Salinity in the South Platte River Basin

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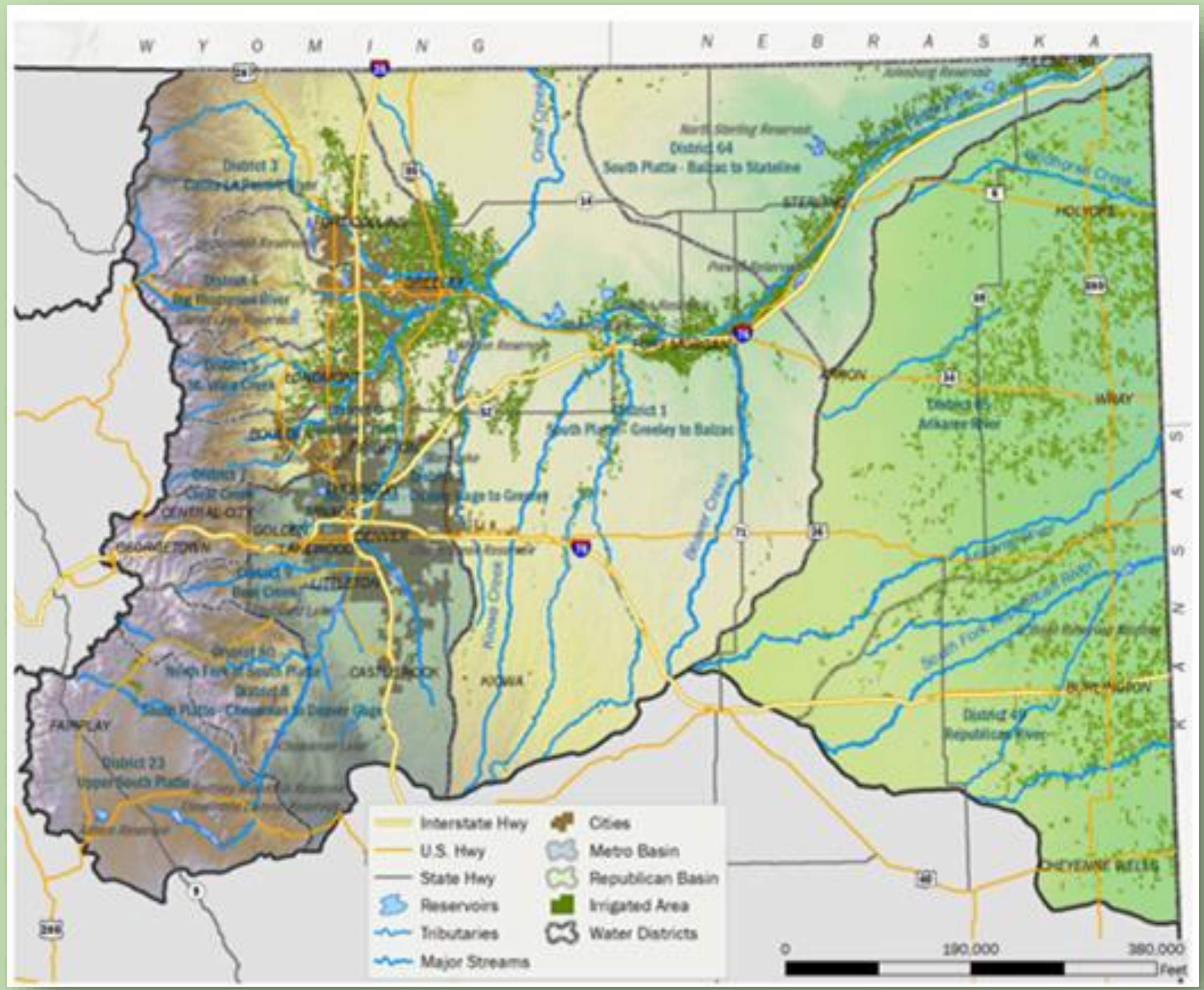
South Platte River Basin

- Irrigation began 1860s
- ~700,000 irrigated acres across > 14,000 fields
- Major crops corn, hay, wheat, vegetables

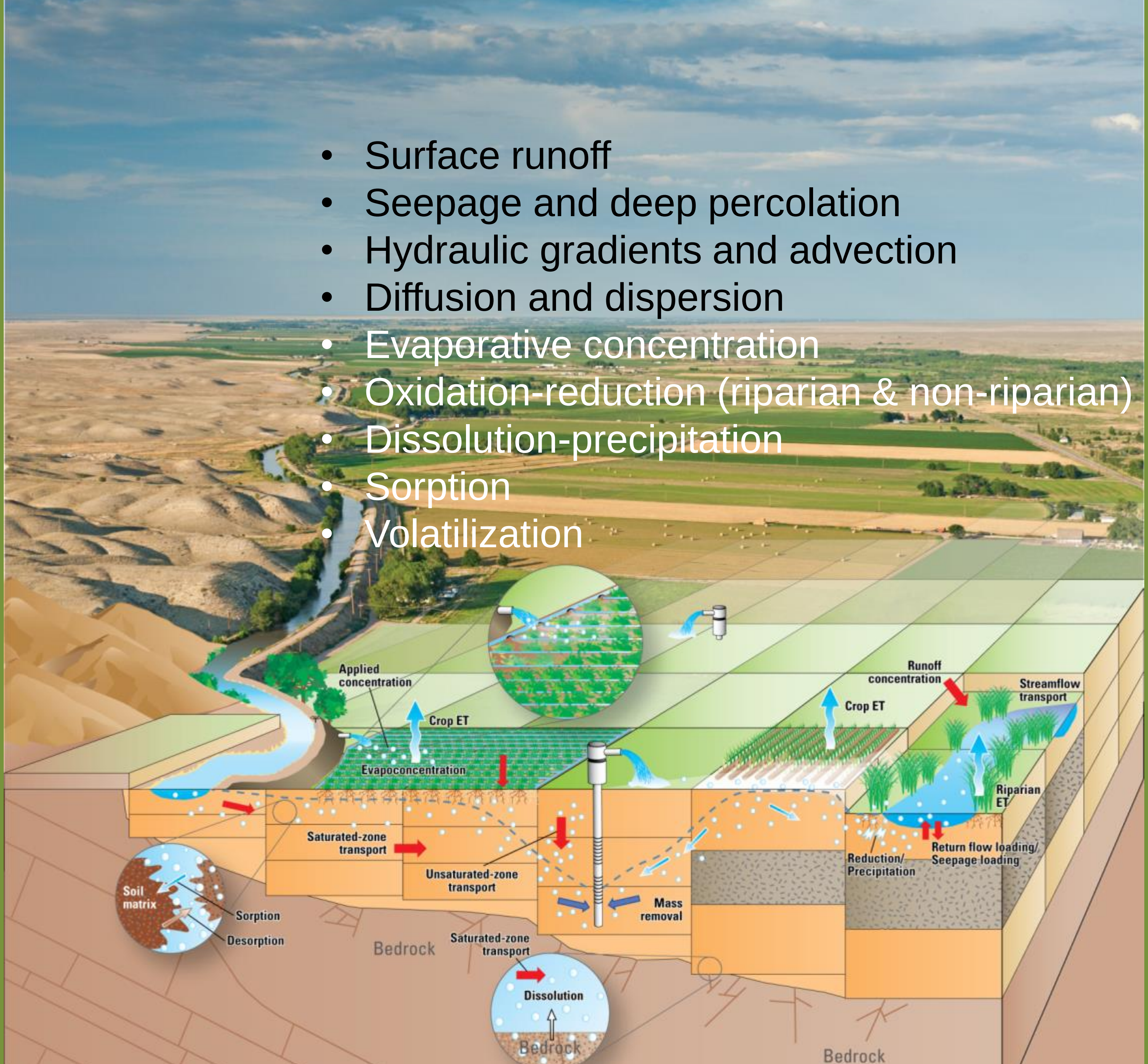






Return Flow and Solute Transport Processes in an Irrigated Stream-Aquifer System

- Surface runoff
- Seepage and deep percolation
- Hydraulic gradients and advection
- Diffusion and dispersion
- Evaporative concentration
- Oxidation-reduction (riparian & non-riparian)
- Dissolution-precipitation
- Sorption
- Volatilization



