Low flow thresholds and in-channel mitigation for the San Diego County HMP

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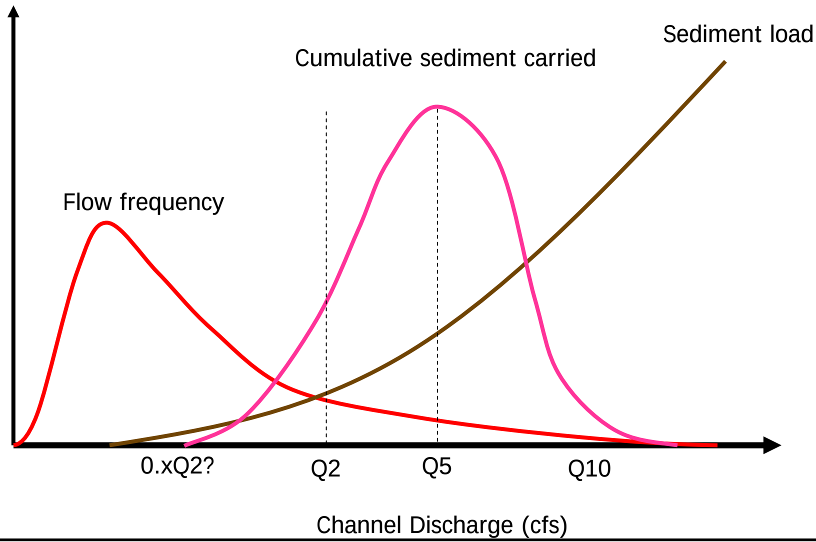
Outline

- Calculating the low flow thresholds
- How it works
- How its used
- Protocol for stream rehabilitation

Low and high flow determination



San Diego permit requires low flow to be based on critical flow for entrainment

- Previous HMPs have not specified entrainment threshold but have used a flow that minimizes risk of erosion (policy based threshold rather than physical threshold).
- 0.1Q2 became fixed in the literature based on Santa Clara HMP (based on modeling of 2 creeks, not based on monitoring actual flows). Propagated from Santa Clara to Contra Costa and beyond.
- Physical threshold is more complicated than a policy-based threshold since the physics vary widely from creek to creek and are hard to measure – need to marry the policy and the physics.

Critical Shear Stress

Sediment Class (mm)	Sediment Size (mm)	Compaction	Critical Shear[a] (lb/ft^2)	Allowable Shear[b] (lb/ft^2)
Coarse Sand	0.5	none	0.006	
lean clayey soils	<0.25	loose		0.02
Very Fine Gravel	2	none	0.026	
sandy clays (<50% sand)	<0.25	loose		0.04
lean clayey soils	<0.25	fairly compact		0.1
sandy clays (<50% sand)	<0.25	fairly compact		0.15
Coarse Gravel	16	none	0.251	
lean clayey soils	<0.25	very compact		0.41
sandy clays (<50% sand)	<0.25	very compact		0.83
Small Cobble	64	none	1.107	

[a] Julien, P.Y. (1998) Erosion and Sedimentation
[b] USDA (2007) Stream Restoration National Handbook

Ideally we would do the following…

- Locate representative receiving channels
- Instrument or conduct event-based modeling
- Measure flow and sediment transport
- Develop rating curves
- Back calculate to critical flow
- Develop a standard or suite of standards

- However – not enough representative sites were available in the initial time frame for completion of the HMP

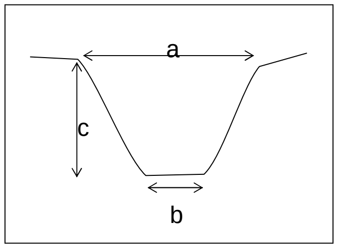
Modeling filled the gaps

- 3 rainfalls (10, 20, 30 inches per year)
- x 4 development watershed areas (0.1, 0.5, 1, 2 square miles)
- x 3 channel width, depth and slope combinations (narrow/deep, medium, wide/shallow) based on SCCWRP, Parker and Thorne and Soar
- = 36 combinations of receiving channel geometry

