

# Steady Flow Hydraulics: Introduction, Examples, and Work Flow



Stanford Gibson, PhD

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# Steady Flow Hydraulics: Introduction and Examples

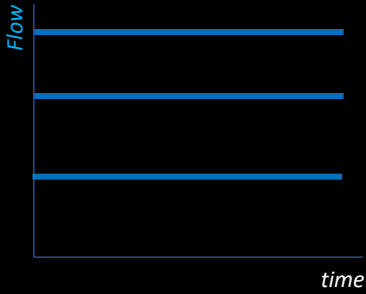
- I. What is Steady Flow?
- II. When Would I Use Steady Flow?
- III. What are the Components of a Steady Flow Model?

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# 1. What is Unsteady Flow?

## Steady Flow

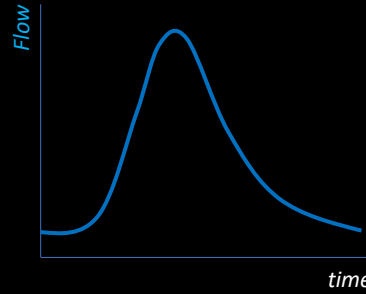
$$Q(\bar{t})$$



*changes gradually*  
Flow **does not change** with time

## Unsteady Flow

$$Q(t)$$

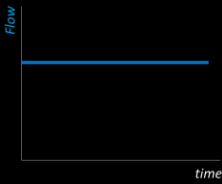


Flow changes with time

# 1. What is Unsteady Flow?

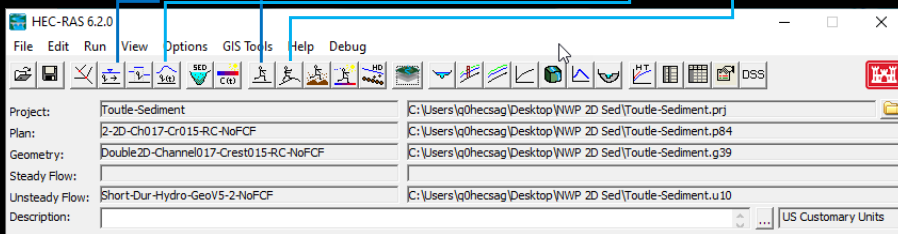
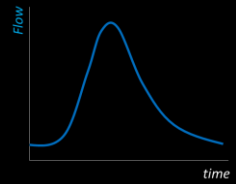
## Steady Flow

$$Q(\bar{t})$$



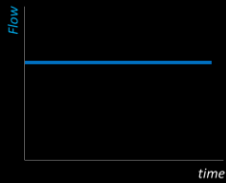
## Unsteady Flow

$$Q(t)$$

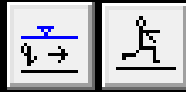


# 1. What is Unsteady Flow?

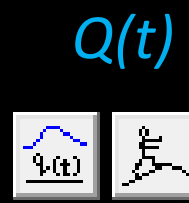
## Steady Flow



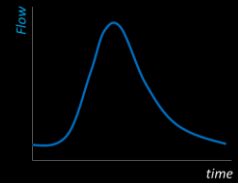
$$Q(\ddot{t})$$



## Unsteady Flow



$$Q(t)$$



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## Steady Flow Hydraulics:

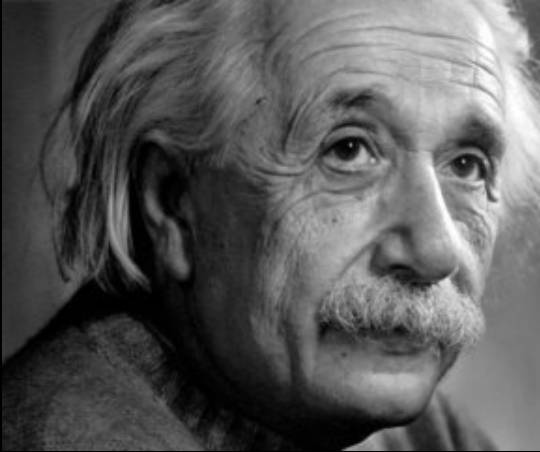
### Introduction and Examples

- I. What is Steady Flow?
- II. When Would I Use Steady Flow?
- III. What are the Components of a Steady Flow Model?

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## II. ~~When~~ Would I Use Steady Flow?

*Why*



“It can scarcely be denied that the supreme goal of all theory is to make

the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience.”

-Actually Einstein (Sr)  
1933 Lecture

The Principle of Parsimony = the simplest model is the null hypothesis

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## II. When ~~Would~~ I Use Steady Flow?

*Wouldn't*

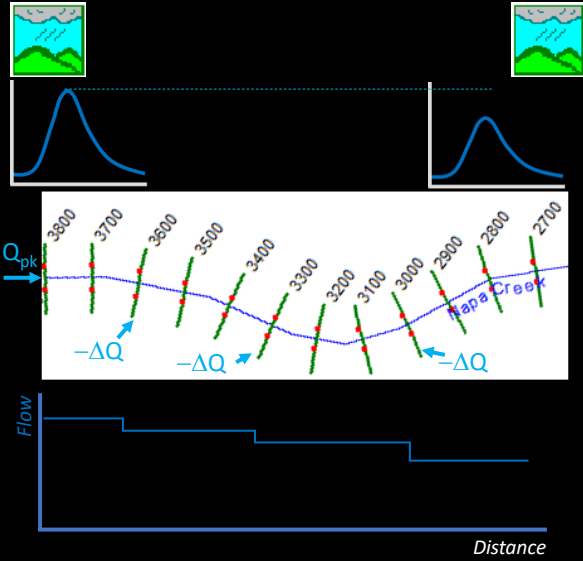
As yourself two questions:

- Does Volume Matter
- Does Timing Matter

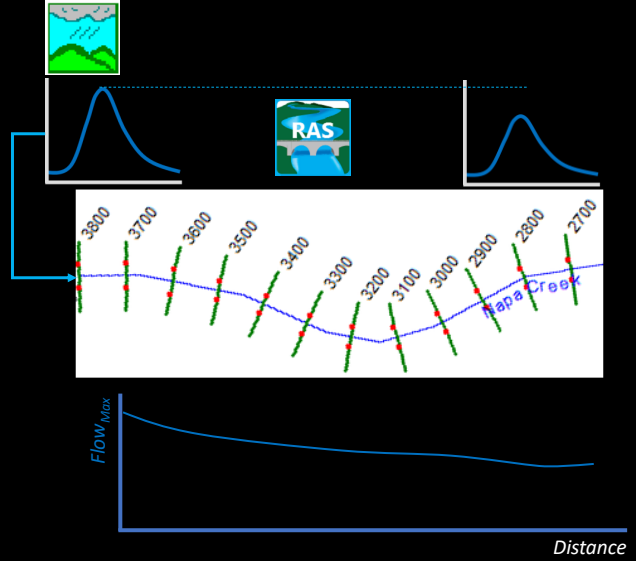
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## Example 1: Flood Attenuation