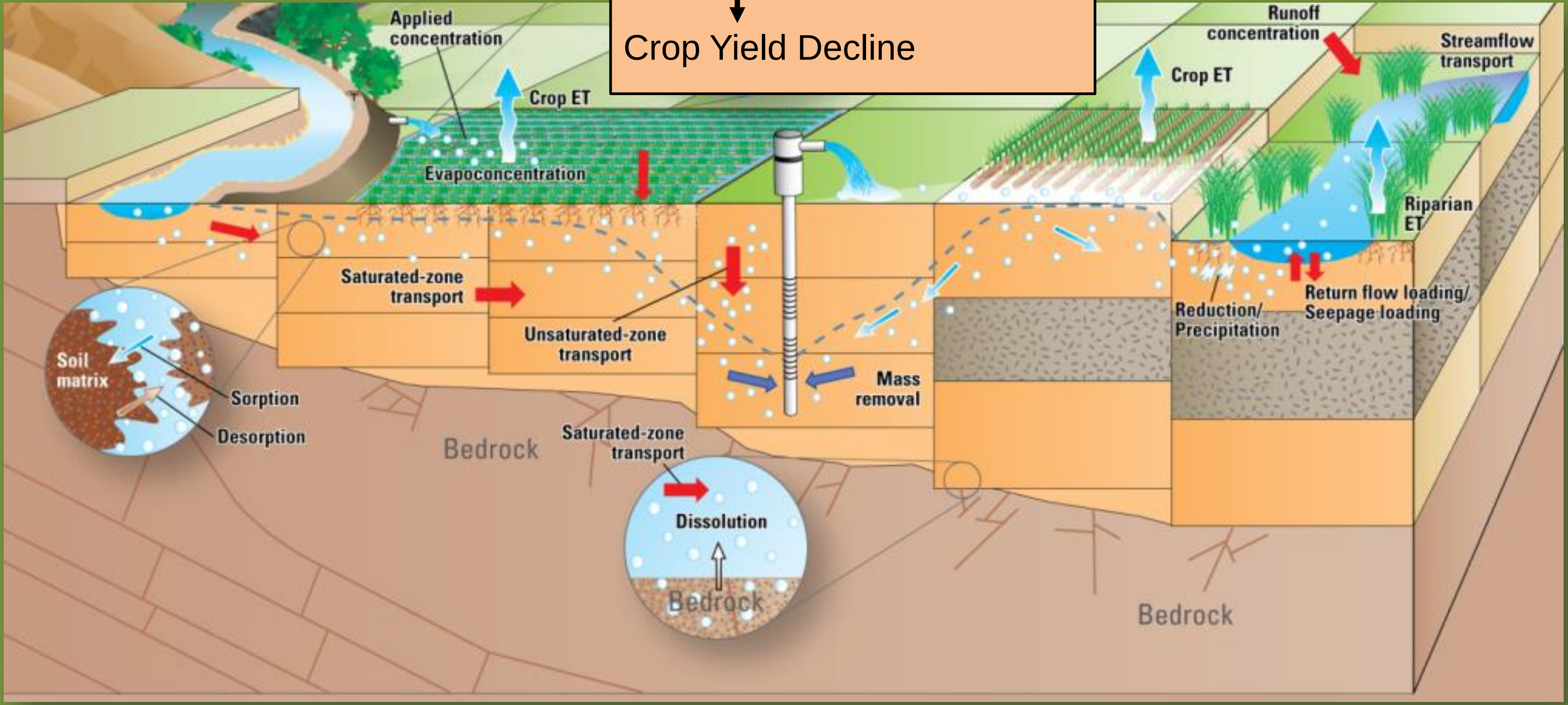
Salt Accumulation

↓

Water and Land Degradation

↓

Crop Yield Decline




Growing Concern about Salinization of
Water and Land Resources in
the South Platte River Basin
Anecdotal Evidence
Intermittent and Limited Data

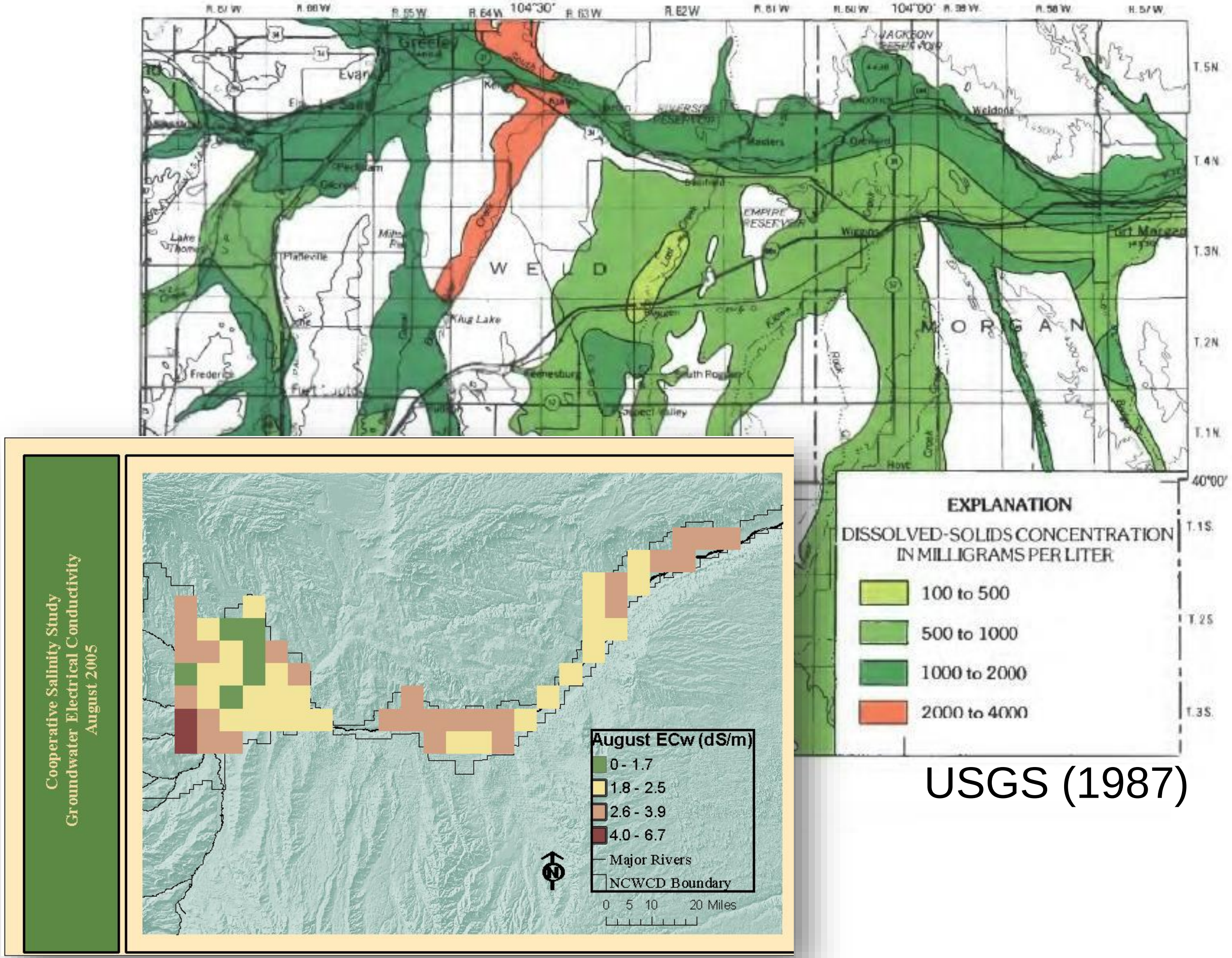
Groundwater Salinity

USGS (1957, 1964, 1987, 1998):

Average TDS ~2000 mg/L

Northern Water (2001 - 2006):

