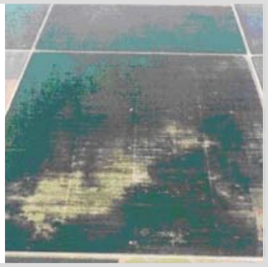
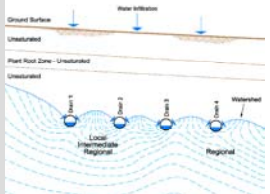
Integrated on Farm Drainage Management (IFDM)

Agencies:
Westside Resources Conservation District
Department of Water Resources
USDA-Natural Resource Conservation Service
University of California, Davis
California State University, Fresno

IFDM

- Provides an alternative to Land Retirement.
- Removes salts from crop root zones.
- Provides for the productivity of high yield commercial crops in a sustainable way.



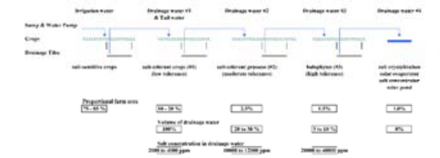


Subsurface Drainage System

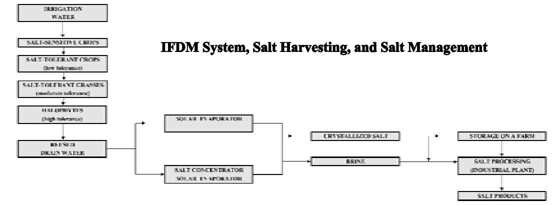
Provides control of the water table and improves salt leaching.

Sequential Water Reuse

Drainage water reuse is the process of reusing subsurface drainage water to irrigate crops on progressively more salt-tolerant plants.



IFDM System, Salt Harvesting, and Salt Management



Salt Sensitive Crops

Irrigation water is used for the production of salt sensitive, high value crops. Lettuce is one of the of the high-value salt sensitive crops grown, which provide maximum economic return. Other crops in rotation include a variety of vegetables (tomatoes, broccoli, onions, garlic, string beans), cotton, and wheat.

(Photo source: G. Huff)

Salt Tolerant Crops

Salt tolerant grasses, irrigated with about 12 g/L TDS drainage water, function as a salt concentrator. They can be used as forage or industrial/energy biomass.

Halophytes

Halophytes survive in highly saline soils.

(Photo description and source: Iodine bush; AndrewsAg)

Trees

Role of trees as a component of the IFDM system:

- Intercept regional subsurface flows to lower water tables.
- Tree plantations for the reuse of low salinity drainage water, 5-10 dS/m. Most promising trees for IFDM system include: Athel (Tamarask aphylla), Eucalyptus, Pistachio, and Casuarina.

Solar Evaporator

The final volume of drainage water is discharged into the solar evaporator. Salts are stored to be later harvested for beneficial uses.

Drainage water is distributed by sprinklers, in correlation with daily evaporation rates, to avoid standing water.

(Photo description and source: Timed sprinklers water distribution system; AndrewsAg)

Stored Salts

Evaporite salts accumulated in the solar evaporator, stored for future beneficial use.

Salt Recovery Process

Solar Evaporator Pilot Project, DWR (top photo):
DWR tested nozzles, characterized by different spray patterns, angles, and pressures, using various evaporative surfaces to collect data on evaporation rates to concentrate subsurface drainage water effluent collected from an IFDM system. From the evaluation of the test data, a pilot solar evaporator was designed and constructed to collect data during seasonal conditions for evaporation rates, weather, wind, and salt drift. This design features a sloped surface, gravel aggregate surface material, catchment basin, water collection system, and two 5-hp pumps. The water is recycled to evaporate drainage water and to recover salts. The data obtained from the pilot solar evaporator will be used to design and construct a solar evaporator for the 640-acre IFDM system at Red Rock Ranch, including future IFDM systems in the San Joaquin Valley.

Salt Recovery Pilot Plant, UC Davis (bottom photo):
The pilot plant processes saline water in batches, by concentrating brine until a desired salt concentration is met for a minimum system volume. This highly concentrated brine is then crystallized, and crystal salts and residuals are harvested from the pilot plant.

Solar Pond

Potential Applications

- Commercial salt production
- Process heat for greenhouse heating, crop drying, boiler feedwater
- Desalination of drainage water
- Electricity production
- Absorption refrigeration

(Photo source: Huanmin Lu, John Walton, The University of Texas at El Paso)

Forages	ECe (dS/m)	ME (MJ/kg DM)	Se (mg/kg)	S (%)
Tall wheat grass	19.1	9.3	6.12	0.4
Tall wheat grass	17.6	9.2	7.38	0.4
Creeping wildrye	13.3	8.2	2.98	0.2
Creeping wildrye	12.9	7.9	10.72	0.4
Puccinellia	15.0	9.6	4.37	0.3
Tall fescue	12.1	9.3	7.41	0.6
Alkali sacaton	12.4	6.7	6.88	0.6
Alfalfa DW	6.9	9.6	1.45	0.4
Alfalfa FW	4.7	9.9	0.80	0.3
Desirable / MTC		> 7	< 2	< 0.4

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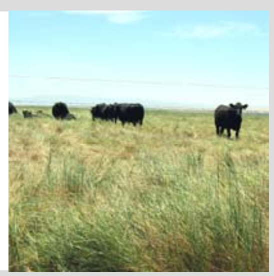
Forages Growing in Saline Drainage Water Reuse Systems

- Very high degree of salt tolerance demonstrated by tall wheatgrass growing in much more saline fields, ECe 17.6 and 19.1 dS/m.
- Metabolized Energy, ME, was 7-10 MJ kg^{-1} for most forages (except alkali sacaton) which is acceptable quality for most ruminants.
- Selenium, Se, contents of the drainage water irrigated forages reached 10.72 mg/kg DM for creeping wild rye (10.72 mg/kg is well above the maximum tolerable concentration). This is due to high Se concentration in the drainage water at Red Rock Ranch.

