Geographic Information System Data Base Requirements for Hydrologic/Water Quality Models

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INTRODUCTION

Hydrologic, water quality, and environmental problems that must be addressed are becoming increasingly complex. At the same time, Hydrologic Water Quality Models (HWQM) available to address these problems are growing in sophistication and in terms of the data they require.

Data management for large models capable of addressing site specific impacts is a major limitation to timely analysis and application of the models.

Geographic Information Systems (GIS) are software that manage complex, spatially variable, geographically referenced data bases. GIS generally permit the development of visual displays of the data in map form that greatly assist the analyst in visualizing physical conditions that exist over a region at a particular point in time. GIS may also be used to display the results of a modeling effort, where the model output is geographically variable. A GIS is a tool for effectively managing the vast arrays of data that are often required by distributed HWQM.

This report assesses the types of data that should be included in a geographic information system data file for modeling studies that include the use of HWQM. The data to be included in GIS data files should meet various modeling objectives. The benefit of a generalized data base defined from the start of a data gathering program is that often as data bases are put together, a few items of additional data can be included with little additional cost, whereas adding the data later may be quite expensive. The omission of certain data may preclude the use of the model or models that might best address a given issue. A second advantage is that the data base will not be model specific so that alternative models can be used without recreating the data base.

OBJECTIVES

The objectives of this report are to define the data requirements for some of the more comprehensive HWQM and to develop recommendations for the types of data that should be included in GIS data files.

HYDROLOGIC/WATER QUALITY MODELS:

The following hydrologic/water quality models have been studied: HEC-1, AGNPS, TR-20, CREAMS, WEPP, HEC-2, PRZM, PRMS, and FESHM.

HEC-1: Flood Hydrograph Package

The HEC-1 model developed by the U. S. Army Corps of Engineers is designed to simulate the surface runoff response of a river basin to precipitation by representing the basin as an interconnected system of hydrologic and hydraulic components. The result of the modeling process is the computation of streamflow hydrographs at desired locations in the river basin (US Army Corps of Engineers, 1983). Depending on the modeling options chosen, the input data of the model include:

* Time interval for input data
* Average precipitation
* Reservoir volume (acre-ft), diversion, and pumpage (cfs)
* Drainage area
* Baseflow
* Maximum value of diverted flow
* Peak flow
* Inflow to the diversion station
* Rate of flow to be diverted
* Maximum and minimum permissible capacity of diversion used as a constraint on optimization
* Flows corresponding to stages
* Stages corresponding to flows

* Initial storage (acre-ft) at the beginning of the simulation
* Percent of drainage basin that is impervious
* Hydraulic conductivity at natural saturation
* Infiltration rate
* Available soil moisture capacity
* Holton long-term equilibrium loss rate for rainfall/snowmelt losses on snow free ground
* Initial abstraction (rainfall) for snow free ground
* Runoff curve number
* Storm reduction coefficient for standard project storm computation equal to the shape factor of the basin
* Observed flow at the beginning of the first period (Time series data)
* Hydrograph ordinates at the beginning of the first period
* Stage at the beginning of the first interval
* Constant channel loss in entire routing (cfs)
* Percolation rate for wetted surface area of channel
* Average invert elevation of channel of length "L" used to compute flow surface area
* Channel length
* Channel roughness (n)
* Channel shape
* Channel bottom width or diameter
* Channel side slope
* Muskingum K coefficient (hours)
* Left overbank roughness coefficient (n)
* Right overbank roughness coefficient (n)
* Channel cross section elevation
* Outflow for Ogee spillway, etc.
* Spillway crest elevation
* Spillway length
* Elevation of the top of the dam at which overtopping begins
* Length of the top of the dam actively being overtopped
* Reservoir cost
* Length of the basin
* Elevation to find the slope
* Clark storage coefficient in hours
* Snyder standard lag in hours
* Snyder peaking coefficient (cp)
* SCS lag time in hours
* Overland flow length
* Overland roughness coefficient (n)
* Overland flow elevation
* Elevation of water surface at which the pump is turned on
* Elevation of water surface at which the pump is turned off
* Pump flow
* Peak flow values corresponding to exceedence frequencies
* Peak stage values corresponding to exceedence frequencies

* Flow values corresponding to stages
* Flow values corresponding to damages
* Stage values corresponding to damages
* Soil texture
* Watershed area
* Reservoir water surface elevation
* Reservoir water surface area
* Center line elevation of down stream end of low-level outlet

Not all of these data are required for a particular HEC-1 simulation .

