

**Sacramento River Flood Control System Evaluation
Initial Appraisal Report - Upper Sacramento Area**

Attachment D

**Risk and Uncertainty
November 1994**

28 November 1994

ENGINEERING EVALUATION OF RISK AND UNCERTAINTY FOR ECONOMICS
UPPER SACRAMENTO AREA, PHASE V, SACRAMENTO RIVER FLOOD CONTROL
PROJECT, SYSTEM EVALUATION

INTRODUCTION

As instructed by the 1 March 1994 Headquarters 2d Endorsement of the Limited Evaluation Report submittal (CESPK-PD-S/29 Oct 93), this engineering report has been prepared to assist in the economic evaluation of risk and uncertainty.

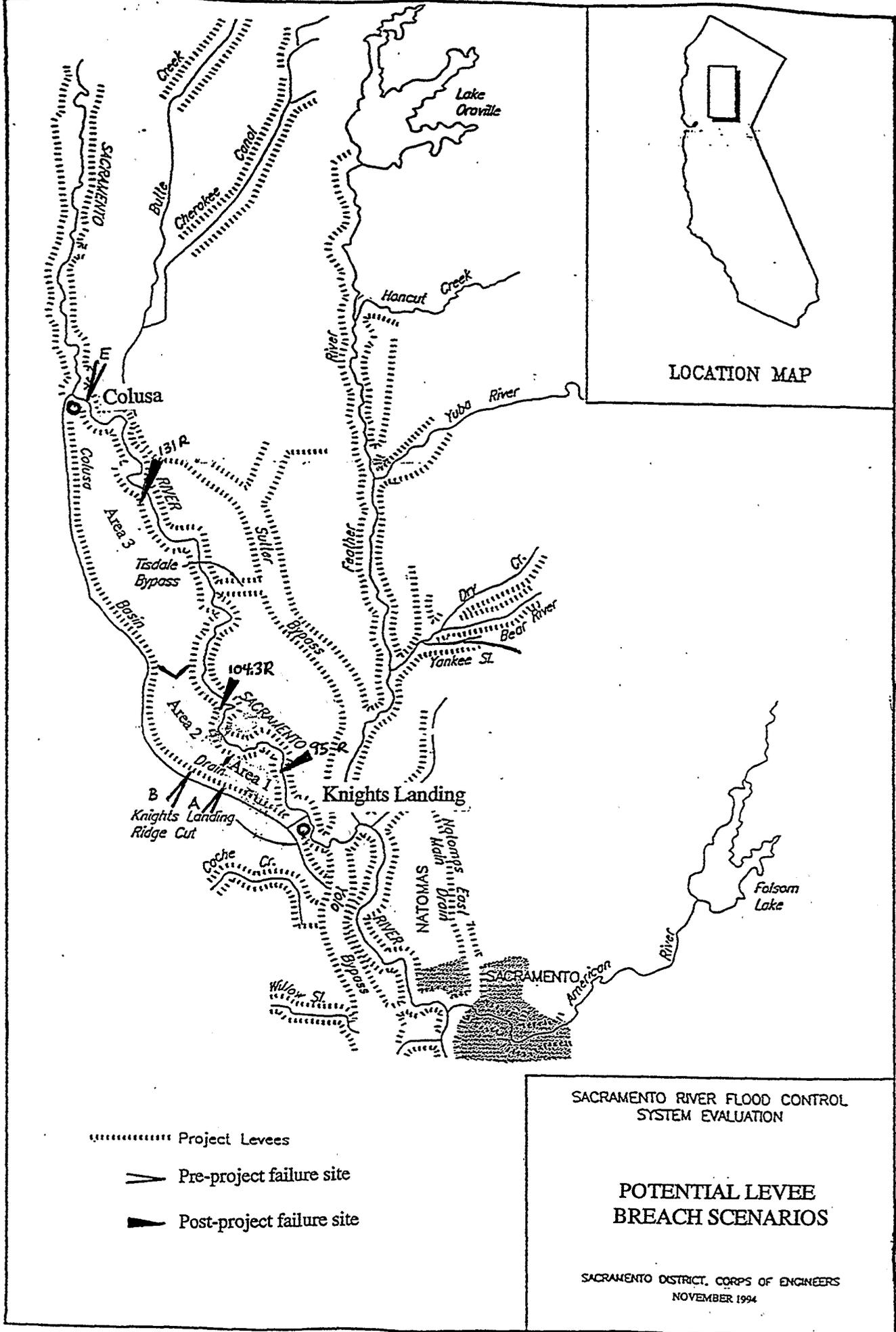
LEVEE BREACHING SCENARIO

Due to the complex nature of the Sacramento River Flood Control Project, a simplified scenario is used to determine how and when levees will break in each incrementally independent area as shown in Figure 1. There are three separate areas (1 through 3), and each area has one or two sites which have been identified as deficient and which had problems in passing the 1986 floodflows.

