Second CE Application: Detention Basin Routing

(using Runge-Kutta)

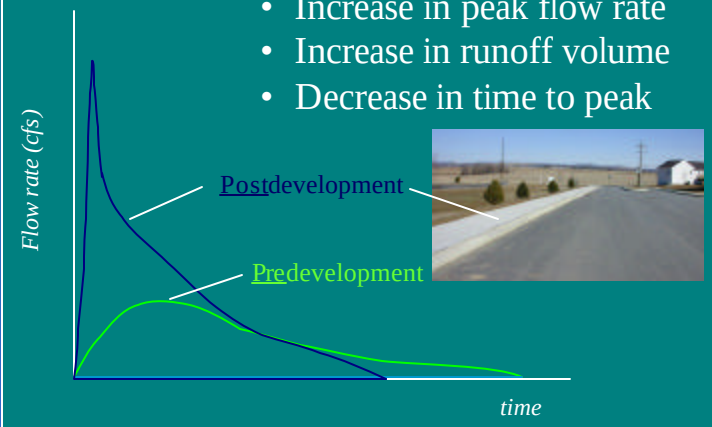
CE 201 Civil Engineering Computing
Spring 2007

Objectives

- Learn why we use detention basins
- Learn how routing is integral to design
- Learn the theory behind routing
- Learn why numerical methods are required to solve the routing equation

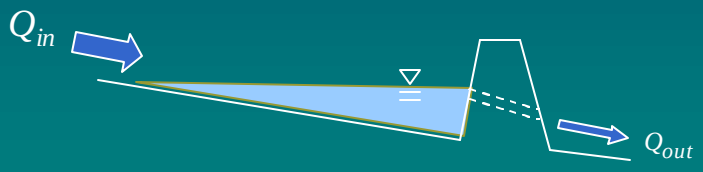
Effect of Land Development on the Stormwater Runoff Hydrograph

- Increase in peak flow rate
- Increase in runoff volume
- Decrease in time to peak



Why we use Detention Basins

- Detention basins detain and slowly release runoff, reducing the peak flow and thus protecting downstream property from higher flows resulting from development



Detention Basins




Outlet Structures



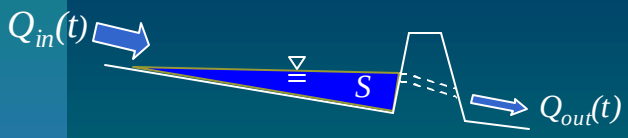

Design Procedure

- Use a runoff model to *estimate* both pre-development and post-development runoff for different design storms (2-yr, 10-yr, 25-yr, etc.)
- Size the pond and overflow structure such that the modeled post-development peak flow from the pond outlet is less than modeled pre-development peak flow from the site

Design Verification Standard

- "the design of any detention basin intended to meet the requirements of this ordinance ***shall be verified by "routing" the design hydrograph through the proposed basin***"
- **Routing**?? - the process of modeling the effect of the pond size and outlet structure geometry on the outflow

Detention Basin Routing



Outflow structure with weirs

$Q_{in}(t)$ = inflow hydrograph ? known
$Q_{out}(t)$ = outflow hydrograph ? ??

Goal: size the basin (S) and outflow structure (orifice diameters and elevations, weir lengths and elevations) to allow a limited peak Q_{out}

Routing Equations

Continuity:

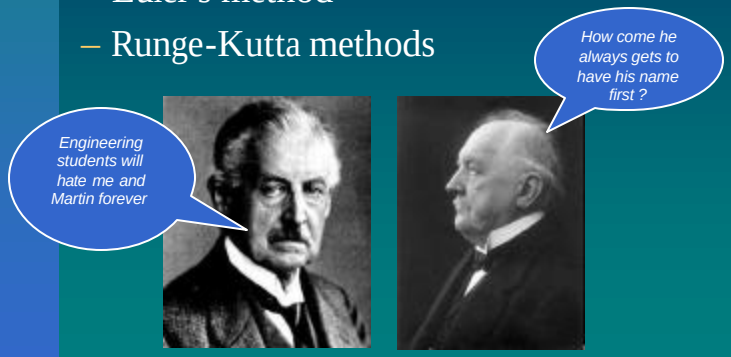
$$\frac{dS}{dt} = Q_{in}(t) - Q_{out}(t)$$

Express the S and Q_{out} terms as function of h (height of water in the basin) – we get a *nonlinear* differential equation like this:

$$A(h)\frac{dh}{dt} = Q_{in}(t) - C_w L_w (h(t) - h_o)^{1.5}$$

Solving the Routing Equation

- Nonlinear ODEs are solved *numerically*
  - Euler's method
  - Runge-Kutta methods



The fun-loving duo Carle Runge and Martin Kutta