WORKING WITH NATURE TRAINING SERIES

APRIL 21, 2022

Valuing nature-based solutions through cost-benefit analyses

LOUISIANA WATERSHED INITIATIVE

working together for sustainability and resilience

AGENDA

- Program overview
- Cost-benefit analysis
- University Lakes case study
- Questions

NATURE-BASED SOLUTIONS PROGRAM OVERVIEW

MAXIMIZE NATURAL FUNCTIONS OF THE FLOODPLAIN

- Fund projects that harness natural features to reduce flood risk, improve water quality and provide additional co-benefits
- Provide training and technical resources to advance understanding and adoption of nature-based solutions
- Prioritize nature-based solutions throughout state programs and projects
- Use tools to quantify benefits and measure performance of nature-based projects

COST-BENEFIT ANALYSIS

Trygve Madsen

SENIOR RESEARCH ANALYST AND COMMUNICATION MANAGER | EARTH ECONOMICS

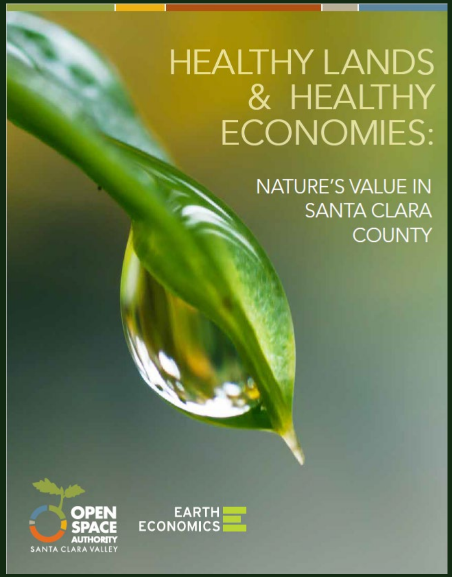
Trygve Madsen joined Earth Economics in 2018. He brings a wide-ranging quantitative skill set to bear on research surrounding the economic value of recreation and public lands, how ecosystem service values change as land cover changes and how community-driven green infrastructure can build resilience and provide local economic benefits.

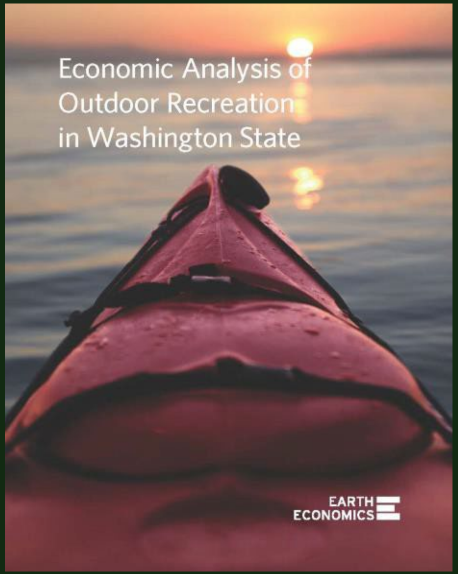
Agenda

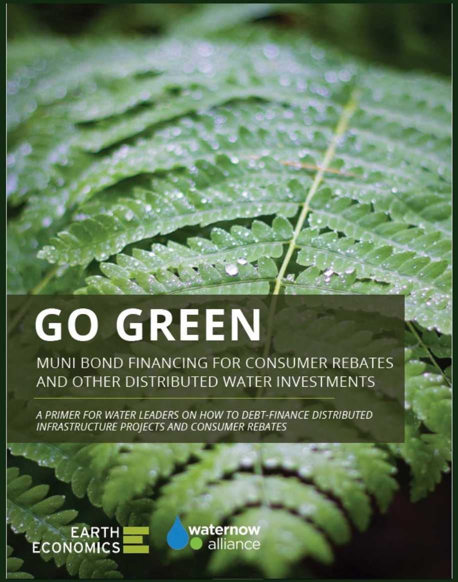
- About Earth Economics
- The big picture
  - Nature-based solutions
  - Getting to scale on climate adaptation
- Cost-benefit analysis
  - Key steps
- Case studies, resources, examples

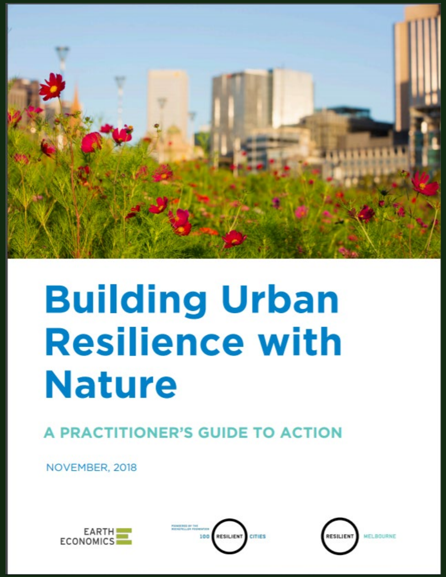
Taking nature into account

EARTH ECONOMICS







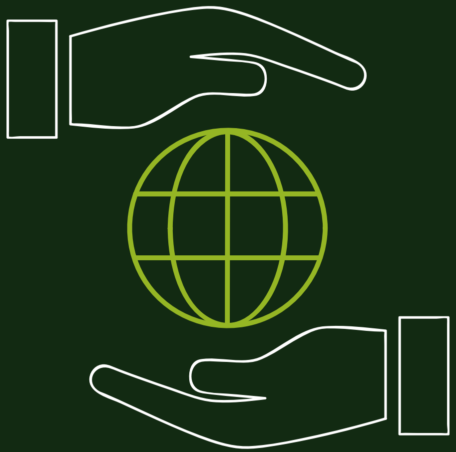


EARTH ECONOMICS

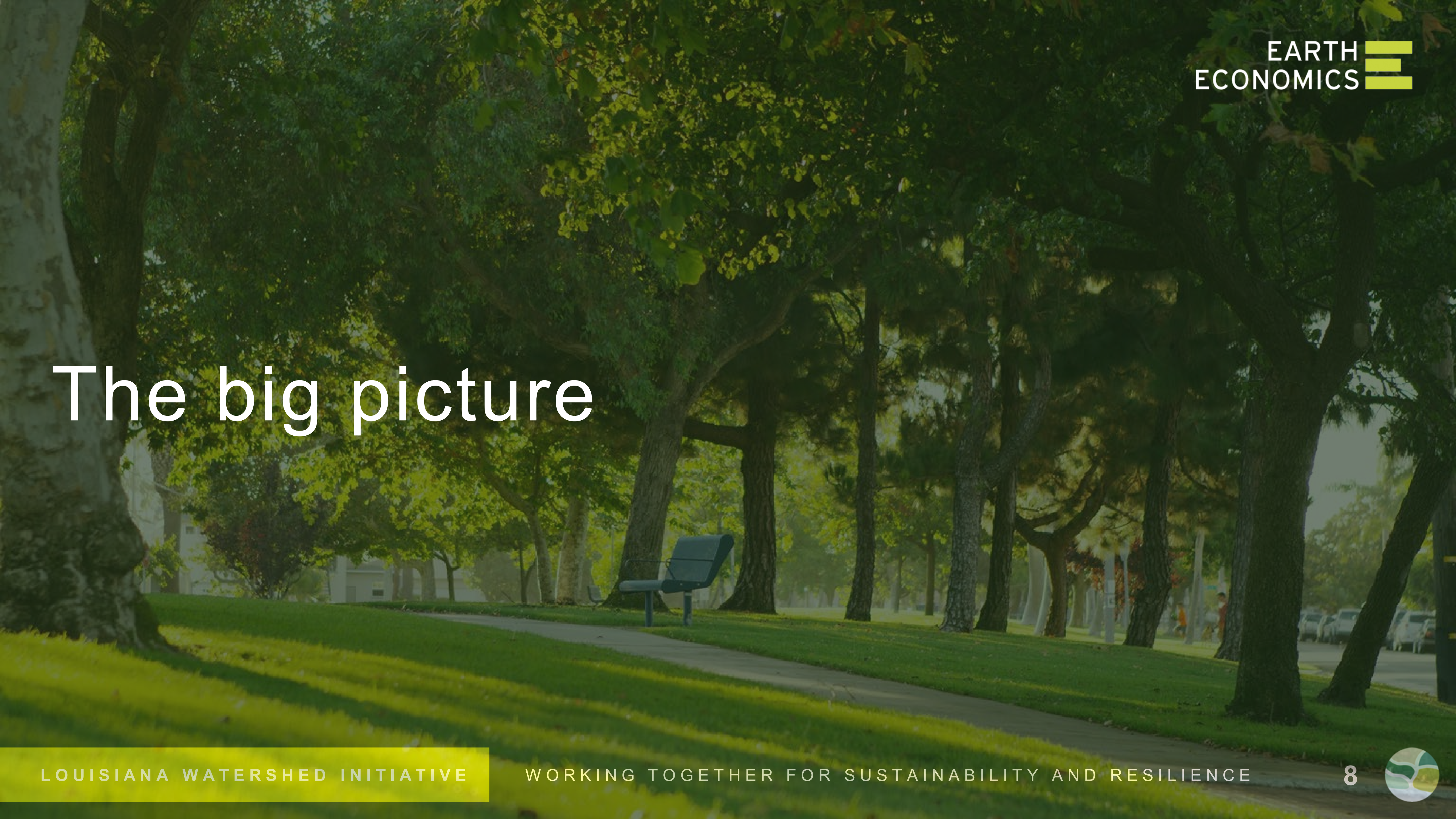
Our approach: Taking nature into account

