USDA U.S. Department of Agriculture

Stormwater Credits for Trees: Minnesota Case Study

Quick facts

Where: Minnesota Stormwater Program
When: Adopted in 2013 in the online Minnesota Stormwater Manual
What:

- Volume reduction credit for engineered Tree Trench/Box practices based on interception, evapotranspiration, and infiltration.
- Annual pollutant removal credits for total suspended solids (TSS) and total phosphorus (TP) are calculated based on volume reduction.
- Requires that users enter soil volume, treatment area, tree size, and other inputs into the Minimal Impact Design Standards Calculator.

Overview

Minnesota was the first State to develop a robust, science-based approach for crediting engineered tree Best Management Practices (BMPs) within State stormwater regulations. With funding allocated in 2009 from the State legislature, the Minnesota Pollution Control Agency convened the Minimal Impact Design Standards (MIDS) Working Group to develop new standards that would ultimately be adopted into the Minnesota Stormwater Manual (Minnesota Pollution Control Agency 2013). Sub-committees were formed to develop stormwater credits and design specifications for a suite of green infrastructure BMPs, including one focused on trees. The tree BMP sub-committee was interested in credits for retaining existing trees but ultimately adopted the Tree Trench/Box credit, which was easiest to quantify and justify in stormwater standards. One valuable feature of Minnesota's crediting approach is that it encourages well-designed tree BMPs with optimal uncompacted soil volume to maximize tree growth and function in processing stormwater runoff.

Key elements of the Minimal Impact Design Standards include the following:

- Stormwater volume performance goal for new development and redevelopment projects with greater than 1 acre of new impervious surface.
- Requires post-construction runoff volume to be retained onsite for 1.1 inches of runoff from impervious surfaces.
- Standardized credit calculations and design specifications for a variety of green stormwater infrastructure (GSI) BMPs, including: green roofs, bioretention basins, infiltration basins, permeable pavement, infiltration trench/tree box, swales, filter strips, and sand filters.
- A model ordinance package that helps developers and communities implement the new standards.

The MIDS approach has received widespread national attention for its innovative and robust crediting approaches. The unique manual was designed as an online Wiki format so that it could be easily adapted over time with new science, technical, and stakeholder input. It has been revisited and updated each year.

The science behind it

The Tree Trench credit methodology was developed by Kestrel Design Group and contract team, with oversight from the tree BMP sub-committee and multiple rounds of stakeholder input (Kestrel Design Group Team 2013). It is based on an extensive literature review of tree interception, evapotranspiration, and infiltration functions. Based on mean values found in Breuer and others (2003), the interception capacity is assumed to be 0.043 inches for a deciduous tree and 0.087 for a coniferous tree, and the canopy projection area is based on the diameter of the canopy at maturity, dependent on the tree species. The

MIDS calculator provides default tree size options (small/medium/large) that can be used in place of tree species.

The team's report reviews the pros and cons of a variety of methods for quantifying evapotranspiration, recommending use of the Lindsey-Bassuk (1991) single whole tree water use equation. This method relates the total water use of a tree to four measurements: (1) canopy diameter, (2) leaf area index, (3) the evaporation rate per unit time, and (4) the evaporation ratio.

Pollutant removal for infiltrated and evapotranspired water is assumed to be 100 percent and is calculated by multiplying the volume of water reduced by event mean concentrations for Total Suspended Solids (TSS) and Total Phosphorus (TP) from the International Stormwater Database, version 3.

How the credit works

Minnesota provides a total runoff volume reduction credit for Tree Trench BMPs, by adding together the reductions provided by tree canopy interception, soil storage (infiltration), and evapotranspiration. The interception credit is a function of tree type and projected leaf area at maturity. The storage credit is a direct function of soil volume. The evapotranspiration credit is a function of plant available water and is indirectly related to soil volume (e.g., available pore space). The total runoff volume achieved for a particular storm is calculated as the lower value of the total runoff volume directed to the tree trench and the total storage provided by that trench through interception, infiltration, and evapotranspiration. The total volume reduction is also translated into annual pollutant removal values for TSS and TP. A Tree Trench BMP without an underdrain is assumed to remove 100 percent of pollutants, while a Tree Trench with an underdrain provides lower volume reduction and pollutant removal credits (**Figure 1**).

To calculate the credits, users must enter into the MIDS Calculator a suite of inputs based on the design of the particular Tree Trench BMP such as:

- » Site Characteristics
  - watershed area/land cover draining to the Tree Trench BMP
  - downstream/routing BMP
- » Soil/Media Characteristics
  - soil volume of the tree box
  - hydrologic characteristics of the soil
- » Tree Characteristics
  - number of trees
  - most common tree type (deciduous or coniferous)
  - average tree size at maturity (small/medium/large)

Figure 2 shows one of the input screens for the **MIDS calculator**, demonstrating how the volume reduction credits are calculated based on the Tree Trench BMP characteristics provided. The figure illustrates how, in this crediting approach, the volume reduction based on soil storage (1201 cubic feet) far exceeds the volume reductions for evapotranspiration (72 cubic feet) and interception (5 cubic feet). Thus, the credit incentivizes providing ample soil volume and high quality, uncompacted soil media that will promote infiltration and storage in the short term and enable trees to grow to their optimal size. A helpful summary and example of Tree Trench credits using the MIDS calculator is included in the Center for Watershed Protection's **Accounting for Trees in Stormwater Models** (Center for Watershed Protection 2018a). Detailed technical information on the credit equations, input definitions, and other guidance can be found in the online Stormwater Manual section **Calculating Credits for Tree Trenches and Tree Boxes.**

In developing the credit calculations, it is assumed the tree practice is properly designed, constructed, and maintained in accordance with guidance in the **tree section** of the Minnesota Stormwater Manual. The manual website notes that if any of these assumptions is not valid, the BMP may not qualify for full credit.

