USACE Perspective on Mississippi River Sediment Diversions

BG Duke DeLuca

Commander, Mississippi Valley Division
President-designee, Mississippi River Commission

January, 2014

US Army Corps of Engineers
BUILDING STRONG®

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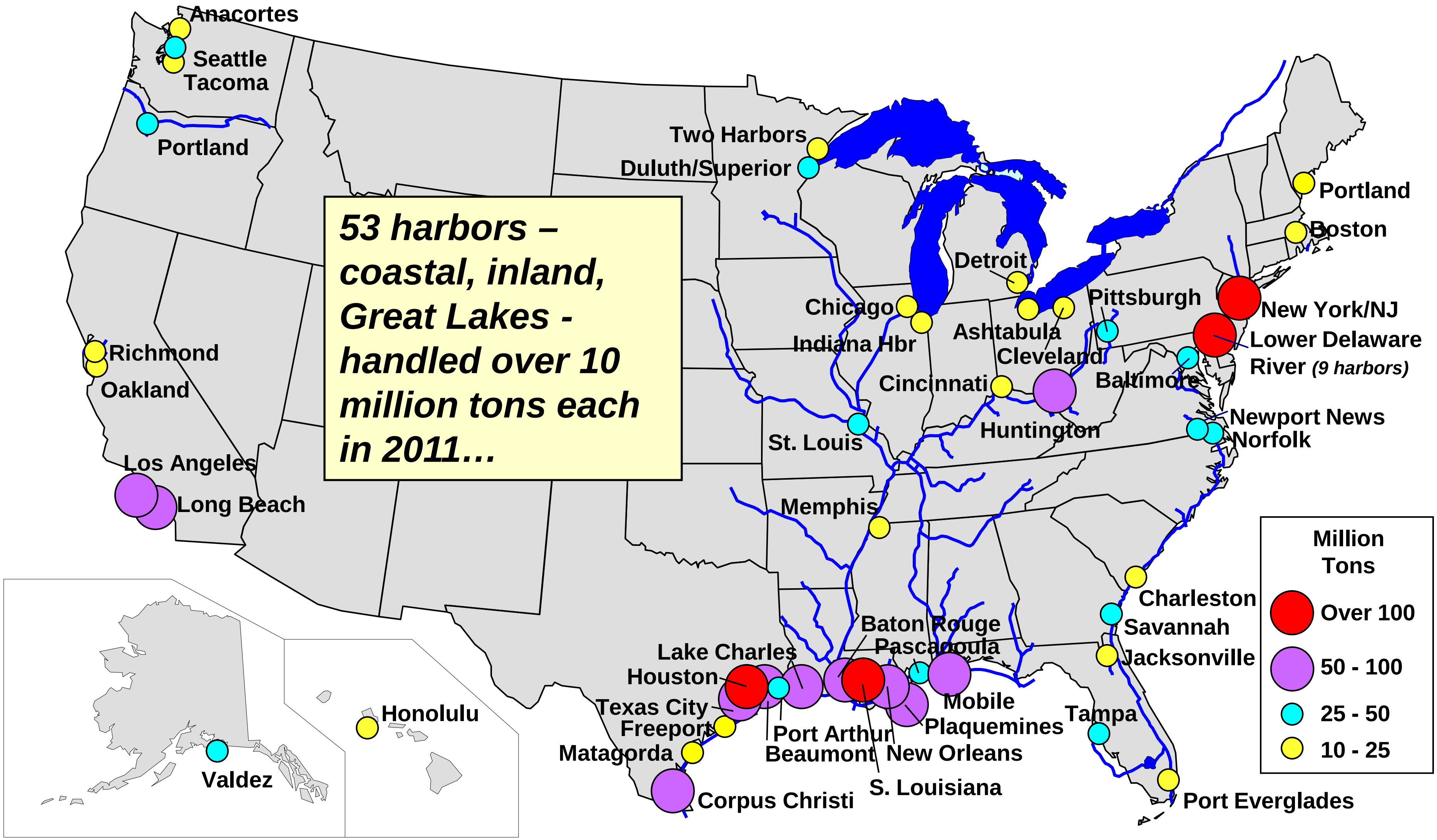
Presentation Outline

- The Value of the Mississippi River to the United States
- The Causes of Wetland Loss in Louisiana
- How Well Will Sediment Diversions Work?
- Can We Quantify and Mitigate for the Unintended Consequences of Diversions?
- How Should a Full Array of Alternatives Best Be Applied?

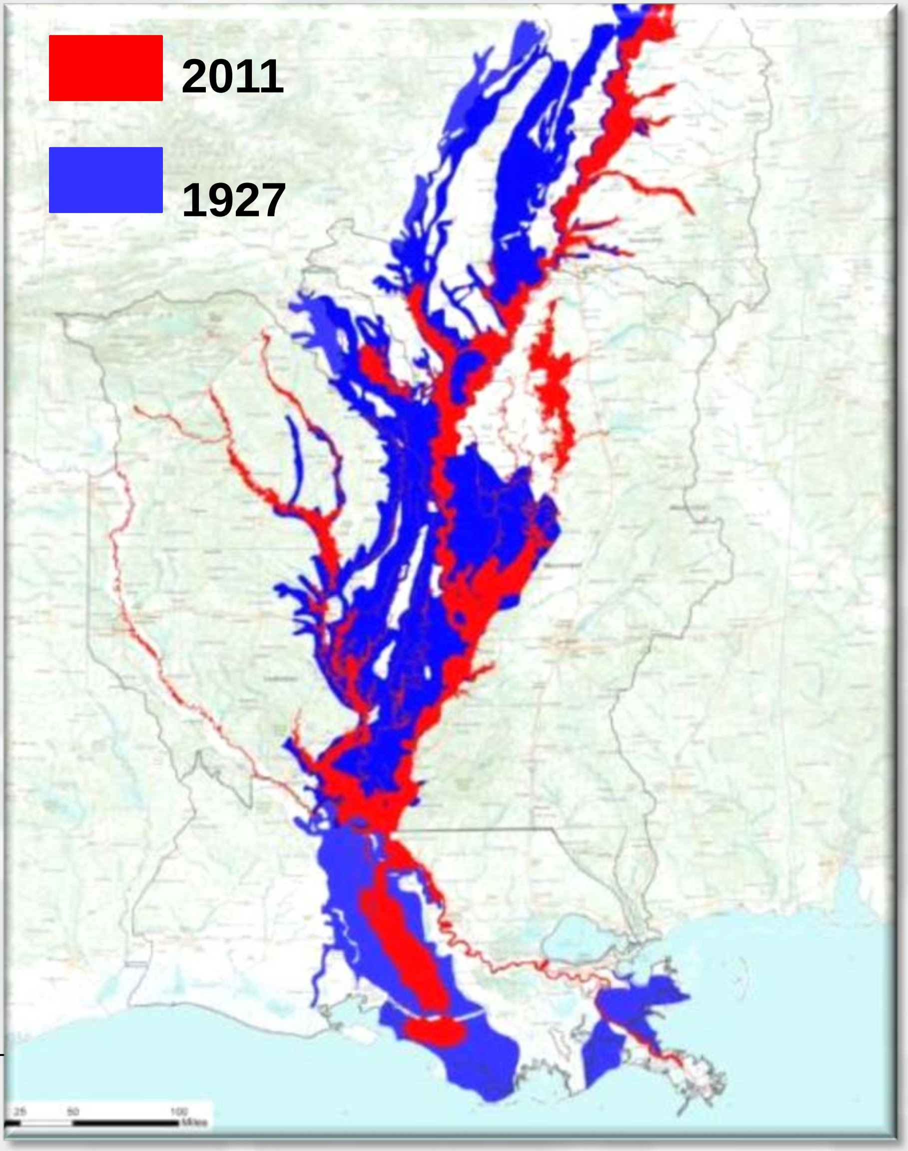
U.S. Ports: Vital to Trade …and to Our National Economy



53 harbors – coastal, inland, Great Lakes - handled over 10 million tons each in 2011…

1927 vs. 2011 Mississippi River Record Flood: From "Levees Only" to "Room for the River"

- 1927 Flood = 16.8 million acres
- 2011 Flood = 6.4 million acres
- $14 billion Investment since 1928
- $234 billion damages prevented (2011) 84% of the damages prevented were in Louisiana
  - ✓ $612 billion since 1928
  - ✓ 44 to 1 return on investment
- Over 4 million people protected
- $3 billion annual transportation rate savings
- Untold economic productivity enabled: Farms, towns, factories



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Value to the Nation

Coastal Louisiana Fisheries and Wetland Values

- USFWS: “Louisiana is the most productive fishery in North America”
  - 25% of continental US commercial fisheries
  - More than 1 billion pounds caught annually with a dockside value $291 million
  - Recreation value $900 million to $1.2 billion

- Louisiana has 40% of the coastal marshlands in the continental United States which support:
  - Five million waterfowl
  - 25 million songbirds
  - 70 rare, threatened or endangered species

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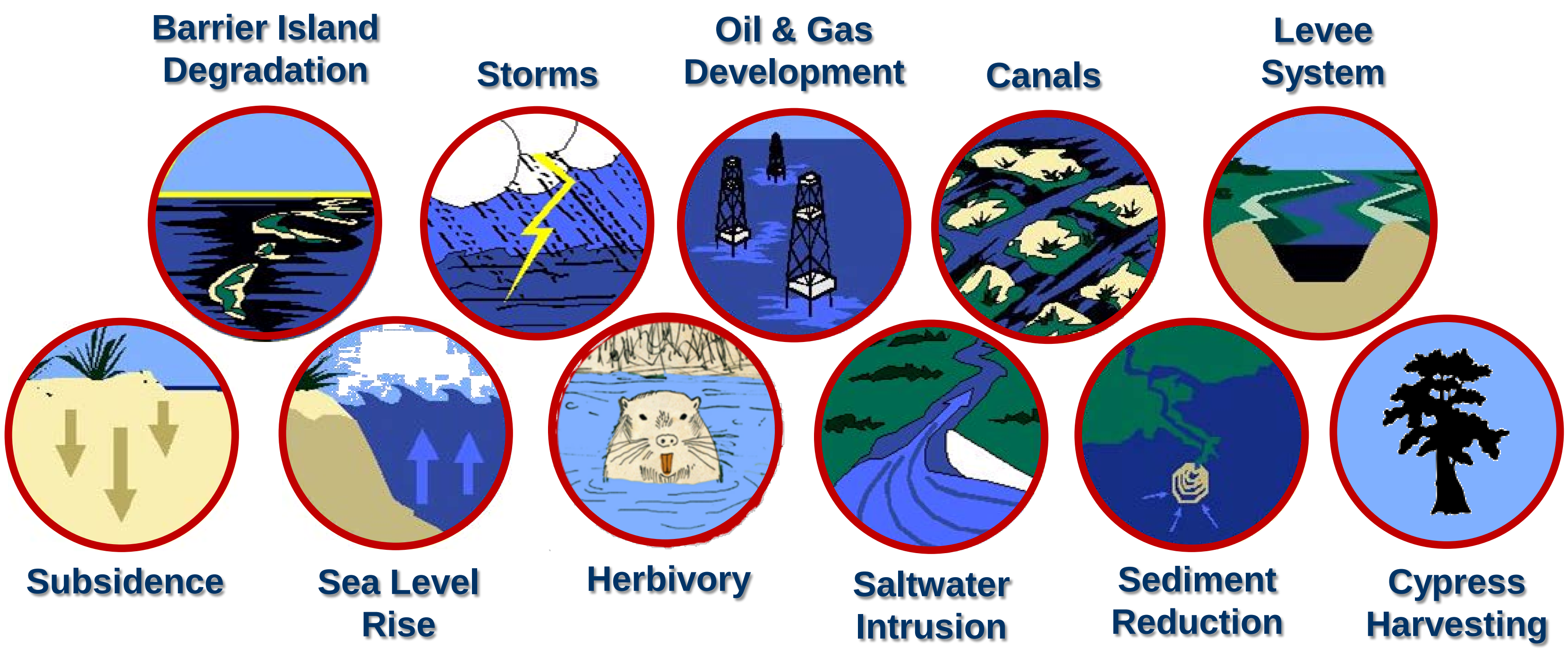
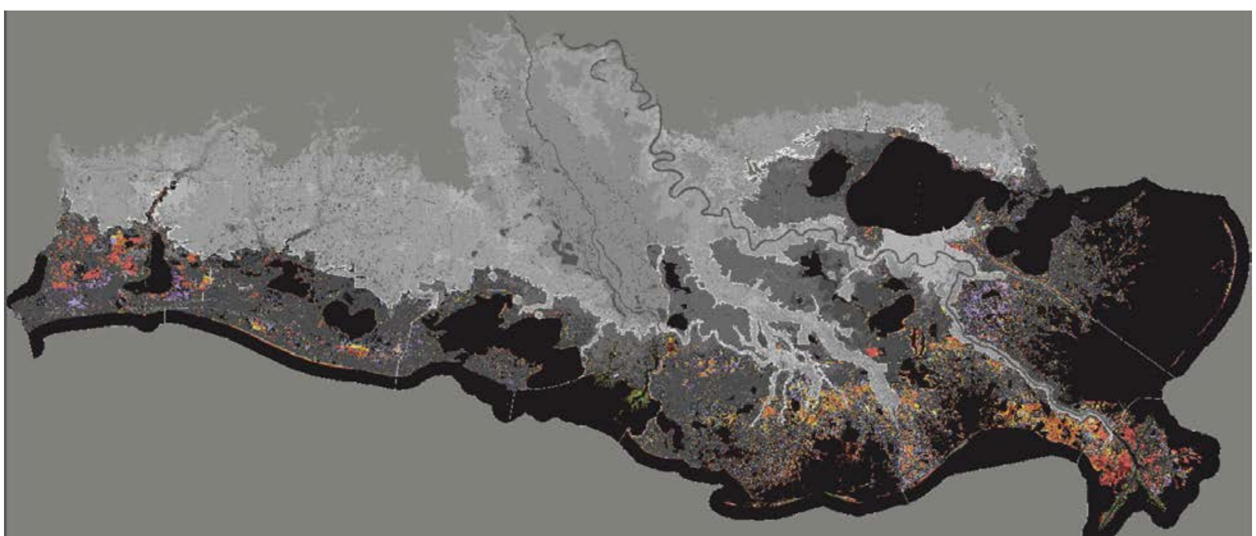
Causes of Land Loss in Coastal Louisiana

Major Causes of Wetland Loss





"Land Area Change in Coastal Louisiana from 1932 to 2010" USGS, 2011.

