Recent Projects Modeling Local and Regional Impacts of Tidal Marsh Restoration

* Suisun Marsh Programmatic EIR/EIS
* Bay Delta Conservation Plan
* Prospect Island

Resource Management Associates Modeling Team

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Edward Gross, Ph.D.
Stacie Grinbergs, P.E.
Marianne Guerin, Ph.D.
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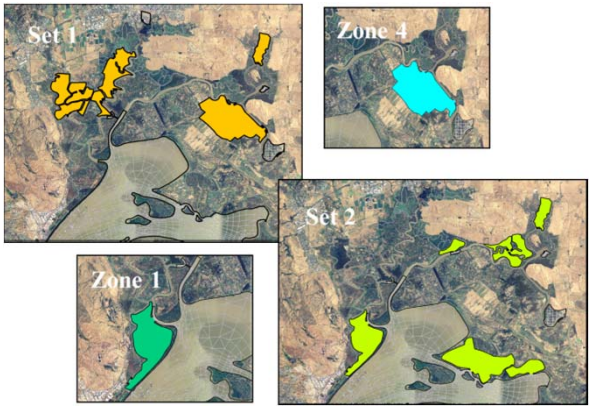


Delta Independent Science Board Meeting
January 17, 2013

But first, why would you believe what a model shows you??

Key Aspects in Calibrating/Testing a Delta Model

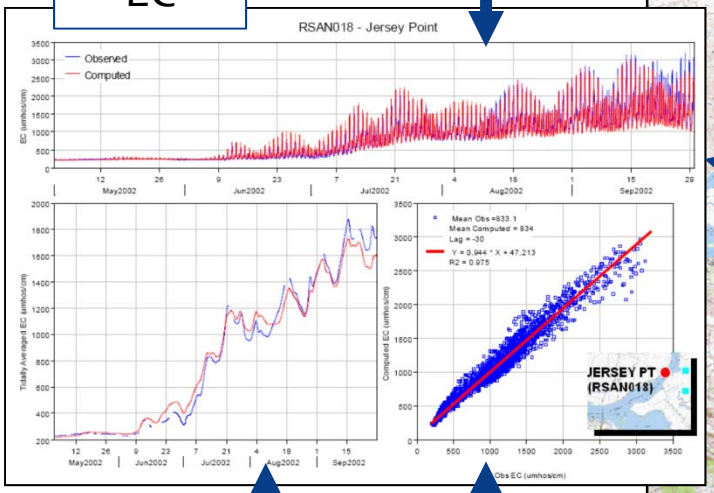
* Matching point observations on tidal and tidally averaged basis
  * Stage
  * Flow
  * Salinity (EC)
* Look for how well a model represents
  * Important net-flow splits (e.g., Sac. River to Delta Cross Channel)
  * Gate/barrier operations (e.g., Clifton Court Gates)
  * Delta Island Consumptive Use
  * Delta Exports
  * Low flow, high flow, and transition periods
  * The yearly cycle of salt intrusion and flushing
  * Spring-neap tidal variation

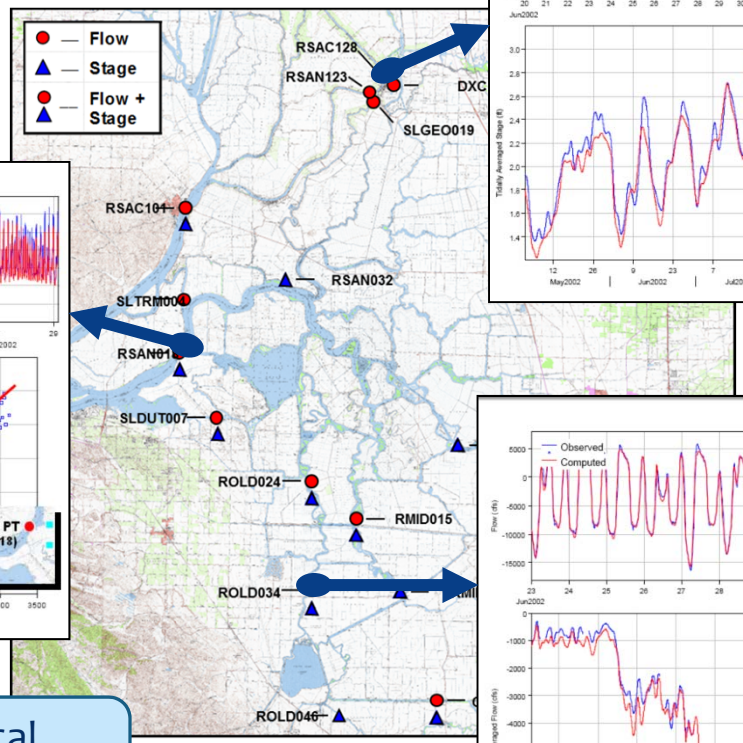
Observed versus Computed…
What can you see in the wiggly lines?

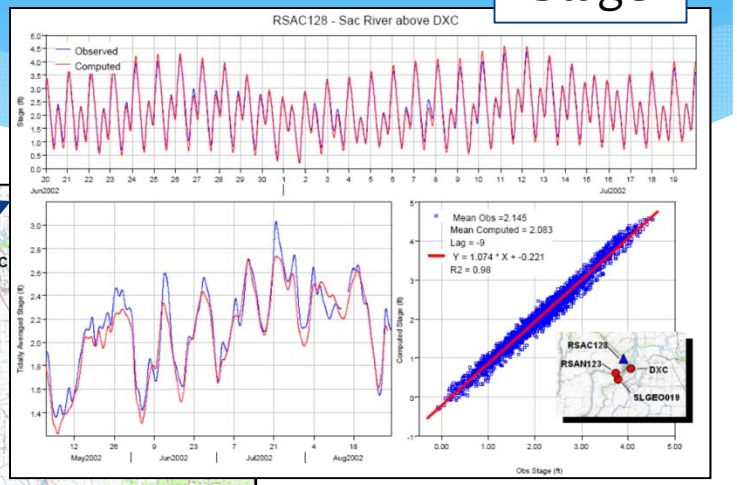
Stage

Tidal Time Scale

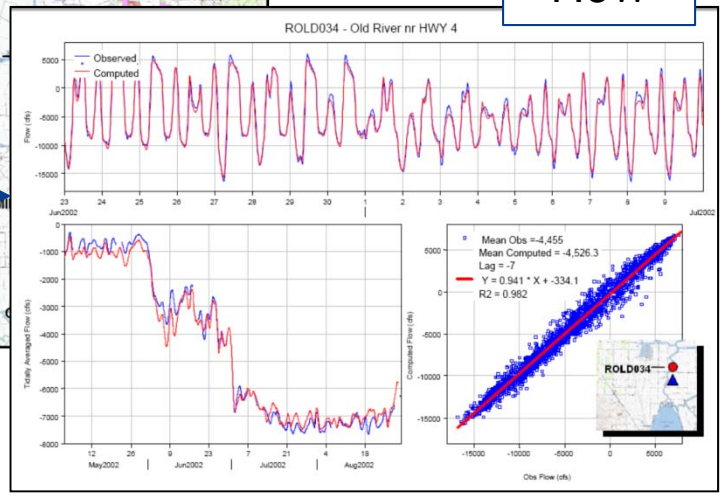
EC







Flow



Tidally Averaged Time Scale

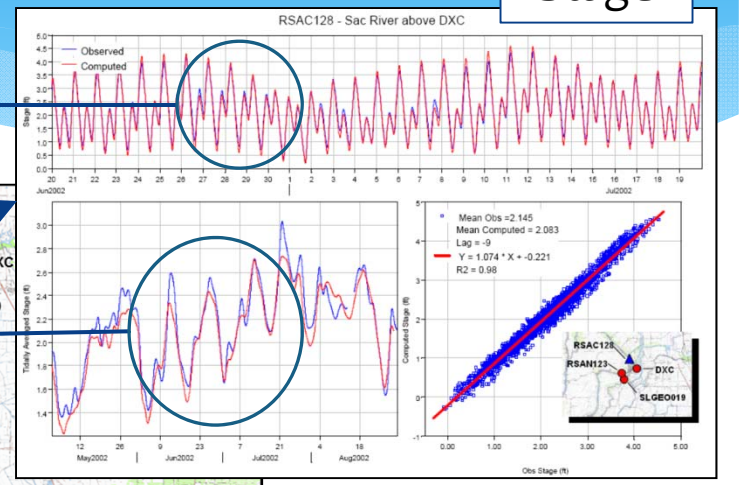
Statistical Comparison

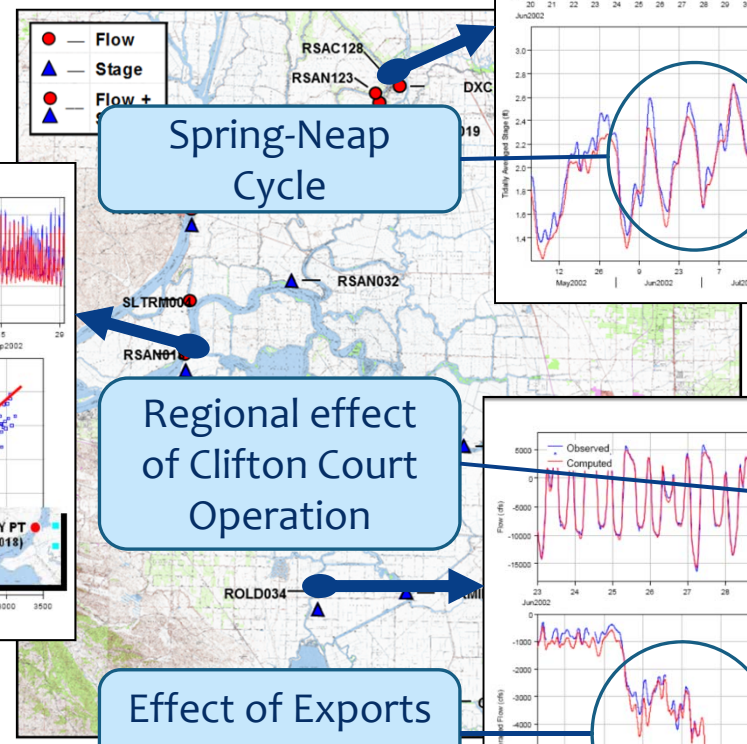
Example plots from RMA Model Calibration, Water Year 2002

Observed versus Computed…
What can you see in the wiggly lines?

Stage

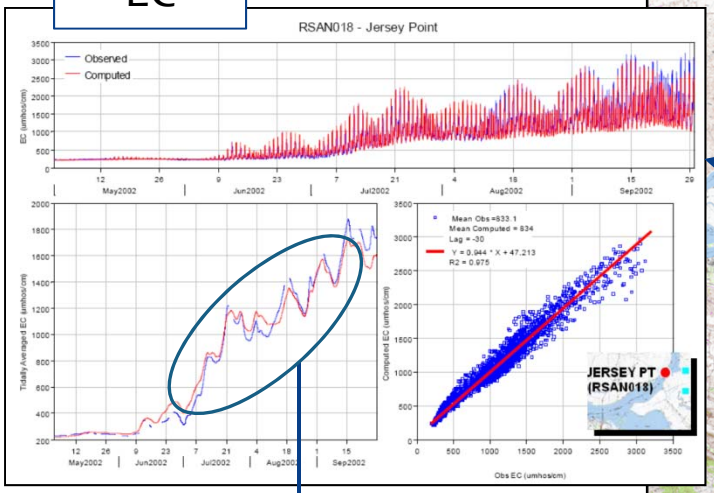
Tide Phase and Amplitude





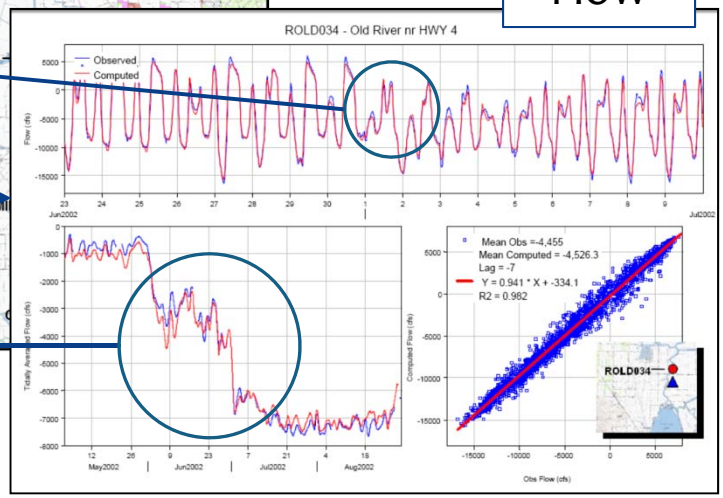
Spring-Neap Cycle

EC



Regional effect of Clifton Court Operation

Flow



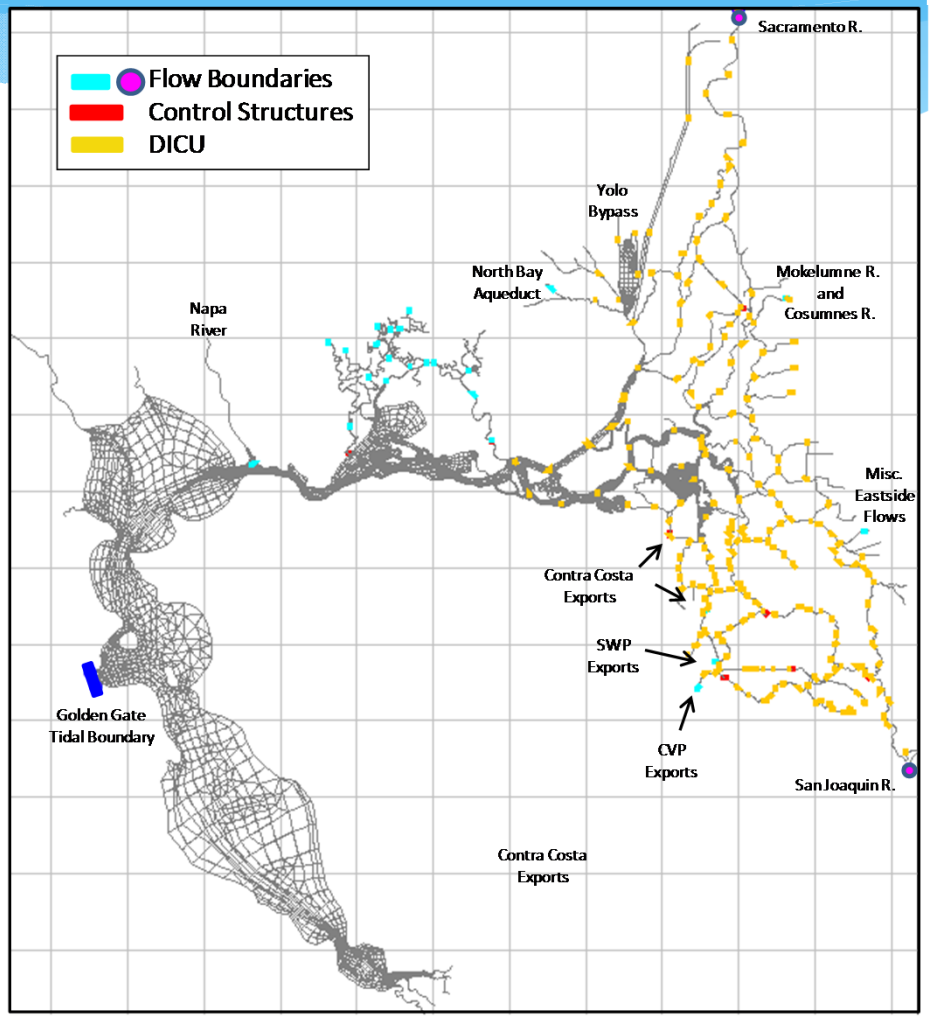
Effect of Exports on net Flow

Rate of salt intrusion

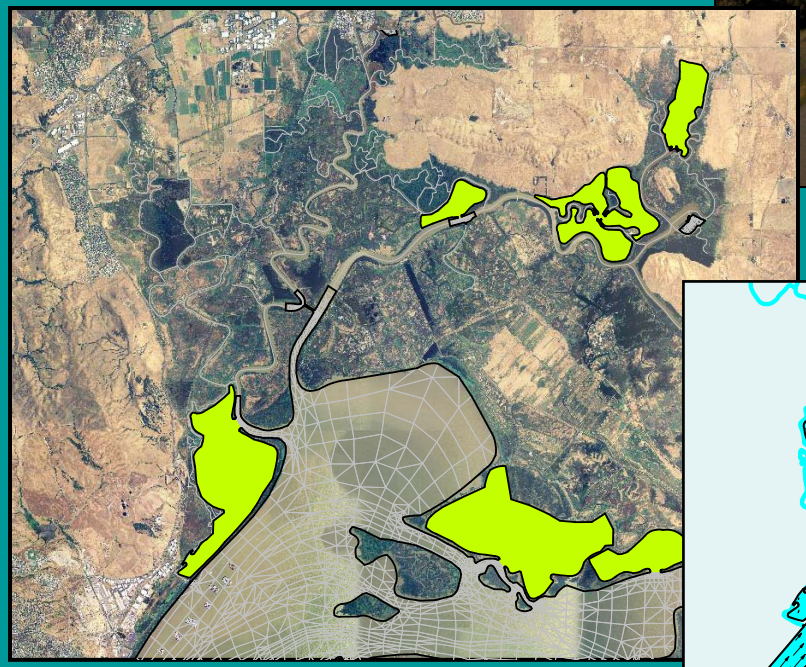
Example plots from RMA Model Calibration, Water Year 2002

RMA Bay-Delta Model

- Finite Element model with 2D depth averaged and 1D cross-sectionally averaged elements
- RMA2 Hydrodynamics and RMA11 Water Quality Transport
- All Delta control structures
- DICU based on DWR DSM2 Model
- Output includes flow, EC, residence time, temperature, turbidity, flow fingerprinting, passive particle tracking, particle tracking with behavior

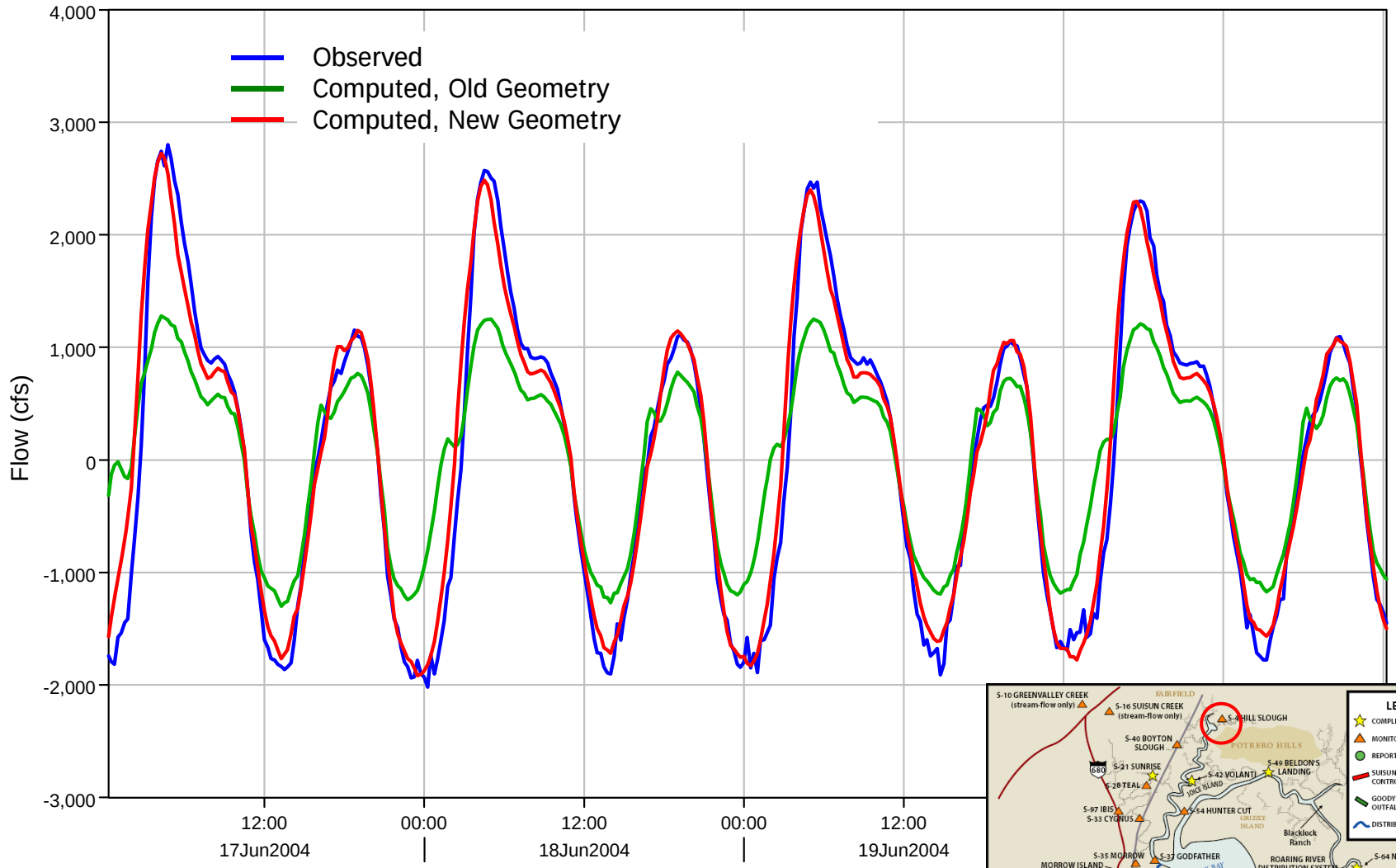


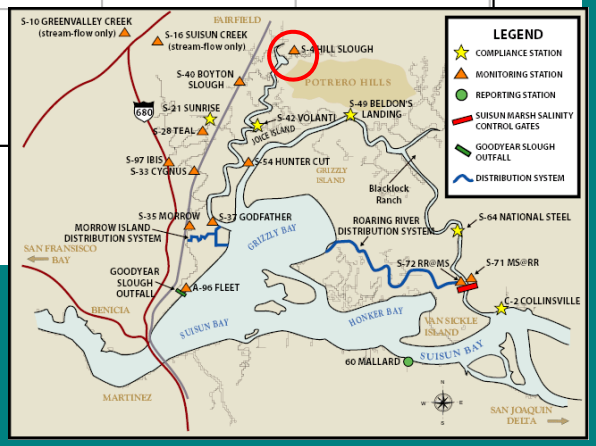
Modeling for the Suisun Marsh Programmatic EIR/EIS



