HYDROMODIFICATION MONITORING

CONCEPTS AND DESIGN RECOMMENDATIONS

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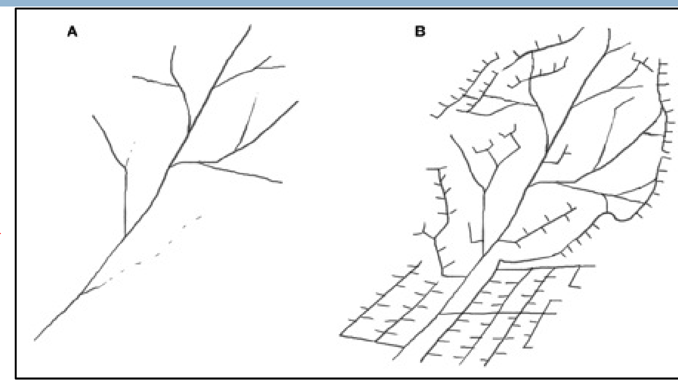
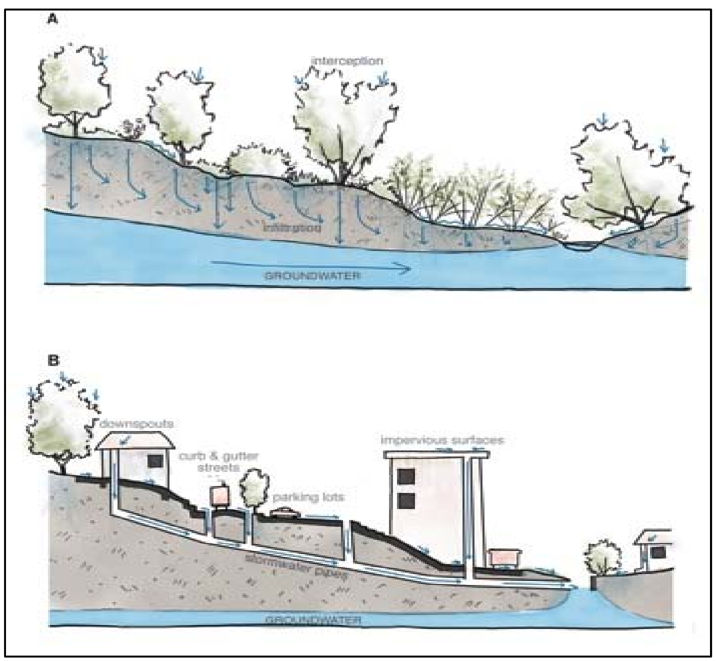
Today's Presentation

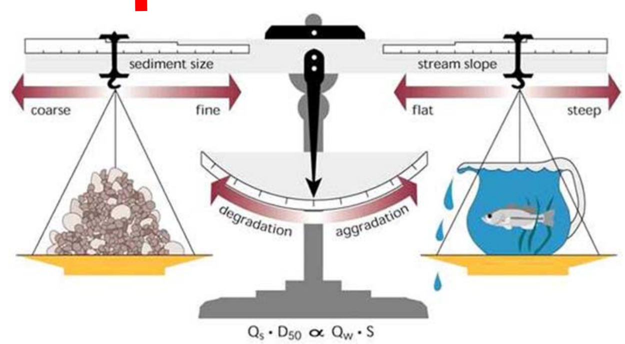
- Challenges of Hydromodification Monitoring
- Context within a Larger Management Framework
- Elements of a Good Monitoring Program
- Questions & Structure of Hydromod Monitoring
- Assessment Tools & Indicators
- Implementation Considerations

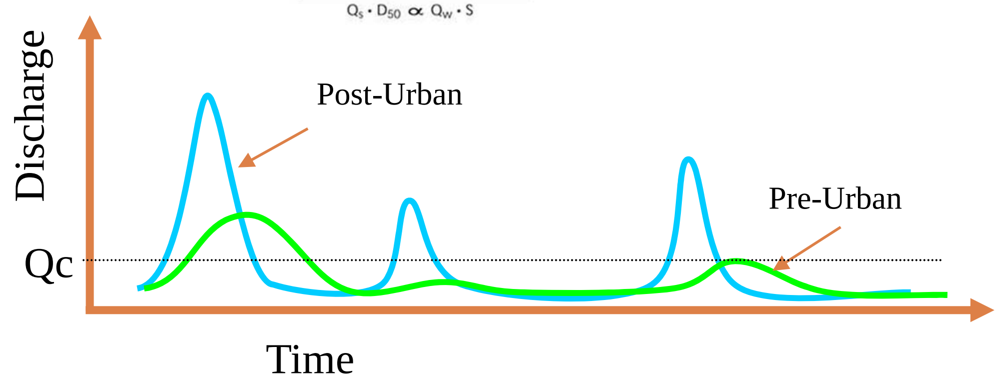
Hydromodification 101

Hydromodification = changes to the runoff hydrograph and sediment supply resulting from land use modifications

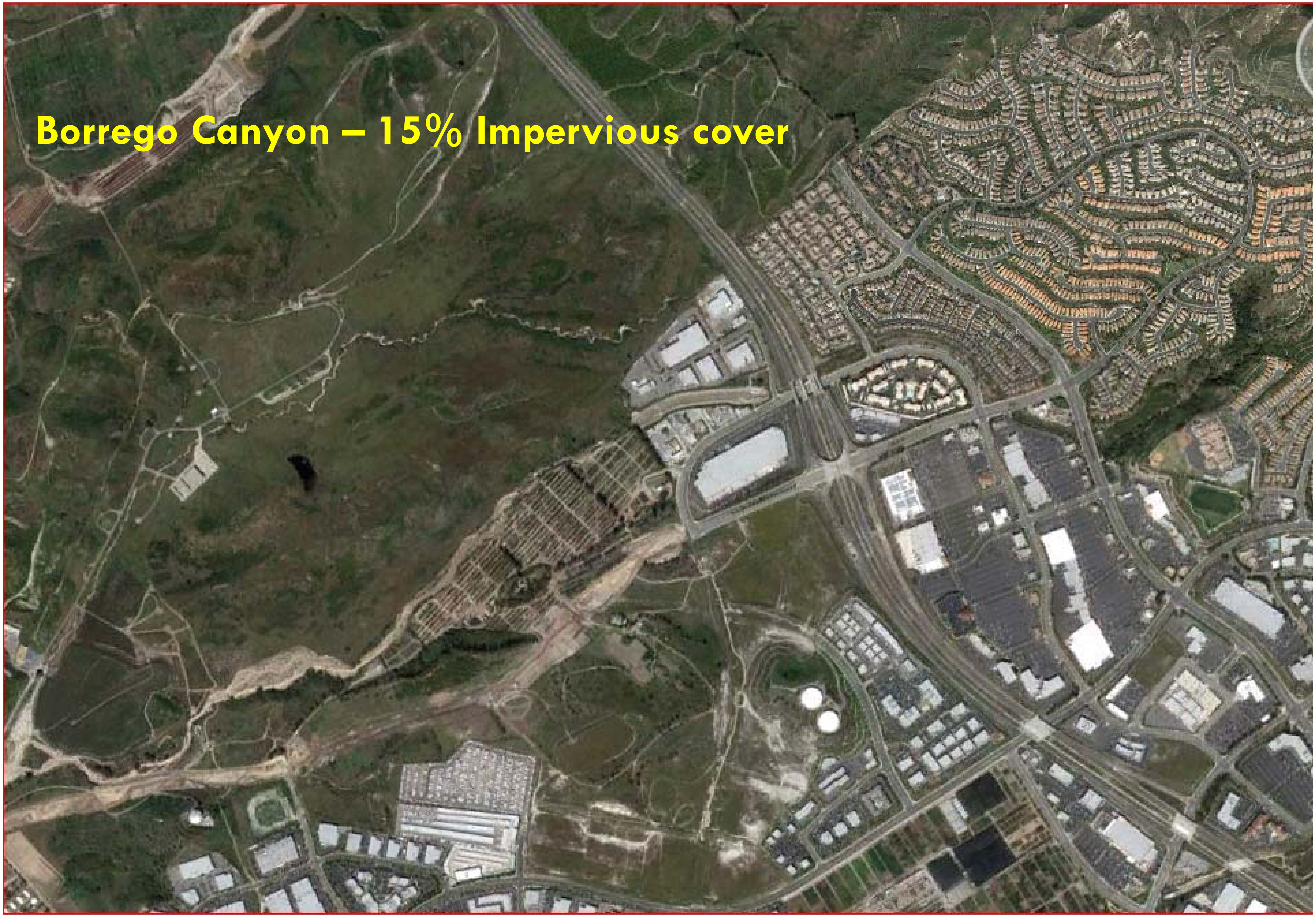


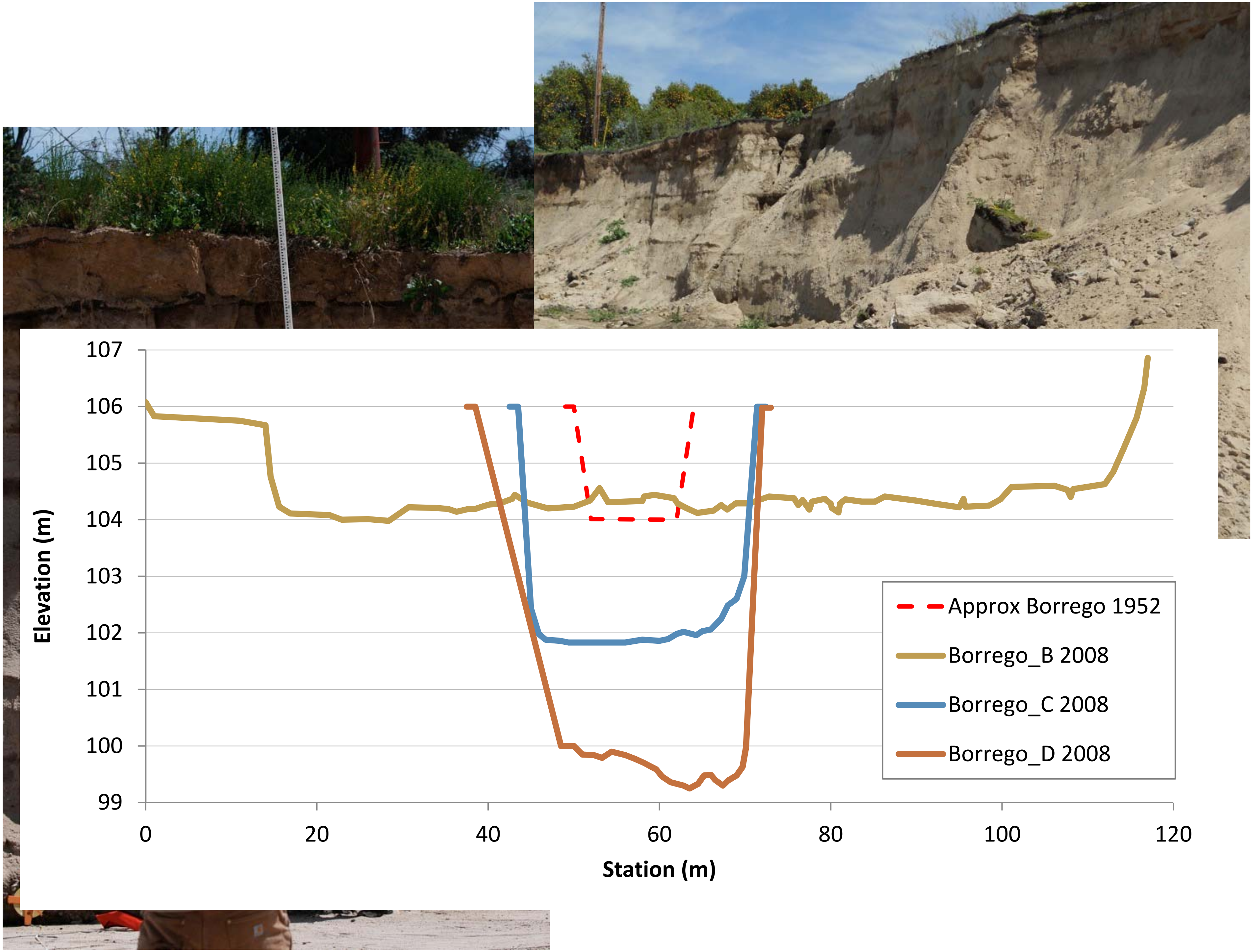






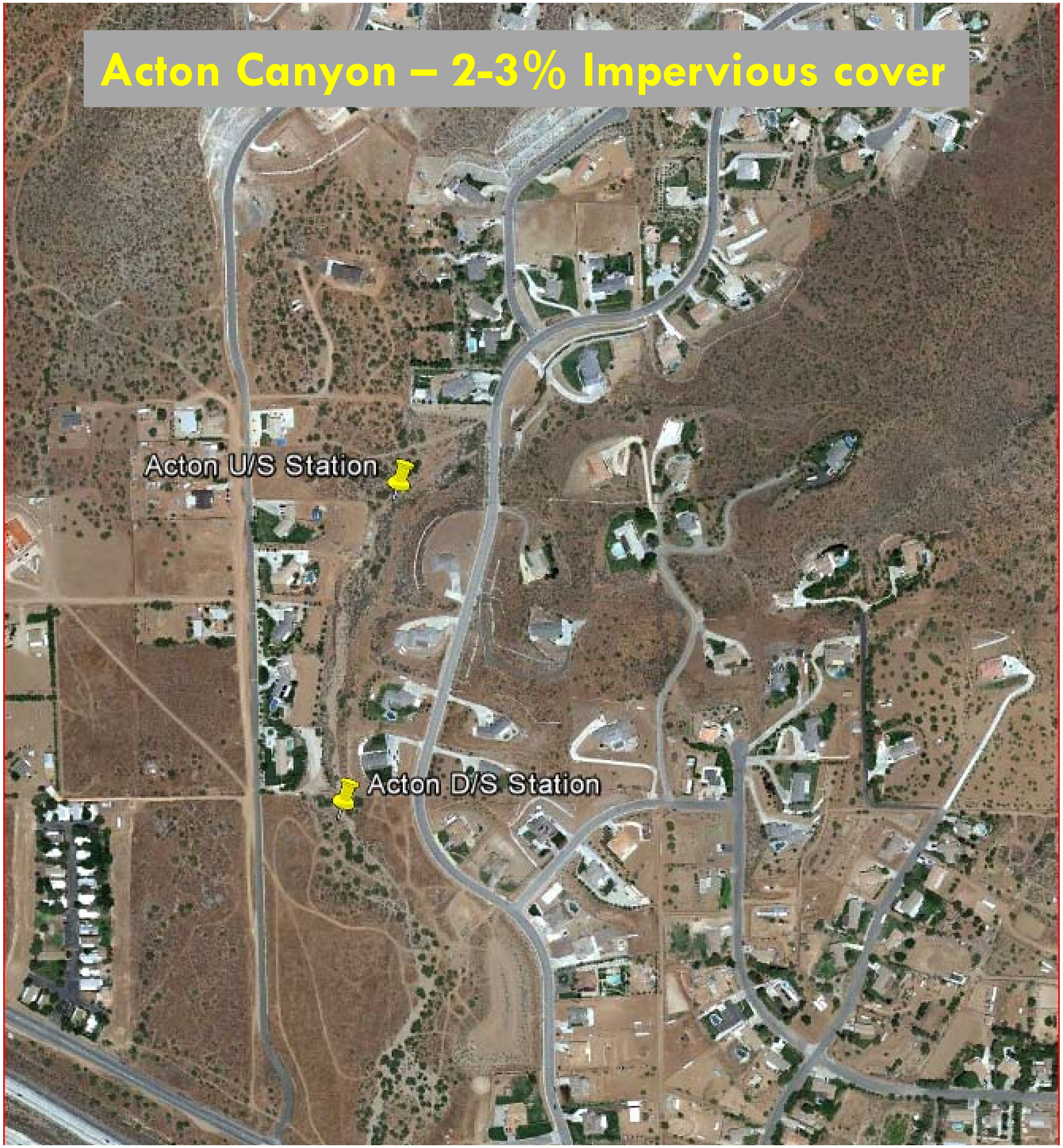
Hydromodification Effects

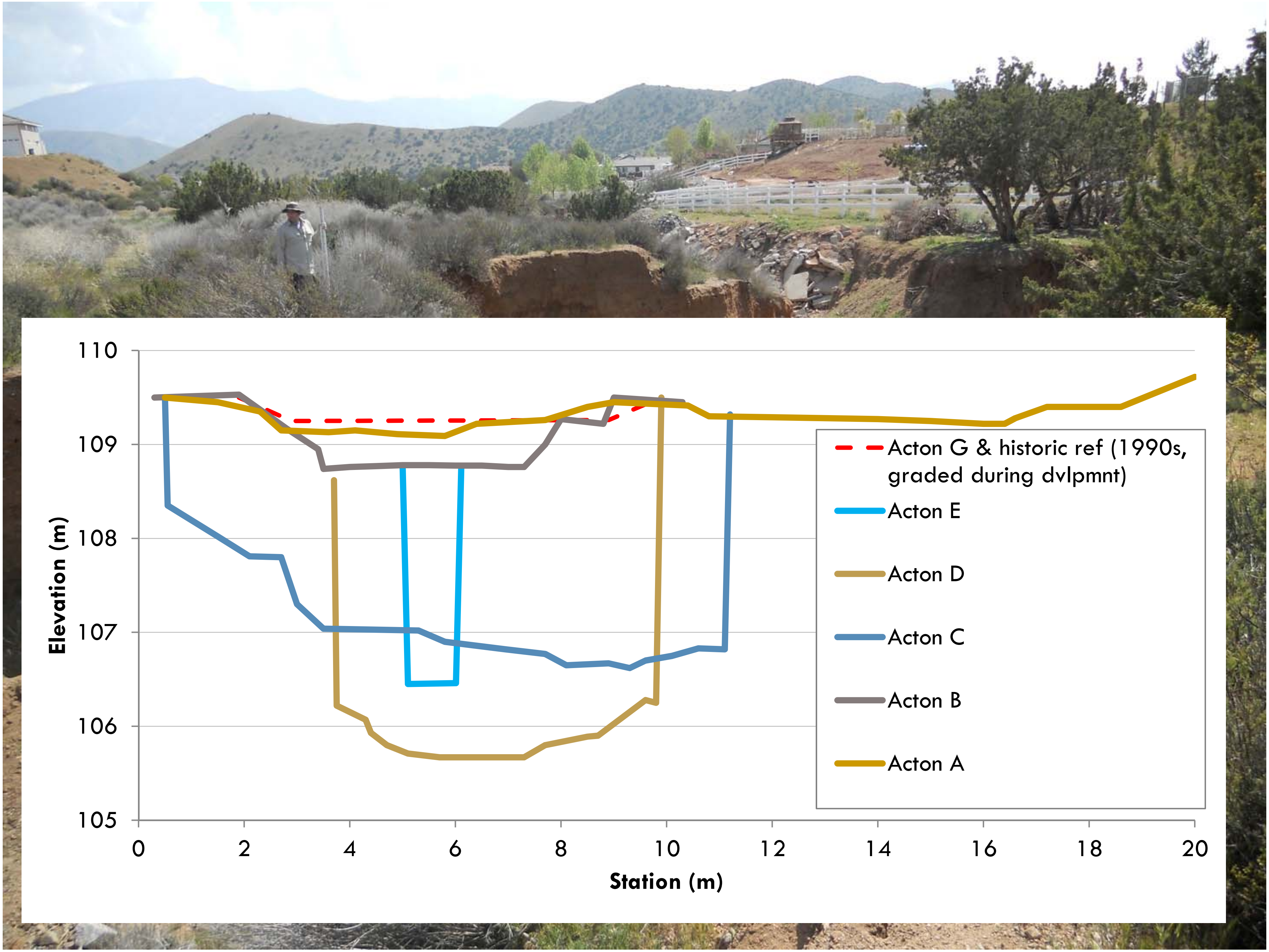

Borrego Canyon – 15% Impervious cover



107
106
105
104
103
102
101
100
99
Elevation (m)
0
20
40
60
80
100
120
Station (m)
Approx Borrego 1952
Borrego_B 2008
Borrego_C 2008
Borrego_D 2008

Acton Canyon – 2-3% Impervious cover





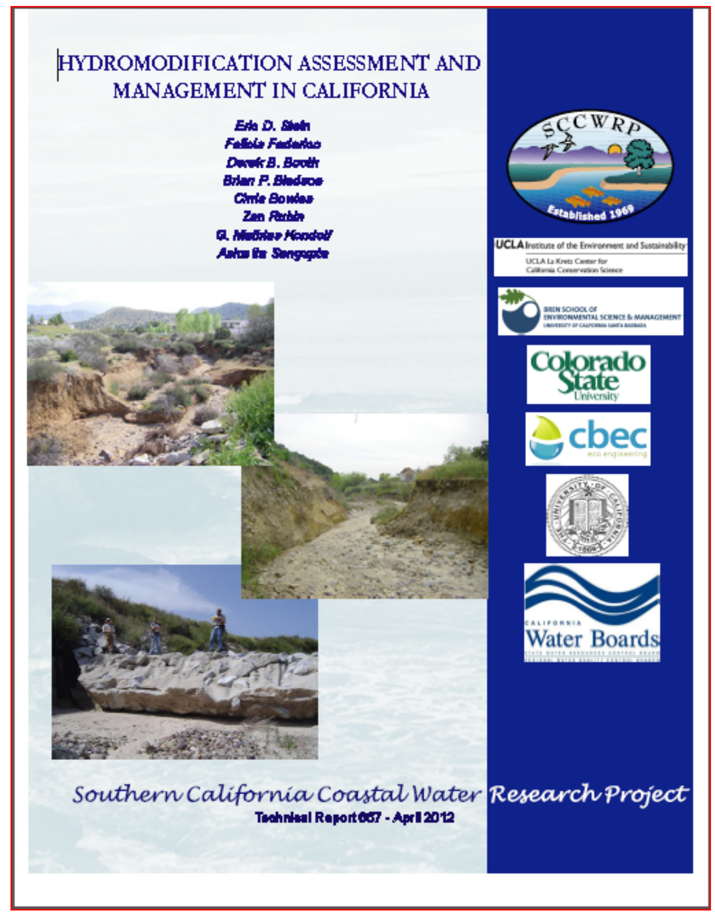
110
109
108
107
106
105
Elevation (m)
0
2
4
6
8
10
12
14
16
18
20
Station (m)
Acton G & historic ref (1990s, graded during dvlpmnt)
Acton E
Acton D
Acton C
Acton B
Acton A

The Challenge of Hydromodification

- Change can occur ra
- Streams are highly v
- May be dealing with
- Responses are difficult to predic -

