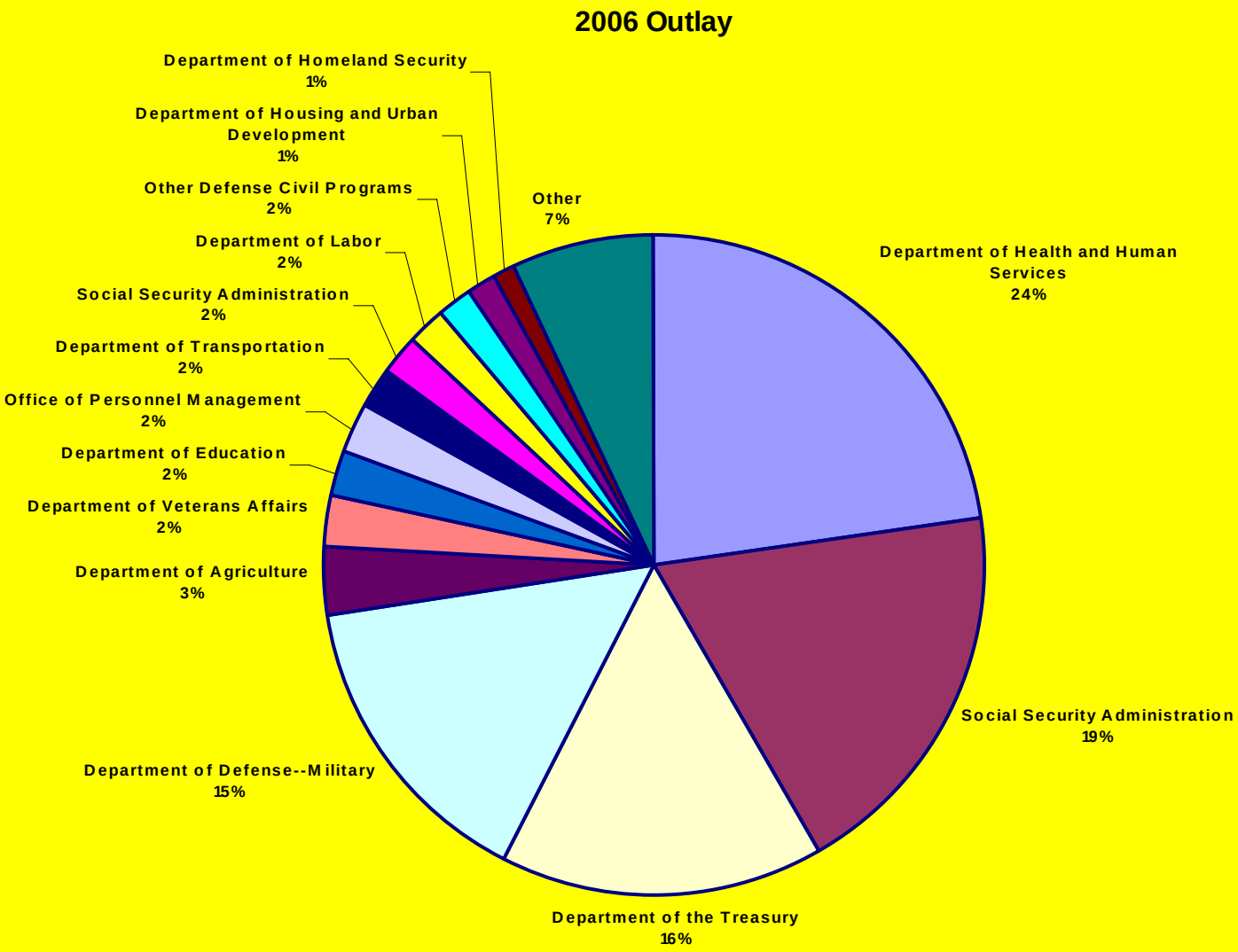
New Orleans Bridges and Levees
A Look at the Future
In Light of Katrina Observations

Jean-Louis Briaud, PhD, P.E.

Professor, Texas A&M University

Member of the NSF-Berkeley Team

USA BUDGET = 2.5 Trillion dollars = 2,500,000,000,000 Dollars



http://www.whitehouse.gov/omb/budget/fy2006/db.html

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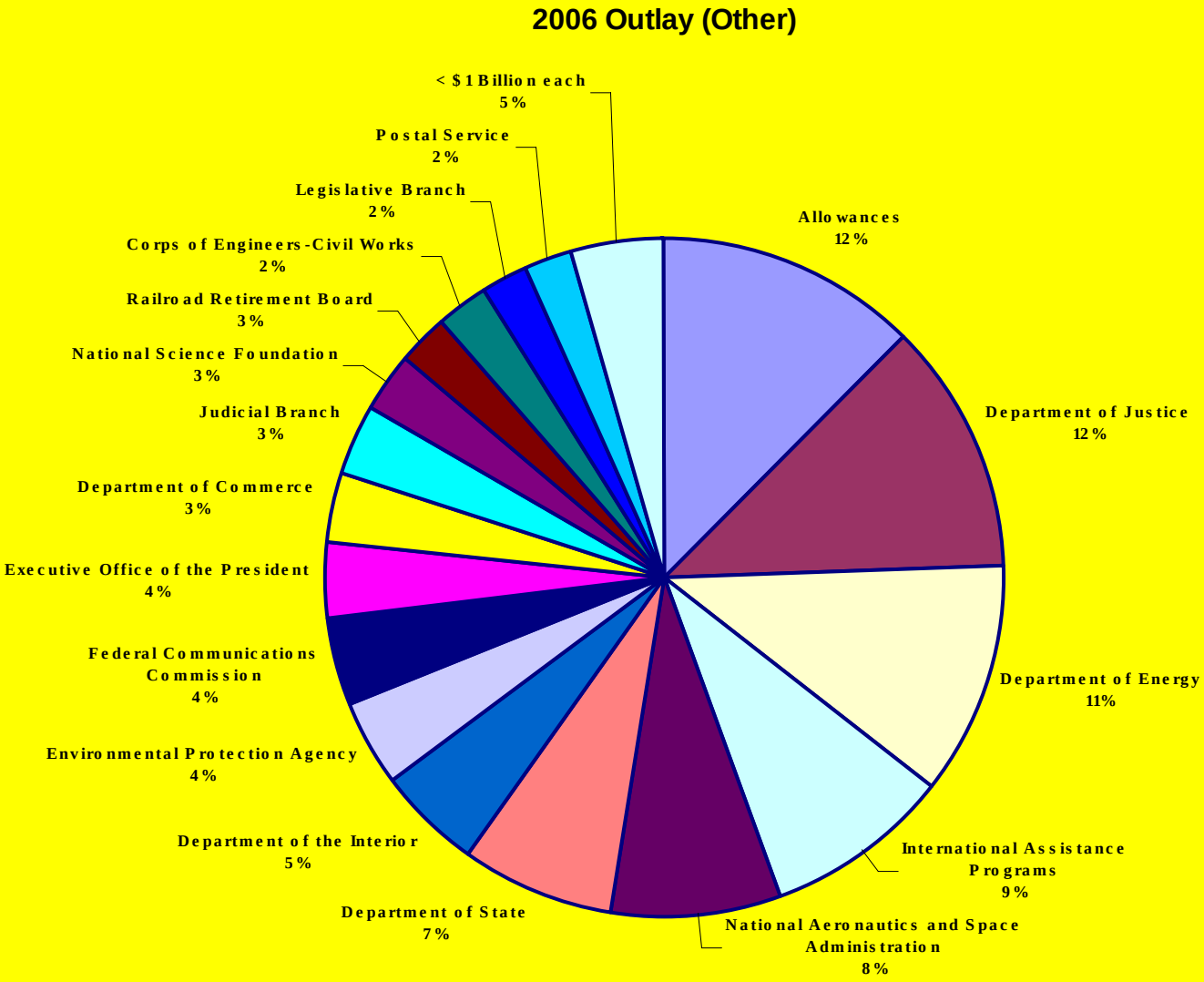
USA BUDGET = 2.5 Trillion dollars = 2,500,000,000,000 Dollars



http://www.whitehouse.gov/omb/budget/fy2006/db.html

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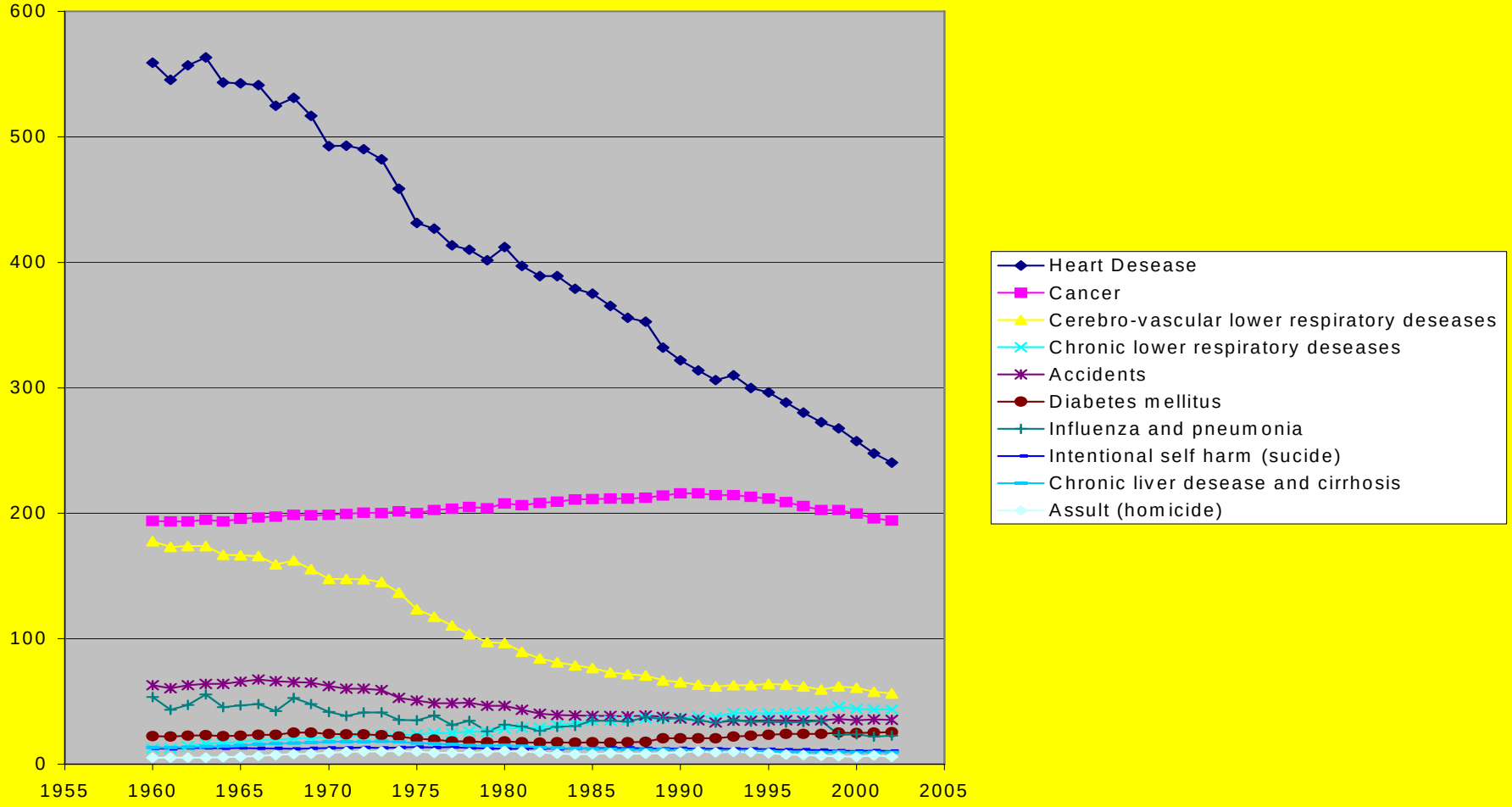
USA POPULATION = 300 Millions
DEATHS PER YEAR = 2.5 Millions

DEATHS PER YEAR AND PER 100,000 PEOPLE



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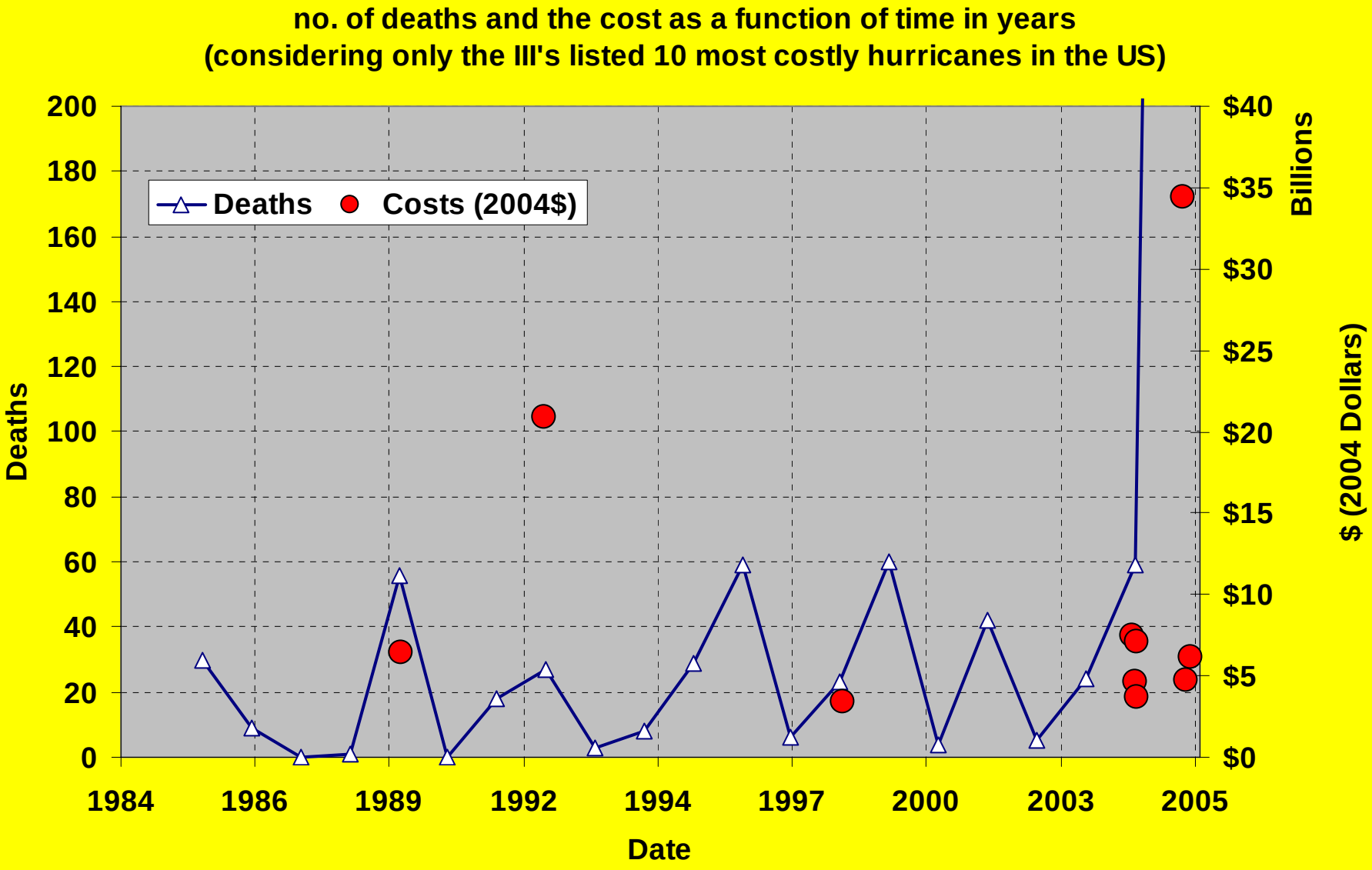
HURRICANE DEATHS and DAMAGE COST



http://www.iii.org/media/facts/statsbyissue/hurricanes/

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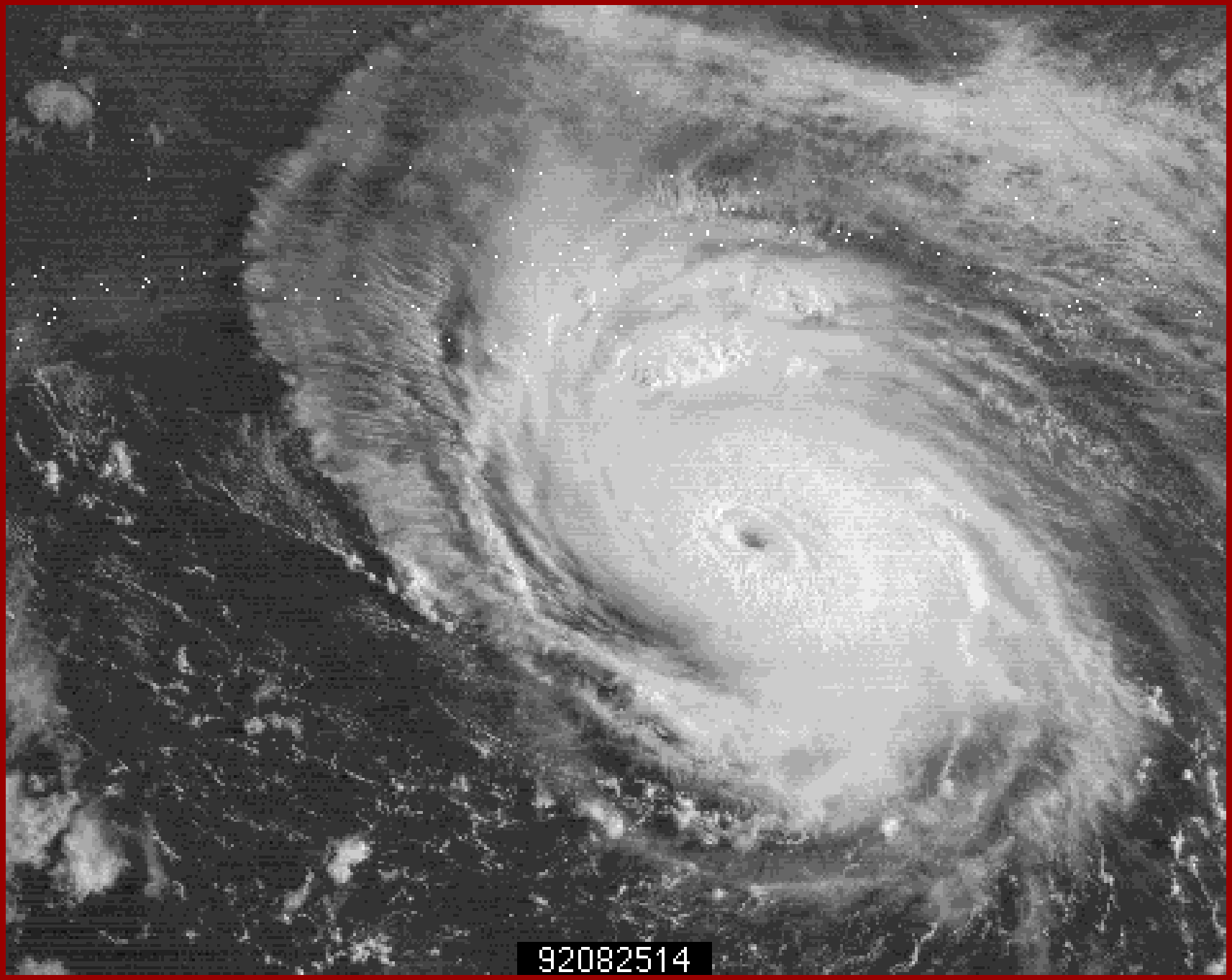

