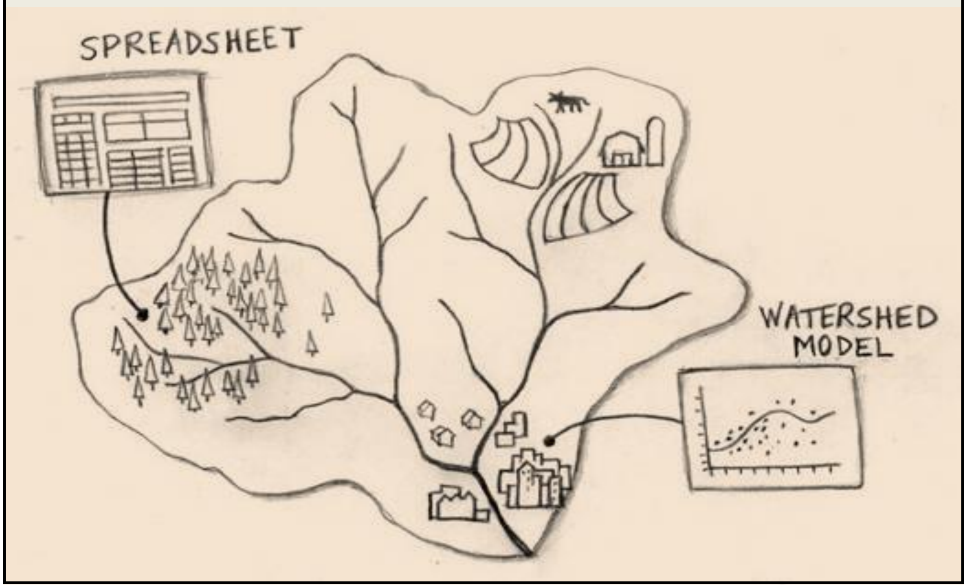
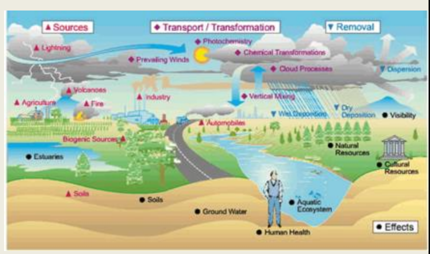
Models Overview: Purposes and Limitations



Pollutant load originates from:

- Point-source discharges (NPDES facilities)
  - Info is available on the discharges (DMRs, etc.)
  - Some are steady-flow, others are precip-driven
- Nonpoint sources
  - All are (mostly) precipitation-driven
  - Calculating the “runoff” load is tough
- Air/atmospheric deposition
  - Can be significant in some locations



Source: www.ctic.purdue.edu

Why is Pollutant Load Estimation Necessary?

- Identify relative magnitude of contributions from different sources
- Determine whether locations of sources are critical
- Evaluate timing of source loading
- Target future management efforts
  - Plan restoration strategies
  - Project future loads under changing conditions
- Develop a mechanism for quantifying potential improvement

Source: Quantify pollutant load: State of Michigan (Es-nps-quantifying-pollutant-loads_195909_7.ppt)

Pollutant Load Estimation Approaches

- Data-driven approaches
  - Monitoring and Literature values (2:00 to 2:45 Presentation)
    - Best when detailed monitoring and literature data available
- **Models**
  - Provide greater insight into impact of sources (temporally and spatially)
  - Readily allow for evaluation of future conditions

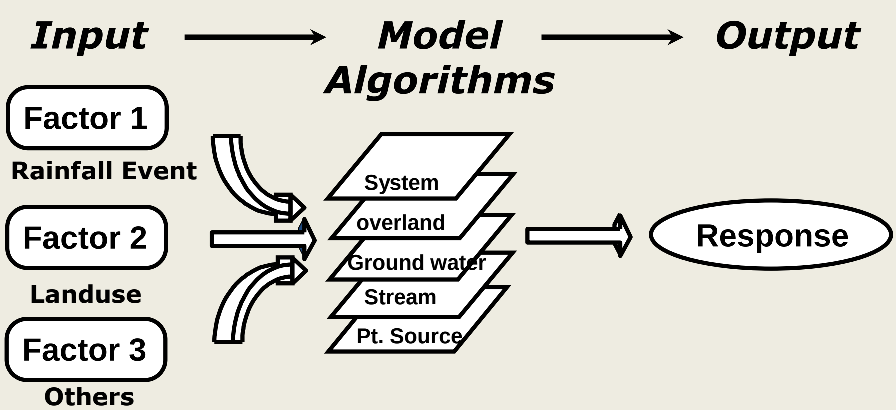
Source: Quantify pollutant load: State of Michigan (Es-nps-quantifying-pollutant-loads_195909_7.ppt)

