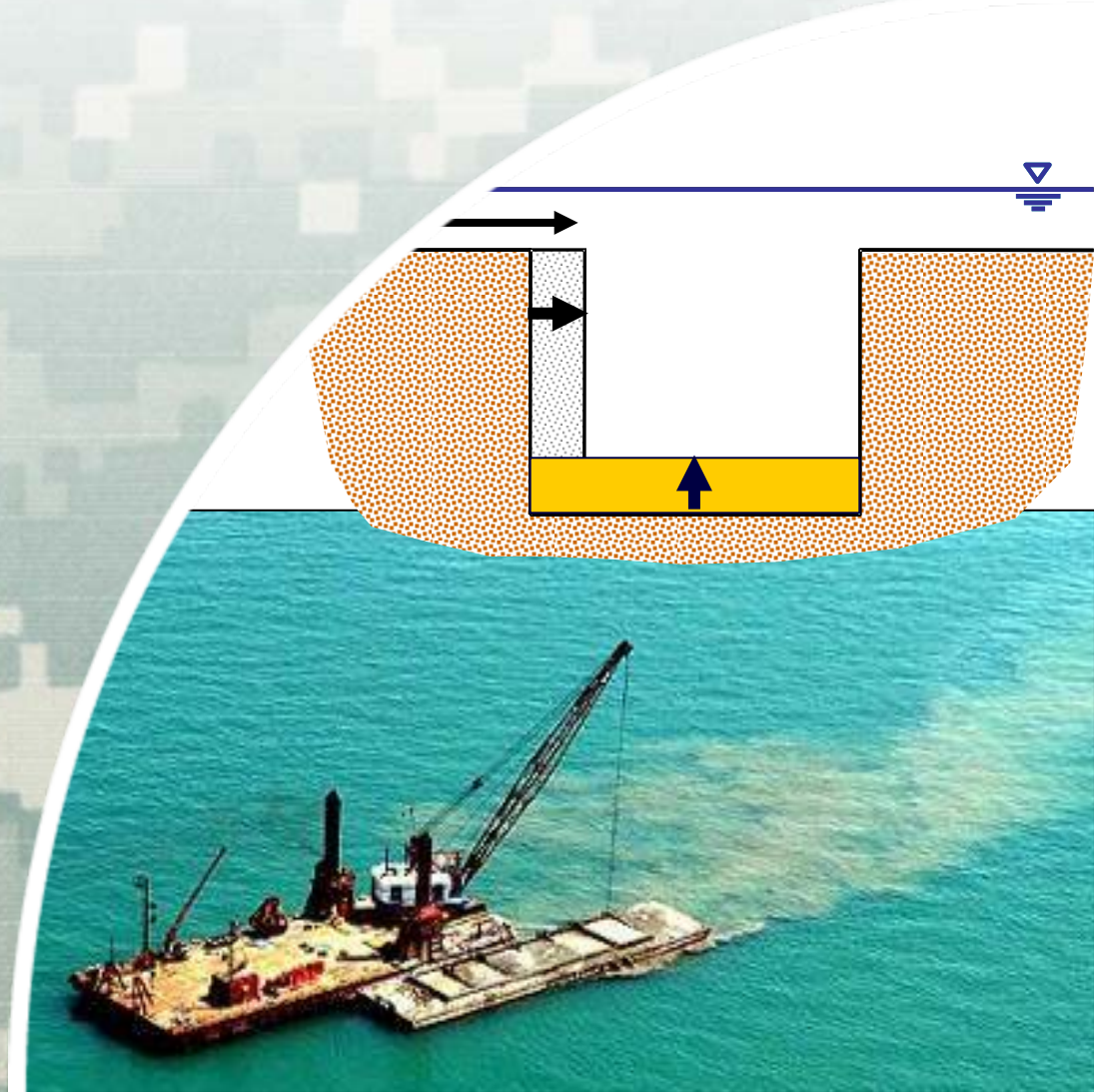
Shoaling of Coastal Navigation Channels

Julie Rosati

ERDC-CHL



US Army Corps of Engineers

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Overview

I. Navigation Mission of the Corps

II. Shoaling processes

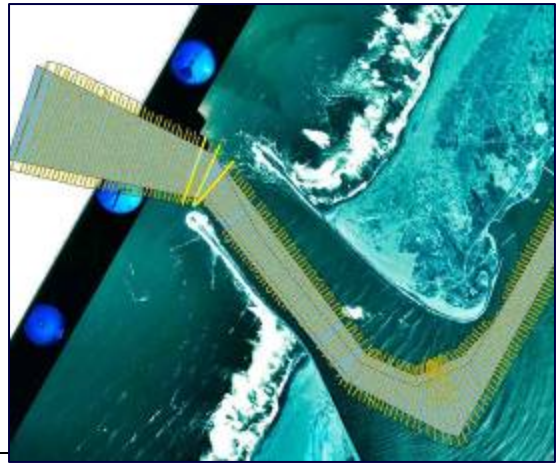
Example: Houston-Galveston Ship Channel

III. Corps perspective: O&M volumes and cost

IV. Historical bar channel O&M dredging

V. Channel shoaling toolbox

VI. Conclusions

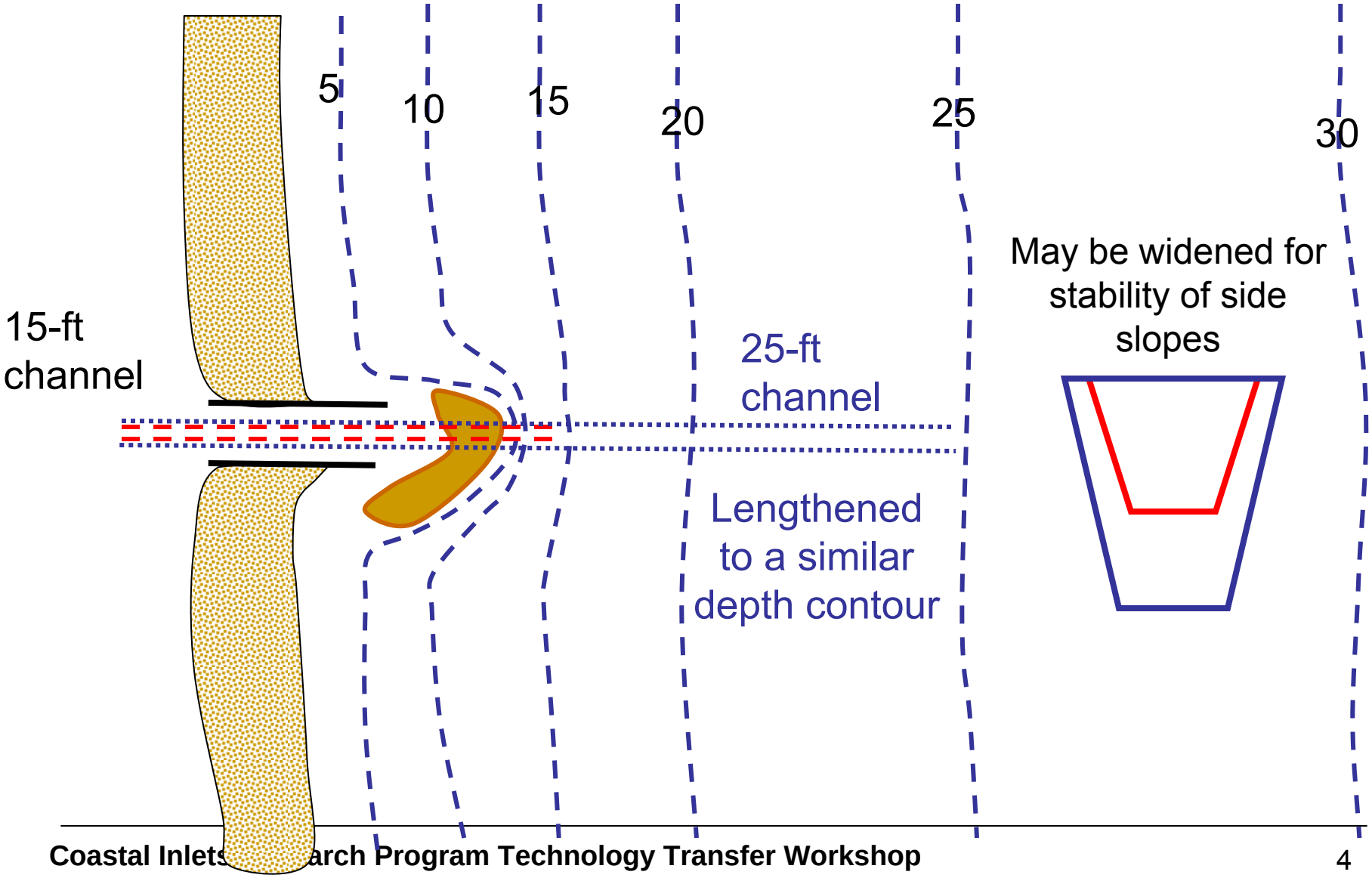


