

**PLAN FORMULATION ADDENDUM**

## **Non-Structural Measure Descriptions**

### **Elevate Critical Infrastructure**

This measure would raise at-risk critical structures above the design inundation level. Elevation would be accomplished by placing structures on pilings or berms that would raise the structure so that critical areas would be above the design inundation level.

### **Ring Levees for Critical Infrastructure**

This measure would protect specific critical infrastructure or facilities through placement of ring levees around those features. Ring levees would be built to a height adequate to reduce expected frequency of inundation of the structure without modifying the flood plain (See Section 3.1). Typical design for a ring levee would include a top width of 12 to 20 feet and side slopes with a ratio of 3 to 1. A cutoff wall for seepage issues may be required depending on the geotechnical analysis of the levee foundation. (Ring levees have recently been defined by USACE as a structural measure because they affect the extent of flooding).

### **Elevate/Relocate/Buy-out Structures**

This measure would elevate at-risk residential and other non-critical structures or remove them from the flood plain. Structures would either be moved to sites outside the flood plain or demolished and the material recycled or disposed of as appropriate.

## **Flood Warning, Emergency Evacuation Plan**

### **Flood Warning System**

This measure would allow for timely warning and evacuation of at-risk areas. This could be accomplished through media announcements and reverse 911 automated calling to residents and businesses within the area.

### **Implement Emergency Evacuation Plan**

This measure is an activity that the non-Federal sponsors would implement to meet the study objective of reducing flood risk to public health, safety and life. Evacuation routes from areas within the flood plain would be identified and provided to the public on maps showing the routes, emergency response staging areas, and contact information for emergency service agencies.

## **Flood Plain Management**

### **Restrictive Zoning/Land Use Planning**

Non-federal interests would implement land use planning and zoning restrictions for areas within the flood plain to minimize risk in those areas. Implementation of this measure

would include the creation and use of a Flood Plain Management Plan (FMP) for the project area in accordance with Section 402 of the Water Resources Development Act of 1986, as amended (33 USC 701b-12), when a project is implemented.

#### Manage Land Use within Flood-prone Areas

This measure is an activity that the non-Federal sponsors would implement to meet the study objective of reducing flood risk to public health, safety and life. California SB 5 described in Section 2.2.2 is such a measure.

### **Structural Measure Descriptions**

#### **Levee Raises**

Raising levee height to increase the level of performance of existing levees is the focus of this measure. Increase in levee height may require additional levee footprint area to meet minimum levee design requirements for levee slopes and top width. Levee raises would be accomplished by adding material to achieve the desired height. Height increases may require additional landside easement(s) to allow for the increase in levee footprint and necessary access easements.

#### **Cutoff Walls**

This measure would be implemented to address through- and under-seepage issues that affect levee performance and safety. Installation of the cutoff wall is accomplished by degrading the levee to one-half height and creating the wall with a soil-bentonite mix. Once the mix has cured, the levee is restored to design height and side slopes to meet current design standards. The depth of the cutoff walls will typically be from 20 to 80 feet, depending on subsurface conditions, which will be determined more precisely during the PED phase through additional borings and corresponding depth required to stop through and under-seepage.

#### **Deep Soil Mixing (Seismic)**

This measure would be implemented to provide seismic stability to the Delta Front levees where required. The measure addresses seismic risk in the Delta Front levees due to the makeup of the foundational geomorphology. The Delta area soils are typically unconsolidated alluvial deposits. The deep soil mixing (seismic) measure would involve installation of a grid of drilled soil-cement mixed columns aligned longitudinally with, and transverse to the levee extending beyond the levee prism. This measure acts to minimize lateral deformation of the levee during seismic events.

## **Setback Levees**

Where in-place improvements of levees may not be effective, and adequate footprint area exists, this measure could be implemented to improve the hydraulic capacity and overall effectiveness of the levee system. This measure would allow for ecosystem restoration measures on the water side of the new levee. Typical design for a setback levee would include a top width of 12 to 20 feet and side slopes with a ratio of 3 to 1. A cutoff wall for seepage issues may be required depending on the geotechnical analysis of the levee foundation. Depending on goals, the existing levee could be degraded, breached or left in place after construction of the setback levee.

## **Seepage / Stability Berms**

Installation of seepage/stability berms in areas where land-side footprint allows, would increase levee stability and reduce through- and under-seepage resulting in increased levee performance and safety. The berm would be installed on the land-side of the existing levee to control seepage exit gradients that occur during an event. Typically the berms are five to 10 feet thick and vary in width extending landward from the landside levee toe from 100 to 200 feet. Actual dimensions will vary depending on the seepage gradients present.

## **Erosion Protection**

This measure would consist of protection of the water-side banks of levees to prevent or reduce erosion due to high flows, tides, or wave action. Bank protection could be placed on existing banks or at the toe and side of the levee to above the design water surface elevation, as necessary. Protection would consist of rock sized to withstand expected flows, tidal action, and wave run-up for the reach of levee installed on which the protection is placed.