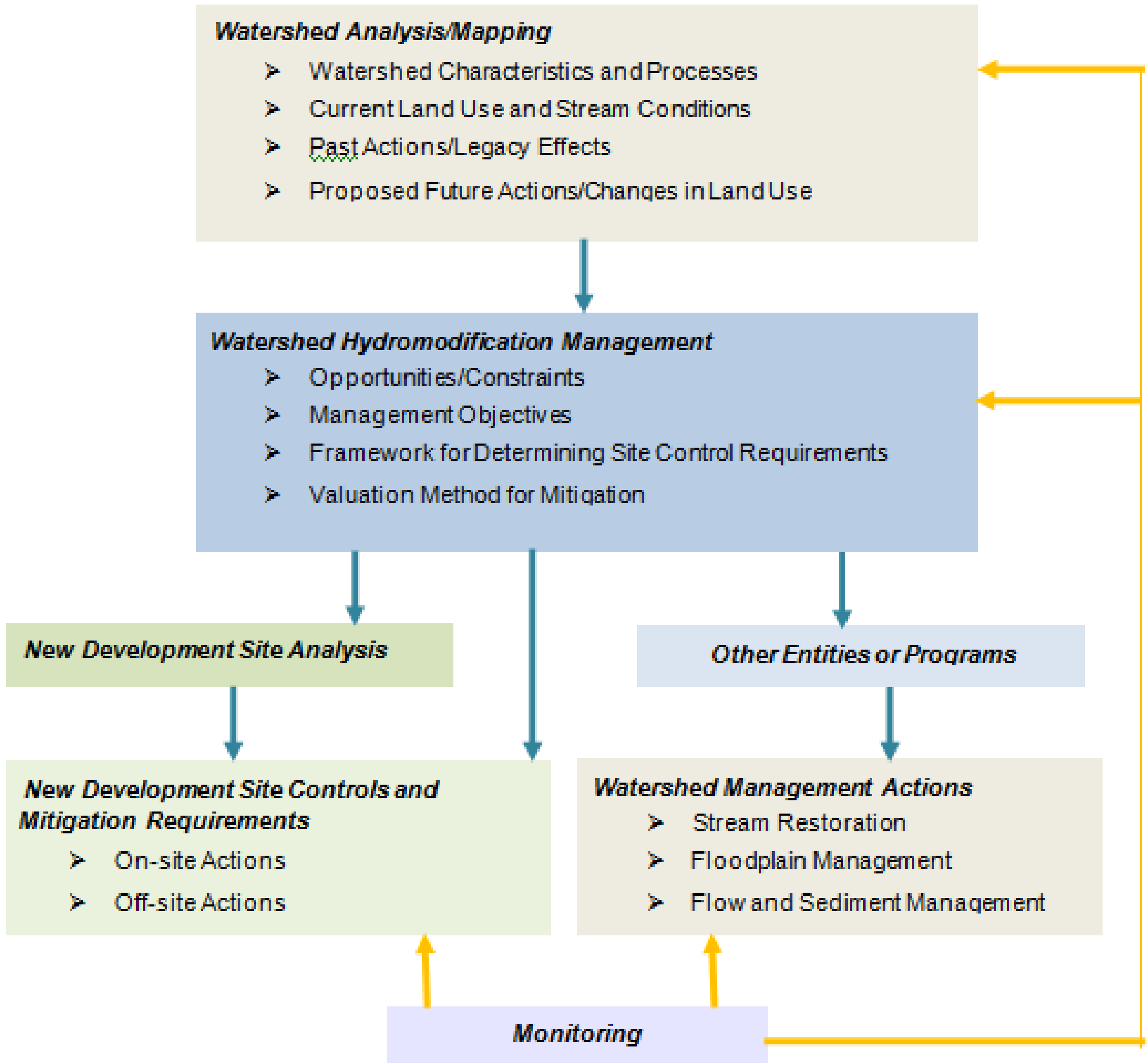
Monitoring in Context of the Overall "Framework"

- Technical guidance on ***assessment*** of hydromodification impacts, development of strategies and approaches to ***management*** of hydromodification effects, and ***monitoring*** the effect of management actions.
  - Support development of integrated strategies
  - Improve information sharing
  - Facilitate longer-term development of new regulatory & program approaches
  - Encourage more consistent monitoring



Report Recommendations
This Workshop

1. Adopt a new paradigm for hydromodification management
2. Focus on restoration and management of watershed processes
3. State agencies to take leadership in developing new tools and methods necessary to implement recommend approach
4. Local agencies to implement new approaches over time and to implement question-driven monitoring programs
5. Develop a mechanism for improved information sharing to inform ongoing refinement of hydromodification management

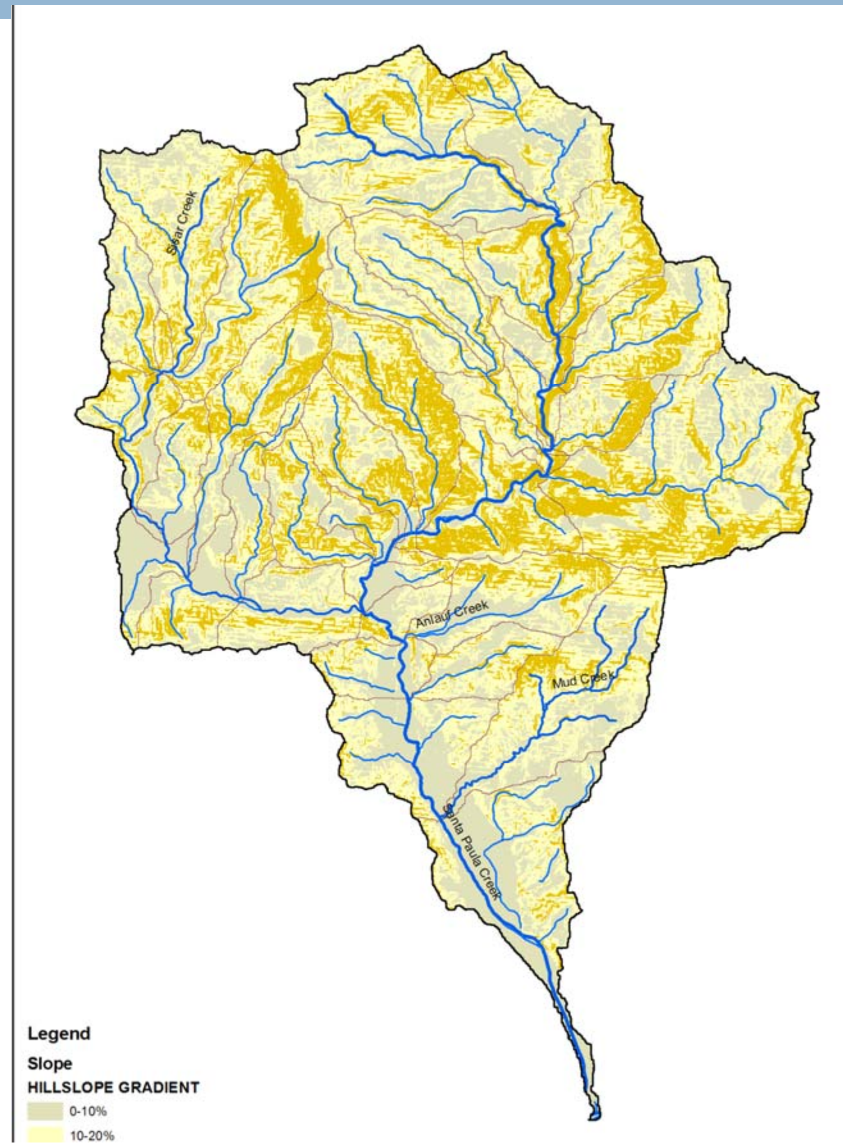

Watershed Analysis/Mapping
Watershed Characteristics and Processes
Current Land Use and Stream Conditions
Past Actions/Legacy Effects
Proposed Future Actions/Changes in Land Use
Watershed Hydromodification Management
Opportunities/Constraints
Management Objectives
Framework for Determining Site Control Requirements
Valuation Method for Mitigation
New Development Site Analysis
Other Entities or Programs
New Development Site Controls and Mitigation Requirements
On-site Actions
Off-site Actions
Watershed Management Actions
Stream Restoration
Floodplain Management
Flow and Sediment Management
Monitoring

Desirable Monitoring Attributes

- Monitoring should be question driven
  - Do not monitor for the sake of monitoring
  - Establish clear assessment endpoints
- Monitoring should be multi-dimensional based on the questions
- Monitoring should be based on multiple indicators
  - Use weight of evidence
  - More robust investigation of potential causative factors
- Monitoring should be modular
  - Phased or tiered implementation
- Monitoring should be consistent with and coordinated with other programs (regulatory and ambient)
- Monitoring should be adapative
- MUST have a long-term commitment to implementation

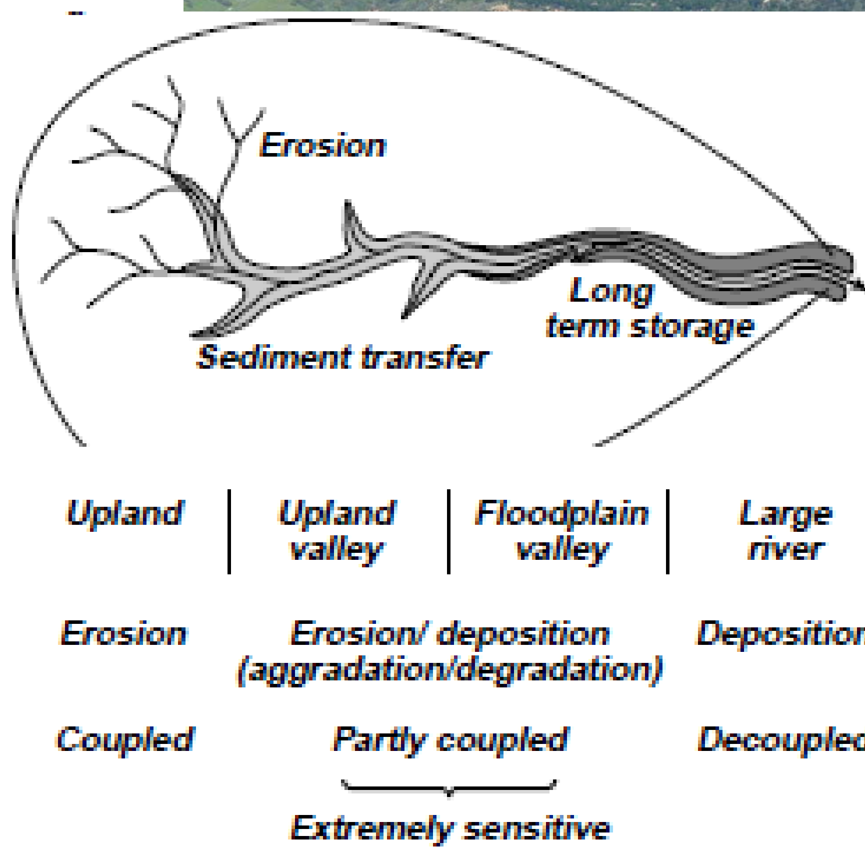
Watershed Analysis

- Start with watershed analysis
- Informs development of monitoring questions
- Priority locations
- Opportunities to leverage off existing programs
- Ability to monitor process indicators over time

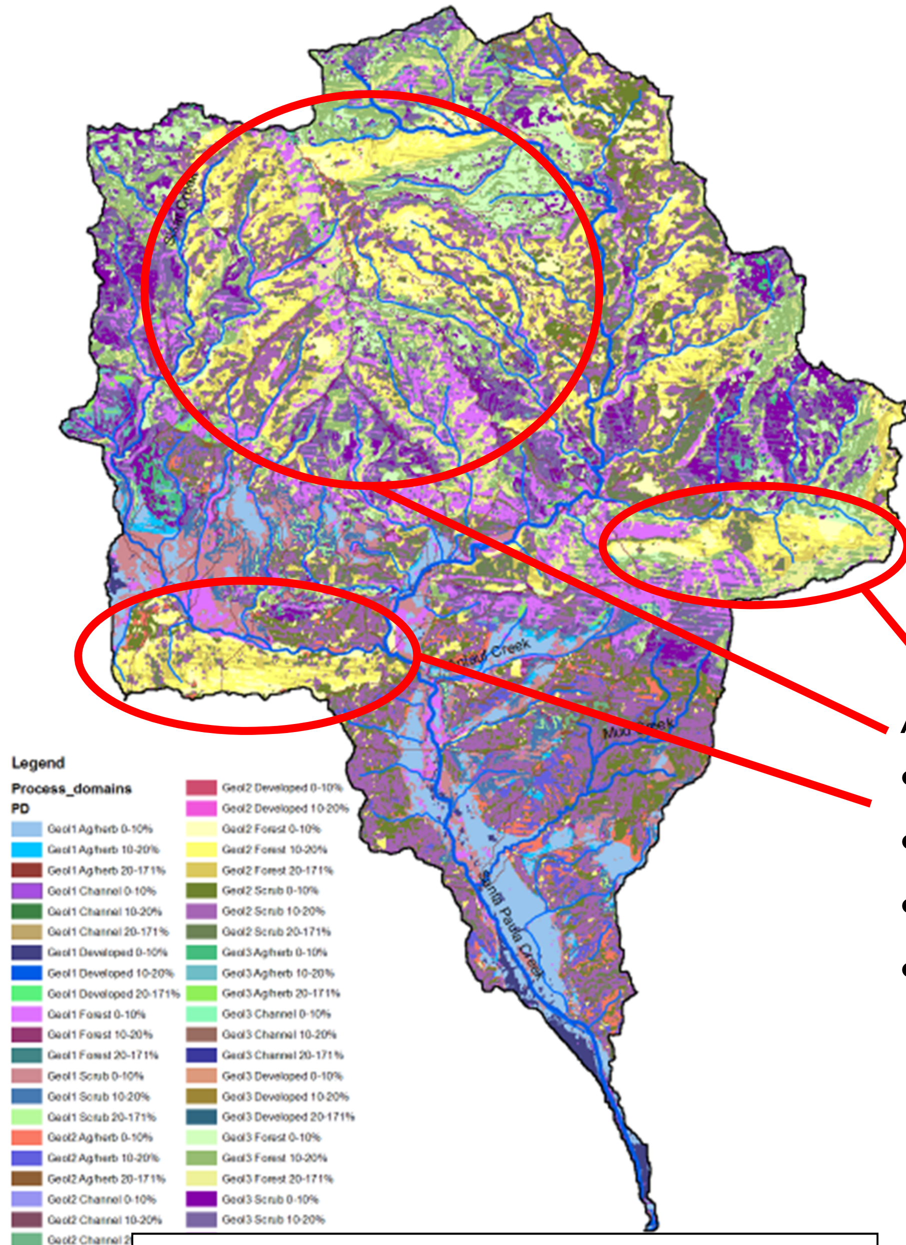


Monitoring in the Context of Watershed Processes

- Sediment supply
- Hillslope coupling
- Sediment transport cap
- Floodplain connections



Monitoring Relates to Management



"Geomorphic Landscape Units"
(slope + geology + land cover)

Goal = Recover and Protect Watershed Processes

Areas of coarse sediment yield

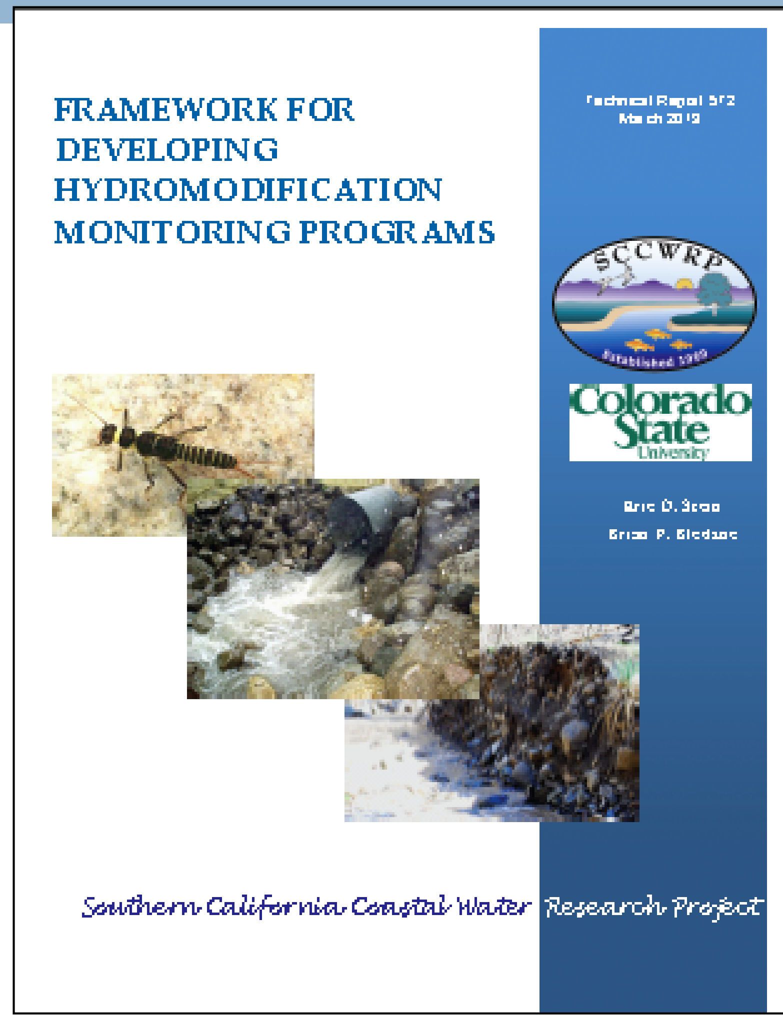
- Avoid
- Alternative development practices
- Opportunities for hillslope restoration
- Identify potential off-site mitigation areas

Monitoring:

- ***Evaluates validity and effectiveness***
- ***Improves knowledge and understanding***
- ***Informs future management decisions***

Framework for Hydromodification Monitoring (draft)

- Question driven with clear assessment endpoints
- Multiple indicators used (hydrologic, physical, and biological)
- Modular
- Consistent with other regional programs
- Adaptive
- Long-term



Multi-dimensional Monitoring Questions

- Performance Evaluation
- Effectiveness Evaluation
- Spatial and Temporal Trends Assessment
- Characterization Monitoring

Monitoring Questions

1. **Performance**
   - How do specific BMPs or facilities function relative to their designs?
2. **Effectiveness**
   - How well do specific management actions or suites of actions protect the condition or beneficial use of receiving waters?
3. **Spatial and Temporal Trends**
   - What is the spatial footprint of responses to management relative to discharge locations?
   - Are conditions improving or declining over time?
4. **Characterization**
   - What is the condition of target areas relative to specific benchmarks (e.g. standards, reference condition, ambient)?

Modular Monitoring Elements

- **Performance**
- **Effectiveness**

• Initial priority
• Basis for assessing compliance
• *Permittees are primarily responsible*
• *Shorter –term (multi-year)*

- **Trends**
- **Characterization**

• Builds from compliance monitoring
• Informs adaptive management
• *Cooperative regional monitoring*
• *Long term, ongoing (decadal)*

Monitoring with Multiple Assessment Endpoints

- Pressure (hydrology)
  - What is affecting the condition?

- State (physical structure)
  - What is the condition?

- Response (biology)
  - What is the status of a management or valued endpoint?

Multiple Types of Monitoring Sites

- **Reference sites**
  - Provide context
  - Differentiate effects from natural variability
- **BMP monitoring sites**
  - Evaluate performance relative to goals or design expectations
  - Evaluate compliance
- **Targeted and sentinel sites**
  - Evaluate effectiveness of management actions
  - Evaluate spatial and temporal trends
- **Probabilistic**
  - Provide regional context
  - Interpret long-term trends
  - Help understand natural variability
  - Inform causal assessment

Sites can serve multiple roles
Roles can change over time

Relationship Between Sites and Questions

	Performance	Effectiveness	Spatial and Temporal	Characterization
Reference Sites				
BMP Sites		Short-term only		
Targeted/Sentinel				
Probabilistic Sites		possible		