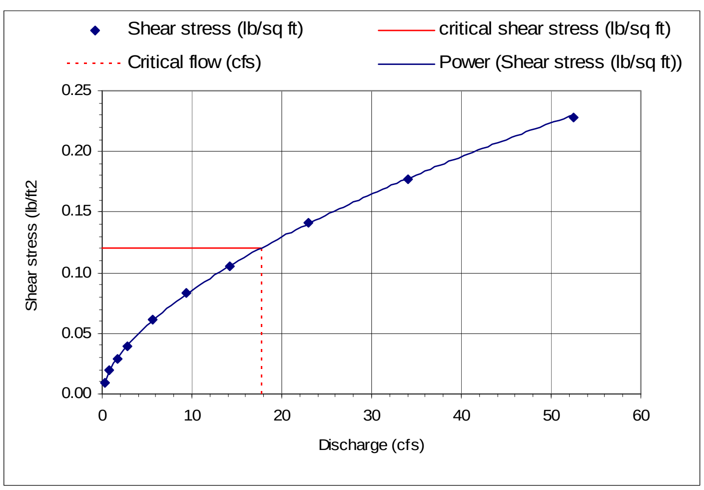
5 Materials

Material	Critical shear stress (lb/sq ft)
coarse unconsolidated sand	0.01
alluvial silt (non coloidal)	0.045
medium gravel	0.12
alluvial silt/clay	0.26
2.5 inch cobble	1.1

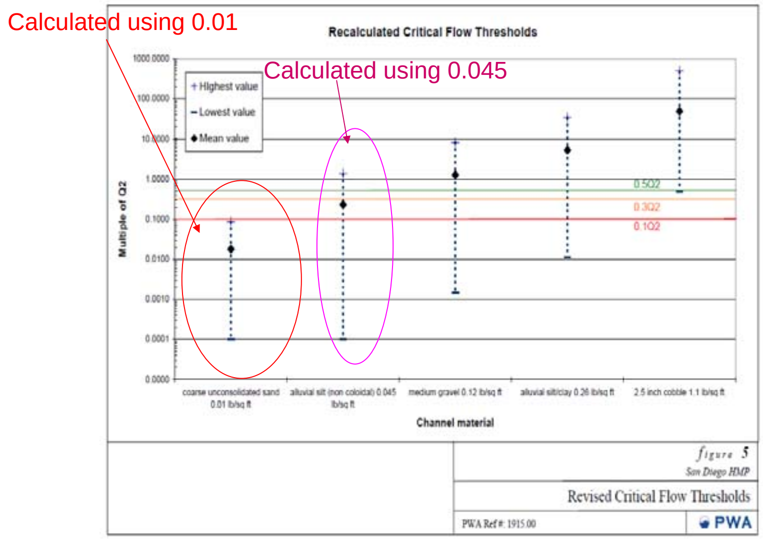
180 combinations of watershed, rainfall, channel morphology and material



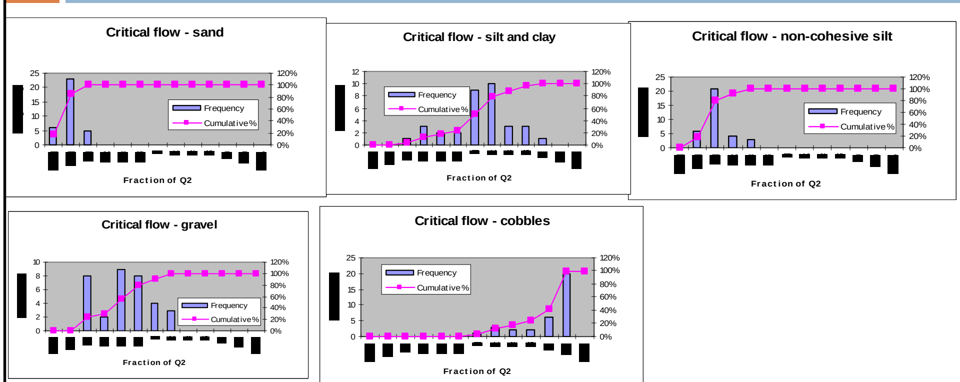
Calculate rating curve and intersection with critical shear stress



Critical flow as a proportion of Q2



Distribution of critical flow thresholds (Qcrit) for different channel materials, channel forms and sizes, watershed sizes, and rainfall.



