Weeks Bay Stakeholder Work Group

Baldwin County Highway Department 3rd Floor CR

8:30 – 10:00 am May 18, 2016

AGENDA

1. Approve minutes of March 16, 2016 SWG Meeting
2. Opening remarks
3. Online survey results
4. Overall project status – Mike Eubanks
5. Water quality model – Dr. Latif Kalin
6. Roundtable discussion
7. Next steps
    a. Future Stakeholder Work Group meeting schedule
    b. Subgroup meeting schedules re action plans

Next meeting: Wednesday, July 20th, 8:30 – 10 am, Baldwin County Highway Department 3rd Floor CR, Robertsdale

Modeling the Environment

Point and Nonpoint Source (NPS)

- Point source: Originates from a single, identifiable source, such as a discharge pipe from a factory or sewage plant
- NPS: Does not originate from a single source, or point
- NPS occurs as water moves across the land or through the ground and picks up natural and human-made pollutants, which can then be deposited in lakes, rivers, wetlands, coastal waters, and even groundwater
- NPS transport of nutrients, sediment, pesticides, pathogens, and a multitude of other chemicals from agricultural, forestry, and urban activities is a major concern
- Often difficult to trace the exact origin of these pollutants because they result from a wide variety of human activities on the land as well as natural characteristics of the soil, climate, and topography.

