Web-based Decision Support for Stakeholder Implementation of Real-time, Basin-scale Salinity Management

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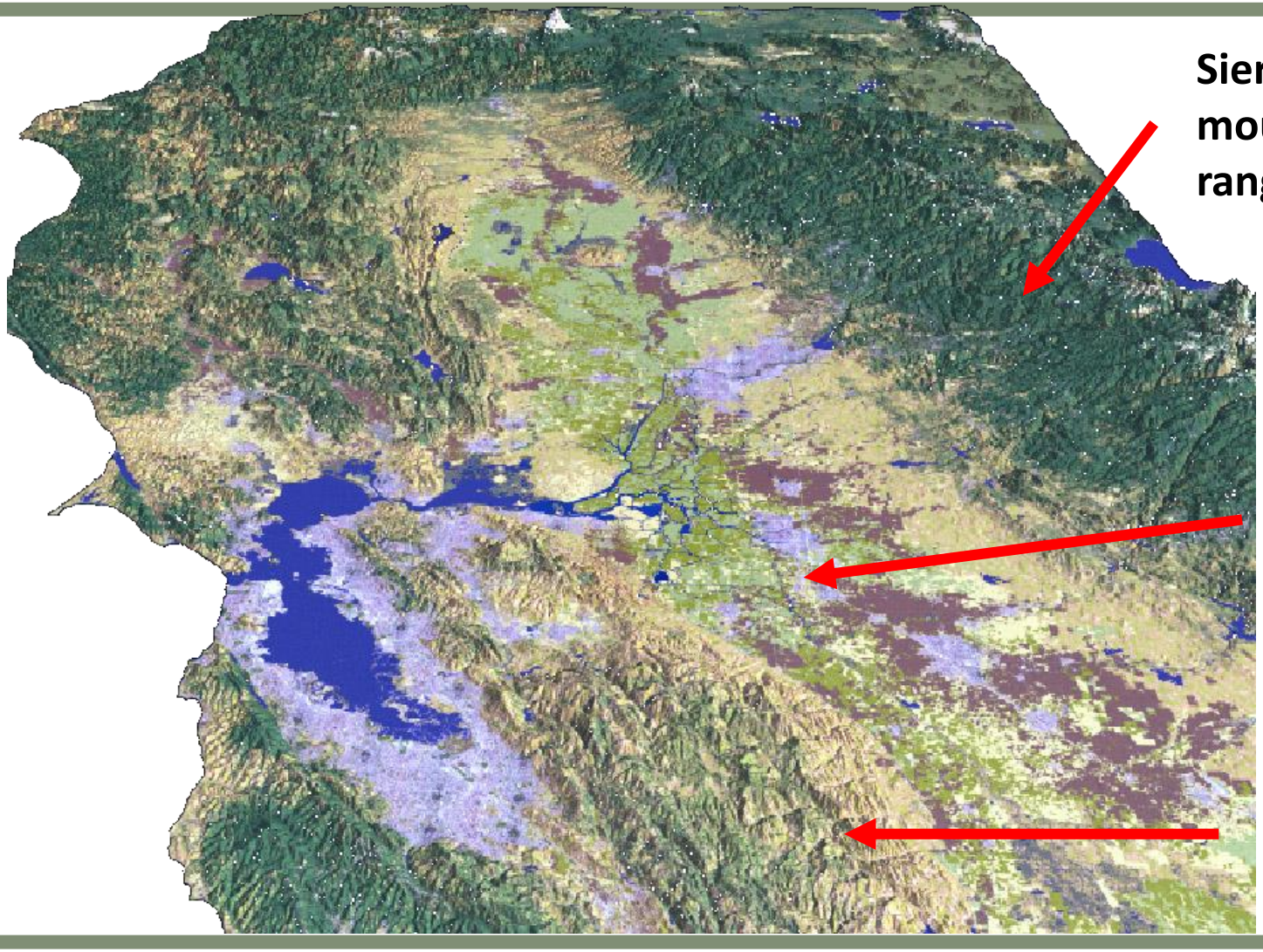
Berkeley National Laboratory

ISESS Conference
May 10, 2017

Central Valley of California – US agricultural hub



Unique features of the San Joaquin River Basin

- The Coastal Range is a uplifted seabed- sedimentary in origin. Soils derived from Coast range are high in native salts, selenium and boron.
- The Sierra Nevada is of volcanic origin. Soils derived from the Sierra are sandy and granitic. The Sierra snowpack is a major water resource. Runoff from Sierran watersheds is of high quality.
- West-side agriculture is supplied with water from the Sacramento- San Joaquin Delta and has elevated salinity.
- A portion of the San Joaquin River is recirculated to the Delta pumps. Salinity objectives were set in the River for salinity to protect Delta agriculture.
- Farmland in San Joaquin Basin require irrigation and produce some of the highest yielding crops in the nation and 13% of entire agricultural output. California produces 82% of the world's almond crop – most in the San Joaquin Basin.

REAL-TIME WATER QUALITY MANAGEMENT

BACKGROUND

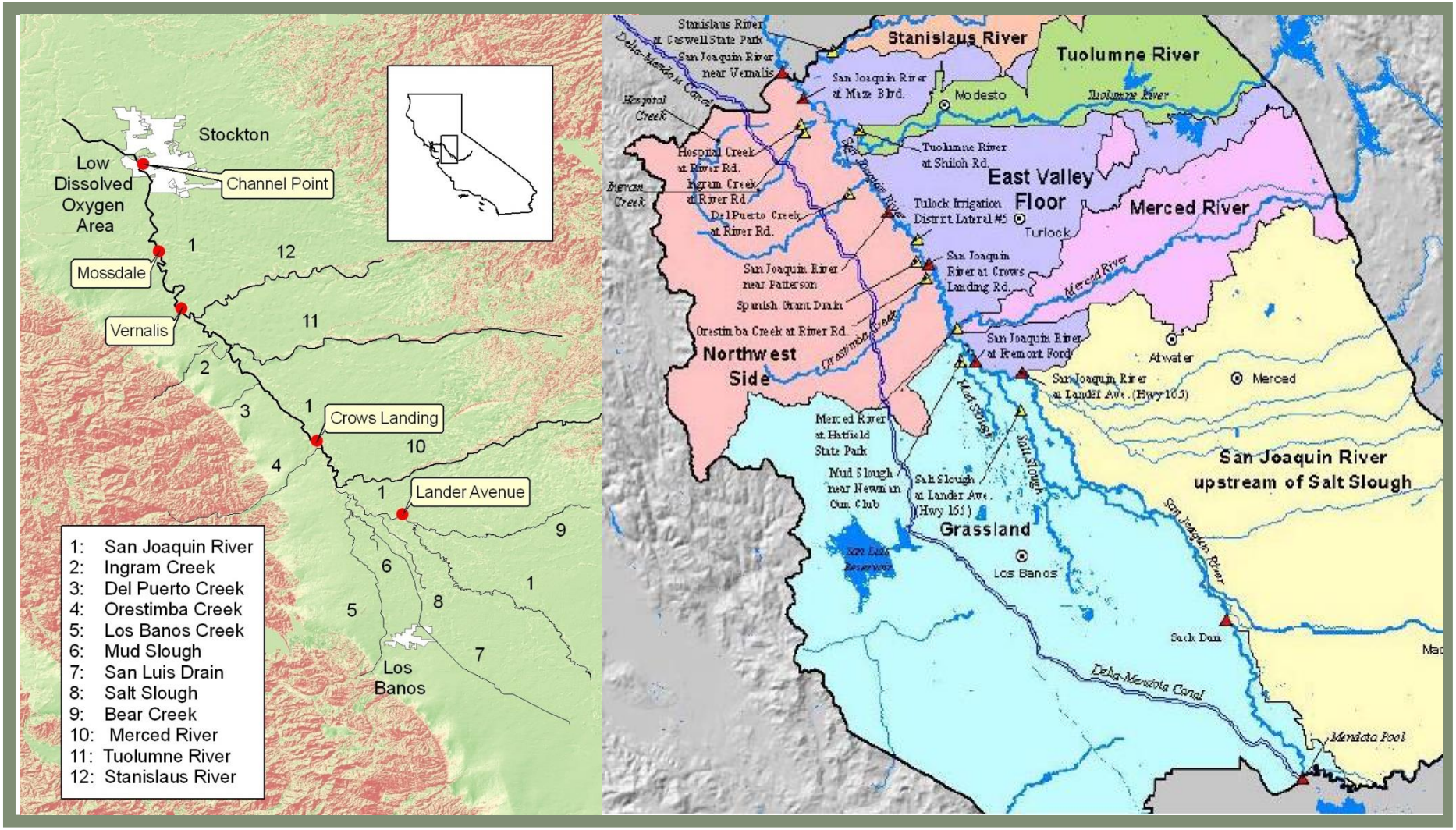
Background – Water Quality

- The TMDL is an EPA mandated policy instrument for non-point source pollution management in watersheds
- Selenium, boron and salt are primary constituents of concern in the San Joaquin River Basin
- Water quality often exceeds CRWQCB conc. limits
  salt : 700 uS/cm as EC April-Aug.; 1,000 uS/cm as EC Aug. – April
- Real-Time Water Quality Management utilizes SJR assimilative capacity to discharge higher annual contaminant loads than a strict TMDL
- Agricultural and wetland dischargers may have unrealized flexibility of operation through real-time coordination to improve compliance with SJR water quality objectives

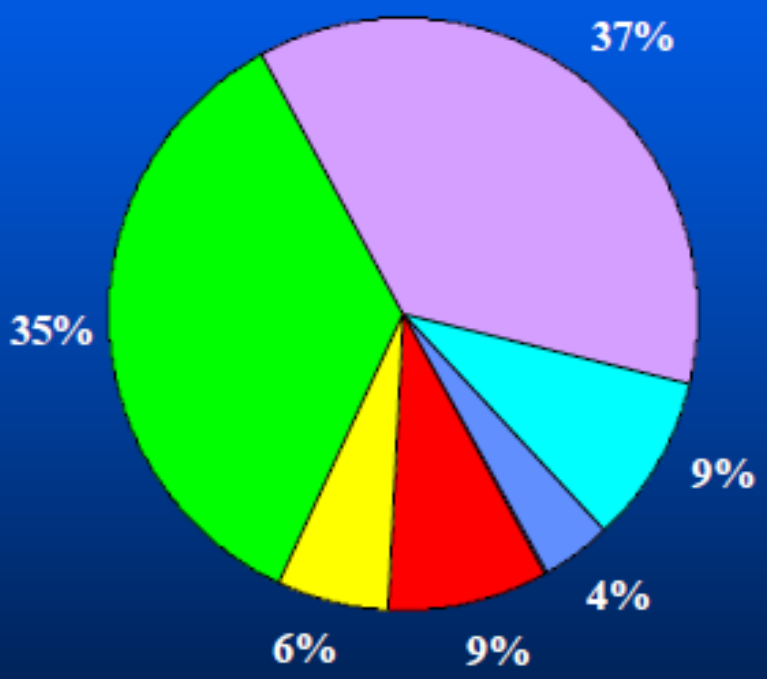
Salinity regulation in the San Joaquin River Basin

- Regulatory agencies adopted a stakeholder-centric approach to salinity planning and regulation. Rewrote Basin Plan for water quality
- Basin Plan includes provision for real-time salinity management
- Requires dischargers otherwise subject to TMDL's to adopt a "Board approved" real-time salinity management program
- Program to include integration of data acquisition, processing, model forecasting, information dissemination and decision support. High reliance on sensor networks and the development of a stakeholder supported sensor web
- Real-time water quality (salinity) management allows greater salt export than traditional load-based TMDL's
- Compliance – requires cooperation and coordination between agriculture, wetland interests, municipal and industrial stakeholders

TMDL-defined subareas within the San Joaquin River Basin



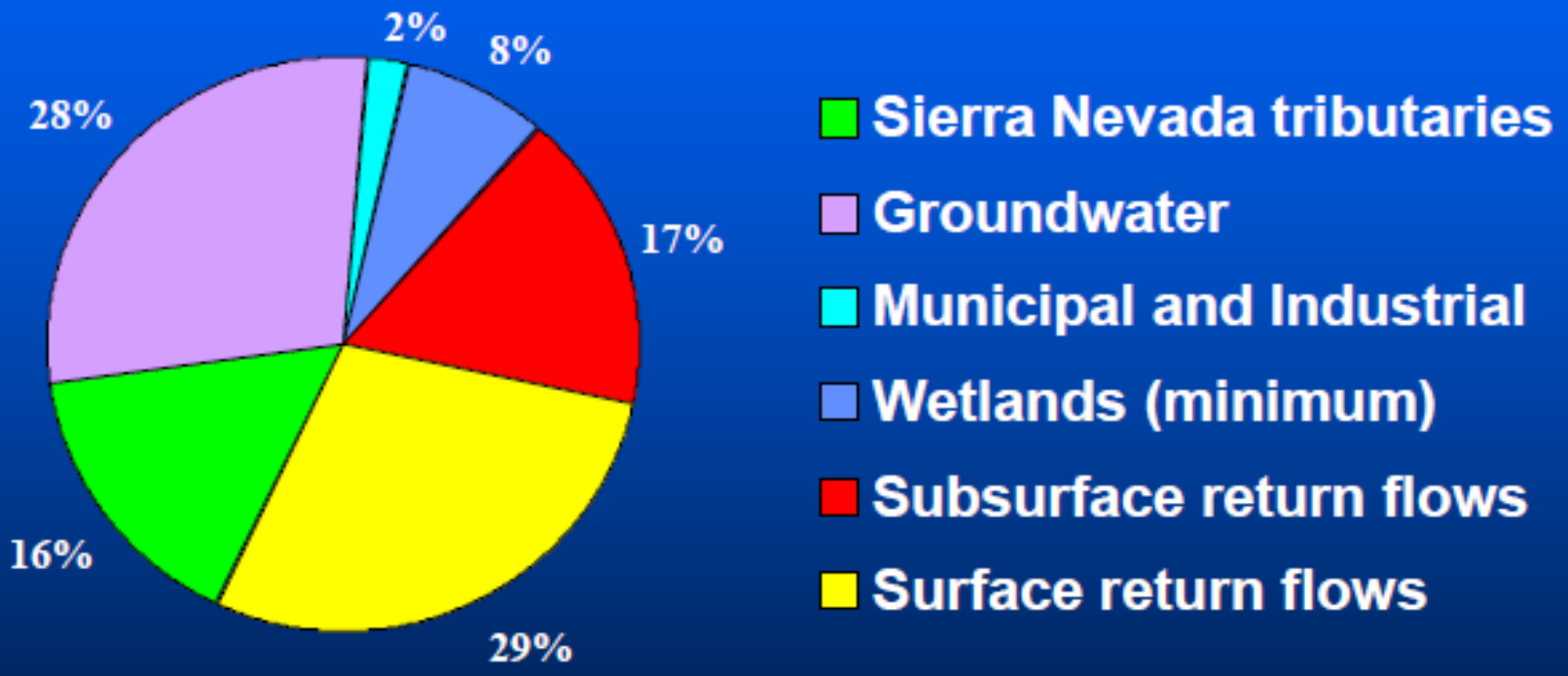
Sources of Salt (by sub-area)



Mean Annual Salt Load to SJR for WY 1977 to 1997: 1.1 million tons

*Northwest Side estimated by difference :Vernalis minus sum of other sources

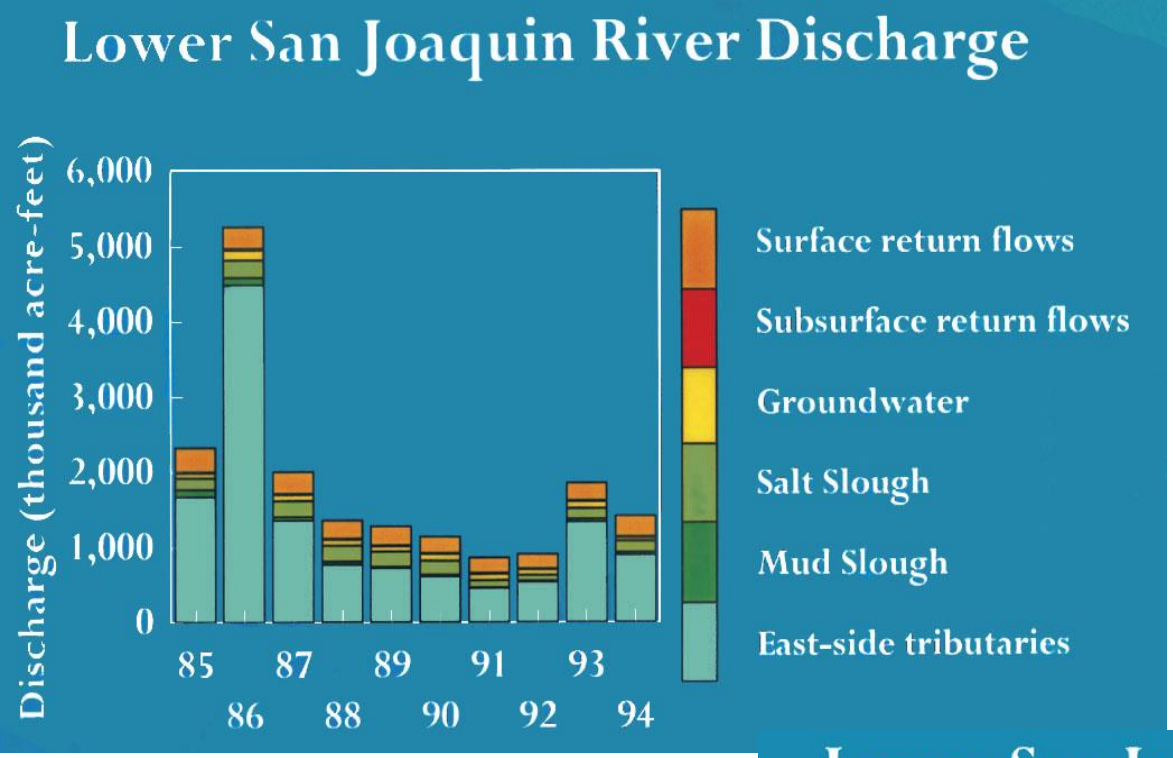
Sources of Salt (by type)



Mean Annual Loading of TDS to SJR for WY 1985 to 1994: 1 million tons

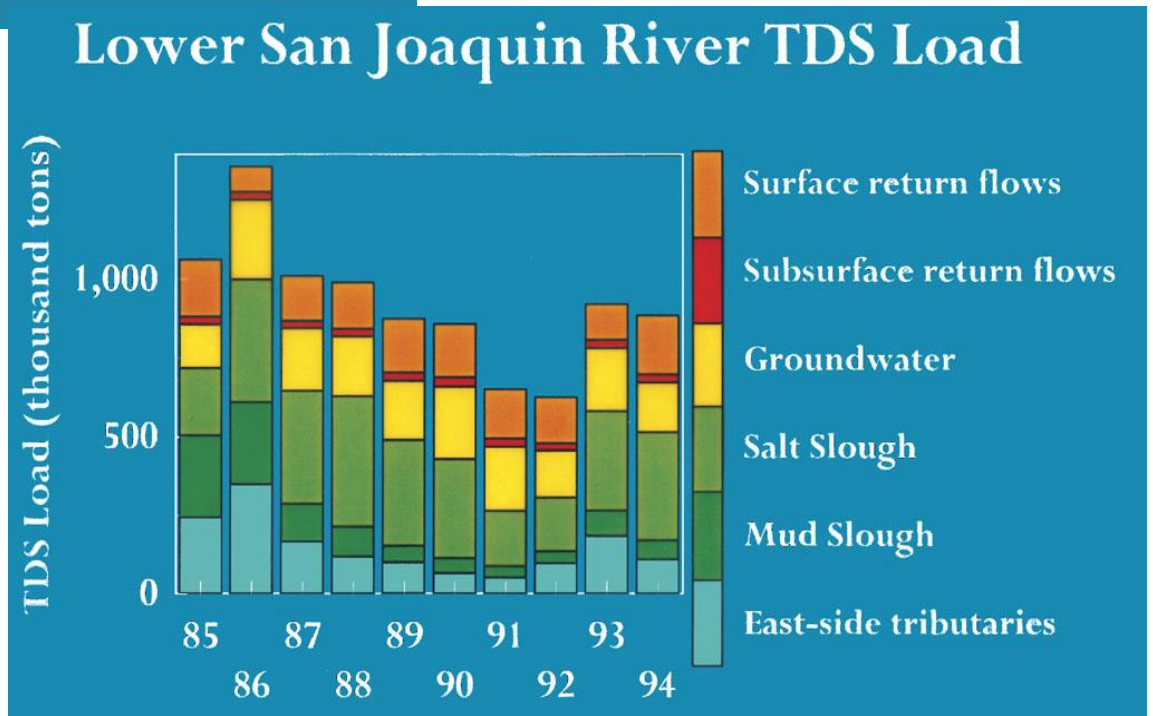
Basis: Historical and SJRIO* model data and spreadsheet analyses

