Green Infrastructure Practices: Tree Boxes

Fact Sheet FS1209

Cooperative Extension

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Tree boxes are a green infrastructure stormwater control measure that are designed to collect the first flush of stormwater and treat it prior to discharge into the storm sewer system or to the subsoil. The structure is a pre-manufactured concrete box which is installed in-ground, filled with soil media and typically planted with native, non-invasive tree or shrub. The tree box functions as a compact bioretention system, which is a green infrastructure or low impact development stormwater control best management practice (BMP). In urban or built-out areas where space is limited, tree boxes can fit within a small existing footprint and as retrofit projects. The tree box chamber can be modified to accommodate for infiltration. If the tree box is modified to infiltrate runoff, the soil properties of karst soils or contaminated sites can create direct discharge of pollutants into groundwater and should be avoided.

How does a tree box work?

A tree box consists of three primary components: a chamber, soil media, and the plant. The underground storage chamber typically is a precast concrete structure which contains a specially formulated soil media to filter the stormwater and the native, non-invasive tree or shrub. Tree boxes are small biofiltration systems that perform pollutant removal via filtration and adsorption. Adsorption is the process by which a substance such as clay or organic matter in soil attracts and holds other particles either through a physical or chemical process. This provides a mechanism for pollutant removal from the stormwater. The plant root system also takes up nutrients which can cause problems when in excess in rivers and streams. The chamber is specifically designed to connect to the existing stormwater network, allowing less frequent, high-intensity storm events to bypass the system.

The chamber is filled with specially designed soil media that is designed for rapid infiltration (e.g., a soil media mixture of 80% sand and 20% compost). Some tree boxes are filled with a proprietary media specially designed to remove a particular pollutant such as bacteria.

The system is planted with one or more trees or shrubs and mulch is applied to a depth of three inches. The top of the chamber typically has a swing tree grate that protects the system from large floatables and vegetation disturbance. This grate is primarily a safety feature, but also serves to filter pollutants from entering the top of the chamber. The majority of the runoff entering the system will occur at the inlet, located on the side of the chamber. The inlet has a flared end section, or throat that funnels runoff into the system and is often protected with rip rap. During the smaller water quality storms and the first flush of large events, water will enter the chamber from the road or parking lot, via the inlet. Within the chamber there is an additional four to six inches of storage for stormwater runoff. The stormwater volume filtrates through the systems, adsorbs to the media, is taken up as a product of microbial activity, infiltrates in open systems or exits to the piping system in closed systems.

Site Selection

When selecting a site for stormwater management or when selecting a best management practice (BMP) for a particular site, goals and constraints should be identified. Waterbody impairment, area to be treated, available area for installation, and maintenance, as well as site specific goals, such as a known fecal coliform exceedance in the stream or local Total Maximum Daily Loads (TMDLs), should all be considered prior to implementation of a tree box or other BMP.

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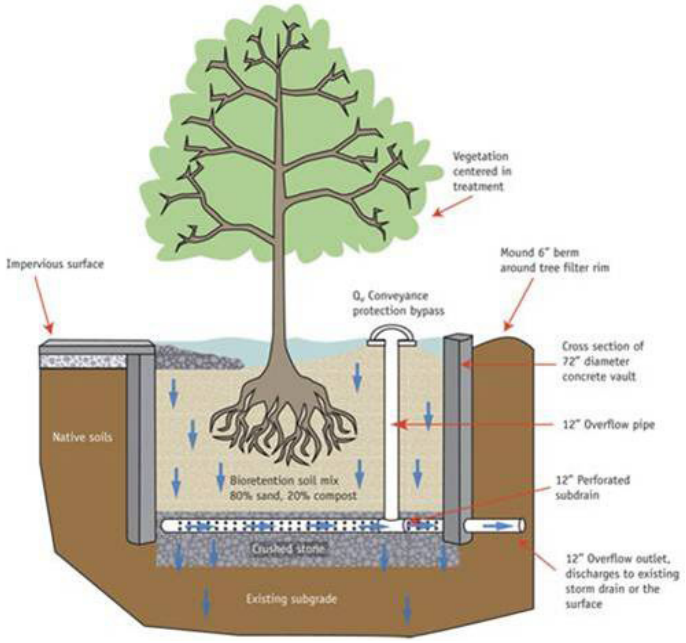


Figure 1. University of New Hampshire, Stormwater Center. (2009) 2009 Biannual Report. p.22.