TR-20: Hydrograph Development and Flood Routing

TR-20 was developed by the U. S. Soil Conservation Service to assist engineers in hydrologic evaluation of individual flood events for water resources projects. The model computes direct runoff resulting from any synthetic or natural rainstorm. It develops flood hydrographs from runoff and routes the flow through stream channels and reservoirs. It combines the routed hydrograph with flow from other tributaries and prints out the peak discharges, their times of occurrence, and the water surface elevations at any desired cross section or structure. The program provides for the continuous analysis of nine different rainstorms over a watershed under present conditions and with various combinations of land treatment, flood water retarding structures, diversions, and channel work. It performs these routings through as many as 200 reaches and 99 structures in any one continuous run (USDA-SCS, 1979). The input data of the model are:

* Subwatershed area
* Runoff curve number
* Time of concentration
* Water surface elevation
* Channel reach length
* End area coefficient (x)
* End area exponent (M)

* Diversion output discharge
* Time increment
* Cumulative rainfall
* Drainage area
* Reservoir water surface elevation and discharge
* End area
* Area flooded
* Baseflow (cfs) or volume (inches)
* Main time increment (hours)
* Rainfall depth (inches)
* Rainfall duration (hours)
* Reservoir storage (acre-ft)
* Soil texture
* Watershed area
* Structure elevation
* Channel cross section elevation
* Watershed length
* Watershed elevation

Not all of these inputs are required for all runs with the model.

AGNPS: Agricultural Non-Point Source Pollution Model

AGNPS was developed by the Agricultural Research Service of USDA. It is a computer simulation model developed to analyze the water quality of runoff from watersheds. The model predicts runoff volume and peak flow rate; eroded and delivered sediment; and nitrogen, phosphorus, and chemical oxygen demand concentrations (ppm) and mass (lb) in the runoff and the sediment for single storm events for all points in the watershed. The model works on a cell basis. These cells are uniform square areas that divide up the watershed. This division makes it possible to analyze any area in the watershed (Robert, et al. 1987). The input data of the model are:

* Area of each cell (10 acres if watershed < 2000 acres, 40 acres if watershed > 2000 acres)
* Precipitation
* Runoff curve number
* Feedlot curve number

* Land elevation and length to find the land slope
* Slope Shape Factor
* Field slope length
* Channel length
* Channel elevation (at bed)
* Channel side slope
* Channel indicator
* Manning's roughness coefficient (n)
* Soil erodibility factor
* Cover and management factor (C - factor in USLE)
* Support practice factor (P - factor in USLE)
* Surface condition constant
* Aspect
* Soil texture
* Fertilization level
* Fertilizer availability factor
* Chemical oxygen demand (COD) factor
* Impoundment factor
* Feedlot area
* Roofed area
* Buffer area elevation and length to find the slope
* Flow length
* Area draining into the impoundment (acres)
* Diameter of impoundment's pipe outlet (inches)
* Crop type
* Tillage practices (fall, spring)
* Point source indicator
* Rainfall erosion index (USLE)
* Crop factor
* Inflow concentration of N, P, COD in (PPM)
* Channel invert elevation
* Bulk density
* Infiltration rate
* Animal type
* Particle fall velocity
* Gully source level (tons)
* Phosphorus factor
* Nitrogen factor

CREAMS: Chemicals, Runoff, and Erosion from Agricultural Management Systems

CREAMS is a field-scale mathematical model developed to evaluate non-point source pollution from field-sized areas. CREAMS is structured as the following separate submodels:

***Hydrology Submodel*:** This submodel operates on given rainfall data plus a record of average monthly radiation and temperature, with information on crops, soil profile, and field shape to generate a sequence of information on runoff, evaporation, and seepage. This output information is used by the erosion, pesticides, and nutrient models in simulating chemical transport. The hydrology submodel is designed to use physically related or easily estimable parameters as much as possible. It does not depend on extensive detail for soil or field topography.

