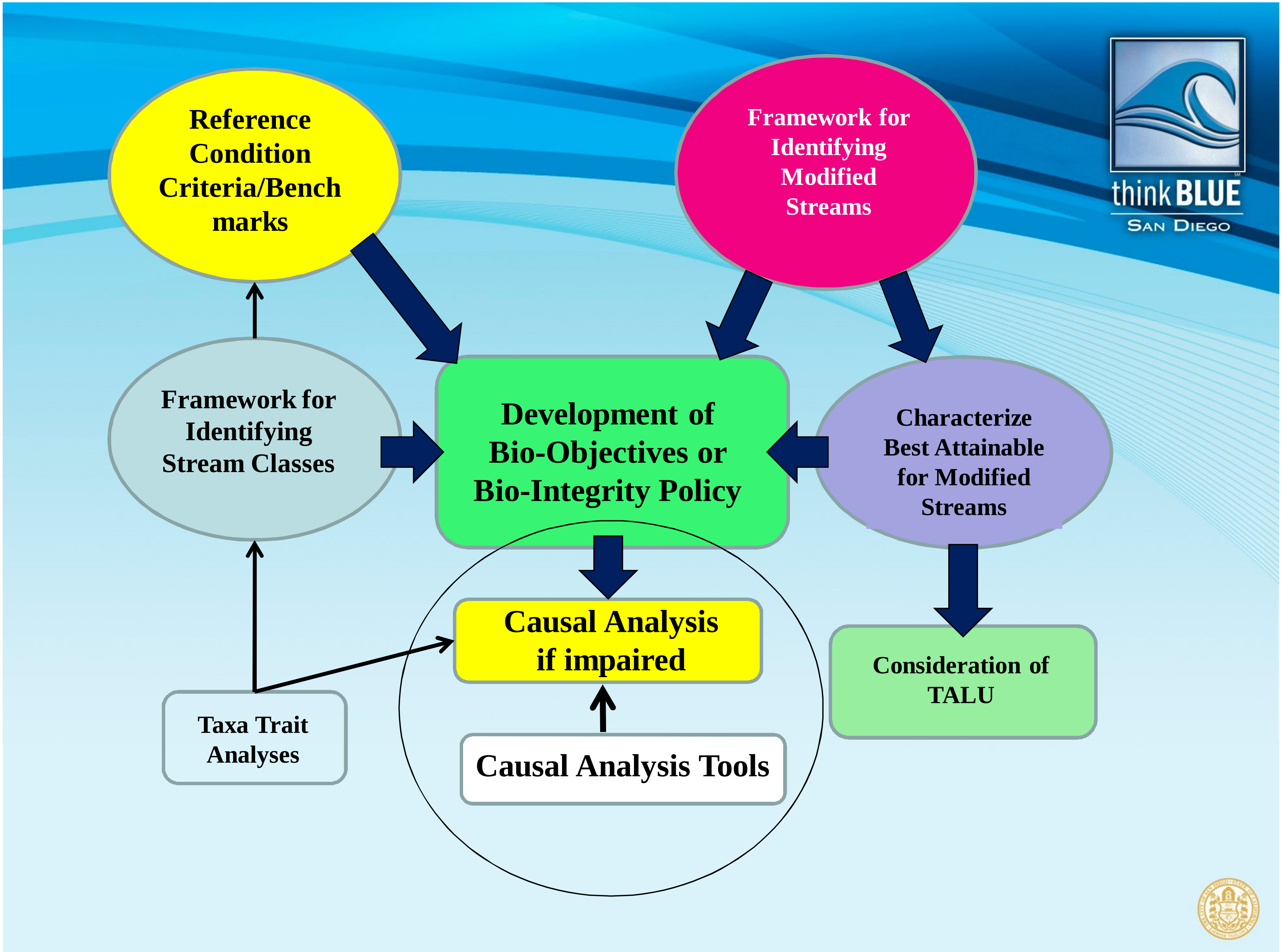
Causal Assessment of TDS or Conductivity as a Potential Cause of Poor Benthic Invertebrate Condition in the San Diego River Watershed

Jerry Diamond, Clint Boschen, Lei Zheng, Ann Roseberry-Lincoln, Tetra Tech
Ruth Kolb, City of San Diego

TETRA TECH

think BLUE SAN DIEGO


Reference Condition Criteria/Bench marks
Framework for Identifying Modified Streams
thinkBLUE SAN DIEGO
Framework for Identifying Stream Classes
Development of Bio-Objectives or Bio-Integrity Policy
Characterize Best Attainable for Modified Streams
Causal Analysis if impaired
Consideration of TALU
Taxa Trait Analyses
Causal Analysis Tools

Causal Assessment is a Framework

- Data-driven process to identify stressors responsible for observed biological impairment
- A retrospective assessment (effects have already occurred); results can help predict impacts elsewhere
- Challenging in many sites because multiple stressors (factors) are present
- May need many tools to provide a useful causal assessment
- Can help determine appropriate restoration actions and recovery potential

Key Components for Success

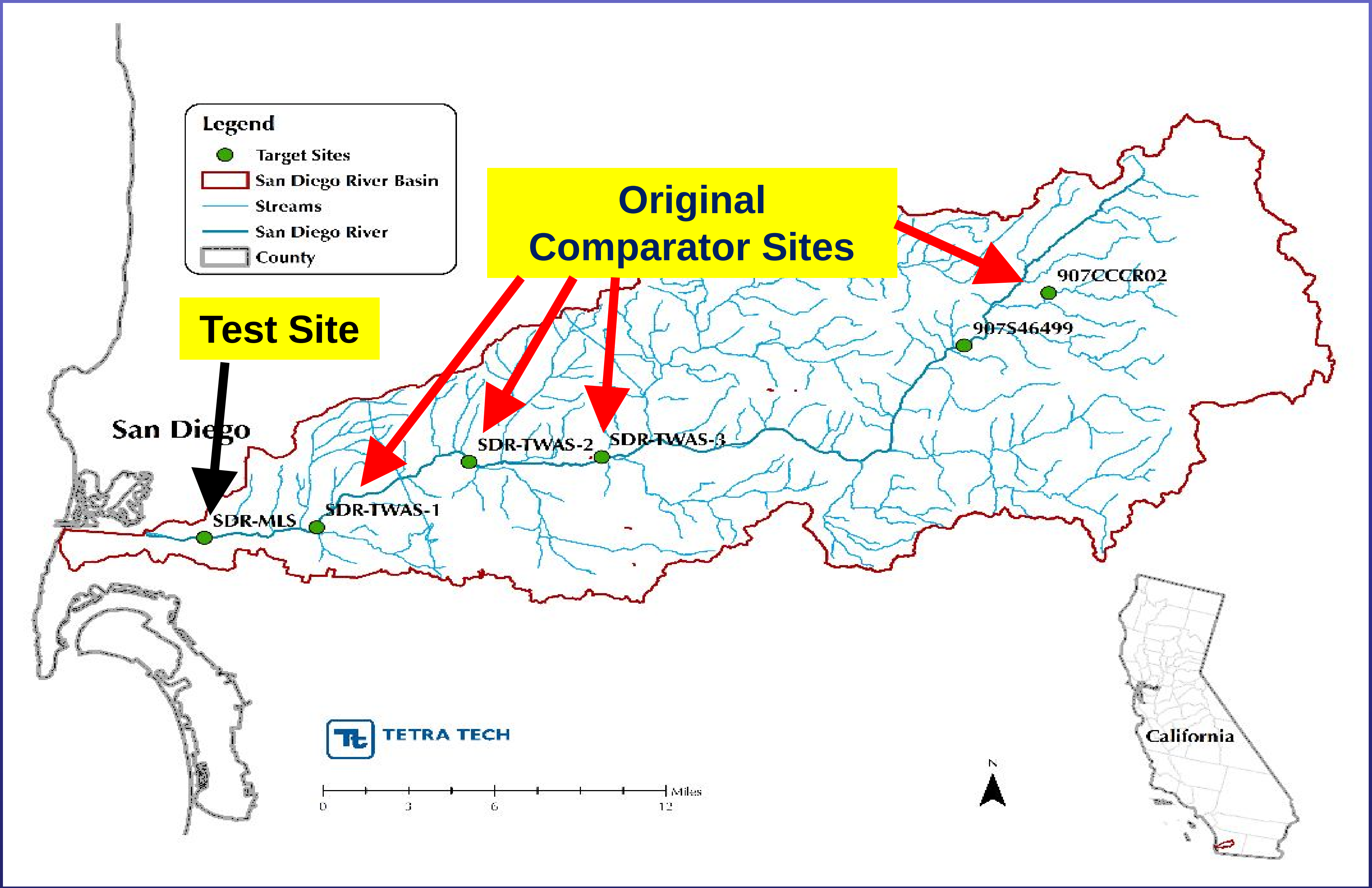
- Stressor as well as bioassessment data
  - Water quality, habitat, other information
- Evaluate multiple lines of evidence (e.g., EPA's CADDIS framework)
- Selection of **appropriate reference or comparator sites**

