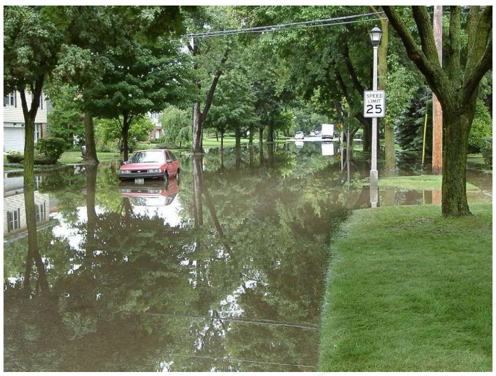
Hydrology

The Science or "Art" of changing rainfall to runoff

It can be complicated!



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Simplified Hydrologic Budget

PRECIPITATION – LOSSES = RUNOFF

- PRECIPITATION
  - Rainfall intensity, duration and volume
  - Snow and subsequent Snow Melt
- LOSSES
  - Evapotranspiration, Infiltration, Depression Storage
- RUNOFF
  - Hydrograph (Peak flow rate, time to peak and volume)

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Precipitation Data Types

Point Source
- Fixed Time Intervals
- Variable Time Intervals
- Design Storm Patterns (ATLAS 14, SCS, HUFF)

Aerial
- Radar
- NEXRAD Weather Sensing Radar Doppler (Since 1991)
- Satellite Sensors

Duration
- Event
- Design Storms
- Continuous

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Storage and Losses

- Interception
- Evapotranspiration
  - Daily/Monthly fixed
  - Recorded Daily Values
- Infiltration
  - Soil moisture storage tracking
  - Groundwater coupled
- Depression storage
  - Ultimately Infiltrated or Evaporated
- Surface Detention
  - Slope, roughness, width and method dependent
- Some Additional Factors
  - ***Season parameter variation***
  - ***Annual parameter variation***
  - Duration of Rainfall Event
  - Antecedent Conditions
  - Temperature, (snowfall events)

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Runoff

- Hydrograph
  - Flow over time with peak, time to peak and volume
  - Many parameters influence the shape, but rainfall is most dominant input
- Related to rainfall frequency and antecedent conditions
- Continuous or event depending on source input
- Varies based on method and catchment parameters
- Parameter sensitivity different for low intensity vs. high intensity rainfall

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SCS Hydrology

- CONCEPT:
  - Developed by the USDA NRCS (Soil Conservation Service)
- Data Needs
  - Drainage Area
  - Curve Number
  - Time of Concentration
  - Shape Factor
  - Initial Abstraction
- Limitations
  - Basic Infiltration description
  - No simulation of soil storage for continuous rainfall
  - Not for storms less than 0.5 inches

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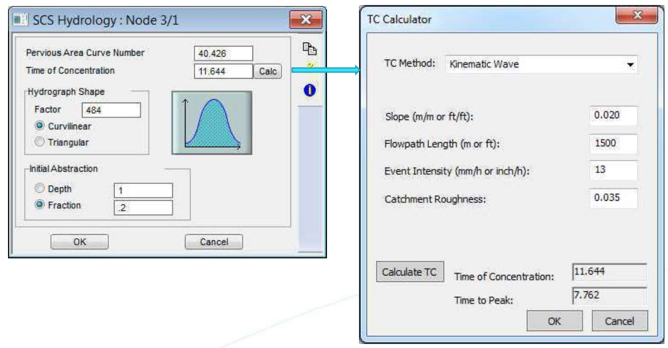
SCS Details

- Curve Number
  - 20 to 98
- Time of Concentration
  - Direct input or calculate
- Shape Factor
  - Q_p=484A/t_p
  - Curvilinear/triangular
  - 100 – 800
  - Default 484
- Initial Abstraction
  - Depth or Fraction options
  - This loss is satisfied prior to start of runoff



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SWMM Runoff

- CONCEPT:
  - Developed by the USA EPA as a deterministic approach to runoff
- Data Needs
  - Drainage Area
  - Percent Impervious (Directly Connected or DCIA)
  - Width
  - Basin Slope
  - Infiltration Method and Infiltration Parameters
  - Evaporation (can be zero)
- Limitations
  - Lumped Catchment Parameters

