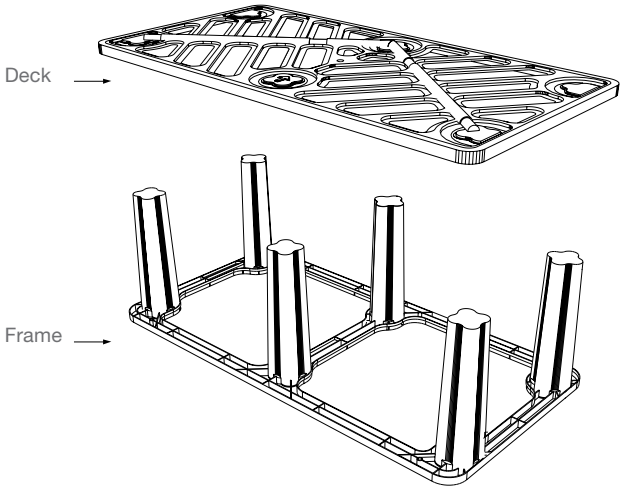
DeepRoot®

Silva Cell Operations Manual

Helping trees live in the urban environment

I. System Overview

The Silva Cell is a modular, underground bioretention system that utilizes the proven capacity of soils for stormwater management and healthy tree growth to bring green infrastructure to the built environment. The large quantities of healthy soil housed within the Silva Cell serves two important functions: growing large trees and treating rainwater onsite. The integration of green utilities like soil, trees and water into our urban areas dramatically enhances their design sustainability and helps alleviate some of our most pressing ecological challenges, including poor air quality, rising temperatures, and flooding and pollution from daily rainfall events.



II. Engineering and Design

Each Silva Cell is composed of a frame and a deck. Frames can be stacked one-, two-, or three-units high and topped with a deck to create the desired depth and accommodate any size planting area. The Cells can be spread laterally as wide as necessary. The Silva Cell is approximately 92% void space and holds 10 ft^3 (.28 m^3) of soil, enabling it to easily accommodate surrounding utilities. Silva Cells are 48" (1200 mm) long, 24" (600 mm) wide and 16" (400 mm) high.

FRAME

Six rigid vertical posts protrude from the bottom of the frame, providing structural support of paving and the loads it carries. Their cross-sectional shape maximizes axial rigidity and prevents them from telescoping together when the Cells are stacked. Their rounded edges prevent significant stress concentrations, meaning that paving supported by the frame does not settle due to compressive forces. The bottom portion of the frame is relatively pliable, allowing it to conform to irregularities in the earth without breaking or suffering loss of strength.

DECK

The deck is a rigid platform with six recesses positioned to rest securely on the six posts of the frame. Openings on the deck allow ample room for air and water to penetrate and nourish the enclosed soil. Two diagonal channels in the upper portion of the deck house galvanized steel tubes that prevent deformation of the posts and help eliminate plastic creep.

III. New Construction Installation Instructions (2-Cell Deep)

Silva Cell frames and decks should at no time be cut, drilled into, or otherwise structurally modified during any installation, inspection or maintenance procedure. Any damaged Silva Cell frames or decks must be replaced.

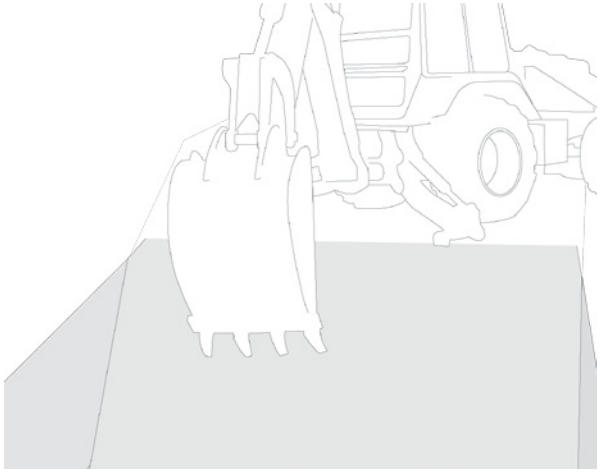
SITE PREPARATION + EXCAVATION

STEP 1

Excavate the trench at the installation site according to the necessary dimensions to accommodate the Silva Cell system. Over-excavate a minimum of 12" (30 cm) beyond the perimeter of the Silva Cells to allow for working room.

STEP 2

Compact the bottom of the excavation to 95% density or to the approval of the Owner's geotechnical representative.



