Delta Levees –
Types, Uses, and Policy Options

Prepared for

Delta Vision

Prepared by

Will B. Betchart, P.E.
Consulting Water Resources Engineer

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1. Introduction

This document was developed to support Delta Vision discussions on the role of levees in the Delta's future. It is to clarify the different types (or design standards) of levees that now exist for the Delta and what improvements could be considered. It is especially oriented toward an improved understanding of what types of levees are suitable for protecting various land uses or for other applications. Based on understanding the levee types, policy options are identified for a) selecting levee improvements to be included in the vision of the Delta's future and b) implementing the improvements selected.

2. Delta Levees Types and Uses

From a policy perspective, there are nine basic types (or design classes) of levees. When assigning levees to various land uses or infrastructure protection duties, the nine classes fit into fourteen different use categories. Three types are used in both a land use category and an infrastructure protection category and one type is used for two land uses and an infrastructure category. The levee classifications and their uses are summarized in ***Attachment A*** and described in more detail in ***Attachment B***. The following are the most important policy-level distinctions between the levee types – which are listed in order of increasing protection:

Wetlands – W-1. This is a minimal levee, oriented toward low cost of construction, opportunistic use of the land during dry periods, and management of water flows on the land. It would be used to enhance habitat values in marsh and wetland areas or for some agriculture such as pasture and a few annual crops. But the applications would recognize a high likelihood of periodic flooding. There is not a specific design standard for this type of levee, but a rule-of-thumb could be to achieve a crest elevation that is one or two feet above winter solstice high tide. However, the design criterion would vary depending on the location and specific wetlands objectives.

Agriculture – A-1 and Infrastructure – I-1 (or the HMP Standard). The Hazard Mitigation Plan (HMP) design standard was defined following the 1983 and 1986 floods as a result of negotiations among the Federal Emergency Management Agency (FEMA), the State of California (Office of Emergency Services (OES) and Department of Water Resources (DWR)), and the Delta Levee Maintaining Agencies (LMAs). The standard's development is set forth in three documents – DWR (1983), DWR, (1986) and FEMA (1987). The goal was to establish a minimal, short-term, interim standard that would lessen the likelihood of repeat damages, so that FEMA disaster assistance funds would not be requested for the same islands after every minor flood. The HMP standard was supposed to be implemented for all Delta levees by September 10, 1991 as a precondition for receiving FEMA disaster assistance if there were a levee breach (see DWR, 1990). At this point (17 years after the deadline), the HMP standard has not yet been achieved for all Delta levees, although many LMAs have complied. FEMA does deny claims for disaster assistance when any of an island's levees are not in strict compliance. The state

then becomes the source of any disaster assistance funds granted. Given this background, the A-1/I-1 or HMP standard is recognized as a very basic level of flood protection. It provides marginal protection that is hardly suitable, even for agricultural areas with annual crops or for habitat areas that are not critically important (e.g., habitats that do not include threatened or endangered species that would be wiped out by flooding). It provides essentially no protection from earthquake-caused failures. Long term, it is not an adequate standard for any land use that is intended to avoid flooding, and it was not intended to be a long-term standard by either the state or FEMA when they established it.

Agriculture – A-2, Infrastructure – I-2, and Urban – U-1 (or the PL 84-99 Standard). The PL84-99 design standard is part of the U. S. Army Corps of Engineers (Corps) Civil Emergency Management Program in response to Public Law (PL) 84-99 (see Corps, 2001a and 2001b). The standard is a minimum requirement for all federal flood control project levees (e.g., the Sacramento and San Joaquin River Flood Control Projects). However, non-project levees can become part of the Corps' PL 84-99 Program (see Corps, 2006). To do so, they must meet the design standard and pass an initial inspection. They then become eligible for Corps emergency assistance and for levee rehabilitation expenses in event of damage or a breach. Recognizing that their nation-wide federal-project standard was developed primarily for major rivers (e.g., the Mississippi) and for situations in which there is engineering analysis of foundation conditions and control of construction methods, the Corps has developed a "Delta-Specific" version of the standard (Corps, 1987) for non-federal levees in the Delta. The Delta-Specific standard makes allowances for the Delta's organic soils and foundation conditions, while still requiring an acceptable static factor of safety. A few LMAs have taken the steps necessary to become qualified under this program, although they tend to be areas that have urban, commercial, or infrastructure uses rather than just agricultural uses. The national design standard (in its basic, minimum form) is usually applied by the Corps to large areas that are protected from river flooding – areas that typically include mostly agriculture but also small towns and long, linear infrastructure such as roads and pipelines. Based on Delta studies, DWR suggests several design features that exceed the Corps' Delta-specific requirements, at modest extra cost (DWR, 1982) and would likely require them as part of a state-funded program. The design class (nationally and Delta-specific) is quite effective in providing basic flood protection at relatively low costs and is widely used. Significant upgrades to the standard would usually be included when addressing larger urban areas (see below). The A-2, I-2, or U-1 design (i.e., the PL84-99 standard) provides very little protection from earthquake-caused failures in the Delta.

Urban – U-2 (or the FEMA Flood Insurance Program Standard). Areas that are protected by levees complying with the U-2 or FEMA Flood Insurance Program (FIP) standard are eligible to be excluded from FEMA's floodplain mapping of "Special Flood Hazard Zones." If an area is not shown to be within a "Special Flood Hazard Zone" on the FEMA map, owners are not required by lenders to purchase flood insurance (see FEMA 2007a and b). Furthermore excluded parcels are not subject to real estate disclosure requirements relative to flood zones (see California Government Code Section 8589.3, 1997). Developers, land use agencies, and the public often wrongly interpret this exclusion as the absence of flooding risk. Such areas then are often fully urbanized, even

though they are likely be flooded if a flood larger than the base flood occurs or if a levee fails for some other reason. Thus, the U-2 (or FEMA FIP) levee design standard is often taken as the suitable level of flood protection for urban areas. FEMA is now conducting a program to review and reaccredit all levees that are recognized by the Flood Insurance Program. Although many miles of Delta levees, including essentially all federal project levees, were accredited by the FEMA FIP, many will have problems being reaccredited because of more stringent reviews and certification requirements relative to FEMA FIP design standards, especially for stability and seepage. The standard provides only slight protection from earthquakes. Levees of this design class may cost two or more times as much as the A-2/I-2/U-1 (PL 84-99) class levees.

