

Chapter 4, part D. DELTA LEVEE SYSTEM INTEGRITY

MONITORING OBJECTIVES

The fundamental goal of the overall Delta Levee System Integrity Program is to "reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees."

The specific elements of the Delta Levee System Integrity Program are discussed fully in the CALFED Long-Term Levee Protection Plan and include:

1. **Base Level Protection Plan:**
Target – Improve and maintain Delta levees to the Public Law 94-99 (PL 84-99) standard.
2. **Special Improvement Projects:**
Target - Improve and maintain levees at key Delta locations to a level commensurate with the benefits protected.
3. **Subsidence Control Plan:**
Target – Reduce or eliminate risk to levee integrity from subsidence.
4. **Emergency Management and Response Plan:**
Target – Enhance existing emergency management and response capabilities to protect critical Delta resources in the event of a disaster.
5. **Seismic Risk Assessment:**
Target – Identify risk to Delta levees from seismic events and develop recommendations to reduce levee vulnerability and improve their seismic stability.

The monitoring elements selected by the CMARP Levees Technical Team will support a determination of whether the above program elements are achieved.

Indicators have been identified for each of the program elements. An indicator is a set of system attributes that collectively provides a convenient way to evaluate the status of the overall system. Indicators will be used to show progress towards the

CALFED Levee Program goals. For example, the indicator for the Base Level Protection Plan element, "number of islands/tracts with levees meeting the minimum PL84-99 standard," will be determined by a compilation of cross-section, inspection, and other data, and this determination will be used to measure progress towards the Base Level Protection Plan goal of improving all Delta levees to the PL84-99 standard.

Additionally, monitoring elements must be developed to insure the success of environmental mitigation required to offset the effects from implementation of any of the above elements.

Levee Monitoring Objectives Containing Physical Properties

1. Establish that a base level of flood protection for Delta levees at the PL 84-99 standard, or higher as necessary, has been achieved and maintained.
2. Establish that special levee improvements have been achieved and maintained in key Delta locations to a level commensurate with the benefits protected.
3. Establish that the risk to levee integrity from subsidence has been reduced.
4. Establish that an emergency management and response plan with the capability to protect critical Delta resources in the event of a disaster has been adopted and maintained.
5. Quantify Delta levee seismic risk and compare it to other failure modes.

Levee Monitoring Objectives Containing Biological Properties

Establish that effects from any construction/management action associated with achieving the overall objectives of the Delta Levee System Integrity Program are mitigated as appropriate.

Construction/management actions include:

- A. Levee improvements or maintenance.
- B. Excavation of material at borrow sites and its transport to the construction sites.
- C. Channel dredging for fill material.
- D. Placement of dredge reuse material.
- E. Subsidence control features.

CONCEPTUAL MODEL AND/OR LISTING OF HYPOTHESES AND ASSUMPTIONS OF THE SYSTEM

Common Survey Standards

Monitoring plans for Delta Levee System Integrity Program elements are directly or indirectly dependent on accurate vertical and horizontal data. A common coordinate system for quantifying and mapping features that are tied to vertical and horizontal position data in the Delta is critical in determining levee standard compliance, providing emergency response, and evaluating the effects of subsidence and seismic activity. Specifically, minimum survey-control standards are needed to develop a network of vertical and horizontal control points in the Delta.

Without this common survey standard, true elevations and horizontal positions for Delta levees cannot be known, thereby leading to a false sense of confidence in survey data and flood protection. Appendix VII.G.f contains specific recommended methodology for establishing the needed common survey standards for the Delta.

Models and Assumptions of the Levee System

The Delta Levees component of CMARP does not have a classic, analytical model levee condition or behavior. However, several specific factors can be measured relative to each of the five Delta Levee System Integrity Program elements.

