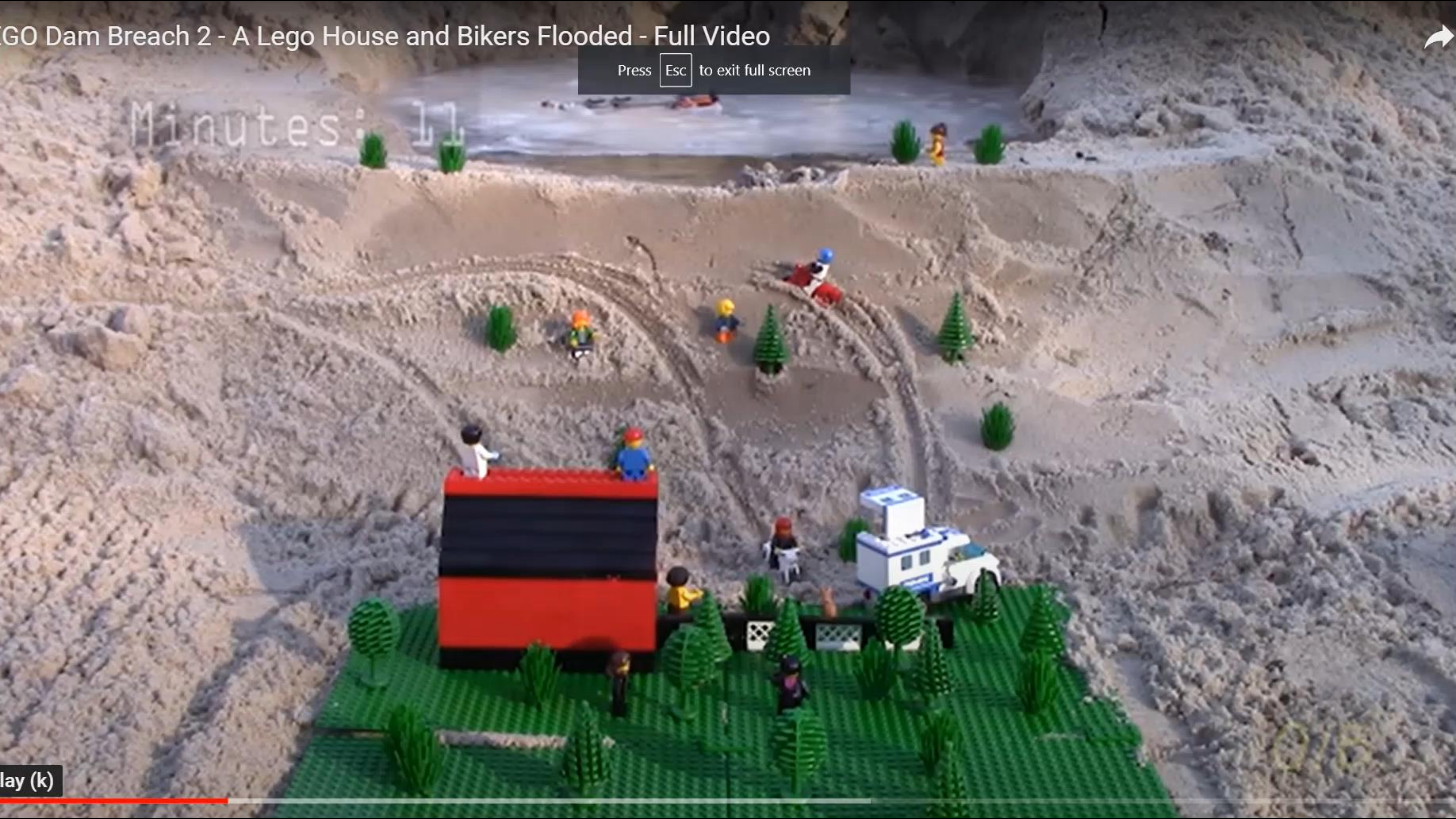
Dam Breach Parameters

Stanford Gibson, PhD


GO Dam Breach 2 - A Lego House and Bikers Flooded - Full Video
Press Esc to exit full screen
Minutes: 11
lay (k)

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...

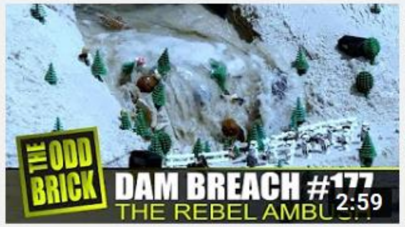
47K views • 3 months ago

LEGO Dam Breach #179 - A Castle Wrecked

51K views • 4 months ago

LEGO Dam Breach #178 - Toy Story Playgound

34K views • 4 months ago



LEGO Dam Breach 177 - The Rebel Ambush

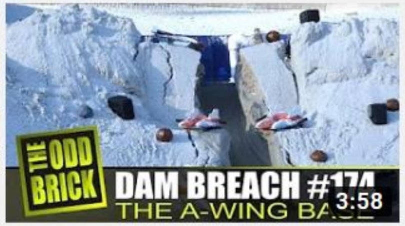
34K views • 4 months ago

LEGO Dam Breach #176 - Toy Story Carnival

26K views • 4 months ago

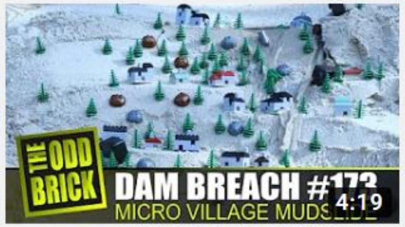
LEGO Dam Breach #175 - The Fantastic T-Rex

52K views • 5 months ago



LEGO Dam Breach #174 - The A-Wing Base

36K views • 5 months ago

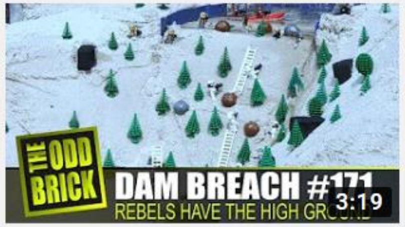


LEGO Dam Breach #173 - Micro Village Mudslide

69K views • 5 months ago

LEGO Dam Breach #172 - Riding the Rapids at Camp

134K views • 5 months ago



LEGO Dam Breach #171 - Rebels Have the High Ground

36K views • 5 months ago

LEGO Dam Breach #170 - Sand Castle Battle

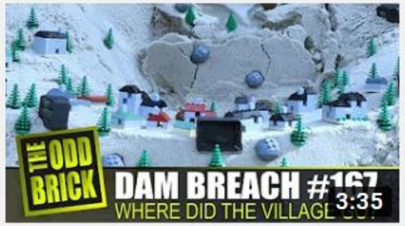
246K views • 5 months ago

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

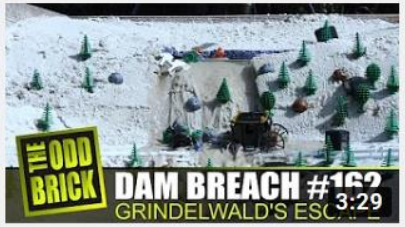
LEGO Dam Breach #166 - Sand Castle Collapse

155K views • 6 months ago

LEGO Dam Breach #165 - Rebuild the Cabin!

LEGO Dam Breach #164 - Raptors in Fantastic Beasts?

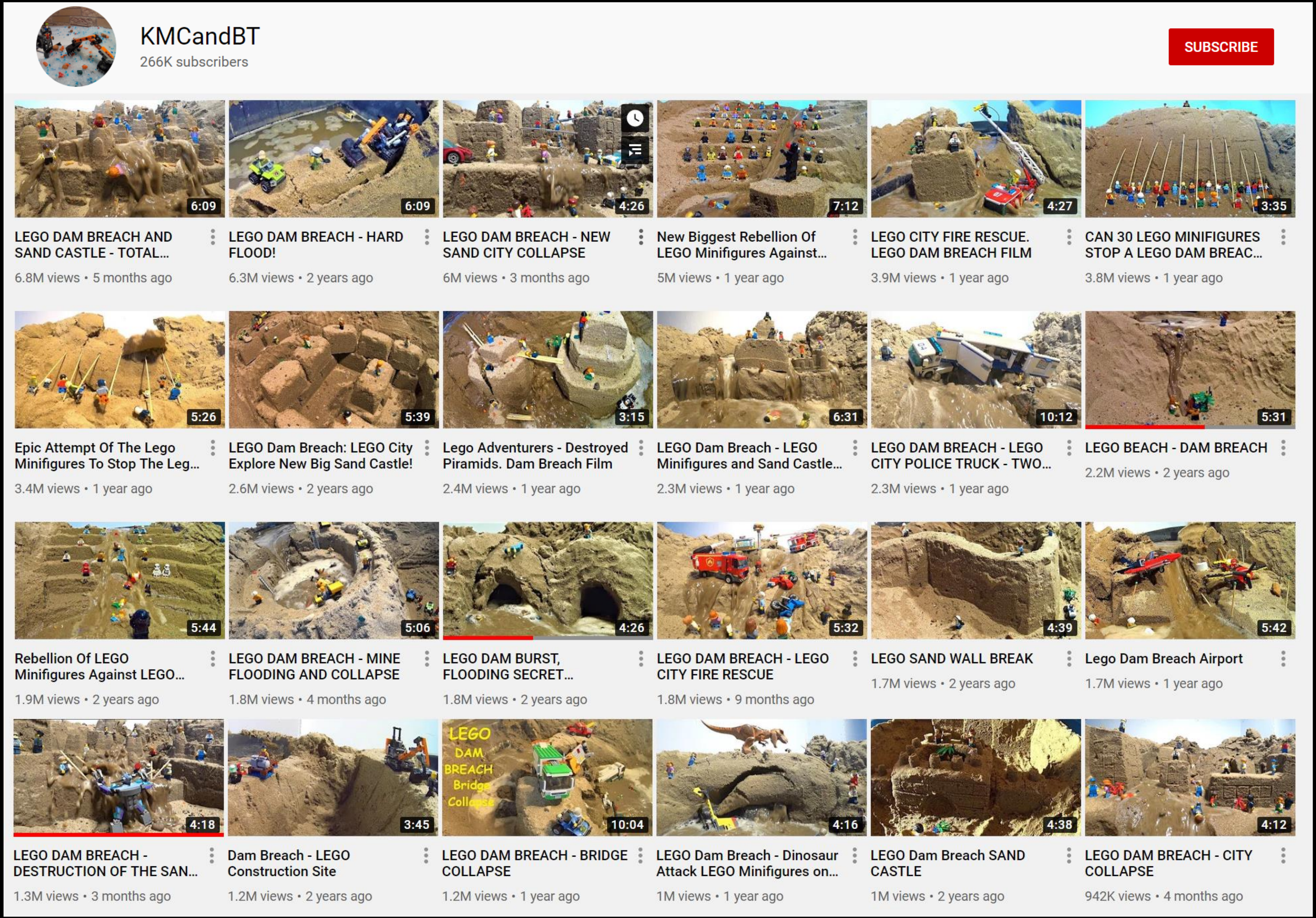
LEGO Dam Breach #163 - Piggy Farm Returns



LEGO Dam Breach #162 - Grindelwald's Escape

LEGO Slow Motion #02 - Monster Truck Crashes

LEGO Dam Breach #161 - A House Washes Away

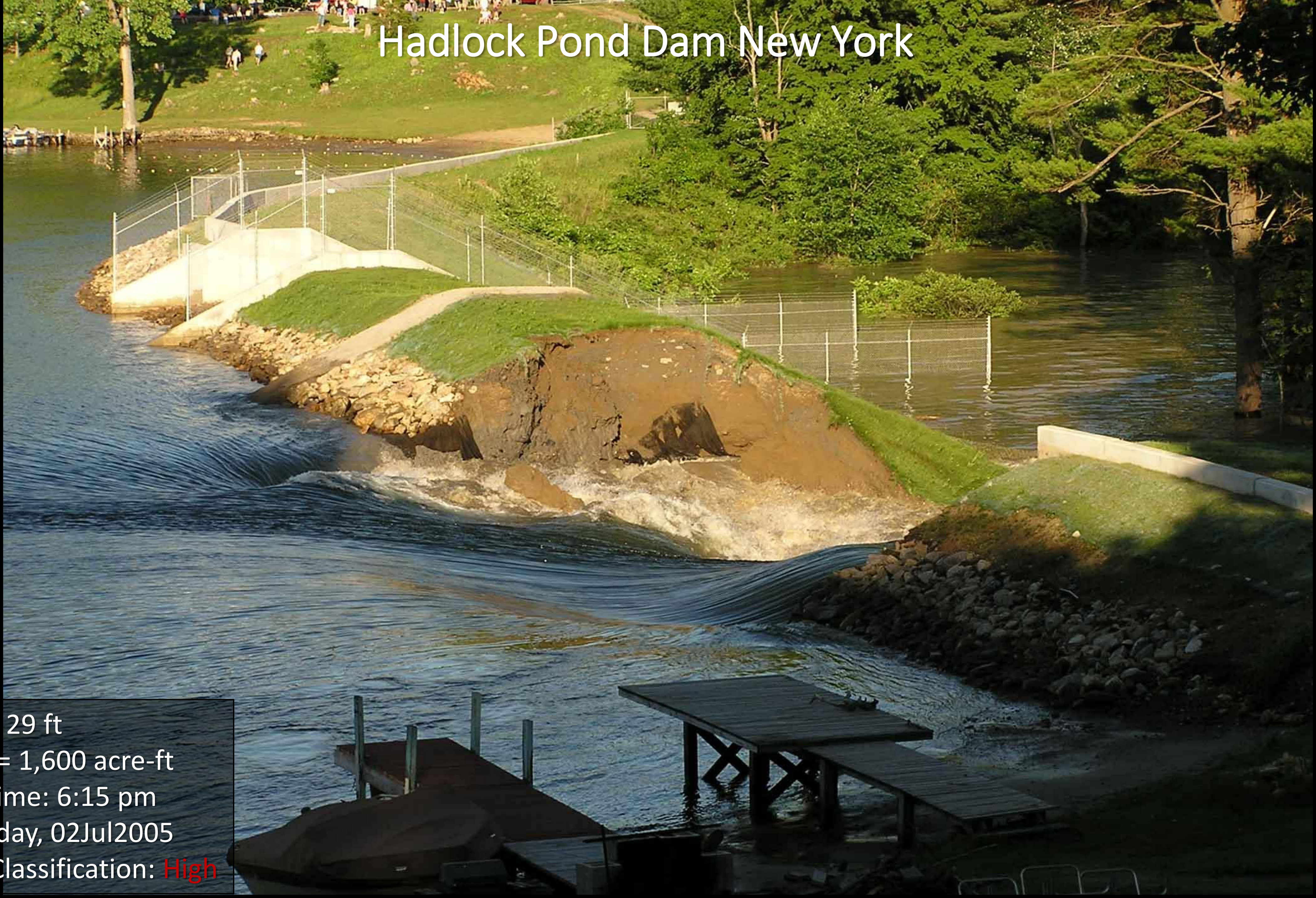

KMCandBT
266K subscribers
SUBSCRIBE
6:09
LEGO DAM BREACH AND SAND CASTLE - TOTAL...
6.8M views • 5 months ago
6:09
LEGO DAM BREACH - HARD FLOOD!
6.3M views • 2 years ago
4:26
LEGO DAM BREACH - NEW SAND CITY COLLAPSE
6M views • 3 months ago
7:12
New Biggest Rebellion Of LEGO Minifigures Against...
5M 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

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.

