UNDERSTANDING

Tree Box Filters

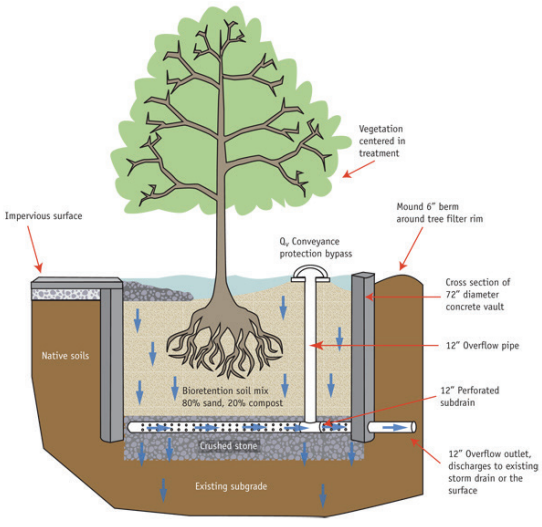
WHAT IT IS

Tree box filters are typically installed along roadways to act as mini bioretention systems. They are particularly useful in urban settings where space is limited and where traditional street tree plantings can be converted to provide stormwater management functions. A tree box filter involves a prefabricated concrete box that can be bottomless to promote infiltration or closed bottomed where soils are not conducive to infiltration. The box typically contains a metal grate at the surface to protect the integrity of the tree's roots and soils, a soils mix designed to both promote tree growth and stormwater function, a tree species (tolerant of road salt and the varying cycles of inundation and drought), and a perforated subdrain located within a bed of crushed stone at the very bottom.

Storm runoff from adjacent roadways and sidewalks enters the box through an inlet along the curbing and then soaks into and gets filtered by the soil mix. Stormwater is then taken up by tree roots, or soaks deeper into the subgrade to recharge groundwater, or collects in a perforated subdrain to discharge to the storm sewer system or to the surface.

WATER QUALITY TREATMENT

Like other bioretention systems, the tree filter box retains, degrades, and absorbs pollutants as stormwater filters through layers of mulch, soil, and plant roots. The University of New Hampshire Stormwater Center (UNHSC) installed its first tree box filter



Source: University of New Hampshire Stormwater | Center, 2009 Biannual Report

Tree box filter boxes are prefabricated bioretention cells that can be integrated into existing curb and catch basins drainage systems along streets to receive runoff from adjacent impervious surfaces.

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in 2004 and reports, "Their water quality treatment performance is high, often equivalent to other bioretention systems, particularly when well distributed through a site." UNHSC's 4-foot deep, 6-foot diameter facility demonstrated the following:

Pollutant	% Removal
Total Suspended Solids (TSS)	93
Total Petroleum Hydrocarbons in the Diesel Range	99
Dissolved Inorganic Nitrogen (NO3)	3
Total Zinc	78
Total Phosphorous	NT
Average Annual Peak Flow Reduction	NT

Source: University of New Hampshire Stormwater Center 2009 Biannual Report

During a two-year study at the University of Virginia using a manufactured tree box filter called Filterra made by Americast, Inc. researchers found "...pollutant removal rates vary as a function of the filter surface area to drainage area." At the minimum of .33% filter surface area to drainage area ratio filtering 90% of the annual runoff (calculations that involved the rainfall distribution and frequency data from the mid Atlantic region) the expected pollutant removal rates are as shown below. They note that higher pollutant removal rates are made possible by increasing the ratio of filter surface area to drainage area.

Total suspended solids: 85%

Total phosphorous: 74%

Total nitrogen: 68%

Metails: 82%

Peak Flow Reduction

UNHSC notes in its 2009 Biannual Report that, "Without additional engineering, the tree box filters can do little to reduce peak flows unless sited in appropriate soils, such as those in groups "A" (sand, loamy sand, or sandy loam with high infiltration rates) and "B" (silt loams or loams with moderate infiltration rates)."

A technical bulletin from the Virginia Stormwater Manual notes that while tree box filters are not used generally for the attenuation of runoff for stream channel erosion control and flood control purposes, "...some degree of volume/flow reduction can be achieved

by combining this filter system with an adjacent [downstream] underground storage / detention system (gravel trench or pipes). Such a combined system may be useful for urban retrofit projects to address problems associated with combined sewer overflows or for stream protection."

DESIGN CONSIDERATIONS

There are numerous prefabricated tree box filter structures that are commercially available. They are generally sized and spaced much like catch basin inlets. Design variations are abundant and as mentioned above, the functionality of the tree box filter can be augmented for volumetric control with adjacent underground storage or given naturally well draining soils (Groups A and B). Design (sizing, spacing, installation, and location) are done in accordance with manufacturer's specifications.