Land Loss in Coastal Louisiana by Basin, 1932 – 2010

MISSISSIPPI RIVER INFLUENCE

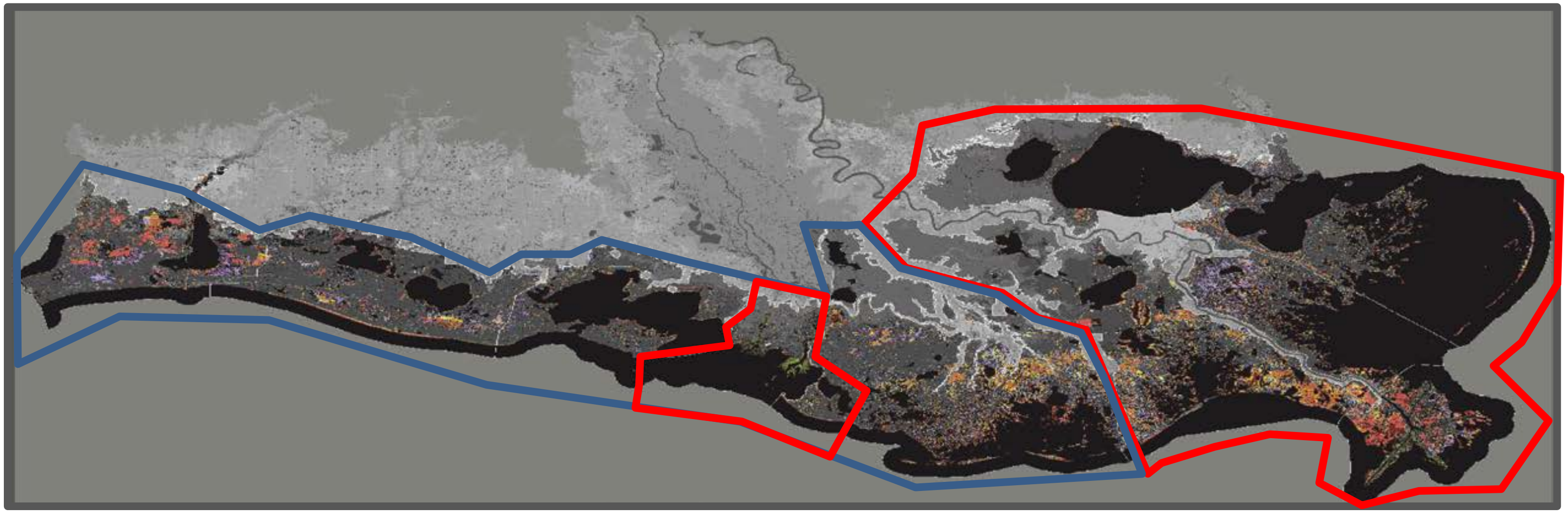
- Atchafalaya: 16 mi^2
- Barataria: - 456 mi^2
- Breton Sound: -174 mi^2
- Miss. Delta: -124 mi^2
- Pontchartrain: -194 mi^2

TOTAL: - 932 mi^2

OUTSIDE OF MISS RIVER INFLUENCE

- Calcasieu-Sabine: - 214 mi^2
- Mermentau: - 154 mi^2
- Teche-Vermillion: - 77 mi^2
- Terrebone: - 506 mi^2

TOTAL: - 951 mi^2



Couvillion, B.R., Barras, J.A., Steyer, G.D., Sleavin, W., Fischer, M., Beck, H., Trahan, N., Griffin, B., and Heckman, D. 2011. Land area change in coastal Louisiana from 1932 to 2010: U.S. Geological Survey Scientific Investigations Map 3164, scale 1:265,000, 12 p. pamphlet.

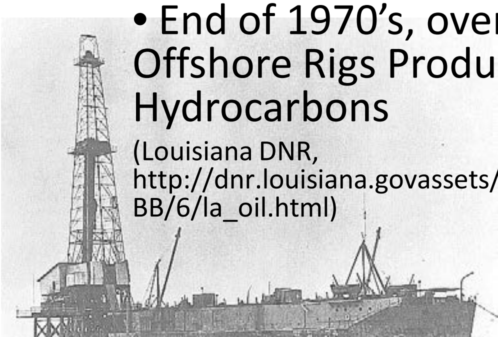
Oil and Gas Extraction

- **Impacts:**
    - 8,000 – 10,000 miles of canals
    - Salt water intrusion
    - Hydrologic alteration
    - Subsidence due to fluid withdrawal
    - Recent article puts value of oil and gas mediated losses are as high as 36%

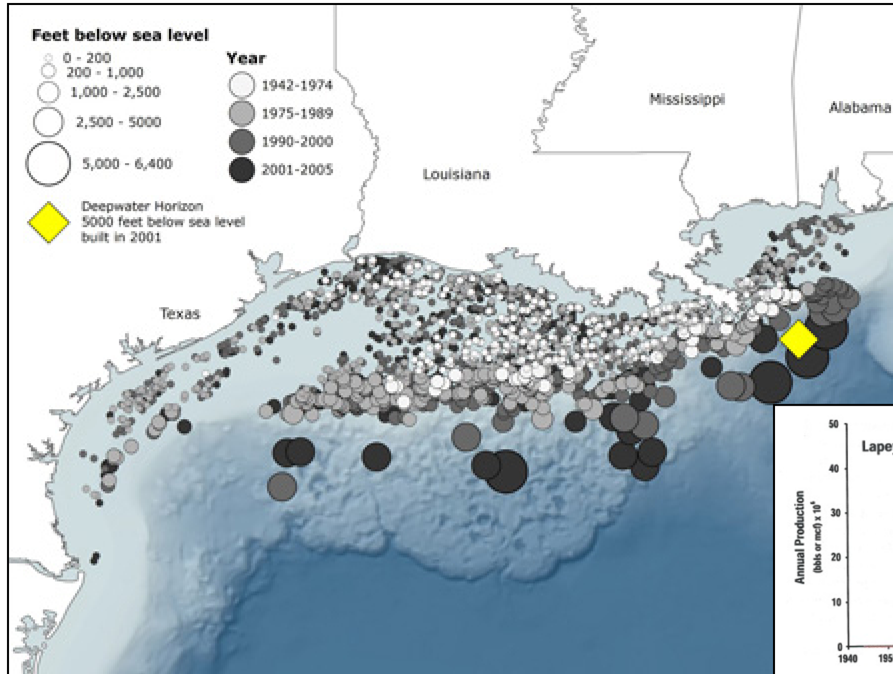
Oil and Gas Exploration:

- First Coastal Oil Well → 1901
- First Offshore Well → 1934
- By 1950's, 92 Offshore Platforms to Depths of 100 Feet
- End of 1960's, 500 Platforms to Depths up to 350 feet
- End of 1970's, over 12,500 Offshore Rigs Producing Hydrocarbons

(Louisiana DNR, http://dnr.louisiana.govassets/TAD/education/BGBB/6/la_oil.html)



1947. First bottom supported platform in 18 feet of water, 12 miles offshore.



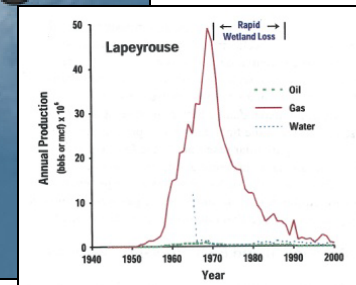
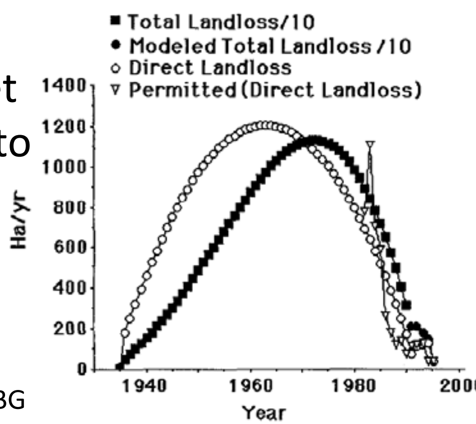


Figure 6. Annual hydrocarbon and water production from the Lapeyrouse field, Terrebonne Parish, Louisiana. Data are from the Louisiana Department of Natural Resources.

http://thes.wordpress.com/2010/06/10/gulf-of-mexico-oil-rigs/ from MI



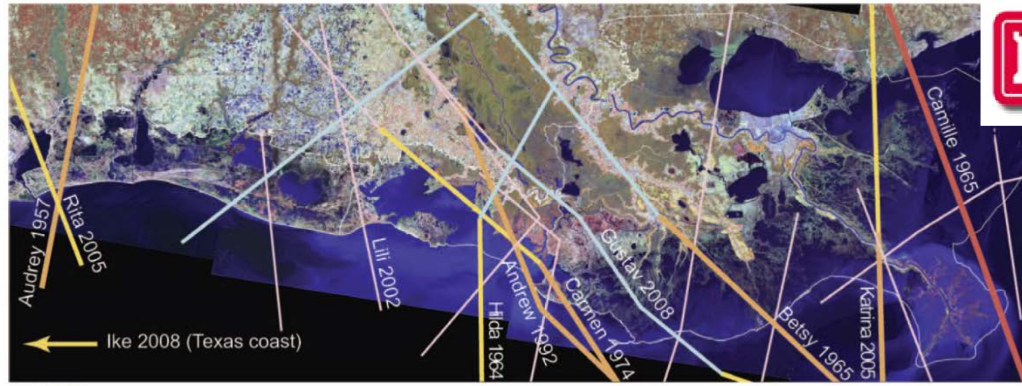
Turner, R.E. 1997. Wetland loss in the Northern Gulf of Mexico: Multiple Working Hypotheses. Estuarine Research Federation, Vol.20, No. 1, p.1-13 .

Canal construction near Golden Meadow, Louisiana.

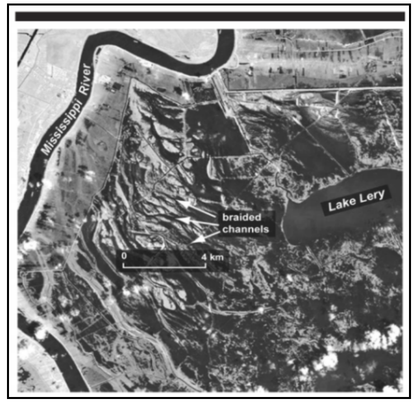
Wetland Loss Due to Hurricane Damage

- **Direct impacts of selected storms:**
  - Audrey (Max. Wind 100 mph)
    - Beach Erosion: 200-300 ft
    - Increased Water Area: Not Measured
  - Hilda (Max. Wind 134)
    - Beach Erosion: Not Measured
    - Increased Water Area: Not Measured
  - Andrew (Max. Wind 121)
    - Beach Erosion: 200-330 ft
    - Increased Water Area: Not Measured
  - Katrina (Max. Wind 125)
    - Beach Erosion: 180 ft
    - Increased Water Area: 89 mi^2
  - Rita (Max. Wind 125)
    - Beach Erosion: 130-260 ft
    - Increased Water Area: 114 mi^2
  - Gustav (Max. Wind 106)
    - Beach Erosion: 150-525 ft
    - Increased Water Area: 48 mi^2
  - Ike (Max. Wind 87)
    - Beach Erosion: 30-150 ft
    - Increased Water Area: 77 mi^2
- **Indirect impacts:**
  - Salt water intrusion
    - Impact unknown
- **Summary:**
  - **Open water area has increased by 328 mi^2 just from the four measured storms that have occurred since 2005**
  - USGS estimates that 25% to 35% of wetland loss since the 1940's is due to direct and indirect storm-induced losses.

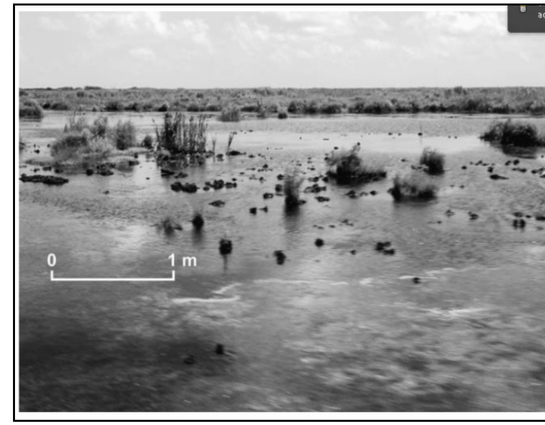
Morton, R.A. and J.A. Barras. 2011. Hurricane Impacts on Coastal Wetlands: A Half-Century Record of Storm-Generated Features from Southern Louisiana. Journal of Coastal Research, Vol. 27, pp 27-43.



