# Guidelines on Soil Volume for Urban Trees

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**Development Bureau**
**The Government of the Hong Kong Special Administrative Region**

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# CONTENTS

# 1 Introduction

1.1 Trees play a vital role in enhancing our urban environment by providing numerous environmental and social benefits, such as air purification, temperature moderation and aesthetic enhancement. As trees grow and reach maturity healthily, the benefits offered by them also increase.

1.2 In order for trees to reach their full potential and thrive in urban landscapes, sufficient amounts of usable soil that is loose, moist, well-aerated, and uncompacted with good drainage, shall be provided for effective uptake of nutrients, oxygen, and water that are essential for their long term healthy growth and development. In addition, sufficient volume of usable soil promotes robust root systems, improves healthy growth and stability of urban trees, making them more resilient with longer life expectancy in the city. The term 'soil volume' employed in this set of guidelines refers to the amount of usable soil that is accessible for tree roots.

1.3 The government advocate the principle of 'Right Plant, Right Place'. This means selecting suitable plants for planting in appropriate places, with due consideration of various factors such as the planting objective, site and spatial constraints, surrounding landscape character, microclimate, etc. Under this principle, it is important to plan ahead and allocate sufficient soil volume for the appropriate tree species, to ensure the tree can grow sustainably and healthily in the given location and perform its intended design function.

1.4 This Guidelines on Soil Volume for Urban Trees ("the Guidelines") provides a practical approach for urban landscape planting in Hong Kong, setting out the general rule to establish soil volume and soil depth requirements for new tree planting and tree replacement. Based on extensive research and findings from scholars, literatures and standards adopted in other cities, the Guidelines aims to promote the best possible underground growing conditions for tree root growth in the urban environment.

1.5 This Guidelines is intended for trees planted at-grade in built-up areas[1], taking into account mainly the daily water loss of trees estimated by their crown size and the water holding capacity of soil. Departments should endeavour to make reference to and implement the Guidelines for new tree planting works, and as far as practicable for tree replacement plantings[2].

1.6 The Guidelines should be read in conjunction with the latest version of the following prevailing circular(s), practice note(s) and guidelines, promulgated by the Greening, Landscape and Tree Management Section:

- DEVB TC(W) No. 2/2012 - Allocation of Space for Quality Greening on Roads
- DEVB TC(W) No. 6/2015 - Maintenance of Vegetation and Hard Landscape Features
- Street Tree Selection Guide
- Proper Planting Practices
- Guidelines on Soil Improvement

## 2 Minimum Soil Volumes (MSV) for Tree Planting

Minimum Soil Volume (MSV) Target

2.1 More soil volume offers a better rooting environment and structural support for trees. The Minimum Soil Volume (MSV) Target recommended in the Guidelines is only a useful starting point, but not necessarily the optimum soil volume for trees. Larger planting area should be considered wherever space is practically allowed, to create a more favourable underground growing environment and promote sustainable healthy growth of trees.

[1] This Guidelines is not applicable for planting trees on man-made slopes or natural terrains. However, departments may still at their own judgment to make reference to the soil volume requirements recommended in the Guidelines for other planting situations.

[2] If the requirement cannot be met in existing congested situation for tree replacement, department(s) may exercise his/her professional judgement to adjust the planting area as far as practicable.

2.2 While other factors, such as soil quality, microclimate, topography, location of trees and maintenance practices affect tree growth and development, it is widely recognized that the available soil volume will critically influence the size of a tree can reach. The crown of a tree usually reveals the concentrated area of rooting volume, hence an indicator of tree size under general circumstances in Hong Kong. To determine the MSV target, it is therefore recommended to consider the desired tree size in terms of the species-specific crown diameter, which shall be reasonably recommended based on the planting design intent.

2.3 When recommending the desired tree size, the relevant professional of bureaux/departments should exercise his/her expertise judgement with due consideration given to the growing habits, mature size of the selected species, and future maintenance, such as pruning. Subsequently, the appropriate MSV Target can be set based on the desired tree size, allowing for adequate soil volumes to support the growth of trees and achieve the desired design effect in a sustainable manner.