Many geographic areas have a watershed plan developed for each stream or river, providing critical information when determining where to place a stormwater BMP, in this case a tree box. A watershed plan identifies areas of a watershed that have high pollutant loads, large amounts of impervious surfaces and/or the specific pollutants of concern. The New Jersey Department of Environmental Protection (NJDEP) provides a list of impaired streams in New Jersey and the status of the impairment. When considering a site for installation of a tree box, verify that the pollutants of concern are pollutants that can be treated by the tree box system.

The utility of a tree box is the ability to be installed in dense urban areas as well as residential and suburban areas; regardless of land use tree boxes are designed to capture and treat small drainage areas. Tree boxes generally capture and treat stormwater runoff from small frequently-occurring storms but are not designed to capture runoff from large storms or extended periods of rainfall. Each tree box is designed to treat approximately 0.25 to 0.5 acre. Filterra® tree boxes suggest that for the mid-Atlantic region, based on rainfall data and the water quality storm event, the optimum filter surface area to drainage area ratio is 0.33%. There is a New Jersey specific sizing table which is available from Filterra® upon request. Sizing for New Jersey is slightly more stringent. (www.filterra.com). For example, the required minimum size filter for 0.25 acre (10,890 square feet) of impervious surface would be 48 square feet of filter surface area or one 8 ft. by 6 ft. filter box (dimensions are internal). The area to be treated and available area for the size of the tree box can constrain or limit a selected site. When looking at a large treatment area, multiple tree boxes or an alternative control measure will be required. The number of tree boxes necessary is dependent on climate, topology, hydrology, and size of the pre-manufactured chamber structure. When considering large treatment areas, it may be feasible to use multiple tree boxes; however that may not be the most cost-effective stormwater management method.

Maintenance, discussed later, should also be considered during site selection and prior to installation. The site should be associated with an entity that will be responsible for and perform the maintenance required. To encourage maintenance, the site should be easily accessible. The cost of maintenance should be considered when selecting sites for implementation. All installations should have maintenance agreements in place guaranteeing access to and maintenance of the tree box. Fig. 2 shows a site chosen from a Plan, with maintenance agreements, problems with bacteria, total suspended solids and phosphorus that can be treated with the Filterra® tree box and installed on municipal property.



Figure 2. Aerial image of a site that fits the criteria for site selection. Photo: Google Earth. 2013 Google Earth.

Installation

Preparation of the site in an urban area is usually within the footprint of the tree box as it will be connected to adjacent stormwater pipes; in parking lots the removal of asphalt may be required to connect the tree box to the existing storm sewer network. Asphalt and concrete can often be recycled. Installation is typically a two to three day process. Installation requires two or three individuals trained to install storm sewer pipes and inlet boxes if the installation is

being conducted by the municipality. It is helpful to have an engineer on-site. Most of the procedures can be completed with a rubber tire back hoe. The installation crew will also need a track-hoe or crane to lift and set the heavy tree box. It is essential to do a mark-out of existing underground utility lines and pipes prior to digging. Contact "One Call" (1-800-272-1000) prior to digging. Utilities locations, even when known, can present challenges during excavation and installation.

The chamber is delivered in two pieces: (1) the concrete base containing the media, pipe connections, and underdrain, and (2) the lid and tree grates. The box is set on a leveled stone base and connected to the existing pipelines. The area is backfilled and restored. Activation, typically by the manufacturer's representative who plants the tree, places the grates and assures that all is functional is the final step. A speed bump or other measure can be installed to direct the flow towards the inlet to the tree box in order to maximize the drainage area to the structure and the efficiency of the unit.

The plant selected will be determined based on available sunlight, maintenance demands and predicted height and width as well as geographic region based on plant hardiness zone. There are extensive lists of plants available for each region of the United States.