Awareness Building

Place-Based Analysis



Policy and Finance



The big picture

WHAT HAS VALUE?

How do we measure it?

How do we fund it?

OLD THINKING:

Nature as an accessory

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NEW THINKING:

Nature as the big picture

Types of capital

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Built Capital

Social Capital

Human Capital

Natural Capital

Financial Capital

Nature-based solutions

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Urban-scale green infrastructure

Permeable pavement, green roofs, bioretention, urban trees

Landscape-scale natural infrastructure

Coastal wetlands, watersheds, aquifers

Infrastructure: A continuum

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Getting to scale on climate adaptation

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KEY ELEMENTS

- Taking inventory of assets
  - Natural, manmade, human, social
- Making the case
  - Performance
  - Cost-efficiency (upfront, O&M costs)
  - Cost-benefit analysis
- Establishing a vision and targets
- Advancing local and national policy
  - Asset management, accounting
  - Regulatory and incentive-based tools
- Funding and financing
- Building stakeholder support
  - The public and decision-makers

Cost-benefit analysis

Cost-benefit analysis

DEFINITION

A cost-benefit analysis (or benefit-cost analysis) is a method of estimating the future benefits of a project compared to its cost. The end result is a benefit-cost ratio, which is derived from a project's total benefits divided by its total cost.

- U.S. Federal Emergency Management Agency

Cost-benefit analysis

KEY STEPS

Define project

Estimate benefits
- Identify, quantify, monetize

Estimate costs
- Identify, monetize

Compare costs and benefits
- Project useful life, discount rate

Cost-benefit analysis

DEFINE THE PROJECT

- What is the primary goal of the project or issue being addressed?
  - E.g., hazard mitigation (flood, drought, wildfire), stormwater management, water supply/quality, recreation
- Does the project address the goal/problem? If so, how?
- Is the project feasible and effective?
- What are the alternatives?
- Are there broader solutions to address the goal/problem?
- What does the "no action" scenario look like?

Cost-benefit analysis

ESTIMATE BENEFITS

- Identify benefit categories
  - Economics, social, environmental
  - Consider separating primary benefits and co-benefits
- Quantify benefits in physical terms
- Monetize benefits using appropriate methods*
- Allocate benefits throughout future years

**Methods and level of precision are contextual—these depend on the intended use of the CBA analysis, project size, audience, data availability, etc.*

Cost-benefit analysis

EARTH ECONOMICS

BENEFIT CATEGORY EXAMPLES – HAZARD MITIGATION PROJECT

- **Avoided physical damages**
  - To structures and contents, roads, bridges, utilities
- **Avoided loss-of-function**
  - To utilities, roads, businesses, residences, critical services
- **Avoided emergency response costs**
  - Sandbagging, evacuation, road closure
- **Avoided harm to people**
  - Injuries, deaths
- **Societal and environmental benefits**
  - Avoided lost productivity, mental stress
  - Enhanced water quality, habitat, recreation

Economic valuation methods

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Valuation Method	Description
Measures	
Market Prices	Assigns value equal to the total market revenue of goods/services
Replacement Cost	Services can be replaced with human-made systems; for example, water quality treatment provided by wetlands can be replaced with costly built treatment systems.
Avoided Cost	Services allow society to avoid costs that would have been incurred in the absence of those services; for example, storm protection provided by barrier islands avoids property damages along the coast.
Production Approaches	Services provide for the enhancement of incomes; for example, water quality improvements increase commercial fisheries' catches and therefore fishing incomes.
Revealed Preference Approaches	
Travel Cost	Service demands may require travel, which has costs that can reflect the implied value of the service; recreation areas can be valued at least by what visitors are willing to pay to travel to it, including the imputed value of their time.
Hedonic Pricing	Service demands may be reflected in the prices people will pay for associated goods; for example, housing prices along the coastline tend to exceed the prices of inland homes.
Stated Preference Approaches	
Contingent Valuation	Service demands may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; for instance, people generally state that they are willing to pay for increased preservation of beaches and shoreline.

Cost-benefit analysis

ESTIMATE COSTS

- Identify cost categories
    - Upfront costs (e.g., capital)
    - Ongoing costs (e.g., O&M)
- Allocate costs throughout future years

Example: Conventional CBA

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ENVIRONMENTAL

STORMWATER CAPTURED

+

ECONOMIC

CAPITAL INVESTMENT

OPERATIONAL COSTS

Example: Expanded CBA

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ENVIRONMENTAL	+	SOCIAL	+	ECONOMIC
STORMWATER CAPTURED		PUBLIC HEALTH		CAPITAL INVESTMENT
CARBON SEQUESTRATION		RECREATION		OPERATIONAL COSTS
HABITAT		EDUCATION		AVOIDED DAMAGES
WATER QUALITY		SOCIAL COHESION		JOBS
WATER SUPPLY				PROPERTY VALUES
AIR QUALITY				

Cost-benefit analysis

COMPARE COSTS AND BENEFITS

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Sankofa Water Garden, Lower 9th Ward

Year	Capital Cost	Annual O&M	Ecosystem Service Value	Education Benefit Value	Public Health Benefit	Total Benefits	Annual Net Benefit
0	$ (500,000)	$ -				$ -	$ (500,000)
1	$ -	$ (200,000)	$ 63,063	$ 22,788	$ 1,301	$ 87,153	$ (112,847)
2	$ -	$ (200,000)	$ 157,658	$ 56,971	$ 3,253	$ 217,882	$ 17,882
3	$ -	$ (200,000)	$ 252,253	$ 91,154	$ 5,205	$ 348,612	$ 148,612
4	$ -	$ (200,000)	$ 315,316	$ 113,942	$ 6,507	$ 435,765	$ 235,765
5	$ -	$ (200,000)	$ 315,316	$ 113,942	$ 6,507	$ 435,765	$ 235,765
6	$ -	$ (200,000)	$ 315,316	$ 113,942	$ 6,507	$ 435,765	$ 235,765
7	$ -	$ (200,000)	$ 315,316	$ 113,942	$ 6,507	$ 435,765	$ 235,765
8	$ -	$ (200,000)	$ 315,316	$ 113,942	$ 6,507	$ 435,765	$ 235,765
9	$ -	$ (200,000)	$ 315,316	$ 113,942	$ 6,507	$ 435,765	$ 235,765

