# Salt Lake County Watershed Water Quality Model

Watershed Symposium
August 5, 2010

Presenters:
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Bryan Close

# Presentation Overview

- Background and Model Objectives (Nick)
- Model Capabilities (Nick)
- Potential Model Applications (Nick)
- Model Structure (Bryan)
- Model Calibration Hydrology (Bryan)
- Model Validation Water Quality (Bryan)
- Open Discussion

# Acknowledgements

- Funding
  - South Valley Sewer District through grant administered by Utah Division of Water Quality
  - Salt Lake County
- Project Team:
  - Salt Lake County
    - Jenni Oman, Project Manager
  - Stantec Consulting Services
    - Nicholas von Stackelberg, Project Manager (Former)
    - Phyllis Mayhew, Project Manager (New)
    - Karen Nichols, Principal (Former)
    - Bryan Close, Lead Modeler
    - Matt Davidson, Engineer
    - Deidre Beck, GIS
  - Expert Review
    - Dr. Tony Donigian and Brian Bicknell, AquaTerra Consultants
    - Dr. Bethany Neilson, Utah State University

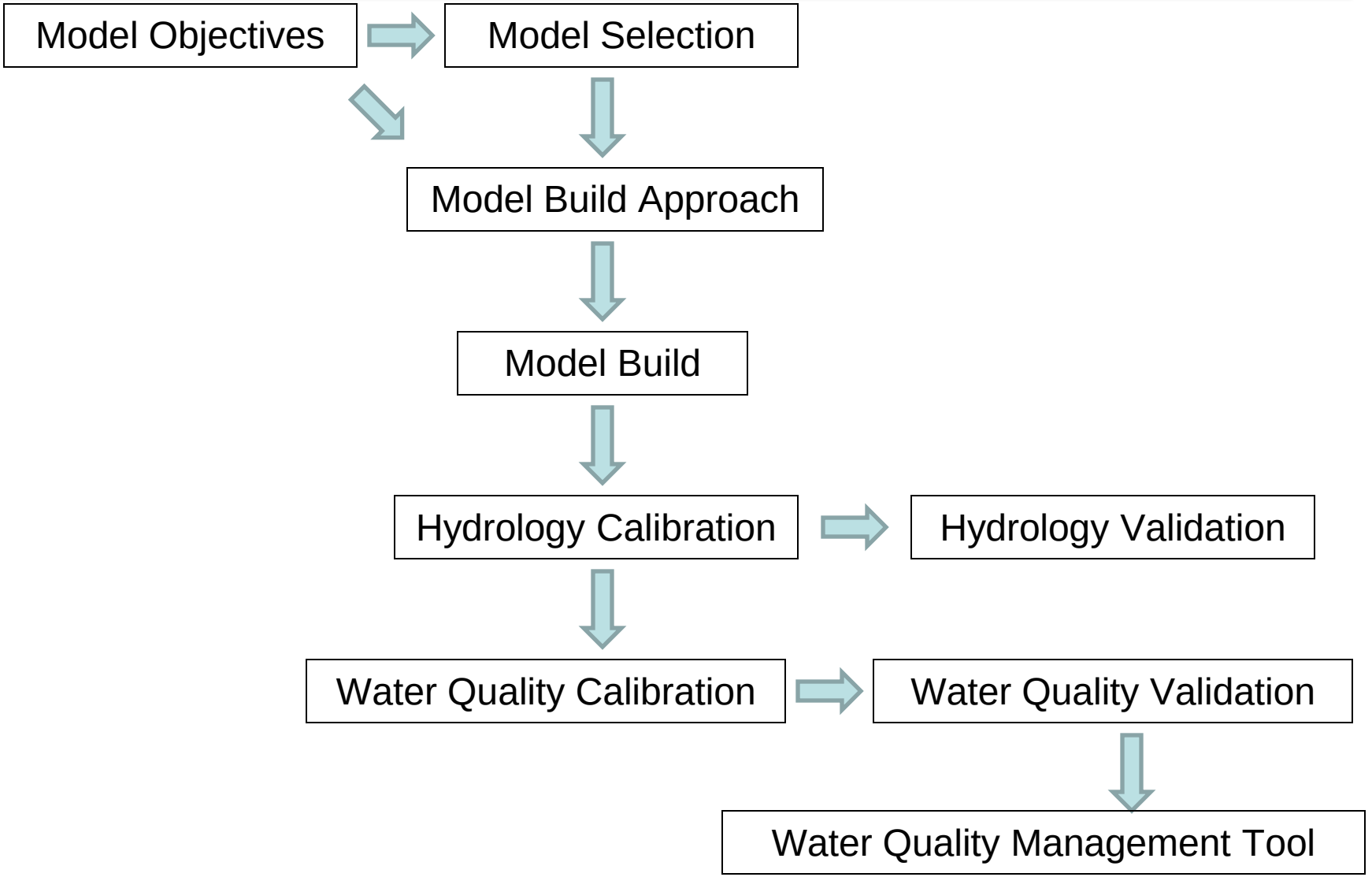
# Watershed Model Advisory Committee

- Meets every other month to review project and provide feedback
- Members
  - Salt Lake County
    - Brent Beardall
    - Robert Thompson
    - Marian Hubbard
    - Dan Drumiler
    - Steve Burgon
  - Utah Division of Water Quality
    - Hilary Arens
    - Dave Wham
  - Salt Lake City Public Utilities
    - Florence Reynolds
    - Greg Archuleta
  - Utah State University
    - Dr. Bethany Neilson

# Background

- Implementation recommendation in 2009 Salt Lake Countywide Water Quality Stewardship Plan
- Grant application and award 2008
- Project initiated April 2009
- Model build and calibration complete October 2010
- Documentation complete March 2011

# Project Overview



# Problem Statement

- How to evaluate the effect of management practices in the watershed on water quality in the tributaries and Jordan River given the complex hydrology of the Salt Lake Valley?
  - Complexities:
    - Water supply and flood control diversions
    - Irrigation return flows
    - Exchange flows
    - Stormwater overflows from canals
    - Stormwater management practices
    - Wastewater treatment plant effluent

# Model Objectives

1. The watershed model will be an on-going drainage and water quality planning and management tool, including future updates to the Water Quality Stewardship Plan.
2. The watershed model will be a decision support tool for potential implementation strategies for the Jordan River Total Maximum Daily Load (TMDL) water quality study. The model may be used for pollutant load estimation, waste load allocation and implementation strategy evaluation for future TMDL water quality studies in Salt Lake County.
3. The watershed model will be a tool for Salt Lake County drainage, flood control and water quality permitting purposes.
4. The watershed model may be used for water quality impact assessments for subbasin-scale proposed actions.
5. The watershed model may be utilized to assess Water Quality Stewardship Plan strategic objectives, such as instream flow analyses and the effect of Utah Lake on the Jordan River and tributaries.

# Desired Model Capabilities

- Estimate pollutant loads from the watershed
- Simulate complex hydrology of the valley with diversions and return flows
- Continuous, dynamic model with capability of simulating multiple years, including dry and wet years
- Simulate constituents of concern
- Ability to evaluate best management practices (BMPs)

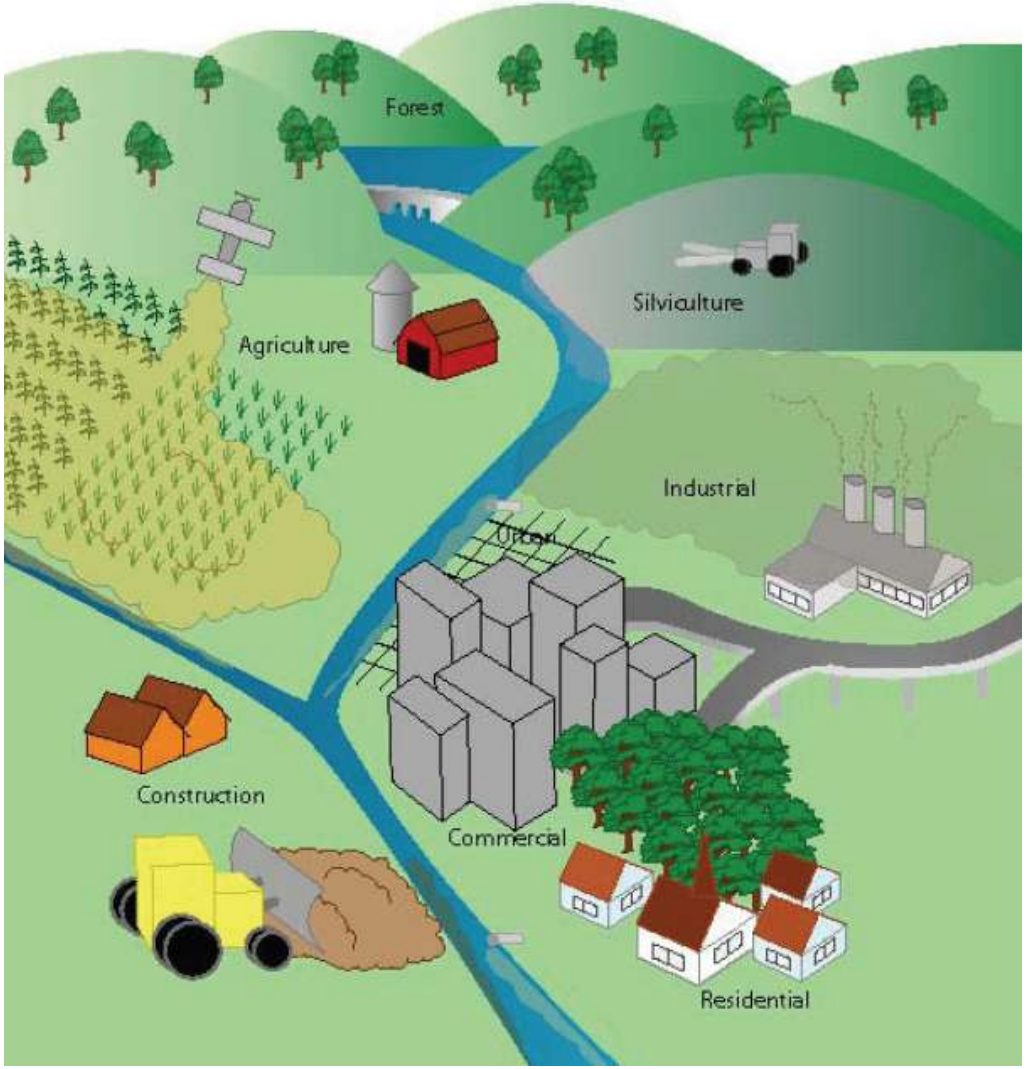
# HSPF Background

- Developers
  - AquaTerra Consultants
- EPA and USGS maintained and distributed
- Core model in EPA BASINS and Army Corps of Engineers WMS
- Utilities for data management, pre- and post-processing, parameter estimation, and help files

