# Beyond Bankfull

*Moving river channel assessment and design to a rational design basis*

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RIVER RESTORATION NORTHWEST

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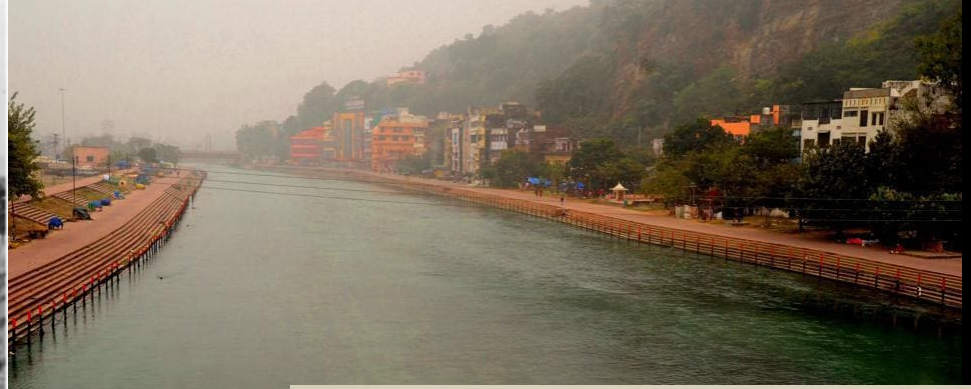
DEPARTMENT OF WATERSHED SCIENCES



1911-1912.

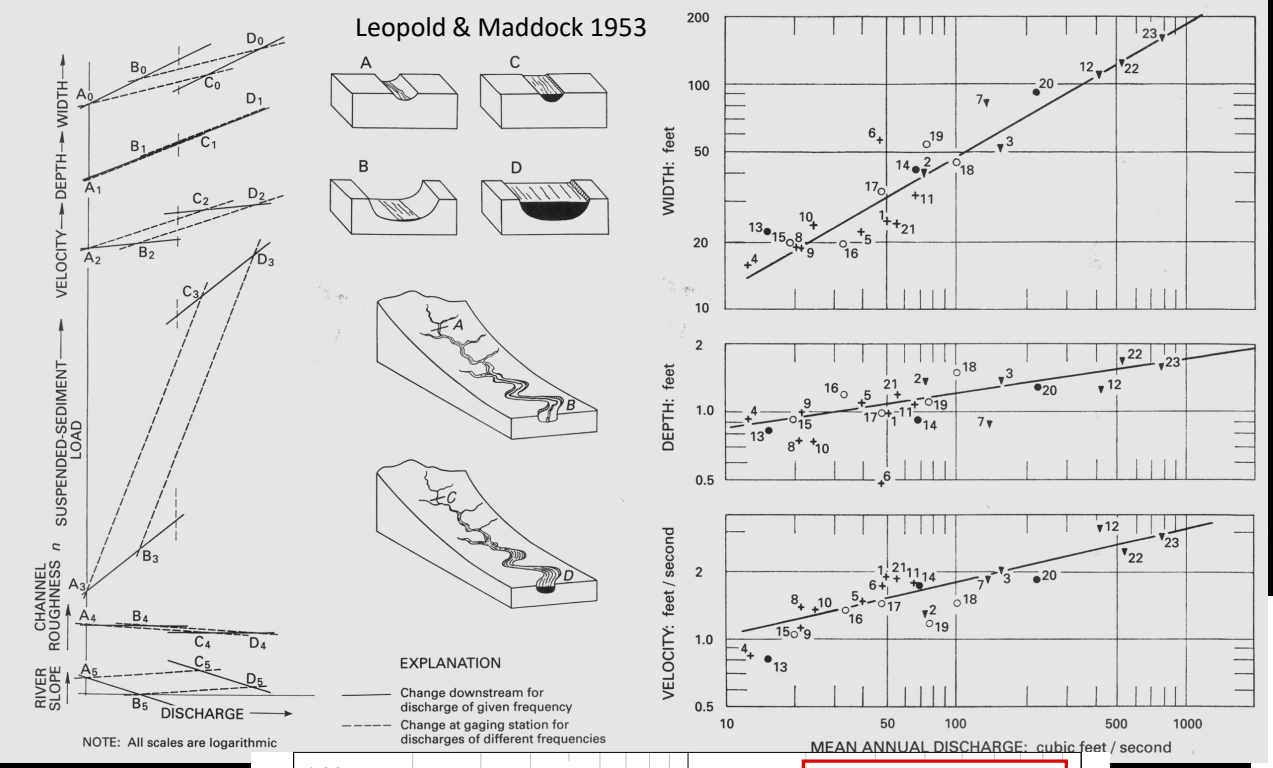
IRRIGATION DEPARTMENT, PUNJAB.

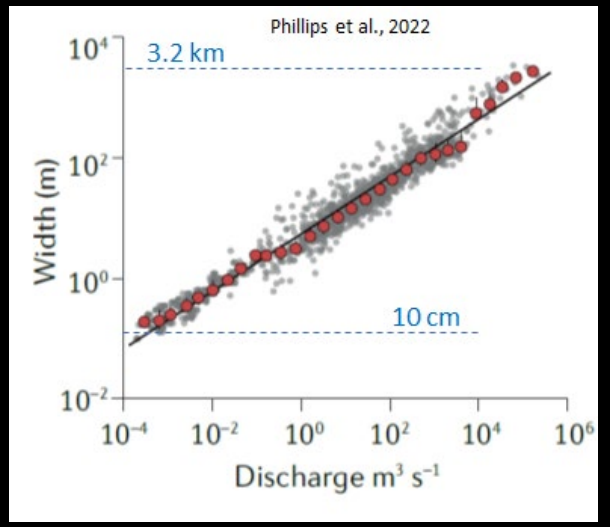
GENERAL MAP.