What is a Model

- A theoretical construct,
- together with assignment of numerical values to model parameters,
- incorporating some prior observations drawn from field and laboratory data,
- and relating external inputs or forcing functions to system variable responses

* Definition from: Thomann and Mueller, 1987

Nuts and Bolts of a Model



Source: Quantify pollutant load: State of Michigan (Es-nps-quantifying-pollutant-loads_195909_7.ppt)

Is a Model Necessary?

It depends what you want to know…

Probably Not

- What are the loads associated with individual sources?
- Where and when does impairment occur?
- Is a particular source or multiple sources generally causing the problem?
- Will management actions result in meeting water quality standards?
- Which combination of management actions will most effectively meet load targets?
- Will future conditions make impairments worse?
- How can future growth be managed to minimize adverse impacts?

Probably

Models are used in many areas…

TMDLs, stormwater evaluation and design, permitting, hazardous waste remediation, dredging, coastal planning, watershed management and planning, air studies

Source: Quantify pollutant load: State of Michigan (Es-nps-quantifying-pollutant-loads_195909_7.ppt)

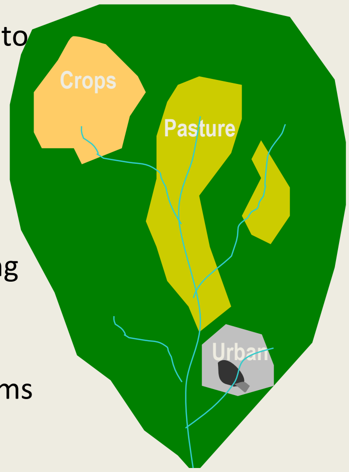
What models do:

- Watershed models use a set of equations or techniques to analyze the following
  - ***Rainfall/runoff:*** The description of precipitation, infiltration, evaporation, and runoff
  - ***Erosion and sediment transport:*** The description of soil detachment, erosion, and sediment movement from a land area
  - ***Pollutant loading:*** The wash-off of pollutants from a land area
  - ***Stream transport:*** description of deposition, re-suspension, decay, and transformation within streams
  - ***Management practices:*** A management practice can be land-based (e.g., tillage or fertilizer application), constructed (e.g., stormwater ponds), or input/output to a stream(e.g., wastewater treatment).

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Type of Models

- Receiving water models
  - Flow of water through streams and into lakes and estuaries
  - Transport, deposition, and transformation in receiving waters
- Watershed models
  - Includes Stream and landscape routing capabilities
  - Runoff of water and materials on and through the land surface and in streams

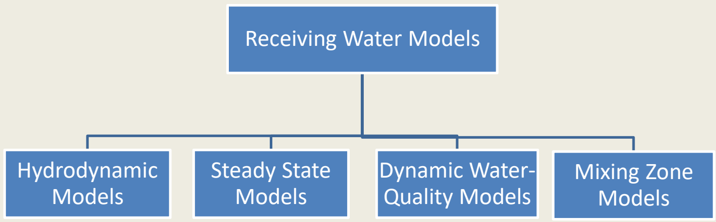


Source: Quantify pollutant load: State of Michigan (Es-nps-quantifying-pollutant-loads_195909_7.ppt)

Who develops these models:

- US EPA
- USDA-ARS
- USCOE
- USGS
- Other Federal Agencies
- Universities
- Local state agencies