Average TDS ~1600 mg/L

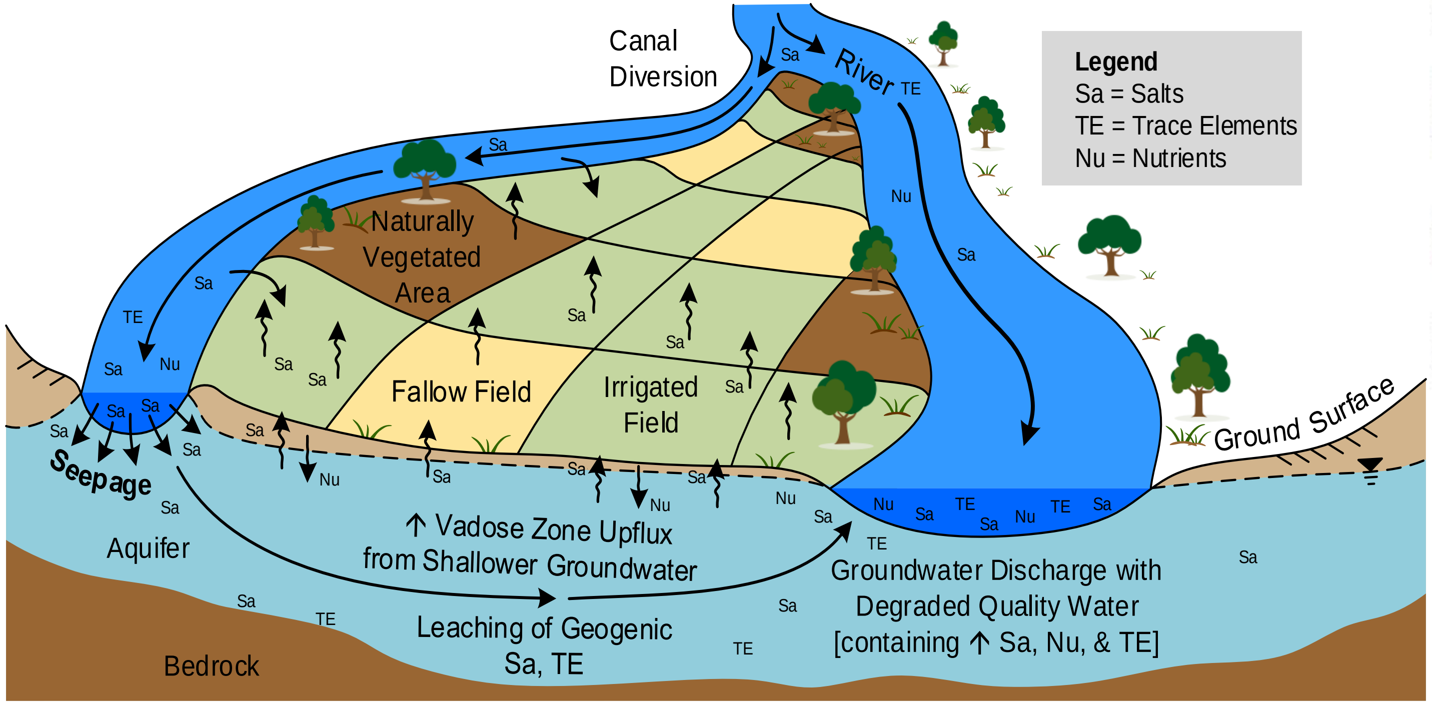


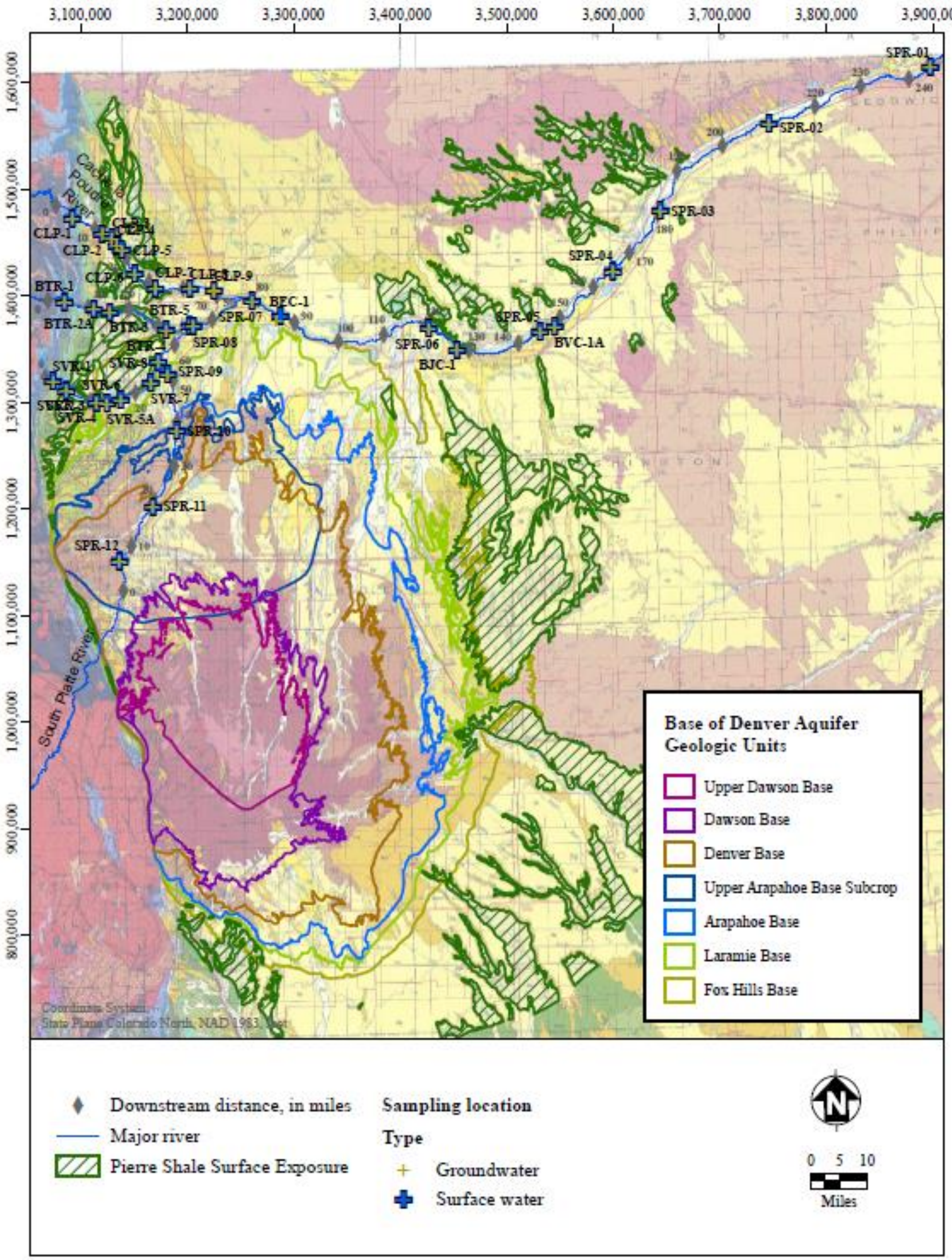
USGS (1987)

Northern Water (2006)

Affected by biogeochemical reactions

- Oxidation-Reduction
- Sorption
- Ion exchange
- Dissolution and precipitation





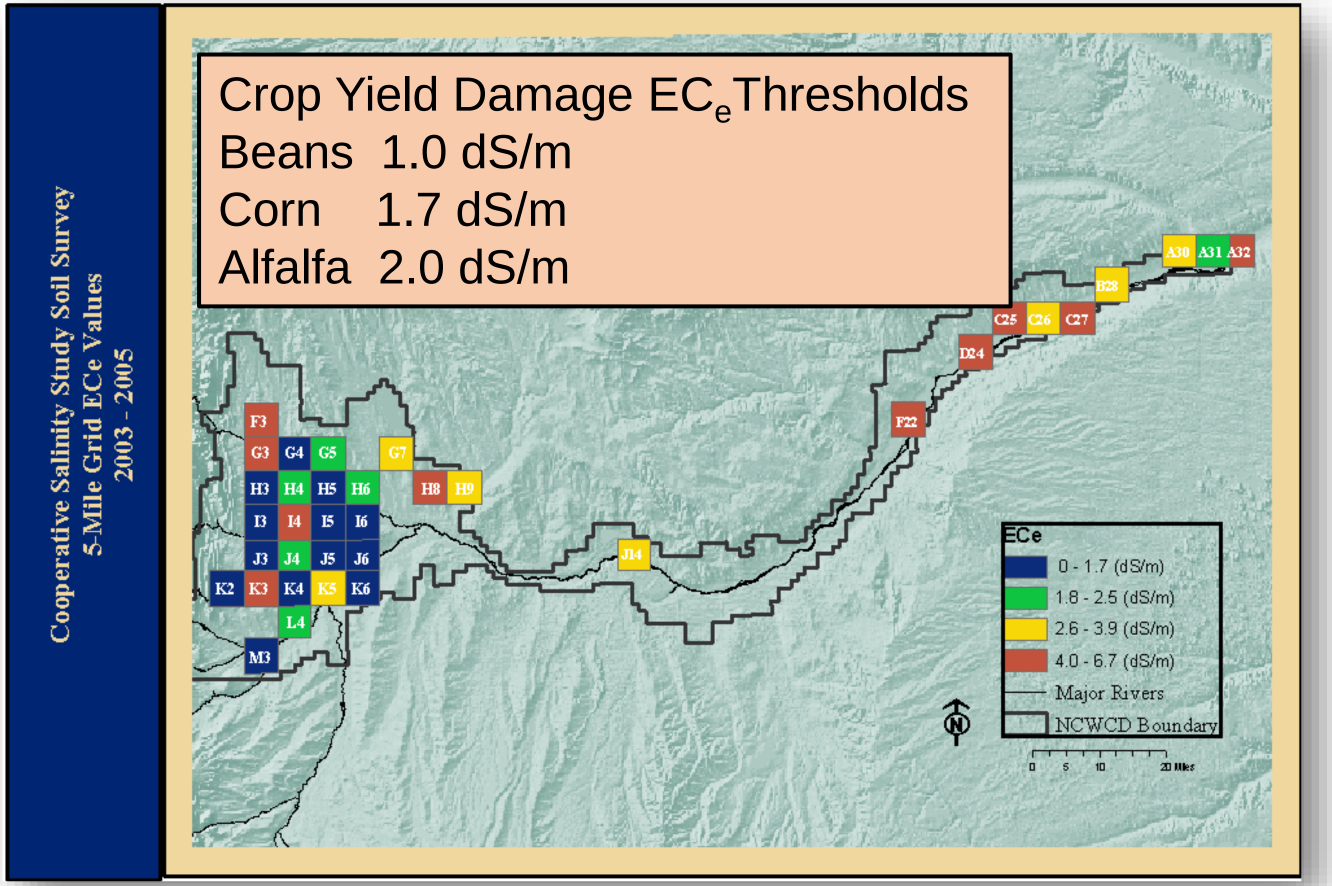
Soil Salinity

Gates (1998):

