Groundwater and Soil Salinity Monitoring Network

CRTR Meeting

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Lower Colorado River Multi-Species Conservation Program

Project Overview

- Response to open call for proposals:
  - Lower Colorado River Multi-Species Conservation Program: Financial Assistance Program for Fiscal Year 2010
    - Announcement No. 09 SF300006
  - Research projects to assist in long-term success of LCR MSCP.

Salinity Concerns

- MSCP riparian trees are salt-intolerant.
- Elevated irrigation (Colorado River) water salinity due to evapo-concentration.
- Elevated soil and groundwater salinity due to river regulation, agricultural practices, and shallow groundwater.

- State of knowledge at MSCP restoration areas:
  - Soil salinity monitored, and sometimes higher than published salinity tolerances.
  - Groundwater salinity is generally not monitored.
  - Relatively little information on remediation of salt-affected soils and groundwater for restoration (more extensive for agriculture).
  - Long-term salt balances have not been determined.

Impetus for Project

- We know (background):
  - Salinity is variable at MSCP habitat creation sites.
  - General drivers of soil and groundwater salinity.
- We want to know (objectives):
  - What is the current status of soil and groundwater salinity at selected sites?
  - What trends can be anticipated over the LCR MSCP duration?
  - What can be done to mitigate soil salinity and maximize habitat creation success?

Project Activities

1. Review salinity literature and LCR data.
2. Establish a soil and groundwater monitoring network to determine salinity trends at three established riparian restoration sites.
3. Conduct aquifer testing to estimate groundwater movement.
4. Monitor soil and groundwater salinity, groundwater elevations.
5. Develop a salt balance model to evaluate accretion or loss in soils and groundwater.
6. Develop strategies for salinity control and long-term monitoring.

Soil Salinity and Sodicity

Salinity

- Soluble salt, with EC as a proxy.
- Per agricultural manuals:
  - <4 dS/m “nonsaline”
  - 4-8 “moderately saline”
  - 8-16 “saline”
  - >16 “severely saline”.
- Alters osmotic potential.
- For riparian trees, 50% growth reduction at 5 dS/m, death at 10-12 dS/m.

Sodicity

- High ratios of Na^+ to Ca^{2+} and Mg^{2+}
- SAR >= 13

$$SAR = \frac{[NA^+]}{\sqrt{\frac{1}{2}([Ca^{2+}]+[Mg^{2+}])}}$$

- Or ESP > 15%

$$ESP = \frac{echangeable\_sodium}{CEC}$$

- Soil dispersion and clogging.
- Phytotoxic pH

Salinity Concerns

Groundwater

- Direct phytotoxicity.

- Contributions to soil water:
  - Capillary rise into the unsaturated zone →
    - Evapoconcentration of salts.

Irrigation

- Potential for leaching, but:
  - Addition of salts to soil profile and groundwater.
  - Additional evaporation and evapoconcentration.
  - Groundwater mounding?

Salinity Management Strategies

1. Avoidance:
   - Plant according to salinity tolerances.

   OR

2. Remediation

   AND THEN

3. Monitoring and mitigation (Adaptive Management).

Soil and Groundwater Monitoring Network

Beal Lake

Palo Verde Ecological Reserve (PVER)

