



U.S. ARMY

Engineering With Nature for Sustainable River Systems

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RNRF Congress
December 3, 2019



US Army Corps of Engineers



ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

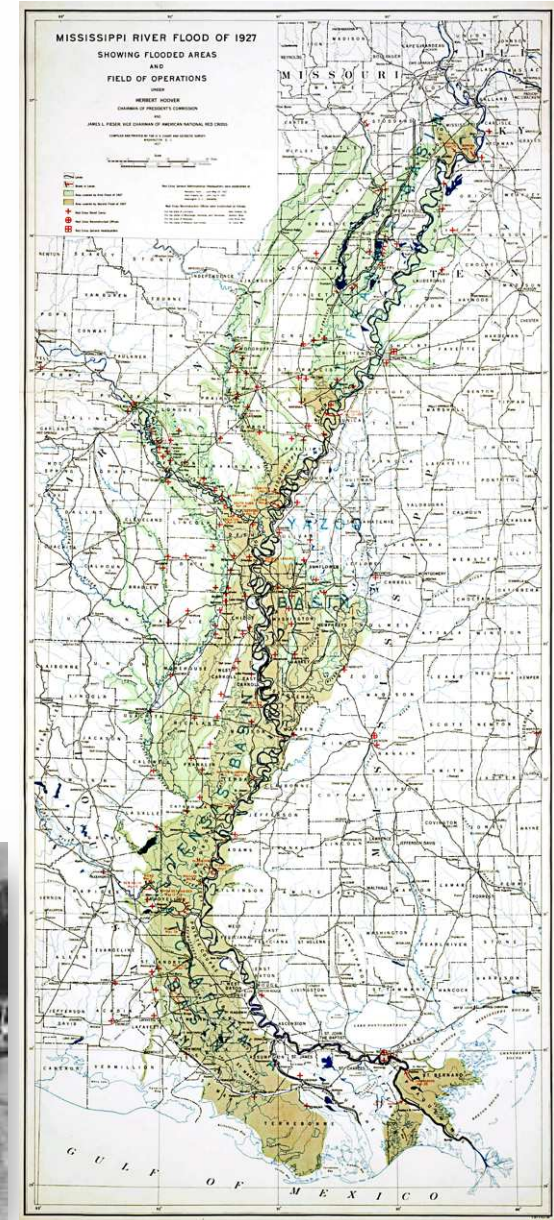




MISSISSIPPI RIVER FLOOD OF 1927

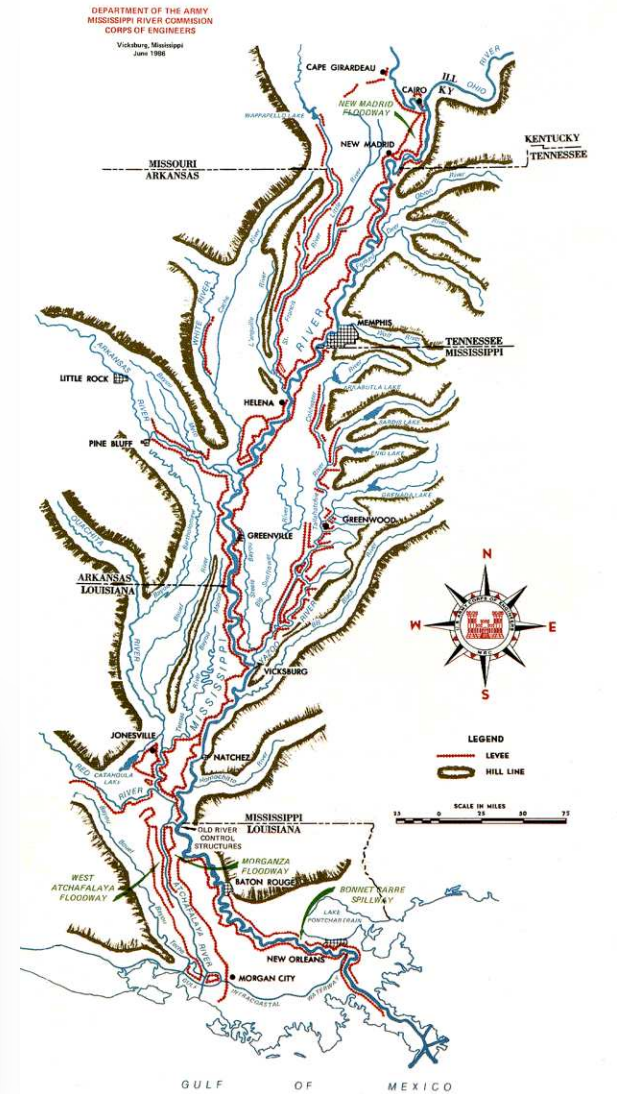
- Most destructive river flood in US history
- River was 60 miles wide south of Memphis
- 27,000 sq. miles inundated
- 500 - several thousand deaths
- Drove 1M people from their homes
 - 700,000 people homeless
- \$1B in flood damages (1/3 of the federal budget in 1927)

