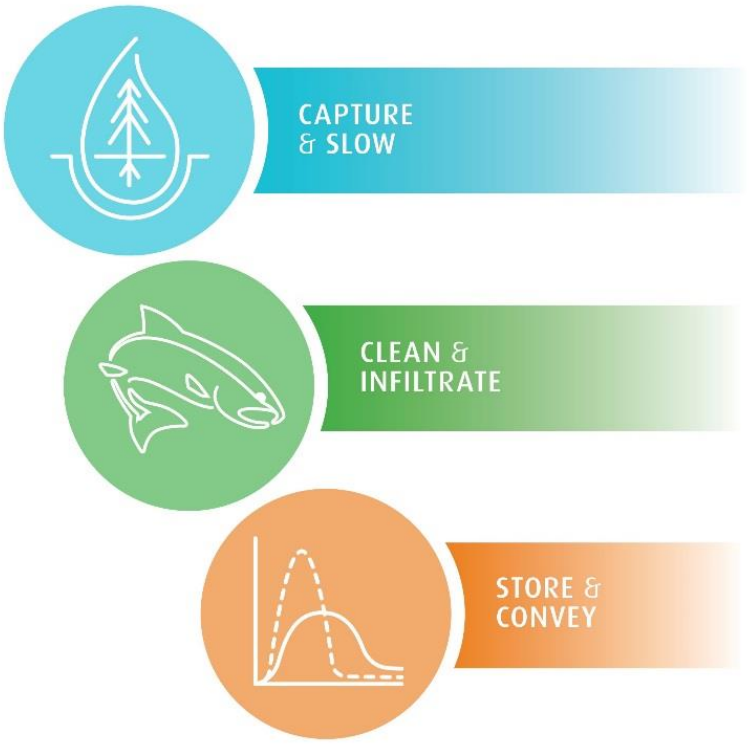

APPENDIX G - STRUCTURAL SOIL: CELLS WITH & WITHOUT TREES

Green Stormwater Infrastructure Design Guidelines for the Capital Region

SPRING 2019

Structural Soil Cells[1]

Description

Structural soil cells are a system for carrying structural loads while also providing a void below the street surface or the amenity zone in the street right-of-way, which is typically filled with a growing medium for trees or a growing medium strictly for bioretention. Structural soil cells transfer the vertical loads from the street or sidewalk to below the structural soil cells without compacting the growing medium through the placement of underground structural supports.

Figure 1 Right-of-way before GSI retro fit. Photo Credit: Credit Valley Conservation

Structural soil cells can support a variety of surface materials including asphalt, concrete, and unit pavers. Structural soil cells can be placed under sidewalks and roadways.

Without structural soil cells, the growing medium would compress under the weight of the surface material and the street users. Structural soil cells provide the opportunity to have larger, healthy trees in locations which have insufficient space to separate planting areas from pedestrian/vehicle traffic. Where the structural soil cell features a single tree, the facility is referred to a tree pit, and for multiple trees, a tree trench.

Figure 2 Same site under construction. Existing catch basin was retrofitted to direct stormwater into GSI facility with a distribution pipe (seen here) with soil cells and bioretention media. Photo Credit: Credit Valley Conservation

Structural soil cells require significant design input from a professional and can also be quite costly to install. Only some utilities may be able to be placed in the root zone; coordination with utility organizations is encouraged.

[1] Authored by: Opus International Consultants (Canada) Limited
Design guidelines drawings by: Kerr Wood Leidal Associates Ltd

Structural soil cells act as a bioretention facility by being able to store stormwater underground in the growing medium, and if trees are present, they will use the water and remove pollutants. If the growing medium is a bioretention soil mix, about 20% of its volume can be used for stormwater storage (1,000 m^3 of soil could store 200 m^3 of stormwater)[2].

Stormwater can be directed to structural soil cells via pervious pavers, curb cuts, and catch basins, among other means.

