ADAPTIVE LANDSCAPES + DESIGNING WITH SEDIMENT

GENA WIRTH
NJCRC Tech Workshop
09/11/2025

SCAPE
Dredge Research Collaborative

SCAPE LANDSCAPE ARCHITECTURE

PROFESSIONAL PRACTICE

90 PEOPLE

scapestudio.com

SCAPE

DREDGE RESEARCH COLLABORATIVE

NON-PROFIT RESEARCH GROUP

6-8 PEOPLE

dredgeresearchcollaborative.org

Dredge Research Collaborative


SCAPE

WHERE WE'RE LOCATED

SCAPE NYC

~70 full-time staff

SCAPE NOLA

~16 full-time staff

SCAPE SF

~8 full-time staff

LANDSCAPE THINKING AT ALL SCALES


Dredge Research Collaborative
Levees and Land Loss
Levees along the river are being raised to protect communities against a changing climate, yet their very existence accelerates a longer-term threat—the rapid loss of the delta's land.
Rob Holmes, Brett Milligan, Gena Wirth
With contributions by Sean Burkholder, Brian Davis, Justine Holzman
APPLIED RESEARCH +DESIGN

DREDGE RESEARCH COLLABORATIVE

SEAN BURKHOLDER - PHILADELPHIA, PA
BRIAN DAVIS - CHARLOTTESVILLE, VA
ROB HOLMES - AUBURN, AL
JUSTINE HOLZMAN - PRINCETON, NJ
BRETT MILLIGAN - DAVIS, CA
GENA WIRTH - NEW YORK, NY

TIM MALY
STEPHEN BECKER

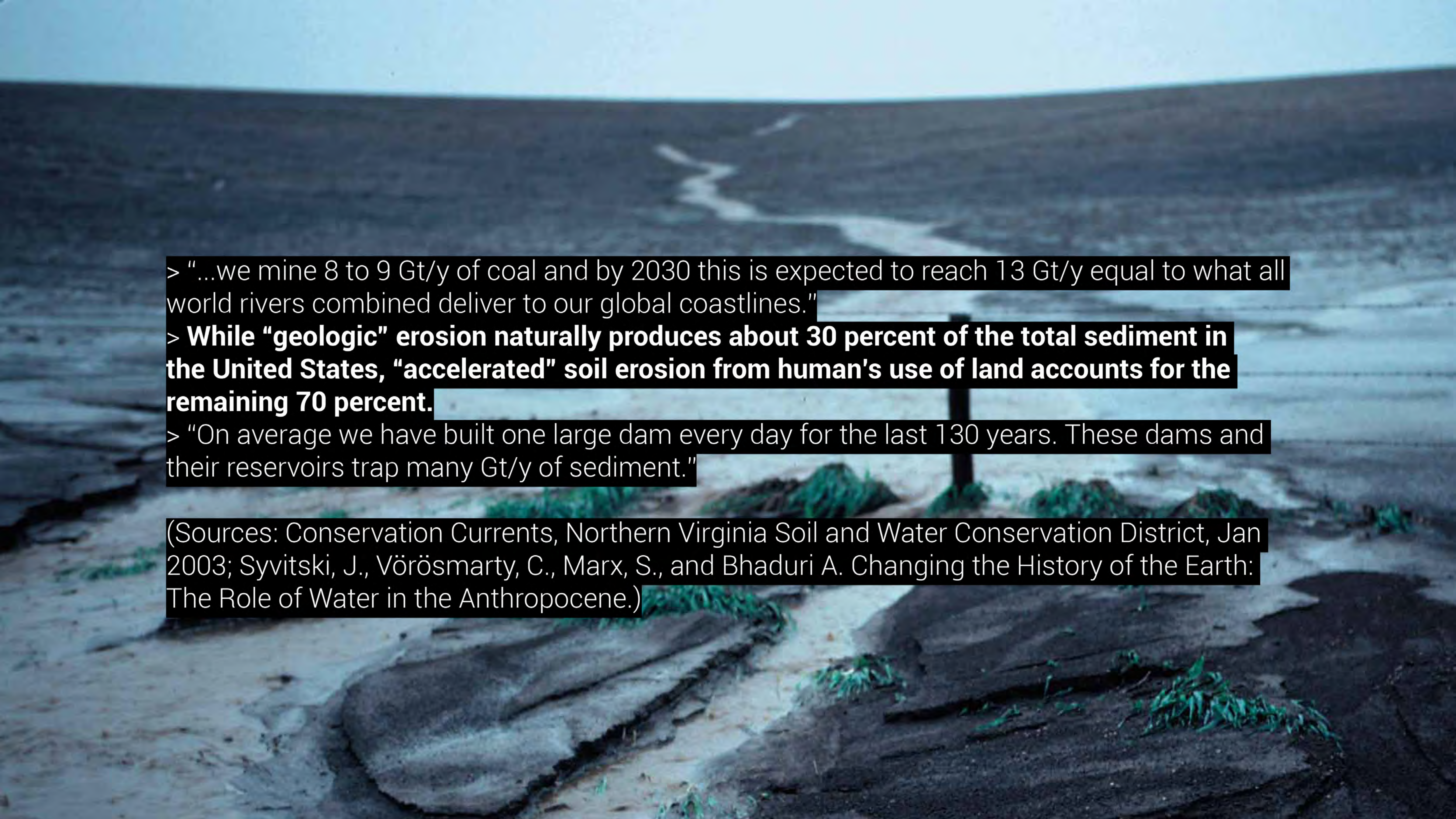
DRC INTERN COLLABORATORS

SYSTEMS OF WATER AND GEOLOGY
VISUAL REPRESENTATION
LANDSCAPE STORYTELLING


Levees and Land Loss
Levees along the river are being raised to protect communities against a changing climate, yet their very existence accelerates a longer-term threat—the rapid loss of the delta's land.
Subsidence, or the sinking of land, is a natural process that has been occurring in southern Louisiana for thousands of years. Human interventions, like levee building, have accelerated this process by preventing annual floods from depositing sediment that rebuilds land and encourages wetland accretion.
communities, providing habitats for a broad range of species, and supporting 30% of the commercial fishing catch in the United States.
232
New Orleans
Boothville - Venice
Bird's foot
233
Silt
Sand
Slurry
Dredging, Sediment, and the Worlds We Are Making
Rob Holmes, Brett Milligan, Gena Wirth
With contributions by Sean Burkholder, Brian Davis, Justine Holzman
APPLIED RESEARCH +DESIGN

Humans as Geologic Agents

[image: USACE]



> “...we mine 8 to 9 Gt/y of coal and by 2030 this is expected to reach 13 Gt/y equal to what all world rivers combined deliver to our global coastlines.”

> **While “geologic” erosion naturally produces about 30 percent of the total sediment in the United States, “accelerated” soil erosion from human’s use of land accounts for the remaining 70 percent.**

> “On average we have built one large dam every day for the last 130 years. These dams and their reservoirs trap many Gt/y of sediment.”

(Sources: Conservation Currents, Northern Virginia Soil and Water Conservation District, Jan 2003; Syvitski, J., Vörösmarty, C., Marx, S., and Bhaduri A. Changing the History of the Earth: The Role of Water in the Anthropocene.)

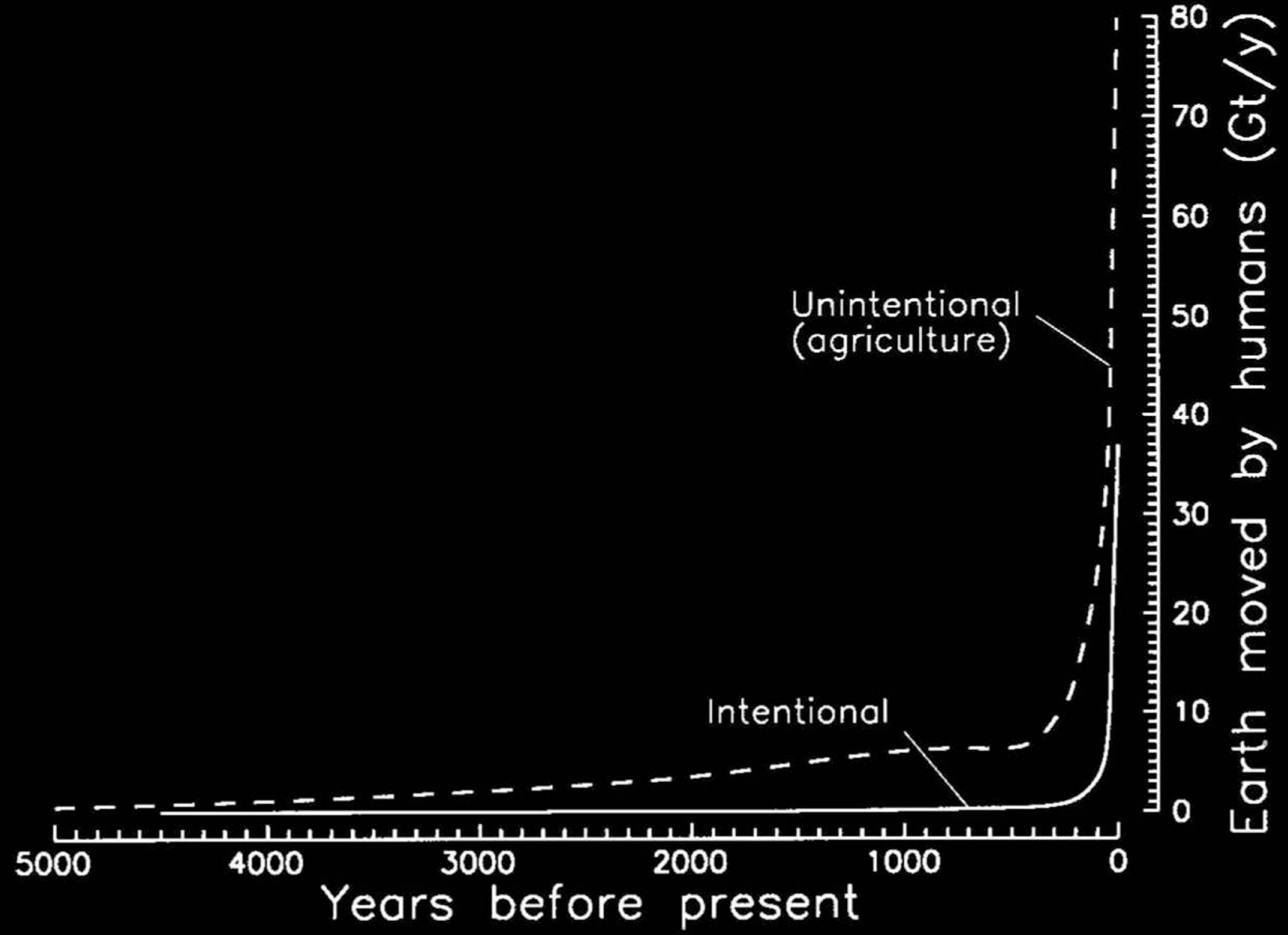
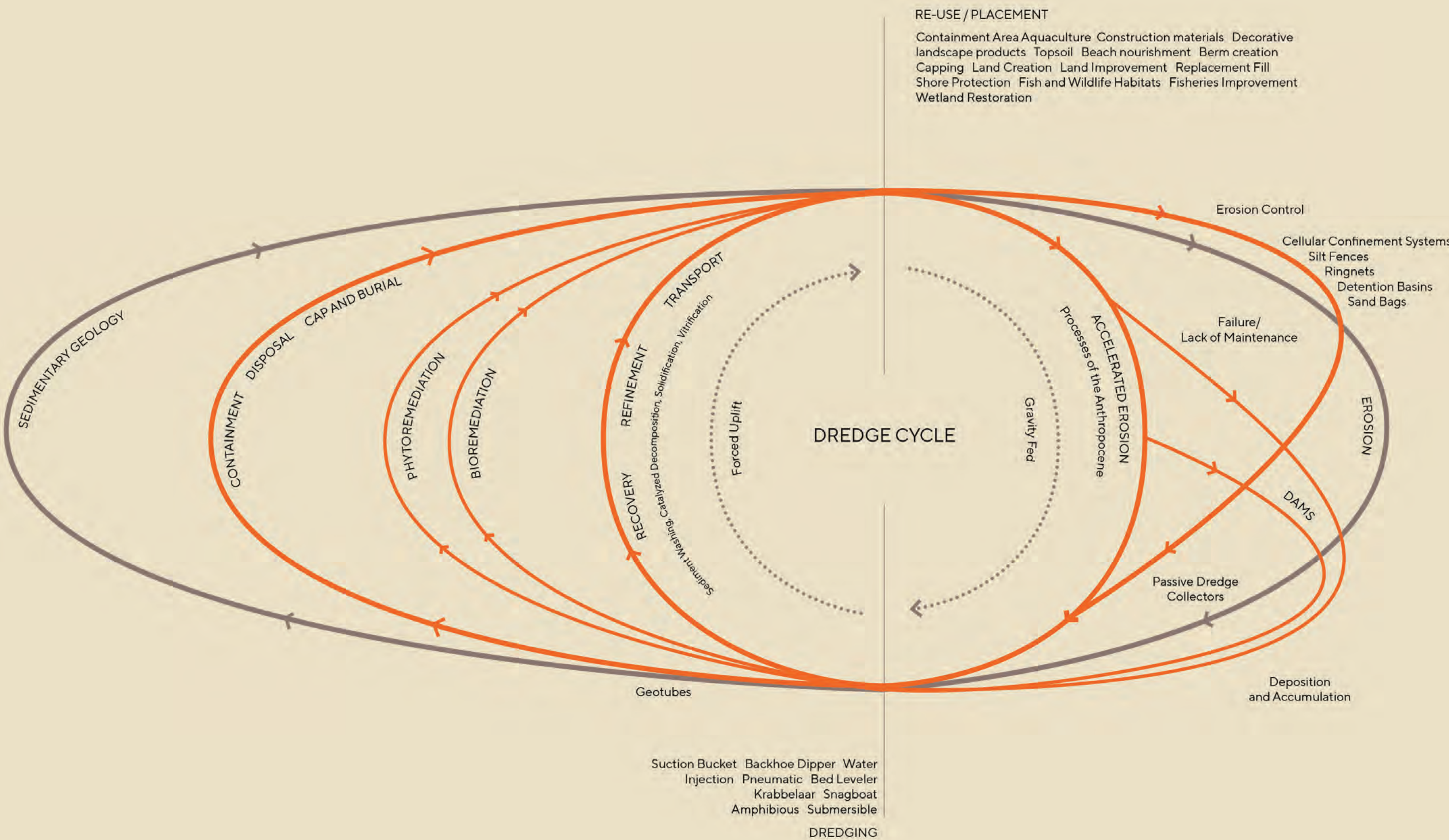


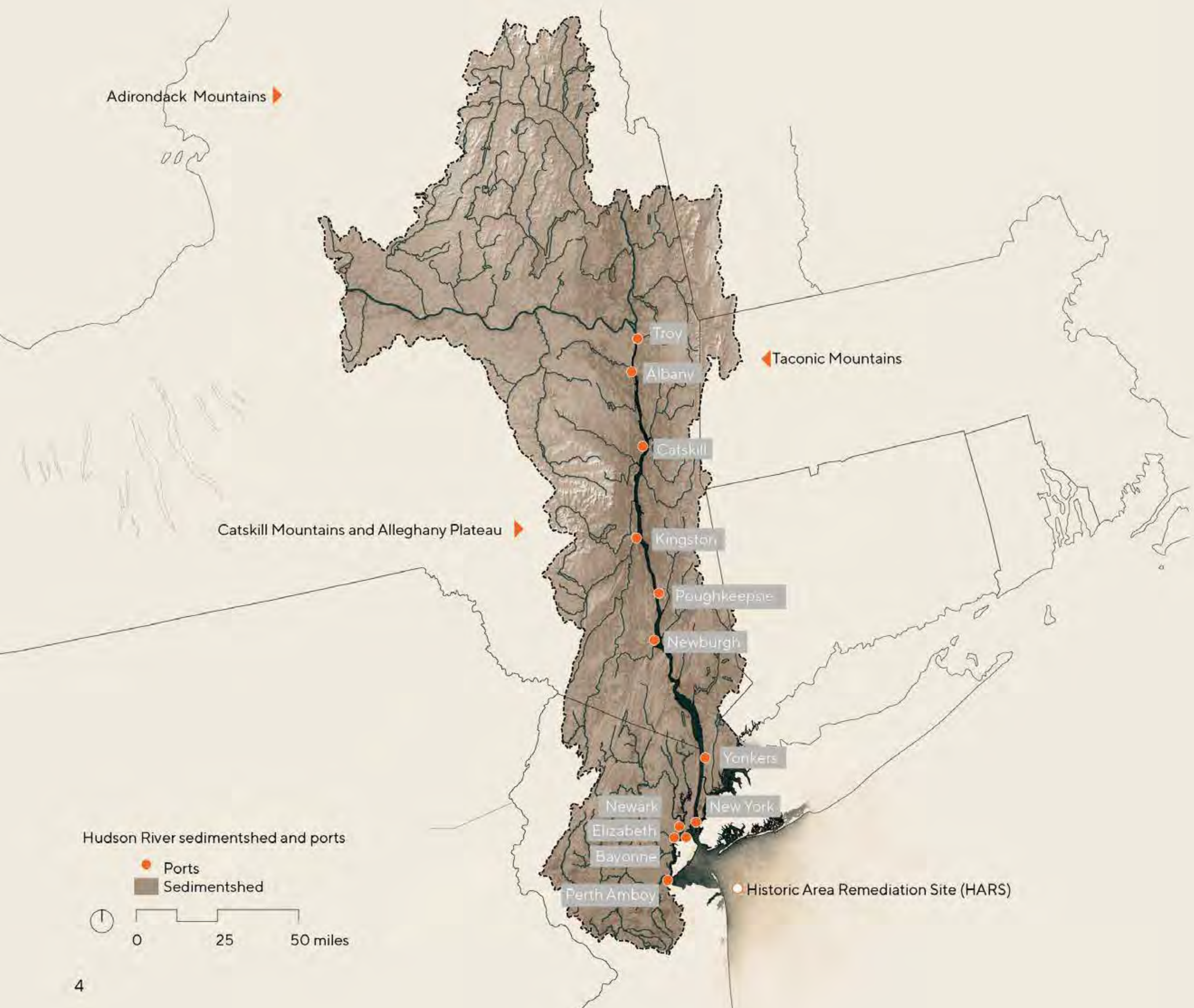
Figure 4. Estimate of total amount of earth moved annually by humans at various times in the past. Curves were obtained by multiplying earth moved per capita (Fig. 2) by population (Fig. 3).