Work performed in 2007-8

Flow Calibration: Hill Slough, 2004

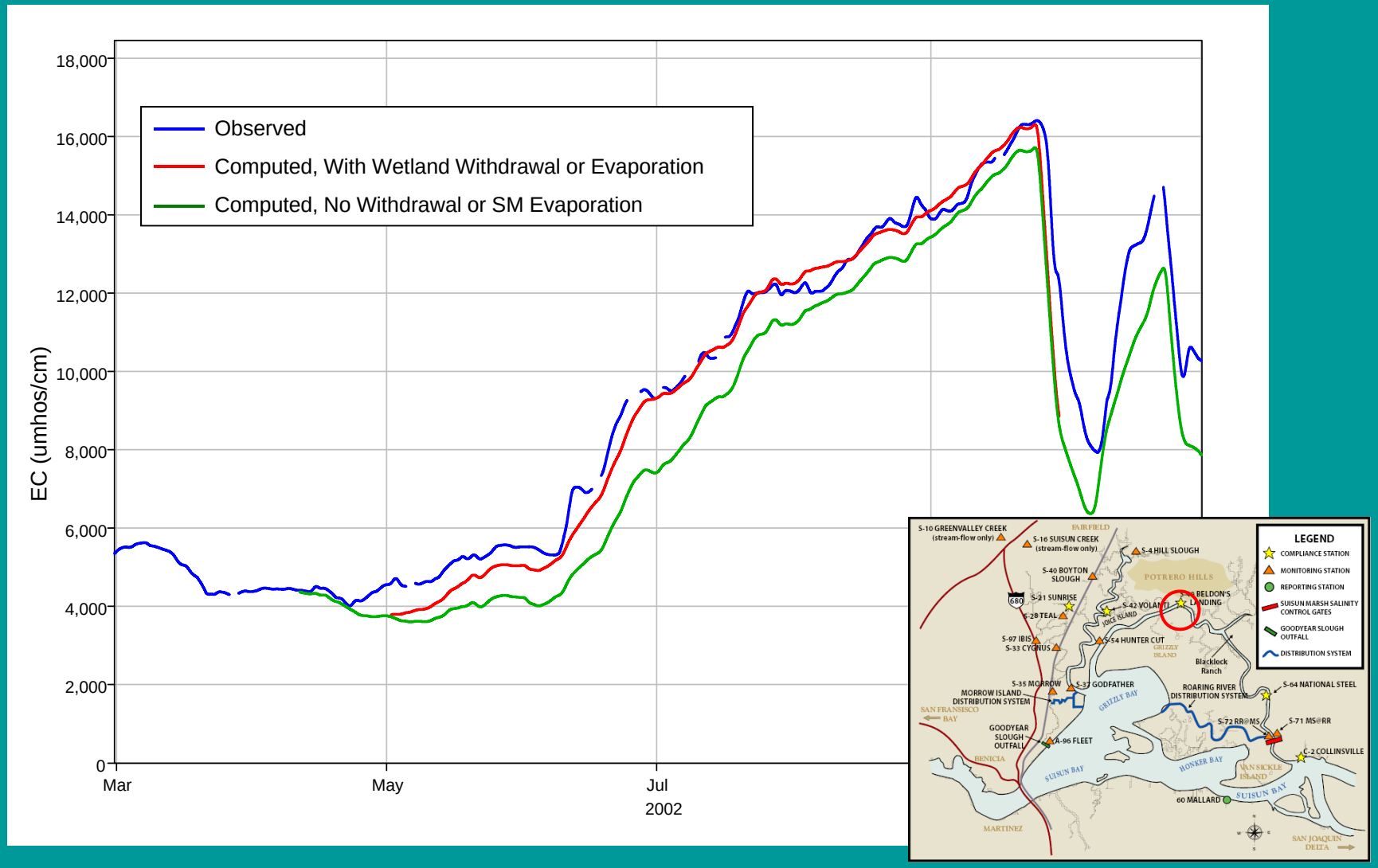




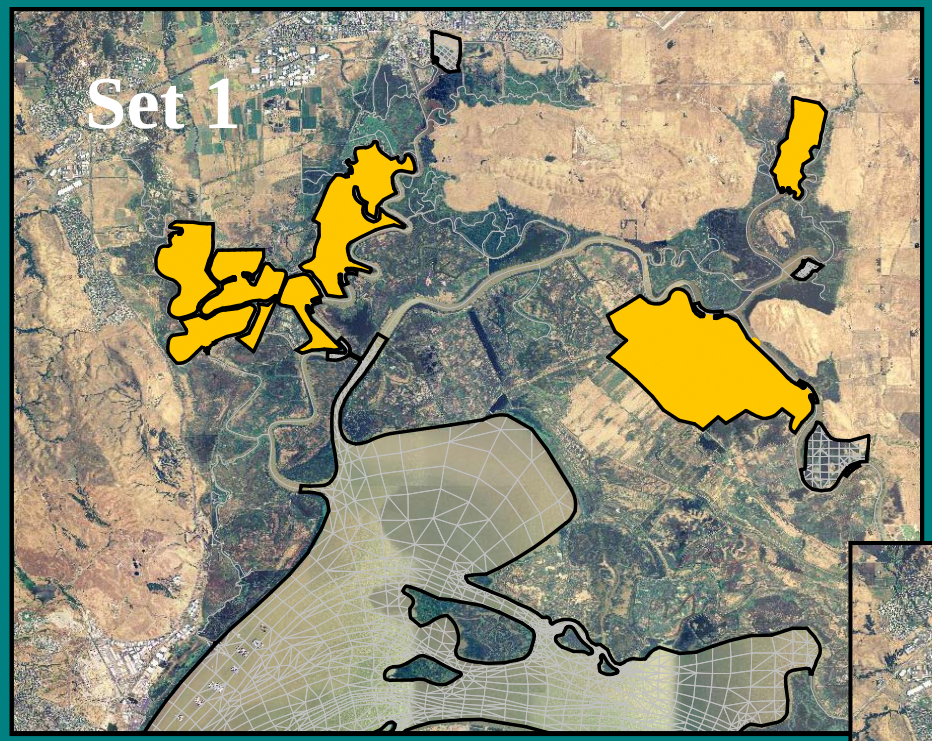
New geometry has new marsh channels and marsh overbank as off channel storage

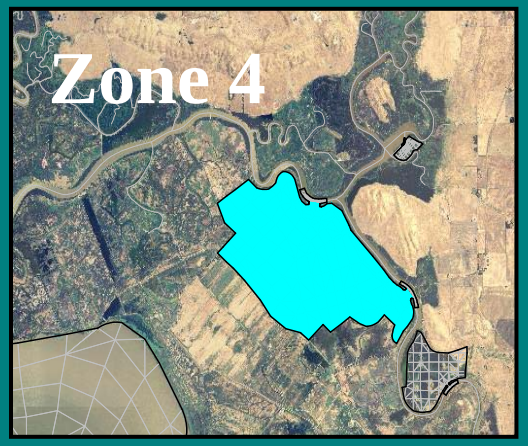
Effect of adding withdrawal by managed wetlands and evaporation in Suisun Marsh.

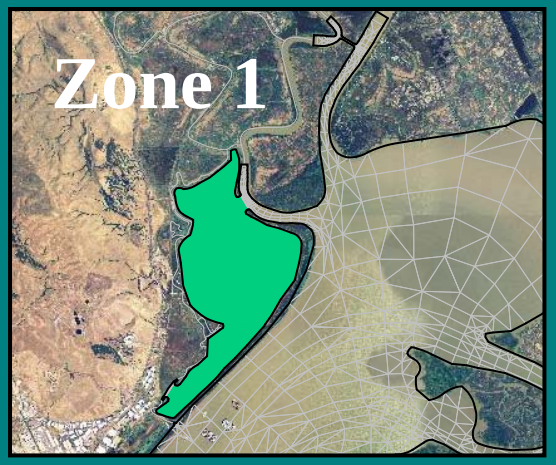
S-49, Montezuma Slough @ Beldon's Landing

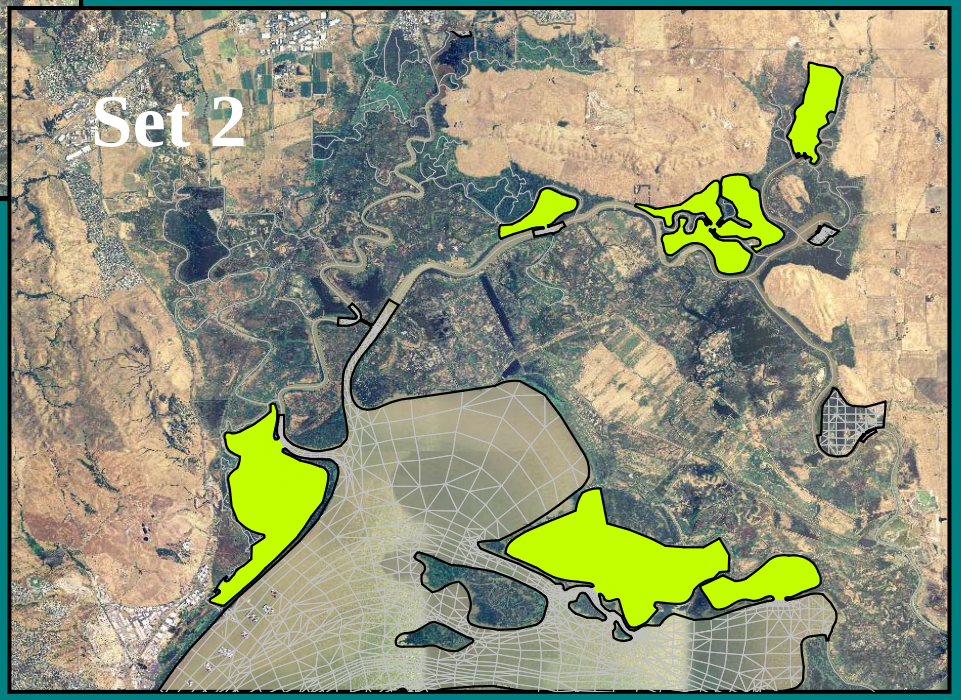


Alternative Comparison

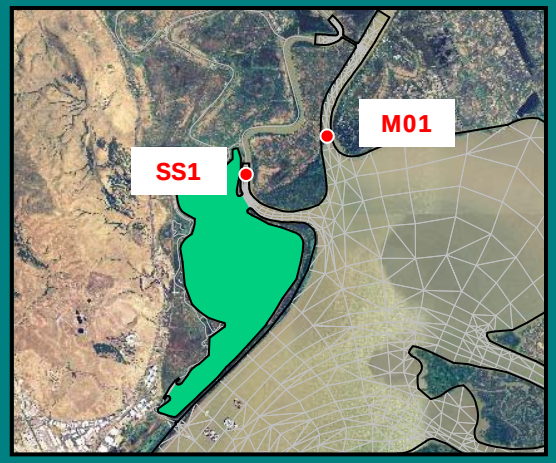


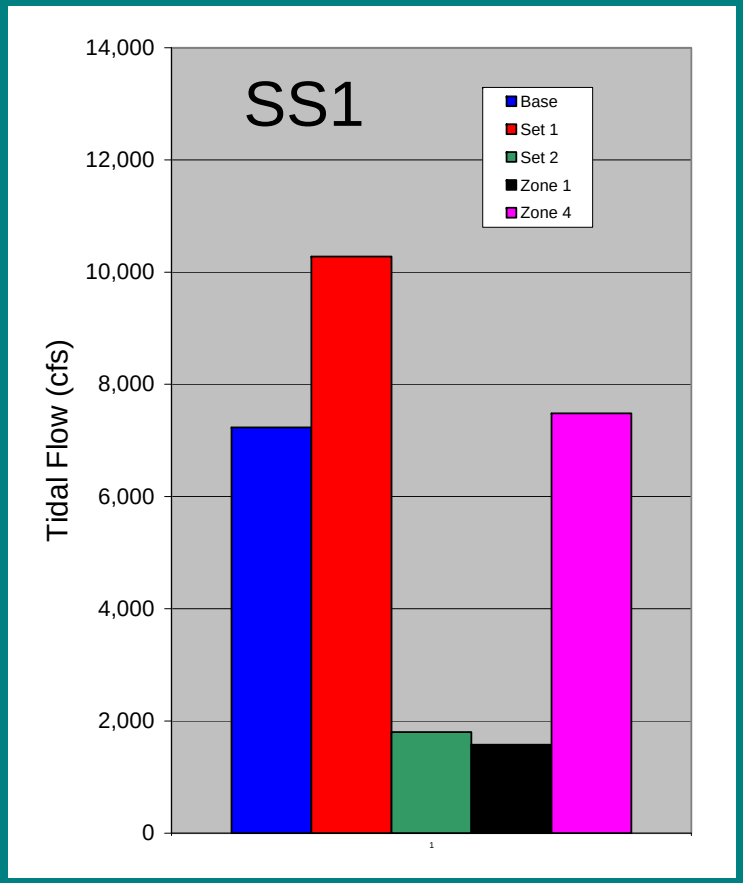


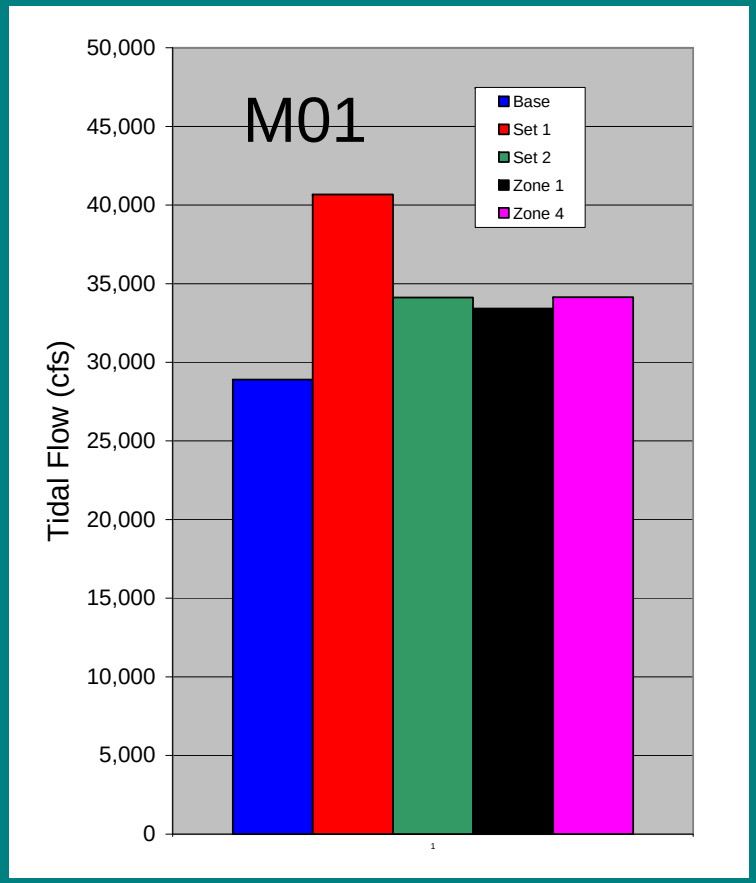




“Tidal Flow” for Spring Tide (Aug 10, 2002)

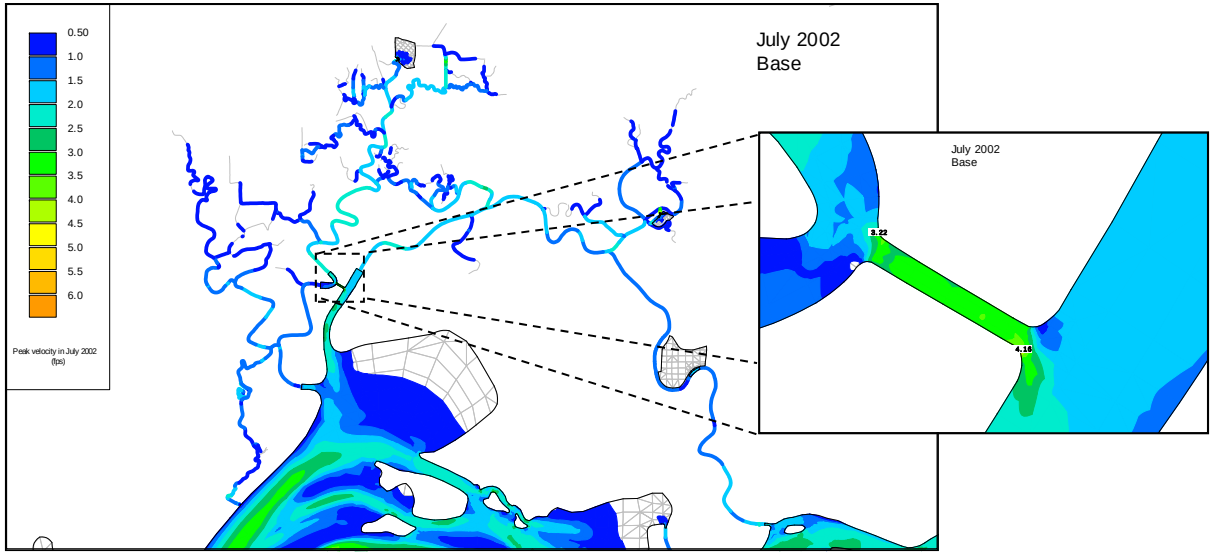


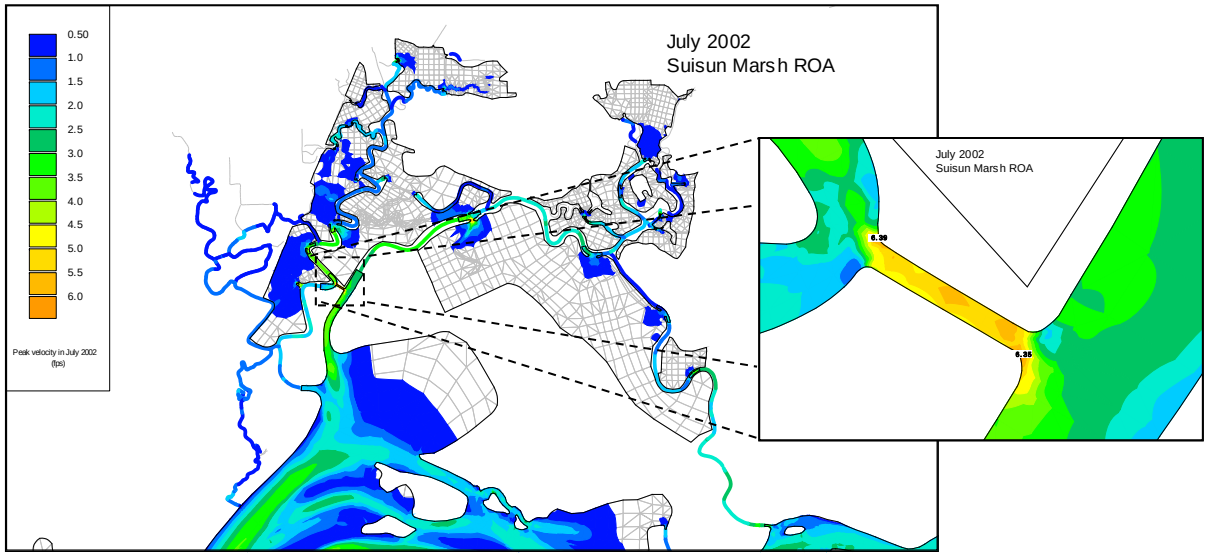




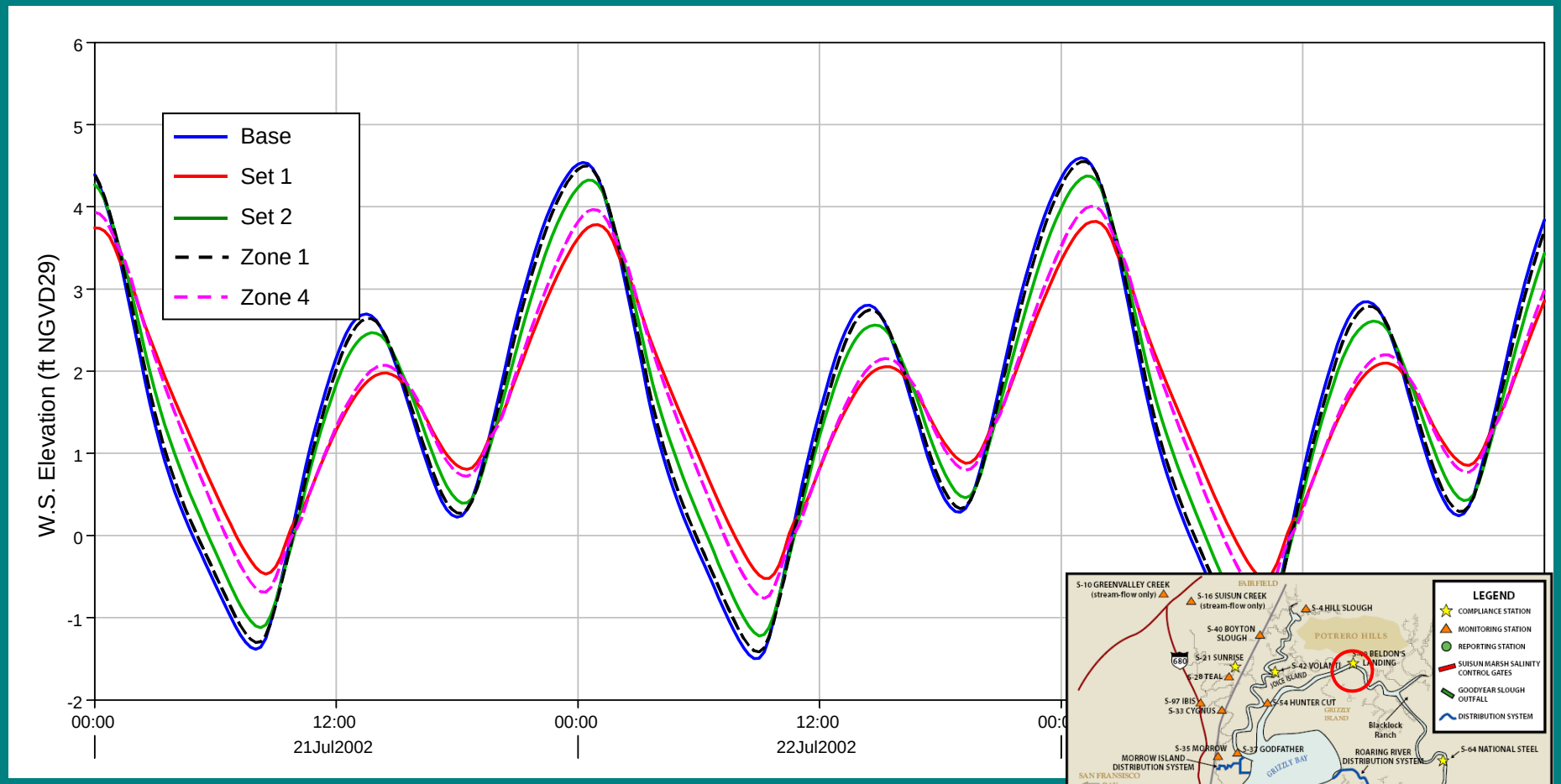
Velocity

- If conveyance is limited in the channels leading to restoration areas high velocities may lead to scour and potential loss of fringe marsh.
- Overtime the channel geometry will tend to adjust until areas of very high velocity are eliminated.

