Salinity Modeling in the Colorado River and Upper Rio Grande Basins Using

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USGS
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Outline

- **Motivation**
- **Background**
- **Water Quality in RiverWare**
- **Application on the Colorado River**
- **Application on the Rio Grande**

Motivation

- **Decision makers must consider quality as well as quantity**
- **Decision support tools must be able to model quality**
- **Many great modeling tools**
- **Scale is important!**

RiverWare's water quality algorithms meet these needs

Constituents / Solution Approach

- **Salinity**
- **Temperature**
- **Dissolved Oxygen (DO)**

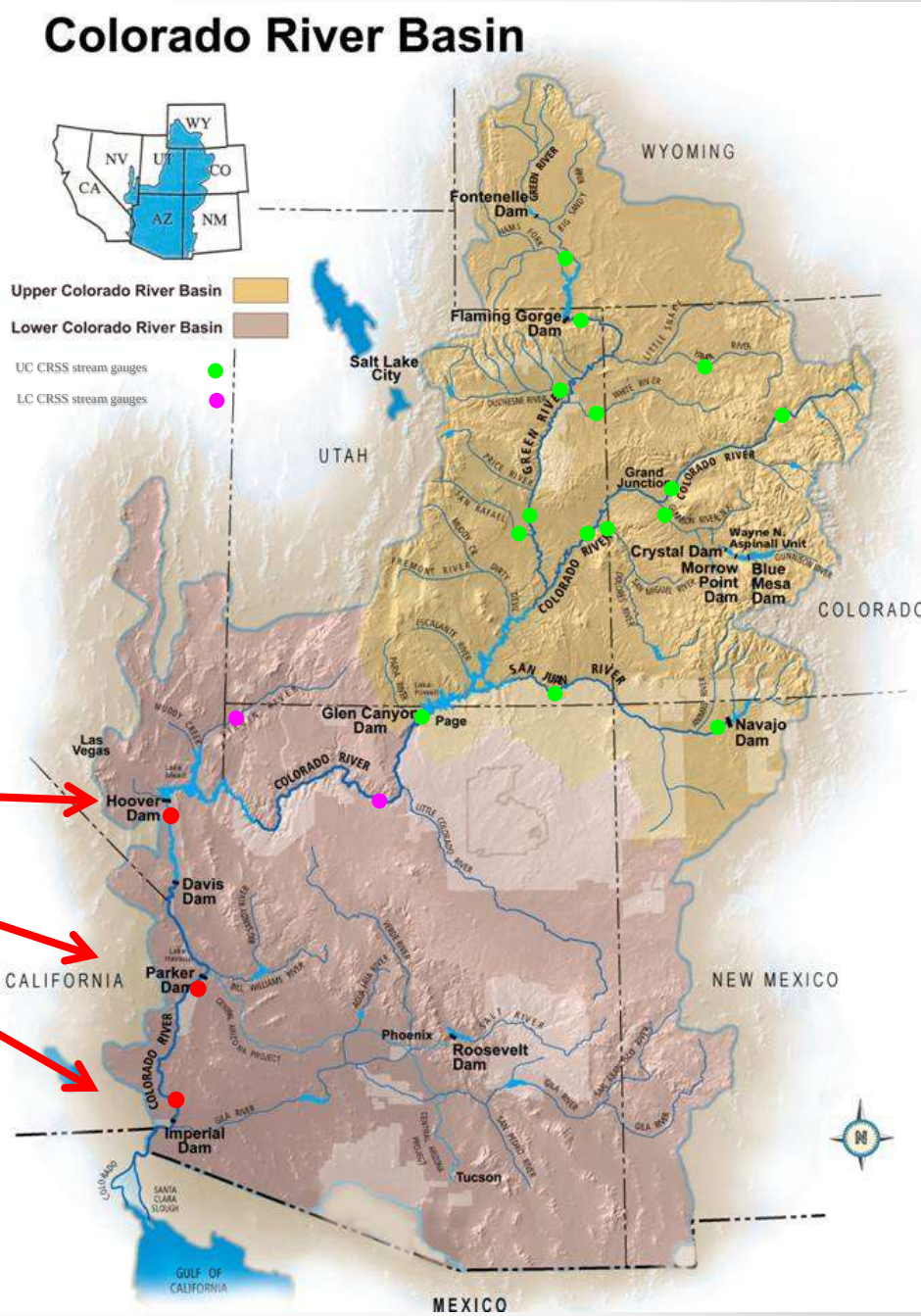
Constituents		Solution Approach
Salinity	1.	Simple Well-Mixed
Salinity	2.	Layered/Discretized
Temperature, Salinity and/or DO		Layered/Discretized

