Use of Physical Habitat Data to Estimate Channel Vulnerability: Example from the Dry Creek Watershed

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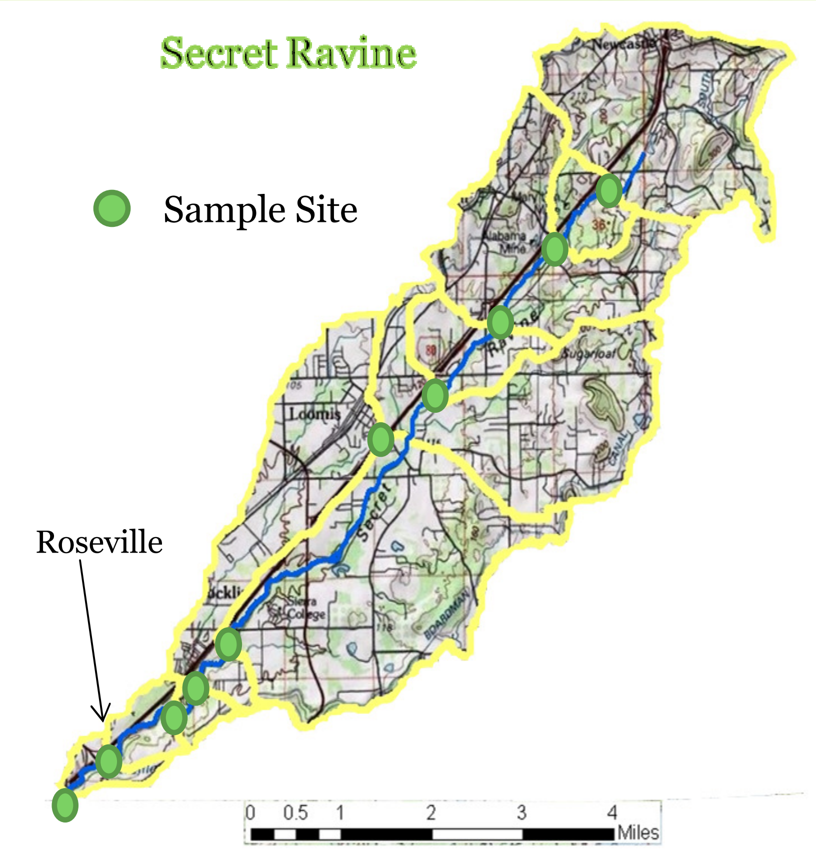
Background

