

CACHE CREEK SETTling BASIN, Yolo County, California

Request to USACE for a Reconnaissance Study

Board Package Documents

CVFPB Meeting: March 22, 2013

Agenda Item 7B

Resolution No. 2013-05

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**Meeting of the Central Valley Flood Protection Board
March 22, 2013**

**Staff Report
Resolution 2013 - 05**

**Approval of Letter to USACE requesting
Section 905(b) / Reconnaissance Study
for
Cache Creek Settling Basin,
Yolo County, Woodland Area, California**

1.0 ITEM

Consider approval of a letter from the Central Valley Flood Protection Board (Board) to the United States Corps of Engineers (USACE) requesting the initiation of a Section 905(b) Reconnaissance Study related to future planned improvements to the Cache Creek Settling Basin (CCSB), including raising the outlet weir.

2.0 SPONSORS

State: The Central Valley Flood Protection Board (Board)

3.0 LOCATION

The CCSB is located at the terminus of Cache Creek in Yolo County where it enters the Yolo Bypass and eventually flows into the Sacramento River. Cache Creek originates at Clear Lake in Lake County and flows generally southeasterly through the Capay Valley and into the CCSB before entering the Yolo Bypass. The outfall of the CCSB is located approximately 15 miles northwest of Sacramento.

4.0 PROJECT DESCRIPTION:

It is the intent of this requested action item that the Board authorize a letter addressed to USACE, Sacramento District, requesting that USACE conduct a Reconnaissance Study (also known as Reconnaissance Report / Section 905(b) Analysis) for the CCSB.

A Reconnaissance Study is the first step in the USACE process to begin a project that potentially includes federal assistance. Upon completion of a Reconnaissance Study, and if it is determined that there is sufficient federal interest, the project would progress to a Feasibility Study phase where flood risk reduction alternatives are analyzed and a project is recommended. Ultimately, a Chief's Report is presented to Congress for authorization for the project design and construction phase.

5.0 PROJECT BACKGROUND

The CCSB is an existing State Plan of Flood Control facility constructed in 1937 by USACE to preserve the flood-way capacity of the Yolo Bypass. Located at the terminus of Cache Creek, its fundamental purpose is to preserve the flood-way capacity of the Yolo Bypass by entrapping the heavy sediment load carried by Cache Creek before its waters release into the Yolo Bypass. The facility was re-authorized in 1987 and improved in 1992/1993 to enlarge the basin to its current sediment management capacity with a new, relocated western levee and the construction of the current weir at a release elevation of 32.5 feet (NGVD 29). Additionally, the authorized plan of improvement described in the 1987 Final General Design Memorandum (GDM) included raising the weir by 6 feet to an elevation of 38.5 feet at year 25 of the project life based on the anticipated rate of sedimentation within the basin. Although raising the weir by 6 feet is identified as a part of the authorized CCSB modification described in the GDM, the weir raise and any improvements to improve or increase basin efficiency, would require review and validation through further study and updated environmental evaluations. In order to complete these studies with federal support, a USACE reconnaissance study is necessary to establish if there is federal interest in performing a feasibility study.

5.1 PREVIOUS BOARD ACTIONS

Date: _____ Action: _____

Related Project:
February 25, 2011

The Board Approved a Feasibility Cost Sharing Agreement and a new Local Feasibility Cost Sharing Agreement (LCCFS) for the Lower Cache Creek Feasibility Study. The purpose of this Feasibility Study is to investigate the feasibility of increasing the level of flood protection for the City of Woodland, Town of Yolo and adjacent communities.

While the study will investigate whether or not the basin is contributing to flood risk in the City of Woodland, the intent of the LCCFS is to be independent of specific issues related to the CCSB.

5.2 PROJECT BENEFITS

Several benefits of approving this letter request to USACE include:

- The letter officially notifies USACE of the State's interest in reviewing the current status of the CCSB and determining necessary improvements to maintain proper function.

- The letter fulfills the requirement for USACE to initiate a Reconnaissance Study for further work previously authorized. The 1987 GDM specified a 25 year target date for a 6-foot increase to the height of the weir. Based on the completion date of the previous improvements in 1993, 2018 was the anticipated target date for the 25 year “trigger” to begin the next phase of improvements to the basin.
- The letter will initiate a USACE Reconnaissance Study which will be 100% federally funded up to \$100,000 and typically completed within 1-year.

5.3 STAFF ANALYSIS

It is appropriate that the Board, as the lead agency representing the State of California, take this opportunity to request the assistance of USACE under Section 905(b) of the Water Resources Development Act of 1986.

The 1987 GDM, prepared by USACE, indicated that additional work would likely be required after 25 years of operation, or after the sediment trap efficiency dropped below 30%. That phase of construction was completed in 1993 and the current configuration of the Basin has now been operating for approximately 20 years. Based on the amount of time it takes to initiate and complete a feasibility study and obtain federal authorization and allocation, it would not be premature to begin the Reconnaissance Study now.

It is assumed the Reconnaissance Study will address the composition of the trapped sediments within the CCSB. While the 1987 GDM did not authorize the CCSB to manage mercury, it is widely believed that the basin’s current configuration significantly reduces the total mercury load to the Yolo Bypass, Delta and San Francisco Bay.

Significant issues likely to be considered during this study and/or subsequent studies include:

1. Possibility of greater extent and depth of flooding of land within and adjacent to the City of Woodland due to changes in CCSB topography
2. Requirements to re-accredit previously de-accredited urban levees forming the CCSB
3. Improving sediment trapping efficiency of the CCSB
4. Managing mercury and methylmercury within the CCSB to reduce mercury loads entering the Yolo Bypass
5. Other possible environmental considerations
6. Sustainable solutions

Reconnaissance Studies - Authorized under Section 905(b) of the Water Resources Development Act of 1986, Reconnaissance Studies are intended to define water resource problems and identify solutions to decide if there is Federal interest in implementing solutions to flooding, ecosystem and other related water resource problems. Studies are typically completed within 12 months from initial obligation of funds to signing of the Feasibility Cost Sharing Agreement (FCSA). During the initial period of the study, the Section 905(b) Analysis Report is prepared, then in the following months, a Project Management Plan and FCSA are negotiated with the Non-federal sponsors and the FCSA is prepared for approval by USACE Headquarters and the sponsors. Reconnaissance Studies are 100% Federal cost, up to \$100,000.

Goals of a Reconnaissance Study -

- Define the Federal interest consistent with USACE policy, costs, benefits, and environmental impacts;
- Complete a 905(b) Preliminary Analysis Report;
- Determine if the water resource problem warrants Federal participation in a feasibility study;
- Prepare a Project Study Plan;
- Assess the level of interest and support from Non-federal entities in cost-sharing a feasibility study and project construction. Obtain a letter of intent from the local sponsor;
- Negotiate and execute a Feasibility Cost Sharing Agreement.

The Section 905(b) Analysis Report - This report is used as a basis for making a decision to proceed or not to proceed into the feasibility phase. The report will be submitted to USACE Headquarters for review and approval as early as possible in the recon phase. The report typically includes:

- Study Authority
- Study Purpose
- Location of Project
- Discussion of prior studies, reports, and existing water projects
- Plan Formulation
 - Identified problems
 - Alternative plans
- Evaluation of alternatives
- Determination of Federal Interest
- Preliminary Financial Analysis
- Summary of Feasibility Study Assumptions
- Feasibility Study milestones
- Feasibility Study Cost Estimate
- Recommendations
- Issues
- Views of other Resource Agencies

- Project Area Map

Plan formulation, evaluation of alternatives, and preliminary financial analysis use existing information and are not detailed analysis, the detailed analysis is performed in the feasibility phase.

Project Management Plan (PMP) - The Reconnaissance Study will result in a PMP which will guide the development and preparation of the feasibility study and is utilized in cost shared feasibility study negotiations. This plan is collaboration between the Sponsor and the Corps. The PMP will include a detailed description of the project, a breakdown of feasibility study work activities and responsibilities, draft schedules and cost estimates, coordination procedures and a quality control plan.

6.0 AUTHORIZATIONS

Federal: The project for flood control, Cache Creek Basin, California was authorized for construction by the Water Resources Development Act (WRDA) of 1986; Public Law 99-662, November 17, 1986. The project was authorized substantially in conformance with the plans and subject to the conditions recommended in “Cache Creek Basin, California: Report of the Chief of Engineers, dated April 27, 1981”

Flood Control Act of 1962, Section 209 (Public Law 87-874)

State: California Water Code Section 8361(m), 8615 and 12616.

7.0 STAFF RECOMMENDATION

Staff recommends approval of Resolution 2013-05 authorizing the subject letter to USACE to initiate the Section 905(b) / Reconnaissance Study process for improvements to the CCSB.

8.0 LIST OF ATTACHMENTS

- A. Resolution 2013-05
- B. Letter addressed to Colonel Leady, USACE
- C. Location Map – Basin Location
- D. PowerPoint Presentation
- E. Reference Document - Cache Creek Basin, California; Final General Design Memorandum, USACE, January, 1987

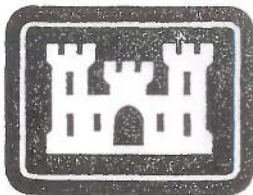
DESIGN MEMORANDUM NO. 1

CACHE CREEK BASIN, CALIFORNIA

CACHE CREEK SETTLING BASIN

FINAL

**GENERAL DESIGN
MEMORANDUM**



**US Army Corps
of Engineers**

Sacramento District

See page 3-21

JANUARY 1987

the low flow outlet structure and weir outlet discharge ratings (shown in Figures 3-06 and 3-05, respectively) and the stage-capacity curve of the basin (shown in Figure 3-07), an estimate was made of the time required to drawdown the basin storage to elevation 26.0 feet, the low flow outlet invert elevation.

Assuming no inflow from Cache Creek, the drawdown time would be approximately 6 days. Assuming an average inflow of 100 cfs from Cache Creek, the drawdown time would be approximately 10 days. Both estimates assume no tailwater in the low flow outlet channel (i.e. Yolo Bypass), and would be longer if tailwater were present. During the period of drawdown, the basin would most likely dewater from the upstream to the downstream ends (depending on basin contours). Thus, not all project levees would be impounding water for the full duration of the drawdown period.

c. The low flow channel system would have four basic functions. First, direct the low flows from the training channel to the low flow outlet structure during periods of low sediment transport. Second, transport flows from the Woodland Pumping Facility to the low flow structure. Third, collect ponded water in the greater basin area and transport those flows to the outlet structure. And finally, drain ponded water which has collected behind the outlet weir. For a description of the low flow system, see paragraph 5-02.b.

d. Sediment Management Plan. - The sediment management plan would consist of the incrementation of the outlet weir, the construction of a training channel and training levee, and scheduling partial removal of the training levee. For a description of training levee removal, see paragraph 3-05.d.2.

1) Outlet Weir Construction. - The outlet weir would be initially constructed to a crest elevation of 32.5 feet as developed using the procedure described in paragraph 3-04.b. At year 25 of the project life, or when a measured trap efficiency of less than 30% is realized, (Refer to paragraph 3-05.d.3, Monitoring Plan) the weir would be raised to a crest elevation of 38.5 feet, the final weir height. Determination of the measured trap efficiency and departures from this weir incrementation plan shall result from a joint effort between the non-Federal sponsors and the Corps of Engineers. The timing of weir incrementation is based on the computed trap efficiency versus time plot as shown in Figure 3-21. This plot was based on incrementing the weir at year 25. Although the plot reveals deviations from the desired trap efficiency range, the average trap efficiency for the life of the project is approximately 55%.

Figures 3-22 through 27 shows the basin topography at 10 year increments. Although a "flat" basin topography is not achieved, the average annual trap efficiency is sufficiently close to the design objective. See Plate X for the outlet weir details.

2) Training Levee and Training Channel. - The training channel and training levee would direct flood flows down into the greater basin area thereby releasing sediments away from the upper channel region. The channel and levee would extend the "effective" Cache Creek down into the basin to Station 163+00LFMR as shown on Plate VI. During years 25-45 of the project

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STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
THE CENTRAL VALLEY FLOOD PROTECTION BOARD

RESOLUTION 2013-05

APPROVAL OF LETTER ADDRESSED TO THE
UNITED STATES ARMY CORPS OF ENGINEERS
REQUESTING INITIATION OF A SECTION 905(b) / RECONNAISSANCE STUDY
FOR THE
CACHE CREEK SETTLING BASIN, YOLO COUNTY, CALIFORNIA

WHEREAS, as a part of the Sacramento River Flood Control Project, authorized by the Flood Control Act of 1917, and as modified by the Acts of 1928, 1937 and 1941, the United States Army Corps of Engineers (USACE) completed construction of the Cache Creek Settling Basin (Basin) in 1937; and

WHEREAS, the Basin's fundamental purpose is to preserve the flood-way capacity of the Yolo Bypass by entrapping the heavy sediment load carried by Cache Creek; and

WHEREAS, Congress authorized the USACE to conduct a study of flood control pursuant to Section 209 of the Federal Flood Control Act of 1962 (Public Law 87-874); and

WHEREAS, Congress authorized the USACE pursuant to Water Resources Development Act of 1986 (Public Law 99-662), House Document No.98-134 to construct improvements to Cache Creek Settling Basin, Yolo County, California subject to the conditions recommended in "Cache Creek Basin, California: Report of the Chief of Engineers", dated April 27, 1981; and

WHEREAS, Central Valley Flood Protection Board (Board) participation in the Study is authorized by Water Code section 8615; and

WHEREAS, the "Cache Creek Basin, California: Final Design Memorandum", dated January 1987 authorized future improvements to the Cache Creek Settling Basin, including raising the outlet weir by 6' at year 25 of the project life or when a measured trap efficiency of less than 30% is realized, and "Year 25" would be 2018; and

WHEREAS, a letter from the Non-federal Sponsor to USACE is required to formally request a Reconnaissance Study be initiated under Section 905(b) of the Water Resources Development Act of 1986.

NOW, THEREFORE, BE IT RESOLVED that the Board:

1. Approves the Letter addressed to the United States Army Corps of Engineers requesting the initiation of a Section 905(b) / Reconnaissance Study for improvements to the Cache Creek Settling Basin; and
2. Delegates to the Central Valley Flood Protection Board Executive Officer the authority to sign the letter in substantially the form attached hereto.

PASSED AND ADOPTED by vote of the Board on _____, 2013.

BY: _____
William H. Edgar
President

Date: _____

BY: _____
Jane Dolan
Board Secretary

Date: _____

Approved as to Legal Form and Sufficiency

Jeremy Goldberg, Staff Counsel

CENTRAL VALLEY FLOOD PROTECTION BOARD

3310 El Camino Ave., Rm. 151
SACRAMENTO, CA 95821
(916) 574-0609 FAX: (916) 574-0682
PERMITS: (916) 574-2380 FAX: (916) 574-0682



March 22, 2013

Colonel William J. Leady
District Engineer
U. S. Army Corps of Engineers
Sacramento District
1325 J Street, Room 1008
Sacramento, California 95814-2922

Request for Section 905(b) Reconnaissance Study;
Cache Creek Settling Basin, Yolo County, California

Dear Colonel Leady,

The Central Valley Flood Protection Board (Board), representing the State of California, would like to take this opportunity to request the assistance of the U.S. Army Corps of Engineers (USACE) under Section 905(b) of the Water Resources Development Act of 1986. Specifically, the State requests a Reconnaissance Study for necessary improvements to the Cache Creek Settling Basin (CCSB) in Yolo County, California.

The settling basin is an existing State Plan of Flood Control facility, initially constructed in 1938 by USACE. It is located at the terminus of Cache Creek and provides a means for suspended sediments to settle out from Cache Creek before it releases into the Yolo Bypass and eventually into the Sacramento River. The facility was re-authorized in 1987 and improved in 1992 to enlarge the basin to its current sediment management capacity of 30,000 cubic feet per second with a new, relocated western levee and the construction of the current weir at a release elevation of 32.5 feet (NGVD 29). Additionally, the 1987 Final General Design Memorandum (GDM) proposed and authorized raising the weir by 6 feet to an elevation of 38.5 feet by 2017 based on the anticipated rate of sedimentation within the basin. Although raising the weir by 6 feet is identified as a part of the authorized CCSB modification described in the GDM, USACE indicated the weir cannot be raised without first performing an environmental analysis.

While the 1987 GDM did not authorize the CCSB with the intention of managing mercury, it is widely believed that the basin's current configuration significantly reduces the total mercury load to the Yolo Bypass, Delta and San Francisco Bay.

It will be important to address certain issues of significance in this study before commencing any new design or construction work. Issues likely to be considered and studied further in the requested Reconnaissance Study and subsequent studies include:

Colonel William J. Leady

March 22, 2013

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1. Possibility of greater extent and depth of flooding of land within and adjacent to the City of Woodland due to changes in CCSB topography.
2. Requirements to re-accredit previously de-accredited urban levees forming the CCSB.
3. Improving sediment trapping efficiency of the CCSB
4. Managing mercury and methylmercury within the CCSB to reduce loads entering the Yolo Bypass.
5. Other environmental considerations.

The Board looks forward to the decision by USACE to commence the requested Reconnaissance Study and will offer its support as necessary.

If you have questions, please contact me or Michael Sabbaghian at (916) 574-1404 or Mahyar.Sabbaghian@water.ca.gov.

Sincerely,

Jay S. Punia, Executive Officer
Central Valley Flood Protection Board

cc: (See attached list.)

cc: Alicia Kirchner, Chief
Planning Division
Sacramento District
U. S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814

Linda Finley
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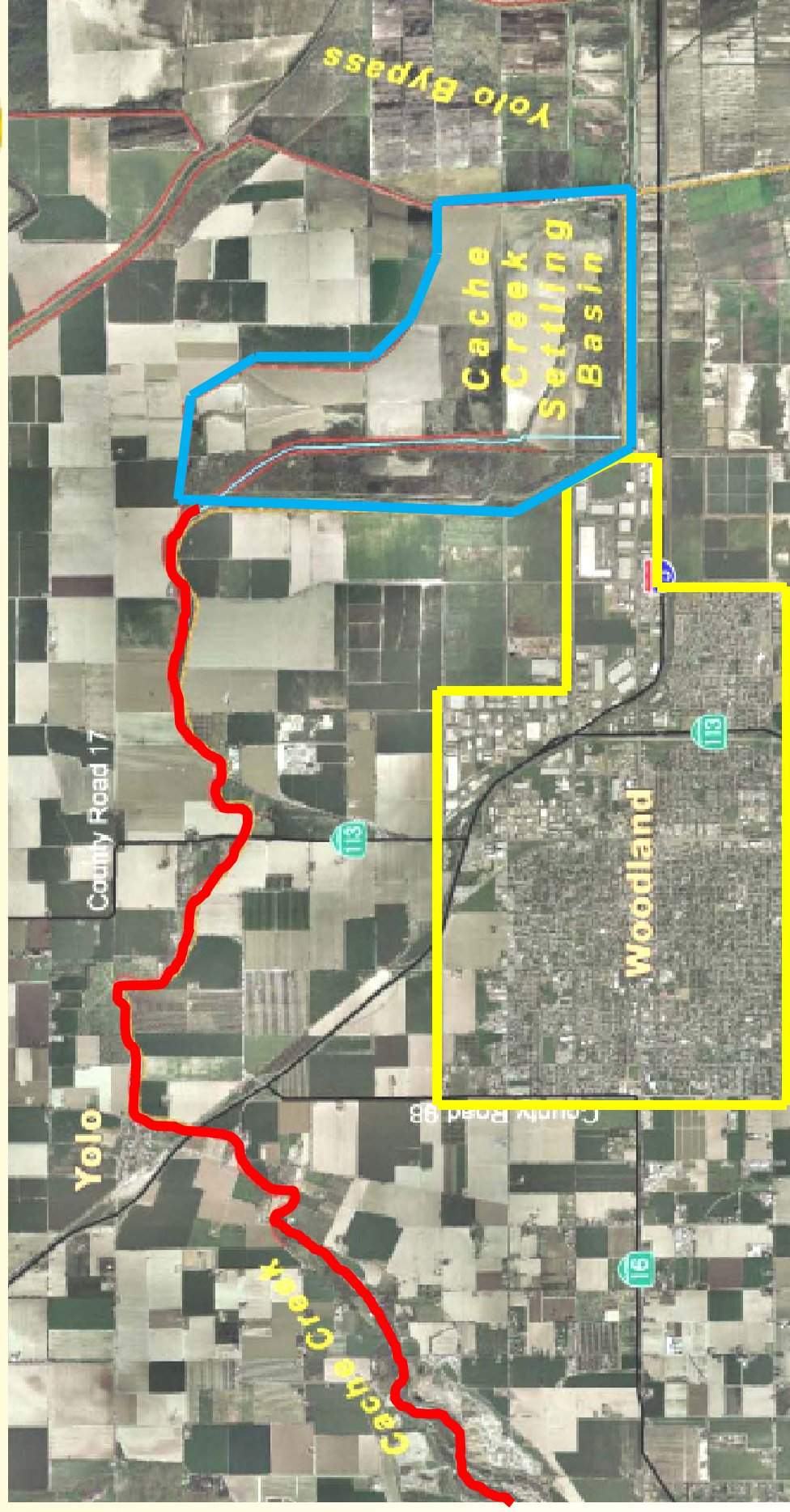
Department of Water Resources
Division of Flood Management
Flood Projects Office
3464 El Camino Avenue, Suite 200
Sacramento, California 95821

Robert E. Scarborough, P.E., Chief
CVFPB/USACE Studies Section

Paul R. Larson, P.E.
Project Manager
CVFPB/USACE Studies Section

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Basin Location



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Cache Creek Settling Basin

Request for USACE Reconnaissance Study

Resolution No. 2013-05

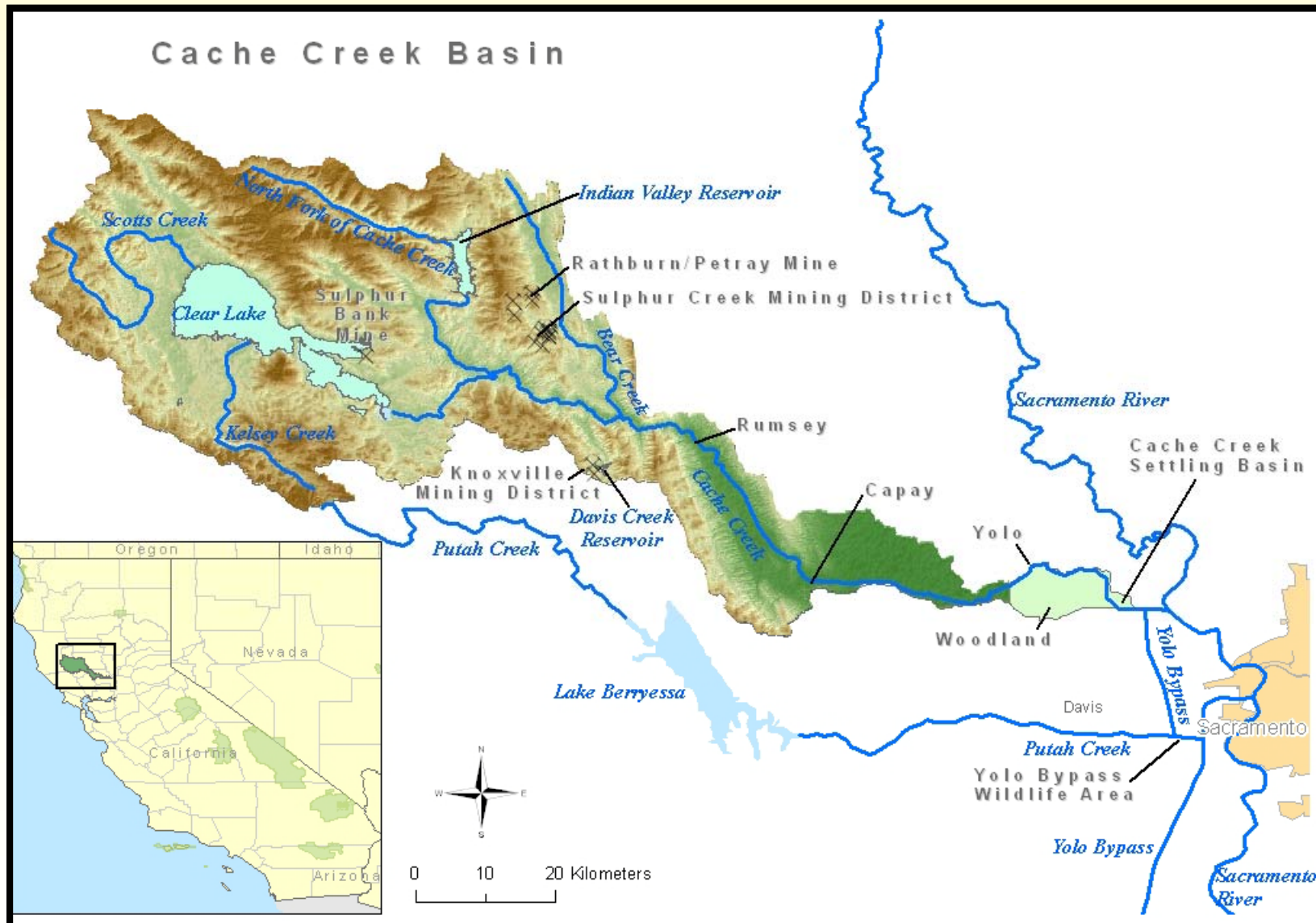
Paul R. Larson, PE
Project Manager
USACE / CVFPB
Studies Section

Agenda Item 7B
March 22, 2013

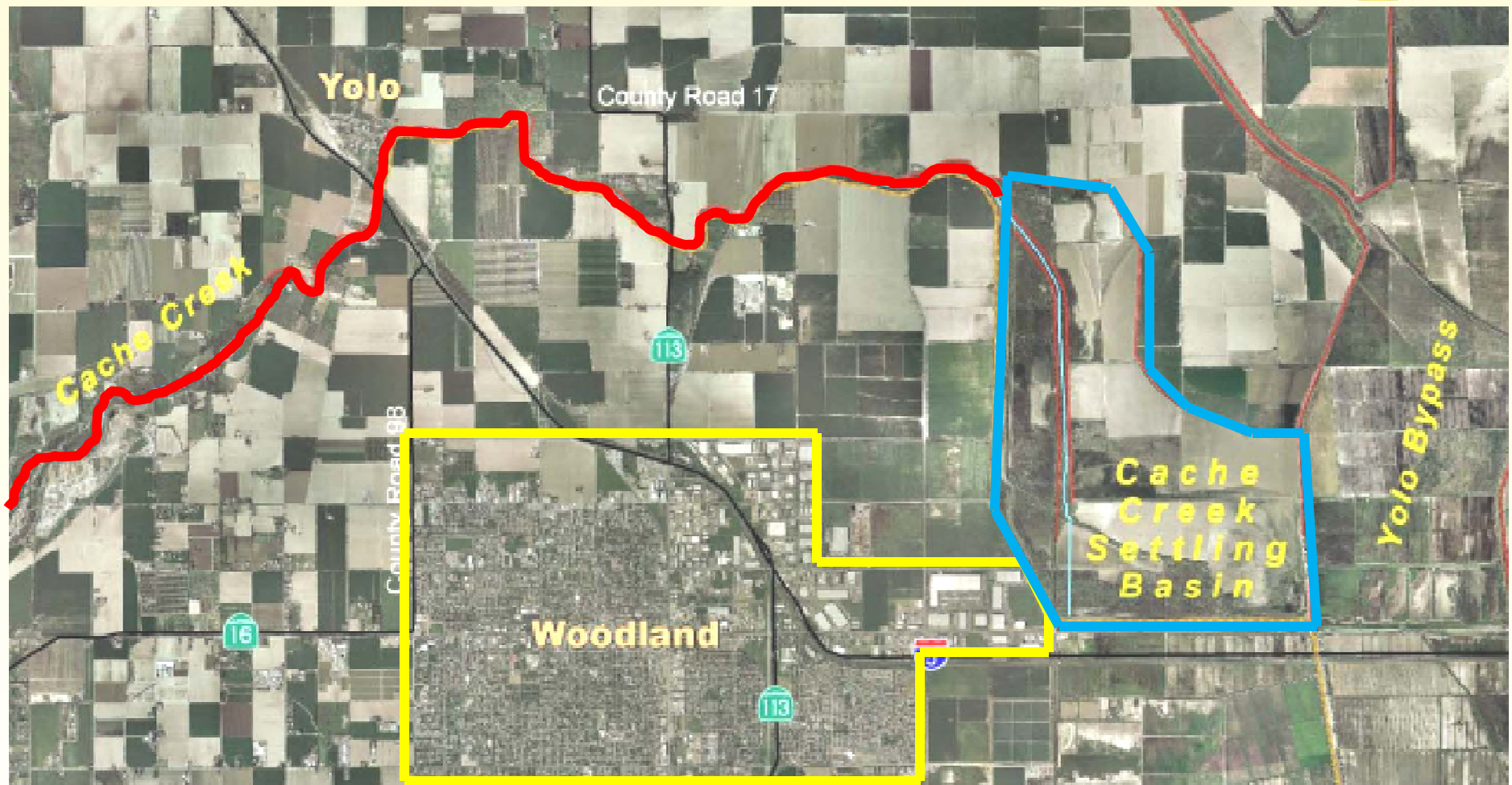


Requested Board Action

1. Approve the Letter addressed to the United States Army Corps of Engineers requesting the initiation of a Section 905(b) / Reconnaissance Study for improvements to the Cache Creek Settling Basin; and
2. Delegate to the Central Valley Flood Protection Board Executive Officer the authority to sign the letter in substantially the form attached hereto.



Basin Location



History of the Cache Creek Settling Basin

- The Settling Basin was initially constructed in 1937
- Current basin configuration was completed in 1993 by USACE to add 50 additional years of sediment storage capacity
- Basin area is 3600 acres
- Current weir is 1,740 feet long, 12 feet high – spills directly into the Yolo Bypass
- Design Flow Rate of 30,000 cfs (15-25 year return interval)
- USACE 1987 Final General Design Memorandum recognized that raising weir by 6' should be considered at year 25 (2018) OR when a measured sediment trapping efficiency of less than 30% was realized



Reconnaissance Studies:

- Are authorized under Section 905(b) of the Water Resources Development Act of 1986 (WRDA)
- Are requested by a local agency (Non-federal sponsor)
- Are typically performed and financed 100% by USACE
- Result in a determination of federal interest to advance the issue into a feasibility study phase.
- Negotiate with Non-federal sponsors for a Feasibility Cost-Share Agreement (FCSA)
- Result in a Project Management Plan (PMP) for a Feasibility Study, including Budget, Schedule and Work Plan



Staff Recommendation

Staff recommends approval of Resolution 2013-05 to:

1. Approve the Letter addressed to the United States Army Corps of Engineers requesting the initiation of a Section 905(b) / Reconnaissance Study for improvements to the Cache Creek Settling Basin; and
2. Delegate to the Central Valley Flood Protection Board Executive Officer the authority to sign the letter in substantially the form attached hereto.



Questions

CVFPB:

Paul Larson, PE
Project Manager

(916) 574-1050

Paul.Larson@water.ca.gov

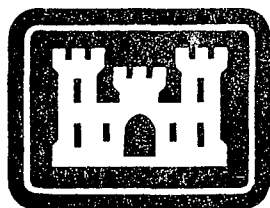
DWR:

Fred Gius

Senior Engineering Geologist
Flood Maintenance Office

Frederick.Gius@water.ca.gov



CACHE CREEK BASIN, CALIFORNIA**CACHE CREEK SETTLING BASIN****FINAL****GENERAL DESIGN
MEMORANDUM****US Army Corps
of Engineers****Sacramento District**

JANUARY 1987



DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO
ATTENTION OF

SPKED-D

29 January 1987

SUBJECT: Cache Creek Basin, California - General Design Memorandum No. 1;
Cache Creek Settling Basin

Commander, South Pacific Division

1. Reference SPKED-D 13 June 1986 letter, subject: "Cache Creek, California- Cache Creek Settling Basin; Draft General Design Memorandum No. 1," forwarding draft General Design Memorandum for review, and SPDED-PC 29 August 1986 1st End. thereto, providing comments on the draft document.
2. Submitted for review and approval are 20 copies of the subject design memorandum in accordance with ER 1110-2-1150. The GDM is the basis of design for the Cache Creek Settling Basin element of the Cache Creek Basin project. A separate and independent GDM covering the basis of design for the Clear Lake Outlet Channel element of the project is being prepared and will be submitted for approval at a later date.
3. The GDM has been revised in accordance with SPD comments provided in the referenced correspondence. A summary of SPK actions in response to SPD comments is provided in Enclosure 2.
4. A draft Local Cooperation Agreement will be coordinated with the local project sponsor and forwarded for approval at a later date.

- 2 Encls
1. GDM (20 cys)
 2. Responses

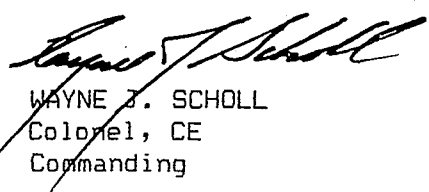

WAYNE J. SCHOLL
Colonel, CE
Commanding

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<u>No.</u>	<u>Plates</u>
I (1)	General Plan
II (1)	Basin Feature Plan
III (1-3)	Profile - Levees

LIST OF PLATES (Cont'd)

<u>No.</u>	<u>Plates</u>
IV (1-2)	Typical Sections - Levees
V (1)	Levee Details
VI (1)	Low Flow System Feature Plan
VII (1-2)	Low Flow System Details
VIII (1-4)	Profile - Low Flow and Training Channels
IX (1-2)	Typical Sections - Low Flow System
X (1)	Weir and Drop Structure Stability Analysis
XI (1)	Conduit and Riser Unit Stability Analysis
XII (1)	Location of Potential Borrow
XII (2-11)	Logs of Explorations
XII (12-15)	Summary of Test Results
XII (16)	Stability Analysis - End of Construction

LIST OF EXHIBITS

<u>No.</u>	<u>Exhibits</u>
1	Final Environmental Assessment and Finding of No Significant Impact, U.S. Fish and Wildlife Service Planning Aid Letter
2	Correspondence
3	Relocation Estimate

LIST OF ABBREVIATIONS

NL	North Levee
SL	South Levee
EL	East Levee
WL	West Levee
TC	Training Channel and Training Levee
LFMR	Low Flow Channel Main Reach
LFSI	Low Flow Channel - Subreach I
LFSII	Low Flow Channel - Subreach II

The perimeter levees and the low flow channel components, as well as the combined training levee and training channel are stationed independently. When a station is referenced for a particular feature, it will be followed immediately by the distinguishing abbreviation i.e. Station 10+00NL which is Station 10+00 on the north perimeter levee.

CACHE CREEK BASIN, CALIFORNIA
CACHE CREEK SETTLING BASIN
GENERAL DESIGN MEMORANDUM NO. 1

PERTINENT DATA

1. General Data.

Authorization	Water Resources Development Act of 1986 (Public Law 99-662)
Project Document	House Document No. 98-134 98th Congress, 1st Session
Stream	Cache Creek
Purpose	Flood Control
Location	Yolo County, California

2. Project Design Flow.

30,000 cfs

3. Levees.

Total Length	14.0 Miles
Maximum Height Increase	13.7 Feet
Average Height Increase	12 Feet
Crown Width	12 Feet
Freeboard	
Perimeter Levee	4 Feet
Training Levee	2 Feet
Landside Slope	1V on 2H
Waterside Slope	1V on 3H
Patrol Road	
Length	14.0 Miles
Width	10 Feet

4. Stone Protection.

Length	3300 Feet
Thickness	12 Inches
Slope	1V on 3H

5. Local Cooperation.

Lands (Easements)	3,600 Acres
Relocations	
Powerline Protection	1 Each
Pumping Plant Modification	1 Each

CACHE CREEK BASIN, CALIFORNIA
CACHE CREEK SETTLING BASIN
GENERAL DESIGN MEMORANDUM NO. 1

PERTINENT DATA
(CONTINUED)

6. Costs.

First Cost (1 Oct. 86 Price Level)	
Construction	\$14,500,000
LERR	<u>4,300,000</u>
Total Project First Cost	\$18,800,000
Total Federal First Cost (1 October 1986 Price Level)	
Construction	\$14,500,000
Non-Federal Contribution	<u>-940,000</u>
	\$13,560,000
Total Non-Federal First Cost (1 October 1986 Price Level)	
LERR	\$4,300,000
Non-Federal Contribution	<u>+940,000</u>
	\$5,240,000
Stage Construction (1 October 1986 Price Level)	\$430,000
Total Project Annual Cost (8-7/8% Interest, 50-Year Amortization)	\$1,852,000

7. Justification.

Average Annual Benefits	\$2,682,000
Benefit-Cost Ratio	1.4

CHAPTER 1 - INTRODUCTION

1-01. Authorization. - The project for flood control, Cache Creek Basin, California was authorized for construction by the Water Resources Development Act of 1986, Public Law 99-662, 17 November 1986. The project was authorized substantially in accordance with the plans and subject to the conditions recommended in "Cache Creek Basin, California: Report of the Chief of Engineers, dated April 27, 1981" (House Document No. 98-134), except that in lieu of constructing the recommended bypass channel, the Secretary shall accomplish the purposes of the project by removing the rock formation at the outlet channel and widening and deepening the channel in accordance with Alternative 8 as described in the Feasibility Study of the District Engineer dated August 1979. The Secretary shall act in coordination with the State of California to assure that such project poses no danger to any component of its State park system.

1-02. PURPOSE AND SCOPE. - The purpose of this report is to present the results of engineering studies and investigations prior to preparing plans and specifications for construction. This GDM provides the basis for local interest and cost sharing agreements; preparation of plans and specifications; acquisition of lands, easements and rights-of-way; accomplishment of relocations; and operation and maintenance. The basis of design for the project is outlined, cost and benefit data are presented, and requirements of local cooperation are explained. This GDM pertains exclusively to the Lower Basin element (Cache Creek Settling Basin) of the proposed project. A separate and independent GDM on the Upper Basin element (Clear Lake Outlet Channel) is being prepared and will be published at a later date.

1-03. DESCRIPTION OF EXISTING PROJECT. -

a. As part of the Sacramento River Flood Control Project, authorized by the Flood Control Act of 1917, as modified by the Acts of 1928, 1937, and 1941, the Corps of Engineers completed construction of the Cache Creek Settling Basin in 1937. The settling basin, located in Yolo County about 2 miles east of Woodland, is bounded by levees on all sides and covers approximately 3,600 acres. The basin's fundamental purpose is to preserve the flood-way capacity of the Yolo Bypass by entrapping the heavy sediment load carried by Cache Creek. Throughout the life of the project, internal "training" levees have been manipulated to partly control sediment deposition and make best use of basin storage. See Plate I for an overview of the existing system. Following is a brief history of development of the basin.

b. As previously mentioned, the initial project levee construction was accomplished in 1937 when training levees, which also constituted the levees along the northern edge of the basin, were constructed. The southern levee along the Sacramento Northern Railroad track was constructed in 1940, and the "Cobble Weir" was constructed in 1944. A levee was not built on the western boundary of the basin because rights-of-way were acquired only to the 32-foot contour, USGS Datum. This was considered to be the westerly limit to which waters would spread.

c. In 1940, the west training levee originally constructed in 1937, was moved 400 feet to the west, and in 1950 the training levees existing at present were constructed. In 1943 levees were constructed along Cache Creek from the mouth of the settling basin to Yolo, providing for a capacity of 20,000 cfs. In 1961, these levees were extended approximately 3 miles upstream of the town of Yolo, and the entire settling basin levee system was strengthened to convey a design flow of 30,000 cfs. This work was authorized in "Design Memorandum No. 10 for the Sacramento River Flood Control Project, California, Cache Creek Yolo Bypass to High Ground Levee Construction" dated 1 November 1958. In the early 1970's, the State of California constructed a levee in two phases, to the west of the existing settling basin. Levee constructed in Phase I extended from the west end of the existing south perimeter levee to County Road 20, approximately 2,800 feet west of the existing west training levee. Construction during Phase II extended the levee completed in Phase I northward, terminating approximately 1,000 feet south of the existing settling basin project levee, maintaining the parallel alignment. In 1973, the Cobble Weir was raised 2 feet by the State of California to provide additional sediment storage capacity. Operation and maintenance responsibility for the settling basin, which is essentially filled with sediment, rests with the State of California.

1-04. DESCRIPTION OF AUTHORIZED PLAN OF IMPROVEMENT. - The authorized plan of improvement for the Lower Basin element of this project consists of enlarging and raising the existing perimeter levees of the Cache Creek Settling Basin an average of 12 feet to provide 50 years of sediment storage capacity and enlarging existing levees of the settling basin upstream to County Road 102. The Cobble Weir would also be reconstructed and enlarged. The existing training levees would be degraded and rebuilt adjacent to the western perimeter levee. Also, the entire 3,600 acres within the basin would be purchased in fee, and a National Wildlife Refuge would be established.

1-05. DESCRIPTION OF RECOMMENDED PLAN OF IMPROVEMENT. - In his 8 November 1983 letter transmitting the 27 April 1981 Report of the Chief of Engineers on Cache Creek Basin, California to Congress, the Assistant Secretary of the Army (Civil Works) (ASA(CW)) did not concur with the Chief of Engineer's recommendation that establishment of a National Wildlife Refuge within the Cache Creek Settling Basin be implemented by the Corps of Engineers. ASA(CW) stated that it would be appropriate for the U.S. Fish and Wildlife Service (USFWS) to consider implementation of the refuge under their authorities and programs. By letter dated 21 May 1986, the USFWS recommended that the Corps should pursue refuge implementation with the non-Federal sponsor. See Exhibit 1. The non-Federal sponsor has not expressed interest in implementing this feature. The plan recommended in this Design Memorandum does not include a wildlife refuge.

1-06. LOCAL COOPERATION. - The authorized local cooperation requirements for the Cache Creek Settling Basin element of the project are as follows:

- 1) pay 5 percent of the cost of the project assigned to flood control during construction of the project;

2) provide all lands, easements, rights-of-way, and dredged material disposal areas required only for flood control and perform all related necessary relocations;

3) operate and maintain flood control facilities after completion in accordance with regulations prescribed by the Secretary of the Army, and conduct sediment control operations in a manner compatible with wildlife enhancement;

4) hold and save the United States free from damages due to the construction and later maintenance of the flood control features of the project, not including damages due to the fault or negligence of the United States or its contractors;

5) publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to ensure compatibility between future development and protection levels provided by the project;

6) at least annually inform affected interests regarding the limitations of the protection afforded by the project; and

7) adjust all claims regarding water rights that might be affected by the sediment control improvements;

In addition to the requirements outlined above, the non-Federal sponsor will be required to conduct periodic surveys within the settling basin for sediment monitoring purposes and remove a portion of the training levee as described in paragraph 3-05.d.2 to ensure an optimized operation of the basin.

1-07. COORDINATION. - The plan presented in this report has been coordinated with the following agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service, California State Reclamation Board, California Department of Water Resources, California Department of Fish and Game, Yolo County, Yolo County Flood Control and Water Conservation District, and the City of Woodland. Coordination with local, state, and Federal agencies will continue throughout the design and construction phases of the project. Correspondence received in response to coordination of the June 1986 draft GDM is attached as Exhibit 2.

CHAPTER 2 - HYDROLOGY

2-01. PREVIOUS INVESTIGATIONS. - A detailed hydrologic analysis was performed for the approved Cache Creek Basin, California, Feasibility Report dated February 1979. This analysis used precipitation and runoff data for major floods in Cache Creek Basin of December 1964, January 1965, and January 1970. An additional source of data was the Cache Creek Basin Standard Project Flood Office Report prepared by the Sacramento District Corps of Engineers and approved by the Division Engineer, South Pacific Division, on 1 July 1974.

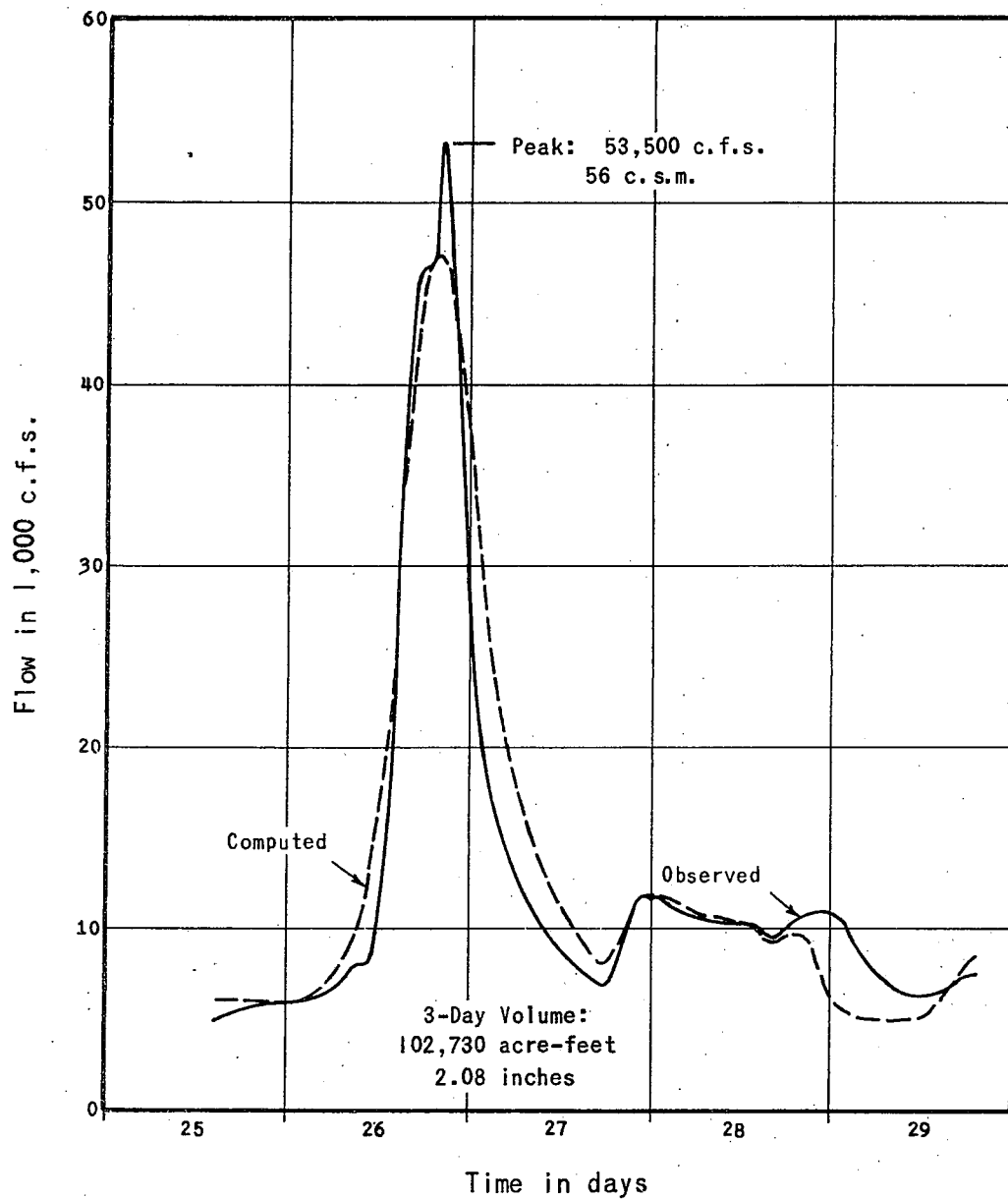
2-02. METHODOLOGY. - All methodology used in the prior hydrologic analysis was detailed in Sections C and E, Appendix 1 of the approved Cache Creek Basin, California, Feasibility Report dated February 1979. Discussion included development of standard project storms (SPS), unit hydrographs, loss rates, base flow, and computation of standard project floods (SPF).

2-03. NEW STUDIES. - In March 1985, the Sacramento District Corps of Engineers conducted a review of the hydrology contained in Sections C and E, Appendix 1 of the above referenced Feasibility Report. Since approval of the Feasibility Report, a rain storm of major proportions occurred in January 1983 which was centered over the ungaged area between Clear Lake Dam and Rumsey. The high magnitude of the resulting runoff from this storm made it apparent that a SPS centered over the same area should be investigated. Therefore, the review included the following: an update of historical streamflow data and lake stage records, an evaluation of the January 1983 storm and flood, checking previously adopted storm centerings, and an assessment of a standard project centering based on the January 1983 storm. Updated peak flow and volume data for gaging stations listed on Table 2-1 are shown on Table 2-2.

2-04. STUDY RESULTS. - Changes and additions were made to the following topics discussed in Section C, Appendix 1 of the referenced feasibility report to assess impacts of the January 1983 storm and flood on the lower Cache Creek Basin. They are:

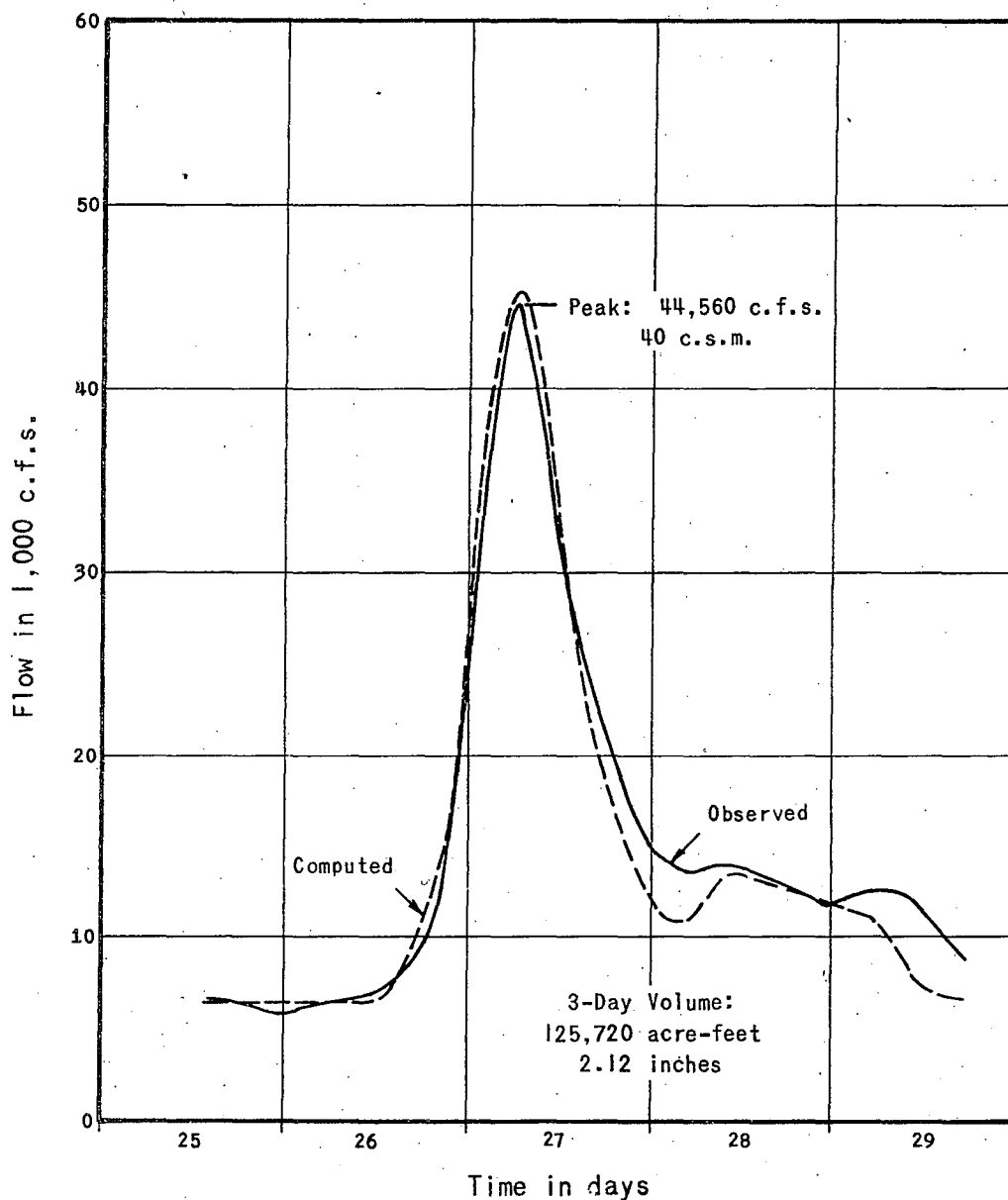
a. General. - In addition to those major floods mentioned in the referenced reports, rainfall and stream flow data of the January 1983 storm and flood were evaluated by reconstitution of this event to verify loss and routing parameters of the updated computer basin model for Cache Creek below the Grigsby Riffles. The January 1983 flood reconstitution hydrograph for Cache Creek at Yolo is shown on Figure 2-1.

b. Storm Analysis. - Basin mean precipitation for the January 1983 storm was estimated by using observed rainfall, and by assigning weights to total rainfall amounts of pertinent precipitation gages. This method is different from that used in referenced reports because a reliable isohyetal map could not be drawn due to insufficient rainfall data. Time distributions for the January 1983 storm amounts are based on precipitation gages at Clearlake Highlands, North Fork near Lower Lake, Hough Springs, PGE-Geysers 13/18, and Williams. Some stations listed on Table C-3 of the feasibility report were



Total Drainage Area: 955.0 Sq. Mi.
Tributary Drainage Area: 927.8 Sq. Mi.

CACHE CREEK BASIN, CALIFORNIA	
JANUARY 1983 FLOOD HYDROGRAPHS	
CACHE CREEK AT RUMSEY	
INDEX PT.-7	
U.S.G.S.-D.W.R. GAGE #11451760	
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA	
Prepared: P.W.	Date: MARCH 1985
Drawn: C.A.P.	



Total Drainage Area: 1,139.0 Sq. Mi.
Tributary Drainage Area: 1,113.5 Sq. Mi.

CACHE CREEK BASIN, CALIFORNIA

JANUARY 1983 FLOOD HYDROGRAPHS

CACHE CREEK AT YOLO
INDEX PT.-10

U.S.G.S.-GAGE #11452500

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date: MARCH 1985

FIGURE 2-1, SHEET 2 OF 2

inoperative during this maximum storm event. Data for all stations listed on the updated Table C-3 (in the 1979 Feasibility Report) were used in various historical storm analyses for the Cache Creek Basin. See Table 2-3.

c. Baseflow. - The baseflow information presented in the 1979 Feasibility Report remains the same.

d. Unit Hydrograph. - The unit hydrograph data used in the updated computer basin model are identical to those used in the referenced reports.

e. Loss Analysis. - Uniform loss rates for the January 1983 flood ranged from 0.04 inches for the North Fork Cache Creek to 0.20 inches in the lower portions of the Cache Creek Basin. These constant loss values approximate those in the feasibility report. Therefore, there is no change to this data.

f. Routing Parameters. - The routing method used in the updated computer basin model was changed from Tatum to the Muskingum method. Muskingum coefficients used for Cache Creek below Grigsby Riffles are based on known channel characteristics and velocities observed during the January 1983 flood. These velocities ranging between 10 and 16 feet per second are much higher than previously observed. Adopted Muskingum parameters are representative of present channel conditions and are used in the updated computer basin model. A routing diagram and a tabulation of adopted Muskingum coefficients are shown on Figure 2-2. Insufficient channel data are available to develop routing data for the modified puls method or more detailed routing methods.