1. Simple Well-Mixed

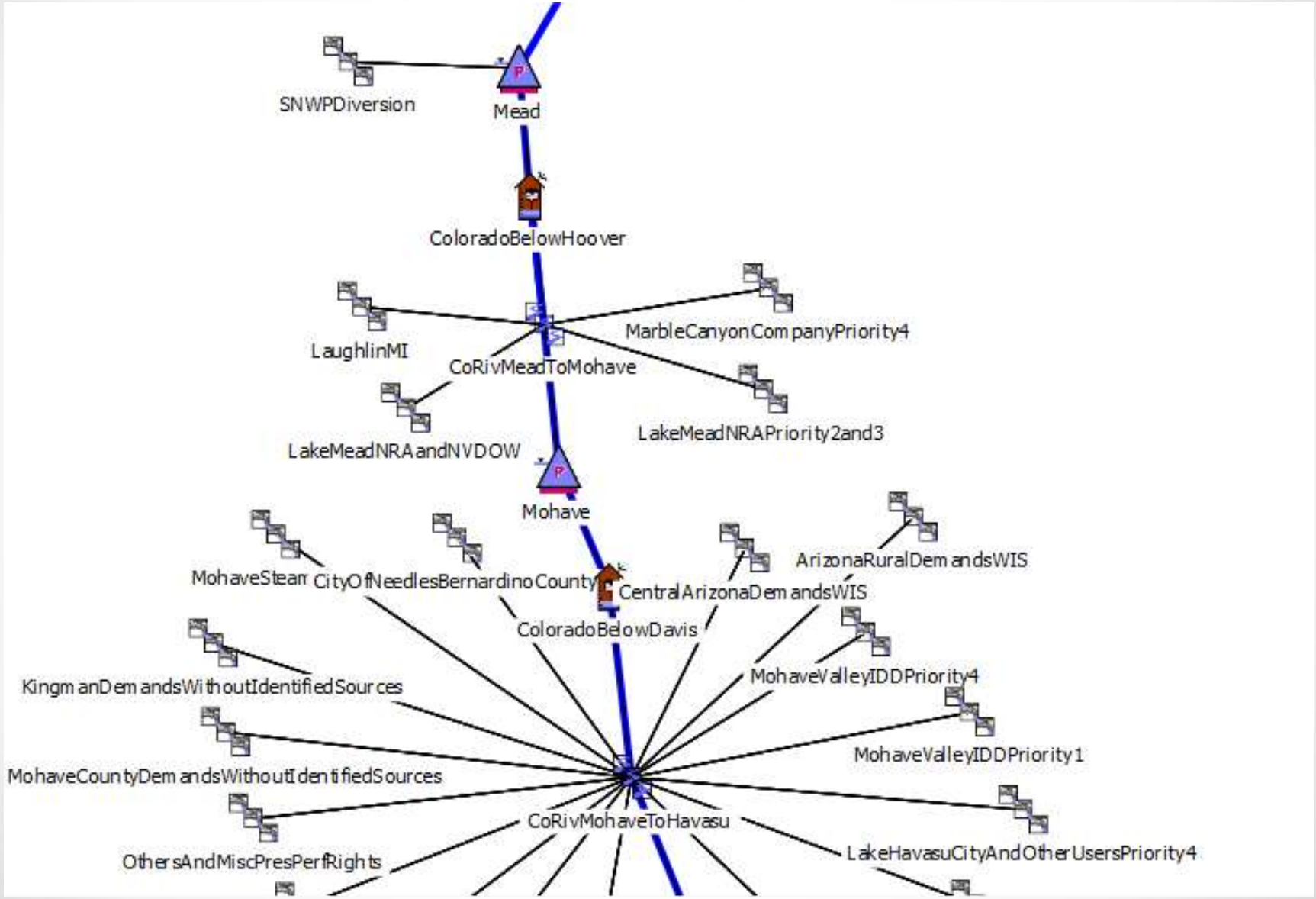
- **Each object is assumed to be fully mixed**
  - Reservoirs have methods to specify how mixing occurs
  - Reaches must have "No Routing"
- **Each object tracks Salt Concentration and Mass**
- **Usually for longer timesteps (monthly)**

Colorado River Basin

- **Salinity gaging sites**
  - 15 upper basin
  - 5 lower basin
- **Numeric criteria sites**



CRSS Model

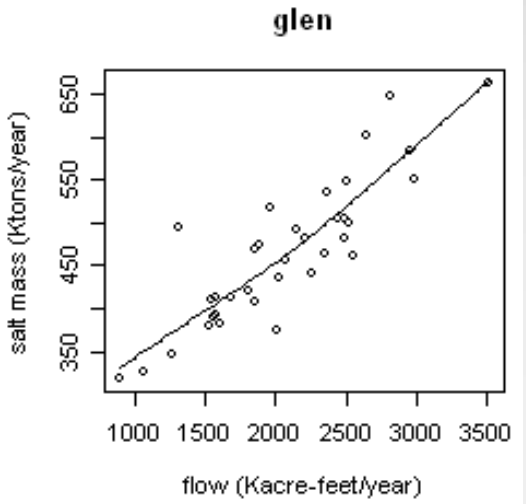

SNWPDiversion
Mead
ColoradoBelowHoover
LaughlinMI
CoRivMeadToMohave
MarbleCanyonCompanyPriority4
LakeMeadNRAandNVDOW
LakeMeadNRAPriority2and3
Mohave
MohaveSteam
CityOfNeedlesBernardinoCounty
ColoradoBelowDavis
CentralArizonaDemandsWIS
ArizonaRuralDemandsWIS
KingmanDemandsWithoutIdentifiedSources
MohaveValleyIDDPriority4
MohaveValleyIDDPriority1
MohaveCountyDemandsWithoutIdentifiedSources
CoRivMohaveToHavasu
OthersAndMiscPresPerfRights
LakeHavasuCityAndOtherUsersPriority4

