# Innovative Study Quantifies Overland Flow in Mississippi Delta

*Data can help direct wetland rebuilding efforts*

Subsiding and choked off from the Mississippi River, southeastern Louisiana's coastal marshlands have steadily sunk and become more saline. According to U.S. Geological Survey (USGS) dayta from 1990 to 2000, Louisiana is losing 24 square miles (62 square kilometers) of wetlands per year – wetlands that are nurseries of coastal fisheries and, as Hurricanes Katrina and Rita illustrated in 2004, can help absorb the brunt of storms blowing in from the Gulf of Mexico. Recognizing the danger of continued wetland degradation and loss, state and federal officials are seeking ways to rebuild Louisiana's threatened wetlands.

The U.S. Army Corps of Engineers' Caernarvon Freshwater Diversion, south of New Orleans, La., is being studied as a possible resource for helping restore wetlands above Breton Sound. Opened in 1991, the diversion was designed to direct controlled releases of Mississippi River water through its levee to help manage rising salinity in the sound. Managers are eager to explore whether the diversion can be managed to also deliver sediments for rebuilding the wetlands and offset the relative sea level rise that the marsh complex has been experiencing.

*Gregg Snedden of Louisiana State University readies an acoustic Doppler Velocimeter (ADV) to measure the flow of water across the surface of a Louisiana marsh.*

The diversion was designed to handle discharges of up to 225 cubic meters per second (m3/s). The Corps typically operates the diversion at a much lower volume, releasing an average of 113 m3/s, with little or no release in late summer and autumn. In conjunction with a study that ran from January 2002 to January 2004, releases were increased at key times to 184 m3/s in pulses lasting for two weeks.

A research team made up of three co-investigators – Dr. Jaye Cable and Mr. Erick Swenson of Louisiana State University and Dr. Christopher Swarzenski of the USGS Louisiana Water Science Center in Baton Rouge – as well as Ph.D candidate Gregg Snedden, worked together on a study of the effects of the pulses funded by the Louisiana Department of Natural Resources and supplemented by grants from the U.S. Environmental Protection Agency and the U.S. Department of Agriculture.

With access to the land and private boat launches of the Delacroix Corporation and the assistance of Michael Benge, Michael Farizo and Donald Ansardi, the team studied the composition and movement of the discharge pulses. Their work offered lawmakers and river managers data on how much sediment is carried through various routes within the wetland system, and how much is likely to be deposited in the marshes or transported down the bayous and larger channels.

"We're trying to get the science to identify the impacts for someone who makes a political decision," notes Swenson. "We're supplying data to help make a better management decision and so they understand the impacts, good and bad."

## Quantity and Quality

The research team set out to measure the quantity and quality of water traveling through two main channel routes, as well as across the wetlands themselves. Shallow, slow-moving systems may lack the drama of fast-moving water, but measuring them can be just as challenging.

"In wetland restoration, you'd often hear, 'the current is too strong; it's eroding the marsh,'" Swenson notes. "We were

*SonTek/YSI, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instrumentation for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories. Headquarters are located in San Diego, California.*

often asked if we could measure it. But until fairly recently, it was impossible

*A flume built for a study on nutrient uptake shelters three ADVs that LSU scientists used to study the movement of water and sediment through Loioisiana;'s Caernarvon Diversion. Pulse-coherent technology offers highly accurate readings even in extremely shallow or slow-moving water.*

"We'd tried for years to get these measurements, but when down there in less than five centimeters of water, in the grass and vegetation, it was very difficult," he explains. Marsh grasses quickly fouled rotors. Dye plumes provided just a snapshot. Electromagnetic sensors encountered interference from plants and the shallow bottom. Not until acoustic Doppler velocimeters (ADVs®) offered the opportunity for three-dimensional measurement of velocity – without bias all the way down to zero – could researchers like Swenson get an accurate picture of the ebb and flow of water in the subtle, confusing, meandering environment of shallow wetlands.

The USGS had four current and quality monitoring stations in the two main channel routes between the Caernarvon Diversion and Breton Sound to measure the high-volume flows that fed the marsh system. In the wetlands, LSU deployed three SonTek® Argonaut® ADVs and YSI 6920 sondes equipped to conduct continuous, unattended monitoring of conductivity, temperature, and depth. Each Argonaut has three sensors to measure direction and velocity; Swenson and his colleagues set one at mud level, one 10 cm above the bottom, and the third at 20 cm above the bottom. A YSI 600OMS (Optical Monitoring System) was used to sample river water turbidity in the outflow channel. The team also took monthly grab samples back to the lab to analyze for total suspended solids (TSS), which allowed Swenson and his colleagues to conduct monthly data downloads, cleaning, battery replacement and other field maintenance.

The continuous monitoring equipment provided a wealth of data, Swenson notes. "We took a 5-minute average every 15 minutes and averaged those out to hourly means," he says. "The Argonaut SLs also allowed us to look at what was changing across the channel. We could get directional flow data from 16 to 20 meters away – that was at least halfway across the channels we were studying, so we could see differences in velocity between the edges and the middle of the channel."

