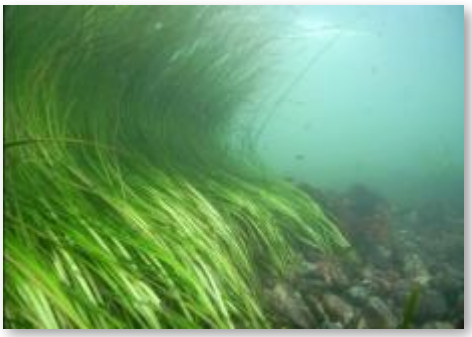
Coastal Assessment and Restoration

Geosyntec has a wide range of expertise in coastal assessment and restoration. Our staff is experienced in taking coastal restoration sites from concept phase, with pre-restoration monitoring and feasibility studies, to development of final restoration designs, construction oversight and post-construction monitoring.

Geosyntec engineers and scientists have the broad range of technical training and practical experience required for assessment of coastal ecosystem health. Our expertise includes coastal ecology, water quantity and quality monitoring, collection of tidal hydrology data and development of hydraulic models to assess tidally restricted coastal environments and potential restoration alternatives. Geosyntec develops restoration plans and implements cost-effective engineering designs including geotechnical investigation, design for culverts and appurtenances, technical specifications and bid documents, construction oversight and post-construction monitoring and restoration assessment.



Geosyntec's coastal assessment and restoration services include:

- Restoration feasibility studies
- Restoration design, mitigation and alternatives analysis
- Coastal resource area delineation and mapping
- Coastal dredging and sediment remediation
- Tidal hydrology monitoring and site assessments
- Hydraulic modeling
- Climate change modeling and assessment
- Geotechnical evaluations
- Preparation of technical specifications, bid documents
- Construction oversight

Project Summaries

TIDEGateway – Tide Gate Inventory & Data Evaluation Tool

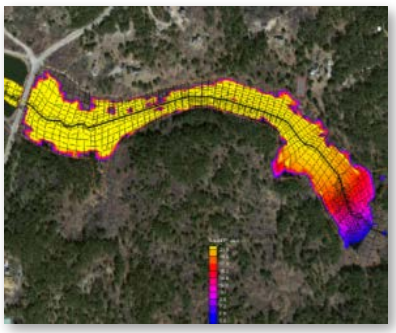
Geosyntec was selected by the Massachusetts Bays National Estuary Program (MassBays) and Massachusetts Office of Coastal Zone Management (CZM) to:

- Gather and assess existing information related to tide gates in the MassBays region;
- Develop and implement a field protocol to gather tide gate data location and current status;
- Develop a desktop tool to assess tide gates for potential impacts to wetland ecology and floodplain function in order to inform the management of these structures, especially in light of potential climate change impacts such as anticipated sea level rise and changes in precipitation patterns; and
- Provide recommendations regarding ecological and floodplain implications of tide gate operations, implications for anticipated impacts of climate change and sea level rise, and use of the tide gate analysis tool to improve management of tide gates.

Geosyntec's conducted each of the above project tasks as components of TIDEGateway - a fully integrated suite of GIS map products, fact sheets, data, modeling projections, and related planning tools. An important component of this project was the development of a TIDEGateway web-based tool that provides convenient access to tide gate information without requiring specialized software training or licenses. TIDEGateway can be easily used, expanded and adapted by MassBays and CZM staff over time as more tide gate information becomes available, and can also be used for other coastal regions.

Eagle Neck Creek Salt Marsh Restoration

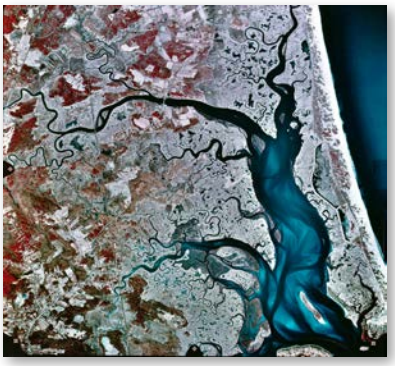
Tidal flows to Eagle Neck Creek have been restricted by an undersized road culvert, resulting in loss and degradation of salt marsh habitat. Geosyntec was selected by the Cape Cod Conservation District to conduct ecological investigations, tidal monitoring and modeling to determine optimal culvert sizing for restoration of tidal flows to the Eagle Neck Creek marsh. The primary goal of the feasibility study was to collect tidal data, including water level and salinity, and create a 2-dimensional hydrologic/hydraulic model to simulate water surface elevations for various culvert sizes.



