TETRA TECH

Laguna de Santa Rosa: Sediment and Nutrients

Presentation to North Coast Regional Water Quality Control Board, August 12, 2015

Jonathan B. Butcher, Ph.D., P.H.
Tetra Tech, Inc.

complex world | CLEAR SOLUTIONS™

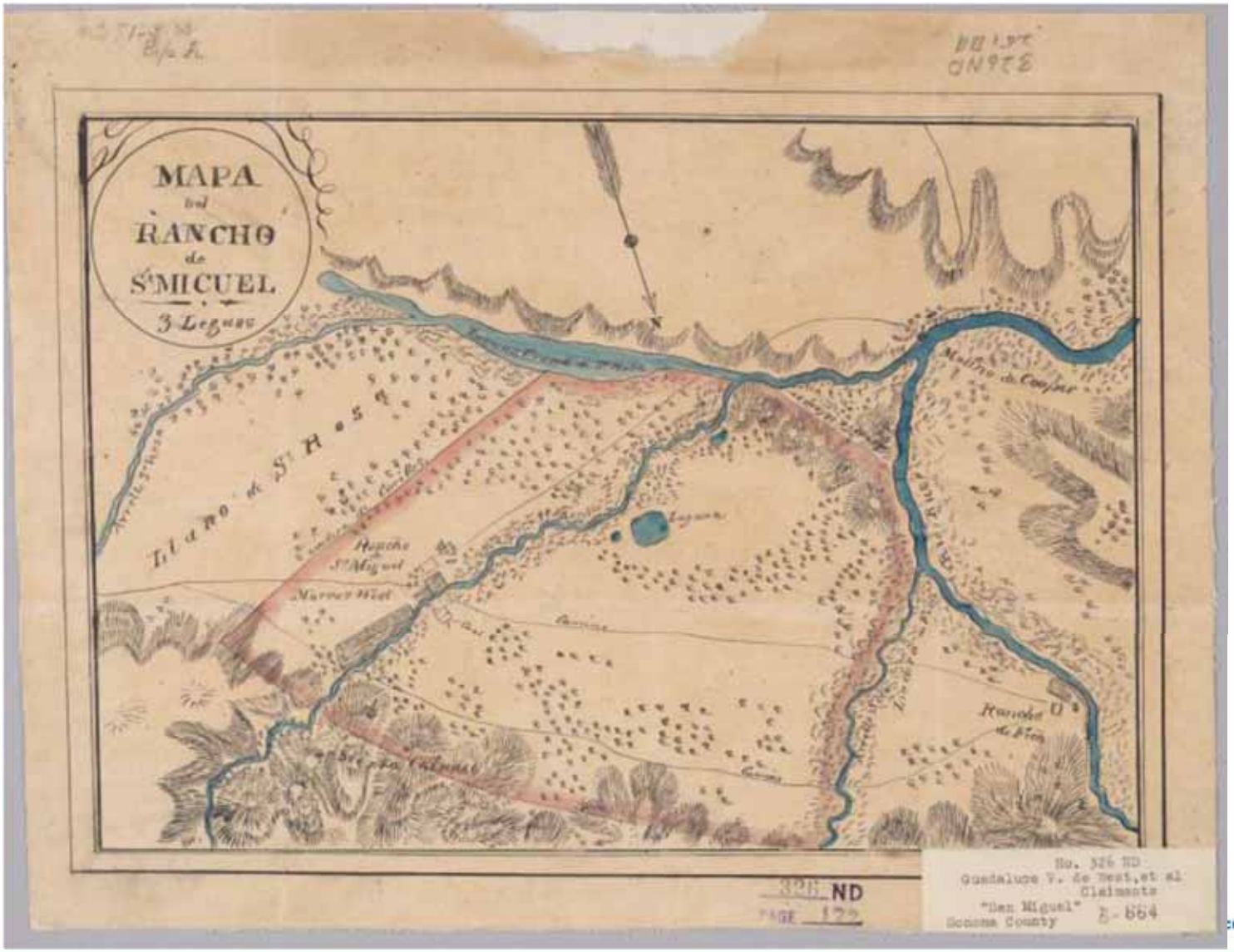
Purposes

- The Laguna de Santa Rosa and its impairments have been extensively studied
- My role:
  - Reconcile and integrate the past work
  - Provide analyses to unify the sediment and nutrient budgets
- Present final results of Sediment Budget analysis
- Discuss ongoing work on Nutrient Analysis and its link to the sediment budget

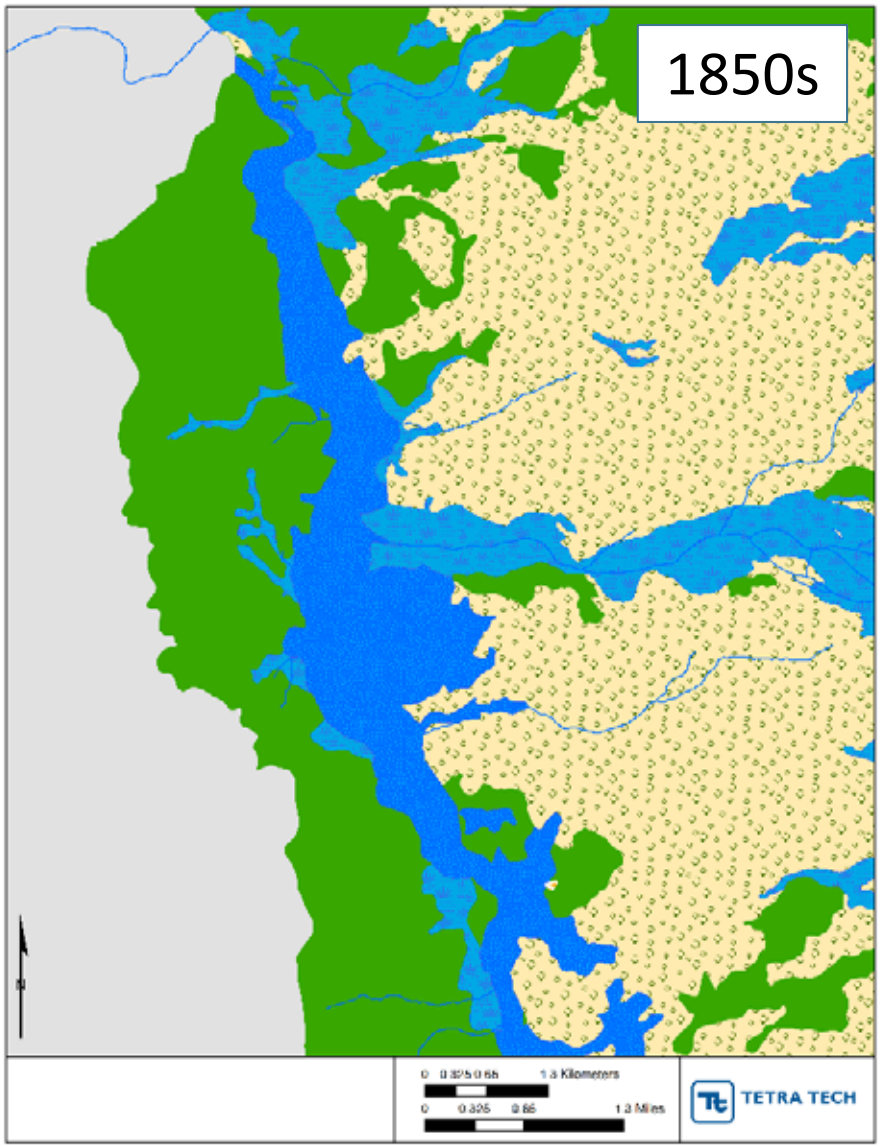
Background: Importance of the Laguna

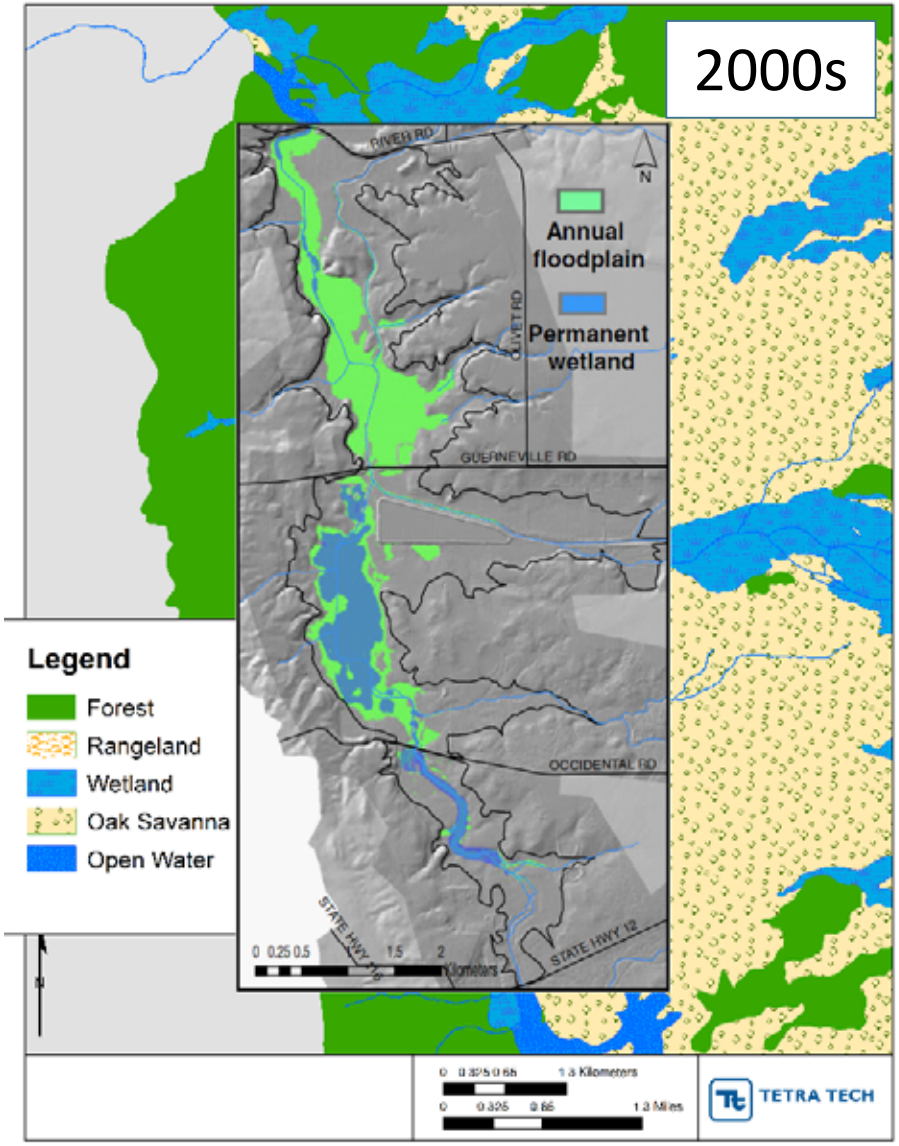
- Largest freshwater wetlands complex on the northern California coast
- Designated in 2010 as a “Wetland of International Importance” by the Ramsar Convention
- Home to threatened and endangered species; important migratory bird resource
- Provides protective flood storage volume
- Aesthetic and recreational benefits to Sonoma County