Courtesy of Bea Nell



MISSISSIPPI RIVER & TRIBUTARIES

- >3,700 miles of levee system (embankments and floodwalls)
- 1,000 miles of articulated concrete mattress revetment
- Floodways:
 - Birds Point - New Madrid (Cairo, IL)
 - Morganza
 - West Atchafalaya
 - Atchafalaya Basin
 - Bonnet Carré
- 4 Back Water Areas (St Francis, White, Yazoo, Red Rivers)
- Old River Control Complex



INLAND NAVIGATION

- 122 lock sites (158 chambers)
- 1,933 cargo-handling docks
- 550 million tons/yr of cargo
 - 97 million tons of agricultural products
 - >\$50B (92% of US farm exports), 60% of grain shipments
- 1/6th of all goods moved between US cities travel on the inland and intracoastal system

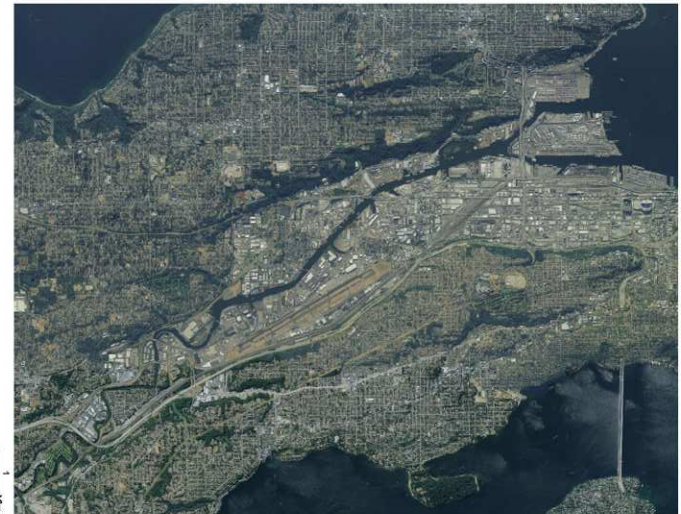
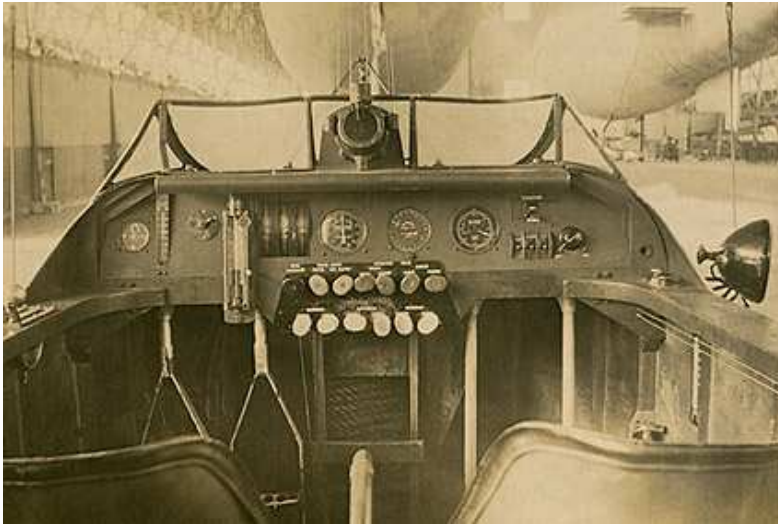


THE ECOSYSTEM

- 1,151,000 square miles of watershed
- Physical processes: hydrology, sediment transport, nutrients, etc.
- Habitats
- Species
 - >250 species of fish (25% of species in NA)
 - 60% of all NA birds use the basin on their migratory flyway
- Ecosystem Services