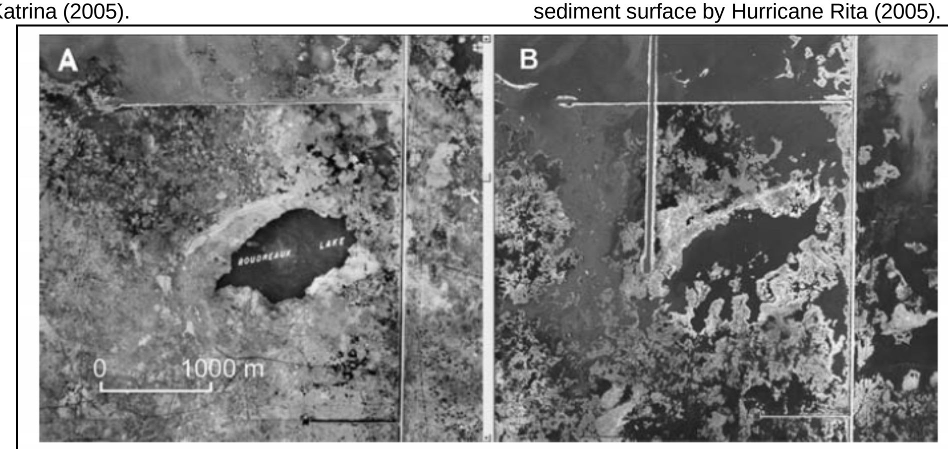
Hurricane tracks that modified the southern Louisiana coastal wetlands between 1957 and 2008. Source: NOAA 2010 .



Breton Sound damage after Hurricane Katrina (2005).



Remnants of march vegetation stripped to the sediment surface by Hurricane Rita (2005).



Boudreaux Lake (A) Before and (B) After Hurricane Audrey 1957.

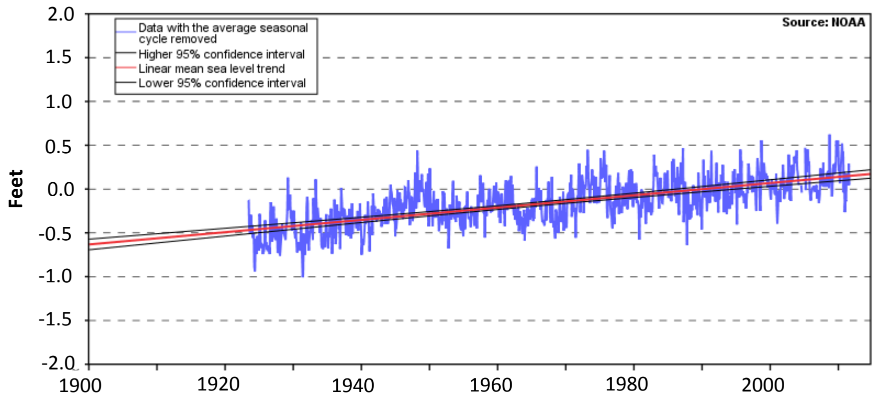
Sea-Level Rise

global rise = 0.07 inches/year

Relative Sea-Level Rise

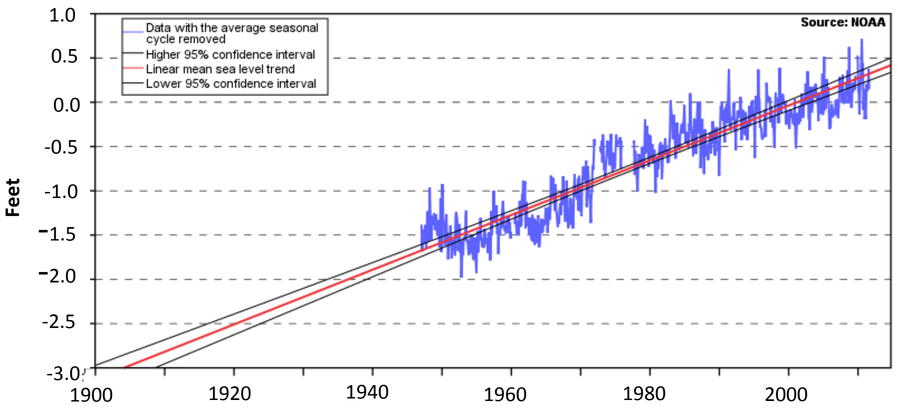
global rise + local sinking

Pensacola, FL (0.08 inches/year)



Mean sea level trend is 0.08 ± 0.01 inches/year or 0.69 feet in 100 years.

Grand Isle, LA (0.4 inches/year)

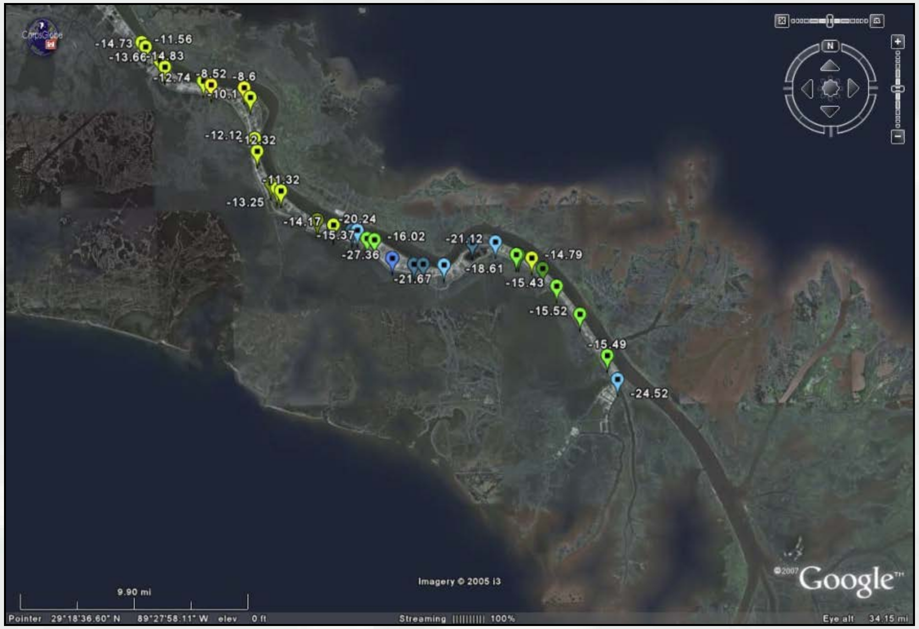


The mean sea level trend is 0.4 inches/year or 3.0 feet in 100 years.

High subsidence rate + sea-level rise makes wetlands more vulnerable to submergence and erosion.

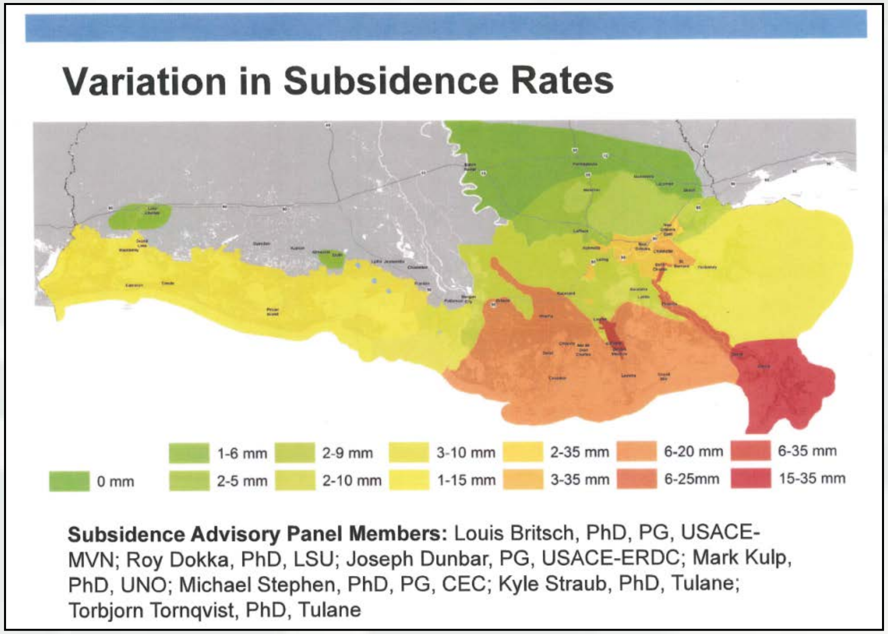
NOTE: Grand Isle is an official NOAA gage with records back to the 1950's. Other gages in the Mississippi River Delta show much higher rates of RSLR, up to 1.0 inches per year.

Additional Estimates of Subsidence Rates



Shinkle & Dokka (2004). NOAA Technical Report – 50
Rates over 24mm (1 inch) per year.

LA State Master Plan, 2012.
Maximum rates in the Bird's Foot between 15-35 mm per year.

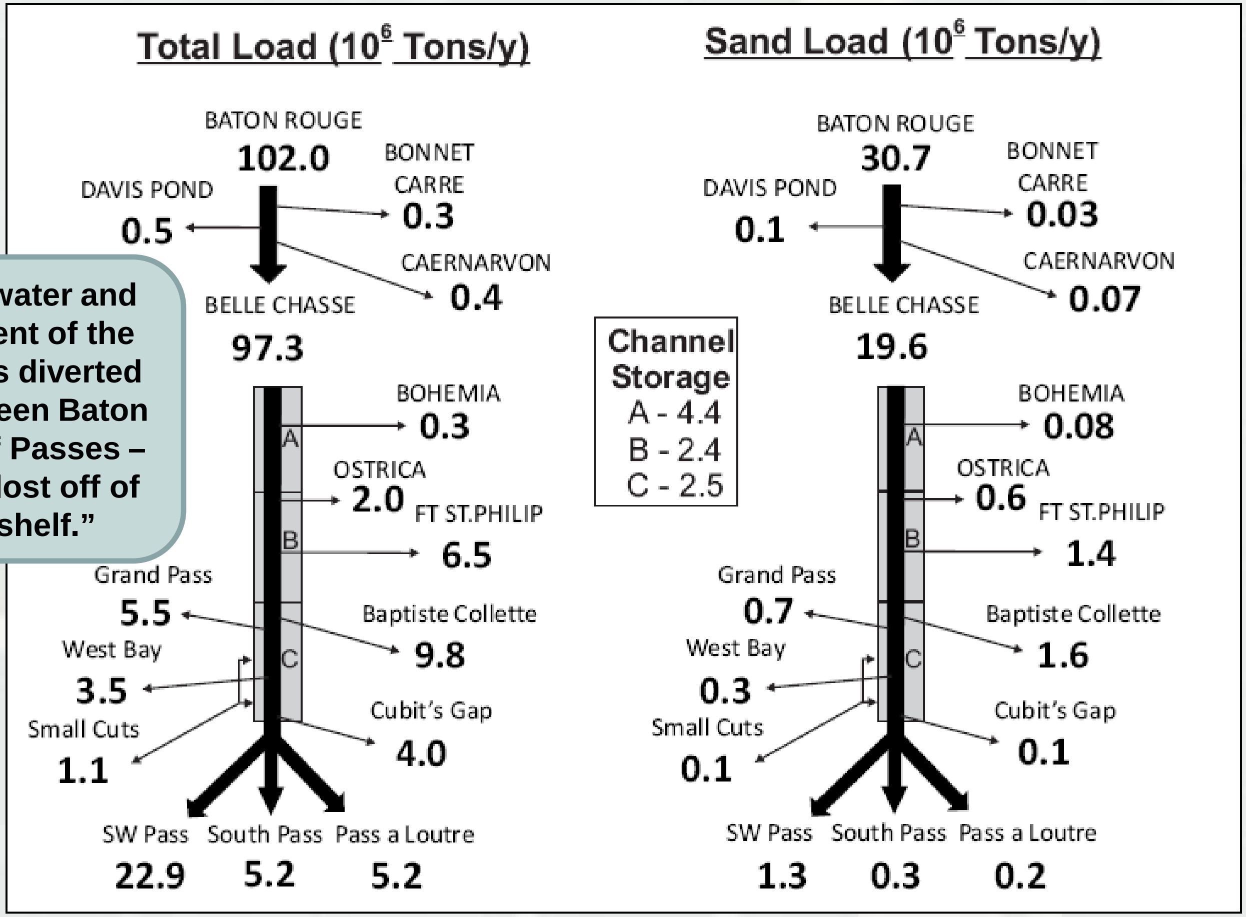


How Well Will Sediment Diversions Work?

(What Have We Learned in the Last Few Years?)

Water and Sediment Budgets

About 50% of the water and suspended sediment of the Mississippi River is diverted from the river between Baton Rouge and Head of Passes – it is not all being “lost off of the continental shelf.”



Allison, et. al. 2012. A water and sediment budget for the lower Mississippi-Atchafalaya River in flood years 2008-2010: J. of Hydrology.

Reach Assessment 1970s to 2000s

Little, C. and Biedenharn, D. 2014. Mississippi River Hydrodynamic and Delta Management Study – Geomorphic Assessment. In press.