U.S. Army Corps of Engineers Navigation Mission

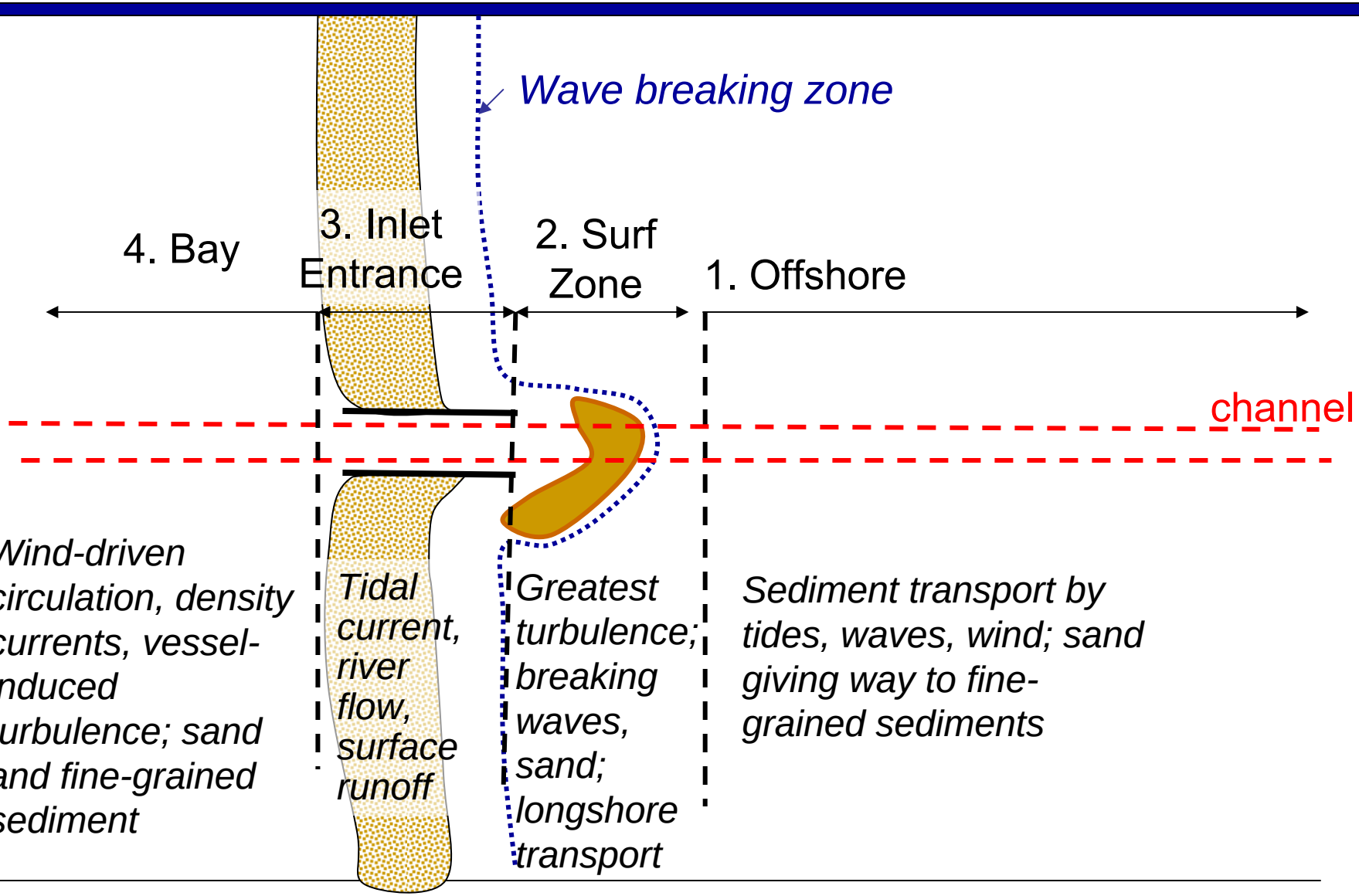
- Corps Navigation Mission established 1824
- Today: dredging of ~ 600 channels through inlets, estuaries, and bays
- Channels have been deepened, widened, and lengthened to…
  - ► Accommodate larger vessels
  - ► Allow greater transit speeds
  - ► Increase maneuverability

- Channel shoaling has increased non-linearly

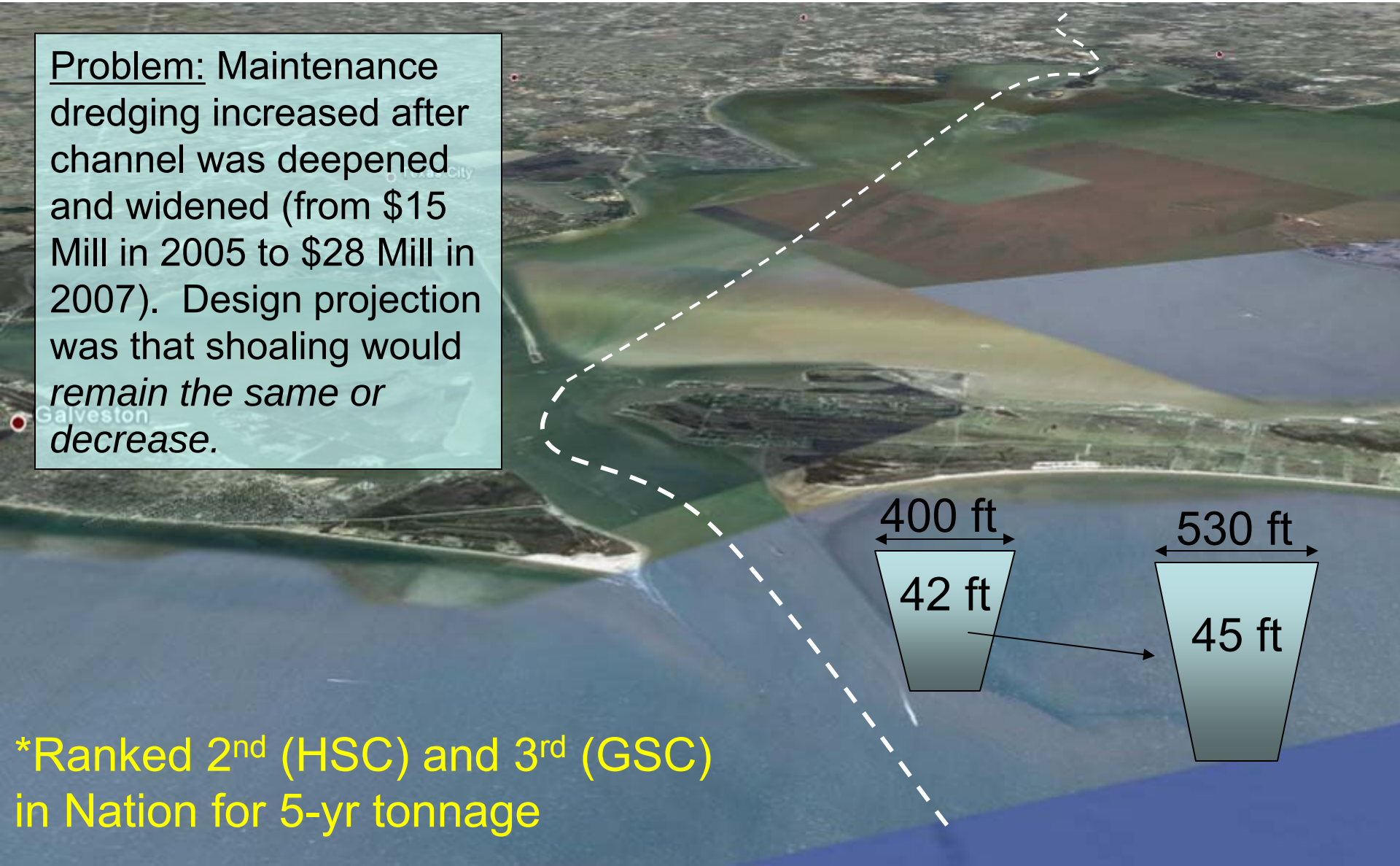
Channel Deepening Includes Widening & Lengthening