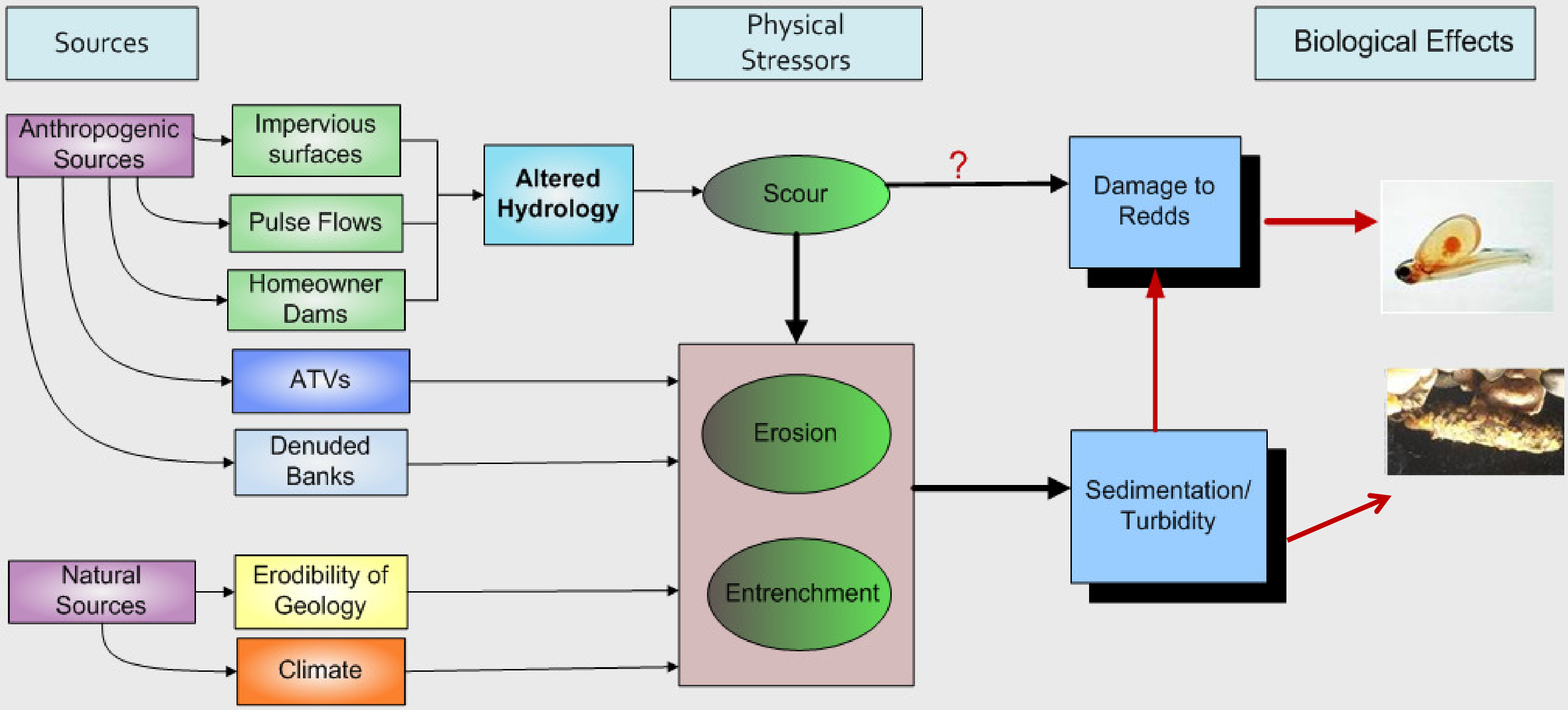
- Assess the vulnerability of Secret Ravine (SR) to erosion
- Test and troubleshoot the Channel Vulnerability Calculator
  - Originally developed as a hydromodification management tool for Contra Costa county
  - Evaluate the Calculators usefulness as a tool for watershed assessment, utilizing data collected with the PHAB protocol

Background on Secret Ravine Creek

- Remnant populations of fall-run chinook salmon
- Rapid urbanization
- Documented sedimentation and turbidity problems