The Historical Laguna



Loss of Historical Water and Wetlands



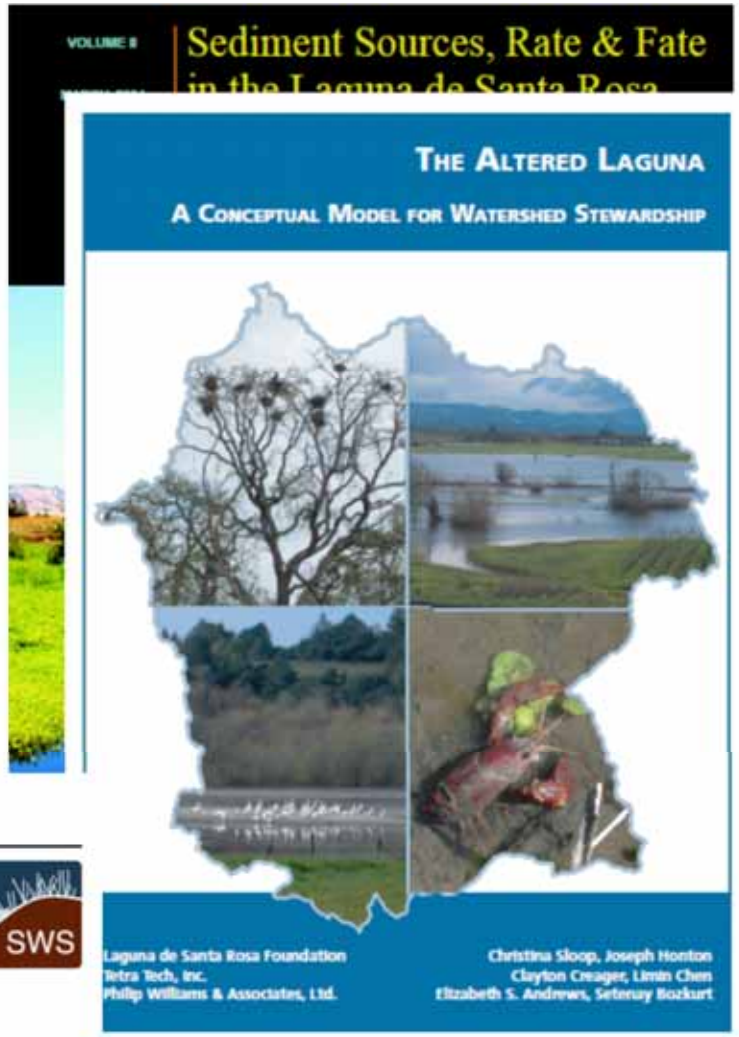


Biostimulatory Conditions and *Ludwigia* Infestation

- Wilfred Channel 2007 (J. Meisler)

Extensive Past Work

- Phil Williams & Associates, 2004 – sediment budget
- Sloop et al., 2007 – conceptual model
- USGS 2006-2012 – measured sediment concentrations, deposition rates, loads



Wetlands
DOI 10.1007/s13157-012-0350-4

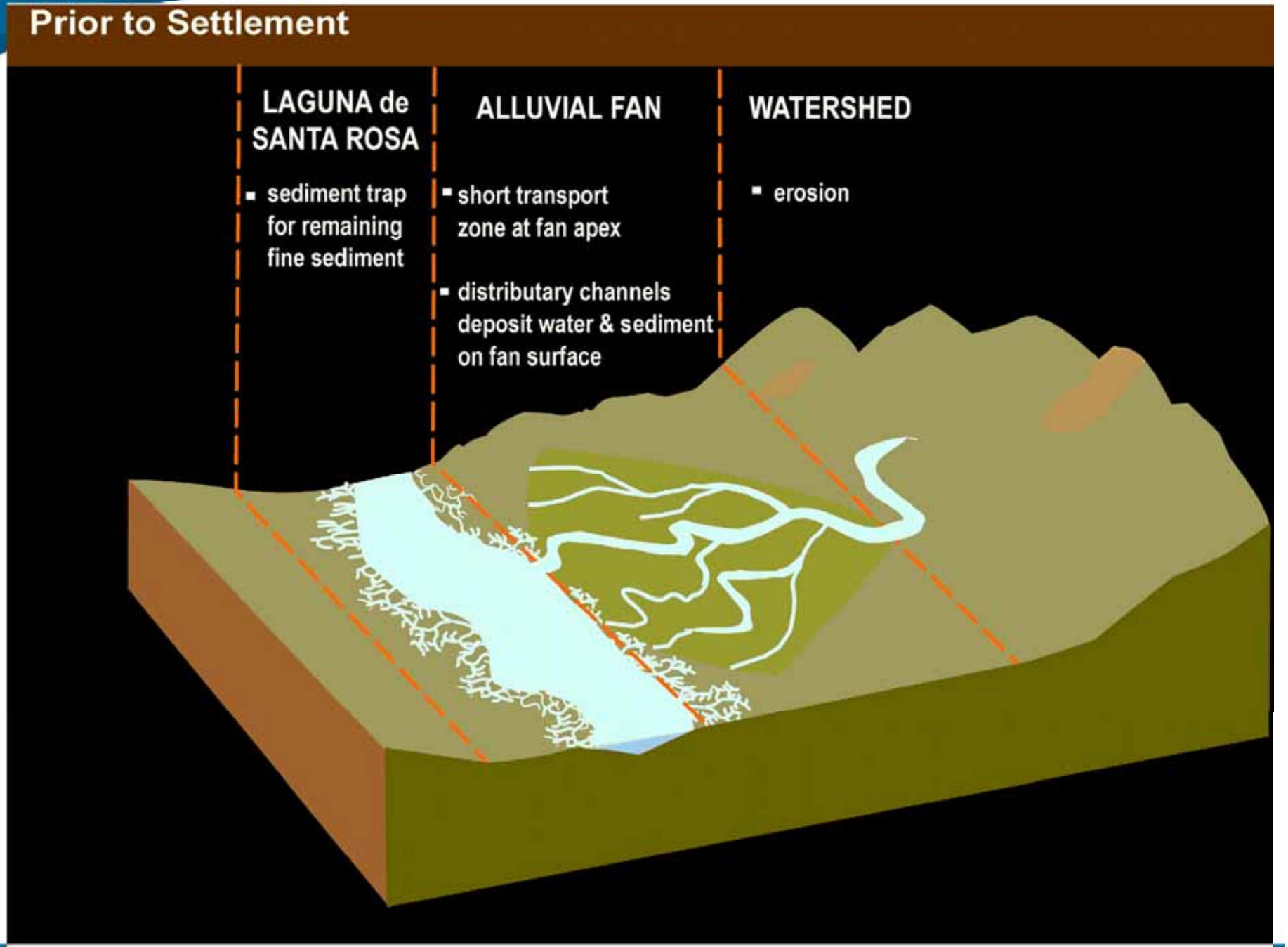
ARTICLE

Estimating floodplain sedimentation in the Laguna de Santa Rosa, Sonoma County, CA