Processes within each Zone



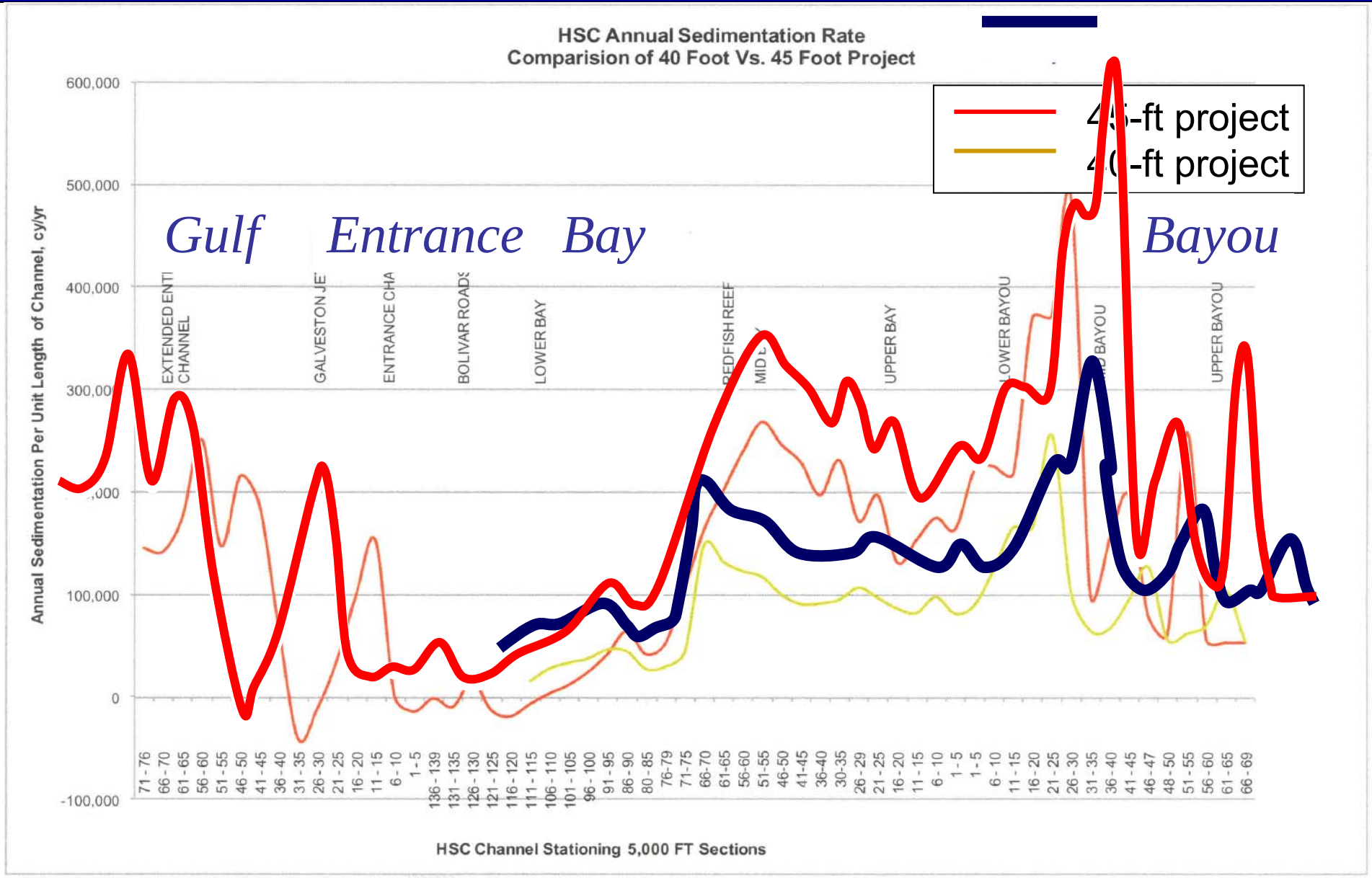
Example: Houston-Galveston Ship Channel

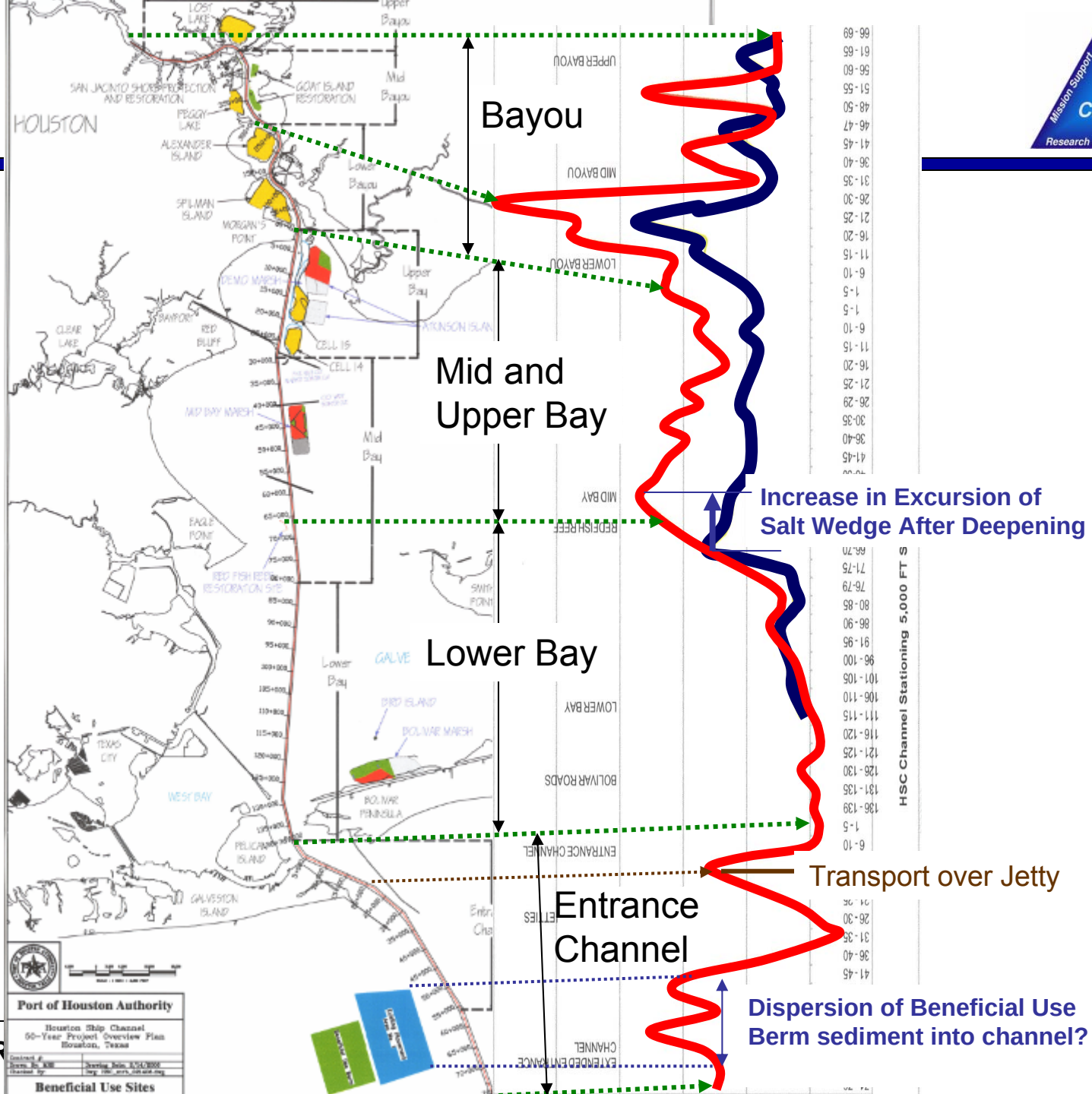


<u>Problem:</u> Maintenance dredging increased after channel was deepened and widened (from $15 Mill in 2005 to $28 Mill in 2007). Design projection was that shoaling would *remain the same or decrease.*

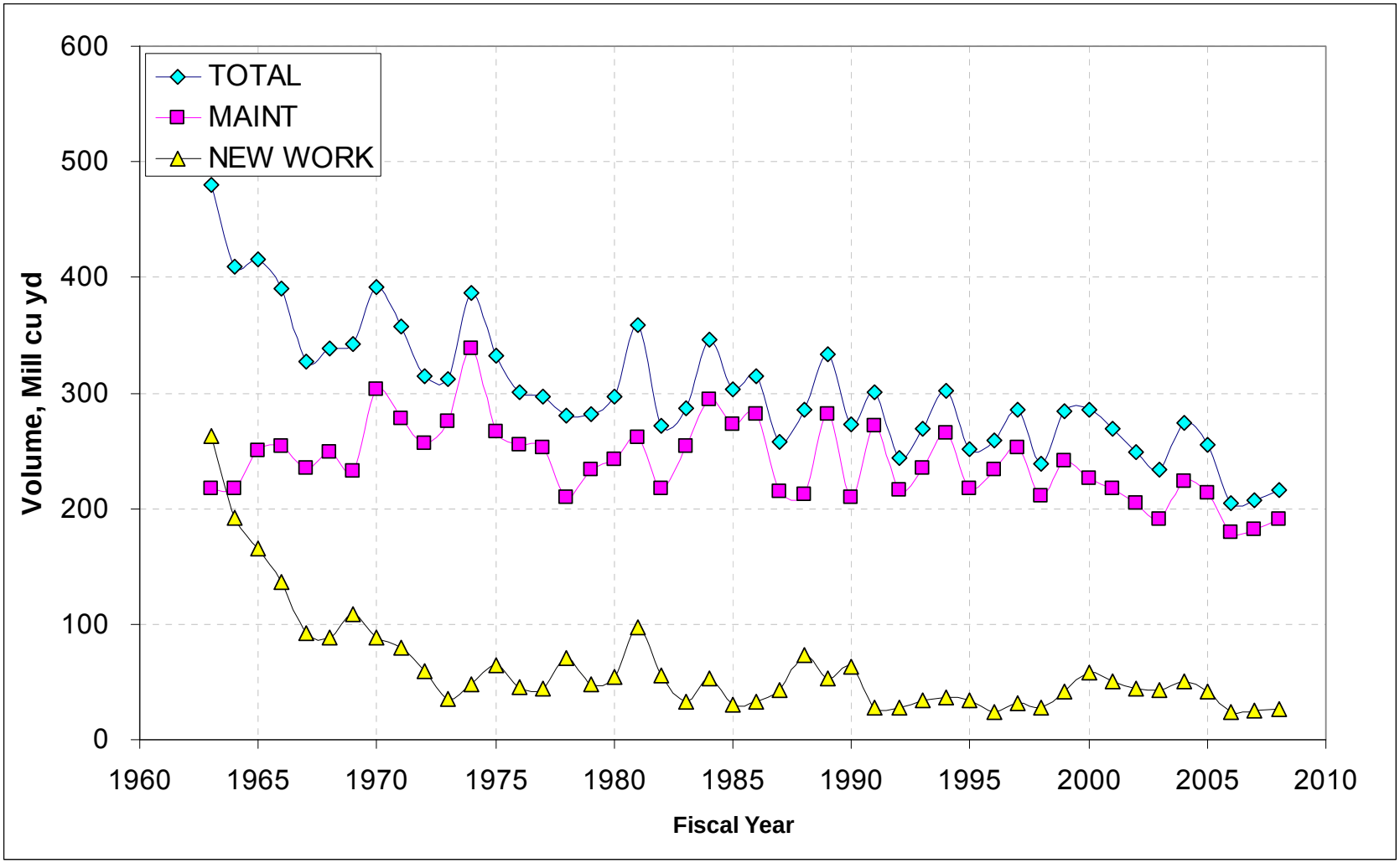
*Ranked 2nd (HSC) and 3rd (GSC) in Nation for 5-yr tonnage