*SJRIO: San Joaquin River Input Output Model

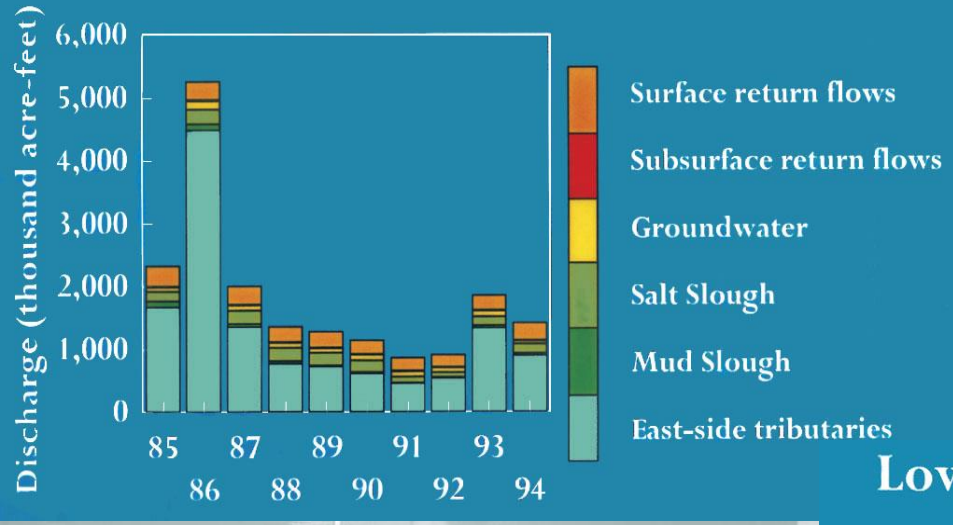


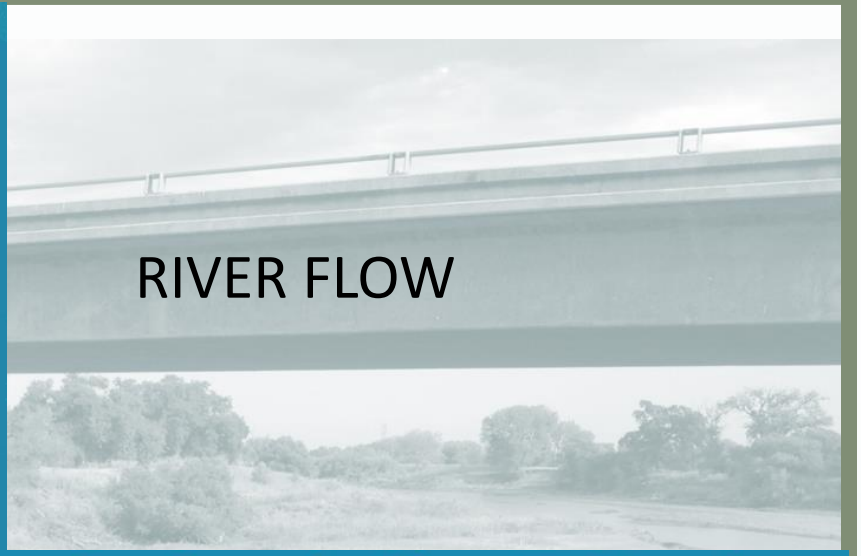
FLOW

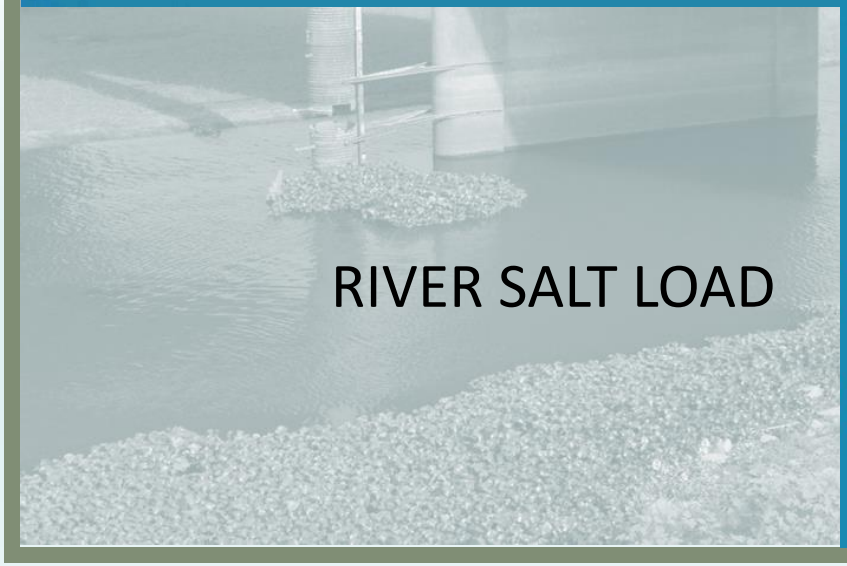
SALT LOAD



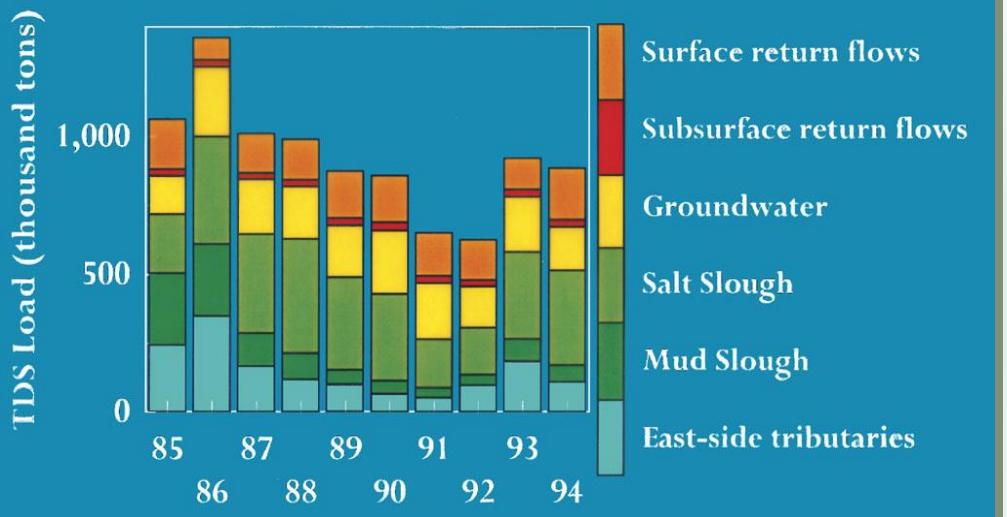
Lower San Joaquin River Discharge



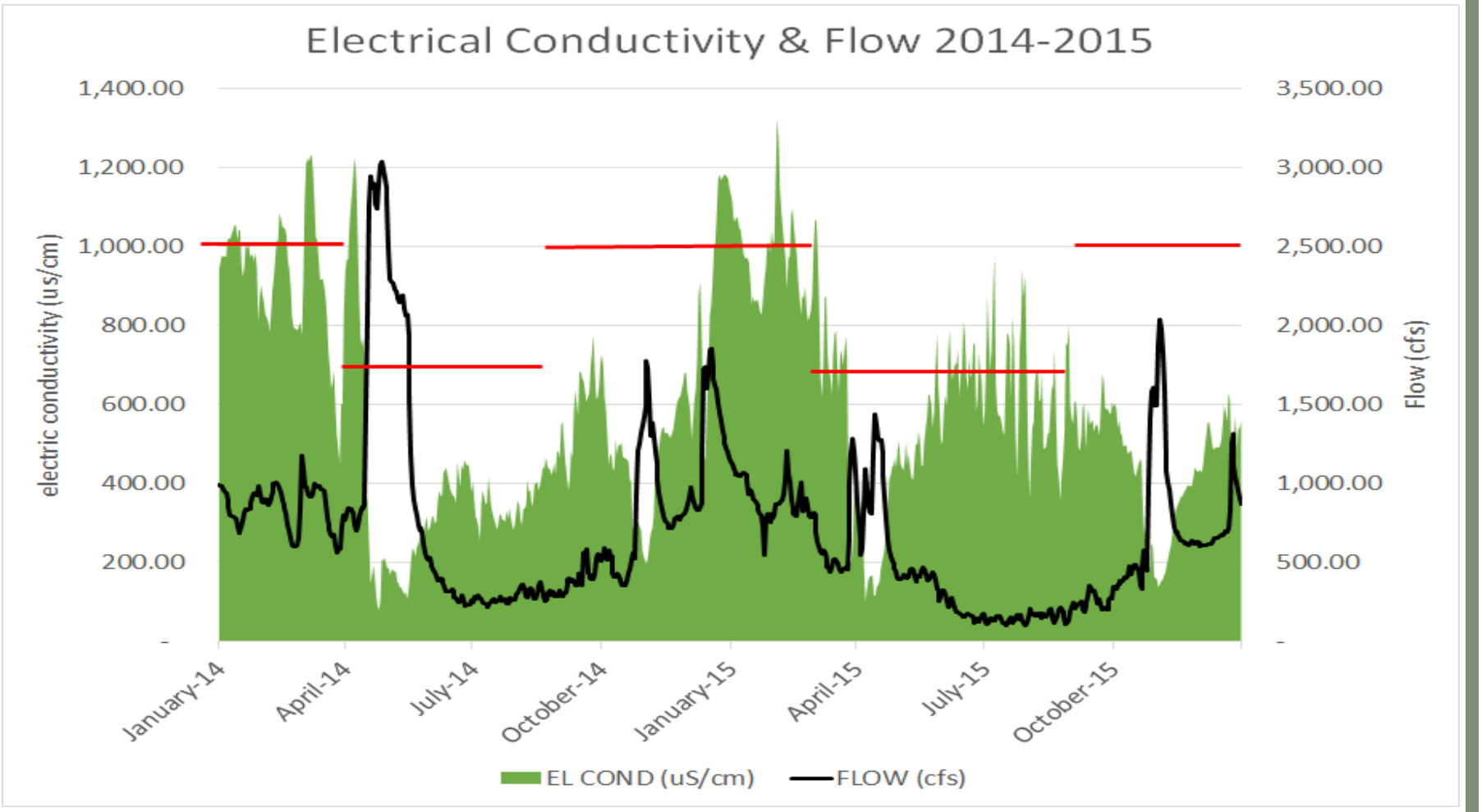




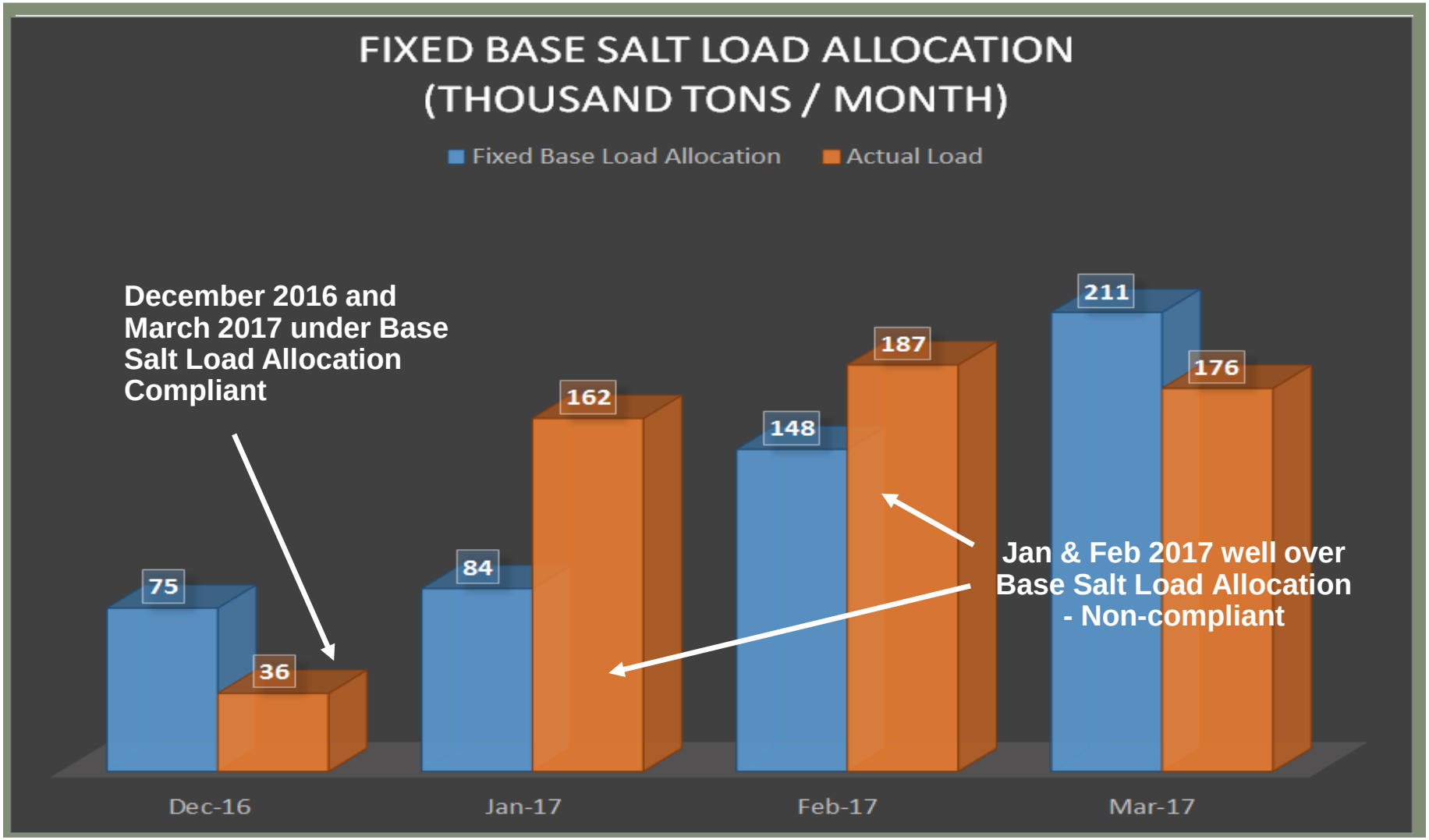
Lower San Joaquin River TDS Load



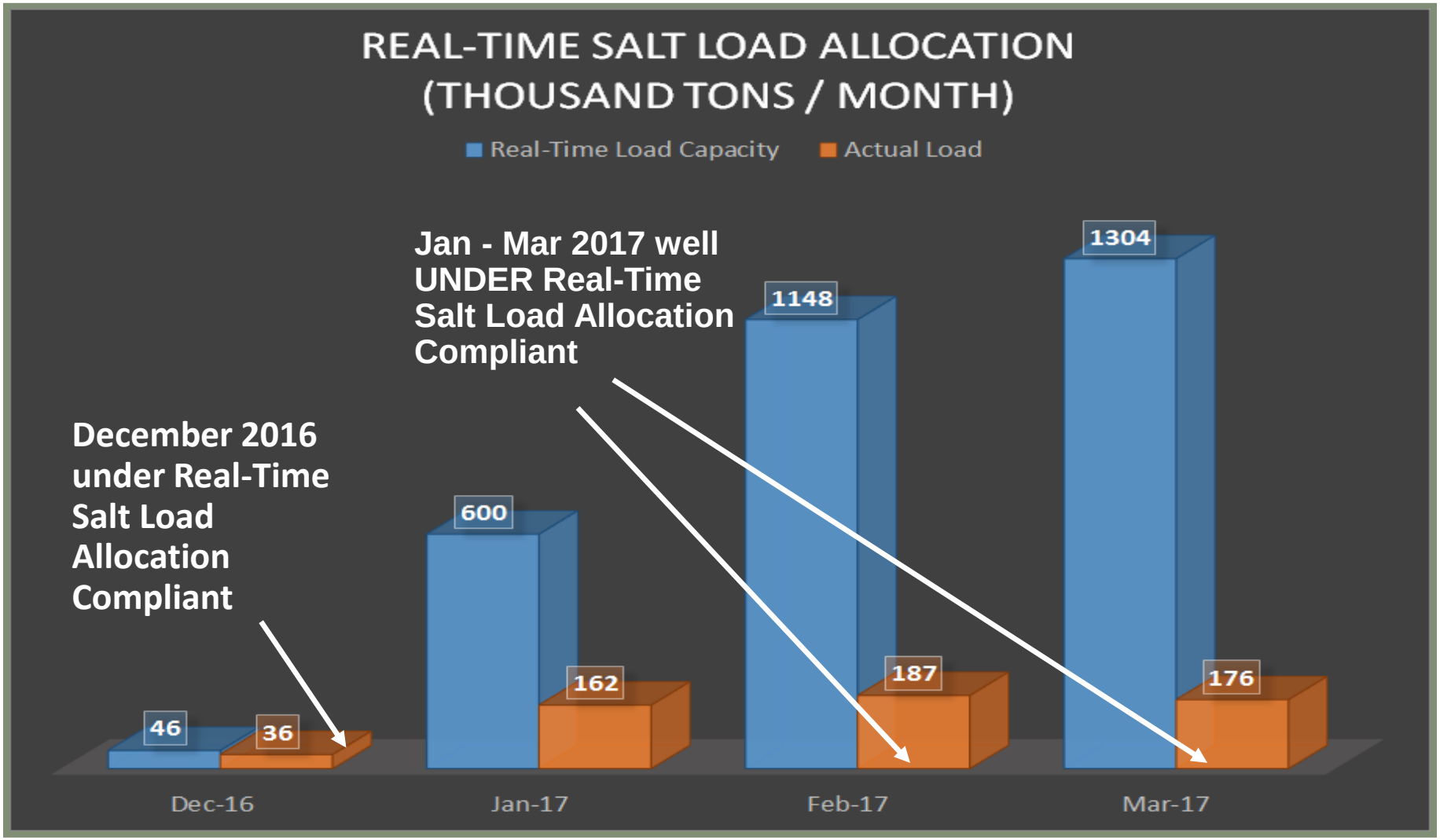
Flow, EC and 30-day running average EC



TMDL-based load allocations 2016/2017



Real-time load allocations winter 2016/2017



Hypothetical stakeholder fines for non-compliance

Subarea	Dates Analyzed	Days of Exceedance	Maximum Penalty ($5,000/day)
Northwest Side	Jan 2005 – Mar 2012	486	$2,430,000
Grassland	Jan 2002 – May 2011	869	$4,345,000
SJR Upstream (Near Stevenson)	Jan 2001 – Sep 2010	1139	$5,695,000
East Valley Floor	Mid Apr 2005 – Dec 2007	273	$1,365,000

Source: James Brownell, Staff Geologist, CVRWQCB, Agenda Item No. 5, Presentation to Lower San Joaquin River Committee, March 18, 2013

Definitions

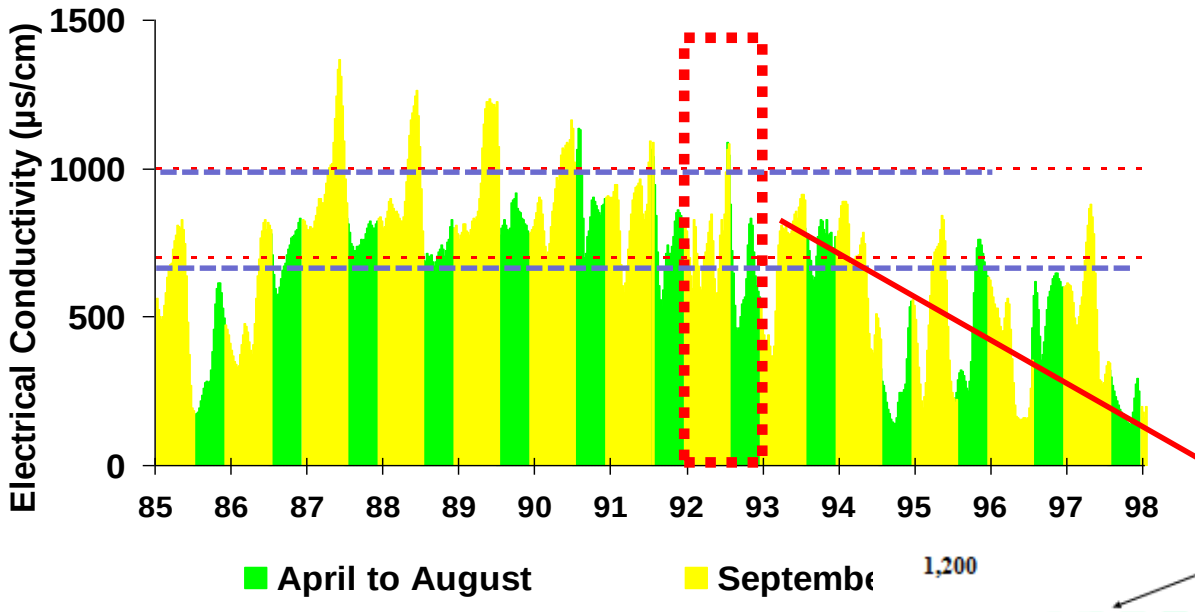
Pollutant assimilative capacity

The mass load of a pollutant that can be safely discharged to a receiving water without exceeding the water quality objective or standard for that pollutant.

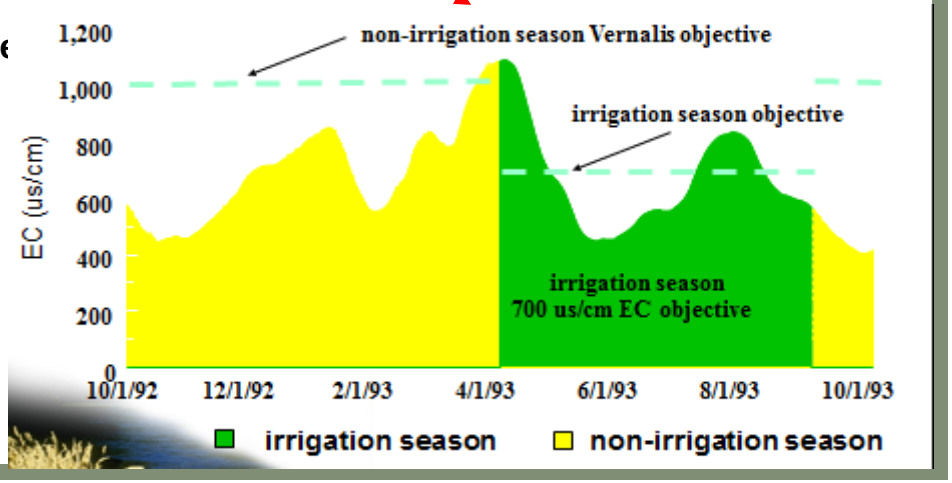
Real-time water quality management

A coordinated and cooperative set of actions based on real-time forecasts of river water quality to consistently meet water quality objectives

Concept of real-time salinity management



30 Day Running Average
Electrical Conductivity



San Joaquin River nr. Vernalis

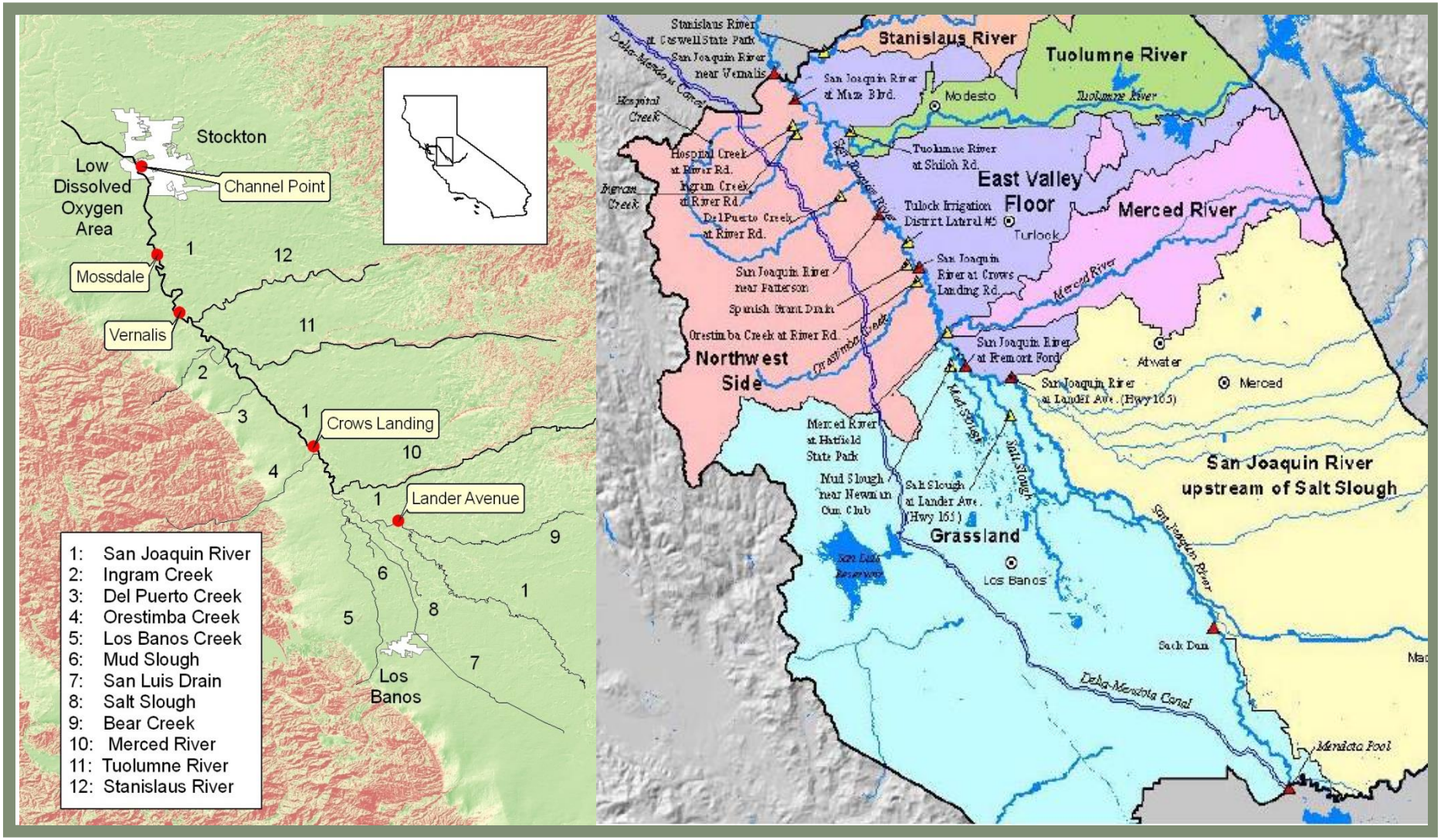
REAL-TIME WATER QUALITY MANAGEMENT

SAN JOAQUIN RIVER MAINSTEM

Regulatory requirements for real-time management system

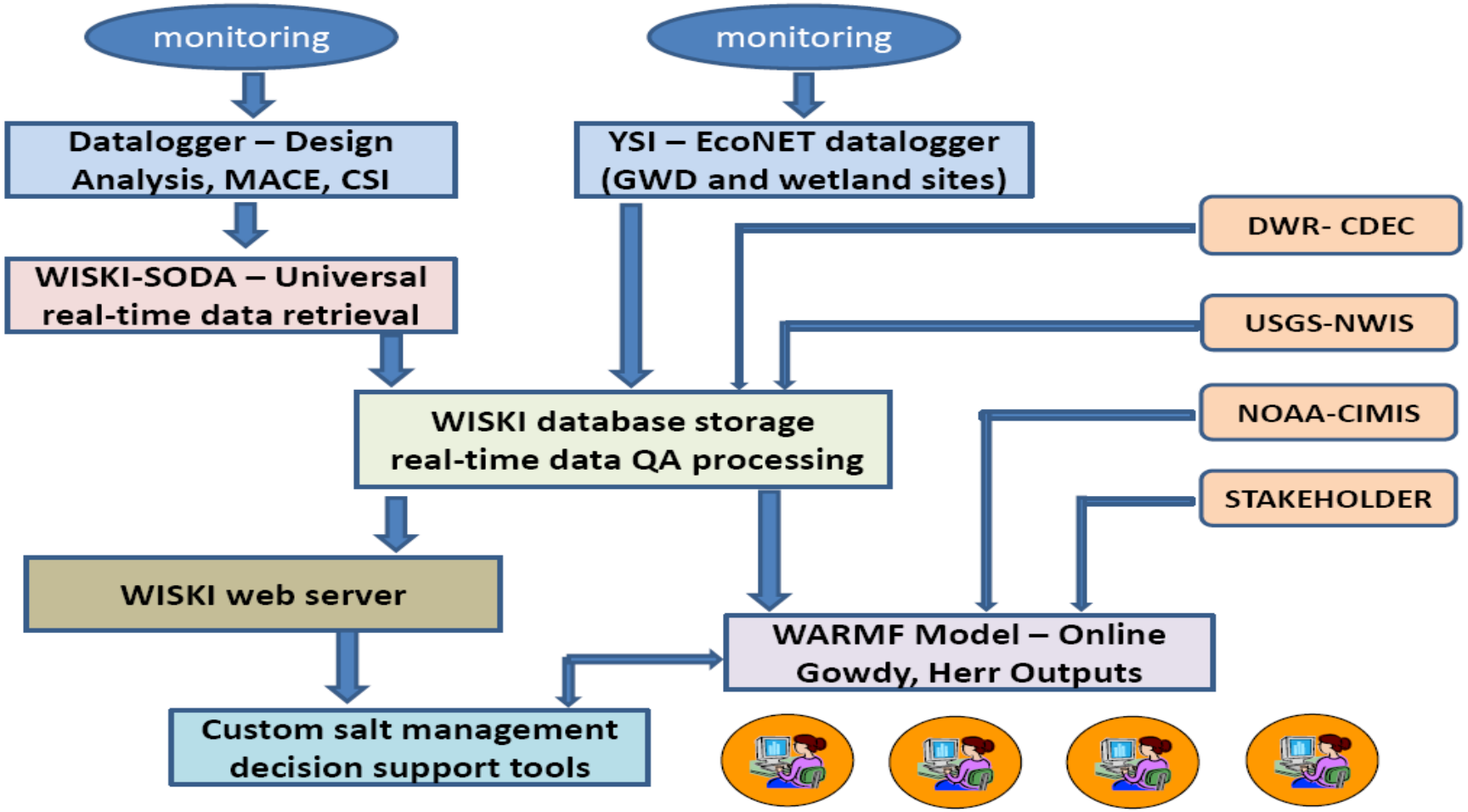
- Development and maintenance of a basin-wide real-time water quality monitoring system
- Flow and water quality control infrastructure must be in place or under development
- Institutions responsible for long-term cooperation and coordination to continuously match real-time contaminant loads with River salt load assimilative capacity. (Subarea delineation to permit assignment of penalties for non-compliance)
- Mechanisms developed for data dissemination, model based salinity forecasting and decision support