Undiscounted values

Assumptions	
Discount Rate	0.03

Results		
PV Costs	$(4,337,691)	USD 2019
PV Benefits	$ 7,738,065	USD 2019
NPV	$ 3,400,374	USD 2019
BCR	1.78	
IRR	24.3%	

Case studies, examples, resources

Case study

SOCIOECONOMIC ANALYSIS OF SEDIMENT DIVERSION OPTIONS

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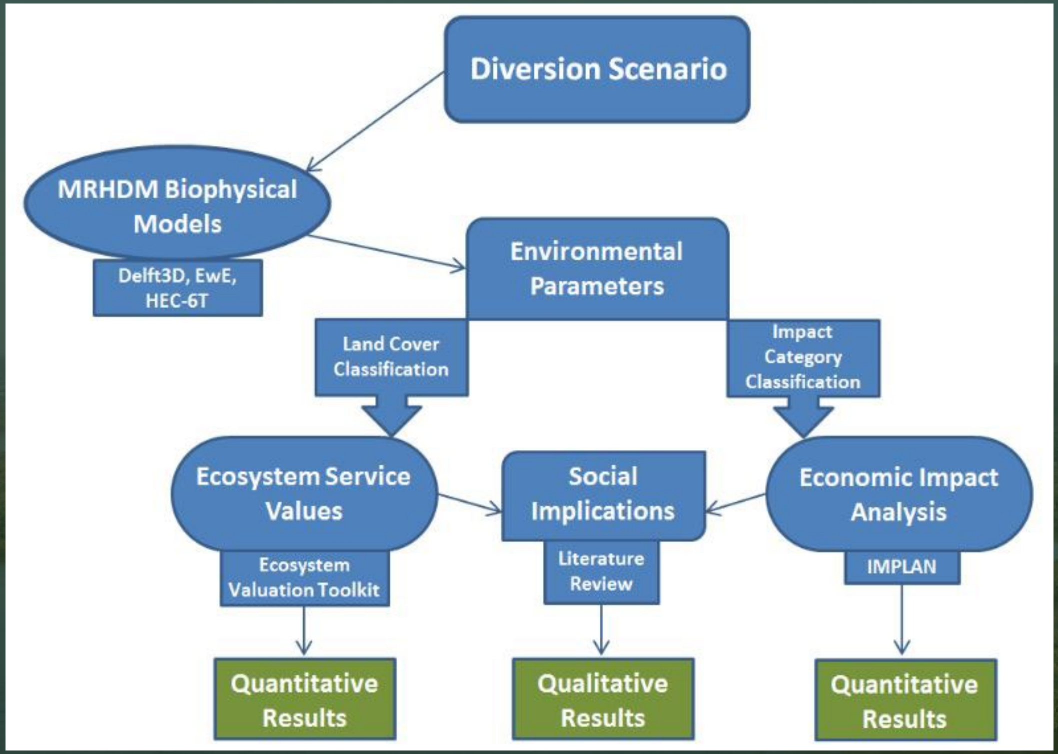
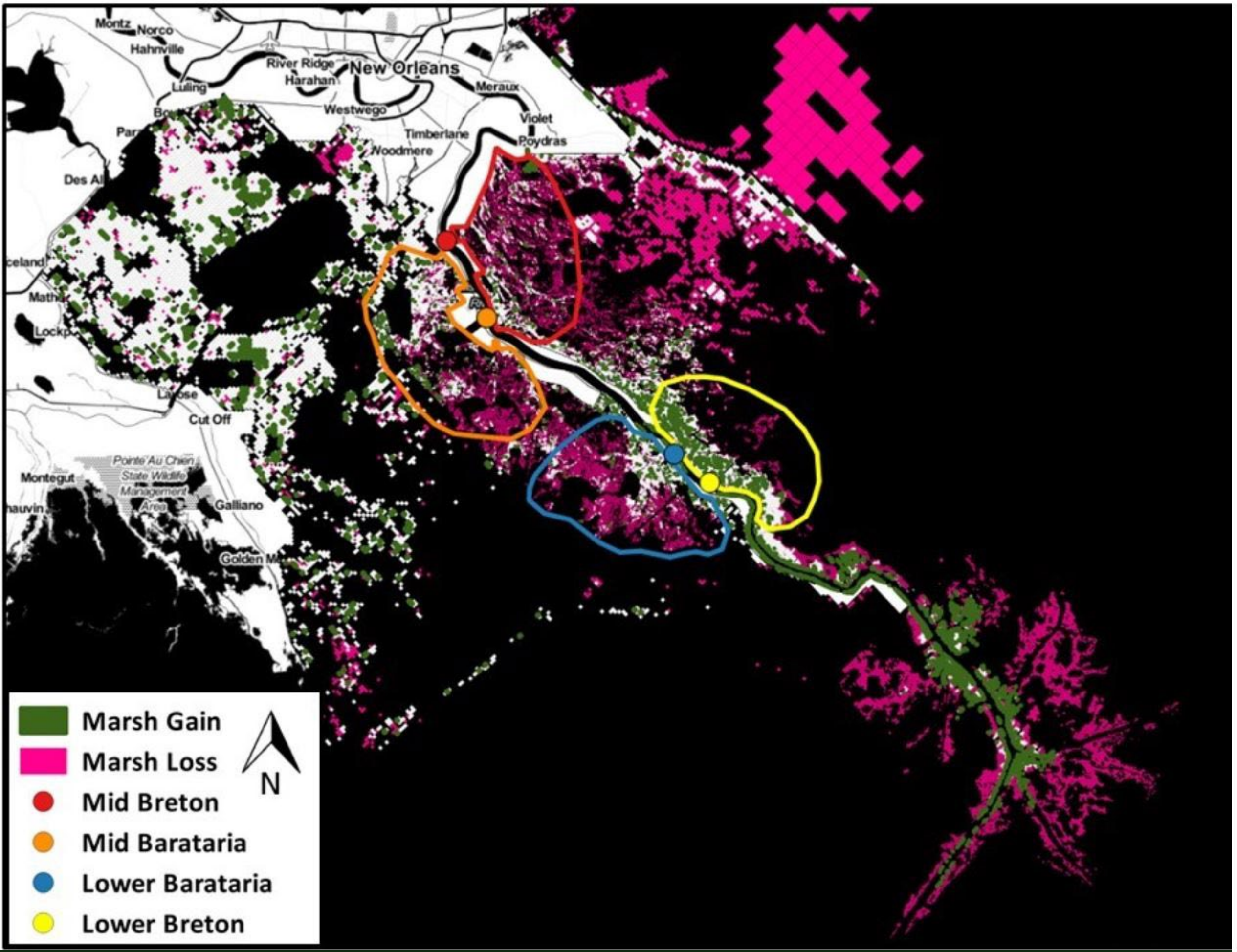
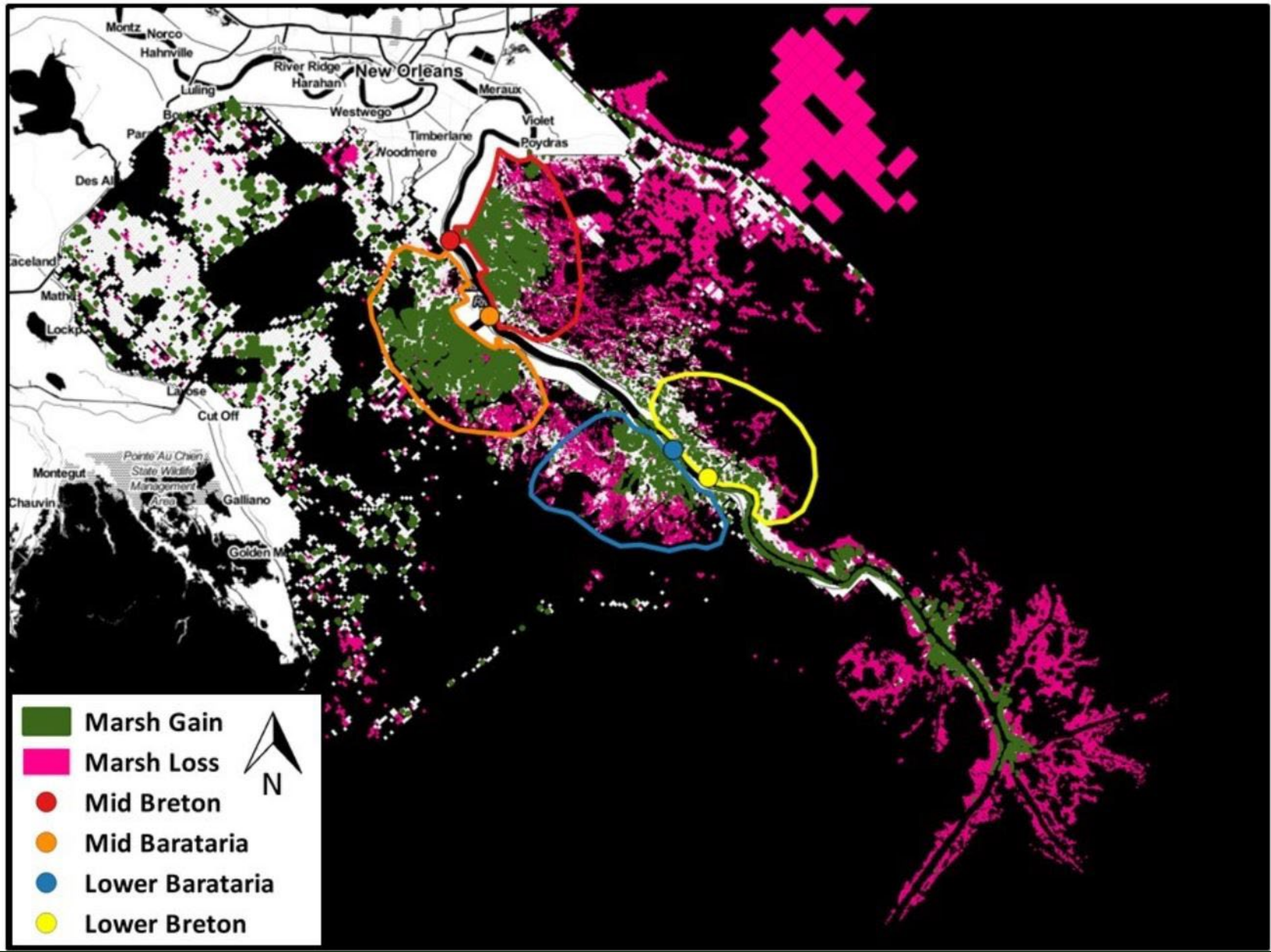


