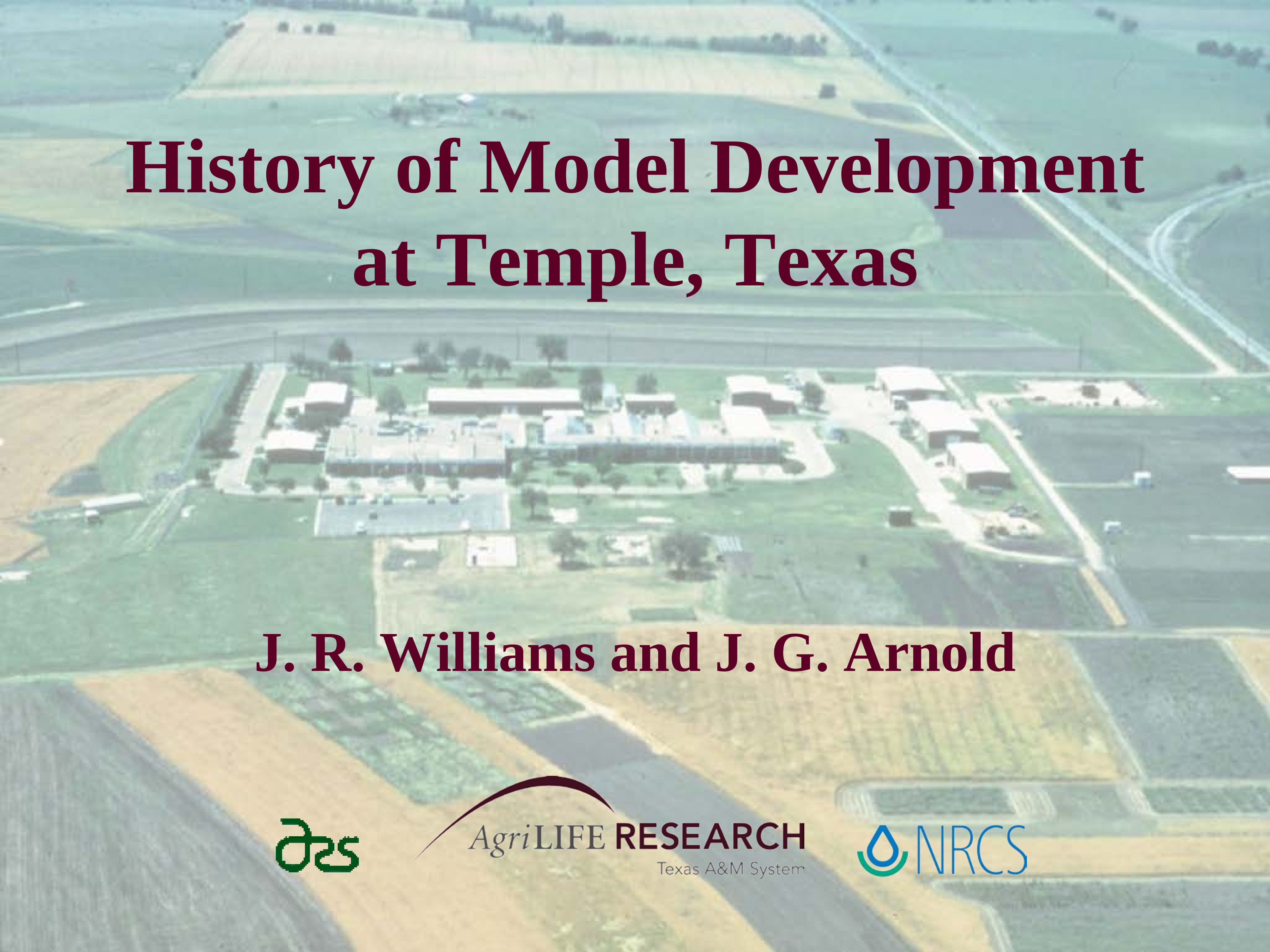


History of Model Development at Temple, Texas

J. R. Williams and J. G. Arnold

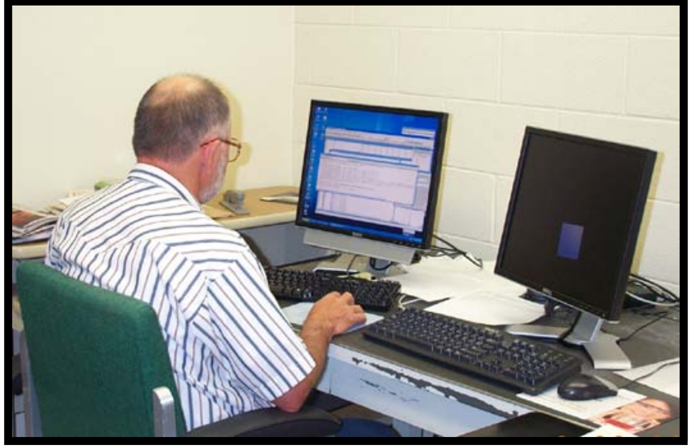
AgriLIFE RESEARCH Texas A&M System

NRCS

INTRODUCTION

- Model development at Temple
  - A long history (1937-present)
  - Many scientists participating in:
    - Data collection
    - Component construction
    - Structural design
    - Validation
    - Application

Then

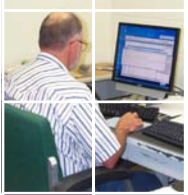


Now

INTRODUCTION

- Model construction—a small group at Temple
  - USDA-Agricultural Research Service (ARS)
  - Texas AgriLIFE Research
  - USDA-Natural Resources Conservation Service (NRCS)
- Components, equations, etc.
  - Contributed by many scientists worldwide
  - Worldwide Scientific link provided
  - Additional expertise needed to develop comprehensive models

INTRODUCTION TEMPLE MODELS

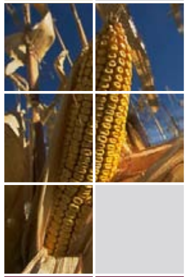


- ALMANAC, EPIC, APEX, SWAT
  - Operate on spatial scales ranging from individual fields to river basins
  - Daily time step
  - Continuously updated and improved as a result of user interaction and feedback

DATA COLLECTION-RIESEL

- Blackland Experimental Watershed-hydrological data collection program
  - Established in 1937 near Riesel, TX.
  - 57 rain gages and 40 watersheds
