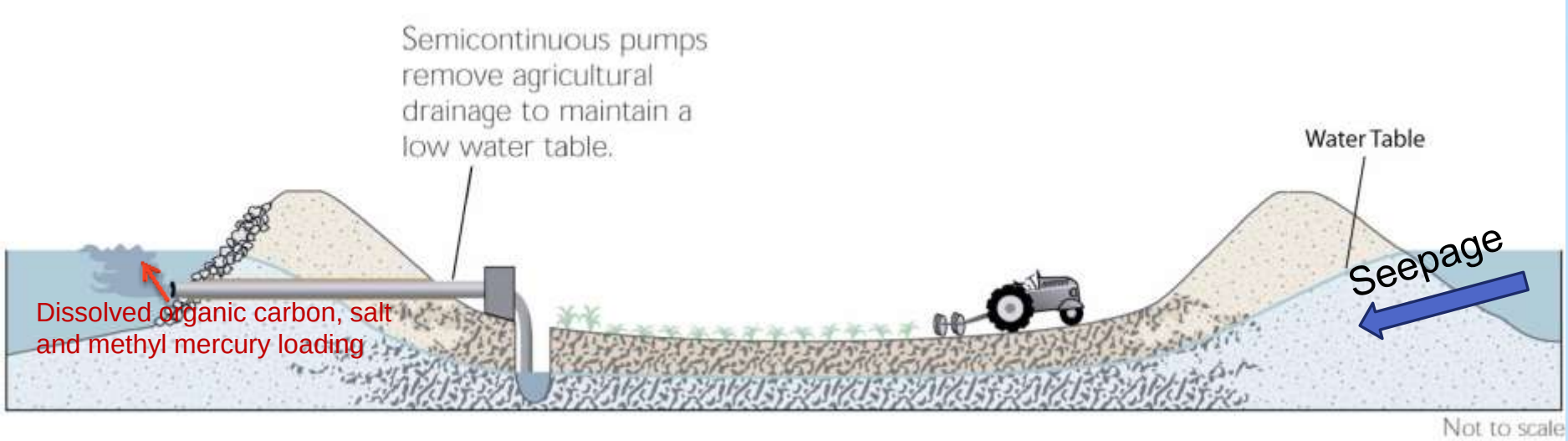
# Hydrologic and Water-Quality Effects of Land Use Changes on Subsided Delta Islands

Steve Deverel, Dave Leighton, Tim Ingrum, Shreya Hegde
HydroFocus, Inc.
Sandra Bachand, TetraTech

sdeverel@hydrofocus.com

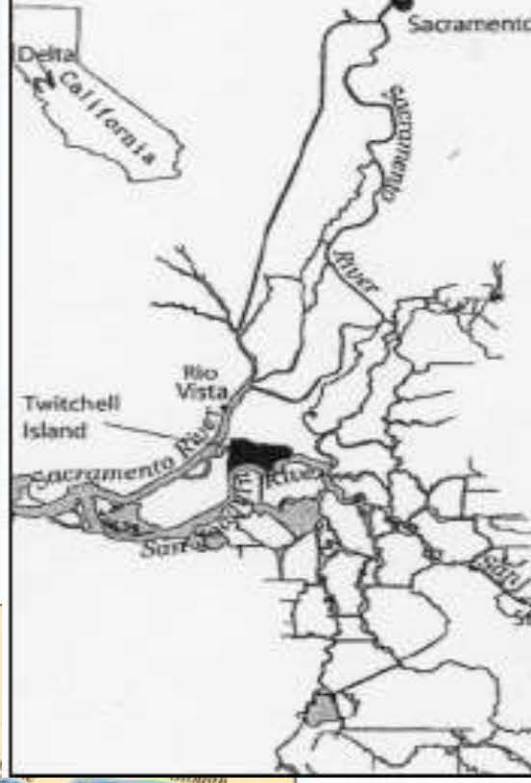
# Overview

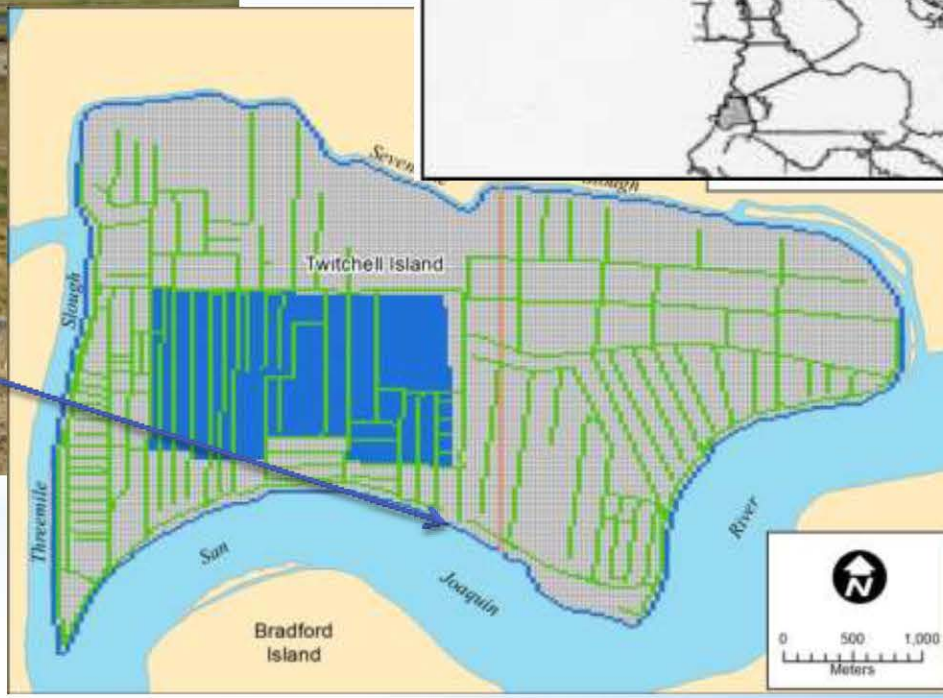
* Groundwater flow modeling for Twitchell Island used to answer questions about effects of land-use changes on drain flow, drain loads and seepage
  * Scenarios
* Results
* Conclusions