While drainage areas may range in size from one-quarter to a half acre, there is an optimum ratio between filter surface area to drainage area that brings together cost effectiveness

Source: Neponset River Watershed Association

The Neponset River Watershed Association worked with the Town of Milton to retrofit an existing "curb and catch basin" drainage system in the Central Crossing neighborhood with tree filter boxes. The project reduced bacterial loading to Pine Tree Brook and the Neponset River while raising awareness of these facilities as a cost effective approach to stormwater management.

with pollutant removal effectiveness. The two-year study at the University of Virginia, which used the tree box filter manufactured by Filterra and rainfall distribution / frequency for the Mid Atlantic region, found that the optimum ratio between filter surface area to contributing impervious surface drainage area is 0.33% (36 ft2) of filter surface for every ¼ acre of drainage area. This would require a 6 by 6-foot filter box.

For locating tree box filters, the State of Virginia Stormwater Management Program offers the following guidelines. Tree box filters are,

> ...best incorporated into the overall site, or streescape or parking lot landscaping plan. The individual box locations represent a combination of drainage considerations (based on final grades and water quality requirements), desired aesthetics, and minimum landscaping requirements, and must be coordinated with the design of the drainage infrastructure.

Because proper functioning of the soil media is so critical (as with other bioretention facilities), there are several additional consideration worth noting:

- **Tree box filters are installed after site work is complete and stabilization measures have been implemented. It is important to protect the filter media from premature clogging and failure.**
- **Exposing the soil, microbes, and plants to prolonged and frequent flooding and wet conditions will significantly change the hydrologic regime reducing the effectiveness of the media to capture pollutant and the microbe's/plant's abilities to cycle nutrients, break down organics and uptake heavy metals. If the filter media remains water logged for 3 or 4 days anaerobic conditions will develop, dropping both oxygen and pH levels which may kill desirable soil microbes and plants. As such, runoff should not be detained and stored in a holding tank to be metered out to the filter media over a long period of time and frequent flows (such as from basement sump pumps) must be excluded.**

BARRIERS TO USE

Following are possible concerns that may serve as barriers to use of tree box filters.

Concern	Experience
Cost	There are a variety of costs described in the available literature on tree box filters, ranging from $1,500 to $10,000. Recent quotes from manufacturers of these systems provide perhaps a more realistic range: $7,000 to $12,000, depending on size and not including installation. For public projects, installations can be done by municipal public works department or they might be bid out as part of a larger construction project. Annual maintenance cost for an owner has been reported at approximately $100 per unit. Annual maintenance by the manufacturer is $500 per unit.
Winter performance	University of New Hampshire Stormwater Center found, "The tree box filter's ability to treat water quality remained relatively stable in all seasons... While some seasonal variation in infiltration capacity and nitrogen removal does occur, cold conditions do not seem to warrant significant design alterations."
Maintenance	Once the tree is established, annual maintenance is typically minimal. In UNHSC's five-year experience with the tree filter box (installed in 2004), they note that maintenance entailed only routine trash removal and periodic inspections to ensure that the bypass and soils are adequately conveying water. In 2008, they also removed the top two inches of surface fines accumulation to restore infiltration capacity (due to an accumulation of sealcoat fines and flakes which caused a noticeable reduction in infiltration). Periodic removal of surface fines (similar to that of deep sump catch basins) may be useful over the long term to support infiltration. Manufacturers may provide services for inspection, care, and maintenance of the tree box filter for the first year or two after installation. Charles River Watershed Association notes that maintenance entails the following: periodic inspection of plants and structural components, periodic cleaning of inflow and outflow mechanisms (the system comes with an observation well that can be used as a clean out), periodic testing of mulch and soil for buildup of pollutants that may be harmful to the vegetation. Biannual replacement of mulch.

LINKS TO MORE INFORMATION

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER. MARCH 2010. "UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER 2009 BIANNUAL REPORT." SEE:
http://www.unh.edu/unhsc/

CHARLES RIVER WATERSHED ASSOCIATION. APRIL 2008. "EVALUATION OF GREEN STREET DESIGN ELEMENTS AND BEST MANAGEMENT PRACTICES: COMPARISON OF CONVENTIONAL AND STORMWATER TREE PITS." SEE:
http://www.crwa.org/hs-fs/hub/311892/file-642201447-pdf/Our_Work_/Blue_Cities_Initiative/Resources/CRWA_Stormwater_Trees_Urban_Environment.pdf

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