Louisiana Coastal Protection and Restoration Authority

Biophysical to monetary benefits



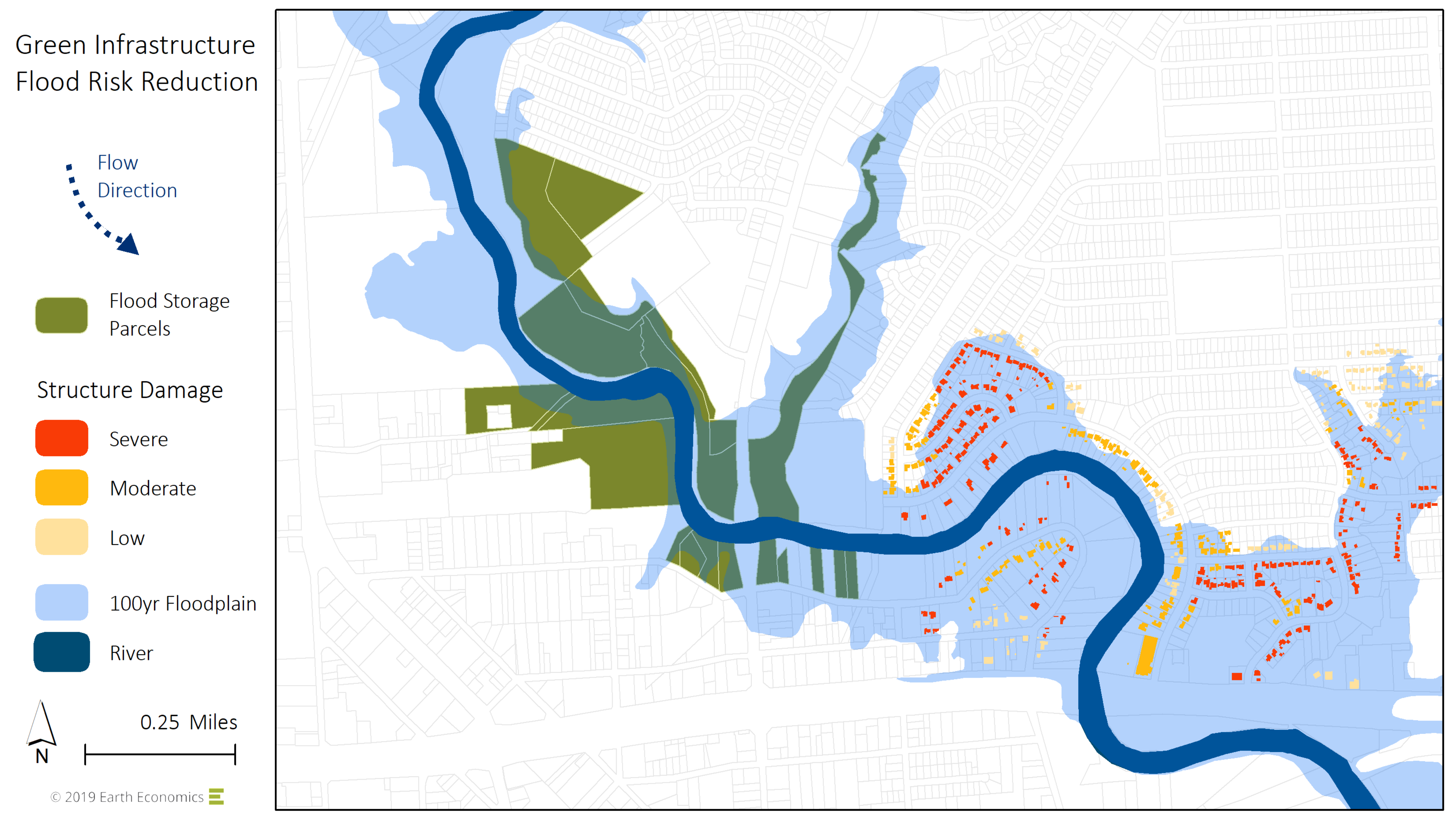


Case study

PLUVIAL FLOODING

EARTH ECONOMICS

Hurricane Harvey, Houston


Green Infrastructure
Flood Risk Reduction
Flow
Direction
Flood Storage
Parcels
Structure Damage
Severe
Moderate
Low
100yr Floodplain
River
N
0.25 Miles
© 2019 Earth Economics