Cibola NWR Unit #1

Three Diverse Habitat Creation Sites

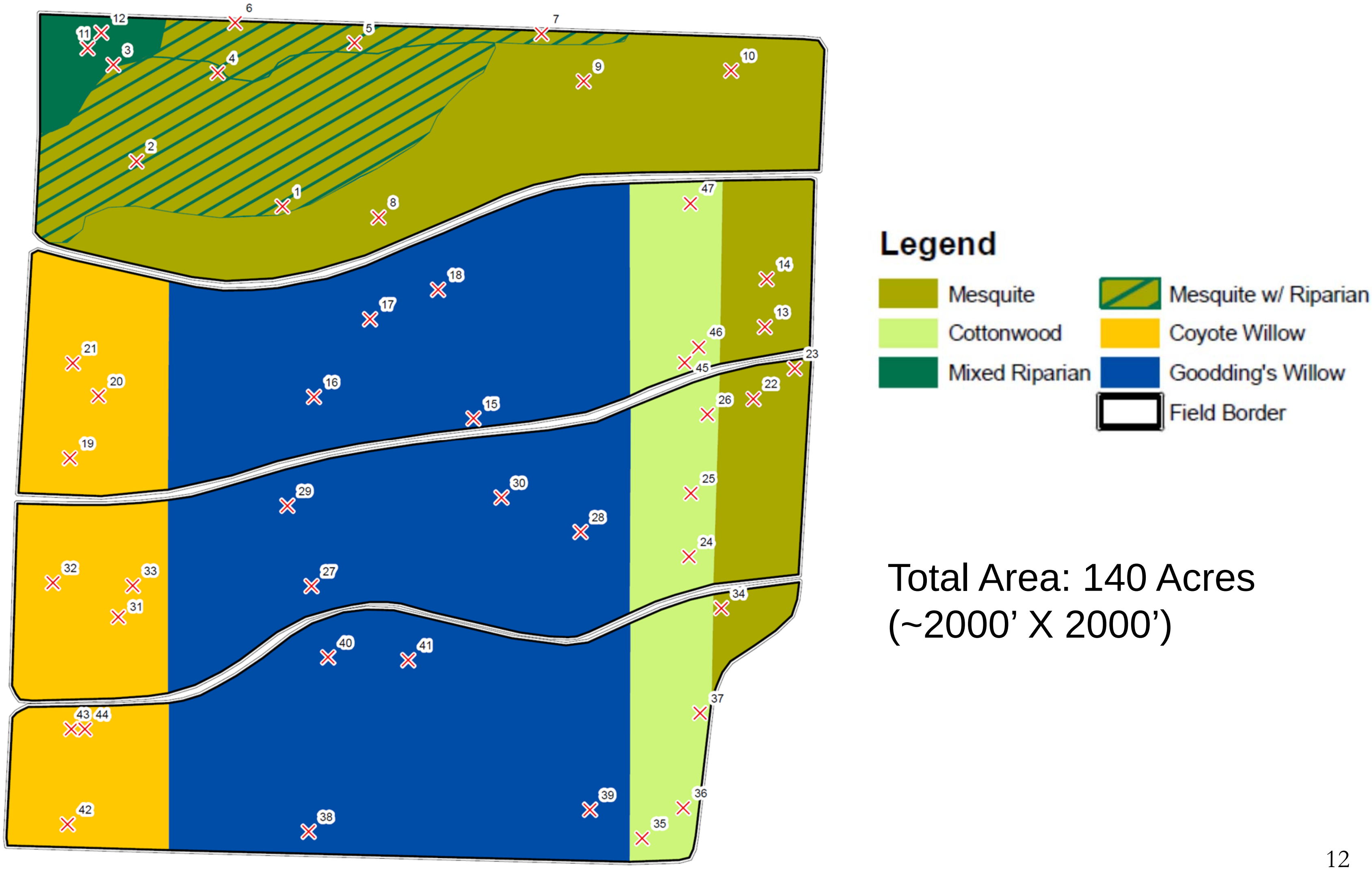
Site	Land Conversion	Soil Type	Depth to Ground Water	Distance from Colorado River
Beal Lake	Dredge Spoils	Lagunita Sand	<5’ ?	0.7-1.5 miles*
Palo Verde Ecological Reserve	Agricultural	Highly Variable	>15’ ?	0-0.6 miles
Cibola NWR Unit #1	Agricultural, Cleared Non-natives	Silty Loam, variably sandy subsurface	5-10’	0.5-1.5 miles

* Immediately adjacent to Topock Marsh and Beal Lake

Soil Sampling and Testing Methods

- Salinity sampling locations selected based on soil type, vegetation, and/or distance from irrigation and then randomized.
- At each location, hand-augered to 6’ below ground surface.
- Composited two-foot intervals (3 samples per location).

Soil Sampling Plan: Crane's Roost at Cibola NWR



Total Area: 140 Acres
(~2000' X 2000')

2010 EC Summary: Beal Lake Restoration Site (Saturated-Paste Extract EC)

Depth Interval (n)	Mean dS/m	Median dS/m	Min dS/m	Max dS/m
0'-2' (70)	3.3 A	1.0	0.6	44.1
2'-4' (70)	3.5 A	1.4	0.9	31.7
4'-6' (70)	2.2 A	1.4	1.1	13.2

EC and RGR:

1. **3 dS/m = 70%**
2. **5 dS/m = 50%**
3. **12 dS/m = 0%**

EC = 3 ≈ 1,500 mg/L TDS

2010 EC Summary: Palo Verde Ecological Reserve (Saturated-Paste Extract EC)

Depth Interval (n)	Mean dS/m	Median dS/m	Min dS/m	Max dS/m
0'-2' (41)	1.2 A	1.1	0.8	2.2
2'-4' (41)	1.1 A	0.8	0.6	2.8
4'-6' (41)	1.2 A	0.7	0.5	5.9

EC and RGR:

1. **3 dS/m = 70%**
2. **5 dS/m = 50%**
3. **12 dS/m = 0%**

EC = 1 ≈ 520 mg/L TDS

2010 EC Summary: Cibola NWR Farm Unit #1 (Saturated-Paste Extract EC)

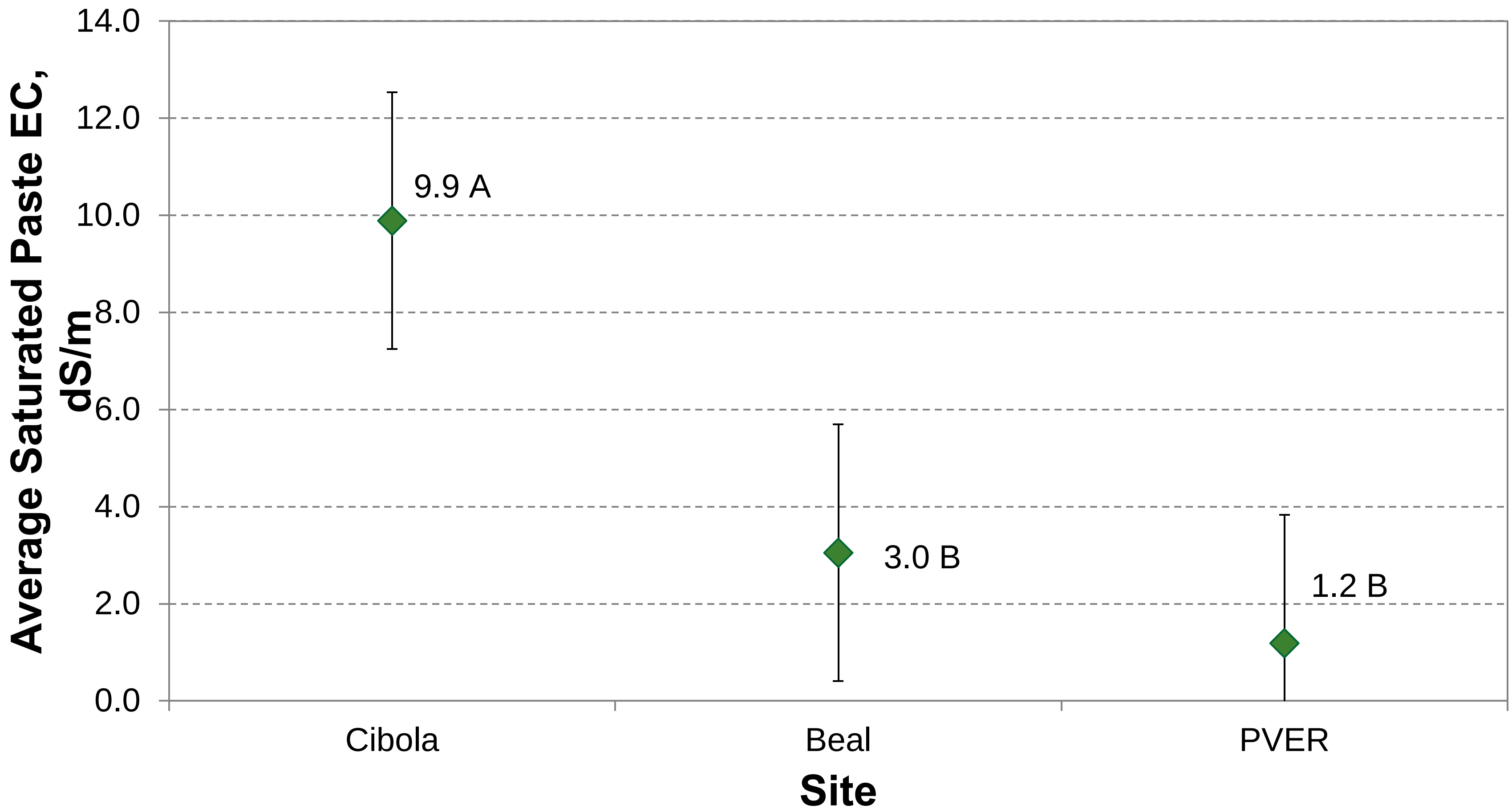
Depth Interval (n)	Mean dS/m	Median dS/m	Min dS/m	Max dS/m
0'-2' (82)	10.6 A	4.9	0.7	95.2
2'-4' (82)	9.3 A	6.3	0.8	49.4
4'-6' (82)	9.9 A	7.7	0.8	31.3