2.4 Table 1 lists the recommended MSV Targets for trees of different sizes[3]. For example, if the desired tree size is 6m crown diameter, which falls under the category of medium-sized trees, an MSV Target of 13 cubic meters (cu. m.) should be achieved.

| **Desired Tree Size** | **MSV Target (cu. m.)** |
|---|---|
| Small (< 5m crown diameter) | 6 |
| Medium (5m - 8m crown diameter) | 13 |
| Large (>8m crown diameter) | 24 |

*Table 1 - Recommended MSV Targets for different sizes of tree*

[3] The recommended MSV Targets were adapted from James Urban's chart in his book *Up by Roots, Healthy Soils and Trees in the Built Environment* (2008), which displays the relationship between soil volume and tree size. For easy application, numbers from the chart were extracted and rounded off to fit.

Minimum Soil Depth

2.5 Most of the roots (up to 90%) are typically found within top 1m soil surface. When calculating MSV Target, only **1m** soil depth[4], free of underground utilities with exclusion of drainage layers, will be counted, even if extra soil depths are provided.

Shared Soil Volume (SSV) Target

2.6 A reduction of up to 30% in the MSV for each tree can be allowed when two or more trees of the same size are planted together in the same planting bed to benefit from soil resources sharing.

2.7 Table 2 lists the recommended SSV Targets for trees of different sizes. For example, if the desired tree size of a group of trees to be planted is 6m crown diameter each, which falls under the category of medium-sized trees, a 30% reduction can be applied to the 13 cu. m. MSV Target, resulting in a SSV Target of 9.1 cu. m. per tree to be achieved.

| **Desired Tree Size** | **MSV Target (cu. m.)** | **SSV Target per tree (cu. m.) (A 30% reduction of MSV Target)** |
|---|---|---|
| Small (< 5m crown diameter) | 6 | 4.2 |
| Medium (5m - 8m crown diameter) | 13 | 9.1 |
| Large (> 8m crown diameter) | 24 | 16.8 |

*Table 2 - Recommended MSV and SSV Targets for different desired tree sizes*

[4] Only the upper three feet of soil, approximately 1 meter, was being considered in James Urban's chart.

## 3 Strategies to Provide Planting Soil in Urban Area

3.1 In fact, trees require not only adequate volume of soil for sustainable growth but also horizontal space on the ground level for the proper establishment of support roots for anchorage. The root spread is not confined to the drip line / crown area.

Open Soil Planting Areas (OS)

3.2 With all tree planting works needed proper planning ahead of time, Open Soil Planting Areas (OS) and continuous planting strip, which provide large and open soil surface areas, should be maximized whenever possible, as large open soil surface in OS could allow better water infiltration and air movement into the planting soil. This approach allows for optimal growing conditions for trees and promotes healthy root development. Example demonstrating how to achieve the MSV target with OS can be found in **Situation 1 of Appendix C**.

Covered Soil Planting Areas (CS)

3.3 The pavements in the built-up areas usually required to accommodate multiple functions such as pedestrian traffic, street furniture, and utility installations. Due to the limited land resources, it may not always be possible to provide ample OS. To allow adequate soil volume, planting areas may need to be extended under pavements as Covered Soil Planting Areas (CS). However, the soil under pavements is often highly compacted for meeting load-bearing requirements and engineering standards, making it inhospitable for tree root growth and hence, nutrients and water cannot be accessed.

3.4 To mitigate these challenges, load-bearing planting systems[5] should be used to provide structural support and load-bearing capacity while

[5] The new measures, such as the load bearing planting systems demonstrated in the Guidelines have been adopted successfully in other international cities. Departments are encouraged to liaise among initiating, works and maintenance departments at planning stage to identify the most appropriate management/ maintenance parties.

also ensuring adequate usable soil can be provided in the CS. Load-bearing planting systems include structural growing media such as gravel based structural soil; and suspended pavement system like soil corridor or soil cells.