Lower San Diego River (SDR) Conductivity/TDS Causal Assessment

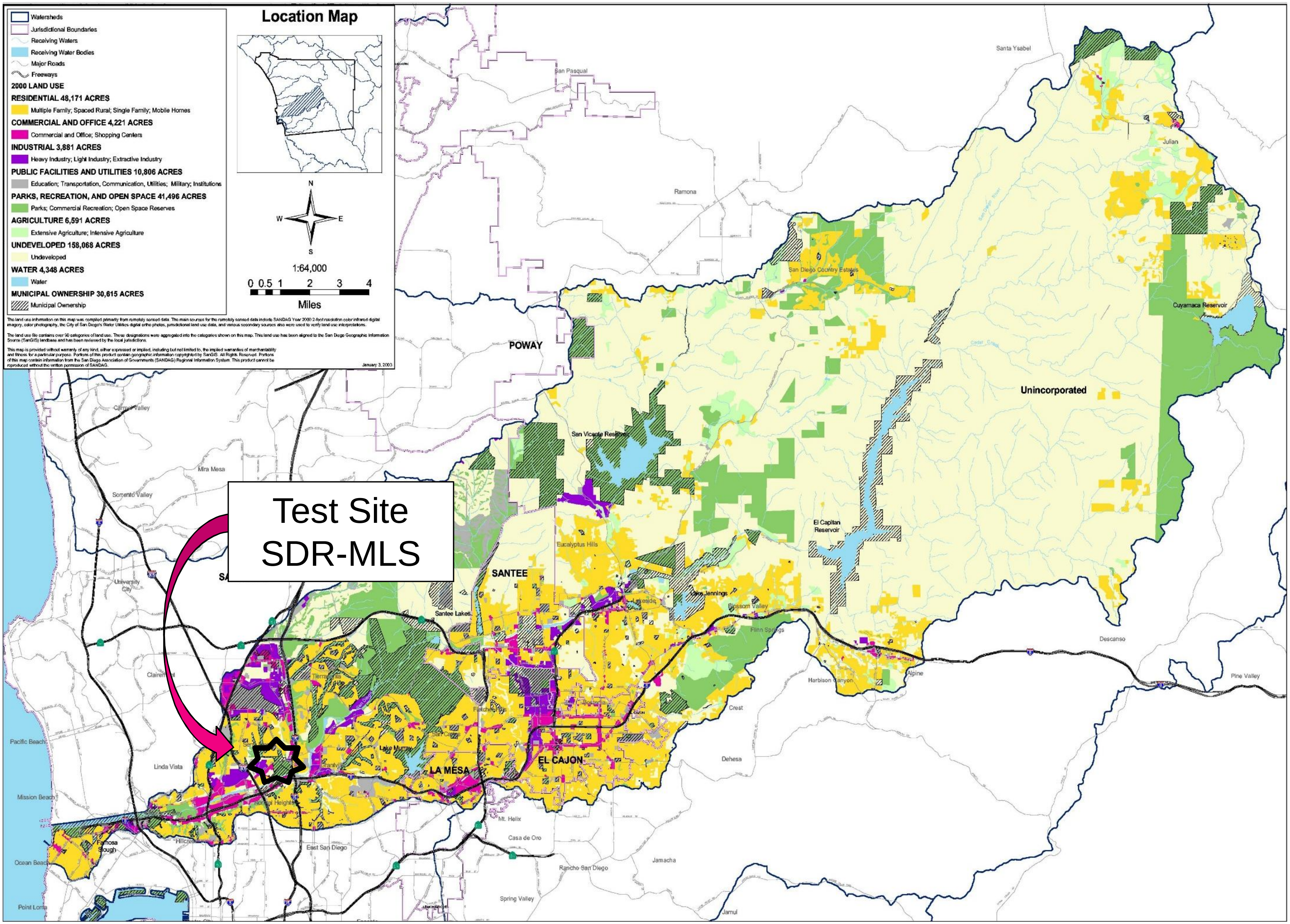
thinkBLUE SAN DIEGO

- Pilot identified several candidate causes:
  - Conductivity/TDS
  - Nutrients
  - Habitat impairment
  - Pyrethroid insecticides
- Challenges with comparator sites used in pilot assessment