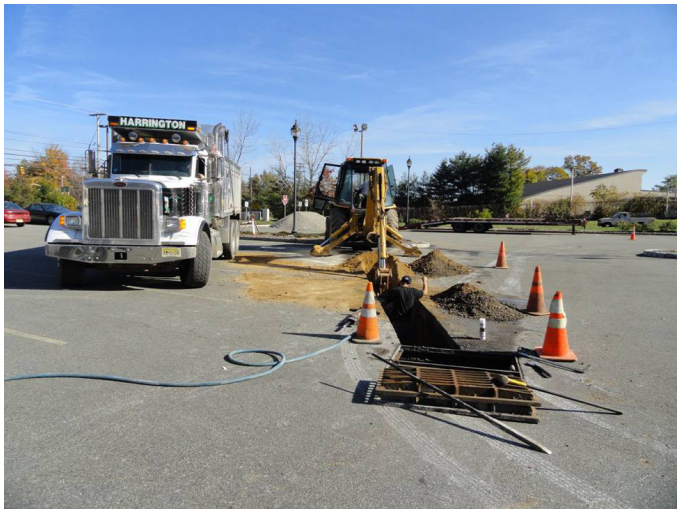


Figure 3. Site preparation. Creating connection to existing stormwater system in a parking lot in Parsippany-Troy Hills Municipal Police and Court parking lot. Photo: Pat Rector.

Costs

In a case study in northern New Jersey, the cost of individual tree boxes was approximately $12,500 with each tree box treating 1/3 of an acre of impervious surface. The total cost of three Filterra® tree boxes to treat a one acre parking lot, including installation and one year of maintenance, was $65,000.



Figure 4. A tree box installed with a speed bump to assist the flow of water towards the inlet. Photo: Pat Rector.

Maintenance

Maintenance consists of annual removal/replacement of mulch, litter and pruning of trees. This can typically be conducted by the facility managers or Department of Public Works on public property when trained by the manufacturers of the system. Performance efficiency is correlated with maintenance. The cost ranges from $100-$500 annually/tree box according to the Charles River Watershed Association (2008). The lower end of this range is indicative of maintenance performed by the owner, whereas the higher end is associated with proprietors of prefabricated systems maintenance plans (CRWA, 2008).

Tree boxes have an average life span of 25 years; however vegetation may have to be replaced more frequently.

Pollutant removal

Some tree boxes, such as Filterra® have been tested for their ability to remove pollutants. The removal rates for total suspended solids range from 80-90+%. The Filterra® boxes have had high removal rates for total petroleum hydrocarbons (90%). The literature results vary on the removal of nitrogen which ranged from 38-65%, and total phosphorus ranged from less than 50-80% with some of the variability potentially dependent upon the form of phosphorus. Removal of zinc (54%) and copper (40%) were also noted, although some tests found higher metal removal rates (CRWA, 2008).

Filterra® has been tested at high flow rates for treatment performance, and the design characteristics allow it to have a high total suspended solids removal (83-88%) at high flows (up to 133 inches per hour) although the removal for total phosphorus and metals was more variable under high flows. Recommendations from the State of Washington were that to achieve the maximum water quality, the design flow rate of 35.46 inches/hour should be used for total suspended solids and phosphorus removal. The pollutant removal rates here are based on tests conducted on Filterra® tree boxes. Although other boxes may have similar removal rates, the data is specific for Filterra®.

Infiltration

Infiltration is a function of the soil media, gravel size, depth and the underlying subsoil. An open chamber system with a gravel and stone chamber allows vertical infiltration. An open system tree box may be able to treat and infiltrate one acre with an 86 square foot tree box. The rate of infiltration and depth of filter media play a role in design of the open system.

As the question often arises whether green infrastructure systems function well in the winter and in cold climates, field testing of tree boxes to determine their efficacy in cold weather, including the ability of the filter to function and hydraulic efficiency, were conducted by the University of New Hampshire. The results indicated that performance in winter was comparable to the overall performance values (Roseen 2009).

Certification

For a Manufactured Treatment Device (MTD) to be approved by the NJDEP to be in compliance with the Stormwater Management Rules (N.J.A.C. 7:8) the MTD must obtain Verification through NJ Corporation for Advanced Technology (NJCAT). In addition there are protocols for sedimentation and filtration MTDs that must be submitted (available at www.njstormwater.org). Filterra® is in the review process of NJCATs certification, has submitted field data and been reviewed by NJ DEP and is in final review process. Filterra® expects NJCATs approval within several months. Although there are no tree boxes certified as an MTD through NJCAT at this time, Filterra® has received the Washington State Department of Ecology Technology Assessment Protocol (TAPE) General Use Designation for Basic (i.e., total suspended solids removal), Enhanced and Oil Treatment and Conditional Use Level Designation for Phosphorus Treatment.

The trade or brand names given herein are supplied with the understanding that no discrimination is intended and no endorsement by Rutgers NJAES Cooperative Extension is implied.

Citations

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