## **Bridge Modifications for Conveyance**

This measure would be used to address areas where existing bridges may be identified as a localized limit to hydraulic capacity. Bridge modifications could include raising or widening bridges to increase hydraulic capacity through the bridge crossing. Low water road crossings will be replaced by bridges as a component of this measure.

## **Upstream Bypass**

This measure would consist of increased diversion of high flows from the mainstem of the San Joaquin River via bypass channels such as Paradise Cut and the Mariposa bypass. New bypass areas could potentially be identified and implemented. Increasing bypass of flows could be accomplished by widening the bypasses via levee setbacks, or redesign of diversion structures to maximize efficiency at specified flows.

## **Channel Modifications for Conveyance**

This measure would be implemented for improvements to the channels of Paradise Cut or Mormon Channel. Conveyance improvements would reduce stages on the mainstem of the San Joaquin River, the Stockton Diverting Canal and Lower Calaveras River. Channel modification would entail removal of material (vegetation and soil) from within the channel to allow for greater capacity. Existing channel width would be maintained during implementation of this measure. Removed material could potentially be used for levee improvements or would be disposed of appropriately. Currently, channel maintenance is not required under the existing Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) manuals, but implementation of this measure would include updates to the OMRR&R manuals to include requirements for maintenance to maintain design capacities.

## **Bypass Channels**

This measure involves improvements to bypass channels such as Paradise Cut and Mormon Channel. Improvements to these channels would potentially result in stage decreases on the San Joaquin River, Diverting Canal and Lower Calaveras River. Improvements to the bypass channels would include channel modifications as described above, the addition of a diversion structure at Mormon Channel and modification to the existing diversion structure at Paradise Cut. Channel modifications would include removal of vegetation and soil as required for flow efficiencies. Diversion structure modifications would include height or width changes upstream of Paradise Cut to allow maximum flows at the desired flow elevations.

## **Control Structure**

This measure would involve construction of a control structure at the upstream end of the Diverting Canal to divert flows into Mormon Channel. The control structure would consist of gated culverts placed in the Stockton Diverting Canal left bank levee to allow flow into Mormon Channel. The culverts would be sized to allow control of flows up to the design capacity of the Mormon Channel.

## **Levee Extensions**

This measure would involve extension of the southern tie-in levee on the south end of RD 17 to an appropriate elevation to reduce flood risk in the southern Manteca area. The levee extension would be combined with repairs or improvements to the existing tie-in levee to meet current standards. Levee extension may also be implemented for the right bank levee of French Camp Slough in RD 404. The levee extensions would be built to a height equal to that of the existing levee system, or to meet the height of included improvements. Typical design for an extension levee would include a top width of 12 to 20 feet and side slopes with a ratio of 3 to 1. A cutoff wall to reduce seepage may be required depending on the geotechnical analysis of the levee foundation.

## **Closure Structures**

This measure would include construction of closure structures at the mouth of backwater sloughs such as Smith Canal and Fourteenmile Slough to provide FRM from flood flows in the Lower San Joaquin River and Delta. The closure structures would consist of side walls placed in the existing embankments, double-sheet pile walls (or similar) within the channel and a 50-foot clear width operable gate crossing the waterway. Typical operation of the gate would have the gate in a fully open position most of the time and closed only during specified high water events or for scheduled maintenance. Implementation of this measure would address the risk of flooding of the Smith Canal and Fourteenmile Slough areas of Central and North Stockton due to backwater flows from the mainstem of the Lower San Joaquin River and Delta. It has been determined that storm water pumping stations would not be required at either of these locations as a result of these gate closures.

## **Improve Existing Levees**

This measure would include improvement of the existing levees to reduce flood risks at the Delta Front levees, Calaveras River levees, and mainstem river levees by enlarging them to design geometry for side slopes and top width. Typically, the levees will have material added where necessary to meet the design height and top width of 12 to 20 feet. Side slopes will be either 2 to 1 or 3 to 1 depending on location and governing criteria. Appropriate vegetation free zones will be established for compliance with USACE vegetation management guidelines (ETL 1110-2-583). Existing easements for inspection and maintenance will be retained, or expanded to meet a minimum 10-foot easement for existing levees on the landside, and 15-foot easement for new levee sections. Water-side inspection and maintenance easement will be established at 15 feet from the water-side toe of the levee. Such improvements would meet current USACE standards.

## **Reservoir Reoperation**

This measure would modify current operations of upstream reservoirs to allow for greater storage during high rain or runoff events, thereby reducing flow stages within the study area. This measure would involve changes to operating manuals of upstream reservoirs to better manage flood events on the San Joaquin River and tributaries. Operating manual modifications could include changes in timing (time of year), duration, and flow rates from the dam.

## **Additional Reservoir Storage**

This measure would involve increase of storage capacity of upstream reservoirs. This would require dam modification (raise and/or extension) and purchase of lands for storage capacity increases.

