


EXECUTIVE SUMMARY

PHASE 1

Delta Risk Management Strategy

FEBRUARY 2009

Prepared by the California Department of Water Resources from documents developed by URS Corporation/Jack R. Benjamin & Associates, Inc., as listed below.

Phase 1 Risk Analysis Report Technical Memoranda

- Seismology
- Flood Hazard
- Climate Change
- Levee Vulnerability
- Wind-Wave Hazard
- Geomorphology
- Subsidence
- Emergency Response and Repair
- Water Analysis Module
- Impact to Ecosystem
- Impact to Infrastructure
- Economic Consequences

These documents are available electronically on the compact disc attached to the back cover of this Executive Summary. They are also available online at http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp.

Pictured on cover [upper left to bottom, then right]:
Earthquake damage – Sylmar [February 9, 1971]
Source: DWR

Upper Jones Tract failure – Delta [June 4, 2004]
Source: DWR

Flood damage – Delta [June 7, 2004]
Source: DWR

Delta islands protected by levees from flooding
Source: DWR

F O R E W O R D

The Sacramento-San Joaquin River Delta, including the Suisun Marsh, is one of California's most important natural resources. An extensive levee system maintains the waterways and islands that define the Delta and Suisun Marsh.

Levees in the Delta and Suisun Marsh are at risk of failing due to a variety of factors, including earthquakes and winter storms. Levee failures and the flooding that follows can cause fatalities, destruction of property and infrastructure, interruption of a large portion of California's water supply, environmental damage and statewide economic impacts.

The Department of Water Resources engaged a team of experts to complete an evaluation of levee failure risks in the Delta and Suisun Marsh. This evaluation is divided into two phases. Phase 1 analyzes various risks to levees and the local and statewide consequences of levee failure. Phase 2 identifies and analyzes measures to reduce the risks and consequences of levee failure. The results of Phase 1 are summarized in this report.

The successful completion of Phase 1 is a major milestone in the ongoing effort to understand the Delta and Suisun Marsh. The results of Phase 1, and the results of Phase 2 to follow, are necessary for informing the decisions that must be made to maintain and improve levees and protect the Delta and Suisun Marsh.

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Pictured facing page: Overlooking the Delta. Source: DWR

L I S T O F F I G U R E S & T A B L E S

A complex system of over 1330 miles of levees in the Delta Region protects property, infrastructure and people. Levees also protect the region's water supply and ecosystem functions.

The Sacramento-San Joaquin River Delta [Delta] and Suisun Marsh, collectively referred to as the Delta Region, is the largest estuary in the western United States. The Delta Region is home to numerous plant and animal species, some of which are found nowhere else. The Delta Region is also the hub of California's water supply system. Diversions from the Delta provide water for about 25 million people and about 3 million acres of farm land. Key transportation, transmission and communication lines cross the region. The region is also important to recreation and tourism. The rich soils of the Delta islands support a highly productive farming industry. Figure 1 is a map of the Delta Region.

Delta Region levees and the areas and resources they protect are not sustainable under business-as-usual practices.

Phase 1 of the Delta Risk Management Strategy [DRMS] Project analyzes the risks and consequences of levee failure in the Delta Region. The Phase 1 analysis considers current and future risks of levee failures from earthquakes, high water conditions [storms and tides], climate change, subsidence, dry-weather events and a combination of these factors. The analysis also estimates the consequences of levee failures to the local and state economy, public health and safety and the environment.

Various scenarios to reduce the risks and consequences of levee failure are considered in Phase 2 of the DRMS Project. Phase 2 is due to be completed in 2009.

One of the objectives of Phase 1 is to determine whether current [business-as-usual] management practices can sustain the Delta Region through the next 100 years. Business-as-usual practices include current management practices and regulatory requirements.

Pictured above: Delta islands protected by levees from flooding. Source: DWR

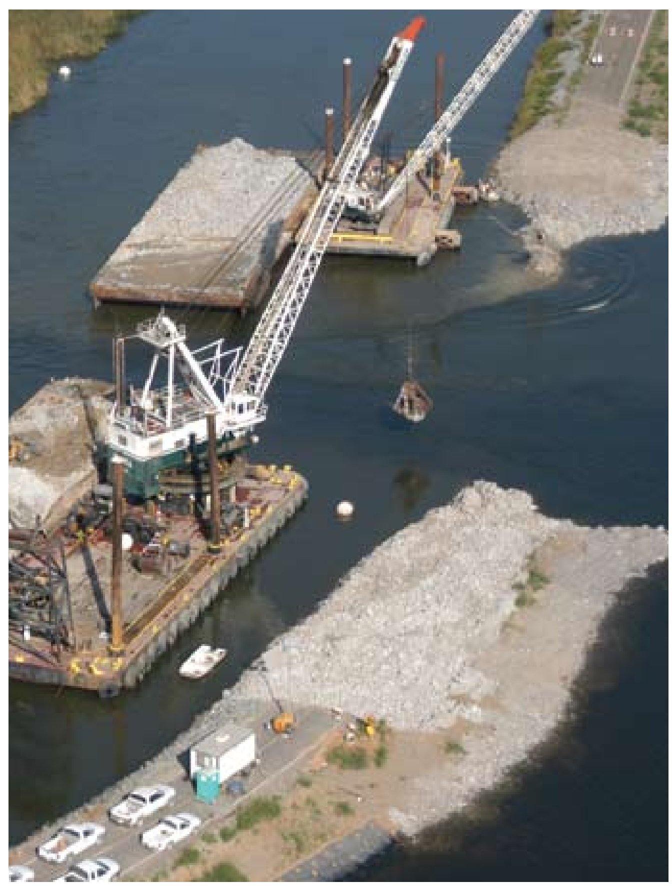
Phase 1 of the DRMS analysis concludes that under business-as-usual practices, the Delta Region as it exists today is unsustainable. Seismic risk, high water conditions, sea level rise and land subsidence threaten levee integrity. A seismic event is the single greatest risk to levee integrity in the Delta Region. If a major earthquake occurs, levees would fail and as many as 20 islands could be flooded simultaneously. This would result in economic costs and impacts of $15 billion or more. All economic costs and impacts presented in this summary are expressed in 2005 dollars.

While earthquakes pose the greatest risk to Delta Region levees, winter storms and related high water conditions are the most common cause of levee failures in the region. Under business-as-usual practices, high water conditions could cause about 140 levee failures in the Delta over the next 100 years. Multiple island failures caused by high water would likely be less severe than failures from a major earthquake, but could still be extensive and could cause approximately $8 billion or more in economic costs and impacts.

Dry-weather levee failures [also called “sunny-day” events] unrelated to earthquakes, such as from slumping or seepage, will continue to occur in the Delta about once every seven years. Costs to repair a single island flooded as the result of a dry-weather levee failure are expected to exceed $50 million.

The risk of flooding in the Delta Region will only increase with time if current management practices are not changed. By the year 2100, Delta levee failure risks due to high water conditions will increase by 800 percent. The risk of levee failure from a major earthquake is projected to increase by 93 percent during the same period.

A major earthquake of magnitude 6.7 or greater in the vicinity of the Delta Region has a 62 percent probability of occurring sometime between 2003 and 2032. This could cause multiple levee failures, fatalities, extensive property destruction and adverse economic impacts of $15 billion or more.