Hadlock Pond Dam New York



Height = 29 ft
Storage = 1,600 acre-ft
Failure time: 6:15 pm
Saturday, 02Jul2005
Hazard Classification: High

Taum Sauk Upper Dam, Missouri

Height = 94 ft
Storage = 1,600 acre-ft
Failure time: 5:20 am
Wednesday, 14Dec2005
Hazard Classification: High

NEW BRAUNFELS Herald-Zeitung HZ

Dunlap Dam Failure

Guadalupe Blanco River Authority May 15, 2019 1


05-14-2019 08:05:46
Press Esc to exit full screen
Dunlap_Dam


Michigan dam failure caught on video
Press Esc to exit full screen

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)

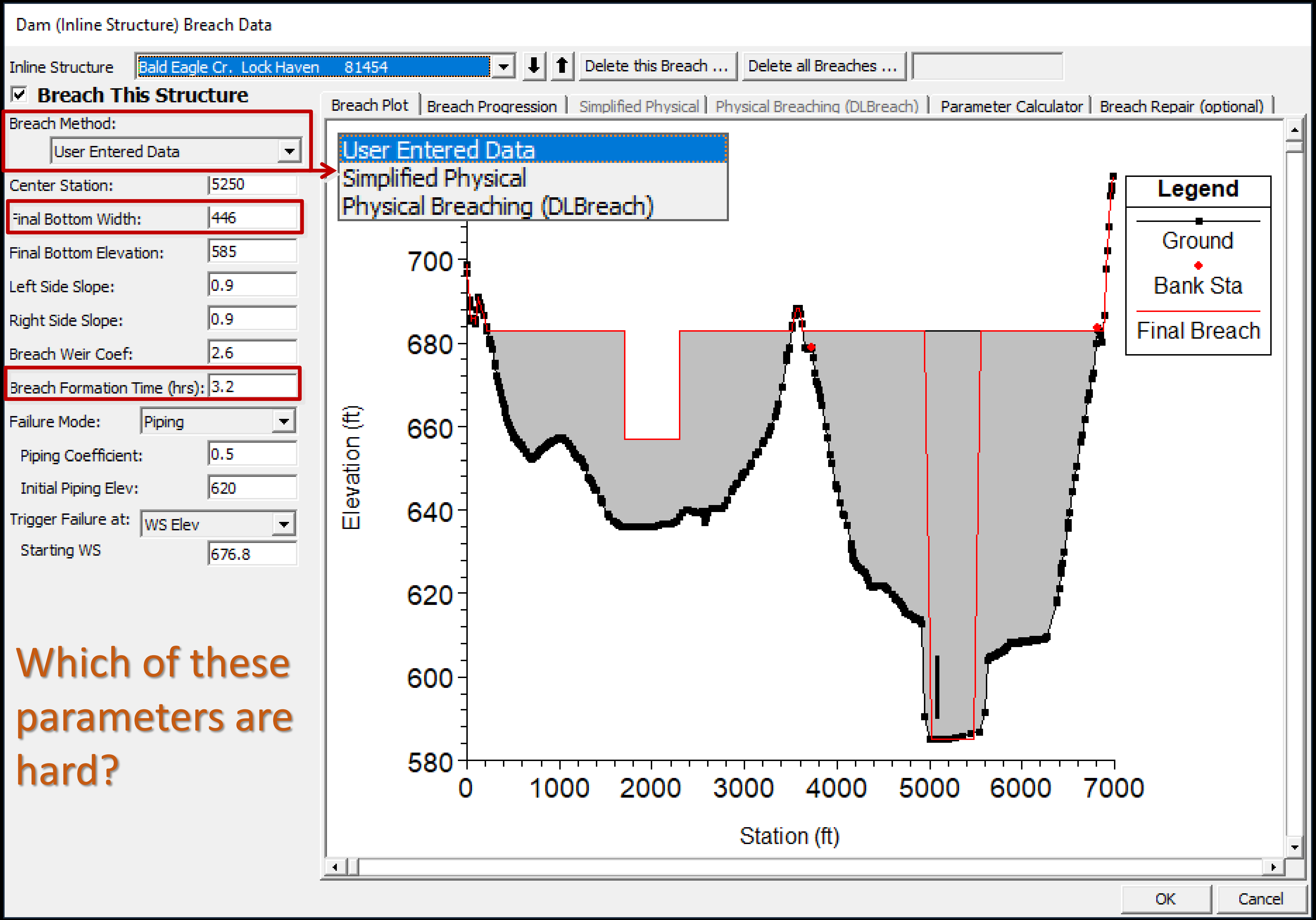
1. User Entered Data

-Parameter Estimation

2. Simplified Physical

3. DL Breach

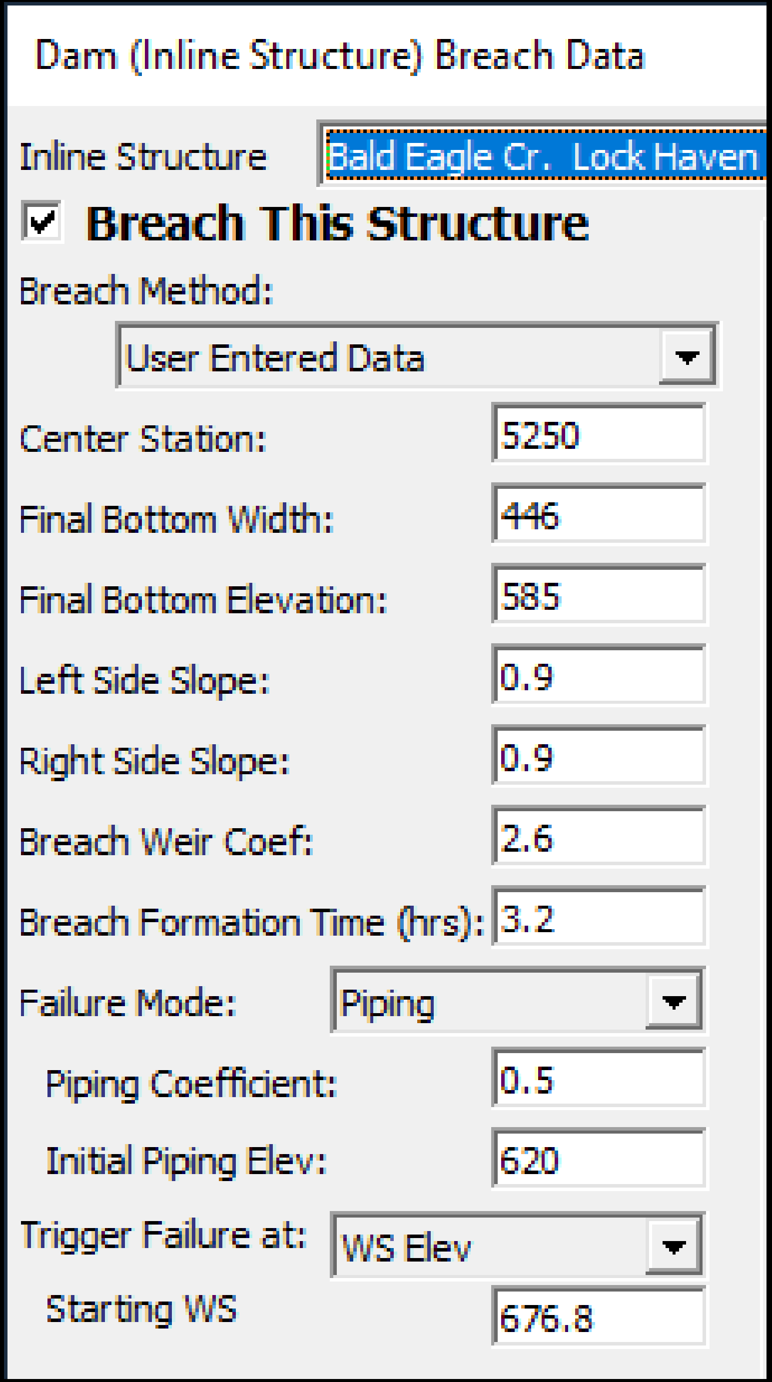
HEC-RAS Breach Data



Which of these parameters are hard?

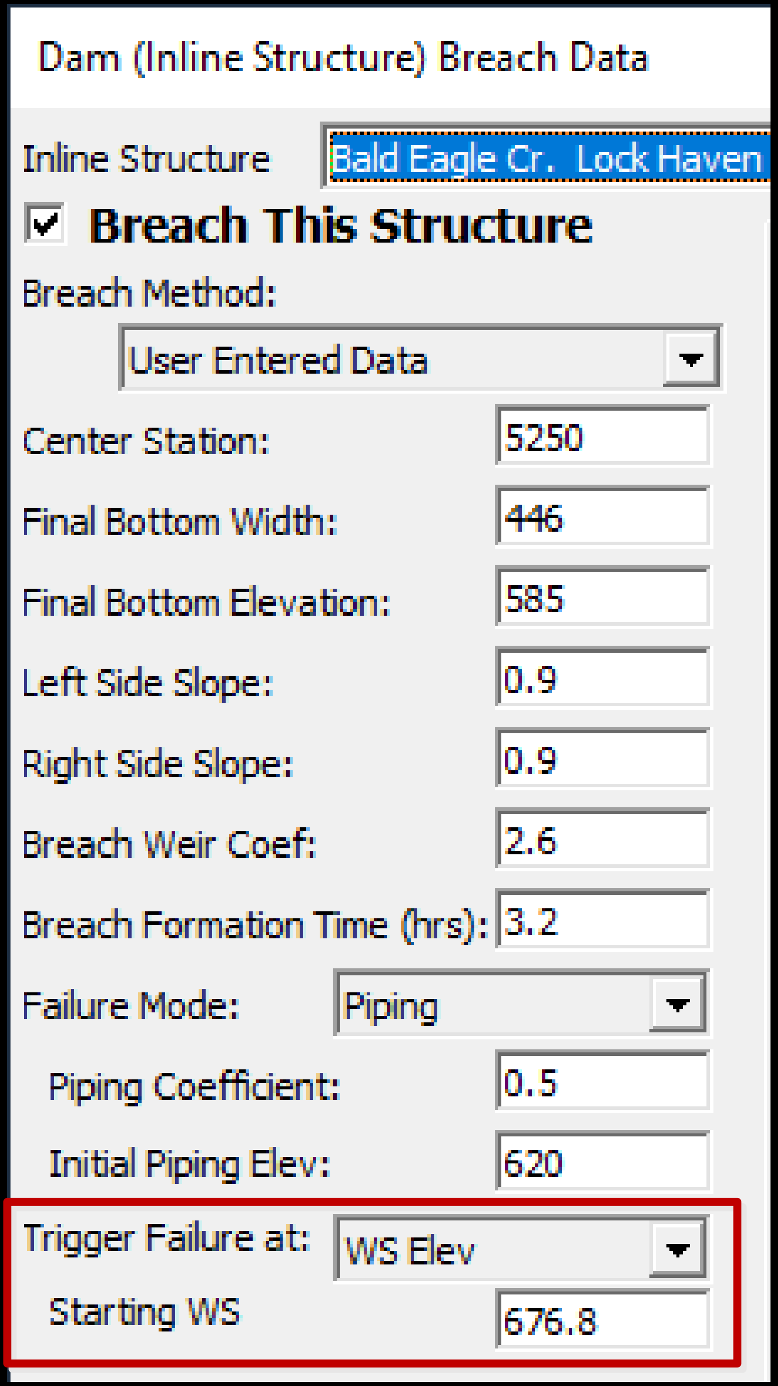
HEC-RAS Breach Data Input

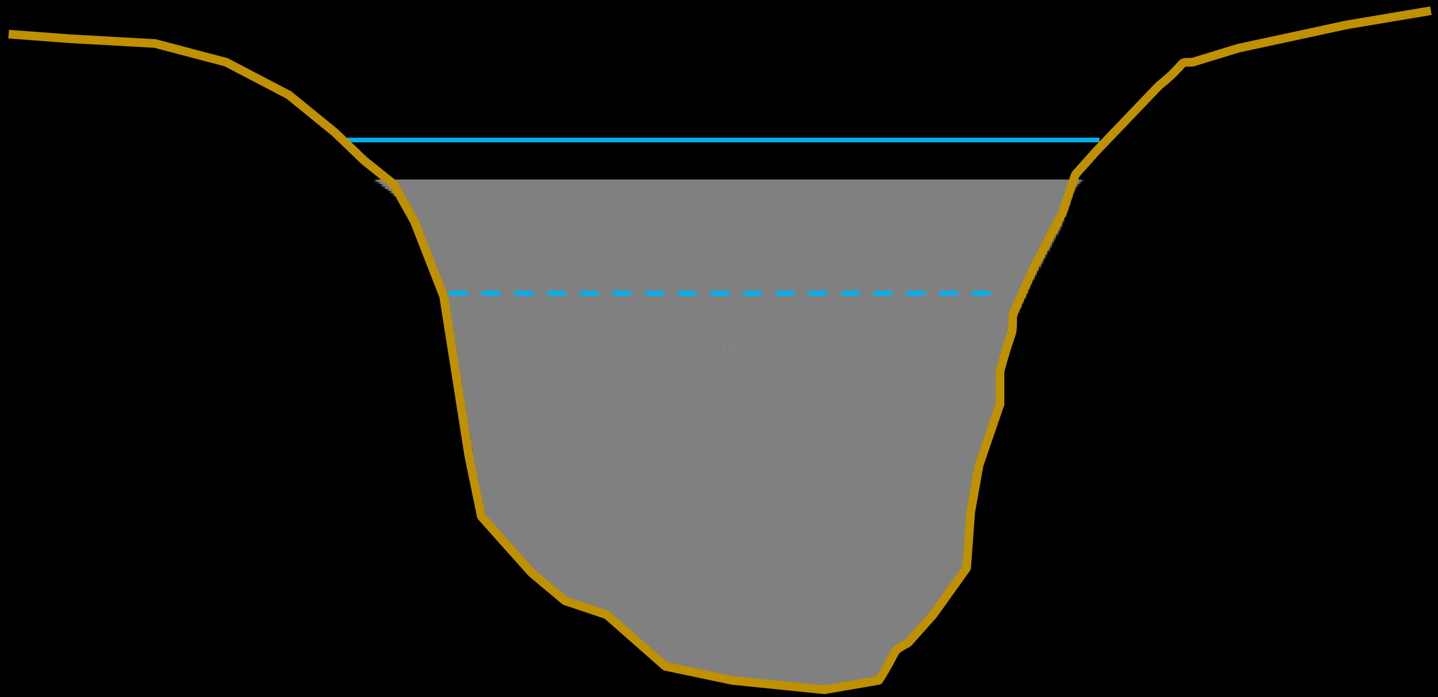
- Location: Centerline of breach
- Type: Overtopping or Piping
- Size: Bottom elevation, width and side slopes
- Time: to maximum size and progression type
- Triggering situation:
  - ✓ Pool elevation
  - ✓ Pool elevation + Duration
  - ✓ Clock time

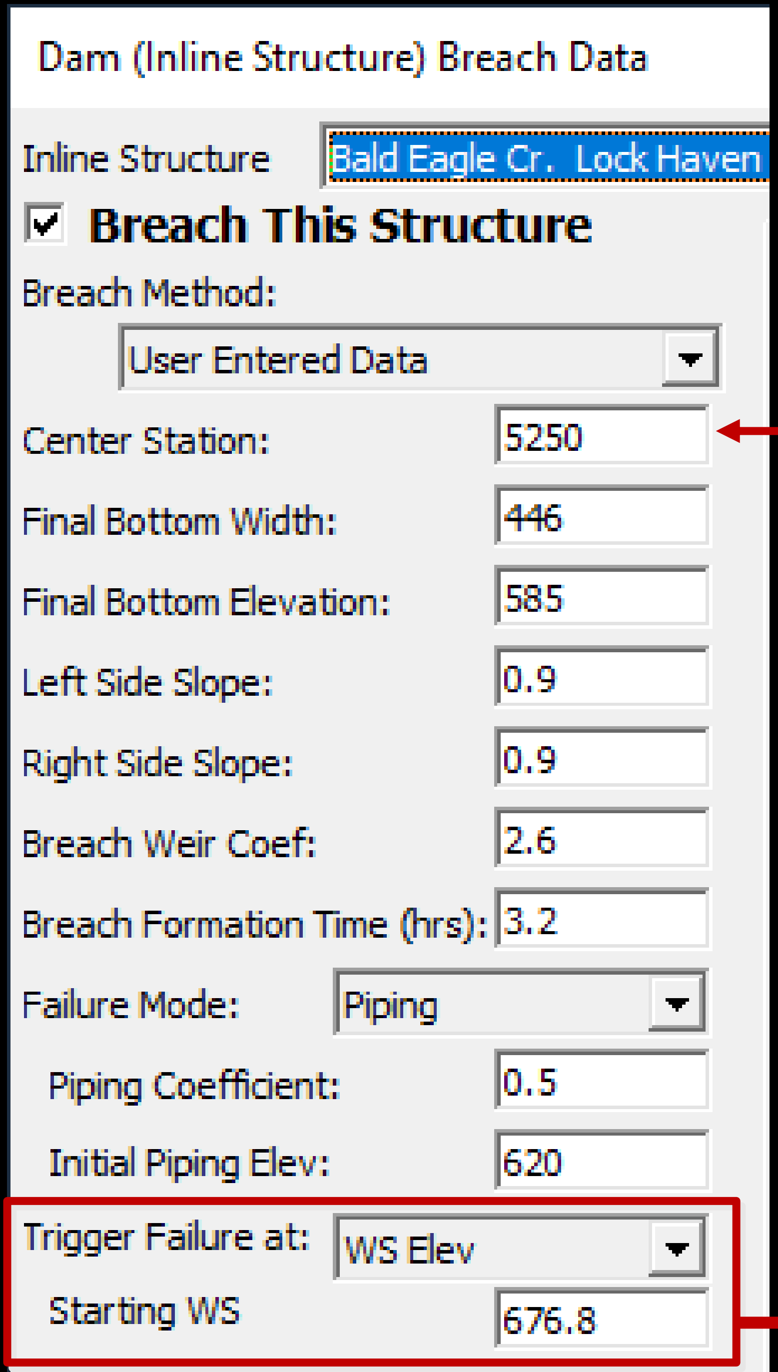


Before we get into the tough parameters…lets take on some of these others.