## **Additional Transitory Flood Plain Storage**

This measure would use upstream flood plain areas on the San Joaquin River to allow high flow events to access flood plains for transitory storage of water. This could be

accomplished by implementation of setback levees in upstream areas of the watershed where possible. The goal of the measure would be to reduce peak discharge and stage during high flow events.

## **Initial Alternative Descriptions and Figures**

### **No Action Alternative**

In this alternative there is no Federal action. It is expected that the future without-project assumptions will be maintained. There are locally sponsored activities ongoing and there is potential that other local or state sponsored projects within the study area may be undertaken without Federal participation. It is expected that current FRM structures would be maintained and residual risk of flooding damages will remain.

### **North Stockton Alternatives**

The North Stockton area is defined by the right bank levees of the Calaveras River and the levees along the Delta Front traveling northward along Ten Mile Slough, Fourteenmile Slough, crossing Five Mile Creek, and traveling north to tie into the Federal project levee across Mosher Slough at the Atlas Tract. The Flood Warning, Emergency Evacuation Plan and Flood Plain Management measures are included in all the alternatives discussed below.

See Figure A-1 for the North Stockton alternatives.

NS-A, Delta Front North and Fourteenmile Slough: This alternative addresses the delta flooding source. It includes the following measures: cutoff wall, deep soil mixing (seismic), erosion protection, improvement of the existing levee, and a closure structure across Mosher Slough. This alternative covers 32,400 linear feet (6.1 miles) of levee.

NS-B, Delta Front North and South, and Calaveras River: This alternative addresses the delta and tidal portion of the Calaveras River flooding sources. It includes the following measures: levee raise, cutoff wall, deep soil mixing (seismic), erosion protection, improvement of the existing levee, and a closure structure across Fourteenmile Slough. The alternative covers 50,400 linear feet (9.5 miles) of levee.

NS-C, Delta Front North: This alternative addresses the delta flooding source. It includes the following measures: cutoff wall, deep soil mixing (seismic), erosion protection, improvement of the existing levee, and closure structures across Mosher Slough and Fourteenmile Slough. The alternative covers 23,700 linear feet (4.5 miles) of levee.

NS-D, Fourteenmile Slough, Delta Front South, and Calaveras River: This alternative addresses the delta and tidal portion of the Calaveras River flooding sources. It includes the following measures: cutoff wall, deep soil mixing (seismic), and improvement of the existing levee. The alternative covers 42,300 linear feet (8.0 miles) of levee.

NS-E, Full Calaveras River: This alternative addresses the right bank of the Calaveras River as the flooding source. This alternative includes the following measures: cutoff wall and improvement of the existing levee. This alternative covers 41,900 linear feet (7.9 miles) of levee.

NS-F, Delta Front North and South, and Full Calaveras River: This alternative addresses the right bank of the Calaveras River and the delta front flooding sources. This alternative includes the following measures: levee raise, cutoff wall, deep soil mixing (seismic), erosion protection, improvement of the existing levee, and a closure structure across Fourteenmile Slough. This alternative covers 69,300 linear feet (13.1 miles) of levee.