Upper Jones Tract levee repair 2004. Source: DWR

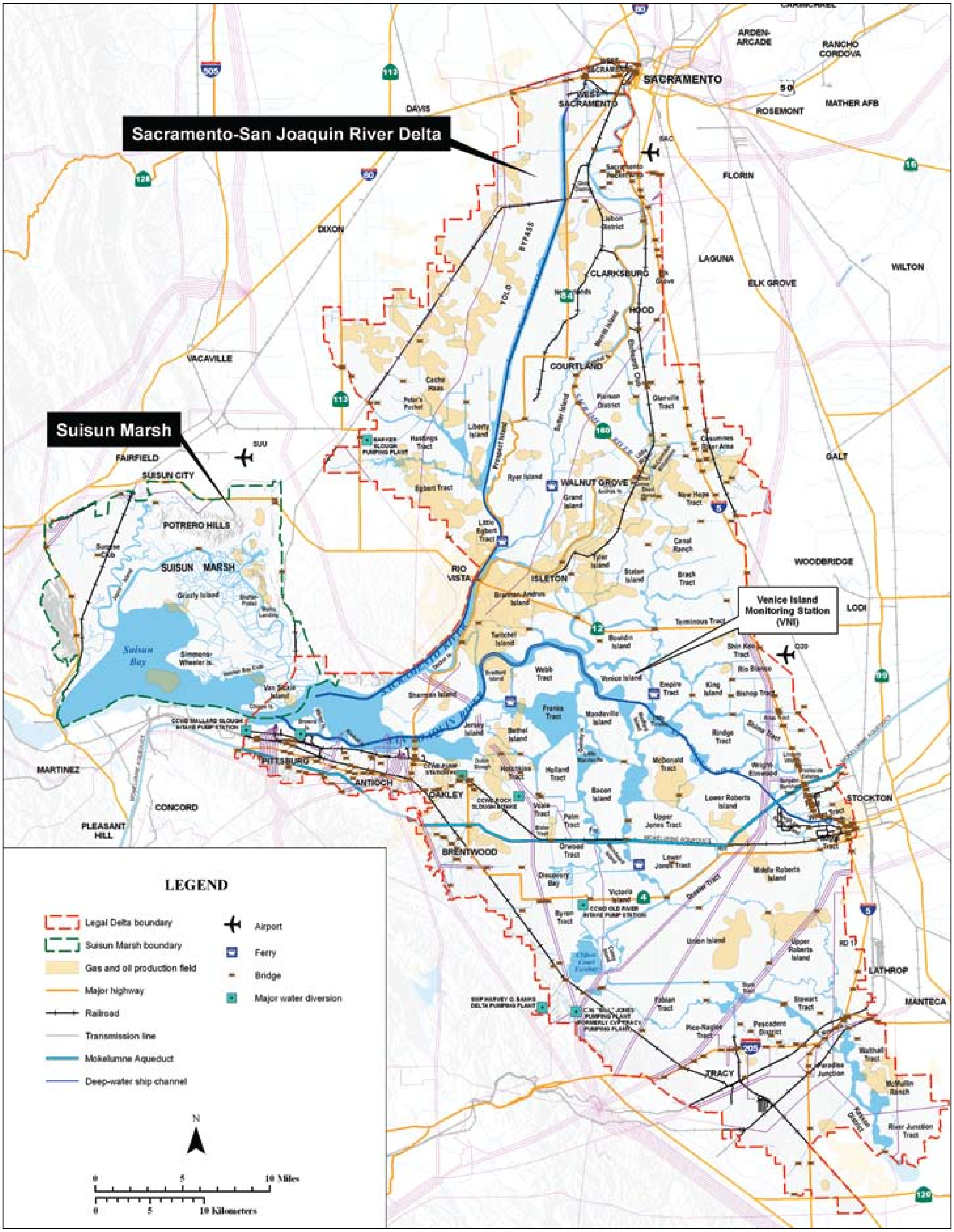


Figure 1 The Sacramento–San Joaquin River Delta and Suisun Marsh [the Delta Region]

Source: Adapted from Status and Trends Report [URS 2007]

INTRODUCTION

The Delta Region is a unique and valuable resource and is an integral part of California's water system.

The Delta Region is vital to California's economy and environment. The region contains highly fertile agricultural land and provides a unique estuarine habitat for many resident and migratory fish and birds, some of which are threatened or endangered. The Delta Region contains critical infrastructure including pipelines, state highways and power and communication lines. The region is the hub of the state's water supply system, which is critical to the state's economy.

Pictured above: Overlooking the Delta at dusk. Source: DWR

Earthquake damage – Sylmar [February 9, 1971]. Source: DWR

Much of the land in the Delta Region is below sea level and is protected by a fragile system of levees. Many of the region's 1330 miles of levees were built in the late 1800s and early 1900s without using modern engineering practices. The Delta Region's levees are critical for protecting the various assets, resources, uses and services that Californians obtain from the region.

A unique feature of the Delta Region is that much of its land is made up of highly organic soils, commonly referred to as "peat soils". Peat soils are very fertile and support an abundant agricultural harvest. Over time, agricultural practices have caused the land surface of Delta islands to subside. During the past century, subsidence has lowered the land surface of some Delta islands to as much as 25 feet below sea level, as shown in Figure 2. Land that is below sea level requires levees to hold back water 365 days a year.

Since 1900, levee failures during high water and during dry weather have caused Delta islands to be flooded a total of 158 times. Some islands have been flooded and recovered multiple times. A few islands, such as Franks Tract, have never been recovered. Franks Tract is located in the central Delta, as shown in Figure 1.

Levee failures have caused the flooding of Delta islands **158 times since 1900**