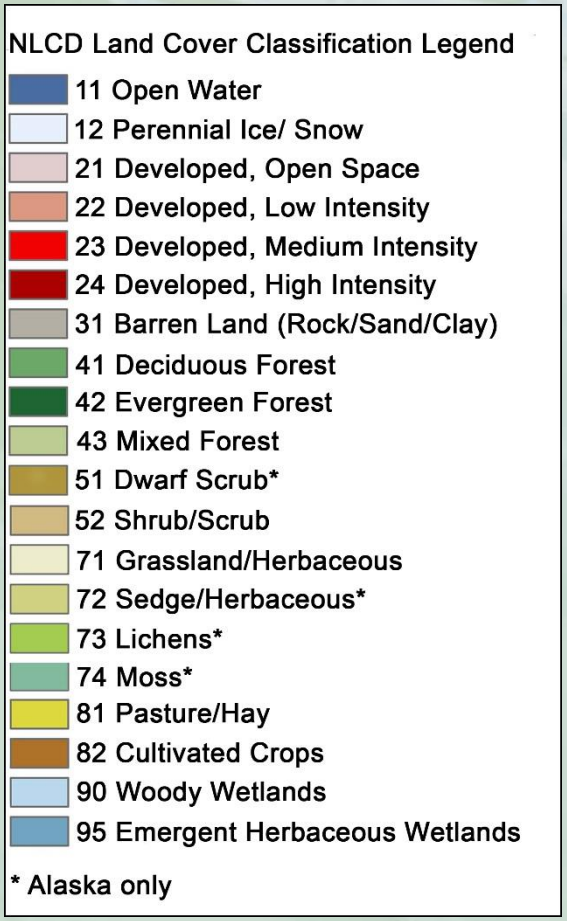
Land use vs. Land Cover

Land cover: the physical land type such as forest or open water

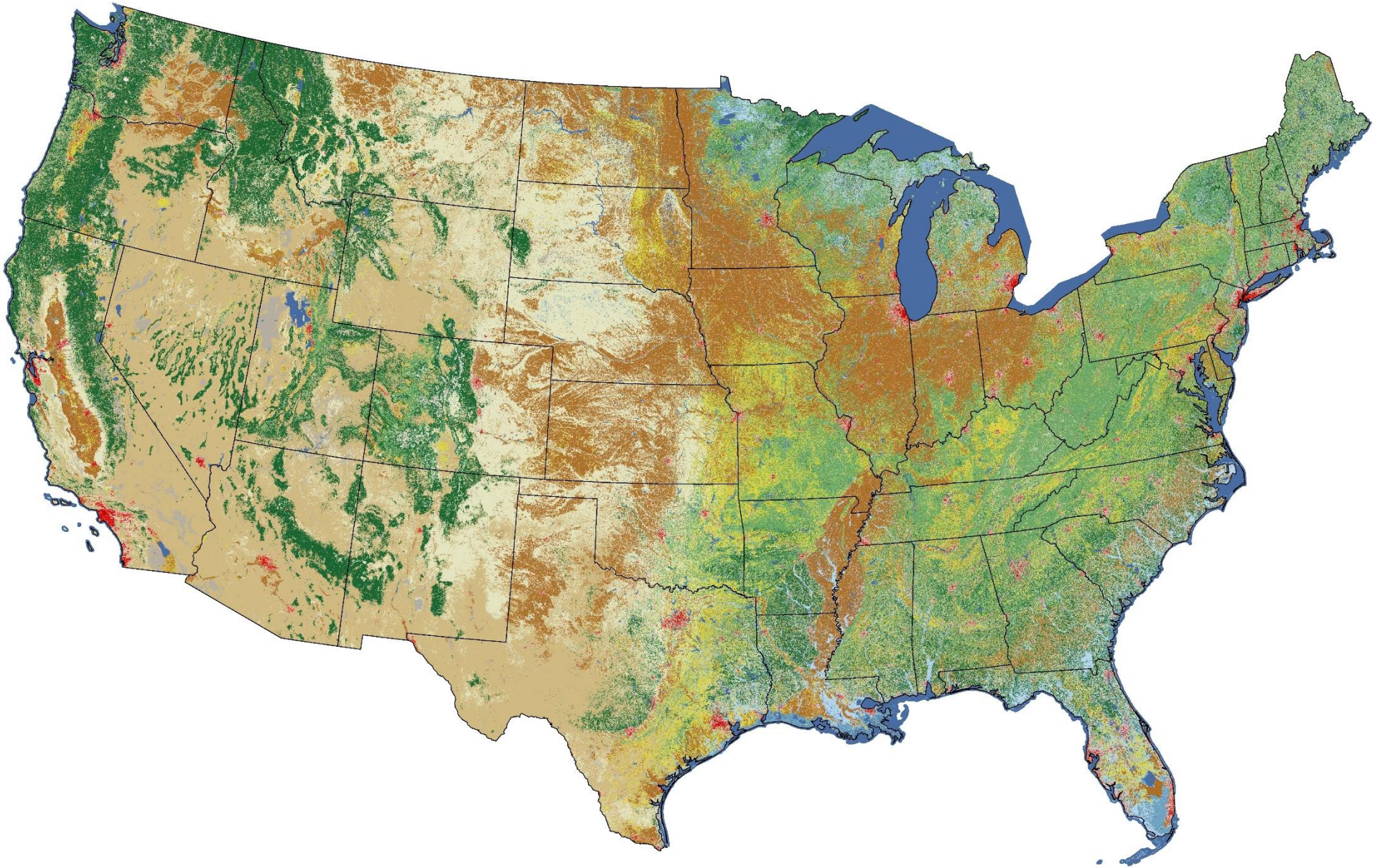
Land use: how people are using the land

NLCD 1992

NLCD 2001/2006/2011



NLCD-2001



NLCD-2011

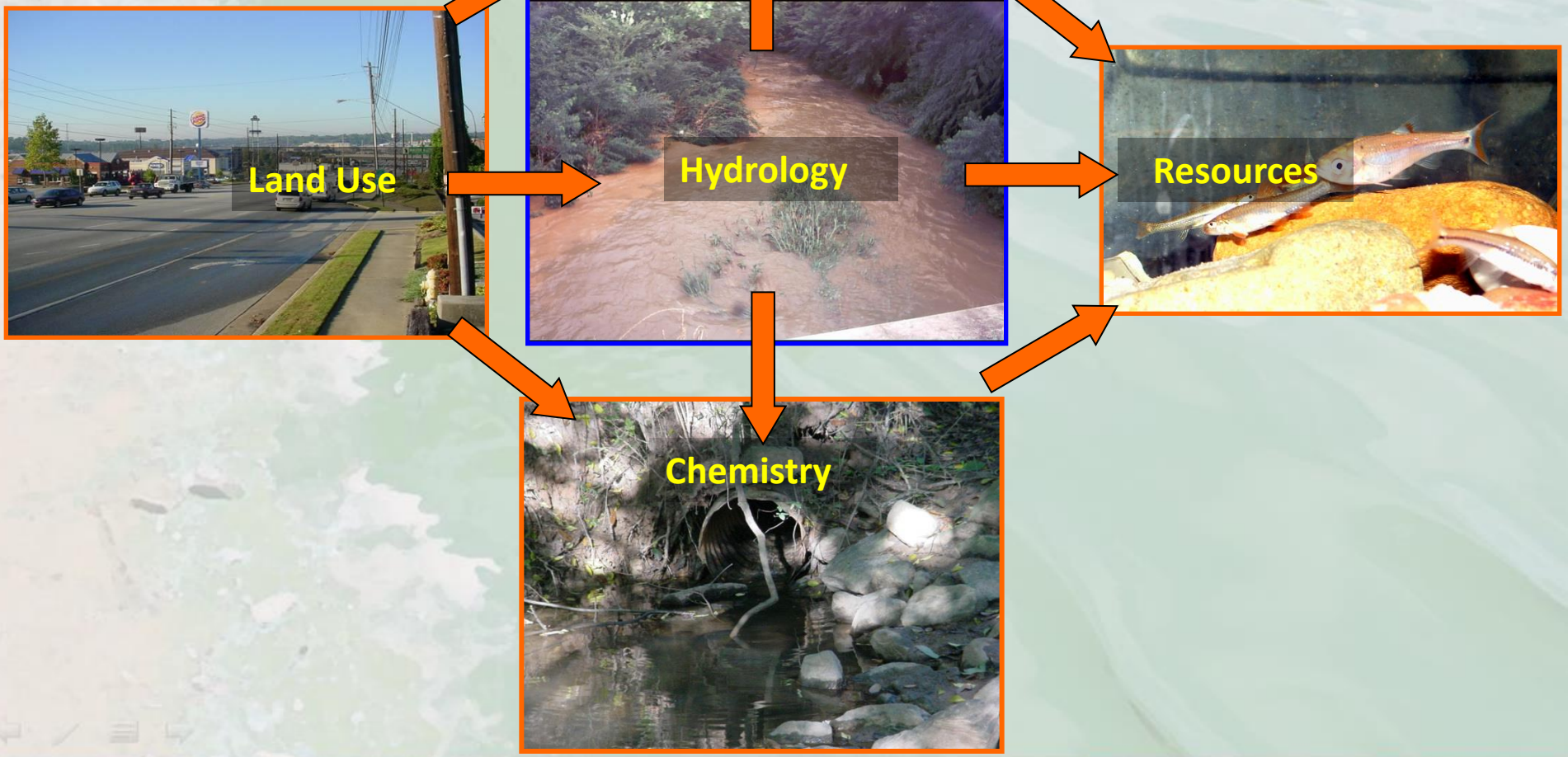
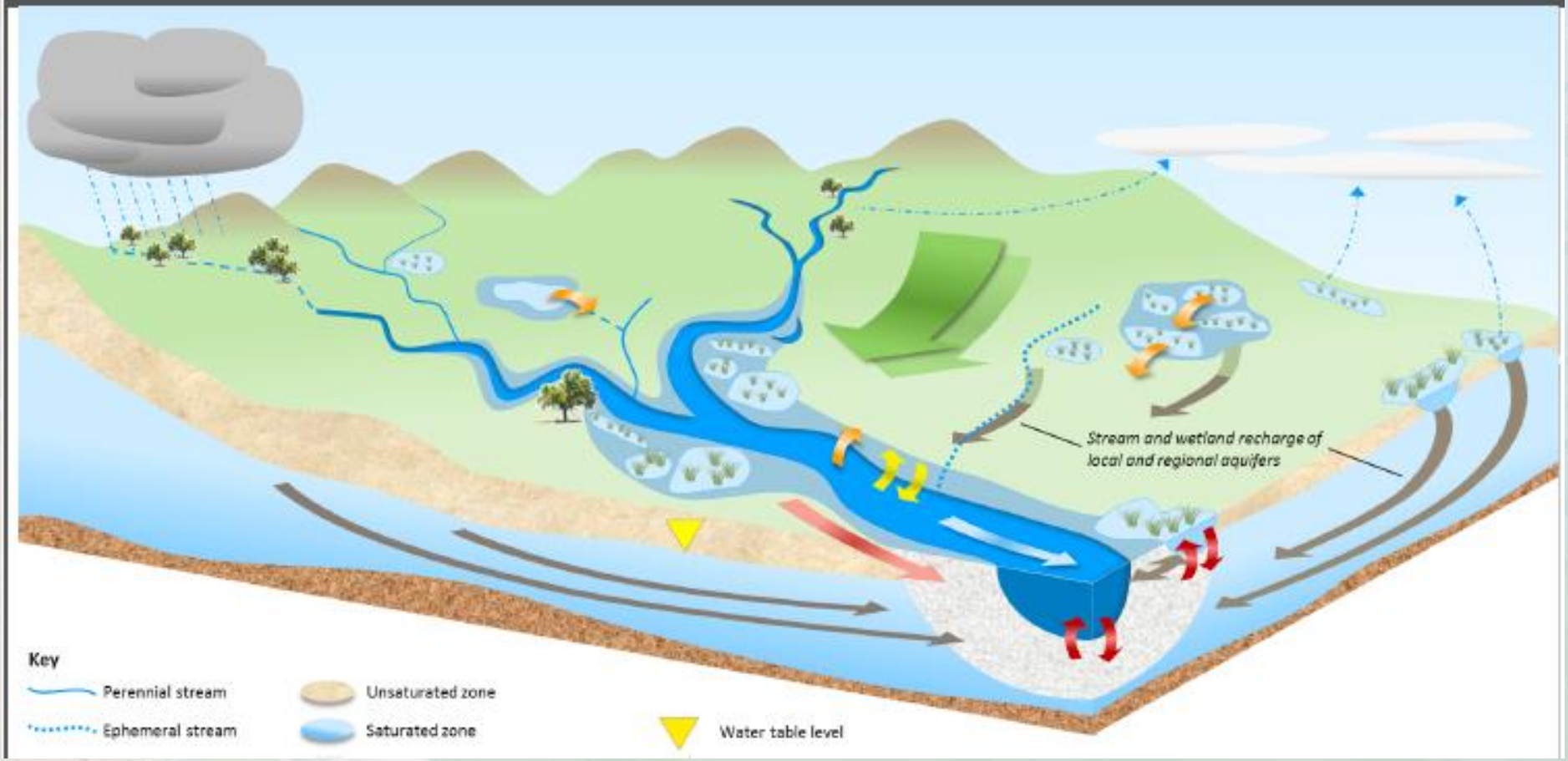

Geomorphology
Land Use
Hydrology
Resources
Chemistry

Figure 1-1A. Hydrologic flowpaths. Arrows are representative of surface-water and ground-water flows occurring throughout the watershed. Subsurface flows are shown within the cross section, and by faded arrows outside the cross section.



Forested

Urbanized

Agricultural

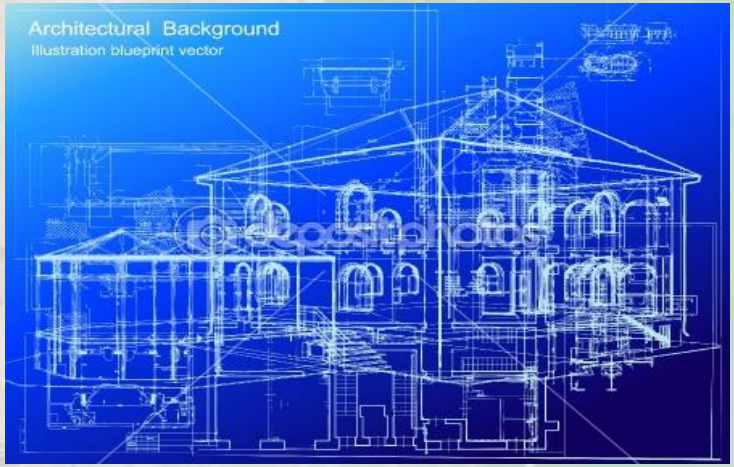
What is a model?

