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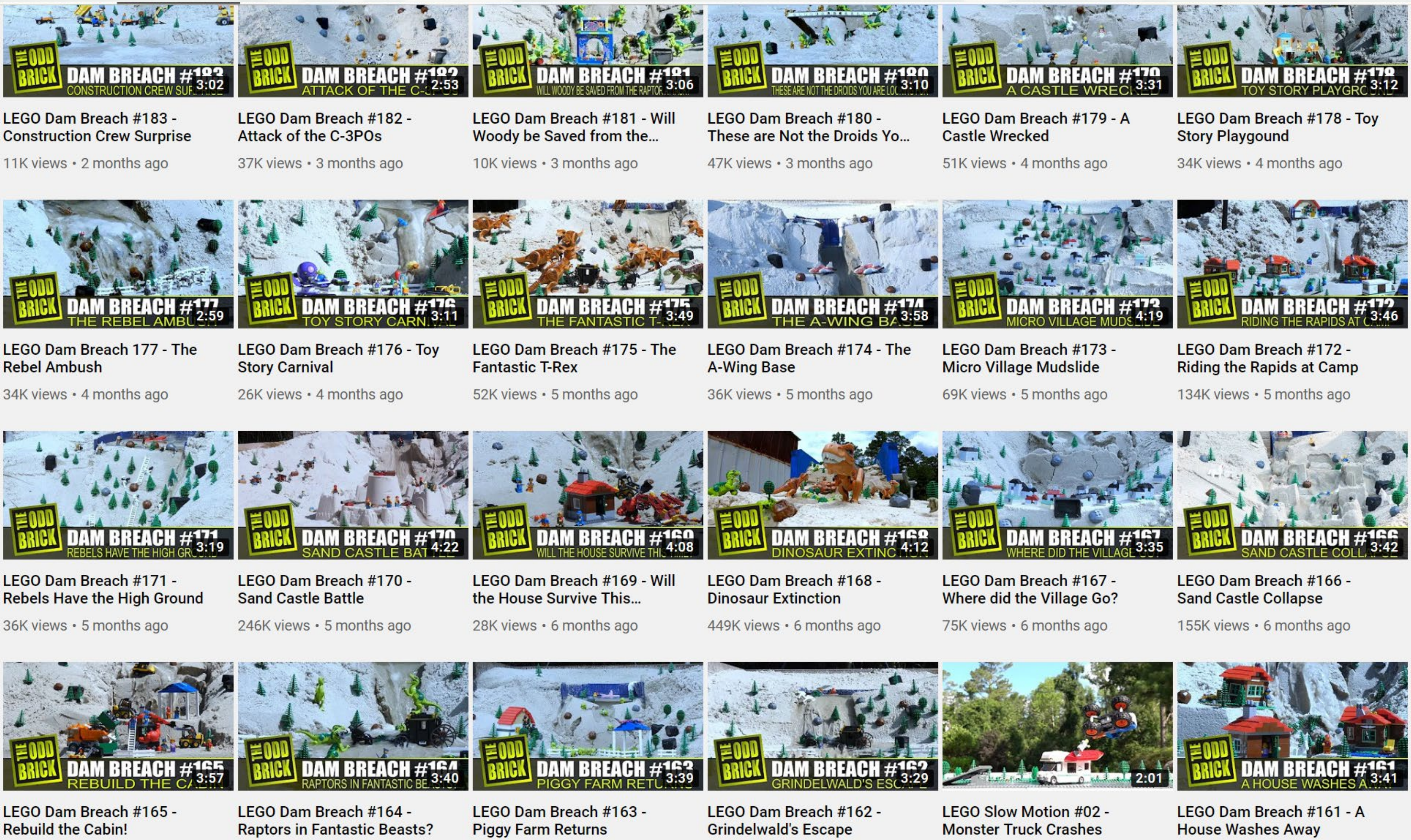
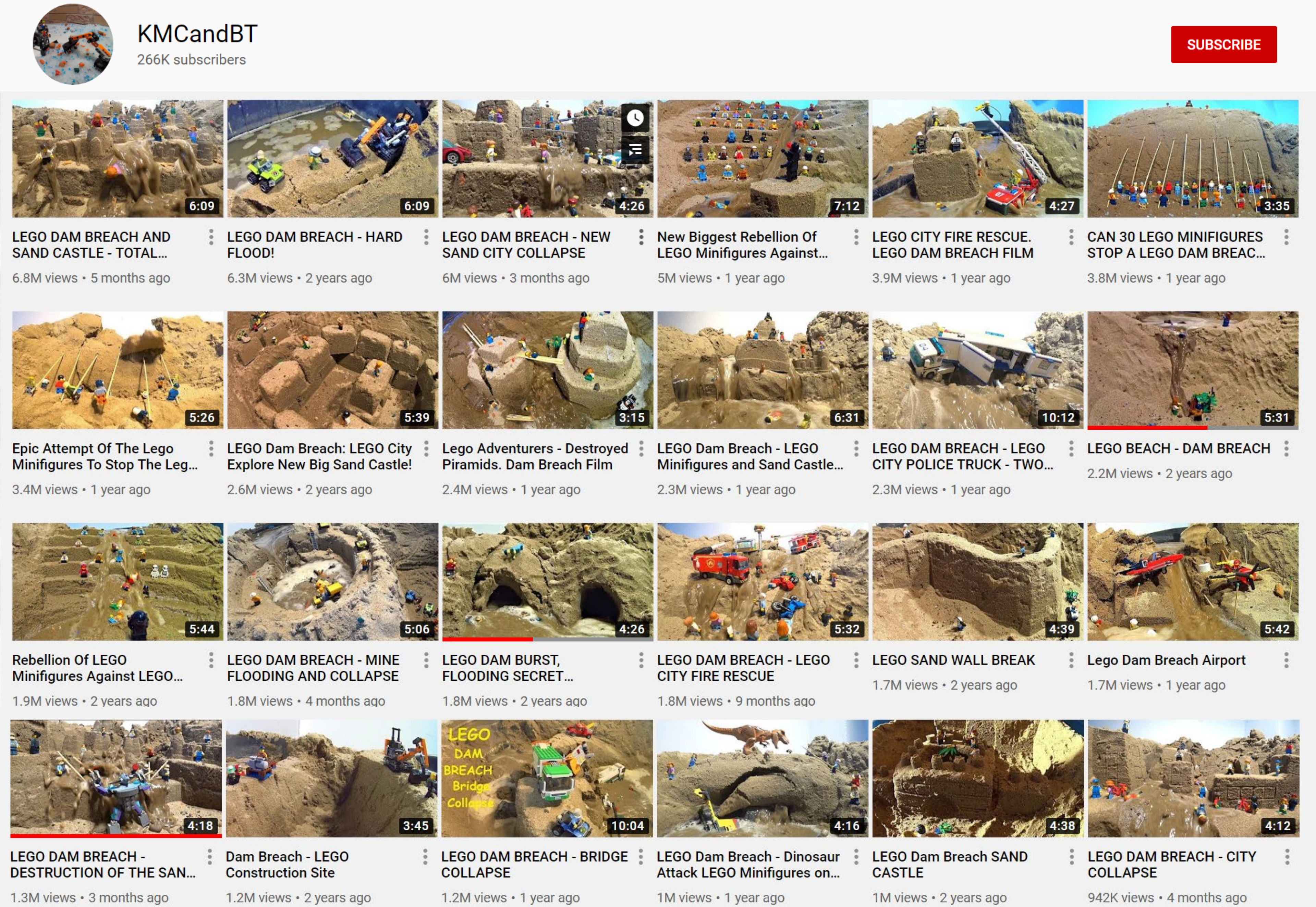

LEGO Dam Breach #183 - Construction Crew Surprise
11K views • 2 months ago
LEGO Dam Breach #182 - Attack of the C-3POs
37K views • 3 months ago
LEGO Dam Breach #181 - Will Woody be Saved from the...
10K views • 3 months ago
LEGO Dam Breach #180 - These are Not the Droids Yo...
47K views • 3 months ago
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
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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
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Lego Adventurers - Destroyed Piramids. Dam Breach Film
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6:31
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LEGO DAM BREACH - LEGO CITY POLICE TRUCK - TWO...
2.3M views • 1 year ago
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LEGO BEACH - DAM BREACH
2.2M views • 2 years ago
5:44
Rebellion Of LEGO Minifigures Against LEGO...
1.9M views • 2 years ago
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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
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LEGO SAND WALL BREAK
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Lego Dam Breach Airport
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Dam Breach - LEGO Construction Site
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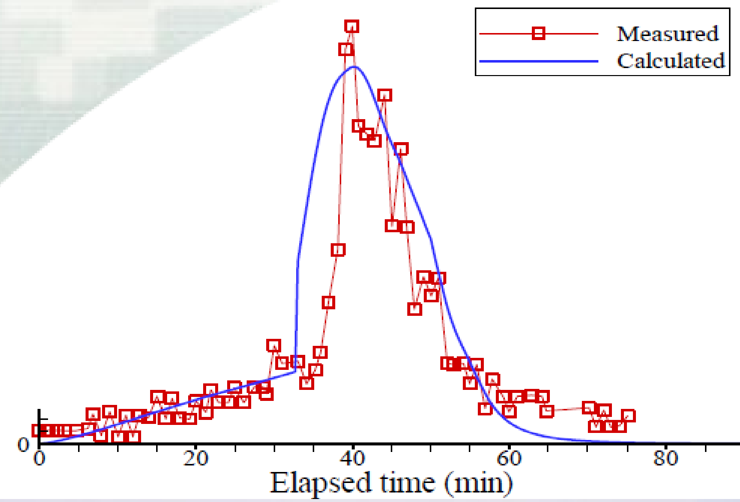
LEGO DAM BREACH Bridge Collapse
10:04
LEGO DAM BREACH - BRIDGE COLLAPSE
1.2M views • 1 year ago
4:16
LEGO Dam Breach - Dinosaur Attack LEGO Minifigures on...
1M views • 1 year ago
4:38
LEGO Dam Breach SAND CASTLE
1M views • 2 years ago
4:12
LEGO DAM BREACH - CITY COLLAPSE
942K views • 4 months ago

