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Figures

The Sacramento–San Joaquin River Delta (Delta) and Suisun Marsh are critically important to the state and the nation for a wide variety of environmental and economic services (benefits derived from the area). Approximately 1,115 miles of levees in the Delta and 230 miles of levees in Suisun Marsh define the configuration of the waterways and landforms of the area. Most of these levees hold back water (i.e., prevent water from flowing onto the adjacent land) for 365 days per year, not just during floods. Over the years, many state and federal agencies and stakeholders have voiced concern over the condition of the Delta and Suisun Marsh levees and the consequences when they fail.

DRMS progress can be followed on the Delta Risk Management Strategy web portal:

http://www.drms.water.ca.gov/

1.1 PURPOSE

The overall purpose of the Delta Risk Management Strategy (DRMS) is to assess expected performance of Delta and Suisun Marsh levees (under various stressors and hazards) and the potential economic, environmental, and public health and safety consequences of levee failures to the Delta region and to California as a whole (Phase 1). After the completion of Phase 1, the purpose of DRMS is to address the consequences of levee failures by developing and evaluating risk reduction strategies (Phase 2). This report presents the methodology and results for Phase 1 of the work, the risk assessment. A separate report presents the methodology and results for Phase 2 of the work, the risk reduction strategies.

The Record of Decision for the CALFED Bay-Delta Program (CALFED 2000) called for a DRMS to be completed by 2001. The California Department of Water Resources (DWR), California Department of Fish and Game (CDFG), and U.S. Army Corps of Engineers (USACE) initiated DRMS in response to Assembly Bill (AB) 1200.

1.1.1 Assembly Bill 1200

AB 1200 (Laird, chaptered October 2005) required the DWR to evaluate the potential impacts on water supplies derived from the Delta resulting from a variety of risks.

The bill amends Section 139.2 of the Water Code, to read, “The department shall evaluate the potential impacts on water supplies derived from the Delta based on 50-, 100-, and 200-year projections for each of the following possible impacts on the Delta:

Delta Facts

- About 1,115 miles of levees protect 700,000 acres of lowland in the Sacramento–San Joaquin Delta. In Suisun Marsh, approximately 230 miles of levees protect over 50,000 acres of marshland.
- Only about a third of the Delta levees (385 miles) are “Project Levees,” which were part of an authorized federal flood control project for the Sacramento and San Joaquin River systems. However, the vast majority of Delta levees, over 730 miles, and about 210 miles of Suisun Marsh levees are non-project (local) levees.
- Local levees were constructed, enlarged, and maintained over the last 130 years by local reclamation districts. In general, the levee work by these districts was financed by the owners of the lands protected by the levees. Over about the last 30 years, the State of California has provided supplemental financial support for levee maintenance and emergency response.
- Flooding from levee failures can influence the following services:
  - Land use (agriculture, urban, and conservation areas)
  - Flood management
  - Ecosystem
  - Water supply
  - Water quality management
  - Transportation
  - Utilities
  - Recreation and tourism
  - Local and state economics

1. Subsidence
2. Earthquakes
3. Floods
4. Changes in precipitation, temperature, and ocean levels
5. A combination of the impacts specified in paragraphs (1) to (4) inclusive"

In addition, Section 139.4 was amended to read: "(a) The department and the Department of Fish and Game shall determine the principal options for the Delta. (b) The department shall evaluate and comparatively rate each option determined in subdivision (a) for its ability to do the following:

1. Prevent the disruption of water supplies derived from the Delta.
2. Improve the quality of drinking water supplies derived from the Delta.
3. Reduce the amount of salts contained in Delta water and delivered to, and often retained in, our agricultural areas.
4. Maintain Delta water quality for Delta users.
5. Assist in preserving Delta lands.
6. Protect water rights of the 'area of origin' and protect the environments of the Sacramento–San Joaquin river systems.
7. Protect highways, utility facilities, and other infrastructure located within the Delta.
8. Preserve, protect, and improve Delta levees."

DRMS was developed to address the provisions of Sections 139.2 and 139.4 of AB 1200.

1.1.2 Goals and Objectives

The project sponsors and the project Steering Committee (see Sections 1.3.1 and 1.3.2 for more details), developed the following objectives for the DRMS work in accordance with the provisions of AB 1200:

1. Evaluate the risk[1] and consequences to the state (e.g., water export disruption and economic impact) and the Delta (e.g., levees, infrastructure, and ecosystem) associated with the failure of Delta levees and other assets considering their exposure to all hazards (e.g., seismic, flood, subsidence, seepage, and sea-level rise) under present as well as foreseeable future conditions. The evaluation shall assess the total risk as well as a disaggregation of the risk for individual islands.
2. Propose risk criteria for consideration for alternative risk management strategies and for use in management of the Delta and the implementation of risk-informed policies.

[1] In the DRMS analysis, risk is defined as the likelihood (frequency) of adverse consequences that could occur as a result of levee failures in the Delta. Quantitatively, risk is defined in terms of three components: loss or consequence, frequency of occurrence, and probability as a measure of uncertainty (Kaplan and Garrick 1981). See Section 3 for more information on the scope of the DRMS risk analysis.

