LECTURE 9
GIS AND MODELING INTEGRATION

CEEN 4800/6965 - Special Topics
Geographic Information Systems and Hydrologic & Hydraulic Modeling
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OUTLINE

- Shamsi's taxonomy of GIS and Modeling Integration Methods
  - Interchange
  - Interface
  - Seamless Integration
- Examples and demos

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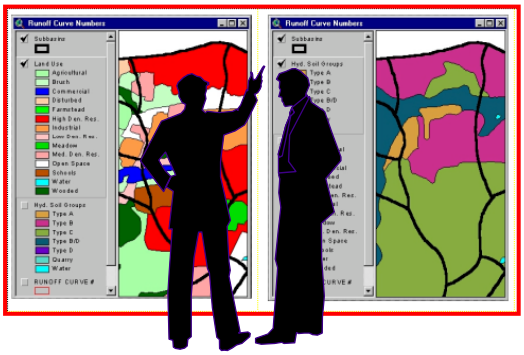
WHAT IS GIS AND MODELING INTEGRATION?

- Model creation is a cumbersome and laborious process
- Model results are not easy to understand
- GIS and modeling integration links a model with a GIS
- Benefits:
  - Fast creation of models using GIS
  - Presentation of model results in easy to understand maps
  - Saves time and money!



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WHY A TAXONOMY?

- Unfortunately, H&H modeling community did not always agree on the meaning of integration which lead to confusion and frustration.
- Software vendors used ambiguous terms to define their own understanding of GIS integration:
  - "GIS Capability"
  - "GIS Support"
  - "GIS Compatible"
  - "GIS Link"
  - "GIS Import/Export"

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SHAMSI'S TAXANOMY

- To standardize various GIS-modeling integration techniques, in 1998 Shamsi developed the first taxonomy to define the different ways a GIS can be linked to computer models (EPA, 1999).
  - Heaney, J.P., Sample, D., and Wright, L. (1999). Geographical Information Systems, Decisions Support Systems, and Urban Stormwater Management. Cooperative Agreement Report No. CZ826256-01-0, U.S. Environmental Protection Agency, Edison, New Jersey.

[1]Geographical Information Systems, Decision Support Systems, and Urban Stormwater Management

James P. Heaney, David Sample, and Leonard Wright
University of Colorado
Boulder, Colorado

Final Report to the US Environmental Protection Agency
Edison, NJ

3.0 Summary of Available GIS Urban Stormwater Modeling Software

As described in section 2, a useful taxonomy to define the different ways a GIS is used in urban hydrologic and hydraulic modeling is presented by Shamsi (1998). The three methods defined by Shamsi (1998) are data interchange, program interface, and program integration (Shamsi 1998). A fourth grouping was added for this report, the "intermediate program". Several commercial modeling products feature a data management program to facilitate data transfer between the GIS and a model. A short description is given below in order of increasing sophistication.

[1] This report was prepared by the University of Colorado under Cooperative Agreement No. CZ826256-01-0 with the EPA. The information presented does not necessarily reflect the views of the Agency, and no official endorsement should be inferred. The mention of trade names or commercial products does not imply endorsement by the United States government.

SHAMSI'S TAXANOMY

Three ways to link GIS and H&H models:

1. Interchange
2. Interface
3. Integration (seamless)

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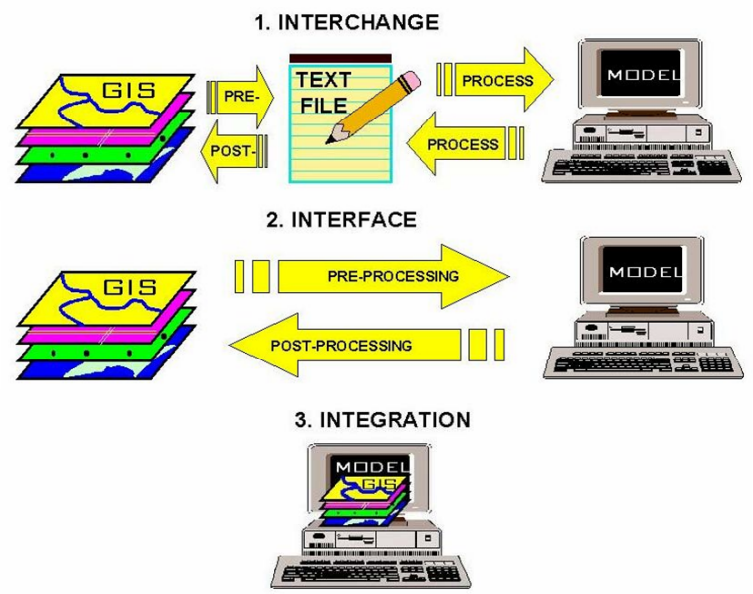
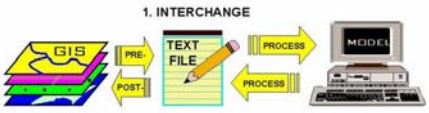
SHAMSI'S TAXONOMY