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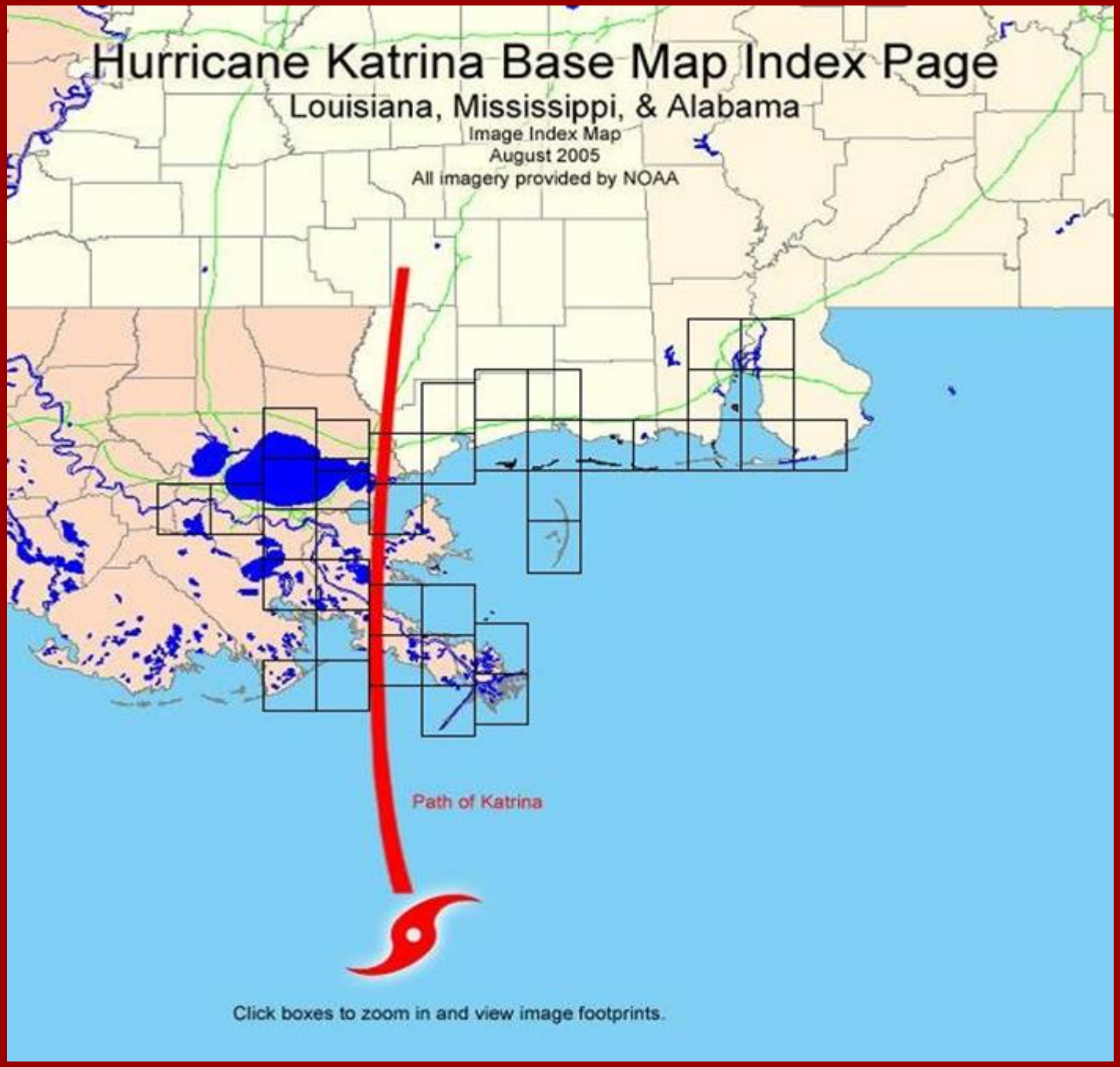
Hurricane = 250 miles in diameter

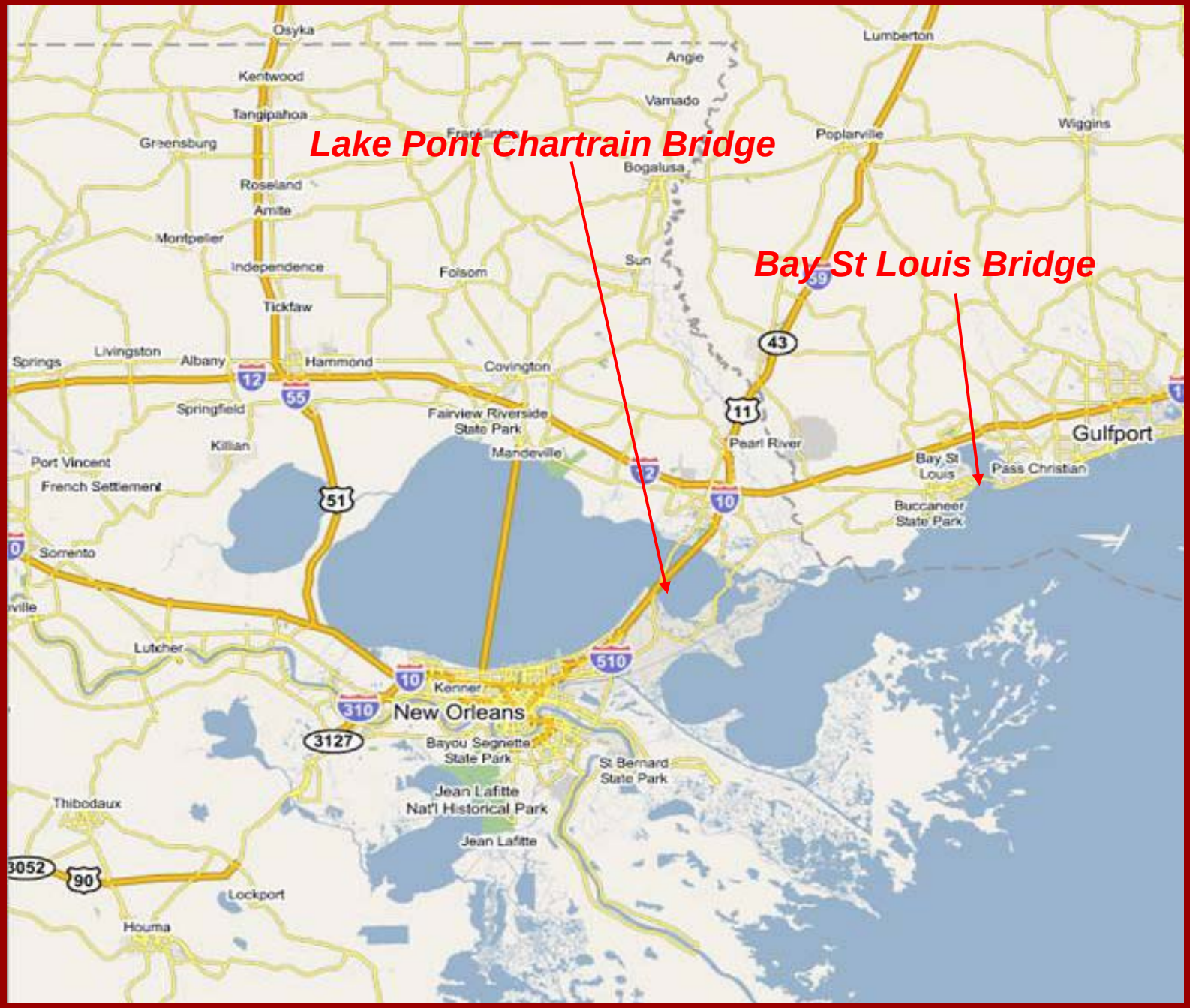
Travel speed = 25 mph

Duration over a bridge or a levee = 10 hours

Storm surge = 10 hours

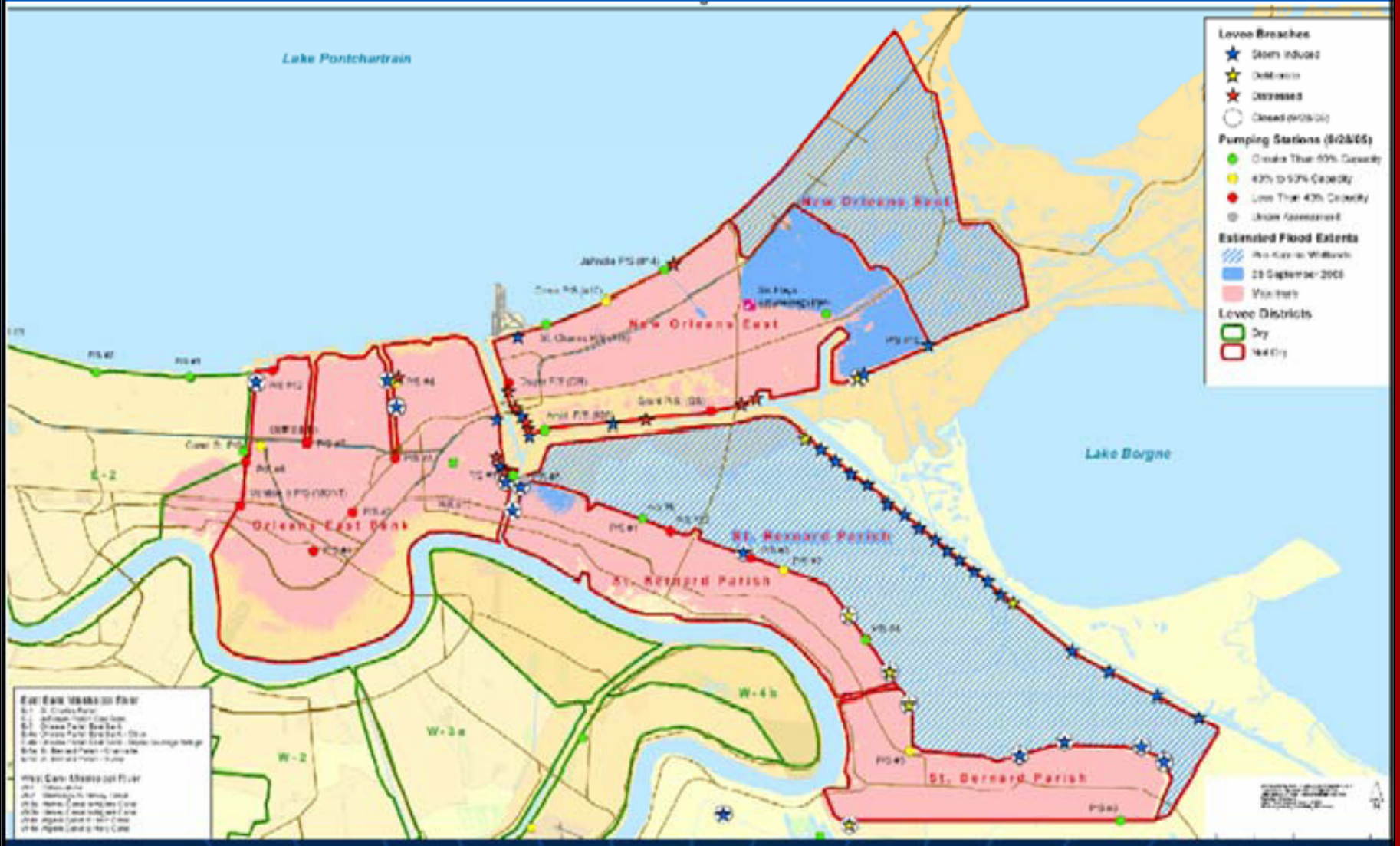
Number of wave cycles = 6000


Hurricane Katrina Base Map Index Page
Louisiana, Mississippi, & Alabama
Image Index Map
August 2005
All imagery provided by NOAA
Path of Katrina
Click boxes to zoom in and view image footprints.


Lake Pont Chartrain Bridge
Bay St Louis Bridge
Osyka
Kentwood
Tangipahoa
Greensburg
Roseland
Amite
Montpelier
Independence
Tickfaw
Folsom
Angie
Vamado
Bogalusa
Sun
Lumberton
Poplarville
Wiggins
Springs
Livingston
Albany
Hammond
Covington
Springfield
Killian
Port Vincent
French Settlement
Fairview Riverside State Park
Mandeville
Pearl River
Bay St Louis
Pass Christian
Gulfport
Buccaneer State Park
Sorrento
Lutcher
Kenner
New Orleans
Bayou Segnette State Park
St Bernard State Park
Jean Lafitte Nat'l Historical Park
Jean Lafitte
Thibodaux
Lockport
Houma