Urban – U-3 (or DWR 200-Year). DWR (1982) and state law (SB 5, 2007) require modest upgrades to the U-2 (FEMA FIP) standard to provide improved flood protection at modest additional costs. These upgrades would be required in levee improvement projects that had state involvement or funding. Seismic protection is not specifically addressed. The additional costs would likely be less than a million dollars per mile.

Critical Infrastructure – I-3a (or Seismic Fail/Repair). There is no formal design standard for this levee class. It is based on the idea that some Delta levees might be susceptible to seismic failure (especially from liquefaction) but could be repaired more readily after an earthquake if they were built up with a substantial amount of extra material. The intention is that, even though the levee may fail, a residual mound of material should remain above the water line after the earthquake. This mound could then be used as a construction platform for rebuilding the levee. Even material that slumps below the water line may be salvaged for rebuilding the levee. The major cost savings in this approach would be avoiding the expensive task of treating loose sand layers in the levee's foundation. Such foundation treatment would be needed in many locations in order to prevent liquefaction, thus the cost savings are potentially quite large. Foundation treatment can be half the total cost of the much more effective seismic design classes described below. This "fail/repair" type of levee would be more effective at withstanding an earthquake than any of the types described previously. However, it would not be suitable for urban areas. In a major earthquake, levee failure could result in rapid flooding with little chance for people to evacuate. The design concept is most suitable for the levees along a "through-Delta" conveyance route where reducing the time required for repair would be advantageous. These levees would again be more expensive than the previous class, perhaps by a factor of two or more. This particular concept would need to be further developed in a "conceptual design" effort if there is interest in it.

Urban – U-4 (Delta Towns). The several towns that are located in the Delta provide a special flavor for Delta life and visits as well as the services that residents and visitors need. They are typically located relatively close to rivers or Delta waterways and often are very close to or encroach on levees. Thus, they complicate both maintenance and improvement of levees and they are key assets that need protection. The safety of these towns' inhabitants is a special concern as well as the rich heritage the towns represent. For these reasons, levees protecting Delta towns require individual designs of suitable robustness. Design concepts such as floodwalls and ring levees may be appropriate for

special circumstances such as achieving a higher level of protection for the limited town area and addressing space constraints that prevent use of a typical levee design. A higher level of flood protection may be considered and seismic protection may also be implemented. In these Delta towns, life safety, especially in case of an earthquake is a major concern because water levels tend to be at or above rooflines and the opportunity for escape may be limited.

Infrastructure – I-3b and Urban – U-5b (or Seismic No Fail/Minimum Slump). This levee class is based on a conceptual design produced by the Delta Risk Management Strategy (DRMS) to build Delta levees that can withstand a design earthquake (URS/JBA, 2007). It includes foundation improvement wherever necessary to avoid levee failure due to liquefaction. It also includes a new, engineered levee built on the improved foundation. It is expected to survive the design earthquake without failing and with no more than one foot of slumping. It would therefore be suitable for protection of urban areas or critical infrastructure from the flooding that could result from a major earthquake. Assuming the levees were also designed to meet flood protection criteria (this should not require additional expense), they would provide that protection as well. These levees would be more expensive than the previous class by a factor of two to three in areas where foundation treatment was needed.

Infrastructure I-3c and Urban – U-5c (or Seismic Super Levees). These levees are similar to the previous class but have much wider crests in order to accommodate houses and other improvements, perhaps including roads or a multi-facility infrastructure corridor. A primary example of this class is the "Delta Coves Project" on Bethel Island. If such a levee were built around the perimeter of an island (e.g., the River Islands Project on Stewart Tract), it would provide a nominal degree of flood and earthquake protection based on the design events for the low-lying areas within the island. However, these low areas would still have vulnerability in event of a larger than design-basis flood or earthquake or any other levee failure. The costs would likely be similar or higher compared with the above I-3b/U-5b class, depending on the specific situation. A critical cost consideration would include foundation conditions and whether there is a need for extensive foundation treatment to address loose sand layers that would be susceptible to liquefaction. Other important factors include height of levee, depth of peat and availability of suitable local material for levee construction.

3. Policy Options for Delta Levee Types Keyed to Land Uses and Other Purposes

A thrust of the Blue Ribbon Task Force's (BRTF's) vision regarding levees is to "…strengthen selected levees…" and "…match levee designs to land uses protected by those levees" (Delta Vision, 2007). This is already being done, but not in a comprehensive or urgent manner. The present effort suffers from a lack of State and Federal commitment, frequent expiration of legislative authorizations, erratic and low funding, and LMA constraints on their ability to fund the local cost sharing amount (25%). CalFed was expected to improve this situation by providing a "base level of protection" – i.e., to the A-2/I-2/U-1 or PL 84-99 design standard. However, CalFed has not accomplished this, primarily due to lack of funds. Recently passed bonds contain

substantial allocations of funds for Delta levee improvements and should improve this situation, provided that the funds are not diverted to other uses. Higher levels of protection (e.g., for urban areas) were to be considered later and are still an open question.

Background. The DWR Delta Levees Program provides state matching funds for local agencies to maintain and improve Delta levees and has done so (at various levels of funding) since 1973. The program evolved into its present form with various legislative changes, including Senate Bill 34 (in 1988) and Assembly Bill 360 (in 1996). The Delta Levees Program now has two parts. The Delta Levees Maintenance Subvention Program (Subvention Program), for levee maintenance and improvements, is available to all levee maintaining agencies throughout the Delta. The Delta Levees Flood Control Special Projects Program (Special Projects Program), for other less routine efforts, is available only to support work on islands with special importance. The Special Projects Program has historically been focused on the eight western Delta islands, generally thought to be most significant in causing salinity intrusion if they were to breach. With proposals for increased funding of the overall Delta Levees Program and recently passed bond funding, consideration is now being given to extending the Special Projects Program to additional territory. Recent funding of the Delta Levees Program has usually been split approximately 50/50 between the Subvention Program and the Special Projects Program, after deducting state operation costs.

