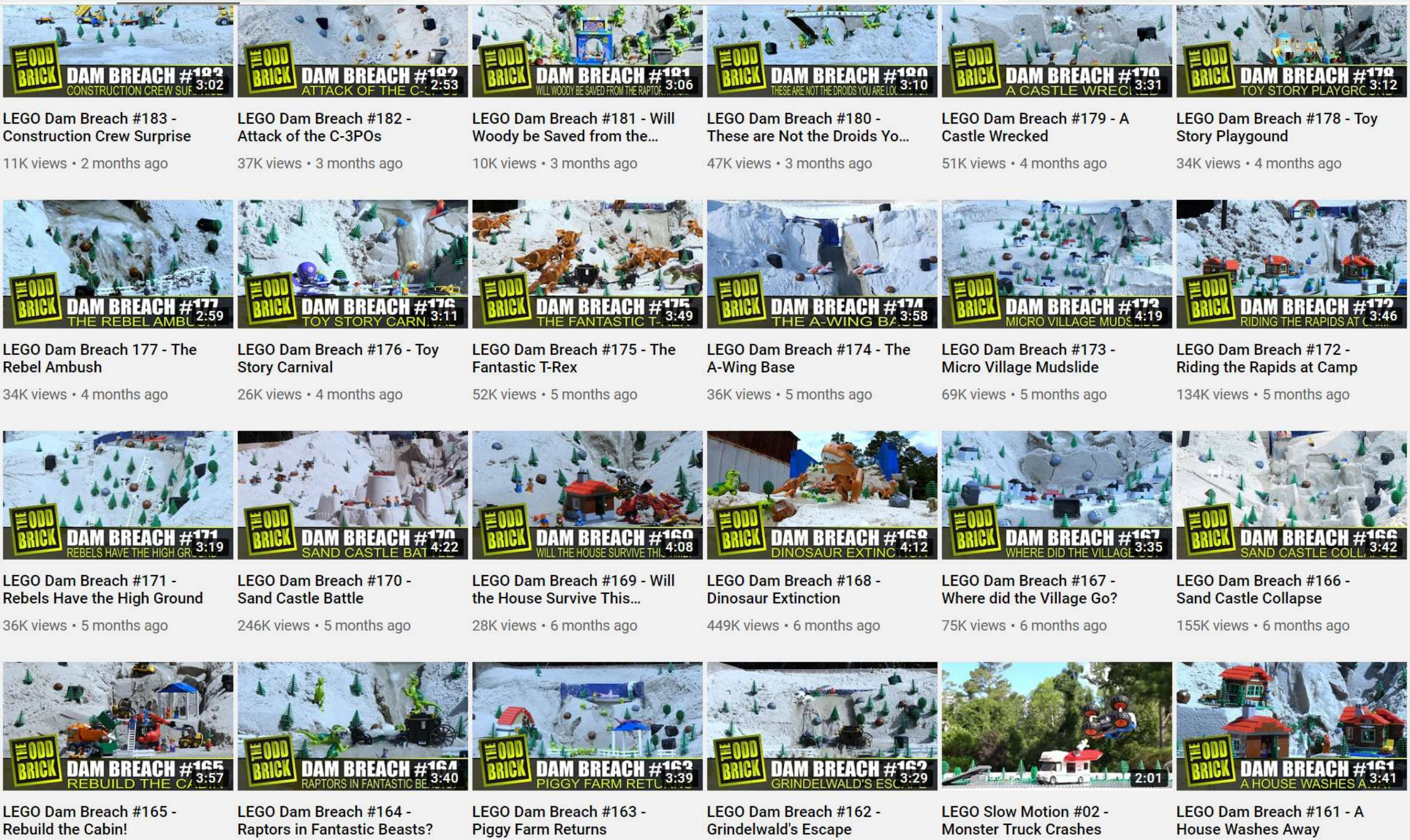
https://youtu.be/E64q4SAiHjg?t=28


LEGO Dam Breach #183 - Construction Crew Surprise
11K views • 2 months ago
LEGO Dam Breach #182 - Attack of the C-3POs
37K views • 3 months ago
LEGO Dam Breach #181 - Will Woody be Saved from the...
10K views • 3 months ago
LEGO Dam Breach #180 - These are Not the Droids Yo...
47K views • 3 months ago
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51K views • 4 months ago
LEGO Dam Breach #178 - Toy Story Playground
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LEGO Dam Breach #176 - Toy Story Carnival
26K views • 4 months ago
LEGO Dam Breach #175 - The Fantastic T-Rex
52K views • 5 months ago
LEGO Dam Breach #174 - The A-Wing Base
36K views • 5 months ago
LEGO Dam Breach #173 - Micro Village Mudslide
69K views • 5 months ago
LEGO Dam Breach #172 - Riding the Rapids at Camp
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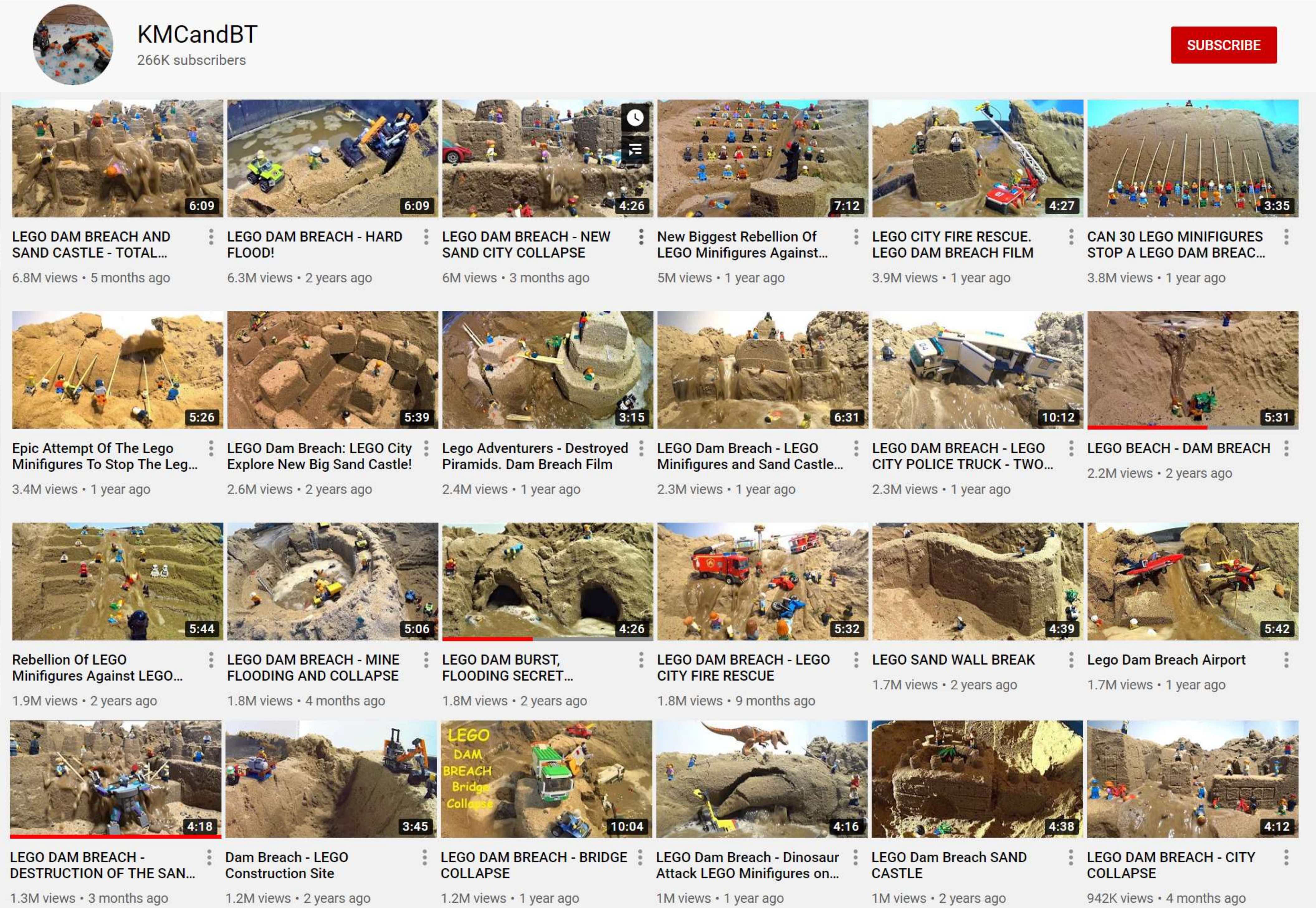
LEGO Dam Breach #171 - Rebels Have the High Ground
36K views • 5 months ago
LEGO Dam Breach #170 - Sand Castle Battle
246K views • 5 months ago
LEGO Dam Breach #169 - Will the House Survive This...
28K views • 6 months ago
LEGO Dam Breach #168 - Dinosaur Extinction
449K views • 6 months ago
LEGO Dam Breach #167 - Where did the Village Go?
75K views • 6 months ago
LEGO Dam Breach #166 - Sand Castle Collapse
155K views • 6 months ago
LEGO Dam Breach #165 - Rebuild the Cabin!
LEGO Dam Breach #164 - Raptors in Fantastic Beasts?
LEGO Dam Breach #163 - Piggy Farm Returns
LEGO Dam Breach #162 - Grindelwald's Escape
LEGO Slow Motion #02 - Monster Truck Crashes
LEGO Dam Breach #161 - A House Washes Away


KMCandBT
266K subscribers
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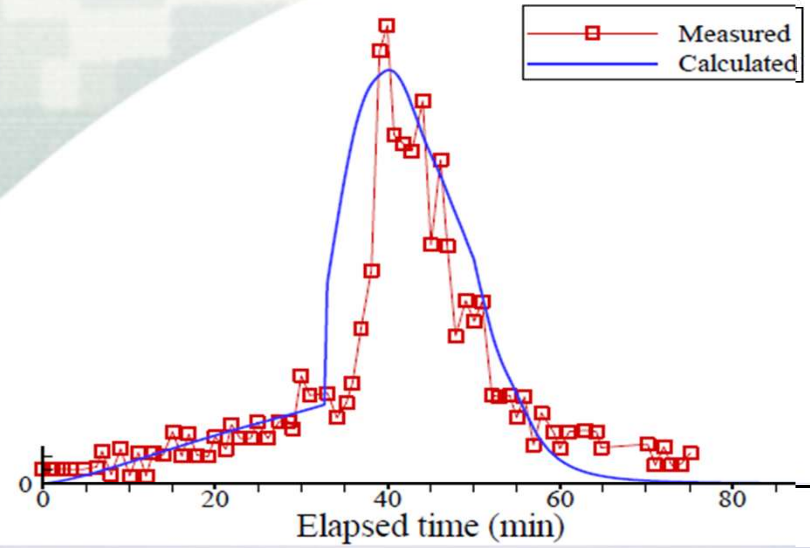
6:09
LEGO DAM BREACH AND SAND CASTLE - TOTAL...
6.8M views • 5 months ago
6:09
LEGO DAM BREACH - HARD FLOOD!
6.3M views • 2 years ago
4:26
LEGO DAM BREACH - NEW SAND CITY COLLAPSE
6M views • 3 months ago
7:12
New Biggest Rebellion Of LEGO Minifigures Against...
5M views • 1 year ago
4:27
LEGO CITY FIRE RESCUE. LEGO DAM BREACH FILM
3.9M views • 1 year ago
3:35
CAN 30 LEGO MINIFIGURES STOP A LEGO DAM BREAC...
3.8M views • 1 year ago
5:26
Epic Attempt Of The Lego Minifigures To Stop The Leg...
3.4M views • 1 year ago
5:39
LEGO Dam Breach: LEGO City Explore New Big Sand Castle!
2.6M views • 2 years ago
3:15
Lego Adventurers - Destroyed Piramids. Dam Breach Film
2.4M views • 1 year ago
6:31
LEGO Dam Breach - LEGO Minifigures and Sand Castle...
2.3M views • 1 year ago
10:12
LEGO DAM BREACH - LEGO CITY POLICE TRUCK - TWO...
2.3M views • 1 year ago
5:31
LEGO BEACH - DAM BREACH
2.2M views • 2 years ago
5:44
Rebellion Of LEGO Minifigures Against LEGO...
1.9M views • 2 years ago
5:06
LEGO DAM BREACH - MINE FLOODING AND COLLAPSE
1.8M views • 4 months ago
4:26
LEGO DAM BURST, FLOODING SECRET...
1.8M views • 2 years ago
5:32
LEGO DAM BREACH - LEGO CITY FIRE RESCUE
1.8M views • 9 months ago
4:39
LEGO SAND WALL BREAK
1.7M views • 2 years ago
5:42
Lego Dam Breach Airport
1.7M views • 1 year ago
4:18
LEGO DAM BREACH - DESTRUCTION OF THE SAN...
1.3M views • 3 months ago
3:45
Dam Breach - LEGO Construction Site
1.2M views • 2 years ago
LEGO DAM BREACH Bridge Collapse
10:04
LEGO DAM BREACH - BRIDGE COLLAPSE
1.2M views • 1 year ago
4:16
LEGO Dam Breach - Dinosaur Attack LEGO Minifigures on...
1M views • 1 year ago
4:38
LEGO Dam Breach SAND CASTLE
1M views • 2 years ago
4:12
LEGO DAM BREACH - CITY COLLAPSE
942K views • 4 months ago