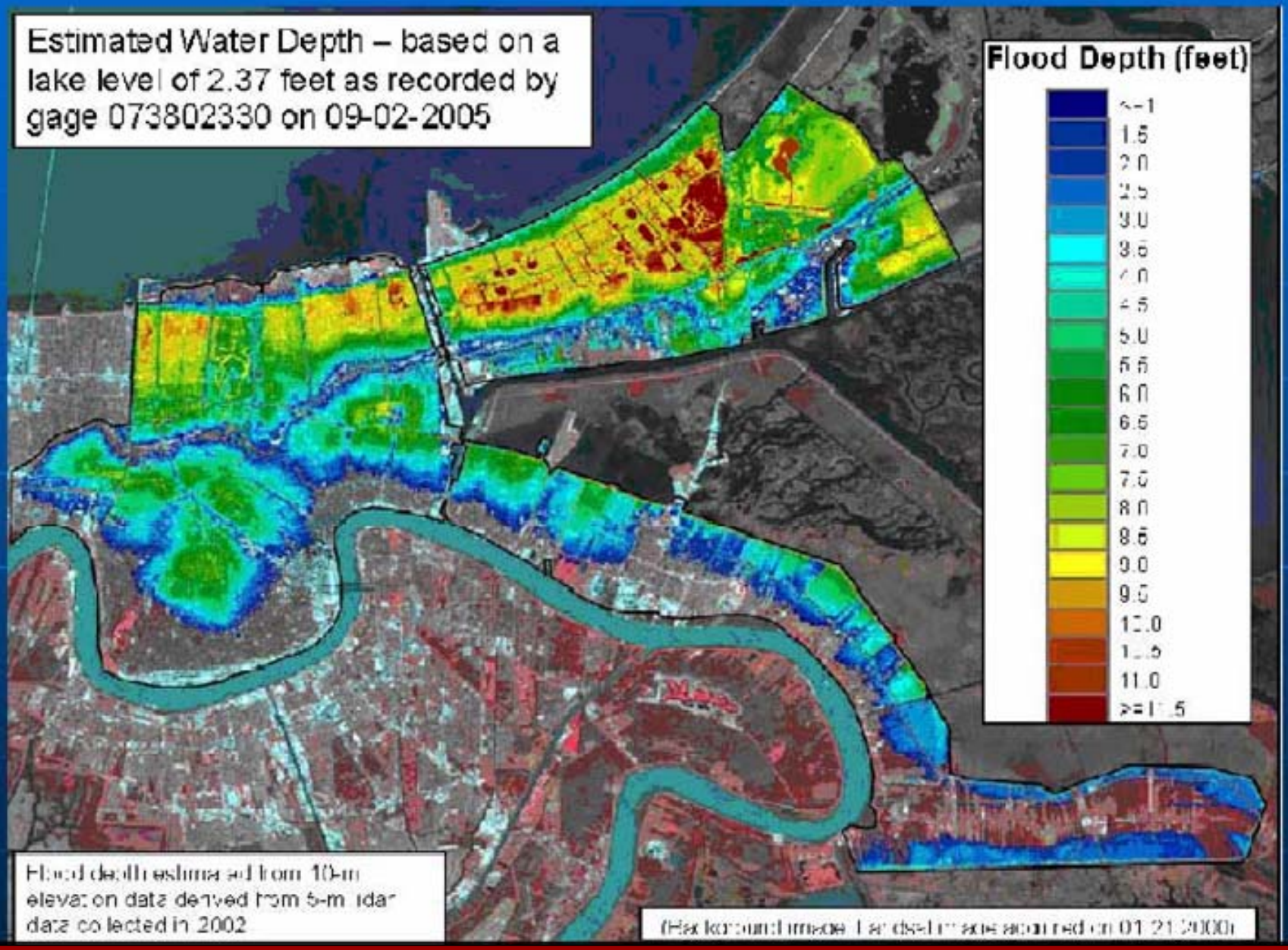
From Raymond B. SEED

New Orleans Area



From Raymond B. SEED

Estimated Flood Depths



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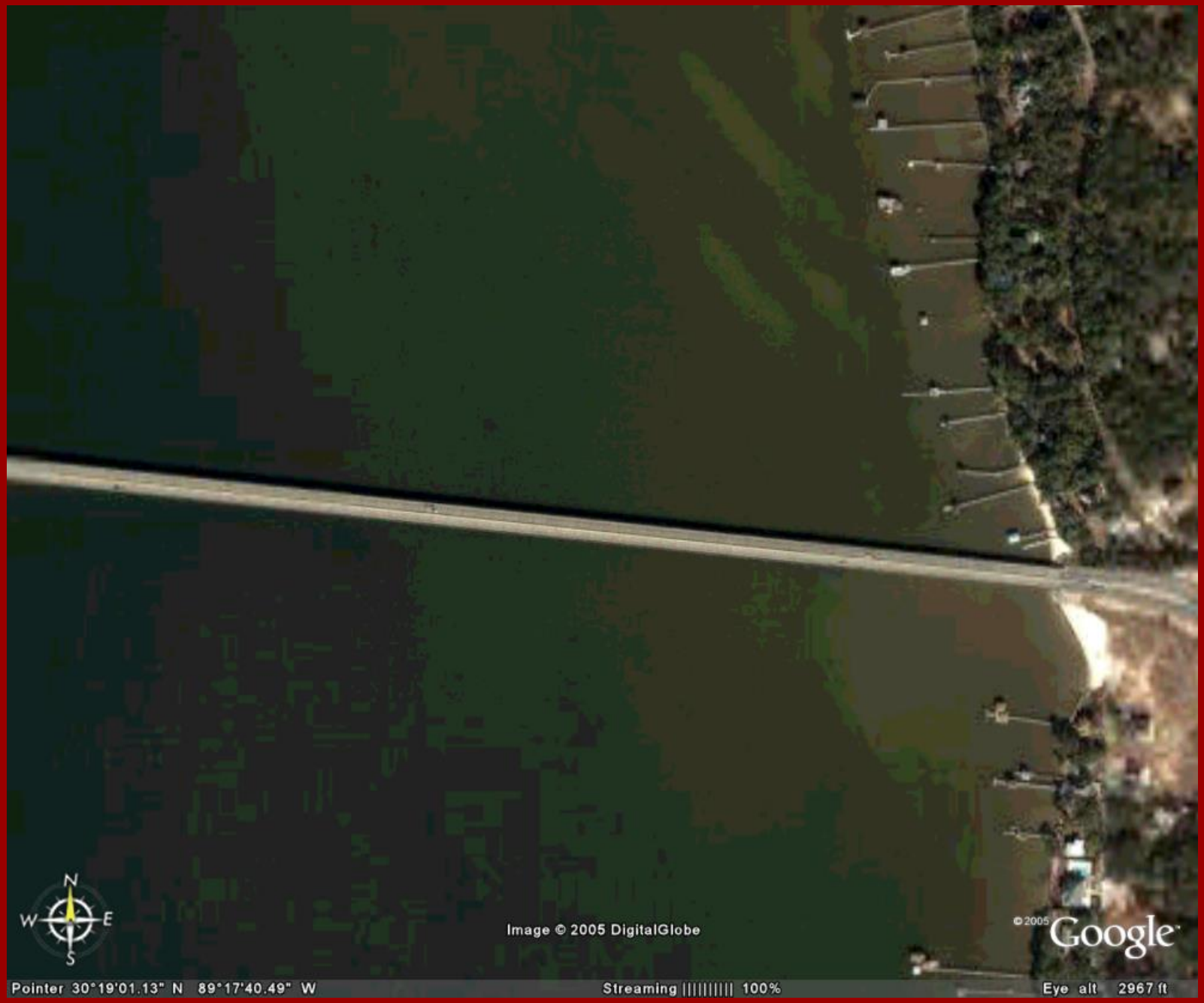
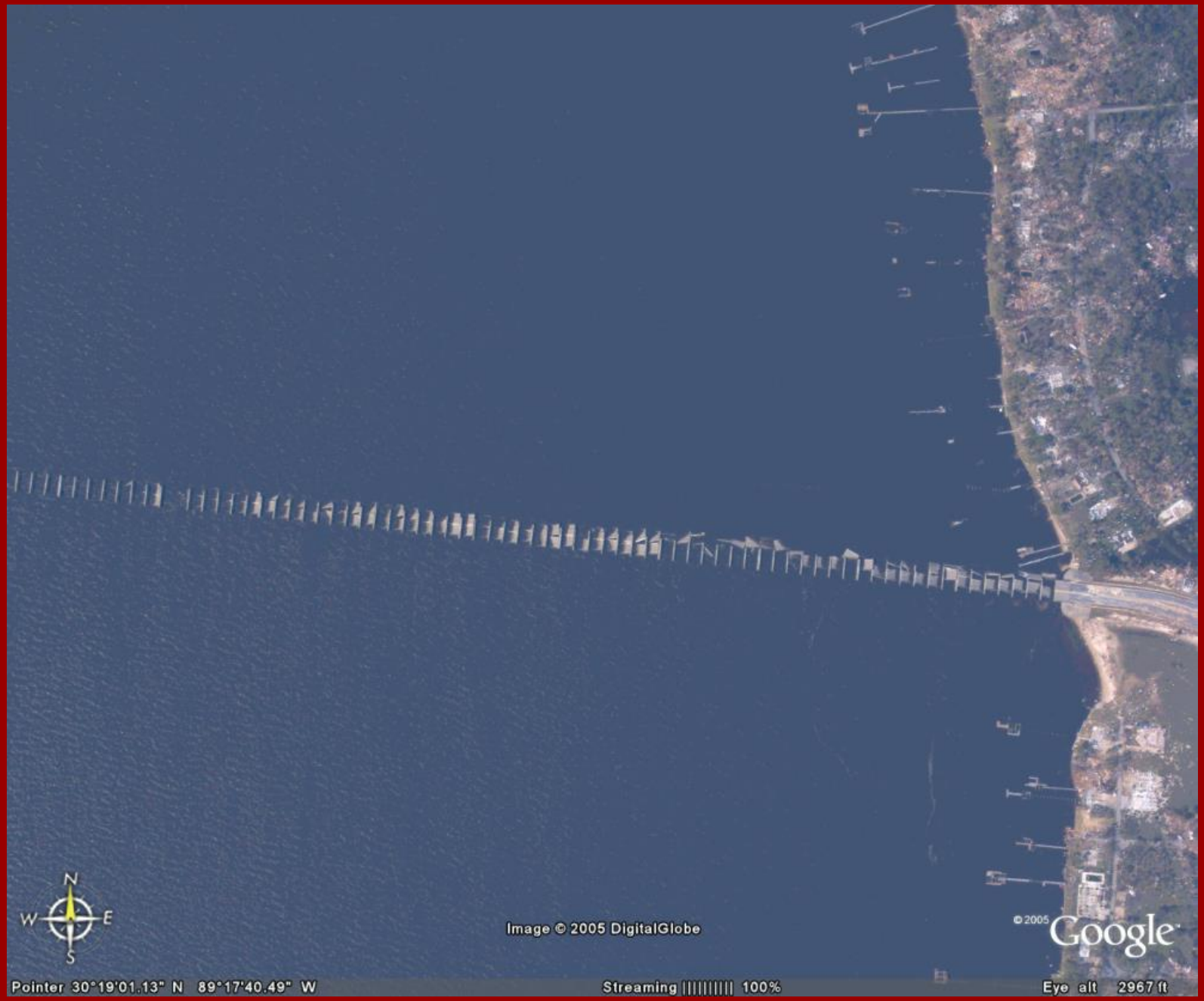
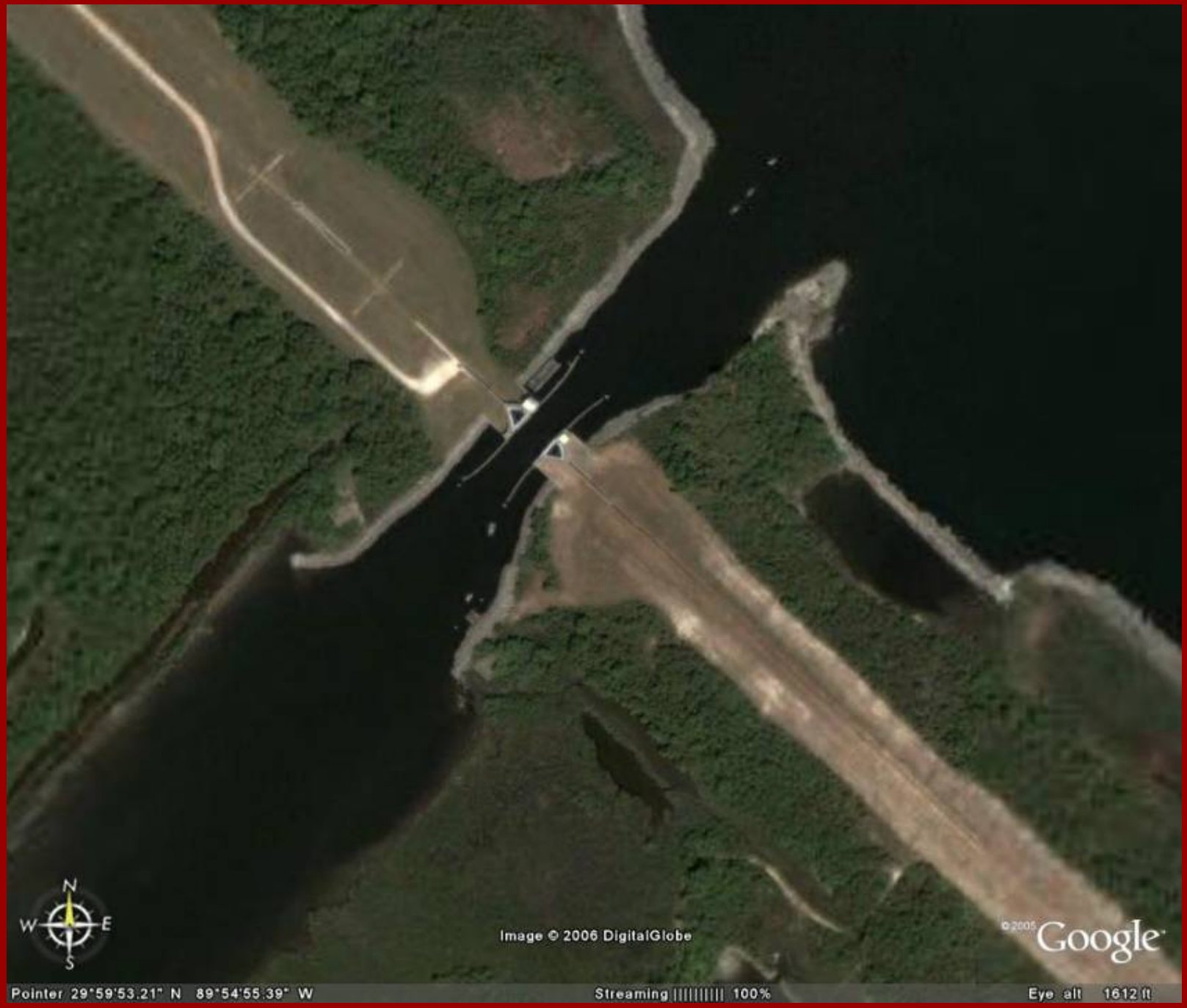

N
W
E
S
Image © 2005 DigitalGlobe
©2005 Google
Pointer 30°19'01.13" N 89°17'40.49" W
Streaming |||||||||| 100%
Eye alt 2967 ft


N
W
E
S
Image © 2005 DigitalGlobe
©2005 Google
Pointer 30°19'01.13" N 89°17'40.49" W
Streaming |||||||||| 100%
Eye alt 2967 ft

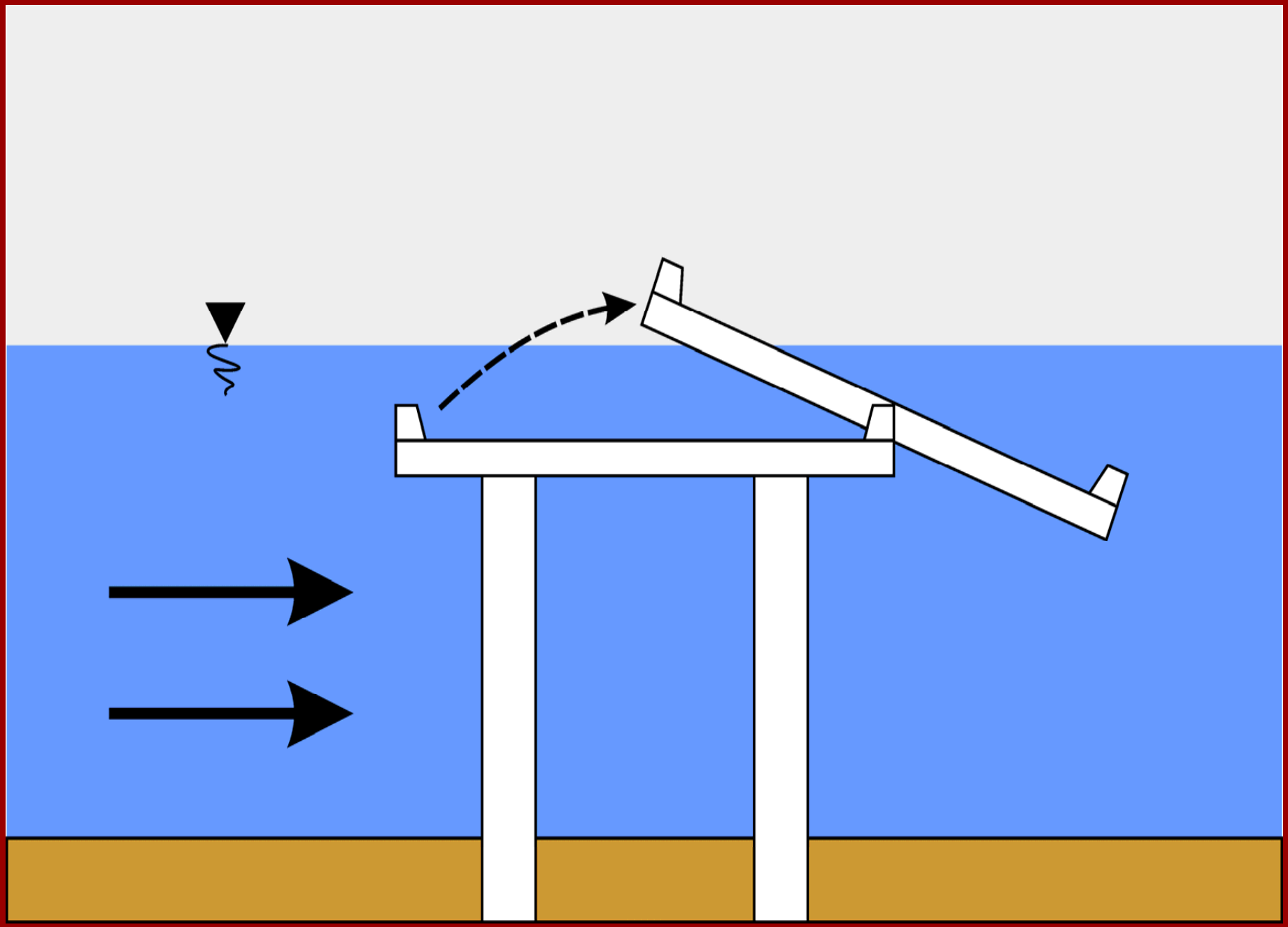

N
W
E
S
Image © 2006 DigitalGlobe
©2005 Google
Pointer 29°59'53.21" N 89°54'55.39" W
Streaming |||||||||| 100%
Eye alt 1612 ft