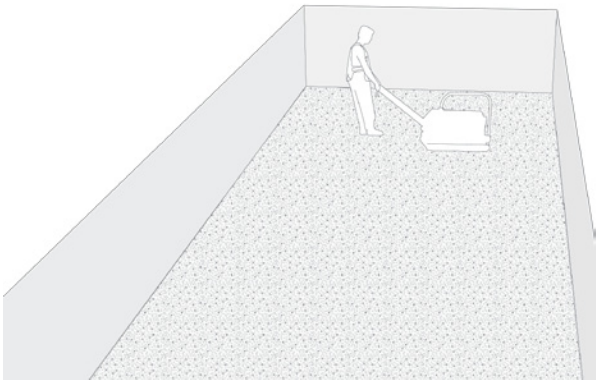
SUB BASE PREPARATION

STEP 1

Place the specified geotextile fabric over the bottom of the compacted excavation and smooth out any wrinkles.

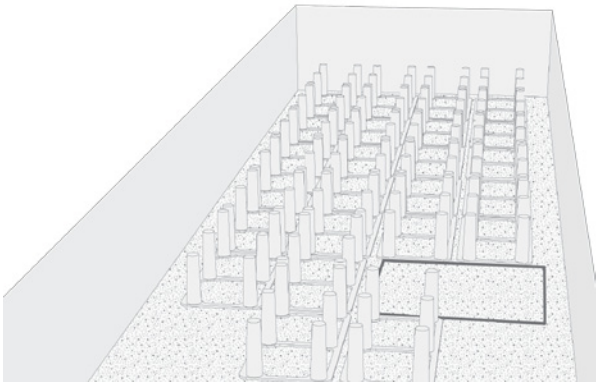
STEP 2

Place the sub base aggregate in the excavation and spread evenly. See Silva Cell specifications for aggregate details.



STEP 3

Compact the sub base aggregate to 95% density or to the approval of the Owner's geotechnical representative. Fine grade the sub base aggregate to the specified evlevation and slope as needed. Use a screed to ensure a consistently level surface. If the sub base is not level the legs of the frames will become misaligned, making it difficult or impossible to attach the decks. It is the responsibility of the Engineer, Contractor or testing company to certify that the base meets specification.



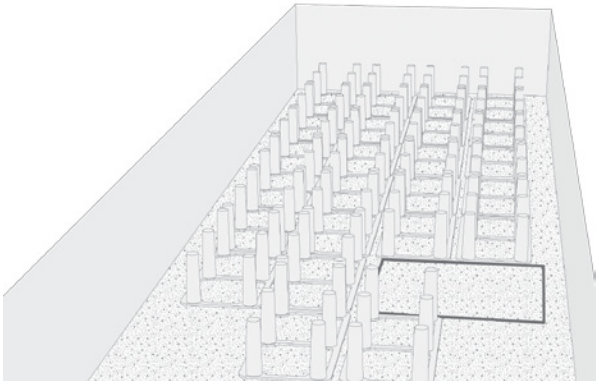
STEP 4

Establish the location of the tree openings per the Landscape Architect's specifications. Once trees are located, mark the inside dimensions of the tree openings on the prepared sub base.

SILVA CELL SYSTEM PLACEMENT

STEP 1

Put down an "area of work" string line to clearly define the limits of the Silva Cell system. Be sure to follow the layout according to the plans in order to ensure proper spacing of the Silva Cells.

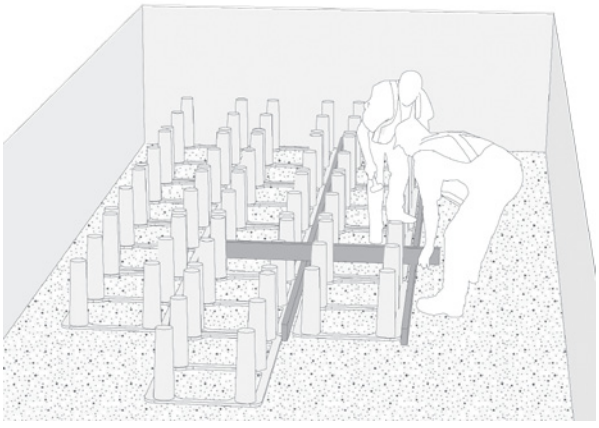


STEP 2

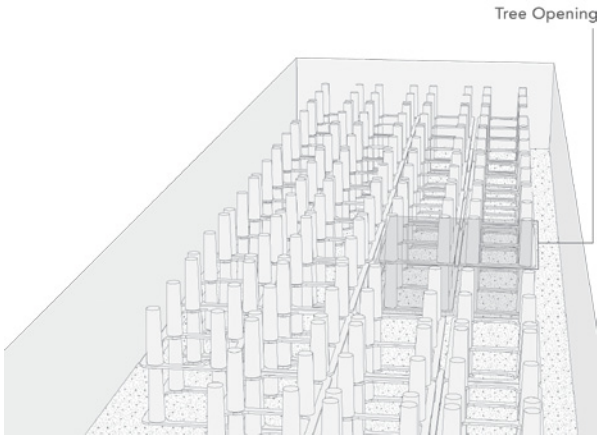
Place the first layer of Silva Cell frames in the trench, starting around the tree openings and expanding outward. Follow the Cell plan as drawn. Unforeseen obstacles may make layout adjustments necessary. Consult with the Owner's representative if adjustments to the plan are needed.