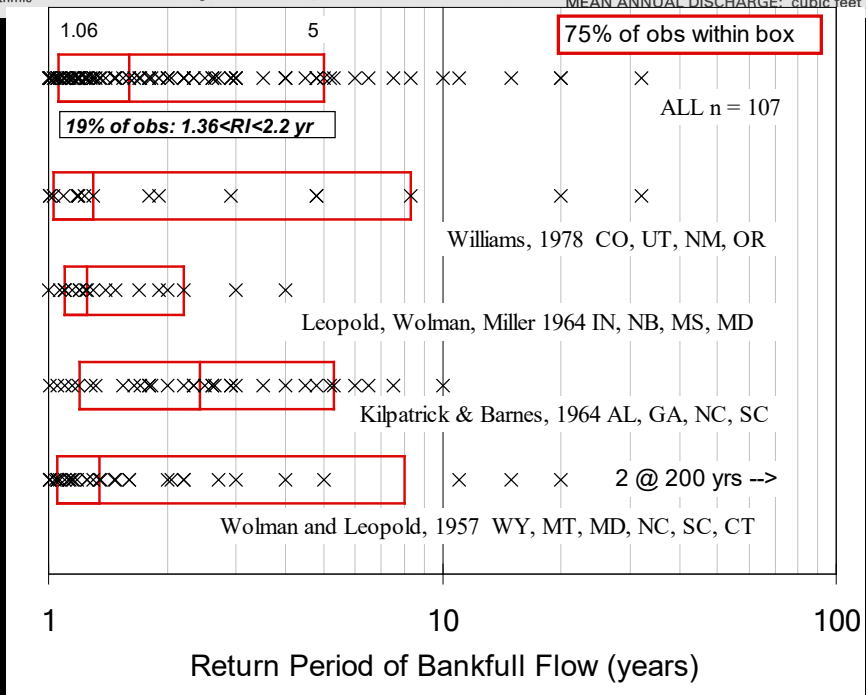
SCALE—16 MILES TO 1 INCH

REFERENCES

Canals navigable
" not navigable
" under construction
" projected
Railway and Stations
" under construction or surveyed
Principal Towns
River Gauges
Irrigation Boundaries
British Boundary
Patiala "
Nabha "
Kaila "
Jind "
Faridkot "
Kalsia "



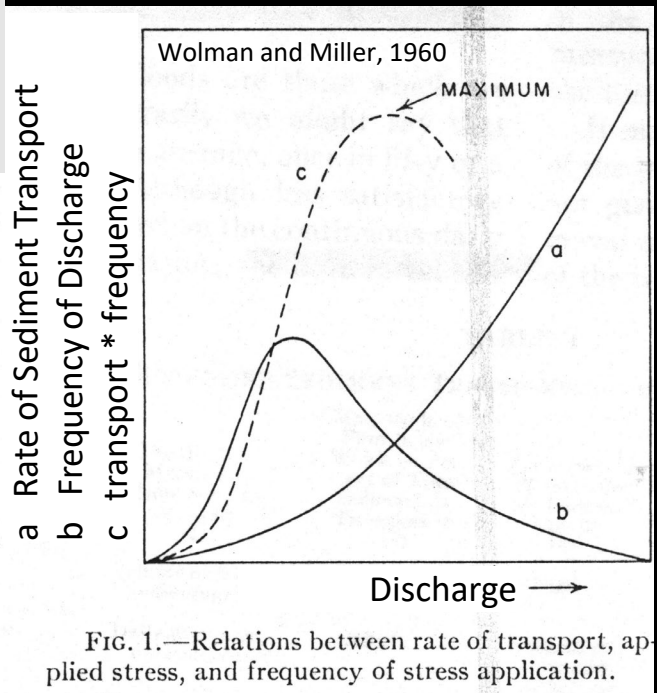
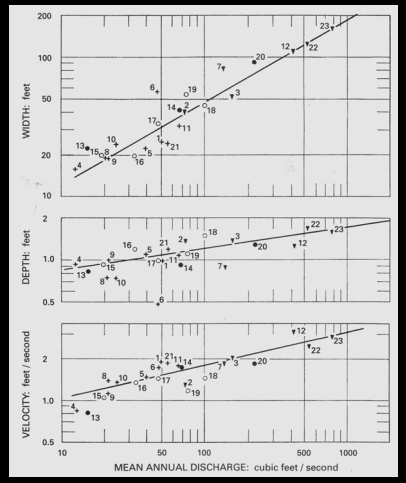



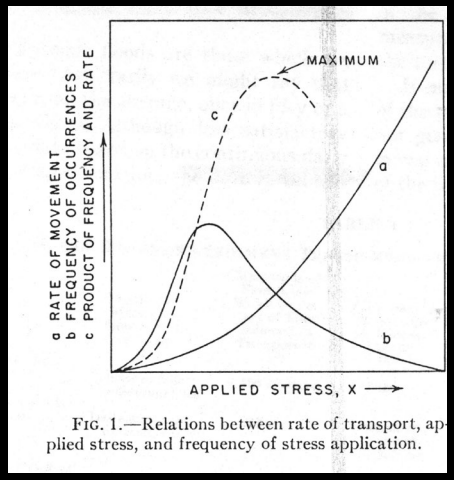

FIG. 1.—Relations between rate of transport, applied stress, and frequency of stress application.

a Rate of Sediment Transport (tons / day)
b Frequency of Discharge (days / yr)
c transport * frequency (tons / yr)

*The width of channels increases consistently with the square root of discharge.*

*The flow that moves the most sediment, over time, tends to just fill the channel and occurs ever year or two.*

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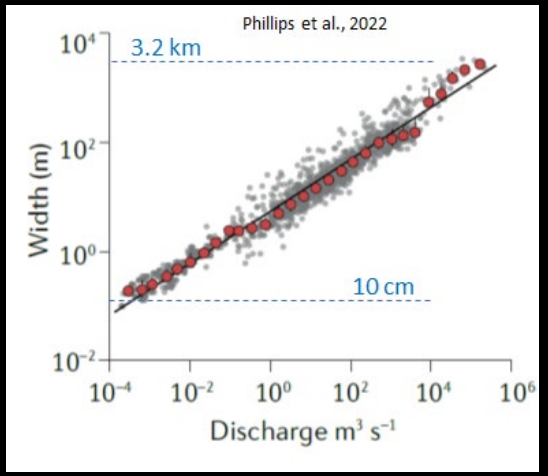
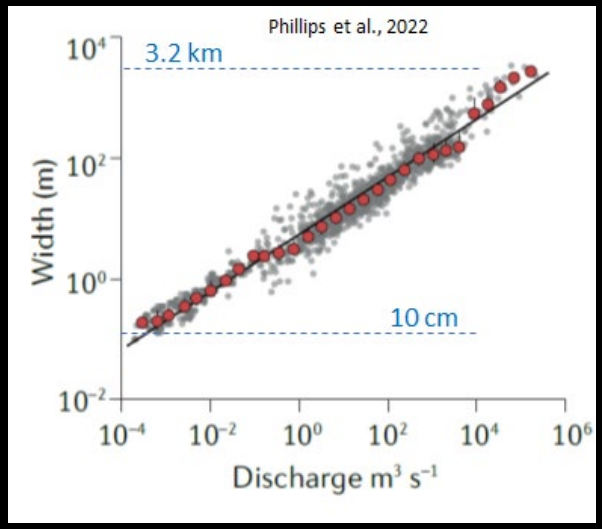



The stable channel
The regime channel
The hydraulic geometry

A basis for channel design?

