DELTA MANAGEMENT RESILIENCY DESIGN GUIDE

About This Guide

Deltas and estuaries are some of the most diverse ecosystems within the coastal system, providing vital habitat for fisheries, migratory and colonial birds, and oyster reefs. A delta is the low-lying area of land at or near the mouth of a river resulting from the accumulation of sediment from the river and an estuary is a partially enclosed coastal body of water that receives discharge from a river. The degradation of these habitats is influenced by long-term chronic stressors, such as water quality impairment, pollutants, shoreline armoring, etc.

Conceptual

Develop project goals and identify existing constraints. These are important steps that will shape future planning for a delta or estuary management project.

Determine project goals	Evaluate system characteristics	Determine basic plan components
• Manage/improve water quantity • Manage sediment transport • Restore natural flow • Restore habitats • Estuarine nutrient cycling • Manage erosion and degradation • Outreach/education	• Hydrodynamics: wave energy, stormwater volumes, interbasin transfer • Water quality: non-point source pollution, harmful bacteria, saltwater intrusion, water filtration needs • Geomorphology: sediment build-up, bank erosion, channel morphology, tidal prism • Existing constraints: urban development, invasive species, wetland loss, agricultural practices, delta buffer space	• Budget and timeline • Environmental, economic, and social drivers • Structural, ecological, and policy needs

Engineering and Management

Develop a plan for management and policy activities that is based on engineering and environmental factors.

Engineering	Environmental Management Factors
• Hydrodynamic analysis – watershed modeling • Geomorphological analysis – sedimentation, geotechnical, erosion • Structural & natural components – type, quantity, configuration • Decommissioning structures, if needed	• Environmental Flow Standards – TCEQ standards for Texas Watersheds • Low flow/drought periods • Water rights • Identify potential strategic land conservation areas in watershed to purchase land for additional conservation benefits • Complete permit applications – Permit-level plans, address review comments

Permitting

Plan for and complete necessary permitting activities to ensure management plans have a robust design and do not adversely impact the surrounding environment or socioeconomic activity. An engineer should also be identified during this step to complete permit-level (and subsequent) design/installation plans.

Identify project partners	Identify potential permits needed	Typical review agencies
• Federal/State • Local • Non-profit • University • *Tribal*	• **U.S. Army Corps of Engineers (USACE) Nationwide Permits:** 3a-Removal of existing structures and 3b-Removal of accumulated sediments, 53-Removal of Low-Head Dams, 54-Living Shorelines • **TCEQ:** Section 401 Water Quality Certificate, Senate Bill 3 Environmental Flow Program • **GLO:** Coastal Boundary Survey and Surface Lease if located on State-owned submerged lands	• USACE • GLO • TCEQ • USFWS • NMFS

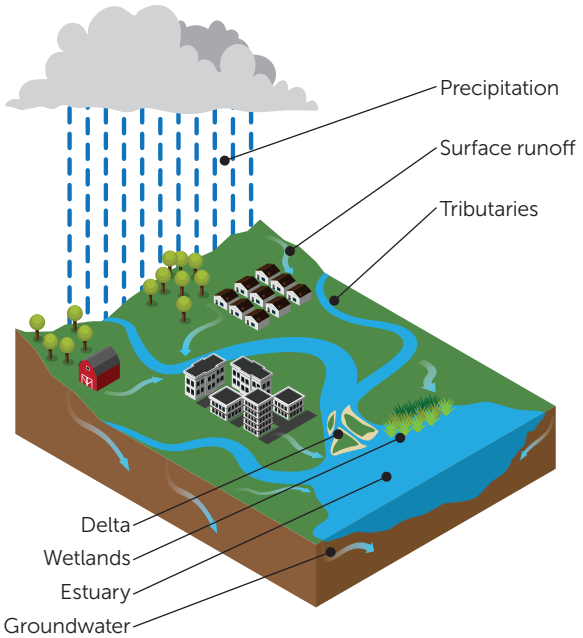
Monitoring

Monitoring site conditions tracks the success of delta and estuary management using metrics aligned with goals.

- Water quality
- Sediment movement/channel morphology
- Environmental flow standards
- Socio-economic benefits
- Commercial and recreational fishery populations/species diversity
- Habitat shifts with relative sea level rise (RSLR) and accommodation space availability
- Climate impacts (e.g., flooding, erosion, hypoxia, etc.)
- Partnering with science/research organizations to collect and synthesize data to inform future management

Watershed Planning

Manage watershed inputs to reduce stressors on the delta and estuarine environment.