Conceptual Model for Aquatic Life in Secret Ravine

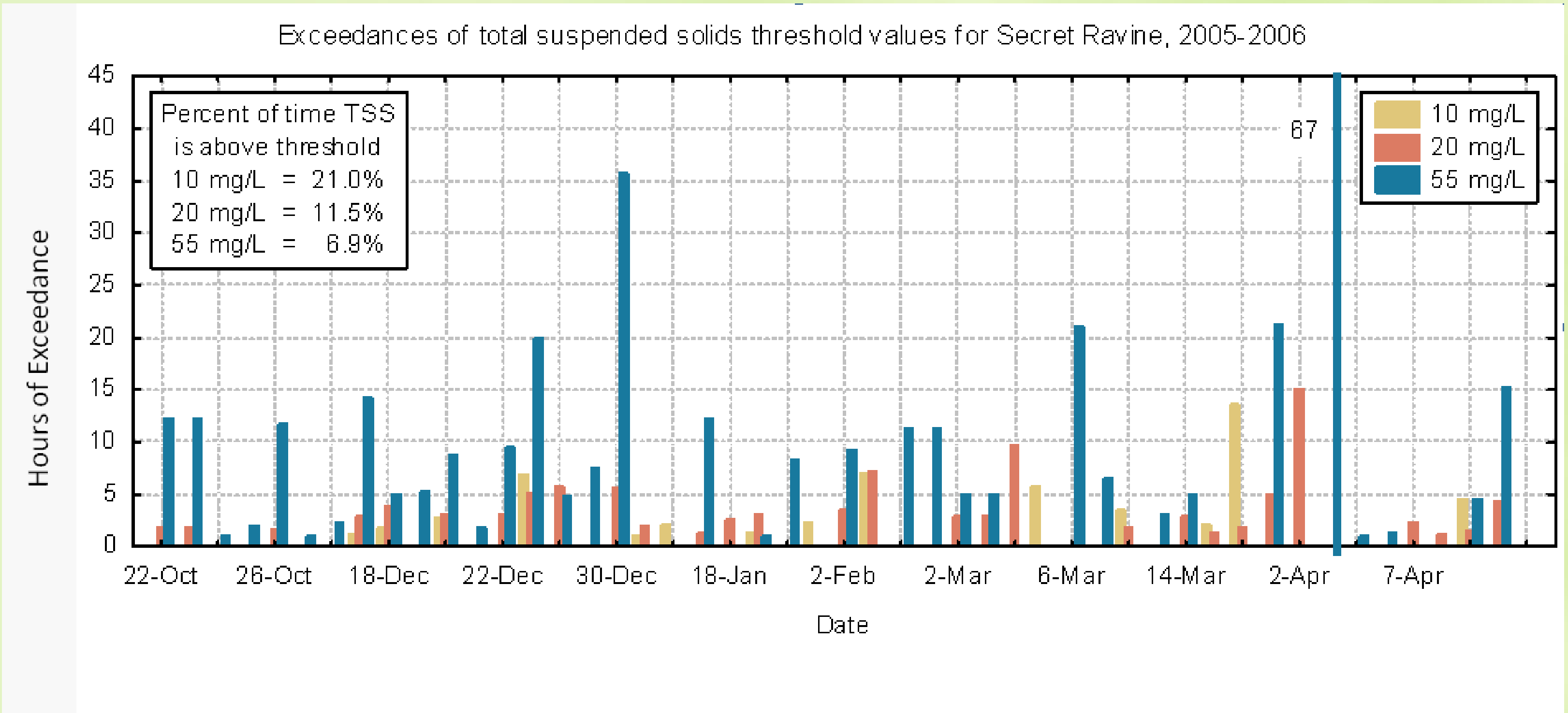


Irrigation Canal

Denuded Bank

Decomposed granite streambed

Exceedances of turbidity criteria 2005-2006 water year



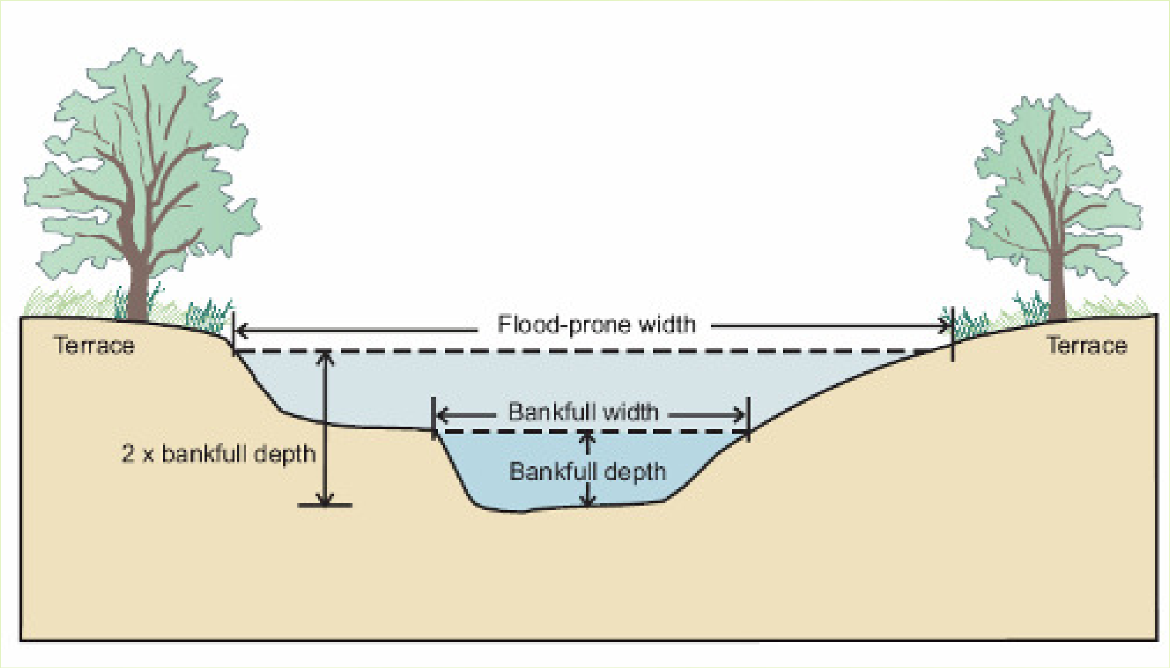
Each bar represents an exceedance in turbidity for a 1 hour (blue), 7 hour (red), or 24 hour (yellow) period.