Average EC_e~2.8 dS/m over 32 sampled fields in Larimer and Weld Counties

Northern Water (2003 - 2005):

EC_e > 1.7 dS/m in 64% of 36 sampled fields
EC_e > 2.5 dS/m in 47% of 36 sampled fields

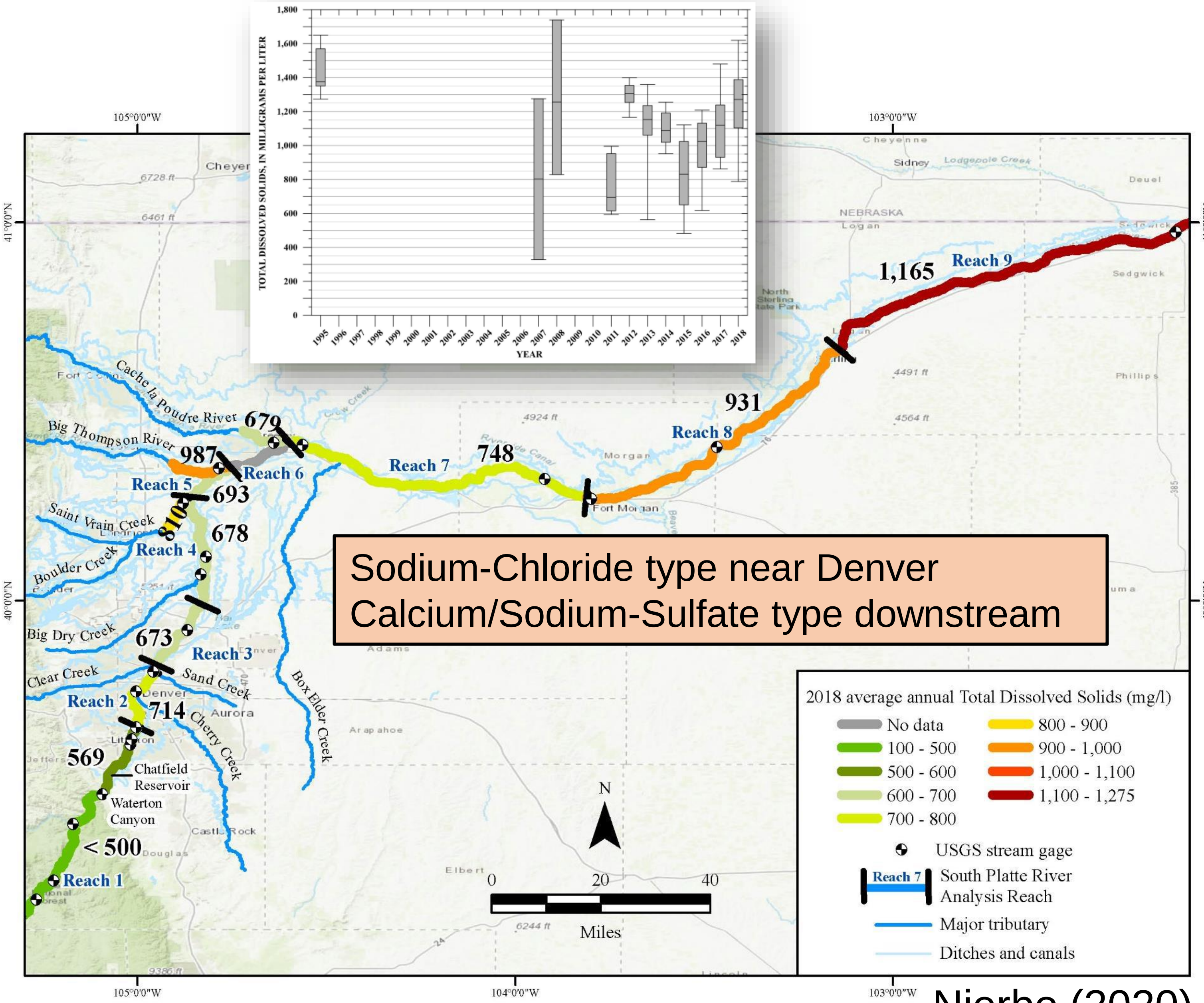


Northern Water (2006)

River Salinity

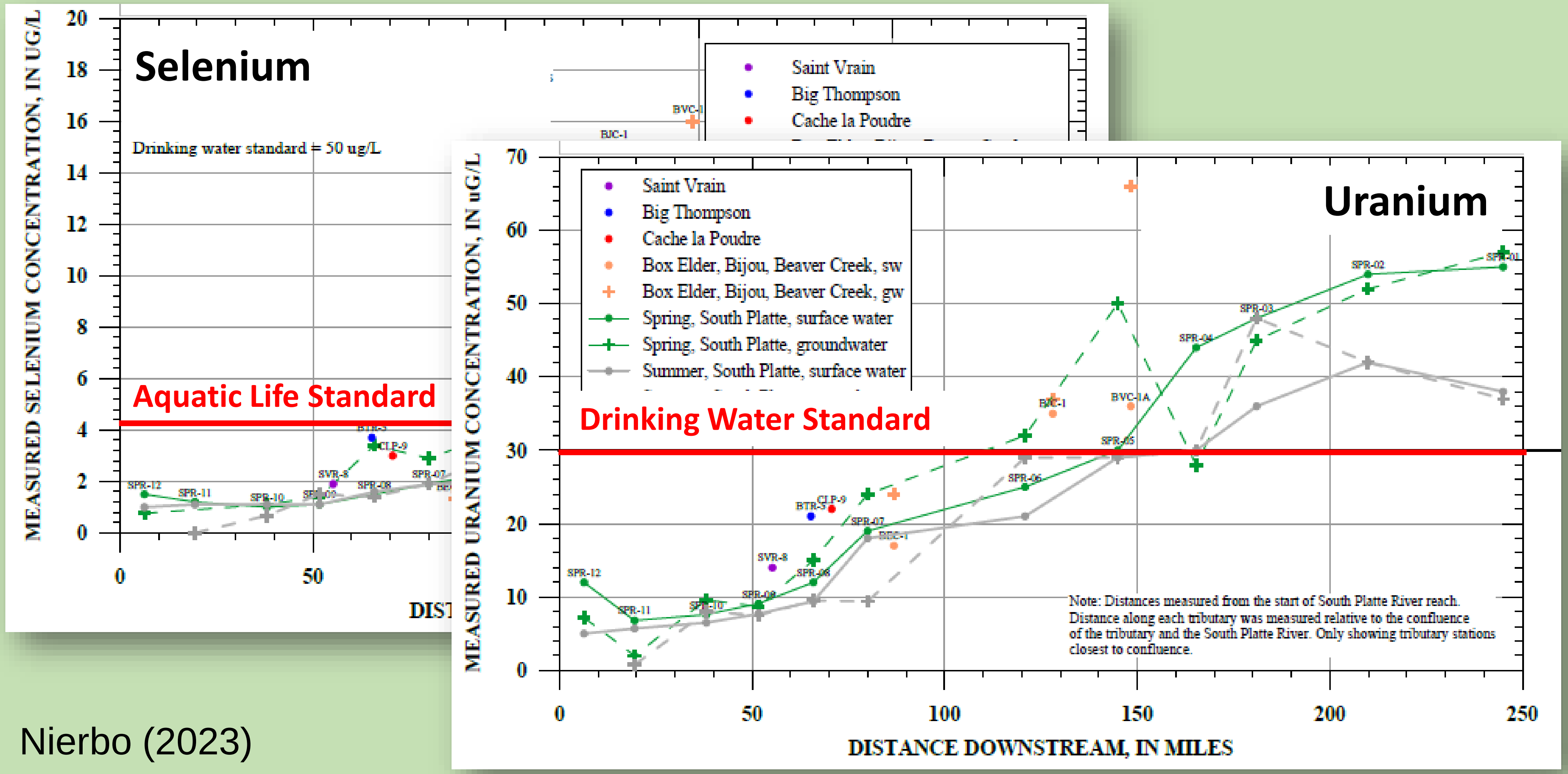
USGS (1998)
Northern Water (2006, 2009)
Neirbo (2020, 2023):

Average TDS ranges From 600 mg/L near Henderson to 1300 mg/L near CO-NE stateline



Nierbo (2020)