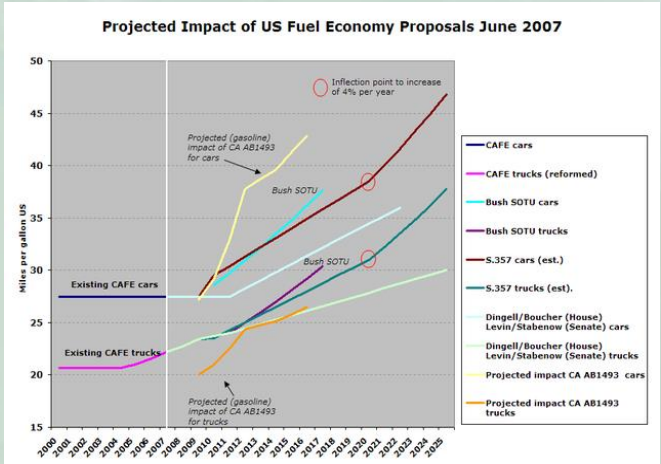
- A model is **anything** used in **any way** to represent **anything else** (*Wikipedia*)
- A model is a **substitute** for a real system
- Models are used when it is easier to work with a substitute than with the actual system
- They represent some aspect of a real system
- They are useful when they **help us learn something new** about the systems they represent

- Architect's blueprint
- Economist's graphs

→

- A Building
- A Nation's Economy





We use models every day : Mental models

- The images we carry in our minds are **simplified representations of complex systems**.
- We use mental models constantly to interpret the world around us, and we may not realize that we are doing so

Physical models (Scale models)

Interrogating Reality

reality

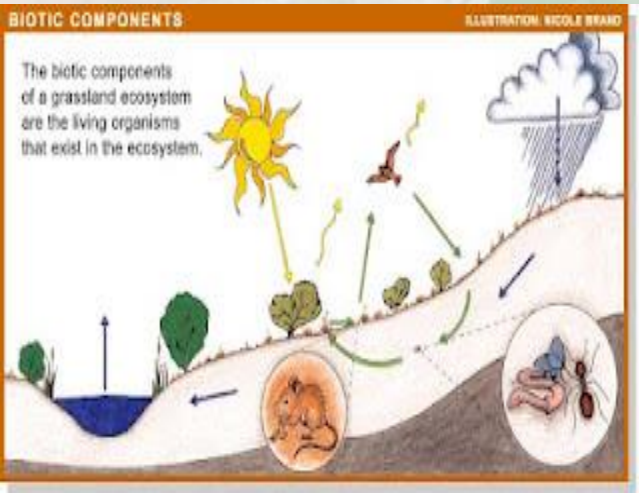
conceptual model, description

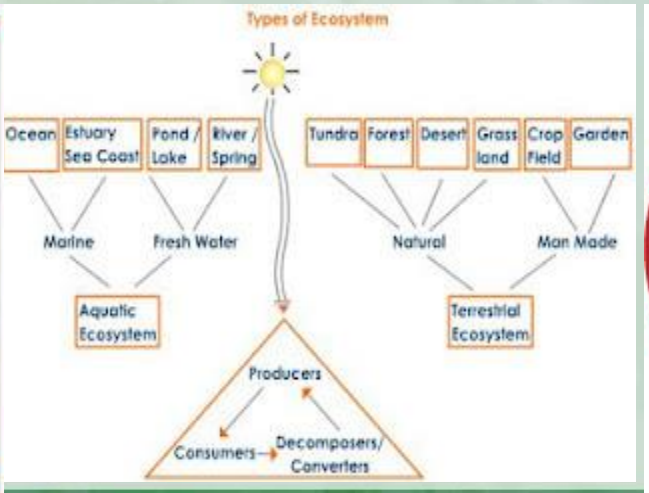
numerical model

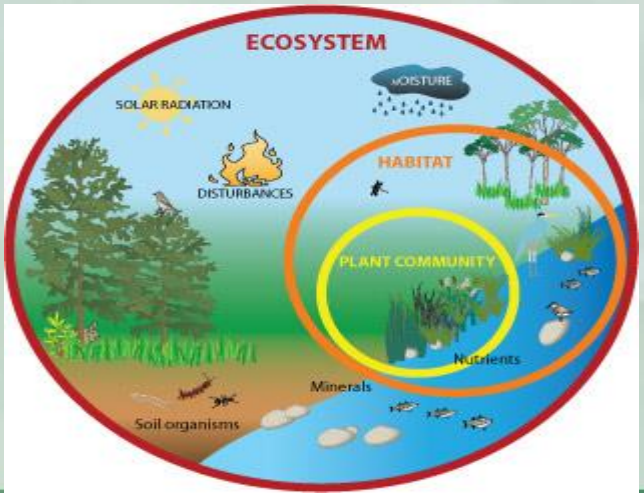
experiment

Ecological/Environmental Modeling

- Mathematical representation of an ecological/environmental system
- We can not experiment with nature to find optimum solution to pollution and resource management, so we use environmental models instead
- Range in scale from an **individual population** (microbial community), to an **ecological community** (forest, lake), or even an **entire biome** (climate change models)





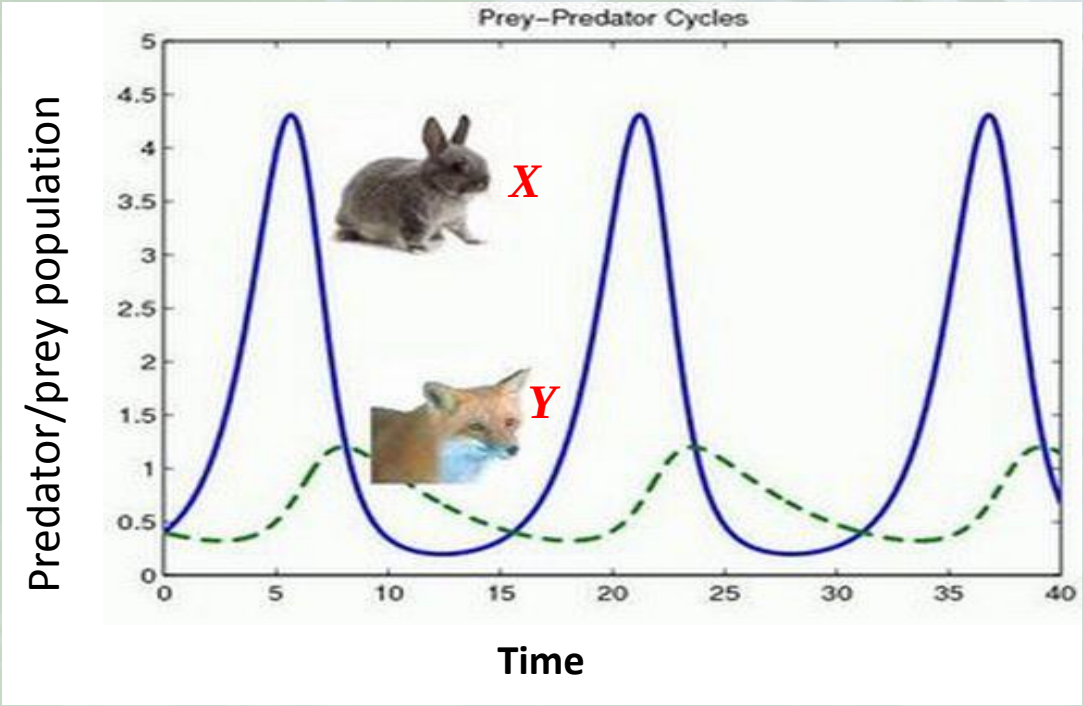


Simple Example:

The Predator-Prey model (Lotka & Volterra, 1925)

$$\frac{dX}{dt} = \alpha.X - \beta.X.Y$$

$$\frac{dY}{dt} = \gamma.\beta.X.Y - \delta.Y$$



X **:** number/concentration of the prey species

Y **:** number/concentration of the predator species

α : prey species' growth rate

β : predation rate of Y upon X

γ : assimilation efficiency of Y

δ : mortality rate of the predator species

Benefits of Environmental Modeling

1. Understand how systems work
2. Predict future conditions
3. Assess & Optimize environmental decision-making
4. Test scientific hypotheses
5. Test the validity of field data and assumptions
6. Simulating centuries in reality in a matter of minutes

Modeling Fundamentals

- Have a clear statement of objectives. Verify the need for modeling. The objectives might be satisfied without a modeling
- Use the simplest model that will satisfy the objectives. Often a screening model, e.g., regression or statistical, can determine whether more complex simulation models are needed
- Only predict the parameters of interest and only over a suitable time scale.
  - Storm event loads and EMCs (Event Mean Concentration) will usually be the most detailed prediction necessary, and seasonal or annual loads will sometimes be all that is required.
  - Do not attempt to simulate intra-storm variations unless it is necessary

Modeling Fundamentals

- Perform a sensitivity analysis on the selected model and familiarize yourself with the model characteristics
- If possible, calibrate and verify/validate the model results.
  - Use one set of data for calibration and another independent set for verification.
  - If no such data exist for the application site, perhaps they exist for a similar catchment nearby
- Perform uncertainty analysis to gain insight to the level of confidence in model estimates. A systematic uncertainty analysis can lead to the identification of the key sources of uncertainty (such as data gaps).