INTERCHANGE

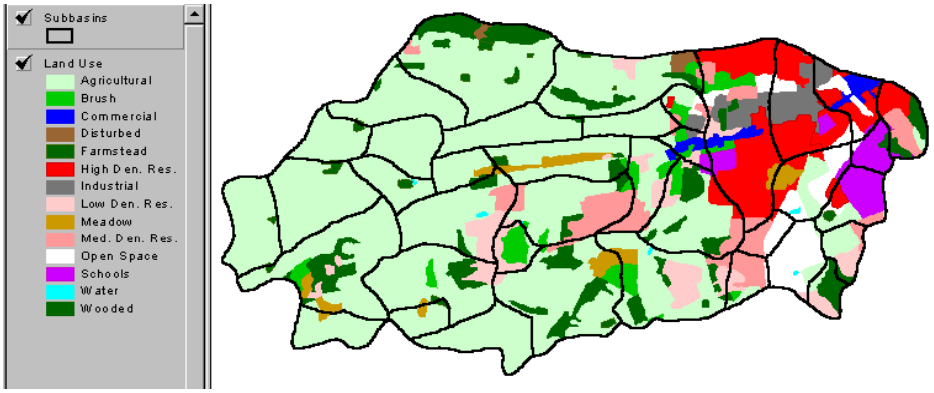


- No direct link between GIS and model
- Transfer GIS data to/from models using a batch process:
  - GIS ➲ Tables (text/spreadsheet) ➲ model input
  - Model output ➲ Tables (text/spreadsheet) ➲ GIS
- Easiest and most practiced
- All models and GISs have this capability
- The most common application of this method is processing GIS data to extract model input parameters
  - Land use ➲ Runoff curve numbers (Lecture 6: Spatial Analysis)
  - Census blocks ➲ Sewershed population (Lecture 4A: GIS Data)
  - Soils ➲ Watershed infiltration parameters (Lecture 4A: GIS Data)
  - DEM ➲ Watershed boundaries and slope (ArcHydro)

DEM = Digital Elevation Model

INTERCHANGE EXAMPLE
ESTIMATING RUNOFF CURVE NUMBERS

OVERLAY LAND USE / LAND COVER AND SUBBASIN LAYERS



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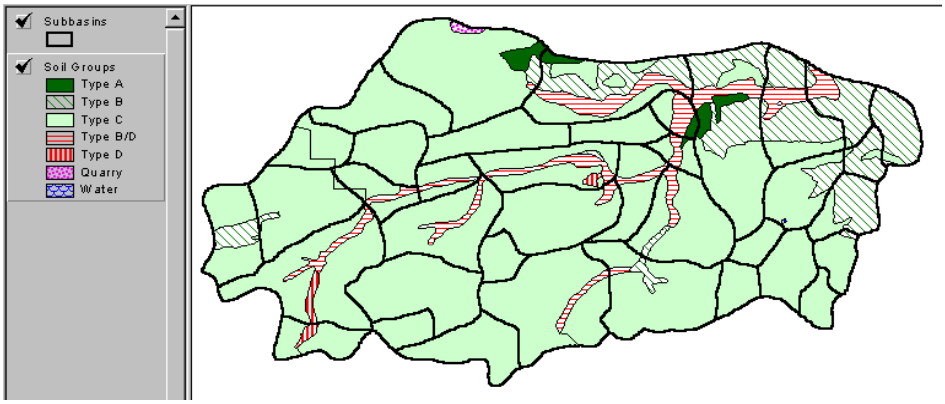
INTERCHANGE EXAMPLE
ESTIMATING RUNOFF CURVE NUMBERS

WITH NRCS (SCS) HYDROLOGIC SOIL GROUP LAYER



Hydrologic Soil Group data can be obtained from NRCS SSURGO data
www.ncgc.nrcs.usda.gov/products/datasets/SSURGO/