Gaining a better understanding of this type of data – one important reason for this project

Evaluate the use of the Calculator for assessing watershed conditions

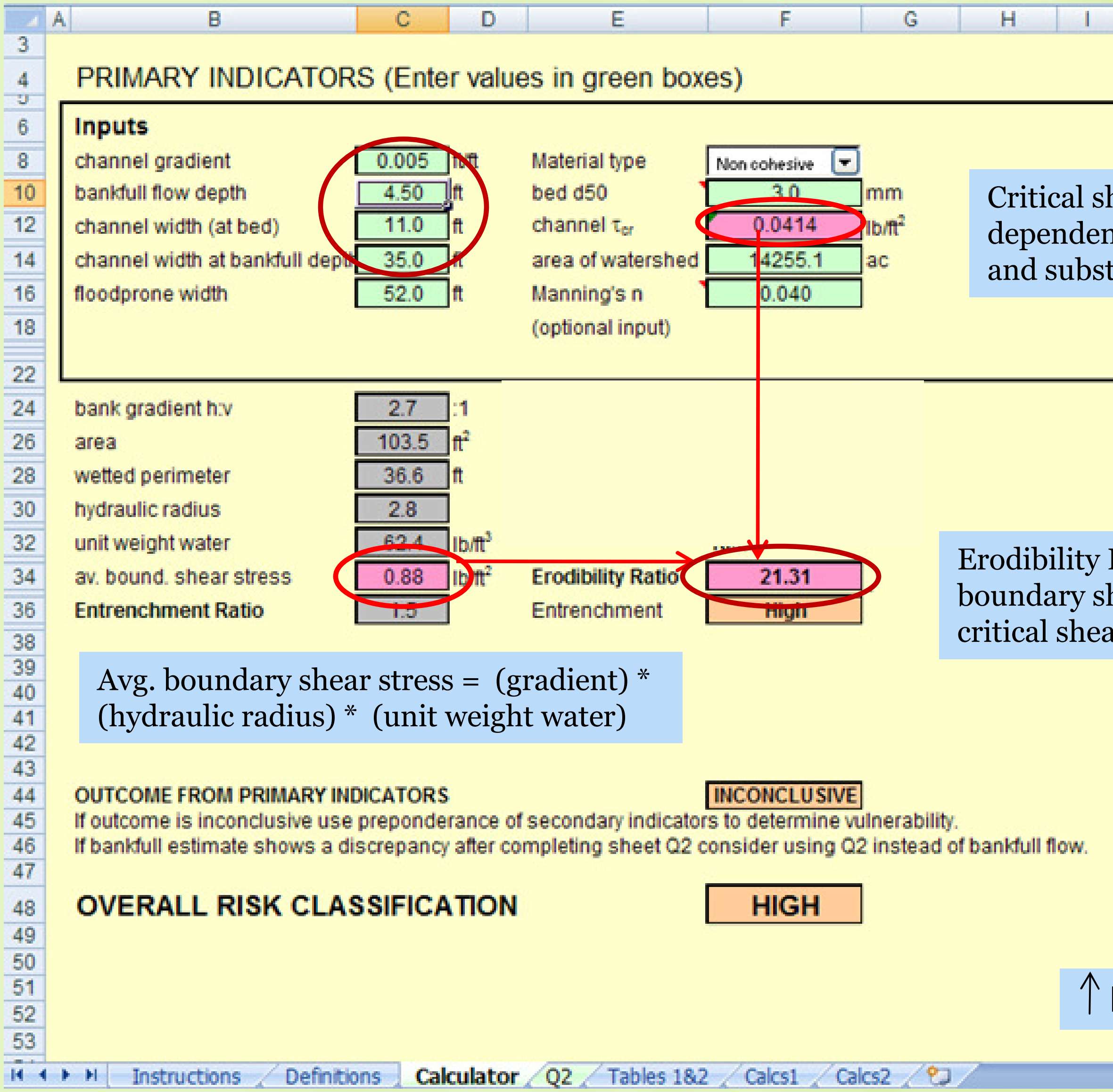
- Gives a quantitative measure of bank stability
- Key metric: erodibility ratio (**ER**) estimates water's erosive force against resistance of bed & bank materials
- Most data needed already collected under the March 09 revised protocol:
  - Particle size/pebble count
  - Gradient
  - Bankfull metrics
    - Bankfull = height water reaches along the bank associated with a 1-2 year storm event

