The Role of GIS in Modeling Urban Nonpoint Source Pollution

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NPS:
Non Point Source Pollution

•Non Point Source Pollution develops from a variety of sources including Rainfall or Snowmelt

•As Runoff moves from these water sources, natural and man-made pollutants are pick-up and moved with the runoff

•These pollutants are carried with water to lakes, rivers, wetlands, oceans, and to underground water deposits

•NPS pollution remains the largest source of pollution of water bodies the United States. *(EPA, 1997)*

NPS:
Non Point Source Pollution

Non Point Source Pollution has many sources including:

•Excess fertilizers, herbicides, and insecticides from agricultural and residential areas

•Oil, grease, and toxic chemicals from urban runoff and energy production

•Sediment from improperly managed construction sites, cropland and eroding streambanks

•Salt from irrigation practices and acid drainage from abandoned mines

•Bacteria and nutrients from livestock, pet wastes, and faulty septic systems

•Atmospheric deposition and hydromodification

(EPA, 1997)

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Reducing Sources of Non Point Source Pollution:

•Problems must be addressed at a variety of levels:

•Federal Action - Ensuring that federal lands are properly managed to reduce soil erosion.

•State Responsibility - Developing legislation to govern mining and logging, and to protect groundwater.

•Locally Action - Zoning or erosion control ordinances

•Individual Role - Practicing conservation

For more information:

http://www.ecn.purdue.edu/runoff/documentation/nps.htm

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Hydrologic Modeling:

•Defined as a mathematical representation of the flow of water and its constituents on some part of the land surface or subsurface environment

•Successful in dealing with time variation

•In many cases, hydrologic models assume uniform spatial properties or allow for small numbers of uniform spatial subunits

•GIS offers potential to increase the degree of definition of spatial subunits, in number and in descriptive detail

•GIS-hydrologic model linkage also offers the potential to address regional or continental-scale processes- whose hydrology has not been modeled previously to any significant extent *(Maidment, 1993)*

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Nonpoint Source Pollution Modeling:

•Stormwater Management Model **(SWMM)** – created by EPA – as first urban runoff quality model

•Hydrological Simulation Program-FORTRAN **(HSPF)** – created by EPA-Athens Laboratory – simulates both watershed hydrology and water quality for conventional & toxic organic pollution

•Chemicals, Runoff, and Erosion from Agricultural Management Systems **(CREAMS)** – to aid in assessment of agricultural BMP's for pollution control / Groundwater Loading Effects of Agricultural Management Systems **(GLEAMS)** – partitioned into three components: hydrology, erosion/sediment yield, and pesticides

(Maidment, 2001)

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Nonpoint Source Pollution Modeling:

- Agricultural Nonpoint Source Pollution Model **(AGNPS)** – created to compare the effects of different watershed pollution control management practices
- Areal Nonpoint Source Watershed Environment Response Simulation **(ANSWERS)** – is a distributed parameter, event-based model for predicting the hydrologic & erosion response of agricultural watersheds
- Soil Water and Assessment Tool **(SWAT)** – simulates runoff, sediment, nutrient, & pesticide movement through a watershed and aids in assessing water supplies & nonpoint source pollution in large basins

(Maidment, 2001)

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Models:

NPS models: simulate generation and transport of pollutants in ***overland flow*** to waterways from upland areas. They generally poorly simulate pollutant transformations in receiving waters.
Examples: AGNPS, ANSWERS, EPIC

Water quality models: focus on transport and fate of pollutants in concentrated flow in water bodies. They generally poorly simulate pollutant transport from upland area.
Examples: HSPF, WASP, QUAL2x

Hybrid Models: Coupled NPS and water quality models. In the ideal hybrid model, a NPS models would be used to supply the needed input to the water quality model.
Examples: (none of these do a good job with the NPS portion) HSPF, WASP, SWAT, MIKE-SHE

Lumped parameter models: simulate an area as if all parameters within the area are uniform. They do not consider the effects of spatial variability. Parameter values for the area are obtained by area-weighting individual values.
Examples: HSPF, WASP, SWAT *(Virginia Tech, 2002)*

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Hydrologic Modeling Coupled with GIS:

- **Hydrologic Assessment** – the mapping in GIS of hydrologic factors that pertain to some situation, usually as a means of risk assessment.
- **Hydrologic Parameter Determination** – goal is to determine the parameters that go into hydrologic models by analysis of terrain and lover cover features. Thus land surface slope, channel lengths, land use, and soil characteristics of a watershed can be extracted from both raster & vector GIS systems.
- **Hydrologic Modeling within GIS** – some hydrologic modeling can be done directly within GIS, so long as time variability is not needed, such as considering annual averages of variables (i.e. annual average flow or pollutant loadings from a watershed).
- **Linking GIS and Hydrologic Models** – two-dimensional finite difference and finite element codes have been linked to GIS for spatial data input to flow computation & for display of results, such as piezometric head surfaces or contaminant plumes *(Maidment, 1993)*