Positioning of a Tree in the Planting Area

3.5 To promote even, radial, horizontal root growth, it is recommended to plan equal soil allowances on all sides of the tree trunk as far as practicable to encourage uniform root growth.

'Connect, Extend and Link'

3.6 The concept of 'Connect, Extend and Link' is a design strategy on providing soil volume for tree planting in urban landscape. 'Connect' refers to the connecting of individual tree planting areas / tree pits for extra soil volume through sharing of soil resources. Continuous and interconnected planting area can be achieved either by using OS or CS.

3.7 'Extend' refers to the addition of CS as an extension to the OS for a tree, providing additional soil volume while accommodating other urban infrastructure needs. 'Link' refers to the process of guiding tree roots growth towards nearby green space through aeration pathways under pavement. By linking up nearby green spaces by root path, a network of soil is created, allowing tree roots to access additional nutrients and water. **Appendix A** illustrates the 'Connect, Extend and Link' concept.

3.8 By planning ahead and prioritizing careful selection and placement, the long-term health and success of urban trees can be achieved. The design thinking process on how to determine and achieve MSV Target and viable alternatives is demonstrated in **Appendix B**.

Soil Efficiency of Load-bearing Planting Systems

3.9 When selecting load-bearing planting systems for CS, the net amount of usable soil available to the tree should be taken into account.

This is due to the module used in the suspended pavement system and significant amount of crushed stones included in the mix of structural growing media. The soil efficiency of the suspended pavement system is around 90%[6], while the soil efficiency of structural growing media, such as the gravel based structural soil, is typically around 20%[6].

3.10 Therefore, to account for these factors that affect net amount of soil available to the tree in CS, discounts of 10% and 80% for suspended pavement system and structural growing media should be applied when calculating the MSV or SSV, respectively.

3.11 While root paths are narrow trenches of loose soil that provide aeration pathways to guide tree roots to grow out of the planting space under pavement and access additional planting soil, they will not increase the overall soil volume significantly and, therefore, should not be counted in MSV or SSV calculation.

3.12 Example demonstrating how to achieve the MSV or SSV Target with CS supplementing OS can be found in **Situation 3 of Appendix C**.

Designing Covered Soil Planting Areas (CS)

3.13 When designing CS, careful consideration should be given to selecting a location that can accommodate the necessary soil volume while minimising maintenance needs. Areas under non-drivable paths such as footpaths and cycle tracks are preferred, while areas within drivable paths which support vehicle traffic should be avoided. On the other hand, areas packed with underground utilities and/or structures should be avoided to prevent potential conflicts or damage. Finally, to encourage soil sharing among trees, it will be beneficial to extend the CS towards other existing planting areas.

[6] The stated percentage is a rule-of-thumb. Should certain proprietary products suggest a significant different percentage of soil efficiency, design should adopt accordingly.

3.14 Additionally, incorporating permeable paving can facilitate water infiltration into the soil, promoting healthy root growth and contributing to sustainable water management.

## 4 Summary

4.1 When designing and planning an underground growing environment for tree planting, the following factors should be taken into consideration:

- Ensure that there is **adequate total soil volume** to support future tree growth. MSV and SSV by no means is the optimum soil volume for tree planting, larger planting area should be considered wherever space and practicality allow.
- Provide sufficient **soil depth with at least 1m** of soil.
- Achieve the required **MSV or SSV by OS in form of continuous planting strips/areas** as far as practicable.
- Arrange trees with preference of **even soil on all sides.**
- Allow for the use of **CS, by using suitable load-bearing planting systems**, to provide additional soil volume to meet MSV or SSV since CS should only be used as a last resort to achieve the required total soil volume.