EC and RGR:

1. **3 dS/m =70%**
2. **5 dS/m =50%**
3. **12 dS/m =0%**

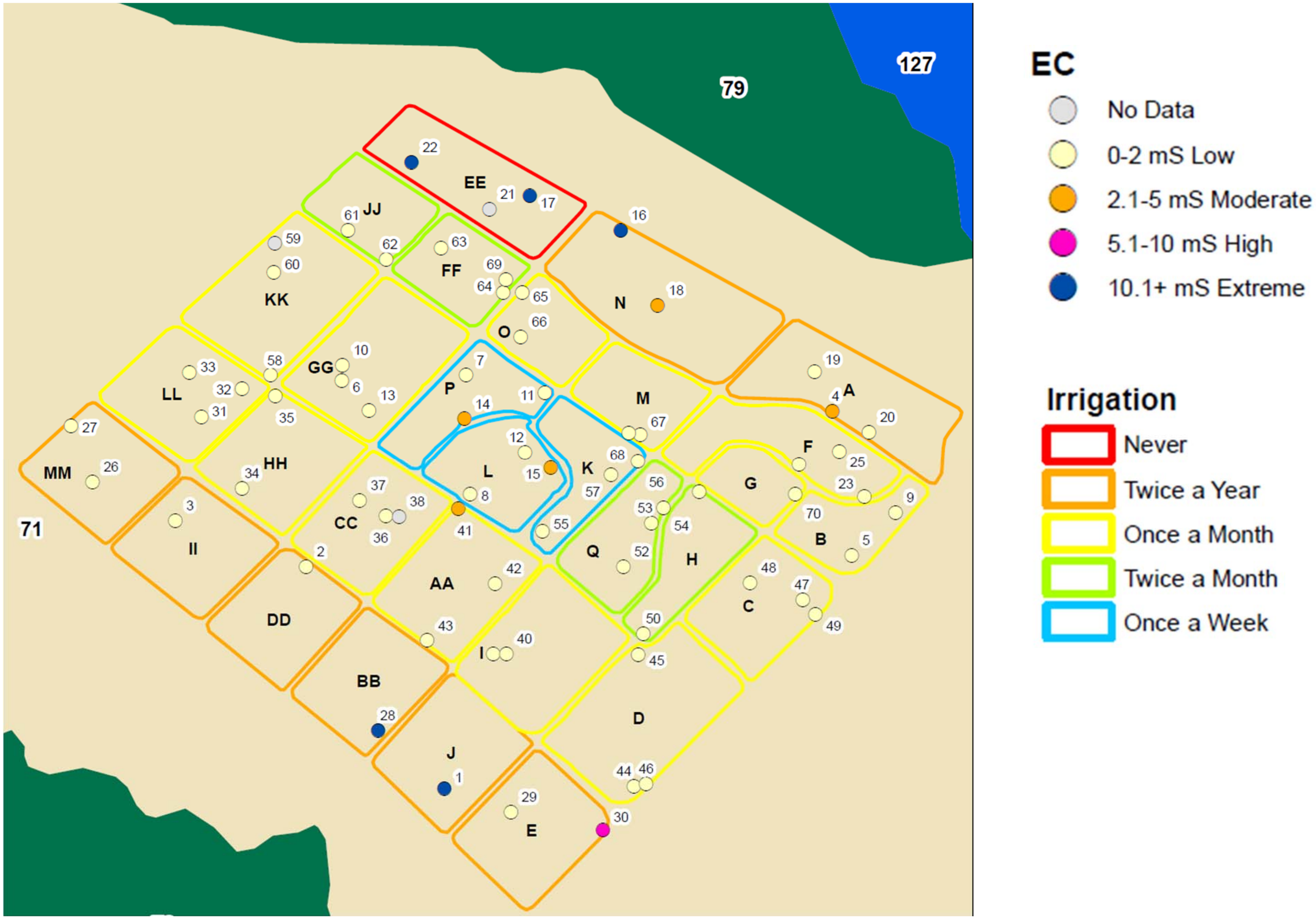
EC = 10 ≈ 5,200 mg/L TDS

0-6' EC Site Comparison

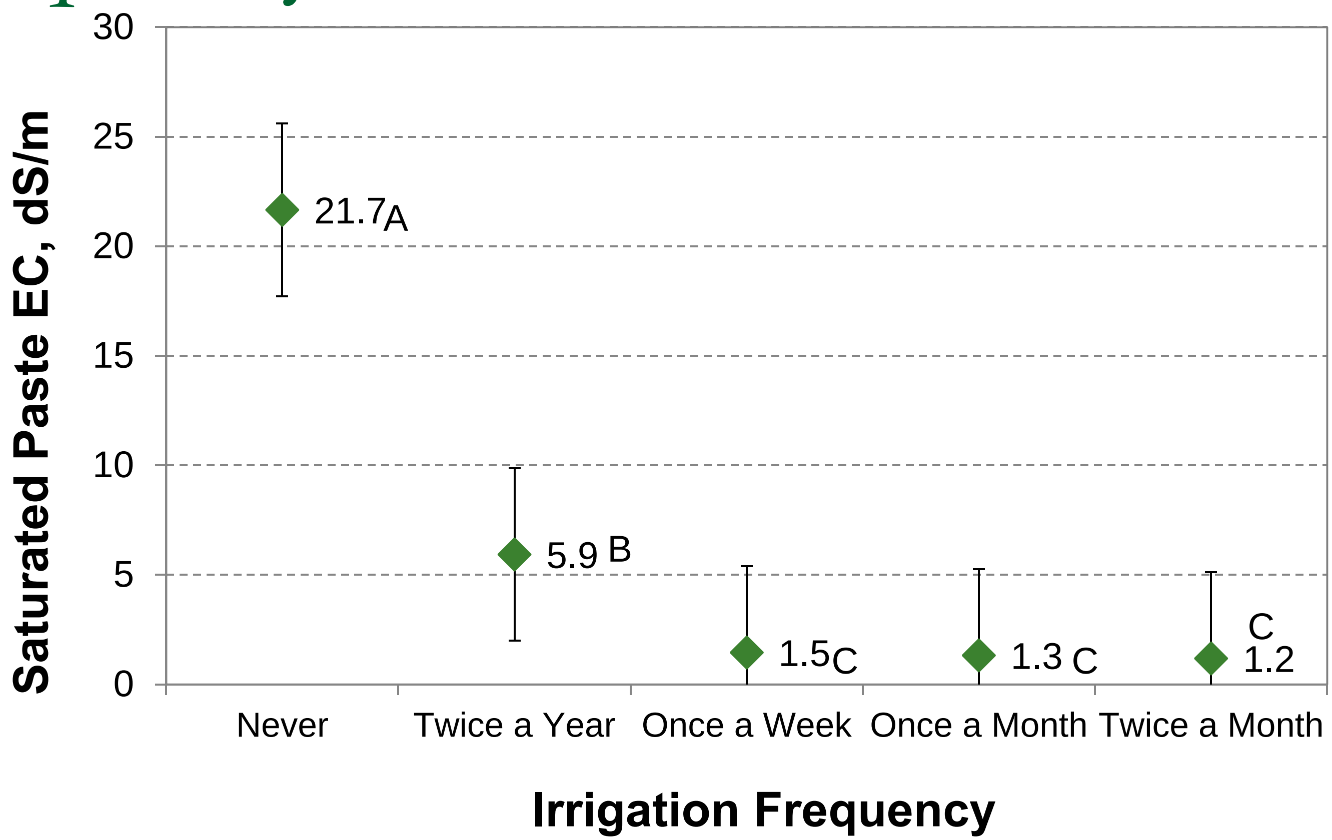


- **Higher soil EC at Cibola.**