3. Develop a DRMS, including a prioritized list of actions to reduce and manage the risks or consequences associated with Delta levee failures.

1.2 RISK ANALYSIS OVERVIEW

In meeting the requirements of AB 1200, the DRMS project is divided into two parts. Phase 1, the work covered by this report, involves the development and implementation of a risk analysis to evaluate the risks from various stressing events to Delta and Suisun Marsh levees. The DRMS Phase 1 risk analysis provides a framework for evaluating major threats, or hazards, to the Delta levee system and the consequences of levee failures. Phase 2 of the project covers risk reduction and risk management strategies for long-term management of the Delta.

The risk analysis report draws information from 12 technical memoranda (TMs). The topics of the TMs are listed below. The TMs can be found at the DWR DRMS web site: http://www.drms.water.ca.gov.

1. Climate Change	7. Levee Vulnerability
2. Flood Hazard	8. Emergency Response and Repair
3. Seismology	9. Water Analysis Module (WAM) (Hydrodynamics and Water Management)
4. Wind-Wave Hazard	10. Impact to Ecosystem
5. Subsidence	11. Impact to Infrastructure
6. Geomorphology	12. Economic Consequences

Each TM presents the scientific and engineering data and assumptions, the methodology applied to each topic area, and the analysis results, which become input to the risk analysis. The Risk Analysis Report summarizes selected relevant information from the TMs to provide a context and background for the risk analysis. Readers should review relevant TMs to access more information on their topics of interest.

This Risk Analysis Report provides an abbreviated compilation of this information and summarizes risk results for 2005 and future conditions. Risk is first evaluated under 2005 base year conditions. Then risks are assessed for future years, assuming that existing management practices (policies, funding, and maintenance) continue ("business as usual").

1.2.1 Hazards

The hazards evaluated in this report for 2005 include:

- Seismic events (earthquakes) that cause levees or their foundations to fail (Section 6)
- Floods (high storm runoff) that can rise above the tops of the levees or increase pressure for seepage through and under the levees and cause them to fail (Section 7)
- High wind waves and erosion that can weaken levees, but are especially damaging to the interior of islands when they are flooded (Section 8)

- Normal sunny-day events caused by undetected problems, such as rodent activity, that cause levees to fail during normal, nonflood flow periods ("sunny-day events") (Section 9)
- The effects of climate change and continuing subsidence, which increase the vulnerability of the levee system over time (Section 14)

The hazard analyses were carried out probabilistically when a probabilistic model existed or when a model could easily be developed. Other hazards, such as climate change and wind-wave models are represented using more of a range of possible outcome as opposed to a formal probabilistic treatment of the subject matter.

1.2.2 Consequences of Levee Failure

DRMS includes analysis of the consequences of levee failures for 2005, including the costs and other impacts due to the failures and resultant flooding (Section 13). Threats to human safety, damage to buildings and infrastructure, flooding of farmland, impacts to the ecosystem, and disruption of water supply are a few examples of consequences. Many of the economic consequences extend well beyond the Delta and Suisun Marsh, especially for the water supply that is exported from the Delta.

1.2.3 Risk Analysis

The DRMS risk analysis combines the various types of hazards, the frequency of different magnitudes of these hazards, and the consequences of failures under each condition in a probabilistic approach (see Section 4 for a discussion of the risk analysis methodology). The overall risks of levee failures are calculated for the 2005 base year conditions (Section 13). All the various components of the risk "equation" are described in more detail in later chapters (Sections 6 through 11) and in their respective technical memoranda. The risk analysis considers the range of possible outcomes and their associated probability of occurrence, from the more frequent events that affect a smaller number of islands/tracts to the less frequent (major) events that affect multiple islands/tracts.

1.2.4 Risk in Future Years

In the future, the magnitude of the hazards, the frequency at which they occur, and the consequences are expected to change (Section 14). For example, sea-level rise is expected to put more pressure on Delta levees in the future. Climate change is expected to increase high winter flood flows into the Delta. Increases in the population within the Delta will increase the consequences of levee failures and flooding. Therefore, the DRMS risk analysis assesses how conditions are expected to change for 50, 100, and 200 years from now. These assessments of future conditions allow computation of risks in future years.

1.2.5 Limitations

For the past few decades, the Delta has been the subject of intense data collection, analysis, and scientific investigation. Despite this new knowledge, a great deal about the Delta and Suisun Marsh is still unknown. These circumstances are not unique to the Delta and

A great deal about the Delta and Suisun Marsh is still unknown. The DRMS work includes an analysis of uncertainty.

DRMS. Rather, they are common to risk analyses of complex natural and man-made systems (SSHAC 1997; USDOE 1998). The DRMS work relied on existing data and information. For example, no opportunity existed to conduct new topographic or bathymetric surveys, obtain subsurface borings to better define levee and foundation material, or conduct other new research. Some areas with data gaps required extrapolation of available data tempered by engineering judgment and experience. A more detailed discussion of the DRMS assumptions and limitations is provided in Section 15.

A particular challenge for DRMS is the analysis of risks as they change from the present (2005 base year) over the next 200 years. As one might expect, the scientific and information uncertainties and data gaps increase when assessing conditions 50, 100, and 200 years from now, particularly with assessments for the ecosystem, population growth, and future changes in the state's economy.