Lower San Diego River Case Study

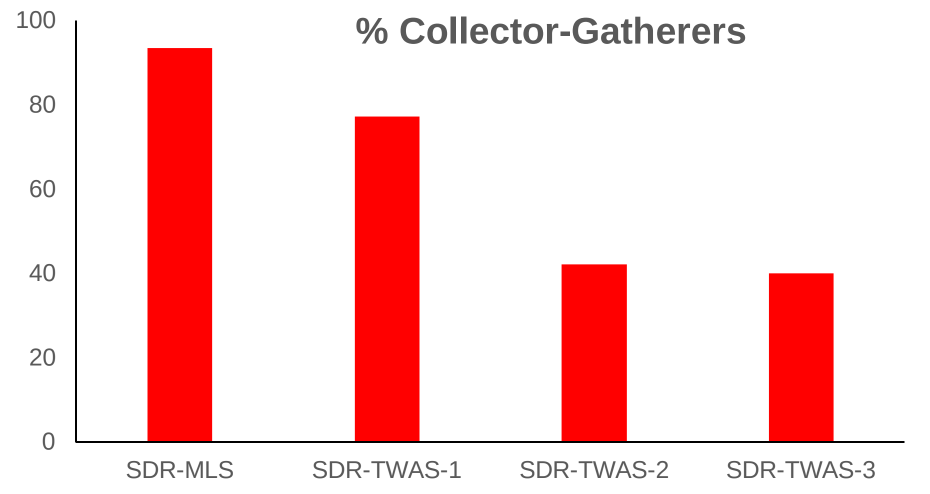


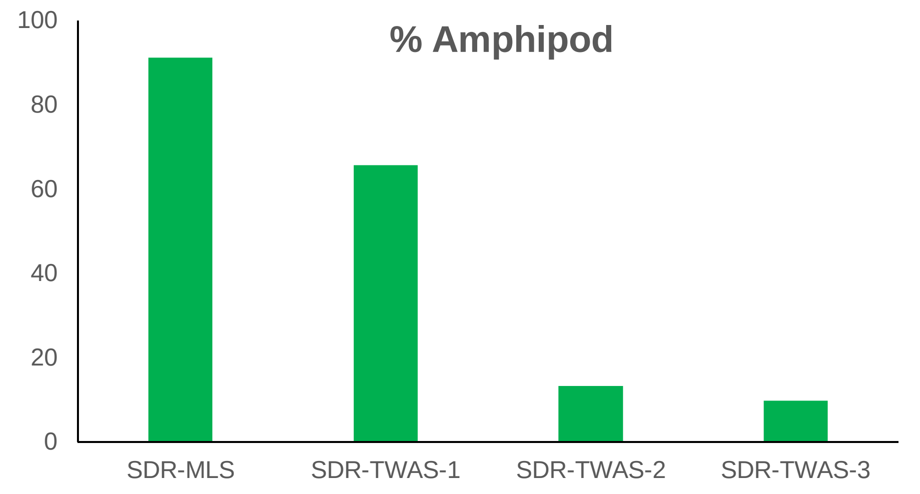
San Diego River Watershed - Land Use

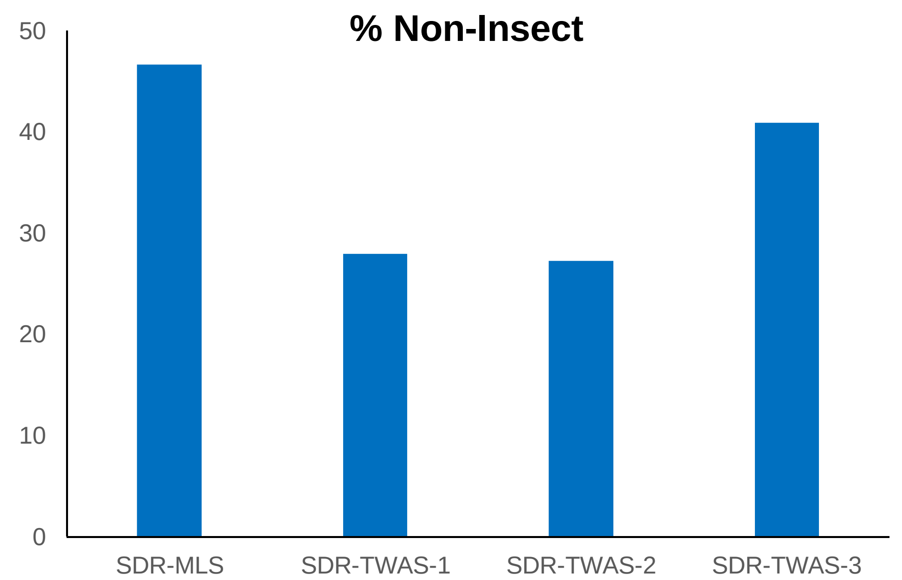


Lower San Diego River

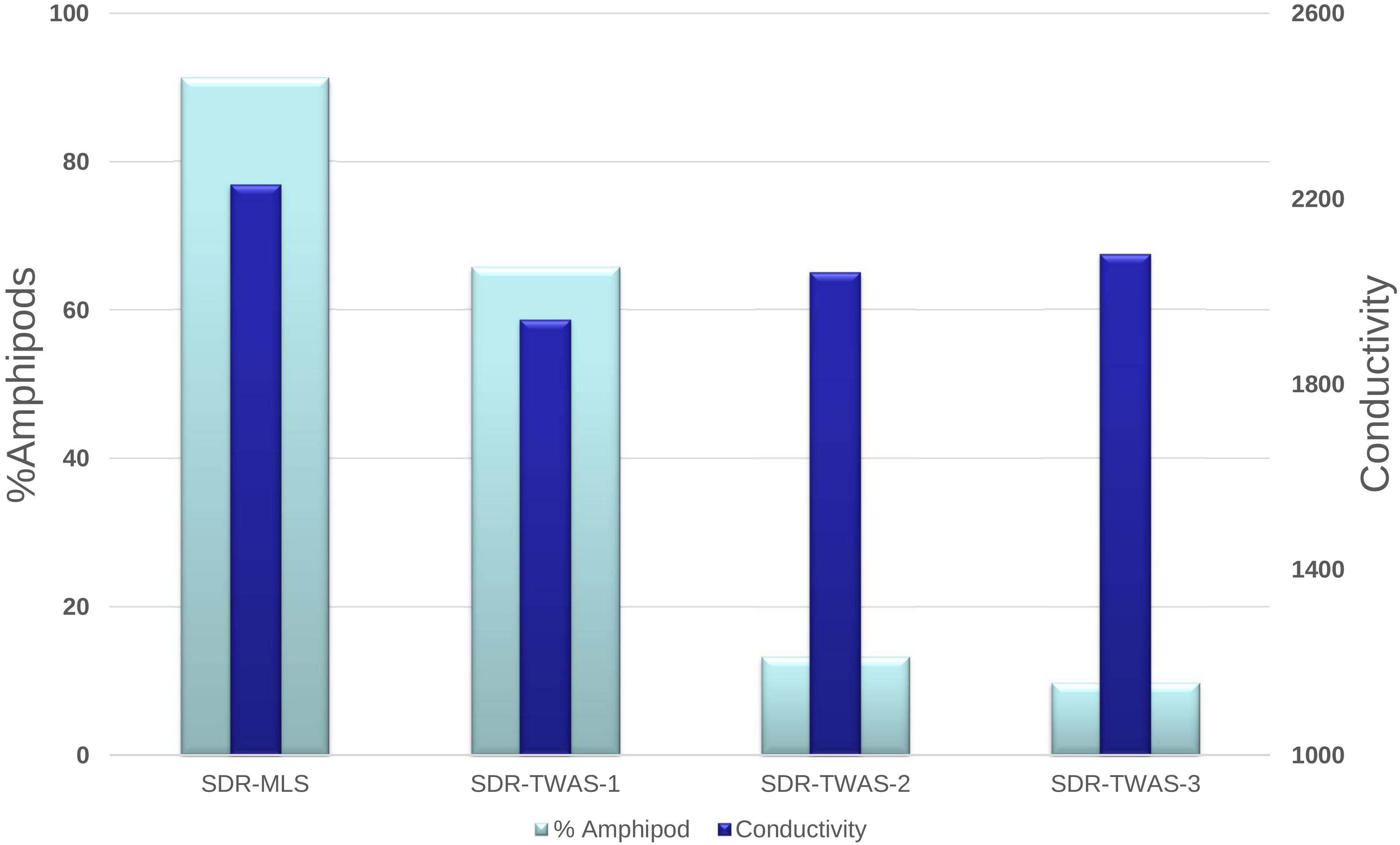
Summary of Pilot Results







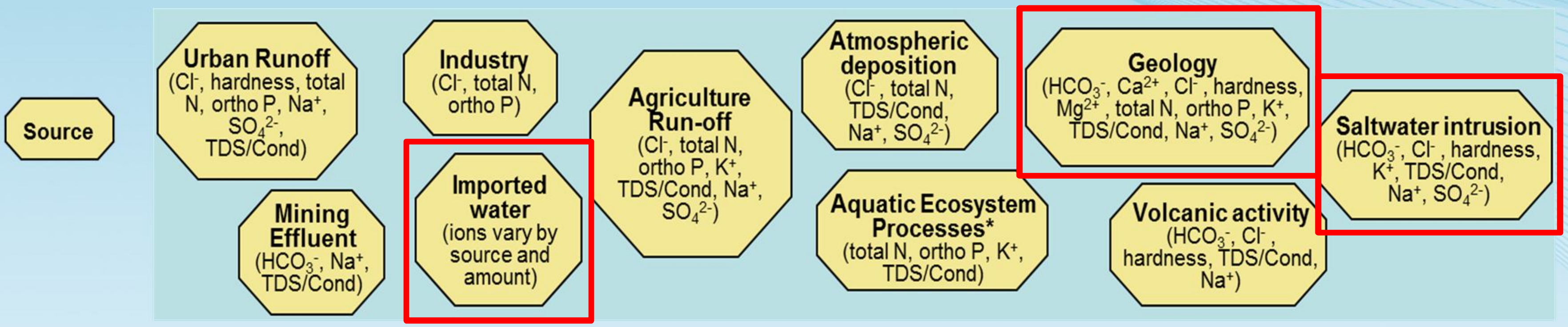
Weak Relationship between Conductivity and % Amphipods



Objectives of this Assessment

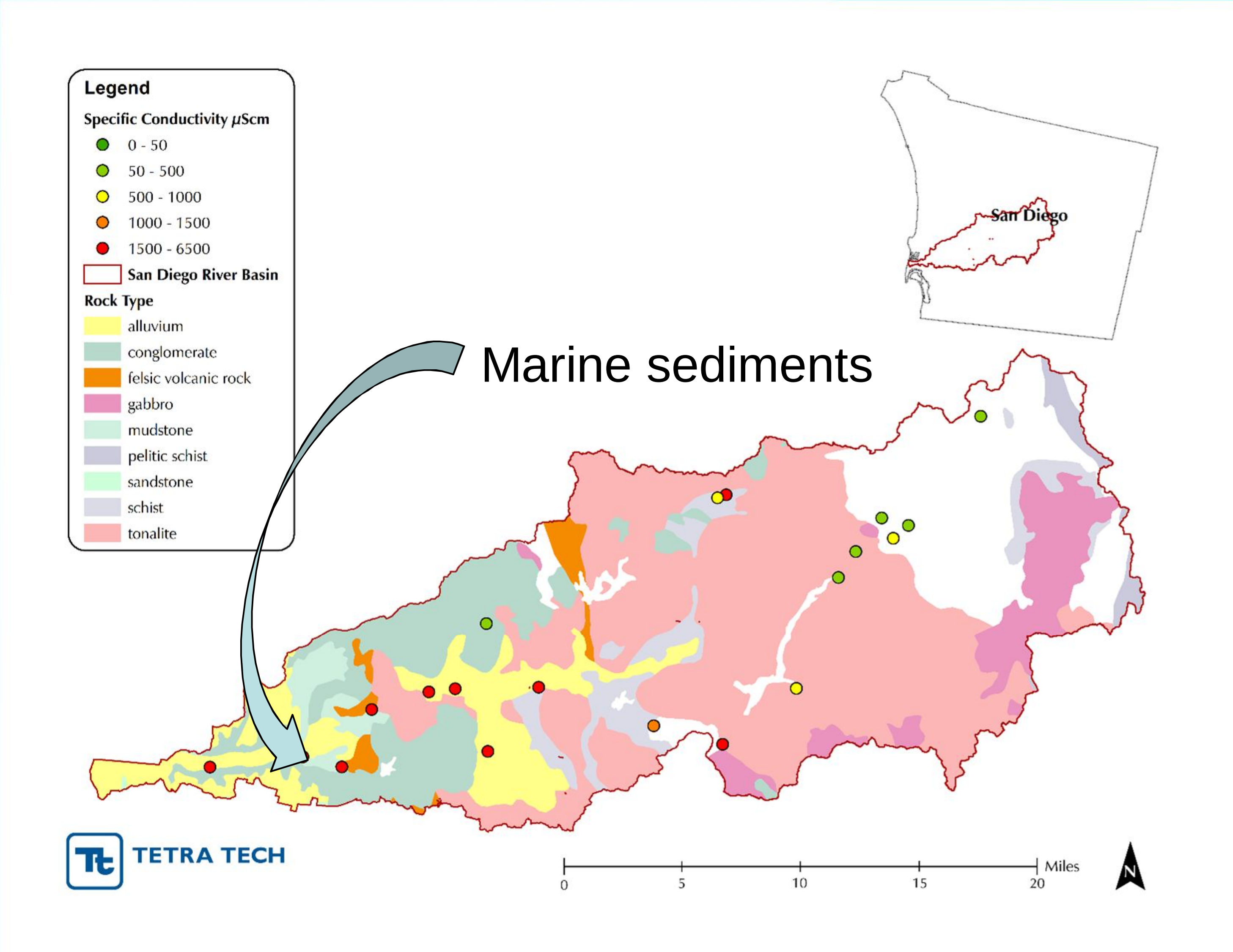
- Determine the influence of natural and anthropogenic sources of conductivity on biological condition
- Use information from outside the case to help determine the strength of relationships within the case
- Identify and employ better diagnostic tools for determining causes of biological impairment in southern California streams

Sources of TDS and Conductivity in the SDR Watershed



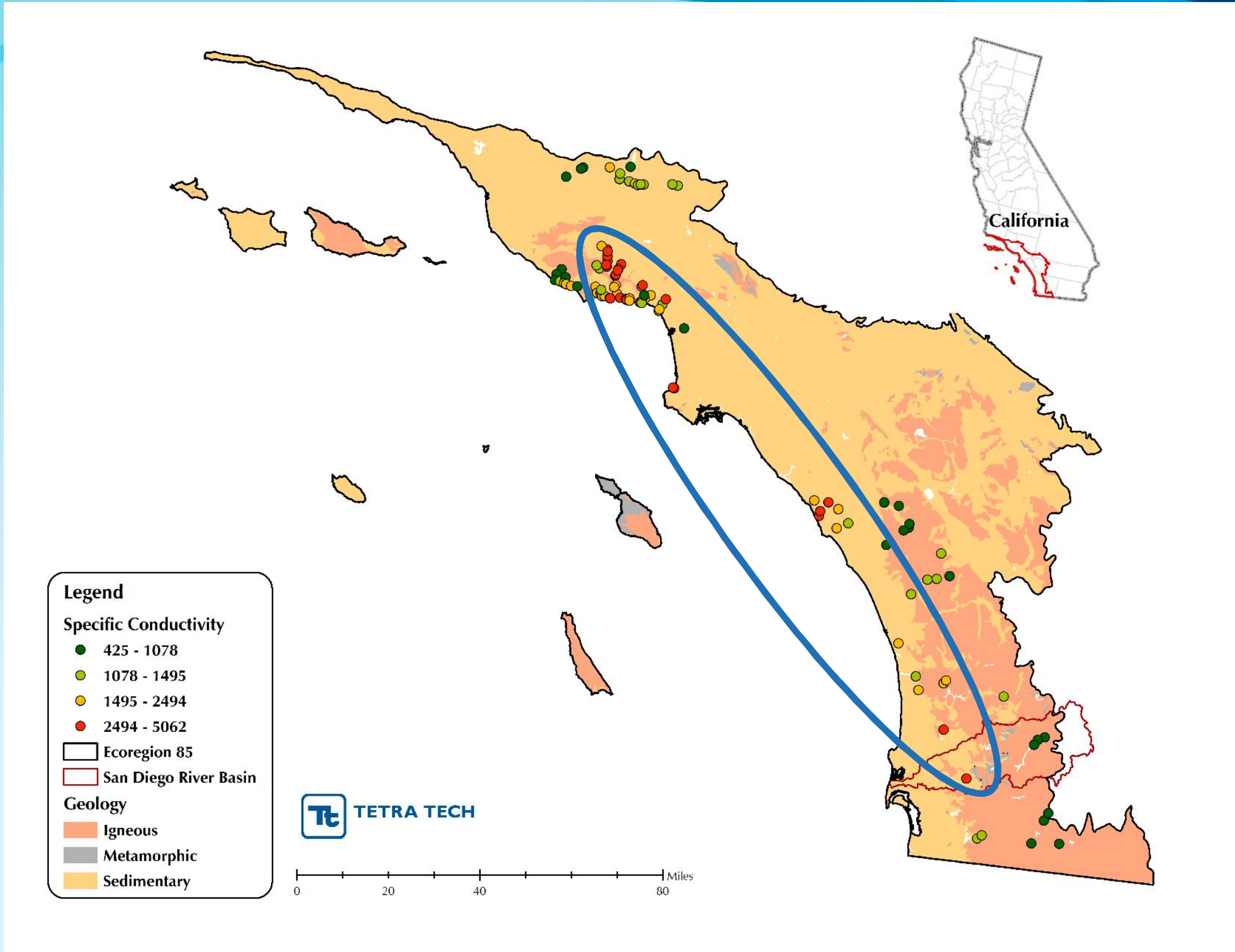
Based on source assessment by Amec-Foster Wheeler 2015