2010 EC Summary: Beal Lake Restoration Site
Bulk Soil EC



Beal Lake: 2010 0-6' EC and Irrigation Frequency



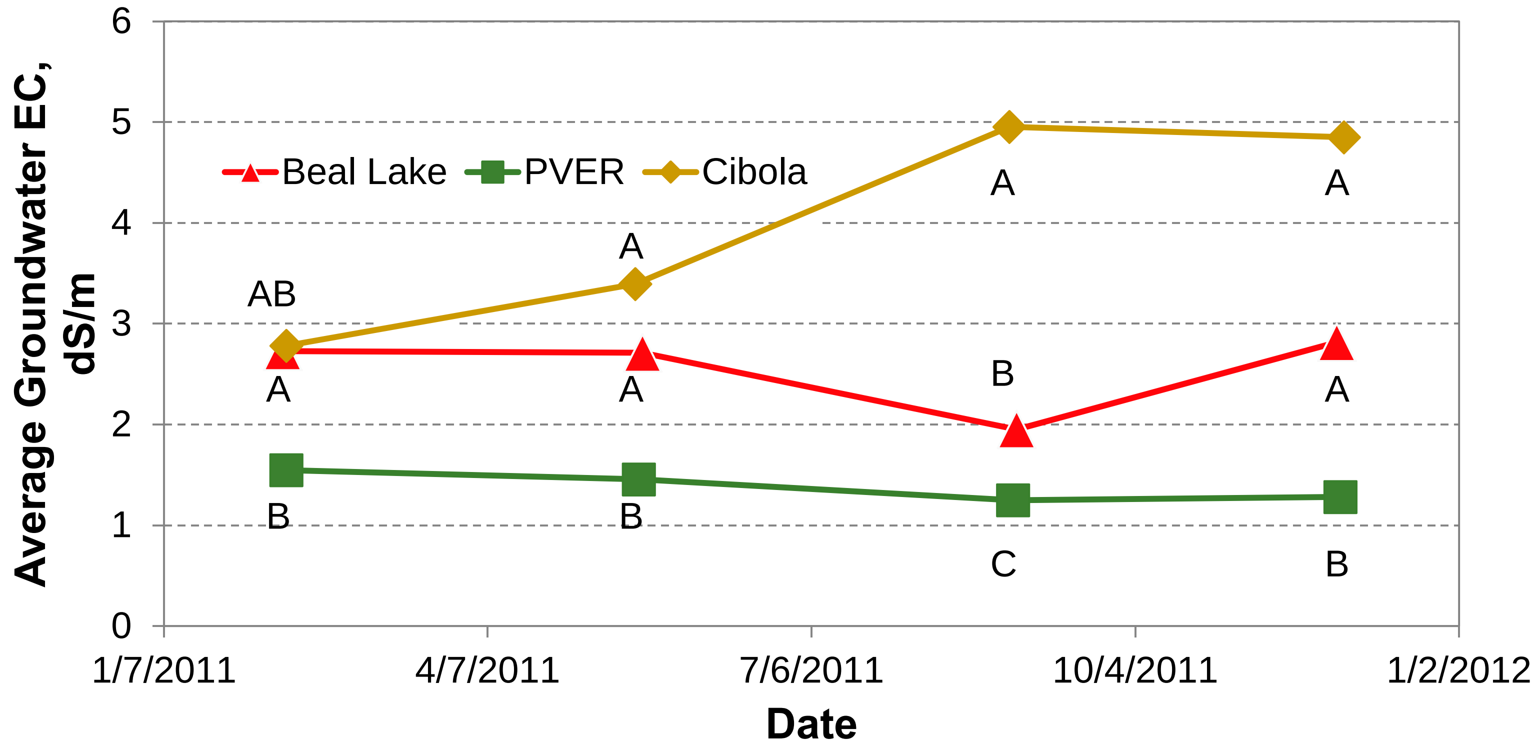
- **Lower EC with increased irrigation frequency.**

Groundwater Monitoring

- Grid of wells established at each site.
- Instrumented to monitor groundwater elevation and temperature.
  - Continuous salinity at two wells per site.
- Groundwater salinity (EC) field-measured quarterly.

