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Anticipating California Levee Failure: Government response strategies for protecting natural resources from freshwater oil spills

Prepared by: Melissa Blach, Karen Jurist, and Sara Morton

The confluence of the Sacramento and San Joaquin Rivers creates a delta system where two rivers fuse with smaller streams, forming a network of waterways that extends for 700 miles. The Sacramento-San Joaquin Delta [the Delta] includes 57 islands, 1,100 miles of levees, and hundreds of thousands of acres of marshes, mudflats, and farmland (www.noaa.gov). This freshwater Delta provides valuable soil for agriculture, habitat for over 500 species of flora and fauna, and is an essential source of drinking water for over 23 million Californians (Department of Water Resources, Nov., 2005). Delta water is also distributed to wildlife refuges, consumed for power plant cooling and other industrial uses and for commercial services. In addition, the Delta serves as a transportation corridor in which highways, pipelines, power lines, railroads and ships merge. These miles of levees, pipelines and roadways, lie just east of many active faults. Furthermore, continuous microbial oxidation, coupled with compaction of organic soils, causes subsidence of these levees.

Historically, the Sacramento-San Joaquin Delta consisted of brackish water. The delta naturally consists of fluvial silt, saline intertidal deposits, clay deposits as well as deep organic soils that began to accumulate in the mid-Holocene epoch, approximately 7000 years ago. Peat formed from decomposition of organisms over thousands of years and is maintained in an anaerobic environment, maintained by a high water table (Rojstaczer and Deverel, 1995). This peat provides fertile soil for agricultural use.

In the late 1800s, Delta islands were drained for farming purposes' defined and reinforced by a system of earthen levees. Traditionally, islands filled with rainfall and seasonal floodwater, creating seasonal wetlands and marsh vegetation (Delta Protection Commission, 2000). In addition to farming, hydraulic mining activities in the late 1800s contributed tons of deltaic deposits of mineral and organic soil, which also produced a need for flood control channels to flush out accumulated sediments (Mount and Twiss, 2004). Presently, the Delta consists of small natural and man-made sloughs that generate wetlands and lowland islands used for agricultural purposes.

Agricultural production consumes approximately 520,000 acres in the Delta. Production areas along the Delta produce nearly $500 million in various crops annually, accounting for 3% of the State's agricultural production, providing a strong incentive to drain many Delta islands (Delta Protection Commission, 2000). However, there are permanently flooded islands such as Big Break, Franks Tract and Mildred Island, as owners could not afford to maintain levees surrounding these islands, which are now deep-water habitats. On Staten, Tyler and Venice islands, farmers traditionally seasonally flood their lands for leaching and weed control, which provides seasonal habitat for migratory birds. Some islands, such as Sherman, grow crops specifically chosen to provide food and habitat for both native and migratory species. Many Delta farms take water directly from sloughs and rivers, while the State Water Project (SWP) takes water from the Delta and distributes it for agriculture throughout the state. Forty percent of State Water Project water is used for agriculture. The Federal Central Valley Project (CVP) water irrigates farmland in the Central Valley. The Delta is a key component in the water transportation system of these projects. In general, the water is held upstream (coming as precipitation in lower elevations and snow in higher elevations) behind dams. When water is

needed, it is released and flows through the Delta via aqueducts to the rest of the state. The State has acknowledged that the water transportation system impacts Delta levees and Delta fisheries (Delta Protection Commission, 2000).

In addition to agricultural irrigation, the Central Valley Regional Water Quality Control Board (CVRWQCB) has designated the following beneficial uses of water in the Delta: "municipal and domestic supply, industrial process and service supply, groundwater recharge, freshwater replenishment, navigation, hydroelectric power generation, water-contact and nonwater-contact recreation, freshwater habitat, preservation of rare and endangered species and fish migration and spawning (Delta Protection Commission, 2000, p. 14)."

Since the late 1800's, deposition of sediments from hydrologic mining in conjunction with land reclamation of the delta has increased the occurrence of subsidence. Before implementation of erosion standards in the 1970's, dried peat was often harvested as fuel or eroded by wind. Subsided land, caused by unnatural processes, not filled with water or sediment, is known as anthropogenic accommodation space (Mount and Twiss, 2004).