But First…A Couple Other Features

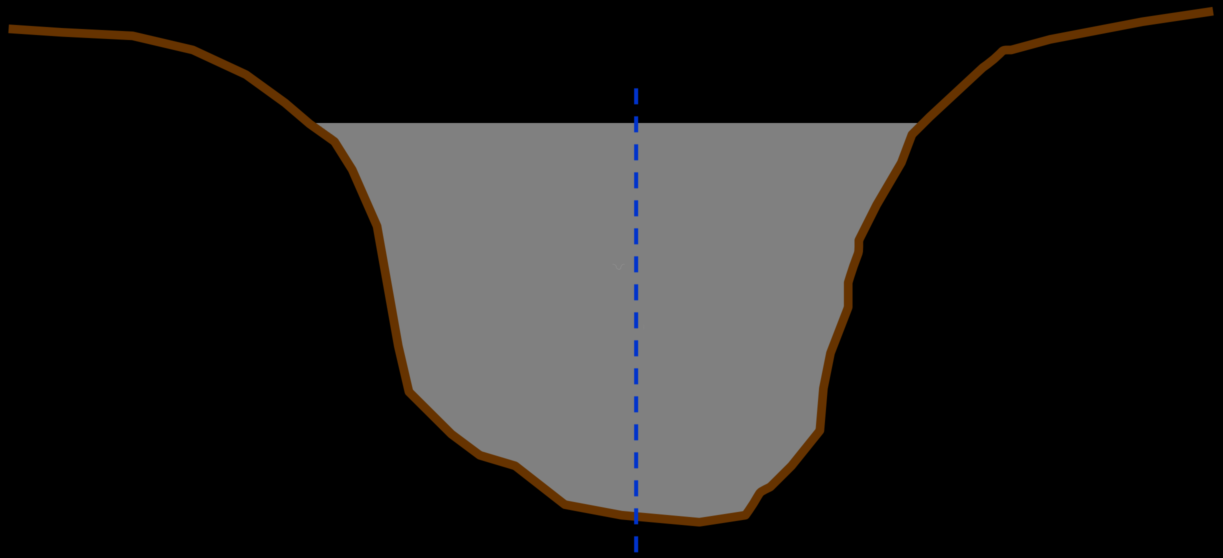




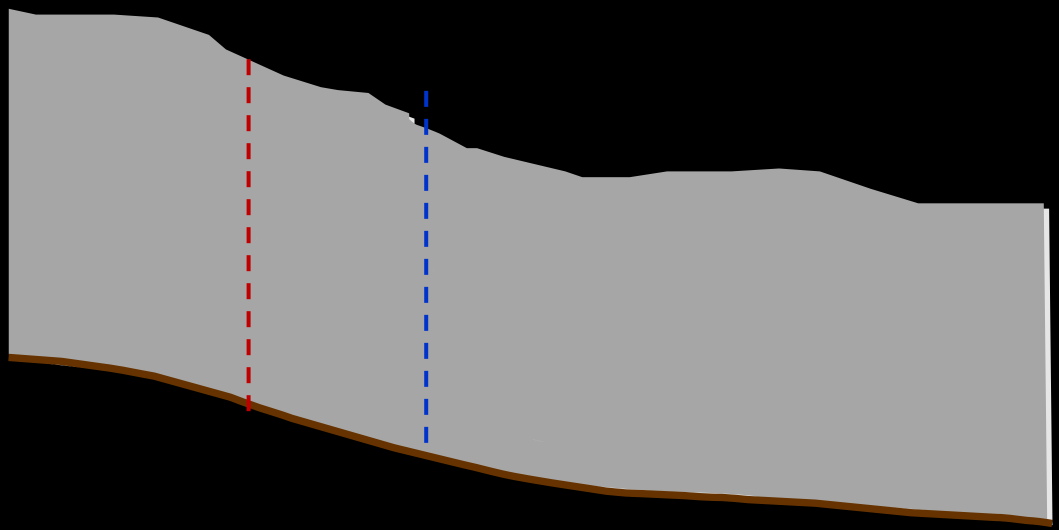


Where?

This doesn’t matter much for a dam



But levees can be more complicated



1. User Entered Data

-Parameter Estimation

2. Simplified Physical

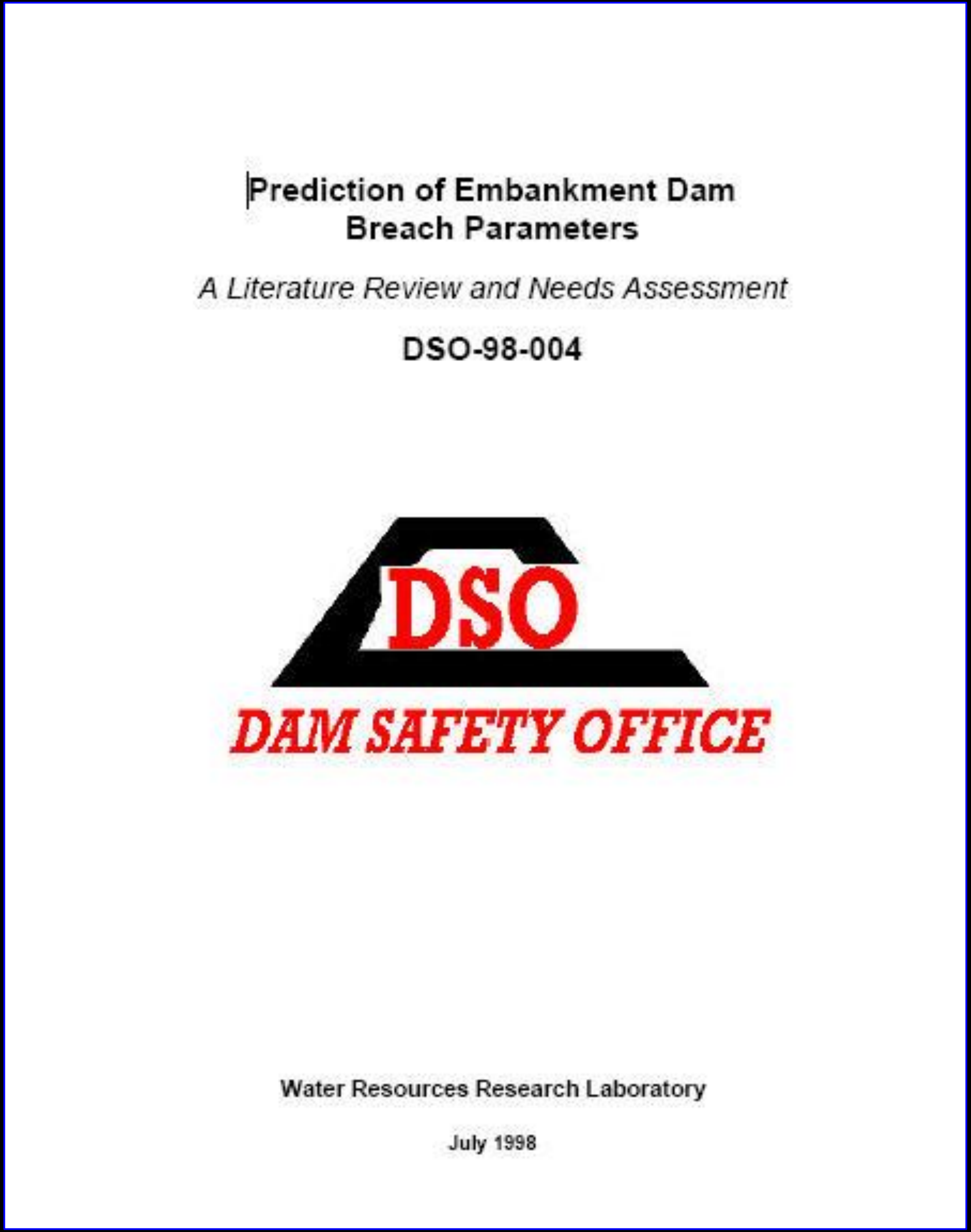
3. DL Breach

Estimating the Breach Parameters

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

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

USBR
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

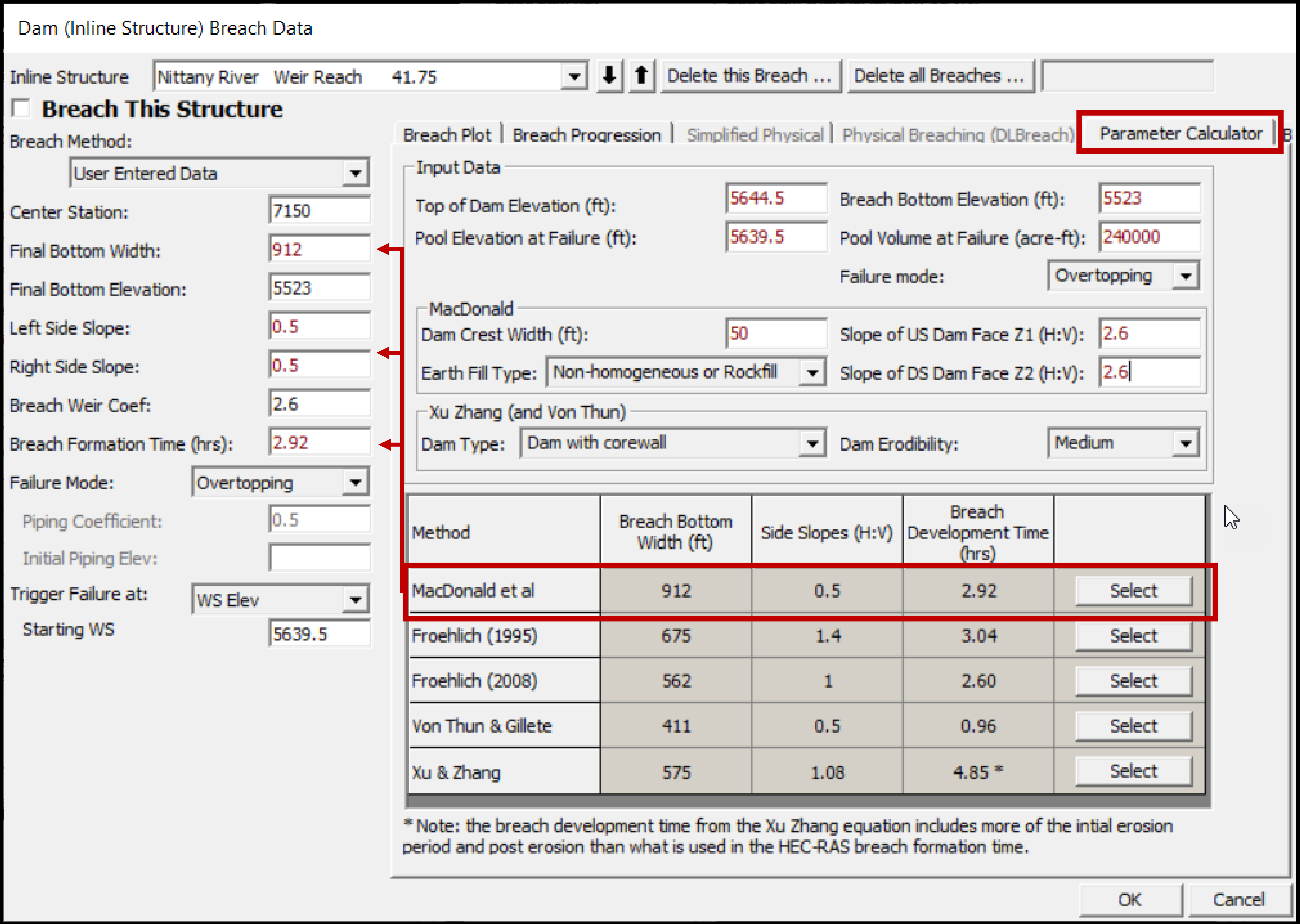
Where: HD = Height of the dam.

L = Length of the dam crest.