Sustainability of Diversions

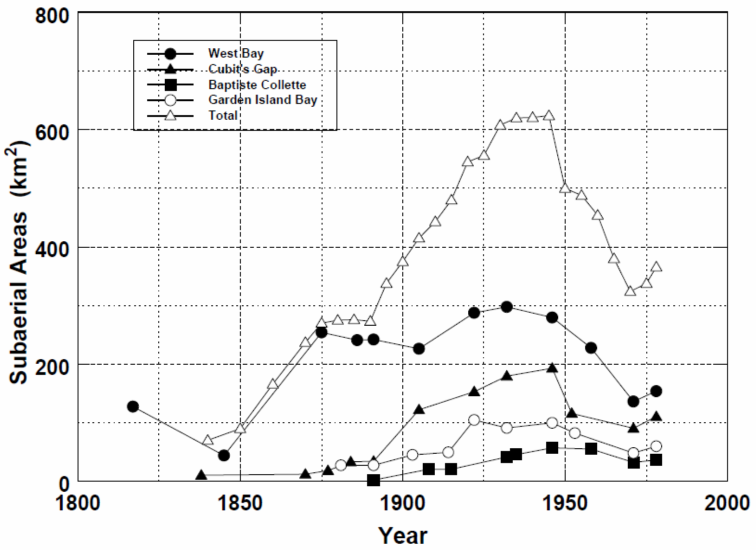
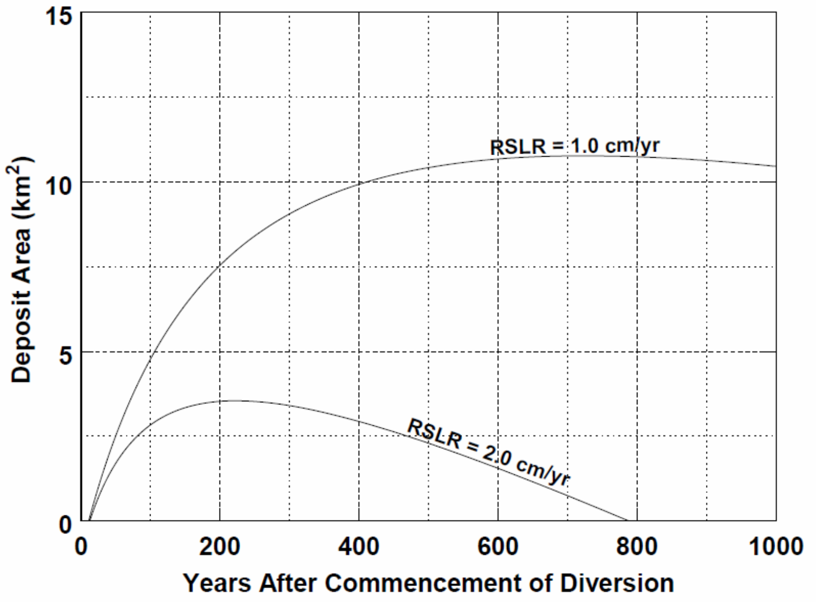


Figure 2. Life cycle of subdeltas of the Mississippi River Delta (from Wells and Coleman, 1987).

Dean, R. G., J.T. Wells, J. Fernando, P. Goodwin. 2012. River Diversions: Principles, Processes, Challenges and Opportunities A Guidance Document. LCA S&T Program.

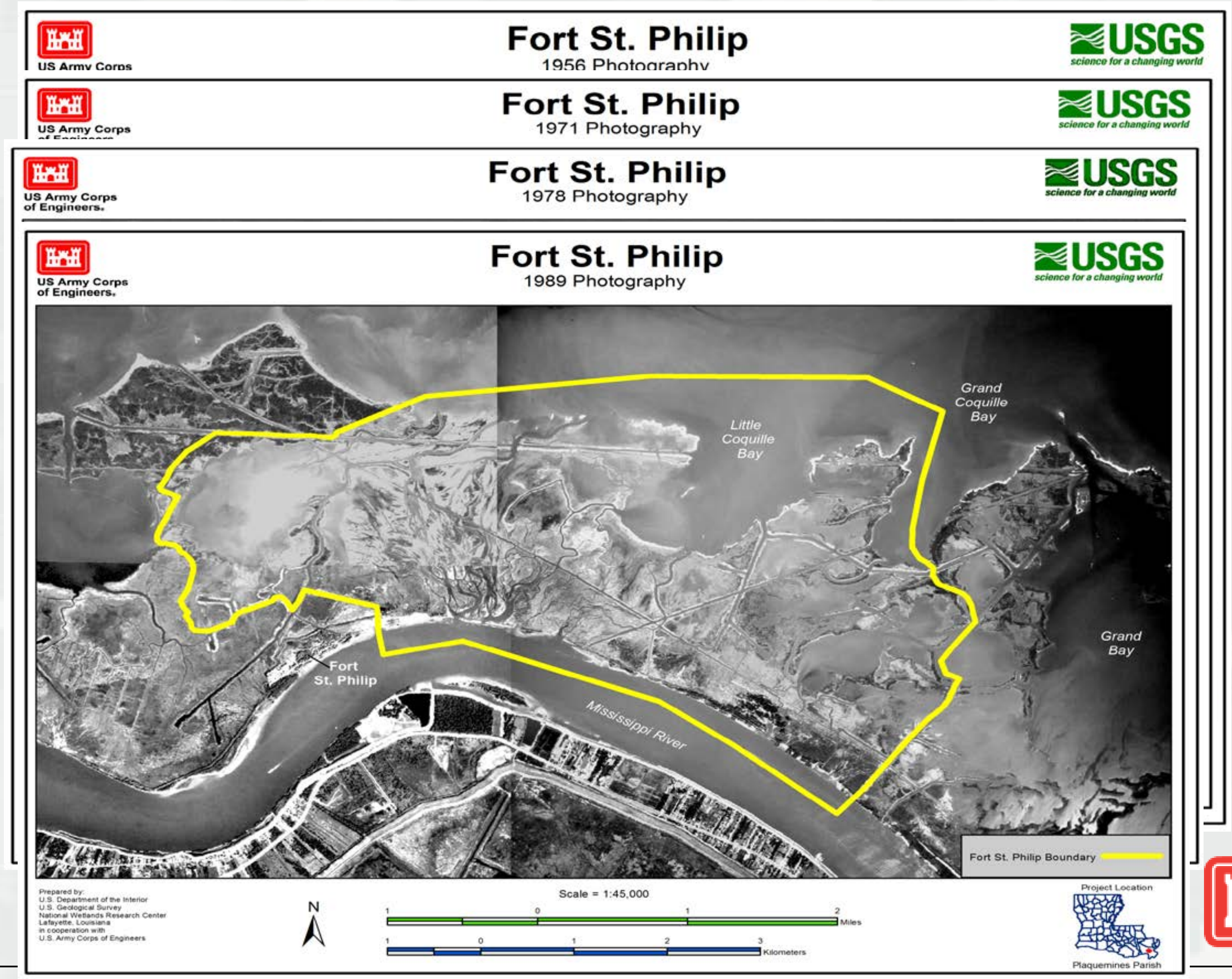


Atchafalaya Basin Land Building

Wax Lake Outlet has built about 1 km^2 per (250 acres) year between 1983-2010, utilizing about 10% of the flow of the MS River. The overall land loss in Coastal Louisiana is about 10,600 acres per year over the same time period.

Allen, et al., 2011. Using Multitemporal Remote Sensing Imagery and Inundation Measures to Improve Land Change Estimates in Coastal Wetlands. Estuaries and Coasts. DOI 10.1007/s12237-011-9437-z

Fort St. Philips



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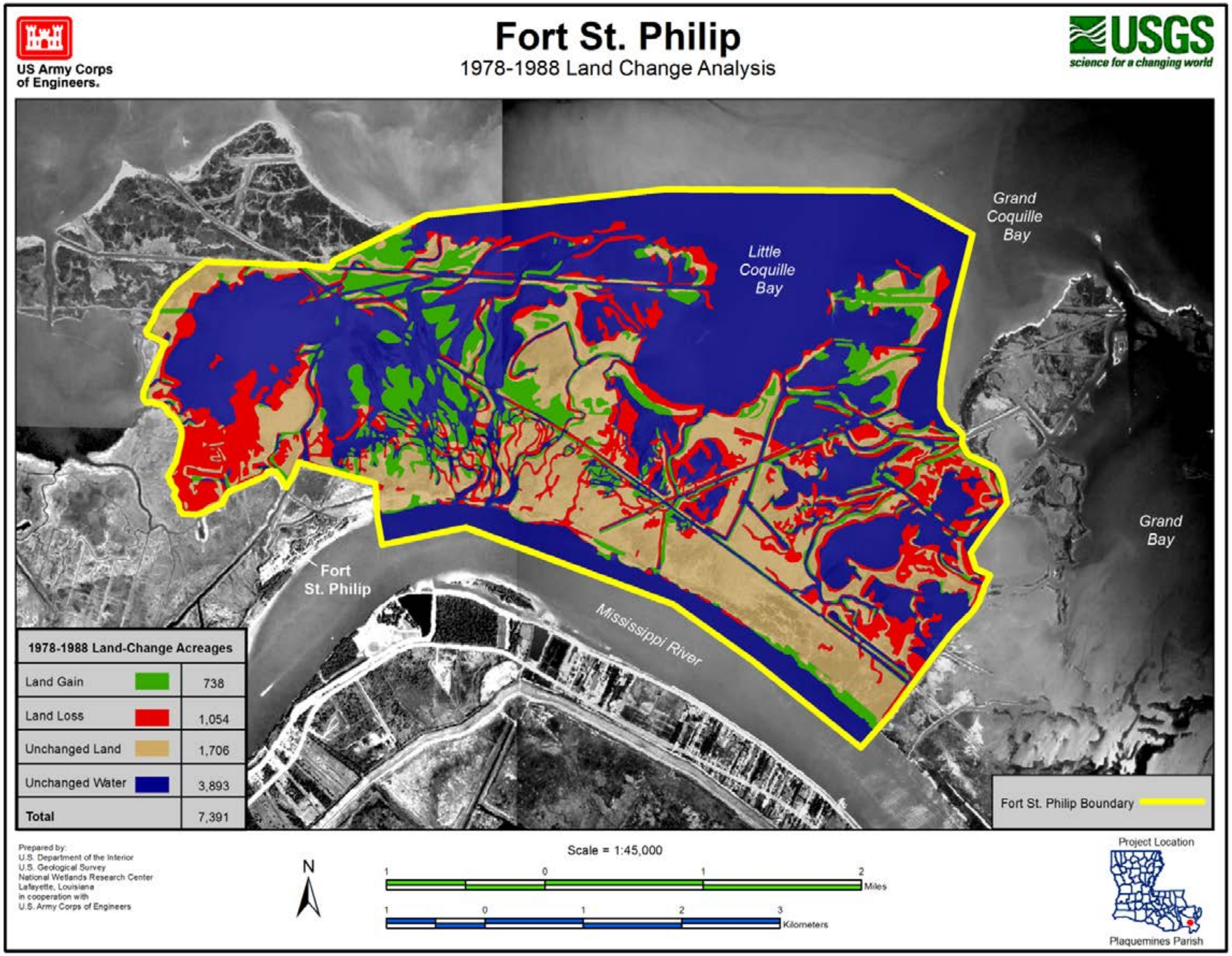
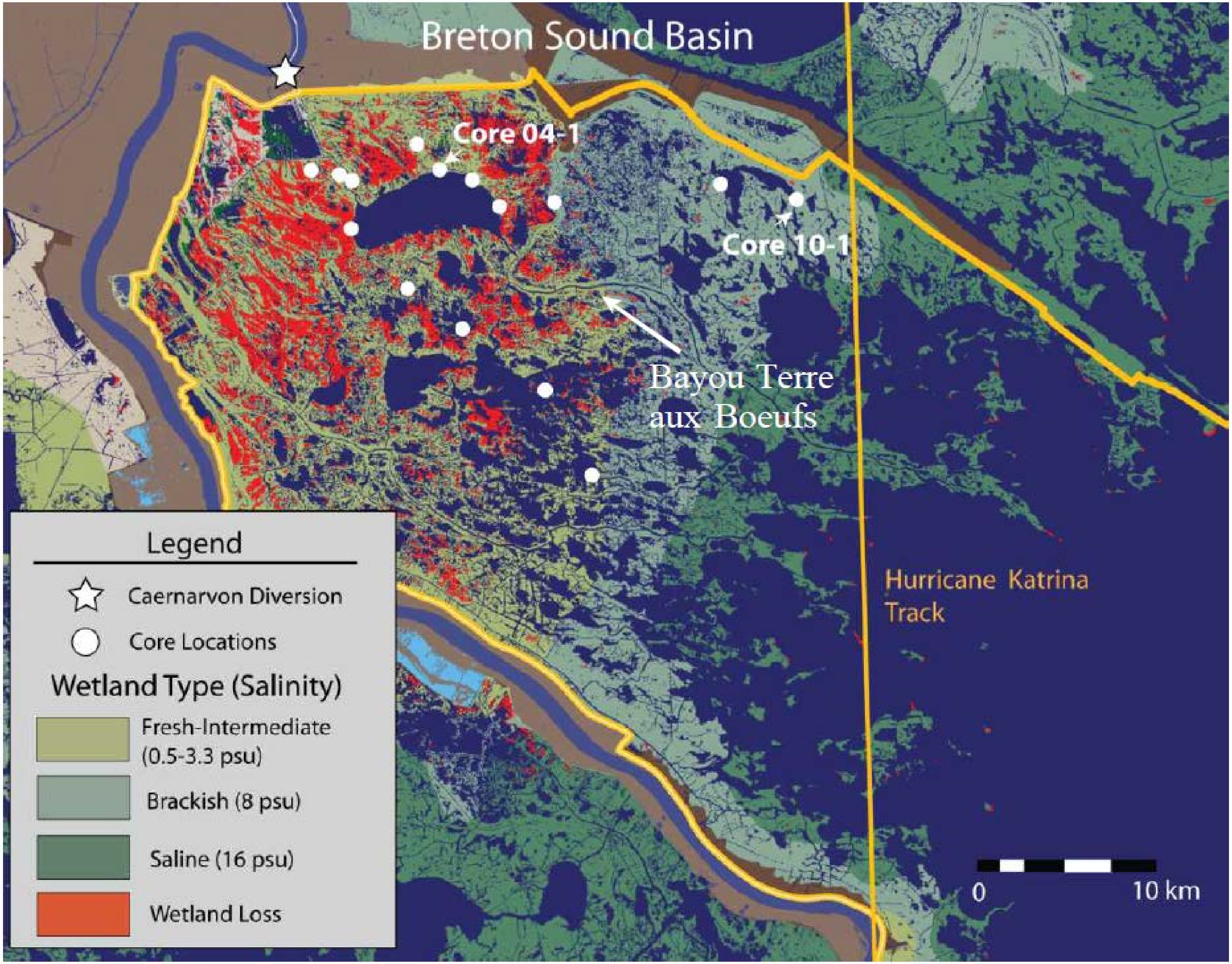