Conclusions

- There is a wide range of critical flows based on:
  - Channel materials
  - Channel dimensions (steepness and confinement)
- Therefore – need multiple values based on channel sensitivity, and tools to calculate specific flows

Conclusions

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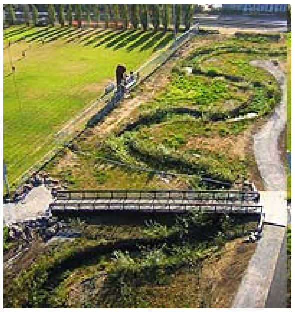
- Caveats
  - There is a real need to verify these numbers with field data (erosion thresholds) – strongly recommended for the monitoring plan
  - Adaptive management – need a feedback loop to alter low flow threshold if the field conditions come back different

Demonstrate the low flow tool

What are instream approaches?

- Physical modifications that change the receiving water so that it is in equilibrium with the changed hydrologic and sediment regime
- Wide spectrum of insteam approaches, depending on:
  - Magnitude of change in water and sediment
  - Sensitivity of channel to those changes
  - Setting, corridor (width and surroundings)



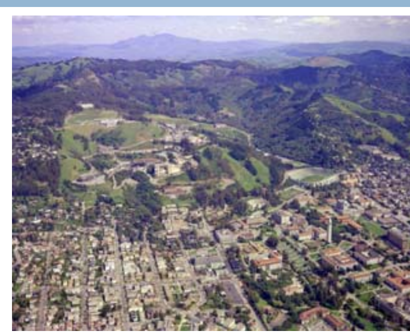
What it is not…

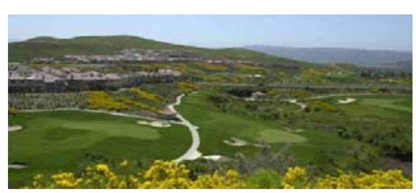
- Channel hardening

- emphasis is on lowering excess stress, not increasing resistance

Why do we need instream approaches?

- Instream approaches make sense where:
- Channels are already impacted and unstable
- Infiltration and flow control are not feasible to extent required to protect receiving water
  - Steep slopes
  - Impermeable soils
- Receiving channel is very short before reaching an exempt water body
- Receiving channel is highly sensitive (fine sand)
- Development will result in high level of sediment depletion?





Why do we need instream approaches?

- In many sites a combination of volume reduction, flow control and instream mitigation may be the lowest impact approach – using any single technique is likely to be heavy handed

Goal of in-channel hydromod mitigation

- The goal of in-channel hydromod mitigation is to modify a receiving channel such that it supports the beneficial uses and physical and ecological functions of the channel to the same extent or greater than it did prior to the proposed development. More specifically it should:
  - Be in geomorphic dynamic equilibrium (it is desirable that is should have small amounts of local scour and deposition to support biological processes, but it should not experience significant net erosion or deposition of sediment over the entire reach over a sustained period of several years).
  - Provide the appropriate physical processes and forms to sustainably support the flora and fauna that existed prior to development.

Need to define more specific goals on a project-by-project basis

- E.g. in a degraded channel goal may be to restore function and stability in face of higher runoff, not maintain existing unstable condition

Understand pre-project conditions and project impacts

- All proposed projects must display a clear understanding of the existing physical and ecological condition of the receiving water prior to project implementation. In particular, applicants must identify the ecological functions and values of the existing channel corridor, the physical processes that control or influence them, and the impact of the proposed project on those factors.

Hypothetical example of functions and impacts

Creek function or attribute	Current controlling / influencing factors	Project impacts on controlling factors	Potential mitigation approach
Vertical channel stability (bed erosion or deposition)	e.g. balance between coarse sediment and water supply, nature of bed materials.	e.g. runoff likely to increase, coarse sediment supply likely to decrease.	Reduce bed gradient using step-pool structures.
Lateral channel stability (e.g. widening, lateral migration)	e.g. vertical stability, riparian vegetation.	e.g. runoff likely to increase, coarse sediment supply likely to decrease.	Widen channel to appropriate geometry and stabilize with biotechnical approaches.
Mulefat assemblage	e.g. requires braided channel with low terraces subject to periodic scour and deposition.	e.g. excess sediment transport capacity over supply will erase terraces and prevent deposition.	Widen channel to lower sediment transport capacity, allow braiding and support terrace formation. Lower gradient to achieve same.
Willow assemblage	e.g. proximity of floodplain to water table.	e.g. incision will lower water table and prevent regeneration.	Prevent incision by grade control, gradient flattening or channel widening.
Ephemeral vegetation assemblage	e.g. absence of summer nuisance flows.	e.g. presence of summer nuisance flows will allow perennial vegetation to colonize.	Elimination of nuisance flows.
Fish spawning	e.g. presence of gravel, relative absence of fine sediment, relatively low shear stresses during winter/spring flows.	e.g. fine sediment will bury spawning gravel.	Promote sediment sorting and reduce bank erosion or other fine sediment sources.
Fish rearing	e.g. channel complexity, riparian shade cover, relative rarity of high velocity flows.	e.g. excess shear stress will erode and simplify channel features, wash out fish.	Widen and flatten channel to reduce shear stresses.