The hydrology submodel has two options: Option 1 uses daily rainfall available from the climatological data of the National Weather Service and from several USDA-SEA-AR research locations. Option 2 uses breakpoint rainfall data available upon request from USDA-SEA-AR for several locations in the United States. Hourly rainfall data can be used as input for hydrology submodel option 2. The data would be input in the same format used for the breakpoint data (Williams, et al. 1980).

***Erosion/Sediment Yield Submodel*:** This submodel is used by planners and managers who select practices to control non-point pollution due to sediment coming from field-sized agricultural areas. This submodel combines new modeling concepts with such commonly accepted relationships as the Universal

Soil Loss Equation (USLE) to provide a flexible, powerful model requiring a reasonable number of inputs. The submodel computes erosion, sediment yield, and particle composition of the sediment on a storm-by-storm basis. Long-term effects are evaluated by simulating over a long record. Main inputs are rainfall erosivity and runoff for each storm and erosion-sediment transport characteristics of the area (Foster, et al. 1980).

***Nutrient Submodel*:** This submodel was developed to provide the user with estimates of nitrogen and phosphorus losses from fields. The user can simulate the effects of such best management practices as erosion control practices or timing and method of nutrient applications. The results of these simulations can be analyzed to determine if any proposed practice increases losses or which practices most effectively control nutrient losses. This model was developed with a minimum amount of information needed for a reasonable or acceptable prediction (Frere, et al. 1980).

***Pesticide Submodel*:** This submodel provides procedures to assess the effects of management options on potential pesticide losses in runoff. Its applicability is in making relative comparisons among options. However, it is not designed to predict pesticide concentration in runoff to be used as an absolute value in assessing water quality. It is used for field-scale application and will provide estimates of pesticide mass and storm-mean concentrations at the edge of the field (Leonard, et al. 1980). The input data of the model are:

- Field area
- Saturated hydraulic conductivity
- Wilting point soil moisture content (at -15 bar tension)
- Runoff curve number
- Channel length

* Channel invert elevation
* Watershed length
* Watershed width
* Maximum rooting depth
* Depth of surface soil layer
* Depth of maximum root growth layer
* Effective capillary tension of soil
* Roughness coefficient (n)
* Effective hydrologic slope length
* Average monthly temperature
* Average monthly solar radiation
* Winter cover factor
* Leaf area index for the crop
* Volume of rainfall
* Volume of runoff
* Percolation below root zone
* Actual evaporation from plants
* Actual evaporation from soil
* Manning's roughness coefficient (n) for overland flow over bare soil
* Soil erodibility for erosion by concentrated flow
* Yalin constant for sediment transport
* Fraction of clay in the original surface soil layer exposed to erosion
* Fraction of silt in the original surface soil layer exposed to erosion
* Fraction of sand in the original surface soil layer exposed to erosion
* Fraction of organic matter in the original surface soil layer exposed to erosion
* Soil texture
* Elevation of overland flow profile
* Length of overland flow profile
* Side slope of the outlet control channel
* Bottom width of the outlet control channel
* Manning's roughness (n) of the outlet control channel
* Total drainage area of channel at lower end of channel (acre)
* Soil water intake rate within the pond
* Cropping management factor
* Contouring factor
* Depth to the nonerodible layer in the middle of channel
* Depth to the nonerodible layer along the side of channel
* Amount of eroded sediment
* Average soil water between storm
* Soil porosity
* Field capacity soil moisture content
* Organic matter available for denitrification (% of soil mass)
* Soluble nitrogen
* Soluble phosphorus
* Nitrate (kg/ha)
* Soil nitrogen