- Rice and wetlands stop oxidation and volume loss
- Wetlands accrete

# Twitchell Island

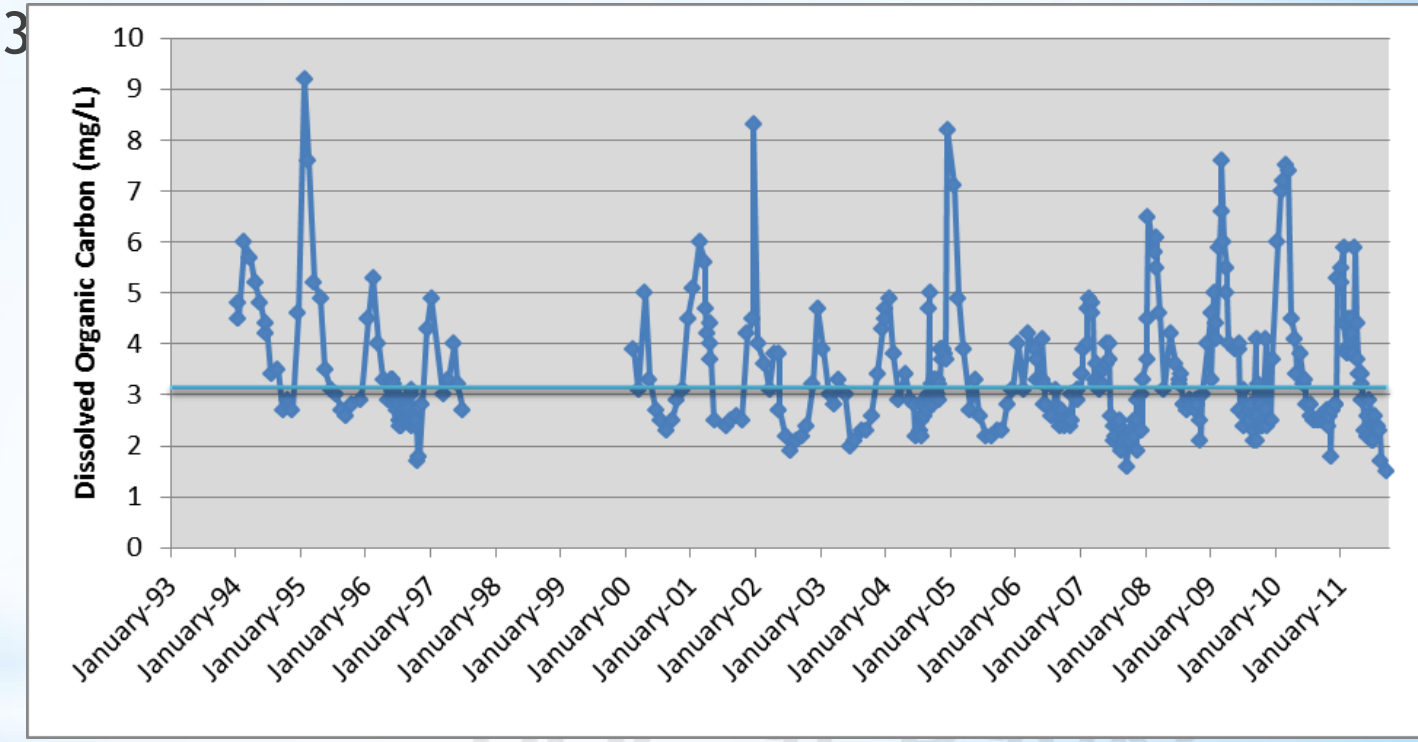


# Dissolved Organic Carbon at Banks

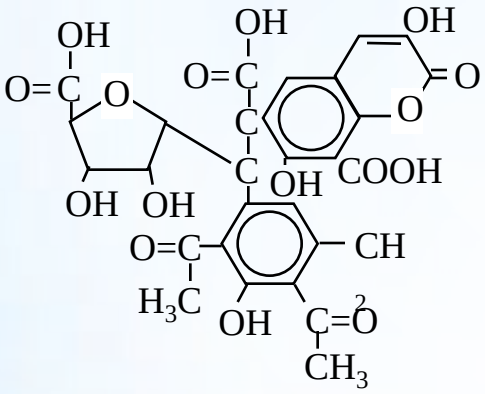
* Ag Drains = 13 50% of load and major contributor during winter[1]

* Formation of disinfection byproducts




[1]Sickman et al. 2010. Biogeochemistry 99:79-96
Kraus et al.,2008, Organic Geochemistry 39:1302-1318