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

Breach Parameter Calculator



MacDonald and Langridge-Monopolis (1984)

Earthfill

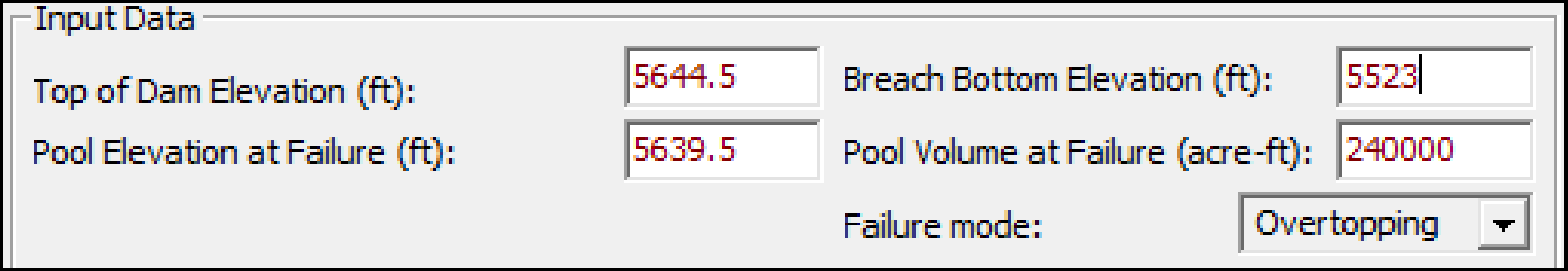
$$V_{eroded} = 0.0216 * (V_{out} * h_w)^{0.769}$$

$$t_f = 0.0179 * (V_{eroded})^{0.364}$$

$$BREACH_{size} = f(V_{eroded})$$

Non-earthfill

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



h_w = Pool Elev – Breach Bottom Elev

V_{out} = Pool Volume at Failure

(but is total flow volume – including inflow)

Von Thun & Gillette (1990)

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

$$t_f = 0.02\ h_w + 0.25$$ (erosion resistant)

$$t_f = 0.015\ h_w$$ (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)

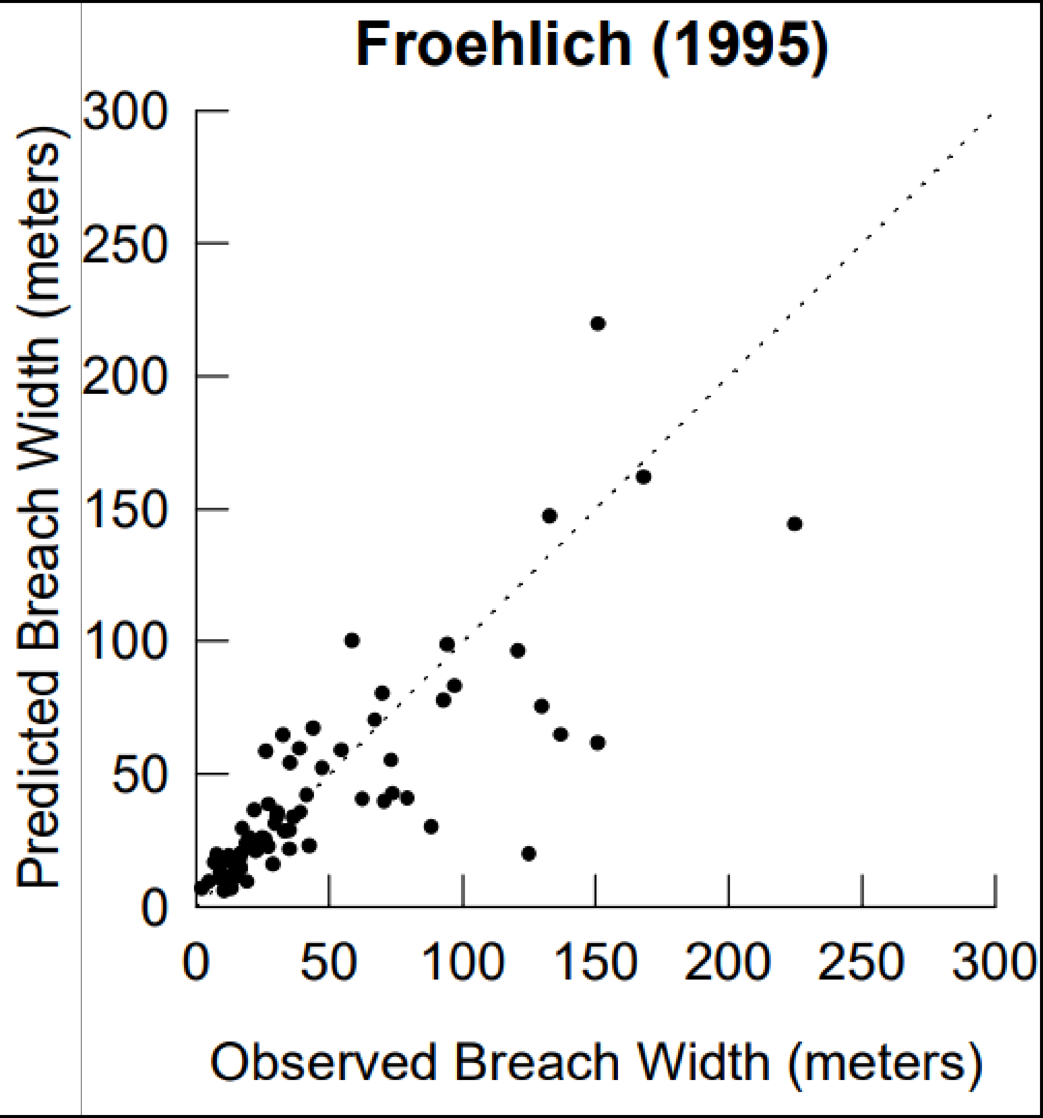
$$B_{avg} = 0.1803\, K_o V_w^{0.32} h_b^{0.19}$$

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

Froehlich (2008)

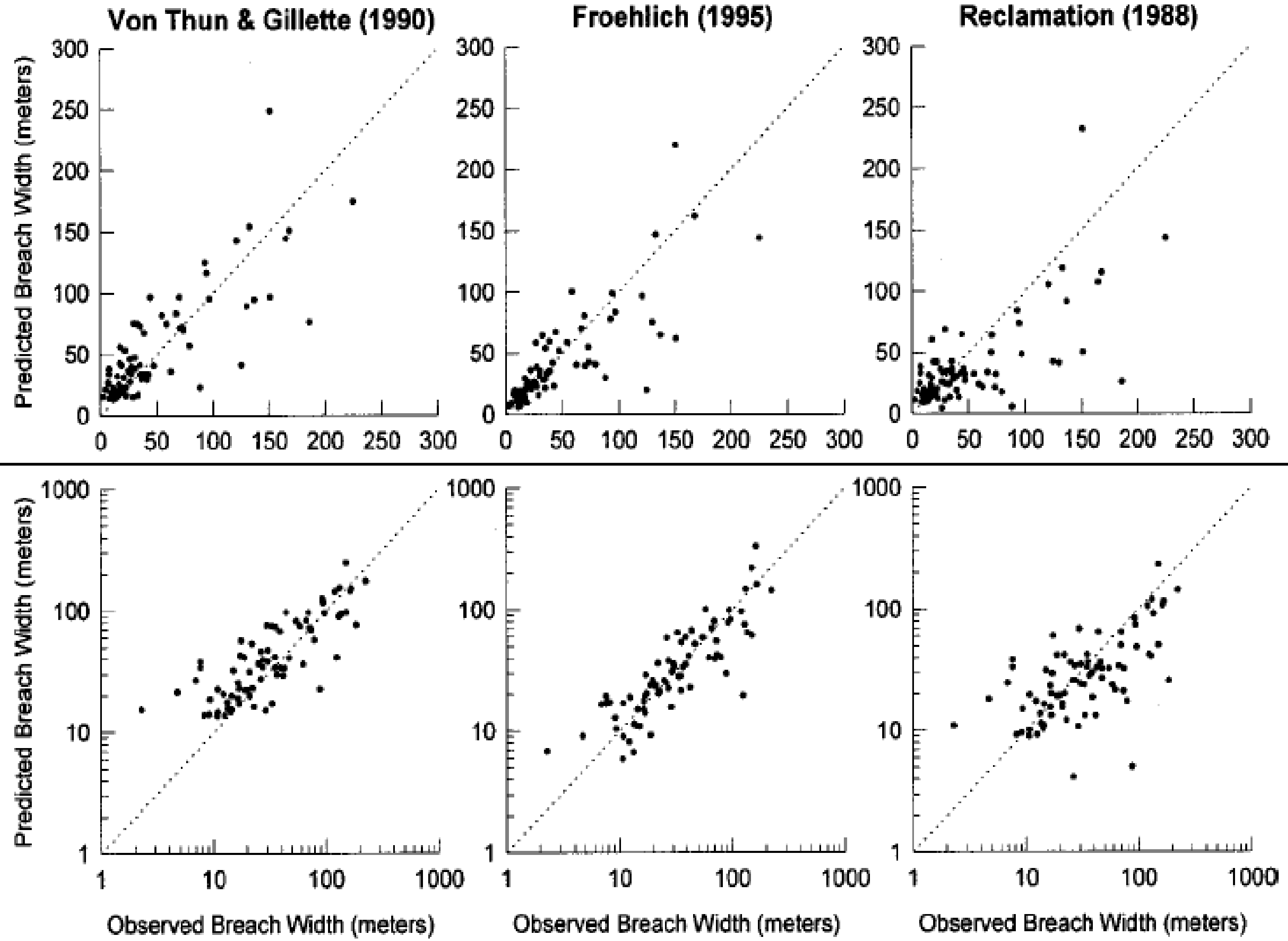
$$B_{avg} = 0.27\, K_o V_w^{0.32} h_b^{0.04}$$

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



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 & Gillete	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.

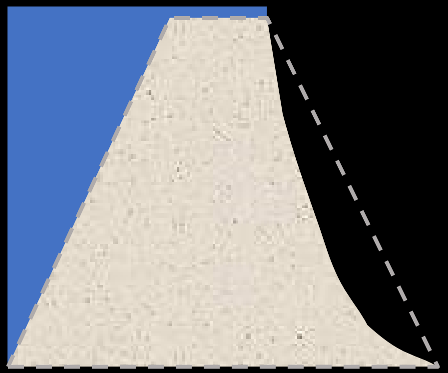
2. Xu & Zang has a different breach development time.

Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	122	0.5	2.57	Select
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

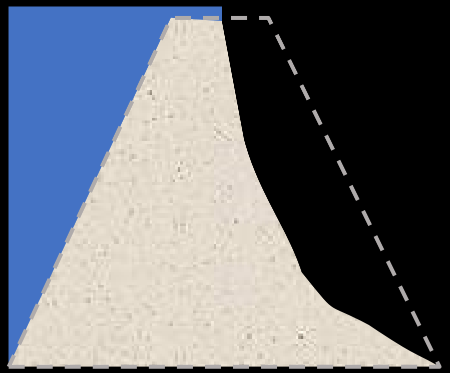
Thought Experiment

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

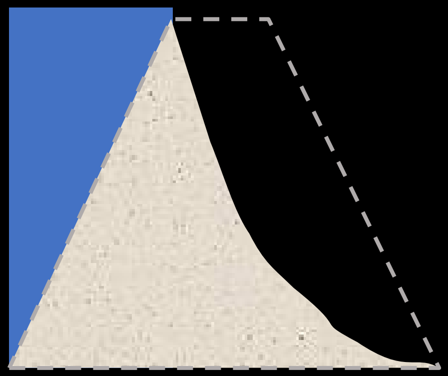
1.)



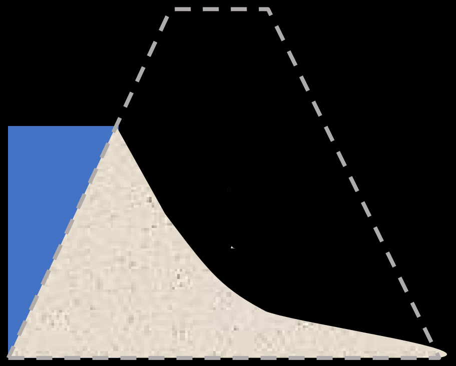
2.)



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?