Design of Monitoring Elements

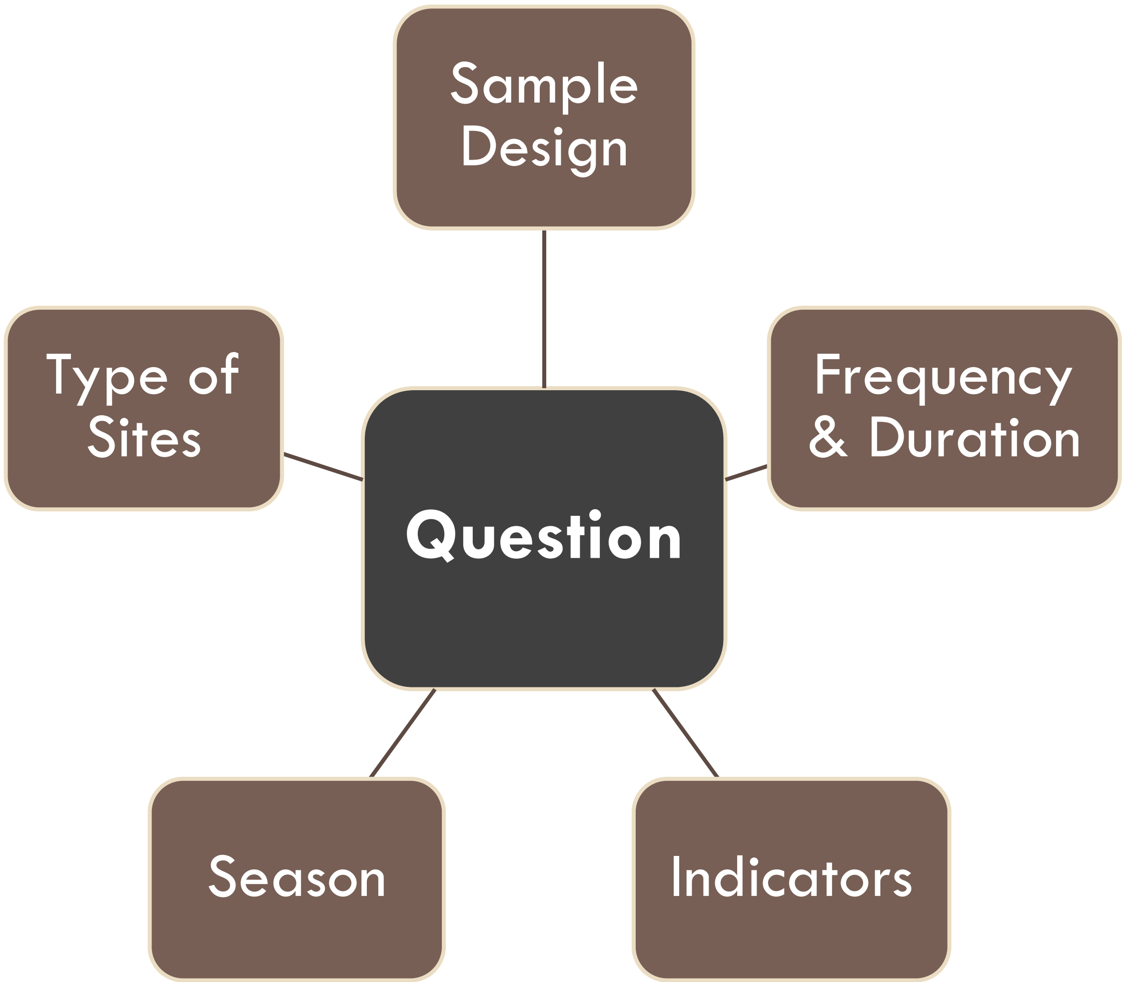
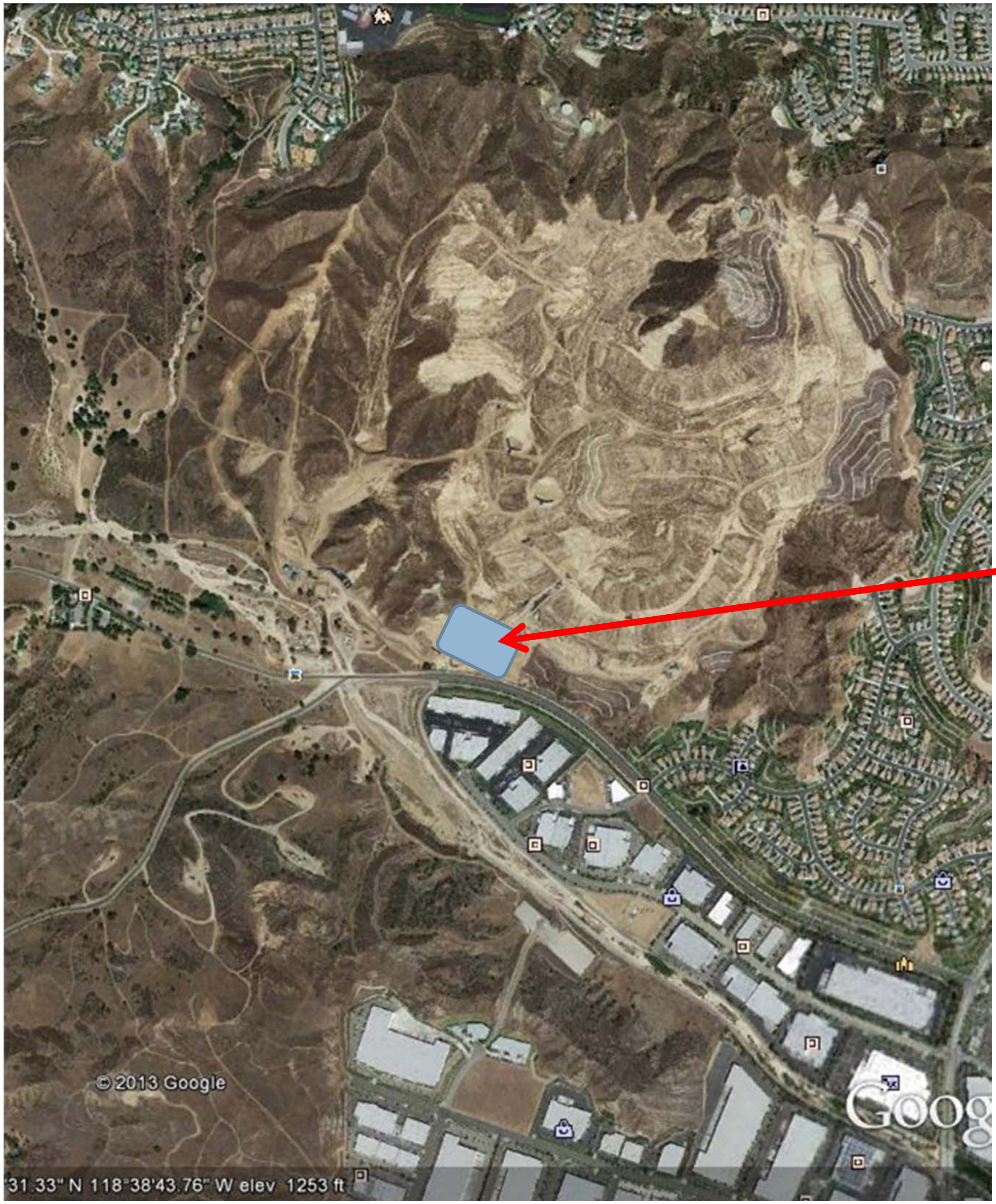


Illustration of Design Elements

Hasley Canyon, Santa Clara Watershed, Los Angeles

Performance

- Targeted Design
- Sites
  - BMP and other management measures
    - Inflow and outflow
    - Pre-project and post-project
  - Reference sites
- Storm season (prefer continuous monitoring)
- Focus monitoring in years following initial installation



Proposed flow-duration basin

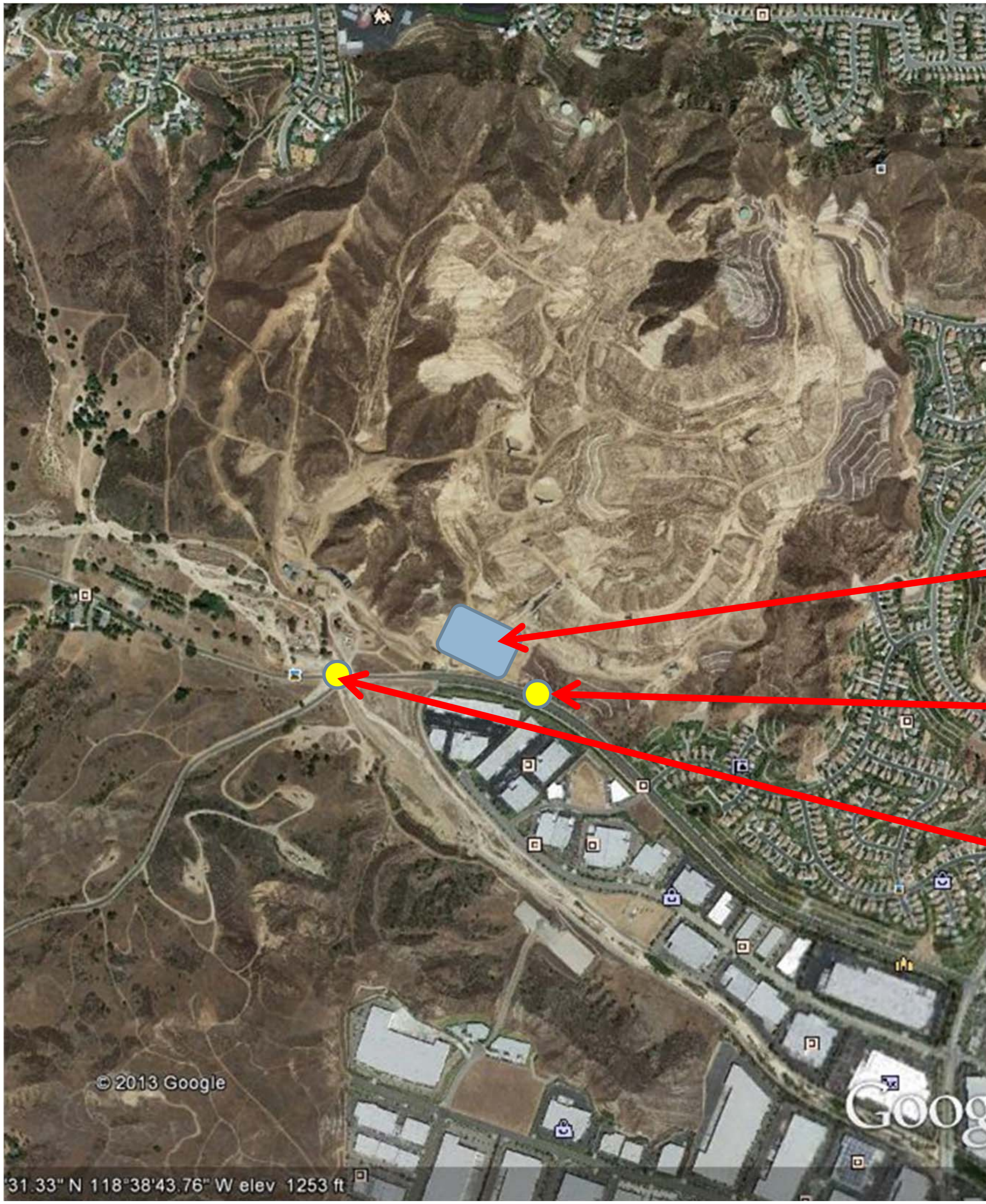
Storm Flow Monitoring

- Pre vs. post project
- BMP and reference

- Continuous monitoring
  - Magnitude
  - Volume
  - Duration

Effectiveness

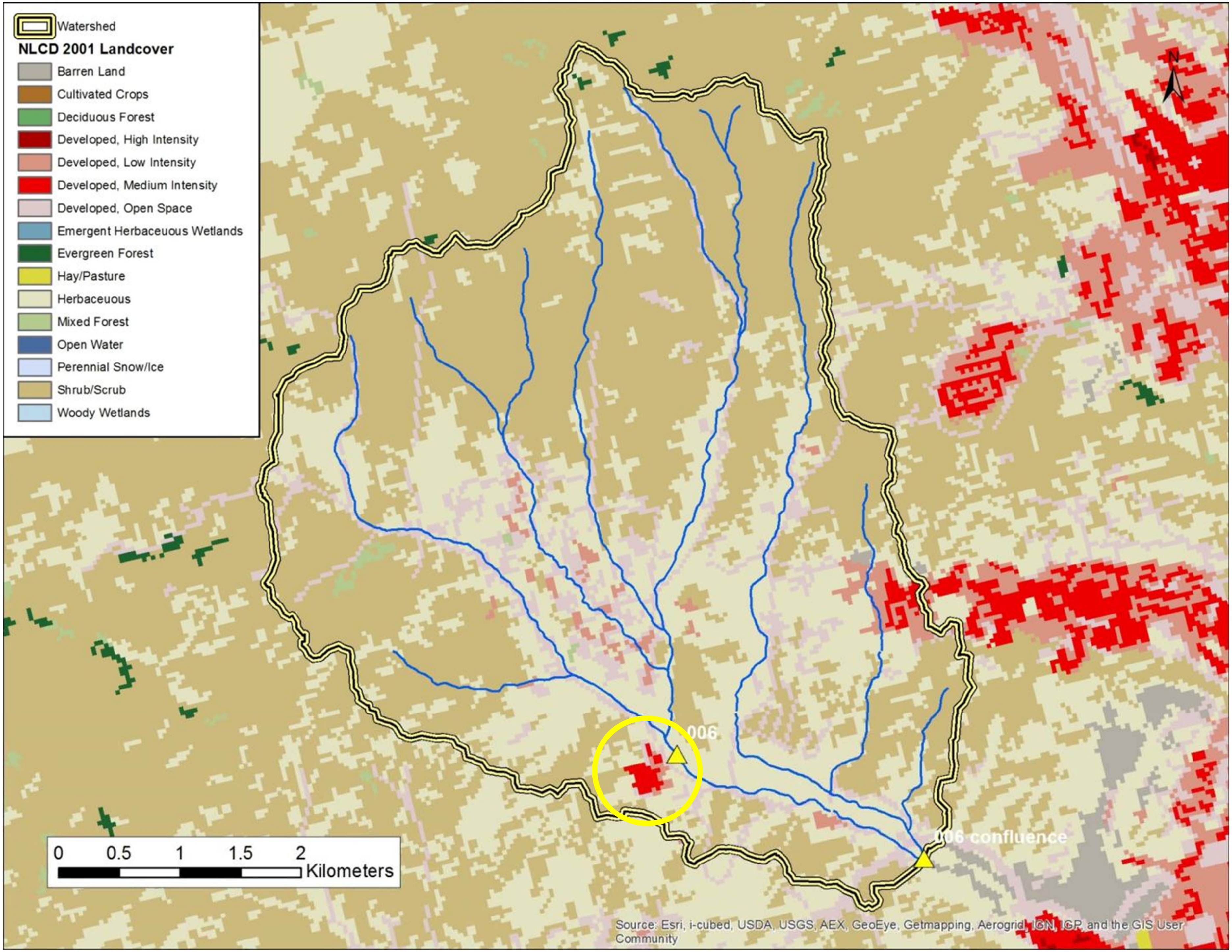
- Targeted Design
- Sites
  - Upstream and downstream of BMPs and other management measures
  - Reference sites
- End of storm season
  - Includes continuous flow monitoring
- GIS/watershed analysis of potential causative factors
- Focus monitoring in years following initial installation



Proposed flow-duration basin

Targeted Monitoring

- Continuous flow monitoring
- Geomorphology
- Biology


Watershed
NLCD 2001 Landcover
Barren Land
Cultivated Crops
Deciduous Forest
Developed, High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Emergent Herbaceuous Wetlands
Evergreen Forest
Hay/Pasture
Herbaceuous
Mixed Forest
Open Water
Perennial Snow/Ice
Shrub/Scrub
Woody Wetlands
N
006
006 confluence
0 0.5 1 1.5 2
Kilometers
Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Spatial and Temporal Trends

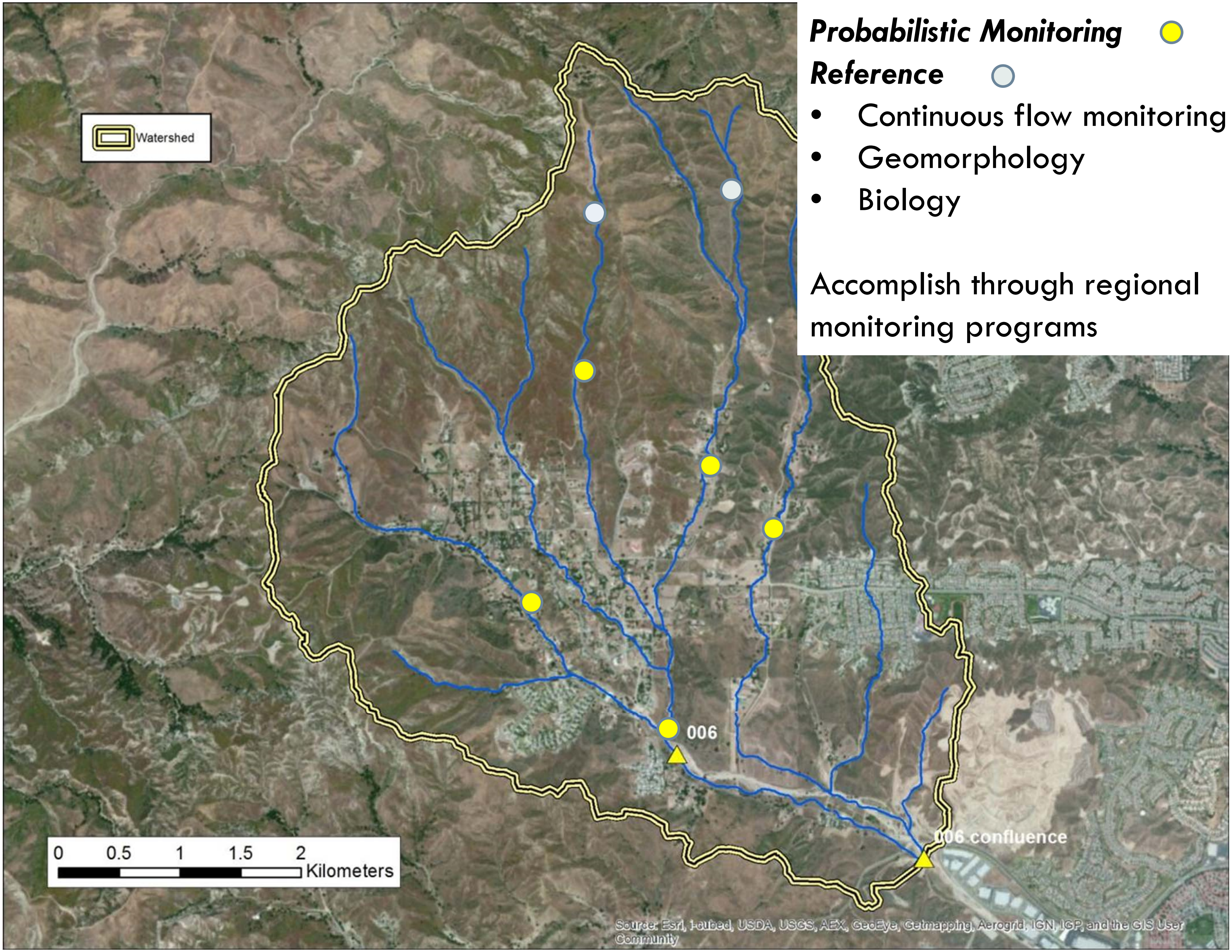
- Targeted Design
- Sites
  - Reference sites
  - Sentinal/integrator sites
  - Downstream of management action
- Dry season
  - Include continuous flow
- Ongoing monitoring
  - Every several years or following large event

Targeted Monitoring

- Continuous flow monitoring
- Geomorphology
- Biology

Characterization

- Probabilistic Design
- Sites
  - Randomly selected
  - Can be stratified by management area or association with BMPs
- Dry seaon
- Ongoing annual monitoring
  - Associated with regional ambient assessment programs



Probabilistic Monitoring

Reference

- Continuous flow monitoring
- Geomorphology
- Biology

Accomplish through regional monitoring programs

Monitoring Indicators

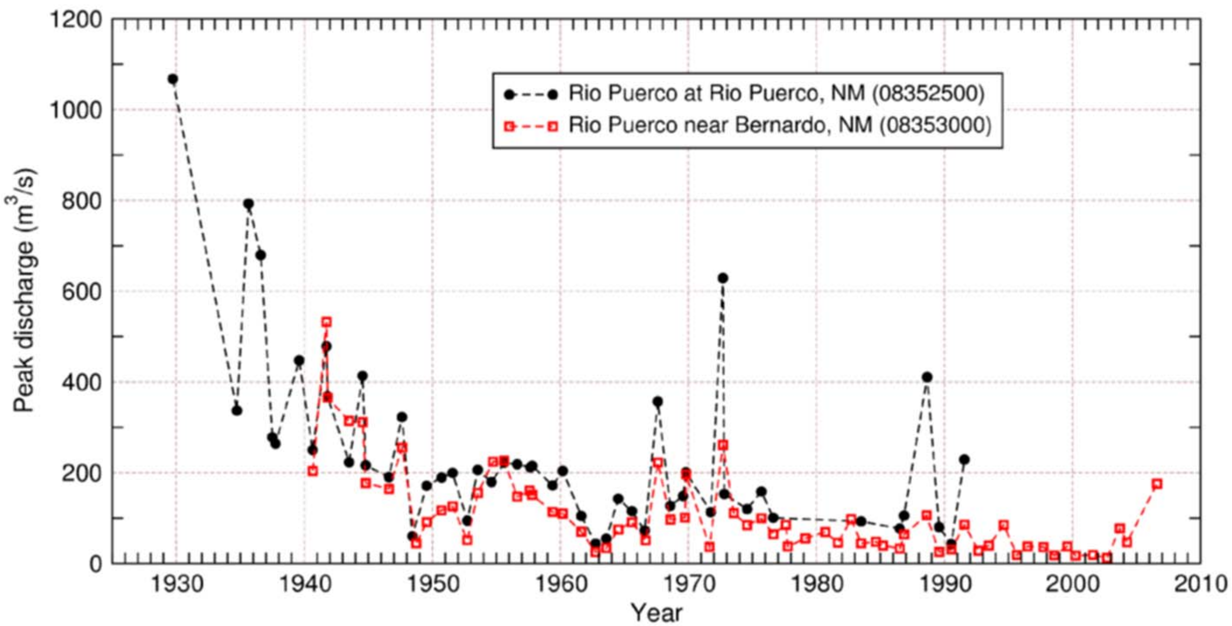
- Hydrologic
  - What is affecting the condition?

- Geomorphic
  - What is the condition?

- Biologic
  - What is the status of a management or valued endpoint?