1. Base Level Protection Plan and Special Improvement Projects

Levees may be built to various standards, depending on the level of flood protection desired. It is the goal of the Long-Term Levee Protection Plan to eventually implement Public Law 84-99 (PL 84-99) performance criteria for non-project levees in the Delta (See Attachment A to Appendix VII.G.a). It is envisioned that higher flood protection standards may be desirable at key Delta locations to a level commensurate with the benefits protected. Most Federal project levees in the Delta already meet the PL 84-99 standard. PL 84-99 criteria include specific cross-section dimensions that must be achieved and maintained. The geometry of the levee will significantly influence how the levee responds to geotechnical and hydraulic forces in the system.

Once a levee is built to a desired standard for flood protection, it is imperative that it be maintained to resist the many forces that work to undermine its integrity. The first step in levee maintenance is levee inspection, which detects various problems before they become critical threats. Levee inspections evaluate the condition of the levee crown road, the condition and inspectability of the land and water sides of the levee, the presence of levee encroachments, and evidence of animal-burrowing damage. Once a problem is detected with any part of the levee, maintenance should proceed. Appendix VII.G.a describes the specific monitoring plan for these elements. (In some cases, the Special Improvement Projects element may include monitoring from other elements such as the Subsidence Control element.)

2. Subsidence Control Plan

Subsidence has substantially contributed to the Delta islands current condition of relatively tall levees protecting interiors below sea level. Recently, however, the risk to levee integrity from subsidence has

diminished. Land management and levee maintenance practices have improved, and subsidence rates have decreased. In addition, it has been determined that a zone of influence (ZOI) extends from the levee crest to some distance inland, beyond which subsidence will not affect levee integrity. However, subsidence within the ZOI may potentially impact levee integrity. The ZOI for a reach of levee can be determined using site-specific data. The Subsidence Control element will include monitoring to determine if levee integrity may be compromised due to subsidence (Appendix VII.G.b).

3. Emergency Management and Response Plan

Delta levees have a history of failure, bringing the devastating effects of flooding to various land uses. Many of these levees failed without warning and were not tied to a single stressful event (storm, etc.). Proper emergency response activities can be a cost-effective supplement for levee protection; however, they cannot substitute for a proper maintenance and repair program.

Delta levees protect approximately 527,300 acres of farmland, 67,000 acres of urban development, and 82,800 acres of native habitat. The Delta's channels and adjacent banks provide habitat for fish and wildlife, accommodate shipping, provide local water supply, protect infrastructure and convey water to nearly 23 million Californians. Most of the protected land is below sea level and therefore emergency response actions are unusually important and require prompt response and action. A levee failure can endanger public safety and inundate thousands of acres of farmland up to 20 feet in depth; it is a costly process to reclaim the island. Also, such an event can cause significant salinity intrusion degrading Delta habitat and impeding the

operations of major State and Federal water delivery systems.

An effective emergency response system is critical to the long-term protection of the Delta. The emergency response system must be monitored to insure that it adapts as conditions and needs change in the Delta (Appendix VII.G.c).

4. Seismic Risk Assessment

Earthquakes can cause levees to fail by slumping or liquefaction of underlying soils. To date, there have been no known Delta levee failures or island inundations as a result of seismic events. However, several active faults are located sufficiently close to the Delta to present a threat to Delta levees.

In 1992, the Department of Water Resources, Division of Engineering completed the "Phase I Report, Seismic Stability Evaluation of the Sacramento-San Joaquin Delta Levees." Subsequently, the Department took several actions to reduce some of the unknowns that influence the evaluation of levee stability during an earthquake.

Assessments by the U.S. Geological Survey concluded that there is a high probability that a large magnitude earthquake will occur in the San Francisco area within the next 30 years. This conclusion, together with the 1989 Loma Prieta Earthquake, has increased concerns for the seismic stability of levees protecting islands in the Sacramento-San Joaquin Delta.