Jennifer A. Curtis · Lorraine E. Flint · Cliff R. Hupp

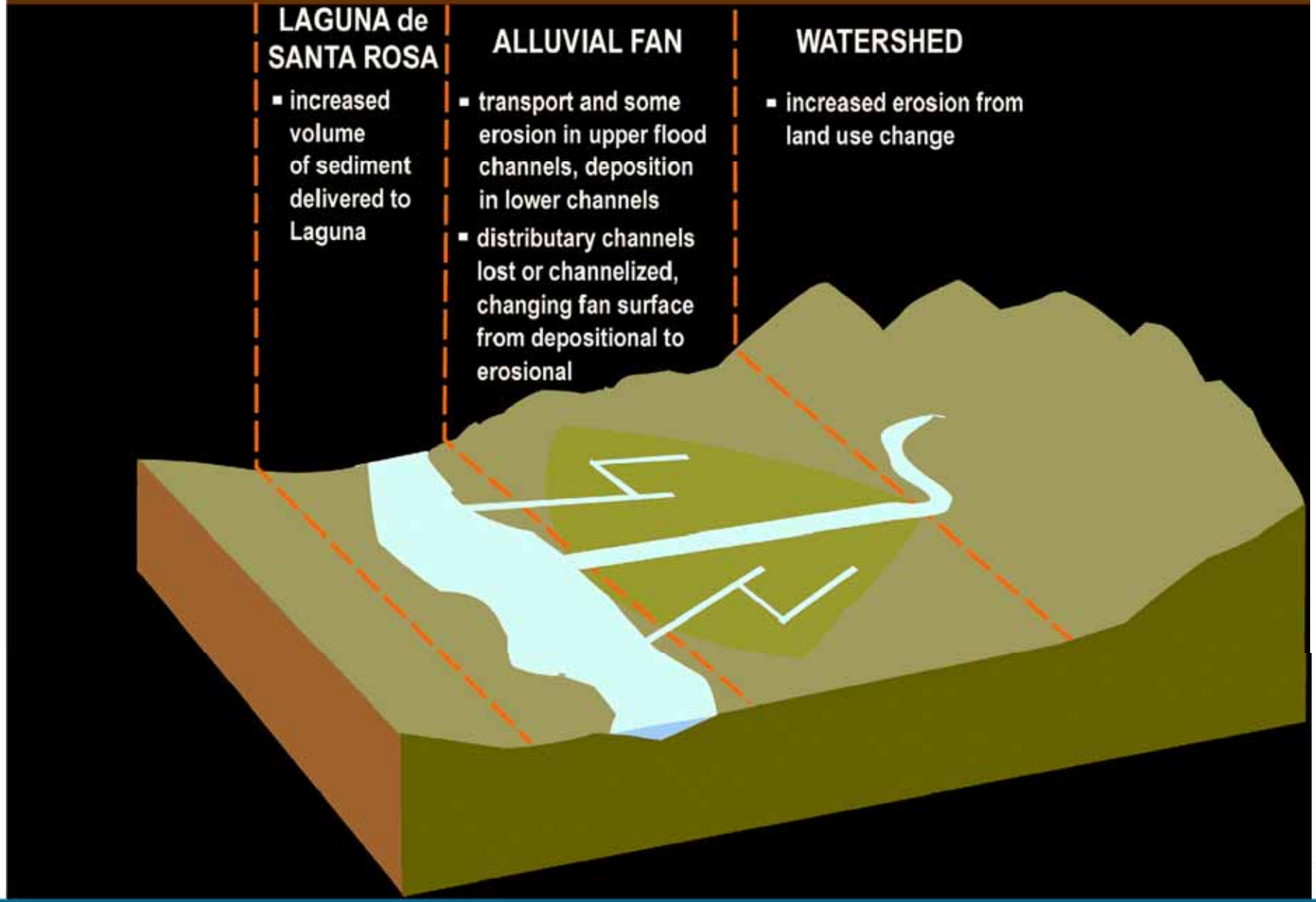
TETRA TECH

Prior to Settlement



TETRA TECH

After Settlement

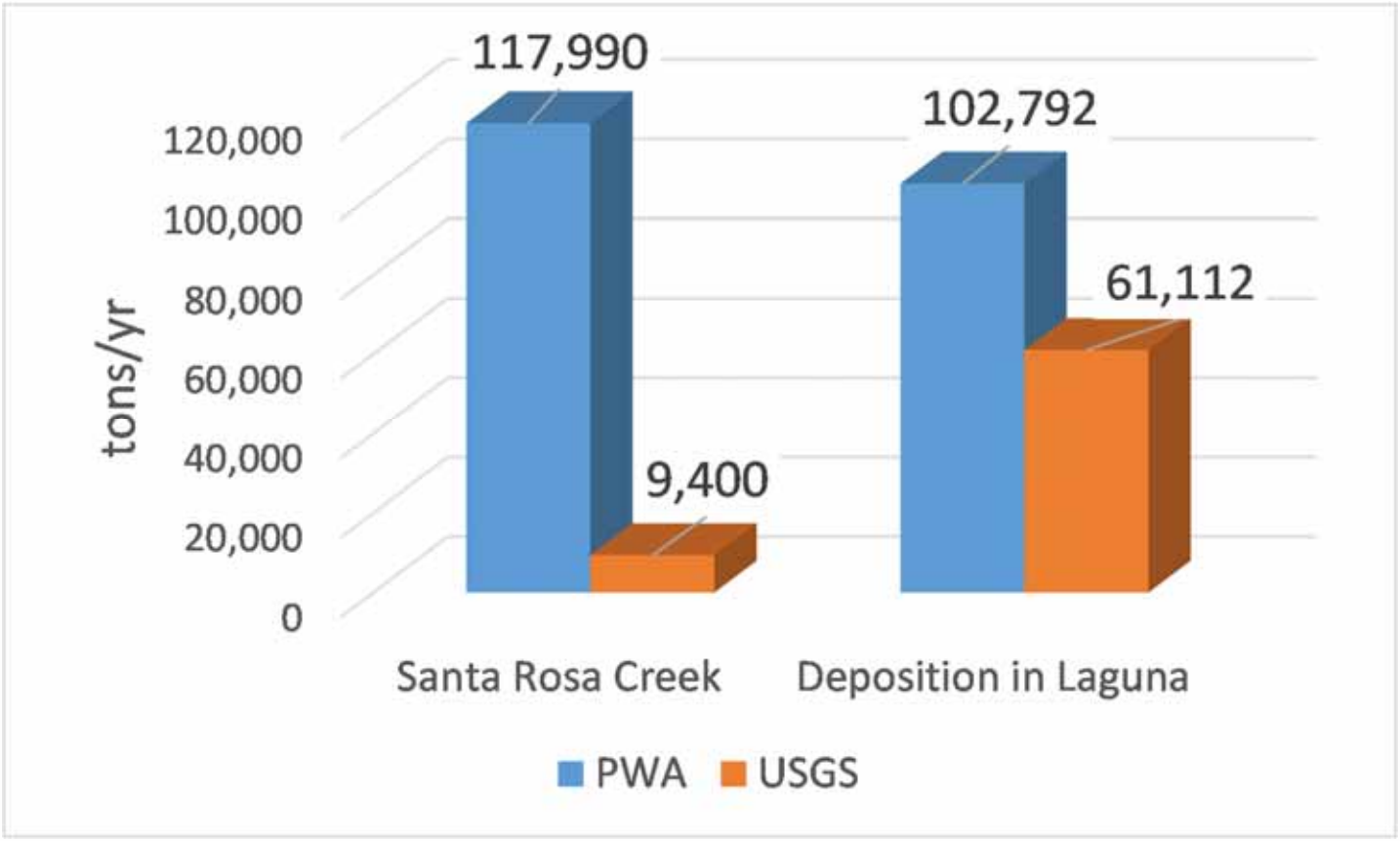


Sediment Budget

- Balancing the checkbook – income and outlays
- Consensus of PWA and Sloop et al.:
  - The empirical method of the Pacific Southwest Interagency Committee (PSIAC) provides the best estimate of delivered loads among available options
  - PSIAC load estimates are supported by multiple lines of evidence, including load estimates from turbidity monitoring and infill rates of Matanzas Reservoir, *but*
  - PSIAC does not identify individual source contributions

Cognitive Dissonance

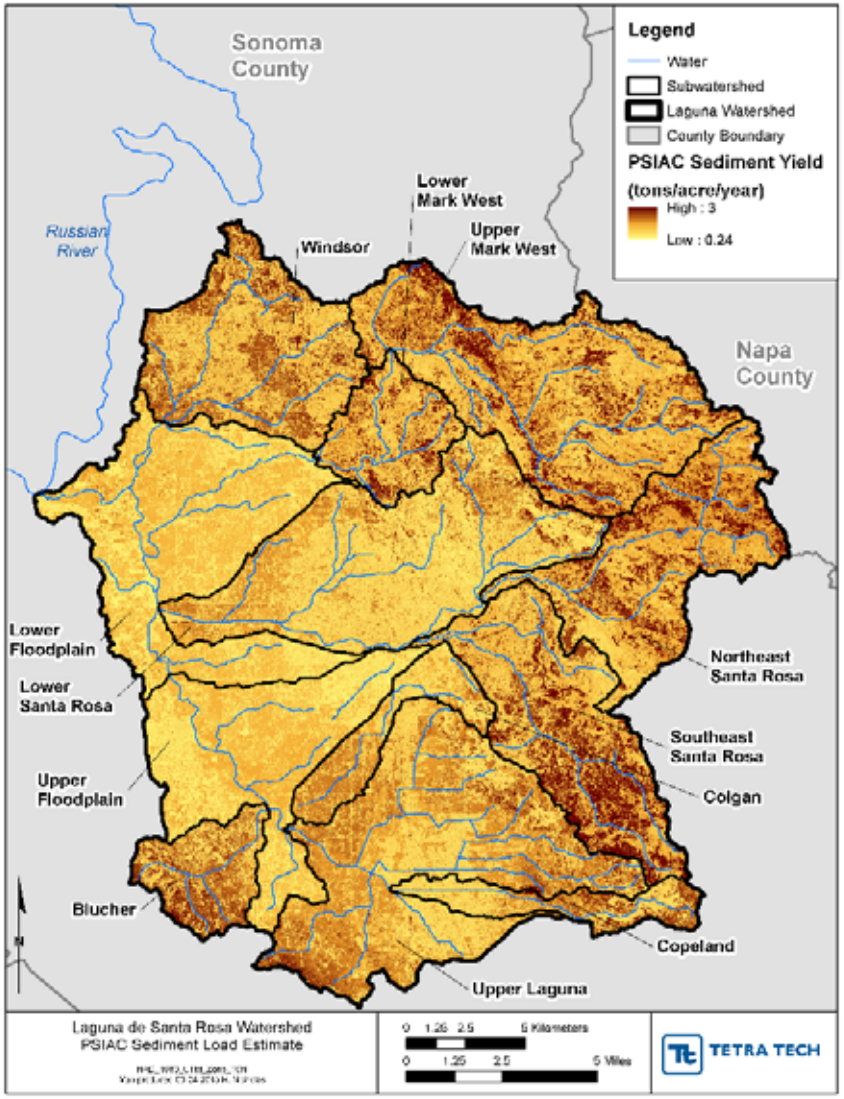
- USGS study does not validate PSIAC estimates of current load



Average Load per year, Current Conditions

At least one of these estimates must be wrong…

- We re-analyzed and confirmed order of magnitude of both PSIAC and USGS load estimates from flow and concentration using multiple methods

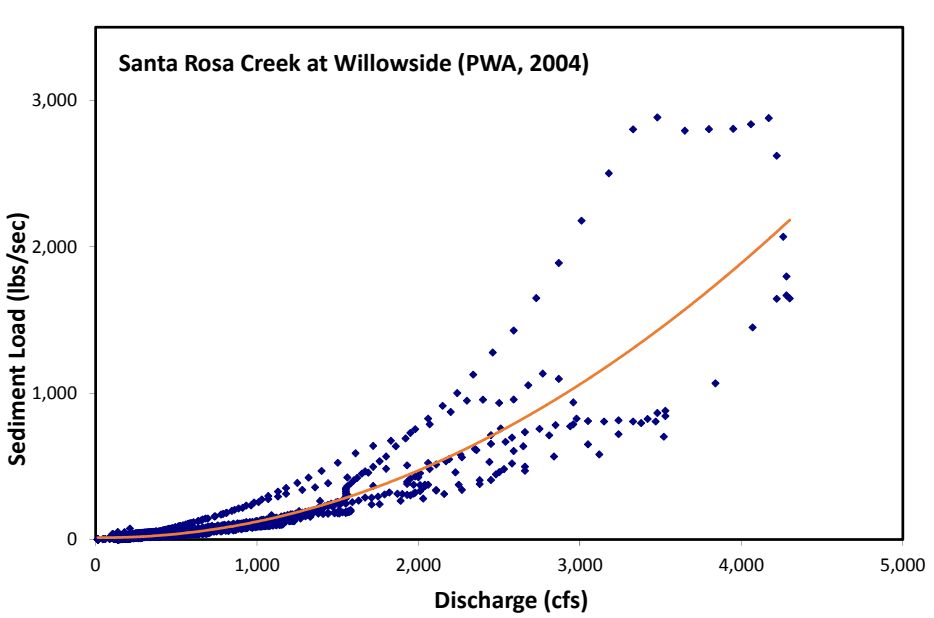


Why are they different?

- PSIAC average sediment yield for Santa Rosa Creek watershed estimates infill of Matanzas Reservoir quite well – but Matanzas is in erosive uplands and should have higher erosion rates than much of the watershed
- Corroboration by comparison to sediment load estimated from turbidity relies on questionable assumptions

Turbidity Corroboration Method

- Establish relationship of suspended sediment and turbidity
- Use continuous flow and turbidity to estimate a sediment loading rating curve
- Apply rating curve to longer-term flow record to estimate sediment loads



Turbidity Corroboration Problems

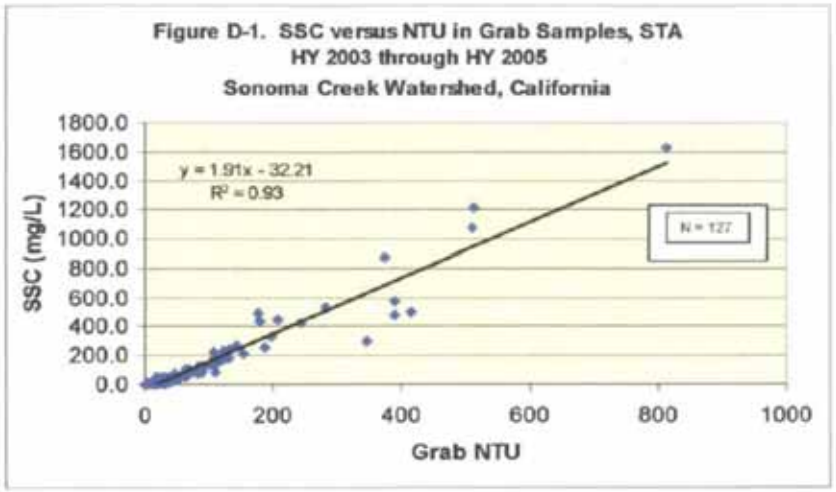
- Rating curve regression did not go through zero (non-zero sediment load with zero flow)
- Turbidity-sediment calibration (recommended by turbidimeter manufacturer)
  - Take sediment from bed at monitoring location
  - Add weighed amount to fixed volume of water
  - Mix with paint mixer
  - Record turbidity for six to eight points
- No split samples for turbidity and instream suspended sediment concentration available