US Army Corps of Engineers.
Fort St. Philip
1978-1988 Land Change Analysis
USGS
science for a changing world
Little Coquille Bay
Grand Coquille Bay
Grand Bay
Fort St. Philip
Mississippi River
1978-1988 Land-Change Acreages
Land Gain 738
Land Loss 1,054
Unchanged Land 1,706
Unchanged Water 3,893
Total 7,391
Fort St. Philip Boundary
Prepared by:
U.S. Department of the Interior
U.S. Geological Survey
National Wetlands Research Center
Lafayette, Louisiana
in cooperation with
U.S. Army Corps of Engineers
N
Scale = 1:45,000
1 0 1 2 Miles
1 0 1 2 3 Kilometers
Project Location
Plaquemines Parish

Table 3. Summary of Fort St. Philip study area acreages, and percentages of area change, for select time periods - from high resolution analyses. The color-ramp illustrates the type and magnitude of land change – the darkest red represents loss maxima and darkest green represent gain maxima.

Period of Analysis	Years	Land Area (initial)	Land Area (ending)	Area Change	Area Change†	Area Change‡
		acres			percentage	
1956 to 1971	15	5,012	4,377	-635	-13%	-13%
1971 to 1978	7	4,377	2,760	-1,617	-37%	-32%
1978 to 1988	10	2,760	2,444	-316	-11%	-6%
1988 to 1998	10	2,444	1,780	-664	-27%	-13%
1998 to 2008	10	1,780	2,102	322	18%	6%
1956 to 2008	52	5,012	2,102	-2,910	-58%	-58%

† Land change percentage is based on initial land area of the period analysis. ‡ Land change percentage is based on the 1956 land area.

Suir , G. and Jones, W., Garber, A. and Barras. J. 2014. Pictorial Account and Landscape Evolution of the Crevasses near Fort Saint Philip, Louisiana. In press. MS River Geomorphology and Potamology Program.



The fresh and brackish portions of the estuary experienced more than 25.7% failure versus 2-4% in the more saline regions. (Kulp, et.al., 2009.)

MISSISSIPPI RIVER FRESHWATER DIVERSIONS IN SOUTHERN LOUISIANA:
EFFECTS ON WETLAND VEGETATION, SOILS, AND ELEVATION

A Position Paper by the Technical Panel from the

Workshop on Response of Louisiana Marsh Soils and Vegetation to Diversions

Coastal marsh near Leeville, Louisiana. Photo Credit: Dennis Demcheck (USGS)

Final Report to the

State of Louisiana and
U.S. Army Corps of Engineers through the
Louisiana Coastal Area Science and Technology Program

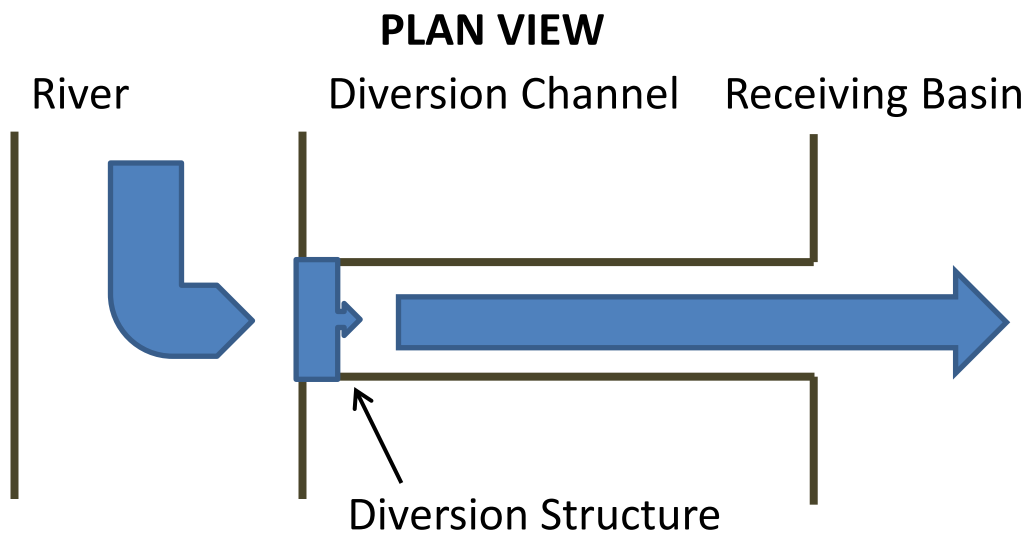
Coordinated by the
National Oceanographic and Atmospheric Administration

December 5, 2012

"A general conclusion on the expected short-term and long-term responses of marsh belowground production to Freshwater Diversions in Louisiana could not be drawn from the available evidence."

"With regard to Freshwater Diversions, data are particularly needed on how changes in water chemistry or plant community composition may influence plant production-decomposition processes and resultant effects on soil volume and elevation change."

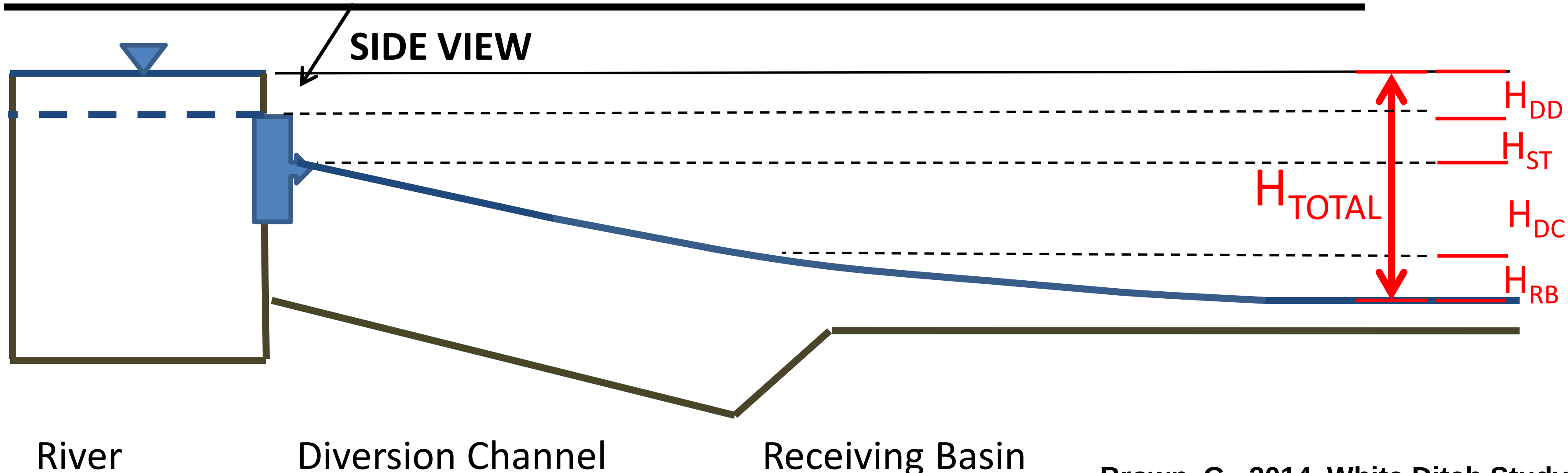
Energy Budget of a Sediment Diversion



The Energy Budget:

$H_{TOTAL} = H_{DD} + H_{ST} + H_{DC} + H_{OF}$

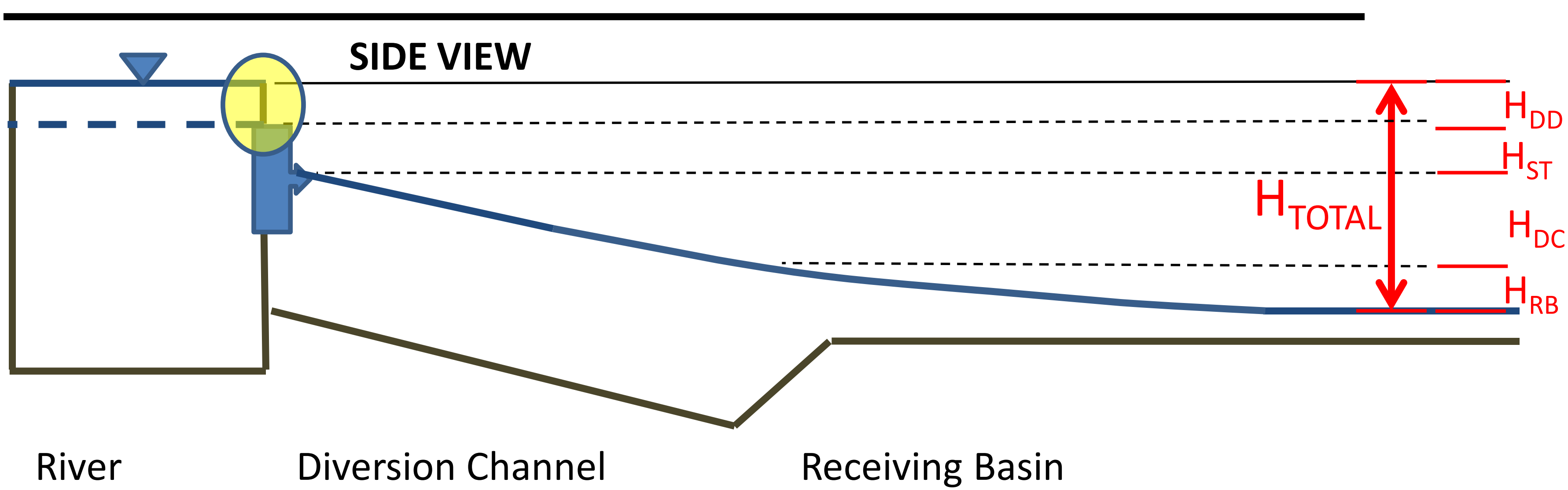
- H_{TOTAL} = The total potential energy available to transport water and sediment
- H_{DD} = The loss of potential energy in the river due to the drawdown caused by the reduction in river flow
- H_{ST} = The kinetic energy loss across the diversion structure
- H_{DC} = The kinetic energy loss due to friction in the diversion channel
- H_{RB} = the kinetic energy loss due to friction (backwater effects) in the receiving basin



Brown, G. 2014. White Ditch Study. Engineering Research and Development Center.

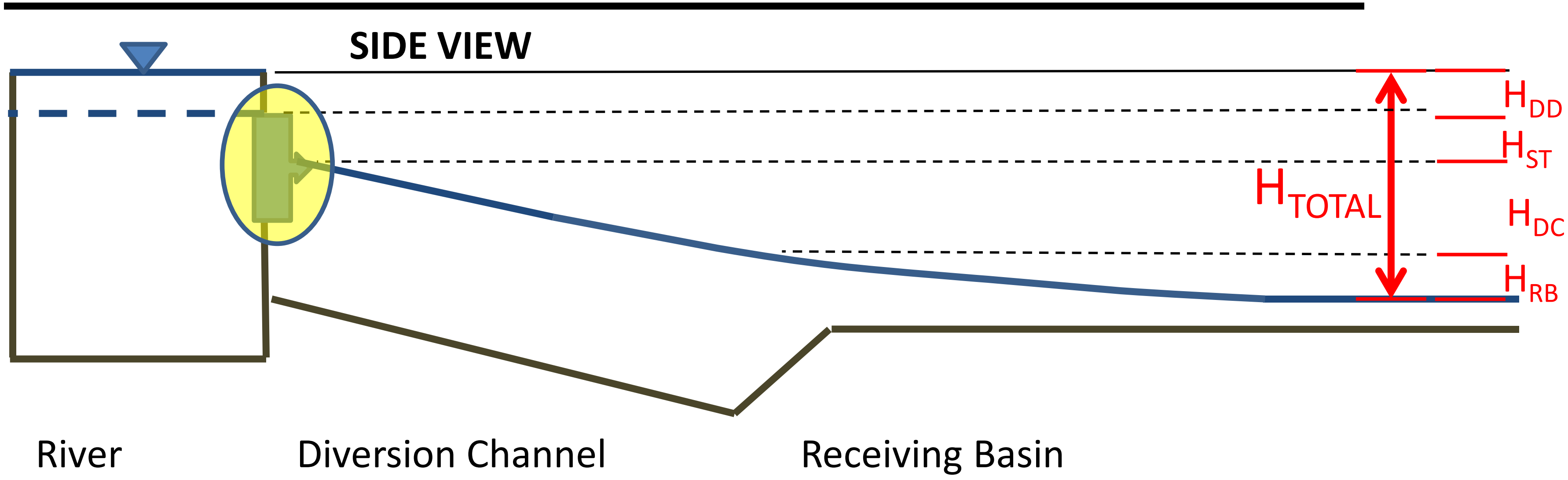
Drawdown Induced by Flow Reduction

- When a diversion is open, the river flow downstream of the diversion is reduced by the amount of flow diverted.
- This produces a corresponding reduction in river stage (which may be estimated from a rating curve at a downstream gage).
- The stage reduction propagates upstream
  (and may be computed using standard methods for determining the shape of the backwater curve)
- The larger the diversion, the greater the reduction in river stage associated with the diversion.