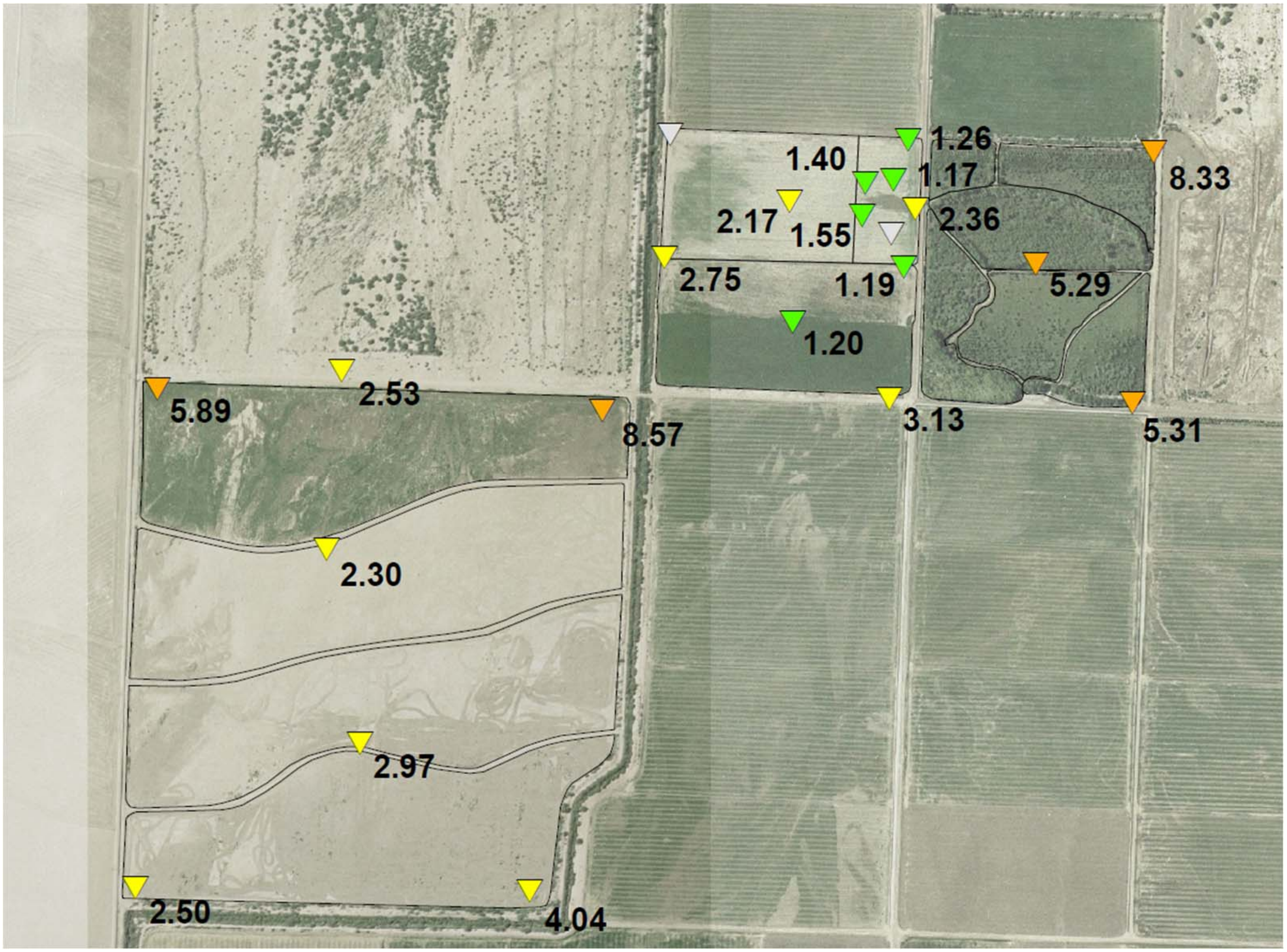

PZ7PVER
PZ5PVER
PZ6PVER
PZ4PVER
PZ2PVER
PZ3PVER
PZ8PVER
PZ1PVER
0 200 400 600 800 1,000 Feet

Groundwater EC Through 2011

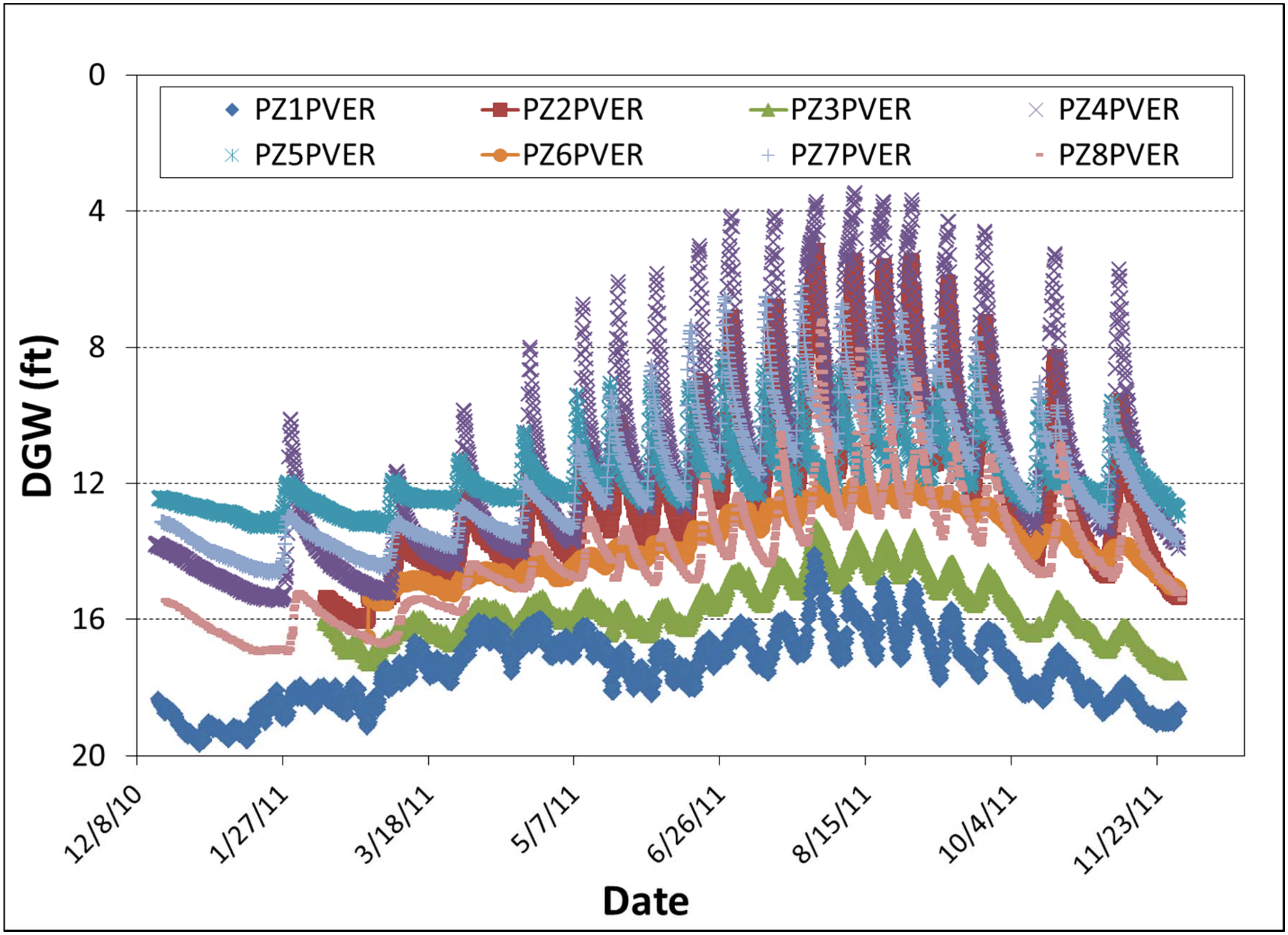


- **Higher groundwater EC at Beal and Cibola.**
- **Lowest EC at PVER—note: greatest depth to GW.**
- **Greater variation at Cibola.**

Groundwater EC Distribution:
Cibola, May 2011



Groundwater Depth: PVER



2012 Activities

- Continued groundwater sampling and groundwater elevation data downloads.
- Repeat soil salinity sampling.
- Further analysis of soil and groundwater salinity results.
- Integration of vegetation monitoring data—correlation of key vegetation characteristics with soil and groundwater salinity?
- Develop salt balance model(s) and analyze irrigation management strategies.

Preliminary Conclusions

- Soil and groundwater salinity is a concern for riparian restoration.
- Various monitoring methods exist and are being implemented during this study.
- Soil and groundwater salinity are likely effects of:
  - Soil texture,
  - Depth to groundwater,
  - Communication with the Colorado River mainstem, and
  - Irrigation and drainage management.
- Long-term management effects will be modeled as a part of this study.
- Remediation options exist at various costs, but their effectiveness is uncertain.

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