STEP 3

There must be a space between each of the frames. The minimum allowable space is 1" (25mm) and the maximum allowable space is 3" (75mm). Proper spacing is critical. Spaces between the cell frames that are greater than the 3" (75 mm) maximum diminish the structural integrity of the Silva Cell system and ultimately its load bearing capacity. Spaces between cell frames that are less than the 1" minimum will cause difficulty when attaching the cell decks. Use of the proper spacing is also critical to ensuring that the correct quantity of product is used. Using too small of space between the cell frames could result in a shortage of product at the end. Using too large of spacing could result in excess product at the end. When getting started we recommend verifying that the number of



cells being placed matches what is shown on the plans. For longer continuous runs you can do this by counting the number of cells used between two tree openings and then comparing that number to the number shown on the plans. The spacing may need to be adjusted to make the two match. If there are inconstancies that cannot be corrected by adjusting the spacing within the allowable range, please contact the Owner's representative or DeepRoot. Once the first layer is laid out, secure the Cells to the ground with the specified anchoring spikes through the four guide holes on the corners of the Silva Cell frames. **Never walk on the frames.**



STEP 4

Place the second layer of Cell frames. There is only one way to properly fit the second layer of frames onto the first layer – in order to secure them correctly, position the arrows on the top of the posts so that they point towards each other.

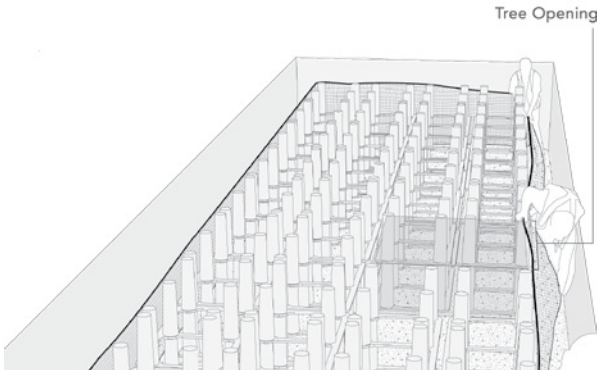
GEOGRID ATTACHMENT

STEP 1

Cut the geogrid to ensure there is an extra 6-8" (15 – 20cm) at the bottom of the frames, and an extra 12" (30cm) at the top layer of frames. A two-Cell system will require a 50" (127 cm) high geogrid.

Once both layers of Silva Cells have been placed, wrap the geogrid around the entire system. Secure both layers of frames with cable or zip ties (3/8" x 12"/5mm x 300mm).

The extra 18-20" of geogrid is necessary slack to allow for proper and complete retention of tree soil within the Cell system once it is filled. .DO NOT LINE THE TREE OPENING WITH GEOGRID.



STEP 2

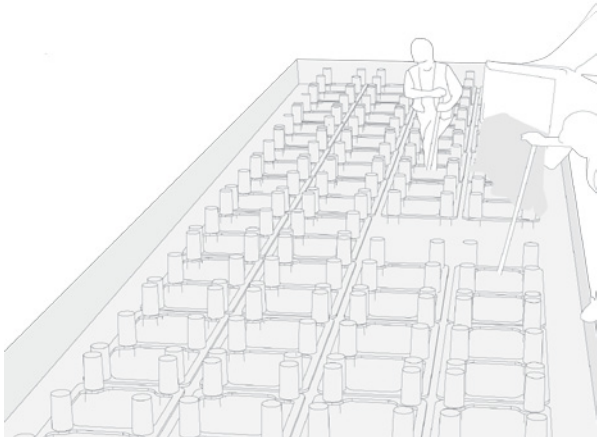
Place approximately 6" (150mm) of suitable backfill material around the perimeter of the Silva Cells to anchor the down the toe of the geogrid prior to placing planting soil inside of the cells

Once the Silva Cell system is filled with soil, the geogrid should be level with the top of the frames (the excess having been pulled down by the soil.) Any excess geogrid above the frames should be folded over and zip tied to the decks once they are in place.