Unlike other risk analyses involving the potential for flooding, the approach developed for DRMS is unique because it addresses multiple hazards and their combination, their individual and aggregated impacts on the levee system, and the consequences resulting from individual events to multiple events. Further, the consequences are estimated for individual islands/tracts or for the Delta and the region as whole. For example, a similar evaluation for New Orleans would consider the risk associated with a single hurricane on 350 miles of levees (e.g., Hurricane Katrina)—a relatively straightforward exercise. In the case of DRMS, all potential floods, earthquakes, and other hazards that might cause levee failures now or in the future are to be considered. To our knowledge, no other risk evaluation has been attempted for the Delta and Suisun Marsh on the scale and at the level of complexity of DRMS. The DRMS evaluation was conducted for:

- About 1,345 miles of levees (over three times the length of the levees for New Orleans)
- An area of 1,315 square miles (almost four times the area of New Orleans)
- Highly variable foundation conditions, including compressible peat soils
- Levees that were constructed without the benefit of modern engineering and construction techniques
- Multiple hazard conditions, including seismic, flood, wind-wave, and even sunny-day breaches from unforeseen conditions
- Changing future conditions, including land subsidence, sea-level rise, more winter flooding, and an increasing risk of a moderate to severe earthquake occurring in the near future
- Consequences of levee failure that extend well beyond the boundaries of the Delta and Suisun Marsh to the entire state of California

The intended result of this risk analysis is a better understanding of the risks that the Delta and Suisun Marsh face today and in the future. The risk results should be considered for the levee system as a whole rather than for any specific levee reach. Some readers may attempt to focus on an individual island or land tract for information—but this tendency should be discouraged. The information in the report should not be used as a basis for design for any individual

Use of Risk Analysis

The results of the risk analysis are intended to provide a broad indication of the risks associated with the Delta and Suisun Marsh levee system. The information in the report should not be used as a basis of design for any individual island or land tract.

island or land tract. In essence, the risk results from this analysis can be considered as a more accurate indication of levee risk for the collective area than for a specific spot in the Delta or Suisun Marsh.

As a result of the DRMS project, parties interested in the future of the Delta and Suisun Marsh will be in a position to begin to assess the relative importance of different hazards, and the nature (both type and severity) of the risks that they face. The analysis will quantify and put into context how significant of a threat the ongoing, relatively frequent events and levee failures are to the future of managing the Delta. The analysis will also quantify what the state may face from a major catastrophe—our version of the flooding of New Orleans as a result of the effects of Hurricane Katrina.

1.3 PROJECT TEAM

1.3.1 Project Funding/Sponsors

The DRMS project was funded entirely by DWR. DWR, CDFG, and USACE serve as the project sponsors for DRMS. The sponsors are assisted by a Steering Committee, which consists of Technical Advisors and Delta stakeholders.

1.3.2 Steering Committee

Steering Committee members are policy advisors who represent the interests of those within the Delta and the interests of those outside it who rely on the infrastructure within it. The role of the Steering Committee members is to ensure the maintenance of proper coordination among agencies, the public, and the DRMS Consultant. The members are expected to speak with authority on the positions of their constituencies and have access to policymakers within their organization, when needed. The Steering Committee provides policy advice to the project sponsors and the DRMS Consultant. The Steering Committee reviews the interim and final work products of the DRMS consulting team and provides written comments. Appendix A contains the written comments from the Steering Committee and member agencies on the April 24, 2007, draft of the DRMS Risk Analysis Report and the technical memoranda (various dates) and the responses of the DRMS consulting team. The Steering Committee consists of the following members:

Norman Abrahamson, Ph.D., University of California, Davis

Gary Bobker, The Bay Institute

Marina Brand, California Department of Fish and Game

Jon Burau, U.S. Geological Survey

Marci Coglianese, Bay Delta Public Advisory Board

Gilbert Cosio, MBK Engineers

Roger Fuji, U.S. Geological Survey

Jim Goodwin, U.S. Bureau of Reclamation

Sergio Guillen, California Bay Delta Authority

Leslie F. Harder, Jr., Ph.D., former DWR Deputy Director, Public Safety and Business Operations

Wim Kimmerer, Ph.D., Romberg Tiburon Center for Environmental Studies

Dennis Majors, State Water Contractors

Frances Mizuno, San Luis and Delta-Mendota Water Authority

Peter Moyle, Ph.D., University of California, Davis

Michael Ramsbotham, U.S. Army Corps of Engineers

Curt Schmutte, Division of Flood Management

Raymond Seed, Ph.D., University of California, Berkeley

Judy Soutiere, U.S. Army Corps of Engineers

Robert Twiss, Ph.D., University of California, Berkeley

Tom Zuckerman, Bay Delta Public Advisory Board

1.3.3 Technical Advisory Committee

Members of the Technical Advisory Committee (TAC) are the non-stakeholder constituents of the Steering Committee. The TAC members are technical subject matter experts, and serve at the direction of the project sponsors, as technical advisors to the DRMS project team. The TAC provides technical guidance or, in some instances, participates in expert elicitation, depending on the topic (e.g., the ecosystem impact analysis topic uses the TAC experts for elicitation). The TAC members who participated in expert elicitation or technical guidance in specific topical areas included:

The TAC for Levee Vulnerability was composed of the following members:

Leslie F. Harder, Jr., Ph.D., former DWR Deputy Director, Public Safety and Business Operations

Raymond Seed, Ph.D., TAC Chair, University of California, Berkeley

Ralph Svetich, Project Manager, DWR

David Mraz, Contract Manager, DWR

Michael Driller, DWR

Michael Ramsbotham, U.S. Army Corps of Engineers

Lynn O'Leary, U.S. Army Corps of Engineers

Gilbert Cosio, MBK Engineers

The TAC for Ecosystem Impacts (for expert elicitation) was composed of the following members.