Hydrologic Routing  
Steady Flow

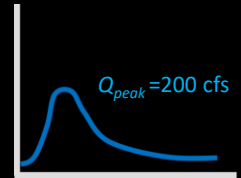
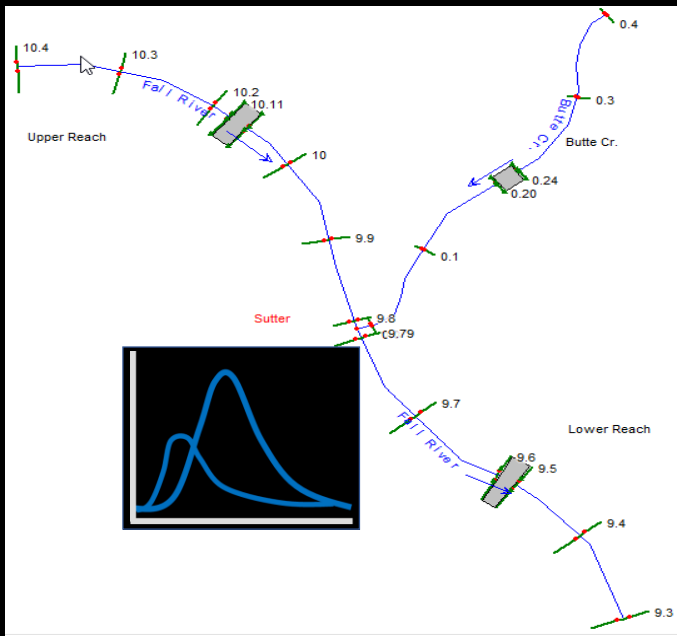
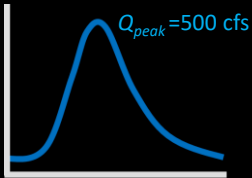


Hydraulic Routing  
Unsteady Flow



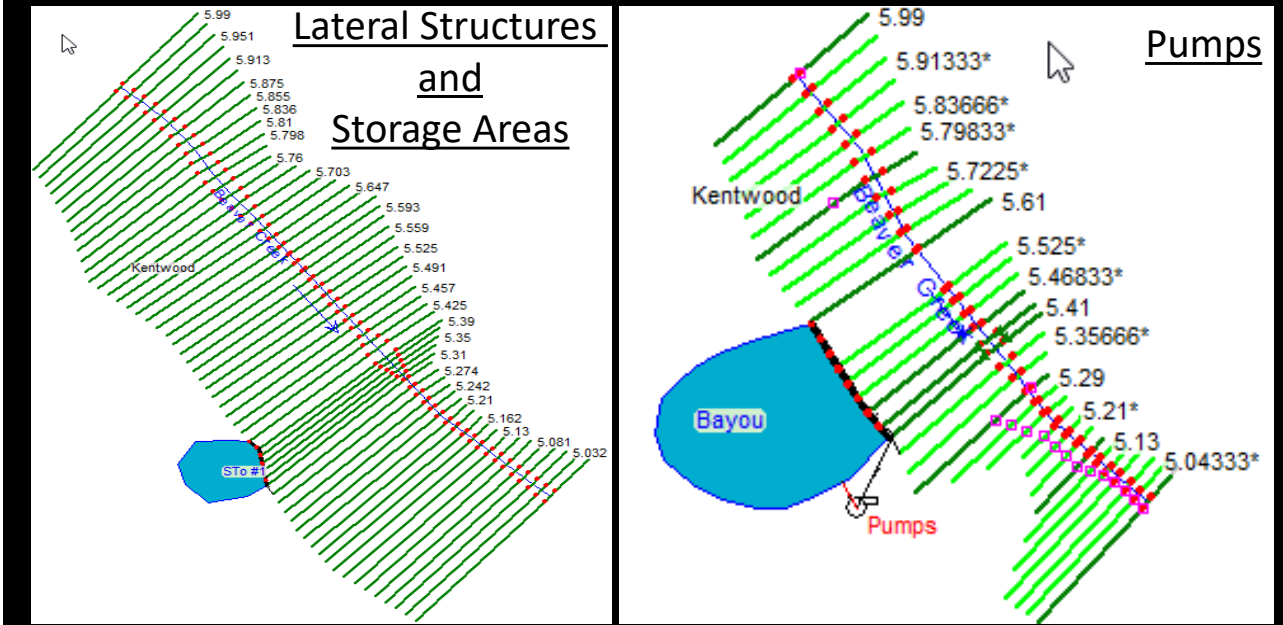
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## Example 2: Tributary Timing



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## Example 3: Time Sensitive Diversions or Attenuating Storage



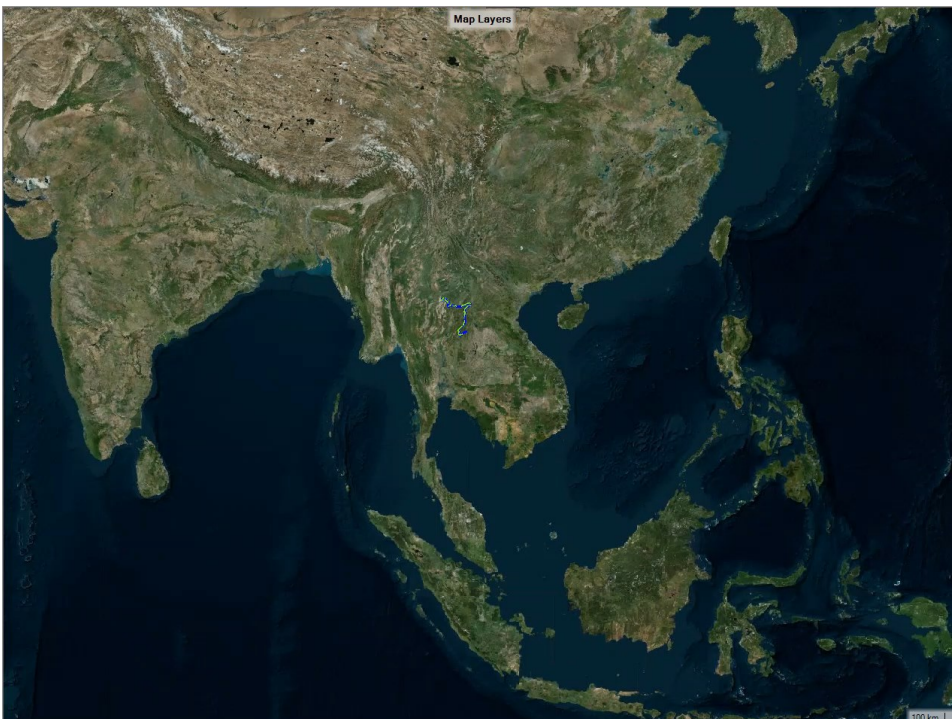
## II. When Would I Use Steady Flow?

1. Big
2. Quick
3. Perks

## II. When Would I Use Steady Flow?

1. Big – Need Fast Runtimes
2. Quick
3. Perks

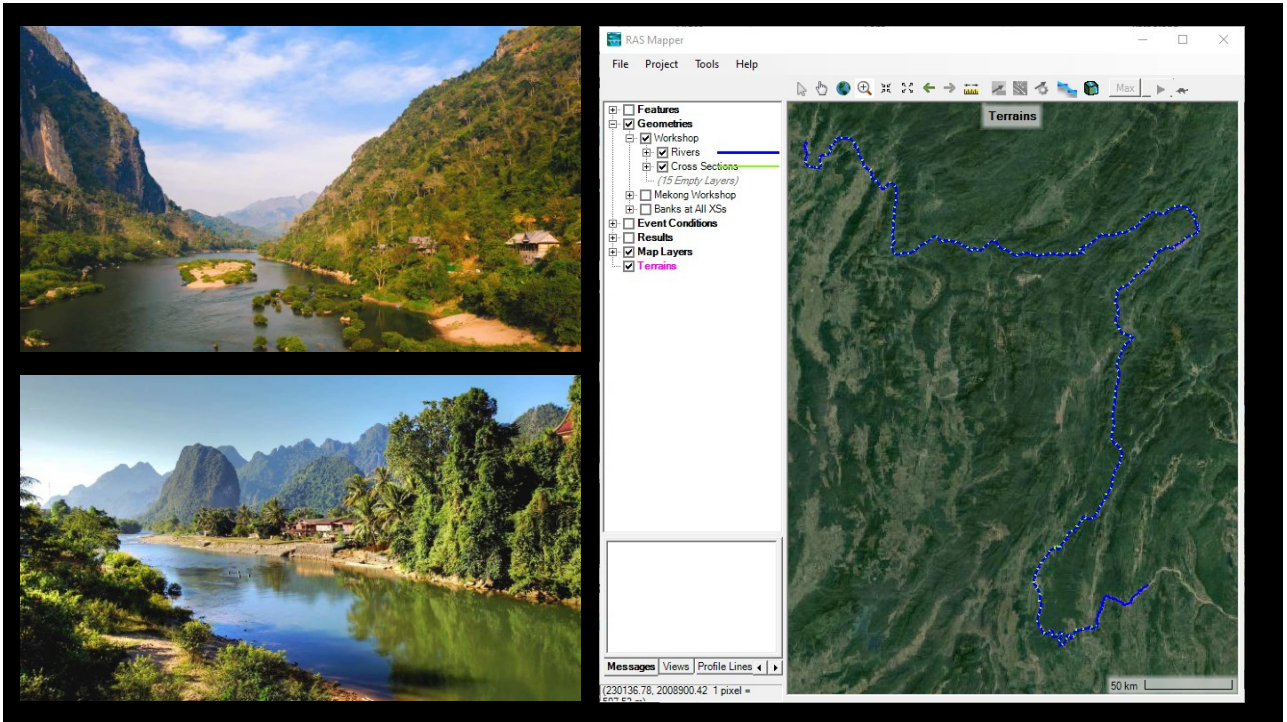
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Mekong  
River  
Model