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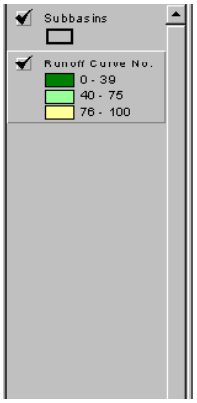
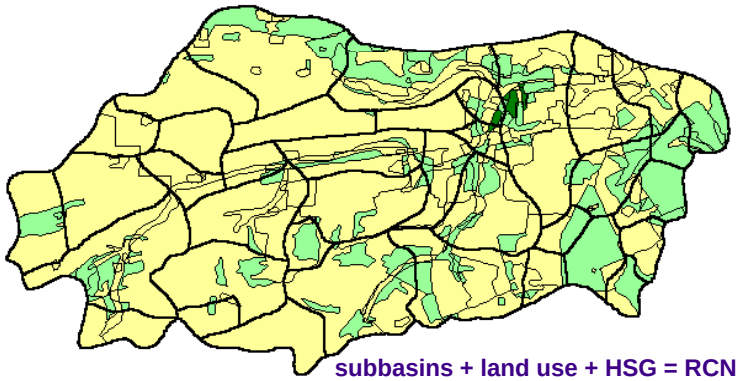
INTERCHANGE EXAMPLE
ESTIMATING RUNOFF CURVE NUMBERS

TO ESTIMATE RUNOFF CURVE NUMBERS



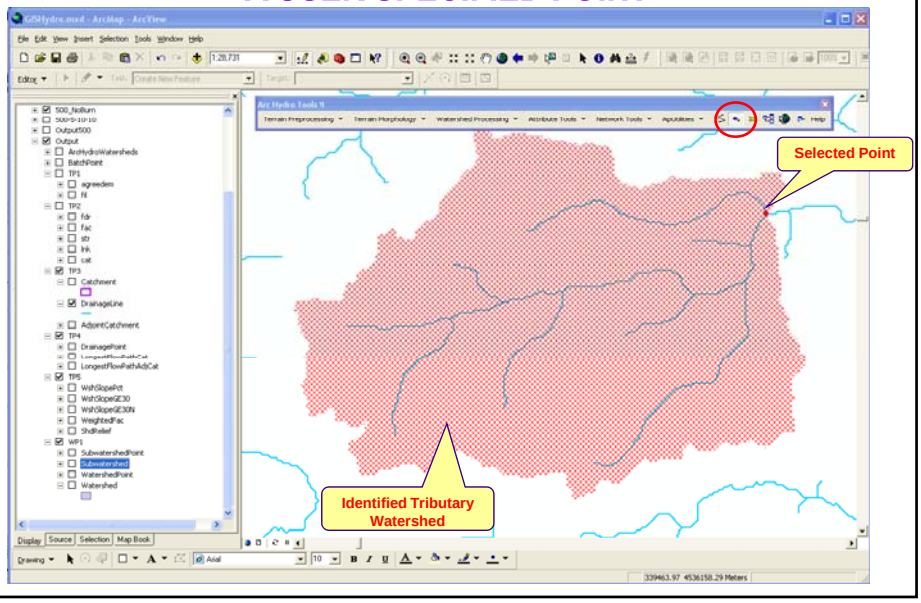


subbasins + land use + HSG = RCN

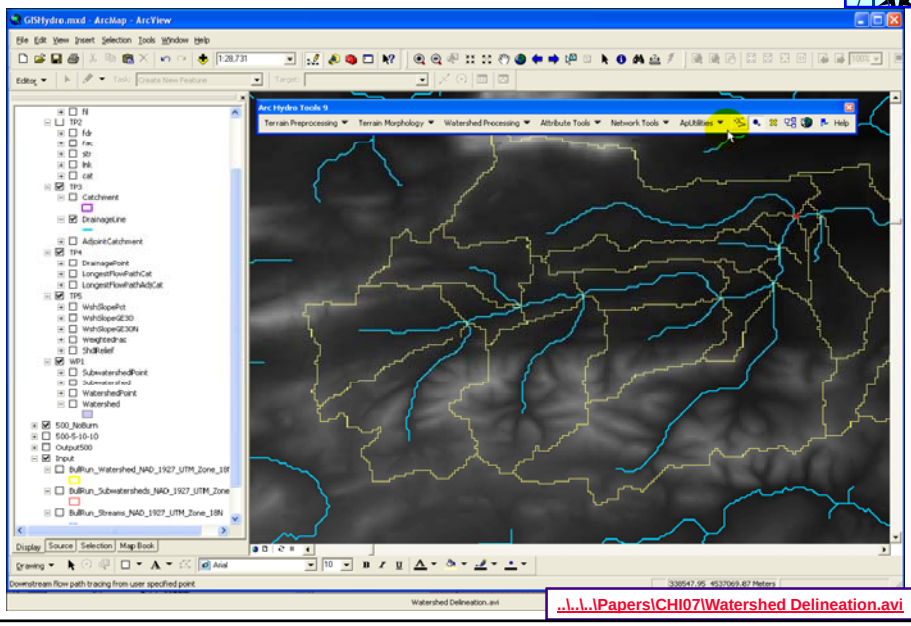
Selected rows from NRCS runoff curve number table