There is concern because the islands in the Delta are generally 10 to 15 feet below sea level. The levees are usually composed of uncompacted sands and silts and are built without engineering design and/or good construction methods. Levees composed of such materials may experience liquefaction and damage during moderate-to-strong

earthquakes. The inundation of one or more islands in the Delta during a period of low outflow could result in saline water from the San Francisco Bay being drawn into the Delta. This could significantly impact the export of water as well as numerous other public facilities and resources that afford a wide range of benefits to the people of California.

Generally, foundation soils in the Delta consist of varying amounts of organic soils. Knowledge of the dynamic behavior of organic soils in the Delta is essential for the determination of ground response to earthquake shaking (Appendix VII.G.d).

5. Habitat Mitigation

The Long Term Levee Protection Program includes measures to control subsidence, and reconstruct, relocate and maintain levees in the Delta. These measures will likely require significant amounts of fill material to be extracted from sources within and around the Delta, including dredging from Delta channels, and their placement on and around levees. This work may result in significant effects on terrestrial and aquatic resources. Monitoring and research will help quantify these effects and any necessary compensation (Appendix VII.G.e).

MONITORING AND RESEARCH ELEMENTS

Following is a list of monitoring elements that the CMARP Levees Technical Team recommends for inclusion in the overall assessment of levee integrity and durability pursuant to the Delta Levee System Integrity Program. Each of these monitoring elements, including their respective research components, is described in detail in Appendices VII.G.a-f. Indicators for each of the Levee Program elements are described in Appendix VII.G.

1. Levee Standard Monitoring Plan: Appendix VII.G.a.
2. Subsidence Control Monitoring Plan: Appendix VII.G.b.
3. Emergency Management and Response Monitoring Plan: Appendix VII.G.c.
4. Seismic Risk Assessment Monitoring Plan: Appendix VII.G.d.
5. Habitat Mitigation Monitoring Plan: Appendix VII.G.e.
6. Common Survey Standard: Appendix VII.G.f.

INDICATORS

Indicators for evaluating progress toward the goals of individual Levee Program elements are described in detail in Appendices VII.G.a-f and are summarized below:

1. Goal: The Base Level Protection goal is to improve and maintain Delta levees to the PL84-99 standard.
Indicator: The number of islands / tracts with levees meeting the minimum PL84-99 standard.
2. Goal: The Special Improvement Project goal is to provide additional flood protection for key islands that provide state wide and national benefit.
Indicator: The number or levee miles or islands / tracks with enhanced, above PL84-99, flood protection, (Static factor of safety greater than 1.5). It is also suggested that a panel be convened to make a qualitative assessment of progress towards the Special Improvement Project goal.
3. Goal: The Subsidence Control goal is to reduce or eliminate the risk to the levee system from subsidence.
Indicator: The number or levee miles or islands / tracks with subsidence control measures.

4. Goal: The Emergency Management goal is to enhance existing emergency and response capabilities.
Indicator: Because of the large number of variables and the qualitative nature of assessing emergency management and response capability, a specific indicator has not been identified. It is suggested that a panel be convened to make a qualitative assessment of progress towards the Emergency Management goal.
5. Goal: The Delta Levee Seismic Risk Assessment goal is to identify the risk to levees from seismic events and develop recommendations to reduce seismic vulnerability.
Indicator: The number of levee miles or islands / tracks that have received seismic upgrades. (Seismic stability factors of safety greater than 1.0). It is also suggested that a panel be convened to make a qualitative assessment of progress towards the Delta Levee Seismic Risk Assessment goal.

LINKAGES

Monitoring and research proposed by the CMARP Levee Workteam overlap with other existing programs, CMARP workteams or components of the CALFED Program in many areas.

Much of CALFED Program work will require horizontal and vertical control. A single base map/control is critical. Horizontal and vertical datum will be needed by the CALFED storage and conveyance and ecosystem restoration program elements in addition to the Levee Program.

