DELAWARE RIVER BASIN FLOOD ANALYSIS MODEL

Authorization

DRBC Resolution 2006-20 authorized the Executive Director of the Delaware River Basin Commission (DRBC) to develop a flood analysis model for the basin. A total of $500,000 was committed by the four basin states.

Flood Mitigation Task Force Recommendations for Reservoir Operations

* Development of a flood analysis model to evaluate alternative reservoir operating plans and to assess the downstream effect of reservoir voids of different magnitudes.

* Evaluation of reservoir spill and discharge mitigation programs.

* Seek release programs that would reduce the likelihood and volume of spills from reservoirs during storm events to help mitigate flooding without adversely impacting the original purposes of the reservoirs.

NOAA's National Weather Service, U.S. Geological Survey, and U.S. Army Corps of Engineers each expressed interest in the development of the flood modeling analysis tool.

The USGS Pennsylvania Water Science Center led the development of an interagency proposal that included additional funds and in-kind services to supplement the state funding.

Agreements with the DRBC were finalized in June of 2007 and work began in August.

Project Funding

$500,000 Basin States

$265,000 USGS, USACE, NWS (Cash and in-kind services)

Total Cost = $765,000

Flood Analysis Model Objectives:

- Allow the evaluation of the effects of reservoir voids and release operations on downstream flood crests for different storm events.

- Provide an analytical tool for the development of flood operating plans for reservoirs.

- Provide for the ability to examine, modify, and improve the model and datasets as new information and technology become available.

- Provide a means of demonstrating the operations of reservoirs and basin hydrology.

What the Model Will Not Do

- Will not be run in a real time mode to direct operational changes during flood events. The model is intended to be a planning tool.

Project Milestones

- **Milestone 1 - Presentation of the integrated model, including rainfall and snowmelt runoff, reservoir simulation, and flow routing for the selected "pilot" basin. This is proof of the model concept, but not intended to provide definitive calculations.**

- **Milestone 2 - Model will be completed and discussion will focus on calibration and operation of the model and details associated with the products. (August 08)**

- **Milestone 3 - Presentation of model results and product deliverable. (January 09)**

Disclaimer

- This information reflects the status of the project as of 12 December 2007. Results presented in the following slides are for illustration only, and do not reflect interpretive findings of the project or project team members.

Delaware River Basin Flood Analysis Model

Pilot Application
December 12, 2007

Delaware River Basin Commission
DELAWARE · NEW JERSEY
PENNSYLVANIA · NEW YORK
UNITED STATES OF AMERICA

US Army Corps of Engineers®

NOAA
NATIONAL WEATHER SERVICE

USGS
science for a changing world

Project Team

- Delaware River Basin Commission
  - Water Resources Management Branch
- NOAA's National Weather Service
  - Middle Atlantic River Forecast Center
- U.S. Army Corps of Engineers
  - Hydrologic Engineering Center (HEC)
  - Philadelphia District

Project Team (cont.)

- U.S. Geological Survey
  - Pennsylvania Water Science Center
  - New Jersey Water Science Center
  - National Research Program
  - Office of Surface Water
- Additional data contributors (so far)
  - New York City Dept. of Environmental Protection (DEP)
  - State DEP's and Geological Surveys

Objectives:

For the non-tidal…

- Delaware River Basin above Trenton
- Schuylkill River Basin
- Christina River Basin

- Build Rainfall/Runoff and Snowmelt models
- Build Reservoir Simulation and Flow Routing models
- Develop a model integration tool with:
  - Data management and storage for model input and output
  - Easy-to-use Interface for running models and viewing results
  - Expansion capability for future incorporation of improved algorithms and datasets.

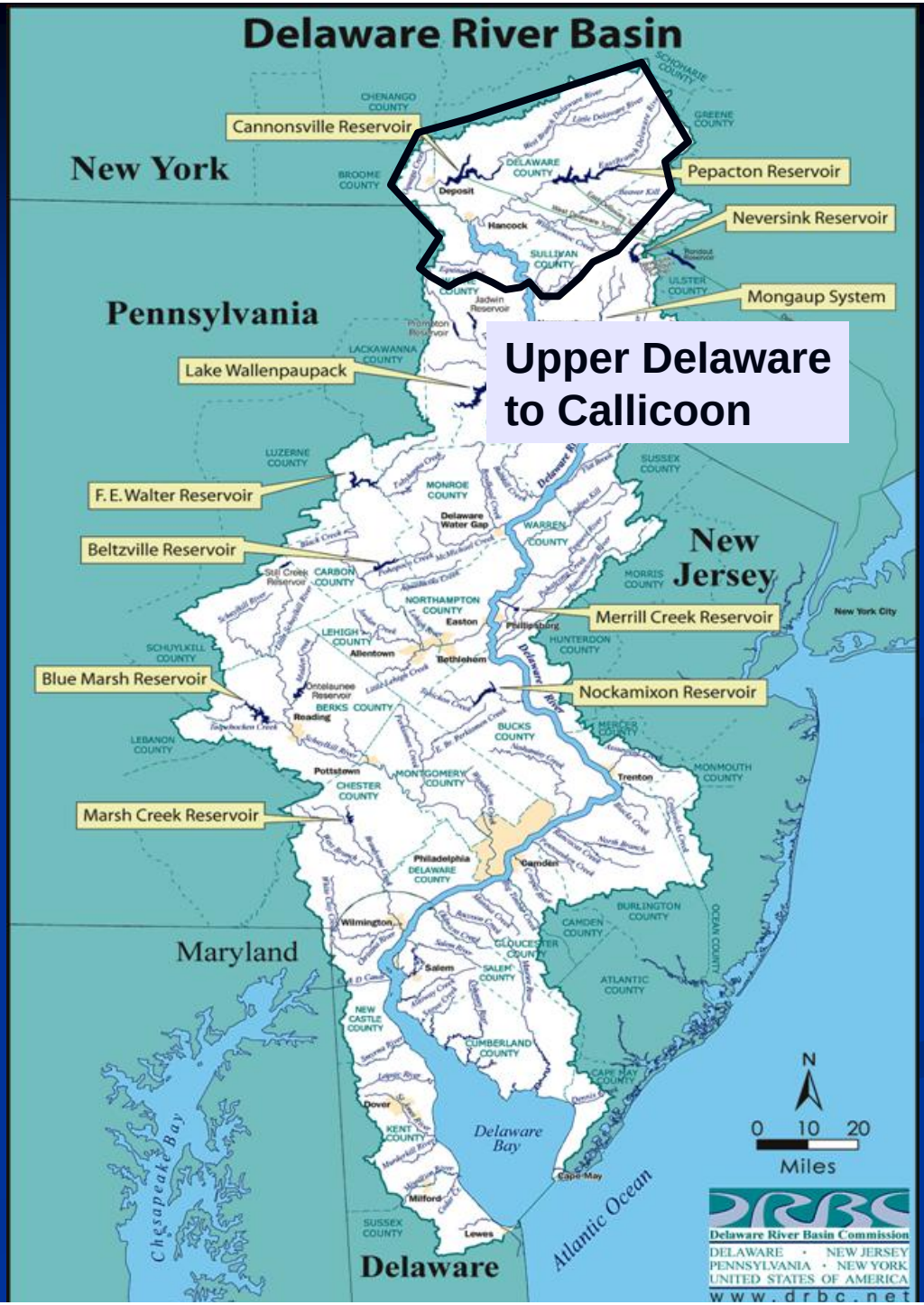
Project Basins

Pilot Application

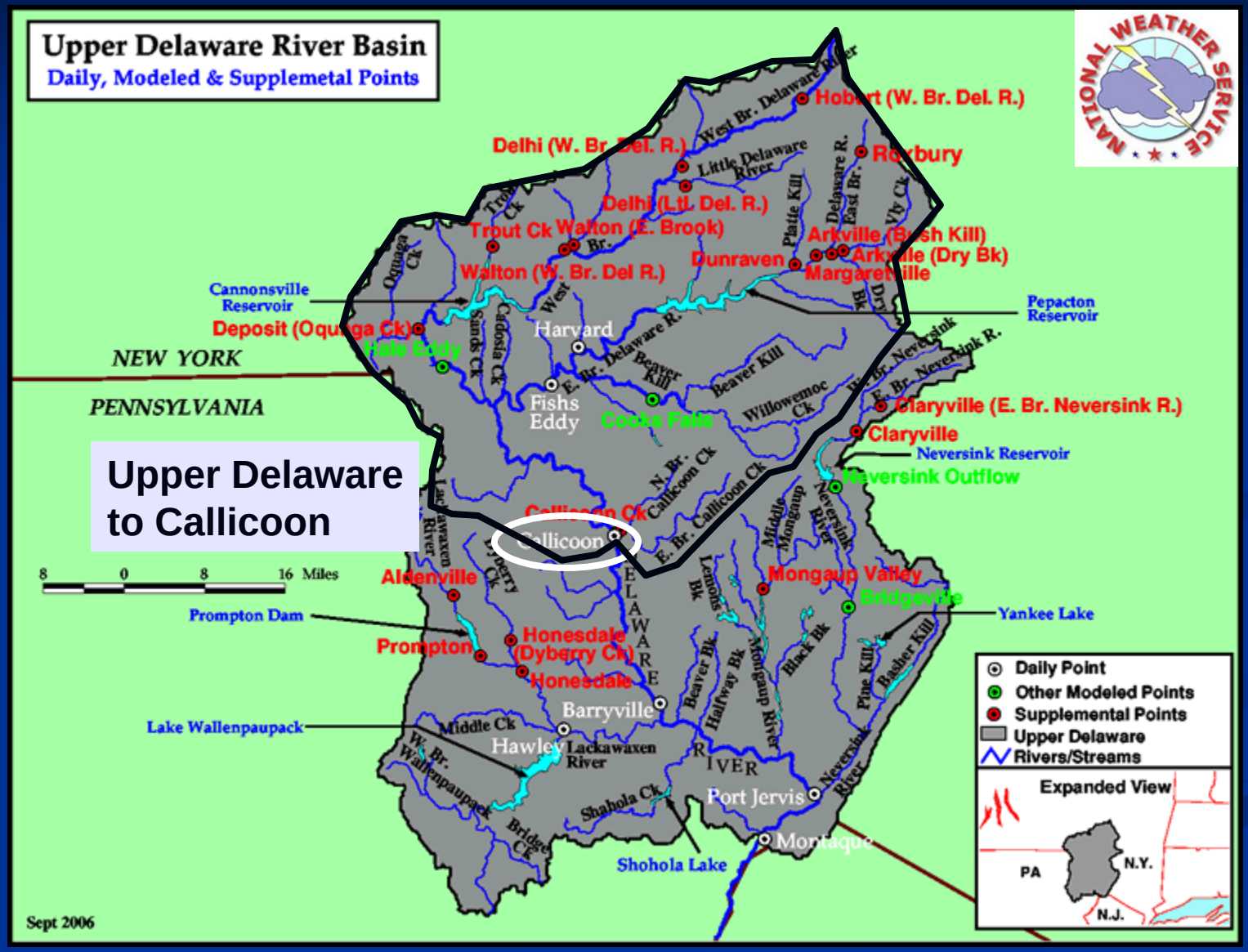
Initially, the model will be applied to a Pilot watershed to:

- avoid incompatibility and integration issues
- provide a test of model functions and integration
- produce a demonstration of ongoing model design at an early stage in project
- provide opportunities for input on the model development approach
- provide ‘proof of concept’ for approach
- Results are shown for illustration only!

Pilot Basin

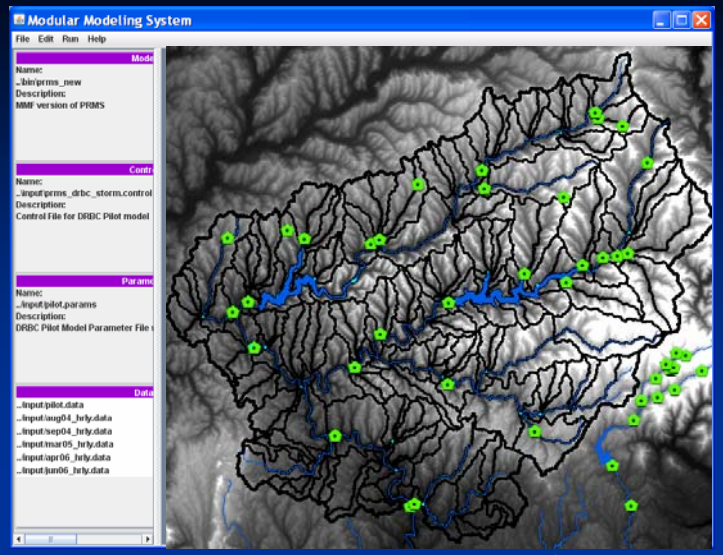

Delaware River Basin
Cannonsville Reservoir
Pepacton Reservoir
Neversink Reservoir
Mongaup System
Upper Delaware to Callicoon
Lake Wallenpaupack
F. E. Walter Reservoir
Beltzville Reservoir
Merrill Creek Reservoir
Blue Marsh Reservoir
Nockamixon Reservoir
Marsh Creek Reservoir
New York
Pennsylvania
New Jersey
Maryland
Delaware
Delaware Bay
Atlantic Ocean
Chesapeake Bay
N
0 10 20
Miles
Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA
www.drbc.net

Pilot Application – Upper Delaware to Callicoon



Project Tasks

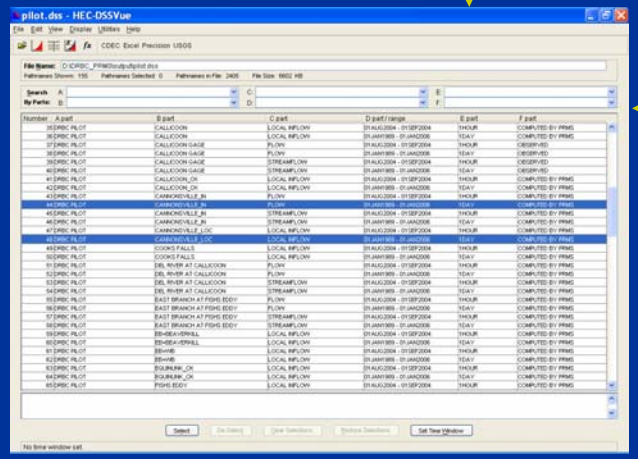
1. Database
2. Rainfall/Runoff and Snowmelt
3. Reservoir Simulation and Flow Routing
4. Integration of Model Components
5. Graphical User Interface

