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5.1 INTRODUCTION

5.1.1 Background

The California Department of Water Resources (DWR) Division of Flood Management is the focal point for DWR's response to flood emergencies and management of flood-fighting efforts in the context of the state's Standardized Emergency Response System. Although several offices and branches have responsibilities and contribute to DWR's overall flood management efforts, the most visible in an actual emergency is the state-federal Flood Operations Center (FOC). This office manages DWR's on-the-ground efforts during an emergency. The FOC is activated in anticipation of or in response to a flood event and is operated 24 hours per day until the emergency passes or is stabilized.

The FOC has extensive experience with rainfall-caused river floods and associated levee-focused flood fights along the state's major rivers. The FOC also has addressed high-tide- and storm-caused wind-wave threats to levees in the Sacramento–San Joaquin River Delta (Delta) and emergencies involving Delta levee breaches (e.g., Jones Tract).

The state is fortunate in that it has not yet experienced a large-scale flood or earthquake emergency in the Delta. However, the Division of Flood Management recognizes the potential for this type of emergency to occur in the Delta and has several initiatives under way that focus on preparations for this emergency and responses for when it occurs.

5.1.1.1 Emergency Operations Plan

DWR has developed an Interim Emergency Operations Plan for major Delta emergencies. This effort is documented in the "Delta Emergency Operations Plan Concept Paper" (DWR 2007a). As a follow-on, DWR has initiated a collaborative effort with partners and stakeholders to develop a formal Emergency Operation Plan (EOP), which will be a vehicle for considering needs and actions to enhance emergency preparedness and response for major Delta levee breach events.

5.1.1.2 Pre-Event Preparation Emergency Materials Inventory

DWR has developed and maintains four material caches of tools and supplies for use in Delta flood fights. These inventory items include sand bags, Visqueen, stakes, twine, tools (e.g., shovels, hammers, chain saws) and other incidental items. The inventory list is presently being expanded to include rock, sand, and other materials. DWR is actively considering several different material and response expediting strategies in anticipation of the state providing a sizable capital investment to facilitate reaction to a major Delta levee incident.

The Metropolitan Water District of Southern California (MWD) has made available the results of analyses it has performed with respect to responding to levee failure emergencies. MWD's analyses indicate that resumption of water exports may be facilitated by placement of structural barriers at selected channel locations and strategic levee repairs to isolate an emergency freshwater conveyance "pathway" through channels that may be surrounded by islands flooded with saline water (Moffatt and Nichol 2007). The specific pathway they address uses the Delta

Cross Channel, the Lower Mokelumne River, the San Joaquin River, Middle River, and the Victoria Canal.

5.1.2 Purpose and Scope of Building Block

The purpose of Building Block 1.3, Enhanced Emergency Preparedness/Response" is to identify potentially useful planning, organizational, or action items that may facilitate a better-organized, more-efficient, or more-effective DWR response to a major levee breach incident in the Delta and thereby reduce the consequences of levee failures. The scope of the response only addresses levees and water quality within DWR's emergency response purview, as defined by the structure of the Standardized Emergency Response System. The scope includes working effectively with other agencies that have overlapping or joint responsibilities on these topics (e.g., the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation). This building block addresses both plans for and the organization of emergency management and the emergency preparation measures. Many other dimensions of emergency response are not addressed in this building block (e.g., evacuation, rescue, public health and safety, law enforcement, transportation closures and detours, emergency shelters, logistics for care and feeding of emergency workers, financial assistance for impacted parties).

5.1.3 Objective and Approach

This building block would involve a continuing commitment on the part of the state (the Legislature and DWR) to enhanced emergency preparedness and response for a Delta levee emergency. Two options for the initial level of commitment are identified: capital expenditures of $50 million and $100 million. Although major material stockpiles (such as rock) are highlighted as the relevant inventory items that are to be addressed, DWR is presently considering—and the Delta Risk Management Strategy (DRMS) Phase 2 analysis also considers—a broad collection of potentially useful transfer facilities, pre-positioned material, and other emergency response preparations. In all cases, the objectives of the preparations are to increase the effectiveness of and reduce the times required for response and through these improvements to reduce the adverse consequences that may result from a Delta levee breach.

When emergency preparedness and response capabilities are enhanced, an annual cost will be associated with the enhancements to maintain and manage inventories and maintain organizational and personnel readiness to respond. These annual expenditures will require continuing legislative commitment and annual appropriations. For the DRMS Phase 2 analysis, we assume annual budgets of $2 million and $3 million, respectively, for the two alternative levels of capital investment.

Figure 5-1 provides an overview of Building Block 1.3, Enhanced Emergency Preparedness/Response. Of note in this overview is the distinction between the enhancements that are considered to be reasonable short-term achievements (within 1 to 2 years) and those that may be more appropriately accomplished in the intermediate term (2 to 5 years). Some of the emergency response enhancements require time to perform strategic analyses, achieve consensus, define details, and negotiate agreements or procure permits needed to deliver desired results.

5.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

5.2.1 Analysis Criteria and Basis of Design

The DRMS risk analysis model is one focal point for considering emergency preparedness and response enhancements. Another focal point is the approach that DWR presently uses for addressing a levee breach emergency. In both cases, the actions considered are oriented to more explicit identification of functional responsibilities and responsible parties and provision of needed tools, materials, and capabilities for expedited, effective response.

5.2.2 Analysis Results

The recent reviews of DWR's present Delta emergency preparedness and response program, as documented in "Delta Emergency Operations Plan Concept Paper" (DWR 2007a) and MWD's analysis (Moffatt and Nichol 2007), identified the following activities to enhance emergency preparedness and response:

- Prepare and adopt a robust Delta levee breach Emergency Operation Plan (now under way).
- Formalize emergency management procedures, tools, training and exercises (e.g., availability and use of models, such as the DRMS Emergency Response and Repair [ER&R] model and Water Analysis Module) for analyzing and developing response strategies for levee repair and salinity recovery in the context of a levee breach incident.
- Establish additional "standard emergency operating procedures" and train field personnel on implementing these procedures during flood fights, levee repair, pumping plant operations, and gate/barrier operations.
- Implement minor improvements to facilities (e.g., auxiliary power for gate operation).
- Establish one or more priority systems for repairs and define their respective applicabilities (e.g., stabilize unflooded islands, stabilize seepage, partially close breaches to prevent tidal mixing, establish priority criteria for deciding which island gets attention next).
- Select sites and develop standard designs for emergency barriers for salinity management and Delta flushing (e.g., as identified in DWR [1986]). Purchase and store prefabricated barriers or barrier materials (intermediate-term activity, see below).
- Develop standard designs and construction plans for levee breach closures.
- Identify and establish additional strategically located sites in or near the Delta to act as both (1) storage sites for pre-positioned materials and (2) transshipment facilities, including barge mooring and loading facilities and reliable road access for the transfer of rock and other materials from land-based sources to barges for deployment to damaged levee sites. Ideally, storage sites for bulky materials like rock would be collocated with transshipment facilities, and the sites and road and barge access routes would not be vulnerable to flood or earthquake disruption. DWR purchase of these sites or facilities would be desirable (intermediate-term activity, see below).
- Purchase emergency repair materials for stockpiling at strategic sites (intermediate-term activity, see below).