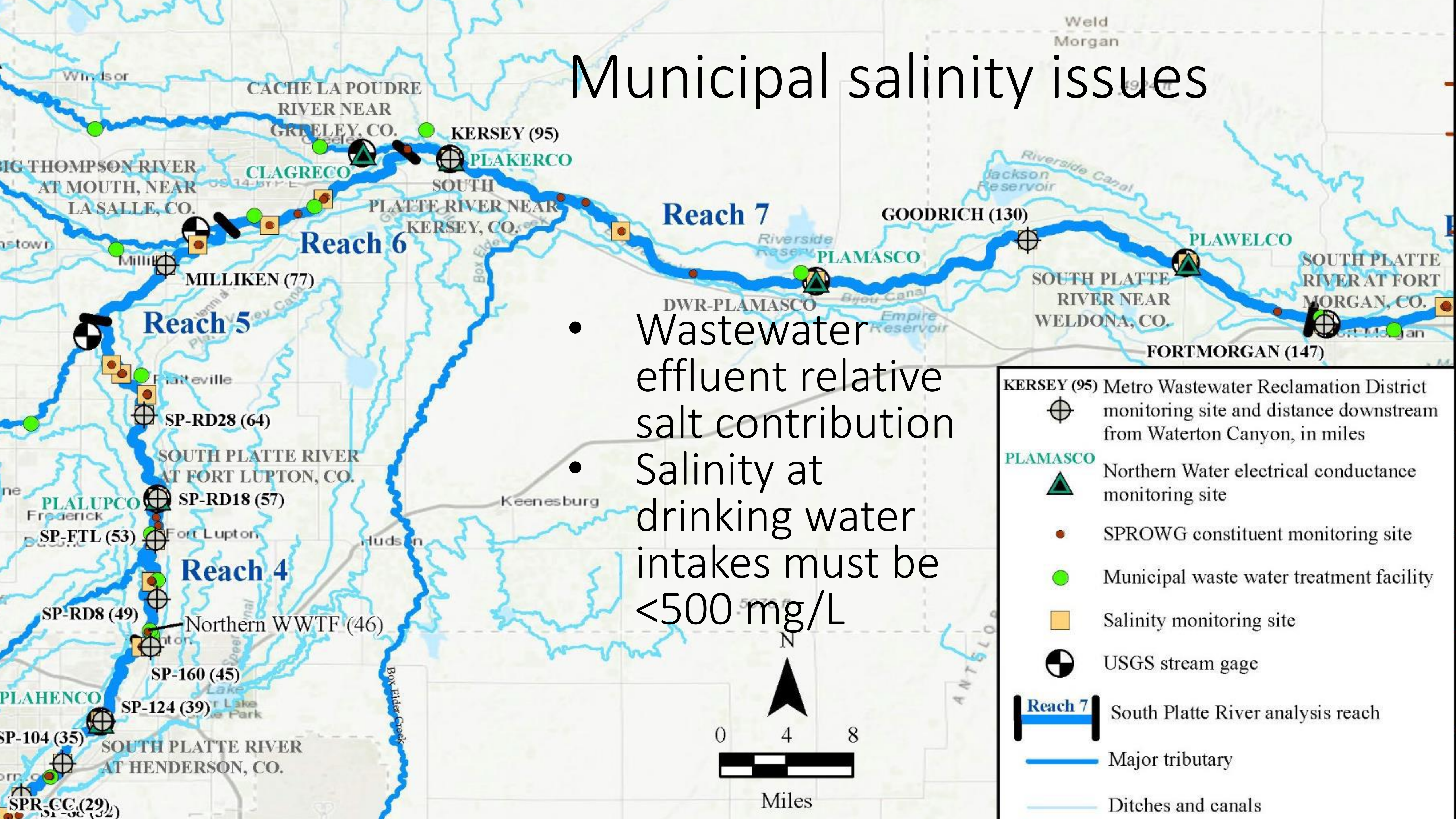
Trace Elements



Nierbo (2023)

Municipal salinity issues

- Wastewater effluent relative salt contribution
- Salinity at drinking water intakes must be <500 mg/L



OVERALL ISSUES OF CONCERN

- spatial and temporal patterns in salinity in streams, groundwater, soils;
- relative contribution to river salt from municipal effluent and pavement runoff point sources compared to agricultural return flow nonpoint sources;
- severity of the salinity impact on farmland soils and productivity;
- effects of expanding sprinkler irrigation and curtailment of well pumping on shallow groundwater and soil salinity;
- long-term impact of recharge ponds for well augmentation on subsurface and surface water salinity;
- influence of salinity on municipal water supply and on water/wastewater treatment;
- implications of dissolved salts/trace elements to aquatic life in the stream network;
- potential of alternative land and water management strategies to lower salinity; and
- economic costs and benefits of salinity management.

Stage 1

Problem Characterization

Phase 1: Data collection for salinity description & assessment

Phase 2: Extended data collection, identification of impacts, sources, controlling factors