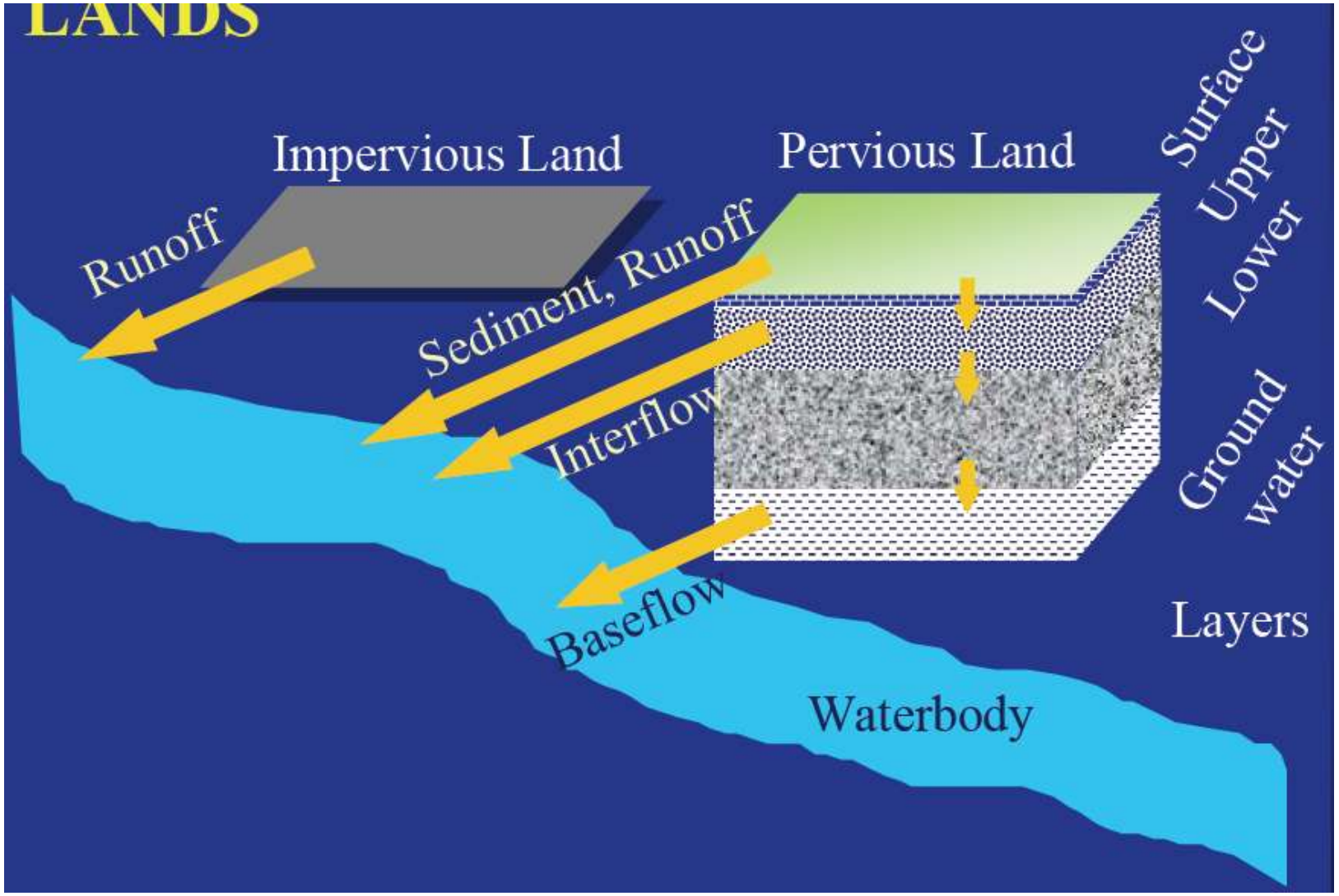
# HSPF Fundamentals

- Watershed model
  - Simulates land surface and subsurface hydrology and quality processes
  - Simulates pollutant transformation and transport through branching stream network
- Dynamic flow - non-uniform, unsteady flow is simulated.
- Continuous time scale – typically hourly or daily.
- Lumped parameter – areas within subbasin with similar hydrologic response are lumped together.
- Empirical model – requires extensive calibration.
- One dimensional - channel is well-mixed vertically and laterally.
- Flow and concentration - Point and nonpoint loads and abstractions are simulated.
- Water quality kinetics – temperature, pH, conservative constituents, sediment, organics, nutrients, DO, BOD, pesticide, metal, pathogen, algae, zooplankton, SOD.

# Nonpoint Pollution Sources



# Watershed Processes



# Salt Lake County Model Basics

- Continuous hourly simulation from 10/1/1994 through 9/30/2006
  - Calibration 10/1/1997 – 9/30/2004
  - Validation 10/1/1994 – 9/30/1997 & 10/1/2004 – 9/30/2006
- Extents
  - Salt Lake County including area tributary to Great Salt Lake and Jordan River
  - Davis County area tributary to Jordan River
- Water quality constituents
  - Temperature
  - Sediment (sand, silt, and clay)
  - Nitrate (NO3)
  - Ammonia (NH3)
  - Orthophosphate (PO4)
  - Biochemical oxygen demand (BOD)
  - Dissolved oxygen (DO)

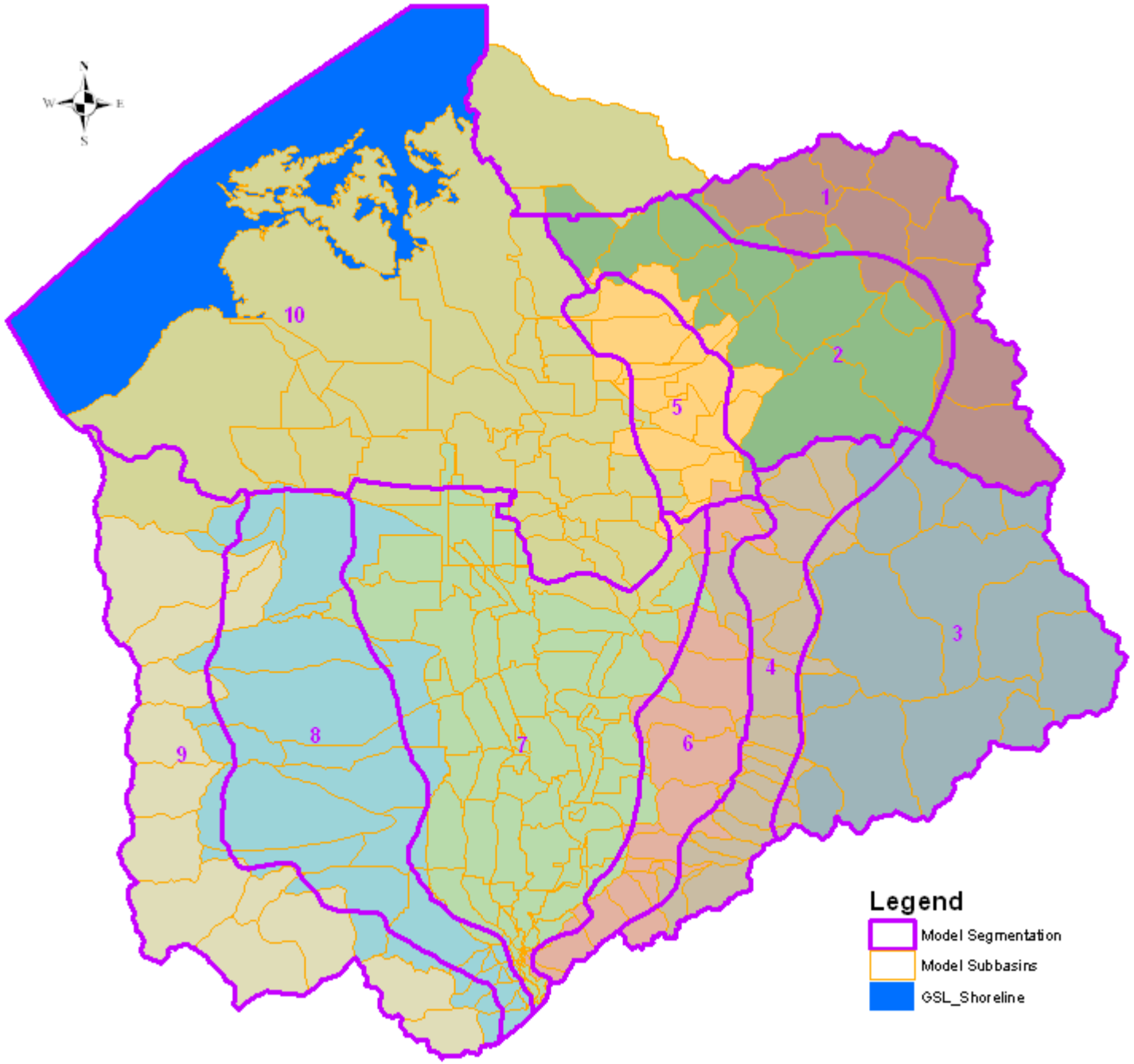
# Potential Future Applications

- BMP Module – simulates pollutant reduction from stormwater BMPs applied to land uses
- Low Impact Development (LID) Toolkit – generates input to simulate hydrologic and water quality benefits of LID
- Climate Assessment Tool – develops climate change scenarios for assessing hydrologic and water quality effects
- TMDL Application – determine point and non-point source reductions to meet water quality endpoints
  - Jordan River TMDL – simulates the loading from the watershed, and the fate and transport of organic matter through the river