The Subvention Program—the Delta-wide matching-funds program for levee maintenance and routine repair/improvement projects – is addressed below as the primary vehicle for achieving accelerated improvement of Delta levees keyed to the land uses to be protected. The funding arrangements for the Subvention Program provide for state reimbursement of up to 75 percent of the costs that a LMA incurs in excess of $1,000 per eligible mile of levees in its district. In recent years, state funding for the Subvention Program has been approximately $6 million per year. The annual participation typically includes 60 to 70 LMAs, and the amounts participants claim for reimbursement are typically twice the available funds.

DWR conducts the program jointly with the California Department of Fish and Game (CDFG), which looks out for environmental mitigation needs and enhancement opportunities. DWR, CDFG, the local districts, their consulting engineers, and other Delta stakeholders all view the program to be extremely effective in terms of cooperation and accomplishments relative to funds expended. Data from recent Delta Levees Program (Subvention and Special Projects) indicate the overall rate of Delta levee failures has decreased from one failure per year (on average) to one failure every two years.

The program has suffered from uncertainty—erratic funding and frequent expirations of key legislative authorizations. Strong sentiment exists among stakeholders to resolve this difficulty through a state legislative commitment to sustained and increased funding of the Subvention Program.

Keying Levee Standards to Land Uses and Other Applications. Based on the above discussion, it should be obvious that few Delta levees are sufficient for the land uses or other uses they are intended to protect. The Delta Levees Program has achieved some progress over the past 20 years. But most Delta levees are substandard. The vast majority of levee miles are at (or almost up to) the A-1/I-1 or HMP standard – a minimal, short-term, interim design standard that was never intended to provide adequate long-term protection, even for agriculture. Although most Delta levees are below any sensible design standard, they have been improving gradually.

With this recognition in mind, ***Attachment C*** provides a template, example, and options for "Delta Vision Policy Options Regarding Types of Levees." The following simplified approach with four fundamental levee types is a brief example:

- Wetlands (W-1) type for land uses that are expected to flood and can tolerate flooding.
- Agriculture (A-2) / Infrastructure (I-2) / Urban (U-1), that is, the PL 84-99 standard (with DWR Bulletin 192-82 agricultural upgrades) for agricultural land uses, normal infrastructure, and small community / rural population protection.
- Urban (U-3) or DWR Urban 200-Year protection standard for urban land uses on the Delta periphery (an enhanced version of U-2, the FEMA FIP standard).
- Urban (U-4) or Delta Town project-specific designs for existing communities that are to be provided increased protection.
- Include accommodations for habitat enhancements and an initial amount of expected sea level rise.

Any higher standard (e.g., seismic levees) would need to be specifically justified within a project analysis of life safety, infrastructure reliability, or economic risks compared with the project costs.

There are three potentially controversial issues to be considered in refining a land-use-based approach for specifying levee types:

- ***Should the A-2/I-2/U-1 (or PL 84-99) design standard be the "base level of protection" for all islands with agricultural or habitat needs for avoiding flooding – even the small islands?*** This question is of vital interest to Delta stakeholders, but a specific, well-justified answer from a state-interest viewpoint is uncertain and difficult. Additional detailed analyses would be needed. For water quality, as an example, we do not know how many islands could be let go nor where such islands would be located. Frank's Tract is an example of one failed island (probably in a key location) that is now receiving a great deal of study to see if it needs to be reclaimed or managed to improve the influence it has on water quality. Besides being a difficult question, the answer may not really be very important to the BRTF. The maximum money that could be saved by leaving a lower level of protection on some islands is a few tens of millions of dollars. This savings would not only provide less protection for those islands, it would give up participation of the Corps of Engineers in emergency assistance and rehabilitations of the levees for those islands.

- ***If Delta Levees are to be improved more rapidly, what relief should be provided to overcome the limited ability of agricultural LMAs to provide the local cost share?*** Presently, most Delta LMAs must provide a 25% local match for any levee project because they only receive state support through the Subventions Program. With the recent availability of funding from Propositions 84 and 1E, the limited financial capacity of LMAs serving agricultural areas has become a severe constraint. These LMAs may be forced to delay levee projects even when state funds are available. The funding may then pass to projects of lower priority in the Delta Levees Program. Such lower priority projects, that have not been funded in the past due to lack of funds, include levee improvements in urban areas that may be expected to encourage urban growth. DWR is now considering policy options for addressing this issue.
- ***If the state provides funding for improving levees in order to protect urban land uses to the U-2 (FEMA FIP) or the U-3 (DWR 200-Year) design standard, should this be linked to a specific restriction on further urbanization of the protected area?*** A strong argument can be made for restrictions. It is a very important public safety issue because earthquakes are not adequately addressed by these standards and more people would be exposed to danger. In low-lying areas below high tides, flooding will be likely after an earthquake failure and it may occur too rapidly to allow evacuation. The question is also significant in view of the large increases in property damage that will result from unrestricted urban growth when a levee eventually fails. It is also of huge financial significance to both disaster assistance agencies and to land owners. It could affect billions of dollars of future development and similar magnitudes of future flooding damages. Furthermore there are the future threats of sea level rise and increasing river floods. But most affected property owners would view development restrictions as unfair. Specific policy guidance from the BRTF is needed.