Receiving Water Models



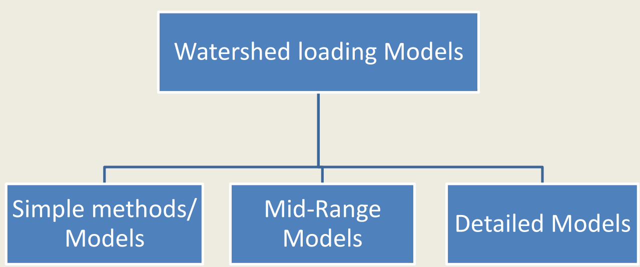
- RIVMOD-H
- DYNHYD 5

- EUTROMOD
- QUAL2E

- DYNTOX
- WASPS

- CORMIX
- PLUME

Watershed Models



- Load Duration Curve
- STEPL
- GWLF

- AnnAGNPS
- SWAT

- SWMM
- HSPF

Level of detail in Watershed Models

Element	Generalized	Mid-level	Detailed
Land			
Land use	Category (Agriculture)	Subcategory (Cropland)	Specific (Corn, ridge-tilled)
Slope	N/A	Average for area	Average for area
Soil moisture	N/A	Antecedent moisture condition (3 levels)	Calculated
Hydrology	Percent runoff	Curve number	Infiltration equations
Pollutants	Single	Multiple	Chemical and biological interactions between pollutants
Load	lb/ac/year	lb/day; daily average concentration	lb/hr; hourly average concentration
Management Practices			
Management Practices	Percent removal	Percent removal and estimated volume captured	Hydrology Deposition/settling First order decay and transformation
Streams/Rivers			
Hydrology	Single flow, steady state	Single flow, steady state	Continuous or variable flow
Water quality	Regression, simple relationships	Eutrophication cycle	Eutrophication cycle, carbon/nutrient/BOD processes
Toxic substances	Regression, simple relationships	Settling, 1st-order decay	Transformation, biodegradation, other processes

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Simple Models

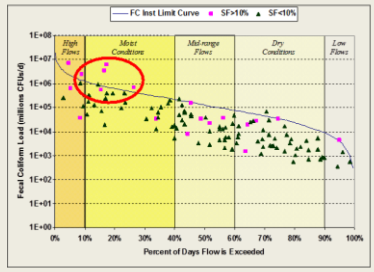
- Based on Empirical relationships
- Minimal data preparation
  - Landuse, soil, slope, etc.
- Good for long averaging periods
  - Annual or seasonal budgets
- No calibration
- Some testing/validation is preferable
  - Comparison of relative magnitude

Limitations:

- Limited to water bodies where loadings can be aggregated over longer averaging periods
- Limited to gross loadings

Load Duration Curve (LDC)

- Easy-to-understand visual display of water quality
- Observed load values located above the Load Duration Curve indicate allowable daily loads have been exceeded
- Clustering of data may help identify when problems
- Help identify seasonal trends
- Help develop water quality goals



STEPL

- Simplified spreadsheet tool for estimating the load reductions that result from BMPs
  - User can modify the formulas and default parameters without any programing skills
- Includes management practice calculator to calculate BMP effectiveness
- Empirical factors used (CN method, USLE)
- Familiarity with the
- Use and limitations of environmental data is helpful.

GWLF

- The Generalized Watershed Loading Function (GWLF) model simulates
  - runoff and sediment delivery using the SCS curve number equation (CNE) and the USLE, combined with average nutrient concentration based on land use
- Simple Model
- Less experience needed
- In stream process not considered

P8-UCM

- The P8-UCM program predicts the generation and transport of stormwater runoff pollutants in small urban catchments
- consists mainly of methods derived from other tested urban runoff models (SWMM, HSPF, D3RM, TR-20)
- Model components include
  - stormwater runoff, assessment, surface water quality analysis, and routing through structural controls
- simulates pollutant transport and removal in a variety of urban stormwater management practices
- Simple model
  - moderate effort to set up, calibrate, and validate

Mid-range Models

- More detailed data preparation
  - Detailed landuse categorization
  - Meteorological data
- Good for seasonal/event issues
- Minimal or no calibration
- Testing and validation preferable
  - Application objectives
  - Storm events, daily loads

Limitations:

- Limited pollutants simulated
- Limited in-stream simulation & comparison w/standards
- Daily/monthly load summaries

SWAT

- The Soil and Water Assessment Tool (SWAT) was developed by the USDA's Agricultural Research Service (ARS)
- SWAT is strongest in agricultural areas
- Pollutants modeled are pesticides, nutrients, sediment, bacteria based on agricultural inputs, and management practices
- Simulates at a variety of time steps, from subhourly, or daily or montly or yearly
- Data intensive and training needed