Channel design begins with a design discharge plus channel dimensions scaled to discharge.

*Bankfull, Effective, Dominant, Design, 1.5-yr flood*




This is the Reference Paradigm:

for the 'correct' discharge,

find reference channel dimensions

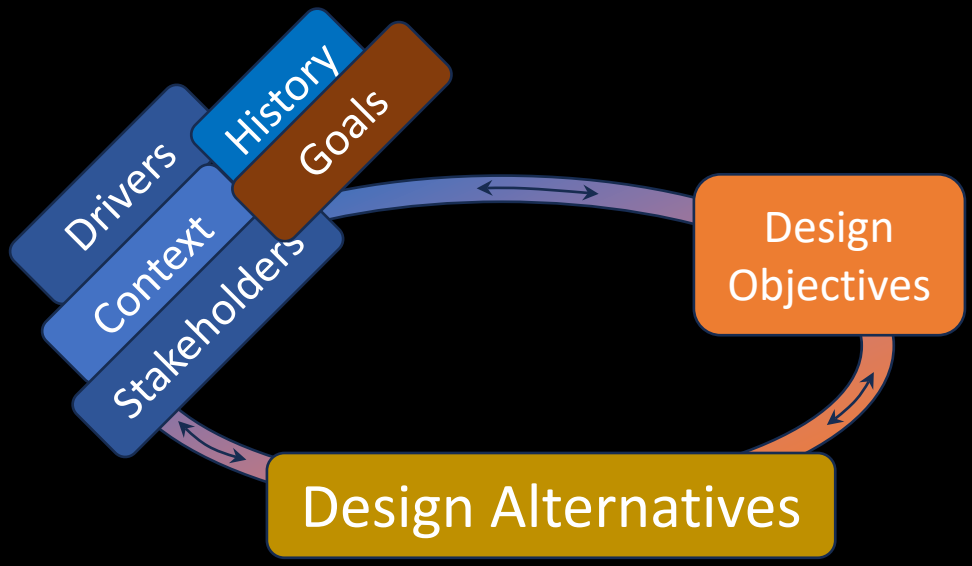
In the Anthropocene, is *any* reference reliable?

How would you know?

How do we connect with specific, local, non-sediment objectives?

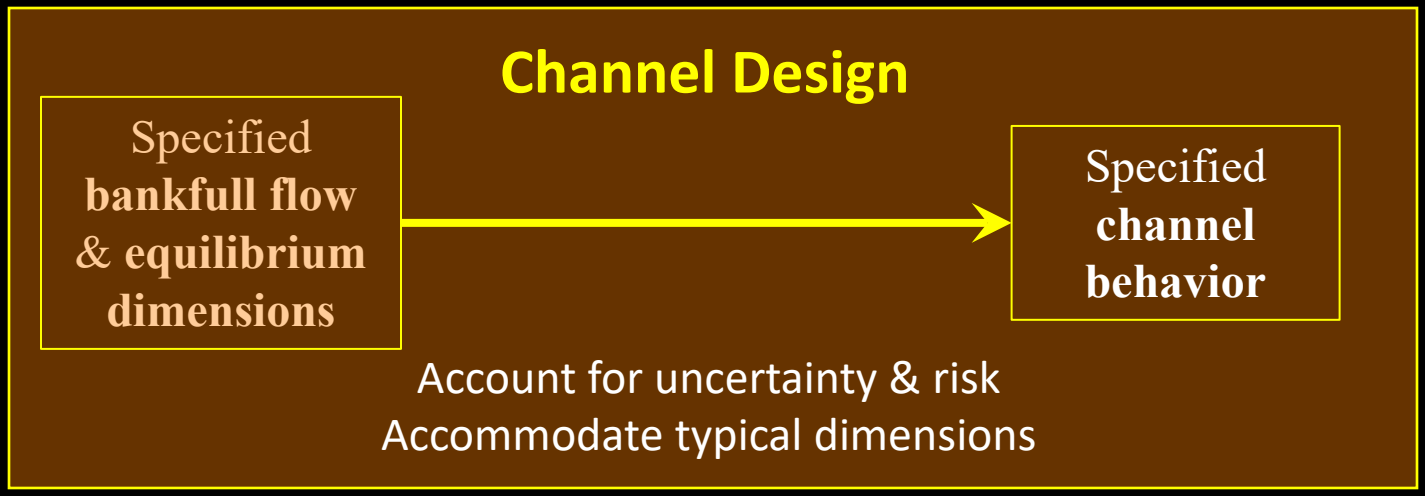
***(if we build it like this … good things will happen)***

**Instead, the Design Paradigm**



What is the supply of water and sediment?
and
What do you want to do with them?

(1) Do you want the bed and banks to be static at a design flow?
(*a 'threshold' channel*)
(2) Do you want to balance transport capacity to sediment supply?
(*an 'alluvial' channel; store or evacuate sediment*)
(3) Both of the above

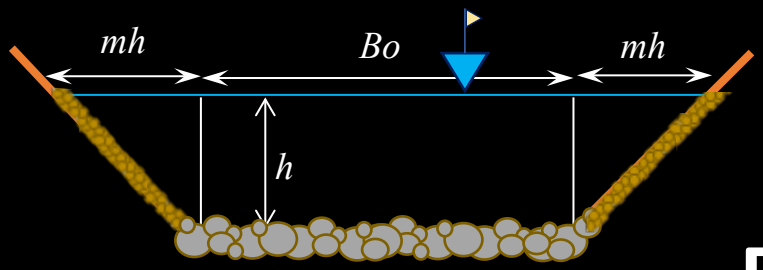


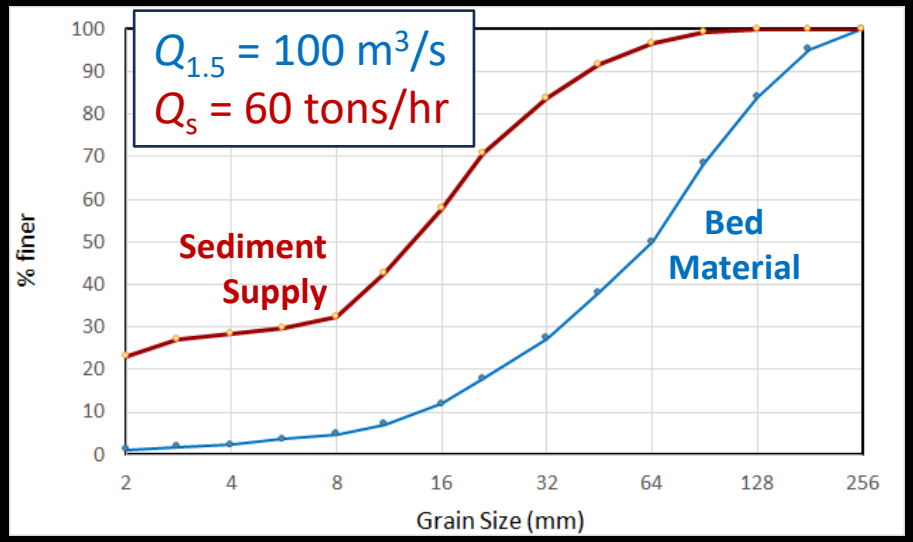
# A simple view of channel behavior design options