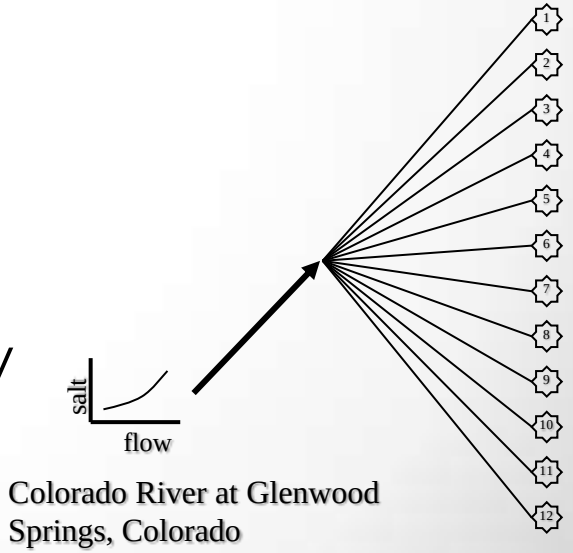
Basin Wide Annual Salt Model

- **Couples a**
  - Statistical nonparametric natural salt model (Prairie et al., 2005)
  - Nonparametric space-time disaggregation technique

    (Prairie et al., 2007)
- **Temporal disaggregation of annual salt mass at multiple sites**
  - Multiple annual natural salt vs. flow regressions
  - Temporal disaggregation to a monthly time step

    (Prairie and Rajagopalan, 2007)

