Vision

- Professional practice in Environmental Engineering requires the integration of field data collection and modeling to appropriately evaluate environmental impacts.
- Information Technology can be used to accelerate data gathering and facilitate model setup and execution.
- Environmental modeling is a means to simulate and forecast the occurrence of a particular scenario given a change in conditions.
What is modeling?

- The word “modeling” is often an ambiguous term. When you hear a person use the term, what is she/he really referring to?
  - Is it a computer model?
  - Is it a conceptual model or diagram?
  - Is it an equation?
  - Is it a prototype of a thing?

- One needs to understand something about the field to know what “modeling” is referring to.

- Be cautious of throwing the word “modeling” around to others.
Examples of Environmental Modeling

- Rainfall/runoff model
  - Given a rainfall amount, can we predict the amount of runoff in a river?

- River mixing model
  - Given a certain pollutant discharge into a river, can we predict the concentration downstream at a location?

- Well-zone capture model
  - Given a new well location, can we predict the aquifer region influenced by the pumping strategy?

- Sediment transport model
  - Given the hydraulic conditions in a river, can we predict the sediment loadings?
Modeling assumptions

- Let us assume that an environmental model exists that is appropriate for our application.
- Furthermore, let us assume that we are simply model users, not developers.
- Most importantly, let us assume that the model is based on sound scientific understanding and predictions are within the bounds of reasonable estimates.
- This does not assume that the model is the truth. What is the truth?
What do models need?

- All models need information about the system and the forcings to the system.
- System descriptions are required for specifying model parameters.
- Forcing data are required as input for making simulations.
- Example:
  - Model = Watershed Computer Model
  - System descriptions = Topography, Soils, Land use
  - Forcings = Rainfall and Meteorological conditions
How do we use and test models?

- **Model Setup:**
  - System descriptors and forcings usually require particular formatting for model input.
  - Forcings are typically assumed to be reasonably accurate.

- **Model Calibration:**
  - Model predictions must be compared against “ground truth” values and the parameter values adjusted.

- **Model Validation:**
  - After properly calibrating a model, it should be tested with new data and once again compared to “ground-truth” values.
We intend to determine the non-point pollution loadings at the watershed scale.

Non-point pollution arises from the use of fertilizers and pesticides on agricultural lands.

Excess nutrients (nitrates/phosphates) are transported from agricultural fields to streams, rivers and estuaries.

Water quality in inland and coastal water bodies is affected by the agricultural runoff (eutrophication)

For water resources that serve as drinking water supplies, excess nutrients must be treated.
ENVIT Data Collection and Modeling: The Big Picture

- Major Science Questions:
  - Are the agricultural practices in New South Wales, Australia, impacting water quality in surface water bodies?
  - Can the nutrient loadings be quantified through a field study?
  - Based on historical data and a targeted field study, can we predict the nutrient loadings?

- To address these questions, we will formulate a field campaign accompanied by a watershed modeling study.
Linking Field Data Collection and Watershed Modeling

Watershed Data

Watershed Model

Address Scientific Questions
Linking Field Data Collection and Watershed Modeling

Field Data Collection:
- Stream Geometry & Velocity
- Water Quality Parameters
Watershed Data

- Watershed Data consists of:
  - Topography – Delineate watersheds
  - Soils – Specify model parameters
  - Land Use – Specify model parameters
  - Rainfall – Model forcing
  - Contaminant source – Model Forcing
  - Stream flow – Calibration goal
  - Contaminant concentration – Calibration goal

- Sources of Watershed Data:
  - GIS data layers
  - Previous water quality studies
  - Rainfall and runoff observations
  - Field measurements during study
Field Sampling

- Water Quality Parameters:
  - Spectrophotometer: Nitrate, Phosphate.
  - Bacteria kits: Total coliform, E. Coli
- 3 Replicate samples in each Cross Section
- Samples are representative for Cross section
Linking Field Data Collection and Watershed Modeling

Watershed modeling:
- Catchment descriptions
- Rainfall Input
- Runoff/Transport Output

Record of a Rainstorm and Flood Event

Flow of Water in a Watershed

- Area = 880 km² (about 29.5 km on a side)
- Soil Thickness = 2 m, Aquifer Thickness = 20 m
- Soil Porosity = 10%, Aquifer Porosity = 10%
- Base Flow = 720 m³/hr (28 m³/sec)
- Length of Perennial Stream Channel = 20 km
- Average Cross-Sectional Area of Channel = 5 m²
Field Sampling

- Water Quantity Parameters
  - Velocity measurements at points along Cross Section (20 points)
  - Depth measurements at each point.
  - Cross Section Width and Mean Depth.
  - Calculation of volumetric discharge.

- GPS measurements to locate the cross section on map. Multiple samples required.
Historical, Field and Model Data

Flow or Concentration

Time (hours or days)

Field Sample

Observed Historical

Model Output
Watershed Modeling Example

- A watershed (or catchment or basin) is a hydrologic unit that describes the area flowing to a particular point.
- We need to describe the land surface to apply a watershed model.
- We need to provide the rainfall that feeds the hydrologic equations in the model and produces runoff.
Watershed Modeling Example

In this example, we developed an ArcView GIS based Hydrology Model that used:

- DEM data
- NEXRAD radar rainfall
- Soils and Land Use

It was capable of predicting runoff at the watershed outlet using the SCS Curve Number method for infiltration and the Time-Area method for routing.

- Simple method for streamflow prediction
- Model Setup, Calibration and Validation exercises performed.
Watershed Modeling Example

ArcView GIS interface

Curve number

Time slice
Watershed Modeling Example

Uncalibrated Run

Calibrated Run
Technology

COMPUTING

Compaq IPAQ
Windows CE
eMbedded VB, VC++
Microsoft Access

SENSING

HydroLab Probe
Teletype GPS
Chemistry Kits
Flow Meters
Technology (II)

Field Deployment

Field Laptop
Wireless Cards
Router
Web Server
Cellular Phone
Technology (III)

Watershed Modeling

ArcView GIS
BASINS Model
GIS Data
Hydro/Quality Data
BASINS
(Better Assessment Science Integrating point and Nonpoint Sources)

- Sales Pitch: A multi-purpose environmental analysis system that integrates a geographical information system (GIS), national watershed data, and state-of-the-art environmental assessment and modeling tools into one convenient package.
- Integrates data at the watershed scale with lumped water quantity and water quality flow models with ArcView GIS.
- Used by EPA and environmental consultants for pollutant loading studies.
BASINS Features

1. Nationally derived environmental and GIS databases
2. Assessment tools for evaluating water quality and point source loadings;
3. Utilities including local data import and management of local water quality observation data;
4. Two watershed delineation tools;
5. Utilities for classifying DEMs, landuse, soils, and water quality data;
6. An in-stream water quality model (QUAL2E);
7. A simplified GIS based nonpoint source annual loading model (PLOAD);
8. Two watershed loading and transport models (HSPF and SWAT);
9. A postprocessor (GenScn) of model data and scenario generator to visualize, analyze, and compare results from HSPF and SWAT; and
10. Many mapping, graphing, and reporting formats for documentation.
BASINS Resources

- http://www.tmdl.org/basins/
- http://www.epa.gov/OST/BASINS/
Ask Me Anything! I’ll be specific!