Simulation and Validation of Pan Evaporation Rates Using COMSOL Multiphysics® Software

L. J. Matel[1]

[1]Green Streets Infrastructure LLC, Seattle, WA, USA

Abstract

The evaporation of liquid water in a Low Impact Development Best Management Practices (LID BMP) stormwater treatment facility is a process that involves the transport of water molecules across the interface between the liquid water surface and the vapor phase, as well as the movement of water vapor molecules away from the near water surface through the porous pavement structure and into the bulk atmosphere. The physics of diffusion provides a means of quantification of this molecular movement from which insight into the controlling factors of LID evaporation is gained.
COMSOL Multiphysics® software can be used as a tool to study how the temperature and pressure parameters affect evaporation in porous pavement. The initial elements of this process are presented here with a discussion of one way in which porous pavement can be modeled. The Effective Diffusivity in Porous Media model available in the base COMSOL software program was employed to simulate the evaporation.

The four foot diameter by ten inch deep class A evaporation pan displayed in Figure 1 is used by the scientific community as the standard for determining evaporation rates for a number of purposes. One use is for input into hydrologic simulation models.

For this analysis a simulation of the variation of water temperatures in the pan was done to examine the water' response to the surrounding ambient air temperature. The daily temperature fluctuation data reported in published weather records was used as temperature input. This analysis used the COMSOL three dimensional modeling capabilities to more precisely study the impact of thermal mass of the pan in relationship to its surroundings.
The pattern of the simulation follows the actual air temperature fluctuations at the surface of the pan over the data collection period of December to July. During that period freezing temperatures were observed, however the simulation indicates that the thermal mass of the water in the pan keeps all of the water in the pan from reaching or dipping below 32 degree F. The heat transfer program to calculate this analysis did not contain phase change provisions for heat of fusion.

With the temperature regime of the evaporation pan defined evaporation can be estimated using the software's ability to model diffusion. Validation of the model can be accomplished by simply comparing simulated flux rates to published evaporation rates. Pan evaporation data for comparison was obtained from the Western Regional Climate Center. Specifically, data used in this analysis was from the Puyallup, Washington

Experiment Station collected during the years 1931 to 1995.

Figures used in the abstract

Figure 1: Class A evaporation pan.