4. Delta Vision Policy Options Regarding Levee Implementation

Beyond the three policy questions identified above, there is a collection of topics for policy guidance that address crucial issues regarding implementation. ***Attachment D*** provides a listing and example options for these topics. The topics addressed include:

- Emergency preparedness, response and recovery
- Levee maintenance
- Levee improvement
- Ecosystem friendliness
- Sea level rise
- Population growth and changes of land use
- Levee exposure to wind and waves
- Legislative authorization
- Financing – Funding continuity for levee maintenance and improvements
- Financing – Cost sharing

- Financing – Coordination with the construction season
- Financing – Timely advances and progress payments

Each of these policy issues should be addressed to achieve a more effective program for maintaining and improving Delta levees within a vision for the Delta's future.

5. Near-Term Actions

The following near-term actions are offered for consideration:

- Relieve the local cost sharing constraint that prevents agricultural LMAs from using available state funds through the Delta Levees Program to initiate needed levee improvement projects. This may be a reduction of the 25% local share through expansion of the Special Projects Program, or in special cases, where State interests are paramount, the requirement for a local share might be waived.
- Extend the legislative authorization for the Delta Levees Program, which now sunsets on July 1, 2010.
- Raise the priority of regular maintenance for all levees and document the accomplishments.
- Satisfy the interim HMP design standard for all Delta levees intended to provide long-term flood protection so that they qualify for FEMA disaster assistance and, thus, the potential draw on state disaster assistance funds will be lessened.
- Qualify non-project levees for the Corps PL 84-99 Inspection and Rehabilitation Program wherever possible in order to be eligible for Corps emergency assistance and repairs. This would be done by initiating Corps preliminary inspections where non-project levees meet Corps geometry requirements. The result may be acceptance by the Corps or a finding of specific deficiencies that could then be corrected to qualify.

6. Summary

The Delta levee system is central to all Delta uses and services, and levee investment (or lack thereof) will shape the future Delta. But the current levee system is not now providing adequate protection, and the existing landscape will not be sustainable over the long run unless substantial additional investments are made. A range of levee design types and standards can be used to respond to sea level rise, river flooding, subsidence, and seismic risk. Application of the range of levee design types and standards can be keyed to the land uses and services protected, and to the levels of risk reduction deemed appropriate for each. If the BRTF's stated goal is to achieve a) congruence between levels of protection and the land uses / services at risk and b) sustainability over the long-term, this can be achieved – given sufficient time, persistence, funding, and some future adaptation.

7. References

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Delta Levee Classifications

Land Use / Levee Use	Levee Class	Description / Design Basis	Basic Cost[a,b,c] ($ Million/mile)
Wetlands	W-1	Habitat and some agricultural (pasture, rice, some annual crops) that can tolerate flooding – e.g., Suisun Marsh, Yolo Bypass Interior, Cache Slough Area, Cosumnes Floodplain	0.3
Agricultural	A-1	HMP – for FEMA Disaster Assistance if a levee fails (unit cost for Delta upgrades in typical cases not yet HMP)	0.5
	A-2	PL 84-99 – Corps Delta-specific standard to qualify for Corps Emergency Levee Assistance and Rehabilitation (for new projects, include upgrades per DWR Bulletin 192-82 agricultural design)	1.0 to 2.0 Up to 3.5 with thick peat
Infra-structure	I-1 = A-1	HMP – for FEMA Disaster Assistance if a levee fails (unit cost for Delta upgrades in typical cases not yet HMP)	0.5
	I-2 = A-2 = U-1	PL 84-99 Corps non-seismic Delta standard (flood control, navigation, highways, railroads, pipelines, electrical and gas facilities), including Bulletin 192-82	1.0 to 2.0 Up to 3.5 with thick peat
	I-3 similar to U-5	Seismic (a) -Fail/Repair – Don't treat, or minimally treat, soft foundation and existing embankment; add mass to existing embankment so it doesn't slump to a below-water-line crest elevation and a platform will remain for repairs after an earthquake. (for through- Delta conveyance.)	16 to 25 Up to 28 for thick peat
		Seismic (b) – No Fail/Minimal Slump (State Water Contractors requirement for through Delta water conveyance)	16 to 29 Up to 65 for thick peat & loose sand
		Seismic (c) – Super Levee (use for a raised infrastructure corridor) – For a corridor across deep peat and loose sand, costs are much higher.	6 to 12 with little peat & loose sand
Urban[d]	U-1 = A-2/I-2	PL 84-99 – Corps Delta specific agricultural standard (pre-urban).	1.0 to2.0
	U-2	FEMA Flood Insurance Remapping – for removal from 100-year floodplain and release from flood insurance requirement. Provides protection from 100-year water level, with 3 feet of freeboard. Anticipated to require improved stability and seepage control compared to PL 84-99 or previous FEMA FIP.	4 to 10, depending on the amount of levee raise needed and other local conditions
	U-3	DWR 200-Year – FEMA FIP plus DWR Bulletin 192-82 urban enhancements and 200-year protection per state law.	Less than 1.0 extra over U-2
	U-4	Delta Towns – Class U-3 plus design features such as floodwalls or ring levees and, potentially, seismic protection and higher levels of flood protection. May need to address deep peat or loose sand.	Widely variable based on local conditions
	U-5 (sub-class (a) does not apply)	Seismic (b) – No Fail/Minimal Slump (treat soft foundation, provide new engineered embankment as setback levee)	16 to 20
		Seismic (c) – Super levee (good foundation, engineered embankment, wide crest, houses on levee crest; Bethel Islands "Coves Project" and Stewart Tract "River Islands Project").	6 to 12 with little peat & loose sand, levee heights of 10 to 20 feet, use of local borrow

[a]The basic cost for each type of levee indicated is based on cost estimates from the DRMS "Levees Optimization Group." It includes vegetation for ecosystem values, as practical and consistent with levee function. Each can be enhanced to incorporate additional ecosystem features such as benches, tidal zones, flood plain areas, and plantings at additional costs of up to $3 million per mile.

[b]Each type of levee can be built to moderately higher crest elevation (with no loss of structural stability) to allow for future sea level rise at an additional cost of approximately $0.2 million per mile for each additional foot of height. These costs would be less for Wetlands and HMP levees and more for Delta Towns and Seismic Super Levees.