Land Use	% Imp.	Runoff Curve Number for Hydrologic Soil			
		A	B	C	D
High density residential	51	69	80	87	90
Medium density residential	28	56	71	81	86
Low density residential	16	49	66	78	83

INTERCHANGE EXAMPLE
ARC HYDRO: INTERACTIVE WATERSHED DELINEATION AT A USER SPECIFIED POINT



ARC HYDRO EXAMPLE: INTERACTIVE WATERSHED DELINEATION AT A USER SPECIFIED POINT



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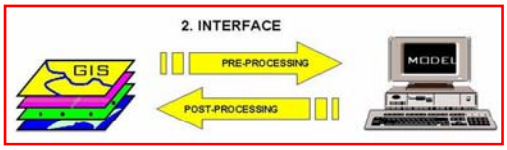
INTERFACE

- Pre-processing of GIS data to create model input files
  - GIS ➲ model
- Post-processing of model data to create GIS maps
  - Model ➲ GIS
- Does not edit or run the model
- Direct link between GIS and model

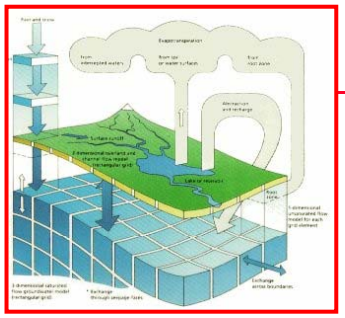


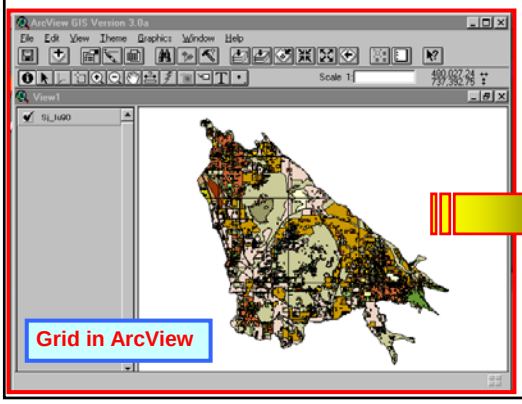
INTERFACE SOFTWARE EXAMPLES

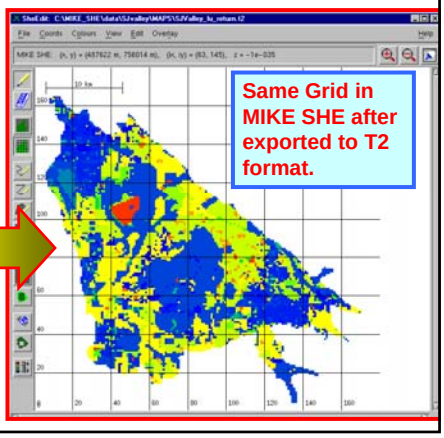
- **Sewer system models:**
  - Mike SWMM (DHI)
  - Mike Urban (DHI)
  - SewerGEMS (Haestad / Bentley)
  - InfoSWMM (MWH Soft)
- **Watershed models:**
  - Mike 11 (DHI)
  - Mike SHE (DHI)
  - Watershed Modeling System (WMS) (Brigham Young University)

INTERFACE EXAMPLE MIKE SHE

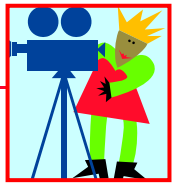
From ArcView grid to MIKE SHE input file