Estimating Dam Breach Parameters

Stanford Gibson, PhD

Sediment Specialist

Hydrologic Engineering Center

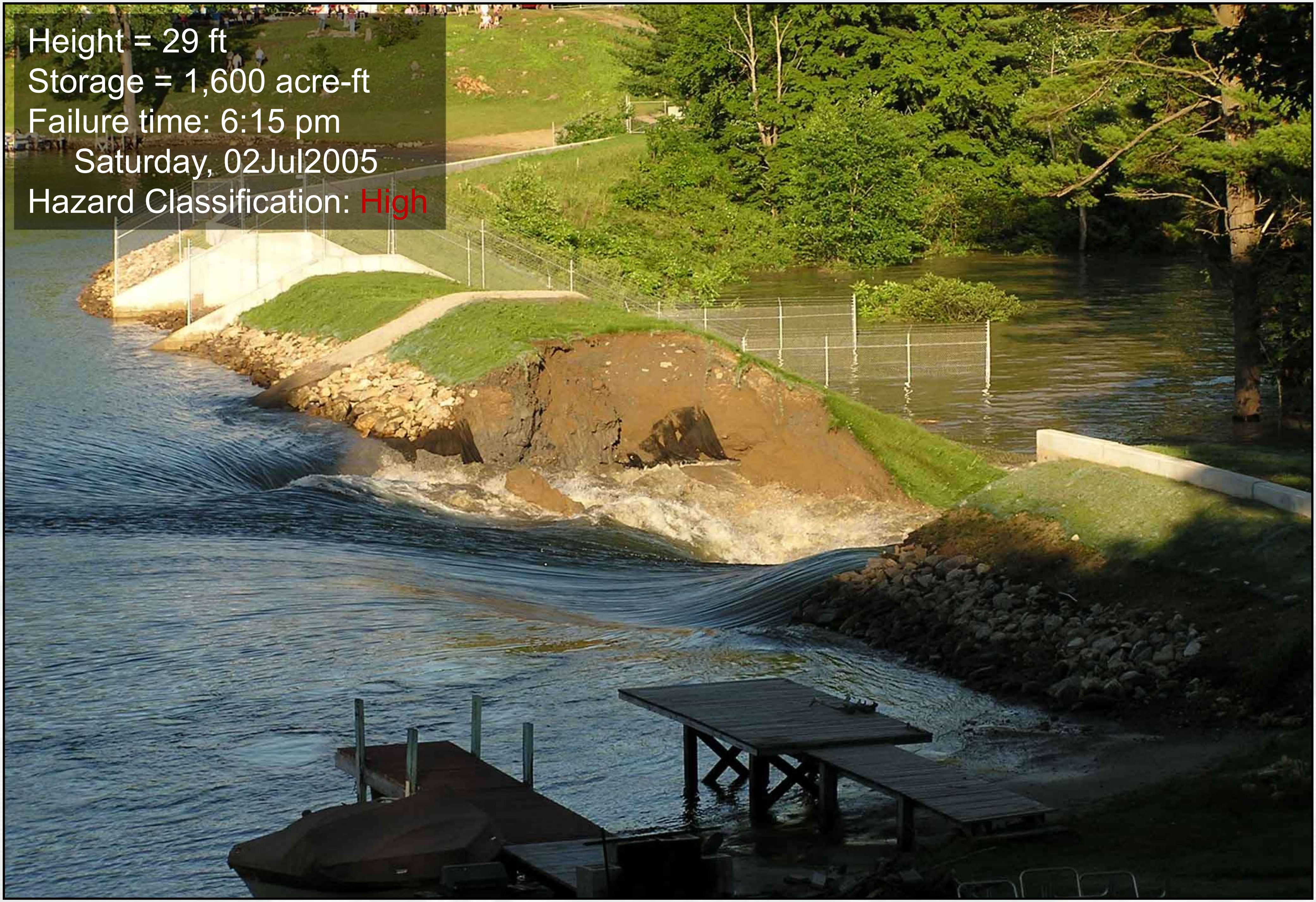


NRCS Embankment Failure Research (SIMBA/WinDAMB model)

Temple, Darrel M., and Hanson, Gregory J., "Earth Dam Overtopping and Breach Outflow," Presented at the ASCE World Water & Environmental Resources Congress 2005, EWRI, Anchorage, AK, 15-19 May 2005.

[redacted]

Hadlock Pond Dam New York



Taum Sauk Upper Dam, Missouri

NEW BRAUNFELS Herald-Zeitung HZ

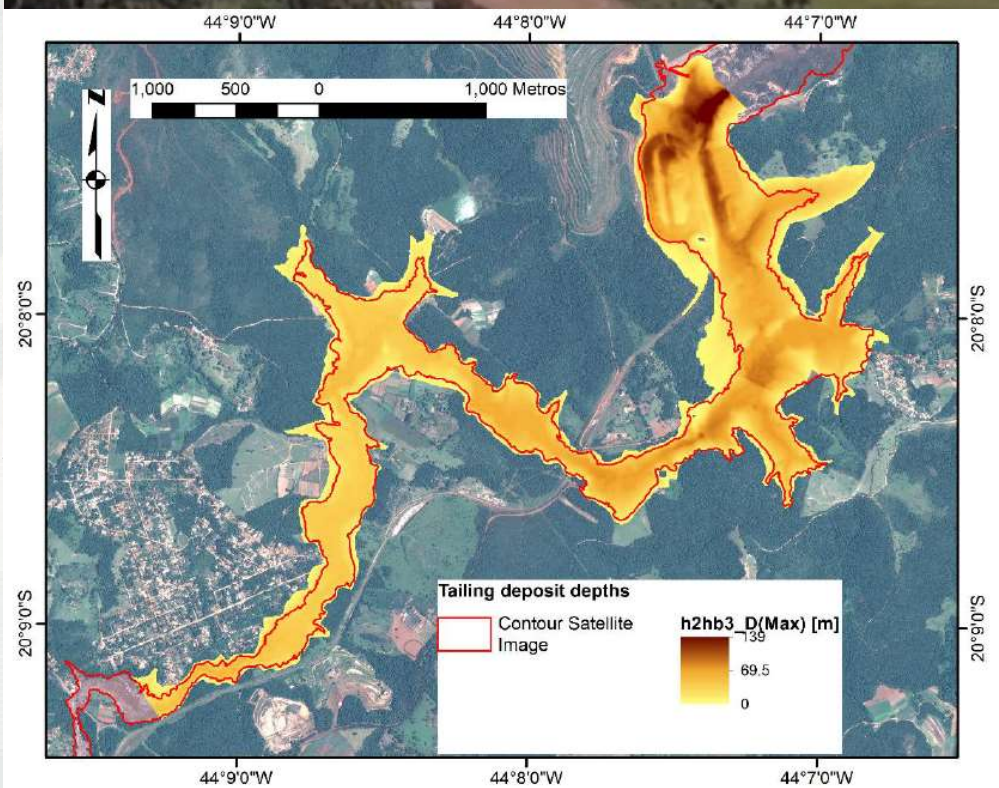
Dunlap Dam Failure

Guadalupe Blanco River Authority May 15, 2019 1

http://herald-zeitung.com/video_e9e0f25c-7756-11e9-b1cc-3f3ca4a52872.html

Brazil Mine Tailings Failure

Modeling by Prof Leonardo Moura
University of Brasilia



Michigan dam failure caught on video

https://youtu.be/Hc3u_CHVHJ8

2,913,549 views • May 20, 2020

10K 1.2K SHARE SAVE

Three Approaches

1. **User Entered Data**
   -Parameter Estimation

User Entered Data ▾

2. **Simplified Physical**

Simplified Physical ▾

3. **DL Breach**

Physical Breaching (DLBreach) ▾

User Entered Data
Simplified Physical
Physical Breaching (DLBreach)

Three Approaches

1. **User Entered Data**

   -Parameter Estimation

User Entered Data

2. **Simplified Physical**

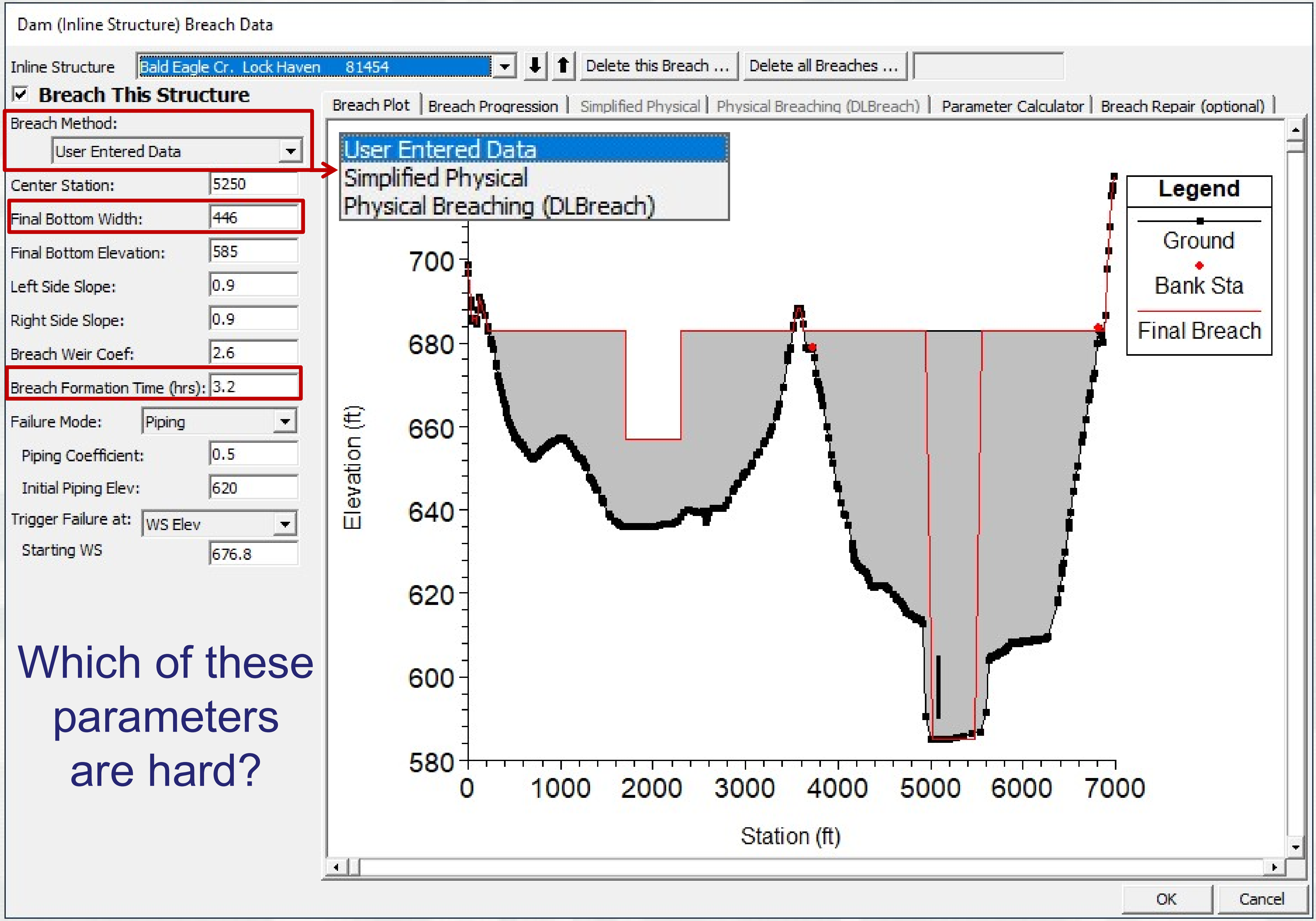
Simplified Physical

3. **DL Breach**

Physical Breaching (DLBreach)

User Entered Data
Simplified Physical
Physical Breaching (DLBreach)

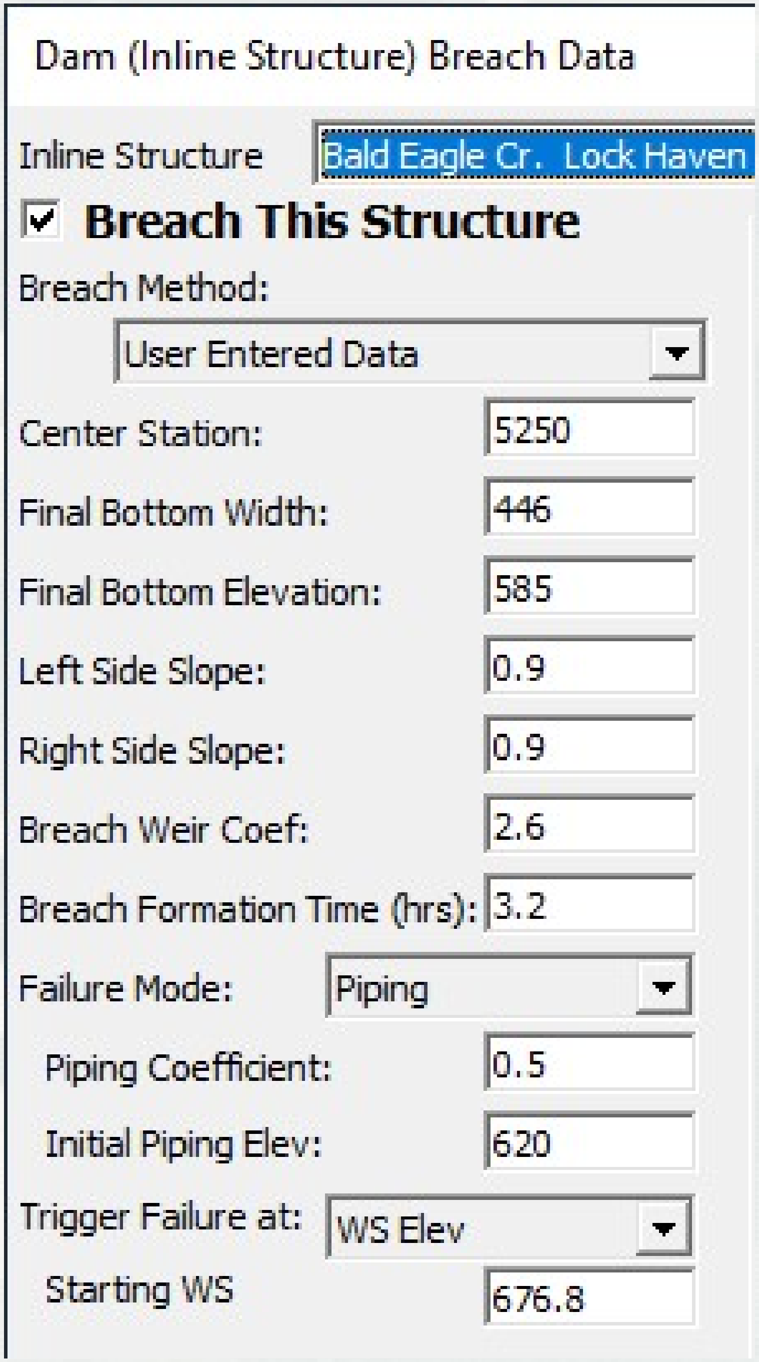
HEC-RAS Breach Data



Which of these parameters are hard?

HEC-RAS Breach Data Input

- **Location**: Centerline of breach
- **Type**: Overtopping or Piping
- **Size**: Bottom elevation, width and side slopes
- **Time:** to maximum size and progression type
- **Triggering situation**:
  - ✓ Pool elevation
  - ✓ Pool elevation + Duration
  - ✓ Clock time



Before we get into the tough parameters… Let's take on some of these others.