# Estimating Dam Breach Parameters

Stanford Gibson, PhD

Sediment Specialist

Hydrologic Engineering Center



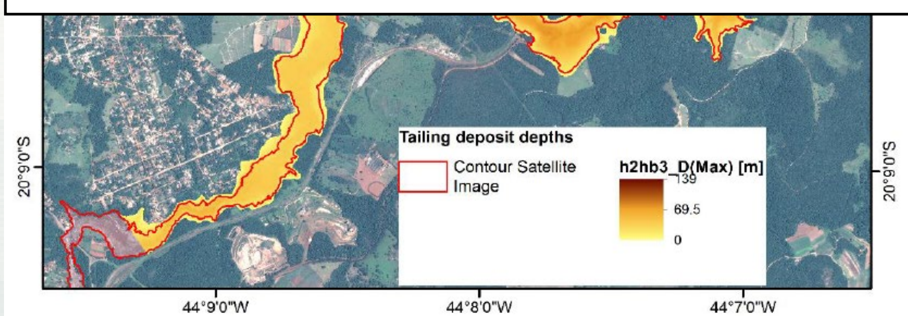

# NRCS Embankment Failure Research (SIMBA/WinDAMB model)

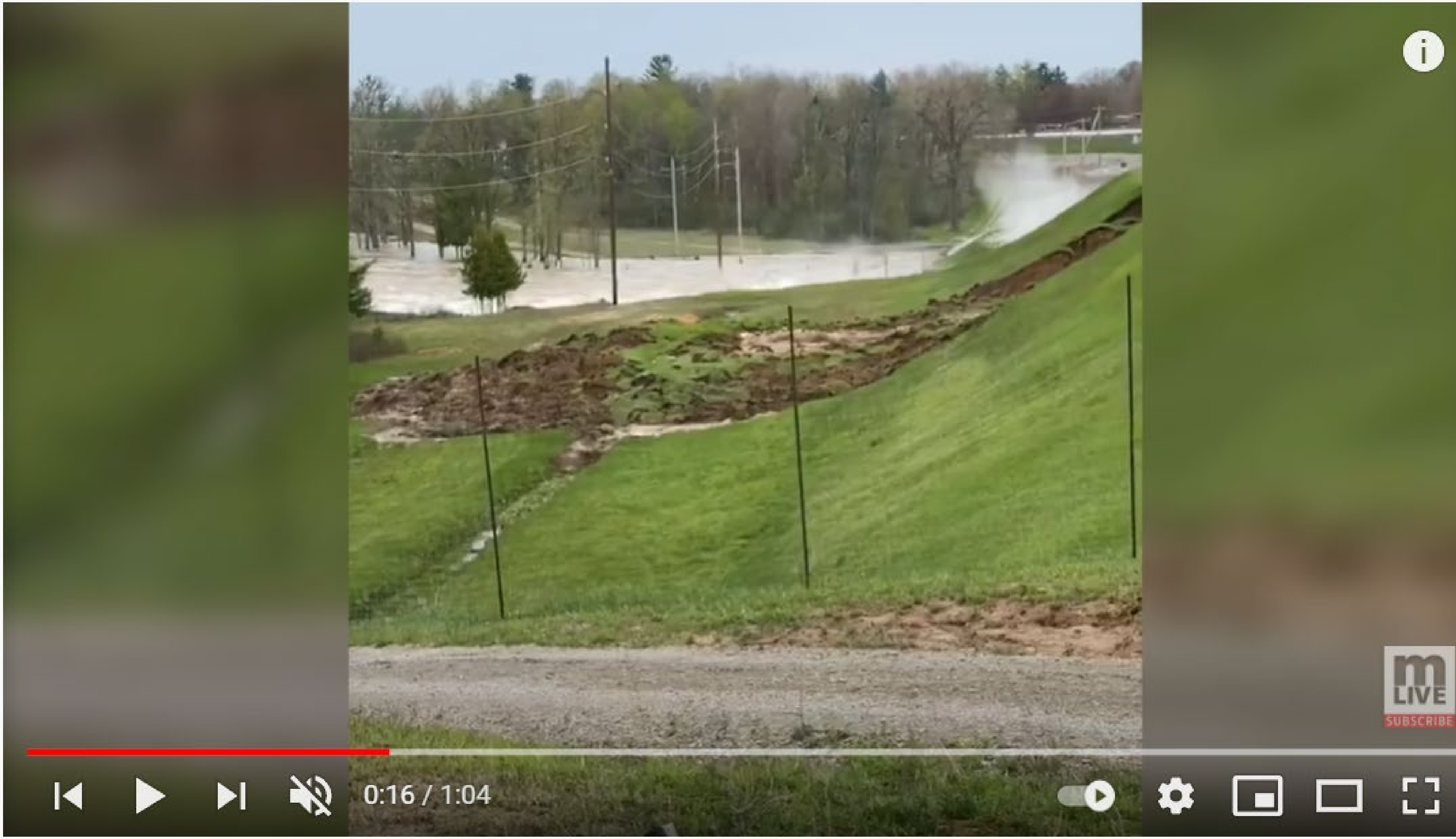
Temple, Darrel M., and Hanson, Gregory J., "Earth Dam Overtopping and Breach Outflow," Presented at the ASCE World Water & Environmental Resources Congress 2005, EWRI, Anchorage, AK, 15-19 May 2005.