A hand-held ADV allowed the crew to skim across the wetlands during discharge pulses to hand-sample flows from an airboat. The LSU team also employed a boat-mounted SonTek RiverCat mini-ADP to conduct cross-channel transects at four depths. Data from the transects, rated against synoptic data from the USGS, allowed Swenson and his colleagues to develop rating curves that in turn let them generate accurate discharge figures from their fixed ADVs. Understanding flows in the channel and combining that with their data on overland flow opened a new window to better understanding the local wetland system.
Kevin Labbé, a SonTek/YSI representative based in Baton

*This LSU station utilized an Argonaut ADV, a YSI 6920 sonde, and a YSI 6000 OMS optical monitoring system to gather data on flow and water quality. The data are invaluable tools as hydrologists and policymakers discuss how to better manage Louisiana's shrinking wetlands.*

Rouge, says the study design reflects Swenson's creative approach to fieldwork. "Erick is really sharp, and he has a great imagination," Labbé says. "He and his team found ways to track and quantify flow that was normally disregarded, but that answers some important questions about the system. It's very admirable."

Chris Ward, global business manager for SonTek, adds that Swenson and his colleagues put ADV technology through rigorous paces. "Work in slow, shallow conditions like those that Erick explored demand a lot from sensors," Ward notes. "Pulse-coherent technology opened up new opportunities for understanding the complex movements in those systems. Being able to continuously sample upstream, cross-stream and vertical motion is extremely informative, and researchers need reliable data in all those dimensions – and not just plus and minus, but all the way down to zero. Our mission is to make sure they have the tools that perform in their environments."

## A True Field Instrument

With all of the different challenges at hand – for long-term deployments, hand-held and boat-mounted instruments and highly variable conditions–choosing the best instrument for the job can be a challenge all its own.


*Slow-moving systems have long been a challenge to study. ADVs allow researchers to collect data on three-dimensional movement.*

Swenson points out that he and his lab have had a long history with SonTek and YSI, and have strong relationships with the company's Baton Rouge-based support team. Durability was also a factor, especially for the unattended monitoring sites. "We had used Argonaut SLs in the field, so we were comfortable with the instruments and the software," he notes. "We wanted the low flow capability, the ability to work in shallow water, and the reliability. The Argonauts included compass data, which meant we could use them in any orientation; even if the instrument was hanging from a mooring in some other study, we could still get directional data. And they're pretty rugged – real field instruments, with solid stainless steel shafts and tough construction."

The durability of their equipment was tested to the extreme when Hurricane Katrina blasted across Breton Sound in August 2005. A year later, Swenson and his team were traveling through the test area on an airboat when they came across one of their YSI sondes, still mounted on its PVC pipe but buried in debris from the storm. "The pressure sensors were ruined when water ran down the pipe, but it didn't lose the data," he says.

## Answering Questions

Swenson says the data he and his colleagues collected broadened the understanding of pulsed releases through the Caernarvon Diversion.

Turbidity levels in the Mississippi River vary widely depending on the season. Using a regression equation ground-truthed by lab analysis of grab samples (TSS (mg/L-1) = 0.89 x Turbidity + 6.40), Swenson's team converted TSS data from NTUs to concentration. The team charted turbidity swings that ranged from an average monthly total of 15 mg/L in September to 130 mg/L in February. Correspondingly, 88 percent of the annual sediment delivery through the diversion occurred between December and March. Swenson's team also noted a hysteresis influence, observing that pulses during river flood events – especially rising limbs of flood events – delivered more sediment than pulses that occurred when the river was low.

The LSU team also found that flows of 100 to 125 m3/s could be accommodated by the two channel routes to the sound, but as volumes exceeded those levels, approximately 40 percent moved in pulses that traveled as sheet flow across the marsh, entering channels or the sound farther

*A boat-mounted ADV allowed Erick Swenson and his colleagues to conduct cross-channel transects at four depths, exploring differences in water movement at four depths and across channels. The team developed rating curves using the transect data and USGS synoptic data.*

downstream. Traveling at 1 to 5 cm/s, the overland flow deposited 100 percent of its sediment in the wetlands, contributing the vital element of protecting and restoring the marsh.

However, the pulses during the study period did not deliver nearly enough sediment to counter the rise in relative sea level in the wetlands. The diversions delivered approximately 360,000 metric tons of sediment for each of the two years of the study period – enough to add about 0.5 mm of sediment to the surface. However, relative sea level in the upper estuary is rising at approximately 3.5 mm per year.

For the Caernarvon Diversion to stem or reverse the loss of the wetlands above Breton Sound, Swenson points out, engineers would probably need to modify the structure so it could convey sediment more effectively. Duration, timing and frequency would also need to be optimized carefully. Swenson's study could be an important guide to that process.

The challenge is that increased pulses, especially in the winter – when they would increase sediment most effectively – could also increase nutrient delivery to the area, increasing eutrophication and threatening the sound's commercial shellfish industry.

Those options will surely be debated in the years to come, with the help of data from Swenson and his team, and their co-investigators at USGS. "It's about how to get science into the decision, and how you can explain the science so it's something they can use," he says. "Now they know what's coming out of the diversion."

*SonTek/YSI, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instrumentation for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories. SonTek/YSI is headquartered in San Diego, California, and is part of YSI Inc., an employee owned company that provides monitoring and data collection instrumentation to global water quality, water quantity, and aquaculture markets. Additional information can be found at www.sontek.com, or email sontek directly at inquiry@sontek.com.*

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