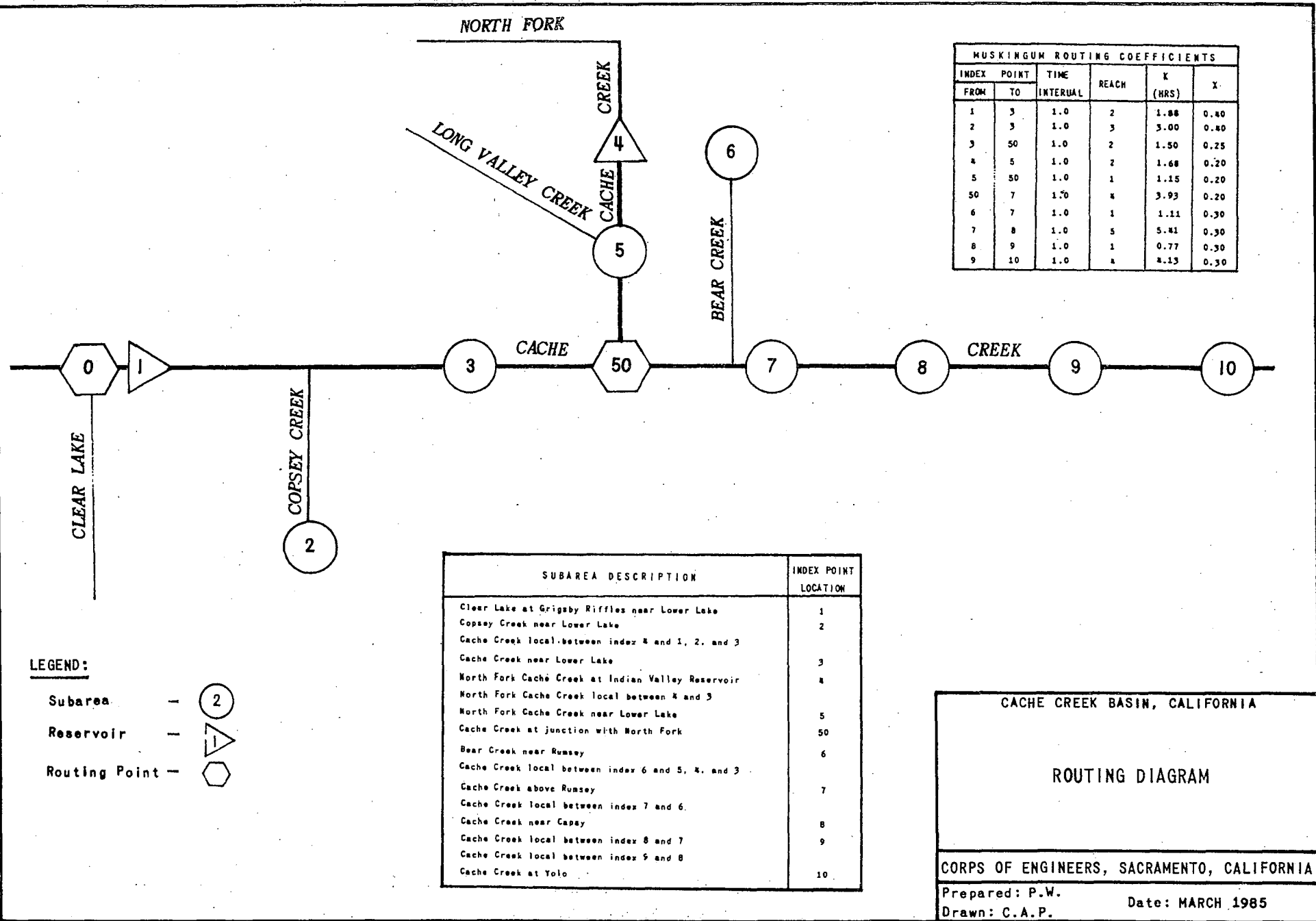
g. Flood Frequency. - Peak and volume frequency curves shown on Plates C-16, C-17, and C-18 in the Feasibility Report were updated with the latest available historical flow data for the Cache Creek at Yolo stream gage location. Additional peak and volume data used for this analysis did not change the frequency curves between the exceedence frequency per hundred years of 50 and 0.1. However, low flow data for the drought period during the 1970's made the frequency, for more frequent events, steeper between the exceedence frequency per hundred years of 50 and 99. Updated frequency curves for stream gage locations mentioned above are shown on Figure 2-3.

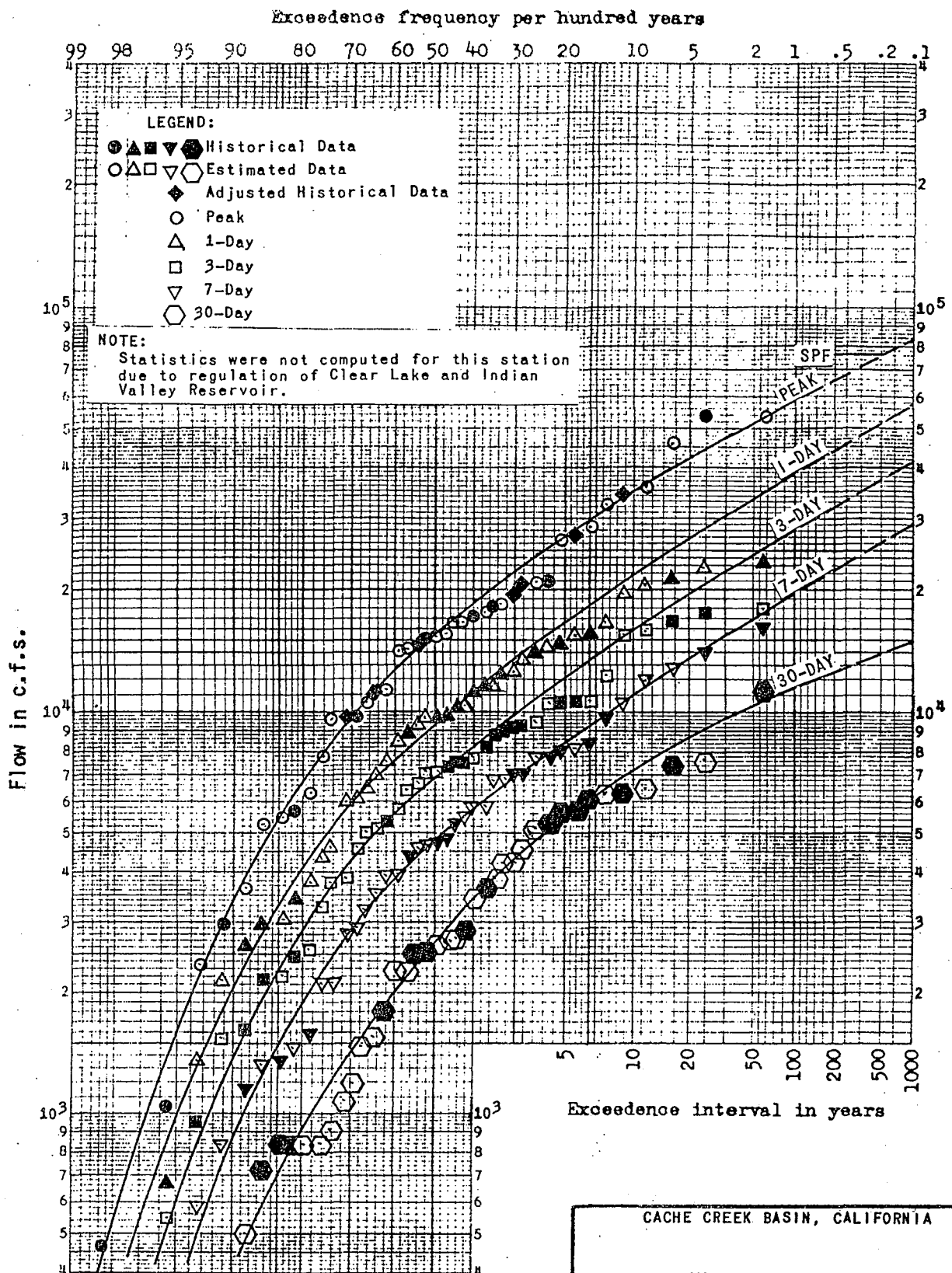
h. Floods of Record. - Stage and flow data related to the large January 1983 flood were added to the Feasibility Report, Table C-5. See Table 2-4.

Changes and additions were made to the following paragraphs of Section E, Appendix 1 of the referenced feasibility report, to present reasons for analyzing a third Standard Project Storm (SPS) centering in addition to those presented in referenced reports. The impact of resulting flood flows on Lower Cache Creek is discussed also.

a. Standard Project Storm - Previously established procedures and criteria were used to compute the specific SPS amount and the concurrent SPS amounts for all other subareas, which were added to SPS data shown on the Feasibility Report, Table E-1. See Table 2-5. Standard project precipitation isohyetal patterns for all storm centerings are shown on Figure 2-4.

FIGURE 2-2





Total Drainage Area: 964.0 Sq. Mi.
Contributing Drainage Area: 939.5 Sq. Mi.
Period of Record: 1943-1984

CACHE CREEK BASIN, CALIFORNIA

RAINFLOOD FREQUENCY

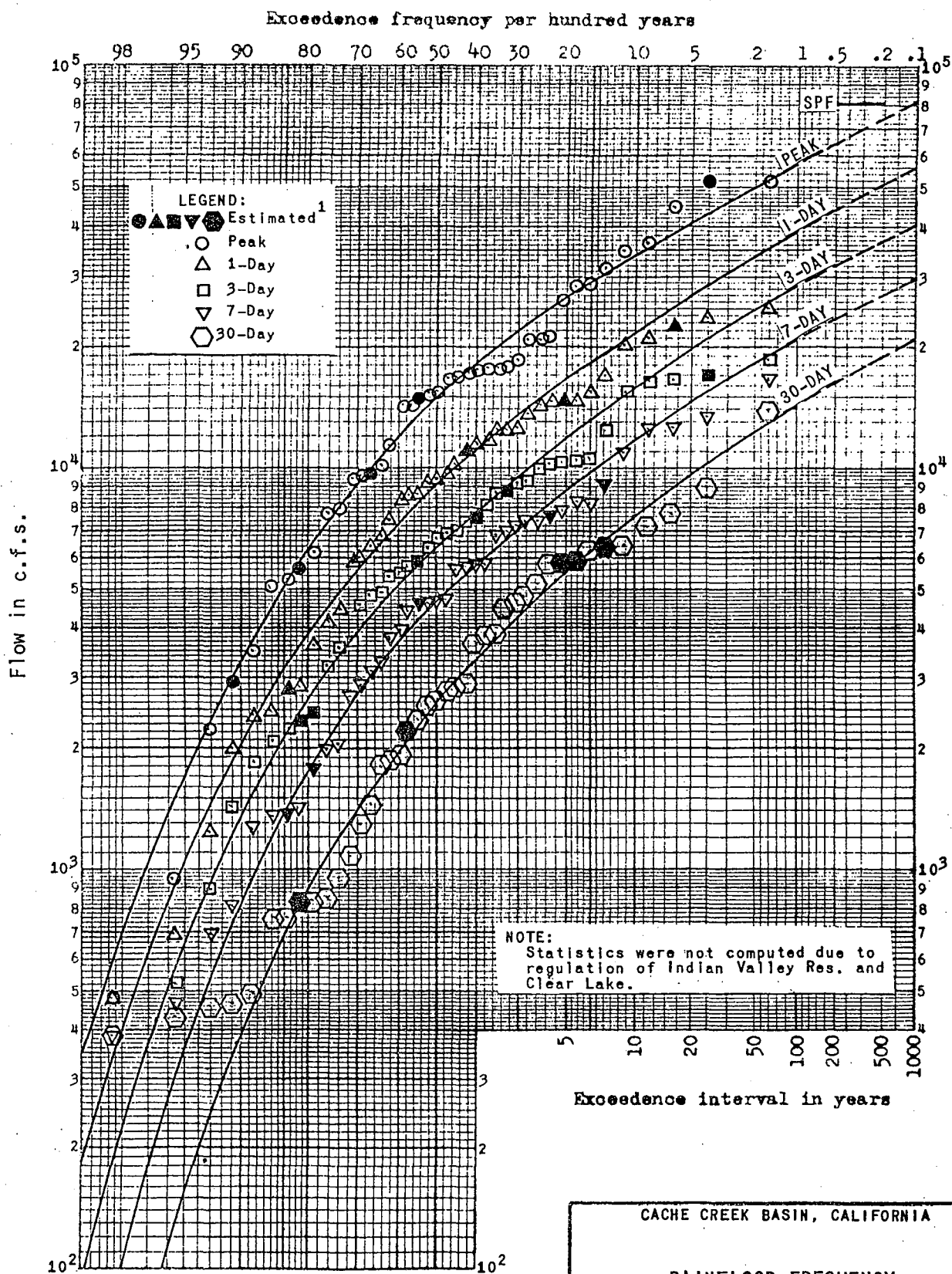
CACHE CREEK AT RUMSEY
INDEX PT. 7

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date: MARCH 1985

FIGURE 2-3, SHEET 1 OF 3



¹UPDATED MARCH 1985

Total Drainage Area: 1,044 Sq. Mi.
Contributing Drainage Area: 1,019.5 Sq. Mi.
Period of Record: 1943-1984

CACHE CREEK BASIN, CALIFORNIA

RAINFLOOD FREQUENCY

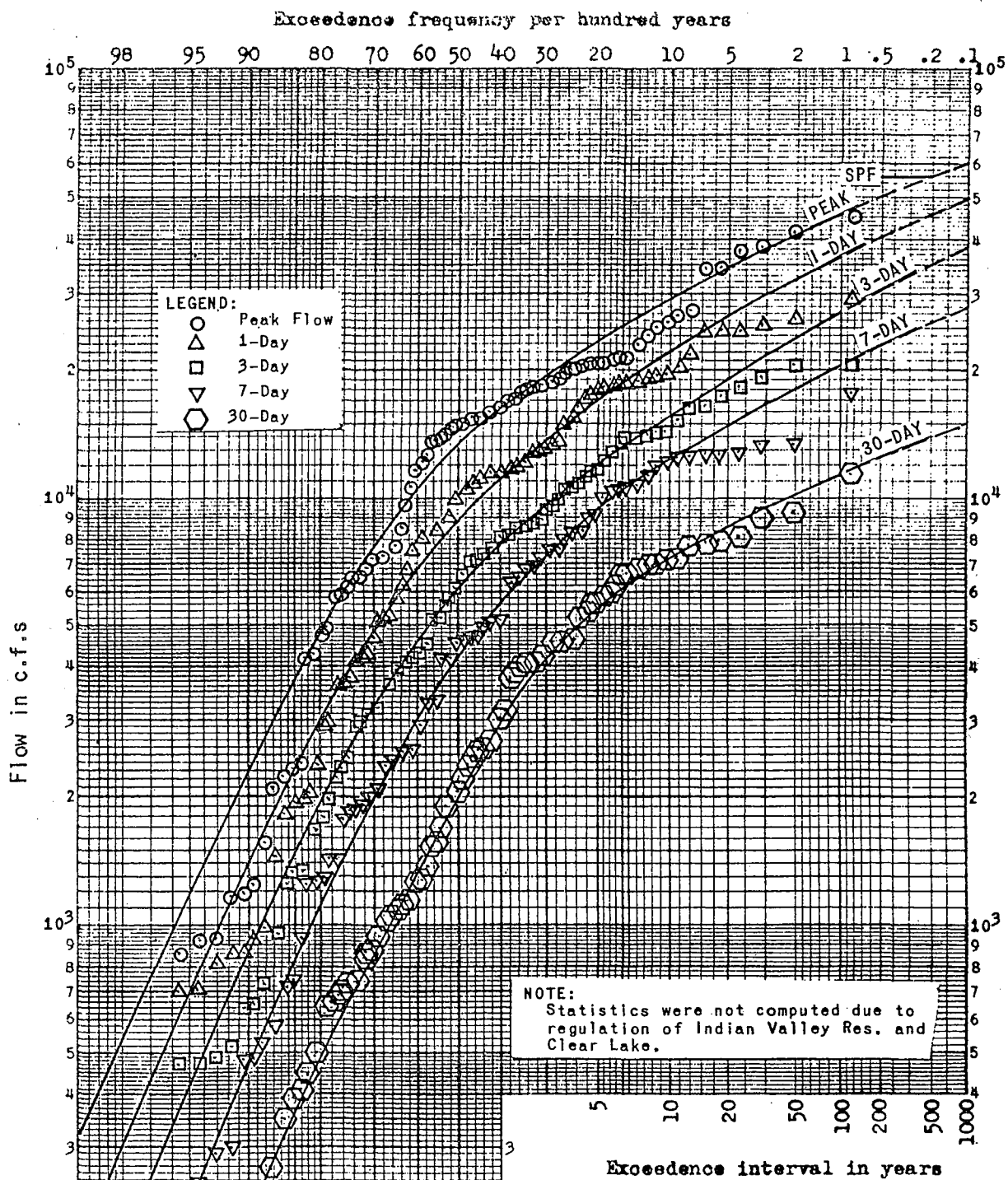
CACHE CREEK NEAR CAPAY
INDEX PT. 8

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date: MARCH 1985

FIGURE 2-3, SHEET 2 OF 3



Total Drainage Area: 1,139.0 Sq. Mi.
Contributing Drainage Area: 1,114 Sq. Mi.
Period of Record: 1903-1984

CACHE CREEK BASIN, CALIFORNIA

RAINFLOOD FREQUENCY

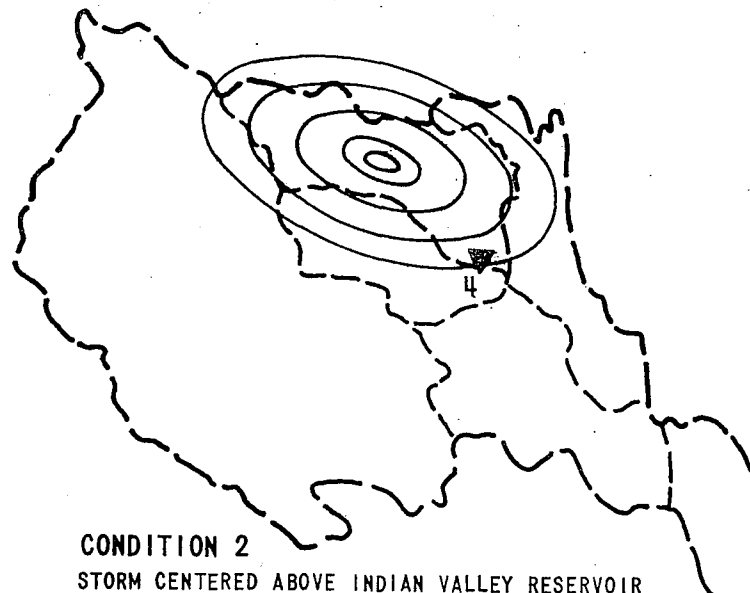
CACHE CREEK AT YOLO
INDEX PT. 10

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

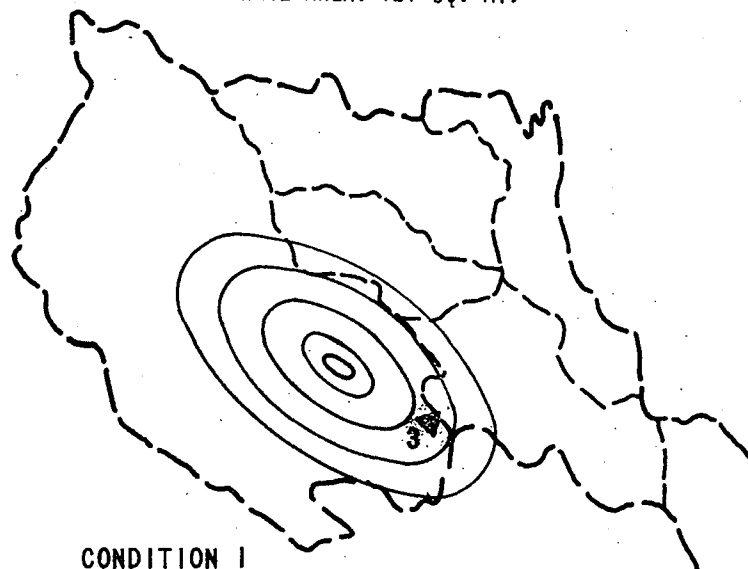
Date: MARCH 1985

FIGURE 2-3, SHEET 3 OF 3



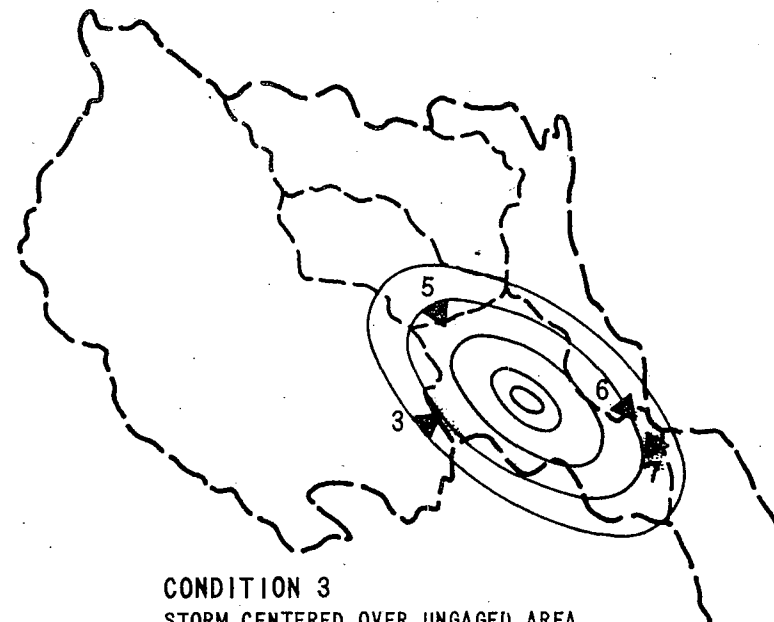
CONDITION 2

STORM CENTERED ABOVE INDIAN VALLEY RESERVOIR
DRAINAGE AREA: 121 SQ. MI.



CONDITION 1

STORM CENTERED ABOVE CLEAR LAKE DAM
DRAINAGE AREA: 528 SQ. MI.



CONDITION 3

STORM CENTERED OVER UNGAGED AREA
BETWEEN CLEAR LAKE DAM AND RUMSEY
DRAINAGE AREA: 127.3 SQ. MI.

NOTE: ISOHYETAL PATTERNS ARE USED TO
DEMONSTRATE ONLY HOW STORM CENTERINGS
WERE LOCATED IN THE WATERSHED AREA.

CACHE CREEK BASIN, CALIFORNIA

**STANDARD PROJECT PRECIPITATION
ISOHYETAL PATTERNS**

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.

Drawn: C.A.P.

Date: MARCH 1985

LEGEND:

5 INDEX POINT LOCATIONS

▼ (SEE CHART 12) OF 1979

FEASIBILITY REPORT

b. Standard Project Floods - Standard Project Floods (SPF) were computed for storm centerings with the updated computer basin model. Storm amounts, unit hydrographs, base flow, and loss rates discussed in preceding paragraphs and in referenced reports were used for the flood computations. Pre-project flood hydrographs for the Condition 3 storm centering shown on Figure 2-4 for Cache Creek at Yolo is shown on Figure 2-5. A comparison of peak flow and 8-day volume data from the referenced report and those computed with the updated computer basin model is shown on Table 2-6. Apparent differences in peak and volume between data of referenced report and those computed with the updated computer basin model resulted from increases in channel velocity in lower Cache Creek. Mining operations in the area below Capay apparently made the Cache Creek channel hydraulically more efficient, as evidenced by the January 1983 flood. The amount of flood flows onto the overbank areas and the infiltration of flow into the groundwater table remains the same. It should be noted that in comparison with previous storm centerings, the storm centered over the ungaged area generally produces higher peak flows and smaller volumes at the Grigsby Riffles and on Cache Creek proper.

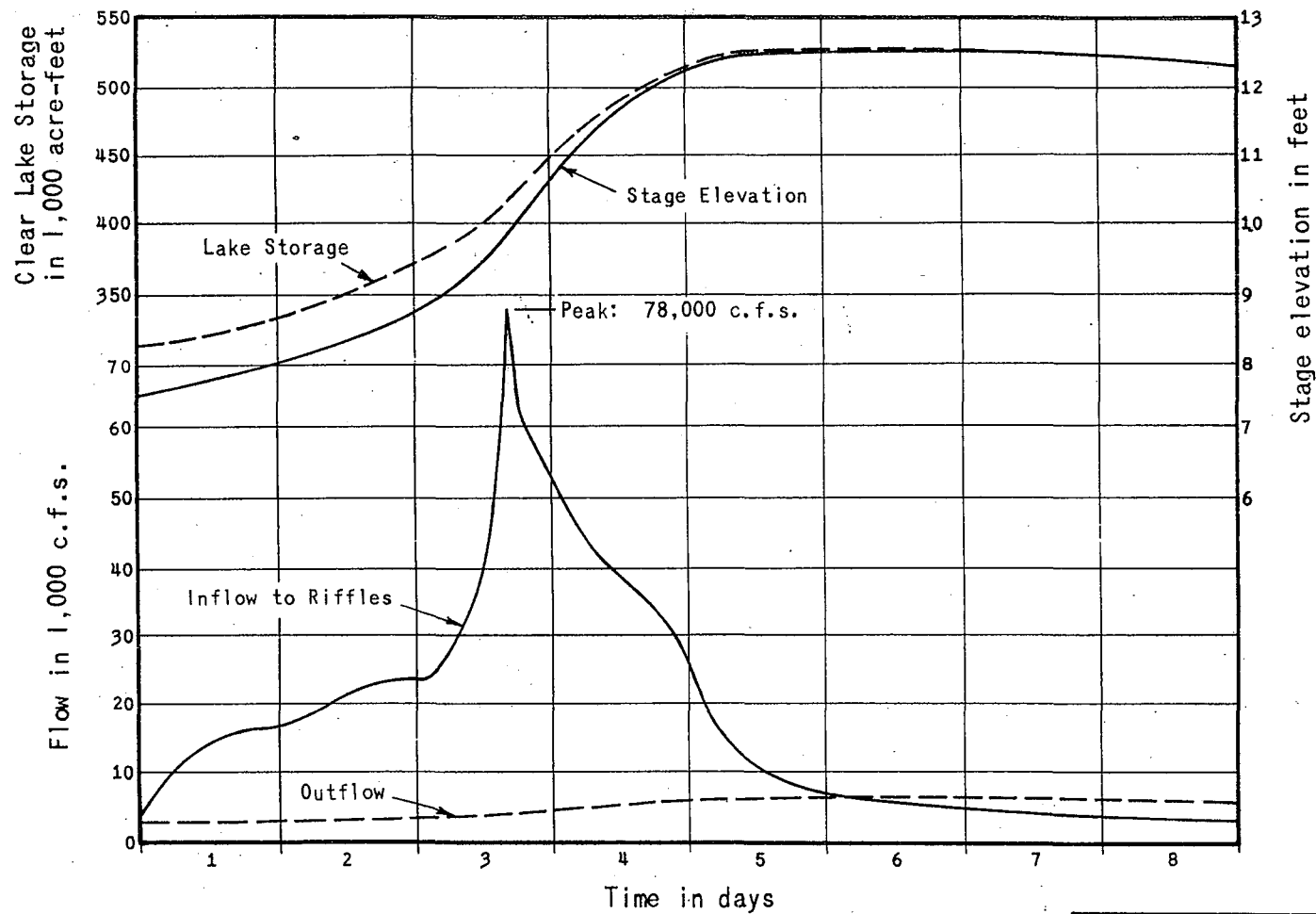
2-05. STUDY CONCLUSIONS. - The review of all hydrologic data in the referenced Feasibility Report shows the following:

a. Hydrologic data shown in Section C of the Feasibility Report continued to be used in this General Design Memorandum (GDM). If frequency data between the exceedence frequencies per hundred year of 50 to 99 was needed for use in any studies, then the flow-frequency curves presented in this review were used.

b. Of the three standard project floods addressed in this review, the severest SPF peak flow condition in Cache Creek is from a storm centered over the ungaged area below the Clear Lake Dam (Condition 3, Figure 2-4). This SPF has been used in the GDM, and will be used for the operational studies.

2-06. INTERIOR DRAINAGE. - A detailed field survey of the area adjacent to the proposed new western perimeter levee indicates that this alignment will not increase drainage flow to the City of Woodland Pumping Plant. However, the plant will require modification due to an increase in pumping head of about 12 feet.

2-07. WIND ACTION ANALYSIS. - Computations of wave runoff and wind setup require the determination of wind velocities and durations for major wind directions, and an evaluation of average fetches for the sediment settling basin. Wind records were not available at the settling basin site; therefore, wind velocity, duration and direction information were based on a study of wind records at the Sacramento Executive Airport located about 13 miles to the south-east of the basin. Average fetches were developed for major wind directions for the orientation and configuration of the settling basin. The maximum recorded wind velocities of 70 miles per hour (1 minute duration) and 38 miles per hour (60 minute duration) were from the south-east. The results of the computational procedure showed that a minimum freeboard allowance for wind action of 4.0 feet, which includes wind setup of



NOTES:

1. Condition 3 (Figure 2-4) storm centering was used to produce this hydrography.
2. Riffle concurrent SPF inflow hydrograph
8-Day Volume: 281,400 acre-feet
11.0 inches
3. Riffle concurrent SPF outflow hydrograph
8-Day Volume: 78,400 acre-feet
3.07 inches
4. Drainage area: 479.52 sq. mi.

CACHE CREEK BASIN, CALIFORNIA

STANDARD PROJECT
FLOOD HYDROGRAPHS

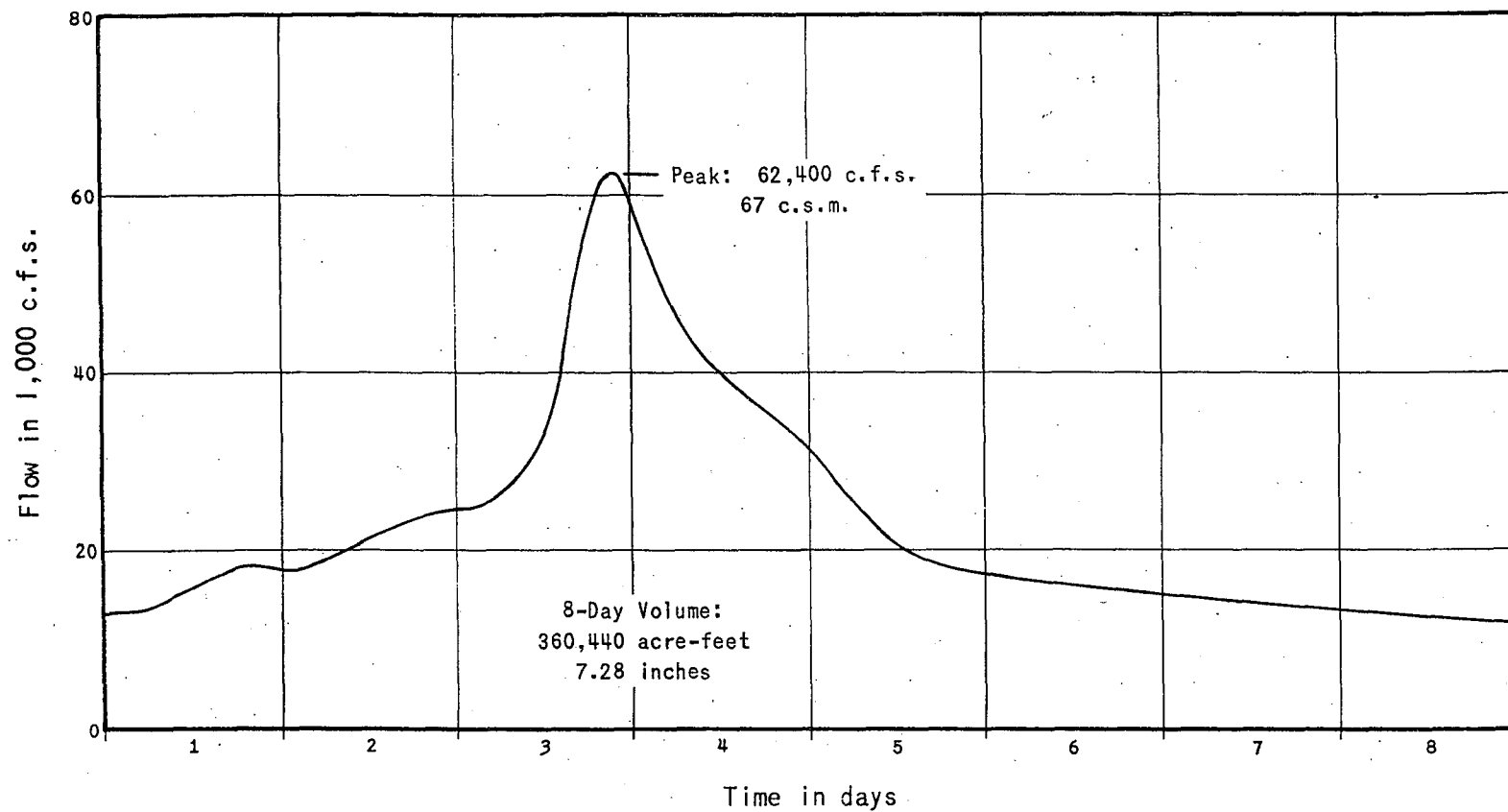
(PRE-PROJECT CONDITIONS)
GRIGSBY RIFFLES
INDEX PT. I

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.

Drawn: C.A.P.

Date: MARCH 1985



NOTES:

1. Condition 3 (Figure 2-4) storm centering was used to produce this hydrograph.
2. Drainage area: 955.0 sq. mi.
3. Tributary drainage area: 927.8 sq. mi.

CACHE CREEK BASIN, CALIFORNIA

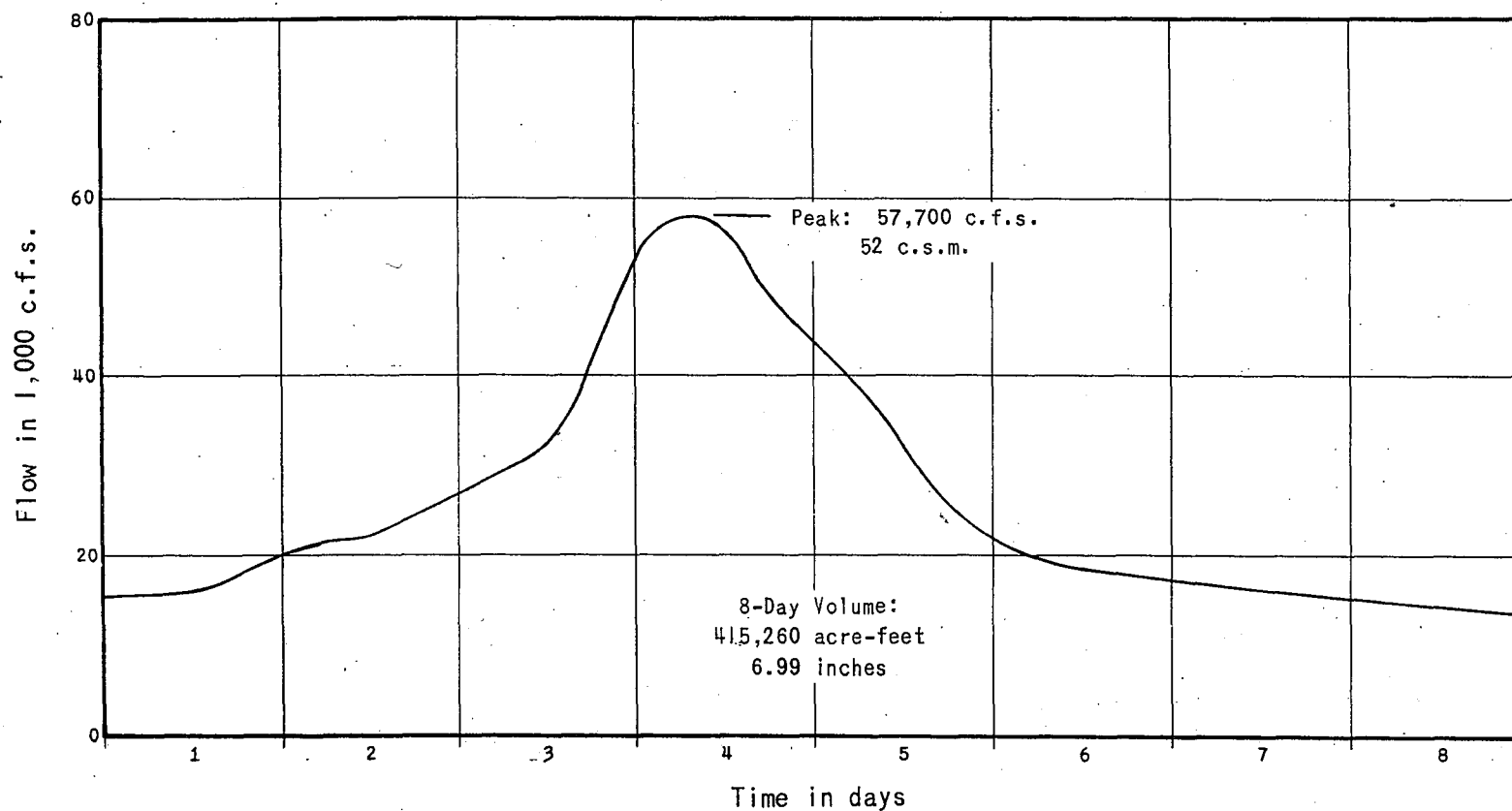
STANDARD PROJECT
FLOOD HYDROGRAPHS

(PRE-PROJECT CONDITIONS)
CACHE CREEK ABOVE RUMSEY
INDEX PT. 7

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date: MARCH 1985



NOTES:

1. Condition 3 (Figure 2-4) storm centering was used to produce this hydrograph.
2. Drainage area: 1,139.0 sq. mi.
3. Tributary drainage area: 1,113.5 sq. mi.

CACHE CREEK BASIN, CALIFORNIA

STANDARD PROJECT
FLOOD HYDROGRAPHS

(PRE-PROJECT CONDITIONS)

CACHE CREEK AT YOLO

INDEX PT. 10

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

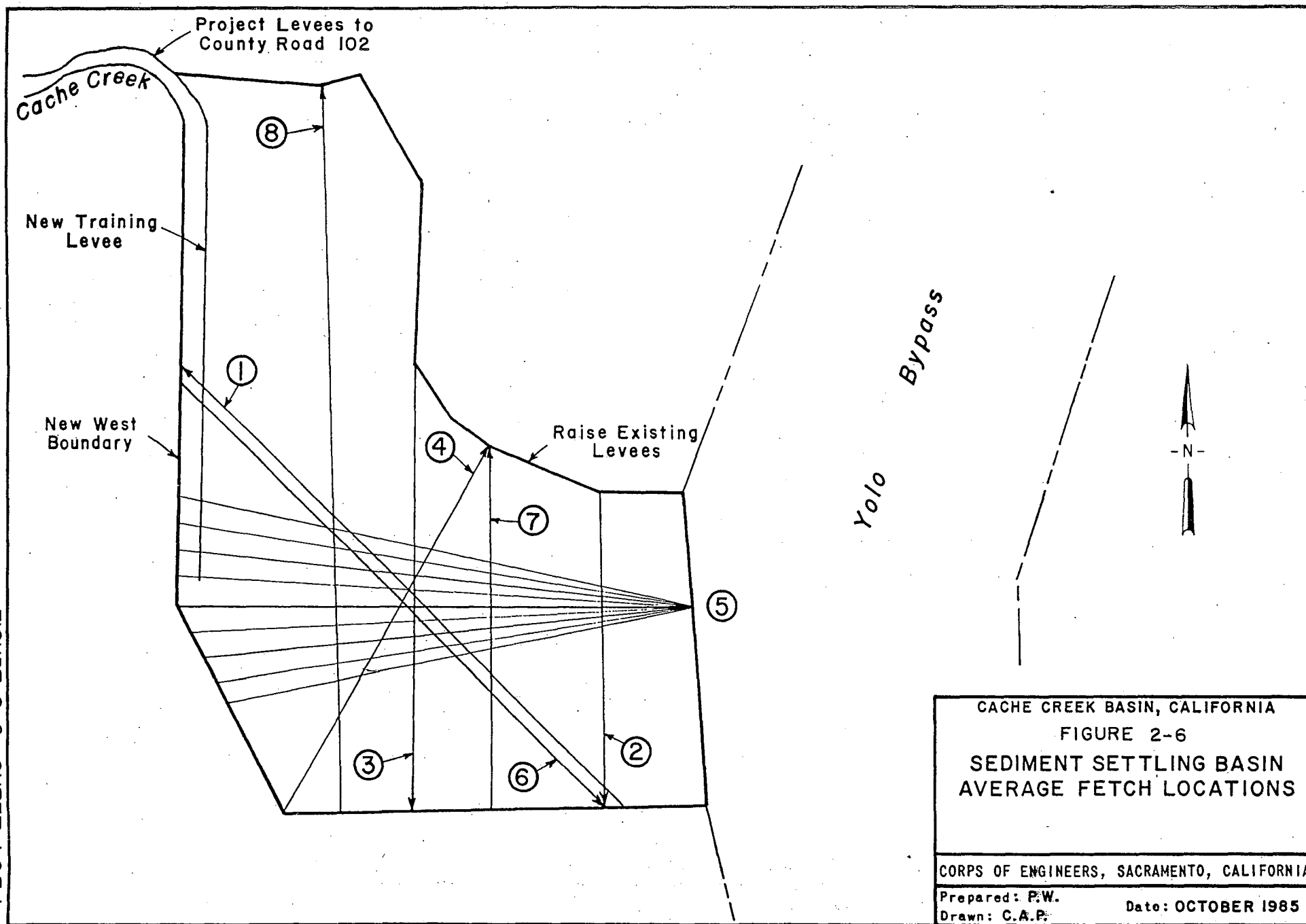
Prepared: P.W.

Drawn: C.A.P.

Date: MARCH 1985

0.5 feet and wave runup of 3.5 feet, is required for exterior levees. See Figure 2-6, and Table 2-7. For a discussion of freeboard criteria, see paragraph 3-03.d. Freeboard allowances for wave runup and wind setup were computed in accordance with following references:

1. ETL 1110-2-305, dated 17 February 1984 for wave height;
2. ETL 1110-2-221, dated 29 November 1976, for wave runup and wind setup;
3. "SHORE PROTECTION MANUAL", US Army Coastal Engineering Research Center, 1977, for wave runup.



CHAPTER 3 - HYDRAULIC DESIGN

3-01. INTRODUCTION. - The objective of this project is to provide system features which would add 50 years of sediment storage capacity to the existing Cache Creek Settling Basin. The basin would collect an average of 340 acre-feet of sediment per year which would represent a 50% trap efficiency. Periodic topographic surveys were taken from 1933 to 1971. The average annual deposition rate from 1937 to 1971 was 340 acre-feet. The current trap efficiency is between 5 and 10%.

a. The current version of the two-dimensional finite element models, RMA-2V and SED4 were used to select, configure, and size the project features. These features would include the increase in levee heights, expansion of the basin boundaries, enlargement of the main outlet weir, and reconstruction of the low flow channel system. The project would also include the implementation of a sediment management plan. The sediment management plan would include the time dependent incrementation of the weir and the construction of a training channel and levee. A newly constructed low flow channel system would be provided incorporating the existing channel where possible.

b. Project features which would meet the design objectives are proposed. The first feature would be to raise the existing east and south levees an average of 12 feet, raise the existing north levee an average of 6 feet, and relocate the west levee 2800 feet to the west. A training channel and levee would be constructed along the new west levee. A new low flow outlet structure would be constructed near the location of the existing low flow structure. The main overflow weir would be lengthened and raised incrementally with time, to an ultimate elevation of 38.5 feet. A sediment management plan would be provided as described in paragraph 3-05.d. See Plates II and VI for the proposed system features and paragraphs 3-05, 5-01, 5-02, and 5-03 for a description of each project component.

c. Due to the unique application of RMA-2V and SED4 for design of the project features, advice and guidance was obtained from both the U.S. Army Engineer Hydrologic Engineering Center, Davis, California and from the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

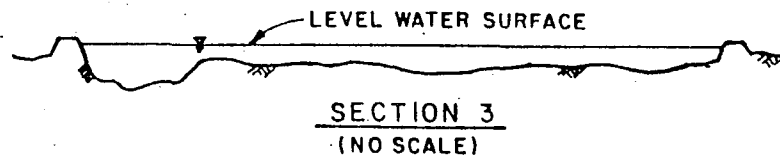
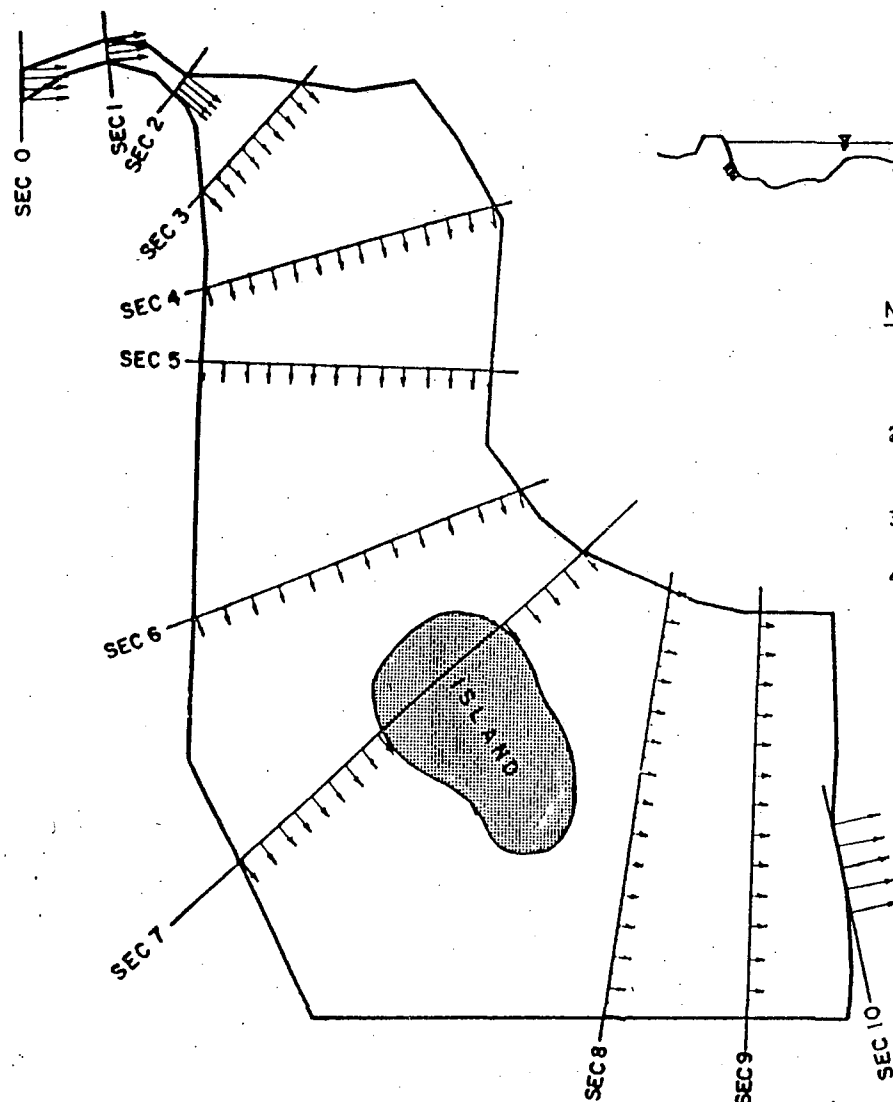
3-02. Project Design Flows. - The project features, including increase in levee heights, training channel and levee and main outlet weir, were designed to safely contain and pass a design flow of 30,000 cfs. This flow has an estimated rate of return from 15 to 25 years. This flow represents the current design capacity of the existing sediment basin and the channel/levee system upstream of the projects limits. The 30,000 cfs discharge was chosen for design so as not to exceed the capacity of the upstream channel system. The low flow outlet structure was designed to pass 400 cfs as described in paragraph 3-05.b.

3-03. Design Considerations and Criteria. - The design of project features combined conventional hydraulic and sediment transport computational procedures with newly developed hydrodynamic and sediment transport modeling tech-

niques. The design effort focused on an accurate description of hydraulic and sediment transport parameters in both the longitudinal and transverse directions. Expansion and contraction at the basin inlet and outlet, flow circulation through the basin and around "islands" (topographic high areas during low flows), and implementation of flow control features (training channels and levees) required that conditions in both longitudinal and transverse directions be determined. A discussion of the detailed design criteria follows: (references are listed in Paragraph 3-08)

a. Hydrodynamic Conditions. - One-dimensional hydraulic analysis of open channels entails the progressive computation of flow conditions from one section of channel to the next. These computations are best illustrated by the Standard Step Method of water surface computations (1, 2). This method entails the trial-and-error solution of the basic energy and headloss equations. The headloss equation describes friction and form losses developed from one section to the next. The flow conditions are assumed steady, gradually varied and one-dimensional. One-dimensional flow is assumed because the velocity is presumed to exist in the direction of flow only. This assumption is based on the premise that the total energy head is constant for all points across a cross-section. Therefore, a level water surface is assumed at a cross-section and parallel velocity vectors are directed perpendicular to this channel section (See Figure 3-01 for a one-dimensional flow representation of the Cache Creek Basin). For watercourses where the width-to-length ratio is small and where velocities are basically parallel at a section, a one-dimensional analysis may be appropriate. However, if the study area is such that the velocity vectors are not parallel, a two-dimensional analysis should be considered. Two-dimensional conditions that may occur are flow around islands, flow in contracting and expanding reaches, flow at junctions, and circulating flow patterns in wide rivers and reservoirs (See Figure 3-02 for a two-dimensional flow representation of the Cache Creek Basin). With a two-dimensional analysis one computes conditions point by point rather than section by section. The hydrodynamic conditions are described by equations for the conservation of fluid mass and momentum, written in a form that is applicable to turbulent flow. These equations are cast into forms which are then solved by a finite element technique. Just as water surface profiles are determined for one-dimensional analysis, so can water surface contours be determined as a result of a two-dimensional analysis. Water surface contours, as with water surface profiles, can be used to establish the limits and configurations of project features such as levee heights, training channels and outlet facilities.

1) RMA-2V Description. - The two-dimensional hydrodynamic modeling for this project was conducted using the current version of RMA-2V. RMA-2V, originally developed by principals of Resource Management Associates (RMA) in 1973 (King et al., 1973) while associated with Water Resources Engineers. Turbulent fluid motion is described in terms of conservation equations for mass and linear momentum, including appropriate friction terms (bottom and wind). RMA-2V solves these two-dimensional depth-integrated equations and gives the solution in terms of vertically averaged velocities at each point. The program combines the Reynolds and continuity equations for turbulent flow with techniques from numerical analysis and finite element solution methods. Much of the model descriptions which follow for both hydrodynamics and sediment transport have been excerpted from Thomas and McAnally (1985). These equations are as follows:



NOTES:

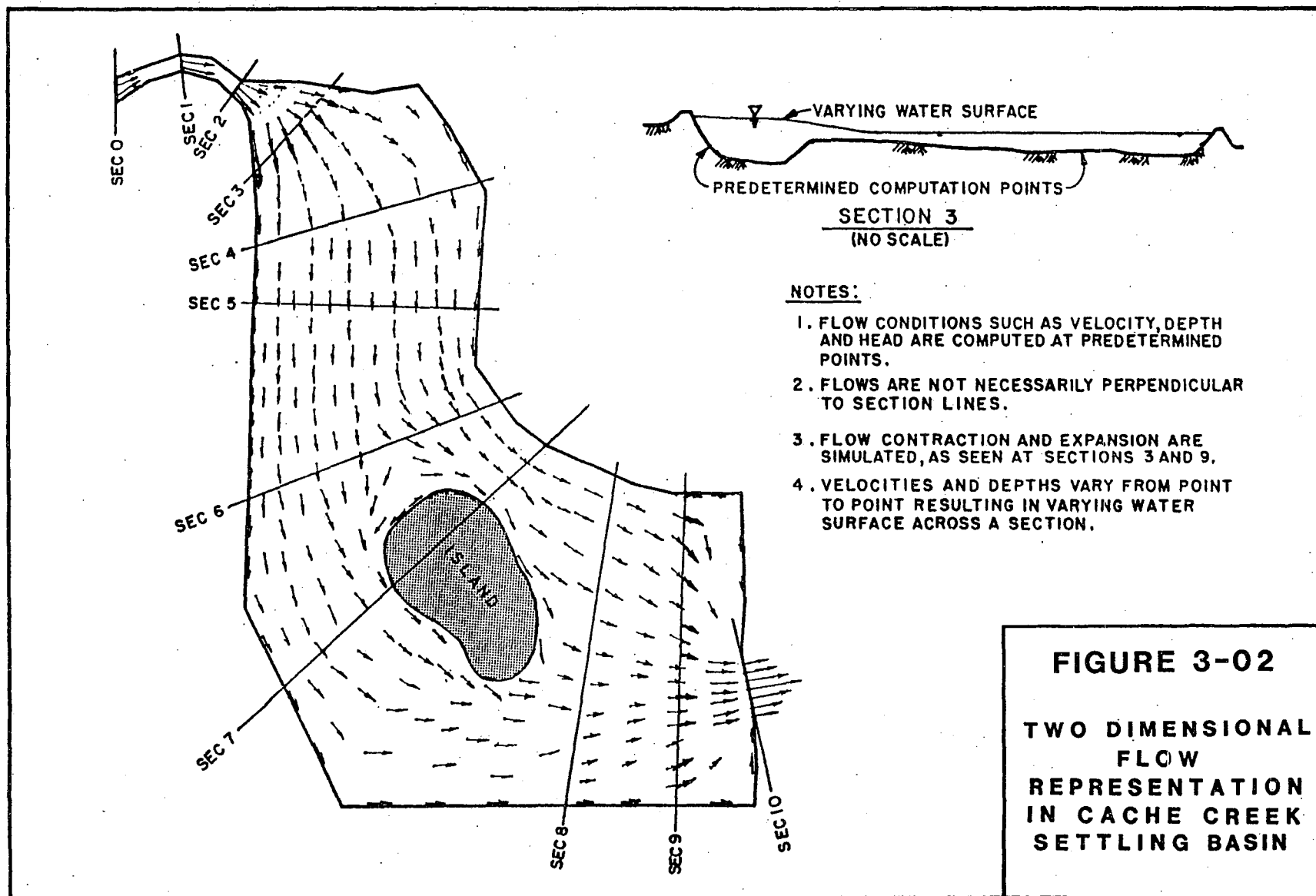
1. SECTION 3 IS APPROXIMATELY 3000 FEET WIDE YET WATER SURFACE IS ASSUMED LEVEL FOR 1-D ANALYSIS.
2. NOTE ASSUMED DIRECTION OF FLOW AT SECTIONS 8 AND 9 APPROACHING SECTION 10. NO CONVERGENCE IS SIMULATED.
3. LOCATION OF SECTIONS MAY PREDETERMINE FLOW DIRECTIONS AND FLOW CONDITIONS.
4. FLOW VELOCITIES ARE ASSUMED CONSTANT ACROSS THE CROSS-SECTION EQUAL TO THE DISCHARGE DIVIDED BY THE TOTAL AREA.

FIGURE 3-01

**ONE DIMENSIONAL
FLOW
REPRESENTATION IN
CACHE CREEK
SETTLING BASIN**

Figure 3-01

Figure 3-02



$$f_u = h \frac{\partial u}{\partial t} + hu \frac{\partial u}{\partial x} + hv \frac{\partial u}{\partial y} - \frac{h}{\rho} (\epsilon_{xx} \frac{\partial^2 u}{\partial x^2} + \epsilon_{xy} \frac{\partial^2 u}{\partial y^2}) \\ + gh \left(\frac{\partial a}{\partial x} + \frac{\partial h}{\partial x} \right) + \frac{gu}{C^2} (u^2 + v^2)^{1/2} - \xi V_a^2 \cos \beta = 0$$

$$f_v = h \frac{\partial v}{\partial t} + hu \frac{\partial v}{\partial x} + hv \frac{\partial v}{\partial y} - \frac{h}{\rho} (\epsilon_{yx} \frac{\partial^2 v}{\partial x^2} + \epsilon_{yy} \frac{\partial^2 v}{\partial y^2}) \\ + gh \left(\frac{\partial a}{\partial y} + \frac{\partial h}{\partial y} \right) + \frac{gv}{C^2} (u^2 + v^2)^{1/2} - \xi V_a^2 \cos \beta = 0$$

$$f_c = \frac{\partial h}{\partial t} + \frac{\partial(uh)}{\partial x} + \frac{\partial(vh)}{\partial y} = 0$$

where

u, v = velocities in the Cartesian directions,

x, y, t = Cartesian coordinates and time,

ρ = density,

g = acceleration of gravity,

a = elevation of bottom,

h = depth,

ϵ_{xx} = turbulent exchange coefficient in the x-direction in the x-plane,

ϵ_{xy} = turbulent exchange coefficient in the y-direction in the x-plane.