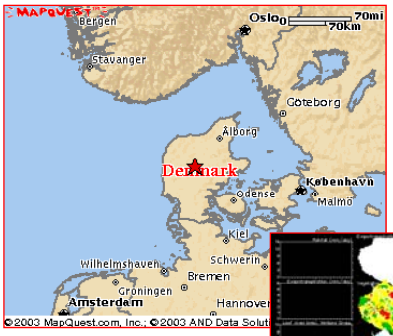


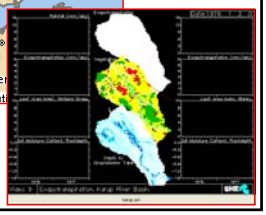


INTERFACE DEMO
MIKE SHE



- Karup (Denmark) catchment, 425 km^2, single unconfined sandy aquifer
- Spatial and temporal variations in evapotranspiration (ET) rate
- ET strongly depends on development stage of crops and depth to groundwater table

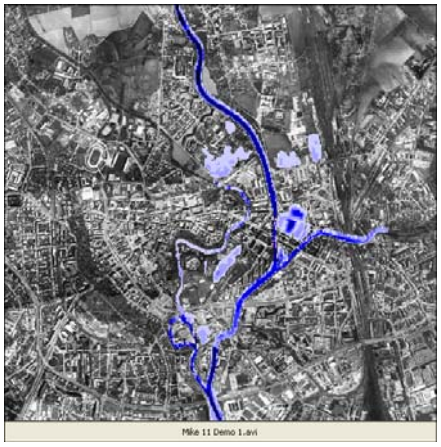




karup.avi

INTERFACE DEMO
MIKE 11 GIS

Drape the time varying flood inundation maps on an aerial photo.

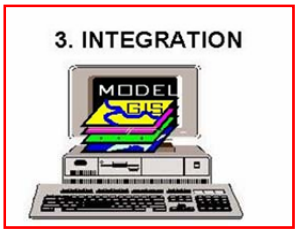


Mike 11 Demo 1.avi

SEAMLESS INTEGRATION

- Both GIS and modeling functions available in one program
- No need to exit GIS to edit/run the model
- Seamless
  - Model input creation
  - Model data editing
  - Model execution
  - Model output display

  … from within GIS



TWO METHODS OF INTEGRATION

1. GIS Based Integration

- Modeling modules are developed in or are called from a GIS
- All the four tasks of creating model input, editing data, running the model, and displaying output results are conducted from GIS.
- No need to exit the GIS to edit the data file or run the model
- Limited modeling and complete GIS capability

2. Model Based Integration

- GIS modules are developed in or are called from a computer model
- Limited GIS and complete modeling capability

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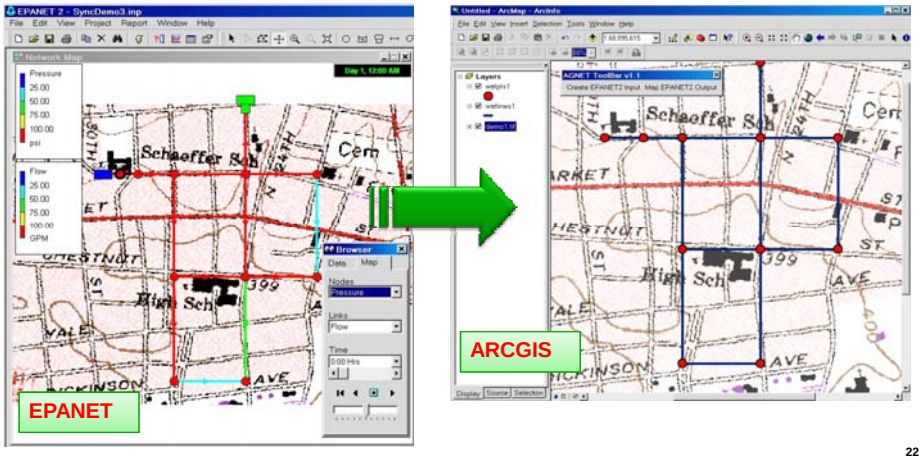
INTEGRATION SOFTWARE EXAMPLES

- **GIS Based Integration:**
  - **ArcNet (Water systems)**
  - **Shamsi, U.M., Maslanik, J.M., and Smith, P. "ArcView and EPANET Integration," GIS at the Edge: Technology for a New Millennium, Seventh Annual Pennsylvania GIS Conference, Pennsylvania State University, Harrisburg, Pennsylvania, May 12-13 1999.**
  - **InfoSWMM (Sewer systems, MWH Soft)**
  - **BASINS (Watershed TMDL, EPA)**
- **Model Based Integration:**
  - **PCSWMM.NET (Watersheds and sewer systems, CHI)**