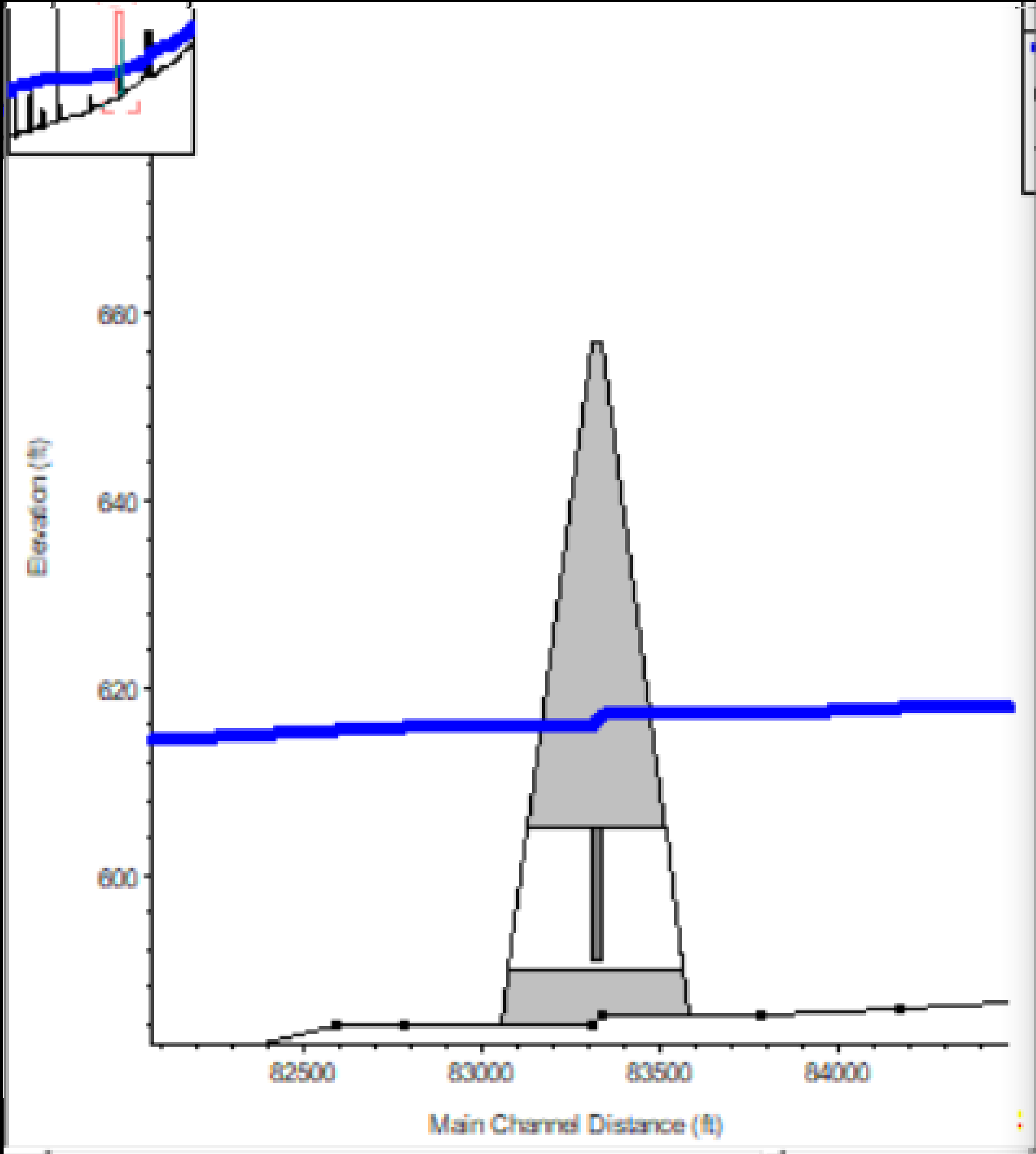
Evaluate Breach Progress

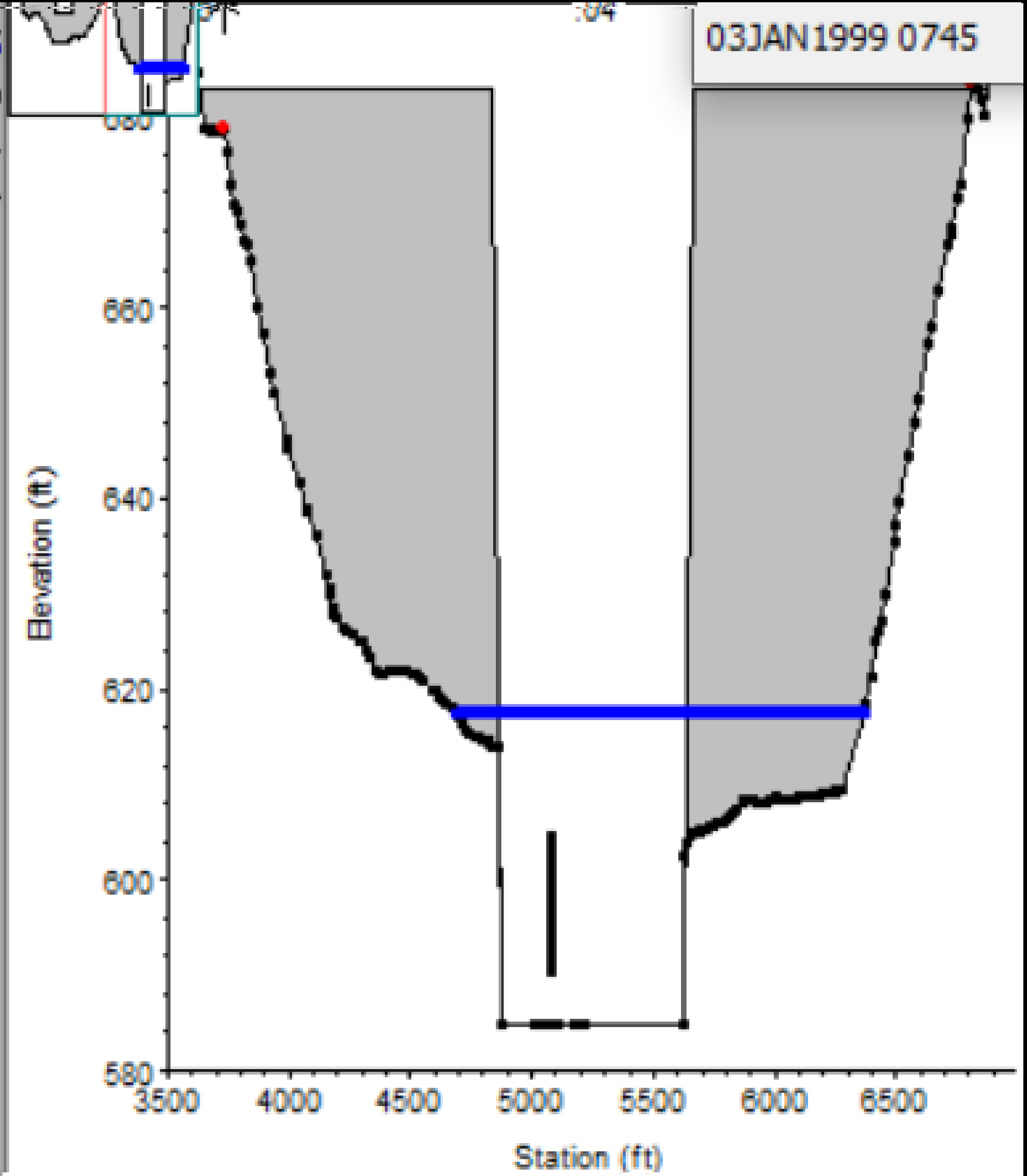
- Breach parameter estimation is uncertain.

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

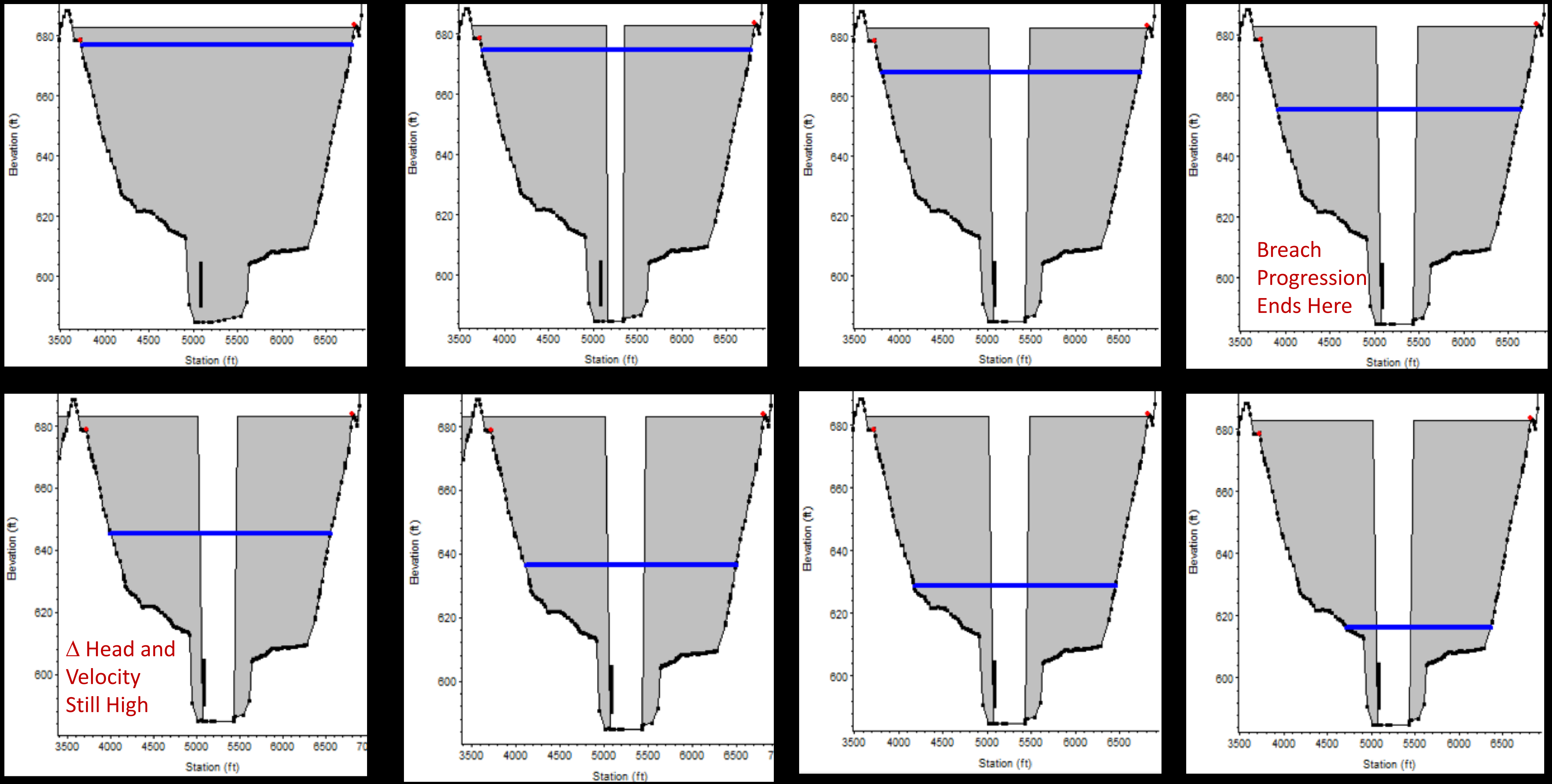
- We can use HEC-RAS hydraulic results to inform our decision on breach parameter selection.

Profile and Breach Plots

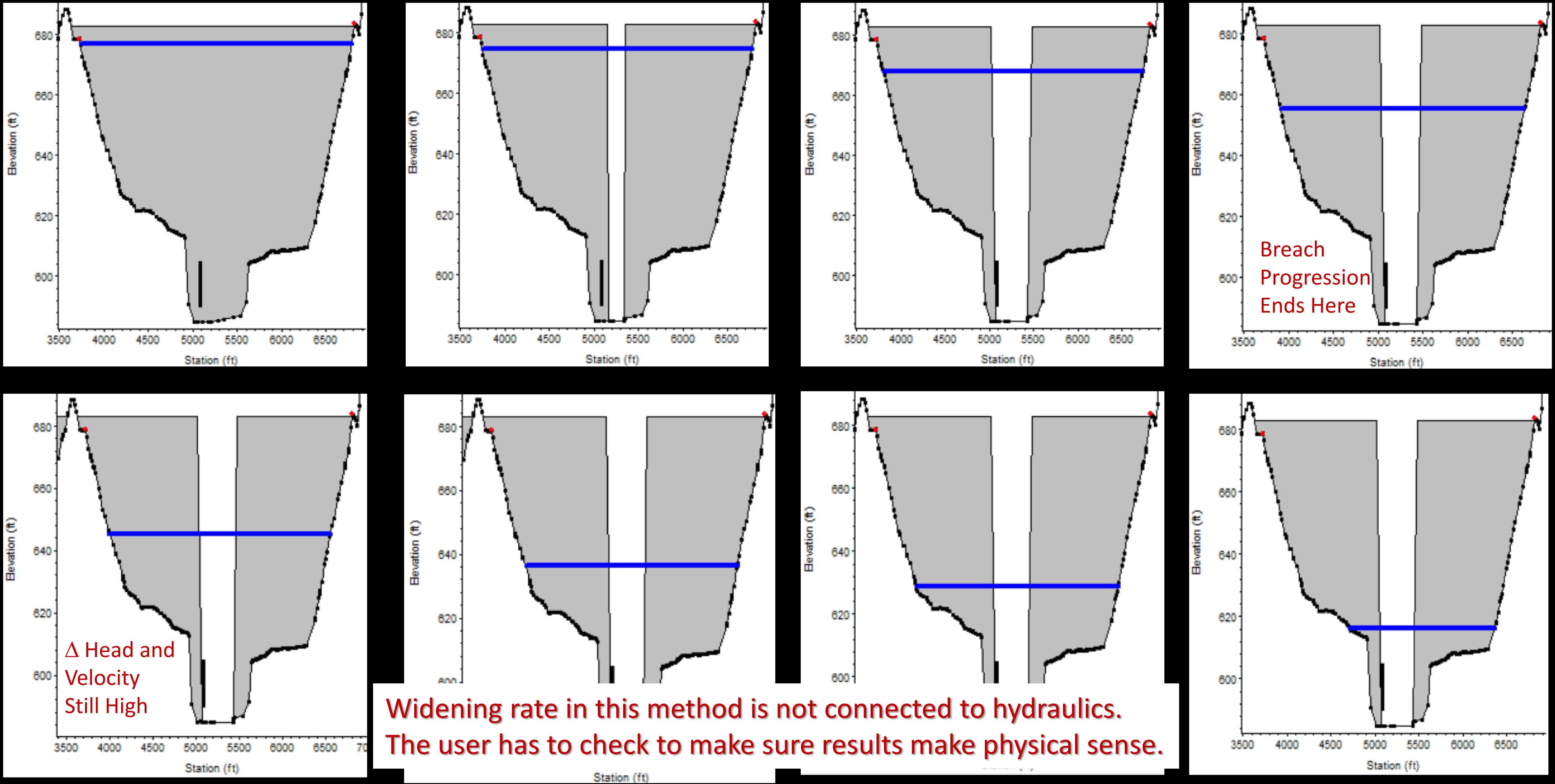




Do you have any concerns about this simulation?



This Simulation Continues to Widen for High ΔHead and Velocities



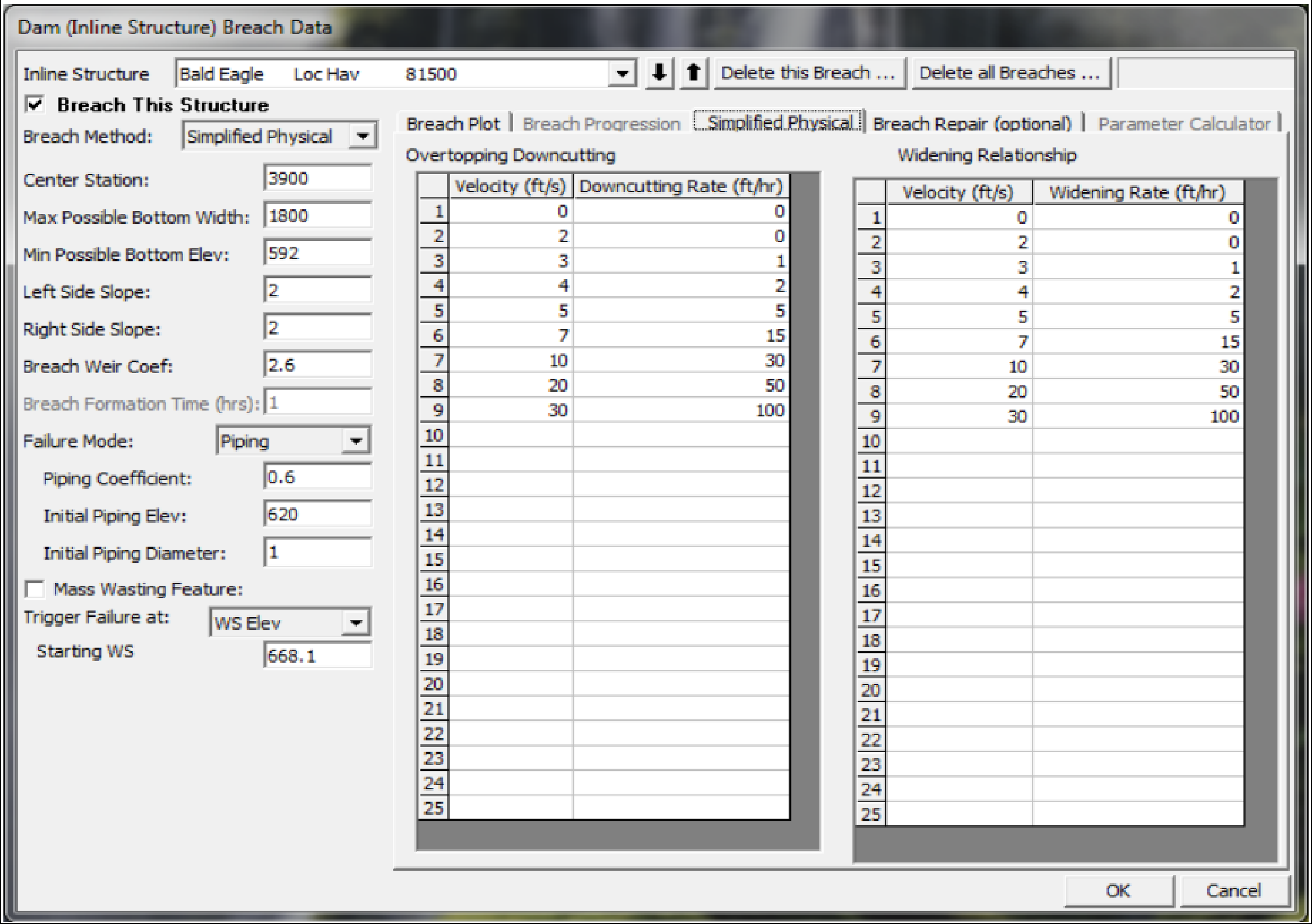
Widening rate in this method is not connected to hydraulics.
The user has to check to make sure results make physical sense.