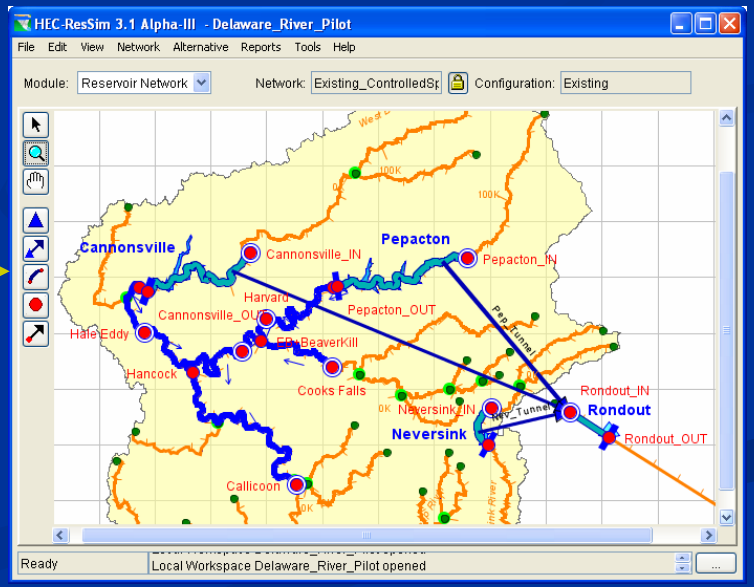


PRMS computes flows to: reservoirs & streams

HEC-ResSim computes flows from reservoirs & routes through streams

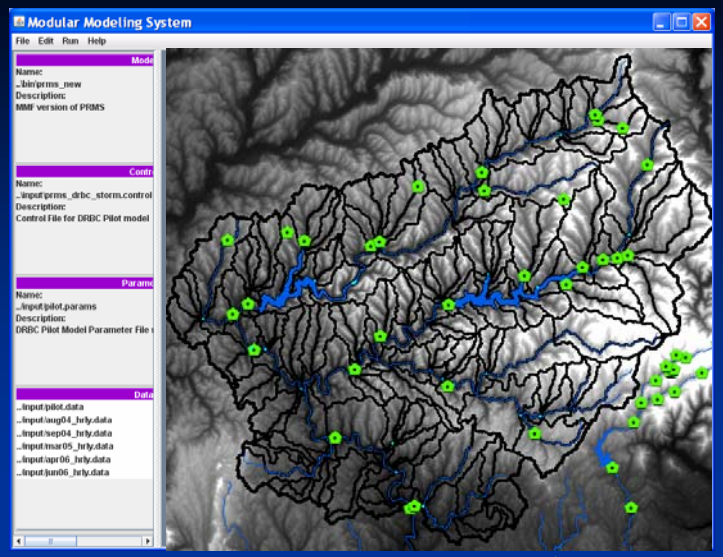
HEC-DSS Database





HEC-**DSS**

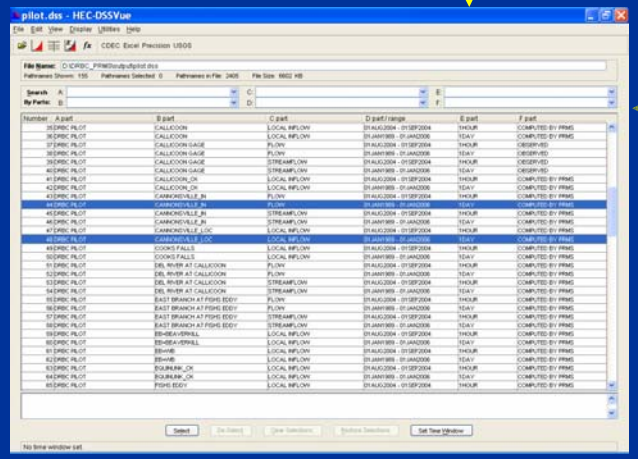
- HEC-**DSS** (**D**ata **S**torage **S**ystem) is a database system developed by the HEC of the USACE designed primarily for water resources applications which allows for:
  - efficient storage and retrieval of time series and other data
  - easy display and editing of data using the HEC-DSSVue software
- PRMS has been updated to store data in and retrieve data from HEC-**DSS** database files

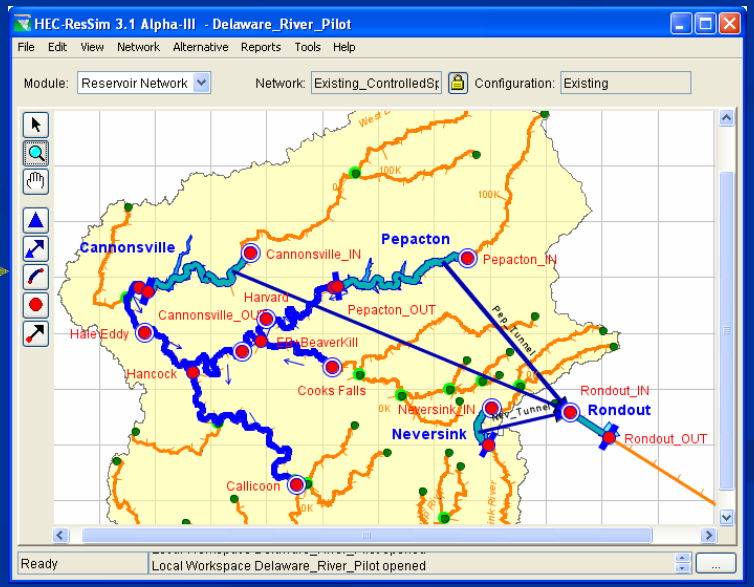


PRMS computes flows to: reservoirs & streams

HEC-ResSim computes flows from reservoirs & routes through streams

HEC-DSS Database

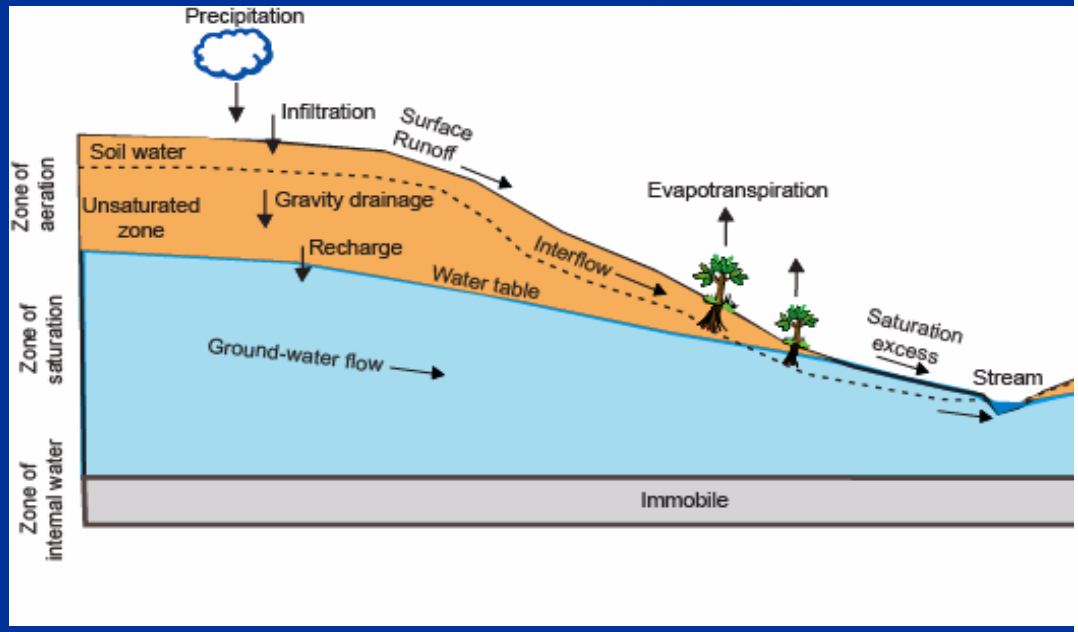




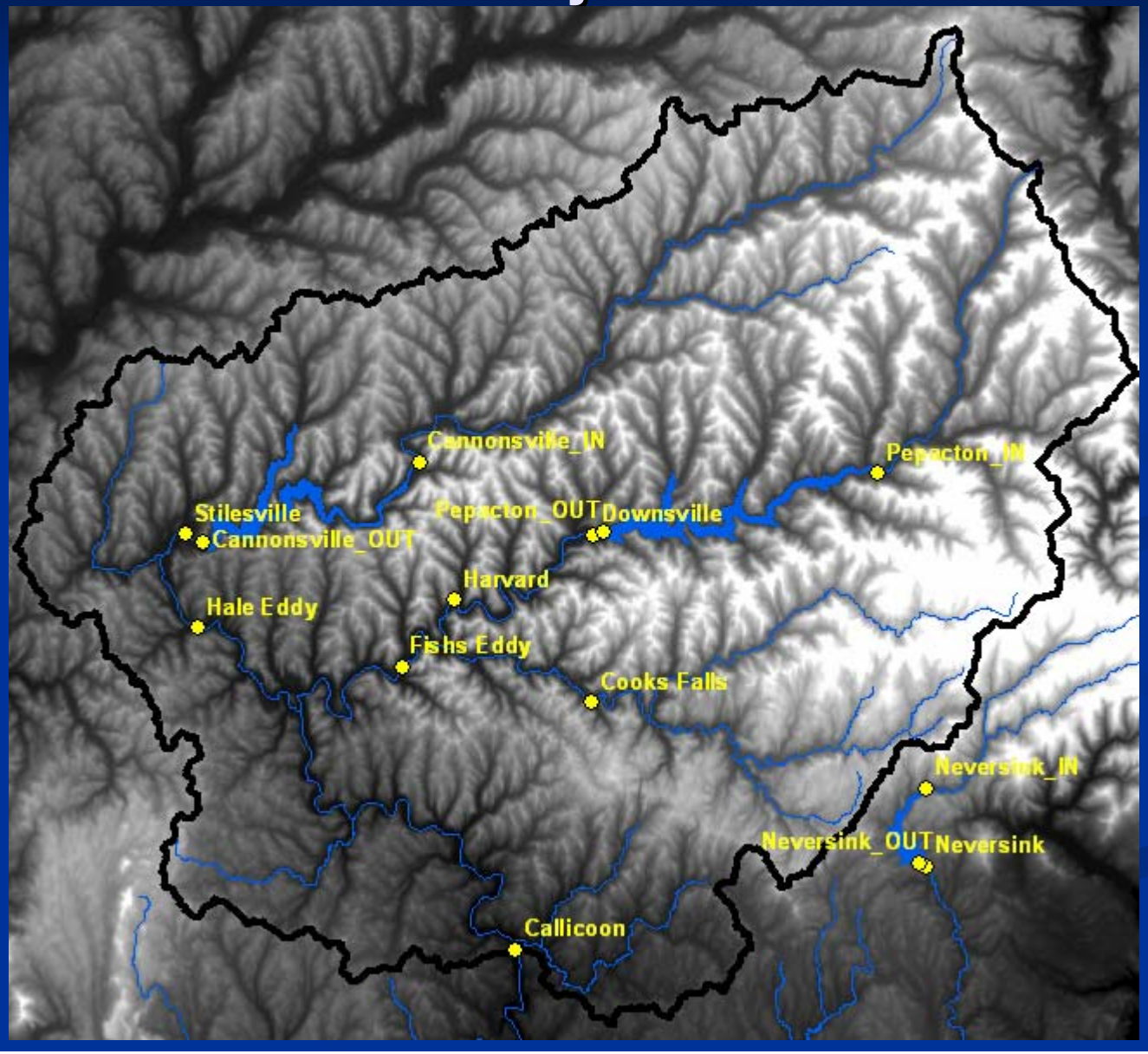
Rainfall/Runoff Model

Precipitation **R**unoff **M**odeling **S**ystem (**PRMS)** is a watershed model developed by the USGS to simulate and evaluate the effects of various combinations of precipitation, climate, and land use on watershed response (Leavesley and others, 1983, 1995, 2005)

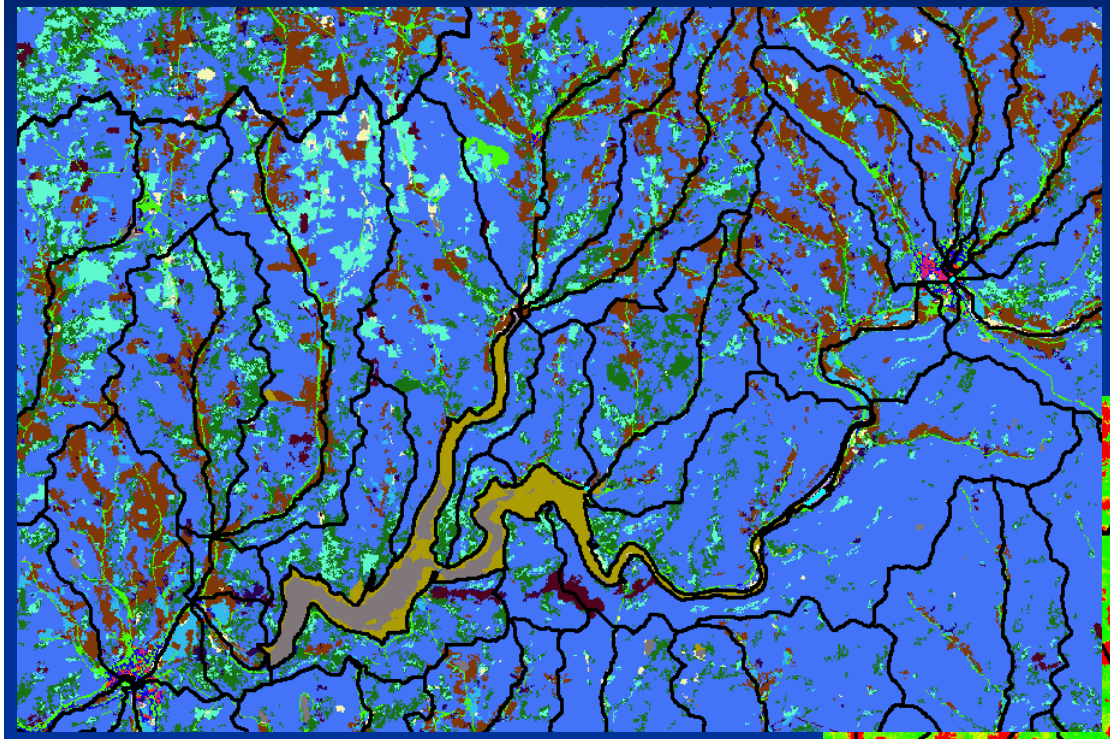
- modularly-designed
- deterministic
- physical-process
- distributed-parameter