# Relevance to Drinking Water Quality

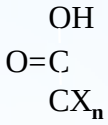


DOC

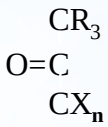
$^{-}OCl$

$^{-}OBr$

$HCX_3$ Trihalomethanes

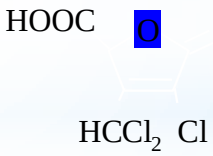


Haloacetic Acids



Haloketones

$CX_3CN$ Haloacetonitriles

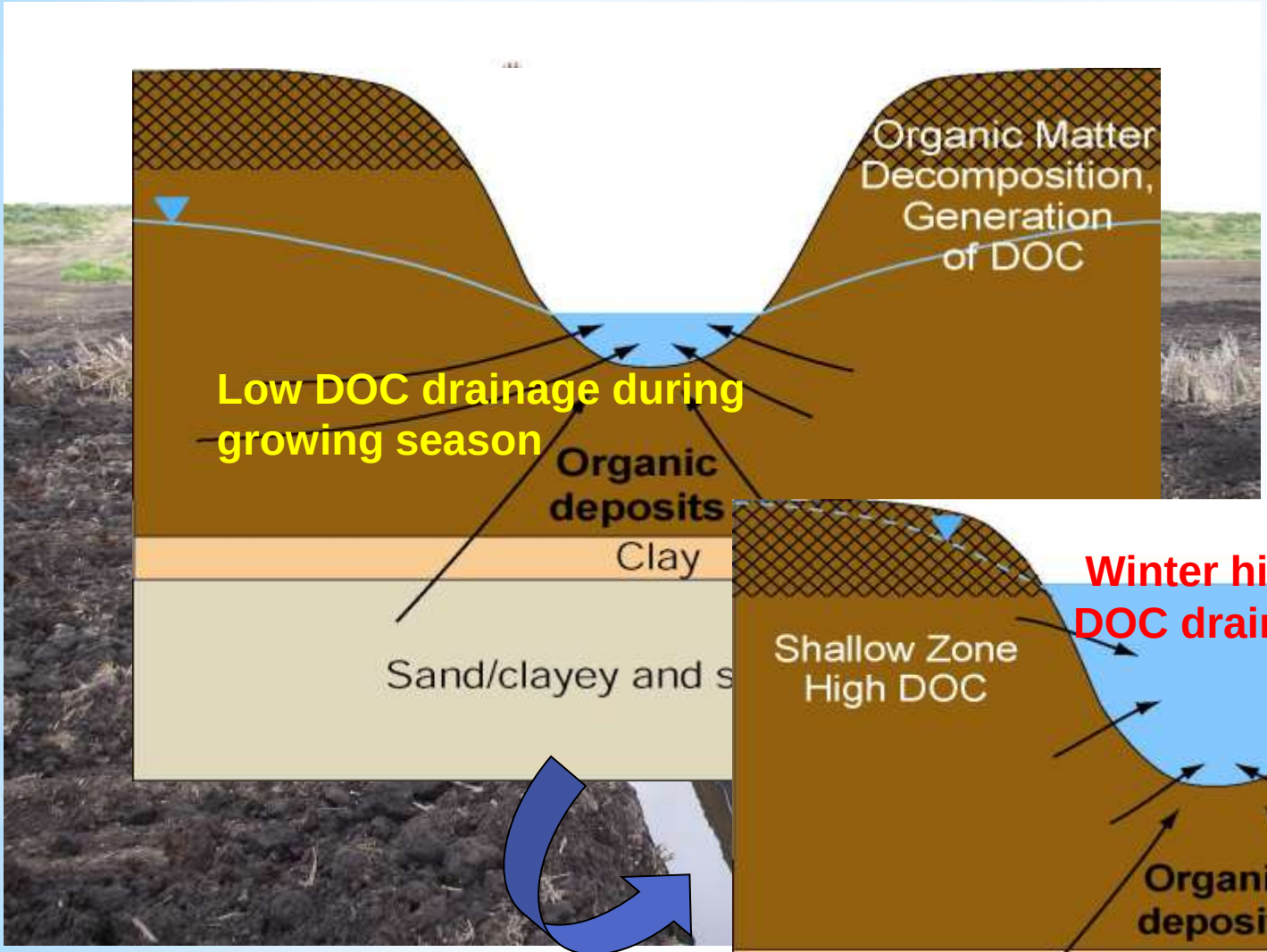


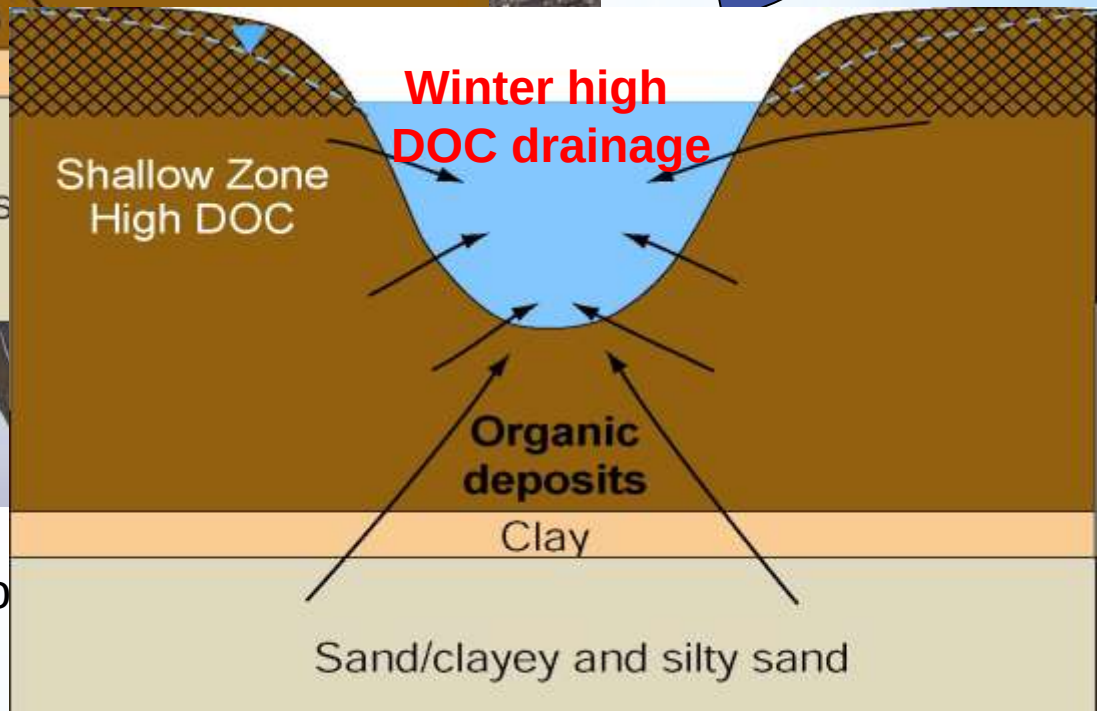
MX

Halophenols

DBPs

# Drainage, oxidation and DOC discharge cycle[2]




[2]Deverel et al., 2007, San Francisco Estuary and Watershed Science

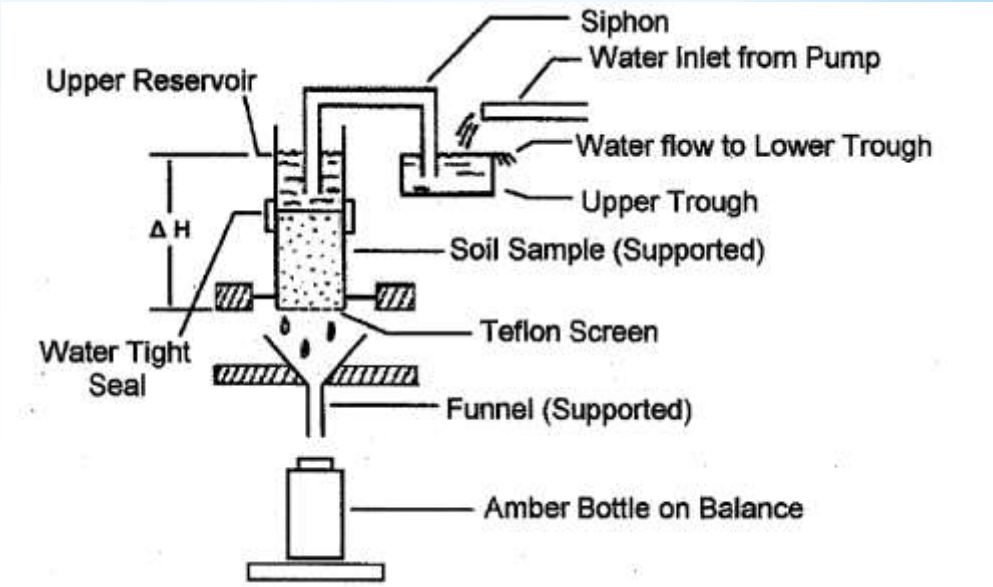
# Groundwater flow and solute transport modeling used to answer questions

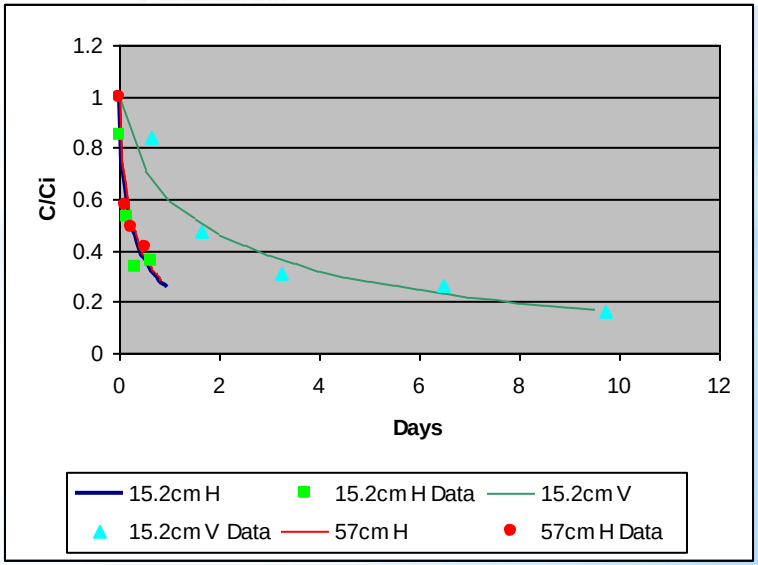
* Used USGS MODFLOW and SSP MTD3D codes
* Parameters and data flow model

- Hydraulic conductivity: slug tests groundwater age dating, tidal analysis, crack measurement
- Boundary conditions: measured river stage
- Drain flow (modeled as head-dependent sinks) from measured drain-flow groundwater level relation
- Measured drain flow and groundwater levels

# Solute transport model

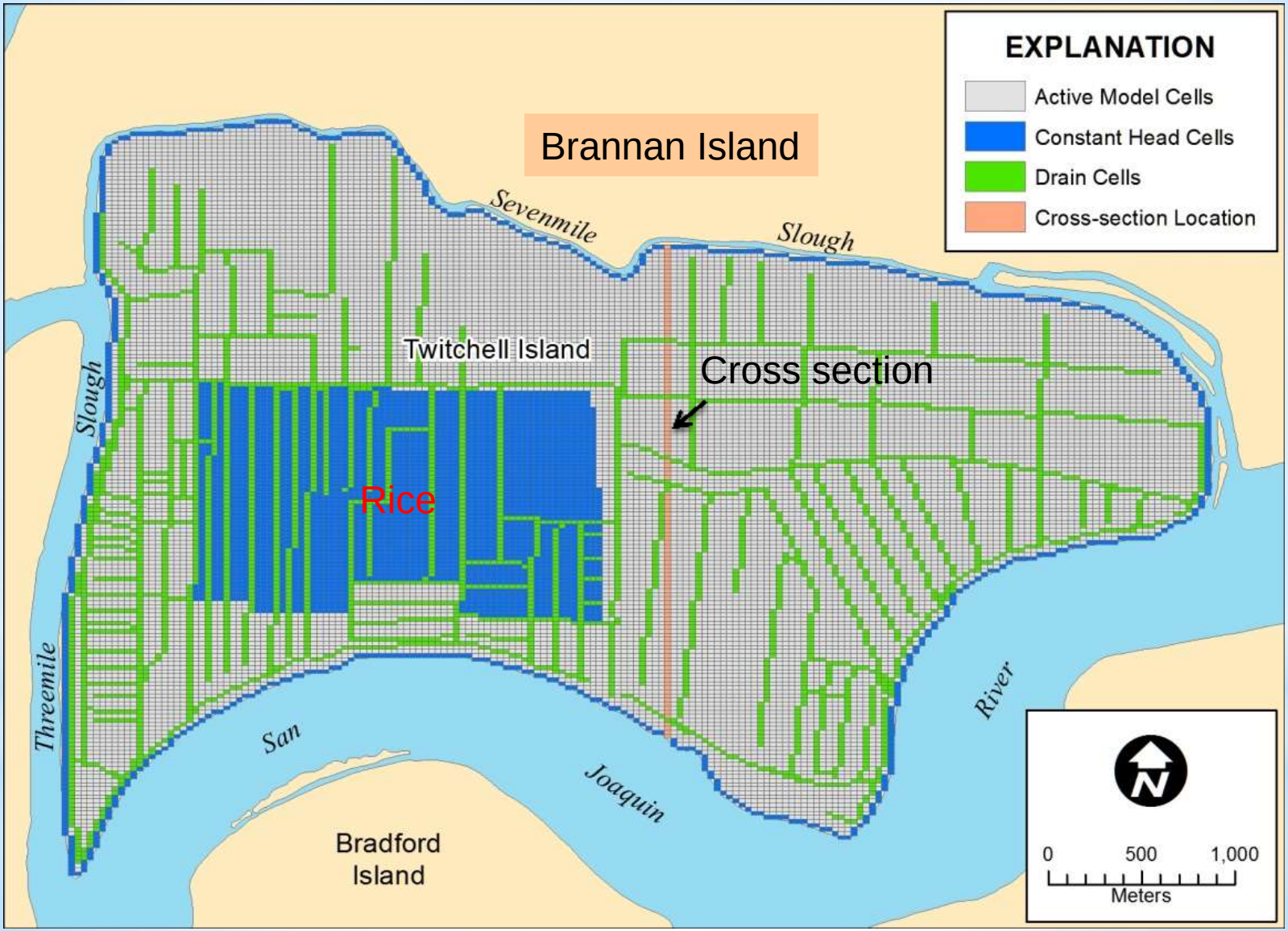
* Assumed conservative transport
* Estimated dispersion coefficient for solute transport equation from USGS column experiments[3]
* Initial DOC concentrations specified from from groundwater wells
* Used literature to scale dispersion up to field scale