From Raymond B. SEED

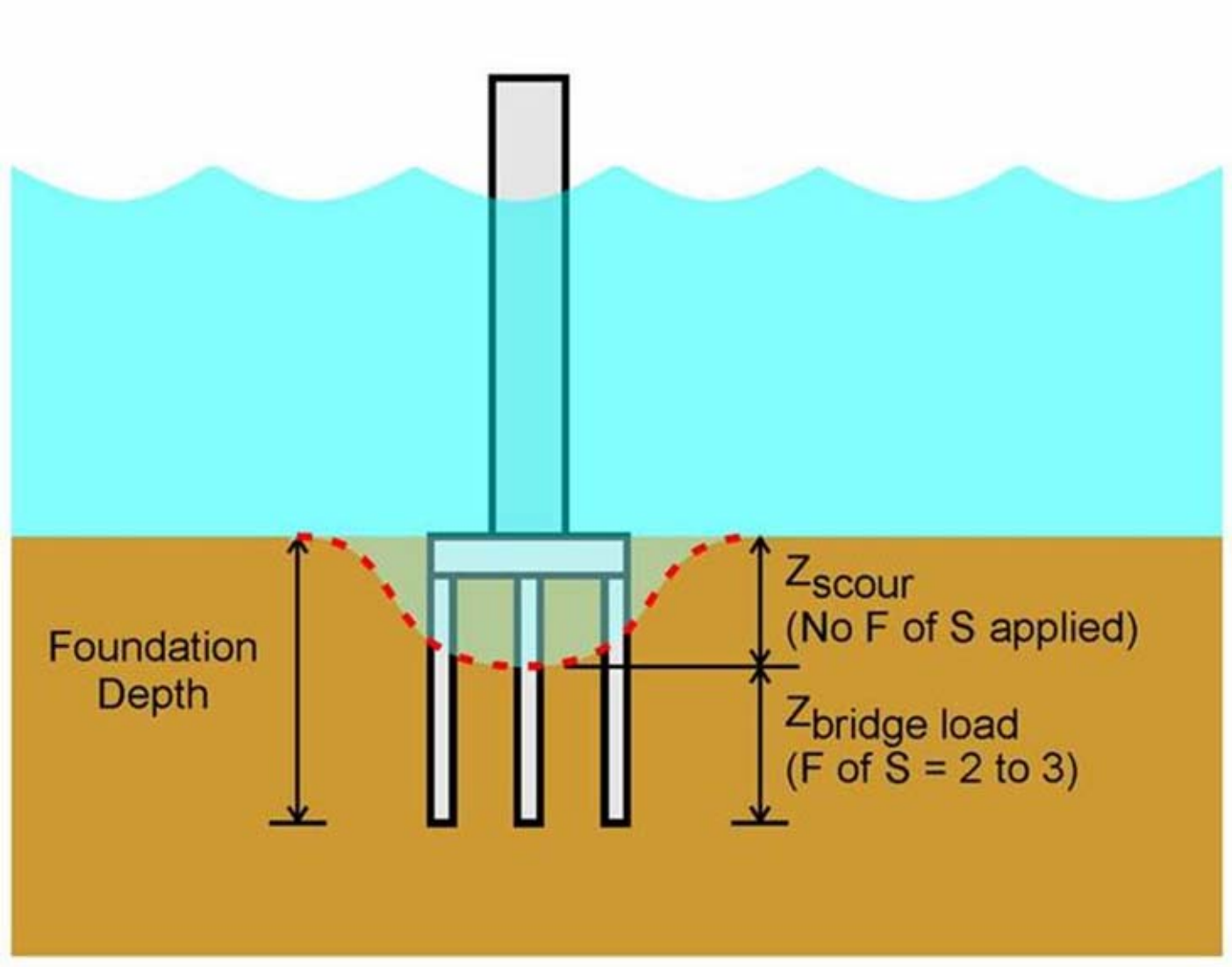
BRIDGES

U.S. 90 bridge
over
the Bay of St. Louis

I -10 bridge
over
Lake Pontchartrain



FOUNDATION DESIGN



LEVEES

From Raymond B. SEED

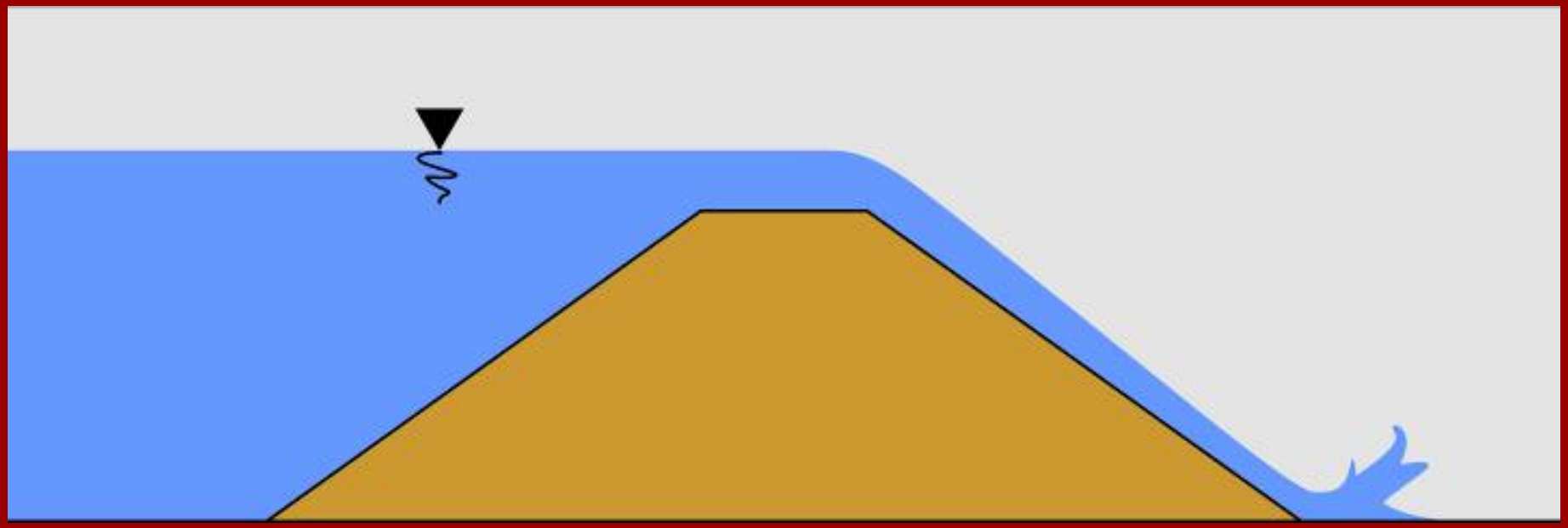
From Raymond B. SEED

MRGO Levees

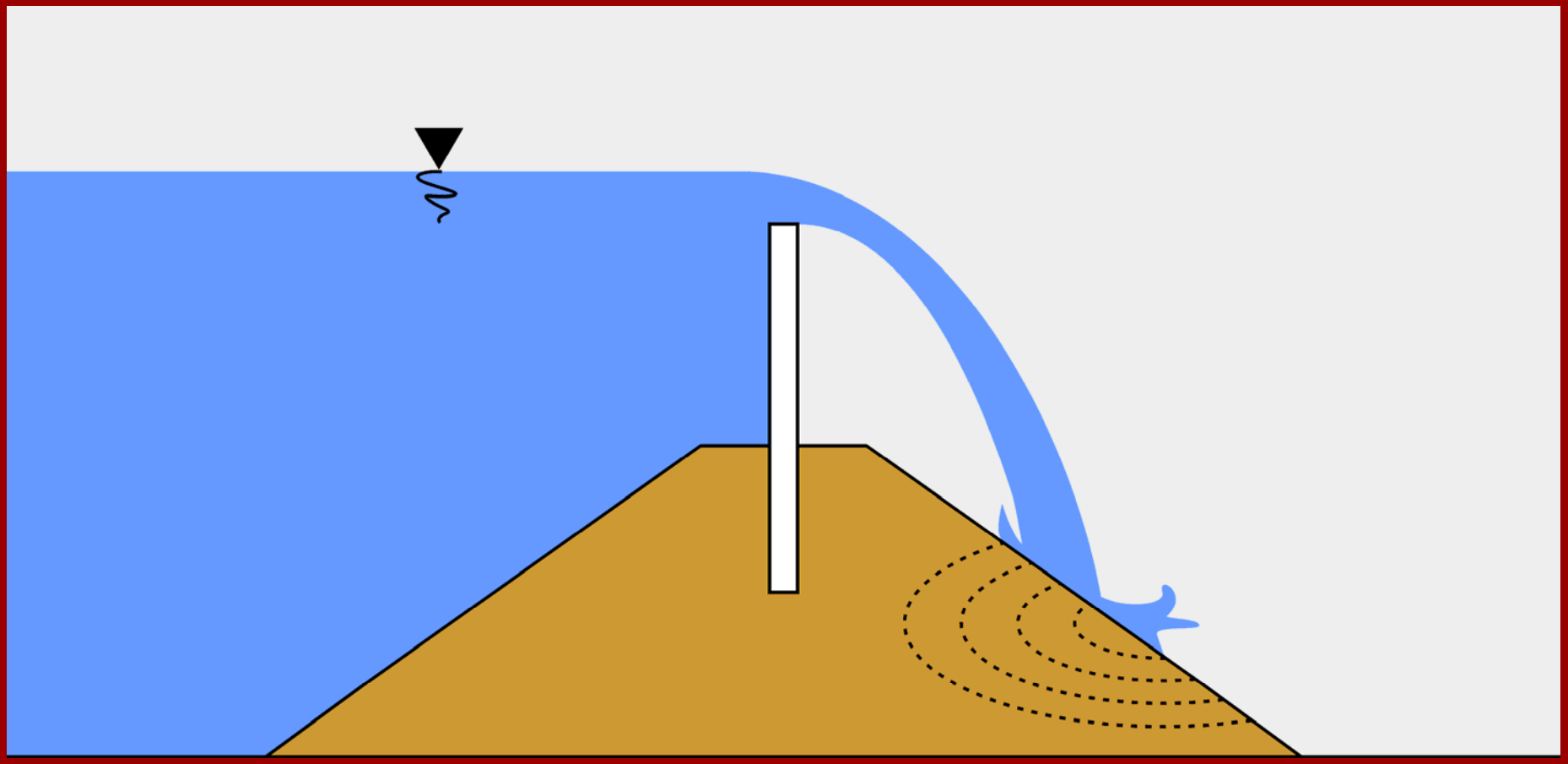
From Raymond B. SEED

17th Street Canal

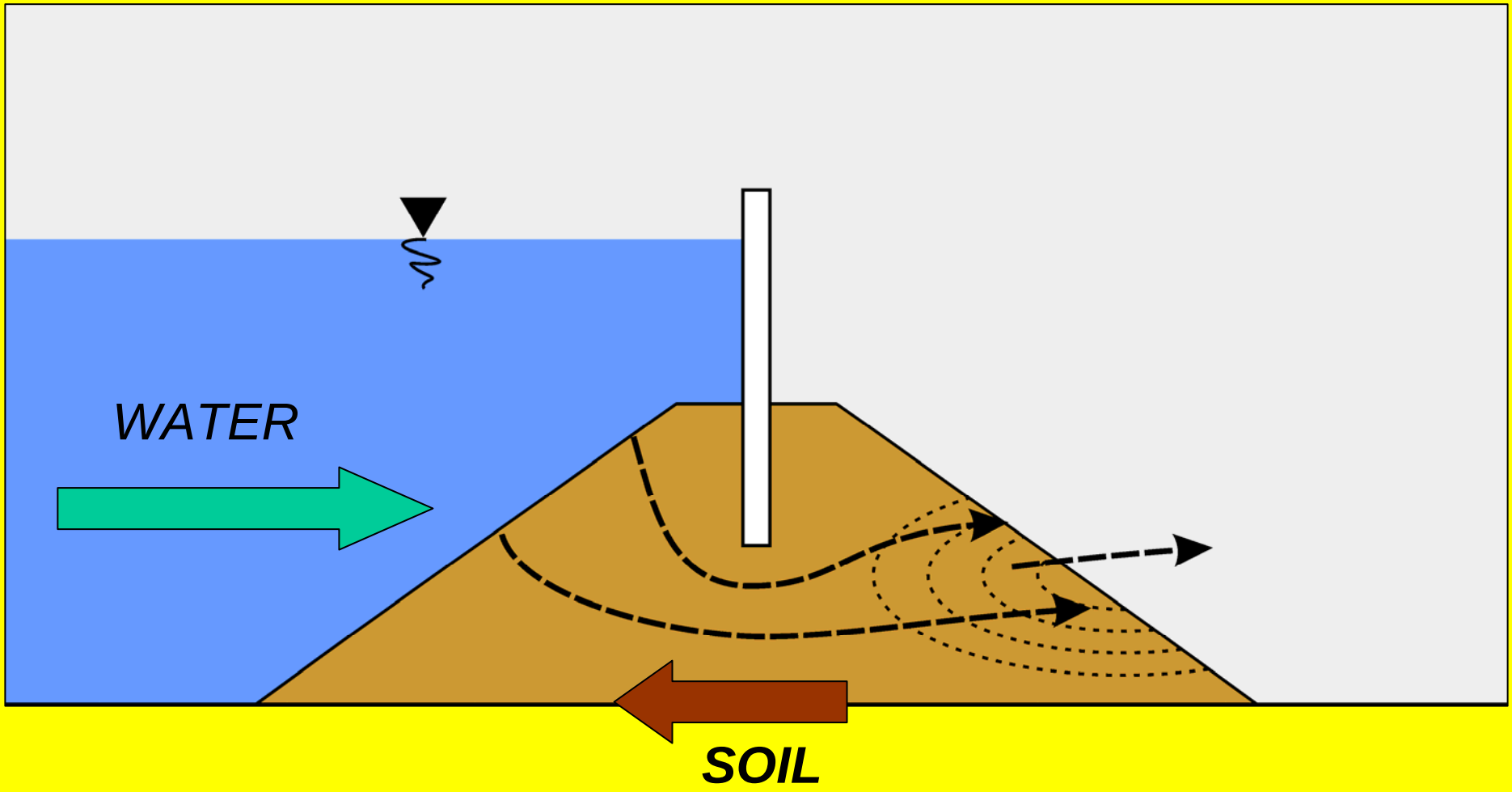
FAILURE BY OVERTOPING AND EROSION



FAILURE BY OVERTOPING AND EROSION



FAILURE BY RIGID BODY TRANSLATION AND SEEPAGE



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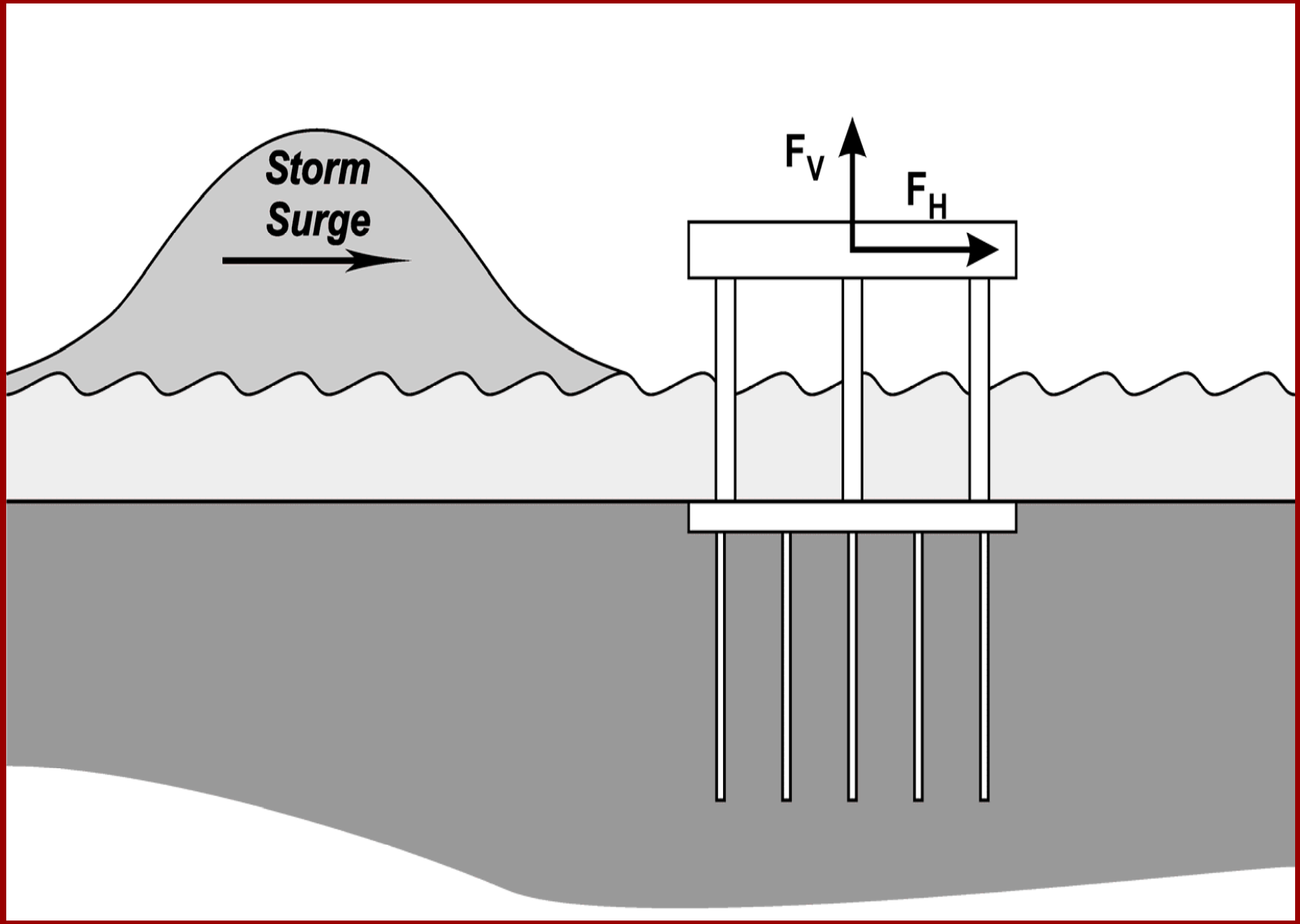
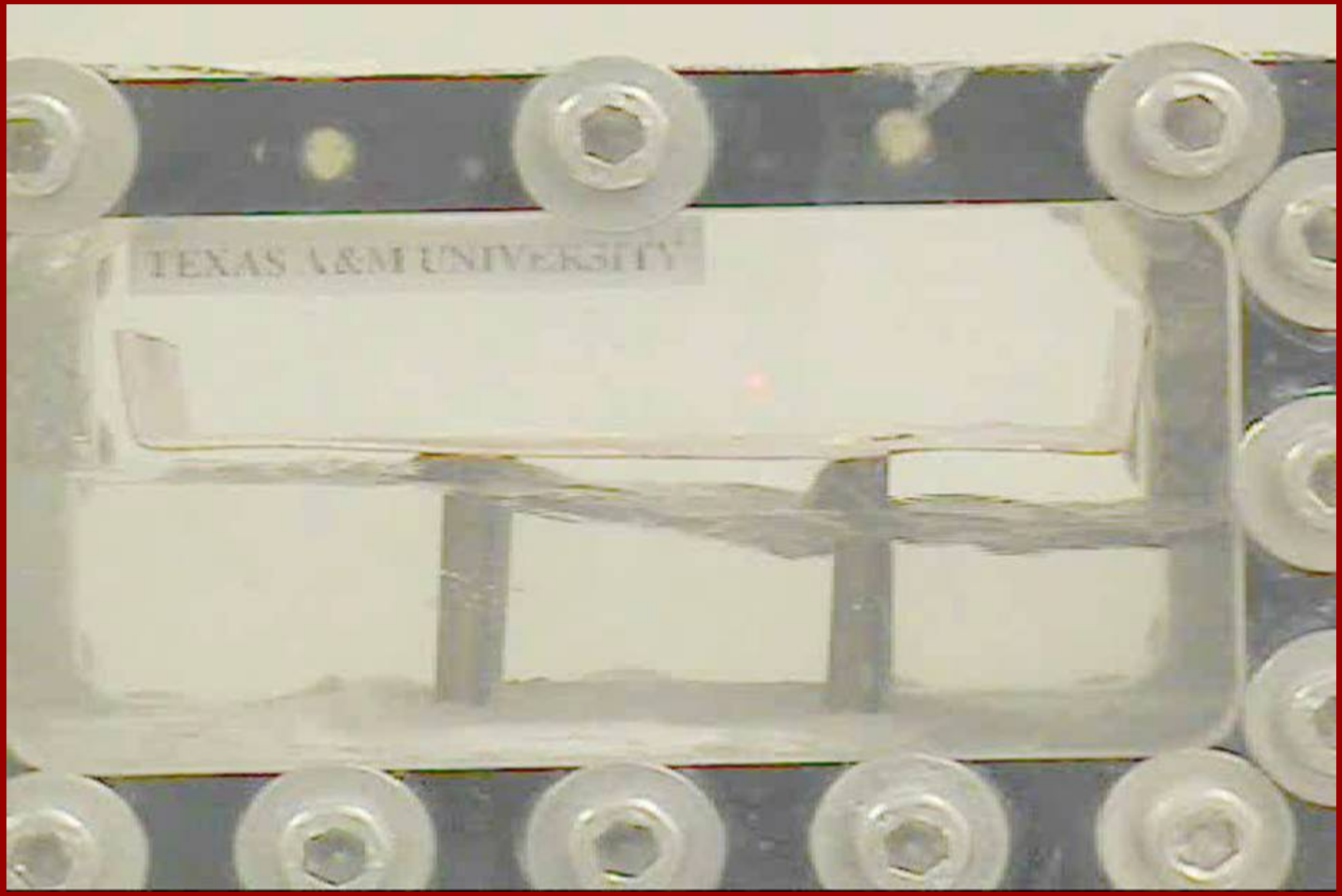
BRIDGES


Storm
Surge
F_V
F_H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NUMERICAL SIMULATION