Stage 2

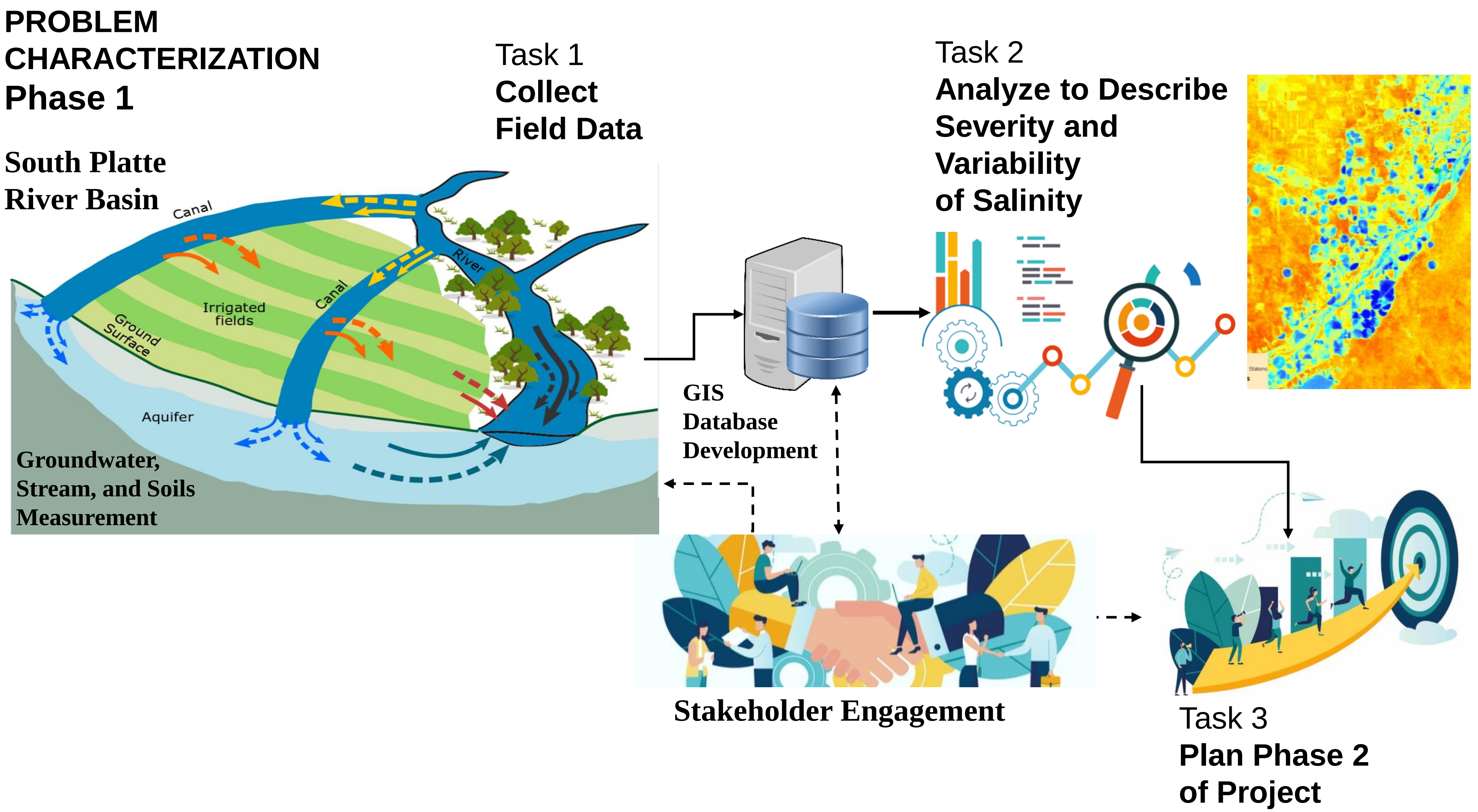
Search for Solutions

Problem Characterization

Phase 1 Research Questions

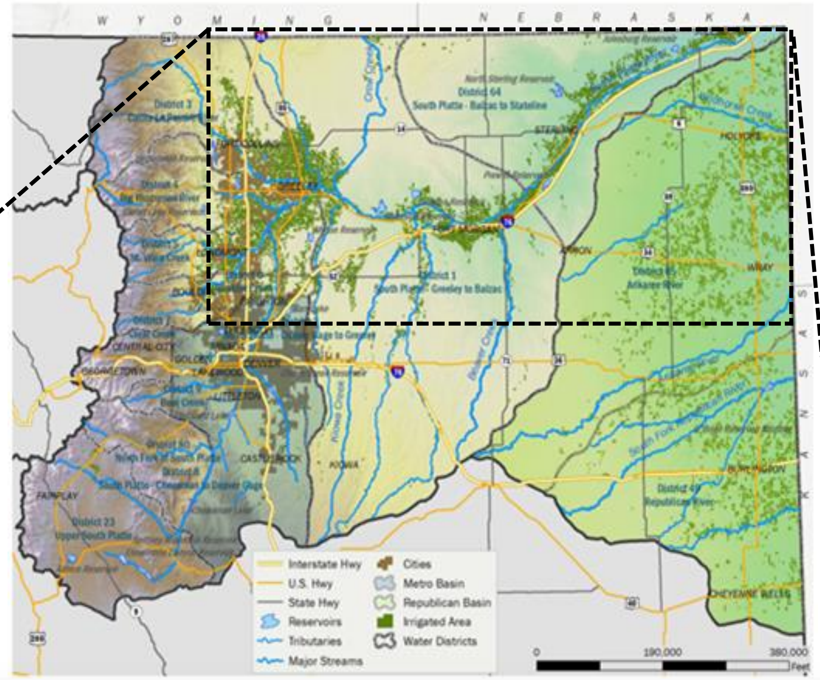
(1) Just how severe and variable is water and land salinity across the SPRB and

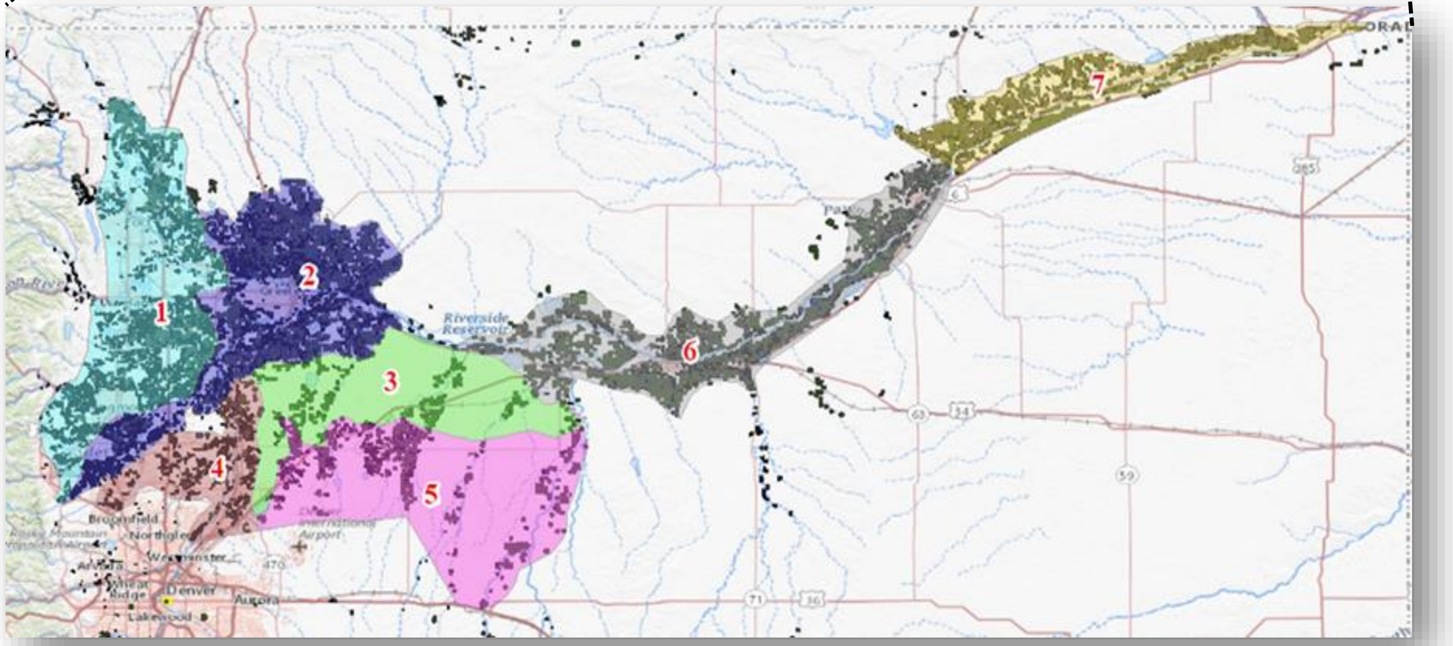
(2) Where and how should further effort be focused to (a) refine understanding and (b) support a search for solutions?


PROBLEM
CHARACTERIZATION
Phase 1
South Platte
River Basin
Canal
River
Canal
Irrigated
fields
Ground
Surface
Aquifer
Groundwater,
Stream, and Soils
Measurement
Task 1
Collect
Field Data
GIS
Database
Development
Task 2
Analyze to Describe
Severity and
Variability
of Salinity
Stakeholder Engagement
Task 3
Plan Phase 2
of Project

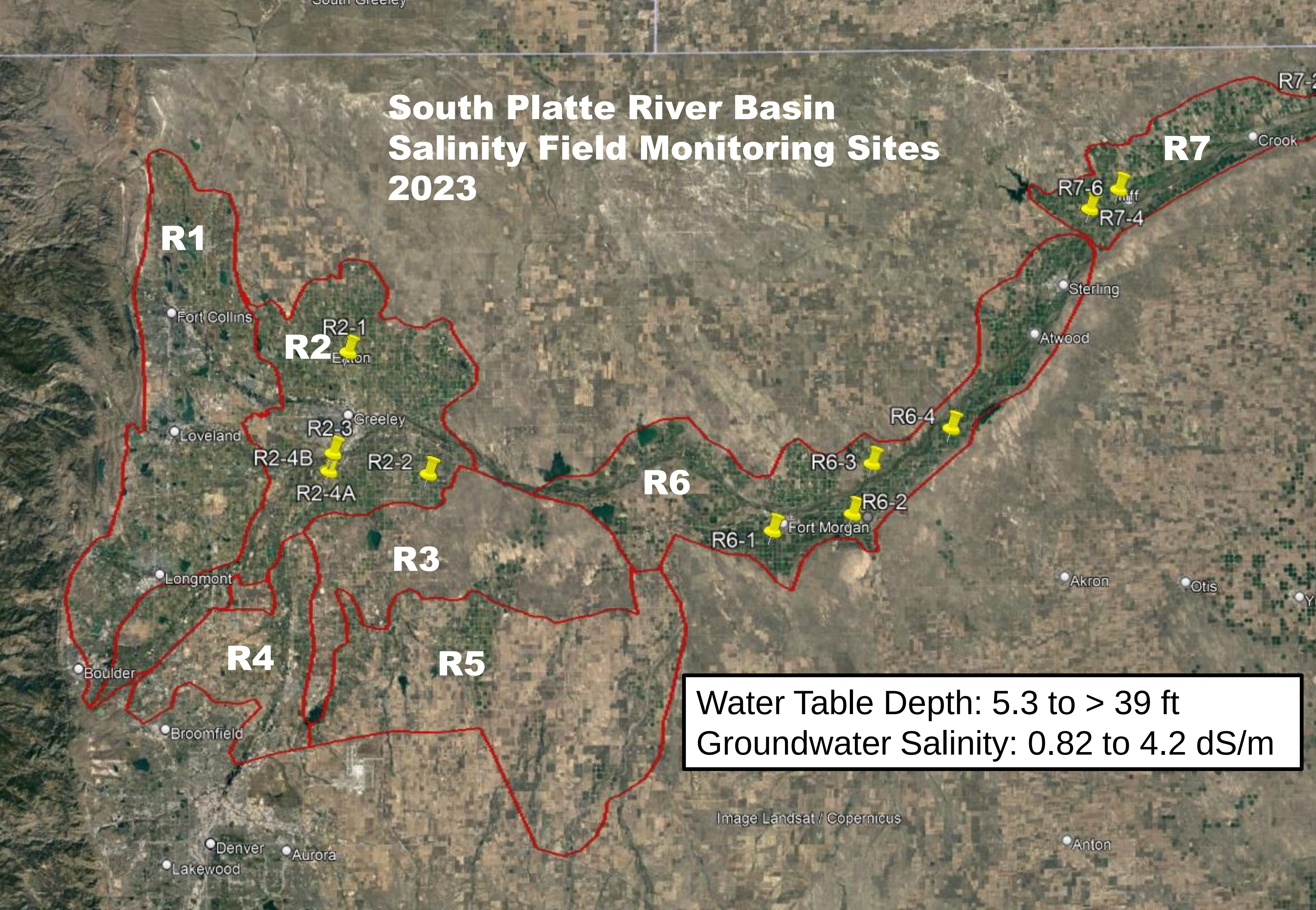
Seven study regions

designated based upon location along stream network, soils, subsurface geology.