# Taum Sauk Upper Dam, Missouri

# Brazil Mine Tailings Failure

Modeling by Prof Leonardo Moura
University of Brasilia






Michigan dam failure caught on video

2,913,549 views • May 20, 2020 10K 1.2K SHARE SAVE

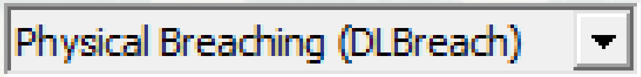
# Three Approaches

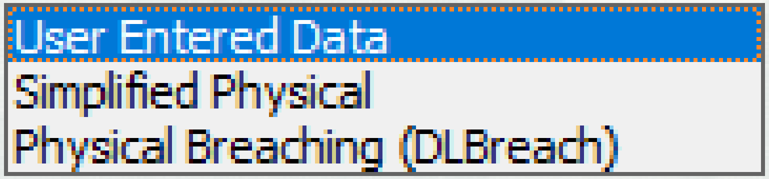
1. **User Entered Data**

   -Parameter Estimation


2. **Simplified Physical**


3. **DL Breach**



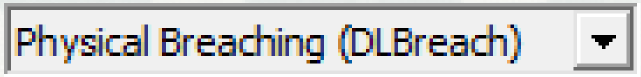
# Three Approaches

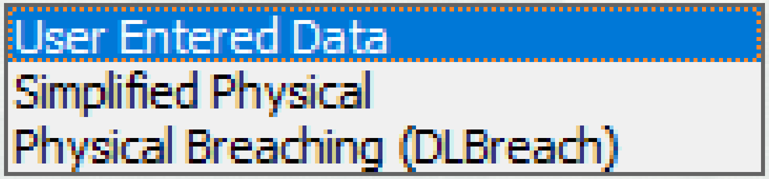
1. **User Entered Data**


   -Parameter Estimation

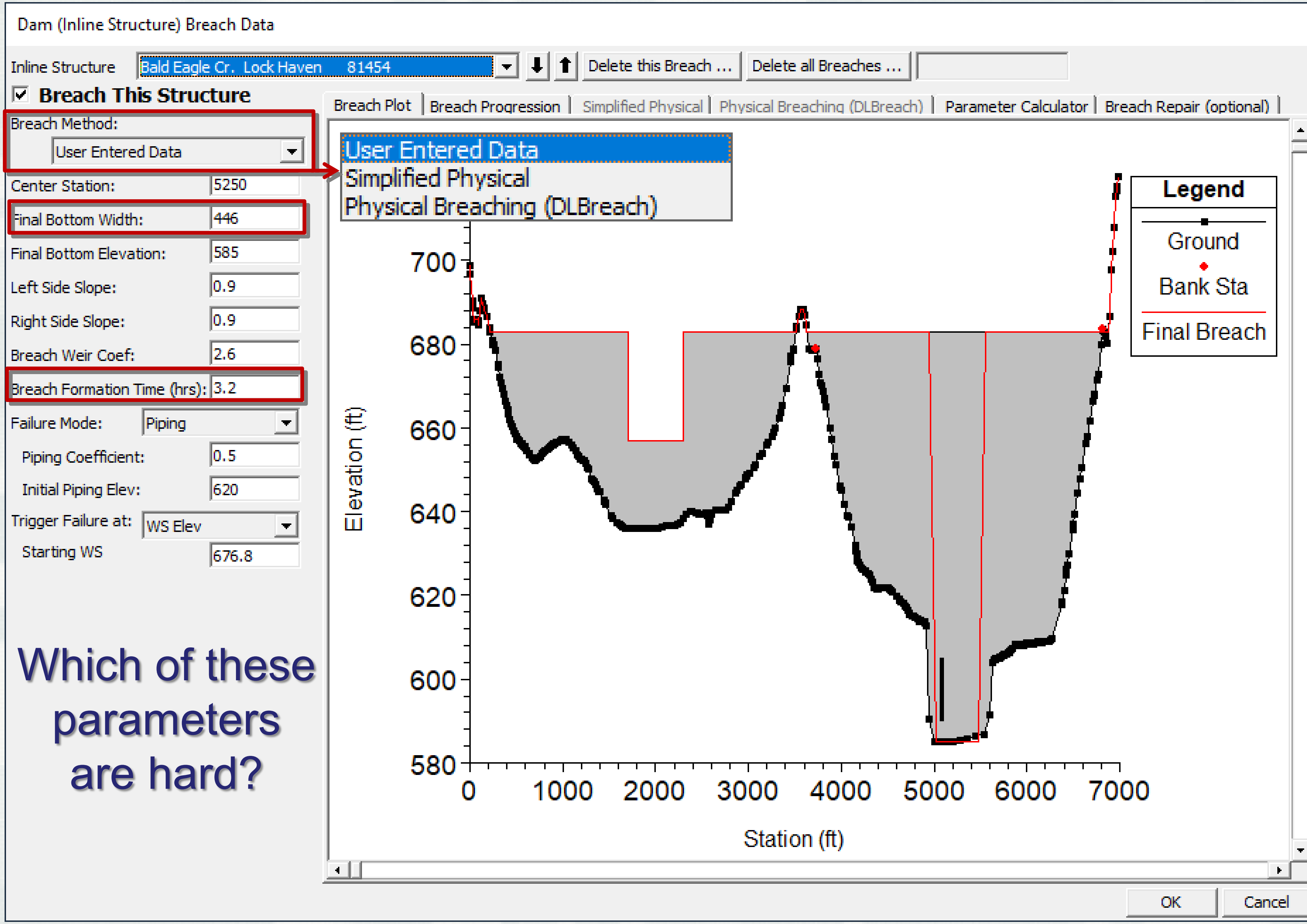
2. **Simplified Physical**


3. **DL Breach**



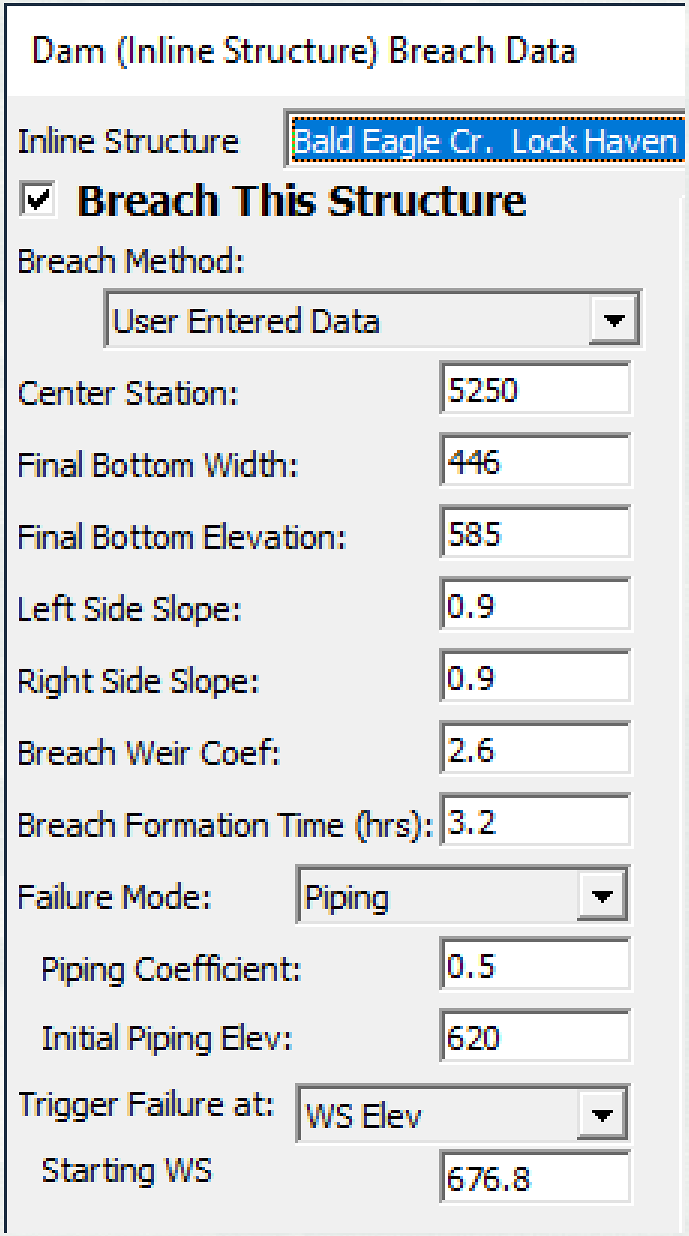
# HEC-RAS Breach Data




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

**Dam (Inline Structure) Breach Data**

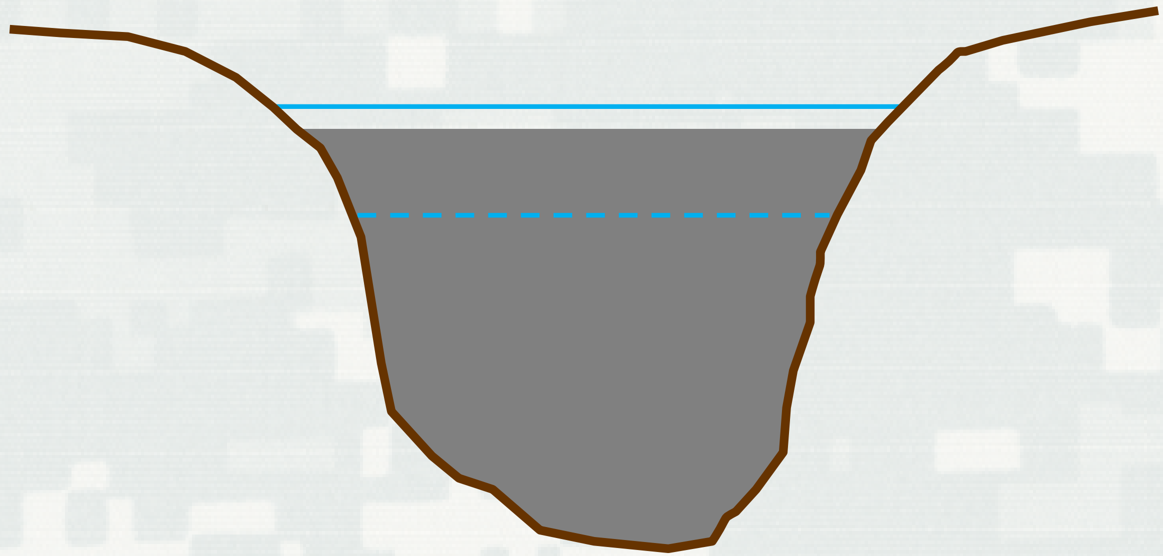
| | |
|---|---|
| Inline Structure | Bald Eagle Cr.  Lock Haven |

☑ **Breach This Structure**

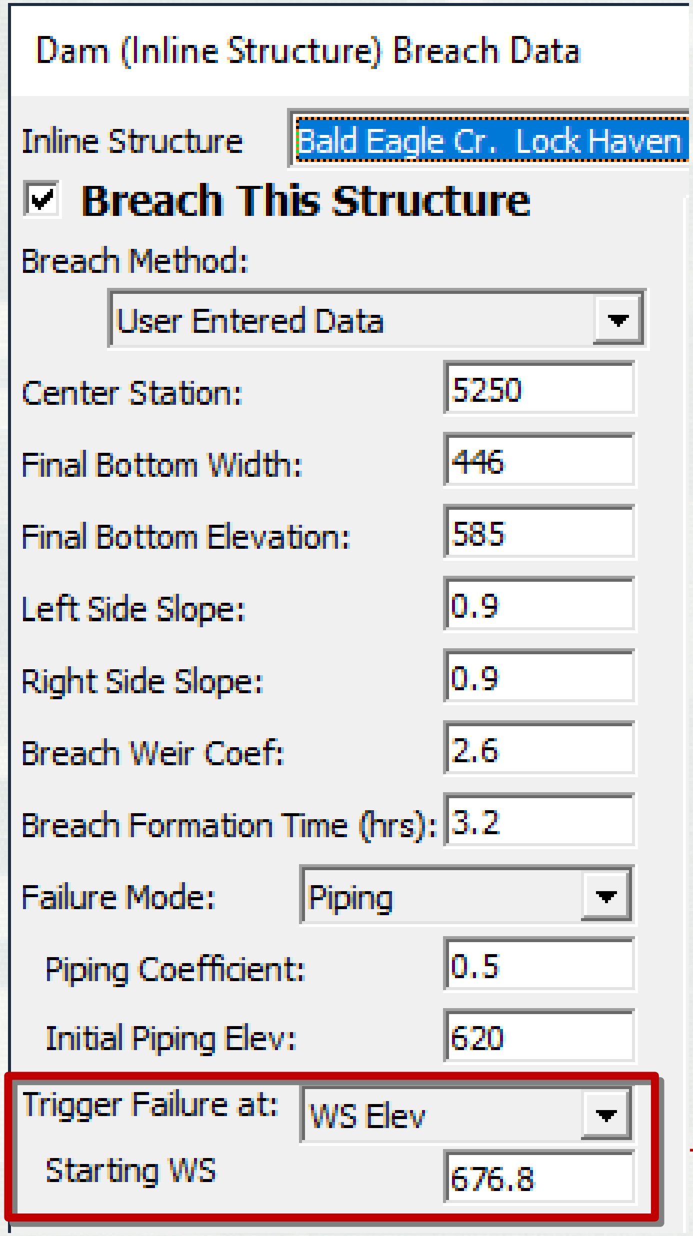
Breach Method:

User Entered Data

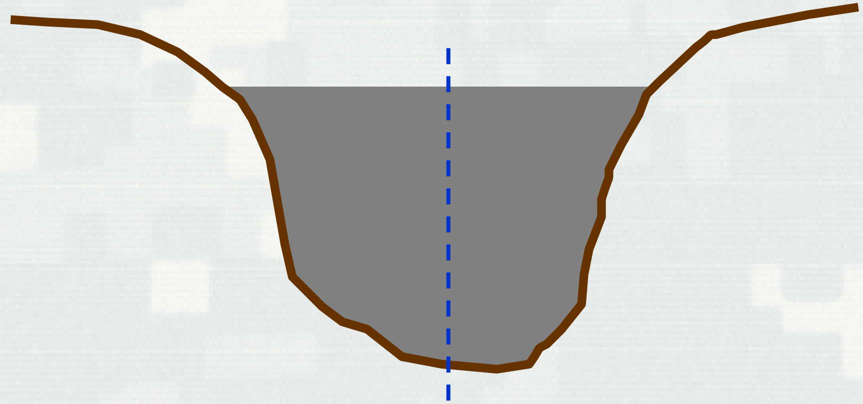
| | |
|---|---|
| Center Station: | 5250 |
| Final Bottom Width: | 446 |
| Final Bottom Elevation: | 585 |
| Left Side Slope: | 0.9 |
| Right Side Slope: | 0.9 |
| Breach Weir Coef: | 2.6 |
| Breach Formation Time (hrs): | 3.2 |
| Failure Mode: | Piping |
| Piping Coefficient: | 0.5 |
| Initial Piping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



# But First…A Couple Other Features

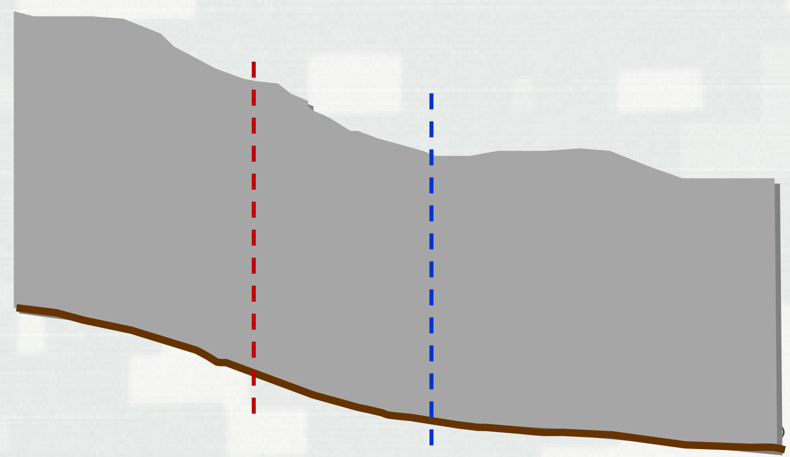



This doesn't matter much for a dam



But levees can be more complicated

Where



# 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 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)

# 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

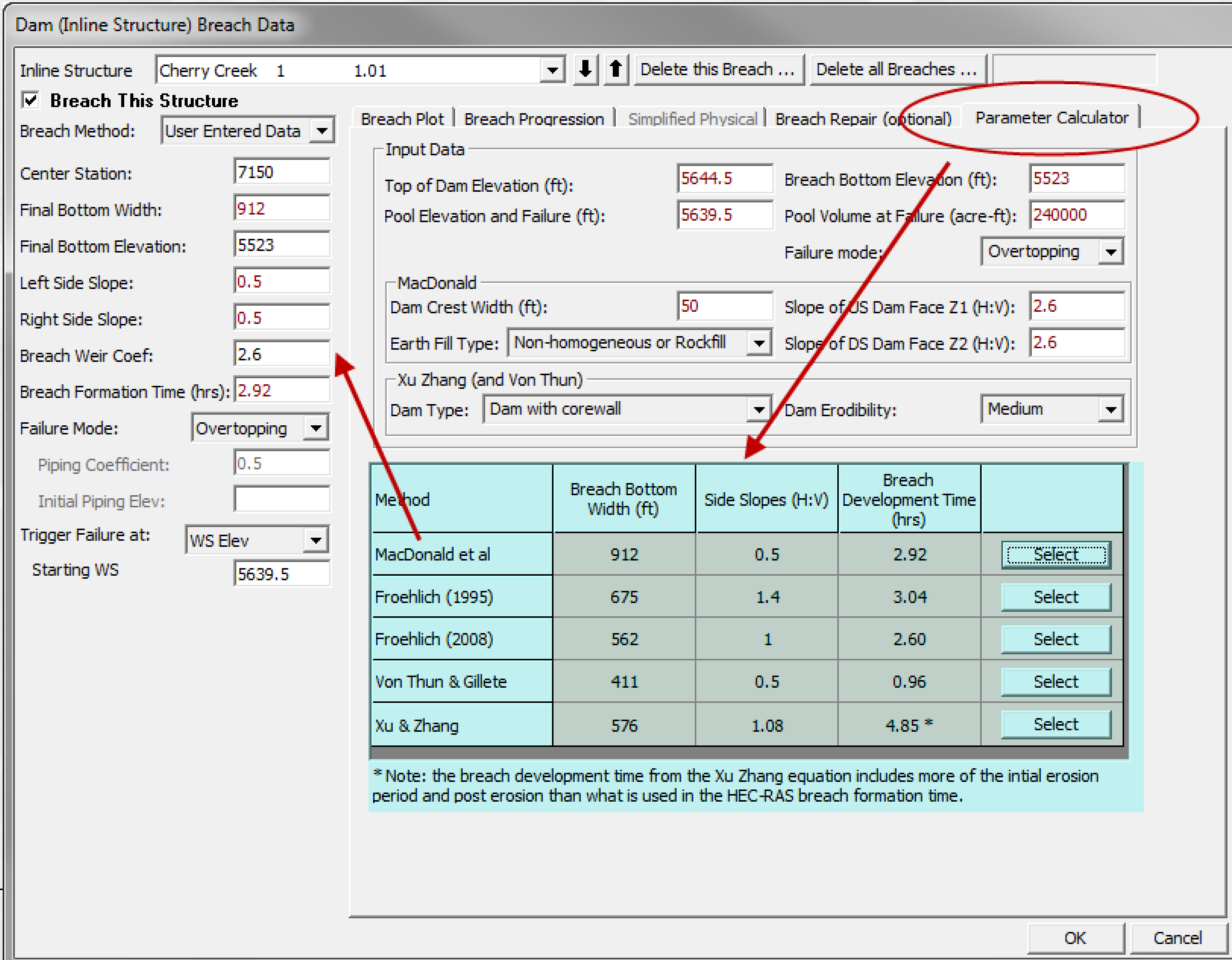
| Dam Type | Average Breach Width ($B_{ave}$) | Horizontal Component of Breach Side Slope (H) (H:V) | Failure Time, $t_f$ (hours) | Agency |
|---|---|---|---|---|
| Earthen/Rockfill | (0.5 to 3.0) x HD | 0 to 1.0 | 0.5 to 4.0 | USACE 1980 |
| | (1.0 to 5.0) x HD | 0 to 1.0 | 0.1 to 1.0 | FERC |
| | (2.0 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.