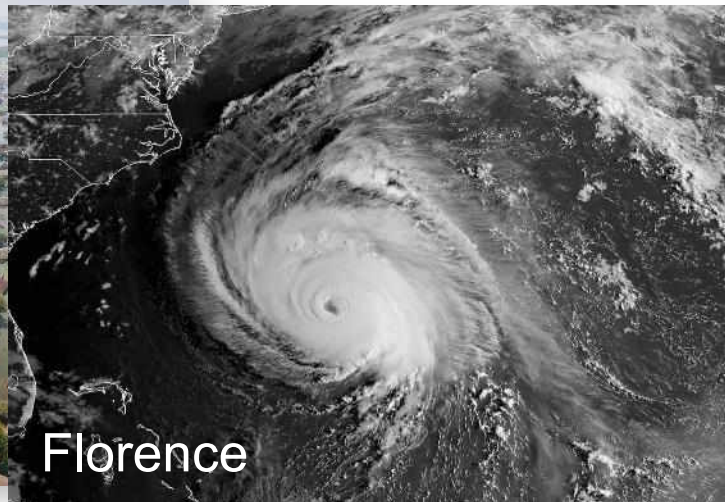
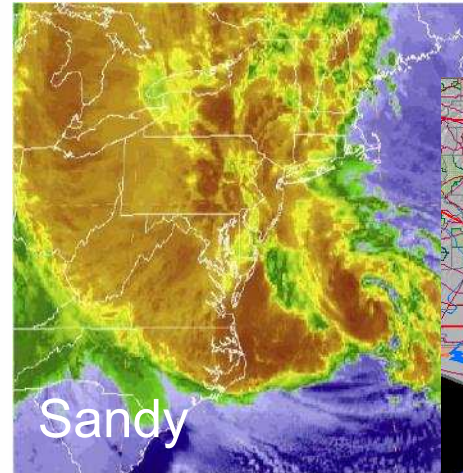
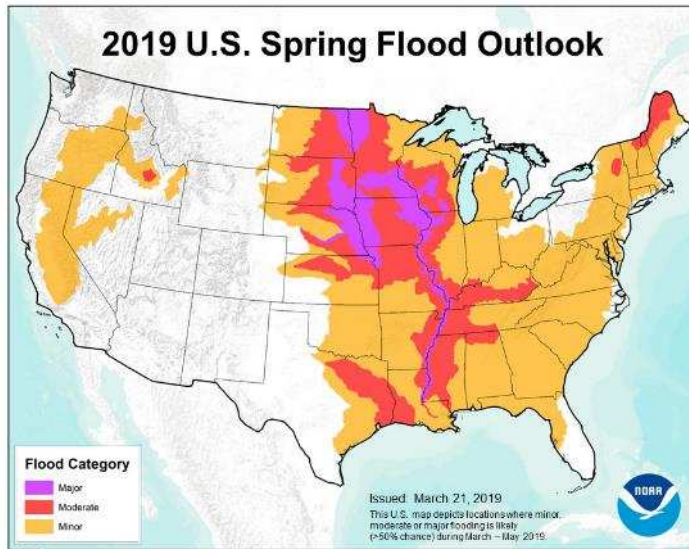


ENGINEERING TRENDS



US Army Corps of Engineers • Engineer Research and Development Center

EVIDENCE SUPPORTING THE NEED FOR INNOVATION



OFFUTT AIR FORCE BASE 2019



U.S. military knew the flood risks at Nebraska's Offutt Air Force Base, but didn't act in time

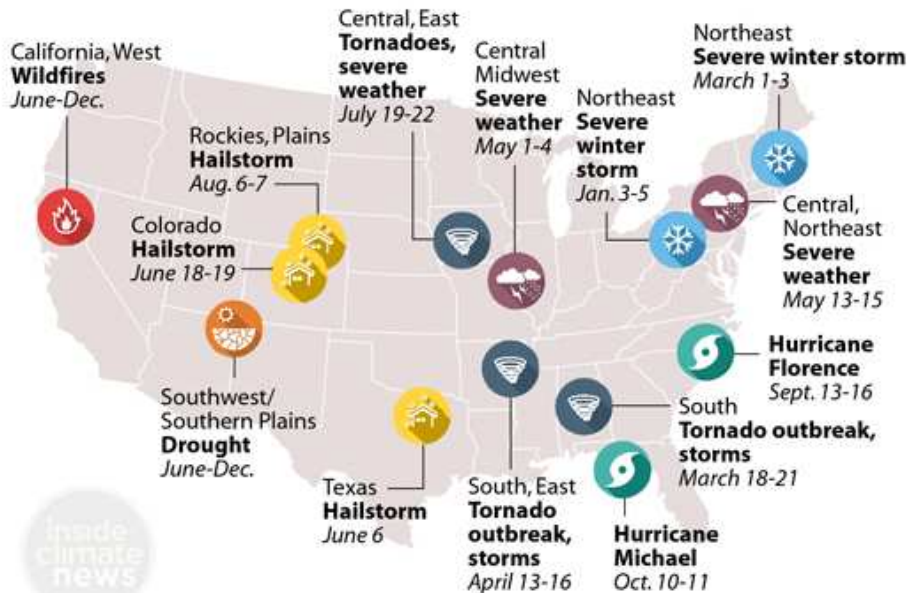
Extreme weather is threatening bases across the nation, but preparations for the changing future have often been too slow.



NATURAL HAZARDS: IMPLICATIONS FOR ECONOMICS AND NATIONAL SECURITY

2018's Billion-Dollar Weather and Climate Disasters

The U.S. faced another series of expensive weather and climate disasters in 2018. Destructive winter storms in the Northeast, severe spring weather in the middle of the country, hurricanes in the Southeast, and wildfires and a year-long drought in parts of the West each caused at least \$1 billion in damage, and many of them cost far more.