Consider a channel,

with bed and bank materials & dimensions,

Specify **water discharge**, **sediment supply**




## DESIGN

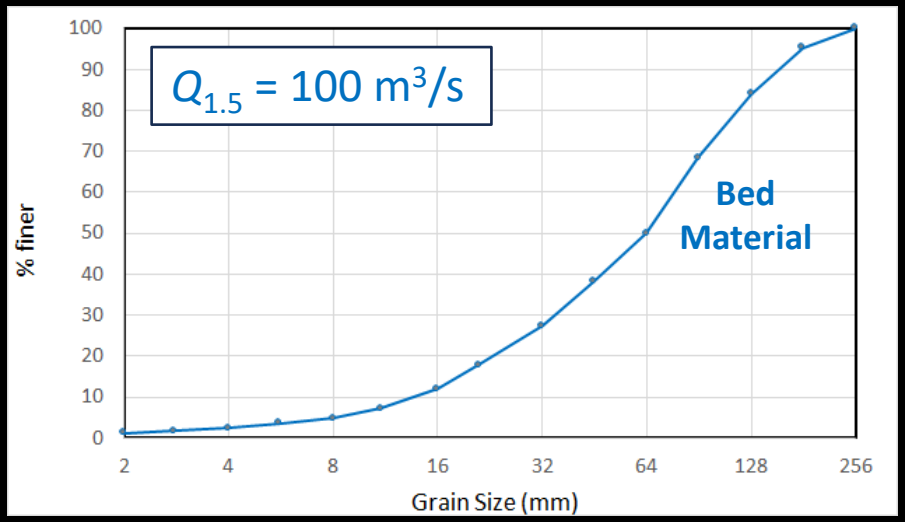
1. **Threshold channel**

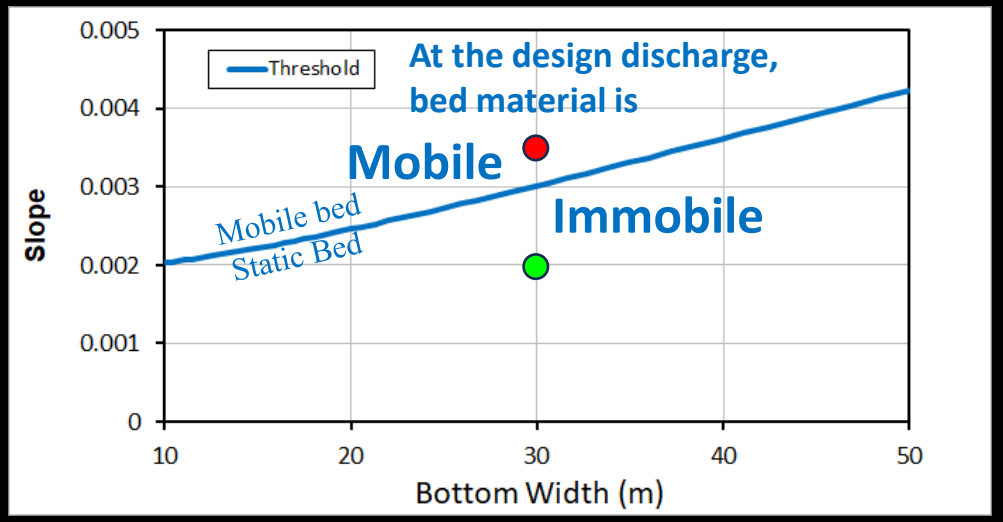
at what slope & width does bed material move?

2. **Mobile channel**

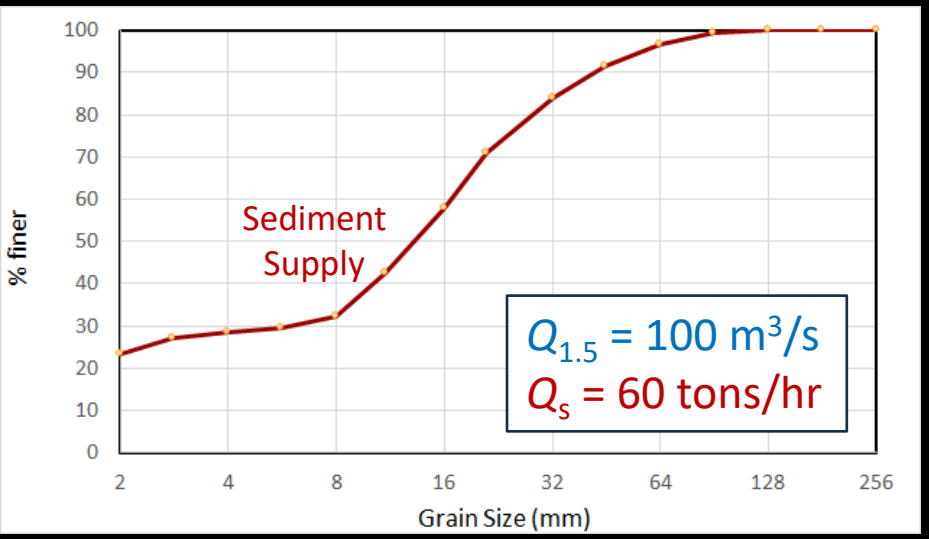
at what slope & width does transport capacity match sediment supply?

