Quantifying Erosional Process in Sediment Diversion Receiving Basins

SUMMARY

One of the recommended coastal restoration methods in Louisiana is the diversion of sediment-laden water from the Mississippi and Atchafalaya Rivers into adjacent basins to build new land. Diversions reconnect the river to the deltaic plain via river reintroductions, the reopening of old distributaries, and land building processes. Mud and sand represent >80% and <20% of sediment load in the Mississippi/Atchafalaya Rivers, respectively, but the significant loss of mud represents a substantial issue in the land-building process. The erosional process can also cause a problem to far-field marsh edge because vegetation generally needs to trap fine-grained sediment to maintain a critical elevation on which marsh can grow and develop.

In diversion receiving basins, closest to the diversion structure, plants and soils are exposed to the full combination of freshwater, sediments and nutrients in the diversion inflows. Coarse sediments fall out of suspension quickly with distance from the diversion as flow velocities decrease across the receiving basin, resulting in proximal and distal differences. Figure 1 shows major physical and geological processes impacting sedimentary environments in an idealized receiving basin. In the proximal site, for instance, sand settles quickly and has a higher critical shear stress for resuspension, contributing to rapid subaerial land building. Mud settles slowly and travels a longer distance, and may be deposited and resuspended multiple times in the subaqueous part of the receiving basin. It should be noted that marsh edge sediment exchange is also a key process in this system.

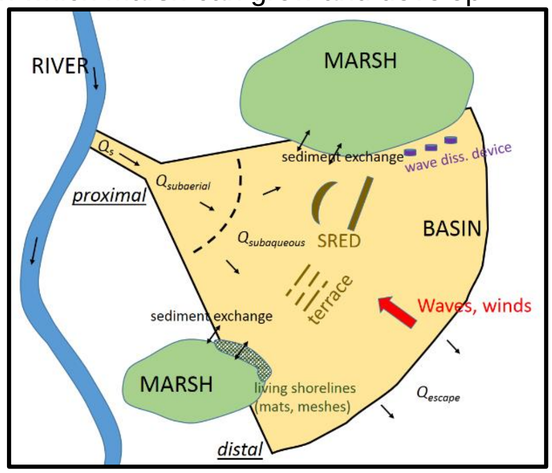

Figure. 1 A conceptual diagram of a diversion receiving basin, from Xu et al. (under review with ECSS, co-authors Bentley, Day and Freeman)

In 2017 Dr. Kehui Xu and others were funded by Louisiana Center of Excellence (CoE) to work on a project entitled "*Enhancing Sediment Retention Rates of Receiving Basins of Louisiana Sediment Diversions*". This project is focused on **distal area (open bay)** in which tripod data will be collected, sediment erodibility will be measured and models will be used to quantify the retention rate in Barataria Bay. Due to time and budget constraints, the sediment exchange along marsh edge (Fig. 1) is neglected in this project. This is a 2-year project but a one-year no cost extension is expected due to the delay on the contract. In collaboration with Bruce Lelong of AECOM, James Hance of Eustis Eng., Craig Jones of Integral Corp. in California, and Mead Allison of Tulane University, Dr. Xu's group is working on another project and will be collecting erodibility data in both **proximal and distal areas** of mid Barataria Bay diversion (along major diverted water pathways, but not near marsh edge). Tens of 30-ft long cores will be collected, SEDFlume will be used to measure deep sediment erodibility, and GEMS will be used to measure erodibility on short push cores. The overarching goal of this AECOM project is to collect data to inform numerical modeling effort in the 1.3-billion Middle Barataria Sediment Diversion project. Due to the short timeline, only a few months of salary of a LSU student was budgeted. A major challenge identified in this project was that there are no much stratigraphy or erodibility data available in this study area, especially in supper shallow water near the diversion structure where large boats cannot access. As now the model being used by AECOM and others includes a highly simplified two-layer setup. It is well known that less-erodible sands are deposited along the river distributary mouths and erodible clays are deposited in the broad interdistributary bays. Significant erosion, up to 20-25 ft deep must occur before significant land can be built in Barataria Bay, but now the modelers cannot improve the prediction much due to lack of erodibility and stratigraphy data.

In this proposal, a 3-year research assistantship is requested to hire a MS student who will work on **super shallow water stratigraphy**, **marsh edge sediment erodibility**, **marsh edge morphology** in proximal and distal areas near middle Barataria Bay and middle Breton Sound diversions. This project does not overlap, but is actually complementary to, two aforementioned ongoing CoE and AECOM projects.

APPROACH

A dual-core Gust Erosion Microcosm System (GEMS) will be used to measure the profiles of eroded mass vs. shear stress. The system consists of a laptop, a power control box, two turbidimeters, a pump controller, two rotating motors, two erosional heads, two sediment chambers, source water, collection bottles, and a suction filtration system. This experimental setup allows for shear stress manipulation from a laptop computer to be applied to the rotating heads that spin the water above the sediment and hence cause sediment suspension.

It is well known that Edgetech 424 subbottom seismic profiler can be used in super shallow water of 1-3 ft. Edgetech 424 uses high frequency of 4-24 kHz, but its penetration depth is less than a few meters in sandy environment like river distributary channels. Edgetech 216 and 0512i are powerful sonar systems using intermediate and low frequency ranges but are generally hard to be used in shallow water due to their bulk sizes and heavy weights. In summer 2018, Dr. Xu's group designed a new pontoon-like floating device for Edgetech 2000 and tested the system in a water depth as shallow as 1.5 ft in Terrebonne Bay and collected high quality geophysical data. In this project, an Edgetech 2000 DSS combined sidescan sonar & sub-bottom profiler system will be used to collect CHIRP seismic profiles using a range of frequency of 2-16 kHz and sidescan data using simultaneous frequencies at both 300 and 600 kHz. The 2000 sub-bottom profiles can reveal erosional and depositional structure with a vertical resolution of several cm and up to 60 m penetration depth on muddy sea floor. Marsh edge erosion collapse, mud slides, erosional gullies and sediment redistribution can all be detected.

In this project, both Gust Erosion Microcosm System and Edgetech 2000 will be used. About 10 sites in Barataria Bay and 10 sites in Breton Sound will be used for marsh edge core collections and erodibility measurements. In combination with two projects funded by CoE and AECOM, our group will compile the largest erodibility database for Barataria Bay and Breton Sound in Louisiana, a valuable dataset for models. About 200 miles of subbottom and sidescan data will be collected in super shallow waters in Barataria Bay and Breton Sound, where deep penetration seismic data are not available yet.

SIGNIFICANCE AND DELIVERABLE

Deliverables in this project include conference presentations, peer-reviewed journal articles, and comprehensive dataset available to scientific communities. A unique dataset of sediment grain size, erodibility, sidescan and subbottom will be collected. These data will be used to investigate the erosional processes in multiple sediment diversion receiving basins. Our proposed project has a direct link and application of demonstrated outcomes to the CPRA's mission "*to develop, implement, and enforce a comprehensive protection and restoration master plan for coastal Louisiana*." Major findings of this project will be presented at Annual CoE All-hands Meeting, the State of the Coast Conference, and national/international conferences. At least one peer-reviewed paper will be published based on the research in this project.

In 2014-2016, Dr. Xu was funded by CPRA CSAP program to support a MS student Courtney Elliton. Courtney did an excellent internship project with Drs. James Pahl and Angelina Freeman at CPRA and is now working as a Science Assistant at U.S. National Science Foundation in Arlington, Virginia. We believe that such kind of successful partnership will continue.