[3]Timothy Mathany, USGS, Sacramento, written communication, 2003

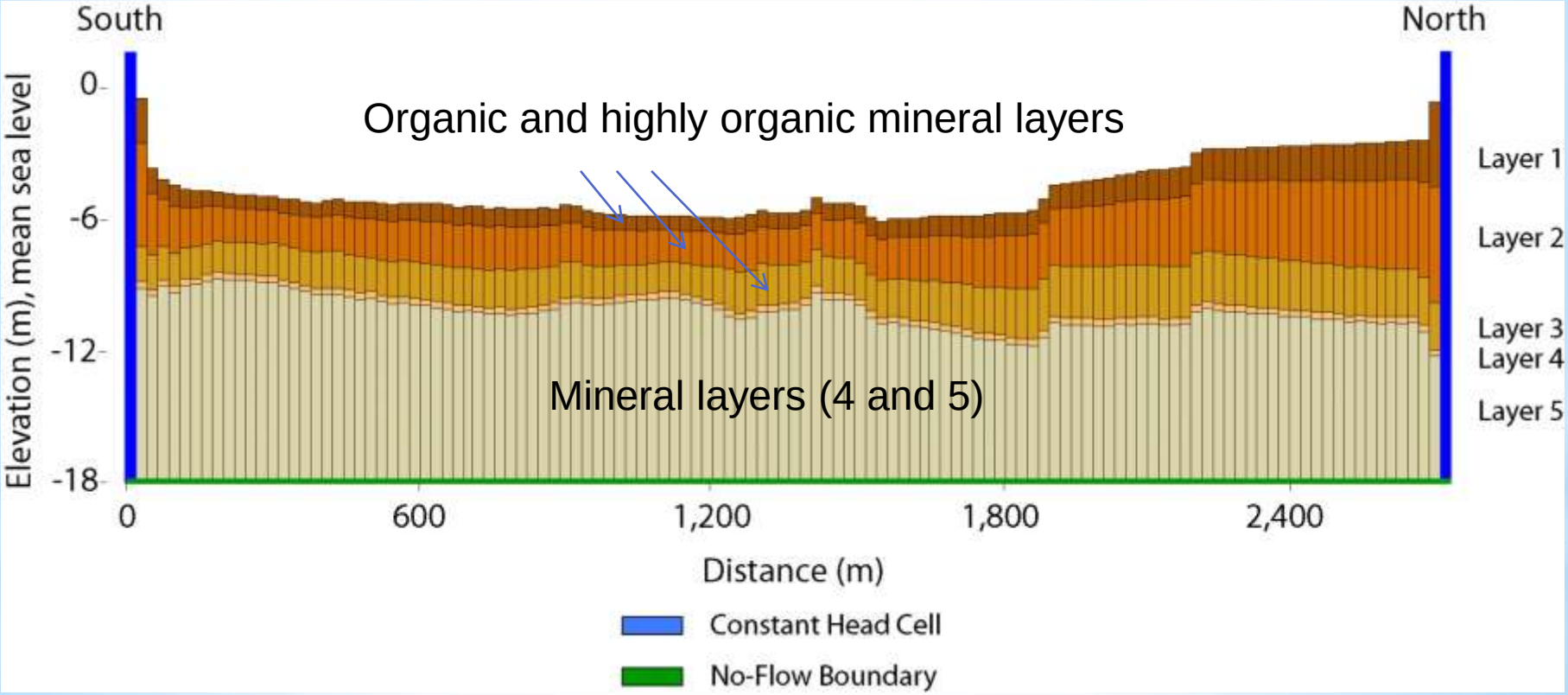
# Groundwater Flow Model




Grid spacing ~ 22 x 33 meters

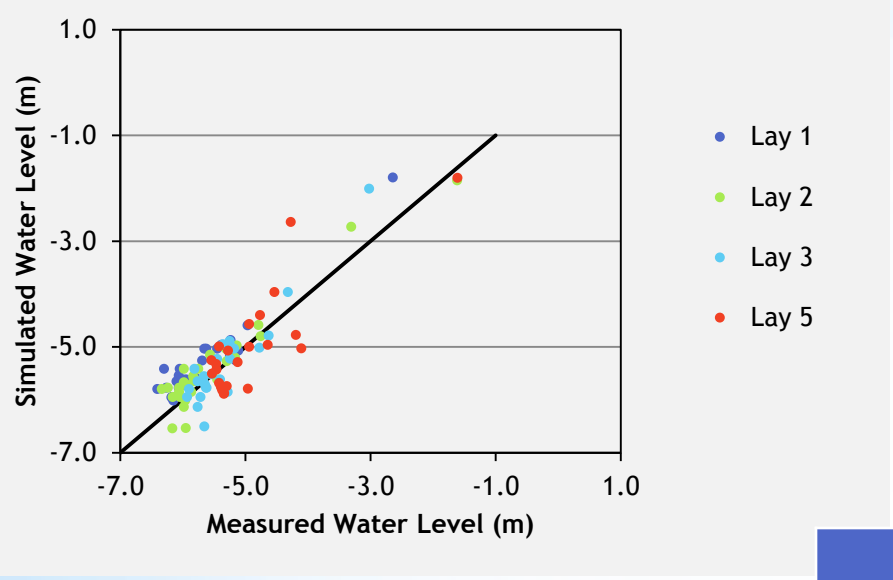
200 rows by 202 columns
Area of cells ~720 $m^2$

# Model Cross-section



# Model Performance

Measured vs. Simulated Water Levels




Measured vs. Simulated Drain flow and DOC Load

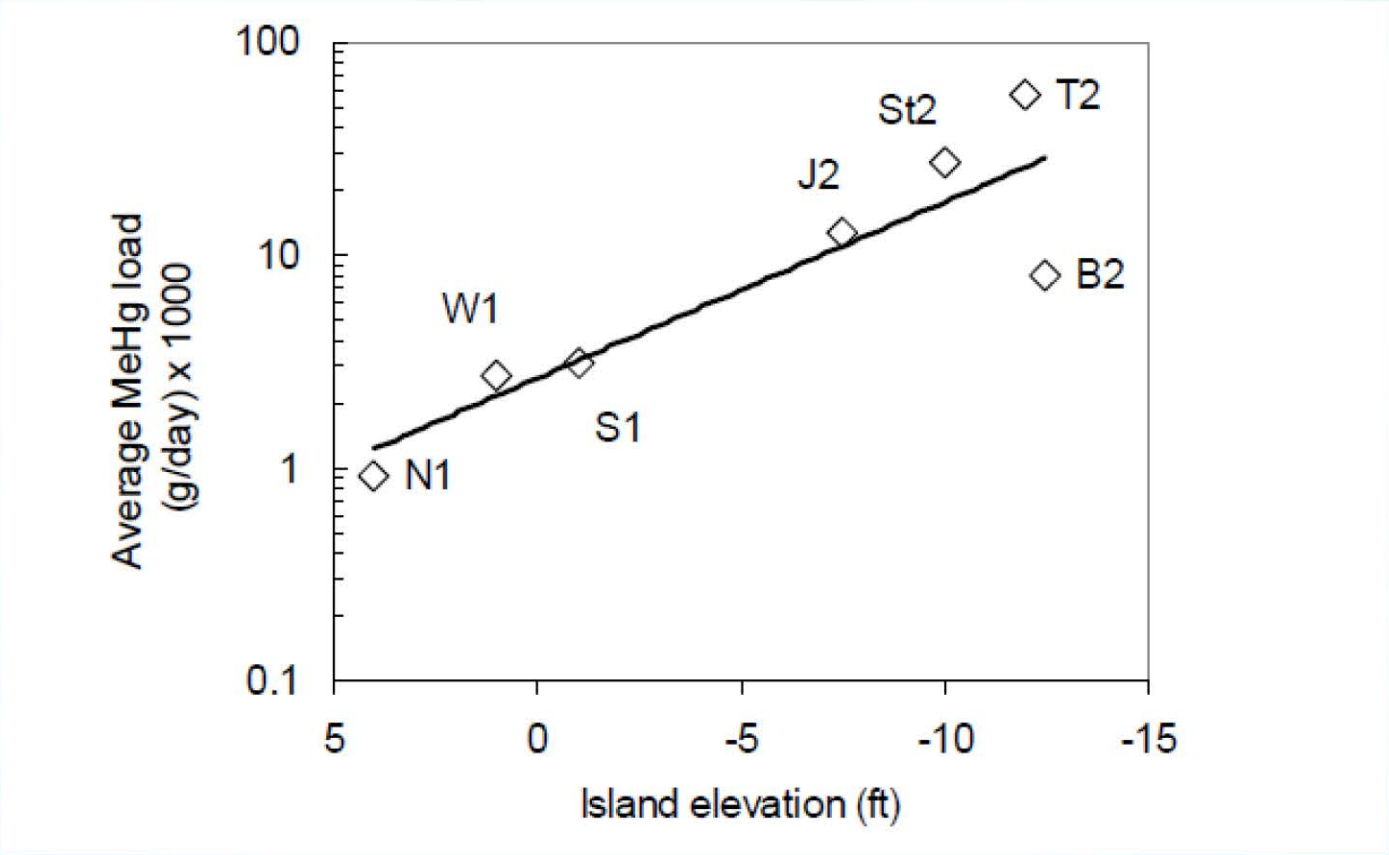
| | Measured | Simulated | Percent Difference |
|---|---|---|---|
| Drain flow (Aft/day) | 35 | 36 | 3% |
| DOC Load (kg/d) | 749 | 718 | -4% |
| Seepage (Aft/day) | | 14 | |

