Report for 2003AR54B: Impact of Urbanization on the Spatial and Temporal Distribution of Infiltration

- Dissertations:
  - Wilson, A.G., 2003, Impact of Urbanization on the Spatial and Temporal Distribution of Infiltration. M.S. Thesis, Department of Civil Engineering, University of Arkansas, Fayetteville, Arkansas, 132p.

Report Follows

Introduction

This project was funded in part through the USGS 104 b program at the level of summer stipend for the graduate assistant in the Department of Civil Engineering at the University of Arkansas. The project was carried out by a Master's candidate in the Department of Civil Engineering and focused on the impacts of urbanization on infiltration. Impervious surfaces reduce infiltration and increase runoff. The impact of urbanization on infiltration at the watershed scale is poorly understood but includes increased soil density due to increased traffic on the watershed surface. This in turn results in reduced infiltration and increased runoff. Most runoff estimations are made using models based on routing water through various hydrologic storage units. However, the differences in infiltration rates and runoff rates resulting from urbanization are significant and ultimately influence stormwater runoff predications using the U.S. EPA Stormwater Management Model (SWMM). This project focused on understanding differences in measured undeveloped and developed infiltration parameters. These parameters were then used as input to SWMM to assess the sensitivity of the model to the differences in infiltration changes from undeveloped and developed watersheds.

Objective

The objectives of this research were to 1) quantify through field experiments the urban impact on the spatial and temporal distribution of infiltration using double-ring infiltrometer tests, 2) develop modified infiltration algorithms for use in stormwater management models, and 3) to develop selection and implementation guidance for site design and stormwater infiltration practices in Northwest Arkansas. The objective for the field experiments was to conduct this to determine the difference in soil hydrological characteristics, specifically infiltration, for the same land parcel before development and after development.

Methods, Procedures, and Facilities

The field experiments were performed at the same site location during pre-development conditions and then developed conditions. The experiments were concentrated in an area roughly 1600 ft^2 (40' x 40'). Measurements were taken at the center of grid cells that are spaced approximately 10 feet apart. Measurements were made once per 3-4 weeks during the months of May, June, July, August, and September. The following suite of soil characteristics were measured:

1. Soil classification (once per development scenario)
2. Soil compaction (at every grid cell)
3. Soil moisture (at every grid cell)
4. Infiltration (at every grid cell)
5. Soil temperature (average throughout the site)
6. Ambient temperature (once per experiment set)

Significant Findings

1. The average initial and final infiltration rates measured within the undeveloped plot were greater than those measured within the developed plot at a commercial development.
2. The average soil water content within the undeveloped plot was higher than the soil water content within the developed plot, while the compaction at the undeveloped plot was lower.
3. Differences between the measured undeveloped and developed Horton infiltration parameters are significant enough to influence stormwater runoff predication using SWMM.
4. Published infiltration parameters used in the SWMM model predicted a peak flow rate 20% lower than the peak flow rate predicted by the developed infiltration parameters.

These findings are relevant to city, county, and state planning personnel involved in design and implementation of stormwater management programs. Using the developed infiltration parameters will provide a more real-world predication of anticipated runoff resulting from site development and will help alleviate problems associated with reductions in runoff lag-time and increased peak discharge resulting from urbanization of watersheds.