AGNPS

- Developed by USDA's Agricultural Research Service
  - To evaluate the effect of management decisions on a watershed system.
- Continuous-simulation, watershed scale model
- Provides spatially explicit results
- Special components included to
  - Nutrients, concentrated sediment gullies and irrigation
- Outputs expressed on event basis for selected stream reaches from land or reach components over the simulation period
- Model can be used to evaluate
  - effect of management practices such as agricultural practices, ponds, grassed waterways, irrigation, tile drainage, vegetative filter strips, and riparian buffers

Detailed Models

- Accommodate more detailed data input
- Short time steps and finer configuration
  - Complex algorithms need state/kinetic variables
  - Ability to evaluate various averaging periods and frequencies
- Calibration is required
- Addresses a wide range of water and water quality problems
- Include both landscape and receiving water simulation

- *Limitations:*
  - More training and experience needed
  - Time-consuming (need GIS help, output analysis tools, etc.)

HSPF

- The Hydrologic Simulation Program–Fortran (HSPF)
  - comprehensive package for simulating watershed hydrology and water quality for a wide range of conventional and toxic organic pollutants.
- Simulates watershed hydrology, land and soil contaminant runoff, and sediment-chemical interactions
- Simulates at a variety of time steps, from subhourly to one minute, hourly, or daily
- Needs training
- Data intensive

SWMM

- SWMM is a dynamic rainfall-runoff simulation model
  - Applied primarily to urban areas and for single-event or long-term (continuous) simulation using various time steps
- SWMM has been applied to urban hydrologic quantity and quality problems in a number of U.S. cities
- SWMM has a variety of options for water quality simulation
  - including traditional buildup and wash-off formulation, as well as rating curves and regression techniques

Capabilities of selected models

Parameter/Endpoint	AGNPS	STEPL	GWLF[a]	HSPF	P8-UCM	SWAT	SWMM
Total phosphorus (TP) load	◗	○	◗	●	●	◗	●
TP concentration	◗	—	◗	●	●	◗	●
Total nitrogen (TN) load	◗	○	◗	●	●	◗	●
TN concentration	◗	—	◗	●	●	◗	●
Nitrate concentration	—	—	—	●	—	◗	●
Ammonia concentration	—	—	—	●	—	◗	●
TN:TP mass ratio	—	—	◗	●	—	◗	●
Dissolved oxygen	◗	—	—	●	—	◗	●
Chlorophyll *a*	—	—	—	●	—	◗	—
Algal density (mg/m²)	—	—	—	—	—	—	—
Net total suspended solids load	—	○	—	●	●	—	●
Total suspended solids concentration	◗	—	—	●	●	◗	●
Sediment concentration	◗	—	◗	●	●	◗	●
Sediment load	◗	○	◗	●	—	◗	●
Metals concentrations	—	—	—	●	—	◗	●
Conductivity	—	—	—	●	—	—	—
Pesticide concentrations	◗	—	—	●	—	◗	—
Herbicide concentrations	◗	—	—	●	—	◗	—
Toxics concentrations	—	—	—	●	—	—	—
Pathogen count (*E. coli*, fecal coliform bacteria)	—	—	—	●	—	◗	●
Temperature	—	—	—	●	—	◗	—

Key: — Not supported ○ Annual ◗ Daily ● Hourly

[a]GWLF calculations are performed on a daily basis, but the results are presented on a monthly basis.

Source: USEPA. 2005. *TMDL Model Evaluation and Research Needs*. EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH. *www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm*

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Land and Water Features Supported by the Selected Watershed Models

Land and Water Feature	AGNPS	STEPL	GWLF	HSPF	P8-UCM	SWAT	SWMM
General Land and Water Features							
Urban	—	○	◗	◗	◗	◗	●
Rural	●	○	◗	●	○	●	◗
Agriculture	●	○	◗	●	○	●	○
Forest	—	○	◗	●	○	●	○
River	—	—	○	●	○	○	○
Lake	—	—	—	◗	—	○	○
Reservoir/impoundment	—	—	—	◗	◗	○	◗
Estuary (tidal)	—	—	—	—	—	—	—
Coastal (tidal/shoreline)	—	—	—	—	—	—	—
Detailed Land Features							
Air deposition	—	—	—	○	—	—	—
Wetlands	—	—	—	◗	○	○	○
Land-to-land simulation	○	—	—	○	—	—	—
Hydrologic modification	—	—	—	◗	—	—	◗
BMP siting/placement	●	—	—	○	◗	—	◗
Urban Land Management							
Street sweeping and vacuuming	—	—	○	—	◗	○	◗
Nutrient control practices (fertilizer, pet waste management)	◗	—	—	○	○	○	○
Stormwater structures (manhole, splitter)	—	—	—	—	○	—	◗
Detention/retention ponds	◗	—	—	○	◗	○	◗
Constructed wetland processes	—	—	—	—	○	○	○
Vegetative practices	◗	—	○	○	○	○	○
Infiltration practices	—	—	—	○	○	—	—
Rural Land Management							
Nutrient control practices (fertilizer, manure management)	●	○	○	●	—	●	○
Agricultural conservation practices (contouring, terracing, row cropping)	●	○	○	●	—	●	○
Irrigation practices/tile drains	○	—	—	—	—	[illegible]	[illegible]
Ponds	◗	—	—	◗	◗	[illegible]	[illegible]
Vegetative practices	◗	○	○	○	—	[illegible]	[illegible]