  - Established to analyze the impact of land use practices on:
    - soil erosion
    - flood events
    - water resources
    - agricultural economy

1938 – Calibrating gauging station W-2



MODEL DEVELOPMENT

- Started with hydrograph development and flood routing research in 1965
  - Background
    - 2.5 years experience in SCS flood control
    - New TR-20 flood routing model
    - Data from Riesel used in developing & testing hydrological models
  - Early models were single event models used as building blocks for today's models
    - Focused on surface water hydrology and sediment yield

SURFACE RUNOFF

- SCS curve number method
- Green & Ampt infiltration equation

Used in EPIC, APEX and SWAT

UNIT HYDROGRAPH MODEL

- Two parameter gamma distribution
  - Rising limb
  - Peak
  - Recession to inflection point
- Exponential recession limb
  - Inflection point to base flow or zero
- For simulating runoff hydrographs from small Texas Blackland watersheds
- (1968)

UNIT HYDROGRAPH MODEL

- Tests showed recession limb depleted too rapidly in many cases
- Hydrograph modified
  - Two parameter gamma distribution
  - Double exponential recession limb

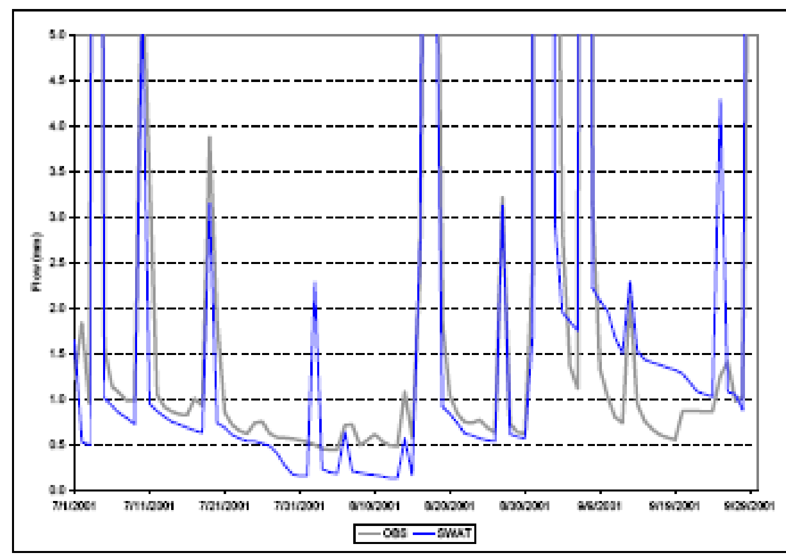


Figure 3-10 Daily base flow hydrograph for winter 2001 (reduced ET scenario – catchment D2).