2-dimensional model of predicted salinity in Eagle Neck Creek marsh.

Geosyntec installed water level transducers and salinity meters within the marsh and surrounding area. We also mapped natural community types and investigated the presence of rare/endangered species. Using LIDAR survey and a topographic survey, Geosyntec developed a baseline map of the marsh, used to build a model geometry of the marsh system. Geosyntec generated a 2-dimensional hydraulic/hydrologic model using RMA2/RMA4. The model was used to evaluate three proposed culvert sizes and their associated water surface elevations based on spring high tide, a 100-year storm-driven high tide and high tide associated with sea level rise due to climate change predictions. Geosyntec provided maps and videos depicting the salinity intrusion plume and water elevation for each high tide condition. For each restoration scenario, we assessed potential impacts to fish passage, low-lying properties, wells and septic systems. Geosyntec provided recommendations on restoration options for Eagle Neck Creek to (1) allow for the water elevation upstream and downstream of Old County Road to represent an unrestricted state and (2) provide maximum salt water intrusion.

Massachusetts Estuary Assessment and Delineation Project



Geosyntec was selected by the Massachusetts Bays Program (MBP) to evaluate the condition of 43 estuaries watersheds on the Massachusetts coast. The project consists of watershed delineation, data collection, and classification of each watershed based on MBP management priorities. The delineation process includes standard delineation methods and adjustment of boundaries based on the seaward extent of estuarine resources and the landward head-of-tide. Statistics for each watershed will be calculated for factors such as population, impervious cover, land use, wastewater discharge, stream continuity, estuarine habitat for shellfish and shorebirds, seagrass beds, tidal flats, etc. The watersheds will be ranked based on estuarine resources and environmental stressors to allow for a comparative analysis which will aid in determining management priorities for each watershed. The results of this analysis will be used to update the MBP Comprehensive Conservation and Management Plan.

Resiliency Innovations for a Stronger Economy (RISE: NYC)

Hurricane Sandy caused an estimated $19 billion in damages in New York City (NYC). Power outages, downed telecommunications, fuel cutoffs, and flooding affected tens of thousands of businesses and drained available resources into recovery efforts. Geosyntec and Opti have been awarded a competitive grant to bring innovative flood proofing technologies to small businesses in NYC. The NYC Economic Development Corporation (NYCEDC) is administering the $30 million grant program known as Resiliency Innovations for a Stronger Economy (RISE: NYC). The projects funded under this program will help NYC businesses deploy "new, innovative, and cost-effective" solutions to "enable buildings and infrastructure networks to better resist, adapt to, and/or bounce back from future storms."

Geosyntec and its project partners will conduct site audits to collect information and evaluate flood risk at 30 small businesses and identify flood monitoring and proofing strategies. A network of sensors and active and passively controlled floodproofing measures will be installed to protect against flooding at 3-5 pilot sites. Opti will provide the Active Floodproofing technology - a flexible and adaptive system capable of autonomously monitoring current and predicted conditions and initiating actions. Business owners will receive alerts, automated flood control, and greater resiliency through Opti's integration of internet-based sensor data, NOAA forecasts, and other site information and control logic for valves and other floodproofing mechanisms, including actions that businesses can take themselves. Regional flood modeling will be integrated to provide problem identification and solutions for each site.