Design Criteria

In-stream mitigation projects must meet the following design criteria:

- The proposed channel and riparian corridor must provide
  - same acreage of habitat as the pre-project channel
  - support geomorphic processes that can reasonably be considered to sustain those acreages.
- The cumulative sediment transport capacity of the proposed channel under the post project flow regime must not exceed that of the pre-project channel under the pre-project flow regime.

Demonstrating compliance

- **Proposed plans for in-stream HMP mitigation must demonstrate that these criteria will be met by proving a biological report and maps showing the acreage of habitat in pre-and post project conditions, and by providing hydraulic and sediment transport analyses that show the following:**
- For projects larger than 50 acres the analysis should be based on continuous rainfall-runoff modeling, and continuous sediment transport capacity modeling. The analysis should demonstrate that the cumulative sediment transport capacity in the proposed channel based on the channel dimensions and watershed runoff under post-project conditions is the same or less than the cumulative sediment transport capacity for the existing channel based on the channel dimensions and watershed runoff under pre-project conditions. The period of analysis should be the approved rainfall record for the closest appropriate rain gage as found on the www.projectcleanwater.org web site.
- For projects smaller than 50 acres the analysis may be based on sediment transport capacity for a series of designated runoff events. The analysis should demonstrate that the sediment transport capacity in the proposed channel based on the channel dimensions and watershed runoff under post-project conditions is the same or less than the sediment transport capacity for the existing channel based on the channel dimensions and watershed runoff under pre-project conditions for the following events: 0.1Q2, Q2 and Q10.

Example for 50 acre development

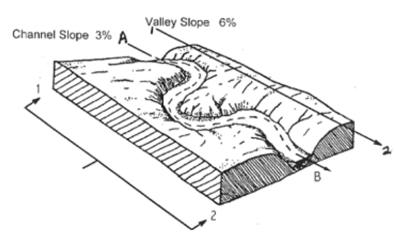
- Run existing and proposed watershed conditions in continuous simulation (e.g. SDHM, SWMM, HEC-HMS) for period of record at nearest gage
- Build existing and proposed conditions hydraulic/sediment transport model for channel in HEC-RAS (channel length define below)
- Run continuous simulation ~40 yrs
- Design proposed channel to have equivalent cumulative sediment transport capacity
- If channel is more erosive, iterate design

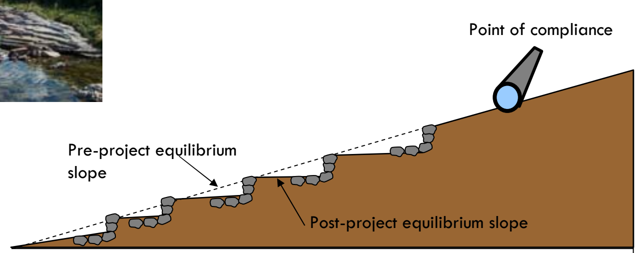
Example for 10 acre development

- Calculate pre- and post-project flows using County Hydrology Manual for 0.1Q2, Q2 and Q10
- Calculate sediment transport capacity for existing and proposed channel at each flow
- Iteratively design channel to have lower or equivalent transport capacity at each event

Methods of reducing cumulative sediment transport capacity

- Slope reduction
- Width:depth ratio increase





Upstream and downstream limits

- It is likely that in-channel mitigation projects will have to be negotiated with permitting agencies on a case by case basis due to different site conditions. However, for guideline purposes we recommend the following approach to identifying the limits of in-channel mitigation projects.
- The upstream limit of an in-channel mitigation project will typically be the point of compliance (PoC - point at which stormwater is discharged into the receiving water). However, as a precaution against potential unplanned erosion following a project it is recommended that either the project extend upstream to the next grade control, or that grade control be added immediately upstream of the point of compliance.
- The downstream limit of an in-channel project is proposed to be:
  - The point at which the receiving water drains into an exempt channel as defined by the HMP.