Geology and Conductivity in the SDR Basin



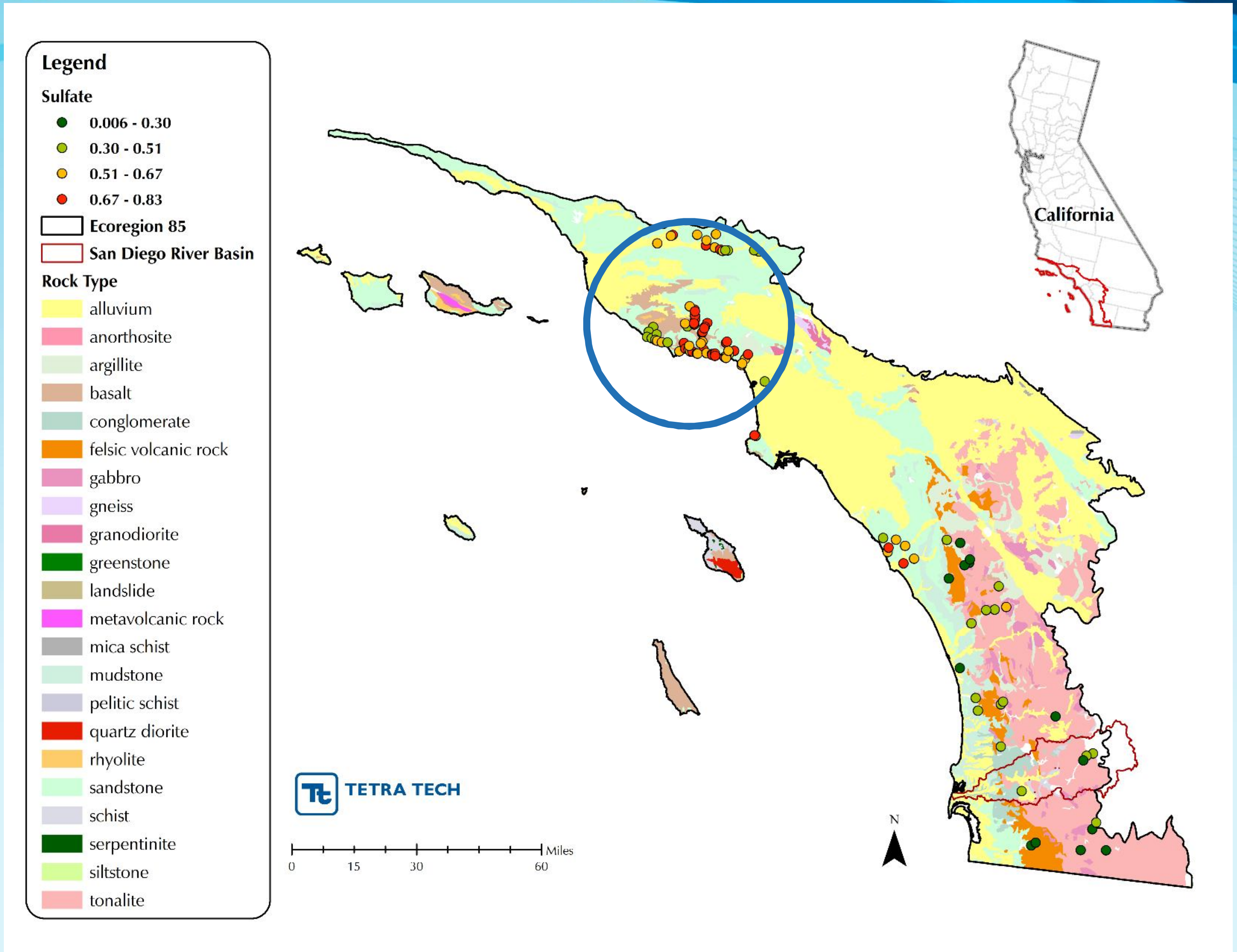
think BLUE SAN DIEGO

Conductivity Levels in the Coastal Xeric Region



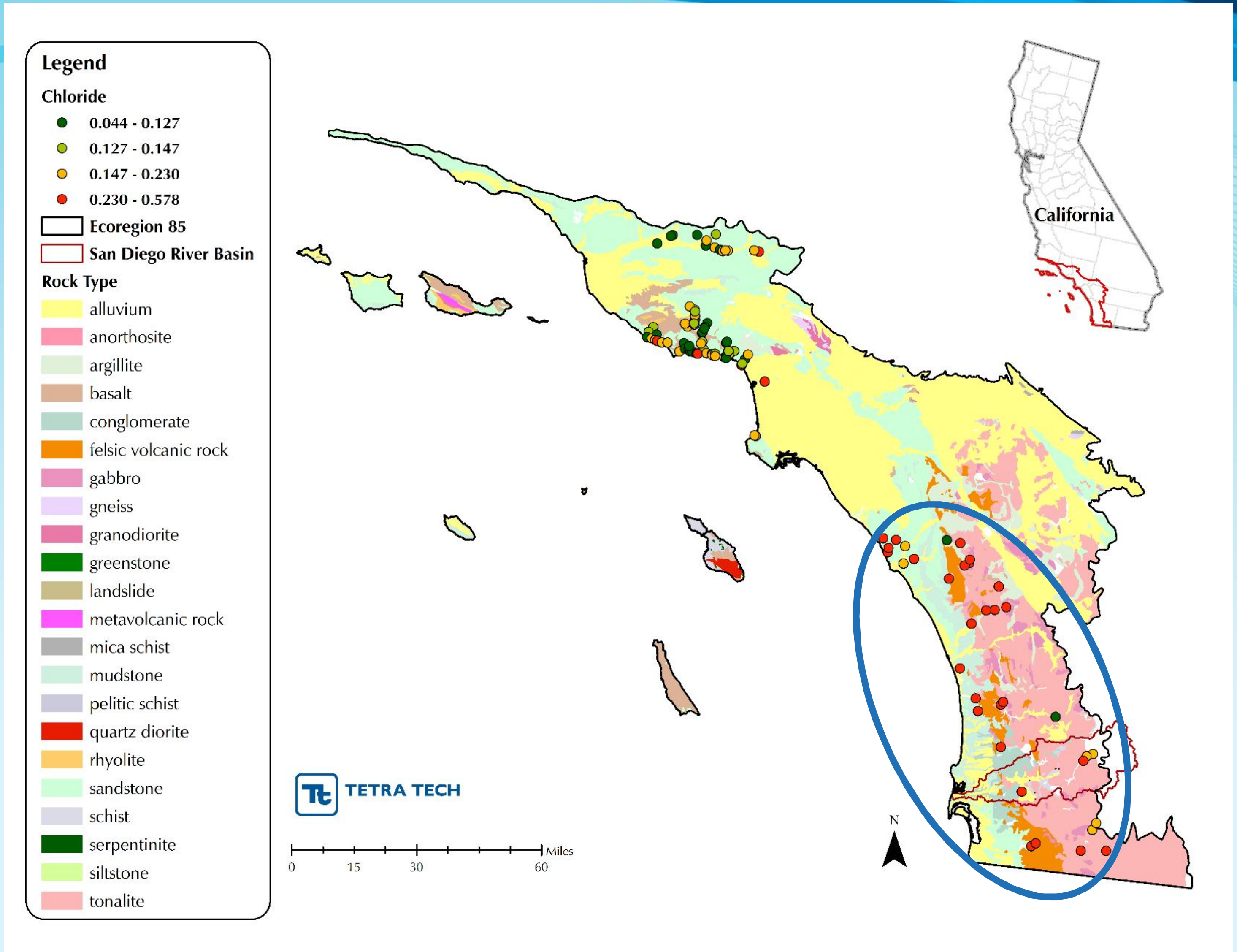
think BLUE
SAN DIEGO

Sulfate Concentrations Higher in the Northern Region



think BLUE
SAN DIEGO

Chloride Concentrations Higher in the Southern Region



think BLUE
SAN DIEGO

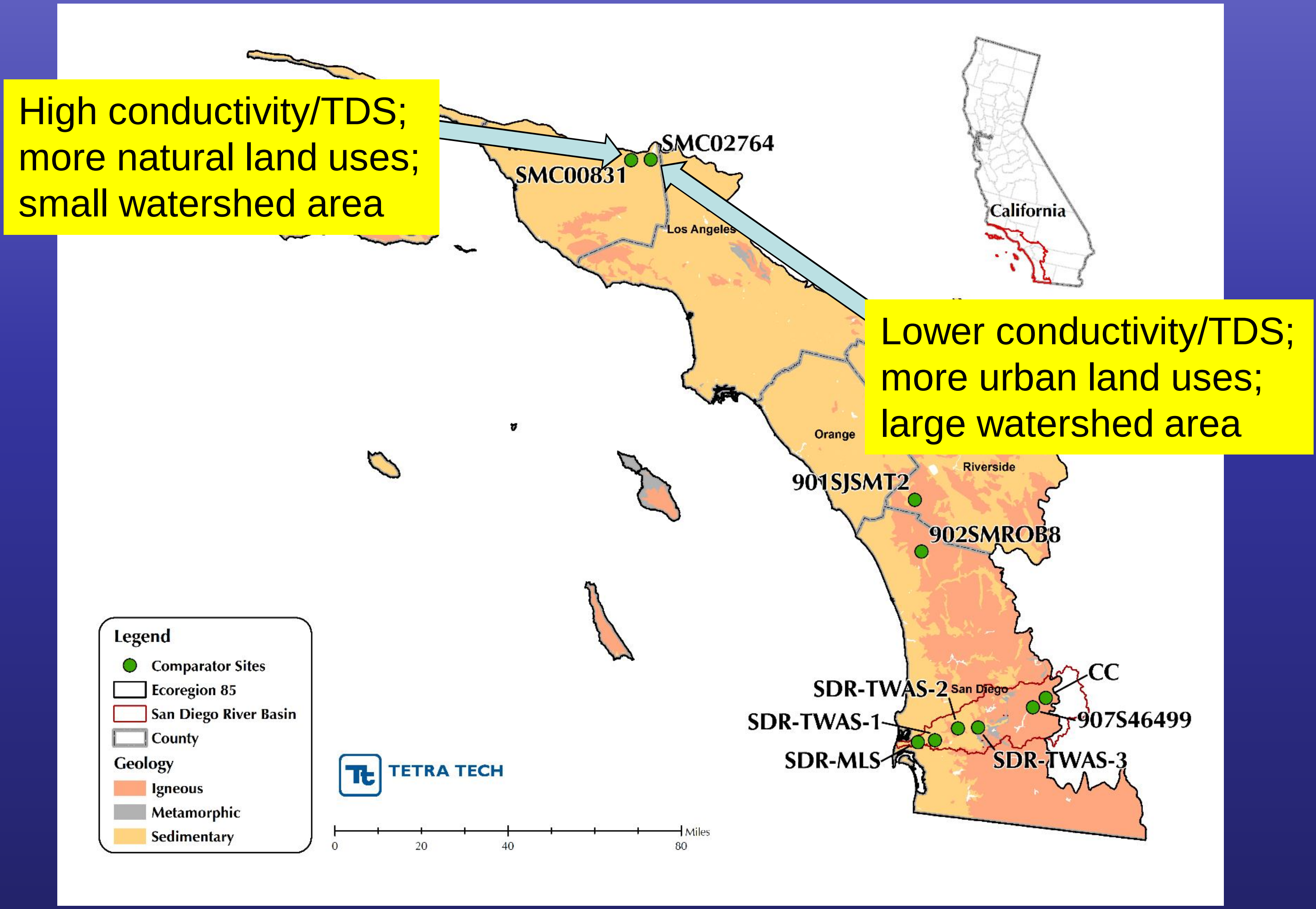
Results of Amec Source Analysis

- Sites underlain by marine sediments have higher TDS (2,000 – 20,000 mg/L) than those underlain by non-marine sediments (200 – 1,200 mg/L).
- Local groundwater aquifers and Colorado River water have intermediate concentrations of TDS (300 – 2,000 mg/L).
- Ion composition (sodium, chloride, sulfate, etc) varies substantially within the SDR

