost as mulch Advise nearby residents and businesses to reduce de-icer applications in winter See EC Soil Management Actions pg 54		Irrigate soil with 2.5 gal of water per sq ft of area weekly Place 2" of compost as mulch	Irrigate weekly with 1.5 gal water per sq ft of area Place 2" of compost as mulch Measure EC 2 times per year	Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	



Texture indicates a soil's relative sand, silt, and clay composition, see Soil Texture Triangle on pg 66. Very sandy soil loses water quickly and too fine-grained is easily compacted (low TEX scores). Poor texture is difficult to alter. Replacing soils or tree species may be required.

TEX Texture

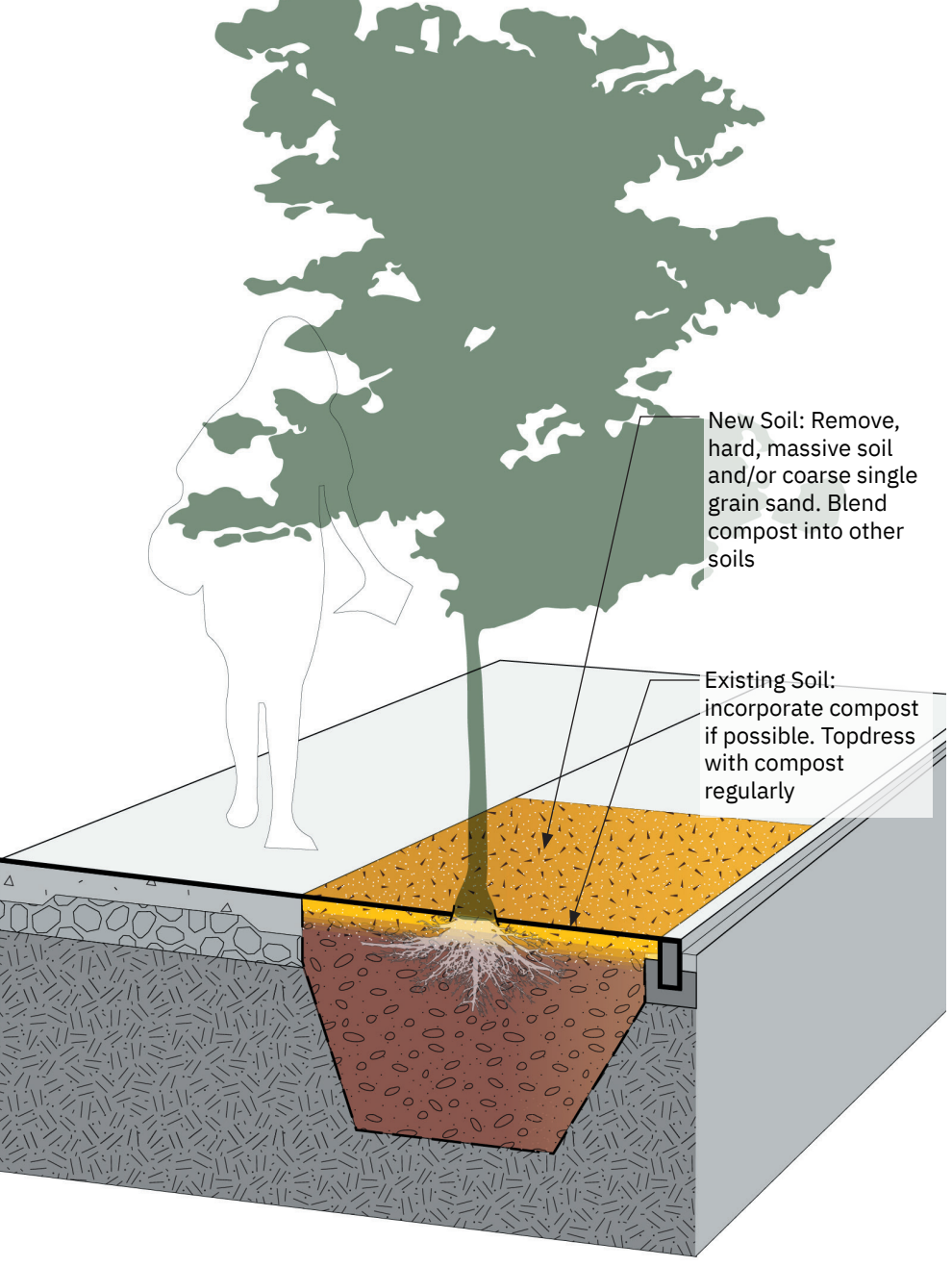
CUSI SCORE	0	1	2 (WORSE)	3 (BETTER)	4	5
	No soil and/ or coarse fragments are >75% of volume	C, SC, SiC, or Si textures, or S (without irrigation)	CL, SiCL, SCL textures, S (with irrigation), or LS (without irrigation)	LS (with irrigation)	SL (without irrigation)	L or SiL texture or SL (with irrigation)
TIME OF PLANTING	If very coarse (gravelly) soil, replace with sandy loam, loam, or silt loam soil as base soil Scarify tree pit floor and sides before installing new soil Inoculate with compost tea/biological amendment See TEX Soil Management Actions pg 46		Soil texture should not be amended, see TEX Soil Management Actions pg 46		Protect healthy soils, especia lly during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	
TREE UNDER STRESS / AT RISK	Blend loam or silt loam into gravelly or sandy soil where possible without damaging tree roots. No adjustment of clay, silty clay, sandy clay soils. Inoculate with compost tea/ biological amendment Topdress soil with 2" of compost See TEX Soil Management Actions pg 55		Place 2" of loamy sand or sand soil over clay, silty clay Topdress soil with 2" of compost See TEX Soil Management Actions pg 55		Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	



Soil organic matter supports tree health by making nutrients available to the root system. Adding organic matter can improve soils relatively quickly.