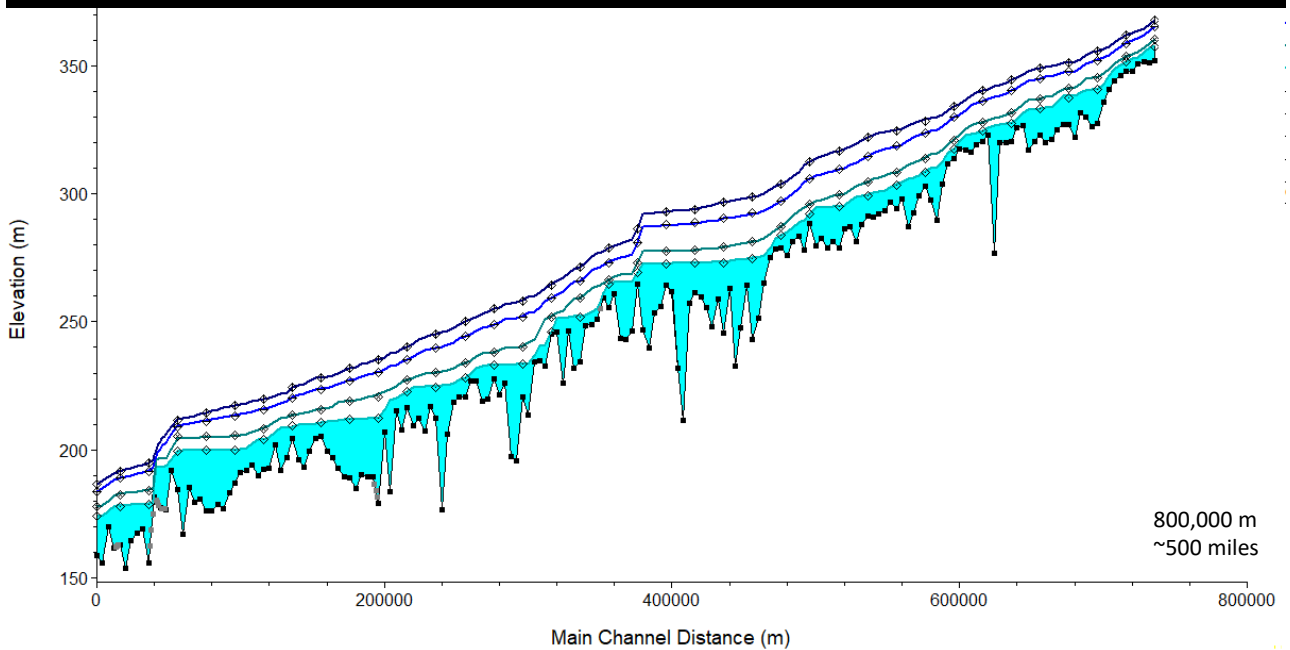
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# Mekong River Model



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## II. When Would I Use Steady Flow?

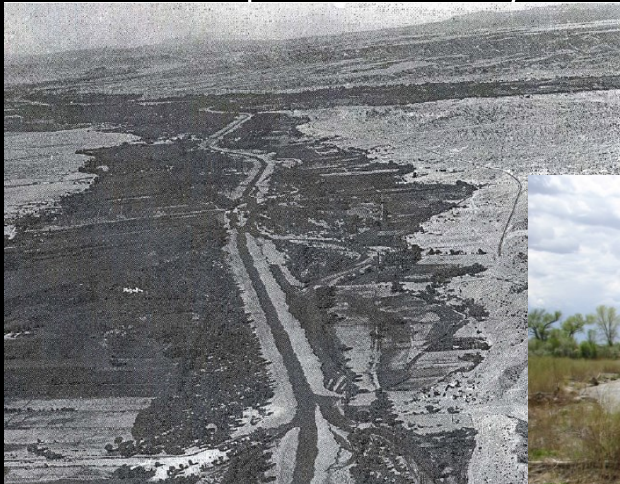
1. Big

2. Quick – Expedited Analysis

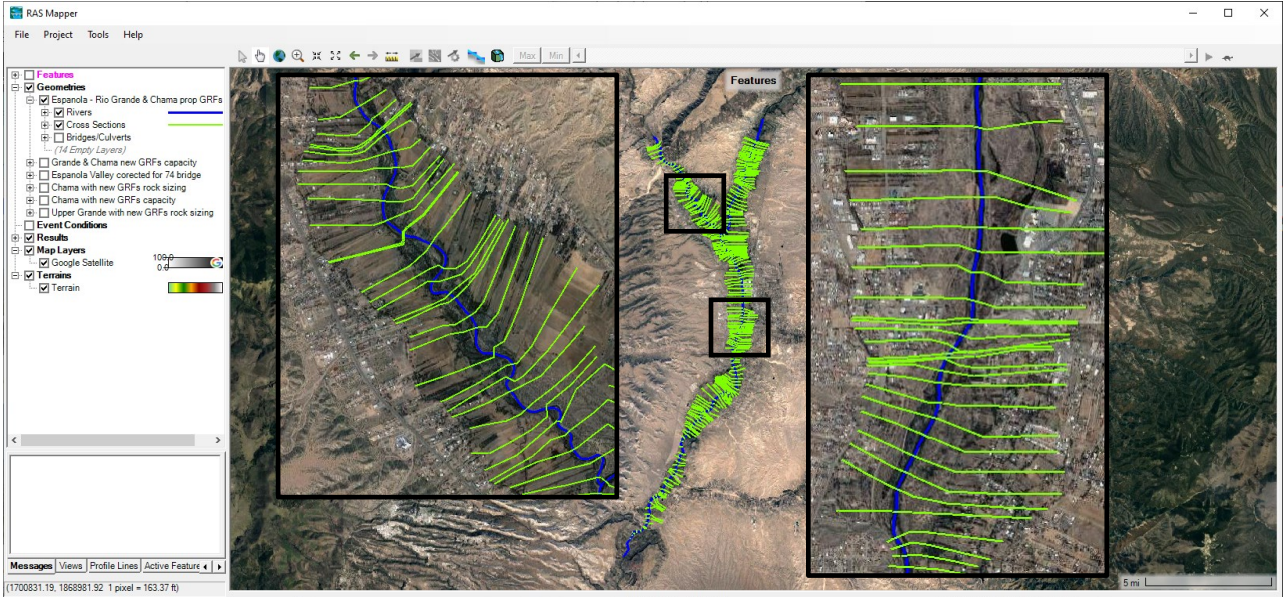
3. Perks

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### Espanola Valley Ecosystem Restoration