Gulf Oil Spill Response – Marsh Protection System

In the weeks following the of the explosion of the Deepwater Horizon and catastrophic oil spill in the Gulf of Mexico in April of 2010, Geosyntec Provided the Northwest Florida Water Management District with the assessment and design of an integrated March Protection System (MPS) to provide protection for highest priority ("first tier") sensitive coastal wetlands owned by the District. These lands are located in the Perdido and Pensacola Bay ecosystems in Escambia and Santa Rosa Counties, Florida. The bayfront portions of NWFWMD's first tier coastal lands within these systems include 4,019 acres and 9.4 miles of shoreline.

As part of the emergency response to the oil spill, Geosyntec conducted an extensive shoreline reconnaissance and developed a comprehensive MPS Plan for the NWFWMD in July 2010. The MSP Plan provided for a multi-line defense initiative at each of the four "priority one" marsh areas owned by the NWFWMD. The Plan also included a detailed implementation strategy and cost evaluation for the

various shoreline protection system designs. The overall objective of the MSP Plan was to: (i) develop shoreline and tidal creek/inlet protection strategies and recommend corresponding materials which can be readily obtained and deployed to defend these sensitive areas; and (ii) develop a plan for the timely procurement and rapid deployment of these protective strategies. The primary, secondary and tertiary diversion/deflection, barrier and collection defense systems were designed by Geosyntec to divert or otherwise capture oil sheen, oil slick, weathered oil (tar balls), emulsified oil (either floating on the surface or dispersed within the shallow water column) and oil-impacted flotsam that may pass through this first line boom defense. The multi-layered MPS utilized proven oil diversion/deflection principals combined with the innovative use of highly effective hydrophilic geosynthetic materials (i.e., material which collect or otherwise retain oil while allowing water to pass) to provide oil barrier protection

Multi-site Tidal Assessment Project

Geosyntec was selected by the Massachusetts Division of Ecological Restoration to assess tidal hydrology at locations upstream and downstream of five restoration projects. This project involved deployment of continuous data-logging pressure-transducer tide-gauges. To assess restoration potential at the sites, the gauges were deployed to collect continuous tide data at 6-minute intervals with time and date stamps for 28 days spanning a monthly spring tide. Geosyntec prepared an assessment of the tide data for each site, including tidal hydrographs, and a discussion of post-construction tidal hydrology, water quality and modeling information for the pre-construction condition. Geosyntec also provided recommendations for adaptive management/improvements that can be made at each site. For pre-construction sites, Geosyntec summarized the existing tidal hydrology and included information on the severity of the restriction.

Bucks Creek Salt Marsh Restoration

Bucks Creek (Chatham, MA) previously flowed under Cranberry Lane through a degraded, 24" culvert. The culvert restricted tidal inundation of the upstream 5-acre salt marsh, leading to loss of salt marsh habitat and restricting passage of anadromous fish species. To restore the salt marsh, the Massachusetts Division of Ecological Restoration retained Geosyntec to develop a construction package and provide environmental permitting support for the culvert's replacement with a 3 foot by 4 foot concrete box culvert. Permitting included a Massachusetts Wetlands Protection Act Notice of Intent, U.S. Army Corps of Engineers Section 404, MEPA Environmental Notification Form, Section 401 Water Quality Certification and Chapter 91 Waterways License. We developed construction plans for the culvert replacement which allowed DER to put the project out for public bid. Geosyntec produced a construction phase Erosion and Sediment Control Plan and "water handling plan" to specify flow management in the creek during construction. Geosyntec also provided construction management services to ensure proper project implementation and installed water level transducers to assess post-construction restoration results.

Salt Marsh Assessment and Restoration Tool (SMART)

Geosyntec, in partnership with the Wells National Estuary Research Reserve, Brown University and Massachusetts CZM, was awarded a research grant from the UNH/NOAA Cooperative program to evaluate several innovative technologies for salt marsh restoration. The SMART (Salt Marsh Assessment and Restoration Tool) project used remote sensing and modeling software for achieving restoration planning by coastal managers. The project approach included: 1) hyperspectral imagery analysis as an aerial-based source of spatial vegetation distribution, 2) light detection and ranging (LIDAR) data as a remote

source of high-resolution elevation data, 3) storm water management modeling (SWMM) for hydrologic simulation of complex restoration designs, and 4) ESRI ArcGIS version 9 with a Visual Basic (VB) delivery platform for SMART predictive ecology and visualization. Remotely-sensed data sources and detailed hydrologic simulations were integrated with existing program logic of the Konisky restoration model to provide a state-of-the-art system for regional restoration managers.