As levees were constructed on reclaimed land, water tables were lowered in order to optimize agriculture. The absence of water results in exposure of surface soil particles to oxygen, which allows the microbial community to aerobically decompose the organic material. Thus, high amounts of carbon stored in the organic soil are oxidized and released into the atmosphere as carbon dioxide. The oxidation process occurs most rapidly when moisture and temperature regimes are optimal for microbial activity, in summer months (Deverel and Rojstaczer, 1996). Subsidence, the gradual sinking of soils to a lower level, is mostly due to this oxidation of soils above the water table, though some is due to compression of subsurface saturated soils and the shrinkage of organic soils above the water table. Small pores due to

compression in unsaturated peat soils can affect capillary flow and have a stronger pull on water than uncompressed particles, thus can negatively affect drainage and further promote settling and reformation of peat in subsurface layers. The ultimate results of draining the water table are spreading, slumping and cracking of levees (Deverel and Rojstaczer, 1996).

Levees' main function is to oppose the hydrostatic force of water and frequency of tides. Levee failure is usually associated with size of the levee and height of the water exerting force on it; levee vulnerability increases with subsidence and the length of the levee on which water pressure is acting. Subsidence decreases levee integrity by reducing lateral support and shear resistance and facilitating settling or deformation of peat layers beneath. This subsidence, in addition to the increase in eustatic tides, contributes to weakening levees (Enright, 2004). Although levee vulnerability in the delta is not easy to quantify, current models suggest that levee breaches are very likely in the event of an earthquake (Mount and Twiss, 2005). Moreover, in seasons of low freshwater flow, risk of salinization of the delta from levee breaches and salt water intrusion would significantly lower water quality (Ingebritsen et al, 2000). Burrowing animals pose further threat to levees since they burrow and weaken levees before they are detected.

The Delta's dynamic ecosystem is at risk of being disrupted. Levees in the west delta receive strongest impact from tidal influences and soils here are least stable and most susceptible to liquefaction. These factors in combination with already large anthropogenic accommodation space put these levees at highest risk for breaches in case of an earthquake. Recent studies suggest there is a two-thirds chance of a levee failure in the next fifty years, due to either seismic activity or a catastrophic hydrological event (Mount and Twiss, 2005). In the case of a 6.5

magnitude earthquake, impacts include oil pipeline ruptures and massive flooding as a result of vast levee breaches.

For purposes of this paper, the simulated seismic situation is based on a model produced by Jack R. Benjamin and Associates, Inc, Resource Management Associates, and Economic Insights, *Preliminary Seismic Risk Analysis Associated with Levee Failures in the Sacramento-San Joaquin Delta (2005)*. The seismic event chosen is a 6.5 magnitude earthquake, which is illustrative of major damage coupled with loss of structural integrity. An earthquake of this magnitude is equivalent to the magnitude California Department of Water Resources chose for its hypothetical situation presented to the Senate Subcommittee on Delta Resources, the Senate Transportation and Housing Committee, and the Joint Committee on Emergency Services and Homeland Security (2005). The 6.5 magnitude earthquake is also used to describe the 100-year seismological event mentioned in Dr Jeffrey Mount's study *Subsidence, Sea Level Rise, and Seismicity in the Sacramento-San Joaquin Delta* (Mount and Twiss, 2005).

In the simulation, the 6.5 magnitude earthquake occurs on the Coast-Range Central Valley Boundary Fault, with an epicenter one kilometer north of Brentwood, CA. This is a thrust fault zone along the western edge of the Central Valley. According to the Preliminary Seismic Risk Analysis, "the earthquake was used as one event that is representative of a suite of earthquakes of varying magnitude and location that could occur (p. 11)." Because of the vulnerability of levees in the Delta, the scenario involves 50 levee breaches, with 20 of these breaches occurring on Sherman Island. Levee breaches create an inrush of water onto the breached islands; a flow gradient forms from the Bay to the Delta. The islands flood with substantially saline water and this high level of salinity persists because of a lack of freshwater to flush the salt out. Three hundred billion gallons of salt-water flow into the Delta within the first

few days, and the water supply south of the Delta must be shut down (DWR, Nov., 2005). Water exports for both State Water Project and Central Valley Project cease because of saltwater intrusion. All levee breaches are assumed to be from 500 feet to 1600 feet wide and are due to liquefaction and inertial failure. A breach of 500 feet owed require 115,000 tons of material to close it (Jack R. Benjamin et al, 2005).