# Building the Model

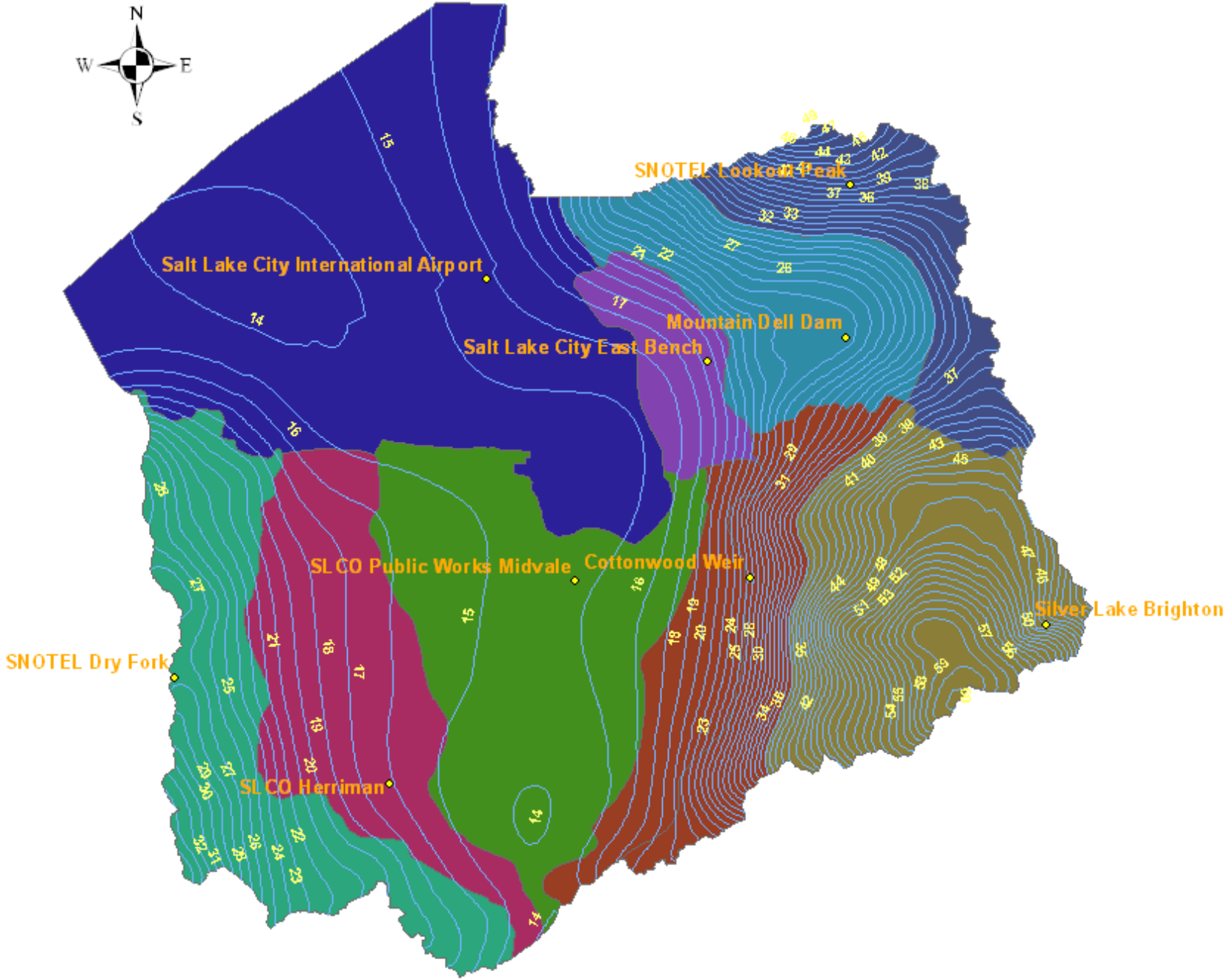
- Model Segments
- Meteorology
- Land-use
- Drainage Basins
- Reaches
- Diversions
- Point Sources
- Data Output

# Model Segments



# Model Segmentation

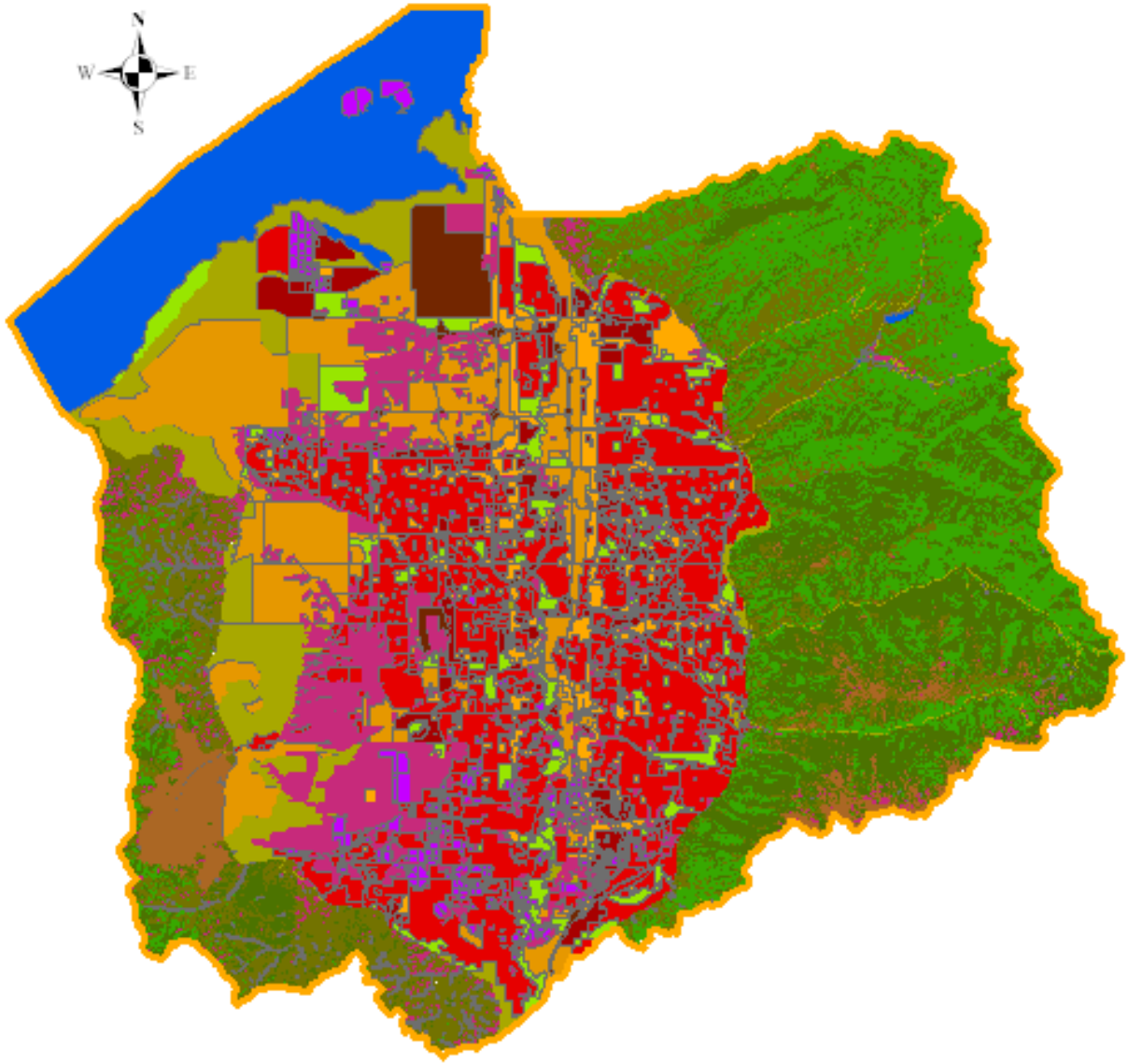
| Segment | Met Station | Recharge Zone |
|---|---|---|
| 1 | SNOTEL Lookout Peak | Wasatch Bedrock – NE Canyons |
| 2 | Mountain Dell Dam | Wasatch Bedrock – NE Canyons |
| 3 | Silver Lake Brighton | Wasatch Bedrock – SE Canyons |
| 4 | Cottonwood Weir | Wasatch Bedrock – SE Canyons |
| 5 | SLC East Bench | East Bench Primary Recharge Basin Fill |
| 6 | Cottonwood Weir | East Bench Primary Recharge Basin Fill |
| 7 | SLCO Midvale | Secondary Recharge Basin Fill |
| 8 | SLCO Herriman | West Bench Primary Recharge Basin Fill |
| 9 | SNOTEL Dry Fork | Oquirrh Bedrock |
| 10 | SLIA | Discharge |


N
W
E
S
SNOTEL Lookout Peak
Salt Lake City International Airport
Mountain Dell Dam
Salt Lake City East Bench
SLCO Public Works Midvale
Cottonwood Weir
Silver Lake Brighton
SNOTEL Dry Fork
SLCO Herriman