Change in O&M with Channel Location



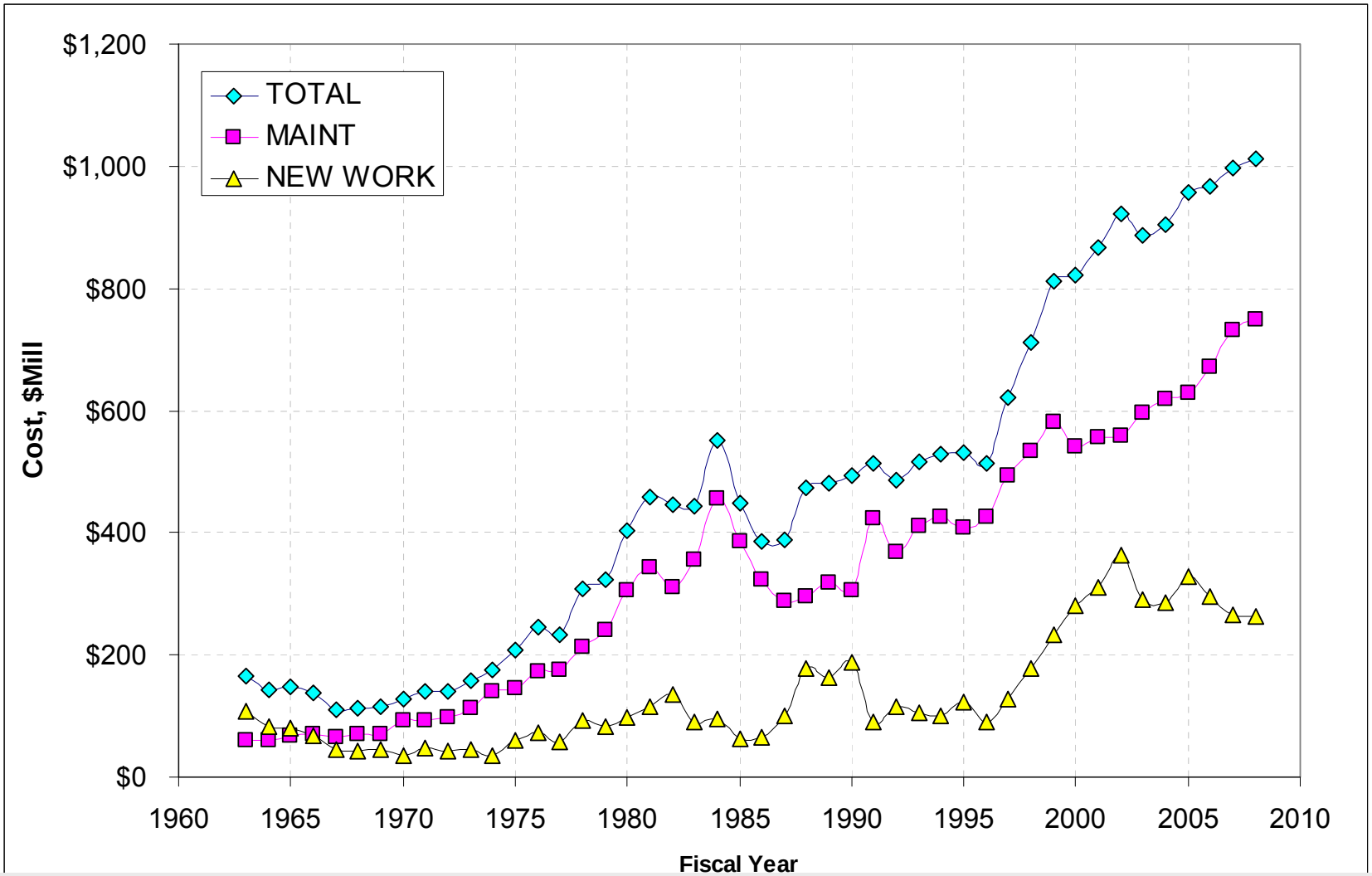

Bayou
Mid and Upper Bay
Lower Bay
Entrance Channel
Increase in Excursion of Salt Wedge After Deepening
Transport over Jetty
Dispersion of Beneficial Use Berm sediment into channel?
HOUSTON
Port of Houston Authority
Beneficial Use Sites
HSC Channel Stationing 5,000 FT S

Operation & Maintenance (O&M) Volume Dredged



Data from U.S. Army Corps of Engineers Navigation Data Center, http://www.iwr.usace.army.mil/NDC/

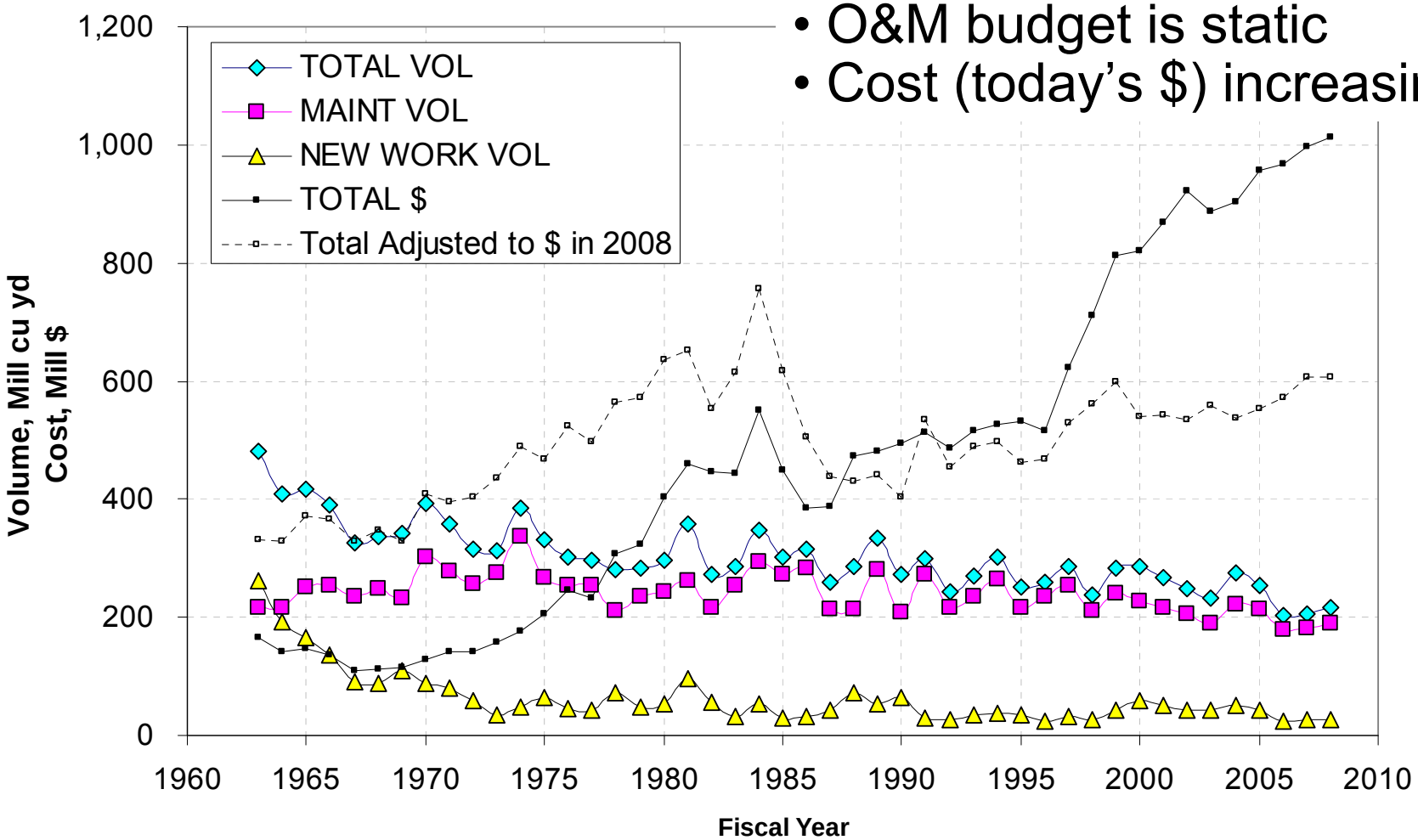
Operation & Maintenance (O&M) Cost



Data from U.S. Army Corps of Engineers Navigation Data Center, http://www.iwr.usace.army.mil/NDC/

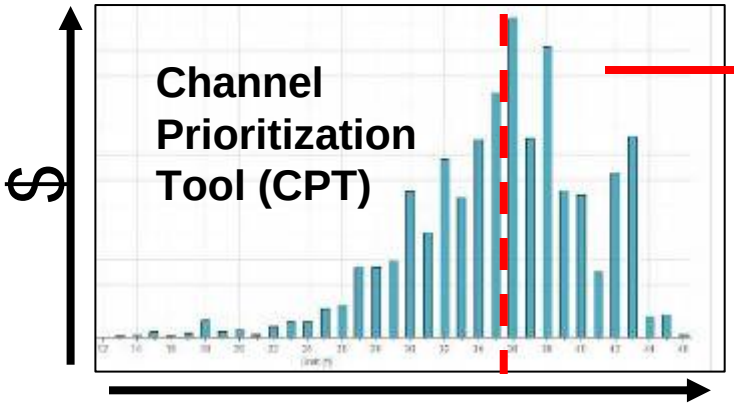
O&M Volume and Adjusted Cost

- Static or declining volume
- O&M budget is static
- Cost (today's $) increasing



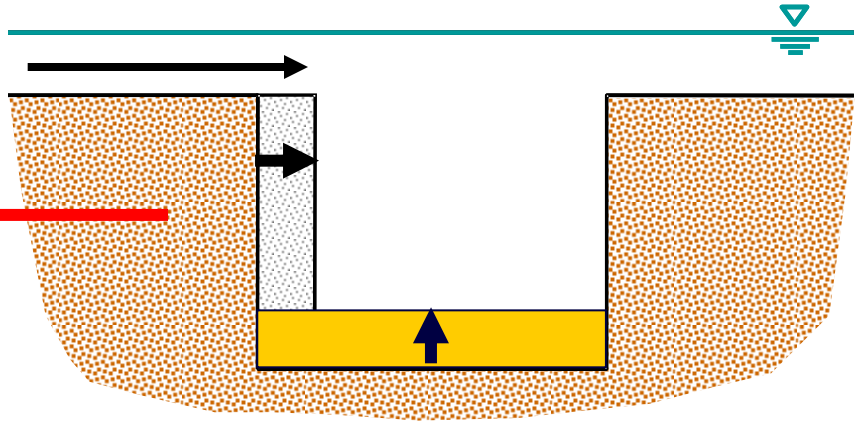
Data from U.S. Army Corps of Engineers Navigation Data Center, http://www.iwr.usace.army.mil/NDC/

Coastal Inlets Research Program: Integrated Decision-Support O&M Tools



What loss in commodity will occur with a decrease in depth by 2 ft? 4 ft?

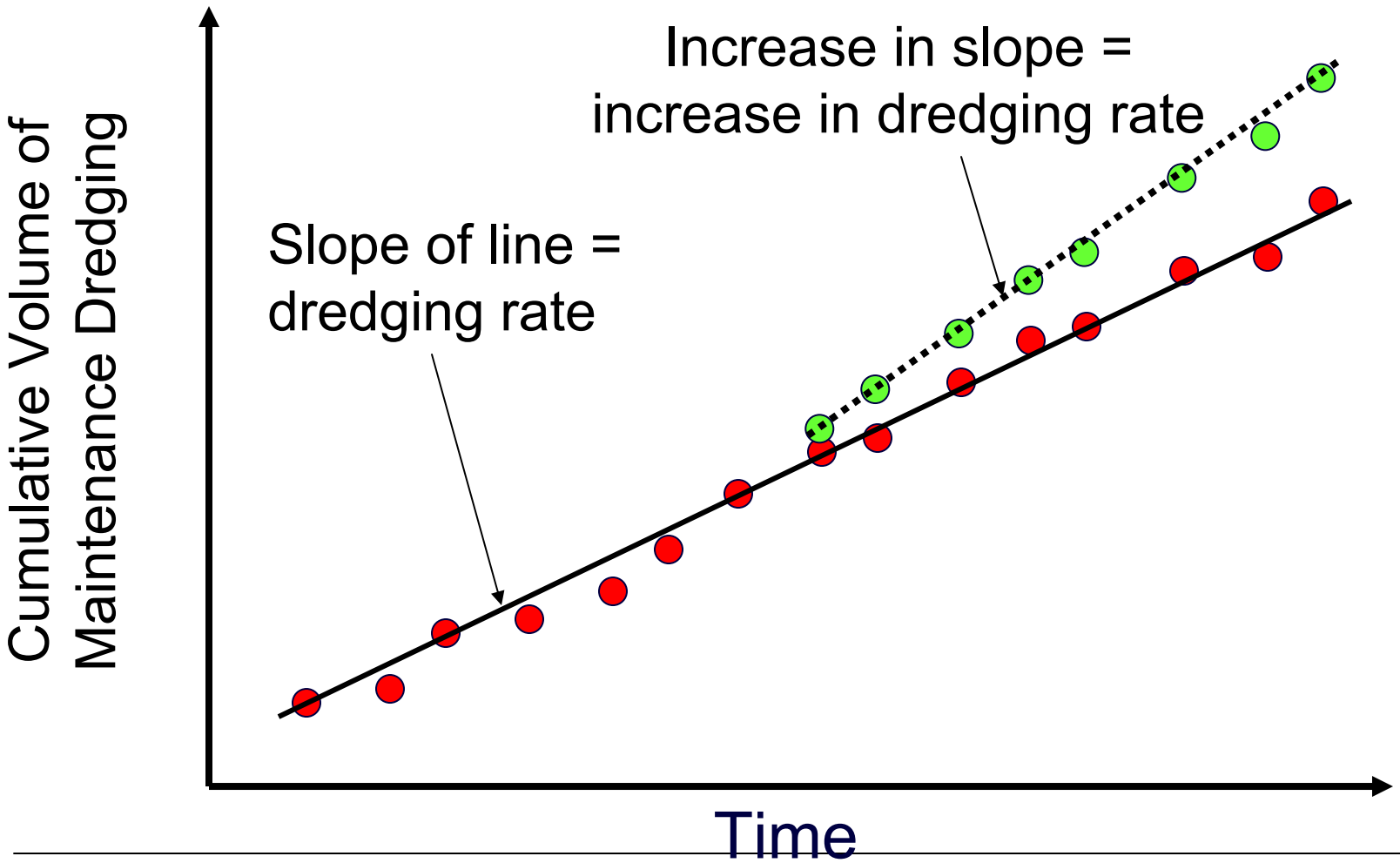
Channel Shoaling:
Historical O&M → *Simple Calculators* → *CMS*