Hydrologic Monitoring

- Main "pressure" variable
- ***Need long-term data sets***
- Understand "natural" ranges of variability
- Detect deviations from past ranges
  - Degradation
  - Improvement
- Model calibration



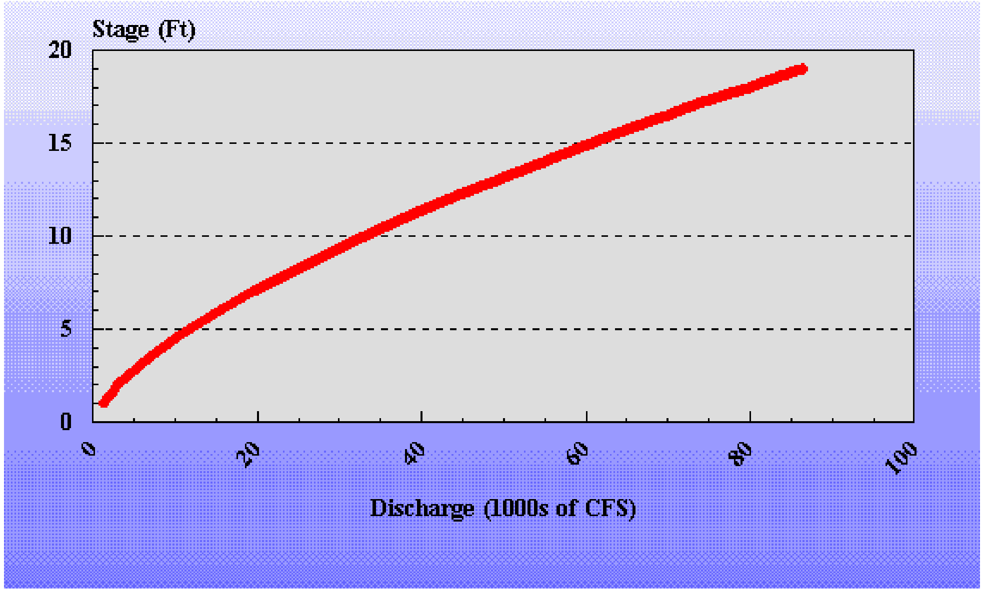
Flow Measurement Options

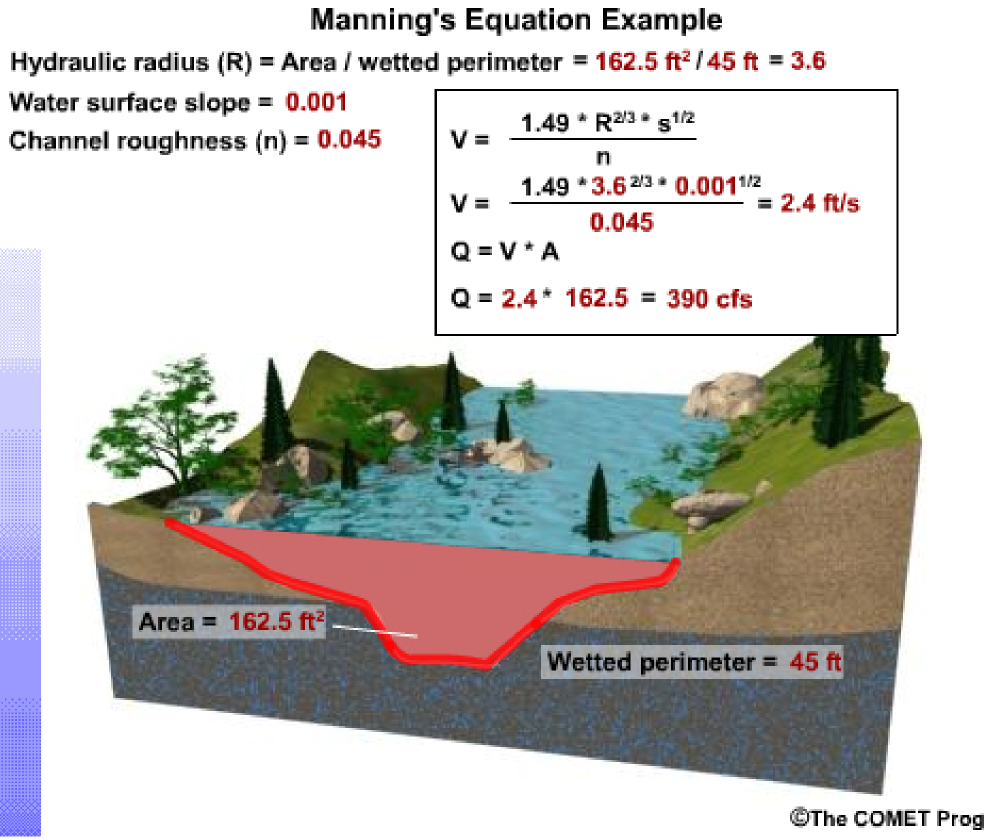
- BMP outflow relative to design standards

- Stream flow measurements
  - Handheld flow meters
  - Pressure transducers
  - Flow gauging stations

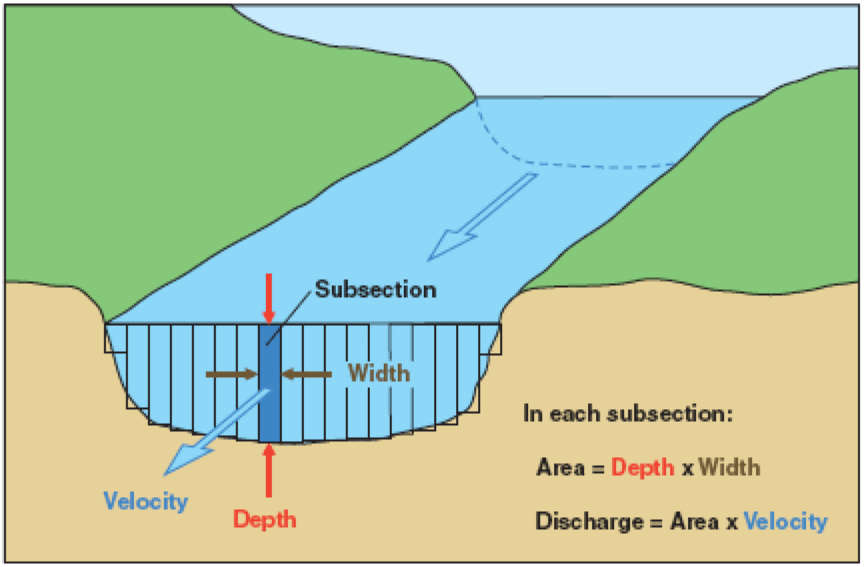
How We Estimate Discharge

- Rely on stage-discharge relationship
- Relatively stable cross-section
  - Contains flow
  - “rateable”
  - Readily accessible





Hand-held Flow Measures

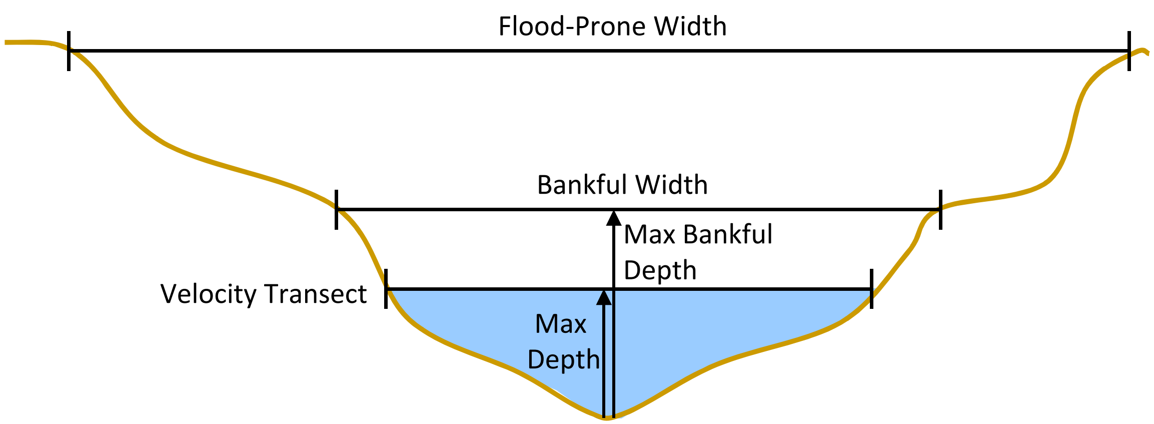


Current-meter discharge measurements are made by determining the discharge in each subsection of a channel cross section and summing the subsection discharges to obtain a total discharge.

- Low cost
- Relatively easy
- Prone to high variability
- Not continuous

Pressure Transducer

- Low cost
- Relatively easy
- Extended deployment
- Regular downloads



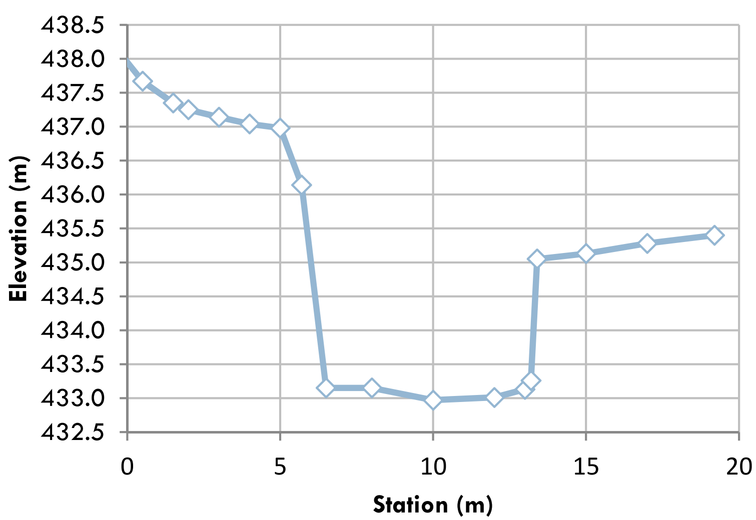
Flow Gauging

- More costly
- More complex to install
- Need external power
- Higher quality data
- Continuous/long-term data

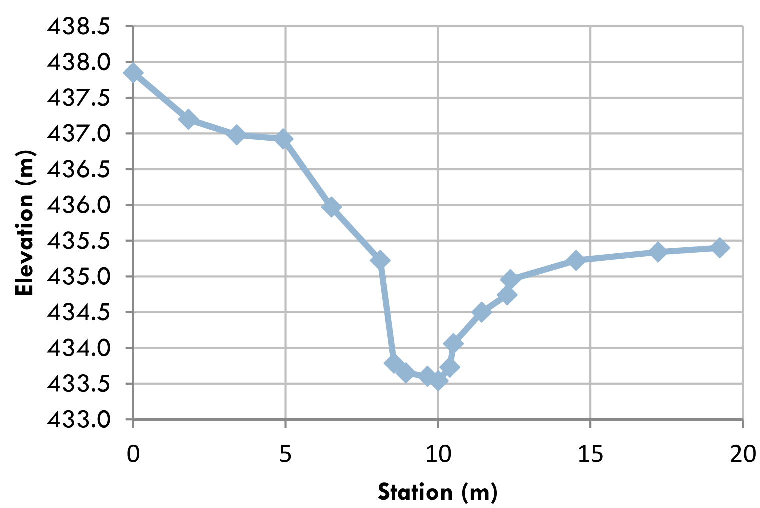
Geomorphic Monitoring

- Main "state" variable
- Evaluate sentinel stations over time
  - Understand natural variability
  - Detect deviation of trajectories and rates of change
- Support deterministic and statistical modeling

Hasley1_A (2011)



Hasley1_A (2007)

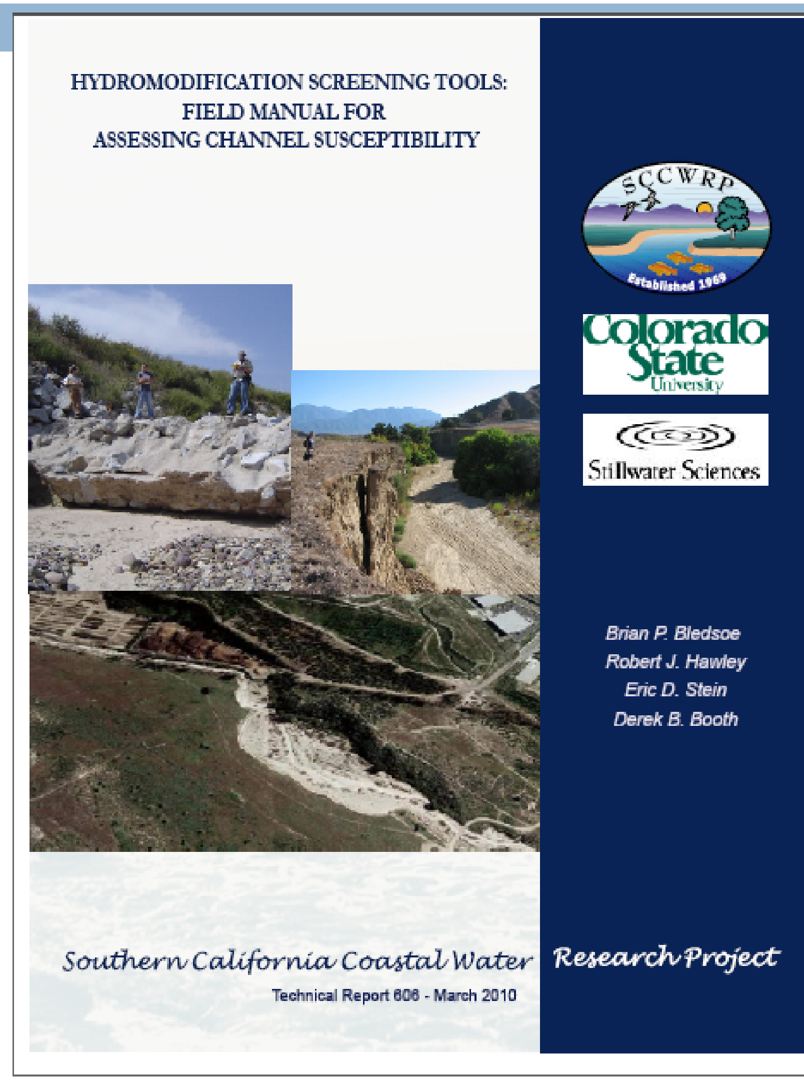


Types of Geomorphic Assessments

- Hydromodification screening tool indicators
- Channel cross-sections and profiles
- Physical Habitat (PHAB) measures
  - Part of routine stream bioassessment

Field Screening Tool

- Classify streams by:
  - Likely severity of response
  - Likely direction of response
- Decision trees
  - Clear endpoints – *very high, high, medium, low*
- Simple to apply field metrics
  - Does not rely on complex field measures
- Locally calibrated
- Rapid - < 1 day in office + 1 day in field



Screening Tool Indicators

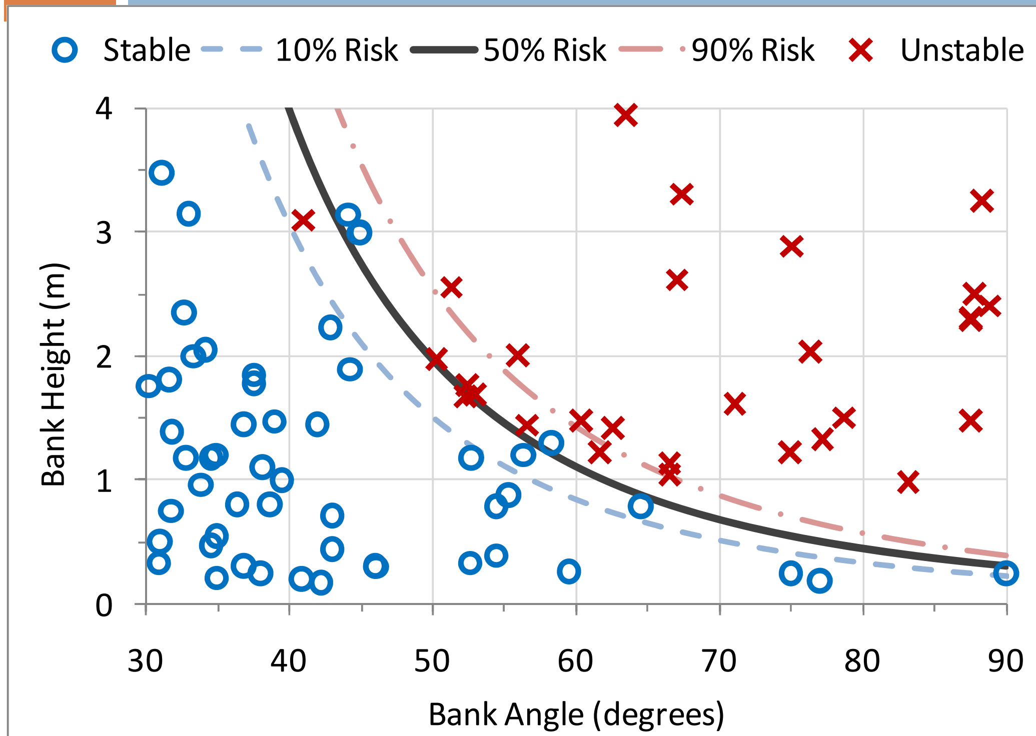
Vertical Susceptibility

- Dominant bed material
  - Labile
  - Transitional armored
- Amount of armoring
- Grade control
  - Spacing
  - Height
  - Integrity
- Proximity to incision threshold

Lateral Susceptibility

- Evidence of mass wasting or bank cutting
- Consolidation of bank material
- Toe material (coarse or fine)
- Bank height and angle
  - Proximity to braiding threshold
- Valley confinement
  - Valley Width Index (VWI)
  - valley bottom width versus channel width
- Vertical susceptibility score

Field Indicators + Empirical Relationships



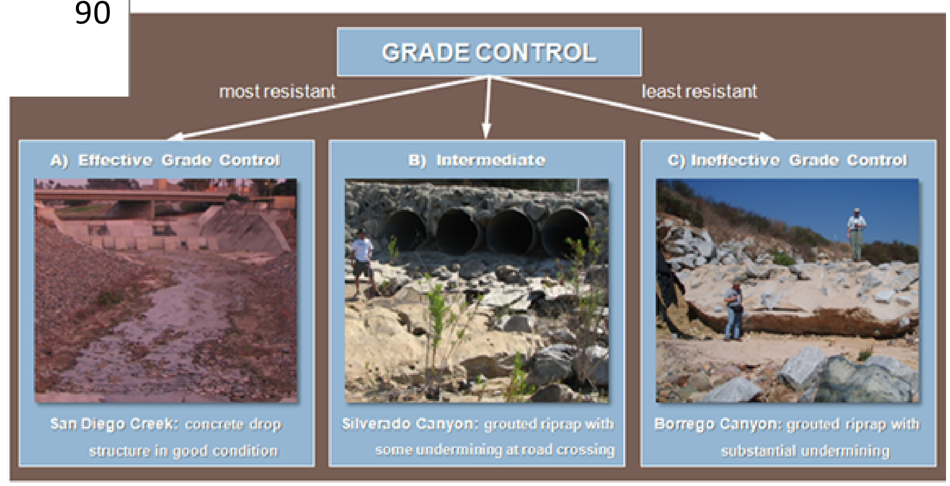
Form 3 Checklist 2: Grade Control

A Grade control is present with spacing <50 m or $2/S_v$ m

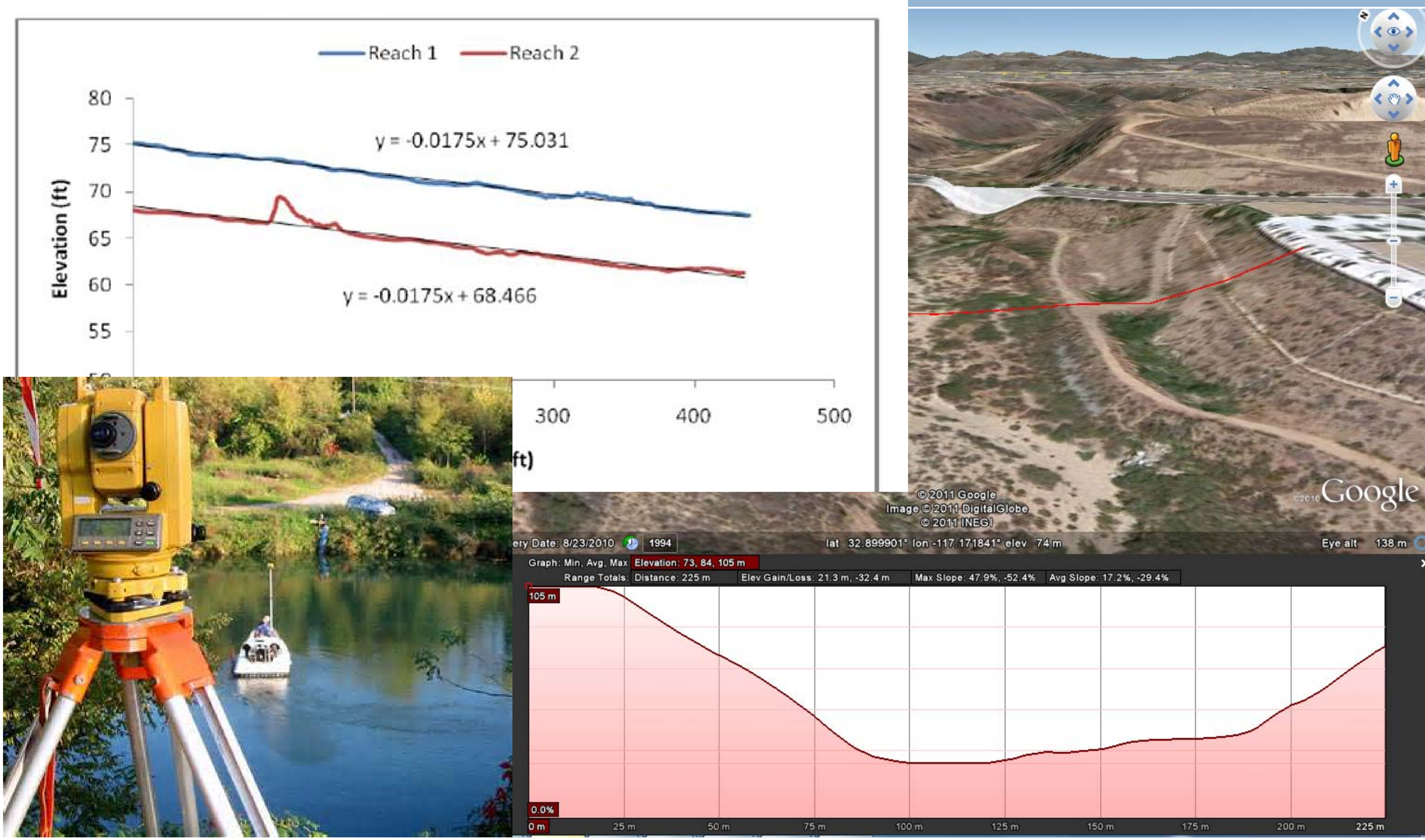
- No evidence of failure/ineffectiveness, e.g., no headcutting (>30 cm), no active mass wasting (analyst cannot say grade control sufficient if mass-wasting checklist indicates presence of bank failure), no exposed bridge pilings, no culverts/structures undermined
- Hard points in serviceable condition at decadal time scale, e.g., no apparent undermining, flanking, failing grout
- If geologic grade control, rock should be resistant igneous and/or metamorphic; For sedimentary/hardpan to be classified as 'grade control', it should be of demonstrable strength as indicated by field testing such as hammer test/borings and/or inspected by appropriate stakeholder

B Intermediate to A and C – artificial or geologic grade control present but spaced 2/Sv m to 4/Sv m or potential evidence of failure or hardpan of uncertain resistance

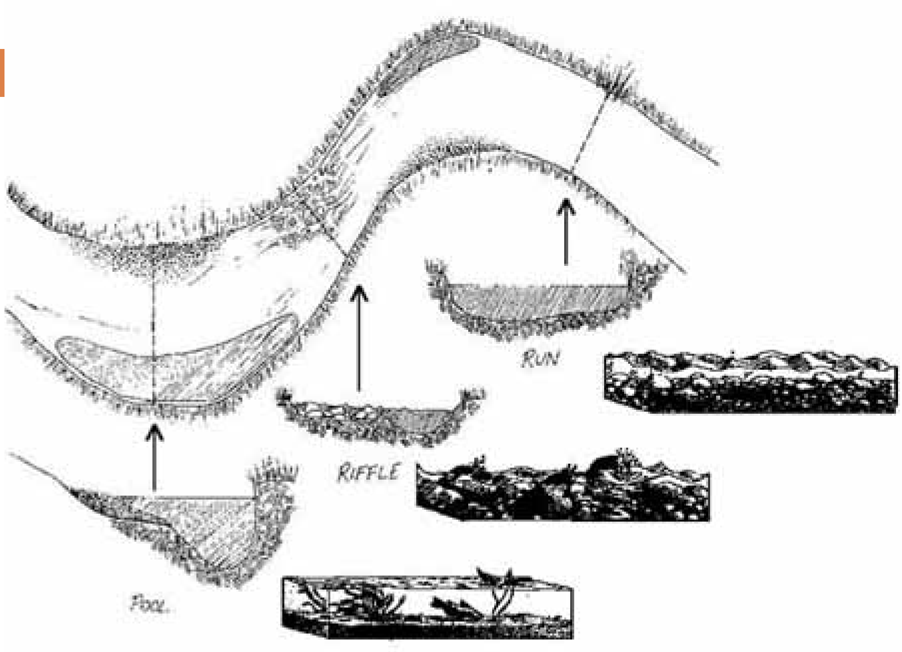
C Grade control absent, spaced >100 m or $>4/S_v$ m, or clear evidence of ineffectiveness



Channel Cross-sections and Profiles



Physical Habitat (PHAB) MMI



Habitat Assessment Field Data Sheet
Low Gradient Streams

Stream Name

Station #________ Rivermile __________

Lat ____________ Long ____________

Storet #

Form Completed By

Date ______
Time ______ AM PM

Habit Parameter				
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover, mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30 - 50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10 - 30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	