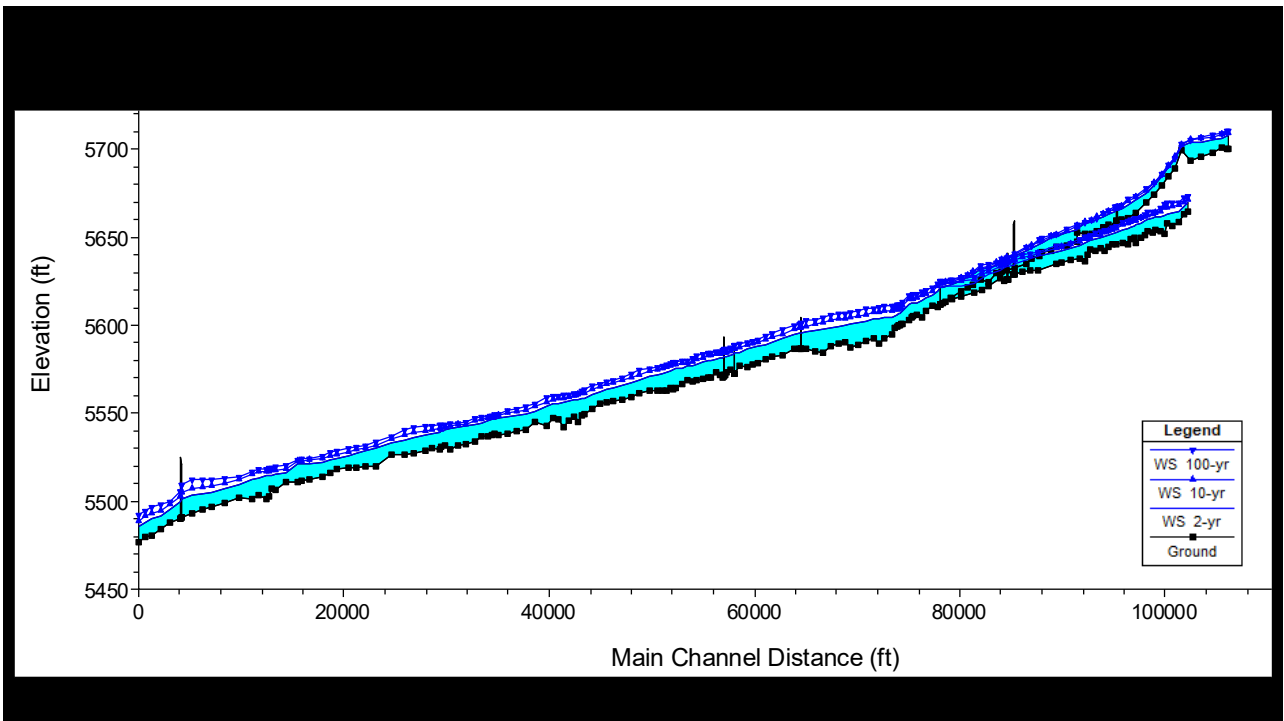


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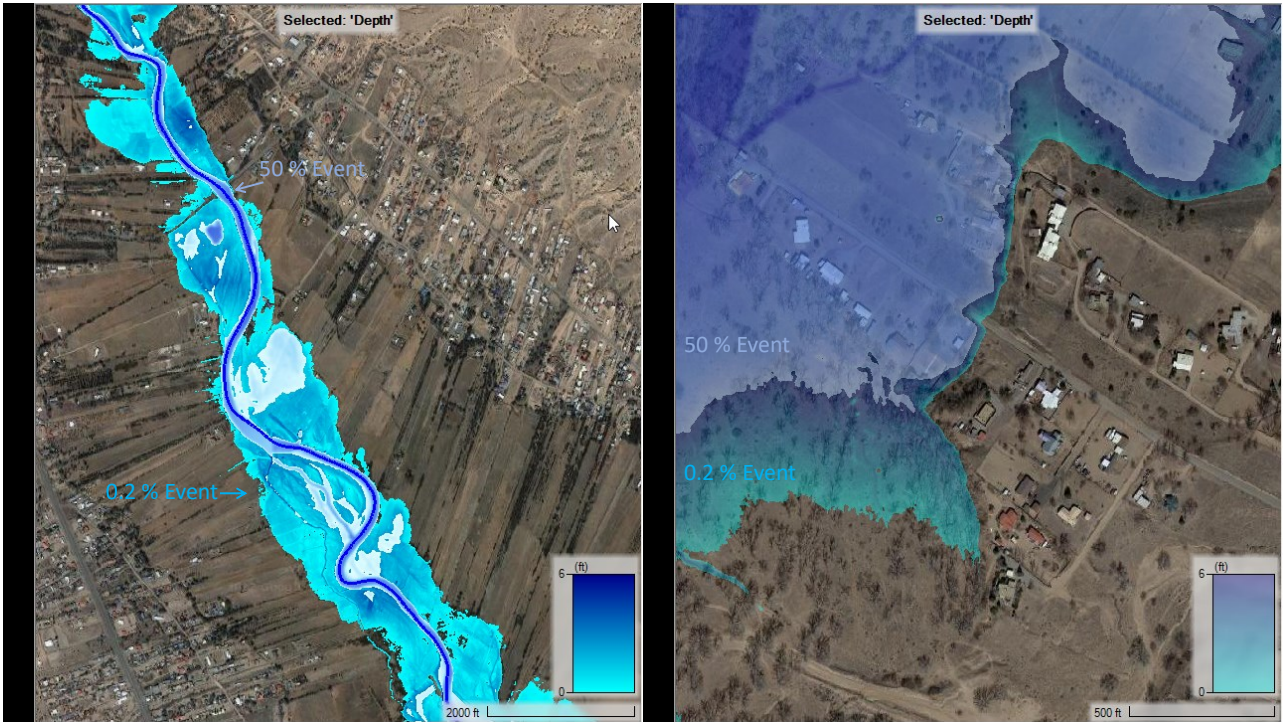
- Steady State Model developed with recurrence peaks
- Used to evaluate inundation and upstream and downstream connections of restoration features
- Quick and inexpensive.

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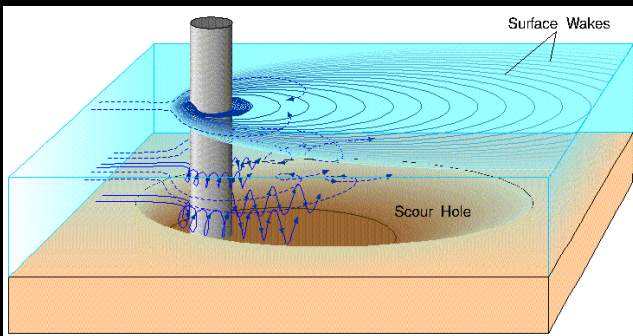
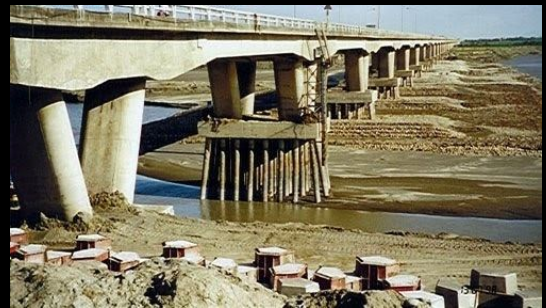
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## II. When Would I Use Steady Flow?