CBA summary

Define project

- Floodplain and stream restoration, with acquisition component

Quantify benefits

- Avoided flood damage to 97 downstream structures (and contents)
- Environmental benefits
- Avoided stress and anxiety

Quantify costs

- Acquisition, annual O&M

Compare costs and benefits

- Discount rate: 7%
- Project useful life: 100 years

Key data inputs for flood damage reduction

- First-floor elevation
- Flood and river elevations (10-, 50-, 100-, 500-year events)
- Depth-damage function (0-50% damage)
- Building replacement value ($/square foot x square footage)

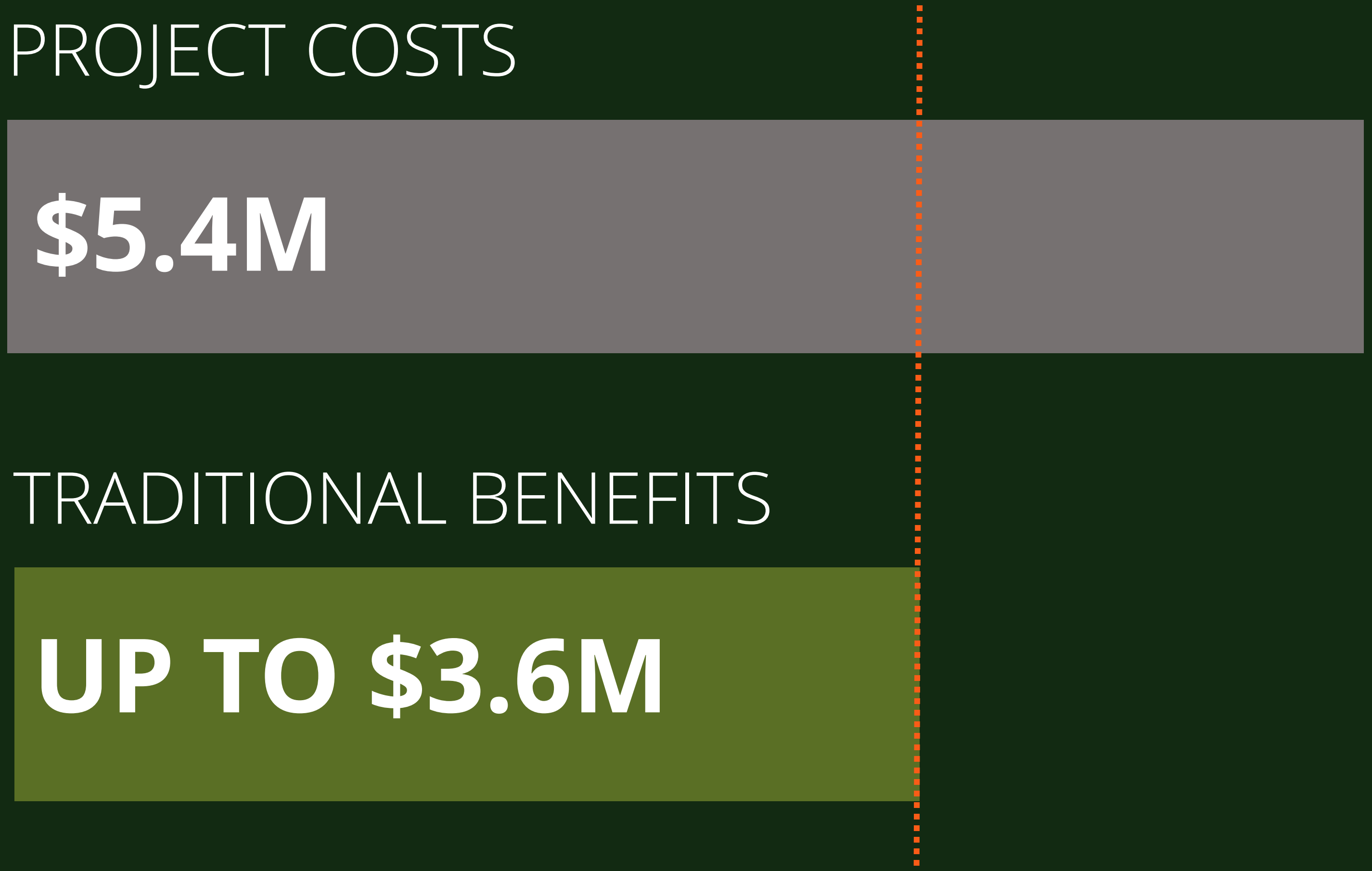
Case study

FLOOD RISK REDUCTION

Thornton Creek, Seattle

Case study

FLOOD RISK REDUCTION



Case study

FLOOD RISK REDUCTION

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PROJECT COSTS

$5.4M

TRADITIONAL BENEFITS	ADDITIONAL BENEFITS
UP TO $3.6M	**UP TO $3.2M**

Resource: The Water Research Foundation

	Market price	Stated preference	Revealed preference	Avoided costs	Benefits transfer
Avoided infrastructure/treatment costs				●	
Asset life extension		●		●	
Energy savings	●			●	
Water supply benefits	●			●	
Improved air quality and related health benefits				●	●
Improved aesthetics and community sustainability/livability			●		●
Flood risk reduction				●	
Reduced urban heat stress and related public health benefits				●	●
Increased recreational opportunities		●			●
Green job creation	●				
Improved water quality		●			●
Carbon emissions reduction and sequestration				●	●
Terrestrial ecosystem and biodiversity benefits		●	●		●

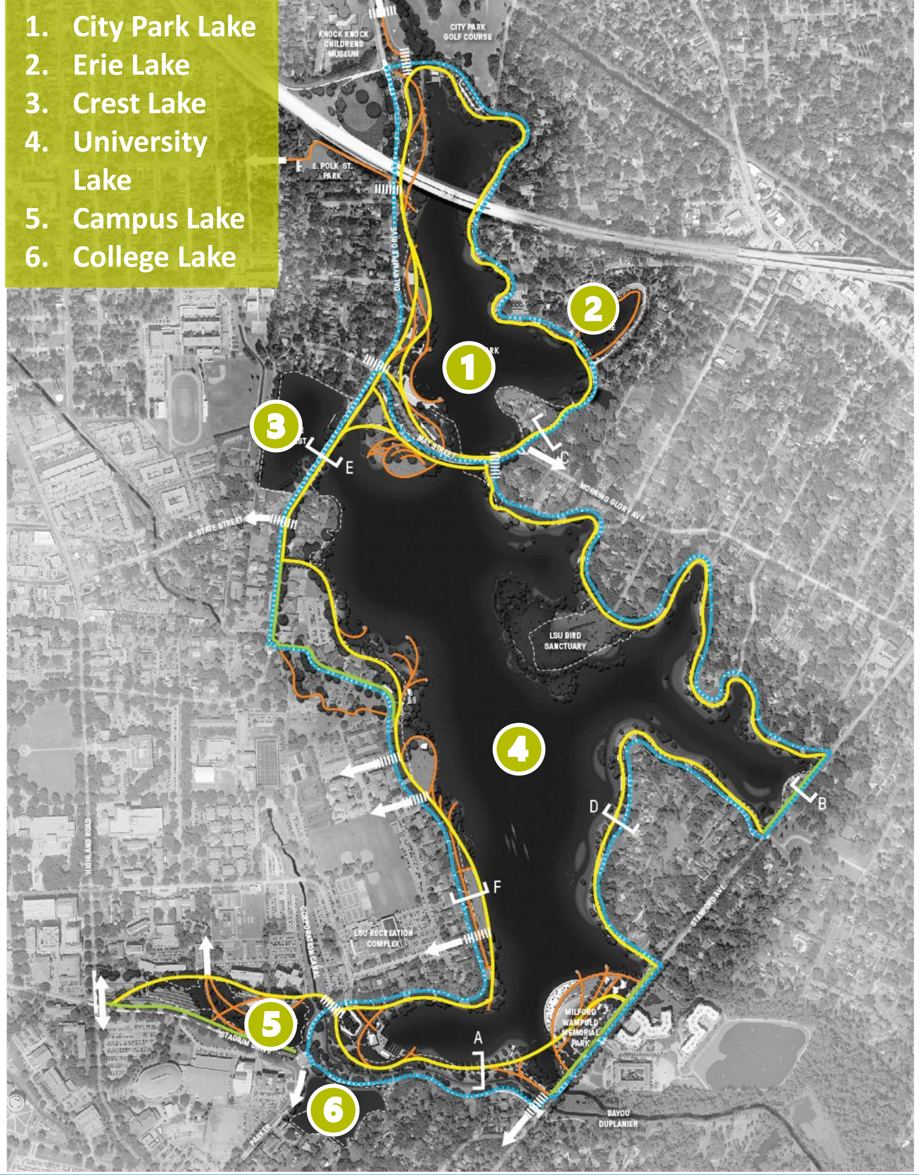
*Graphics via: Clements, J., Henderson, J., Flemming, A., 2021.
Framework and Tools for Quantifying and Monetizing the Triple Bottom Line Benefits of Green Stormwater Infrastructure.
The Water Research Foundation.