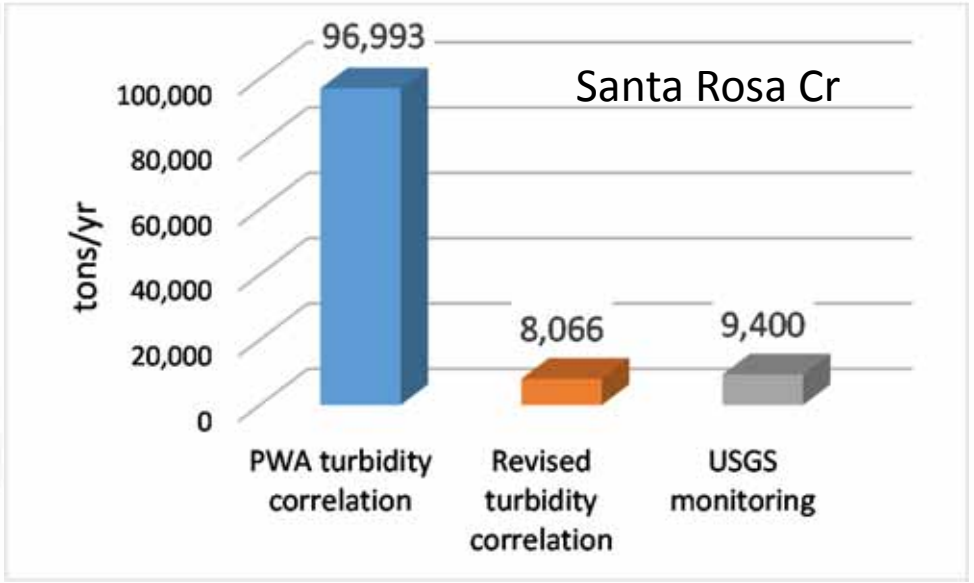
Turbidity Corroboration Problems

- Turbidity (light scattering) mostly due to fine clay particles
- Bed sediment ≠ Suspended sediment
  - Bed sediment dominated by sand
  - Suspended sediment often dominated by fine particles
- Bench calibration approach and regression not through zero ensures over-estimation of sediment load from turbidity data

Revised turbidity correlation

- Apply measured relationship of suspended sediment concentration to turbidity from Sonoma Creek TMDL

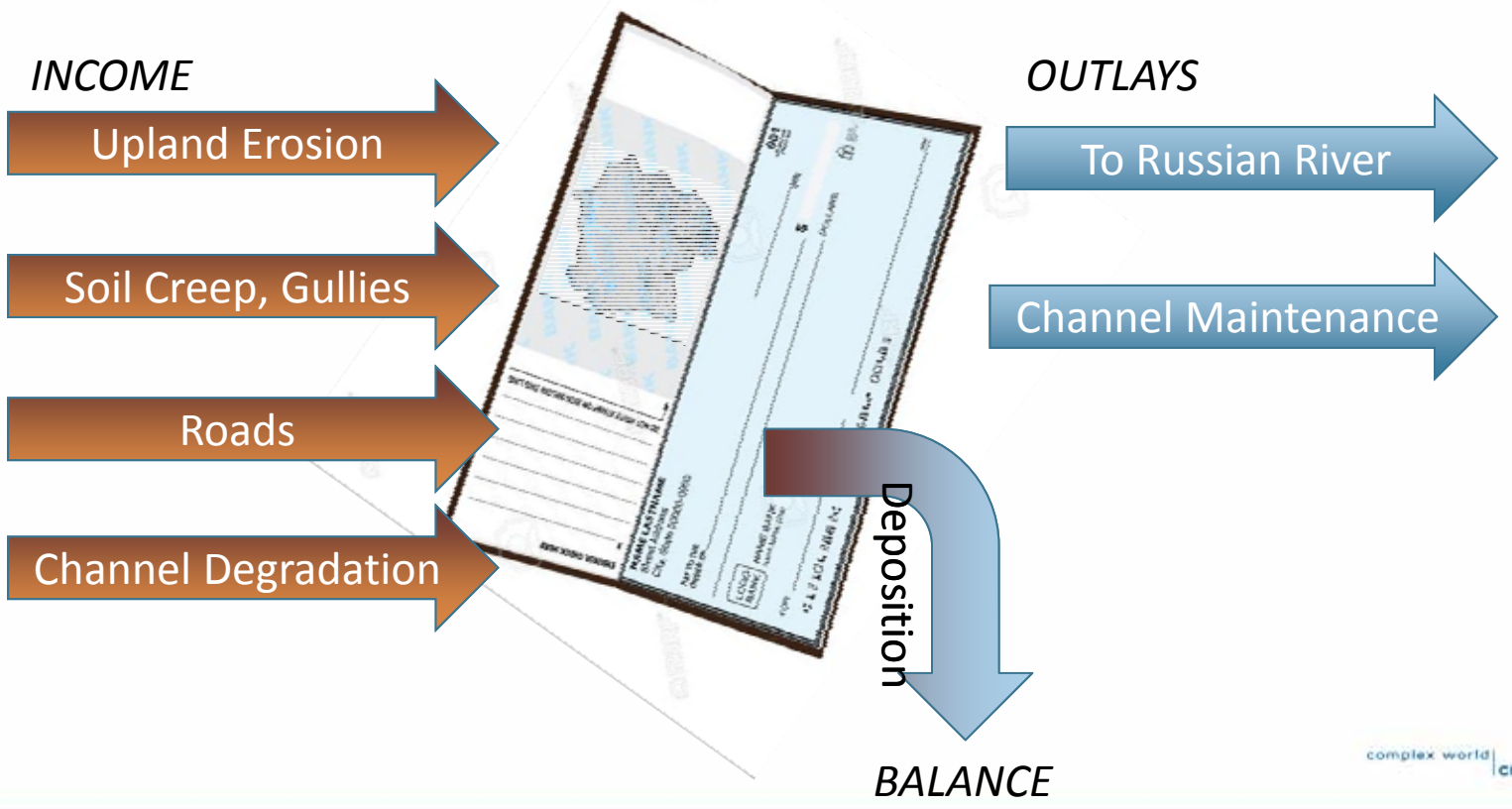




- Additional confirmation from SCWA MS4 monitoring

Assembling the sediment budget

- Constrain delivered loads to be consistent with estimates at 5 gages (re-analyzed)
- Weight of evidence to balance all sources and sinks

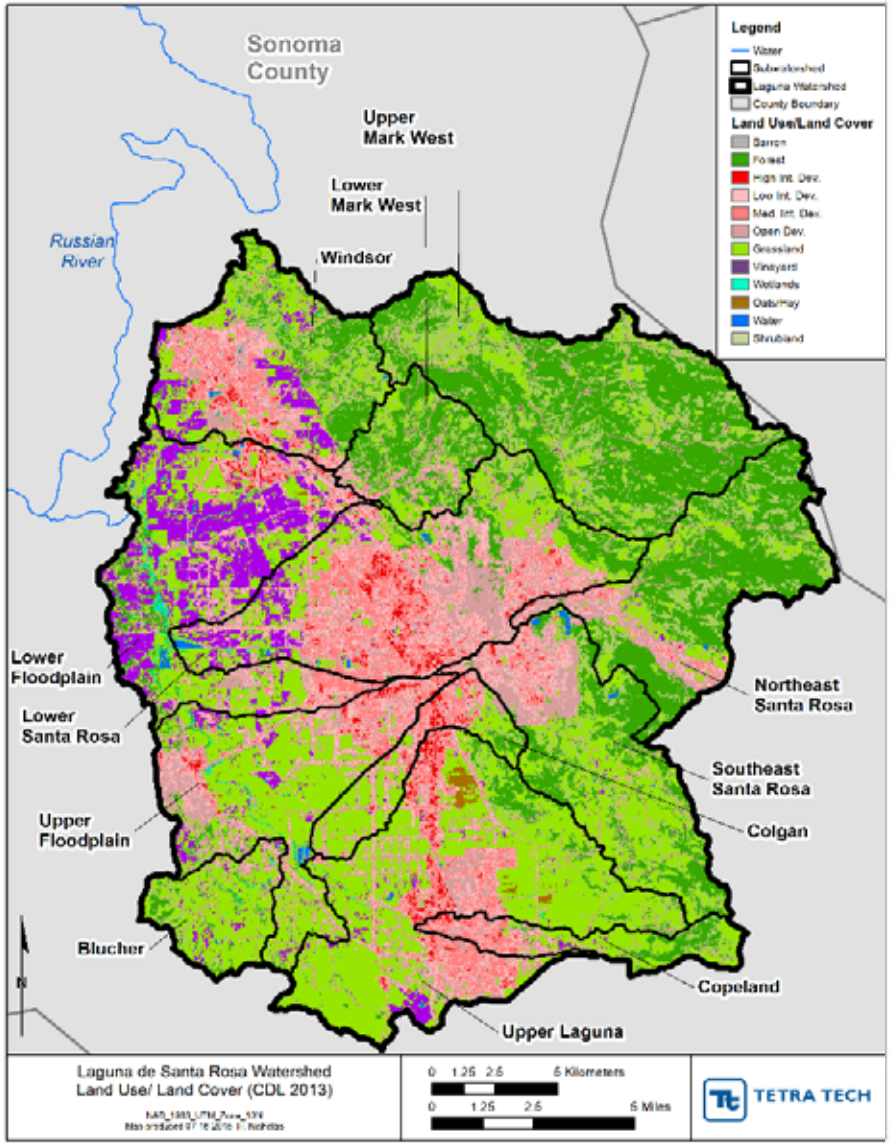


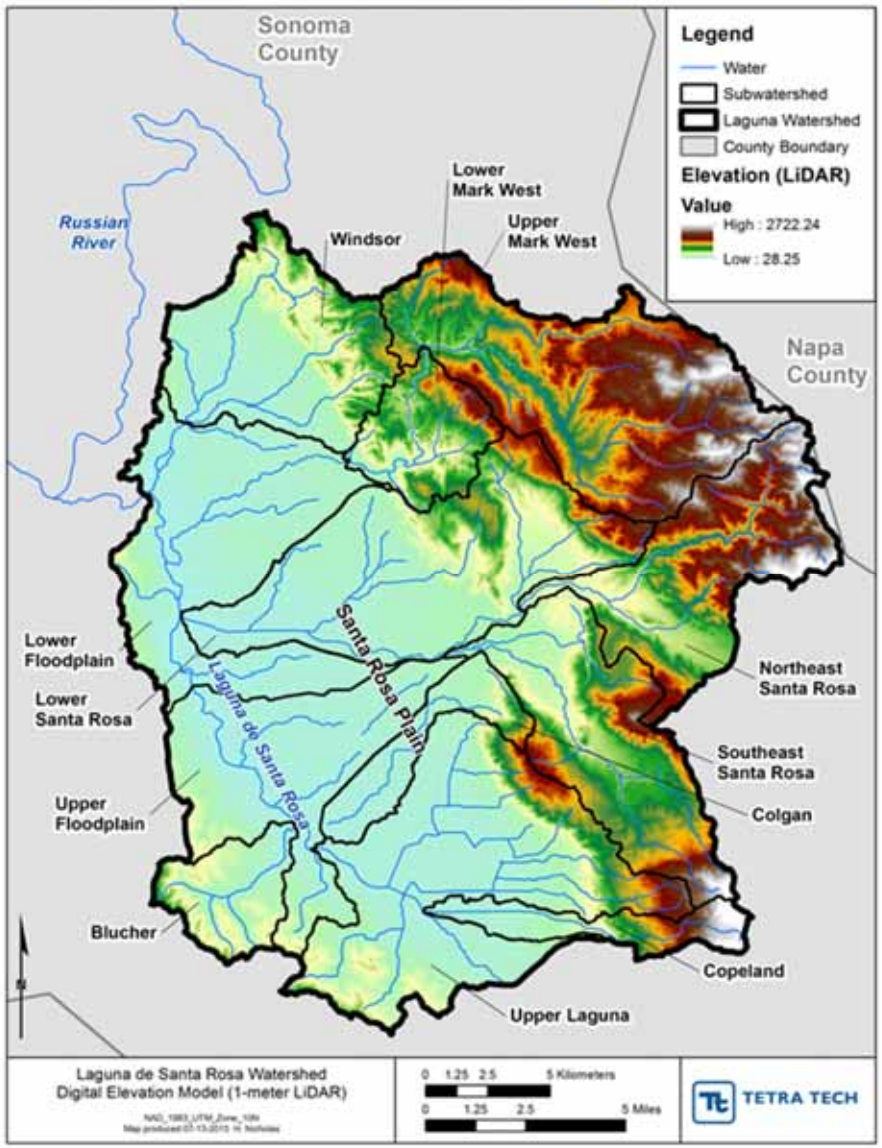
Upland Erosion: RUSLE Method

- Most important component for nutrient loads
- **R**evised **U**niversal **S**oil **L**oss **E**quation – trusted method for estimating soil *loss* as a function of rainfall and runoff (not soil delivery)
- New methods available to convert soil loss to delivered yield in GIS
  - Based on Connectivity Index (Borselli et al.)
  - Being incorporated into the InVEST simulation model for the Natural Capital Project supported by Stanford University, The Nature Conservancy, World Wildlife Fund, and the University of Minnesota