EVENT	DATES	COST ESTIMATE	DEATHS
● Northeast severe winter storm	Jan. 3-5	\$1.1B	22
● Northeast severe winter storm	March 1-3	\$2.2B	9
● Southern tornadoes, storms	March 18-21	\$1.5B	0
● South & East tornadoes, storms	April 13-16	\$1.3B	3
● Central Midwest severe weather	May 1-4	\$1.4B	0
● Central & Northeast severe weather	May 13-15	\$1.4B	5
● Texas hailstorm	June 6	\$1.3B	0
● Colorado hailstorm	June 18-19	\$2.2B	0
● Central & East tornadoes, severe weather	July 19-22	\$1.6B	0
● Rockies & Plains hailstorms	Aug. 6-7	\$1.0B	0
● Hurricane Florence	Sept. 13-16	\$24.0B	53
● Hurricane Michael	Oct. 10-11	\$25.0B	49
● Southwest & Southern Plains drought	June 1-Dec. 30	\$3.0B	0
● California & Western wildfires	June 1-Dec. 31	\$24.0B	106

SOURCE: NOAA

PAUL HORN / InsideClimate News

SUSTAINABILITY

Sustainability is achieved by efficiently investing resources to create present and future value



USACE ENVIRONMENTAL OPERATING PRINCIPLES

- **Foster Sustainability as a way of life throughout the organization.**
- **Proactively consider environmental consequences of all Corps activities and act accordingly.**
- **Create mutually supporting economic and environmentally sustainable solutions.**
- **Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.**
- **Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs.**
- **Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.**
- **Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.**



US Army Corps
of Engineers®

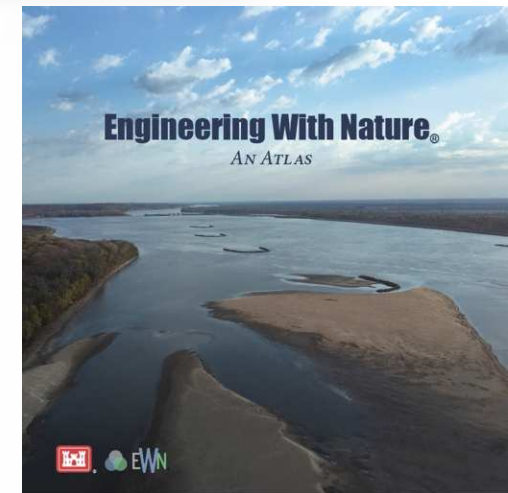
Engineering With Nature®



...the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

Key Elements:

- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners

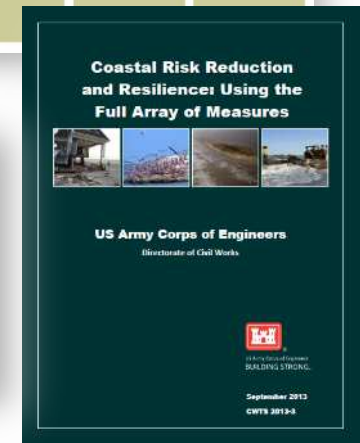


www.engineeringwithnature.org

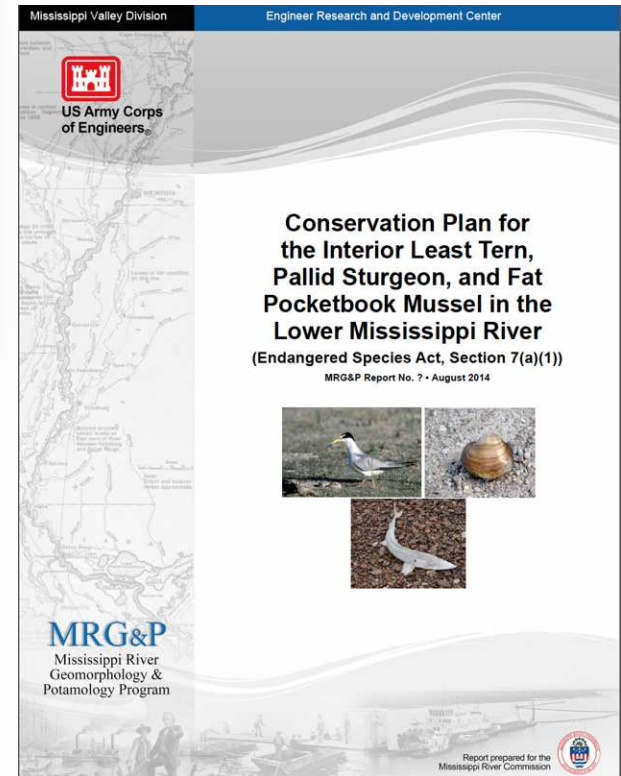
RESTORING NATURAL PROCESSES / FUNCTIONS

Adding back natural complexity to gain multi-purpose function:

- Engineering functions:
 - Flood capacity/storage
 - Water treatment (e.g., nutrients)
 - Groundwater recharge (e.g., drought resilience)
- Environmental benefits
 - Habitat diversity
 - Biodiversity
 - Species recovery
- Social value
 - Human wellbeing
 - Recreation
 - Community resilience



