Inner Harbor Navigation Canal program sector gates, surge barrier, and floodwalls under construction. The methods that rapidly brought multiple lines of defense to bear on reducing risk in greater New Orleans can guide other communities facing impacts from climate change. PHOTO COURTESY OF USACE

WATER PLANNING AND MANAGEMENT

Achieving the Unprecedented in New Orleans

Two alternative delivery projects on opposite sides of New Orleans epitomize the ingenuity that can arise when industry and government come together to build something historic.

BY WENDI GOLDSMITH, CPG, CPSSC, M.SAME, ANGELA DESOTO-DUNCAN, P.E., M.SAME, AND KAREN DURHAM-AGUILERA, P.E., SES, M.SAME

Editor's Note: *Five years after work began on the now-completed Greater New Orleans Hurricane and Storm Damage Risk Reduction System, numerous awards are rolling in—including the 2012 Grand Conceptor award given to the Lake Borgne Surge Barrier as the year's most outstanding engineering achievement, and the U.S. Army Corps of Engineers Innovation of the Year award for the West Closure Complex. In this article, three integral figures come together to take one final look at a $15 billion design and construction program that has become the new standard of engineering excellence, and of collaboration between public and private enterprise, in the United States and around the world.*

Not only did the U.S. Army Corps of Engineers (USACE) and its legion of supporting contractors design and construct complex and monumental infrastructure to provide New Orleans with improved flood defense, they used creative methods throughout. The scope of the work was enormous and the pace of completion unprecedented; perhaps equally impressive, though, was the range of partnerships and collaboration that made it possible.

Unlike most water resources infrastructure projects, which tend to be executed at an extended pace based on level of funding, the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS) was conceived and executed as a truly integrated system. For the first time, an infrastructure system in the United States was designed using a comprehensive risk-based approach, drawing on state-of-the-art modeling and analysis. Furthermore, to get critical components in place quickly, bold steps were taken to use alternative delivery methods including Design-Build and Early Contractor Involvement (ECI). Previously, alternative delivery methods were virtually unheard of in civil works, despite their propensity for saving time and money.

COMPREHENSIVE AND SUSTAINABLE SOLUTIONS SOUGHT

A tightly functioning partnership of multiple USACE districts, and private sector engineering, science, program management and construction professionals helped develop solutions to problems arising from the project location's unique conditions and the essential need for risk reduction. The high-profile and fast-paced design of this seminal program involved thousands of design engineers across the United States and Europe.

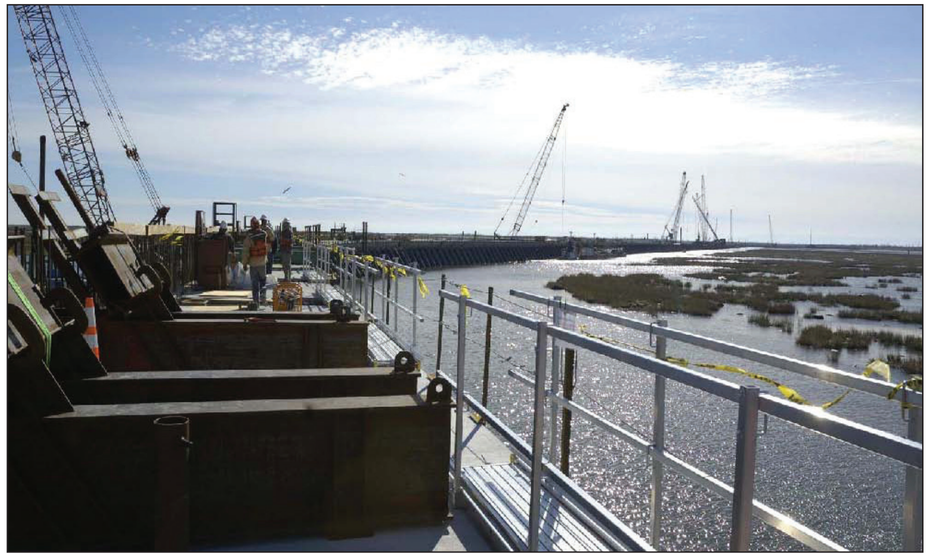
To create a robust and resilient infrastructure system for greater New Orleans demanded evaluating existing conditions, understanding weaknesses, modeling numerous scenarios, and factoring in trends and uncertainties surrounding climate change, sea level rise and land subsidence. For the system to function best under a variety of conditions, it had to improve and expand upon previous infrastructure elements, and rely on new structures to complement and supplement them.