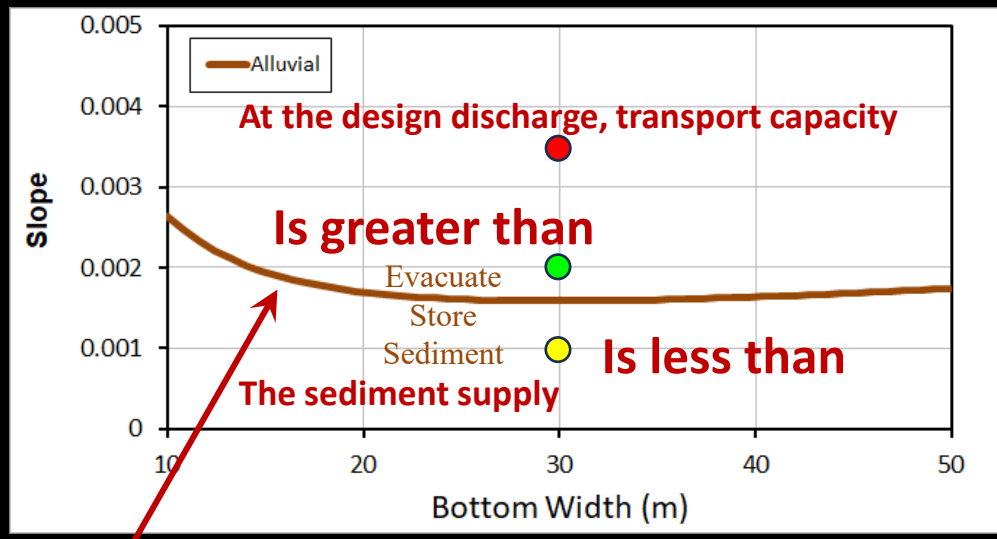
# Threshold Design for $Q_{1.5}$



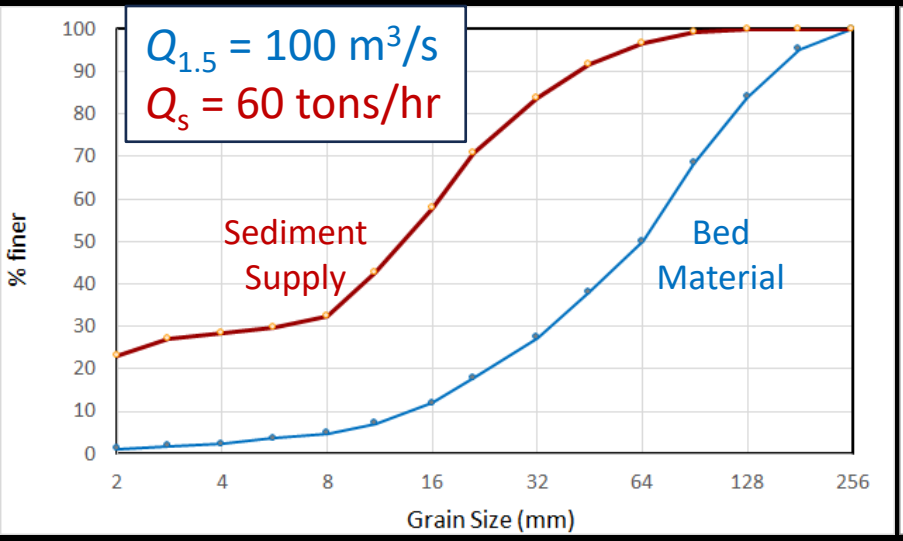
# Mobile-bed Design

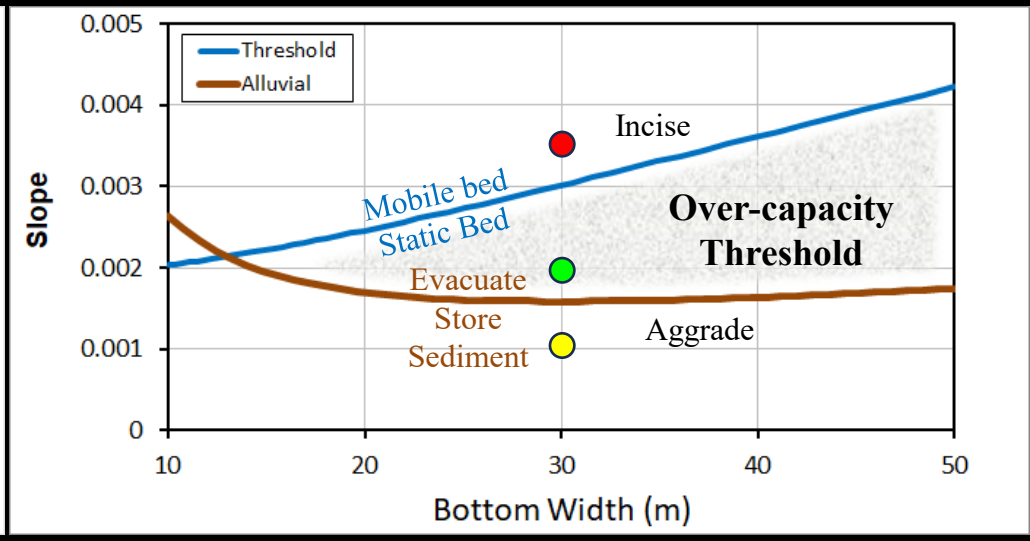



At this slope (and width), the channel is able to transport the supplied sediment at the specified flow