SUSTAINABLE ENGINEERING



MISSOURI RIVER LEVEE SETBACK

“Getting out of the river’s way”



HWY-2 Levee Setback

NOORDWAARD, THE NETHERLANDS



THE BELGIAN SIGMAPLAN



THE BELGIAN SIGMAPLAN



SOCIAL ENGAGEMENT: FACILITATING CHANGE

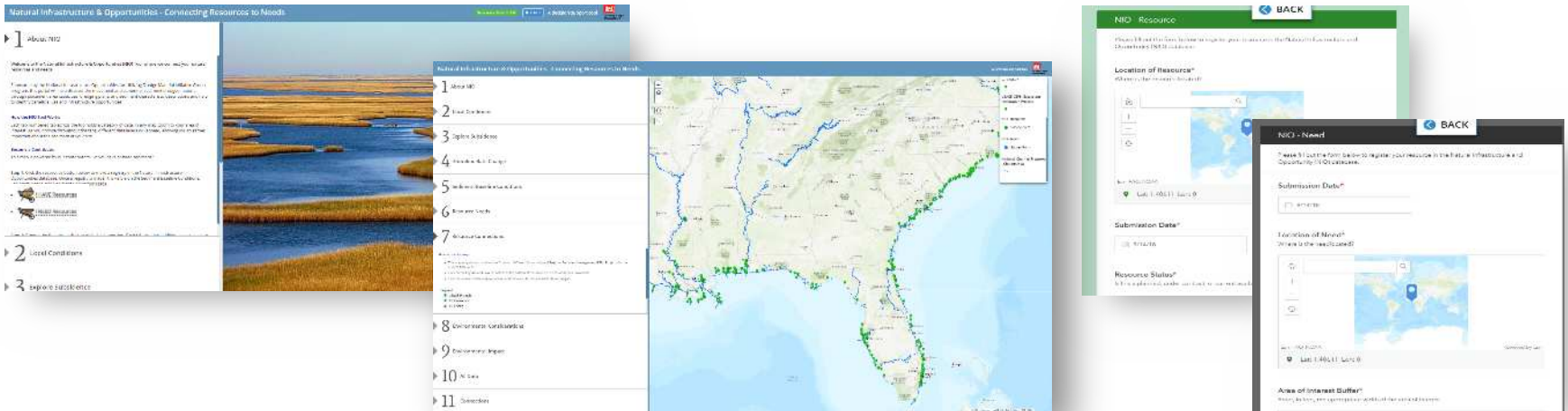


***ENGINEERING WITH NATURE*[®]: BRINGING PEOPLE AND ORGANIZATIONS TOGETHER TO INNOVATE**



NATURAL INFRASTRUCTURE OPPORTUNITIES TOOL

The public facing *Natural Infrastructure Opportunities Tool*, developed in collaboration with the Natural Infrastructure Initiative, focuses on identifying natural infrastructure and beneficial use opportunities. Through map based visualizations of environmental, geomorphic and sediment conditions, as well as upcoming USACE projects, and an interface for users to add their resource needs and resource availability, this portal will help discover natural infrastructure connections and inspire innovative opportunities.



NATURE-BASED SOLUTIONS AS LEADING PRACTICE

TECHNIEK MAAKT JE WERELD

DE INGENIEUR

"HYDRAULIC ENGINEERING COMPANIES MUST USE NATURAL PROCESSES"

OCTOBER 3, 2019

In the coming decades, the principle of '*building with nature*' must be leading in hydraulic engineering. That said Delta Commissioner Peter Glas on Wednesday on the Waterbouwdag, in the Jaarbeurs in Utrecht. '*Building with nature*' must become the guideline for future hydraulic engineering projects, says Glas. "Natural processes are more flexible and adaptive than concrete." Moreover, building where you use the power of nature is generally a lot more sustainable. "We have to think about the consequences of our actions," said Glas.



Delta Commissioner Peter Glas
Rijkswaterstaat

NATURE-BASED SOLUTIONS AS LEADING PRACTICE

“There are many examples around the country where we have seen the positive role creating or restoring natural habitats such as salt marsh, floodplain meadows and woodland can play in reducing flooding or where natural flood management measures that create or restore habitats can slow the flow of floodwaters. Risk management authorities should work with those seeking to create or restore natural habitats as part of the nature recovery network to help ensure the network can contribute to reducing risk.” Page 29-30



Draft National Flood and Coastal Erosion Risk Management Strategy for England



Vision: a nation ready for, and resilient to, flooding and coastal change – today, tomorrow and to the year 2100.

Measure 1.4.3: From 2021 risk management authorities will help to ensure that 75% of all water bodies are in natural or near-natural condition within 25 years.