Stantec

# Model Land Use/Land Cover




**Legend**

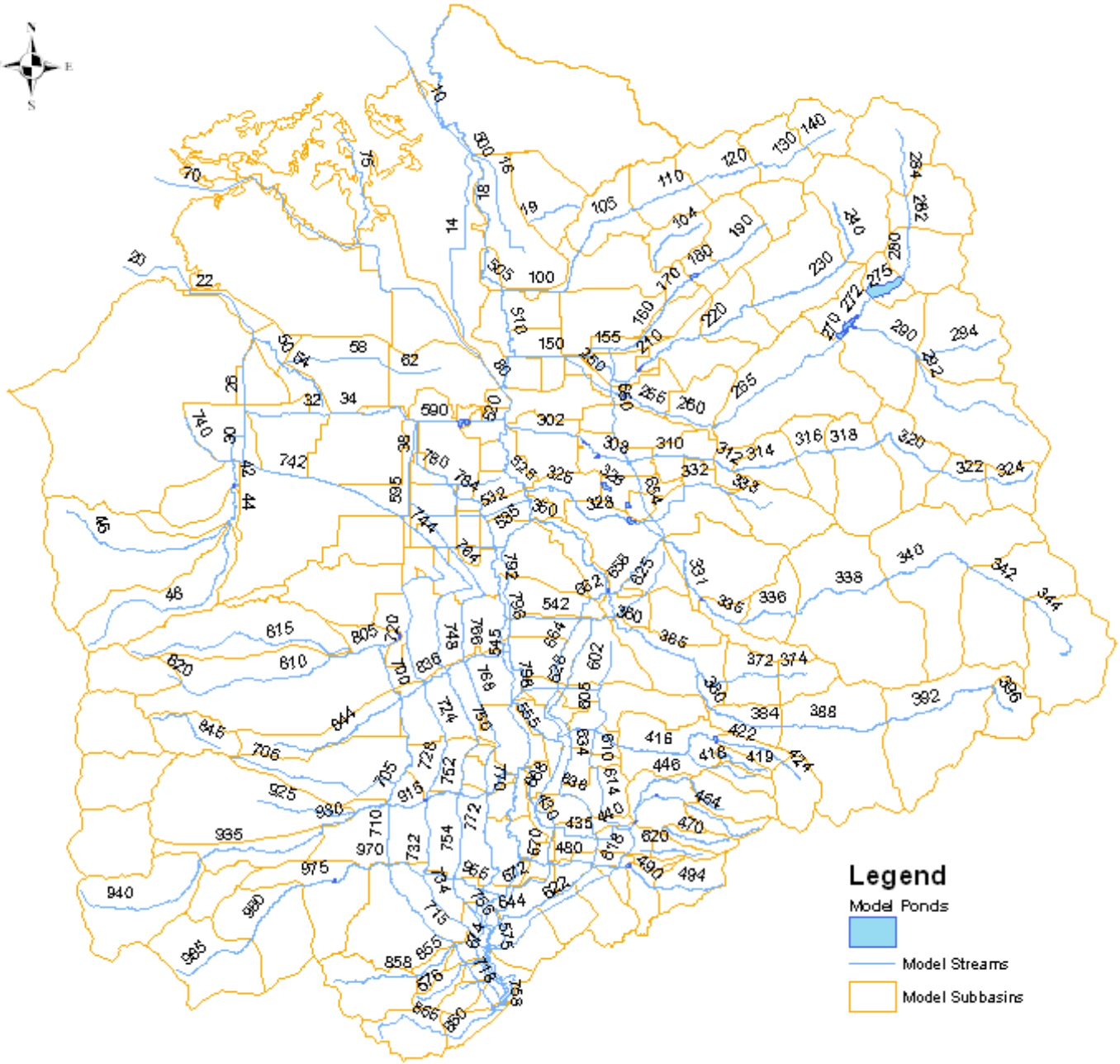
Model Land Use/Land Cover

- COMMERCIAL
- CULTIVATED CROPS
- DECIDUOUS FOREST
- EVERGREEN FOREST
- GRASSLAND/PASTURE
- HIGH DENSITY RESIDENTIAL
- INDUSTRIAL
- LOW DENSITY RESIDENTIAL
- OPEN SPACE
- OPEN WATER
- PARKS
- SHRUB/SCRUB
- TRANSPORTATION
- VACANT
- WETLANDS

# Model Subbasins

# Model Reaches

- 273 total
- Attributes:
  1. ID #
  2. Downstream ID #
  3. Length
  4. Slope
  5. Width
  6. Depth
  7. Min. Elevation
  8. Max. Elevation
  9. Stream Name



# Reaches - Flow Tables

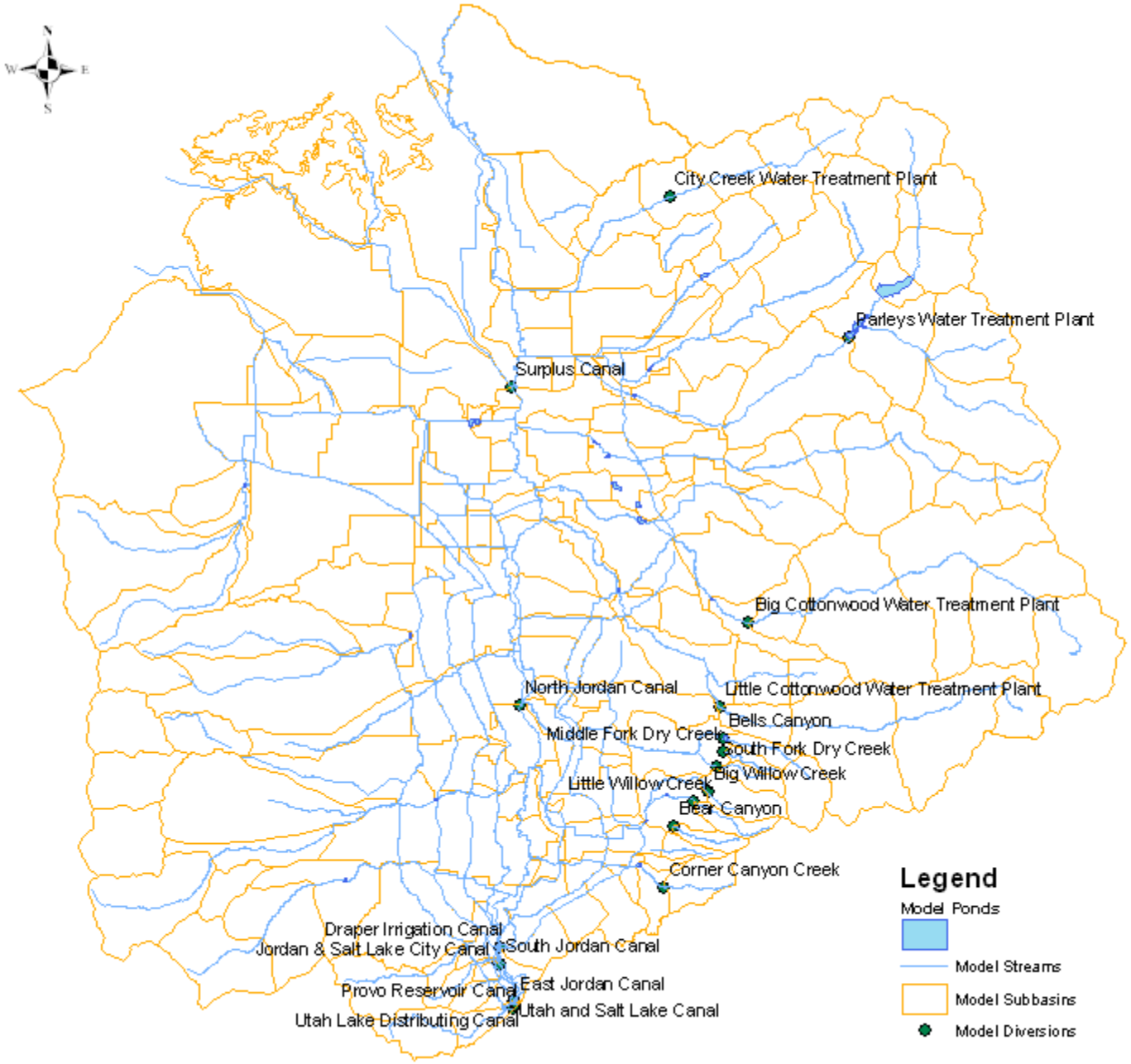
1) FTABLE: stage-storage-surface area-discharge

```
 FTABLE     103
ROWS COLS ***
   3    5
    DEPTH       AREA     VOLUME   outflow1   outflow2 ***
     (FT)    (ACRES)    (AC-FT)      (CFS)      (CFS) ***
      0.0        0.0        0.0        0.0        0.0
      5.0       10.0       25.0       20.5       10.2
     20.0      120.0     1000.0      995.0      200.1
 END FTABLE 103
```

2) Ponds – inventory information
3) Streams
   - Rely on existing HEC-RAS/HEC-2 files, where available
   - Use HEC-GeoRAS with 2-m terrain to generate HEC-RAS files for other streams
4) Canals – same approach as for streams
5) Drains
   - Use Mannings equation
   - Inventory information: pipe diameter, pipe length, ground slope, pipe type