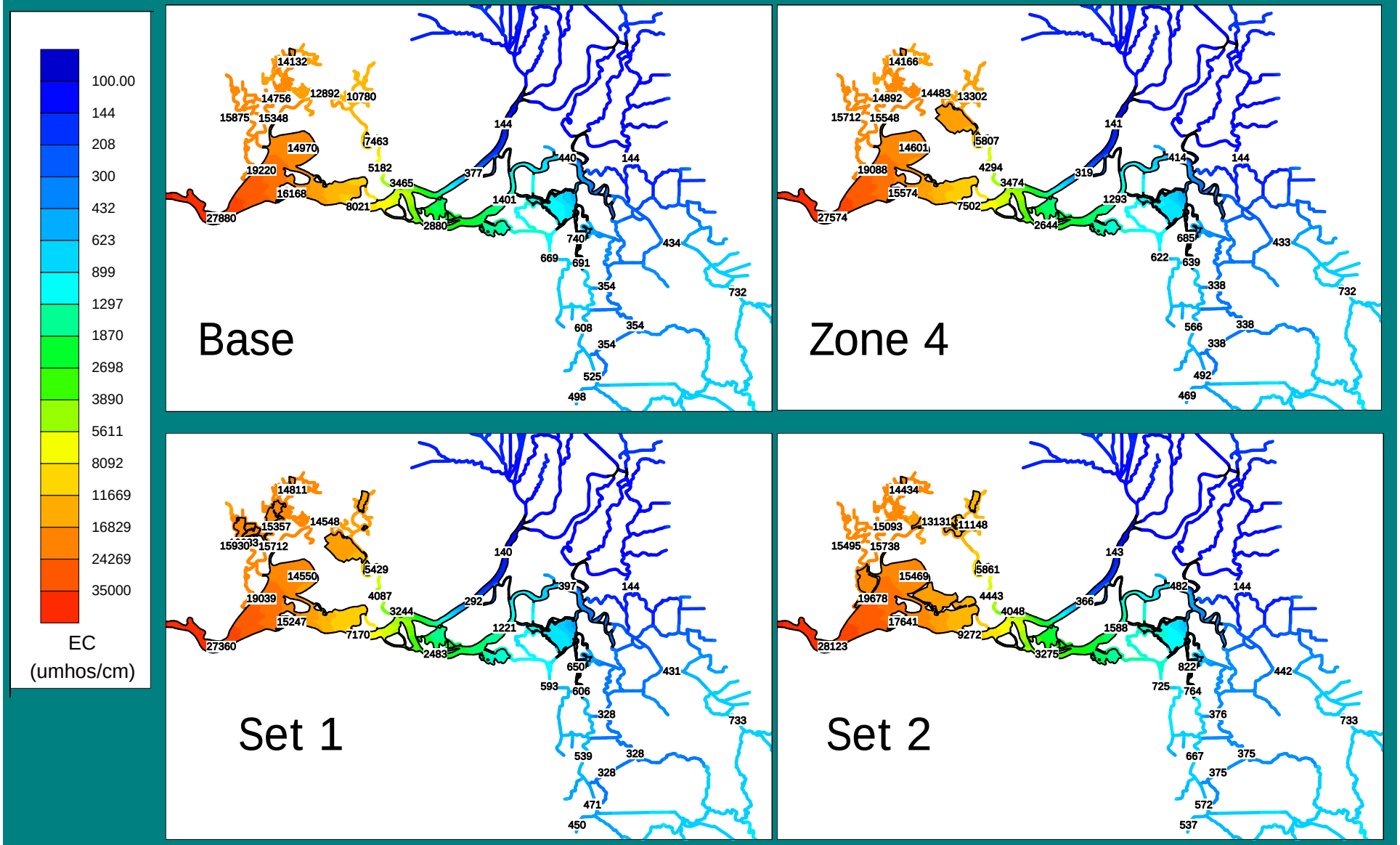




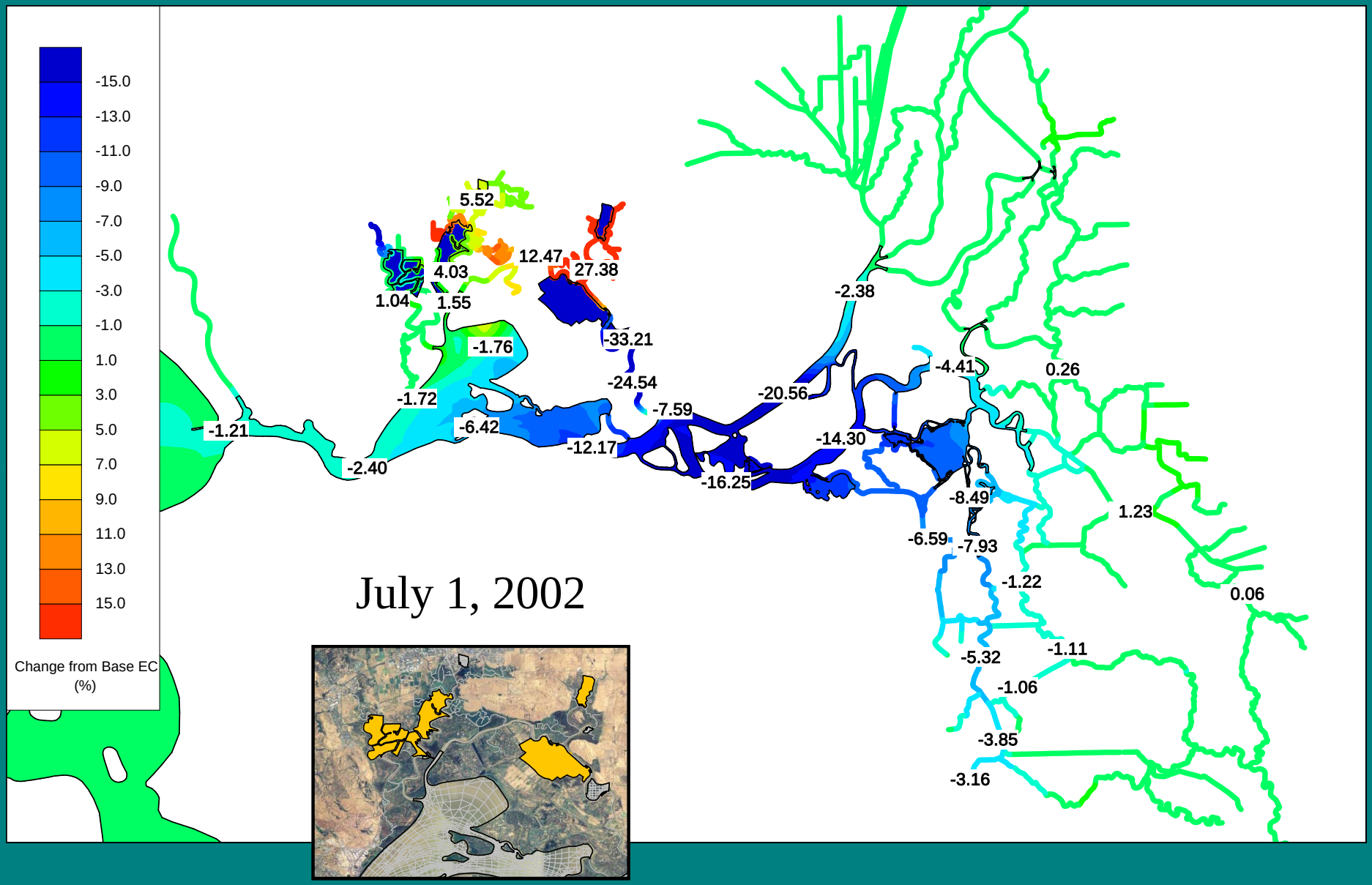
Stage Time Series at S-49
Montezuma Slough at Beldon's Landing



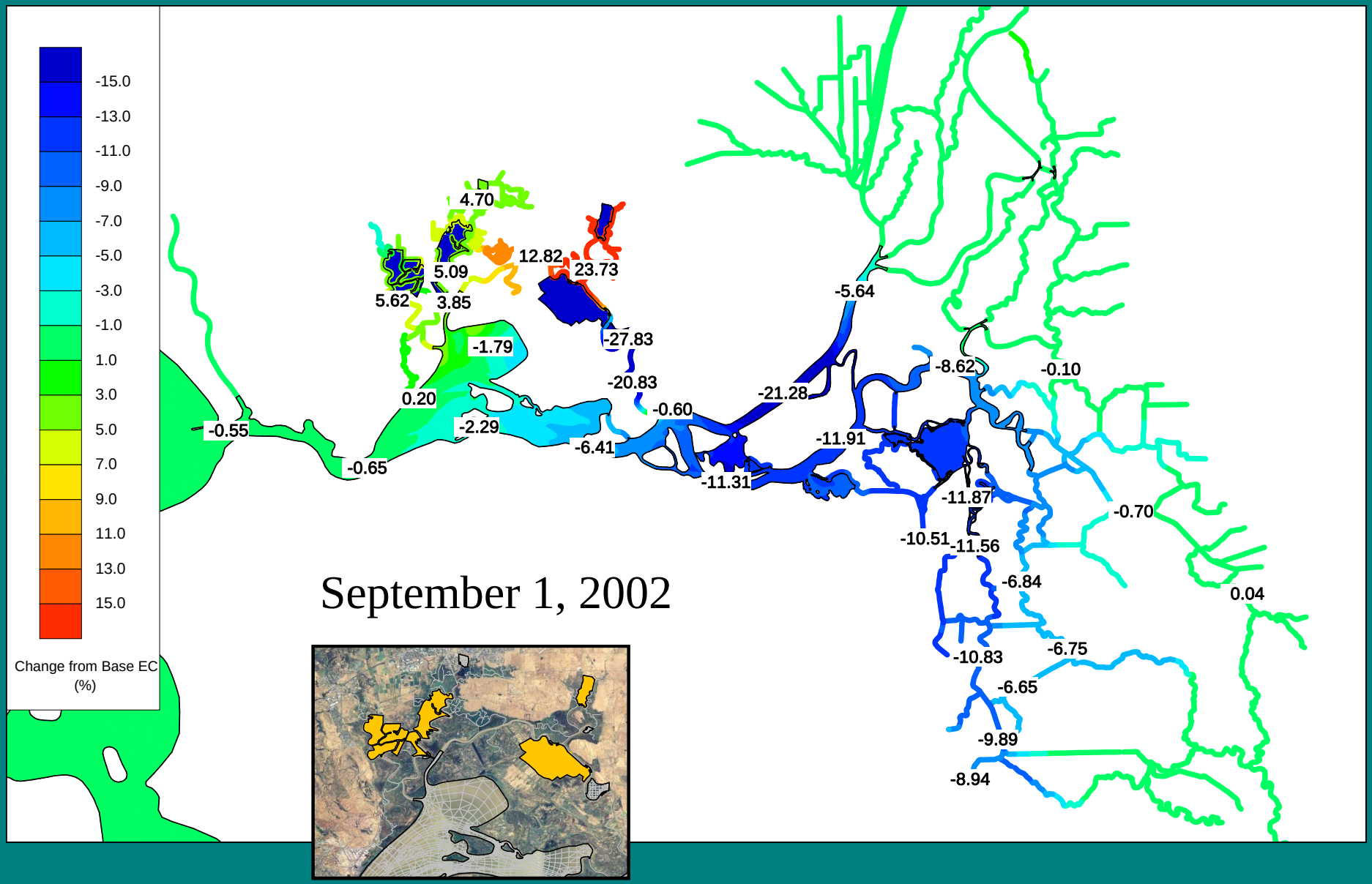
Regional EC Distribution: August 1, 2002



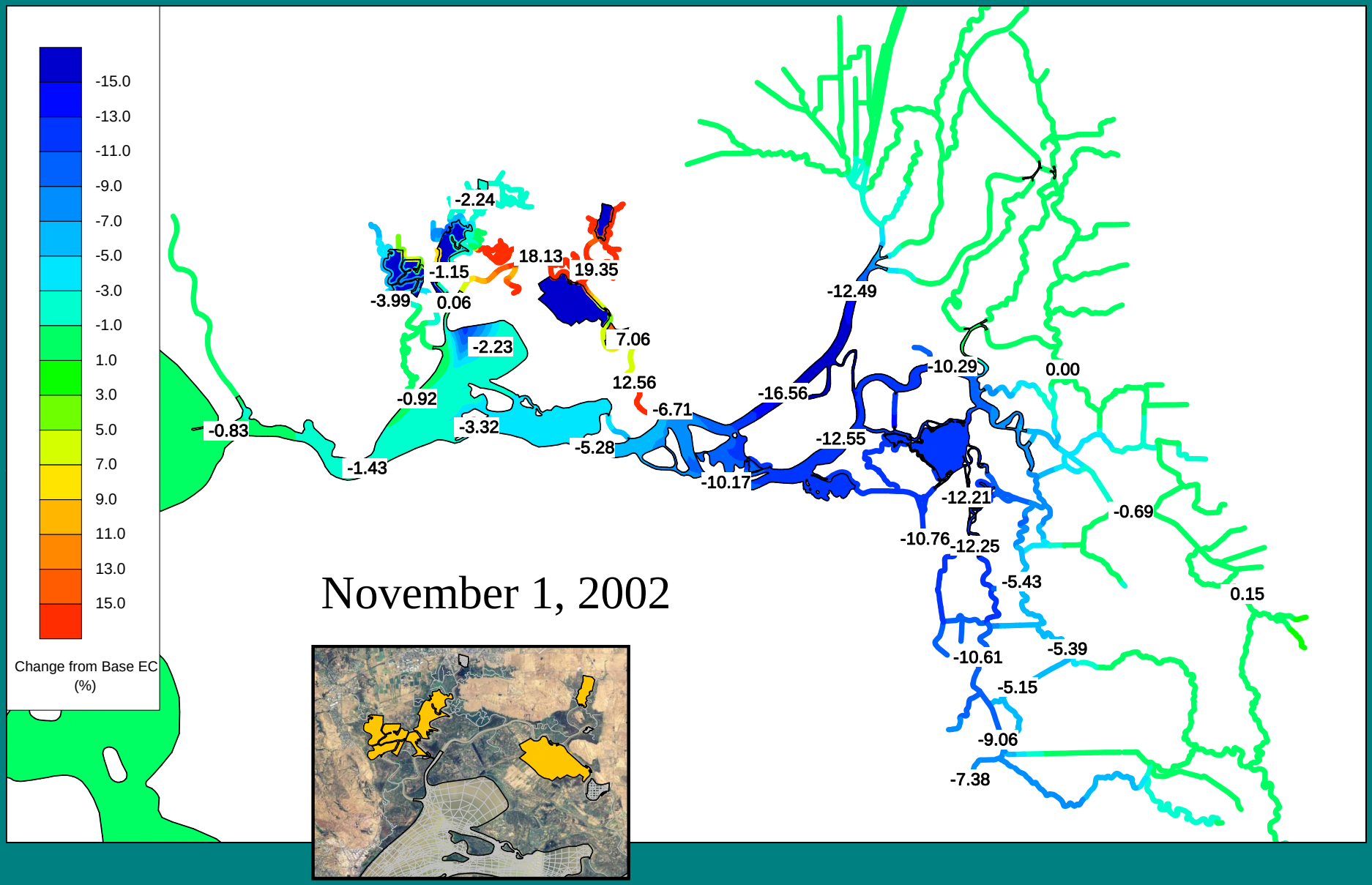
Set 1 - EC % Change From Base
July 1, 2002



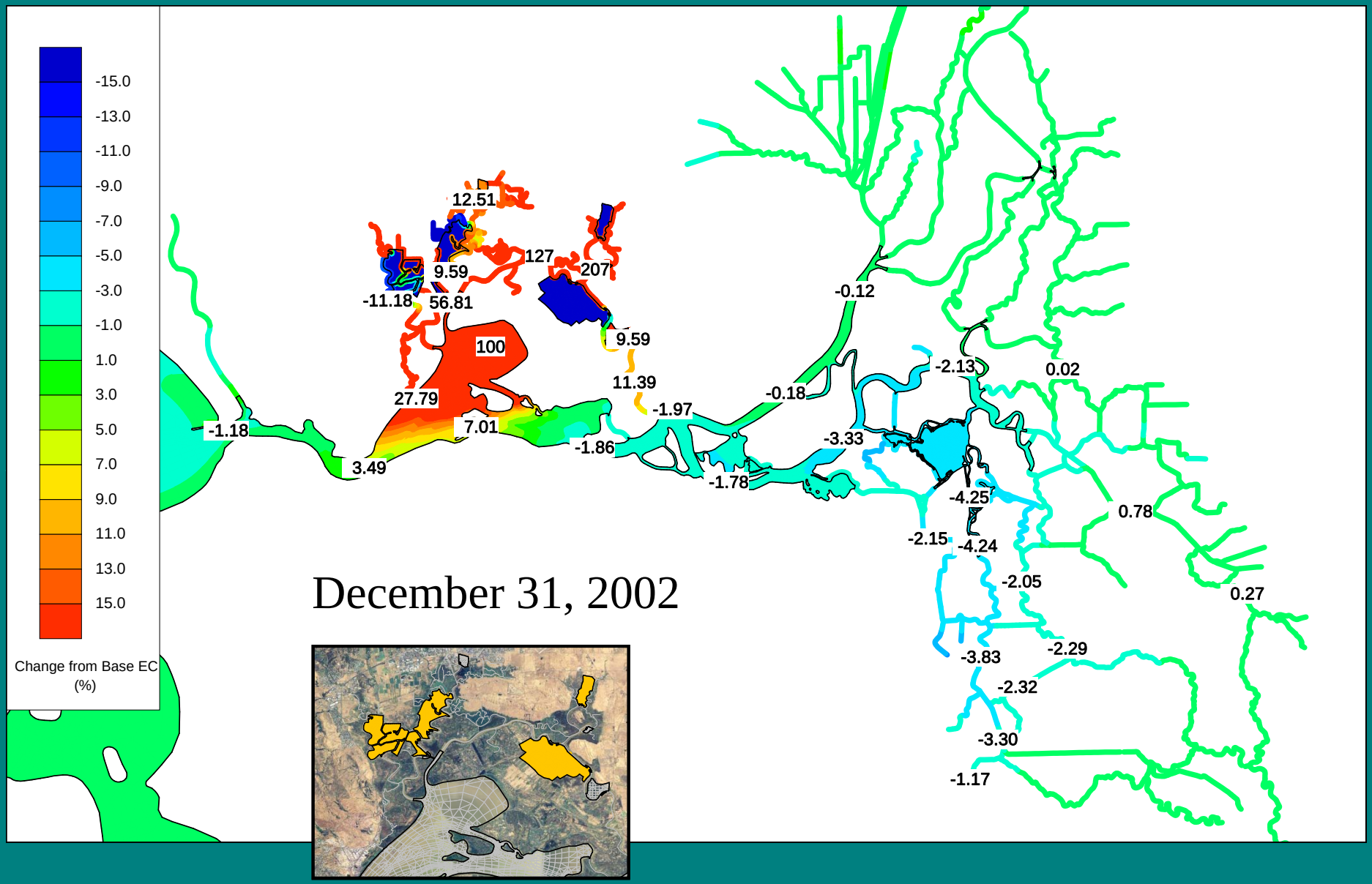
Set 1 - EC % Change From Base
September 1, 2002



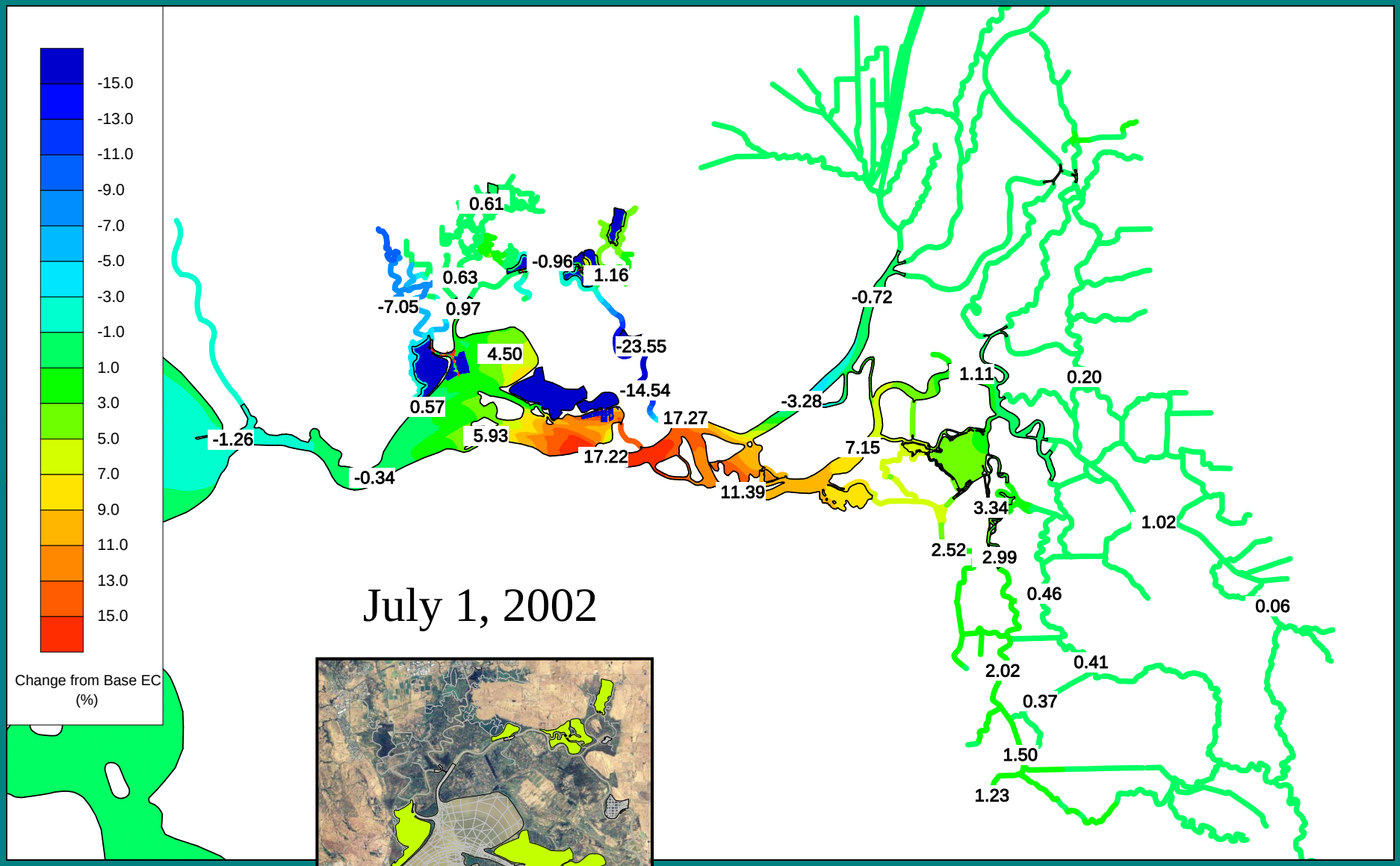
Set 1 - EC % Change From Base
November 1, 2002



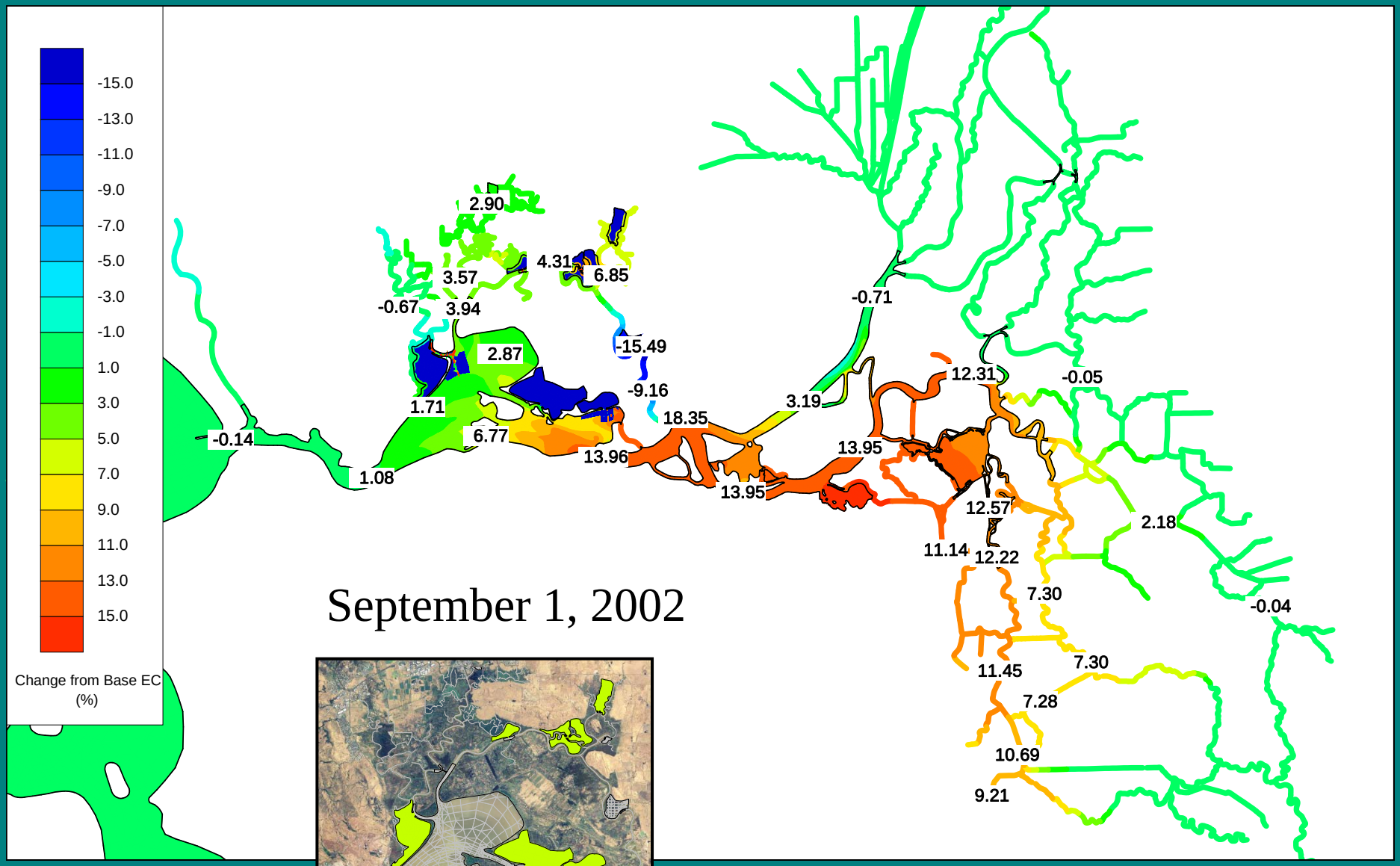
Set 1 - EC % Change From Base
December 31, 2002