SOM Soil Organic Matter

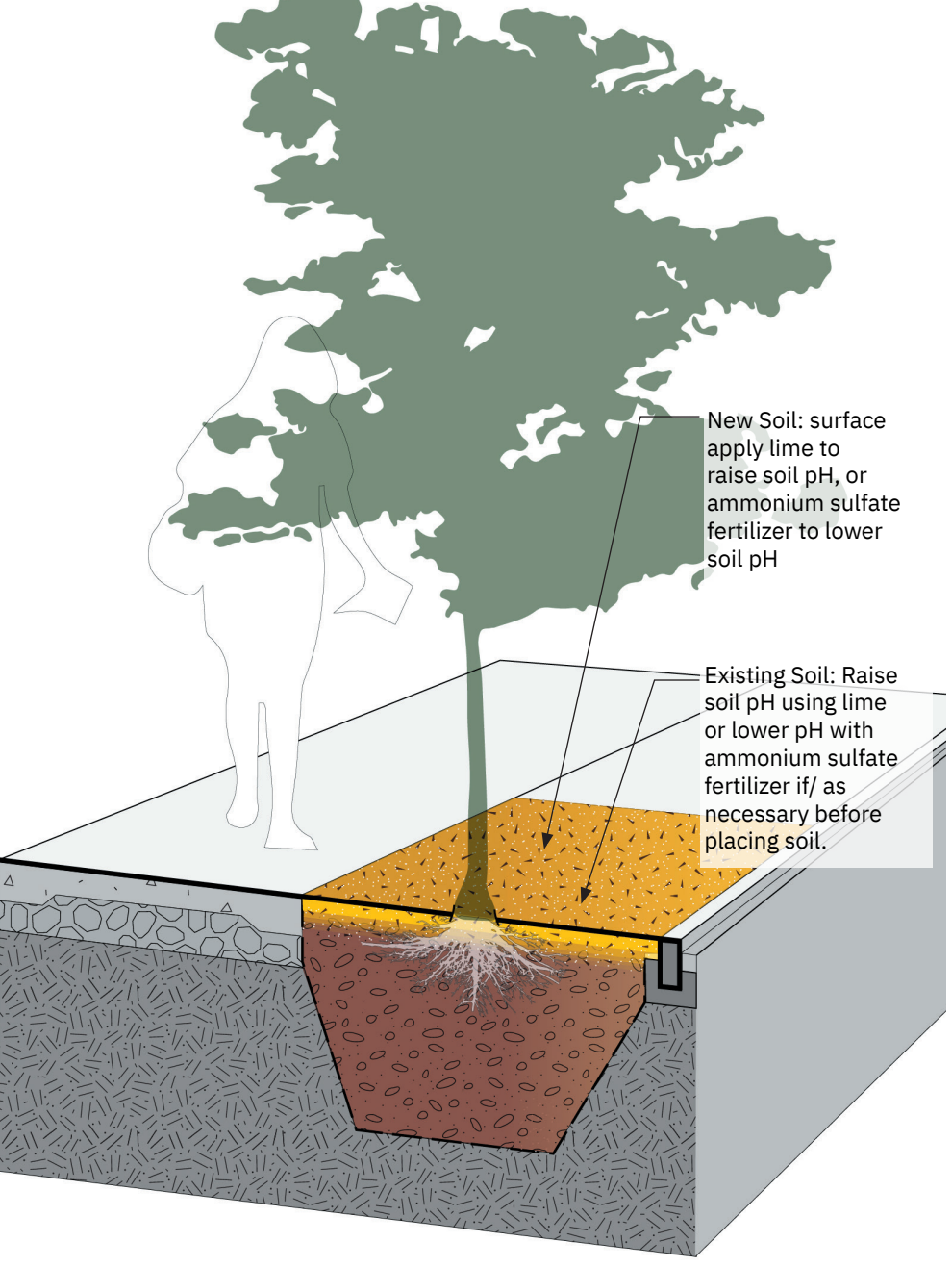
CUSI SCORE	0	1	2 (WORSE)	3 (BETTER)	4	5
	A horizon <5 cm depth and low organic matter	A horizon <5 cm depth and medium organic matter	A horizon <5 cm depth and high organic matter	A horizon ≥5 cm depth and low organic matter	A horizon ≥5 cm depth and medium organic matter	A horizon ≥5 cm depth and high organic matter
TIME OF PLANTING	Blend compost into excavated soil in a ratio of 4 parts soil to 1 part compost and replace into the tree soil pit Amend soil with compost tea/biological inoculants Topdress installed soil with 2” of compost See SOM Soil Management Actions pg 47				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	
TREE UNDER STRESS / AT RISK	Blend 1” of compost into the top 2” of soil without damaging tree roots Auger 2” coreholes to 12” to 15” deep 3” - 6” from edges of tree pits and fill with compost. Avoid damage to roots. Inoculate with compost tea Topdress soil with 2” of compost in spring and fall See SOM Soil Management Actions pg 56				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	



Good structure (high WAS) allows air and water to penetrate the soil and promotes root growth and biological activity. The practices listed here can build better structure in existing soils if followed over multiple growing seasons.

WAS Water Stable Aggregates

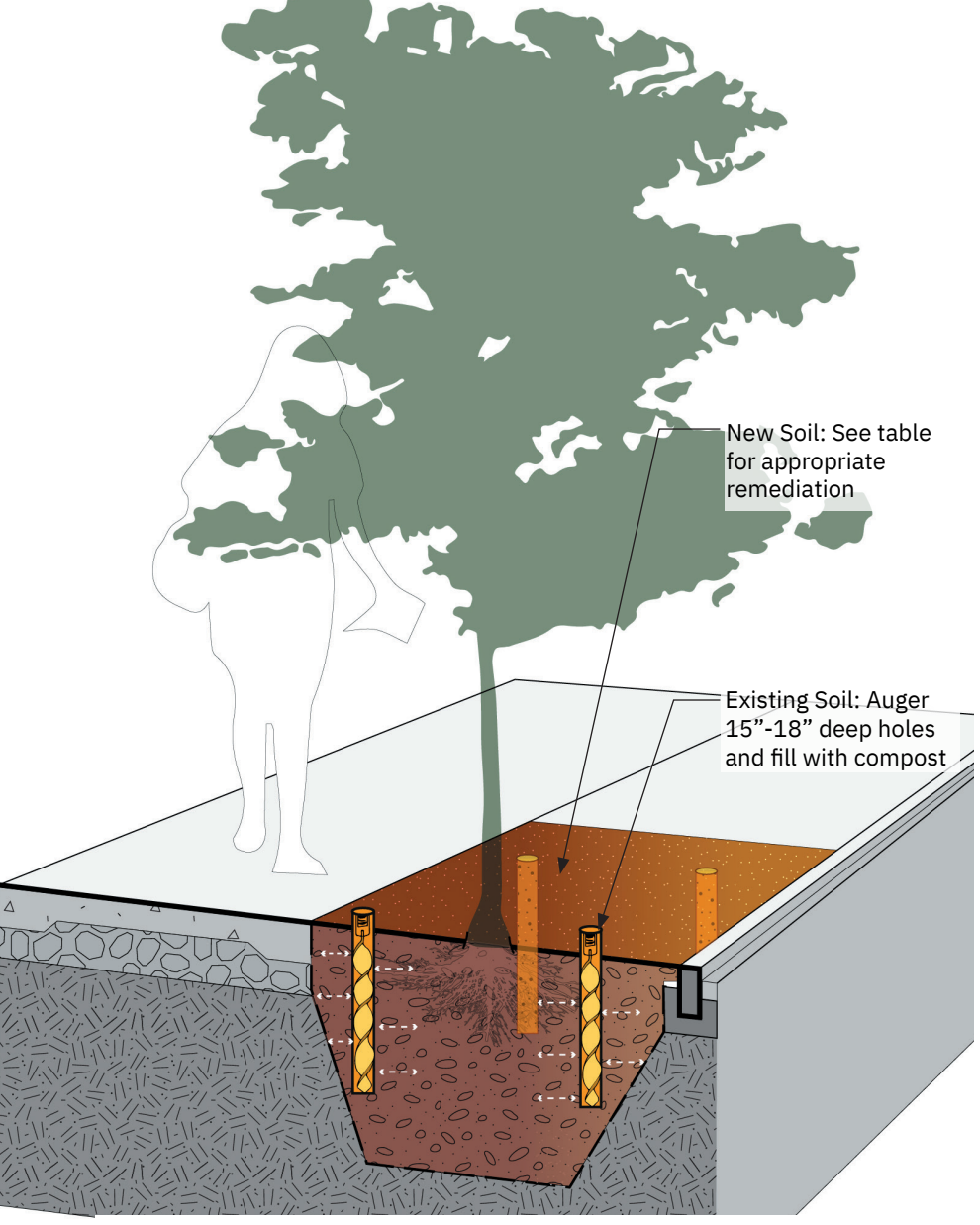
CUSI SCORE	0	1	2 (WORSE)	3 (BETTER)	4	5
	Massive, Single Grain, or Platy	Platy with weak or strong aggregates	Blocky with weak aggregates	Granular with weak aggregates	Blocky with strong aggregates	Granular with strong aggregates
TIME OF PLANTING	Massive, Single Grain, or Platy Structure: Remove soil and replace it with granular soil with strong aggregates. Platy with weak or strong aggregates: remove platy-structured soil component, replace with granular soil with strong aggregates Blocky or granular with weak aggregates: blend excavated soil with compost in a ratio of 4 parts soil to 1 part compost and replace into tree pit Topdress installed soil with 2” of compost See WAS Soil Management Actions pg 48				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	
TREE UNDER STRESS / AT RISK	Massive or platy structure (including platy with weak/ strong aggregates): break surface compaction without damage to roots (air spade) and blend 1” of compost into top 3” of soil. Single grain: topdress with loam/silty loam and blend into top 3 inches of soil. Repeat annually in the fall. Topdress with 2” of compost Blocky or granular with weak aggregates: Blend 2” compost into top 3 inches of soil with care not to damage roots. See WAS Soil Management Actions pg 56				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	



Nutrients can be less available in more alkaline soils and these soils are often impacted by salts, while more acidic soils can also be nutrient poor (low pH scores).