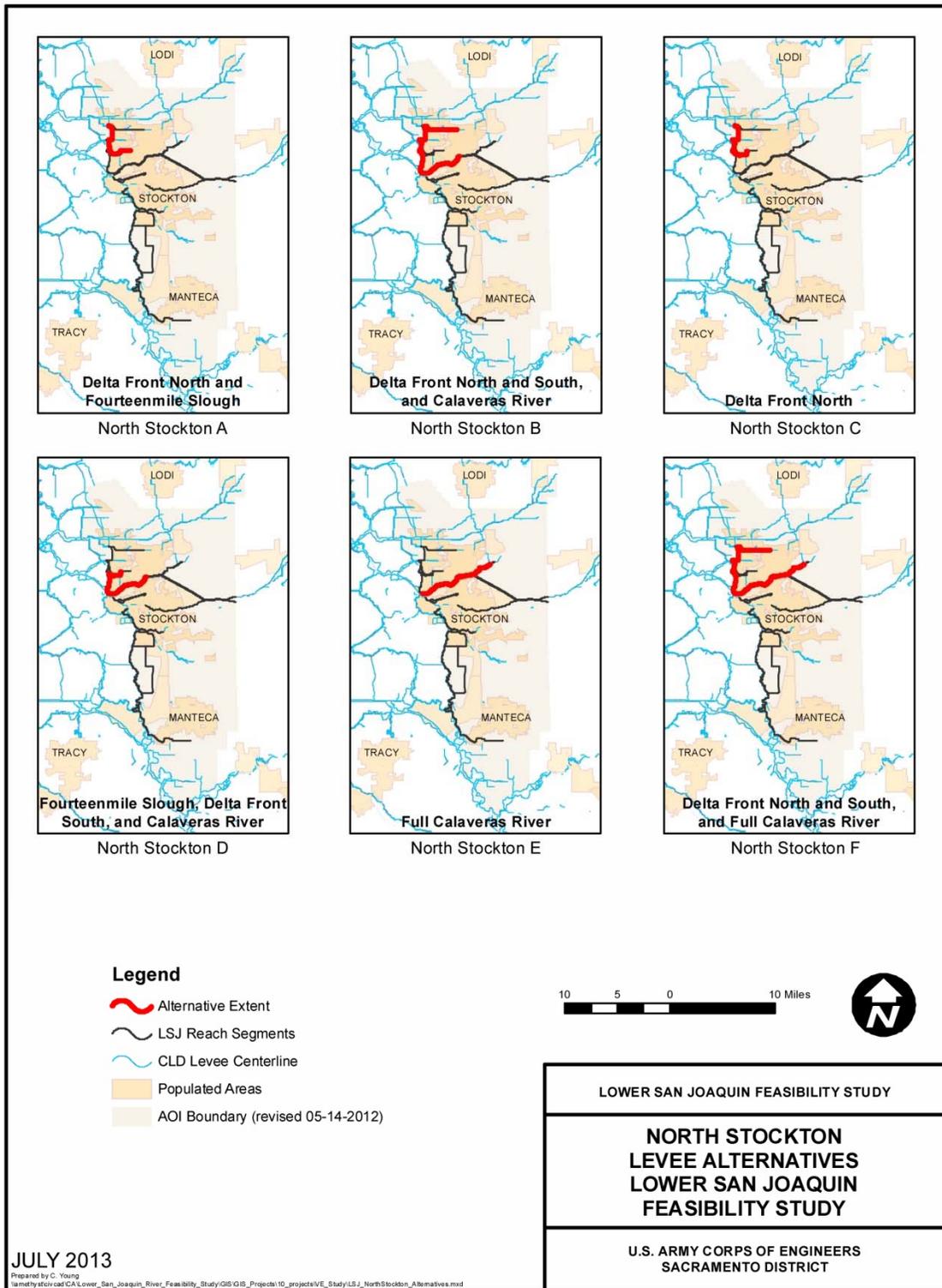


Figure A-1. North Stockton Levee Alternatives.

## Central Stockton Alternatives

The Central Stockton Area is defined by the left bank levees of the Stockton Diverting Canal, the left bank levees of the Calaveras River, the right bank levees of the San Joaquin River, and the right bank levees of French Camp Slough. The Flood Warning, Emergency Evacuation Plan and Flood Plain Management measures are included in all the alternatives discussed below.

See Figure A-2 for the Central Stockton alternatives.

**Central Stockton (CS)-A, Calaveras and Diverting Canal:** This alternative addresses the Stockton Diverting Canal and Calaveras River flooding sources. It includes the following measures: cutoff wall and improvement of the existing levee. The alternative covers 55,800 linear feet (10.6 miles) of levee.

**CS-B, Calaveras River:** This alternative addresses the tidal portion of the Calaveras River and the San Joaquin River sources of flooding. It includes the following measures: cutoff wall, improve existing levee and the Smith Canal closure structure. The alternative covers 19,000 linear feet (3.6 miles) of levee.

**CS-C, San Joaquin River Front:** This alternative addresses the San Joaquin River, French Camp Slough, and Duck Creek sources of flooding. It includes the following measures: cutoff wall and improvement of the existing levee. The alternative covers 23,100 linear feet (10.2 miles) of levee.

**CS-D, Calaveras River, Diverting Canal, and San Joaquin River:** This alternative addresses the San Joaquin River, Stockton Diverting Canal, Calaveras River, French Camp Slough and Duck Creek flooding sources and includes the following measures: levee raise, cutoff wall, improvement of the existing levee and the Smith Canal closure structure. The alternative covers 88,900 linear feet (16.8 miles) of levee.

**CS-E, Calaveras River and Smith Canal:** This alternative addresses the tidal portion of the Calaveras River and Smith Canal area sources of flooding. This alternative includes the following measures: cutoff wall and improvement of the existing levee. The alternative covers 46,800 linear feet (8.9 miles) of levee.

**CS-F, Calaveras River and San Joaquin River:** This alternative addresses the tidal portion of the Calaveras River, the San Joaquin River, French Camp Slough, and Duck Creek flooding sources. It includes the following measures: levee raise, cutoff wall, improve existing levee and the Smith Canal closure structure. The alternative covers 51,600 linear feet (9.8 miles) of levee.

**CS-G, Mormon Channel Bypass:** This alternative would include a 1,200 cubic feet per second capacity diversion to an improved Mormon Channel from the Stockton Diverting Canal (Figure 7; also shown as Central Stockton G on Figure 5). The improvements along Mormon Channel would extend over 33,400 linear feet (6.3 miles), and include flood containment berms, bridge and culvert replacements, road relocations and channel clearing. This alternative provides

for flood plain restoration in accordance with E.O.11988 flood plain goals. The non-Federal sponsors support this alternative as it meets the multipurpose goals of SB 5 by potentially providing habitat restoration and recreation opportunities in addition to FRM.