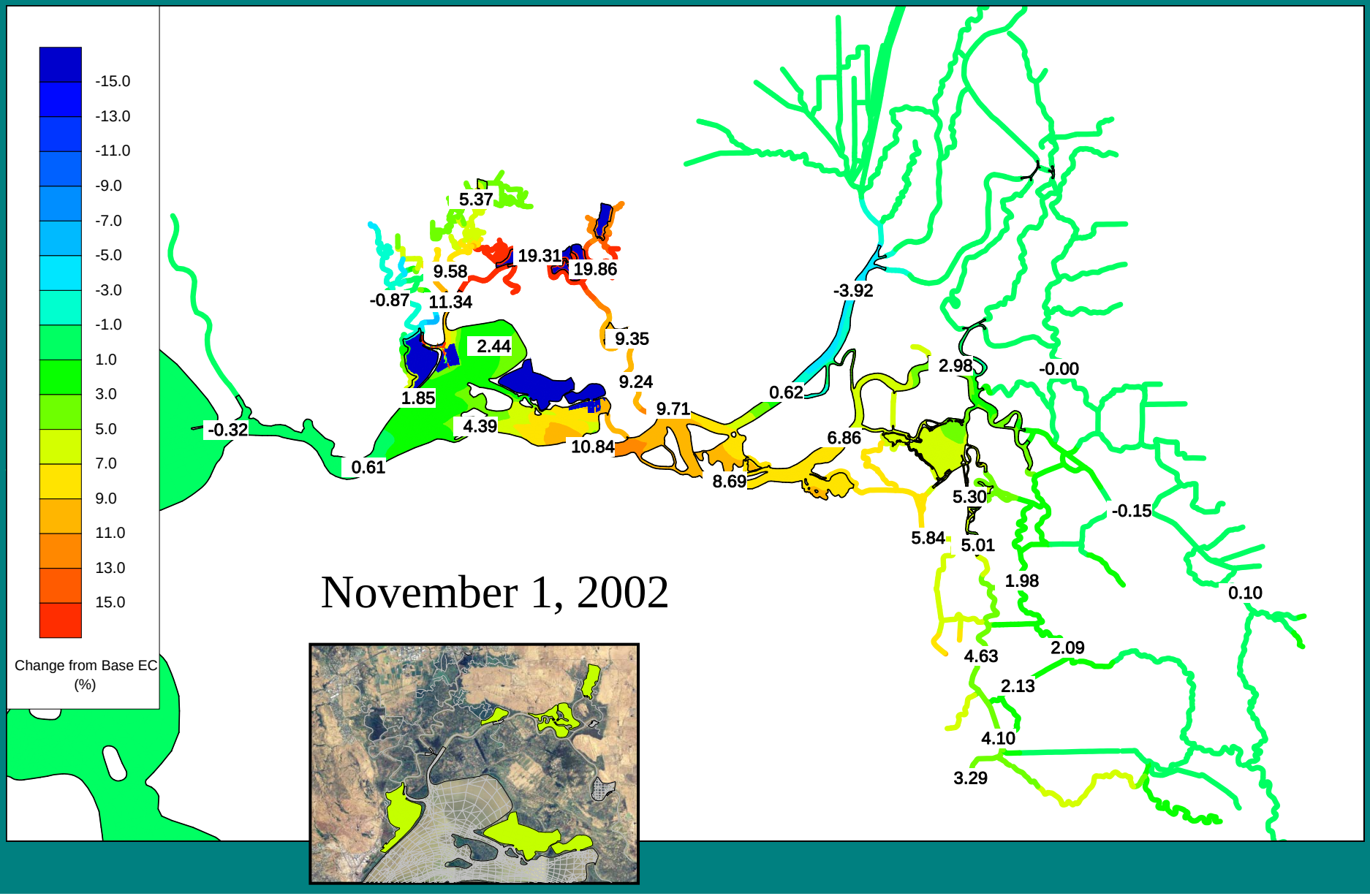
Set 2 - EC % Change From Base
July 1, 2002



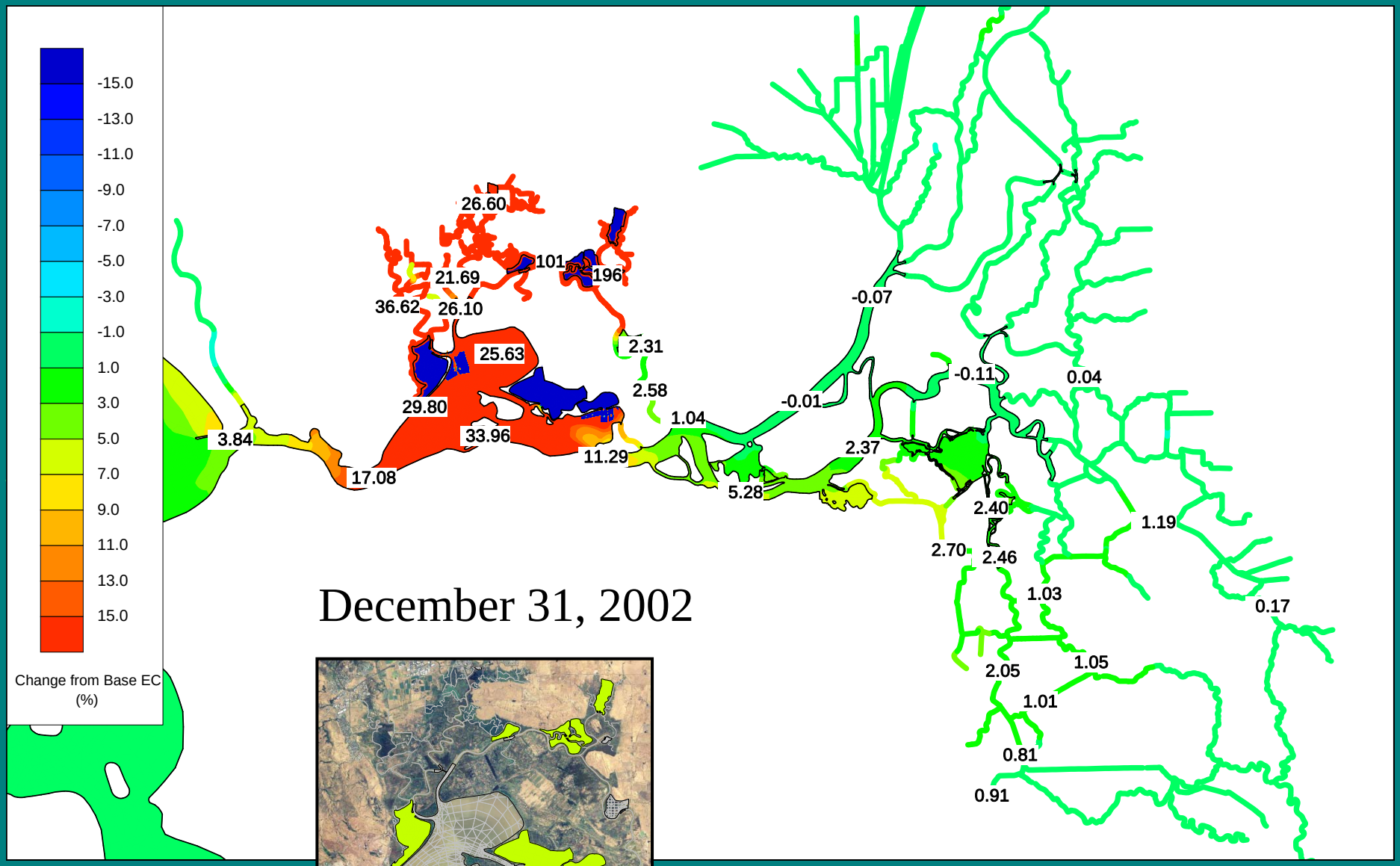
Set 2 - EC % Change From Base
September 1, 2002



Set 2 - EC % Change From Base
November 1, 2002



Set 2 - EC % Change From Base
December 31, 2002



Local and Delta-Wide Hydrodynamic Impacts of Large Scale Tidal Marsh Restoration

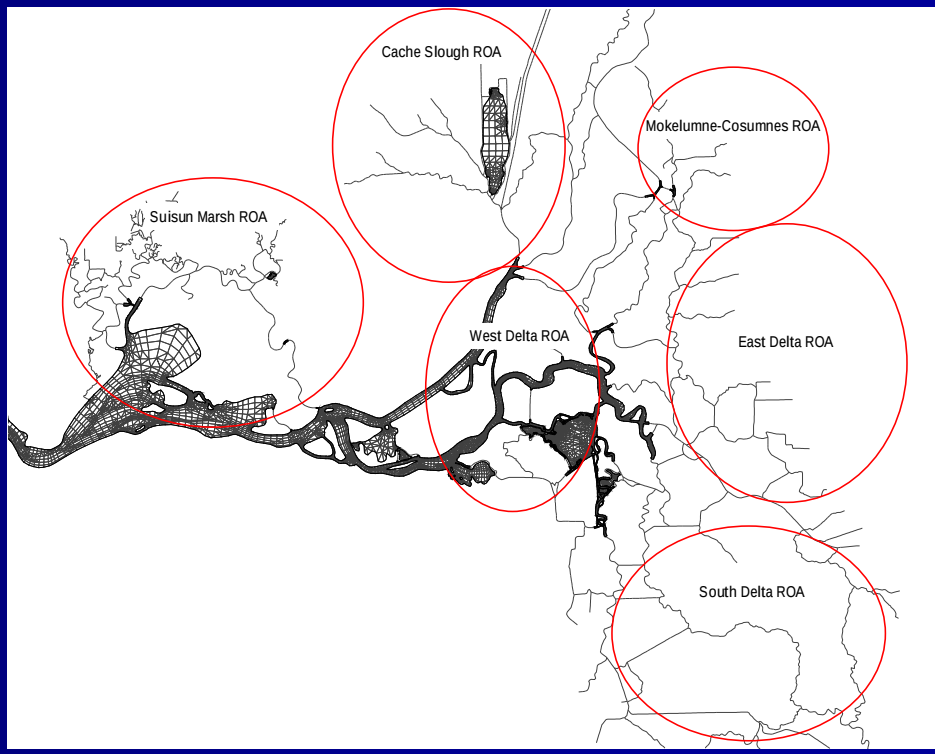
Modeling in support of the Bay Delta Conservation Plan

John DeGeorge
Stacie Grinbergs
Richard Rachiele
Resource Management Associates

Bay-Delta Science Conference 2010

Restoration Opportunity Areas

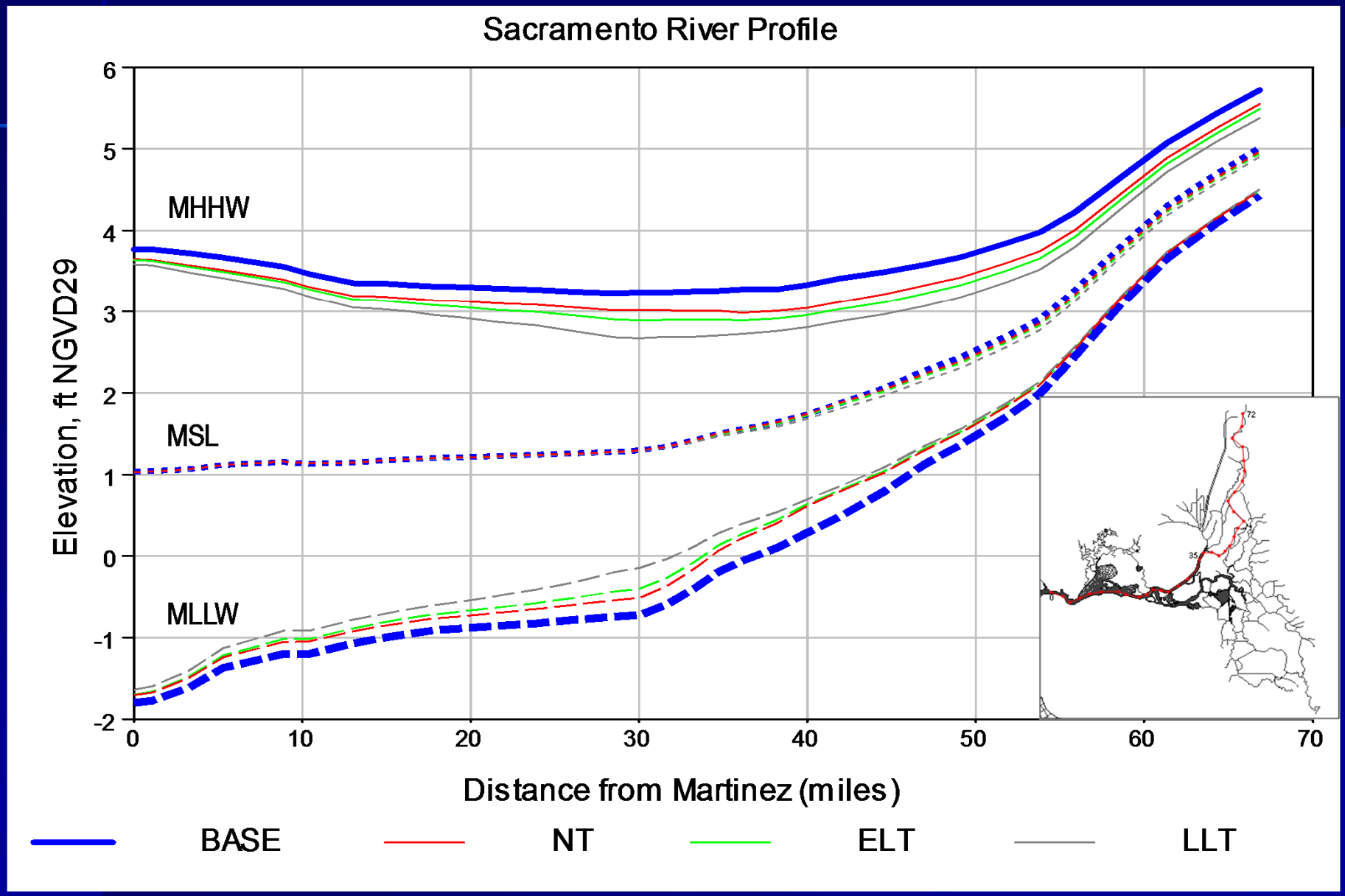
- Near Term
  - Before Implementation of an isolated facility
  - Restoration Target: 16,000 ac
- Early Long Term
  - After implementation of an isolated facility
  - Restoration Target: 25,000 ac
- Late Long Term
  - 40 to 50 years in the future, climate change and sea level rise possible
  - Restoration Target: 65,000 ac



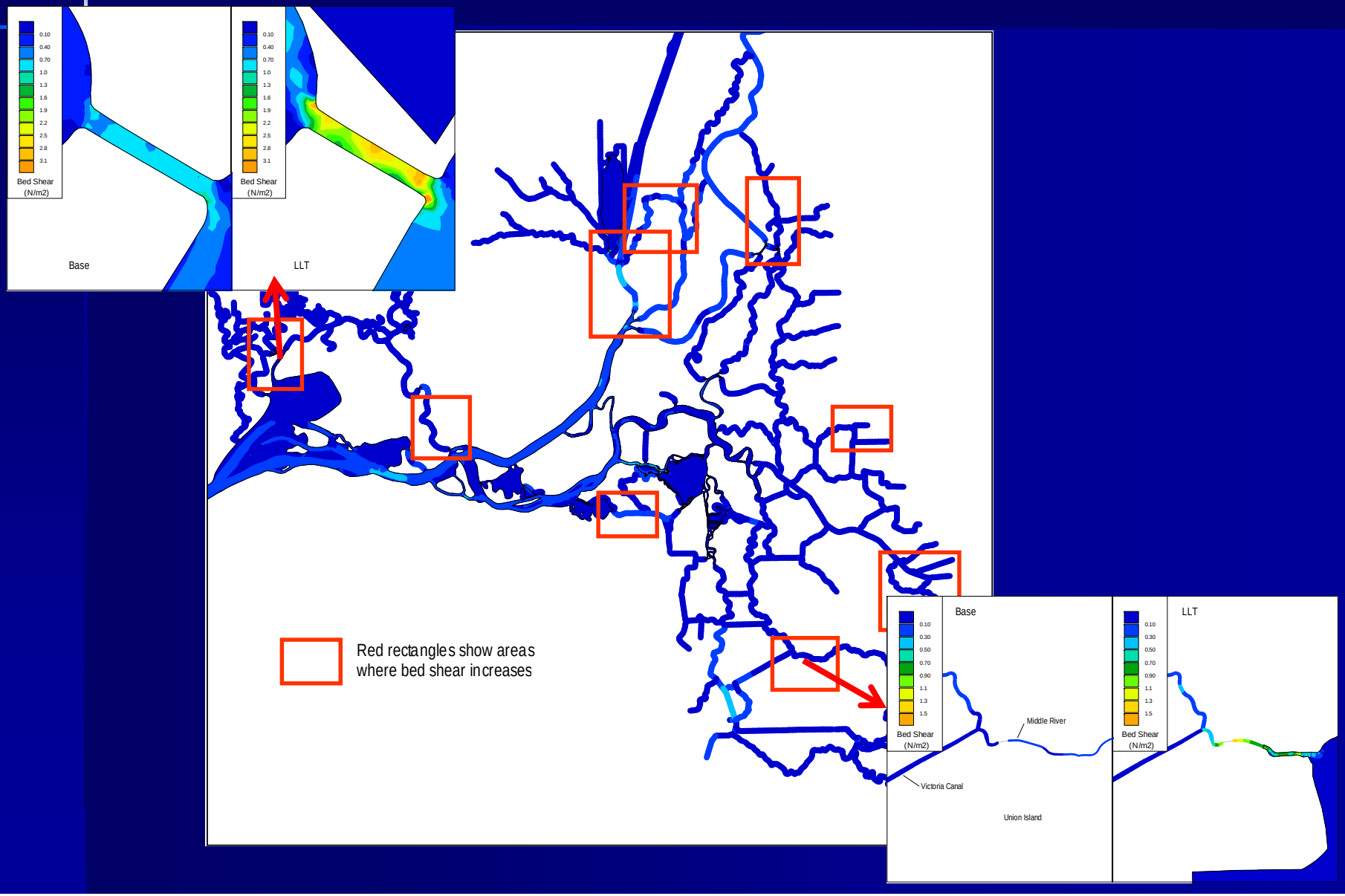
Modeled Restoration Acreages

	Near Term		Early Long Term		Late Long Term	
ROA	Total Area (acres)	% Tidal Marsh* (acres)	Total Area (acres)	% Tidal Marsh* (acres)	Total Area (acres)	% Tidal Marsh* (acres)
Suisun Marsh	6,454	43%	8,133	43%	14,389	26%
Cache Slough	6,749	45%	12,897	46%	20,334	34%
West Delta	2,306	51%	3,992	69%	4,236	70%
Mokelumne - Cosumnes	2,904	29%	2,904	29%	3,293	25%
East Delta	-	-	-	-	2,163	70%
South Delta	-	-	-	-	22,483	8%
Total	18,413	43%	27,926	43%	66,898	25%

*Tidal Marsh acreage calculated as the area between mean higher high and mean lower low water from developed from hydrodynamic model results, definition still under discussion

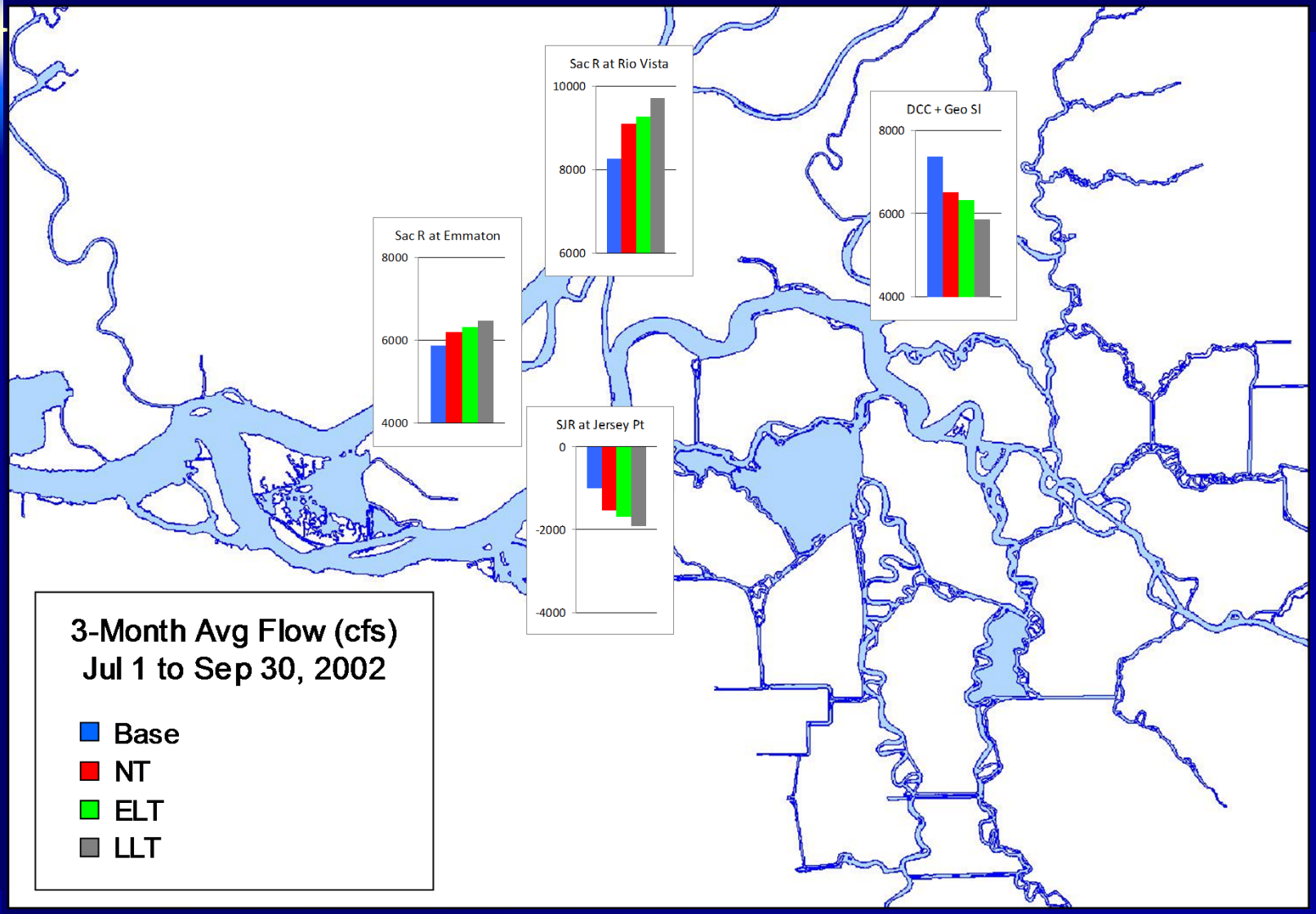

Sacramento River Profile
Elevation, ft NGVD29
6
5
4
3
2
1
0
-1
-2
MHHW
MSL
MLLW
0
10
20
30
40
50
60
70
Distance from Martinez (miles)
BASE
NT
ELT
LLT