["On the History of Humans as Geomorphic Agents", Roger Hooke, 2000]



RE-USE / PLACEMENT
Containment Area Aquaculture Construction materials Decorative landscape products Topsoil Beach nourishment Berm creation Capping Land Creation Land Improvement Replacement Fill Shore Protection Fish and Wildlife Habitats Fisheries Improvement Wetland Restoration
Erosion Control
Cellular Confinement Systems
Silt Fences
Ringnets
Detention Basins
Sand Bags
Failure/
Lack of Maintenance
SEDIMENTARY GEOLOGY
CONTAINMENT
DISPOSAL
CAP AND BURIAL
PHYTOREMEDIATION
BIOREMEDIATION
TRANSPORT
REFINEMENT
RECOVERY
Sediment Washing, Catalyzed Decomposition, Solidification, Vitrification
Forced Uplift
DREDGE CYCLE
Gravity Fed
Processes of the Anthropocene
ACCELERATED EROSION
EROSION
DAMS
Passive Dredge
Collectors
Geotubes
Deposition
and Accumulation
Suction Bucket Backhoe Dipper Water Injection Pneumatic Bed Leveler Krabbelaar Snagboat Amphibious Submersible
DREDGING

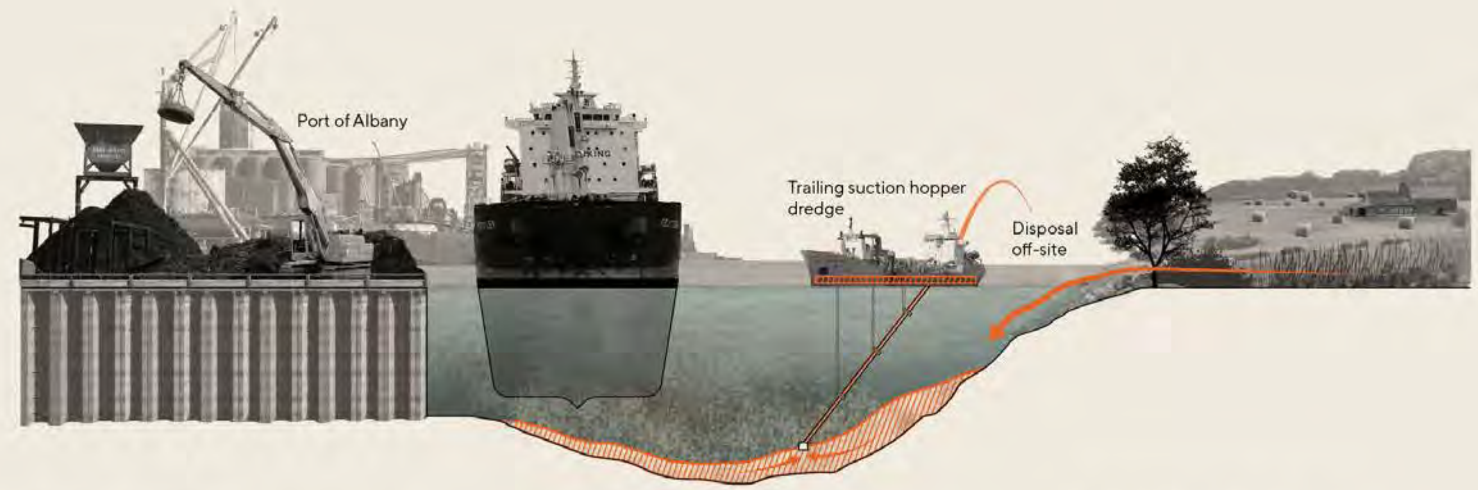

INLAND COAST
The Great Lakes
Major Ports: Duluth & Toledo
Major River: St. Lawrence
Sedimentshed: approx 295,700 sq. mi.
EAST COAST
New York & New Jersey
Major Port: NY & NJ
Major River: Hudson
Sedimentshed: 13,400 sq. mi.
WEST COAST
California
Major Ports: San Francisco
Major River: Sacramento / San Joaquin
Sedimentshed: 75,000 sq. mi.
GULF COAST
Louisiana
Major Port: New Orleans
Major River: Mississippi
Sedimentshed Area: 1.2 M sq. mi.



UPSTREAM SEDIMENT SOURCES:
Storm runoff and spring snow melt

Small tributaries channel sediment to larger river systems

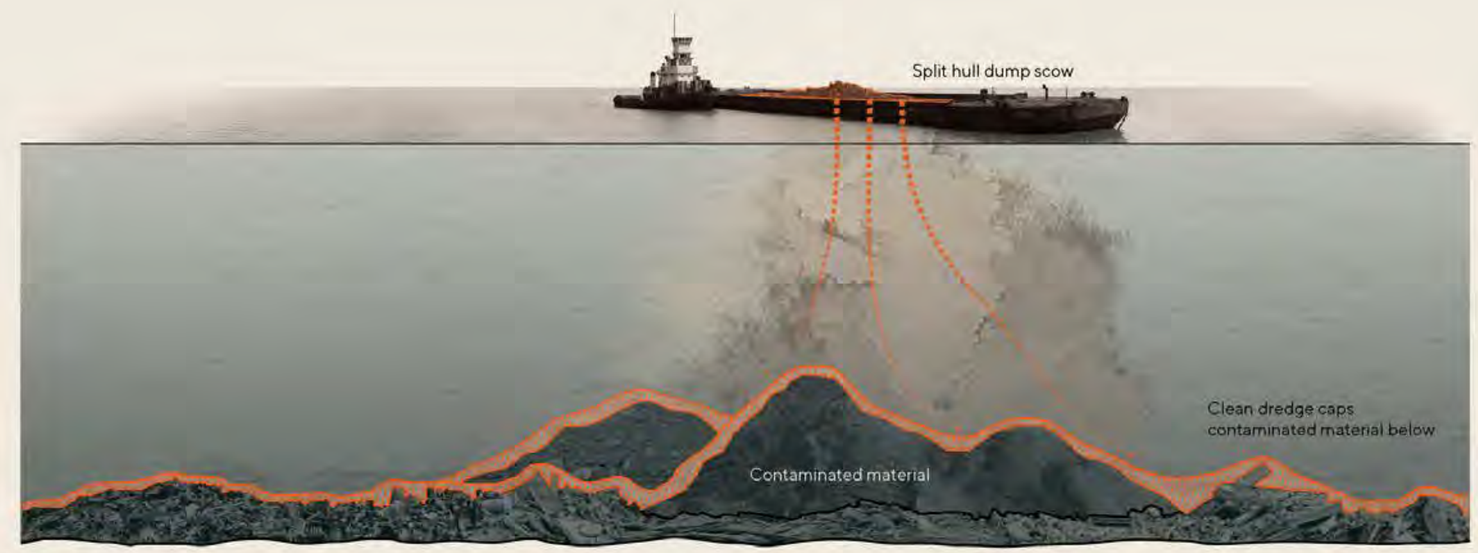
Deforestation and developed lands increase erosion and sediment flows downstream



HUDSON RIVER PORTS:
River edges are straightened and hardened for port operation

Sediment accumulates on river bottom, impacting water transport

Dredging occurs throughout the river to maintain navigable waterways



OFFSHORE PLACEMENT:
Much of the dredged material from the New York / New Jersey Harbor is placed offshore

Tug boats push dump scow barges filled with dredge which is then release into the site

Newly placed dredged material caps contaminated spoils below

Harbor deepening and acceleration

Early container ship
1970
1,000 - 2,500 TEU

Panamax Max
1985
3,400 - 4,500 TEU

Post Panamax II
2000
6,000 - 8,500 TEU

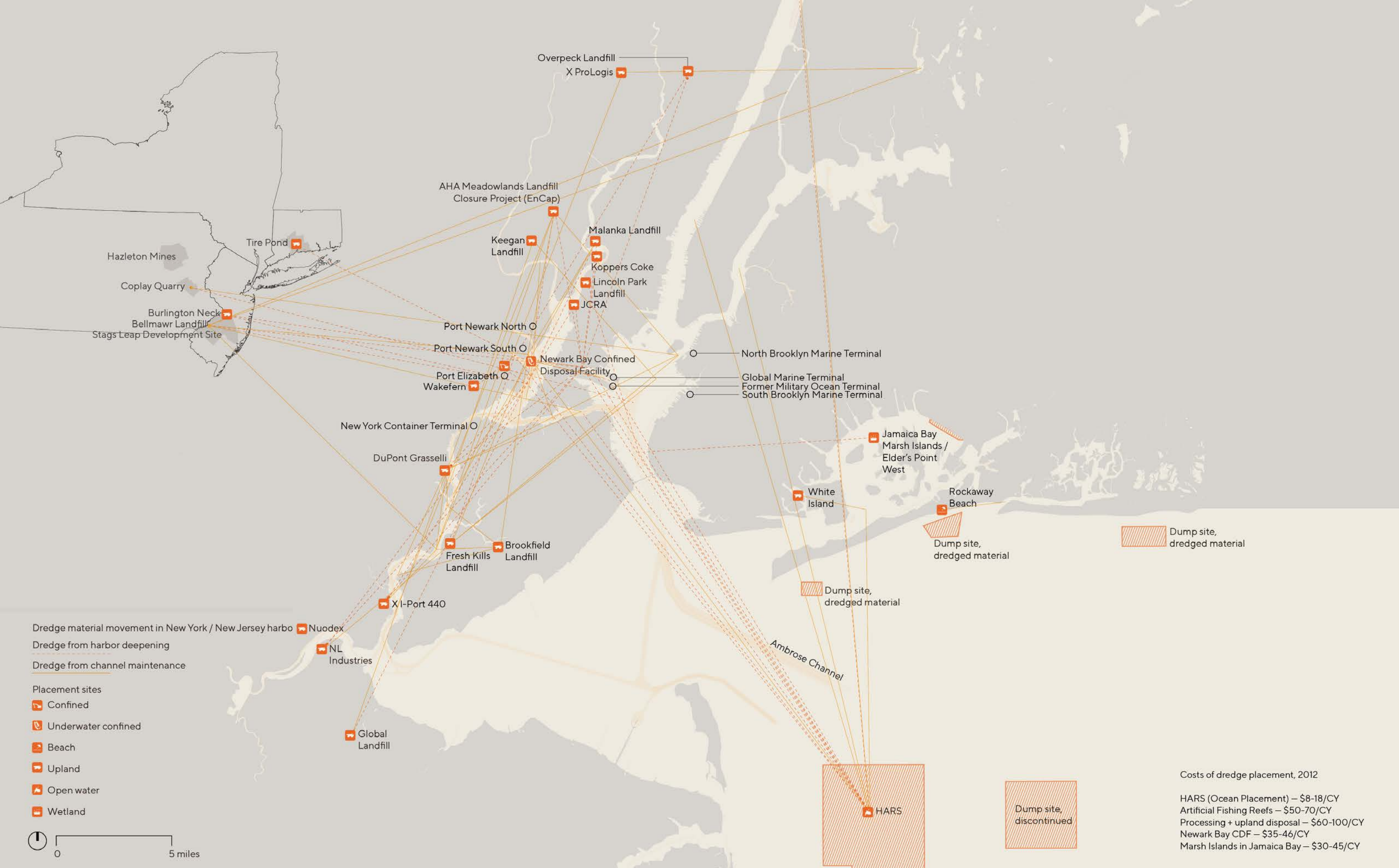
Very large container ship (VLCS)
2006
11,000 - 15,000 TEU

Ultra large container ship (ULCS)
2019
21,000 - 25,000 TEU

Global Container Ship Evolution
TEU= twenty foot equivalent unit

Blasting bedrock to deepen harbor channels for larger container ships

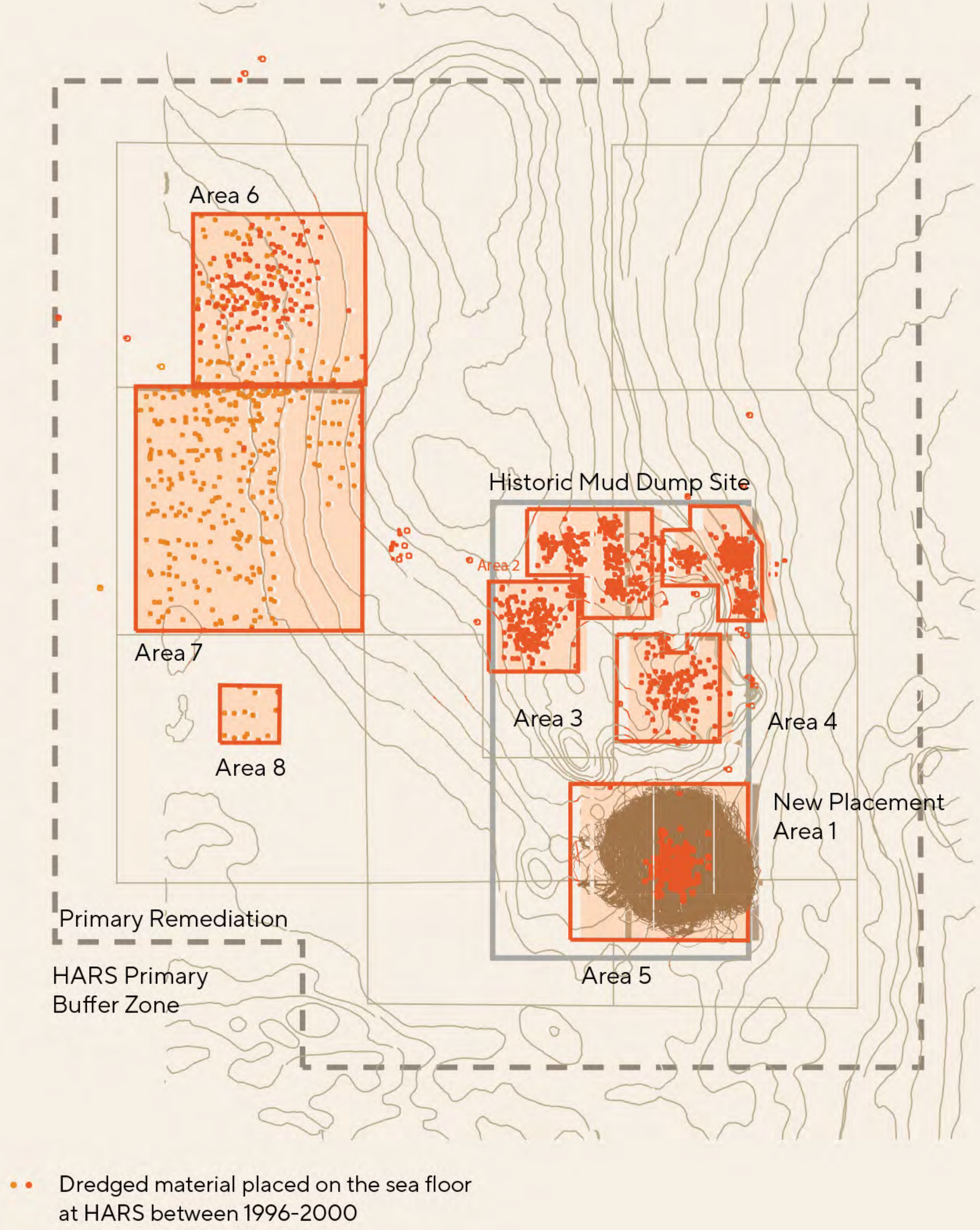
Dredge 54 Bucket Arthur Kill Channel Deepening (USACE



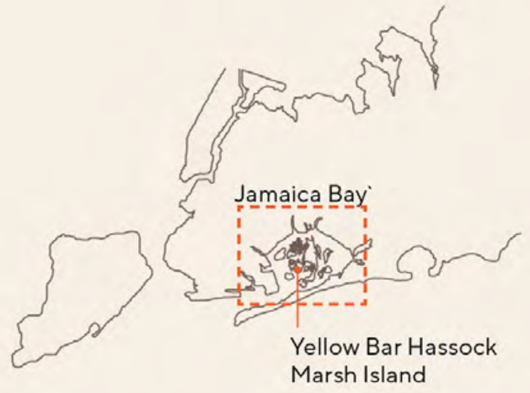
Costs of dredge placement, 2012

HARS (Ocean Placement) – $8-18/CY
Artificial Fishing Reefs – $50-70/CY
Processing + upland disposal – $60-100/CY
Newark Bay CDF – $35-46/CY
Marsh Islands in Jamaica Bay – $30-45/CY


Troy
Albany
Taconic Mountains
Catskill
eghany Plateau
Kingston
Poughkeepsie
Newburgh
Yonkers
Newark
Elizabeth
New York
Bayonne
Perth Amboy
Historic Area Remediation Site (HARS)


Area 6
Area 7
Area 8
Historic Mud Dump Site
Area 2
Area 3
Area 4
New Placement
Area 1
Area 5
Primary Remediation
HARS Primary
Buffer Zone
Dredged material placed on the sea floor
at HARS between 1996-2000

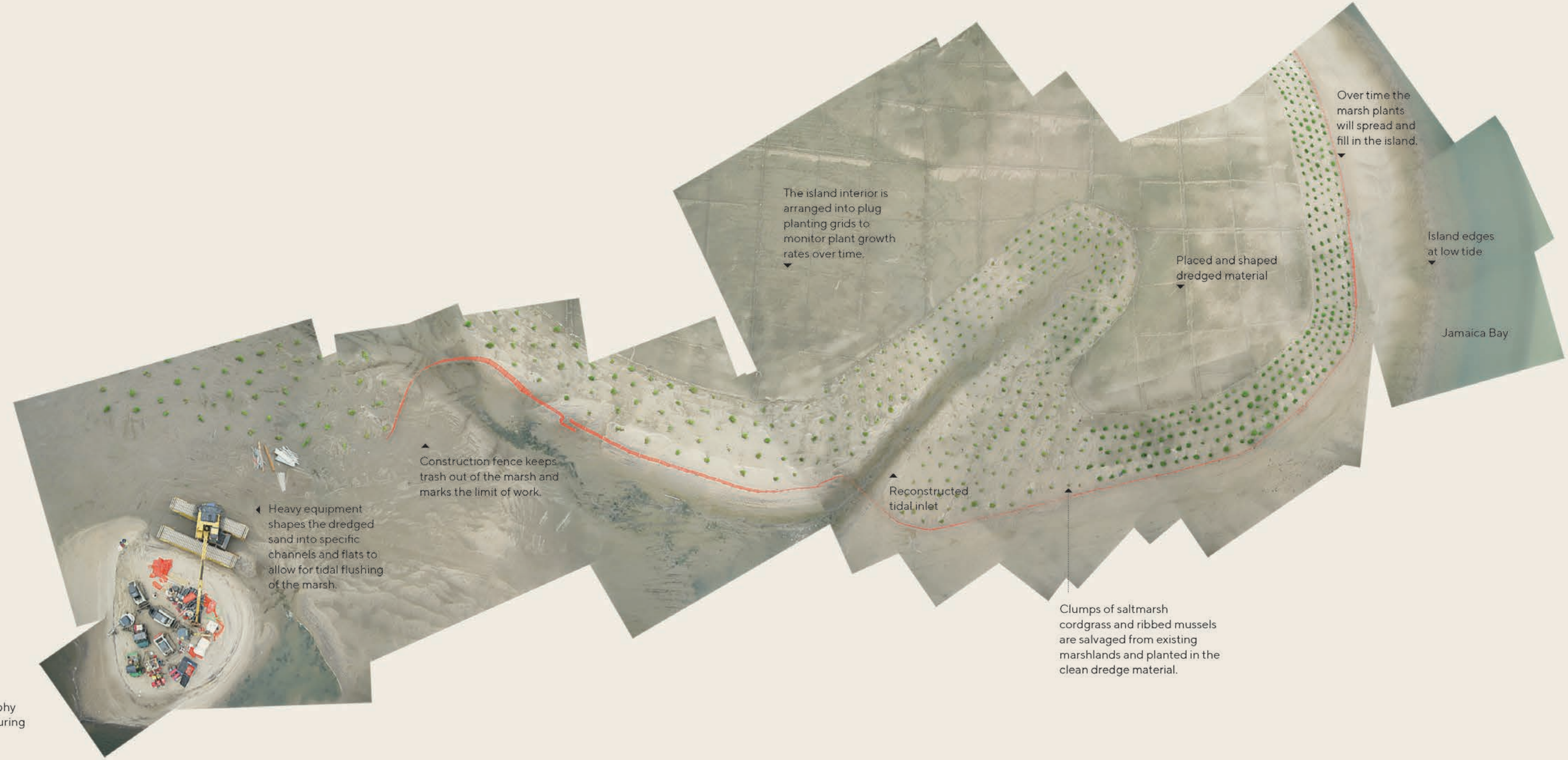
Rebuilding lost marsh islands



Aerial image of Yellow Bar Hassock at beginning of construction (Google Maps, 2011)

Aerial image of Yellow Bar Hassock under construction
overlaid with construction drawings and balloon photography (2012)

Jamaica Bay Marsh Island Stakeholders (USACE, 2000)