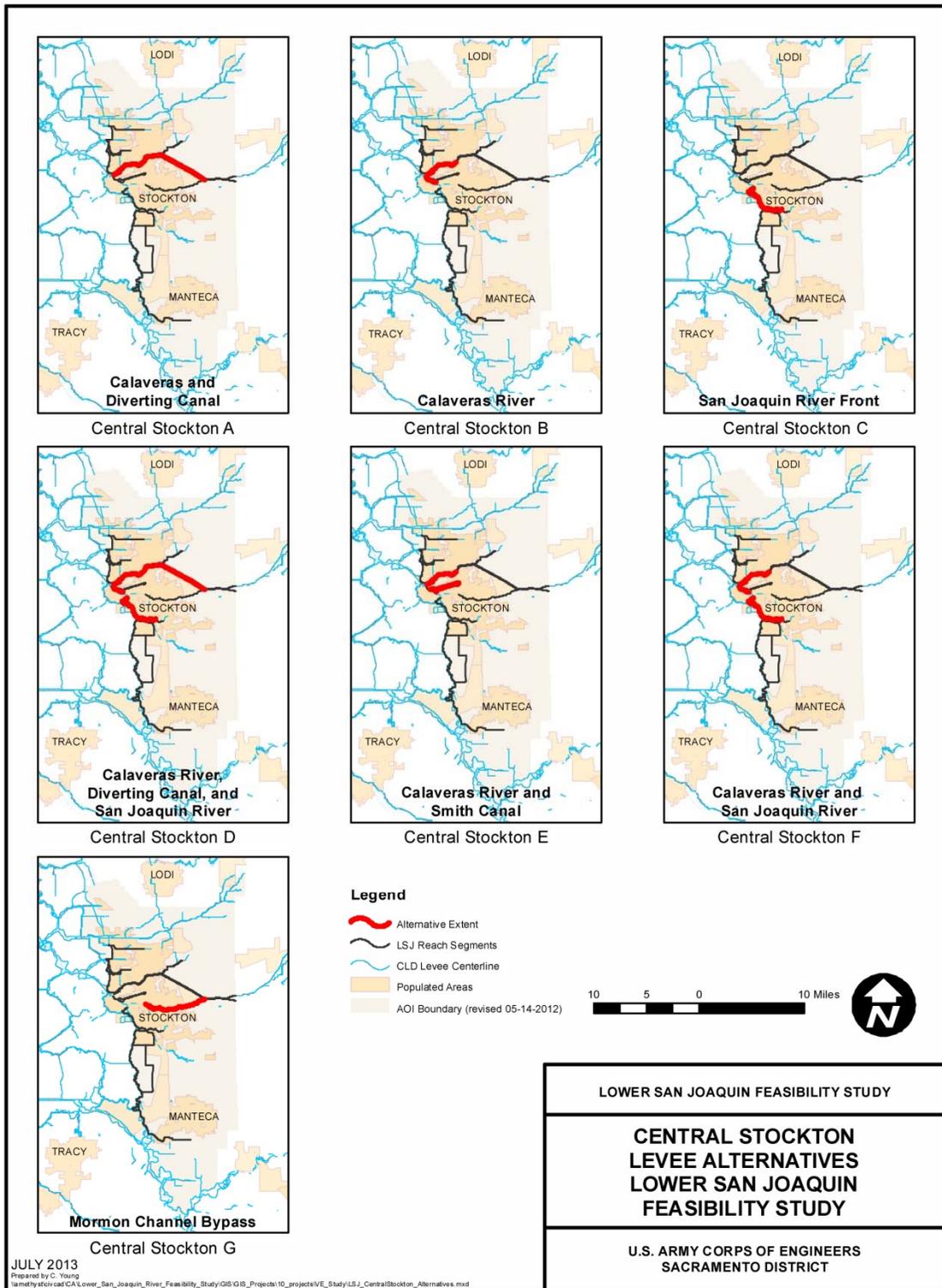


Figure A-2. Central Stockton Levee Alternatives.

## **RD 17 Alternatives**

The RD 17 area is defined by the levees along the right bank of the San Joaquin River, the left bank levees of French Camp Slough, and a dry-land levee at the upstream end of the reclamation district. A small secondary levee is included in RD17-A, RD17-C, RD17-D, and RD17-E for potential flood plain restoration. RD17-D includes a significant setback levee for potential floodplain restoration. RD17-F includes a ring levee for Weston Ranch to determine the viability of ring levee alternatives for the RD 17 area. The Flood Warning, Emergency Evacuation Plan and Flood Plain Management measures are included in all the alternatives discussed below.

See Figure A-3 for the RD 17 alternatives.

**RD17-A, SJR (San Joaquin River) North:** This alternative addresses the San Joaquin River and French Camp Slough flooding sources. This alternative includes the following measures: cutoff wall and improvements to the existing levee. The alternative covers 77,000 linear feet (14.6 miles) of levee.