Selection of Alternate Comparator Sites

- Identify sites that match SDR-MLS in terms of land uses and other factors, but where conductivity or TDS were unlikely to be stressors
- Used underlying geology to identify high conductivity sites with natural surrounding land uses
- Identified 5 additional comparator sites

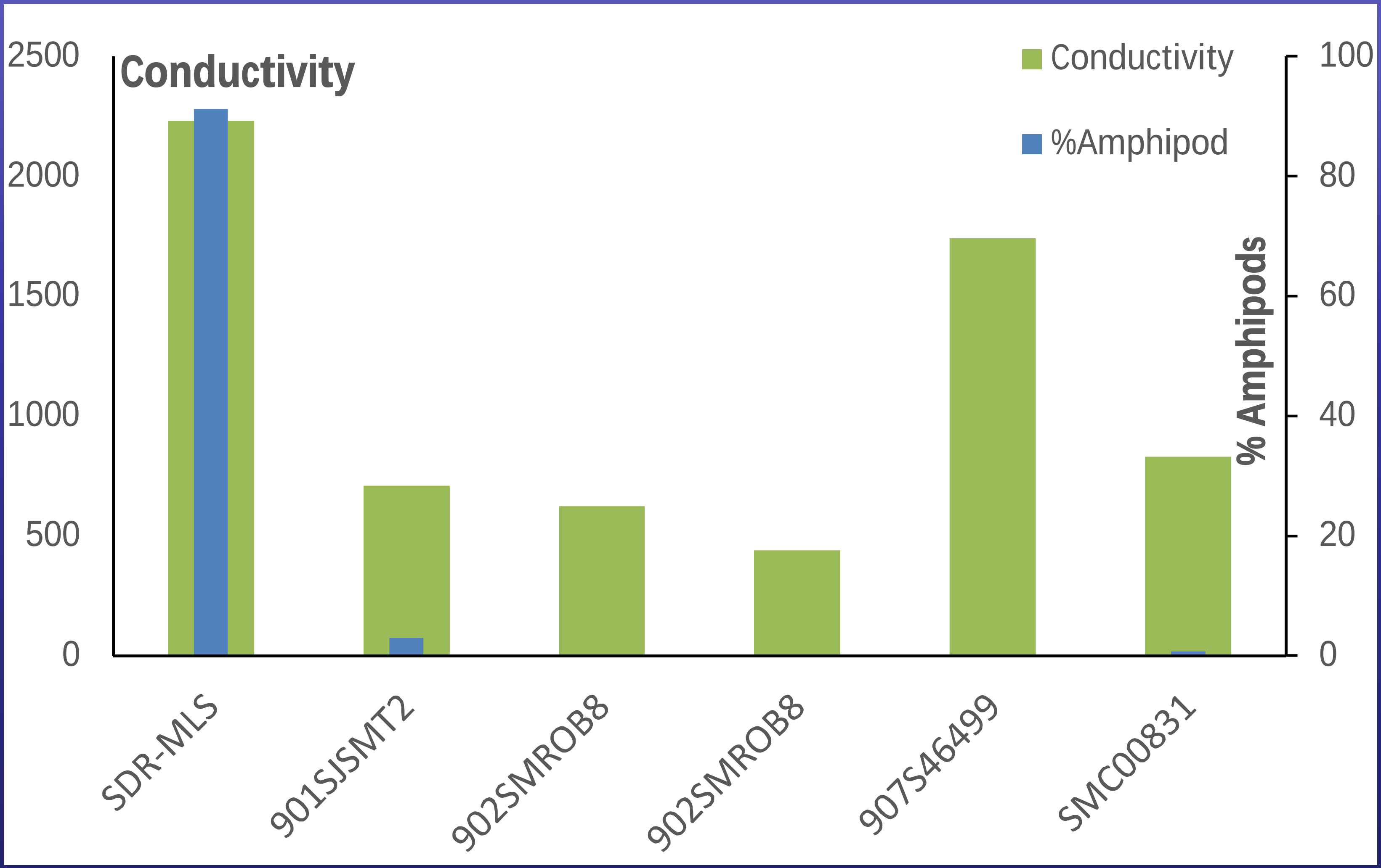
Test and Comparator Sites with Associated Geology



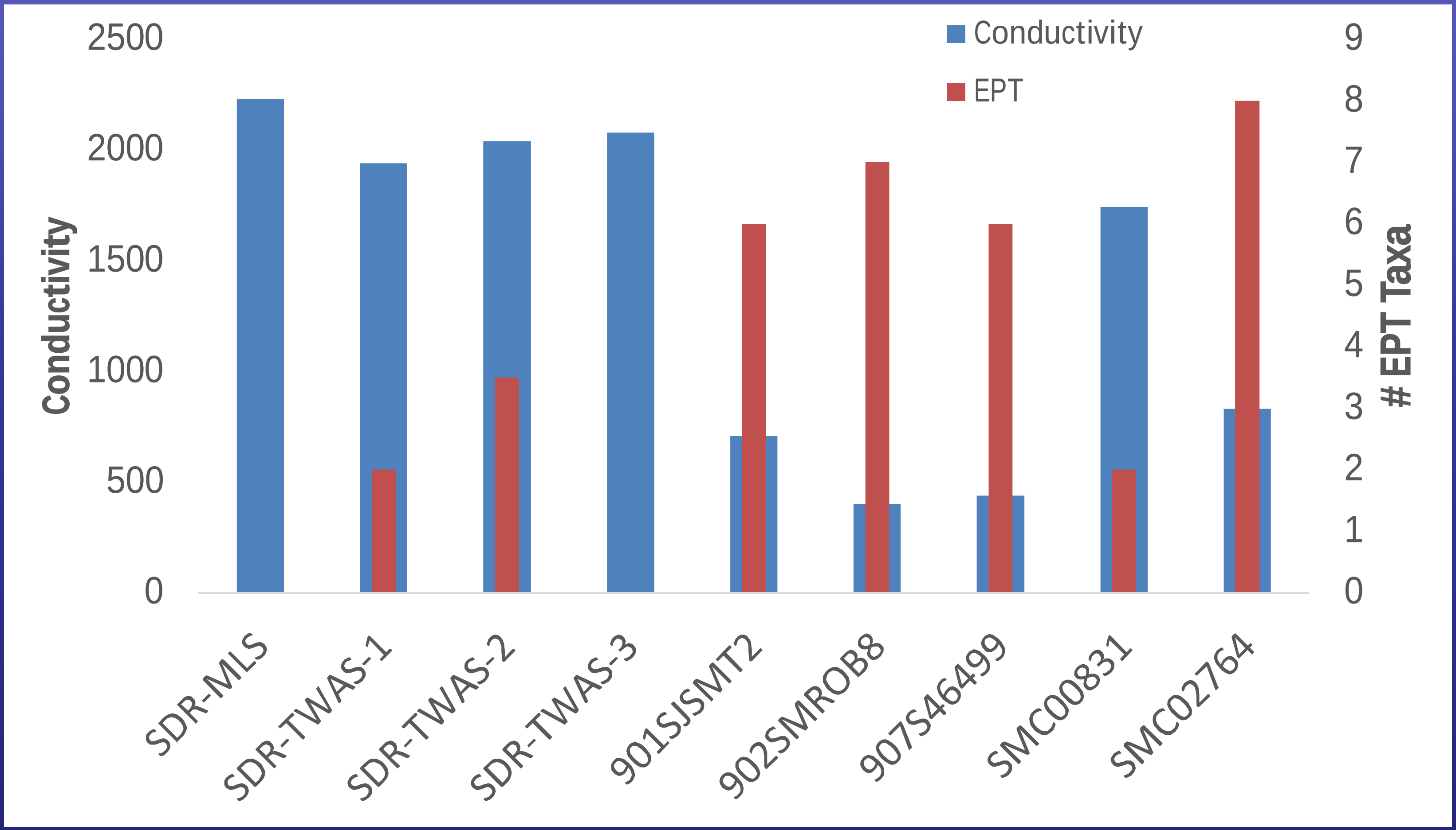
Conductivity/TDS alone do not explain results within the case

Station	Date	Cond. (µS/cm)	TDS (mg/L)	% NI.	% Tol.	%Coll.	% Amph.	# EPT Taxa
MLS (test site)	2010	2,292	1,300	46.7	40	93.5	91.25	0
CC (foothills)	2008-10	401-741	306	11-26	25-53	27-66	1-62	6-16
SMC00831	2010	1,742	1,190	7.14	50	61.25	0	2