The proposed levee reconstruction in Phase V will correct the sites that have seepage and stability problems as well as deficient levee crown elevations. A 3-day duration was used for design purposes. Stage and duration are important for defining a levee breaching scenario under existing or without-project conditions.

Levee breaks that result from seepage or stability problems are dependent on the levee embankment and foundation soils, levee geometry, peak flood stages, and duration of peak flood stages. The phreatic water surface within the levee embankment is important in determining potential locations where levees could fail. Higher phreatic water surfaces at a specific location increase the potential for seepage and stability problems and higher phreatic water surfaces are generally associated with coarser soil materials and longer flood durations.

Engineering judgment was used to determine where levees could break in each incremental area. During the 1986 flood, a number of sites exhibited seepage, and one site had water within 1 foot of the levee crown or 2 feet into the authorized freeboard. For most reaches of the Upper Sacramento Area, the 1986 flood was not the flood of record as it was in the other areas considered in the Sacramento River Flood Control System Evaluation. The 1983 flood had higher water surface elevations than the 1986 flood in many parts of Phase V study area.



JUDGMENTS OF EXISTING LEVEE RELIABILITY

Table 1 presents the Upper Sacramento Probable Nonfailure Points and Probable Failure Points for both preproject and postproject conditions. This discussion is for the economic analysis only and, due to the complexities of the flood control system, is not related to future levels of flood protection.

AREA 1

The potential failure point for Area 1 consists of Site A, 15,500 linear feet on the left bank of the Colusa Basin Drain channel mile 1.4 to 4.5. Site A has fat clays and organic material in the levee and its foundation. The upper levee soils undergo weathering during the hot dry summer and the wet winter months and develop dessication cracks which fill with rainwater and further decrease levee stability. Levee slopes have failed and are expected to fail on both the landside and waterside without levee reconstruction. Shallow failures on the levee slope may occur any time on the Colusa Basin Drain, failures are more likely during periods of high water when precipitation fills the cracks. The cracks may be several inches wide and up to 5 feet deep.

For Site A, Hydraulic Design Section completed an office report, "Colusa Basin Drain, Knights Landing Ridge Cut, June 1991" using a DWOPER computer model. Site A is adjacent to Section 76 of the DWOPER model used in that report, where levee failure was estimated to be at 38.5 feet msl based on a 3-day duration of high flows. Site A had slope failures in 1971 and 1975; currently creep and sloughing; and levee slope cracks are visible. The 1983 flood peak water-surface elevation was about 38 msl and the 1986 flood peak water-surface elevation was about 36.5 msl for Site A.

The preproject Probable Nonfailure Point (PNP) and Probable Failure Point (PFP) for Site A will be the same as for Site B, since the two areas are adjacent to one another. The preproject PNP to be used is 35.0 msl (15 percent chance of failure) and the preproject PFP is estimated to be 38.5 msl (85 percent chance of failure).

The postproject PNP based on engineering judgment will be on the Sacramento River side of Area 1 at channel mile 95.0 Right. The postproject PNP is estimated to be 41.7 msl (15 percent of failure) and the postproject PFP is estimated to be 42.5 msl (85 percent chance of failure). For preproject and postproject conditions, the top of levee at the area breakpoint is about 43.0 msl.

Hydrologic information from the gage at the Colusa Basin Drain and Knights Landing was used for Site A. The stage of the Colusa Basin Drain is more dependent on the stage of the Yolo Bypass than flows from its drainage basin due to backwater effects. An adjusted gage from the Sacramento River at Knights Landing was used for the postproject breakpoint at Sacramento River channel mile 95.0.

AREA 2

There are two potential failure sites in Area 2: Site B and Site C. Site B consists of 29,000 linear feet on the left bank Colusa Basin Drain from channel mile 4.6 to 10.1; the site has fat clays and organic material as levee and foundation material. Site C, located on 1,500 linear feet of the Sacramento River, has a deficient levee crown section due to poor levee material and foundation. Site C is more likely to have a complete levee failure than Site B, where most of the slope failures are fairly shallow and can occur at any time of the year.

For Site C overtopping would cause levee failure; the existing levee is 2 feet below the authorized freeboard due to settlement caused by poor levee material and foundation (the levee incorporates an Indian mound with broken shells, bone, and abundant organic material). In 1986 the Sacramento River was reported to be within 1 foot of the top of the levee at Site C.

Under postproject conditions the PNP for the reach of the Sacramento River in Area 2 at channel mile 104.3 Right is estimated to be 45.8 msl (10 percent chance of failure) and the PFP is 46.5 msl (90 percent chance of failure). The preproject breakpoint levee crown at for Area 2 on the Sacramento River is 45.0 msl, and the postproject breakpoint levee crown for Area 2 on the Sacramento River is 47.5 msl at channel mile 104.3 Right.