But First…A Couple Other Features

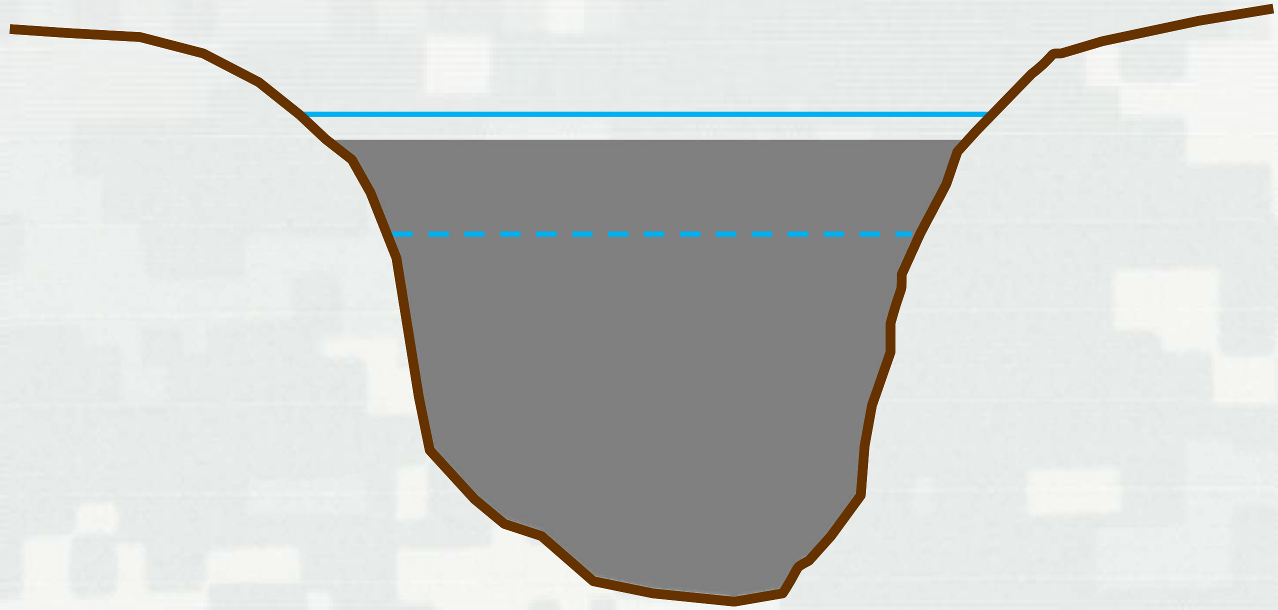
Dam (Inline Structure) Breach Data

Inline Structure: Bald Eagle Cr. Lock Haven

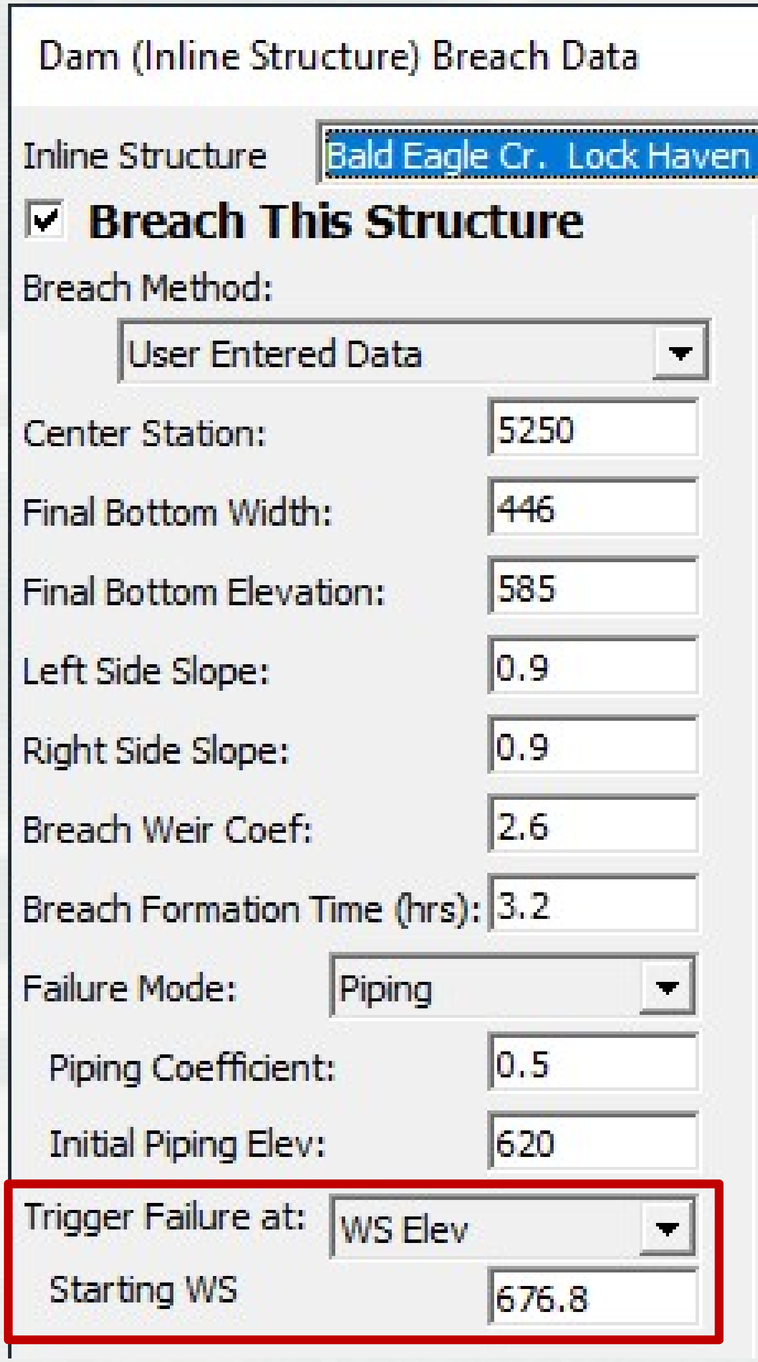
☑ **Breach This Structure**

Breach Method: User Entered Data

Center Station:	5250
Final Bottom Width:	446
Final Bottom Elevation:	585
Left Side Slope:	0.9
Right Side Slope:	0.9
Breach Weir Coef:	2.6
Breach Formation Time (hrs):	3.2
Failure Mode:	Piping
Piping Coefficient:	0.5
Initial Piping Elev:	620
Trigger Failure at:	WS Elev
Starting WS	676.8

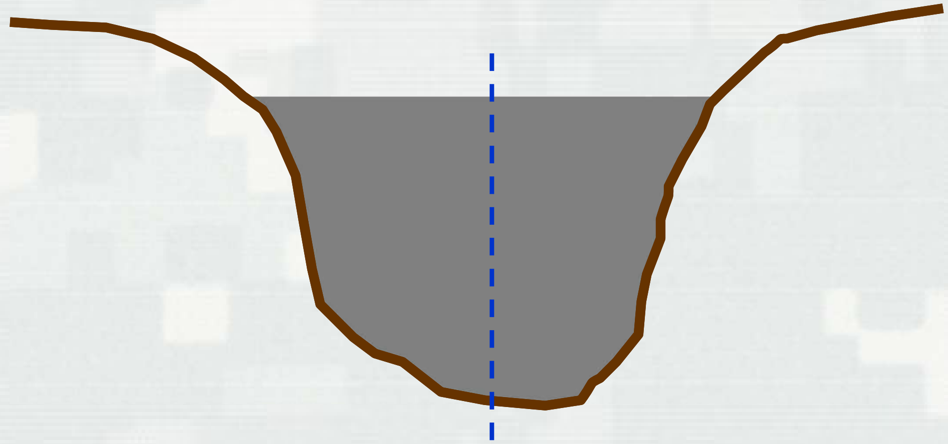


But First…A Couple Other Features

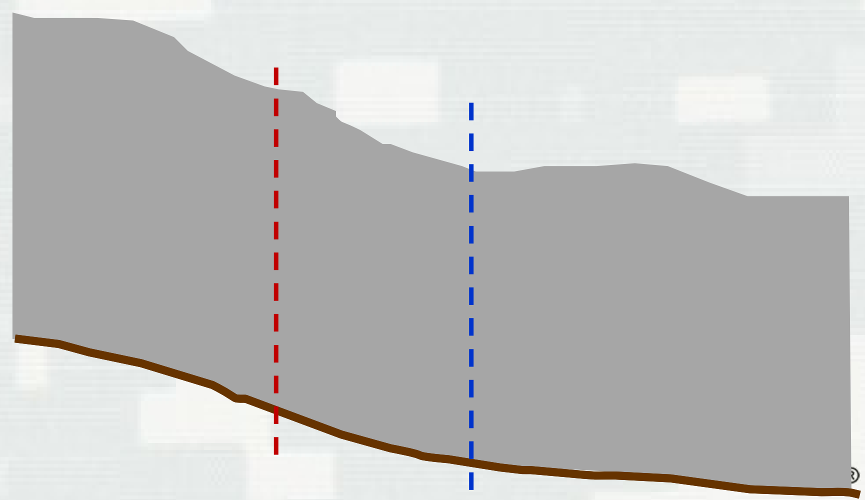


Where

This doesn't matter much for a dam



But levees can be more complicated



Three Approaches

1. **User Entered Data**

   -Parameter Estimation

2. **Simplified Physical**

3. **DL Breach**

Estimating the Breach Parameters

- **Literature And Guidance**
  - Existing COE guidance
  - Prediction of embankment dam breach parameters: *USBR (1998) Dam Safety Research Report*

- **Regression Equations-**
  - MacDonald and Langridge-Monopolis (1984)
  - Froehlich (1995b)
  - Von Thun and Gillette (1990)
  - Xu and Zhang (2009)

Technology Review (1998)

Prediction of Embankment Dam Breach Parameters

A Literature Review and Needs Assessment

DSO-98-004

DSO

DAM SAFETY OFFICE

Water Resources Research Laboratory

July 1998

Suggested Breach Parameters

Dam Type	Average Breach Width (B_{ave})	Horizontal Component of Breach Side Slope (H) (H:V)	Failure Time, t_f (hours)	Agency
Earthen/Rockfill	(0.5 to 3.0) x HD	0 to 1.0	0.5 to 4.0	USACE 1980
	(1.0 to 5.0) x HD	0 to 1.0	0.1 to 1.0	FERC
	(2.0 to 5.0) x HD	0 to 1.0 (slightly larger)	0.1 to 1.0	NWS
	(0.5 to 5.0) x HD*	0 to 1.0	0.1 to 4.0*	USACE 2007
Concrete Gravity	Multiple Monoliths	Vertical	0.1 to 0.5	USACE 1980
	Usually ≤ 0.5 L	Vertical	0.1 to 0.3	FERC
	Usually ≤ 0.5 L	Vertical	0.1 to 0.2	NWS
	Multiple Monoliths	Vertical	0.1 to 0.5	USACE 2007
Concrete Arch	Entire Dam	Valley wall slope	≤ 0.1	USACE 1980
	Entire Dam	0 to valley walls	≤ 0.1	FERC
	(0.8 x L) to L	0 to valley walls	≤ 0.1	NWS
	(0.8 x L) to L	0 to valley walls	≤ 0.1	USACE 2007
Slag/Refuse	(0.8 x L) to L	1.0 to 2.0	0.1 to 0.3	FERC
	(0.8 x L) to L		≤ 0.1	NWS

***Note:** Dams that have very large volumes of water, and have long dam crest lengths, will continue to erode for long durations (i.e., as long as a significant amount of water is flowing through the breach), and may therefore have longer breach widths and times than what is shown in Table 3. HD = height of the dam; L = length of the dam crest; FERC - Federal Energy Regulatory Commission; NWS - National Weather Service

Where: HD = Height of the dam.

L = Length of the dam crest.

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	[illegible]	[illegible]	[illegible]	[illegible]C
	(2.0 to 5.0) x HD	0 to 1.0 (slightly larger)	0.1 to 1.0	NWS
	(0.5 to 5.0) x HD*	0 to 1.0	0.1 to 4.0*	USACE 2007
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	(0.8 x L) to L		≤ 0.1	NWS

You can start by trying 1h and 4 hrs and seeing if it makes a difference

***Note:** Dams that have very large volumes of water, and have long dam crest lengths, will continue to erode for long durations (i.e., as long as a significant amount of water is flowing through the breach), and may therefore have longer breach widths and times than what is shown in Table 3. HD = height of the dam; L = length of the dam crest; FERC - Federal Energy Regulatory Commission; NWS - National Weather Service

Where: HD = Height of the dam.

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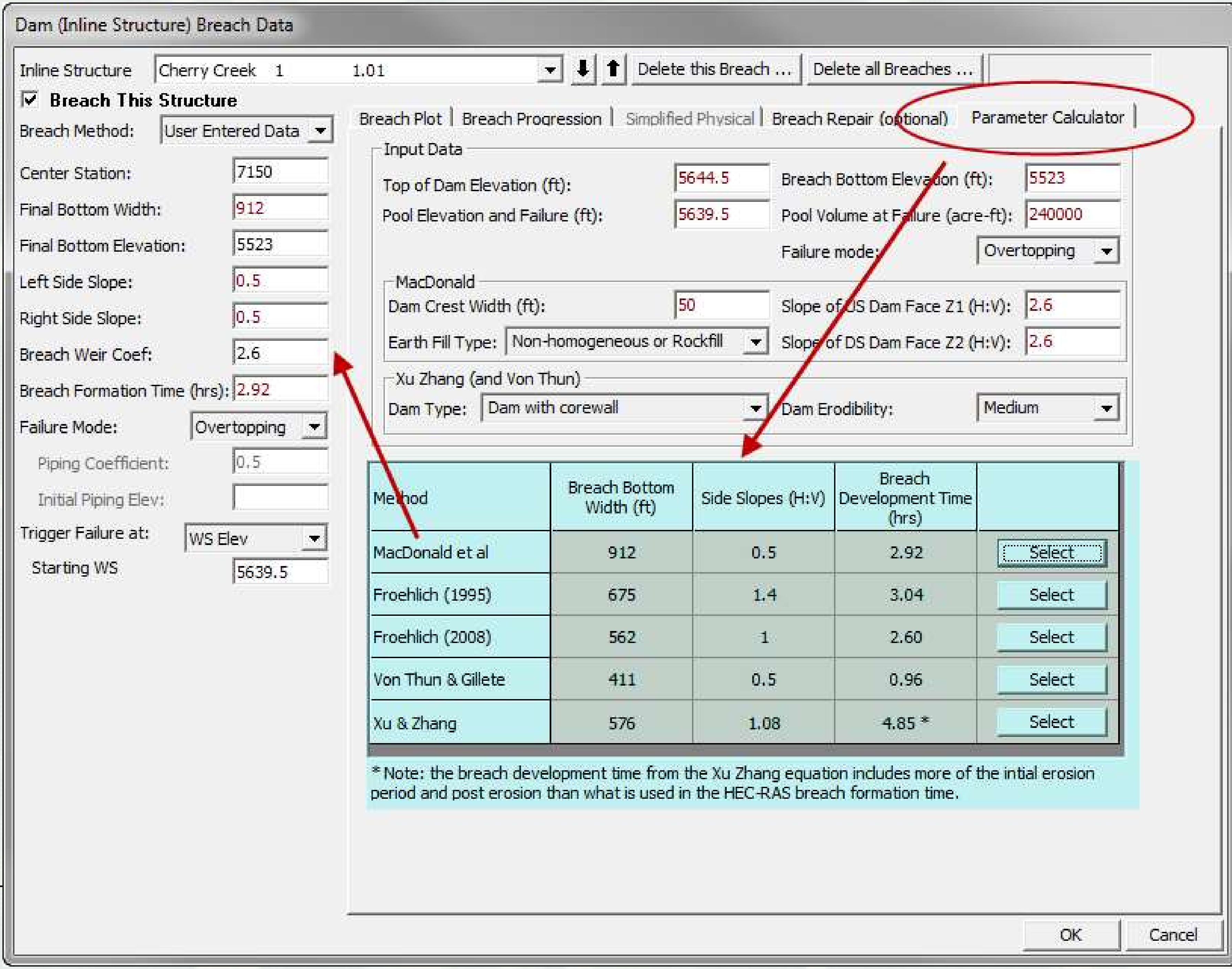
Breach Parameter Calculator



Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	912	0.5	2.92	Select
Froehlich (1995)	675	1.4	3.04	Select
Froehlich (2008)	562	1	2.60	Select
Von Thun & Gillete	411	0.5	0.96	Select
Xu & Zhang	576	1.08	4.85 *	Select

MacDonald and Langridge-Monopolis (1984)

Earthfill

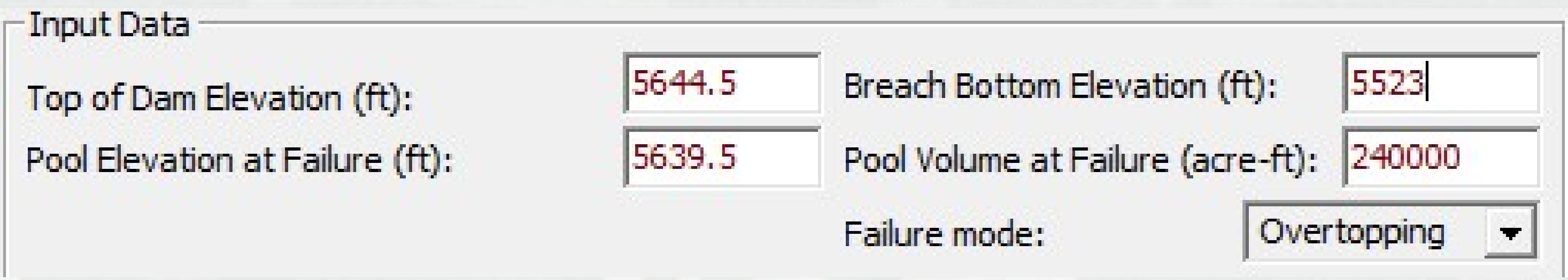
$$V_{eroded} = 0.0261\left(V_{out} * h_w\right)^{0.769}$$

$$t_f = 0.0179\left(V_{eroded}\right)^{0.364}$$

$$BREACH_{size} = f\left(V_{eroded}\right)$$

Non-earthfill

$$V_{eroded} = 0.00348\left(V_{out} * h_w\right)^{0.852}$$



h_w = Pool Elev – Breach Bottom Elev

V_{out} = Pool Volume at Failure

(but is total flow volume – including inflow)

Von Thun & Gillette (1990)

$$B_{avg} = 2.5h_w + C_b$$

$$t_f = 0.02h_w + 0.25 \quad \text{(erosion resistant)}$$

$$t_f = 0.015h_w \quad \text{(easily erodible)}$$

Reservoir Size, m^3	C_b, meters
$< 1.23*10^6$	6.1
$1.23*10^6 - 6.17*10^6$	18.3
$6.17*10^6 - 1.23*10^7$	42.7
$> 1.23*10^7$	54.9

Reservoir Size, acre-feet	C_b, feet
< 1,000	20
1,000-5,000	60
5,000-10,000	140
>10,000	180

Input Data

Top of Dam Elevation (ft): 5644.5

Breach Bottom Elevation (ft): 5523

Pool Elevation at Failure (ft): 5639.5

Pool Volume at Failure (acre-ft): 240000

Failure mode: Overtopping

h_w = Pool Elev – Breach Bottom Elev

V_{out} = Pool Volume at Failure

Froehlich (1995)

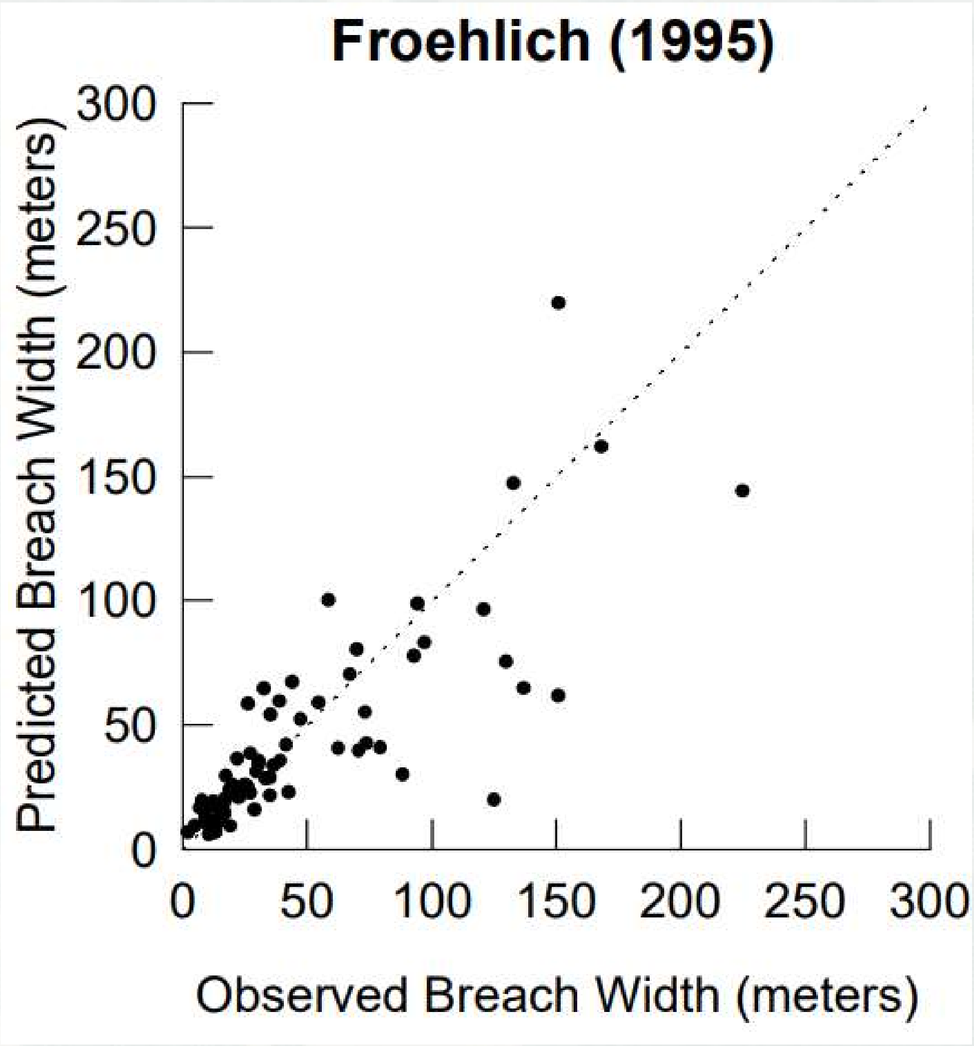
$$B_{ave} = 0.1803\, K_o\, V_w^{0.32}\, h_b^{0.19}$$

$$t_f = 0.00254\, V_w^{0.53}\, h_b^{-0.90}$$

Froehlich (2008)

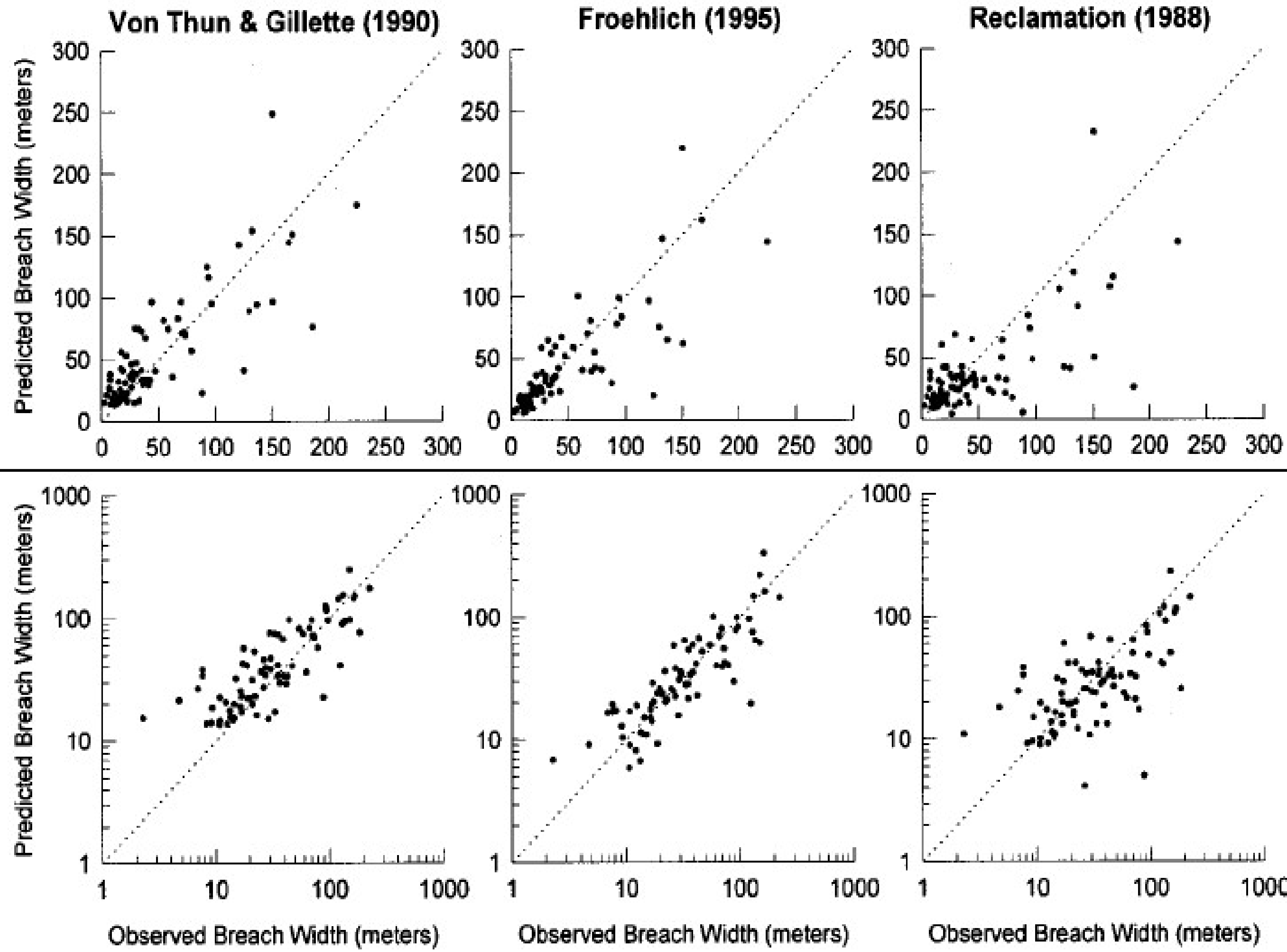
$$B_{ave} = 0.27\, K_o\, V_w^{0.32}\, h_b^{0.04}$$

$$t_f = 20.18\, V_w^{0.5}\, h_b^{-1.0}$$



V_w = Volume of water at h

Width Comparison



Predicted and observed breach widths (Wahl 1998), plotted arithmetically (top) and on logarithmic scales (bottom)

Four Important Ideas

1. Do not mix-and-match width and breach time.

Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	122	0.5	2.57	Select
Froehlich (1995)	628	1.4	3.44	Select
Froehlich (2008)	544	1	3.04	Select
Von Thun & Gilete	363	0.5	0.81	Select
Xu & Zhang	499	1.06	5.05 *	Select

Four Important Ideas

1. Do not mix-and-match width and breach time.

2. Xu & Zang has a different breach development time.

Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	122	0.5	2.57	Select
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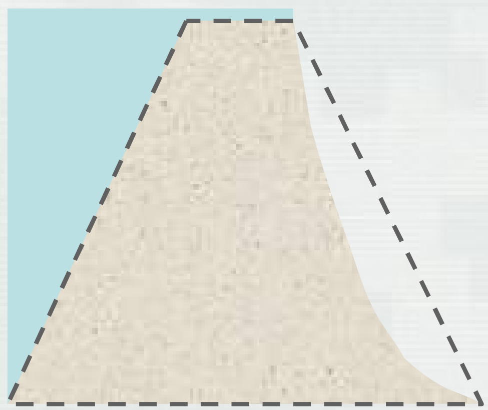
Von Thun & Gilete	363	0.5	0.81	Select
Xu & Zhang	499	1.06	5.05 *	Select

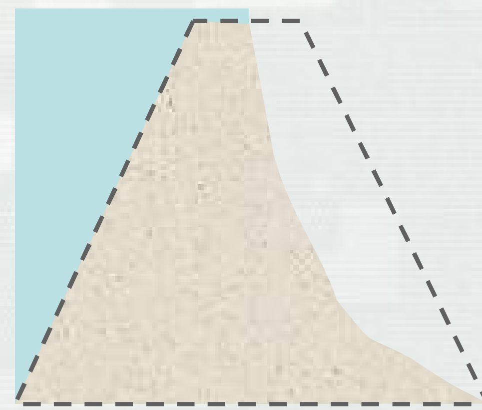
Thought Experiment

When does the clock start for “breach time” in HEC-RAS?

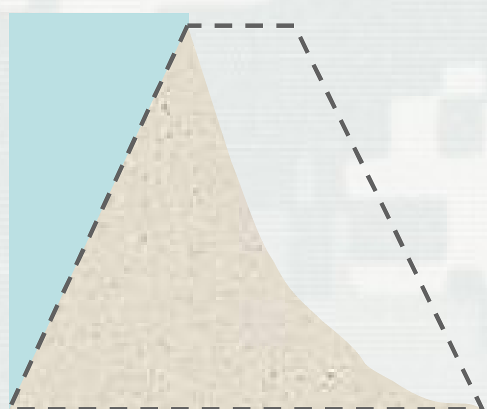
1.)



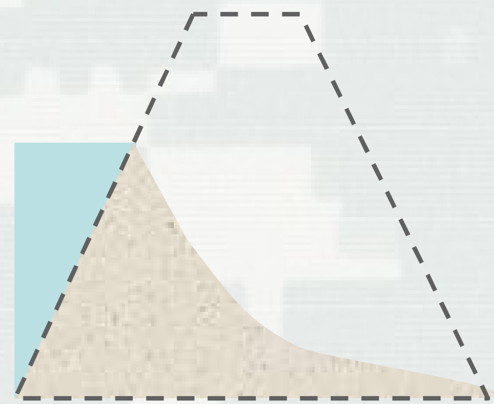
2.)



3.)



4.)



Four Important Ideas

1. Do not mix-and-match width and breach time.

2. Xu & Zang has a different breach development time.

3. Does the breach progression make physical sense?

    -Does it keep eroding at low head?
    -Does it stop eroding with despite high head and velocity?