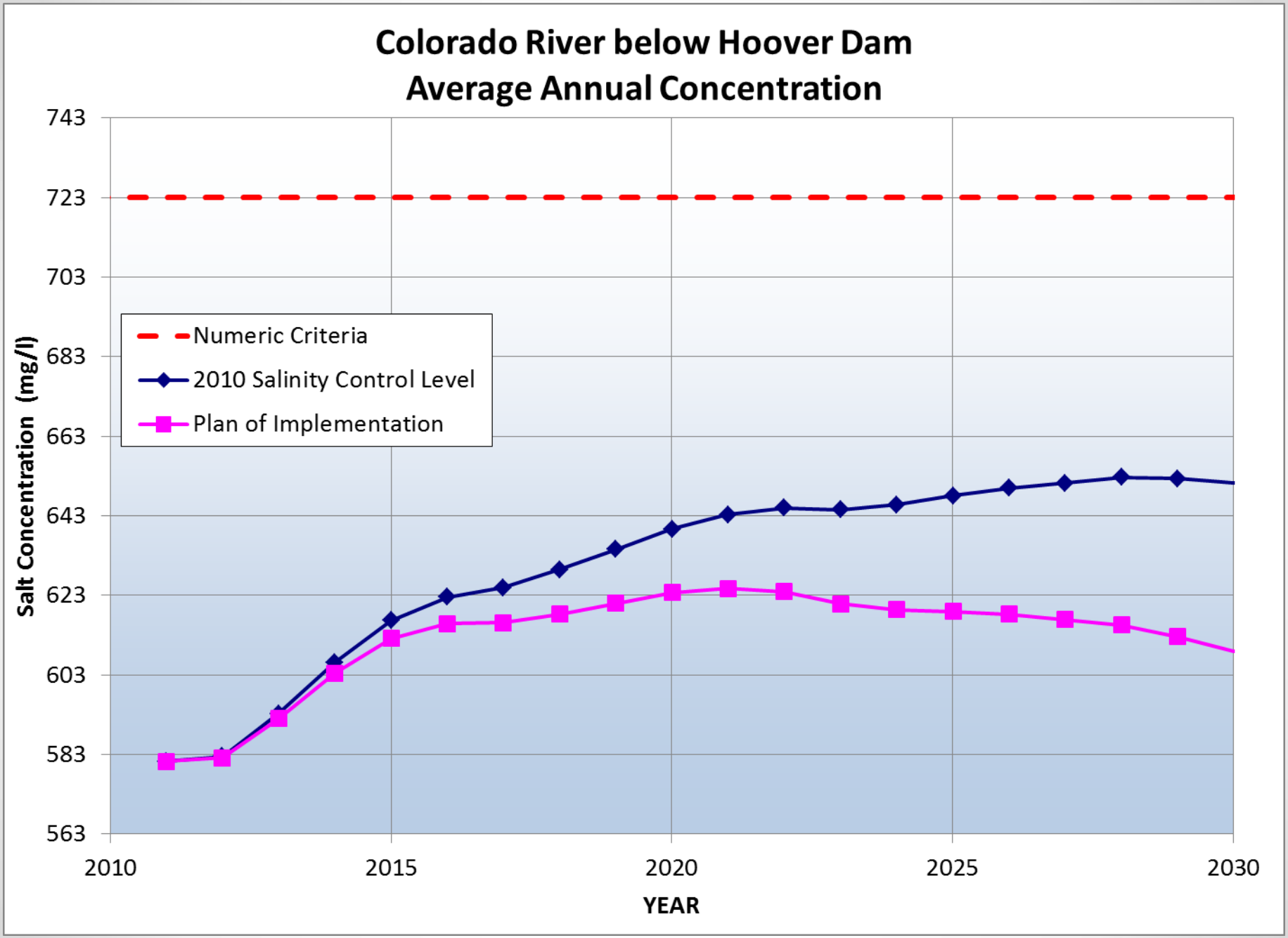




Colorado River at Glenwood Springs, Colorado

Colorado River Basin Salinity Modeling Applications

- **Salinity Control Forum's**
  - Triennial Reviews
  - Salinity Control Plan of Implementation
- Annual projections of salinity at Parker Dam for **Metropolitan Water Board**'s planning purposes for future diversions
- NEPA studies as requested

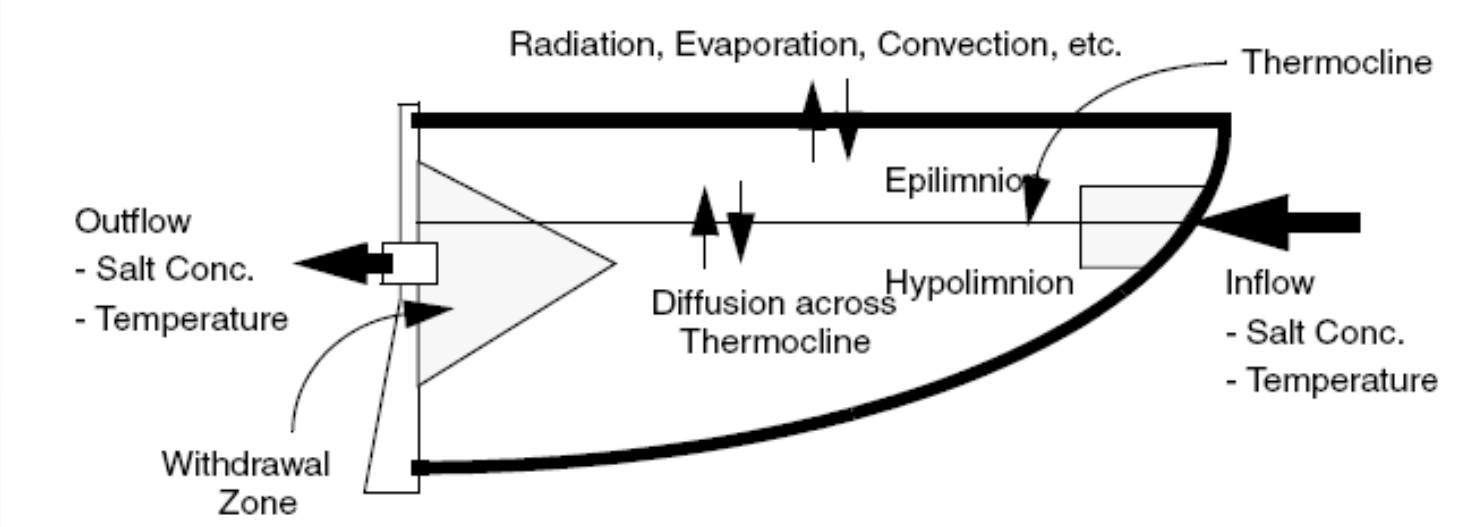

Colorado River below Hoover Dam
Average Annual Concentration
743
723
703
683
663
643
623
603
583
563
Salt Concentration (mg/l)
Numeric Criteria
2010 Salinity Control Level
Plan of Implementation
2010
2015
2020
2025
2030
YEAR

Recent Enhancements to Simple Well-Mixed Salinity

- **Reach**
  - Max Salt Concentration and Salt Storage better preserve mass during low flows
  - Dispatch methods (salinity mass balance) now solved in terms of mass instead of concentration.
- **Aggregate Diversion Site**
  - Distributed Annual Salt Mass Loading method now allows Return Flow Salinity Pickup Mass to be specified (previously only concentration)
  - New Salt Mass Removal methods allow salt mass to be removed from a linked reach. Removal is limited by the specified minimum concentration on the reach.