Reservoirs, Elevation Data (DEM), and Locations of Major Model Points

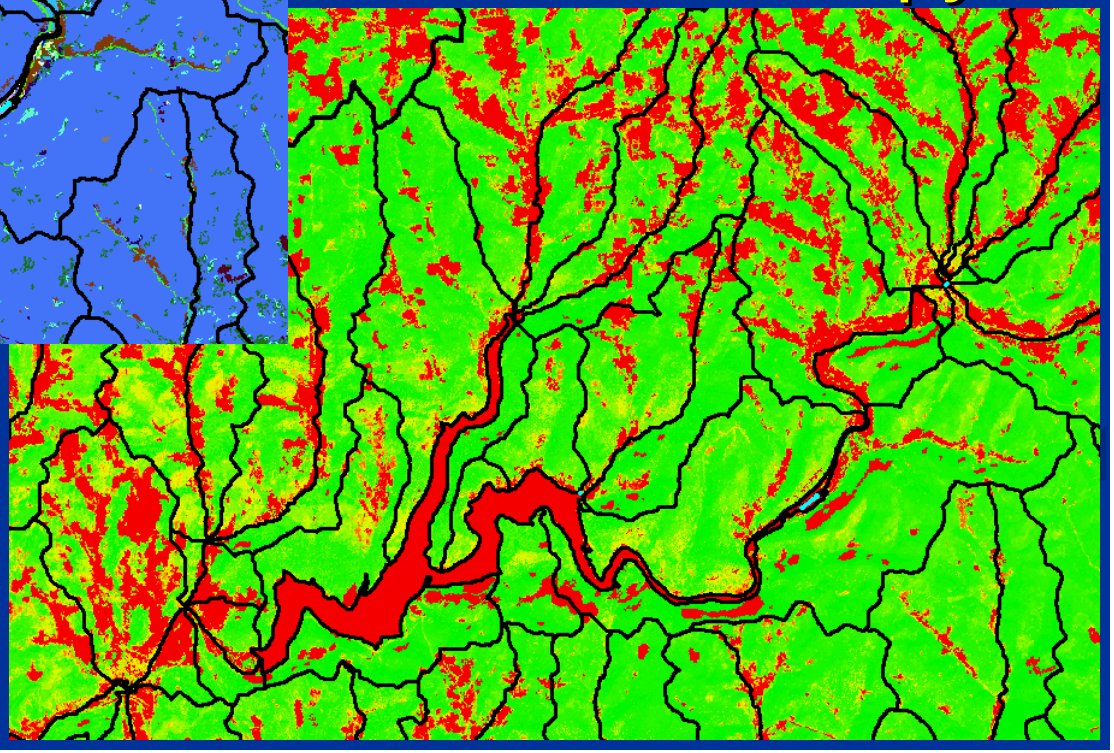


Examples of GIS Input for Rainfall/Runoff Model

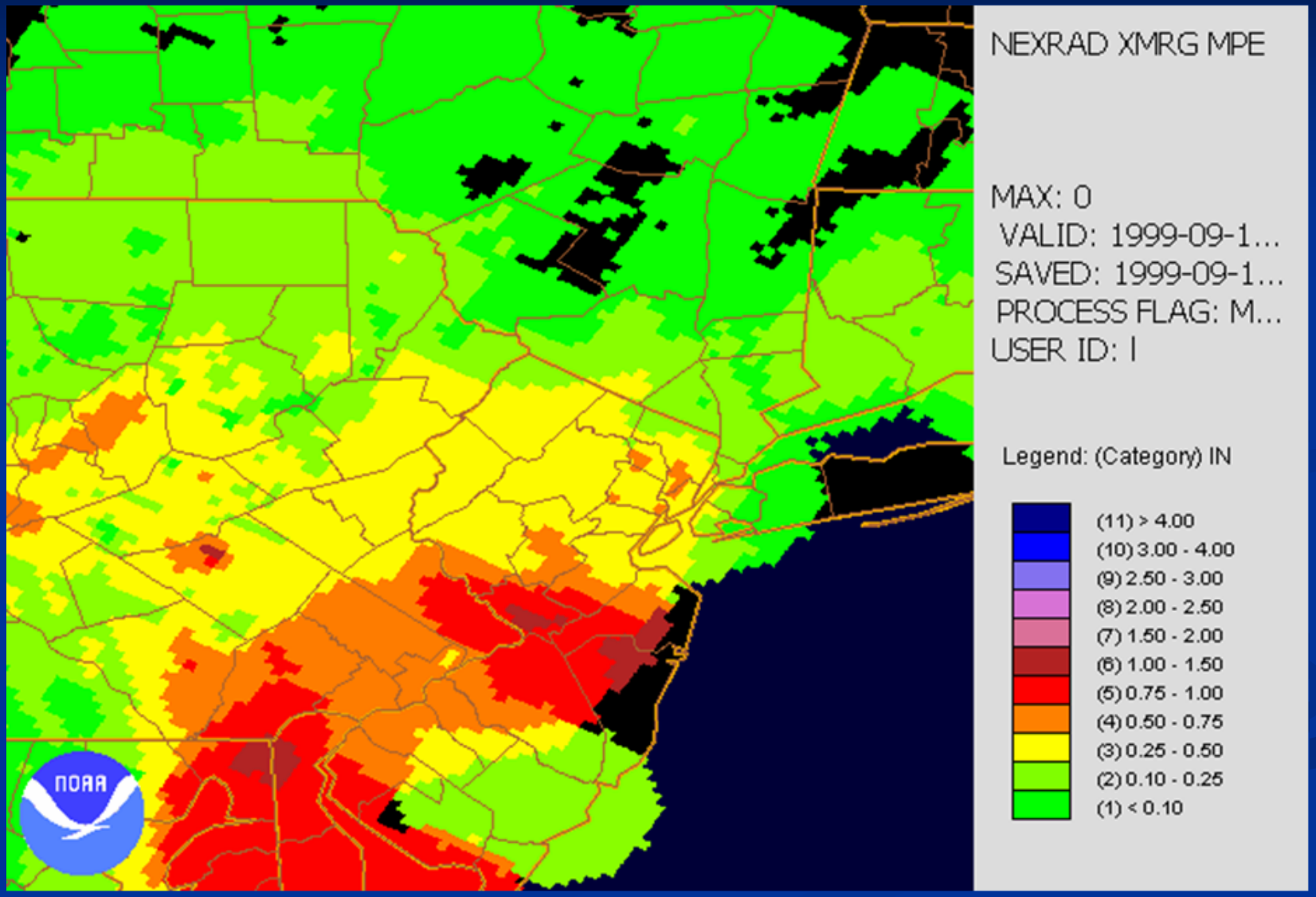


Land Use

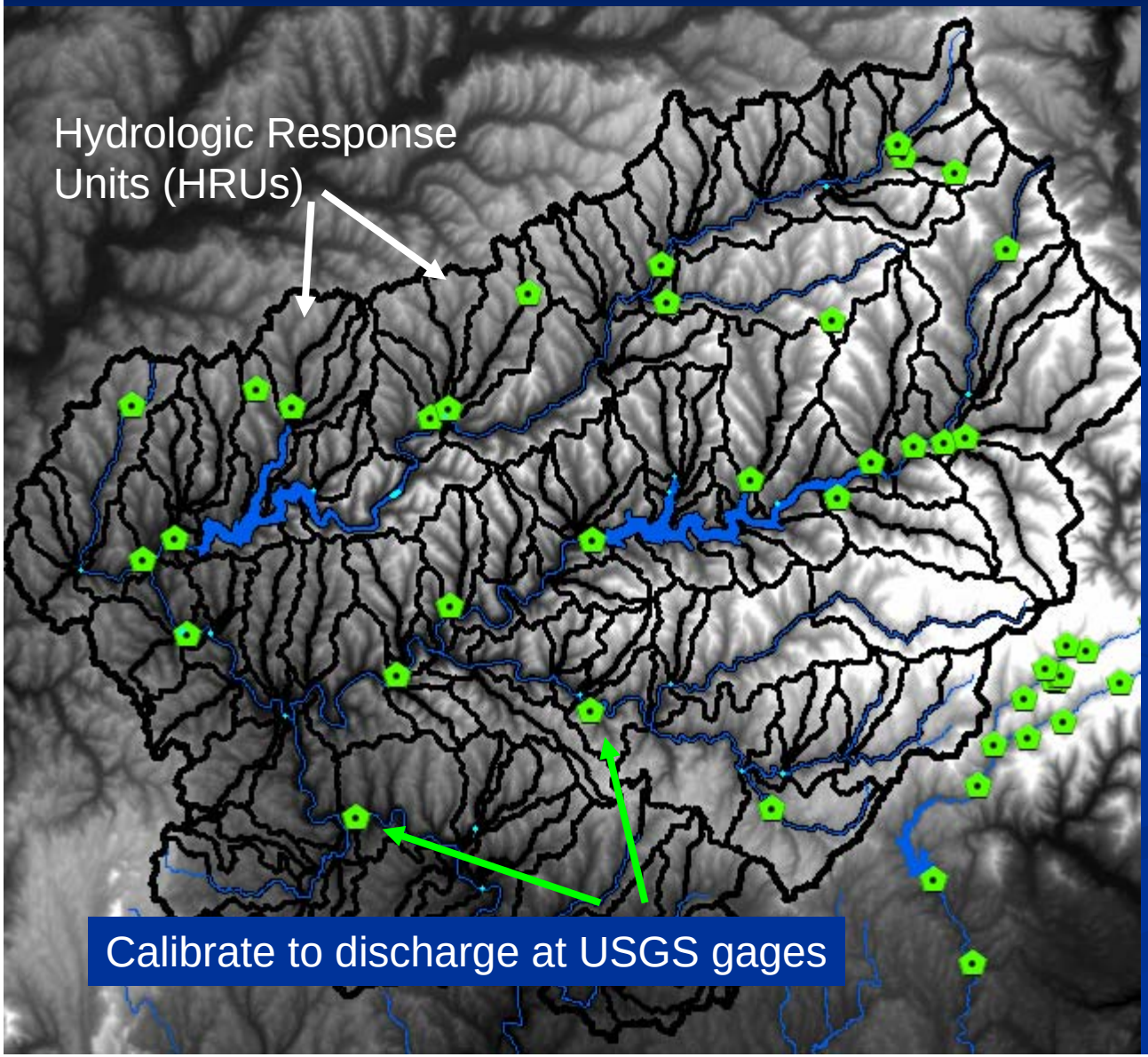
Canopy



Precipitation by Radar (NWS)