Levee breaches at Tyler Island [1986]. Source: DWR

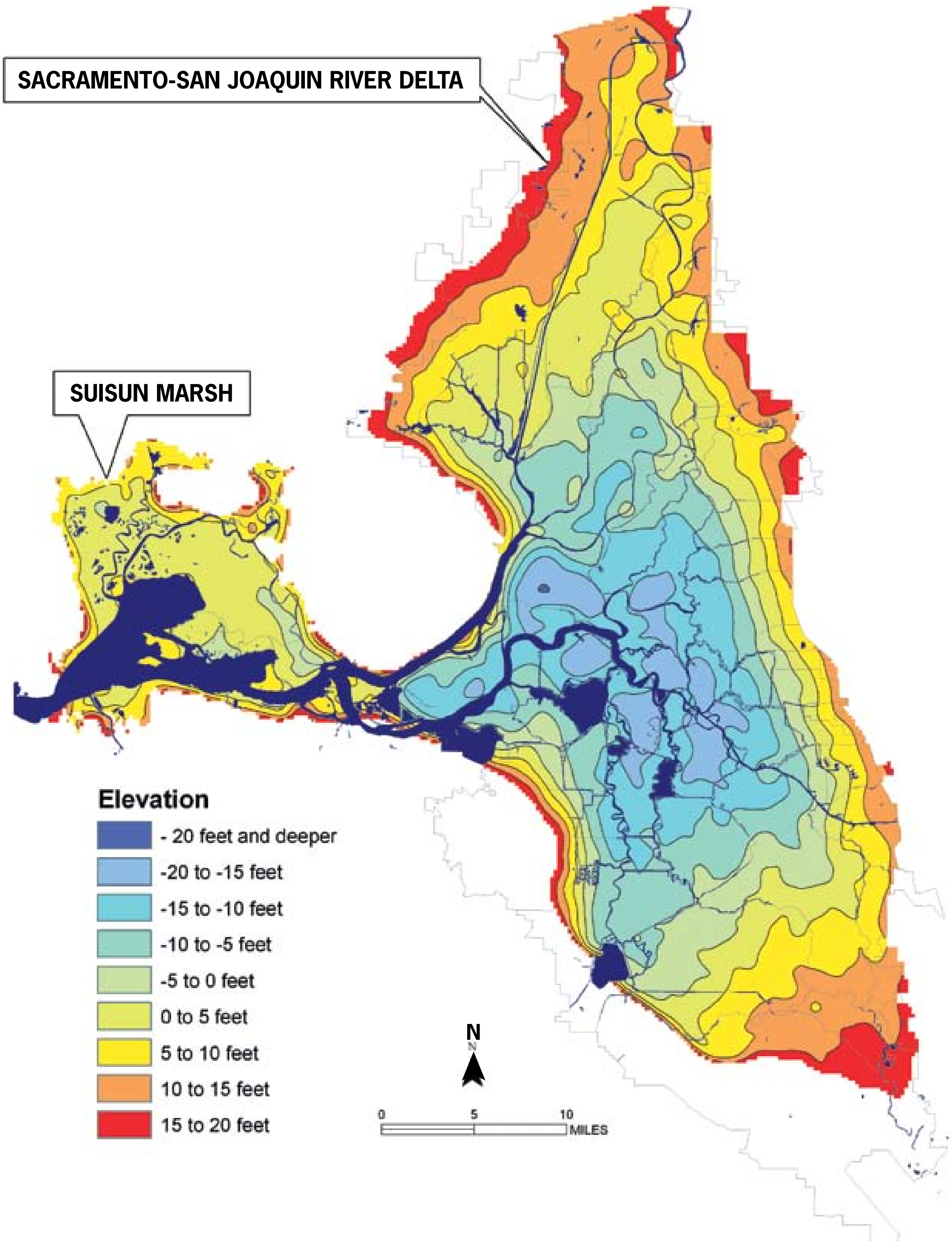


Figure 2 Surface elevation map of the Delta Region
Source: DRMS Risk Report [URS/JBA 2008c], Figure 5-14

Delta Region levees, in their current state and configuration, have not yet experienced a damaging earthquake. The risk of a major earthquake in the Delta Region is high. A major earthquake could cause multiple levee failures and several islands to be flooded simultaneously. If such an event occurs during a time of low-to-moderate fresh water inflow to the Delta from rivers and streams, saline water would move upstream into the Delta from Suisun Bay. Delta waters would then become salty and could not be used for in-Delta irrigation, local urban supplies [such as for the Contra Costa Water District] or State and federal water project exports. The Delta's ecosystem would also be impacted.

The following summary of the Phase 1 DRMS analysis provides estimates of the risks and consequences of levee failures.

The Delta Region has highly fertile agricultural land and provides a unique estuarine habitat for many resident and migratory fish and birds…

Great Blue Heron. Source: DWR

RISKS & CONSEQUENCES

Earthquakes, high water events, continued land subsidence and climate change pose risks to the Delta Region's levee system.

A massive failure of the Delta Region's levee system would have significant adverse effects on the Delta Region and California's economy. Levee failure risks evaluated in the DRMS analysis include seismic, high water and dry-weather levee failures.

Pictured above: Upper Jones Tract Failure [June 4, 2004].
Source: DWR

SEISMIC RISKS

Seismic risk in the Delta Region is characterized as moderate-to-high because of many active faults in the San Francisco Bay Area. Figure 3 illustrates the locations of faults in and near the San Francisco Bay Area and the Delta Region. As shown in Figure 4, area seismic activity during the last 100 years is significantly less than what was experienced during the 1800s and the first part of the 1900s. Seismic experts predict increased seismic activity in the future similar to that which occurred up to the first part of the 1900s.

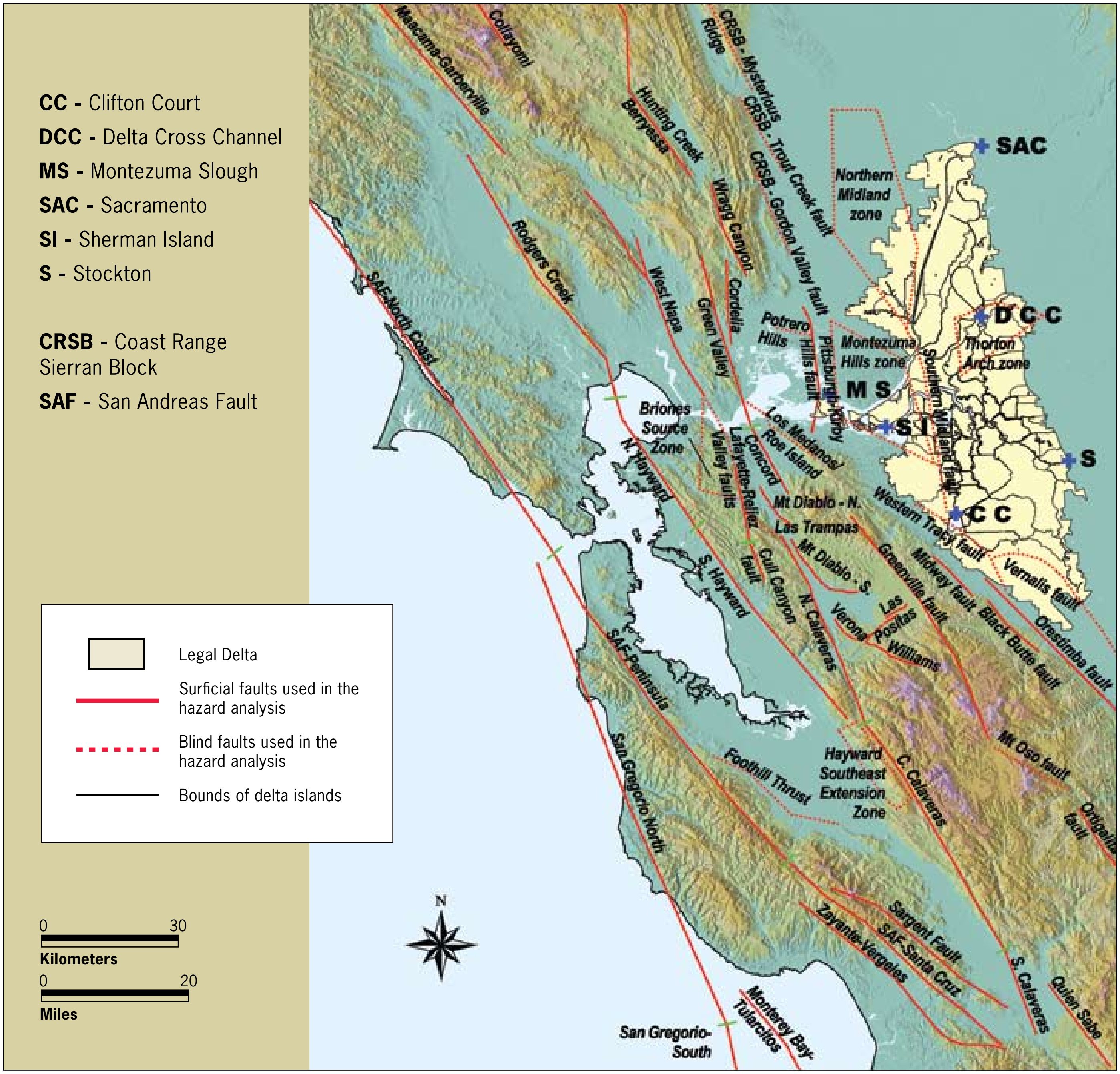


Figure 3 Faults and seismic sources in the vicinity of the Delta Region
Source: DRMS Risk Report [URS/JBA 2008c], Figure 6-1