Monitoring return flow and salinity to the SJR

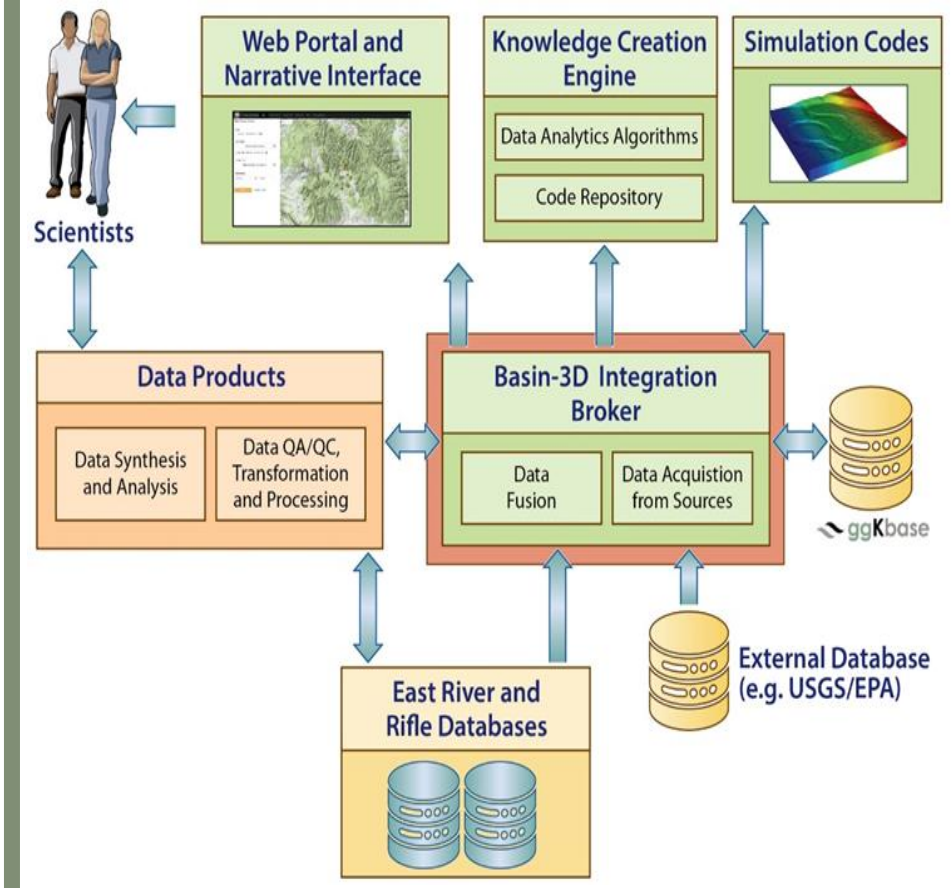


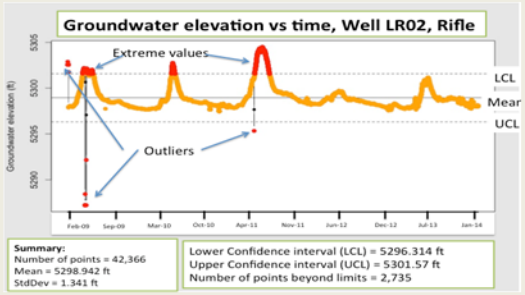
Flow / EC / salt load monitoring 1985 - 2017

NEXT GENERATION WEB-BASED SALINITY DECISION SUPPORT TOOLS



Elements of an environmental decision support system



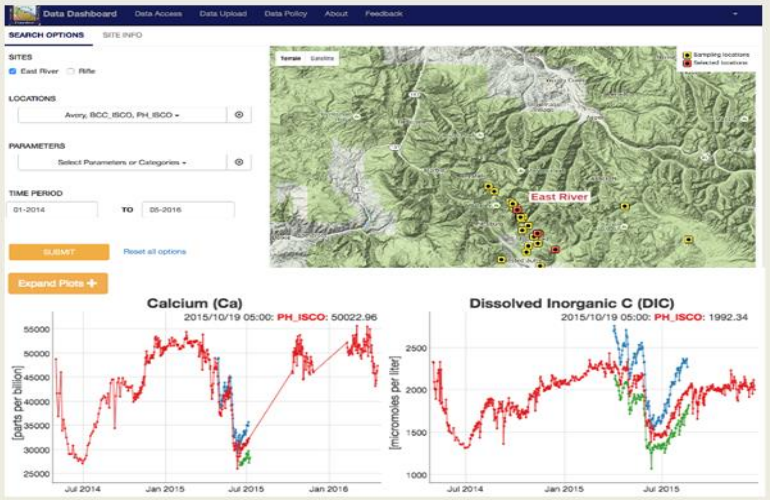


Data QA/QC

Statistical methods to flag outliers and clean data

Data Dashboard

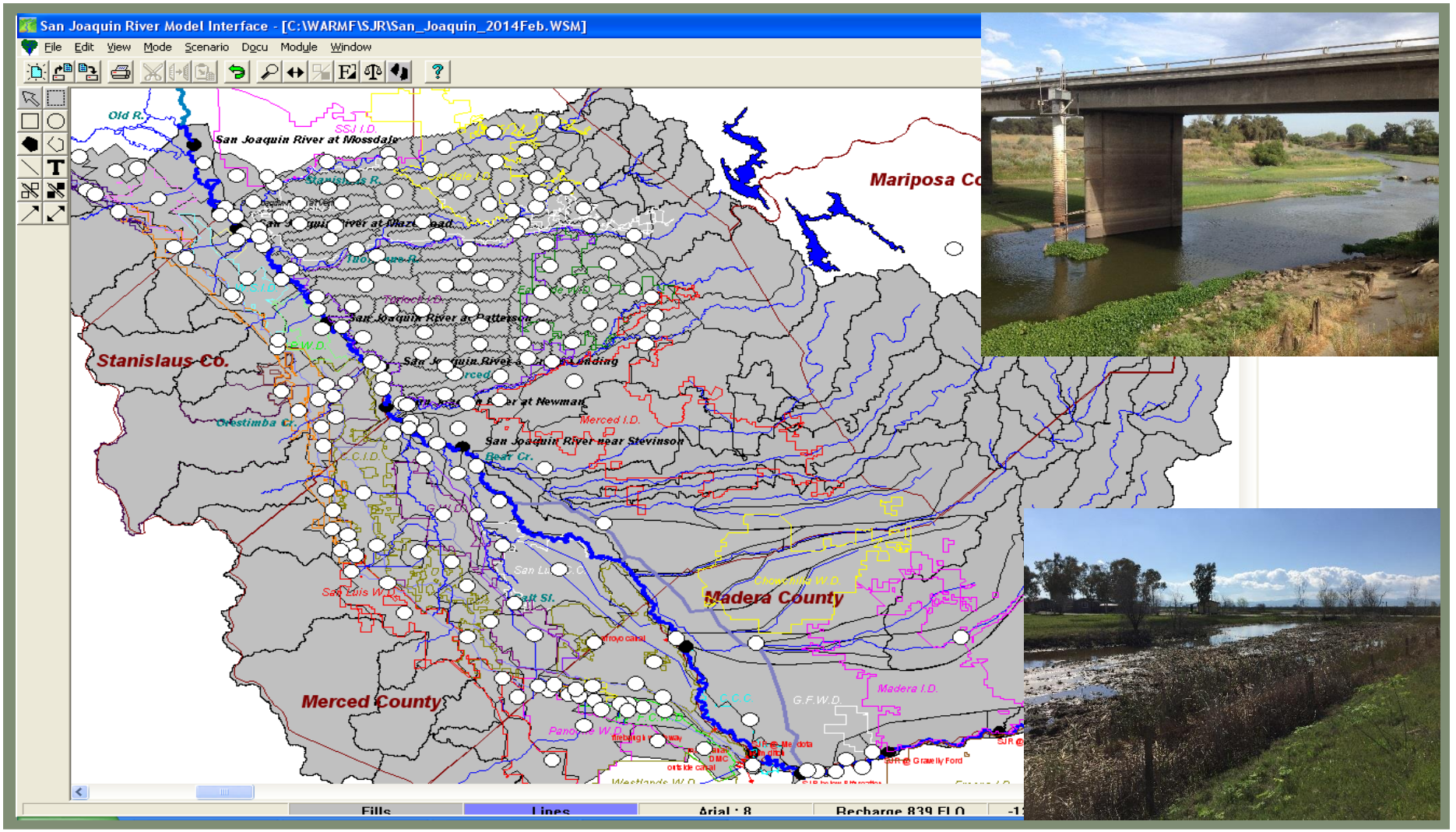
Enhanced search and interactive visualizations for data exploration



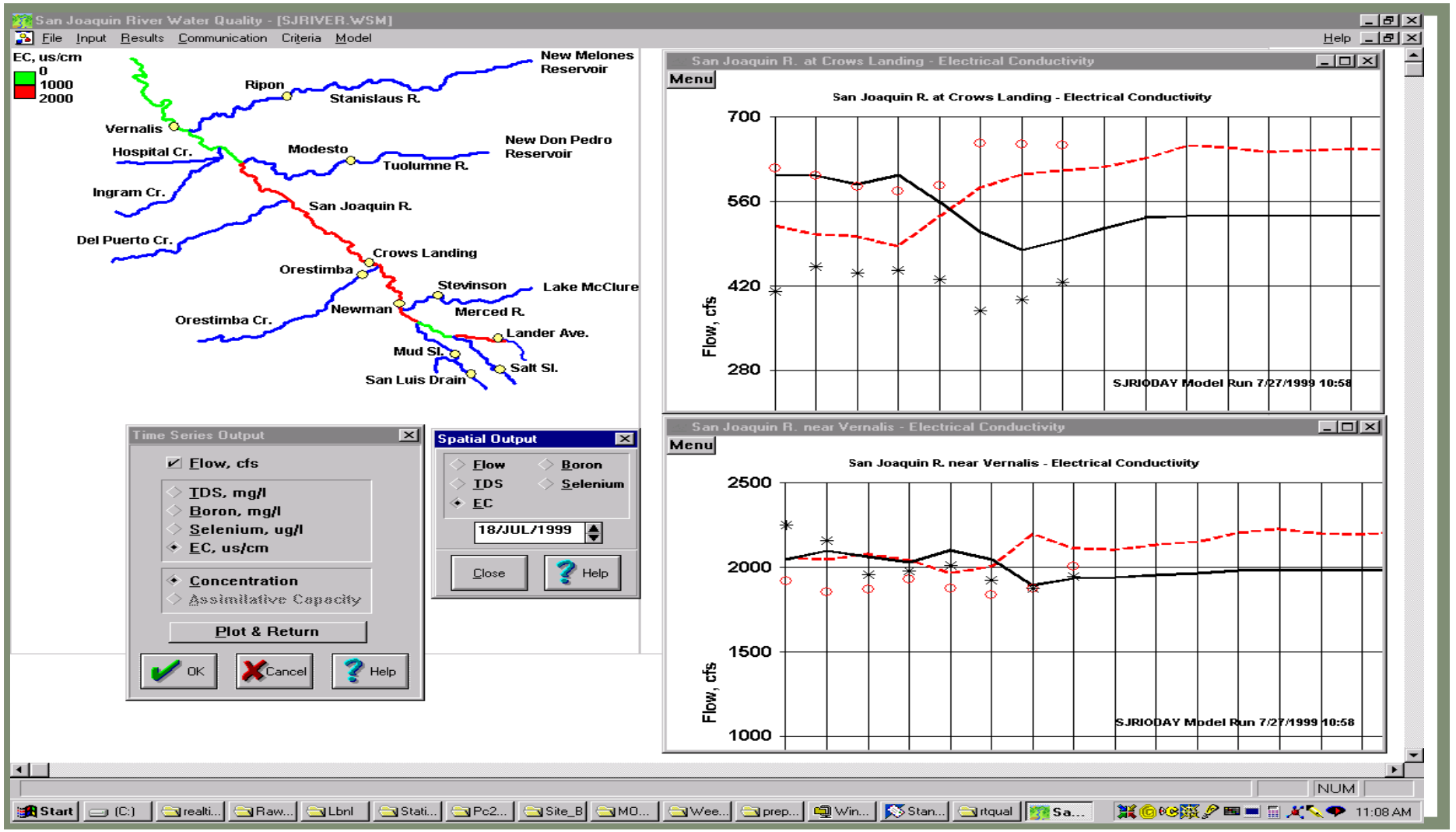
Environmental decision support systems

- Provide accurate and reliable watershed data needed to make informed environmental management decisions
- Work with stakeholder entities to help customize information to suit their applications and specific needs
- Invest resources to broadly disseminate information and provide continuous data quality assurance
  - sponsor academic research to improve information technology
  - strive for improved sensor technology with greater reliability at low cost
  - encourage cooperative monitoring (add sensors to existing platforms)
- Elicit user feedback and technical suggestions. Create opportunities for stakeholders to share salinity monitoring experiences in open forums

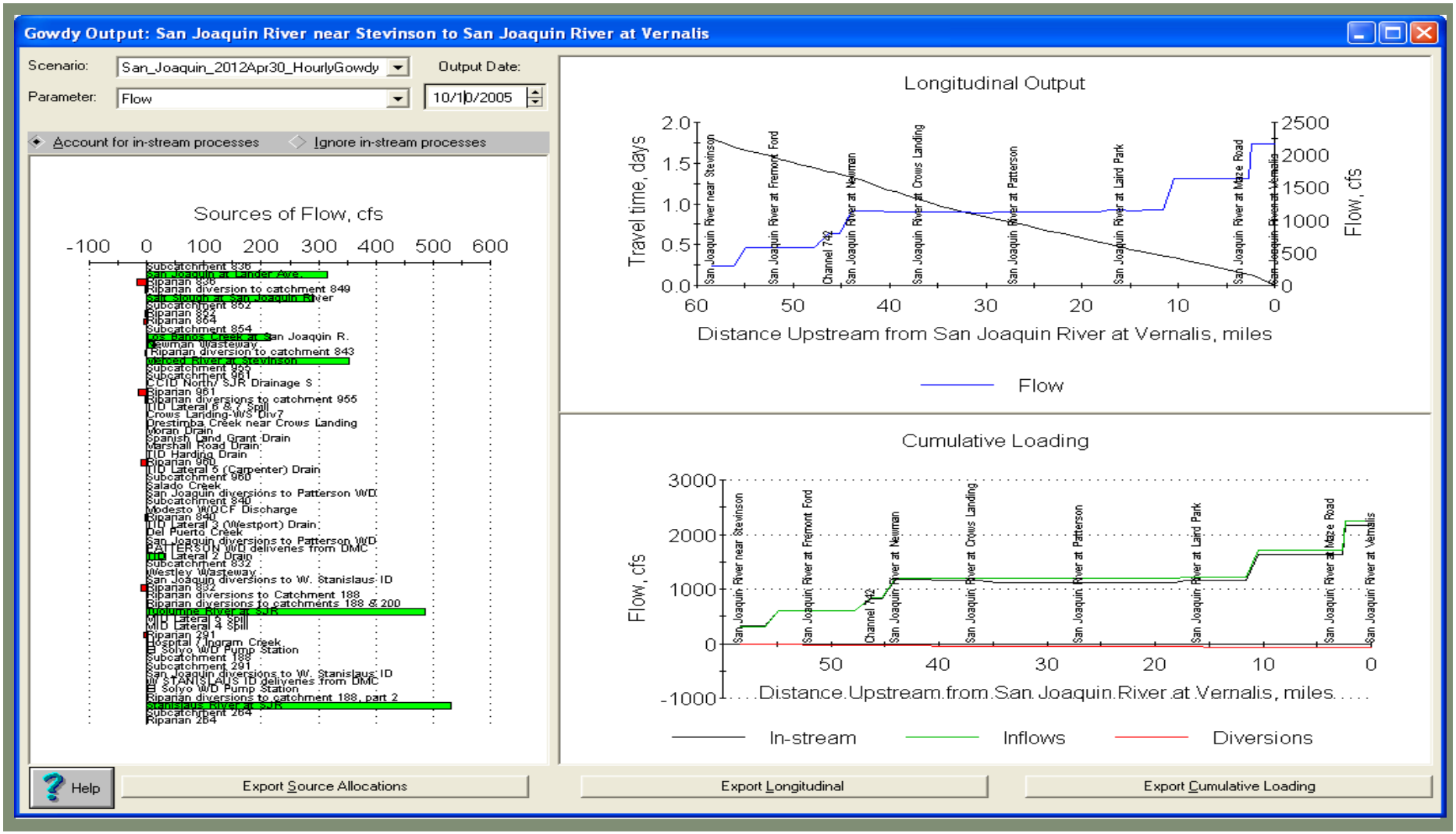
WARMF salt assimilative capacity forecasting model



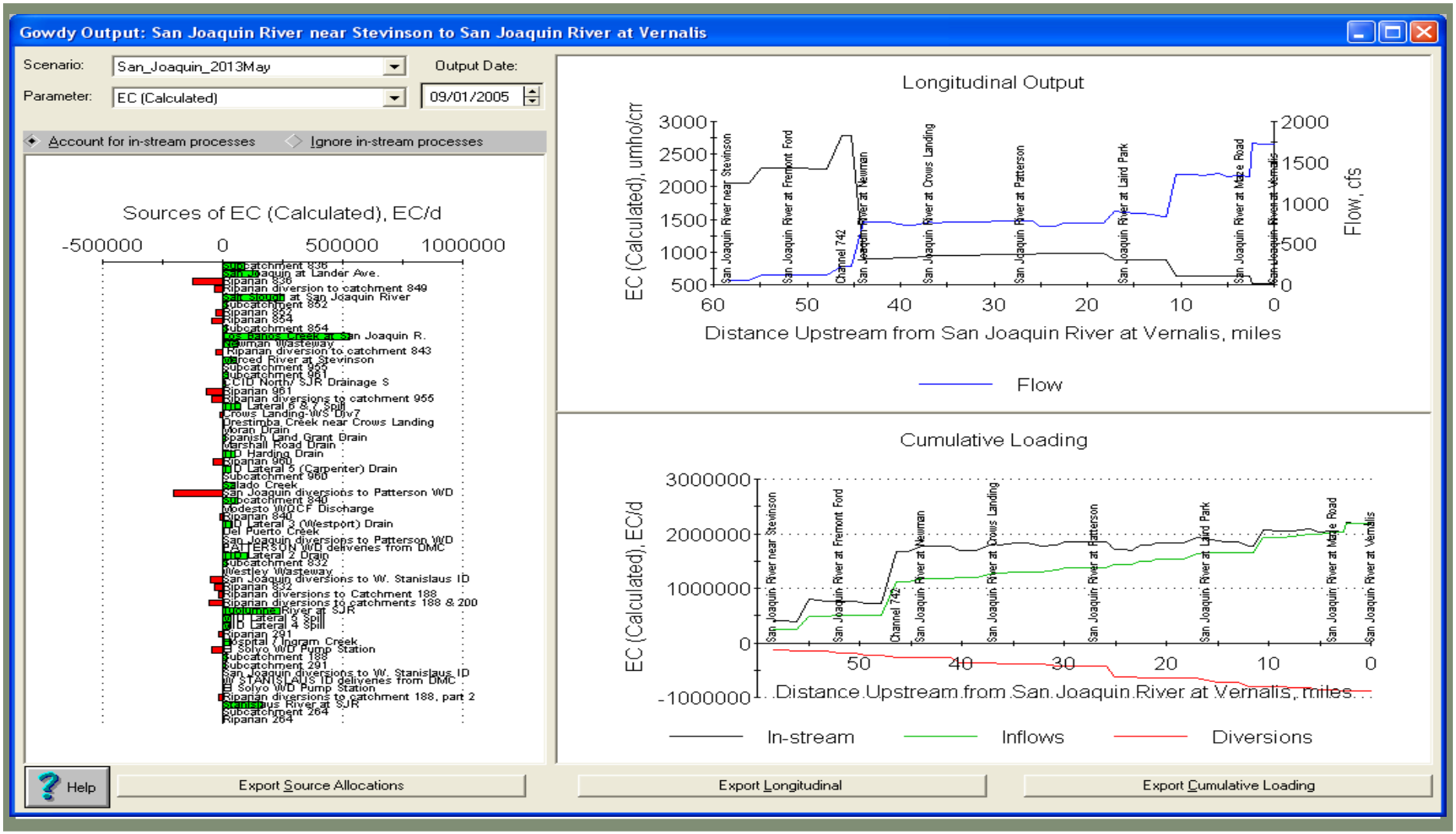
SJRIO model hindcasts and 14 day forecasts



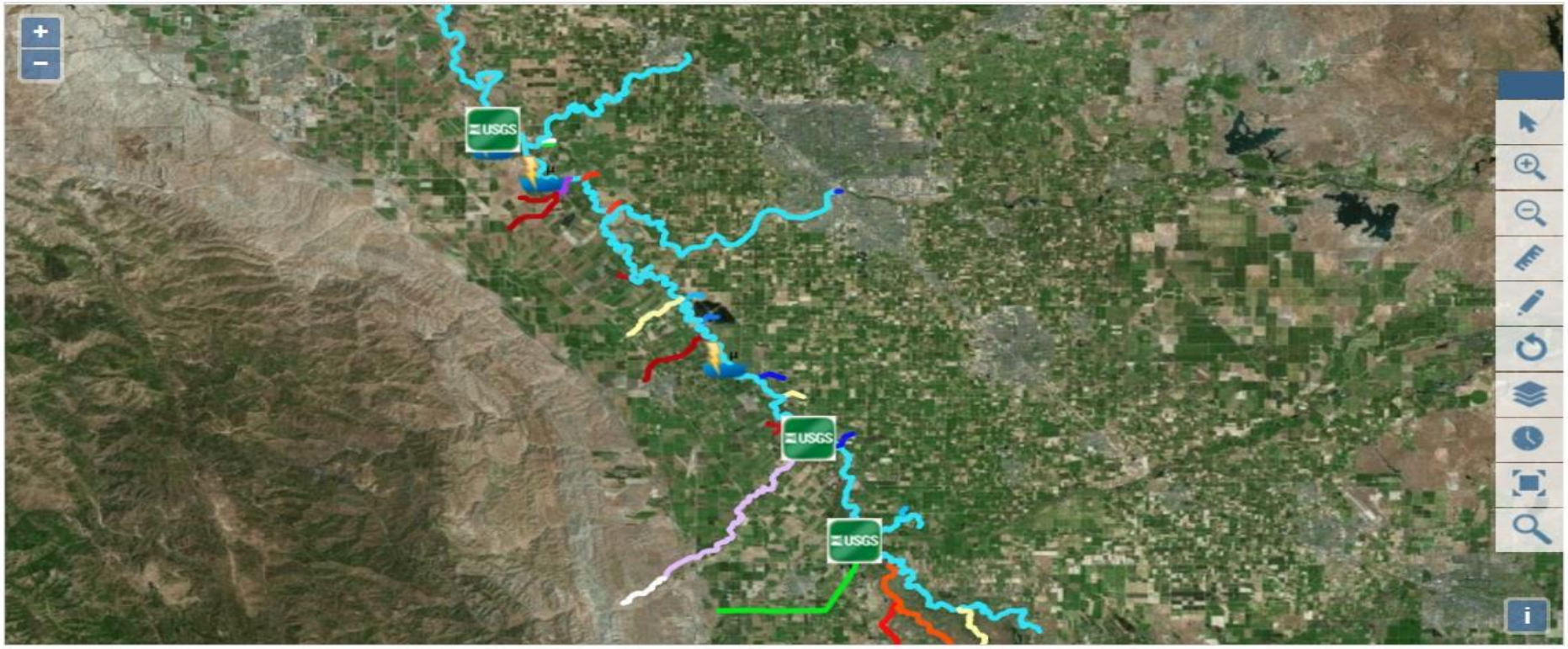
GOWDY output for daily flow visualization



GOWDY output for daily salinity visualization



WARMF model output visualization



WARMF Model Forecast: EC uS/cm + Observed Data

Latest Simulated Electrical Conductivity Forecast

0 300 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2200 2400 2600 2800 3000

M

Mar 24, 2017
12:00AM

Timestep
1 day

Adjust Timeline

?