1. Big Models (Fast Runtime)
2. Quick Analyses
3. Perks - Steady Flow Only Options
  - i. Scour
  - ii. Floodways (for now)
  - iii. Ice

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# Bridge Scour



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# Bridge Scour

Hydraulic Design - Bridge Scour

Title: New HD File: C:\Users\j0hecsao\Documents\HEC Data\HEC-RAS\Applications

River: Pine Creek Profile: Low Flow

Reach: Pine Creek River Sta.: 10.36 BR

Contraction | Pier | Abutment

	LOB	Channel	ROB
Y1:	3.84	8.39	3.84
V1:	2.00	4.43	2.00
Y0:	3.69	7.19	
Q2:	3853.48	26146.52	
W2:	218.06	388.86	
D50:	2.01	2.01	2.01

Equation: Defau Defau Defau

Live Bed Specific Data

	7566.82	14866.37	7566.81
Q1:			
W1:	984.67	400.00	984.67
K1:	K1...	0.590	0.640
		0.590	0.590

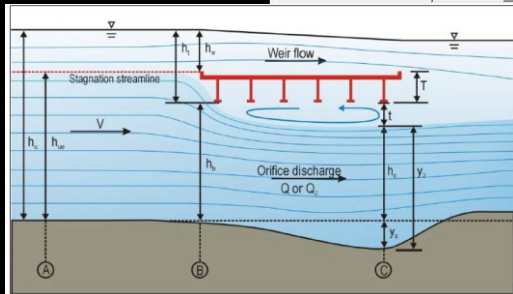
Approach XS River Sta.: 10.48

Bridge Scour RS = 10.36

Legend

- WS Low Flow
- Ground
- Ineff
- Bank Sta
- Abutment Toe
- Contr Scour
- Total Scour

Contraction Scour	Left	Channel	Right
Ys (ft):	2.06	6.67	
Vc (ft/s):	2.63	2.99	
Equation:	Clear	Live	



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# River Mechanics Podcast

HEC-RAS Training

HEC Home RAS Docs Downloads

HEC-RAS Classes

Presentations and Webinars

RSM River Mechanics Podcast

Episode 1-2 - Molly Wood

Molly Wood is the National Sediment Specialist for the USGS Water Resources Mission Area's Observing Systems Division. She develops policies and methods for measuring fluxial sediment transport and for computing streamflow using complex rating techniques. She also teaches national and international training courses on surface-water and sediment data collection.

I have lost track of just how much of what I understand about sediment data I've learned from Molly. But a substantial percentage of what I know about sediment measurements, sediment data processing, and potential data pitfalls comes either from her publications or conversations we've had over the years. This was a fun conversation that hit on several of those topics.

Episode: [here](#)

Bonus Material/Video Shorts

Sediment Measurement Variability

You can find the data we talked about at the USGS NWIS Water Quality and Sediment Data Site: <https://waterdata.usgs.gov/nwis/qw>  
The HEC-RAS tool that downloads and analyzes these data is described [here](#)

Episode 3: Ron Copeland  
Episode 2: Molly Wood  
Episode 1: David Bledenbarn  
Podcast Trailer

River Mechanics Podcast

Listen on Apple Podcasts Listen on Spotify Listen on Google Podcasts

<https://www.hec.usace.army.mil/confluence/rasdocs/rastraining/latest/rsm-river-mechanics-podcast>

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# Floodways/Encroachments

Encroachments

Equal Conveyance Reduction

Left bank offset: 0 Right bank offset: 0

River: Rio Chama Profile: 500 cfs

Reach: Espanola Import to Method 1 ...

Set Range of Values

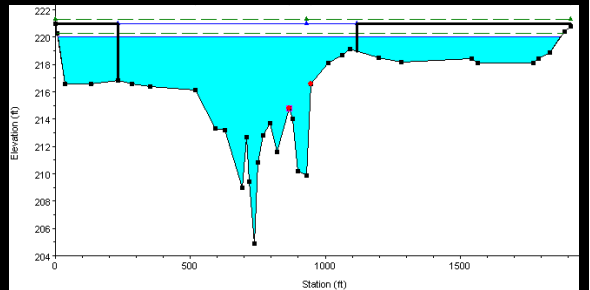
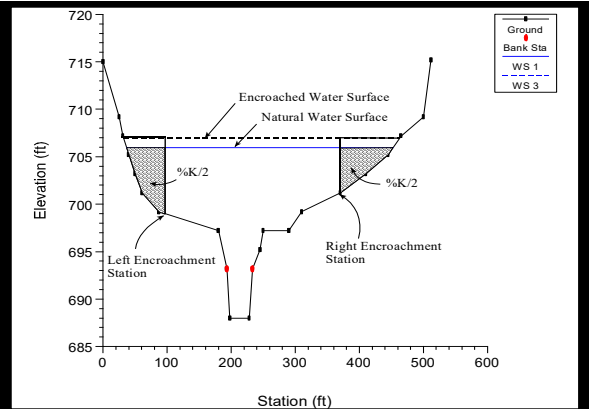
Upstream RS: 28075.65 Method: 4

Downstream RS: 267.61 Target WS change: 0.8

Set Selected Range Value 2

River Sta	Method	Value 1	Value 2
1 28075.65	4	0.8	
2 27975.56	4	0.8	
3 27488.01	4	0.8	
4 26561.37	4	0.8	
5 25449.96	4	0.8	
6 24403.35	4	0.8	
7 23495.83	4	0.8	
8 22903.82	4	0.8	
9 22282.13	4	0.8	
10 21570.12	4	0.8	
11 20824.01	4	0.8	
12 20064.61	4	0.8	
13 19113.69	4	0.8	
14 18271.76	4	0.8	

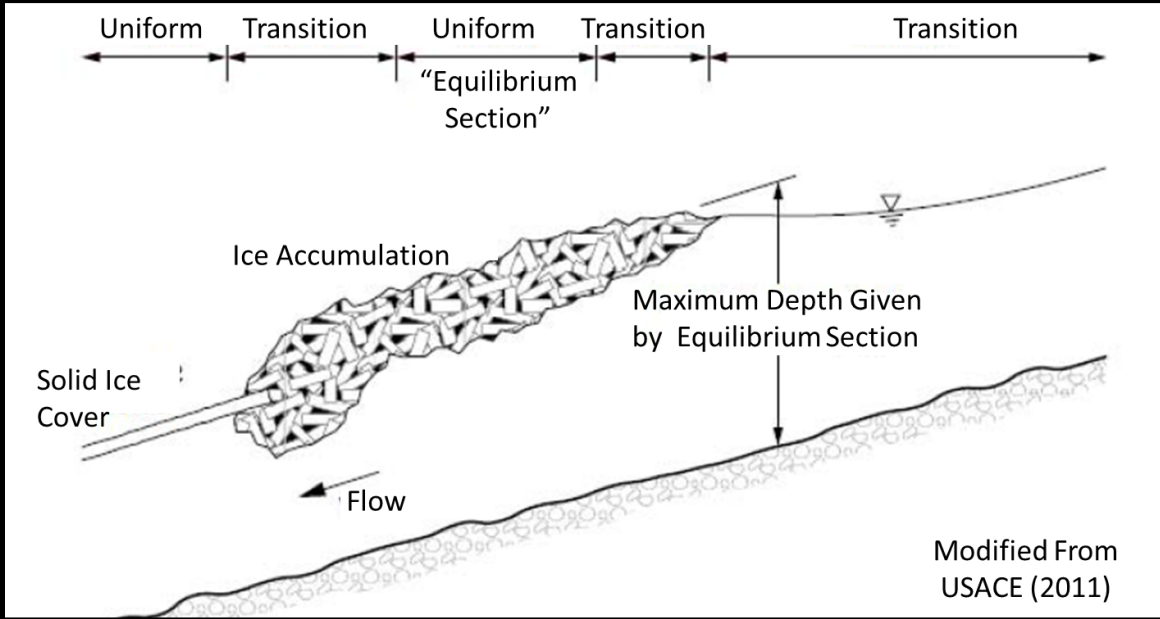
OK Cancel Clear Profile Clear All Profiles