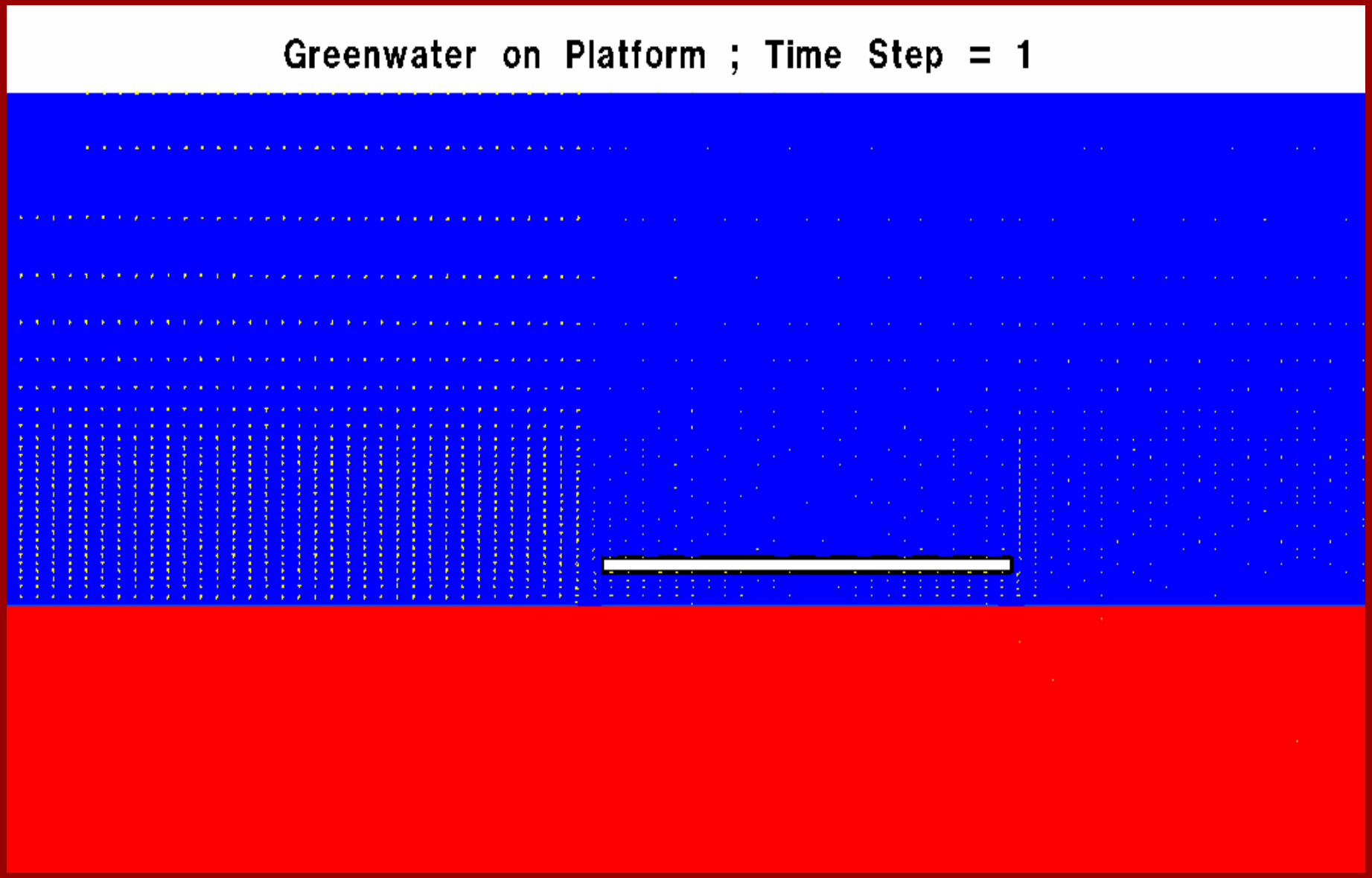
Wave Length = 60 m

Wave Period = 6 s

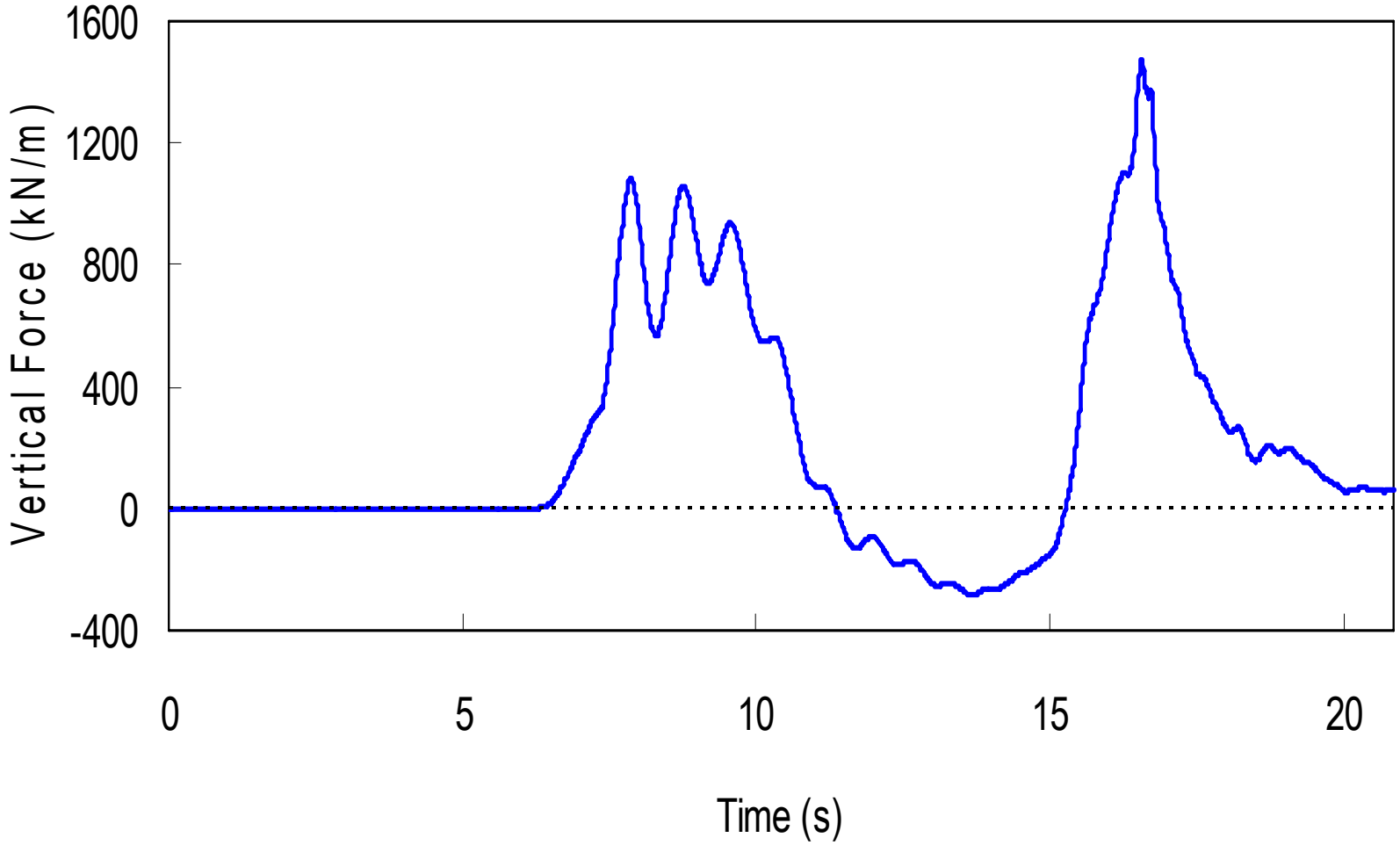
Wave Height = 5.2 m

Wave Speed = 10 m/s

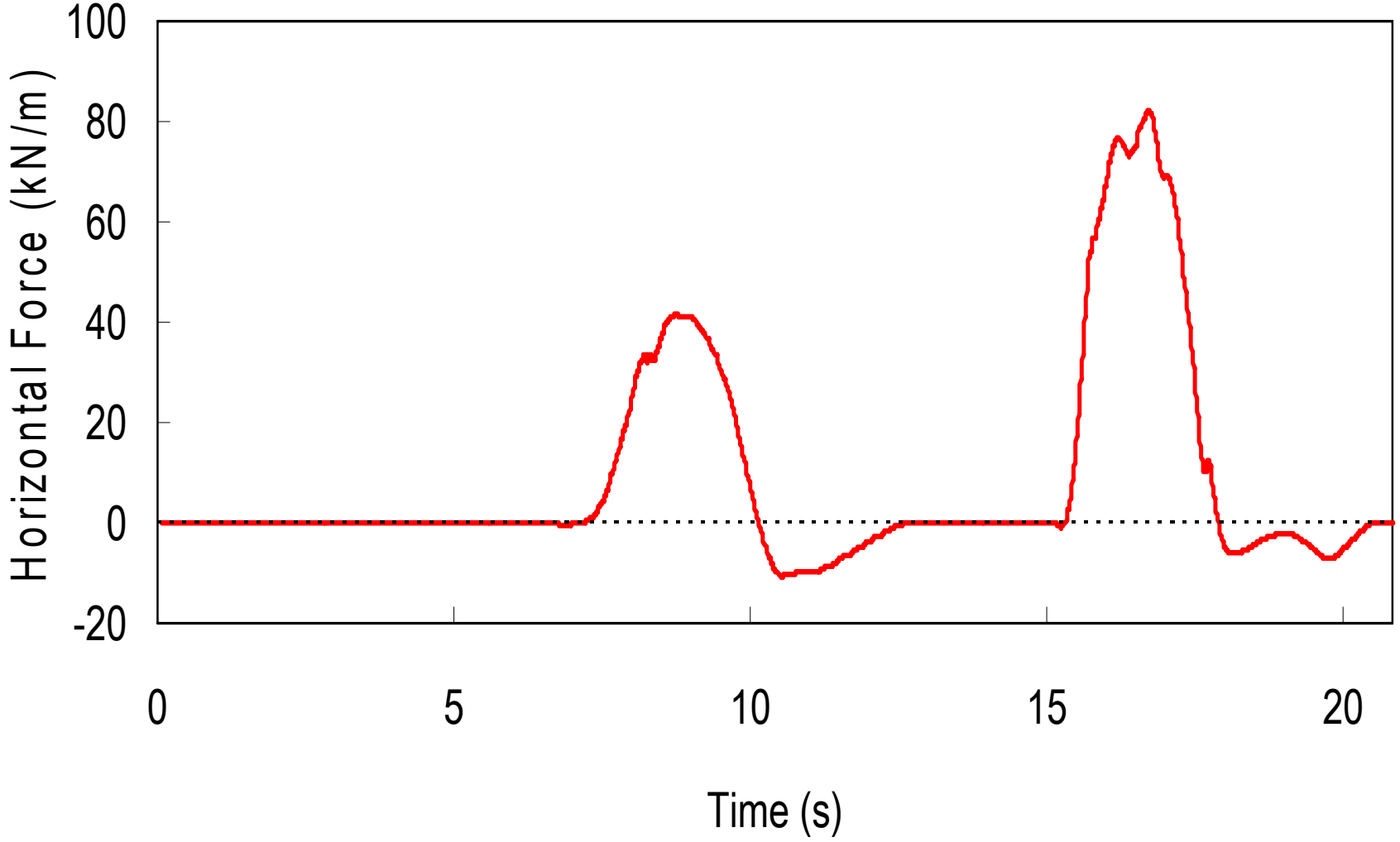
CHEN 3D - Wave Impact on Bridge Deck

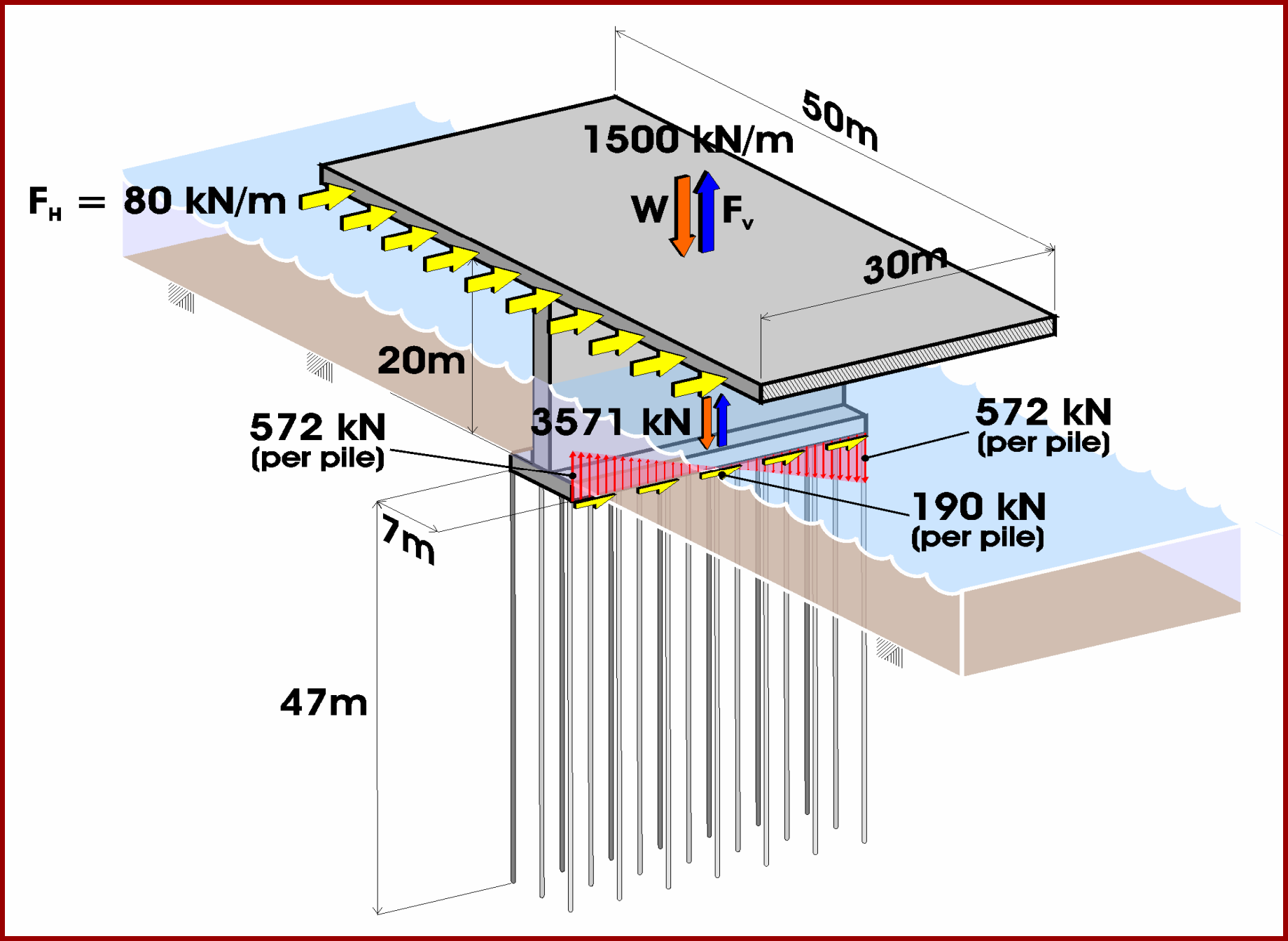


CHEN 3D - Vertical Forces on Deck



CHEN 3D - Horizontal Forces on Deck




50m
1500 kN/m
W
F_v
F_H = 80 kN/m
30m
20m
572 kN
(per pile)
3571 kN
572 kN
(per pile)
190 kN
(per pile)
7m
47m