<https://consult.environment-agency.gov.uk/fcrm/fcrm-national-strategy-info/>

WATER INFRASTRUCTURE IMPROVEMENTS FOR THE NATION ACT (WIIN ACT) 2016

SEC. 1184. Consideration of measures.

(a) Definitions.—In this section, the following definitions apply:

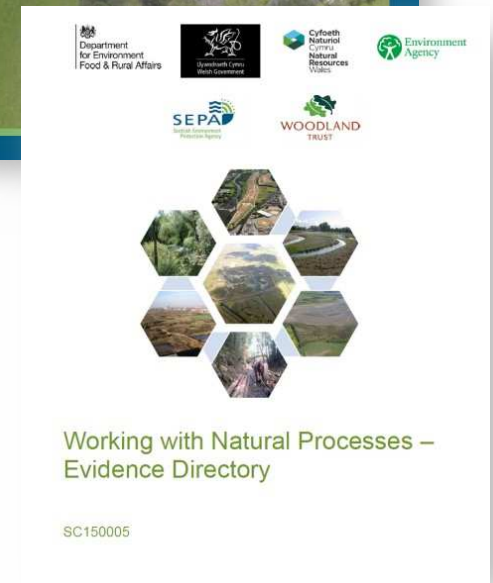
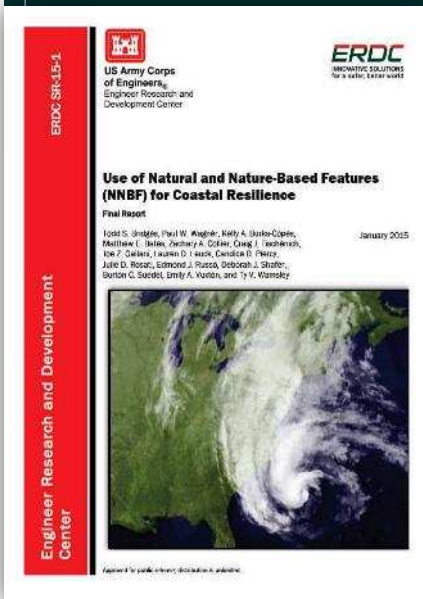
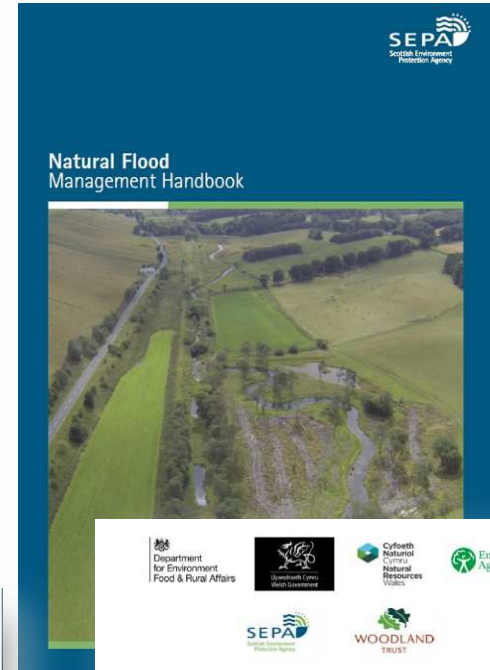
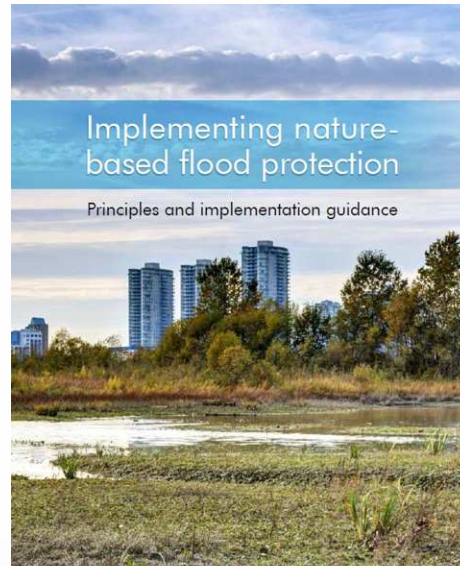
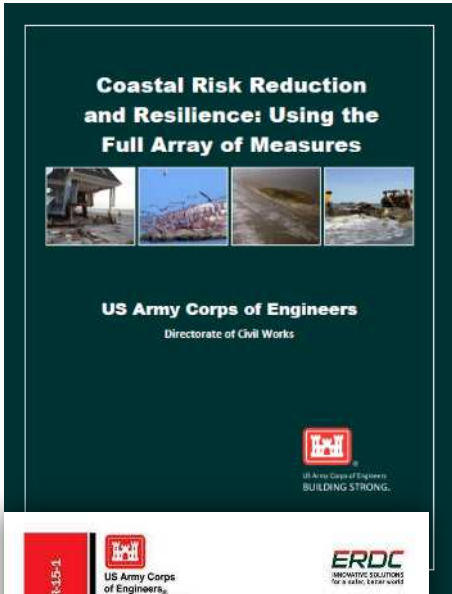
(1) NATURAL FEATURE.—The term “natural feature” means a feature that is created through the action of physical, geological, biological, and chemical processes over time.