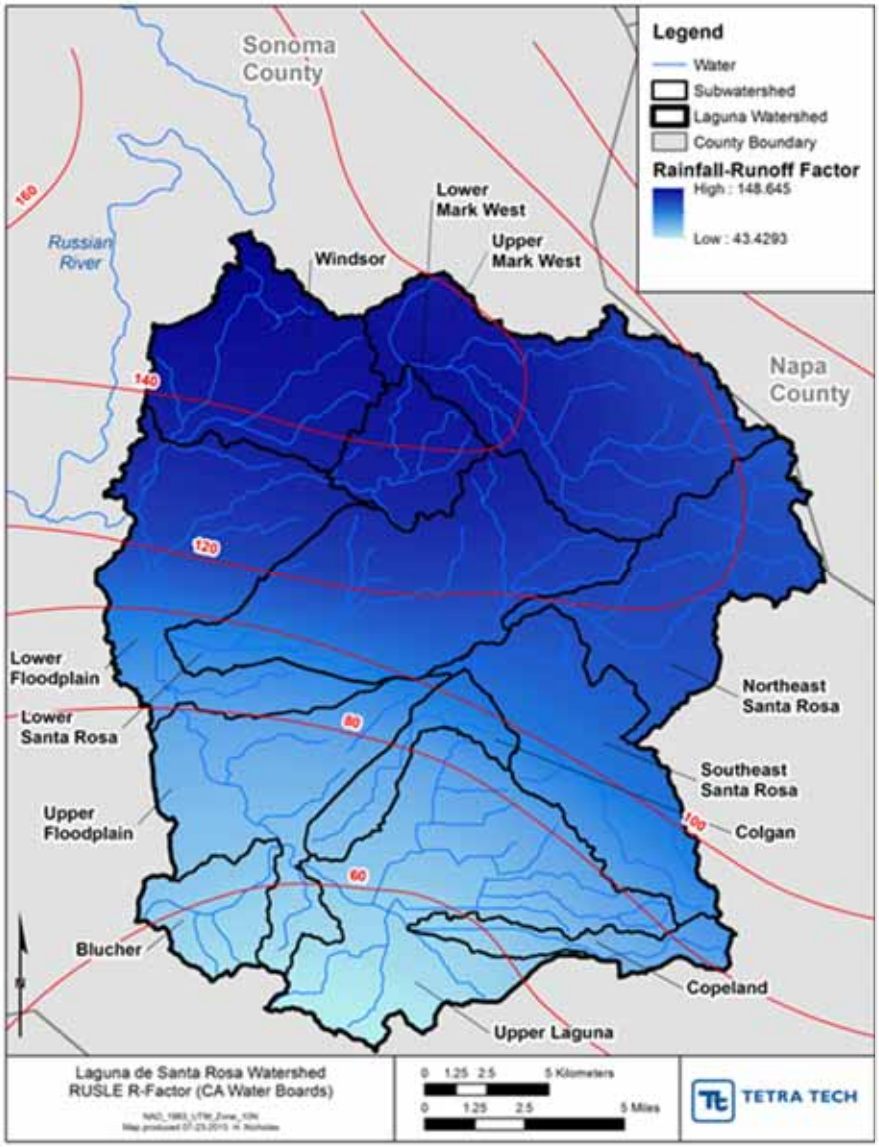
TETRA TECH

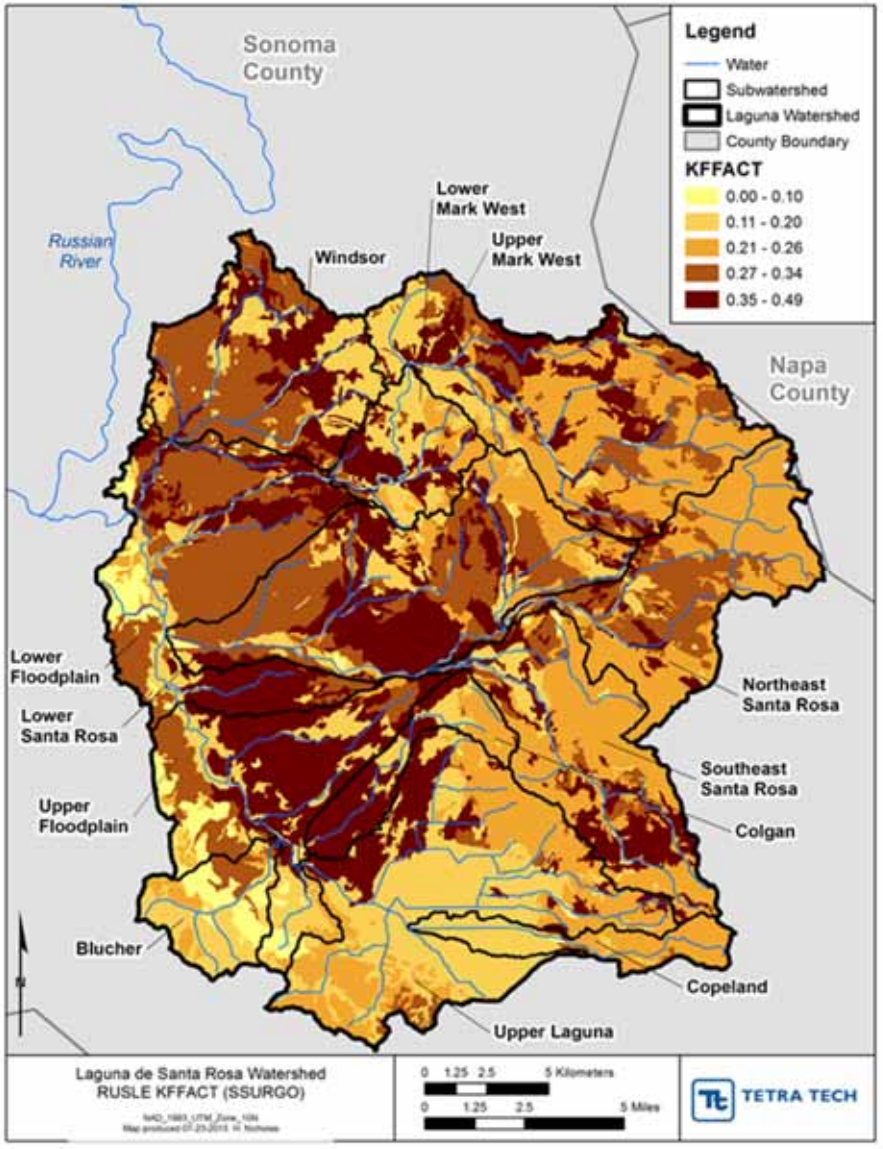
Land Use + Topography



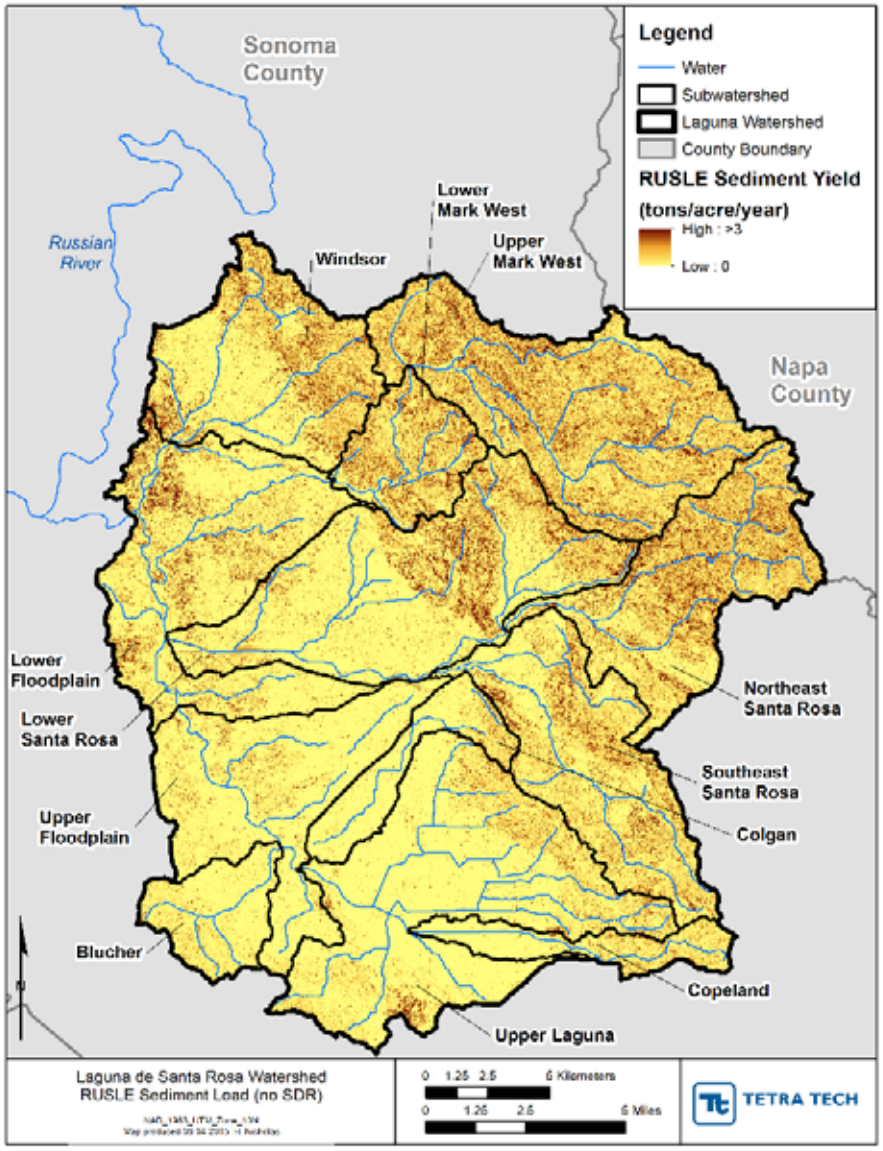


+ Rainfall Energy + Soil Erodibility





+ Cover (from LiDAR) = RUSLE Soil Loss

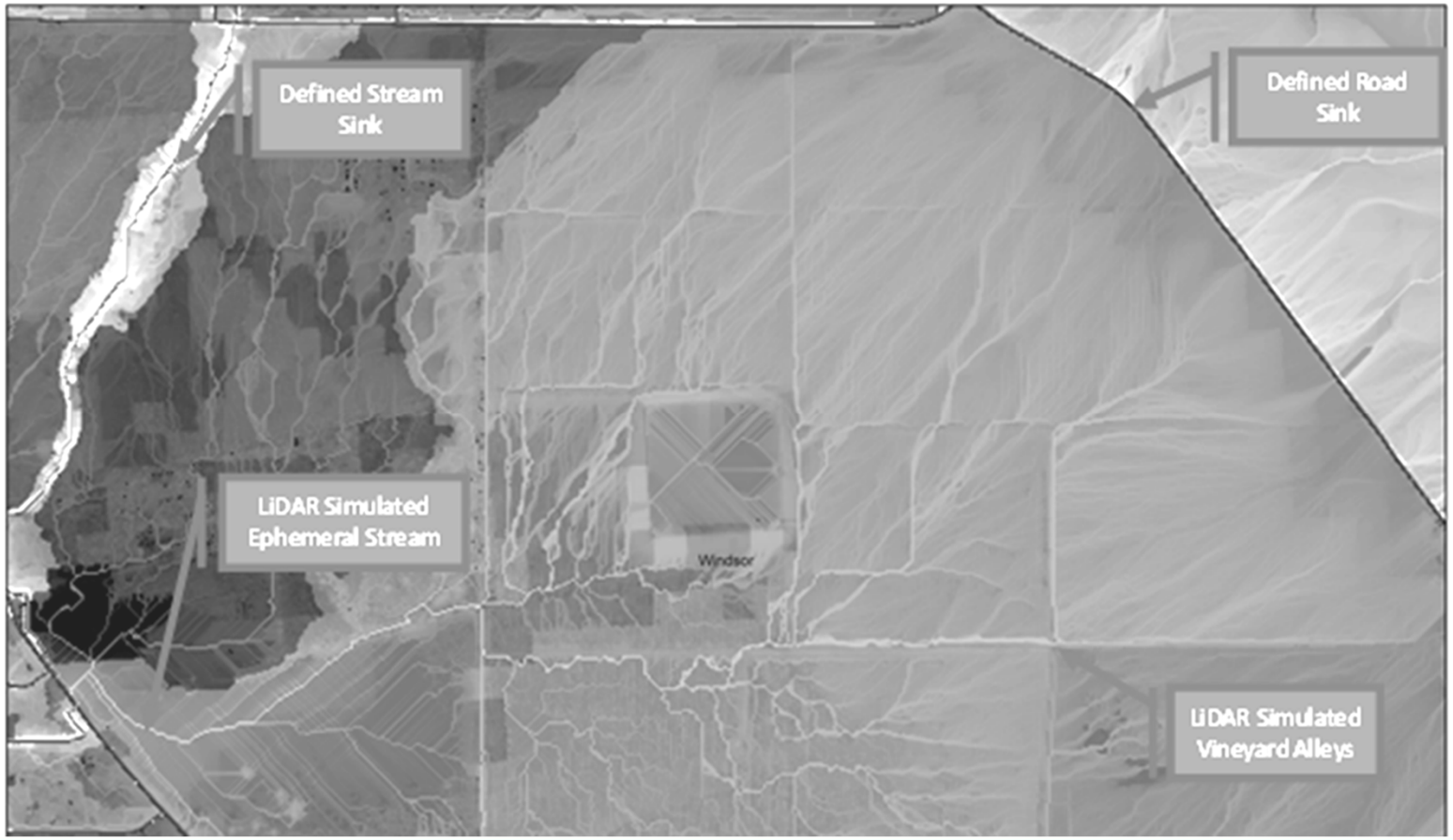