Wim Kimmerer, Ph.D., Romberg Tiburon Center for Environmental Studies

Peter Moyle, Ph.D., University of California, Davis

William (Bill) Bennett, Ph.D., University of California, Davis

1.3.4 CALFED Science Program Independent Review Panel

The Independent Review Panel (IRP) conducted the formal independent review of the Risk Analysis Report dated June 26, 2007. The written comments from the IRP and the responses of the DRMS consulting team are provided in Appendix B. This appendix also provides a copy of the IRP written comments on the July 16, 2008, revision of the Risk Analysis Report. The IRP is composed of the following members:

Rich Adams, Ph.D., Oregon State University, Corvallis, OR

Bob Gilbert, Ph.D., University of Texas, Austin, TX

Katharine Hayhoe, Ph.D., Texas Tech University and ATMOS Research & Consulting, Lubbock, TX

W. F. Marcuson III, Ph.D., P.E., W. F. Marcuson III & Associates

Johnnie Moore, Ph.D., University of Montana, Missoula

Arthur Mynett, Sc.D., Delft Hydraulics, UNESCO-IHE Delft, The Netherlands

Deb Neimeier, Ph.D., P.E., University of California, Davis

Kenny Rose, Ph.D., Louisiana State University, Baton Rouge

Roy Shlemon, Ph.D., Roy J. Shlemon, and Associates, Inc., Newport Beach, CA

1.3.5 Special Topics Independent Review Panels

The Levee Seismic Vulnerability Review Panel (SRP) members provided thorough technical review of the characterization, modeling, and results of the development of the seismic fragility functions and the seismic probability of levee failure. Members of the SRP included:

Ross W. Boulanger, Ph.D., University of California, Davis

Jeffrey A. Schaeffer, Ph.D., USACE, Louisville District, KT

Richard (Dick) Volpe, Santa Clara Valley Water District, CA

The written comments of the SRP and the responses from the DRMS consulting team are included in Attachment 2 of the Levee Vulnerability TM (URS/JBA 2008c).

The Probabilistic Seismic Hazard Review Panel (PSHRP) provided independent review of the Probabilistic Seismic Hazard Analysis Technical Memorandum. The PSHRP was composed of the following members:

U.S. Geological Survey (Jack Boatwright, Ph.D.; Tom Brocher, Ph.D.; Russ Graymer, Ph.D.; Tom Hanks, Ph.D.; Tom Holzer, Ph.D.; and David Schwartz, Ph.D.)

California Geological Survey (Michael Reichle, Ph.D.)

The written comments from the PSHRP and the responses from the DRMS consulting team are included as part of the comments and responses to the Seismology TM in Appendix A.

The Economic Analysis Independent Review Panel: Professor David Sunding from University of California, Berkeley, provided independent review of the Economic Impact Technical Memorandum. His review letter and the DRMS responses are included in Appendix H of the Economic Consequences TM.

1.3.6 DRMS Consulting Team

The project sponsors selected the consulting team of URS Corporation and Jack R. Benjamin & Associates, Inc., to perform the DRMS work. The team was given authorization to proceed with work in March 2006. The work schedule calls for the Phase 1 work to be completed in December 2008 and the Phase 2 work to be completed in January 2009.

The consulting team includes 30 firms and independent consultants located in the Sacramento/Bay Area/Stockton region. These local firms and independent consultants bring extensive local experience with the Delta in their respective fields of specialization. The firms and the services they provided are described below. Figure 1-1 shows the program functional organization. (Tables and figures are typically located at the end of each section.) Figure 1-2 shows the project team organization.

URS Corporation (URS): Risk Analysis, Geotechnical Engineering, Seismic Hazard and Earthquake Engineering, Hydraulic/Hydrology, Flood Hazard, Water Quality, Vegetation and Habitat Analysis, Infrastructure, GIS

Jack R. Benjamin & Associates, Inc. (JBA): Risk Analysis and Modeling, Water Management

Resource Management Associates (RMA): Delta Hydrodynamic Modeling

MBK Engineers: Reservoir Operation and Water Management

Bay Modeling-Hydrodynamics (Bay Modeling): 3-D Hydrodynamic Modeling, Sea-Level Rise Simulation

Watercourse Engineering, Inc. (WE): Hydrodynamics and Water Management

Geomatrix Consultants, Inc. (Geomatrix): Seismic Hazard, Earthquake & Geotechnical Engineering