ϵ_{yy} = tangential turbulent exchange coefficient in the y-direction in the y-plane,

ϵ_{yx} = normal turbulent exchange coefficient in the x-direction in the y-plane,

β = angle between wind direction and x-axis,

V_a = wind velocity,

C = Chezy roughness coefficient, and

ξ = coefficient relating wind speed to stress exerted on the fluid

The equations are presented in a form which is applicable to the solution of both steady and unsteady flow conditions. However, transitions from subcritical to supercritical flows cannot be modeled.

a) Bed and Wind Friction and Roughness Characteristics. - Bed friction is calculated using Manning's equation. The Chezy roughness formulation of the original computer code was modified in the input portion so that Manning's n roughness coefficients may be specified in the input. Manning's n-values can be specified for predetermined subareas or elements over the study area. See paragraph 3-03.a.1.c for a description of the elements used to model the study area. This feature eliminates the need for computation of composite roughness values, as in one-dimensional models. For the Cache Creek Basin modeling, n-values proved to be a minor hydraulic parameter, as the velocities are very low. Manning's n-values were set at 0.30 for all elements. Surface wind friction on the water surface is modeled by using the equation:

$$\tau_w = \frac{\xi V^2 \cos \beta}{a}$$

where

τ_w = shear stress due to wind friction

The coefficient ξ relates the local wind speed to stress exerted on the fluid. Wind effects can be superimposed on the results of a no-wind condition.

b) Turbulence Exchange Coefficients. - The turbulence exchange coefficients were introduced into the Reynolds equations to make them more mathematically tractable. The turbulent exchange coefficient is dimensionally the same as the coefficient of viscosity. This allows one to combine the Reynolds stress terms in the Reynolds equations with the viscous stresses (King et al., 1973). Since the turbulent exchange coefficient is large compared to the coefficient of viscosity, the entire stress term is essentially the same as the turbulent stress term. Physically, turbulence is a significant factor in the momentum exchange due to velocity gradients. The Reynolds stresses are represented by multiplying a suitable turbulent exchange coefficient by the second derivative of the proper velocity component with respect to the x or y-direction.

The exchange coefficients can vary over the study area on an element by element basis. They are generally dependent on the velocity and the area over which they apply. The model is sensitive to the values of the exchange coefficients, and some trial-and-error testing is generally required before final values are used to obtain reasonable results. When the elements' sides are approximately the same size all four turbulence exchange coefficients are the same. Long and narrow elements will require smaller values along the narrow side than along the long side. Several tests of trial coefficients were needed to set values for the Cache Creek Settling Basin. Regions of comparably sized elements, such as the inlet, the training channel, and the outlet, were modeled with turbulence coefficients of 250 lb sec/ft. The turbulence coefficients for the remaining basin elements were set at 500 lb sec/ft. These values for the coefficients resulted in computed hydrodynamic conditions comparable to conditions measured near the Road 102 bridge and to conditions which appeared reasonable in the basin.

c) Finite Element Solution Technique. - The RMA-2V computer model uses the Finite Element Method (FEM) to solve the two-dimensional Reynolds and continuity equations. The FEM replaces a set of simultaneous partial differential equations with ordinary differential equations which are considered an approximate representation of the problem. The "exact" solution of these equations is computed by applying the Galerkin variation of the method of weighted residuals where the error terms are forced to a minimum (Zienkiewicz, 1971). The Finite Element model is constructed by preparing a mesh of three and/or four-sided elements. The corner and midside points of each element form the "nodal" point connections for adjacent elements. The sides of the element's boundaries are placed so that they coincide with the study boundary. See Figure 3-03 for the basic finite element grid for the Cache Creek Settling Basin. Boundary conditions are integrated and applied at the appropriate nodes. Then by using a Newton-Raphson solution scheme, the set of resulting equations is solved and then conditions at each node can be determined.

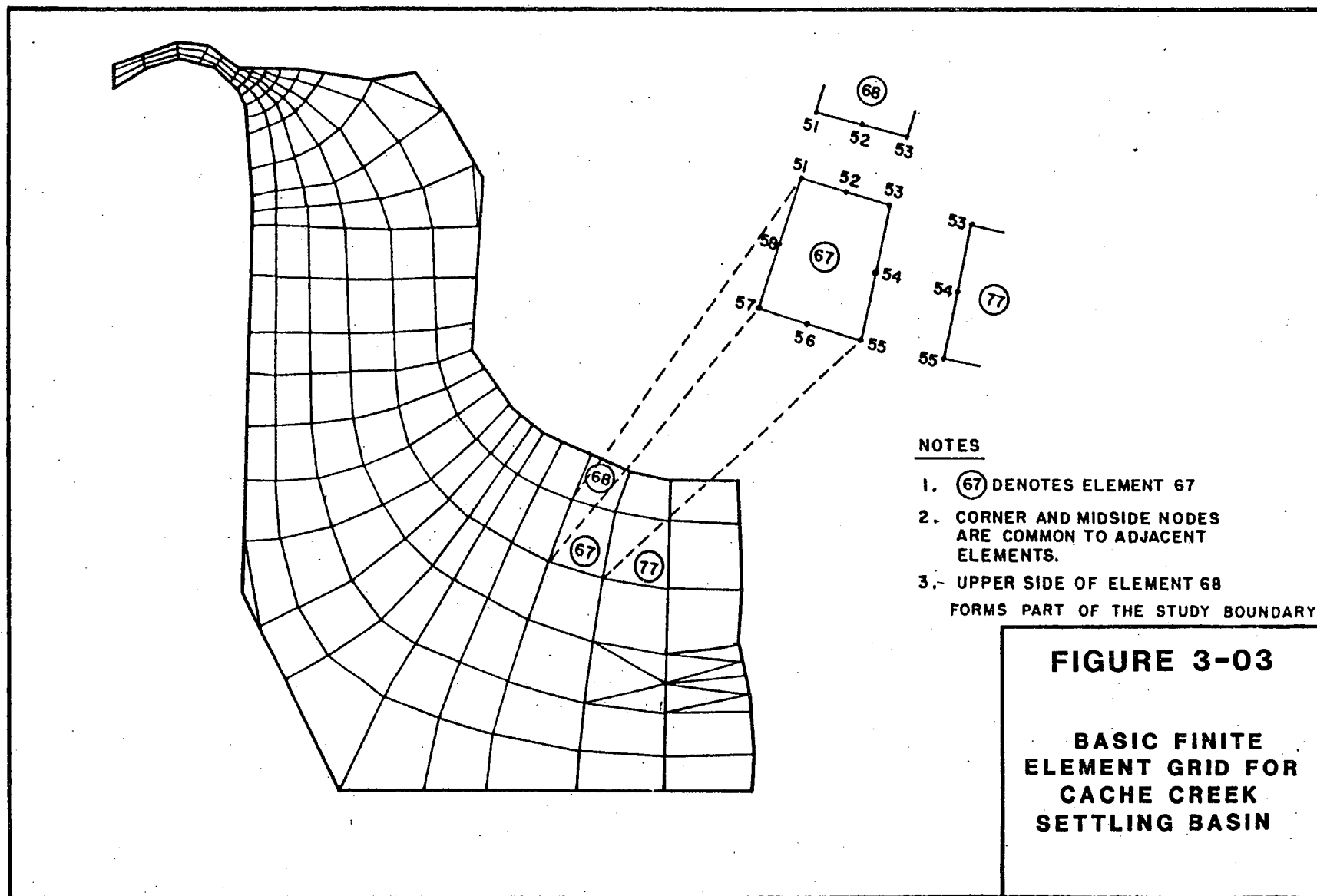
d) Wetting and Drying. - The current version of RMA-2V is capable of modifying the initial mesh configuration by adding or deleting elements as they become wet or dry. If the depth at any one node crosses a predesignated wetting or drying tolerance depth, the entire element is added or deleted. It is apparent that two problems can arise if nodes are added or removed. An irregular boundary with sharp corners may result as the mesh is modified, and computational instabilities may occur each time an element is added or deleted. These problems can be minimized by defining small enough elements and by the careful placement of elements in regions where wetting and drying may occur.

2) Boundary Conditions. - The boundary conditions for the finite element model can be specified for both exterior nodal points and nodes within the system. Generally, nodes located on the boundaries are divided into flow, slip and stagnation boundary categories. At interior nodes one either prescribes a water-level boundary condition or no conditions are specified.

a) Exterior nodal boundary conditions are those that define the study extent and how the exterior world interacts with the system. All exterior boundary nodes which are not subject to specified flow conditions such as inflow, outflow, or depth, are called system boundary nodes. RMA-2V assumes that fluid can only move parallel to a system boundary, thus the name slip-boundary. Exterior boundaries which define flow conditions are analogous to a starting water surface elevation imposed on a one-dimensional Standard Step water surface computation. These exterior boundary conditions are given in the form of specified flow across a predetermined section, specified head at individual nodes or across a section, or as a stage discharge relationship across a section.

b) Interior nodal points are generally left as unspecified, thus allowing the model to compute the conditions at that location. The model will solve for the finite element equations in response to the given exterior boundary conditions. It is possible to specify water surface elevations at interior nodal points, however, the continuity principle may be violated near that point. The solution scheme accepts those conditions and solves for the remain-

Figure 3-03



ing hydraulic parameters accordingly. Stagnation velocity conditions can also be specified for both exterior and interior nodal points.

b. Sediment Transport and Deposition. - A major goal of the analysis is to predict the sediment distribution and deposition within the basin as a function of time. The basin configuration and the proposed sediment management strategy will be based on the ability to determine the deposition behavior. The current version of the two-dimensional sediment transport model, SEDIMENT4 (SED4), can be used to simulate the basic sediment transport processes: erosion, entrainment, transportation, and deposition.

1) SED4 Description. - SED4 is a two-dimensional, finite element sediment transport model. It uses the hydrodynamic parameters (velocities and depths) computed by RMA-2V to simulate the sediment processes. SED4 is a depth-averaged model which allows for the wetting and drying to occur anywhere in the domain. SED4 was designed to simulate the transport of either cohesive or noncohesive sediment. A computational model of each of the four sediment processes is briefly described below. More detailed discussion on the model and sediment processes can be found in References 5, 7, and 8.

a) Advection-Diffusion - Most sediment is transported in suspension. The sediment is dispersed and mixed in suspension and can be described by the basic advection diffusion equation in the form:

$$\frac{\partial C}{\partial t} + u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = \frac{\partial}{\partial x} \left(D_x \frac{\partial C}{\partial x} \right) + \frac{\partial}{\partial y} \left(D_y \frac{\partial C}{\partial y} \right) + S$$

where

C = concentration of suspended sediment,

D_x = effective diffusion coefficient in x-direction,

D_y = effective diffusion coefficient in y-direction,

S = bed source term (See paragraph 3-03.b.1.c for description of term).

This transient equation is the master transport equation which brings together the individual processes of erosion, entrainment and deposition and allows them to interact. These processes are further described below.

b) The Bed Shear Stress - There are several methods available for computing the shear stress using the basic expression:

$$\tau_b = \rho u_*^2$$

where:

τ_b = shear stress at the bed,

ρ = water density, and

u_* = shear velocity.

The options for computing u_* are given below.

1. Smooth-wall logarithmic velocity profile:

$$\frac{\bar{u}}{u_*} = 5.75 \log \left(3.32 \frac{u_* D}{\nu} \right)$$

where:

$\bar{u}$ = vertically averaged mean fluid velocity,

D = water depth, and

ν = kinematic viscosity of water.

2. The Manning shear stress equation:

$$u_* = \frac{(g)^{1/2} \bar{u} n}{(CME)^{1/2} D^{1/6}}$$

where:

g = acceleration of gravity,

n = Manning's roughness value, and

CME = coefficient of 1 for Metric units and 1.486 for English units.

3. A Jonsson-type equation for surface shear stress (plane beds) caused by waves and currents.

$$u_* = \frac{1}{2} \left(\frac{f_w u_{om} + f_c \bar{u}}{u_{om} + \bar{u}} \right) \left(\bar{u} + \frac{u_{om}}{2} \right)^{1/2}$$

where:

f_w = shear stress coefficient for waves,

u_{om} = maximum orbital velocity of waves, and

f_c = shear stress coefficient for currents.

4. A Bijker type equation for total shear stress caused by waves and currents in the form:

$$\tau_x = \left(\frac{1}{2} f_c u^2 + \frac{1}{4} f_w u_{om}^2 \right)^{1/2}$$

c) The Bed Source - The bed source term, S , in the advection-diffusion equation describes the source of supply or the withdrawal mechanism for the material which is making up the suspended sediment load. The bed source term can be written as:

$$S = \alpha_1 C + \alpha_2$$

where:

α_1 = source term coefficient, and

α_2 = equilibrium concentration coefficient in the source term.

S has the same form for deposition and erosion of both sands and clays. The values of the alpha coefficients are governed by the type of material, sand or clay, and process, erosion or deposition. The expressions for S are given below for sand and clay transport.

1. Sand Transport. -

$$S = \frac{C_{eq} - C}{t_c}$$

where:

S = sand source term,

C_{eq} = equilibrium concentration (transport potential),

C = sediment concentration in the water column, and

t_c = characteristic time for effecting the transition from the sediment concentration to the equilibrium concentration.

The Ackers-White formula was used to compute the transport potential C_{eq} . The characteristic time, t_c , is the amount of time required for the concentration in the flow field to change from C to C_{eq} . For deposition, t_c is related to the fall velocity and is the larger of:

$$t_c = \begin{matrix} C_d \frac{D}{V_s} \\ \text{or} \\ DT \end{matrix}$$

where:

C_d = coefficient of deposition,

D = flow depth,

V_s = fall velocity of a sediment particle,

DT = computation time interval.

For scour, t_c is the larger of:

$$t_c = \begin{matrix} C_e \frac{D}{v} \\ \text{or} \\ DT \end{matrix}$$

where:

C_e = coefficient for entrainment, and

v = depth averaged flow velocity at the point of computation.

2. Clay Transport. - For deposition rates of clay beds the equations of Krone (1962) are used in the forms:

$$S = - \frac{2V_s}{D} C \left(1 - \frac{\tau}{\tau_d} \right) \quad \text{for } C < C_c$$

and

$$S = - \frac{2V_k}{D} C^{5/3} \left(1 - \frac{\tau}{\tau_d} \right) \quad \text{for } C > C_c$$

where:

τ = bed shear stress,

τ_d = critical shear stress for deposition, and

C_c = critical concentration.

Erosion rates are computed by a simplification of Partheniades (1962) results for particle-by-particle erosion. The source term is computed by

$$S = \frac{P}{D} \left(\frac{\tau}{\tau_e} - 1 \right)$$

where:

P = erosion rate constant, and

τ_e = critical shear stress for particle erosion.

Deposits are calculated as incremental layers. For clay materials, these layers consolidate as they are covered with increasing amounts of overburden. When bed shear stress is high enough to cause mass failure of a bed layer, the erosion source term is:

$$S = \frac{T_L \rho_L}{\Delta t} \text{ for } \tau > \tau_s$$

where:

T = thickness of the failed layer,

ρ_L = density of the failed layer,

Δt = time interval over which failure occurs, and

τ_s = bulk shear strength of the layer.

d) Bed Model. - The source-sink term in the general advection-diffusion equation becomes the source-sink term for the bed model. The bed model keeps track of the elevation of the bed as well as the composition and character of the bed.

1. In this model sand beds are considered to consist of a sediment reservoir of finite thickness, below which is a non-erodable surface. Sediment is added to, or removed from, the bed at a rate determined by the value of the sink-source term at the previous and present time steps. The mass rate of exchange with the bed is converted to a volumetric rate of change with the aid of a bed porosity parameter.

2. Clay or mixed sand and clay beds are treated as a sequence of layers. Each layer has a set of its own characteristics such as thickness, density, age, bulk shear strength, and type. Each layer is also described by a second set of parameters which are the critical shear stress for erosion, the erosion rate constant, the initial and one-year densities, the initial and one-year bulk shear strengths, and the consolidation coefficient, and whether the material is clay or sand. New clay deposits form layers that acquire their own characteristics. In the program each layer is allowed to grow to a prespecified maximum thickness; if further growth occurs, the formation of a new layer will be initiated. The density and strength increase over time as the overburden and/or age increase.

2) Boundary Conditions. - Sediment inflow characteristics such as concentration and gradation, are used as the sediment model boundary conditions. Sediment concentrations are supplied to SED4 at each time step, if they change with time. Sediment gradations can only be described in terms of a single representative grain size. This parameter is entered into the program as a corresponding particle settling velocity. See Figure 3-04 for a plot of settling velocity versus particle size. The boundary conditions are specified at the water inflow boundaries. For boundaries at which there is always fluid and sediment flow out of the model, such as the downstream section of a non-tidal river, boundary concentrations need not be specified, and the model will calculate the outflow concentrations.

c. Stone Slope Protection Criteria.

1) Project features were designed to preclude the necessity for extensive stone protection. However, stone protection is to be provided at some locations to protect against erosive forces caused by wind generated waves and localized accelerated flows in the channel features of the project near structures such as bridges, bends, and outlet works.

2) Stone riprap protection was designed in accordance with EM 1110-02-1601, "Hydraulic Design of Flood Control Channels", ETL 1110-2 -120, "Additional Guidance for Riprap Protection", and WES Miscellaneous Paper H-78-7, "Practical Riprap Design. Stone slope protection for the low flow outlet structure was sized to accomodate the design discharge of 400 cfs at flow conditions resulting in a discharge velocity of 10 ft/sec. Using the Froude number method (WES, 1978) of sizing,

$$D_{50} = CF^3y$$

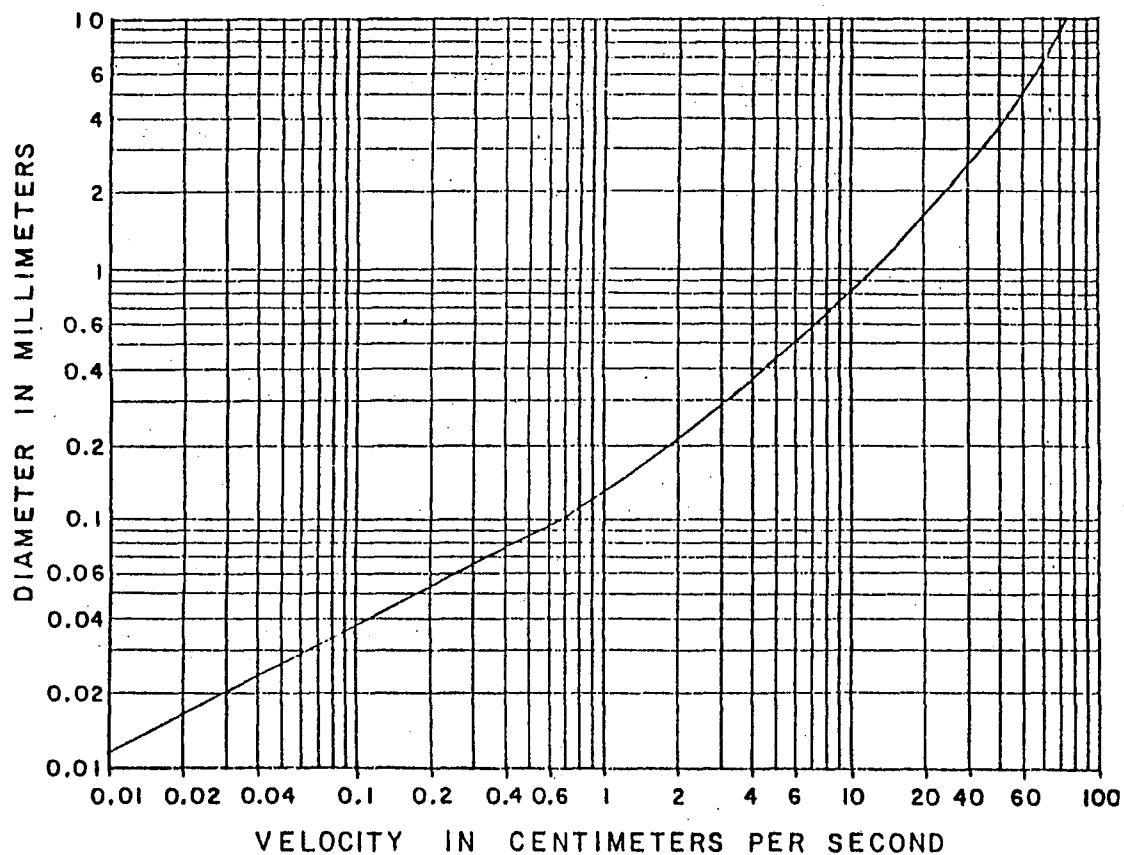
where

F = Froude number

y = flow depth

C = coefficient with a factor of safety of 1.5 = 0.30

and a specific gravity of rock riprap of 165 lbs/ft³, a layer thickness of 18 inches was required.



NOTES:

1. VELOCITIES ARE FOR QUARTZ SPHERES IN WATER AT 15°C.
2. SOURCE: REFERENCE 10.

FIGURE 3-04

**SETTLING VELOCITY
VS.
PARTICLE SIZE**

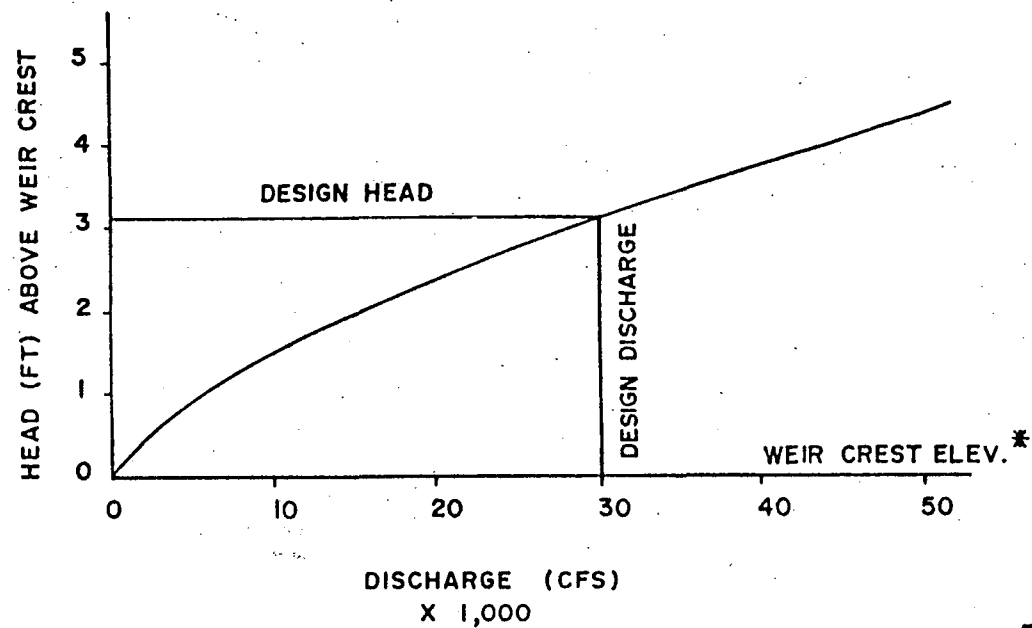
3) Stone slope protection for the outlet weir abutments was placed to protect the levees from flows approaching the weir inlet. The layer thickness was based on the minimum requirement of 12 inches increased to 18 inches for potential wind wave action.

d. Freeboard Criteria. - Freeboard constitutes the vertical distance from the design water surface to the top of an excavated channel, a channel wall, top of levee or the soffit (lowest point) of a bridge or culvert. It assures that the desired degree of protection is not compromised by erratic hydrologic phenomena, future development of urban areas, unforeseen embankment settlement, or accumulation of silt, trash, and floating debris. The minimum required freeboard is 3.0 feet for leveed channels and other waters impounded by embankments. In addition, freeboard may be established by the effects of wave action such as wind setup and wave runoff. Wind setup is the vertical displacement of the water surface by the force of the wind. This may be thought of as the "tilt" of the water surface due to the wind. The wind force also produces another effect on the waterside bank known as wave runoff. Wave runoff is the vertical distance the water encroaches on the embankment or bank. Both wind setup and wave runoff are combined to produce an additional criteria for the establishment of freeboard. The greater of the two freeboard criteria, wind allowance or standard allowances, will establish the design project freeboard. The wind action freeboard of 4.0 feet was chosen for the project design freeboard. For a discussion of the wind action analysis, see paragraph 2-07. Freeboard for the training levee was set at 2.0 feet, 2.0 feet below the design project freeboard. The training levee freeboard was established to insure overtopping of the training levee before the basin levee height is exceeded in the event of an extreme storm discharge.

e. Outlet Weir. - The straight drop outlet weir was configured in accordance with the criteria set forth in "Hydraulic Design Criteria for a CIT - Type Drop Structure." The weir layout and structural details are shown on Plate X. The weir length was set at 1740 feet, as presented in Reference 11, to minimize levee heights near the outlet weir and so as not to increase the existing water surface at County Road 102. The weir was designed to pass 30,000 cfs at a design head of 3.15 feet. Maximum tailwater conditions in the Yolo Bypass will not restrict flow over the weir at the initial or final weir elevation. The no-tailwater condition was used to establish basin sizing. Basin length and end sill height determined from Plate 43 of EM 1110-2-1601, were modified to account for sediment buildup and low tailwater conditions. A discharge rating for the outlet weir is shown on Figure 3-05.

f. Low Flow Outlet Structure. -

1) The low flow outlet structure was sized using the methods given in EM 1110-2-1602 and related Engineering Manuals. The conduits were assumed to flow full with high head conditions downstream compared to full channel flow upstream. Selection of culvert size was based on the difference in upstream/downstream head versus the design discharge (See paragraph 3-05.b for design flow determination and paragraph 5-02.b.1 for description of the low flow outlet structure).



* FIRST STAGE - ELEVATION 33.5' NGVD
ULTIMATE ELEVATION 38.5' NGVD

FIGURE 3-05

**DISCHARGE
RATING FOR
OUTLET WEIR**

2) The total headloss through the outlet works included loss at the outlet, including flap gate, friction loss in the conduits upstream and downstream of the control gate, loss through the control gate and loss at the entrance. The rating for the outlet works was computed using the following equation:

$$h_1 - h_4 = \frac{Q^2}{A^2} 2g \left(K_o + f \frac{L}{D} + K_{CG} + K_e \right)$$

where

$h_1 - h_4$ = The difference in headwater and tailwater,

Q = Discharge,

D = Equivalent Diameter = $\frac{4A}{P}$ (EM 1110-2-1602, Page 2-9),

A = Area,

P = Wetted Perimeter,

K_o = Loss coefficient of outlet = 1.0,

K_{CG} = Loss coefficient of control gate = 0.1 (Fully open),

K_e = Loss coefficient of entrance = 0.2, and

f = Coefficient of friction,

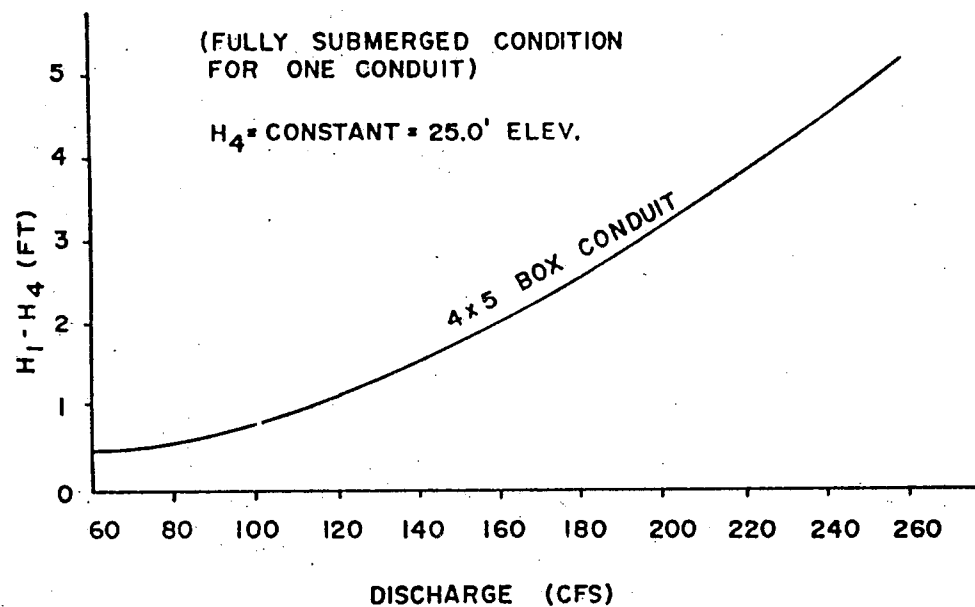
L = Length of conduit.

The discharge rating for a single 4 foot by 5 foot box with control gate and flap gate is shown on Figure 3-06.

3-04. Design Analysis and Study Procedure. - The design procedure used to develop project features is comprised of three phases. Phase I of the procedure identifies design objectives and design criteria. Phase II develops general project features and tentatively proposes the form of certain control features. A preliminary evaluation of these configurations is conducted to determine which combination of feature would best meet the design objectives. Phase III of the design procedure refines the system developed in Phase II to ensure that all sediment management objectives can be achieved. A sediment management plan is also developed in Phase III. This plan would include a sediment monitoring schedule would allow for the adjustment of project features if needed.

a. Phase I - Design Objectives and Criteria. -

1) Major design criteria such as design discharge capacity, basin sediment storage capacity, design life and basin trap efficiency have been



NOTES:

H_1 = SETTLING BASIN STAGE

H = YOLO BYPASS STAGE

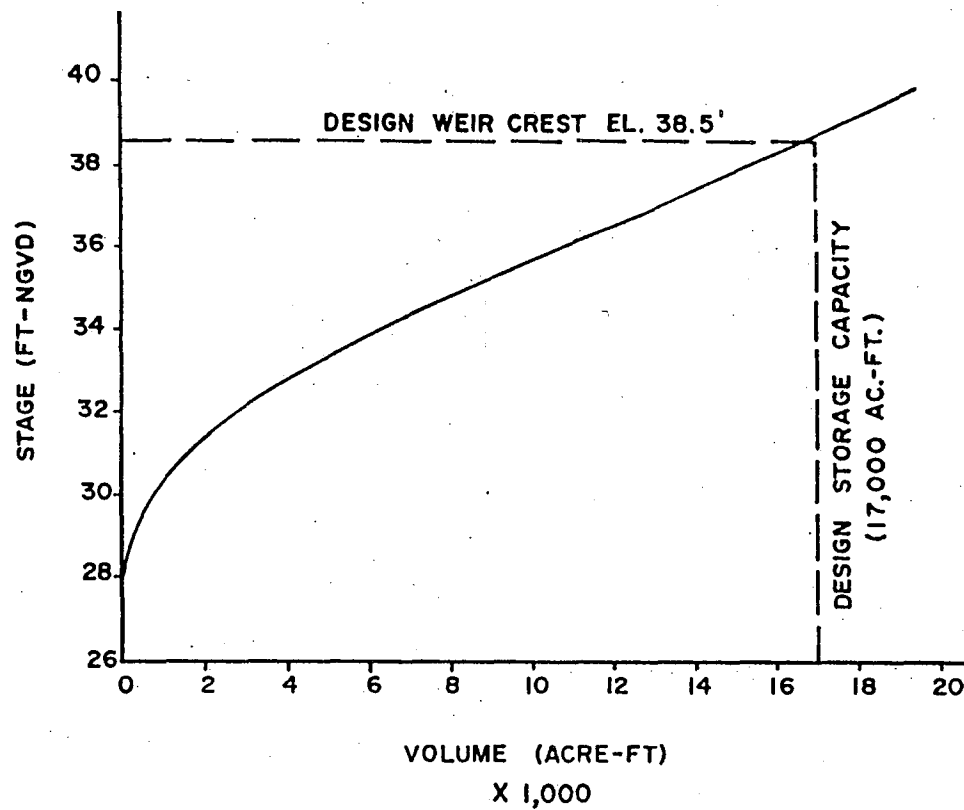
FIGURE 3-06
DISCHARGE
RATING FOR LOW
FLOW OUTLET
WORKS

developed in previous studies. These parameters were presented in Reference 9 and are listed below;

1. Design Discharge - 30,000 cfs,
2. Design Life - 50 years,
3. Basin Trap Efficiency - 50% (average), and
4. Sediment Capture Rate - 340 acre-feet/year.

2) Basic system requirements were determined from these parameters. Total basin volume for storage of 50 years of sediment accumulation was computed to be 17,000 acre-feet. The levee heights and the ultimate weir crest elevation were designed to accommodate the design discharge and to provide the required sediment storage capacity. 1983 surveys were used to develop elevation contours for existing basin topography. The contour map was then used to develop the stage-capacity curve as shown in Figure 3-07 (this assumes a uniform, "flat" deposition pattern over the entire basin area) and also to determine the elevation the design storage capacity would achieve. A design range of basin trap efficiency was set at 30% to 70%. Project features were allowed to function within this range resulting in an average trap efficiency of 50%. Trap efficiencies above 70% and below 30% would trap too much sediment and too little sediment respectively. A rebuilding or modification of some project features will be required when the trap efficiency falls out of the allowable range.

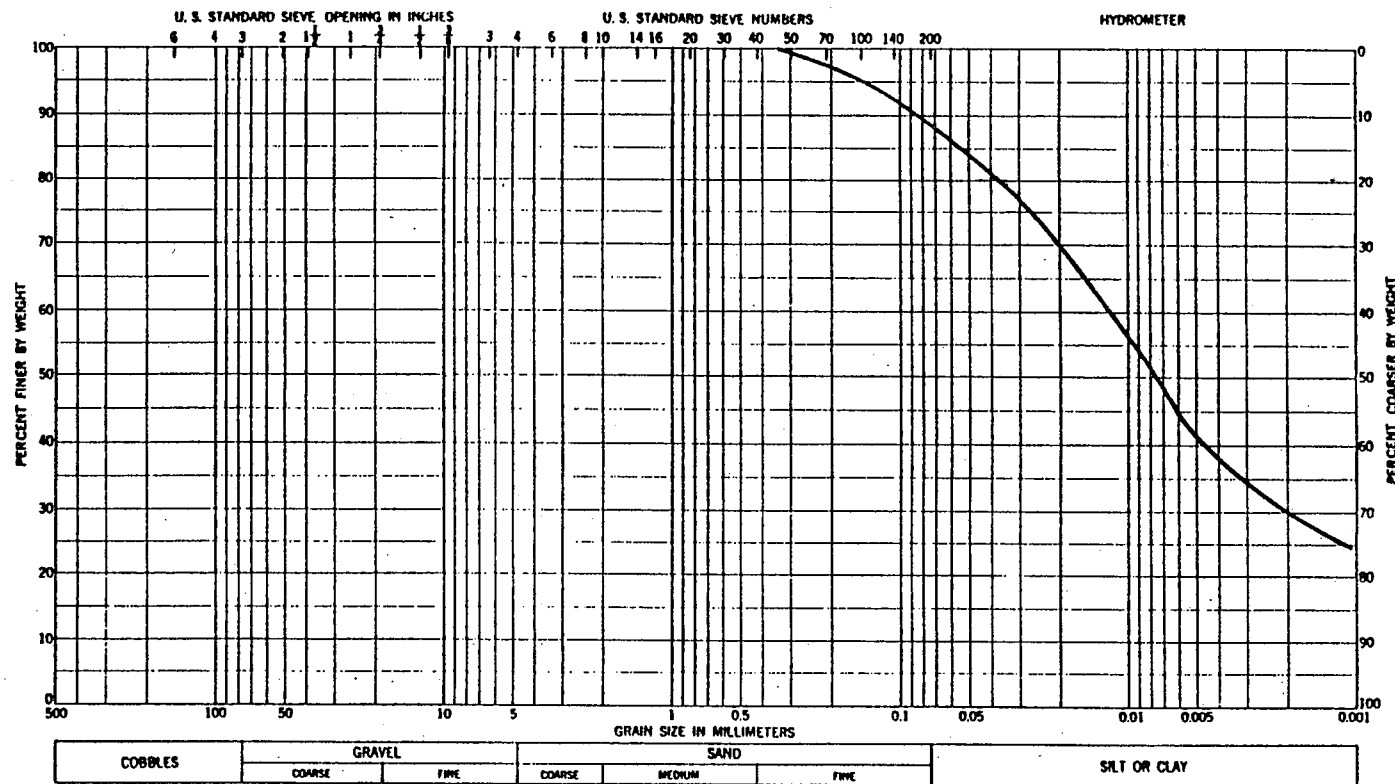
3) The project design objectives or criteria resulted from an analysis of the sediment inflow load and associated sediment characteristics. This information was obtained from the U.S.G.S. monitoring gage located at Yolo, which is approximately 5 miles upstream of the basin inlet. The information was gathered from 1943 to 1971. Of the total sediment inflow load, the USGS reports that approximately 93% is suspended load and 7% is bed load. The suspended load particle size ranges approximately from 0.001 mm (clays) to 0.2 mm (fine sands) (See Figure 3-08). This load was designated as the "target" load to be used for primary feature design. The bed load particle size ranges approximately from 0.2 mm to 20 mm (coarse gravels) and was considered only after the major features had been designed. This approach was taken since the bed load was only 7% of the total load. As the suspended sediment passes into the basin, nearly 50% continues into the Yolo Bypass. A large portion of that material then passes into the Sacramento River and eventually into the San Francisco Bay. This range of particle sizes, often defined as the wash load, was not considered to be a significant factor which could affect the flow capacity of the Yolo Bypass or to be a significant factor in the design of the sediment basin. A portion of the material does deposit in the bypass, in particular near the outlet weir. The upper limit of the particle sizes that pass through the basin and outlet weir can be determined by examining those materials which have deposited near the basin outlet in the Yolo Bypass. These are the materials which cannot be carried by the transport capabilities of the bypass flows. This particle size then became the lower limit of the "target" range for which the basin features were designed. Once the "target" range of sediment sizes was determined, Phase II-General Feature Development and Evaluation of Features, was conducted.



NOTES:

CAPACITY CURVE BASED ON 1983
TOPOGRAPHIC SURVEYS.

FIGURE 3-07
STAGE -
CAPACITY CURVE



NOTES:

1. CURVE REPRESENTS SUSPENDED SEDIMENT LOAD.
2. CURVE REPRESENTS A MEAN OF A NUMBER OF SAMPLES FOR SELECTED DISCHARGES AND LOCATIONS.
3. BASED ON USGS DATA AT YOLO GAGE

FIGURE 3-08

**GENERAL SEDIMENT
INFLOW
GRADATION CURVE**

b. Phase II - General Feature Development and Evaluation of Features. - The basic objective of the design was to trap and distribute the "target" sediments evenly over the basin. The objective of this phase of design process was to evaluate the effectiveness of various control features such as training channels, training levees or distribution vanes. It was apparent at the outset that many combinations of feature configurations were possible. Considering the established "target" range of sediment sizes and the sediment distribution objectives, an evaluation of control features was performed.

1) Preliminary Hydrodynamic Modeling. - Preliminary hydrodynamic computer runs using RMA-2V provided information about the expected velocities and flow patterns associated with various internal features. Single and multiple levees were placed both parallel and perpendicular to flow. Efforts were made to direct flows into distinct "paths" of higher velocities which would carry sediments into the greater basin area. Because of the basin size, it became apparent that the interior levees had little effect on the general flow velocities over the basin. After discharges entered the greater basin, velocities no larger than 0.5 to 1.5 ft/sec were quickly established, regardless of the extent of control features within the basin. Higher velocities were realized in the basin when the control levees were tied into the inlet channel banks and extended down into the basin. This confined the flow and caused higher velocities until the levees ended. At that point velocities again dropped into the 0.5 ft/sec range. Considering the "target" sediment sizes and the ineffectiveness of the interior control features, it became apparent that distribution levees or channels would not be effective. See Figures 3-09, 10, and 11 for test levee configurations. The relatively uniform velocity distribution over the basin, without levees, appears to be the most desirable considering the small sizes of the sediment. The silts and clays which make up a large fraction of the "target" sediments, require large distances, slow velocities, or both in order to settle. These conditions can best be achieved without interior training levees and are the conditions needed to meet the design objectives.

To add support to the proposed design concept, an evaluation of the existing features was performed. Except for the single interior training levee, no other features were provided within the basin. Sediments seemed to be well distributed over the basin area available for deposition. During high flows and complete basin inundation, sediments seem to be well distributed except for the area immediately downstream of the levee. The sands and small gravels are deposited at the end of the levee where velocities drop from 3.5 ft/sec to 0.5 ft/sec. Using the information as described above, the following design concept was developed.

2) Preliminary Design. - The primary design effort targeted the sediment sizes which range from 0.001 mm to 0.2 mm. These particles make up 93% of the total load. Therefore, the primary design focus was on the capture of these materials. Since interior features (levees and channels) were eliminated as the method for control, the primary means for effective capture was the manipulation of the outlet weir. Temporal incrementation of the weir would establish the hydrodynamic conditions needed for the desired trap efficiency. The secondary design effort dealt with the less abundant larger particle sizes. The emphasis here was to create conditions which would carry the sediments into the basin away from the inlet where clogging might occur.

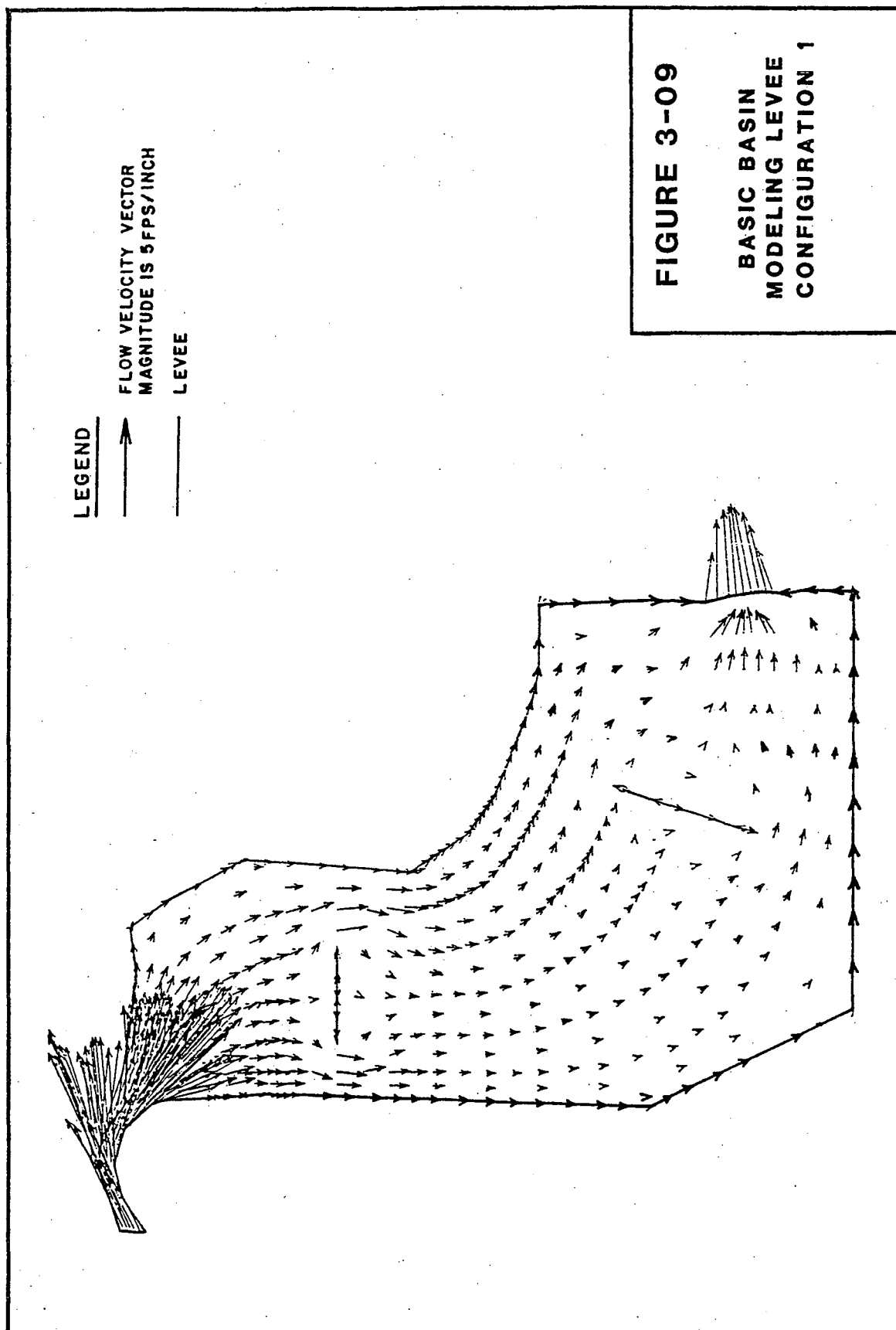


FIGURE 3-09

**BASIC BASIN
MODELING LEVEE
CONFIGURATION 1**

Figure 3-09

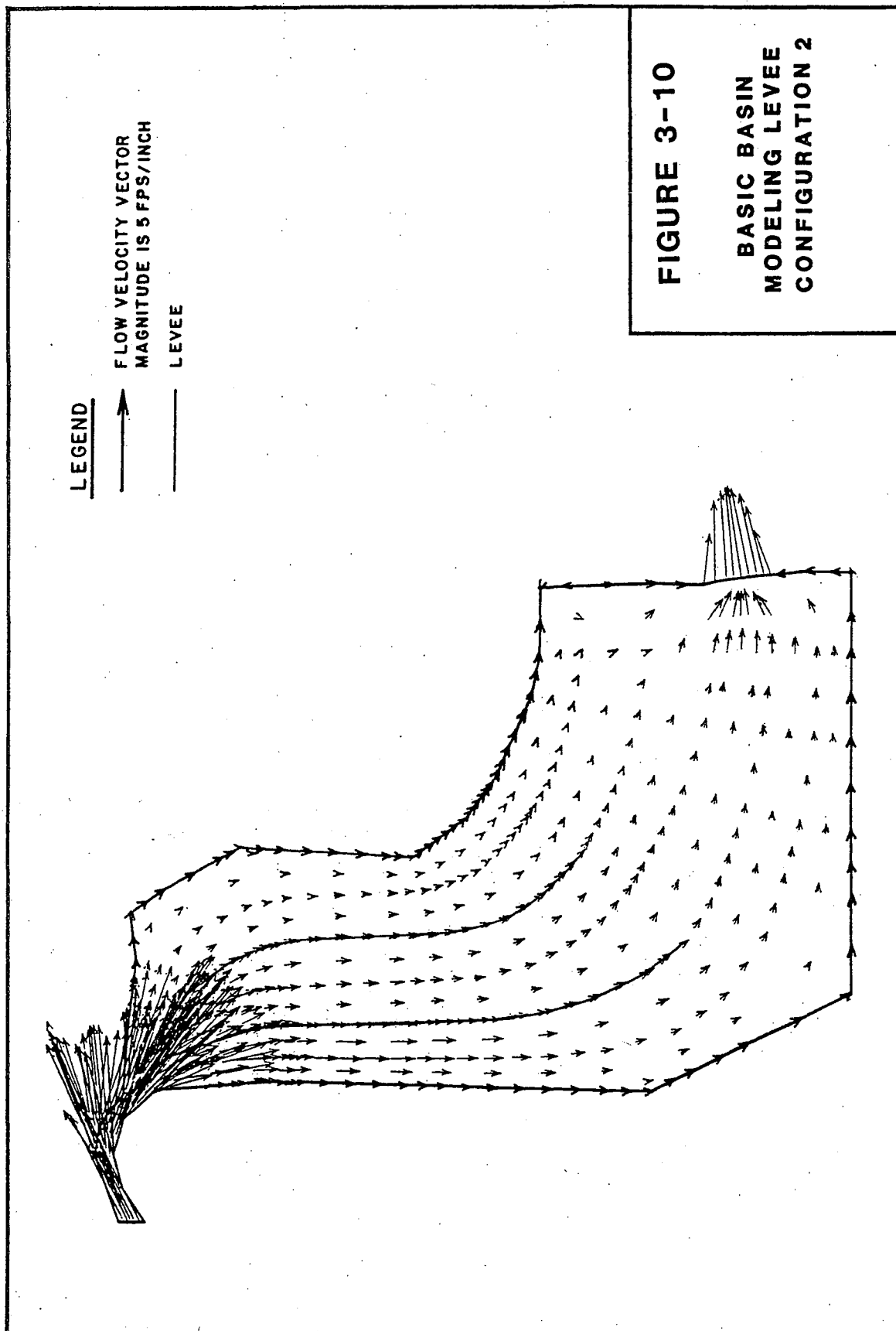


FIGURE 3-10

**BASIC BASIN
MODELING LEVEE
CONFIGURATION 2**

Figure 3-10

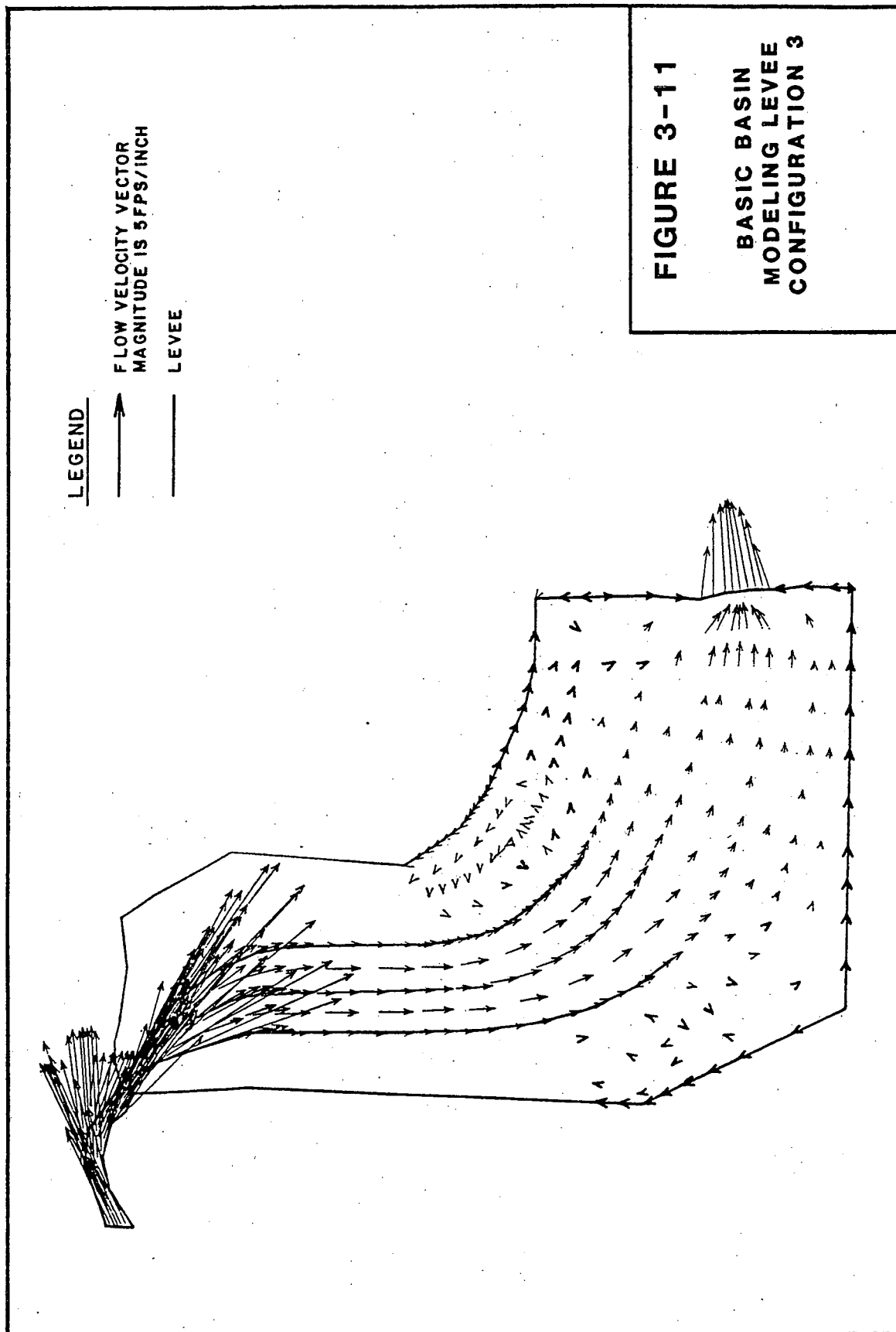


Figure 3-11

A training levee was provided to achieve these conditions. The downstream extent of the levee will be adjusted as needed to allow for effective distribution. This may be done by lengthening or shortening the levee as time goes by (Refer to Figure 3-12). Two alternatives of levee length adjustment were considered. The first alternative was to begin with a short training levee which would be lengthened over the life of the project. The second alternative was to begin with a long training levee which would be shortened over the life of the project. The second alternative was chosen for several reasons. First, considering an even distribution of the sediment was a design objective, filling of the basin beginning with the lower elevations is desired. Beginning with a short levee would only result in mounding on the already high contour elevations. Second, with a long levee it may appear that the upper basin would not be utilized. However, as time passes and the lower contours continue to fill, the levee would be cut back, thus bringing more and more of the basin into direct use. A short initial levee length would in fact allow more of the basin to be in immediate contact with sediment laden discharge. This would certainly result in too high of a trap efficiency. Lastly, a major concern of the project features is the resulting water surface conditions at Road 102. It is important to keep sediment deposits from creating increase flood stages at Road 102. This would be achieved if the deposits due to the larger-sized sediments are transported further into the basin. Effects of the project features, including the shortening of the training levee, can be monitored over the life of the project. The results of the Phase II - General Evaluation are listed below:

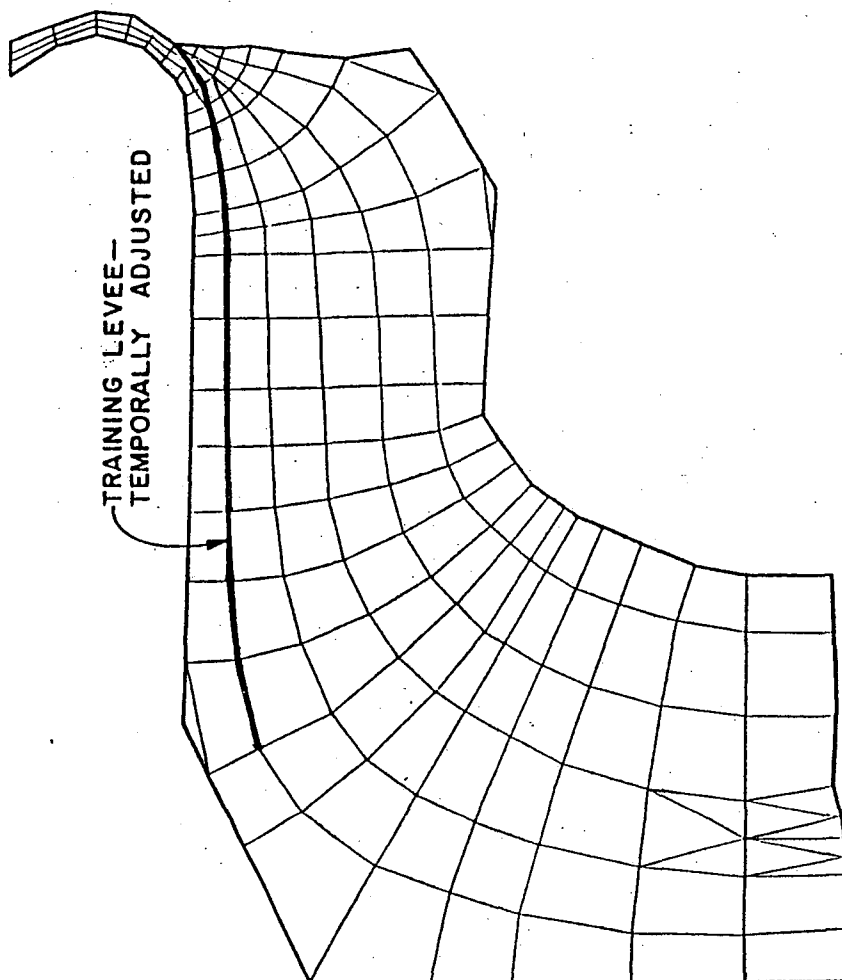
Primary Design Effort- Obtain design conditions by weir incrementation based on primary target sediment sizes.

Secondary Design- Direct larger sized (low volume) materials by internal levee manipulation.

Implementation of the Phase II design resulted in the basic feature configuration. Phase III - System Refinement was used to determine the actual sediment distribution for a given weir setting and training levee location. Temporal manipulation of these two features was determined using the 30-70% trap efficiency as the general criteria.

c. Phase III - System Refinement. - In this phase the Phase II design is completely evaluated by modeling the actual system and carefully predicting the expected sediment distribution and trap efficiency. By determining these parameters, the time-dependent adjustment or operation of the features can be determined. Figure 3-13 provides an overview of the final design process for the Cache Creek Settling Basin. This flow chart presents the sequence of steps that were used to develop the basin model and complete the evaluation of the system trap efficiency. The progression advances from Stage 1 to Stage 4 and is described below. Figure 3-14 shows the Phase II configuration that was used in the evaluation of the sediment basin trap efficiency.

1) Stage 1 - Model Construction. - Model construction entails the assemblage of the system features into finite element form in preparation for RMA-1. RMA-1 is used to generate the two-dimensional finite element grid to be used by RMA-2V. The basic model, as developed in Phase I, was modified in



NOTES:

1. THE BULK OF PARTICLE SIZES WOULD BE CAPTURED BY THE ADJUSTMENT OF THE OUTLET WEIR.
2. A TRAINING LEVEE WOULD DIRECT LARGER PARTICLE SIZES AWAY FROM THE BASIN INLET AND ALLOW FOR MORE OF THEIR EFFECTIVE DISTRIBUTION.
3. NOTE COARSE F.E. DEFINITION OF INLET CHANNEL AND WEIR.