[c]Each type of levee can have a variable design (such as a floodwall) at additional cost, if necessary due to special circumstances such as limited space.

[d]It is assumed that urban levees (except for "Delta Towns") are not applicable in the Primary Zone or with deep peat.

Delta Levee Types Summary – Applications, Descriptions, and Costs (in order of increasing strength)

Land Use/ Levee Use	Levee Class	Levee Descriptive Name	Present Occur-rence (miles)	Upgrade Needed (miles)	Description/Design Basis	Application Notes	Technical Characteristics[a]	Cost per Mile (Millions of 2005 $)				
								Basic Cost[b]	Add for Ecosystem Friendly[c]			Add for One Foot of Sea Level Rise[d]
									Vegeta-tion	*Bench*	*Setback*	
Wetlands	***W-1***	***Wetlands***	Unknown, Includes most of Suisun 200+/-	New or Upgrade, Unknown	-- Economical; no design standard. -- Used for protected areas that can tolerate flooding.	-- Used for habitat and some agricultural (pasture, rice, some annual crops) – e.g., Suisun Marsh, Yolo Bypass Interior, Cache Slough Area, Cosumnes Floodplain.	Typical height is less than 8 feet. Crest width is 12 feet or less. Exterior & interior slopes, assume 2H:1V No seismic capability. Freeboard varies but levee is usually overtopped for water level with 1% annual frequency (i. e., 100-year return period or 100-year flood). Expect frequent failure.	For new levee is 0.2 to 0.3. Upgrade from existing levee would be less.	Included	N/A	N/A	0.05
Agriculture, Infra-structure	***A-1, I-1***	***Hazard Mitigation Plan (HMP)***	600+/-	In Delta = 100+/- ?Policy? ?Include Suisun Bay Edge?	-- Qualifies levee maintaining agency to receive FEMA Disaster Assistance for levee repair if a Delta levee fails. -- Based on agreement among FEMA, State, and Delta Reclamation Districts after 1983 and 1986 floods.	-- Agriculture, habitat (possibly as bay boundary or major slough levee)	16 foot crest width All-weather patrol road. Steep exterior slope (1.5H:1V) Steep interior slope (2H:1V) Marginal static stability (FS = 1.1+/-) No seismic capability Freeboard = 1.0 foot (for water level with 1% annual frequency or 100-year flood)	Upgrade from existing 0.45. New levee (Suisun) would be more.	Included	N/A	N/A	0.1
Agriculture, Infra-structure, Urban	***A-2, I-2, U-1***	***Corps Public Law 84-99 (Delta Specific)***	366 project plus 28 non-project	?Policy? Nearly all Delta except urban or seismic? 400 to 600	-- Qualifies levees for Corps of Engineers Emergency Assistance and Rehabilitation. -- For new projects, include upgrades to meet DWR Bulletin 192-82 agricultural design. -- For Infrastructure, this is a non-seismic design (flood control, navigation, highways, railroads, pipelines, electrical and gas facilities).	-- Used for agriculture (including permanent crops), low-density populations, infrastructure, and water conveyance. -- Would also meet HMP requirements. -- This is the CalFed base level of Delta protection.	16 foot crest width All-weather patrol road Exterior slope (2H:1V) Interior slope (2H:1V to 5H:1V), based on levee height and depth of peat. Static stability (FS = 1.25) Levee toe drain 30 feet landward. Essentially no seismic capability. Freeboard = 1.5 feet (for 1% annual frequency or 100-year flood).	Upgrade – For 10 ft of peat 1.3 to 1.8. For thicker peat, up to 3.5. Per MBK 0.7 to 2.0.	Included	Add: 1.0 to 2.0	Change to setback: 2.0 Add to setback: 0.5 to 1.0	0.2
Urban	***U-2***	***Urban*** (per FEMA National Flood Insurance Program)	Before FEMA remap, 110+/- After remap, 50+/-	?Policy? For Urban with existing population >1,000 = 200+/-	-- FEMA Flood Insurance Remapping qualifies protected area for removal from 100-year floodplain and release from flood insurance requirement. -- Provides protection from 100-year water level, with 3 feet of freeboard; is anticipated to require stronger embankments and less seepage than before remapping. -- New upgrades will be to 200-year protection per State law and other DWR Bulletin 192-82 urban design criteria (see U-3 below).	-- Dense to high-density urban, critical (compact) infrastructure. -- Qualifies levees for Corps emergency assistance and rehabilitation. -- Would also meet HMP requirements.	16 foot crest width. All-weather patrol road. Toe drain. Exterior Slope (2H:1V) Interior Slope (varies, stability/seepage, 3 H:1V to 5H:1V). Static stability (FS = 1.4 to 1.9). Seepage exit gradient </= 0.5. (FS and Seepage per Corps documents) Very little seismic capability. Freeboard = 3.0+ feet (for 1% annual frequency or 100-year flood).	For 10 ft peat, 9.1 For special local conditions may be 4.0 or less	Included	Add: 1.0 to 2.0	Change to setback: 2.0 Add to setback 0.5 to 1.0	0.2

Notes: [a] These are the most significant differences. [b-d]All cost estimates are from the DRMS "Levee Optimization Group."

[b] Basic cost is cost to upgrade from prevalent non-compliant type – e.g., nearly HMP to really HMP, HMP to PL 84-99, etc; assumes peat thickness of 10 feet; costs are higher for thicker peat. These costs assume barrier is a levee. If a floodwall is needed, costs go higher.

[c] Additional cost (if any) to upgrade to an ecosystem friendly configuration, including such components as landscaping soils, tidal zones, flood plain areas, and plantings.

[d] Additional cost to add one foot to levee crest elevation in anticipation of sea level rise, without decreasing static factor of safety.