Laguna Creek Bacteria Source Tracking Study

The City of Santa Barbara selected Geosyntec to conduct a bacteria source tracking study for the Laguna Creek. This project is part of the City's efforts to address dry weather sources of Fecal Indicator Bacteria (FIB) and human fecal contamination at its beaches. The City had previously identified ozone disinfection at the Laguna Channel outlet as an option for reducing pathogen concentrations in dry weather runoff that discharges to the Pacific Ocean at East Beach, which is a 303(d)-listed impaired water body for bacteria. Geosyntec's tasks project included (1) reconnaissance of the channel and storm drain network to identify sources of dry weather flow and human fecal contamination, followed by installation of automated gauges to measure flow; (2) monitoring of FIB and human bacteroides marker (HBM), followed by estimation of FIB/HBM loads from the watershed; and (3) a cost/feasibility evaluation of dry weather flow treatment alternatives, including diversion to sewer and UV/ozone disinfection and source control recommendations.

Mill Pond Tidal Assessment Project

Geosyntec was selected by the Massachusetts Division of Ecological Restoration to assess tidal hydrology at locations upstream and downstream of Mill Pond Road in Truro, MA. Mill Pond Road crosses a tidal channel that connects flow from the Pamet Harbor to Mill Pond. The channel flows under the road via a 3-foot corrugated plastic culvert. There is evidence that tidal flow into Mill Pond is restricted by the culvert, including impacts to vegetation and major scouring basins/erosion on both sides of the culvert. This project involved the deployment of continuous data-logging water level transducers, to assess restoration or restoration potential at site. The gauges were deployed to collect continuous tide data at 6-minute intervals with time and date stamps for 14 days. Geosyntec prepared an assessment of the tide data for the site, including tidal hydrographs, and presented the findings at a public meeting to discuss potential future restoration along Mill Pond Road including increasing the culvert size.

Santa Ana River Marsh - Sediment Sampling and Remediation

Geosyntec performed a remedial investigation and design at the Santa Ana River Marsh for the U.S. Army Corps of Engineers in preparation of dredging to widen the Santa Ana River and restoration of the marsh. The work included soil/sediment sampling for hydrocarbons, chlorinated compounds, pesticides, metals, and PCBs. Samples were generally collected using a specially designed and constructed piston sampler. Many samples were collected below the water by wading or from a boat in tidally-influenced channels in the wetlands. Geosyntec then compiled and analyzed the sampling and chemical data to define areas of concern at the site. Geosyntec defined action levels for petroleum hydrocarbon based on potential ecological impacts. Geosyntec also developed a remedial plan which included excavation of impacted material, on-site soil and sediment consolidation, and capping of impacted materials. The remediation plan was integrated with the wetland restoration project to reduce overall project cost and disturbance of the environment due to remediation activities. Geosyntec also

designed habitat features for the California Least Tern. The remediation and restoration of 91 acres of the Santa Ana River Marsh is now complete and the area provides a vibrant wetland habitat for many types of wildlife.

Boat Meadow Creek Salt Marsh Restoration

Geosyntec conducted an engineering design and permitting project for the Massachusetts Office of Coastal Zone Management, to evaluate options for restoration of the Boat Meadow Creek Salt Marsh in Eastham. Boat Meadow Creek is a tidal stream extending from Cape Cod Bay into the extensive salt marshes of the Cape's North Shore. Tidal flow and drainage in the creek is affected by two crossings in Eastham, the Cape Cod Rail Trail and Smith Lane. Geosyntec conducted an existing conditions/wetlands survey, a feasibility study including hydrologic modeling, developed a draft restoration plan, and provided permitting services and related technical assistance.