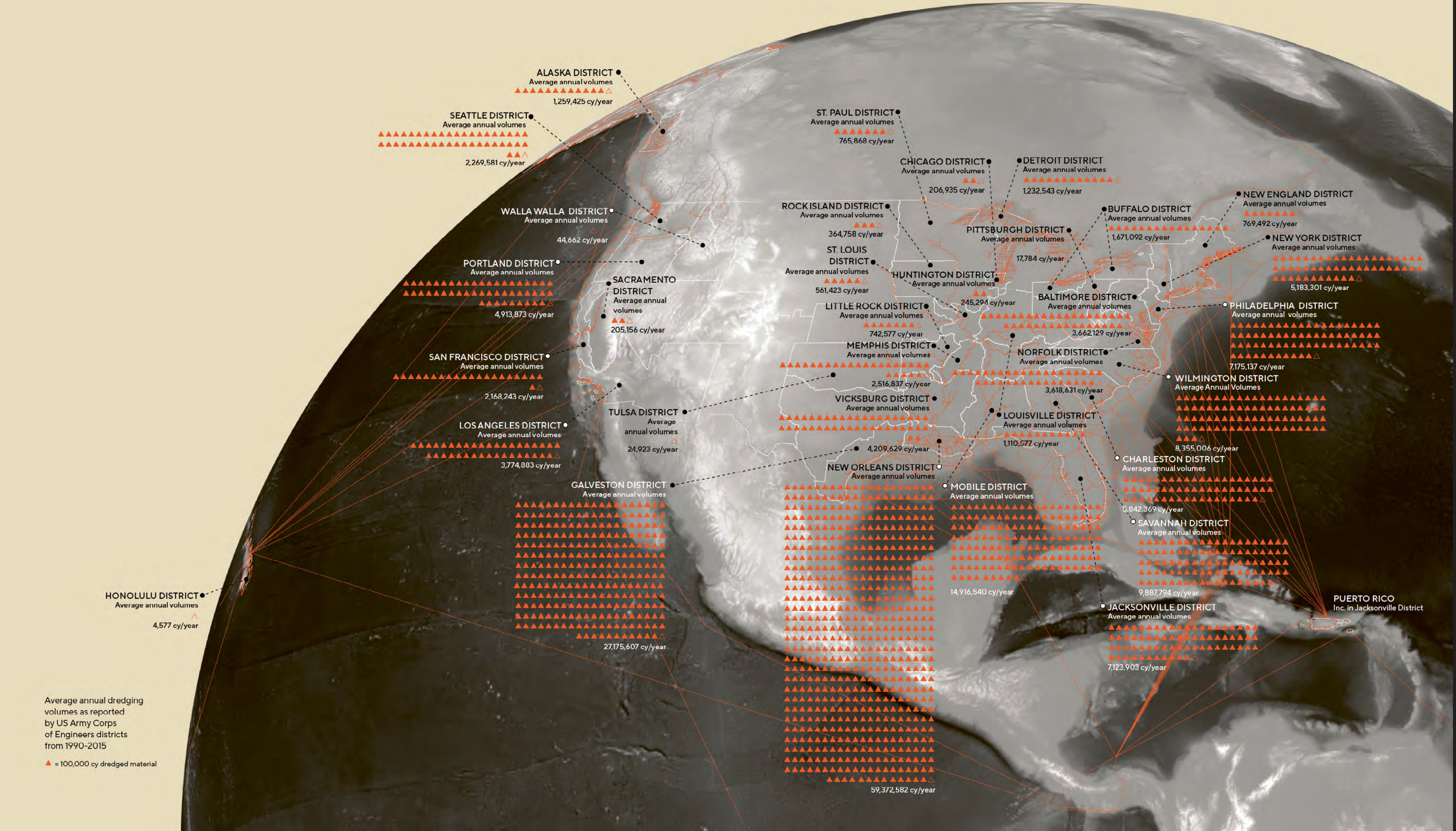


Balloon aerial photography of Yellow Bar Hassock during restoration planting

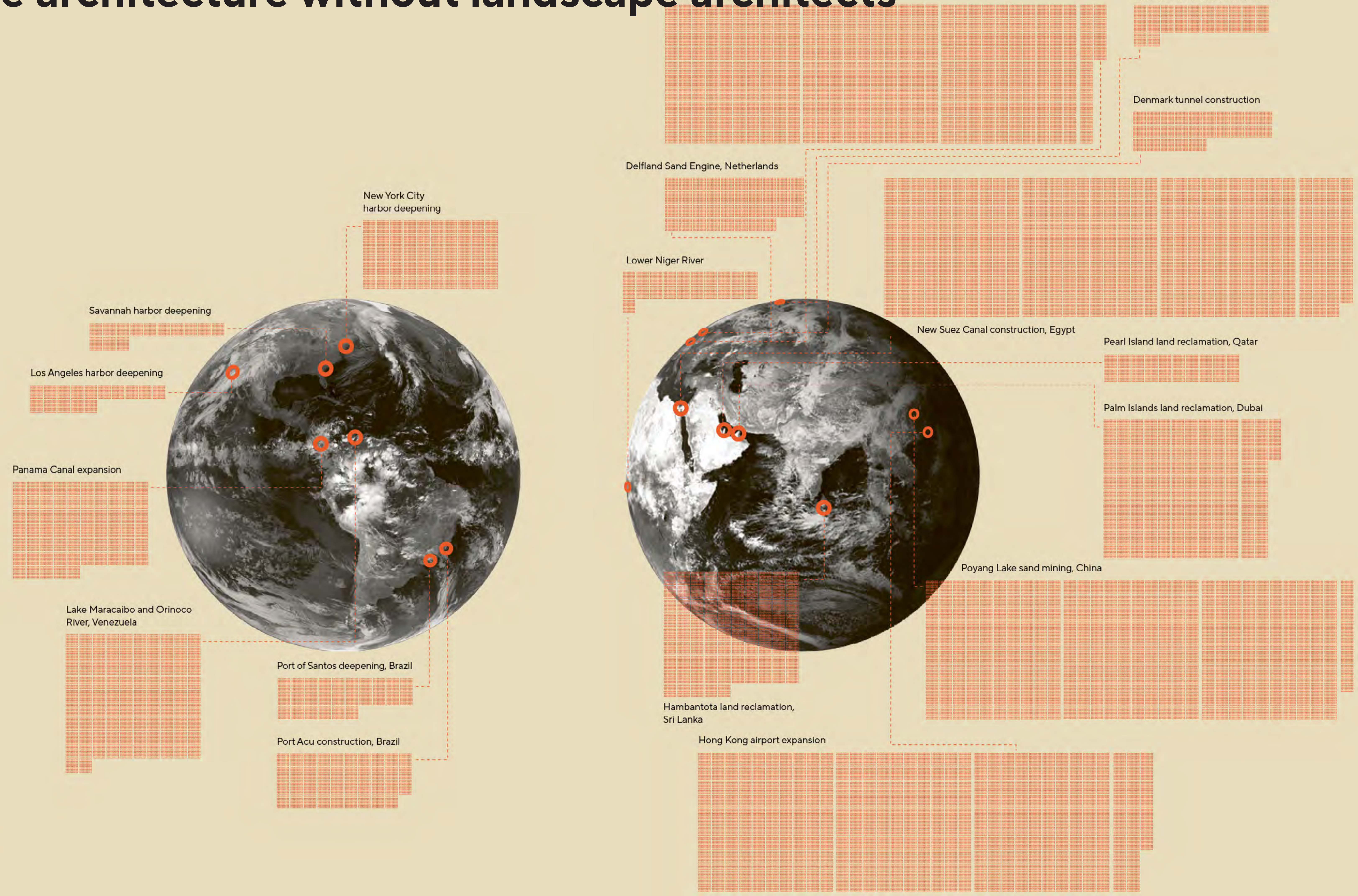





The scale at which landscapes are being made



Landscape architecture without landscape architects

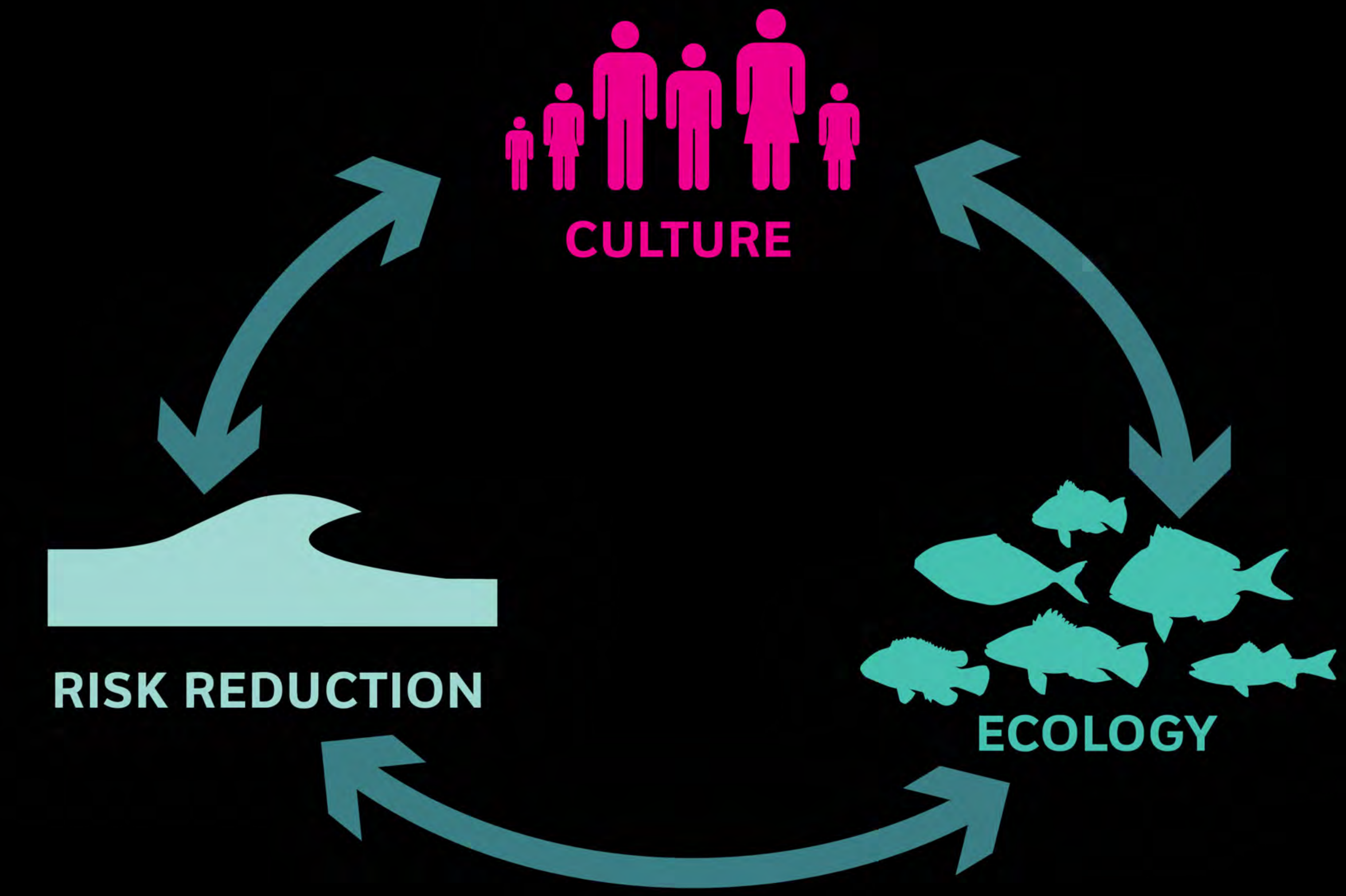


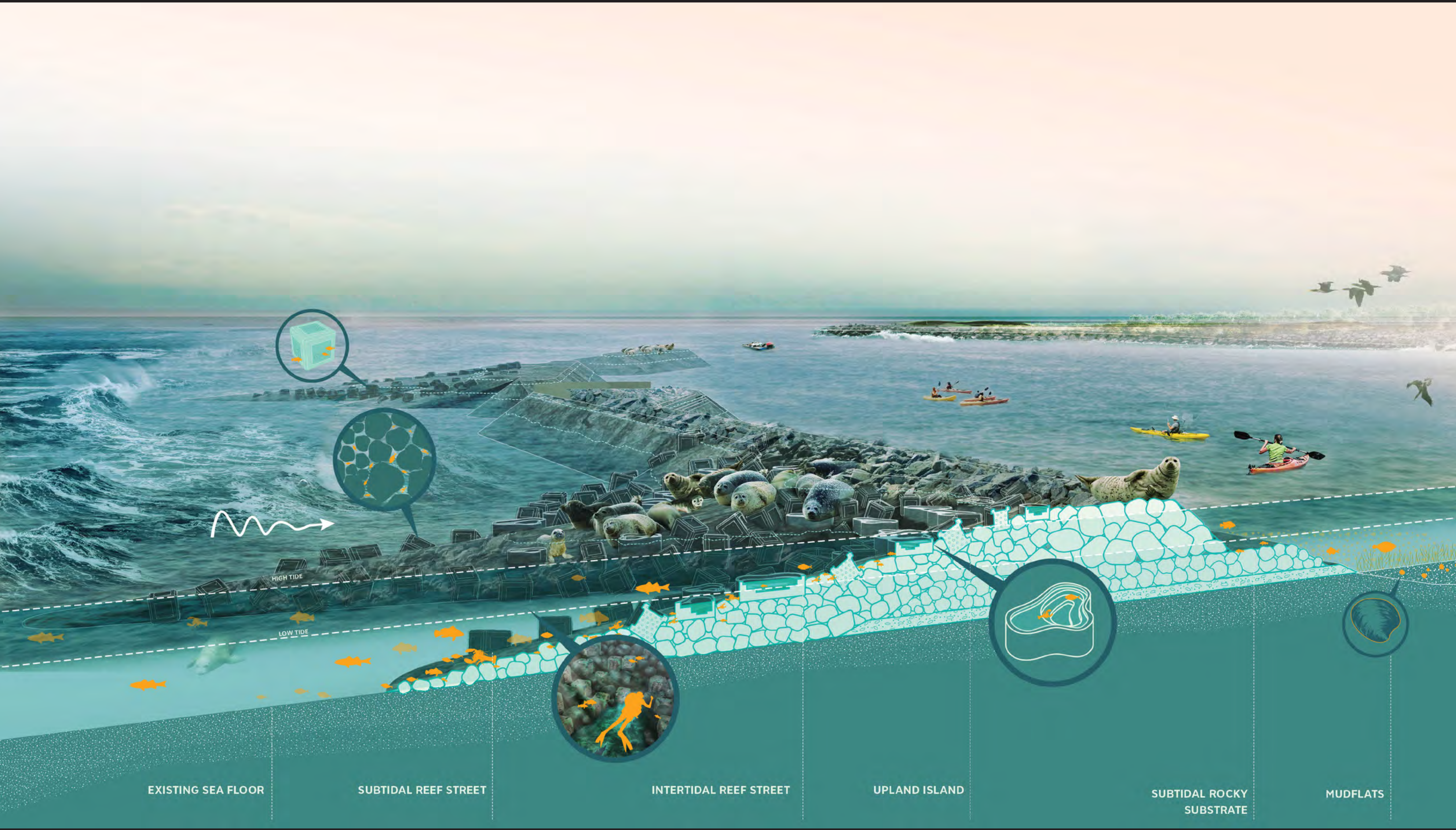
Volumetric comparison of a selection of recent global dredging projects

= 1,000,000 cy dredged material

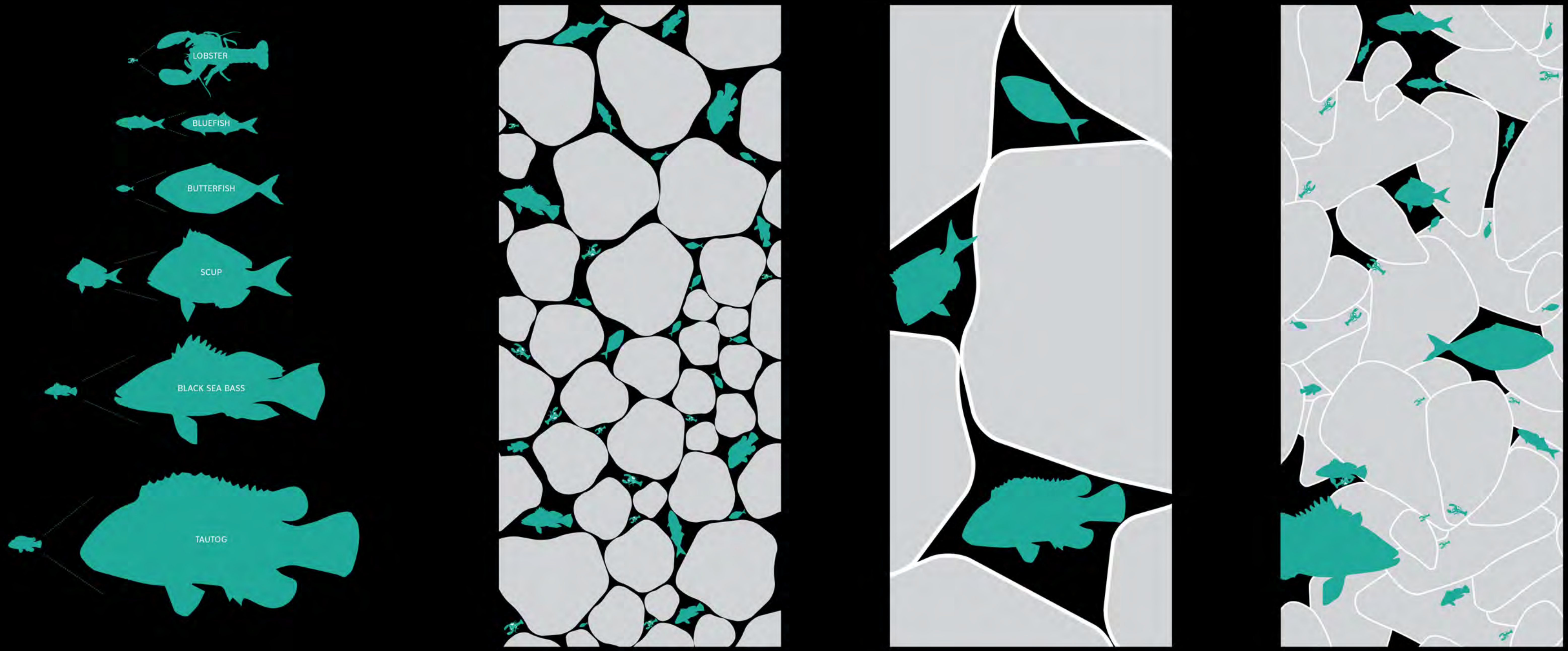
LIVING BREAKWATERS


LIVING BREAKWATERS
STATEN ISLAND + RARITAN BAY
HUD REBUILD BY DESIGN
$60M FUNDING
GOVERNORS OFFICE OF STORM RECOVERY
LIVING BREAKWATERS
NY RISING
SCAPE TEAM
SCAPE / LANDSCAPE ARCHITECTURE
OCEAN AND COASTAL CONSULTANTS
PARSONS BRINCKERHOFF
ARCADIS
SEARC ECOLOGICAL MARINE CONSULTING
LOT-EK ARCHITECTURE
MFS CONSULTING ENGINEERS
PRUDENT ENGINEERING


CULTURE
RISK REDUCTION
ECOLOGY


HIGH TIDE
LOW TIDE
EXISTING SEA FLOOR
SUBTIDAL REEF STREET
INTERTIDAL REEF STREET
UPLAND ISLAND
SUBTIDAL ROCKY SUBSTRATE
MUDFLATS

CREATE NICHES

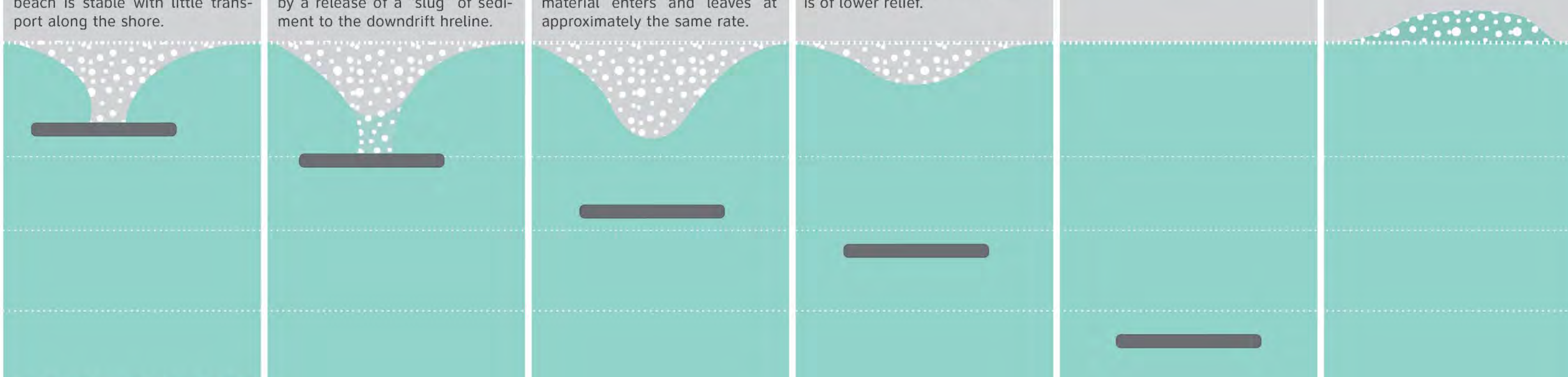



West Marine


EAGLES
TRIDENT
AQUATIC CLUB

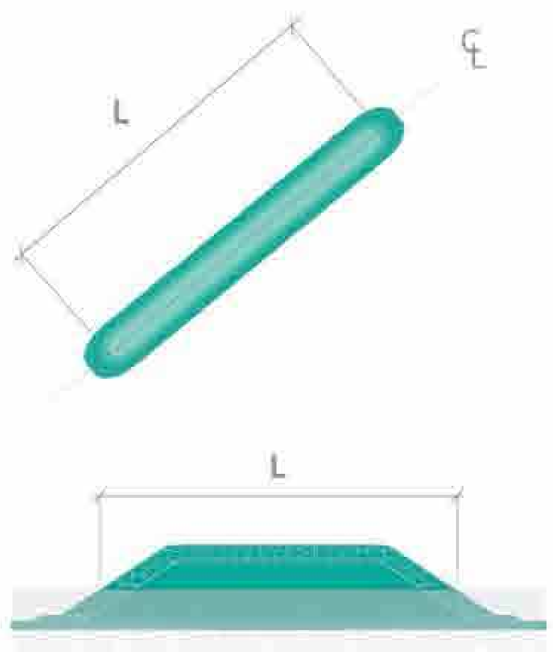
SHORELINE RESPONSE

X	?	√	√ √	√	X
TOMBOLO	**PERIODIC TOMBOLO**	**STRONG SALIENT**	**SUBDUED SALIENT**	**NO SINUOSITY / MINIMAL IMPACT**	**ERODED**
very little wave energy reaches the shore, sediment builds up behind the breakwater, connecting it to the shoreline, and the beach is stable with little transport along the shore.	One or more of the breakwater segments is periodically backed by tombolos with a periodic trapping of littoral material followed by a release of a "slug" of sediment to the downdrift hreline.	somewhat higher wave energy reaches the lee of the structures; characterized by a balanced sediment budget. Longshore moving material enters and leaves at approximately the same rate.	yet higher wave energy reaches the shoreline; the shoreline response is not as pronounced and the amplitude of the salient is of lower relief.	high wave energy reaches the beach, resulting in little, if any shoreline response.	