PH pH

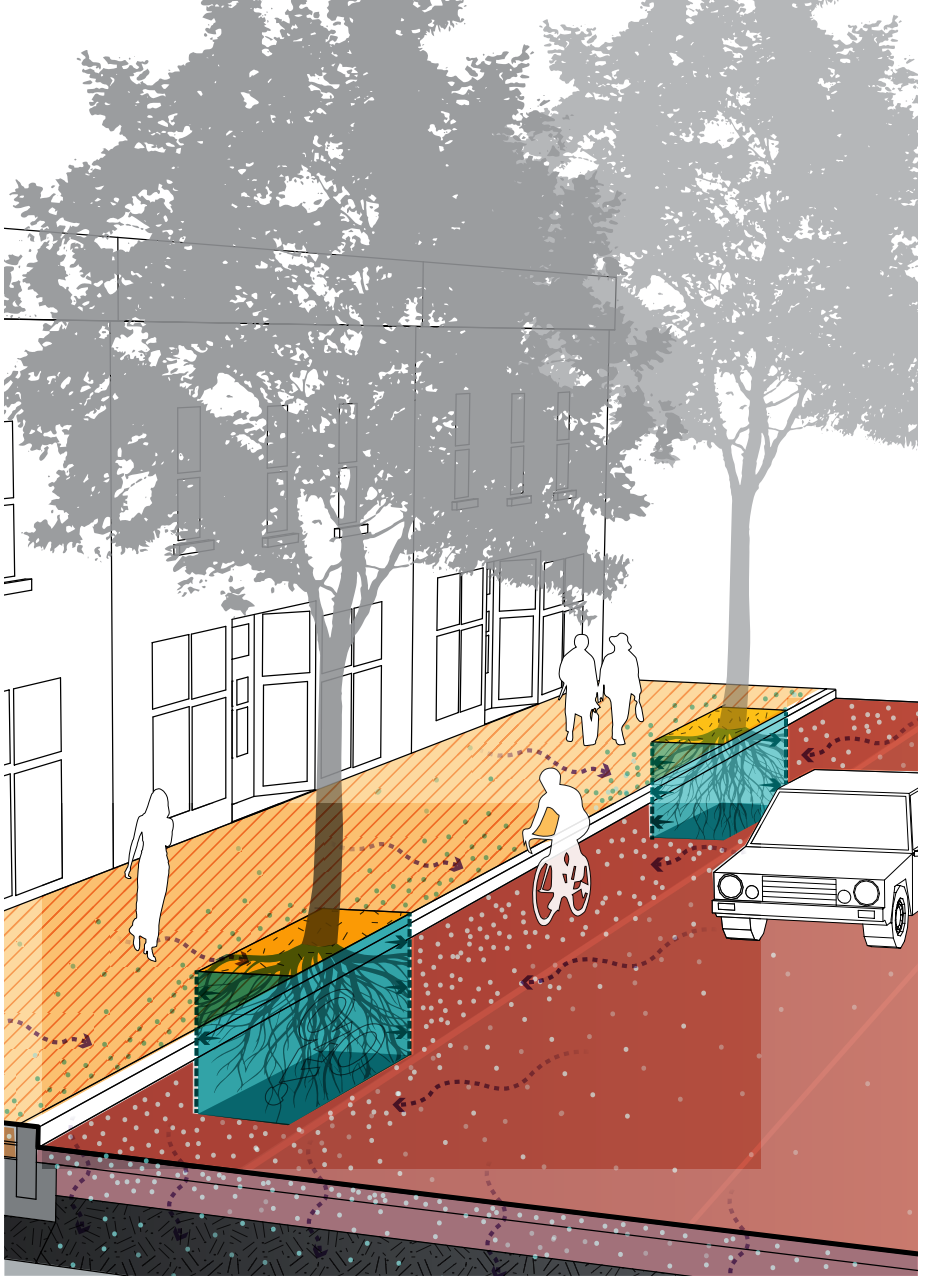
CUSI SCORE	0	1	WORSE ◁ 2	BETTER 3 ▷	4	5
	<4.5 or >8.5	4.5-5.0 or 8.1-8.5	5.1-5.4 or 7.6-8.0	5.5-5.9 to 7.1-7.5	6.0-6.3 or 6.8-7.0	6.4-6.7
TIME OF PLANTING	Low pH: Blend 10 lbs lime per cubic yard of excavated soil to raise soil pH to greater than 6.0 High pH: Blend 3.2 lbs of ammonium sulfate per cubic yard of soil to lower soil pH to less than 6.8 Blend compost into soil in a ratio of 1 part compost to 6 parts soil See pH Soil Management Actions pg 49		Low pH: Blend 4- to 5 lbs of lime per cubic yard of excavated soil to raise pH to greater than 6.0 High pH: Blend 1.5 lbs of ammonium sulfate per cubic yard of excavated soil to lower pH to less than 6.8 Blend compost into soil in a ratio of 1 part compost to 6 parts soil See pH Soil Management Actions pg 49		Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	
TREE UNDER STRESS / AT RISK	Low pH: Apply 10 lbs lime per 100 sq ft of soil surface to increase pH by 1.0 unit. Adjust lime application accordingly for each pH unit increase (ex. 15 lbs lime to raise pH 1.5 units ply about 0.5 to 0.75 lbs of elemental sulfur to 100 sf to lower pH by 1.0 pH unit. High pH: Apply 2.0 lbs of ammonium sulfate per 100 sq ft of sol surface to lower pH by 1.0 unit. Adjust ammonium sulfate application accordingly for each pH unit decrease (ex. 3 lbs of ammonium sulfate to lower soil pH by 1.5 units Topdress soil with 2” of compost Irrigate all amendments into the soil See pH Soil Management Actions pg 57				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	



Compaction (low PEN) can lead to low aeration, poor drainage, physical root restricting layers, and other negative impacts. Penetration resistance is highly dependent on moisture conditions, so conduct PEN assessments when soils are near similar moisture content. Surface compaction is relatively easy to address, but may reoccur easily as well. Deeper compaction can be addressed by the augering method noted in the table.