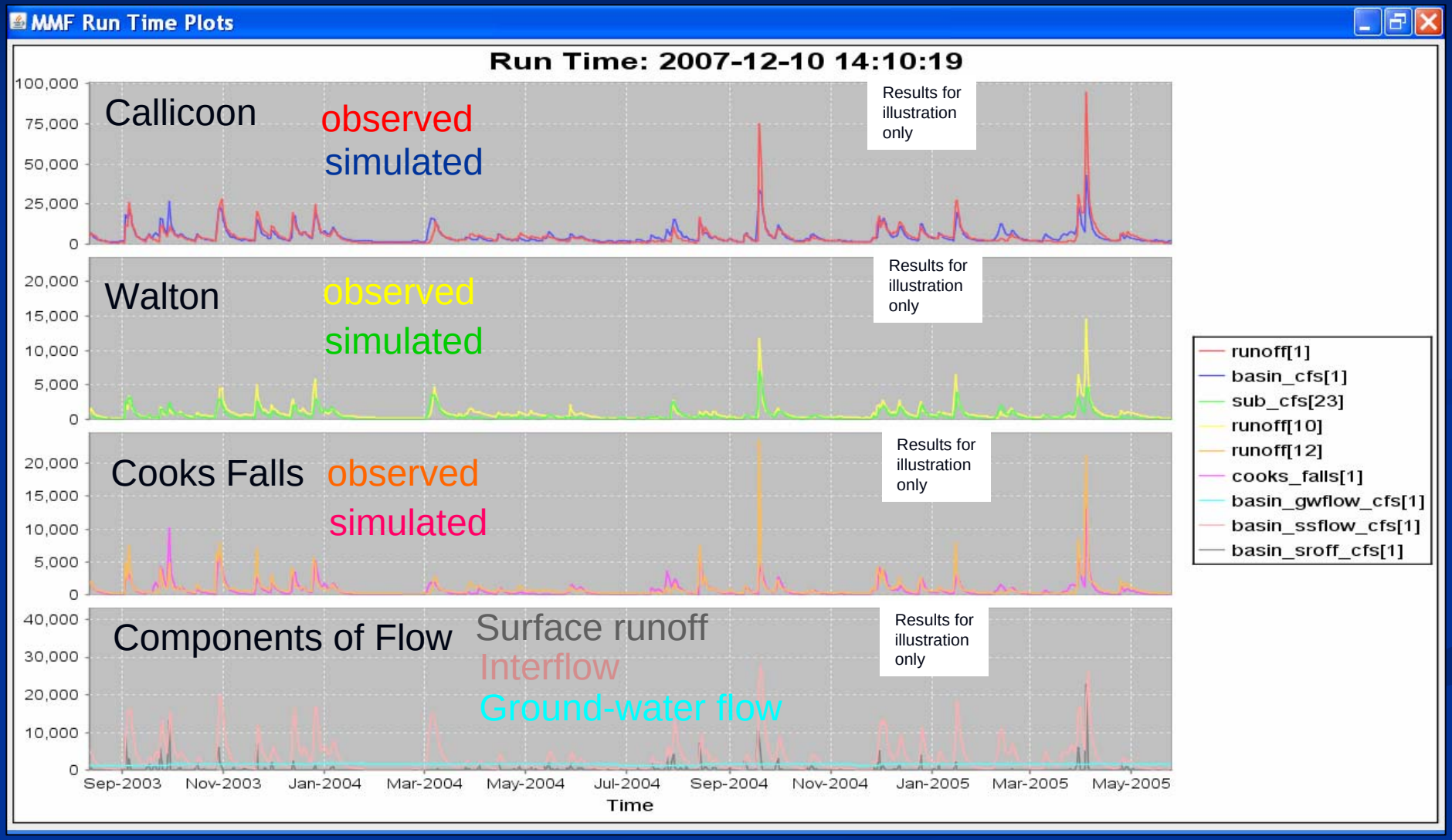


PRMS



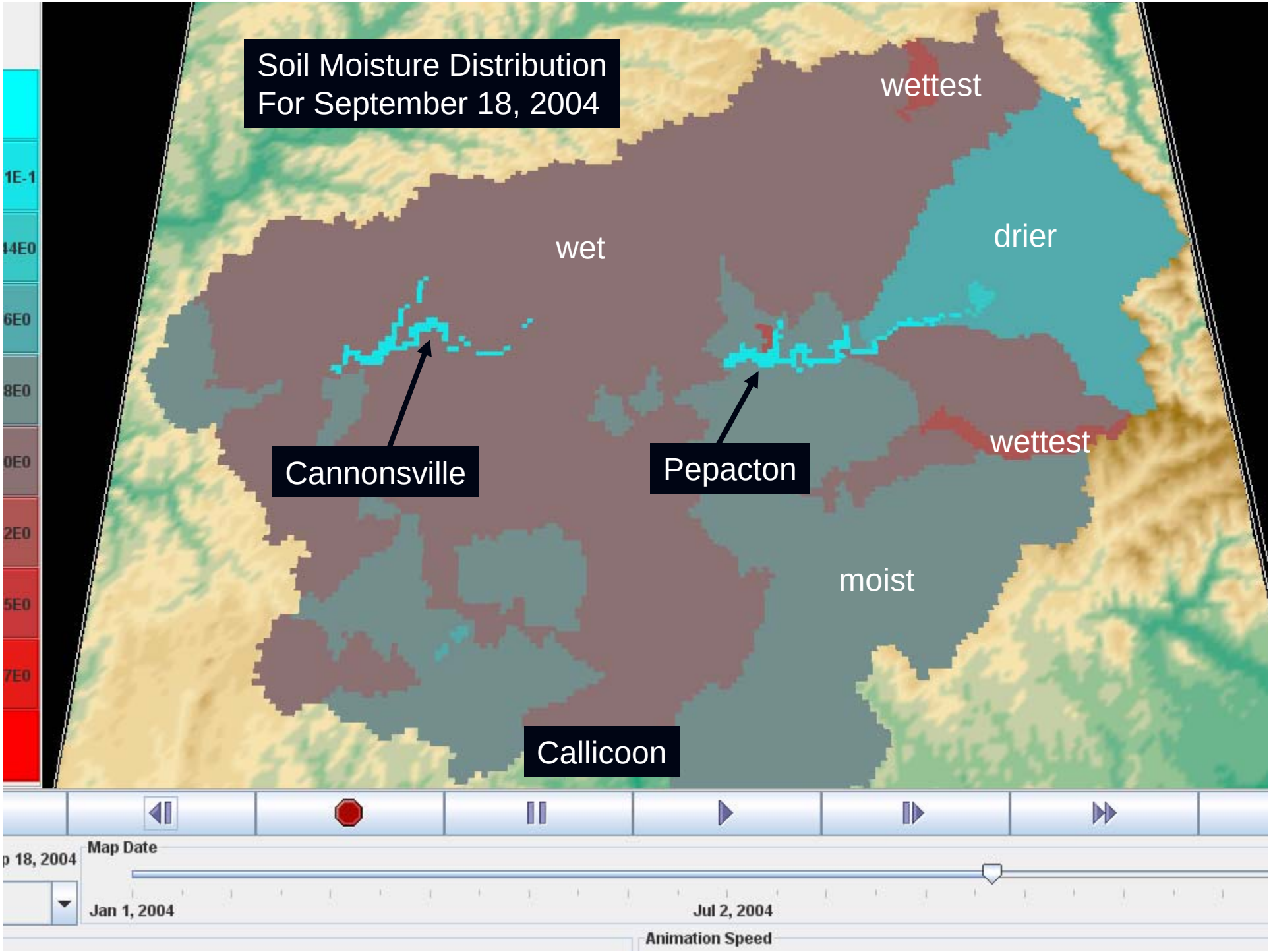
- Discretize Watersheds
- Hydrologic Parameters
- Precipitation Time Series
- Store data & results in DSS File