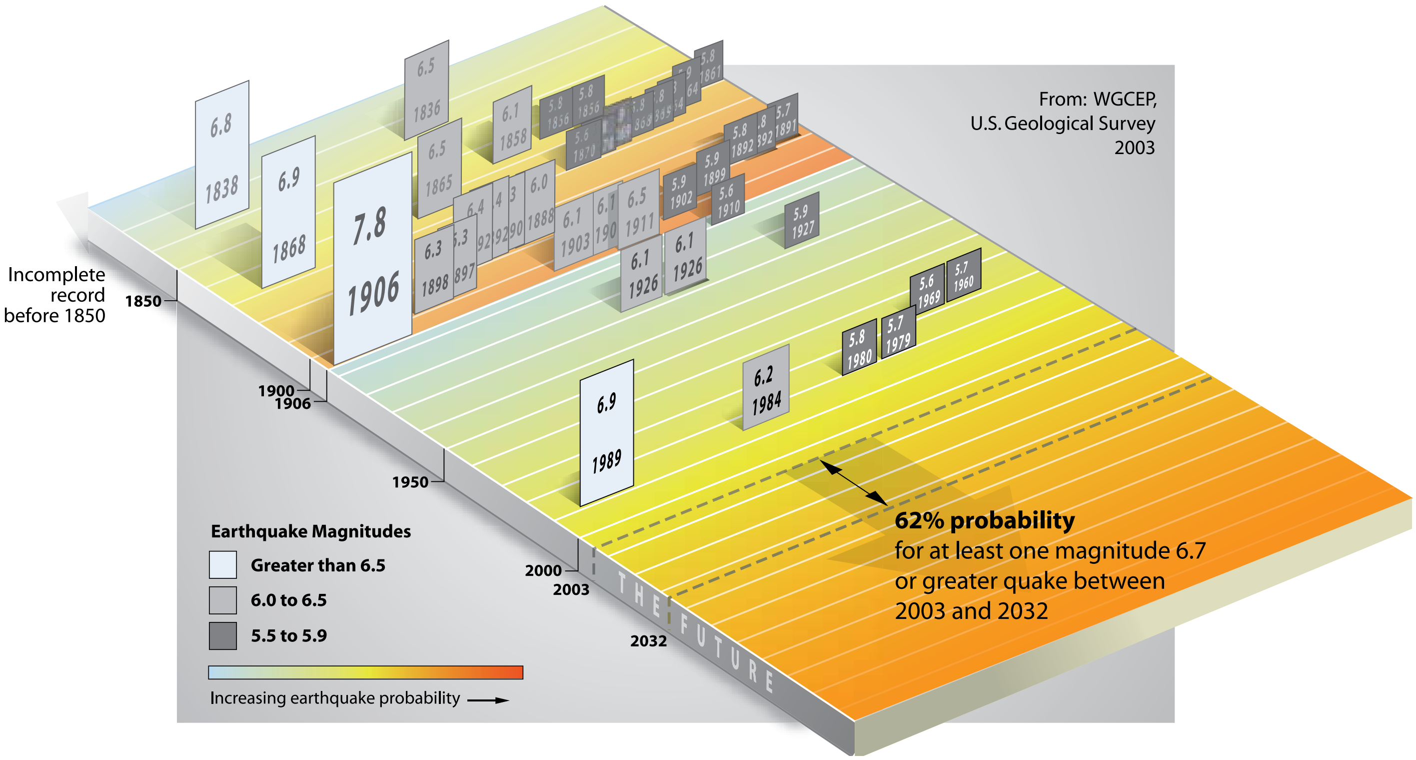


Figure 4 Past and future earthquakes in the San Francisco Bay Area and the Delta Region

Source: DRMS Risk Report [URS/JBA 2008c], Figure 13-8

The U.S. Geological Survey estimates that an earthquake of magnitude 6.7 or greater has a 62 percent probability of occurring in the San Francisco Bay Area between 2003 and 2032 [Figure 4]. Such an earthquake is capable of causing multiple levee failures in the Delta Region which could result in fatalities, extensive property damage and the interruption of water exports from the Delta for an extended period of time. Potential earthquakes on the Hayward, Calaveras or San Andreas faults pose the highest risk to Delta Region levees.

Probability of Multiple Levee Failures

A major earthquake can cause extensive damage to large sections of levees on multiple islands at the same time. As a result, many islands could be flooded simultaneously. For example, there is a 40 percent probability of a major earthquake causing 27 or more islands to flood at the same time in the 25-year period from 2005 to 2030, as shown in Figure 5.

Emergency Response and Levee Repair

The duration and cost of levee repairs increases with the number of islands that are flooded due to an earthquake, as shown in Table 1. This is not only due to the extensive amount of repairs required, but also to the availability of labor and materials to make the repairs.

Table 1 – DURATION AND COST OF REPAIRS
for earthquake-induced levee failures

Number of flooded islands	Estimated range of cost of repair and dewatering [$million]	Estimated range of time to repair breaches and dewater [days]
1	43 – 240	136 – 276
3	204 – 490	270 – 466
10	620 – 1,260	460 – 700
20	1,400 – 2,300	750 – 1,020
30	3,000 – 4,200	1,240 – 1,660

Source: DRMS Risk Report [URS/JBA 2008c], Table 13-9

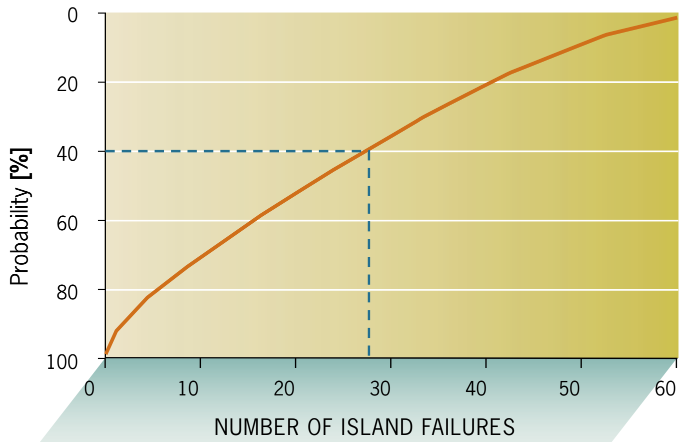


Figure 5 Probability of exceeding a number of simultaneous islands flooding due to earthquake events over a 25-year period [2005-2030]

Source: Adapted from DRMS Risk Report [URS/JBA 2008c], Figure 13-4

Export Disruption

Earthquake damage to levees and to the islands they protect could take years to repair following a major earthquake. One significant impact of levee failures would be to the state's water supply. For example, if 20 islands were flooded as a result of a major earthquake, the export of fresh water from the Delta could be interrupted for about a year and a half. Water supply losses of up to 8 million acre-feet would be incurred by State and federal water contractors and local water districts. The area served by the Contra Costa Water District, an urban water supply agency in the vicinity of the Delta, is an example of an area at high economic risk from water supply disruption. The district's service area is particularly vulnerable to the loss of its Delta water supply since other sources of water are not readily available.