PEN Penetrometer (measure of compaction)

CUSI SCORE	0	1	2	3	4	5
			◁ WORSE	BETTER ▷		
	<5 cm and/ or evidence of severe compaction	5-25 cm and/ or evidence of moderate compaction	26-50 cm and/ or evidence of minor compaction	>50 cm or no evidence of compaction	>50 cm and no evidence of compaction	>100 cm and no evidence of compaction
TIME OF PLANTING	<5 cm penetration: over-excavate tree pit to break compacted soil on the floor and sidewalls of the tree pit and replace excavated soil with granular loam, sandy loam, or silt loam with strong, aggregated structure 5 - 25 cm penetration: scarify floor and sidewalls of tree pit to 6”. Place the compacted excavated soil in a large container or vessel to break the soil into smaller, blocky and granular peds (soil aggregates) if possible. Blend the soil with compost (5 pts soil to 1 pt compost) 26 - 50 cm penetration: scarify tree pit floor and walls to 3”. Break excavated, compacted soil to blocky or granular soil peds. Blend soil with compost (7 pts soil to 1 pt compost) If tree pit floor and walls are excessively compacted, the site may not be suitable for tree planting. See PEN Soil Management Actions pg 51				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	
TREE UNDER STRESS / AT RISK	<5 cm penetration (deep compaction): advance 2” auger holes 3” - 9” from tree pit edge to depth of 15” to 18” and fill with compost. Topdress with 2” of compost. 5 - 25 cm penetration: Scarify surface soil using hand tools, such as shovels and rakes, and topdress with 2” compost. Care must be used when breaking the soil compaction around tree roots See PEN Soil Management Actions pg 58				Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives	



Traffic and street disturbance can add deleterious substances and physically damage roots and soil (low TRF). However smaller streets (high TRF) can have smaller tree pits (lower ERA) so TRF should not be assessed in isolation.

TRF Traffic

CUSI SCORE	0	1	2 (WORSE)	3 (BETTER)	4	5
	>4 lanes and disturbance	2 – 4 lanes, no parking, disturbance	2 -4 lanes, parking either side, disturbance	<4 lanes, xxxx, no disturbance	2 -4 lanes, parking either side, no disturbance	<2 lanes, no disturbance
TIME OF PLANTING	Restore possible soil damage Minimize impacts from potential salts, compaction, see EC and PEN Select tree species resilient to harsh conditions			Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives		
TREE UNDER STRESS /	Bi-annual monitoring			Protect healthy soils, especially during construction Apply nutrients appropriately (type, timing, etc.) and only when identified to be deficient and necessary for tree health objectives		

Amending Soils for New Planting

Before discussing the specifics of amending soils, it's important to note that high quality soils may take many years to develop, but they can be destroyed in minutes. Do not excavate, amend, or install soils when they are wet as this will destroy its structure. It's more efficient to accept lost time due to rain delays rather than work with wet soils and create new problems that require still more hours to repair.

ERA Soil Management Actions

CUSI score is 0 to 2 – the space for tree growth is too limited. The following actions are recommended:

- Available rooting area for trees is too limited. Do not plant a tree in the planned location.
- Coordinate with City Engineer to expand tree planting area to at least 4 square meters by cutting and removing paved surface panels to increase the tree rooting area
- Assure adequate depth of soil for tree root growth – open tree pit to 30 inches or greater in depth.
- Remove paved surface panels to expand root growing area volume to include soil below paved areas
  - Cut and remove paved surface panels and base gravel.
  - Loosen existing soil or remove old soil and place new soil in an area next to the tree pit. Compact soil in place using tamping rods and/or foot pressure.
  - Replace gravel base material and removed surface pavement
- Cut panels and create a linear tree planting trench.
  - Follow the instructions above, but expand rooting area in a linear trench or corridor to connect to close-by non-paved, pervious areas. The trench shall be filled with existing soil or imported soil if appropriate
- Connect tree pit and rooting area to adjacent or nearby non-paved, pervious area.
  - Cut and remove paved surface panels and base gravel extending from the tree pit along a line parallel to the edge of the paved area to another tree pit.
  - Loosen existing soil or remove old soil and replace new soil in the trench. Grade the soil smooth and even. Add new soil at the surface to raise the soil grade even or slightly below the paved area surface. Prepare the surface of the soil by raking smooth and leaving as a firm, friable (loose) planting bed.
  - Plant new ground cover plants in the soil of the trench, between the tree pits.

CUSI score 3 to 5 – rooting area is adequate

- Assure adequate depth of soil for tree root growth – open tree pit to 30 inches or greater in depth.
  - If soil rooting depth of greater than 30 inches cannot be opened, do not plant tree

EC Soil Management Actions

CUSI score is 0 to 3:

- After excavation of the tree pit, flush the open pit with 2.5 gallons of clean water per square foot of tree pit floor and wall area and allow the water to drain.
  - If the water is excessively slow to drain, use hand tools to scarify soil surfaces on the floor and walls of the tree pit
- Blend compost into the removed soil at a rate of 1 cubic foot of compost per 4 cubic feet of removed soil.
  - Blend the compost and soil to a uniform, even mix in a large container or wheel barrow using shovels to mix the soil and compost
- After placement of the tree, replace treated soil into the tree pit, making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping rods/plates and foot pressure, and then scarified before placement of the next soil lift.
- After soil has been replaced, cover the soil with compost and irrigate with 5.0 gallons of water per square foot of tree pit area.
- If EC is greater than 3,000 $\mu S\ cm^{-1}$, remove and replace soil with sandy loam or loam soil. Install soil as described above.

- Plant salt-tolerant species such as ginkgo, hawthorns, honeylocust, London plane, English and red oak, Sargent cherry, or Scholar Tree. https://www.umass.edu › factsheets › 18roadsalttrees

CUSI Score 4 – 5:

No action for treatment of EC is needed.

TEX Soil Management Actions

CUSI score 0 – 1

- Excavate gravel, sand, clay, silty clay, sandy clay, or silty soil from the tree pit for removal from the site.
- Replace soil with loam, sandy loam or silt loam soil with strong aggregate structure.
    - After the new tree has been positioned in the tree pit, place new soil into the pit making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping rods/plates and foot pressure, and then scarified before placement of the next soil lift.
    - After soil has been replaced, cover the soil with a 2-inch layer of compost.

CUSI score 2 – 3

- Excavate clay loam, silty clay loam, sandy clay loam or loamy sand soil from the tree pit and place in a large container (truck bed, wheel barrow, or similar).
- Prepare the tree pit floor and side walls by scarifying the surfaces to a depth of 2 inches using rakes and/or shovels.
- Blend compost into the removed soil at a rate of 1 cubic foot of compost to 5 cubic feet of soil. Mix the soil and compost using shovels. Soil must be dry to moist to complete this task efficiently.
    - If the soil is wet, break the soil into smaller clumps and allow to dry over several hours if possible before blending with compost.
- After the new tree has been positioned in the tree pit, place new soil into the pit making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping rods/plates and foot pressure, and then scarified before placement of the next soil lift.
- After soil has been replaced, cover the soil with a 2-inch layer of compost.

CUSI score 4 – 5

- Remove soil from the tree pit excavation.
- Scarify the floor and sidewalls of the tree pit to a depth of 2 inches using rakes and shovels.
- After the new tree has been positioned in the tree pit, place new soil into the pit making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping rods/plates and foot pressure, and then scarified before placement of the next soil lift.
    - After soil has been replaced, cover the soil with a 2-inch layer of compost.

SOM Soil Management Actions

CUSI score 0 – 3

- Excavate soil from tree pit and place in a large container.
- Prepare the tree pit by scarifying the floor and sidewalls to a depth of 2 inches using rakes and shovels.
- Blend compost into the excavated soil in a ratio of 5 parts soil to 1 part compost.
    - Use shovels to blend the soil and compost together, mixing the soil and compost to a uniform, even blend
    - If the soil is wet, break the soil to smaller pieces and allow to dry for several hours if possible before blending compost into the soil.
- After the new tree has been positioned in the tree pit, place new soil into the pit making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping rods/plates and foot pressure, and then scarified before placement of the next soil lift.
- After soil has been replaced, cover the soil with a 2-inch layer of compost.