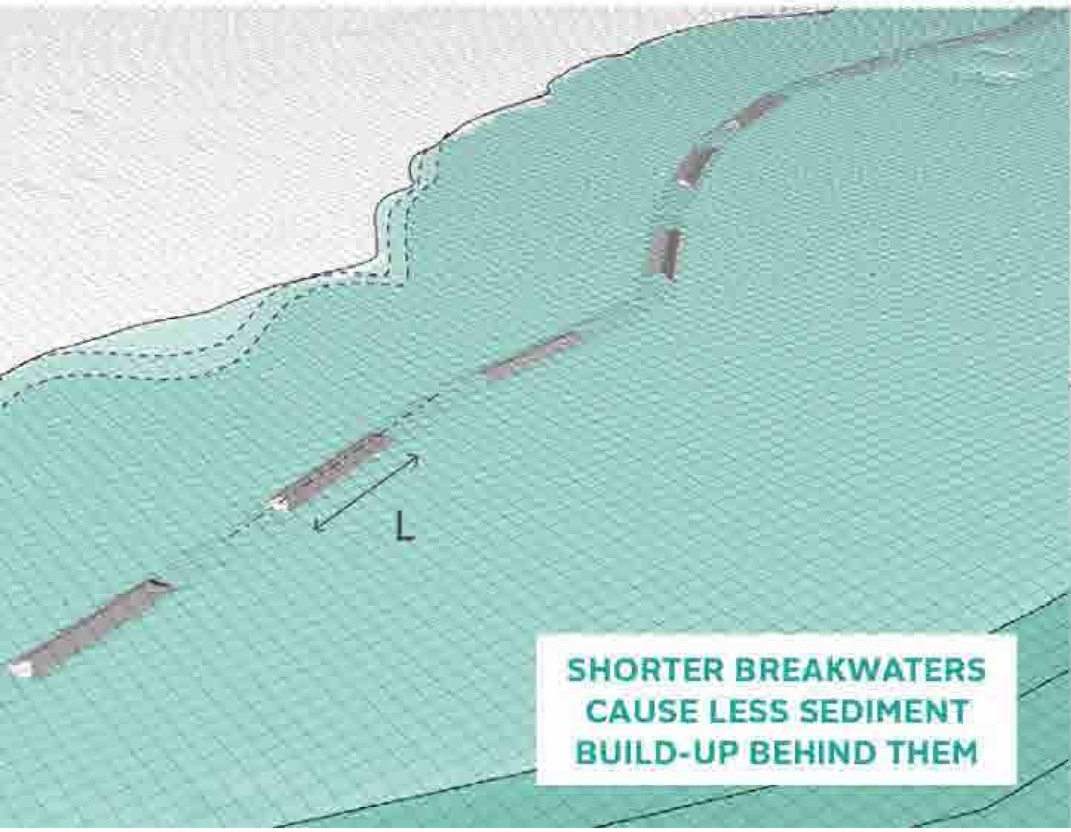


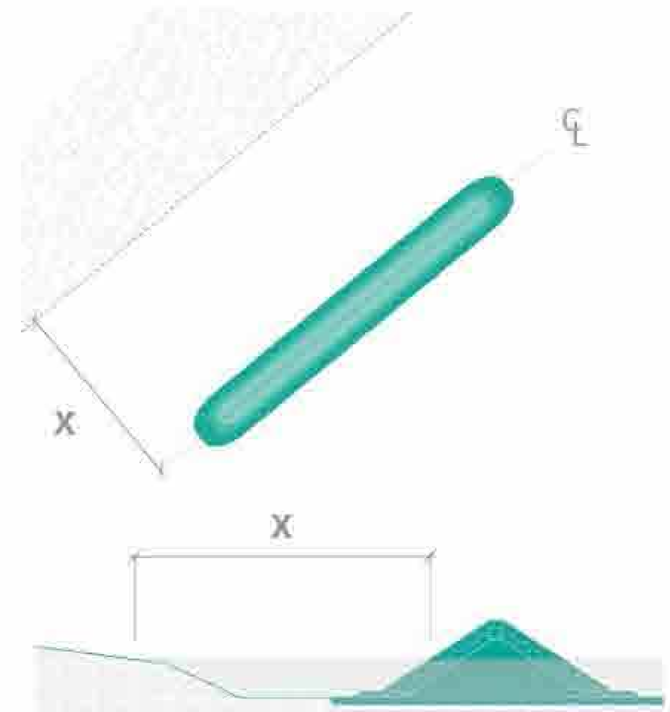
(FOR BREAKWATERS IN A SYSTEM)

Tombolo	Periodic Tombolo	Strong Salient	Subdued Salient	No Sinuosity / Minimal Impact	Source
	Ls/X >2.0	1.5 > Ls/X > .8	.8 > Ls/X	.27 > Ls/X	Ahrens & Cox (1990)
	Ls/X > 1.5	.67 > Ls/X > .5		.125 > Ls/X	Dally & Pope (1986)
	Ls/X > 2B/L				Suh & Dalrymple (1987)
				.17 > Ls/X	Nobel
	Ls/X > 1.3	1.3 > Ls/X > .5		.5 > Ls/X	Bricio, Negro and Diez (2008)

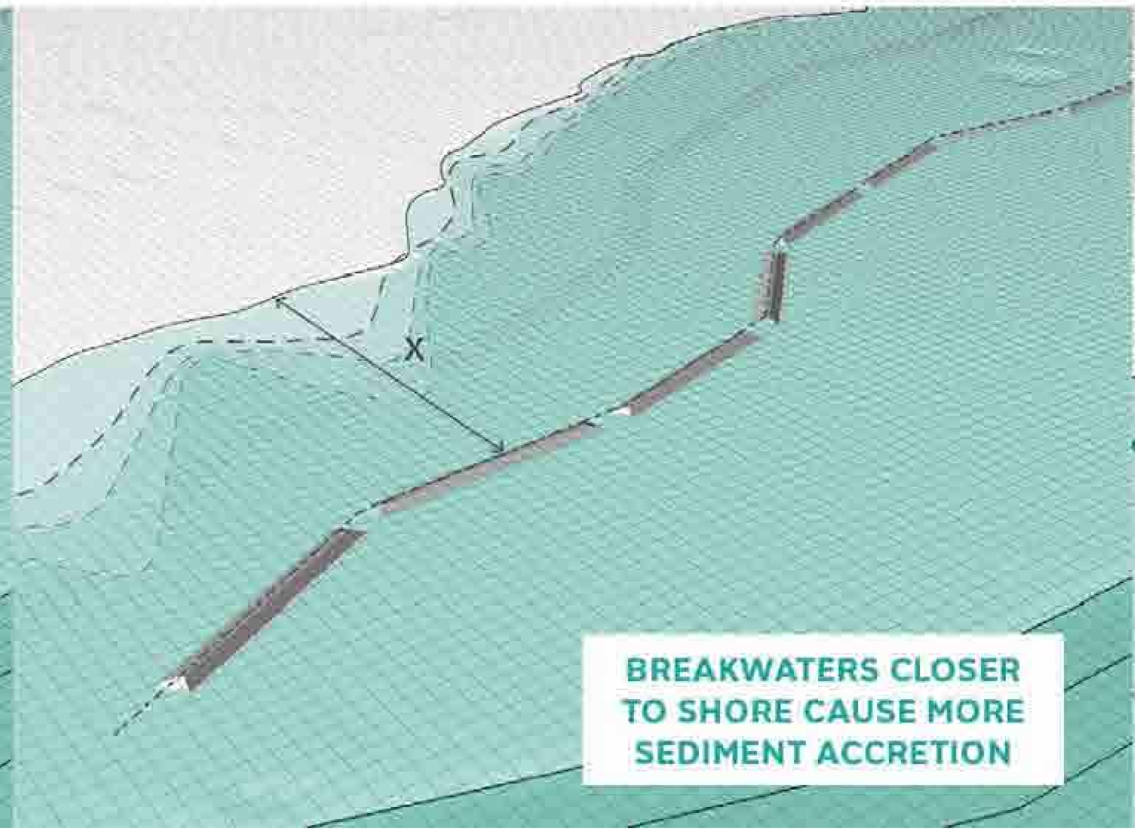


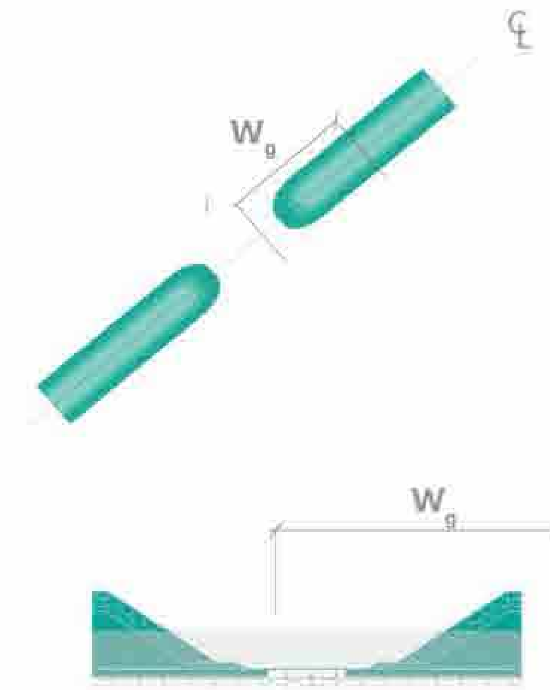
LENGTH (L)



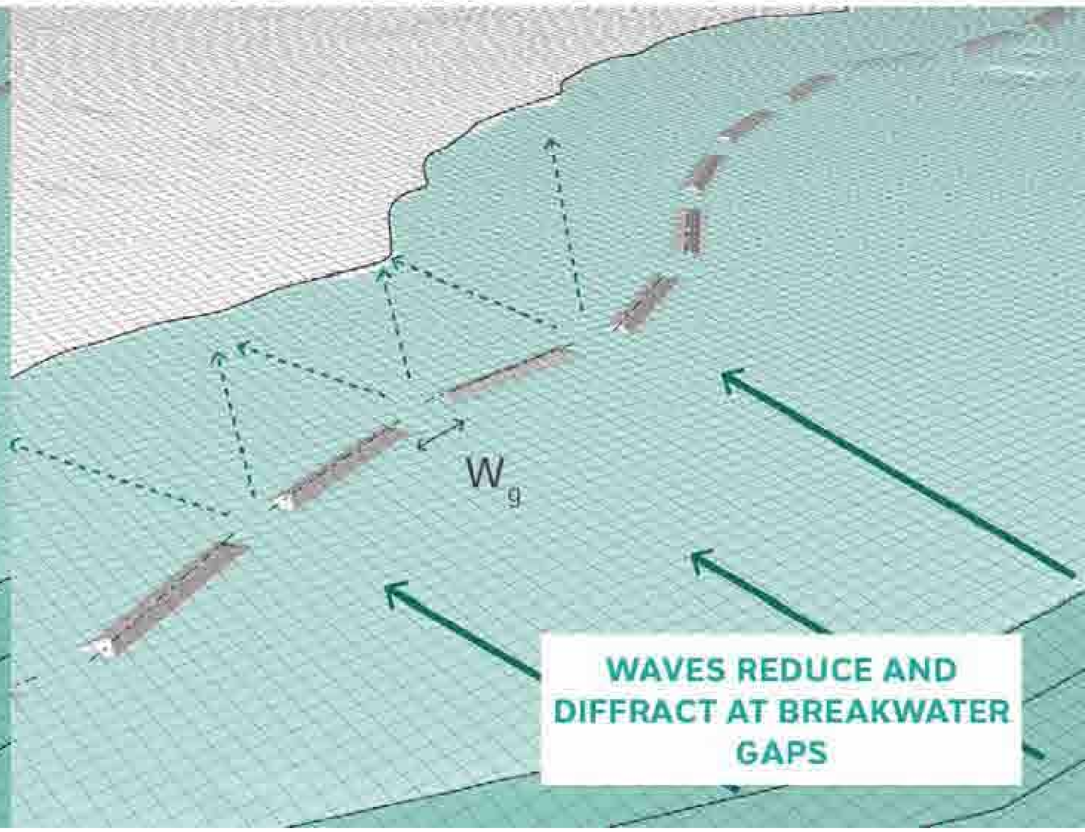


DISTANCE FROM SHORE (X)





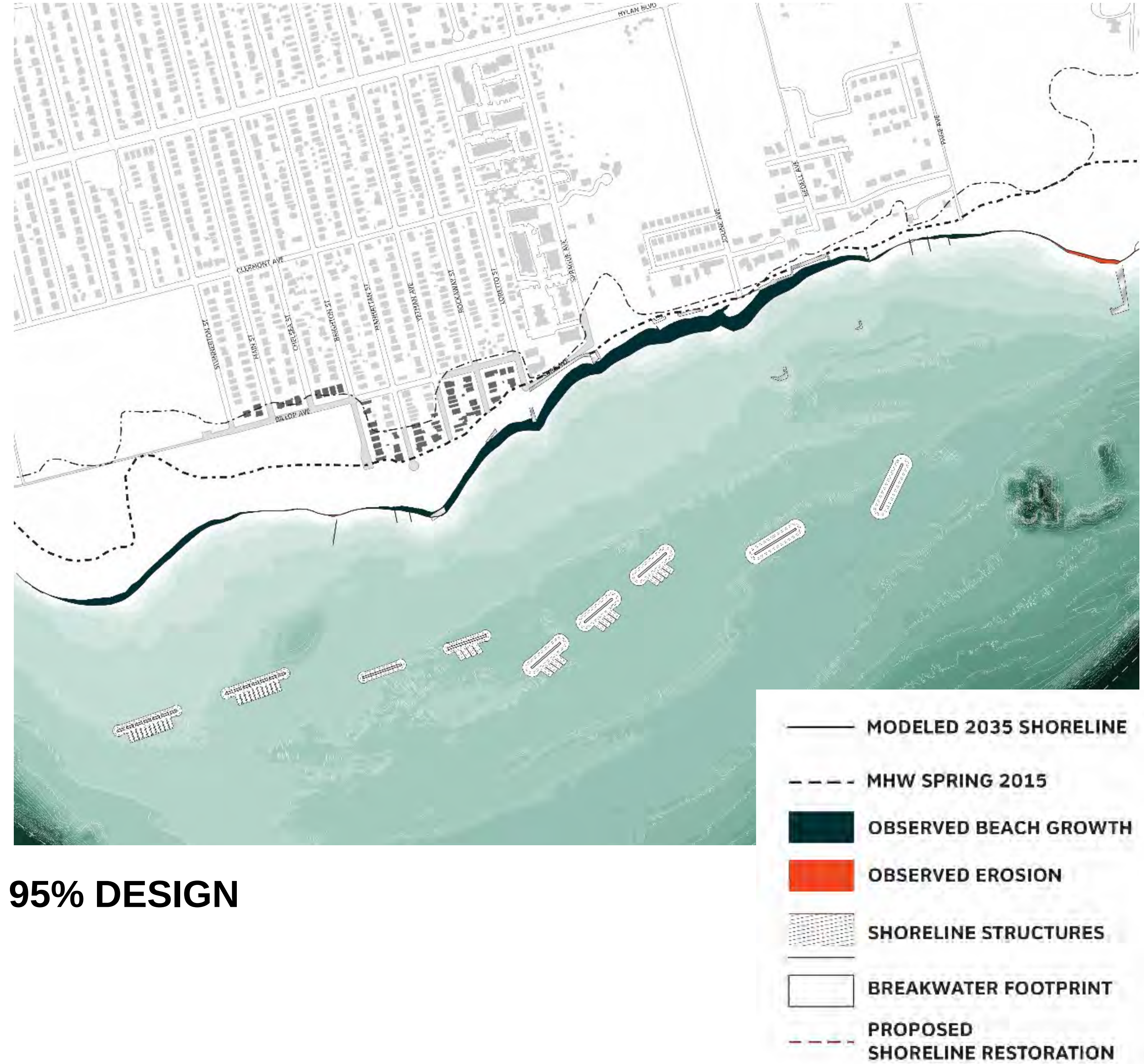
GAP WIDTH (W_g)