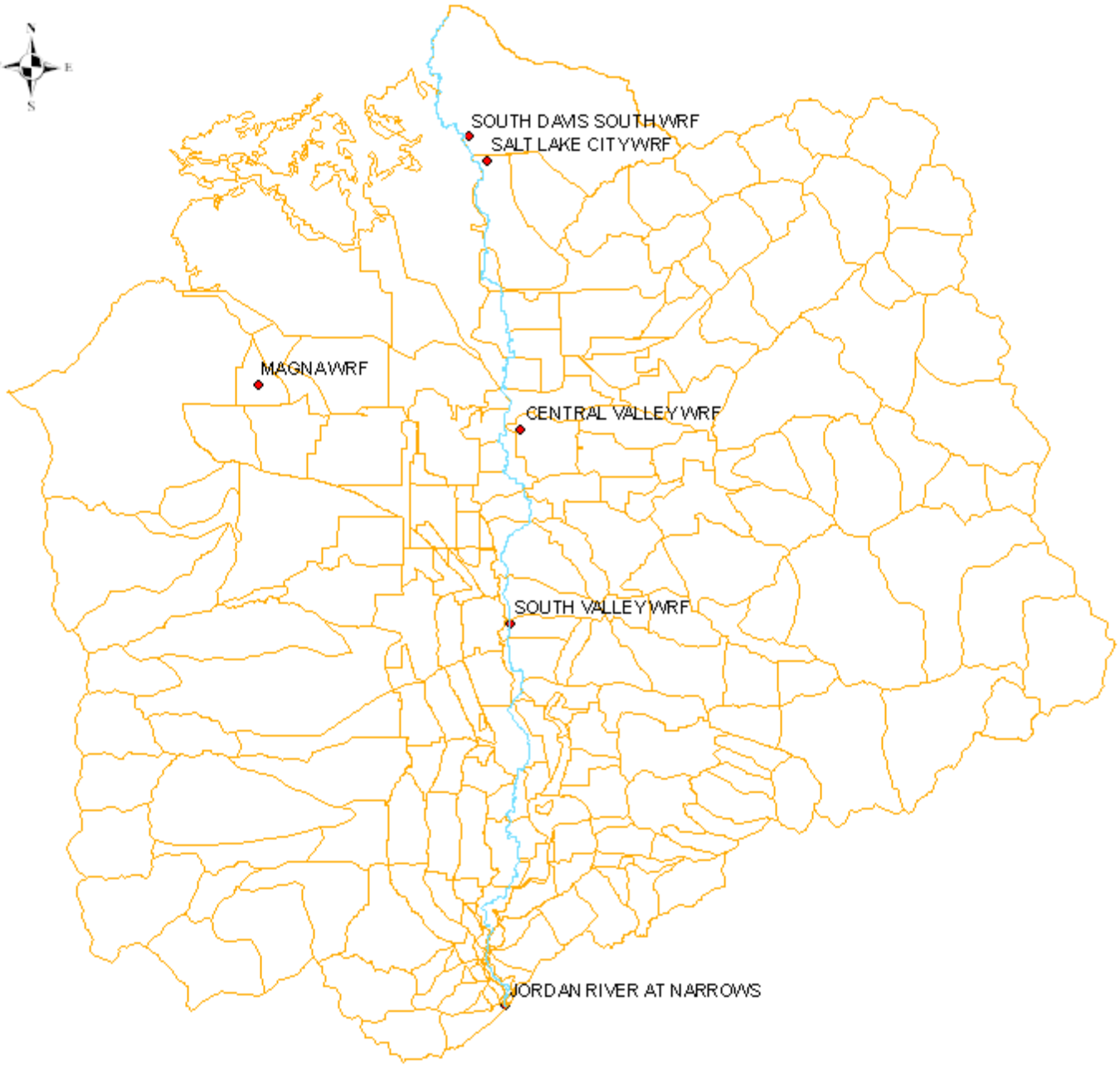
# Diversions

- 19 total
  - 12 time series
  - 7 constant rate



# Point Sources

- 6 total
- Attributes:
  1. ID #
- Time Series:
  1. Flow
  2. Temperature
  3. TDS
  4. TSS
  5. NH4, NO3, Organic N
  6. PO4, Organic P
  7. CBOD
  8. DO
  9. Total Coliform
- USGS LOADEST for Narrows



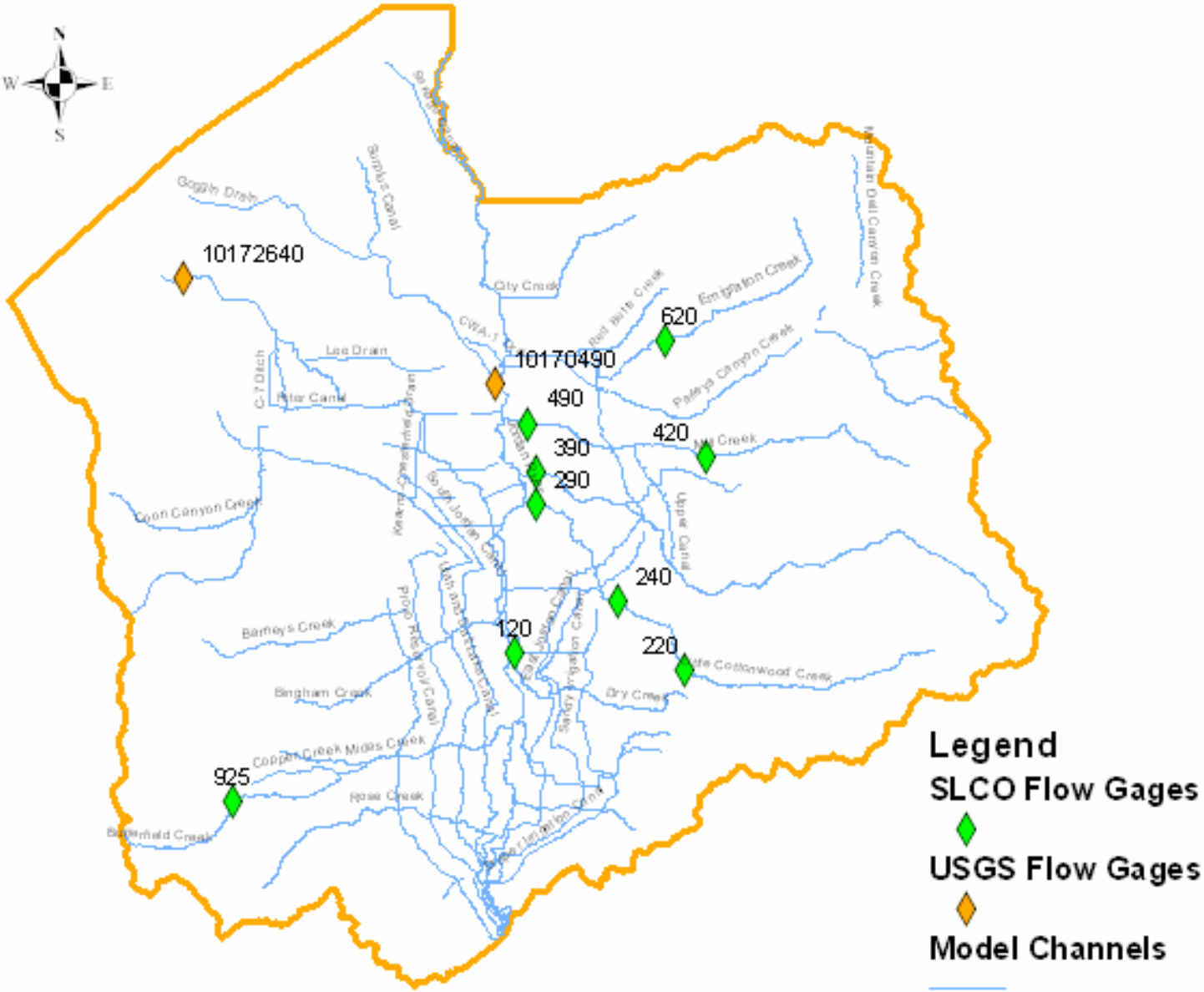
# Model Hydrology Calibration

- Snow – SNOTEL Data
- Flows – Gage Data

Calibration Locations:

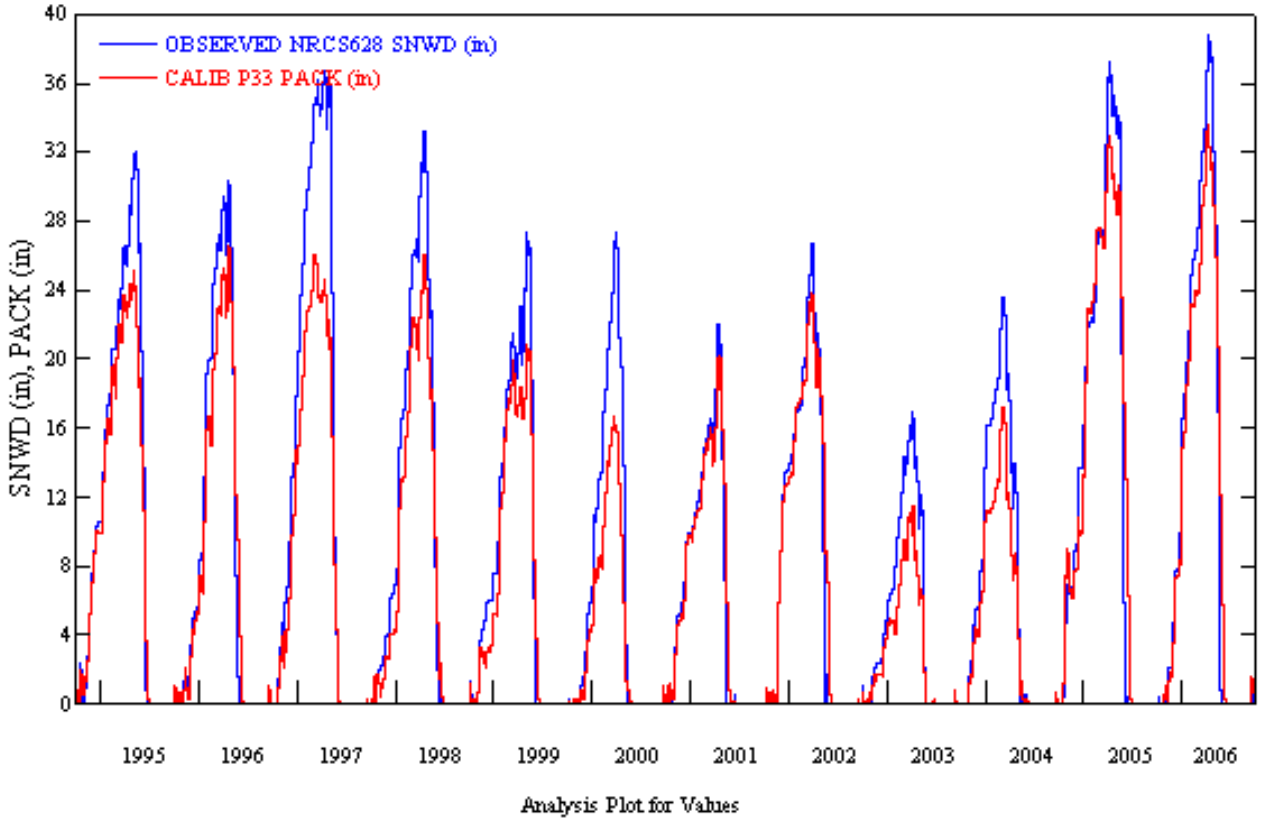
  - Jordan River at 9000 S
  - Combined Flow at Surplus Canal
  - Jordan River at 500 N
  - Mill Creek at Canyon Mouth
  - Mill Creek at Jordan River
  - Big Cottonwood at Canyon Mouth