PHAB MMI Metrics

Condition Categories

- Riparian condition
- Substrate condition
- Productivity
- Channel equilibrium
- Riparian condition

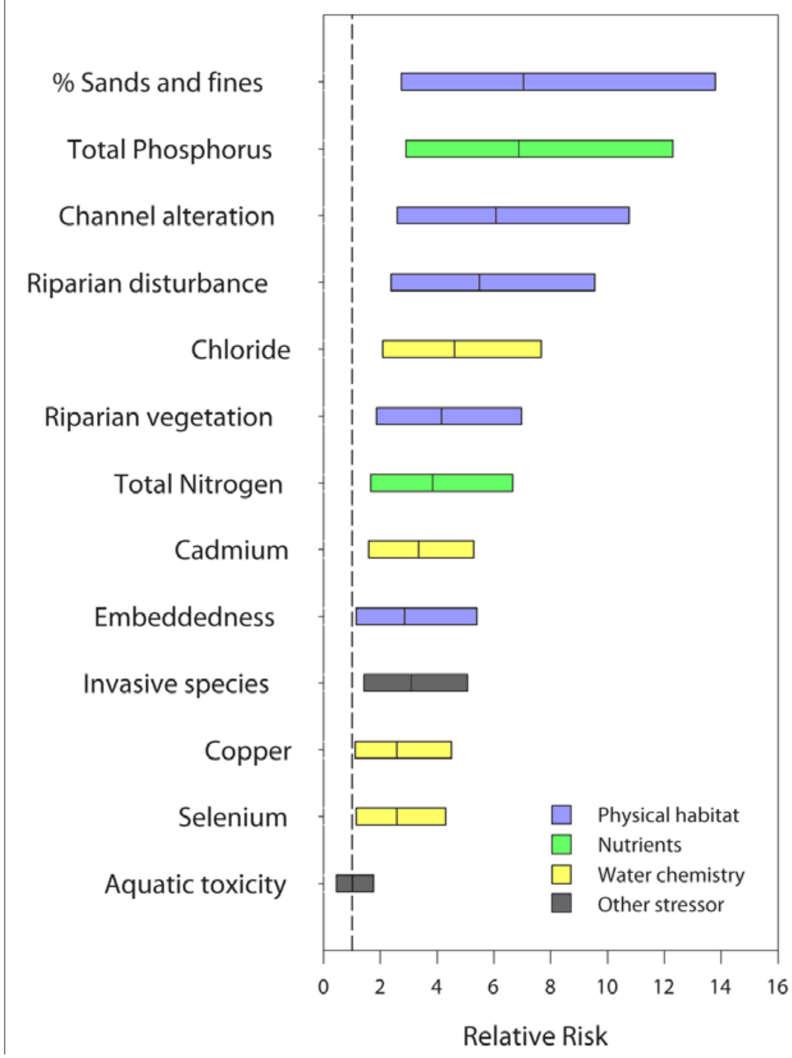
Index under development

Candidate Metrics

- Percent Presence of Macroalgae
- Percent Stable Banks
- Percent Fast Water of Reach
- Natural Shelter cover - SWAMP
- Mean Mid-Channel Shade
- Canopy cover
- Riparian Vegetation All 3 Layers
- CPOM Presence
- Particle Size Median (d50)
- Percent Substrate <2 mm

Biological Monitoring

- Main "response" variable
- Direct measure of biological endpoint
  - Integrate stream conditions
  - Monitor for shifts in community structure
- Support characterization and effectiveness assessments



Biological Assessment Tools

- California Rapid Assessment Method (CRAM)

- Benthic Macroinvertebrates

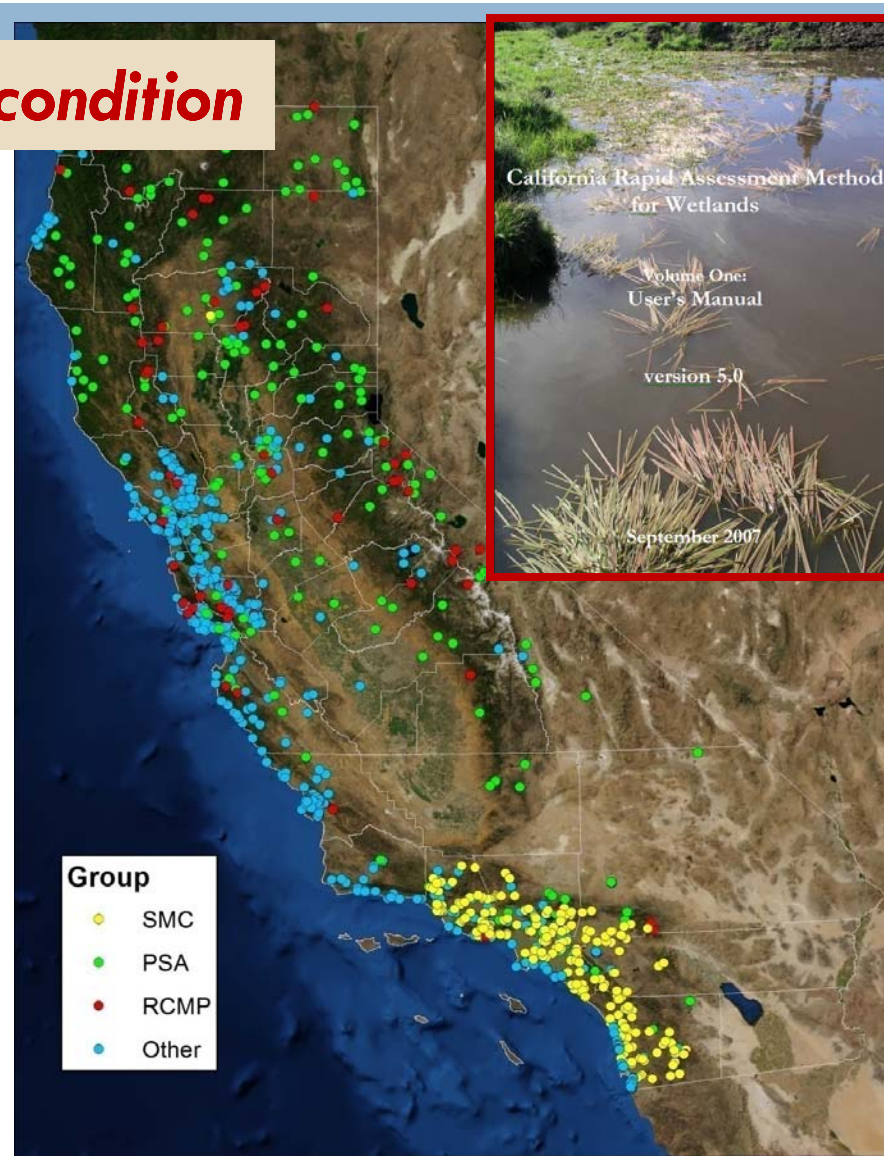
- Stream Algae

- Emerging Bioassessment Indicators

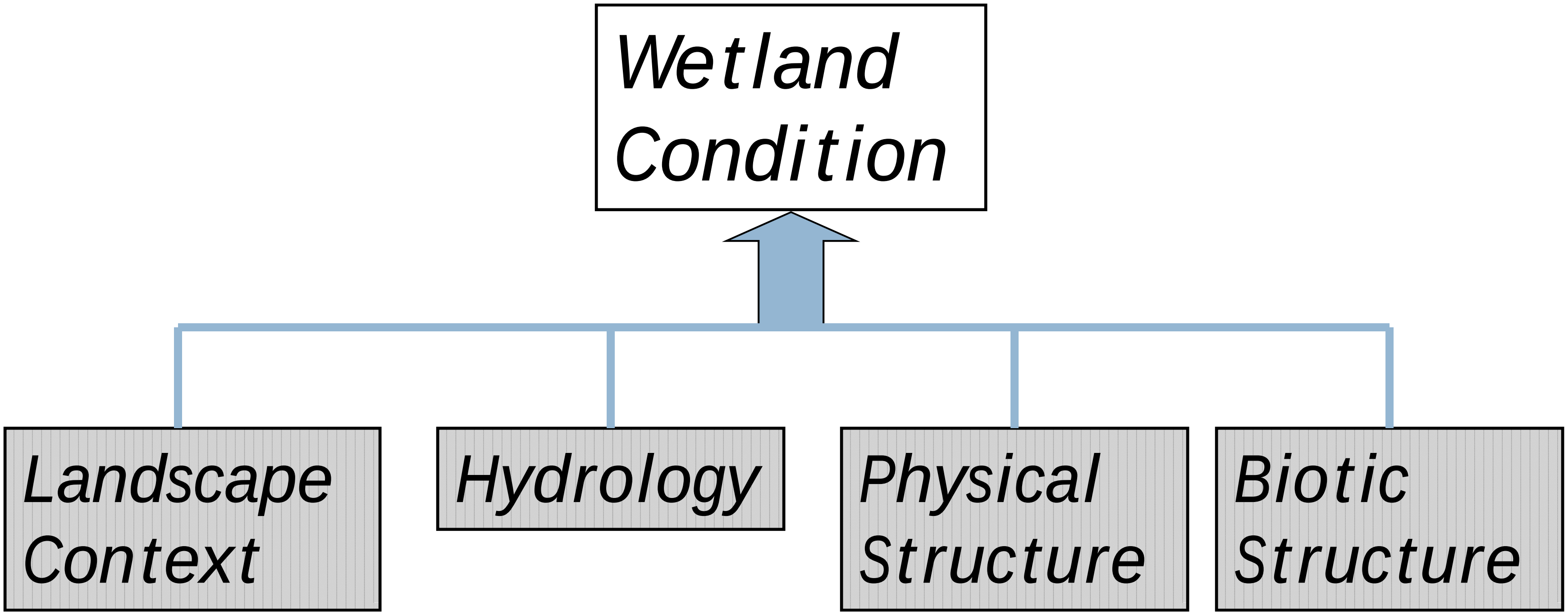
California Rapid Assessment Method (CRAM)

Field-based, rapid tool to assess condition

- Applicable to all wetland types, including streams
- Based on readily observable field indicators
- Evaluates broad suite of conditions
- Validated with more intensive measures of condition

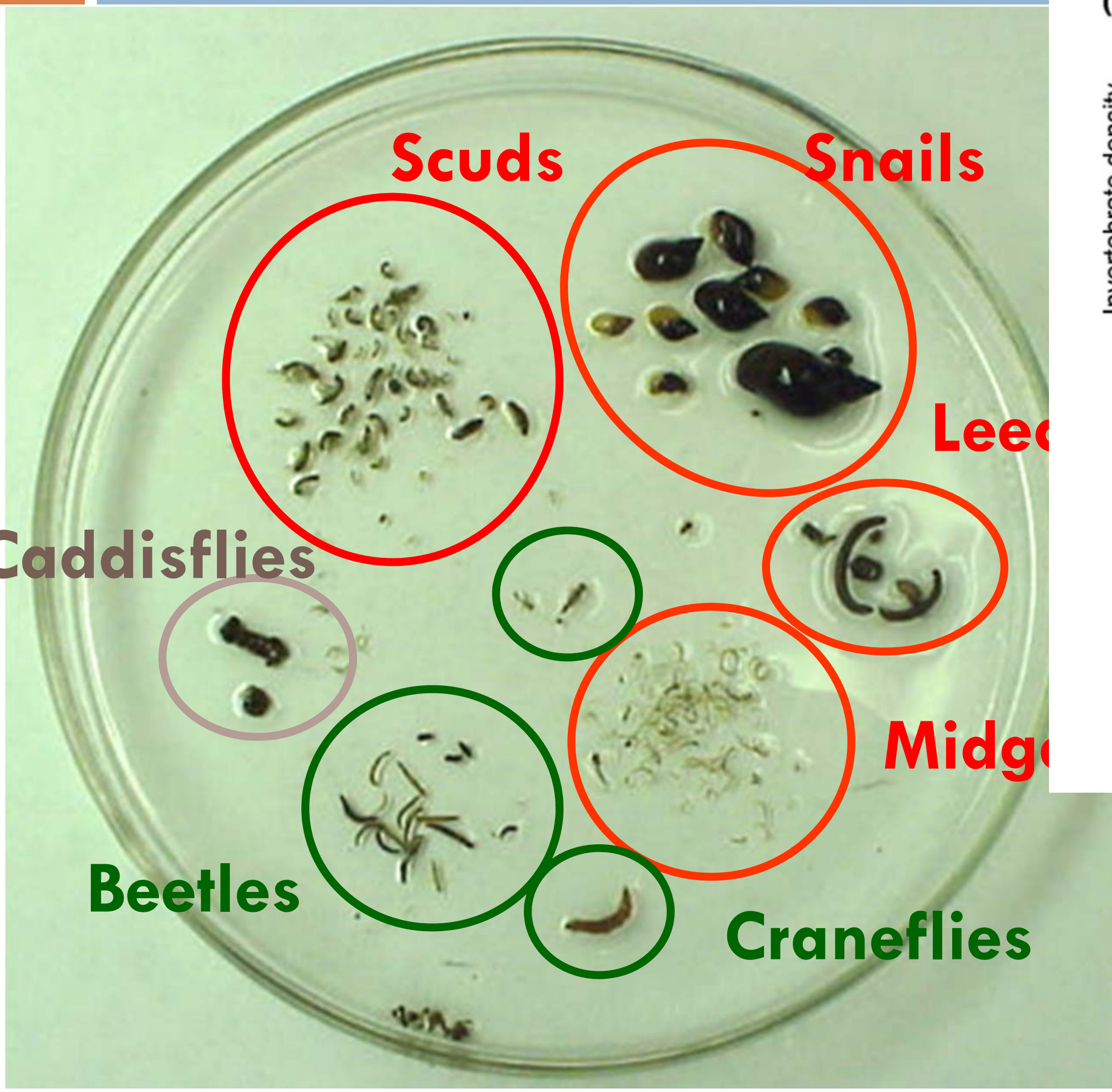


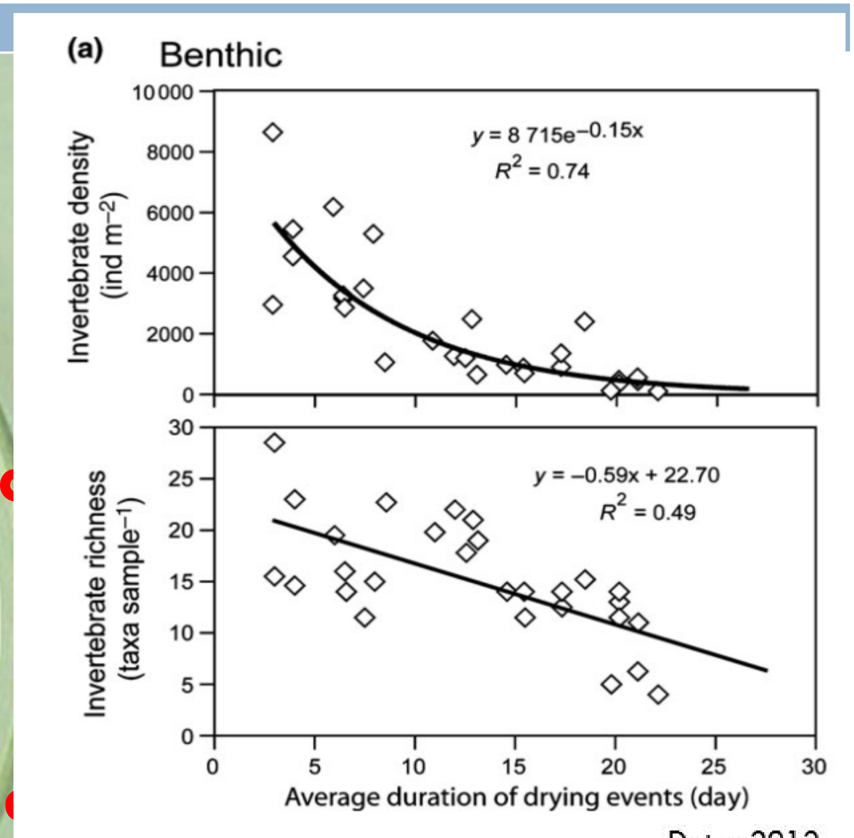
CRAM Attributes



- CRAM recognizes four attributes of wetland condition
- Each attribute is represented by 2-3 metrics, some of which have sub-metrics.

Benthic Invertebrate Assessments



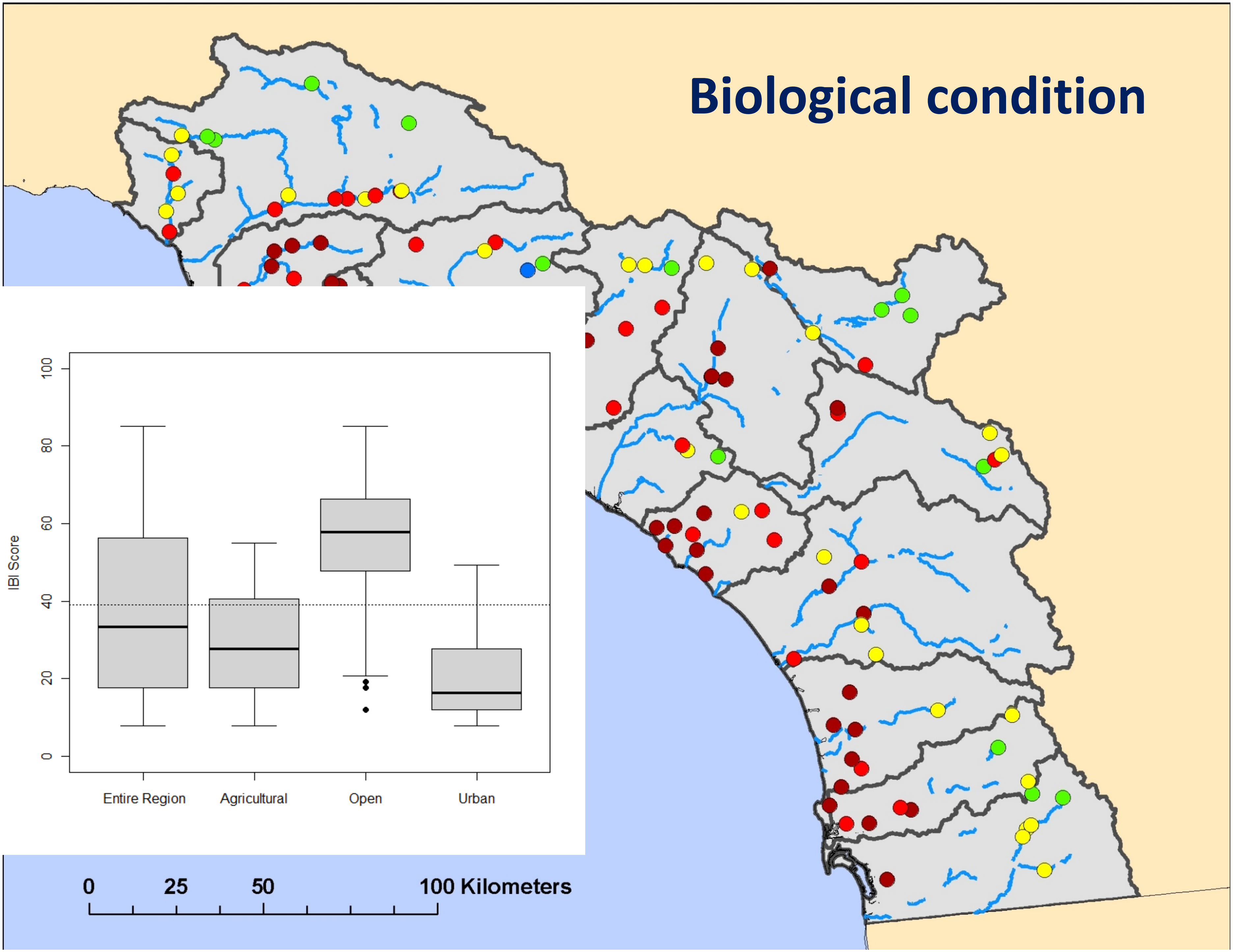


Datry 2012

Tolerant Groups

Found at low integrity sites

Biological condition

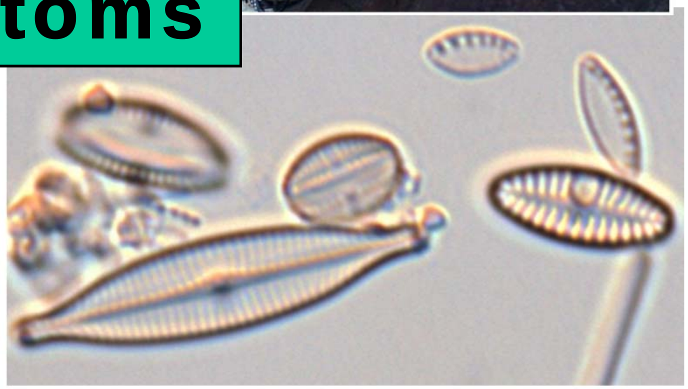


Algae Bioassessment

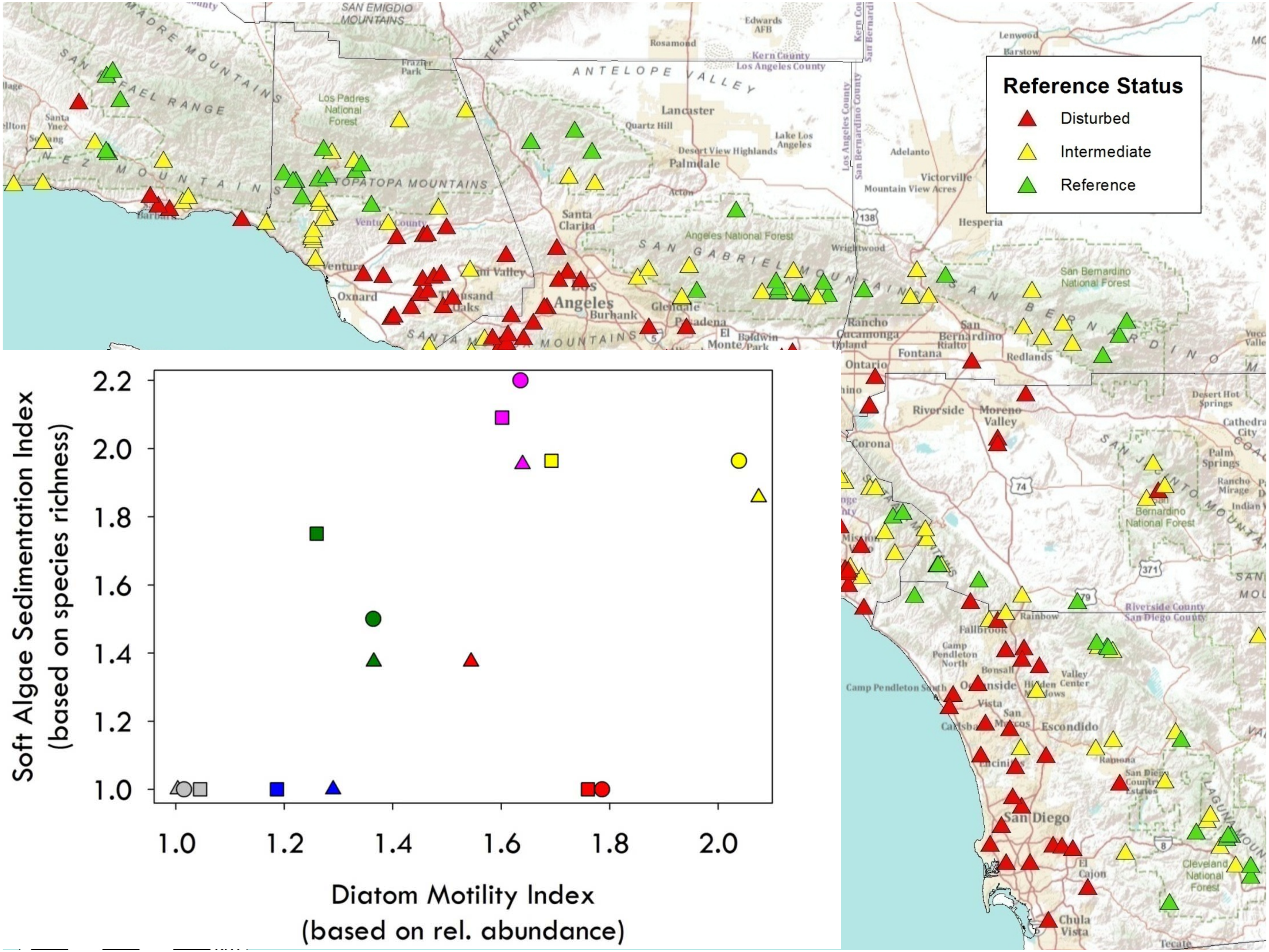
- Information complementary to bugs
  - Response to different stressors
  - Strongest responses evident over different ranges of disturbance
- Weight of evidence
- Potential for broader range/flexibility in interpretation of results
  - Applicability on different substrate types