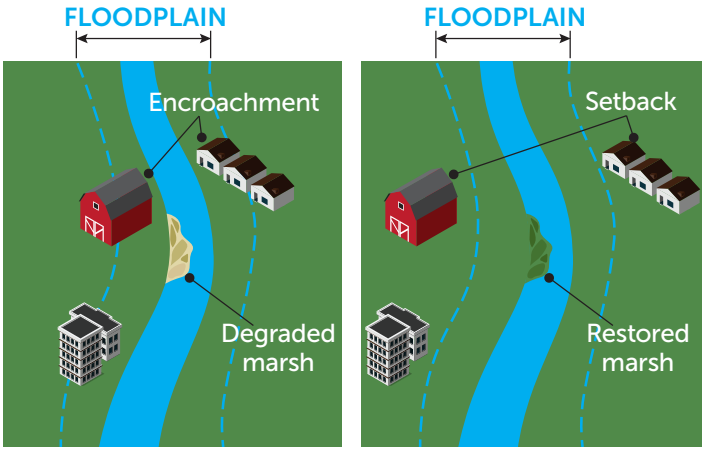
Watershed stressors	Estuary stressors	Watershed-Estuarine Interaction
• Pollution from point and nonpoint sources • Runoff – stormwater, urban, agricultural • Development – along waterways and within floodplains • Upstream damming A **watershed** is an **area of land that funnels all of the surface water and ground water into waterways that drain into a single output** (i.e. estuaries, lakes, the ocean).	• Hypoxia from eutrophication • Loss of habitat for commercially important species • Loss of wetland habitats • Loss of biodiversity • Poor water quality • Shoreline erosion • Channel erosion • Sediment starvation • Flooding An **estuary** is the **confluence of inland, freshwater flows with tidal waters in a partially enclosed basin**. A typical component of an estuary is a delta, which is usually formed by sediment deposits at the mouth of the river as it enters into the estuary. These environments typically contain some of the most diverse aquatic habitats as nutrients from freshwater inflows and saltwater inputs interact. These are unique environments that can be influenced negatively by a range of external stressors.	

Restoration Alternatives

Manage watershed inputs and implement restoration activities to support healthy delta and estuarine environments and reestablish more natural hydrology.

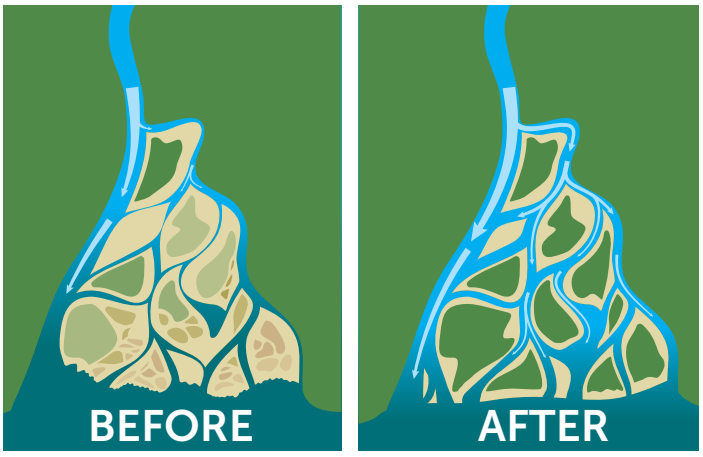
Strategic Land Conservation Areas

Purchasing strategic land conservation areas within floodplains allow rivers to function naturally and store more floodwater. This management practice can reduce urban flooding by preventing development in flood prone areas.



Restoring Natural Hydrology

Restoring more natural hydrology and removing blockages, such as sediment deposits, can replenish sediment-starved downstream habitats and shorelines and increase freshwater flows to provide needed nutrients for nutrient cycling. This supports diverse wildlife, healthy wetlands, bountiful marine nursery grounds, and resilient shorelines.