- Inventory existing rock suppliers to determine their ability to produce rock materials of the types necessary for emergency levee repairs, material qualities, material reserves, and production capacity. The database with the results of this inventory will enable the state to develop advanced planning for emergency response
- Consider advance arrangements for critical marine construction resources, including advance drafting of contracts, plans and specifications, pre-qualification of contractors, and (perhaps) advance, contingency-based contracting, while ensuring that such arrangements and potential contracts do not limit the state's ability to select other contractors. Opinions vary on the desirability of actually executing contracts in advance. The state has authority to issue emergency contracts quickly. However, a contractor's ability to respond may vary based on his active contracts, equipment deployment at the time of the emergency, and the specifics of the emergency. Thus, draft contracts, plans, and specifications, even including discussions with and pre-qualification of contractors, may be more effective than executed contracts.
- Consider establishment of contingency funding (including contingent legislative appropriations) sufficient to support emergency operations for 60 to 90 days. Contingency funding is a more significant problem than emergency contracting because state agencies do not have funding available for such contracts and are forced to fund such contracts out of their existing budgets. For a major event, agency budgets are usually not adequate for all needed operations, and they are not adequate for the durations needed.
- Consider purchase of, or other arrangements for, critical equipment (intermediate-term activity, see below).
- Consider acquiring emergency flushing water, especially on eastern Delta and San Joaquin River tributaries (intermediate-term activity, see below).
- Consider designation of one or more specific emergency freshwater conveyance routes to the south Delta export pumps and associated prefabrication and deployment of needed channel barriers (e.g., MWD's suggested "South Delta Freshwater Pathway" or "straw" [MWD 2007]) with associated barriers) (intermediate-term activity, see below).

Many of the above activities are planning or engineering tasks that simply need to be budgeted, assigned, and executed. They can be accomplished in the near term and most will not require large commitments of funds.

The few items that may require larger commitments of funds for implementation are establishment of supplemental marine transfer/loading facilities, additional sites for and expansion of material stockpiles, purchase or other arrangements for critical equipment, pre-fabrication and pre-deployment of barriers, and acquisition of emergency flushing water. These activities are addressed in more detail in Section 5.2.3. Some progress can be achieved in the near term, but several items require more detailed design, analysis, strategic evaluation, agreement negotiations, or permits or regulatory approvals. Those items should be regarded as enhancements to be achieved in the intermediate term (2 to 5 years).

5.2.3 Description of Improvements

Major capital items that could occur for enhancement of emergency response are discussed in the following paragraphs.

5.2.3.1 Establishment of Supplemental Marine Transfer/Loading Facilities

Strategic locations around the Delta are being considered (in conjunction with stockpile locations) for barge loading facilities. Marine transfer/loading and stockpile facilities would serve two primary purposes in large-scale emergency conditions: (1) they should enhance initial response (approximately the first month or two after an event), and (2) they should act as a contingency against a prolonged outage or inaccessibility of the San Rafael Rock Quarry (SRRQ).

Potential loading and storage sites under consideration include Rio Vista, Stockton, Sacramento, Hood, Brannan Island State Park, and Clifton Court Forebay. The locations of these potential sites are shown on Figure 5-2.

Facilities at Hood, Brannan Island, and near Clifton Court are attractive because the state currently owns property or has existing material stockpiling agreements at these locations. These sites also generally have good water access and good proximity to much of the Delta. In particular, the Brannan Island site is attractive due to land elevations that are generally 20 feet above sea level.

The vulnerability of these three sites and their access roads to liquefaction and flooding-related damage and potential inaccessibility due to seismic or flood events should be a prime consideration during site evaluation. Sites that are flooded during or after an emergency event have no use or indefinitely delayed use, and sites without road access would have very limited benefit. The vulnerabilities of sites at Hood, Brannan Island, and Clifton Court need to be carefully considered. They are on islands and/or are accessible by roads that are susceptible to flooding and damage.

Sites in Rio Vista, Stockton, and Sacramento are more favorable on initial evaluation, because these locations are believed to be less vulnerable to seismic or flood damage or access restriction. Rio Vista is outside the region of highest vulnerability for the west Delta islands, and it has reliable access via State Route 12 to two nearby quarries (SRRQ and Lake Hermann in Vallejo). Stockton and Sacramento are similar in that they have good access to quarries in the Sierra Nevada foothills, and they are in locations of relatively low seismic vulnerability. A site near Sacramento may also provide direct benefits to annual flood-fighting efforts in the Delta and north of Sacramento.

Loading/transshipment facility costs have been estimated (Moffatt and Nichol 2007) based on general facility requirements. These requirements include barge access and moorage (fender system for mooring during loading/unloading), a material-loading system that uses conveyor(s), security and access controls, sufficient land area to store rock and other materials, and general site and other improvements such as roads and office/maintenance buildings. General facility costs could vary widely depending on the size and location of the site.

For an initial example, Moffatt and Nichol assumed no significant levee or foundation improvement exists, storage of 400,000 tons of rock, and sheet pile quantities required for roughly four levee breach closures. The required facility footprint is estimated to be 18 acres, including small maintenance/office buildings and roads for material delivery vehicles (Moffat and Nichol 2007). Total cost for this facility was estimated to be $4 million. Two facilities of half this size may cost about $2.6 million each. Such facilities should be sized and designed to accommodate immediate material purchases and to provide room for other material that may be

identified for storage in the intermediate term. DWR ownership of the sites is desirable to avoid the difficulty of lease renegotiations with material already on-site. Seismic and inundation design criteria for the various facilities and functions at the site should be specifically defined.

5.2.3.2 Increased Stockpiles of Emergency Materials

DWR is considering acquisition and stockpiling of materials (including additional inventories of flood-fighting materials, rock, sand, sheet piles, and geo-tubes). In general, stockpiles should be located at marine transfer/loading facilities (see Section 5.2.3.1). Such facilities should have both secure road access for stockpile recharge and secure barge-loading capability to facilitate water transport of materials to the places where they are needed. “Secure” means little possibility of earthquake or flood disruption. This action would necessarily involve managing inventories, including potential use of warehouses with climate control, as necessary to prevent degradation of some materials, and maintenance of pre-positioned sand, rock, and other material quantities, as needed for specific anticipated responses.