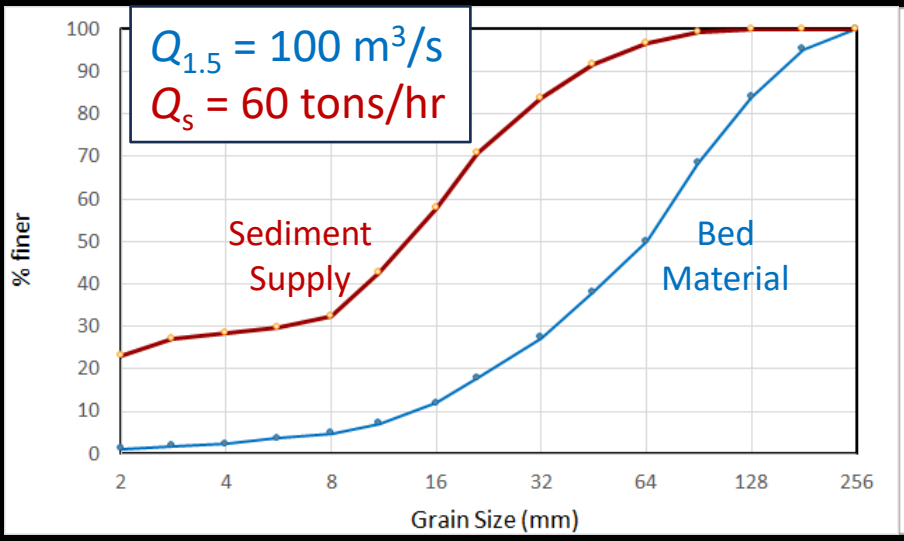
# Put both designs on one chart

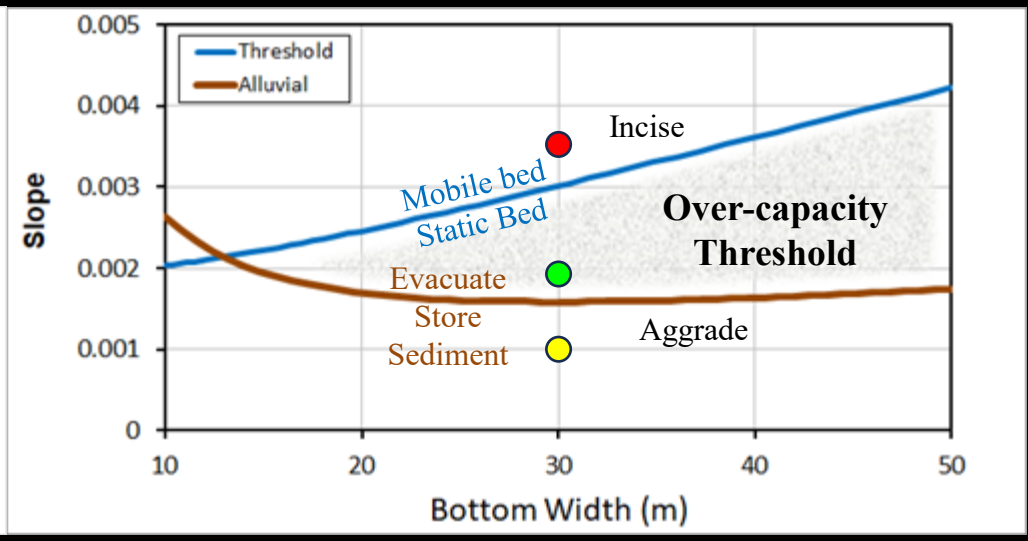


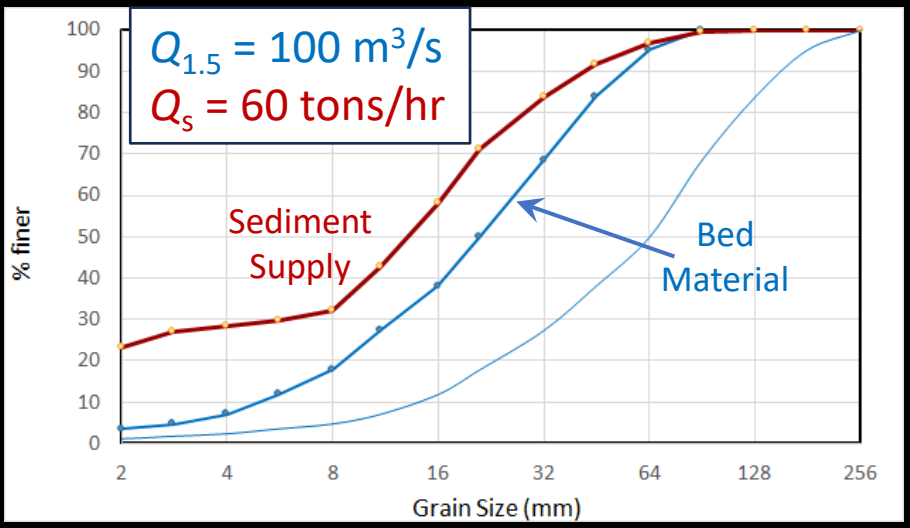




Over-Capacity Threshold Channel – some call it semi-alluvial

Much more common than we account for!


$Q_{1.5}$ = 100 m³/s
$Q_s$ = 60 tons/hr
Sediment Supply
Bed Material
% finer
Grain Size (mm)


Threshold
Alluvial
Incise
Mobile bed
Static Bed
Over-capacity Threshold
Evacuate
Store
Sediment
Aggrade
Slope
Bottom Width (m)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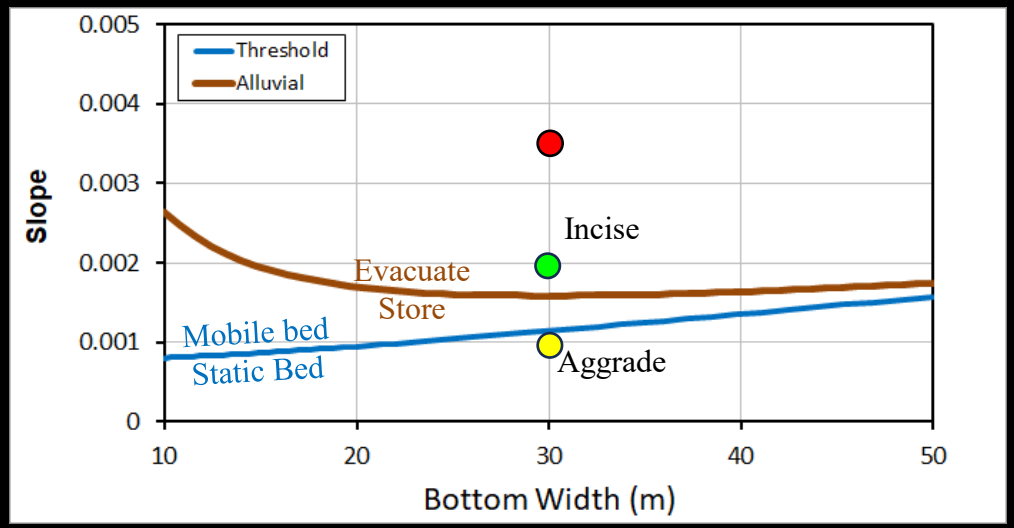
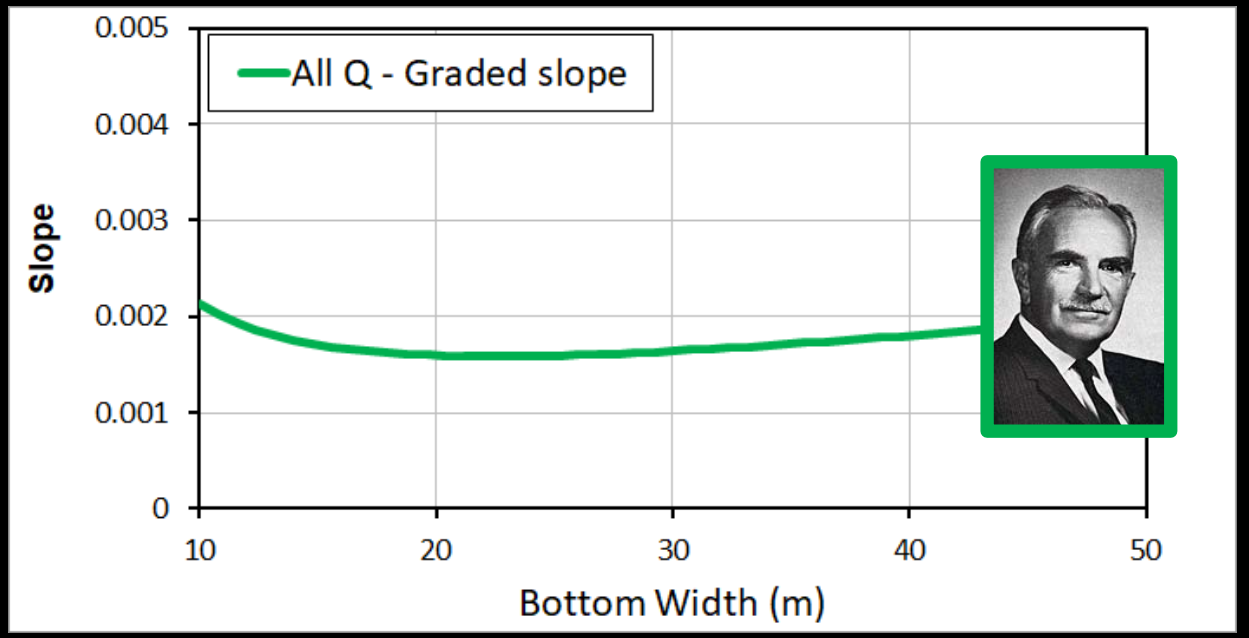