Kleinfelder, Inc.: Geotechnical Engineering

Hultgren & Tillis Engineers (HTE): Geotechnical Engineering

HydroFocus, Inc.: Subsidence

WLA Consulting, Inc.: Seismic Geology, Fault Characterization

Pacific Engineering & Analysis (PE&A): Ground Motions and Site Response

Phillip Williams Associates (PWA): Geomorphology, Wind-Wave Modeling

Moffatt & Nichol Engineers (MNE): Emergency Response, Erosion

Economic Insight (EI): Economic Analysis

RM Econ: Economic Analysis

Western Resource Economics (WR Economics): Economic Analysis

M-Cubed: Economic Analysis

Redars Group (RG): Traffic Impact Analysis

Hanson Environmental, Inc. (HEI): Environmental and Ecosystem Impact Analysis

Stevens Consulting: Environmental and Ecosystem Impact Analysis

Science Applications International Corporation (SAIC): Terrestrial Habitat

Jones & Stokes: Water Quality, Environmental Impacts

Coppersmith Consulting, Inc.: Seismic Hazard

JRP Historical Consulting: Delta Historical Resources

Philip B. Duffy, Ph.D., Lawrence Livermore National Laboratory: Climate Change

C. Allin Cornell (deceased), Ph.D., Stanford University: Risk Analysis

Gregory Baecher, Ph.D., University of Maryland: Risk Analysis

Aquatic Restoration Consulting: Environmental Impacts

Loren Bottorff, Independent Consultant: Technical Writing and Editing

1.3.7 Topical Work Groups

The DRMS consulting team is organized into 15 topical work groups. The topical groups, the lead for each group, and other contributors are listed below.

1) **Seismic Hazard:**
   Lead: Ivan Wong (URS)
   Patricia Thomas (URS)
   Walt Silva, PhD (PE&A)
   Robert (Bob) Young (Geomatrix)
   Jeffrey Unruh (WLA)
   Kathryn Hanson (Geomatrix)
   Kevin Coppersmith, PhD (I)
2) **Flood Hazard:**
   Lead: Thomas MacDonald, PhD (URS)
   Phillip Mineart (URS)
   Joe Countryman (MBK Engineers)
3) **Subsidence:**
   Lead: Steven Deverel (HydroFocus)
4) **Climate Change:**
   Lead: Philip Duffy, PhD (LLNL)
   Louis Armstrong (URS)
5) **Levee Vulnerability:**
   Lead: Said Salah-Mars, PhD (URS)
   Rajendram Arulnathan, PhD (URS)
   Faiz Makdisi, PhD (Geomatrix)
   Edward Hultgren (HTE)
   Kevin Tillis (HTE)
   Segaran Logeswaran (URS)
   Thang Kanagalingam, PhD (URS)
   Scott Shewbridge, PhD (Kleinfelder)
   Ron Heinzen (Kleinfelder)
   Lelio Mejia, PhD (URS)
   Michael Forrest (URS)
   Ulrich Luscher, PhD (I)
6) **Geomorphology:**
   Lead: David Brew (PWA)
   Chris Bowles, PhD (PWA)
7) **Emergency Response:**
   Lead: Rick Rhoads (MNE)
   Ingrid Maloney (MNE)
   Curtis Loeb (MNE)
   H. Frank Du (MNE)
8) **Wind-Wave Modeling:**
   Lead: Nick Garitty (PWA)
9) **Hydrodynamic Modeling:**
   Lead: John DeGeorge, PhD (RMA)
   Edward Gross, PhD (Bay Modeling)
   Michael MacWilliams, PhD (Bay Modeling)
   Nicholas Nidzieko (Bay Modeling)
10) **Water Management:**
    Lead: Will Betchart (JBA)
    Walter Bourez (MBK Engineers)
    Michael Deas (WE)
    Stacy Tanaka (WE)
11) **Infrastructure:**
    Lead: Michael Forrest (URS)
    Danielle Lowenthal-Savy (URS)
    Liz Elliott (URS)
12) **Economic Impacts:**
    Lead: Wendy Illingworth (EI)
    Roger Mann (RM Econ)
    Steve Hatchet (WR Economics)
    David Mitchell (M-Cubed)
    Liz Elliott (URS)
    Stewart Werner (RG)
    George Muehleck (URS)
    Steve Ottemoeller (URS)
    Lance Johnson (URS)
13) **Ecological Impacts:**
    Lead: Chuck Hanson, PhD (HEI)
    Kristie Karkanen (HEI)
    Alexandra Fraser, PhD (URS)
    Jeannie Stamberger, PhD (URS)
    Jon Rosenfield, PhD (I)
    Peter Rawlings. PhD (SAIC)
    Craig Stevens (Stevens Consulting)
    Terry Cooke (URS)
    Elizabeth Nielsen (URS)
14) **Risk Modeling and Analysis:**
    Lead: Martin McCann, Jr., PhD (JBA)
    Said Salah-Mars, PhD (URS)
    Ram Kulkarni, PhD (URS)
    Chi-Wah Wong (URS)
15) **GIS Support:**
    Lead: Amy Keeley (URS)
    Douglas Wright (URS)
    Sarah Lewis (URS)