For the purposes of this report for Site B, the June, 1991 office report, "Colusa Basin Drain, Knights Landing Ridge Cut," was used to determine the PFP, since Section 76 in the DWOPER model in that report corresponds to Site B. Slope failures occurred in 1968, 1971, 1973, 1980, and 1983 along Site B. Emergency repairs were done in 1983 on part of Site B. The preproject PNP is estimated to be 35.0 msl (15 percent chance of failure) as the 1986 flood high-water surface was about 35.5 msl. For Site B an elevation 38.5 msl is used as the preproject PFP (85% chance of failure), which is below the design elevation by about 1.5 feet.

For Site B the postproject conditions based on engineering judgment include a PNP of 40.0 msl (15 percent chance of failure) and a PFP of 42.5 msl (85 percent chance of failure) as the next failure point is on the Colusa Basin Drain between channel mile 10.2 to 12.0 Left. The projected breakpoint levee crown for preproject and postproject is about 43.0 msl for the Colusa Basin Drain reach that includes Site B.

The hydrologic information for Site B uses the gage at the Colusa Basin Drain at Knights Landing. The water-surface elevation of the Colusa Basin Drain depends mostly on the stage of the Yolo Bypass rather than on flows in the Colusa Basin Drain.

AREA 3

Potential failure sites for Area 3 consist of two sites on the Sacramento River, Site D at Sacramento River channel mile 119.1 to 119.6 Right with 2,700 linear feet and Site E at Sacramento River channel mile 140.0 to 143.17 Right with 16,700 linear feet. Deficiencies are due to sandy levees which have seepage problems and the potential for levee failures due to piping.

The primary potential for failure is at Site E adjacent to Colusa. A break at the west end of Site E would inundate much of the City of Colusa, especially newly constructed areas east and south of the old town. The old town of Colusa is elevated and was not inundated in the 1907 flood, but was surrounded by floodwaters. During the 1986 flood seepage occurred at Site E, which peaked at 1.5 feet below the design elevation and 4.5 feet below design plus freeboard (this reach has 3 feet of authorized freeboard). A previous levee break occurred at Sacramento River channel mile 141.1 Right (within Site E) before the Federal flood control system was in place. For the purpose of this economic evaluation a preproject PNP of 65.0 msl (15 percent chance of failure) is based on the 1986 flood. A preproject PFP of 66.0 msl (65 percent chance of failure) at the top of design plus freeboard is used for Site E.

The postproject PNP for the Sacramento River reach of Area 3 is 59.5 msl (10 percent chance of failure) and the post-project PFP is 62.5 msl (40 percent chance of failure) at Sacramento River mile 131.0 Right. The preproject breakpoint levee crown is 66.7 msl at Site E. The postproject breakpoint levee crown, 64.0 msl for the Sacramento River reach, at channel mile 131.0 Right.

The left bank levee crown on the Sacramento River opposite Site E and most of this reach is generally 2 to 4 feet lower than the right levee crown so it is almost impossible to overtop the Site E levee. Site E is just downstream from the Colusa Bypass which controls flow splits from the Sacramento River to the Butte Basin.

The Colusa gaging station was used to determine hydrologic information for Site E. Gages were adjusted to Sacramento River channel mile 131.0 for postproject conditions.

Site D is a sandy levee located at a right angle to a bend in the Sacramento River. This site has a levee setback and has been riprapped three times due to erosion. During the 1986 flood, seepage occurred at this site. Site E is used for the analysis of Area 3 for the preproject conditions.

The Colusa Basin Drain is located on the west side of Area 3, but has no sites recommended for reconstruction. Failures on the Sacramento River side are more likely than on the Colusa Basin Drain, so no further PNP or PFP analyses were made.

TABLE 1

PNPs AND PFPs
UPPER SACRAMENTO AREA, PHASE V,
SACRAMENTO RIVER SYSTEM EVALUATION
PRE-PROJECT (CHANCE/FAILURE) POST- PROJECT (CHANCE/FAILURE)

AREA I

SITE A Colusa Drain 1.4-4.5L

PNP 35.0 MSL (15%)
PFP 38.5 MSL (85%)
TOP OF LEVEE 43.0 MSL

gage: Colusa Drain at Knights Landing

breaks @ Sac River 95.0R

41.7 MSL (15%)
42.5 MSL (85%)
43.0 MSL

*gage: adjust to RM 95.0 Sac River, from
Sac River at Knights Landing*

AREA 2

SITE B Colusa Drain 4.6-10.1L

PNP 35.0 MSL (15%)
PFP 38.5 MSL (85%)
TOP OF LEVEE 43.0 MSL

gage: Colusa Drain at Knights Landing

breaks @ Sac River 104.3R

45.8 MSL (10%)
46.5 MSL (90%)
47.5 MSL

*gage: adjust to RM 104.3 Sac River at
Knights Landing/Sac River at Wilkins Slough
near Grimes*

AREA 3

SITE E breaks @ Sac River 143.0R

PNP 65.0 MSL (15%)
PFP 66.0 MSL (65%)
TOP OF LEVEE 66.7 MSL

gage: Colusa at Sac River

breaks @ Sac River 131.0R

59.5 MSL (10%)
62.5 MSL (40%)
64.0 MSL

gage: adjusted Colusa gage to RM 131.0