CUSI score 4 – 5

No action to amend soils with organic matter is necessary. Excavated soils can be replaced around new tree plantings as described above.

WAS Soil Management Actions

CUSI score 0 – 1

- Soils with massive and/or platy structure will be excavated and disposed or used for fill soils at a different location.
  - After soils have been excavated, scarify the floor and sidewalls of the tree pit to a depth of 2 inches using rakes and shovels.
  - Loam or silt loam soil with strong, well-aggregated granular structure will be used for replacement into the soil pit
- Soils with platy structure and weak to strong aggregates shall be removed and placed in a container.
  - After soils have been excavated, the floor and sidewalls of the tree pit will be scarified to a depth of 2 inches using rakes and shovels.
  - The excavated soils will be broken into smaller clods and peds and blended with compost in a ratio of 5 parts soil to 1 part compost. Blend the soil and compost using shovels to create a uniform, even mix.
- If the soils are wet, allow them to dry for several hours before mixing with compost, if possible.

CUSI score 2 – 3

- Soils with weak blocky or aggregate structure will be excavated from the tree pit and placed in a large container for treatment.
- After soils have been excavated, the floor and sidewalls of the tree pit will be scarified to a depth of 2 inches using rakes and shovels.
- The excavated soils will be broken into smaller clods and peds and blended with compost in a ratio of 5 parts soil to 1 part compost. Blend the soil and compost using shovels to create a uniform, even mix.
  - If the soils are wet, allow them to dry for several hours before mixing with compost, if possible.

CUSI score 4 – 5

- Soils with blocky or granular structure with strong aggregate need no treatment.
- After soil have been excavated, the floor and the sidewalls of the tree pit will be scarified to a depth of 2 inches using rakes and shovels.
- After trees have been placed and positioned, soil will be replaced into the tree pit, making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping rods/plates and foot pressure, and then scarified before placement of the next soil lift.
  - After soil has been replaced into the tree pit, cover the soil with a 2-inch layer of compost.

pH: Soil pH Management Actions

CUSI score 0 – 1

- For soils with pH less than 4.5 to ph 5.0 (low pH) or soil with pH from 8.1 to greater than 8.5 (high pH), tree pit soils will be excavated and placed in a large container for treatment.
- The floor and sidewalls of the tree pit will be scarified to a depth of 2 inches using shovels and rakes.
  - For soil with low pH less than 5.0, mix 0.15 lbs of lime (calcium carbonate) per square foot of tree pit floor into the soil. For example, if the tree pit floor is 40 square feet (approximately 4 square meters), 6 lbs of lime (about 4 measuring cups) would be blended into the soil of the tree pit soil.
  - For soil with pH greater than 8.0, mix 0.10 lbs of ammonium sulfate fertilizer into each 1.0 square feet of the tree pit floor. For example, if the tree pit with 40 square feet, 4.0 lbs (about 4 measuring cups) of ammonium sulfate will be mixed into the tree pit floor.
- The excavated soil with pH less than 5.0 shall be blended with lime at a rate of 10 lbs of lime for each cubic yard of soil. Compost will also be blended into the soil in a ratio of 1 cubic foot of compost per 6 cubic feet of soil
  - Soil shall be placed in a wheelbarrow (note: a large wheelbarrow will hold about 1/4 to 1/3 cubic yard of

soil). The soil should be dry to moist. Place about 2 to 3 pounds (about 2 measuring cups) of lime on the soil (assuming 1/4 cubic yard) as it is being stirred and begin mixing the soil with the lime, blending the lime into the total mass. Mix one cubic foot of compost into the soil as the lime is also being mixed into the soil

- Soil with pH greater than 8.0 shall be treated with ammonium sulfate fertilizer at a rate of 3.2 lbs of ammonium sulfate per cubic yard of soil.
    - Soil shall be placed in a wheelbarrow and as above (and assuming 1/4 to 1/3 cubic yard per mix load) and blended with approximately 0.75 to 1 pound of fertilizer (about 1 measuring cup) evenly spread over and into the soil as it is being stirred. Mix 1 cubic foot of compost into each load of the soil as the fertilizer is being blended.
- After placement and positioning of the tree, replace the treated soil into the tree pit around the tree, making sure to pack the soil around the base of the tree root ball and firmly into all areas of the tree pit.
- After all soil has been placed into the tree pit and the tree planting is completed, topdress the soil with a 2-inch layer of compost.

CUSI score 2 – 3

- Soils with pH between 5.1 to 5.9, or pH between 7.1 to 8.0 shall be treated with lime (for low pH soil) or ammonium sulfate fertilizer (high pH soils) as describe above with the following rates of lime or amendment.
    - After excavation of tree pit soils and scarification of the tree pit floor and sidewalls (to depths of 2 inches),
        - The tree pit soil with low pH will be treated with approximately 1.25 lb (about 1 measuring cup) of lime for every 10 square feet of tree pit floor surface area. A tree pit with 40 square feet would receive 5 lbs of lime.
        - The tree pit soil with high pH will be treated with approximately 1/2 lb (about ½ measuring cup) of ammonium sulfate fertilizer for every 10 square feet of tree pit floor area. A tree pit with 40 square feet would receive 2 pounds of ammonium sulfate.
    - Low pH soils will be blended with about 4- to 5 lbs (about 3 measuring cuips) of lime per cubic yard of soil. Soil shall be blended in wheelbarrows or similar vessels as described above by mixing 1- to 1.25 lbs (about 3/4 measuring cup) of lime and 1 cubic foot of compost with approximately 1/4 cubic yard (about 7 cubic feet) of soil.
    - High pH soils will be blended with about 1.5 to 1.75 lbs (about 1.5 to 1.75 measuring cups) of ammonium sulfate per cubic yard of soil. Soil shall be blended in wheelbarrows or similar vessels as described above by mixing about 0.4 lb (or 1/2 measuring cup) of ammonium sulfate and 1 cubic foot of compost spread evenly over and into . approximately 1/4 cubic yard of soil as the soil is stirred.
- After placement and positioning of the tree, replace the treated soil into the tree pit around the tree, making sure to pack the soil around the base of the tree root ball and firmly into all areas of the tree pit.
- After all soil has been placed into the tree pit and the tree planting is completed, topdress the soil with a 2-inch layer of compost.

CUSI score 4 – 5

Soils with pH between 6.0 to 7.0 do not need to be treated to adjust pH.

PEN Soil Management Actions

CUSI score 0 – 2

- Soils with compaction measured with less than 5 cm of penetration:
    - Soil shall be excavated from the tree pit. Additional excavation with a back hoe or shovels to break compaction on the floor and sidewalls of the tree pit will be done to break compacted layers on the edges of the tree pit.
    - After the tree(s) has been placed and positioned, loam, sandy loam, or silt loam soil with strong, aggregated granular structure will be used to replace soils. Soil will be replaced into the tree pit, making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping

rods/plates and foot pressure, and then scarified before placement of the next soil lift.
    - After soil has been replaced into the tree pit, cover the soil with a 2-inch layer of compost.