* Soil phosphorus
* Depth of incorporation
* Distribution coefficient (KD)
* Potential minerizable nitrogen (kg/ha)
* Potential nitrogen uptake (kg/ha)
* Bulk density
* Field length
* Area draining into each impoundment
* Diameter of outlet pipe of each impoundment
* Overland flow area
* Drainage area draining into upper end of channel
* Pond surface area
* Soil moisture content
* Soil evaporation parameter
* Drainage area above pond

WEPP: USDA-Water Erosion Prediction Project Hillslope Profile Model

The USDA - Water Erosion Prediction Project (WEPP) hillslope profile model developed by the Agricultural Research Service of USDA represents erosion prediction technology based on fundamentals of infiltration theory, hydrology, soil physics, plant science, hydraulics, and erosion mechanics. The model provides several major advantages over existing erosion prediction technology. Spatial and temporal distributions of soil loss can be estimated. Net soil loss for an entire hillslope or for each point on a slope profile can be estimated on a daily, monthly, or average annual basis. Since the model is processed-based, it can be applied to a broad range of conditions that may not be practical or economical to field test. Processes considered in the model include climate, snowmelt, stationary sprinkler irrigation, furrow irrigation, soil evaporation, plant transpiration, percolation, infiltration, surface runoff, rill hydraulics, plant growth, residue decomposition, as well as sediment generation, transport, and decomposition on interrill and rill areas. The model is intended to accommodate spatial and temporal variability in topography, surface roughness, soil properties, crops, and land use conditions on hillslopes. The model components are:

* Climate component (daily weather information)
* Infiltration component (Green-Ampt infiltration equation)
* Surface runoff component (Kinematic wave equation)
* Daily water balance component
* Plant growth and residue decay component
* Rill-Interrill erosion component

The model provides explicit estimates of when and where the hillslope erosion is occurring so that conservation measures can be designed to most effectively control soil loss and sediment yield (Lane, et al. 1989). The input data of the model are:

* Latitude
* Longitude
* Precipitation
* Maximum and minimum temperatures
* Solar radiation
* Wind velocity and direction
* Aspect of the field
* Width of the field
* Length of overland flow element
* Elevation
* Soil texture
* Number of soil layers
* Soil albedo
* Initial saturation
* Thickness of soil layer
* Initial bulk density
* Initial saturated hydraulic conductivity
* Wilting point soil moisture content
* Field capacity soil moisture content
* % of sand
* % of clay

* % of organic matter
* % of rock fragments
* Cation exchange capacity
* Vegetation type (1-crop, 2-range, 3-forest)
* Cropping system (1-annual, 2-perennial, 3-fallow)
* Maximum root depth
* Maximum leaf area index
* Base daily air temperature
* Mean tillage depth
* Elevation and length of contour row
* Bulk density after last tillage
* Field area
* Land use (1-agricultural, 2-rangeland, 3-forestland)
* Crop type
* Primary tillage layer
* Secondary tillage layer
* Pasture area
* Field length
* Depth of surface soil layer
* Number of soil layers

HEC-2: Water Surface Profile Model

This model, developed by the U. S. Army Corps of Engineers, is intended for calculating water surface profiles for steady, gradually varied flow in natural or man-made channels. Both subcritical and supercritical flow profiles can be calculated. The effects of various obstructions, such as bridges, culverts, weirs, and structures, in the flood plain may be considered in the computations. The computational procedure is based on the solution of the one dimensional energy equation with energy loss due to friction evaluated with Manning's equation. The program is also designed to evaluate floodway encroachments and to designate flood hazard zones in flood plain management and flood insurance studies. In addition, capabilities are available for assessing the effects of channel improvements and levees on water surface profiles (US Army Corps of Engineers, 1982). The input data of the model are:

* Elevation of weir coordinate
* Manning roughness coefficient (n)
* Elevation across the channel or river (cross section area)
* Depth of flow and discharge (for rating curve)
* Water surface elevation
* Manning roughness (n) for left overbank
* Manning roughness (n) for right overbank
* Manning roughness (n) for the channel
* Bottom width of the channel
* Flow rate to be used for multiple profiles
* Average length of roadway "L" for use in weir flow equation
* Bottom width of bridge opening including any obstruction
* Elevation of channel invert at upstream and downstream of the bridge
* Side slope of the channel
* Length of channel reach between current cross section and next downstream cross section
* Elevation of a horizontal top of roadway for use by the normal bridge method
* Drag coefficient to be used for calculating pier losses
* Total cross section area (below water surface)
* Reservoir water surface elevation
* Watershed elevation
* Watershed length

PRZM: Pesticide Root Zone Model

This model, developed for the U. S. Environmental Protection Agency, simulates the vertical movement of pesticides in unsaturated soils, within and below the plant root zone, and extending to the water table using generally available input data that are reasonable in spatial and temporal requirements. The model consists of hydrology and chemical transport components that simulate runoff, erosion, plant uptake, leaching, decay, foliar washoff, and volatilization (implicitly) output (Robert, et al. 1984). The input data of the model are:

* Daily precipitation
* Daily pan evaporation

* Daily temperature
* Pan factor (coefficient)
* Average daily hours of daylight for each month
* Soil erodibility factor (USLE)
* Topographic factor (USLE)
* Supporting practice factor (USLE)
* Field or plot area
* Maximum active root depth of the crop
* Soil surface condition after crop harvest (1=fallow, 2=cropping, 3=residue)
* Runoff curve number
* Cover management factor (USLE)
* Total pesticide application (kg/ha)
* Depth of pesticide incorporation
* Total depth of soil core
* Bulk density
* Field capacity soil moisture content
* Wilting point soil moisture content
* Soil/pesticide sorption partition coefficient
* Soil horizon thickness
* Initial soil moisture content in the horizon
* Field capacity soil moisture content in the horizon
* Wilting point soil moisture content in the horizon
* Organic carbon content in soil horizon
* % sand in soil horizon
* % clay in soil horizon
* Dispersion coefficient
* Drainage parameter
* Depth of unsaturated zone
* Uptake efficiency factor
* Crop type
* Pesticide decay rate
* Leaf area index
* Soil moisture content
* Saturated soil moisture content
* Number of soil layers

PRMS: Precipitation-Runoff Modeling System

The precipitation-runoff modeling system of the U. S. Geological Survey is a modular design, deterministic, distributed-parameter modeling system developed to evaluate the impacts of various combinations of precipitation, climate, and land use of stream flow, sediment yields, and general basin hydrology. Basin response to normal and extreme rainfall and snowmelt can be simulated to evaluate changes in water balance relationships, flow regimes, flood peaks and volumes, soil water relationships, sediment yields, and ground water recharge. Parameter optimization and sensitivity analysis capabilities are provided to fit selected model parameters and evaluate their individual and joint effects on model output (Leavesley, et al. 1983). The input data of the model are:

* Total basin drainage area
* Elevation of the plane
* Length of the plane
* Aspect of the plane
* Latitude of basin
* Maximum temperature lapse rate in degree/1000 ft change in elevation for month
* Elevation of hydrologic response unit (HRU)
* Elevation of climate station
* Daily minimum air temperature for each HRU
* Daily precipitation depth observed in the rain gauge associated with HRU
* Maximum air temperature
* Minimum air temperature
* Daily potential solar radiation for the slope and aspect of HRU
* Daily potential solar radiation for a horizontal surface
* Total precipitation received on an HRU
* Seasonal cover density
* Evaporation pan coefficient
* Storage in each subsurface flow routing reservoir (inch)
* Storage in each ground water flow routing reservoir (inch)
* Predominant vegetation cover (0=bare, 1=grass, 2=shrubs, 3=trees)
* Current soil moisture
* Soil type (1=sand, 2=loam, 3=clay)
* Maximum available water holding capacity of soil profile
* Drainage area of HRU
* Initial reservoir storage (cfs-day)
* Initial day mean outflow (cfs)
* Initial day mean inflow (cfs)
* Average base flow rate
* Peak discharge rate
* Hydraulic conductivity of transmission zone (in/hr)
* Field capacity soil moisture content
* Wilting point soil moisture content
* Length of overland flow plane
* Manning roughness coefficient (n)