Model Reliability

- Accuracy and reliability decrease with increased complexity and size of the modeled system
- Most accurate: hydrologic models simulating runoff from small, uniform and impervious surfaces
- Least reliable: water quality models for large watersheds
- Order of reliability decline in this order (Novotny and Olem 1994):

  Hydrology with impervious surface, Hydrology, Sediment, phosphates and metals, nitrogen and organic chemicals, bacteria
- Hydrologic and sediment transport models have lower uncertainty compared to other processes, such as fate and transport of nutrients
- Consider physics used to describe each process

Model Classifications

- **Empirical models (Black-box models):**
  - usually based on statistical relationships obtained through regression analysis of observed data
  - usually suitable for conditions under which the relationships have been developed
  - less reliable under the conditions outside the limit of the original environment and generally are not suitable for predictions under different conditions

- **Physically based models:**
  - based on physical principles such as conservation of mass and momentum
  - input parameters can usually be obtained through field measurements

Example: ET Estimation

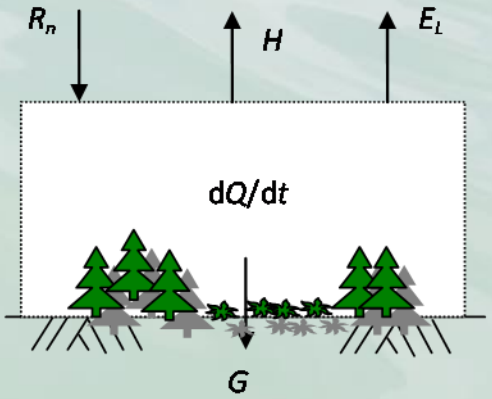
- Empirical model:
  - Turc Equation

    P: Mean annual precipitation

    T: Mean air temperature

$$ET = \frac{p}{\sqrt{0.9 + \left(\frac{p}{\lambda}\right)^2}} \quad , \quad \lambda = 300 + 25T + 0.05T^3$$

- Physically based model
  - R_n : net solar radiation
  - H : heat conducted from surface to air
  - G : heat conducted from surface to soil
  - Q : amount of heat energy stored
  - E_L : latent heat flux
  - λ_v : latent heat of vaporization
  - ρ_w : density of water

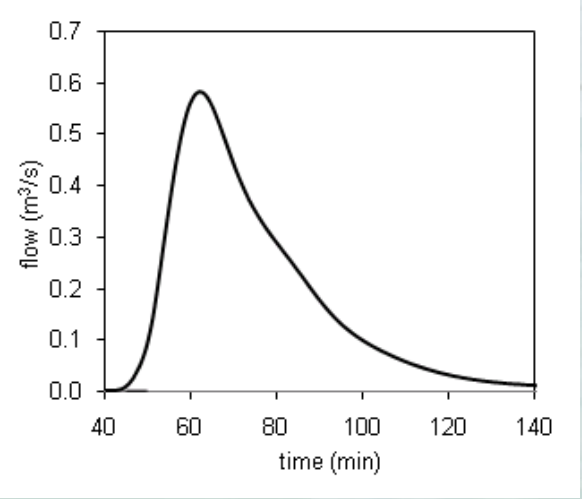


$$\frac{dQ}{dt} = R_n - G - H - E_L$$

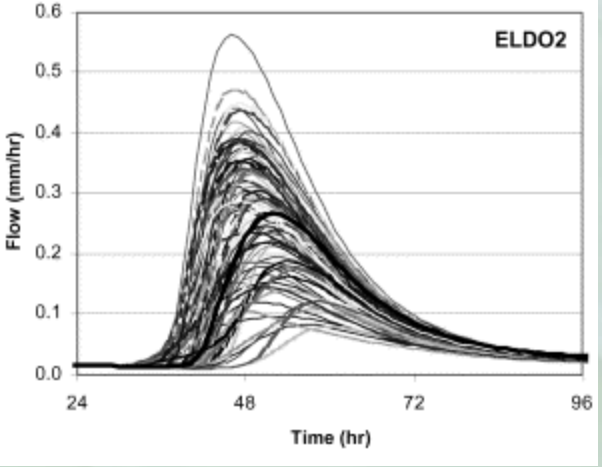
$$ET = \frac{E_L}{\rho_w \lambda_v}$$

Model Classifications

- **Deterministic Models:**
  - do not consider the *randomness* involved in the data
  - always produce the same result for a given input parameter set



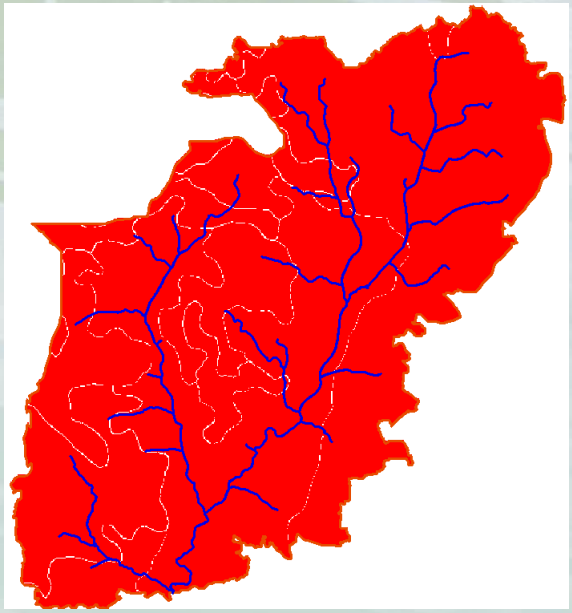
- **Stochastic Models:**
  - reflect the uncertainty in the data
  - may produce different output from the same input parameter set

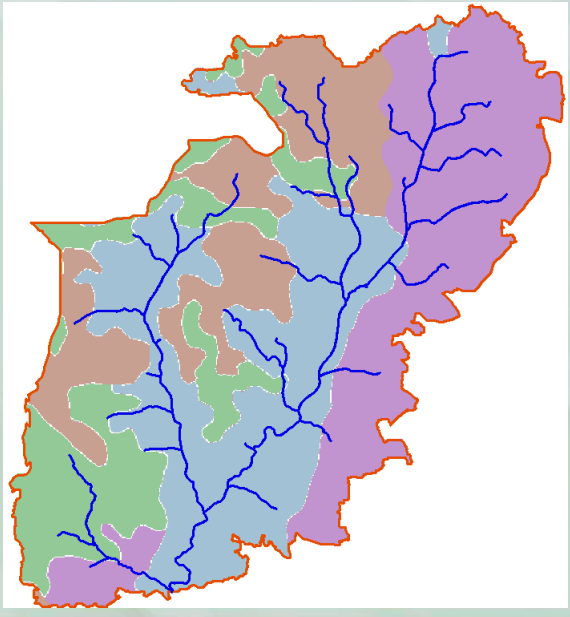


Model Classifications

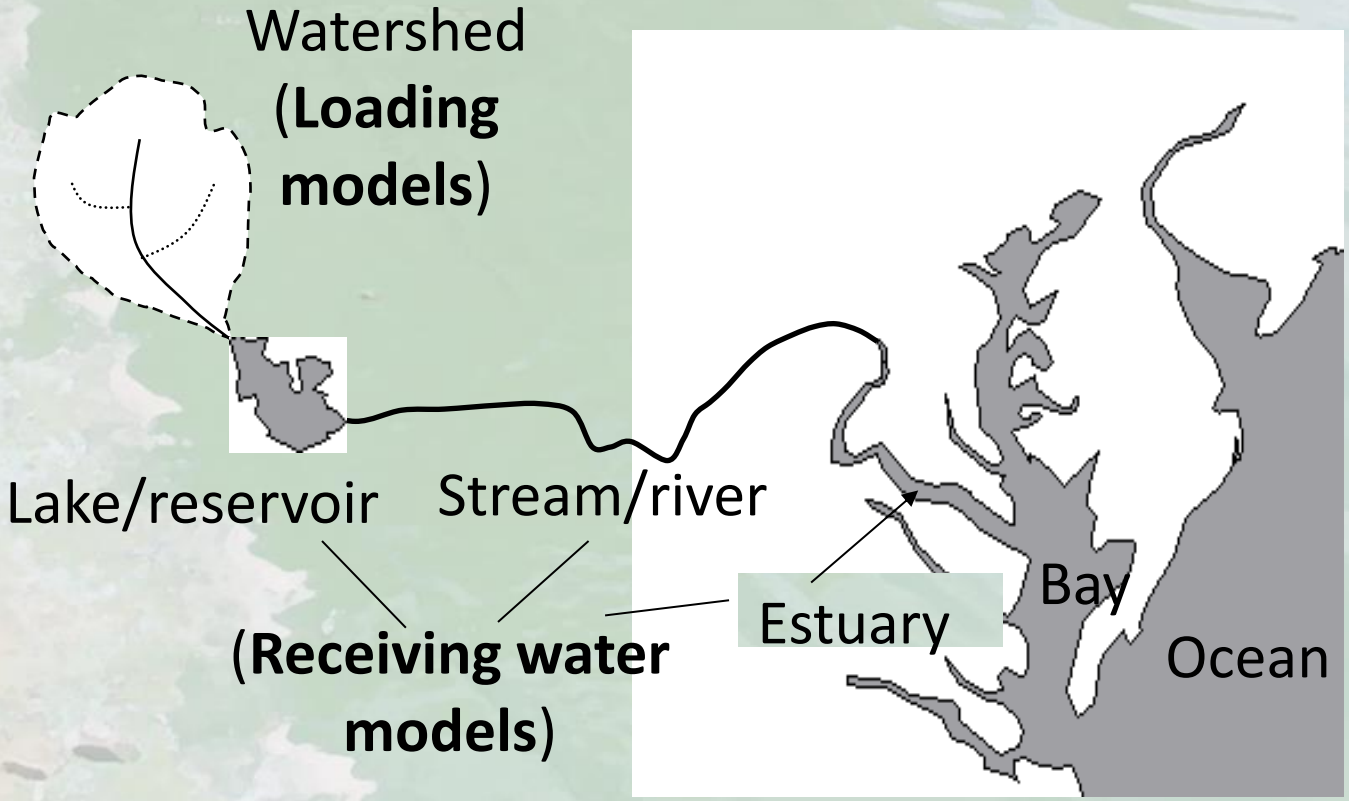
- **Lumped Models:**
  - usually consider the system as a black box
  - everything is spatially averaged over that single system