1. User Entered Data

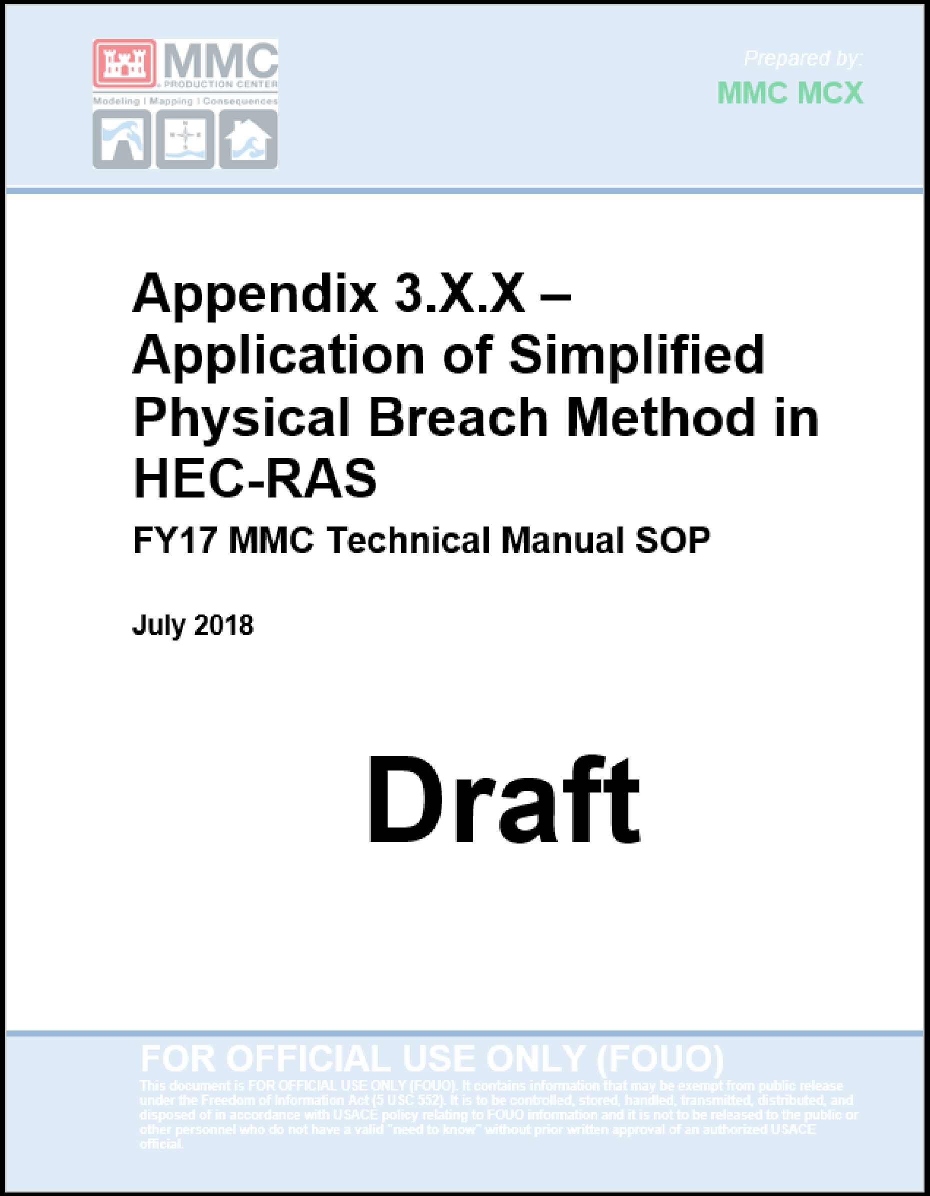
-Parameter Estimation

2. Simplified Physical

3. DL Breach


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)
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
OK
Cancel

Where do these rates come from?


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)

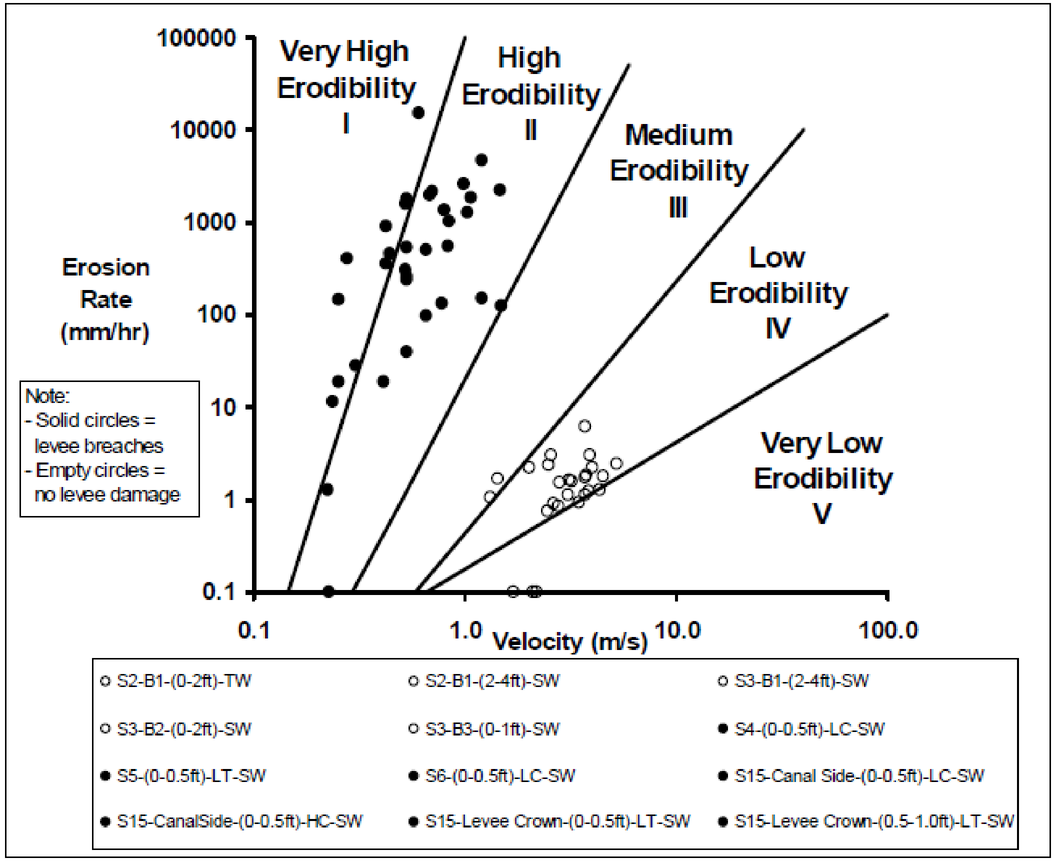
The guidance is under development.
There are some historic values that can help.

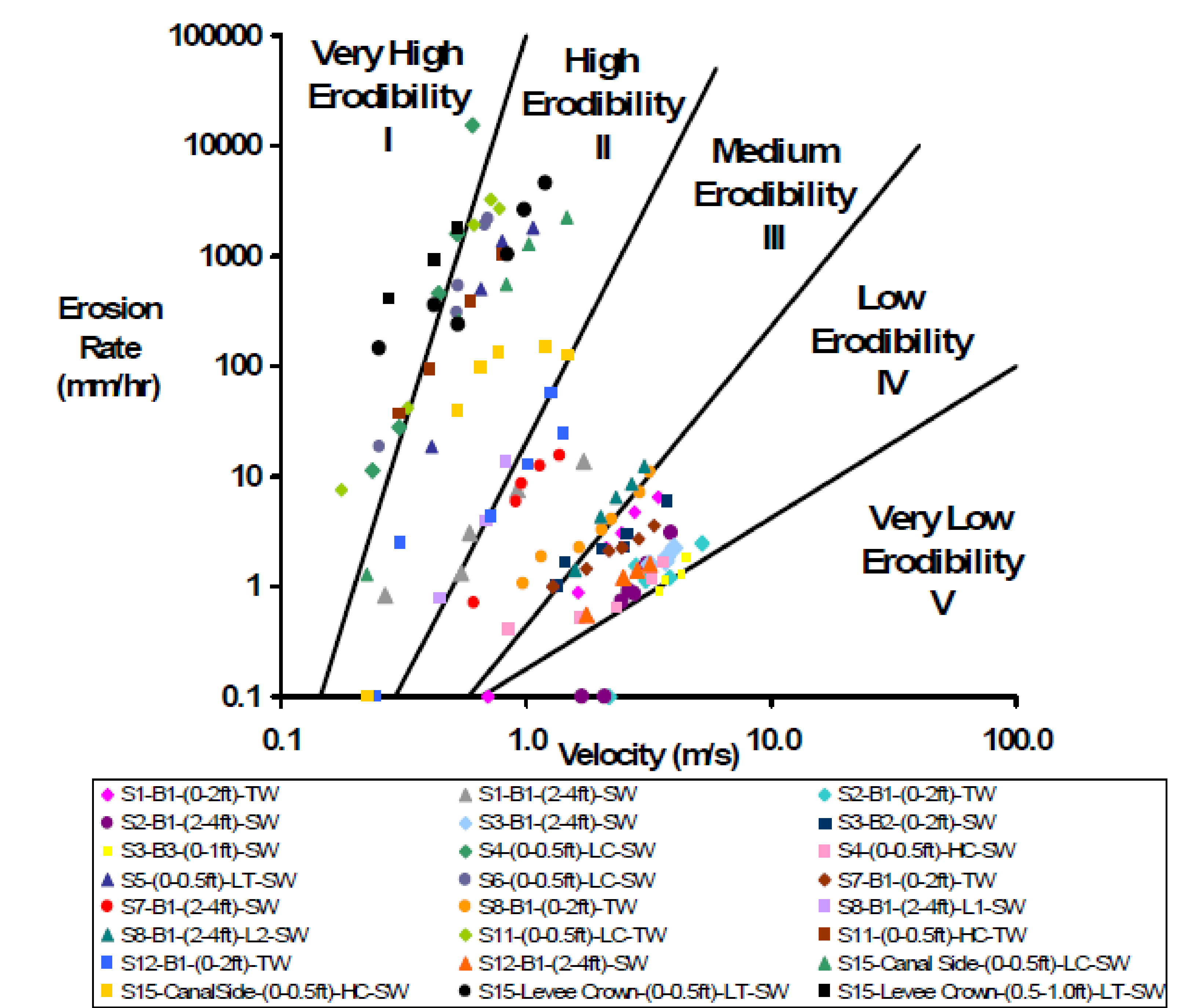
Technical Memorandum for Record

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

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

Subject: Updated Levee Breach Characteristics for MMC SOP





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

1. User Entered Data

   -Parameter Estimation

User Entered Data ▾

2. Simplified Physical

Simplified Physical ▾

3. DL Breach

Physical Breaching (DLBreach) ▾

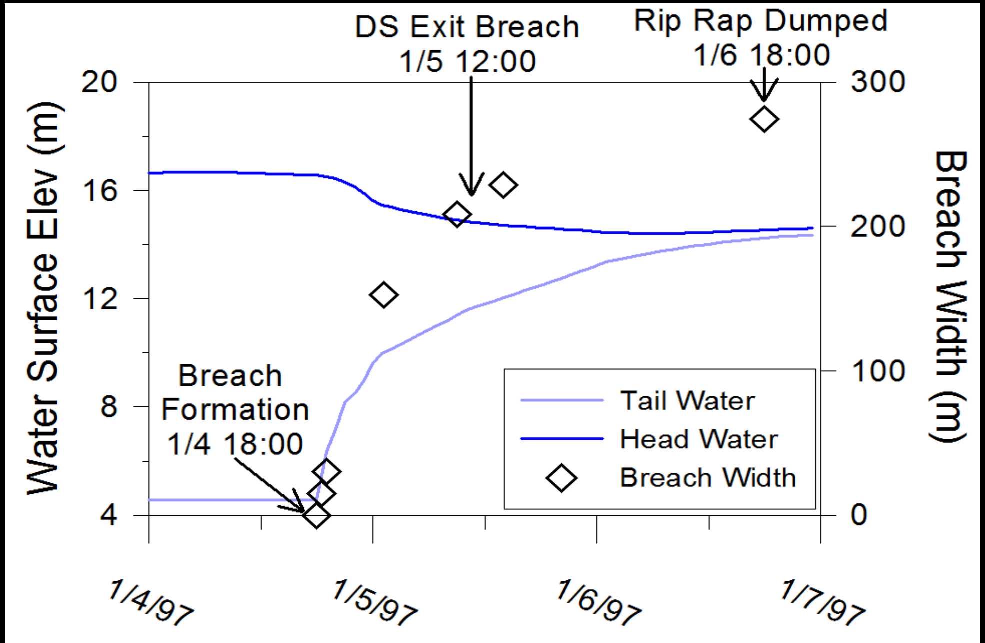
User Entered Data
Simplified Physical
Physical Breaching (DLBreach)

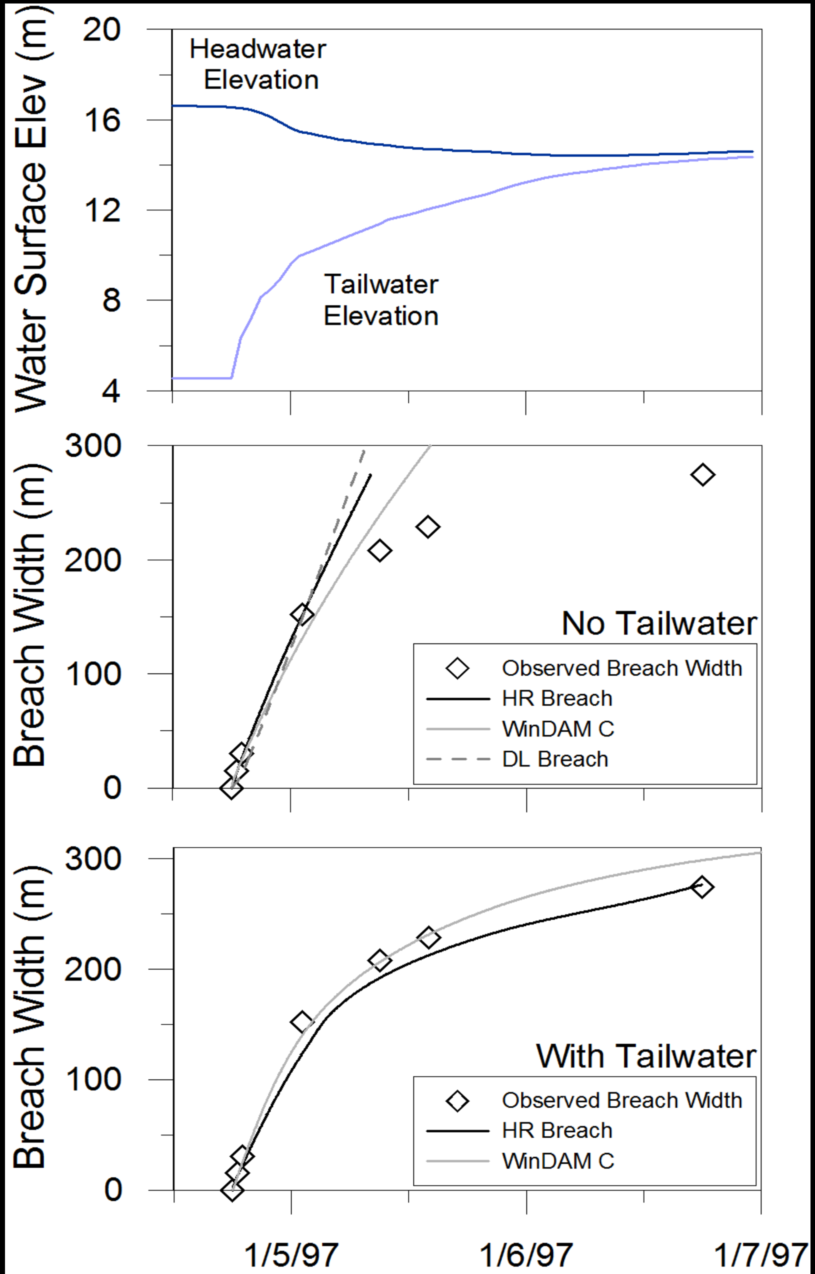
Process Models:

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

Sutter Bypass Levee Breach

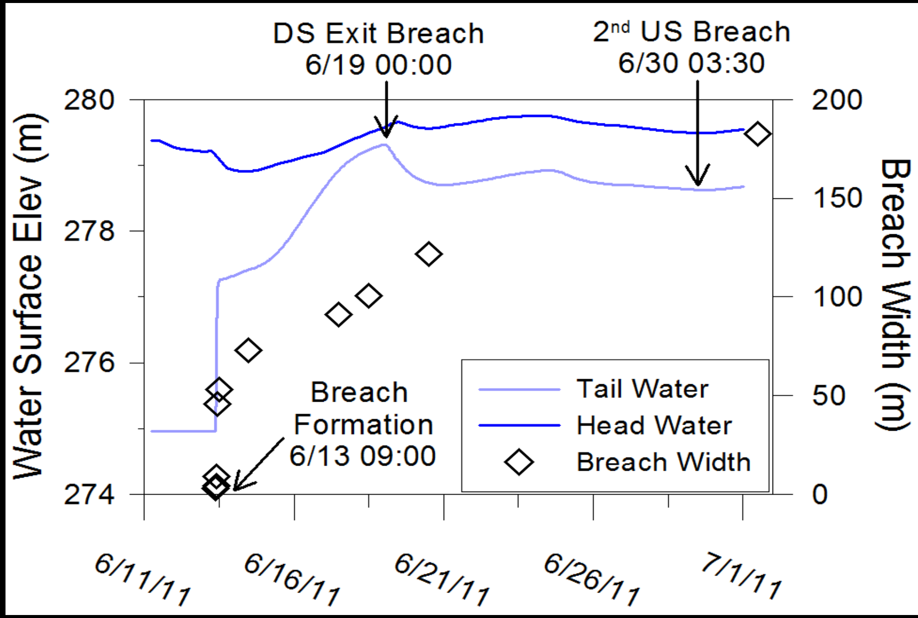
From: Risher, P. and Gibson, S. (2016) “Applying Mechanistic Dam Breach Models to Historic Levee Breaches,” Proceedings FloodRisk 2016.