A 6.5 magnitude quake is projected to cause disruption of water delivery from the Delta that may last for 28 months, with 21 Delta islands flooded. Pumping of Delta water could not occur for one year as breach repairs would be needed as well as removal of saline waters (Jack R. Benjamin et al, 2005).

Economic impacts include loss of revenue from as many as 85,000 acres of agricultural land as crops flooded, and costs associated with repairing as many as 3000 homes inundated with flood water. After one year, damage is estimated to reach at least $6 billion (DWR, Nov., 2005).

In the described scenario, several key aspects of the delta infrastructure are highly vulnerable. Vulnerable parts we focus on include, but are not limited to, those that may lead to oil and hazardous material releases into the delta system: transportation corridors, including highways, waterways and railways; pipelines carrying oil products; agricultural and residential sources including storage tanks, household utilities and oil products; and an increasing number of gas stations and fuel sources related to urbanization in the delta.

Four major highways skirt and cross the Sacramento-San Joaquin Delta: Highways 4, 12, 84 and 160. On any given day, thousands of vehicles use these highways, all of which contain gasoline, diesel and motor oil, as well as cargo. There are busy seaports in Sacramento and Stockton through which barges, fishing vessels and private vessels pass. The Port of Sacramento is a deepwater port connected to the San Francisco Bay by a channel through Suisun Bay and the

Sacramento River Delta. The Port of Stockton is the third largest landholder seaport in California and has also been designated a Foreign Trade Zone. The Port operates a transportation center with berthing space for fourteen vessels. In addition, a major Union Pacific railroad carries diverse goods, including hazardous materials.

Approximately 400 miles of oil and hazardous liquid pipelines operated and maintained by Conoco-Phillips, Chevron, Shell, Pacific Gas and Electric, Mirant Delta, and SFPP, L.P. run alongside and/or across the delta. Martinez, located west of Bethel and Sherman islands, contains several major oil refineries. In 2004 and 2005, the US EPA led drills in four of the facilities in the Delta considered "substantial harm" facilities and thus have Facility Response Plans (FRP). There are 5 FRP facilities near the Port of Stockton and 4 in the Sacramento/West Sacramento, which include Tesoro, Conoco Phillips and BP West Coast Products. Subsurface hazardous liquid pipelines, containing products such as nitrogen and liquefied natural gas, cross the delta and are adjacent to faults. The density of oil is less than the density of water, so when soil liquefies, pipes have a tendency to rise. If they rise too far, they can rupture. In the event of a major earthquake in the area, these pipelines are vulnerable to rupture, leading to crude oil, gas, and/or other hazardous liquid releases.

Agriculture is the mainstay of the reclaimed tracts and islands in the Delta. Farmers often store fuel for tractors and other farm equipment in storage tanks on this reclaimed and often subsided land. Pesticides and herbicides are abundant, and pose environmental threat if released into waterways. Residential areas contribute pollutants from fuel tanks, household and automobile products. Levee breaches and subsequent flooding of the Delta tracts and islands create heightened risk that agricultural and household products will be released and contaminate delta water.

Not withstanding levee vulnerability and flood risk, urbanization of delta islands is increasing. The rising cost of homes in California has spurred developments on cheaper land, even when danger is imminent. San Francisco Magazine, in the article *Is This the Next New Orleans?*, states "…there's such demand for waterfront property that soon the levee [on Bethel Island] will be intentionally breached to devise inlets for a development of 494 homes, called Delta Coves (p. 87)." In response to the developers' belief that their new levee will resist earthquake damage, Jeffrey Mount states "There are two kinds of levees, those that have failed, and those that will fail (p. 88)." New homes lead to an increase in household pollutants, automobiles and local infrastructure additions including gas stations. Urbanization will only lead to more severe pubic health and environmental damage, should a catastrophe occur in the delta.