* Channel shape
* Length of channel segment
* Elevation of channel segment invert
* Manning roughness coefficient (n) of channel segment
* Width of channel segment
* Side slope of channel segment
* Average rooting depth
* Cross sectional area of flow
* Pervious drainage area for HRU
* Impervious drainage area for HRU
* Field area
* Elevation across the channel

FESHM: The Finite Element Storm Hydrograph Model

FESHM developed at Virginia Polytechnic Institute and State University is a distributed parameter hydrologic model, designed to simulate runoff and streamflow from a single rainfall event. It is based upon physical principles and uses a flexible distributed parameter structure to account for the spatial variability of watershed characteristics.

The fundamental concept of FESHM is that the complex watershed system can be subdivided or discretized into less complex subsets. These may then be analyzed independently such that the response of the independent subsets can be assembled to simulate the overall system response (Smolen, et al. 1984). The input data of the model are:

* Cover factor
* Depression storage
* Roughness coefficient
* Cropping & management factor (USLE)
* Soil texture
* Bulk density
* Watershed elevation
* Watershed length
* Soil erosivity factor (USLE)
* Soil layer thickness
* Infiltration rate

* Control depth
* Saturation
* Field capacity soil moisture content
* Wilting point soil moisture content
* Overland flow path length
* HRU area
* Channel length
* Channel Manning roughness coefficient (n)
* Cross section geometry (described as trapezoid where the user supplies base and top widths and the depth)
* Rainfall data (equal interval)
* Computational time step
* Subwatershed area
* Saturated hydraulic conductivity of the restrictive layer below the control depth
* Element length
* Element width

MODEL DATA REQUIREMENTS:

A matrix of data requirements by models is presented in Table 1.

Table 1. Model Data Requirements.

Models	HEC-1	TR-20	AGNPS	CREAMS	WEPP	HEC-2	PRZM	PRMS	FESHM	DATA-TYP
Runoff curve number (CN)	x	x	x	x			x			D
Cover & management factor (USLE)			x	x			x		x	D
Surface condition constant			x				x			A
Overland flow Manning's roughness coefficient	x		x			x		x	x	A
Soil erodibility factor (USLE)			x	x			x		x	A
Soil texture	x	x	x	x	x			x	x	A
Bulk density			x	x	x		x		x	A
Infiltration rate	x		x						x	A
Channel roughness (n)	x			x		x		x	x	A
Left overbank roughness (n)	x					x				A
Right overbank roughness (n)	x					x				A
Watershed area	x	x		x				x		D
Watershed elevation	x	x	x	x	x	x		x	x	D
Watershed length	x	x	x	x	x	x		x	x	D
Channel reach length	x	x	x	x		x		x	x	D
Water surface elevation		x				x				D
Elevation across the channel	x	x	x			x		x	x	A
Subbasin area	x	x							x	D
Reservoir water surface elevat.	x	x				x				D
Field slope length			x	x	x			x		D
Channel side slope	x		x	x		x		x		A
Support practice factor (USLE)			x				x			D
Aspect			x		x			x		D
Overland flow length	x		x	x	x			x	x	D

Table 1. (continued)

Models	HEC-1	TR-20	AGNPS	CREAMS	WEPP	HEC-2	PRZM	PRMS	FESHM	DATA-TYPE
Contouring factor (USLE)				x						A
Intake rate				x						A
Wilting point soil moisture				x	x		x	x	x	A
Field capacity soil moisture				x	x		x	x	x	A
Saturated hydraulic conduct.				x	x			x	x	A
Maximum rooting depth				x	x		x	x		A
Number of soil layers					x		x			A
% of sand				x	x		x			A
% of clay				x	x		x			A
% of organic matter				x	x		x			A
% of rock fragment					x					A
Soil horizon thickness					x		x		x	A
Core depth							x			A
Porosity				x						A
Channel invert elevation			x	x				x		A
Structure elevation		x								A
Reservoir volume	x									A
% of pervious drainage basin	x									A
% of impervious drainage basin	x									A
Hydraulic conductivity	x							x		A
Channel bottom width or diamet.	x							x		A
Channel shape	x									A
Watershed width				x						D
Latitude					x			x		A
Longitude					x					