# Calibration Locations - Flow



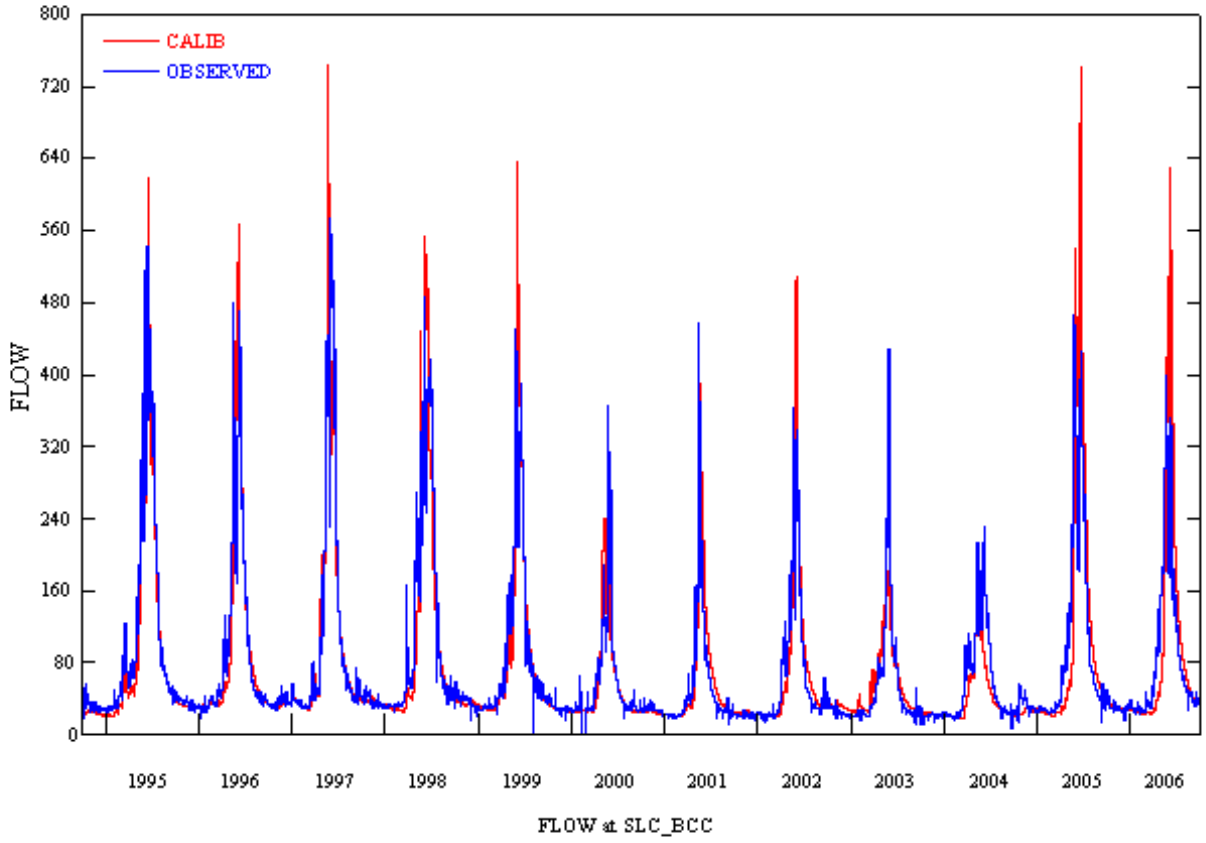
# Model Calibration Hydrology

Snow Calibration – Mill-D SNOTEL Site



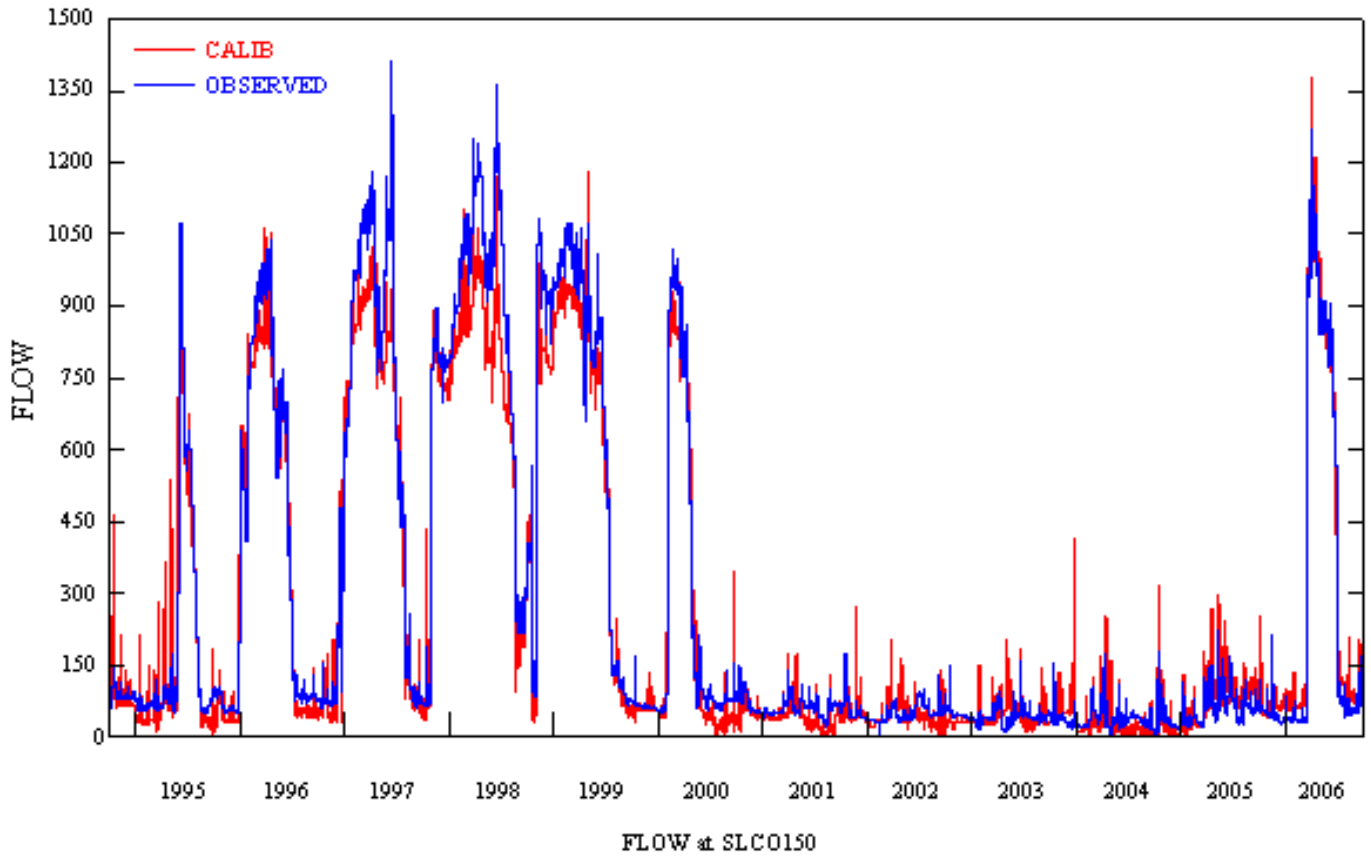
# Model Calibration Hydrology

Flow Calibration - Big Cottonwood Creek at Canyon Mouth



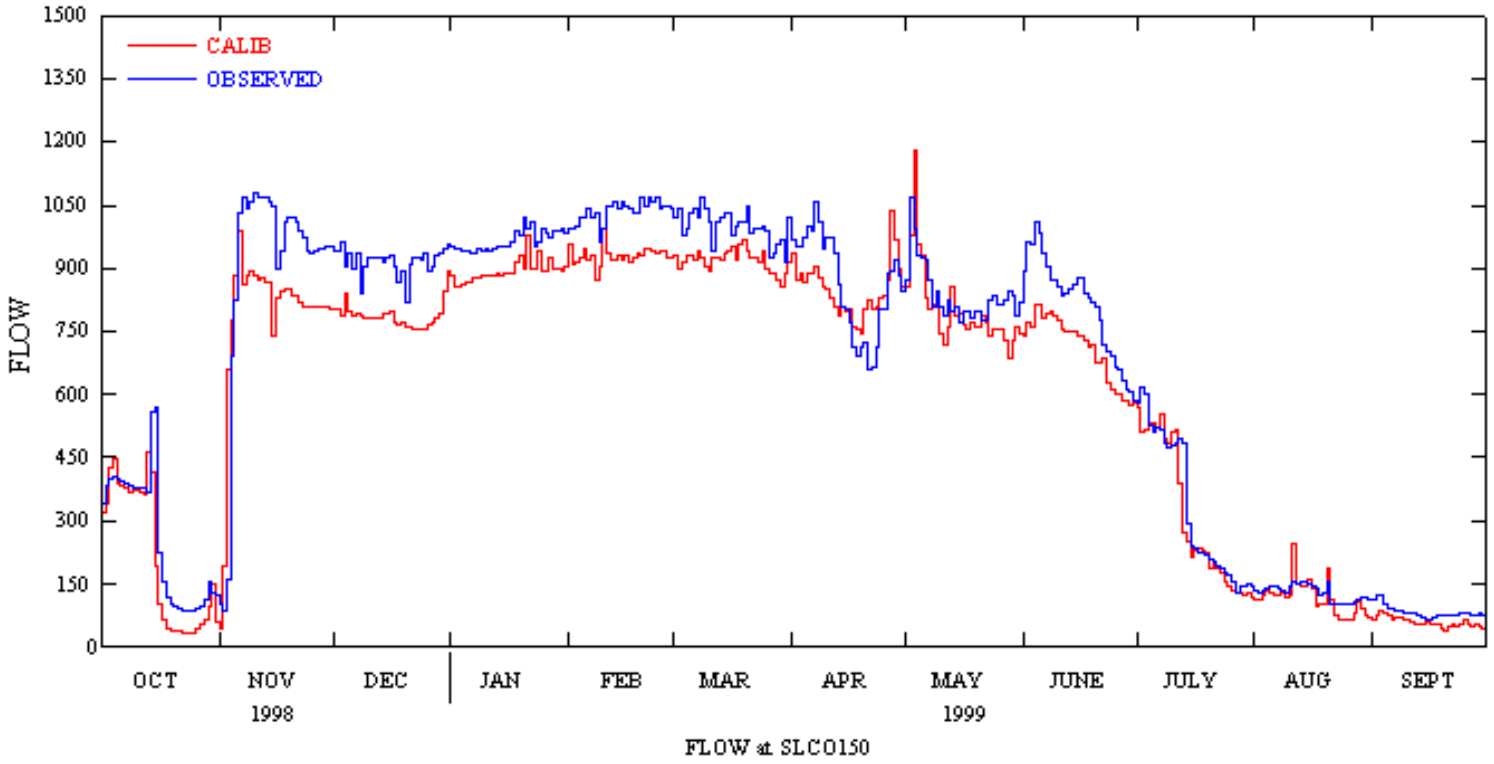
# Model Calibration Hydrology

Flow Calibration - Jordan River at 9000 South



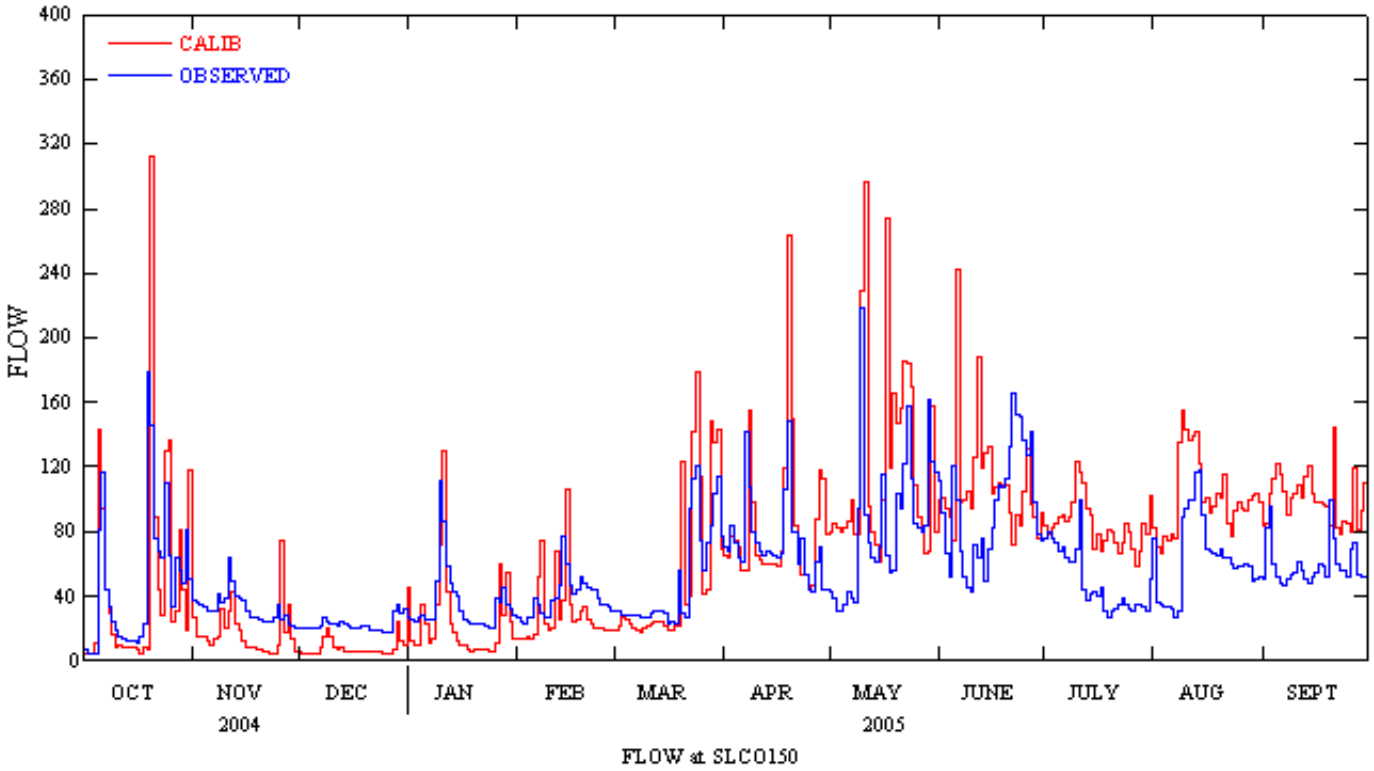
# Model Calibration Hydrology

Flow Calibration - Jordan River at 9000 South – Wet Year