- Soils with compaction measured with 5 - 25 cm of penetration:
    - Soil shall be excavated from the tree pit. The tree pit floor and sidewalls will be scarified to a 6 inch depth.
    - Excavated soil will be placed in a container and broken to blocky and granular clods and peds (aggregates) if possible using hand tools (shovels, rakes, mallets).
    - The excavated soil will be mixed with compost in a ratio of 5 cubic feet soil to 1 cubic foot of compost (5 units soil to 1 unit compost) in a uniform, even blend of soil and compost.
    - After the tree(s) has been placed and positioned, the treated soil will be replaced into the tree pit, making sure to fill all areas around the planted tree, including below and around the tree root ball. Soil shall be replaced in 8- to 12-inch lifts, with each lift compacted using tamping rods/plates and foot pressure, and then scarified before placement of the next soil lift.
    - After soil has been replaced into the tree pit, cover the soil with a 2-inch layer of compost.
- Soils with compaction measured with 25 - 50 cm of penetration:
    - Soil shall be excavated and treated as described above, except that soil will be blended with compost in a rate of 7 cubic feet of soil to 1 cubic foot of compost before replacing in the tree pit.
    - Soil will then be replaced in the tree pit after the tree(s) has been placed and positioned, and a 2-inch layer of compost will be placed on the soil.

CUSI score 3 – 5

Soil will not need treatment before being replaced into the tree pit.

PREPARATION OF SUB-GRADE FOR NEW TREES

Prior to placement of soils and planting of trees, subgrade conditions may need to be improved, including:

Remove large rocks or other debris that could restrict root growth.

Break compacted subgrade surfaces, including the floor and walls of the tree pit subgrade. It may be necessary to backfill cavities left after decompacting the subgrade or removal of large objects.

Scarify the floor and sides of all tree pits. Do not leave smooth surfaces as these can impede water movement and root growth.

Check drainage by partially filling the pit with water to assure that it will adequately move through and/or out of the soil profile. If the subgrade does not drain, it may be necessary to add a drainage wick, see glossary.

SOIL INSTALLATION

The existing subgrade soil must be prepared to accept new planting soils.

Soil needs to be installed in lifts not to exceed 8- to 10 inches in thickness. Each lift must be uniformely compacted per specification requirements and scarified before placement of each successive soil lift to avoid clay pans or slickened/smeared faces between soil layers.

Soil must be firmly placed around the tree root ball with no voids left in the soil

Soil Maintenance for Existing Trees

Before discussing the specifics of maintenance BMPs, it's important to note that high quality soils may take many years to develop, but they can be destroyed in minutes. Protect soils from compaction during construction and avoid any work with wet soils to prevent damaging the soils which would take still more time to remedy.

ERA Soil Management Actions

CUSI scores 0 – 2
- If the tree is stressed or in decline, remove the tree, or
- Increase rooting volume to a minimum of **4 square meters (44 sf)** by cutting paved surface panels around the tree.
- Increase rooting volume by expanding available soil below pavement as described above.
- Expand and connect rooting volume to close-by pervious surface areas as described above.
- Expand rooting area by constructing a linear planting trench as described above.

CUSI cores 3 – 5

No action to expand the estimated rooting area is needed.

EC Soil Management Actions

CUSI Score 0 - 2
- Flush the tree pit soil with 2.5 gallons of clean water (potable water) per square foot of tree pit surface area.
  - Pour water slowly and evenly onto the soil surface, being careful not to splash water off the soil onto surrounding areas, or erode soil.
- Repeat soil flushing weekly until soil EC daily until the EC is below 100 µS cm-1
- Evenly spread 1 inch of compost over the soil surface of the tree pit ;land raking the compost into the top 1 inch of soil.
- Add an additional 2 inches of compost as topdress covering of the soil.

CUSI Score 3
- Flush the tree pit soil with 2.5 gallons of clean water (potable water) per square foot of tree pit surface area.
  - Pour water slowly and evenly onto the soil surface, being careful not to splash water off the soil onto surrounding areas, or erode soil.
- Repeat soil flushing weekly until soil EC weekly until the EC is below 100 µS cm-1
- Evenly spread 1 inch of compost over the soil surface of the tree pit ;land raking the compost into the top 1 inch of soil.
- Add an additional 2 inches of compost as topdress covering of the soil.

CUSI Score 4 – 5

No action is needed

TEX Soil Management Actions

CUSI Score 0 - 1
- Coarse gravelly or sandy soil is not sustainable for trees and may need to be removed and replaced with well-aggregated loam, sandy loam, or silt loam soil.
  - Removal of soil will require removal and replacement of the existing tree with a new tree.
- Where soil and tree removal is not an option, blend loam or silt loam into the top 1- to 2" of existing gravelly or sandy soil where possible with care not to damage tree roots.
  - Irrigate the treated soil with 2 gallons of water per square foot of treated area to move fine (silt, clay, and fine sand) into the soil.
  - Repeat process for 3- to 5 years to continue to alter soil texture.
- For young trees in gravelly or coarse sand, or clay soil, remove soil from the periphery (outer 3- to 4 inches, or more if possible) of the tree pit with care to not damage tree roots.
  - Replace removed soil with loam, sandy loam, or silt loam soil.
  - Pack new soil into the space using light pressure with tamping rods, but do not over compact the soil.

CUSI score 2 – 3

- For sandy soil, blend 1 inch of sandy loam or loam soil into the top 2” of the soil with care not to damage tree roots.
    - Irrigate the soil with 2.5 gallons of water per square foot of area to allow silt, clay, and fine sand particles to move into the sandy soil
- For clay loam, silty clay, and sandy clay soil, soil texture should not be attempted to be altered.

CUSI score 4 – 5

No amendment or action is needed.

SOM Soil Management Actions

CUSI score 0 – 3

- Evenly spread a 1” layer of compost on the surface of the existing soil and gently work (using a rake or shovel) into the top 2 inches of soil with care not to damage tree roots.
- Topdress the soil surface with 2 inches of compost.

CUSI score 4 – 5

No action is needed.

WAS Soil Management Actions

CUSI score 0 – 1

- Existing soils with massive, platy, and/or platy structure with weak aggregates will be treated using a pneumatic air spade.
    - Prior to use of an air spade, evenly spread 1 inch of compost across the surface of the soil.
    - The air spade will be used by an experienced technician to break soil structure to depths up approximately 6 inches. The process will allow compost to fall into the broken soil while it is being treated with pressured air.
    - After air spading has been completed, rake remaining compost into and over the soil.
    - Topdress the treated area with a 2-inch layer of compost.

- If an air spade is not available, break the compacted soil surface to a depth of 2- to 3-inches using hand tools, including shovels, rakes, or hand trowels. Use care to not damage tree roots.
    - Blend a 1-inch layer of compost into the broken soil, again, using care not to damage tree roots.

CUSI score 2 – 3

- Soils with blocky or granular structure with weak aggregates will be treated by evenly spreading a 1-inch layer of compost over the soil surface. Shovels, rakes, and hand trowels will be used to gently work the compost into the top 2- to 3 inches of soil with care not to damage tree roots.
    - After treatment, a 2-inch layer of compost will be placed over the soil.

CUSI score 4 – 5

No action or treatment of soil is necessary.

pH Soil Management Actions

CUSI score 0-1

- Low pH soils (soil pH less than 5.0) will be treated with 15 lbs of lime (about 10 measuring cups) per 100 square feet of soil surface area of the tree pit.
    - Evenly spread the lime on the surface soil of the tree pit.
    - Cover the soil with 2 inches of compost.
    - Irrigate the surface of the soil with approximately 2.5 gallons of water per square foot of surface area.
- High pH soils (soil pH greater than 8.0 will be treated with 3.0 lbs (about 3 measuring cups) of ammonium sulfate fertilizer per 100 square feet of soil surface area of the tree pit.
    - Evenly spread the ammonium sulfate on the surface soil of the tree pit
    - Cover the soil with 2 inches of compost
    - Irrigate the surface of the soil with approximately 2.5 gallons of water per square foot of surface area.