Table 1. (continued)

Models	HEC-1	TR-20	AGNPS	CREAMS	WEPP	HEC-2	PRZM	PRMS	FESHM	DATA-TYPE
Topographic factor LS (USLE)							x			D
Base flow	x	x						x		A
Max. diverted flow	x	x								A
Peak flow	x							x		A
Inflow to diversion station	x									A
Flow rate to be diverted	x									A
Available soil moist. capacity	x			x	x		x	x		D
Slope shape factor of basin	x		x							D
Percolation rate	x		x	x						A
Muskingum K coefficient	x									D
Spillway outflow	x									A
Spillway crest elevation	x									A
Spillway length	x									A
Dam top elev. at overtopping	x									A
Dam top length at overtopping	x									A
Clark storage coefficient	x									A
Snyder standard lag	x									D
Snyder peaking coefficient	x									D
SCS lag time	x									D
Reservoir W.S. area	x									D
Downstream end center line elevation of low-level outlet	x									A
End area coefficient (x)		x								A
End area exponent (M)		x								A
Cummulative rainfall		x								D

Table 1. (continued)

Models	HEC-1	TR-20	AGNPS	CREAMS	WEPP	HEC-2	PRZM	PRMS	FESHM	DATA-TYPE
Flooded area		x								D
Precipitation	x		x	x	x		x	x	x	A
Feedlot curve number			x							D
Channel indicator			x							D
Fertilization level			x							A
Fertilizer availability factor			x							A
Chemical oxygen demand (COD)			x							D
Impoundment factor			x							D
Feedlot area			x							D
Roofed area			x							D
Buffer area elevation			x							D
Buffer area length			x							D
Area draining into impoundment			x							D
Impoundment pipe outlet diameter			x							A
Crop type			x		x		x			A
Cropping factor			x							A
Rainfall erosion index (USLE)			x							A
Average monthly temperature			x							D
Climate station elevation								x		A
Soil Mapping Unit	x	x	x	x	x		x	x	x	B
Land Use	x	x	x	x		x	x	x	x	B
Elevation	x	x	x			x		x	x	B
Field area				x	x		x	x		D

Table 1. (continued)

Models	HEC-1	TR-20	AGNPS	CREAMS	WEPP	HEC-2	PRZM	PRMS	FESHM	DATA-TYPE
Avg. monthly solar radiation				x						D
Winter cover factor				x						D
Leaf area index				x	x					D
Actual evap. from plant				x						D
Actual evap. from soil				x						D
Soluble nitrogen				x						D
Soluble phosphorus				x						D
Nitrate				x						D
Soil nitrogen				x						A
Soil phosphorus				x						A
Distribution coefficient (KD)				x						A
Soil evaporation parameter				x						A
Drainage area above pond				x						D
Maximum temperature					x			x		A
Minimum temperature					x			x		A
Solar radiation					x			x		A
Wind velocity					x					A
Drag coefficient for pier losses calculation						x				A
Yalin constant for sediment transport				x						A
% of silt in original surface soil layer				x						A
Drainage area of channel at lower end of channel				x						D
Drainage area above upper end of channel				x						D
Daily pan evaporation							x			A

Table 1. (continued)

Models	HEC-1	TR-20	AGNPS	CREAMS	WEPP	HEC-2	PRZM	PRMS	FESHM	DATA-TYPE
Hydraulic structure	x	x				x		x		B
Feature location	x	x				x		x		B
Total pesticide application							x			A
Soil/pesticide sorption partition coefficient							x			A
Pesticide decay rate							x			A
Maximum temperature lapse rate								x		A
Seasonal cover density								x		D
Predominant vegetation cover								x		D
Saturated soil moist. content							x		x	A
Initial reservoir storage								x		A
Pervious drainage area of HRU								x		D
Impervious drain. area of HRU								x		D
Avg. daily daylight hours for each month							x			A
Flow rate of channel for multiple profile						x				A

Where A is Attribute Data, B is basic data, and D is Derived Data

GIS data bases for hydrologic models consist of these types of data — BASIC Data (BD), DERIVED Data (DD), and ATTRIBUTE Data (AD). BD consists of those data that describe elemental, geographically referenced information, such as elevation, soil mapping unit, and land use. AD are properties of BD that may be included in the GIS as data files attached to BD. Examples of AD attached to soil mapping units are Hydrologic Soil Group (HSG), soil erodibility (K), soil permeability, and soil organic matter content.