I= Independent Consultant
LLNL = Lawrence Livermore National Laboratory

1.3.8 Risk Resources Group

The DRMS consulting team also includes a Risk Resources Group, which was formed to advise on specialized risk modeling issues in the various topical groups. These individuals served primarily as individual consultants on an as-needed basis. The Risk Resources Group consists of the following experts:

C. Allin Cornell (deceased), PhD (Stanford University): Risk Analysis, Uncertainty, Seismic Hazard
Gregory Baecher, PhD (University of Maryland): Probability, Reliability, Geotechnical
Des Hartford, PhD: Policy and Risk Analysis, Geotech, Flood
Ralph Keeny, PhD (Purdue University): Decision Analysis, Public Policy
James H. Cowan, Jr., PhD (Louisiana State University): Aquatic Fishery
Mark T. Stacey, PhD (University of California, Berkeley): Fluid Mechanics/Hydrology
Michael W. Hanemann, PhD (University of California, Berkeley): Economics
Stuart W. Siegle, PhD: Wetland, Estuarine and Riparian Ecosystem
Mark A. Snyder, PhD (University of California, Santa Cruz): Climate Change
Jeff Hart, PhD: Delta Botanicals and Restoration
Chris Kjeldsen, PhD: Delta Botanicals and Restoration

1.4 RELATIONSHIP TO OTHER INITIATIVES

1.4.1 Delta Vision

The role of the Delta Vision initiative (Governor Schwarzenegger's Executive Order S-17-06) is to identify a strategy for managing the Delta as a sustainable system for all environmental and economic services that the Delta provides. The Delta Vision initiative is a significant public process designed to find substantial agreement on recommendations among elected officials, government agencies, stakeholders, subject matter experts, and affected California communities on:

1. The multiple uses, resources, and ecosystem in the Delta that can be sustained over the next 100 years or more
2. The array of public policies and resource management strategies needed to move toward this strategic vision for the Delta
3. A near-term (next 25–50 years) contingency and emergency response plan for a catastrophic event in the Delta.

Although the DRMS risk analysis focuses on the Delta levees and the effects of flooding, the Delta Vision initiative directly considers the needs of a wide variety of resources and activities within the Delta and Suisun Marsh and beyond.

A key principle is to build the Delta Vision initiative around existing Delta planning, technical, and scientific efforts and avoid creating redundant organizational structures. In this way, DRMS will become a major source of scientific and technical information on the Delta and Suisun Marsh levees. Before the Delta Vision initiative, DRMS has already considered and taken on many of the same goals, activities, and functions as the Delta Vision initiative relating to levees. The Delta Vision initiative will build on the information developed from the DRMS effort. The Delta Vision initiative will use many work groups that will work closely with, and preferably include, subject matter experts from ongoing Delta evaluations, such as the DRMS.

A key component of Delta Vision is a Governor-appointed independent Blue Ribbon Task Force that is responsible for recommending future actions to achieve a sustainable Delta. The process includes a diverse Stakeholder Coordination Group and broad public outreach to evaluate different Delta visions and management scenarios. The Task Force will submit a Delta Vision

Report by the end of 2008 as well as a Delta Strategic Plan. A recommendation for conveyance should be included in the plan. A Cabinet-level Delta Vision Committee will submit the Delta Strategic Plan to the Governor and Legislature by December 31, 2008. More detail on the Delta Vision initiative can be found on its web site: http://www.deltavision.ca.gov/.

1.4.2 Bay-Delta Conservation Plan

The Bay-Delta Conservation Plan (BDCP) is a Natural Community Conservation Planning effort to address water operations and facilities in the legal Delta. The BDCP focuses primarily on aquatic ecosystems and natural communities, but may also cover adjacent riparian and floodplain natural communities. Among other things, the plan will:

- Provide for conservation and management of covered species
- Preserve, restore, and enhance aquatic, riparian, and associated terrestrial habitats
- Provide clear expectations and regulatory assurances for the water operations and facilities

The results from DRMS will provide levee risk information to inform the BDCP process. BDCP will work on a conservation strategy through late 2008. The Final BDCP is expected to be completed in October 2009. More information on BDCP can be found on its web site: http://www.resources.ca.gov/bdcp/.

1.4.3 CALFED End of Stage 1

CALFED is preparing an assessment of performance toward objectives during Stage 1 (first 7 years of implementation) and the likelihood that the program will meet its objectives in the future (CALFED 2007). Levees play a major role in the landscape of the Delta and how the CALFED program is implemented in the future. CALFED will use the results of DRMS to inform its planning process. More information on CALFED program planning can be found on the CALFED Bay-Delta Program web site: http://calwater.ca.gov/index.aspx.