Materials and Methods



- Supplemental Field measurements
  - floodprone width
  - channel width at bed
- GIS data
  - Watershed area calculation

Channel Vulnerability Calculator



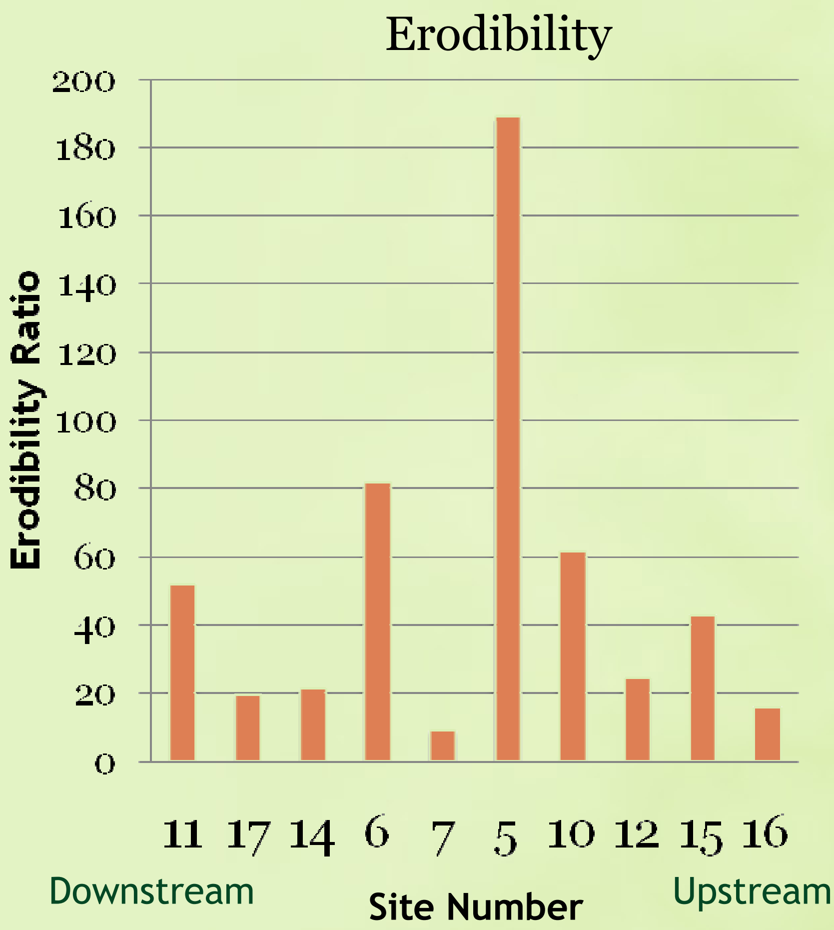
Critical shear stress dependent on d50 and substrate type

Erodibility Ratio= avg. boundary shear stress / critical shear stress

Avg. boundary shear stress = (gradient) * (hydraulic radius) * (unit weight water)

↑ ER = ↑ Erosion Potential

Results



ER = Boundary Shear Stress / Critical Shear Stress (threshold)

- Mean ER = 52
  - Suggests a highly erodible system
- Site 5
  - ER = 185
  - Likely caused by sediment starved pulse flows from local irrigation canal
- Site 7 and 16
  - Two lowest erodibility ratios
  - Two highest d50
  - Site 7 most favored salmon spawning site

Checking the Accuracy of Bankfull Measurements

- Calculation of ER requires accurate measurements of:
  - Bankfull width and depth
  - Gradient
- Method to validate bankfull measurements:
  1. Calculate bankfull discharge based on bankfull measurements
  2. Obtain Q2 data from an independent source ie local flood control agency
  - If greater than 30% difference, potential error in measurements

Inputs					
channel gradient	0.006	ft/ft	Material type	Non cohesive	
bankfull flow depth	5.5	ft	bed d50	2.0	mm
channel width (at bed)	20.0	ft	channel τ_{cr}	0.0104	lb/ft^2
channel width at bankfull depth	40.0	ft	area of watershed	64000.0	ac
floodprone width	50.0	ft	Manning's n (optional input)	0.025	
bank gradient h:v	1.8	:1	bankfull velocity	11.3	ft/sec
area	165.0	ft^2	bankfull discharge	1800.0	cfs
wetted perimeter	42.8	ft	Q2 (see "Q2")	1160.0	cfs
hydraulic radius	3.9		bankfull estimate	Discrepancy	
unit weight water	62.4	lb/ft^3		**Risk**	
av. bound. shear stress	1.44	lb/ft^2	**Erodibility Ratio**	138.42	
entrenchment ratio	1.3		**Entrenchment**	High	