# Breach Parameter Calculator



# MacDonald and Langridge-Monopolis (1984)

**Earthfill**

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

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

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

**Non-earthfill**

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

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

(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 |
|---|---|
| $< 1.23 \times 10^6$ | 6.1 |
| $1.23 \times 10^6$ - $6.17 \times 10^6$ | 18.3 |
| $6.17 \times 10^6$ - $1.23 \times 10^7$ | 42.7 |
| $> 1.23 \times 10^7$ | 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)

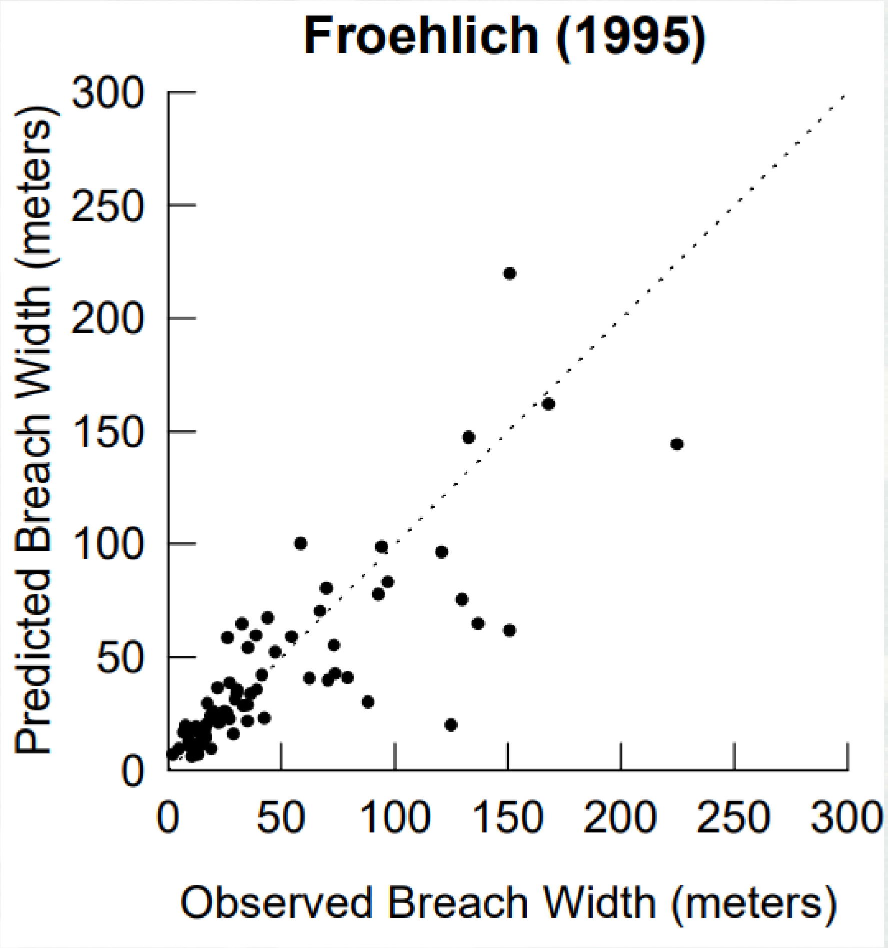
$$B_{ave} = 0.1803\,K_o\,V_w^{0.32}\,h_b^{0.19}$$

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

# Froehlich (2008)

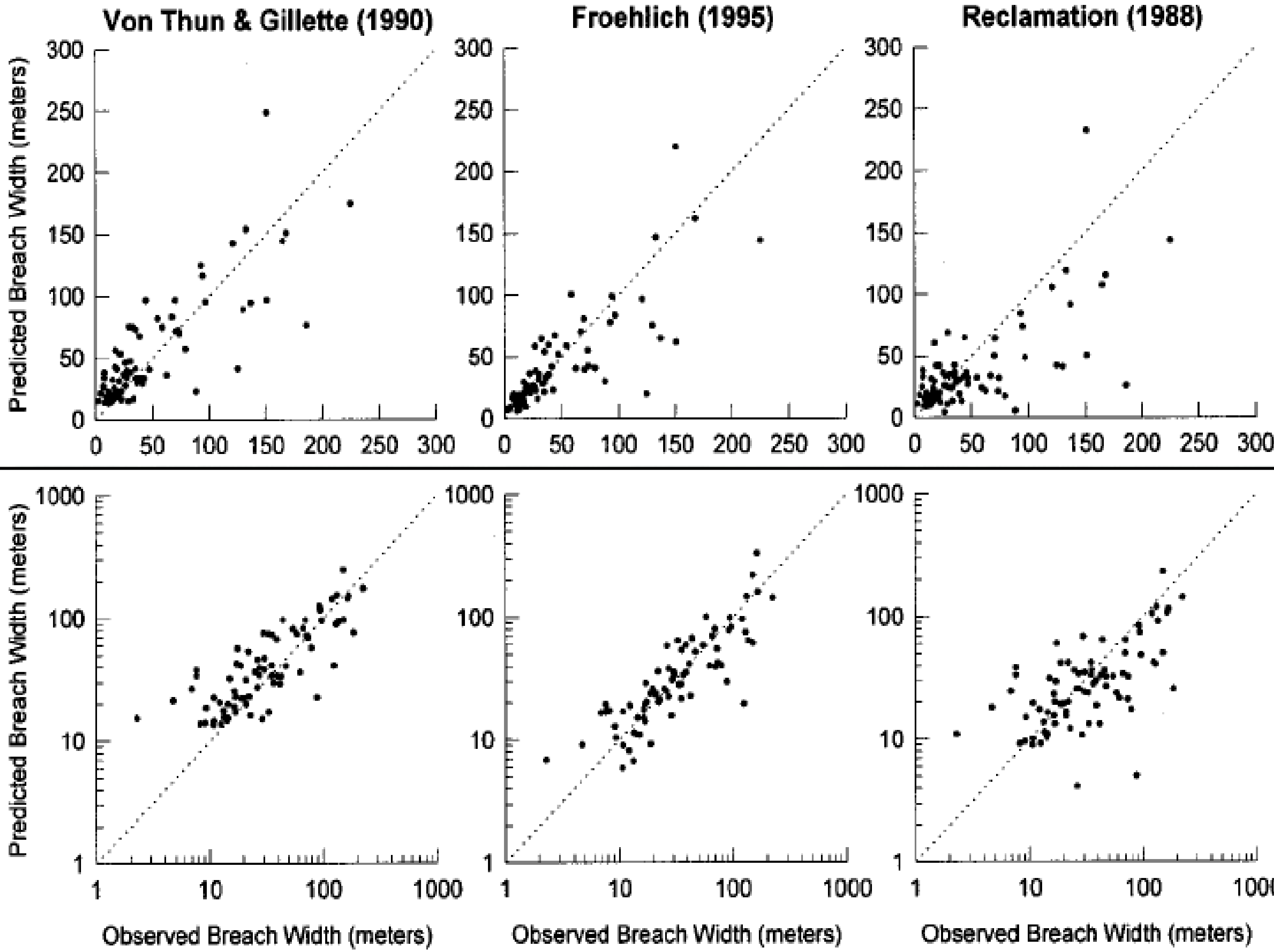
$$B_{ave} = 0.27\,K_o\,V_w^{0.32}\,h_b^{0.04}$$

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




$V_w$ = 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 & 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) | |
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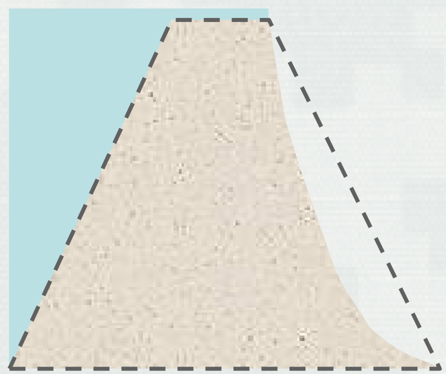
| Froehlich (2008) | 544 | 1 | 3.04 | Select |
| Von Thun & Gillete | 363 | 0.5 | 0.81 | Select |
| Xu & Zhang | 499 | 1.06 | 5.05 * | Select |

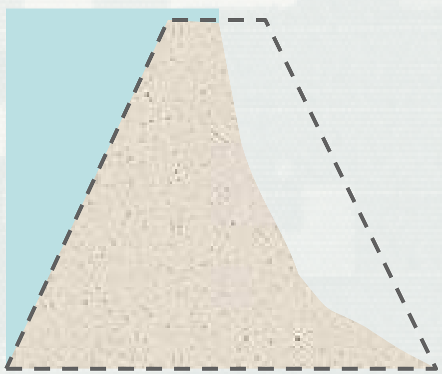
# Thought Experiment

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

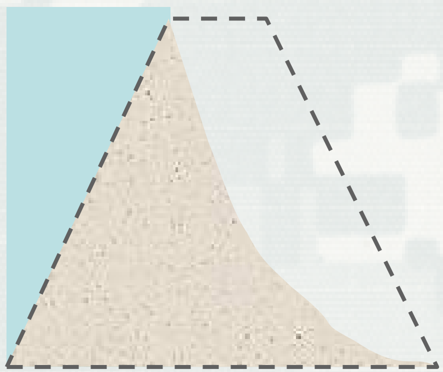
1.)



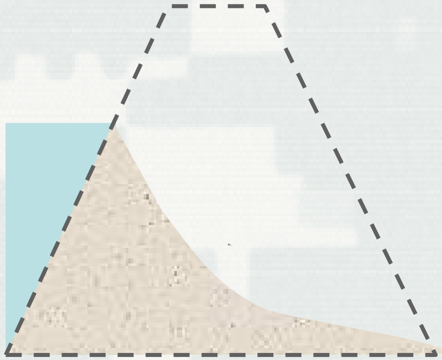
2.)



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?