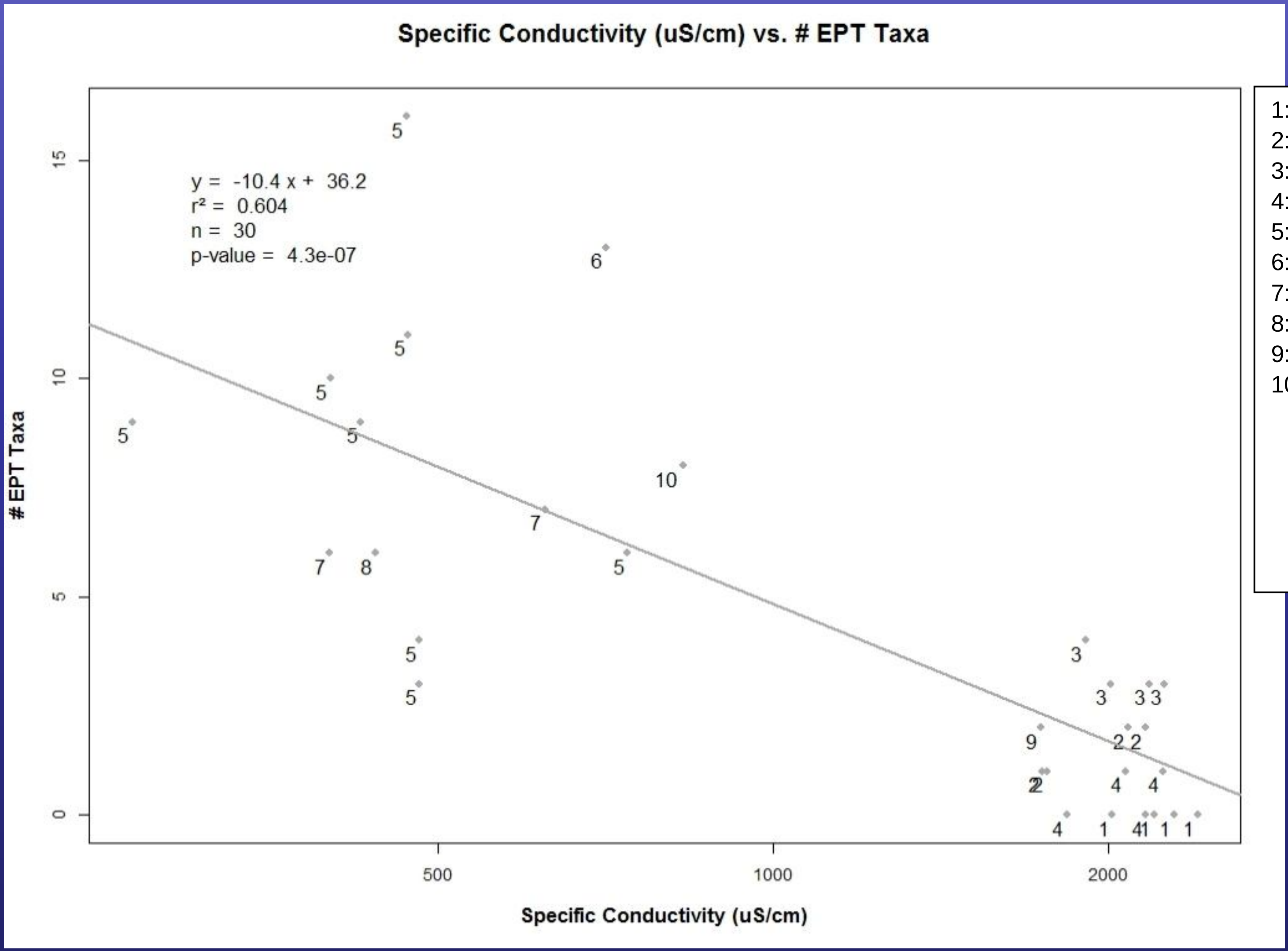
Weak evidence for co-occurrence between conductivity and % amphipods outside the case



Strong evidence for co-occurrence between conductivity and EPT taxa

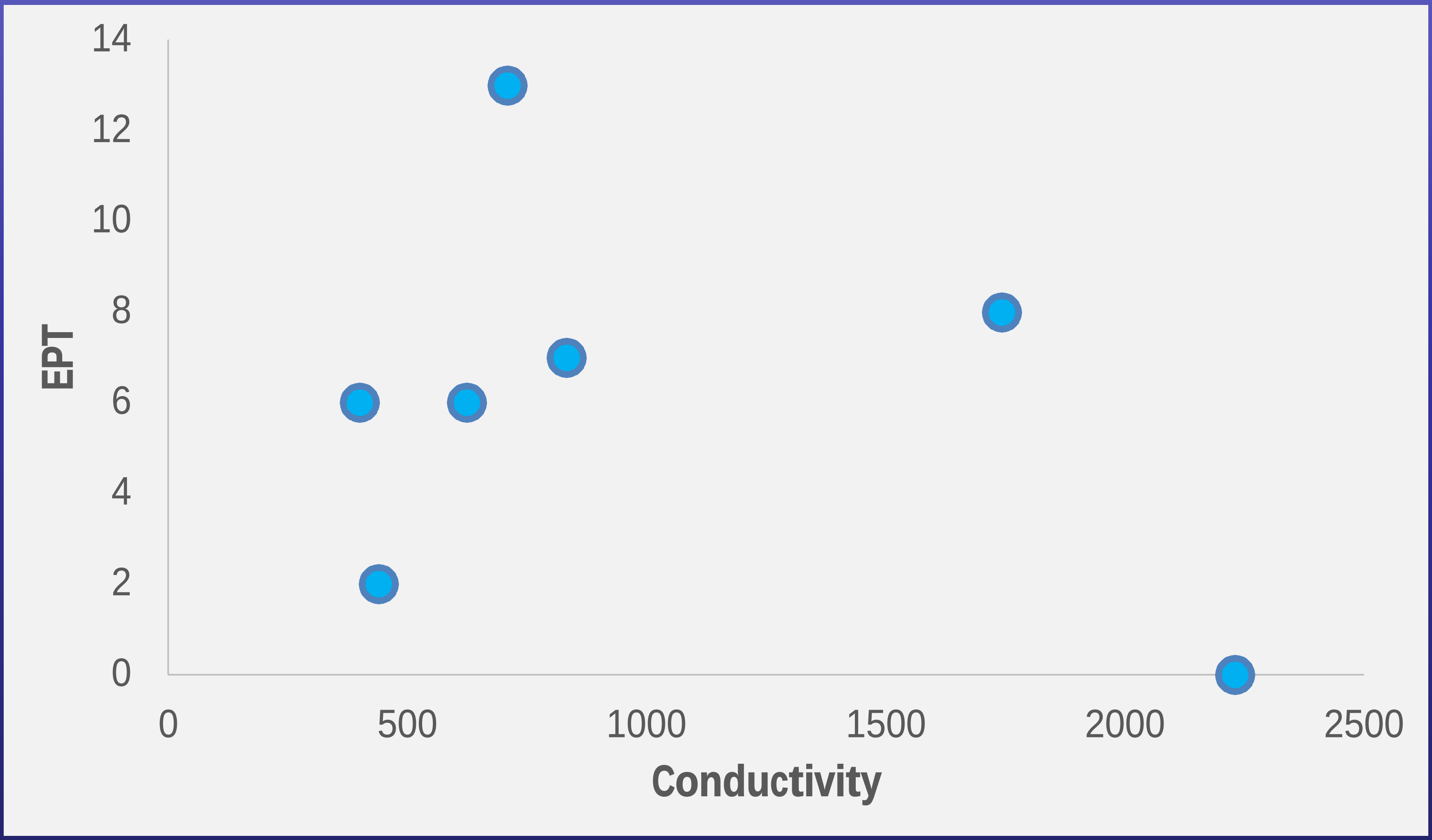


Biological gradient between conductivity and EPT Taxa inside the case



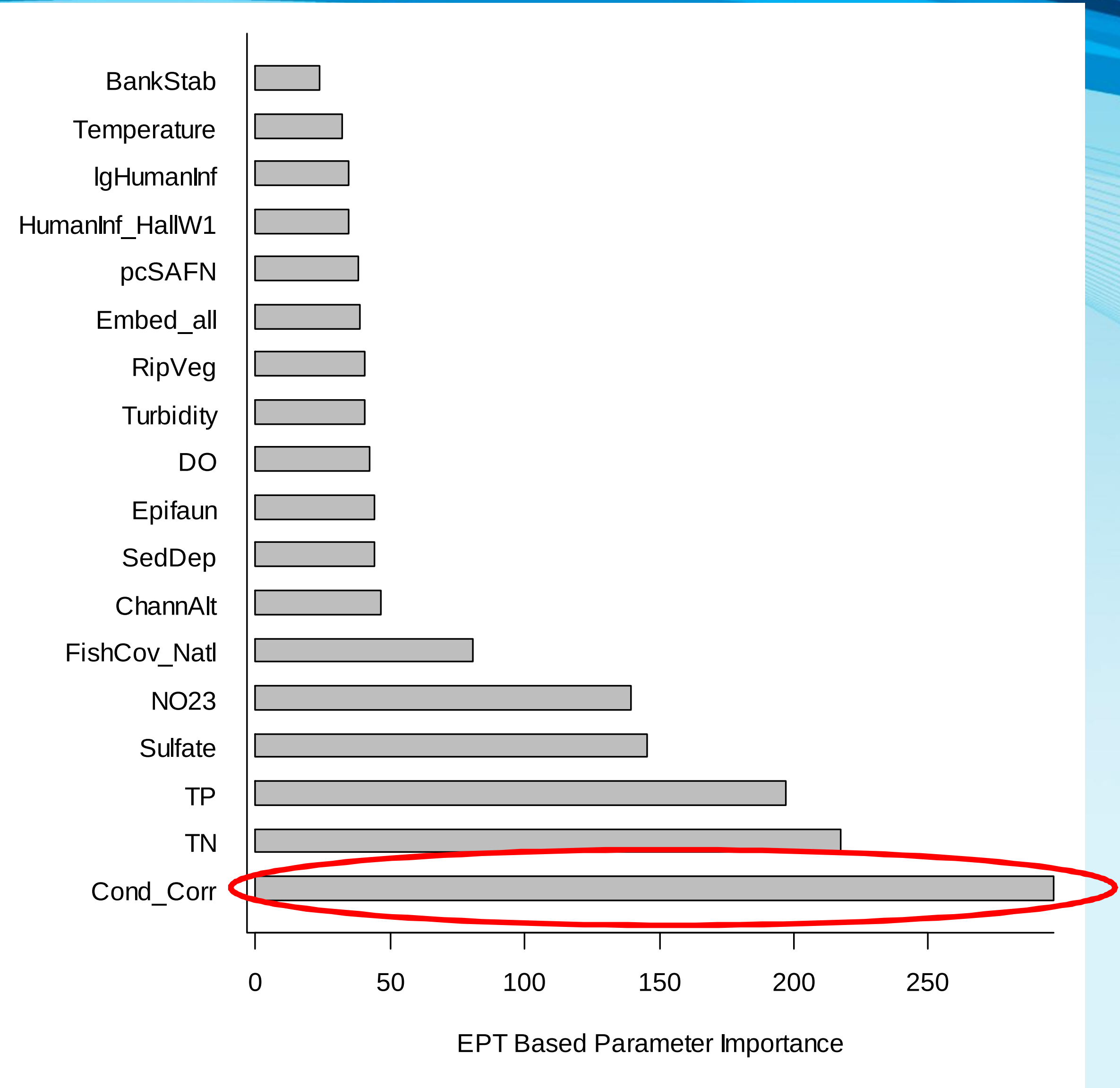
1: SDR-MLS
2: SDR-TWAS-1
3: SDR-TWAS-2
4: SDR-TWAS-3
5: CC
6: 901SJSMT2
7: 902SMROB8
8: 90746499
9: SMC00831
10: SMC02764