Figure 3 Same site under complete installation of soil cells and tree trench. Photo Credit: Credit Valley Conservation

Selection, Application and Limitations

- Structural soil cells are used to provide an un-compacted growing medium for trees where they are not fully separated from pedestrian/vehicle traffic.
- Multiple trees planted in the amenity zone between the street and sidewalk is a type of structural soil referred to as a tree trench.
- As structural soil cells are quite costly they are typically only used in heavily urbanized environments where there is limited space to separate trees from pedestrian/vehicle traffic.
- Structural soil cells (with or without trees) act as an underground bioretention facility by being able to store large amounts of stormwater.
- Only limited utilities can be installed in the growing medium. Approval from utility providers is required.

[2]Suspended Pavements, Alberta Low Impact Development Partnership, https://alidp.org/what-is-lid/article/suspended-pavements 2013

Design Guidelines

Structural Soil Cells

1. Detailed design requirements should be evaluated for each individual application based on site-specific constraints and objectives.
2. Follow all applicable federal, provincial and municipal regulations.
3. Geo-technical investigations are required for design.
4. The design must be completed by a qualified professional. A structural engineer must design the structural supports for the soil cells.
5. A variety of structural soil cells are produced by different private companies. The producer design specifications should be used when completing the design.
6. The structural soil cells should be designed to a load capacity of AASHTO-H20[3].
7. Each stack of structural soil cells should be structurally independent of adjacent stacks.
8. Use either 1, 2, or 3 layers of structural soil cells.
9. Each cell should enable the movement of roots and water.[4]
10. An inspection riser should be installed in the concrete/pavement/paver surface.

Table 1 Non-Proprietary Structural Soil Cell Growing Medium

Component	Percentage by Volume
Base Soil	40-45
Coarse Sand	45-50
Organic Compost	8-10

Also see the Bioretention Soil Medium (BSM) mixes suggested in Appendices B-F.

Venders of various proprietary structural soil cell systems will recommend their proprietary growing medium.

Tree Trenches

1. A tree trench can treat runoff from the adjacent street and sidewalk.
2. A tree trench must be placed such that an upstream area drains to it.
3. Stormwater passes through a gravel filter for pre-treatment, then is conveyed through an underdrain to 1 or more trees, and exits through a water level control structure.

[3] Southeast False Creek Private Lands: Public Realm Enrichment Guide, City of Vancouver, 2009
[4] Suspended Pavements, Alberta Low Impact Development Partnership, https://alidp.org/what-is-lid/article/suspended-pavements 2013

4. Discharge from the underdrain is typically to a nearby inlet or manhole.
5. Trees are typically located 1.2 m to 2.0 m from the back of curb.
6. Final tree planting area minimum width of 0.5 m.
7. Preferred treatment around the tree is a 100 mm curb.
8. If tree grates are preferred, a minimum separation between the grate and tree trunk of 100 mm should be provided.
9. The growing medium should match the values presented in Table 1. Adjust the ratios to achieve water infiltration between 20 mm and 50 mm per hour[5]. See more information about growing media in Bioretention Soil Medium (BSM) mixes suggested in Appendices B-F.
10. Placement of permeable pavers above the tree trench is recommended.
11. Structural soil cells should be designed to provide a minimum of 30 m^3 of soil per tree[6]. Where multiple trees are sharing the same soil, the minimum amount of soil may be reduced. Trees in trenches typically require a rooting volume of 21 m^3 to 28 m^3.
12. A maximum of 3 trees is recommended per group of structural soil cells, but tree trenches can be placed back to back for any desired length.
13. For recommended tree species see Supplemental 1, Plant Templates & Plant Lists for planting considerations.
14. See Table 2 for structural soil cell setbacks.
15. Refer to qualified professional for guidance on curb inlet options.

Table 2 Structural Soil Cell Setbacks

Setback From	Distance (m)
Foundation	1.5
Property Line	3
Drinking Water Well	30
Septic Field	3
Seasonal High Water Table	1

[5] Southeast False Creek Private Lands: Public Realm Enrichment Guide, City of Vancouver, 2009
[6] Southeast False Creek Private Lands: Public Realm Enrichment Guide, City of Vancouver, 2009

Guideline Specifications

Materials shall meet Master Municipal Construction Document 2009 (MMCD) requirements, and:

1. Infiltration Drain Rock: clean round stone or crushed rock, with a porosity of 35% to 40% such as 75 mm max, 38 mm min or MMCD Section 31 05 17 Part 2.6 – Drain Rock, Coarse.
2. Pipe: PVC, DR 35, 150 mm min. dia., with cleanouts, certified to CSA B182.1, as per MMCD.
3. Geosynthetics: as per Section 31 32 19, select for filter criteria or from approved local government product lists.
4. Sand: Pit Run Sand, as per Section 31 05 17.
5. Seeding: conform to Section 32 92 20 Seeding or 32 92 19 Hydraulic Seeding (Note: sodding will be required for erosion control in most instances).
6. Sodding: conform to MMCD Section 31 92 23 Sodding.

Construction Practices shall meet Master Municipal Construction Document 2009 (MMCD) requirements, and:

1. Follow the manufacturer's recommendations during construction.
2. The growing medium should be protected from rain before and during construction.
3. Do not install structural soil cells when materials are wet, muddy or frozen.
4. The location of the structural soil cells should be recorded at the time of construction and incorporated into the record drawings.

Design Examples

The design of structural soil cell systems should be completed by a professional, meeting the recommendations listed in the design guidelines noted above. The design of a structural soil cell system is unique for each context, however, manufacturers typically provide design details for using their products.

The following design example shows how structural soil cells can be applied.

Case Study: Road Right-of-Way Retrofit, Soil Cells with Tree Trench, Central Parkway, Mississauga, Ontario.

Can be found at: http://www.creditvalleyca.ca/wp-content/uploads/2016/06/CaseStudy_CPW_Final.pdf

GSI Driver Effectiveness – Runoff Reduction and Contaminant Removal

International Stormwater BMP Database http://www.bmpdatabase.org/ is a recommended resource for performance summaries of GSI facilities and latest research.

Bioretention areas function as soil and plant-based devices that can achieve both runoff reduction and pollutant removal. Runoff reduction is achieved through canopy interception, soil infiltration, and evapotranspiration. Pollutant removal is achieved through a variety of physical, biological, and chemical treatment processes. A number of pollutants including trace metals, suspended solids, and nutrients are removed from stormwater by filtering, adsorption, biological uptake, and denitrification within the bioretention cell's mulch and soil media. The pollutant removal efficiency can be increased or decreased based on the design components and what pollutants are being targeted for reduction. The following table shows the effectiveness of the structural soil cell with trees for effectiveness of GSI drivers. Run-off reduction would primarily be based on the size of any trees placed in the structural soil cell system. The tested systems removed slightly more pollutants than typical at-grade bioretention facilities.

Table 3 GSI Driver Effectiveness – Runoff Reduction and Contaminant Removal

Bioretention and Vegetated Infiltration GSI Facilities Structural Soil Cells	
GSI Driver	***Estimated Effectiveness or Typical % Reduction or Removal**
Capture & Slow – Volume Runoff Reduction	40-80%
Store & Convey – Rate Control Delay Peak	High
Clean & infiltrate – Water Quality Treatment	
Copper	85-86%
Lead	90-94%
Zinc	76-83%
Total Phosphorus	72-74%
Total Nitrogen	66-82%
Total Suspended Solids	86-92%

**Source: Page, J.L, Winston, R.J., Hunt, W, F., Soils beneath suspended pavements: An opportunity for stormwater control and treatment (2015), Ecological Engineering, Vol. 82, Sept. 2015. Pg. 40-48.*

Maintenance

Structural soil cells do not require regular maintenance. However, additional care is needed when maintenance activities are required in close proximity to the structural soil cells.

Utility Access

The following steps should be taken when access to utilities either within or below the structural soil cell voids is required:

- Surface concrete or pavement is removed via sawcut where there is unit paving, the pavers are removed.
- The geotextile fabric is peeled back.
- The structural soil cells are removed by hand and set aside.
- An excavator may be used for the remaining excavation once the structural soil cells are removed.

Repair

Repairs should be undertaken as per manufacture's specifications. The steps to undertake repairs should generally follow the steps for initial construction. Any damaged structural soil cells should be replaced prior to the repair being completed.