Only a fraction of soil loss is delivered to the stream network!

TETRA TECH

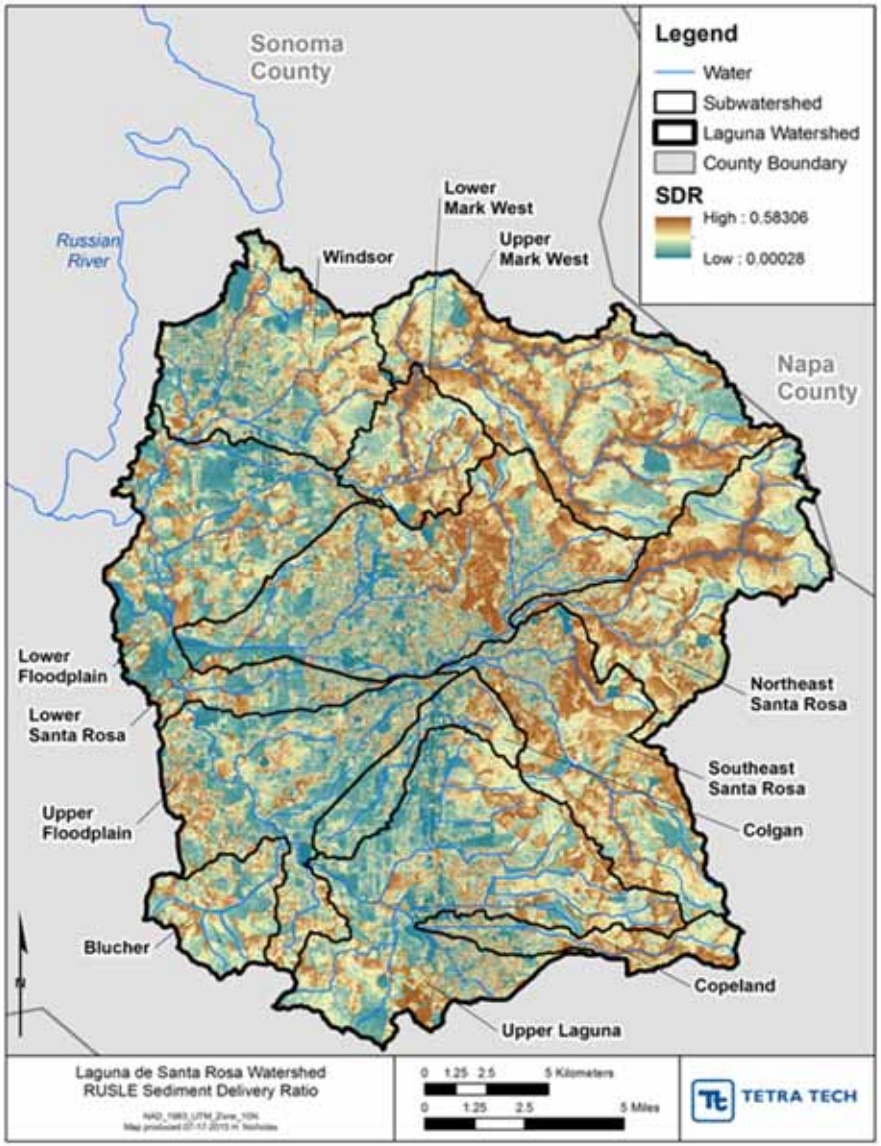
Calculating Connectivity

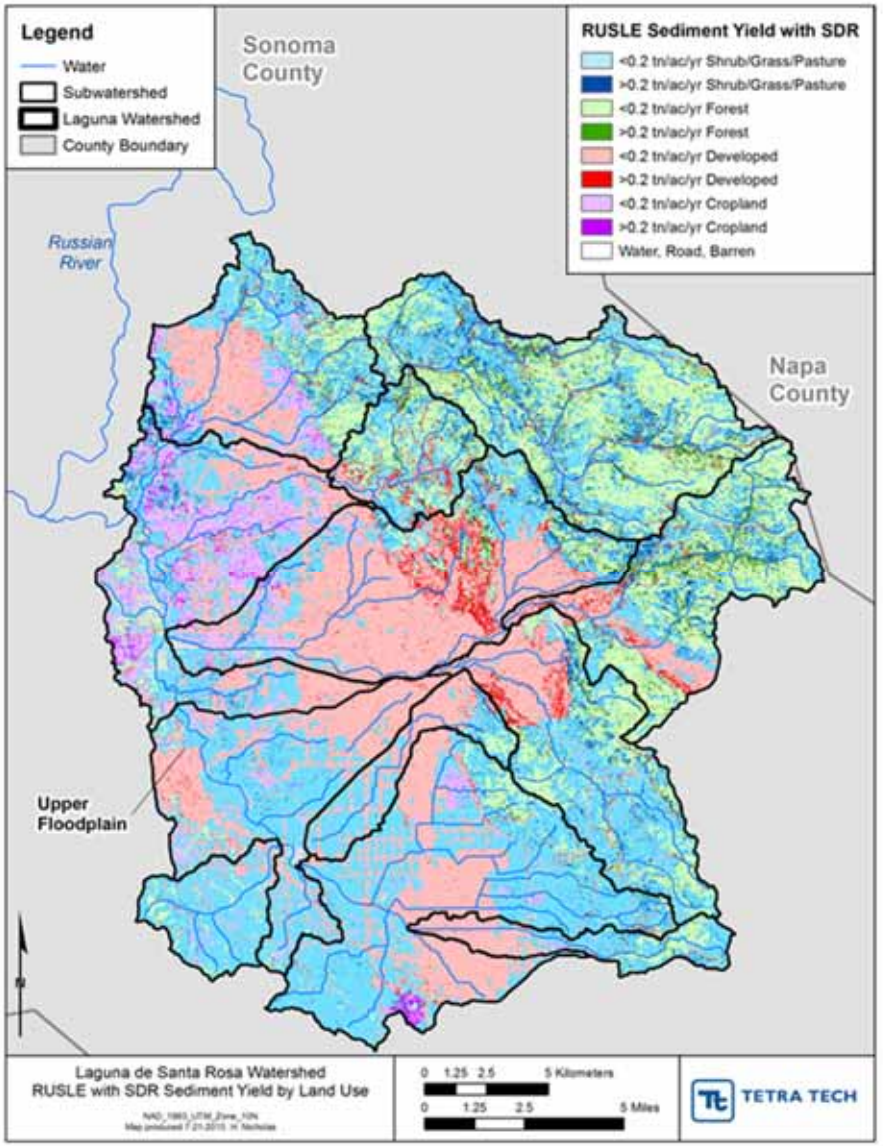
- Ratio of delivery to deposition depends on upstream and downstream characteristics
- LiDAR from Sonoma VegMap enables high resolution