...emergency repairs for 20 flooded islands could cost up to

$2.3 billion

and take about three years.

North Walnut Grove Rd. Bridge between Tyler and Staten Islands [larger bridge]. Source: DWR

Economic Consequences

The total economic cost and impact of multiple levee failures due to a major earthquake in the Delta Region could be tens of billions of dollars. Figures 6a and 6b show the probability of economic costs and impacts from potential earthquakes during the 25-year period from 2005 through 2030. For example, there is a 40 percent probability of incurring $22 billion or more in costs [Figure 6a] and $3 billion or more in impacts [Figure 6b] in the period from 2005 through 2030.

Impacts to Water Quality

Though not specifically analyzed in the DRMS Project, it is reasonable to conclude that, if subsided Delta islands are flooded due to levee breaches, significant amounts of dissolved organic carbon [DOC] would be released into Delta waters from the highly organic peat soils on these islands. Disinfectants used during the drinking water treatment process react with DOC to produce disinfection byproducts in treated water. Many of these chemical byproducts can increase cancer risks or cause other health effects.

Other water quality problems resulting from island flooding include increased algae blooms. Algae blooms can complicate drinking water treatment processes and can adversely affect some aquatic species.

Some soils in the Delta Region contain moderate levels of mercury due, among other things, to historical gold mining activities that occurred upstream of the Delta during the Gold Rush. Mercury in soils can, under certain circumstances, be converted to the highly toxic methylated form when islands are flooded. Methylated mercury can accumulate in the food chain

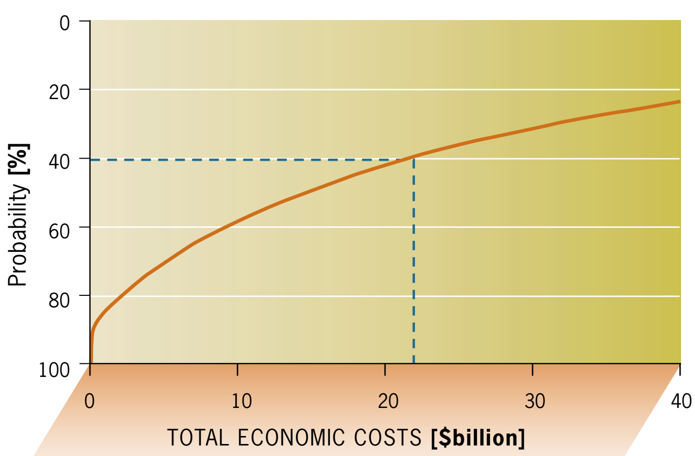


Figure 6a Probability of exceeding an amount in total economic costs due to earthquake events over a 25-year period [2005-2030]

__Economic Costs__ include the direct economic losses associated with the repair of levees, tracts, islands, and infrastructure; the replacement of lost homes and the payment of living expenses for displaced persons; agricultural losses; and the lost water supply to State and federal water contractors and local water districts.

Source: Adapted from DRMS Risk Report [URS/JBA 2008c], Figures 13-19a [costs] and 13-19b [impacts]

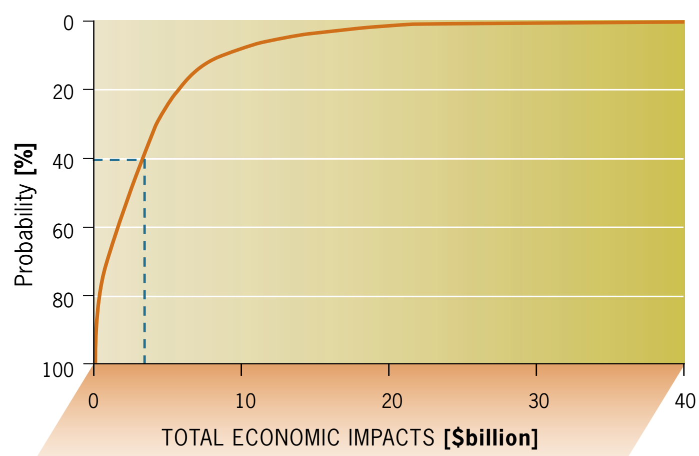


Figure 6b Probability of exceeding an amount in total economic impacts due to earthquake events over a 25-year period [2005-2030]

__Economic Impacts__ include the indirect economic losses associated with the loss of potential revenues because of services not provided. These include the loss of revenue that customers of Pacific Gas and Electric Company, Metropolitan Water District of Southern California, railroads and other service providers suffer because they lose the services these companies provide, combined with lost wages and jobs that result because consumers lose these services.

Decker Island Habitat Restoration Project. Source: DWR

potentially affecting fish. Humans and animals that consume fish contaminated with methylated mercury are at risk of poisoning.

Ecosystem Consequences

Ecosystem impacts and consequences due to levee failure were not fully quantified in the DRMS Project. The main factors that influence ecosystem effects are the location and number of levee failures, time of year and water conditions. Potential ecosystem effects due to levee failures from high water, seismic or dry-weather levee failure events are expected to be similar.

IMPACTS TO AQUATIC SPECIES: Impacts to aquatic species were not quantified in the DRMS Project and require further study.

IMPACTS TO EXISTING VEGETATION: Most of the land in the Delta is used for agricultural purposes. However, areas of vegetation exist where land has not been cleared for agriculture or other uses. Riparian vegetation exists along many waterways in the Delta Region. Wetland vegetation occurs in areas where shallow water often exists, including areas where wetting occurs through tidal action. Upland vegetation is found in areas that remain dry most of the time.

Great Blue Heron. Source: DWR

The results of the DRMS Project suggest that large-scale levee breaches in the Suisun Marsh will cause substantial losses of available habitat, food shortages and the displacement of birds and other species.

In all seismic levee failure scenarios, the area of vegetation impacted increases with the area flooded. The degree of impact depends on the type of vegetation flooded. Results of the DRMS Project indicate potential losses of up to 39 percent of herbaceous wetland, seasonal grasses and low-lying vegetation, 29 percent of non-native trees, and 24 percent of shrub wetland due to an event where multiple islands are flooded.

IMPACTS TO TERRESTRIAL SPECIES: The failure of levees in Suisun Marsh could result in impacts on several terrestrial wildlife species of concern, including the federally-endangered saltmarsh harvest mouse and the California clapper rail. The results of the DRMS Project suggest that large-scale levee breaches will cause substantial losses of available habitat, food shortages and the displacement of birds and other species. However, ecosystem benefits could also result from increases in tidal water habitat.

Public Health and Safety Consequences

The Delta levees most likely to fail due to earthquakes are generally located in the central-west area of the Delta. Their failure will cause rapid flooding and leave little time for evacuation.

The greatest immediate public safety concern is for the people working and living on Delta islands, and for people traveling through the Delta on various roads and highways. Figure 7 shows the estimated loss of life resulting from an earthquake affecting the Delta Region. For example, there is a 40 percent probability of 90 or more fatalities in the Delta from levee failures due to a seismic event in the 25-year period from 2005 through 2030. The expected fatalities from earthquake-related island flooding is high due to the lack of warning for earthquakes and because of the rapid rate of flooding likely to occur after an earthquake.

Future Seismic Risk

Assuming a major earthquake does not occur in the Delta Region before 2050, the probability of earthquakes and the seismic vulnerability of levees in the Delta Region will continue to increase. The risk of levee failure in the Delta due to an earthquake will increase by 35 percent over the next 50 years and by 93 percent over the next 100 years. The risk of levee failure will increase even more significantly if a major earthquake does not occur by 2100.

