Pooled Monitoring Initiative's Restoration Research Award Program

Impacts of Urban Soil Compaction on Stormwater Runoff Volumes and BMP Sizing

Penn State Harrisburg

Research question(s)

Understand the impact of urban soil compaction, and particularly a nearly-impermeable compaction layer, on the amount of stormwater infiltrated and runoff generated.

Issue addressed

Runoff from urban sites often is underestimated, which can lead to undersized infrastructure and increased flooding. This is due to overestimation of infiltration rates and volumes during design. Improved infiltration model parameters will reduce this error.

Project findings

- Depth to the nearly impermeable compaction layer is a critical design parameter and will greatly affect the runoff generated on a site.
- Models need to include a depth to compaction layer (max water storage) for all infiltration options (Horton, Green-Ampt, Curve Number).
- A field procedure was developed to convert single soil-moisture sensor data to Horton infiltration parameters for use in SWMM.
- A combination field-modeling procedure was developed to convert compaction layer depth to effective Curve Number for modeling.

The Pooled Monitoring Initiative pools resources to support scientists who answer key restoration questions posed by the regulatory and practitioner communities. The research teams then provide the answers back to those who asked the questions for direct application. The goal of the program is to answer these key restoration questions that serve as a barrier to watershed restoration project implementation.

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Recommendations

- Already-developed sites: Measure the depth to the compaction layer and measure or estimate the bulk density to determine whether the soil is compact or not. Use that information to determine effective Horton parameters (f_0, fc, k), Curve Numbers (CN), or Volumetric Runoff Coefficient (R_v).
- Sites in Design: Estimate depth to compaction layer using the estimated depth of the topsoil layer after construction. Use that information to determine effective Horton parameters (f_0, f_c, k), Curve Numbers (CN), or Volumetric Runoff Coefficient (R_v).
- In SWMM modeling, for Horton's infiltration options, the maximum water storage depth is equal to the compaction layer depth multiplied by the estimated porosity.
- In SWMM modeling or spreadsheet calculations, for the Curve Number methods, use the provided graphs based on soil type and compaction level, and compaction depth to estimate the effective Curve Number.

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Why does this study matter?

With climate change challenges in the mid-Atlantic region, an area with densely developed urban areas, flooding is an increasing problem. Updating the infiltration methods provides a more realistic calculation of runoff volume, peak flow rate, and amount of stormwater to be treated.

What should we do with this information?

Use the effective Curve Number (CN) or volumetric runoff coefficient (R_v) in modeling and design to better reflect the urban site behavior and reduce the underprediction of runoff.

What will the end-user (regulator/manager and practitioner) do with this information?

The information on effective Curve Numbers and volumetric runoff coefficients (Rv) as a function of compaction layer depth/water storage depth could be incorporated into design guidance.

For more information:

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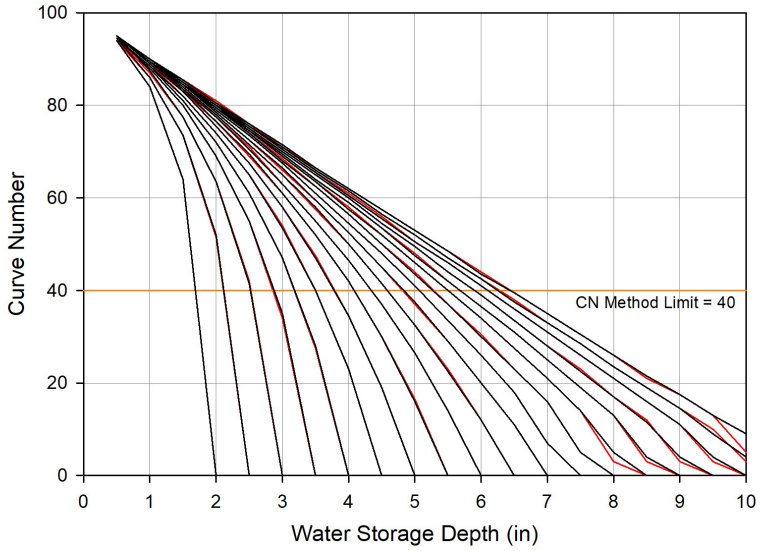
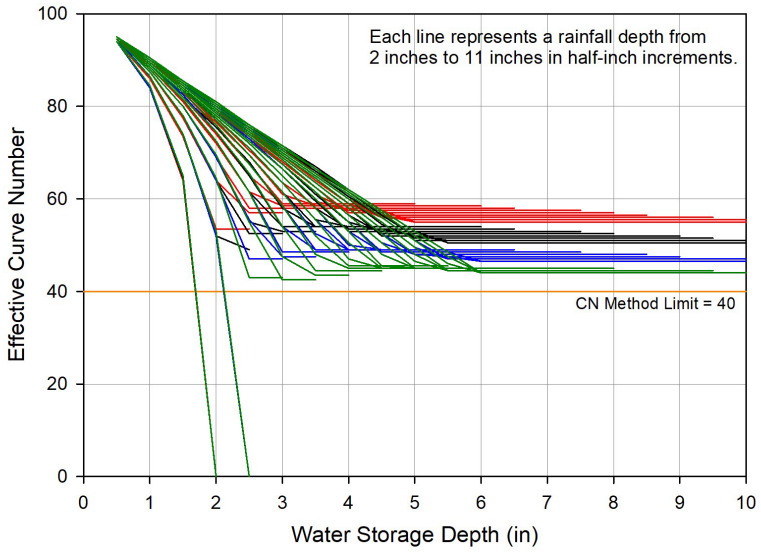
Relationships between Water Storage Depth and Effective Curve Number