The amount of stockpiled material must be justified based on estimates of the amounts that may be needed and potential delays in receiving newly ordered materials under emergency conditions. DWR staff is considering the options regarding the materials and amounts to stockpile. Specific possibilities are described below:

- Flood-Fighting Materials. To address a major Delta levee incident, inventories of flood-fighting materials will need to be increased, and controlled-atmosphere storage is being considered for degradable items. Additional storage sites beyond those that currently exist will likely be identified and will logically be collocated with bulk material stockpiles and transshipment facilities.
- Rock Stockpiles. The rock stored in stockpiles would be of the type anticipated for use in levee repairs and breach closures, if it were procured in the context of an actual emergency. If the stockpile site is near potential sites for channel barriers, gradations for that purpose should also be considered. The primary reason for considering the stockpiling of rock materials within or near the Delta is to enhance the emergency response capacity in a major incident while the SRRQ ramps up production. The SRRQ is uniquely positioned as the only Bay Area/central California quarry that has capability to load directly onto barges. SRRQ production/supply rates for the early phases of the response, as supplemented by other (more remote) marine sources in later phases, are shown on Figure 5-3. These rates for the availability of marine-based rock are listed in Table 5-1.

  Production of rock is expected to increase over time as SRRQ commences work, increases to current maximum production, increases further as additional equipment and facilities are brought online, and as other (out of the region) marine sources supplement local production rates. Variation is also expected during any given production period; this variation is represented by the low, expected, and high production rate categories listed in Table 5-1.

  Consideration of stockpile sizes and locations should also include potential contributions from land-based quarries. Nearly 20 land-based sources of rock are in northern and central California (roughly within and between Tehama and Tuolumne counties) produce material suitable for levee repairs. Differences between maximum placement rates and SRRQ production rates could be offset by production from these facilities. Estimated production

rates and stockpile quantities from all these land-based quarries are 15,000 to 25,000 tons per day and 150,000 to 180,000 tons, respectively.

Because these land-based quarries offer an alternative to large stockpiles of rock on sites in or near the Delta, drawing on these quarries for stockpile recharge is an important strategy for emergency response. This approach would reduce the size of the stockpiles needed, provided that good road access and a reasonable response time for deliveries from the quarries can be anticipated.

Because of likely complications in increasing quarry production rates, the total available rock supply rate (from both marine- and land-based sources) could be less than the ability of equipment to use rock for levee repairs during the first month of repairs. This shortage of rock could be in the range of 5,000 to 15,000 tons per day. If this deficit were to occur, rock availability deficits could range from 150,000 tons to 450,000 tons. Thus, a total stockpile quantity in this range could be useful. Assuming access routes remain open for transport, land-based quarry stockpiles could likely cover a portion of the deficit. Still, a prudent quantity to retain in stockpiles in or near the Delta may be in the range of 100,000 to 300,000 tons.

Although more detailed analyses should be conducted, the rock stockpile sites that DWR may target for activation would likely consist of 50,000 to 100,000 tons each. This target range should be reviewed based on updated information on potential production and placement rates and DWR decisions on the number and locations of the stockpiles.

If the SRRQ and many land-based quarries were unavailable or inaccessible, stockpiles of any practical size would be inadequate to maintain anticipated placement rates for long and could not supply a significant portion of the overall rock requirements in response to a major levee breach event. For reference, the DRMS Phase 1 ER&R model analyses estimate that total rock repairs could range from 16 million tons (scenario involving 3 flooded islands) to 58 million tons (scenario involving 20 flooded islands).

An important basis for stockpiling rock and having transshipment facilities is to offset the risk that the SRRQ (the marine source) is damaged by the same earthquake or flood and is unable to produce or ship rock for some period after an event. This possibility reinforces consideration of stockpile locations that allow for re-charging the stockpile from land-based sources after the event. Each potential site would require a careful assessment of its susceptibility to seismic or flood-induced damage and an assessment of the potential damage to the transportation corridors to the site that may inhibit re-supply.

For the portion of the rock actually stored in or near the Delta, rock delivered to Delta stockpiles costs about $40 per ton. Use of $5 million for initial rock purchase would provide about 125,000 tons of rock. Assuming that early quarry production/delivery rates lag placement by 10,000 tons per day (during the first couple weeks of an emergency), this stockpile amount would suffice to keep placement crews essentially at capacity for 2 weeks. A second phase of rock purchase for stockpiling might double this quantity. Provided suitable long-term stockpiling and transshipping sites can be chosen and secured, initial stockpiling should be possible in the near term.

- Sheet Pile Stockpiles. Sheet pile serves as a non-competing alternative to rock construction. Sheet pile can be used in the following emergency repair applications:

- Seepage Control. The present common use of sheet pile in the Delta is for cutting off seepage underneath or through a levee to prevent piping and eventual levee failure. Instances of seepage onto unbreached islands may increase in a major flood or earthquake. Thus, a supply of sheet pile of the normal shapes and lengths used for seepage control could serve an important need and prevent additional island failures.
- Repair of Damaged Levees. In a major incident, especially in an earthquake, extensive non-breach levee damage is expected, both on islands that do not flood immediately and on islands that are flooded due to breaches elsewhere. Sheet piles could be considered (subject to careful design) as part of expedited response to some of this damage.
- Channel Barriers. It may be feasible to use a combined sheet pile wall system to act as a channel barrier to control flow or limit saltwater mixing. To date, specific analyses have not considered this application, though analyses have considered sheet pile use in breach closures, as described below. The design concept would be similar to and may be less challenging than breach closures because channel depths are likely to be less than breach scour depths. However, if prefabricated barriers are developed (see below), sheet pile used for channel barriers may only be an interim option pending design and implementation of the prefabricated barriers.
- Breach Closure. Breach closures using sheet piles require large king pile combination wall systems (king piles such as H-beams or large-diameter pipe piles combined with intermediate sheet pile panels). Examples of combination wall systems are shown in Appendix 5A (as developed for MWD by Moffatt and Nichol [2007]). Large section combination wall systems are required to support expected head differentials (3 to 4 feet) with potentially deep scour holes at breach locations.

  Estimated total construction cost for a large section combination wall system is about $22,000 per linear foot of breach (about $6.6 million for a 300-foot breach). The pre-purchased material portion of this cost is about 95 percent of the total cost because the large-section wall members are very costly.

  In the absence of stockpiled material, procurement times for the large combination wall shapes could exceed 3 months. Procurement cannot be expedited because the large king pile shapes are made per order and are not stocked. Thus, advance material procurement would significantly reduce construction schedules. Aside from material lead times, the estimated construction rate is about 10 to 15 linear feet of breach repair per day on average. This rate includes crew and equipment mobilization and barge transit times (to retrieve stockpiled sheet piles from a storage site in the Delta and delivery to the breach site).

The consulting team regards the pre-purchase and stockpiling of combination sheet pile wall systems for channel or breach closures to be a specialized application of a unique and costly material that needs careful evaluation by DWR. It is therefore suggested that this material and application be considered for the intermediate term as a potential supplement to initial stockpile purchases. Initially, the stockpiling of normal shapes and lengths of sheet pile that can be used for seepage control and expedited temporary repair of slumped levees should provide a versatile and useful form of emergency preparation.