1.4.4 Other Initiatives

The results of DRMS could prove useful to other initiatives in the region, including:

- The Delta Regional Ecosystem Restoration Implementation Plan, which is under the direction of California Department of Fish and Game
- The Habitat Management, Preservation, and Restoration Plan for Suisun Marsh (Suisun Marsh Plan), which is currently being prepared by the Suisun Marsh Charter agencies
- Planning activities by state and federal agencies and local entities (for example, the Delta Islands and Levees Feasibility Study, which is being undertaken by the U.S. Army Corps of Engineers)
- Other new initiatives

1.5 REPORT ORGANIZATION

After this introduction, the following sections and appendices collectively present the risk analysis of the Delta and Suisun Marsh levees:

- **Section 2** provides an overview of the Delta and Suisun Marsh. It is based largely on the recent report *Status and Trends of Delta-Suisun Services* (URS 2007).
- **Section 3** is an overview of the scope of work for the risk analysis.
- **Section 4** summarizes the risk analysis methodology.
- **Section 5** provides the technical basis for the 2005 Base Case, the current conditions used for the risk analysis.
- **Section 6** summarizes the seismic risk analysis.
- **Section 7** summarizes the flood risk analysis.
- **Section 8** summarizes the wind and wave risk analysis.
- **Section 9** summarizes the sunny-day, high-tide risk analysis.
- **Section 10** summarizes the planned response to levee breaches.
- **Section 11** summarizes salinity impacts and use of the Water Analysis Module (WAM).
- **Section 12** summarizes the consequences modeling.
- **Section 13** summarizes the risk analysis for the 2005 Base Case, under existing regulatory and management practices.
- **Section 14** summarizes the risk analysis for future conditions in the Delta and Suisun Marsh, assuming continuation of present regulatory and management practices.
- **Section 15** describes assumptions and limitations of the analyses.
- **Section 16** provides the references consulted to prepare the report.
- **Appendix A** contains the written comments from the Steering Committee and member agencies on the April 24, 2007, draft of the DRMS Risk Analysis Report and technical memoranda (various dates) and the responses of the DRMS consulting team.
- **Appendix B** contains the August 23, 2007, comments of the IRP on the June 26, 2007, draft of the Risk Analysis Report and the responses of the consulting team (dated November 2, 2007). This appendix also provides the October 2008 comments of the IRP on the July 16, 2008, revision of the Risk Analysis Report.

The report is supported by 12 TMs that provide background and other technical information used in the risk analysis. Each TM should be considered to be a technical appendix to this report. The following TMs can be found on the DWR DRMS web site (http://www.drms.water.ca.gov).

Technical memoranda	Technical memoranda
1. Climate Change 2. Flood Hazard 3. Seismology 4. Wind-Wave Hazard 5. Subsidence 6. Geomorphology 7. Levee Vulnerability	8. Emergency Response and Repair 9. Water Analysis Module (WAM) (Hydrodynamics and Water Management) 10. Impact to Ecosystem 11. Impact to Infrastructure 12. Economic Consequences