What will be the limiting shoaling depth during the next year for the channel?

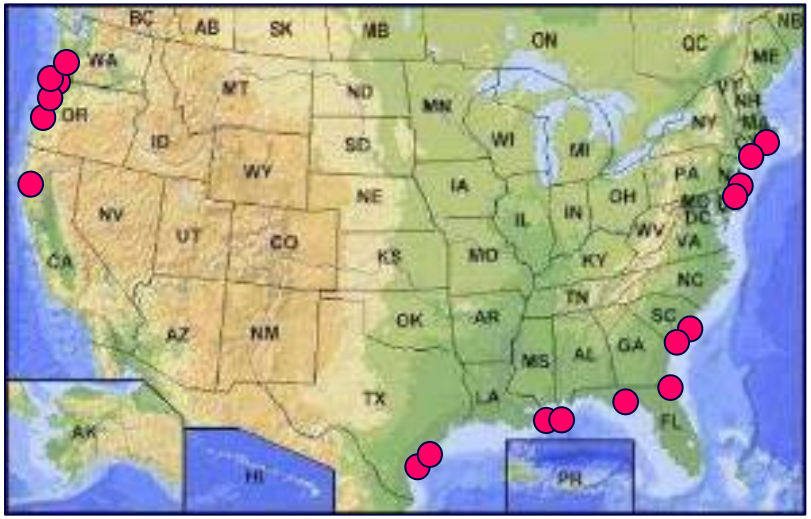
Orientation to Historical Data Plots

Maintenance dredging ~ proxy for channel shoaling



Historical Bar Channel O&M Data
Pre- and Post-deepening* O&M

Grays Harbor, WA
Mouth of Columbia River, WA/OR
Yaquina, OR
Siuslaw River, OR
Coos Bay, OR
Humboldt Bay, CA



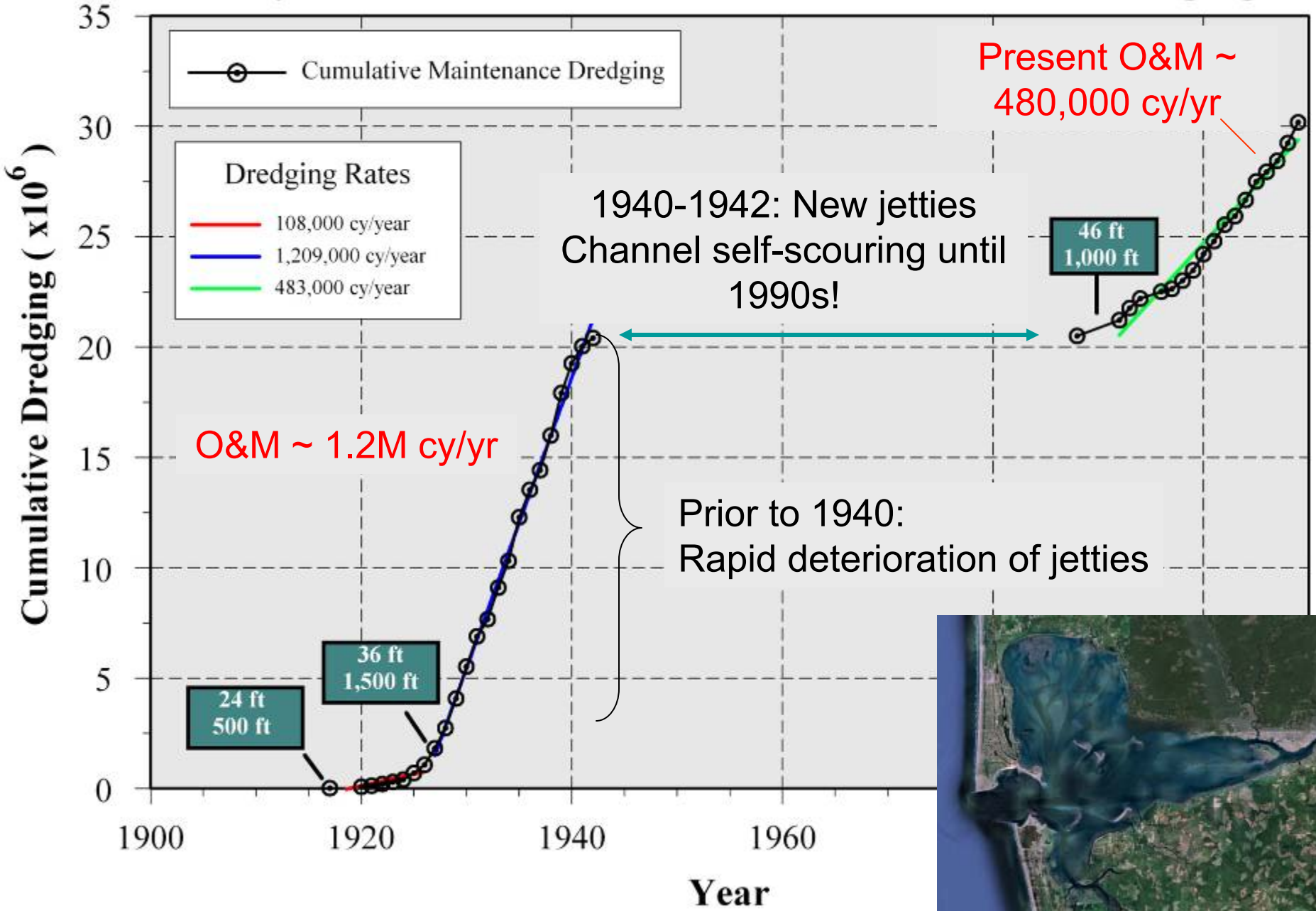
Shinnecock Inlet, NY
Fire Island Inlet, NY
Manasquan Inlet, NJ
Barnegat Inlet, NJ
Lockwoods Folly, SC
Charleston Entrance, SC
St. Marys Entrance, FL

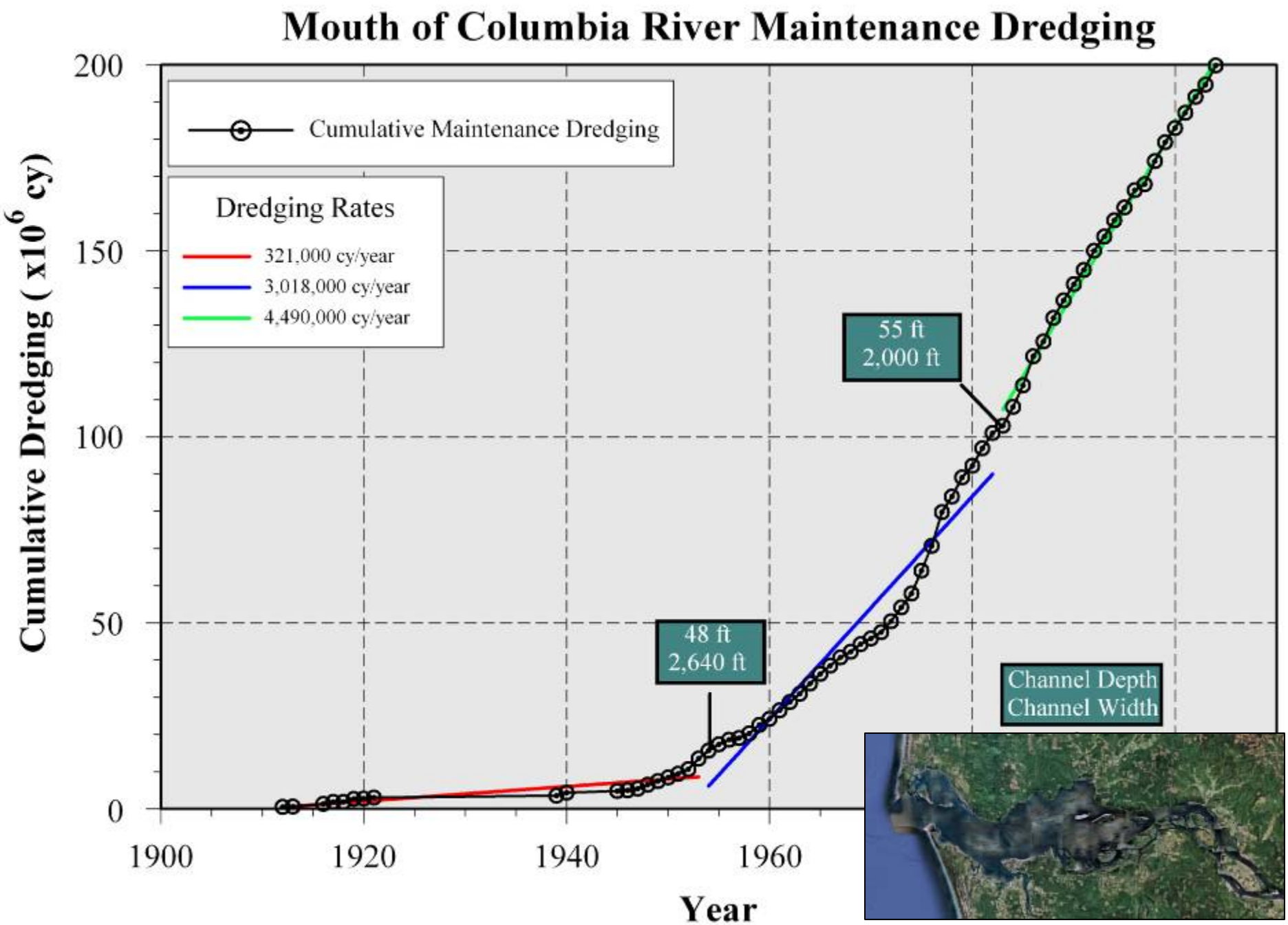
Pensacola Pass, FL
Horn Island Pass, MS
Ship Island Pass, MS
Freeport Harbor, TX
Brazos Island Harbor, TX