Key: — Not supported
○ Low: Simplified representation of features, significant limitations
◗ Medium: Moderate level of analysis, some limitations
● High: Detailed simulation of processes associated with land or water feature

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Application considerations of the selected models

Application Considerations	AGNPS	STEPL	GWLF	HSPF	P8-UCM	SWAT	SWMM
Experience required	◗	●	●	—	●	○	—
Time needed for application	◗	●	●	—	●	◗	○
Data needs	◗	●	●	○	●	◗	○
Support available Support available	◗	○	○	●	○	◗	◗
Software tools	◗	●	●	●	○	●	○
Cost to purchase	●	●	●	●	●	●	●

Key:

Experience:

— Substantial training or modeling expertise required (generally requires professional experience with advanced watershed and/or hydrodynamic and water quality models)

○ Moderate training required (assuming some experience with basic watershed and/or water quality models)

◗ Limited training required (assuming some familiarity with basic environmental models)

● Little or no training required

Support Available:
- — None
- ○ Low
- ◗ Medium
- ● High

Time Needed for Application:
- — > 6 months
- ○ > 3 months
- ◗ > 1 month
- ● < 1 month

Software Tools:
- — None
- ○ Low
- ◗ Medium
- ● High

Data Needs:
- ○ High
- ◗ Medium
- ● Low

Cost to Purchase:
- — Significant cost (> $500)
- ○ Nominal cost (< $500)
- ◗ Limited distribution
- ● Public domain

Source: USEPA. 2005. *TMDL Model Evaluation and Research Needs*. EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH. www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Model Application Process

- **Watershed delineation**
  - Watershed is divided in subwatersheds
  - Most models use GIS to delineate watersheds using Digital Elevation Models (DEMS)
    - Predefined watershed boundaries such as 14-digit hydrologic units can be used.
  - Considerations when subdividing watersheds
    - Land use distribution and diversity
    - Location of critical areas
    - Stream gauging stations and water quality monitoring locations (subwatersheds should match key monitoring locations for testing)
    - Location of physical features like lakes, dams, and point source discharges
    - Changes in topography
    - Soil distribution
    - Areas where management might change

Examples of Number and Size of Subwatersheds in Modeling Applications

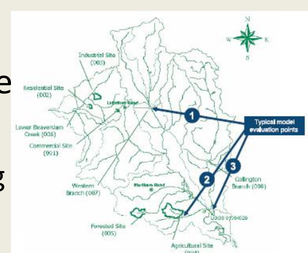
Watershed	Location	Watershed Size (mi²)	Number of Subwatersheds	Average Subwatershed Size (mi²)
Mobile River Basin	AL/GA/MS/TN	43,605	152	286.88
French Gulch Creek	AZ	16	26	0.62
Boulder Creek	AZ	138	9	15.33
Clear Lake Watershed	CA	441	49	9.00
San Gabriel River	CA	689	139	4.96
San Jacinto River	CA	770	32	24.06
Los Angeles River	CA	834	35	23.83
Sacramento River	CA	9,147	249	36.73
Lake Tahoe Watershed	CA/NV	314	184	1.71
Christina River	DE/MD/PA	564	70	8.06
Tug Fork River	KY/VA/WV	1,500	455	3.30
Upper Patuxent River	MD	130	50	2.60
Lower Tongue River	MT	3,609	30	120.30
Lake Helena Watershed	MT	616	49	12.57
Wissahickon Creek	PA	64	5	12.80
Tyger River	SC	750	75	10.00
Salt River	USVI	5	13	0.38
Tygart Valley River	WV	1,362	1,007	1.35
West Fork River	WV	880	645	1.36