**Reference**

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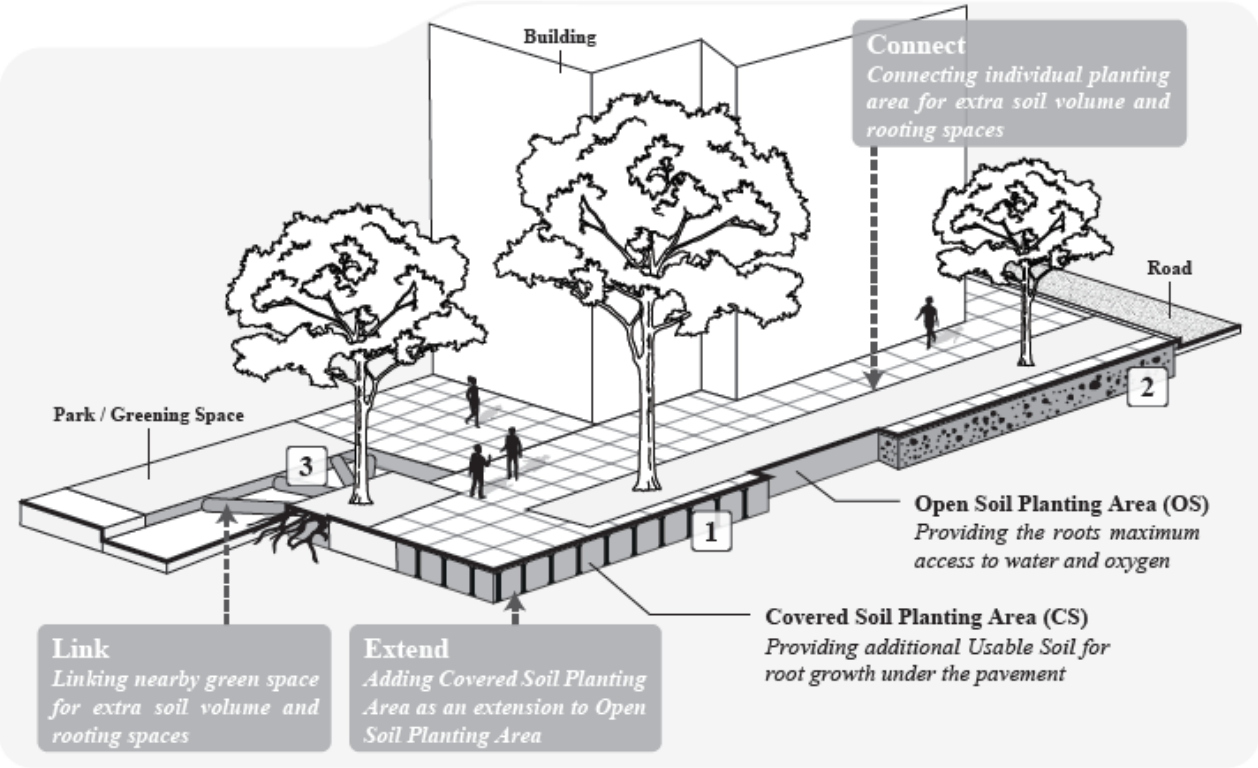
# Appendix A Designing with 'Connect, Extend and Link'




1 

**Suspended Pavement Systems**
*Systems to prevent the settlement of the paving and provide ample non-compacted soil below to support sustainable tree growth, examples include soil cells and soil corridors.*