SHORELINE CHANGE

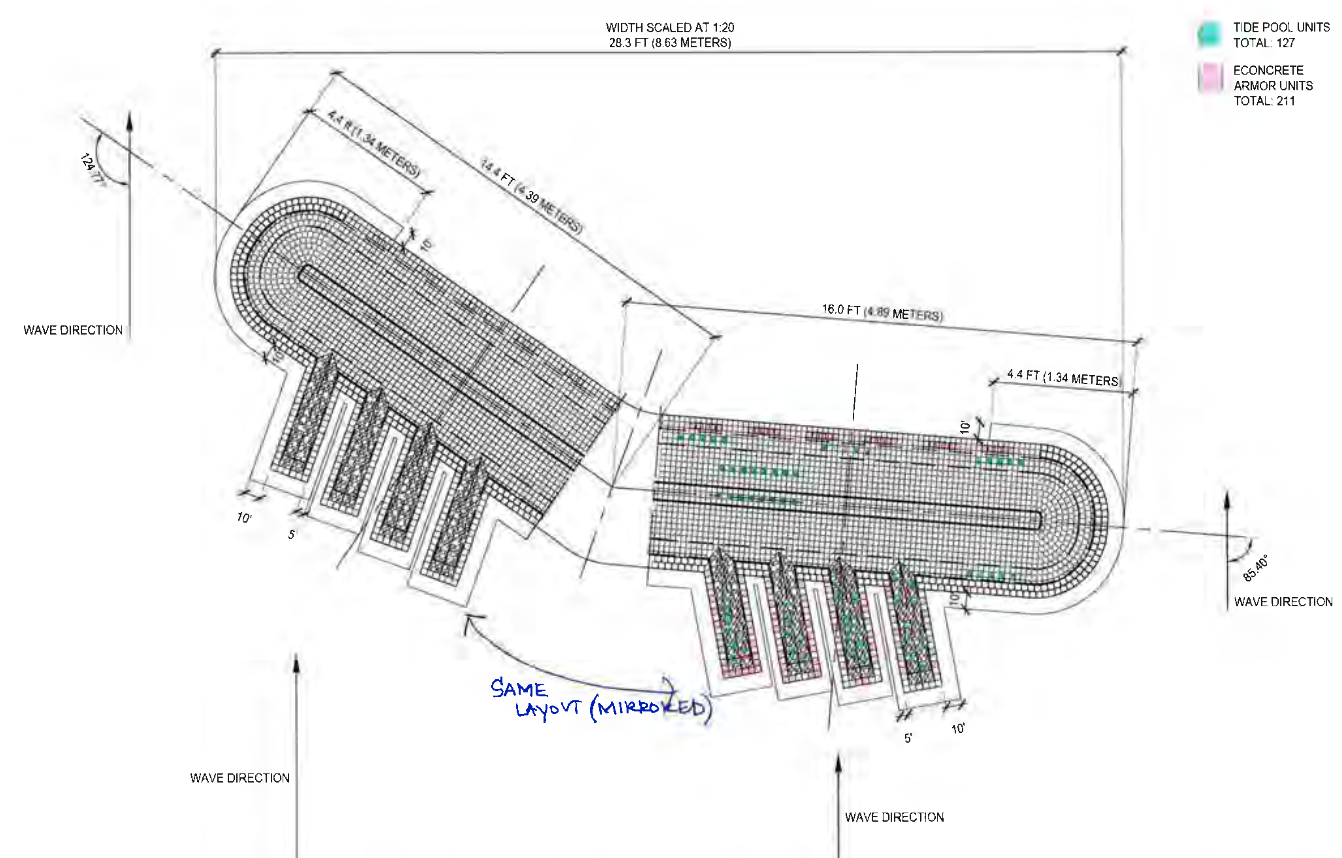
20 year simulation (2015 - 2035)

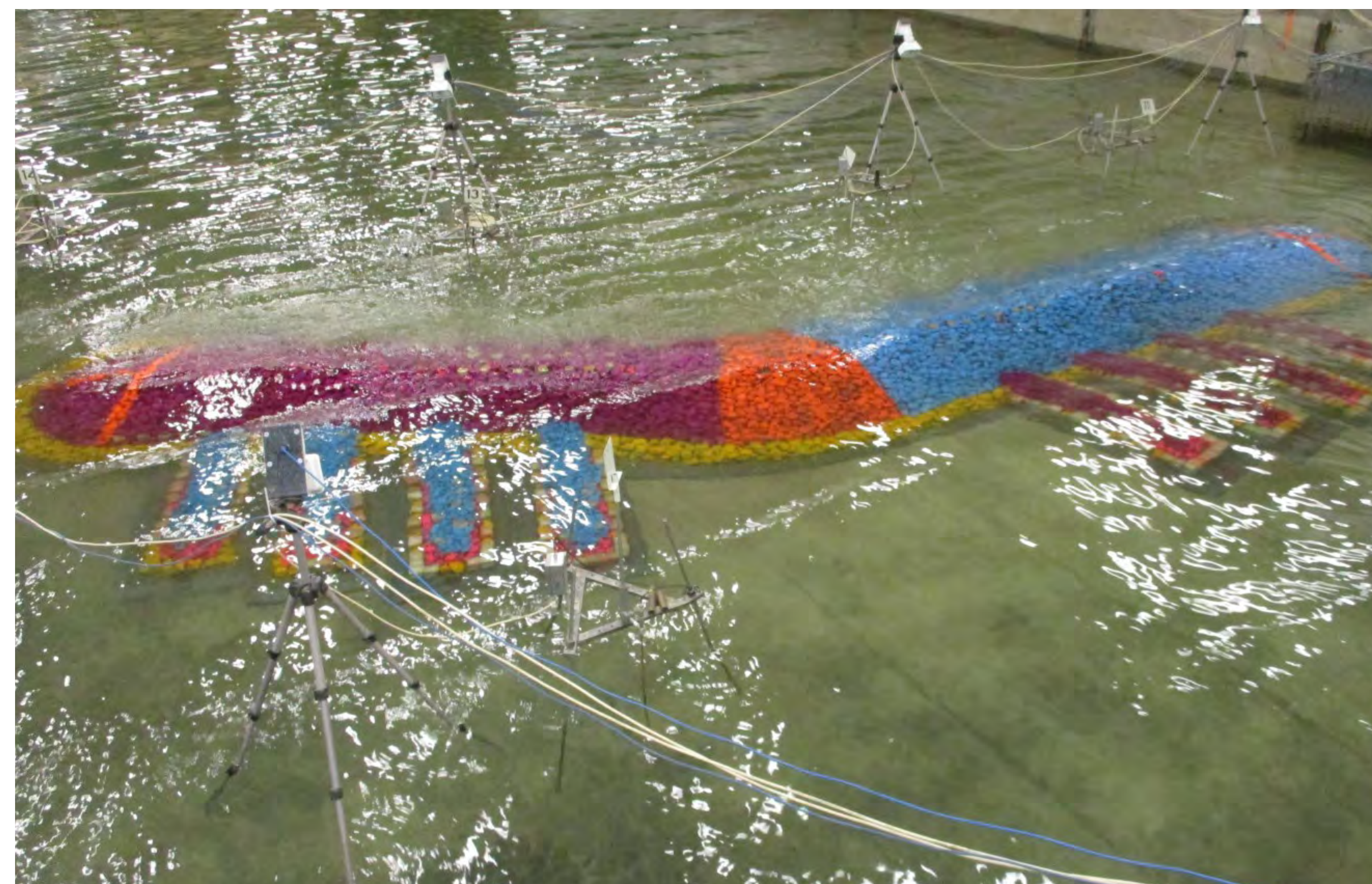
NO ACTION

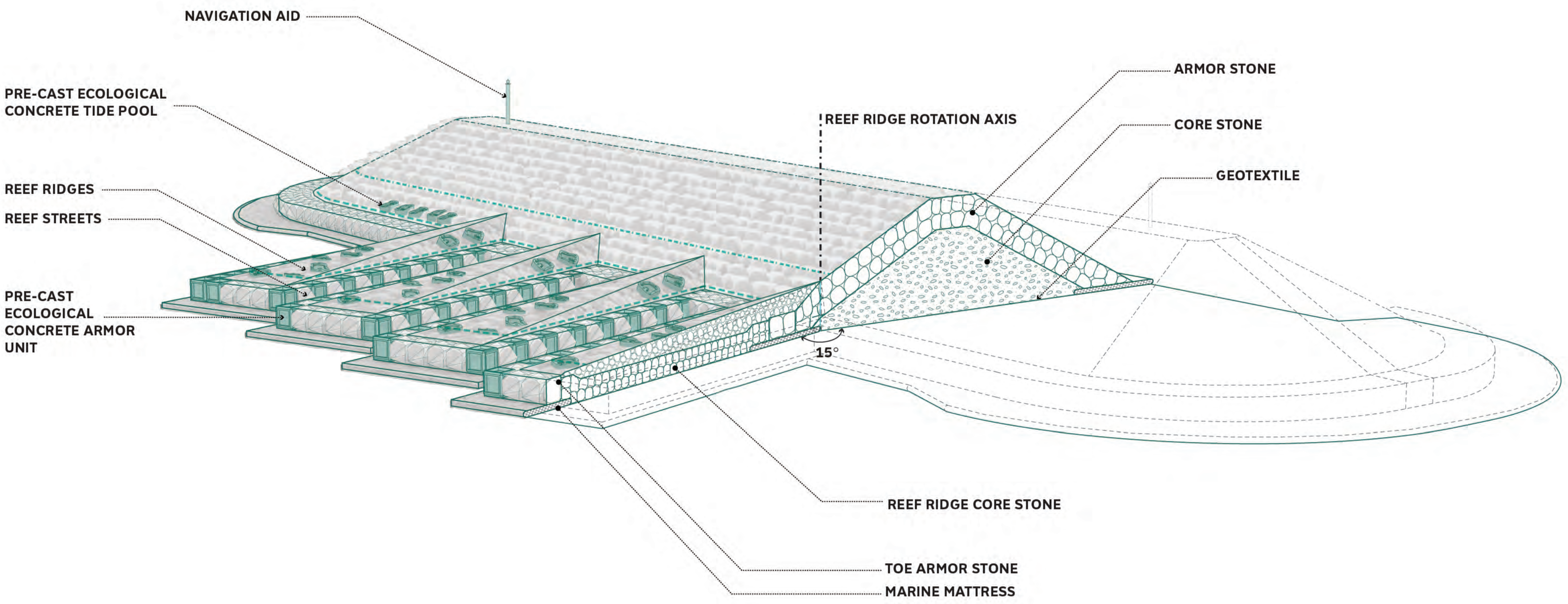


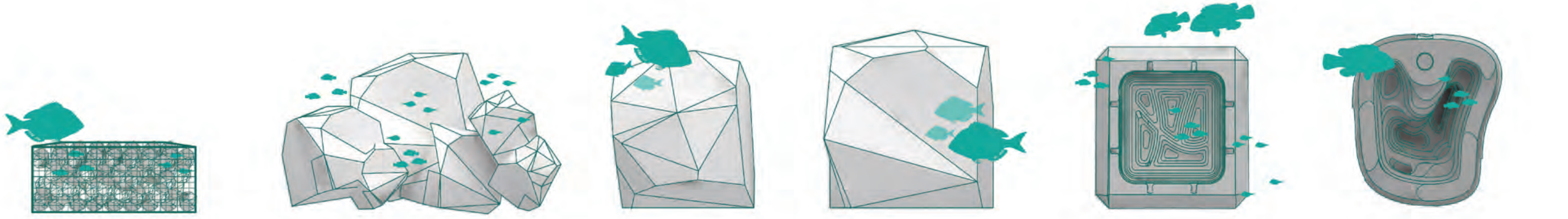
95% DESIGN

PHYSICAL MODELING









MARINE MATTRESS
HT= 12″

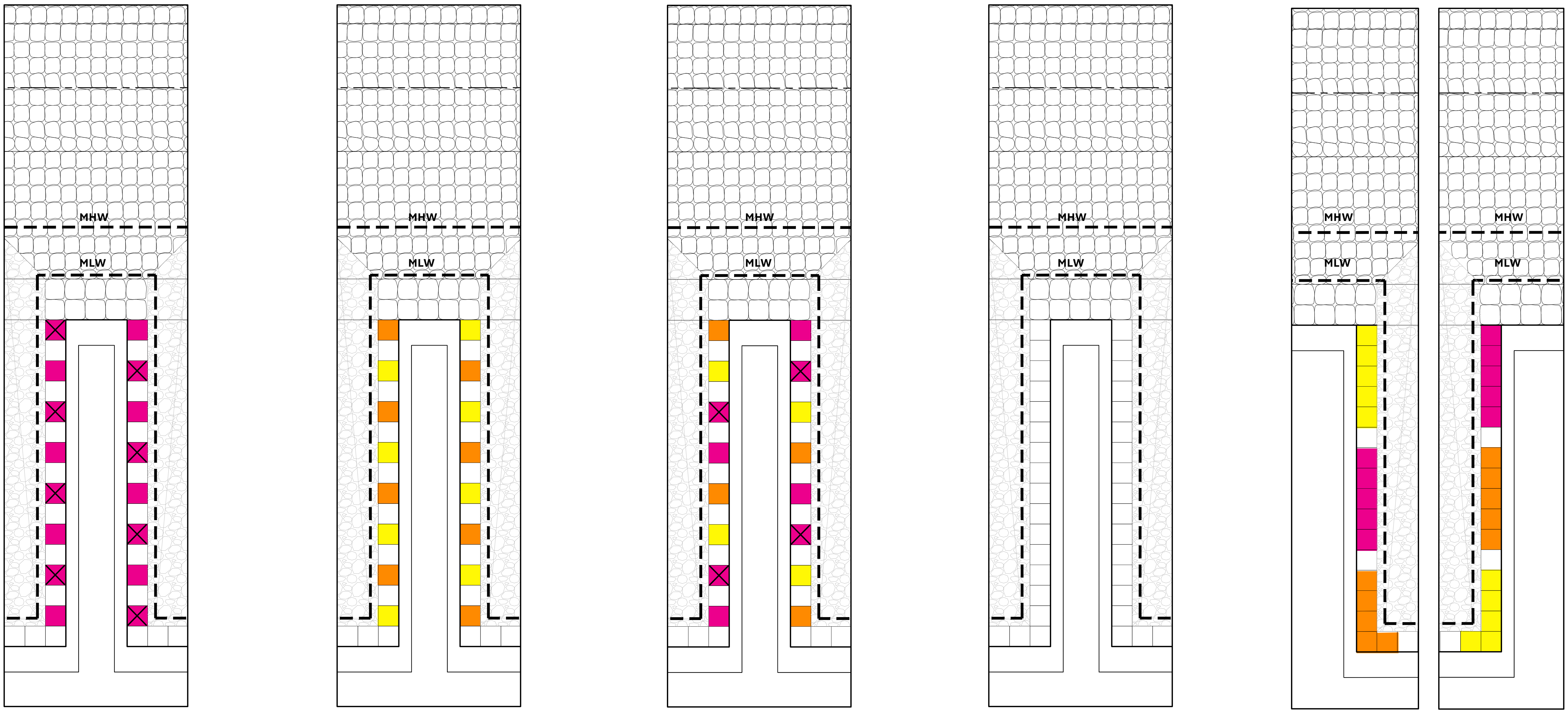
REEF RIDGE CORE STONE
Dmin= 24″ D_{50}= 30″ Dmax=36″

STONE ARMOR UNIT
D_{50}= 40″

STONE TOE ARMOR UNIT
D_{50}: 48″

PRE-CAST ECOLOGICAL CONCRETE ARMOR UNIT
Dimension: 48″x 48″x 48″

PRE-CAST ECOLOGICAL CONCRETE TIDE POOL
Dimension: 44″X 48″X27



TYPE B: 64' BW REEF RIDGES
FISH STREET

8 Total Fish Hub 1 (mesh only)
8 Total Fish Hub 2 (mesh and rock)

TYPE B: 64' BW REEF RIDGES
OYSTER STREET

8 Total Oyster Hub 1 (disks)
8 Total Oyster Hub 2 (mesh+shell)

TYPE B: 64' BW REEF RIDGES
COMBINED STREET

4 Total Fish Hub 1 (mesh only)
4 Total Fish Hub 2 (mesh and rock)
4 Total Oyster Hub 1 (disks)
4 Total Oyster Hub 2 (mesh+shell)

TYPE B: 64' BW REEF RIDGES
CONTROL STREET

TYPE B: 64' BW REEF RIDGES
NON -STREET

5 Total Fish Hub 1 (mesh only)
- Total Fish Hub 2 (mesh and rock)
5 Total Oyster Hub 1 (disks)
5 Total Oyster Hub 2 (mesh+shell)

BREAKWATER TYPE B:
REEF RIDGE ECO UNIT LAYOUT
SUBTIDAL

FISH HUB 1 (MESH ONLY)
FISH HUB 2 (MESH+ ROCKS)
OYSTER HUB 1 (DISKS)
OYSTER HUB 2 (MESH AND SHELL)

Figure 8. **BREAKWATER TYPE B REEF STREET TREATMENTS: SUBTIDAL**

HARBOR SEAL
Phoca vitulina

QUAHOG CLAM
Mercenaria mercenaria

BARNACLES
Cirripedia spp.

SHOREBIRDS

QUAHOG CLAM
Mercenaria mercenaria

MARINE LIFE FOUND ON LIVING BREAKWATERS DURING CONSTRUCTION

Governor's Office of Storm Recovery

SCAPE TEAM

DREDGE FEST CA + PUBLIC SEDIMENT


INLAND COAST
The Great Lakes
Major Ports: Duluth & Toledo
Major River: St. Lawrence
Sedimentshed: approx 295,700 sq. mi.
EAST COAST
New York & New Jersey
Major Port: NY & NJ
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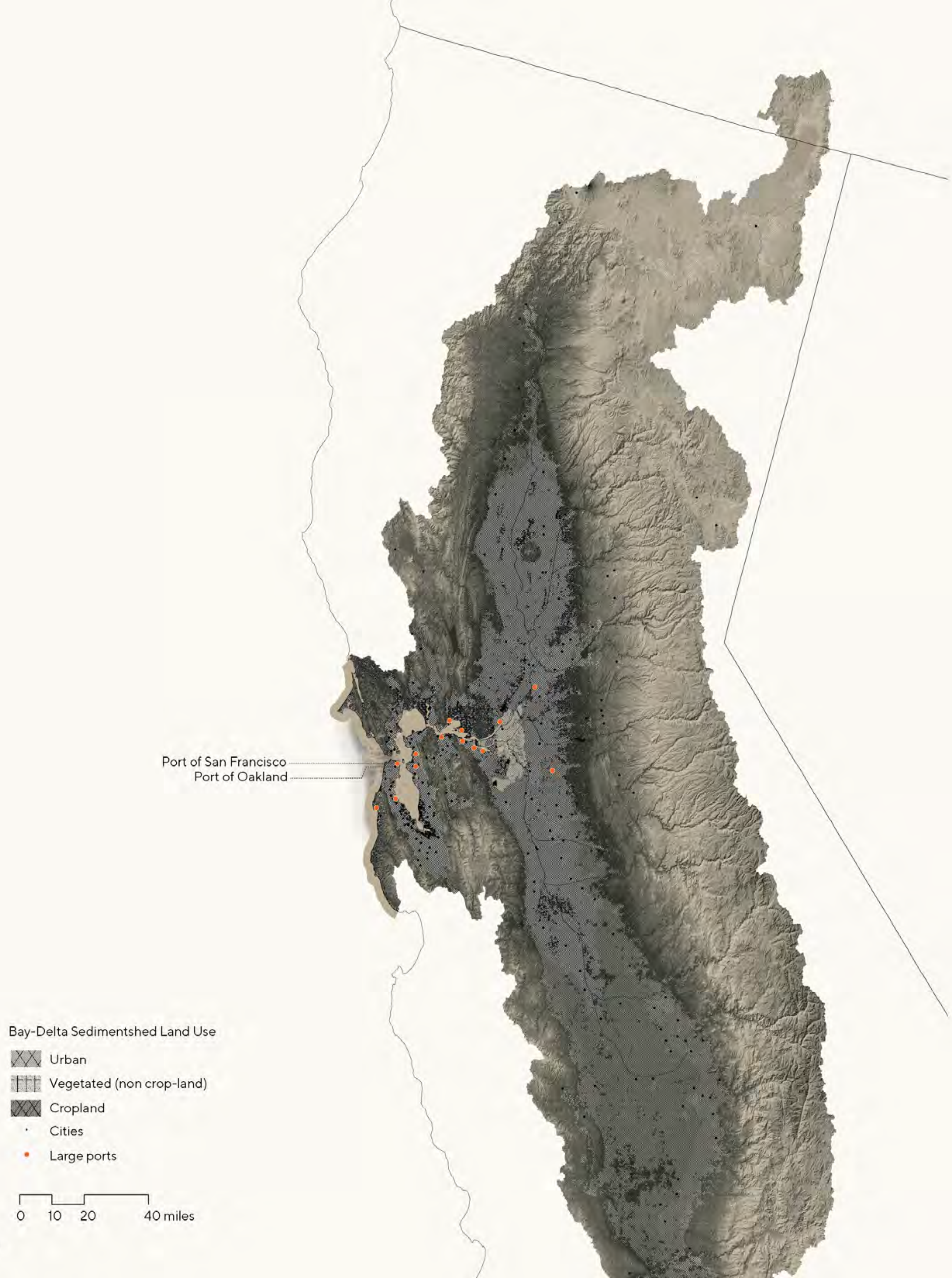
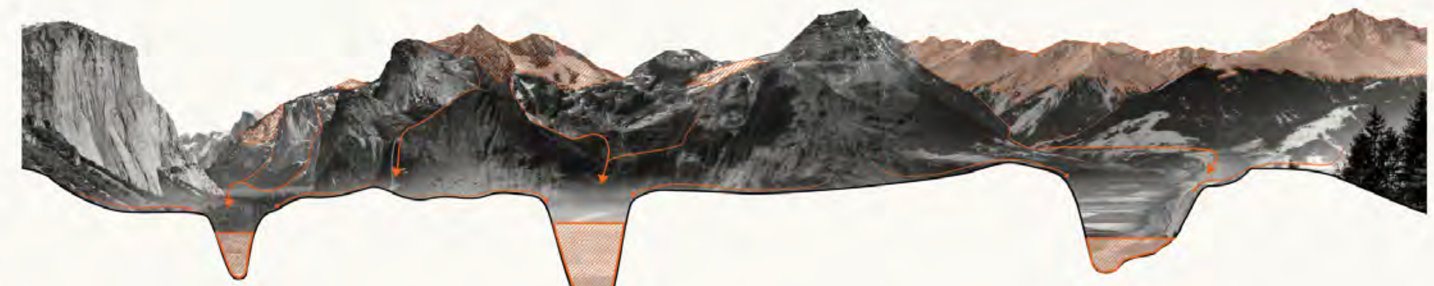
WEST COAST
California
Major Ports: San Francisco
Major River: Sacramento / San Joaquin
Sedimentshed: 75,000 sq. mi.
GULF COAST
Louisiana
Major Port: New Orleans
Major River: Mississippi
Sedimentshed Area: 1.2 M sq. mi.