HYDROECOLOGICAL ENGINEERING ADVANCED DECISION SUPPORT (HEADS)

ESD EARTH SCIENCES DIVISION

BERKELEY LAB

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Regional Water Quality Monitoring

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San Joaquin River Real-Time Managment

View Real Time Data

Search, find, view and download Real-Time data from all of California's data network

The SJRRTM Data Portal offers easy access to CDEC, NWIS and CIMIS data services. Set your time extents and location to .....

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Modelers

The WARMF-SJR application simulates the hydrology of San Joaquin River Basin.

The WARMF-Online web portal is designed to serve all stakeholders in the SJRB that discharge to the SJR. Estimates of SJR ...

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About the San Joaquin River Real Time Data Portal

Real-time water quality management (RTWQM) is a strategy for meeting down-stream water quality objectives by making use of river assimilative capacity and

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Reporting Dashboards

View data visualizaitons using the inter-active dashboards.

These tools provide real time updates to flow, EC (and calculated salt load), water temperature, etc. in SJR watershed's water supply and drainage conveyance channels.

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What's New

Sed sollicitudin placerat dolor hendrerit

Is it Safe to Swim in the San Joaquin River and its Tributaries
April 13, 2016
DOWNLOAD MORE

Does Water Temperature in the San Joaquin River
April 13, 2016
DOWNLOAD MORE

Is Salt Affecting Beneficial Uses in the San Joaquin
April 13, 2016
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Are excess nutrients a problem in the San Joaquin River?
April 13, 2016
DOWNLOAD MORE

Managment Activities
April 13, 2016
DOWNLOAD MORE

Data and GIS

More data link

Explore Data and Contribute Data from the San Joaquin River Real-Time Managment Program

Real Time Monitoring Data

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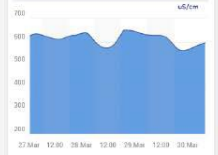
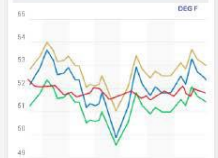
Lower San Joaquin River | Upper San Joaquin River | Tributaries

CURRENT CONDITIONS

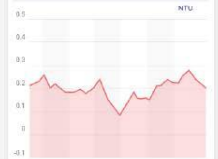
ELECTRICAL CONDUCTIVITY MICRO S



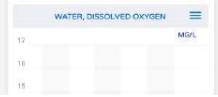
TEMPERATURE, WATER



TURBIDITY



WATER, DISSOLVED OXYGEN



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Real Time Management

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Vernalis Objective Real Time WARMF Visualization Overview Modelers Visualization Comments Help Summary

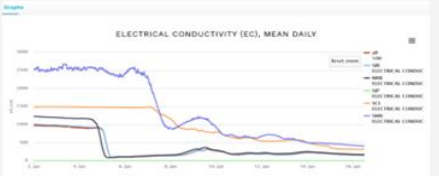
Quick Graph Links

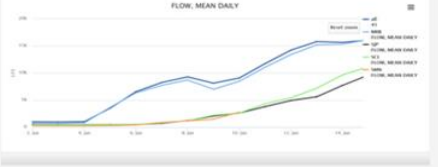
WARMF FORECAST Output: Salt Load (TDS, Tons/d)

WARMF Forecast for Salt Load. This visualization of the WARMF model will play the last 14 Days to the Next 14 Days.

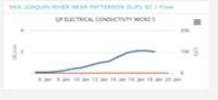
Jan 28, 2017 10:00AM Timestep 6 Hour Adjust Timeline

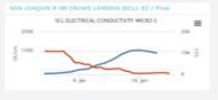
25 26 27 28 29 30 31 1 2 3 4 5

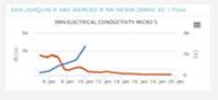




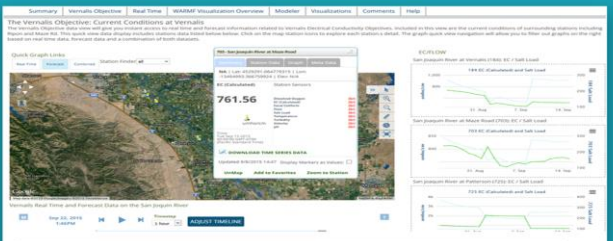
Electrical Conductivity and Flow Conditions







IMPROVE WATERSHED COORDINATION TO MEET WATER QUALITY OBJECTIVES



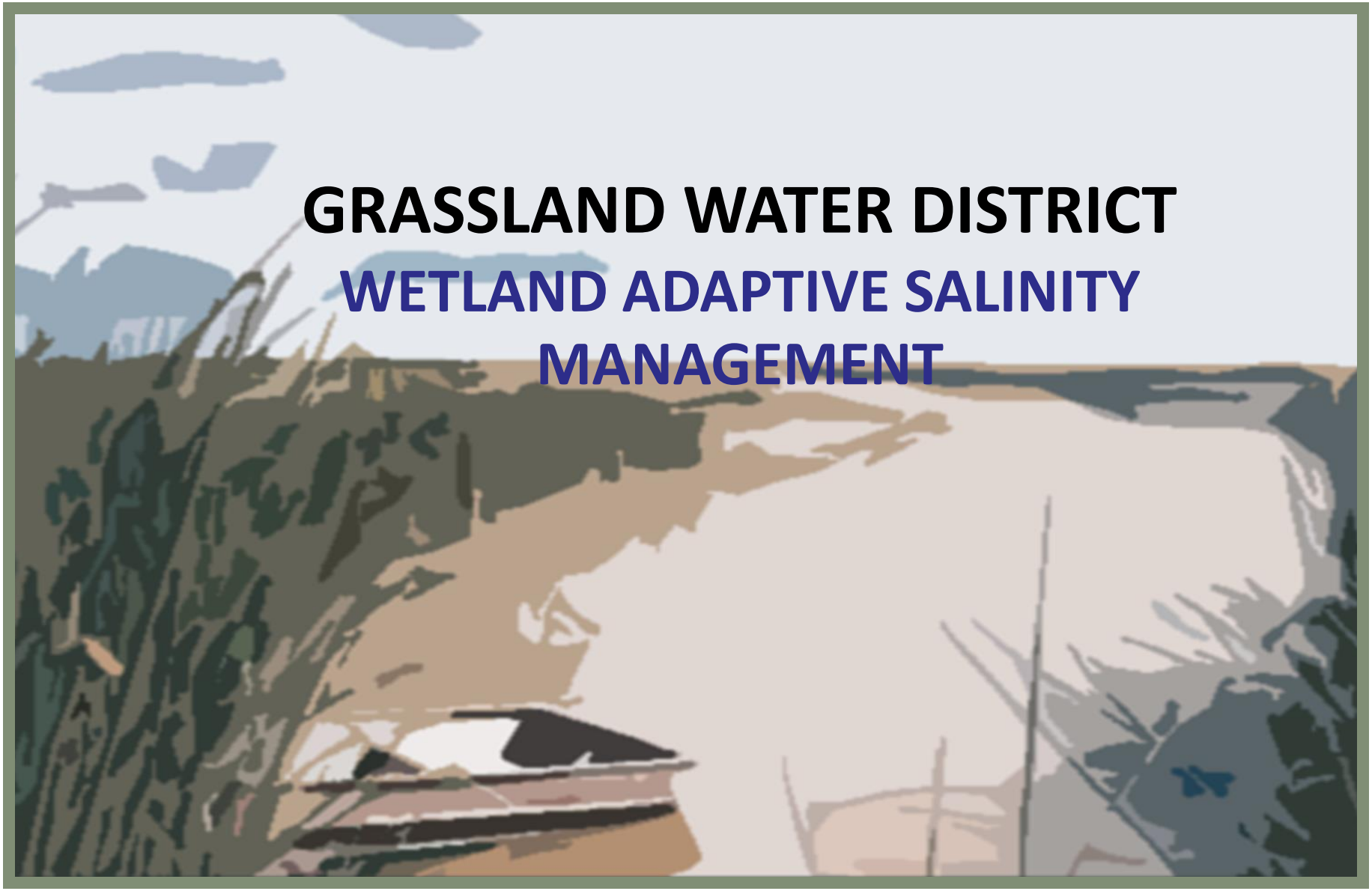
Vernalis Objective Dashboard for Managers

REAL-TIME WATER QUALITY MANAGEMENT

WATERSHED SCALE PROOF OF CONCEPT

Sub-regional proof-of-concept implementation

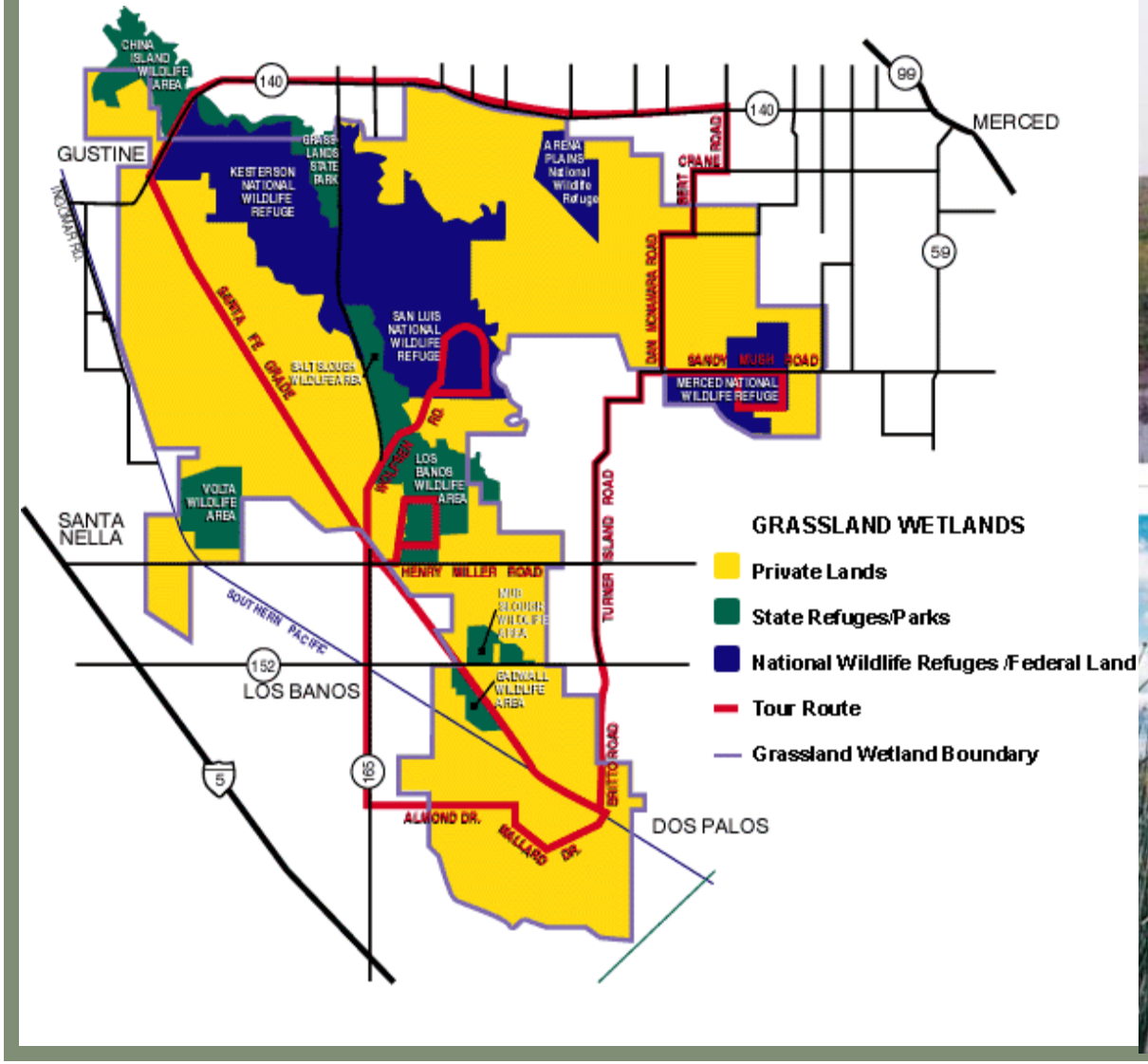
- Size of basin, high cost and newness of concept constrain implementation on a Basin-scale
- Initially select sub-basin that has the same technical and institutional issues as larger San Joaquin Basin:
  - data sharing and cooperation between entities not accustomed to sharing information
  - No existing sensor network
  - Lack of decision support tools or model capability
  - Distrust of regulators and water agency intentions
- State, federal refuges and private wetlands chosen as real-time salinity management exemplar



GRASSLAND WATER DISTRICT

WETLAND ADAPTIVE SALINITY MANAGEMENT

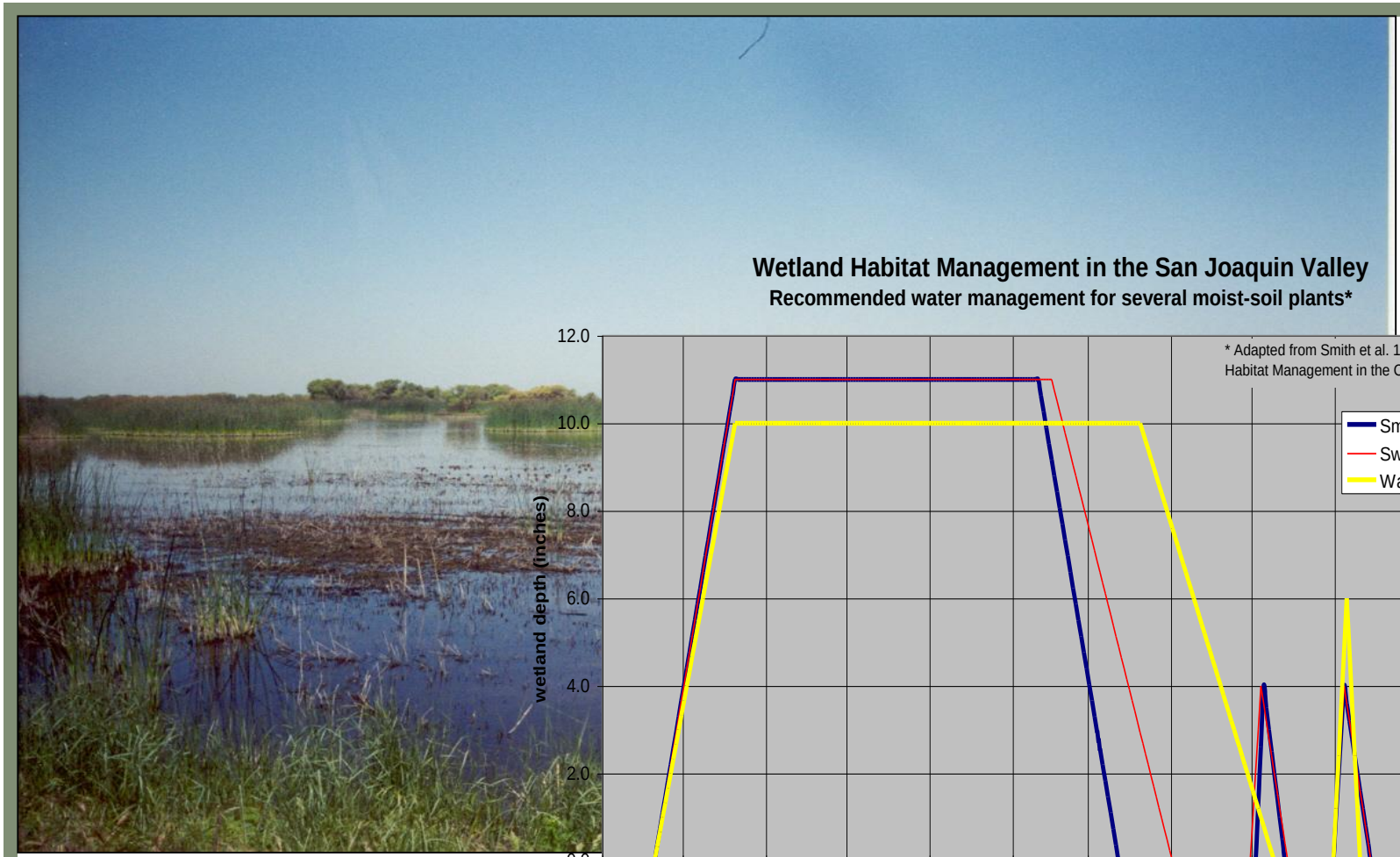
HYDROECOLOGICAL ENGINEERING ADVANCED DECISION SUPPORT (HEADS)



GRASSLAND WD ADAPTIVE SALINITY MANAGEMENT PROJECT

- Flow/EC monitoring at GWD outlets
- Monitoring/adaptive management of habitat
  - early drainage release
  - flow through wetland management
- Develop flow and salt forecasting capability
- Improve coordination of discharges with basin assimilative capacity for salinity (EC)

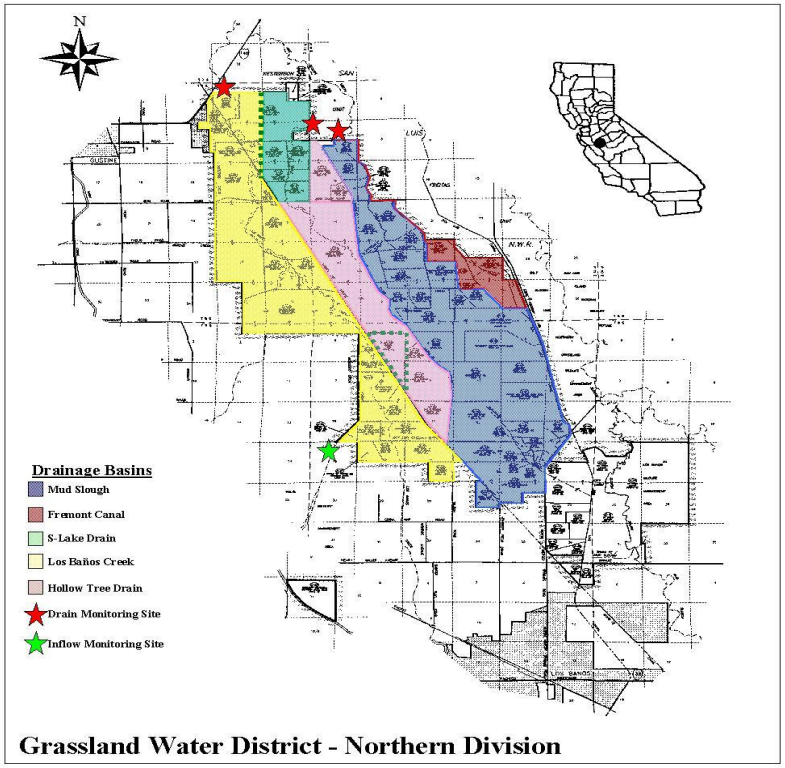
Water management for moist soil plant habitat

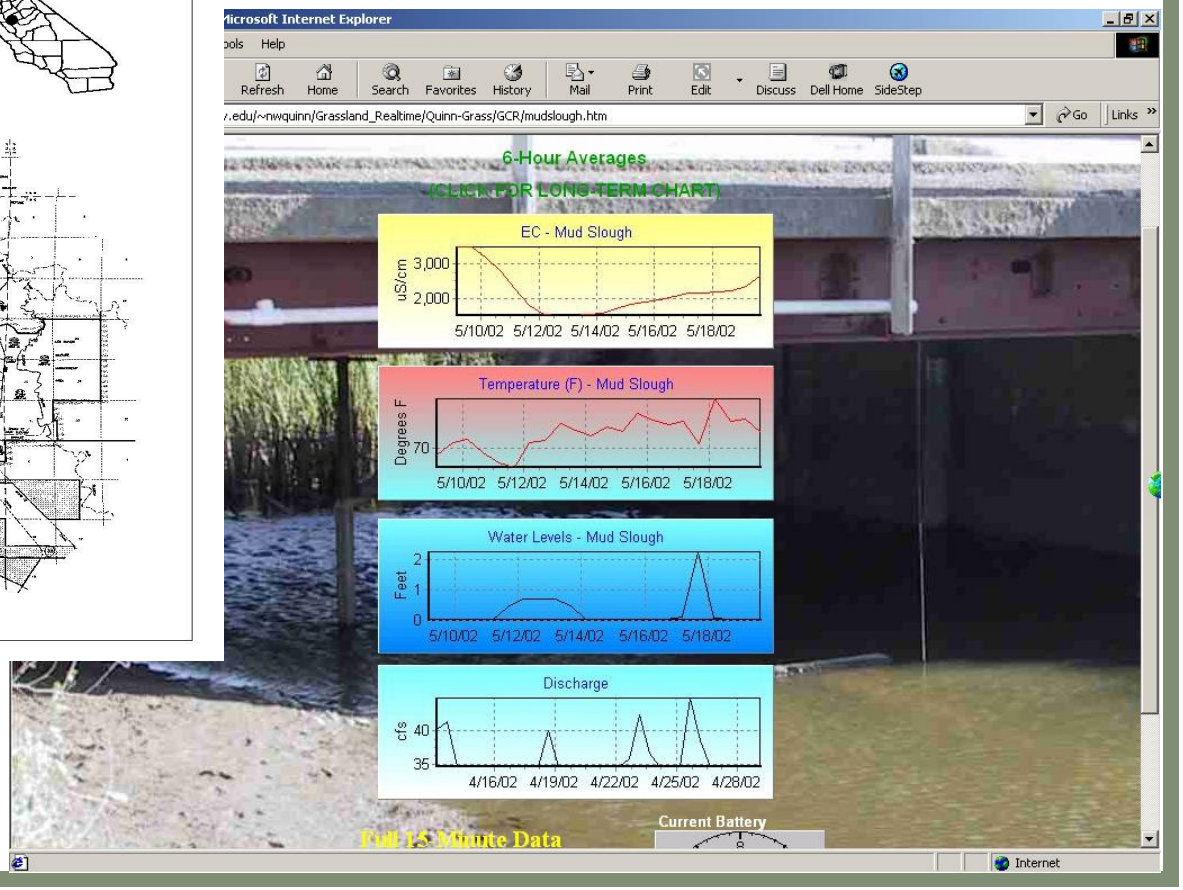


Real-time salinity management technical issues

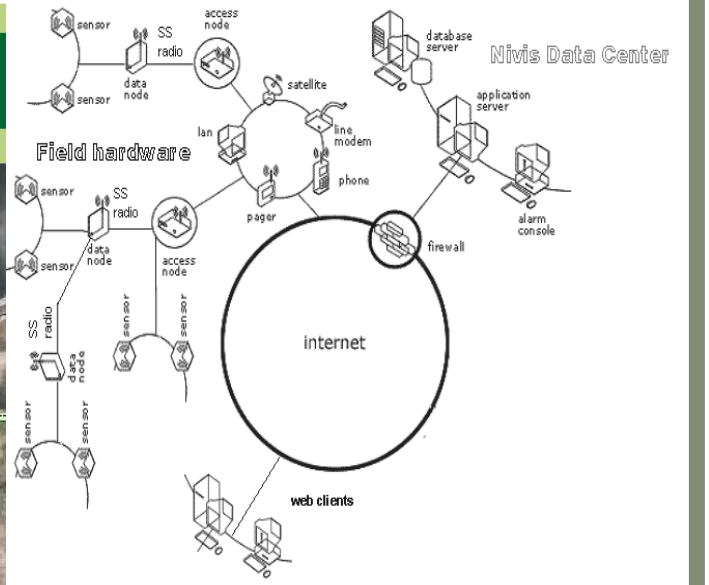
- Development of reliable salinity budgets.
- Assessment of the reliability of existing techniques for estimating ET of wetland moist soil plants.
- Simulation of salt evapoconcentration in seasonal wetlands for salt load forecasting
- Human factors integrated into decision support tools to aid technology transfer to water managers