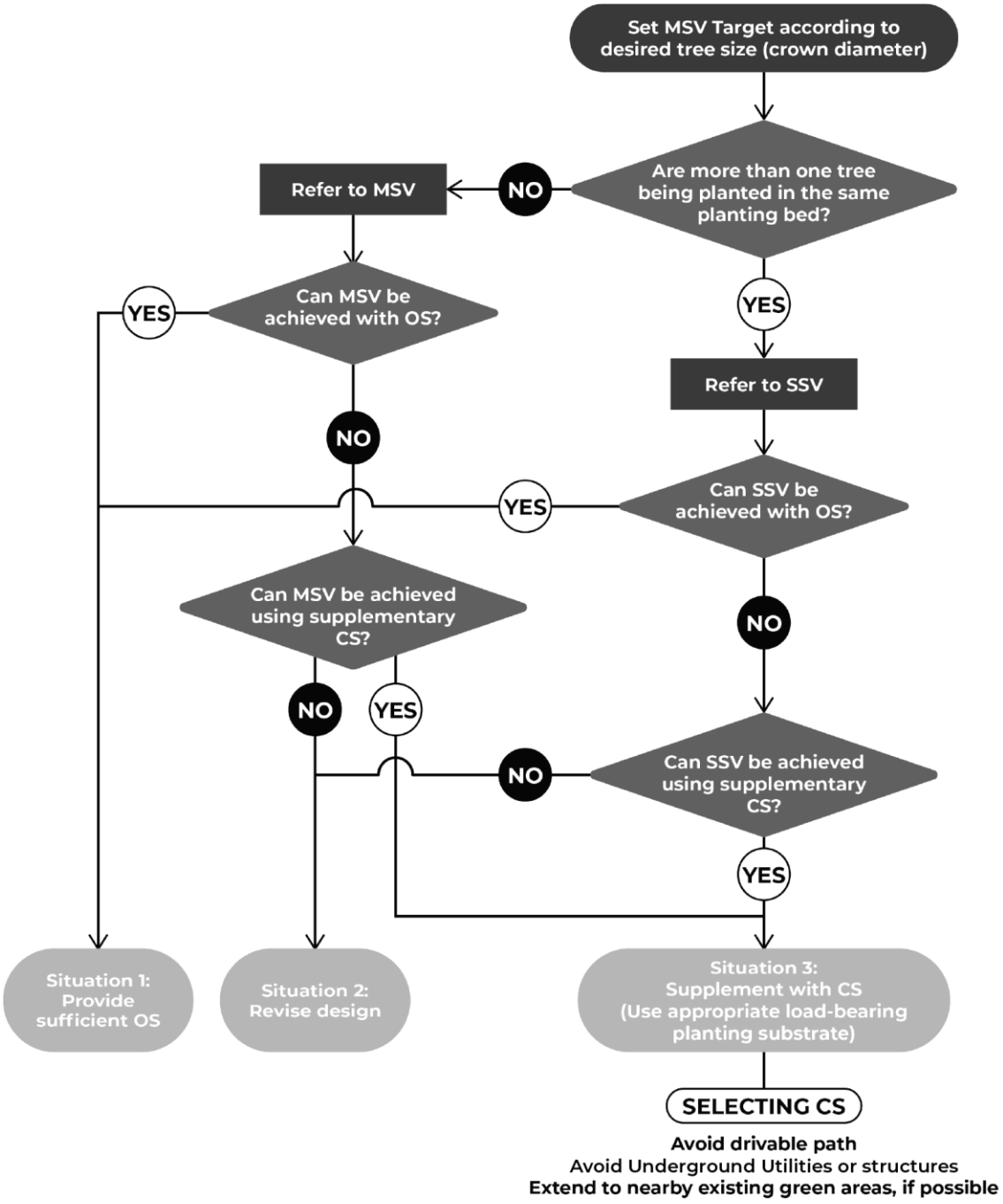
2 

**Structural Growing Media**
*A mix of soil and load-bearing components such as sand, gravel or rocks to achieve a larger non-compacted soil volume, while meeting the loading requirements above ground, examples are gravel-based structural soil and sand-based structural soil.*

3 

**Root Path**
*A constructed soil connector for roots to grow out of the planting pit under pavement and access better planting soil in the nearby green space.*

## Appendix B Work Flow to Determine and Achieve MSV Target



## Appendix C Example on Calculations of MSV and SSV Targets

Situation 1 - Provide sufficient Open Soil Planting Area (OS)