**RD17-B, SJR Tieback:** This alternative addresses the San Joaquin River as the flooding source. It includes the following measures: cutoff wall, seepage/stability berm, and improvement of the existing levee. The alternative covers a total 21,900 linear feet (4.148 miles) of levee.

**RD17-C, SJR North and Tieback:** This alternative addresses the San Joaquin River and French Camp Slough flooding sources. It includes the following measures: cutoff wall, erosion protection, and improvement to the existing levee. The alternative covers 98,900 linear feet (18.7 miles) of levee.

**RD17-D, SJR Setback and Tieback:** This alternative addresses the San Joaquin River as the flooding source. This alternative includes the following measures: cutoff wall, seepage/stability berm, erosion protection, improve existing levee and a setback levee to limit protection of already developed but non-urbanized flood plain within RD 17. The alternative covers a total 100,300 linear feet (19.0 miles) of levee.

**RD17-E, SJR North with Tieback and Extension:** This alternative addresses the San Joaquin River and French Camp Slough flooding sources. It includes the following measures: cutoff wall, seepage/stability berm, erosion protection, improvement to the existing levee, small secondary levee and an extension of the tie-back levee to address flanking issues. The alternative covers 106,900 linear feet (20.2 miles) of levee.

**RD17-F, Weston Ranch Ring Levee:** This alternative addresses the San Joaquin River and French Camp Slough flooding sources for Weston Ranch. It includes a new levee to form a ring levee around Weston Ranch, and an extension of the RD 404 levees to prevent flanking during lower frequency events. The alternative covers 33,370 linear feet (6.3 miles) of levee.

RD17-G, SJR Setback and Tieback Extension: This alternative addresses the San Joaquin River as the flooding source, and includes a setback levee to limit protection of already developed but not urbanized flood plain within RD 17. It extends the tieback levee at the southern-most end of the RD to minimize probability of flanking during extreme high water events. The alternative covers 113,500 linear feet (21.5 miles) of levee.