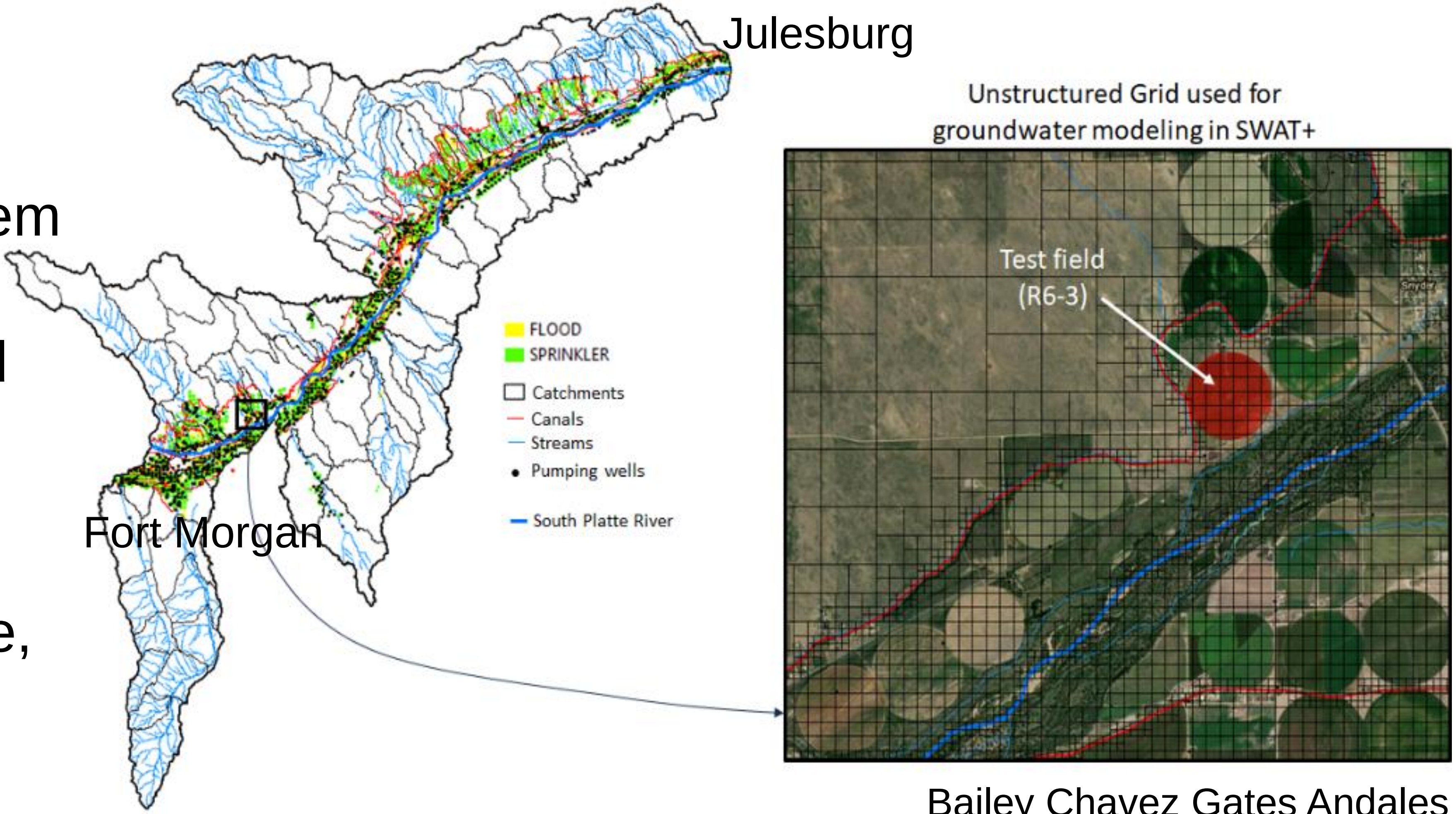
South Platte River Basin
Salinity Field Monitoring Sites
2023



Water Table Depth: 5.3 to > 39 ft
Groundwater Salinity: 0.82 to 4.2 dS/m

Search for Solutions

- Data from problem characterization
- SWAT+ flow and salt transport model
- Study impact of climate, land use, water and land management strategies on salinity



Bailey Chavez Gates Andales
USDA Proposal (2023)

WATER & LAND MANAGEMENT BMPS

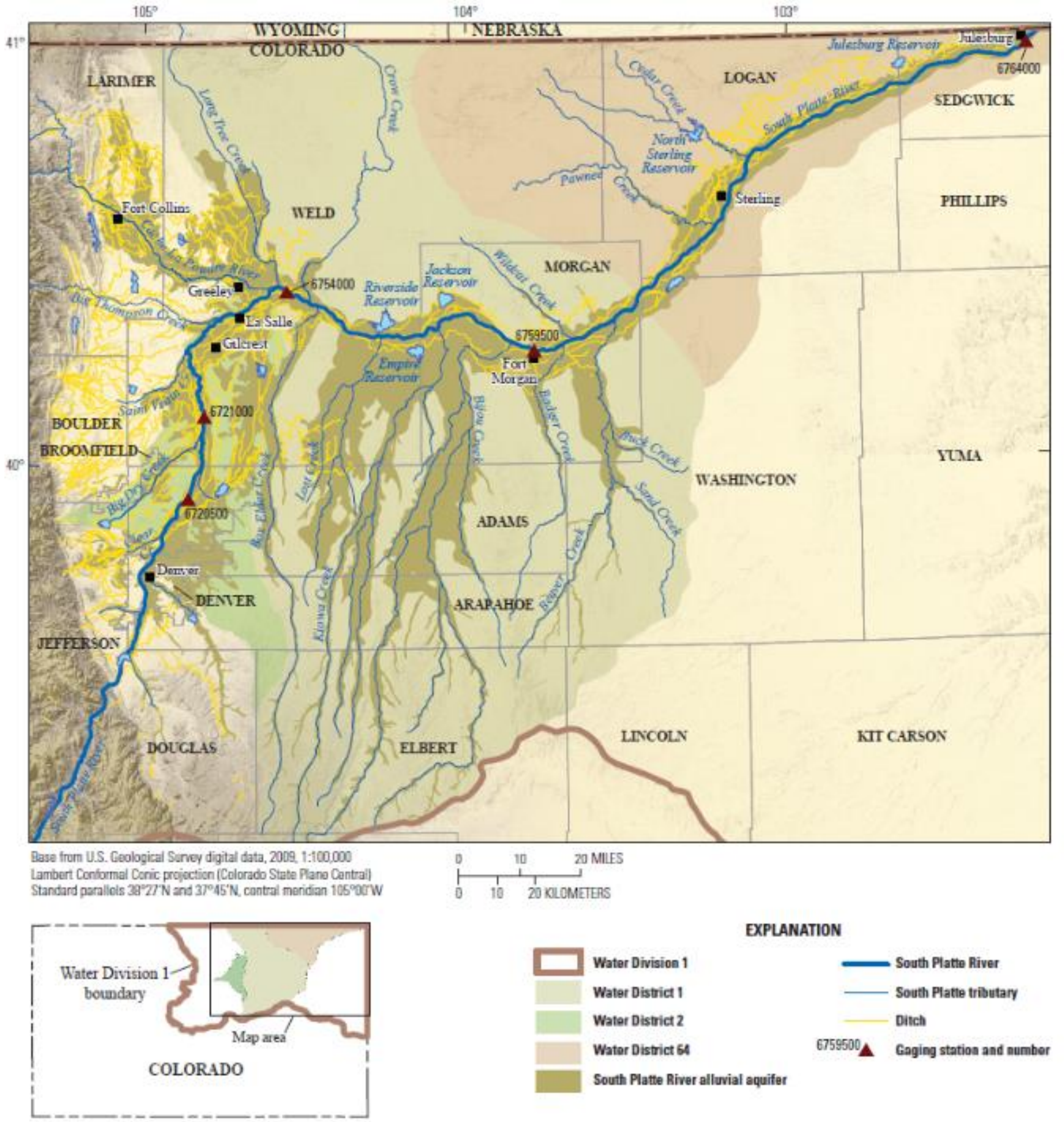
- Reduce excess irrigation applications;
- Control canal seepage;
- Insure adequate leaching under sprinkler irrigation;
- Strategically locate recharge ponds and augmentation wells;
- Lower excess fertilizer and manure applications;
- Enhance treatment of urban effluent discharge; and
- Refine control of urban road salt runoff.