The role of coastal wetlands and protective landforms such as barrier islands were considered for function to shield structures that could otherwise not withstand direct open water exposure. Together, the natural landforms, built structures, and operating procedures were capable of mitigating storm damage based upon multiple lines of defense. Many elements were improved through increased height, better protection from scour and other stability measures. Where gaps or missing links were identified, vulnerable areas received new solutions to address weaknesses. USACE selected a joint venture of Bioengineering Group and ARCADIS to lead the evaluation study and design process, and provide construction management and environmental compliance. Bioengineering Group and ARCADIS received $150 million and $50 million Indefinite Delivery/Indefinite Quantity (IDIQ) contracts with, respectively, USACE's Hurricane Protection Office and the Protection and Restoration Office. One of the first assignments was to engage a diverse set of stakeholders in a formal brainstorming process, drawing upon leading Dutch sea defense experts, local levee agencies, members of the environmental community, and the full array of professionals with water resources, infrastructure and coastal wetlands expertise.

The main entry for the Gulf Coast storm surge from Katrina was from the east, across Lake Borgne, and into the Inner Harbor Navigation Canal toward downtown New Orleans. A perimeter defense was chosen to mitigate a similar storm surge, acting as a first defense to densely populated areas.

The largest open water surge barrier and first of its kind in North America, the Lake Borgne barrier stands 12-mi from downtown New Orleans in marshlands accessible only by boat. The project rests on soils and alluvial deposits with very poor structural capacity; yet the design required reducing risk of storm surge from a 100-year storm, and providing significant resistance from a 500-year storm.

The goal was to get the barrier built as fast as possible, given that it was deemed the major contributor to achieve risk reduction. Work began in early 2007, before plans were very far along, in order to start collecting and assessing complex information. One of several challenges was complying with the *National Environmental Policy Act* (NEPA). Compliance required the study of environmental



The Lake Borgne Surge Barrier is situated to keep storm surges away from urban areas based on systems approach. PHOTO COURTESY OF USACE

impacts of project alternatives on significant resources—namely hydrology, water quality, wetlands, fisheries and Essential Fish Habitat; terrestrial and upland resources and wildlife; and a full range of socio-economic issues including recreation, noise, air quality, aesthetics, cultural resources and environmental justice. The geography, navigational significance, sensitive habitat, hydrodynamics, urbanization, and cultural and political factors complicated specifying an acceptable engineering solution.

This study was extraordinary because, unlike most studies of this nature, as a Design-Build project, a final design would not be developed until after award to a contractor, and a specific alternative was not designated prior to the study.

NEED FOR SPEED

Design-Build was selected to meet USACE's aggressive goal of achieving 100-year-level risk reduction by June 1, 2011. This goal was achieved on May 24, 2011—three years after contract award.

Using a competitive request for proposals and best value source selection, USACE awarded, in April 2008, the Design-Build contract for the surge barrier to Shaw Environmental and Infrastructure Inc. As a subconsultant to the prime contractor, Tetra Tech INCA led design of the $1.1 billion structure as part of a joint venture with Ben C. Gerwick Inc. Tetra Tech INCA provided design project management and developed preliminary and detailed designs of the Gulf Intracoastal Waterway buoyant sector gate and the structural monoliths and foundations of the Bayou Bienvenue vertical lift gate, as well as Value Engineering and engineering during construction.

The project team simultaneously designed and constructed the barrier, an approach that drastically shortened the 15-year delivery time considered normal for a project of this magnitude under traditional design-bid-build. Decisions regarding materials procurement and fabrication had to be made early. Many innovative applications of new and existing techniques were used to build the largest surge barrier of its kind in the world. A high level of originality was needed to meet budget, stay on schedule and adhere to strict performance requirements.