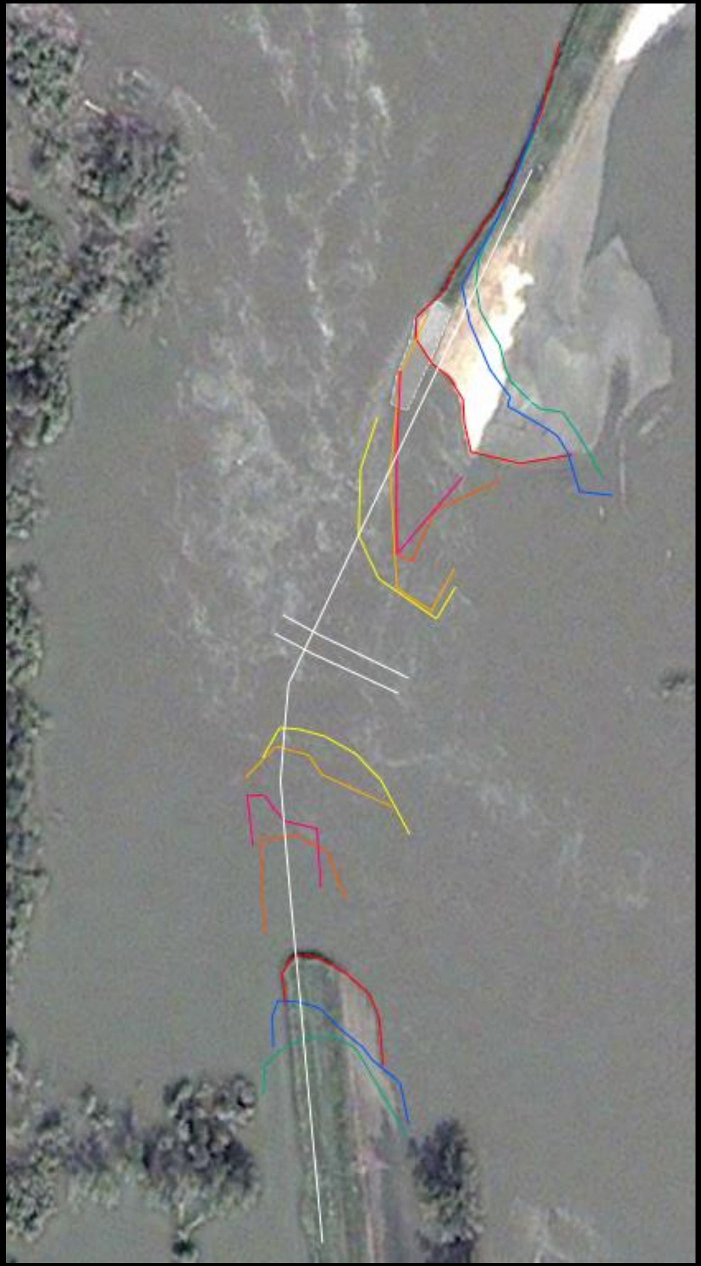


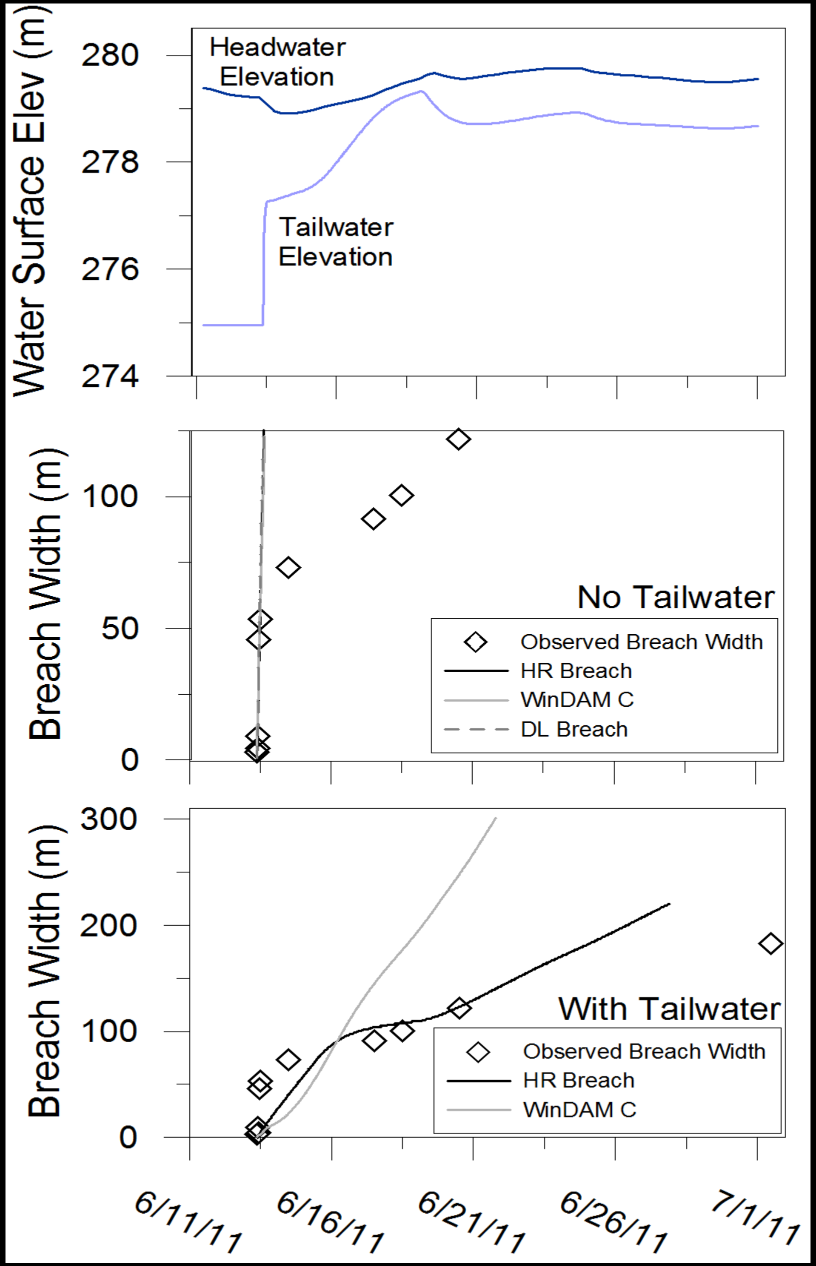


Hamburg Breach (Missouri River)

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

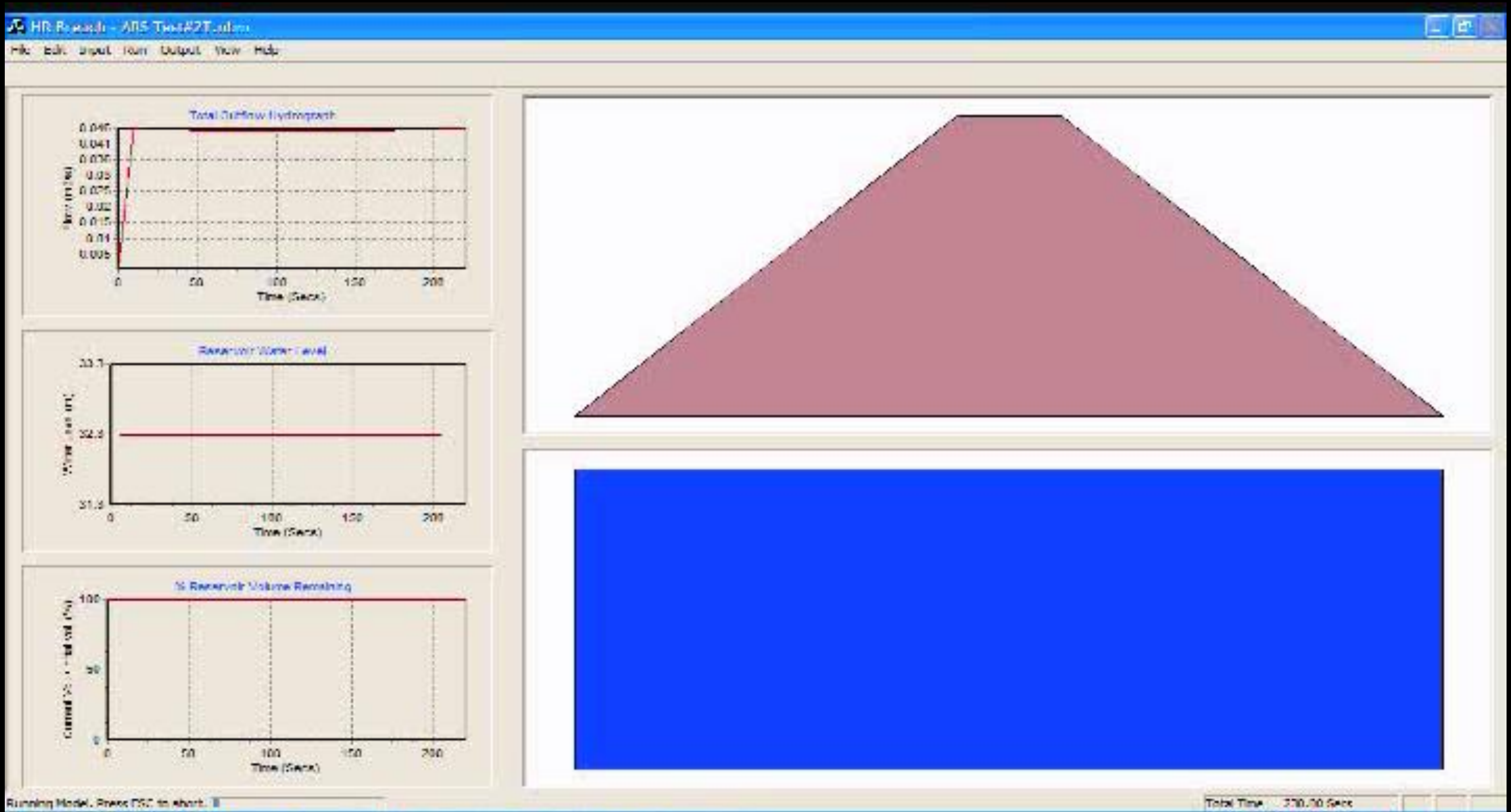






HR BREACH

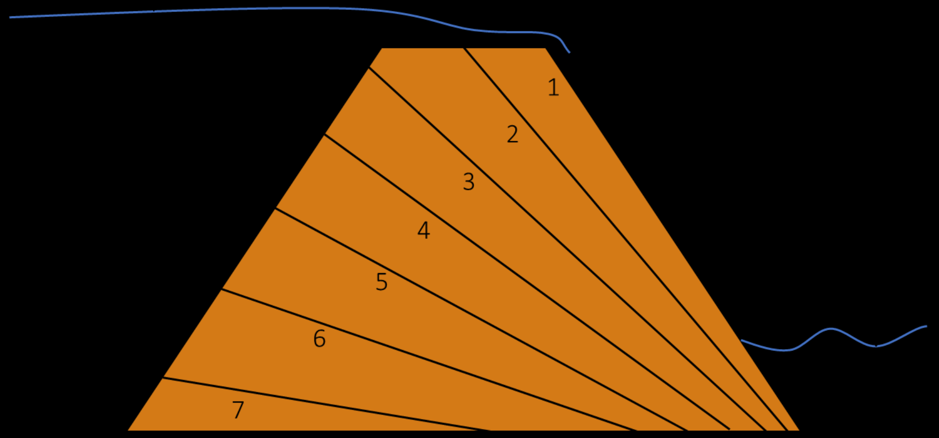
- Erosion through homogeneous or simple composite dams
- Channel erosion, head cutting and side slope instability + piping
- Storage routing with quasi-steady hydraulics thru the breach



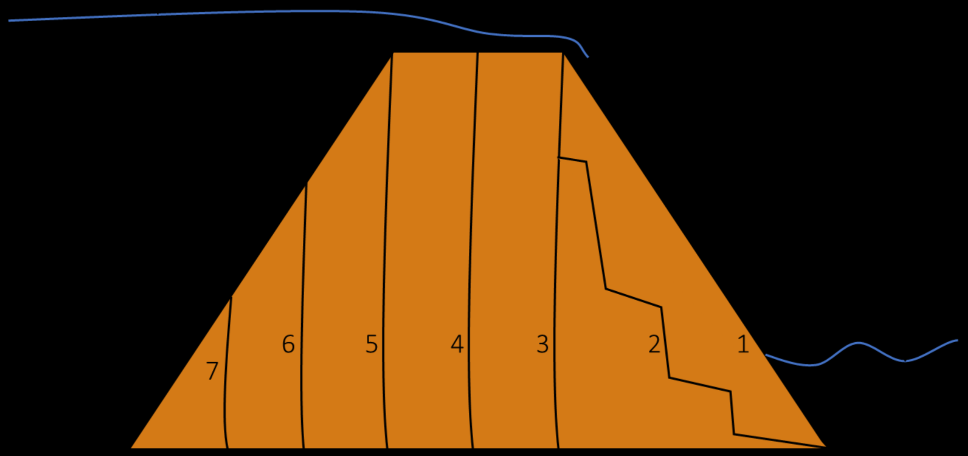
DLBreach

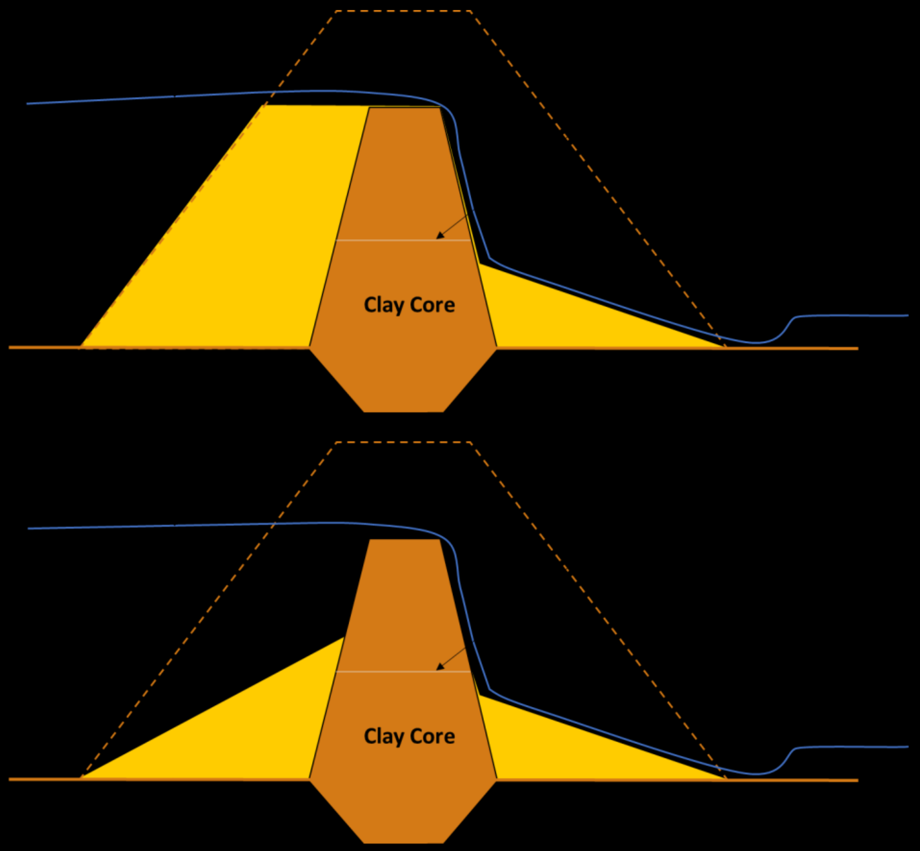
- Surface Erosion
- Headcut Erosion
- Composite (Zoned) Structure