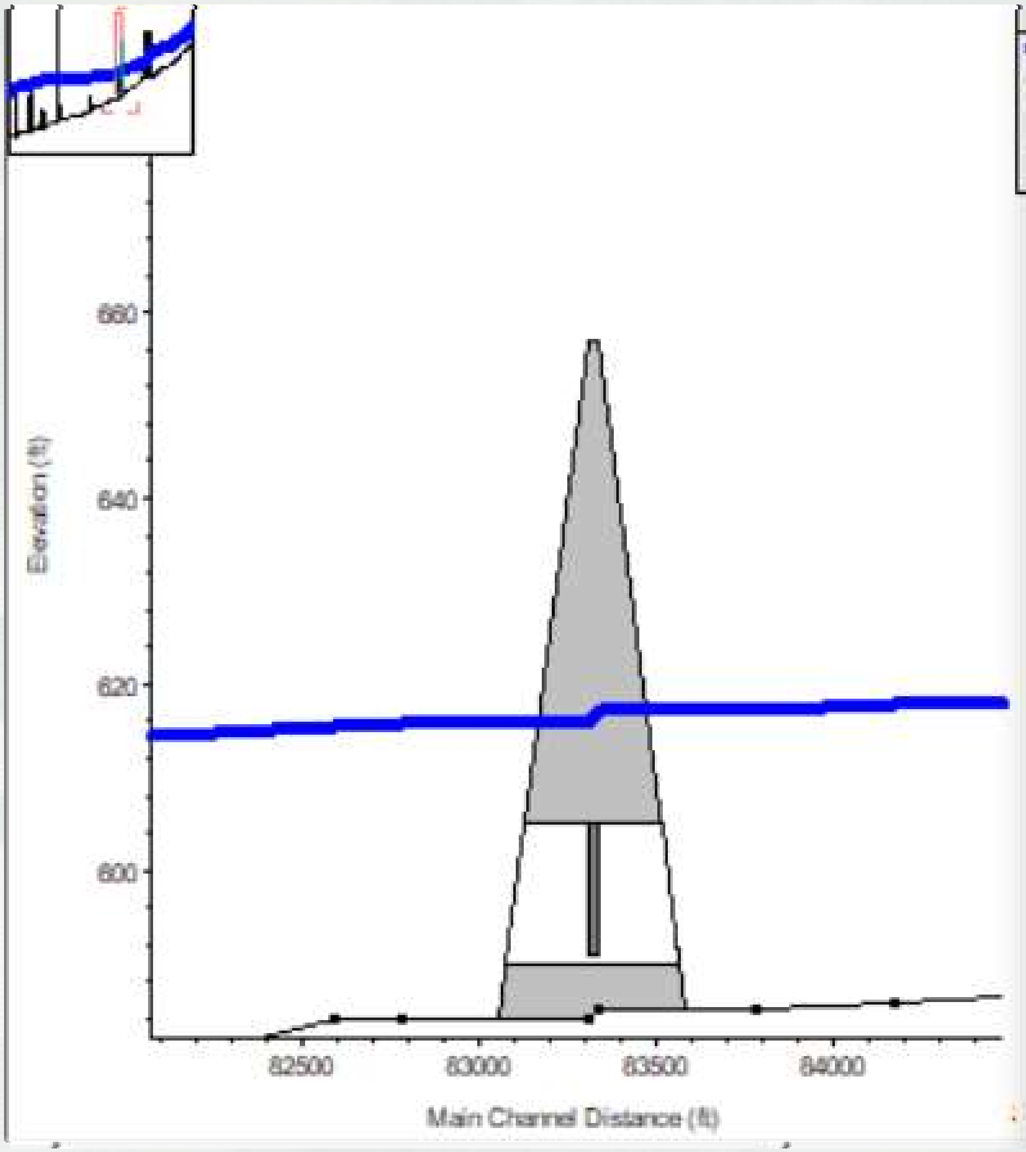
Evaluate Breach Progress

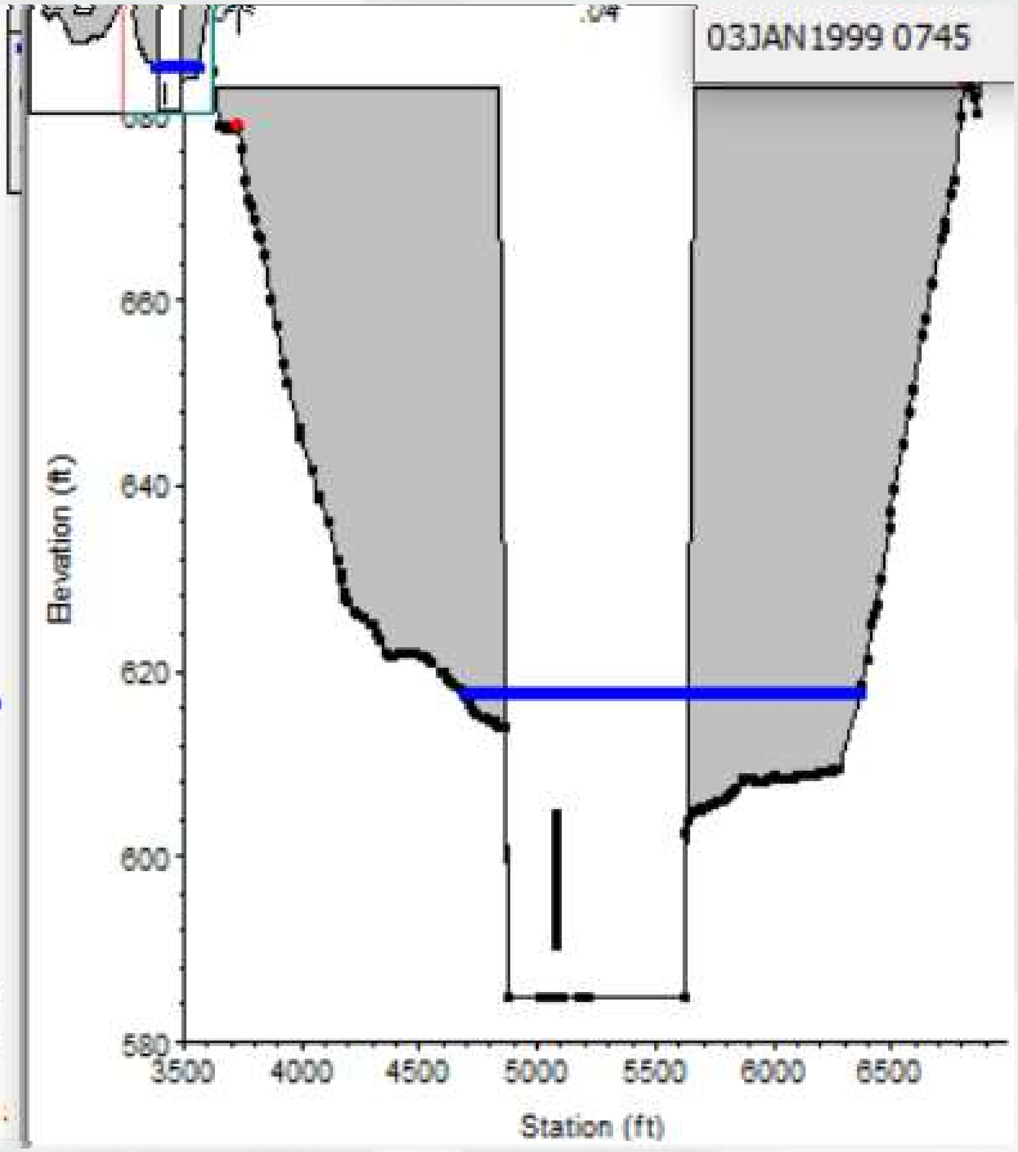
- Breach parameter estimation is uncertain.

Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	122	0.5	2.57	Select
Froehlich (1995)	628	1.4	3.44	Select
Froehlich (2008)	544	1	3.04	Select
Von Thun & Gillete	363	0.5	0.81	Select
Xu & Zhang	499	1.06	5.05 *	Select

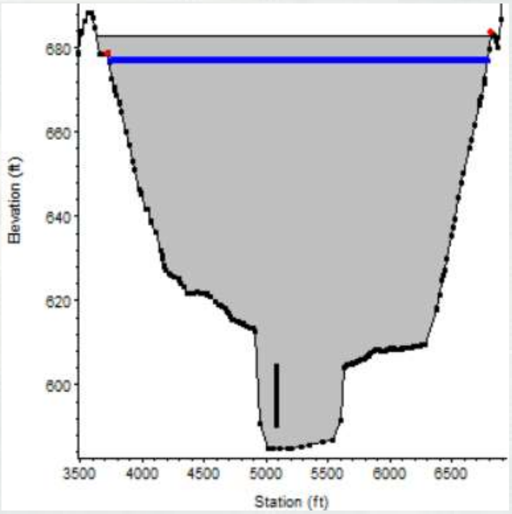
- We can use HEC-RAS hydraulic results to inform our decision on breach parameter selection.

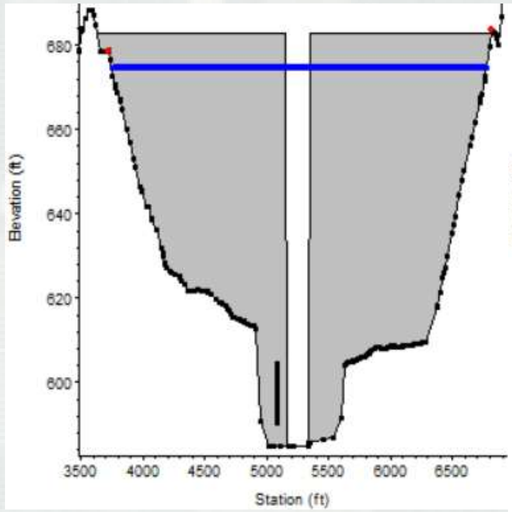
Profile and Breach Plots

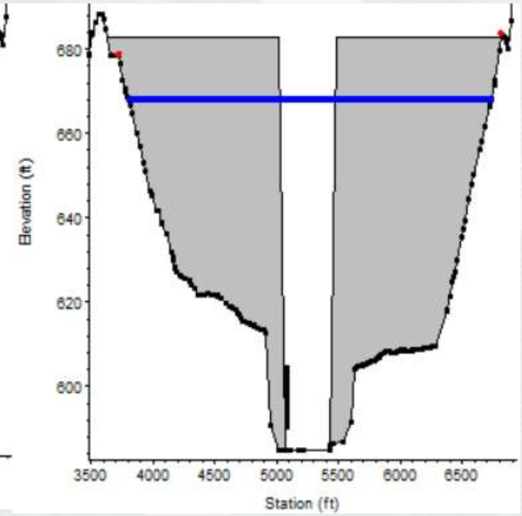


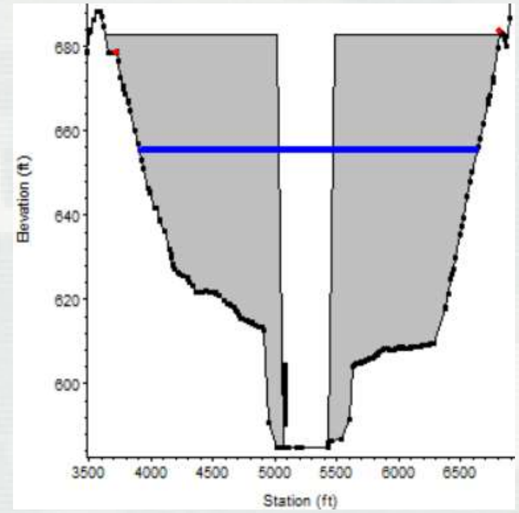


Do you have any concerns about this simulation?