The 42-ft-tall barrier features a hydraulically operated, buoyant sector gate at Gulf Intracoastal Water Way. It weighs more than 675-T per leaf and closes a 150-ft-wide navigation channel. Because of the unique nature of the loads, extensive physical modeling was conducted to confirm how it would perform. A second, more detailed model was developed and placed in the basin model for studying the effect of the hurricane-induced waves. Both mass and stiffness of the design were modeled to assess hydro-elastic effects

The world's largest drainage pump station keeps water flowing out of town, even when the nation's largest sector gate closes the waterway. PHOTO COURTESY OF WENDI GOLDSMITH

such as gate vibration, wave slamming and wave downfall. In providing physical evidence of what would otherwise have only been shown through theoretical hydraulic analysis, the models allowed USACE to achieve "buy-in" from the project stakeholders who would ultimately own, operate and utilize the gates. Ultimately, the use of advanced modeling provided important technical information to demonstrate the project would result in a safe and efficient navigation channel.

SETTING NEW STANDARDS

On the opposite side of greater New Orleans lies the other main perimeter defense against flooding from storm surge: the West Closure Complex Pump Station. The team led by Bioengineering Group and ARCADIS performed all civil, mechanical, geotechnical and structural engineering. They provided design and management of major project components, including flood walls, levees, navigation gates and the $350 million pump station, which is set amongst a heavily populated and industrial corridor.

More than 700,000-y^3 of material excavated from the Algiers Canal was used beneficially in a marsh restoration project in nearby Jean Lafitte National Historical Park and Preserve. Serving to close off the Gulf Intracoastal Waterway and prevent floodwaters from entering the Harvey and Algiers Canals along the West Bank of the Mississippi River, the pump station is critical to the federally mandated hurricane risk reduction system. Designed to mitigate hurricane storm surges and heavy rains from flooding the area, it was executed swiftly by using ECI delivery. It is the first time USACE used ECI for a civil works project. This approach was selected to reduce design risks, allow for early ordering of materials and equipment, improve constructability, enhance safety, and most importantly, minimize the construction schedule. A joint venture of Kiewit and Traylor Brothers was awarded the roughly $1 billion construction contract through a competitive best value source selection acquisition.

Innovative solutions for the superstructure are many, as it really involves a collection of six sub-projects—the largest drainage pump station in the world, largest sector gate in the nation, T-Walls, closure wall, sluice gate and a system of site work featuring an inlet road, levees and channel excavation.

The West Closure Complex must operate in a fail-safe mode whenever severe storms threaten New Orleans, to prevent interior flooding of the West Bank area inhabited by 250,000 people and industries critical to national defense. When the navigable sector gate is closed to block hurricane induced storm surges from moving from the Gulf of Mexico upstream, catastrophic flooding can be prevented. However, to move water downstream during stormy weather, bypassing the closed gate, enormous pumping capacity was demanded. The West Closure Complex can fill an Olympic-sized swimming pool in less than 21 seconds.

The risk-based method of identifying, modeling and shaping solutions for various combinations of flood impacts allows for future planning to operate or modify the infrastructure to respond to emergent demands triggered by changing climate. Like many elements within the greater New Orleans post-Katrina infrastructure program, the project is not only massive, it embodies first-of-a-kind execution strategies carried out under extreme public scrutiny and reflects a new generation of standards and procedures for the industry.

A GLOBAL MODEL TO FOLLOW

The Lake Borgne Surge Barrier and the West Closure Complex are the central features of HSDRRS. Because this system was built using the best science, technology, engineering and rapid construction methods available, New Orleans is now better protected than at any time in its history, and serves as a model for other communities facing potentially destructive impacts from climate change, sea level rise and related risks.

The engineering approaches applied in greater New Orleans will long help serve the people who live and work in the area. These approaches are increasingly viewed as a global example of quality yet swiftly completed infrastructure suited for adaptation and resiliency—and in particular, they exemplify new levels of teamwork, and innovation.

Wendi Goldsmith, CPG, CPSSc, M.SAME, is CEO, Bioengineering Group; 978-224-3107, or wgoldsmith@bioengineering.com.

Angela DeSoto-Duncan, P.E., M.SAME, is Director of Civil Works, Tetra Tech INCA.; 504-832-8911, or angela.desotoduncan@tetratech.com.

Karen Durham-Aguilera, P.E., SES, M.SAME, is Director of Contingency Operations and Homeland Security, U.S. Army Corps of Engineers; 503-975-4143, or karen.l.durham-aguilera@usace.army.mil.