Tree Replacement

The following steps should be taken when a tree utilizing the structural soil cells need to be replaced:

- Remove any structure(s) at the tree opening such as tree grates.
- Remove any excess mulch and soil above the tree root using hand tools making sure the structural soil cells are not damaged.
- Consult and arborist to remove the tree.
- If using construction equipment to remove the tree, ensure that it meets the structural soil cell loading limits.
- Plant the new tree as per the structural soil cell manufacturer's specifications and with the consultation of an arborist. Replace any damaged structural soil cells

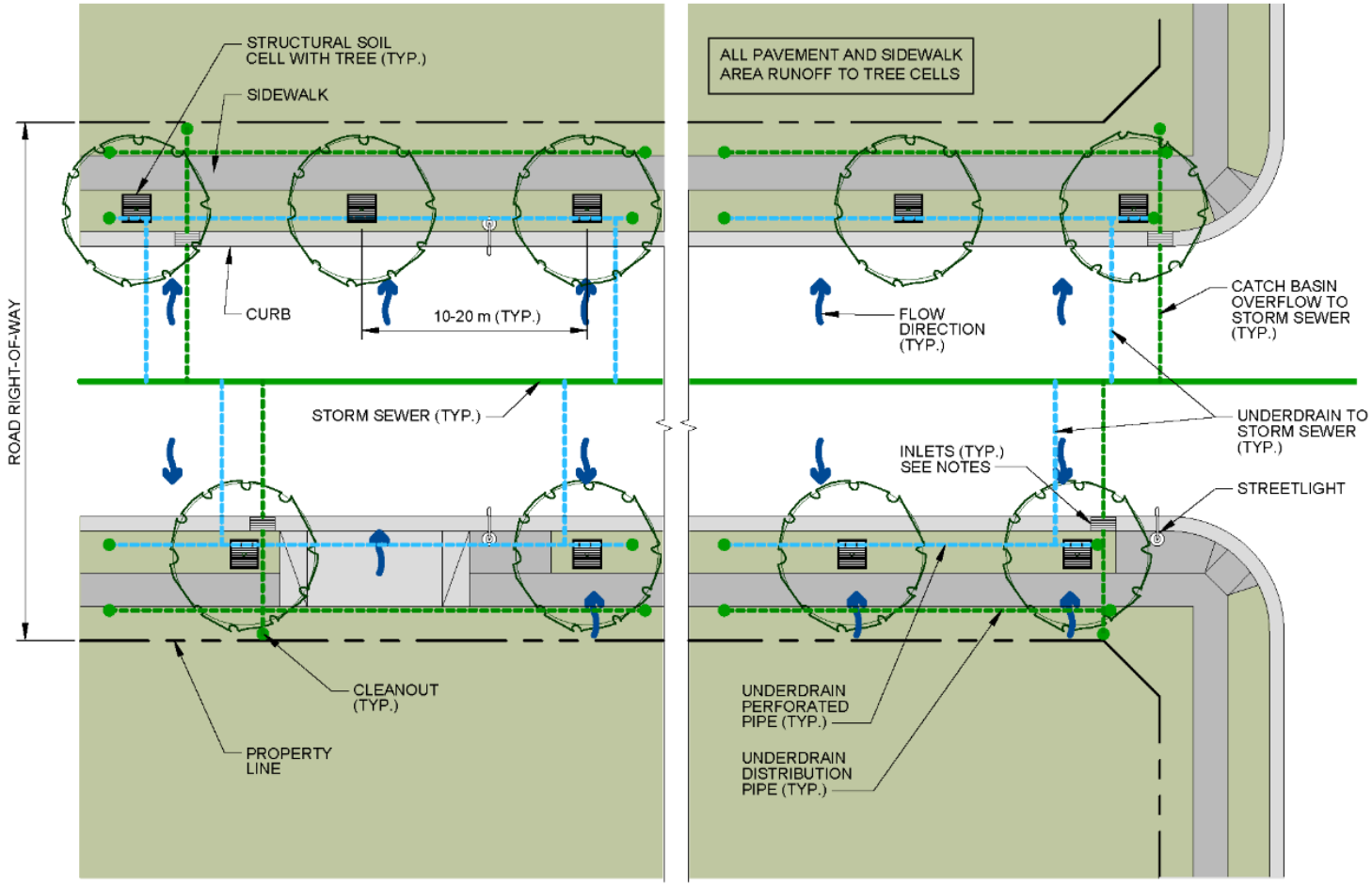

Figure 4 Structural Soil Cell with Tree – Plan View

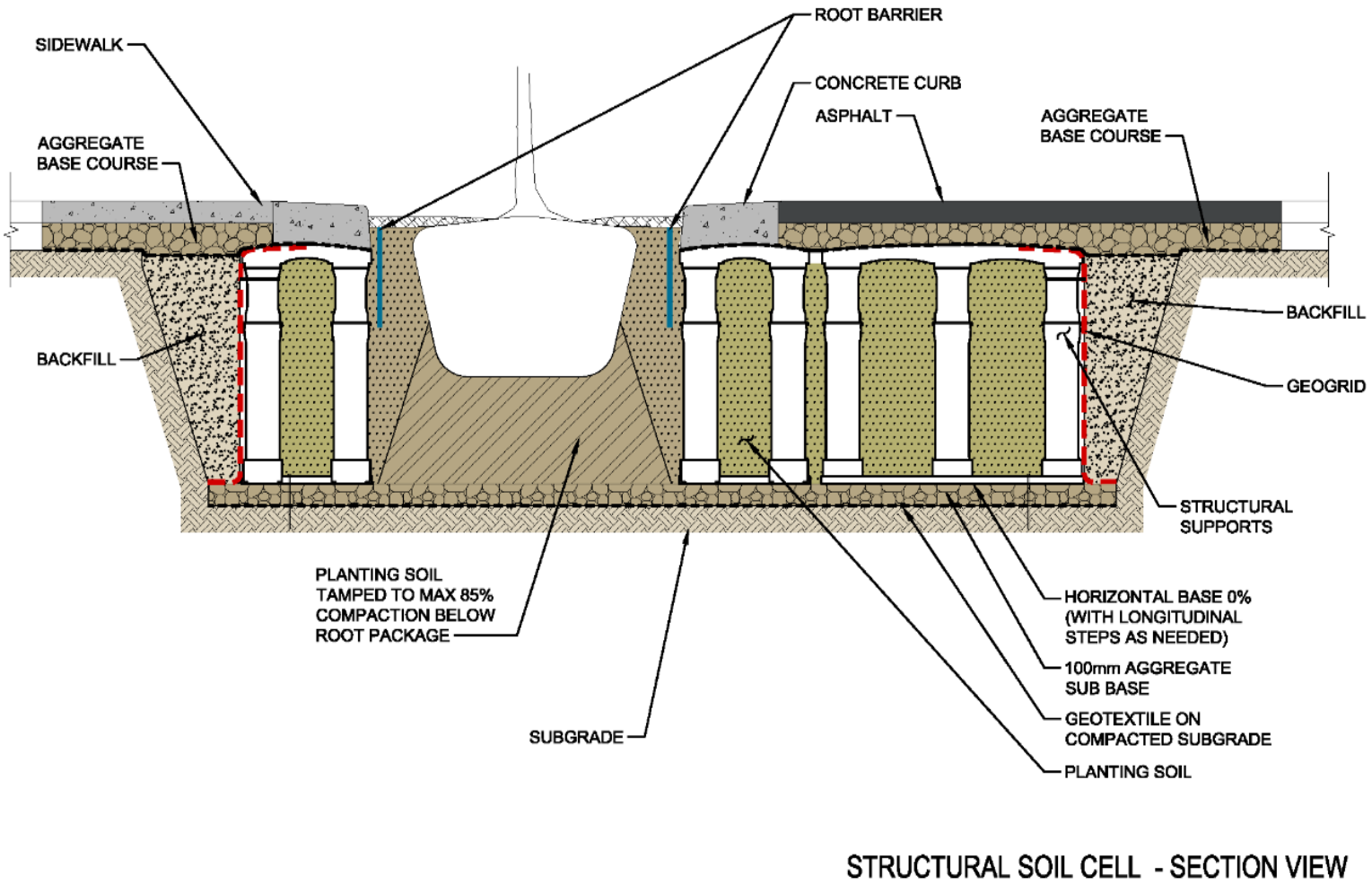

Figure 5 Structural Soil Cell – Section View

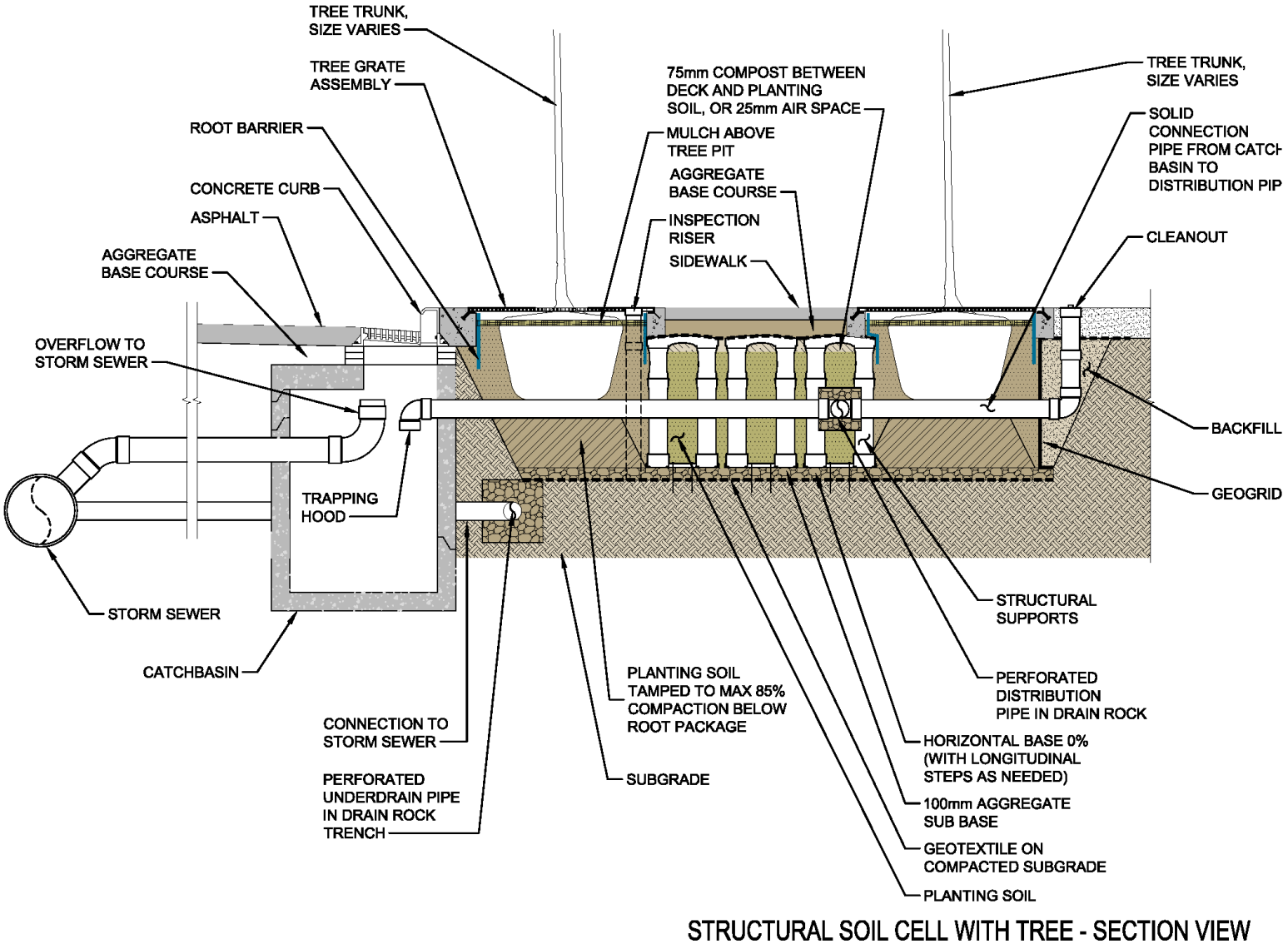

Figure 6 Structural Soil Cell with Tree – Section View