SOIL PLACEMENT

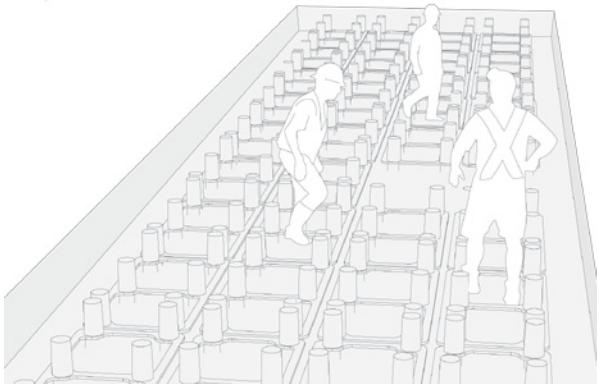
STEP 1

Place specified planting soil into several areas of the system in 8" (20.5cm) lifts. Spread throughout the system with shovels. Soil should not rise above the first layer of Cells. *Note: When distributing soil with a bucket, operator must ensure the bucket does not come into contact with any part of the frames.*



STEP 2

Loosely compact soil in the first layer by walking through the entire system. Make sure each frame is filled with soil. *Note: Do not walk on any portion of the frames.*

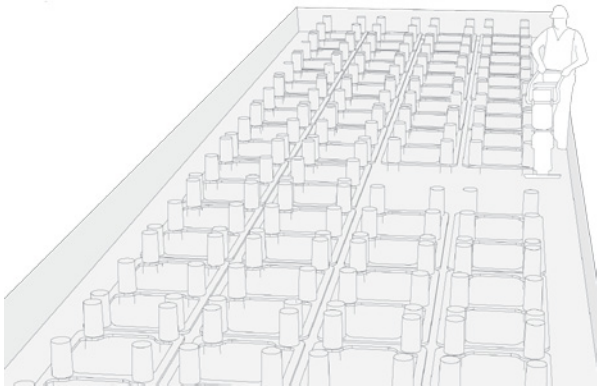


STEP 3

Once the first layer is filled and loosely compacted, backfill and compact the perimeter trench in 8" (20.5 cm) lifts, being careful to prevent damage to the frames. Plywood (or cardboard) can be used to direct each backfill lift as it is poured to prevent it from mixing with the planting soil in the Cell system.

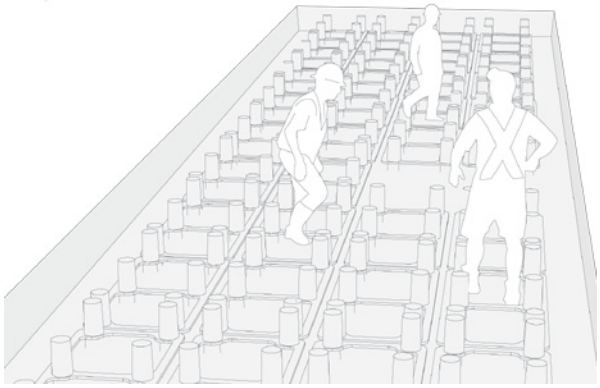
STEP 4

Add the strongbacks to the second layer of Silva Cells. Repeat Step 1 and Step 2 (above). Fill the second layer of cells even with the top of the posts or the bottom of the strongback frames. Settlement of the soil over time will create a desired 1-2" air gap under the frames. *Note: Overfilling the second layer of Cells with soil, mulch, or compost will make it impossible to secure the decks once the strongbacks have been removed.*



STEP 5

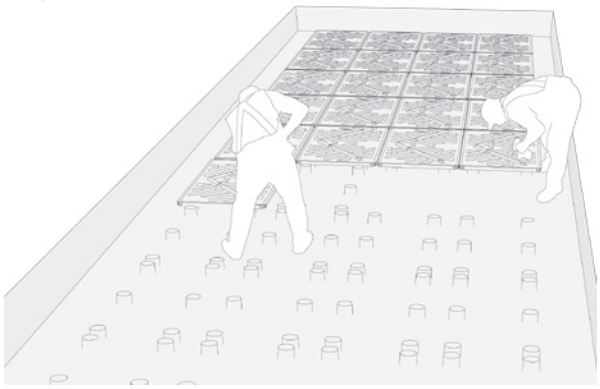
Backfill the perimeter trench in 8" (20.5 cm) lifts to the top of the second layer of frames. The trench should be compacted to 95% of maximum dry density.



DECK ATTACHMENT AND INSTALLATION COMPLETION

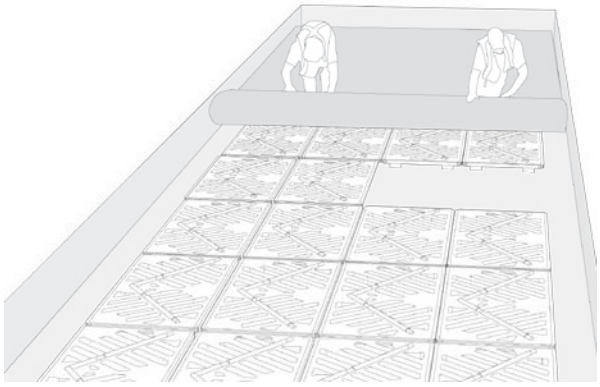
STEP 1

Stage decks nearby. Remove the strongbacks and sweep posts clean of debris one at a time, replacing each strongback **immediately** with a deck. Place decks on frames by aligning the arrow on the deck cup with the arrow on the frame post. When adjacent to the arrow on the deck, the corners to the upper left and the lower right have snapping mechanisms to secure the deck to the frame. A rubber mallet may be used to hammer the snaps into places. Finish attaching the decks by screwing on the corners of the deck with the specified screws.