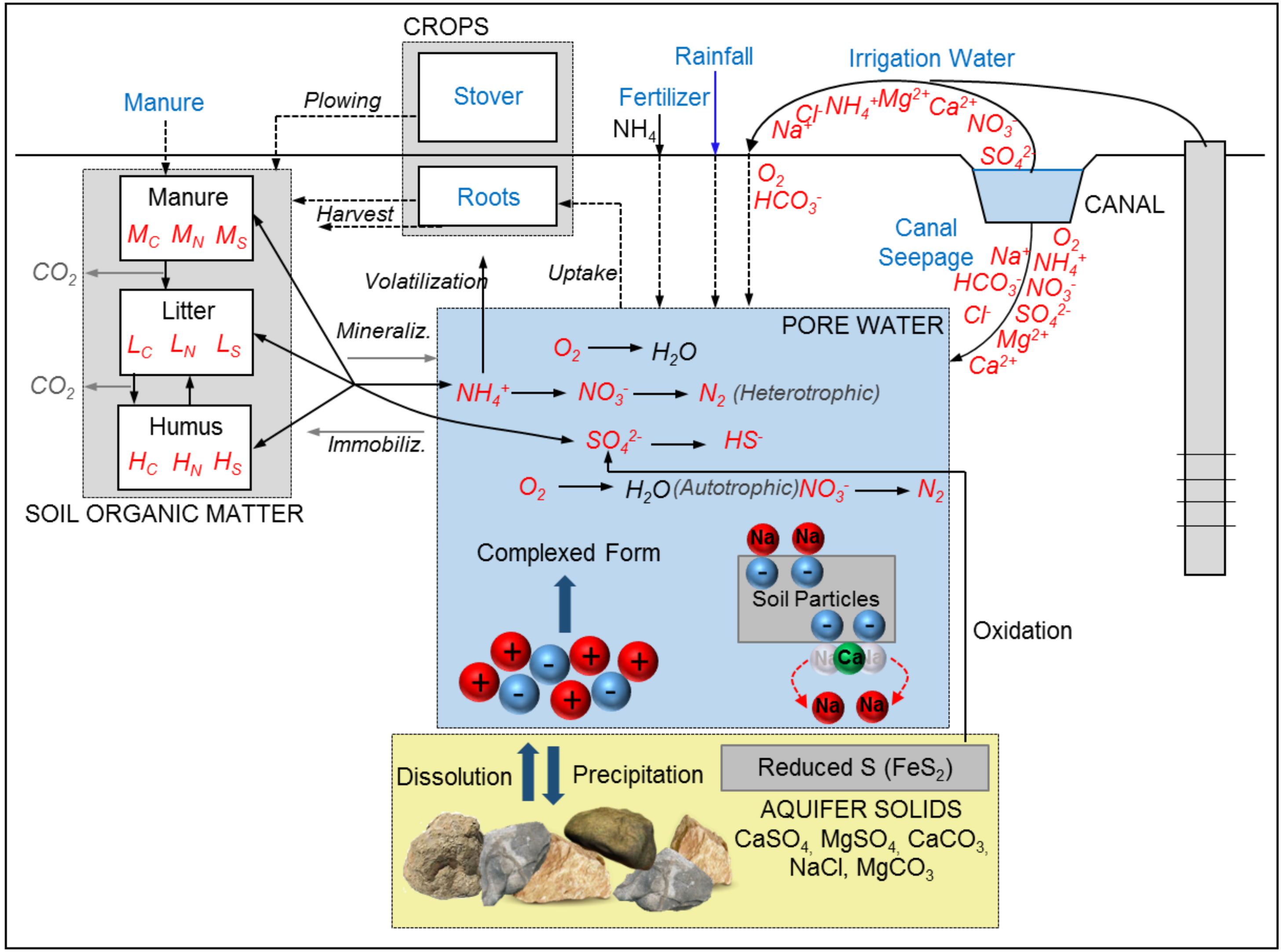
- *CAES, CO Corn, CWCB Current Projects*
- *USDA Proposal Submitted Sep 23*
- *CWCB WPG Proposal Dec 23*


Questions &
Comments

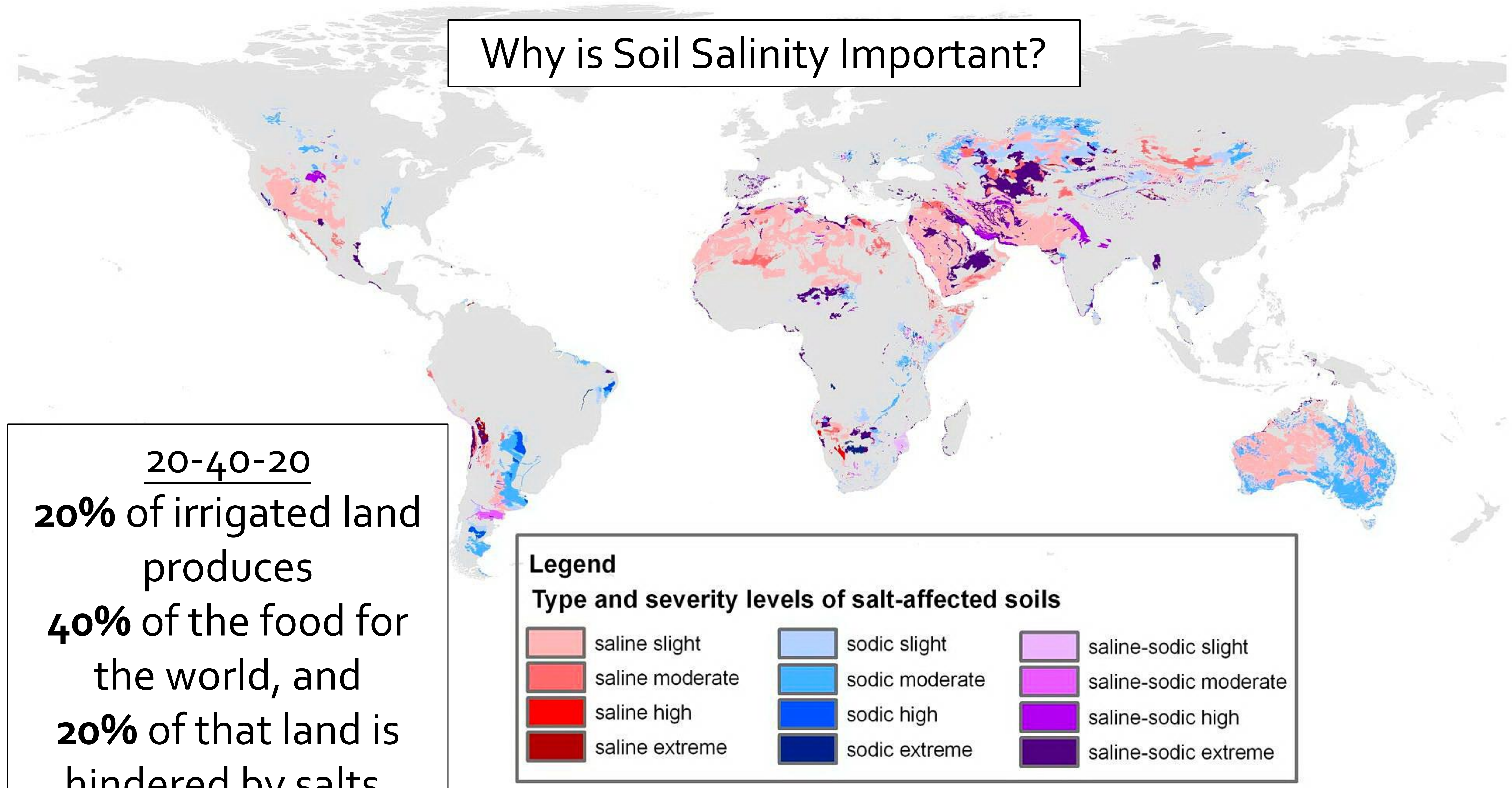
SPRB Alluvial Aquifer

(USGS 2015)




CROPS
Stover
Roots
Manure
Plowing
Harvest
Manure
M_C M_N M_S
Litter
L_C L_N L_S
Humus
H_C H_N H_S
CO_2
CO_2
SOIL ORGANIC MATTER
Volatilization
Uptake
Mineraliz.
Immobiliz.
Rainfall
Fertilizer
NH_4
Irrigation Water
Na^+ Cl^- NH_4^+ Mg^{2+} Ca^{2+} NO_3^- SO_4^{2-}
O_2
HCO_3^-
CANAL
Canal Seepage
Na^+ O_2 NH_4^+ HCO_3^- NO_3^- Cl^- SO_4^{2-} Mg^{2+} Ca^{2+}
PORE WATER
O_2 → H_2O
NH_4^+ → NO_3^- → N_2 (Heterotrophic)
SO_4^{2-} → HS^-
O_2 → H_2O (Autotrophic) NO_3^- → N_2
Complexed Form
Soil Particles
Na
Ca
Oxidation
Dissolution
Precipitation
Reduced S (FeS_2)
AQUIFER SOLIDS
$CaSO_4$, $MgSO_4$, $CaCO_3$, NaCl, $MgCO_3$

Why is Soil Salinity Important?



<u>20-40-20</u>

20% of irrigated land produces **40%** of the food for the world, and **20%** of that land is hindered by salts.

Data from Harmonized World Soil Database v 1.2