TETRA TECH

Connectivity-based Sediment Delivery Ratio





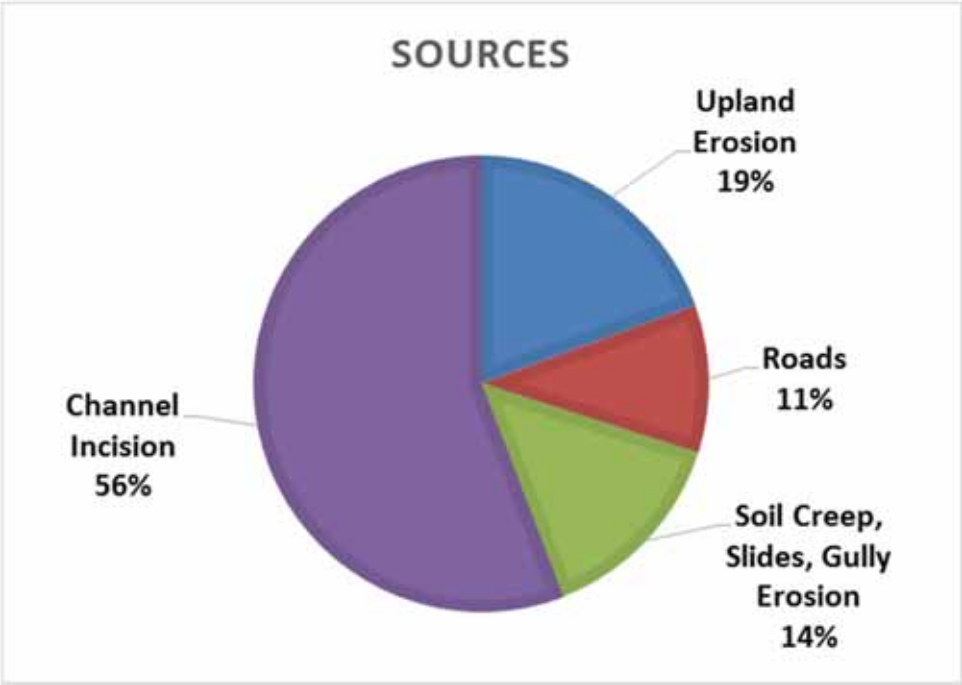
Other Sediment Sources

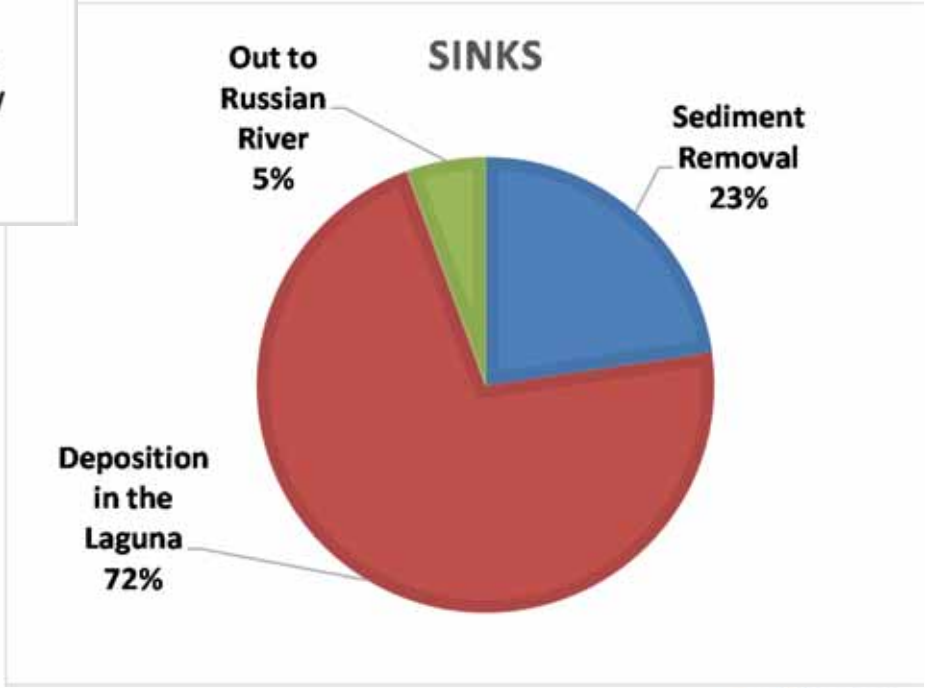
- Roads: No detailed study in Laguna watershed; rely on rates established in Sonoma Creek TMDL source analysis (Sonoma Ecology Center, 2006)
- Soil creep, slides, and colluvial bank erosion: Non-runoff related processes in tectonically active region. Rely on Sonoma Creek TMDL.
- Channel erosion and gully formation: Qualitative documentation by PWA in accessible stream reaches, but many reaches inaccessible. Incision into old alluvial fans.

Sediment Sinks

- Deposition in the Laguna: Curtis et al. (USGS) estimates: 61,000 tons/yr.
- Output to Russian River: Extended USGS analysis of load past Mark West Creek near Mirabel: 4,800 tons/yr
- Deposition in upstream impoundments: Assume majority of sediment is trapped (e.g., Matanzas Creek Reservoir in Santa Rosa watershed)
- SCWA Stream Maintenance: Removed over 19,000 tons/yr (2008-2014) – load prevented from reaching the Laguna!

Sediment Budget for Existing Conditions

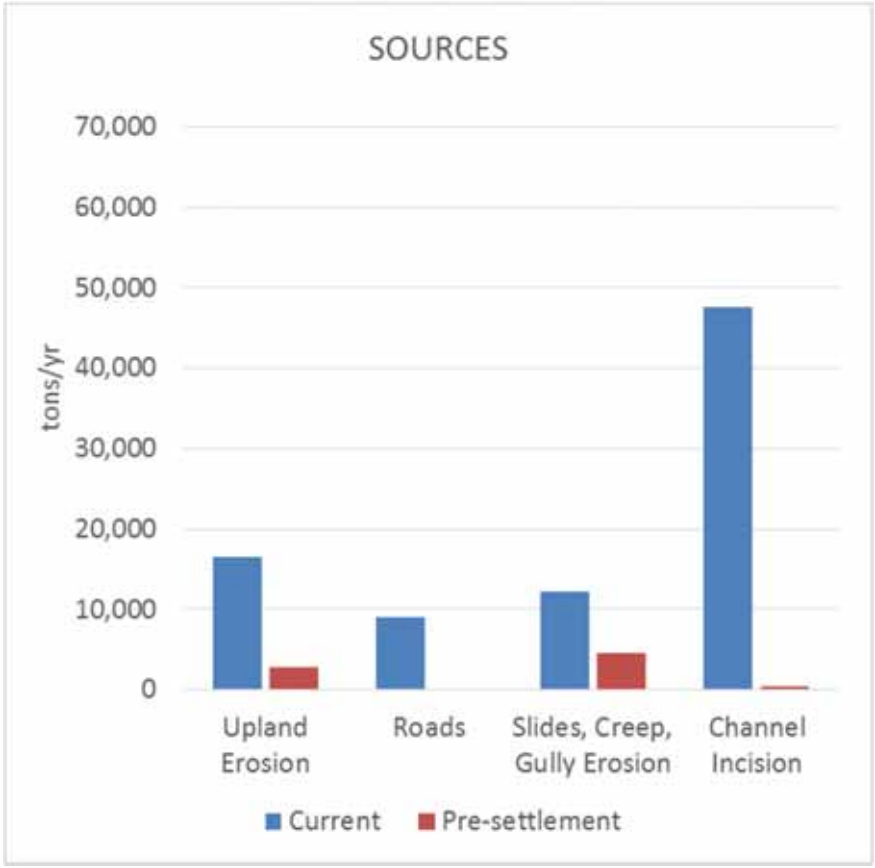


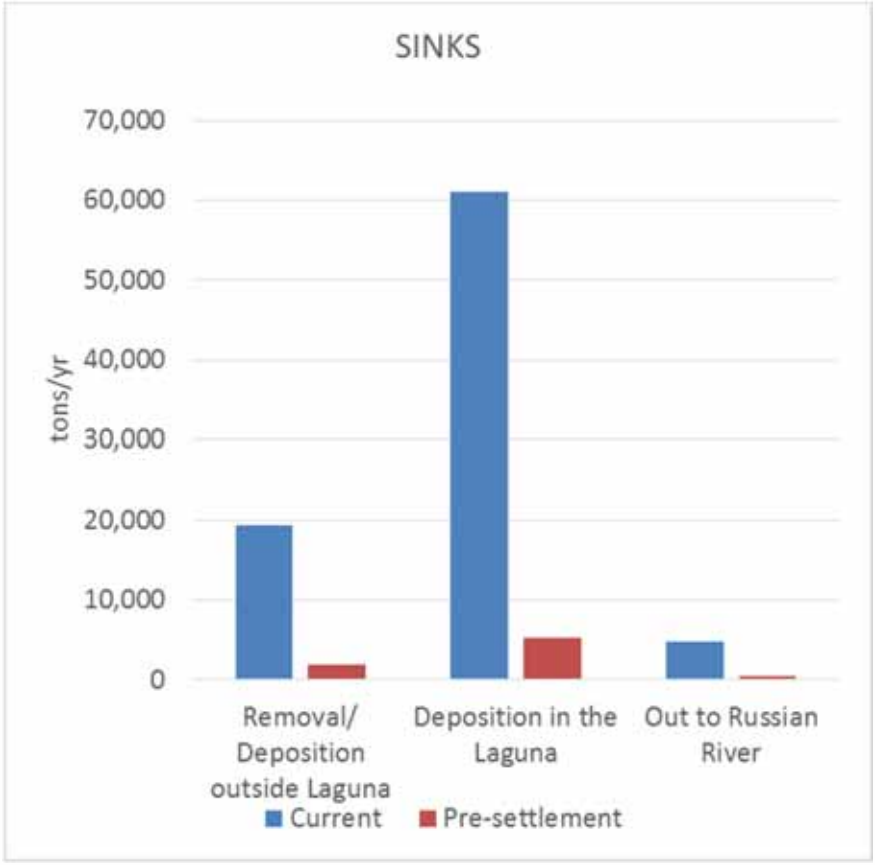


Channel incision mostly on alluvial fans

- Hydromodification
- Change in base level
- Inadequate riparian vegetation

Sediment Budget for Pre-settlement Conditions





(Work in progress)

Nutrient Analyses

Linkage to Sediment Analysis

- Laguna is impaired for phosphorus; *load* of phosphorus is closely tied to movement of sediment
- Upland fraction of sediment load key for phosphorus movement – surface soils and impervious surfaces that receive fertilizer or other phosphorus containing materials and fresh organic matter
- *Concentration* also matters, especially in summer low flows

Lines of Evidence for Biostimulatory Problems

- Nutrients, Sediment, and *Ludwigia*
- Models of DO Impairment and Nutrient Load
- Models of nonpoint source nutrient loading
  - Land Cover Loading Model
  - Sediment Potency Model
- Nutrient Numeric Endpoints (NNE) Analysis

Nutrients, Sediment, and *Ludwigia*

- High phosphorus concentrations encourage *Ludwigia* dominance
  - Water column and sediment pathways
- Shallow water promotes *Ludwigia* growth
  - Feedback: Channels choked with *Ludwigia* slow flow, promote sediment and nutrient deposition
- Research is not available to assign specific numeric nutrient targets to address *Ludwigia*