Earthquakes and floods lead to the release of these products. Should thirty to fifty levees breach simultaneously or sequentially, containing pollutants, particularly oil products, is nearly impossible. Tidal influence from the San Francisco Bay, and flow of water from Sacramento and San Joaquin Rivers will naturally facilitate the dispersal of hazardous materials. As Sacramento- San Joaquin Delta is an integral part of California's complex water supply system, dispersing hazardous materials may adversely affect drinking water supply for 23 million citizens who depend on the system. Moreover, contamination could also impact agricultural interests, which support the majority of California's growing economy.

The state's water system discharges through the Sacramento-San Joaquin Delta, which contains over 1,000 miles of non-project (local) levees, generally maintained by local reclamation districts. CA DWR inspects and evaluates maintenance of all the state's federally designated project levees and channels. Most project levees are maintained by local agencies, such as reclamation and levee districts (DWR, Jan., 2005). However, ongoing erosion

(subsidence) of leveed tracts causes more damage than can be repaired by the State or local reclamation districts using normal maintenance programs (p. 3). During a typical 30-year mortgage period, there is a 26% chance that homeowners living behind a levee will experience a flood larger than the 100-year flood (p. 9). Local resources are not adequate to address floods of this magnitude, requiring state (and likely) federal assistance.

Local reclamation districts are responsible for ongoing observation and minor maintenance of most levees in the Delta. They are county agencies comprised of approximately five board members elected by private property owners. When levee repairs are needed, reclamation districts request assistance from local contractor Dutra. For additional resources, they are more likely to contact state agency DWR than the counties directly (counties in the Western Delta we are focusing on are Sacramento, Solano, and Contra Costa Counties). Local reclamation districts have developed an ongoing relationship with DWR through involvement in the state Flood Control Subventions Program, administered by the Division of Flood Management within DWR with the purpose of administering State financial assistance for flood control projects and of enhancing communication between DWR and local agencies. Many local reclamation districts utilize individual Emergency Plans, often as simplistic as directions for moving equipment to higher ground. They generally do not address oil or hazardous material spills or severe levee failure.

In the case of an emergency in the delta, local reclamation districts are unlikely to possess adequate resources for emergency response. Contra Costa, Sacramento, and Solano Counties are low on funds and do not have programs specifically aimed at the levee system. However, they have general emergency response plans and County Sheriff's Offices, Fire Departments, and

Emergency Services Departments would be among the first responders during a large-scale emergency such as an earthquake.

After County resources have been exhausted and requests submitted for state level assistance, the California Office of Emergency Services (OES) would take the lead. OES produced the State Emergency Plan, which encompasses response procedures during floods, earthquakes, and other emergency scenarios. When requested by local agencies for response support, OES sets up Regional Emergency Operations Centers (REOC). The REOC is comprised of personnel from local and state agencies involved in the response and who serve as liaisons between the REOC and their respective agencies. Once regional resources are overwhelmed, OES would establish an EOC which allows access to state-wide resources. At this level, US Army Corps of Engineers and FEMA would likely join the response effort. OES's role is to coordinate efforts by processing requests and communicating with various local, state, and federal agencies with diverse expertise.

DWR is another state agency that would work with OES and participate in the REOC and EOC. DWR's expertise being limited, the agency's primary responsibilities would include general assistance in life-saving operations, provision of state funds and other resources, and salinity tracking necessary due to inflows of saltwater from San Francisco Bay.

The California Department of Fish and Game (DFG) would join the response effort at the REOC level. DFG can provide extensive local and regional knowledge, including that of native plant and animal species, water patterns, and other unique aspects of the delta ecosystem. DFG's oil spill division, the Office of Spill Prevention and Response (OSPR), would provide expertise for containing and mitigating harmful effects of oil and hazardous materials spills due to a large earthquake and massive flooding.

An Area Contingency Plan was developed to protect the San Francisco Bay and Delta, which includes the 1100 miles of levees. The Area Contingency Plan (ACP) for this area was developed to protect the sensitive and valuable resources of the San Francisco Bay and Delta Estuary and associated coastline in the event of an oil spill. The Plan distinguishes the various species supported by the delta, including 50 species of plants and animals listed in the federal and state Endangered Species Act, and identifies key habitats unique to the area.