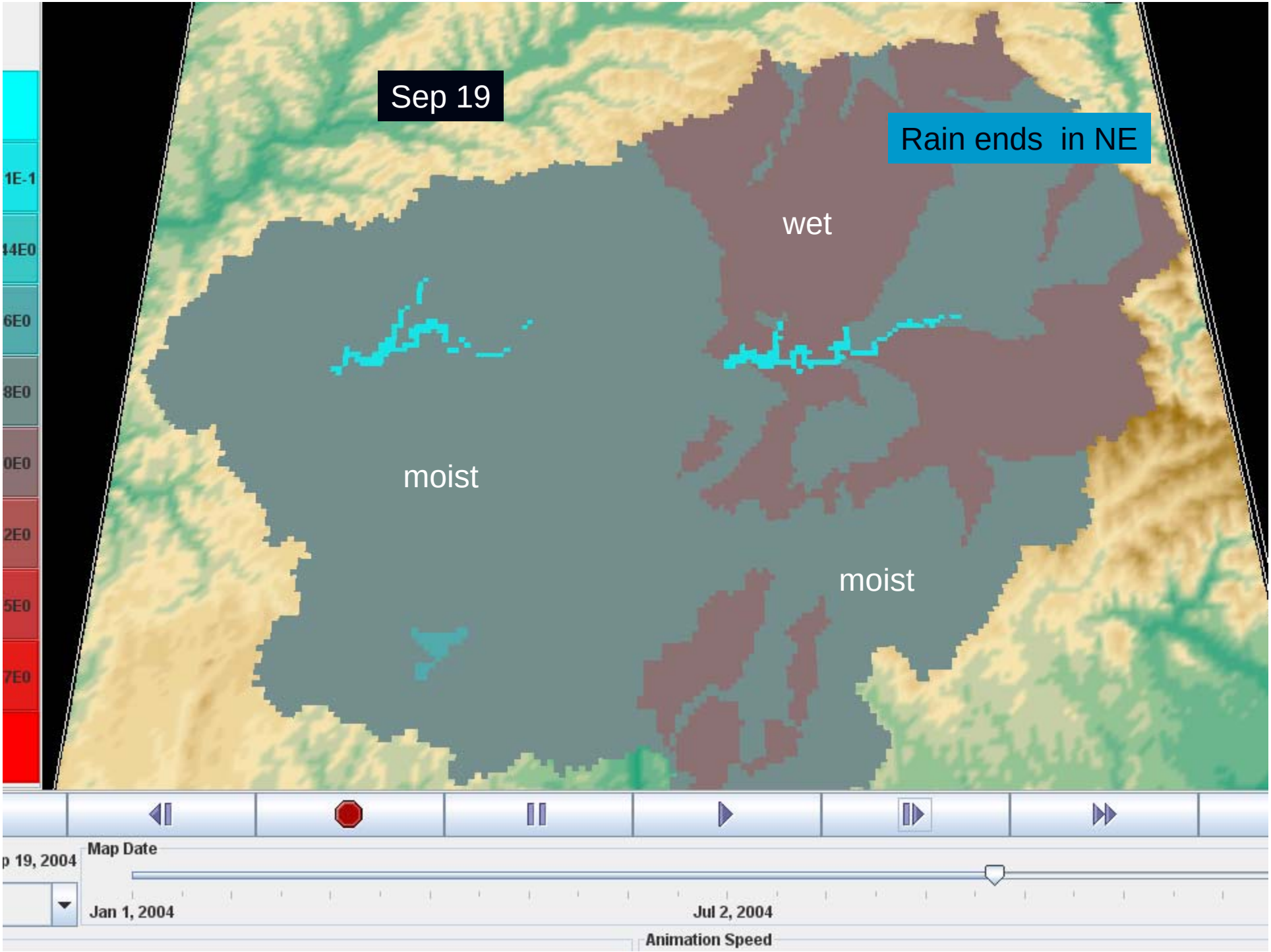
PRMS Execution

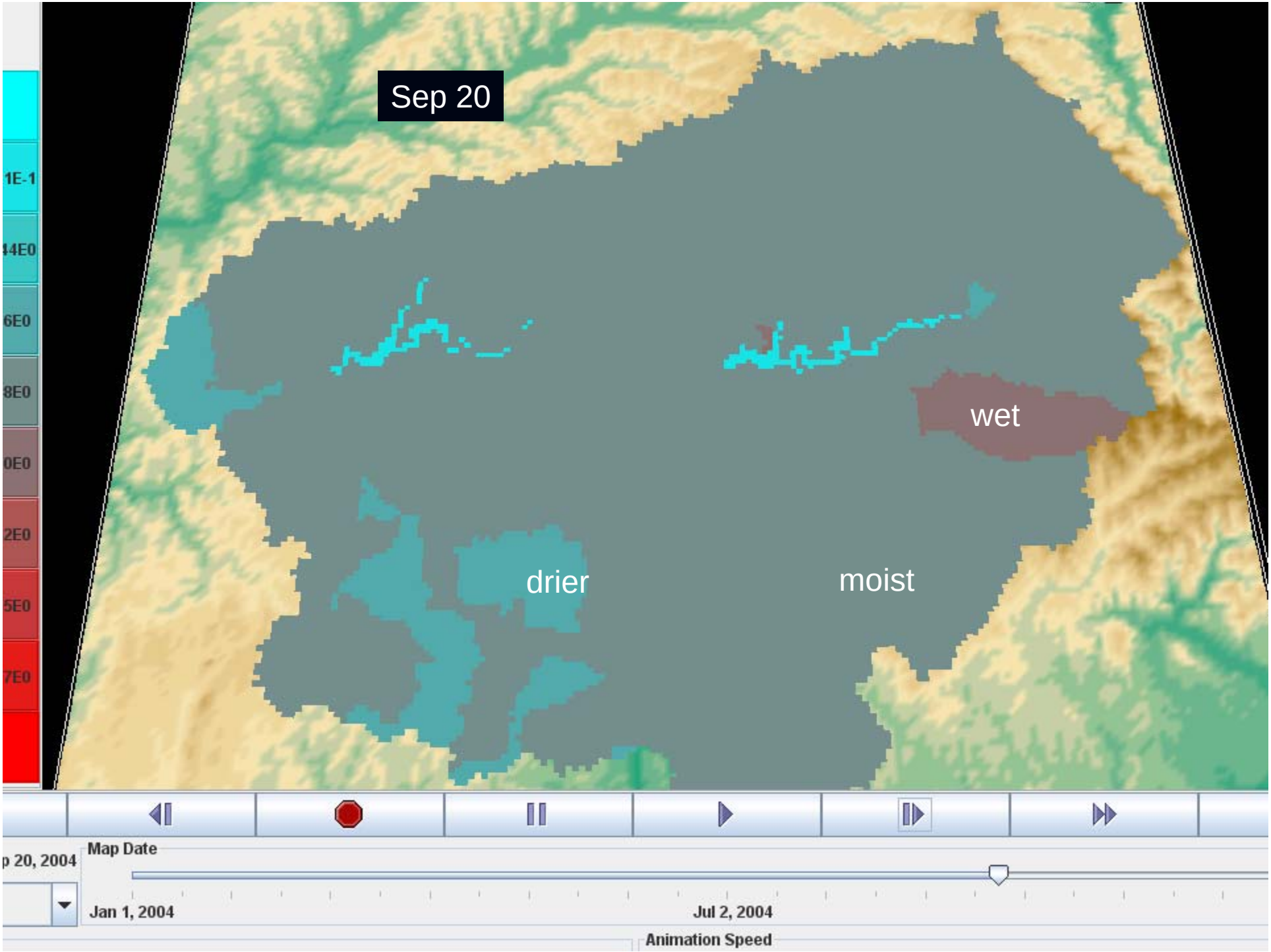


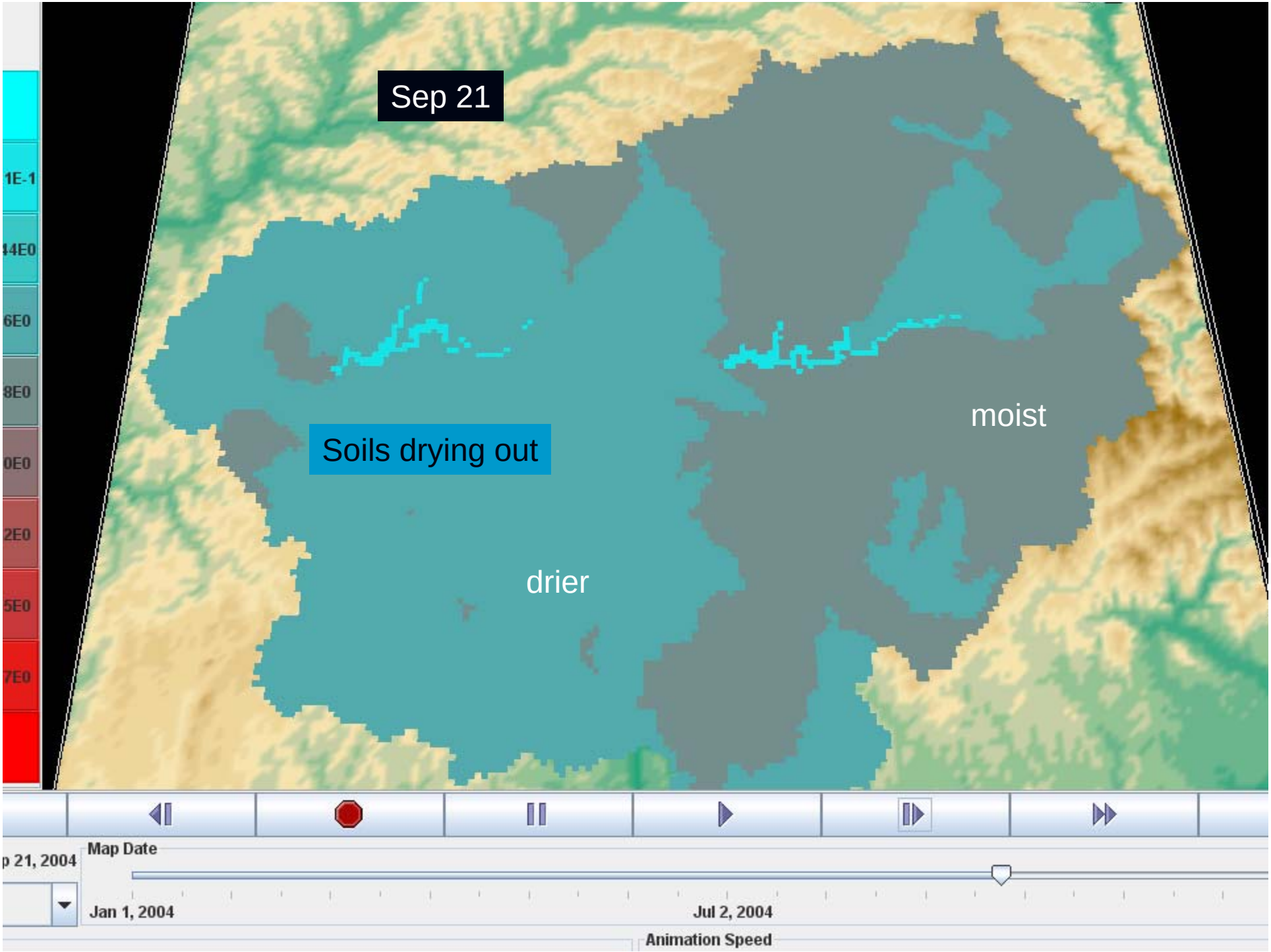
PRMS

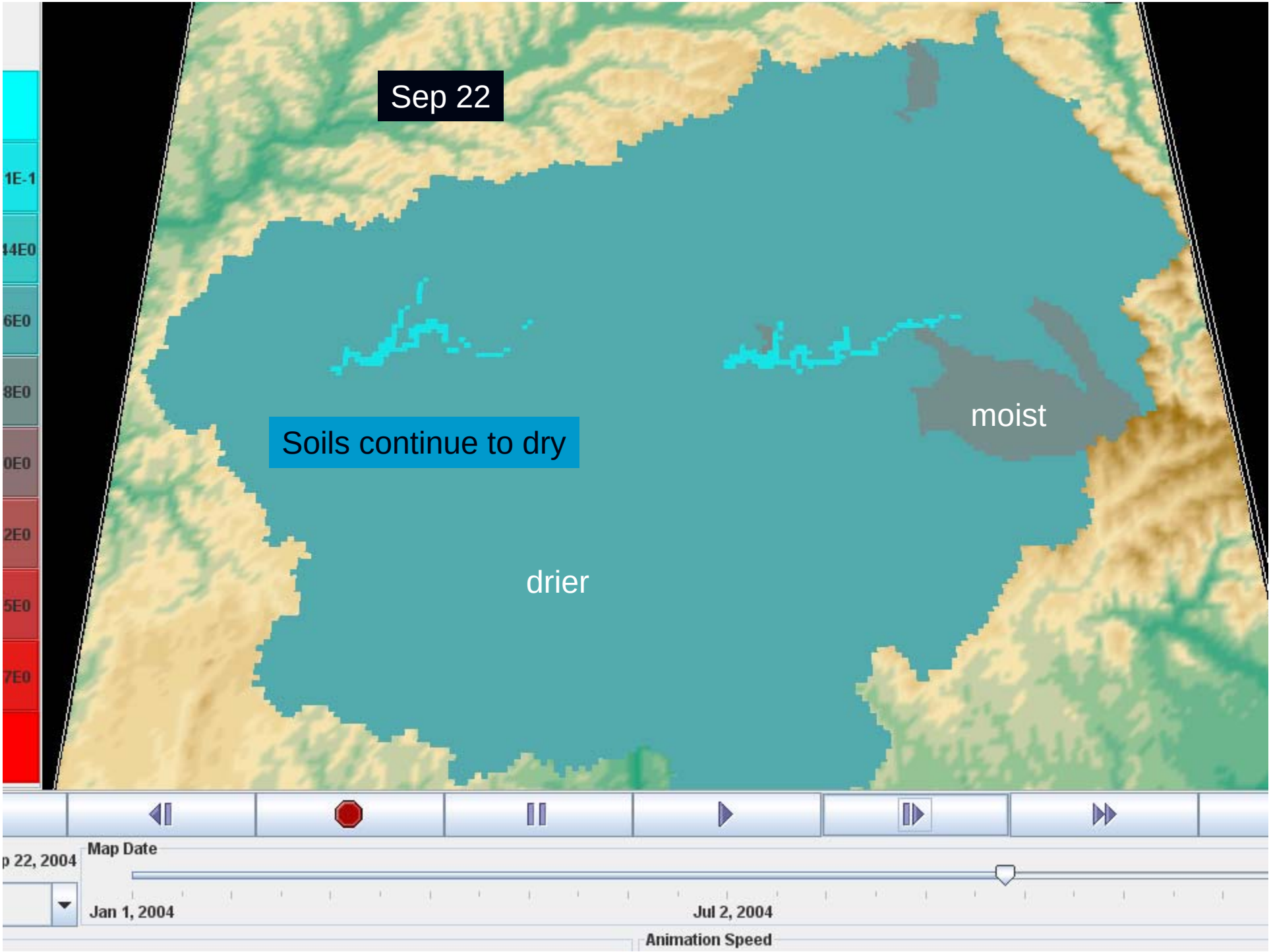
- Demo of PRMS for the Pilot basin…

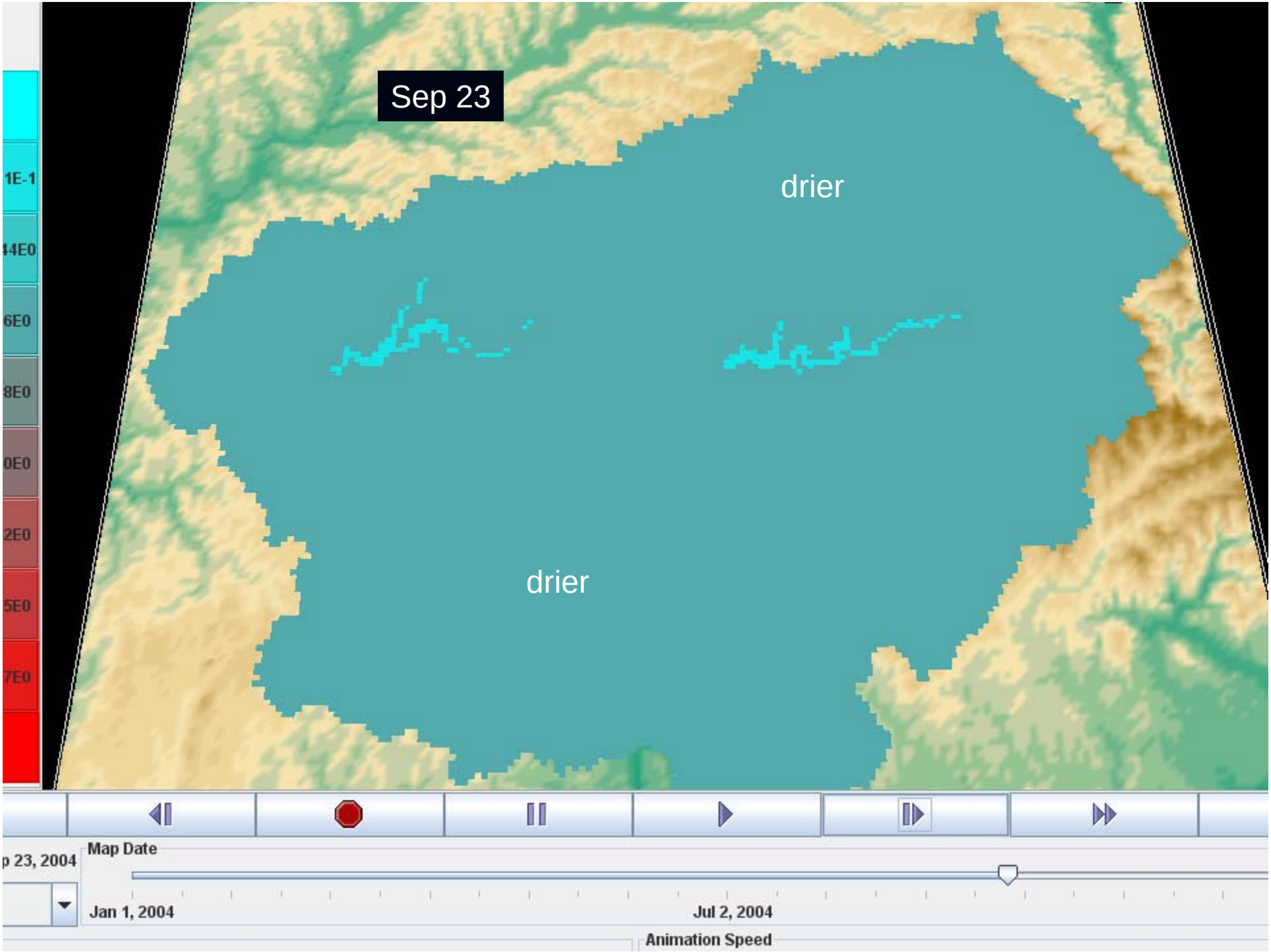

Soil Moisture Distribution
For September 18, 2004
wettest
wet
drier
wettest
moist
Cannonsville
Pepacton
Callicoon
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 18, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed

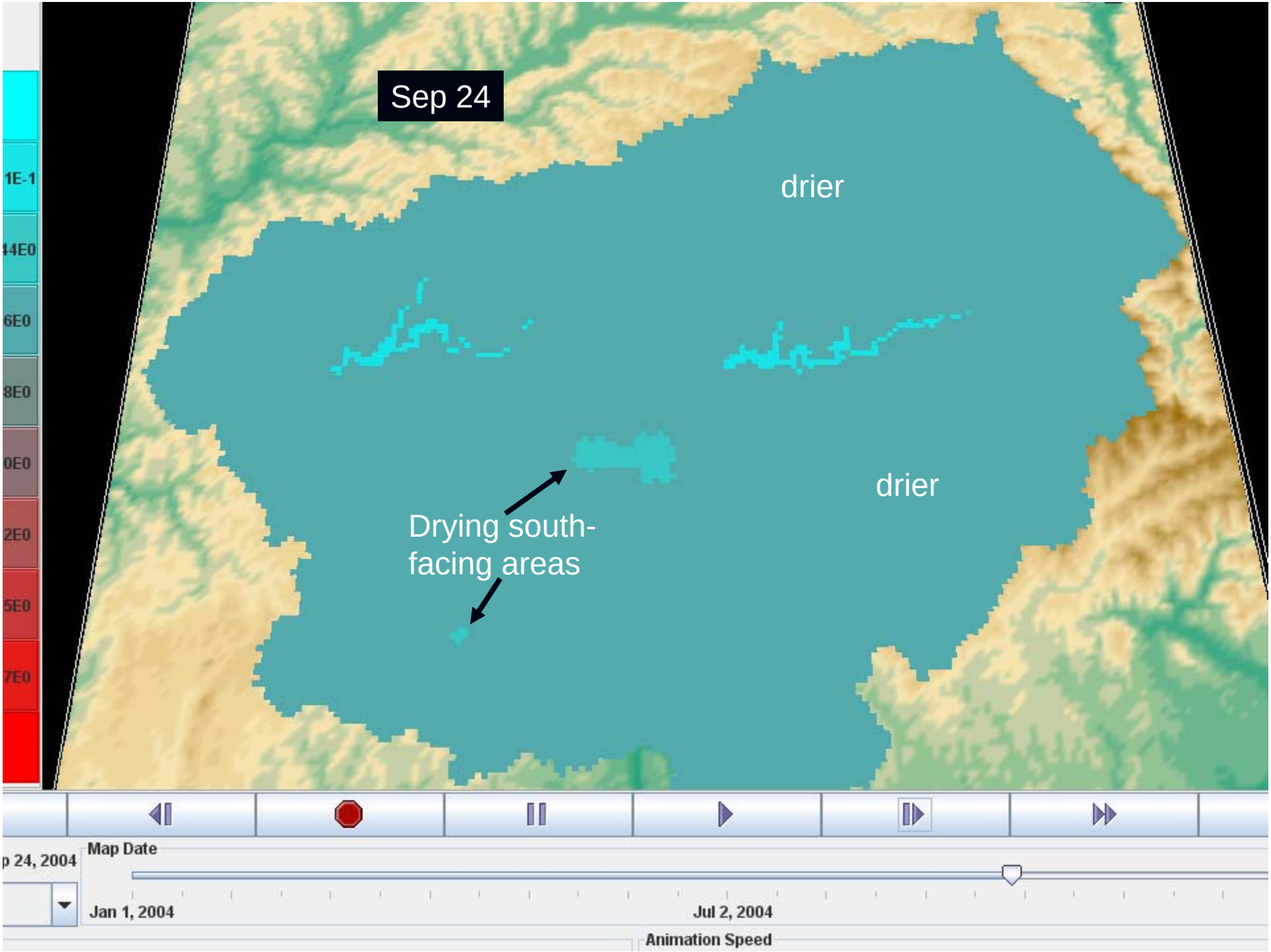

Sep 19
Rain ends in NE
wet
moist
moist
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 19, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed

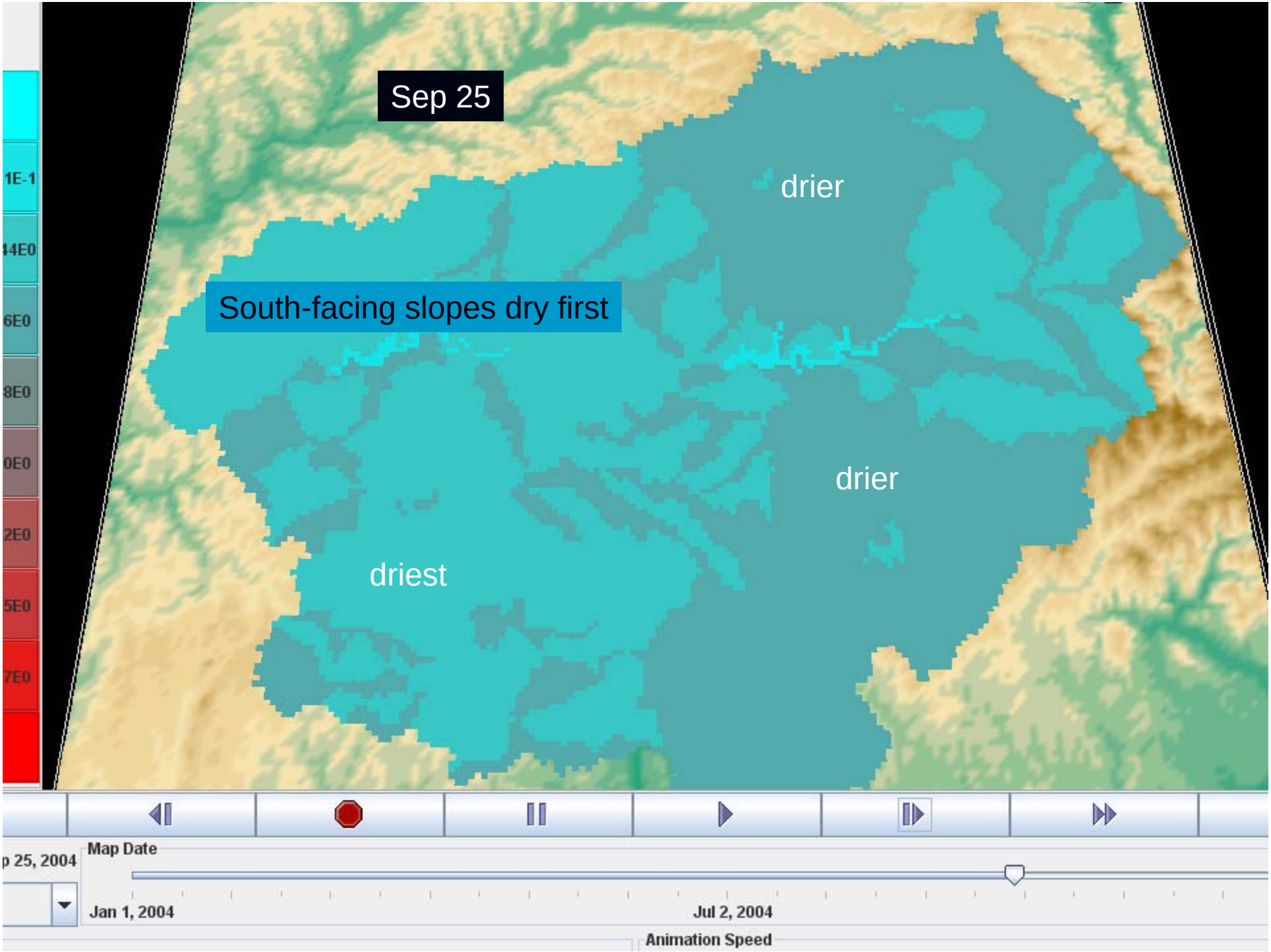

Sep 20
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
wet
drier
moist
p 20, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed

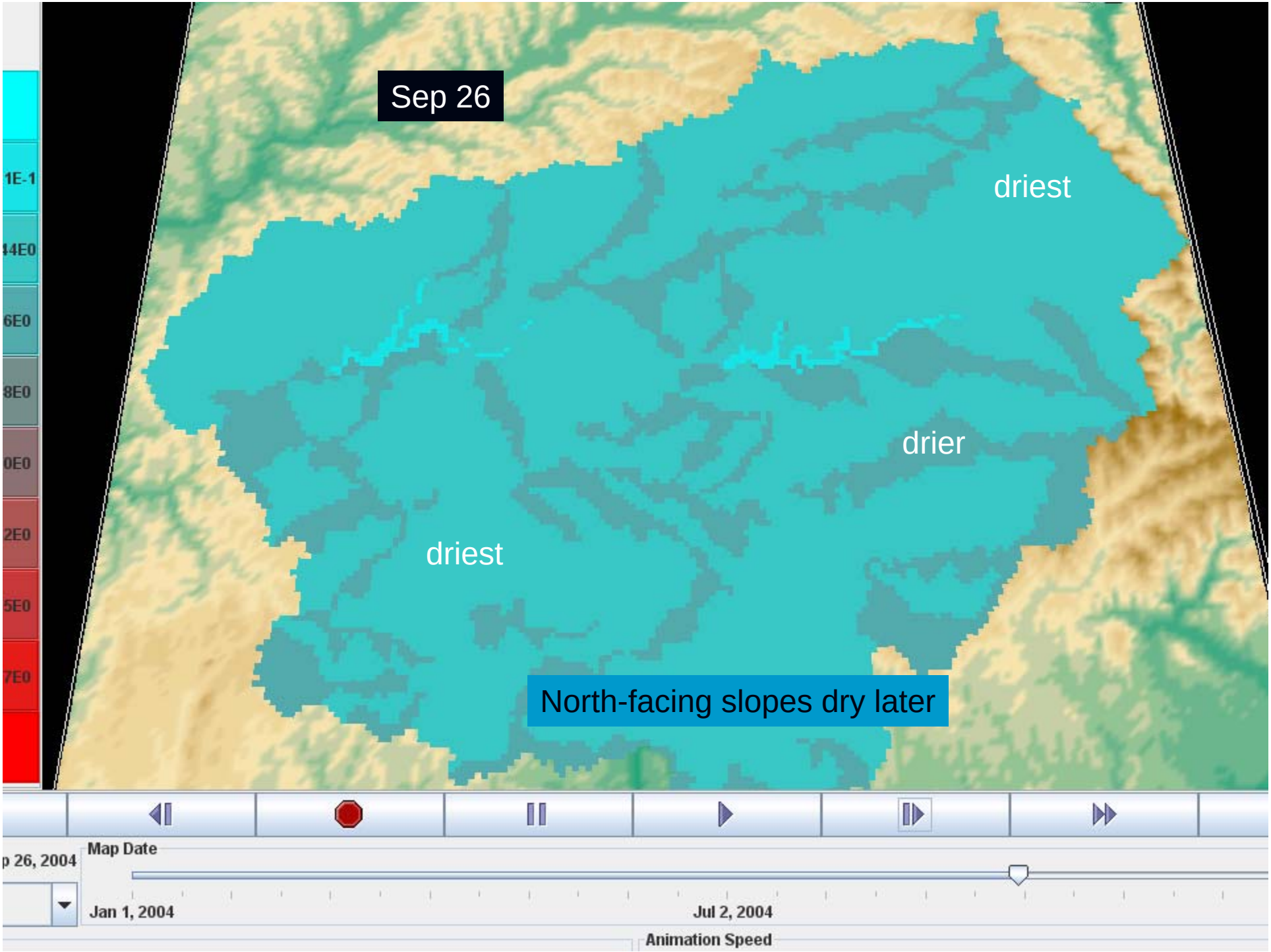

Sep 21
Soils drying out
moist
drier
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 21, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed


Sep 22
Soils continue to dry
moist
drier
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 22, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed


Sep 23
drier
drier
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 23, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed

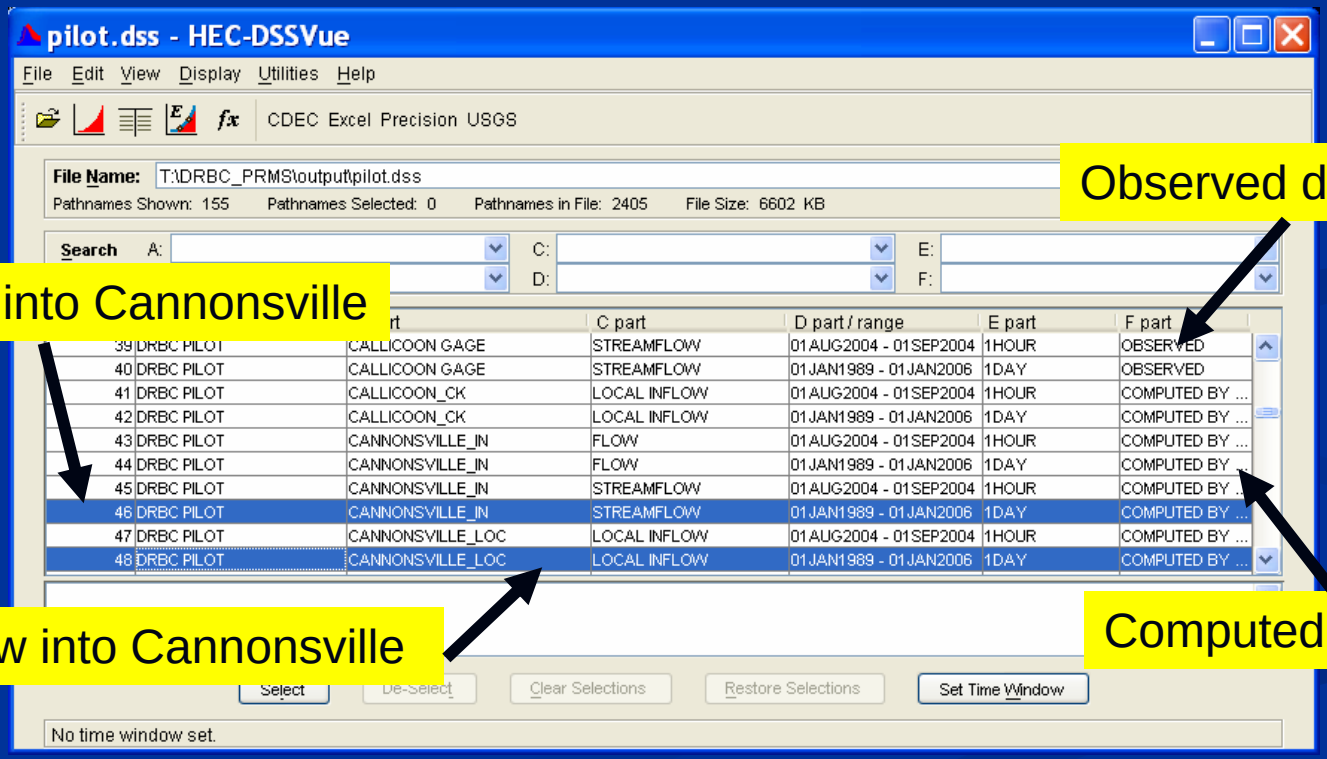

Sep 24
drier
drier
Drying south-
facing areas
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 24, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed


Sep 25
South-facing slopes dry first
drier
drier
driest
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 25, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed

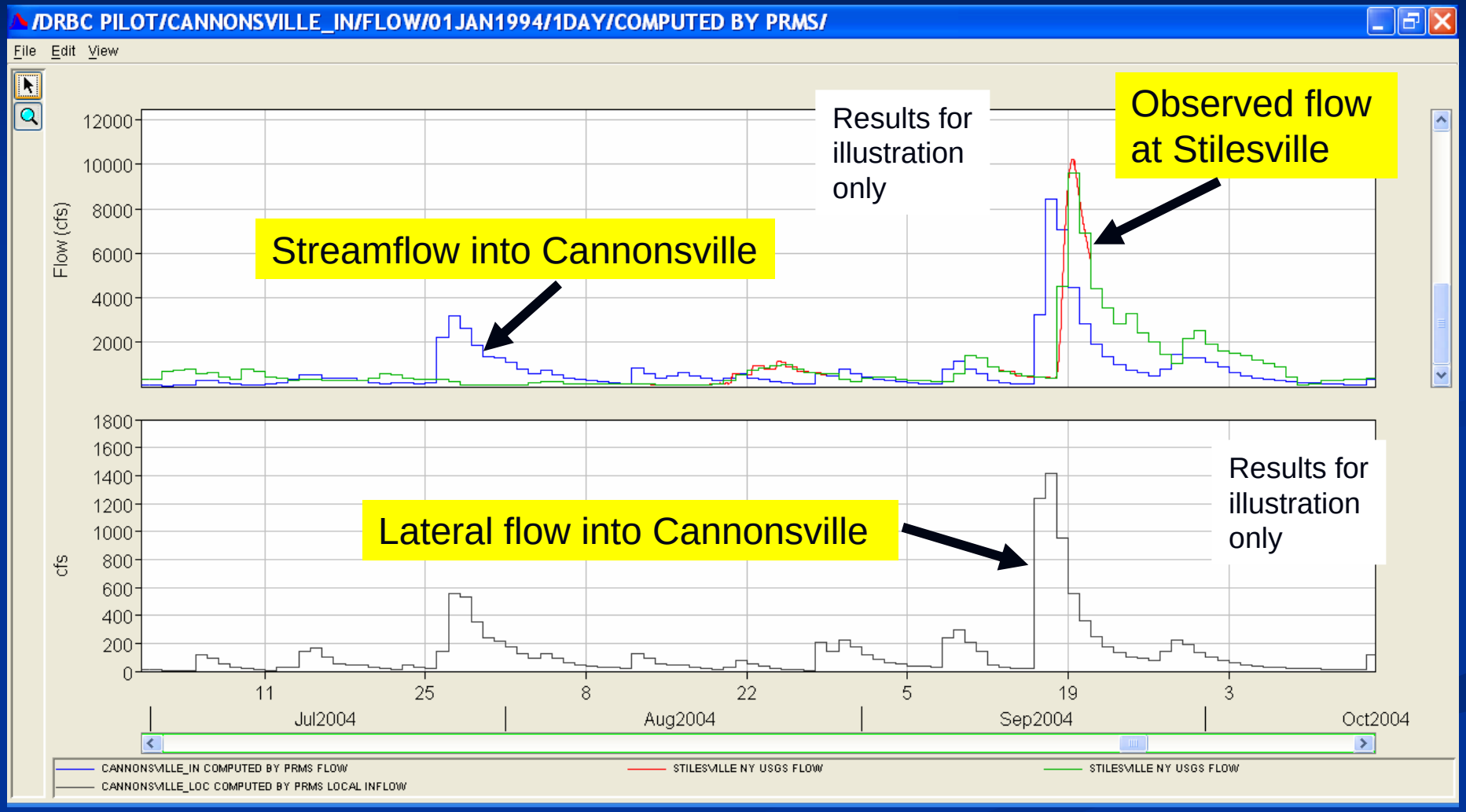

Sep 26
driest
drier
driest
North-facing slopes dry later
1E-1
44E0
6E0
8E0
0E0
2E0
5E0
7E0
p 26, 2004
Map Date
Jan 1, 2004
Jul 2, 2004
Animation Speed

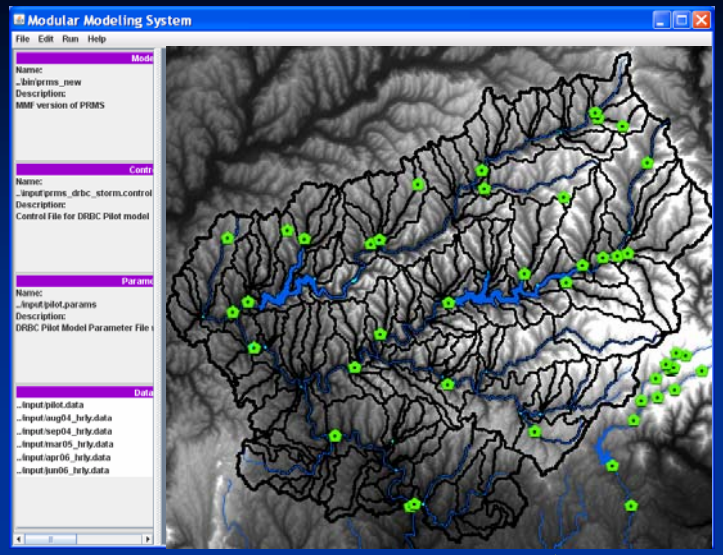
List of data stored in a DSS file

- **HEC-DSSVue** is a graphical user interface program for viewing, editing, and manipulating data in **HEC-DSS** database files