(2) NATURE-BASED FEATURE.—The term “nature-based feature” means a feature that is created by human design, engineering, and construction to provide risk reduction in coastal areas by acting in concert with natural processes.

(b) Requirement.—In studying the feasibility of projects for flood risk management, hurricane and storm damage reduction, and ecosystem restoration the Secretary shall, with the consent of the non-Federal sponsor of the feasibility study, consider, as appropriate—

- (1) natural features;
- (2) nature-based features;
- (3) nonstructural measures; and
- (4) structural measures.

NATURE-BASED GUIDANCE, STANDARDS, EVIDENCE



www.engineeringwithnature.org

INTERNATIONAL GUIDELINES ON THE USE OF NATURAL AND NATURE-BASED FEATURES FOR SUSTAINABLE COASTAL AND FLUVIAL SYSTEMS

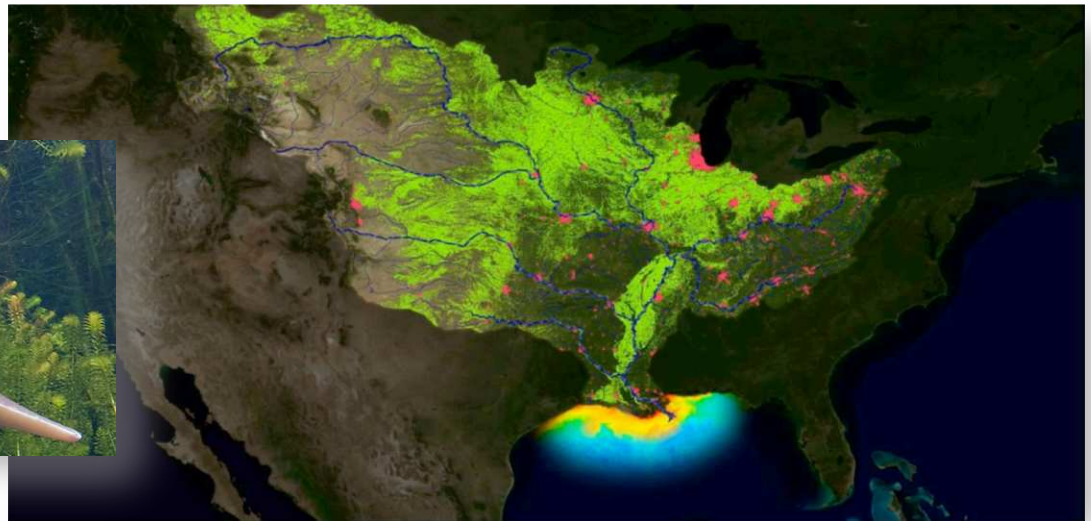
Purpose: Develop guidelines for using NNBF to provide engineering functions relevant to flood risk management while producing additional economic, environmental and social benefits.

- Publish NNBF technical guidelines by 2020:
 - ▶ Multi-author: government, academia, NGOs, engineering firms, construction companies, etc.
 - ▶ Addressing the full project life cycle
 - ▶ Guidelines in 4 Parts
 - Overarching
 - Coastal Applications
 - Fluvial Applications
 - Conclusions



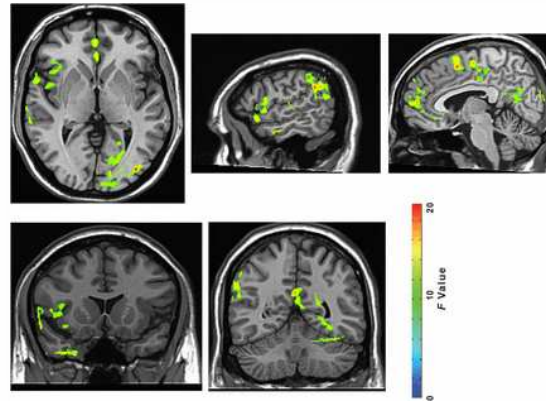
THE OTHER TWO LEGS OF THE SUSTAINABILITY STOOL: NATURE AND HUMAN WELLBEING

- Wetlands provide water quality function:
 - Nutrient loading, HABs, GoM “Dead Zone”
 - 22,000 km² of restored wetlands would remove 40% of N discharging to GoM (Mitsch et al., 2005)
- Habitat for Threatened and Endangered Species
 - >150 species