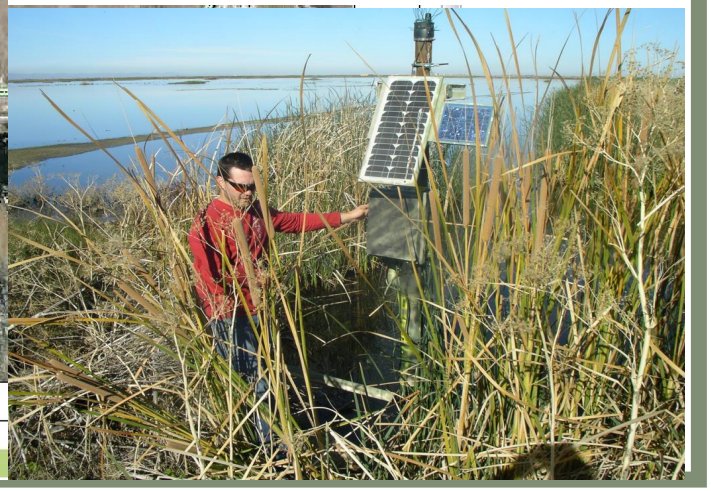
Grassland WD web-based wetland drainage monitoring



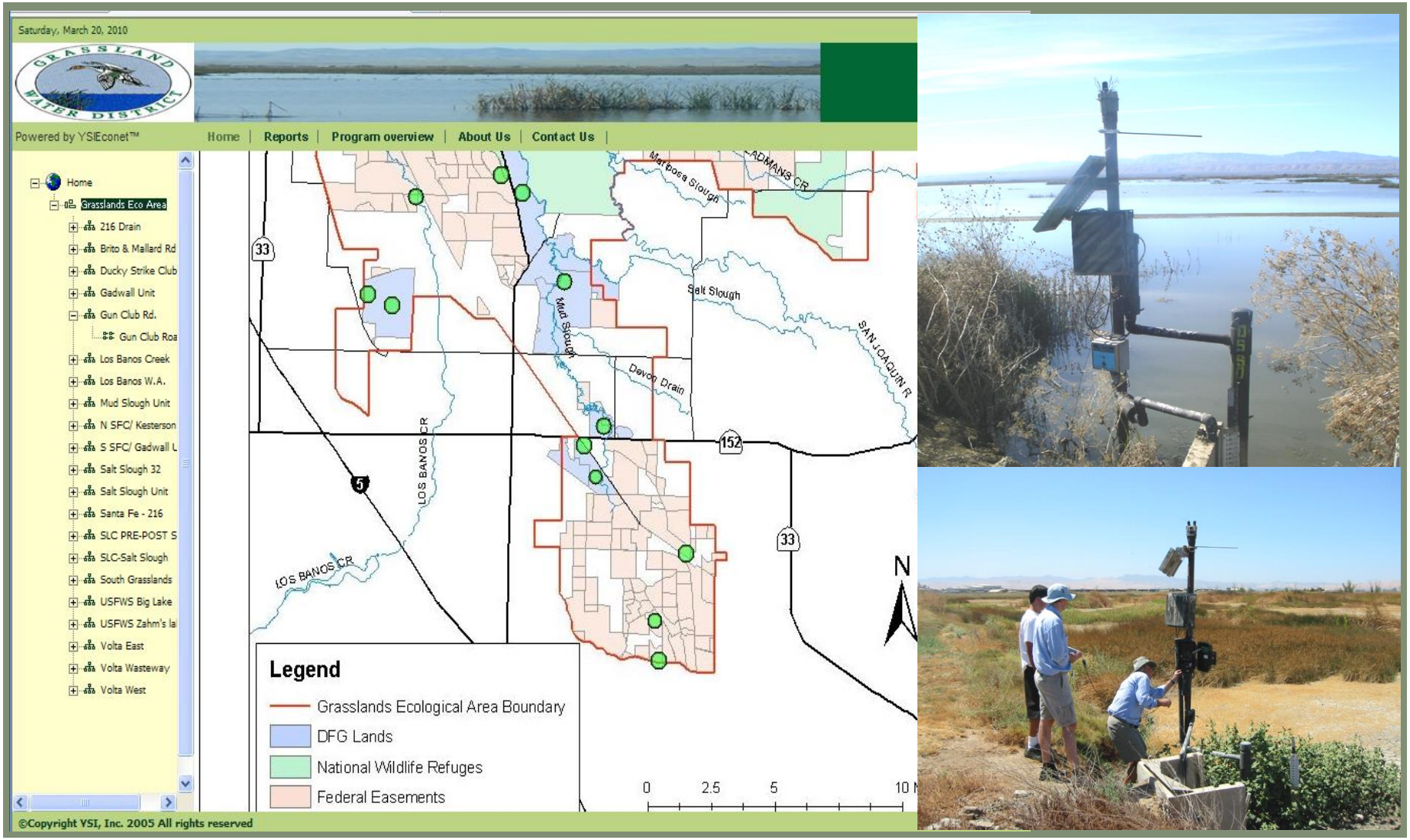


Real-time, telemetered flow/EC monitoring stations

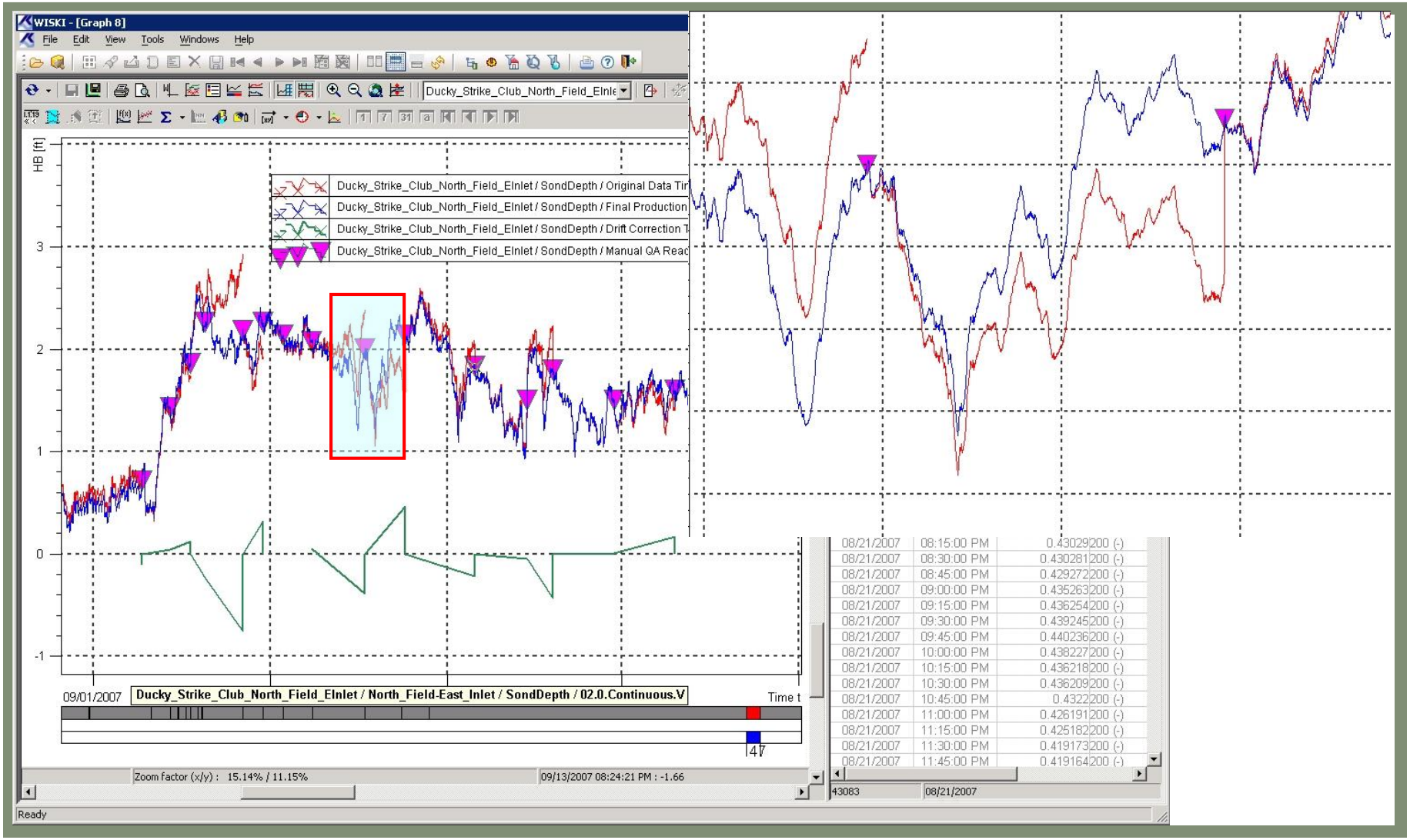




Water management for moist soil plant habitat



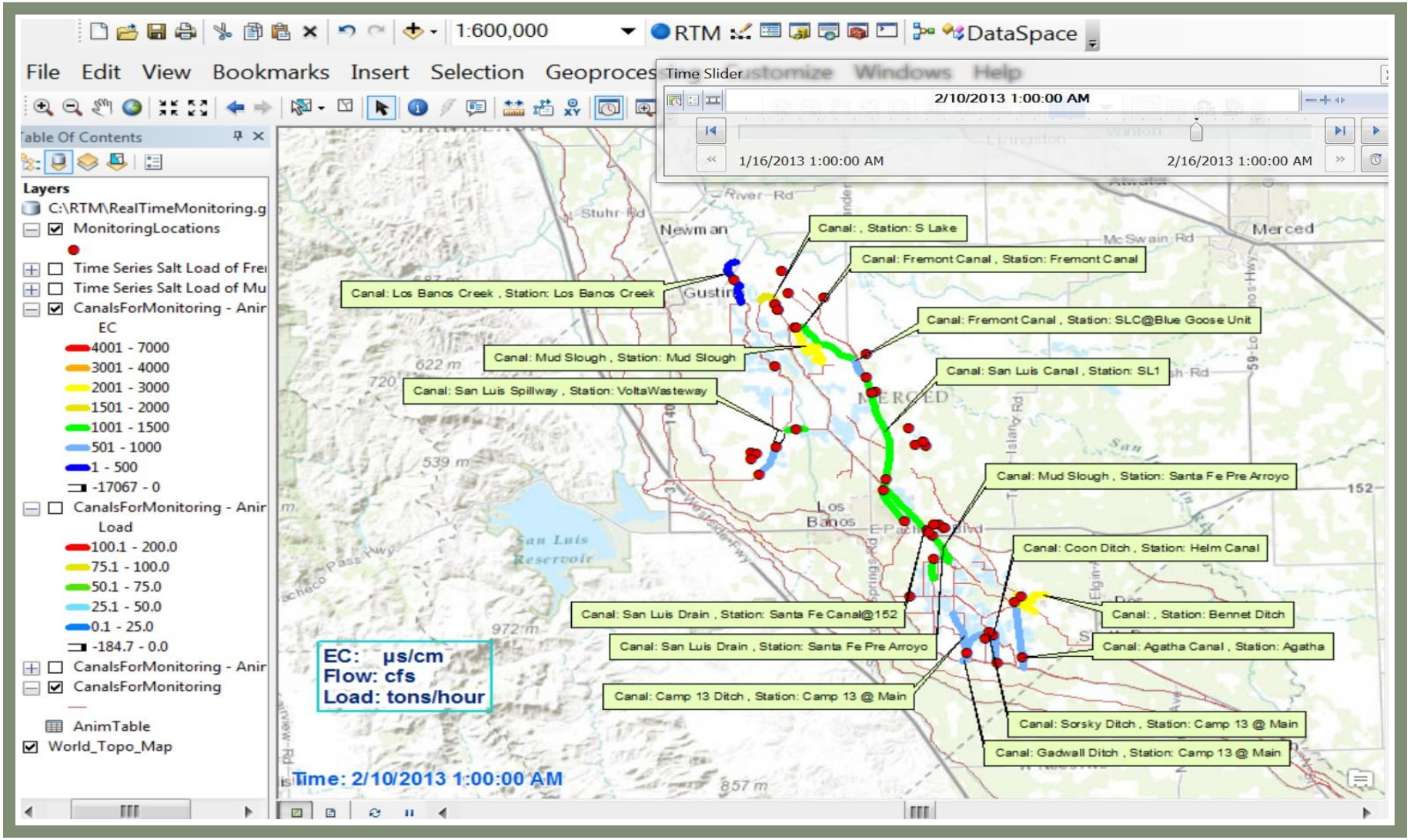
Automated drift correction of real-time data using WISKI



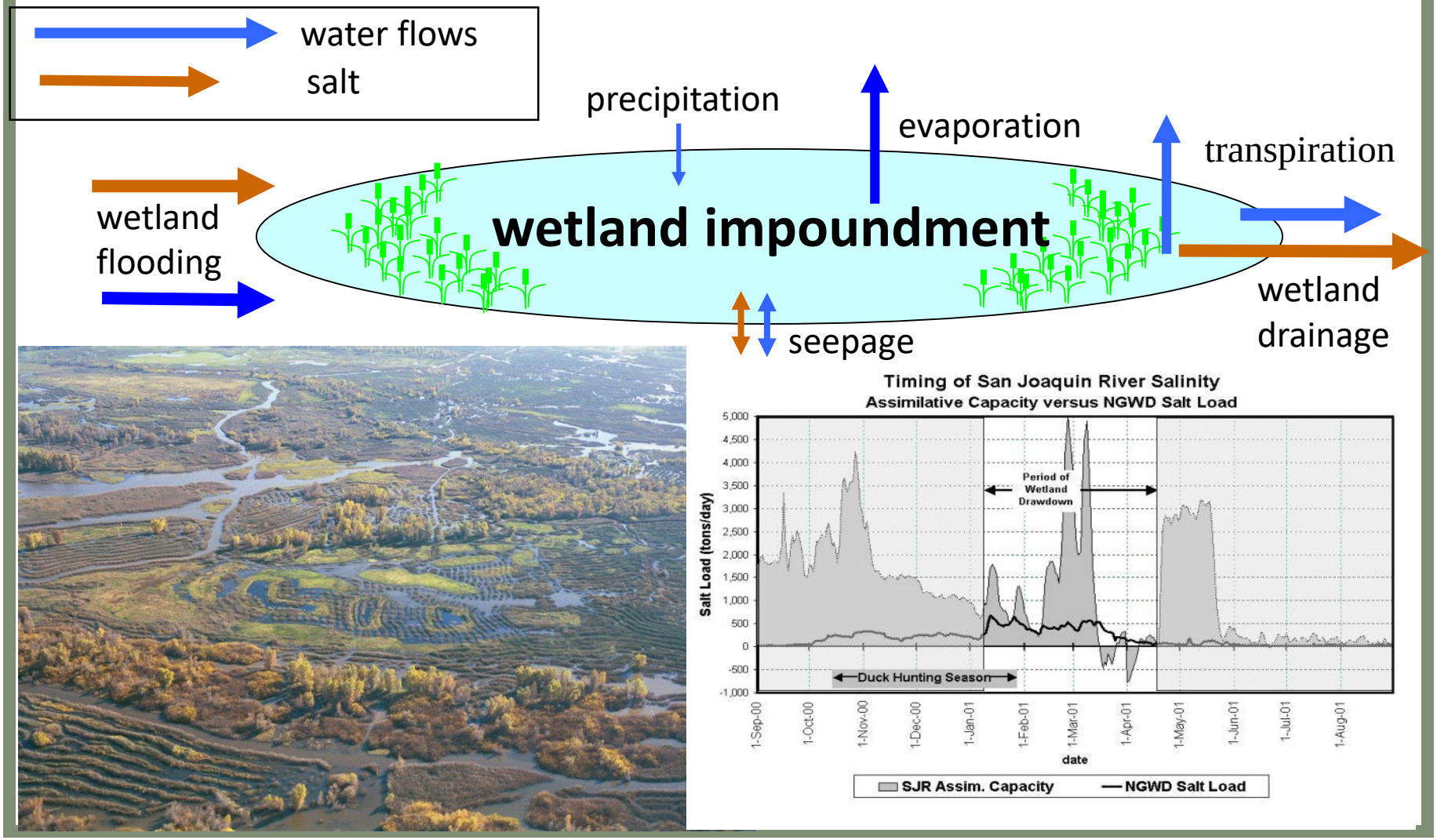
Data and model visualization requirements for GWD

- Water master and wetland managers need real-time access to canal flow data to optimize deliveries and reduce operational spill.
- Real-time access to EC data needed to ensure agricultural drainage is not diverted into wetland impoundments.
- Support for real-time salt export decision making – view salt load in various sectors of the system (45,000 acres).
- Share data with public or State and Federal refuges – allowing coordination of operations.
- Provide regulators with evidence of proactive compliance with spirit of real-time management initiative.

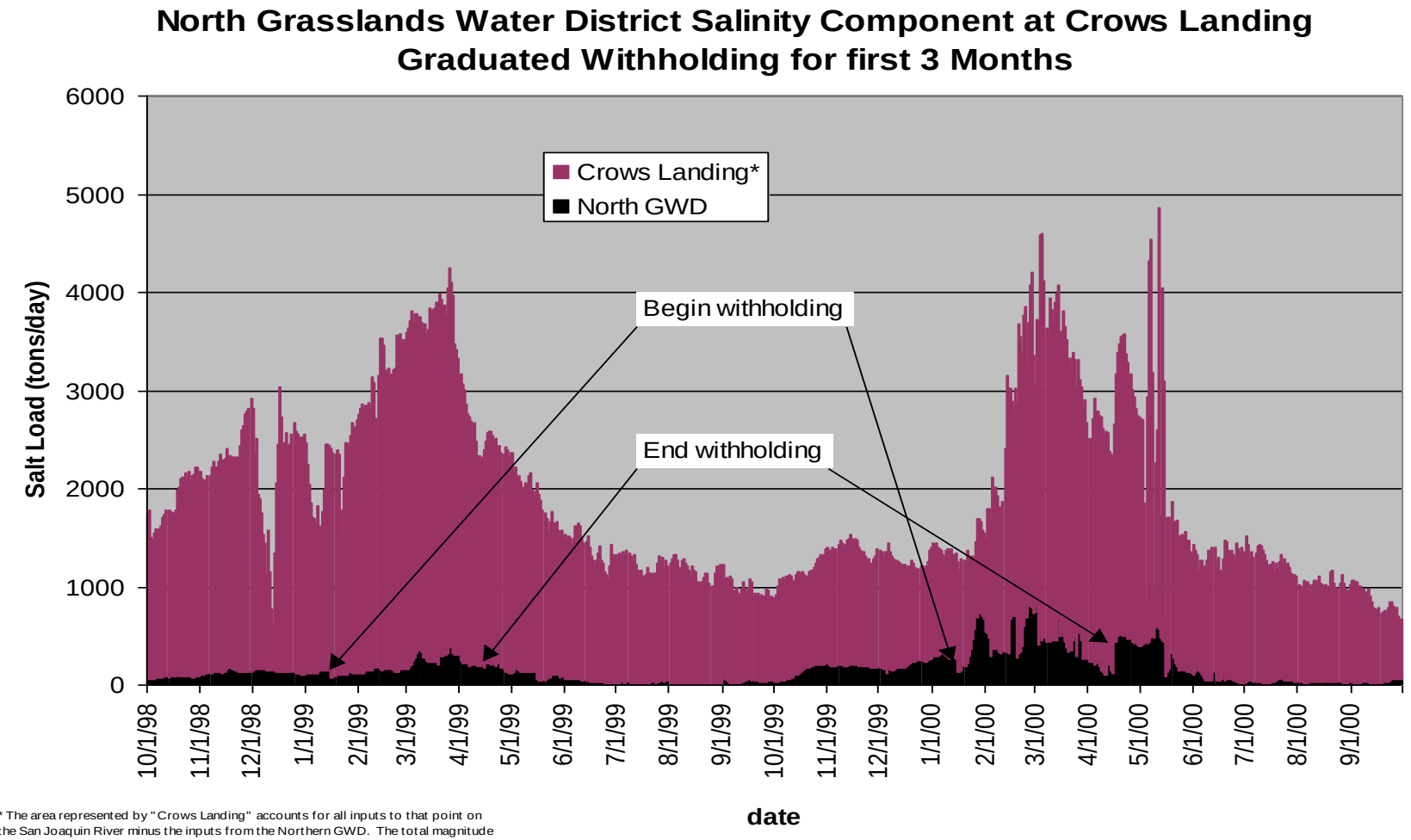
GWD real-time data visualization tool



Wetland water quality modeling



Relative salt loading from GWD - 1989-1990

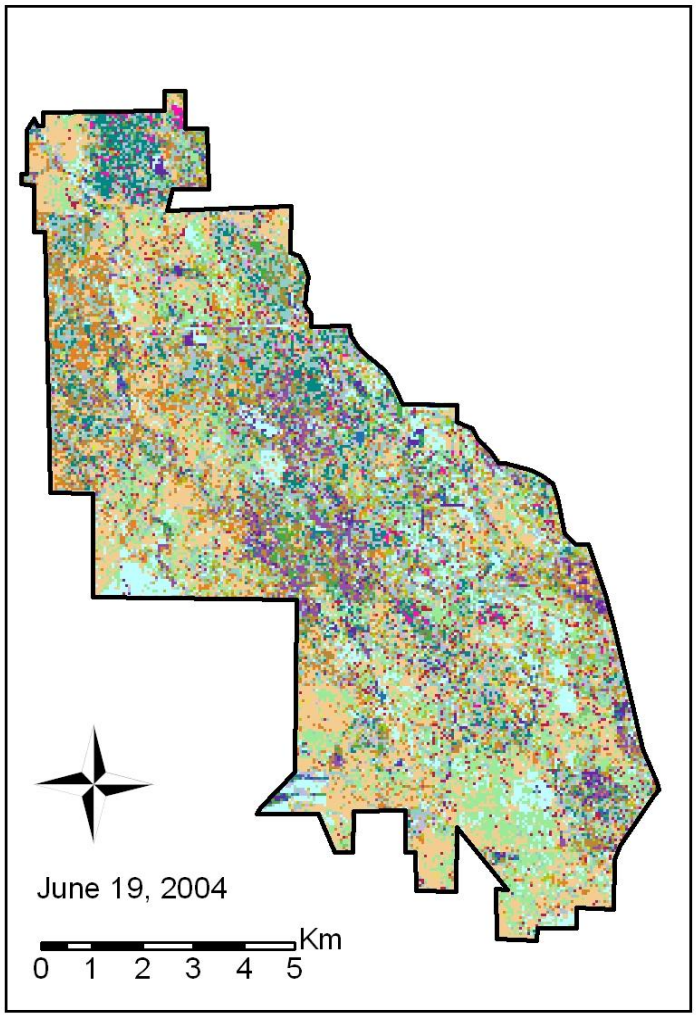


* The area represented by "Crows Landing" accounts for all inputs to that point on the San Joaquin River minus the inputs from the Northern GWD. The total magnitude shown, however, is the total salt load at the Crows Landing station.