The consequences of a major earthquake in the Delta Region will also increase with time. Because of increasing water demand and the state's growing population and economy, the economic consequences of an interruption in Delta water supply operations due to an earthquake will increase. Consequences to the Delta Region will also increase due to additional development. Total expected economic losses are anticipated to increase by about 200 percent by 2050 and by about 500 percent by 2100. The risk of fatalities is expected to increase, on average, by about 250 percent from 2005 to 2050.

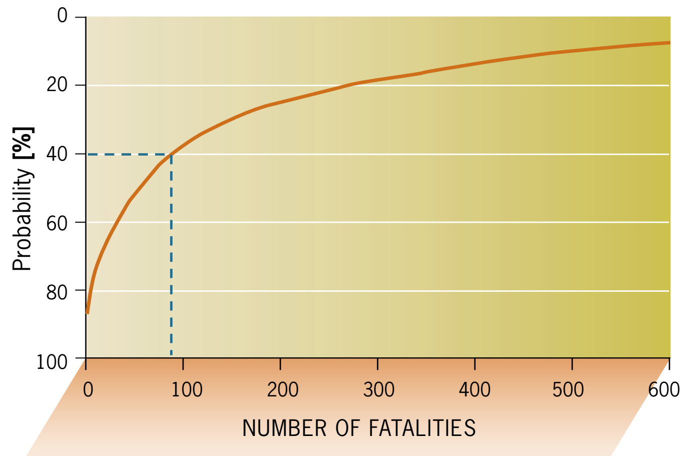
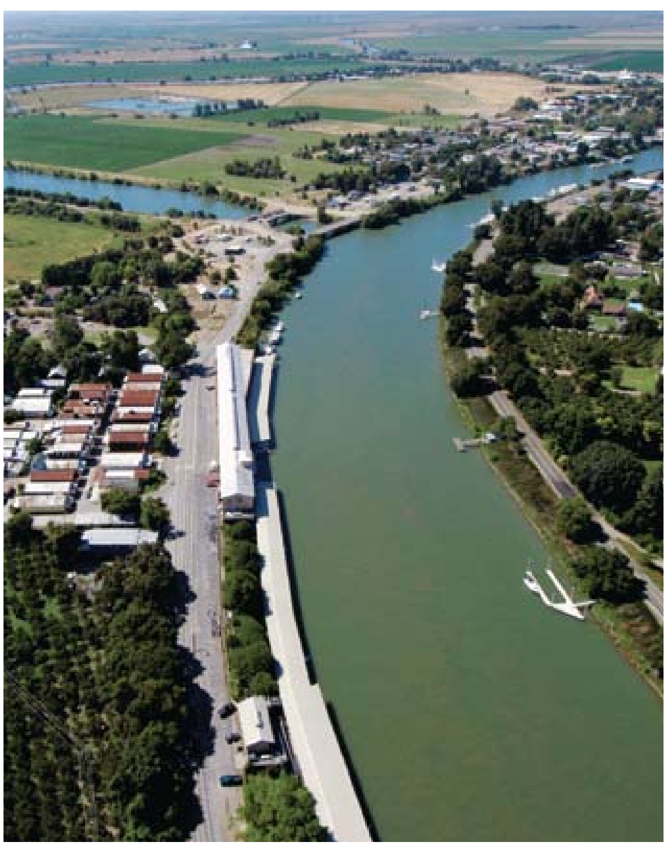


Figure 7 Probability of exceeding a number of fatalities due to earthquake-related levee failures over a 25-year period [2005-2030]

Source: Adapted from DRMS Risk Report [URS/JBA 2008c], Figure 13-20



Sacramento River and Delta Cross Channel. Source: DWR

The risk of levee failure in the Delta due to an earthquake will increase by 35 percent over the next 50 years and by 93 percent over the next 100 years.

HIGH WATER RISKS

Although earthquakes pose the greatest single risk to Delta Region levees, winter storms and related high water conditions are also a serious risk. High water in the Delta Region can overtop levees. High water also increases the hydrostatic pressure on levees and their foundations, causing instability. The risk of through-levee and under-levee seepage failures increases as well.

Most levee failures in the Delta Region have occurred during winter storms and related high water conditions, often in conjunction with high tides and strong winds. Figure 8 shows measured and modeled [predicted] water surface elevations and ranges as a function of return periods at the Venice Island Monitoring Station. The location of the monitoring station is shown on Figure 1.

Considering the probability of all high water-related levee failures under current conditions and existing levee maintenance programs, about 140 levee failures are expected to occur in the Delta over the next 100 years [compared with 158 during the past 100 years]. This corresponds to an average rate of 1.4 levee failures per year.

Probability of Multiple Levee Failures

Depending on the severity of the high water conditions, tides, wind and other factors, multiple levees could fail during a single high water event. Figure 9 illustrates the probability of multiple islands being flooded due to high water conditions for the 25-year period from 2005 through 2030.

Flood damage – Delta [June 7, 2004]. Source: DWR

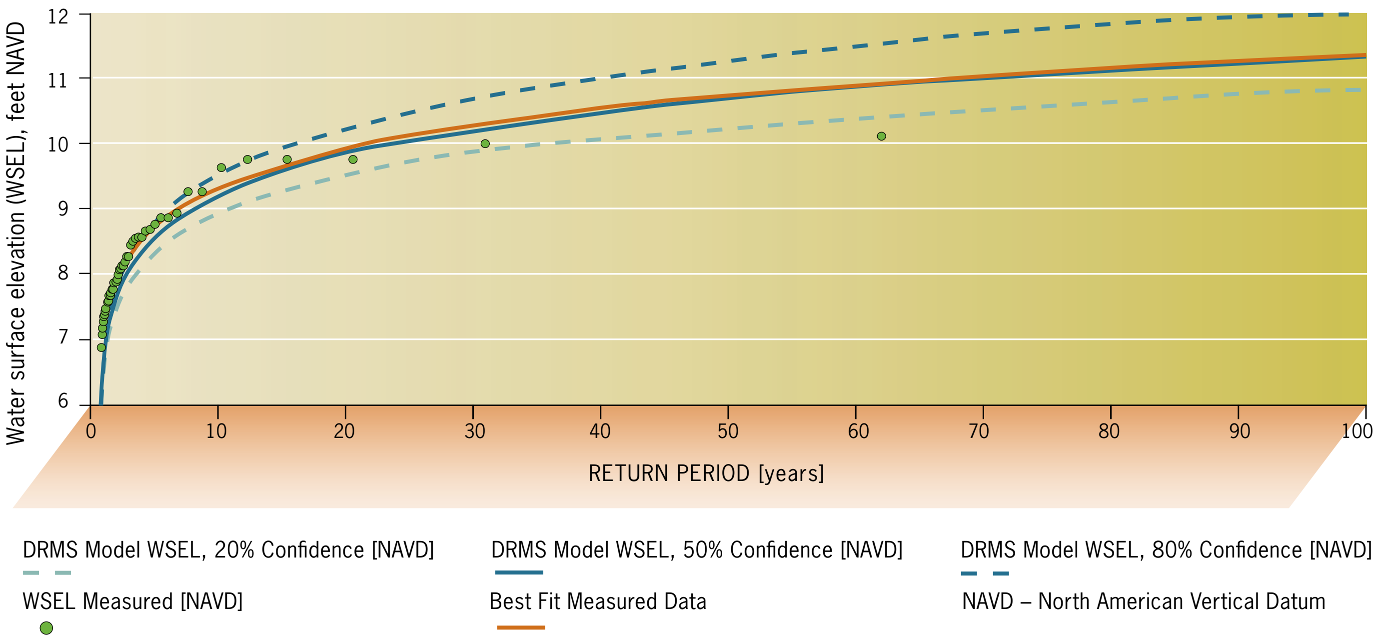


Figure 8 DRMS model predictions versus measured water-surface elevation – Venice Island Monitoring Station
Source: DRMS Flood Hazard TM [URS/JBA 2008a], Figure 7-1

Emergency Response and Levee Repair

The duration and cost of repairs due to high water-related levee failures is listed in Table 2. The cost of levee repairs is generally less for high water conditions than that predicted for earthquakes. This is because high water-related levee failures tend to be more localized and much smaller than those expected for seismically-related failures. The duration of island repair and dewatering efforts for high water-related levee failures are generally similar to earthquake-related failures for a given number of flooded islands.