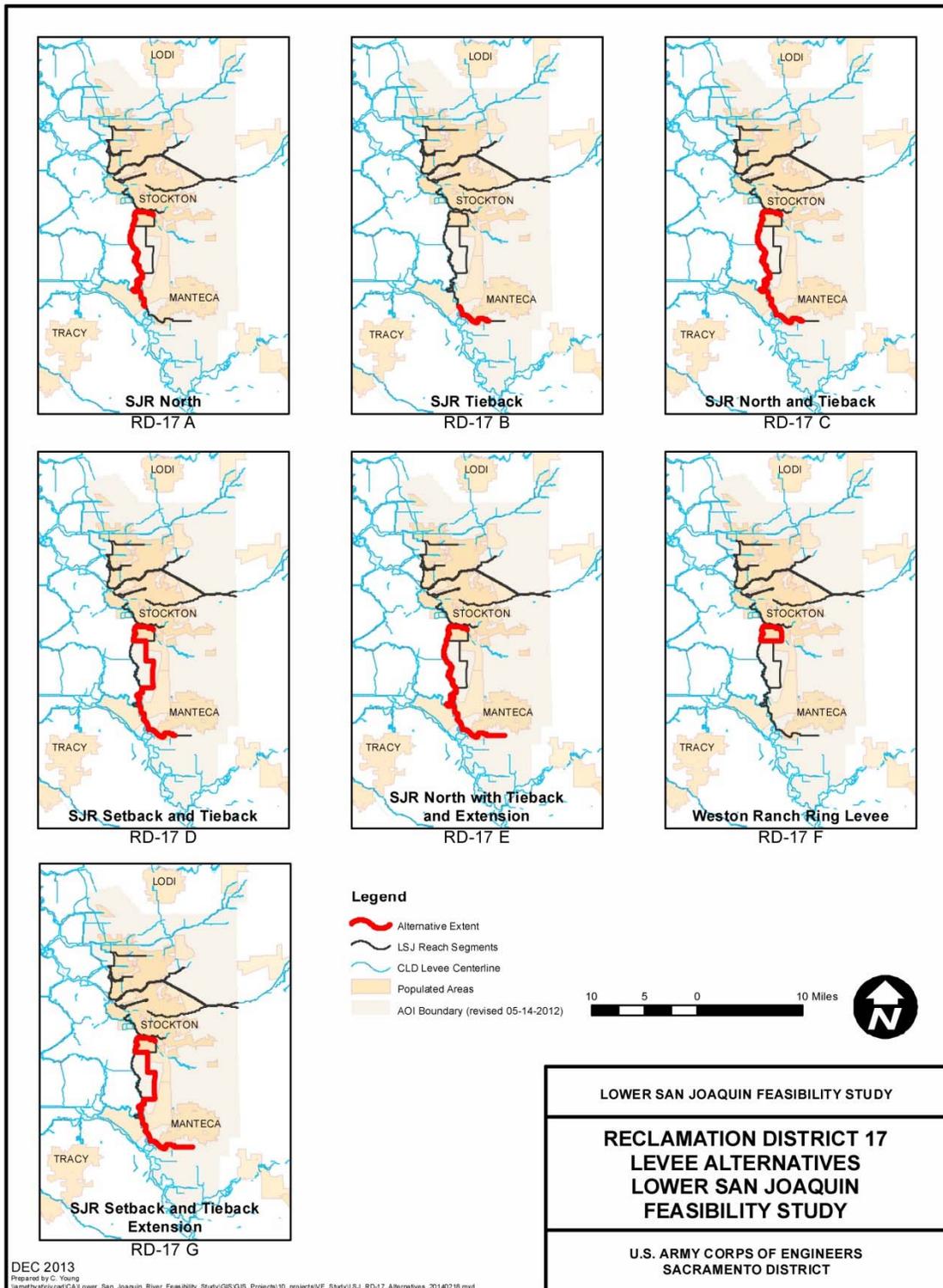


Figure A-3. Reclamation District 17 Levee Alternatives.

## **Bypass Alternatives**

**Paradise Cut Bypass Alternative:** This alternative includes levee setbacks, dredging, and construction of a short bypass at the upstream end of Paradise Cut. The levee along the right bank of Paradise Cut would be set back. Salmon Slough and Doughty Cut would be dredged to increase channel capacity. A channel would be cut through the island between Salmon Slough and Doughty Cut. Paradise dam would be widened from 180 feet to 400 feet. An additional weir would be constructed on the San Joaquin River upstream of Paradise Dam, and a channel would be constructed to Paradise Cut. New levee segments would have soil-bentonite cutoff walls installed during construction for management of through- and under-seepage.

**Mormon Channel Bypass:** This alternative would include a 1,200 cubic feet per second capacity diversion to an improved Mormon Channel from the Stockton Diverting Canal (Figure A-4; also shown as Central Stockton G on Figure A-2). The improvements along Mormon Channel would extend 33,400 linear feet (6.3 miles) and include flood containment berms, bridge and culvert replacements, road relocations, and channel clearing. It provides for flood plain restoration in accordance with E.O. 11988 goals. The non-Federal sponsors support this alternative as it supports the multipurpose goals of SB 5 by potentially providing habitat restoration and recreation opportunities, in addition to its FRM benefits.