Delta Levee Types Summary – Applications, Descriptions, and Costs (in order of increasing strength) (continued)

Land Use/ Levee Use	Levee Class	Levee Descriptive Name	Present Occur-rence (miles)	Upgrade Needed (miles)	Description/Design Basis	Application Notes	Technical Characteristics[a]	Cost per Mile (Millions of 2005 $)				
								Basic Cost[b]	Add for Ecosystem Friendly[c]			Add for One Foot of Sea Level Rise[d]
									Vegeta-tion	*Bench*	*Setback*	
Urban	***U-3***	***DWR 200 Year***	None	200 +/-	On top of Corps Pl 84-99 and FEMA FIP, meet all DWR Bulletin 192-82 and the state law requirement for 200 year design	Like U-2 but improved design and higher level of protection	Freeboard = 3.0+feet (for 0.5% annual frequency or 200-year flood).	Less than 1.0 more than for U-2	Included	Add 1.0 to 2.0	New set-back 2.0 Add to setback 0.5 to 1.0	0.2
Urban	***U-4***	***Delta Towns***	None	6 towns @ 3 to 5 = 20 to 30	On top of U-3 (above), consider extra flood protection and seismic design because of life safety due to deep flooding.	Like U-3 but will occur in the Primary Zone, often with deep peat and loose sand.	May require ring levees, floodwalls or other special features due to space constraints. Tend to be close to existing levee and water.	Widely variable based on situation	Included	N/A	N/A	0.2 plus more, depending on design
Infra-structure	***I-3a***	***Seismic Fail/ Repair***	None	Depends on Policy or Scenario	-- Don't treat, or minimally treat, soft foundation and existing embankment; add mass to existing embankment so it doesn't slump to a below-water-line crest elevation and one has a platform for repairs after an earthquake. (Ray Seed idea for through- Delta conveyance.)	-- This design would be used only for levees along a through-Delta water conveyance. In any other circumstance where a seismic design is indicated (urban or infrastructure), one would address the foundation at increased cost to achieve better seismic performance.	16 foot crest width All-weather patrol road; toe drain Exterior Slope (3H:1V and 5H:1V) Interior Slope (3H:1V and 10H:1V) Static stability (FS = 1.8 to 2.1) May slump up to 5 feet in design earthquake (200-year earthquake). Some breaches expected. Freeboard = 3.0+ feet (for 1% annual frequency or 100-year flood)	For 10 ft peat 21.1 For thicker peat, up to 28.1	Included	Bench is Included: Up to 2.9 additional for ecosystem features	Setback is Included: Up to 2.9 additional for ecosystem features	0.2
Urban, Infra-structure	***I-3b U-5b***	***Seismic No Fail, Minimal Slump***	None	Depends on Policy or Scenario	-- Seismically resistant design -- No fail/minimal slump. -- Treat soft foundation, provide engineered embankment. -- Water Contractors require this for through Delta water conveyance, per Dennis Majors.	-- Satisfy HMP, Corps, NFIP. -- Use for high-density urban, highly critical infrastructure, or water conveyance. -- Qualifies protected area for removal from 100-year floodplain. -- Qualifies for FEMA disaster assistance -- Qualifies for Corps emergency assistance and levee rehabilitation.	16 foot crest width All-weather patrol road; toe drain Exterior Slope (3H:1V and 5H:1V) Interior Slope (3H:1V and 10H:1V) Static stability (FS = 1.8 to 2.1) Dynamic stability (Ky = 0.15 to 0.27) Foundation and levee prepared, treated or compacted to resist liquefaction. May slump up to 1 foot in design earthquake (200-year earthquake). Freeboard = 3.0+ feet (for 1% annual frequency or 100-year flood)	For 10 ft peat 21.1 to 38.0 For thicker peat, up to 63.5.	Included	Bench is Included: Up to 3.1 additional for ecosystem features	Setback is Included: Up to 3.1 additional for ecosystem features	0.2
Urban, Infra-structure	***I-3c U-5c***	***Seismic Super Levee***	20+/-	Depends on Policy or Scenario	--Has good foundation, engineered embankment, wide crest, houses on levee. -- Stewart Tract "River Islands"& Bethel Islands "Coves" Projects. -- For Infrastructure, raised infrastructure corridor.	-- Same notes as above for Seismically Resistant. -- Used for new, high budget, urban and subdivision development.	Wide crest (as much as 200 feet). All weather road(s) on crest. Other design factors similar to seismically resistant above. Cost estimates do not cover deep peat, extensive loose sand layers, levees over 20 feet, or non-local borrow.	6 to 12 -- little peat & sand, short levee height (10 to 20 ft), use of local borrow	Included	Add: 1.0 to 2.0	Change to setback: 2.0 Add to setback 0.5 to 1.0	0.4

Notes: [a] These are the most significant differences. [b-d]All cost estimates are from the DRMS "Levee Optimization Group."

[b] Basic cost is cost to upgrade from prevalent non-compliant type – e.g., nearly HMP to really HMP, HMP to PL 84-99, etc; assumes peat thickness of 10 feet; costs are higher for thicker peat. These costs assume barrier is a levee. If a floodwall is needed, costs go higher.

[c] Additional cost (if any) to upgrade to an ecosystem friendly configuration, including such components as landscaping soils, tidal zones, flood plain areas, and plantings.

[d] Additional cost to add one foot to levee crest elevation in anticipation of sea level rise, without decreasing static factor of safety.