* Including widening, lengthening, or reorientation as applicable

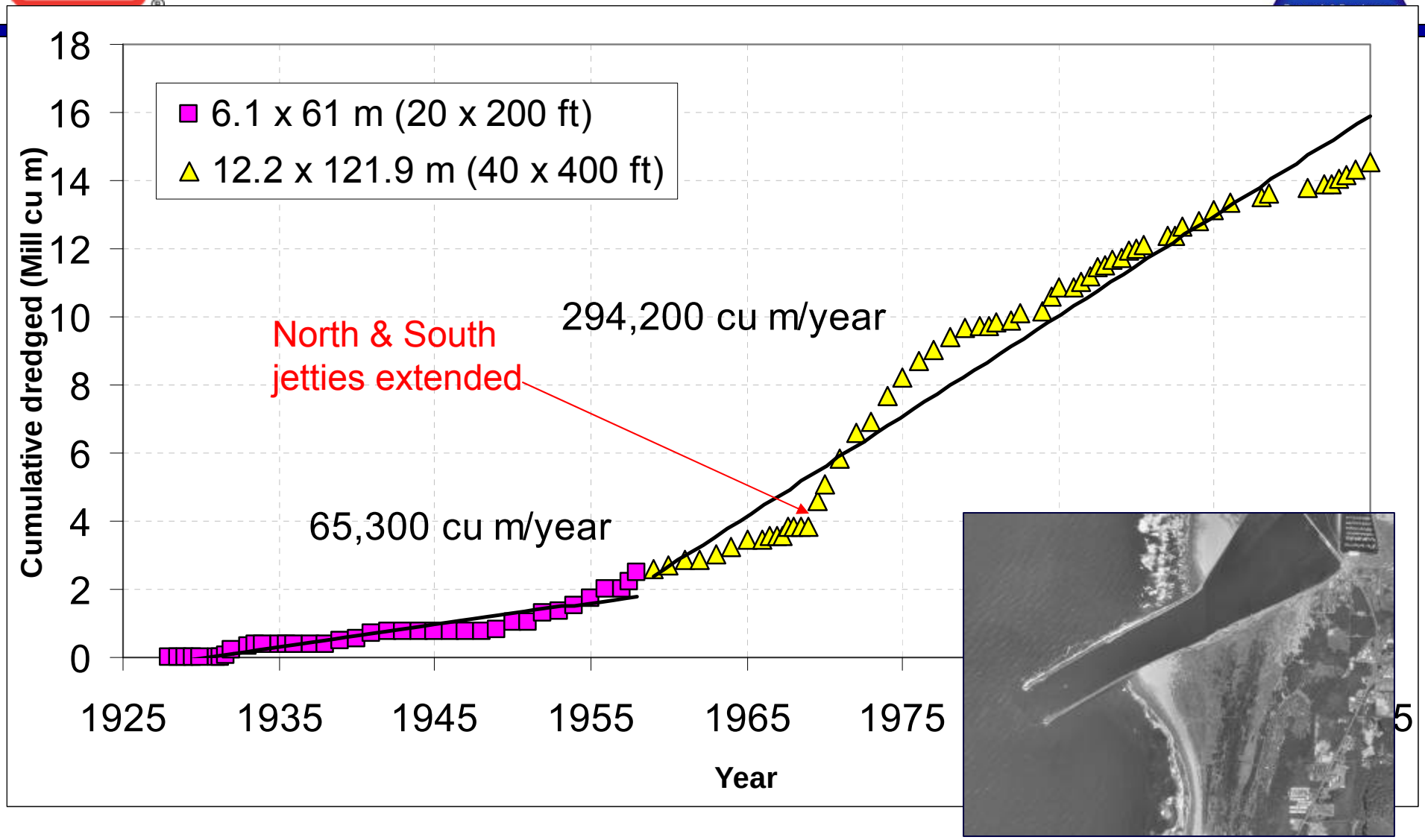
Pacific Coast Sites

Grays Harbor Outer Bar Channel Maintenance Dredging

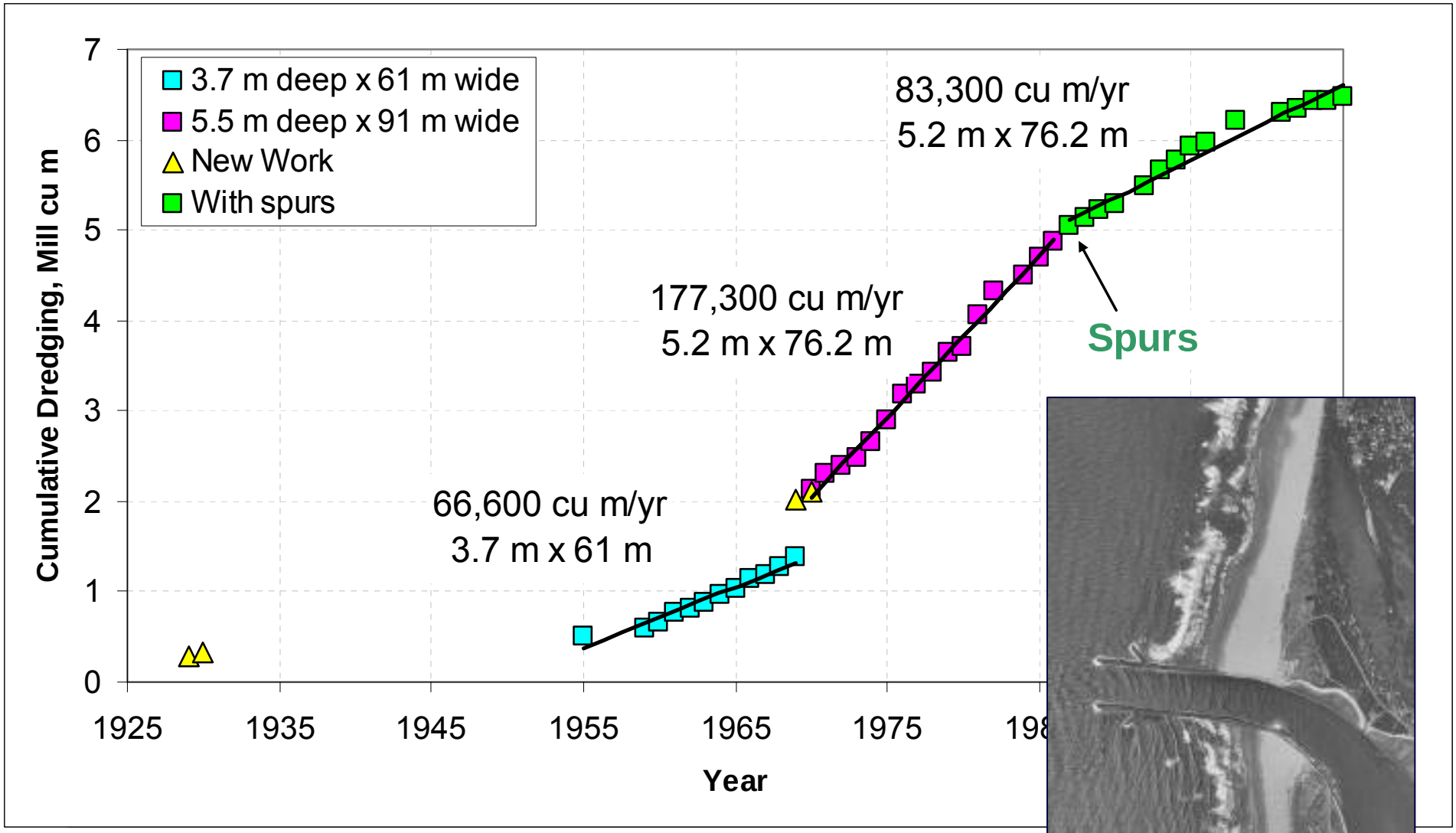


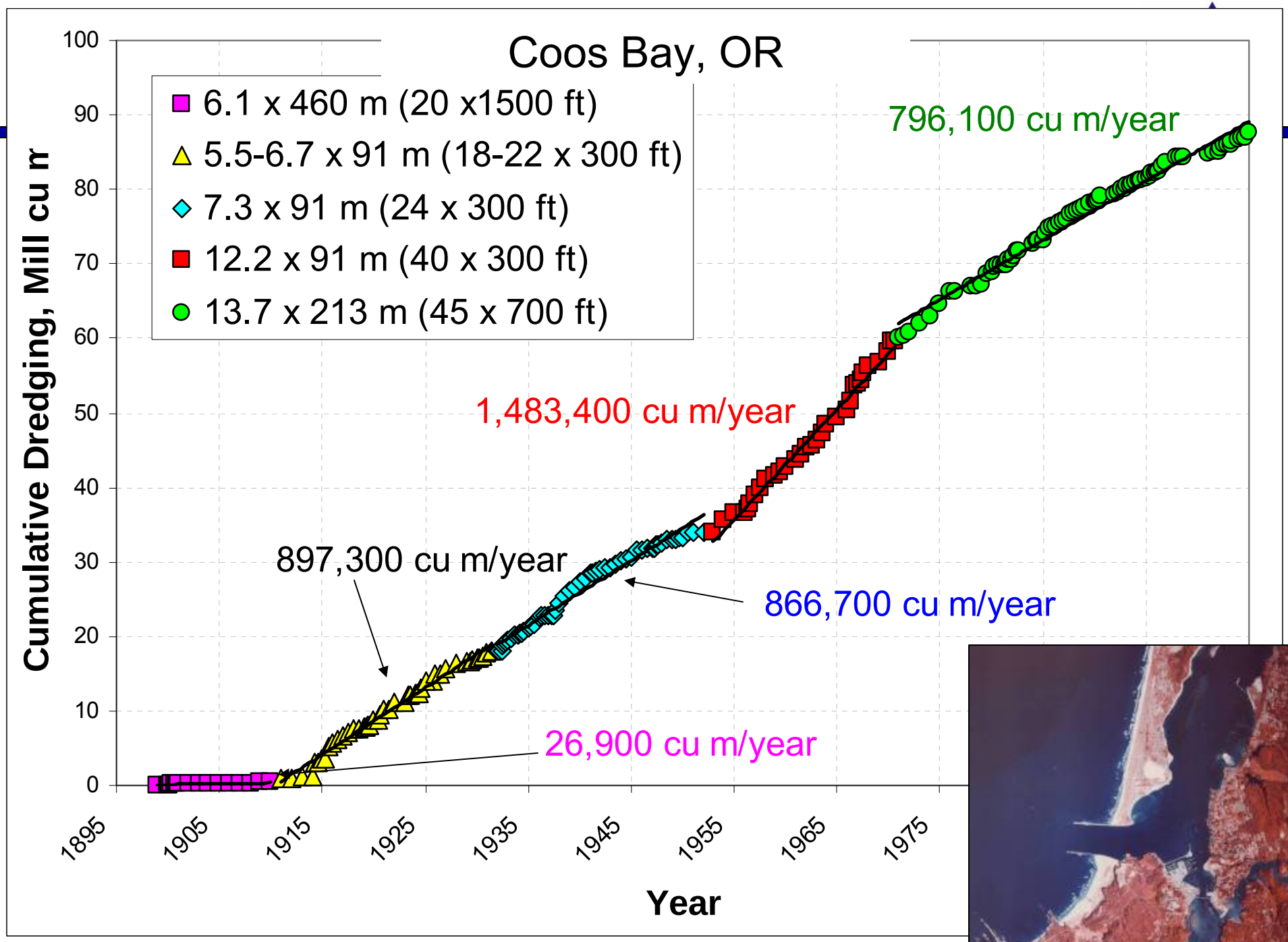

Mouth of Columbia River Maintenance Dredging
Cumulative Maintenance Dredging
Dredging Rates
321,000 cy/year
3,018,000 cy/year
4,490,000 cy/year
55 ft
2,000 ft
48 ft
2,640 ft
Channel Depth
Channel Width
Cumulative Dredging (x10^6 cy)
Year
200
150
100
50
0
1900
1920
1940
1960

Yaquina, OR

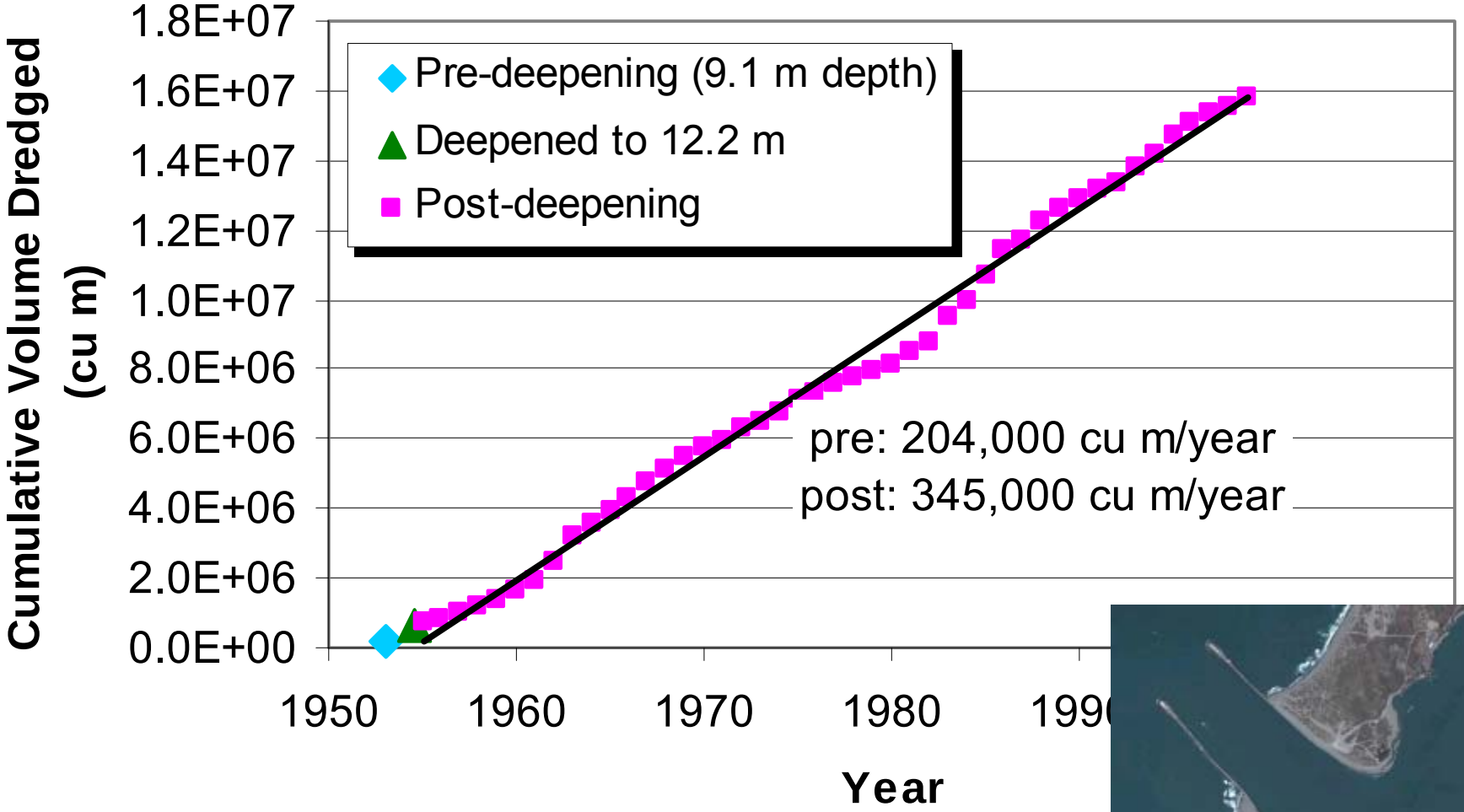

6.1 x 61 m (20 x 200 ft)
12.2 x 121.9 m (40 x 400 ft)
North & South jetties extended
294,200 cu m/year
65,300 cu m/year