Landscapes of Dredge
The Great Lakes Basin



UPLAND: Hydraulic mining in the late 1800's generated large amounts of sediment runoff from the Sierra Nevadas

Sediment was transported downstream through valleys and rivers

Downstream sediment transport today is limited as dam and water infrastructure projects trap sediment upstream

DELTA: River flows provided water for agriculture but also threatened livelihoods with flooding.

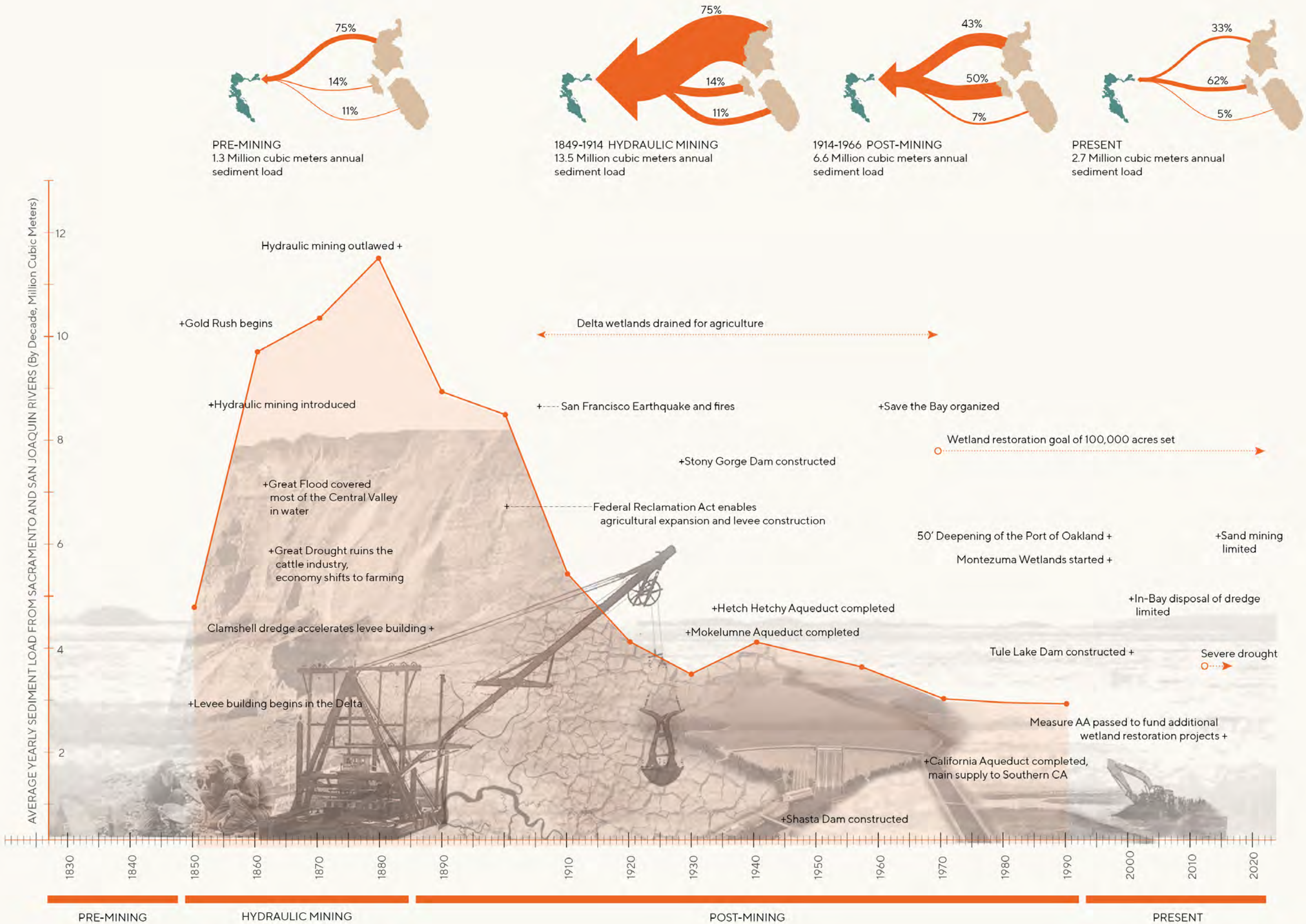
In the 1850's, farmers dredged channels and used the material to build up levee edges. With time, the process was mechanized with clamshell dredges.

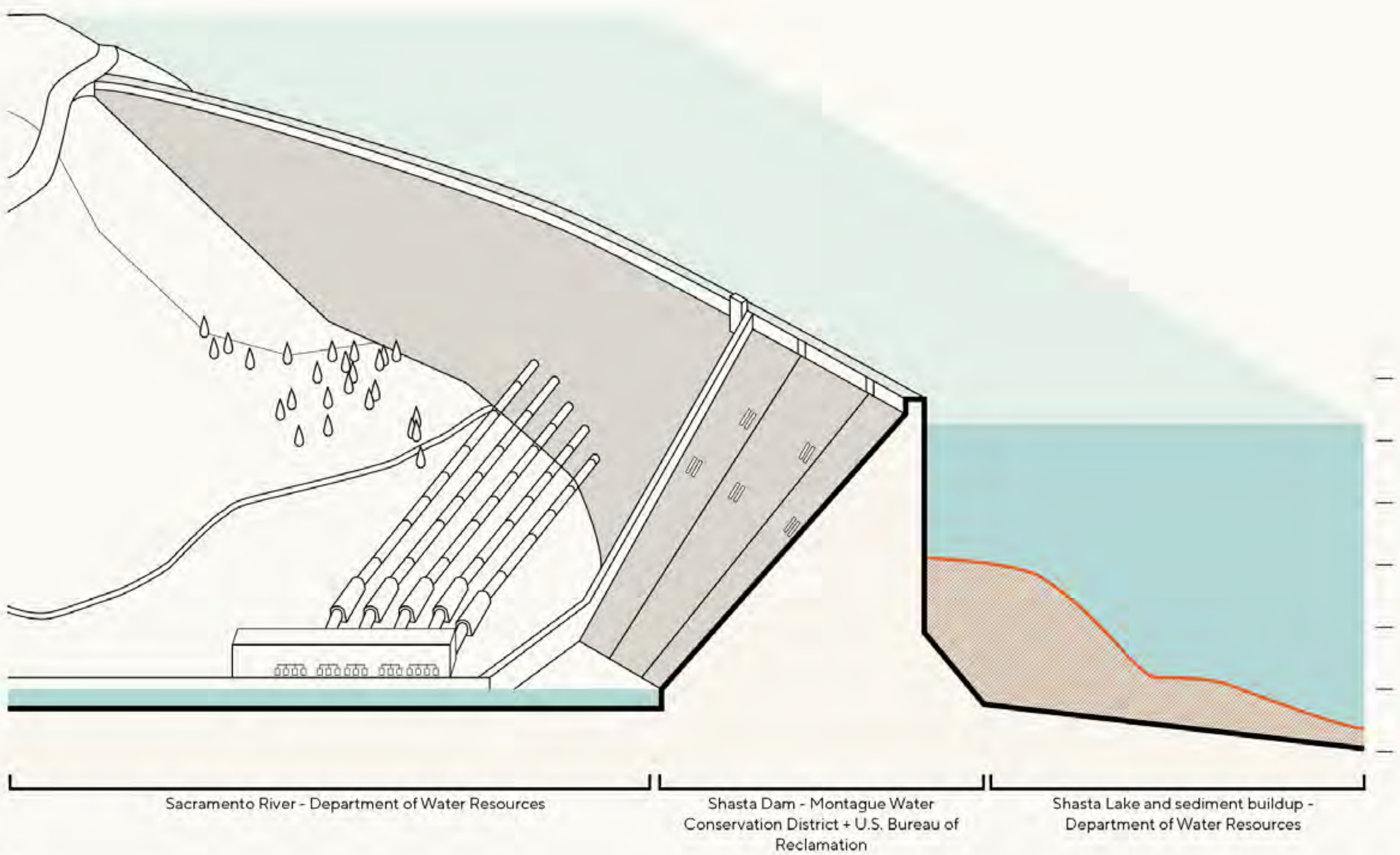
By the 1950s sediment inputs slowed to the Delta and Bay. Farm land subsides and levees are at risk of failure.

BAY: Historic industrial uses increased heavy metal and chemical sources of contamination

Harbor deepening projects abound, generating contaminated and clean sediment

Urbanized edges of the bay contribute to negative sedimentation impacts on bay ecosystems


75%
14%
11%
PRE-MINING
1.3 Million cubic meters annual sediment load
75%
14%
11%
1849-1914 HYDRAULIC MINING
13.5 Million cubic meters annual sediment load
43%
50%
7%
1914-1966 POST-MINING
6.6 Million cubic meters annual sediment load
33%
62%
5%
PRESENT
2.7 Million cubic meters annual sediment load
AVERAGE YEARLY SEDIMENT LOAD FROM SACRAMENTO AND SAN JOAQUIN RIVERS (By Decade, Million Cubic Meters)
12
10
8
6
4
2
Hydraulic mining outlawed +
+Gold Rush begins
+Hydraulic mining introduced
+Great Flood covered most of the Central Valley in water
+Great Drought ruins the cattle industry, economy shifts to farming
Clamshell dredge accelerates levee building +
+Levee building begins in the Delta
Delta wetlands drained for agriculture
+ San Francisco Earthquake and fires
+Stony Gorge Dam constructed
+ Federal Reclamation Act enables agricultural expansion and levee construction
+Hetch Hetchy Aqueduct completed
+Mokelumne Aqueduct completed
+Shasta Dam constructed
+Save the Bay organized
Wetland restoration goal of 100,000 acres set
50' Deepening of the Port of Oakland +
Montezuma Wetlands started +
Tule Lake Dam constructed +
Measure AA passed to fund additional wetland restoration projects +
+California Aqueduct completed, main supply to Southern CA
+Sand mining limited
+In-Bay disposal of dredge limited
Severe drought
1830
1840
1850
1860
1870
1880
1890
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
PRE-MINING
HYDRAULIC MINING
POST-MINING
PRESENT

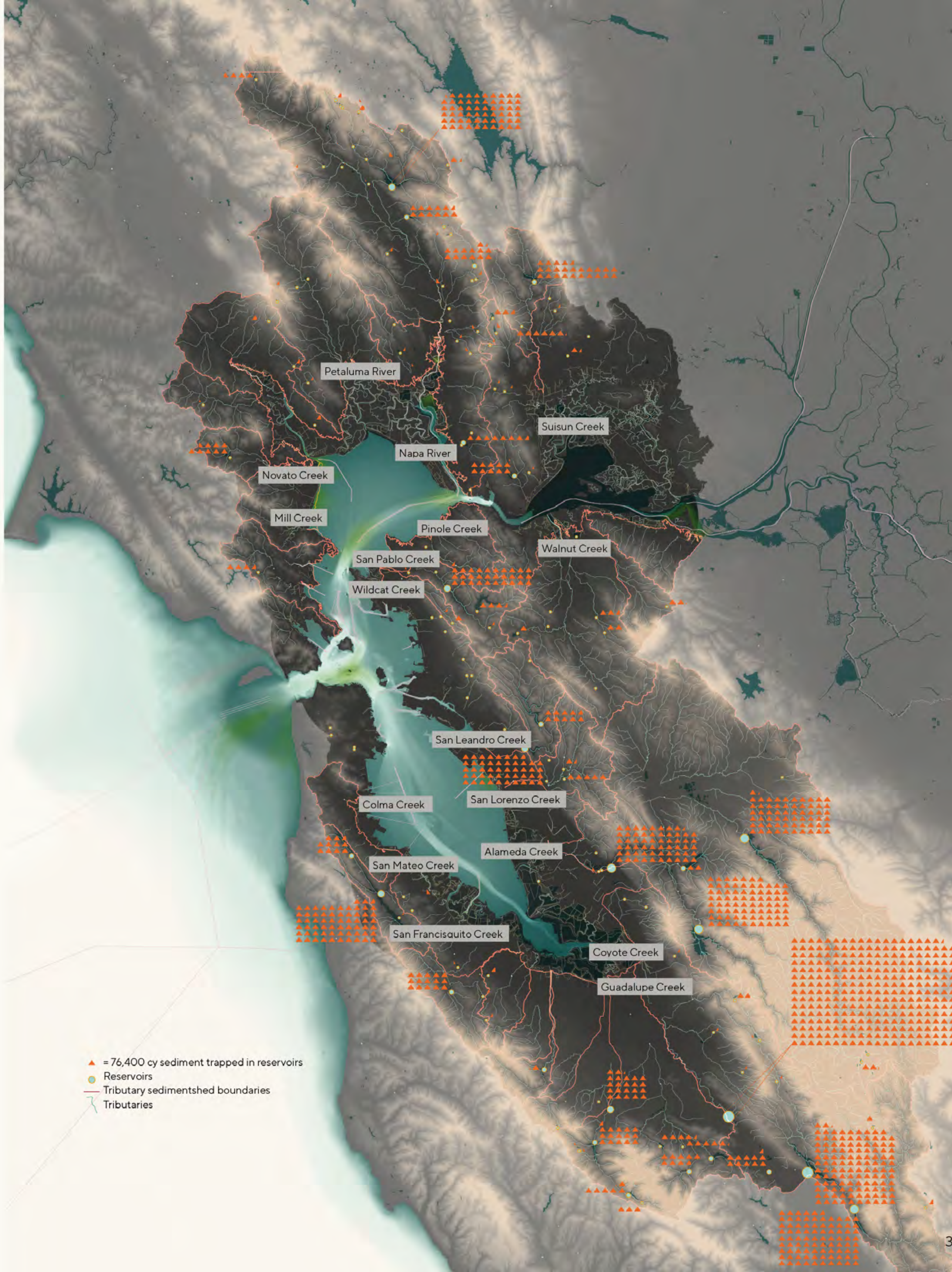


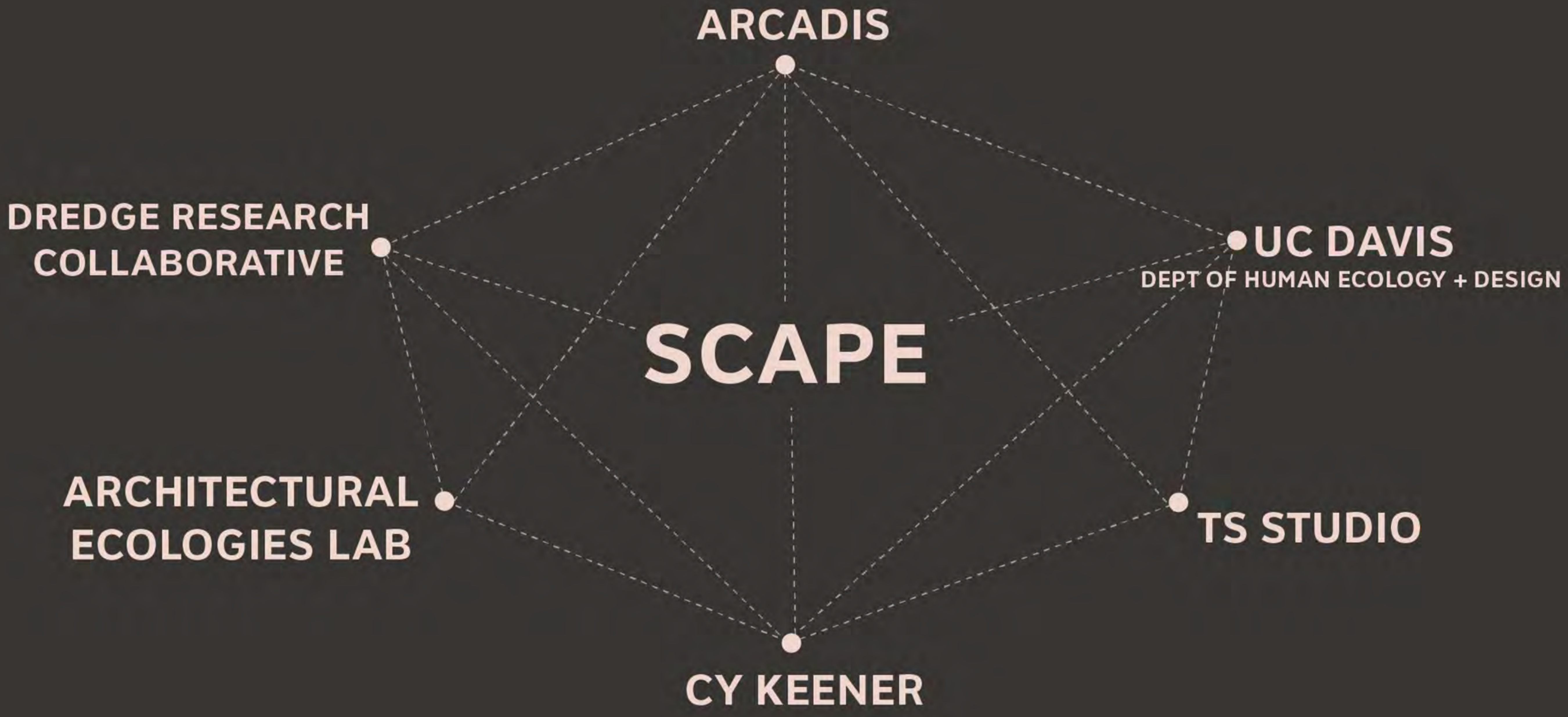
Shasta Dam During Construction (Russell Lee, 1942

Napa River
tributary and sedimentshed

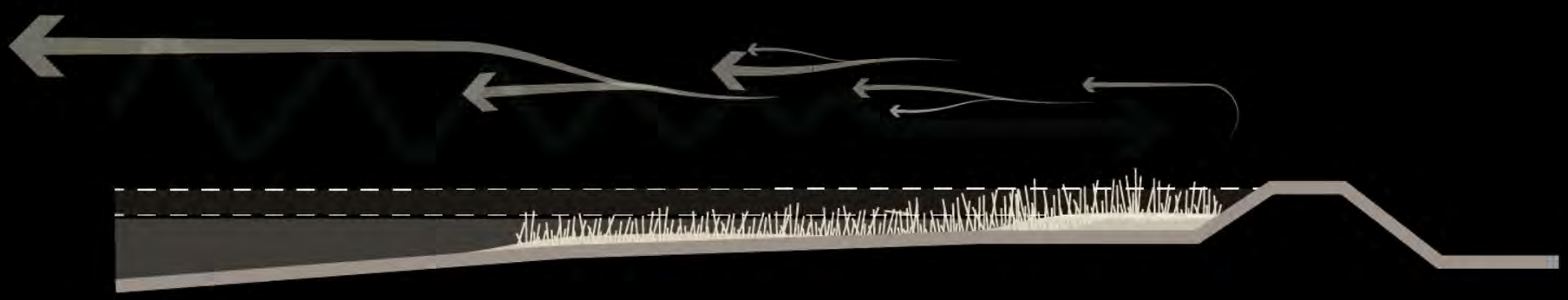
San Lorenzo Creek
tributary and sedimentshed

Total annual sediment load




ARCADIS
DREDGE RESEARCH COLLABORATIVE
UC DAVIS
DEPT OF HUMAN ECOLOGY + DESIGN
SCAPE
ARCHITECTURAL ECOLOGIES LAB
TS STUDIO
CY KEENER


BAYLANDS = LIVING INFRASTRUCTURE



TIDAL BAYLANDS CUSHION URBAN EDGES +
AND MITIGATE THE RISKS OF SEA LEVEL RISE.