Many proposed components in the "Levee Standard Monitoring Plan," Appendix VII.G.a, are already being monitored by the DWR Central District as part of its administration of the Delta Levee Maintenance Subventions and Special Flood Control Projects Programs. The

Subventions Program Maintenance Criteria presently conforms to the 1986 Flood Hazard Mitigation Plan for the Delta. Many nonproject "local" levees in the Delta have adopted the State's Short Term Levee Rehabilitation Plan standard found in the Flood Hazard Mitigation Plan for the Delta (1986)(HMP). To continue eligibility for FEMA disaster-assistance funding, these districts have submitted profiles and cross sections documenting minimum geometry and levee profiles to FEMA, the State Office of Emergency Services and the Delta Levee Maintenance Program. Requirements for compliance with the HMP are summarized below:

1. Levee Profile. Program participants are required to make a profile of the levee crown not less than every fifth year, or more often if determined necessary by the District Board (such as after severe storms).
2. Levee Cross Section. DWR retains copies of existing cross sections documenting that levees meet minimum HMP cross section criteria. When districts have brought their levees into compliance with HMP they are required to update cross sections, at intervals no greater than 500 feet, in rehabilitation projects areas. Copies of this information have also been submitted to FEMA.
3. Annual Levee Maintenance Inspection DWR and DFG annually inspect nonproject levees in the Delta in accordance with Water Code Section 12989, the 1986 Flood Hazard Mitigation Plan, and AB360 habitat requirements. The reviews include the following levee maintenance:
 - vegetation removal, road surface maintenance, roadway crown grading, and gate repair on the levee crown,
 - vegetation removal, hazard tree removal, mature tree trimming, slipouts, erosion, cracking, and subsidence on the land side levee slopes,
 - vegetation removal, revetment slippage, slipouts, erosion, cracking,

and Subsidence of the water side levee slopes,

- control of encroachments that affect levee integrity, and
- control of rodents that affect levee integrity.

In addition, approximately every two years, the U.S. Army Corps of Engineers inspects those levees for continuing eligibility with PL 84-99 certification.

The Storage and Conveyance Program of CALFED will also need the bathymetric data proposed in the "Levee Standard Monitoring Plan," Appendix VII.G.a, to monitor for sedimentation and scour. In addition, the Ecosystem Restoration Program will require information on sedimentation and scour as they impact benthic habitat and other ecosystem elements.

Research on sediment toxicity and characterization data proposed in the "Levee Standard Monitoring Plan," Appendix VII.G.a, is also of concern to the Ecosystem Restoration Plan. The ERP goals include the creation of shallow water habitat, which may involve dredged material. This research is also of concern to the Water Quality Program to quantify water-quality effects from dredge activities and placement of dredged materials.

Some data collection proposed in the "Subsidence Control Monitoring Plan," Appendix VII.G.b, is currently completed by other agencies. The Natural Resources Conservation Service obtains soil property information for publication, and some of this information may be applicable to the Plan. The "Subsidence Control Monitoring Plan" also calls for sea-level data, which are collected by NOAA, EPA, and USGS.

Some monitoring proposed in the "Seismic Risk Assessment Monitoring Plan," Appendix VII.G.d, is currently being done as part of the DWR DOE seismic studies program. This includes installation and monitoring of surface and subsurface strong motion instruments at four locations in the

Delta, field and laboratory testing of soils at locations where surface and subsurface seismographs were installed, sponsored research on the dynamic response characteristics of organic soils, and additional dynamic response analysis.

Many monitoring elements proposed in the "Habitat and Mitigation Monitoring Plan," Appendix VII.G.e, are currently completed by DWR's Central District in conjunction with DFG in administering the Subventions and Special Programs Projects. Documentation for participation in the AB360 Program includes habitat assessments in areas where levee work may occur. DWR's Central District has begun compiling these data on a GIS database. In addition, many individual permits for levee construction and maintenance will likely require monitoring for success of mitigation. Finally, permits for dredging will likely require monitoring to assess effects of dredge activity.