- (1973)

FLOOD ROUTING

- Variable travel time method (VTT)
- VTT converted to Variable storage coefficient (VSC)
  - Improve accuracy of storage flood routing
  - Convenience in computer solutions
  - Accounts for variation in travel time
  - Maintains correct water balance
  - Later included effects of water surface slope (Williams, 1975)
  - Included in APEX and SWAT
- (1969)

HYMO

- Problem oriented computer language
  - Consisted of
    - Runoff curve number
    - Unit hydrograph
    - VSC flood routing method
    - MUSLE (sediment yield)
- (1972)

MUSLE

- Single storm event sediment yield
- Introduced runoff energy factor
- Eliminated need for delivery ratio
  - Runoff factor represents energy used in detaching and transporting sediment
- (1975)

SEDIMENT ROUTING

- Based on
  - MUSLE
  - Exponential function of travel time and particle size
  - One routing coefficient determined for all sub-areas in a watershed
  - Provided estimates of sediment deposition from subarea outlet to watershed outlet
  - Did not locate deposition
  - Ignored degradation

- (1975)

SEDIMENT ROUTING

- Worked in conjunction with flood routing model
  - Transported sediment from reach to reach adding subarea contributions as flow was routed downstream
- Deposition similar to previous model
- Degradation component developed
  - Bagnold's stream power equation
- Applies to individual routing reaches

- (1978)

SEDIMENT ROUTING

- Current model uesd in APEX and SWAT
- Modified Bagnold
  - Sediment concentration function of
    - Flow velocity
    - Sediment load
    - Particle size
    - Vegetative cover
    - Soil erodibility
- (2000)

WIND EROSION

- EPIC wind erosion model
  - Modified Manhattan, KS model (WEQ)
    - Converted annual to daily time step
      - Simulated
        - » Vegetative cover
        - » Tillage effects
- (1984)

WIND EROSION

- Current EPIC/APEX model
  - Wind Erosion Continuous Simulation (WECS)
  - Revised original model
    - Driven by daily wind speed
      - Bagnold's equation
    - Function of daily wind run
      - Wind direction
      - Field orientation
- (1995)

CROP GROWTH

- CERES model
  - Simulated crop growth and yield in uniform field
  - Maize and wheat
  - Simulates effect on development, growth & yield as a function of:
    - Cultivar
    - Plant population
    - Weather
    - Soil

- (1986)

CROP GROWTH

- EPIC crop model
  - Used some concepts from CERES
  - Generic model simulates 100+ crops
    - Annuals/perennials
    - Field crops/pastures
    - Legumes
    - Trees/shrubs
    - Unique parameters for each crop
- (1989)

CROP GROWTH

- ALMANAC crop model
  - Based on EPIC crop model
  - Plant competition (up to 10 crops)
    - Assess impact of weeds on crop yields
    - Grown in same space
    - Compete for
      - Water
      - Nutrients
      - Light

WEATHER SIMULATION

- WGEN
  - Simulated daily
    - Precipitation
    - Temperature (max and min)
    - Radiation
    - Wind speed and direction
- (1981)

WEATHER SIMULATION

- WXGN
  - Combination of WGEN and CLIGEN
  - Used in all Temple Models
  - Simulates daily
    - Precipitation
    - Temperature (max and min)
    - Radiation
    - Relative humidity
    - Wind speed and direction
- (1984)

WATER YIELD MODEL

- Developed to estimate water yield from agricultural watershed
- Based on SCS curve number
- Continuous daily time step
- Soil moisture accounting
  - Driven by pan evaporation
  - One parameter optimized to match average annual water yield
- (1976)