- Geo-tube Material Stockpile. Moffatt and Nichol (2007) has suggested that geo-tubes filled with sand could be useful as an expeditious water barrier on a long stretch of slumped levee to prevent tidal mixing between a salty flooded island and an adjacent freshwater channel. Current consideration of geo-tube construction methods has been limited to levee extents along the freshwater pathway channels. Estimates suggest that a total of about 5 miles of pathway levees could experience significant slumping of as much as 6 feet. Total construction costs for geo-tube repairs equate to about $700 per linear foot of damaged levee, including levee preparation or other means of stabilizing the tube during filling. Construction rates range from about 100 to 250 linear feet per day, depending on the extent of damaged levees. Geo-tube material and placement/filling equipment are candidates for pre-purchase and stockpiling in the near term.
- Super Sacks and Sand Stockpiles. DWR is considering the concept of helicopter delivery of super sacks filled with sand to address levee damage. It is not yet clear which types of levee damage might be most advantageously addressed by this method. The DWR evaluation is focused on experience from New Orleans in the context of Hurricane Katrina. If evaluation results are favorable, super sacks would be a candidate for pre-purchase and stockpiling in the near term.

5.2.3.3 Purchase of Critical Equipment

DWR cannot immediately decide whether it should purchase critical equipment and if so, what equipment to purchase. Several of the emergency planning tasks listed above need to be conducted to define equipment needs and identify potential shortages of critical equipment. Once these tasks have been completed, then equipment purchases or other arrangements to relieve constraints can be considered. Some equipment, such as conveyors, stackers, loaders, and forklifts, may be needed to establish and manage stockpile sites. However, any owned equipment must be kept in operating condition and be available when the emergency occurs. One possibility is leasing owned equipment out, subject to recall when needed. Alternatively, it may be practical to identify sources for some equipment to be leased by the state as needed (e.g., large loaders).

Equipment purchases should be analyzed to assess the need and practicality of ownership. Some types of equipment may be relatively abundant and quickly available during an emergency, but other equipment may be a relatively obvious constraint in responding to an emergency. Some major equipment, such as barges or dump scows, may be impractical for state ownership.

If the state sees a specific need (e.g., doubling the availability of dump scows in the Bay Area), an innovative approach for subsidizing achievement of this goal or providing incentives to private-sector operators may be needed. Presently, specific actions relative to major equipment items are open issues that could be addressed in the intermediate term, after more in-depth analysis of emergency preparedness/response strategies and constraints.

5.2.3.4 Development of an Emergency Freshwater Pathway Using Prefabricated Barriers for Channel Closures

MWD (2007) and Moffatt and Nichol (2007) have developed a conceptual design for an emergency freshwater pathway using the Delta Cross Channel and existing channels of the Lower Mokelumne River, the San Joaquin River, Middle River, and Victoria Canal (see Figure 5-4). Development of the pathway requires placement of several channel barriers, which could

be temporary rock barriers such as those now used in the south Delta. However, mechanical, operable barriers could also be used and may expedite implementation in an emergency by avoiding competition for rock (which is expected to be in high demand during an emergency) or by being pre-installed and available in standby position. Various approaches for emergency channel barriers have been considered that could be prefabricated and either stored for installation when the emergency occurs or pre-installed for more rapid deployment. The concepts being considered are illustrated in Appendix 5B. The use of prefabricated barriers is considered an option that has potential value in the intermediate term. This action might become a central feature of the larger ($100 million) option for DWR emergency preparedness/response enhancement, provided that capital expenditure can be extended to the intermediate term.

The evaluation of alternative barriers indicates that a barrier design involving a pivot structure (butterfly gate) in combination with louver gates may provide the most benefit because of its versatility (Moffatt and Nichol 2007). The combined pivot and louver design can function with the following beneficial effects:

- Allow tidal pumping for improved water quality at export locations
- Reduce salinity intrusion under extreme drawdown conditions after catastrophic island flooding
- Operate with flexibility to accommodate environmental concerns (e.g., allow passage and migration of sensitive fish species)
- Provide recreational boat passage

Pivot and louver barrier costs are generally on the order of $10 million per channel location. Costs total close to $40 million for the four locations considered in the MWD “pathway” concept (MWD 2007). Four other barriers are also shown in MWD’s concept drawing, and three of them seem to have potential for prefabricated barriers. Thus, the overall cost of this concept could easily exceed $50 million and may approach $70 or $80 million. Still, in spite of the substantial cost, this concept has promise.

5.2.3.5 Acquisition of Emergency Flushing Water

An initial step in defining the need for emergency flushing water is to perform analyses of what the availability of such water may accomplish. A second step is to assemble data on quantities of water that might be made available in various locations and circumstances. These analyses can help identify where the needed volumes of water can be pursued. These analyses require detailed analysis that the Phase 2 schedule for DRMS does not accommodate.

An initial amount of emergency flushing water to consider would be 120,000 acre-feet from New Melones (or some combination of reservoirs on tributaries of the San Joaquin River). This amount would allow supplemental Delta inflow from the San Joaquin River of 4,000 cubic feet per second (cfs) for 15 days. If this amount were an outright purchase at $100 to $200/acre-foot, the cost would be $12 to $24 million.

It is not clear whether this price range would be appropriate for water that is on call from a reservoir (i.e., to be delivered if and when it is needed due to a defined emergency). One viewpoint would be that this on-call water would effectively remove that volume of storage from the reservoir owner’s active management pool. Another point of view is that it simply represents

a bit more risk to be recognized in reservoir operation, especially in the later portion of the water year as schedules and decisions are made on the maximum drawdown before the wet season. If the emergency water were to come from several different reservoirs rather than just one, that risk would be spread among reservoir owners and water rights holders and represent several more modest commitments.

Proper development of this option will require analysis and discussions with entities that control the potential sources of water. It should be viewed as an option to be implemented in the intermediate term (2 to 5 years).

A specific concern in the DRMS Phase 2 analysis is to include the effects of building block risk reduction in the scenario assessments performed with the risk analysis model. For purposes of Phase 2 scenario analysis, it is assumed that the major capital expense is to develop two strategically located rock stockpiles (at 100,000 tons each) in coordination with supplemental rock-barge-loading facilities. It is also assumed that the stockpile and transshipment facility has reliable road access so that the stockpile can be recharged from land-based quarries. This assumption provides expedited rock delivery on initiation of an emergency. These assumptions allow for faster ramping up of rock delivery and placement in the context of the ER&R model and provide a mechanism for initial evaluation of risk consequence benefits.

5.2.3.6 Planning and Engineering Tasks

The planning and engineering tasks that would contribute to enhanced emergency response are identified and detailed in DWR's "Delta Emergency Operations Plan Concept Paper" (DWR 2007a). It is assumed that DWR will follow through on these recommended tasks under either option for enhancement of emergency preparedness/response being considered within the scope of this building block.