- **Distributed Models:**
  - take into account heterogeneities by dividing the system into smaller units (e.g. cascade of planes in case of a watershed)
  - assume that the model parameters and initial conditions are uniform within each unit
  - can produce outputs at various locations (e.g. at subwatershed outlets in a watershed)

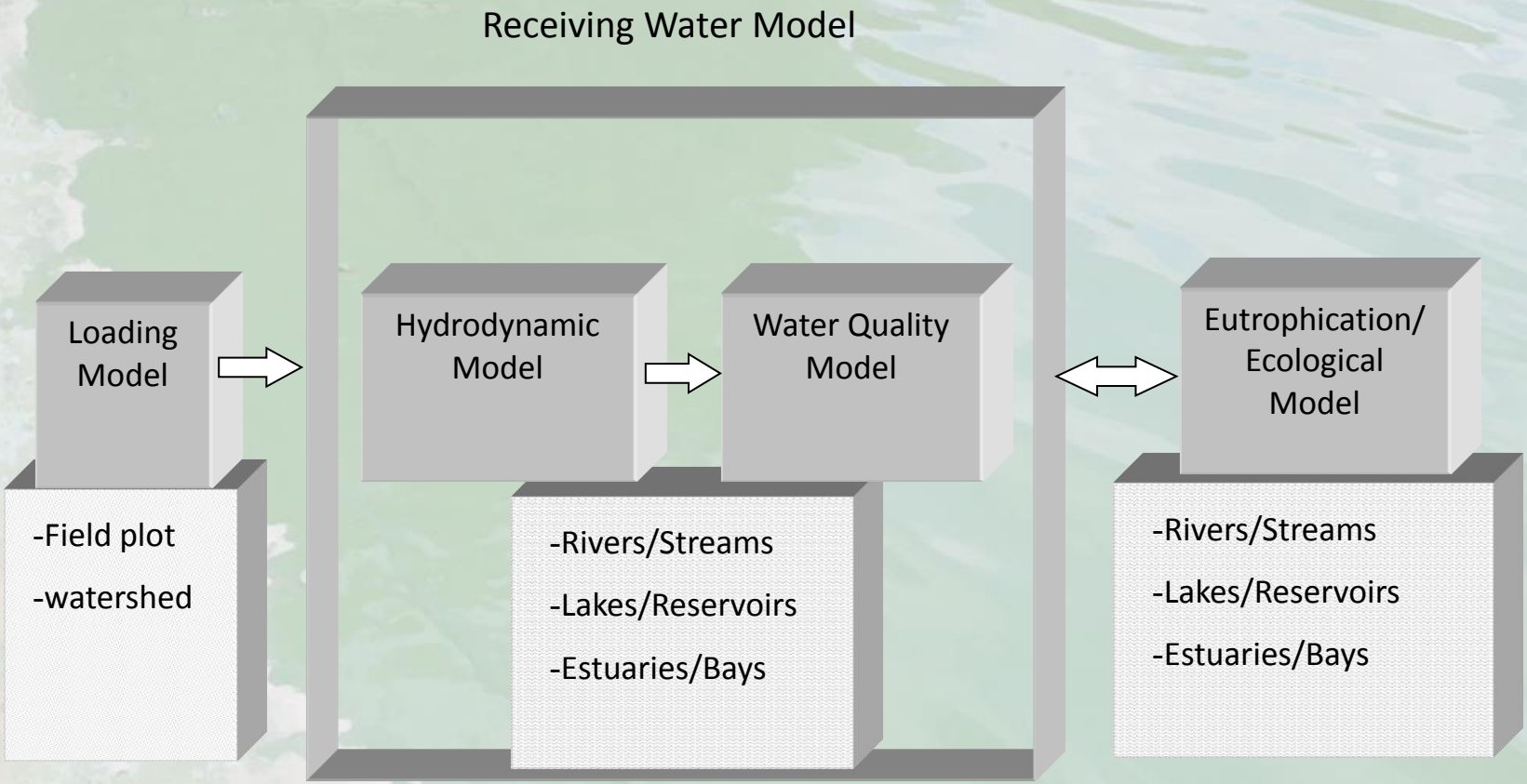




Model Classifications

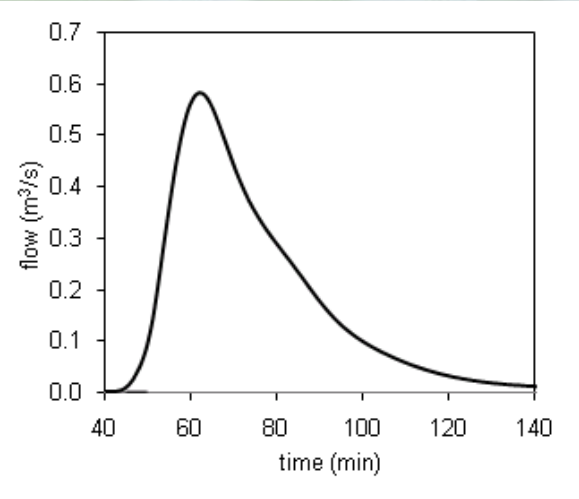


Water Bodies

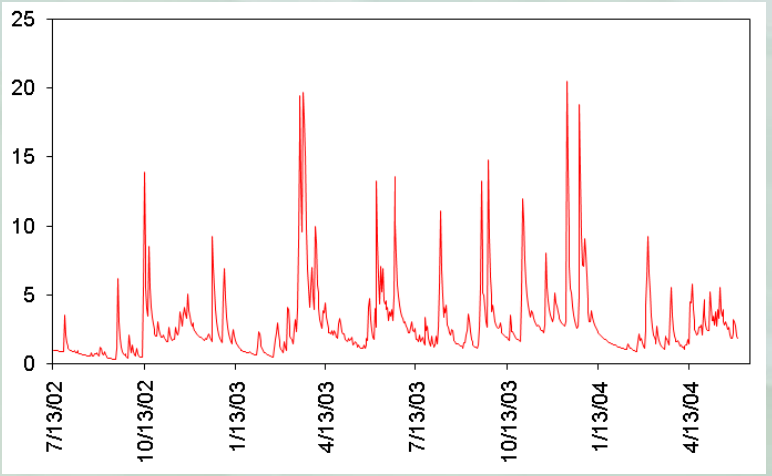


Temporal scale

- Event Based models
  - Individual storm/rain events
  - Small time step: order of minutes
  - Suitable for studying large storms, e.g. flooding
  - Antecedent conditions crucial
  - ET can be ignored