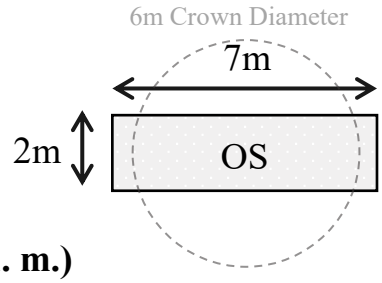
*Example*

| Desired Tree Size | MSV Target | SSV Target per tree |
|---|---|---|
| Medium (6m crown diameter) | 13 cu. m. | 9.1 cu. m. |

1A. Individual tree planting area achieving MSV Target by OS

*Length × Width × 1m Soil Depth ≥ MSV of Desired Mature Tree Size*

OS Soil Volume:
7m × 2m × 1m
**= 14 cu. m.**

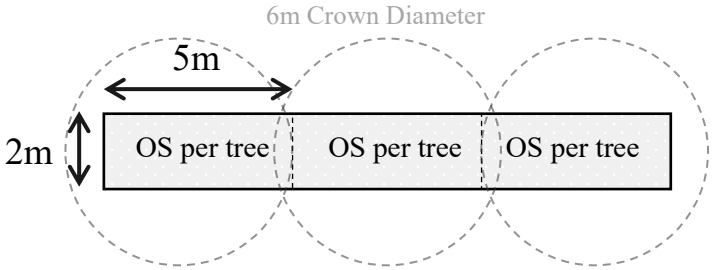



**> MSV Target for medium-sized tree (13 cu. m.)**

1B. Shared tree planting area achieving SSV Target by OS

*Length × Width × 1m Soil Depth*
*≥ SSV of Desired Mature Tree Size × No. of Trees to be planted*

OS Soil Volume per tree:
5m × 2m × 1m
**= 10 cu. m.**



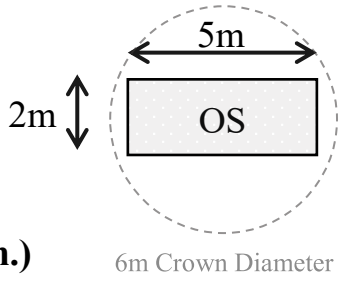

**> SSV Target for medium-sized tree (9.1 cu. m.)**

Situation 2 – Alternative design

*Example*

| Desired Tree Size | MSV Target |
|---|---|
| Medium<br>(6m crown diameter) | 13 cu. m. |

OS Soil Volume per tree:
5m × 2m × 1m
**= 10 cu. m.**

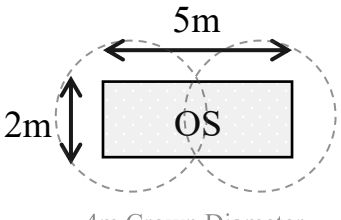



**< MSV Target for medium-sized tree (13 cu. m.)**

Besides adding CS like in *Situation 3A*, alternative design can be considered, such as planting smaller trees species:

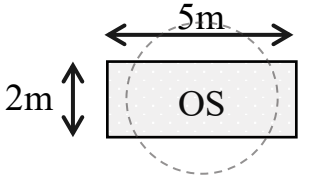
| Desired Tree Size | MSV Target | SSV Target per tree |
|---|---|---|
| Small<br>(4m crown diameter) | 6 cu. m. | 4.2 cu. m. |

OS Soil Volume per tree:
2.5m × 2m × 1m
**= 5 cu. m.**




**> SSV Target per tree for small-sized tree (4.2 cu. m.)**

OS Soil Volume per tree:
5m × 2m × 1m
**= 10 cu. m.**




**> MSV Target per tree for small-sized tree (6 cu. m.)**

Situation 3 – Supplement with Covered Soil Planting Area (CS)