DD are those data that can be directly determined from BD and AD. DD can be manually entered into the data base or computed based on BD and AD and specially derived algorithms and models. For example, the SCS curve number can be determined from knowledge of the HSG and land use. HSG is AD attached to the soil mapping unit (BD), and land use is BD.

The location of a pond or reservoir is BD. Stage-storage and stage-discharge data for a particular pond or reservoir are AD. Elevation data are BD. Land slope, catchment area, stream slope, and stream length are examples of DD that can be computed from the BD (elevation) using a Digital Elevation Model (DEM).

A GIS data base should include BD and a data base manager that allows AD to be referenced to BD. Special programs, sometimes called interface programs, can then be developed to query the BD and AD, compute the required DD for a particular hydrologic model, and then put all of the data in a format compatible with the input requirements of the particular hydrologic model. Such an approach will improve the efficiency in using computer memory and will allow for a more general use of the data base for modeling purposes.

BD required for hydrologic modeling include soil mapping unit; land use; elevation; location of hydraulic features, such as ponds, reservoirs, and channel cross sections; and location of climate information. AD that might be attached to these BD are shown in Tables 2-6.

Some input data, especially time varying data, such as data on climate, may require a geographically referenced input file. For example, data on rainfall, temperature, radiation, etc., may best be handled by an input file. This permits the analysis of several storms, events, or years by changing only these specific files while leaving all other files and data unchanged.

Table 1 indicates which data for the various models discussed might be considered BASIC Data (BD), ATTRIBUTE Data (AD), or DERIVED Data (DD). Table 7 provides a list of some widely used DERIVED parameters.

Table 2. Soil Mapping Unit Attribute Data.

Soil texture
Land slope
Hydrologic soil group (A, B, C, or D)
Erodibility factor
Infiltration rate
Bulk density
Soil horizon thickness
Number of soil layers
Core depth
Field capacity soil moisture content
Wilting point soil moisture content
Porosity
Soil albedo
Organic carbon content
Slope shape factor
Saturated hydraulic conductivity
Maximum rooting depth

Table 3. Land Use Attribute Data.

Land use	Surface Condition Constant
Fallow	0.22
Row crop (straight row)	0.05
Row crop (contoured)	0.29
Small grain	0.29
Legumes or Rotation Meadow	0.29
Pasture (poor)	0.01
Pasture (fair)	0.15
Pasture (good)	0.22
Permanent Meadow	0.59
Woodland	0.29
Forest with heavy litter	0.59
Farmsteads	0.01
Urban (21%-27% impervious surface)	0.01
Grass waterway	1.00
Water	0.00
Marsh	0.00
Animal lot (unpaved)	
Animal lot (paved)	
Roof area	

Table 4. Channel Cross Section Attribute Data.

Channel shape
Channel width
Channel side slope
Channel depth

Table 5. Reservoir Attribute Data.

Reservoir volume
Initial reservoir storage
Spillway crest elevation
Spillway length
Spillway outflow
Dam top elevation at overtopping
Dam top length at overtopping
Down stream end centerline elevation of low level outlet

Table 6. Climatic Attribute Data.

Weather station elevation

Type of data and record length collected at the station such as:

- Precipitation
- Maximum temperature
- Minimum temperature
- Solar radiation
- Pan evaporation
- Average daily daylight hours for each month
- Wind velocity

Table 7. Examples of Derived Data.

Runoff curve number
Cover & management factor
Winter cover factor
Leaf area index

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