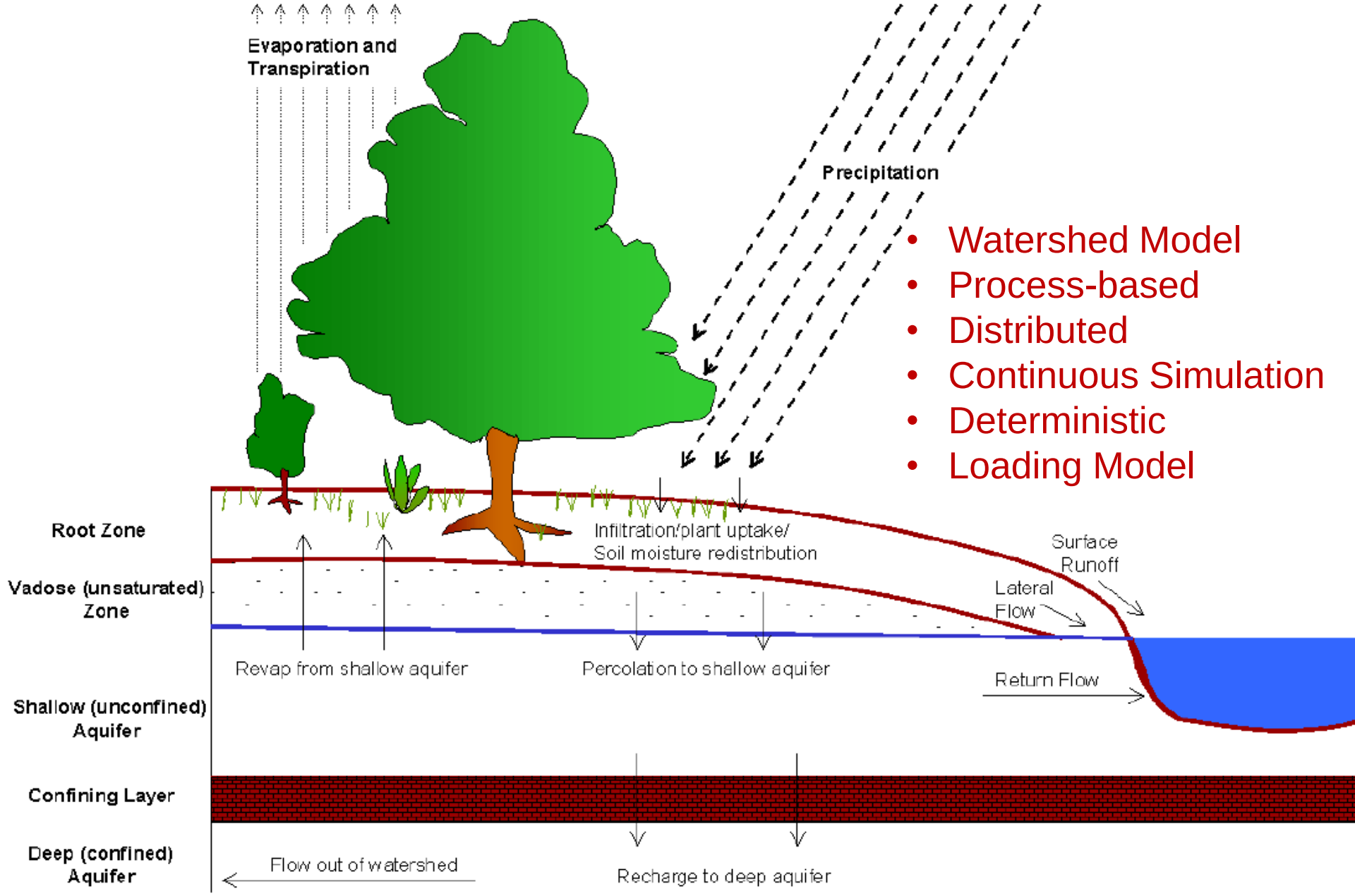
- Continuous Simulation models
  - Long term effects (years)
  - Coarse time scale: usually days or months
  - Antecedent conditions can be resolved through use of warm up periods
  - ET is crucial part of water balance



Spatial scale

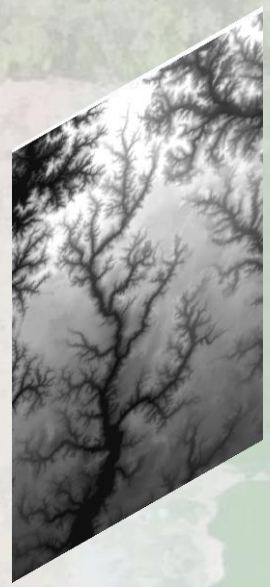
- Point Scale
  - Movement of water and chemicals in the vadose (unsaturated) zone
  - ~ 1m
- Field Scale
  - Order of 100m
  - Surface and/or Subsurface flow
  - No channel routing
- Watershed Scale:
  - Aggregation of
    - fields or
    - hydrologic response units or
    - grid cells
  - Routing
  - Heterogeneities are important

Soil Water Assessment Tool (SWAT)

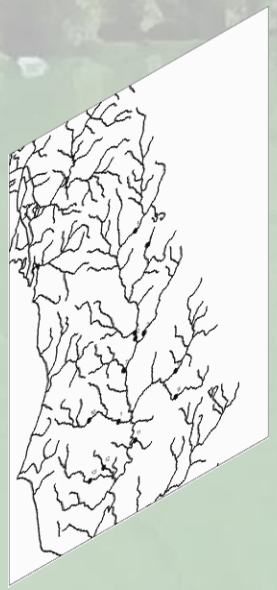


- Watershed Model
- Process-based
- Distributed
- Continuous Simulation
- Deterministic
- Loading Model

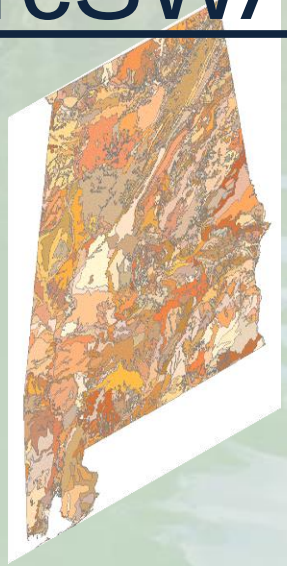
ArcSWAT



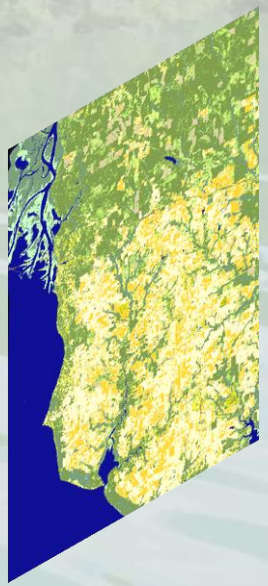
Digital Elevation Model (DEM)