Benthic Algae IBIs

diatoms

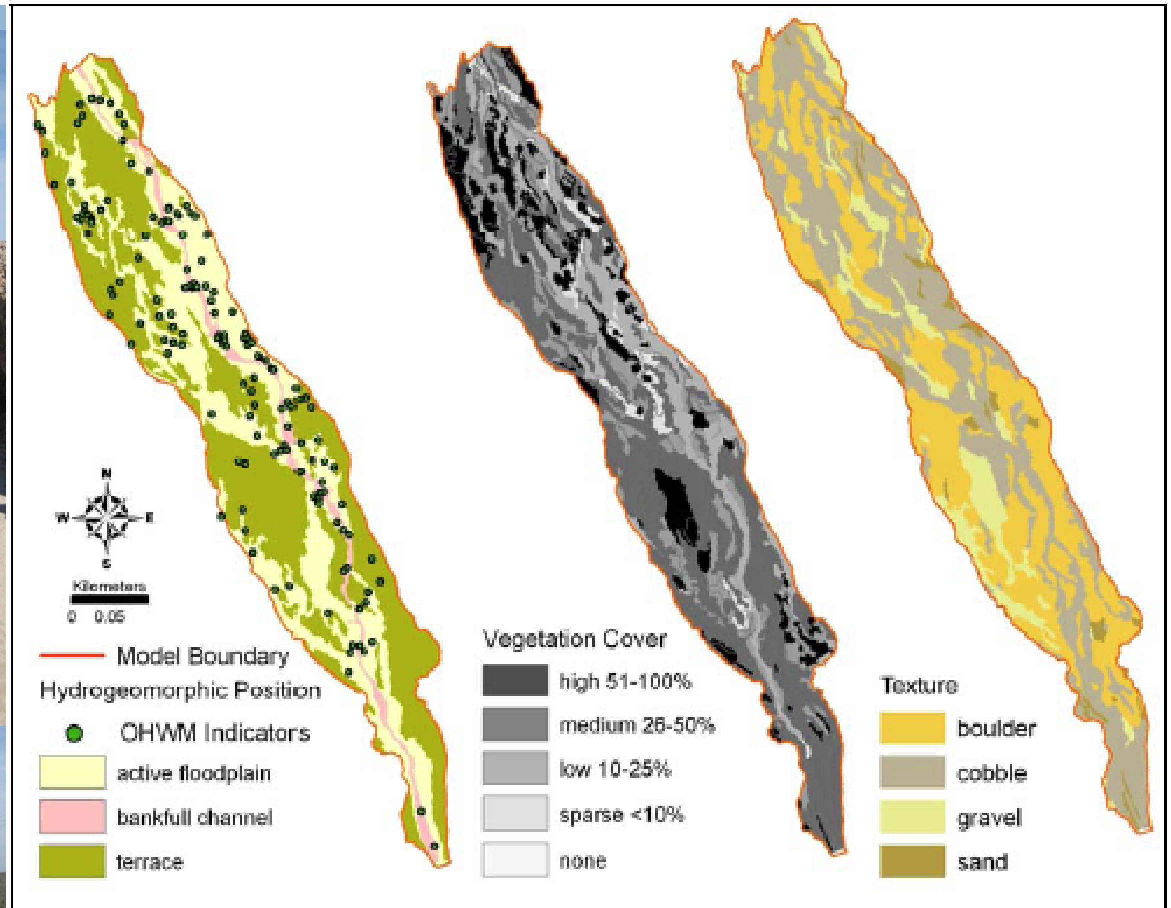


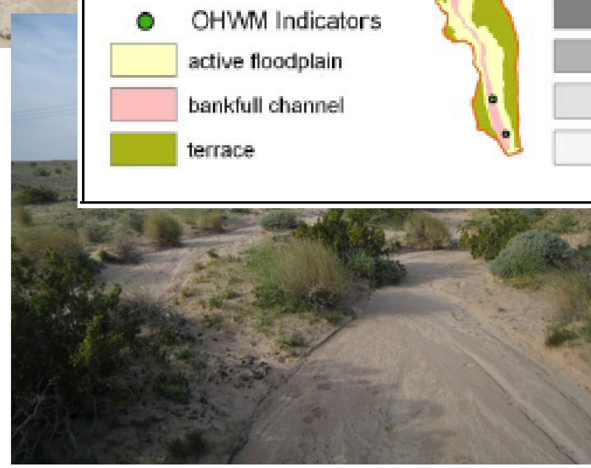
soft-bodied algae
(& cyanobacteria)

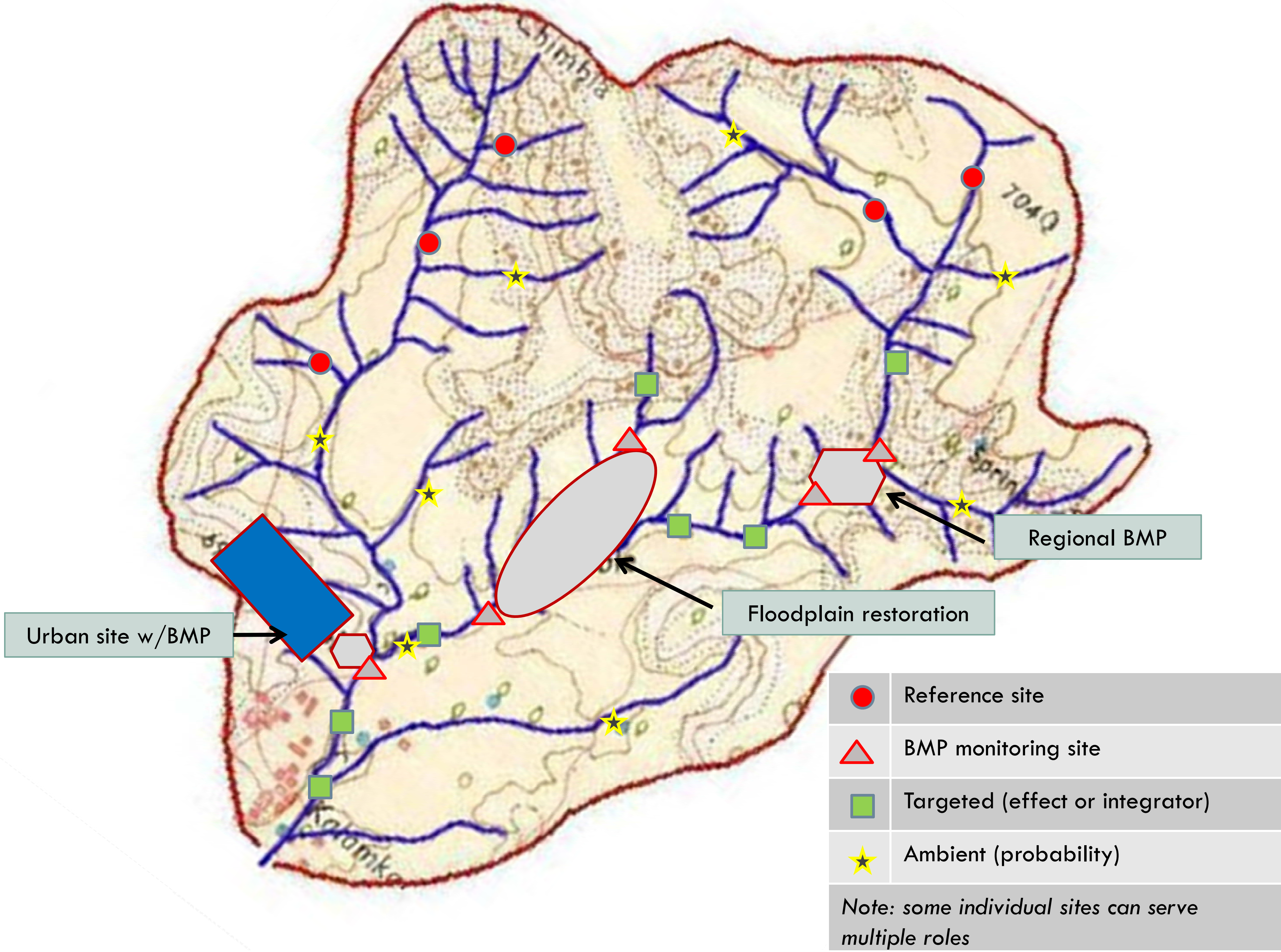


Reference Status
Disturbed
Intermediate
Reference
Soft Algae Sedimentation Index
(based on species richness)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
1.0
1.2
1.4
1.6
1.8
2.0
Diatom Motility Index
(based on rel. abundance)

Emerging Indicators for Non-perennial Streams






Urban site w/BMP
Floodplain restoration
Regional BMP
Reference site
BMP monitoring site
Targeted (effect or integrator)
Ambient (probability)
Note: some individual sites can serve multiple roles

What Do I Do With This Info?

- Identify successful management measures
- Identify areas of the watershed w/need of:
  - Additional management
  - Protection
- Calibrate, validate, refine models and tools
- Improve understanding of stress-response relationships
- Characterize natural variability

- Pre vs post project
- Upstream vs downstream
- Differences from reference
- Relative to ambient condition

How Much Will this Cost?

	Up-front Costs	Recurring Costs
Hydrology	$2,500	$5,000
Biology & Geomorphology	$3,000	$6,500

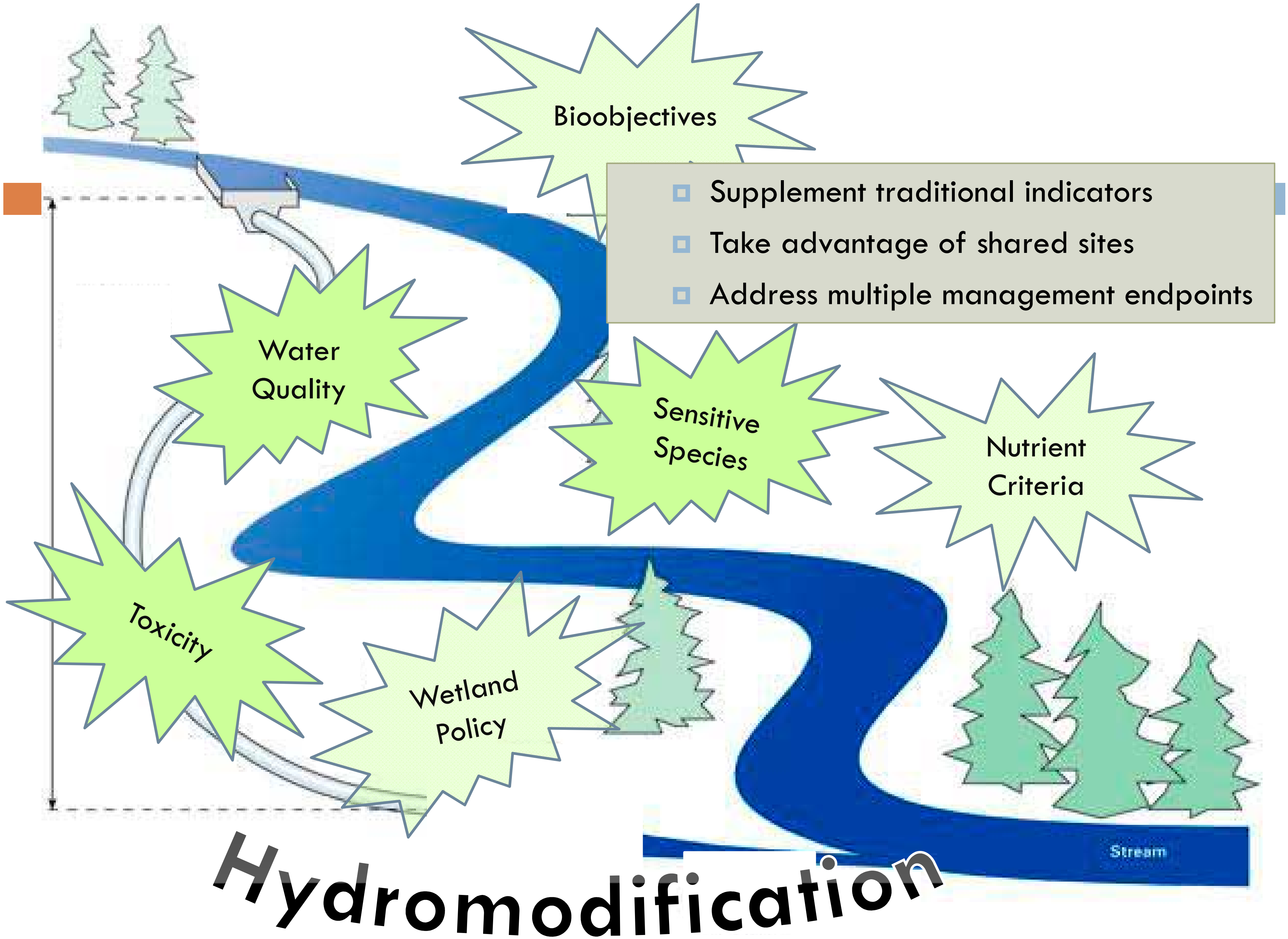
Type of Site	No. of sites
BMP monitoring sites	6 - 9
BMP reference sites (sites w/o BMPs)	3 - 5
Instream effectiveness monitoring sites	6 - 9
Spatial effects sites	12 - 15
Trends sites	6 - 9
Reference sites	6 -9
Probalisitic sites	30

Overall Estimated Costs

		Up front	Annual
Short term questions	Performance & Effectiveness	$40,000 - $80,00	$85,00 - $120,000
Longer term questions	Trends and Spatial Patterns	$45,000 - $70,000	$100,000 - $150,000
Probabilistic		$90,000	$200,000

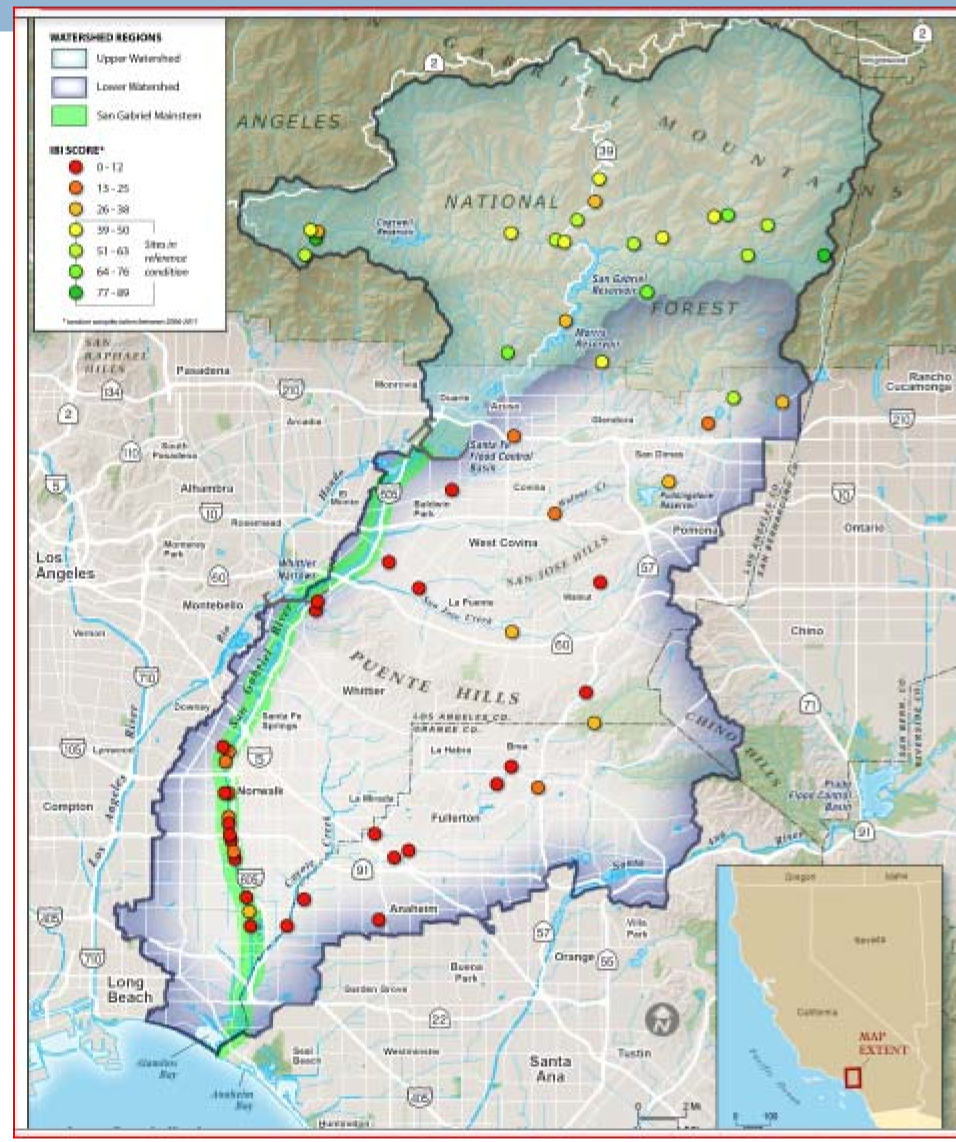
Don’t Freak Out!

- Supplement traditional indicators
- Take advantage of shared sites
- Address multiple management endpoints



Leverage off Existing Programs

- Regional Monitoring
  - Characterization
  - Regional reference
- Stormwater Monitoring
  - Effectiveness
- Section 404/401
  - Performance



Challenges

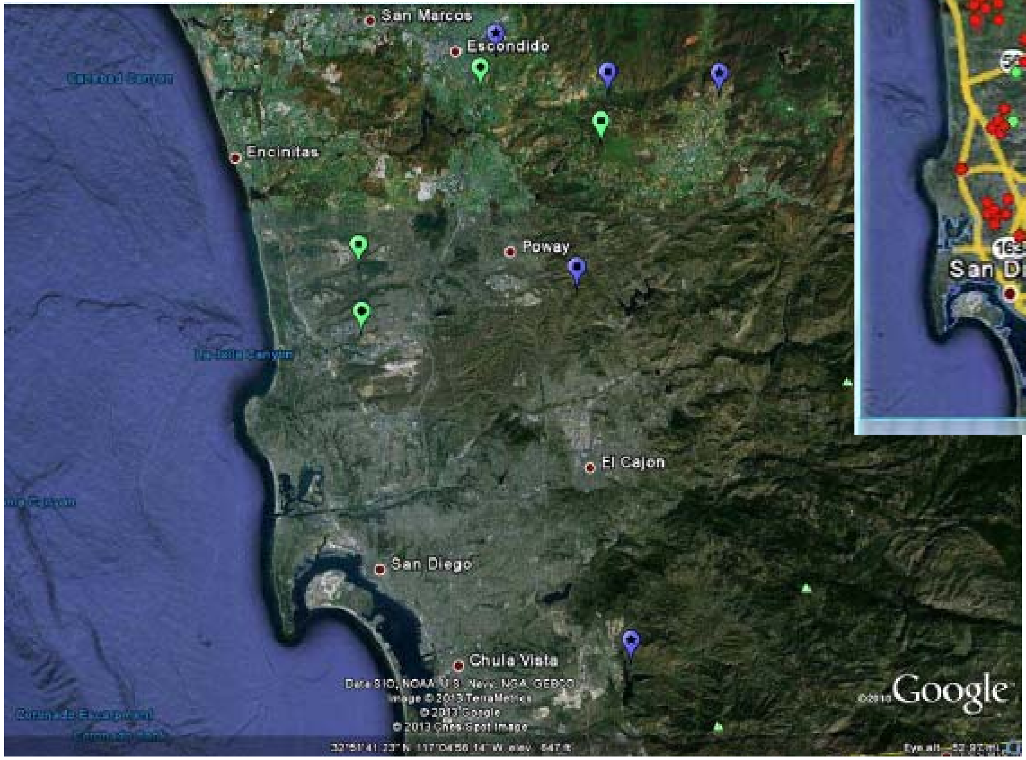
- Site identification

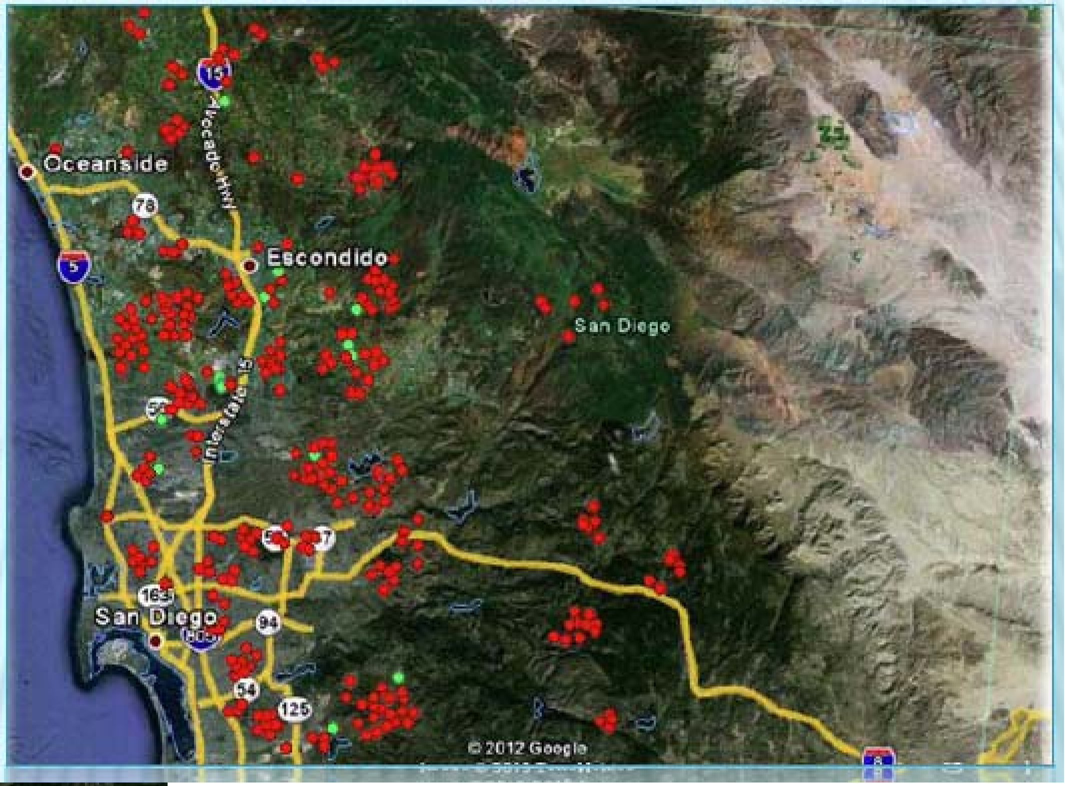
- Long-term commitment
  - Responsibility
  - Funding