Salinity impacts assessment using remote sensing

- Acquisition of high resolution multispectral satellite imagery
- Development of spectral signature file using ground-truthed moist soil plant vegetation data
- Pattern recognition using segmentation algorithms in E-Cognition software
- Mapping of moist soil vegetation using supervised classification for North Grasslands and San Luis National Wildlife Refuge

Habitat classification of northern GWD using LANDSAT



Legend

- dense baltic rush/alkali bulrush
- bare soil/iodine bush
- bermuda grass low density
- bermuda grass high/water hyacinth
- buildings
- alkali bulrush low density
- dock low density
- litter/senescent grass
- shallow flooding
- mustard
- pepperweed
- uplands - creeping wild rye/star thistle
- dense saltgrass/poison hemlock
- dense saltgrass
- scirpus spp
- dense smartweed/cocklebur
- swamp timothy/alkali weed low density
- swamp timothy/watergrass med density
- dense swamp timothy
- water

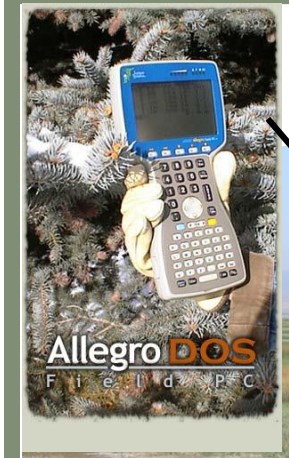
Salinity impact assessment using EM-38 mapping

- Development of a sampling grid
- Continuous EM data acquisition from a motorized rig
- Data processing in the field to determine soil sampling grid
- Soil samples taken at 2 depths, bagged and taken to lab for saturated extract soil salinity determination
- EM data calibrated against lab EC values to produce final salinity map
- Maps show soil salinity trends and impacts due to potential future changes in drawdown management practices

Grassland WD web-based wetland drainage monitoring

- Paired wetland experiment
  12 wetland pairs within GEA
- Control:
  traditional draw-down date of March 15
- Treatment:
  delayed draw-down date of April 15

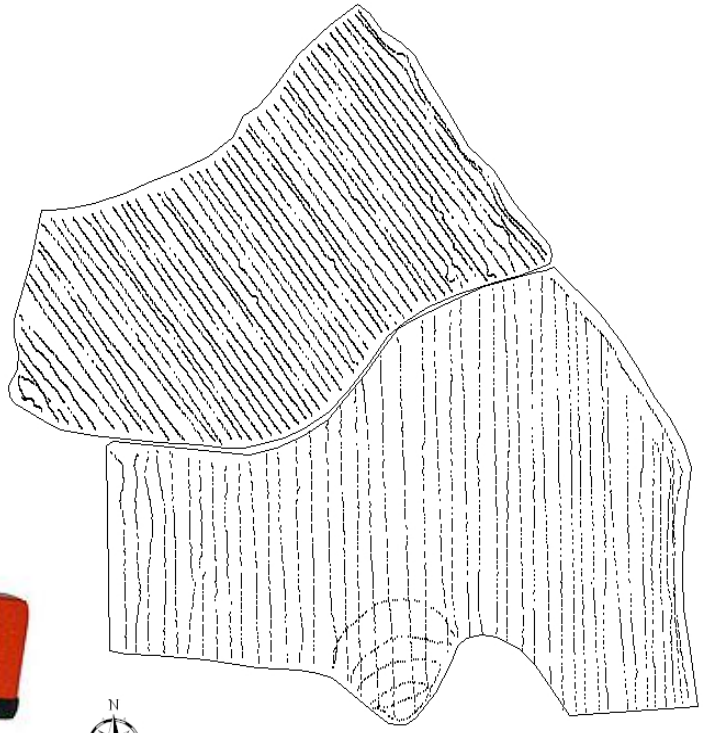
Soil salinity mapping for delayed drawdown assessment



Trimble Ag114

Transects spaced 15m apart - auto sampling every 4m along transect

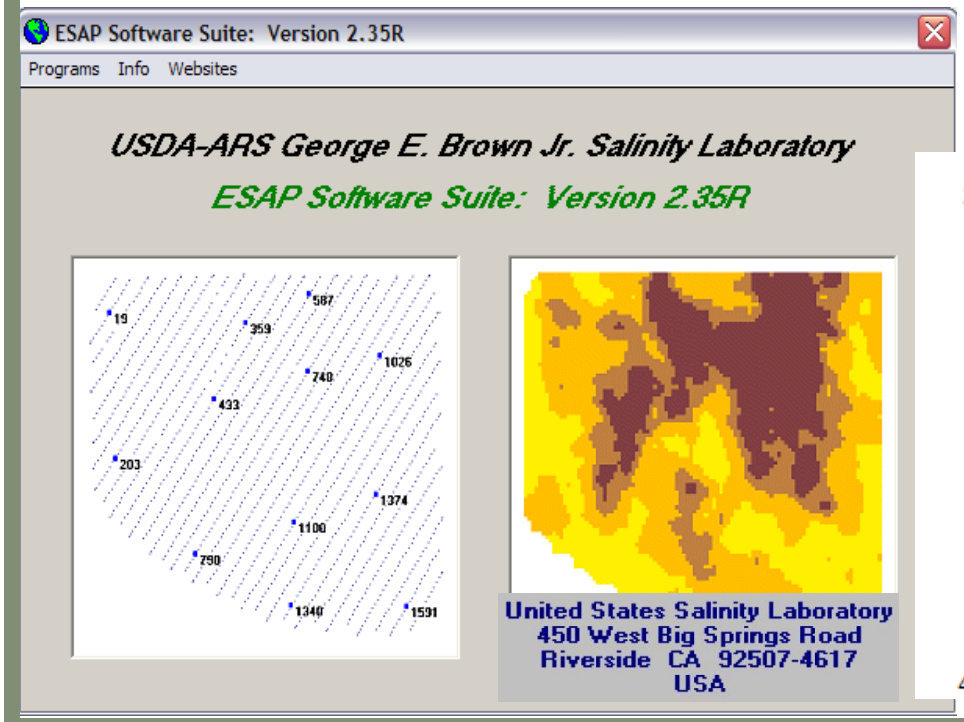
EM-38 Survey Transects

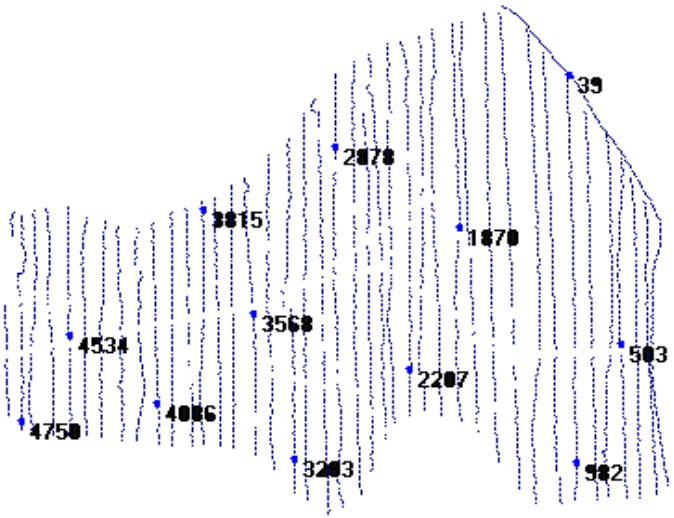


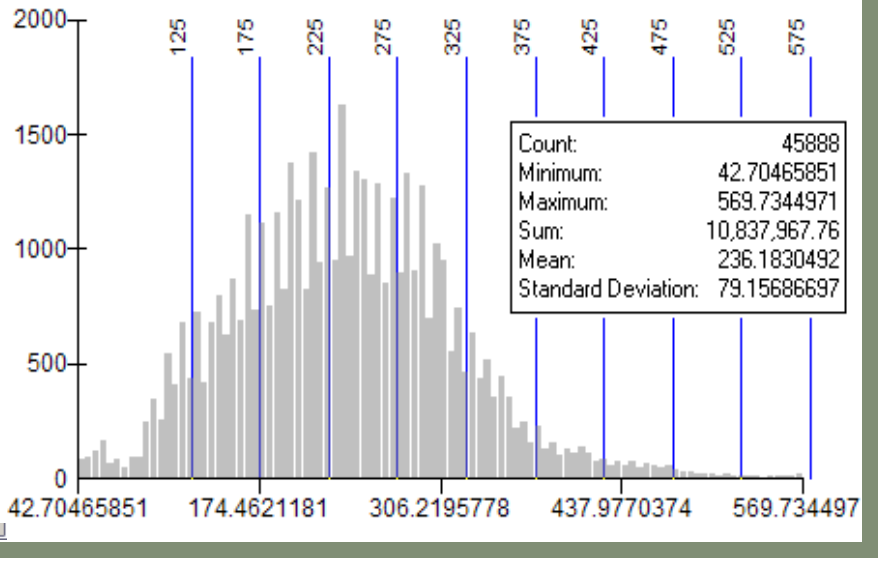
Geonics EM-38 MK1

ESAP software: statistics, soil sampling, EM38 calibration

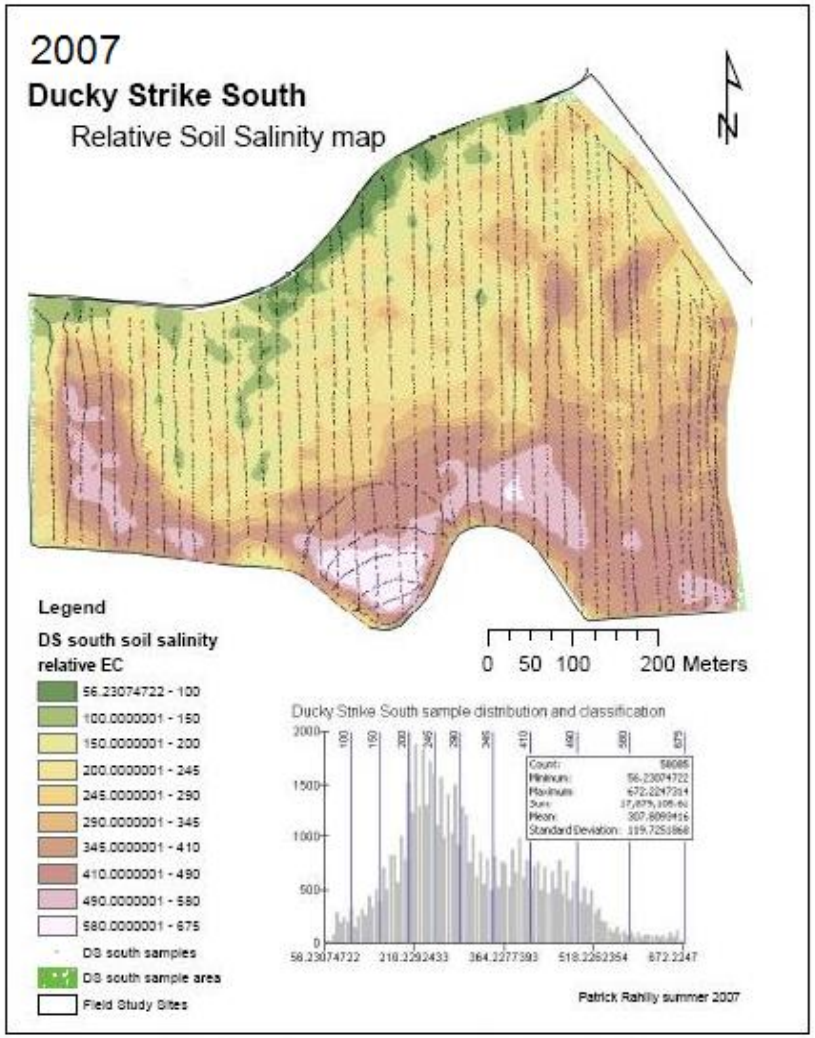
- ESAP designates 12 soils samples on the survey grid with 3.5 StdDev. from the mean.
- Allows for log transformation to ensure a normal distribution for accurate sampling strategy.

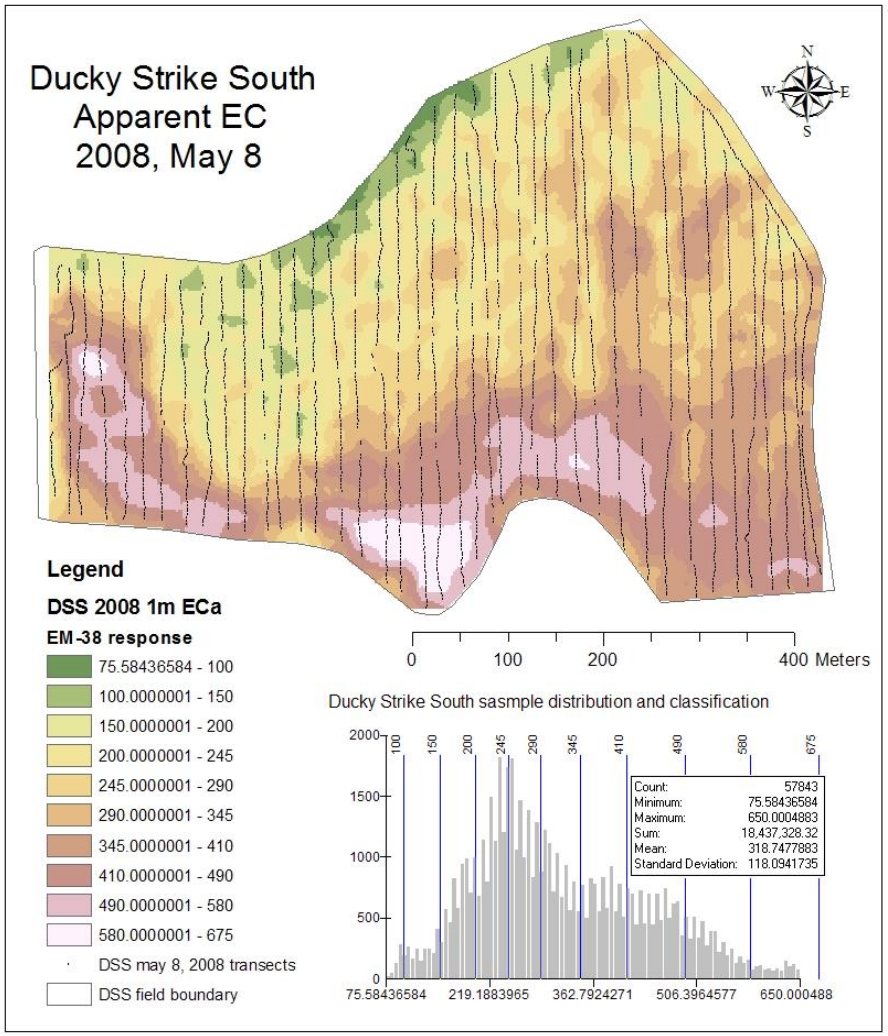






Impact of delayed drawdown Ducky Strike – 2007-2008



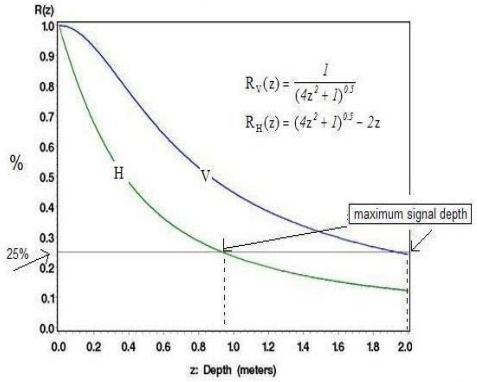


Marbling of infiltrating salts in wetland clay soils

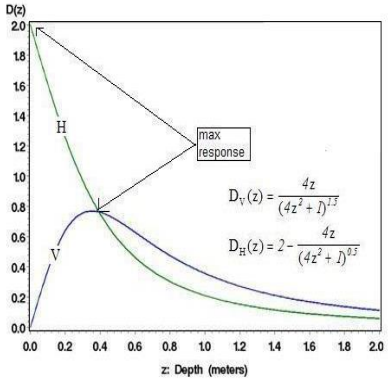
EM38 cumulative and relative signal repsonses where H is horizontal orientation and V is vertical orientation

From: Scott Lesch. 2004. Lesson Plan for use of Salinity Assessment Technology. USDA, NRCS.

A: EM38 cummulative signal response



B: EM38 relative signal response
(or integrated depth-weighting pattern)



Real-time, telemetered flow/EC monitoring stations

Friday, March 03, 2017

Login to YSI EcoNet

Username:

Password:

Site: Private Site

Remember my information

| Login |

Contact Tech Support:
877-392-9950 (US)
systems@ysi.com

EcoNet End-of-Life Notice

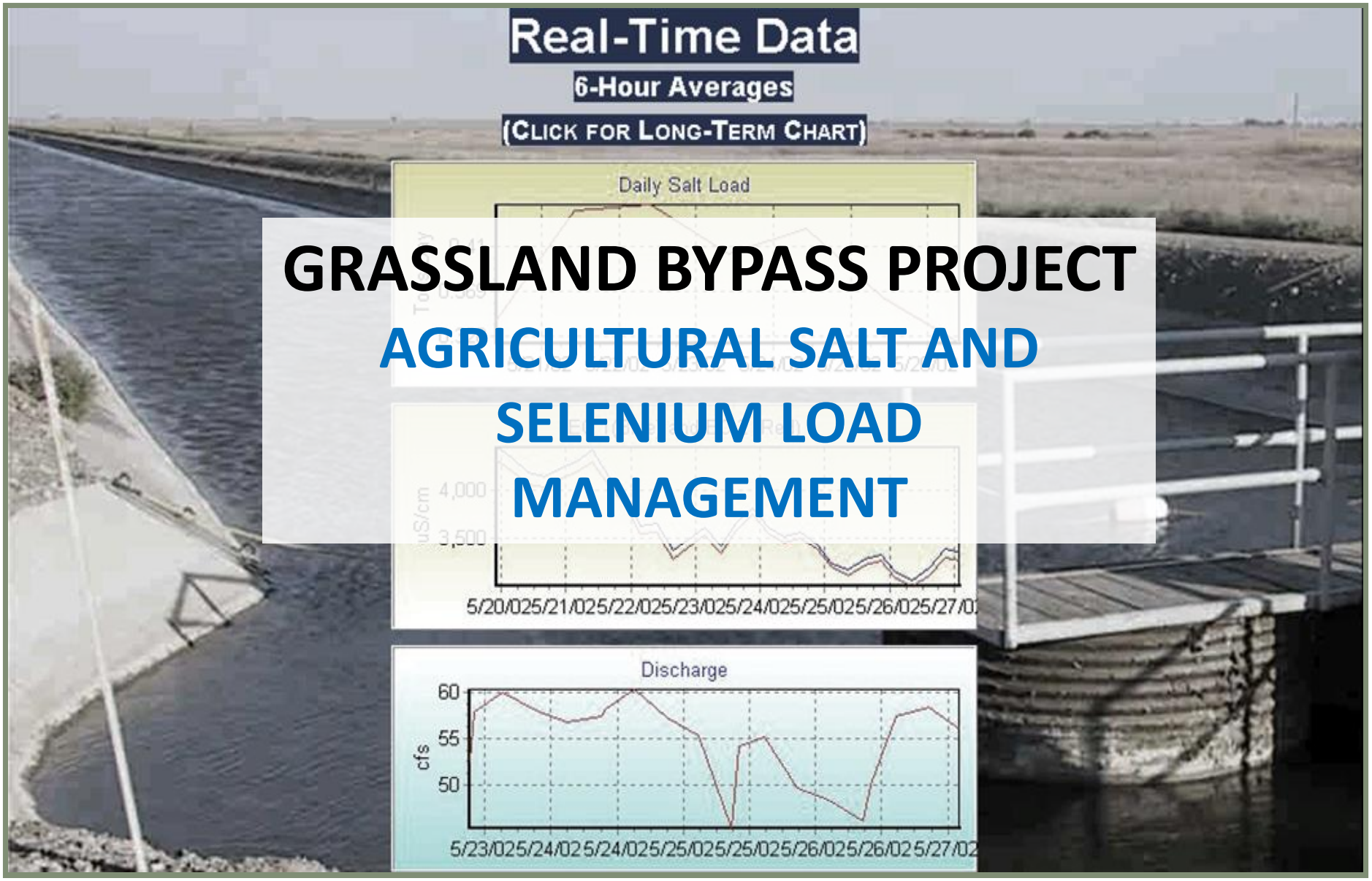
Effective May 31, 2017, all EcoNet services will be shut down.

If you would like to have a YSI representative contact you to discuss the options available and/or if you need assistance with downloading your historical data before the shutdown, please complete and **submit this form**.

YSI would like to take this opportunity to thank you for being a loyal EcoNet customer and we hope that you continue to be a YSI customer by choosing one of our other great platforms for data collection.

We encourage you to learn more about our:
>Storm Central Data Hosting Solution
>Storm 3 Data Logger

 Version : 1.0.4.0



GRASSLAND BYPASS PROJECT

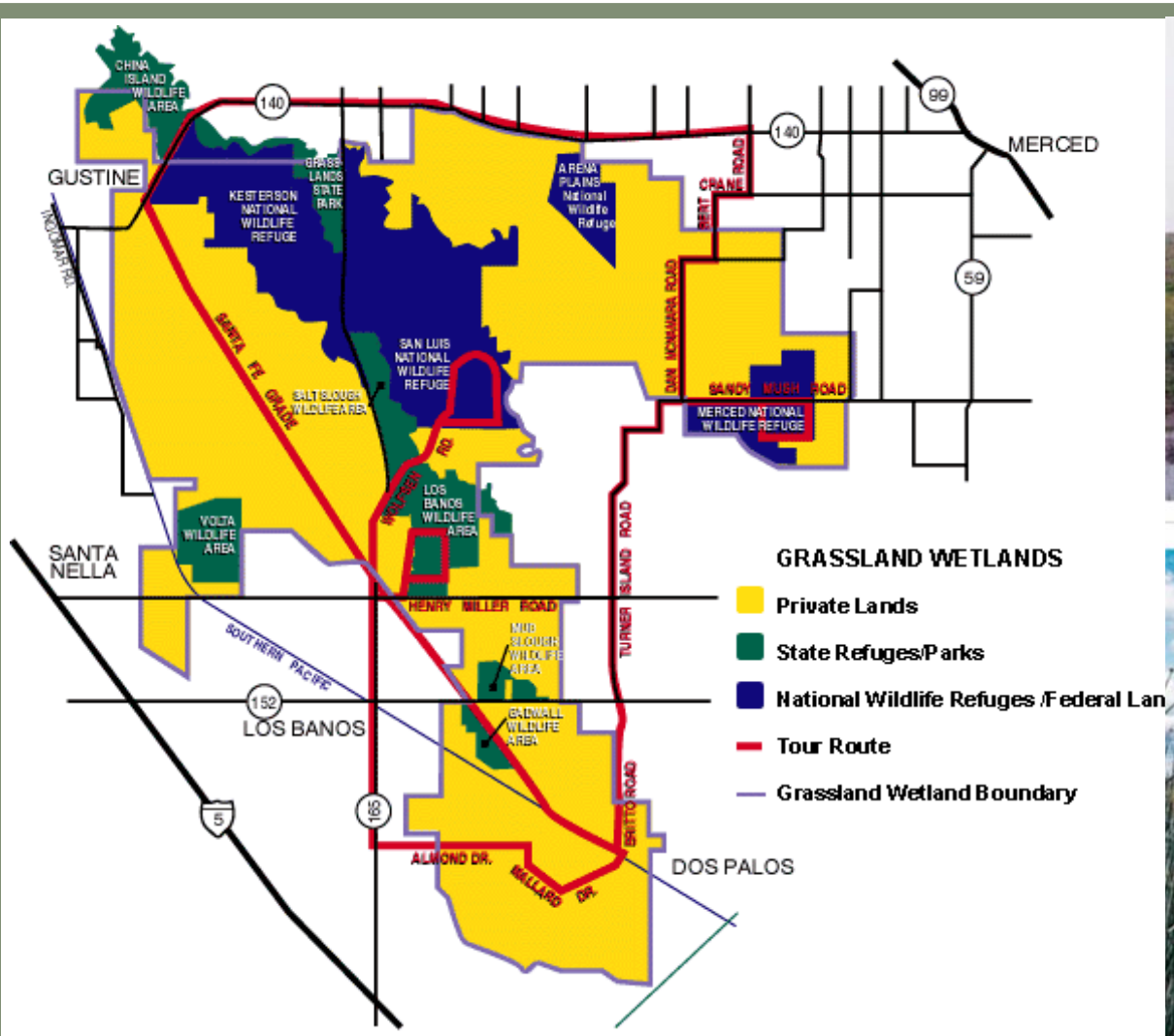
AGRICULTURAL SALT AND SELENIUM LOAD MANAGEMENT