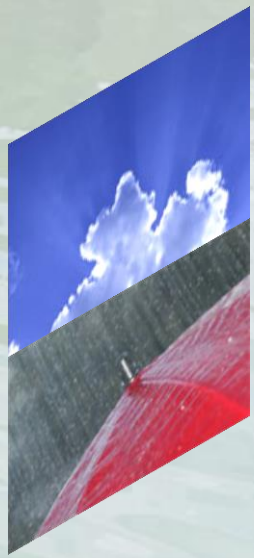
Stream Network



Soil

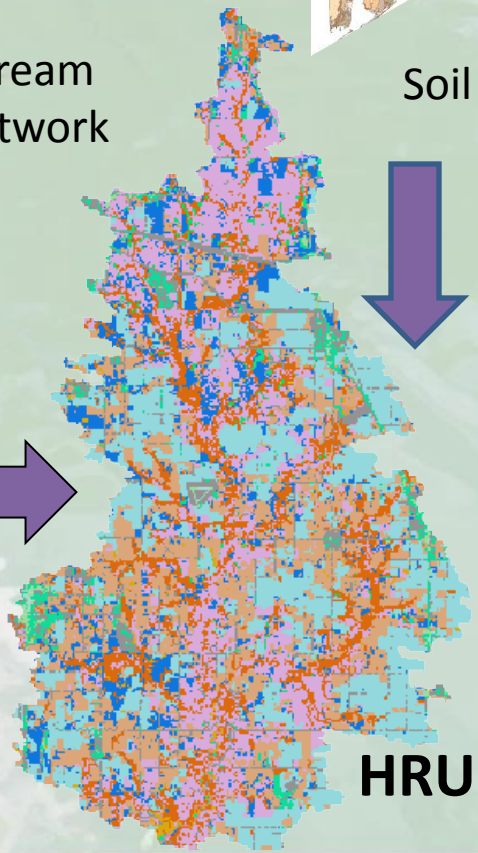


Land use/ cover



Climate

- Management Operations
- Water withdrawal
- Fertilizer Application
- Etc…



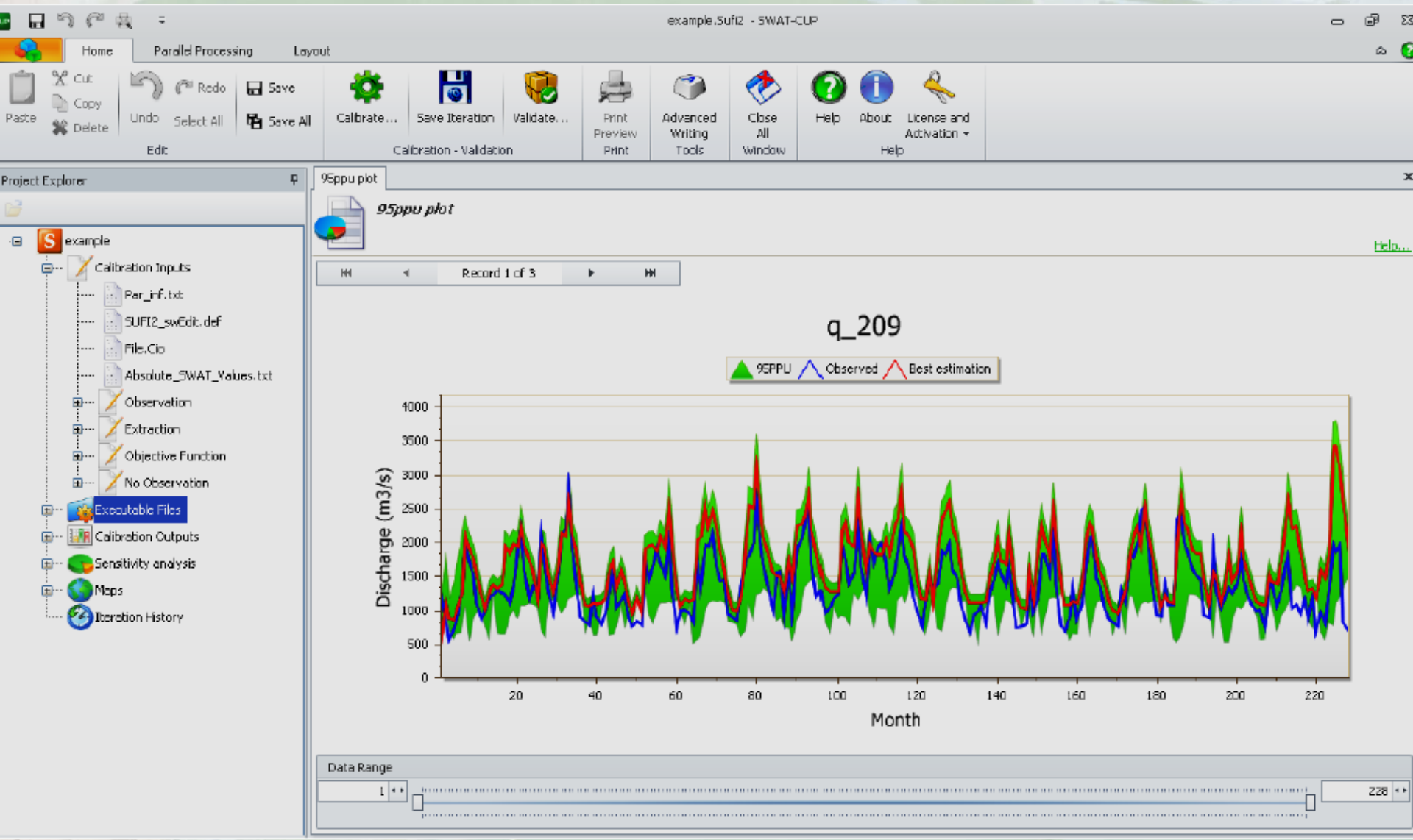
HRU

Outputs:

- Flow
- Sediment
- Nutrient
- Carbon
- Pesticide
- Bacteria

SWAT-CUP

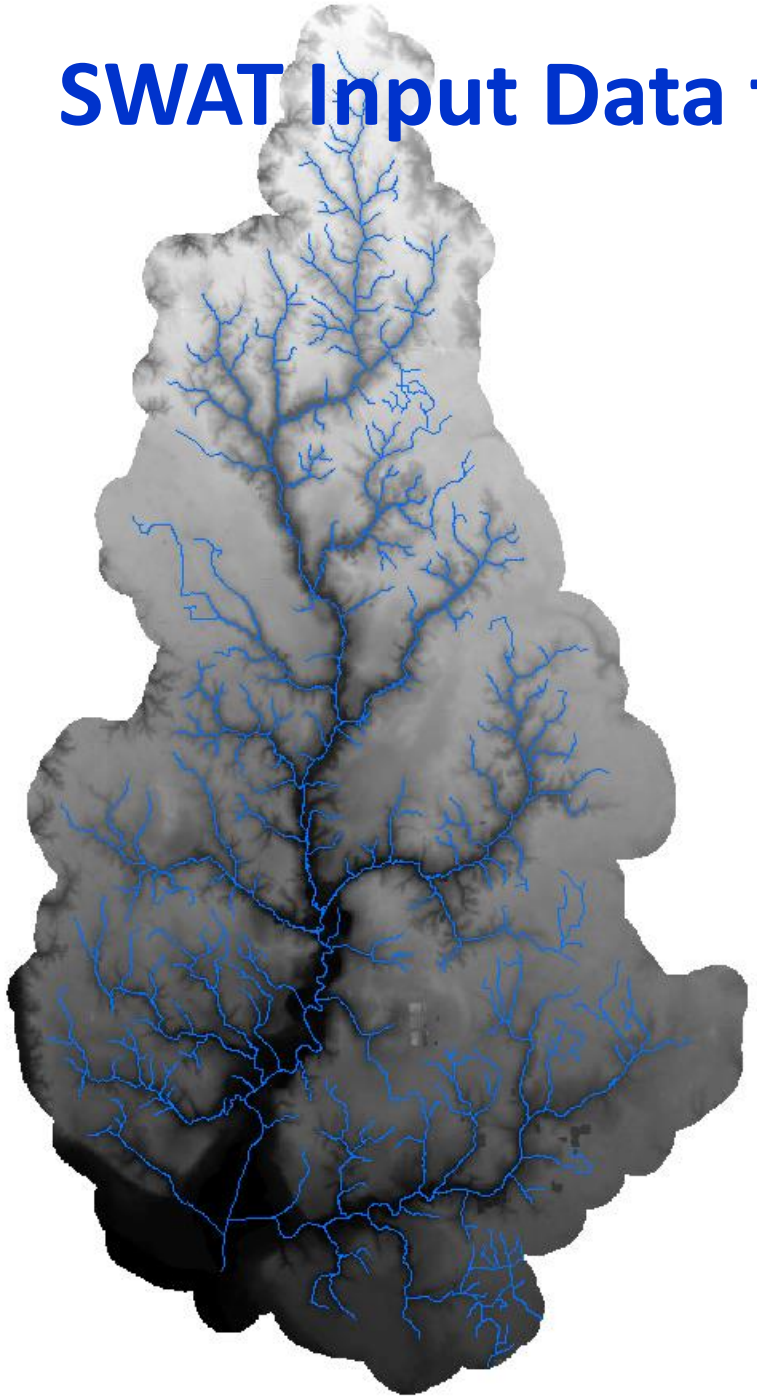
SWAT Calibration and Uncertainty Program