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

- **Landuse/soil assignment**
  - Land use/soil information is typically provided as a GIS coverage or map
    - with many individual codes that describe detailed land use types
  - Factors to consider in deciding on land use/soil grouping include the following:
    - Dominant land use/soil types
    - Land uses subject to change or conversion
    - Land use types where management changes are expected
    - Spatial diversity of soil within the watershed
    - Availability of information on individual land use/soil types
  - Too many categories is difficult for model to process, too little results in oversimplification
    - Decision depends on local conditions and management concerns being evaluated

- **Weather**
  - Models need precipitation and Temperature for time period of interest
    - Relative humidity, Windspeed, Solar radiation can also be given
  - Most models accept daily data
    - Hourly can also be given for more detailed analysis
- **Management Operations**
  - Agriculture
    - Planting, harvesting, pesticide and feltilizer application, irrigation
  - Urban
- **Best management practices (BMPs)**
  - Can simulate already installed and future BMPs in models by altering parameters
    - Eg. Reduce curve number by 6 units; P factor in USLE to 0.2

- **Calibration and validation**
  - How do we know if the model is simulating appropriately?
    - Calibration is performed to answer
  - Compare observed data (flow, sediment, nutrients, etc) to simulate data at different testing points
    - Upstream subwatershed at monitoring station
    - Small single landuse monitoring site
    - Downstream at main watershed USGS gauging station



- **Calibration and Validation (cont..)**
  - Adjusting or estimating parameters through a calibration process
    - parameters are adjusted within reasonable ranges until the best fit with the observed data is determined

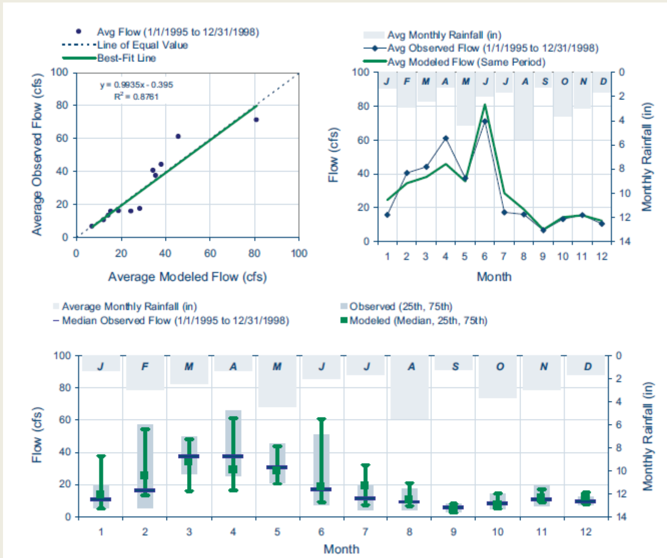
Typical Calibration Options for Selected Example Models

	Flow Calibration	Pollutant Calibration
AGNPS	Limited CN	Nutrient concentrations in water and sediment
STEPL	Limited/CN only	Loading rate
GWLF	Ground water recession	Nutrient concentrations in water (runoff, ground water) and sediment
HSPF	Multiple, infiltration, soil storage, ground water	Pollutant buildup and wash-off, instream transport/decay
P8-UCM	Limited/CN only	Loading rate or more detailed buildup and wash-off of dust and pollutants
SWAT	Ground water	Nutrient concentrations in water and sediment
SWMM	Multiple, infiltration, soil storage, ground water	Pollutant buildup and wash-off, instream transport/decay

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

- **Model testing**
  - Constituents calibrated or evaluated
    - 1. flow 2. sediment 3. Nutrients 3. various pollutants
  - Multiple time scales are also evaluated
  - Typical factors used in evaluating model performance include the following
    - Water balance (general assessment of precipitation, evaporation, infiltration, and runoff)
    - Observed versus measured flow (daily average, monthly, annual, and flow duration curves)
    - Observed versus measured load (annual loads, seasonal variation, source loads)
    - Observed versus modeled pollutant concentrations or pollutant loads