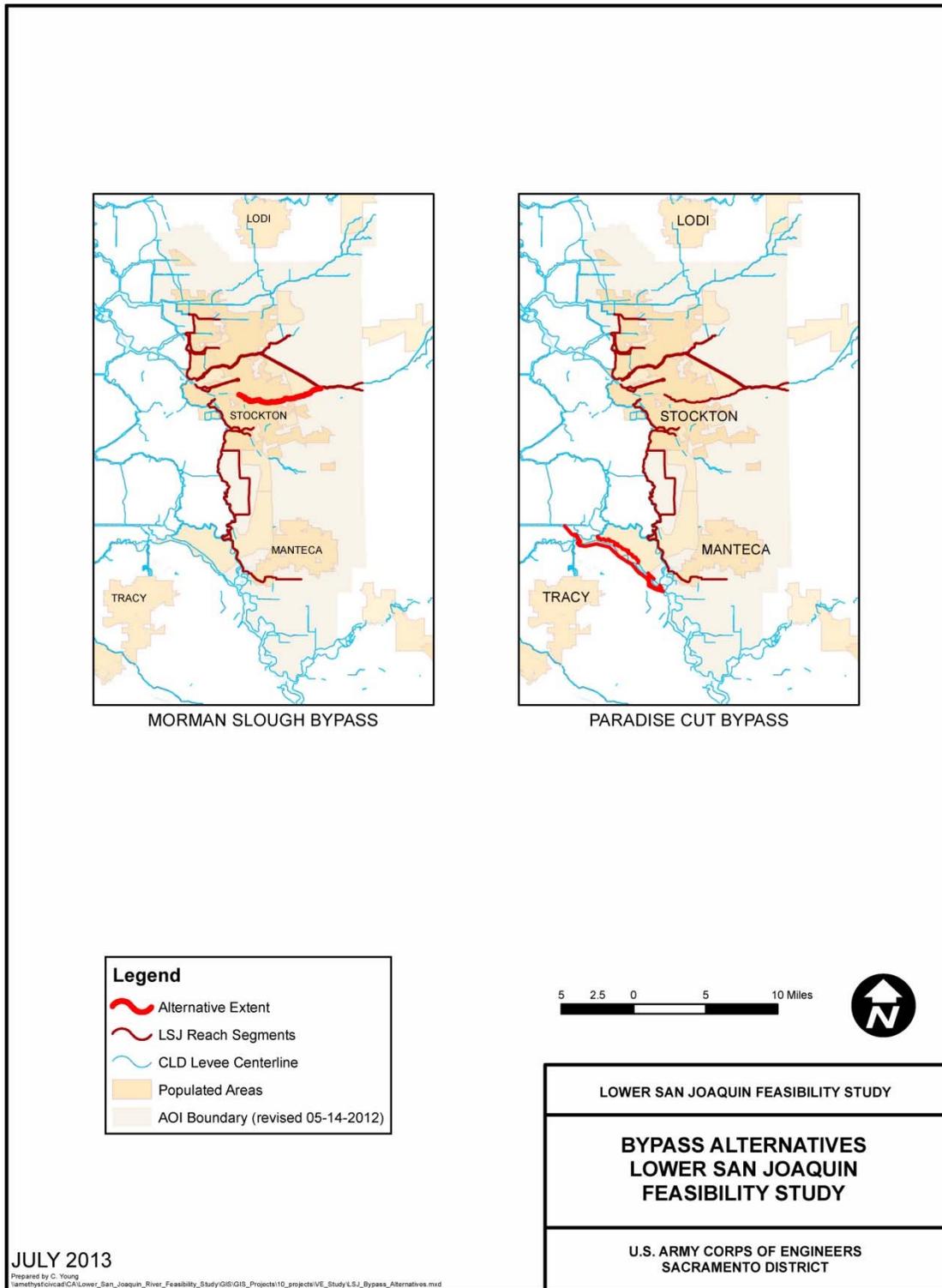


Figure A-4. Bypass Alternatives.

**Initial Alternative Benefit Analysis Tables**

The following tables display the benefits analysis for the initial alternatives and present alternatives carried forward in the plan formulation process.

**Table A-1. North Stockton Alternatives Analysis**

<b>Alternative</b>	<b>Annual Benefits (\$1,000s)</b>	<b>Net Benefits (\$1,000s)</b>	<b>Life Safety</b>	<b>Residual Critical Infrastructure</b>
NS-A Delta Front North and 14-mile Slough	31,000	17,000	Fair	51
NS-B Delta Front North and South, and Calaveras River	72,000	53,000	Very Good	0
NS-C Delta Front North	31,000	22,000	Fair	51
NS-D 14-mile Slough, Delta Front South and Calaveras River	41,000	23,000	Fair	53
NS-E Full Calaveras River	23,000	17,000	Fair to Poor	21
NS-F Delta Front North and South and Full Calaveras River	76,000	54,000	Excellent to Very Good	0

Alternatives NS-B and NS-F were carried forward into final focused array because they have the highest net benefits.

**Table A-2. Central Stockton Alternatives Analysis**

<b>Alternative</b>	<b>Annual Benefits (\$1,000s)</b>	<b>Net Benefits (\$1,000s)</b>	<b>Life Safety</b>	<b>Residual Critical Infrastructure</b>
CS-A Calaveras and Diverting Canal	3,000	-5,000	Good	83
CS-B Calaveras River	44,000	38,000	Poor	134
CS-C San Joaquin River Front	6,000	3,000	Poor	129
CS-D Calaveras River, Diverting Canal, and San Joaquin River	69,000	56,000	Excellent to Very Good	0
CS-E Calaveras River, Smith Canal	44,000	33,000	Poor	134
CS-F Calaveras River and San Joaquin River	56,000	46,000	Good	5
Potential added increment to above alternatives:				
CS-G Mormon Channel Bypass	13,000	11,000	Fair	134

Alternatives CS-D, CS-F and CS-G were carried forward into the final focused array because they had the highest net benefits.

**Table A-3. RD 17 Alternatives Analysis**

<b>Alternative</b>	<b>Annual Benefits (\$1,000s)</b>	<b>Net Benefits (\$1,000s)</b>	<b>Life Safety</b>	<b>Residual Critical Infrastructure</b>
RD17-A SJR North	10,000	-300	Good	49
RD17-B SJR Tieback	0	-2,000	Poor	49
RD17-C SJR North and Tieback	10,000	-3,000	Good	49
RD17-D SJR Setback and Tieback	10,000	-10,000	Good	49
RD17-E SJR North with Tieback and Extension	27,000	12,000	Excellent to Very Good	51
RD17-F Weston Ranch Ring Levee	12,400	5,000	Poor	49
RD17-G SJR Setback and Tieback Extension	24,000	0	Good	49

Alternative RD17-E was carried forward into the focused array because it had the highest net benefits. RD17-F was not carried forward because of lack of effective evacuation routes. If the remaining urbanized areas in RD 17 were also protected by ring levees, the net benefits would become negative because the cost of the ring levees would exceed the benefits (based on professional judgment). Although RD17-G is economically justified, it was not carried forward since RD17-E outperforms it with greater net benefits.

**Table A-4. Bypass Alternative Analysis**

<b>Alternative</b>	<b>Annual Benefits (\$1,000s)</b>	<b>Net Benefits (\$1,000s)</b>	<b>Life Safety</b>	<b>Critical Infrastructure</b>
PCB Paradise Cut Bypass	12,000	-10,000	Poor	-

Alternative PCB (Paradise Cut Bypass) was not carried forward due to the negative net benefits.