Other alternatives could include:

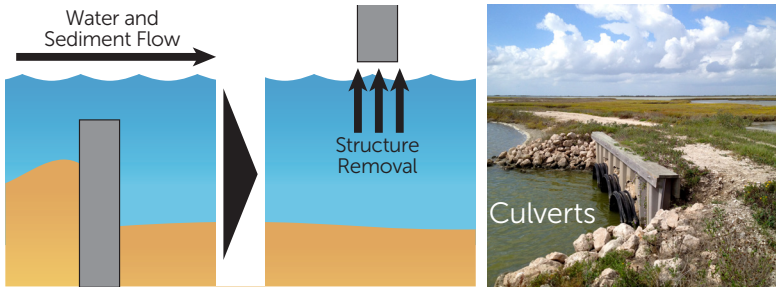
- Restricting future development in floodplains
- Decommissioning, replacing, or removing infrastructure that restricts freshwater flows and sediment transport to the estuary (e.g., removing dams, enlarging culverts)
- Constructing new projects, such as living shorelines, to prevent wave-induced shoreline erosion and improve habitat functionality and biodiversity

Engineering Considerations for Delta and Estuary Management

Structural

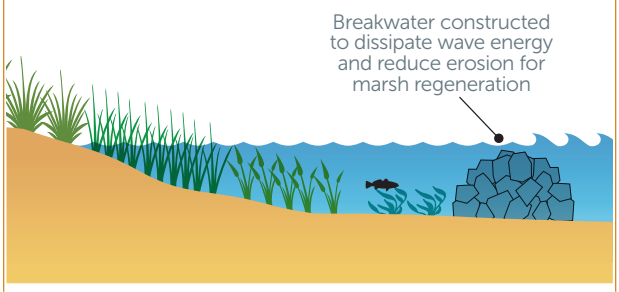
The location of needs within the watershed and project goals as well as the project budget and timeline will be the primary considerations when selecting which approach to use in a delta/estuary management project.

Manage Inflows



- Water/Sediment Budgets – Removing upstream channelization or structures can allow natural sediment transport and restore freshwater flows into estuaries
- Culverts – Improving flow of freshwater within the watershed can create/restore more freshwater input into an estuary

Control Erosion



Breakwaters can prevent erosion from the seaward side of estuaries by reducing wave action along a shoreline. They can be constructed of natural materials and aid in building up estuarine habitats.

UPSTREAM TO DOWNSTREAM LOCATIONS WITHIN WATERSHED

Non-Structural

Ecological management strategies are useful when trying to preserve or enhance the natural environment and can be used in conjunction with structural and policy management strategies to further protect habitats.

Habitat Creation

- Cost is dependent on size of wetland area and materials used, but can be the least expensive option
- Longevity is within low-to-mid range, but can be longer with a structural component
- Project Examples:
  - » Marsh planting
  - » Beneficial use of dredged material to replenish sediment

Land Conservation

- Acquiring conservation areas is the primary form of protecting vital habitats within the watershed
- Cost tends to be greater and is dependent on identifying a willing seller and price point the seller is willing to accept
- Land acquisitions can in some cases be related to water rights within a watershed
- Land acquisitions can be the longest lasting solution to delta management and watershed planning

PROJECT COST & LONGEVITY

Ecological

Identify the connections between ecological components to inform project design.

Environmental Components

- Fisheries – Breeding, feeding, and nursery for juveniles supports biodiversity
- Flora – Nutrients, dissolved oxygen, salinity levels, habitat growth impact flora presence

Physical Components

- Sedimentation – Erosion/subsidence leads to habitat degradation in the intertidal region
- Water Quality/Quantity – Proper balance of freshwater input and tidal influence

Study/Policy

Environmental studies and policies can establish project requirements, such as monitoring and permitting, and should be incorporated early in the project timeline to reduce long-term cost.

Monitoring Studies

- Identify Best Management Practices for individual watersheds
- Set environmental baselines for comparison with future post-restoration monitoring studies
- Address estuarine health from multiple entrance points (watershed, tidal/coastal influences, etc.)
- Cost of the study is dependent on scale and scope

Indicators of Interest

- Salinity stabilization within an estuary with return of freshwater inflow
- Abundances of key species before, during, and after restoration projects
- Impacts on oysters and indicator species
- Change in sedimentation after breakwater installation