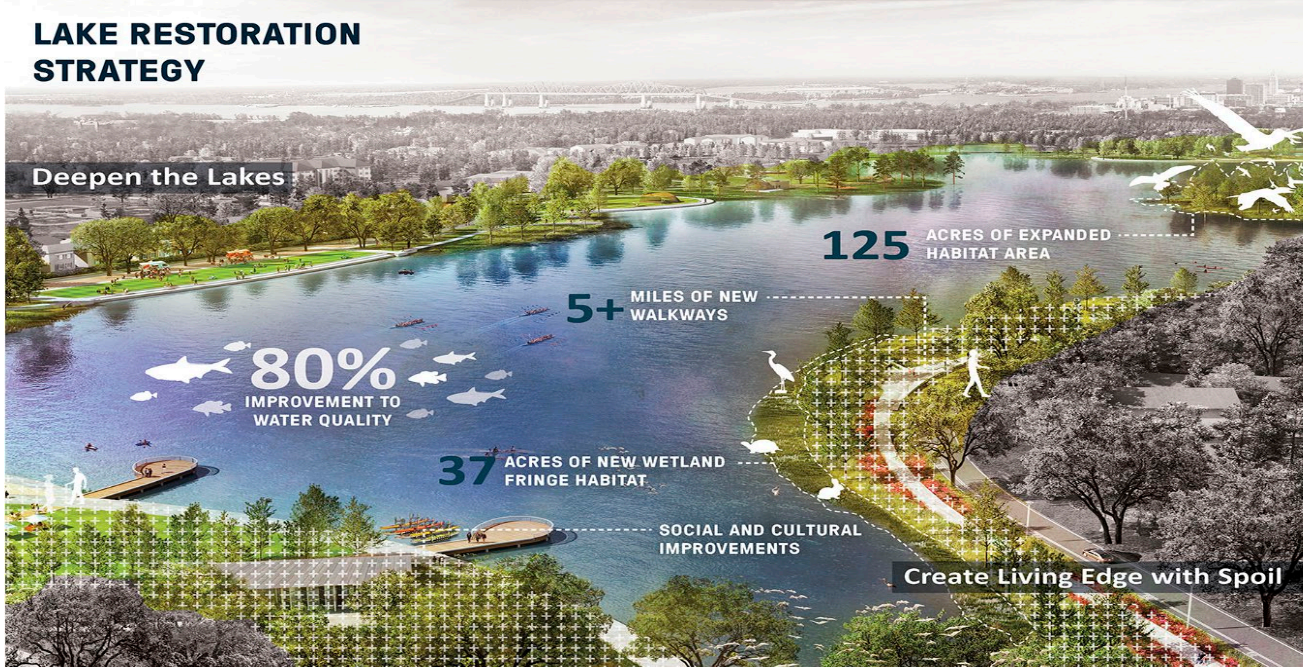
UNIVERSITY LAKES PROJECT CASE STUDY

Stokka Brown

PRINCIPAL AND WATER RESOURCES LEADER | CSRS

Stokka Brown is a professional engineer and certified floodplain manager with 11 years of experience in water resources and coastal engineering, including numerical modeling and analysis of estuarine, coastal and stormwater systems. He uses these models to understand the complex nature of drainage systems, identify problems, develop solutions through the application of hydraulics and hydrology and gauge the impact of alterations to the natural system.





LEGEND

- Primary Multi-Use Path
- Secondary Path
- Improved Sidewalk
- Bike Path
- Road: Two-Way
- Road: One-Way
- Trail Connection
- Improved Crosswalk
- Existing Water Line

swa | JEFFREY CARBO LANDSCAPE ARCHITECTS

PREVIOUS WORK: 2016 MASTERPLAN

University Lakes

ILLUSTRATIVE PLAN

Legend

1. City Park Lake Forebay & Improvements (Further Design Coordination Needed)
2. May St Bridge & Site Improvements
3. Active Edge along LSU
4. Campus Lake Improvements
5. Corporation Canal Improvements
6. Baton Rouge Beach
7. Stanford Ave Improvements
8. Bird Sanctuary Improvements
9. Connection to Mckinley High School

--- Existing Shoreline

0 1000 ft

N

Conceptual Design

Schematic Design (30% Design)

Bathymetry, Stump Identification, Sediment sampling

Hydrologic/Earthwork/Dredging model development

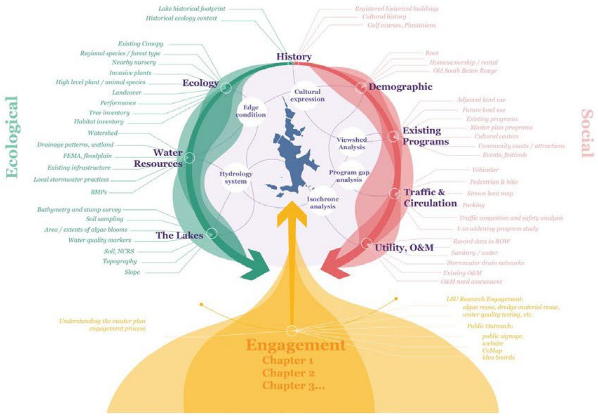
Dredging Implementation

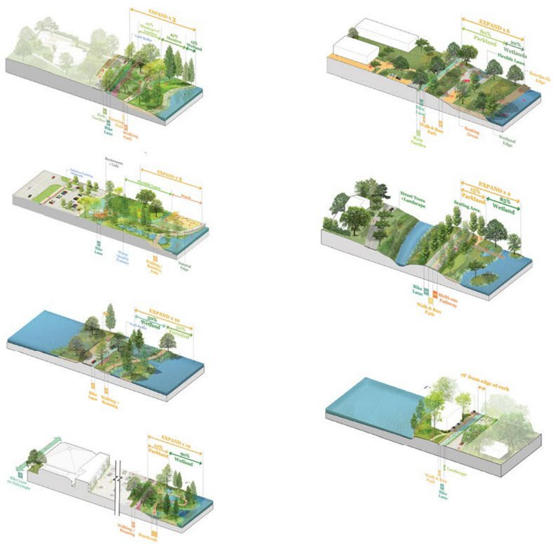
2021

2022

Construction begins Summer 2022

PROJECT SCOPE AND TIMELINE





Due diligence

Gain comprehensive understanding of the site

Concept Typologies

Leverage interactive tool to explore lake edge possibilities

Focus Area Study

Use Baton Rogue Beach and Stanford Avenue to study ecology, hydrology, program and circulation