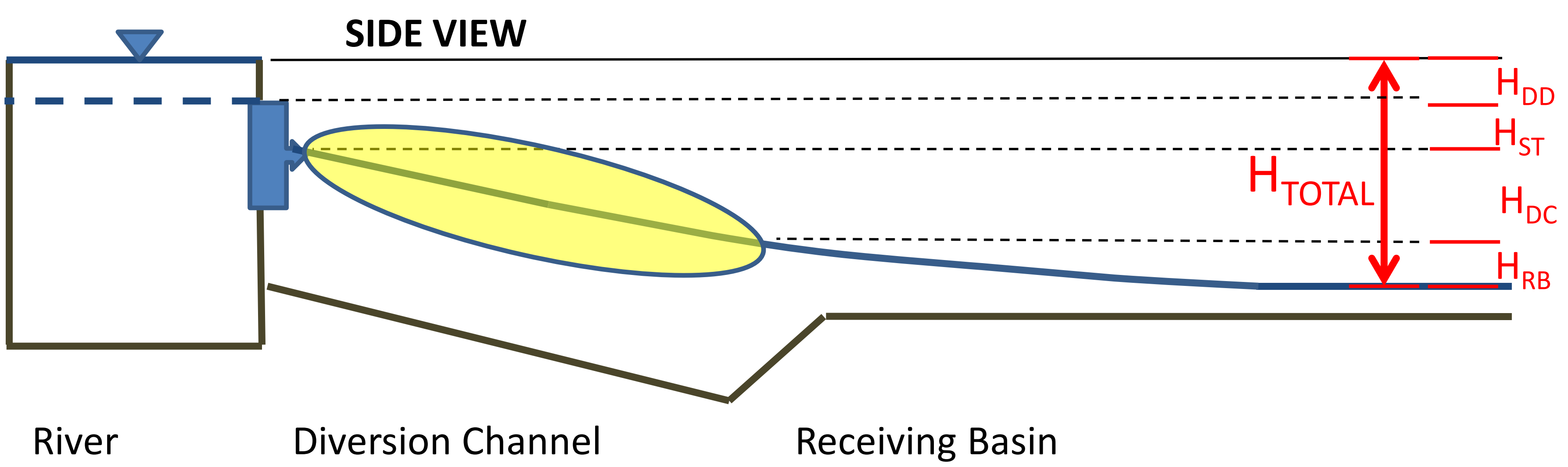
Energy Loss at the Diversion Structure

- Energy losses at the diversion structure are typically associated with drag, flow separation ,flow contraction, and flow expansion as water passes through the structure
- These losses can be minimized with design specifications that limit their magnitude and number.



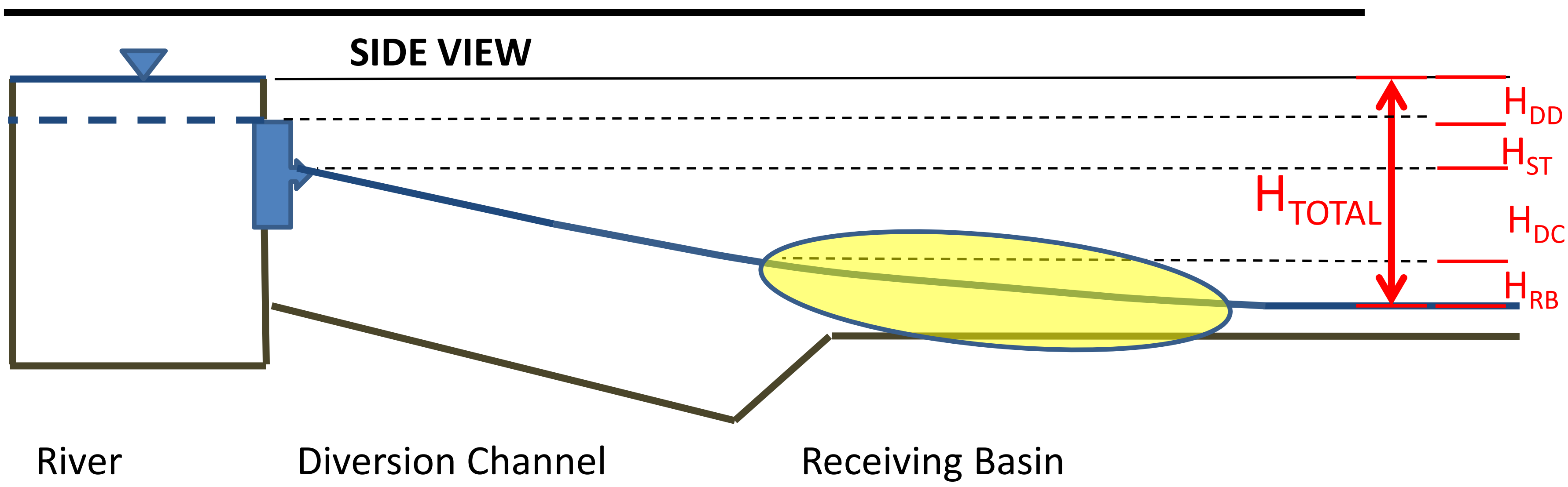
Energy Loss in the Diversion Channel

- The diversion channel must be designed with sufficient "stream power" (essentially, velocity) to transport the diverted sand.
- Therefore, diversions with higher concentrations of sand require a higher velocity diversion channel than do diversions with lower concentrations of sand.
- This results in more energy loss, or a "steeper" water surface slope in the channel.
- This results in a **constraint**.
- *For a given total available head (H_{TOTAL}), a diversion carrying a higher sand concentration must be **steeper** and **shorter** than a diversion carrying a lower sand concentration. Hence, a diversion with a higher sand concentration cannot transport sediment as far as a diversion with a lower sand concentration.*



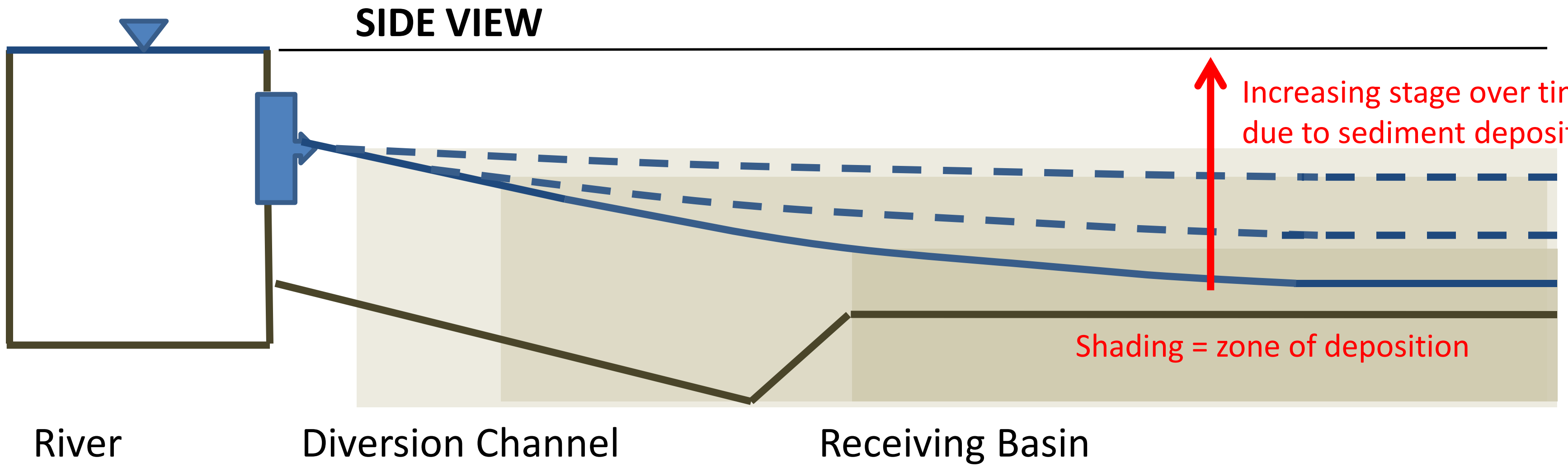
Energy Loss in the Channel Receiving Basin

- As water exits the diversion, it forms a jet of water into the receiving basin.
- If the receiving basin is relatively shallow , this exiting water tends to pile up, forming a "dome" of water with a maximum elevation at the channel outfall.
- This "backwater" effect is more pronounced for larger discharges than it is for smaller discharges.
- This results in a **constraint**
- *For a given total available head (H_{TOTAL}), a diversion carrying a larger discharge will result in a larger backwater effect in the receiving basin than a diversion carrying a smaller discharge. This means that there is **less** head available for use in transporting the sediment load for a diversion carrying a larger discharge than there is for a diversion carrying a smaller discharge.*