- **Model testing (cont…)**



Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Presenting Pollutant Loads

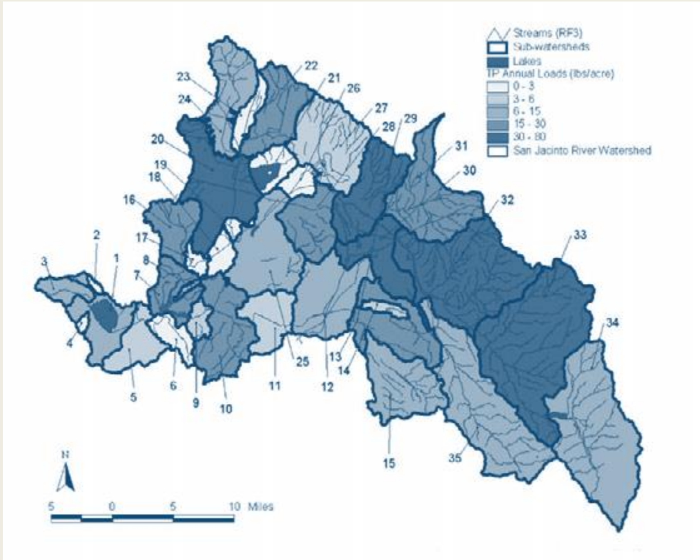
- Two factors affects presenting pollutant loads
  - Space and time
    - Need to decide spatial resolution for loads as well as time scale for their calculation

Typical Loading Presentation Categories and Types

Spatial Scale	Land Use	Time Scale
• Watershed • Tributary (multiple-subwatershed) • Region (political or other boundaries) • Subwatershed • Critical areas	• Watershed general land use category (agriculture, urban) • Land use subcategory (cropland, pasture, residential)	• Average annual • Annual • Seasonal • Monthly • Storm • Design storm

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

- Spatial scale



Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

- Time scale

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Appendix

- Available Models

Model Acronym	Source	Type		Level of Complexity			Time step				Hydrology		Water Quality							Type of BMPs				
		Landscape only	Comprehensive	Export coefficients	Loading functions	Physically based	Sub-daily	Daily	Monthly	Annual	Surface	Surface and ground water	User-defined	Sediment	Nutrients	Toxic/pesticides	Metals	BOD	Bacteria	Detention basin	Infiltration practices	Vegetative practices	Wetlands	Other structures
P8-UCM	Dr. William Walker	—	—	●	●	—	●	—	—	—	●	—	●	●	●	—	●	—	—	●	●	●	—	●
PCSWMM	Computational Hydraulics Int.	—	●	—	●	●	●	—	—	—	—	●	●	●	●	●	●	—	●	●	●	—	—	●
PGC–BMP	Prince George's County, MD	—	—	—	●	—	●	—	—	—	—	—	—	●	●	—	●	—	—	●	●	●	●	●
REMM	USDA-ARS	—	—	—	—	—	—	—	—	—	—	—	—	●	●	●	●	—	—	—	—	●	—	—
SHETRAN	University of Newcastle (UK)	—	●	—	—	●	●	●	—	—	—	●	—	●	—	—	—	—	—	—	—	—	—	—
SLAMM	University of Alabama	—	—	—	—	—	●	—	—	—	●	—	—	●	●	—	●	—	—	●	●	●	●	●
SPARROW	USGS	—	●	—	—	—	—	—	—	●	●	—	—	●	●	●	—	—	—	—	—	—	—	—
STORM	USACE (mainframe version), Dodson & Associates, Inc. (PC version)	—	—	●	—	●	●	—	—	—	●	—	—	●	●	—	—	—	●	—	—	—	—	●
SWAT	USDA-ARS	—	●	—	—	●	—	●	—	—	—	●	—	●	●	●	●	—	—	●	●	●	—	●
SWMM	EPA	—	●	—	—	●	●	—	—	—	—	●	●	●	●	●	●	●	●	●	●	—	—	—
TMDL Toolbox	EPA	—	●	—	—	●	●	—	—	—	—	●	●	●	●	●	●	●	●	●	—	●	—	●
TOPMODEL	Lancaster University (UK), Institute of Environmental and Natural Sciences	—	—	—	—	●	●	●	—	—	—	●	—	—	—	—	—	—	—	—	—	—	—	—
WAMView	Soil and Water Engineering Technology, Inc. (SWET) and EPA	●	●	—	—	●	●	—	—	—	—	●	—	●	●	●	●	—	●	●	●	●	●	●
WARMF	Systech Engineering, Inc.	—	●	—	—	●	—	●	—	—	—	●	—	●	●	●	●	●	●	—	—	—	●	●
WEPP	USDA-ARS	—	—	—	—	●	—	●	●	●	—	●	—	●	—	—	—	—	—	—	●	—	—	—
WinHSPF	EPA	—	●	—	—	●	●	—	—	—	—	●	●	●	●	●	●	●	●	—	—	—	—	—
WMS	Environmental Modeling Systems, Inc.	—	●	—	—	●	●	—	—	—	—	●	●	●	●	●	●	●	●	●	●	—	●	●
XP-SWMM	XP Software, Inc.	—	●	—	—	●	●	—	—	—	—	●	●	●	●	●	●	●	●	●	●	—	—	●