If a large earthquake hits the bay area, competing interests in need of the state's resources would quickly exhaust California's ability to respond effectively and timely to any one area. Once the EOC has been established, FEMA would consult with state agencies, including the Governor's office to determine if Federal assistance is necessary. In response to a disaster for which the President (through FEMA) determines that Federal assistance is required to supplement the response efforts of the affected State and local governments, under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Emergency Support Function (ESF) #10 – Hazardous Materials – may be activated. ESF #10 provides Federal support to State and local governments in response to an actual or potential discharge and/or release of hazardous materials following a major disaster or emergency (www.FEMA.gov, "Emergency Support Function #10 Hazardous Materials Annex").

The lead agency for ESF #10 is the US Environmental Protection Agency (EPA) and support agencies including USCG (United States Coast Guard) and Department of the Interior (DOI). Upon notification of occurrence of potential or actual major disaster or emergency, ESF #11 – Food - can be activated. ESF #11 identifies, secures, and arranges for transportation of food assistance to affected areas following a major disaster or emergency or other event requiring Federal response. The primary agency for ESF #11 is the Department of Agriculture

(www.fema.gov, Emergency Support Function #11 Food Annex"). A subsection of ESF #11, part (d), applies to the protection of cultural and historic resources. The lead for ESF #11 (d) is DOI.

The Department of the Interior (DOI) is the nation's principal conservation agency. Its mission is to protect America's natural resources for future generations, provide access to the nation's natural and cultural heritage, offer recreational opportunities, honor its trust responsibilities to American Indians and Alaska Natives and its responsibilities to island communities, conduct scientific research, provide wise stewardship of energy and mineral resources, foster sound use of land and water resources, and conserve and protect fish and wildlife (www.doi.gov, 2006).

As a support agency of ESF #10, DOI provides assistance and expertise in fish and wildlife resources, geology and hydrology, earthquakes and other natural hazards, minerals, soils, vegetation, mining activities, identification of hazardous substances, biologic and general natural resources, cultural resources, matters affecting lands administered by DOI, and matters affecting Indian lands and resources, National parks, wildlife refuges, and fish hatcheries (www.fema.gov, 2006). ESF #11 (d) further details DOI's involvement in protection of cultural and historic resources. DOI's bureaus include the Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), Bureau of Reclamation (BOR), National Park Service (NPS), US Fish and Wildlife Service (FWS), US Geological Survey (USGS), Office of Surface Mining (OSM), and Minerals Management Service (MMS).

The Delta does not contain any Indian Reservations, limiting BIA's involvement in emergency response under the scenario used in this paper. MMS regulates and manages the mineral resources in Federal waters off the nation's shores. OSM ensures that coal mines are

operated and maintained in the interest of human and environmental safety. Neither MMS nor OSM would be involved in emergency response in the Delta. BOR is responsible for the quantity (not quality) of water reaching many of the homes in the Central Valley and the Delta itself. Field offices in the area house personnel with expertise in the complex water system of Sacramento and San Joaquin Rivers, as well as the Delta, who could assist State and local agencies as part of the EOC. BLM has, in the past, provided archaeologists to assist FWS in protecting cultural and historic resources during large oil spills, as was the case during the Suisun Marsh spill in 2004. NPS could provide general assistance, although there are no park lands in the vicinity. USGS tracks fault activity all over the country and could provide the highest level of expert knowledge regarding earthquake severity and assessing the possibility of aftershocks.

FWS would have the greatest presence of DOI Bureaus in the Delta. FWS staff includes Wildlife Biologists, Environmental Scientists, Contaminants Specialists, and others who are knowledgeable in areas of ecosystem conservation and protection, threatened and endangered species, and other environmental matters. During Hurricane Katrina Relief, FWS provided helicopters and personnel for search and rescue, infrastructure repair, and environmental safety and protection. FWS offices in Sacramento could be quickly on hand for support during an emergency in the Delta and would bring local knowledge to benefit other response personnel on scene.