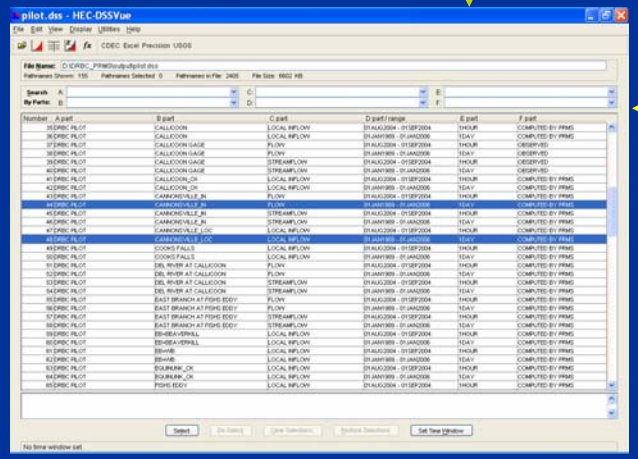
Selected Data from DSS File



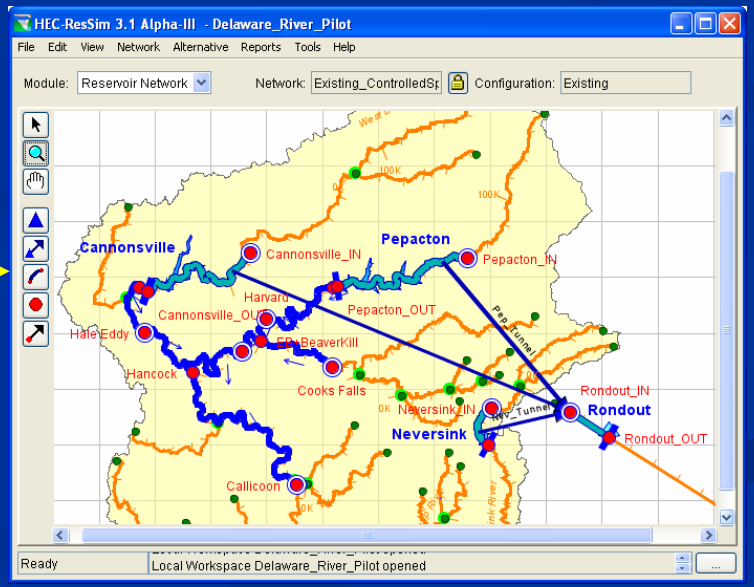


PRMS computes flows to: reservoirs & streams

HEC-DSS Database



HEC-ResSim computes flows from reservoirs & routes through streams



Reservoir Simulation

HEC-ResSim is:

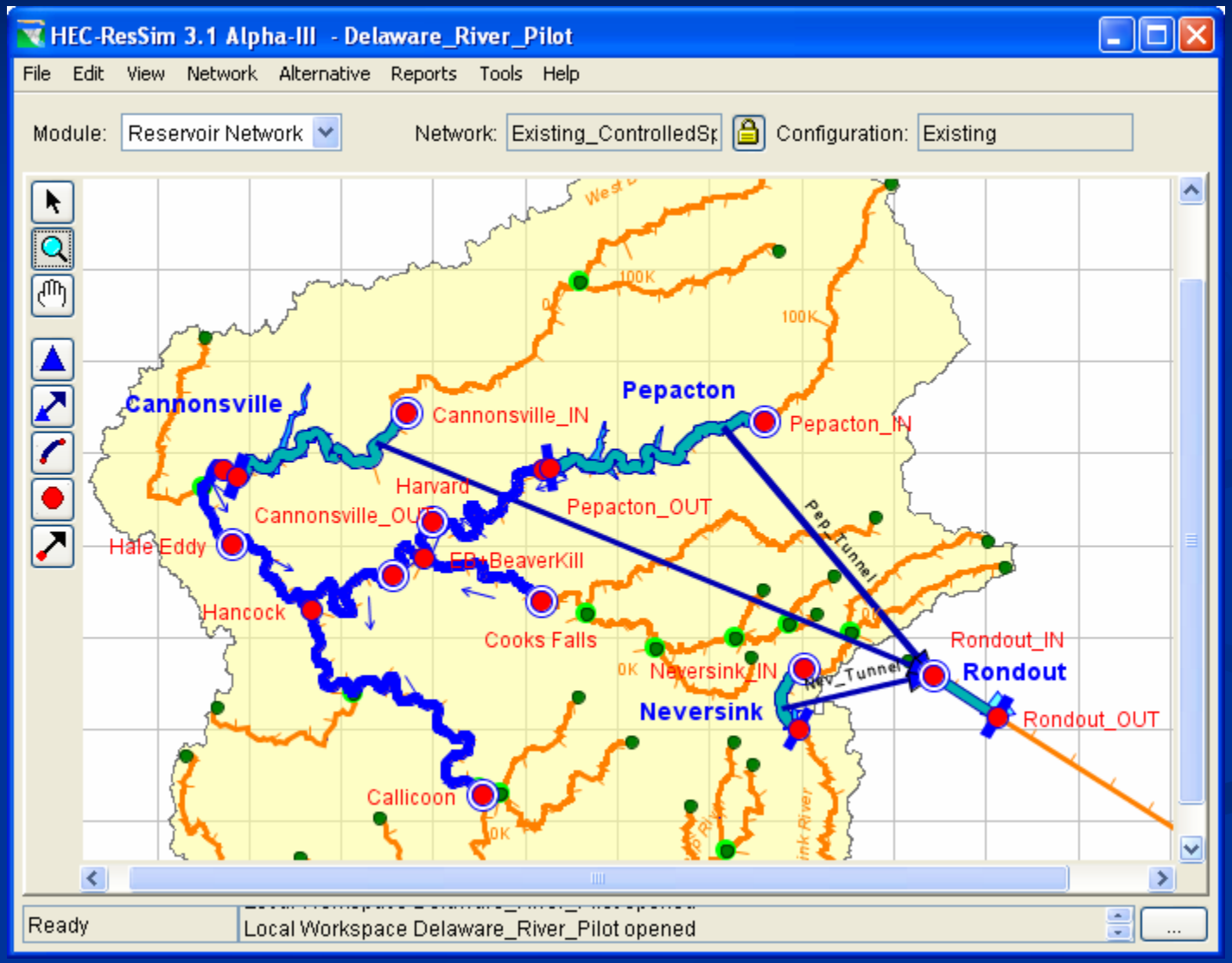
- a *generalized* reservoir simulation program developed by the US Army Corps of Engineers.
- designed to simulate the operation of a reservoir or reservoir system for flood management, as well as flow augmentation, using a user-specified rule-based operation scheme.
- quickly becoming the state-of-the-practice by those performing reservoir analysis.
- currently being used on a number of sophisticated, comprehensive, and, at times, controversial projects.

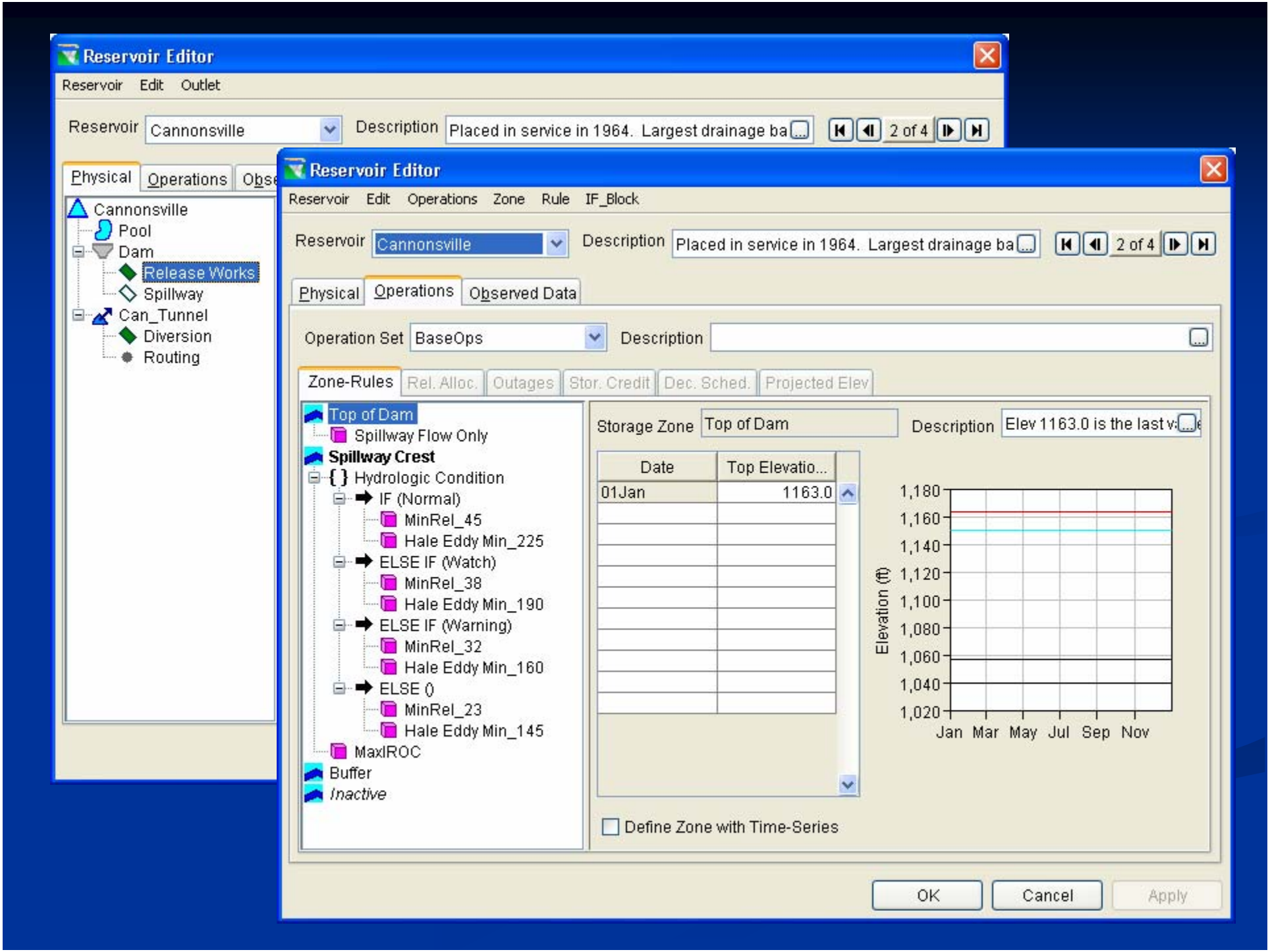
Reservoir Simulation

HEC-ResSim is being used to develop the reservoir simulation component of the Delaware River Basin Flood Analysis Model to:

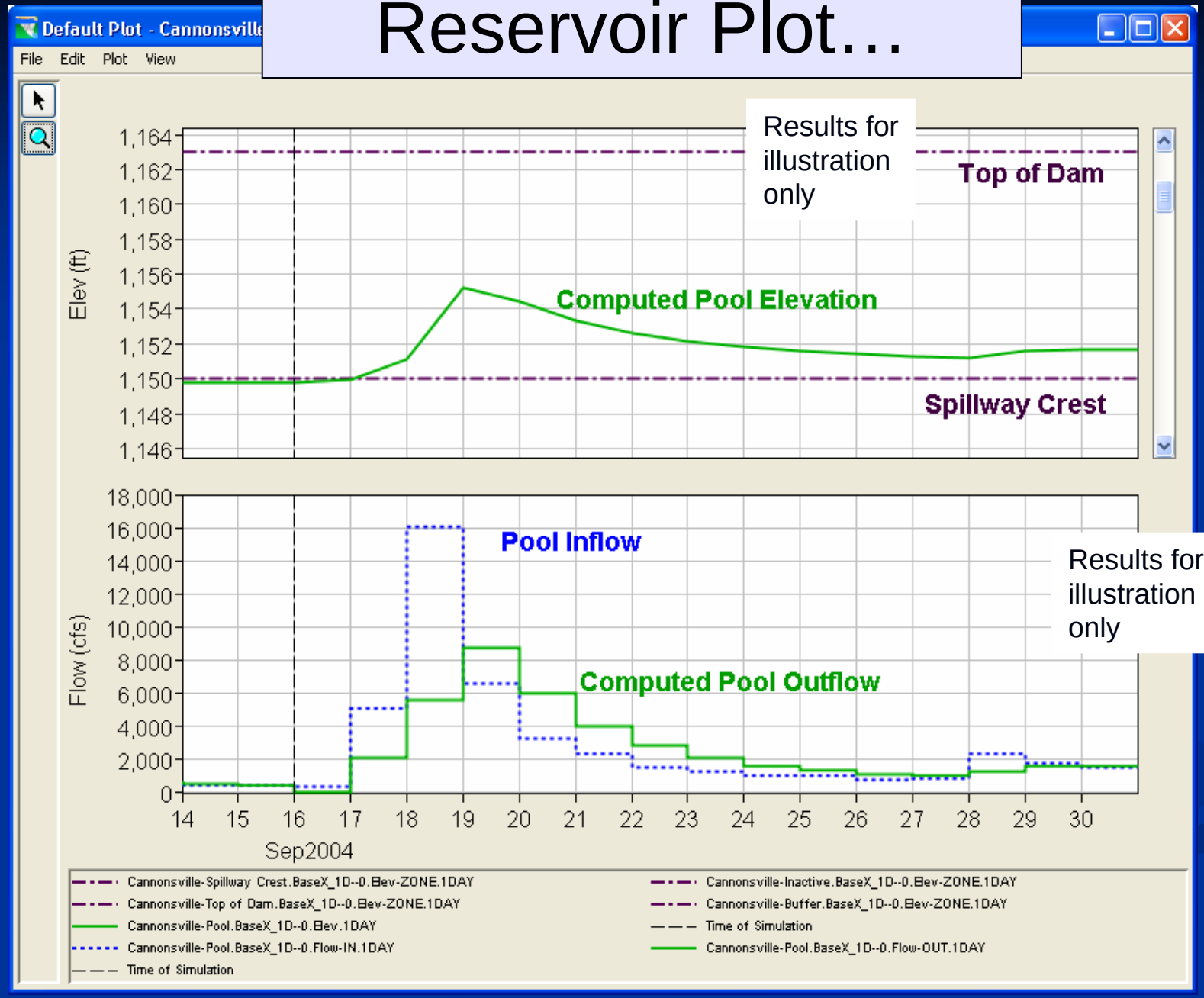
- simulate the operation of the 15 major reservoirs in the Delaware River basin
- route flows through the Delaware River system to facilitate operation for downstream locations
- perform alternative analyses
  - different basin conditions
  - various operational schemes