CUSI score 2 – 3

- Low pH soils (soil pH less than 6.0) will be treated with 7.5

lbs (about 5 measuring cups) of lime per 100 square feet of soil surface area of the tree pit.
    - Evenly spread the lime on the surface soil of the tree pit.
    - Cover the soil with 2 inches of compost.
    - Irrigate the surface of the soil with approximately 2.5 gallons of water per square foot of surface area.
- High pH soils (soil pH greater than 8.0 will be treated with 2.0 lbs (about 2 measuring cups) of ammonium sulfate fertilizer per 100 square feet of soil surface area of the tree pit.
    - Evenly spread the ammonium sulfate on the surface soil of the tree pit
    - Cover the soil with 2 inches of compost
    - Irrigate the surface of the soil with approximately 2.5 gallons of water per square foot of surface area.

CUSI score 4-5

No action or treatment of soil is necessary.

PEN Soil Management Actions

CUSI score 0-2

- For soil with compaction measured with less than 5 cm of penetration:
    - A pneumatic air spade can be used to break areas of surface compaction.
        - Prior to use of the air spade, a 1-inch layer of compost will be placed evenly over the surface of the soil.
        - The air spade will be operated by an experienced technician to break soil compaction to as much as 6- to 12 inches. Care must be used not to harm tree roots. The compost will be blended into the soil with the action of the air spade.
        - After completion of the air spade action, a 1-inch layer of compost will be placed over the soil and gently raked or mixed into the top 3 inches of soil with care not to damage tree roots.
    - If an air spade is not available, 2-inch diameter auger holes will be advanced approximately 3- to 9 inches from tree pit edge.

        - The auger holes will be advanced to depths of 15” to 18” and filled with compost.
        - Compacted soil on the surface of the tree pit will be gently broken to a depth of approximately 2 inches. A 1-inch layer of compost will then be spread on the soil and gently raked or mixed into the top 2 inches of soil.
        - A 2 inch layer of compost will be placed over the soil.
- For soil with compaction measured with 5 to 25 cm of penetration:
    - The soil surface will be gently raked and broken to a depth of 2 inches with care not to damage tree roots.
    - A 2-inch layer of compost will then be placed over the soil.
- For soil with compaction measured with 25 – 50 cm of penetration:
    - A 2-inch layer of compost will be placed over the soil

CUSI Score 3 – 5

No action is necessary to treat soils measured with more than 50 cm of penetration.

GENERAL SOIL MAINTENANCE

Basic soil maintenance includes:

- Improving soil surface conditions: breaking soil crusts and/or surface compaction, removing silt deposits.
- Scarifying the soil surface to open sealed soil “skins” and open soil pores.
- Leaching excess salts: flushing (irrigating) soils in which high soluble salts may be accumulating
- Building soil aggregate stability: amending soil with compost
- Protecting soil: placement of mulch cover to reduce protect from rainfall impacts, reduce erosion, buffer compaction, and filter stormwater

Simple soil maintenance can be completed in 20 to 30 minutes for each tree pit. Routine maintenance should be completed annually where trees and soils are impacted by moderate to heavy urban activities such as traffic, street maintenance, pedestrian use, and harsh climate conditions.

Common soil issues or concerns that typically need attention include:

- Sediment depositions that can include fine silts and sands as well as salts and organic pollutants
- Soil surface crusts resulting from weak soil aggregate development and dispersed soil particles. Soil crusts can limit infiltration and air exchange with deeper soil
- Soil compaction: tree soils may show signs of compaction resulting from settling of soils or, more likely, foot traffic or other forces that impact the soil.
- Low organic matter nutrient content. Organic matter builds soil structure, improves infiltration, and cycles nutrients for plant uptake.
- Soil cover: soil cover, such as vegetation or mulch, will protect soil from degradation and result in better tree and plant growth.

Tools and materials needed include:

- Shovels and rakes
- Containers for removal of deleterious materials (silts, salts, debris)
- Fresh, good quality compost
- Fresh mulch, no added dyes.
- Water source and hoses for irrigating tree pits and soils to leach salts deep into the soil profile BMP.

Annual Soil Maintenance Calendar

	CUSI SCORE	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
EC	0	Public outreach regarding deicer use	Flush soils after spring rains	Assess soils for salts	Public outreach regarding deicer use
	1				
	2				
	3				
	4-5				
TEX	0		Topdress with 2” of compost		
	1				
	2				
	3				
	4-5				
SOM	0		Topdress soil surface with 1- to 2- inches of good-quality compost		Topdress soil with 1” of good quality compost
	1				
	2				
	3				
	4-5				
WAS	0		Inspect soil structure, topdress with compost		Open boreholes/fill with compost
	1				
	2				
	3				
	4-5				
pH	0		Test soil pH, add amendments		
	1				
	2				
	3				
	4-5				

2.4 References

Scharenbroch, Bryant C., E. Thomas Smiley, and Wes Kocher *Soil Management for Urban Trees*, Atlanta
: International Society of Arboriculture, 2014

Scharenbroch, B.C. and Catania, M., 2012. *Soil quality attributes as indicators of urban tree performance.* Arboriculture & Urban Forestry, 38(5), pp.214-228.

Scharenbroch, B.C., Carter, D., Bialecki, M., Fahey, R., Scheberl, L., Catania, M., Roman, L.A., Bassuk, N., Harper, R.W., Werner, L. and Siewert, A., 2017. *A rapid urban site index for assessing the quality of street tree planting sites.* Urban Forestry & Urban Greening, 27, pp.279-286.

2.5 Glossary

Texture is one of the key features we use to describe soils. Soil texture is a term we use to describe particle sizes of the soil. The distribution of sand (2-0.05 mm), silt (0.05-0.002 mm), and clay (<0.002 mm) particles are used to assign one of 12 soil textural classes (Figure 1). Soil texture has great influence on soil water and fertility. Much useful information can be inferred from texture (Table 2). Loams are ideal for plants because they have better water and nutrient supply capacities compared to sandy soils. Loams are preferred to clay soils because they have better drainage. Soil texture can be measured in laboratory or determined in the field using the feel method (Figure 2).

Structure is the arrangement of primary particles into aggregates. Classification of soil structure is based on its shape, size of the aggregates, and aggregate distinction (Table 1). Soil structure greatly affects the air and water status of soil. Large pores favor aeration and rapid water movement between aggregates. Small pores favor water retention. The presence of stable structural aggregates is very useful to infer biological activity and disturbance of the soil. For example, soil compaction may destroy soil aggregates, creating massive or platy structure, inhibiting drainage in the soil.

Color is one of the most obvious and telling soil properties, consequently a favorite of soil scientists and practitioners. Soil color is expressed by its hue, chroma, and value, described in the Munsell color book. A soil's color can give valuable clues to organic matter, aeration/drainage, and parent material of the soil. For example, soils with high organic matter contents tend to have lower values (Table 3). Poorly drained soils tend to have low chromas. Soils weathering from iron-rich sediments may have redder hues.