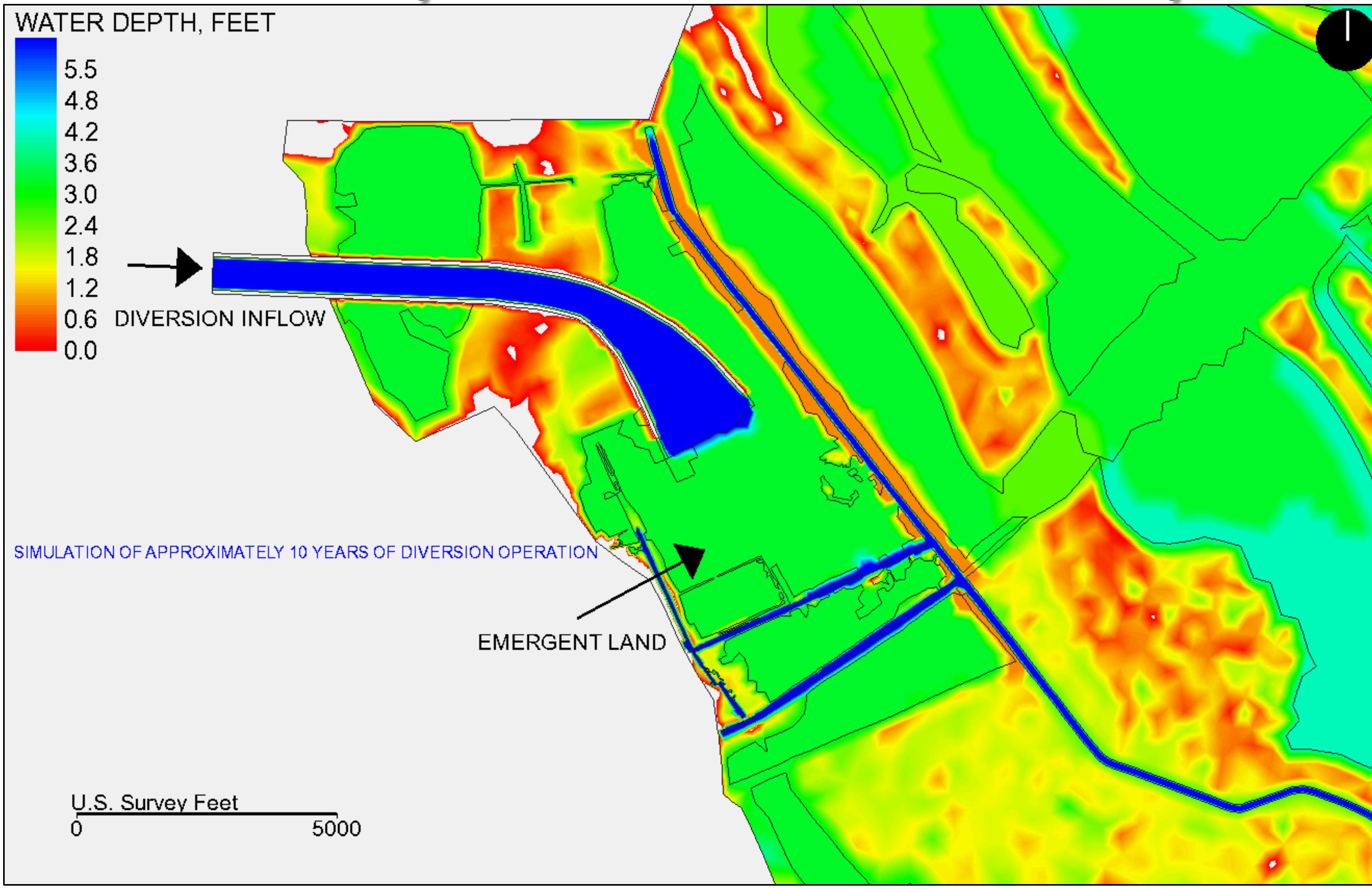


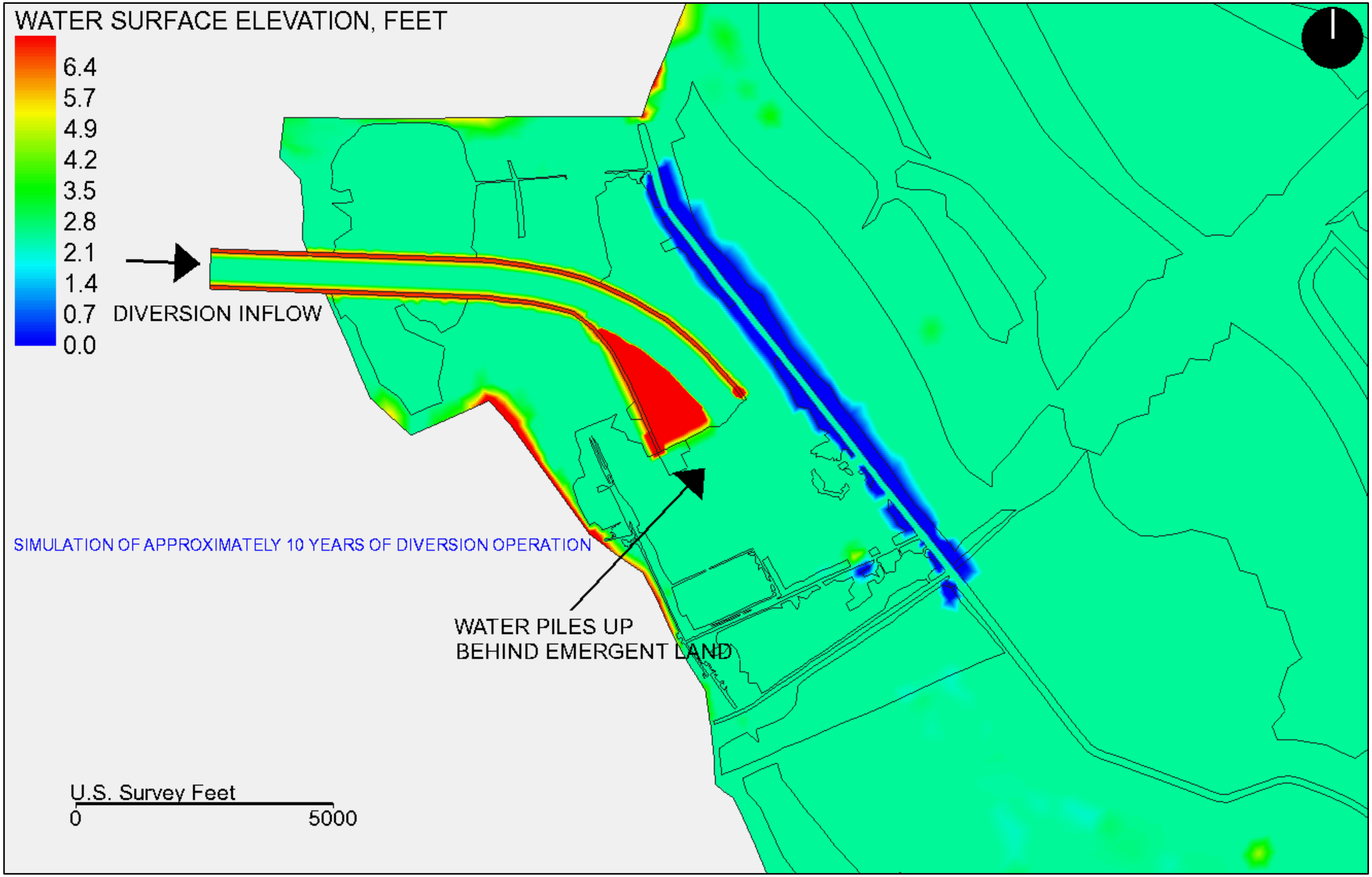
Summary of Energy Budget Constraints on Diversion Design

- The application of basic hydraulic and geomorphic principles to a sediment diversion has shown that, for a given total available head, the greater the sand load one diverts, the shorter the distance one can transport it.
- As time progresses, deposition in the diversion outfall will become emergent land and begin to obstruct flow. This will induce an increase in the water surface elevation at the downstream end, and an upstream extension of the of the zone of deposition.
- When the water surface elevation increases to the point where the diversion can no longer pass the design flow, the diversion can no longer be operated at full capacity.
- If the diversion channel is too short to be truncated or redirected, and if there is no mechanical redistribution of the deposited sediment, then the life-cycle of the diversion is effectively complete.
- Hence, this results in the following general statement of the consequences of the energy constraint on sediment diversion design:
- *In the absence of any mechanical redistribution of the deposited sediment, the greater the sand load diverted, the shorter the life-span of the diversion.*
- Note that this conclusion is essentially **qualitative** and **simplified**. To determine whether or not this principle has a measureable and quantifiable impact on any specific diversion, it is necessary to do a more sophisticated analysis, including modeling.
- Preliminary attempts at this type of analysis have indicated that the energy budget ***is*** likely to be a significant and measureable constraint on diversion design.



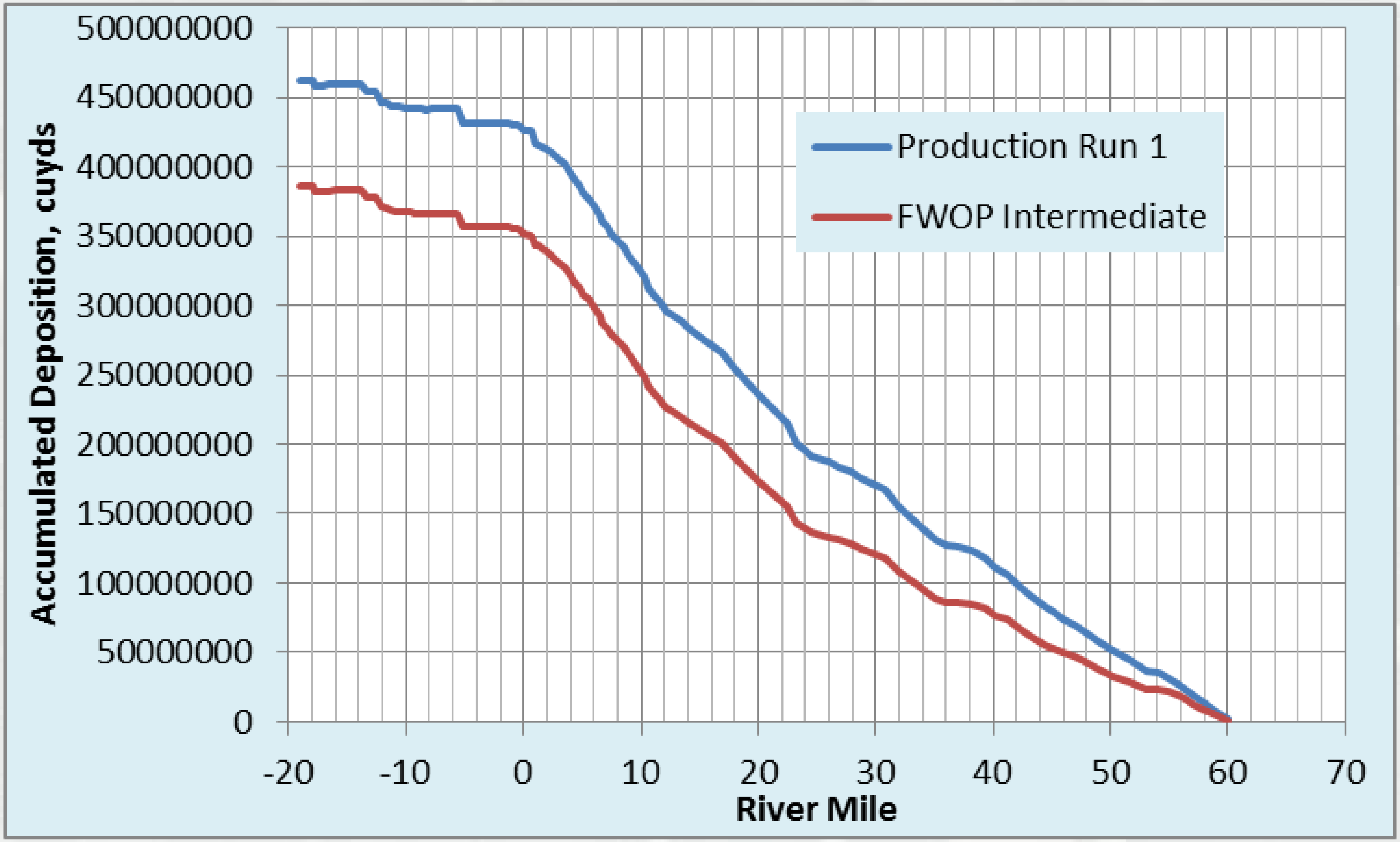
Preliminary Outfall Channel Analysis




WATER SURFACE ELEVATION, FEET
6.4
5.7
4.9
4.2
3.5
2.8
2.1
1.4
0.7
0.0
DIVERSION INFLOW
SIMULATION OF APPROXIMATELY 10 YEARS OF DIVERSION OPERATION
WATER PILES UP
BEHIND EMERGENT LAND
U.S. Survey Feet
0
5000

Can We Quantify and Mitigate for the Unintended Consequences of Diversions?

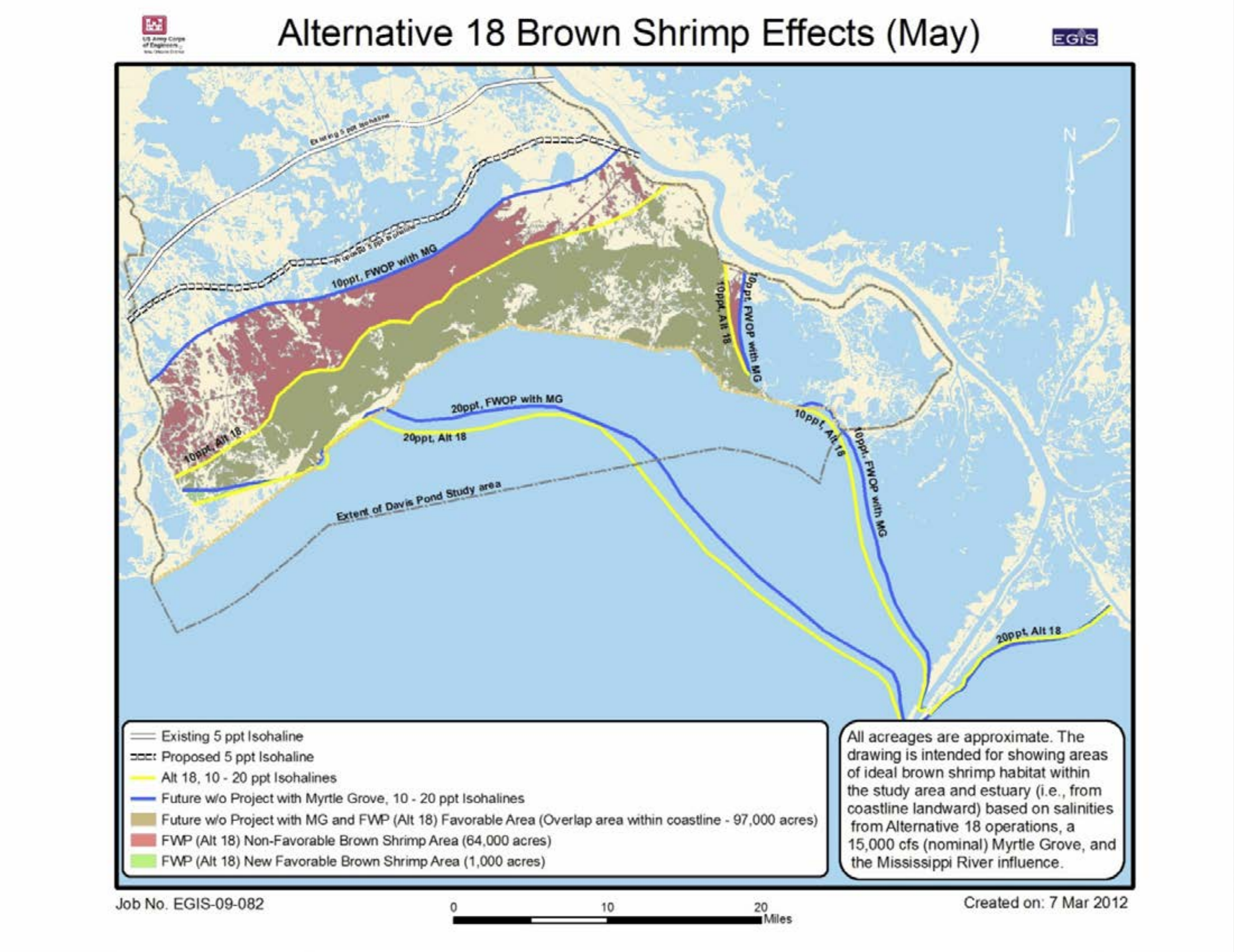
ACCCUMULATED DEPOSITION 2020 - 2079



DRAFT

Thomas, M. T.and Trawle, M. 2014. One-Dimensional Modeling of the lower Mississippi River. In press.