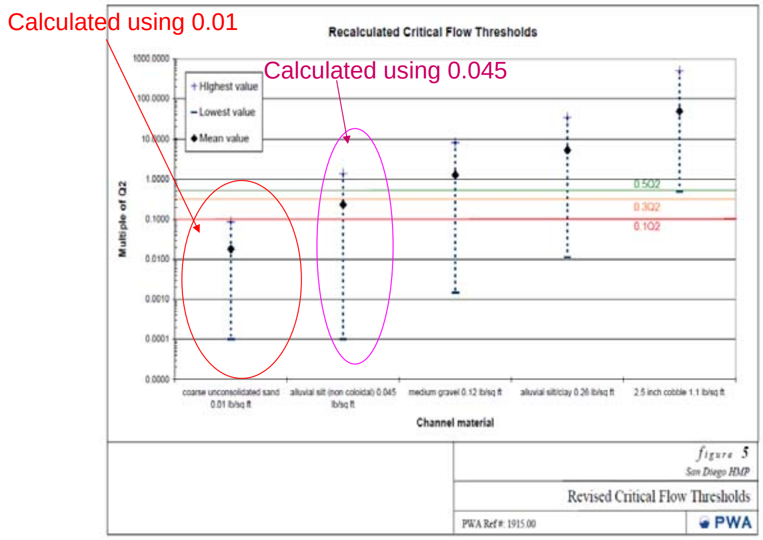
  In future may be modified to include:
  - The location downstream from the PoC at which the receiving water, under pre-project conditions, has either gained additional flow from tributaries or has discharged into a larger channel such that the increase in Q2 as a result of the proposed project is less than 10% of the total Q2 of the channel at that location. For example, if a proposed development increases the receiving water Q2 at the PoC from 100 cfs to 200 cfs, the in-stream mitigation would be required from the PoC to the location downstream where the channel had picked up flow from tributaries such that its pre-development Q2 was at least 1,000 cfs.

Relationship between HMP and existing permit requirements

- The HMP does not replace existing permit requirements for in-channel projects. In addition to meeting the HMP requirements, applicants proposing an in-channel mitigation project will likely require the following permits:
- A CEQA/NEPA review and document
- California Department of Fish and Game – 1602 Streambed Alteration Agreement
- US Fish and Wildlife Service – Authorization Under the Endangered Species Act
- US Army Corps of Engineers – Nationwide 404 Permit
- Regional Water Quality Control Board – 401 Water Quality Certification
- County of San Diego – Grading Permit
- County of San Diego Flood Control

Questions?

Critical flow as a proportion of Q2



Understanding existing conditions

- Where are we in landscape? Erosive, transportational, depositional

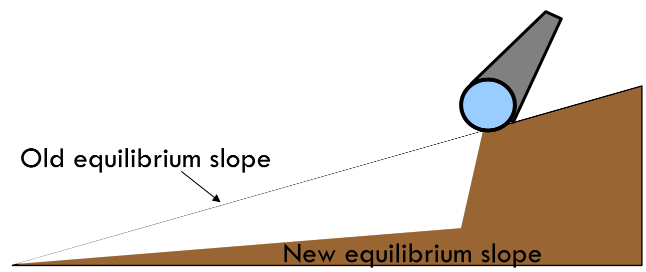
Channel sensitivity

- For an identical change in erosion potential, two receiving channels may have different sensitivities, resulting in different responses