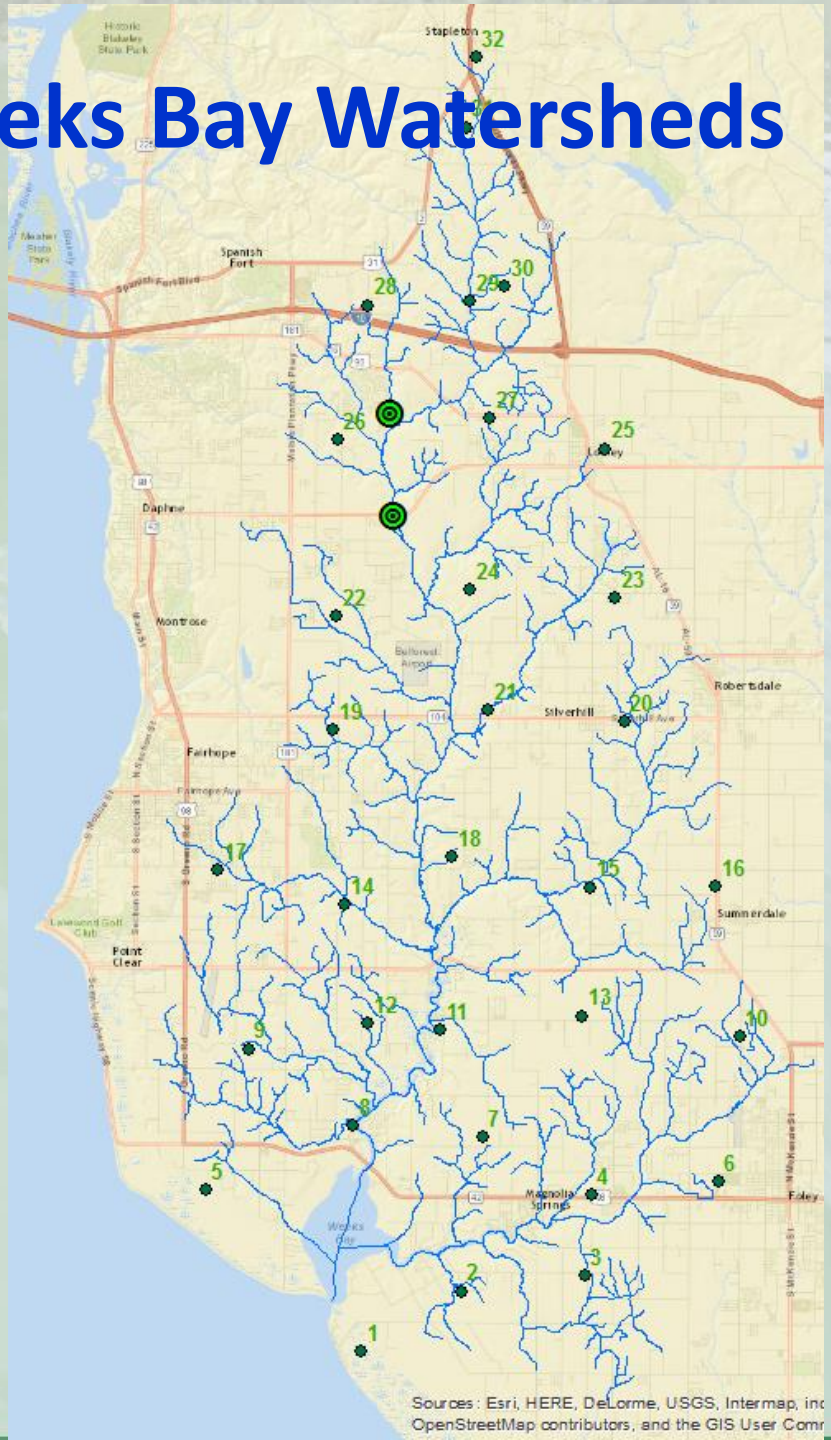


SWAT Input Data for Weeks Bay Watersheds

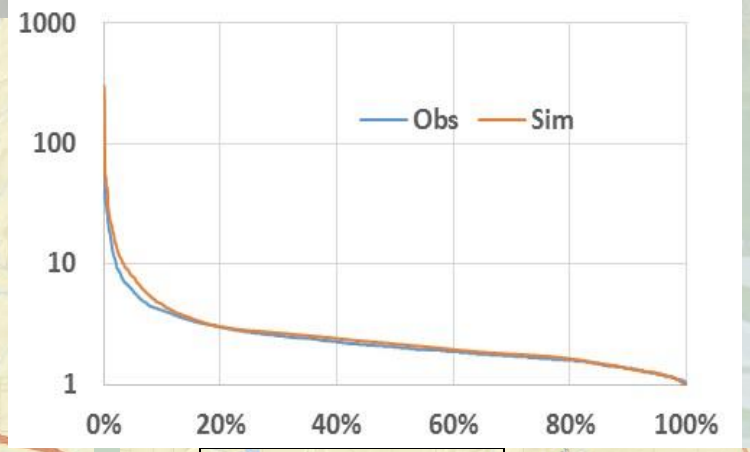
- ***Elevation:*** 10 m resolution (USDA Geospatial Data Gateway, *https://gdg.sc.egov.usda.gov*)
- ***Soil:*** SSURGO soil database (USDA Geospatial Data Gateway, *https://gdg.sc.egov.usda.gov*)
- ***Hydrography:*** NHD v2 (USDA Geospatial Data Gateway, *https://gdg.sc.egov.usda.gov*)
- ***Land Use/Cover (LULC):*** NLCD 1992, 2001, 2006, 2011 (USGS, *http://www.mrlc.gov*)
- **Climate:** Data was downloaded from multiple sources such as the PRISM dataset distributed by Oregon State, NLDAS from NASA, and NOAA gauge stations. Data were compared to select the best dataset to have a good coverage. The gridded PRISM data was eventually used for precipitation and temperature.
- ***Point sources:*** Obtained from ADEM's e-file system.
- ***Crop types:*** Crop data layers (in GIS) were downloaded from USDA National Agricultural Statistics Service (http://nassgeodata.gmu.edu/CropScape) for years 2008 to 2014.
- ***Streamflow:*** Daily time series for Fish River and Magnolia Rivers (source USGS)

SWAT Input Data for Weeks Bay Watersheds



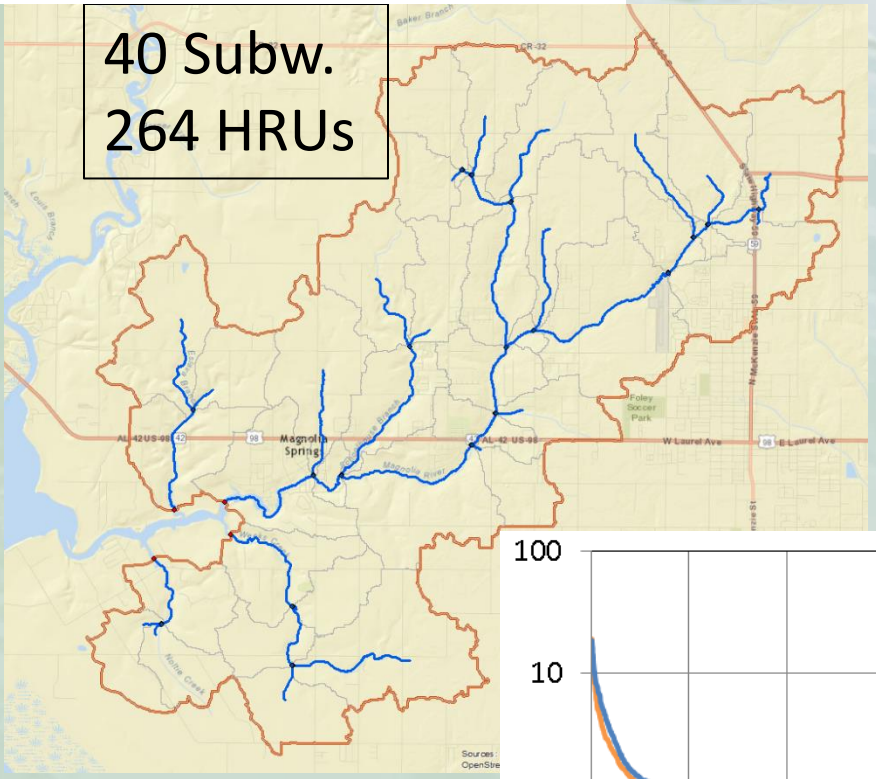


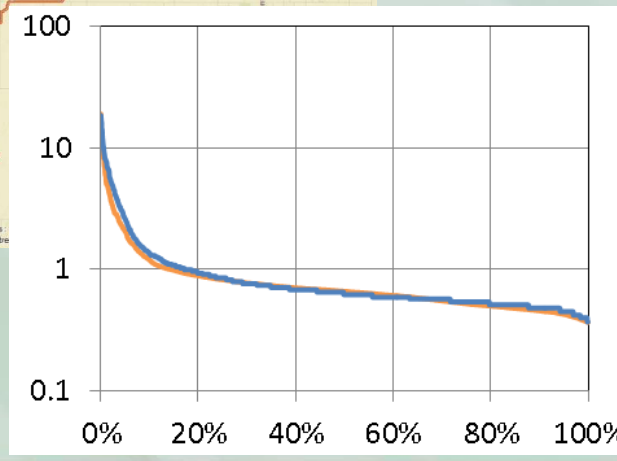
197 Subw.
858 HRUs



Daily Flow Duration Curve - FDC (m^3/s)

40 Subw.
264 HRUs





Sources: Esri, HERE, DeLorme, USGS, Intermap, OpenStreetMap contributors, and the GIS User Co