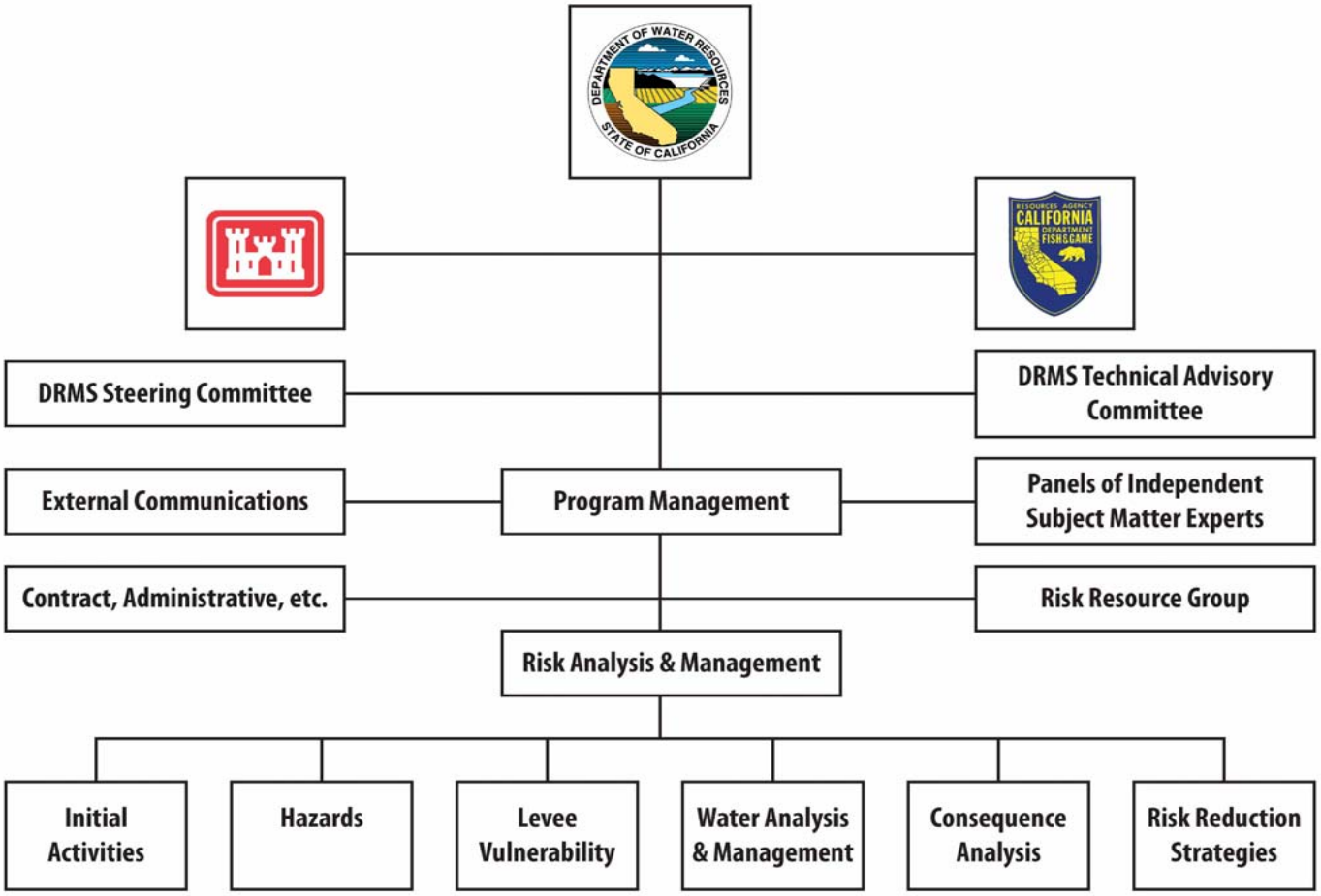

Figure 1-1 Program Functional Organization

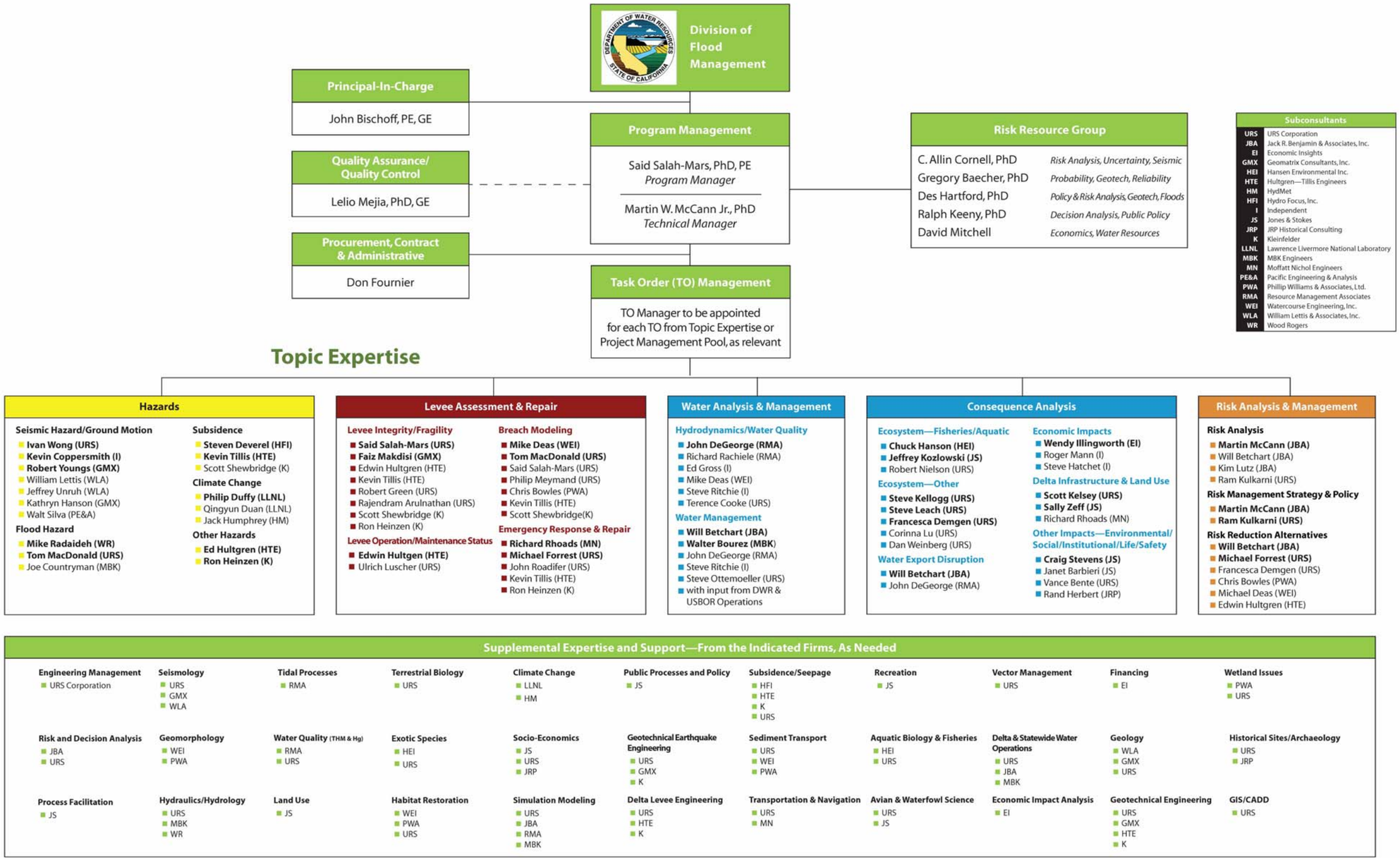

Figure 1-2 Consulting Team Organization