FIGURE 3-12

**BASIC BASIN
CONFIGURATION
FROM
PHASE II RESULTS**

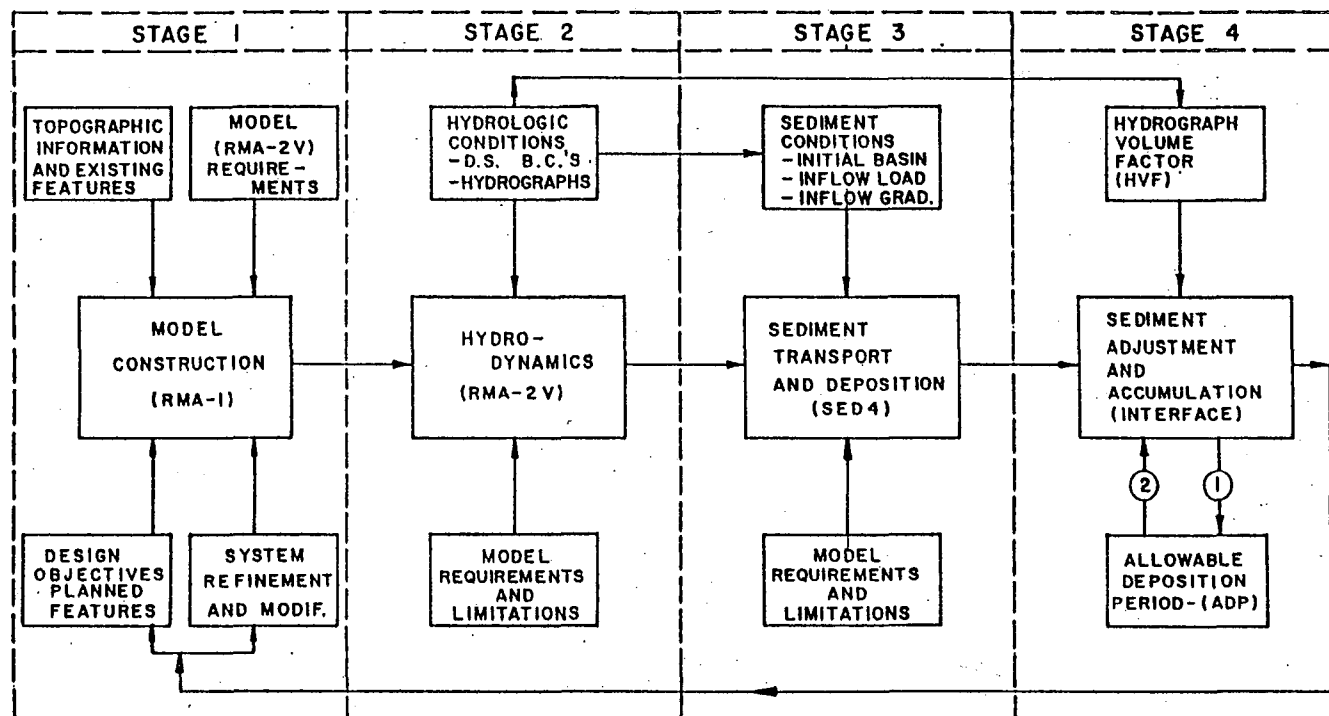
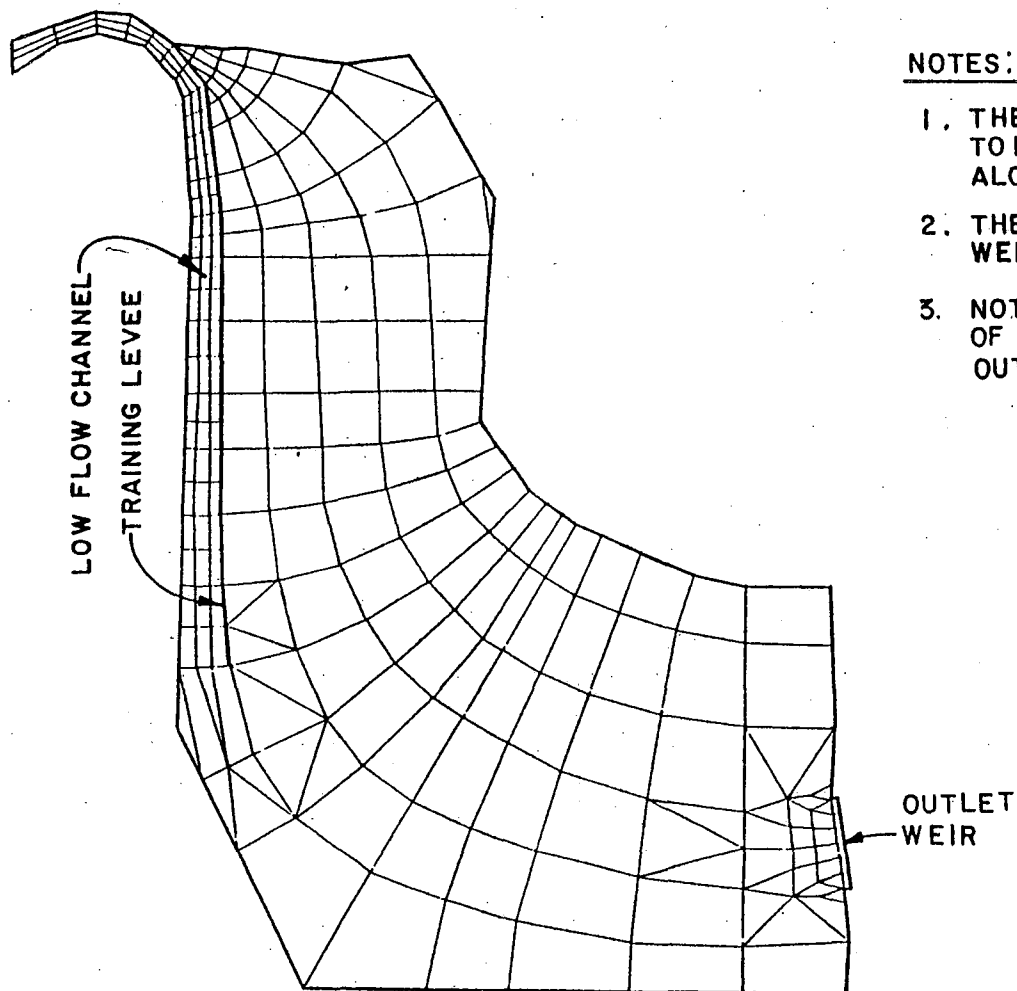


FIGURE 3-13

**DESIGN PROCEDURE
FLOW CHART**



NOTES:

1. THE BASIN ELEMENTS WERE REFINED TO INCLUDE A LOW FLOW CHANNEL ALONG THE TRAINING LEVEE.
2. THE ELEMENTS NEAR THE WEIR WERE ALSO REFINED.
3. NOTE DETAILED F.E. DEFINITION OF TRAINING CHANNEL AND OUTLET WEIR.

FIGURE 3-14

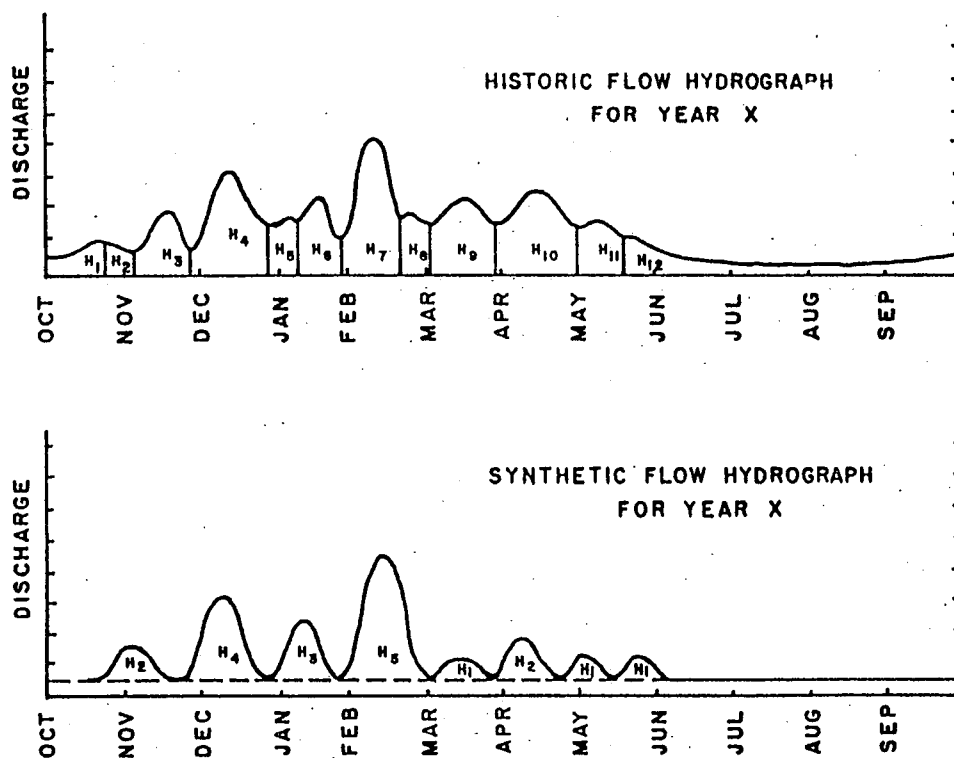
**REFINED BASIN
CONFIGURATION**

minor ways to include the low flow channel and interior training levee. Data for the existing topography was developed from surveys conducted in 1984. Contour lines and elevations for the predetermined nodal points were generated using the current version (Version 5.4) of the MOSS surface modeling program. MOSS is a proprietary contouring package from Control Data Corporation. The Stage 1 data file preparation was repeated for each system modification, including the periodic raising of weir crest.

2) Stage 2 - Hydrodynamics. - Determination of the hydrodynamic conditions provided the vehicle for sediment transport, distribution, and deposition. To model a "real water year" (continually measured discharge of the entire flow year) would be impractical. This is due to the excessive amount of computer time required to model an entire year with the small time steps that are required. An abbreviated method of analysis was developed whereby a representative flow year was modeled with a small set of predetermined hydrographs.

a) Hydrologic Conditions. - By examining a number of water years, it was apparent that the collective hydrograph could be divided into a relatively small number of specific hydrographs. These hydrographs could be grouped into categories and ranked according to volume, peak discharge, duration and/or frequency (See Figure 3-15). In each category, a representative hydrograph and corresponding number of occurrences per year could be developed. Using this procedure, a finite number (4 to 8) of hydrographs could be used to model a typical year of discharges into the basin. Owing to the limited amount of measured data that could be used to generate these hydrographs, a different but similar approach was used. From 69 years of instantaneous flow measurements, a plot of peak discharge versus frequency of occurrence was developed (Ref. 11) as shown in Figure 3-16. The frequency curve was divided into 5 ranges. The midpoint ordinate of each range was used to represent each range. Figure 3-16 shows the breakdown of the curve into ranges and the corresponding discharge for each range. The SPF hydrograph as previously developed for the Cache Creek Basin Office Report, May 1974, was used to represent a general hydrograph shape. The SPF hydrograph was scaled by the ratio of midpoint ordinate to the SPF peak. The resulting hydrograph was used to represent the storms occurring in that specific percentage interval. See Figure 3-17 for the SPF and individual storm hydrographs. Because these runoff hydrographs were used to transport and distribute the sediments through the basin, it was important that the volume of water delivered to the basin by each storm be volumetrically correct.

Because the general hydrograph shape was derived from the SPF hydrograph, the duration for all hydrographs are the same. Volumes for a given hydrograph are skewed depending on the interval it represents. The summation of all inflow hydrographs should equal the total expected inflow volume. This total volume was determined from the average annual flow measured for the period between 1904 and 1983. Higher frequency hydrographs would occur more often than would a lower frequency hydrograph. To determine the number of storm occurrences, called the Hydrograph Volume Factor (HVF), the total flow volume was multiplied by the appropriate percentage interval of occurrence and then divided by the volume of that particular hydrograph. This computation gives the number of storms per year for that hydrograph. The hydrograph is named by the midpoint value.

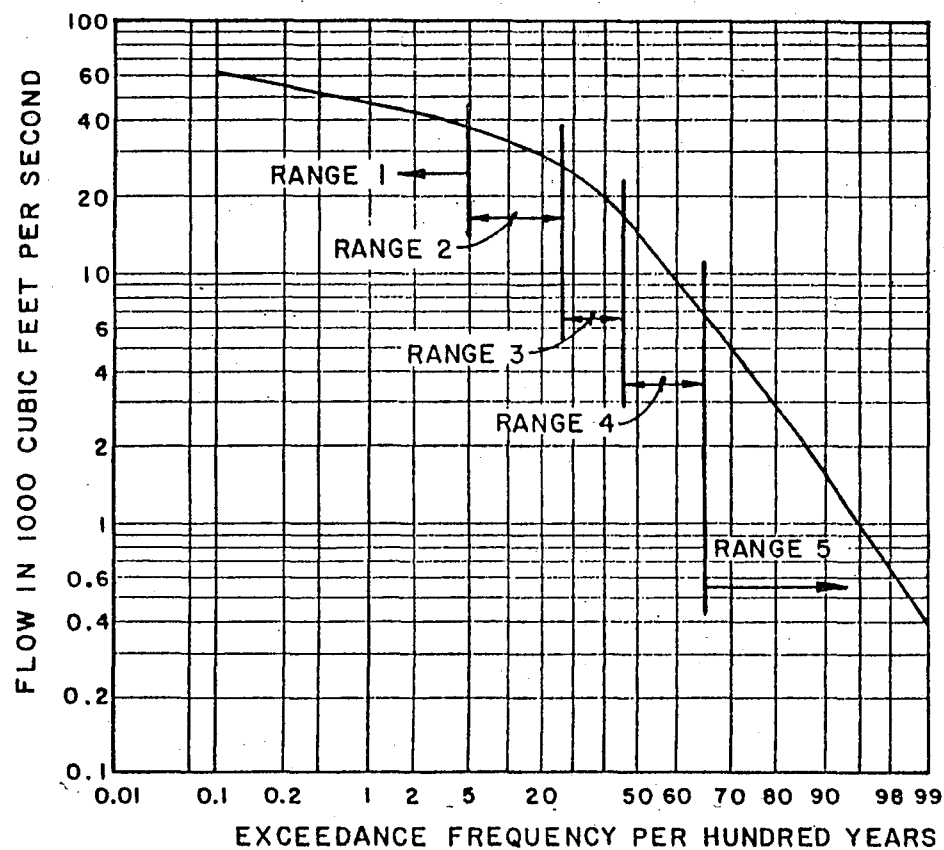


NOTES:

1. ALTHOUGH RMA-2V IS CAPABLE OF ACCEPTING SUCH DATA, IT WOULD BE IMPRACTICAL TO INPUT DISCHARGE VALUES FOR AN ENTIRE WATER YEAR.
2. EACH FLOOD HYDROGRAPH H_i CAN BE RANKED INTO CLASSES ACCORDING TO PEAK, VOLUME, DURATION OR COMBINATIONS OF EACH. ALL FLOOD HYDROGRAPHS FOR A TYPICAL WATER YEAR CAN BE DESCRIBED BY THESE CLASSES.
3. THE FLOOD HYDROGRAPH CLASSES OR REPRESENTATIVE FLOODS CAN BE DEVELOPED FROM SYNTHETIC HYDROGRAPHS. THE SPF HYDROGRAPH WAS USED FOR THE CACHE CREEK STUDY.
4. FIVE CLASSES OF FLOODS WERE CHOSEN FOR THE CACHE CREEK STUDY AS DESCRIBED IN PARAGRAPH 5.4.3. (a) AND DEPICTED ON FIGURE 14
5. NUMBER OF STORMS OCCURRING IN EACH CLASS IN A GIVEN YEAR IS BASED ON TOTAL VOLUME FOR A TYPICAL WATER YEAR.

FIGURE 3-15

**HISTORIC VS.
SYNTHETIC
ANNUAL
HYDROGRAPHS**



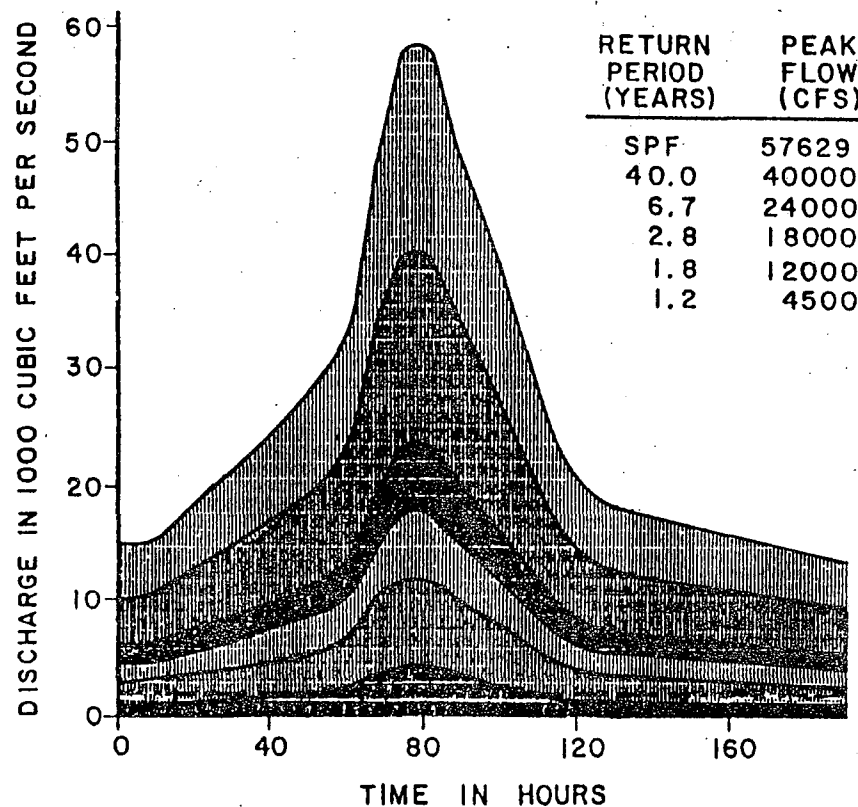
EXCEEDANCE LIMITS	EXCEEDANCE INTERVAL	MIDPOINT ORDINATE	DISCHARGE
0.01 - 5.0	4.99	2.5	40,000
5.0 - 25.0	20	15	24,000
25.0 - 45.0	20	35	18,000
45.0 - 65.0	20	55	12,000
65.0 - 99.0	34	82.5	4,500

NOTES:

1. RAINFALL FREQUENCY OF CACHE CREEK AT YOLO, INDEX POINT 10.
2. DRAINAGE AREA IS 1139 SQUARE MILES--(WITH INDIAN VALLEY RESERVOIR)
3. PERIOD IS 1902-1971
4. SOURCE: OFFICE REPORT, STANDARD PROJECT FLOOD, CACHE CREEK BASIN, CA.

FIGURE 3-16

**DISCHARGE -
FREQUENCY CURVE**



NOTES:

1. THE PEAK OF EACH HYDROGRAPH REPRESENTS THE MIDPOINT OF EACH DISCHARGE-FREQUENCY RANGE AS SHOWN ON FIGURE 14
2. THE 1.2 YEAR FLOOD WAS MODIFIED TO ACCOUNT FOR RMA-2V LIMITATIONS. FLOWS BELOW 2000 CFS WERE ELIMINATED. THE APPROPRIATE VOLUME WAS ADDED ON THE MODIFIED HYDROGRAPH BY SHORTENING THE DURATION AND SETTING EACH FLOW TO 2000 CFS.

FIGURE 3-17

**DESIGN AND SPF
HYDROGRAPHS**

b) Downstream Boundary Conditions. - The entire basin system, including inlet channel, flows within the subcritical regime. Because of this flow behavior, boundary conditions (stage and discharge) must be specified at the downstream end of the flow domain. Initially, downstream boundary conditions were set at the water surface elevation that is observed in the Yolo Bypass. However, records show that maximum water surface elevations in the bypass are not sufficiently high to act as a control at the outlet weir. Downstream boundary conditions were then set using the stage-discharge option of RMA-2V. This option allows the boundary conditions to be described by the equation:

$$Q = A1 + A2(ELEV - E0)^C$$

where:

A1 = a base flow condition. This was set to zero for the weir condition,

A2 = (weir length)*(discharge coefficient),

E0 = weir crest elevation,

ELEV = computed water surface elevation, and

C = 1.5.

This boundary condition is used in the solution of the flow equations developed in RMA-2V.

c) Hydrodynamic Computations. - Each of the five design hydrographs were supplied as input data to the RMA-2V model, which was then used to compute the hydraulic conditions in the basin. These conditions were subsequently used as input for the SED4 model which determined the sediment transport behavior caused by these flows. In addition, a steady state flow of 30,000 cfs was supplied to determine the water surface elevations (contours) needed to set the proposed levee heights. These same inflow conditions were used to set interior training-levee heights and overflow weir crest elevation. After the hydrodynamic conditions that are associated with each of the inflow hydrodynamics were determined, the distribution and deposition of sediments could be computed using SED4 in Stage 3 of the final design.

3) Stage 3 - Sediment Transport and Deposition. - Using the results of Stage 2, transport and deposition of sediment over the basin with the aid of SED4.

a) Sediment-Discharge Curve. - Instantaneous sampling of suspended sediment was taken from 1943 to 1971. The highest sediment loads during a storm normally occur on the rising limb of the hydrograph. An equivalent discharge on the falling limb normally would not carry the same load. However, when sediment samples were collected, there was no distinction between the relative hydrograph location. Therefore, the resultant sediment-discharge curve represents an "average" load between an upper and lower limit. The curve represents a least squares fit of the data plotted on log-log grid (See Figure 3-18).

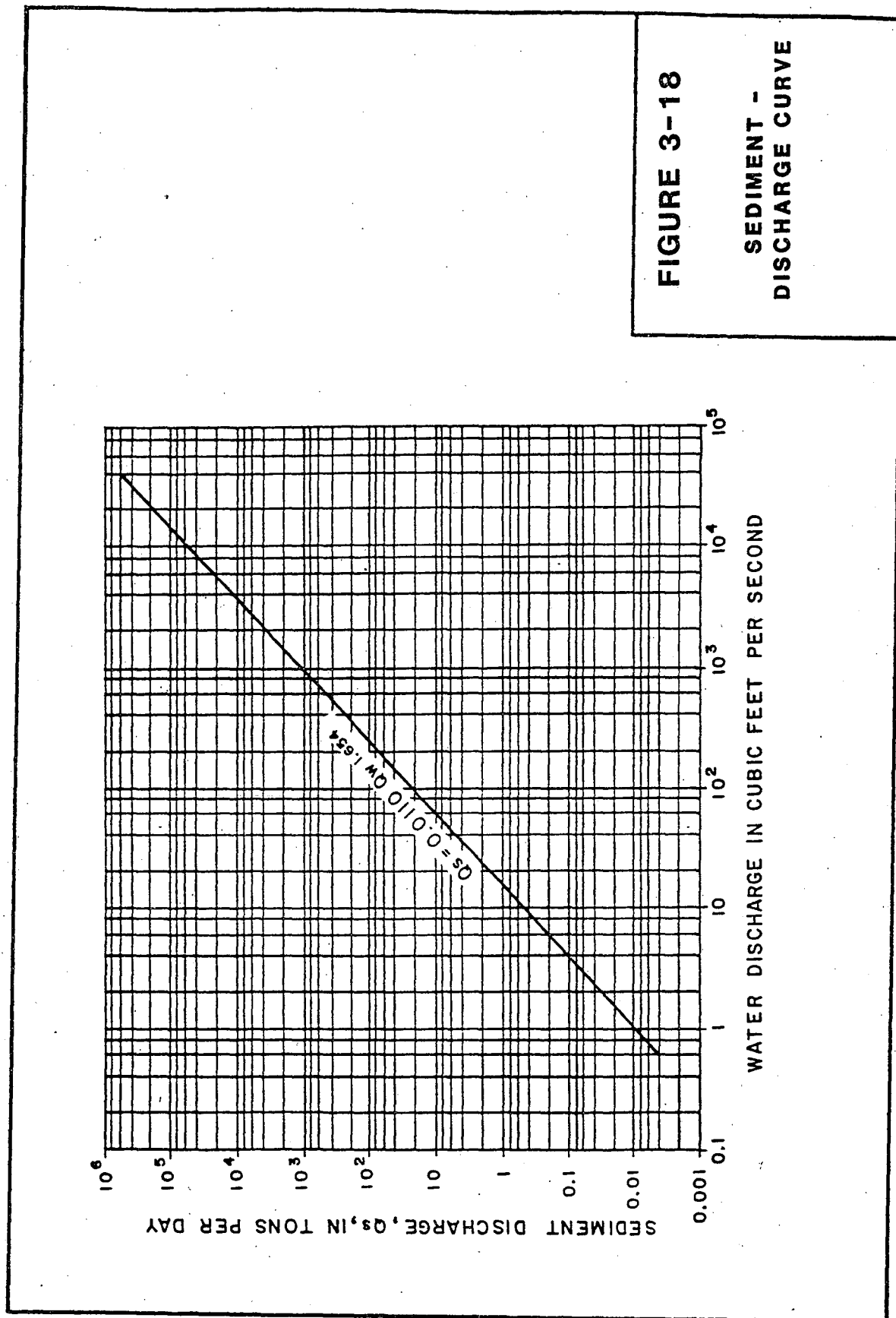


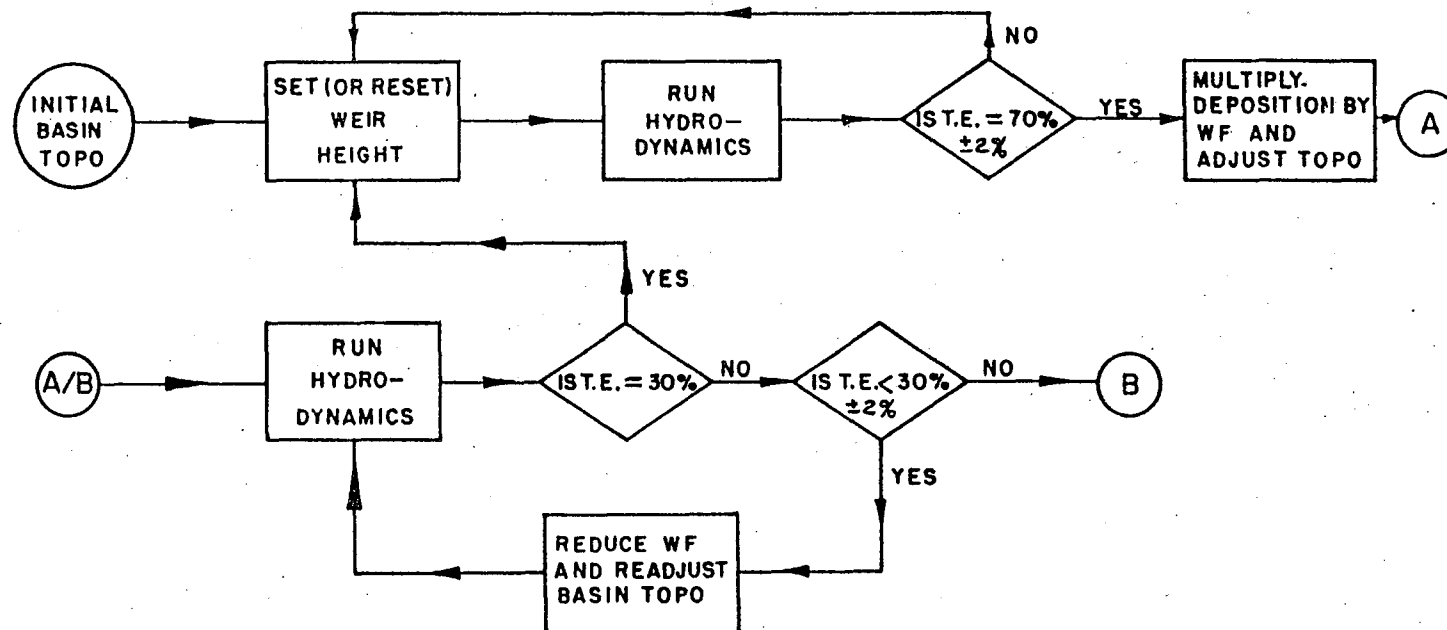
Figure 3-18

b) Inflow Concentration. - SED4 requires the inflow concentration of sediment as input data at each time step. The time steps and concentrations are chosen to correspond to the discharge input data which was supplied to RMA-2V. By using the sediment-discharge curve (See Figure 3-18) and each of the five hydrographs, five sediment concentration versus time curves were developed as input data for SED4. Each sediment inflow hydrograph would then be associated with the corresponding hydrodynamic condition at any given time step.

c) Calibration. - Calibration of the inflow concentrations was presumed to be needed to insure the target inflow volume was correct. The target sediment volume was 675 acre-feet per year as presented in Reference 9. The 675 acre-feet represents the total expected sediment yield which will enter the upstream limit (Road 102) of the Cache Creek Basin. Therefore, it is the target volume that the five hydrographs must collectively deliver to the basin. The collective volume of inflow was computed using the sediment-discharge curve and the corresponding discharge for each of the five hydrographs, including the respective Hydrograph Volume Factors. The resultant volume was checked against the target and found to be within 1%. At this point, both discharge and sediment data have been adjusted or calibrated to represent historical or measured data.

d) Transport and Deposition Computation. - For each of the five hydrographs, transport and deposition conditions were computed by SED4. These conditions were computed at each nodal point. For each point, both change in bed elevation and final elevation were computed. The results are then processed in Stage 4 for determining the total sediment change over a one year period.

4) Stage 4 - Sediment Adjustment and Accumulation. - In this stage of the final design the adjustment and collection of the computed results for each of the five inflow hydrographs is performed. Each sediment hydrograph result is multiplied by the respective Hydrograph Volume Factor (HVF). See paragraph 3-04.c.2.a for a description of the HVF. The five sediment deposition patterns are then summed to obtain the yearly sediment deposition accumulation. This summation is completed at each node for each sediment hydrograph. The yearly deposits are then multiplied by a period of years and the topography is adjusted. The period is defined as WF, the "weighting-factor." Depending on the magnitude of deposition for the period chosen, two design decisions are made. These two decisions deal with the weir height incrementation. First, the amount of the weir height adjustment must be chosen; the time to increase the height must also be selected. The following flow chart, shown in Figure 3-19, describes the procedure which was followed in making both design decisions. As previously stated, an average trap efficiency of 50% was used for design. The operating trap efficiency was allowed to range from 70% to 30%. It is up to the designer to decide how close to these limits one must be before an action is taken. For the Cache Creek Basin study, a tolerance of 2% was chosen as a "target variance" to make a decision in the design procedure. This is indicated on Figure 3-19 in the decision elements of the flow chart. Trap efficiency was computed by dividing volume deposited by average inflow load of 680 acre-feet per year.



NOTES:

1. T.E. = TRAP EFFICIENCY
2. WEIGHTING FACTOR WF REPRESENTS ALLOWABLE PERIOD OF DEPOSITION BEFORE TOPOGRAPHY ADJUSTMENT. WF WILL GENERALLY BE SET AT 5 YEARS.

FIGURE 3-19

**DESIGN PROCEDURE
FOR WEIR
INCREMENTATION**

3-05. PROJECT DESCRIPTION. -

a. Project feature improvements on Cache Creek Settling Basin would extend from Station 0+00LFMR the downstream limit (See Plate II for Basin Feature Plan and Plate VI for Low Flow System Feature Plan, as well as index for list of abbreviations for definition and delineation of levee and low flow system stationing scheme), upstream to Station 151+00LFMR, the upstream study limit. The project basin would be bounded by the existing levees on the north, east, and south, and by a new levee on the west. The new west levee would be constructed approximately 2800 feet to the west of the existing west training levee (See Plate I). The project features would include raising of the existing north, south, and east levees and relocating the west levee, replacing the "Cobble Weir", reconstructing the low flow channel system and outlet works, and implementing a sediment management plan.

The project features were designed to accommodate an additional 50 years of sediment deposition (at an average deposition rate of 340 acre-feet per year). In addition, basin levees and outlet structures were designed to contain, within freeboard limits, a design flow of 30,000 cfs. The proposed project improvements for the Cache Creek Settling Basin are described in paragraphs 5-01, 5-02 and 5-03. See Figure 3-20 for the water surface contours produced by the design discharge. Water surface contours were generated assuming the ultimate weir height of 38.5 feet.

b. 1) The low flow structure was sized using a design flow of 400 cfs. The design flow was derived using five low flow scenarios and the flow conditions associated with each. First, an existing outlet discharge of 250 cfs was estimated. The proposed structure was designed to pass at least the discharge of the existing structure. Second, the capacity of the existing low flow channel system was estimated to be approximately 750 cfs. Third, the flow at which insignificant sediment is transported was determined. Flows equal to or less than a discharge of 1000 cfs could be allowed to pass through the basin without impoundment. Fourth, the maximum discharge of 900 cfs that could be expected from the Woodland Pumping Facility. And finally, the summer irrigation return flows were estimated at 200 cfs, and considered as a basis for outlet sizing. Each of these low flow scenarios were considered separately and, where applicable, concurrently. From this analysis the design flow of 400 cfs was developed. For a description of the low flow structure, see paragraph 5-02.b.1.

2) An estimate of the average annual duration of water impoundment under project conditions after passage of a typical flood event was made. This information is required for the evaluation of the stability and design of the project levees. The controlling, worse case condition was assumed to be the impoundment of water by the outlet weir at its initial crest elevation of 32.5 feet (N.G.V.D.), 5 feet above the existing crest elevation. At impoundment stages above the weir crest, outflow from the basin (and thus duration of impoundment) is controlled principally by the outlet weir, and to a much lesser extent the discharge capacity of the low flow outlet structure. However, at impoundment stages below the weir crest, outflow from the basin is controlled by the discharge capacity of the low flow outlet only. Utilizing

FIGURE 3-20

**WATER SURFACE
CONTOURS FOR
DESIGN FLOOD**

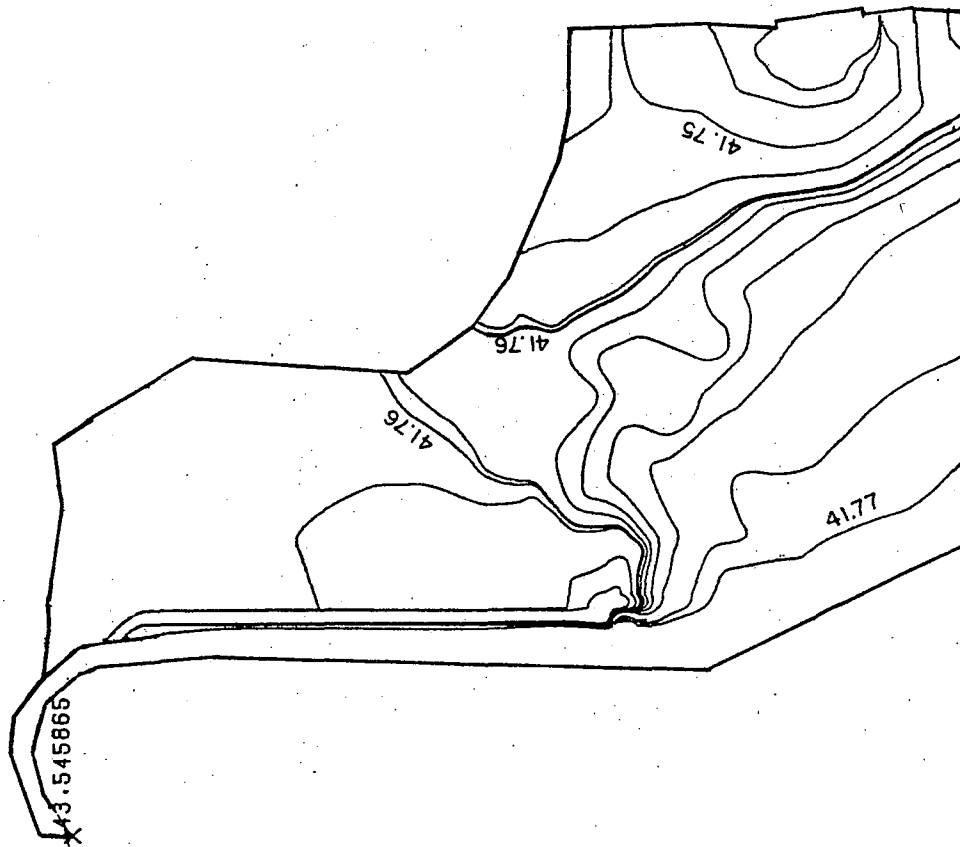


Figure 3-20

the low flow outlet structure and weir outlet discharge ratings (shown in Figures 3-06 and 3-05, respectively) and the stage-capacity curve of the basin (shown in Figure 3-07), an estimate was made of the time required to drawdown the basin storage to elevation 26.0 feet, the low flow outlet invert elevation.

Assuming no inflow from Cache Creek, the drawdown time would be approximately 6 days. Assuming an average inflow of 100 cfs from Cache Creek, the drawdown time would be approximately 10 days. Both estimates assume no tailwater in the low flow outlet channel (i.e. Yolo Bypass), and would be longer if tailwater were present. During the period of drawdown, the basin would most likely dewater from the upstream to the downstream ends (depending on basin contours). Thus, not all project levees would be impounding water for the full duration of the drawdown period.

c. The low flow channel system would have four basic functions. First, direct the low flows from the training channel to the low flow outlet structure during periods of low sediment transport. Second, transport flows from the Woodland Pumping Facility to the low flow structure. Third, collect ponded water in the greater basin area and transport those flows to the outlet structure. And finally, drain ponded water which has collected behind the outlet weir. For a description of the low flow system, see paragraph 5-02.b.

d. Sediment Management Plan. - The sediment management plan would consist of the incrementation of the outlet weir, the construction of a training channel and training levee, and scheduling partial removal of the training levee. For a description of training levee removal, see paragraph 3-05.d.2.

1) Outlet Weir Construction. - The outlet weir would be initially constructed to a crest elevation of 32.5 feet as developed using the procedure described in paragraph 3-04.b. At year 25 of the project life, or when a measured trap efficiency of less than 30% is realized, (Refer to paragraph 3-05.d.3, Monitoring Plan) the weir would be raised to a crest elevation of 38.5 feet, the final weir height. Determination of the measured trap efficiency and departures from this weir incrementation plan shall result from a joint effort between the non-Federal sponsors and the Corps of Engineers. The timing of weir incrementation is based on the computed trap efficiency versus time plot as shown in Figure 3-21. This plot was based on incrementing the weir at year 25. Although the plot reveals deviations from the desired trap efficiency range, the average trap efficiency for the life of the project is approximately 55%.

Figures 3-22 through 27 shows the basin topography at 10 year increments. Although a "flat" basin topography is not achieved, the average annual trap efficiency is sufficiently close to the design objective. See Plate X for the outlet weir details.

2) Training Levee and Training Channel. - The training channel and training levee would direct flood flows down into the greater basin area thereby releasing sediments away from the upper channel region. The channel and levee would extend the "effective" Cache Creek down into the basin to Station 163+00LFMR as shown on Plate VI. During years 25-45 of the project

Average Trap Efficiency is 55%

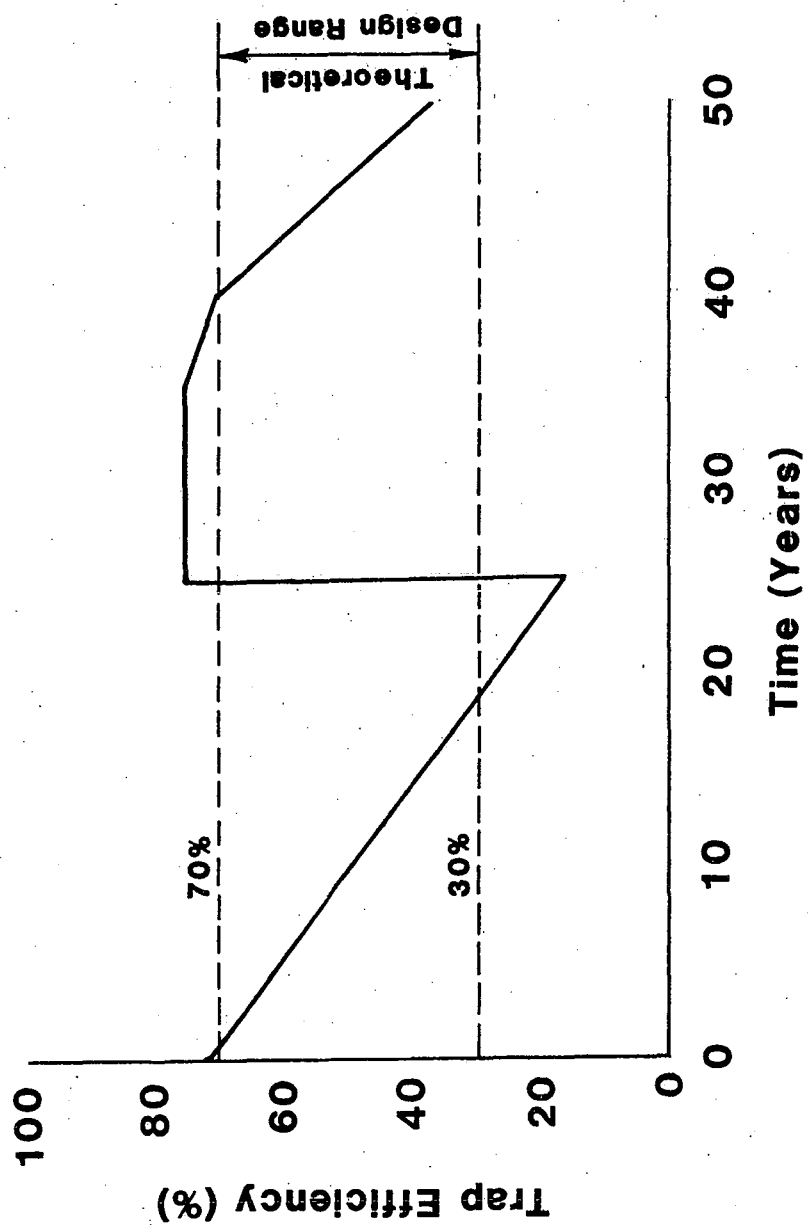


FIGURE 3-21

BASIN TRAP
EFFICIENCY VS.
TIME

Figure 3-21

FIGURE 3-22

**TOPOGRAPHY
CONTOURS,
YEAR 0**

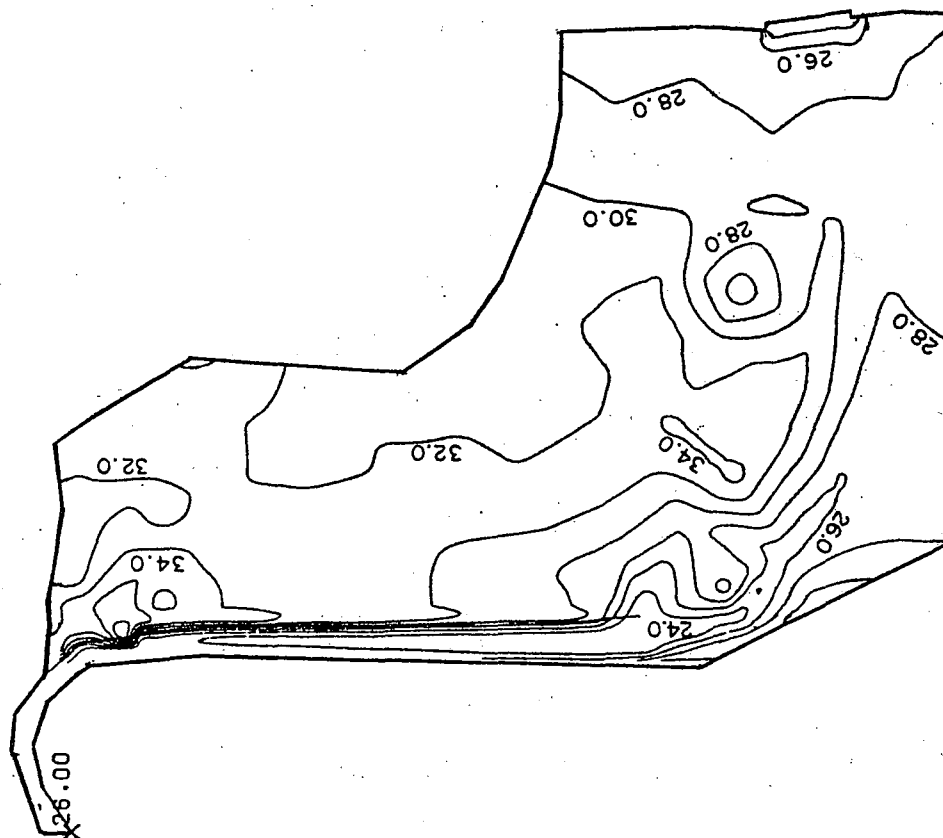


Figure 3-22

FIGURE 3-23

**TOPOGRAPHY
CONTOURS,
YEAR 10**

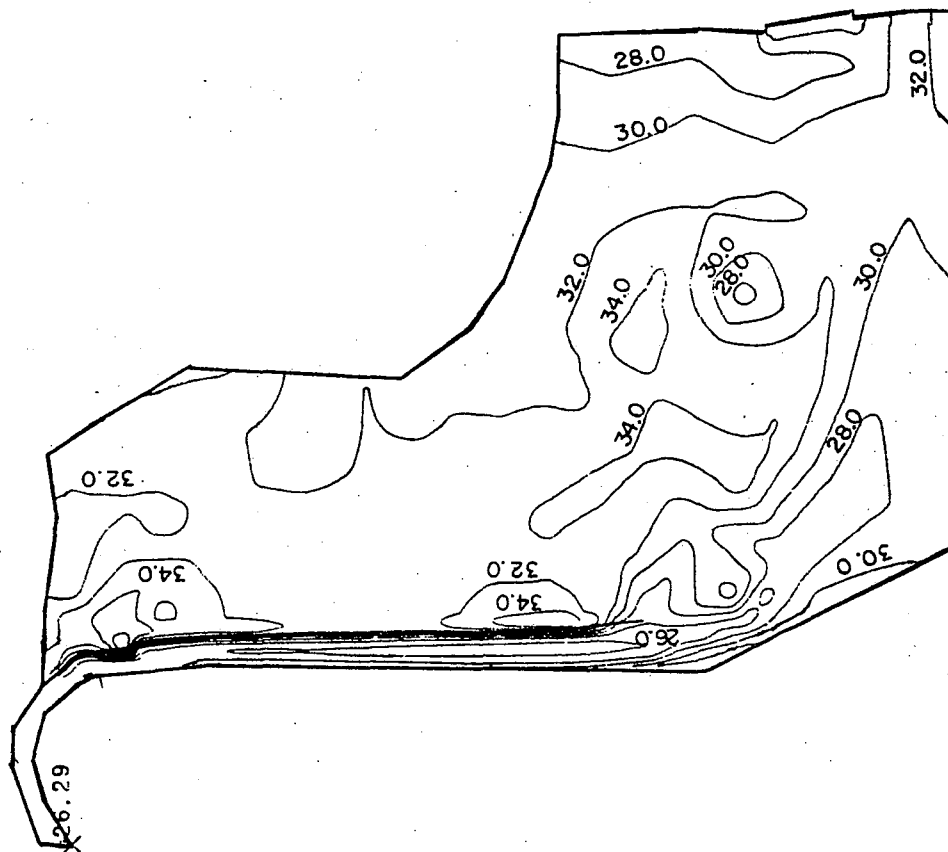


Figure 3-23

FIGURE 3-24
TOPOGRAPHY
CONTOURS,
YEAR 20

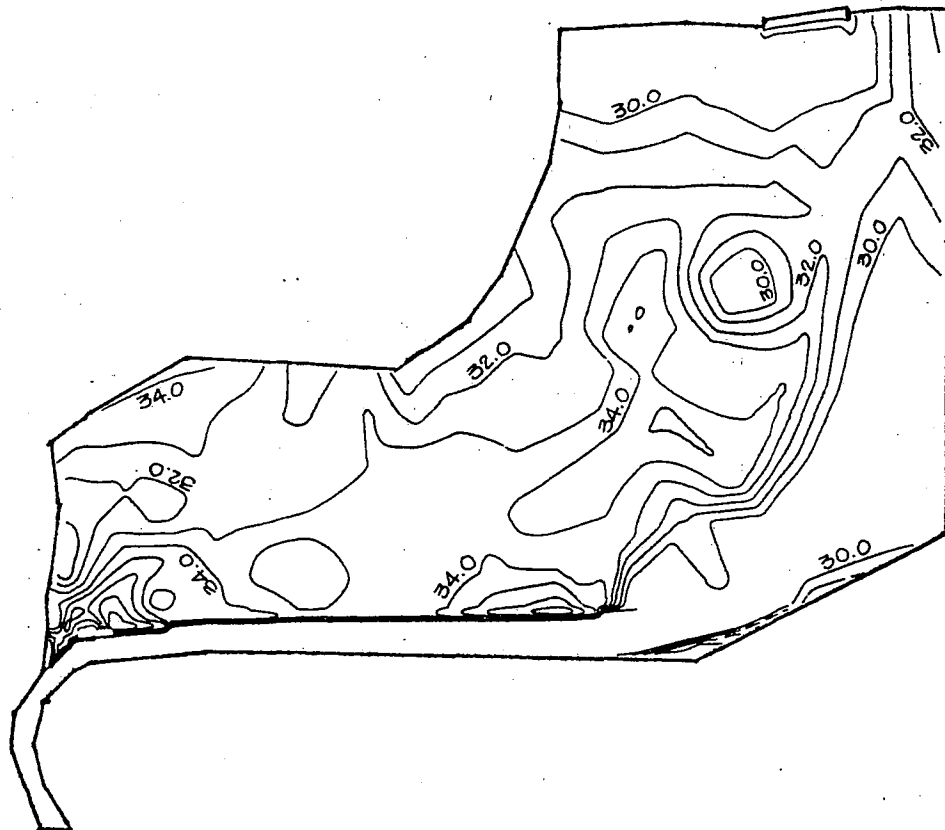


Figure 3-24

FIGURE 3-25
TOPOGRAPHY
CONTOURS,
YEAR 30

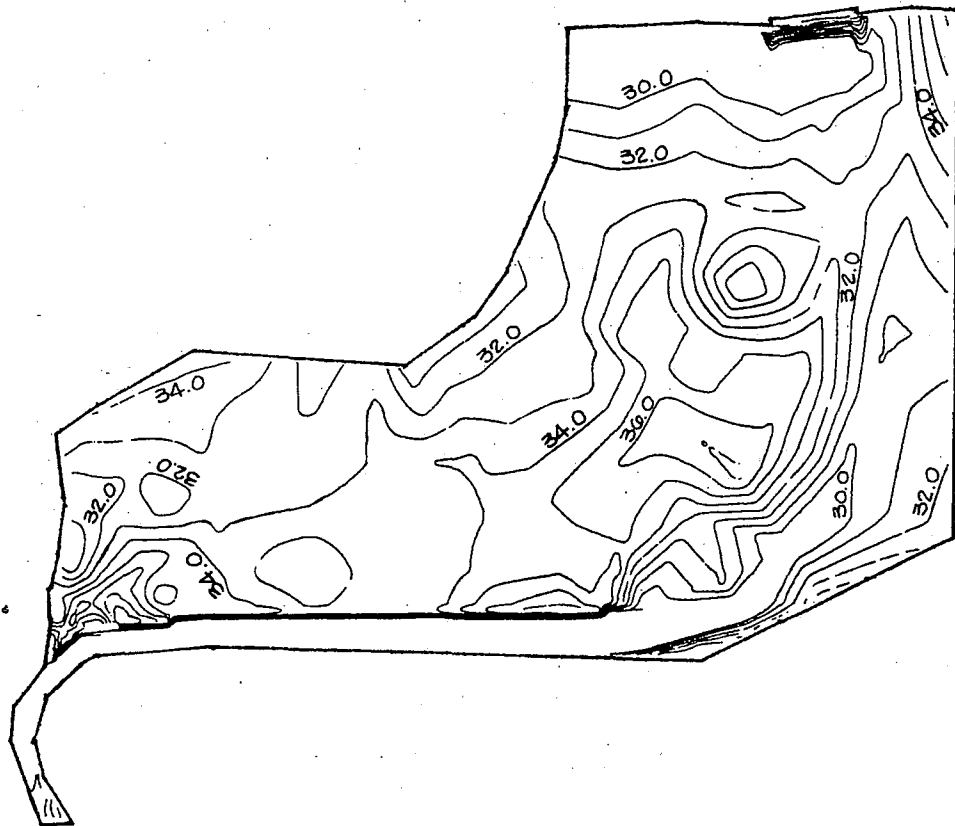


Figure 3-25

FIGURE 3-26
TOPOGRAPHY
CONTOURS,
YEAR 40

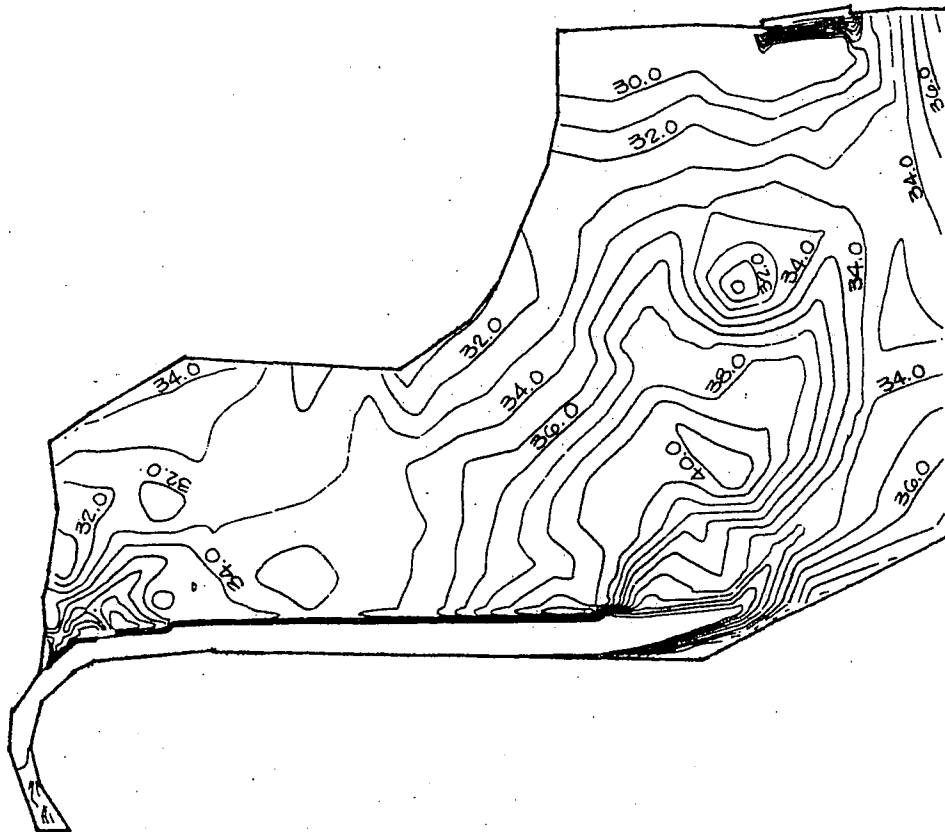


Figure 3-26

FIGURE 3-27
TOPOGRAPHY
CONTOURS,
YEAR 50

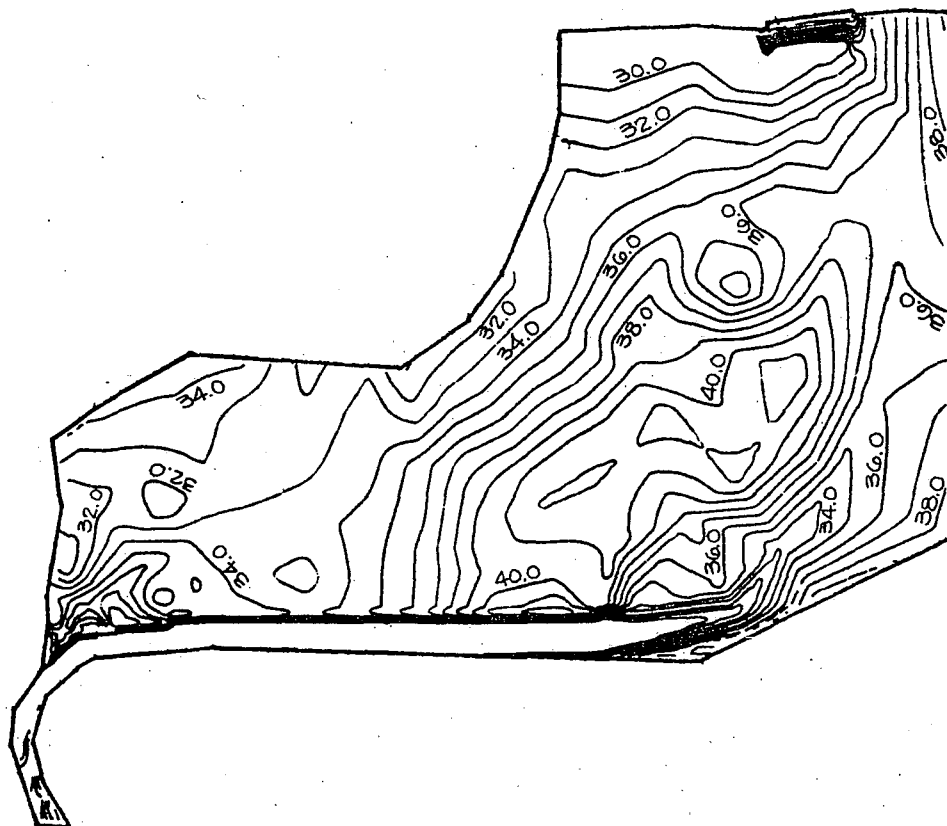


Figure 3-27

life, portions of the training levee will be removed by the non-Federal sponsor. 400-foot sections of levee will be removed at 5 year intervals, starting with year 25 of the project life. The portions to be removed will be spaced every 1100 feet, starting at the bottom of the training levee, Station 0+00TC. For a description of training levee removal by cross section, refer to Table 3-01. This will allow for better distribution of the sediment delta. This delta is formed by larger sized particles which are dropped out at the training channel outlet. The effectiveness of shortening the training levee can be seen in comparison of, with and without levee plots of velocity, contour and bed change (Figure 3-28 through 3-33). Departures from this levee shortening plan shall result from a joint effort between the non-Federal sponsor and the Corps of Engineers, based on the result of surveys conducted for the sediment monitoring plan.