CREAMS

- Designed to evaluate non-point source pollution from field-size areas
- Components
  - Hydrology
  - Erosion
  - Nutrients
  - pesticides
- Daily time step hydrology
  - Surface runoff estimation
    - Based on SCS water yield model
    - Infiltration approach
  - Added ET and percolation
- Later revised to become GLEAMS
  - Emphasized pesticide fate
- (1980)

SWRRB

- Based on CREAMS daily hydrology
- Watershed scale
  - Subdivided
  - Spatial weather generator (CLIGEN)
  - Water and sediment yield (MUSLE)
  - Water & sediment balances for ponds and reservoirs
- Provided the basis for SWAT

- (1985)

SWRRB APPLICATIONS IN U.S. – 1980'S

- National Oceanic and Atmospheric Administration (NOAA) National Coastal Pollutant Discharge Inventory

- U.S. Environmental Protection Agency Pesticide Registration Model

EPIC

ENVIRONMENTAL POLICY INTEGRATED CLIMATE MODEL

- Designed to define the erosion-productivity relationship throughout the U.S.
- Field scale
- Components
  - – Weather simulation
    - Weather generator
  - – Hydrology
    - Runoff (CN or Green and Ampt)
  - – Erosion-sedimentation
    - Wind and water
  - – Nutrient cycling
- (1984)

EPIC

- Components continued
  - Plant growth
  - Tillage
  - Soil temperature
  - Economics
  - Management
- (1984)

EPIC

- Applications
  - Used to evaluate soil erosion impacts for 135 U.S. land resource regions
  - AUSCANE model (spin-off of EPIC) created to simulate Australian sugarcane production
  - Assessed the impacts of future climate change on U.S. corn, soybean, alfalfa, and wheat yields
  - Assessed impacts of typical Mayan culture agricultural cropping systems and practices on erosion and development of Mayan civilization
  - Assessed irrigation timing and amount strategies for sunflower in Southern Italy to determine critical growth stage for irrigation application

APEX

AGRICULTURAL POLICY / ENVIRONMENTAL EXTENDER MODEL

- Whole farm/watershed scale
- Subarea component (EPIC)
- Routing (water, sediment, nutrients, pesticides)
- Groundwater & reservoir
- Feedlot dust distribution
- Daily time step
- Capable of simulating 100’s of years
- (2000)

APEX

- Management capabilities
  - Irrigation
  - Drainage
  - Furrow diking
  - Buffer strips
  - Terracing
  - Waterways
  - Fertilization
  - Manure management
  - Lagoons
  - Reservoirs
  - Crop rotation and selection
  - Pesticide application
  - Grazing
  - Tillage