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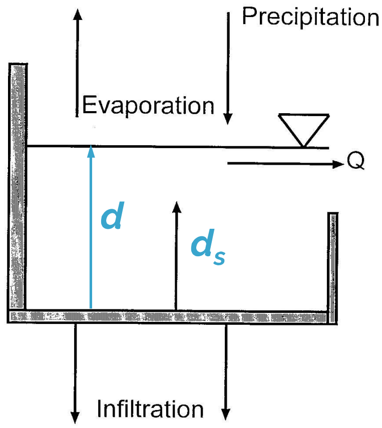
SWMM Runoff



EPA Surface Runoff
Non-linear Reservoir

$$Q = \frac{1.486}{n} \bullet W \bullet (d - d_s)^{5/3} \bullet S^{1/2}$$

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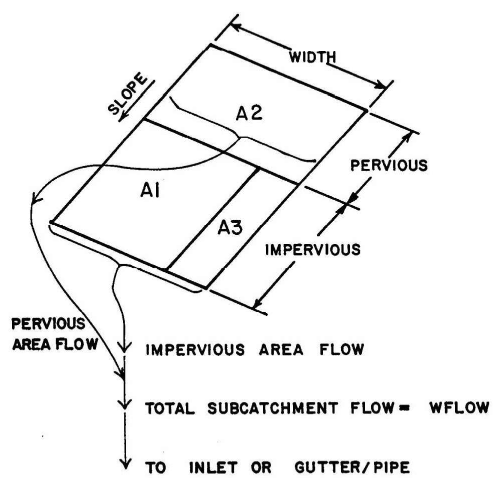
Catchment Detail

- A2: Pervious Area
- A1 & A3: Impervious Area
  - A1 with depression storage
  - A3 without depression storage
- Slope and Width same
- Depression Storage and roughness are unique



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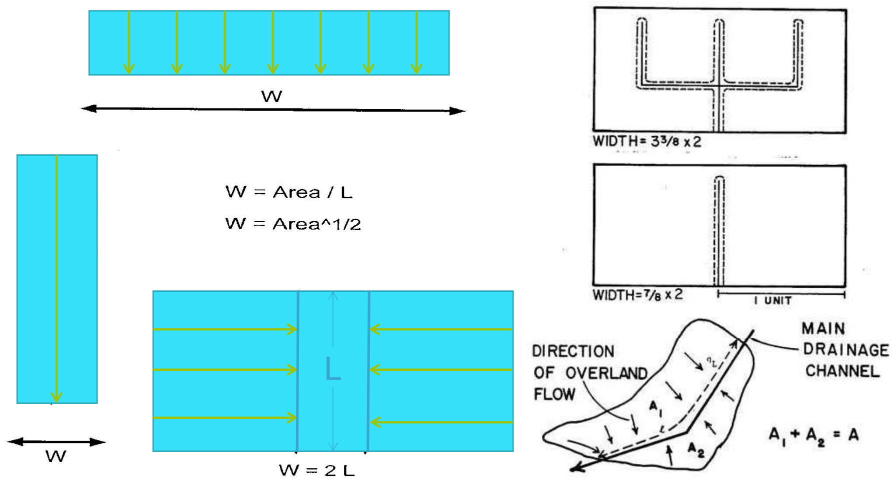
Subcatchment Width



The subcatchment or watershed width parameter is a key parameter in calibrating peak flow and total flow volume.

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Infiltration Options

- Horton
  - optional cumulative max infiltration (i.e. wetland)
- Green-Ampt (best continuous simulation choice)
- Uniform Loss
  - Proportional Loss
  - Initial and Continuing Loss
  - Initial and Proportional Loss
- SCS
  - Fraction Initial Abstraction
  - Fixed Depth Initial Abstraction

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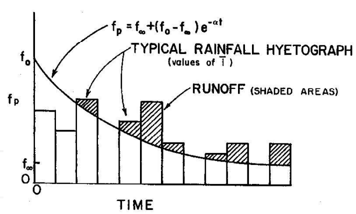
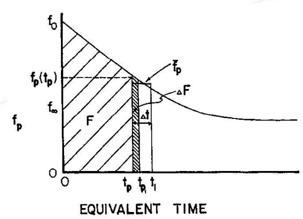
Horton Infiltration

Infiltration capacity as a function of time:

$$fp = fc + (fo - fc)\, e^{-kt}$$

where:
fp = infiltration capacity into soil, ft/sec,
fc = minimum or ultimate value of fp (WLMIN, ft/sec,
fo = maximum or initial value of fp (WLMAX), ft/sec,
t = time from beginning of storm, sec, and
k = decay coefficient (DECAY), sec^{-1}.