Threshold
Alluvial
Incise
Evacuate
Store
Mobile bed
Static Bed
Aggrade
Slope
Bottom Width (m)

But what happens at flows other than 100 $m^3/s$?
Why $Q_{1.5}$? Or any particular discharge?
Are we saying that ***if we design to $Q_{1.5}$, then 'good things will happen' over all flows***?

It turns out that we can identify the unique slope that will transport the sediment supplied over the full range of flows and their duration.




This is the graded slope of J. Hoover Mackin.
We can go beyond bankfull. We do not need to specify the "correct" discharge in order to achieve a functioning channel design.

You can’t estimate sediment supply OR transport capacity with any accuracy.

And

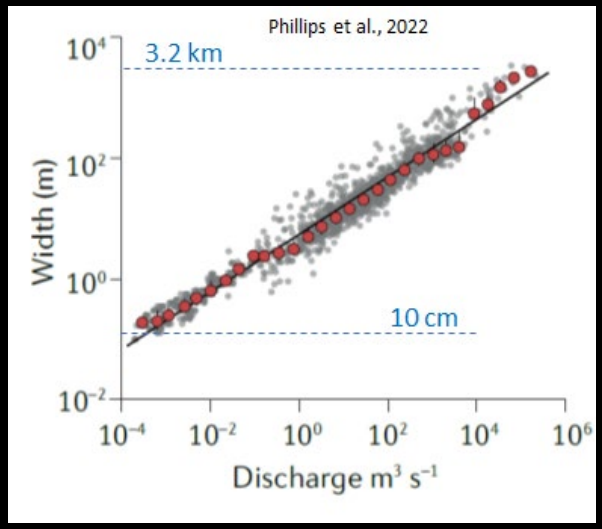
Nobody can predict the sediment supply next year

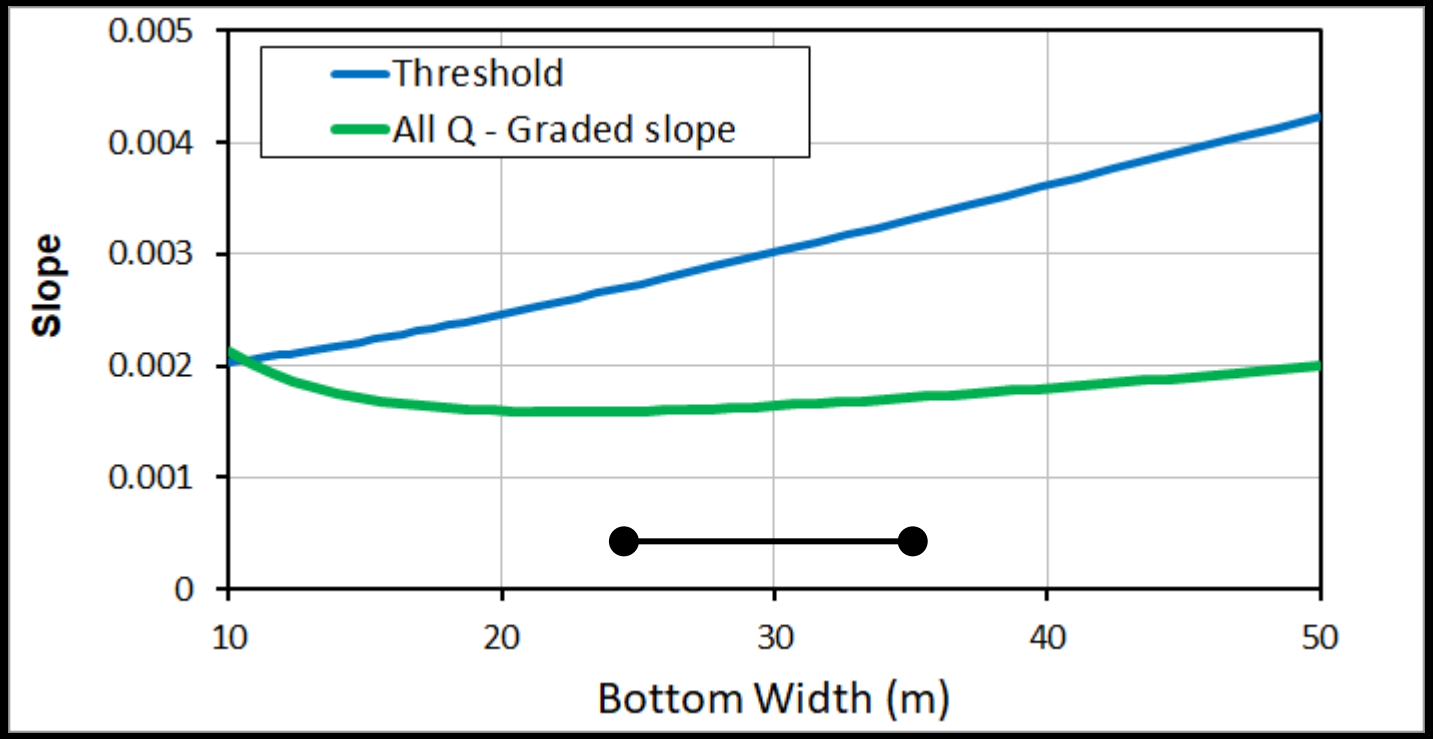
These are tools – not answers. Part of a broader tool kit. Part of a broader analysis of watershed and stream system.