Surface



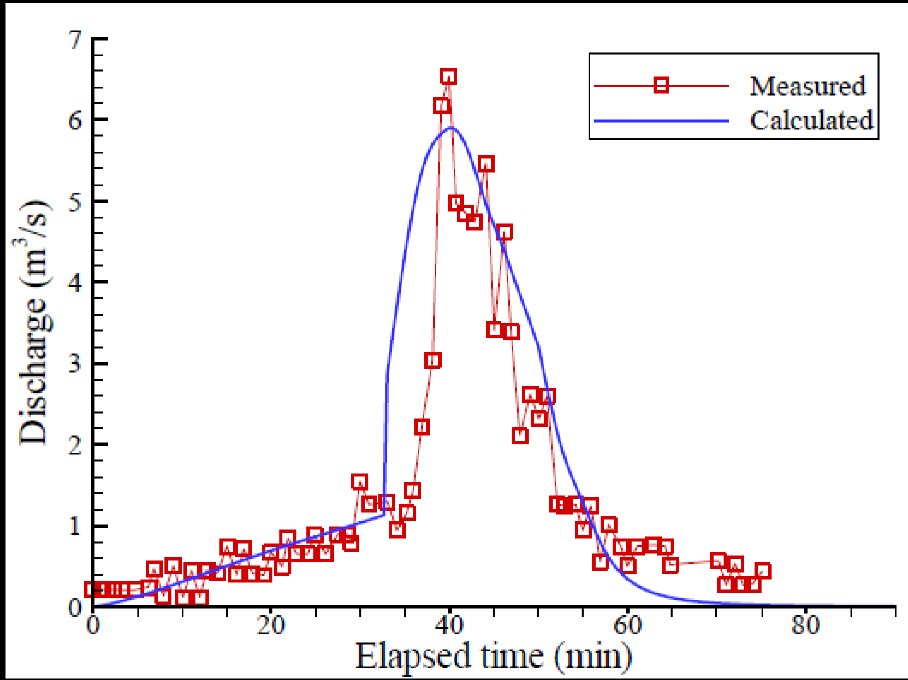
Headcut

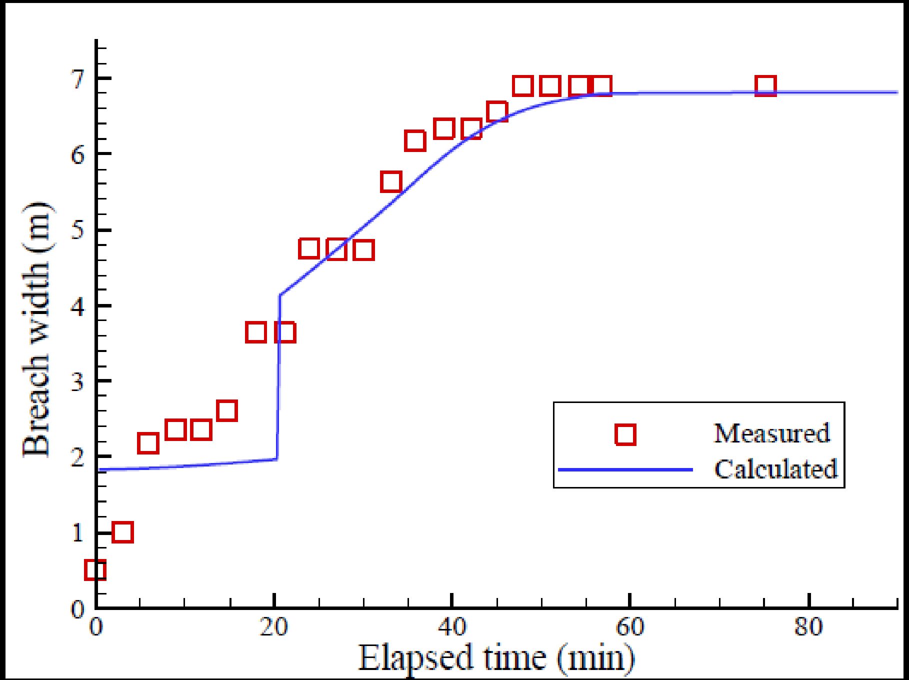


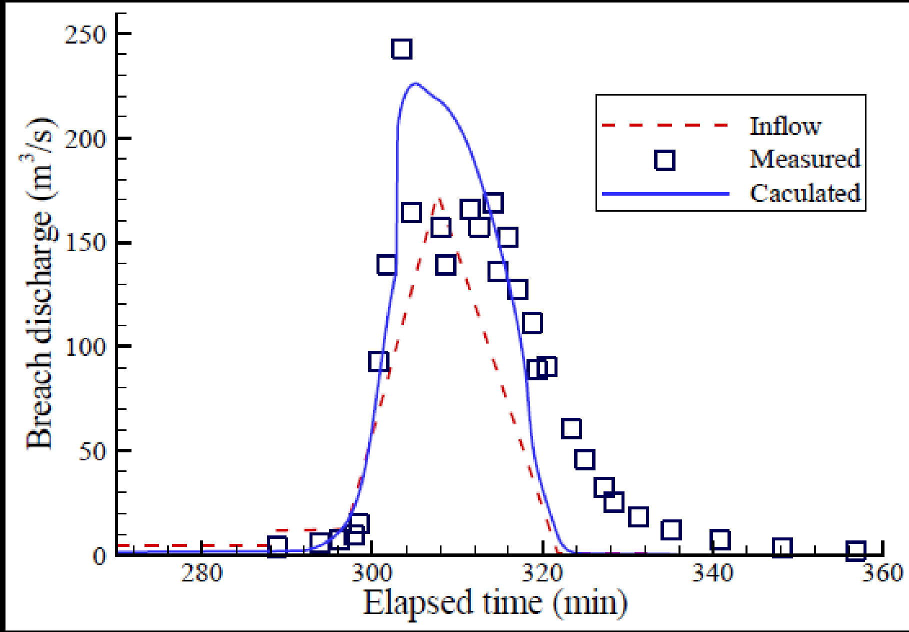


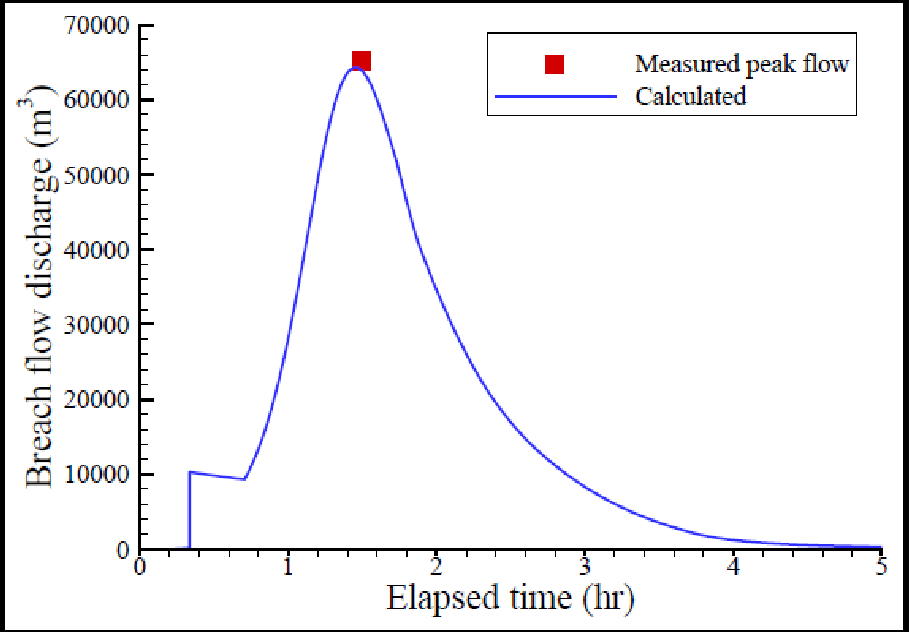
Composite

DLBreach

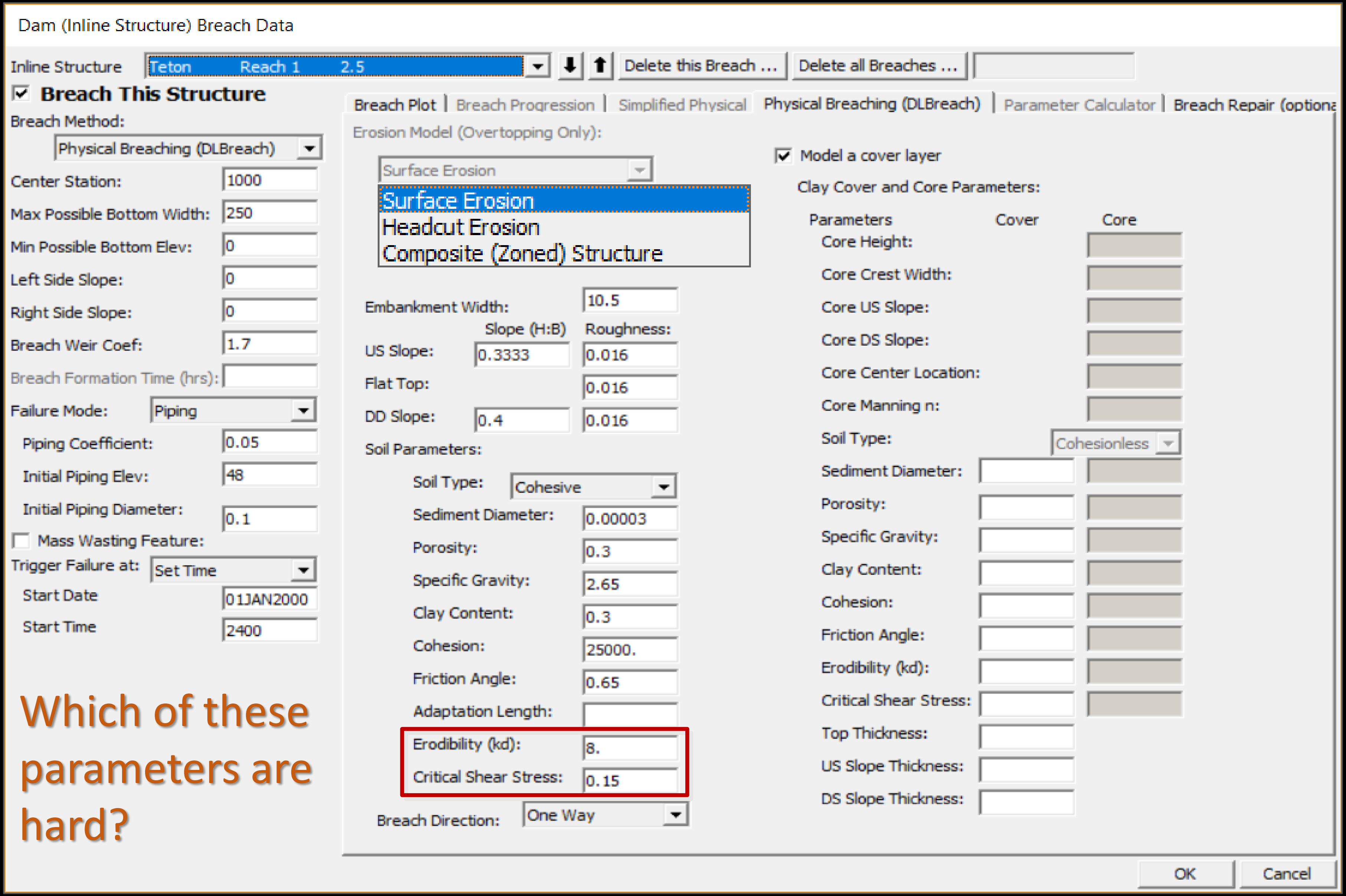

Measured
Calculated
Discharge (m³/s)
Elapsed time (min)
0
1
2
3
4
5
6
7
20
40
60
80


Measured
Calculated
Breach width (m)
Elapsed time (min)
0
1
2
3
4
5
6
7
20
40
60
80


Inflow
Measured
Caculated
Breach discharge (m³/s)
Elapsed time (min)
0
50
100
150
200
250
280
300
320
340
360


Measured peak flow
Calculated
Breach flow discharge (m³)
Elapsed time (hr)
0
10000
20000
30000
40000
50000
60000
70000
1
2
3
4
5

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

TD-39

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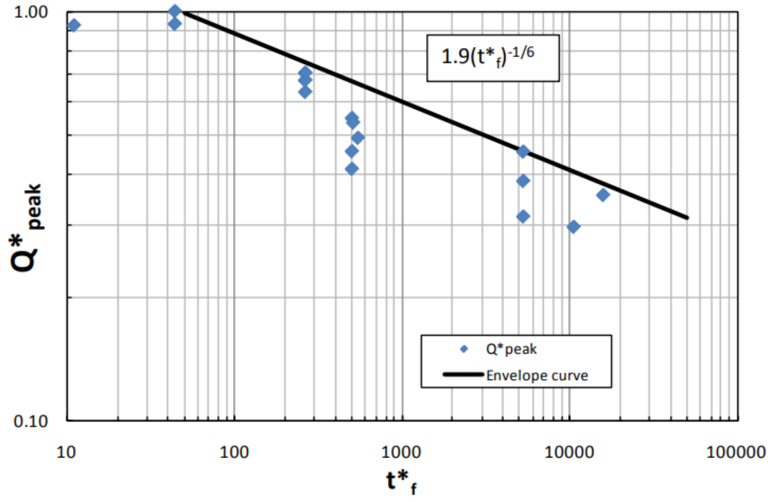

Figure 28. — Dimensionless peak discharge as a function of dimensionless breach development time.

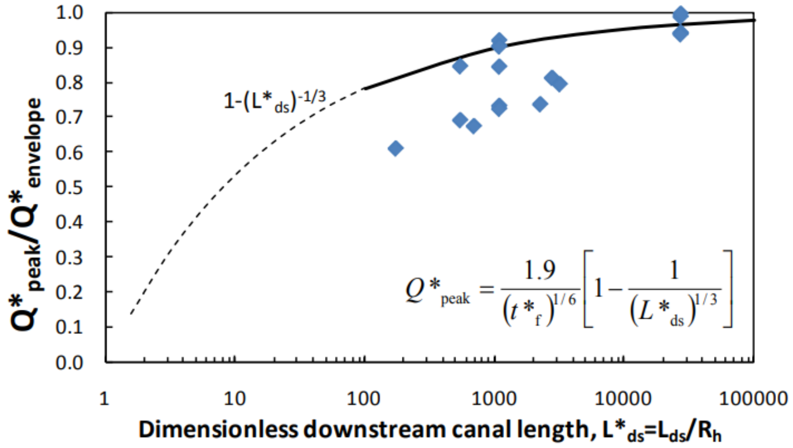

Figure 29. — Effect of downstream canal reach length on peak breach outflow.

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