ARCNET: EXAMPLE OF GIS-BASED INTEGRATION

- **Developed by Shamsi and Smith**
- **EPANET Pre- and Post-Processor**



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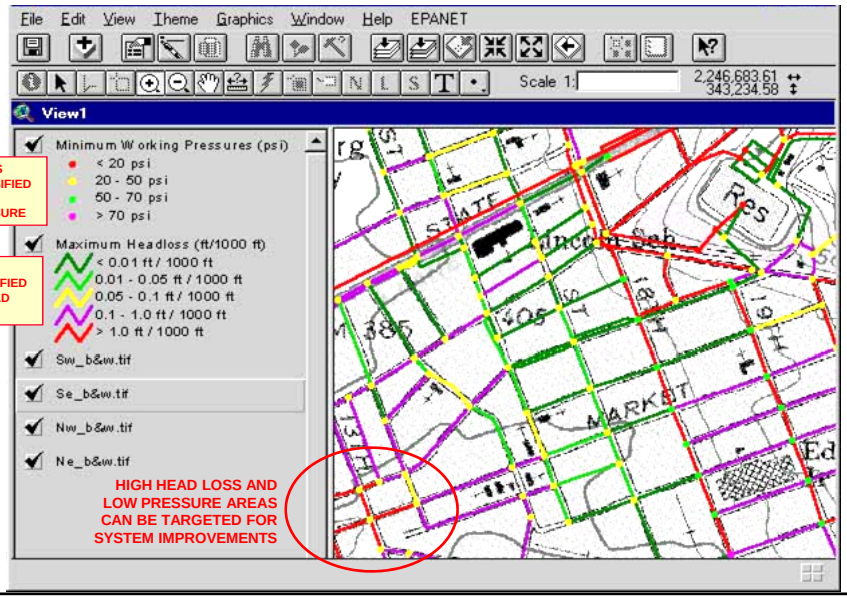
SEE EPANET OUTPUT IN ArcView



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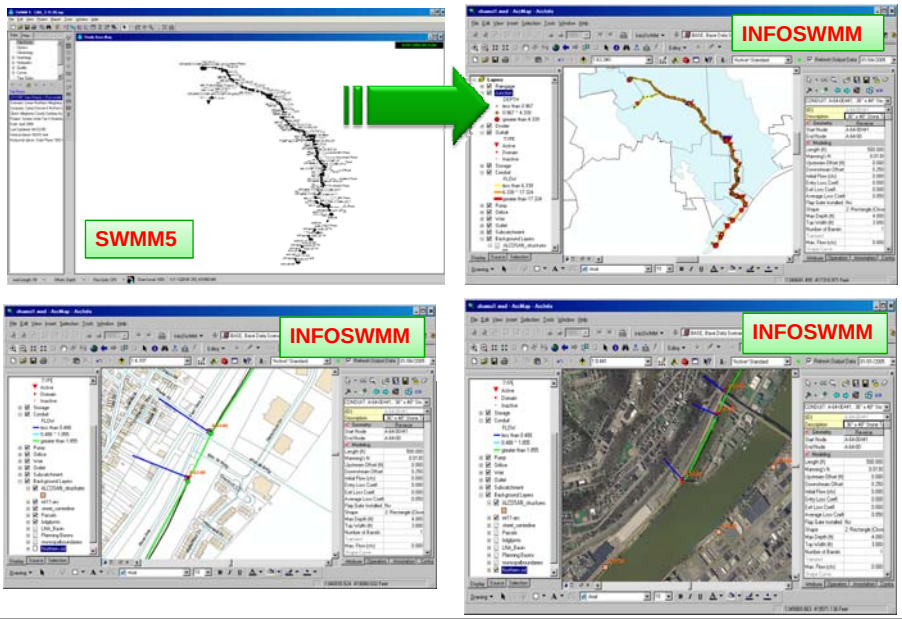
INFOSWMM: EXAMPLE OF GIS-BASED INTEGRATION