THE OTHER TWO LEGS OF THE SUSTAINABILITY STOOL: NATURE AND HUMAN WELLBEING

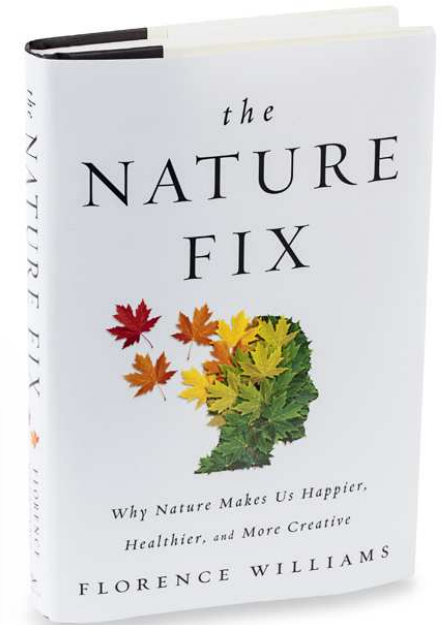
- Science supports positive health benefits of nature:
 - Physical health
 - Blood pressure
 - Healing
 - Immunity
 - Mental health
 - Cognitive function
 - Anxiety
 - Depression
 - Socialization



Nature experience reduces rumination and subgenual prefrontal cortex activation

Gregory N. Bratman, J. Paul Hamilton, Kevin S. Hahn, Gretchen C. Daily, and James J. Gross

PNAS July 14, 2015 112 (28) 8567-8572; first published June 29, 2015 <https://doi.org/10.1073/pnas.1510459112>



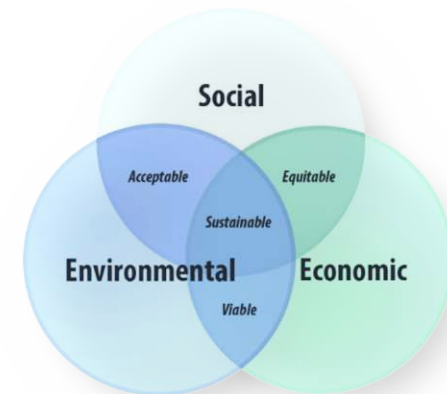
“Wicked Problems”

- No definitive formulation of the problem
- No right or wrong solutions, only better or worse solutions
- A broad diversity of values and opinions that are germane to defining solutions
- No ultimate test of a solution to the problem

(Rittel and Webber, 1973)

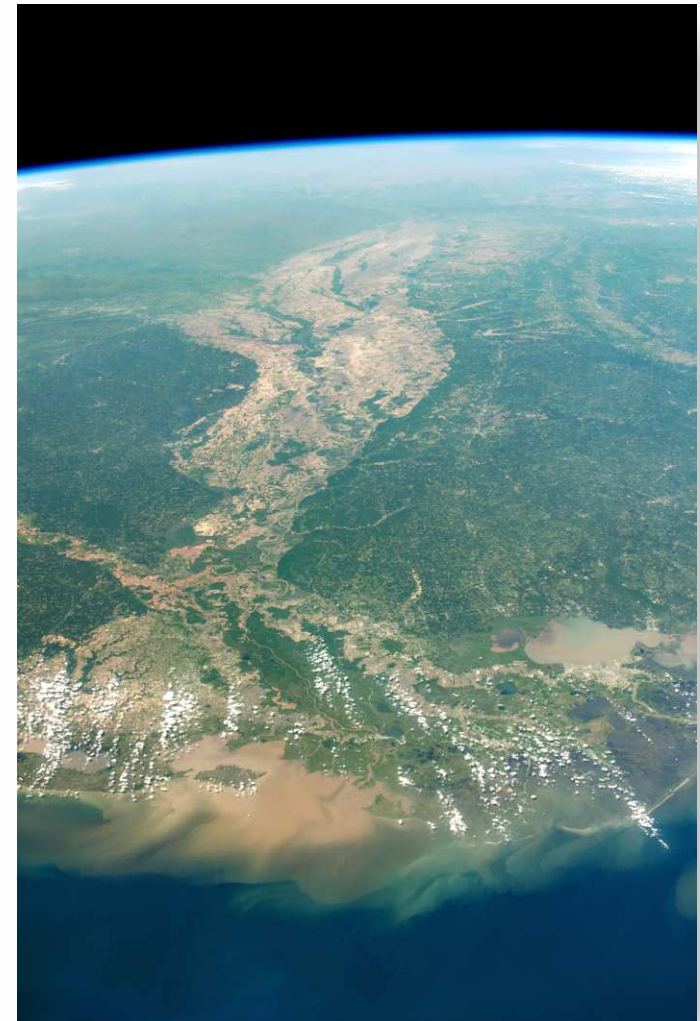


Horst Rittel, 1930-1990



A SYSTEMS APPROACH: GETTING BEYOND THE PATCHWORK

- Increase efficiency AND overall value
- Conventional AND natural infrastructure
- Develop the value case for change and innovative solutions
- Engage the private sector to develop the business case for new solutions
- Think, engage and plan BIG... AND over the long-term
 - Mississippi System Plan (MsPlan)???



A SYSTEMS VIEW OF SOLUTIONS