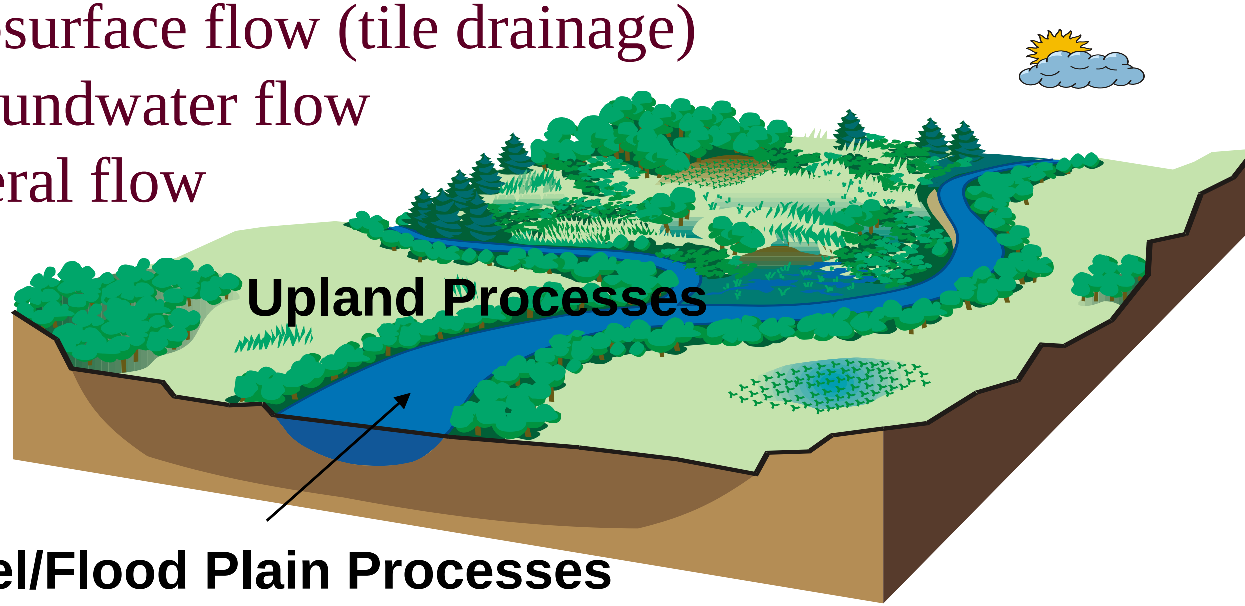
APEX

- Applications
  - Evaluate effects of global climate/CO_2 changes
  - Design environmentally safe, economic landfill sites
  - Design biomass production systems for energy
  - Livestock farm and nutrient management (manure and fertilizer)
  - Forest management
  - Evaluate effects of buffer strips nationally
  - Simulate runoff, erosion/sediment yield, nutrient and pesticide losses from cropland in the U.S. (CEAP)

SWAT

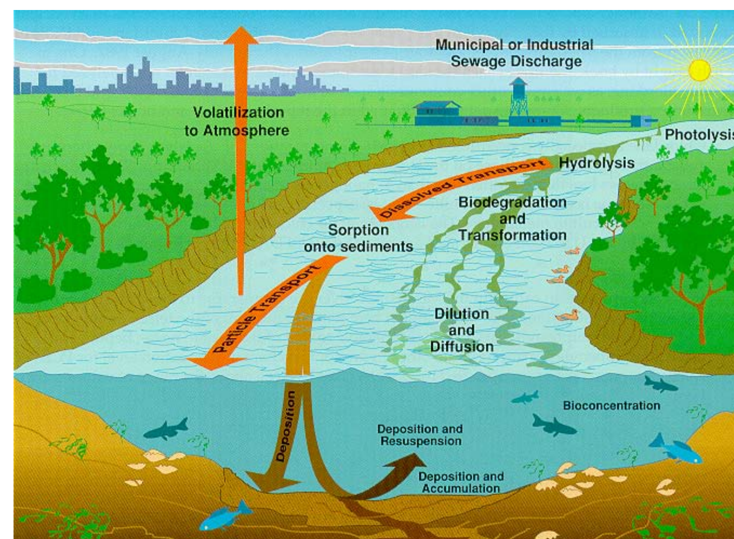
SOIL AND WATER ACCESSMENT TOOL

- Basin scale
- Based on SWRRB
- Readily available input—physically based
- Comprehensive-Process interactions
- Simulates streamflow (not just water yield),
  - subsurface flow (tile drainage)
  - groundwater flow
  - lateral flow



SWAT

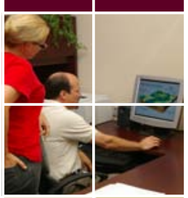
- Upland Processes:
  - Weather
  - Sedimentation
  - Plant Growth
  - Nutrient Cycling
  - Hydrology (impoundment, irrigation, subsurface)
  - Pesticide Dynamics
  - Soil Temperature
  - Management (Agricultural & Urban)
  - Bacteria
- Continuous Time
  - Daily Time Step (sub-hourly)
  - 1 Day to 100s of Years
- Links with APEX, EPIC, ALMANAC
- AVSWAT-X interface (SSURGO soils, splitting tools, auto-calibration and uncertainty tools)



SWAT

- Applications
  - Simulated hydrologic and/or pollutant loss impacts of agricultural & municipal water use, tillage and cropping systems trends (HUMUS)
  - Assess benefits of different conservation practices at scale national scale (CEAP)
  - Perform U.S Environment Protection Agency Total Maximum Daily Load (TMDL) analyses for impaired waters
  - Quantify the impacts of climate change
  - U.S. Environmental Protection Agency HAWQS National Environmental Assessment

PARTICIPATION IN OTHER MODEL DEVELOPMENT



- GLEAMS
- SPUR
- WEPP
- WEPS
- NLEAP