# Model Scenarios

1. BAU and current conditions
2. Combinations of traditional crops, rice, wetlands
3. Recirculation of drainage water
4. Varying drain-water levels
5. Future subsidence using SUBCALC[4]

[4]Deverel, Steven J. & Leighton, David A. 2010. Historic, Recent, and Future Subsidence, Sacramento-San Joaquin Delta, California, USA. San Francisco Estuary and Watershed Science, 8(2), 1-23

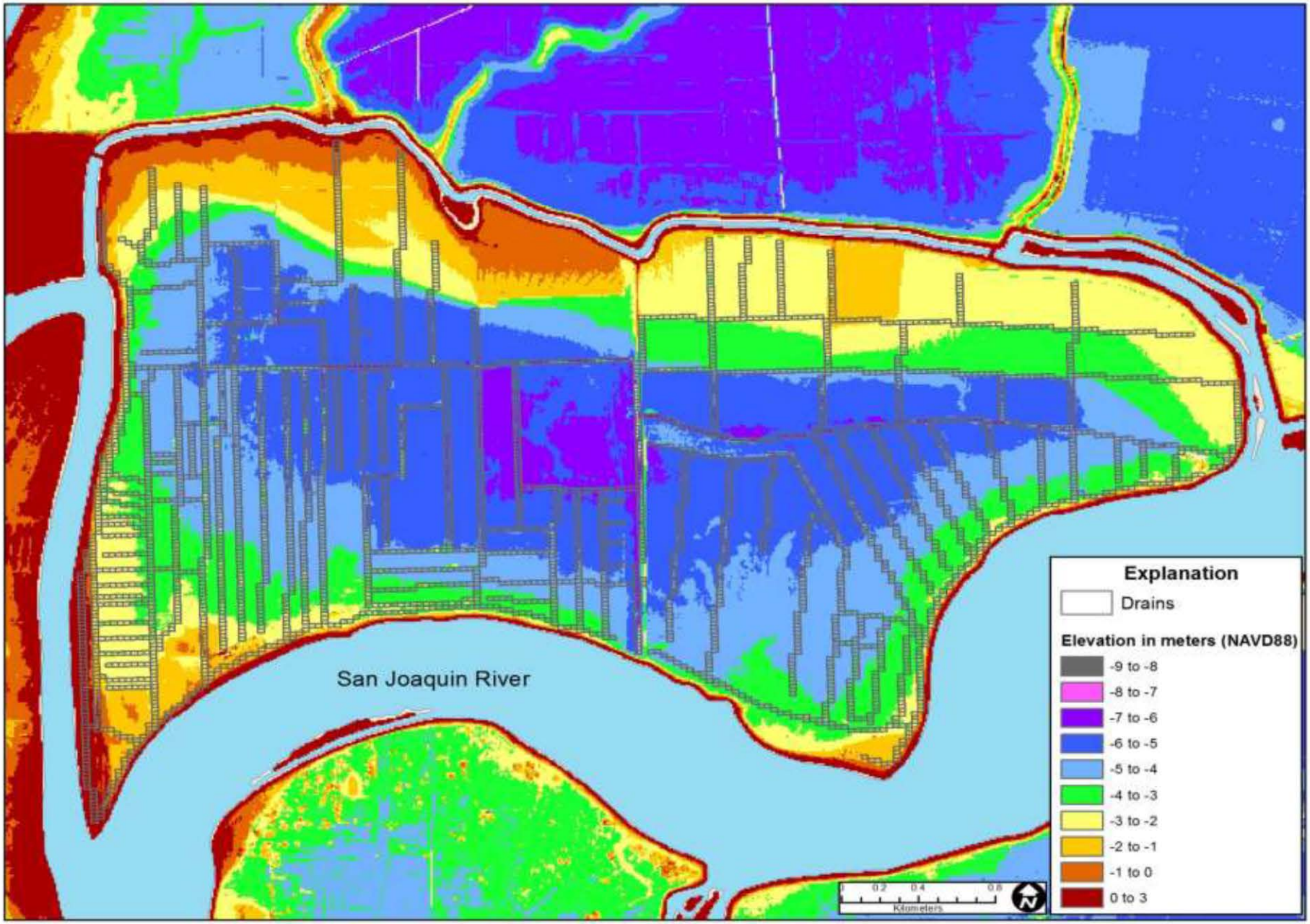
# Methylmercury loads and subsidence




Heim, W.A, Deverel, Steven, Ingrum Timothy, Pierrarski, Witold, Stephenson, Mark, 2009 Assessment of methylmercury contributions from Delta farmed islands, Report to the Central Valley Regional Water Quality Control Board

# Restricted Drainage

# * LiDAR map of Twitchell Island with drains



# Current Conditions

600 A Rice

San Joaquin River

Explanation

Drains

Rice

Elevation in meters (NAVD88)

-9 to -8

-8 to -7

-7 to -6

-6 to -5

-5 to -4

-4 to -3

-3 to -2

-2 to -1

-1 to 0

0 to 3

# Rice & Wetland

600 A Rice

800 A Wetland

San Joaquin River

EXPLANATION

Wetland

Rice

Drains

Existing Ditch

Elevation in meters (NAVD88)