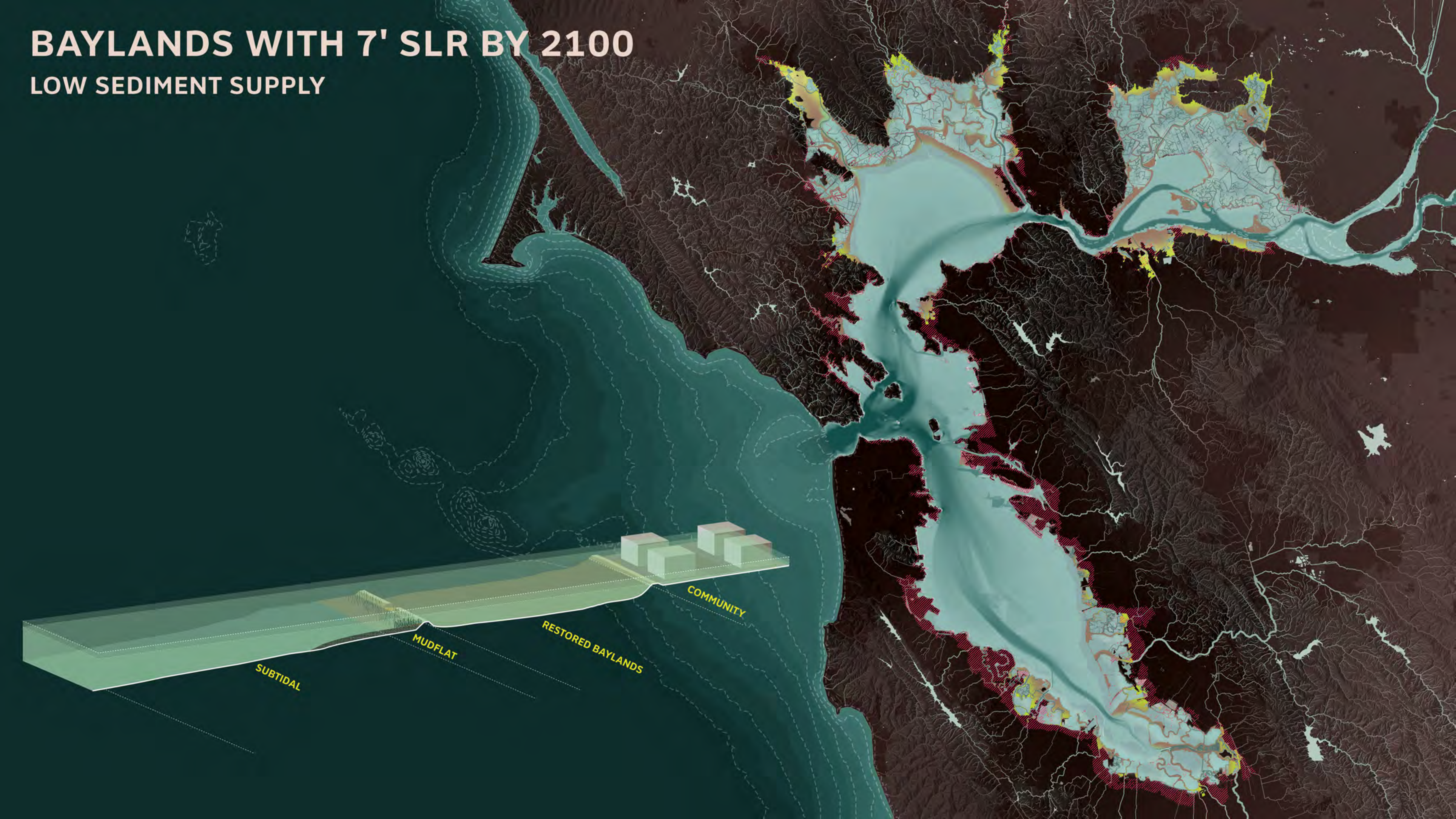
BAYLANDS TODAY

BAYLANDS WITH 3' SLR BY 2100

LOW SEDIMENT SUPPLY

BAYLANDS WITH 7' SLR BY 2100

LOW SEDIMENT SUPPLY

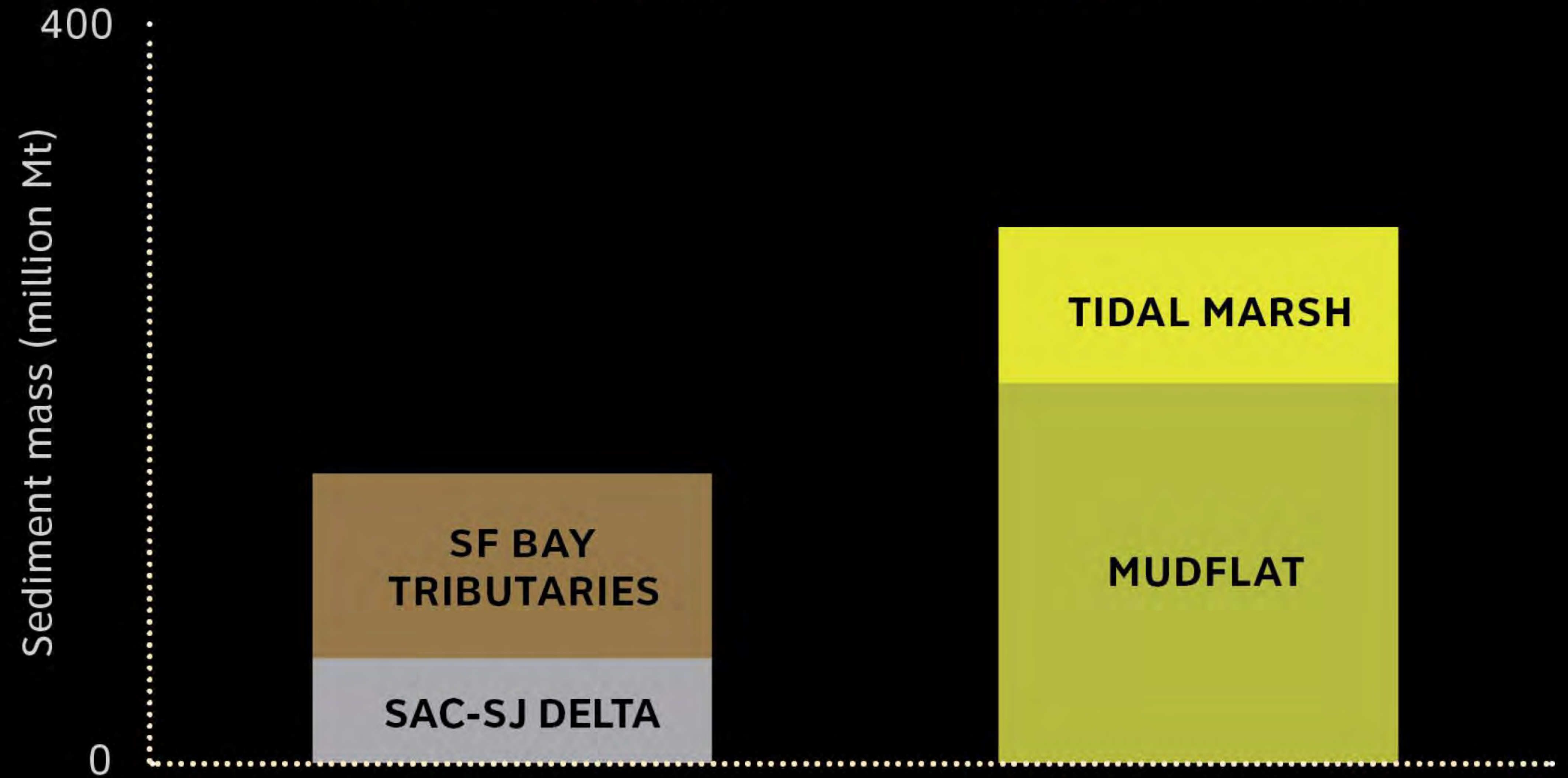


[image: SCAPE Landscape Architecture + the Public Sediment team]

2100, 3.5 ft SLR

ESTIMATE OF POSSIBLE FUTURE BAYLAND SEDIMENT SUPPLY[1] (assuming current average annual load)

ESTIMATE OF POSSIBLE FUTURE BAYLAND SEDIMENT DEMAND[2] (assuming current baylands extent)



Based on preliminary analysis by SFEI. A more detailed analysis is being conducted as part of the Healthy Watersheds Resilient Baylands project (hwrb.sfei.org)

[1]Sediment supply was estimated by multiplying the current average annual sediment load values from McKee et al. (in prep) by the number of years between 2017 and 2100.

[2]Sediment demand was estimated using a mudflat soil bulk density of 1.5 g sediment/cm^3 soil (Brew and Williams 2010), a tidal marsh soil bulk density of 0.4 g sediment/cm^3 soil (Callaway et al. 2010), and baywide mudflat and marsh area circa 2009 (BAARI v1).

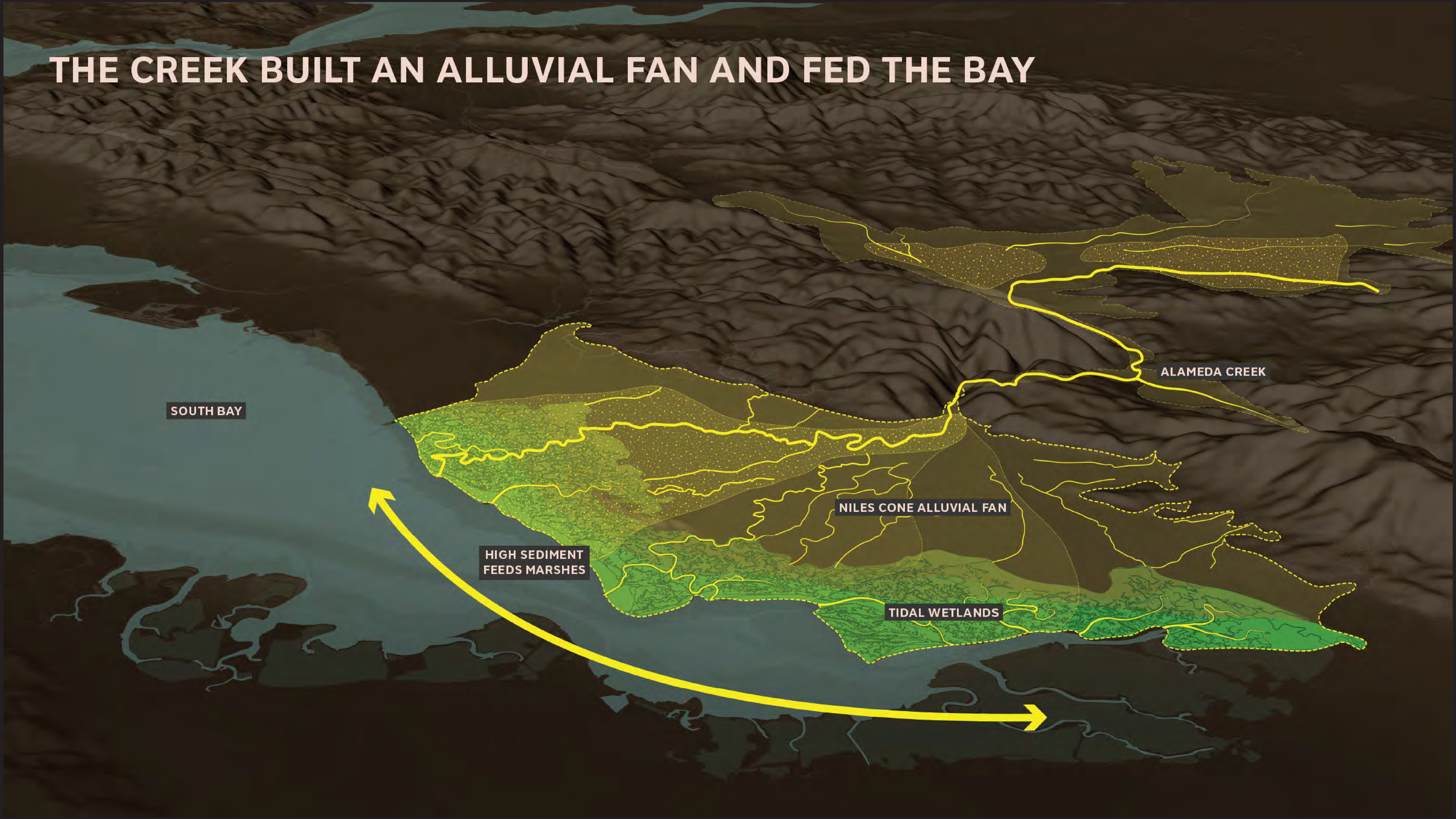
Inadequate supply

ALAMEDA CREEK WATERSHED

[image: SCAPE Landscape Architecture + the Public Sediment team]

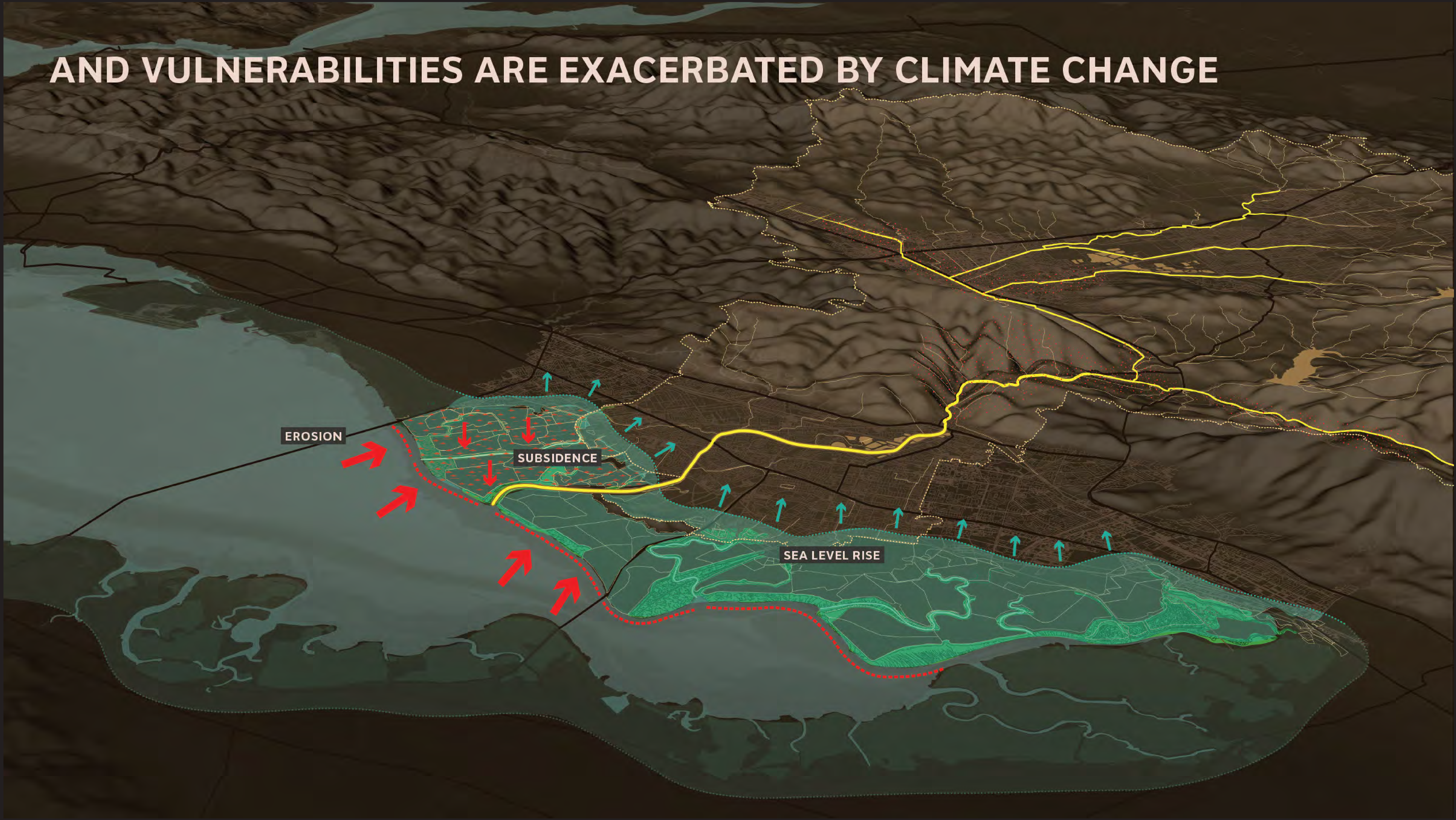
The most untapped potential

[image: SCAPE Landscape Architecture + the Public Sediment team]



[image: SCAPE Landscape Architecture + the Public Sediment team]

AND VULNERABILITIES ARE EXACERBATED BY CLIMATE CHANGE



[image: Brett Milligan + the Public Sediment team]

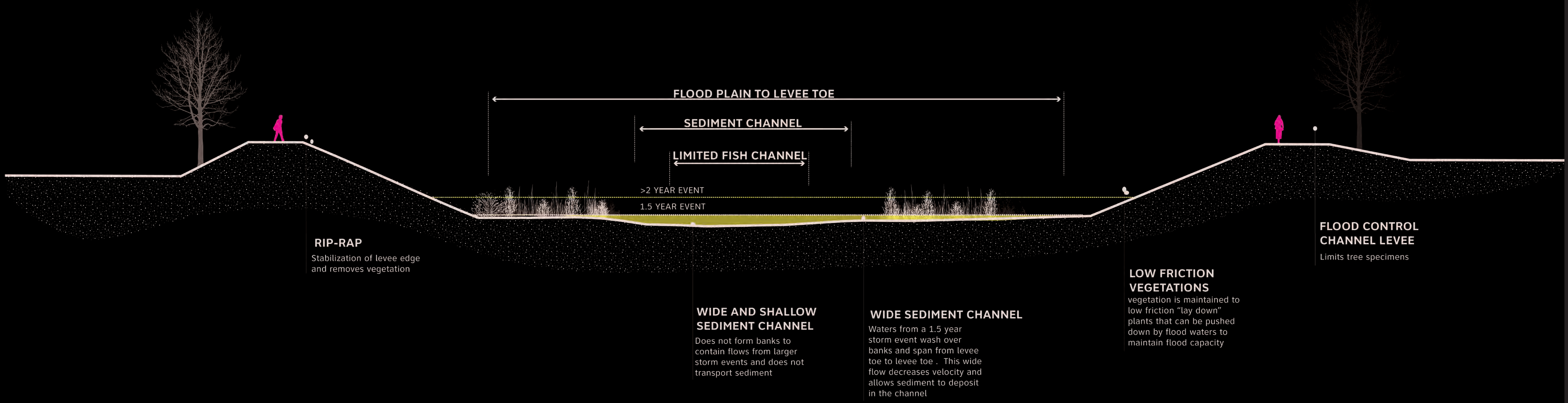
The channel today

PHYSICAL: DESIGN WITH MUD

SOCIAL: MAKE SEDIMENT PUBLIC


SEDIMENT
+
PEOPLE
+
FISH

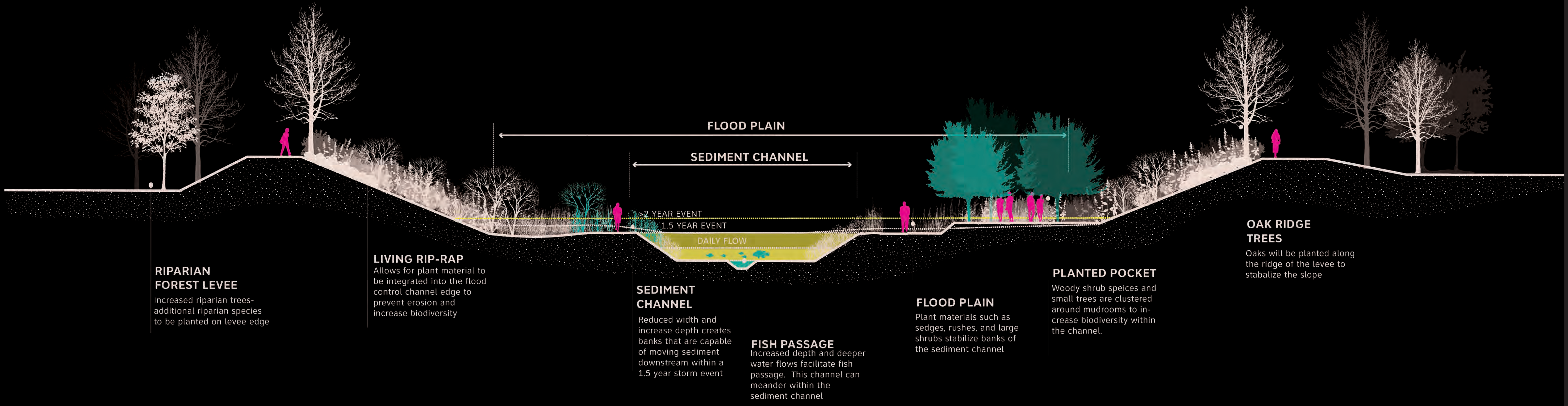
THE FLOOD CONTROL CHANNEL



[image: SCAPE Landscape Architecture + the Public Sediment team]