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PCSWMM.NET

EXAMPLE OF MODEL BASED INTEGRATION

- Computational Hydraulics International, Guelph, Canada (near Toronto) www.computationalhydraulics.com
- GIS integration of EPA's SWMM.
- Model input parameters (node, conduit, and subcatchment) are extracted from an ODBC compliant database using SQL queries:
  - MS Access or shapefile
- Extracted data is saved in an intermediate database (MS Access) for pre-processing into a useful model
- Processed data is exported to a SWMM input file
- Can drape SWMM output results on Google Earth
- Cost: $1500 (the lowest cost model-based integration software)

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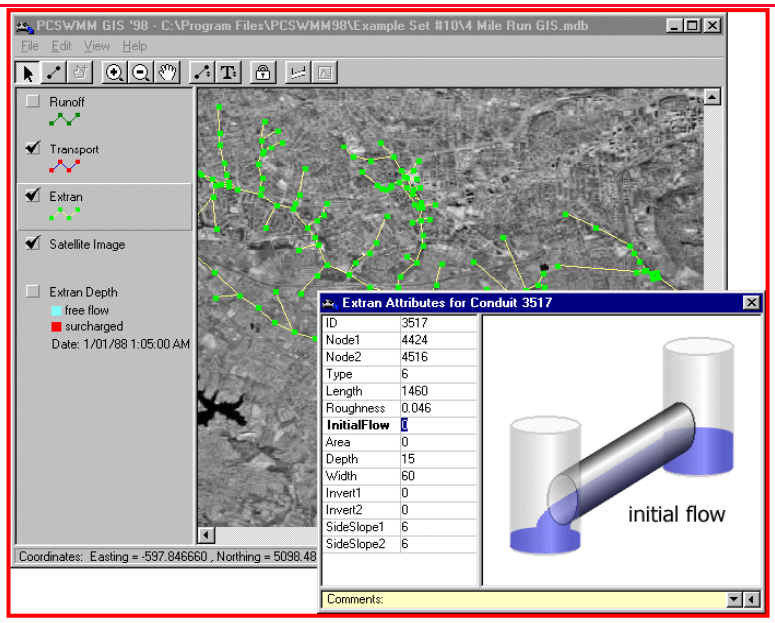
PCSWMM's ArcView LIKE INTERFACE



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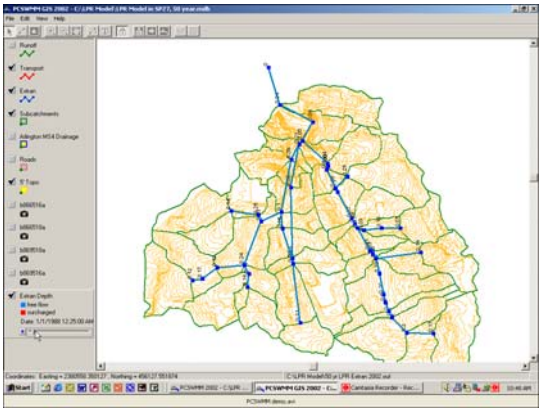
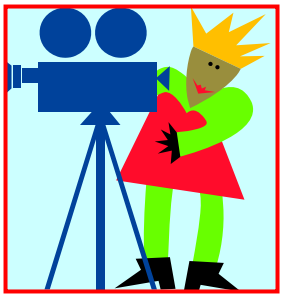
INTEGRATION DEMO PCSWMM GIS

Drape the SWMM results on an aerial photo.





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PCSWMM demo.avi

WHICH METHOD TO USE?

Feature	*Interchange Method*	*Interface Method*	*Integration Method*
Automation	None; requires manual batch processing to copy data	Some; must frequently switch between model and GIS software	Full; all tasks can be performed from within one software
Ease of use	Cumbersome	Easy	Very user-friendly
Learning curve	Steep	Average	Short
Data entry error potential	High	Moderate	Low
Data error tracking	Easy	Difficult	Very difficult
Misuse potential by inexperienced users	Low	Moderate	High
Computer programming and scripting	Optional	Moderate	Extensive
Suitability	Small projects, one time use	Medium projects, periodic use	Large projects, frequent use

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GIS INTEGRATION BENEFITS

- **Facilitates data input: pre-processing**
- **Improves interpretation of output results: post-processing**
- **GIS and model integration allows the users to be more productive**
  - **Users devote more time in understanding the problem and less time on mechanical tasks of preparing input data and interpreting reams of output results**
- **Saves analysis time and reduces total project cost**
  - **Bridges the gap between the information and its recipients**
  - **Facilitates rapid comprehension and interpretation of results**

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