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# Ice Jam



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Feb 2, 1988

PIONEER/Brad Coville and Chris Jensen

Feb 2, 1988

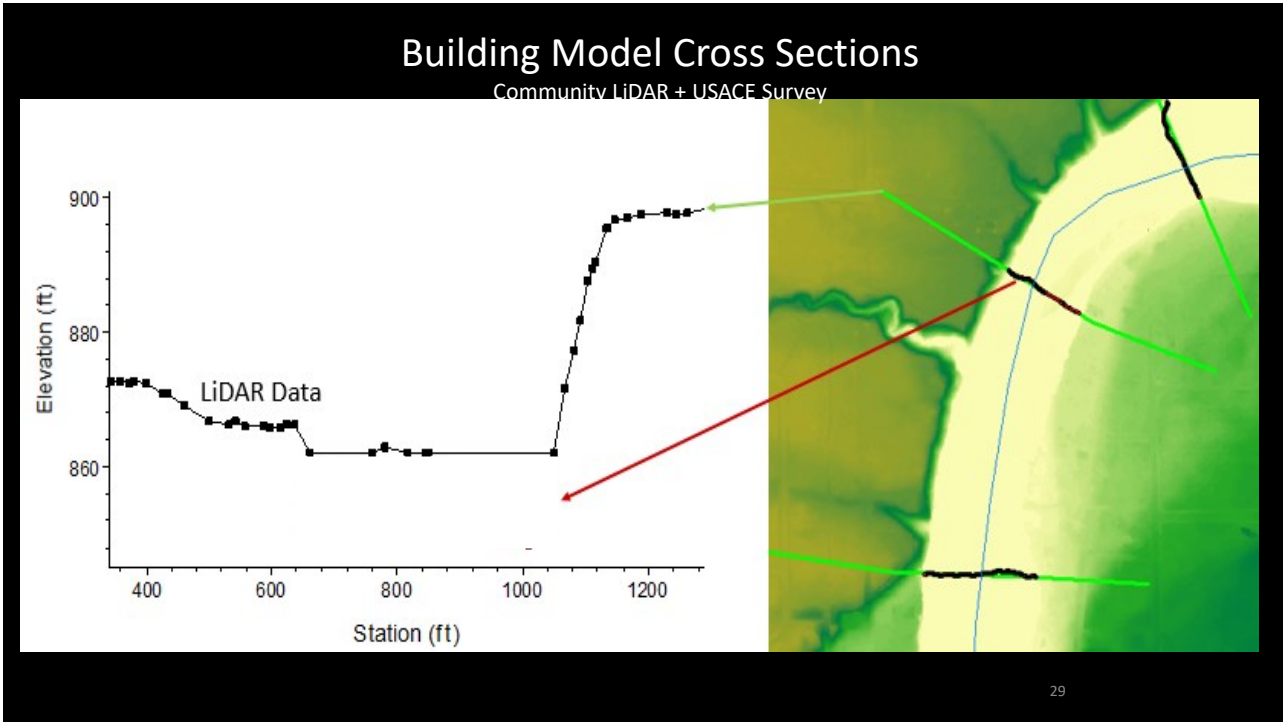
## Muskegon Ice Jam Model

Muskegon River

Feb 2, 1973

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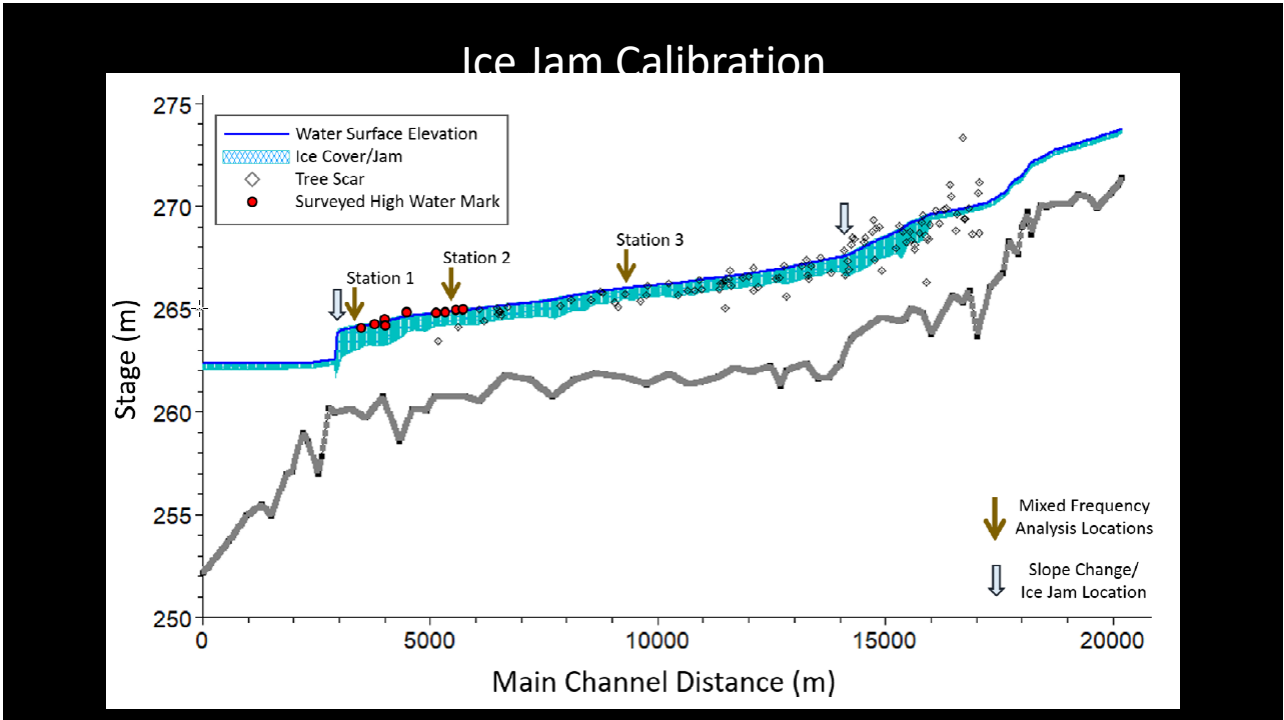




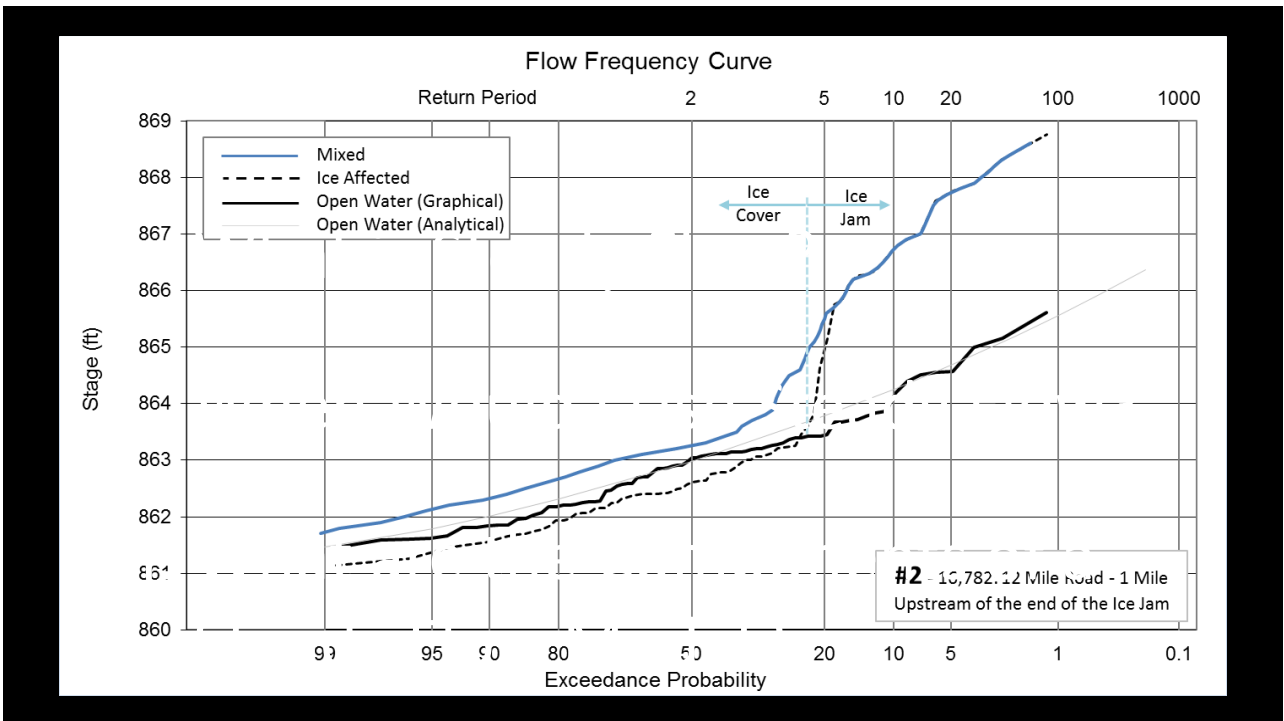
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## II. When Would I Use Steady Flow?