EPT-conductivity gradient not as strong with additional comparator sites



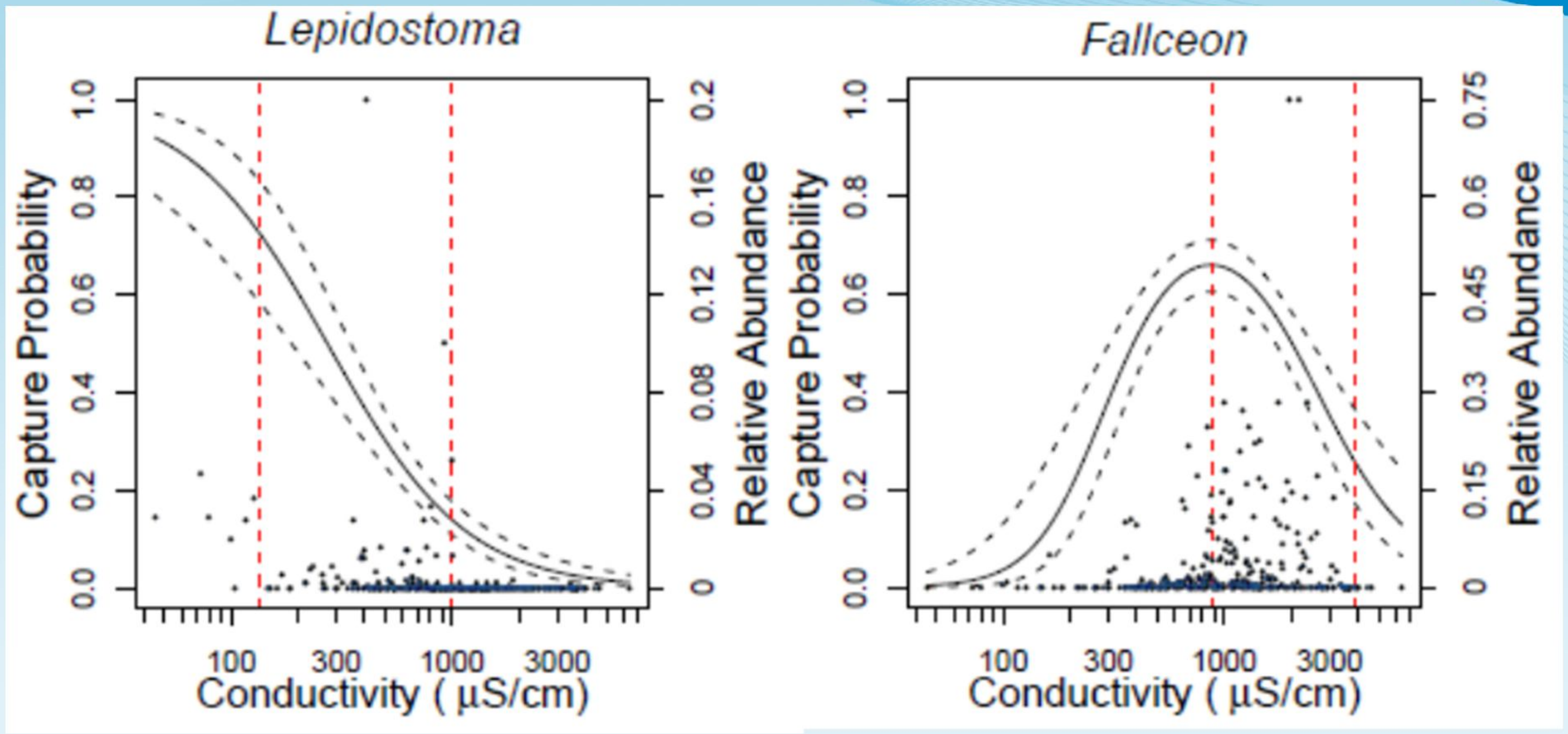
Need multivariate analyses and other diagnostic tools to interpret multiple stressor situations

Random Forest Model: EPT Metric using ecoregional data



think BLUE
SAN DIEGO

Conductivity-Specific Taxa Tolerance Values

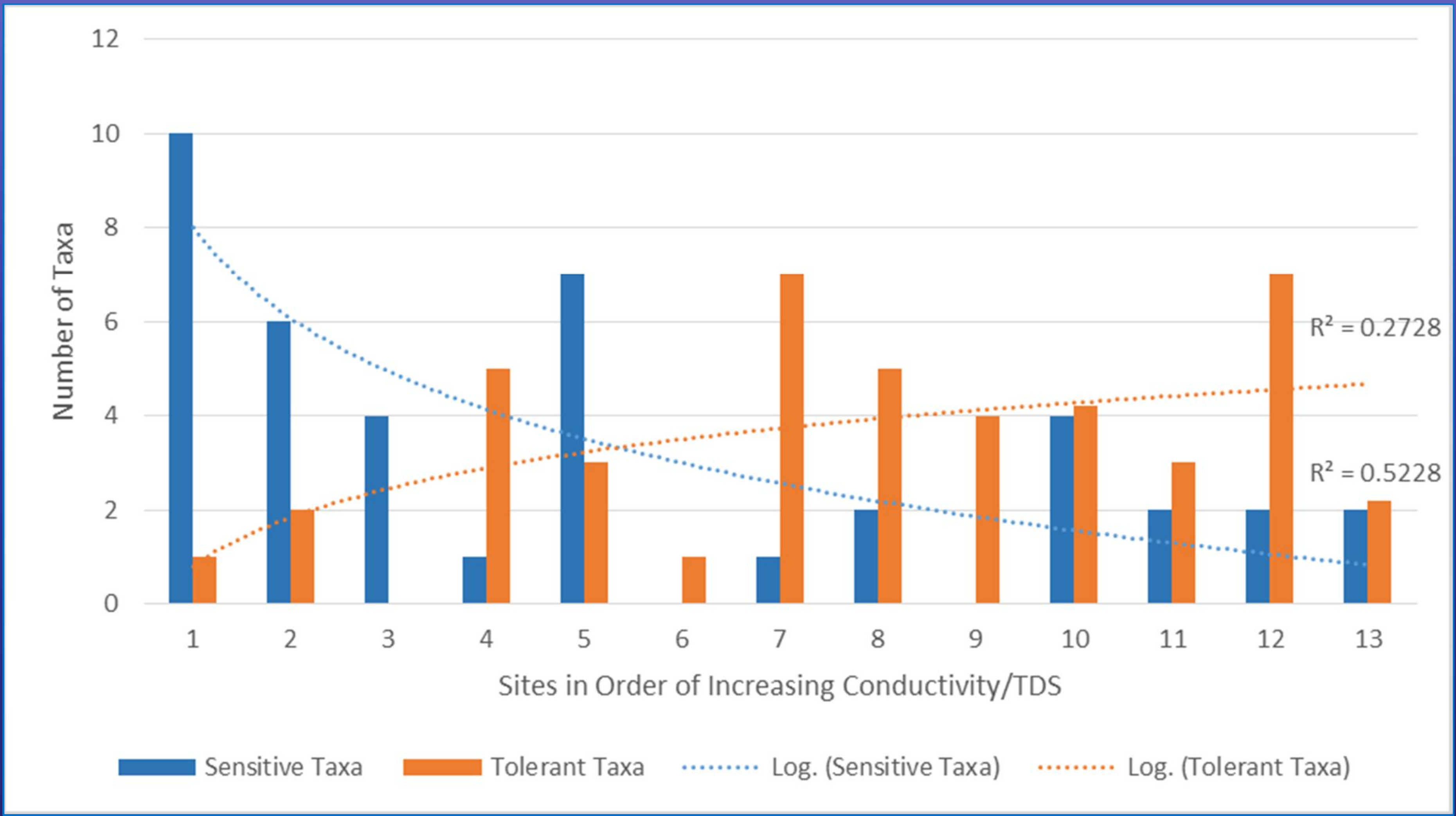


Vertical lines indicate 50th and 95th probability of occurrence based on a generalized additive model.