Ongoing work on the Calculator

- Add instructions
- Add Q2 and d50 worksheets
- Develop ranking system for ER

Conclusions

- PHAB data can be used in the Calculator to produce new information on habitat conditions.
- The Calculator suggests Secret Ravine is a highly erodible system
  - Further analysis is ongoing

Key reference

Fischenich, C. Stability Thresholds for Stream Restoration Materials. EMRRP Technical Notes Collection, U.S. Army Engineer Research and Development Center, Vicksburg MS. 2001

Further Information

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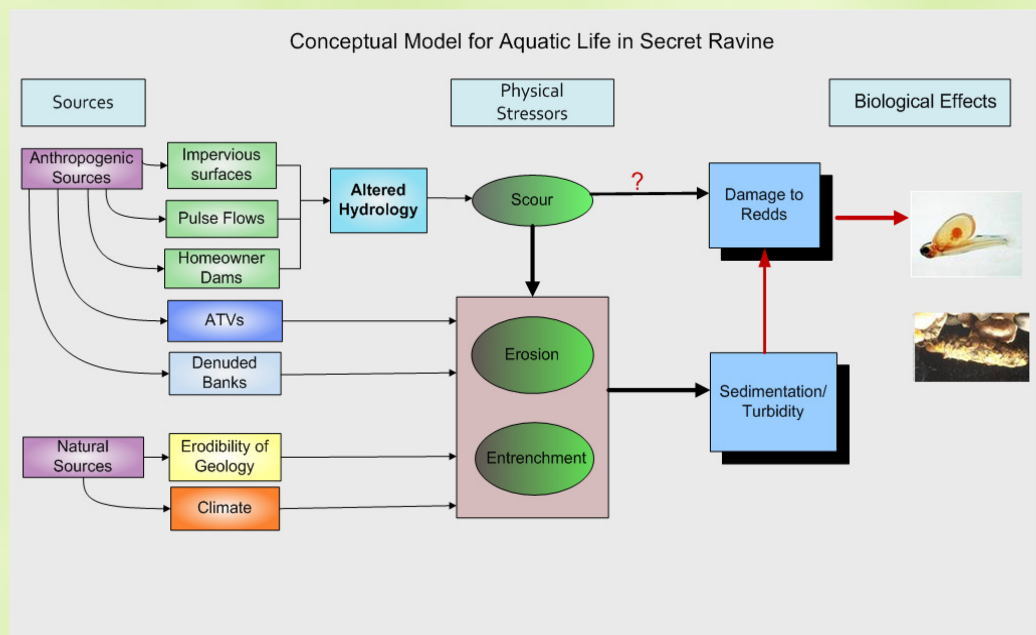
Questions/Comments?

Further steps in SR assessment

- Collect additional field data on bankfull measurements where we found discrepancy in internal validations
- Examine relation between sources of stress and erodibilty ratio
- Impervious Cover
- Geology
- Pulse flows
- Denuded banks



References

- Standard Operating Procedures for Collecting Benthic Macroinvertabrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California. February 2007.
- Swanson, Mitch. "Reconnaissance Hydrology and Geomorphology Study of Secret Ravine, Placer County, California with Emphasis on Habitat Conditions for Fisheries." January, 2000.
- Cowan, Woody L. "Estimating Hydraulic Roughness Coefficients" *Agricultural Engineering*, pp. 473-475, 1956.
- Fischenich, Craig. "Stability Thresholds for Stream Restoration Materials". EMRRP Technical Notes Collection, U.S. Army Engineer Research and Development Center, Vicksburg MS.
- Bates, Gregg. Dry Creek Conservancy.
- Yancey, Katie. *GIS Consultant*

Field Data Collection Sheet

Date: ________________ Start Time:___________ End Time:___________

Site:____ Temperature:_____________

Coordinates: ____ Accuracy:____________

Collectors: ____

Transcect #			
Bankfull width (meters)			
Bankfull depth (feet)			
Width at water level (meters)			
Width at channel bed (meters)			
Floodprone Width			

Manning's N:_______________

Gradient Measurement

Measurement should be taken at riffles if present

If no riffles at site, take 3 measurements 50 ft in length.