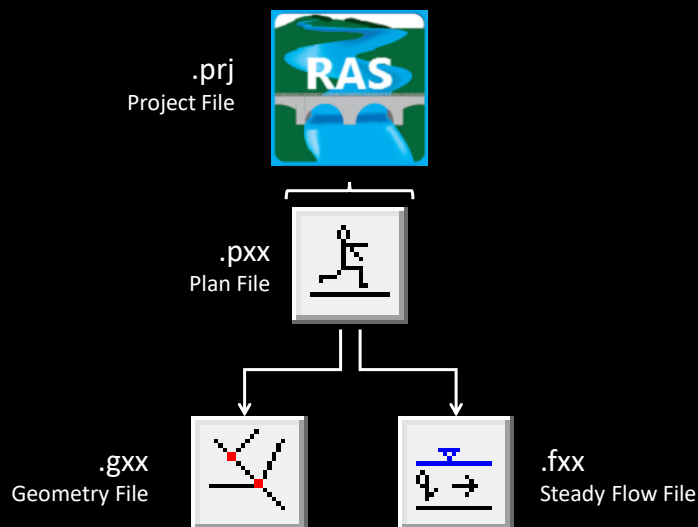
### I. What is Steady Flow?

## II. When Would I Use Steady Flow?

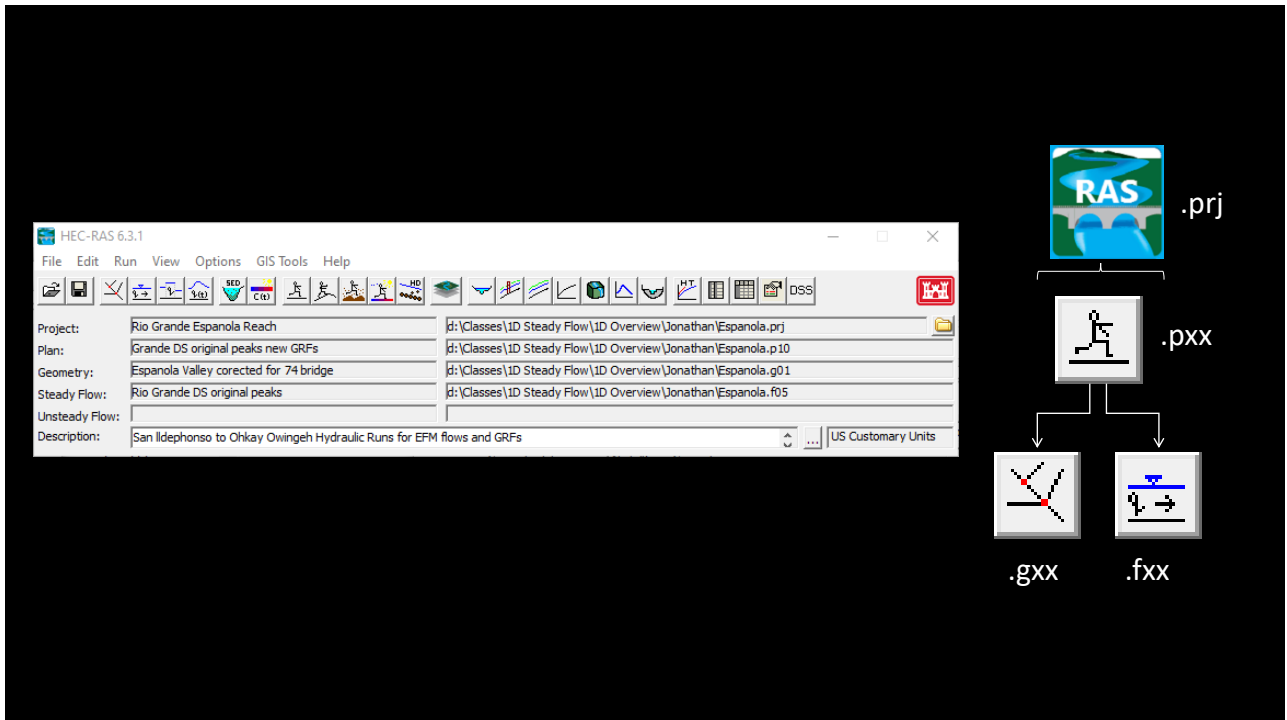
### III. What are the Components of a Steady Flow Model?

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## Steady Flow Model Components

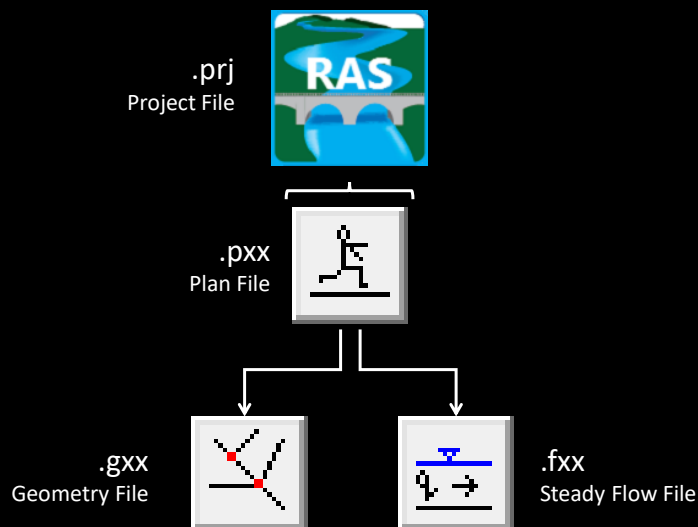


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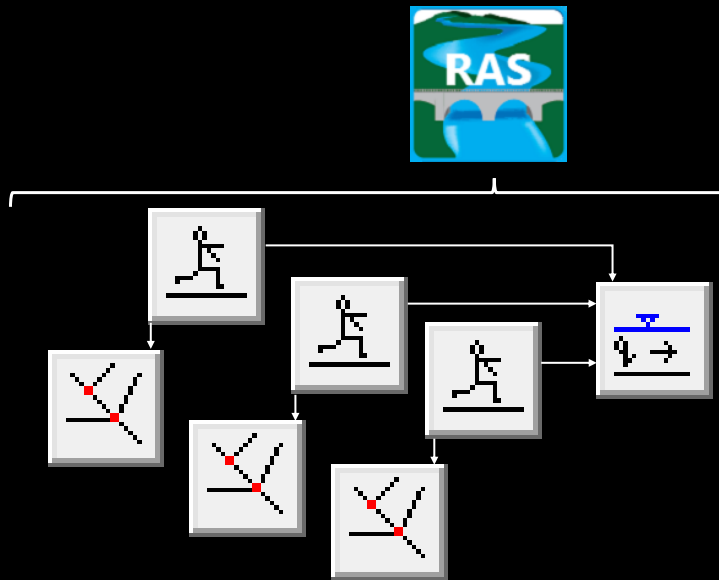
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## Steady Flow Model Components