3) Monitoring Plan. - A supplemental monitoring plan shall be implemented to provide a means for checking effectiveness of the outlet weir setting. Permanent range lines or survey grid shall be established over the basin and within a 2000 foot radius of the outlet weir in the Yolo Bypass, to provide a base from which periodic surveys shall be taken. Range line within the basin have been established, see paragraph 5-10. The surveys shall be taken every five years with enough detail to generate topography contours of 1.0 foot intervals. Sediment samples shall be taken near the inlet to the Cache Creek Basin so that total load discharge into the basin can be determined. Sediment data shall be used to verify and adjust assumed sediment discharge curve, and to compute the basin trapping efficiency. Computation of the progressive trap efficiency shall be made based on the volume of material trapped and the sediment inflow. Adjustments to the recommended weir incrementation as presented in paragraph 3-05.d.1 and training levee removal can then be considered.

3-06. Bank Protection Requirements. - Slope protection consisting of rock riprap would be provided at critical locations over the project area as described in paragraph 3-03.c. Bank protection will be required on the abutments of the outlet weir. The rock will extend 50.0 feet from both outlet weir abutments from the top of levee to the levee toe on both basin and bypass sides. Rock will also be provided at the inlet and outlet of the low flow structure as shown on Plate VII, Sheet 1.

3-07. Project Impact on the Standard Project Flood and Floodplain. -

Hydraulic analyses were performed to evaluate the impact flows exceeding the design flow (30,000 cfs) and up to the Standard Project Flood (SPF), would have on the project and on the adjacent areas. The purpose of this evaluation was to ensure the project features would not induce flooding during the SPF event on previously unflooded overbank areas for preproject conditions. The evaluation also determined whether the project features imposed any increase in depth or encroached on the existing freeboard of bridges or levees outside of the project limits. Correspondingly, effects of the project features on conditions in the Yolo Bypass were evaluated to determine if induced flooding existed.

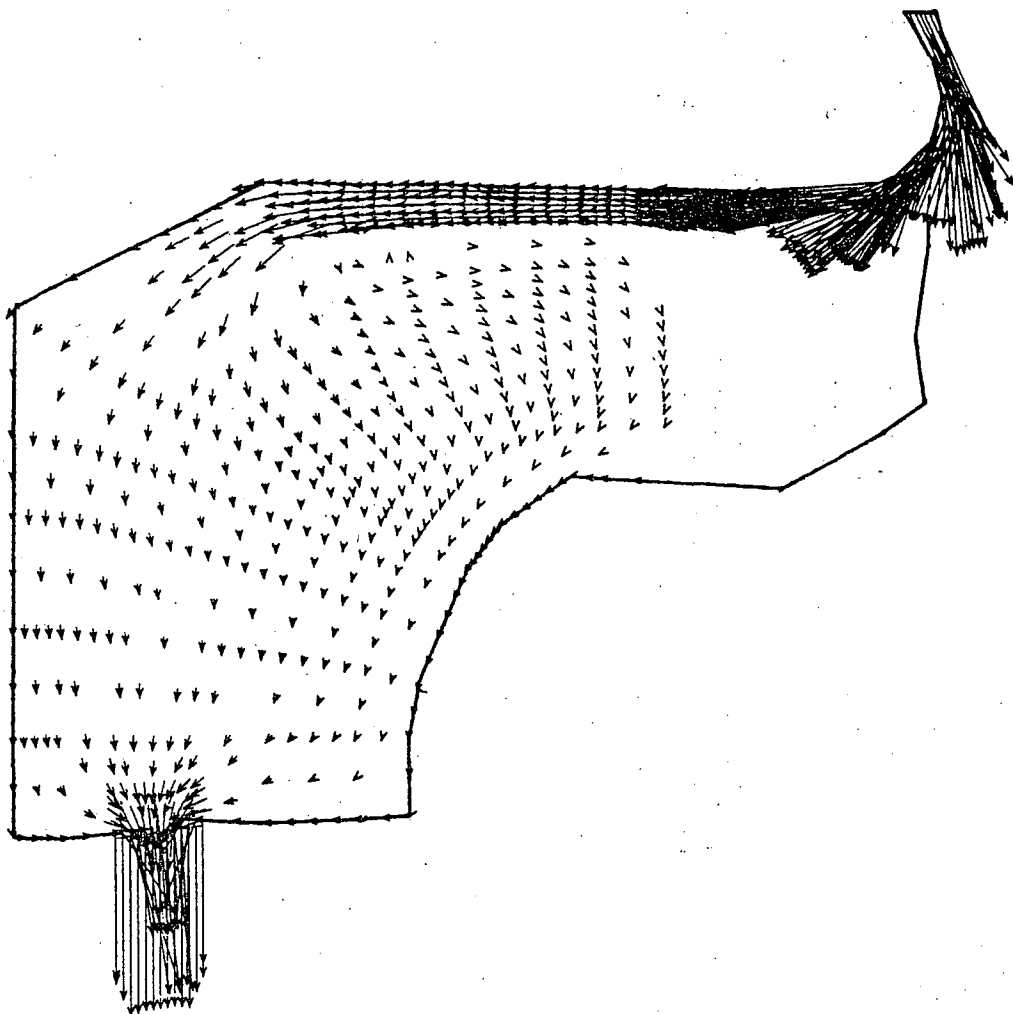


FIGURE 3-28
VELOCITY VECTORS
FULL LEVEE

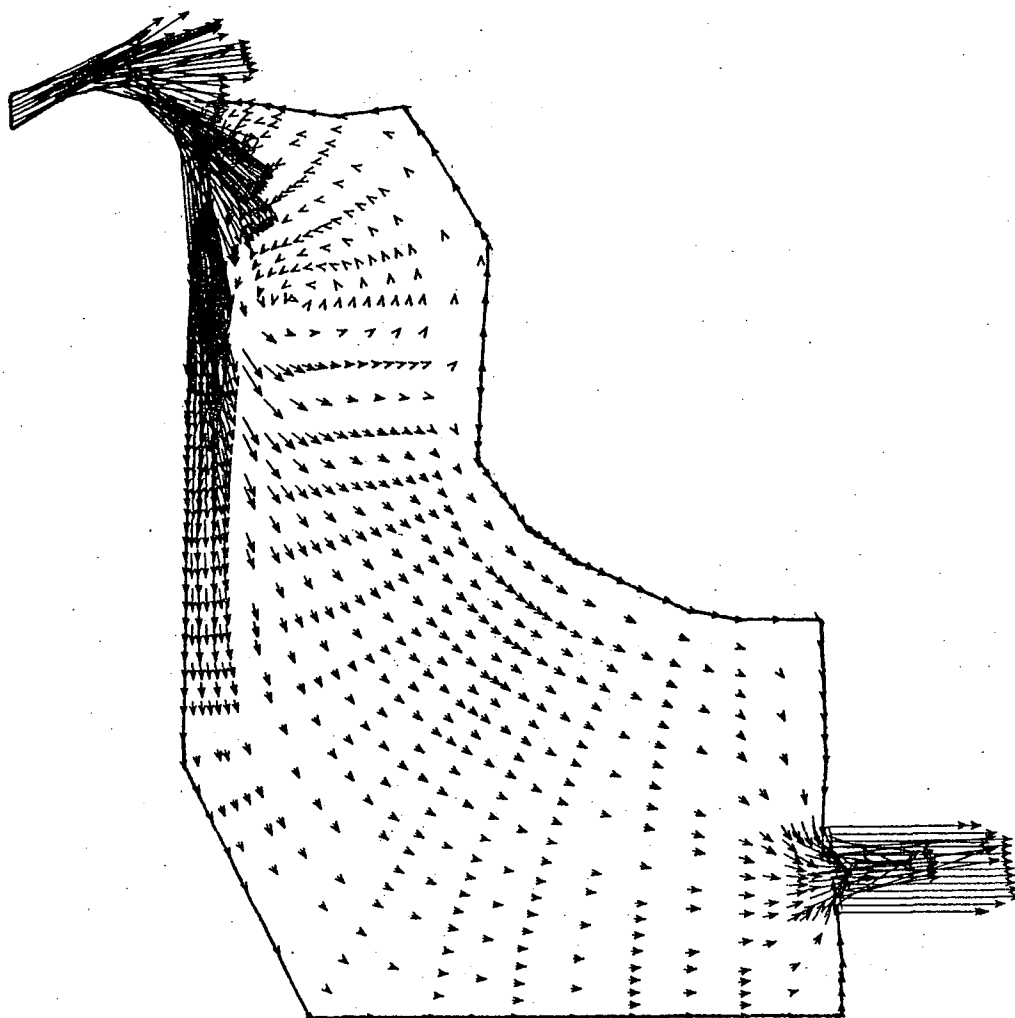


FIGURE 3-29
VELOCITY VECTORS
1/3 FULL LEVEE

FIGURE 3-30
TOPOGRAPHY
CONTOURS, YEAR
35, FULL LEVEE



Figure 3-30

FIGURE 3-31
TOPOGRAPHY
CONTOURS, YEAR 35
1/3 FULL LEVEE



Figure 3-31

FIGURE 3-32
BED CHANGE FROM
YEAR 30 TO 35
FULL LEVEE

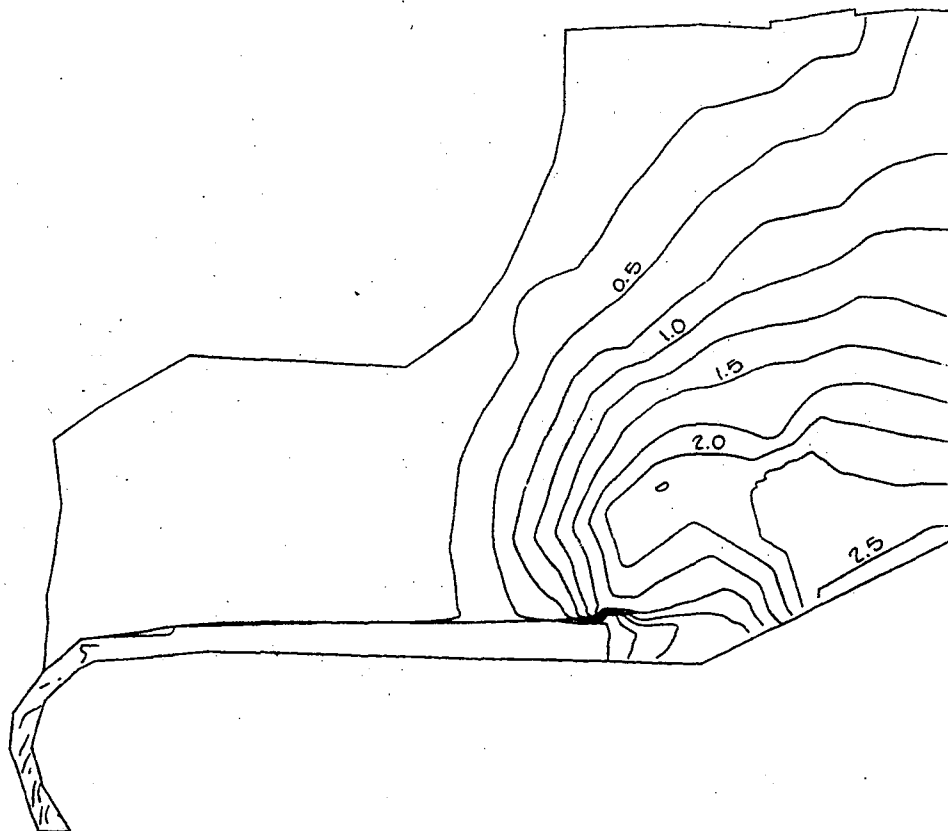


Figure 3-32

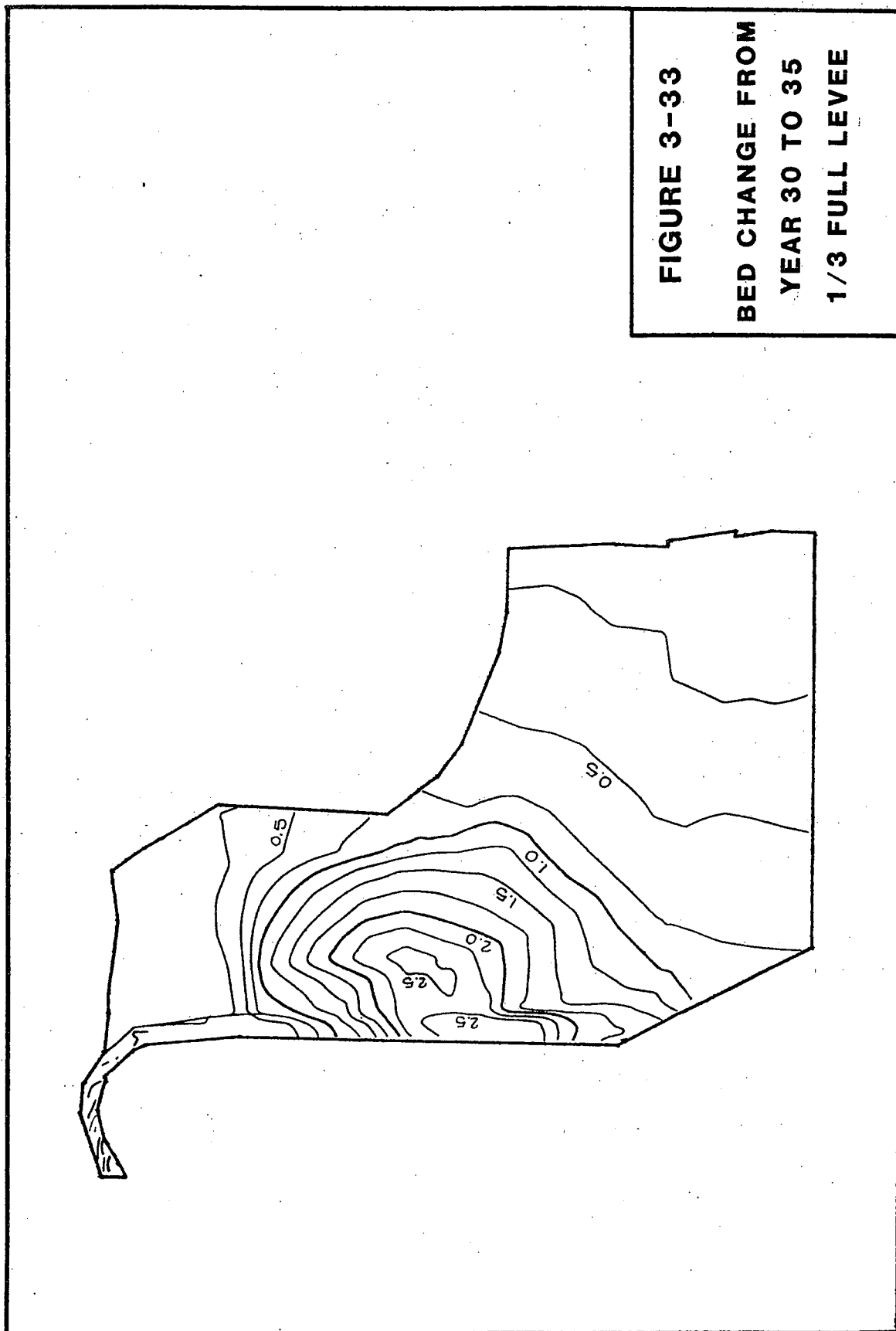


Figure 3-33

a. The current version of RMA-2V, "Two-Dimensional Finite Element Hydrodynamics", was used to compute water surface contours through the basin and profiles along the training and low flow channels. Using the same geometric data set as that used for project feature development, several flows between the design flow and the peak SPF (57,629 cfs) flow inclusive, were modeled. The resultant water surface profiles were compared to two previous studies to determine if the project would induce flooding. Both basin and training channel elevations were adjusted to project-end conditions to encompass the worst case condition. The basin elevations were adjusted using the SED4 sediment distribution and deposition model.

b. Channel elevations were adjusted by estimating channel transport capacities versus sediment inflow. The comparison water surface elevations were imposed at the County Road 102 bridge. The sources of these elevations were historical stage discharge measurements at Road 102 and computed water surface profiles from the 1958 Design Memorandum No. 10 for Levee Construction.

c. It was found that flows up to 30,000 cfs would not increase the water surface above existing conditions and that flows up to the SPF would encroach on the existing freeboard only, as with the pre-project condition. The analysis of flood inducement for flows over 30,000 cfs is only relevant for the region below Road 102. It has been determined that the channel capacity upstream of the Cache Creek Levee system is limited to approximately 30,000 cfs. Therefore, for flows "available" to the Cache Creek Settling Basin, no flood inducement would occur.

3-08. References. - The following references were used to develop design criteria and project features;

1. CHOW, V.T., "Open-Channel Hydraulics." McGraw-Hill Book Company, (1959), 265-268.
2. "HEC-2 Water Surface Profiles." U.S. Army Corps of Engineers, (1982).
3. KING, I.P., NORTON, W.R. and ORLOB, G.T., "A Finite Element Model for Lower Granite Reservoir," Water Resources Engineers, (1973).
4. KING, I.P., "Finite Element Model for Two-Dimensional Depth Averaged Flow - RMA-2V, Version 3.2," Resource Management Associates, (1985).
5. THOMAS, W.A., and McANALLY, W.H., "Users Manual for the Generalized Computer Program System - Open-Channel Flow and Sedimentation TABS-2," Department of the Army - Waterways Experiment Station, Corps of Engineers (1985).
6. ZIENKEWICZ, O.C., "The Finite Element in Engineering Science," McGraw-Hill (1971).
7. "Sedimentation Engineering," Manuals and Reports on Engineering Practice No. 54, American Society of Civil Engineers (1975).
8. "National Engineering Handbook-Section 3, Sedimentation" Soil Conservation Service, U.S. Dept. of Agriculture (1983).
9. "Cache Creek Basin, California - Communication from the Assistant Secretary of the Army - House Document No. 98-134, (1983).
10. ARIATHURAI, R., "Fundamentals of Sediment Transport," Resource Management Associates, (1985).
11. OFFICE REPORT - "Cache Creek Basin, California - Standard Project Floods," Department of the Army, Sacramento District, Corps of Engineers, (1974).

CHAPTER 4 - GEOLOGY, FOUNDATION CONDITIONS, CONSTRUCTION MATERIALS, AND GROUNDWATER

4-01. GEOLOGY. -

a. Regional. - The Cache Creek Settling Basin lies within the westcentral portion of the Great Valley geomorphic province. The Great Valley is an elongate, asymmetric geosynclinal trough whose axis trends nearly north-south and is inclined to the west. The valley is bounded on the east by the foothills of the Sierra Nevada and on the west by the Coast Ranges. The two major river systems which drain the Great Valley are the Sacramento River to the north and the San Joaquin River to the south. Outward drainage is through Carquinez Strait, downstream from where the two rivers converge and then flow into San Francisco Bay. The primary material types in the Great Valley consist of thick sequences of Upper Cretaceous to Recent sediments of marine, lacustrine and alluvial origin. The Late Cretaceous sediments originated from erosion of the Sierra Nevada and were deposited into a shallow sea. Uplift of the Coast Ranges to the west created an additional source of sediments for deposition into these marine waters. The simultaneous deformation of the Coast Ranges and deposition in the valley continued through the Pliocene Epoch until most of the marine waters were gone, leaving isolated brackish and freshwater lakes. Continued uplift of the Coast Ranges entrenched the Sacramento-San Joaquin River systems which are responsible for alluvial deposition which continues to the present time. Sediments are generally thicker and more steeply dipping on the western side of the valley and are thinner and flatter-lying on the eastern edge. This thick sequence of sedimentary deposits overlies the basement complexes of the Sierra Nevada and the Coast Ranges which are believed to be in fault contact at considerable depth beneath the valley.

b. Areal. - The Cache Creek Settling Basin lies within the Sacramento River Valley on the eastern flank of the geosyncline. The geology is typical of that of the Great Valley geomorphic province. The three major surficial deposits at the site are: Recent alluvial fan deposits, Recent basin deposits, and Recent river and major stream channel deposits. The fan deposits are sediments deposited from streams emerging from Cache Creek highlands and are composed of a heterogeneous mixture of particles from clay to gravel. The basin deposits were deposited during flood stages of Cache Creek and the Sacramento River in the area between the natural stream levee and the adjacent fan and are composed of silt and clay. Recent river sediments were deposited along river channels and major streams including adjacent natural levees and are primarily silt, sand and gravel with some clay. These materials are generally flat-lying and their margins somewhat interfinger.

c. Seismicity and Seismic Hazards. - The Cache Creek Settling Basin lies within Seismic Zone 3. This indicates the potential exists for major damage to structures from earthquakes. The nearest possible sources for seismic ground motion are from the Dunnigan Hills fault (8 miles northwest), and the Midland fault zone (approximately 15 miles southwest). Farther southwest (about 35 to 45 miles) is the Green Valley-Concord-Calaveras fault systems.

To the northwest is the Foothill fault zone at a distance of about 35 miles. No study has been done to determine specific faults and their capability with respect to the Cache Creek Settling Basin project.

4-02. FOUNDATION CONDITIONS. -

a. Explorations and Testing. - Three separate investigation programs have been conducted in the Cache Creek Settling Basin area (see Plate XII, Sheet 1 for location of explorations). The results of these programs were analyzed with respect to existing conditions within the Settling Basin. The programs can be summarized as follows:

1) US Army Corps of Engineers (1958). - A total of 10 auger holes were drilled in the basin by the Sacramento District from May to July 1958. The holes are identified by 2F-8 or 2B-8 designations, and were drilled to investigate field conditions and determine soil types. All materials encountered were field classified, and representative disturbed samples were lab tested.

2) University of California, Davis (1975). - As part of a report initiated to investigate the proper use of basin soils and to evaluate the feasibility of different proposed operational schemes, Dr. Shen, assisted by Dailey and Cox, two UCD students, conducted an exploration program in the Cache Creek Settling Basin area. Sampling with a five-inch diameter hand auger was limited to sediments deposited in the basin interior. Surficial borings designated as A through O ranged from three to ten feet. Materials encountered were field classified and representative samples were collected for laboratory analysis.

3) US Army Corps of Engineers (1984). - In June 1984, the Sacramento District drilled 30 auger holes in the basin area. 20 of the explorations, identified with 2F-84 designations were drilled with an eightinch diameter hollow stem auger along the project alignment. Standard Penetration tests were conducted, and selected materials were sampled with Shelby tubes. Depths of these explorations ranged from 15 to 30 feet. The remaining 10 explorations were drilled with a 24-inch diameter auger in the proposed borrow area. These holes, identified by 2B-84 designations ranged from 10 to 20 feet in depth. All materials were field classified and representative samples were lab tested.

b. Typical Properties. - Based on the sub-surface exploration programs conducted, project foundation and existing levee conditions were established. In general, materials are composed of sandy clay (CL-CH). The average gradation of 98 samples tested contained 85% fines and 15% sand. A majority of the materials had medium to high plasticity. Consistencies, based on Standard Penetration Resistance values (N), varied from soft (N=3) to very stiff (N=27) for the foundation and firm (N=8) to very stiff (N=28) for the existing levees. Since the materials are fine-grained, permeabilities will be low. Due to proposed loading conditions and the extent of clay deposits, maximum foundation settlements will be on the order of eight to ten inches. Surficial overconsolidated materials, extending to depths of ten feet, will

limit these displacements somewhat. Foundation materials in the weir area, as depicted in explorations 2F-8-18 and 2F-8-19, consist of 6 to 8 feet of loose surficial silts, sands, and gravels, underlain by stiff to very stiff clays.

4-03. CONSTRUCTION MATERIALS. -

a. Borrow Areas. - The primary source of required fill will be from excavation in the western portion of the expanded basin. Fill obtained from required removal of the existing training levees will augment this primary borrow source. The locations of the available borrow area and the existing training levees are shown on Plate XII, Sheet 1.

b. Borrow Materials. - Materials to be excavated in the western portion of the proposed enlarged basin are predominately sandy clays (CL-CH). Plasticities range from low to high, with a majority of the values in the medium plasticity range. Materials average six percent wet of optimum, so aeration of the borrow will be required. Prior to excavation of borrow material, the top six inches of material shall be stripped and wasted. Borrow areas containing high plasticity material will be avoided, since material will be hard to compact and will tend to desiccate when dried.

c. Training Levee Removal. - Removal of the existing training levees will be required. The total estimated volume of these levees is 442,000 cubic yards. Prior to use as levee fill, 47,000 cubic yards of this total must be stripped and wasted. Stripping shall be limited to a minimum of 6-inches normal to the exposed levee surfaces. Material from the existing training levees varies from clay to silt and sand. Based on the results of the different exploration programs, it appears that the noncohesive materials were taken from recent alluvial deposits, while the cohesive materials were excavated from the underlying clays. The basis of this hypothesis lies in the fact that plasticities and gradations of the cohesive material are similar to those established for materials located in the western borrow area, while cohesionless materials have characteristics similar to basin sediments. Aeration of material from training levee excavation will not be required. However, due to the high erosional potential of silts and sands, placement of noncohesive material shall be limited to the center of the expanded levee sections. See paragraph 4-09 for complete fill restrictions.

d. Material Sources. - Portland Cement concrete will likely come from commercial readymix suppliers in the vicinity of the project. Sources for concrete aggregate are Cache Creek sands and gravels, American River and terrace deposits, and Yuba River dredge tailings. There are numerous commercial aggregate mining companies operating in these areas. Portland cement and pozzolan may be acquired from prequalified sources. A list of these sources may be obtained from the Waterways Experiment Station. If cement or pozzolan comes from a source which is not prequalified, it must be tested for conformance with specifications. Rock for stone protection can be obtained from the following quarries:

1. Bangor Quarry - located near Marysville, an 85-mile haul distance. This Quarry was last tested by SPD Laboratory in September 1986 and last field investigated in May 1986. All

test results indicate that the rock is suitable for riprap and the recent field investigation indicates that the quarry rock is consistent with the rock previously tested. Reserves of the quarry are estimated to be 2 million tons in place. The rock was used for bank protection on the Sacramento River, River Mile 80 to River Mile 193 in 1984. The service record has not been evaluated at this time.

2. Greenstone Quarry - located near Ione, a 75-mile haul distance. The Greenstone Quarry was last tested by SPDLE in May 1986 and all test results indicate that the rock will make suitable riprap. In an April 1986 site visit, the leasee indicated the in-place reserves were at 10 million tons. Materials from the Quarry were used in construction of Comanche Reservoir and as levee protection on Mormon Slough, Bear Creek, and the lower San Joaquin River. The service record has not yet been evaluated.
3. Lewis Ranch Quarry - located near Lincoln, a 61-mile haul distance. Lewis Ranch Quarry was visited in May 1986 and last tested by SPDLE in November 1970. The site visit indicated that the material was the same hard fresh granodiorite that was tested in 1970, and no additional testing was determined necessary. The Quarry is estimated to have reserves of 20 million tons. Rock from the Lewis Ranch Quarry has been used for bank protection for the Sacramento Deep Water Ship Channel by the Corps, and by Sacramento County for stone protection along the American River. The service records have not yet been evaluated.
4. Parks Bar Quarry - located near Marysville, a 67-mile haul distance. The rock is currently being tested by SPDLE. When last tested in 1972, the results indicated that the rock would make suitable riprap except for the wetting and drying test where the rock split prior to completion of the testing. Riprap is currently being provided for the Sacramento River Bank Protection Project Unit 38B. The service records for this quarry have not yet been evaluated.

4-04. BASIN INTERIOR. - Soils in the interior of the basin are composed of two distinct material types. The first type, limited to surficial deposits, is a cohesionless alluvial sandy silt (ML) to silty sand (SM). The second type, underlying the alluvium, is a sandy clay (CL-CH). Depth of the alluvial material varies from approximately one to ten feet. The deepest deposits are located in the basin interior, while less sedimentation has occurred in the northern and perimeter areas of the basin. Organic contamination was noted throughout. Underlying the sediments is a sandy clay layer. Although this sandy clay is similar to soils encountered in the western borrow area, use of this material for levee fill was rejected due to the associated excavation cost of the surficial sediments. Use of noncohesive sediment as a primary levee fill source was rejected since this material is highly erosive and also more pervious than clay fills.

4-05. GROUNDWATER. - Observation of groundwater varied throughout the project area. While some explorations in the basin interior hit water just below the surface, others along the levee alignment were extended to depths as great as 25 feet without encountering free water. The portion of the project having the highest potential for groundwater-related problems is construction of the inspection trench. However, since this excavation will be limited to 6 feet, and observed groundwater, when encountered, generally ranged from 8 to 12 feet below existing ground surface, water should have minimal impact on construction (see Plate III, Sheets 1 through 3). Basin interior groundwater was measured at depths ranging from 2.5 to 5 feet. Based on field observations, it is probable that this water was derived from irrigation flows that have perched on the underlying clays. Since basin foundation materials have low permeabilities, levels of the perched water will be very sensitive to precipitation, irrigation practices, and creek flows.

4-06. LABORATORY TESTING. - The scope of laboratory testing for the three exploration programs varied widely. A summary of the work is as follows:

a. US Army Corps of Engineers (1958). - Samples obtained during the 1958 Corps of Engineers exploration program were subjected to primary testing only. Tests included mechanical analysis, Atterberg limits, moisture contents, and specific gravities.

b. University of California, Davis (1975). - Samples of sediments trapped in the basin were tested to determine both engineering and agricultural properties. Testing included mechanical and hydrometer analysis, Atterberg limits, moisture contents, specific gravities, field densities, shrinkage and swell measurements, compaction, California Bearing Ratio (CBR), and chemical analysis. Testing was conducted at the University of California at Davis Soil Morphology and Soil Mechanics Laboratories.

c. US Army Corps of Engineers (1984). - Samples obtained from the 1984 Sacramento District exploration program were tested by the Corps' South Pacific Division Laboratory for grain-size distribution, Atterberg limits, moisture contents, specific gravity, permeability, consolidation, and shear strength. Testing methods conformed to the procedures described in Engineer Manual, EM 1110-2-1906, "Laboratory Soil Testing," 30 November 1970.

4-07. SELECTED DESIGN VALUES. - A summary of test results for proposed fills, existing levees, and foundation materials, are depicted on Plate XII, Sheets 12 through 15.

Unconsolidated undrained shear strengths for foundation and existing levee materials were established based upon both field and laboratory test results. Field work consisted of Standard Penetration testing (SPT), and laboratory procedures included both unconfined compression and unconsolidated undrained triaxial testing.

In order to establish the relationship between SPT results and unconsolidated undrained shear strength, a correlation between the two was developed. Samples having both N values and unconsolidated undrained shear

strengths were used. The relationship, as shown on Plate XII, Sheet 13, is linear, and compares well with the published results listed in Table 45.2 of Terzaghi and Pecks Soil Mechanics in Engineering Practice, 2nd edition, 1967.

Standard Penetration Test (SPT) results were next plotted versus depth for both foundation materials and existing levees. Penetration (N) values representative of the weakest materials found were then correlated to unconsolidated undrained design strengths. Standard Penetration values utilized ranged from N=3.5 for foundation materials to N=8 for existing levees. Though such values are conservative, their selection can be justified based upon the length of the project (over 9 miles) and since localized weak foundation conditions may exist between the explorations drilled at the site.

A summary of the selected design values are as follows:

a. Foundation Materials. - Design values listed in this section are applicable for both existing levee fills and foundation materials.

Dry Unit Weight (PCF)	97.5
Moist Unit Weight (PCF)	122.7
Saturated Unit Weight (PCF)	123.9
Unconsolidated Undrained Shear Strength (Q)	C=0.32 TSF, $\phi=0^\circ$
Consolidated Drained Shear Strength (S)	C=0 $\phi=25^\circ$
Consolidated Undrained Shear Strength (R)	C=0.25 TSF, $\phi=16^\circ$
Specific Gravity (G_s)	2.71
Permeability (K)	4.5×10^{-4} FPD

b. Fill Materials. - Design values listed are for fill materials samples compacted to 95% Standard Density at $\pm 2\%$ moisture content.

Dry Unit Weight (PCF)	102.5
Moist Unit Weight (PCF)	121.2
Saturated Unit Weight (PCF)	127.2
Unconsolidated Undrained Shear Strength (Q)	C=2400 PSF, $\phi=7^\circ$
Consolidated Drained Shear Strength (S)	C=0, $\phi=30^\circ$
Consolidated Undrained Shear Strength (R)	C=600 PSF, $\phi=15^\circ$

Specific Gravity (G_s)	2.72
Shrink Factor	10%
Permeability (K)	1.8×10^{-2} FPD

c. Existing Levee Materials. - Design values listed are for existing levee materials.

Dry Unit Weight (PCF)	97.5
Moist Unit Weight (PCF)	122.7
Saturated Unit Weight (PCF)	123.9
Unconsolidated Undrained Shear Strength (Q)	$C=0.55$ TSF, $\phi=0^\circ$
Consolidated Drained Shear Strength (S)	$C=0$, $\phi=25^\circ$
Consolidated Undrained Shear Strength (R)	$C=0.25$ TSF, $\phi=16^\circ$
Specific Gravity (G_s)	2.71
Permeability (K)	4.5×10^{-4} FPD

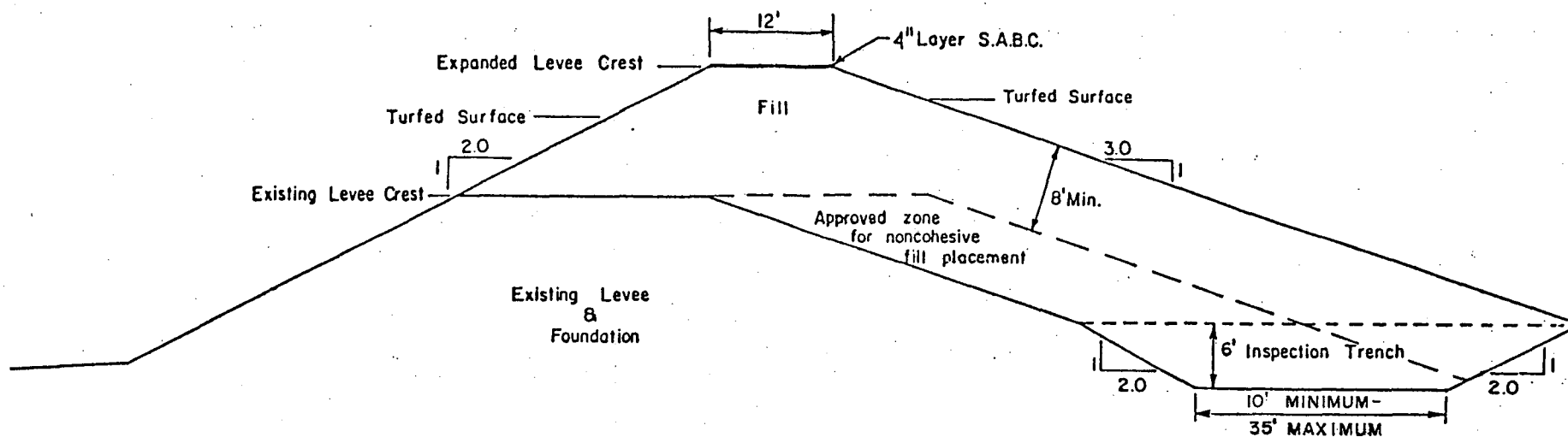
4-08. DESIGN ANALYSIS. -

a. Typical Section. - The proposed levee section for Cache Creek Settlement Basin has 1V on 3H basin interior slopes, 1V on 2H basin exterior slopes, and a 12-foot crest width. All construction shall be offset toward the interior of the basin. See Figure 4-01 for typical section. Access to various project locations will be provided by a patrol road constructed with 4 inches of Stabilized Aggregate Base Course.

b. Slope Stability. -

1) Only the "End of Construction" condition was investigated since the short-term stability of embankments on soft subsoils is usually more critical than long-term stability. Furthermore, since basin detention times are short, and permeabilities low, saturation of levee material will not occur. If levee materials will not become saturated, stability analyses of other than "End of Construction" conditions are not applicable. Additionally, as foundation materials consolidate, strengths and thus stability will increase.

2) A possible stability problem associated with levee construction on soft foundations is the formation of longitudinal cracks. Potential for such cracking can be analyzed based on the work of J.M. Duncan and A.L. Buchignam presented in, "An Engineering Manual for Slope Stability Studies," March 1975. Results of such a study indicate cracking will not be a problem. However, it is noted that the effect of differential settlement will be more



NOTES:

1. Strip top 6-inches from surfaces to receive fill prior to levee expansion.
2. Excavate inspection trench as shown.
3. Cut additional 1.5 feet from crest of existing levee to insure all dessication cracks removed prior to levee expansion.
4. Limit placement of noncohesive fill to approved zone.
5. If existing levee is less than or equal to 2.0 feet high, center inspection trench under crest of expanded section. If existing levee is higher than 2.0 feet, initiate excavation of inspection trench at the waterside toe of the existing section.

NOT TO SCALE

CACHE CREEK BASIN
CACHE CREEK, CALIFORNIA
SETTLING BASIN ELEMENT
TYPICAL SECTION
FIGURE 4-1

pronounced when levee materials dry out and become brittle. Therefore, cracks in the embankment fill were assumed when slope stability analyses were conducted.

3) Results of an "End of Construction" analysis using the Modified Swedish Method, Finite Slice Procedure indicate that slope stability is not a problem with the selected levee section (see Plate XII, Sheet 16). The minimum factor of safety calculated equaled 1.74. Not only is this value greater than the 1.3 required by Corp's criteria, but a crack extending to an elevation 6 feet below the levee crest was conservatively assumed for the analysis. Additionally, results of a sensitivity study conducted indicate that even if a crack extended completely through the fill material, the IV on 2H landside slope would still have a factor of safety against instability equal to 1.4.

4) Slope stability analyses were also conducted for levee sections constructed over reaches of previously unloaded foundation. However, due to the planned excavation of a 6-foot deep, 35-foot wide inspection trench, and due to the limited height of the proposed levee (16-foot maximum), slope instability problems are not anticipated. Even with a foundation strength equal to 640 PSF and assuming a crack has developed to an elevation 6 feet below the levee crest, a slope stability factor of safety equal to 4.9 was calculated. Due to the non-critical nature of this solution, a graphical presentation of this analysis is not presented.

c. Slope Protection. - Levee slope protection will be provided by a combination of erosion resistant clays and native grasses. Support for such a design lies with the acceptable performance of existing slopes constructed of similar materials at identical grades and subjected to comparable impoundments. Should minor beaching occur, the IV on 3H waterside slopes will afford easy access. However, since interior basin deposition will be ongoing, any damage that might occur would more than likely be buried prior to required maintenance.

d. Weir Foundation. - Foundation conditions in the weir area are depicted in explorations 2F-8-18 and 2F-8-19). The abutment wall design was revised from a retaining wall design to a tee wall design. The tee wall is backfilled at 1V on 3H on the upstream face and varies on the downstream face from 1V on 2.5H to 1V on 3H (see Plate X). Under this design scheme, transverse differential settlement will be avoided due to nearly equal lateral loads on each face of the wall, while effects of longitudinal settlement will be controlled by periodic joint spacing. The use of concrete friction piles to support the abutment walls was evaluated, but did not prove to be feasible.

The foundation for the outlet weir will consist of a roller compacted concrete mat. Differential settlement related problems are not anticipated. Not only is the maximum proposed design load of 1.61 Kips/Ft² low, but foundation soils have already been pre-loaded by approximately 6 feet of overburden. To further ensure settlement problems do not develop, material beneath the outlet weir and 5 feet beyond will be over-excavated by 2 feet. A geotextile will be spread on the excavated surface to provide a working platform. A silty sand (SM) or sandy silt (ML) backfill will then be used to bring the excavation to design grade.

e. Settlement. - A settlement analysis, based on Terzaghi's theory of one dimensional consolidation was conducted on typical project levees. The first section analyzed consisted of a new, homogenous levee with 1V on 2H land-side slopes, 1V on 3H water-side slopes, a 12-foot wide crest, and a maximum height of 20 feet. The second section consisted of a new portion built on top of an existing levee to form a similar final geometry as the homogeneous levee section but with a maximum total height of 26 feet. The calculated settlements for the homogeneous section ranged from 1 foot at the levee's center to 2 inches at the water-side toe. Thus, the differential settlement is about 10 inches. The calculated settlements for the over-built section ranged from 8 inches throughout the levee's maximum section to 1 inch at the water-side toe. Thus, the differential settlement is about 7 inches.

Differential settlements of project levees should not be a problem. Analyses of the stress-strain relationships of project soils indicate that for less than 15% strain, materials are plastic in nature. Time rate calculations for both levee sections predict that as much as 75% of the total primary settlement will occur within the first 15 years. The remaining 25% will not occur until well past the design life of the project. However, since wide variations typically exist between predicted and actual settlement rates, it is recommended that all levee sections be overbuilt by the maximum predicted settlement of 1 foot.

f. Seepage. - Seepage will not be a problem in the settling basin area. Not only are basin detention times short, but both embankment fills and foundation materials are relatively impervious. Furthermore, excavation of the inspection trench will ensure that any pervious near surface sediments deposited in the basin interior are removed prior to levee expansion.

4-09. CONSTRUCTION CONSIDERATIONS. -

a. Specific construction requirements related to excavation stripping, fill placement and compaction will be imposed on the contractor. All existing levee surfaces to receive fill shall be stripped a minimum of 6 inches prior to construction. The crests of existing levees shall be excavated an additional 1.5 feet to ensure removal of any materials which might have undergone desiccation cracking. All fill placement shall be notched into the existing levee to ensure adequate bonding.

b. An inspection trench will be excavated beneath the expanded levee section. Excavation of the trench will initiate at the toe of the existing levee and finish the cut at the toe of the expanded section. Maximum excavation cut slopes are 1V on 2H. The depth of the trench will generally be limited to 6 feet. The exception to this limit is if at the completion of the excavation the trench invert is founded in pervious materials. For such instances the excavation shall be continued to a depth sufficient to remove the previous materials or to a maximum of 10 feet in the contract plans and specifications. The minimum required invert width will be specified as 10 feet. Invert widths greater than 35 feet will not be required.

c. Noncohesive materials encountered during excavation at the inspection trench or in the course of removal of the existing training levees will be used for levee fill. Fill placement must be limited to the interior of the expanded levee. Noncohesive material will not be placed above the crest elevation of the existing levee section, nor shall this material be placed closer than 8 feet normal to the final design grades. Material stripped from levee slopes shall be wasted. Material removed from the crest of the levee after the stripping operation can be used as fill.

d. No ditches or canals shall be allowed within 50 feet of the basin side toe of the expanded levee. Any such existing excavations shall be filled as part of the construction contract. Basin sediments may be used as ditch or canal fill, provided that it is not used within the expanded levee section. No borrow excavation shall be allowed closer than 50 feet from the expanded levee. All project fills shall be placed at 95% Standard Density. Water contents can vary between $\pm 2\%$ of optimum.

4-10 FUTURE EXPLORATIONS AND TESTING. - During preparation of contract plans and specifications, an additional exploration program with laboratory testing will be implemented. Additional explorations and testing will be designed to evaluate outlet weir settlement, and spatial and seasonal groundwater conditions. Completion of this work will ensure that current designs are appropriate and that more economical alternatives are not available.

a. The initial portion of the exploration program shall include drilling 6 additional hollow stem auger holes to a maximum depth of 50 feet. Two of the drill holes will be located along the basin inlet channel, two in the vicinity of the outlet weir, and two along typical levee reaches. Continuous standard penetration tests (SPT) will be conducted to a 20-foot depth and then every 5 feet to the bottom of the hole. Four 3-inch diameter Shelby tubes will be pushed in the explorations located at the outlet weir. Consolidation tests will be conducted on the undisturbed materials sampled. Upon completion of drilling, all holes will be backfilled with cuttings to within 15 feet of the invert of adjacent excavations, with the unfilled portion of the holes to be converted into observation wells.

b. Installation of observation wells will ensure a complete understanding of spatial and seasonal groundwater fluctuations. Since the current design calls for the excavation of borrow material, an inspection trench, and an inlet channel, it is imperative that the contractor be provided sufficient groundwater information to evaluate impacts prior to preparing project bids. Installation and monitoring of observation wells will accomplish this purpose.

c. The final portion of the exploration program shall include the collection of a composite sample of basin sediments and completion of selective primary and secondary testing. Initial design concepts envisioned utilization of low to medium plasticity clays for levee fill. Such material would be erosion resistant, have fairly high strength properties, good placement characteristics and be impervious. However, the plasticity of on-site borrow materials ranged from low to high, with no distinct zones or layers of suitable material evident. The main consequence of this wide range

in plasticities is that fill placement will be more difficult and thus more costly than initially envisioned. If suitable strengths were obtained for the low to non-plastic basin sediments, this material could be used extensively in the levee interiors. Such utilization would result in economic savings due to reduced haul distances and lower placement costs. Surface erosion potential could be minimized through the use of extensive clay facings.

CHAPTER 5 - PROJECT PLAN

5-01 LEEVE CONSTRUCTION. - This element of the project would consist of raising the existing north, south, and east levees and also includes the construction of a west perimeter levee at a location approximately 2800 feet to the west of the existing west training levee, along the alignment of an existing nonproject levee. All levees would have the same cross-sectional geometry except for the east levee. The east levee would have a 1V on 3H side slope on both the basin and Bypass sides. The remainder of the levees would have a 1V on 3H side slope on the basin side and a 1V on 2H side slope on the land side. All elevations for the project plan are referenced to the National Geodetic Vertical Datum (N.G.V.D.). All levees would have a 12.0 foot crown width. See Plate III for levee profiles and Plate IV for typical levee sections. The existing training levees will be degraded, and a new training levee will be constructed on a parallel alignment to the new west levee. The locations of the new west perimeter levee and training levee, as well as existing perimeter levees and training levees are shown on Plate I. Two borrow areas will be established in the expanded basin. For a discussion of borrow requirements, see paragraph 4-03. Borrow area 1 will be limited to the new training channel. Borrow area 2 will be located to the east of the new training levee and will run parallel to it. For borrow area locations, see Plate II. For details of the borrow areas, see Plate V. Levee construction is as follows:

a. The south levee begins in the extreme southeast corner of the basin, near the low flow outlet structure. The south levee begins at Station 0+00SL, with a top-of-levee elevation of 47.25 feet, and extends west to Station 105+72.88SL, having a top-of-levee elevation of 47.40 feet N.V.G.D.. The south levee would be raised an average of 12 feet from the existing levee height. See Plates II and III for plan and profiles.

b. The west levee begins at the end of the south levee in the southwest corner of the basin. The new west levee begins at Station 0+00WL with a top-of-levee elevation of 47.40 feet N.G.V.D., and extends in a northerly direction to Station 183+90.00WL, the upstream limit of the new west levee construction. The new west levee will incorporate an existing non-project levee (location of the non-project levee, see Plate I). The non-project levee is 3 feet in height, on average. The new west levee will be raised an average of 12 feet above it. For typical sections, see Plate IV, Sheet 2. The new west levee blends to the existing west levee height at this point and would have a top-of-levee elevation of 51.50 feet N.G.V.D.. The new west levee would be constructed to an average height of 15 feet.

c. The east levee also begins in the extreme southeast corner of the basin near the low flow structure. The east levee would begin at Station 0+00EL and have a top-of levee elevation of 47.25 feet. The levee would then extend north to Station 19+57EL, the south end of the outlet weir. The outlet weir extends 1740 feet to Station 36+97EL (See Plate X for the outlet weir details and paragraph 5-02.a for the outlet weir description). From Station 36+97EL, the east levee would continue north to Station 78+61.01EL, the end of the east levee. The east levee would have a top-of-levee elevation of 47.25 feet.

d. The north levee would begin at Station 0+00NL, the end of the east levee, Station 78+61.01EL. The top-of-levee elevation at Station 0+00NL would be 47.25 feet. The north levee would extend in a northwesterly direction to Station 236+56.16NL, near Road 102. The new levee would tie into the existing Cache Creek north levee at Station 192+00NL with a top-of-levee elevation of 52.00 feet. The north levee would be raised an average of 6 feet.

5-02 OUTLET WEIR AND LOW FLOW FACILITIES. -

a. Outlet Weir. - The outlet weir would consist of a rectangular shaped straight drop 1740 feet in length, with a roller compacted concrete invert. Sources, testing, and recommendations on use of concrete materials will be detailed in a supplement to this GDM. It would begin at Station 19+57EL and end at Station 36+97EL. The weir was designed to pass flood flows exceeding the design capacity of the low flow structure to a maximum of 30,000 cfs. The weir height would be constructed to 12.0 feet (elevation 32.5 feet) and then to 18.0 feet (elevation 38.5) at year 25 of the project life, as described in paragraph 3-05.d.1, Sediment Management Plan. The weir consists of the straight drop, 25.0 foot long stilling basin and abutment walls. The stilling basin would have a 2.0 foot high end sill to allow for tailwater formation for energy dissipation. The drop structure was designed using the criteria as described in paragraph 3-03.e. Rock riprap would be provided both at the end of the stilling basin and on the levees on either side of the outlet weir abutments. Rock riprap details are shown on Plate V.

b. Low Flow Facilities. - This element of the project would consist of a low flow outlet structure, newly excavated channel, relocated channel, and the existing channel (See Plate VI for a plan of the low flow system features).

1) Outlet. - The low flow structure is located in the extreme southeast corner of the project limits at Station 1+79.00EL. The low flows discharge into an existing outlet channel upstream of the project limits at Station 0+80LFMR (See Plate VI for station definition). The low flow structure would consist of a double box culvert with each culvert being 5-foot wide by 4-foot high (See Plate XI for low flow structure details). The box culvert would be controlled by a dual sluice gate system which would be fully accessible through a gate riser unit. This riser would be located on the Yolo Bypass side of the levee, immediately adjacent to the top of levee. The structure inlet would be uncontrolled and equipped with trash collecting facilities. The outlet would be flap-gated to prevent reverse flow when water levels in the Yolo Bypass are higher than in the basin. The outlet channel downstream of the low flow outlet would be rock lined to prevent scour. Rock placement details are shown on Plate VII, Sheet 1. The rock riprap would begin at Station 1+35LFMR, and extend upstream to Station 2+40LFMR, the downstream end of the low flow structure.

2) Channel System. - The low flow channel system is shown on Plate VI.

a) The main reach of the low flow system, designated Low Flow-Main Reach (LFMR), begins at Station 0+00LFMR, 240 feet downstream of the low flow outlet structure. This is the downstream project limit. The main reach

extends west to Station 39+50LFMR where it turns north into the basin. This reach would replace the channel displaced by the levee enlargement. The channel from Station 0+00 to Station 54+00LFMR would have a bottom width of 25.0 feet and side slopes of 1V on 3H. From Station 54+00LFMR to Station 120+00LFMR, the low flow channel would consist of the existing low flow channel (See Plate IX, Sheet 1 for typical cross section). At Station 120+00LFMR, a new channel would be excavated to connect the existing channel to the downstream end of the training channel at Station 163+00LFMR. This new channel would have a bottom width of 25.0 feet and side slopes of 1V on 3H.

b). Low Flow Subreach I (LFSI) would drain the ponded waters which would collect in the region around the outlet weir. This reach would begin at Station 4+76LFMR = Station 0+00LFSI. It would replace the channel displaced by the east levee enlargement and would extend north to Station 36+00LFSI, the end of Low Flow Subreach I. This reach would have a bottom width of 15.0 feet and side slopes of 1V on 3H.

c) Low Flow Subreach II (LFSII) connects the downstream end of the training channel to the Woodland Pumping Facility and then to the Low Flow Main Reach. This reach of newly constructed channel would begin at Station 39+50LFMR = 0+00LFSII. The Low Flow Subreach II junctions with training channel at Station 139+00LFSII as shown on Plate VI. This reach would have a bottom width of 15.0 feet and side slopes of 1V on 3H. See Plate VIII for design gradelines for each of the three low flow channel reaches.

5-03. TRAINING CHANNEL AND LEVEE. - The training channel would have a bottom width of 300 feet with side slopes of 1V on 3H and would tie into the existing channel at Station 128+00TC, approximately 350 feet downstream of County Road 102. The training levee would be offset 100.0 feet from the training channel left bank and would have 1V on 3H side slopes. The training levee would tie in to the existing Cache Creek left bank levee at Station 117+40NL. The training channel and levee system was designed to convey the design flow of 30,000 cfs. Between years 25-45 of the project life, portions of the training levee will be removed as described in paragraph 3-05.d.2. See Plate VI for training channel and levee locations, and Plate VIII for their design gradelines.

5-04. PATROL ROADS AND ACCESS RAMPS. - An all-weather patrol road will be constructed on the crown of the training and perimeter levees for maintenance, inspection, and flood fighting purposes. The patrol road will be surfaced with a 4-inch thick by 10-foot wide section of compacted stabilized aggregate. A total of 14 turnouts will be provided on all perimeter levees, and the new training levee will be provided with a turnaround at its downstream terminus. Six access road ramps and eight interior basin ramps will also be provided, all to be surfaced with gravel, at a grade no steeper than 10%, and side slopes not less than 1V on 3H. Levee gates will be placed across points of access to limit traffic to official use. See Plate II for location of turnouts, access road ramps, and interior basin ramps. For details of patrol roads, access and interior ramps, turnouts, turnarounds, and levee gates, see Plate V.

5-05. RELOCATIONS. - The non-Federal project sponsor, the Reclamation Board of the State of California is responsible for the relocation and/or modification of utilities within the Cache Creek Settling Basin. Utility relocations

would consist of protecting five existing PG & E electrical transmission line towers, and modification of the City of Woodland's storm water pumping plant, located in the southwest corner of the existing settling basin. Modification to the pump will be necessary due to increased pumping head, determined to be about 12 feet. The Reclamation Board has furnished estimated costs for this work, attached as Exhibit 3.

5-06. ENVIRONMENTAL ANALYSIS. - The Final Environmental Impact Statement (FEIS) for the project was published in House Document 98-134, 98th Congress, 1st Session. Since completion of the FEIS, there has been a modification to the project plan. The establishment of a National Wildlife Refuge over the entire Cache Creek Settling Basin is no longer a fish and wildlife enhancement feature for the project. An Environmental Assessment outlining changes in environmental effects resulting from removal of this feature was conducted and coordinated with the U.S. Fish and Wildlife Service. The Draft EA and Finding of No Significant Impact (FONSI) were distributed to the public on 15 April 1986. The Final EA and FONSI were completed and transmitted to the EPA on 30 July 1986, and are included in the GDM as Exhibit 1. The U.S. Fish and Wildlife Service prepared a Planning Aid Letter (PAL), also included in Exhibit 1. Environmental impacts to the following resources as stated in the FEIS remain unchanged with the deletion of the wildlife refuge as an enhancement feature: geology and seismicity, hydrology and flood control, archeology and history, and water quality. Resources that will experience a change in impacts from those determined for the FEIS are: vegetation, fish and wildlife, land use, and socioeconomic. Without the refuge feature, these resources would remain in their pre-project states and would not accrue benefits.