Ballard Street Salt Marsh Restoration

Geosyntec was selected by the Massachusetts Division of Ecological Restoration to provide engineering, ecological and permitting services for the Ballard Street Salt Marsh Restoration Project. Geosyntec has been advancing this restoration project in phases since 2004, including wetland regulatory support, sediment sampling for development of specifications for dredging and dewatering, and development of construction cost estimates. The most recent phase includes (1) wetland delineation, (2) development of permit-level design plans for a culvert enlargement and tide gate to restore tidal flushing to a historic salt marsh that has become dominated by Phragmites, (3) development of permit-level designs for restoration dredging of an approximate 18-acre area upstream of the culvert enlargement, and (4) preparation of permit applications for the proposed dredging and tide gate/culvert installation.

Mayo Creek Salt Marsh Assessment

The Mayo Creek Salt Marsh, which is connected to Wellfleet Harbor by a single 2-foot diameter culvert under Commercial Street, is a degraded salt marsh system. The culvert is equipped with a duckbill valve that prevents incoming tides from entering the former tidal creek and restricts tidal exchange. The elevation of the culvert combined with the unidirectional influence of the duckbill valve has reduced the tidal range as well as the mean water level in the creek to such a degree that normal tidal inundation of the surrounding marsh area no longer occurs. Geosyntec assessed tidal hydrology at locations upstream and downstream of Commercial Street by deployment of continuous data-logging pressure-transducer tide-gauges. The gauges collected continuous tide data at 6-minute intervals with time and date stamps for 28 days. Geosyntec analyzed the tide data for the site, including tidal hydrographs, and developed an alternative tide gate to allow additional tidal flushing.

Oak Island Salt Marsh, Self-Regulating Tidegate Operation

Geosyntec was contracted by Massachusetts CZM/WRP to create an Operation and Maintenance Plan for a self-regulating tide gate (SRT) at the Oak Island Marsh. As part of this plan, we evaluated marsh inundation elevations to provide maximum flood protection for local homes while also maintaining the goal of salt marsh restoration. Geosyntec conducted an

innovative modeling and visualization approach to provide the needed information for the tide gate's operation required by the tide gate managers, as well as an important public information tool to educate local property owners.

Little Namskaket Salt Marsh Restoration

In support of the feasibility design and associated permitting of a salt marsh restoration project for the Massachusetts Office of Coastal Zone Management, Geosyntec performed field reconnaissance to conduct an existing conditions survey. This effort included detailed wetland resources boundary mapping, elevation verification of marsh and surrounding topography, location of nearby utilities, and other field efforts. Geosyntec also developed a continuous simulation hydrologic and hydraulic model based on the EPA Stormwater Management Model (SWMM) to provide time series data for parameters such as water surface elevations, flow rates, and velocities within modeled natural channel sections.

Town Creek Marsh Restoration

Geosyntec was contracted by the Massachusetts Office of Coastal Zone Management to perform the data collection and mapping necessary to support future modeling and design of restoration options for Town Creek Marsh. Geosyntec evaluated marsh inundation elevations and salinity to aid in the determination of the extents of the marsh capable of supporting a salt marsh ecosystem. We created base maps using high resolution aerial imagery and we assessed salinity concentrations in this tidal marsh.

Morro Bay Wasteload Allocation Attainment Plan

Water quality monitoring in the Morro Bay Watershed has revealed high concentrations of fecal indicator bacteria, prompting the development of a Total Maximum Daily Load (TMDL) for bacteria by the Central Coast Regional Water Quality Control Board (Regional Board). The City of Morro Bay (City), as a responsible discharger to the Morro Bay Watershed, has been required to develop a Wasteload Allocation Attainment Plan (WAAP) addressing this TMDL to supplement the City's Phase II MS4 Storm Water Management Plan (SWMP). The WAAP is required to define the approach to be implemented within the portion of the watershed under the City's jurisdiction to achieve the TMDL's concentration-based wasteload allocations. Geosyntec was hired by the City to develop the WAAP