2. Layered / Discretized

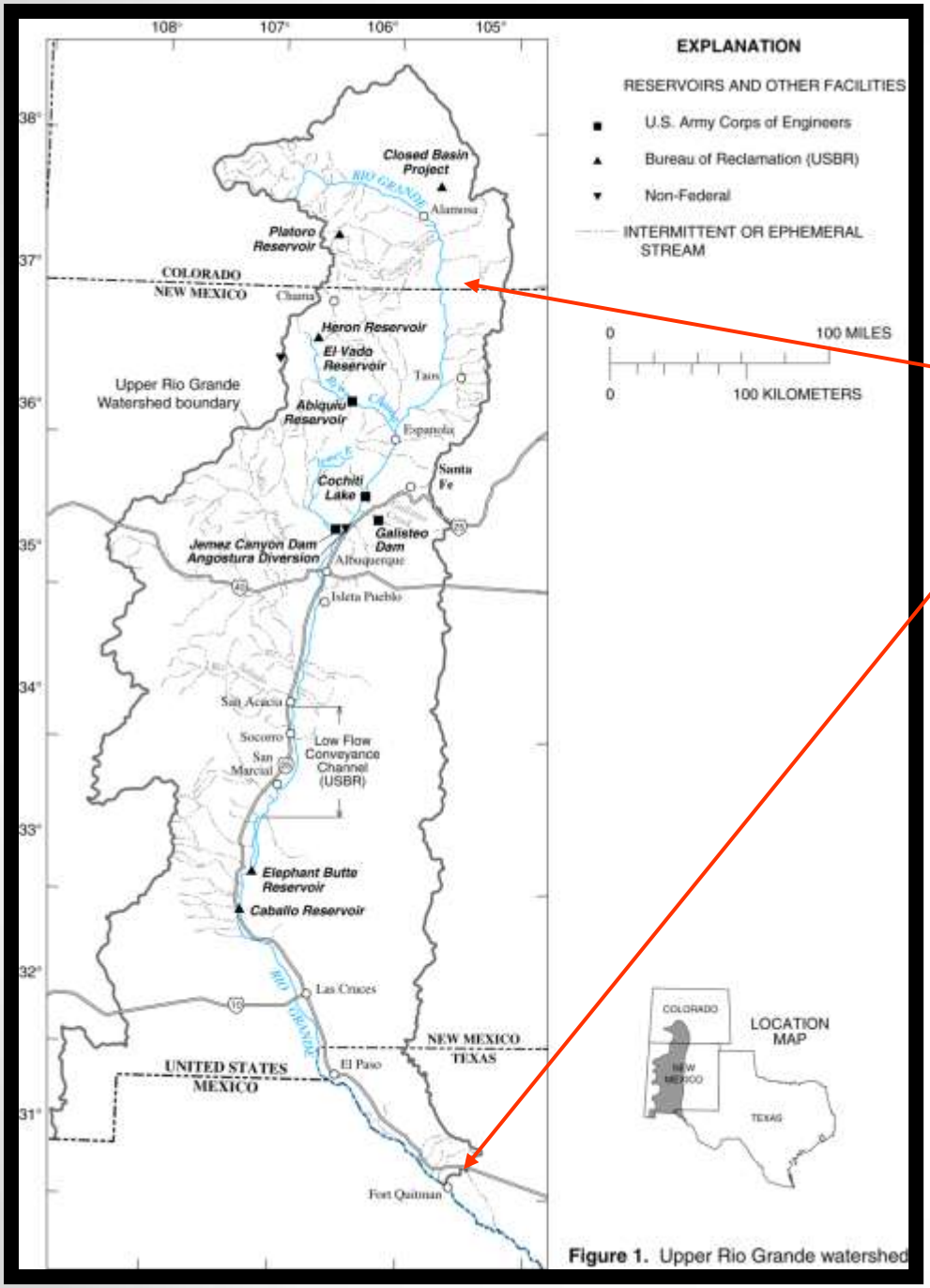
- **For shorter timesteps (1hr/ 6 hr / 1 day)**
- **Layered Reservoirs (and GW objects):**



- **Reach Routing:**
  - No Routing
  - Time Lag and Variable Time Lag
  - MacCormack, Kinematic, MuskingumCunge: Explicit or Implicit

Application:

Upper Rio Grande



Colorado – New Mexico state line to Ft. Quitman, Texas

Upper Rio Grande Water Operations Model (URGWOM)