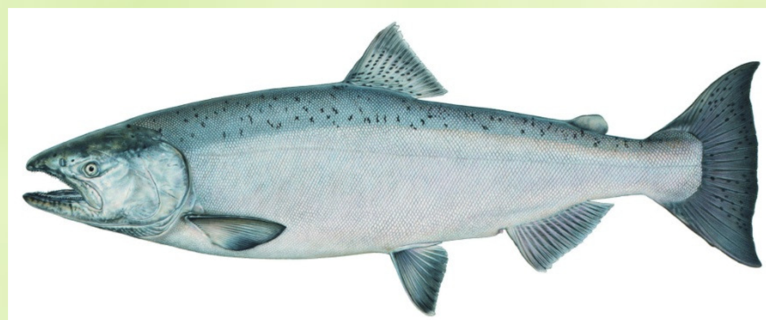
Measurement was taken at a riffle/pool or run/glide (circle one)

Pebble Count

Transect	Left	Left center	Center	Right center	Right	Elevation (feet)	Lat	Long
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								

Background

- Opportunity to use PHAB data to assess channel vulnerability to erosion
  - Would require additional data collection
    - Bankfull width and depth
    - Gradient
    - D50 (median particle size)



CHANNEL/RIPARIAN TRANSECT FORM

Site Code: Antelope AC @ ... V.B. ... Dic 8) | Date: 10/05/2006 | Transect: 1

Substrate Cross-Sectional Information

	Dist LB XX.XX m	Depth XXX cm	Size Class Code	Cobble Embed 0-100% *
Left	0	2	SA	
LCtr	1.5	39	SA	
Ctr	3	30	CB	10
RCrt	4.5	40	CB	10
Right	6	20	CB	20

Substrate Size Class Codes

- RS = Bedrock (Smooth) - Larger Than a Car
- RR = Bedrock (Rough) - Larger Than a Car
- RC = Concrete/ Asphalt
- LB = Larger Boulder (1000 to 4000 mm) - Meterstick to Car
- SB = Small Boulder (250 to 1000 mm) - Basketball to Meterstick
- CB = Cobble (64 to 250 mm) - Tennis Ball to Basketball
- GC = Coarse Gravel (16 to 64 mm) - Marble to Tennis Ball
- GF = Fine Gravel (2 to 16 mm) - Ladybug to Marble
- SA = Sand (0.06 to 2 mm) - Gritty up to Lady Bug
- FN = Silt/ Clay/ Muck - Not Gritty
- HP = Hardpan - Firm Consolidated Fine Substrate
- WD = Wood - Any Size
- OT = Other (Write comment below)

* Cobble Embeddedness on first 25 cobbles only.

Habitat Complexity

0 = Absent (0%); 1 = Sparse (<10%); 2 = Moderate (10-40%); 3 = Heavy (40-75%); 4 = Very Heavy (>75%) (Circle one)

Cover in Channel

Estimate channel features for the stream section 5m above and 5m below transect.

Filamentous Algae	0	[1]	2	3	4
Macrophytes	0	1	[2]	3	4
Woody Debris >0.3 m (Big)	[0]	1	2	3	4
Brush/ Woody Debris <0.3 m (Small)	0	[1]	2	3	4
Live Tree Roots	0	1	[2]	3	4
Overhanging Veg. =<1 m of Surface	0	[1]	2	3	4
Undercut Banks	0	[1]	2	3	4
Boulders	0	[1]	2	3	4
Artificial Structures	[0]	1	2	3	4

Visual Riparian Estimates

0 = Absent (0%); 1 = Sparse (<10%); 2 = Moderate (10-40%); 3 = Heavy (40-75%); 4 = Very Heavy (>75%) (Circle one)

Visual Riparian Estimates made 5m above and 5m below the transect and 10m to the side starting at the bank. Orientation is looking downstream.