STEP 2

After the decks are installed place and compact final layer of backfill, between the perimeter of the Silva Cells and the walls of the excavation, to the grade of the decks. Ensure the compactor does not come into contact with or damage decks.

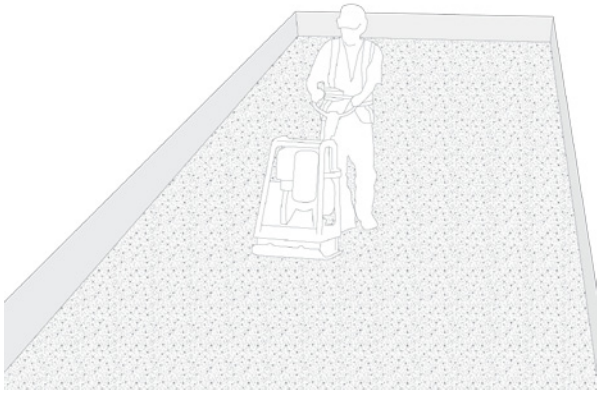


STEP 3

Cover the Silva Cells with the specified geotextile fabric. Make sure to extend the geotextile out past the cells to the edges of the excavated area, ensuring that there is 18" (45 cm) of overlap on each side. Cut the geotextile **inside** the tree openings so that it extends beyond the edge of the deck by 6-8" (15 – 20 cm). The extra slack in the geotextile allows for the aggregate base course to push the geotextile down into the deck openings. The extra material ensures that when the curb is poured there will be enough geotextile to keep the decks covered. More overlap is better; excess can be cut away.

STEP 4

Place the aggregate base course in two 6" (15 cm) lifts for pavers or asphalt (compacting after each lift.) If the paving is concrete, place the aggregate base course in one 4" (10 cm) lift and compact. Utilize a roller or plate compactor with a maximum weight of 1000 pounds. Compact to the specified density. *NOTE: The Silva Cell system does not achieve its full weight bearing capacity until the final surface pavement has been placed. Do not drive vehicles or operate equipment over the cells until the final surface material has been installed.*

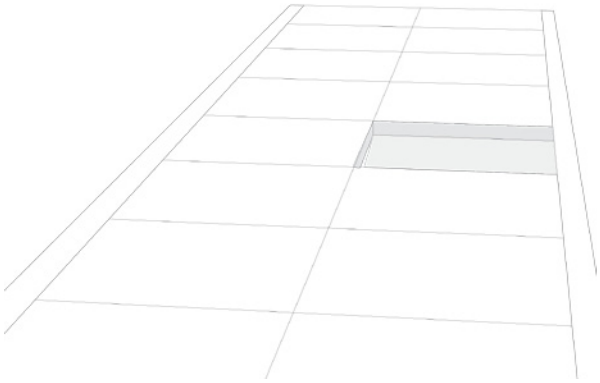


STEP 5

Install paving.

For bituminous paving operations consult DeepRoot to determine allowable loads for pavers and vibratory compactors. For concrete or pavers in a setting bed the material will need to be placed from the street.

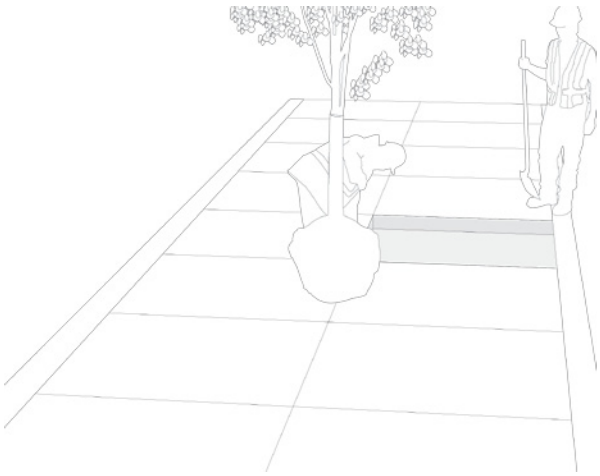
When staking concrete forms (i.e. for curb around tree openings tree openings) ensure that the stakes do not go through the decks. This is especially important when using only 4” (10cm) of aggregate and concrete.



STEP 6

Plant tree into opening and install appropriate Deep Root Tree Root Guide as specified. Make sure to plant the tree at the correct elevation, with the top of the root ball flush to the soil line.

A change in surface materials may require aggregate base course depth to change based on standard details and specifications. Changes shall be executed according to specification.