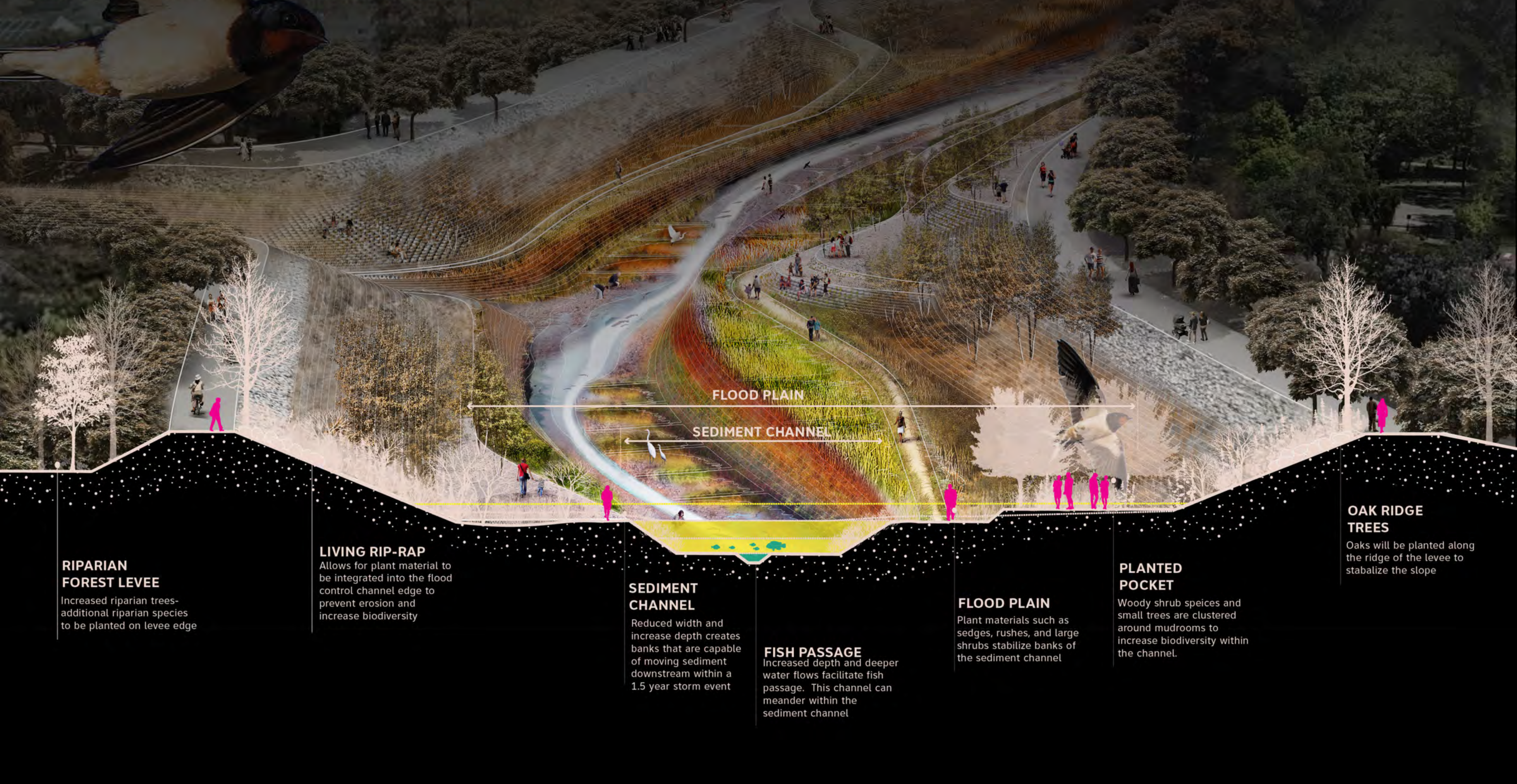
THE ACTIVE CHANNEL

PROPOSED ALAMEDA CREEK ACTIVE CHANNEL



BUILDING OFF CONCEPT DEVELOPED BY ALAMEDA COUNTY FLOOD CONTROL DISTRICT

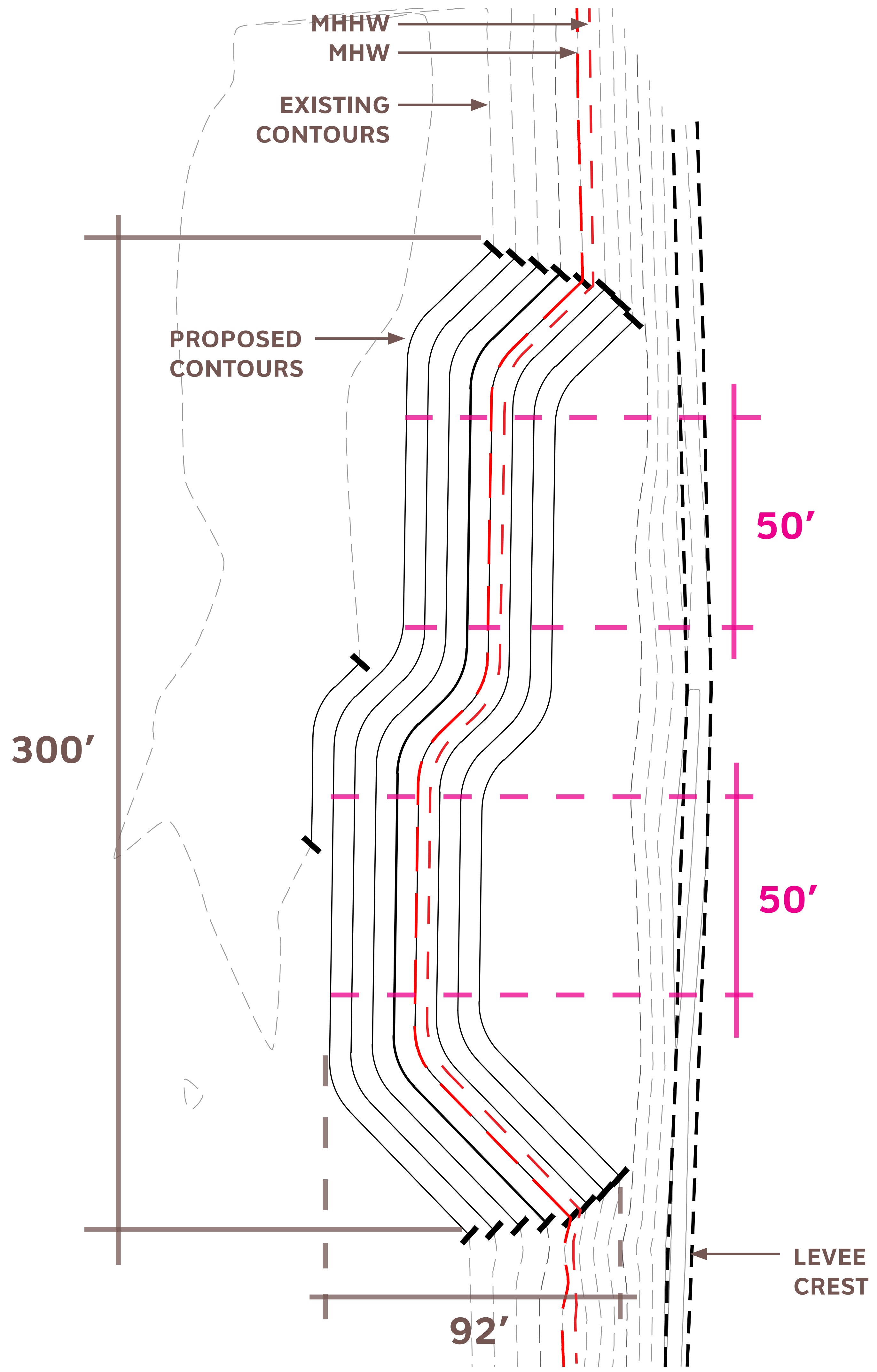
UNLOCK ALAMEDA CREEK



CONNECT THE CREEK WITH THE BAYLANDS

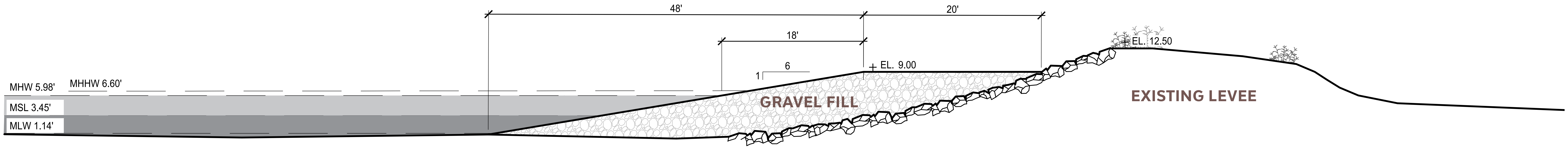
UNLOCK ALAMEDA CREEK

Public Sediment Pilot Project: Eden Beach

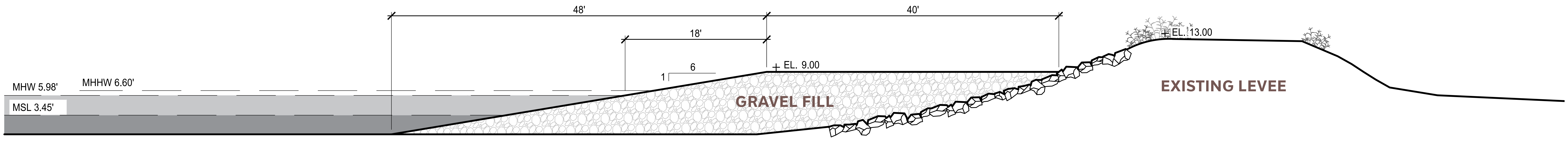


- Feature length = 300′
- Testable length = 100′
- Max. footprint width = 92′
- Beach width$_1$= 20′
- Beach width$_2$= 40′
- Approx. volume = 2,600 cubic yards

- **Gravel**
  1. Most accurate translation from model to pilot
  2. Affordable
  3. Full control over grain size and distribution
- **Shell (Half-shell and hash)**
  1. Difficult to model
  2. Expensive (10x typical gravel costs)
  3. Limited control over grain size and distribution
  4. More naturally present in San Francisco Bay margins
- **Gravel-Shell Hybrid**
  1. Gravel is used as primary fill material combined with a surficial application of shell



SECTION B



SECTION A

Dredge Research Collaborative

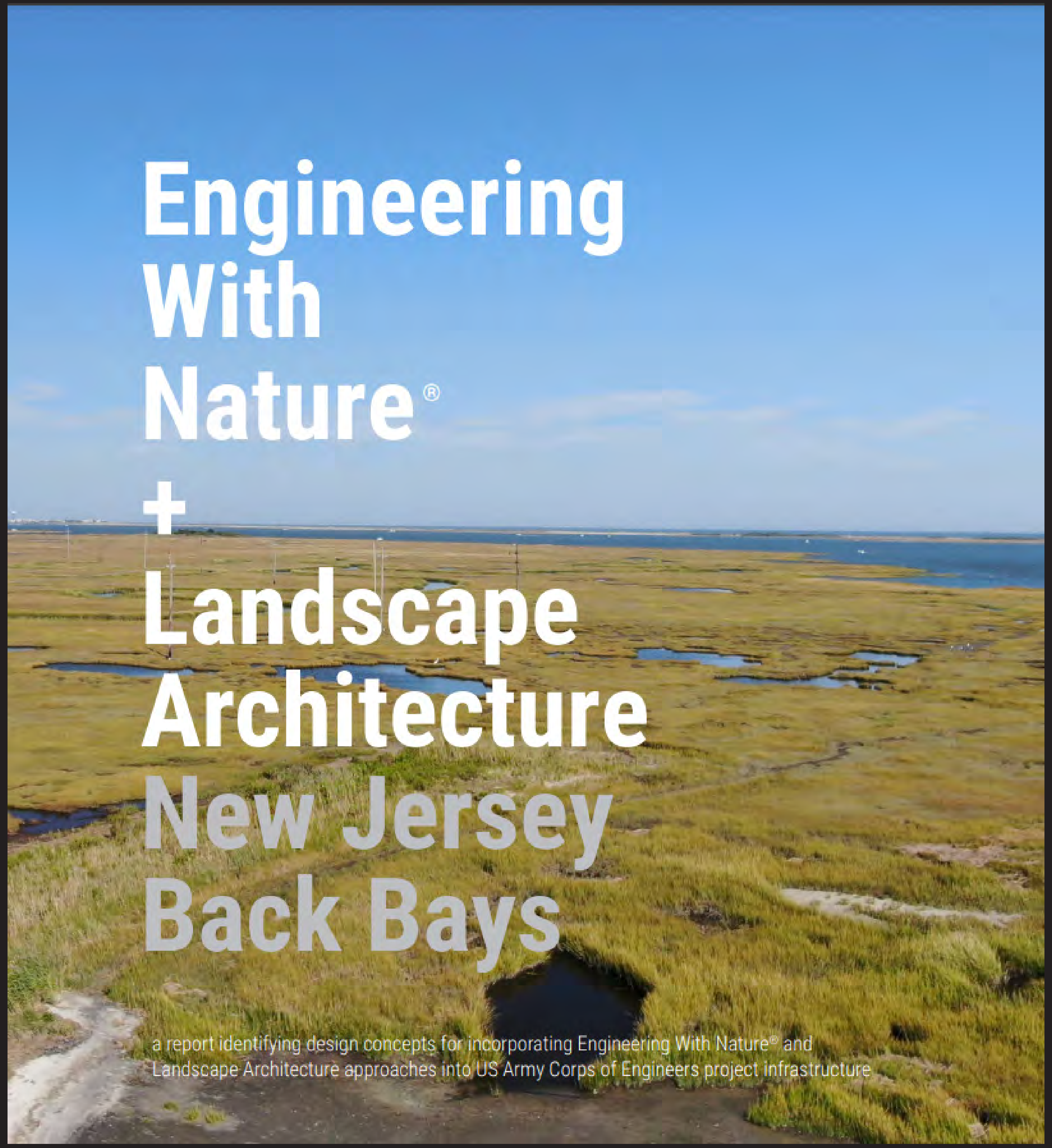
EWN ENGINEERING WITH NATURE

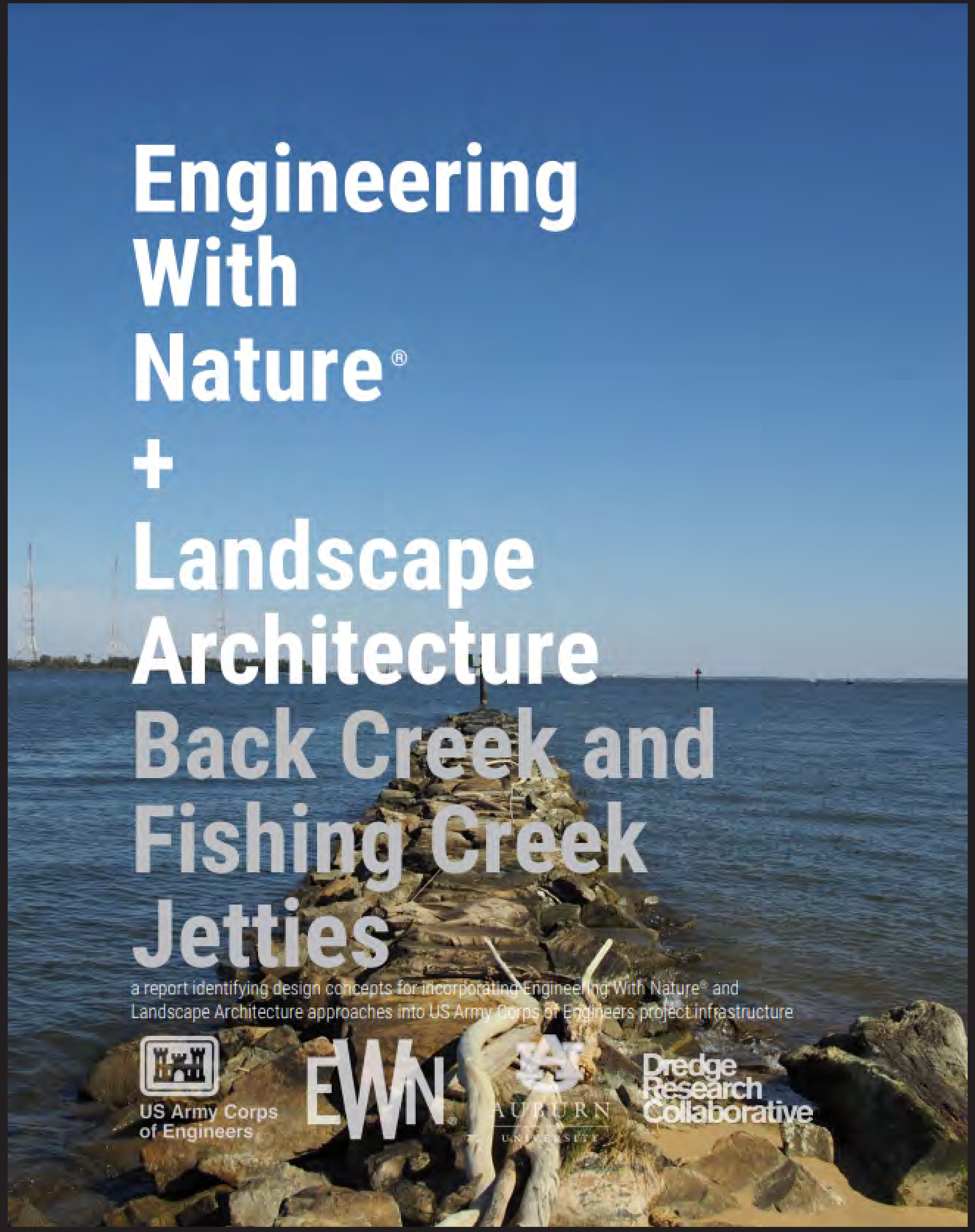
US Army Corps of Engineers®

Workshop Participants

// USACE / Landscape Architecture
Workshop on Engineering with Nature

Vicksburg, MS | July 25-27, 2017





DRC + EWN / USACE + Auburn

https://ewn.erdc.dren.mil/designs/

THANK YOU

@scape_studio on insta
@DredgeRC on X