Vegetation Cover	Left Bank	Right Bank
Canopy (>5 m High)		
BIG Tree (Trunk >0.3m DBH)	[0] 1 2 3 4	0 [1] 2 3 4
SMALL Trees (Trunk <0.3m DBH)	0 1 [2] 3 4	0 1 [2] 3 4
Understory (0.5 to 5 m High)		
Woody Shrubs and Saplings	0 [1] 2 3 4	0 [1] 2 3 4
Non-Woody Herbs, Grasses and Forbs	0 1 [2] 3 4	[0] 1 2 3 4
Ground Cover (<0.5 m High)		
Woody Shrubs and Saplings	[0] 1 2 3 4	[0] 1 2 3 4
Non-Woody Herbs, Grasses and Forbs	0 1 [2] 3 4	0 [1] 2 3 4
Barren, Bare Dirt or Duff	0 [1] 2 3 4	[0] 1 2 3 4

Human Influence

0 = Not Present; CH = Within Channel; B = On Bank; C = Within 10m of Channel; P = >10m of Channel

	Left Bank					Right Bank			
Wall/ Dyke/ Rip-rap/ Revetment/ Dam	0	B	C	[P]	CH	0	B	[C]	P
Buildings	[0]	B	C	P	CH	0	B	C	[P]
Pavement/ Cleared Lot	0	B	[C]	P	CH	0	B	[C]	P
Road/ Railroad	0	B	C	[P]	CH	0	B	C	[P]
Pipes (Inlet/ Outlet)	0	B	[C]	P	CH	0	B	[C]	P
Landfill/ Trash	[0]	B	C	P	CH	[0]	B	C	P
Park/ Lawn	[0]	B	C	P	CH	[0]	B	C	P
Row Crops	[0]	B	C	P	CH	[0]	B	C	P
Pasture/ Range/ Hayfield	[0]	B	C	P	CH	[0]	B	C	P
Logging Operations	[0]	B	C	P	CH	[0]	B	C	P
Mining Activity	[0]	B	C	P	CH	[0]	B	C	P

Photograph at Transect

Densiometer (0-17 Max)

Left Bank	8
CenUp	14
CenDwn	14
Right Bank	5
CenL*	2
CenR *	17

*Center Left and Center Right Optional — 62

Inter-Transect Substrate Cross-Sectional Information

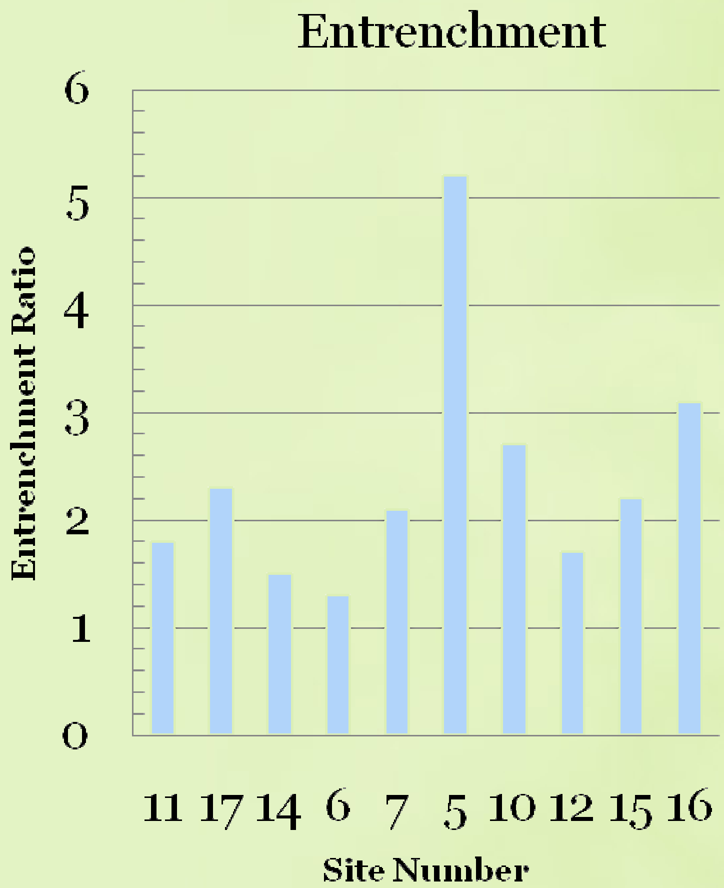
Taken 7.5m above Transect

	Dist LB XX.XX m	Size Class Code	Cobble Embed. 0-100%
Left	0	SA	
LCtr	1.25	GC	
Ctr	2.5	GC	10
RCrt	3.75	GB	
Right	5	CB	90

Comments:

✓

Results



- Average entrenchment ratio 2
- High number is *less* confined
- Gives historical perspective for confinement
- Site 5 highest entrenchment ratio
  - Opposite of expected from erodibility data

Low Entrenchment Ratio

High Entrenchment Ratio

Entrenchment = Flood prone width / Bankfull width