As a first step, Geosyntec conducted a detailed data review, including microbial source tracking studies, historic water quality trends, tidal and rainfall data, other MS4 bacteria source investigations, and GIS data, to support an assessment of key pollutant sources. Recognizing that the City developed their SWMP with specific BMPs aimed at reducing bacteria loads, Geosyntec sought to leverage and prioritize existing BMPs. Based on the City's 2010 SWMP and Geosyntec's data review, an implementation and assessment strategy was proposed to employ the most cost effective means to achieve TMDL compliance. Geosyntec first prioritized existing nonstructural BMPs developed to reduce bacteria loading. Next, Geosyntec proposed the addition of three nonstructural BMP programs. These programs included a dye tablet program to detect illicit discharges from live-aboard boats, a public outreach program for sewage disposal at RV and trailer parks, and a beach walk program to encourage citizens to participate in illicit discharge detection surveys.

The WAAP also included a BMP implementation schedule, with milestones and measurable goals to be used by the City to track and assess implementation efforts; a proposed adaptive management strategy for assessment

of attaining the wasteload allocations, which will rely on internal tracking of effectiveness measures for BMP modifications; and a proposed water quality and BMP monitoring program.

Ventura County Watershed Protection District – TMDL Implementation Planning

Historic water quality monitoring at Kiddie and Hobie Beaches, located in the Channel Islands Harbor in Ventura County and hereafter referred to as Harbor Beaches, has revealed high bacteria concentrations, prompting the development of a Total Maximum Daily Load (TMDL) for bacteria by the Regional Water Quality Control Board (RWQCB). The TMDL became effective in December, 2008. Dischargers to the Harbor Beaches, including Ventura County Watershed Protection District (County), have conducted numerous studies and implemented various controls to identify and address likely bacteria sources at these beaches, however bacteria concentrations remain above the TMDL's allowable exceedance day Waste Load Allocations (WLAs), which are now incorporated into the County's MS4 NPDES permit at numeric effluent limits. The TMDL requires MS4 dischargers to submit dry and wet-weather implementation work plans. Geosyntec was hired by the County to develop these Implementation Plans, with input from multiple stakeholder agencies, including the County, County Harbor Department, and County Environmental Health Division. Geosyntec worked with Malcolm Pirnie on the dry-weather Plan.

As a first step, Geosyntec conducted a detailed review of previous studies, including DNA source tracking, harbor circulation modeling, and various groundwater, stormwater, sand, surfzone, and harbor water bacteria sampling studies, to support an assessment of key dry and wet weather bacteria sources at the beaches. For the dry-weather Plan, after also reviewing studies of structural control effectiveness from other enclosed beaches, Geosyntec identified specific non-structural BMPs and pilot study and implementation of structural controls, such as enhanced circulation devices and bird deterrents. For the wet-weather Plan, Geosyntec analyzed beach monitoring data to establish bacteria load reductions required for TMDL compliance, identified and prioritized non-structural and structural BMPs for County areas, and applied the Strategic BMP Prioritization and Analysis Tool (SBPAT) – a cost effectiveness-based structural retrofit BMP prioritization model developed by Geosyntec and approved by the RWQCB for use in TMDL implementation plans in the Los Angeles region – to quantify expected bacteria load reduction and costs associated with these proposed measures.

Strategic regulatory guidance was also provided to evaluate options to minimize uncertainties regarding (a) the applicability of an open beach reference watershed (Leo Carrillo) to enclosed systems (noting that a Natural Source Exclusion approach is a possible alternative to the current reference watershed-based TMDL approach), and (b) the reliability of bacterial indicators for assessing human health risk. Geosyntec proposed a microbial source tracking study to quantify human fecal markers at the beaches and in stormdrain outfalls to inform bacteria source assessments and support alternative TMDL compliance approaches. Geosyntec also developed a quantitative Microbial Risk Analysis (QMRA) study plan for RWQCB staff consideration as a special study option for developing site specific recreational criteria for bacteria, if estimated bather illness rates are confirmed to be below the USEPA's allowable levels.