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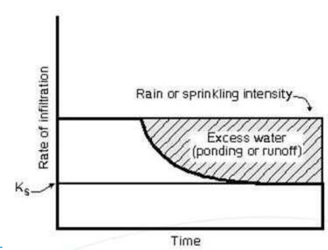
Green-Ampt Equation

For F < Fs: f=i and Fs=Su IMD/(i/Ks-1) for i>Ks
and no calculation of Fs for i<Ks

For F > Fs: f = fp and fp=Ks(1+Su IMD/F)



Where:
f = infiltration rate, ft/sec,
fp = infiltration capacity, ft/sec,
i = rainfall intensity, ft/sec,
F = cumulative infiltration volume, this event, ft,
Fs = cumulative infiltration volume causing surface saturation, ft,
Su = average capillary suction (SUCT), ft water,
IMD = initial moisture deficit for this event (SMDMAX), ft/ft, and
Ks = saturated hydraulic conductivity of soil, (HYDCON) ft/sec.

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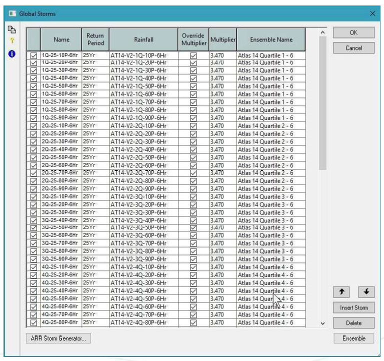
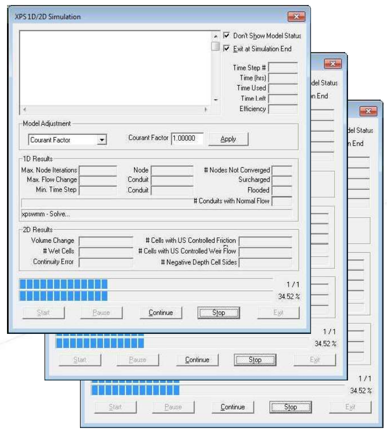
Global Storms

- Storms grouped as Ensembles
- Use Solve Manager for concurrent simulations
- Atlas 14 Rainfall





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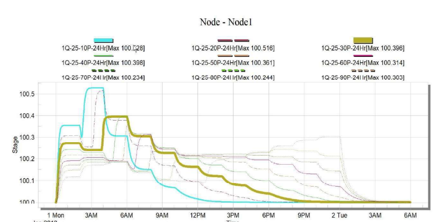
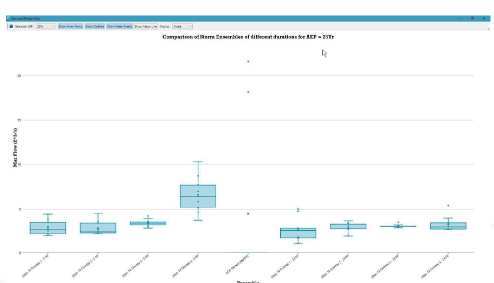
Global Storm Comparisons

- Multiple results in tables and graphs
- Specialized Box and Whisker Plot





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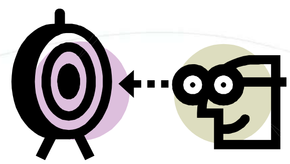
Workshop Example Preview

- Interface skill development adding
  - CAD, Aerial Images and DTM layers
  - Import Node, Catchments and Links from GIS
- Derive Hydrologic data and catchment connections
- Use SCS and SWMM Hydrologic Methods
- Solve and Review Runoff analysis
- Use Global Storms



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Empowering water experts

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