Areas with Increased Bed Shear



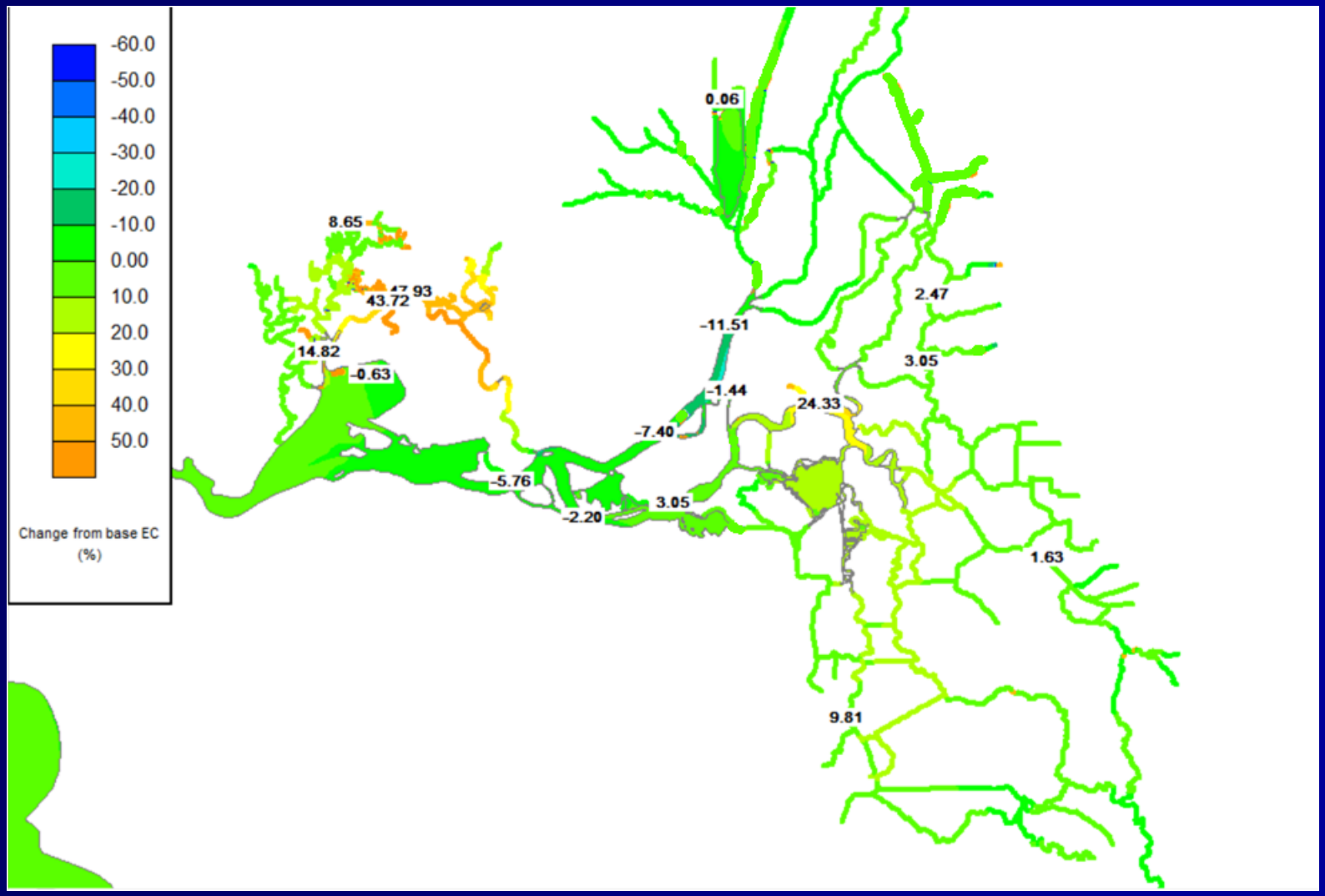
Net Flow in the Central Delta

BDCP test flow data set

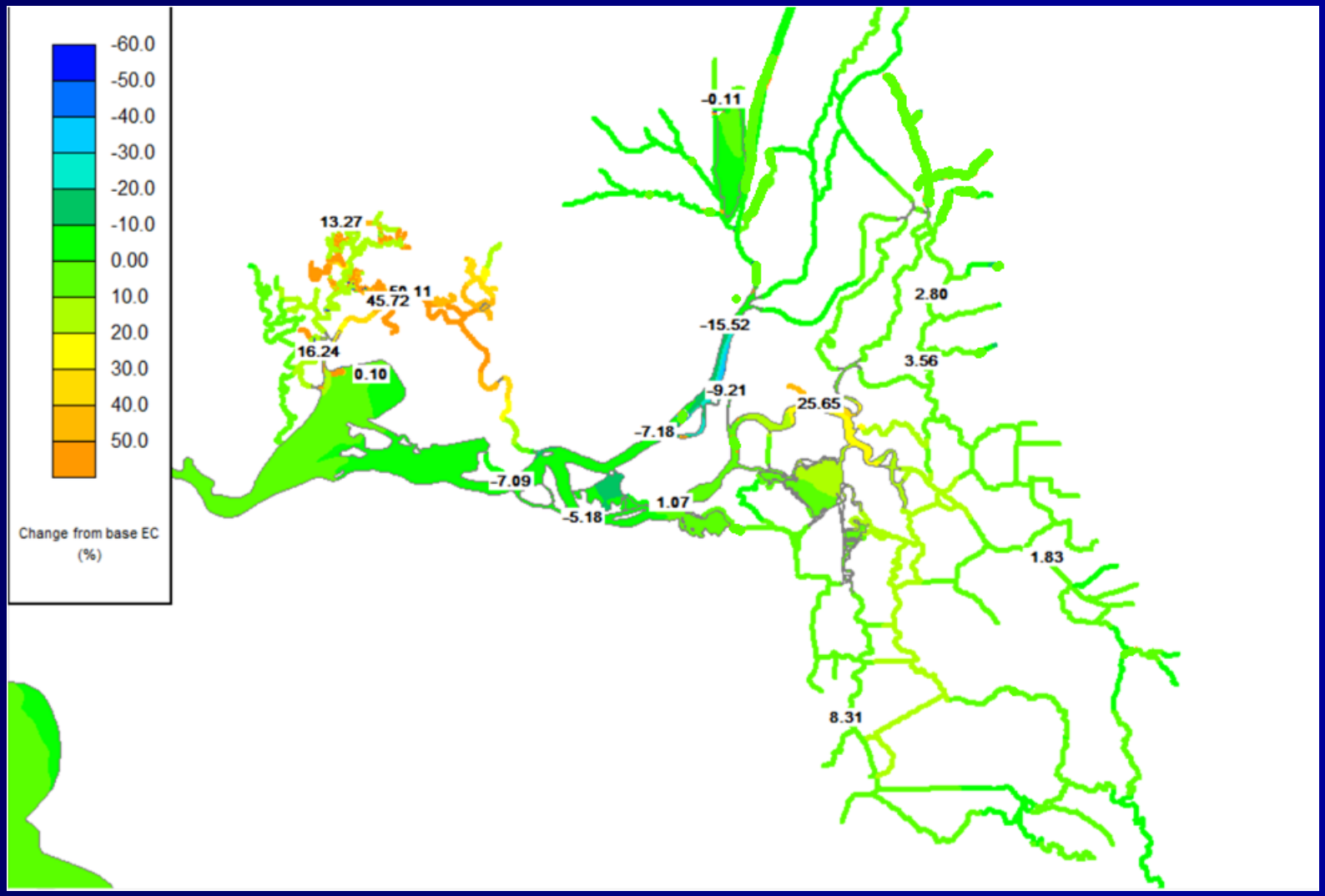


Note: flows do not exactly reflect 2002 historic conditions

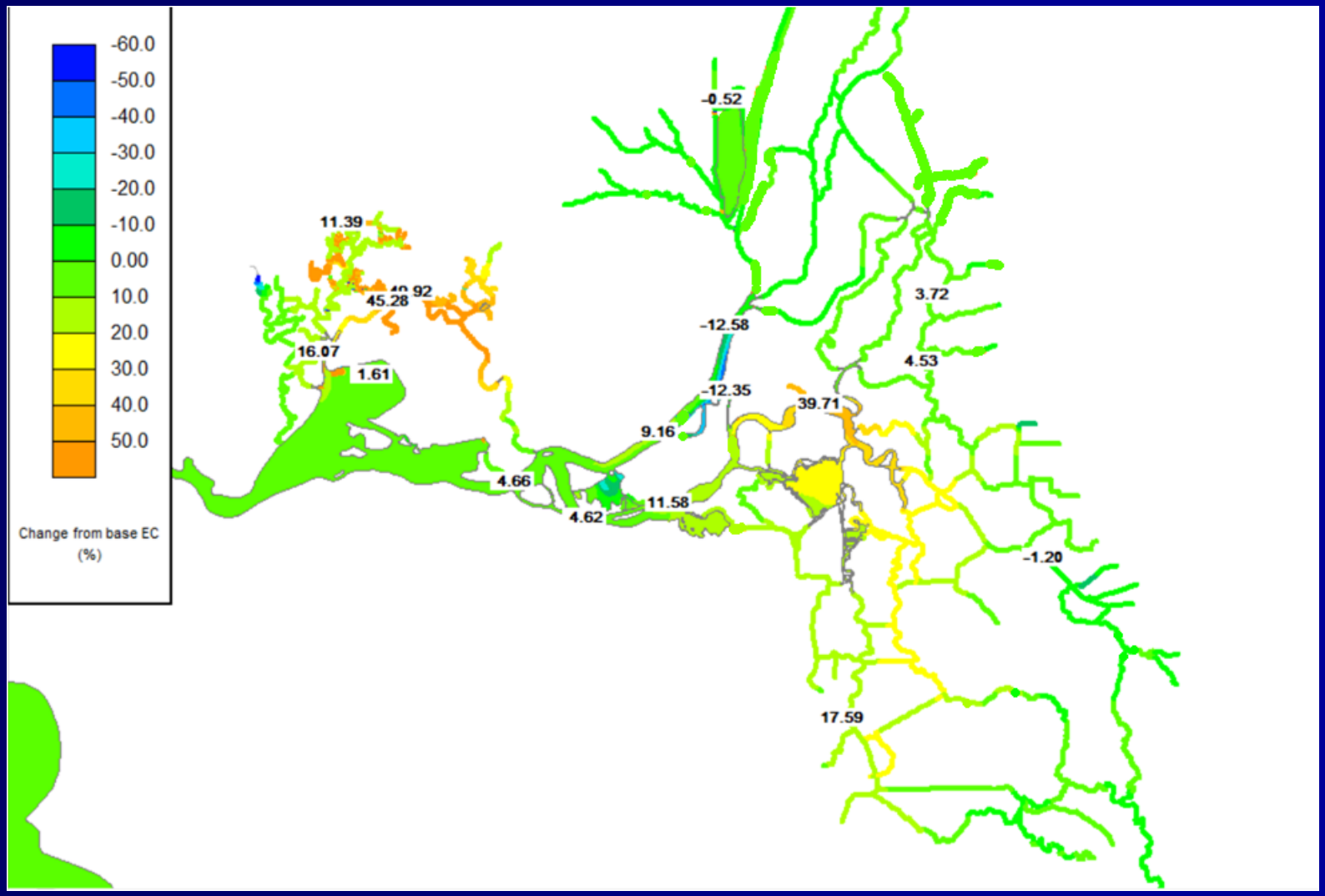
Percent change in Tidal Average EC from Base to NT September 30, 2002



Percent change in Tidal Average EC from Base to ELT September 30, 2002



Percent change in Tidal Average EC from Base to LLT September 30, 2002

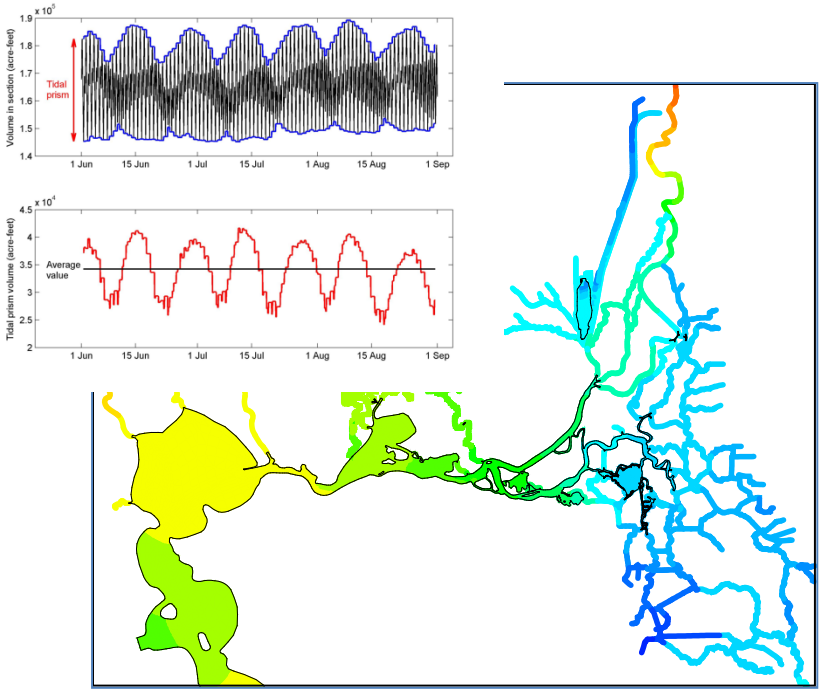


RMA

Resource Management Associates

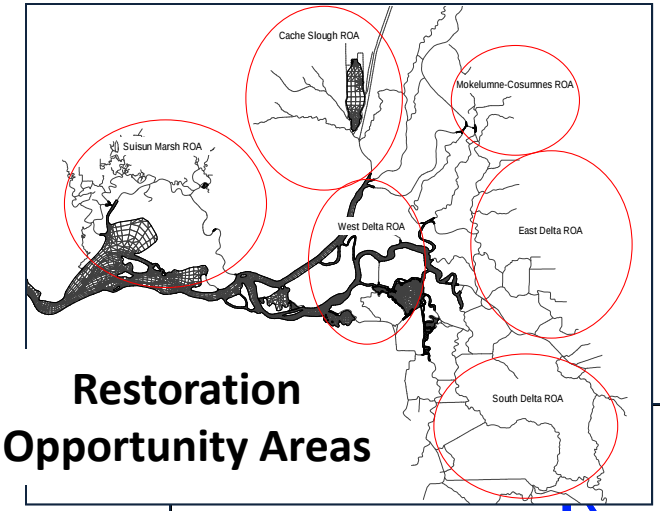
Analysis of the Distribution of Tidal Prism in the Sacramento-San Joaquin Delta

John DeGeorge
Stephen Andrews
Richard Rachiele
Stacie Grinbergs

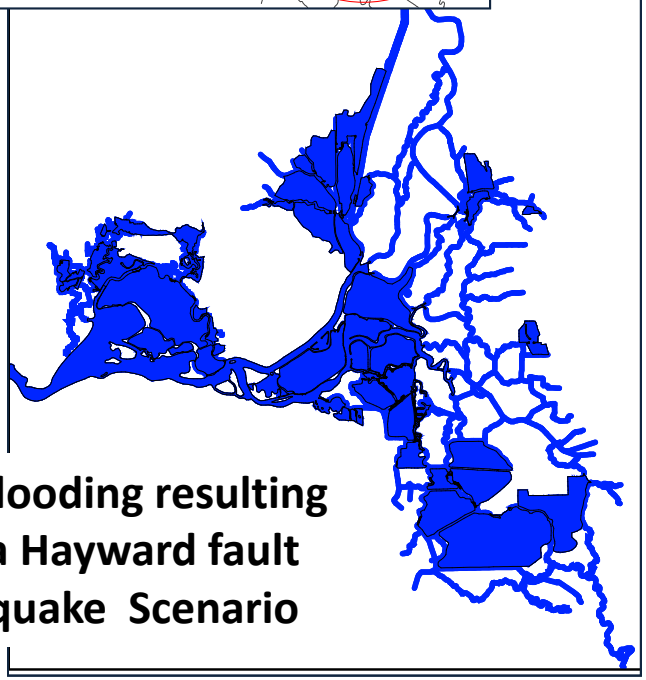


Large Scale Restoration and Island Failure Scenarios Simulated for BDCP

- Near Term
  - Before Implementation of an isolated facility
  - Restoration Target: 16,000 ac
- Early Long Term
  - After implementation of an isolated facility
  - Restoration Target: 25,000 ac
- Late Long Term
  - 40 to 50 years in the future, climate change and sea level rise possible
  - Restoration Target: 65,000 ac
- LLT + Hayward Fault Scenario
  - 12 Delta Islands and Grizzly Island failures



Restoration Opportunity Areas



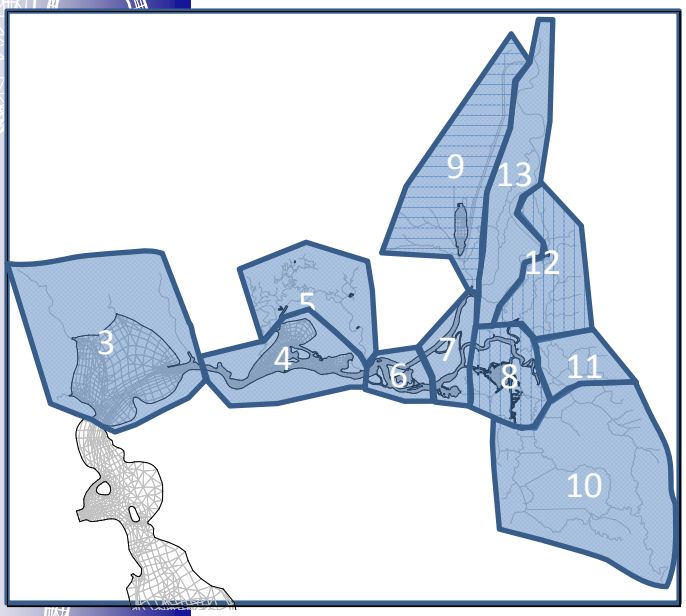
Island flooding resulting from a Hayward fault earthquake Scenario

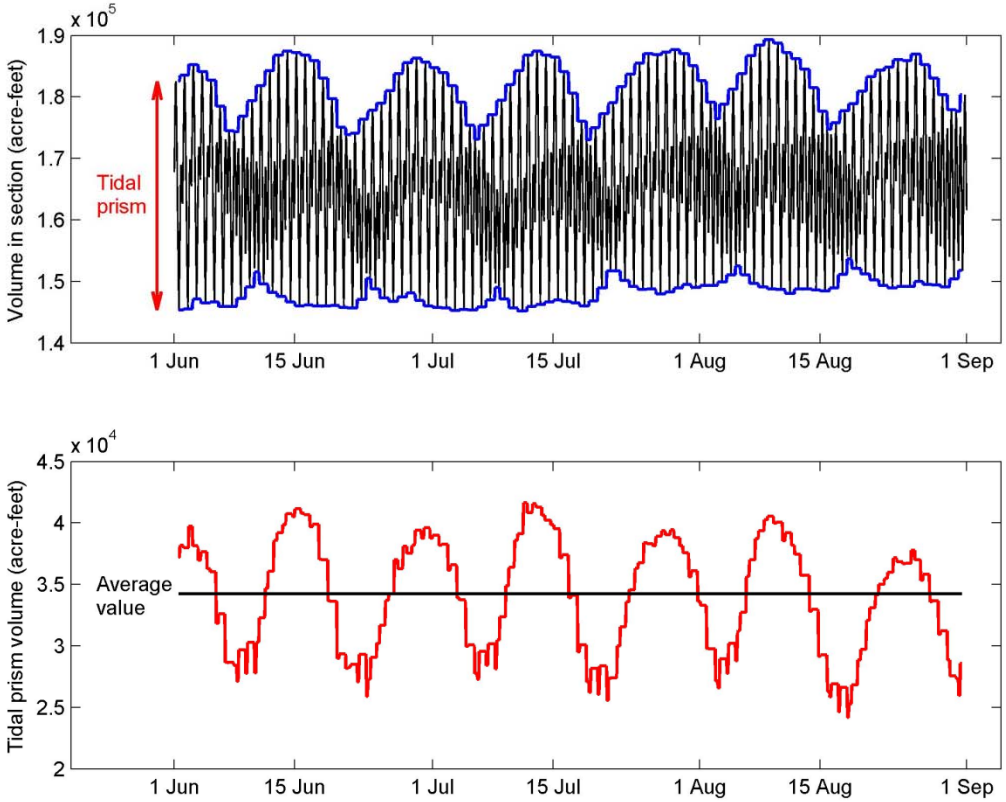
Model results show that tidal flow into the Delta does not increase much with added wetted area for current sea level…..Why?

- How is the tidal prism (or tidal energy) limited ?
- How does it distribute over the Delta?
- What are the trade offs when planning large scale restoration?

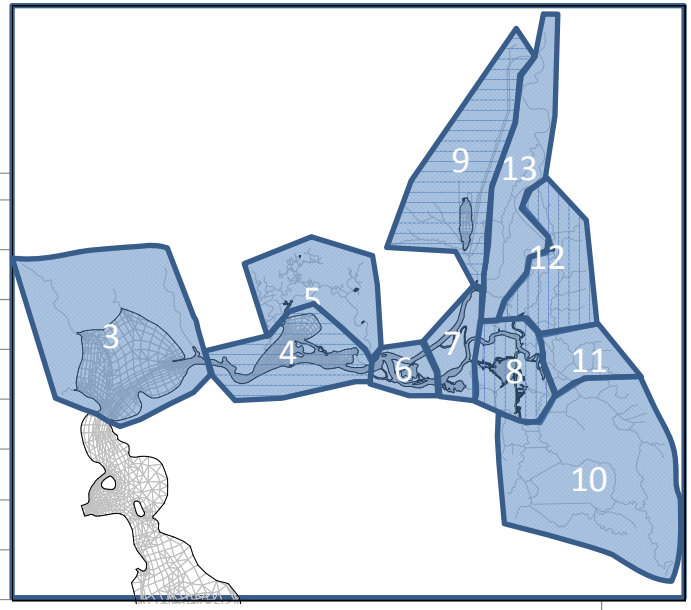
Regional Tidal Prism (a Metric)

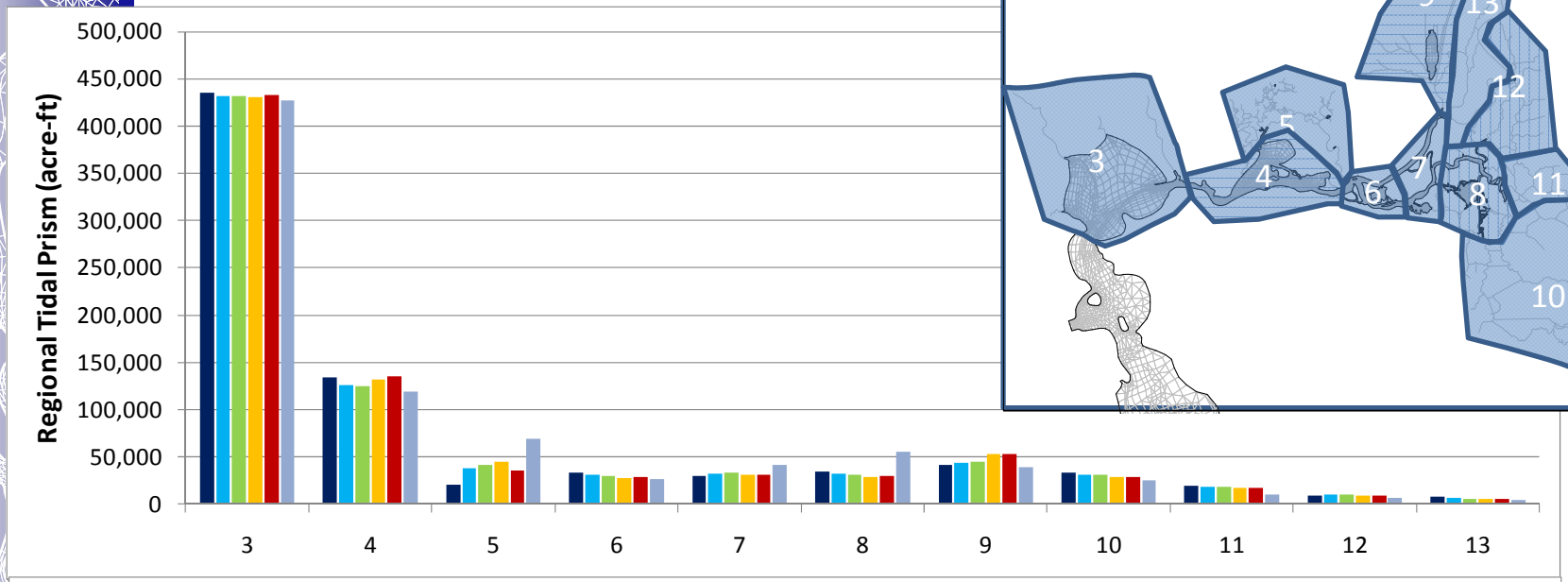
- Average tidal prism calculated from daily maximum and minimum region volume