The DOI's Office of Environmental Policy and Compliance provides a coordinated and unified approach and response to environmental issues that affect multiple bureaus, in order to ensure that Department of the Interior speaks as one entity with respect to those issues (http://www.doi.gov/oepc/, 2006). OEPC's regional office in Oakland is responsible for providing regional leadership and direction in coordination and development of environmental

policy and program evaluation in California. OEPC Oakland serves a coordinating role for DOI's bureaus. In addition, OEPC Oakland can coordinate with the EOC to verify that appropriate and necessary DOI bureaus are involved in the response effort; provide contact information for bureau and non-bureau staff in Region 9, and other regions when necessary; help secure federal funding for hazmat containment and clean-up; provide an on-staff Natural Resource Damage Assessment (NRDA) expert for detail on-site; and provide stand-by support in areas of environmental protection.

Under the scenario established in this paper, emergency response in the delta will be carried out by numerous local, state, and federal agencies with a wide variety of skills and knowledge necessary to protect human life and the environment. Ultimately, limited resources may hinder response efforts and impede speedy levee repairs. Levee repair materials, barges needed to carry these to the delta, and other repair equipment would be difficult to procure during a geographically-widespread catastrophe. Federal assistance would mitigate the lack of regional resources, but may not be timely. The response community must address these shortfalls and plan for them accordingly.

After recent events in New Orleans, the Gulf Coast, and recent severe storms in Northern California, the threat of levee breaches is in the forefront of media, public and political attention. As citizens of California, we depend on a complex water system that depends upon the Sacramento-San Joaquin Delta for our drinking and irrigation water. It is in our best interest to protect the quality of this water for our consumption and livelihoods. As environmentalists, we are concerned about further damaging the already endangered wetland ecosystem, including threatened and endangered species in the area. As members of the federal community and employees of the Department of the Interior, we seek to protect natural, cultural and historic

resources. It is our responsibility and duty to increase awareness and preparedness for such emergencies. We aim to facilitate and coordinate with leaders at the local, state and federal level to respond in a local catastrophe with national consequences.

In January 2006, California Governor Arnold Schwarzenegger announced an ambitious Strategic Growth Plan for the state of California and he declared a state of emergency for the levee system on February 24. The State of Emergency declared that the California Department of Water Resources shall develop a plan this year to repair levee erosion sites that are in critical condition. The Strategic Growth Plan, however, would invest $2.5 billion, over the next ten years, to make levee repairs, improve emergency response, and provide adequate flood protection. Part of this plan includes at least $115 million to achieve 200-year flood protection for the Sacramento region and plans to upgrade Delta levees and begin seismically fortifying critical levees to ensure their long-term reliability. In order to augment state funding and reduce the amount of time it will take to repair the levees, Schwarzenegger asked US Homeland Security Secretary Michael Chertoff for federal assistance. Chertoff pledged to seek an increase of federal funding but could not guarantee that the region would be declared a federal emergency (Kollars 2006).

While we cannot claim to understand the financial intricacies of the proposed Strategic Growth Plan, we support pragmatic action by local, state, and federal governments to address California's weak flood control system. This includes increased cooperation among local, state and federal agencies to address Delta vulnerability. Furthermore, we support proposals to intentionally flood several key islands, possibly preemptively, in the Delta and restore them to their natural wetland state, contingent on thorough environmental and economic analyses. The prospect of a peripheral canal has been introduced to divert water from the Delta and transport it

directly to Southern California. This canal could further reduce the quantity of water input into the Delta, thereby reducing habitat for native species. Finally, new developments on Delta islands create greater risk for oil and hazardous materials releases and for residents and their surrounding environment. Developments on subsiding islands surrounded by weakened levees in an area with potential seismic activity do not provide for safe human habitation. Increased awareness regarding this issue is mandatory, however, we suggest the use of planned exercises with participation from all parties with a stake in the area, whether it be an environmental interest, an agricultural interest, a local landowner, or a political interest. A catastrophe of the magnitude we have addressed in this paper would be devastating to all the aforementioned stakeholders. Thus, to safeguard all interests, cooperation and participation from all involved is necessary and is the only sufficient means to adequately address the dangers of impending levee failure and the subsequent environmental damage.

The levee system provides a sub-optimal habitat for naturally-occurring wetland species in order to support environmentally draining and costly agricultural endeavors. However, we recognize that the best measure for public and ecosystem health for the current status of California's water supply is to encourage ongoing maintenance and seismic retrofitting and research to strengthen the Delta levee system. The levee system in the Sacramento – San Joaquin Delta is extremely complex and deserves further attention and prompt action.

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