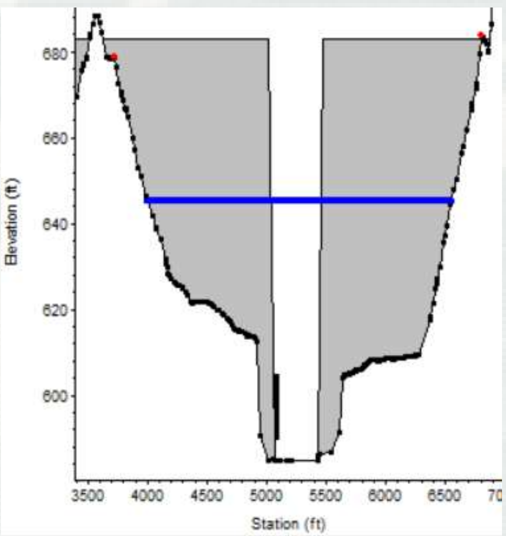


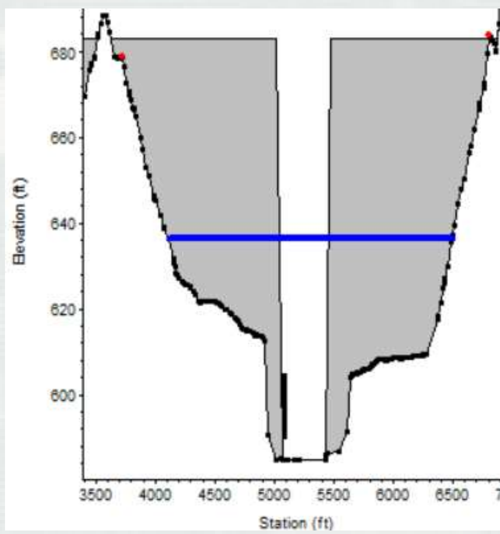


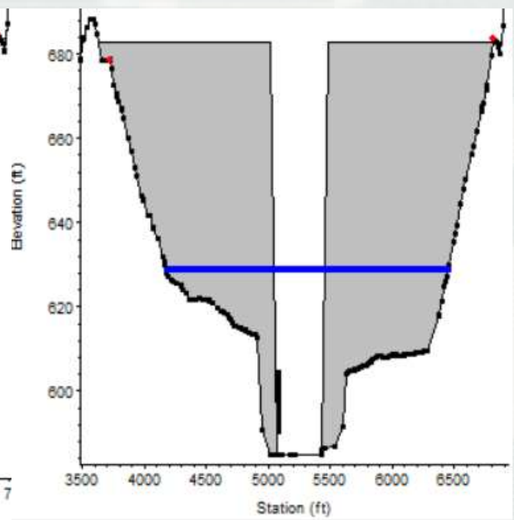


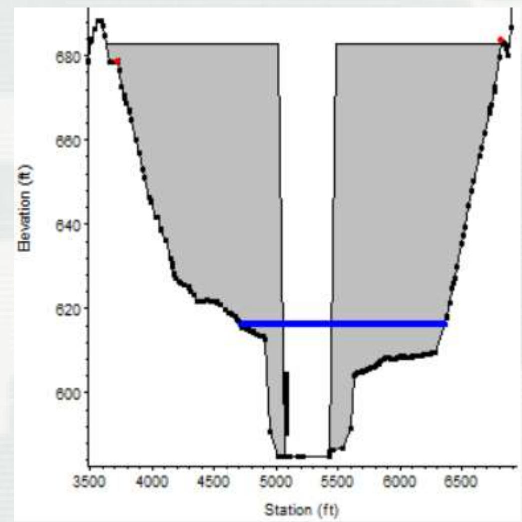


Breach Progression Ends Here



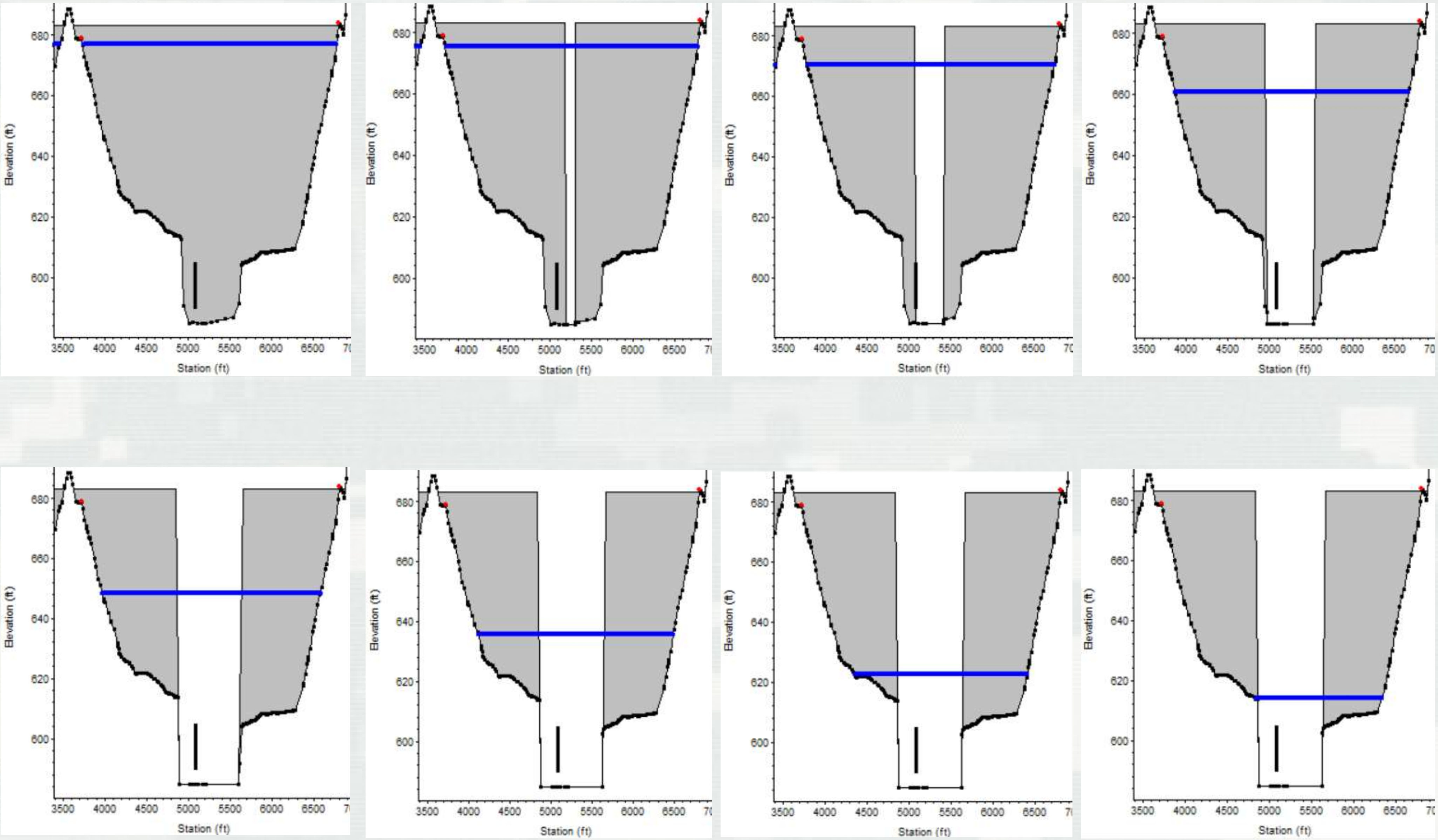






Δ Head and Velocity Still High

This Simulation Continues to Widen for High ΔHead and Velocities



Widening rate in this method is not connected to hydraulics.
The user must check to make sure results make physical sense.

Three Approaches

1. **User Entered Data**

   -Parameter Estimation

User Entered Data

2. **Simplified Physical**

Simplified Physical

3. **DL Breach**

Physical Breaching (DLBreach)

Dam (Inline Structure) Breach Data

Inline Structure: Bald Eagle   Loc Hav   81500

Delete this Breach ... | Delete all Breaches ...

☑ **Breach This Structure**

Breach Method: Simplified Physical

Center Station: 3900

Max Possible Bottom Width: 1800

Min Possible Bottom Elev: 592

Left Side Slope: 2

Right Side Slope: 2

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 1

Failure Mode: Piping

Piping Coefficient: 0.6

Initial Piping Elev: 620

Initial Piping Diameter: 1

☐ Mass Wasting Feature:

Trigger Failure at: WS Elev

Starting WS 668.1

Breach Plot | Breach Progression | Simplified Physical | Breach Repair (optional) | Parameter Calculator

Overtopping Downcutting

	Velocity (ft/s)	Downcutting Rate (ft/hr)
1	0	0
2	2	0
3	3	1
4	4	2
5	5	5
6	7	15
7	10	30
8	20	50
9	30	100
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

Widening Relationship

	Velocity (ft/s)	Widening Rate (ft/hr)
1	0	0
2	2	0
3	3	1
4	4	2
5	5	5
6	7	15
7	10	30
8	20	50
9	30	100
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

OK | Cancel

Where do these rates come from?

MMC PRODUCTION CENTER
Modeling | Mapping | Consequences

Prepared by:
MMC MCX

Appendix 3.X.X – Application of Simplified Physical Breach Method in HEC-RAS

FY17 MMC Technical Manual SOP

July 2018

Draft

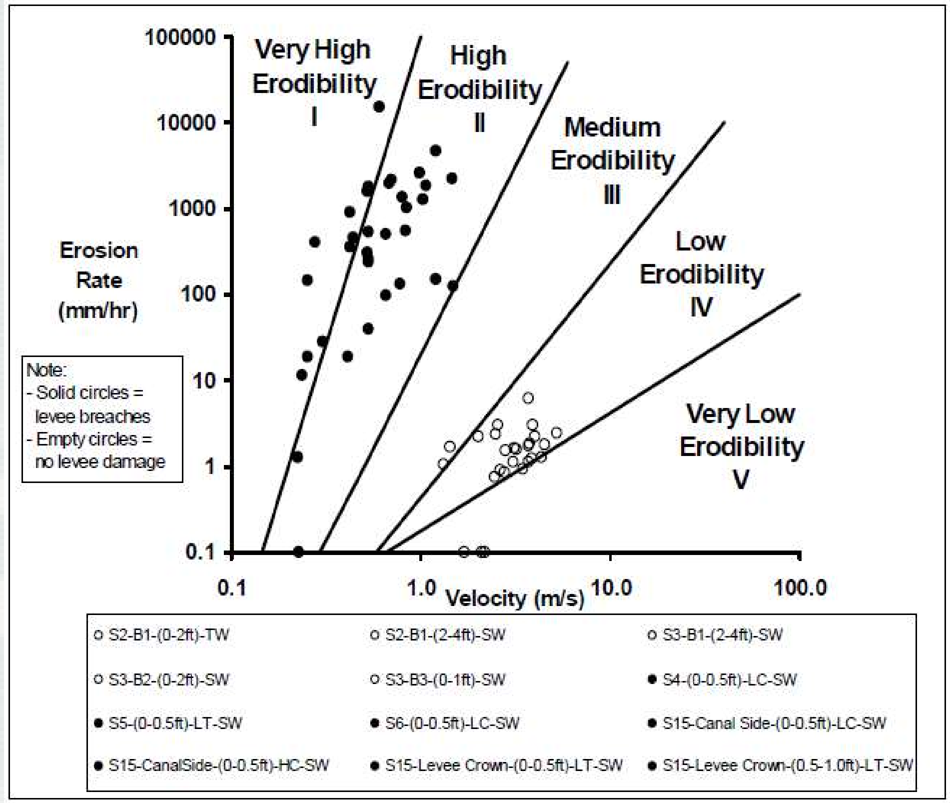
FOR OFFICIAL USE ONLY (FOUO)

Technical Memorandum for Record

Date: May 31, 2013 (Revised July 2, 2013)

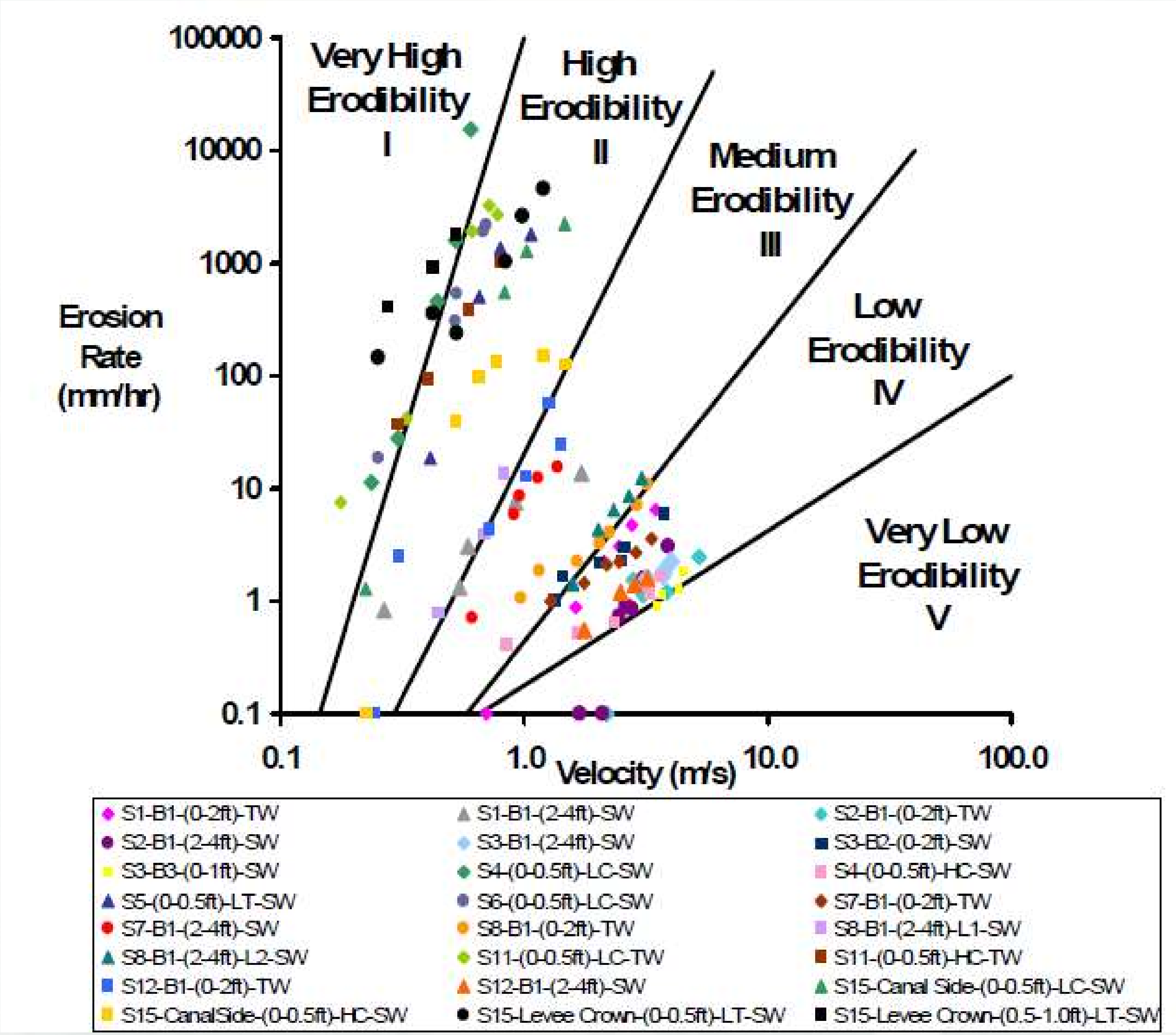
From: Chris Bahner, P.E., D. WRE

Subject: Updated Levee Breach Characteristics for MMC SOP



The guidance is under development.
There are some historic values that can help.

BUILDING STRONG®


Very High Erodibility I
High Erodibility II
Medium Erodibility III
Low Erodibility IV
Very Low Erodibility V
Erosion Rate (mm/hr)
100000
10000
1000
100
10
1
0.1
0.1
1.0
10.0
100.0
Velocity (m/s)
S1-B1-(0-2ft)-TW
S1-B1-(2-4ft)-SW
S2-B1-(0-2ft)-TW
S2-B1-(2-4ft)-SW
S3-B1-(2-4ft)-SW
S3-B2-(0-2ft)-SW
S3-B3-(0-1ft)-SW
S4-(0-0.5ft)-LC-SW
S4-(0-0.5ft)-HC-SW
S5-(0-0.5ft)-LT-SW
S6-(0-0.5ft)-LC-SW
S7-B1-(0-2ft)-TW
S7-B1-(2-4ft)-SW
S8-B1-(0-2ft)-TW
S8-B1-(2-4ft)-L1-SW
S8-B1-(2-4ft)-L2-SW
S11-(0-0.5ft)-LC-TW
S11-(0-0.5ft)-HC-TW
S12-B1-(0-2ft)-TW
S12-B1-(2-4ft)-SW
S15-Canal Side-(0-0.5ft)-LC-SW
S15-CanalSide-(0-0.5ft)-HC-SW
S15-Levee Crown-(0-0.5ft)-LT-SW
S15-Levee Crown-(0.5-1.0ft)-LT-SW

Three Approaches

1. **User Entered Data** — User Entered Data

   -Parameter Estimation

2. **Simplified Physical** — Simplified Physical

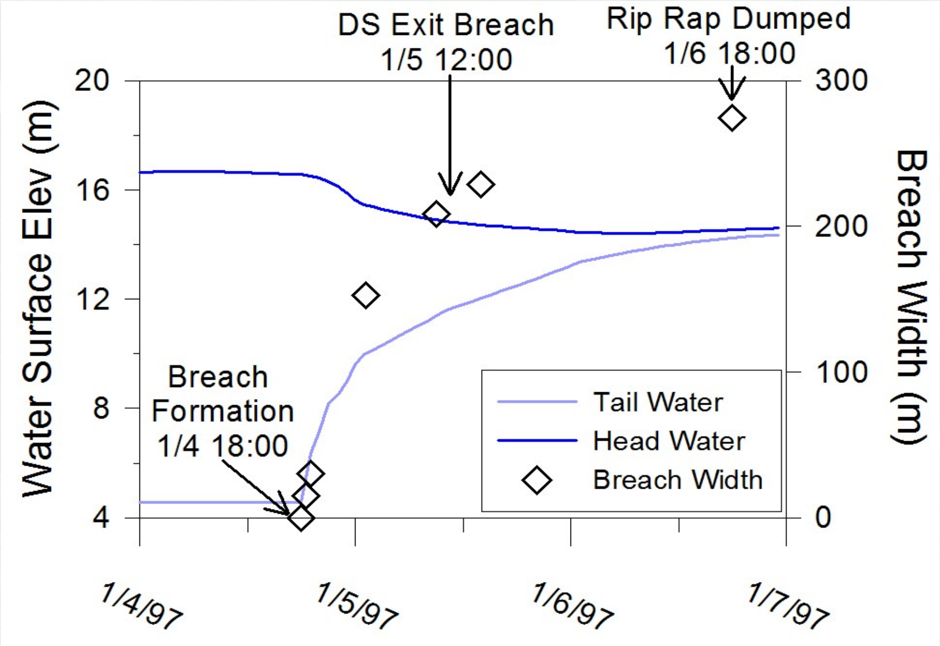
3. **DL Breach** — Physical Breaching (DLBreach)