NonCompact Sand (Red) and Dry Clay (Black)



Dry Compact or Saturated Clay:
NOAA A (Black), NOAA B (Red), NOAA C (Blue), NOAA D (Green)



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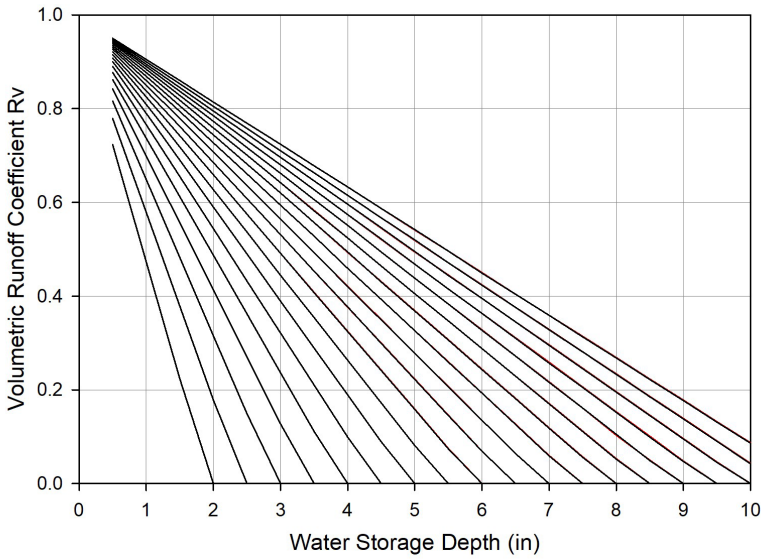

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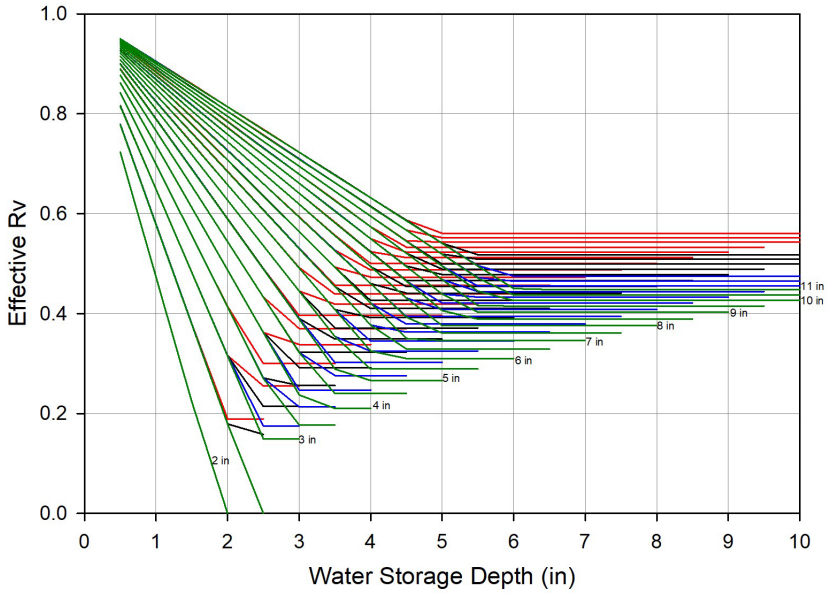

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