The primary need for the DRMS Phase 2 analysis is to anticipate the contributions that these tasks can make by increasing the effectiveness of and reducing time frames within the ER&R model. Revisions or improvements to the priority system used to allocate levee repair resources (for marine construction) will have the most significant effect.

The DRMS Phase I analysis assumed a business-as-usual, island-by-island approach to emergency response. Revised priority systems could be used in the analysis of the Phase 2 EOP scenarios, with scenario specifics to be reflected in each priority system. The discussion of each scenario should document the specific priority system(s) assumed for the scenario.

5.3 COST ESTIMATE

Capital cost budgets have been set forth as the basis for distinguishing between the two options for Enhanced Emergency Preparedness/Response. Annual operating costs must also be anticipated for both options. The pre-established budgets are shown in Table 5-2.

5.4 RISK REDUCTION ESTIMATE

Improvements in emergency preparedness are expected to reduce the impacts of Delta levee failures. The extent of these benefits is closely tied to other actions that are taken with respect to managing the Delta in the future. At one extreme, if an in-Delta armored pathway is

implemented, emergency preparedness will be a key element of the success (risk-reduction benefit) of this approach. At the other extreme, if an Isolated Conveyance Facility option is considered, the benefit of improved emergency response (i.e., stockpiled materials) will be limited. For this option, the on-island damage associated with an island flooding will be unchanged even if levee damage is repaired and the island de-watered sooner.

In this and in other options, improved emergency preparedness will provide the opportunity to limit interior levee damage on flooded islands and repair damage on non-flooded islands, potentially limiting further breaches and preventing larger repair costs.[1]

In light of the above two paragraphs, the risk-reduction benefits of this building block can be summarized as follows:

- No risk-reduction benefit occurs with respect to reducing the likelihood of initial levee failures.
- The number of subsequent breaches (stemming from non-breach damage) in the days or weeks after the event should be reduced, because capabilities to repair such damage and prevent the flooding of additional islands may be significantly improved.
- Better emergency preparedness offers the opportunity to:
  - Ramp up levee damage repairs more quickly than would occur under business as usual.
  - Reduce the period of island flooding, allowing people and businesses to return sooner and recover from the event.
  - At least partially reduce the cost of levee repairs due to lower cost of materials and limiting the amount of repair required (by protecting levee interiors sooner rather than allowing erosion damage to advance).
  - Support a strategy for implementing an in-Delta freshwater conveyance, which will reduce water export disruptions.

As the foregoing discussion indicates, it is premature to quantify anticipated risk reduction results, especially results that sharply distinguish between $50 million and $100 million of capital investment. Results will depend largely on the overall Delta management strategy (combination of other building blocks) considered. This building block may also facilitate development or purchase of additional strategic sites for materials and thereby facilitate adaptability of response based on the specific emergency occurrence.

For the DRMS Phase 2 analysis, the assumptions within the Emergency Response and Repair Module and the Water Analysis Module will be reviewed to reflect enhanced and expedited response where it seems feasible. An in-Delta freshwater conveyance route may be defined to explore changes in the length of time that exports are disrupted. Analyses conducted in developing the EOP are anticipated to be most helpful in identifying specific expenditures that seem justified and in assessing the response improvements expected from those expenditures. Unfortunately, those analyses will not be completed in time for use in DRMS Phase 2. DRMS Phase 2 will be based on anticipated results.

[1] The Phase 1 analysis revealed that interior levee erosion on flooded islands was a major cost of estimated repairs.

5.5 FINDINGS AND CONCLUSIONS

5.5.1 Findings

It is clear that enhanced emergency preparedness/response can make a contribution to reducing adverse impacts from levee breach incidents. It is less clear what specific enhancements will be most effective, especially which major investments and which level of commitment. While developing its EOP, DWR has the opportunity to focus on Delta levee breach emergencies, to conduct analyses detailing prospective preparations and responses, and to evaluate their impacts.

5.5.2 Conclusion and Recommendations

DWR should proceed with initiatives now under way to enhance Delta levee emergency preparedness and response and include the outcomes of these program design/enhancement efforts in the developing vision for the future Delta. It is particularly important that DWR achieve an appropriate balance between near-term and intermediate-term actions.

Tables

Table 5-1 Production Rates by Time (SRRQ and Others, Marine-Based)

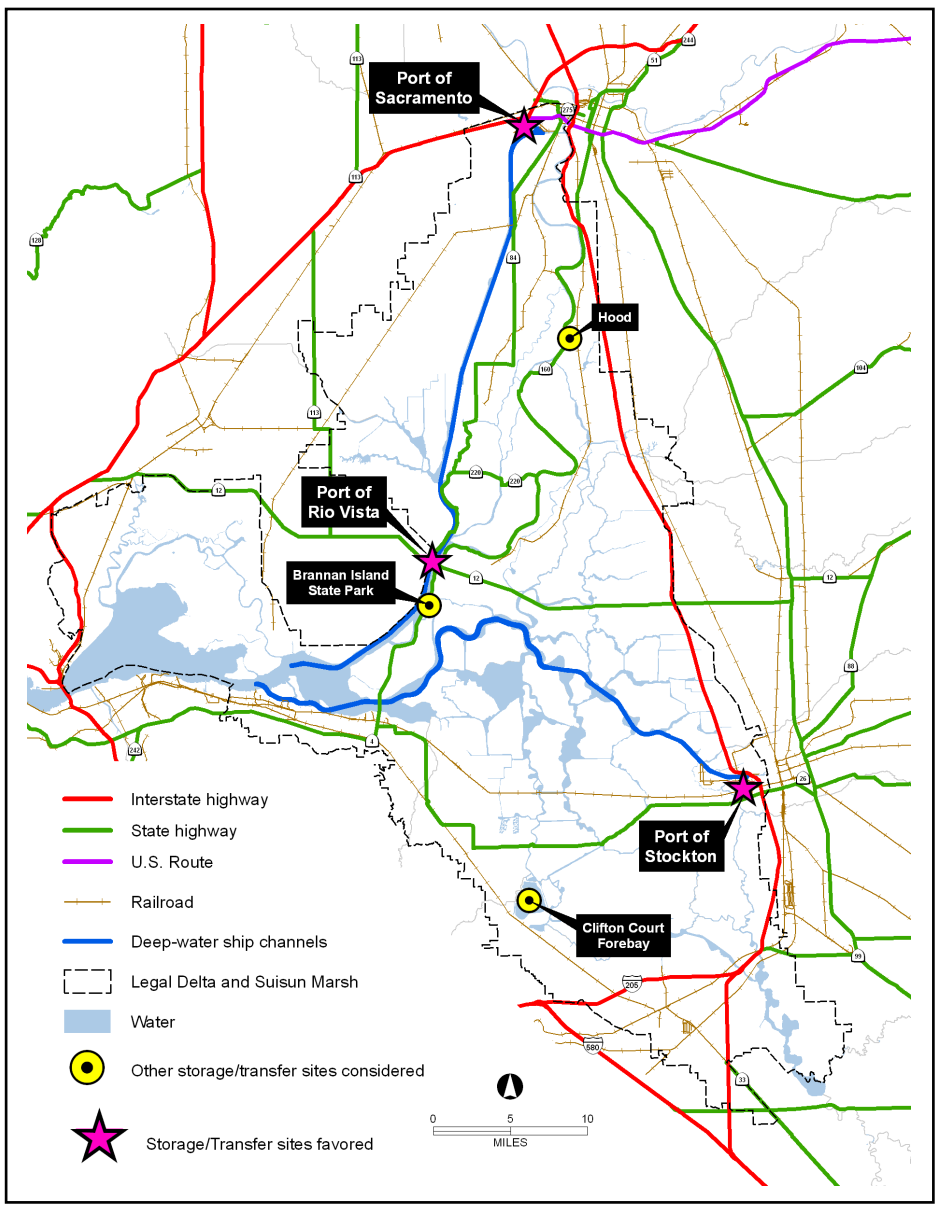
Days	Production Rate			Remarks
	Low (tpd)	Expected (tpd)	High (tpd)	
0 to ½ day	0	0	0	Time required for contractor to commence work.
½ to ~3 days	2,000	4,000	8,000	
~3 to 10 days	4,000	10,000	12,000	Maximum SRRQ capacity with current equipment and configuration.
10 to 90 days	8,000	20,000	24,000	Addition of more mining equipment. Increase only if repairs are estimated to take longer than 180 days.
90 to 180 days	20,000	40,000	48,000	Additional barge loading facility. Increase only if repairs are estimated to take longer than 360 days.
180+ days	30,000	50,000	58,000	SRRQ plus other marine sources. Increase only if repairs are estimated to take longer than 720 days.