The U.S. Fish and Wildlife Service stated in their 21 May 1986 PAL (Exhibit 1, sheets 5-9) that without the refuge the basin would continue in agricultural use as under existing conditions, and benefits that would accrue due to establishment of the wildlife refuge will not materialize. USFWS recommended that the Corps pursue establishment of a refuge with the local sponsor and/or the State of California. The non-Federal sponsor, the Reclamation Board of the State of California has not expressed interest in sponsoring establishment of such a feature. Although the USFWS also included a recommendation that the Corps implement a riparian planting program along 4 acres of the bypass channel and along the outlet channel to compensate for the loss of 2.5 acres of riparian habitat, this is not a requirement for mitigation in the Lower Basin since the habitat loss would occur in the Upper Basin portion of the project. The wildlife refuge described in the Feasibility Report was an enhancement feature in the Lower Basin, and was not used for mitigation of impacts in the Upper Basin. Project impacts to the Upper Basin will be coordinated separately with the USFWS and addressed in Design Memorandum No. 2.

5-07. REAL ESTATE REQUIREMENTS. - Acquisition of lands, easements, and rights-of-way will be the responsibility of the non-Federal sponsor, the Reclamation Board of the State of California. Since the National Wildlife Refuge is no longer a project feature, fee purchase of lands will not be required. The non-Federal sponsor will acquire easements over the entire 3,600 acre basin, which are estimated to be 60% of fee cost. Local interests must also obtain the project lands to the west of the existing basin training levees, for construction of the new west perimeter levee. A permanent ease-

ment would be required extending a minimum of ten feet from the landside levee toe of the new west perimeter levee, and the existing north, south, and east perimeter levees. All easements acquired will grant the right to:

1. Construction, reconstruct, enlarge, fence, plant with trees, shrubs and other vegetation, repair and use flood control works, which shall include but not be limited to access, haul and patrol roads, levees, ditches, embankments, channels, berms, fences and appurtenant structures, and operate and maintain said flood control works in conformity with the Code of Federal Regulations, Corps of Engineers' Standard Operation and Maintenance Manual, and State of California Standards.

2. Clear and remove any or all natural or artificial obstructions, improvements, trees and vegetation.

3. Flow waters and materials and by said flow erode.

4. Place or deposit earth, debris, sediment or other material.

5. Excavate and remove earth, debris, sediment, or other material including that placed or deposited as above.

6. Restrict any use by others which may interfere with any of the uses listed herein or any use necessary or incidental thereto.

7. Locate or relocate roads and public utility facilities by grantee or others.

5-08. SEDIMENT MANAGEMENT PLAN. - A description of the sediment management plan for the settling basin is found in paragraph 3-05.d.

5-09. STAGE CONSTRUCTION OF WEIR. - For a discussion of incremental construction of the outlet weir, refer to paragraph 3-05.d.1.

5-10. SURVEYS. - A topographical survey was performed during the months of May through September 1984. The scope of the survey extended from County Road 102 to the head of the settling basin, and around the perimeter and interior of the basin. Horizontal and vertical control were established for cross sections, structure sections, sediment ranges, and traverse. Horizontal control was tied into the California coordinate system, Zone II, and vertical control was tied into the National Geodetic Vertical Datum of 1929 N.G.V.D. Cross sections were taken at 500 foot intervals from County Road 102 to the head of the basin, along the existing training levees, and along the alignment of the new west levee. Cross sections were taken at 1,000 foot intervals along the existing north, east, and south perimeter levees. Cross sections through the existing Cobble Weir were taken at 50-foot intervals. Seven sediment ranges were established throughout the basin interior for later resurvey under the sediment monitoring plan. Structure sections of the existing drainage structures were also taken.

5-11. BANK PROTECTION. - Bank protection consisting of rock riprap will be provided at critical locations throughout the project as described in paragraph

3-03.c. Rock gradation specifications are shown on Table 5-01. Bank protection will be required in the following areas:

a. Outlet Weir Abutments. - An 18-inch layer of rock will extend 50 feet from both outlet weir abutments from the top of the levee to the levee toe on both the basin and bypass sides. For rock placement details, see Plate X.

b. Low Flow Outlet. - A 12-inch layer of rock will extend both upstream and downstream of the low flow outlet. For placement details, see Plate VII, sheet 1.

5-12. ALTERNATIVE PLANS CONSIDERED. - During the review of the draft GDM, comments were received from the State of California Reclamation Board, the non-Federal project sponsor, and the City of Woodland. These are included in the GDM as Exhibit 2.

The Reclamation Board suggested in a letter dated 19 August 1986 that by separation of summer flows from the training channel, maintenance of vegetation could be reduced. A possible method proposed by the Reclamation Board for achieving this goal was construction of an outlet structure at the upper end of the training levee leading to a ditch paralleling it on its east side. By keeping the gates to the ditch closed during winter, they felt that the ditch would be free of sedimentation. By keeping summer flows confined to this ditch, it and the training channel would be relatively free of vegetation. The training channel would then be accessible for mechanical and chemical vegetation control and sediment removal without working in and around flowing water.

This proposal was evaluated and it was found that due to sediment deposition patterns within the basin, the proposed channel would be subject to a buildup of sediment, necessitating frequent maintenance. The vegetation control problem due to summer flows would merely be transferred to the proposed channel, creating a need for vegetation control in both the training channel and the proposed channel.

Comments were also received from the Reclamation Board in a letter dated 1 August 1986 concerning an increase in the project design flow, low flow outlet gate operation, ramp locations, and sediment removal. Our studies have concluded that the cost of additional protection by channel improvement over and above 30,000 cfs, which would have required a major reconstruction and relocation of the existing levee system is not economically justified. The proposal for enlarging the Settling Basin will not induce flooding upstream of County Road 102. Although the design water surface downstream of County Road 102 will be higher under project conditions, all proposed project features have been designed to maintain the water surface upstream of County Road 102 at preproject conditions. Low flow outlet gate operation will be outlined in the operation and maintenance manual for the project. The gates will take pressure from the Cache Creek side as presently designed. Interior basin ramps have been provided at each end of the weir. Without the wildlife refuge feature, the settling basin will no longer be required to be purchased in fee. Easement purchase will be required as described in paragraph 5-07. Sediment removal of 50,000 cubic yards annually is no longer a project requirement.

The City of Woodland, by letter dated 29 July 1986 also expressed concern with project design flows. Other items of concern were modification costs for their pumping plant, and infringement into their low flow channel. Costs for modification of the plant were furnished by the Reclamation Board and are shown in Exhibit 3. The existing low flow channel will be relocated to the interior of the basin from the new south levee toe. This work is considered to be a project cost, since the channel will be an integral element of the project.

CHAPTER 6 - OPERATION AND MAINTENANCE

6-01. GENERAL. - The California Reclamation Board has indicated its intent to provide the assurances of local cooperation for the project. Under these assurances, it will be the responsibility of the Reclamation Board to accept the project after completion of construction and insure that all operation and maintenance is in accordance with Federal law. The Reclamation Board will also be responsible for the sediment monitoring plan. Currently, the basin is operated and maintained by the State of California Department of Water Resources under the requirements established in the "Supplement to Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project Unit No. 126 - Cache Creek Levees and Settling Basin, Yolo Bypass to High Ground."

6-02. MAINTENANCE REQUIREMENTS. - Periodic maintenance of the levees, channels, and around the various structures will be required to assure the sediment control system will function as designed. Situations that might require maintenance include erosion and debris accumulation around structures, excessive vegetal growth, channel and levee shape changes, and excessive sediment deposition in the training and low flow channels.

Maintenance requirements will be discussed in more detail in the operation and maintenance manual. However, this portion of the report will discuss the above items as related to the hydraulic function of the project. In addition, a monitoring and inspection program will be developed to establish damage and operation trends over the project life, and to monitor sediment deposition.

The training and low flow channels shall be monitored for sediment deposition and the reduction of channel capacity due to sediment and vegetal accumulation. Cross section surveys shall be performed after each major flood event, or every three years at the locations listed in Table 6-01. Channels shall be maintained to design grade and cross section when the deposition exceeds two feet, or when the cross sectional area is reduced by 20 percent or more.

Sediment deposits in the basin shall be surveyed after each major flood event or every five years. These surveys are required to be performed over the basin and within a 2000 foot radius of the outlet weir in the Yolo Bypass. Permanent range lines established during the 1984 topographical survey (see paragraph 5-10) may be used, or a survey grid may be established. Surveys will be taken with enough detail to enable generation of topographic contour maps with contour intervals of one foot. This information shall be used to determine the time at which the weir height is increased and the training levee is cut back (see paragraph 3-05.d).

a. Erosion Around Structures - If neglected, erosion around structures can result in eventual failure of the structures and/or malfunctioning of the sediment control system. A determination that erosion around a structure actually endangers the structural stability versus erosion that will stabilize and cause no further damage necessarily involves engineering judgement. For this reason, an engineer experienced in making such determinations shall make inspections

of all structures following each flood and make recommendations for corrective measures.

b. Excessive Vegetal Growth. - Management of vegetal growth that would increase channel roughness and flow stages will be necessary. No trees or shrubs shall be allowed to grow on the levees, or within the channel system. When trees and shrubs grow to a height of 2.0 feet, they shall be cut or otherwise removed prior to the next flood season. Grasses and other vegetation on the levees that would lie down during floods would be allowed, but must be regulated to allow levee inspections.

c. Levee and Channel Bank Maintenance. - Periodic monitoring of levee and channel banks will be performed in an effort to locate areas of settling, slumping and damage due to wind action. Isolated areas of damage could jeopardize the integrity of the entire system. Particular attention should be focused on the existing channel immediately upstream of the transition to the training channel. Hydraulic analysis indicate a potential for scour due to moderately high velocities. These velocities have occurred in the past and will continue to occur during high flows. Field investigations after high flows show little damage, if any, to the channel banks or levees. However, the area remains a concern and should be monitored throughout the life of the project.

d. Sediment Deposition and Debris Accumulation. - Sediment deposits in the training and the low flow channels will be removed according to the criteria discussed in paragraph 6-02. The non-Federal sponsor will be responsible for providing disposal areas for this material. Sediment and other debris will be removed from around structure inlets and outlets so as not to reduce flow capacities or to reduce potential for structural damage. Particular attention should be focused on the inlet to the low flow outlets. The trash racks should be cleaned regularly during heavy flow periods. Operation of the gates will be detailed in the O&M manual.

6-03. OPERATION AND MAINTENANCE MANUAL. - Subsequent to project completion, an operation and maintenance manual for the project will be prepared by the Sacramento District. The manual will be furnished to the California State Reclamation Board.

CHAPTER 7 - COSTS

7-01. BASIS OF FIRST COSTS. - The detailed estimate of first costs for the Cache Creek Settling Basin project was based on October 1986 price levels and is shown on Table 7-01. The estimated lands and relocation costs were furnished by the Reclamation Board of the State of California. See Exhibit 3 for the estimate of relocation costs. The unit prices for construction items were based on adjustments of average bid prices received on comparable work in the Sacramento District. For construction items, a 15 percent allowance was included for contingencies. Suitable allowances were made for engineering and design, and supervision and administration based on costs experienced on comparable work within the District. Construction of the outlet weir, as discussed in paragraph 3-05.d.1, is shown in two stages. The detailed estimate of stage two construction cost is shown on Table 7-01A.

7-02. SUMMARY OF COSTS. - The detailed estimate of annual costs for the Cache Creek Settling Basin project is given on Table 7-02. The costs are based on October 1986 price levels with an 8-7/8 percent interest rate, and a 50-year amortization period.

7-03. COMPARISON OF FIRST COSTS. - Comparison of cost estimates for the authorized plan and the recommended plan are shown on Table 7-03, and changes are discussed in Table 7-04.

7-04. COST SHARING. - The non-Federal sponsor is subject to cost sharing requirements as set forth in the Water Resources Development Act of 1986, Public Law 99-662. The non-Federal sponsor is required to provide a payment of not less than 5 percent of the total project costs. The construction first cost of the project is currently estimated to be \$14,500,000, and the LERR cost is estimated at \$4,300,000, for a total project first cost of \$18,800,000. Therefore, the required payment is estimated to be \$940,000. The required payment will be adjusted on the basis of actual costs incurred.

CHAPTER 8 - BENEFITS

8-01. INTRODUCTION. - The Cache Creek Basin, California, Feasibility Report and Environmental Statement for Water Resources Development, dated February 1979 is the basis for establishment of economic benefits associated with the recommended plan of improvement. Benefits attributable to the recommended plan of improvement are flood damage reduction and reduced sediment dredging costs. Sacramento County is no longer designated by the U.S. Department of Commerce as an area of substantial and persistent unemployment; therefore, the Cache Creek Settling Basin element of the project is now ineligible for National Economic Development employment benefits. With removal of the National Wildlife Refuge as a project feature, all associated wildlife enhancement benefits have been deleted. The following is an update of the benefit analysis presented in the Feasibility Report.

8-02. FLOOD DAMAGE REDUCTION. - If sediment were allowed to continue to deposit in the Yolo Bypass, damage to development in the Bypass would occur. In addition, a backwater effect would be created which would cause infringement of the design flow on freeboard in the Yolo Bypass, Knights Landing Ridge Cut, and a portion of the Sacramento River. These levees would need to be strengthened to restore freeboard requirements. If sediment from Cache Creek were controlled and made to deposit upstream of the Yolo Bypass, a benefit would accrue since the following work would not have to be done.

a. Sediment depositing in the Yolo Bypass in the vicinity of the Cobble Weir would inundate and render useless 435 acres of industrial waste oxidation ponds owned by the city of Woodland. The first cost to replace this facility is \$1,790,000, and the average annual cost is \$115,000. The 2,100 acres of agricultural land over which the sediment would deposit would not suffer significant productivity losses. However, backwater effects caused by the sediment obstruction would be significant. The Yolo Bypass levees would need to be raised a maximum of 2.2 feet from 0.8 mile downstream of Interstate 5 upstream to the Fremont Weir, and the Knights Landing Ridge Cut levees would need to be raised 1.8 feet. The total first cost to complete this work is \$6,660,000 and the average annual cost is \$633,000. Since backwater effects are still significant at the Fremont Weir, Sacramento River levees would need to be raised a maximum of 1.0 foot from that location downstream to the Sacramento Bypass at a first cost of \$15,400,000 and an average annual cost of \$1,420,000. Therefore, the total first cost for such activities necessary to preserve the integrity of the Sacramento River Flood Control Project in the project area and prevent damages to development in the Yolo Bypass would be \$23,790,000, the average annual cost of which would be \$2,168,000. This analysis is based on October 1986 price levels, an 8-7/8 percent discount rate and a 50-year period of analysis. If freeboard requirements were not reestablished on the previously described levees, flood damages could occur. If these average annual flood damages incurred were less than \$2,168,000, then this new figure should be used as a basis for benefits under the "least costly alternative" analysis.

b. Failure of the Sacramento River Flood Control Project could conceivably occur at any of an infinite number of locations in the project area. Six areas were selected as being representative, and damages for all six were calculated. See Table 8-01 for area locations, acres inundated, and average annual equivalent damages and benefits.

1) The evaluation of flood damage requires a knowledge of land use patterns. For the agricultural areas, acreage for various crops was calculated from land use maps provided by the California Department of Water Resources. On-site inventories, and the Marshall and Swift Valuation Service were utilized to evaluate the densely populated residential, industrial, and commercial areas. Current newspaper articles, and city and county planning reports were also utilized to calculate damages in the flood plains.

2) Future growth was not taken into account. However, the Sacramento City Council has approved the rezoning of approximately 6,500 acres of agricultural land in the Sacramento River - Left Bank (Reach 6) region. The rezoning includes a permanent sports complex, middle density residential (5 to 7 units per acre), light industrial (7 million square feet), and high-technology and office growth (18 million square feet) within 20 years. This new construction will bring approximately 65,000 new jobs to the Sacramento area. The value of property in this location will show an enormous increase in the future.

3) Analysis shows that the probability of failure at any of the six locations is about the same. Since average annual damages from failure could be as high as \$4,818,000 in one reach alone, and it would require an average annual cost of \$2,168,000 to maintain freeboard and thus prevent this damage, the latter figure was used as a basis for flood control benefits associated with sediment control upstream of the Yolo Bypass.

8-03. REDUCTION IN REQUIRED DREDGING. - Without upstream control, it has been determined that 100 acre-feet of sediment will annually deposit adjacent to the Cobble weir. That portion of Cache Creek's sediment load which would not deposit in the Yolo Bypass immediately adjacent to the weir, about 575 acre-feet per year, would continue on downstream. The recommended Cache Creek Settling Basin project would reduce annual sediment loads to the Yolo Bypass and beyond by 340 acre-feet. This reduction in sediment deposition would decrease the amount of dredging necessary in the Sacramento River System, and also the San Francisco Bay System. Therefore, reduced sediment dredging requirements that can be attributed to the recommended plan would be a benefit. It is estimated that with the recommended project in place, dredging in the Sacramento River system would be decreased by 88 acre-feet annually, and dredging in the San Francisco Bay System would decrease by 7 acre-feet.

Costs for current dredging activities in the subject areas were developed for benefit determination. Included are costs for lands, site preparation, mobilization and demobilization, and dredging.

Sacramento River System	\$3.45 per cubic yard
San Francisco Bay System	\$2.30 per cubic yard

Based upon the amount of reduced sediment deposition in these two areas, a weighted average cost of \$3.35 per cubic yard was used for dredging reduction requirements associated with the recommended plan. Applying this average cost to the total decrease in dredging, 95 acre-feet, an average annual savings of \$514,000 would be realized.

8-04. PROJECT JUSTIFICATION. - A comparison of the average annual benefits with the average annual costs for the recommended plan of improvement is shown in Table 8-02. The project benefit-to-cost ratio is 1.4.

CHAPTER 9 - DESIGN AND CONSTRUCTION SCHEDULE

9-01. GENERAL. - The preparation of plans and specifications for the construction of the Cache Creek Settling Basin element of the project will follow approval of the final General Design Memorandum. Contract plans and specifications along with local interest coordination will take approximately 14 months from receipt of funds. The construction time is estimated to span two construction seasons. The Reclamation Board will design the modification of the City of Woodland storm water pumping plant. A construction schedule is shown on Table 9-01. Work which will be accomplished under the first contract includes the enlargement of the existing north and south perimeter levees, construction of the new west perimeter levee, degradation of the existing training levee, construction of the new training levee, training channel, low flow channel, and low flow outlet works. Work which will be accomplished under the second contract includes the construction of the outlet weir, and enlargement of the east perimeter levee.

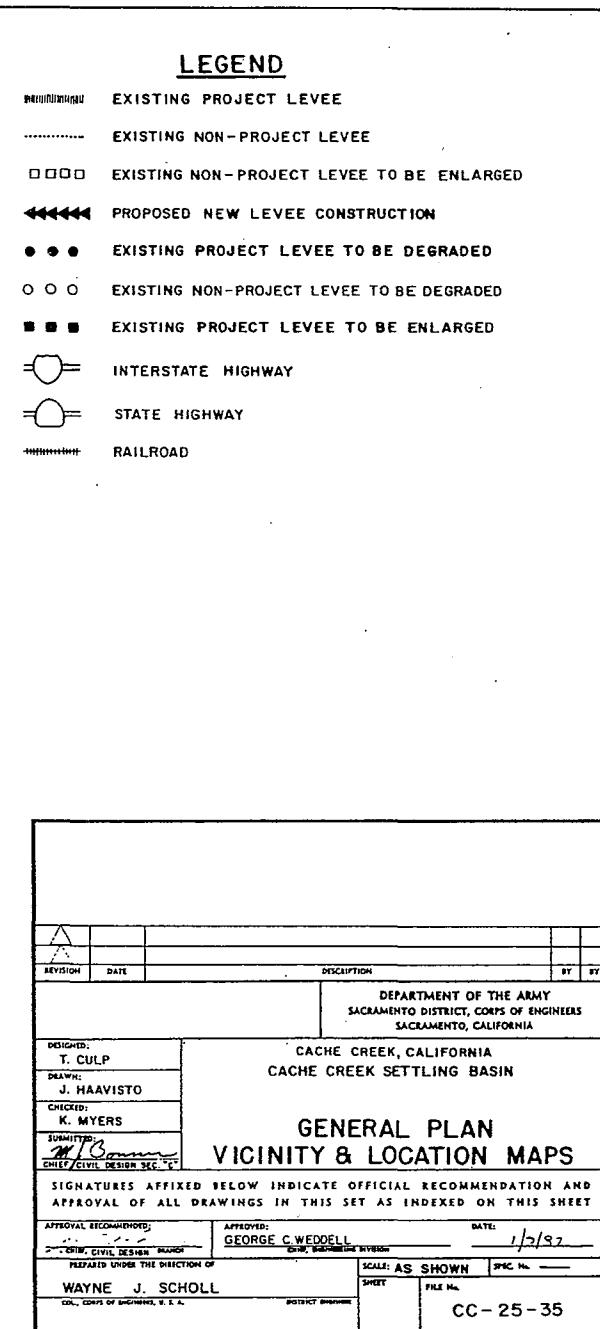
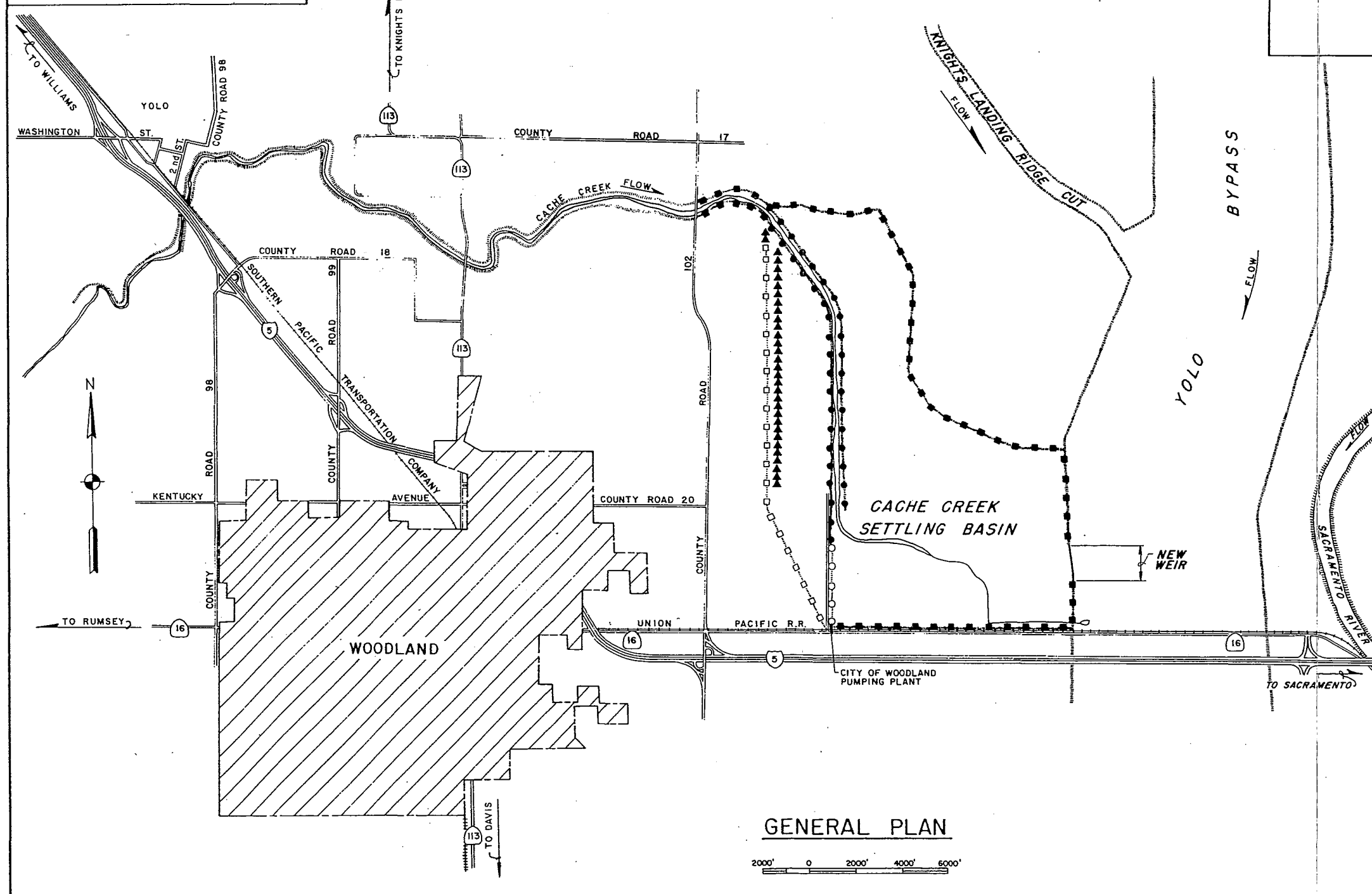
9-02. WORK BY FEDERAL GOVERNMENT. The Federal contract will include all levee construction, reconstruction of the outlet weir and the low flow outlet works and channels, levee patrol road and ramp surfacing, and stone protection.

9-03. WORK BY OTHERS. - The Reclamation Board will be responsible for the relocation and alteration of all overhead power and telephone lines and miscellaneous surface and subsurface utilities affected by project construction, as well as modification of the City of Woodland's storm water pumping plant.

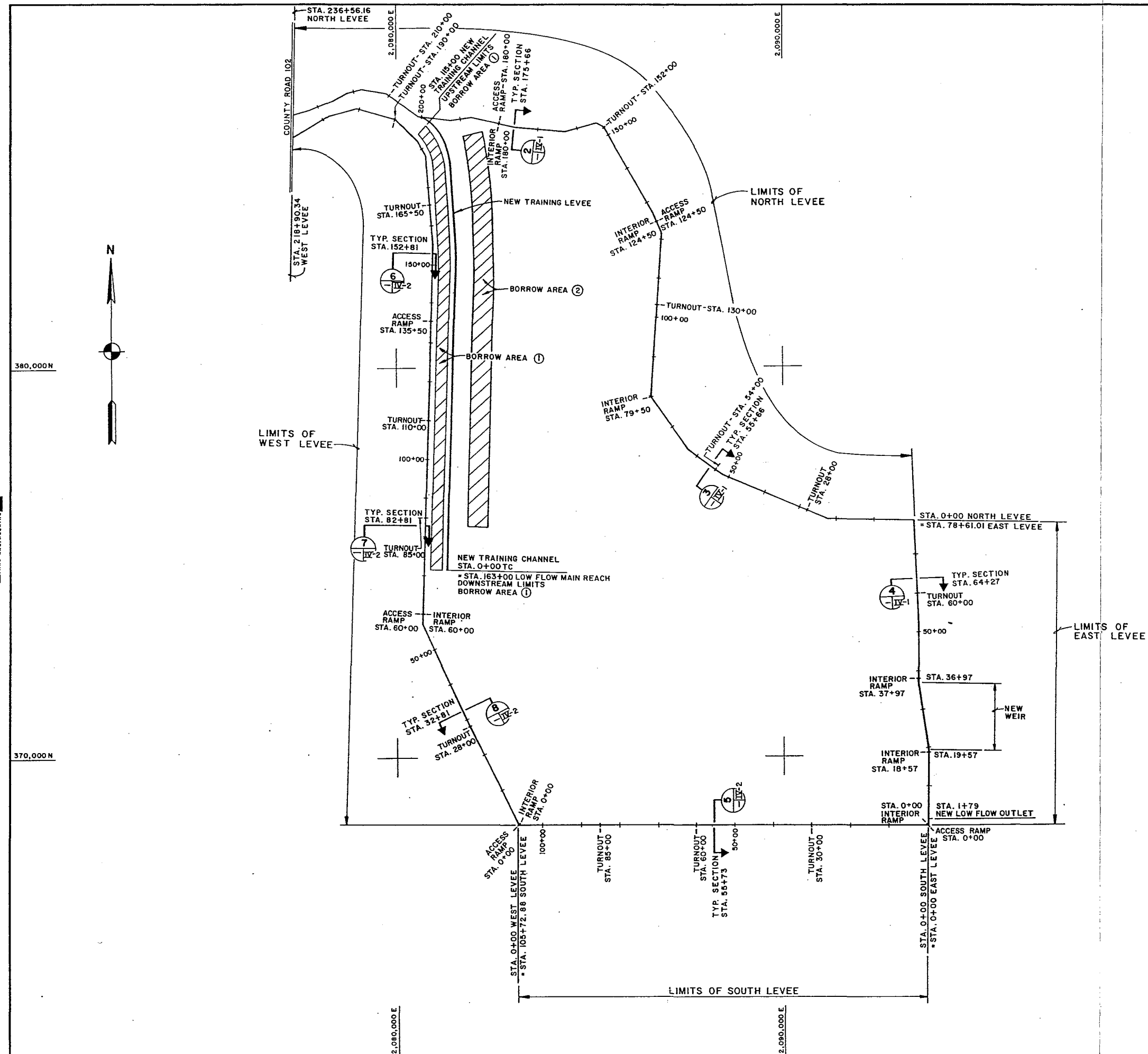
CHAPTER 10 - RECOMMENDATIONS

10-01. RECOMMENDATIONS. - It is recommended that this General Design Memorandum, which presents a plan for restoration of sediment storage capacity of the existing Cache Creek Settling Basin, be approved as the basis for plans and specifications and construction.

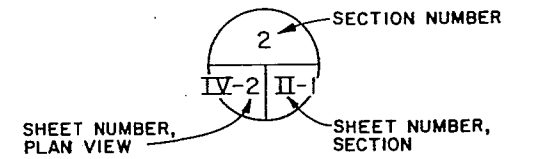
References



FUNCTIONAL ANALYSIS - VE PAYS



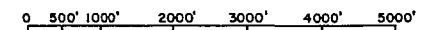
GENERAL LEGEND



NOTES:

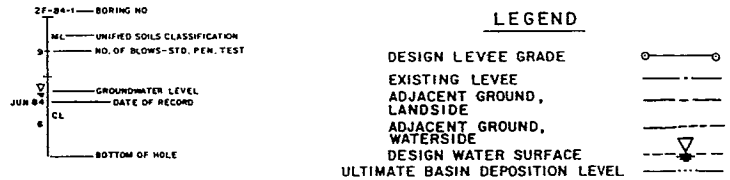
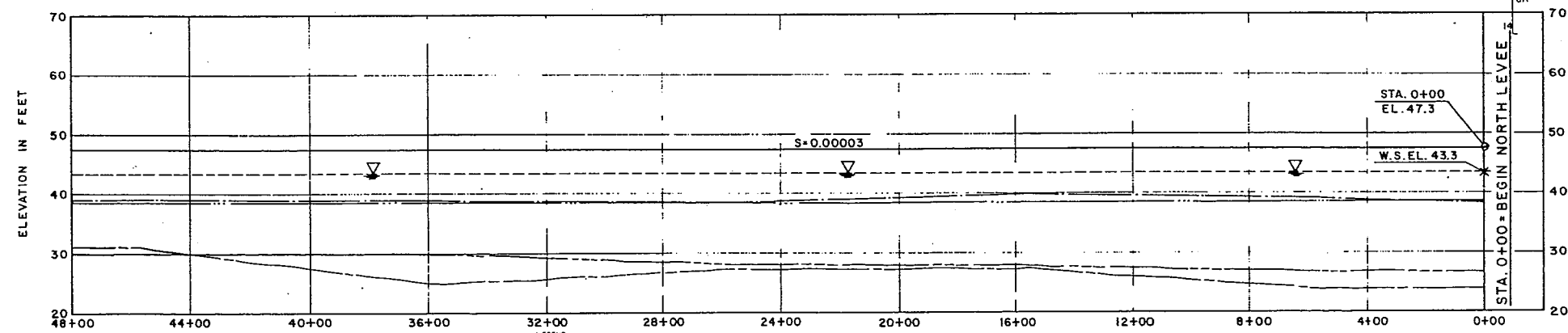
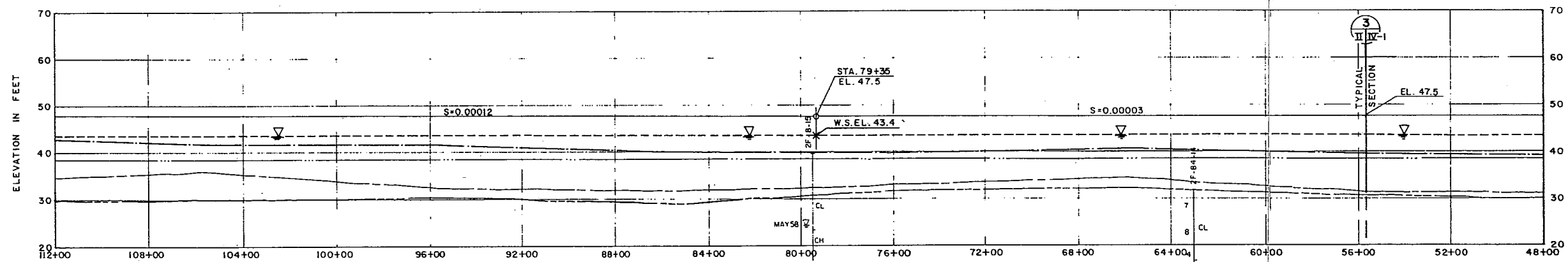
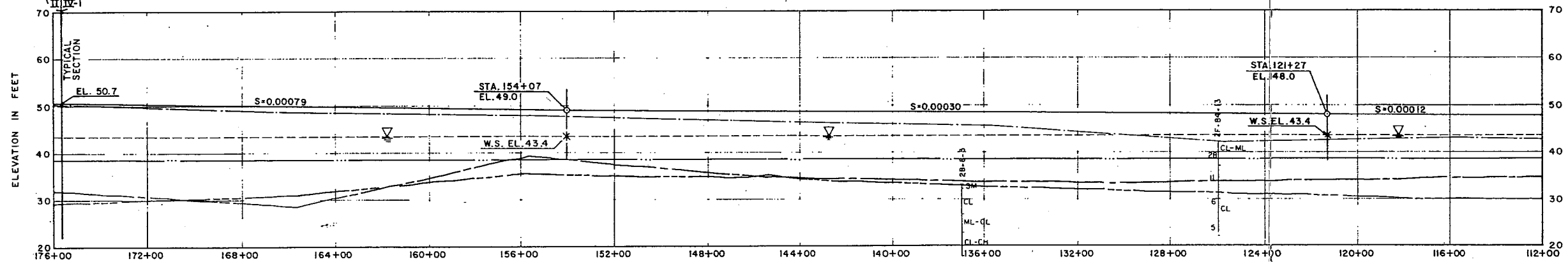
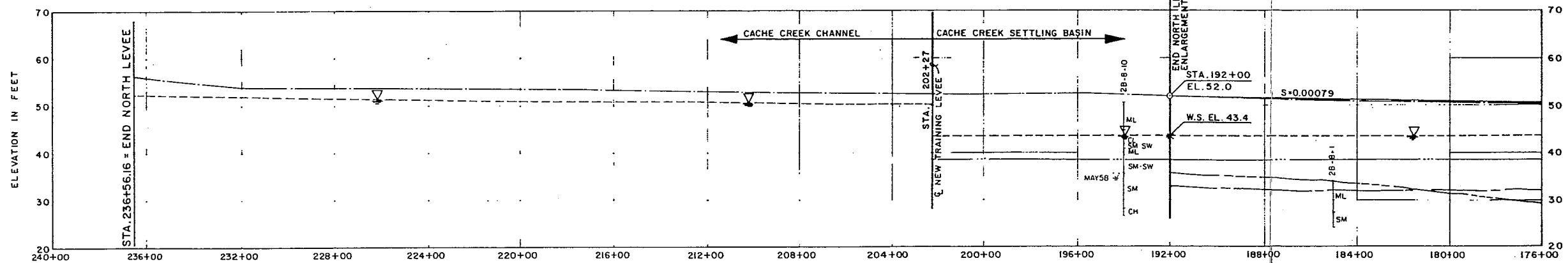
1. FOR LEVEE PROFILES, SEE PLATE III.
2. FOR TRAINING CHANNEL AND LOW FLOW SYSTEM STATIONING, SEE PLATE VI.
3. FOR DETAILS OF BORROW AREAS, RAMPS, AND TURNOUTS, SEE PLATE V.
4. FOR STRUCTURAL DETAILS OF WEIR AND DROP STRUCTURE, SEE PLATE I.
5. FOR DETAILS OF NEW LOW FLOW OUTLET, SEE PLATE VII, SHEET I. FOR STRUCTURAL DETAILS OF NEW LOW FLOW OUTLET (CONDUIT AND RISER UNIT), SEE PLATE II.
6. GRID COORDINATES REFER TO CALIFORNIA STATE COORDINATE SYSTEM, ZONE II. DATE OF SURVEY: MAY-SEPTEMBER 1984.

GRAPHIC SCALE

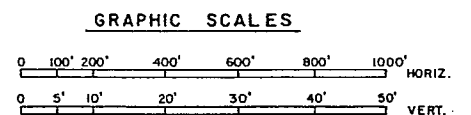


REVISION		DATE	DESCRIPTION	BY	BY
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
DESIGNED:		CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN			
DRAWN:		BASIN FEATURE PLAN			
CHECKED:		SCALE: AS SHOWN SHEET: 1/2 FILE NO.: CC-25-35			
SUBMITTED:		DATE APPROVED: 1/2/87 CHITRAVIL DESIGN SECTION "C"			

FUNCTIONAL ANALYSIS - VE PATS



NOTES:
1. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
2. FOR GENERAL LEGEND, SEE PLATE II.



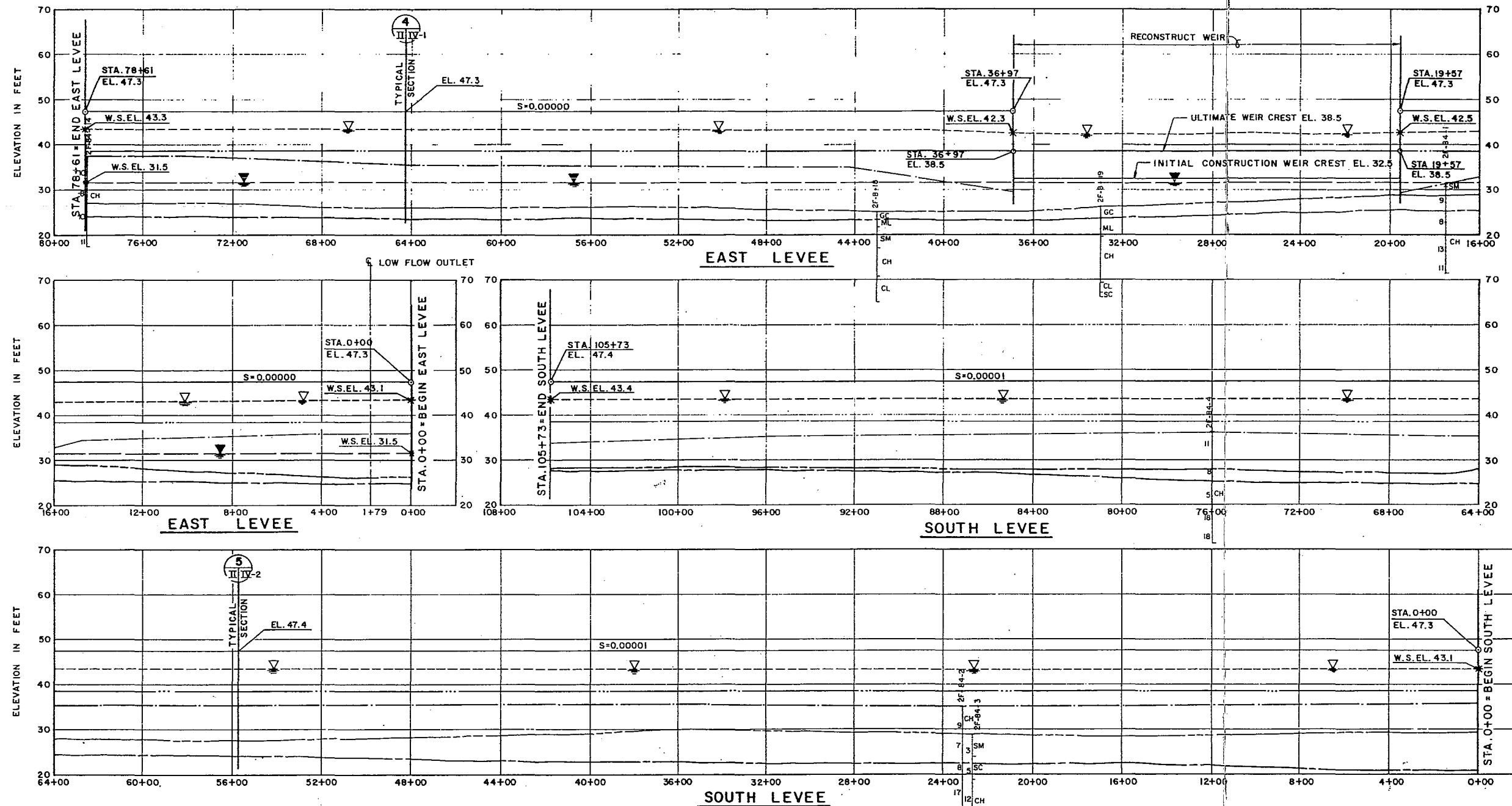
DESIGNED: T. CULP		DRAWN: S. JANG		CHECKED: K. MYERS	
SUBMITTED: 1/10/57		DATE APPROVED: 1/10/57		SCALE: AS SHOWN	
SHEET 1		FILE NO. CC-25-35		SPEC. NO.	

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

CACHE CREEK, CALIFORNIA
CACHE CREEK SETTLING BASIN

PROFILE
NORTH LEVEE

FUNCTIONAL ANALYSIS - VE PAYS



LEGEND

2F-B4-1—BORING NO.

ML—UNIFIED SOILS CLASSIFICATION

9—NO. OF BLOWS—STD. PEN. TEST

—GROUNDWATER LEVEL

JUN 84—DATE OF RECORD

CL

6—BOTTOM OF HOLE

SEE NOTE 3, THIS SHEET

LEGEND

DESIGN LEVEE GRADE —○—○—

EXISTING LEVEE ———

ADJACENT GROUND, LANDSIDE ———

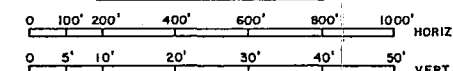
ADJACENT GROUND, WATERSIDE ———

DESIGN WATER SURFACE —▽—

DESIGN WATER SURFACE—YOLO BYPASS (ESTIMATED) —▽—

ULTIMATE BASIN DEPOSITION LEVEL ———

GRAPHIC SCALES



NOTES:

- ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
- FOR GENERAL LEGEND, SEE PLATE II.
- FOR EAST LEVEE ONLY, ADJACENT GROUND LANDSIDE REFERS TO THE YOLO BYPASS SIDE OF THE LEVEE.

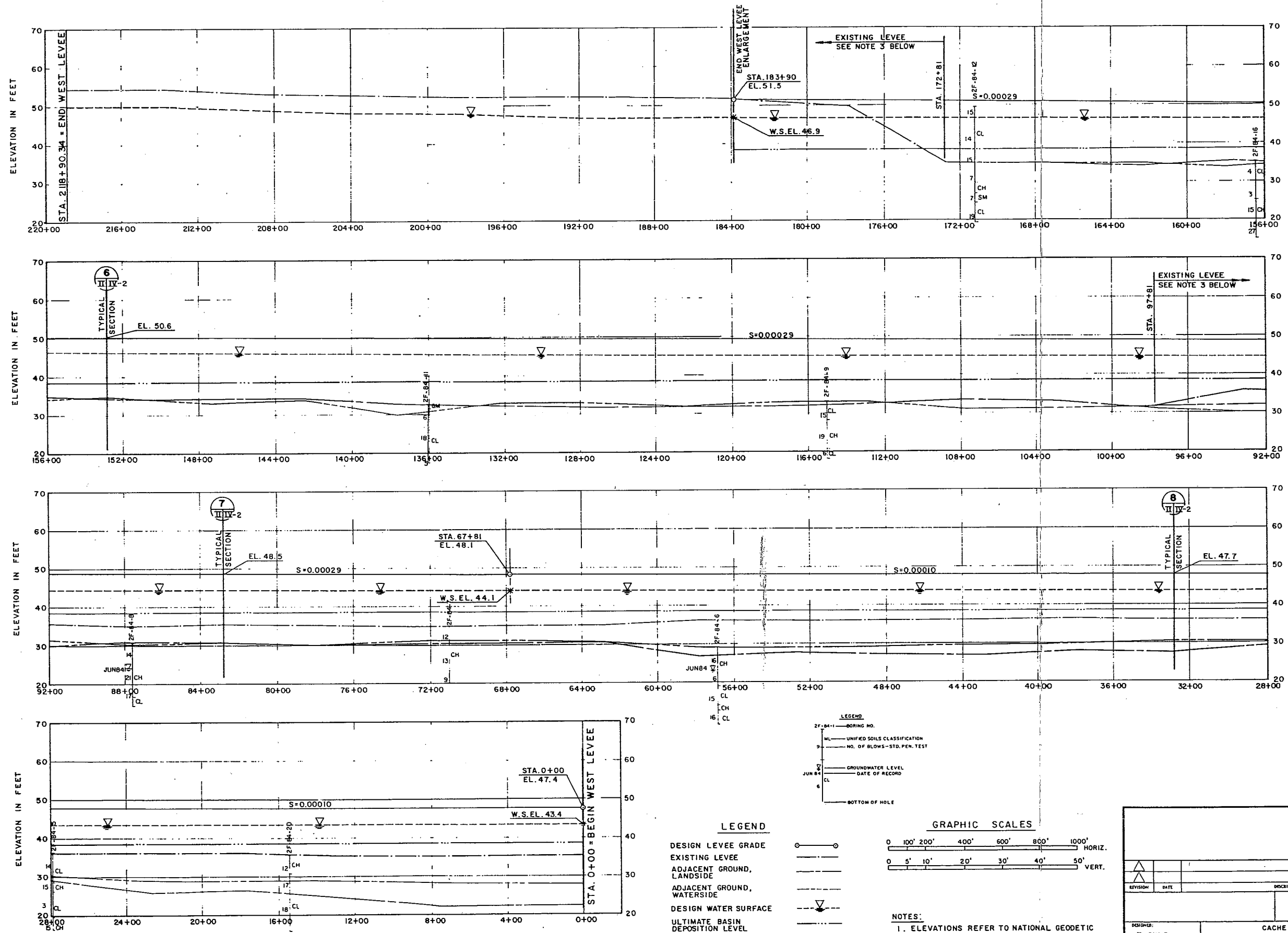
REVISION		DATE	DESCRIPTION	BY	BT
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
DESIGNED:		T. CULP DRAWN: S. JANG CHECKED: K. MYERS			
SUBMITTED:		DATE APPROVED:		SCALE: AS SHOWN	
11/1/84 CHIEF, CIVIL DESIGN SECTION "C"		1/1/85		CC-25-35	



SAFETY PAYS

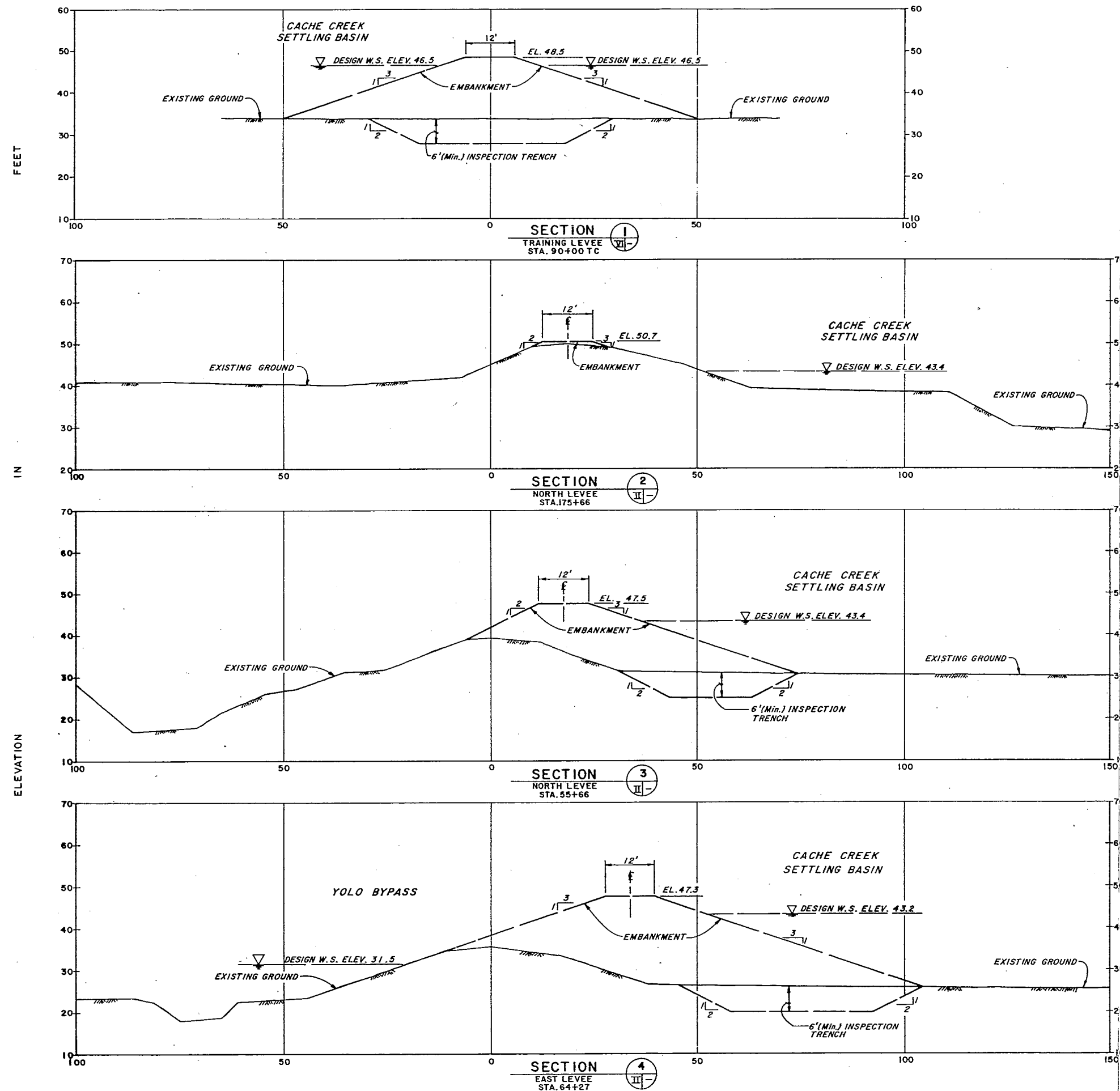


FUNCTIONAL ANALYSIS - VE PAYS



DESIGNER: T. CULP		DRAWN: S. JANG		CHECKED: K. MYERS		SUBMITTED: M. J. S. JANG		DATE APPROVED: 1/2/81		SCALE: AS SHOWN		SHEET NO. CC-25-35	
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN PROFILE WEST LEVEE													

FUNCTIONAL ANALYSIS - VE PAYS



NOTES:

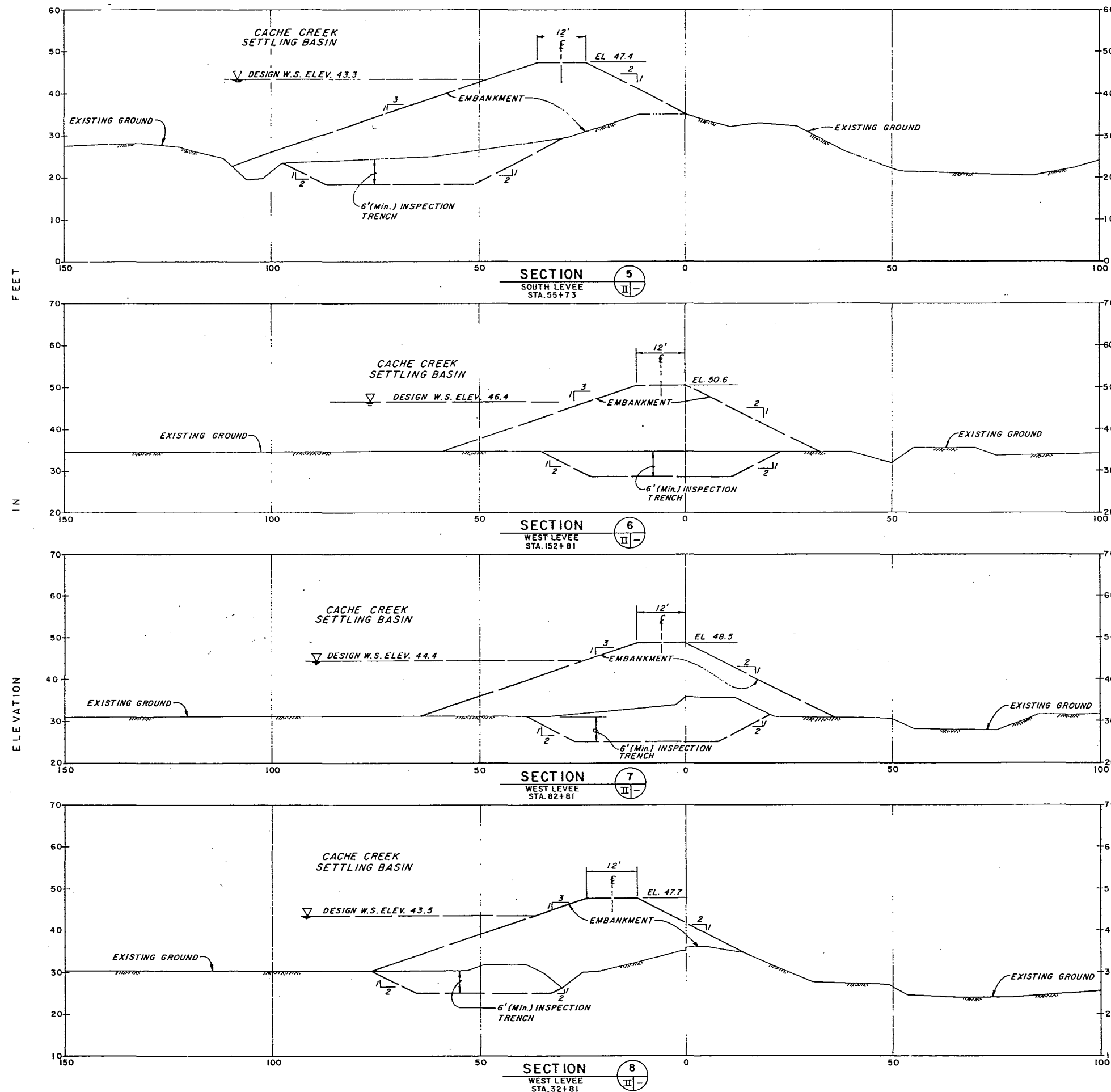
1. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
2. FOR LEVEE PROFILES, SEE PLATE III.
3. FOR GENERAL LEGEND, SEE PLATE II.
4. MINIMUM WIDTH OF INSPECTION TRENCH IS 10 FEET.

GRAPHIC SCALE

0 5' 10' 20' 30' 40' 50' HORIZ. & VERT.

DESIGNED:	T. CULP	TYPICAL SECTIONS-LEVEES CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN
DRAWN:	S. JANG	
CHECKED:	K. MYERS	
SUBMITTED:		
DATE APPROVED:		SCALE: AS SHOWN
1/2/37		FILE NO. CC-25-35

FUNCTIONAL ANALYSIS - VE PAYS



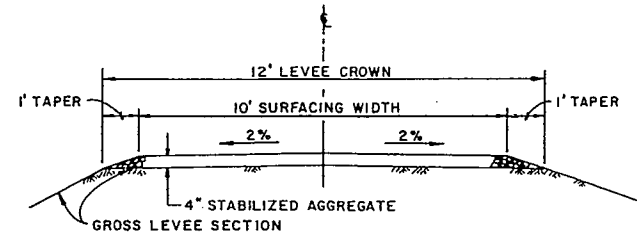
NOTES:

1. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
2. FOR LEVEE PROFILES, SEE PLATE III.
3. FOR GENERAL LEGEND, SEE PLATE II.
4. MINIMUM WIDTH OF INSPECTION TRENCH IS 10 FEET.