- Information management and dissemination
  - Central database for hydromodification BMP/LID performance and effectiveness monitoring data

Challenges of Site Identification

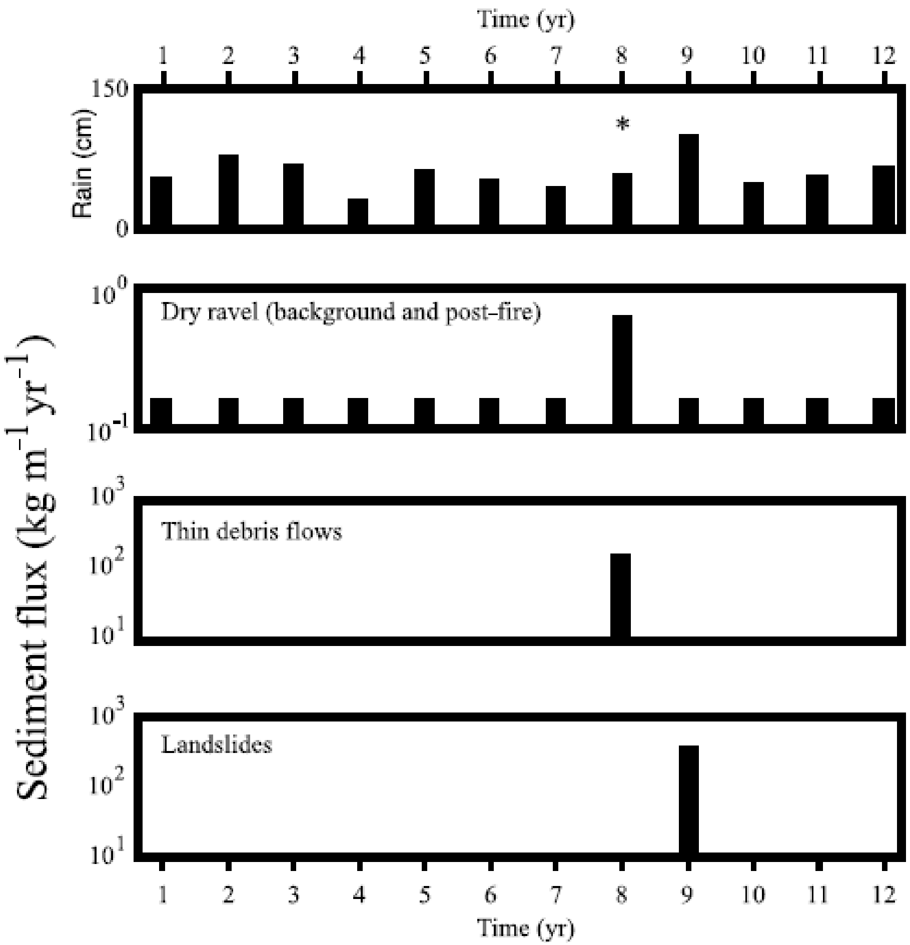
- Identify candidate sties
- Office screening
- Field screening
- Legal access and permissions



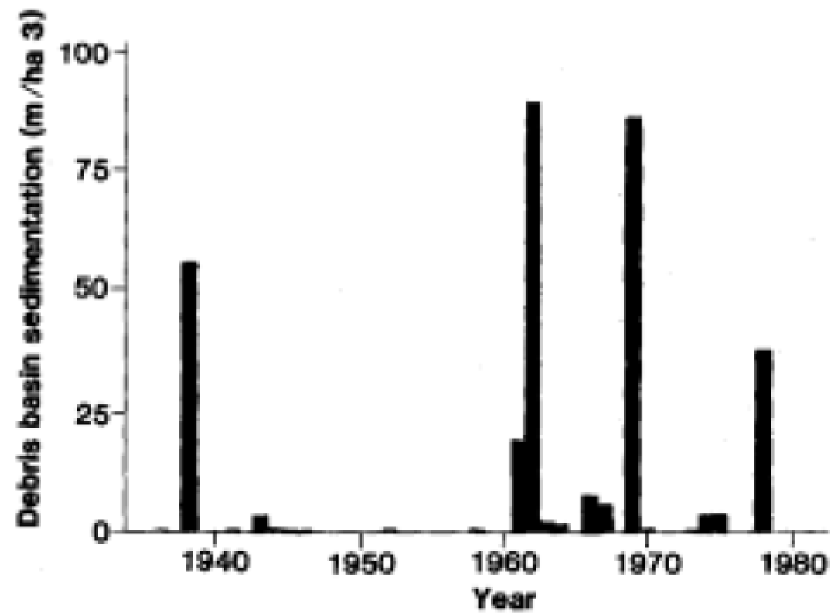


- 300 sites researched
- 10 sites selected

MUST Monitor for the Long-view



Gabet and Dunne (2003)



Rice (1982)

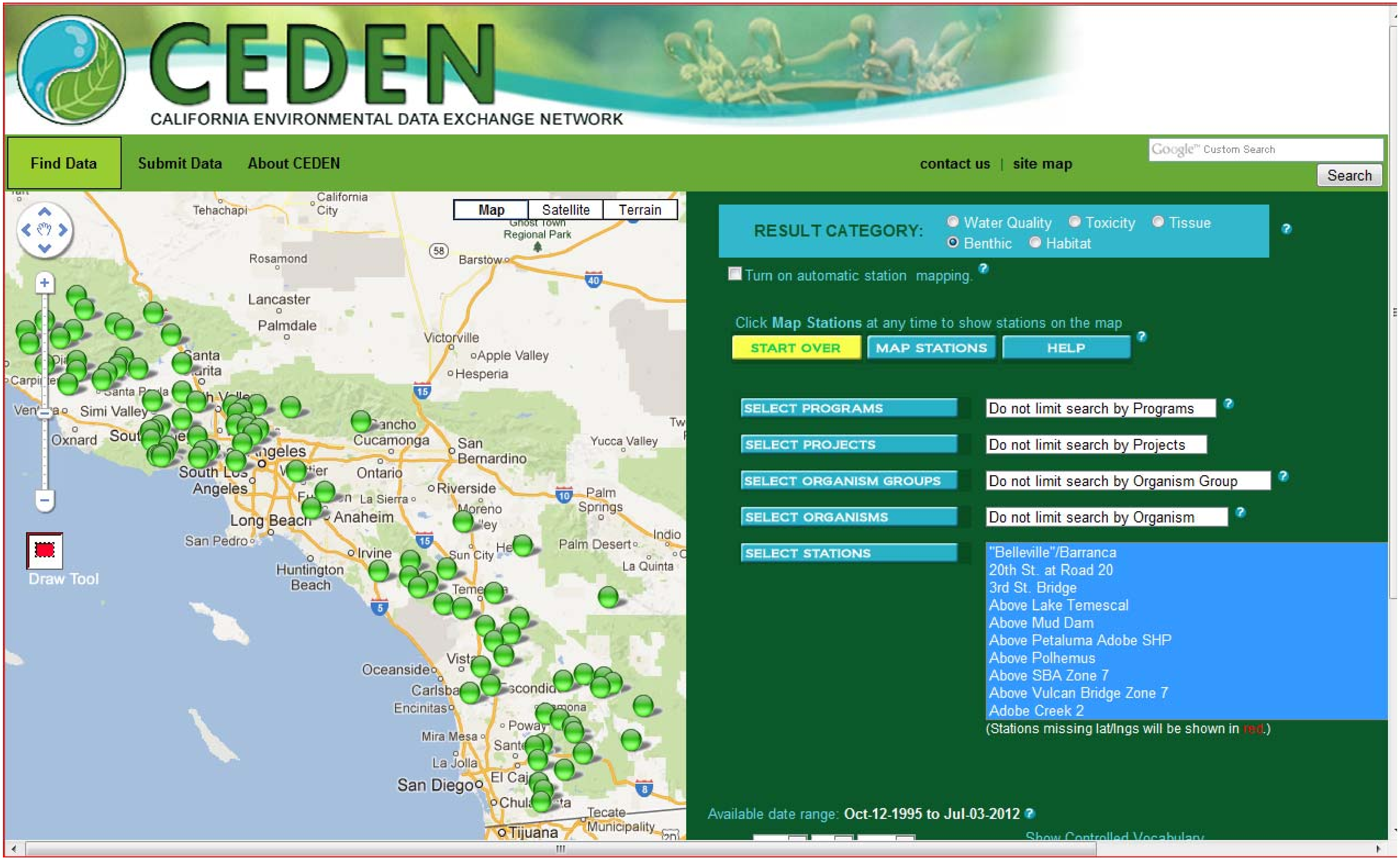
How Can You Access the Data

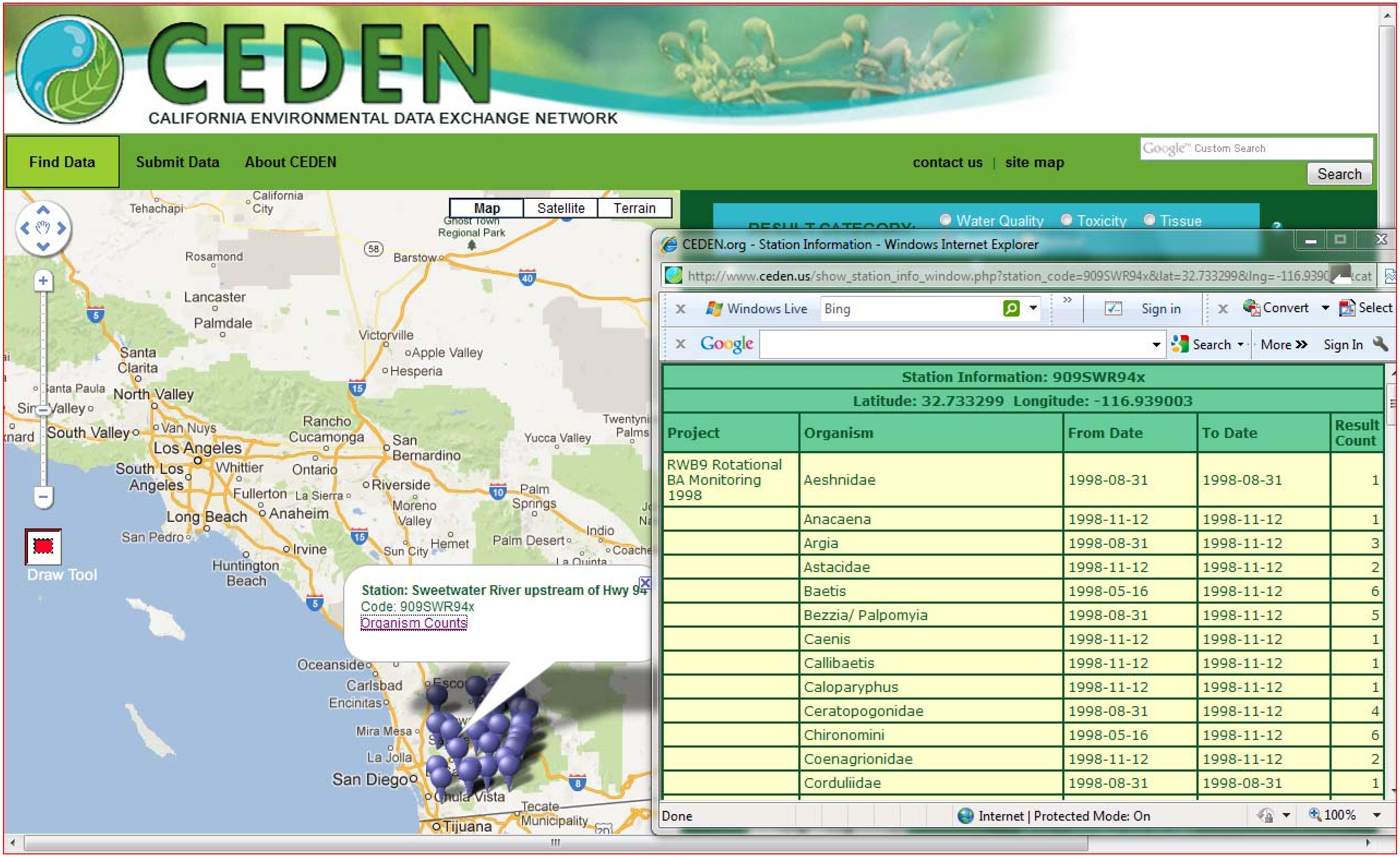
CEDEN
CALIFORNIA ENVIRONMENTAL DATA EXCHANGE NETWORK

Benthic invertebrates, Algae, Chemistry, Toxicity

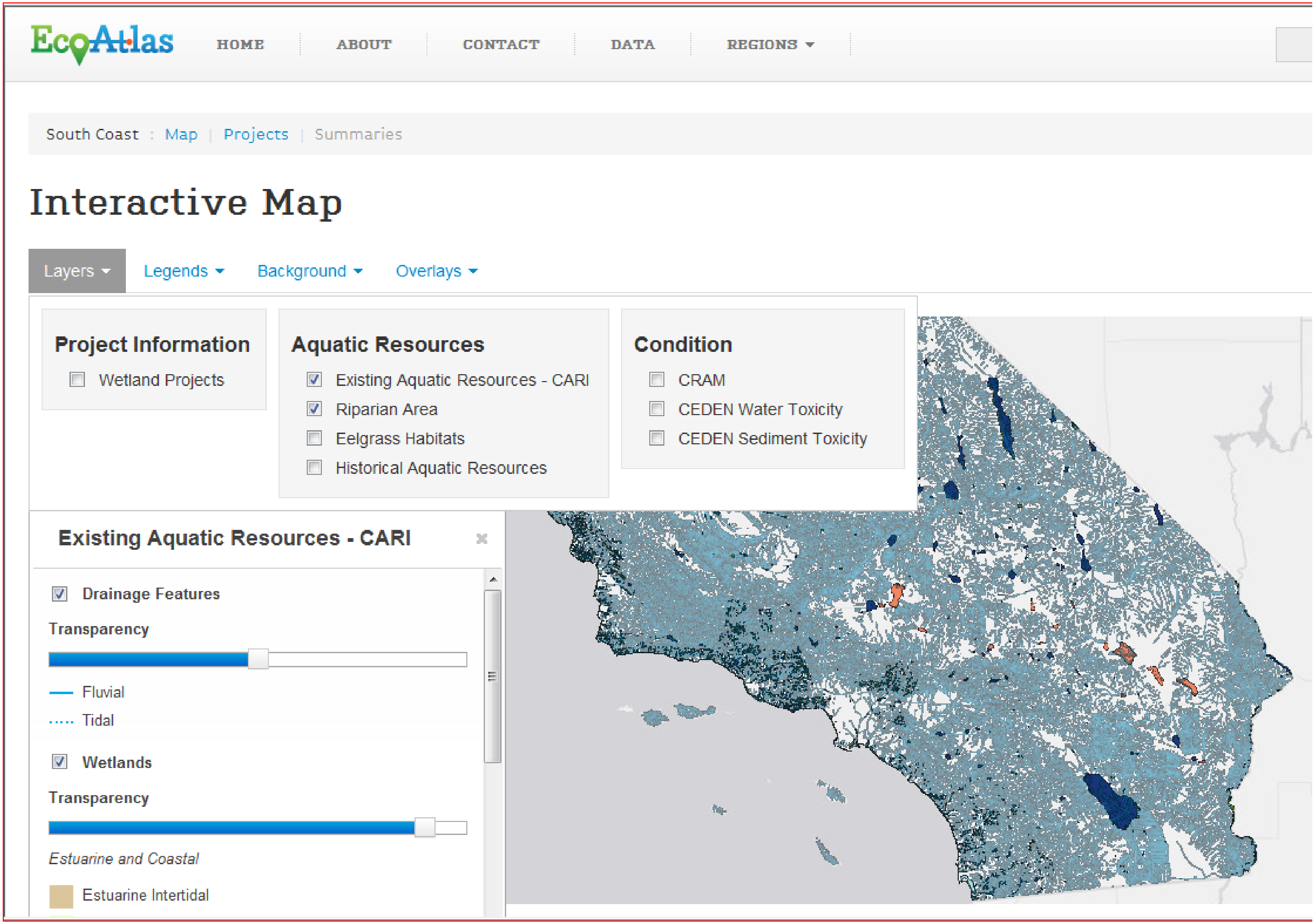
EcoAtlas

CRAM, Chemistry, Toxicity, + Project info

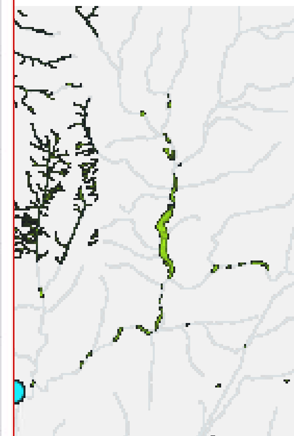

CEDEN
CALIFORNIA ENVIRONMENTAL DATA EXCHANGE NETWORK
Find Data
Submit Data
About CEDEN
contact us | site map
Search
Map
Satellite
Terrain
Draw Tool
RESULT CATEGORY:
Water Quality
Toxicity
Tissue
Benthic
Habitat
Turn on automatic station mapping.
Click Map Stations at any time to show stations on the map
START OVER
MAP STATIONS
HELP
SELECT PROGRAMS
Do not limit search by Programs
SELECT PROJECTS
Do not limit search by Projects
SELECT ORGANISM GROUPS
Do not limit search by Organism Group
SELECT ORGANISMS
Do not limit search by Organism
SELECT STATIONS
"Belleville"/Barranca
20th St. at Road 20
3rd St. Bridge
Above Lake Temescal
Above Mud Dam
Above Petaluma Adobe SHP
Above Polhemus
Above SBA Zone 7
Above Vulcan Bridge Zone 7
Adobe Creek 2
(Stations missing lat/lngs will be shown in red.)
Available date range: Oct-12-1995 to Jul-03-2012



Station Information: 909SWR94x				
Latitude: 32.733299 Longitude: -116.939003				
Project	**Organism**	**From Date**	**To Date**	**Result Count**
RWB9 Rotational BA Monitoring 1998	Aeshnidae	1998-08-31	1998-08-31	1
	Anacaena	1998-11-12	1998-11-12	1
	Argia	1998-08-31	1998-11-12	3
	Astacidae	1998-11-12	1998-11-12	2
	Baetis	1998-05-16	1998-11-12	6
	Bezzia/ Palpomyia	1998-08-31	1998-11-12	5
	Caenis	1998-11-12	1998-11-12	1
	Callibaetis	1998-11-12	1998-11-12	1
	Caloparyphus	1998-11-12	1998-11-12	1
	Ceratopogonidae	1998-08-31	1998-11-12	4
	Chironomini	1998-05-16	1998-11-12	6
	Coenagrionidae	1998-11-12	1998-11-12	2
	Corduliidae	1998-08-31	1998-08-31	1


EcoAtlas
HOME
ABOUT
CONTACT
DATA
REGIONS
South Coast : Map | Projects | Summaries
Interactive Map
Layers
Legends
Background
Overlays
Project Information
Wetland Projects
Aquatic Resources
Existing Aquatic Resources - CARI
Riparian Area
Eelgrass Habitats
Historical Aquatic Resources
Condition
CRAM
CEDEN Water Toxicity
CEDEN Sediment Toxicity
Existing Aquatic Resources - CARI
Drainage Features
Transparency
Fluvial
Tidal
Wetlands
Transparency
Estuarine and Coastal
Estuarine Intertidal

Name	File Type	Submitted On	Submitted By	Includes
Coastal Conservancy Staff Recommendation	Other	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	
Fish Survey	Dataset	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	
Initial Project Concepts and Alternatives	Other	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	Map
October 2002 Pollutant Source and Sedimentation Analyses	Monitoring Report	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	Map
October 2003 Sediment Characterization Study	Monitoring Report	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	Map
Plant Species by Habitat Type	Dataset	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	
Project Cost Estimates	Dataset	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	
Terrestrial Wildlife Species Occurrence by Habitat	Dataset	06/30/2008	Christopher Solek, Southern California Coastal Water Research Project	



Search

			3.6
			0.64
			16.6
Balboa Marina Dock Replacement Project Other	Construction in-progress	Orange	0.34
Ballona Wetlands F Performance Criter	on in-progress	Los Angeles	600
Bolsa Chica Wetlan Map	on completed	Orange	939
Bristol Cove Dredgi Other	on completed	San Diego	0.91
Buena Vista Creek Prepared Map Ma	on completed	San Diego	133.8
Buena Vista Lagoon ... Phase II Dataset Monitoring Report Prepared Map Map Other	... in-progress	San Diego	225.71

Hydromodification Data

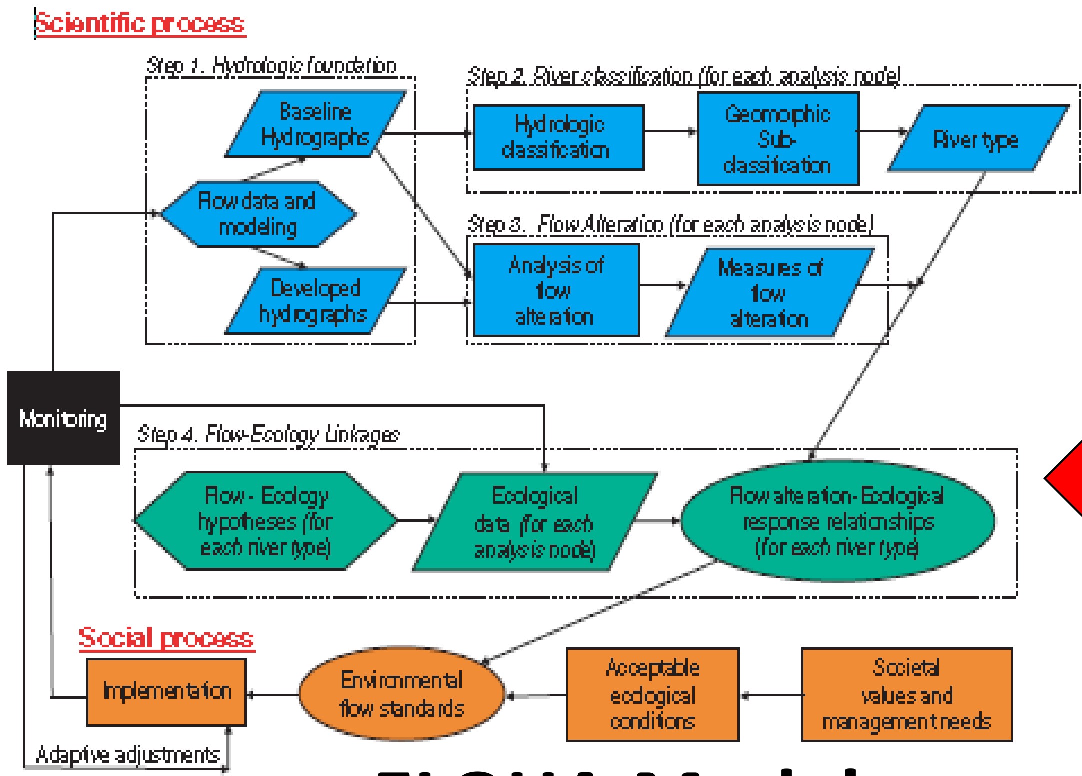
- BMP/LID sites
- Monitoring Data

???