Export Disruption

High water-related levee failures pose less risk to water supplies than failures from earthquakes. The Delta would likely be receiving large volumes of fresh water inflow from upstream when high water-related levee failures occur. As long as levee breaches are managed appropriately, and repairs are completed when fresh water inflows into the Delta are still relatively high, no long-term water supply export disruptions should occur. Also, the size and number of levee failures due to high water events are expected to be less than earthquake-related failures. With fewer and smaller failures, repairs would take less time.

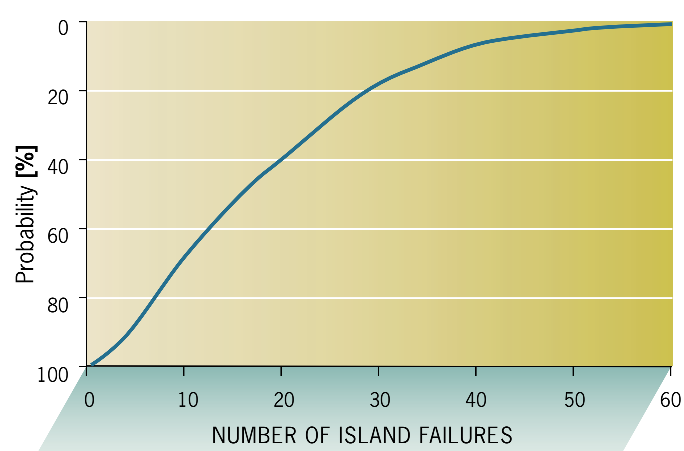


Figure 9 Probability of exceeding a number of simultaneous islands flooding due to high water conditions over a 25-year period [2005-2030]
Source: Adapted from DRMS Risk Report [URS/JBA 2008c], Figure 13-11

Table 2 – DURATION AND COST OF REPAIRS for high water-related levee failures		
Number of flooded islands	Estimated range of cost of repair and dewatering [$million]	Estimated range of time to repair breaches and dewater [days]
1	30 – 110	47 – 170
3	140 – 260	240 – 450
10	490 – 680	590 – 1,060
20	990 – 1,200	930 – 1,110
30	1,500 – 1,800	1,380 – 1,580

Source: DRMS Risk Report [URS/JBA 2008c], Table 13-26

Economic Consequences

Figures 10a and 10b show the probability of economic costs and impacts due to high water-related levee failures over the next 25 years from 2005 though 2030. Levee failures from high water events are generally predicted to result in lower economic **costs** than levee failures from seismic events. In the case of economic **impacts**, levee failures from either high water events or seismic events carry similar impacts for exceedance probabilities greater than about 40%. However, when exceedance probabilities are less than 40%, these economic impacts tend to be larger for failures from high water events.

Impacts to Water Quality

Impacts to water quality from high water-related levee failures are expected to be less than from a major earthquake. Salt, DOC and methylated mercury concentrations during and after high water-related levee failures are expected to be lower because of greater freshwater inflows.

Ecosystem Consequences

Impacts to aquatic species, vegetation and terrestrial species from multiple high water-related levee failures are expected to be similar to impacts that would be experienced from a major earthquake.

Public Health and Safety Consequences

The primary public safety concern from high water-related levee failures is for the people living and working on Delta islands, and for people traveling through the Delta on roads and highways. Figure 11 presents estimates of the probability of fatalities due to high water-related levee failures. For example, there is about a 40 percent probability of 80 fatalities or more in the Delta Region from levee failures due to a high water event during the 25-year period from 2005 to 2030.

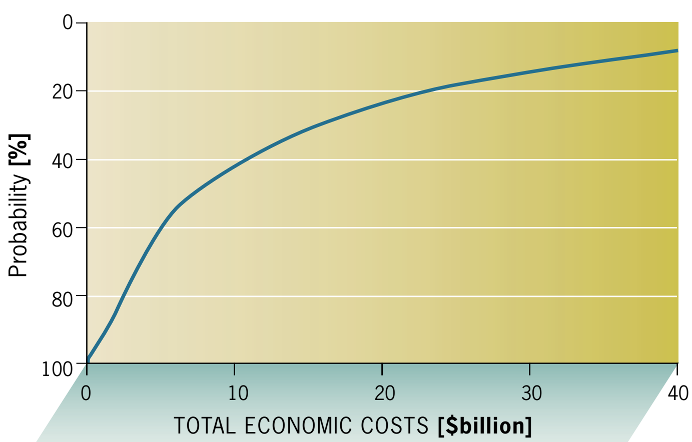


Figure 10a Probability of exceeding an amount in total economic costs due to high water-related levee failures over a 25-year period [2005-2030]

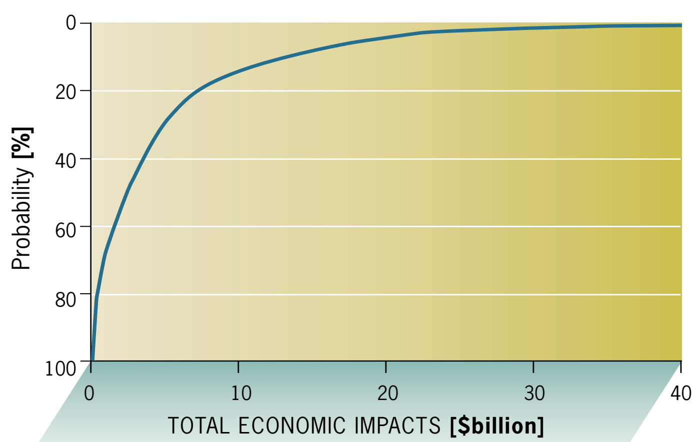


Figure 10b Probability of exceeding an amount in total economic impacts due to high water-related levee failures over a 25-year period [2005-2030]

Source: Adapted from DRMS Risk Report [URS/JBA 2008c], Figures 13-21a [costs] and 13-21b [impacts]

Some densely populated areas, such as the Sacramento Pocket Area and West Sacramento, are especially at risk of fatalities.

Future High Water Risks

Under business-as-usual practices, climate change will cause more frequent high water conditions in the Delta [and increase the risk of related levee failure] due to more winter precipitation falling as rain rather than snow. Sea level rise will also increase the probability of levee failure. The continued deterioration of the Delta's levees further increases levee failure risk.

The consequences of high water-related levee failure in the Delta Region will increase with time due to increased population and development.