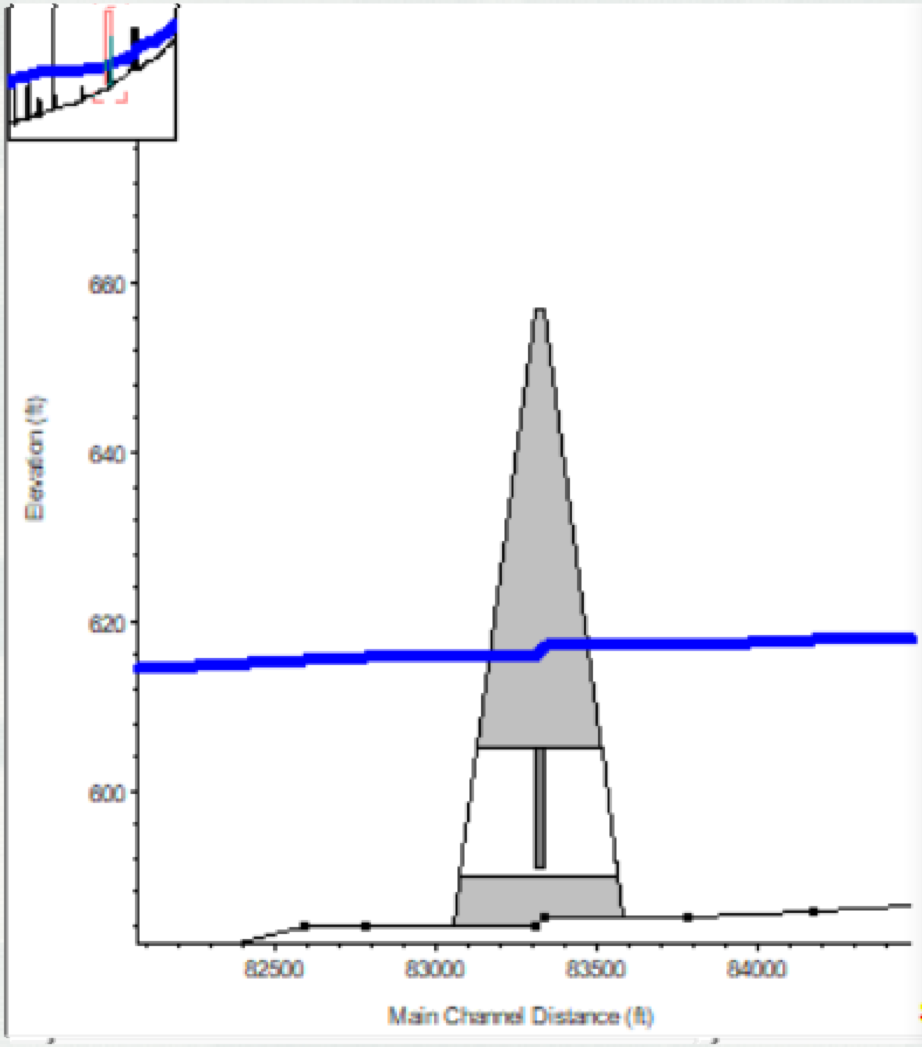
# Evaluate Breach Progress

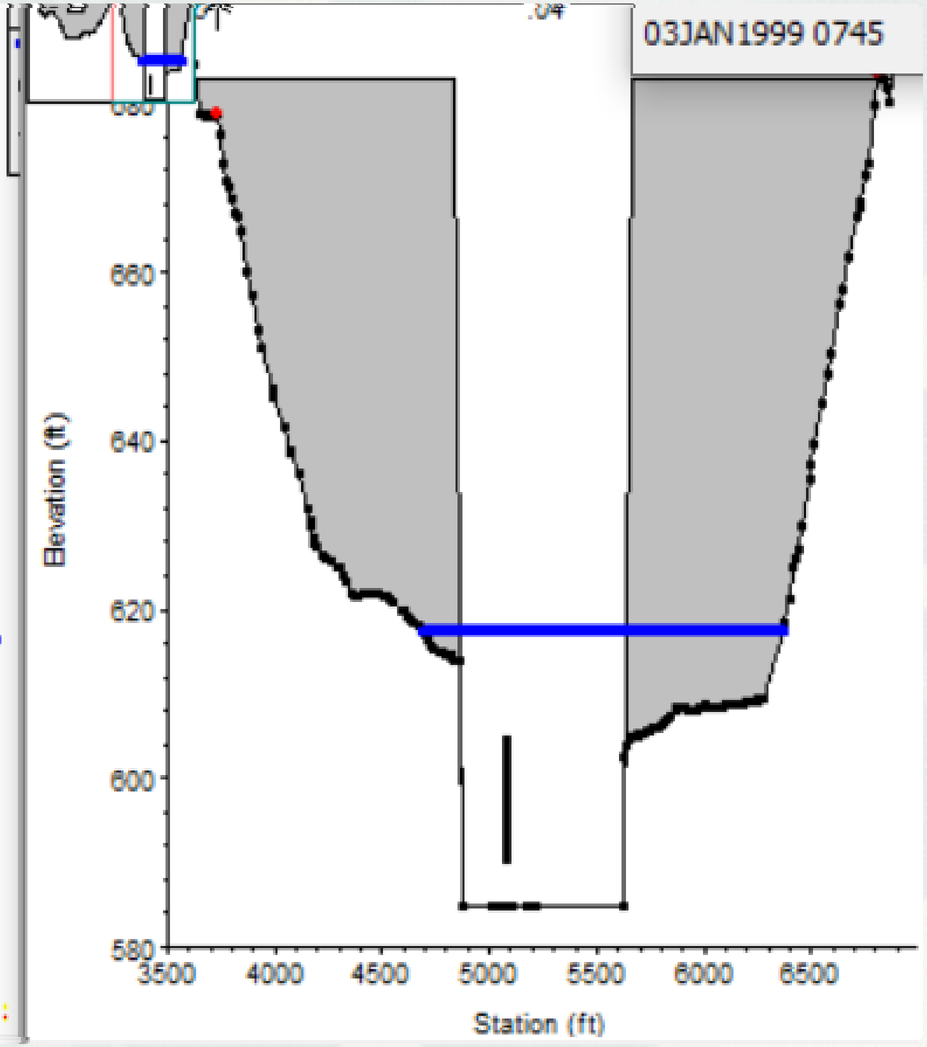
- Breach parameter estimation is uncertain.

| 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 |

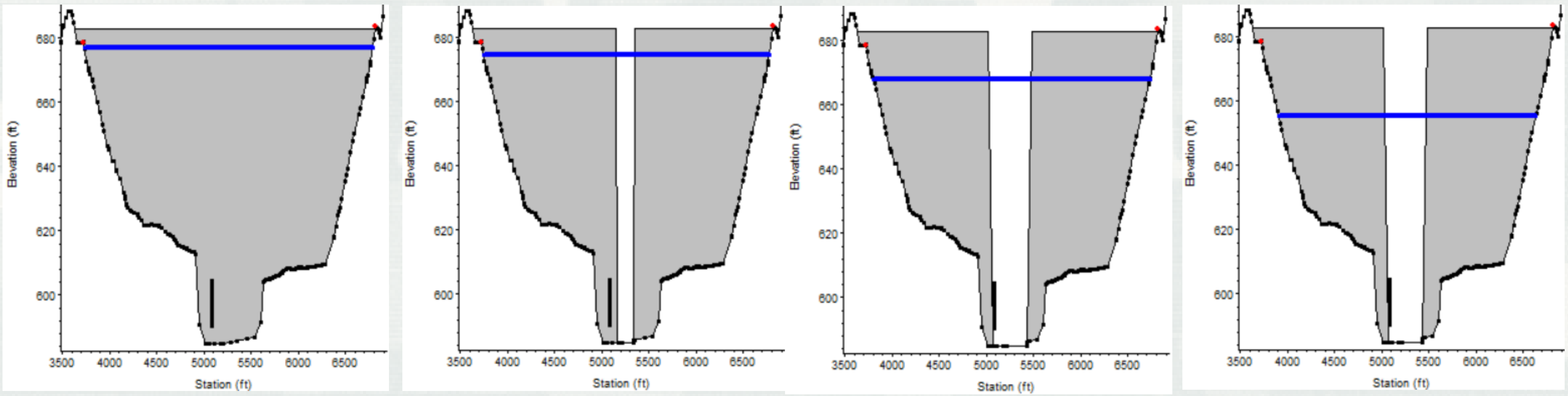
- We can use HEC-RAS hydraulic results to inform our decision on breach parameter selection.