-9 to -8

-8 to -7

-7 to -6

-6 to -5

-5 to -4

-4 to -3

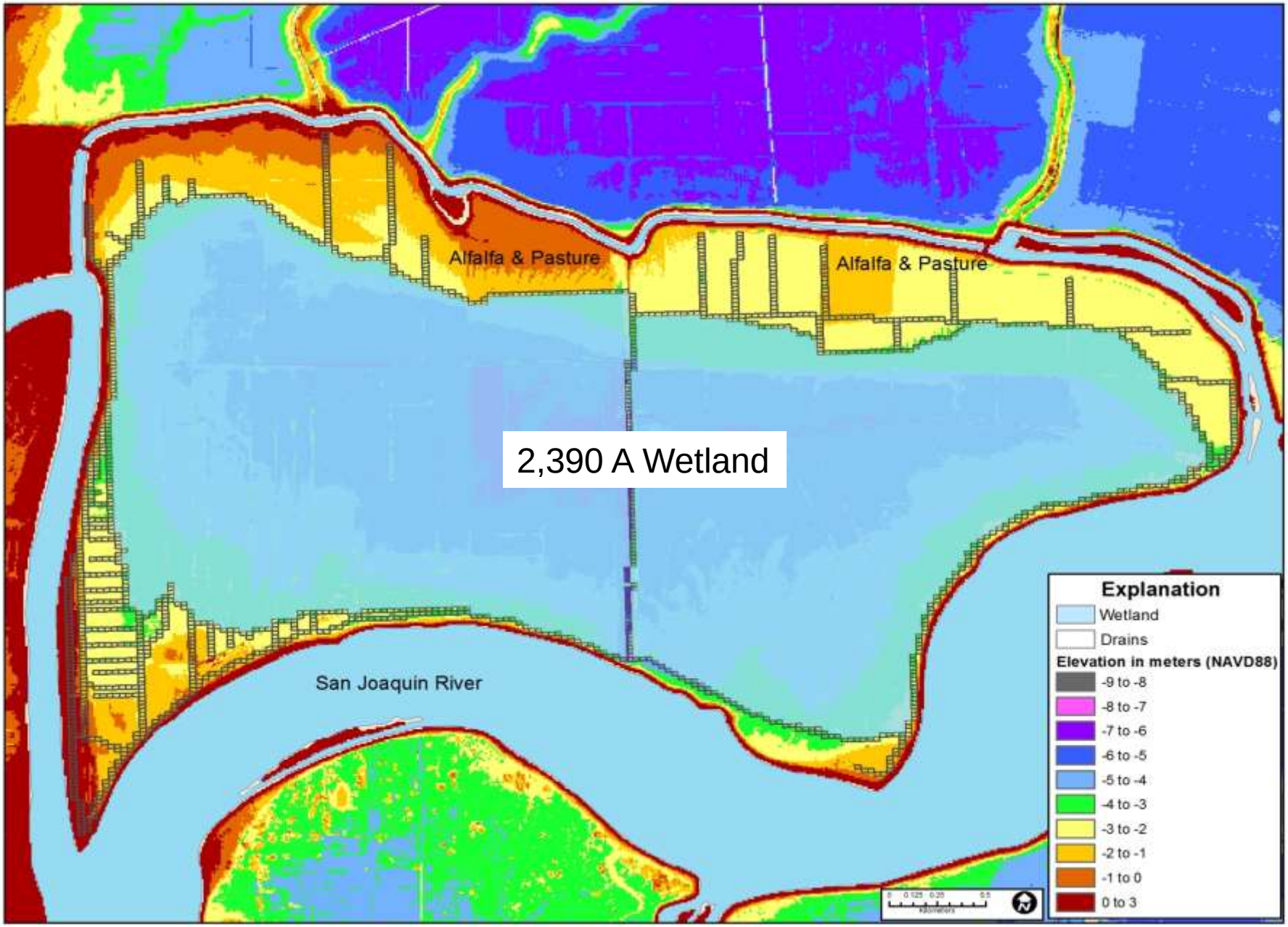
-3 to -2

-2 to -1

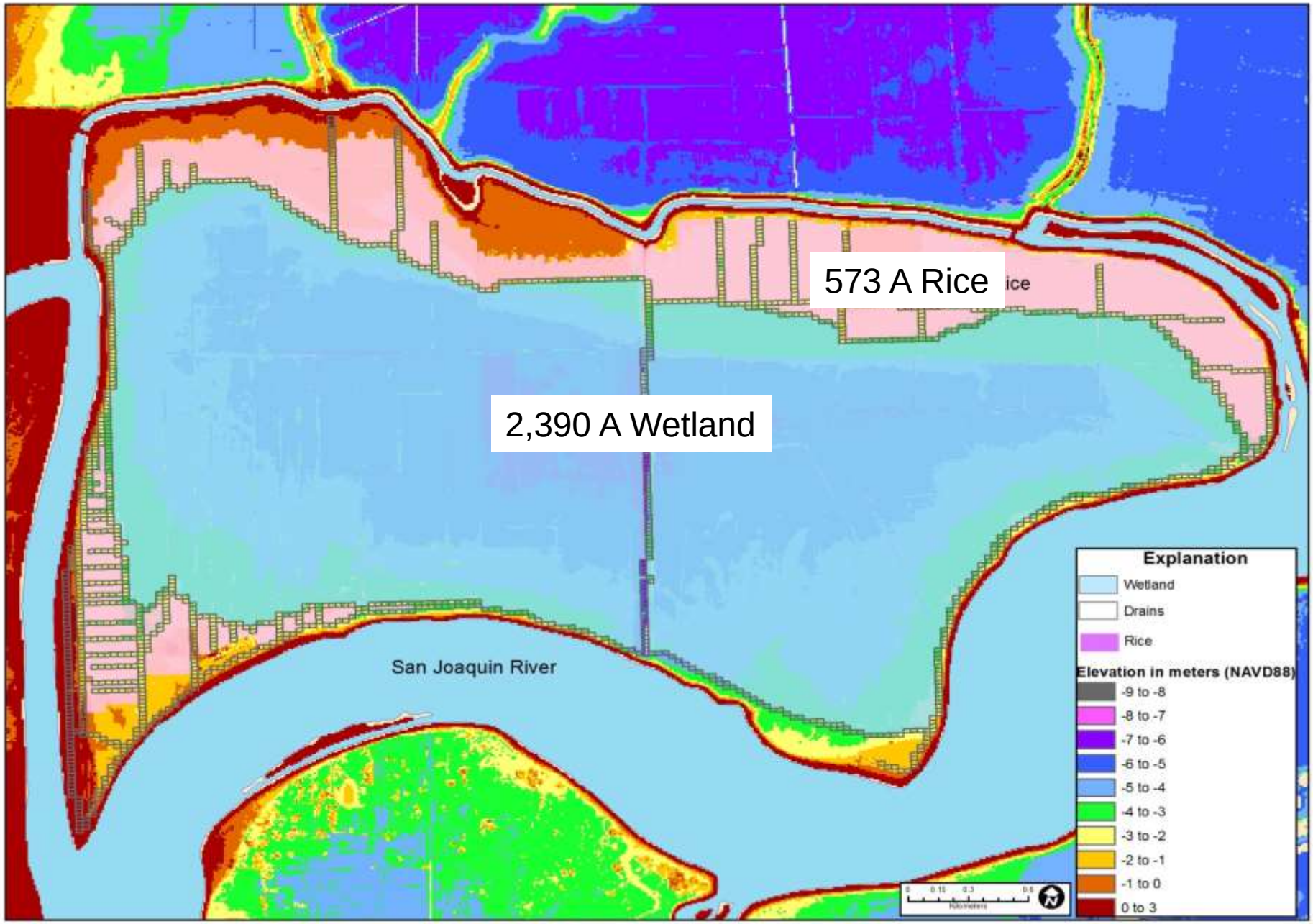
-1 to 0

0 to 3

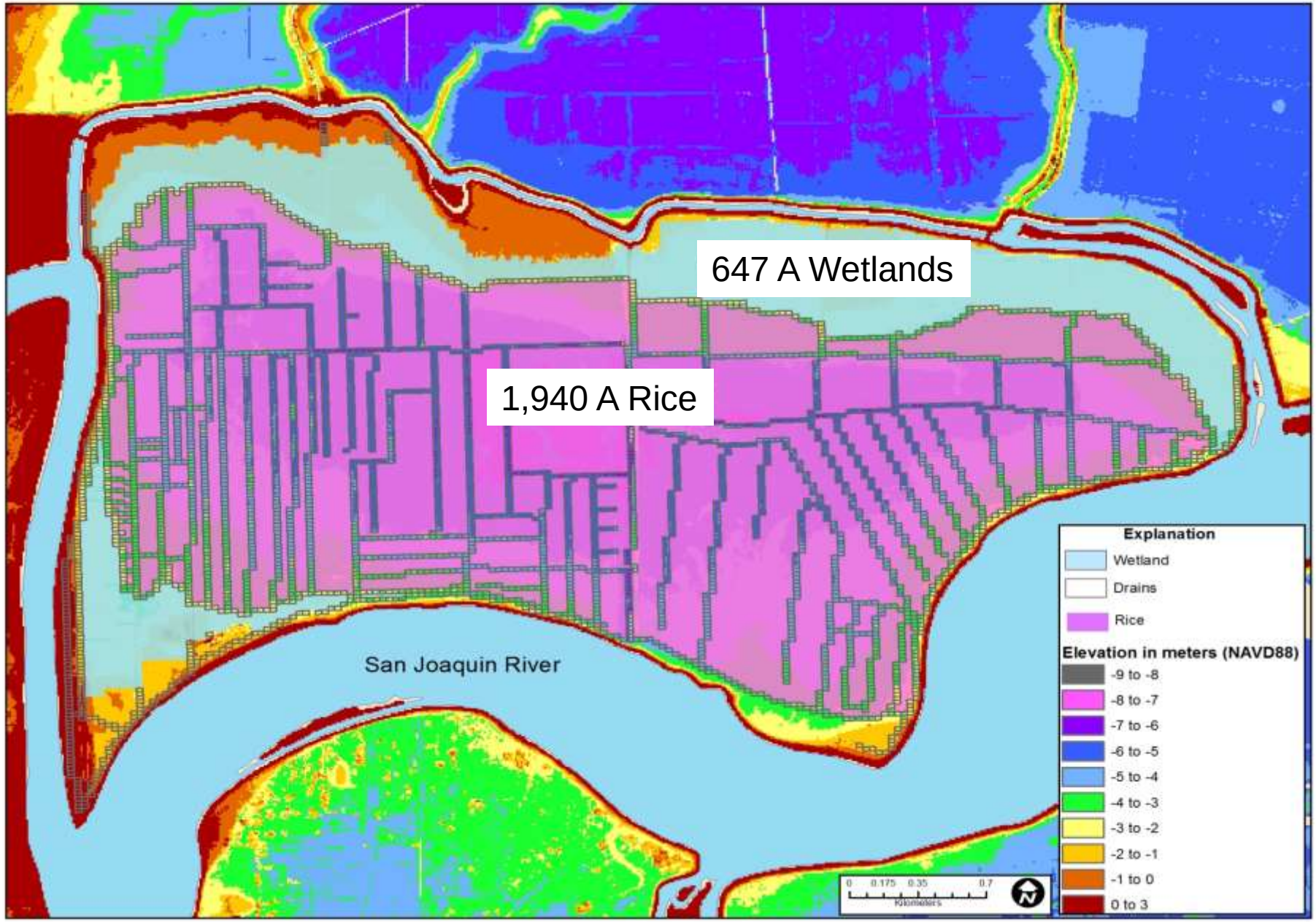
# Wetlands below -3 m



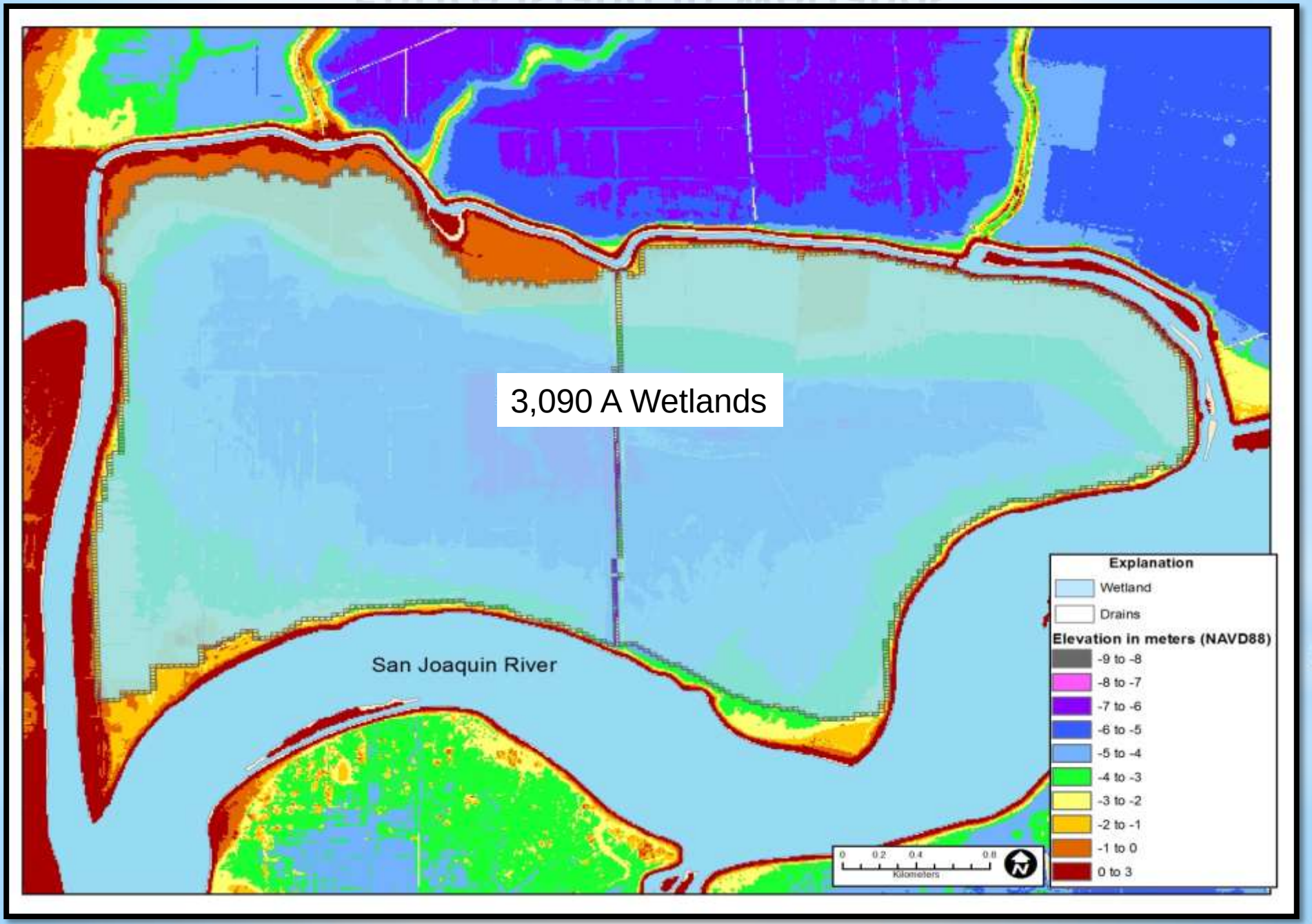