Delta Vision Policy Options Regarding Types of Levees

Variable Levee Standards Based on Designated Land Use / Levee Application – An overall policy must address all the different areas within the legal Delta and Suisun. For example:

- W-1 – Wetland Class levees for habitat areas where species can tolerate periodic (relatively frequent) flooding such as Suisun Marsh, inside the Yolo Bypass, Cache Slough and for some agriculture that can also tolerate flooding such as pasture and some annual crop areas.
- A-1/I-1 – Hazard Mitigation Plan (HMP) levees for small islands with only habitat or agriculture and little impact on Delta salinity if flooded. This levee standard was established in negotiations with FEMA as a very basic, interim standard to lessen damages from future floods and as a requirement in order to qualify for future FEMA disaster assistance. It is not suitable for areas with listed species that are adversely impacted by flooding or for permanent crops. Any area that is to be protected from flooding in the longer term will need to achieve a higher standard.
- A-2/I-2/U-1 – PL 84-99 levees for the rest of the Delta islands or tracts foreseen for the long term as land dedicated to agriculture (including permanent crops that are intolerant to flooding or salinity), habitat (e.g., listed species), year-2000 population less than some population threshold (several hundred or one to two thousand), and non-critical infrastructure.
- U-3 – DWR 200-Year Urban levees (also satisfying FEMA Flood Insurance Program requirements) for Delta periphery islands or tracts with year 2000 population equal to or greater than the above population threshold and with infrastructure if economically justified.
- U-4 –Delta Town levees as needed to ensure an adequate degree of life and property protection, potentially at a higher level than the periphery urban areas because of the severe hazard of deep flooding.
- I-3b/U-5b – Seismic no fail/minimal slump levees only if warranted by life-safety concerns (time for evacuation) or by economic analysis of the risks associated with urban, critical infrastructure, and/or water conveyance damages.

Variations on the above policy would match lower or higher Delta Levee Classifications with specific land uses or levee applications – For example:

- Within the W-1 class (or as a second W class) it might be reasonable to have a higher design standard that upgrades high-exposure levees in habitat areas (e.g., Suisun) – that is, to have more robust levees in areas that are exposed to wind and waves from Suisun Bay or that border major sloughs.
- Upgrade A-1/I-1 (HMP) levees (per above) that are identified in the CDEW Plan for long term maintenance as agricultural land or terrestrial habitat to A-2/I-2/U-1 (PL 84-99). Note that the present CalFed policy, per the Record of Decision, is to upgrade all levees, but there has been inadequate funding during the initial phase of CalFed. Upgrading all levees to A-2/I-2/U-1 (PL 84-99) is a preferred policy component by the Delta

Reclamation Districts (LMAs) and other Delta stakeholders, recognizing that the A-1/I-1 (HMP) standard was defined as a basic, interim step on the way to levees that provide a more adequate level of flood protection for the longer term.

- Make the urban population threshold a smaller number so that less dense urban areas are protected by the U-3 class (DWR 200-Year Urban Levees).
- Implement I-3b/U5b class (seismic-no fail/minimal slump) levees for all urban areas with year 2000 population equal to or greater than some higher threshold. This would provide maximum protection for existing urban areas such as the Sacramento Pocket Area and perhaps parts of Stockton.
- Implement the I-3a class (seismic-fail/repair) for a through-Delta water conveyance route (e.g., an "Armored Pathway" or the Delta channel part of "Dual Conveyance"). This would be oriented toward a more rapid recovery of through-Delta conveyance after a major earthquake.

Any complete policy on application of various levee types would need to match a levee design class to each Delta-Suisun island, tract or analysis area or portions thereof. It would need to be developed to conform to an overall long-term plan for land use, ecosystem, water quality and conveyance.

Delta Vision Policy Options Regarding Levee Implementation

To implement the selected future levels of protection chosen for various Delta/Suisun land uses, the following policy topics are recommended for consideration. Tentative policy statements are set forth, recognizing that they should be amended or refined to better reflect the intentions of the Delta Vision implementation strategy.

1. **Emergency Preparedness, Response, and Recovery –** One of the Delta-Vision-recommended near-term actions is "State Government should embark upon a comprehensive series of emergency management and preparation actions …" (Delta Vision, 2007). Relative to levees, the following is a specific policy for implementation:

   - The potential for a Delta levee breach event should receive attention every year with a) funding, b) review of material inventories and augmentation as prudent, c) review of equipment and personnel availability and training, d) supplemental training and scenario practices -- including specific procedures and practice with levee patrols, communications/reporting, and standard (automatic) response procedures, and e) review and practice application of criteria for response prioritization and other response protocols.
   - Emergency response exercises should be sufficiently realistic to identify potential delays, bottlenecks and gaps in preparation, and needed improvements should be documented and implemented immediately (within 60 days).
   - Delta/Suisun levees specified in the CDEW Plan for services other than wetlands management should meet the minimum standards to be eligible for reimbursement for flood fight and damage repairs under the FEMA disaster assistance program. To be eligible, they must be upgraded to and maintained in continuous compliance with at least the A-1/I-1 (HMP) design standard.
   - Delta/Suisun levees improved and maintained to a higher standard than the A-1/I-1 (HMP) standard (i.e., at least to the A-2/I-2/U-1 or PL84-99 standard) should qualify for and be accepted in the Corps PL84-99 Rehabilitation and Inspection Program and thereby be eligible for Corps assistance in responding to and recovering from levee damage or breach events.
   - Delta levees that are a) in congruence with the CDEW Plan and b) are damaged or breached should be repaired.

2. **Levee Maintenance –** Levee maintenance is a vital annual obligation for the state and each Levee Maintaining Agency (LMA) in order to detect and correct problems that could compromise presently implemented levee design standards. Levee maintenance should:

   - Have precedence for state funding over levee improvements or special projects on a Delta-wide basis.
   - Occur regularly within the jurisdiction of each LMA.
   - Be proposed by each LMA and reviewed by the state annually before the beginning of each construction season and any shortcoming (especially for compliance with HMP

or PL84-99 requirements) should be corrected during the same construction season as a condition for receipt of state funds.

- Any LMA that is unable to keep up with maintenance needs (as determined by state review) should be automatically submitted to the Central Valley Flood Protection Board for development and implementation of a joint state/LMA remediation plan, including potential consideration of LMA financial hardship and special state funding.
- Local cost sharing requirements for maintenance (percentage cost coverage above the deductible by the local agency) should be set at an amount, not greater than 25%, but consistent with the local portion of the overall benefits that result from the levees and the local land owners' overall ability to pay.
- Hardship funding should be available from the state to cover the local share for maintenance, if hardship has been confirmed in a review by the Central Valley Flood Protection Board.
- A lien should be attached to all the protected land to ensure eventual recovery (with 3% annual interest) of the funds thus advanced for hardship.