# Profile and Breach Plots

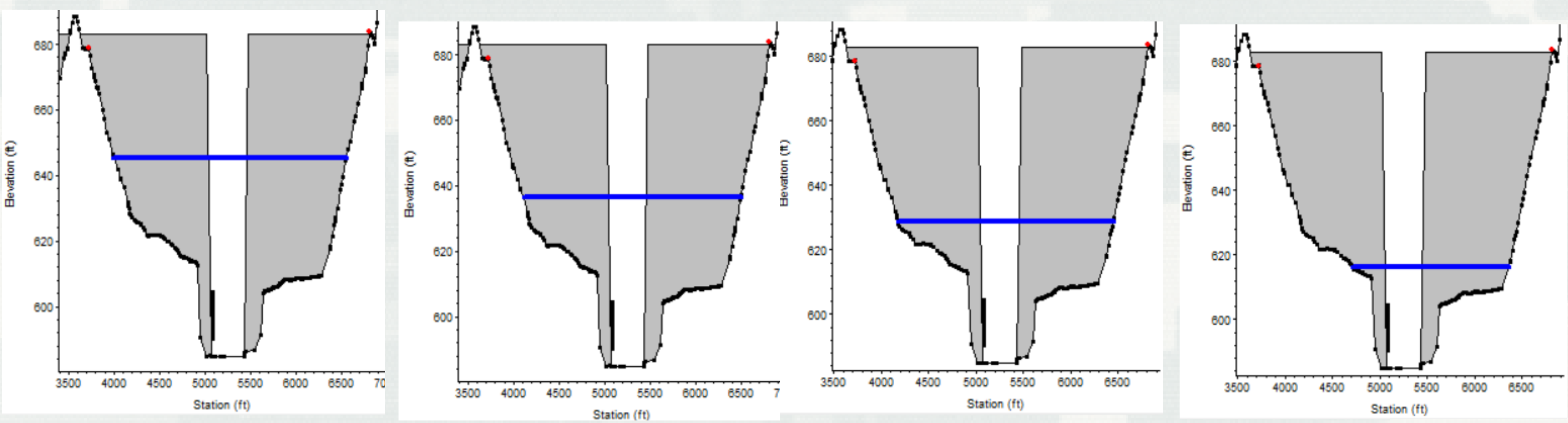


# Do you have any concerns about this simulation?

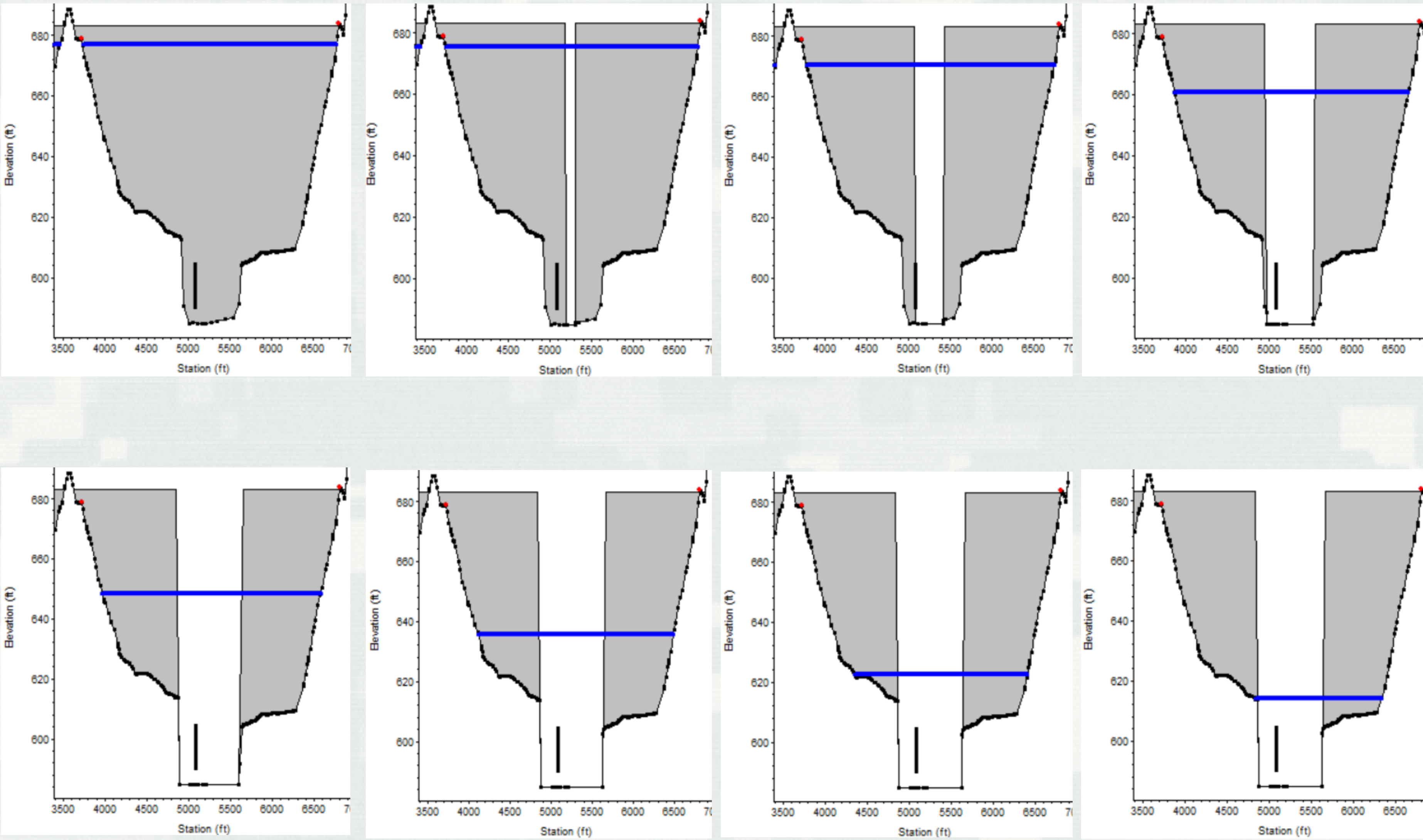



**Breach Progression Ends Here**




**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

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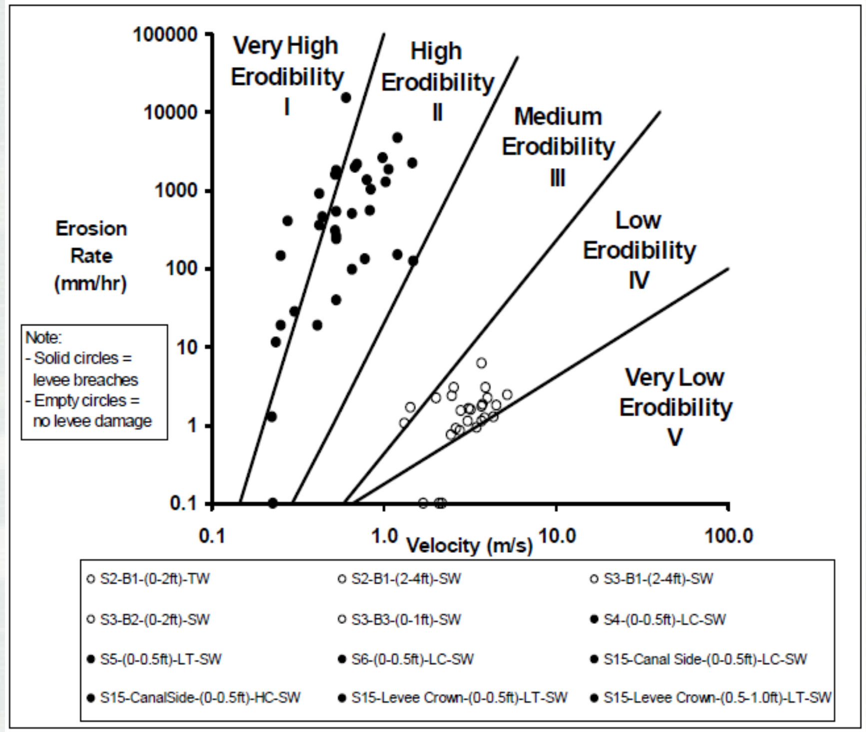
## Technical Memorandum for Record

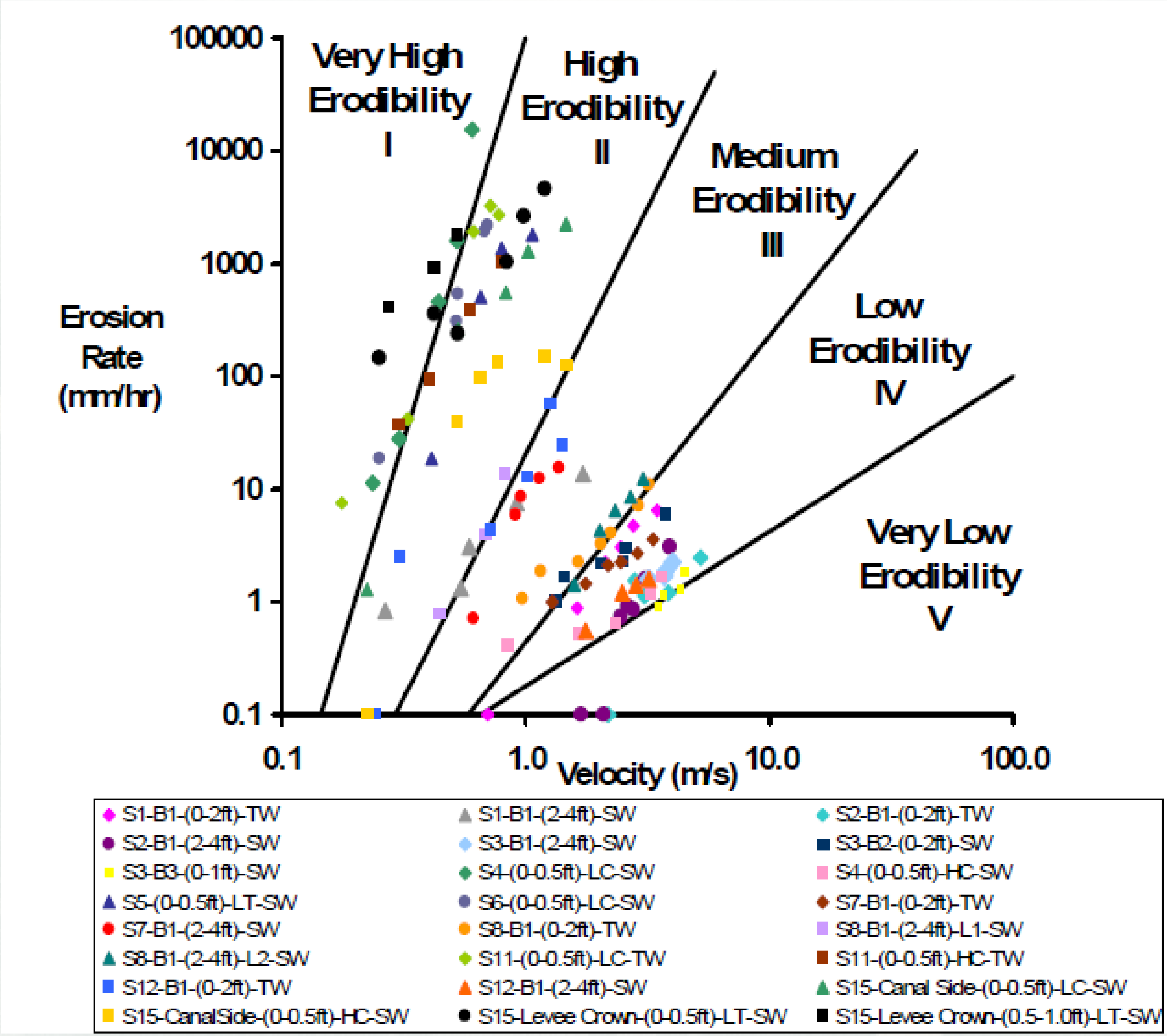
**Date:** May 31, 2013 (Revised July 2, 2013)

**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.



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**

   -Parameter Estimation

   User Entered Data

2. **Simplified Physical**

   Simplified Physical

3. **DL Breach**

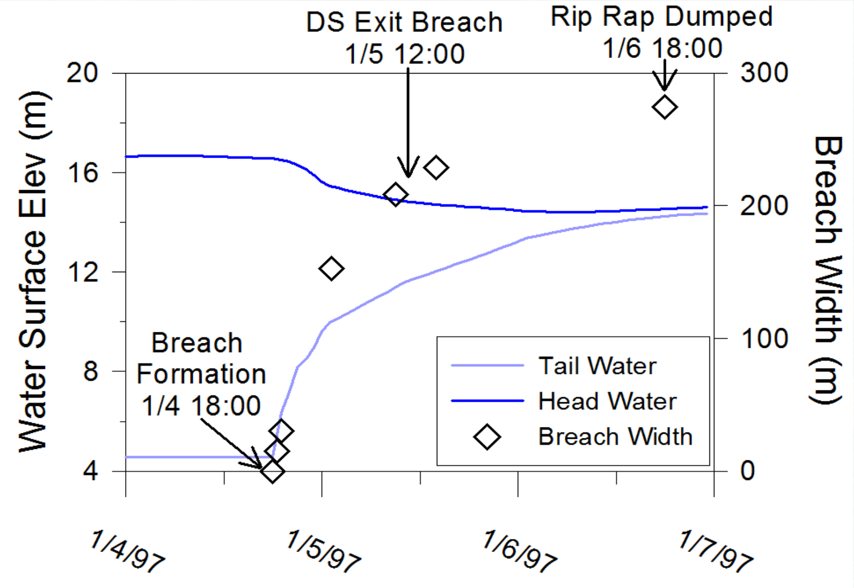
   Physical Breaching (DLBreach)