IV. Protection and Maintenance

Contact DeepRoot Partners, L.P.
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Tel: 800 458 7668 or 415 781 9700
Fax: 800 277 7668 or 415 781 0191

Notes: Each Silva Cell stack is independent of the Silva Cell stack adjacent to it – therefore if individual Silva Cells are disturbed, the entire system is not compromised.

Silva Cell frames and decks should at no time be cut, drilled into, or otherwise structurally modified during any installation, inspection or maintenance procedure. Any damaged Silva Cell frames or decks shall be replaced.

1. PROTECTION OF THE SILVA CELL SYSTEM

To help avoid future disturbance of the Silva Cell system the location of the system should be accurately recorded at the time of construction and incorporated into an as-built drawing.

If possible register the location of the Silva Cell system with the local One-Call utility locating program.

Accurately locate the limits of the Silva Cell system prior to any future excavation in the area. (Some types of underground utility locating equipment, such as ground penetrating radar, are capable of detecting Silva Cells and may be used to locate the limits of the system. Contact a professional utility locating contractor for more information).

Utility warning tape/ribbon and locating wires can also be incorporated into the system and are recommended.

2. UTILITY INSTALLATION, MAINTENANCE, RELOCATION OR REPLACEMENT WITHIN SILVA CELL SYSTEM

If the Silva Cell system is accidentally unearthed by future excavation in the area, cease the excavation immediately and consult the as-built drawings to determine the limits of the system.

Using hand tools only, expose the impacted portion of the Silva Cell system and carefully inspect the Silva Cell frames and decks for any signs of damage or cracking.

Replace any damaged Silva Cell frames or decks and reconstruct any disturbed portion of the system as per DeepRoot's installation Guidelines.

Note: The Silva Cell system is designed to meet H-20 Loading Requirements when the pavement is in place. To prevent damage to the underlying Silva Cells ensure that machinery operated on pavement supported by the Silva Cell system does not exceed H-20 Loading. Do not operate any machinery over the Silva Cell system without the pavement being in place.

3. UTILITIES AND ACCESSING THE SILVA CELL SYSTEM

The Silva Cell system can be easily accessed for utility installation, maintenance, relocation, replacement, etc. using the following procedure.

First, locate the limits of the Silva Cell system.

Carefully remove the existing pavement. Take care to not operate machinery exceeding H-20 loading on any of the

surrounding pavement supported by the system. Do not operate any machinery over the Silva Cell system once the pavement has been removed.

Using hand tools remove the aggregate base course and expose the underlying geotextile fabric. If working near the perimeter of the system there will be also be approximately 12" (30.5 cm) of geogrid that is folded over and attached to the cell decks. Cut the geotextile fabric as needed to allow for the removal of Cell decks. If Geogrid is encountered, detach it from cell decks and fold it back as well. Do not cut the Silva Cell frames or decks. Remove the Silva Cell decks by removing the four corner screws and set it aside. Remove the soil from inside the frames using hand tools only or a HydroVac. (If the existing soil is to be reused, store it separately to ensure that it does not become contaminated with other spoil material. Otherwise dispose of the soil and replace it with soil meeting the requirements specified for the project. All soil must be inspected and approved prior to reinstallation.) Carefully remove any of the frames needed to complete utility work. Upon completion of the utility work visually inspect the surrounding exposed Silva Cell frames and decks and remove any of those showing signs of damage or cracking. Restore the disturbed portion of the system using one of the two following methods:

METHOD 1:

Replace the Silva Cell frames, soil and decks as required per Silva Cell installation details and specifications. Re-wrap geogrid over decks with an overlap at cut seam. Restore the aggregate base course and pavement. Re-use only Silva Cell frames and decks that have been thoroughly inspected and found to be free of damage or cracking. Replace any frames or decks showing signs of damage or cracking with new.

METHOD 2:

Structurally bridge the gap with 1 ½” (3.8 cm) clear stone. Install geogrid around the perimeter of the area from which the Silva Cells were removed per DeepRoot’s construction guidelines. Fill inside void area with 1 ½” (3.8 cm) clear stone up to the level of the adjacent Silva Cell decks. Cover the stone with geotextile fabric making sure to overlap the existing geotextile fabric by a minimum of 2 feet on all sides. Restore the aggregate base course and pavement.

4. PAVEMENT REPAIR OR REPLACEMENT OVER SILVA CELL SYSTEM

When the existing pavement over a Silva Cell system is to be replaced by a different type of pavement, refer to the Silva Cell standard details and specifications. A change in surface materials may require a change in the depth of the underlying aggregate base course.