Briaud (1997) Method for Overturning of Piles

TRANSFER LENGTH

$L_o = (4EI/K)^{0.25}$ $L_o = 4.1$ m

MAX BENDING MOMENT

$M_o = -0.5\ H_o\ L_o$ $M_o = 410$ kN.m

MAX HORIZONTAL LOAD

$H_{ou} = 0.75\ p_L\ B\ D_v$ $H_{ou} = 288$ kN

GROUNDLINE DEFLECTION

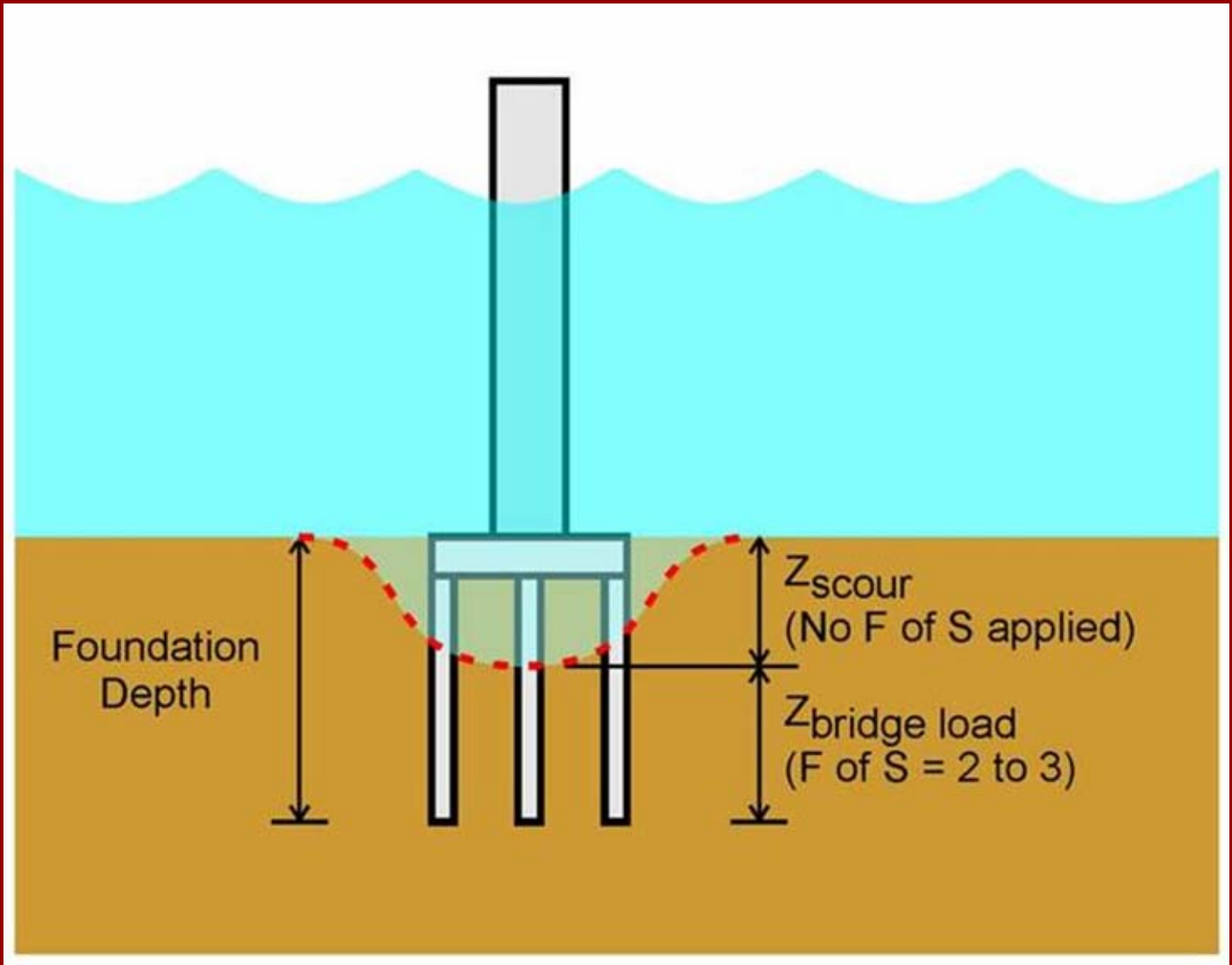
$y_o = H_o/L_oK$ $y_o = 0.24$ m

RATCHETING MOVEMENT

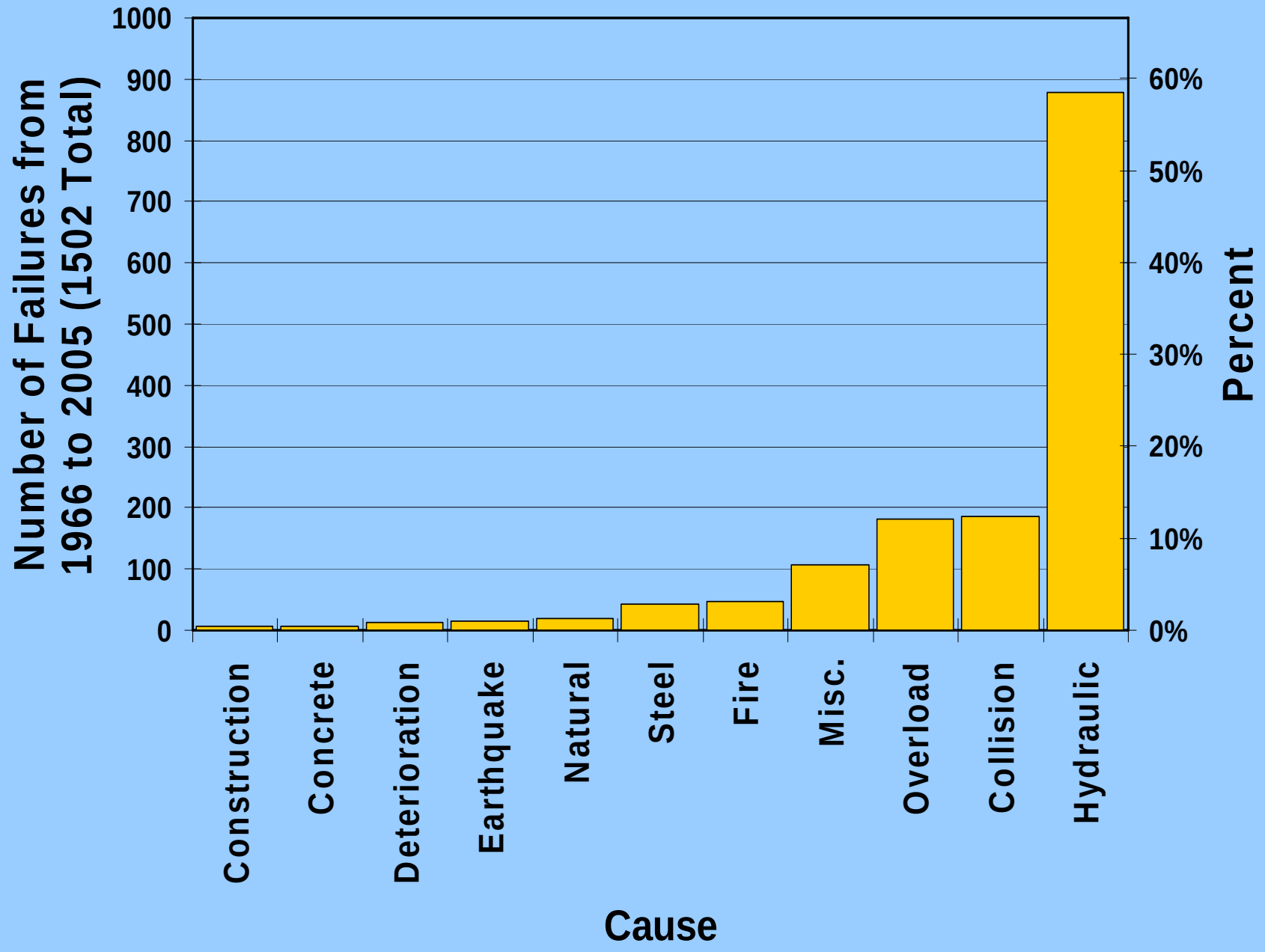
HORIZONTAL SOIL FAILURE @ PILES

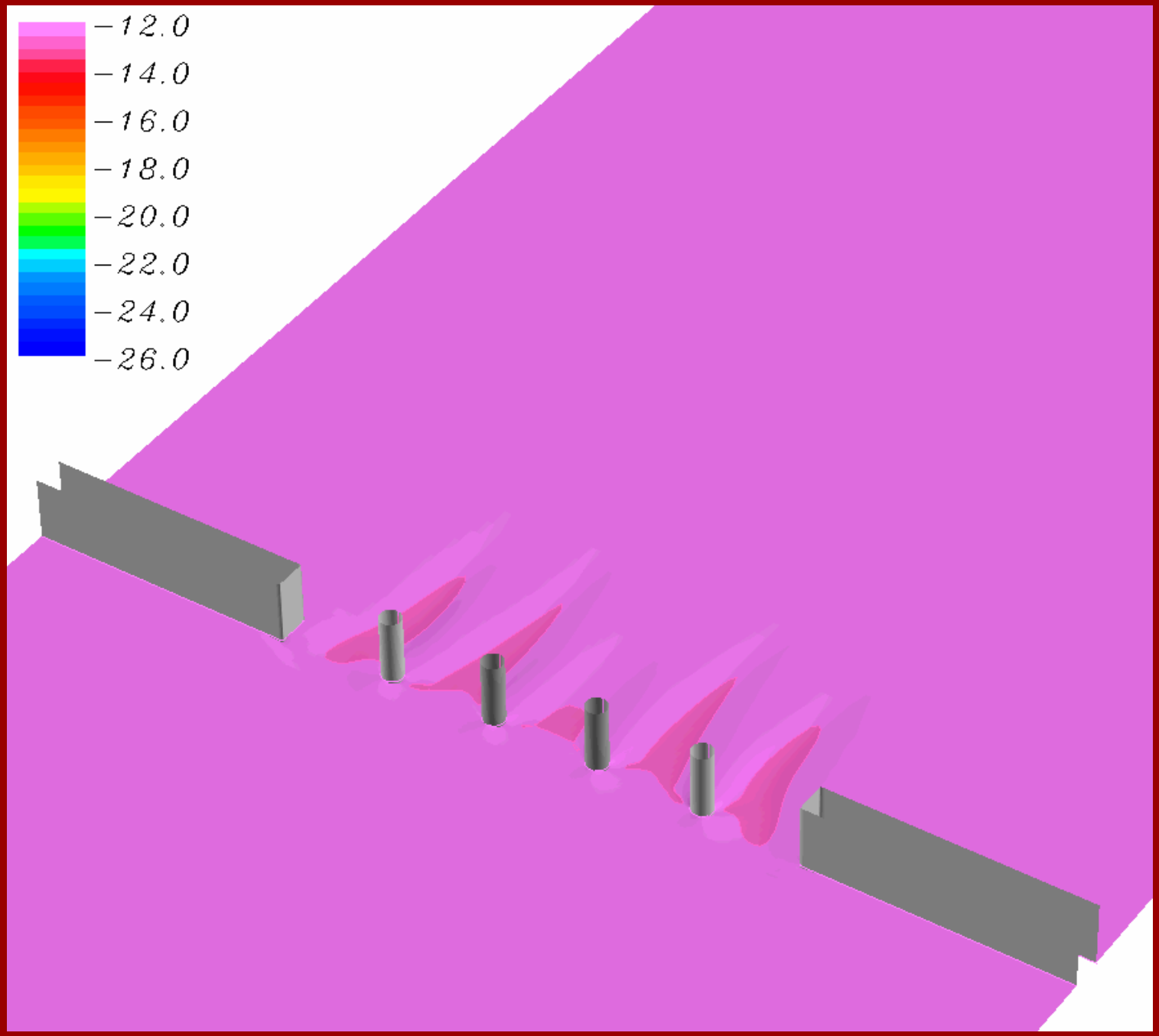
RATCHETING MOVEMENT

FOUNDATION DESIGN

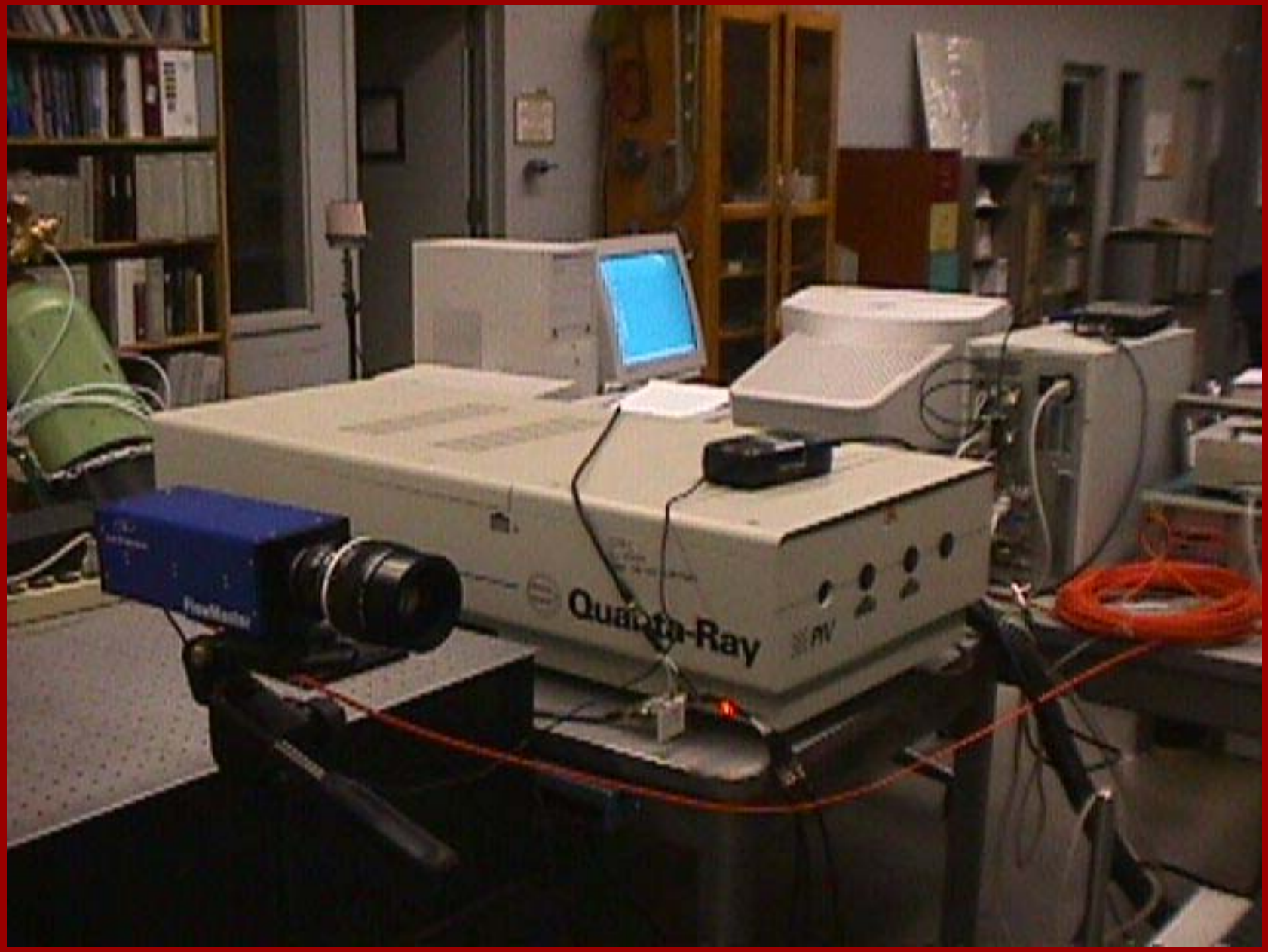


CSX


Number of Failures from 1966 to 2005 (1502 Total)
1000
900
800
700
600
500
400
300
200
100
0
60%
50%
40%
30%
20%
10%
0%
Percent
Construction
Concrete
Deterioration
Earthquake
Natural
Steel
Fire
Misc.
Overload
Collision
Hydraulic
Cause


-12.0
-14.0
-16.0
-18.0
-20.0
-22.0
-24.0
-26.0

Nd:YAG PIV System



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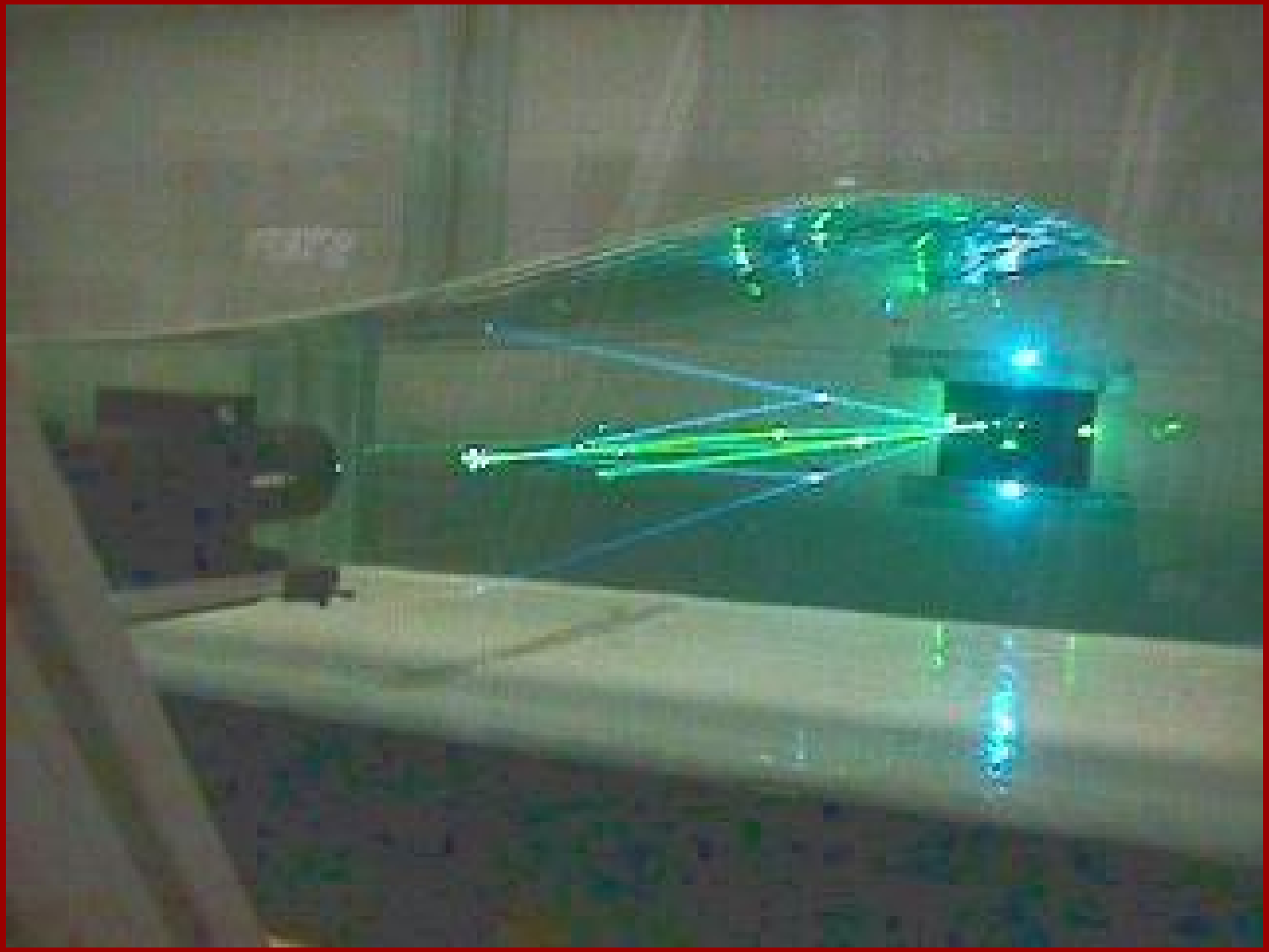
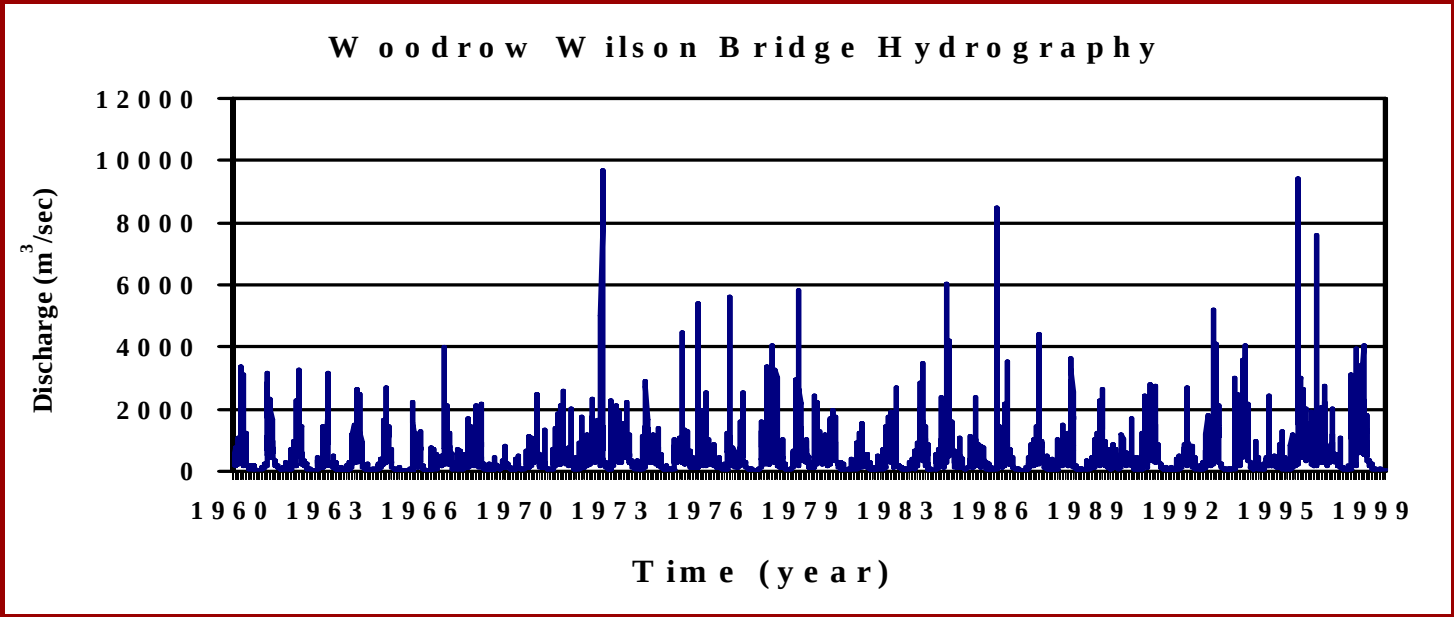
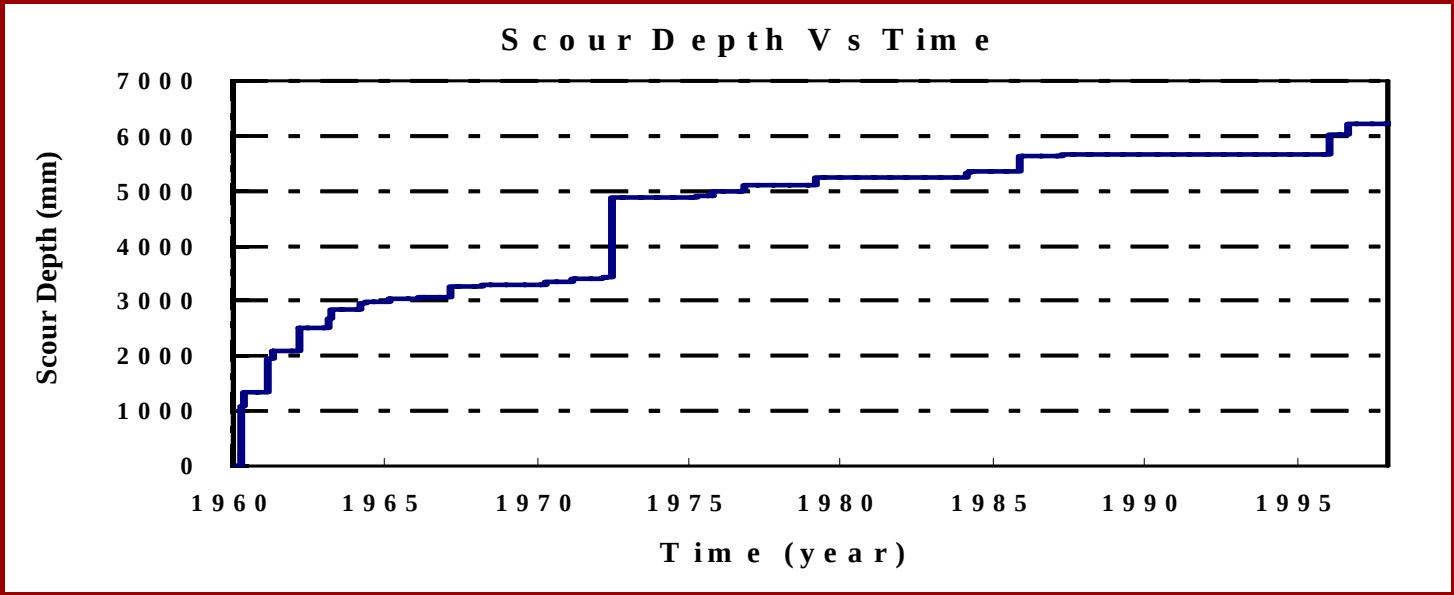
LDV Head with Traverse