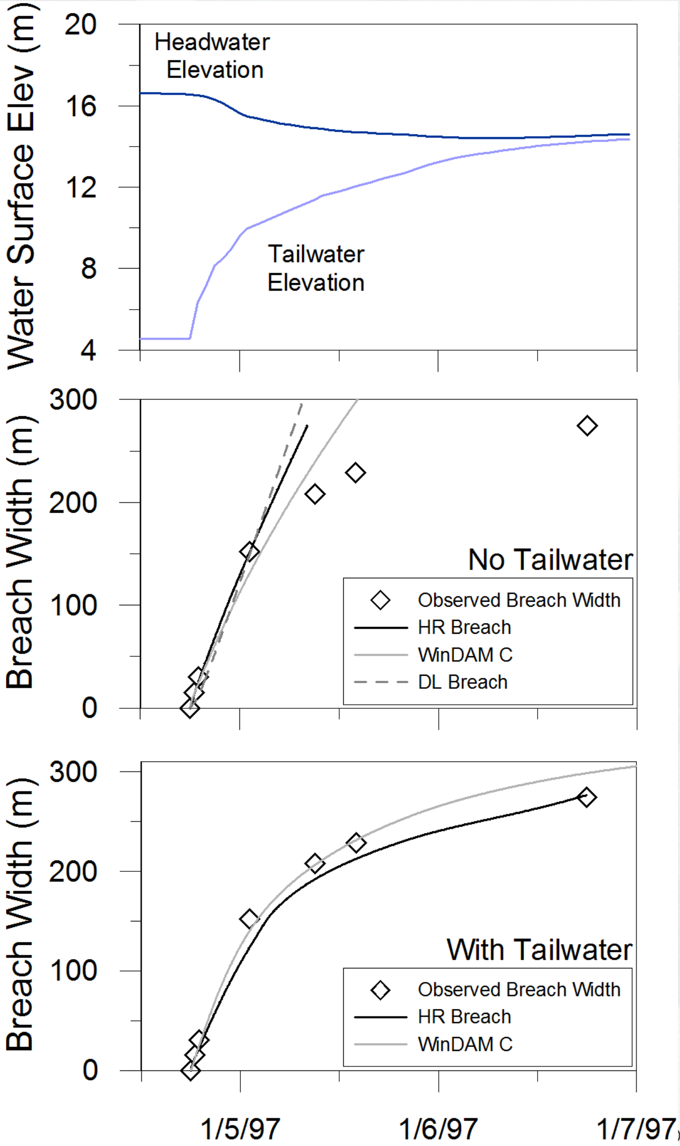
# Estimating the Breach Evolution

## Process Models:

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

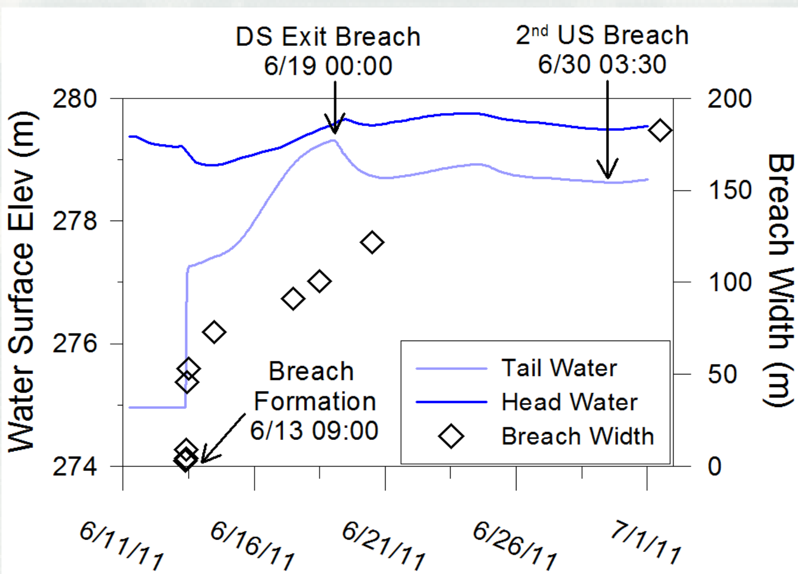
# Sutter Bypass Levee Breach

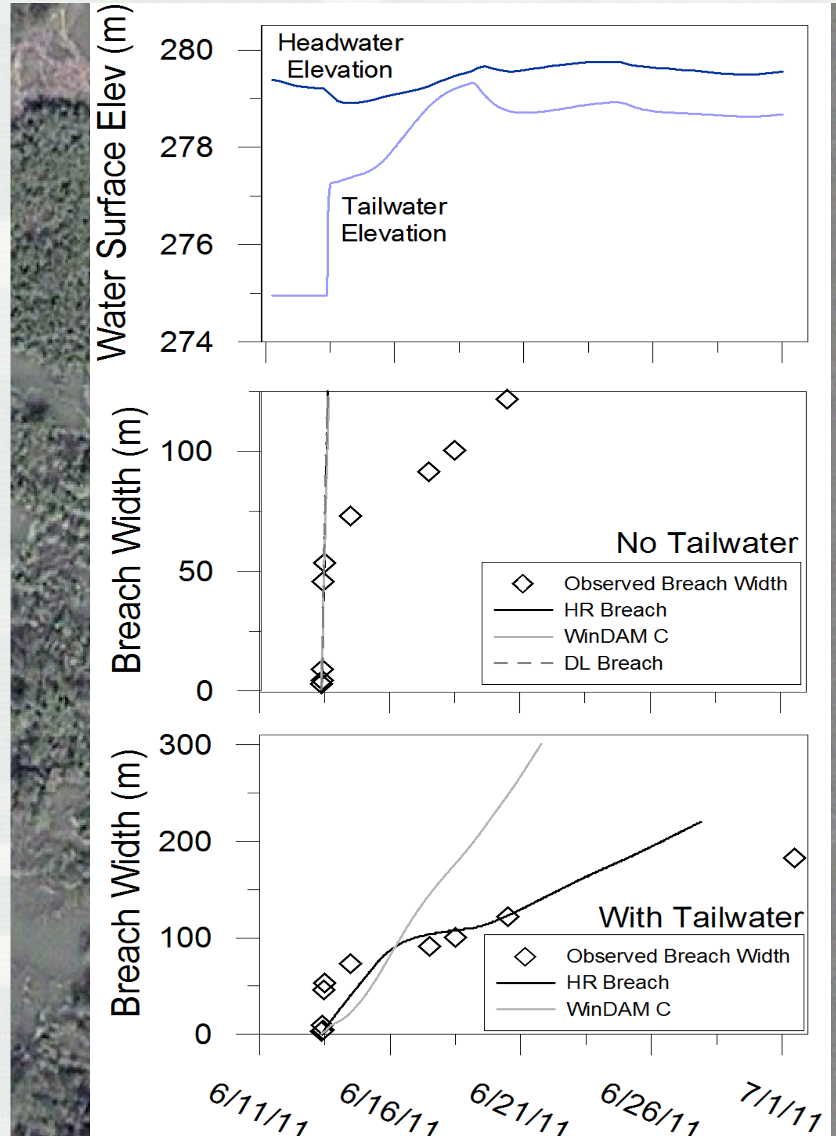



From: Risher, P. and Gibson, S. (2016) "Applying Mechanistic Dam Breach Models to Historic Levee Breaches," Proceedings FloodRisk 2016.

# Hamburg Breach (Missouri River)



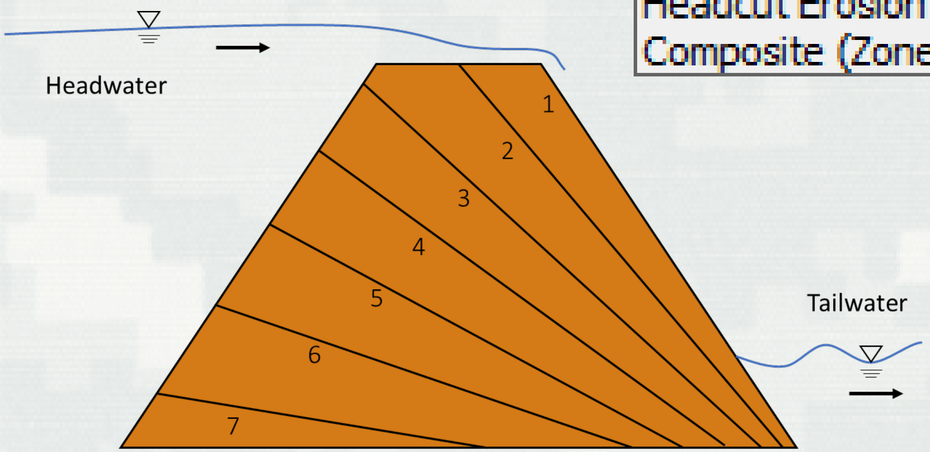



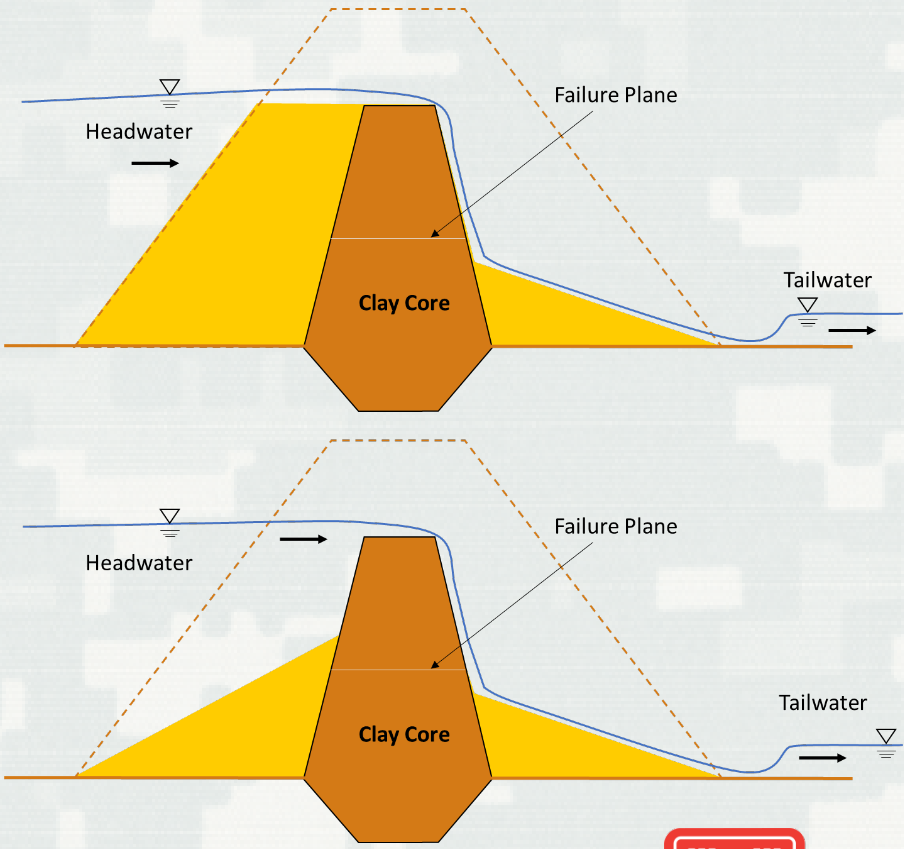

From: Risher, P. and Gibson, S. (2016) "Applying Mechanistic Dam Breach Models to Historic Levee Breaches," Proceedings FloodRisk 2016.