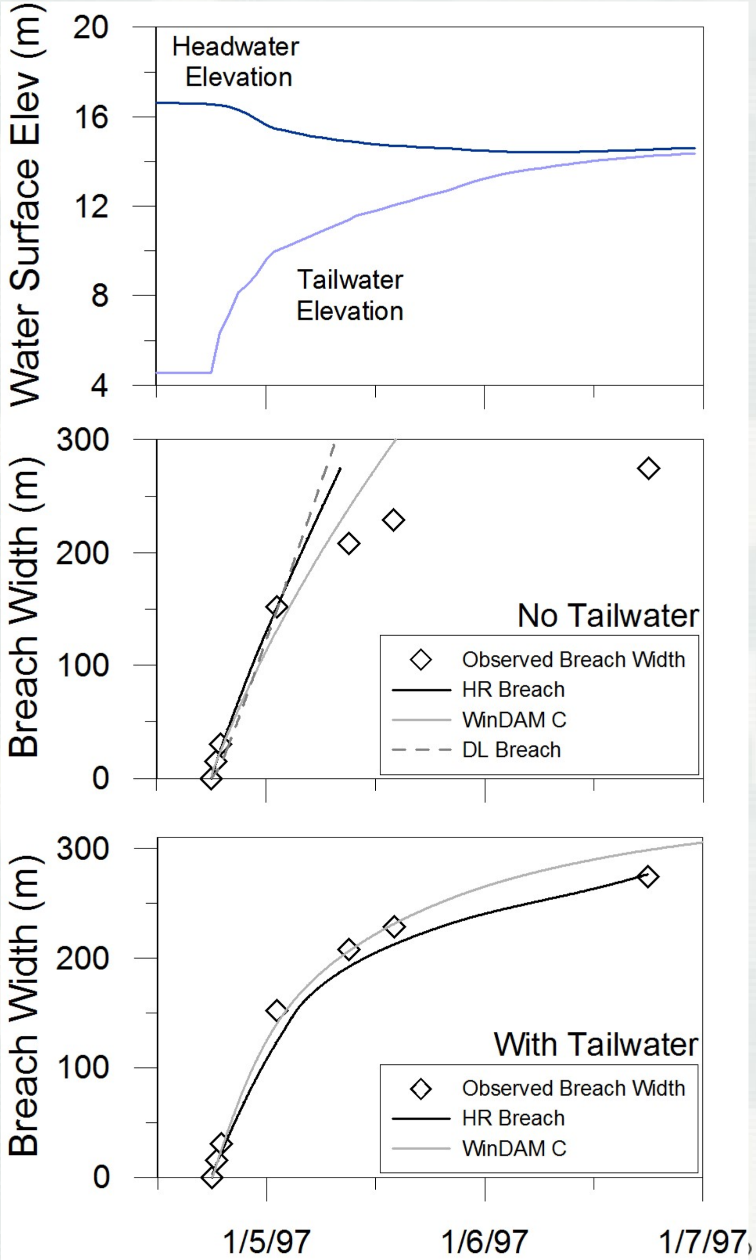
Estimating the Breach Evolution

Process Models:

- ►ARS SIMBA/WinDAMB
- ►HR-BREACH (HR Wallingford)
- ►DL Breach (Dr Weiming Wu)

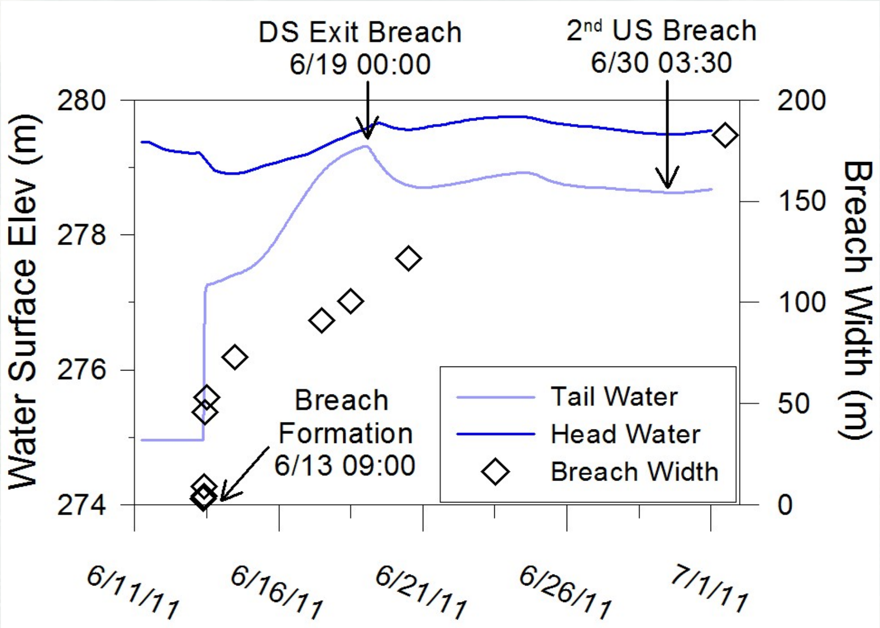
Sutter Bypass Levee Breach

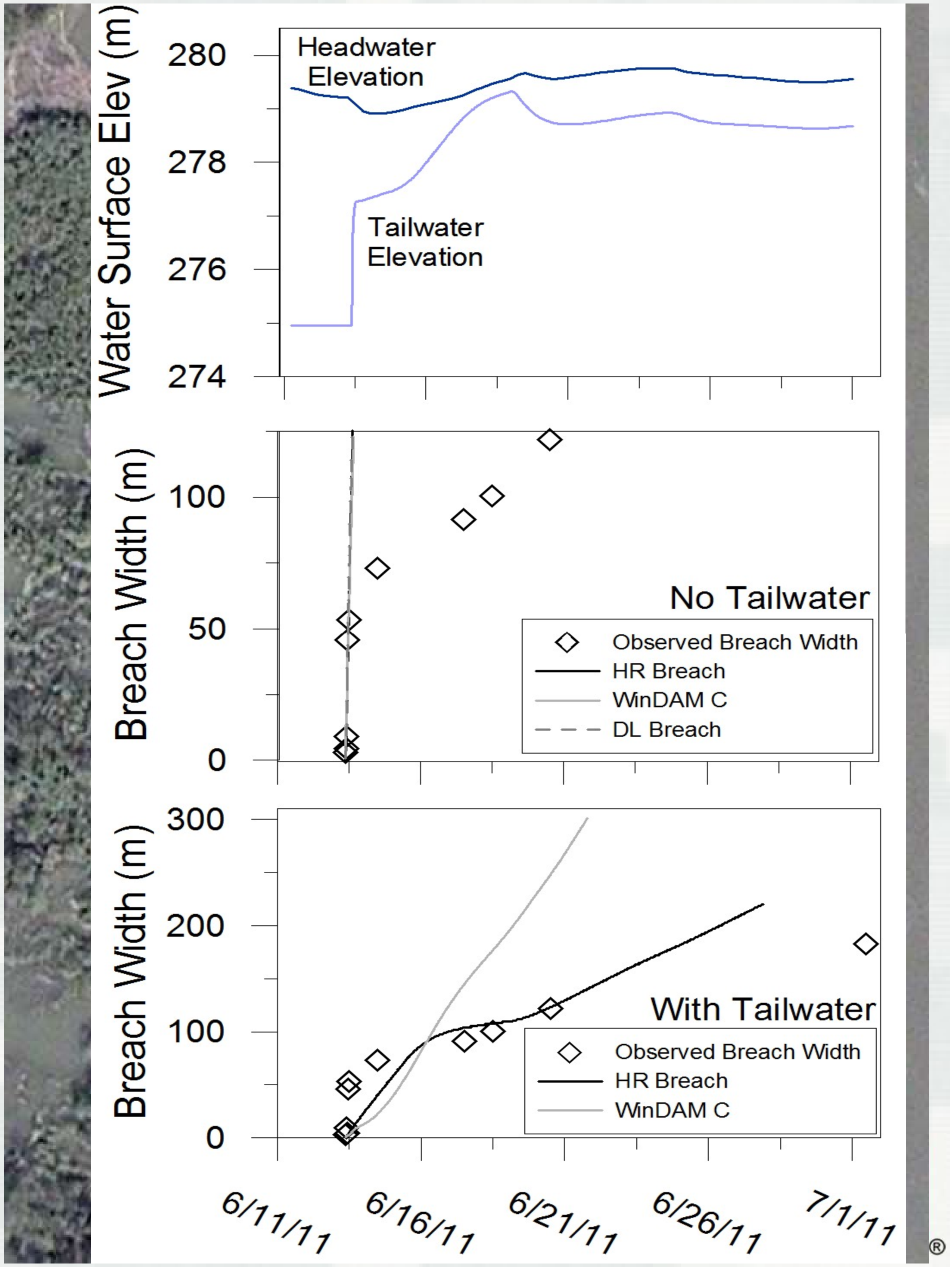




From: Risher, P. and Gibson, S. (2016) "Applying Mechanistic Dam Breach Models to Historic Levee Breaches," Proceedings FloodRisk 2016.

Hamburg Breach (Missouri River)



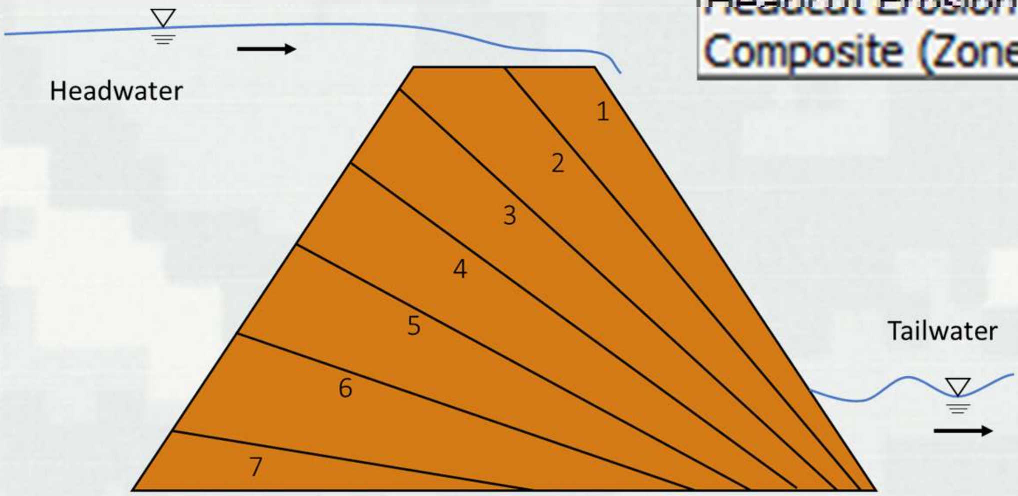


From: Risher, P. and Gibson, S. (2016) "Applying Mechanistic Dam Breach Models to Historic Levee Breaches," Proceedings FloodRisk 2016.

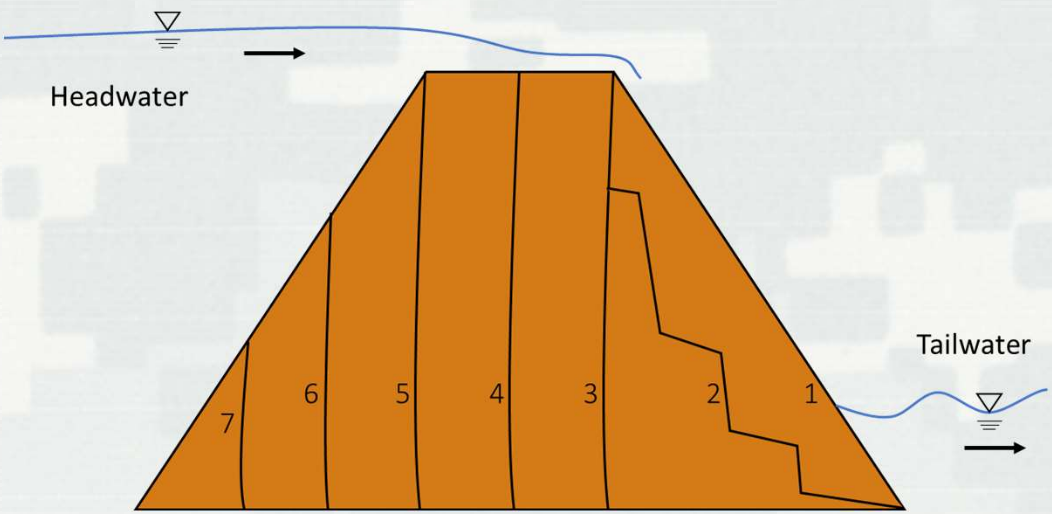
DLBreach

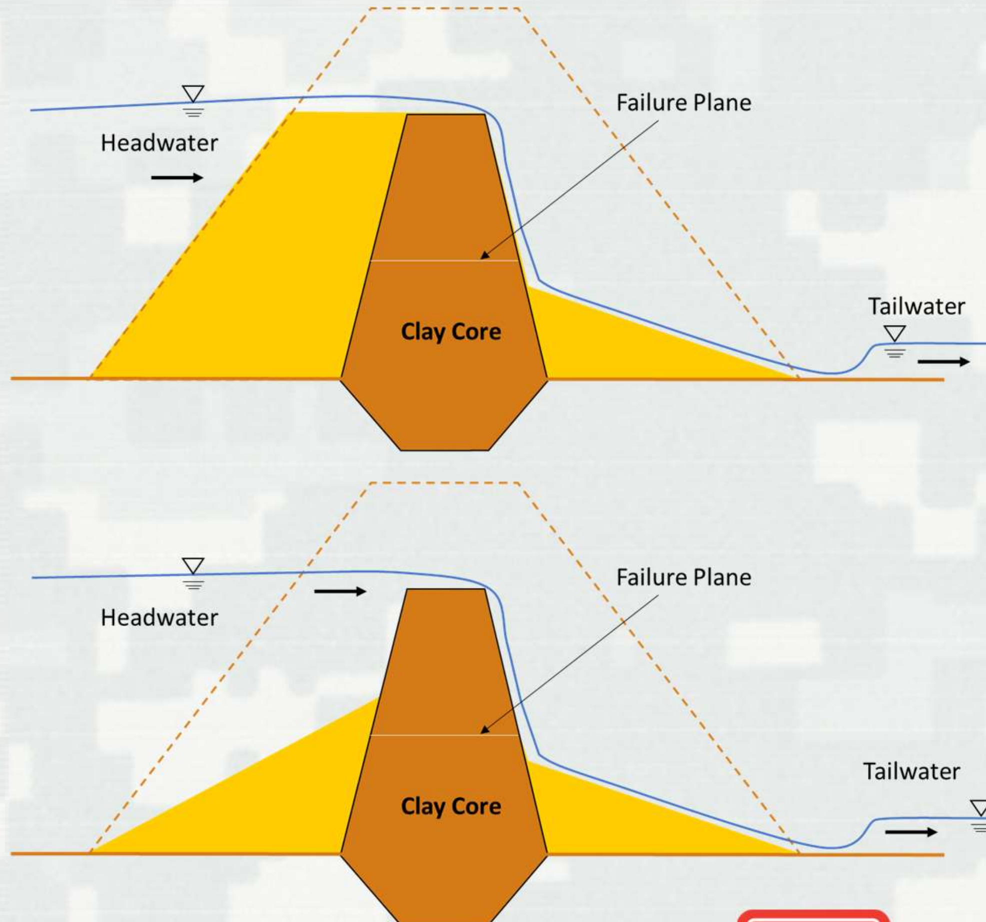
Surface Erosion
Headcut Erosion
Composite (Zoned) Structure