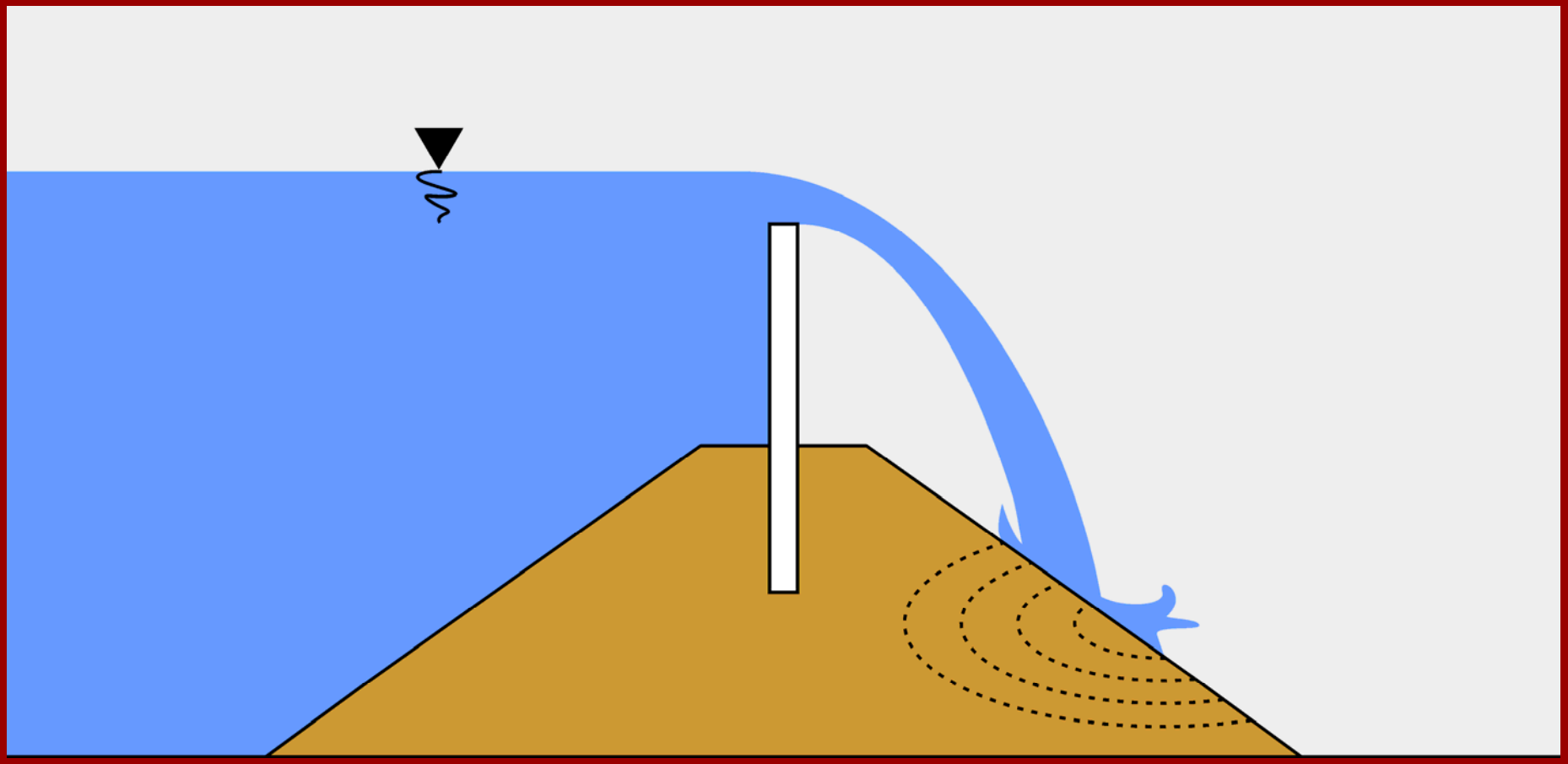



Woodrow Wilson Bridge Hydrography
Discharge (m3/sec)
12000
10000
8000
6000
4000
2000
0
1960 1963 1966 1970 1973 1976 1979 1983 1986 1989 1992 1995 1999
Time (year)

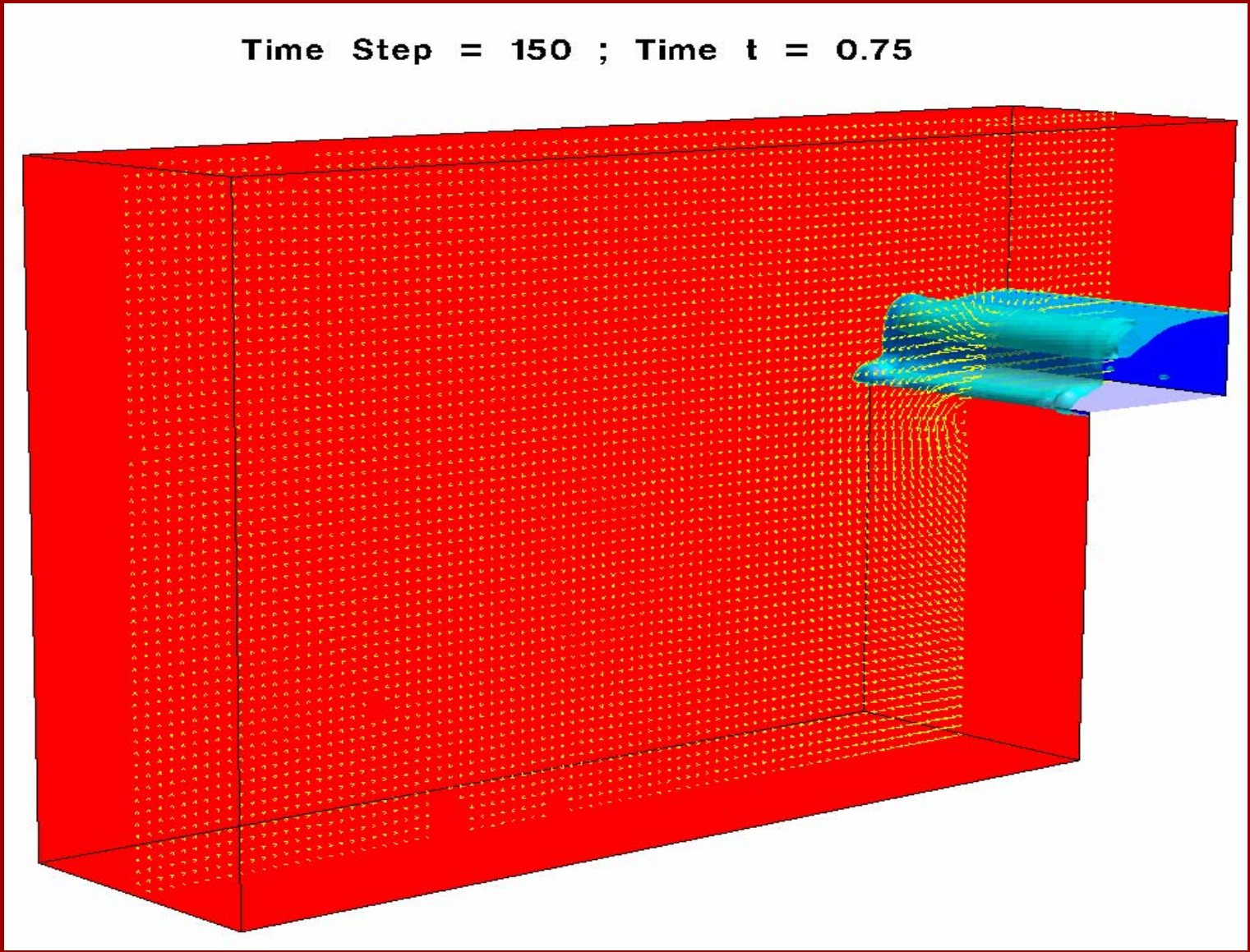

Scour Depth Vs Time
Scour Depth (mm)
7000
6000
5000
4000
3000
2000
1000
0
1960 1965 1970 1975 1980 1985 1990 1995
Time (year)

LEVEES

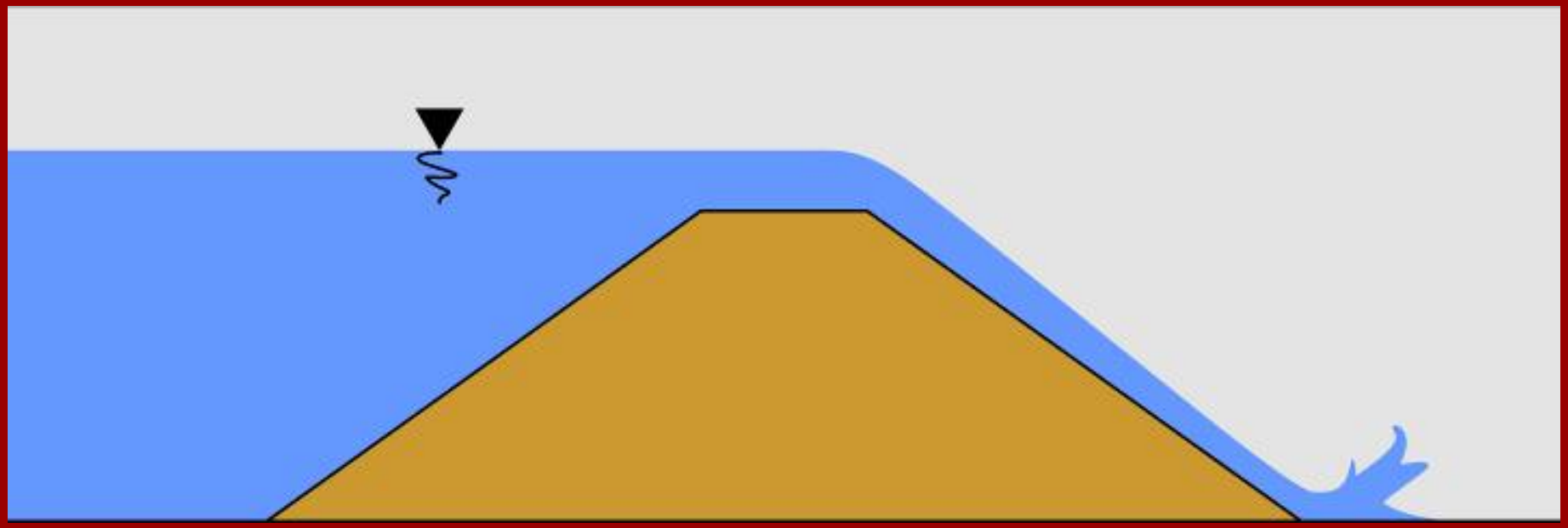
FAILURE BY OVERTOPING AND EROSION



CHEN 3D - Splash Impact on Levee



FAILURE BY OVERTOPING AND EROSION



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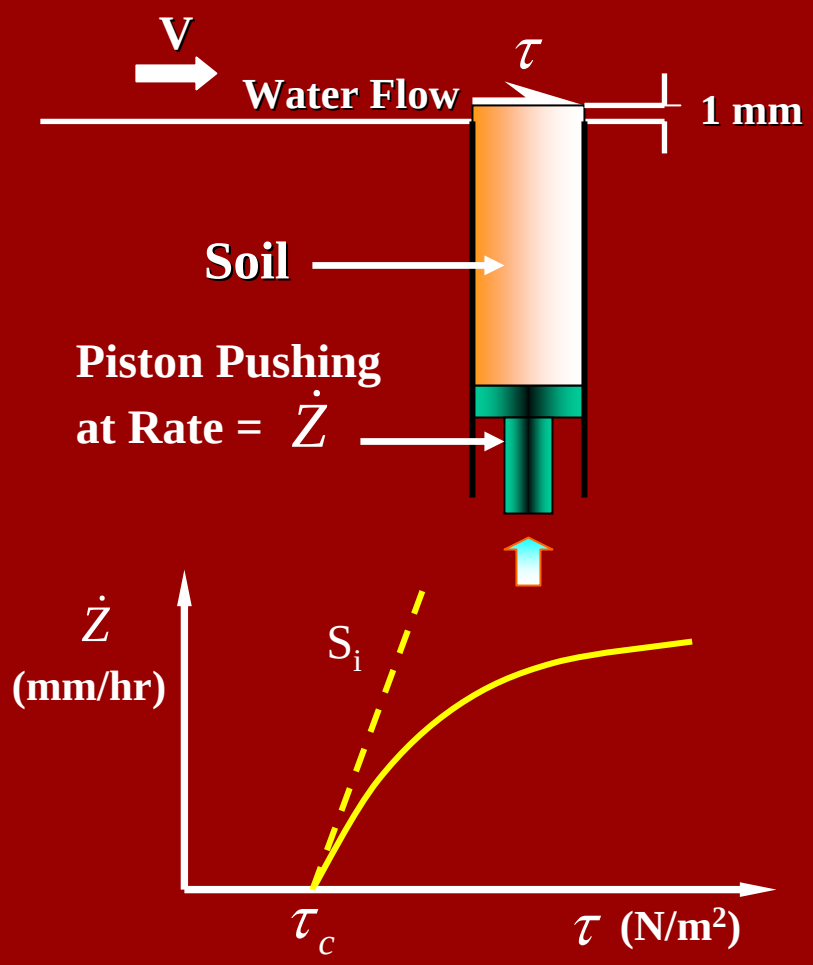
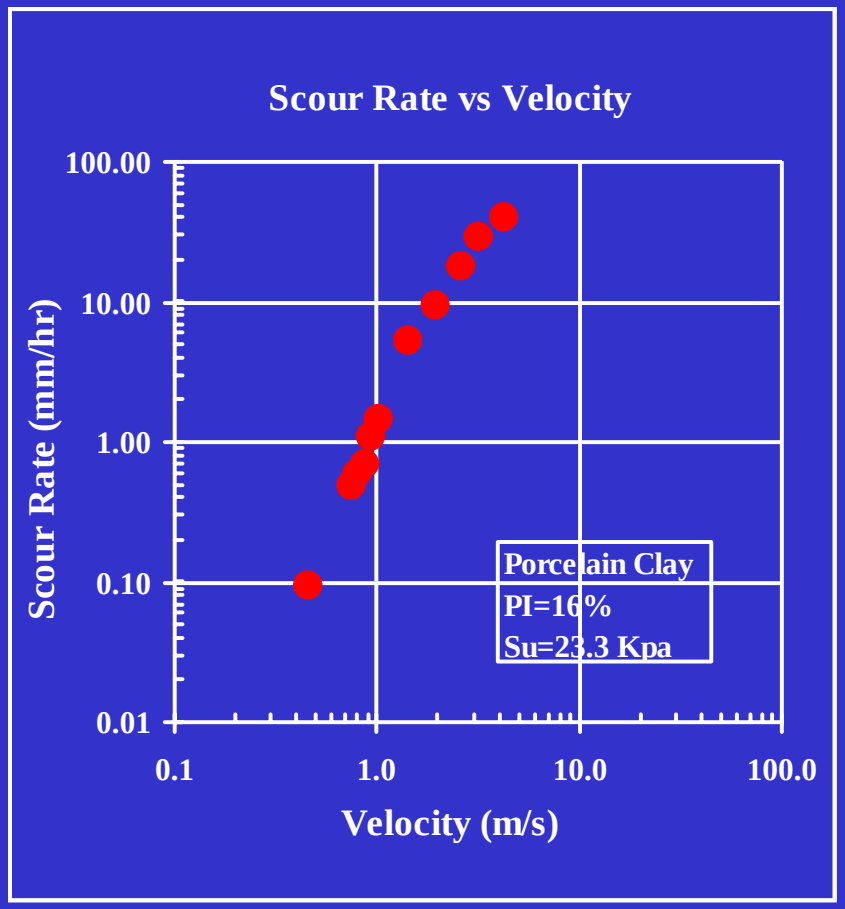
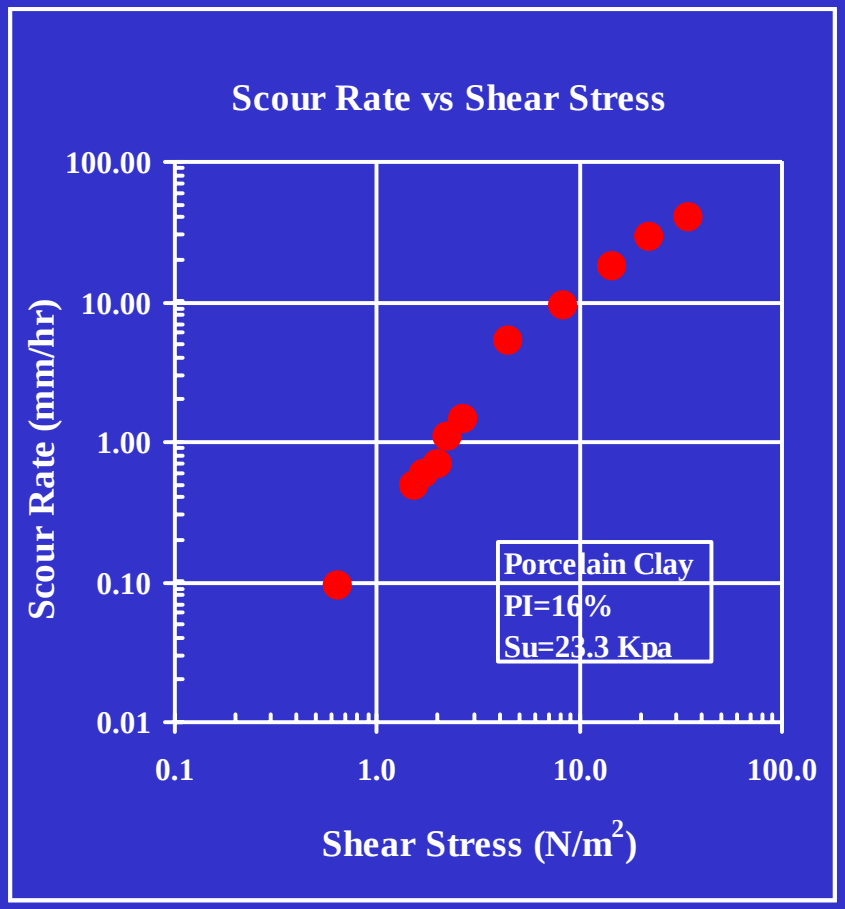
EFA Erosion Function Apparatus