SASAKI

PHASE 1: SCHEMATIC DESIGN (30% DESIGN)

2021 TO PRESENT

Baton Rouge Beach

LANDSCAPE TYPOLOGY

Botanic Native

Submerged Aquatic Shelf

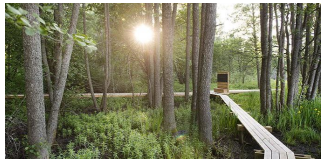
Fringe Wetlands

Upland Grassland

Ornamental Rain Garden / Bioswales

Lawn

Forested Wetland



Reforested Area

SASAKI

FOCUS AREA CONCEPT PLAN

FOCUS AREA CONCEPT DESIGN:
BATON ROUGE BEACH

Funding sources

(as of February 2022)

SOURCE	AMOUNT	RESTRICTIONS?	STATUS
BREC	$5M	Yes	Funded
East Baton Rouge City-Parish	$5M	Yes	Funded
LSU	$260K	No	Funded
State (OCD)	$10M CDBG-MIT	Yes	$5M funded, $5M pending CEA amendment
State (Capital Outlay)	$10M	Yes	Approved, CEA executed
State (DOTD)	$5M	Yes	Committed

TOTAL SHORT-TERM FUNDING AVAILABLE = $35,260,000

*Additional funding from Memorandum of Understanding not included above:

- $10 million in State Capital Outlay ($6 million approved in Priority 5 for FY 2022)
- $5 million from LSU Athletic Department

BENEFIT TYPES

- Loss avoidance
- Ecosystem services

COST-BENEFIT ANALYSIS

FEMA BCA TOOLKIT 6.0
ECOSYSTEM SERVICE BENEFITS

- This section will only display if ecosystem services benefits relate to the selected Mitigation Action Type from the project configuration section.
- Ecosystem service benefits accrue when land use is changed or enhanced by a mitigation activity to provide a higher level of natural benefits.

PROVISIONING SERVICES: tangible goods such as trees that can be used for lumber and paper, a river providing fresh water, etc.

- Water supply, food, raw materials

REGULATING SERVICES: benefits obtained from the natural control of ecosystem processes

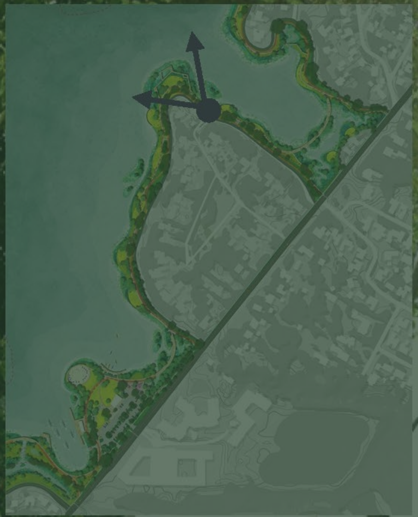
- Water quality, waste processing, soil erosion control, nutrient regulation

SUPPORTING SERVICES: refuge/reproduction habitat for wild plants and animals, contributing to the in-situ conservation of biological and genetic diversity processes

- Habitat and biodiversity, primary productivity, pollination

CULTURAL SERVICES: meaningful human interaction with nature

- Aesthetics, scientific knowledge, spiritual/religious experience, educational value



LAND USE OPTIONS:

Users need to know the land use status after the project is completed. If a parcel will be maintained as open space, then **green open space** is the best option.

Expected annual ecosystem services benefits:

forests | $554/acre/year

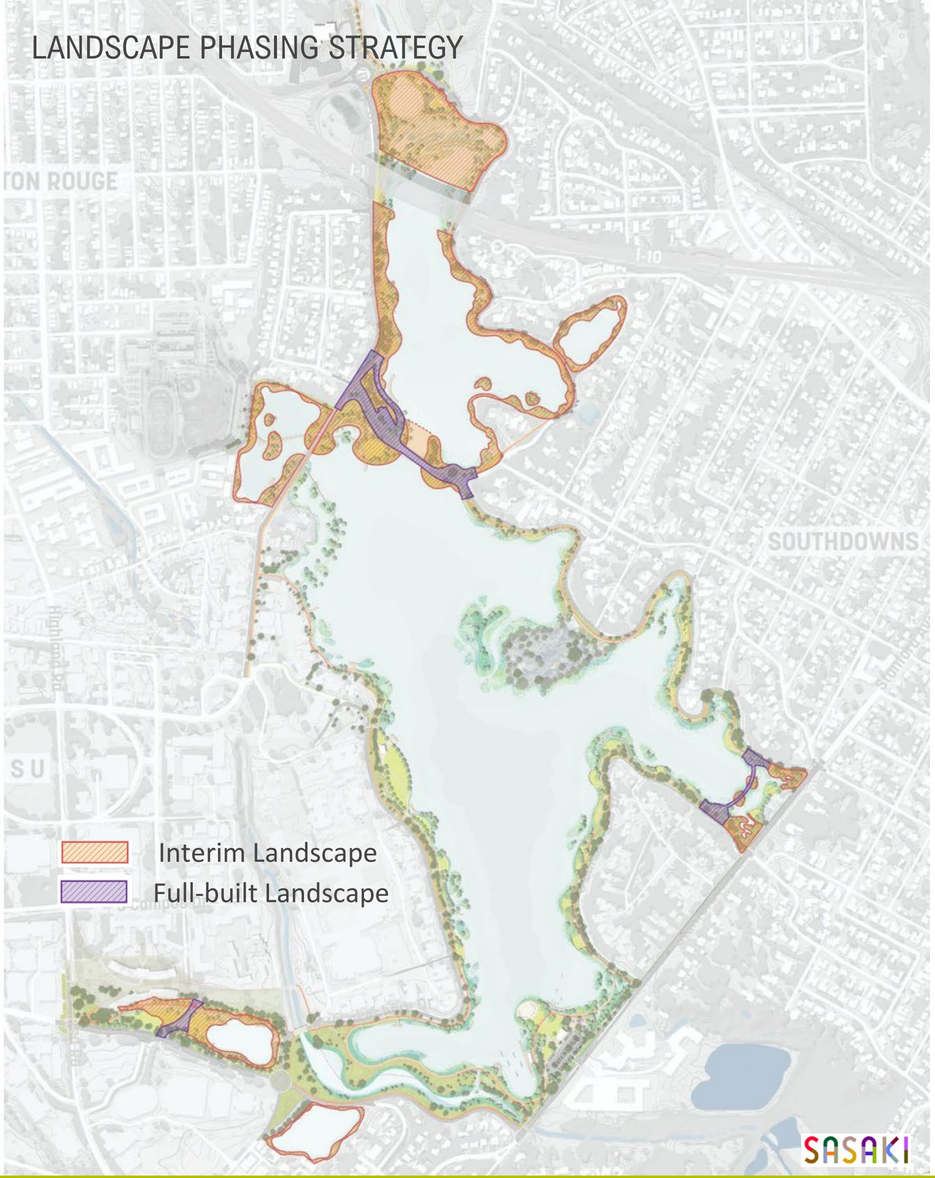
marine and estuary | $1,799/acre/year

wetlands | $6,010/acre/year

green open space | $8,308/acre/year

riparian | $39,545/acre/year

LAND USE OPTIONS AND PERCENTAGES



FEMA BCA TOOLKIT 6.0

Standard Benefits - Ecosystem Services	
Total Project Area (acres or sq.ft):	124
Enter the percent land use of the project area below:	
Green Open Space (%)	4
Riparian (%)	15
Wetlands (%)	15
Forests (%)	6
Marine & Estuary (%)	60
Expected Annual Ecosystem Services Benefits ($)	1,026,498

FINAL BCA

Benefit-Cost Summary	With Ecosystem Service benefits	Without Ecosystem Service benefits
Total Standard Mitigation Benefits ($):	$ 14,387,292	$ 220,853
Total Social Benefits ($):	$ 0	$ 0
Total Mitigation Project Benefits ($):	$ 14,387,292	$ 220,853
Total Mitigation Project Cost ($):	$ 7,988,812	$ 7,988,812
Benefit Cost Ratio - Standard:	1.80	0.03
Benefit Cost Ratio - Standard + Social:	1.80	0.03

FEMA BCA TOOLKIT 6.0

QUESTIONS?