Resiliency for Delta and Estuary Management

	Concerns	Effect on Deltas and Estuaries	Solutions
Drought	• Low freshwater input due to low water conditions within the watershed • Increased salinity throughout the estuary	• Important fisheries that utilize estuary and delta environments cannot survive in high salinity waters • High salinity can kill Submerged Aquatic Vegetation (SAV) and destroy wetland habitats and oysters	• Obtain Water Rights throughout the watershed to help maintain freshwater flow during drought • Enact policies to manage water demand • Remove upstream features that might be restricting flows • Plan reservoir capacities to help manage salinity
Storm	• Degraded water quality • Increased pollution • Storm frequency and intensity increases are expected in the future	• Reduction in the salinity of an estuary can lead to the loss of oyster beds and SAV • Increased coastal erosion • High levels of pollutants and pesticides can degrade habitats and kill vital species	• Develop adaptive stormwater management practices (e.g. promoting natural stream buffers, reconfiguring culvert design, removing impervious surfaces) • Restore and preserve existing wetland habitats with living shorelines
RSLR	• Increased salinity as tidal water moves further inland • Increases in sustained coastal flooding episodes • Increased water depth	• Altered diversity of key species • Habitat loss • Less sunlight available to SAV • Increased erosion • Altered tidal range	• Allow coastal wetlands to migrate inland and promote wetland accretion by introducing sediments • Plant vegetation to stabilize sediment and reduce erosion • Incorporate RSLR into planning for new infrastructure
Development	• Increased development along the coast as populations migrate to coastal communities	• Loss of habitat to development (within wetlands, floodplain, etc.) • Increased urban runoff disrupting nutrient cycling through addition of contaminants and nutrients • Possible implications for infrastructure to restrict sediment • Inability of wetlands to migrate adjacent to built environment	• Land acquisition/exchange programs to move development out of the floodplain • Prevent development in the floodplain • Enforce permitting rules that regulate locations for landfills, hazardous waste dumps, toxic chemical facilities, etc.
Water Quality	• Increased water temperatures • Increased nutrients • Increased sedimentation • Altered nutrient cycle	• Lower oxygen levels in the water can drown SAV and kill fisheries • Increased hypoxic zones • Smothered habitats	• Preserve and restore biodiversity of vegetation in tidal marshes, SAV, and mangroves • Outreach and education programs to municipalities/agricultural groups to manage output of nutrients into watershed • Identify and protect ecologically significant areas within the estuary

Additional Information and Resources:

- **Texas Commission on Environmental Quality Water Quality Certification:** https://www.tceq.texas.gov/permitting/401certification/401certification_definition.html
- **U.S. Army Corps of Engineers Nationwide Permits**
  - » NWP 3 - Maintenence: https://www.swt.usace.army.mil/Portals/41/docs/missions/regulatory/NationwidePermits/Nationwide%20Permit%2003%20-%20Maintenance.pdf?ver=2017-03-31-150712-083
  - » NWP 53 - Removal of Low-Head Dams: https://www.swt.usace.army.mil/Portals/41/docs/missions/regulatory/NationwidePermits/Nationwide%20Permit%2053%20-%20Removal%20of%20Low-Head%20Dams.pdf?ver=2017-03-31-150712-113
  - » NWP 54 - Living Shoreline: https://www.nao.usace.army.mil/Portals/31/docs/regulatory/nationwidepermits/Nationwide%20Permit%2054.pdf
- **Texas Permitting Assistance:** https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=31&pt=16&ch=504&rl=10
- **Texas Environmental Flows from TPWD:** https://tpwd.texas.gov/education/water-education/texaswatersprogram/mayes-environmental-flow-2020.pdf
- **Texas Environmental Flows from TWDB:** https://www.twdb.texas.gov/surfacewater/flows/environmental/index.asp#trinity
- **Development of Watershed Management Plans from the EPA:** https://www.epa.gov/sites/production/files/2015-12/documents/watershed_mgmnt_quick_guide.pdf
- **Understanding Morphological Change in Estuaries:** http://www.estuary-guide.net/pdfs/chapter2_estuary_management.pdf
- **Open Rivers Fund:** https://hewlett.org/openriversfund/
- **Galveston Bay Plan:** https://gbep.texas.gov/wp-content/uploads/2019/08/CCMP_2ndEdition_FINAL-TCEQ-Approved-DRAFT.pdf
- **Climate Ready Estuaries:** Synthesis of Adaptation Options for Coastal Areas, EPA: https://www.epa.gov/cre