Surface



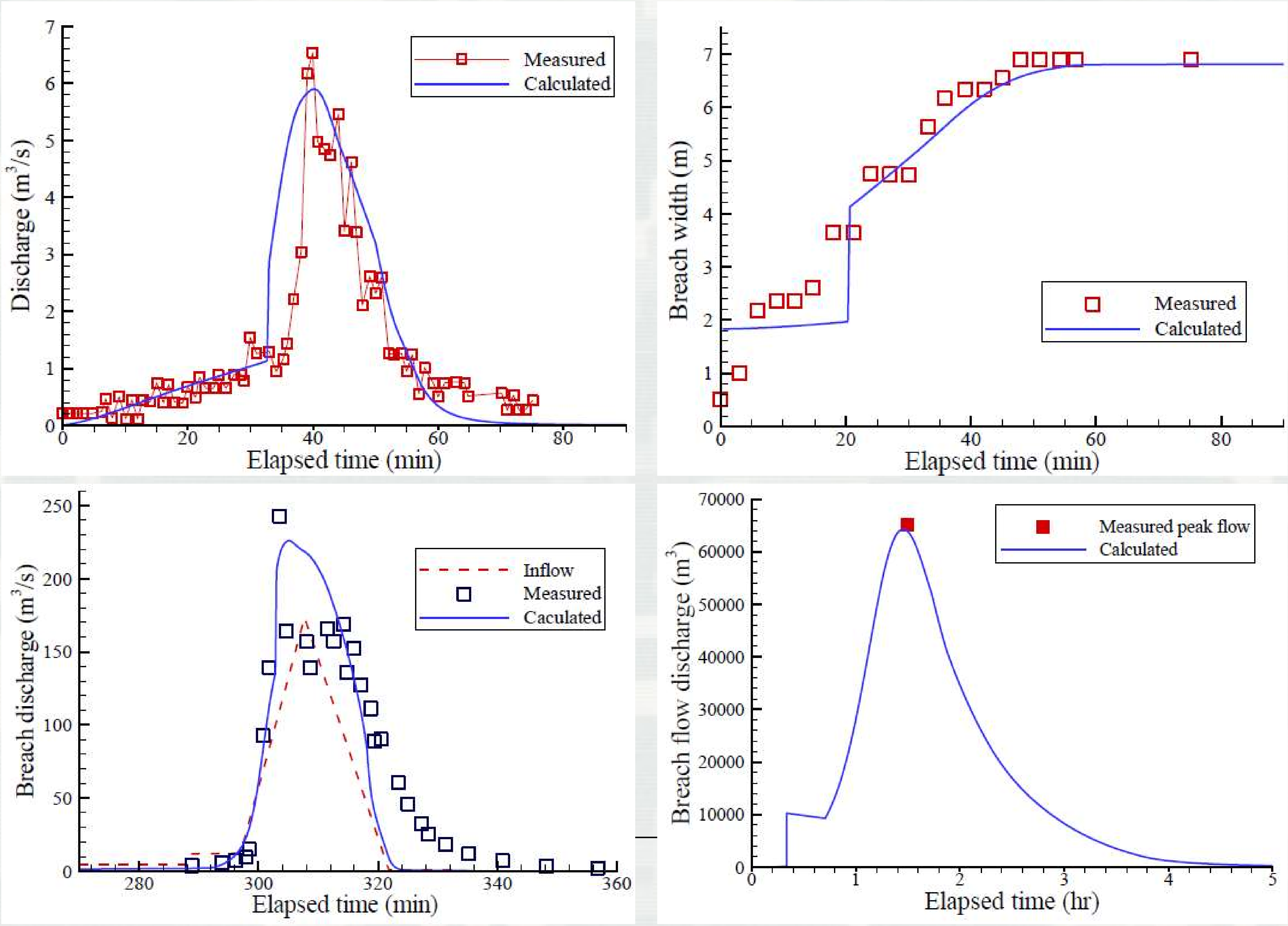
Headcut





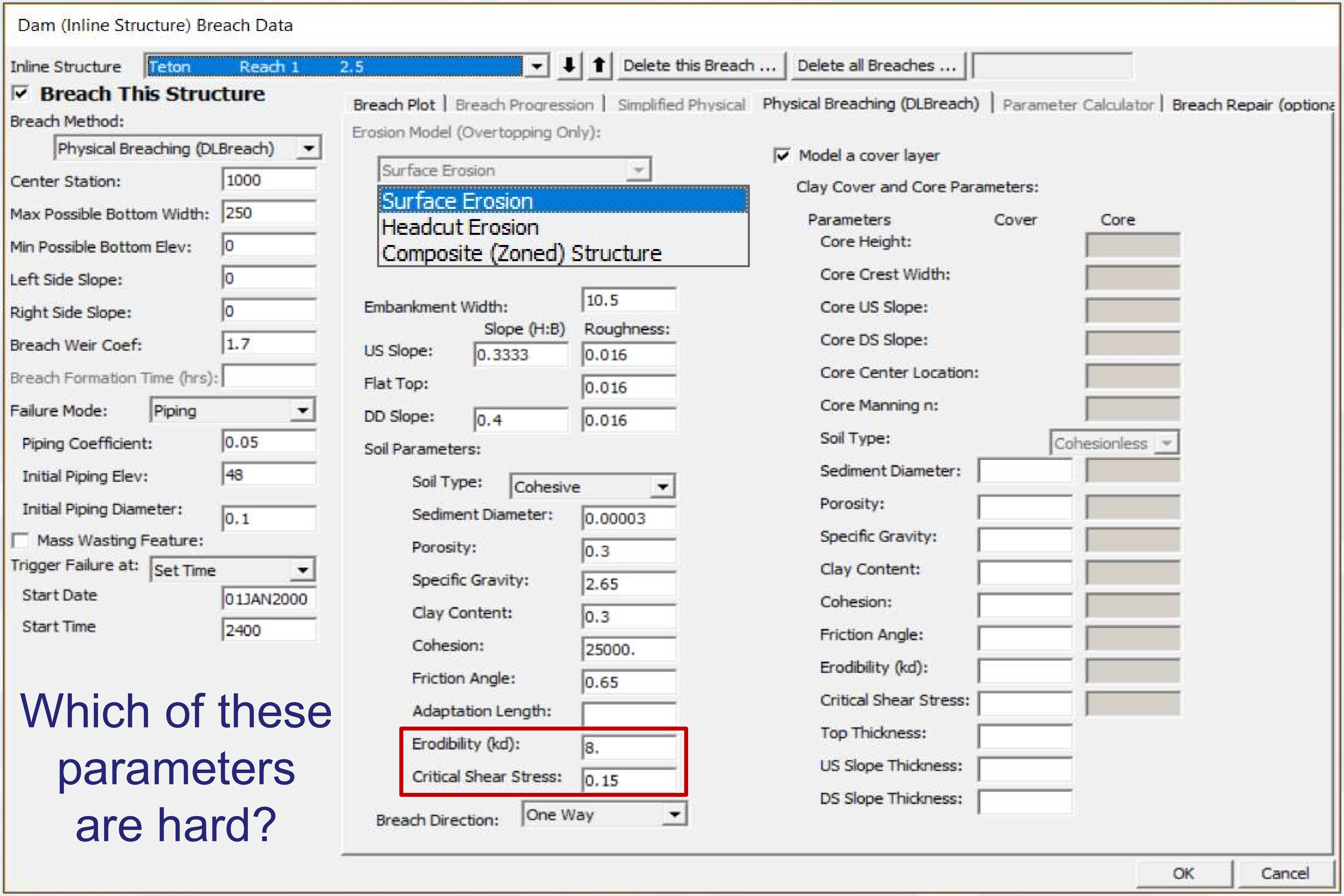
Composite

DLBreach



Measured
Calculated
Discharge (m³/s)
Elapsed time (min)
Measured
Calculated
Breach width (m)
Elapsed time (min)
Inflow
Measured
Caculated
Breach discharge (m³/s)
Elapsed time (min)
Measured peak flow
Calculated
Breach flow discharge (m³)
Elapsed time (hr)

DLBreach



Which of these parameters are hard?

Four Important Ideas

1. Do not mix-and-match width and breach time.

2. Xu & Zang has a different breach development time.

3. Does the breach progression make physical sense?

4. Test sensitivity…on important result.

   (e.g. Arrival Time/Max Stage vs Breach Geometry)

   -Try multiple methods

US Army Corps
of Engineers
Hydrologic Engineering Center

Using HEC-RAS for Dam Break Studies

August 2014

https://www.hec.usace.army.mil/publications/TrainingDocuments/TD-39.pdf

Approved for Public Release. Distribution Unlimited.

TD-39

USBR Levee Breach Lab Studies

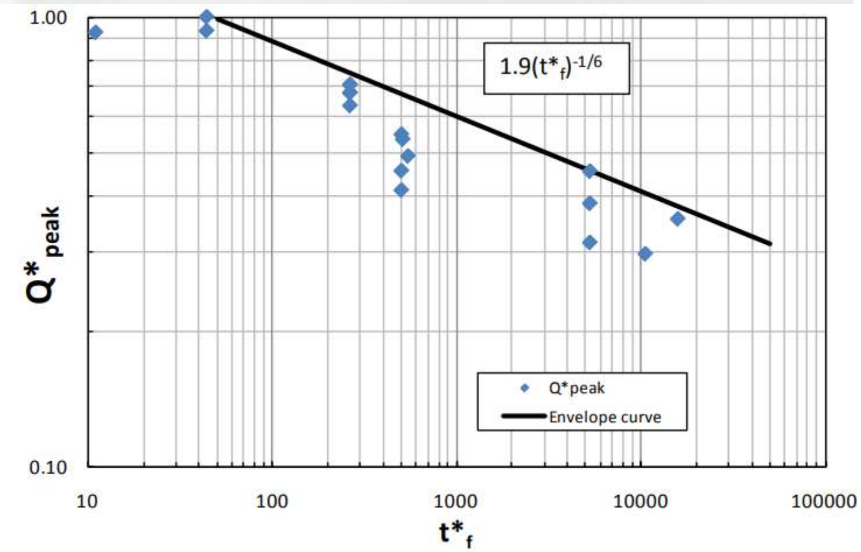


Figure 28. — Dimensionless peak discharge as a function of dimensionless breach development time.

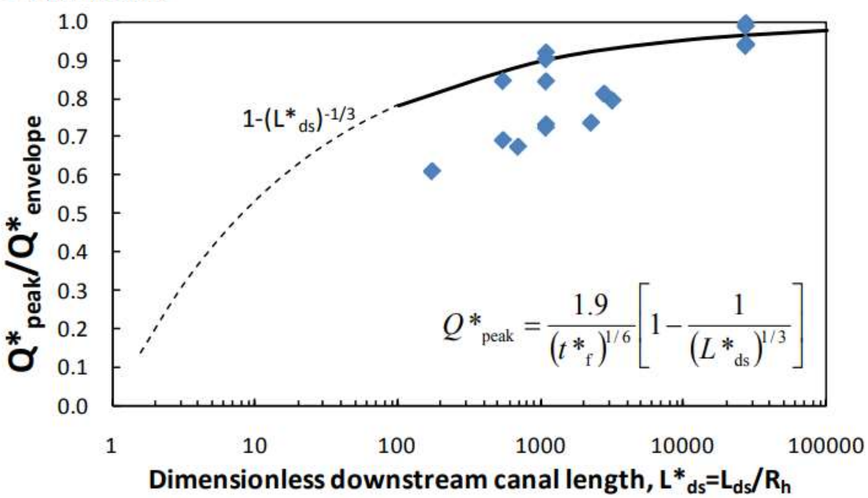


Figure 29. — Effect of downstream canal reach length on peak breach outflow.

RECLAMATION

Managing Water in the West

Hydraulic Laboratory Report HL-2011-09

Physical Hydraulic Modeling of Canal Breaches

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

September 2011

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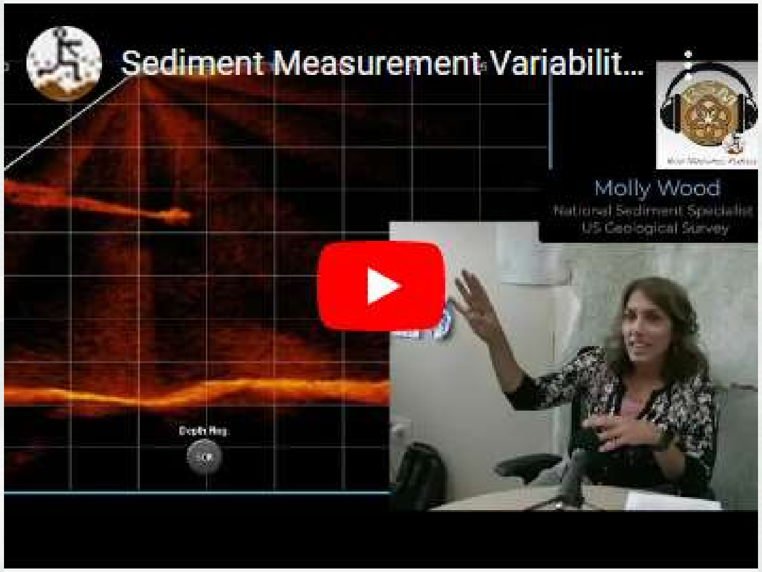
A Brief Plug

The RSM River Mechanics Podcast

River Mechanics Podcast



Includes Conversations on:

- ►Sediment Transport
- ►River Processes
- ►Channel Response to Engineering Measures
- ►Dam Removal Modeling
- ►River Restoration

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