Notes: BMPs = best management practices. — Not supported ● Supported
Source: USEPA. 2005. *TMDL Model Evaluation and Research Needs*. EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH. *www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm*

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)

Model Acronym	Source	Type		Level of Complexity			Time step				Hydrology		Water Quality							Type of BMPs				
		Landscape only	Comprehensive	Export coefficients	Loading functions	Physically based	Sub-daily	Daily	Monthly	Annual	Surface	Surface and ground water	User-defined	Sediment	Nutrients	Toxic/pesticides	Metals	BOD	Bacteria	Detention basin	Infiltration practices	Vegetative practices	Wetlands	Other structures
AGNPS (event-based)	USDA-ARS	●	●	—	—	●	●	—	—	—	●	—	—	●	●	●	—	—	—	●	—	●	—	—
AnnAGNPS	USDA-ARS	—	●	—	—	●	—	●	—	—	●	—	—	●	●	●	—	—	—	●	—	●	—	—
BASINS	EPA	—	●	●	●	●	●	●	—	—	●	●	●	●	●	●	●	●	●	●	—	●	—	●
DIAS/IIDLMAS	Argonne National Laboratory	—	—	—	—	—	—	—	—	●	—	—	—	●	—	—	—	—	—	—	—	—	—	—
DRAINMOD	North Carolina State University	—	—	—	—	●	●	—	—	—	—	●	—	—	●	—	—	—	—	—	—	—	●	—
DWSM (event-based)	Illinois State Water Survey	—	●	—	—	●	●	—	—	—	●	—	—	●	●	●	—	—	—	●	●	—	—	—
EPIC	Texas A&M University–Texas Agricultural Experiment Station	—	—	—	—	—	—	●	—	—	●	—	—	●	●	●	—	—	—	●	●	—	●	—
GISPLM	College of Charleston, Stone Environmental, and Dr. William Walker	—	●	—	●	—	—	●	—	—	●	—	—	—	●	—	—	—	—	—	—	—	—	—
GLEAMS	USDA-ARS	—	—	—	—	—	—	●	—	—	●	—	—	●	●	●	—	—	—	—	—	—	—	—
GSSHA	USACE	●	●	—	—	●	●	—	—	—	—	●	—	●	—	—	—	—	—	●	●		●	●
GWLF	Cornell University	—	●	—	●	—	—	—	●	—	—	●	—	●	●	—	—	—	—	—	—	●	—	—
HEC-HMS	USACE	—	●	—	—	●	●	—	—	—	●	—	—	—	—	—	—	—	—	—	—	—	—	—
HSPF	EPA	—	●	—	—	●	●	—	—	—	—	●	●	●	●	●	●	●	●	—	—	—	—	—
KINEROS2 (event-based)	USDA-ARS	—	●	—	—	●	●	—	—	—	●	—	—	●	—	—	—	—	—	●	—	●	—	●
LSPC	EPA and Tetra Tech, Inc.	—	●	—	—	●	●	—	—	—	—	●	●	●	●	●	●	●	●	●	—	●	—	●
Mercury Loading Mode	EPA	—	—	—	—	●	—	—	—	●	●	—	—	—	—	—	●	—	—	—	—	—	—	—
MIKE SHE	Danish Hydraulic Institute	—	●	—	—	●	●	—	—	—	—	●	—	—	—	—	—	—	—	—	—	—	—	—
MINTEQA2	EPA	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—	—	—
MUSIC	Monash University, Cooperative Research Center for Catchment Hydrology	—	—	—	—	●	●	—	—	—	●	—	●	—	—	—	—	—	—	●	●	●	●	●

Source: EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (http://water.epa.gov/polwaste/nps/handbook_index.cfm)