5. ADDING SILVA CELLS TO THE SYSTEM/ REMOVING SILVA CELLS FROM THE SYSTEM

To make changes to the size of the Silva Cell systems locate the limits of the system. Carefully remove the pavement taking care to ensure that no machinery which exceeds H-20 loading is operated on pavement supported by the Silva Cells and that no machinery is operated over the Silva Cells once the pavement has been removed. Using hand tools remove the aggregate base and expose the underlying geotextile fabric. Cut the geotextile fabric as needed to visually confirm the limits of the Silva Cells. Excavate to no closer than 1' (30.5 cm) of the limits of the Silva Cells. Using hand tools, expose the geogrid which wraps the perimeter of the system. Cut and fold back the geogrid as needed to add or remove cells. If adding to the system, install the new Cells per Silva Cell specifications. Ensure that the gap between the existing Silva Cell frames and the new Silva Cell frames does not exceed the 3" (7.6 cm) maximum. If removing frames or decks, re-install the geogrid along the new perimeter of the Silva Cell system and backfill along the new limits of excavation per Silva Cell specifications.

6. TREE REPLACEMENT

Tree replacement may be necessary based upon unforeseen or severe site, climate or circumstantial conditions.

Limit disturbance area as possible. Ensure all equipment meets H20 loading requirements.

Remove any structure at the tree opening (tree grate, etc.) Remove mulch and any excess soil from above tree root package. Do not damage Silva Cell frames or decks. Remove soil using hand tools only or HydroVac and set aside. If hand dug, ensure clean storage of soil material by excavating into contained/isolated location and cover during utility work. Soil must be inspected and approved prior to reinstallation.

Consult a certified arborist to remove tree. If necessary to cut tree roots from main root package, do not cut Silva Cell frames or decks. Remove tree root package from planting bed. If using construction equipment to remove tree, ensure meeting of H20 loading requirements.

Prior to planting new tree, install additional planting soil, to the depths indicated, within the tree opening adjacent to paving supported by Silva Cells. Assure that the planting soil under the tree root package is compacted to approximately 85-90% to prevent settlement of the root package. The planting soil within the tree opening shall be the same soil as in the adjacent Silva Cells. See Silva Cell specifications for further detail. Replace root barrier.

Plant tree according to owner specifications or at the direction of consulting arborist.

Cover the planting soil finished grade with 2" (5cm) of mulch per Silva Cell specifications.

When a large portion of a Silva Cell installation is to be removed, first locate the area of disturbance. Limit disturbance area as possible. Ensure all equipment meets H-20 loading requirements.

Remove paving and aggregate base course. Carefully cut geotextile to allow for removal of Cell decks. Ensure at least 18" (45.7 cm) overlap into new limits of excavation. Do not cut Silva Cell frames or decks. Unfold geogrid from Cell decks and carefully fold away from Silva Cell frames. Remove Silva Cell decks by removing screws and set aside. Remove soil using hand tools only or HydroVac and set aside. If hand dug, ensure clean storage of soil material by excavating into contained/isolated location and cover during utility work. Soil must be inspected and approved prior to reinstallation Remove anchoring spikes from Cell base and set aside. If geotextile is at base of system, carefully cut geotextile at least 6" (15.2 cm) within new limits of excavation.

Install aggregate base course and paving, ensuring no damage to Silva Cells or other installation components.

7. ADDITIONAL SILVA CELLS TO BE INSTALLED ADJACENT TO EXISTING INSTALLATION

When additional Silva Cells are to be installed adjacent to an existing Silva Cell system, first locate the area of disturbance. Limit disturbance area as possible. Ensure all equipment meets H20 loading requirements.

Excavate up to 12" (30.5 cm) from existing Silva Cells. Excavated remaining 12" (30.5 cm) by hand. Cut geogrid from face of existing Silva Cell system. Do not cut Silva Cell frames or decks.

V. Definition of terms

Asphalt paving: Flexible asphalt paving with aggregate base course of material types and thickness as required to achieve the design loads over Silva Cell system.

Aggregate Sub Base material (underneath Silva Cell system): Stone aggregate of type, thickness, and compaction as defined in the specification, placed below the Silva Cell system to distribute loads and level the bottom of the excavation.

Aggregate Base Course material (above Silva Cell system, underneath paving): Stone aggregate of type, thickness, and compaction as defined in the specification, placed below the paving and above the Silva Cell deck to distribute loads and serve as a leveling course for the paving material.

Backfill material: Soil or aggregate material of the type and compaction as defined in the specifications placed between the outer limits of the Silva Cell system and adjacent soil.

Beam: The horizontal bars connecting the posts at the base of the frame.

Channel: The slot molded into the underside of the deck that receives the steel reinforcing tube.

Concrete paving: Poured-in-place concrete paving placed over the aggregate base base (above the deck), of type and thickness defined in the specifications.

Cup: The depression molded into the underside of the deck which snaps on to the post of the frame below.

Deck: The top member of the Silva Cell assembly, with steel reinforcing tubes.

Finish Grade: Elevation of finished surface of planting soil or paving.

Frame: The base member of the Silva Cell assembly, with posts and beams.

Geogrid: Woven, net-shaped synthetic polymer-coated fibers that provide a stabilizing force within soil structure as the fill interlocks with the grid.