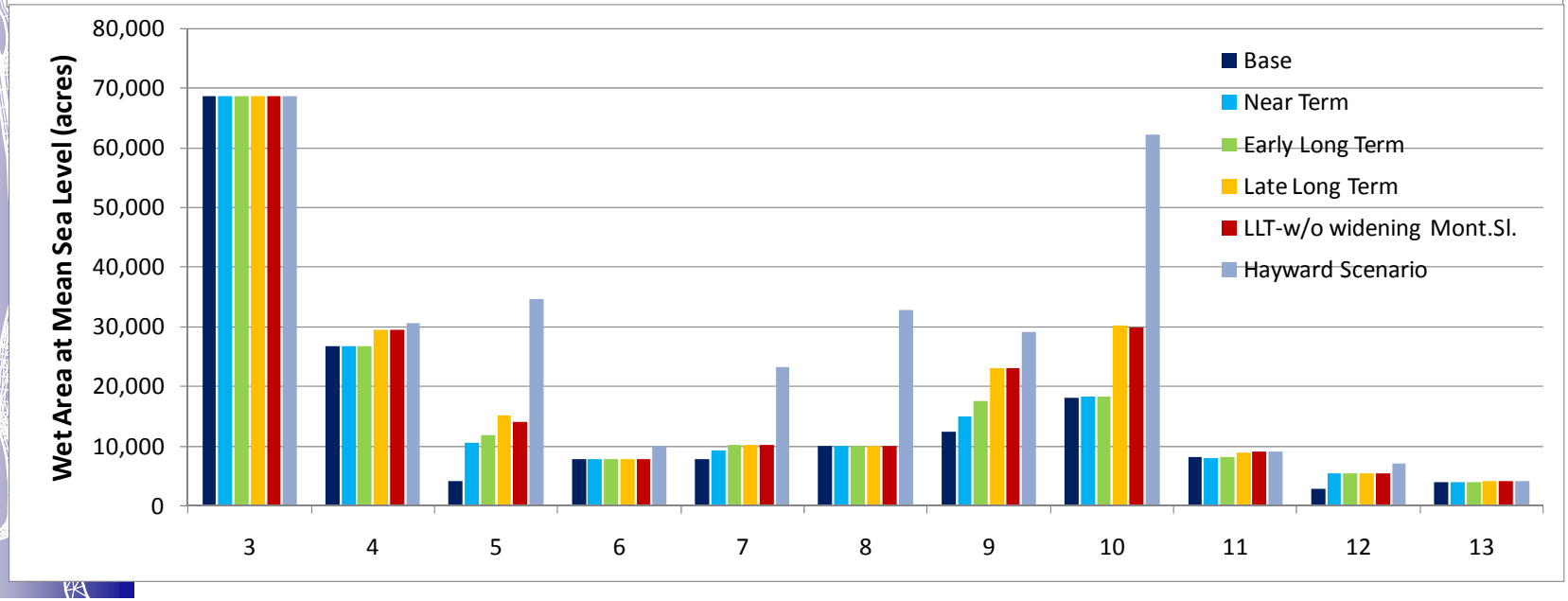




Regional Tidal Prism and Area

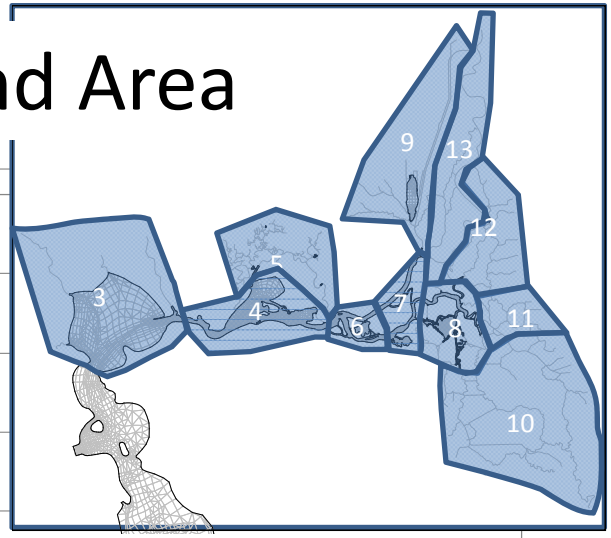


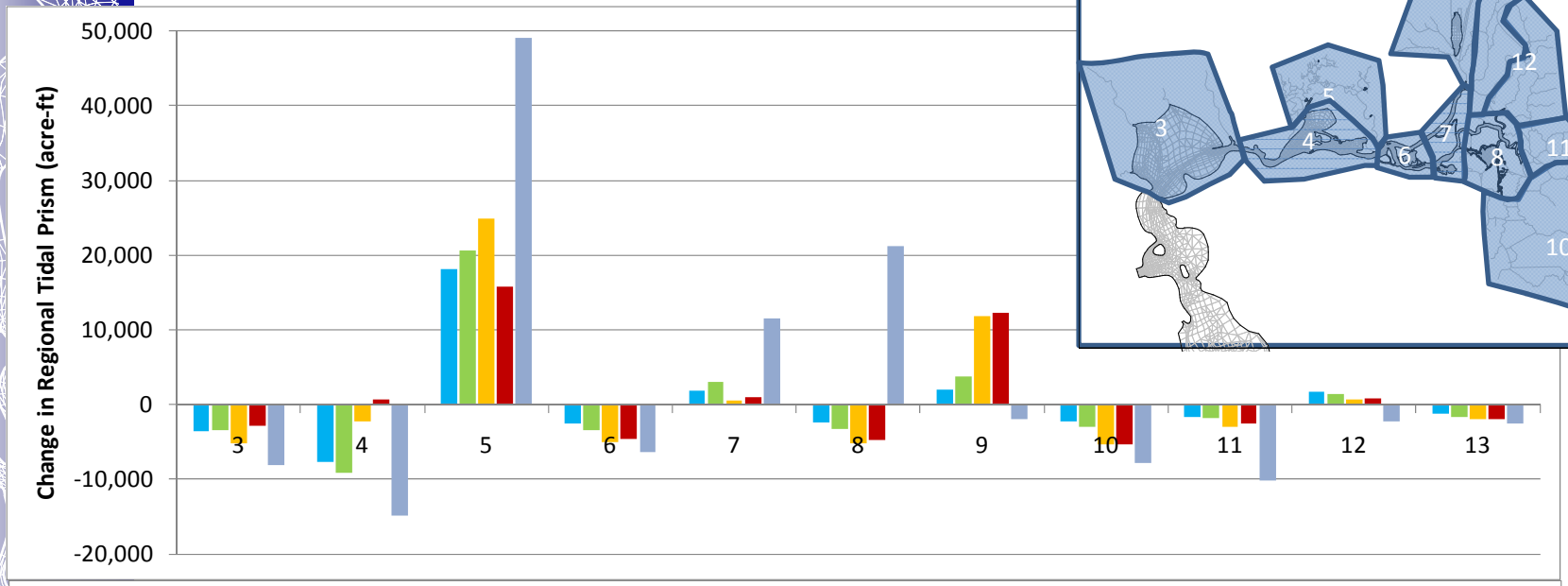


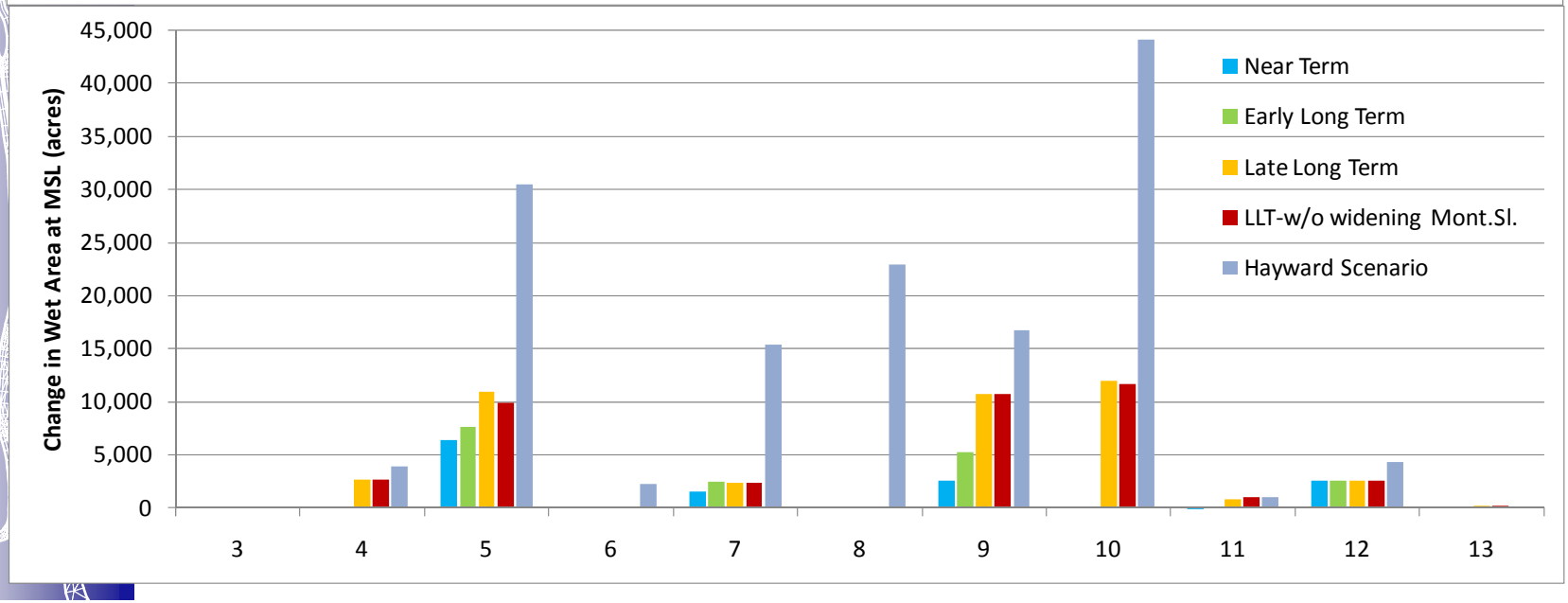


Preliminary Results....Work in Progress....Subject to Revision

Change in Regional Tidal Prism and Area







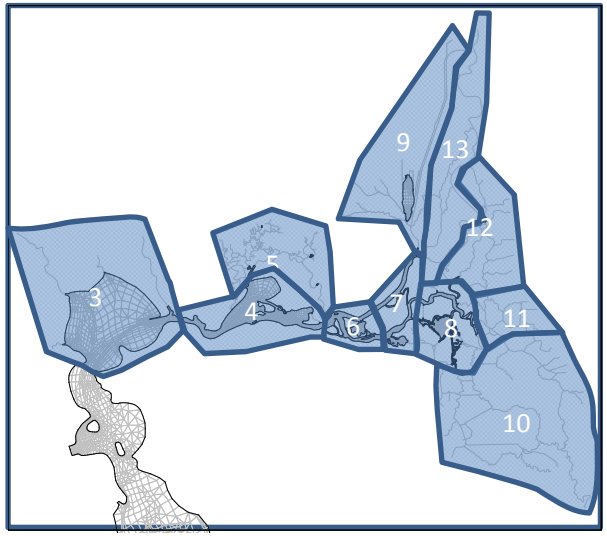
Preliminary Results....Work in Progress....Subject to Revision

%Change in Tidal Prism, Area, and Stage Range

Preliminary Results....Work in Progress....Subject to Revision

Tidal Prism

		NT	ELT	LLT	LLT-M.	Hayw.
San Pablo Bay	3	-1%	-1%	-1%	-1%	-2%
Suisun Bay	4	-6%	-7%	-2%	1%	-11%
Suisun Marsh	5	90%	101%	123%	78%	242%
Confluence	6	-8%	-10%	-15%	-14%	-19%
Emmaton/JP	7	6%	10%	2%	3%	39%
Central Delta	8	-7%	-9%	-15%	-14%	62%
Cache Slough	9	5%	9%	29%	30%	-5%
South Delta	10	-7%	-9%	-16%	-16%	-23%
East Central Delta	11	-9%	-9%	-15%	-13%	-51%
Mokelumne	12	20%	16%	8%	9%	-25%
Upper Sacramento	13	-16%	-22%	-26%	-26%	-34%
Upstream of Carquinez		2%	2%	4%	3%	10%



Wet Area

		NT	ELT	LLT	LLT-M.	Hayw.
San Pablo Bay	3	0%	0%	0%	0%	0%
Suisun Bay	4	0%	0%	10%	10%	15%
Suisun Marsh	5	152%	181%	260%	236%	726%
Confluence	6	0%	0%	0%	0%	29%
Emmaton/JP	7	19%	32%	31%	31%	197%
Central Delta	8	0%	0%	0%	0%	229%
Cache Slough	9	21%	42%	86%	86%	135%
South Delta	10	1%	1%	66%	64%	242%
East Central Delta	11	-1%	0%	10%	12%	12%
Mokelumne	12	93%	93%	93%	93%	154%
Upper Sacramento	13	0%	0%	5%	5%	3%
Upstream of Carquinez		13%	18%	41%	40%	138%

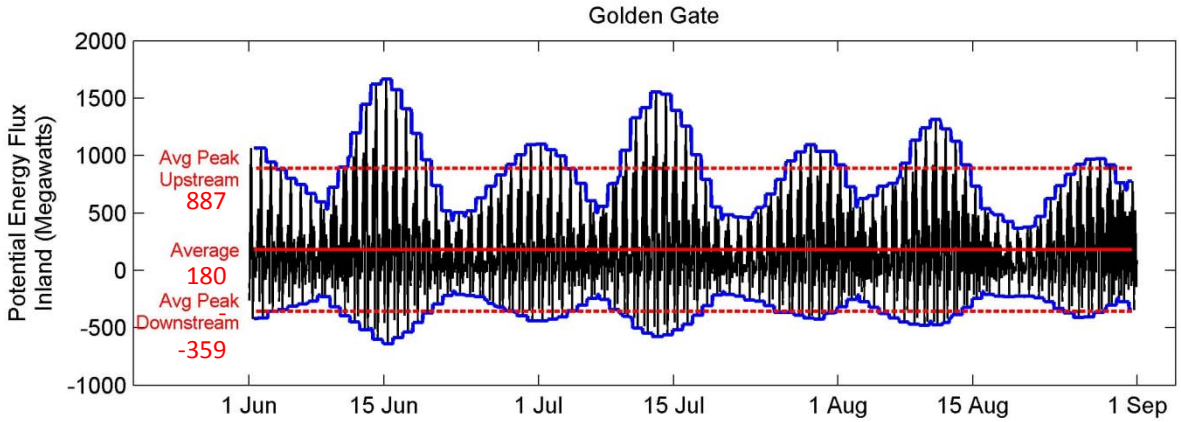
Stage Range

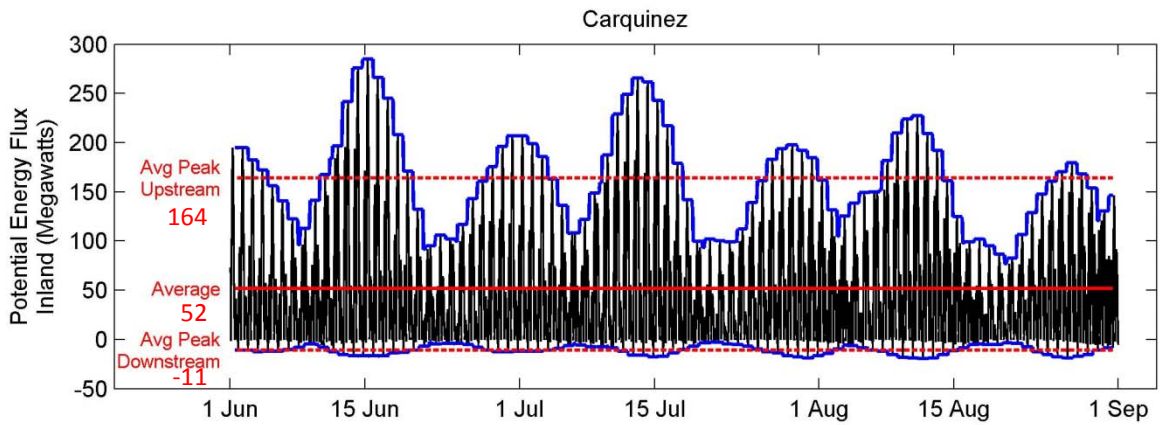
		NT	ELT	LLT	LLT-M.	Hayw.
San Pablo Bay	3	-1%	-1%	-1%	-1%	-2%
Suisun Bay	4	-6%	-7%	-11%	-9%	-22%
Suisun Marsh	5	-25%	-28%	-38%	-47%	-59%
Confluence	6	-8%	-10%	-15%	-14%	-38%
Emmaton/JP	7	-11%	-17%	-22%	-21%	-53%
Central Delta	8	-7%	-9%	-15%	-14%	-51%
Cache Slough	9	-13%	-23%	-31%	-30%	-59%
South Delta	10	-7%	-9%	-49%	-49%	-78%
East Central Delta	11	-7%	-9%	-23%	-23%	-56%
Mokelumne	12	-38%	-40%	-44%	-43%	-71%
Upper Sacramento	13	-16%	-22%	-29%	-29%	-35%
Upstream of Carquinez		-10%	-13%	-26%	-26%	-54%

Potential Energy Flux Estimate

$$\text{PE Flux (W)} \cong \rho g Q h$$

- Q = cross section flow
- h = the water surface elevation difference from mean sea level





References:

Egbert, G. and R. Ray, "Estimates of M2 tidal energy dissipation from TOPEX/Posidon altimeter data", Journal of Geophysical Research, VOL 106 No C10, pages 22,475-22,502, Oct. 2001

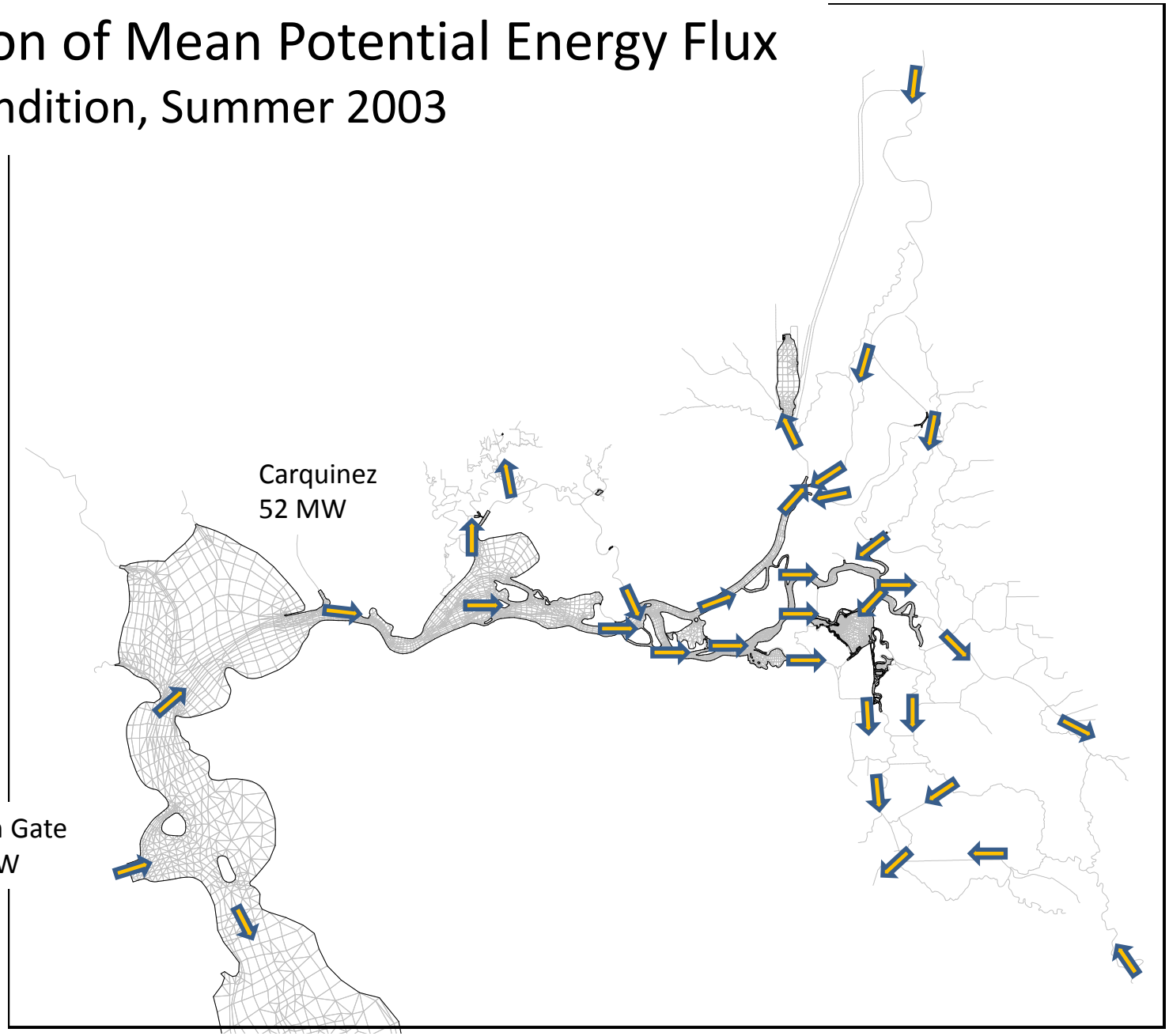
Taylor, G.I., "Tidal Friction in the Irish Sea", Philosophical Transactions of the Royal Society of London. Series A, Containing Papers of a Mathematical or Physical Character, Vol. 220 , pp. 1-33, 1920

Thanks to Edward Gross for a preliminary Literature Review!