SRRQ = San Rafael Rock Quarry
tpd = tons per day

Table 5-2 Enhanced Emergency Preparedness/Response Budgets

Emergency Response Option	Capital Cost	Annual Cost
$50 Million Capital Investment	$50 Million	$2 Million
$100 Million Capital Investment	$100 Million	$3 Million

Figures



Enhanced Emergency Response Purpose

•Provide a maximally organized, coordinated, and effective response when a major levee breach event occurs

•Lessen impacts to people and property

•Lessen the times of disruption for Delta residents and businesses, Delta facilities/infrastructure, water supply conveyance, and ecosystem functions

Time Frame for Emergency Response Enhancements – 2 to 5 Years – Extra Items

•Additional barge loading/stockpile sites (possibly state purchased)

•Designate emergency water conveyance route(s)

•Prefabricated channel barriers (e.g. MWD straw) and barrier site preparation

•Secure east & south flushing water

•Purchase or arrange enhancements of critical equipment

•Improvements to critical facilities & some levees oriented toward emergency response

•Maintain stockpiles

Time Frame for Emergency Response Enhancements – 1 to 2 Years

•Emergency Operation Plan (EOP)

•Priority system for repairs

•Identify/secure intial stockpile / barge loading sites

•Start stockpiles of rock, sand, and/or sheet pile

•Increase flood-fighting inventories

•Minor facility improvements (e.g. aux power)

•Standard procedures & designs for response

•Advance work with quarries & contractors

•Increase interagency coordination and emergency response training

Emergency Response Issues / Concerns

•Reliable road access to storage/transshipment sites?

•How much and what gradation of rock in stockpiles?

•What are foreseen uses and designs / installation methods for sheet pile?

-Seepage control?
-Some non-breach damage repair?
-Channel barriers?
-Breach closure?

•Whether to include items with 2 to 5 year time frame

•State / DWR commitment and funding for long-term maintenance of emergency preparedness

Emergency Response Benefits

•Through planning, practice, and preparation, responders will have established tasks and will react efficiently and effectively

•Tools and materials will be available when and where they are needed

•Adverse impacts will be reduced

•Risk reduction estimates – In model will be shown as more rapid ramp-up of production rates and improved priority system for repairs