# Model Calibration Hydrology

Flow Calibration - Jordan River at 9000 South – Dry Year



# Model Calibration Water Quality

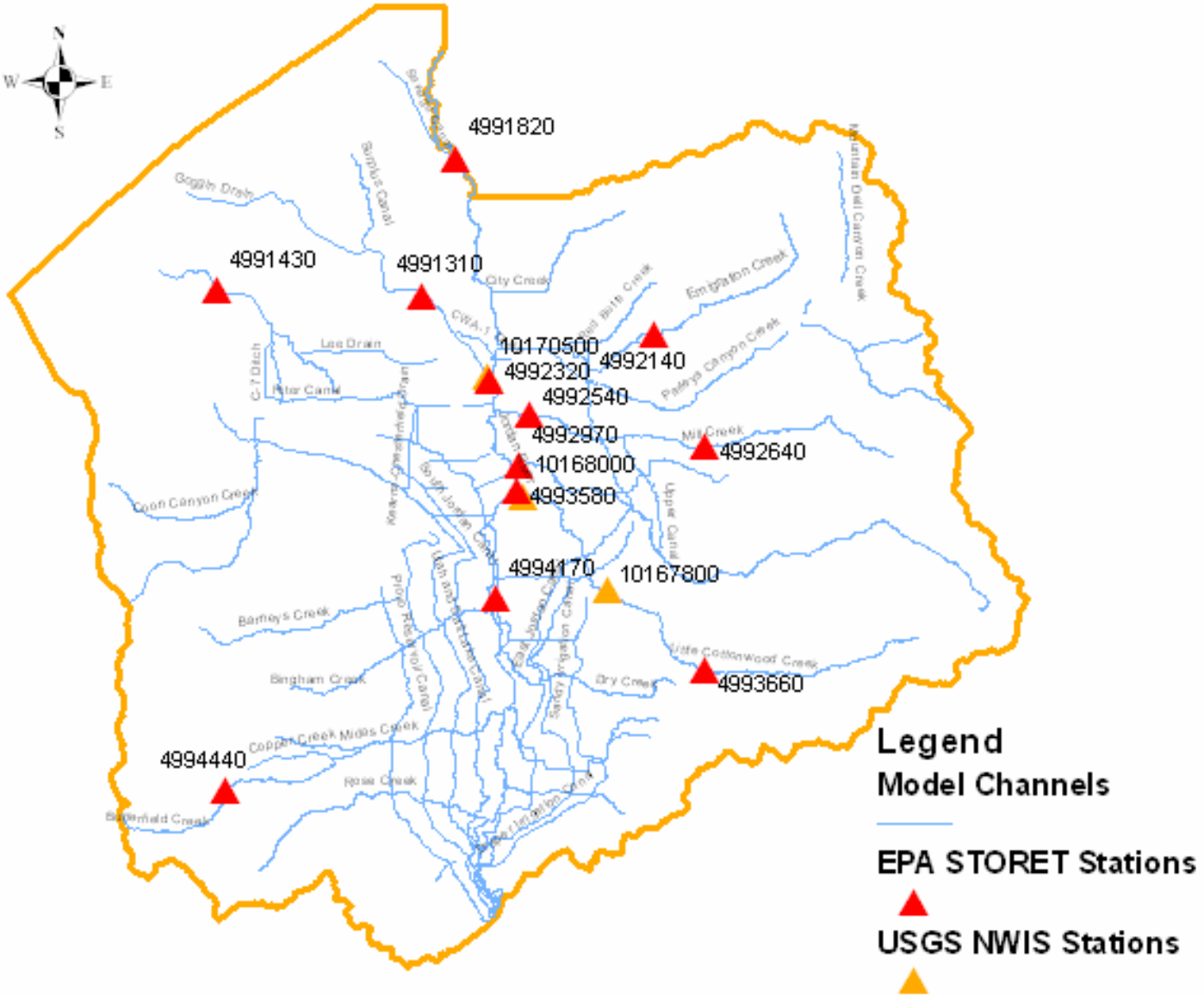
## Calibration Constituents

- Sediment
- Temperature
- DO
- BOD
- Ammonia
- Nitrate
- Orthophosphate

## Calibration Locations:

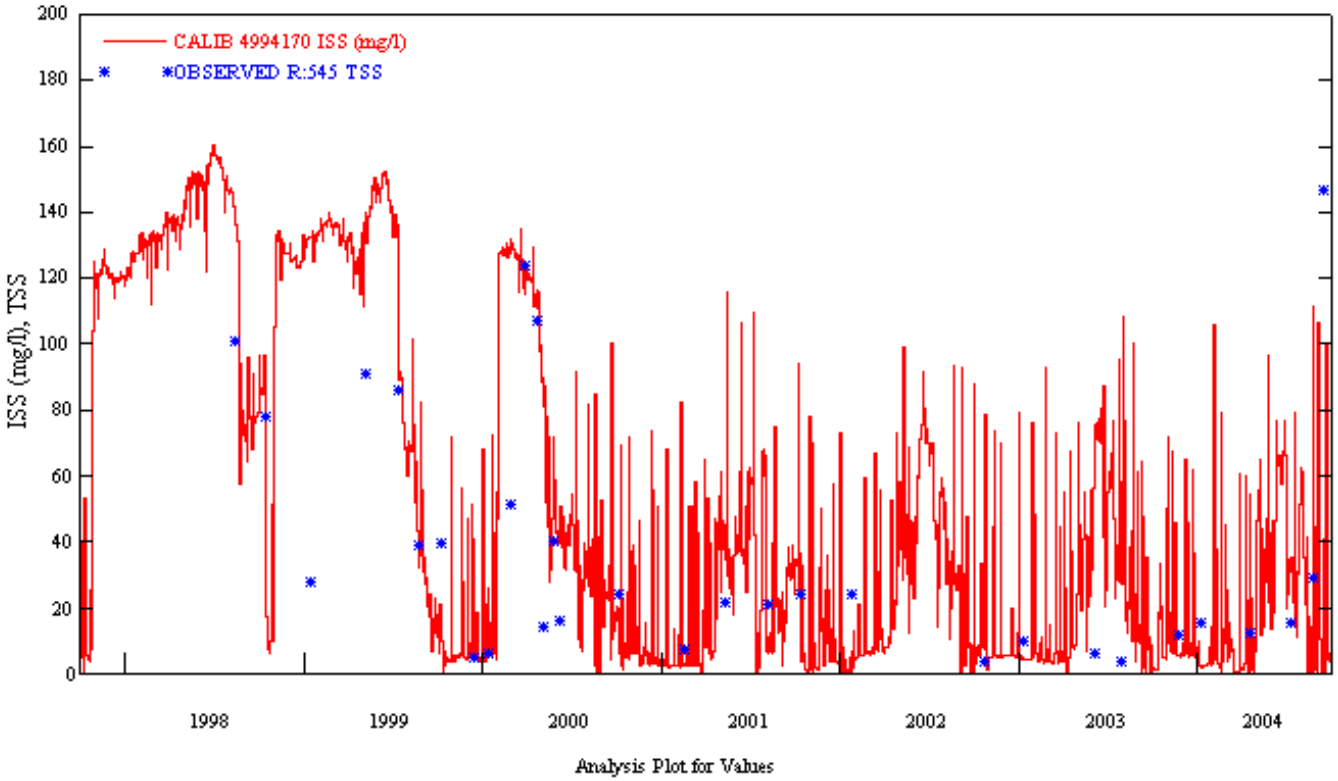
- Jordan River at 9000 S
- Jordan River at 7800 S
- Combined Flow at Surplus Canal
- Jordan River at 1700 S
- Jordan River at Cudahy Lane