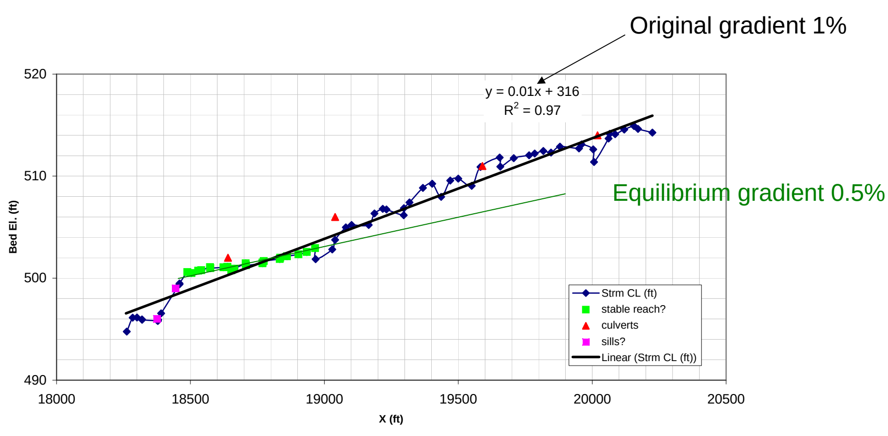
Instream approaches to Hydromod

Slope reduction

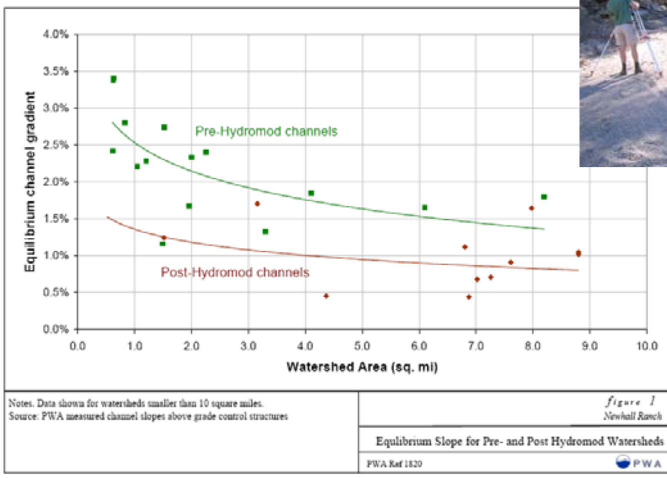
How do we calculate the new equilibrium slope?