Cumulative dredged (Mill cu m)
Year
0
2
4
6
8
10
12
14
16
18
1925
1935
1945
1955
1965
1975

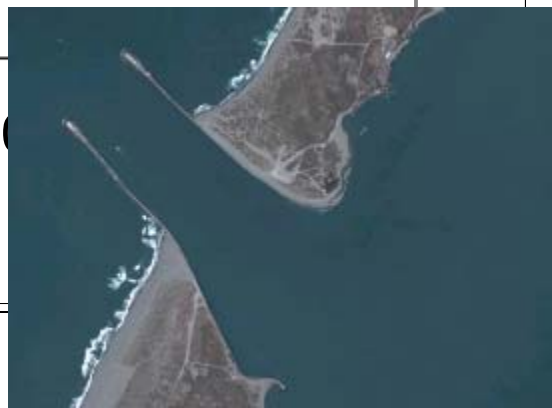
Siuslaw River, OR




Coos Bay, OR
6.1 x 460 m (20 x1500 ft)
5.5-6.7 x 91 m (18-22 x 300 ft)
7.3 x 91 m (24 x 300 ft)
12.2 x 91 m (40 x 300 ft)
13.7 x 213 m (45 x 700 ft)
796,100 cu m/year
1,483,400 cu m/year
897,300 cu m/year
866,700 cu m/year
26,900 cu m/year
Cumulative Dredging, Mill cu m
Year
0
10
20
30
40
50
60
70
80
90
100
1895
1905
1915
1925
1935
1945
1955
1965
1975

Humboldt Bay, CA





Vision: Channel Shoaling Toolbox

Linked to CPT

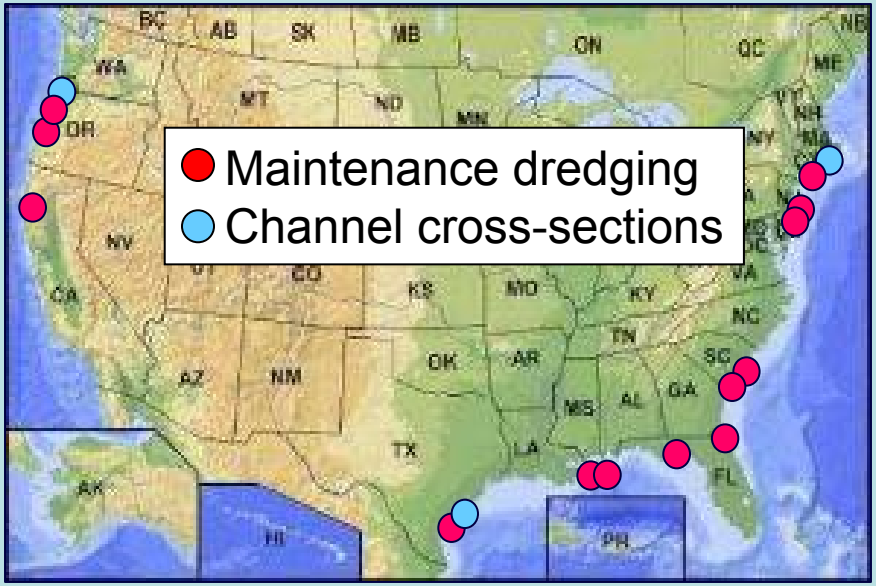
Historical Data | Empirical | Analytical | Numerical

[Background]

[Download Database]

[References]