3A. Individual tree planting area achieving MSV Target by OS and CS

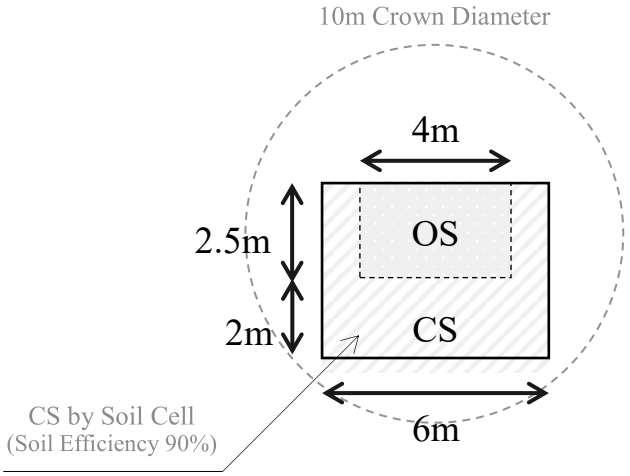
$$[\ (\text{Length}_{OS} \times \text{Width}_{OS} \times 1\text{m Soil Depth}) + (\text{Length}_{CS} \times \text{Width}_{CS} \times 1\text{m Soil Depth}) \times \text{Soil Efficiency}\ ] \geq \text{MSV of Desired Tree Size}$$

*Example*

| **Desired Tree Size** | **MSV Target** |
|---|---|
| Large<br>(10m crown diameter) | 24 cu. m. |

OS Soil Volume:
4m × 2.5m × 1m
= 10 cu. m.

CS Soil Volume
(Volume of CS × Soil Efficiency)
(6m × 4.5m × 1m – 10 cu. m.) × 90%
= 15.3 cu. m.




OS + CS Soil Volume:
10 cu. m. + 15.3 cu. m.
**= 25.3 cu. m.**

**> MSV Target for large-sized tree (24 cu. m.)**

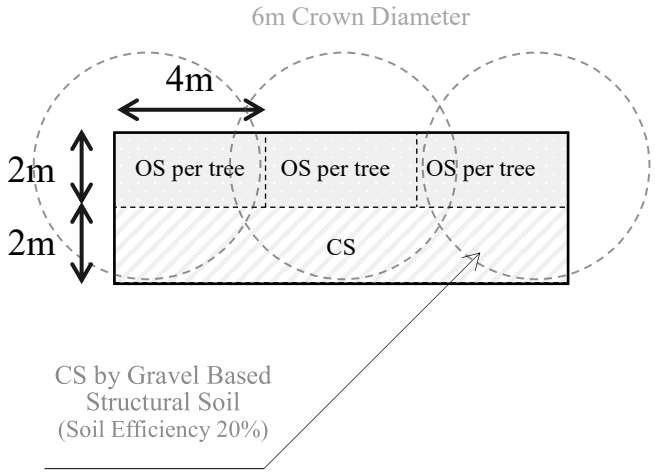
## 3B. Shared tree planting area achieving SSV Target by OS and CS

$$[\,(\,Length_{OS} \times Width_{OS} \times 1m\ Soil\ Depth\,) +$$
$$(\,Length_{CS} \times Width_{CS} \times 1m\ Soil\ Depth\,) \times Soil\ Efficiency\,]$$
$$\geq\ SSV\ of\ Desired\ Tree\ Size \times No.\ of\ Trees\ to\ be\ planted$$

*Example*

| **Desired Tree Size** | **MSV Target** | **SSV Target per tree** |
|---|---|---|
| Medium<br>(6m crown diameter) | 13 cu. m. | 9.1 cu. m. |

OS Soil Volume per tree:
4m × 2m × 1m
= 8 cu. m.




CS Soil Volume:
(Volume of CS × Soil Efficiency)
(12m × 2m × 1m) × 20% ÷ 3
= 1.6 cu. m.

OS + CS Soil Volume:
8 cu. m. + 1.6 cu. m.
**= 9.6 cu. m.**

**> SSV Target for medium-sized tree (9.1 cu. m.)**