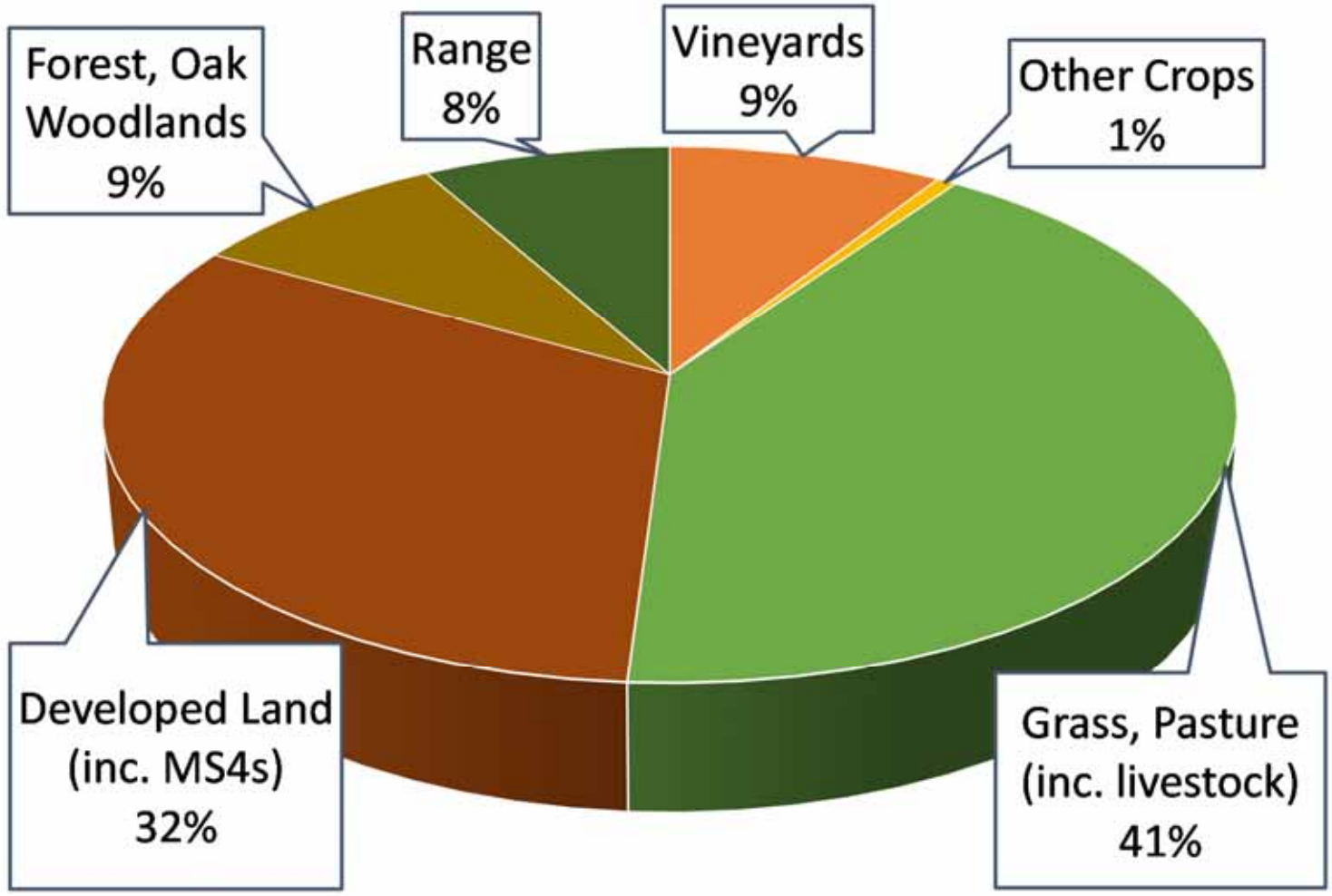
Models of DO impairment & nutrient loads

- DO most sensitive to Sediment Oxygen Demand, which depends on local growth plus inputs of organic matter
- DO also sensitive to reaeration rate, which is restricted by macrophyte cover

Models of nonpoint source nutrient loading

- Staff developed **L**and **C**over **L**oading **M**odel (LCLM)
- LCLM predictions are corroborated and supported:
  - Comparison to loading rates in literature
  - Analysis of loading rates from SCWA MS4 permit monitoring of phosphorus at Fulton Road
  - Comparison to loads based on upland sediment source analysis and sediment potency factors
- Let's not forget the other loads:
  - Wastewater discharges
  - Dry weather urban and agricultural flows
  - Recycling of historic "legacy" loads stored in the Laguna

Source attribution of upland phosphorus load



Note: Upland loads only; preliminary results

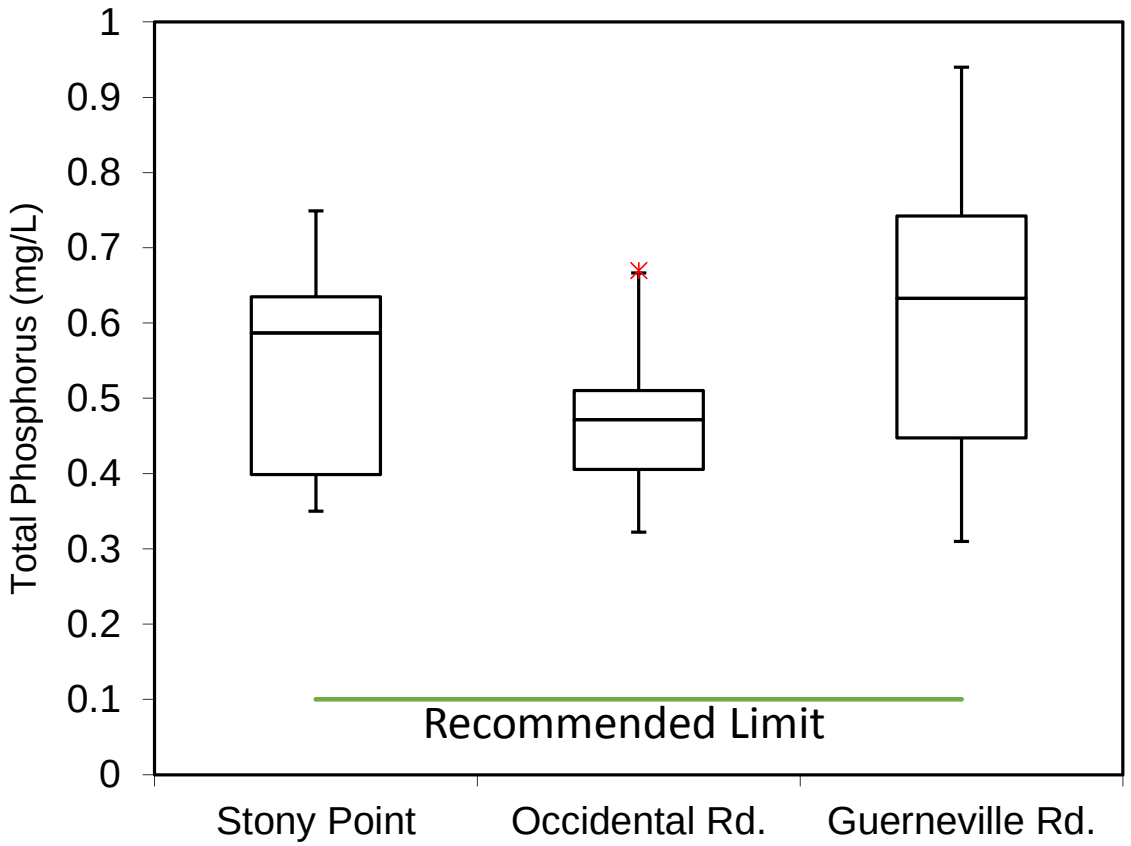
Comparison to Pre-settlement Conditions

- Current conditions:
  - 128,000 lb-P/yr upland nonpoint load
  - Continuing point source contributions
- Pre-European settlement:
  - 30,000 lb-P/yr upland nonpoint load
  - Zero point source contributions

Nutrient Numeric Endpoints Analysis

- *Analysis relative to draft recommendations being considered by State Board*
- Planktonic chlorophyll-*a* concentrations highly elevated in open water at Occidental Road:
  - Recommended: 150 µg/L
  - Observed median: 401 µg/l
- Phosphorus concentrations
  - Observed: 0.4 – 0.9 mg/L
  - Recommended maximum to prevent hyper-eutrophication: 0.1 mg/L

Total P Concentrations in the Mainstem Laguna de Santa Rosa 2005-2012



Nutrient Endpoints…

- Initial analyses suggest reduction in phosphorus on order of 65-85% is needed
- Much of current phosphorus concentration is supported by recycling from hypoxic sediment
  - Joint control of sedimentation, organic matter loading, Ludwigia growth, and external phosphorus load is needed

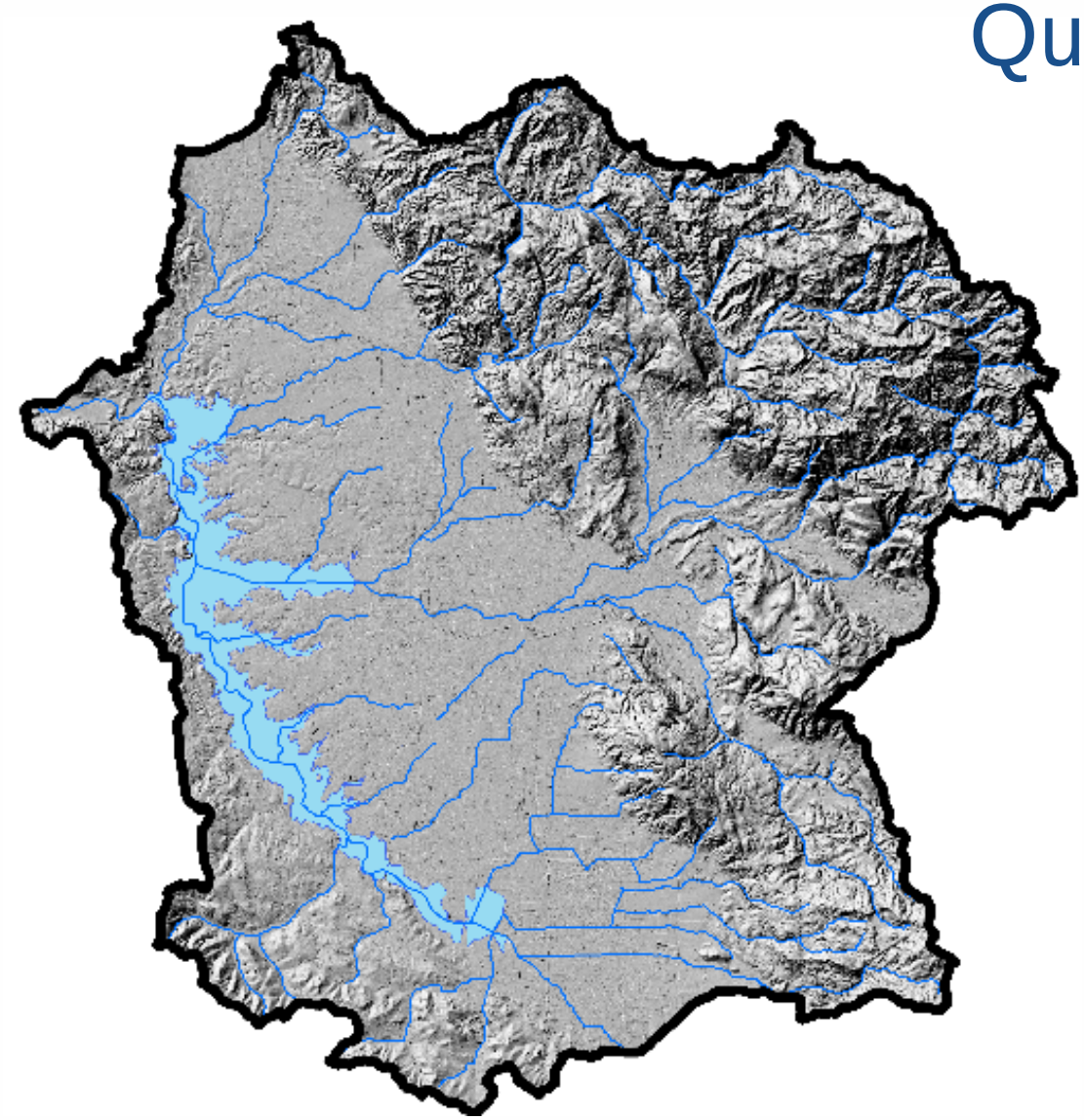
Next Steps…

- Release completed sediment budget documents (Coming soon!)
- Complete ongoing nutrient analyses
- Evaluate opportunities (w/ stakeholders) for future data collection, analysis, and adaptive management

Next Steps…

- Integrate sediment, nutrient, and other TMDL analyses to address biostimulatory conditions in the Laguna
- Incorporate TMDL-related monitoring and special study needs into the Russian River Regional Monitoring Program (R3MP)
- Reserve space in our TMDL Implementation Plan for Water Quality Credit Trading

Questions?



Contact:
David.Kuszmar@waterboards.ca.gov