Figure 1. Soil texture triangle

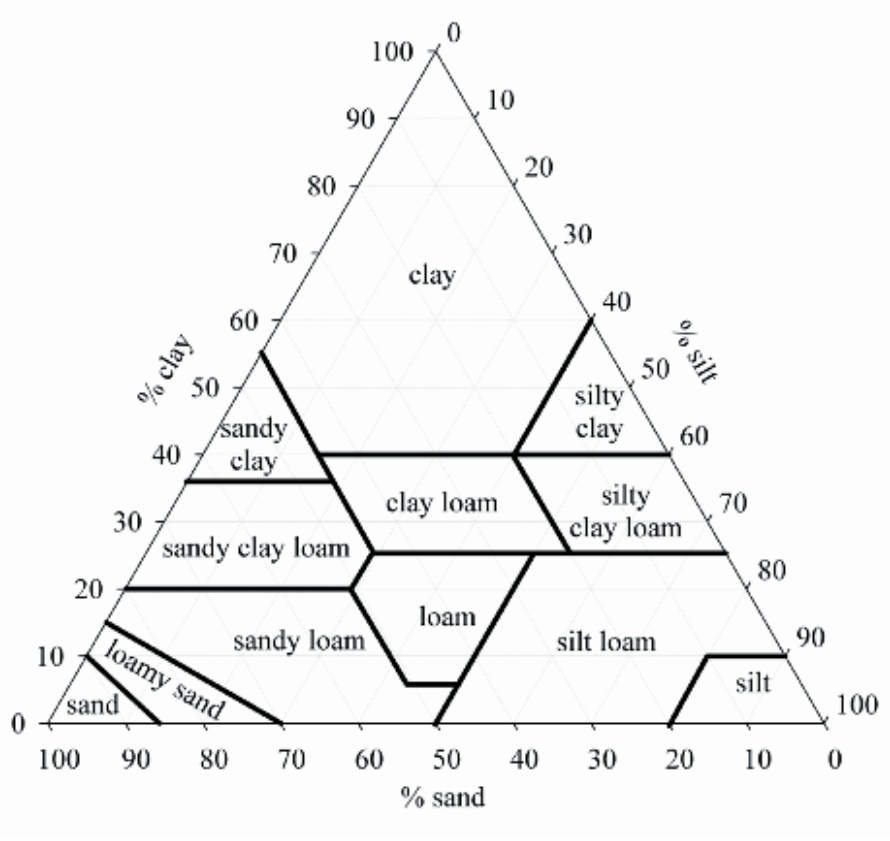


Figure 2. Soil texture via feel method

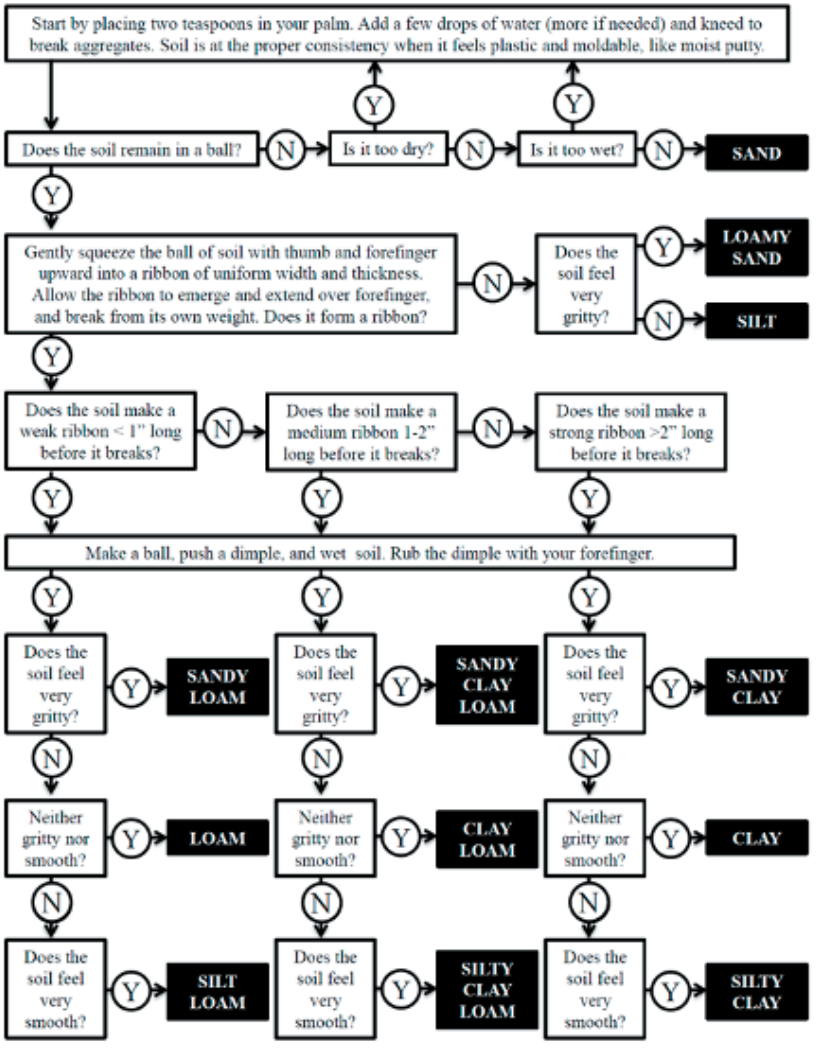


Table 1. Soil structure types, images, and descriptions

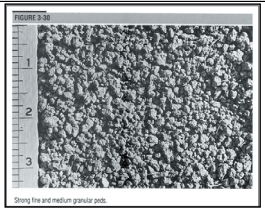
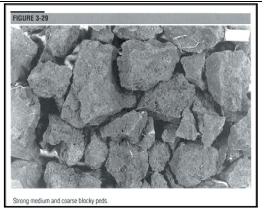
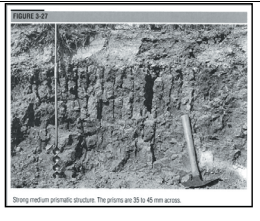
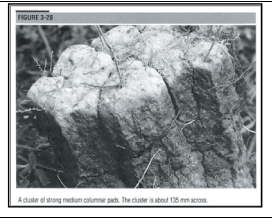
Structure	Image	Description and Interpretation
Granular		DES: Units are spherical or polyhedral and are bounded by curved or very irregular faces that are not casts of adjoining peds. INT: High biological activity and not disturbed.
Blocky		DES: Units are block-like or polyhedral; angular and subangular. INT: Moderate biological activity and may have been disturbed. If found in the subsurface, may be indicative of clay accumulation.
Platy		DES: Units are flat and plate-like. INT: Low biological activity and the soil has most likely been disturbed. If found on the surface, may be indicative of dispersion from salts and/or compaction.
Prismatic		DES: Units are bounded by flat to rounded vertical faces; distinctly longer vertically, and the faces are typically molds of adjoining units; vertices are angular or subrounded; tops are somewhat indistinct and normally flat. INT: Subsurface structural type associated with clay accumulation.
Columnar		DES: Units are similar to prisms and are bounded by flat or slightly rounded vertical faces; tops of columns, in contrast to those of prisms, are very distinct and normally rounded. INT: Subsurface structural type associated with high salt contents.

Table 2. Organic matter content by soil color

Soil color	Munsell soil value	Organic matter (%)
	<2	>10
	3	5-10
	4	3-4
	5	1-2
	>5	<1

PRODUCED IN COLLABORATION WITH

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View the City of Cambridge Urban Forest Report and
UFMP Technical Report at
www.cambridgema.gov/UFMP

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Attachment D

City of Cambridge Parcel Block Map of Thomas P. O'Neill Jr. Golf Course

BLOCK 266

Cambridge GIS maps available online at: https://www.cambridgema.gov/GIS

FY 2021

City of Cambridge
Assessing Department

795 Massachusetts Ave.
Cambridge, MA 02139

Buildings
Lot Line
Block Line
City Boundary
Water
Sub-Parcel Line
Easement
Railway

10 Lot Number
266 Block Number
10 Cam Street Number
(125.0) Deed Dimension
100 Parcel size in Sq. Ft.
44.0LC Land Court Dimension
65.0 Survey Dimensions

N

0 90 180 360 Feet

1 inch = 193 feet

Parcel Block Map

266