3. **Levee Improvement –** Levee improvements conforming to the BRTF Delta Vision and Implementation Strategy (see policy regarding "Types of Levees") are vital to achieving the vision and goals for ecosystem viability, water supply reliability and Delta as place. Accordingly, the following policies are recommended:

   - Levee improvements required to satisfy the adopted policy regarding "Types of Levees" should have at least equal priority with any other Delta-area projects addressing water supply or ecosystem needs.
   - Levee improvement projects should be scheduled to occur on manageable year-to-year basis with stable and predictable state funding levels so that LMAs are able to plan and fund their participation on a pay as you go basis (i.e., without obligating themselves to more than three years of debt and associated interest payments).

4. **Ecosystem Friendliness –** Given recognition of ecosystem values as a fundamental goal in the future of the Delta, ecosystem friendliness should be incorporated in all future levee projects according a policy such as the options articulated below:

   Option A – Continue the present policy of requiring mitigation and enhancement as part of each Delta levee project under the criteria now applied by California Department of Fish and Game within the Delta Levees Program.

   Option B – Continue the present policy, but facilitate mitigation and enhancement through programmatic actions designed to provide equivalent or superior ecosystem value for the Delta as a whole.

   Option C – Continue the present policy (Option A or B) plus encourage and sponsor extra enhancement by including a water-side habitat bench wherever reasonable (as was provided on a recent Twitchell Island project).

5. **Sea Level Rise –** The amount of long-term sea level rise is uncertain. In the near to intermediate term (10 to 30 years), a period of observation and assessment is anticipated.

Based on this expectation, a transition policy which states that Delta levees are to accommodate a limited amount of sea level rise seems advisable:

Option A – Include an extra six inches of levee crest elevation in levee improvement projects. This should provide for 10 to 65 years of sea level rise accommodation from 2005 (per DRMS high and low estimates of rates).

Option B – Include an extra twelve inches of levee crest elevation in levee improvement projects. This should provide for 30 to 150 years of sea level rise accommodation (per DRMS high and low estimates of rates).

Option C – Include an extra eighteen inches of levee crest elevation in levee improvement projects. This should provide for 48 to 185 years of sea level rise accommodation (per DRMS high and low estimates of rates).

6. **Population Growth and Changes of Land Use –** Levee capabilities interact with population growth and land use decisions in direct and important ways. The BRTF stated "Housing development should be discouraged in flood-prone areas, including areas below sea level and in deep flood plains" (Delta Vision, 2007). An approach for levee improvements relative to urbanizing areas is that any Delta levee project that includes levee maintenance or improvement funding from the state and includes any design feature beyond the A-2/I-2/U-1 or PL 84-99 criteria, will require local agency agreement to prohibit densification of urban activities in the protected area.

7. **Exposure to Wind and Waves (Southwest Exposure and/or Long Fetch) –** Some sections of levees have particularly severe exposures to wind and resulting waves. It is reasonable to supplement normal design criteria for freeboard and erosion protection to address such exposures according to the policy articulated below:

   Option A – As justified by engineering calculations for a 0.04 annual frequency event (i.e., a once in twenty-five year event)

   Option B – As justified by engineering calculations for a 0.02 annual frequency event (i.e., a once in fifty year event)

   Option C – Add environmentally friendly areas on the water side of the levee (or set back the levee) where feasible to dissipate wave energy.

8. **Legislative Authorization –** The Delta Levees Program has suffered from uncertainty due to frequent expiration of key legislative authorizations. Since adequate maintenance and improvement of Delta levees is essential to meet Delta Vision goals for ecosystem, water supply and Delta as place, the legislative authorization for the Delta Levees Program should be extended through June 30, 2020.

9. **Financing (Funding Continuity for Levee Maintenance and Improvements) –** Funding for levee maintenance and improvement has been inadequate and uncertain during CalFed's first seven years, but may now have improved with:

   - State Bond Funding for Delta levees by Propositions 84 ($275 million) and 1E (estimated to be $500 million)

- Expected initiation of the Corps of Engineers "Levee Stability Program"

Funding is likely to again become unreliable if other needs are allowed to divert bond funding intended for Delta levees or when bond funding expires. Policy would be improved by secure funding for continuing levee maintenance and needed improvements through the following actions:

- The intended allocations of Proposition 84 and 1E funds to Delta levees should be protected and maintained.
- State annual funding for Delta levees should be maintained in the amount of at least $50 million per year after existing bond funds expire and at a higher level if remaining needed improvements so justify.

10. **Financing (Cost Sharing) –** Local cost sharing under the present formula (25% of state recognized costs) is a severe constraint on the capacity of some LMAs to implement levee improvements. Delta levee improvement projects for achieving levee design standards in accord with the "Types of Levees" Policy for various land uses should have a local cost sharing requirement of:

    Option A – 10% of state recognized costs with no deductible (assuming that maintenance is already covered with the required deductible).

    Option B – Not more than 50% based on a) the designated land use or facilities being protected and b) the ability-to-pay of the protected entities.

11. **Financing (Coordination with Construction Season) –** Presently, the state budget for a July through June fiscal year is often not approved until September and the Delta levees maintenance and improvement programs (Subventions and Special Projects) are usually approved by the Central Valley Flood Protection Board in October. However, waterside construction on Delta levees must terminate for the season on October 31. There is usually less than one month to mobilize and perform projects. Most projects are delayed until the next construction season and only about two months (May and June) remain before the end of the fiscal year. This creates major problems in managing an effective, efficient program. Each year's Delta levees appropriation should be available for obligation during not only the year of appropriation, but also during the subsequent fiscal year.

12. **Financing (Timely Advances and Progress Payments) –** Improved procedures for advances and progress payments (once a local agency's project has been approved) would mean less interest cost to the LMA and more money available for maintenance and improvement of levees. The levees program administrators (DWR and Fish and Game) should conduct all needed reviews before project initiations so that only minimal reviews are required for dispersal of advances and progress payments and that only a nominal amount of state funds (5%) will be retained until final closeout.