Geotextile: Non-woven geosynthetic fabric, applied to either the soil surface or between materials, providing filtration, separation, or stabilization properties.

Location symbol: Engraved symbol molded into the top of the center deck cup that indicates that this cup should be placed over the location arrow on the post of the frame below.

Location arrow: Engraved arrow symbol molded into the top of a center frame post that indicates that this post is to be placed opposite from the location arrow on the post of the frame below.

Paver edge restraint: Plastic, steel or concrete edge material between sand set unit pavers and planting soil designed to keep the pavers from moving into the planting soil.

Perforated drain line: Plastic, perforated drainage pipes, either flexible or rigid, designed to collect and convey water from the subsurface collection mediums toward a storm drain or outfall.

Planting soil: Soil as defined in Division 2 Section “Planting Soil for Silva Cells” in specifications intended to fill the frames and other planting spaces.

Porous concrete: Poured-in-place concrete of a mix formula that permits water and air to move freely through the concrete once cured.

Porous unit pavers: Pre-cast or clay pavers shaped with spacer or other design features to conduct storm water through the joints or spaces.

Post: The vertical member or column of the Silva Cell base unit that transfers paving loads vertically downward to the base of the Cell.

Riser: Plastic or metal pipe that connect drain lines to the surface for inspection and cleanout.

Screw: 316 stainless steel pan head Phillips sheet metal screw, number 14, 3/4" (2 cm) length, to securely connect deck to frame below.

Screw hole: Round hole to receive screws positioned at each corner of deck and frame.

Silva Cells: Fiberglass reinforced polymer structural cellular system with posts, beams and decks designed to be filled with planting soil for tree rooting and/or for water storage and to support vehicle loaded pavements. Silva Cells conform to USA patent 7,080,480. Other patents pending.

Spike: 10" (250mm) long x 19/64" (8mm) diameter, spiral, galvanized timper spikes used to stabilize the Cell frame on the Aggregate Sub Base material.

Spike hole: Hole molded into the frame beam to receive the spike.

Steel reinforcing tube: Galvanized steel tube inserted in the channel on the underside of the deck to increase the rigidity of the deck and improve loading capability.

Strongback: Modified Silva Cell frame designed to be attached to the top of the Silva Cells for stability while installing planting soil and backfill.

Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill.

Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

Tab: Connector clips molded into the underside of the frame or deck to secure the deck to the frame or one frame to another.

Tree: A perennial woody plant with one or several trunks and a distinct crown and intended to become large enough to shade people and/or vehicles.

Tree opening: The space surrounded by paving where the tree is planted.

Tree Grate: A metal, plastic or pre cast concrete frame designed to fit over the tree opening designed such that a young tree trunk may grow through a hole in the middle of the frame.

Root Barrier: A plastic root division device with vertical members placed along the edge of the tree opening, designed to deflect tree roots down, under the barrier and into the soil within the Silva Cell system.

Unit paver: Clay, pre-cast concrete or stone pavers.

Water harvesting: The process of diverting storm water from surface flows into a storm water management system.

Zip ties: Plastic ties to attach geogrids to the Silva Cell frame or deck.

VI. Deep Root Warranty

DeepRoot® warrants to the original purchaser of its Silva Cell™ product that such product will be free from defects in materials and workmanship, and perform to DeepRoot's written specifications for the warranted product, when installed and used as specifically provided in the product's installation guidelines for a period of 20 years from the date of purchase. This warranty does not cover wear from normal use, or damage caused by abuse, mishandling, alterations, improper installation and/or assembly, accident, misuse, or lack of reasonable care of the product. This warranty does not apply to events and conditions beyond DeepRoot's control, such as ground subsidence or settlement, earthquakes and other natural events, acts of third parties, and/or Acts of God. If this warranty is breached, DeepRoot® will provide a replacement product. Incurred costs, such as labor for removal of the original product, installation of replacement product, and the cost of incidental or other materials or expenses are not covered under this warranty

DEEPROOT® MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIMS THE WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. DEEPROOT® SHALL NOT BE LIABLE EITHER IN TORT OR IN CONTRACT FOR ANY DIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, LOST PROFITS, LOST REVENUES, LOSS OF USE, OR ANY BREACH OF ANY EXPRESS OR IMPLIED WARRANTY.

Some states do not allow the exclusion of incidental or consequential damages, so the above limitations and exclusions may not apply to you. This Warranty gives you specific legal rights, and you may also have other legal rights, which vary from state to state, or in Canada, from province to province.

VII. Project Application Review Checklists

DeepRoot mandates that each project undergo a product application review in order to ensure that the use of the Silva Cell is optimized on a case-by-case basis.

A technical review checklist (for tree-focused installations) and stormwater review checklist (for stormwater-focused installations) are attached.

DeepRoot®

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