CONTACT INFORMATION

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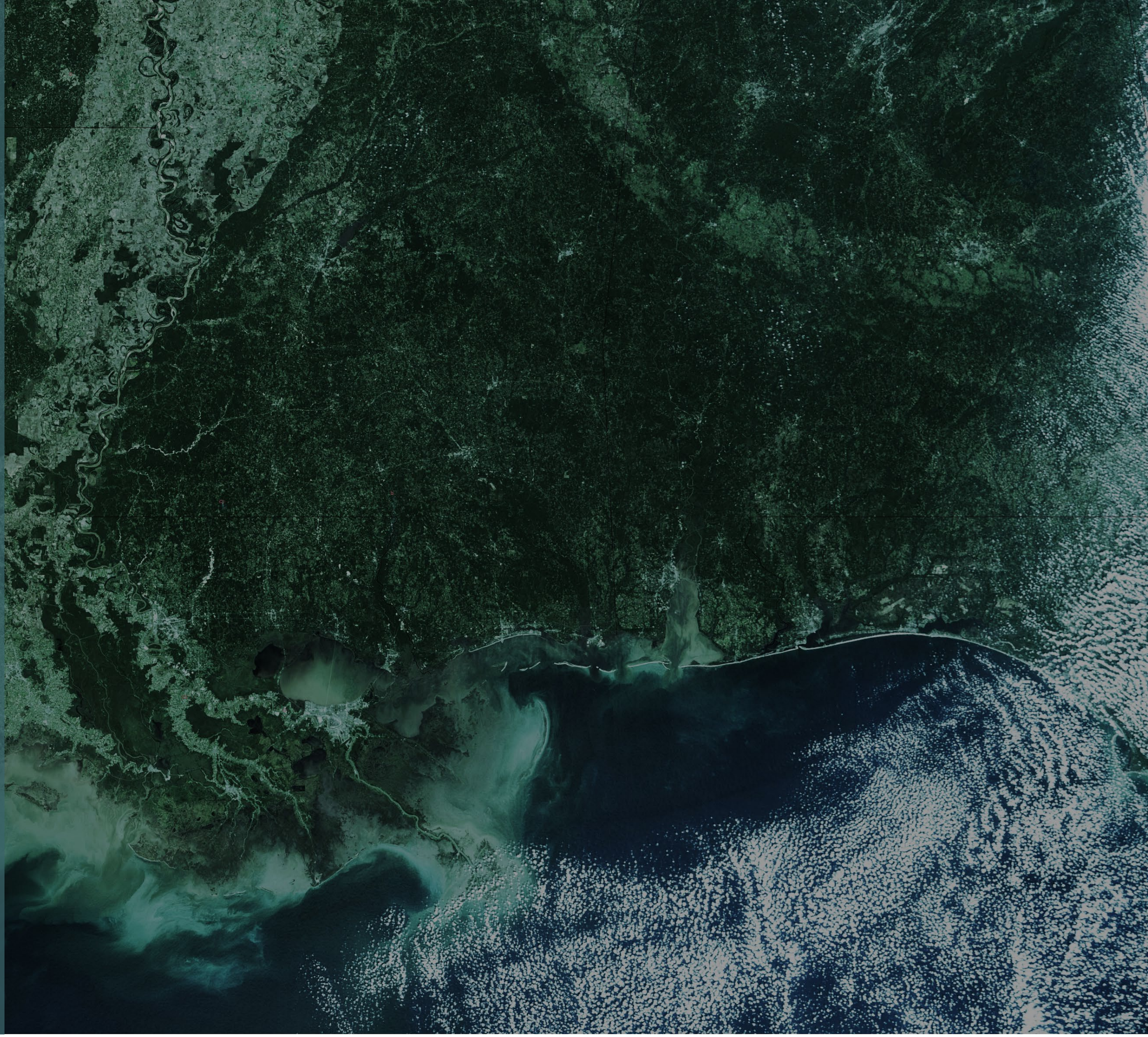
stokka.brown@csrsinc.com



THANK YOU

@LAWATERSHEDINITIATIVE

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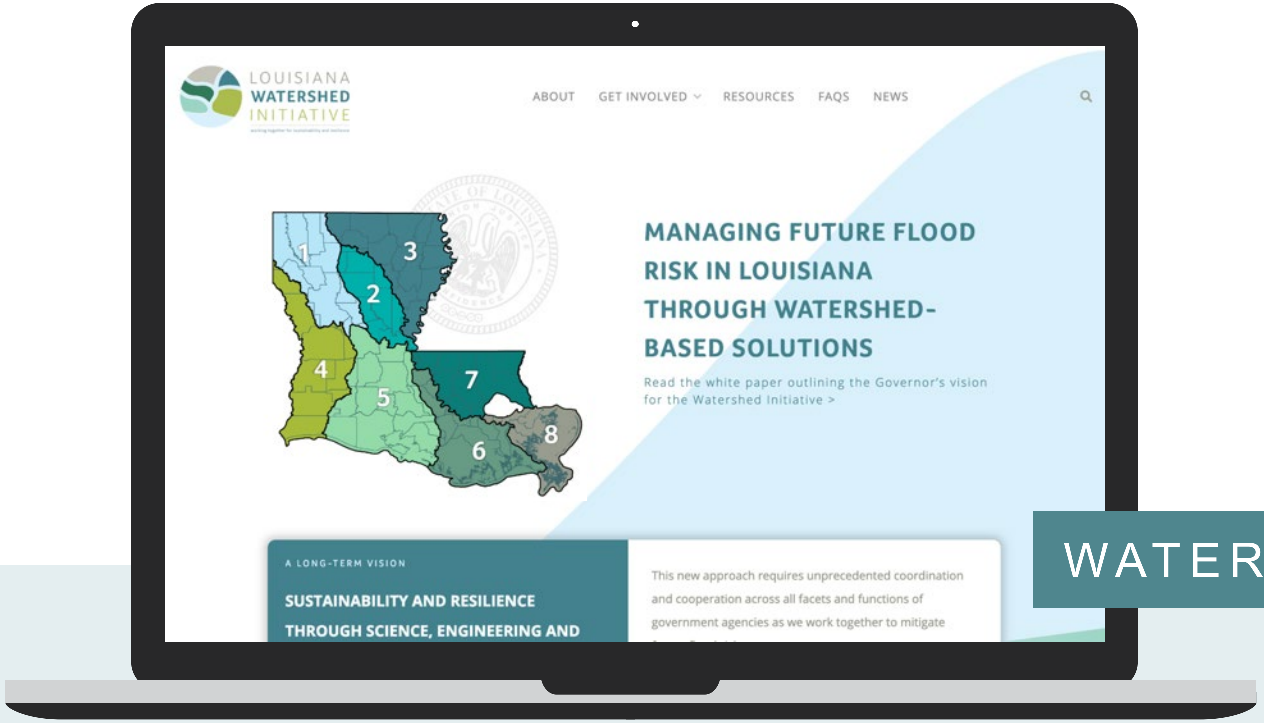
LOUISIANA WATERSHED INITIATIVE

WATERSHED@LA.GOV



WATERSHED.LA.GOV