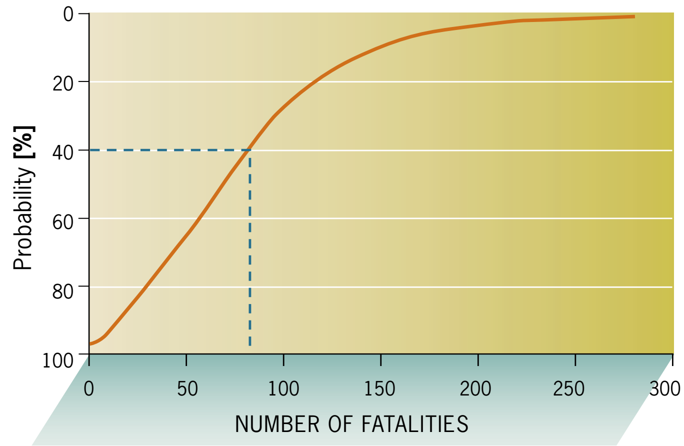


Figure 11 Probability of exceeding a number of fatalities due to high water-related levee failures over a 25-year period [2005-2030]

Source: Adapted from DRMS Risk Report [URS/JBA 2008c], Figure 13-22

Pictured above: Protecting the land side of a levee on a flooded island [Upper Jones Tract, 2004].
Source: DWR

Sandbags temporarily control a sand boil on Staten Island on June 18, 2007. The muddy water indicates that material in the levee or its foundation is being washed away. Unnoticed, sand boils can lead to a failure of the levee.
Source: DWR

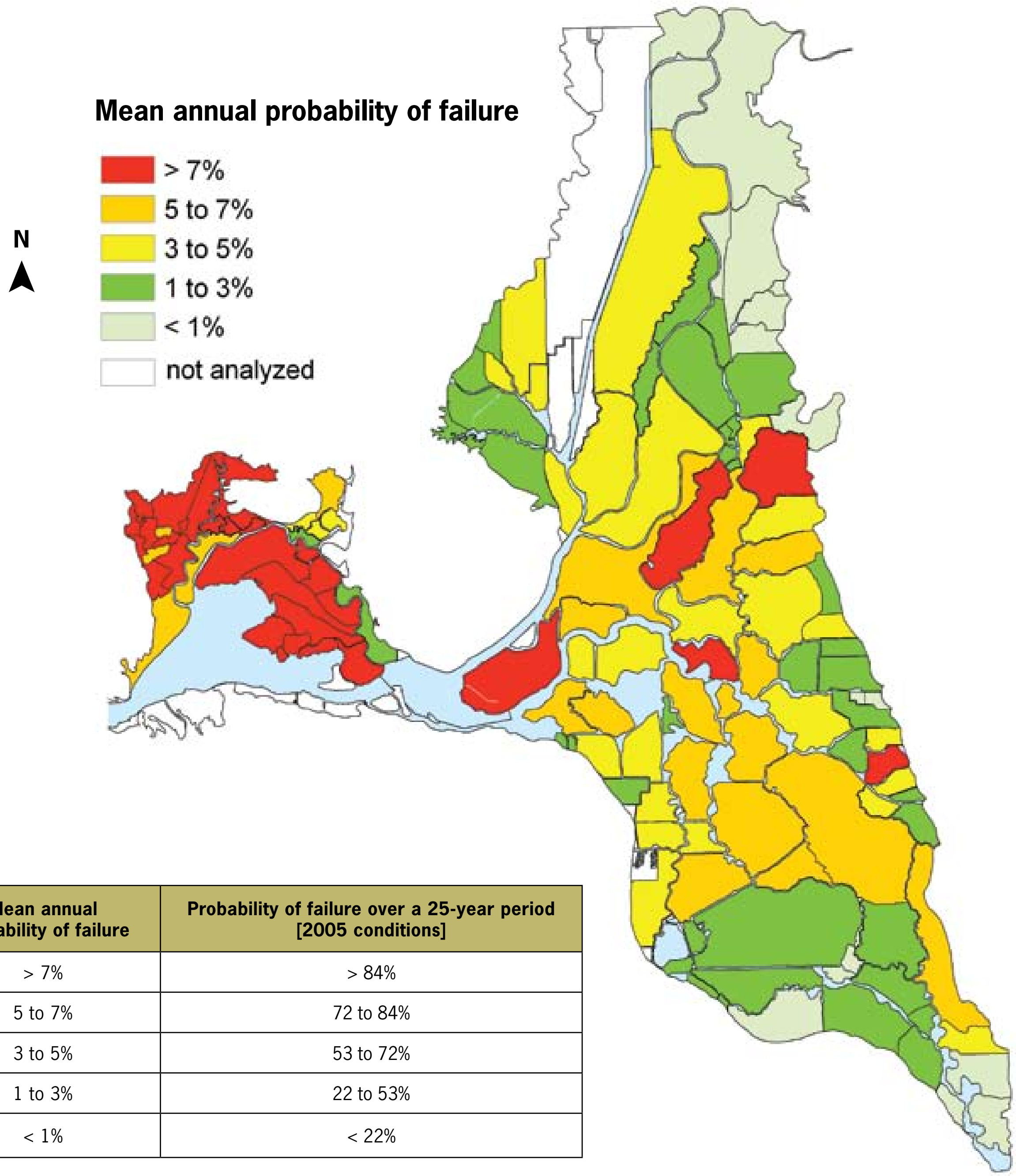
DRY-WEATHER RISKS

Dry-weather levee failures, also known as sunny-day events, occur occasionally in the Delta Region. Individual failures can be attributed to factors such as burrowing animals, pre-existing weaknesses in levees and their foundations, slow deterioration of levees over time and other circumstances. High astronomical tides can also be a factor in dry-weather levee failures. The most recent example of a dry-weather failure is the June 2004 Upper Jones Tract levee breach. The total cost of damages and island recovery efforts was well over $50 million.

Historical levee failures were used as the model to estimate the future rate of dry-weather levee failures in the Delta Region. Under business-as-usual practices, the Delta is expected to have about 10 dry-weather levee failures during a 100-year period. The Suisun Marsh is expected to have approximately four dry-weather levee failures during the same period.

COMBINED RISKS

The combined risk of an individual island being flooded due to earthquakes, high water and dry-weather events can be estimated. Considering the probability of levee failures from all hazards under business-as-usual practices, the expected annual probability of island flooding is illustrated in Figure 12. This figure shows that islands in Suisun Marsh and the western and central Delta are the most vulnerable.



Mean annual probability of failure	Probability of failure over a 25-year period [2005 conditions]
> 7%	> 84%
5 to 7%	72 to 84%
3 to 5%	53 to 72%
1 to 3%	22 to 53%
< 1%	< 22%

Figure 12 Mean annual probability of levee failure in the Delta Region from the combined risk of earthquakes, high water and dry-weather failures [2005 conditions]

Source: DRMS Risk Report [URS/JBA 2008c], Figure 13-16

NEXT STEP

Phase 2 of the DRMS Project will evaluate long-term risk-reduction options for Delta and Suisun Marsh levees. It will not propose a new plan for the Delta Region; rather, Phase 2 will describe a discrete set of actions that can be taken to reduce the risks and consequences of levee failures. Phase 2 is expected to be available for public review in 2009.

More information on the DRMS Project can be found on the DRMS Web portal, http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp, part of the California Department of Water Resources' Web site.

Pictured above: Bridge on the Sacramento River, near Courtland. Source: DWR

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