Selenium avian toxicosis in Kesterson NWR

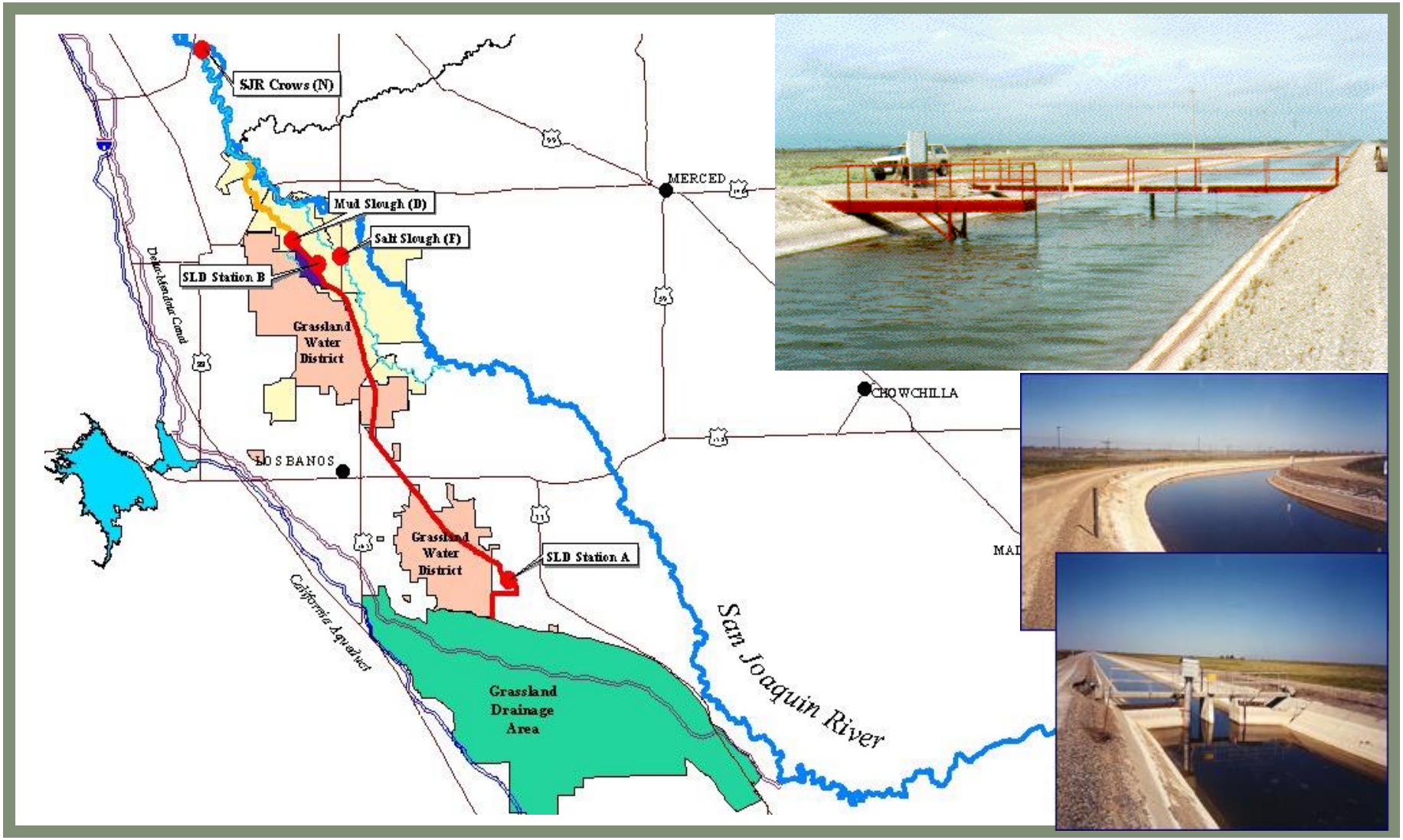
Grasslands Bypass Project use agreement

- Negotiated between stakeholders, four Federal, three State Agencies and environmental groups
- Quantitative limits on selenium load discharge was set in advance and strictly enforced
- Districts and landowners accountable for meeting monthly and annual selenium load limits
- Districts and farmers can design their own mixes of drainage control actions

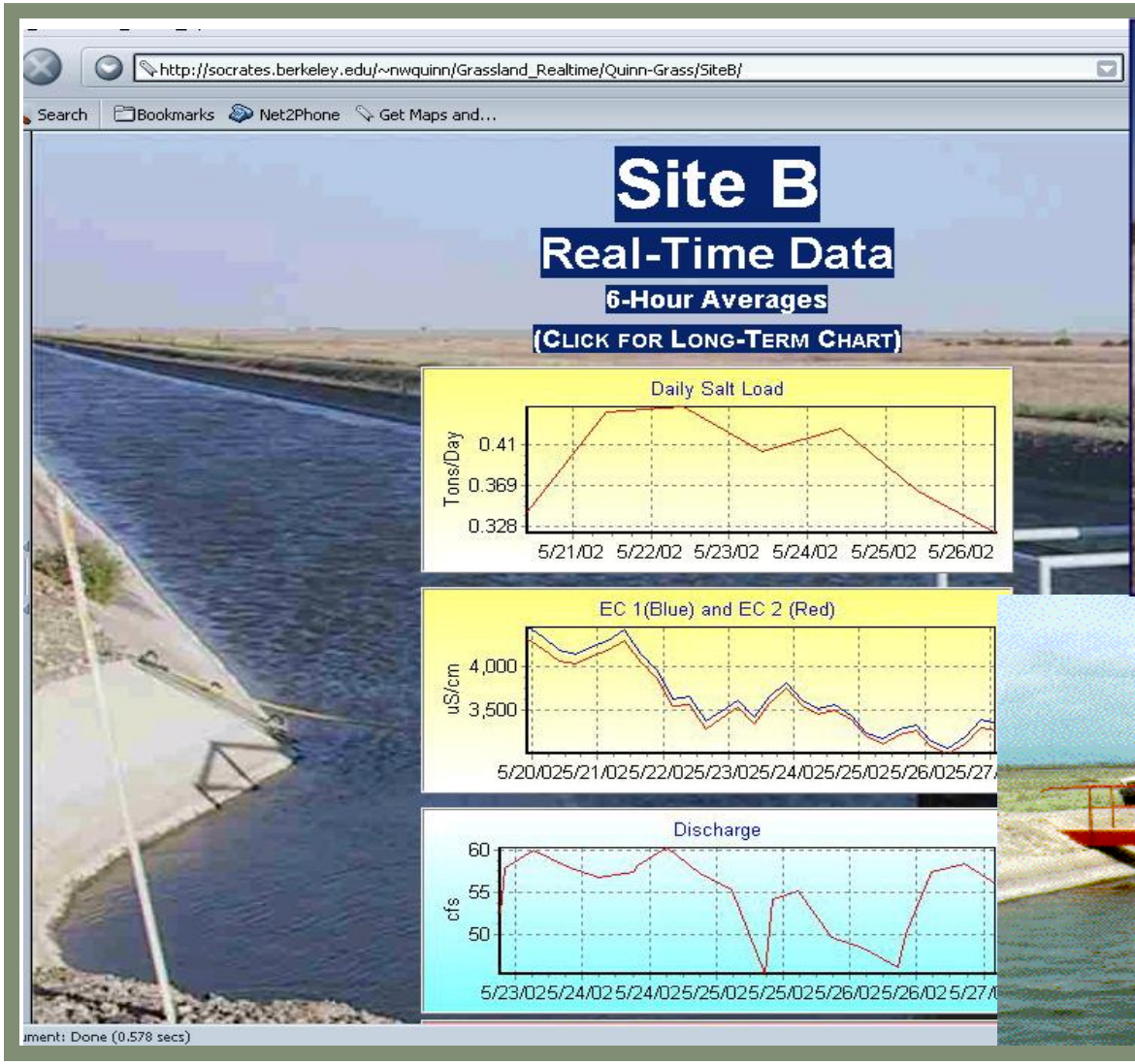
Grasslands Ecological Area managed wetlands



Alignment of San Luis Drain for agricultural drainage



Real-time monitoring of flow, EC and salt load in the SLD



Options for real-time salt and selenium load management

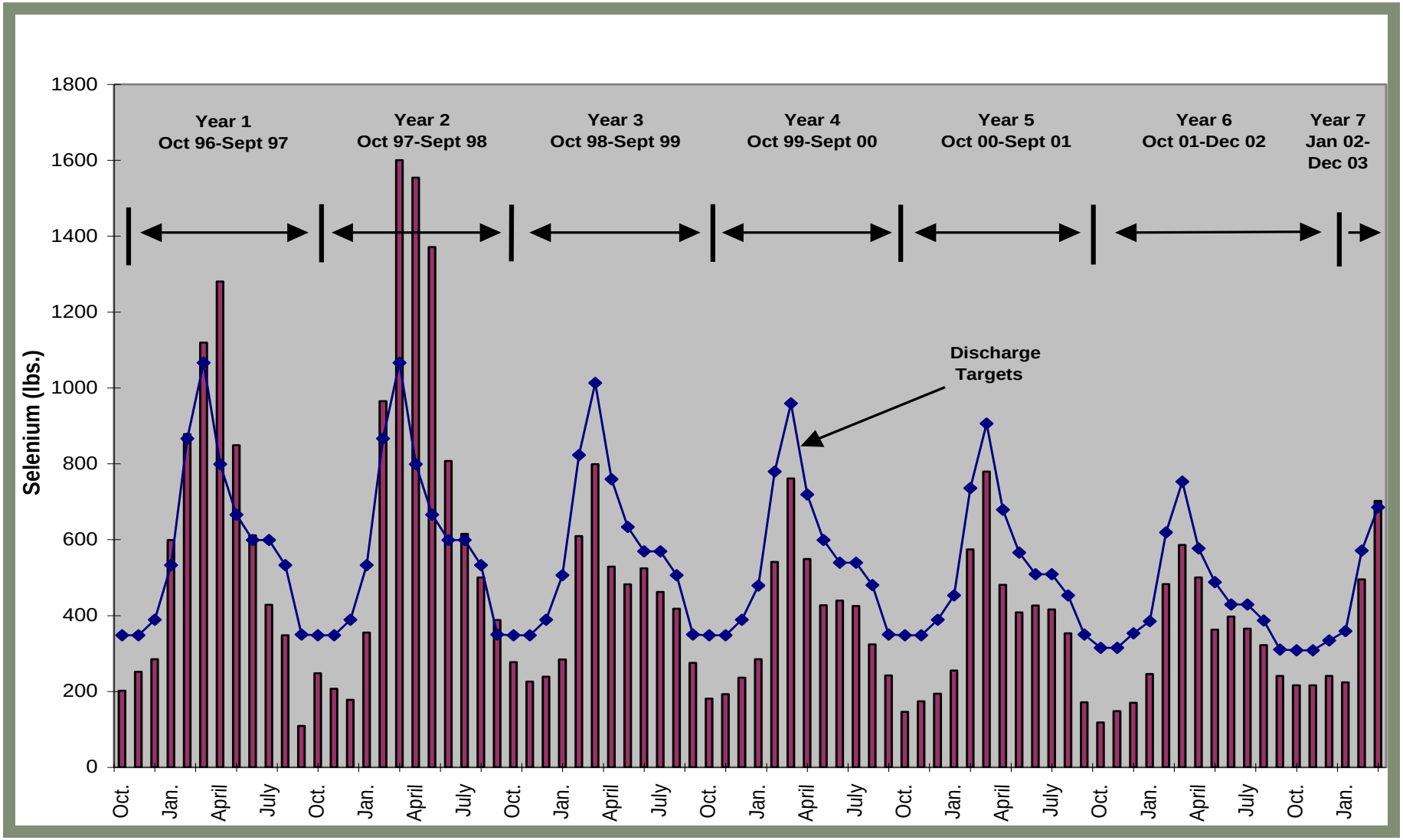
- Increase on-farm irrigation efficiency
- Reuse and recycle drainwater – moratorium on surface water drainage from individual fields
  - Blend with higher quality irrigation water
  - Convert acreage to more salt-tolerant crops
- Fallow cropland to minimize drainage volume
- Retire the land and sell the water rights
- Discharge annually diminishing salt load to the San Joaquin River – zero discharge by 2018

Policy options for on-farm salt and selenium management

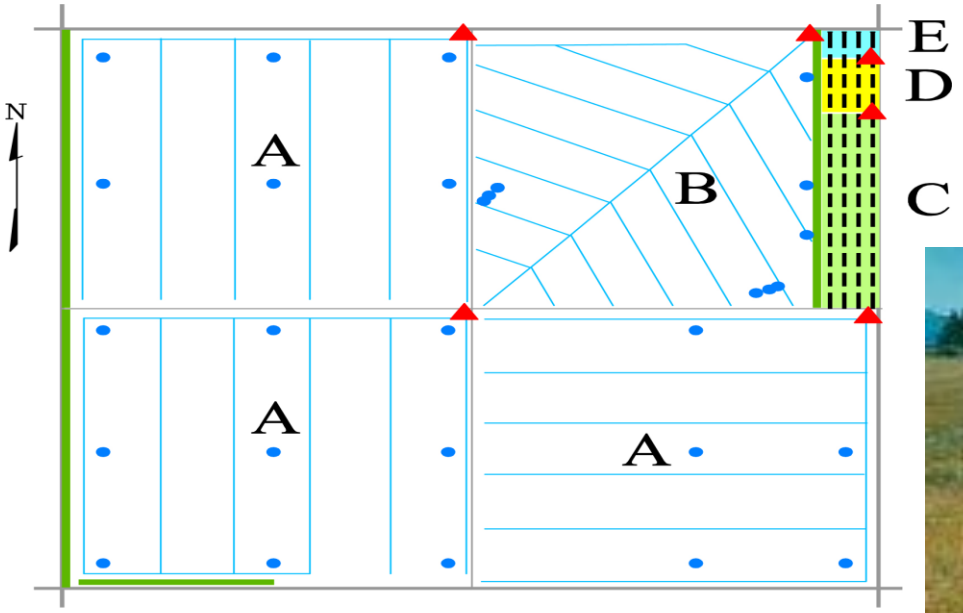
- **Cost-effectiveness:**
  - Tradable discharge permits among districts could promote regional cost-effectiveness
  - Tiered water pricing could promote less water consumptive crops that produce less drainage

- **Local control:**
  - Farmers and districts can tailor crop selection, irrigation and drainage technology investments and regulate discharges to accommodate their own management practices

Selenium load reduction by GBP - 1996-2003

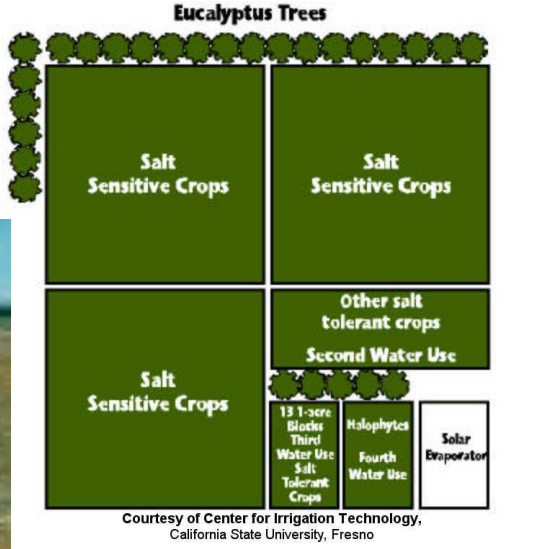


Integrated farm drainage management concept



Legend

- A Non-Salinity Zone - Vegetables
- B Low-Salinity Zone - Alfalfa or Cotton
- C Moderate-Salinity Zone - Trees or Grass
- D High-Salinity Zone - Halophytes
- E Solar Evaporator
- Eucalyptus Trees
- Drainage Tiles in A and B
- Drainage Tiles in C, D and E
- Sump
- Monitoring Well

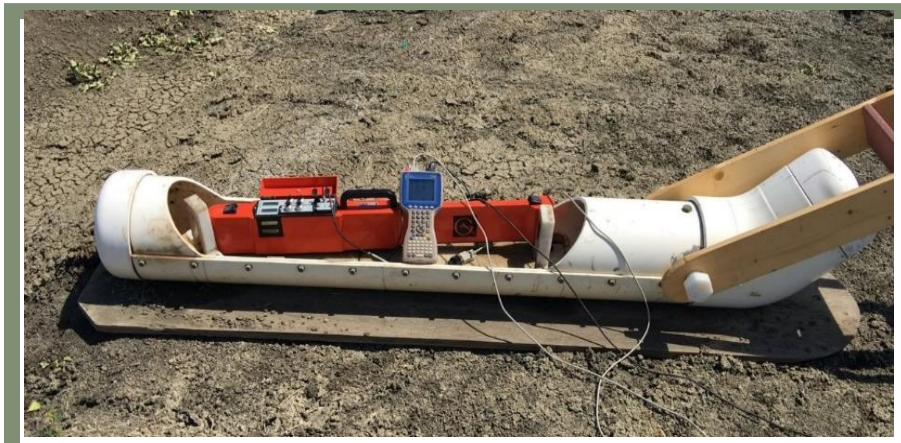


Courtesy of Center for Irrigation Technology, California State University, Fresno

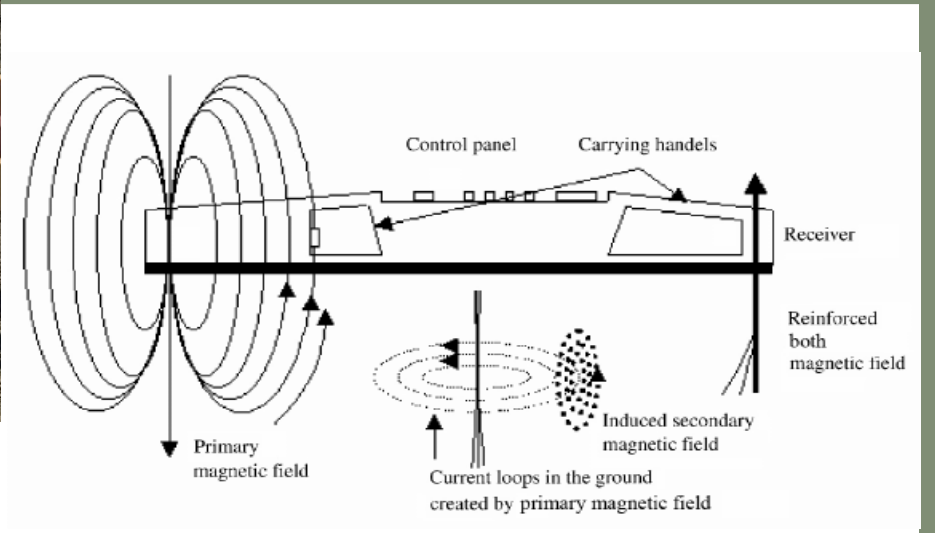
SJRIP: subsurface drainage reuse in Panoche Water District

Experimental fields within drainage reuse area

EM-38 deployment for soil salinity mapping in re-use area



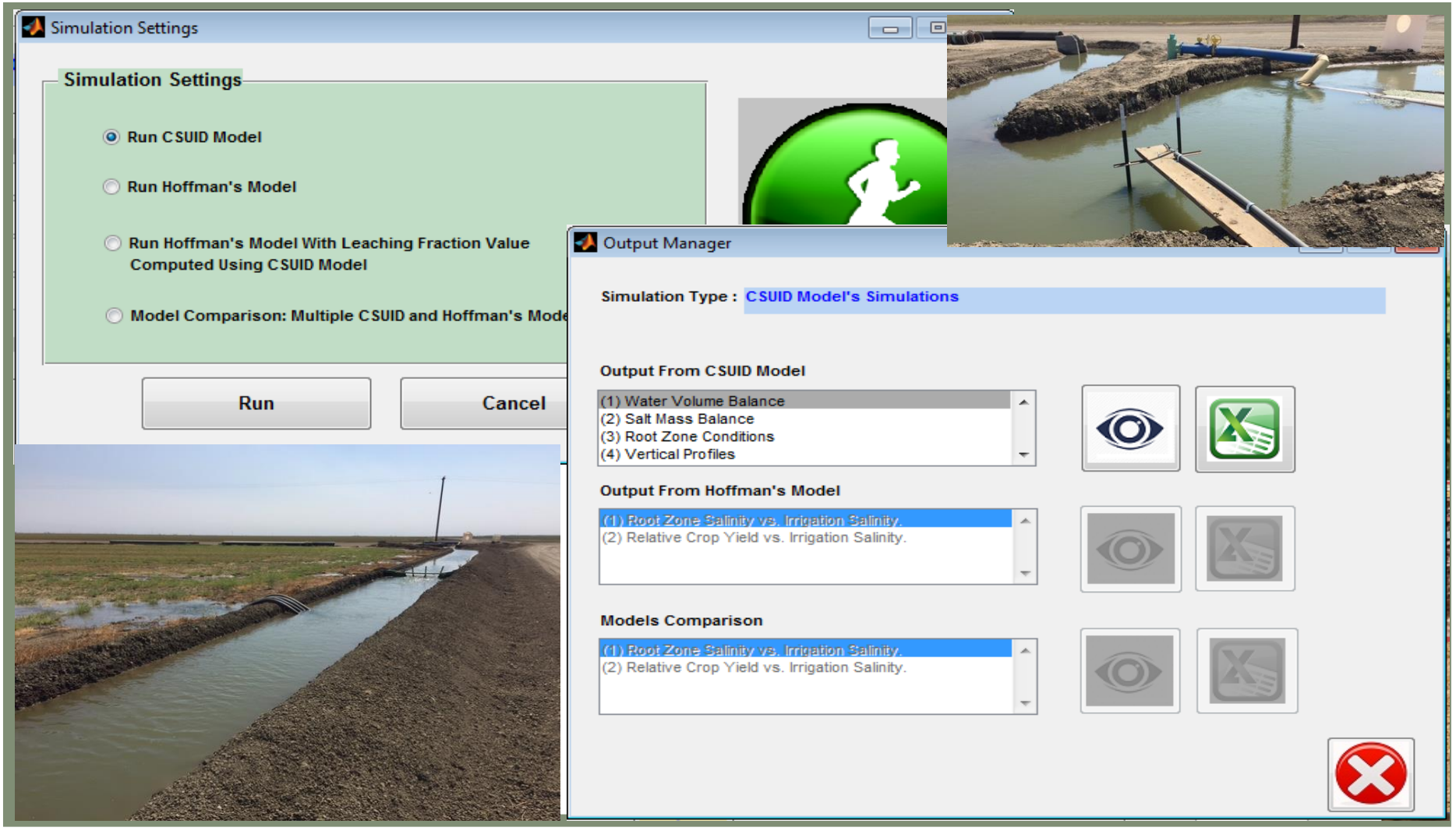
Two transmitter receiver coil separation at 1 m and 0.5 m, for 3 effective depth ranges: 1.5 m and 0.75 m in vertical dipole mode



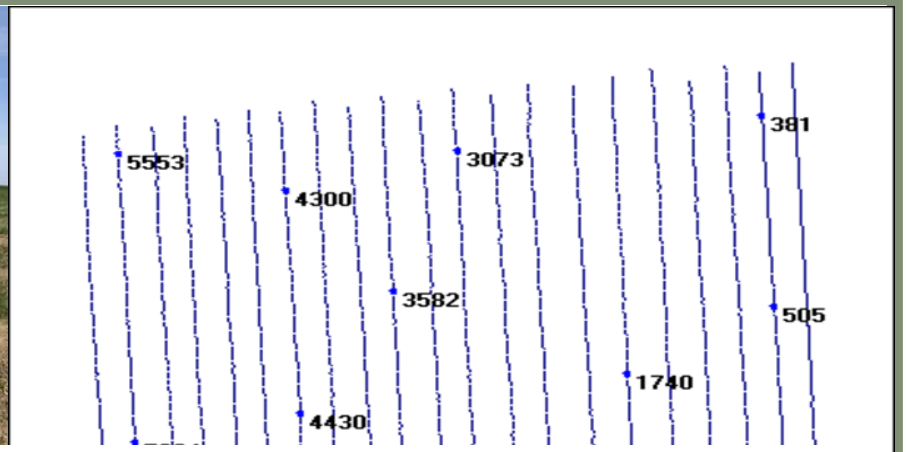
Torpedo sled and gantry non-metallic to avoid signal noise

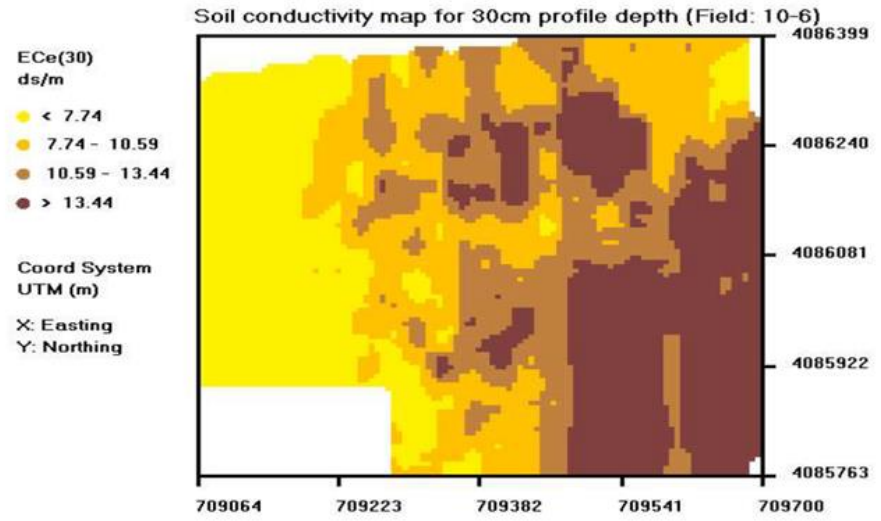
Data logged to on-board laptop computer

Salinity modeling with steady-state/transient DSS



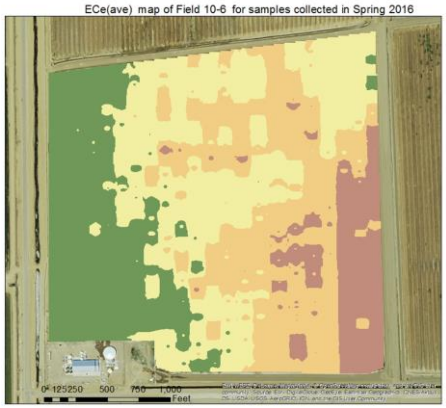
EM-38 electromagnetic surveys in Panoche WD- SJRIP