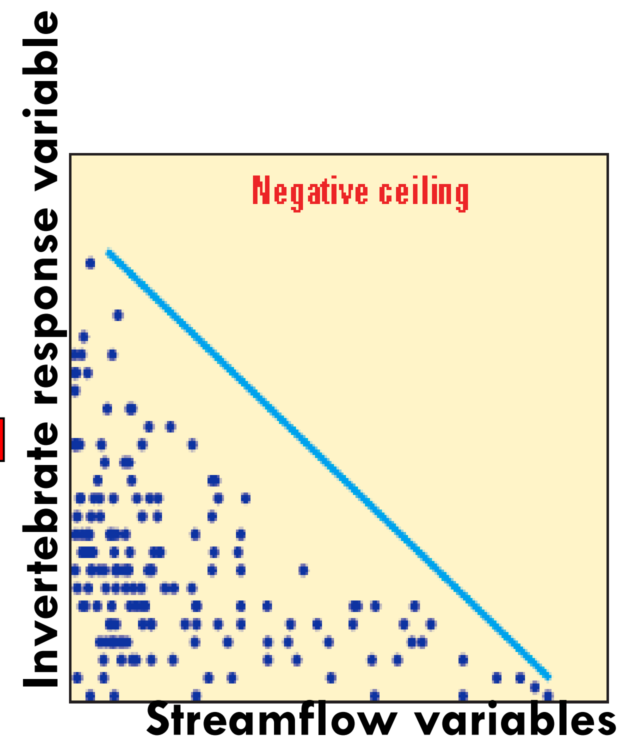
Programmatic Needs & Future Directions

- Central database for hydromodification BMP/LID performance and effectiveness monitoring data
- Examples/demonstrations of how to apply the framework and integrate multiple monitoring efforts to better leverage effort
- Develop more explicit connections with biological endpoints
  - Coordination with bio-objectives and causal assessment

Toward Flow-Ecology Models



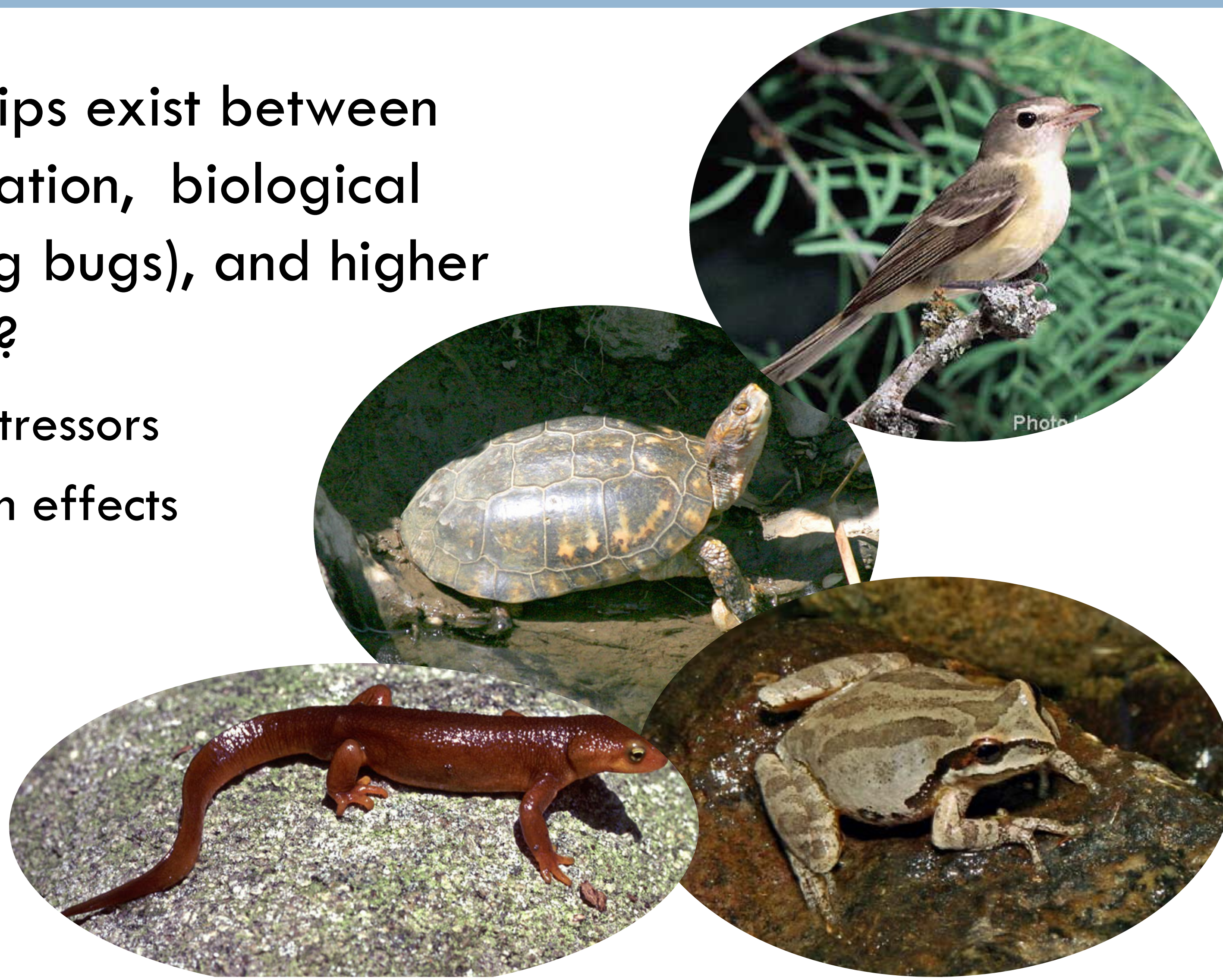
ELOHA Model



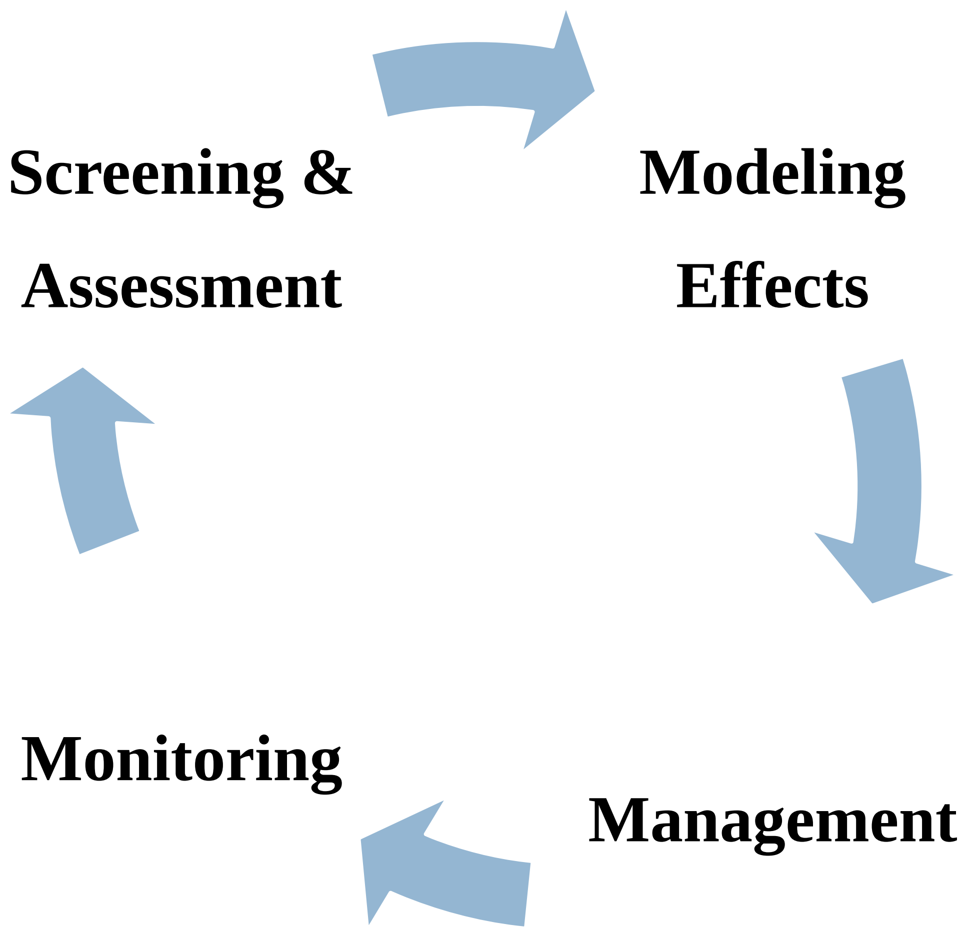
Relating Water Quality Indicators to Higher Trophic Level Functions

Do relationships exist between hydromodification, biological indicators (e.g bugs), and higher trophic levels?

- Common stressors
- Food chain effects



Monitoring Informs Future Management



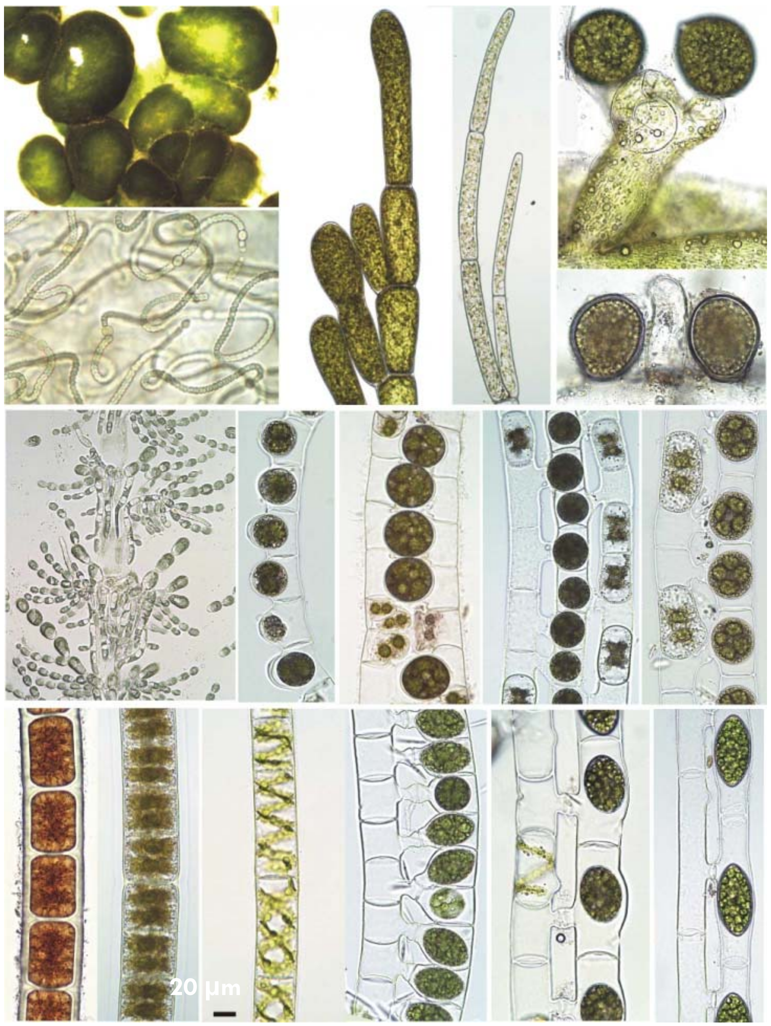
Final Thoughts

- Questions drive monitoring
- True benefits will only be realized over the long-term
  - Need long-term implementation mechanisms
- Monitoring data contributes to new knowledge
  - Data must be made broadly available

Thank You

Eric D. Stein - erics@sccwrp.org
www.sccwrp.org

Algae Come in a Variety of Shapes/Sizes…



same scale!

Component Metrics

1. proportion sedimentation tolerant (incl. highly motile)
2. proportion low-nitrogen indicators (incl. N fixers)
3. proportion haplobiontic
4. proportion nitrogen heterotrophs
5. proportion requiring > 50% saturation DO
6. proportion of organic-associated spp
7. proportion of copper-associated spp
8. proportion of low-phosphorus-associated spp

Sample Application: Sweetwater

Taxonomic Completeness

Observed	Missing
Acari	Bezzia
Baetis	
Chironominae	
Orthocladiinae	
Simulium	
Oligochaeta	
Tanypodinae	

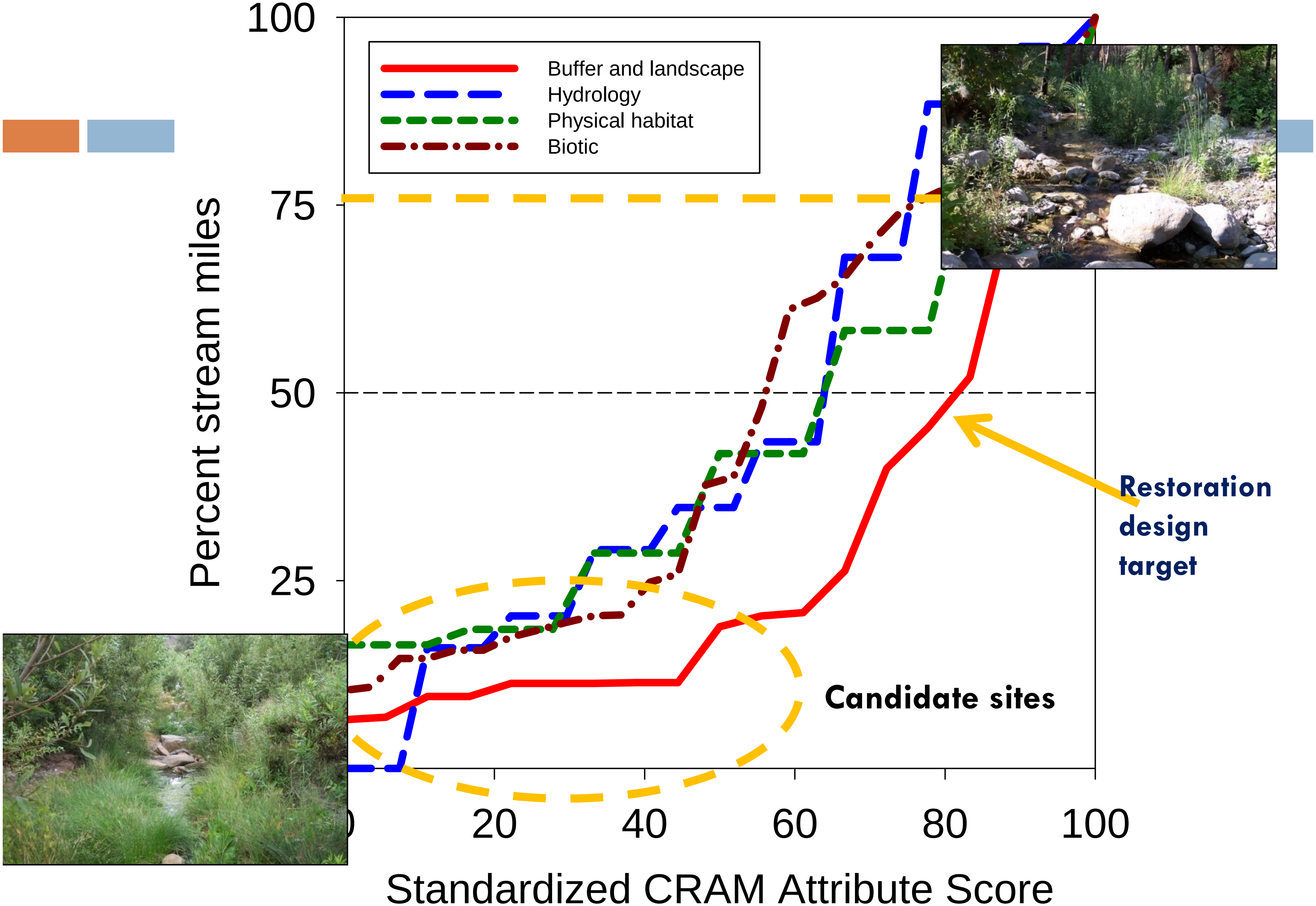
low taxa richness at Sweetwater, but hardly anything missing.

Index/Component	Sweetwater
CSCI	1.04
MMI	0.96
O/E	1.13

Ecological Structure

Metric	O	E	Score
Shannon Div	2.3	1.6	1.0
% Intol Taxa	0.06	0.23	0.3
Tol Value	6.2	5.8	0.7
Shredder Taxa	0	0.8	0.6
Clinger Taxa	5.6	6.5	0.7
Coleo Taxa	5.1	3.1	1.0
% Noninsect Taxa	0.2	0.2	0.9
Collector Taxa	12.2	9.4	1.0

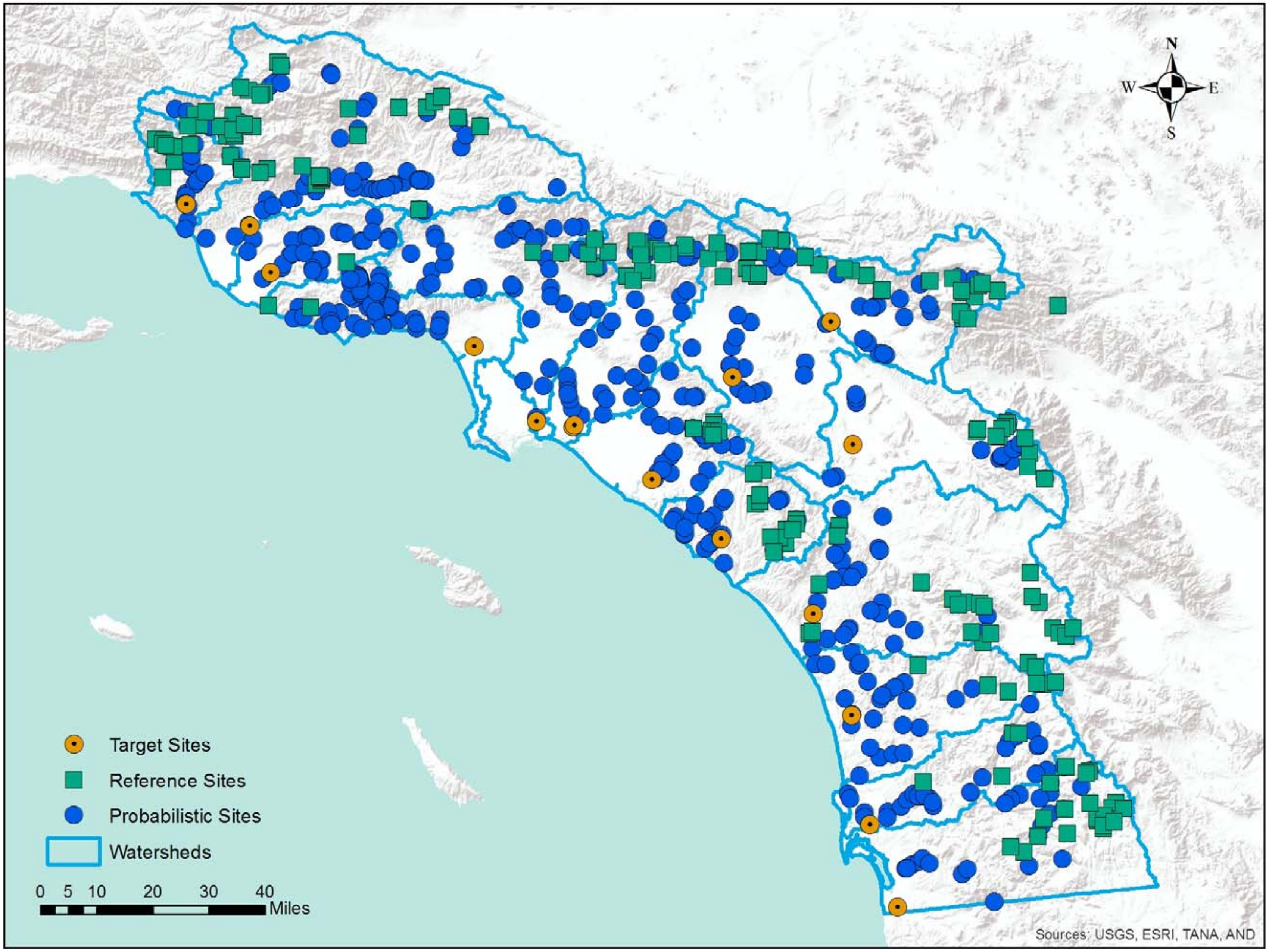
Ambient Data Provides Context for Decisions



Report Recommendations

1. Adopt a new paradigm for hydromodification management
2. Focus on restoration and management of watershed processes
3. State agencies to take leadership in developing new tools and methods necessary to implement recommend approach
4. Local agencies to implement new approaches over time and to implement question-driven monitoring programs
5. Develop a mechanism for improved information sharing to inform ongoing refinement of hydromodification management


Imagery Date: 8/26/2012
1994
Eye alt 4984 ft


N
W
E
S
Target Sites
Reference Sites
Probabilistic Sites
Watersheds
0 5 10 20 30 40
Miles
Sources: USGS, ESRI, TANA, AND