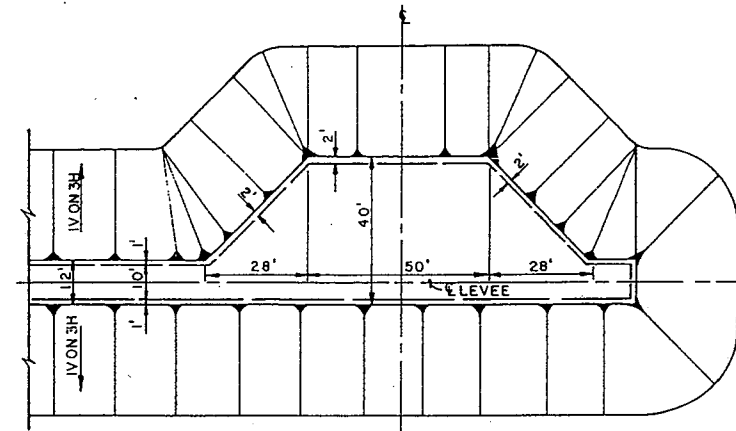
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0 5' 10' 20' 30' 40' 50' HORIZ. & VERT.

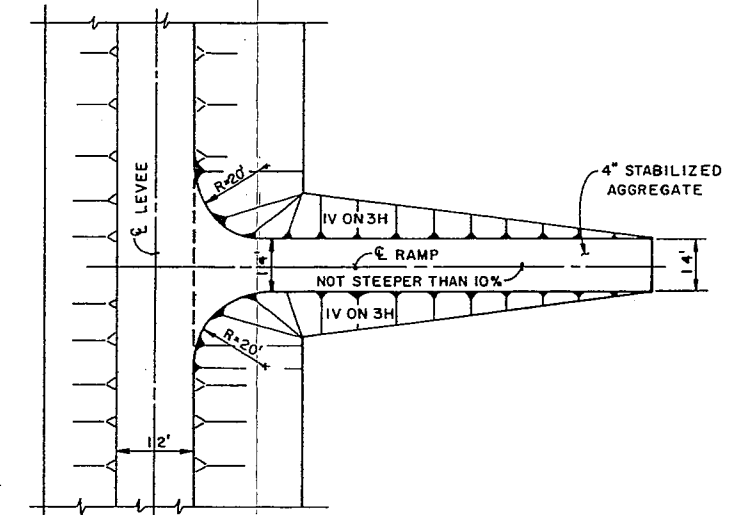
DESIGNED: T. CULP		DRAWN: S. JANG		CHECKED: K. MYERS		SUBMITTED: M. L. LOMAX CHIEF, CIVIL DESIGN SECTION "C"	
DATE: 1/1/17		SCALE: AS SHOWN		SHEET: FILE NO.		SPEC. NO. CC-25-35	
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN TYPICAL SECTIONS-LEVEES							



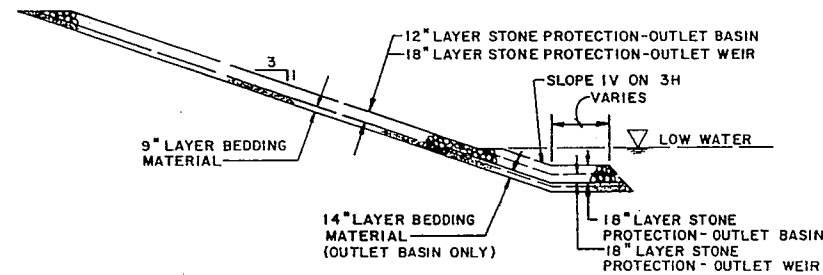
DETAIL-PATROL ROAD SURFACING



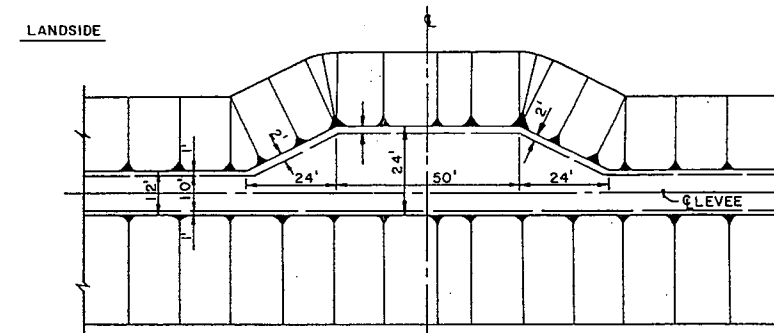
DETAIL-PATROL ROAD TURNAROUND



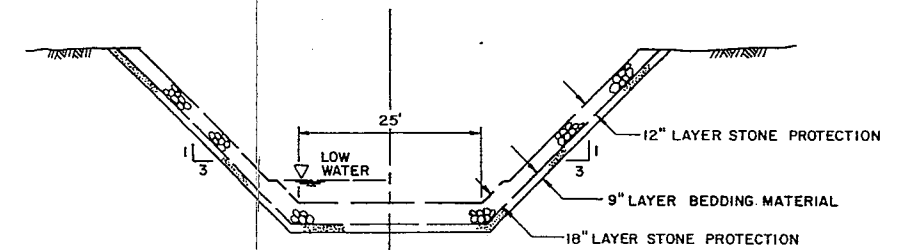
DETAIL-RAMP



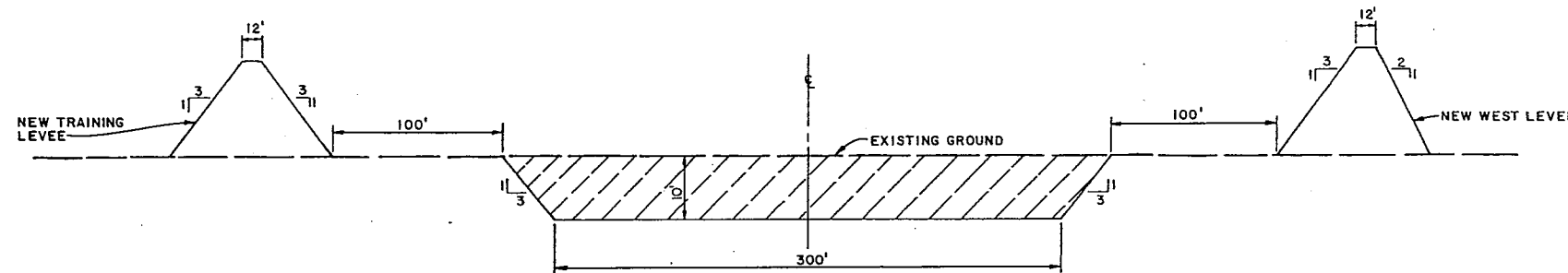
DETAIL-STONE PROTECTION (3)



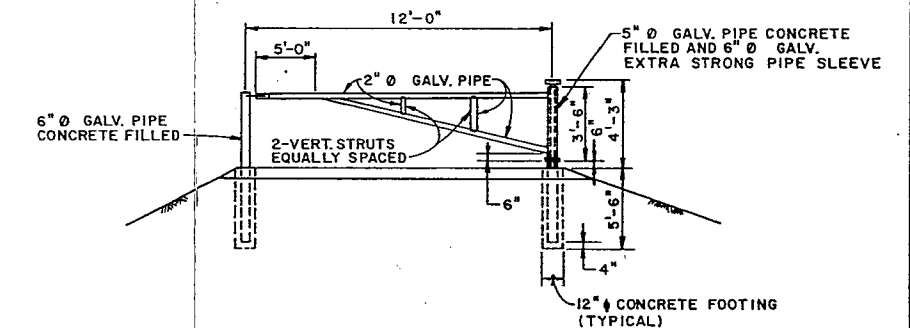
DETAIL-PATROL ROAD TURNOUT



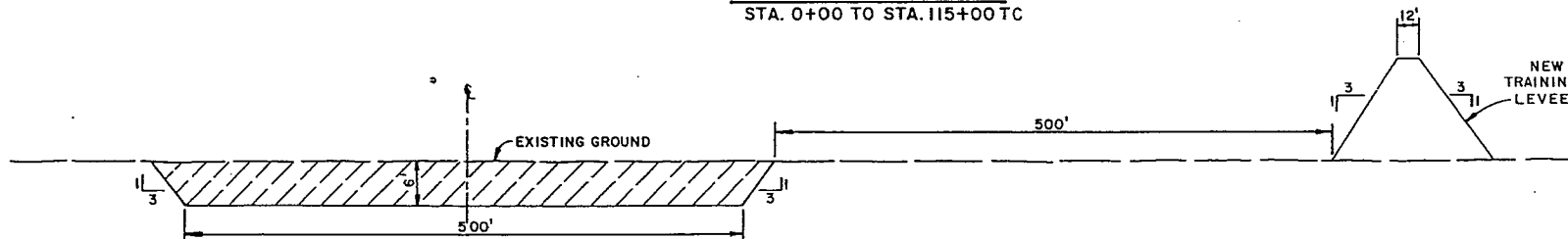
DETAIL-STONE PROTECTION (4)



BORROW AREA
TRAINING CHANNEL (1)
STA. 0+00 TO STA. 115+00 TC



LEVEE GATE-DETAIL



BORROW AREA (2)

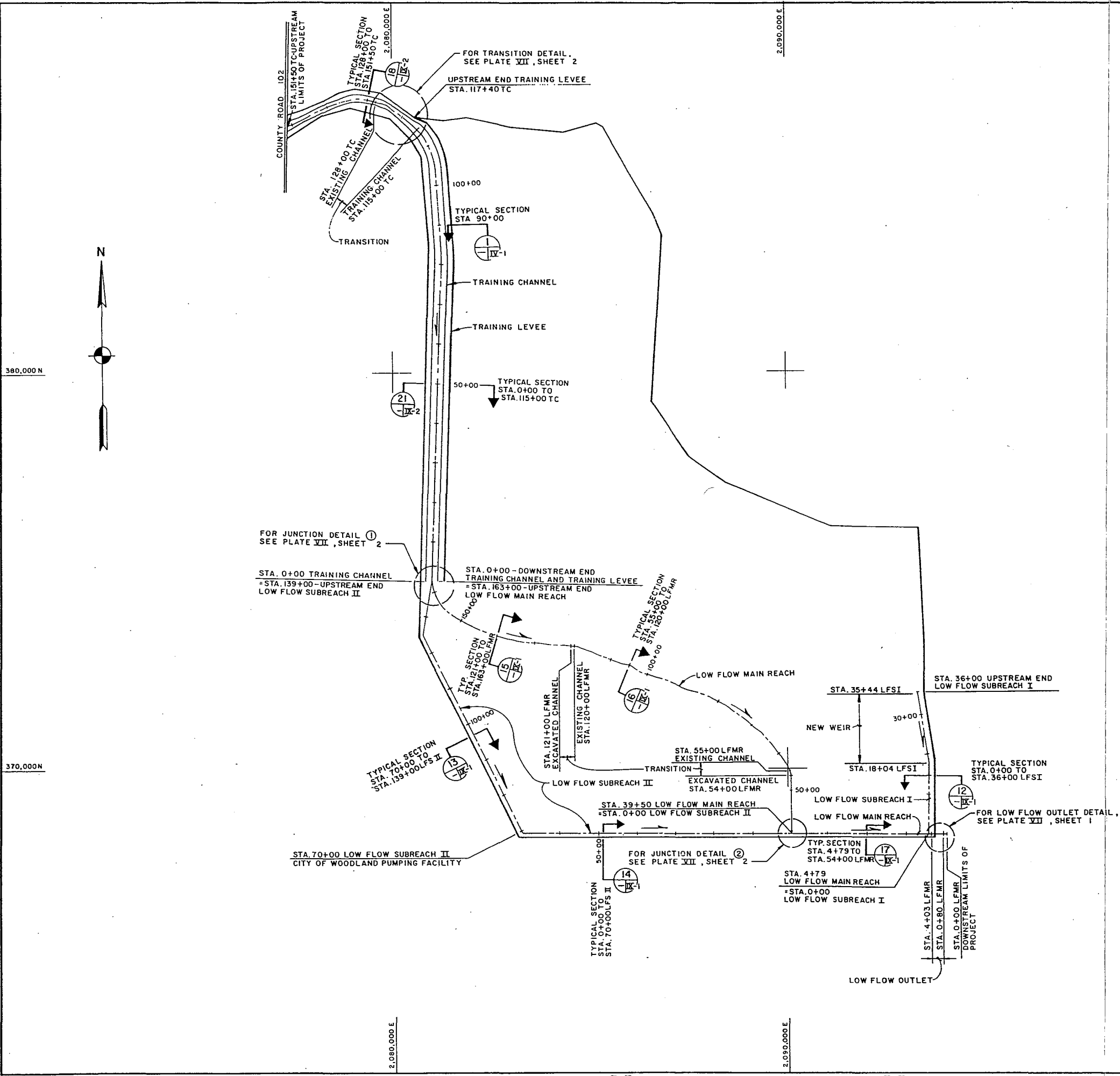
NOTE:
BORROW AREA (2) IS LOCATED EAST OF NEW TRAINING LEVEE. IT BEGINS APPROXIMATELY AT STA. 1+10 TC AND ENDS APPROXIMATELY AT STA. 10+10 TC.

NOTES:

1. FOR LOCATION OF BORROW AREAS, RAMPS, AND TURNOUTS, SEE BASIN FEATURE PLAN, PLATE II.
2. FOR LOCATION OF TRAINING LEVEE TURNAROUND, SEE JUNCTION DETAIL (1), PLATE VII-2.
3. FOR LOCATION OF STONE PROTECTION, SEE PLATES VII-1 AND XI (DETAIL (3)). SEE PLATE VII-1 FOR STONE PROTECTION IN OUTLET CHANNEL (DETAIL (4)).

DESIGNED: T. CULP		DRAWN: S. JANG		CHECKED: K. MYERS	
SUBMITTED: M. Bonner		DATE APPROVED: 1/1/1		SCALE: NO SCALE	
SHEET		FILE NO.		SPEC. NO.	
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN		LEVEE DETAILS	
CC-25-35		PLATE V 10F1			

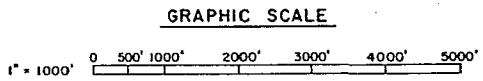
FUNCTIONAL ANALYSIS - VE PAYS



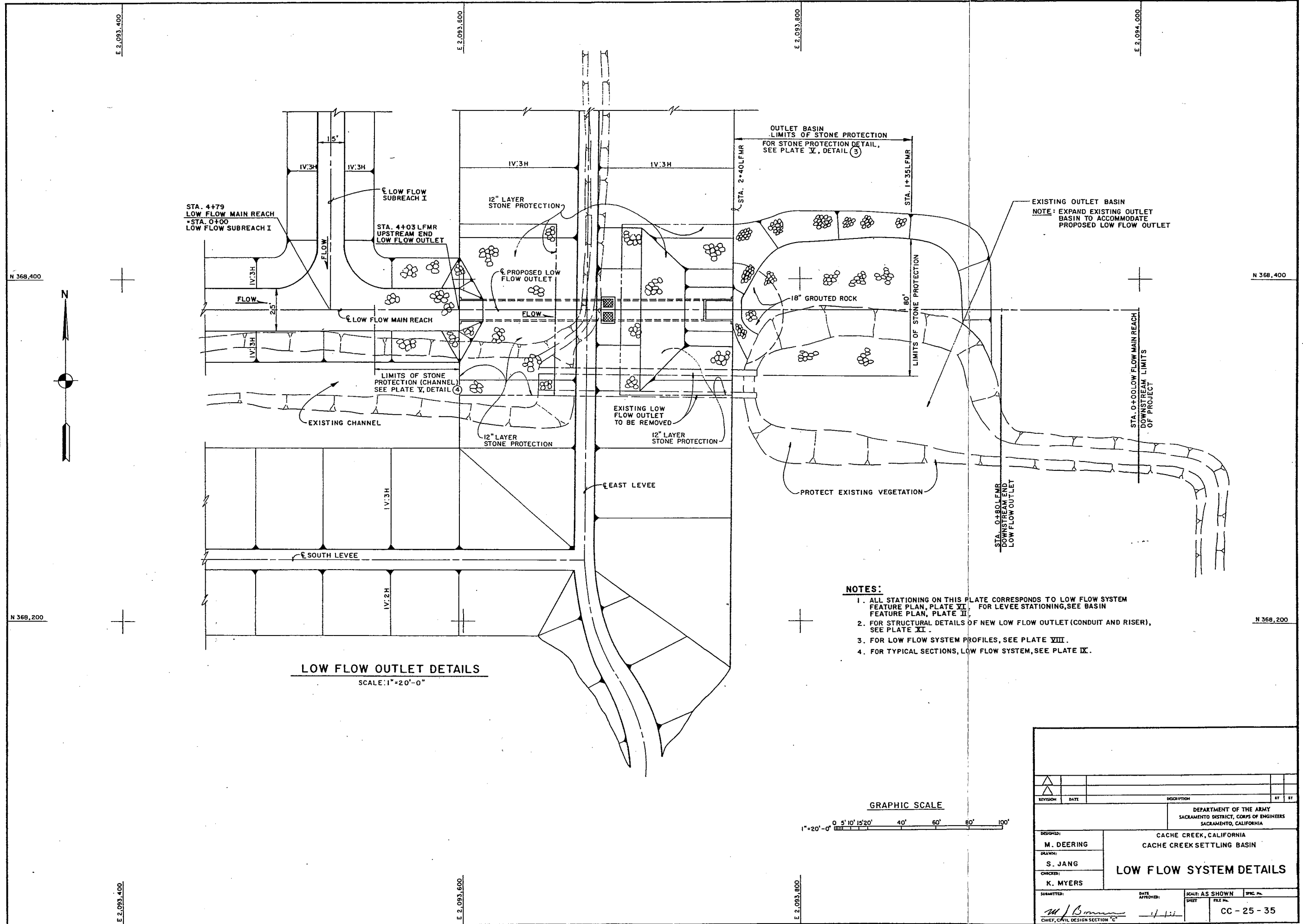
- NOTES:**
- 1. FOR BASIN LEVEE STATIONING, SEE PLATE II.
 - 2. FOR LOW FLOW SYSTEM DETAILS, SEE PLATE VII.
 - 3. FOR LOW FLOW SYSTEM PROFILES, SEE PLATE VIII.
 - 4. FOR STRUCTURAL DETAILS OF WEIR AND DROP STRUCTURE, SEE PLATE IX.
 - 5. FOR STRUCTURAL DETAILS OF NEW LOW FLOW OUTLET (CONDUIT AND RISER), SEE PLATE XI.
 - 6. FOR GENERAL LEGEND, SEE PLATE II.
 - 7. GRID COORDINATES REFER TO CALIFORNIA STATE COORDINATE SYSTEM, ZONE II. DATE OF SURVEY: MAY-SEPTEMBER 1984.

STATION ABBREVIATIONS

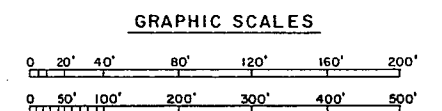
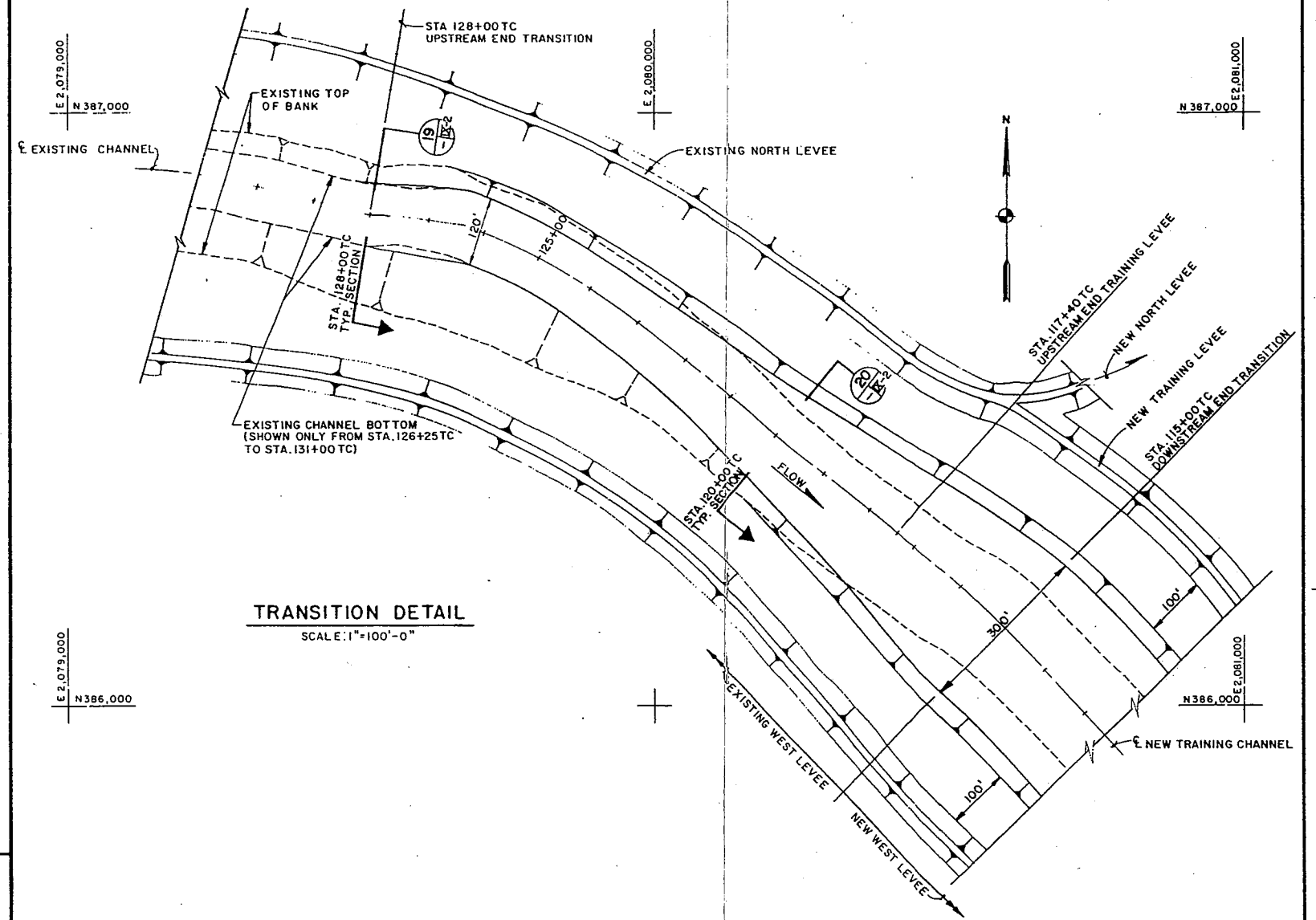
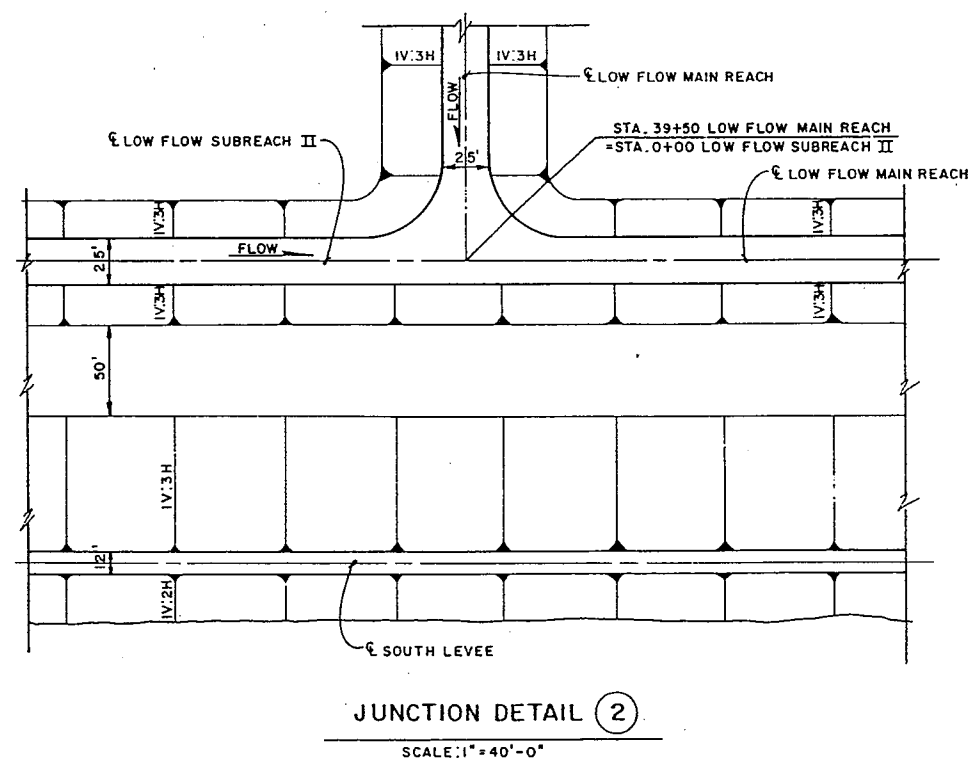
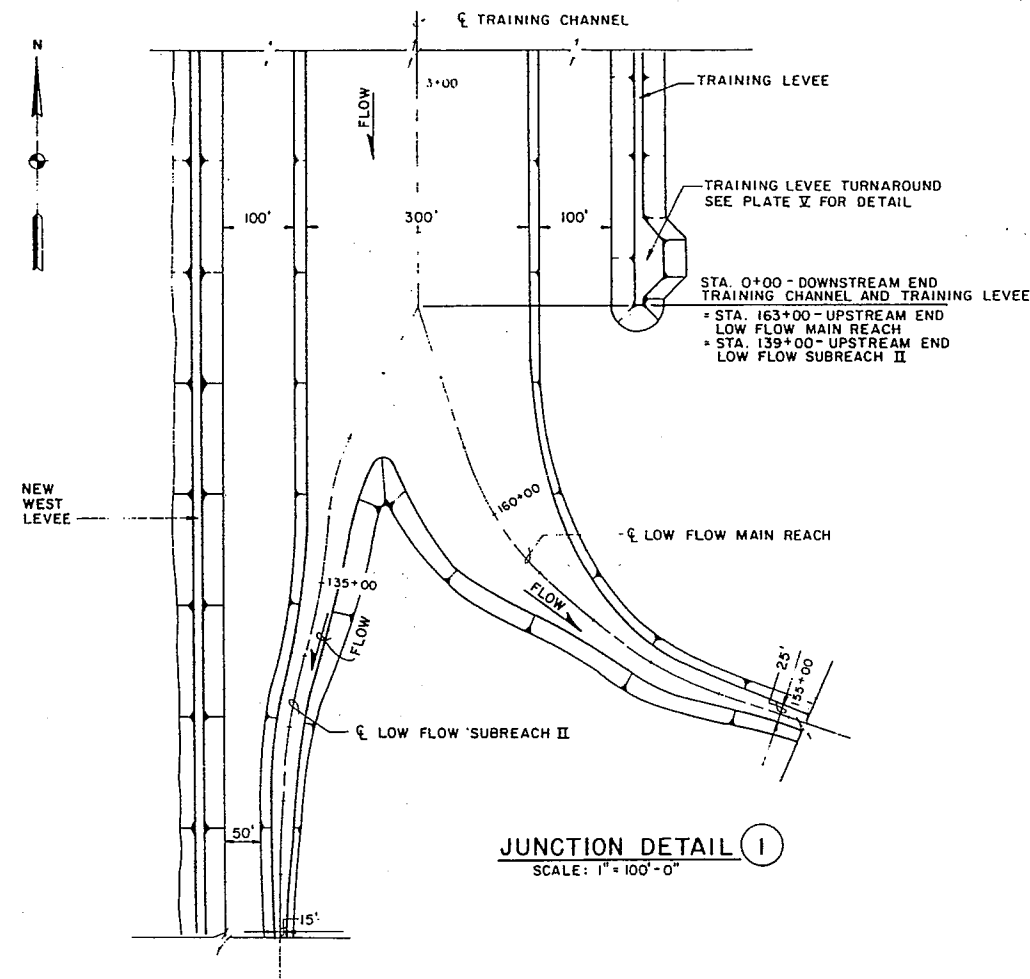
LFMR LOW FLOW CHANNEL MAIN REACH
LFSI LOW FLOW CHANNEL - SUBREACH I
LFSII LOW FLOW CHANNEL - SUBREACH II
TC TRAINING CHANNEL AND TRAINING LEVEE



REVISION		DATE	DESCRIPTION	BY	ST
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
DESIGNED: M. DEERING		CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN			
DRAWN: S. JANG		LOW FLOW SYSTEM FEATURE PLAN			
CHECKED: K. MYERS					
SUBMITTED:		DATE APPROVED:	SCALE: AS SHOWN	SHEET NO.	
CHIEF, CIVIL DESIGN SECTION "C"		CC-25-35			



FUNCTIONAL ANALYSIS - VE PAYS

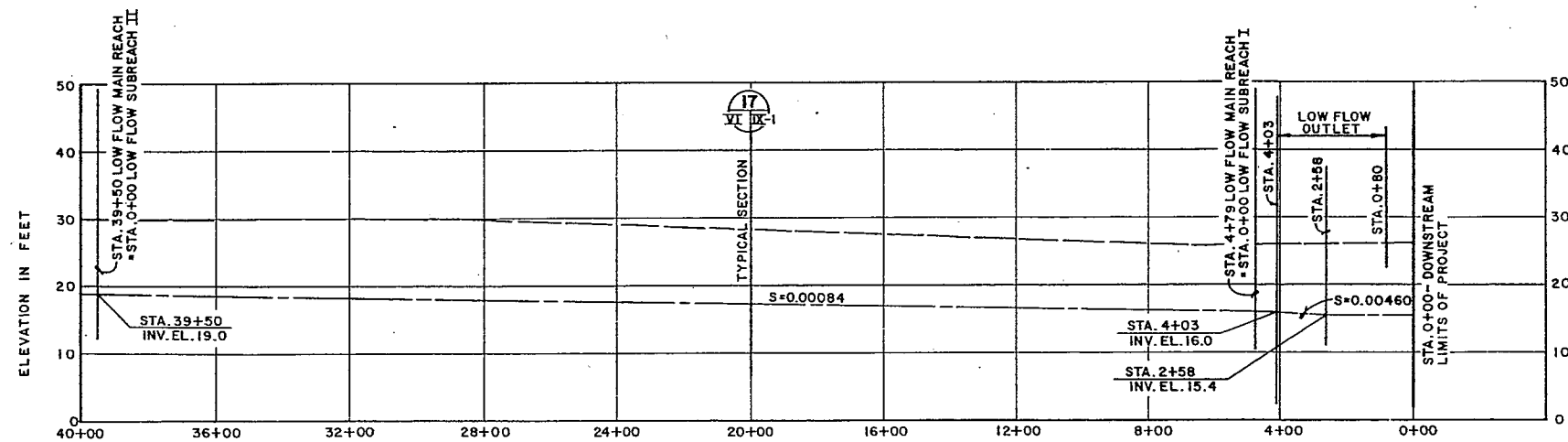
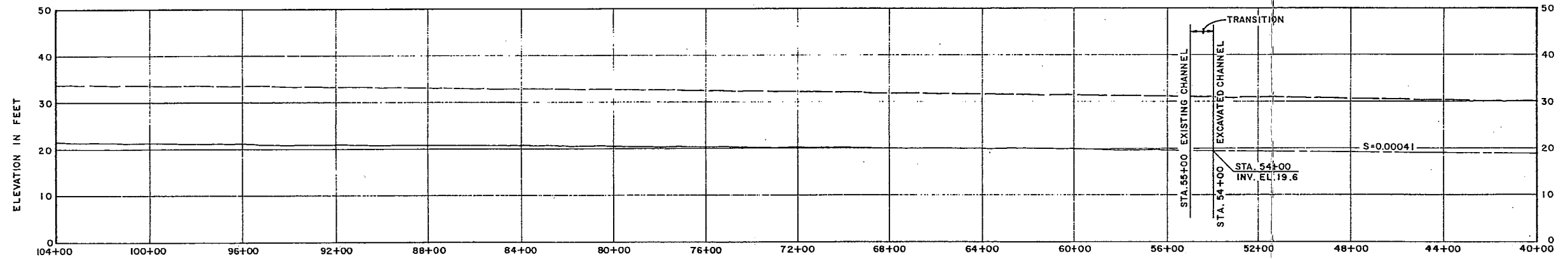
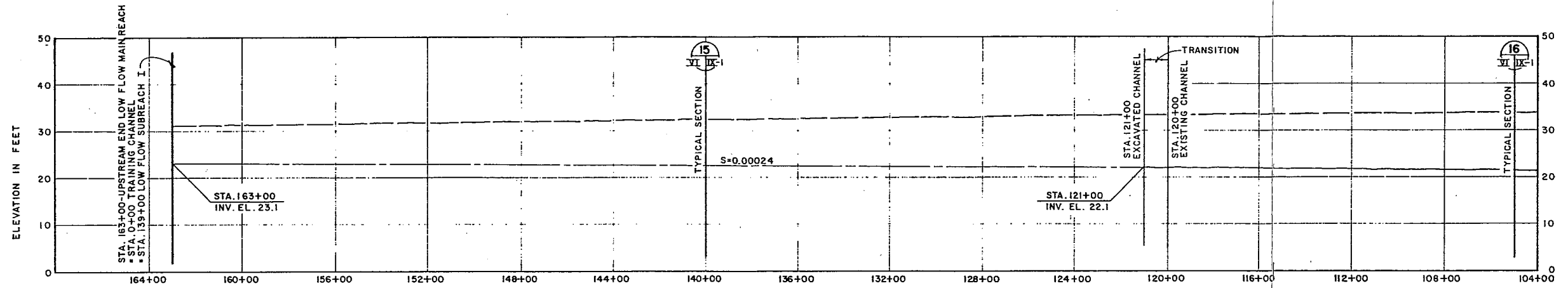


NOTES:

1. ALL STATIONING ON THIS PLATE CORRESPONDS TO LOW FLOW SYSTEM FEATURE PLAN, PLATE VII. FOR LEVEE STATIONING, SEE BASIN FEATURE PLAN, PLATE II.
2. FOR LOW FLOW SYSTEM PROFILES, SEE PLATE VIII.
3. FOR TYPICAL SECTIONS, LOW FLOW SYSTEM, SEE PLATE IX.
4. FOR GENERAL LEGEND, SEE PLATE II.

DESIGNED: M. DEERING		DRAWN: S. JANG		CHECKED: K. MYERS		SUBMITTED:	
DATE:		DATE:		DATE:		DATE:	
DESCRIPTION:		DESCRIPTION:		DESCRIPTION:		DESCRIPTION:	
DIVISION:		DIVISION:		DIVISION:		DIVISION:	
DATE:		DATE:		DATE:		DATE:	
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN		LOW FLOW SYSTEM DETAILS		CC - 25 - 35	
SCALE: AS SHOWN		SCALE: AS SHOWN		SCALE: AS SHOWN		SCALE: AS SHOWN	
SHEET		SHEET		SHEET		SHEET	
FILE NO.		FILE NO.		FILE NO.		FILE NO.	
CHIEF, CIVIL DESIGN SECTION "C"		CHIEF, CIVIL DESIGN SECTION "C"		CHIEF, CIVIL DESIGN SECTION "C"		CHIEF, CIVIL DESIGN SECTION "C"	

FUNCTIONAL ANALYSIS - VE PAYS

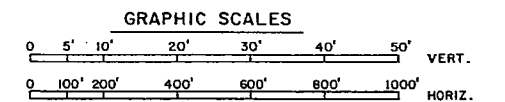


LEGEND

DESIGN CHANNEL INVERT ———
EXISTING CHANNEL INVERT - - -
EXISTING GROUND ———
RIGHT AND LEFT BANKS ———

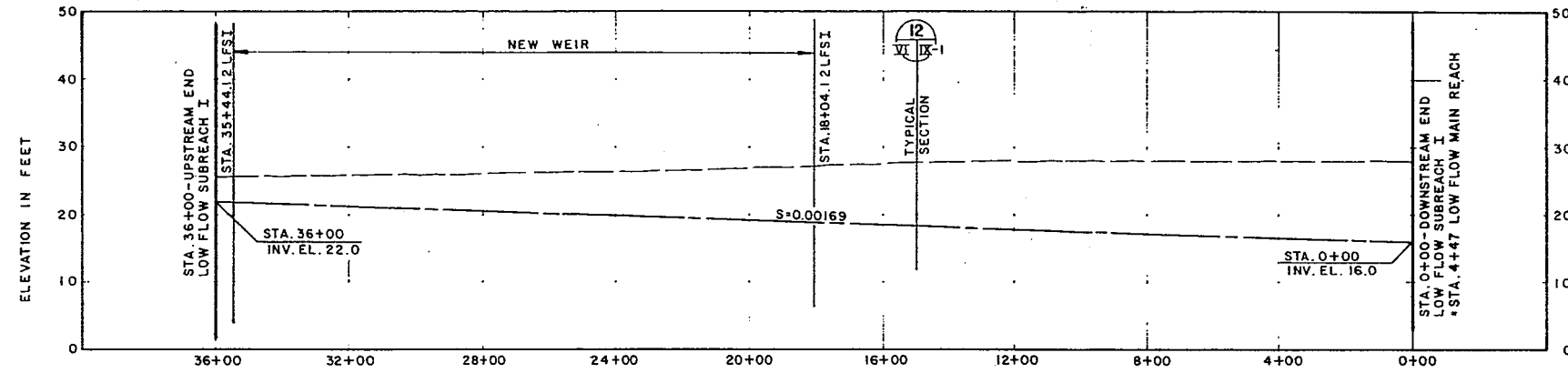
NOTES:

- ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
- FOR GENERAL LEGEND, SEE PLATE II.



DESIGNED BY M. DEERING		DATE		DESCRIPTION		BY	ST
DRAWN BY S. JANG		DATE		DESCRIPTION		BY	ST
CHECKED BY K. MYERS		DATE		DESCRIPTION		BY	ST
SUBMITTED BY <i>M. Deering</i>		DATE APPROVED 1/2/72		SCALE AS SHOWN		SHEET FILE NO.	
CHIEF, CIVIL DESIGN SECTION "C"				DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		CC-25-35	
				CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN		PROFILE LOW FLOW MAIN REACH	

FUNCTIONAL ANALYSIS - VE PAYS



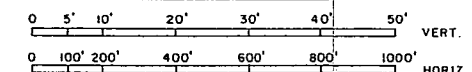
NOTES:

- ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
- FOR GENERAL LEGEND, SEE PLATE II.

LEGEND

DESIGN CHANNEL INVERT
EXISTING GROUND -
RIGHT AND LEFT BANKS

GRAPHIC SCALES



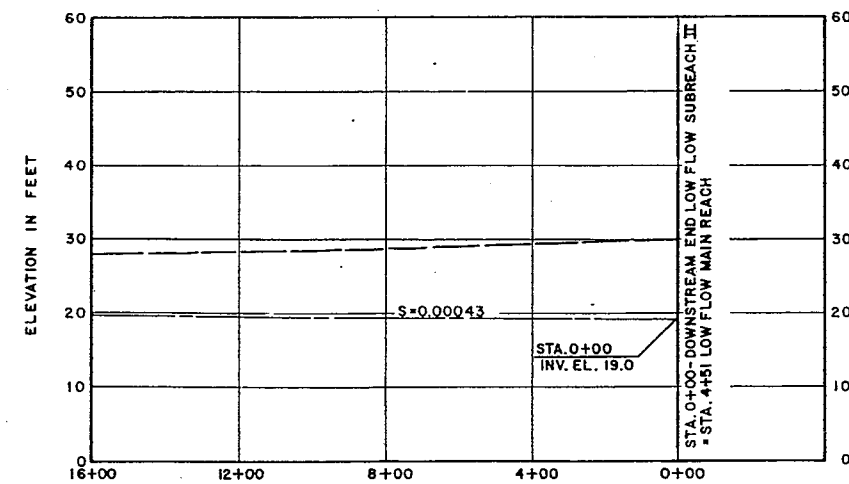
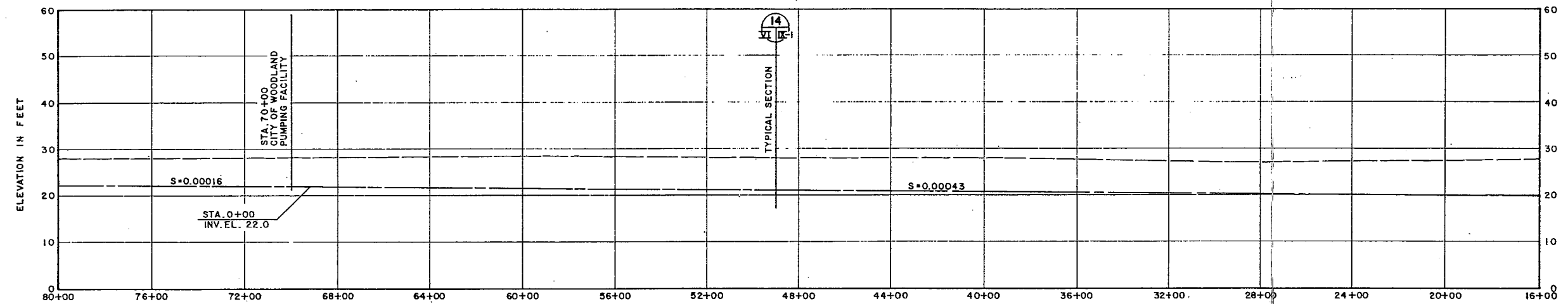
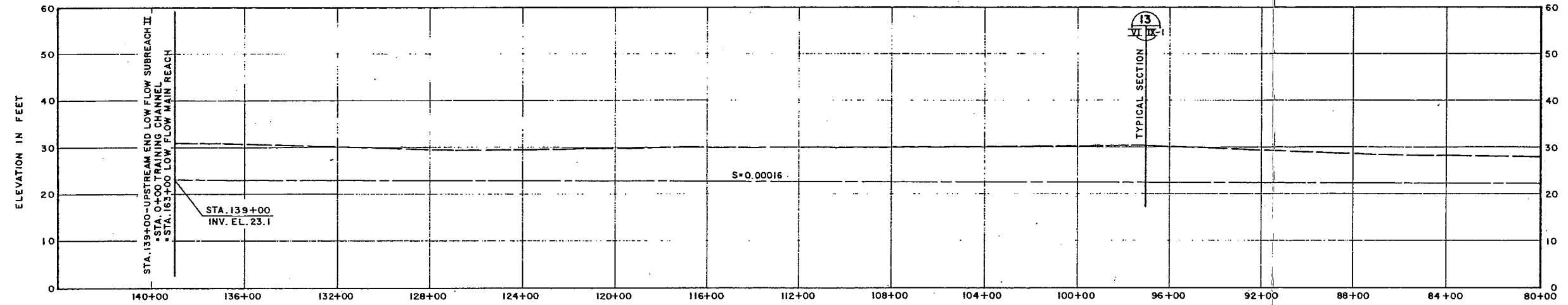
DESIGNED: M. DEERING		DATE		DESCRIPTION		BY	BT
DRAWN: S. JANG							
CHECKED: K. MYERS							
SUBMITTED:		DATE APPROVED:		SCALE: AS SHOWN		SHEET	
CHIEF, CIVIL DESIGN SECTION "C"				FILE NO.		CC-25-35	

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

CACHE CREEK, CALIFORNIA
CACHE CREEK SETTLING BASIN

PROFILE
LOW FLOW SUBREACH I

FUNCTIONAL ANALYSIS - VE PAYS

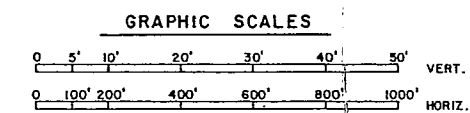


LEGEND

DESIGN CHANNEL INVERT ———

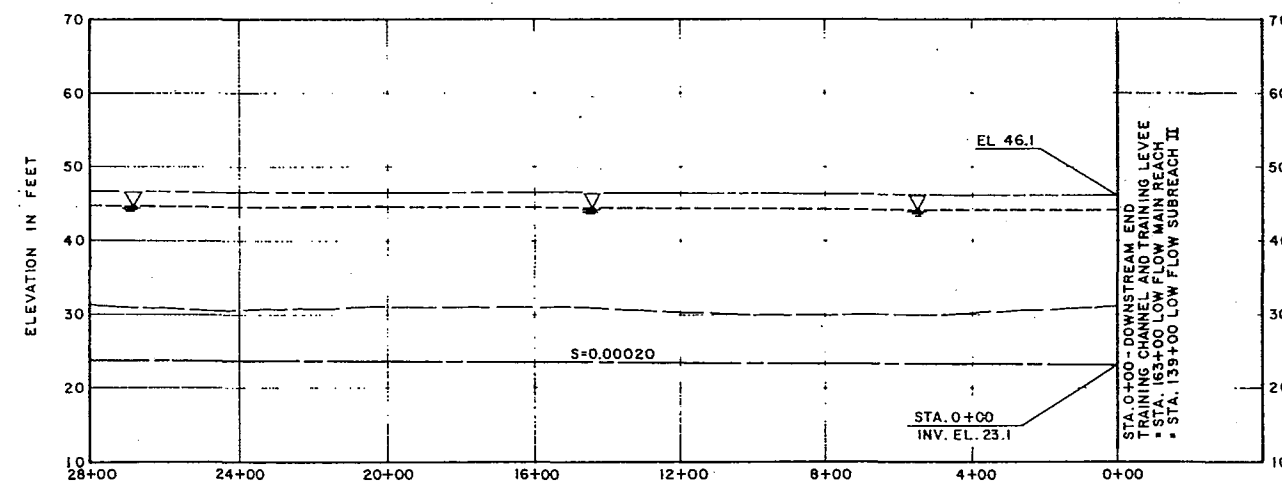
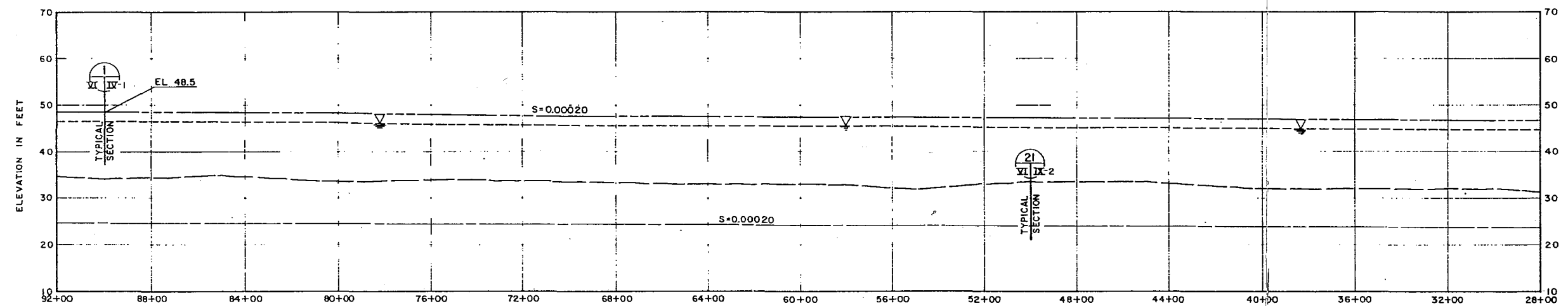
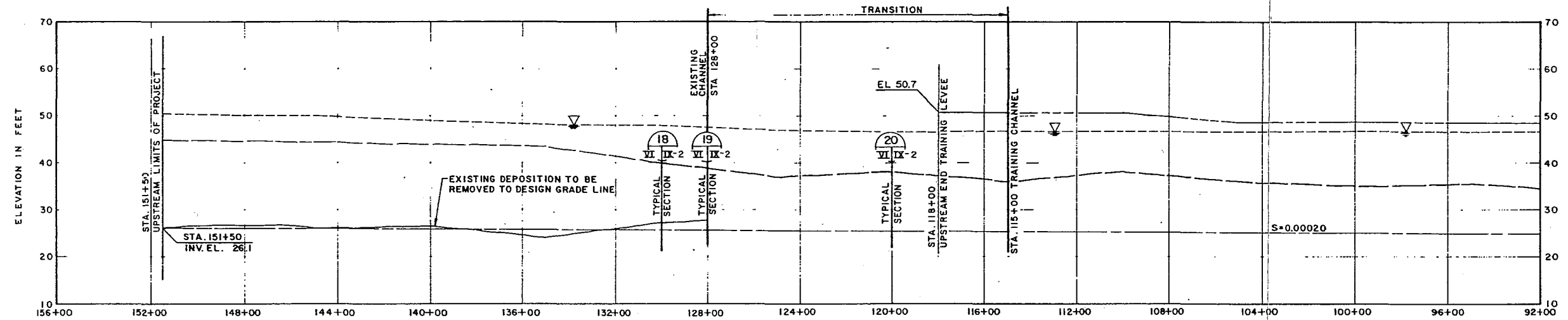
EXISTING GROUND— ———

RIGHT AND LEFT BANKS ———



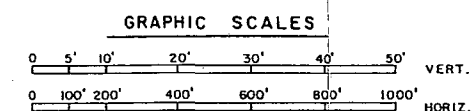
- NOTES:**
- ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
 - FOR GENERAL LEGEND, SEE PLATE II.

REVISION		DATE	DESCRIPTION	BY	BY
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
DESIGNED:		M. DEERING S. JANG K. MYERS			
DRAWN:		S. JANG			
CHECKED:		K. MYERS			
SUBMITTED:		DATE APPROVED:		SCALE: AS SHOWN	SPEC. No.
M. Deering CHIEF, CIVIL DESIGN SECTION "C"		1/1/31		SHEET CC-25-35	FILE No. CC-25-35



LEGEND

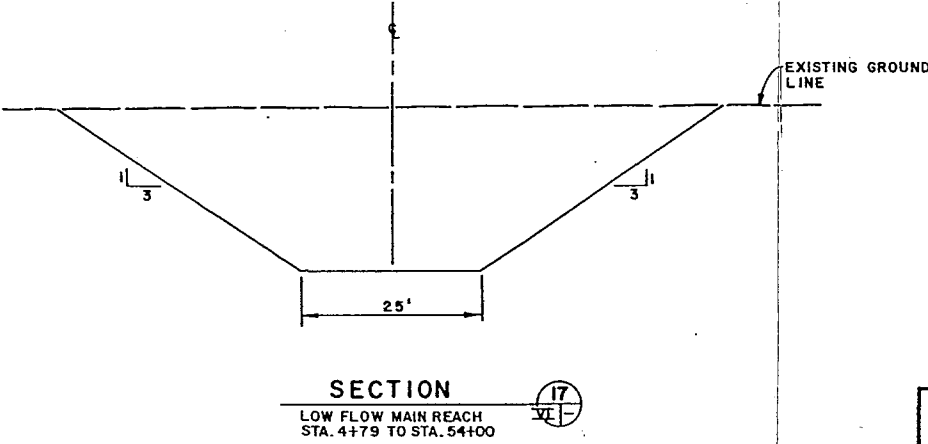
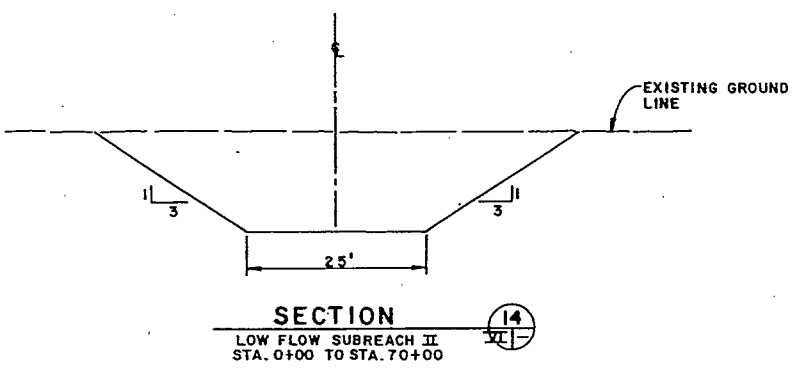
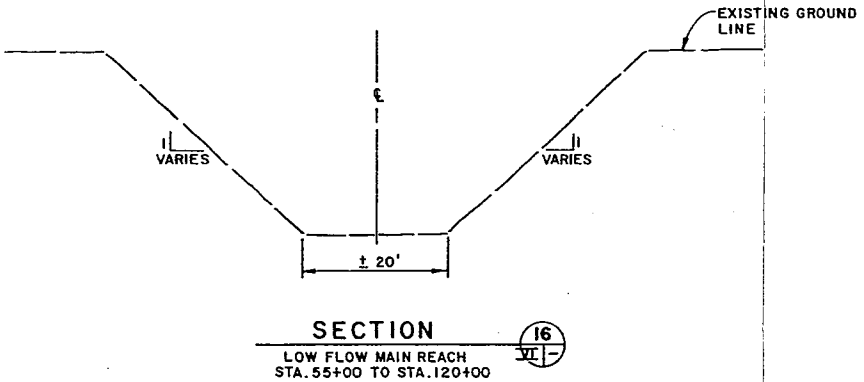
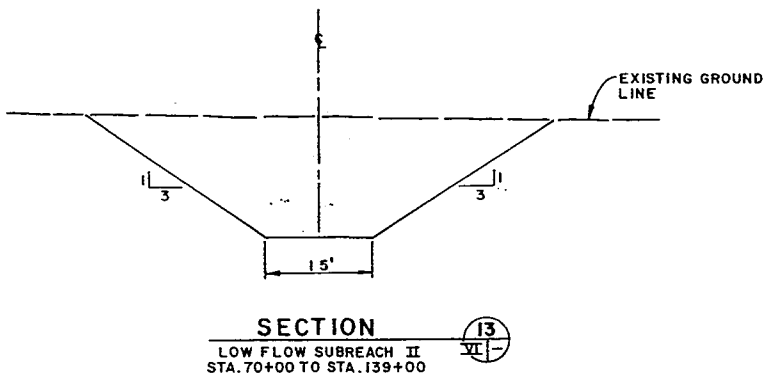
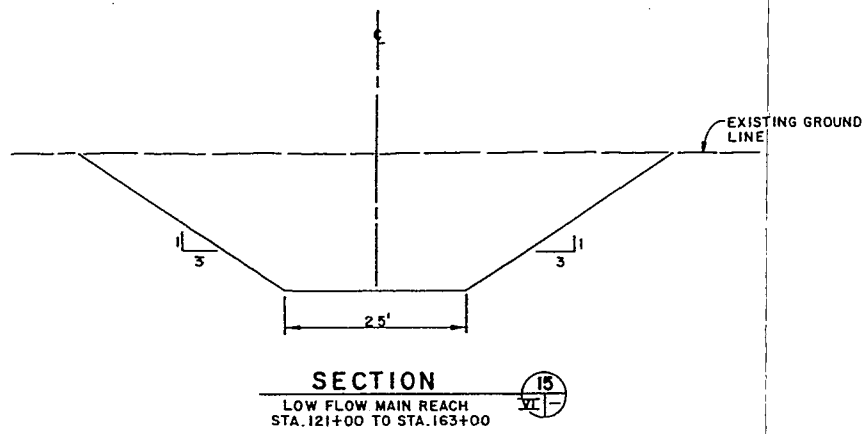
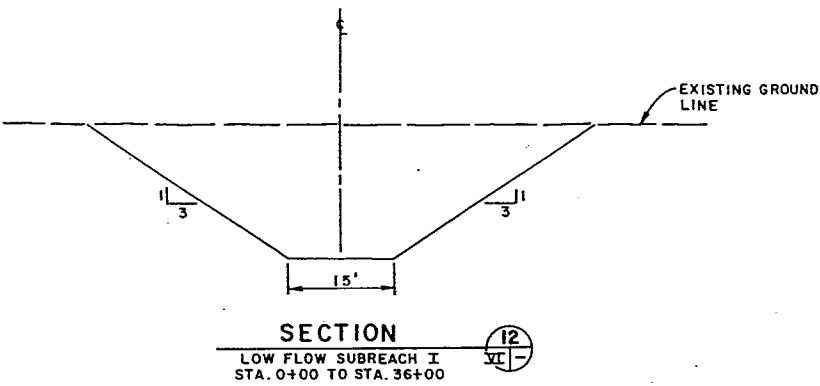
DESIGN CHANNEL INVERT	---
DESIGN WATER SURFACE	---
DESIGN LEVEE GRADE (TRAINING LEVEE)	---
EXISTING GROUND	---
RIGHT AND LEFT BANKS	---
EXISTING CHANNEL INVERT (CACHE CREEK)	---



NOTES:

1. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
2. FOR GENERAL LEGEND, SEE PLATE II.

