Evaluating the Use of High Resolution Data to Support Watershed-Water Quality Modeling

Objectives Determine if water model output is enhanced as a direct consequence of input data resolution and/or representation.

Hypotheses 1) A proportional increase in input resolution of elevation, land cover, and soils data leads to a statistically significant improvement in the results of watershed and water quality models. 2) Changes in the form of representation of the input data can significantly affect the output results of the water modeling process.

Discussion The University Consortium for Geographic Information Science (UCGIS) recently identified water resources as a major application area of geographic information science data and an area requiring additional research to achieve better use of GIS technology. In the UCGIS white paper on water resources, Wilson (1999) identifies four areas in which GIS have influenced the development of hydrological models. First, GIS has provided the opportunity to develop and test fully-distributed models efficiently. Second, GIS allows operation of lunped models more efficiently and allows inclusion of some spatial effects. Third, GIS has been used to transform some site-specific models into spatially-distributed models. The fourth item in his list is using GIS to vary model inputs and compare model outputs in hopes of improving the scientific basis of key water quality policies and management plans. This statement forms the core of this research project.

Inskeep *et al*. (1996) varied the resolution of model input parameters according to different sources of data primarily from detailed soil profile characterization and site-specific measurements of precipitation, irrigation, and pan evaporation. Testing the models LEACHM and CMLS revealed that both performed adequately with high-resolution inputs. However, CMLS predictions were less sensitive to data input resolution because of the simplified description of transport processes used. An indication from this work is that model input data sets with low spatial resolution may not accurately reflect transport processes occurring *in situ*.

Several researchers have examined the characteristics of digital elevation models and their impacts on hydrological and water quality models. Using two16 ha study sites in Atchison County, Missouri, Hammer *et al.* (1994) compared standard 30 m USGS DEM's with field data and found that the DEM's correctly predicted slope at only 21 and 30 percent of the field sampling locations. Similar results were obtained by Srinivasan and Engel (1991), Zhang and Montgomery (1994) and Mitasova *et al*. (1996). Wilson (1999) and other authors have argued that DEMs with spatial resolutions of 2-10 m are required to represent important hydrologic processes and patterns in many agricultural landscapes.

Panuska *et al.* (1991) and Vieux and Needham (1993) quantified the effects of data structure and cell size on AGNPS pollution model inputs and demonstrated that computed flowpath lengths and upslope contributing areas vary with element size. Vieux (1993) tested the sensitivity of a direct surface runoff model to the changing effects of cell size aggregation and smoothing using different sized windows. Using three moderately large (>100 km^2) areas in Australia, Moore *et* *al*. Examined the sensitivity of computed slope and topographic wetness index values across 22 grid spacings. Hodgson (1995) showed that slopes and aspects computed from USGS 30 m DEM's are representative of elevation post spacings two to three times (60-90 m) larger than the original DEMs. USGS 1 arc-sec DEMs have been compared to 30 m DEM's by Issacson and Ripple (1991) while Lagacherie *et al.* (1996) examined the effect of DEM data source and sampling pattern on computed topographic attributes and the performance of a terrain-based hydrology model. Chairat and Delleur (1993) quantified the effects of DEM resolution and contour length on the distribution of the topographic wetness index as used by TOPMODEL and the model's peak flow predictions.Wolock and Price (1994) and Zhang and Montgomery (1994) also examined the effects of DEM source scale and DEM cell spacing on the topographic wetness index and TOPMODEL watershed model predictions. Garbrecht and Martz (1994) examined the impact of DEM resolution on extracted drainage properties for an 84 km^2 study area in Oklahoma using hypothetical drainage network configurations and DEMs of increasing size. They derived various quantitative relationships and concluded that the grid spacing must be selected relative to the size of the smallest drainage features that are considered important for the work at hand. Bates et al (1998) showed how high frequency information is lost at progressively larger grid spacings.

Approach Three geographic study areas will be modeled with elevation, land cover, and soils data of various resolution and representation. The modeled results will be validated against field measurement and statistically analyzed for significant differences resulting from the resolution/representation changes. Field measurements of water quality must be synchronized with acquisition of other data, particularly land cover which changes seasonally.

Study sites Potential NAWQA test sites (in priority order) selected based on data availability (to be finalized by WRD).

1. 02317797 Little River, Georgia (335 sq km)
2. 39434008 Sugar Creek, Indiana (246 sq km)
3. 2473740 El 68 D Wasteway , Washington (377 sq km)

Data sources Elevation and land cover as available with base set at 30 m pixel resolution (corresponding to USGS 7.5 minute DEM and MRLC resolution). Soils data to be acquired at the corresponding 30 m base resolution.