Sample Schematic of Irrigation System in NM

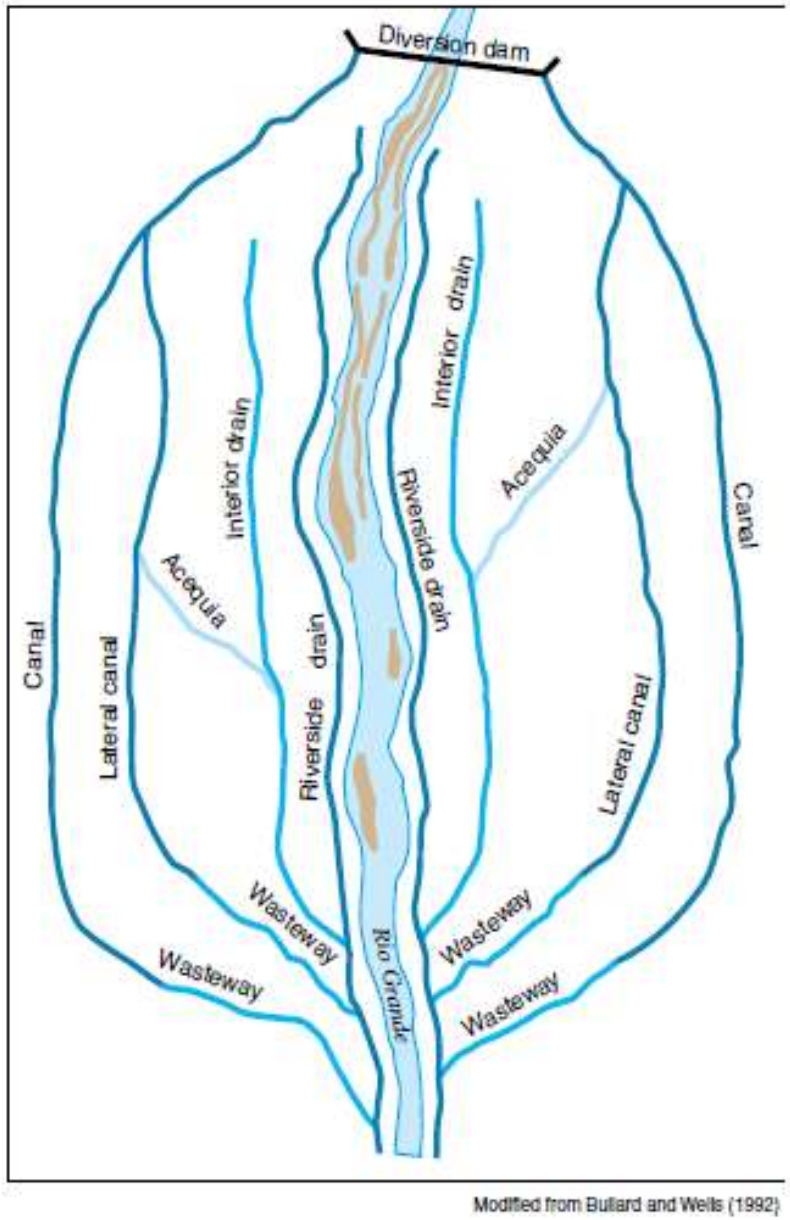
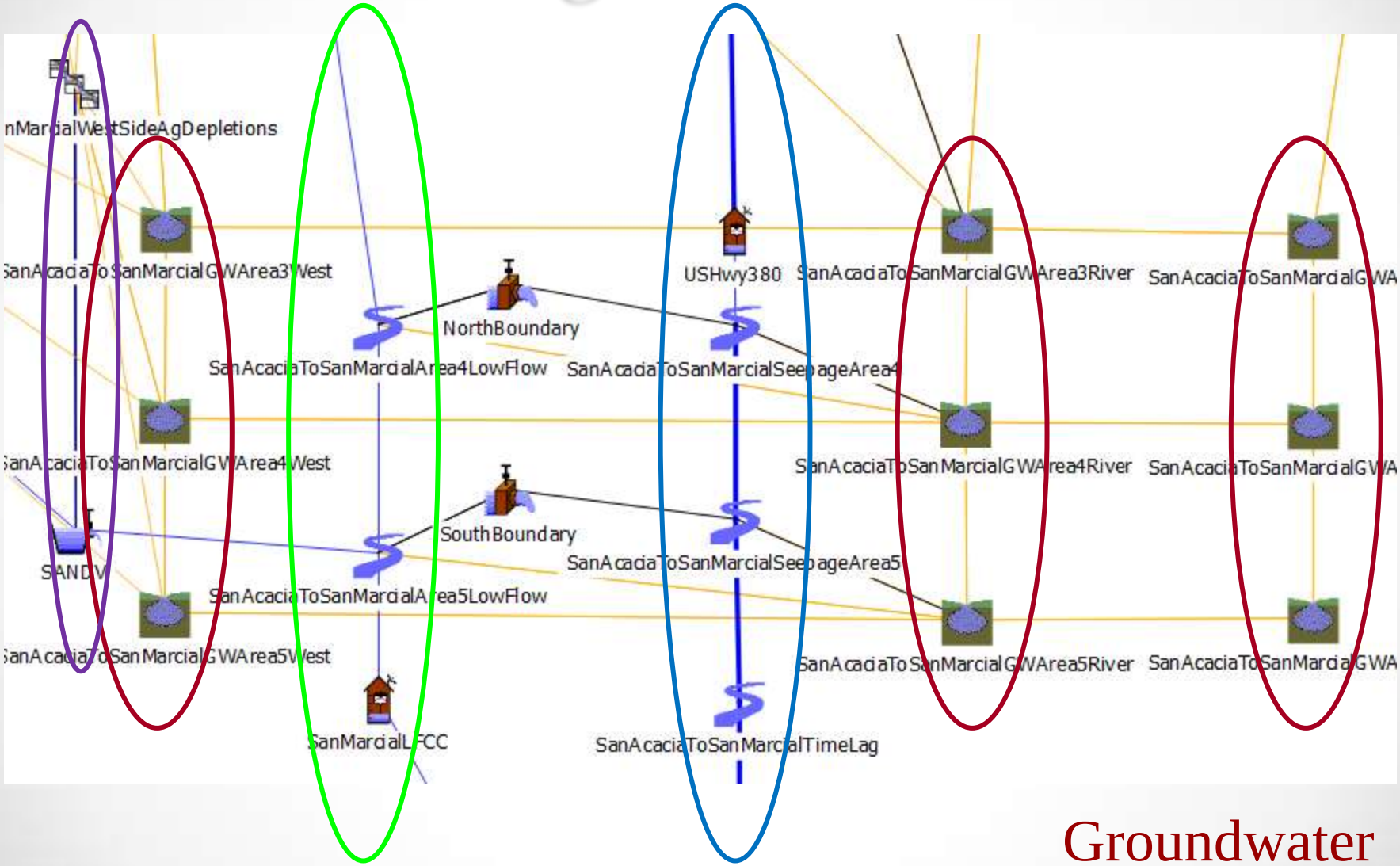