Select a Site



Export to CPT

Vision: Channel Shoaling Toolbox

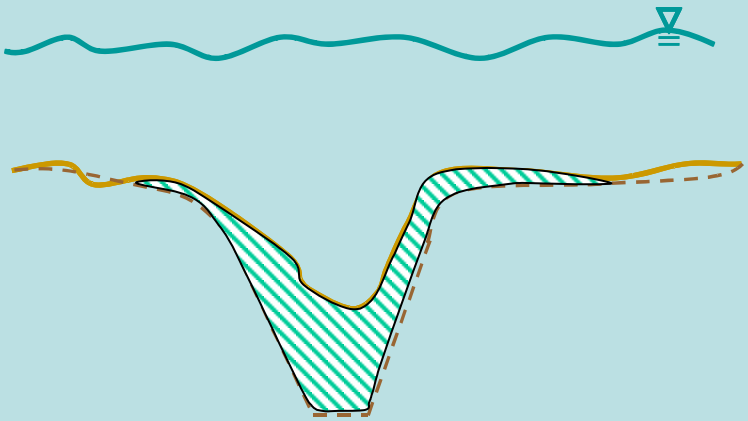
Historical Data | **Empirical** | Analytical | Numerical

Background

Methods

- Trawle (1981)
- Galvin (1982)
- Vincent and Uva (1984)
- Rosati (2005)

References



Export to CPT

Vision: Channel Shoaling Toolbox

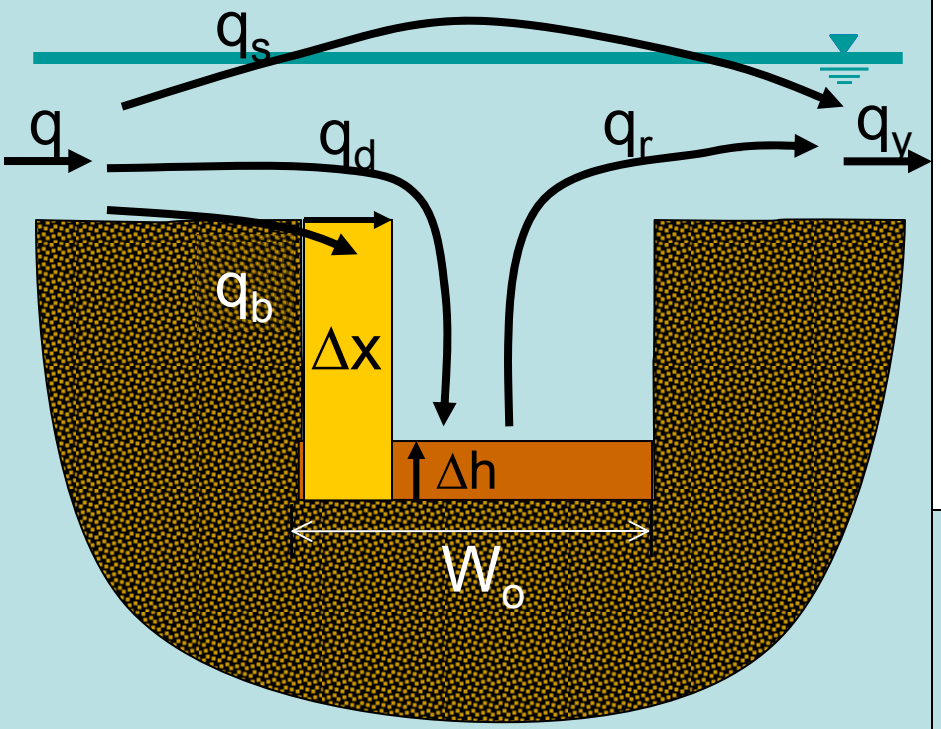
Historical Data | Empirical | **Analytical** | Numerical

Background

Calculate

References

- Kraus & Larson (2003)
- Rosati & Kraus (2009)



Export to CPT

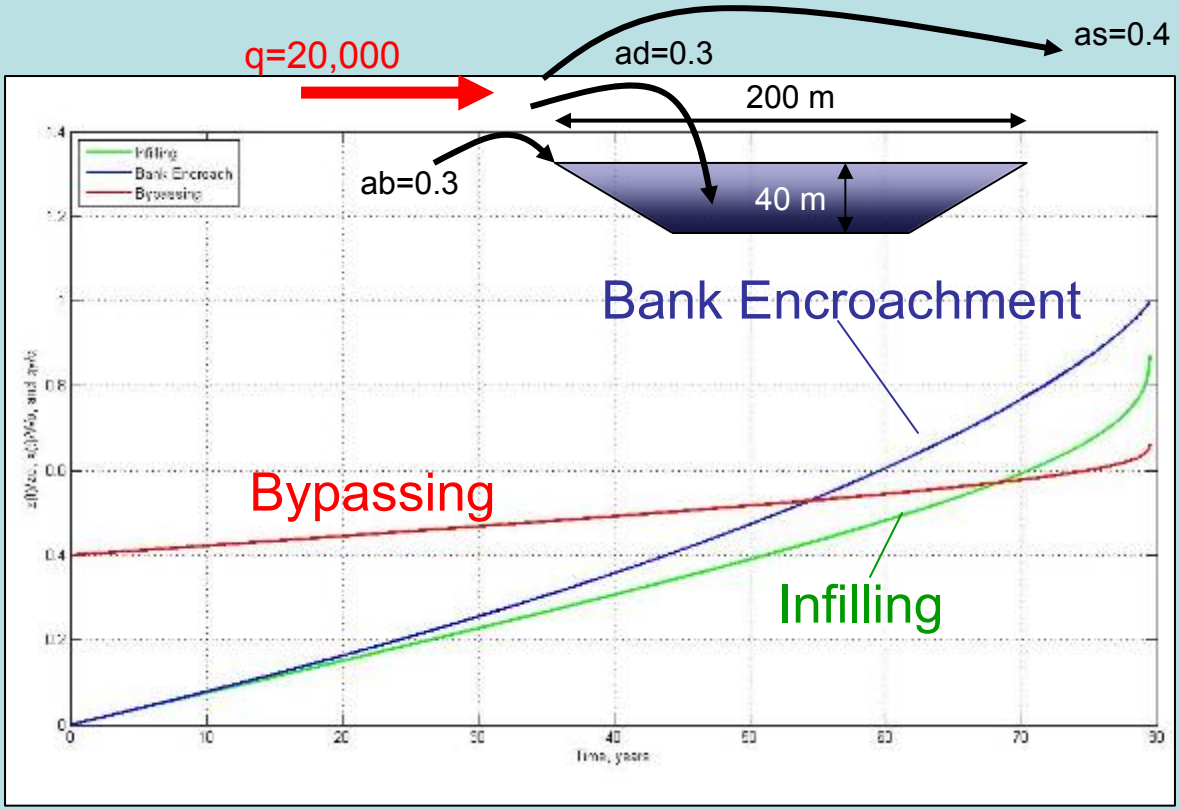
Example Morphologic Shoaling Calculation

Historical Data | Empirical | **Analytical** | Numerical

Background

Calculate

References



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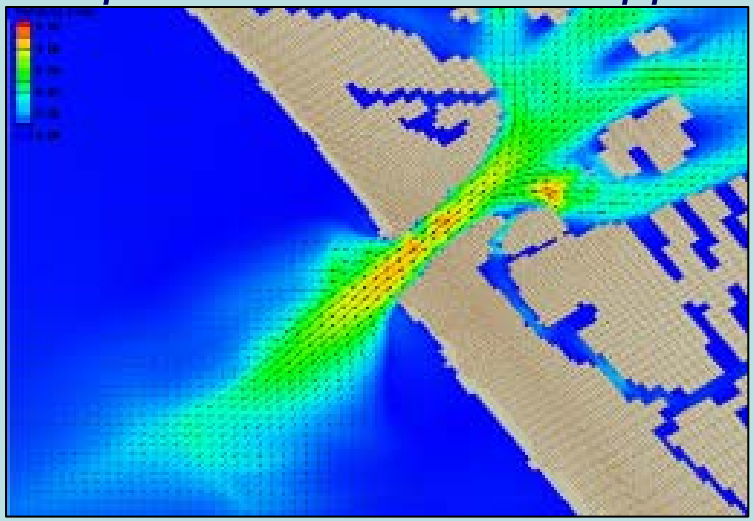
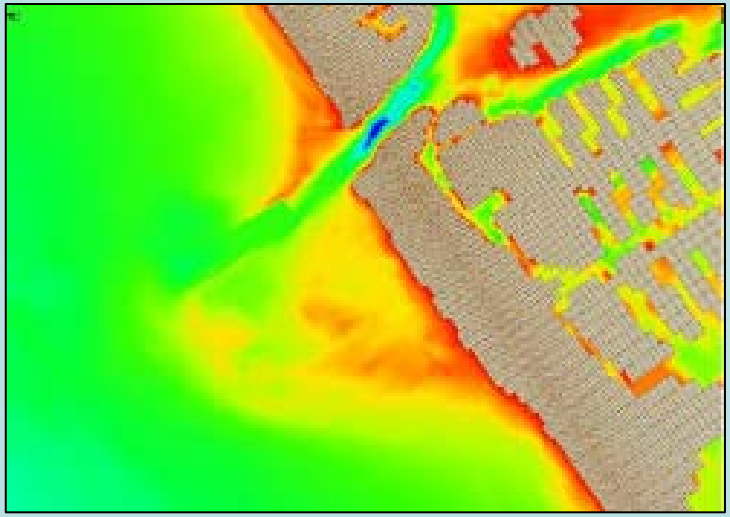
Vision: Channel Shoaling Toolbox

Historical Data | Empirical | Analytical | Numerical

Coastal Modeling System Numerical Calculations

Experiences with CMS applied studies





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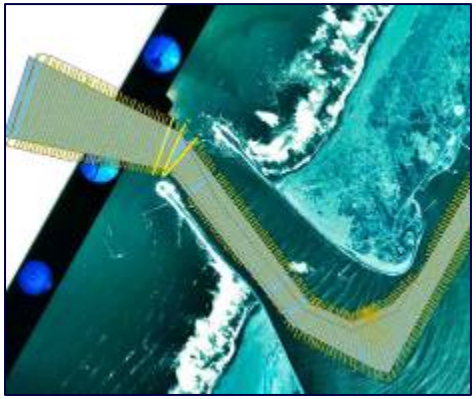
Conclusions

- Deepening & widening channels increases channel shoaling non-linearly.
- CIRP developing integrated decision-support tools to calculate O&M requirements with channel improvements:
  - Reconnaissance-level estimates (Shoaling Toolbox)
  - Feasibility and design-level estimates (CMS)
- Link Channel Prioritization Tool (CPT) to Channel Shoaling Toolbox
  - Explore how alternative channel designs change navigation channel shoaling, and resulting increases or decreases in port commodities
- Next steps: incorporate jetty condition with O&M requirements