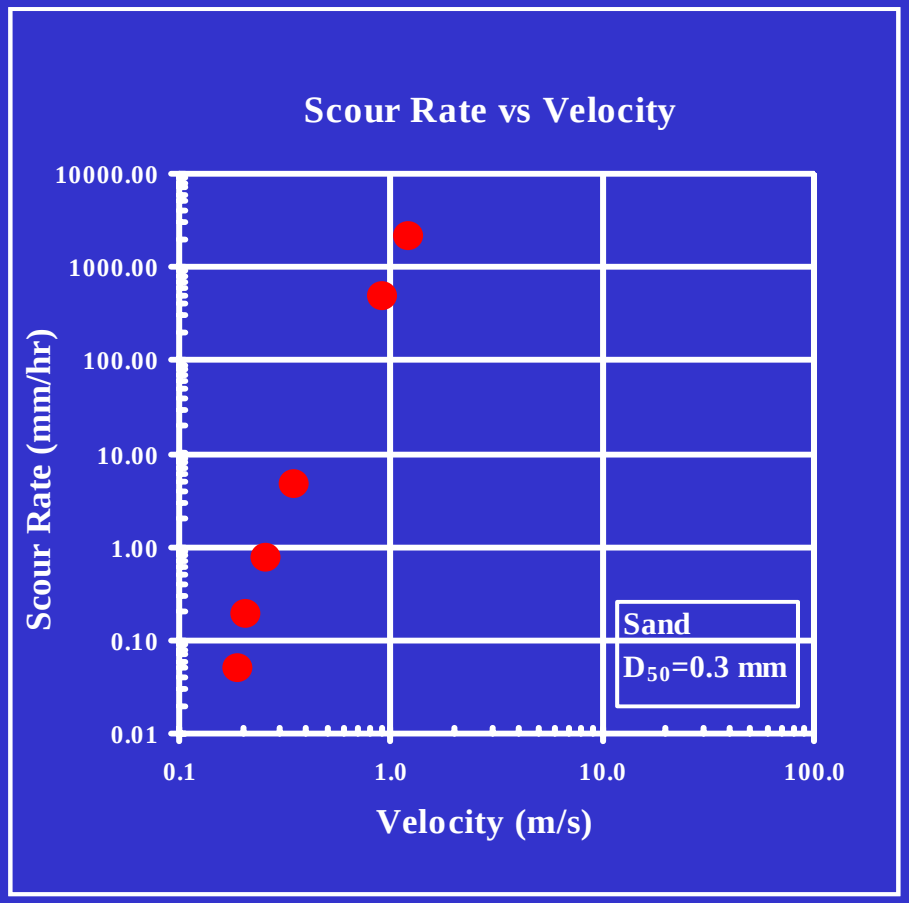


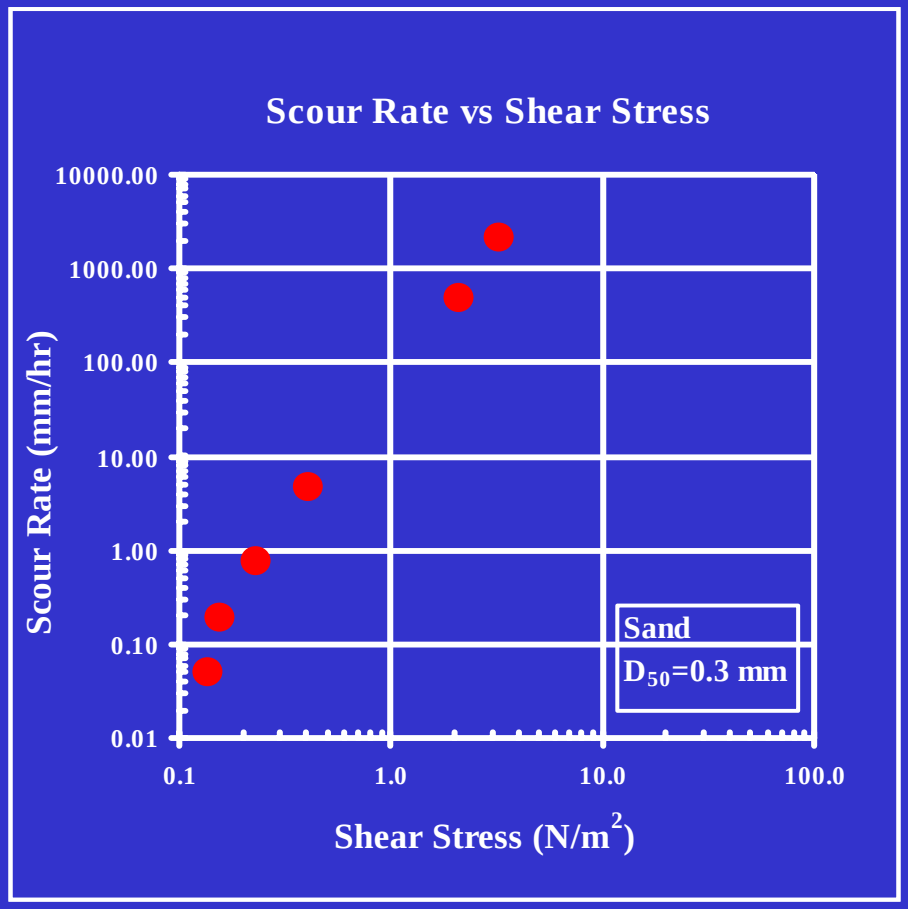
Typical EFA Test Results (Clay)

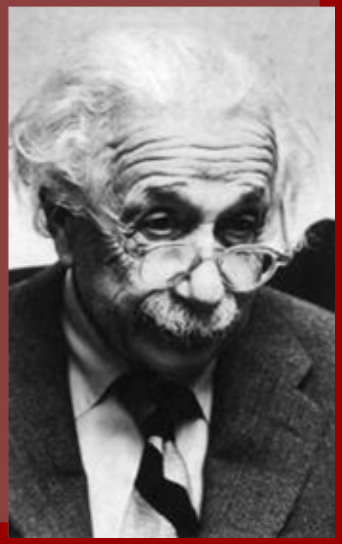


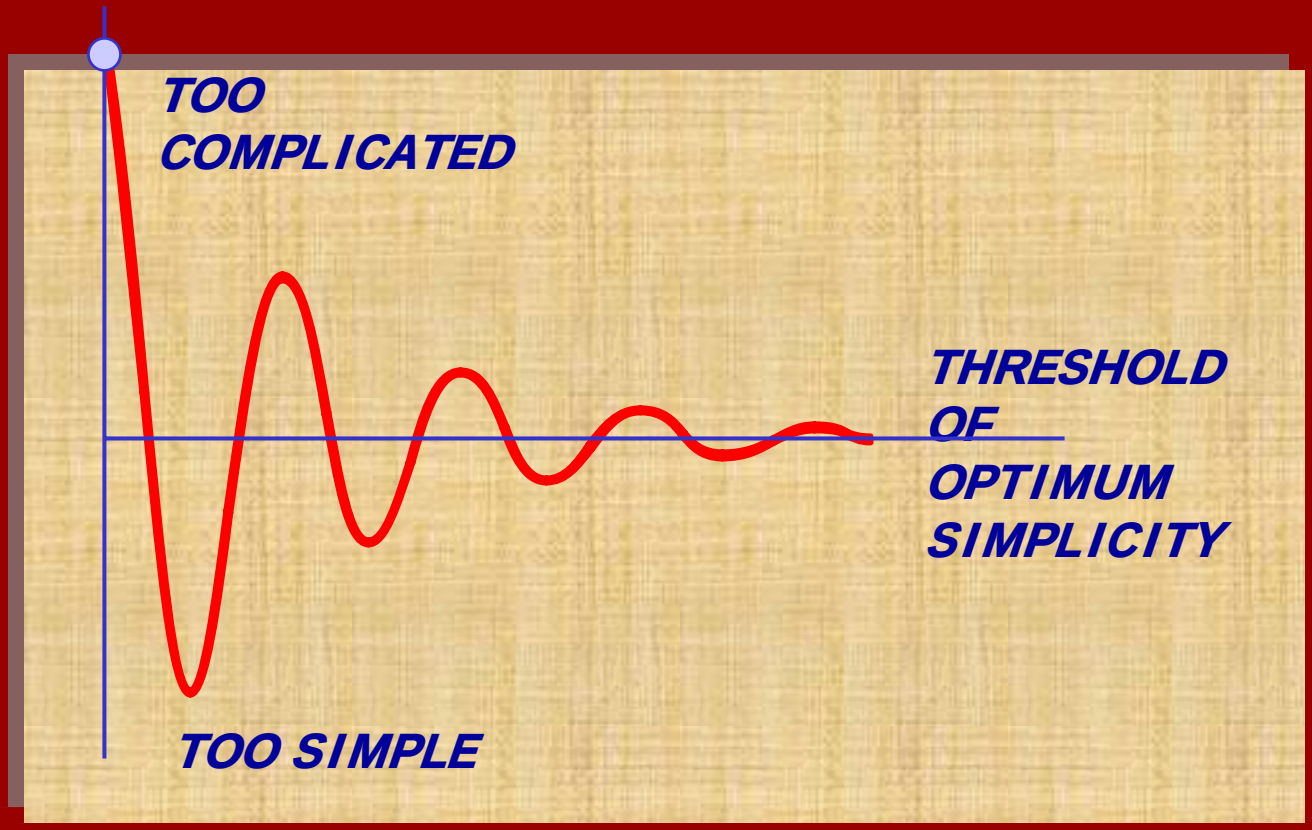


Typical EFA Test Results (Sand)





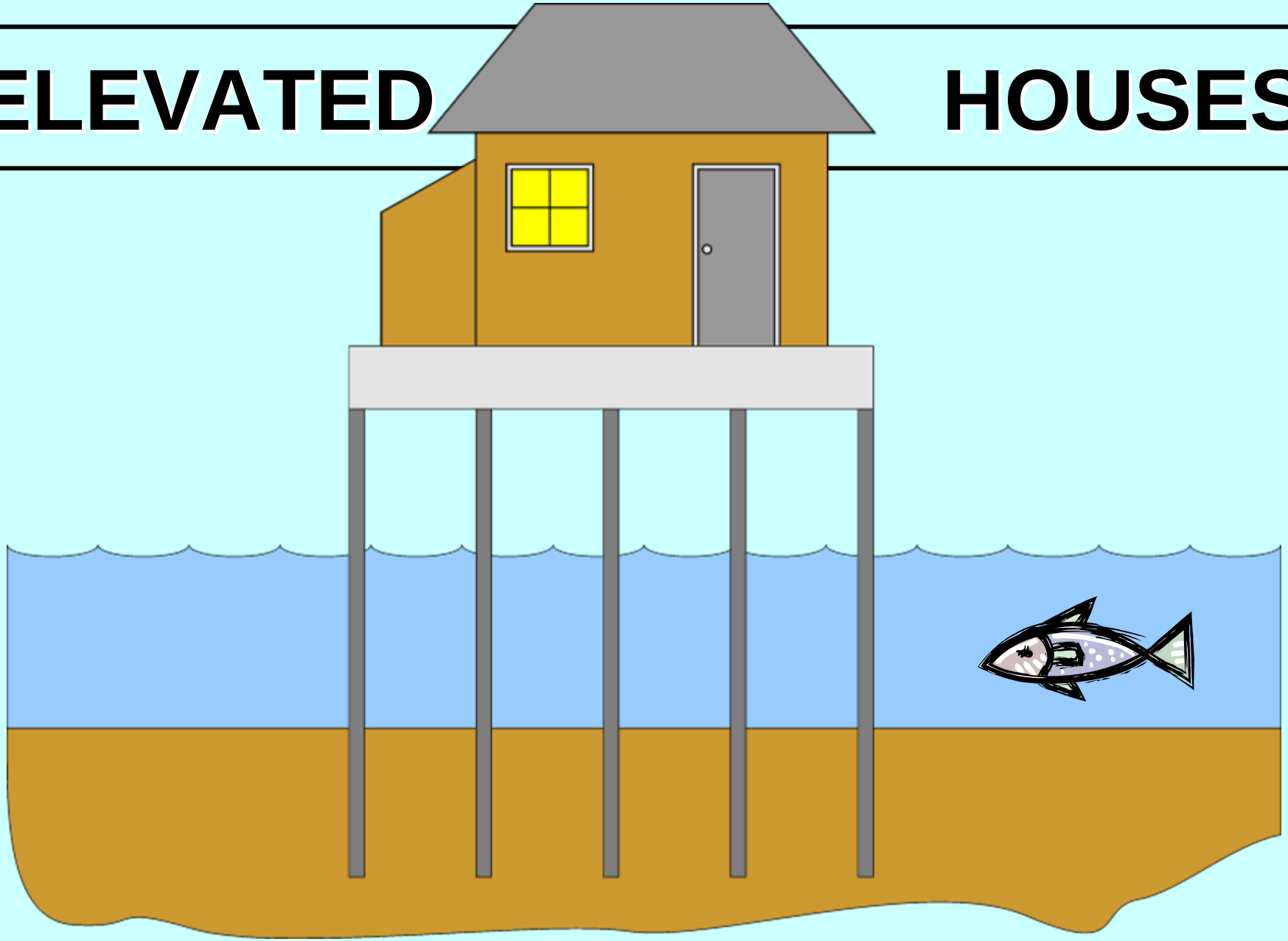




"THINGS SHOULD BE MADE AS SIMPLE AS POSSIBLE BUT NOT ANY SIMPLER THAN THAT"

---------Albert Einstein (Safir and Safire, 1982)

ELEVATED HOUSES



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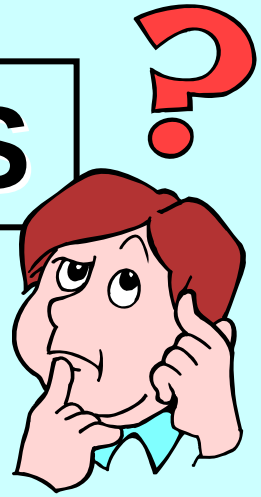
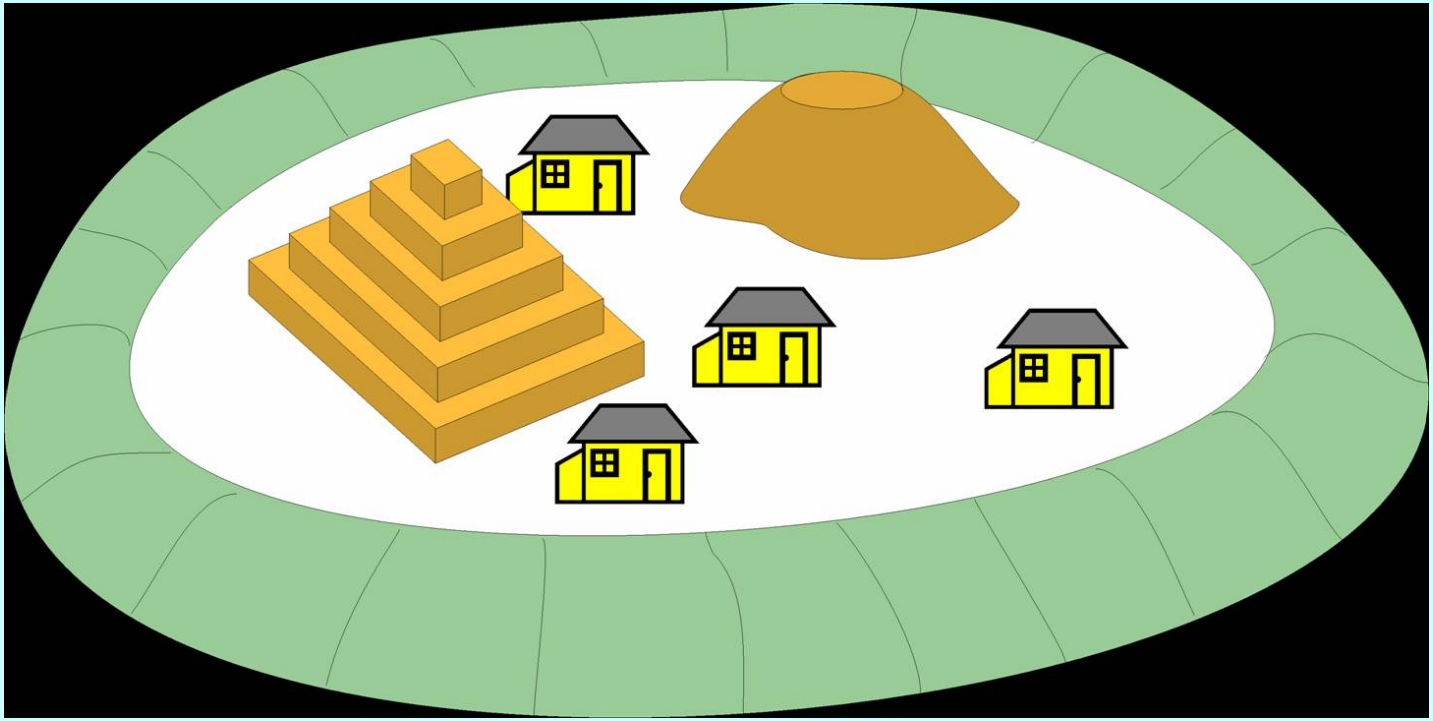
ESCAPE STRUCTURES





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CONCLUSIONS

1. Choose a target risk and quantify current risk levels
2. Develop solution to wave forces on bridge decks
3. Tie decks down and design foundation accordingly
4. Develop better understanding of soil erosion process
5. Goal of 4. is to develop guidelines for levee soils
6. Develop tools to evaluate miles of levees efficiently
7. Check concept of elevated houses
8. Check concept of escape structures
9. Implement research techniques into practice