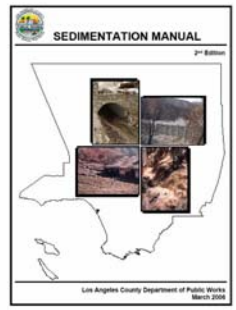


Calculating equilibrium slope in the field



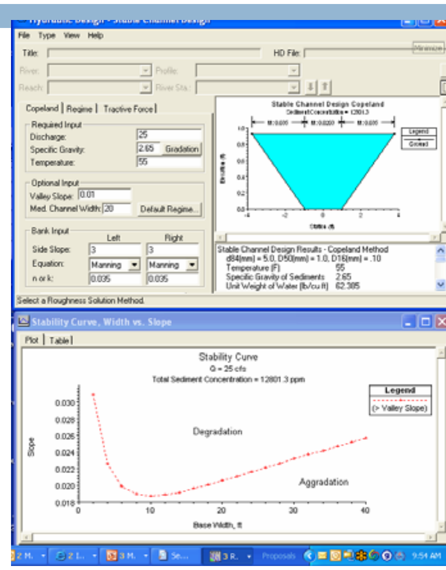
Calculating equilibrium slope





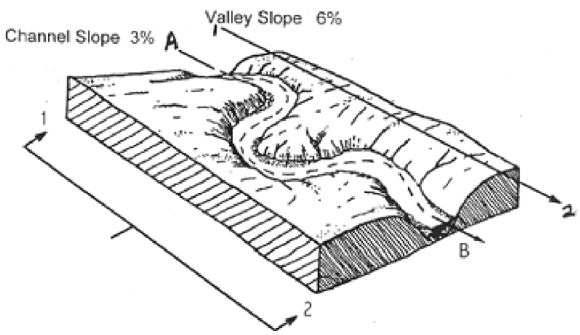
Calculating equilibrium slope

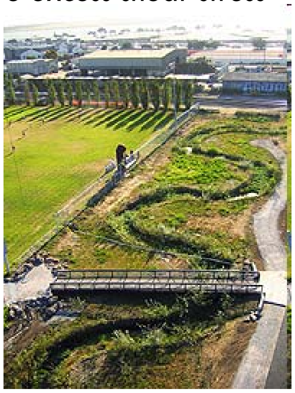
- HEC-RAS Sam package



Slope reduction

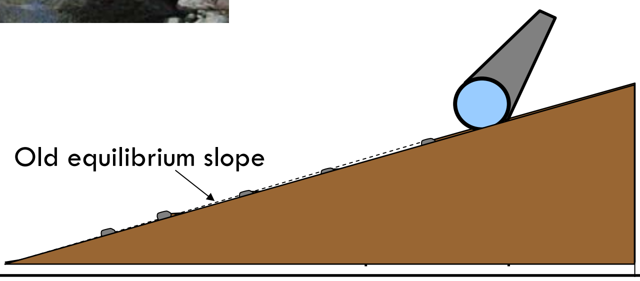
Sinuosity can reduce slope, and therefore excess shear stress



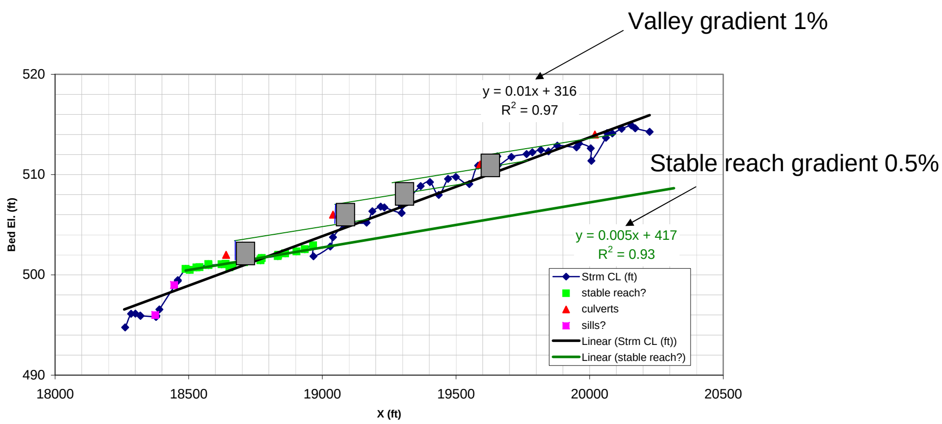


However, high sinuosities are only stable on fairly flat floodplains.
Risk of channel avulsion on higher gradient floodplains.
High sinuosities are generally a function of high sediment loads.

Slope reduction using steps or drops



Designing steps and drops



8 ft of excess elevation
must be lost on steps

Design criteria for steps or drops

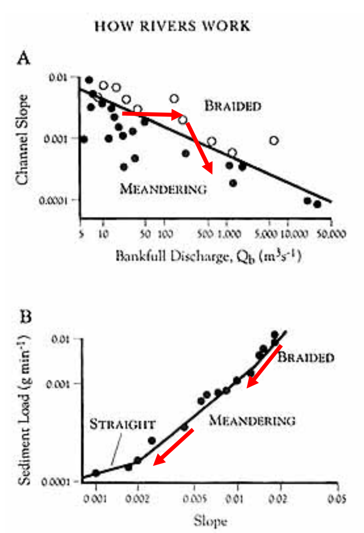
- Fish passage criteria
  <3 ft steps for adult salmonids, <6" steps for juveniles
- Geomorphic criteria
  - step pool spacing typically every 0.4 to 2.4 channel widths (Chin, 2002), rocks typically mobilized every 25-50 yrs
- Construction and O&M cost criteria
  - small v. large placed rock, loose rock, grout, soil cement? How much movement can you tollerate?
- These criteria are often in conflict
  e.g. large rocks = big steps K juvenile fish passage

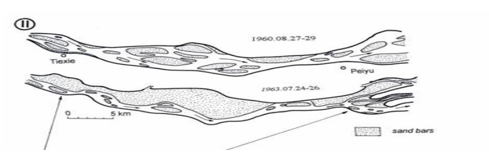
Examples of drop and step structures

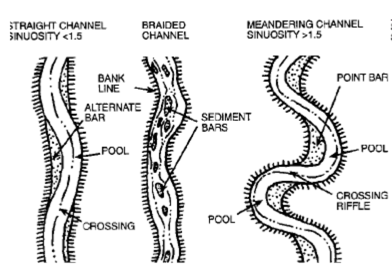




Caution: Changes in sediment regime may lead to changes in form







Evaluate local regimes to predict what form will result