Figure 4.2.—Schematic diagram of the inner valley irrigation network in the Middle Rio Grande Basin.

Bartolino, J.R. and J.C. Cole, 2002, Ground-water resources of the middle Rio Grande basin, New Mexico, 2002, USGS Circular: 1222

Modeling in URGWOM



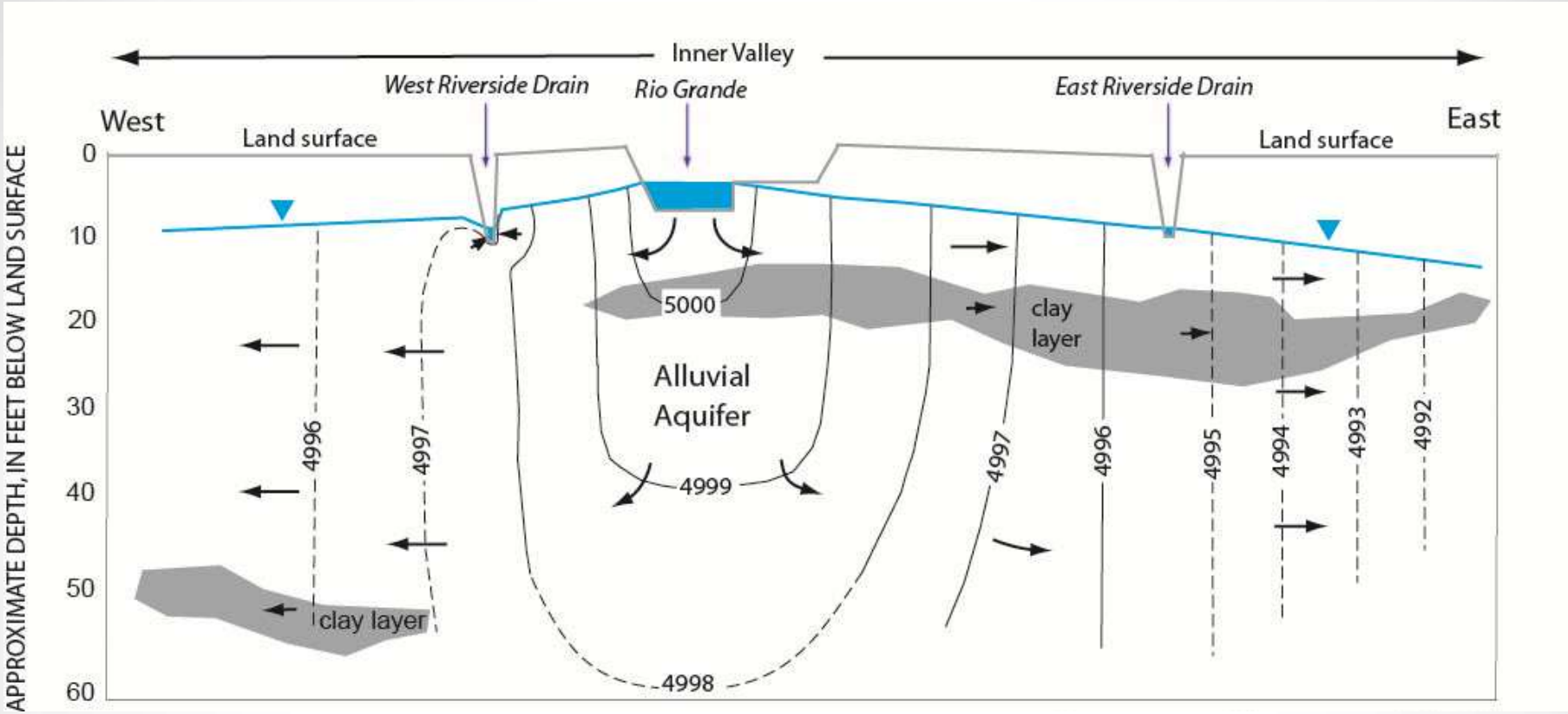
Ag

Drain

Main River

Groundwater Network

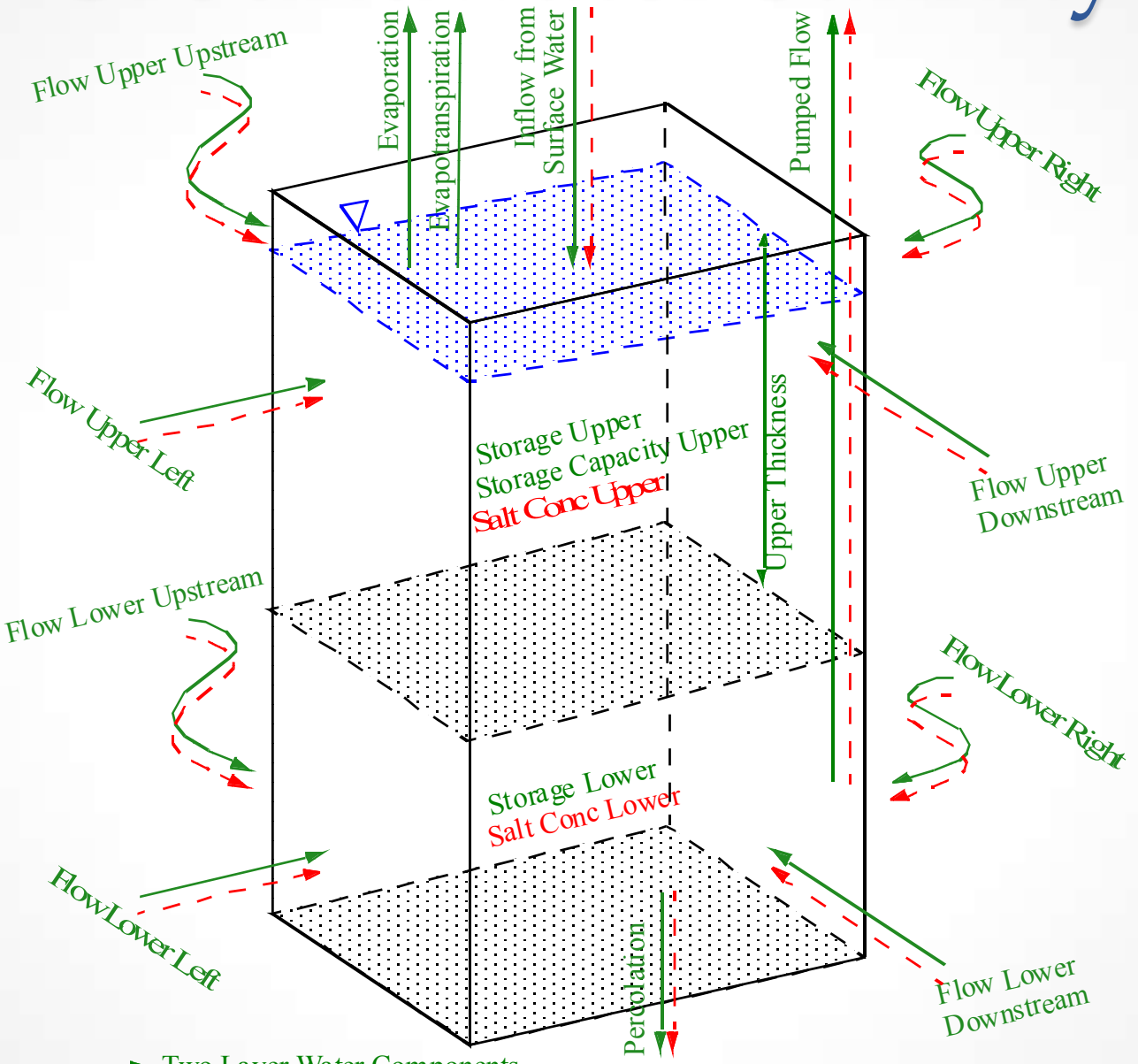
Groundwater Salinity



- Currently URGWOM models the alluvial aquifer which averages 80 feet thick
- Previous work in the basin suggests that only the upper portion of the alluvial aquifer is actively exchanged with the agricultural and irrigation systems
- A 2-Layer groundwater object allows the system and water quality to be more accurately represented

Modified from: Rankin, D.R., McCoy, K.J., Moret, G.J.M., Worthington, J.S., and Bandy-Baldwin, K.M., 2013, Groundwater hydrology and estimation of horizontal groundwater flux from the Rio Grande at selected locations in Albuquerque, New Mexico, 2003–9: U.S. Geological Survey Scientific Investigations Report 2012–5007, 75 p. (http://pubs.usgs.gov/sir/2012/5007/)

Groundwater Salinity



URGWOM Salinity Model

- **Salinity is the primary water quality issue in the Rio Grande**
- **Understanding salinity is key to managing available water and minimizing salinity downstream**
- **Modeling salinity allows us to understand the salinity system**
  - Determine the (relative) contribution of salinity sources
  - Test mitigation options

Summary

- The **Colorado River Basin uses a simple well-mixed** approach to track salinity on a monthly scale
- **URGWOM uses the layered** approach to track salinity on a daily scale in both the surface and shallow groundwater