- Mill Creek at Canyon Mouth
- Big Cottonwood at Canyon Mouth

# Calibration Locations – Water Quality



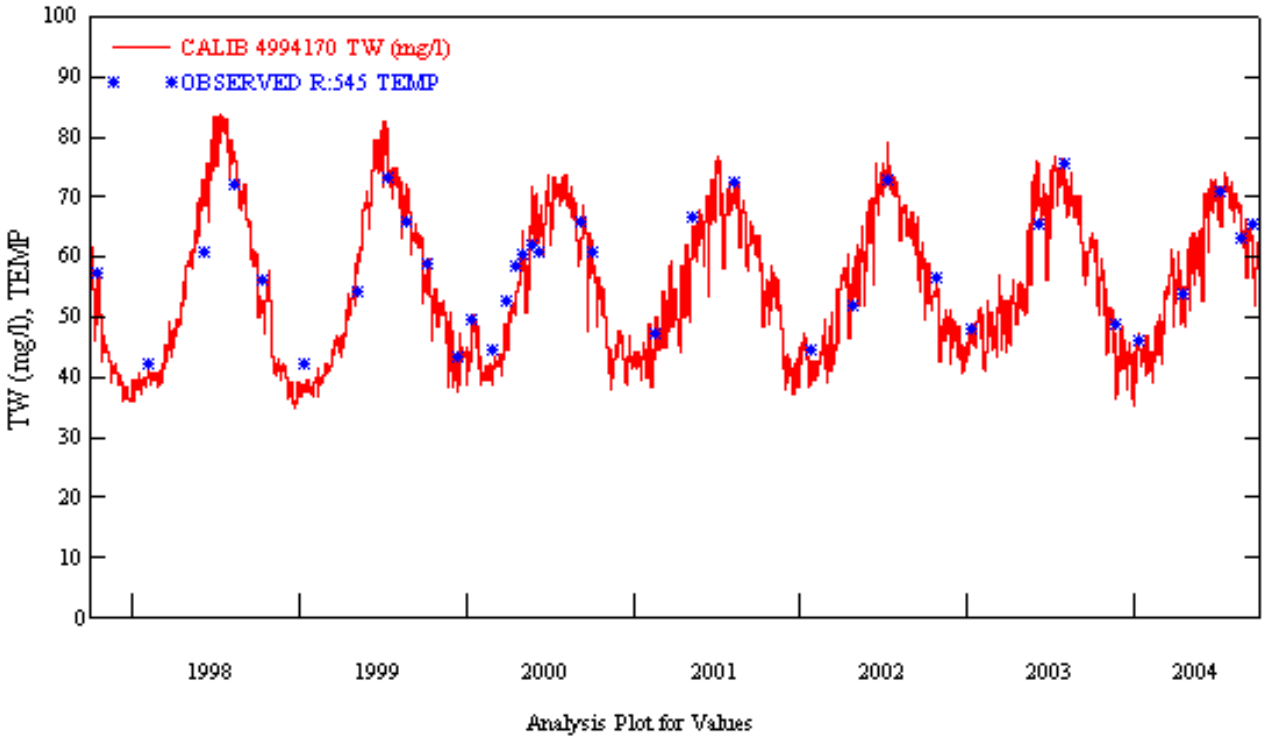
# Model Calibration Water Quality

Inorganic Suspended Sediment – Jordan River at 7800 South



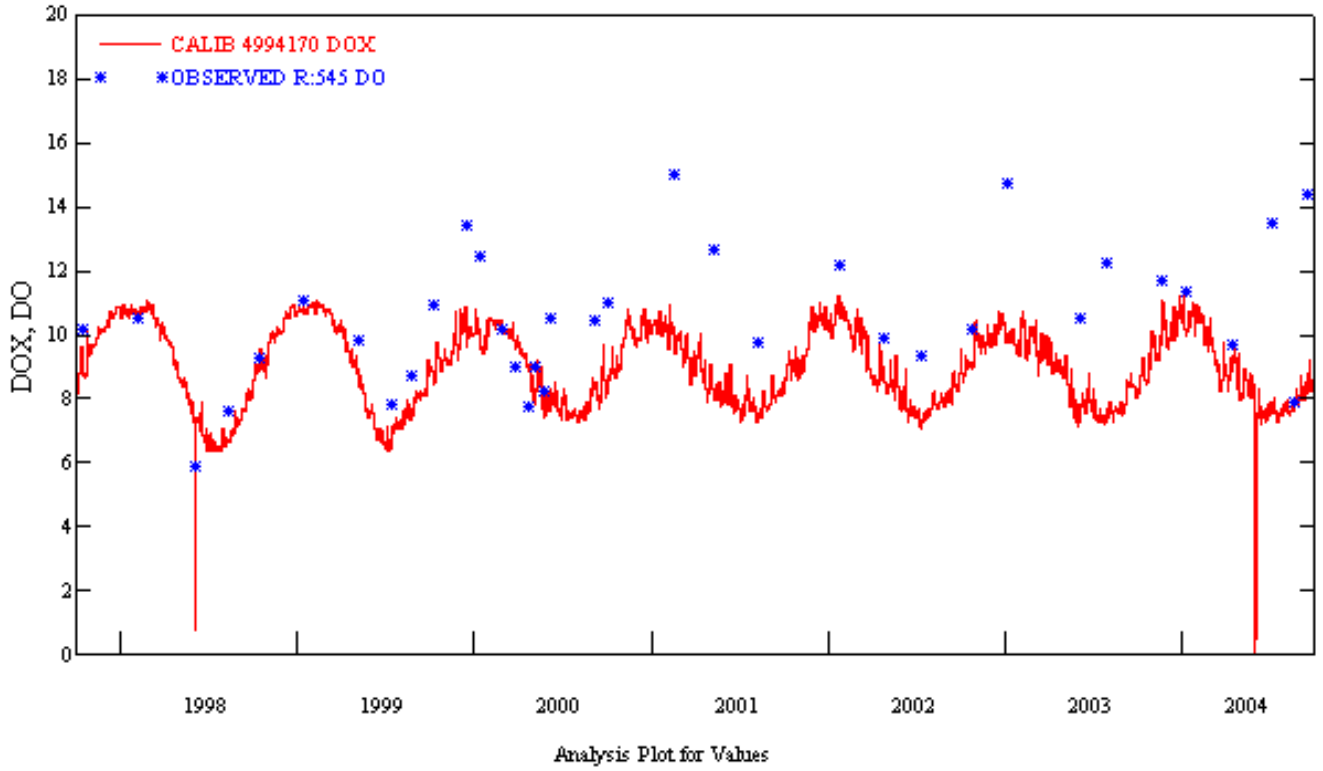
# Model Calibration Water Quality

Temperature – Jordan River at 7800 South



# Model Calibration Water Quality

Dissolved Oxygen – Jordan River at 7800 South



# Open Discussion

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