# Wetlands below -3 m & Rice above -3 m



# Rice below - 3m & Wetlands above -3 m

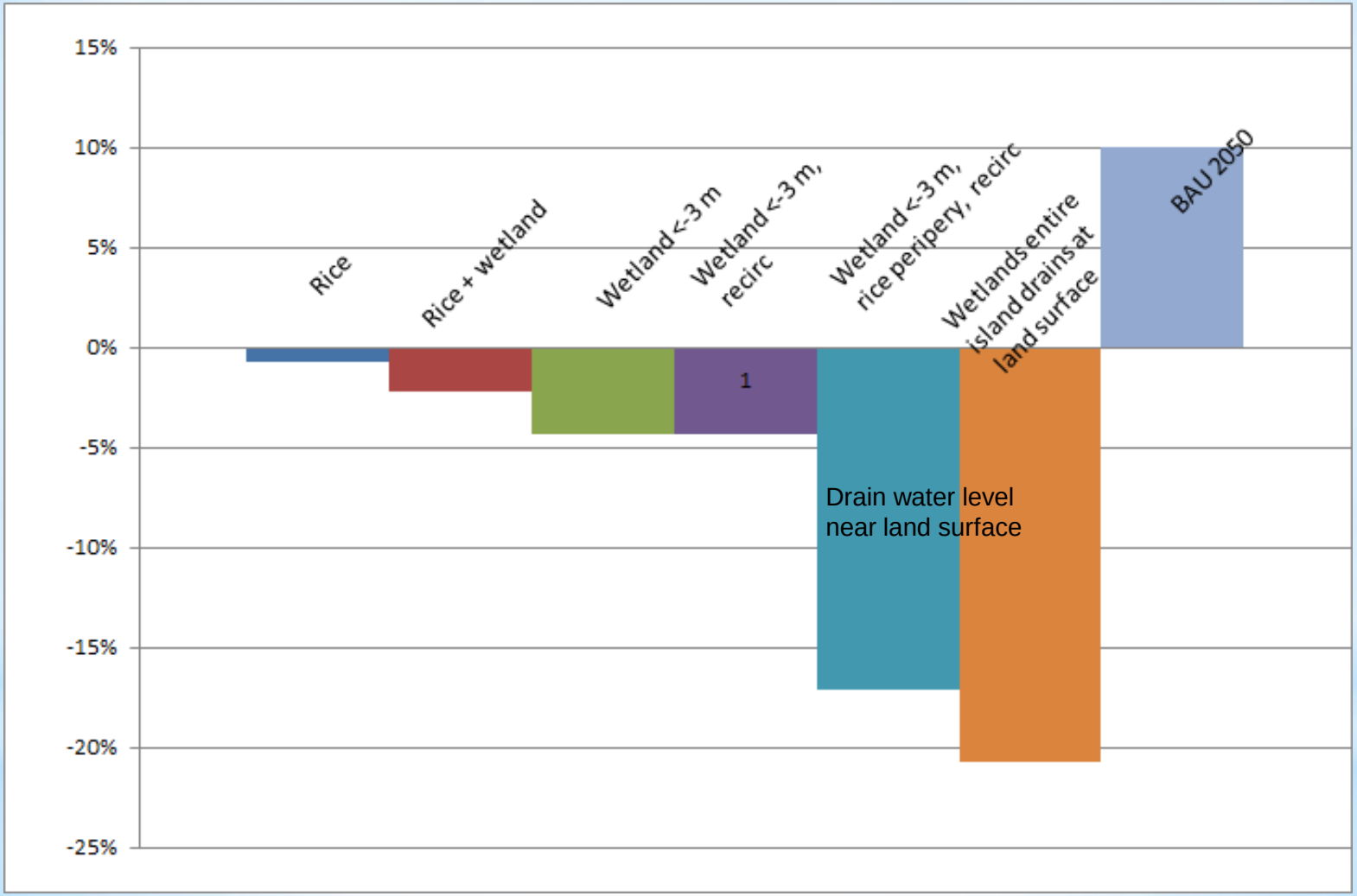


# Entire Island in Wetlands



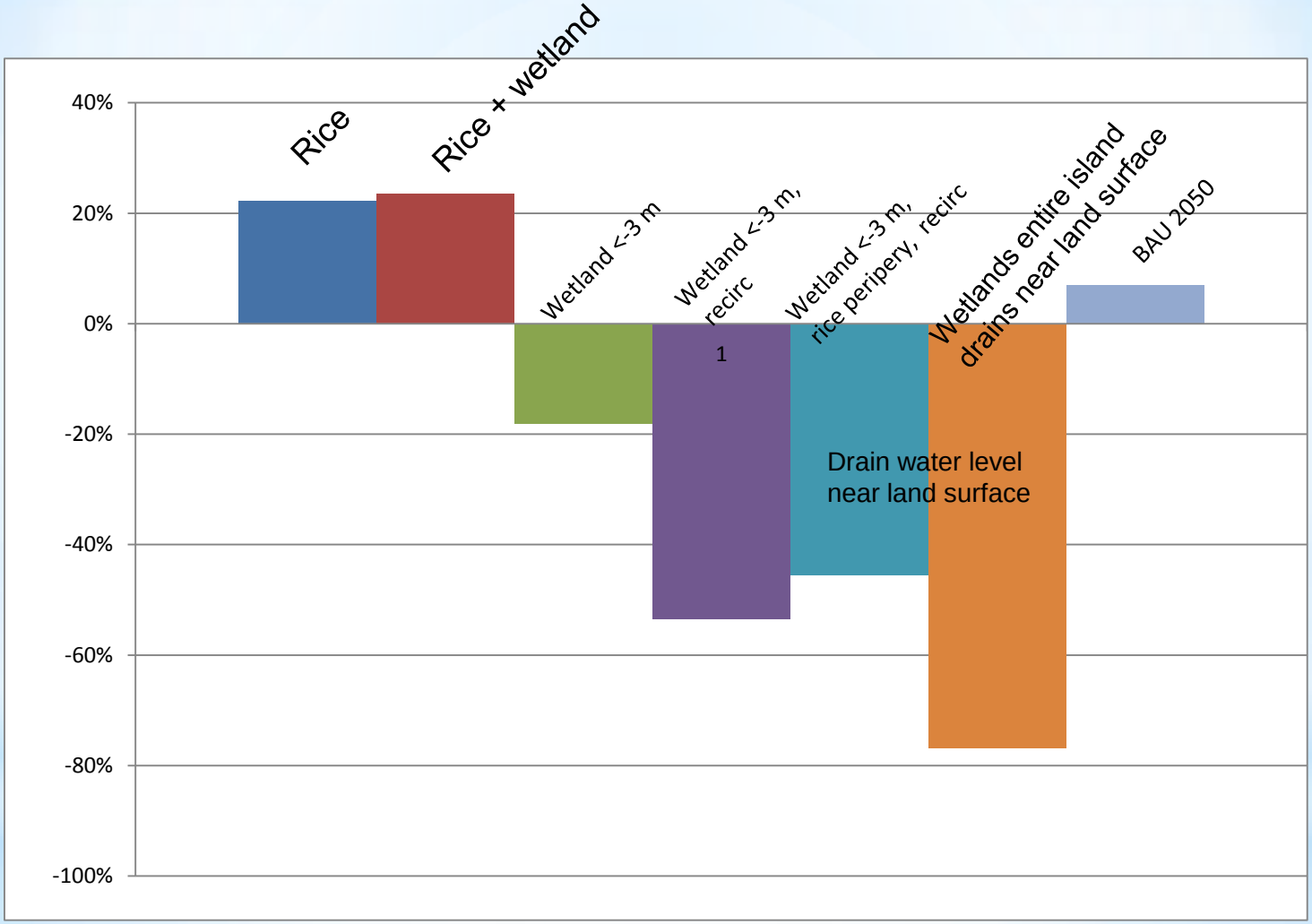
# Results

Percent change in seepage



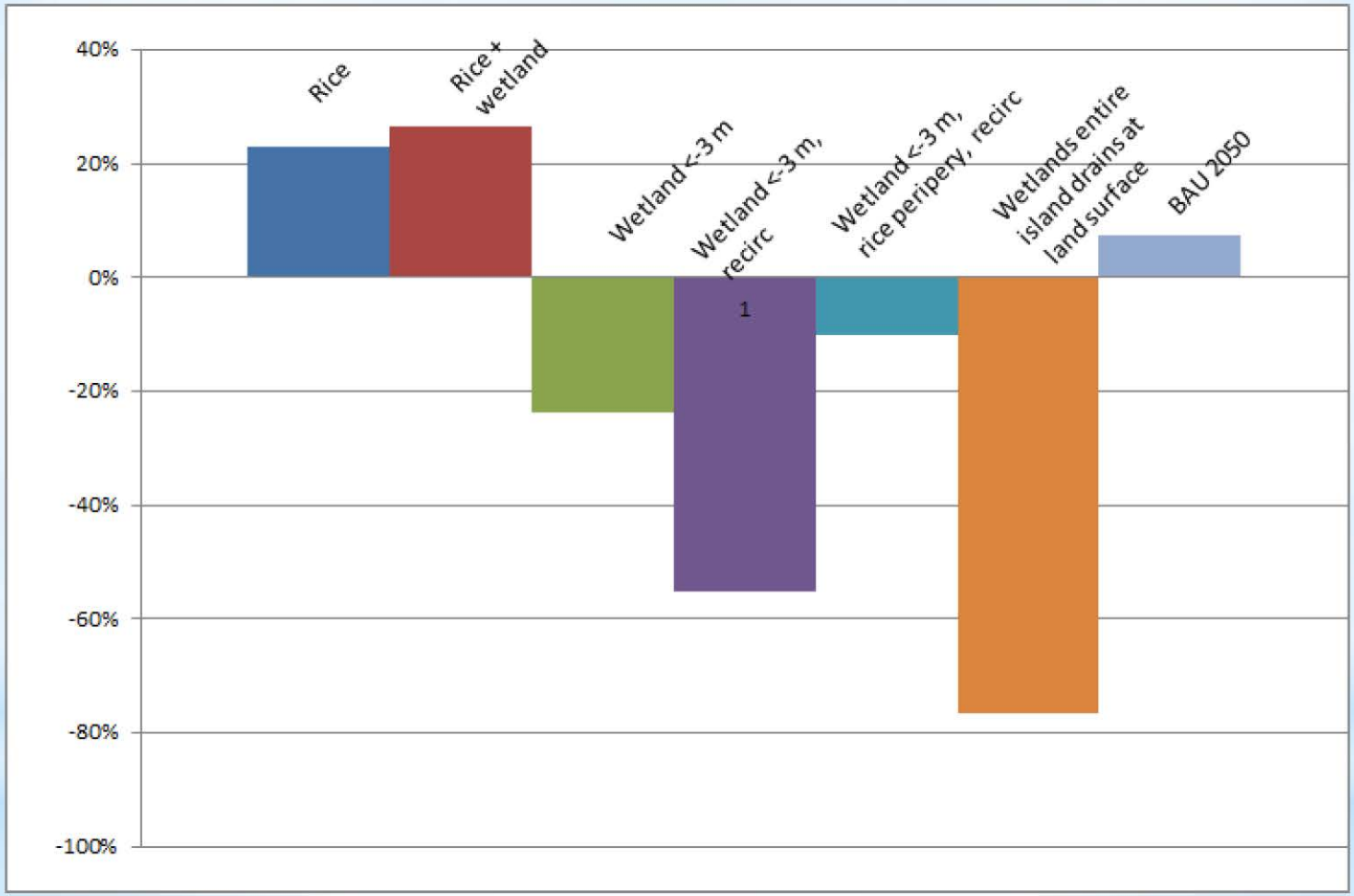
# Results

Percent change in drain flow



# Results

Percent change in DOC load



# Conclusions

* Ongoing subsidence will increase seepage, drain flow and loads
* Little benefit from rice and wetlands unless extended to the edge of the island
* Most benefit for reducing seepage and loads comes from maintaining high water levels in drains