Pilot Basin Reservoir Model

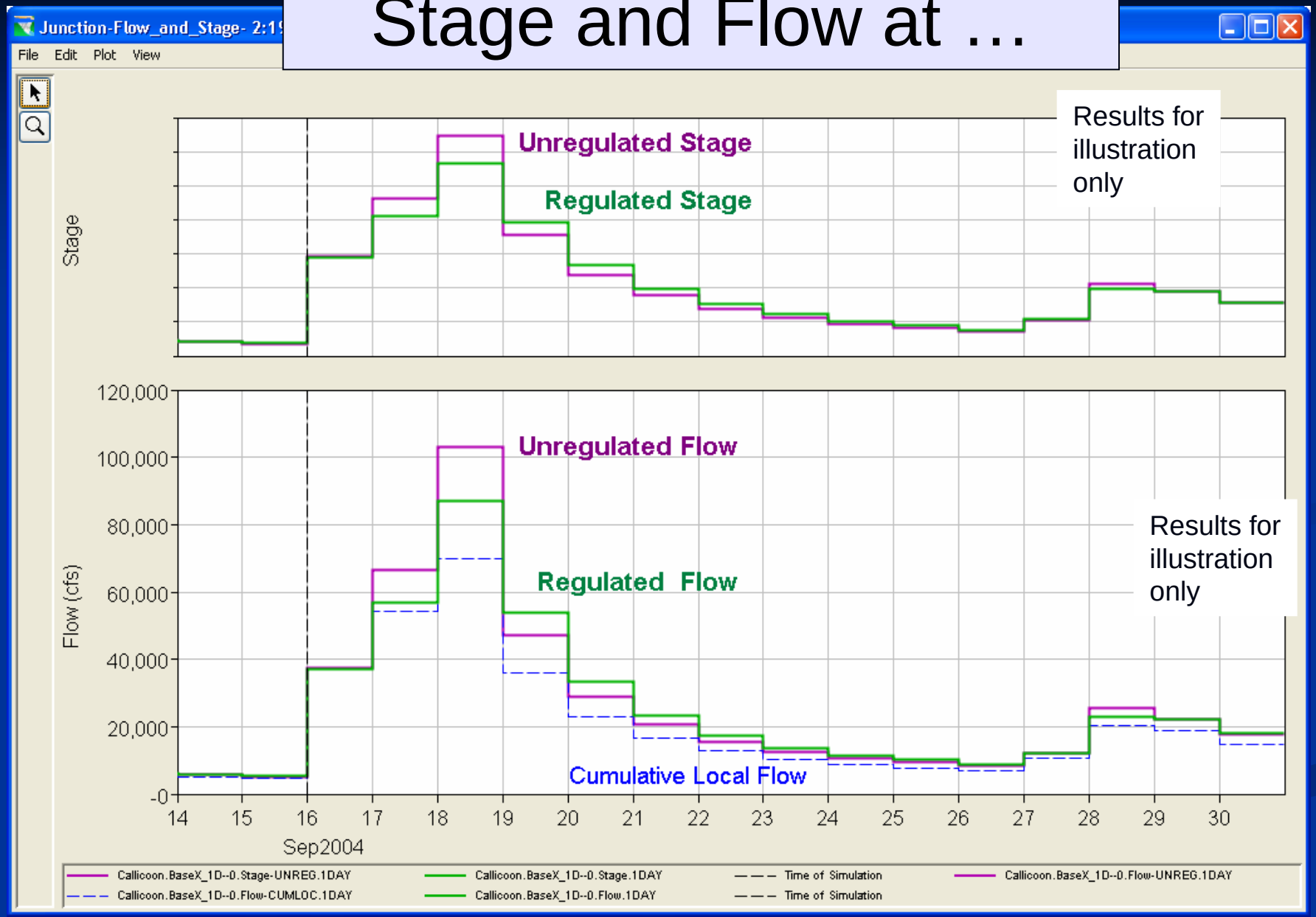



Reservoir Editor
Reservoir Edit Outlet
Reservoir Cannonsville
Description Placed in service in 1964. Largest drainage ba
2 of 4
Physical Operations Obse
Cannonsville
Pool
Dam
Release Works
Spillway
Can_Tunnel
Diversion
Routing
Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Cannonsville
Description Placed in service in 1964. Largest drainage ba
2 of 4
Physical Operations Observed Data
Operation Set BaseOps
Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Top of Dam
Spillway Flow Only
Spillway Crest
Hydrologic Condition
IF (Normal)
MinRel_45
Hale Eddy Min_225
ELSE IF (Watch)
MinRel_38
Hale Eddy Min_190
ELSE IF (Warning)
MinRel_32
Hale Eddy Min_160
ELSE ()
MinRel_23
Hale Eddy Min_145
MaxIROC
Buffer
Inactive
Storage Zone Top of Dam
Description Elev 1163.0 is the last v
Date
Top Elevatio...
01Jan
1163.0
Elevation (ft)
1,180
1,160
1,140
1,120
1,100
1,080
1,060
1,040
1,020
Jan Mar May Jul Sep Nov
Define Zone with Time-Series
OK
Cancel
Apply

Reservoir Plot…



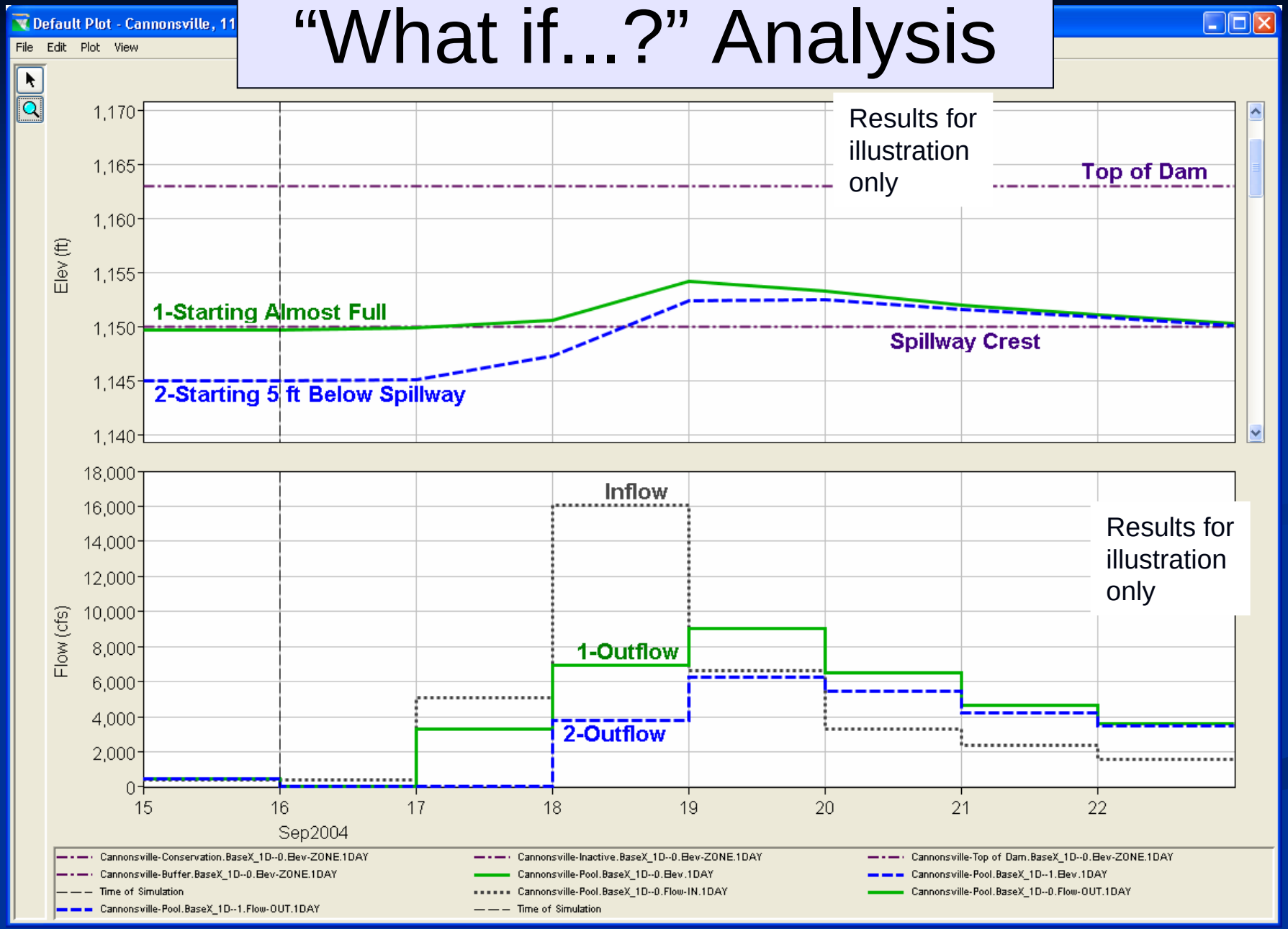
Stage and Flow at …



HEC-ResSim

- Let’s take a quick look at the Pilot basin reservoir model…
  - Alternative Analysis – What if…?

“What if...?” Analysis



Flow Routing

- Both **PRMS** and **HEC-ResSim** use hydrologic routing to route flows through the river network.
- **PRMS** will perform the flow routing *upstream* of the modeled reservoirs.
- **ResSim** will perform the flow routing *downstream* of the modeled reservoirs.
- HEC will add the ***NWS Lag & K routing method*** into **ResSim** so existing routing parameters developed by NWS for the Delaware River basin can be used in the Flood Analysis Model.

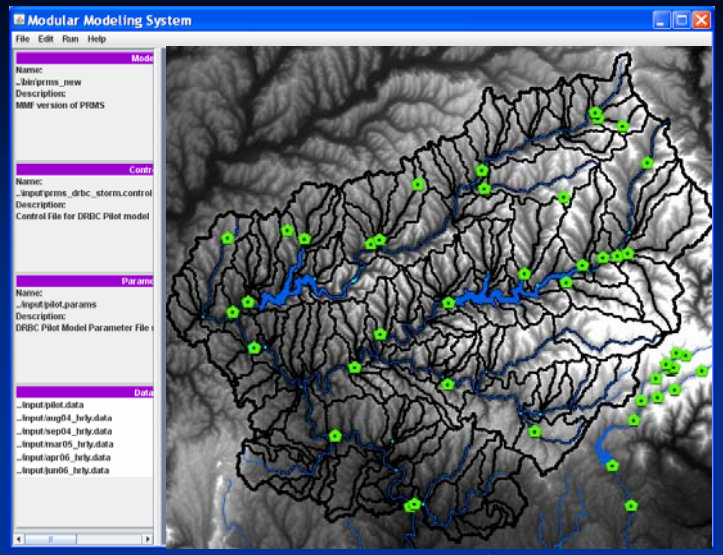
HEC-ResSim Data Flow

- **ResSim** will *retrieve* the **PRMS** flows from **DSS**
- **ResSim** will *store* simulation results to **DSS**
- The Model Integration Tool will manage the **DSS** files for program execution, user interaction, and alternative analysis.

HEC-**DSS**

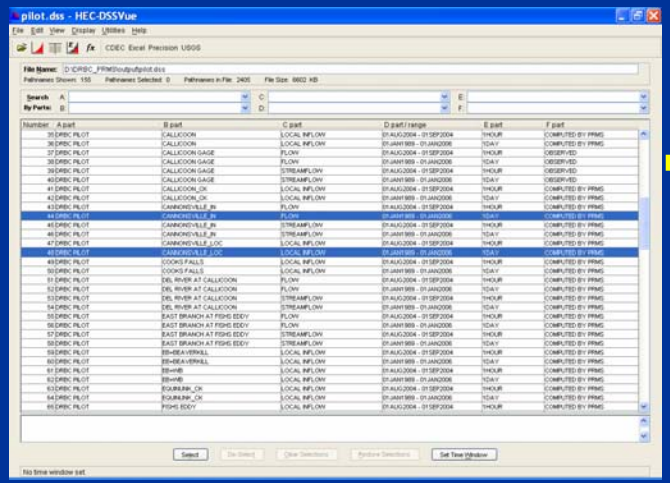
- HEC-DSS is a *database system* developed by the Hydrologic Engineering Center of the US Army Corps of Engineers designed to:
  - efficiently store and retrieve
    - time series data
    - curve data
    - spatial-oriented gridded data
  - be easy for users and application programs to retrieve and store data. HEC-**DSS** is incorporated into most of HEC's major application programs.
  - Data in HEC-**DSS** database files viewed and edited with HEC-DSSVue.

Data Flow Diagram



PRMS

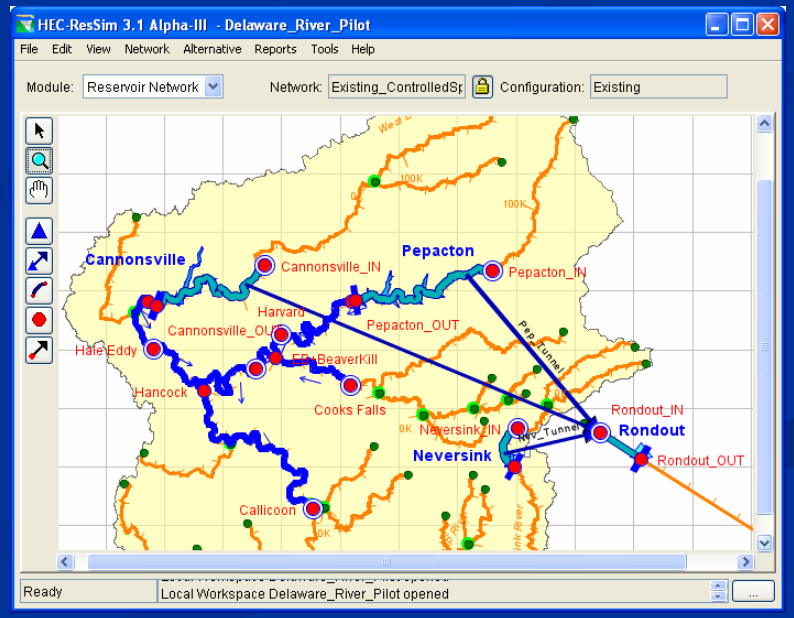
HEC-DSS Database



PRMS flows

ResSim results

HEC-ResSim



Delaware River Basin Flood Analysis Model

An integrated rainfall/runoff, reservoir operations and flow routing model that will

- use a shared database
- allow simulations of alternative reservoir operations
- allow incorporation of new data or modeling procedures
- access the full flexibility and capability of PRMS and HEC-ResSim model components

Graphical User Interface

Using the Graphical User Interface, a non-expert user will be able to

- modify input data and initial conditions and simulate stream discharge
- view input and output on maps and in tables
- organize and compare simulations of stream discharge under alternative operational conditions

Project Milestones

- Kick-off
  August 2007
- Pilot Demonstration
  December 2007
- Delaware R. (beta)
  March 2008
- Schuylkill, Christina (beta)
  May 2008
- Calibrate & Verify Models
  June 2008
- Graphical User Interface
  July 2008
- Demo Basin Models
  August 2008
- Delivery of Final Models & Draft Reports
  January 2009