# DLBreach

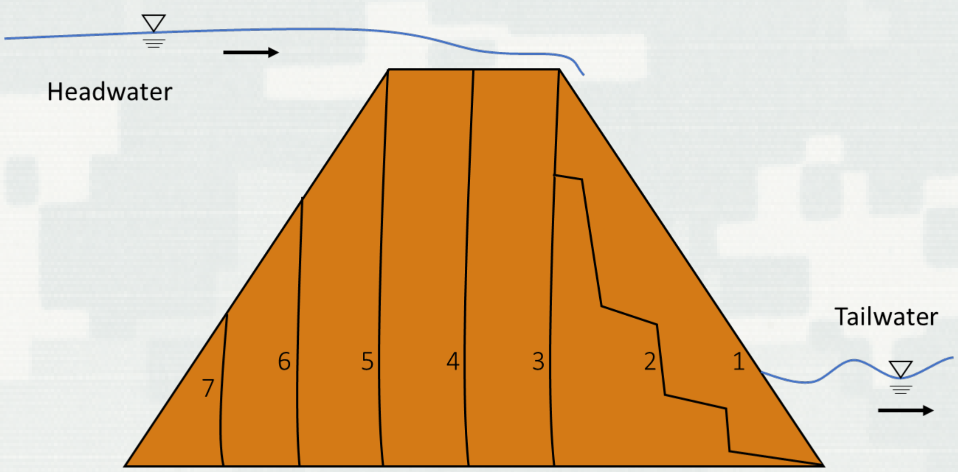
## Surface

Surface Erosion
Headcut Erosion
Composite (Zoned) Structure



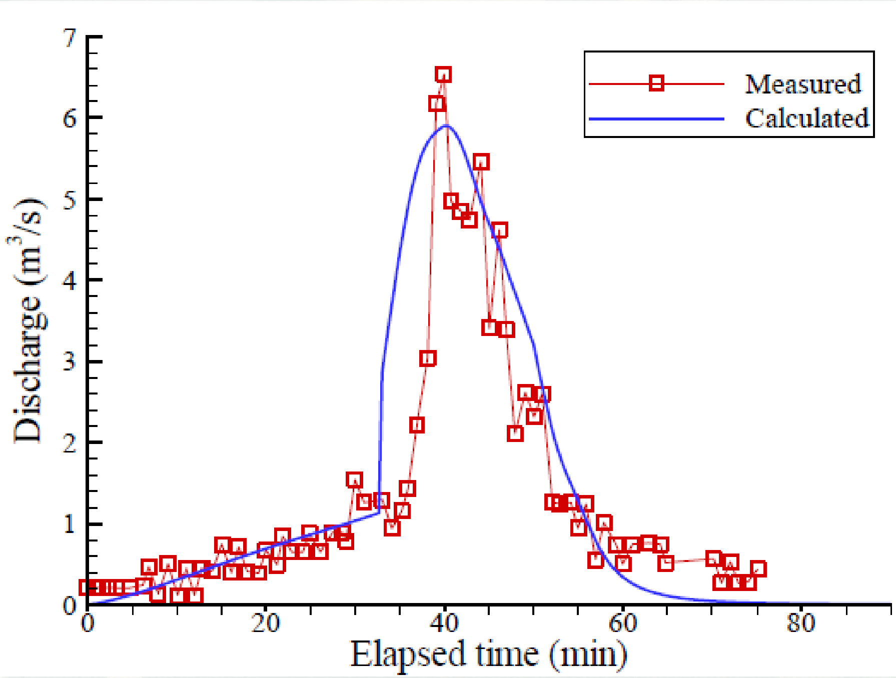




## Headcut

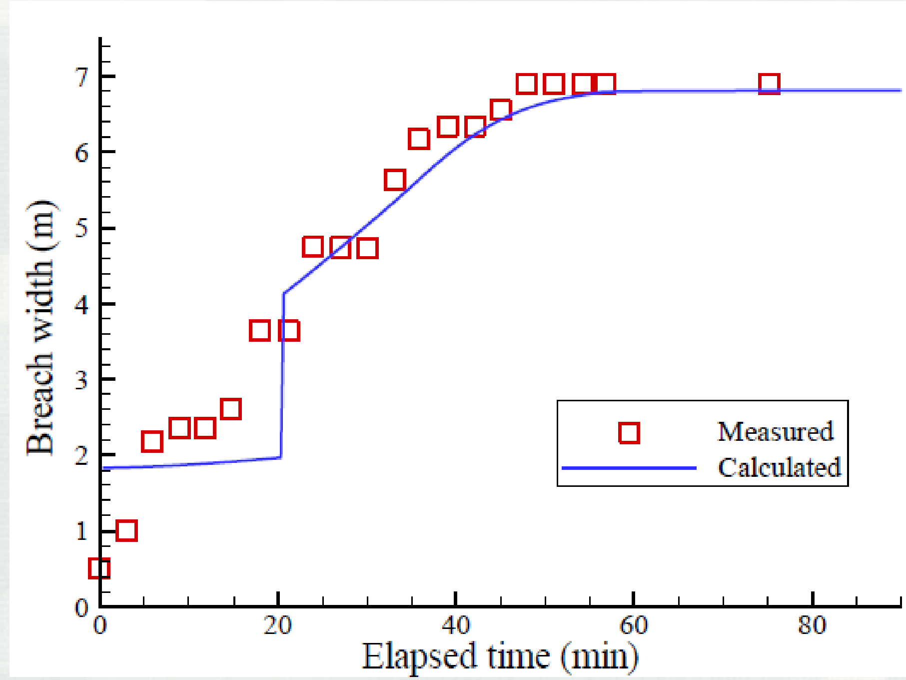



## Composite

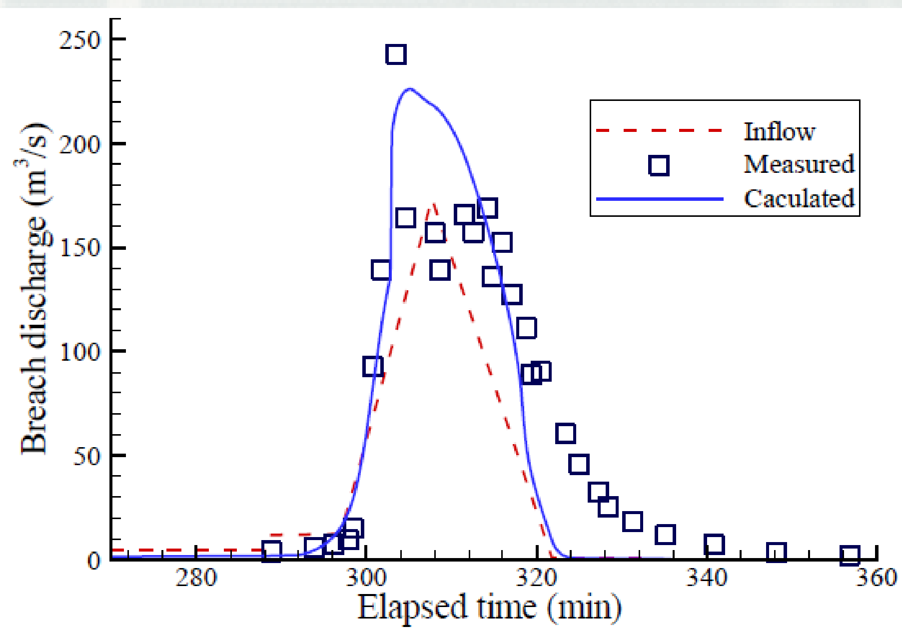
# DLBreach



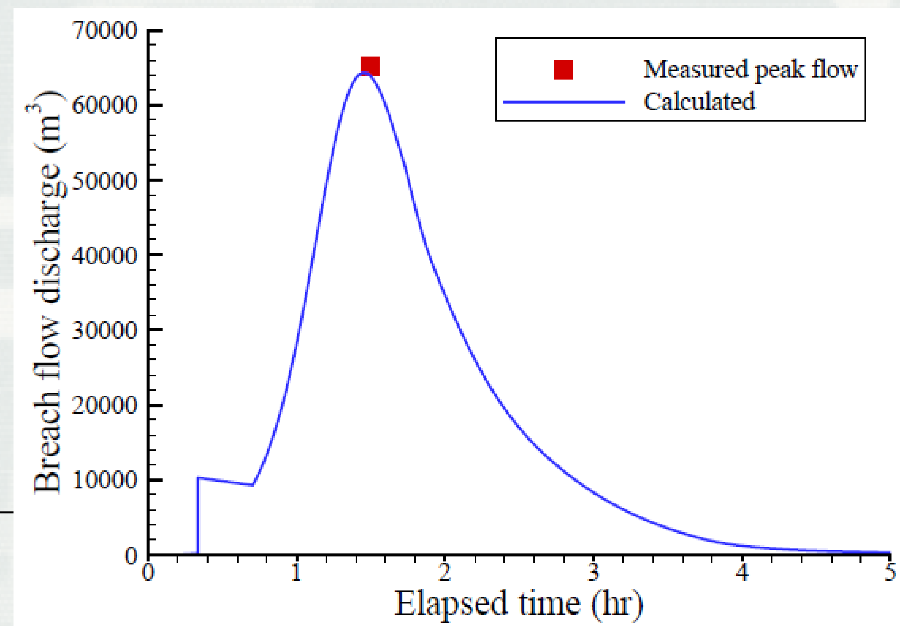
Discharge (m^3/s)
Elapsed time (min)
Measured
Calculated
0
1
2
3
4
5
6
7
0
20
40
60
80

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

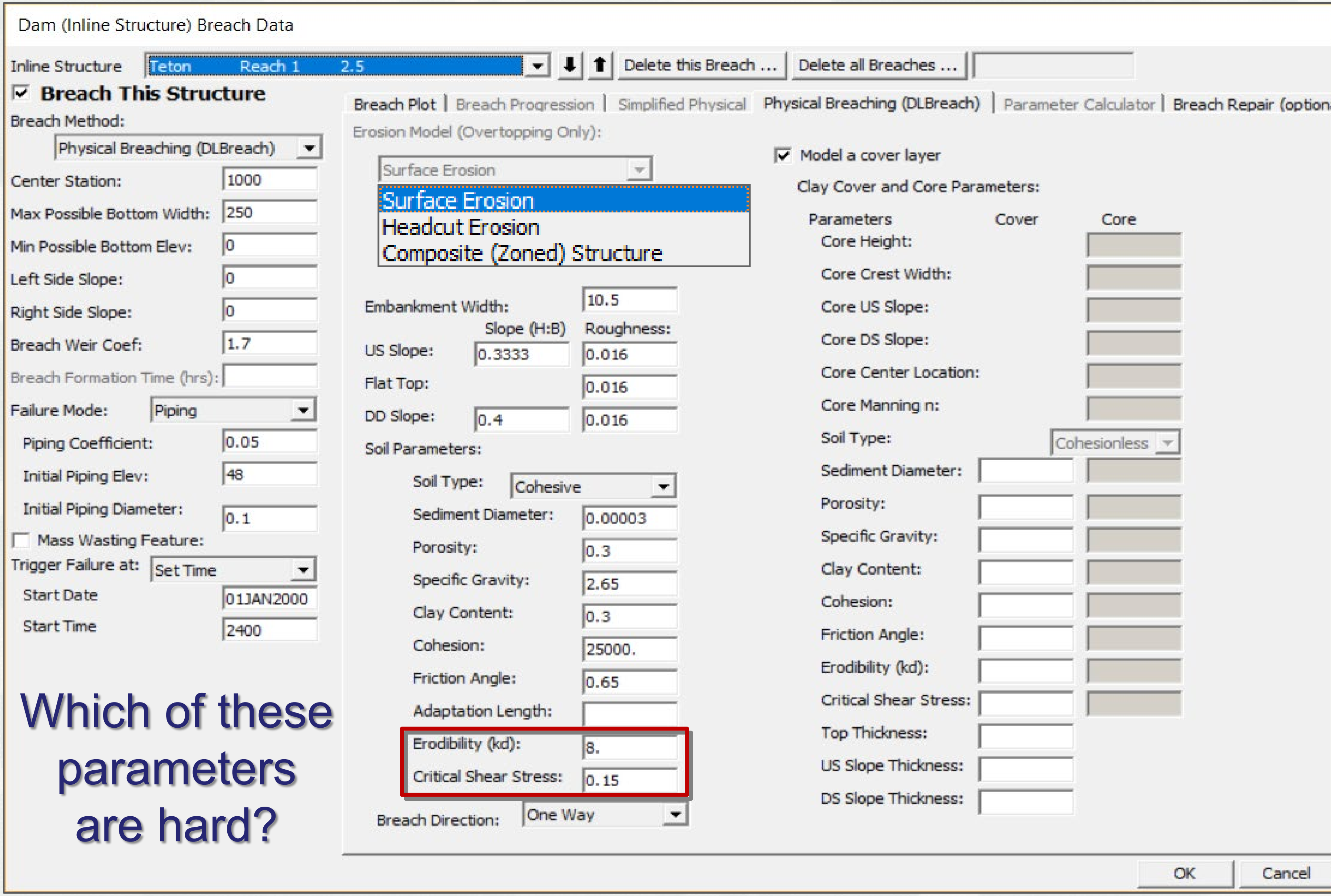



Breach discharge (m^3/s)
Elapsed time (min)
Inflow
Measured
Caculated
0
50
100
150
200
250
280
300
320
340
360

Breach flow discharge (m^3)
Elapsed time (hr)
Measured peak flow
Calculated
0
10000
20000
30000
40000
50000
60000
70000
0
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

Approved for Public Release. Distribution Unlimited.

TD-39

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# USBR Levee Breach Lab Studies

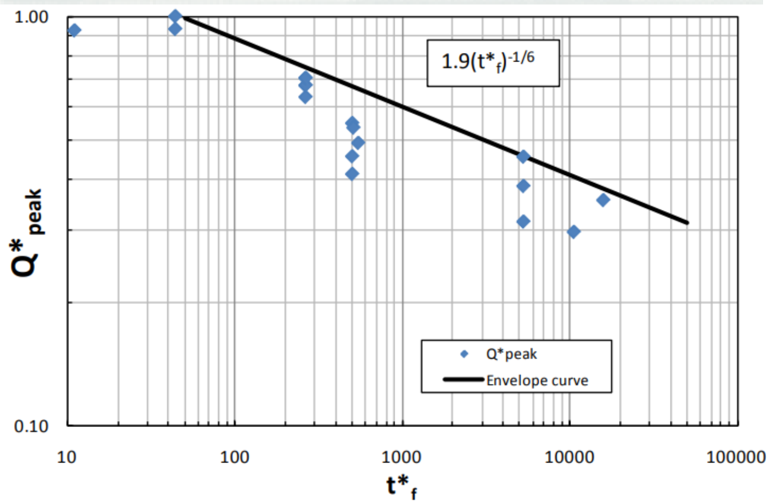


Figure 28. — Dimensionless peak discharge as a function of dimensionless breach development time.

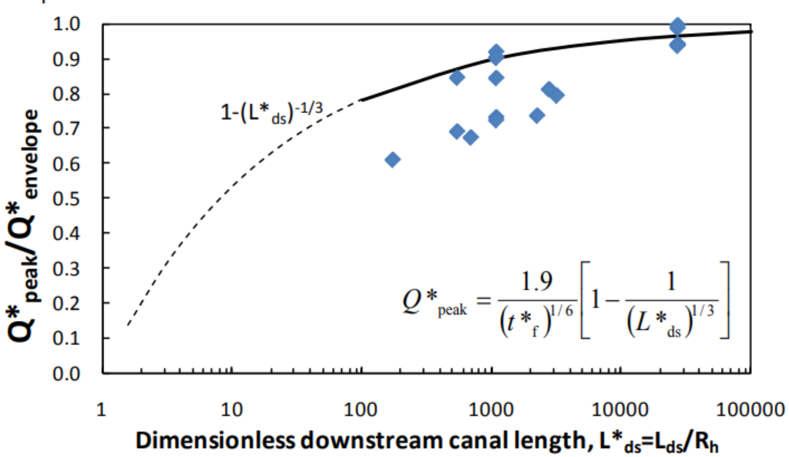


Figure 29. — Effect of downstream canal reach length on peak breach outflow.

**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**