Final Conductivity Tolerance Values based on GAM model results

Taxon	Order	Family	Common name	FFG[1]	Habit[2]	Conventional Tolerance Value[3]	Number of Samples	Specific Conductivity (µS/cm)		Conductivity Tolerance Score[4]
								GAM 50th	GAM 95th	
Ablabesmyia	Diptera	Chironomidae	midge	CG	SP	8	19	1,340	5,248	4
Agabus	Coleoptera	Dytiscidae	predaceous diving beetle	P	SW	8	37	349	3,690	3
Agapetus	Trichoptera	Glossosomatidae	caddisfly	SC	CN	0	11	184	1,045	1
Alotanypus	Diptera	Chironomidae	midge	P	BU	7	34	1,750	5,808	6
Ambrysus	Hemiptera	Naucoridae	creeping water bug	P	CN	5	11	1,002	1,644	4
Apedilum	Diptera	Chironomidae	midge	CG	SP	6	66	867	5,140	5
Archilestes	Odonata	Lestidae	spread-winged damselfly	P	CB	9	18	256	1,159	2
Argia	Odonata	Coenagrionidae	narrow-winged damselfly	P	CB	7	104	1,023	5,358	5
Arrenurus	Trombidiformes	Arrenuridae	mite	P		5	11	302	3,258	4
Atractides	Trombidiformes	Hygrobatidae	mite	P		8	72	328	2,704	2
Baetis	Ephemeroptera	Baetidae	mayfly	CG	SW	5	241	610	4,831	4
Berosus	Coleoptera	Hydrophilidae	water scavenger beetle	MH, P*	SW	5	13	506	923	1
Brillia	Diptera	Chironomidae	midge	SH	SP	5	53	335	3,467	2
Brundiniella	Diptera	Chironomidae	midge	P	SP	6	10	3,258	5,808	6
Caenis	Ephemeroptera	Caenidae	mayfly	CG	SP	7	29	429	1,067	2

Changes in Sensitive Taxa with Increasing Conductivity

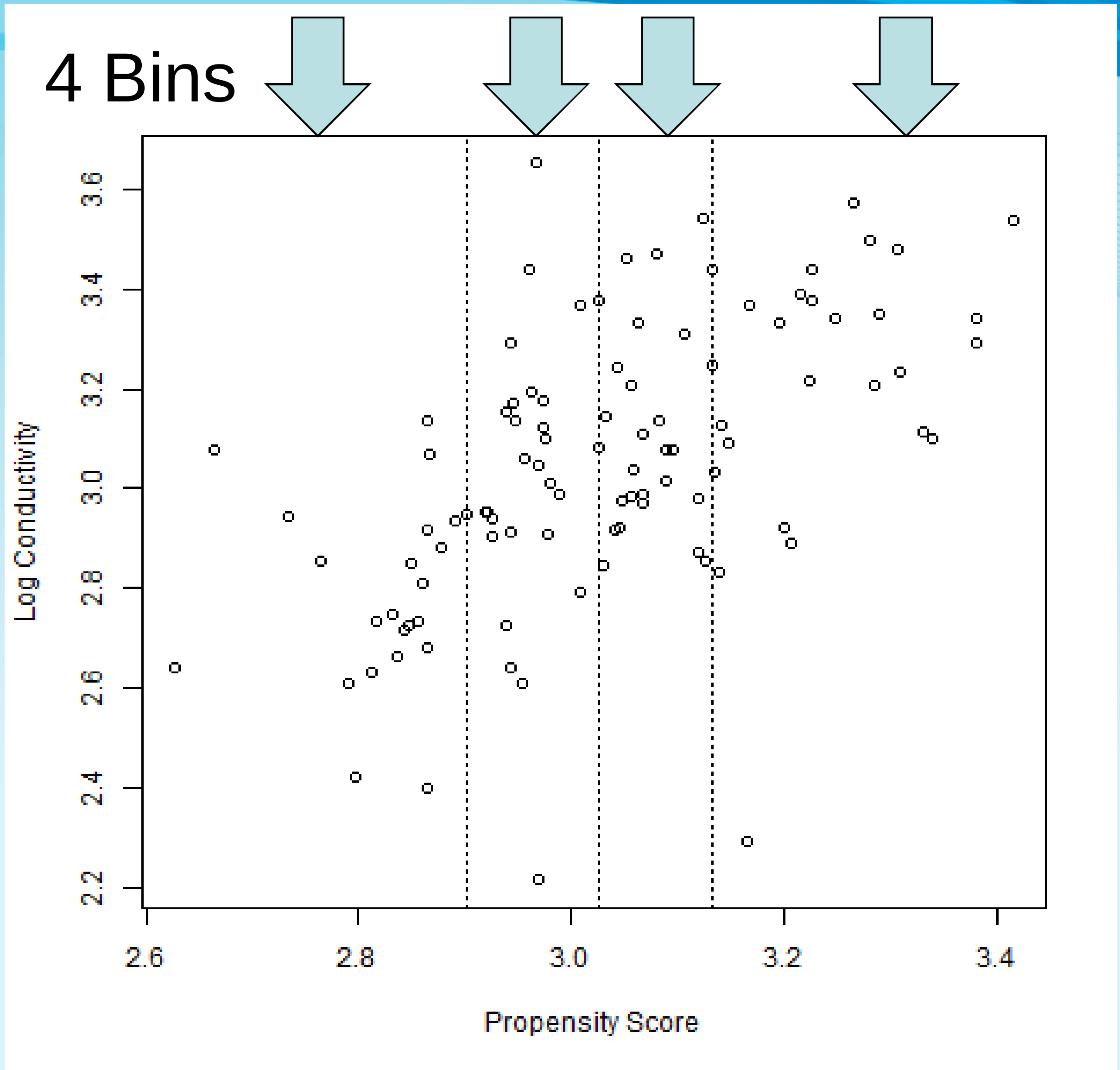


From Amec Foster Wheeler; Spring 2014

Propensity Score Analysis

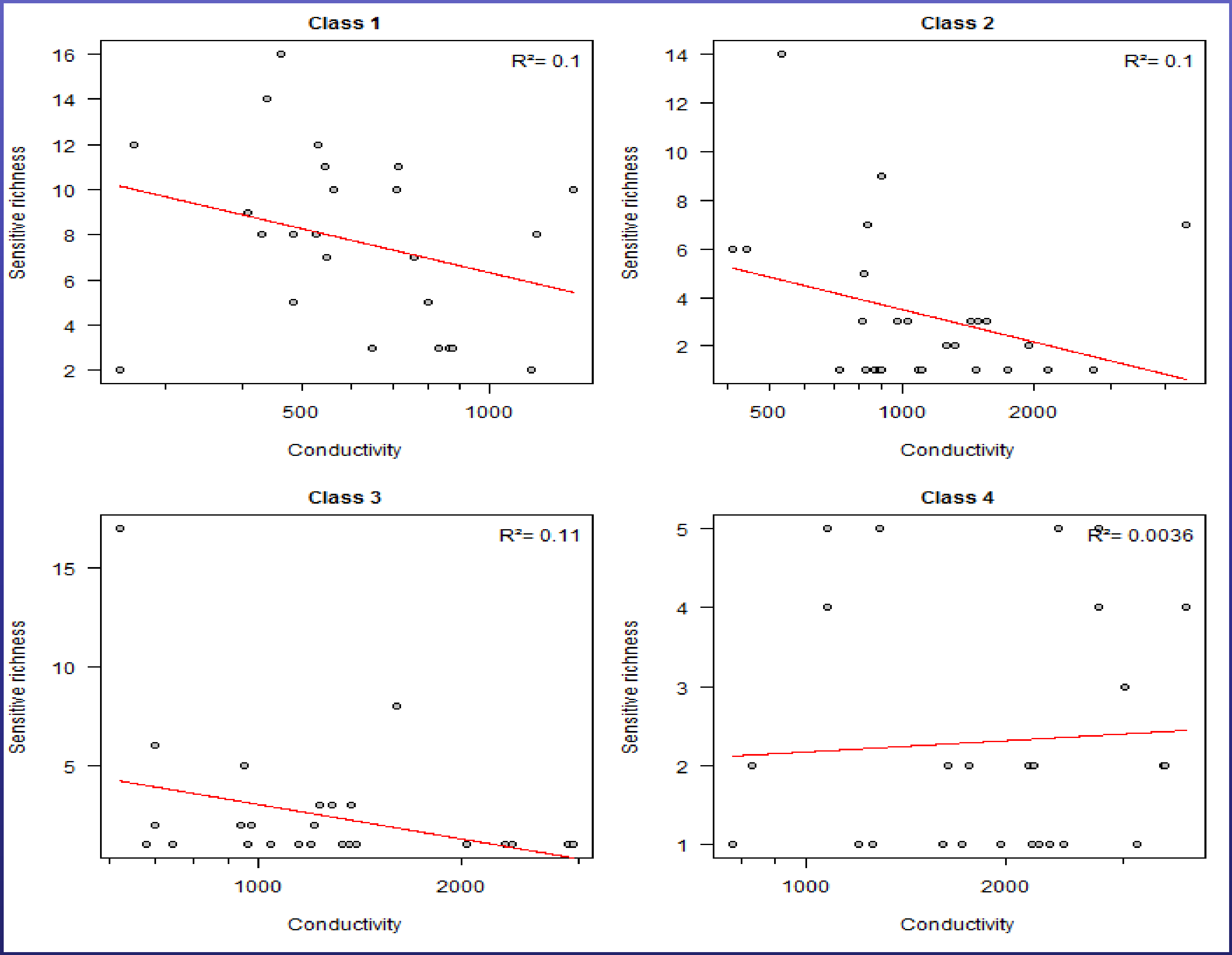
- Propensity score = the probability of a particular response due to a specific environmental variable (i.e., conductivity or TDS)
- Propensity bins represent sites with similar levels of covariates (e.g., nutrients, sedimentation, channel slope), but with changes in the desired variable (i.e., conductivity or TDS)
- Groups of sites with similar levels of co-varying factors were identified
- The conductivity-response relationship within each propensity score “bin” or “group,” was analyzed

Relationship between propensity score and $\log_{10}$(conductivity)



thinkBLUE
SAN DIEGO

Conductivity correlated with sensitive taxa richness in Strata 1-3; nutrients still a factor



Lines of evidence supporting conductivity as a cause of impairment

- Conductivity levels near 1,500 μS/cm associated with decreased EPT taxa richness
- Dominance of *Hyalella* at SDR-MLS is consistent with evidence from outside the case but evidence is weak
- Propensity score and random forest analyses suggest conductivity is a major factor associated with benthic invertebrate condition in the region
- Amec Foster Wheeler field study of reference sites observed a general decrease in conductivity-sensitive taxa and increase in conductivity-tolerant taxa as TDS increased

Lines of evidence not supporting conductivity as a cause

- Evidence within the case was weak or non-existent and the lower SDR is potentially affected by many factors
- TDS at one of the Amec reference sites (Silverado Creek) was higher (1,340 mg/L) than that observed at SDR-MLS, yet EPT taxa and other metrics were similar to the best reference sites evaluated
- Apparent discordance between TDS and macroinvertebrate composition is perhaps due to sulfate being the main anion at Silverado Creek while chloride is dominant at MLS (underlying geology is important!)
- TDS (or conductivity), by itself, may not be a good predictor of invertebrate integrity in this watershed.

Recommendations

- Conductivity and TDS thresholds should be defined for different areas of the SDR basin (and perhaps the ecoregion) to differentiate natural from anthropogenic sources and true impairment.
- Biological expectations should be defined when different major anions are present, e.g., sulfate vs chloride.
- Conductivity-specific tolerance values should be explored further as a diagnostic tool.
- Characterize reference conditions for naturally high conductivity sites similar to those in the SDR basin.