Preliminary Results....Work in Progress....Subject to Revision

Direction of Mean Potential Energy Flux

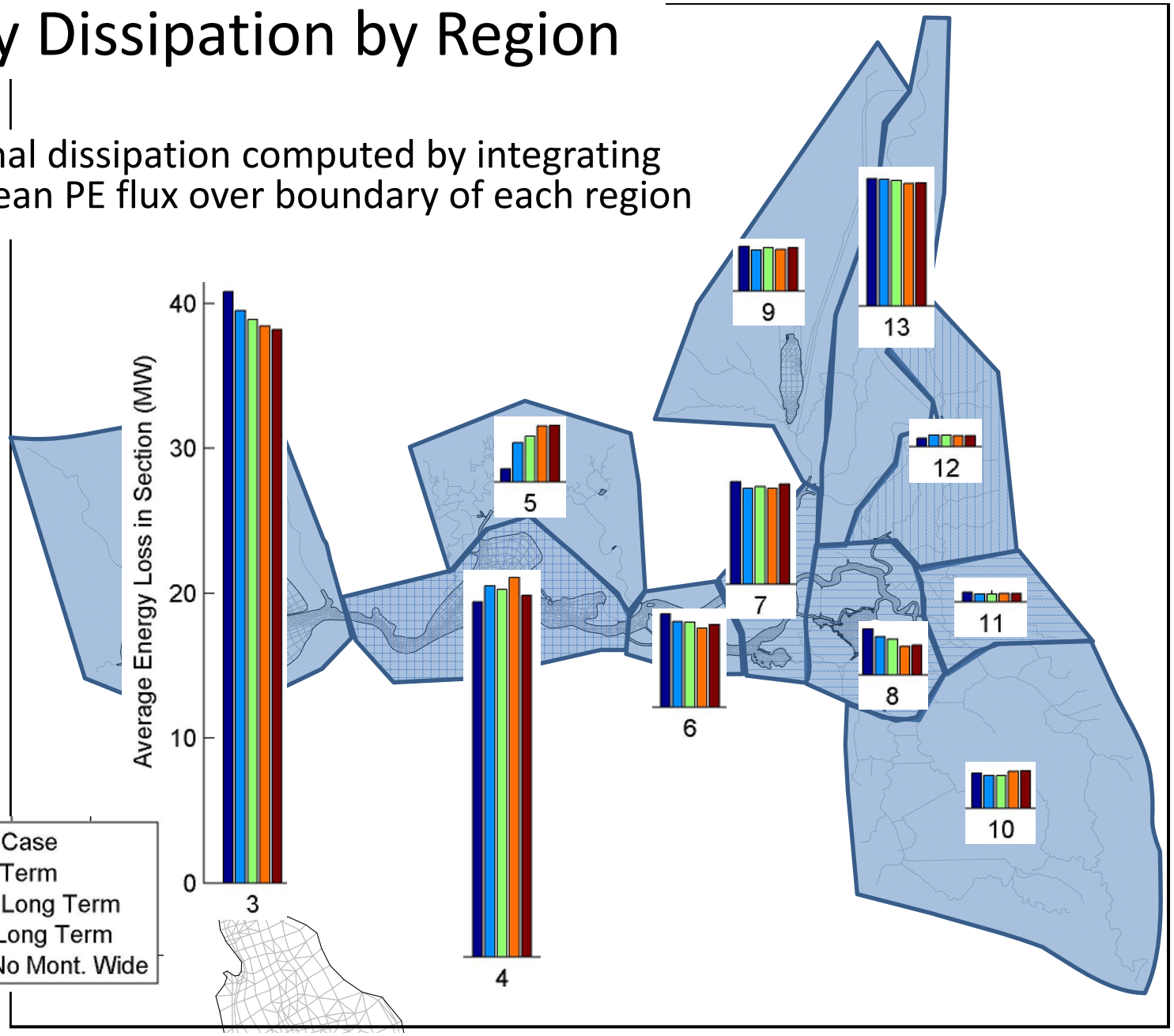
Base Condition, Summer 2003



Preliminary Results....Work in Progress....Subject to Revision

Energy Dissipation by Region

- Regional dissipation computed by integrating the mean PE flux over boundary of each region



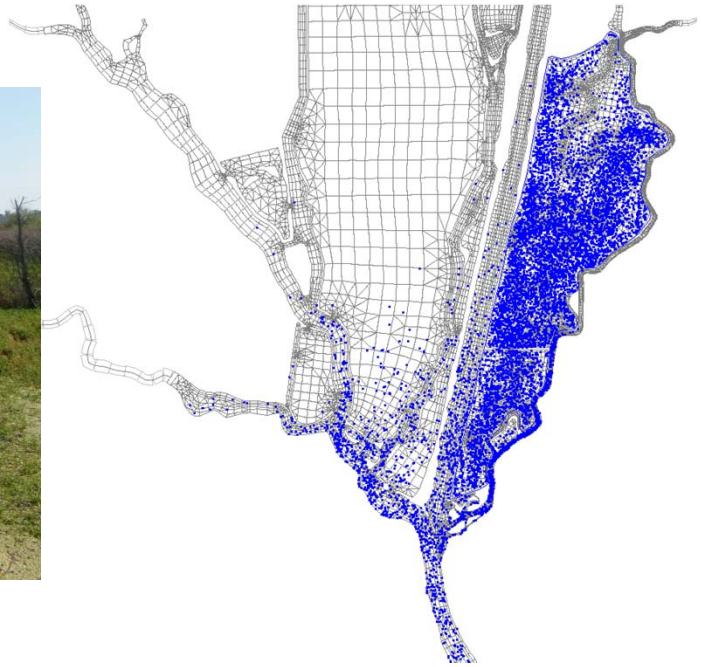
Preliminary Results....Work in Progress....Subject to Revision

RMA

Resource Management Associates

Evaluating Productivity Potential for Prospect Island Restoration Alternatives using Particle Tracking Methods

Stephen Andrews, Richard Rachiele, John DeGeorge

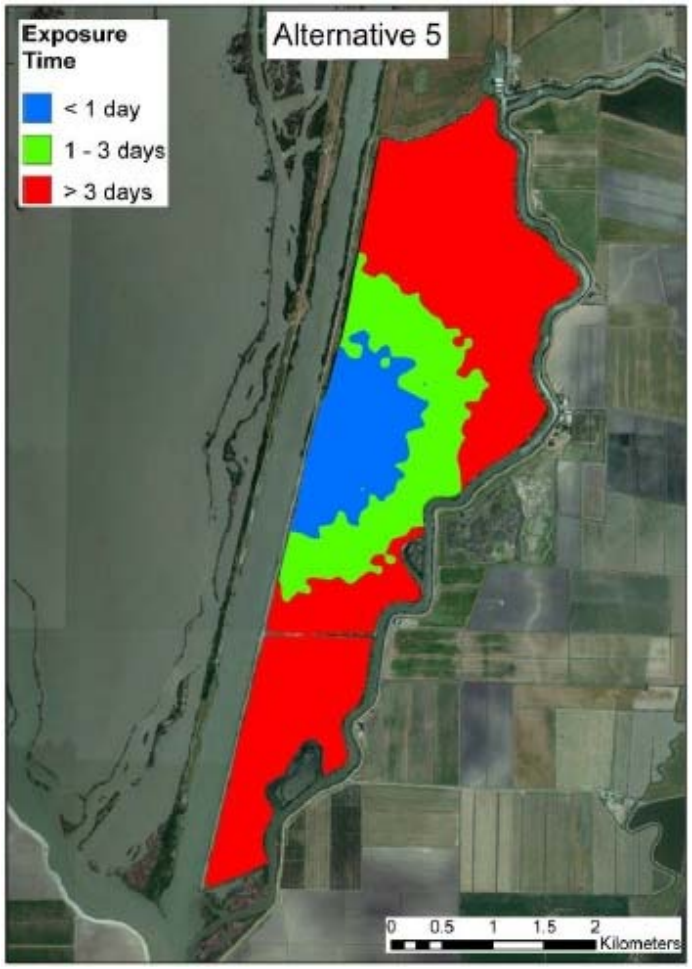


Phase I Screening Level Objectives

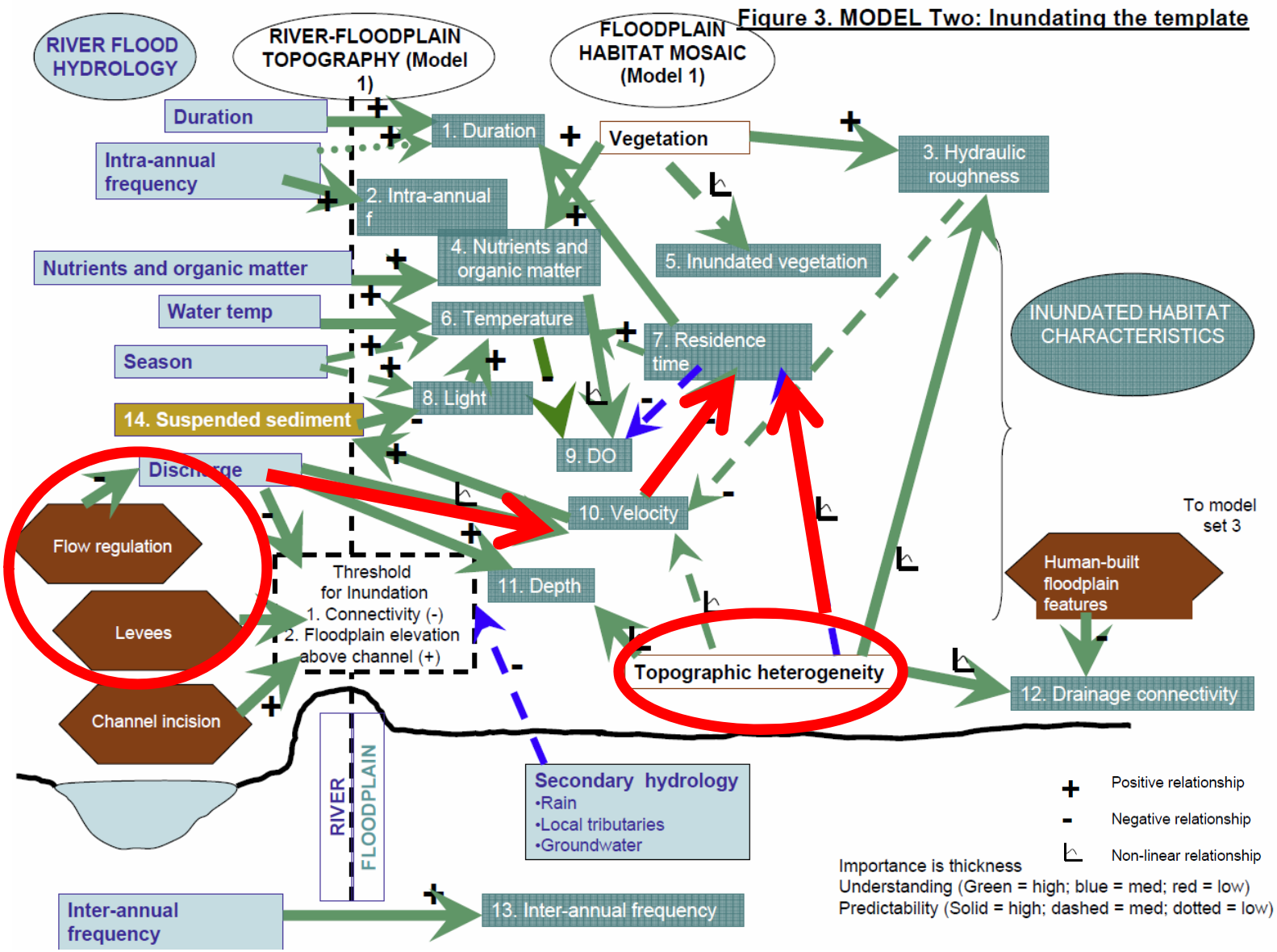
- Maximize
  - food web productivity within the restoration site
  - tidal mixing of exported productivity
- Minimize
  - dissolved organic carbon (DOC) impacts at Barker Slough Pump Plant
  - flood conveyance impacts on the Yolo Bypass
  - flood conveyance impacts on Miner Slough
  - reduction of tidal range
  - velocity cross currents in the DWSC
  - scour potential to Ryer Island Miner Slough levee

Metrics for Assessing Alternative Performance

- Focus on exposure time within a specific optimal time range
  - 1 to 3 days
  - Enough time to support diatom production
  - Not enough to support Cyanobacteria production

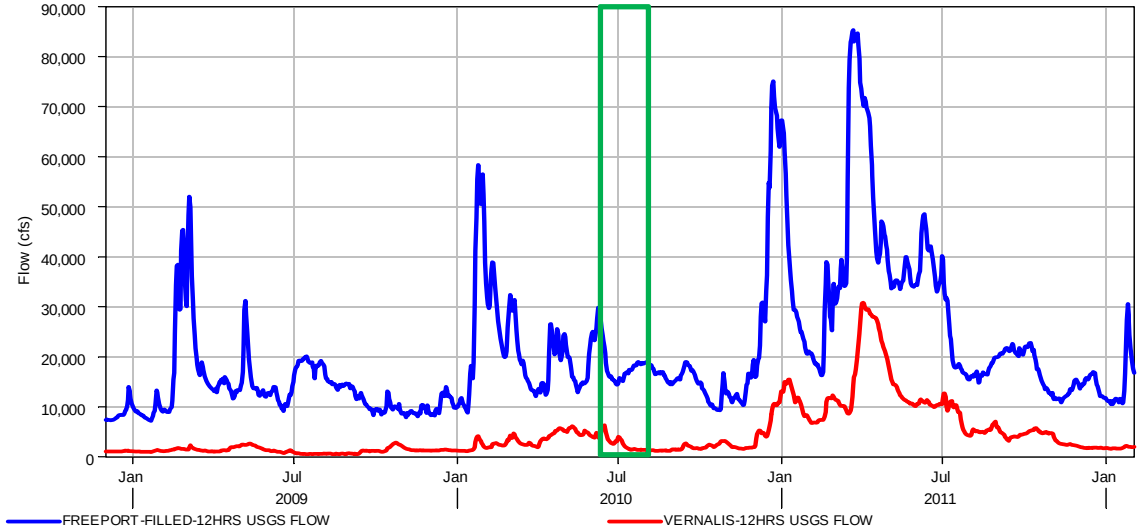


DRERIP Floodplain Conceptual Model

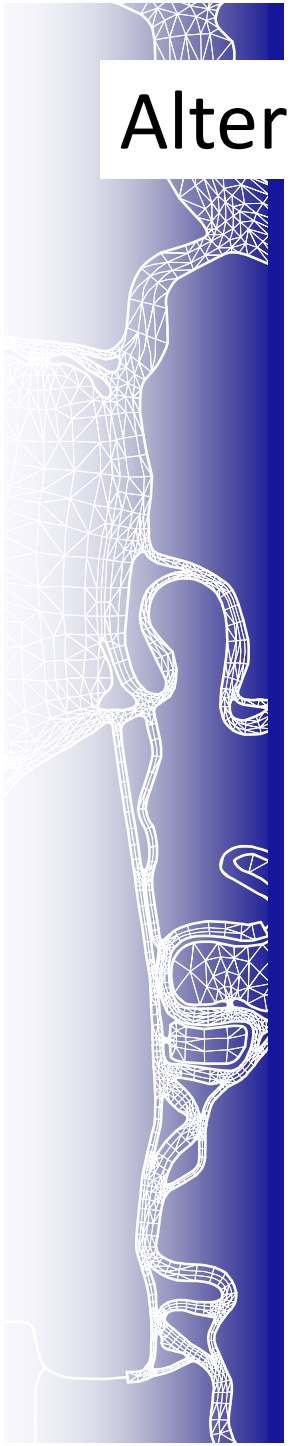


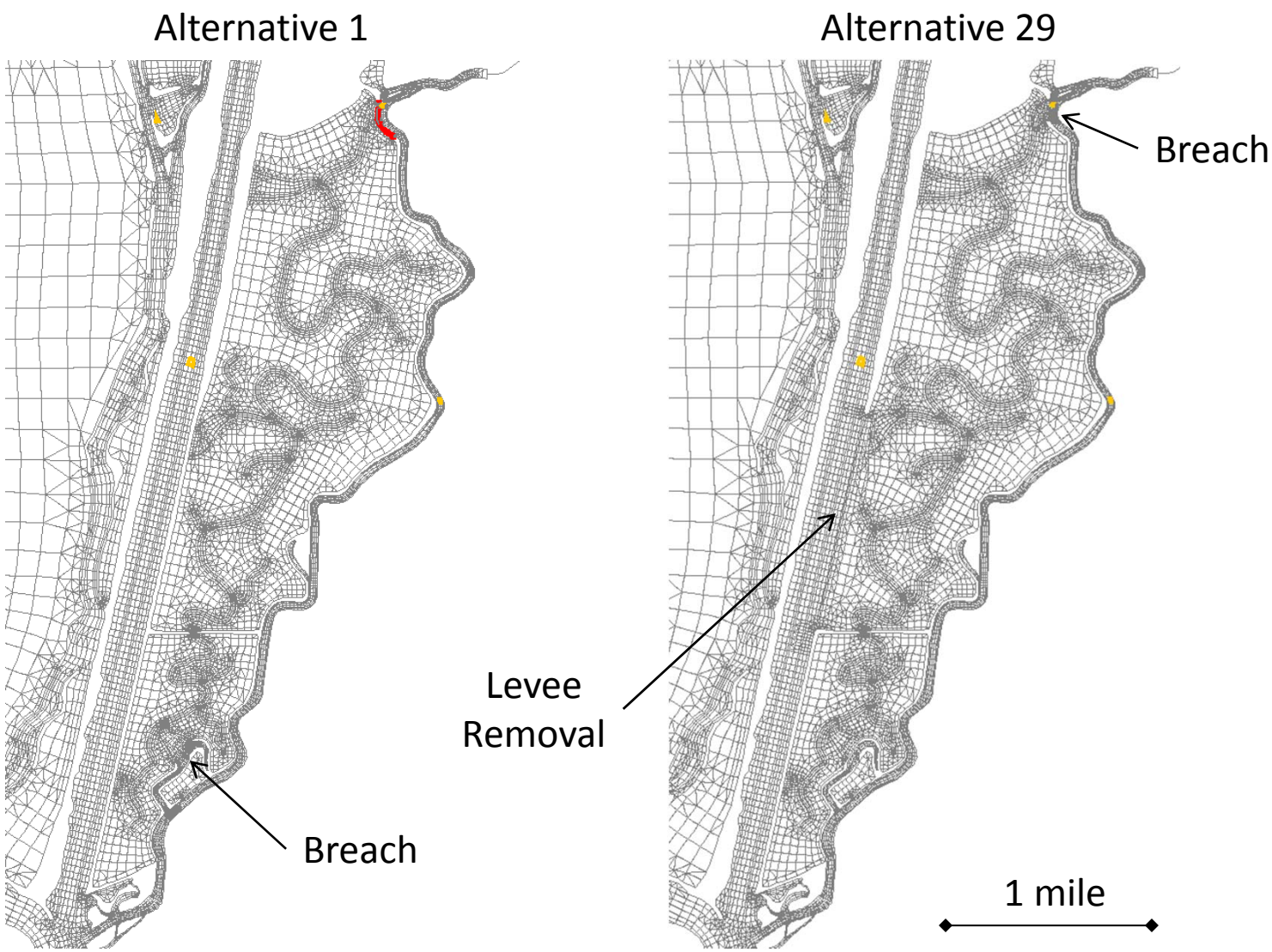
Modeling Approach

- Hydrodynamic modeling of June - July 2010
- Particle tracking simulations
  - Drops made every 2 hours over a 2 week spring neap cycle
    - ~160,000 particles
  - Calculate total particle exposure time to interior Prospect Island conditions
  - Track ultimate fate of particle