Data Availability

See attached table

Work Plan While enhanced resolution data will be collected for three study sites, the existing 30 m data will also be degraded before entry into the modeling process. This allows the models to be tested at multiple resolutions: enhanced resolution (5 m) of newly collected data; the base resolution of 30 m; several degraded resolutions, 60 m, 120 m, 240 m, 480 m, 960 m. For the Little River test site, panchromatic photography will be acquired in late Jan, 1999, for use in generating 5 m post-spacing DEM's, and color infrared photography will be acquired in late July, 1999, to support collection of land cover data with 5 m resolution. Following is a list of tasks to be accomplished with current status.

NMD Tech	*Task 1* - Acquire DEM and MRLC data for all test sites (*Complete for Little River, In progress on other sites*).
NMD	*Task 2* - Acquire soils data for all test sites (Complete for Little River).
WRD	*Task 3* - Acquire water quality measurements (N) for same time as MRLC data for all test sites.
NMD PI/Tech	*Task 4* - Process and reformat data as necessary for entry into water quality modeling software.
WRD	*Task 5* - Implement water quality model with base resolution data.
NMD PI/Tech	*Task 6* - Degrade resolution of DEM, MRLC, and soils data to various resolutions and reformat as necessary for entry into the water quality model.
WRD	*Task 7* - Implement water quality model with degraded resolution data.
NMD PI/ analyze. WRD	*Task 8* - Test results of *Task 5* and *7* against results of *Task 3* and statistically
NMD	*Task 9* - Collect new high resolution elevation, land cover and soils data for all test sites.
WRD	*Task 10* - Collect water quality measurements (N) for same time as high resolution land cover for all test sites.
NMD PI/Tech	*Task 11* - Process and reformat data as necessary for entry into water quality modeling software.
WRD	*Task 12* - Implement water quality model with new high resolution data.
NMD	*Task 13* - Degrade resolution of DEM, MRLC, and soils data to various resolutions and reformat as necessary for entry into the water quality model.
WRD	*Task 14* - Implement water quality model with degraded resolution data.
NMD PI/ WRD	*Task 15* - Test results of *Task 12* and 14 against results of *Task 10* and statistically analyze.

NMD/WRD *Task 16* - Document results and organize for presentation and publication.

NMD PI/Tech *Task 17* - Convert terrain data at various resolutions to alternative representations:
A) Raster to vector and vector to raster.
B) Mathematical representations.

WRD *Task 18* - Compute model parameters from alternative representations.

NMD PI/Tech *Task 19* - Implement water quality models with outputs from Task 18.

NMD PI/ WRD *Task 20* - Test results of Task 19 with previous results. Statistically analyze.

NMD/WRD *Task 21* - Document results and organize for presentation and publication.

Data Availability by Test Site

Little River, Georgia

Data	Source	Resolution/Scale	Date/Duration
Geographic Data			
Watershed Boundary	NAWQA		
DEM	USGS	30m, 3 arc-sec	
Land cover	GA-DNR	30 m	1990
	NESPAL	30 m	1997
Soils	USDA	1:15,840	
Hydrography	USGS	1:24,000	
DRG	USGS	1:24,000	
Roads	USGS	1:24,000	
Railroads	USGS	1:24,000	
Water Data			
Stream flow	USDA		30 years
Water quality	USDA/NESPAL		1995-present
Continuous monitoring of water quality			

Sugar Creek, Indiana

Geographic Data

Watershed Boundary	NAWQA	
DEM	USGS	30m, 3 arc-sec
Hydrography	USGS	1:24,000
DRG	USGS	1:24,000
Roads	USGS	1:24,000
Railroads	USGS	1:24,000

Water Data ?

El 68D Wasteway, Washington

Geographic Data

Watershed Boundary	NAWQA	–
DEM	USGS	30m, 3 arc-sec
Hydrography	USGS	1:24,000
DRG	USGS	1:24,000
Roads	USGS	1:24,000
Railroads	USGS	1:24,000

Water Data ?

Budget (NMD-FY 2000)

NMD-SIR

Salaries -- PI, 0.2 FTE; GS-9 Technician, 1-FTE; GS-11 Computer Specialist, 1/4 FTE

Equipment/Software	$30,000
Mapping Contracts	30,000
Travel	4.400
Training	2,200
Books, misc.	1,000

WRD

NRP	$40,000
NAWQA	50,000