Emergency Preparedness / Response Options

•Emergency preparedness capital investment of $50 million

•Emergency preparedness capital investment of $100 million

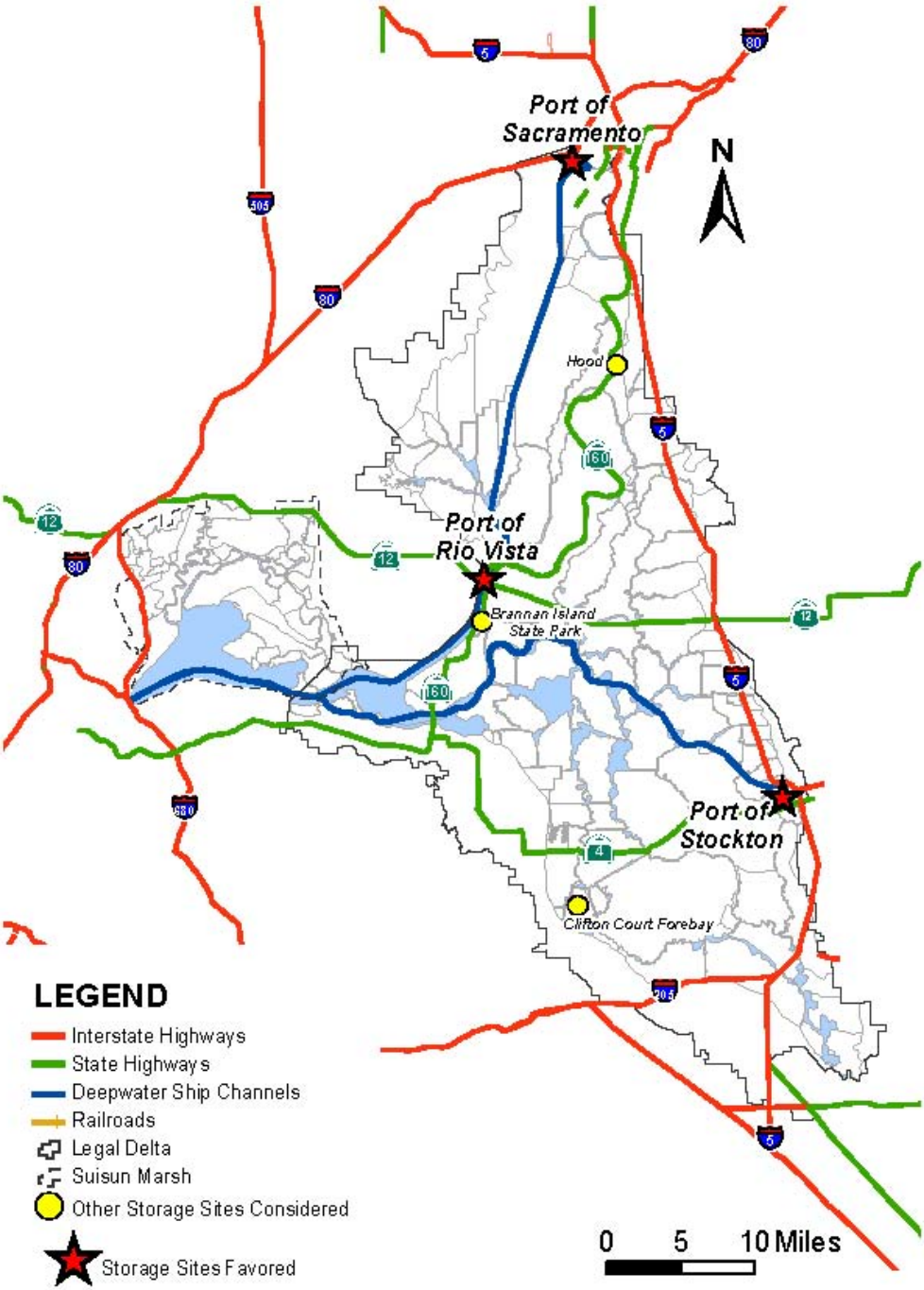


Figure 5-2 Potential Delta Area Emergency Material Stockpiles and Transshipment Sites

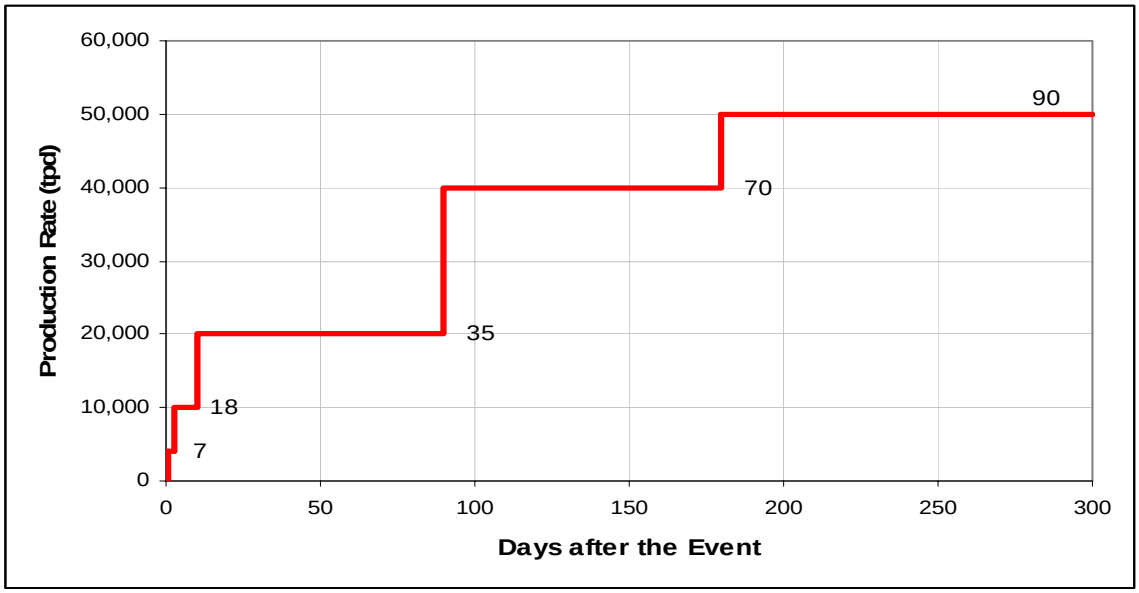


Figure 5-3 Material Supply Rates by Time after Event (SRRQ and Others, Marine-Based)

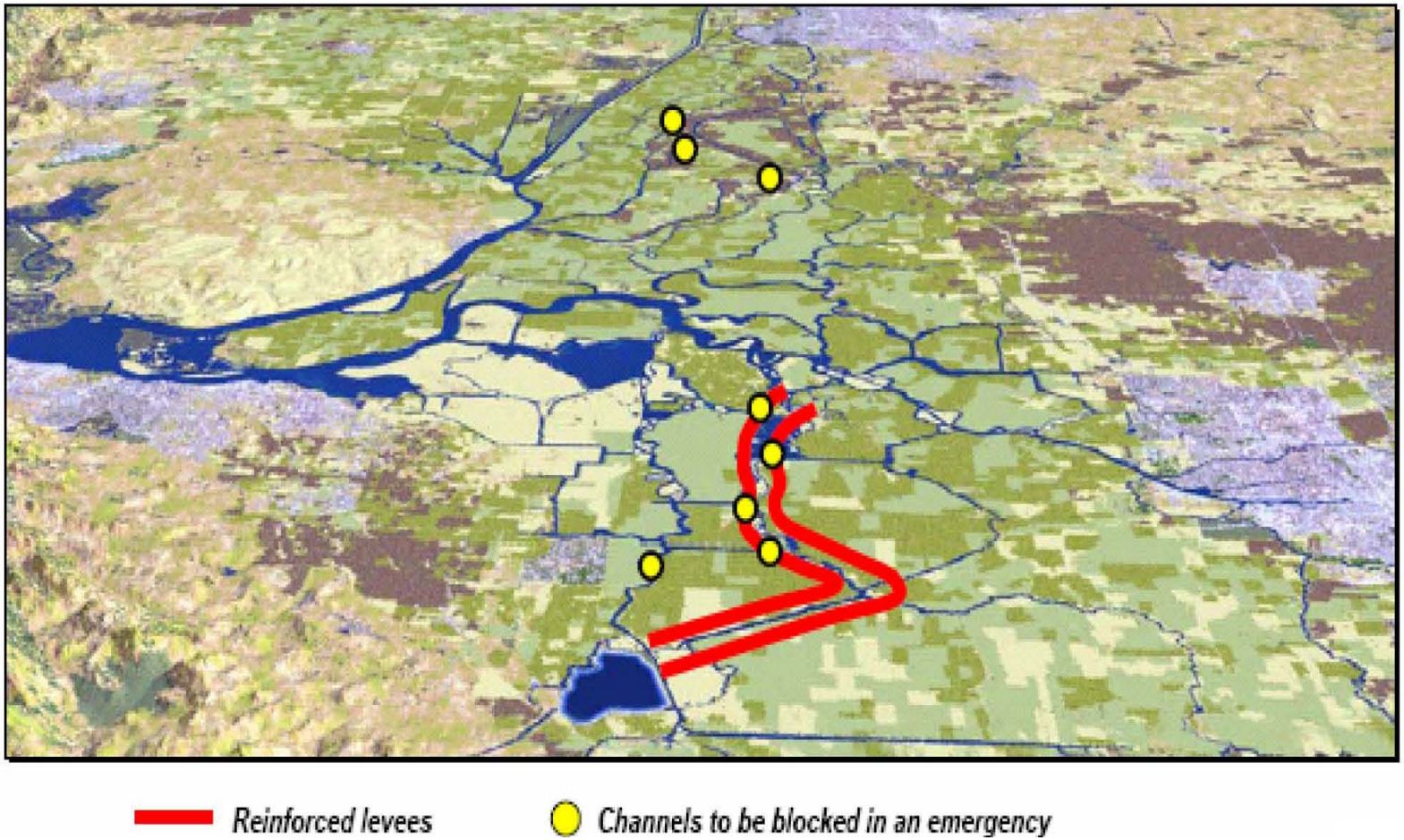
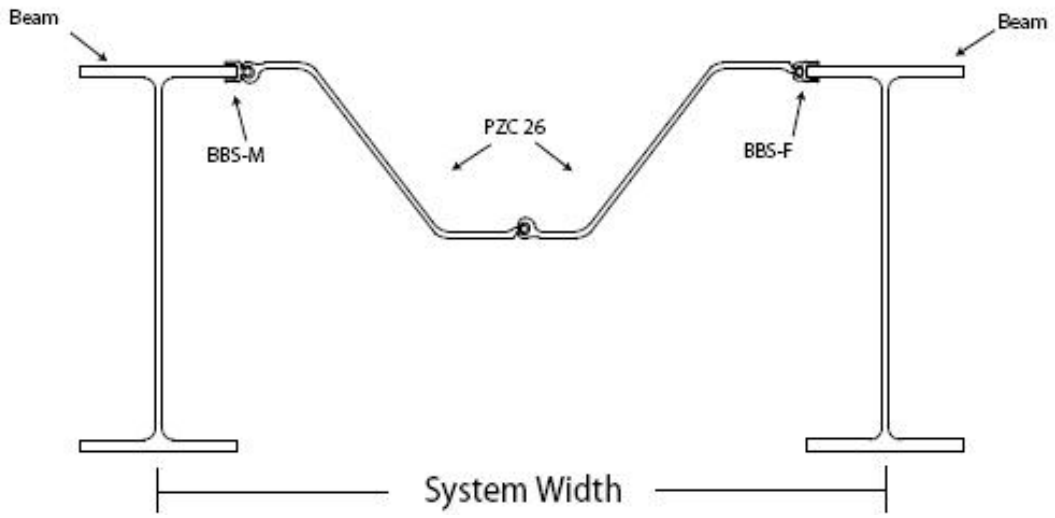