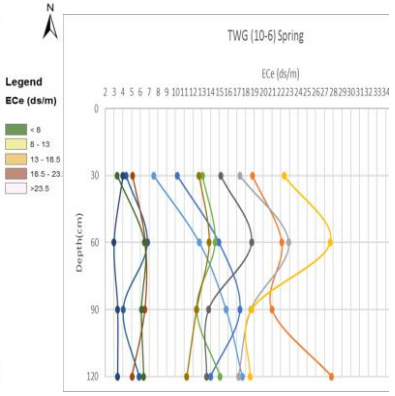


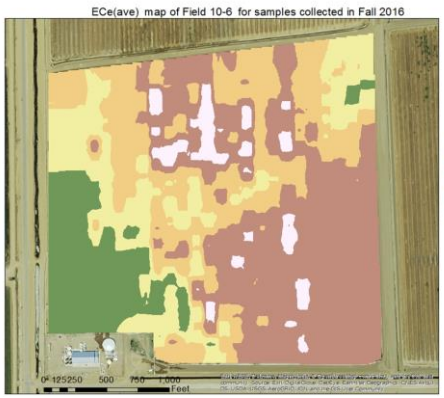


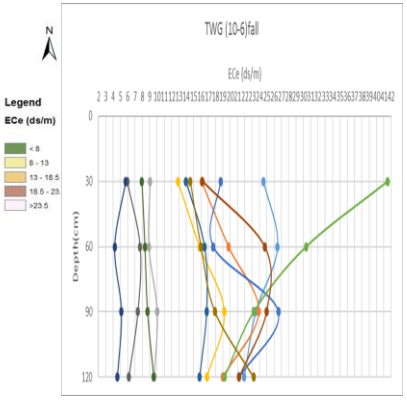
EM-38 survey results – soil salinity accumulation

Soil salinity profiles 10-6



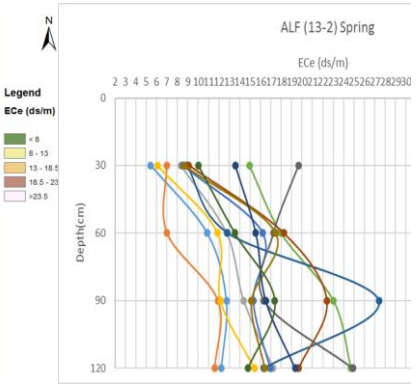


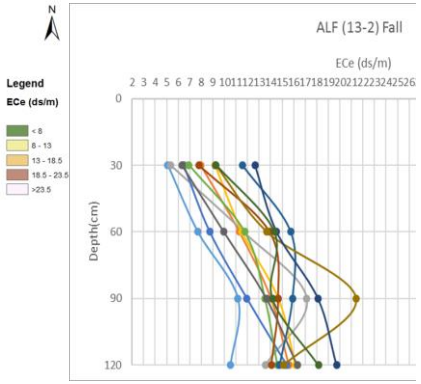




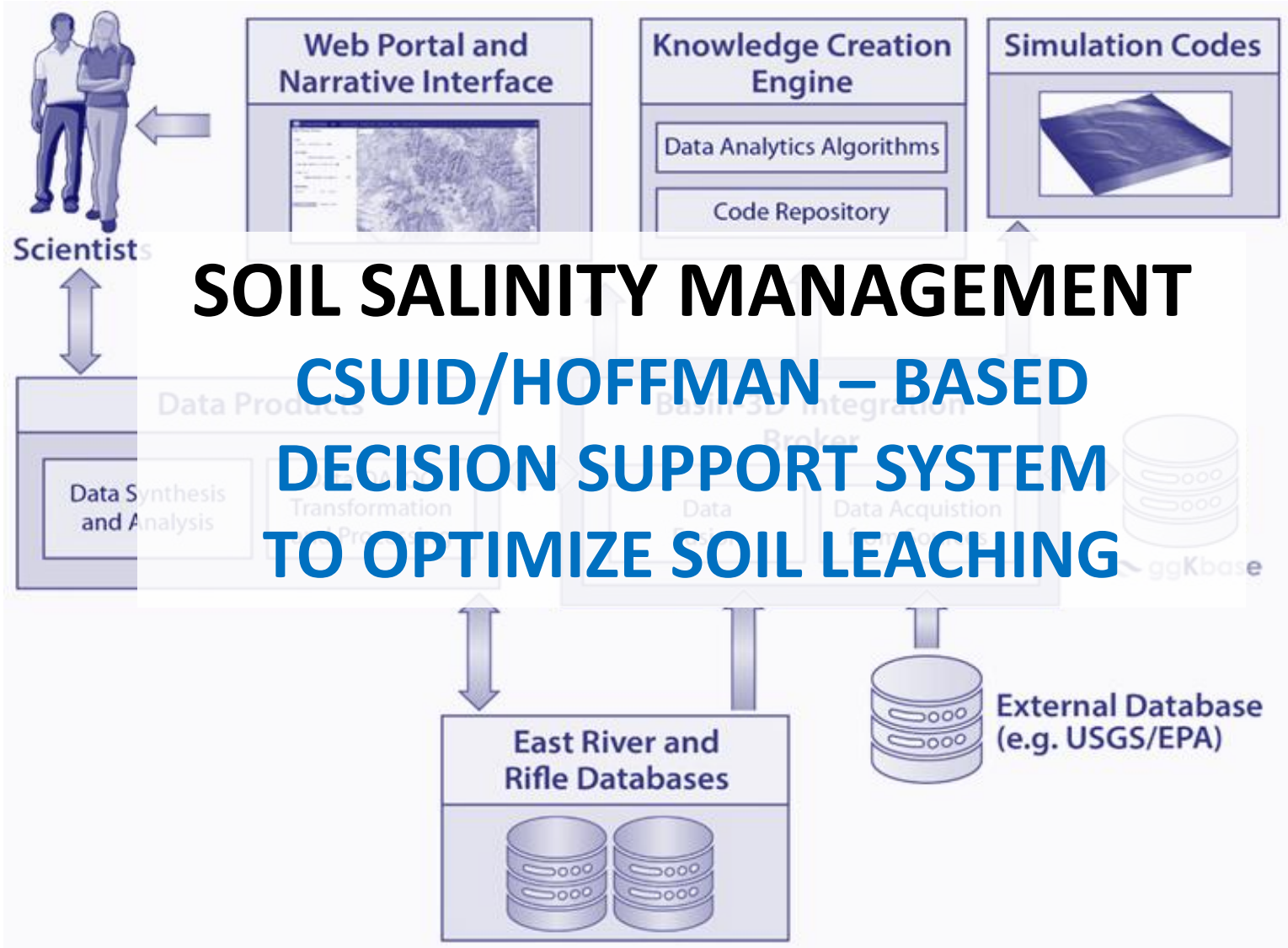
Jose tall wheatgrass – spring/fall 2016

Soil salinity profiles 13-2





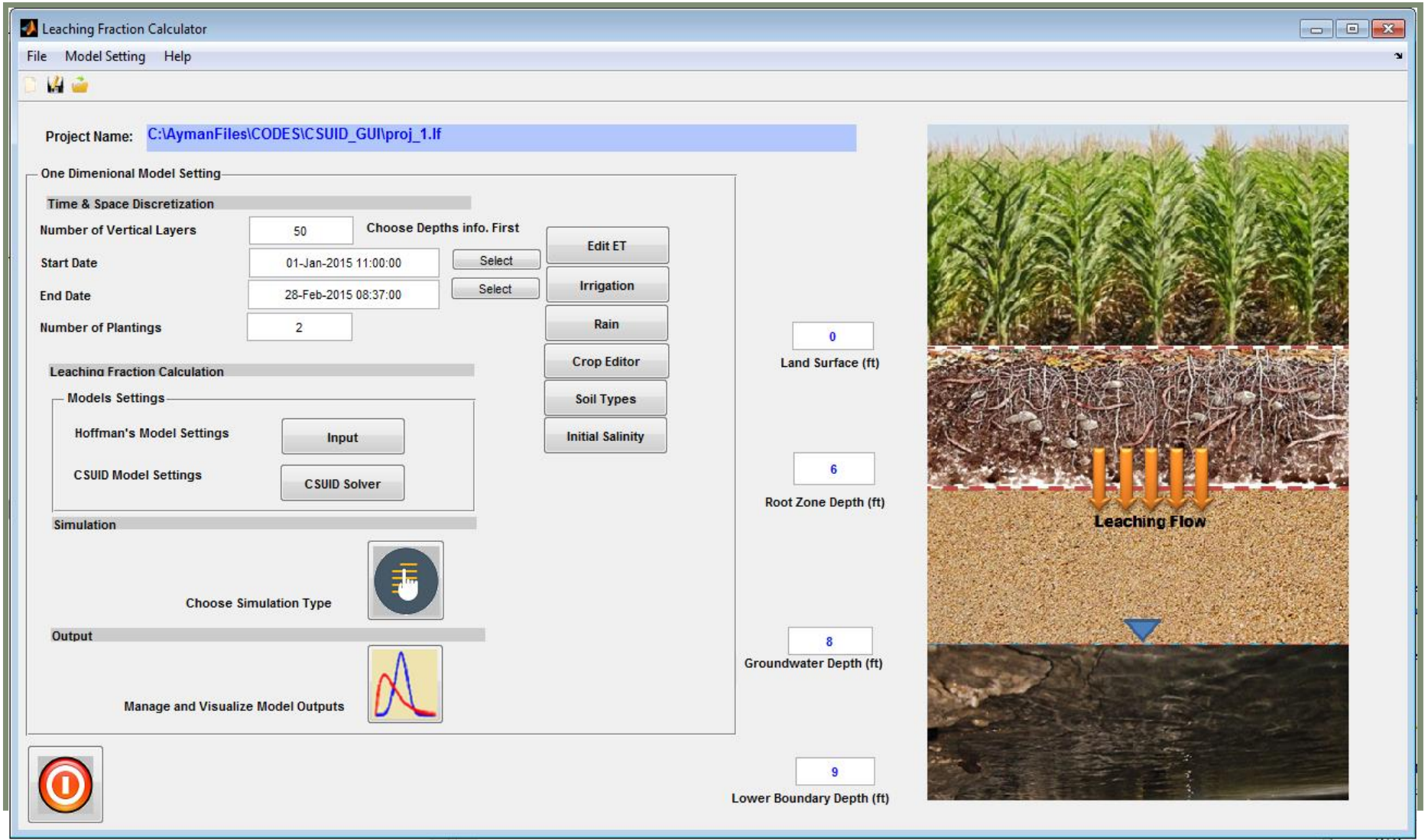
Alfalfa – spring/fall 2016



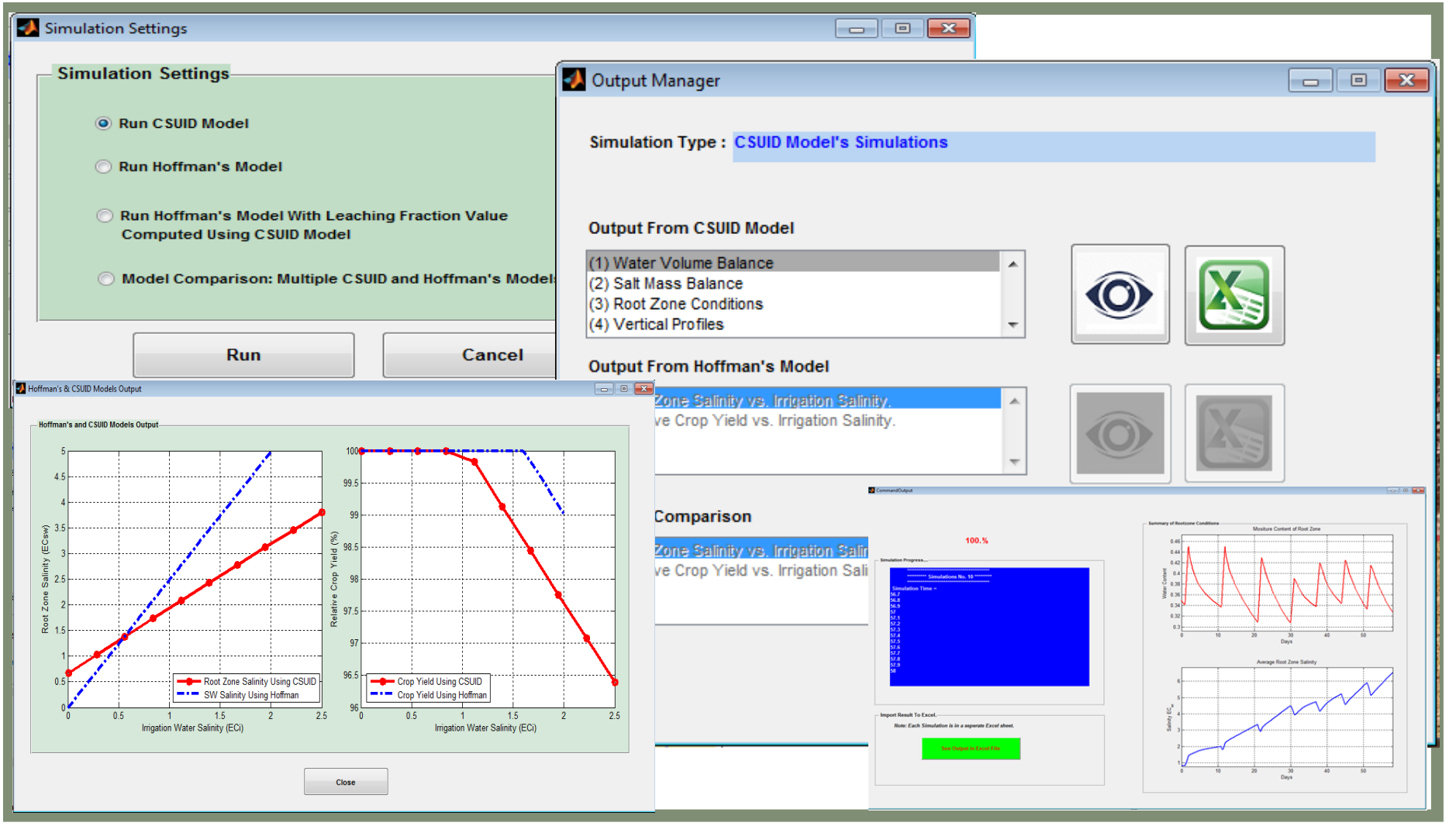
SOIL SALINITY MANAGEMENT

CSUID/HOFFMAN – BASED DECISION SUPPORT SYSTEM TO OPTIMIZE SOIL LEACHING

User interface for CSUID/Hoffman salinity model



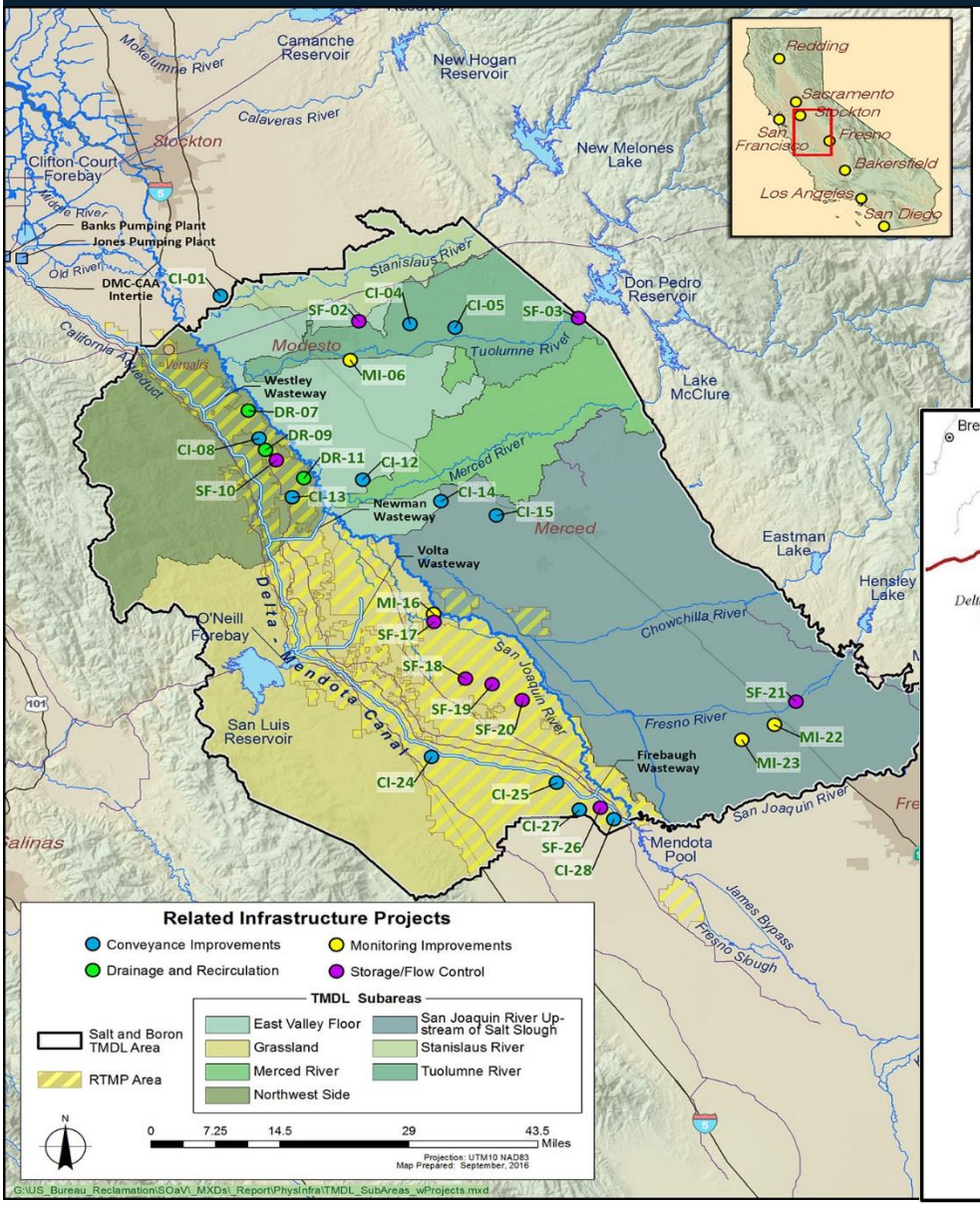
Run options and CSUID/Hoffman model output

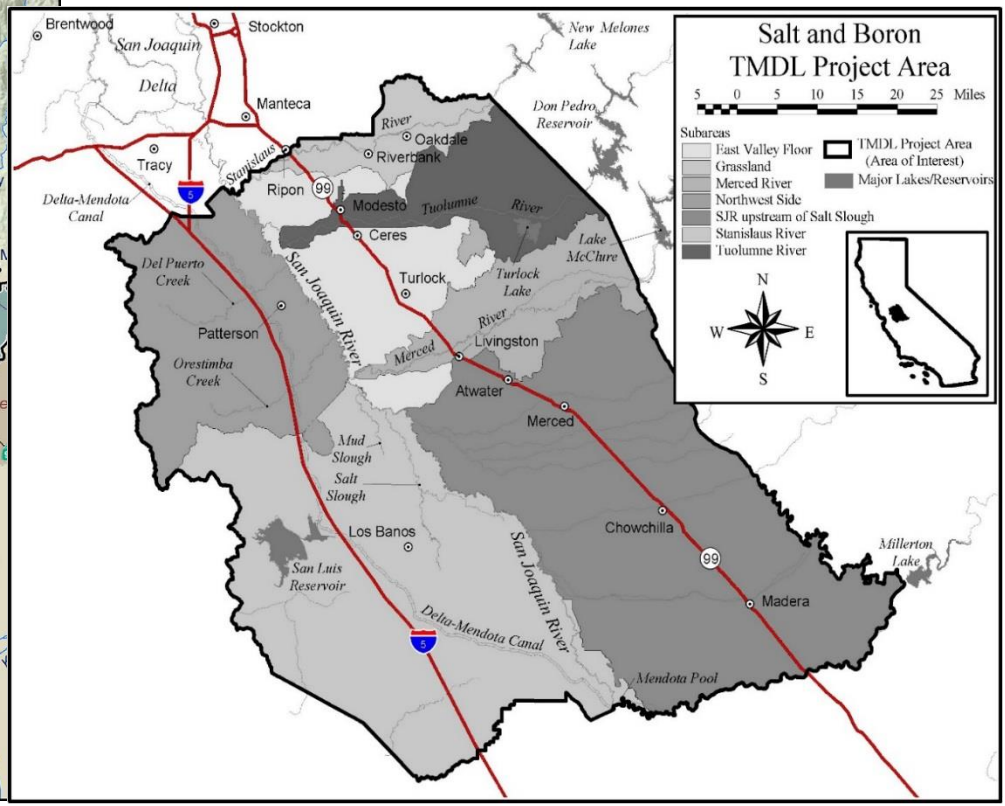


STAKEHOLDER TECH TRANSFER

PROJECT IMPLEMENTION IN RIVER BASIN WITH REAL-TIME MANAGEMENT COMPONENT

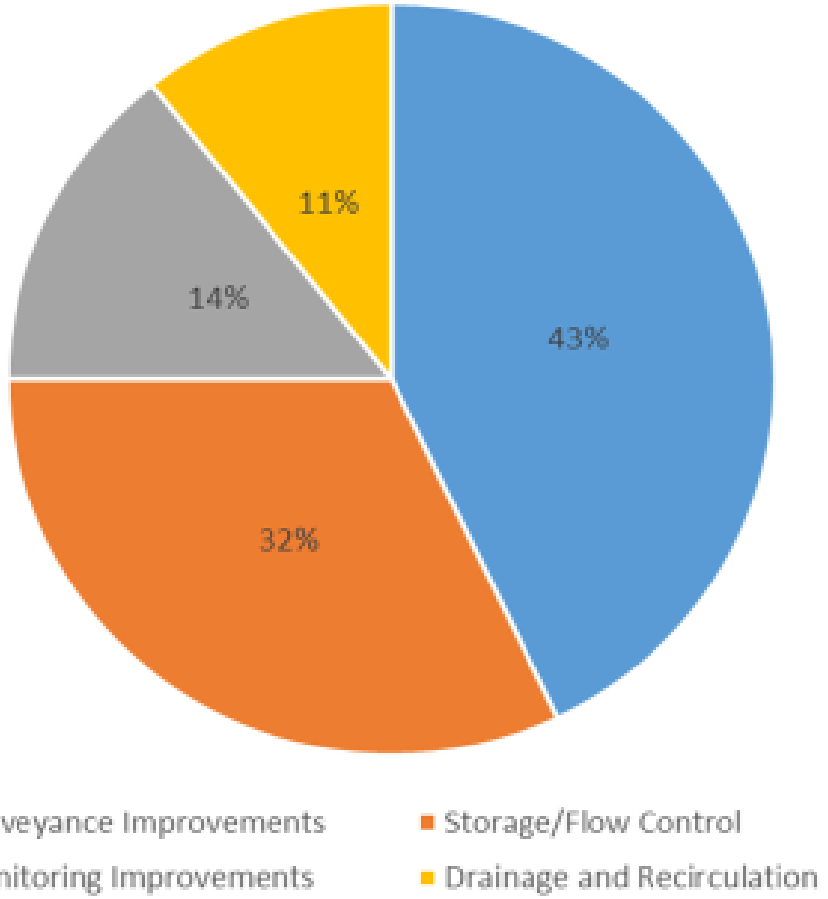
Publicly financed real-time related infrastructure projects in the SJRB over past decade





SJRB real-time infrastructure projects in past decade

Project Type	Project Count
Conveyance Improvements	12
Storage/Flow Control	9
Monitoring Improvements	4
Drainage and Recirculation	3



Project Type Classification by Subarea and Percentage Relative to Total Number of Projects within Salt and Boron Total Maximum Daily Load Project Area

Summary and Conclusions

- Real-time water quality (salinity) management allows greater salt export than traditional load-based TMDL's.
- For seasonally managed wetlands RTSM is the only long-term option if waterfowl habitat is to be sustained
- RTSM will require integration of data acquisition, processing, model forecasting, information dissemination and decision support
- Technical progression in capability of sensors and supporting software over past decade essential for implementation of RTSM
- Full basin-wide TMDL compliance required by 2022 – major challenge for cooperative data sharing and coordination of actions between agriculture, wetland interests, municipal and industrial stakeholders