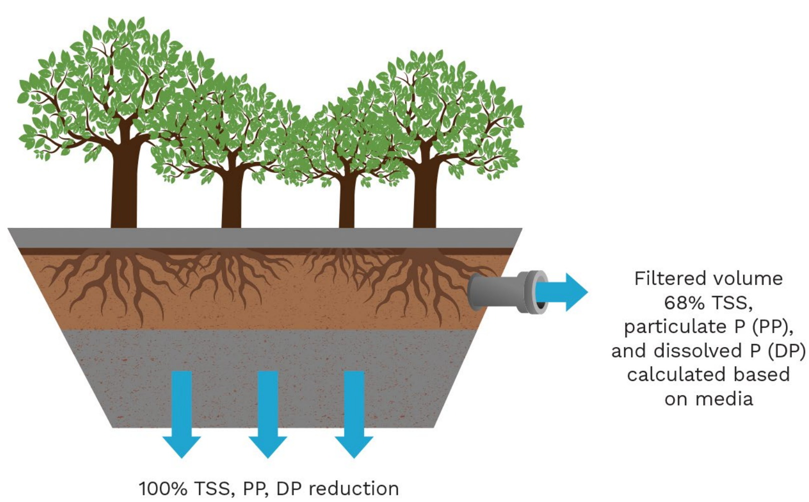
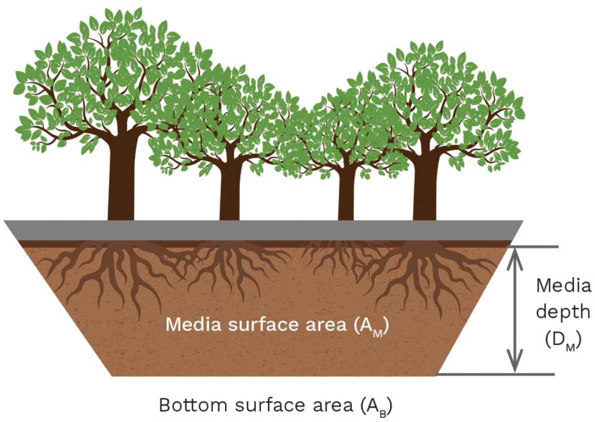


Figure 1. The Minimal Impact Design Standards (MIDS) total volume reduction is translated into annual pollutant removal values for Total Suspended Solids (TSS), particulate phosphorus (PP), and dissolved phosphorus (DP). A Tree Trench Best Management Practice (BMP) without an underdrain is assumed to remove 100 percent of pollutants, while a Tree Trench with an underdrain provides lower volume reduction and pollutant removal credits based on the type of media used.

$$V = \left(\frac{A_M + A_B}{2} \times n \times D_M \right) + V_I + V_{ET}$$



Media surface area [A_M]	2000
Bottom surface area [A_B]	2000
Media depth [D_M]	2.73
Media field capacity – wilting point [FC - WP](range 0.05-0.17)	0.12
Media porosity – field capacity [n – FC](range 0.15-0.35)	0.22
Tree type (most common)	Deciduous
Tree size (average for all trees)	Medium
Number of trees	3
Interception capacity [IC]	0.043
Canopy projection [CP]	490
Leaf area index [LAI]	4.1
Soil volume per tree [S_V]	
Underlying soil – Hydrologic Soil Group	7 MH (HSG B, 0.3 in/
Infiltration rate of underlying solids	0.3
User defined infiltration rate	
Required drawdown time	24
Volume reduction of BMP from ET [V_{ET}]	72
Volume reduction of BMP from interception [V_I]	5
Volume reduction stored in soil media	1201
Volume reduction capacity of BMP [V]	1279

Figure 2. One of the Minimal Impact Design Standards (MIDS) Calculator Tree Trench Best Management Practice (BMP) input screens showing tree and soil inputs (white boxes) and model outputs (gray).

Some of the model inputs used in the MIDS calculator for Tree Trench practices are only applicable to Minnesota and similar climates, so it is not recommended to use the calculator itself beyond those geographic zones. However, the equations and calculations behind the credit could readily be adapted for other climate zones.

References

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Lindsey, P.; Bassuk, N. 1991. Specifying soil volumes to meet the water needs of mature urban street trees and trees in containers. Journal of Arboriculture. 17(6): 141-149.

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For more information on crediting trees in the context of stormwater management, refer to the suite of resources developed by the Center for Watershed Protection on **Making Urban Trees Count**.

Adapted from: U.S. Department of Agriculture, Forest Service. 2020. Urban forest systems and green stormwater infrastructure. FS-1146. Washington, DC. 23 p.
https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Urban-Forest-Systems-GSI-FS-1146.pdf

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