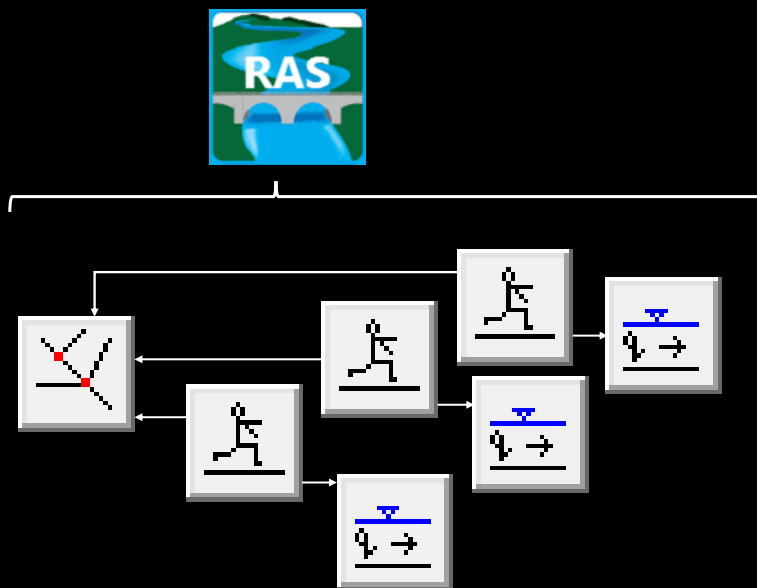
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## Steady Flow Model Components



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## Steady Flow Model Components



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# Steady Flow Model Components

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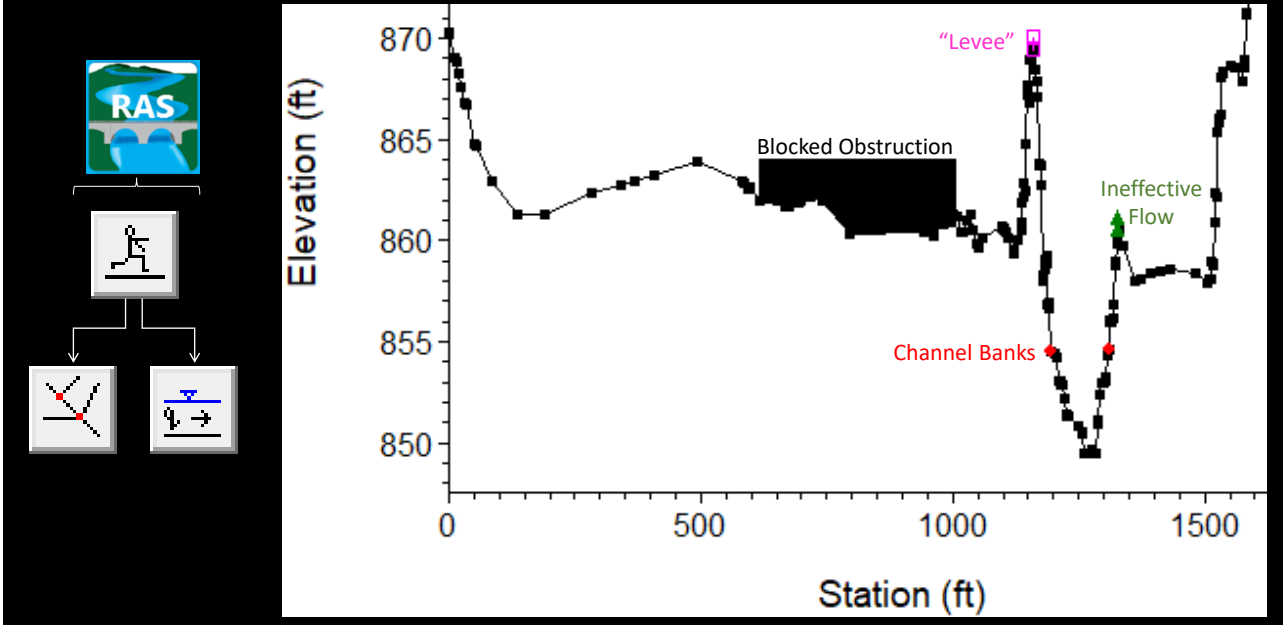
# Steady Flow Model Components

Del Row	Ins Row	Station	Elevation	n Val
1	0	870.32	870.32	0.035
2	0.75	870.24	870.24	
3	11.79	869.04	869.04	
4	13.64	868.86	868.86	
5	19.13	868.23	868.23	0.035
6	24.62	867.59	867.59	
7	31.83	866.84	866.84	
8	33.04	866.71	866.71	
9	51.79	864.77	864.77	
10	54.11	864.63	864.63	
11	83.46	862.97	862.97	
12	83.89	862.96	862.96	
13	85.71	862.9	862.9	
14	137.07	861.3	861.3	
15	189.99	861.3	861.3	
16	282.3	862.31	862.31	
17	343.13	862.75	862.75	
18	370.13	862.91	862.91	
19	406.32	863.27	863.27	

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# Steady Flow Model Components



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# Steady Flow Model Components

Flow Change Location			Profile Names and Flow Rates								
River	Reach	RS	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr	
5	Rio Grande	Espanola	95223.61	3583	6599	8928	11293	14536	16999	19467	22769
6	Rio Grande	Espanola	89565.54	3578	6586	8907	11271	14514	16977	19421	22748
7	Rio Grande	Espanola	88977.91	3575	6572	8884	11249	14491	16952	19359	22718
8	Rio Grande	Espanola	84545.25	3575	6571	8879	11246	14487	16948	19354	22717
9	Rio Grande	EspanolaDS	82450.43	7180	11599	14799	17898	22097	25396	28696	33196
10	Rio Grande	EspanolaDS	79396.80	7179	11598	14798	17897	22096	25394	28694	33194
11	Rio Grande	EspanolaDS	74499.63	7179	11597	14796	17894	22095	25392	28691	33188
12	Rio Grande	EspanolaDS	68232.63	7178	11595	14793	17891	22092	25388	28688	33184
13	Rio Grande	EspanolaDS	62350.51	7178	11595	14793	17891	22092	25388	28688	33184
14	Rio Grande	EspanolaDS	61271.61	7177	11593	14792	17890	22091	25387	28687	33183

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# Steady Flow Model Components

**Steady Flow Analysis**

File Options Help

Plan: Grande DS original peaks new GRFs Short ID: GrandeDSorgPlks

Geometry File: Espanola Valley corected for 74 bridge

Steady Flow File: Rio Grande DS original peaks

Flow Regime

- Subcritical
- Supercritical
- Mixed

Optional Programs

- Floodplain Mapping

Plan Description

Espanola Valley Watershed Study MEI#07-24  
 Plan for Rio Grande peak flows (downstream from Rio Chama),  
 2-yr & 5-yr from existing conditions L4PMLPAS added 4  
 flows from EFM modeling  
 Rio Grande and Rio Chama with lidar topo and main  
 channel geometry from 2007 survey (adjusted BOR)

Compute

Enter/Edit short identifier for plan (used in plan comparisons)

Toolbar icons: [Save] [Cross-section] [Flow profile] [Velocity profile] [Discharge profile] [SED] [C(t)] [Subcritical flow] [Supercritical flow] [Mixed flow] [HD]

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