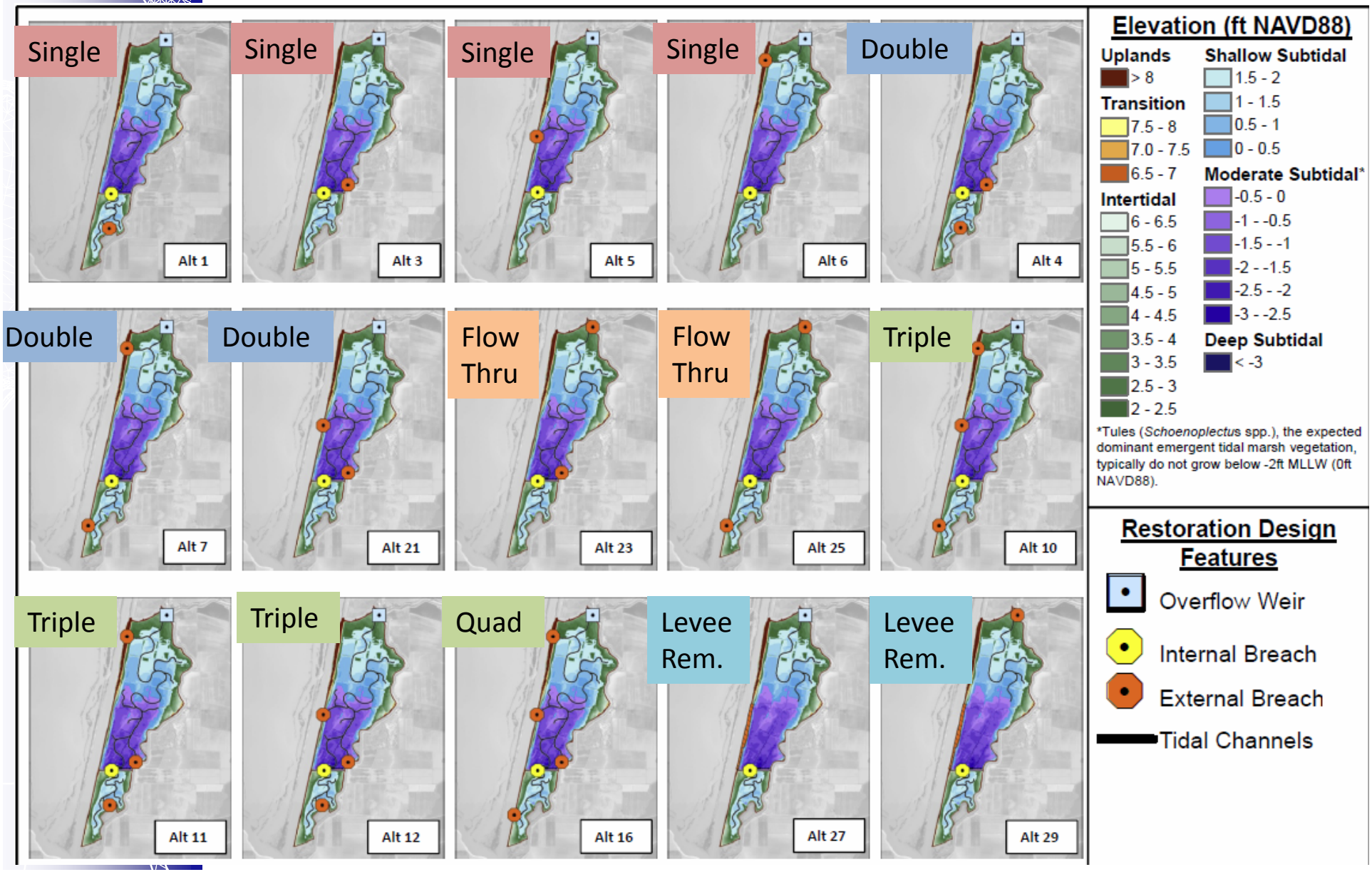


Alternative Grids

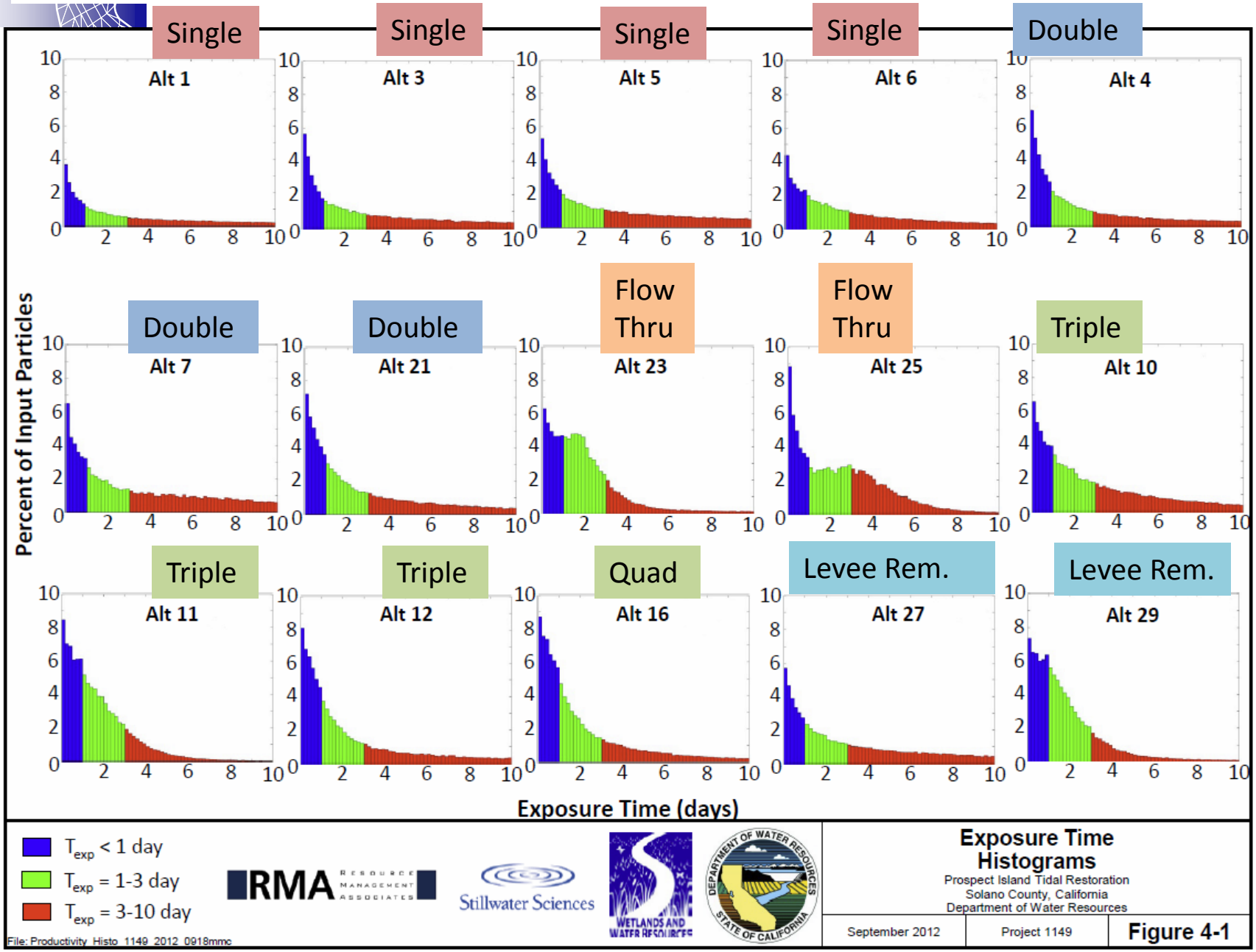




Restoration Alternative Configurations



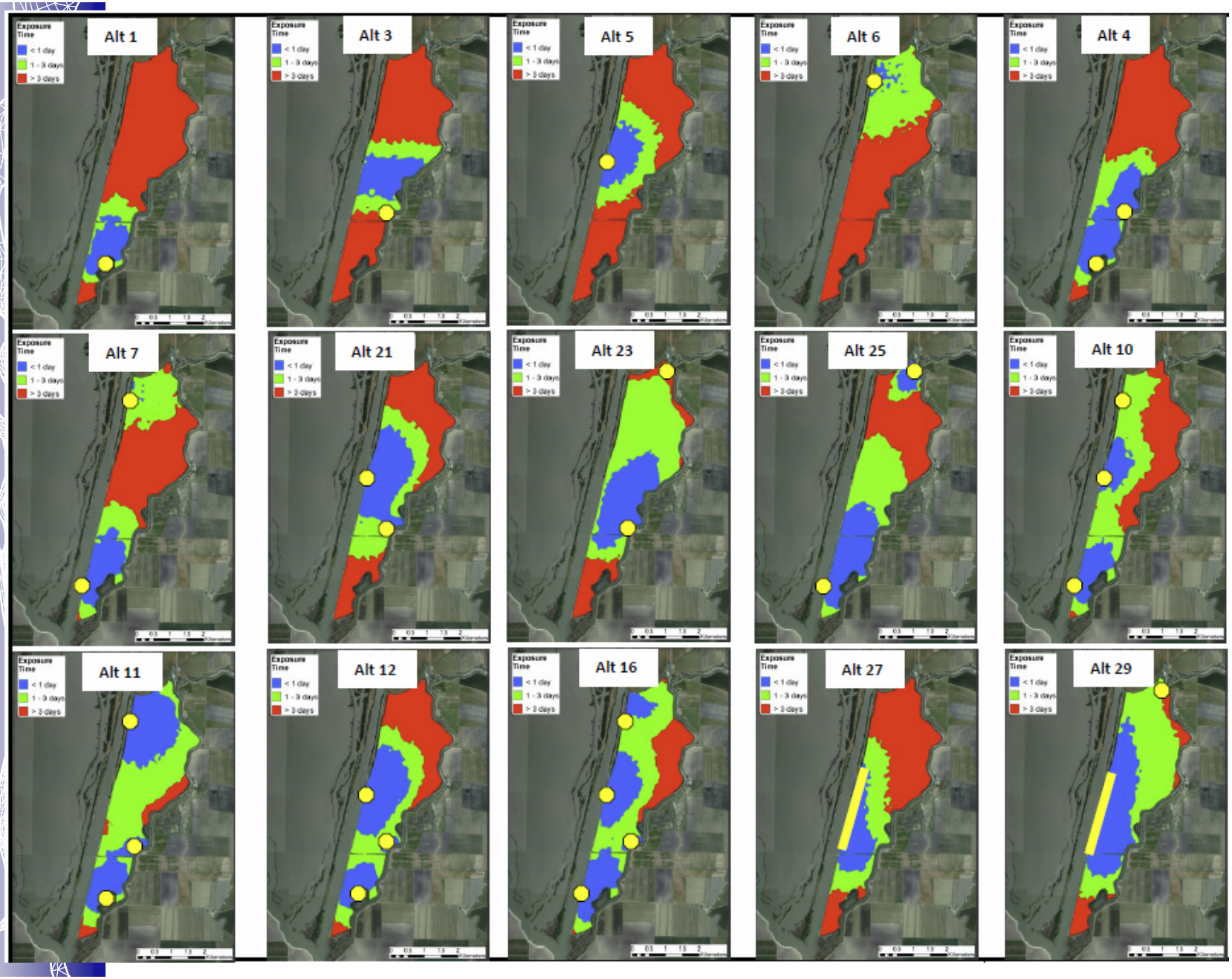
Exposure Time Histograms



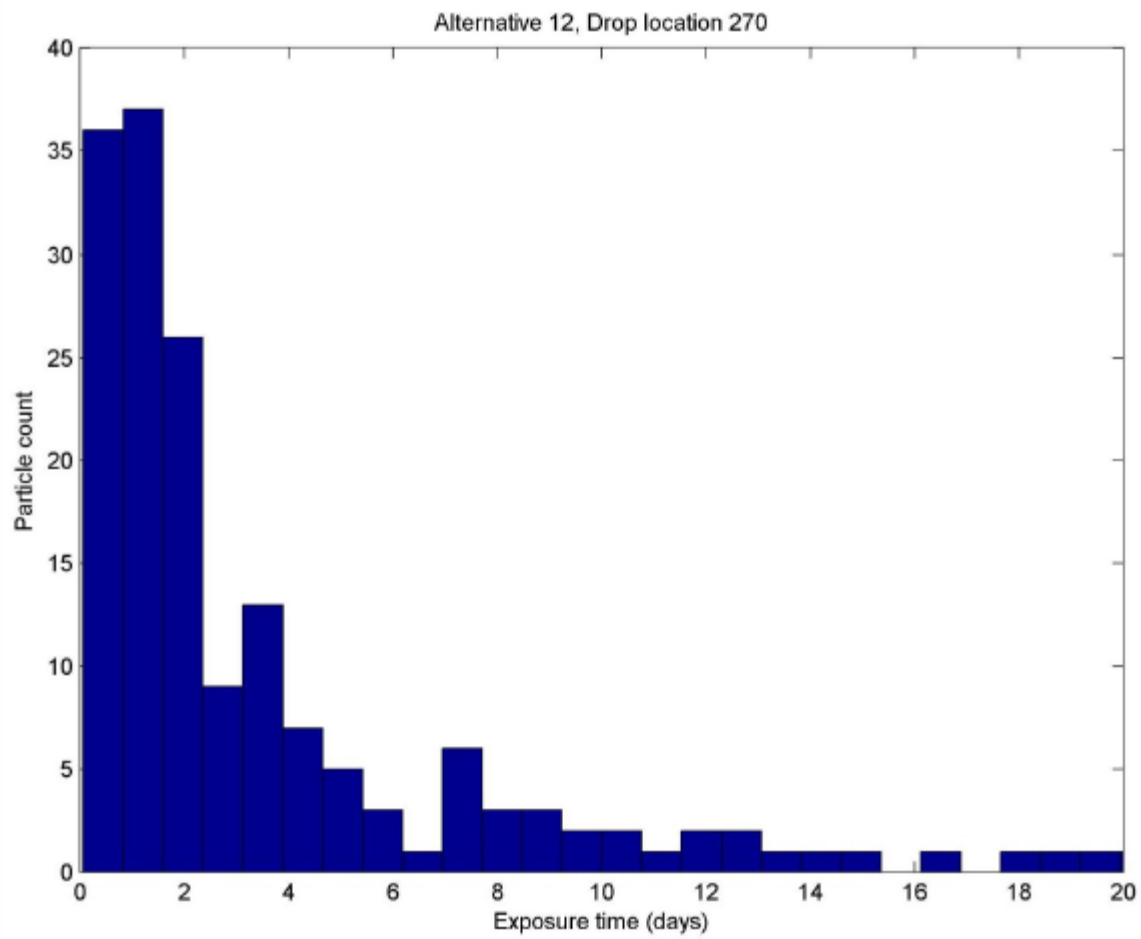
Exposure Time Results by Time Class

		Particle Exposure Times (%)		
	Alternative No.	< 1 day	1-3 days	> 3 days
Single Breach	1	12.9	9.1	78.0
	3	19.6	13.9	66.5
	5	20.4	17.1	62.5
	6	16.9	16.6	66.5
Two Breaches	4	25.6	16.2	58.2
	7	25.2	21.6	53.2
	21	30.5	23.5	46.0
Flow-through Two Breaches	23	30.6	46.1	23.3
	25	30.6	32.0	37.4
Three and Four Breaches	10	28.7	28.3	43.0
	11	40.7	42.9	16.4
	12	36.6	25.5	37.9
	16	41.8	31.2	27.0
Levee Removal	27	23.4	19.2	57.4
	29	38.8	43.4	17.8

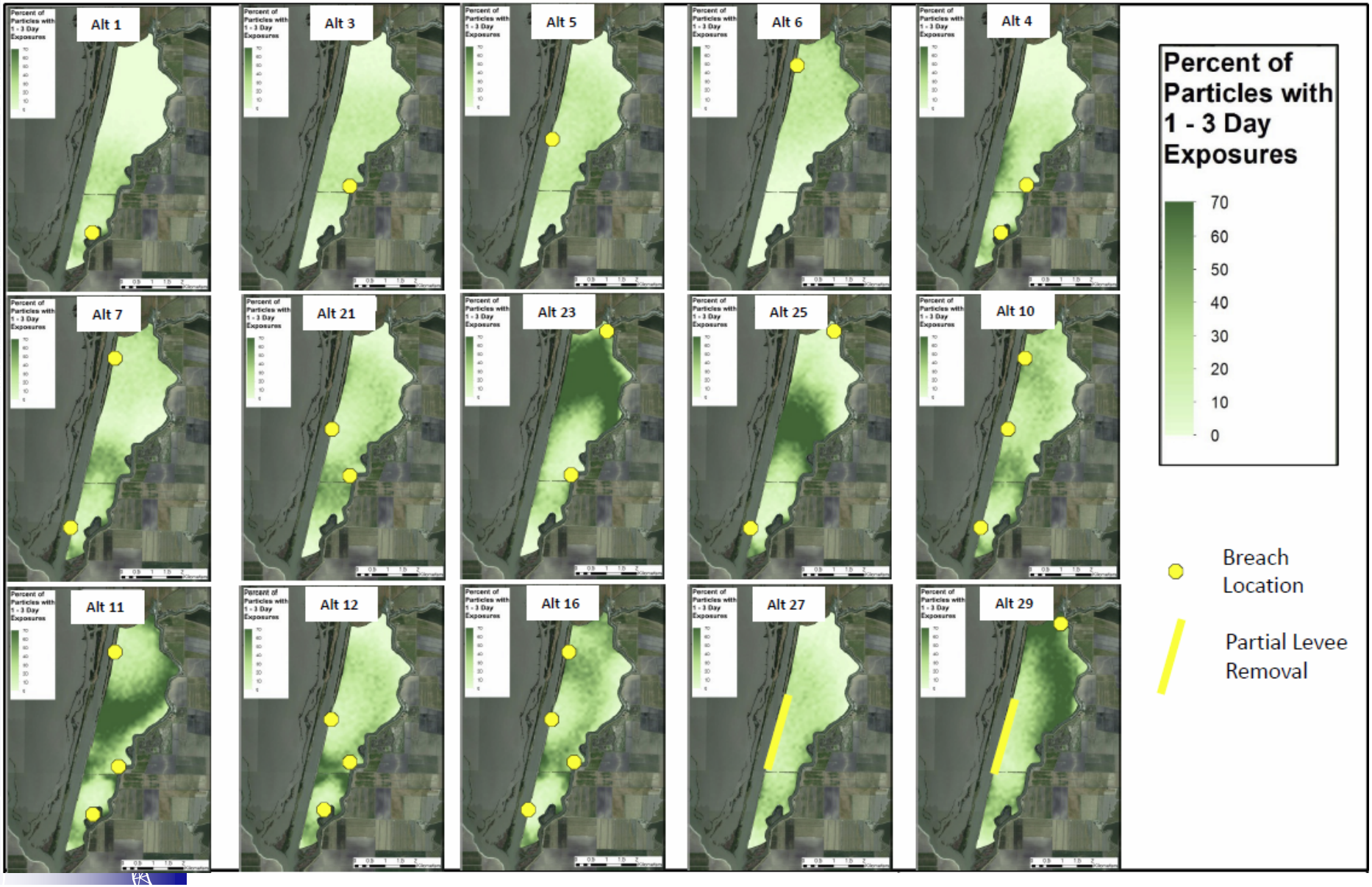
Exposure Time Maps



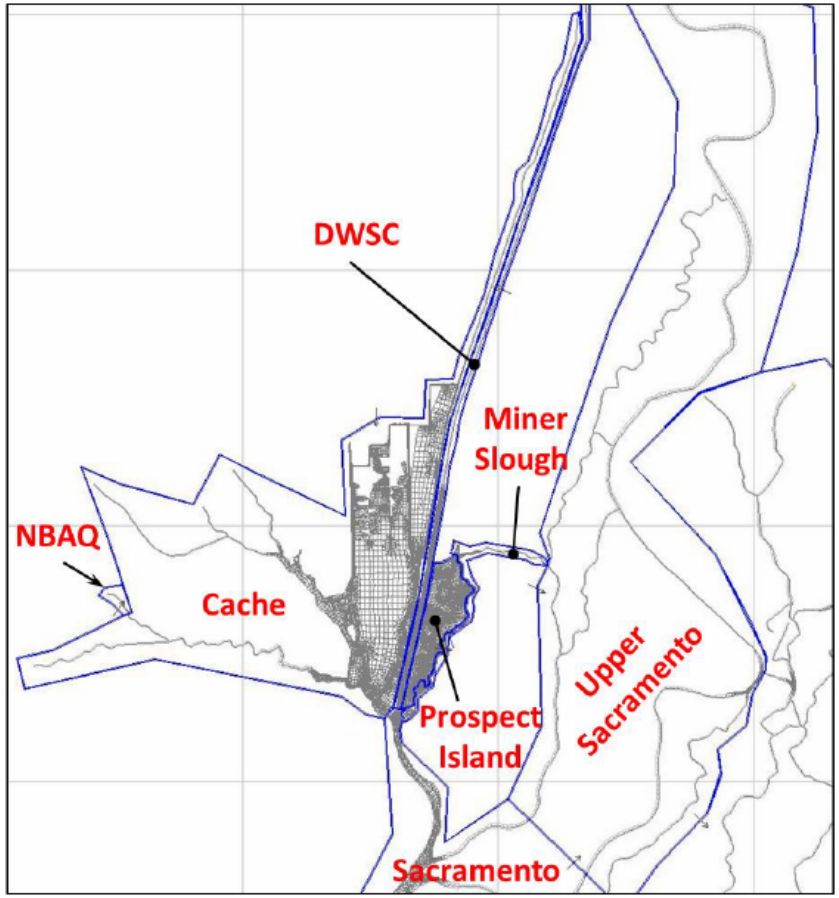
Distribution in Residence Times at a Location

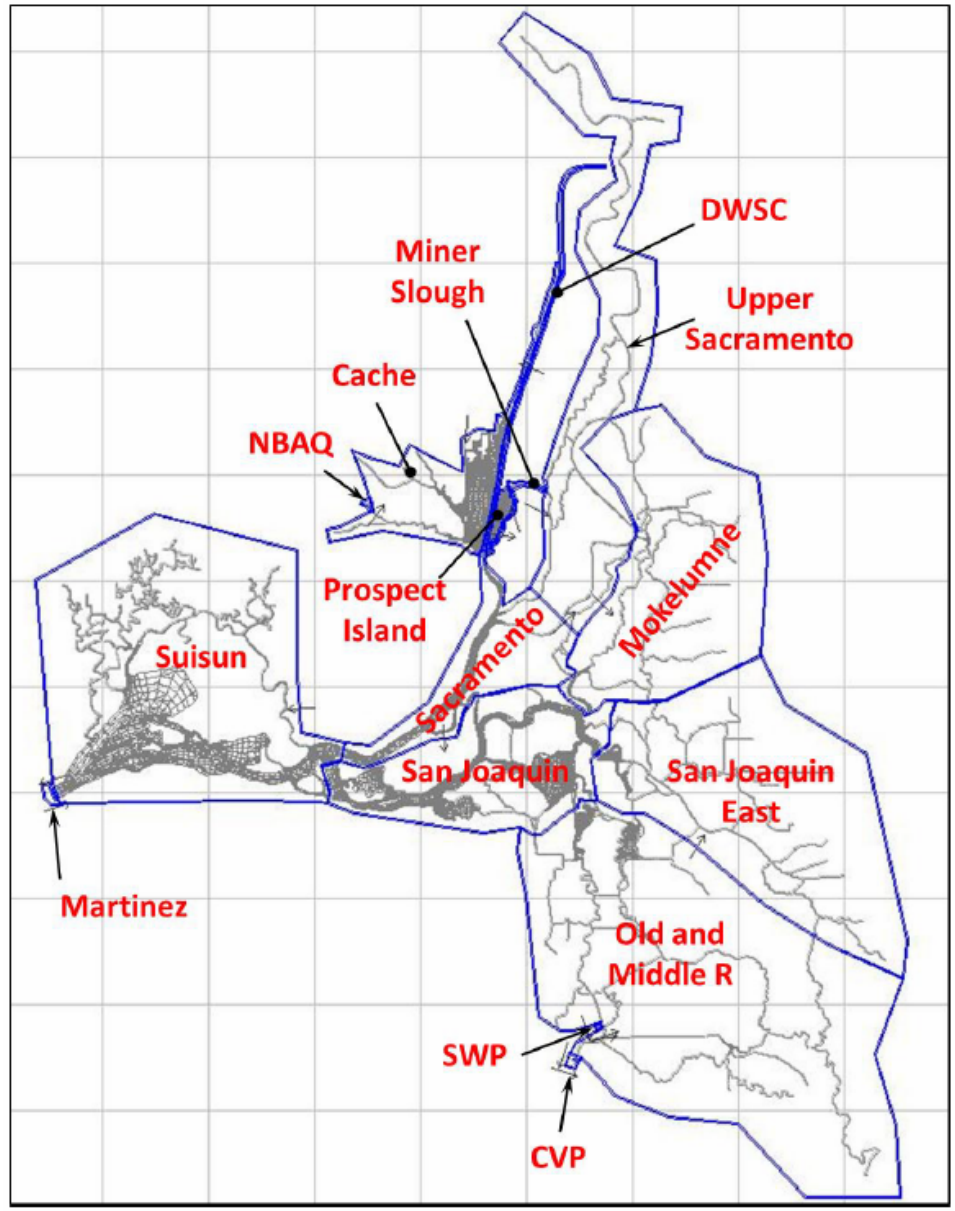


1-3 Day Exposure Time Maps

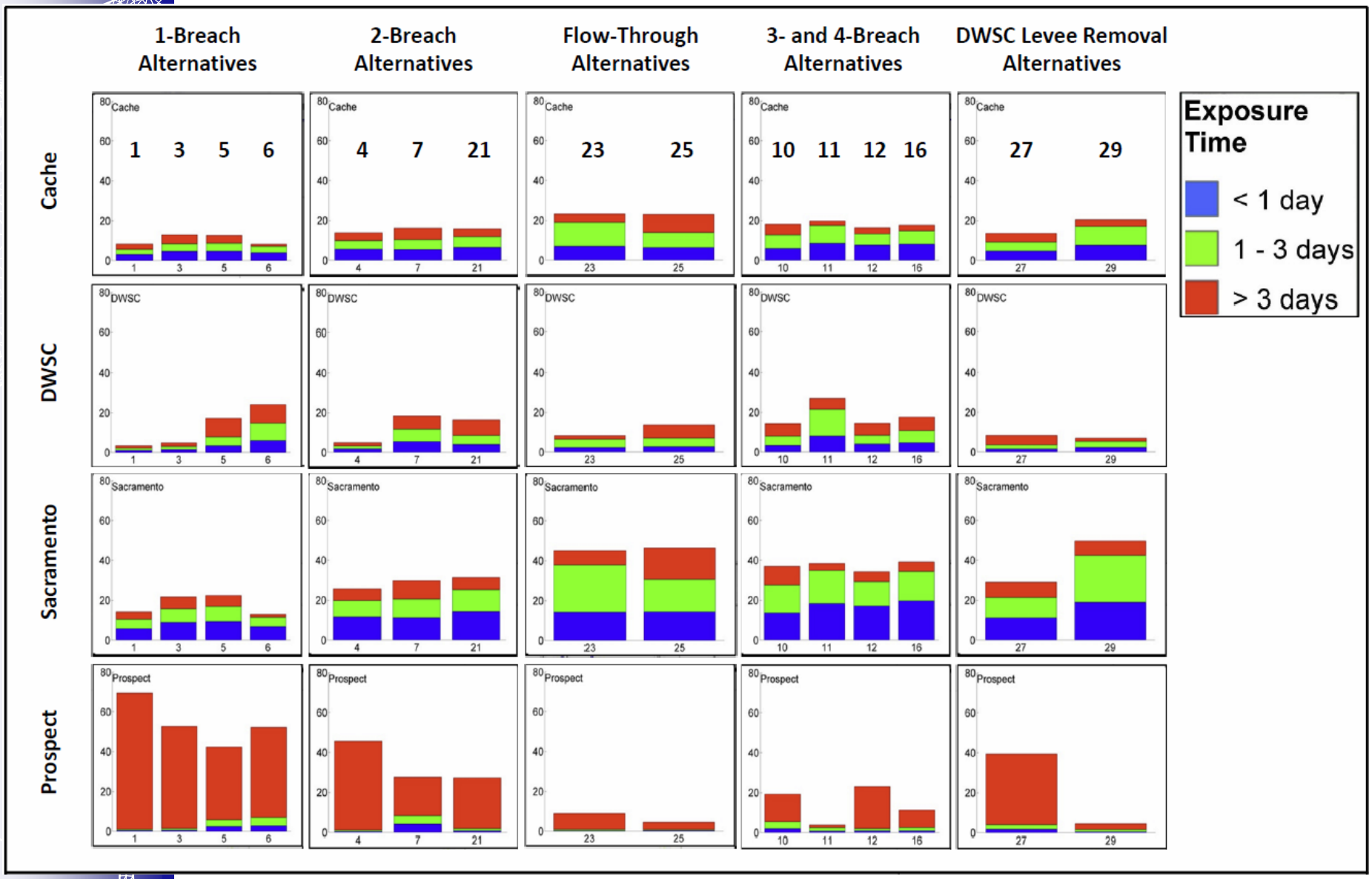


Tracking Regions





Particle Fate



Particle Fate

		Percentage of Total Particles with 1-3 Day Prospect Island Residence Times in Region after 1 Week						
	Alt No.	Sacramento	Prospect Island	Cache	DWSC	San Joaquin	Suisun	Miner
Single Breach	1	4.54	0.45	2.45	0.99	0.81	0.15	0.13
	3	6.68	0.72	3.79	1.35	1.17	0.24	0.40
	5	7.46	3.35	4.02	4.33	0.96	0.16	0.04
	6	4.61	4.02	3.09	8.69	0.31	0.04	0.01
Two Breaches	4	8.13	0.54	4.15	1.44	1.57	0.34	0.36
	7	9.18	4.19	4.77	6.30	1.51	0.31	0.03
	21	10.86	0.98	5.29	4.54	1.50	0.30	0.33
Flow-through Two Breaches	23	23.65	0.53	11.88	4.19	4.34	0.95	0.86
	25	16.17	0.39	7.54	4.30	2.89	0.67	0.26
Three and Four Breaches	10	13.94	3.49	6.62	4.55	2.52	0.58	0.06
	11	16.50	1.61	8.82	13.40	1.95	0.37	0.65
	12	12.05	0.96	5.55	4.19	1.99	0.42	0.38
	16	14.69	1.54	6.48	6.00	2.36	0.53	0.34
Levee Removal	27	10.07	2.28	4.44	1.99	1.95	0.44	0.05
	29	23.46	0.98	9.39	2.94	5.29	1.26	0.25

5-10%
10-20%
>20%

Observations

* It is hard to get more tidal prism into the Delta… even with 140% increase in area open to tidal exchange there was only a 10% increase in tidal prism.
* Suisun Marsh has the easiest time getting more tidal exchange provided the conveyance of Montezuma Slough is increased.
* It is hard to get more tidal exchange into the south Delta with the current channel geometry
* Understanding the distribution of energy dissipation may be very helpful in understanding the distribution of tidal prism… More work is needed here!
* Immediately imposing large scale changes to the Delta geometry puts the system out of balance, but if the energy dissipation distribution does not change (much) will channels naturally scour to increase conveyance where needed??

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