Using Forages and Livestock to Manage Drainage Water

Livestock grazing on salt tolerant grasses irrigated with agricultural drainage water.



Oil Crops and Biodiesel

- Biodiesel fuels made from saline crops such as canola, mustard seed, and sunflowers are high in oil content. Canola shows promise both as a selenium accumulator and as a biodiesel crop.
- Biodeisel as an alternative fuel for everyday transportation or can be used on-farm; pickup trucks or biodiesel pumps.

(Photo descriptions: **Top** - Canola field. **Bottom** - Oilseed crusher and oil meal (white bin), Canola grown at Red Rock Ranch.)

Characterization and Utilization of Saline Biomass

Particle boards were made from saline wood:

- Jose Tall Wheatgrass
- Athel
- Eucalyptus

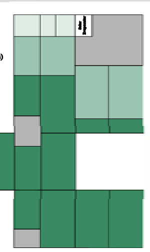
(Researchers: Yi Zheng, Zhongli Pan, Ruihong Zhang, Bryan Jenkins, Sherry Blunk (USDA ARS WRRC, UC Davis)

AndrewsAg IFDM Design - Kern County

- For a 15-year period, 1100-acres of irrigated land were drained using a 100-acre evaporation basin as the terminus for drainage water.
- For regulatory and economic reasons landowner opted to close evaporation basin. An IFDM system was implemented which includes a solar evaporator component to evaporate drainage water and collect salts.

Project Design:

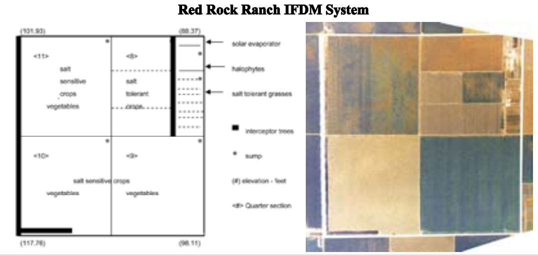
- Stage 1 - 750 ac: Fresh water-irrigated (bell peppers, cotton, others)
- Stage 2 - 225 ac: Drainage + fresh water (cotton)
- Stage 3 - 40 ac: (Salt tolerant forages)



Water Management and Monitoring

- Salt sensitive crops
  Irrigation water
- Salt tolerant crops
  Blended drainage water + tail water + irrigation water
- Halophytes
  Drainage water
- Solar evaporator
  Drainage water (increased concentration)

Red Rock Ranch IFDM System



JJ Farms - West of Mendota

Eucalyptus trees were planted to intercept regional subsurface flows to lower water tables.

Future Improvements being considered at JJ Farms:

- Implement a water use efficiency plan to decrease volume of drainage water.
- Plant additional salt-tolerant tree plantations to intercept regional flows; select different species for diversification.
- Implement an IFDM system, with a solar evaporator.

Water Use Efficiency

- Irrigation efficiency--the key to any drainage management program is improved irrigation efficiency. This reduces potential drainage water volumes and salt loads.
- Drainage water sequential reuse--the process of reusing subsurface drainage water to irrigate crops on progressively more salt tolerant plants.

(Photo descriptions: **Top** - Subsurface drainage water is collected in a cistern to store for reuse. **Bottom** - A flowmeter is an instrument used for measuring the rate of flow.)

Water Quality and Monitoring

Importance of monitoring: Integrated on-farm drainage management systems are to be designed and operated to prevent threats to water quality, fish and wildlife, and public health.

Typical water quality parameters may include the following constituents to be measured:

1) Trace Elements
a. Selenium c. Arsenic
b. Boron d. Molybdenum

2) Standard Minerals
a. Calcium d. Potassium
b. Magnesium e. Alkalinity
c. Sodium f. Sulfate

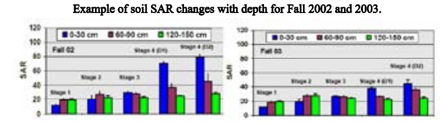
(Photo description: Conductivity meter and probe)

Characterization of Soils Irrigated with Saline-Sodic Drainage Water: Chemical Composition

Characterization of these chemical properties is essential for agronomic management and an understanding of flow/& solute transport:

- Soil salinity
- SAR
- Boron

Example of soil SAR changes with depth for Fall 2002 and 2003.



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Economic Benifits

- Increased land value.
- Higher crop yields.
- Ability to grow high value crops.

Item	Initial Cost ($/acre)	Annual Cost ($/acre)
The Subsurface Drainage System		
Estimated installation cost	400.00	
Amortized installation cost		35.58
Operations & Maintenance		5.00
Sum of estimated annual costs for the drainage system		40.58
The Solar Evaporator on Open Land		
Estimated installation cost	1,000.00	
Amortized installation cost		137.48
Operations & Maintenance		120.00
Taxes and assessments		25.00
Rental or opportunity cost		150.00
Sum of estimated annual costs for the evaporator		432.48
Land Use for Salt-Tolerant Crops and Forages		
Taxes and assessments		25.00
Rental or opportunity cost		150.00
Annual production costs		339.00
Sum of estimated annual costs for salt-tolerant crops		514.00
Land Used for Halophytes		
Taxes and assessments		25.00
Rental or opportunity cost		150.00
Annual production costs		200.00
Sum of estimated annual costs for halophytes		375.00