Figure 5-4 South Delta Pathway Levees, Adjoining Channel Barriers, and North Delta Channel Closures

Source: MWD 2007.

Appendix 5A
Combination Sheet Pile Wall Examples
(Moffat and Nichol 2007)



Plan View – Wide Flange King Pile Beam with PZC Intermediate Sheet Piles
(Source: LB Foster, Inc.)

HZ Combination Wall Shown with Double King Piles and AZ Intermediate Sheet Piles
(Source: Skyline Steel, Inc.)

Installation of King Piles Using Driving Template
(Source: Skyline Steel, Inc.)

Field Splicing Large King Piles During Installation
(Source: Skyline Steel, Inc.)

Appendix 5B
Channel Barrier Concepts
(Moffat and Nichol 2007)

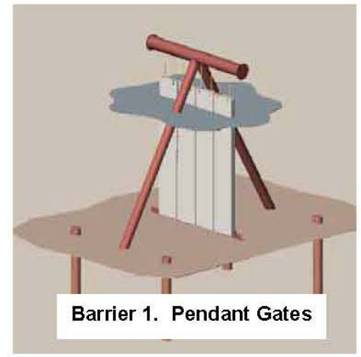
Summary of Channel Closure Barrier Concepts

Barrier Type	Design Features:			
	Temporary/ Removable	Flow Control: Tidal Pumping	Flow Control: Salinity Barrier	Navigation
1. Pendant Gates				*
2. Pivot Gates				
3. Louver Gates				*
4. Stop Log Barriers				*
5. Floating Barge				
6. Sheet Pile Barrier				
7. Rock Barrier				

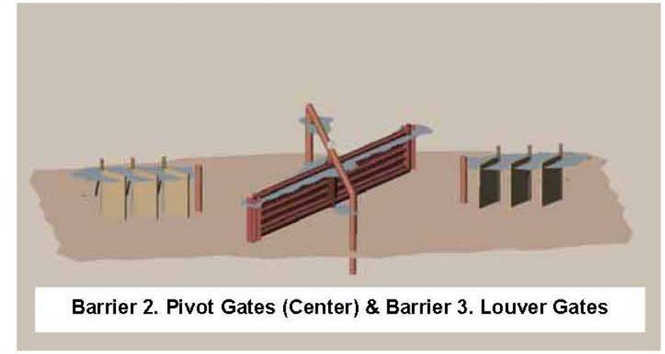
* Feasible when used in conjunction with 2. Pivot Gates

Key:

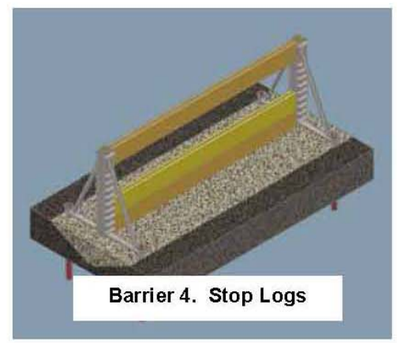
- Good/Feasible with Current Design
- Moderate/Feasible with Re-design
- Poor/Not Feasible



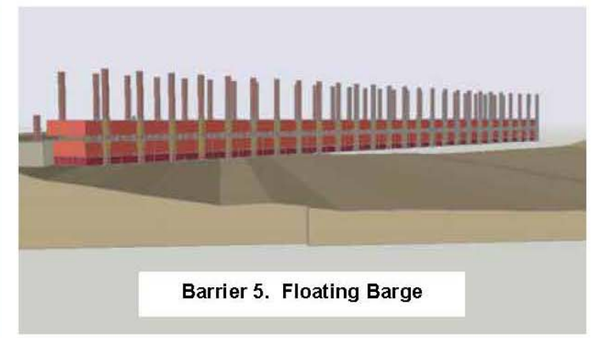
Barrier 1. Pendant Gates



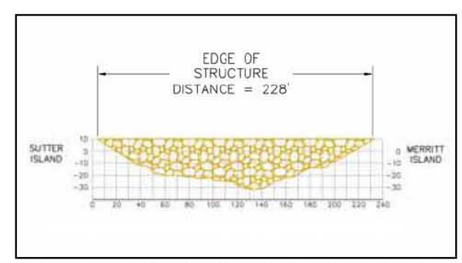
Barrier 2. Pivot Gates (Center) & Barrier 3. Louver Gates



Barrier 4. Stop Logs



Barrier 5. Floating Barge



Barriers 6. & 7. Representative Section for Rock Barrier (& Sheet Pile Barrier)