Banking on protection

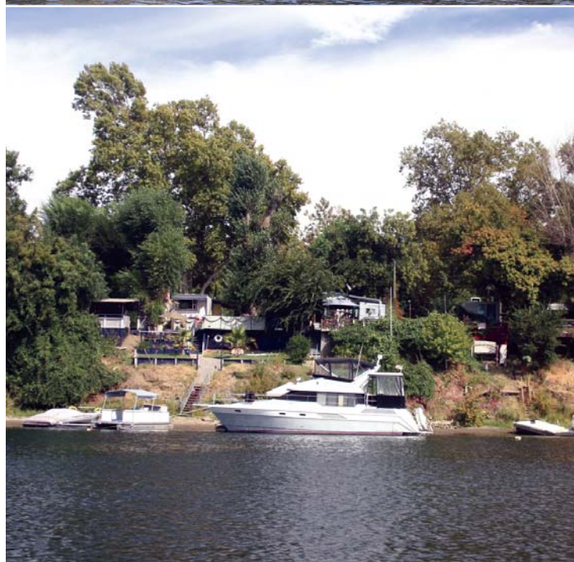
Levee repairs work to limit flood potential of Sacramento River

By Tawny Quast

The Sacramento River stretches more than 300 miles through California's Central Valley, winding past vast stretches of agricultural land and thousands of homes and through the heart of downtown Sacramento. Along the way, a 1,300-mile-long maze of levees weaves a complicated path, protecting farmland and homeowners from what could be catastrophic flooding. The importance of these levees cannot be understated: A major levee failure on the Sacramento River system could engulf more than 1 million acres and affect more than 2.3 million people who live in the potential flood path, according to the U.S. Army Corps of Engineers (USACE). In all, the levee system protects $38 billion in infrastructure.

But this century-old levee system is seriously degrading after years of forgone maintenance and neglect. In February 2006, California Governor Arnold Schwarzenegger declared a state of emergency for the levee system, setting aside $500 million to repair and evaluate the levees. In November 2006, California voters approved nearly $5 billion in bonds to evaluate and repair the levee system. Also that year, the American Society of Civil Engineers (ASCE) issued a "report card" for the state's levee system. Its grade was a "D," and the report card showed that in most cases the levees don't even offer a minimum 100-year level of flood protection. These measures, compounded by heightened public awareness of levee protection following 2005's Hurricane Katrina in New Orleans, set the stage for a massive effort to repair Sacramento's levees.

Left: The Sacramento River winds it way through downtown Sacramento, California. Right: Businesses, homes, and agricultural land line the banks of the Sacramento River.



"Erosion was absolutely threatening the integrity of the levees and the entire flood protection system," said Dave Wheeldon, project manager for the Sacramento River Bank Protection Project for the California Department of Water Resources (DWR). "A levee is only as strong as its weakest point, and a failure at almost any point in a levee could result in major flooding and damages."

In fact, Sacramento is the largest city in the United States at risk for major flooding. "After Hurricane Katrina, they realized Sacramento could be next," explained Thomas Smith, PE, PG, vice president in Ayres Associates' Sacramento office and a leader of the ASCE report card on the levee system. While pre-Katrina New Orleans reportedly had flood protection that would stand up to the 250-year flood, Sacramento has roughly an 80-year level, he said.

Recognizing the dire need for action after the Governor's declaration the USACE and DWR quickly stepped in using in-house resources and consultants to design and construct repairs to the critical erosion sites listed in the 2006 Erosion Inventory of the Sacramento Flood Control System.

Ayres Associates began performing the annual erosion site reconnaissance in 1997 for the USACE's Sacramento District as part of the Sacramento River Bank Protection Project. The objective is to monitor and document the condition of previously identified erosion sites, inventory new erosion sites, and identify critical sites that pose an imminent threat to the structure of the flood control system. Critical sites are the highest priority for repair. Multiple data are collected for each of the erosion sites and brought into a single GIS database. The data include GPS coordinate information, tables, historical database records, field notes, site photographs, videos, graphical data, and maps. To date, Ayres Associates has inventoried 1,200 miles of levee in the Sacramento River system. At the time of the governor's emergency declaration in 2006, 25 critical erosion sites were identified.

During these site investigations, the Ayres Associates team found critical erosion sites where the river was eroding into the toe, or base, of the levee. Given the growing concern for levee stability after Hurricane Katrina, design and repair of the critical sites were put on a fast track in 2006. Ayres Associates completed plans and specifications for repairs to five critical erosion sites in a matter of months, allowing construction to begin in summer 2006.

Shortly thereafter, 14 more sites were added to the list of those needing repair. Ayres Associates used an innovative two-phase approach to meet the repair schedule. Phase 1 involved design of toe rock at all sites, built primarily by barge during the winter's high flow when barges could freely traverse the river. Phase 2 focused on the upper slope, which included

Left top and middle: Erosion along the Sacramento River banks threatens the integrity of the levee system. Left bottom: This image shows a quarry stone toe under the water surface and benches, or berms, above the water surface to provide for environmental mitigation. Right: Levee repair on the American River, a tributary of the Sacramento River, was conducted during the summer low-flow season.

designing riprap and mitigation measures to be constructed during the summer low-flow period, when more of the bank was exposed.

Maintaining function and appearance of the natural environment was a priority. Woody debris at the base provides habitat and shelter for migrating salmon and steelheads. Rock was infilled above the water line with a mix of soil to allow replanting of low-growing shrubs and grasses. Trees were saved to provide shade on the water. Elderberry shrubs, home for the endangered Valley elderberry longhorn beetle, were transplanted. When feasible, the design included berms or benches along the waterside slope where willows and shrubs could be planted.

Wheeldon of the DWR said the team's methods to preserve the environment were extraordinary. "The way Ayres Associates designed the repairs is a model that I believe will be followed throughout the country as how to provide mitigation measures that are environmentally friendly," he said.

In the past, a typical design would involve placing rock from the base of the levee to the top. Smith said this does not have to be the solution. "The Sacramento levees have not been overtopped in recent history; all the recent failures have been through the foundation," he said. "Erosion is slow, so you protect the toe and leave the rest as-is. You don't need to put rock clear to the top. I don't want the river to look like rock from one end to the other."

James Baker, project manager with USACE, Sacramento District, praised the team's ability to provide a solid levee repair design under demanding time frames. "Ayres Associates has been very instrumental in assisting us with this large program and making it happen," he said. "They have used innovation and have been quick to respond to this constantly moving target. The dynamics of the project were always changing, and Tom (Smith) was able to keep up with us."

The work is far from over. Erosion never ends, Smith said, and neither must levee maintenance. "We have to repair more than we add to the inventory if we are ever going to succeed," he said. "It's not like erosion is going to stop suddenly one day. But if it's caught early, you can fix it with maintenance."

Baker agreed. "We are making progress, but it's also a dynamic river system that is constantly eroding," he said. "We prioritize the worst, but it's probably a never-ending job." ■

For information on the California Department of Water Resources levee repair and floodplain management program, go to http://www.water.ca.gov/floodmgmt/lrafmo/

Left top: A completed levee repair site on the Sacramento River showing vegetation growth. Left middle and bottom: Wherever possible, trees were saved to provide shade on the water for fish and other wildlife. Right: Large woody debris at the base of the riverbank provides habitat for migrating salmon and steelhead during the winter's high-flow.