Design choices can address risk and accommodate uncertainty.

What about common channel dimensions?

Use them to inform choice of channel width

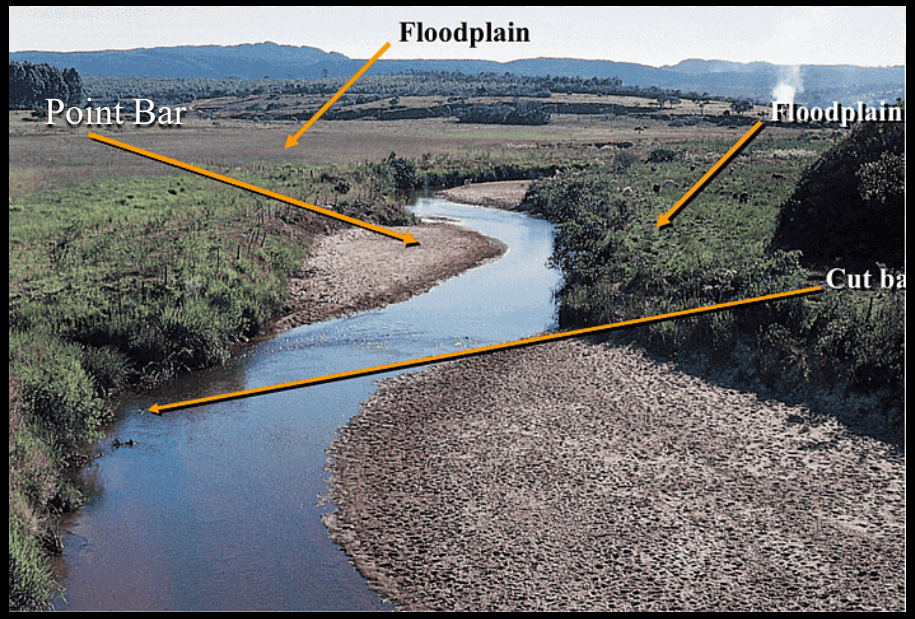


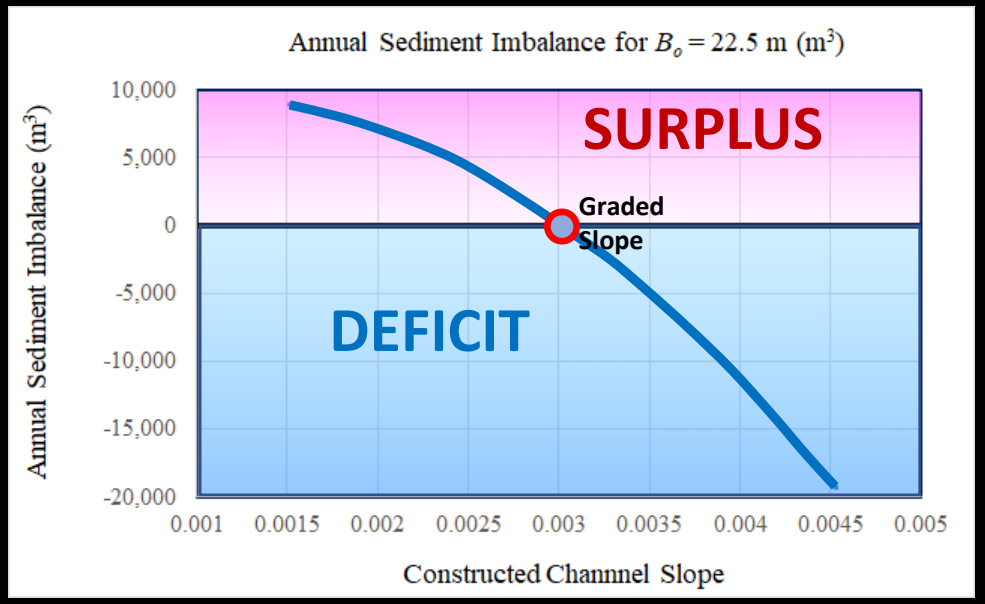



# Design can accommodate ‘failure’

**What happens if we build the channel at the “wrong” slope?**

If bed mobilizes more frequently, how much might it incise? Will it armor?
What is the risk? What are the consequences?
If sediment is stored in the reach, is that a good thing or a bad thing?




How big is a bar?

What is the supply of water and sediment?
and
What do you want to do with them?

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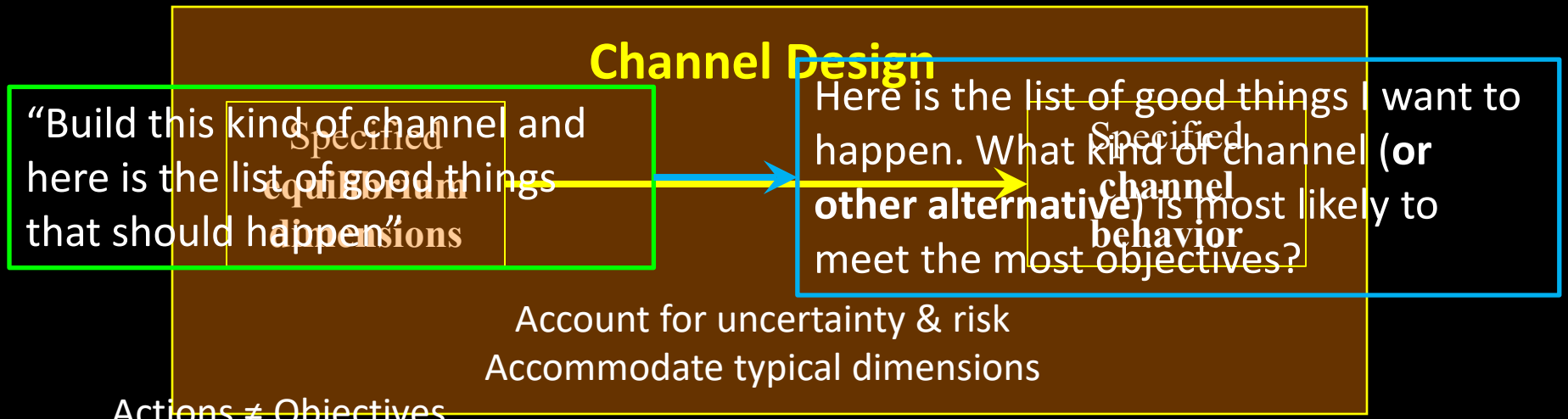


Actions ≠ Objectives
If we specify objectives in terms of actions, we have no basis for developing and evaluating alternatives.

Embrace design
What do people want?
Find feasible space between what is wanted and what is possible.
(hug an engineer)