Alternative 18 allows for the "free flow" of Davis Pond, subject to river head, and assumes a 15,000 cfs diversion at Myrtle Grove



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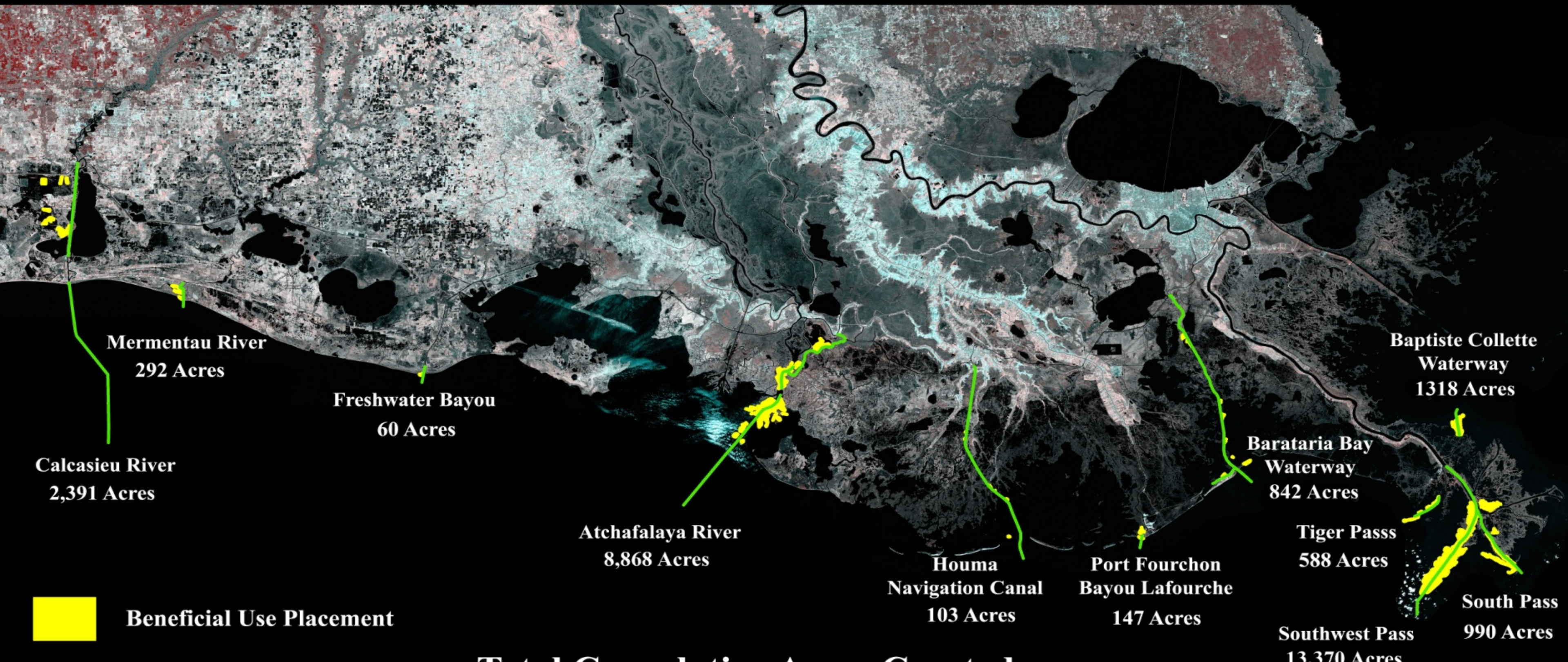
Should a Full Array of Alternatives be Applied?

Louisiana Coast
Beneficial Use Placement



Beneficial Use Placement

Federal Authorized Navigation Channels

Total Cumulative Acres Created:
28,969 Acres

MVN Beneficial Use of Dredged Material

Average Annual Totals

Maintenance Dredging	=	67,663,000 CY
Fluff	=	16,000,000 CY
Unavailable	=	18,000,000 CY
Suitable & Available for BU	=	33,663,000 CY
BENEFICIAL USE	=	16,442,000 CY

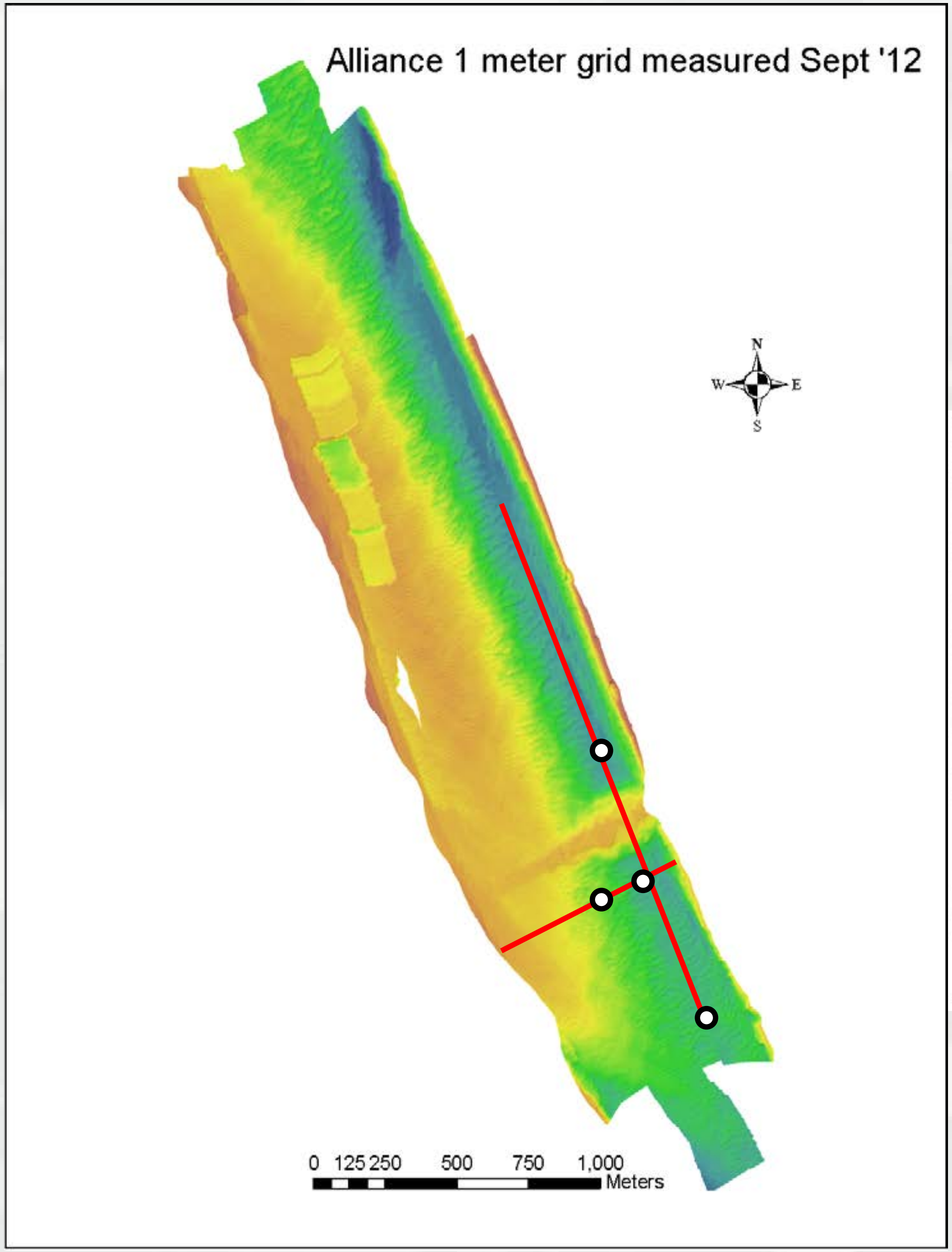
~22,026 acres wetlands
~3,943 acres other habitats
~3,000 acres uplands (Southwest/SouthPass)

1976-2011 ~28,969 acres of created land
(~45 square miles of land)

Myrtle Grove Vicinity

August 23, 2012
ADCP
175,000 cfs

- CTD/turbidity/LISST casts



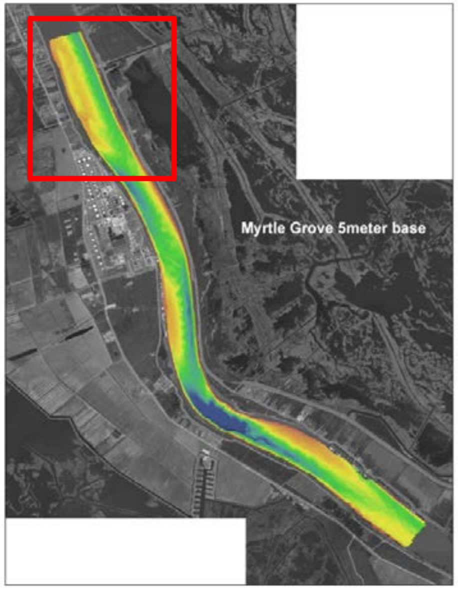
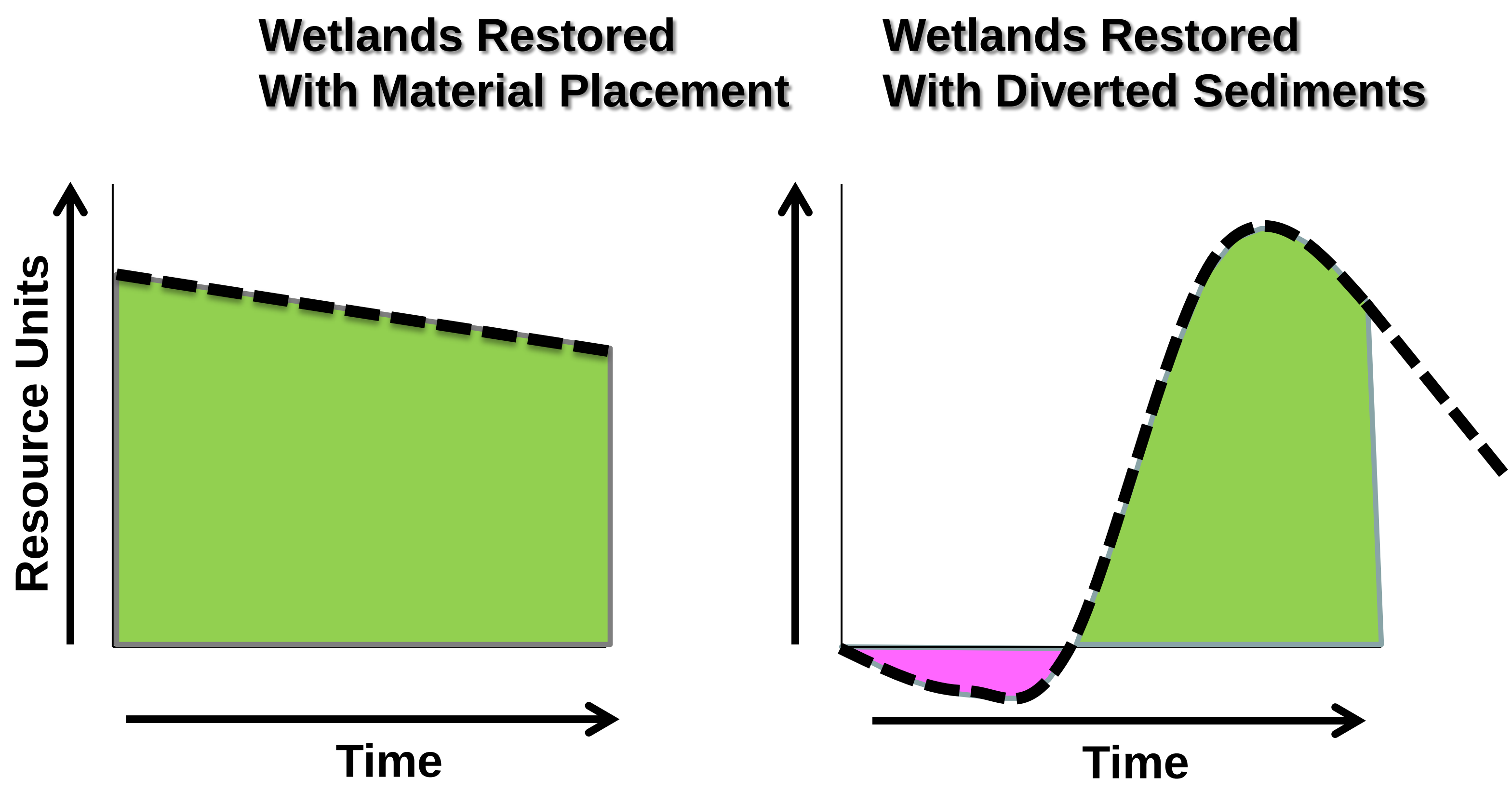


Figure from Mead Allison, 2013


Wetlands Restored
With Material Placement
Wetlands Restored
With Diverted Sediments
Resource Units
Time
Time

Summary: LMR Diversion Principles

- Consider All Coastal Loss Mechanisms
- Balance Competing Uses of the River and River Resources
- Apply Sound Science
- Reasonable Use of River Resources
- Evaluate State's Diversion Portfolio as a System
- Utilize Controlled Diversions
- Employ Diversion Adaptive Management
- Consider Mississippi River Commission Recommendations