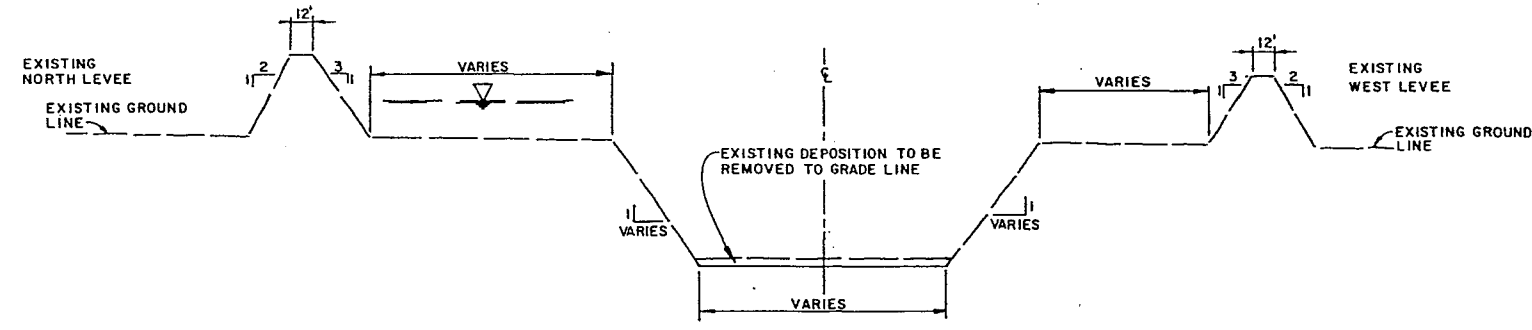
DESIGNED M. DEERING		DRAWN S. JANG		CHECKED K. MYERS	
SUBMITTED <i>[Signature]</i>		DATE APPROVED 1/2/31		SCALE: AS SHOWN SHEET FILE NO.	
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN PROFILE TRAINING CHANNEL					
				CC - 25 - 35	



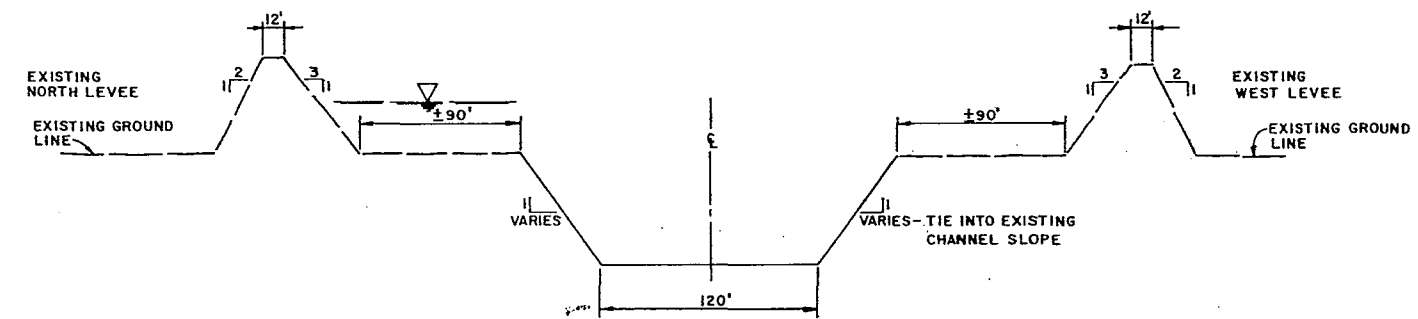
- NOTES:
1. FOR LOW FLOW SYSTEM PROFILES, SEE PLATE VIII, SHEET 1-3.
 2. FOR GENERAL LEGEND, SEE PLATE II.

REVISION		DATE	DESCRIPTION	BY	BT
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
DESIGNED BY: M. DEERING		CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN			
DRAWN BY: S. JANG		TYPICAL SECTIONS- LOW FLOW SYSTEM			
CHECKED BY: K. MYERS					
SUBMITTED BY: <i>M. Deering</i>		DATE APPROVED: 1/2/31	SCALE: NO SCALE	SHEET FILE NO. CC - 25-35	
CHIEF, CIVIL DESIGN SECTION "C"					

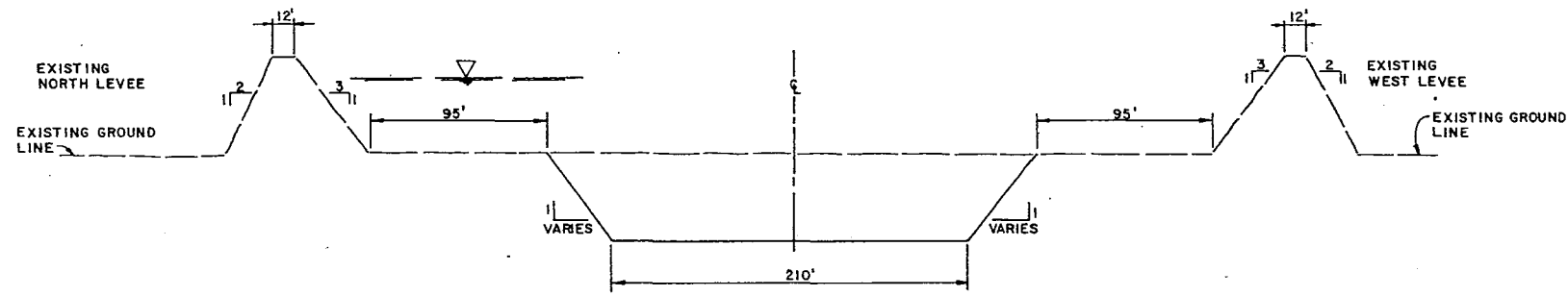
FUNCTIONAL ANALYSIS - VE PAYS



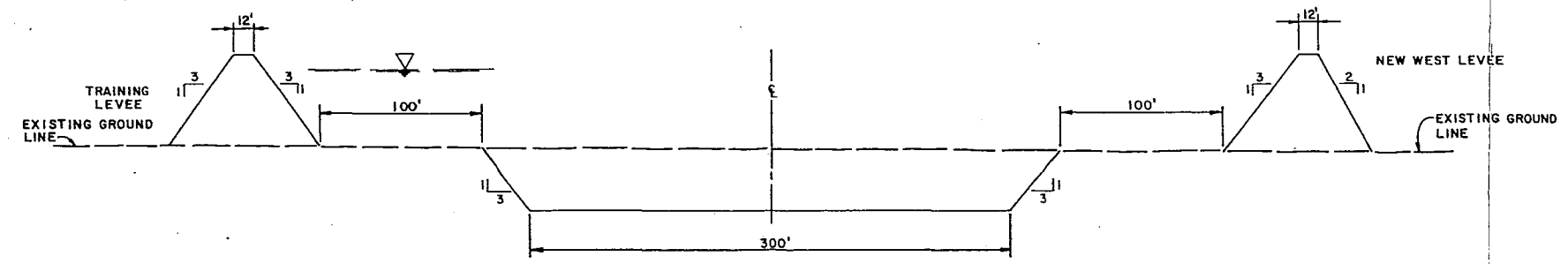
SECTION 18
TRAINING CHANNEL - EXISTING
STA. 128+00 TO STA. 151+50



SECTION 19
TRAINING CHANNEL TRANSITION -
UPSTREAM END
STA. 128+00



SECTION 20
TRAINING CHANNEL TRANSITION
STA. 120+00

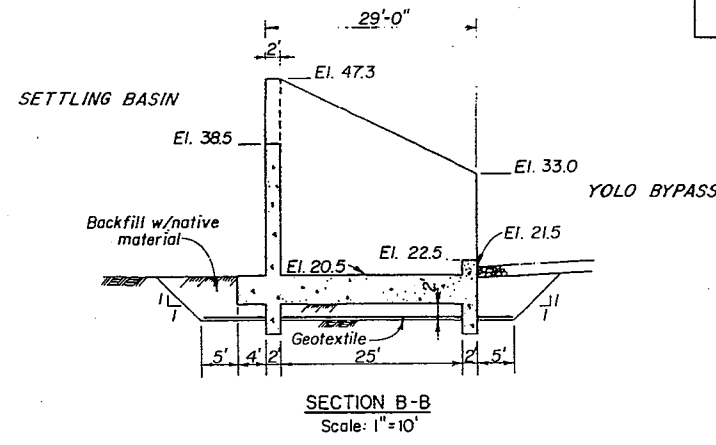
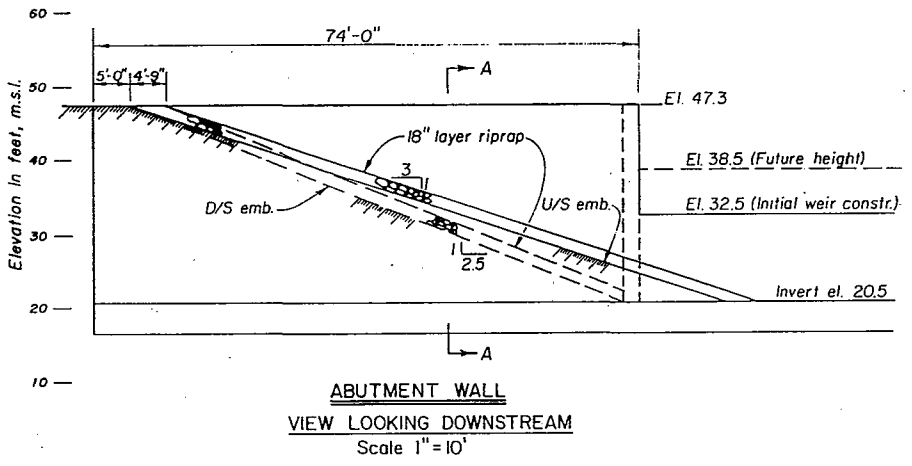
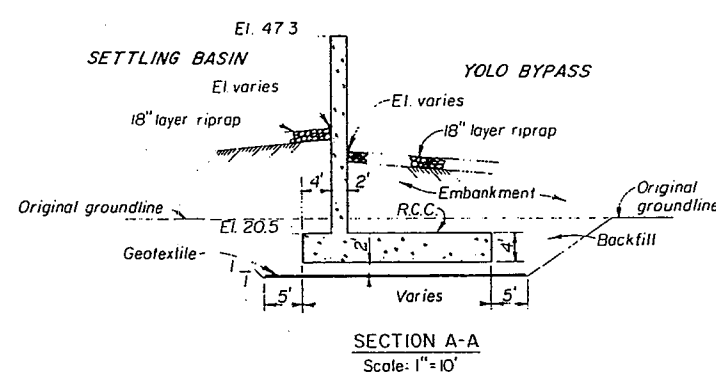
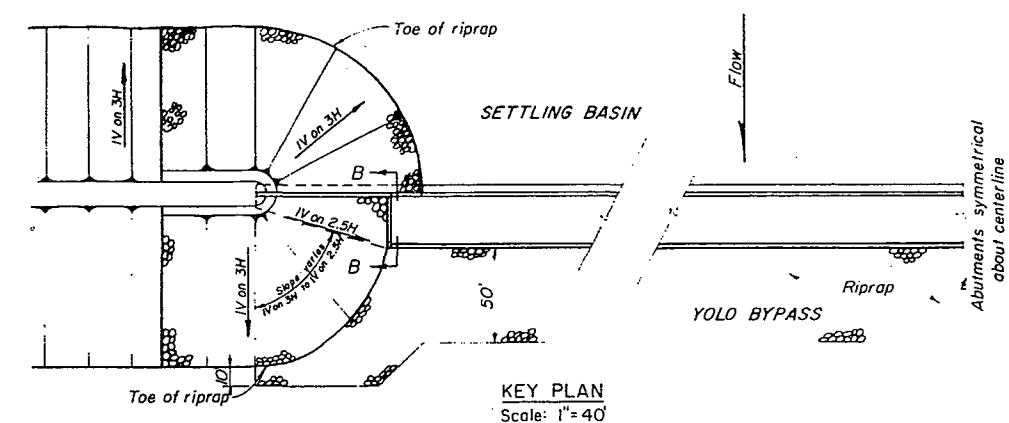


SECTION 21
TRAINING CHANNEL
STA. 0+00 TO STA. 115+00

- NOTES:**
1. FOR TRAINING CHANNEL PROFILE, SEE PLATE VIII-4.
 2. FOR GENERAL LEGEND, SEE PLATE II.

REVISION		DATE	DESCRIPTION	BY	BT
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
DESIGNED:		M. DEERING S. JANG K. MYERS			
DRAWN:		S. JANG K. MYERS			
CHECKED:		M. Deering CHIEF, CIVIL DESIGN SECTION "C"			
SUBMITTED:		DATE APPROVED:	SCALE: NO SCALE	SHEET	FILE NO.
					CC-25-35

FUNCTION ANALYSIS - VE PAYS



ABUTMENT WALLS								
CASE	EV (kips)	EH (kips)	EM (kip-ft)	X (ft)	PRESSURE IN KIPS/SQ. FT.			SLIDING F. S.
						σ_T	σ_H	
I	15.2	0.9	99.5	5.59	Base Pressure	1.23	1.31	6.60
II	47.6	1.8	545.3	6.05	Base Pressure	4.06	3.88	10+
III	16.1	23.4	225.6	14.06	Base Pressure	1.72	0.77	1.52
					Uplift	0.25	0.69	
					Total	1.97	1.46	

					DROP BASIN			
CASE	EV (kips)	EH (kips)	EH (kip-ft)	X (ft)	PRESSURE IN KIPS/SQ. FT.			SLIDING F. S.
						σ_T	σ_H	
I	27.6	0.7	502.8	18.22	Base Pressure	0.32	1.24	16.70
II	33.6	10.7	641.8	19.10	Base Pressure	0.34	1.61	1.83
III	20.6	23.3	295.6	14.33	Base Pressure	0.74	0.17	1.52
					Uplift	0.25	0.89	
					Total	0.99	0.86	

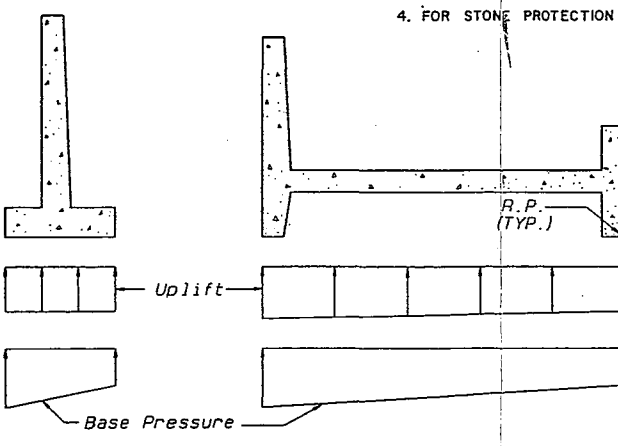
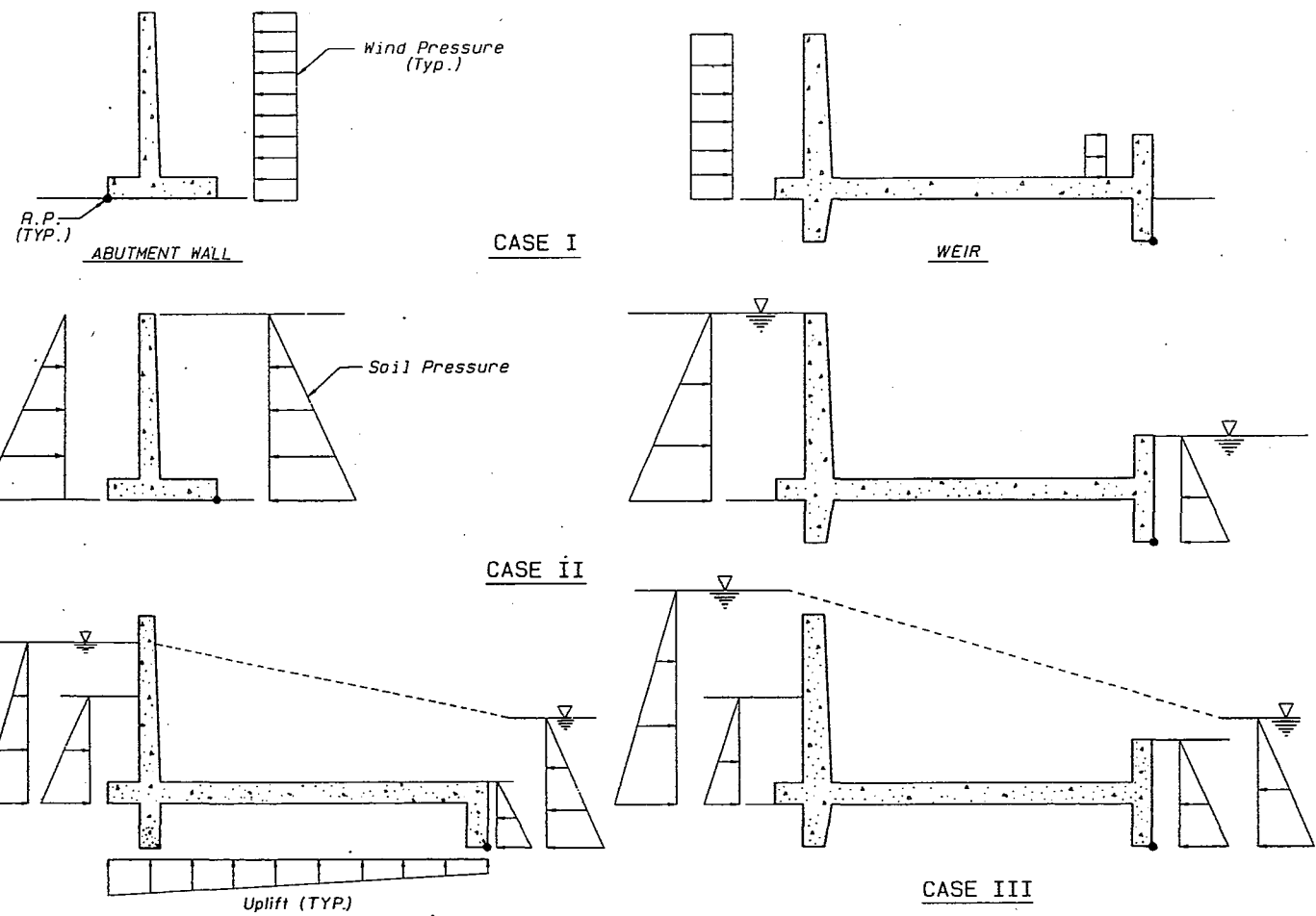
- LEGEND**
- EV Summation of Vertical Forces
 - EH Summation of Horizontal Forces
 - EM Summation of Moments About Reference Point
 - X Distance from Reference Point to Resultant
 - σ_T Pressure at Toe
 - σ_H Pressure at Heel
 - R.P. Reference Point for Stability Analysis
 - Water Surface

- STABILITY LOADING CONDITIONS**
- CASE I - - - - Wind on completed structure during construction, no backfill in place and 30 psf wind on exposed surface, 33-1/3% overstress permitted, 75% of base in compression.
- CASE II - - - - Channel empty, backfill submerged, no uplift pressure, resultant within the kern of the base, normal working stress.
- CASE III - - - - Flood discharge condition, channel full, backfill behind wall submerged to a height equivalent to uplift pressure and naturally drained above with the uplift pressure taken as full tailwater plus 50% of the difference between headwater and tailwater at the upstream end. Resultant within the kern, normal stresses.

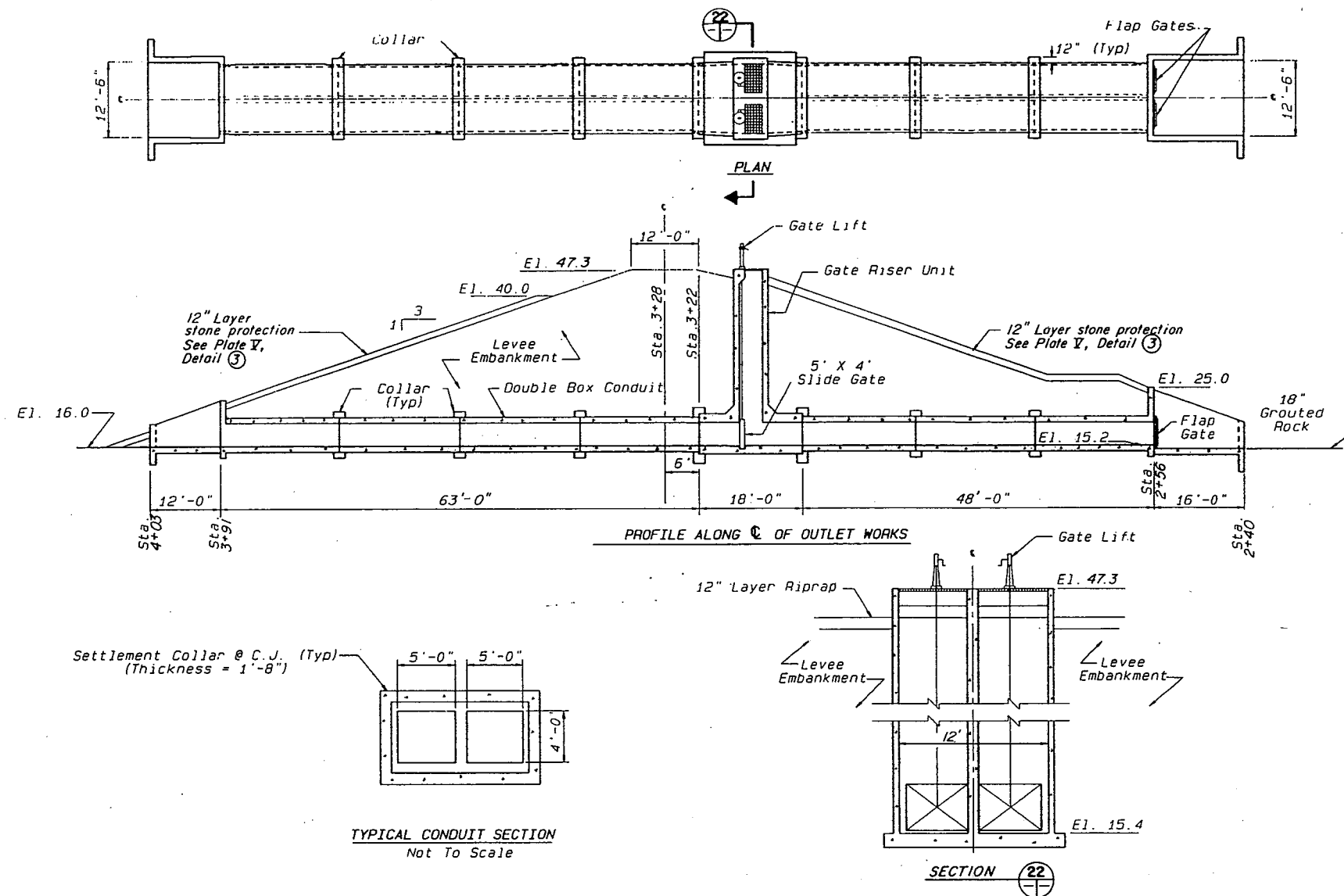
1. The unit weight of soil used for the stability analysis are as follows:
- | | |
|-----------|--------------------------|
| Dry | 102.5 lb/ft ³ |
| Moist | 121.2 lb/ft ³ |
| Saturated | 127.2 lb/ft ³ |

2. The total foundation pressure is equal to uplift pressure plus base pressure as shown in the following diagram:

- NOTES:**
- FOR LEVER, STATIONING AND LOCATION OF WEIR, SEE BASIN FEATURE PLAN, PLATE II.
 - FOR EAST LEVEE PROFILE, SEE PLATE III-2.
 - FOR GENERAL LEGEND, SEE PLATE II.
 - FOR STONE PROTECTION DETAIL, SEE PLATE V.



DESIGNED BY	E. ARREDONDO	CACHE CREEK, CALIFORNIA
DRAWN BY	L. CLAY	CACHE CREEK SETTLING BASIN
CHECKED BY	J. WHITE	WEIR AND DROP STRUCTURE
APPROVED BY	John White	STABILITY ANALYSIS
DATE	2 Jan 87	SCALE NO SCALE
BY		DATE



GATE RISER UNIT								
CASE	IV (kips)	EH (kips)	EM (kip-ft)	X (ft)	PRESSURE IN KIPS/SQ. FT.			SLIDING F. S.
						σ_T	σ_H	
I	328	0.96	2821	9.0	Base Pressure	1.14	1.14	136
II	950	0.00	0.00	9.0	Base Pressure	3.30	3.30	---
III	499	0.00	0.00	9.0	Base Pressure	1.73	1.73	---

LEGEND

- ΣV = Summation of Vertical Forces
- ΣH = Summation of Horizontal Forces
- ΣM = Summation of Moments About Reference Point
- $\bar{x}$ = Distance from Reference Point to Resultant
- σ_v = Pressure at Toe
- σ_h = Pressure at Heel
- R.P. = Reference Point for Stability Analysis
- ∇ = Water Surface

STABILITY LOADING CONDITIONS FOR GATE RISER UNIT

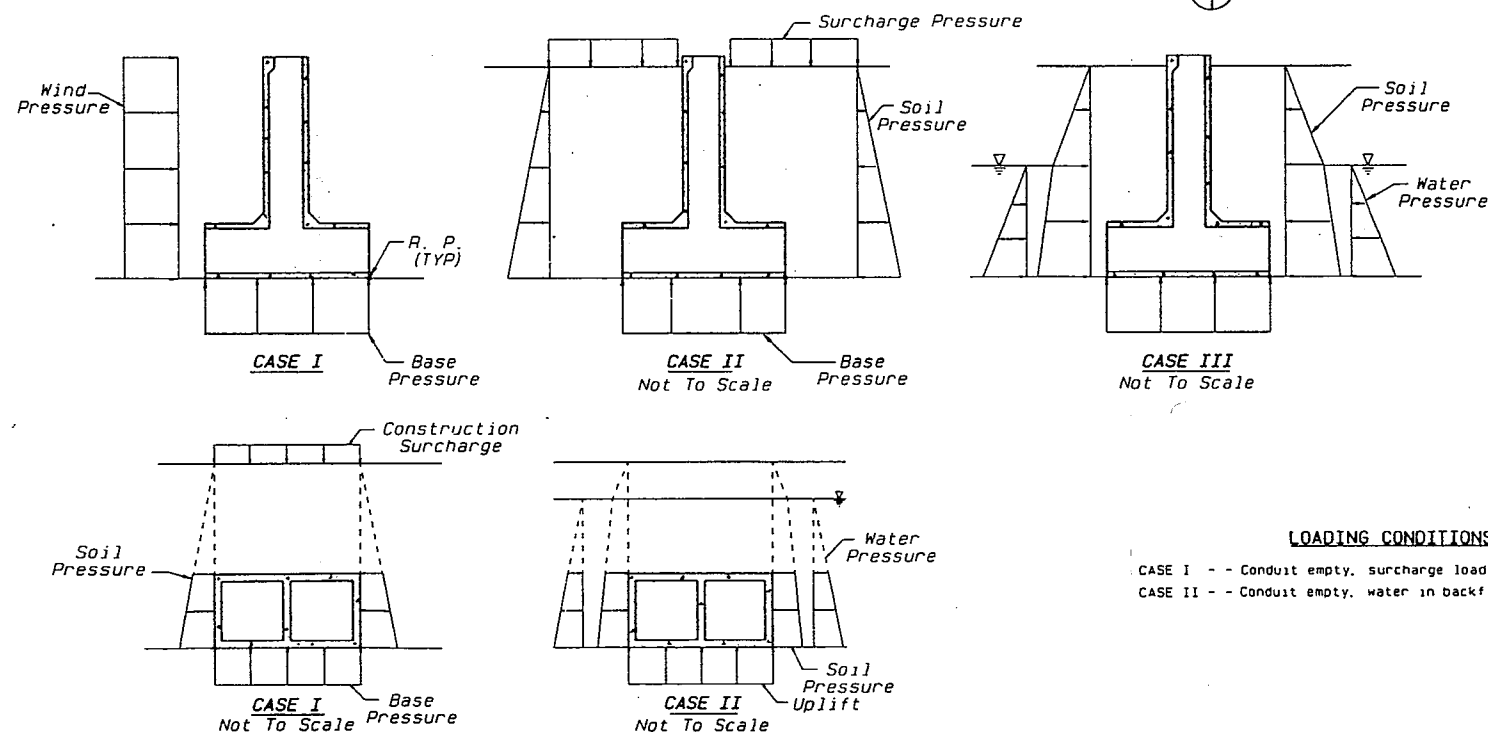
CASE I - - - - Wind on completed structure during construction, no backfill in place and 30 psf wind on exposed surface, 33-1/3% overstress permitted, 75% of base in compression.

CASE II - - - - Stilling Basin empty, surcharge load due to construction. Resultant within kern of base.

CASE III - - - - Flood condition, 100% uplift, resultant within the kern of base.

NOTES:

1. FOR LOW FLOW SYSTEM STATIONING AND LOCATION OF CONDUIT, SEE LOW FLOW SYSTEM FEATURE PLAN, PLATE VII.
2. FOR PROFILE, SEE PLATE VIII-1.
3. FOR GENERAL LEGEND, SEE PLATE II.
4. FOR LOCATION OF STONE PROTECTION, SEE PLATE VII-1.



LOADING CONDITIONS FOR CONDUIT

CASE I - - Conduit empty. surcharge load due to construction equipment.
CASE II - - Conduit empty. water in backfill.

							
DESIGN	DATE	DESCRIPTION				BY	DT
		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
DESIGNED E. ARREDONDO		CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN LOW FLOW OUTLET CONDUIT AND RISER UNIT STABILITY ANALYSIS					
DRAWN L. CLAY							
CHECKED J. WHITE							
SUBMITTED 		DATE APPROVED 1/1/71		SCALE NO SCALE SHEET		SPEC. IN. FILE IN CC-25-35	
CIVIL DESIGN SECTION A							

LOCATION MAP
NOT TO SCALE

VICINITY MAP
NOT TO SCALE

LEGEND

- Army Corps of Engineers (1958)
 - 2F-8-12 Foundation Exploration
 - 2B-8-4 Borrow Exploration
- University of California, Davis Exploration (1975)
 - A thru O Hand Auger Exploration
- Army Corps of Engineers (1984)
 - 2F-84-1 Foundation Exploration
 - 2B-84-1 Borrow Exploration

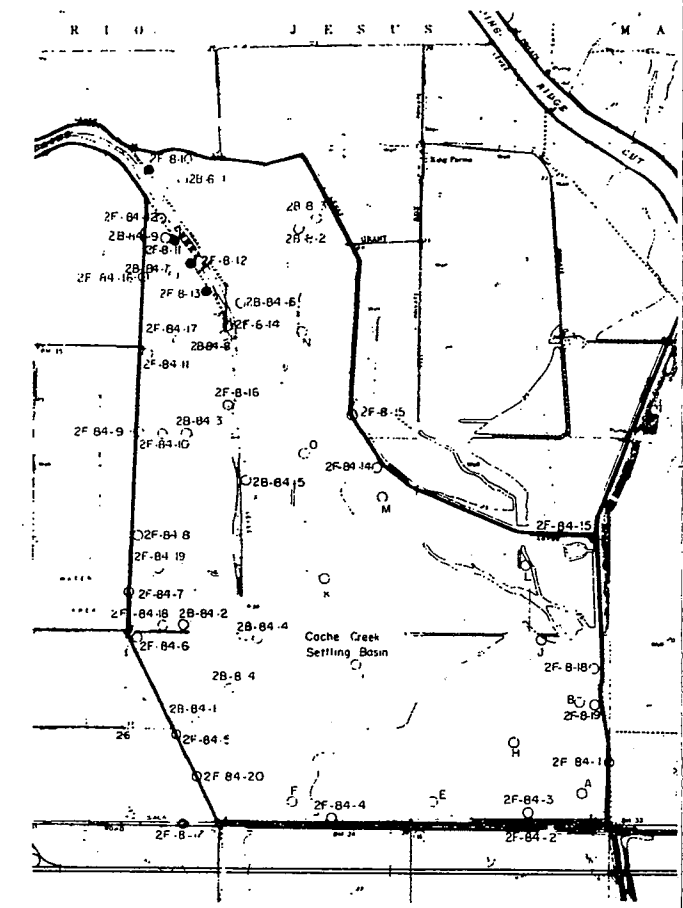
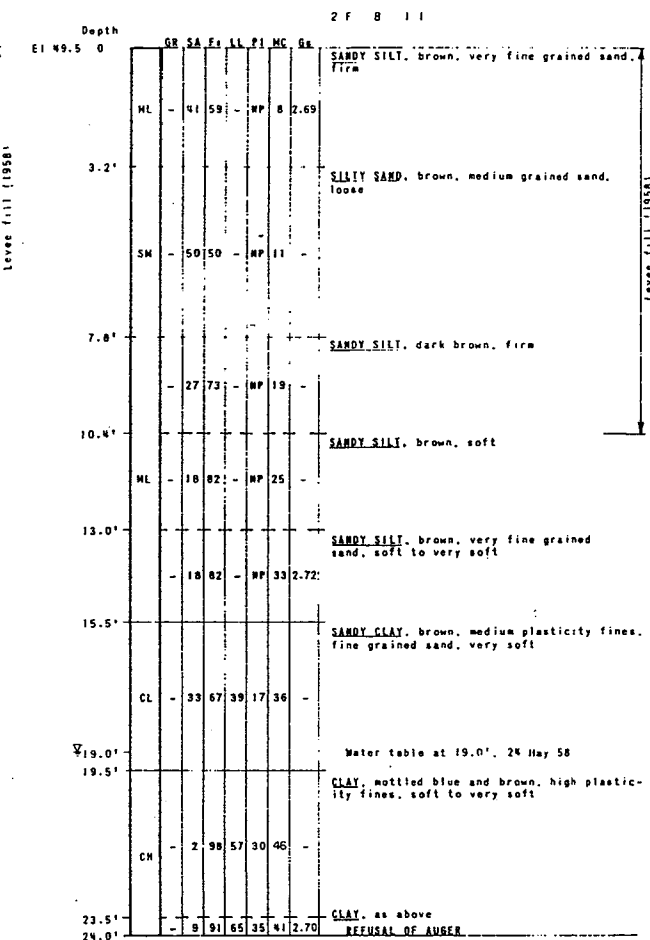
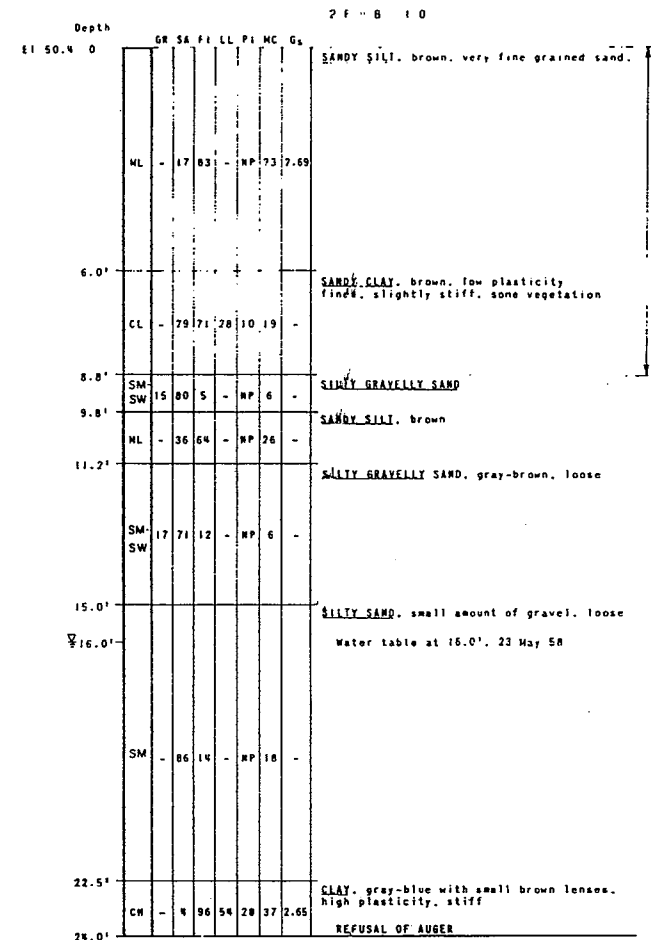
Potential Borrow Area

REVISION		DATE	DESCRIPTION	BY	BT

DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DRAWN BY: K. Wahl CHECKED BY: D. Anderson	CACHE CREEK BASIN CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN ELEMENT PROJECT & BORROW AREA LOCATION

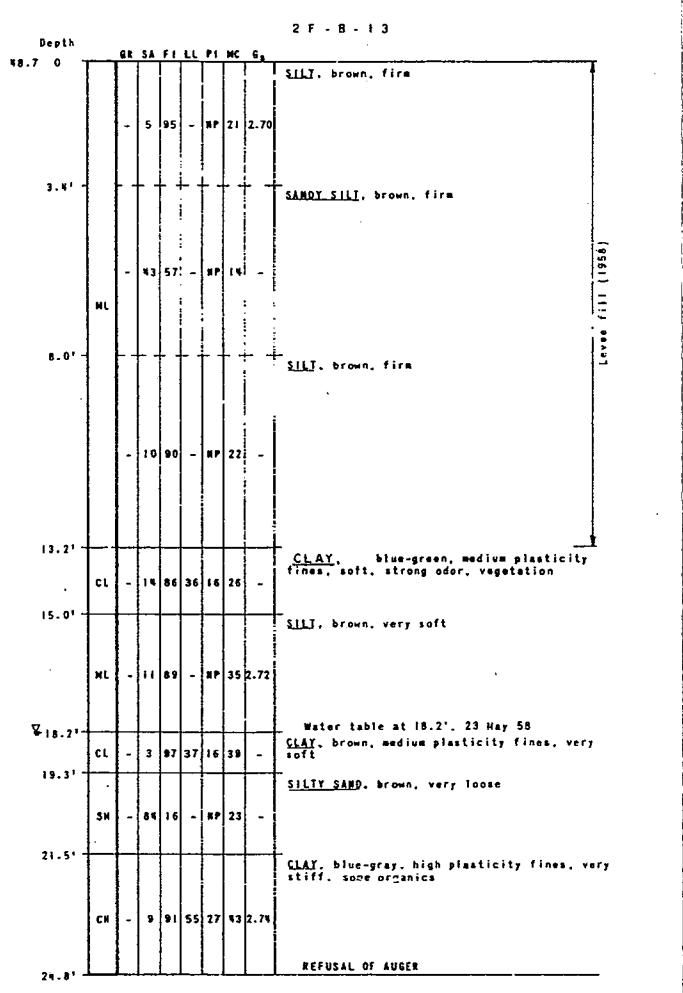
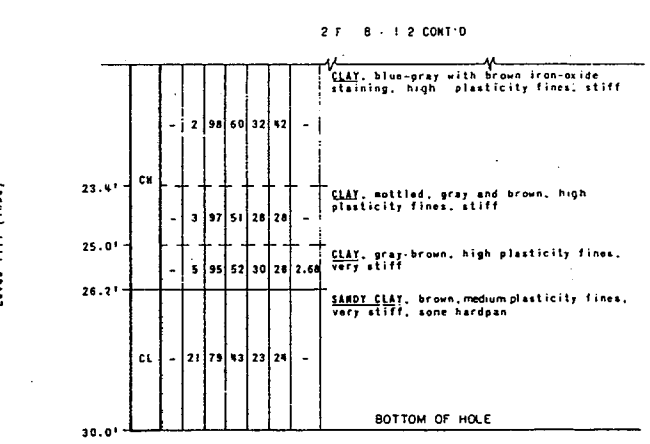
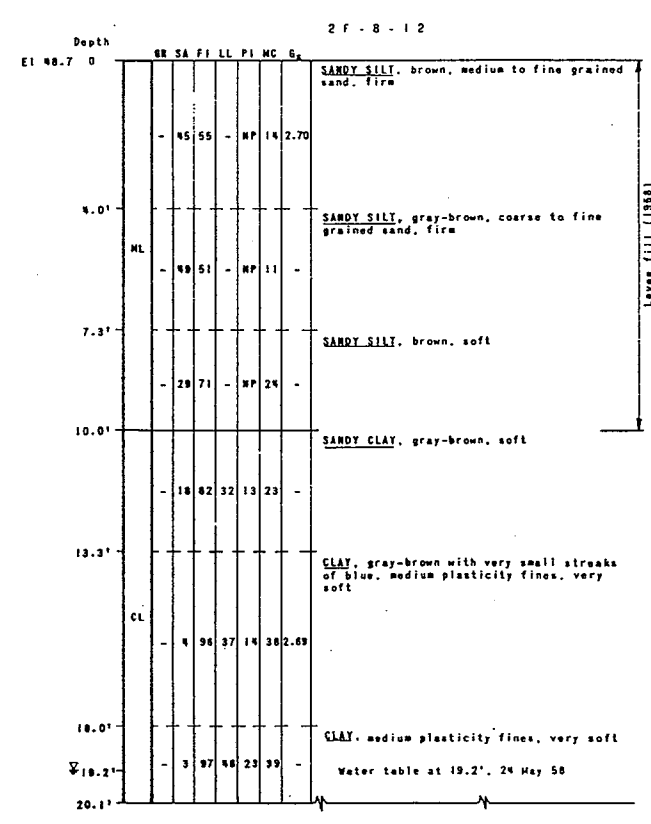
SUBMITTED BY: <i>[Signature]</i> CHIEF, SOIL DESIGN SECTION	DATE APPROVED: 1/9/31	SCALE: SHEET	FILE NO. CC-25-35
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FUNCTIONAL ANALYSIS - VE PAYS



UNIFIED SOIL CLASSIFICATION SYSTEM				
MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES	
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half coarse fraction retained on the No. 4 sieve.	GW	Well-graded gravel, gravel-sand mixtures, little or no fines.	
		GP	Poorly-graded gravel, gravel-sand mixtures, little or no fines.	
		GM	Silty gravel, gravel-sand mixtures.	
		GC	Clayey gravel, gravel-sand-clay mixtures.	
SANDS More than half coarse fraction retained on the No. 4 sieve.	SANDS More than half coarse fraction retained on the No. 4 sieve.	SW	Well-graded sands, gravelly sands, little or no fines.	
		SP	Poorly-graded sands, gravelly sands, little or no fines.	
		SM	Silty sands, sand-silt mixtures.	
		SC	Clayey sands, sand-clay mixtures.	
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit 50% and above	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts, Plasticity below "A" line.
			CL	Inorganic clays, gravelly silts, sandy clays, lean clays. Plasticity above "A" line.
		Liquid Limit Below 50%	OL	Organic silts and organic clays, Plasticity below "A" line.
			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, Plasticity below "A" line.
Highly organic soils		CH	Inorganic fat clays, Plasticity above "A" line.	
		OH	Organic clays or organic silts, Plasticity below "A" line.	
		PT	Peat, organic content greater than 65%.	

- LEGEND:**
- 2F-8-10 Location of Explorations on this Sheet.
 - 2F-8-1 Location of Exploration in the Cache Creek Settling Basin Area.
 - GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
 - SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
 - FI Fines, percent by weight passing the No. 200 sieve.
 - LL Liquid Limit.
 - PI Plasticity Index (Liquid Limit Minus Plastic Limit).
 - MC Field Moisture Content in Percent of Dry Weight.
 - G_s Groundwater Level.
 - G_s Specific Gravity.
 - () Visual Field Classification.
- NOTES:**
- Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
 - All sieve sizes on the chart are U.S. Standard.
 - The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
 - Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
 - Borings 2F-8-10 thru 2F-8-13, 2F-8-18, 2F-8-19, and 2F-8-21, were drilled to refusal and the required depth using 24" bucket and a 6" auger on a Calwell drill rig during 23 May thru 28 May 1958. Borings 2F-8-14 thru 2F-8-17, and 2F-8-2 thru 2F-8-4, were drilled to the required depths using an 8" auger on a Sullivan drill rig during 8 July thru 14 July 1958.
 - Depth to groundwater is shown if measured.



GRAPHIC SCALES

0 1' 2' 4' 6' 8' 10'

0 1000' 2000' 4000' 6000' 8000' 10000'

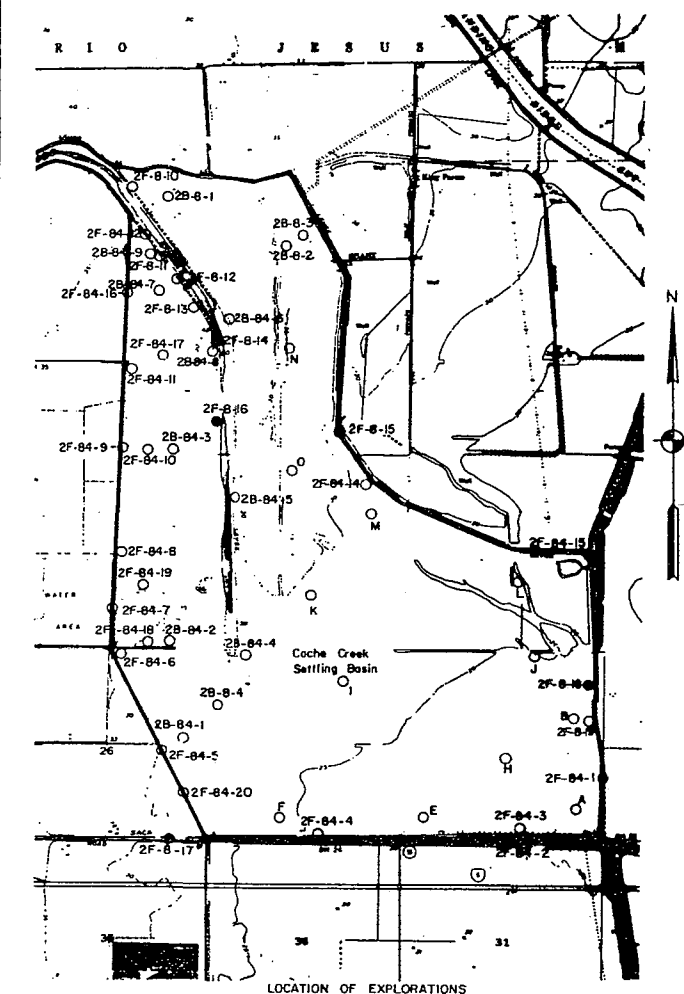
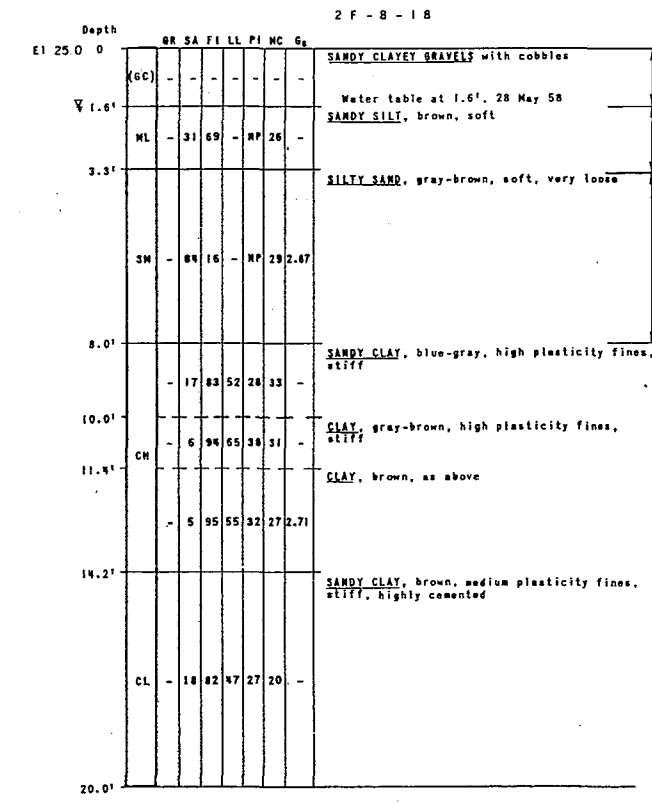
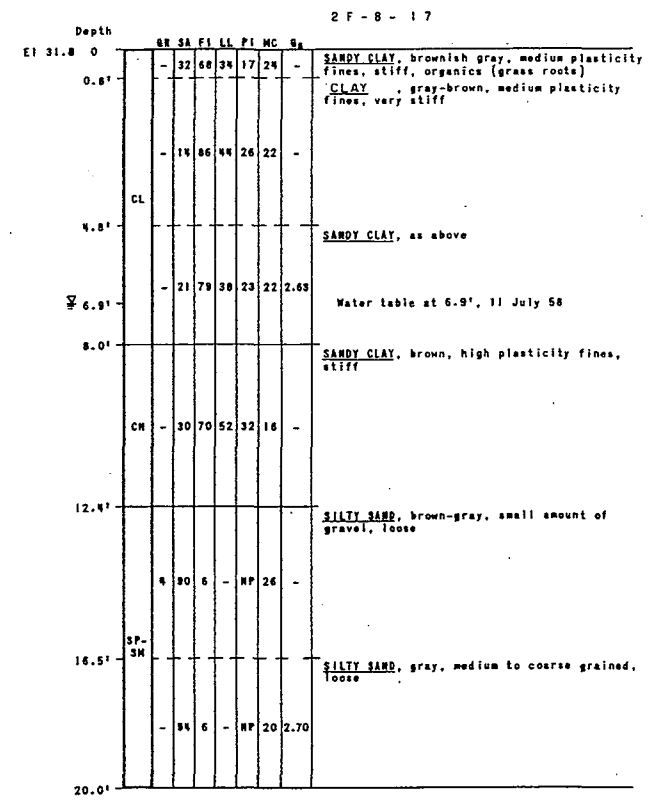
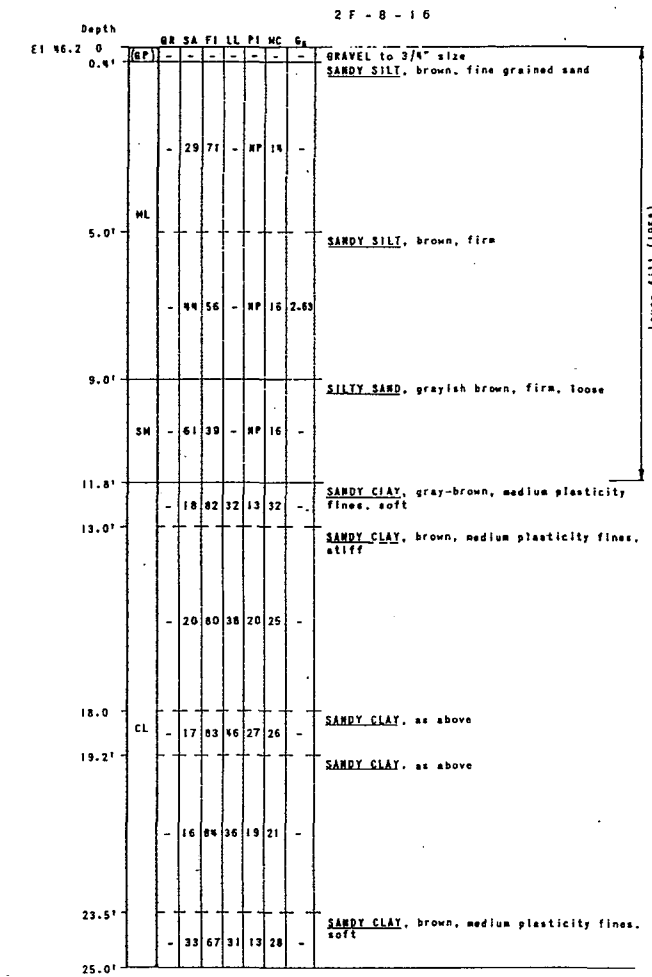
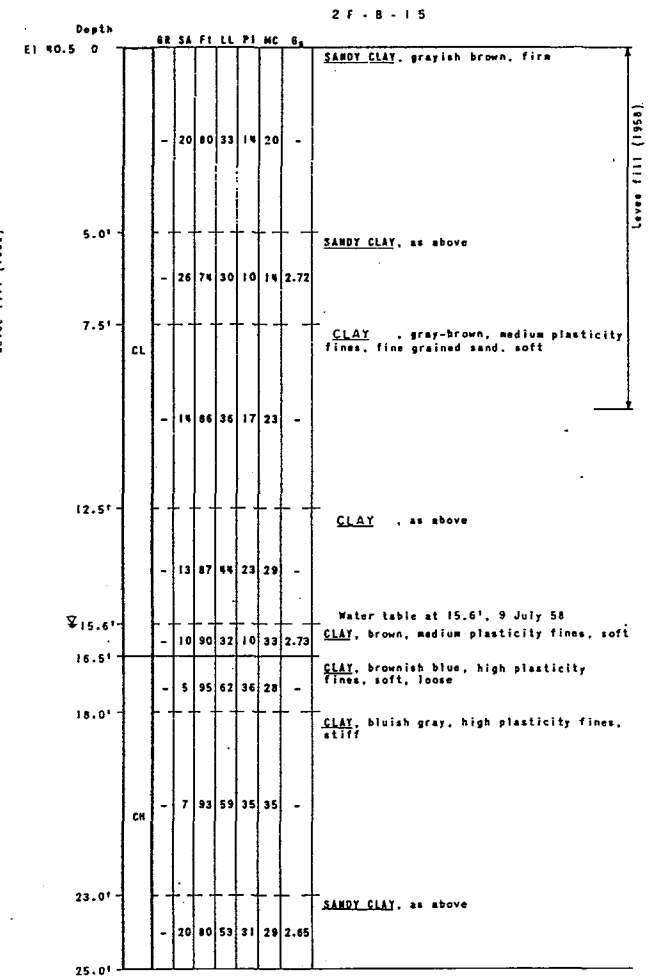
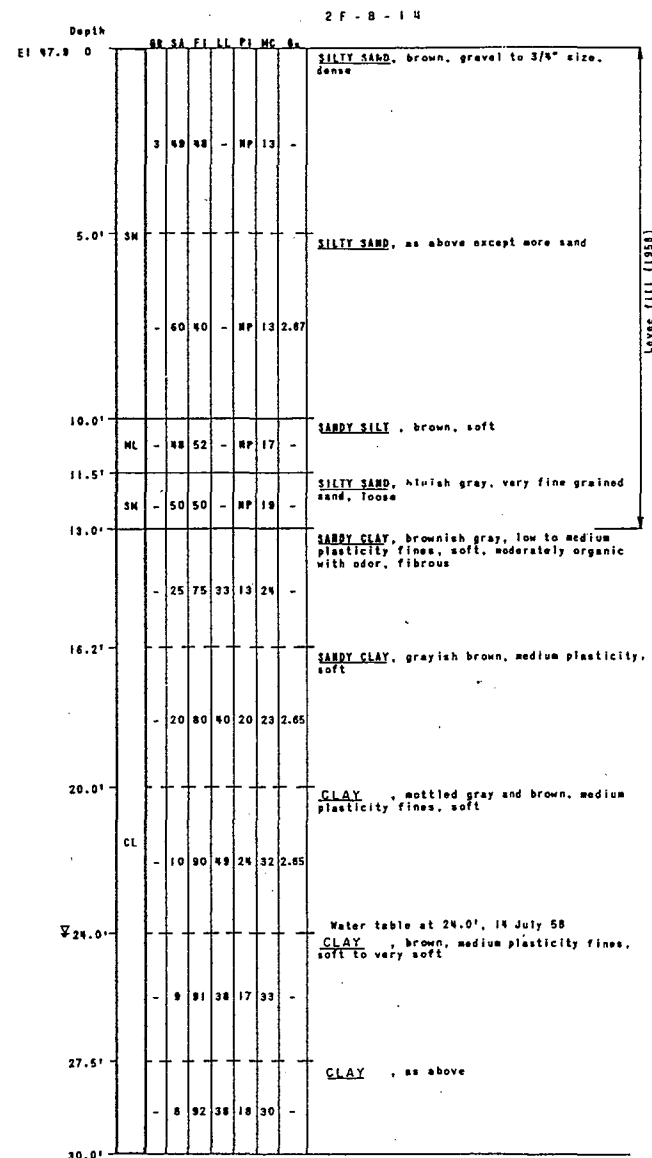
DESIGNED:	K. Wohl	DATE:	1/2/58
DRAWN:	K. Wohl / V. Marino	SCALE:	AS SHOWN
CHECKED:	D. Anderson	FILE NO.:	CC-25-35
SUBMITTED:		DATE APPROVED:	

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

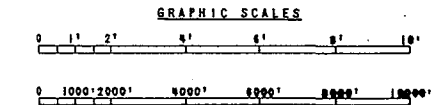
CACHE CREEK BASIN
CACHE CREEK, CALIFORNIA
CACHE CREEK SETTLING BASIN ELEMENT
LOGS OF EXPLORATIONS
2F-8-10 thru 2F-8-13

PLATE XII 2 OF 16

FUNCTIONAL ANALYSIS - VE PAYS



NOTE:
1. For additional notes and legend, see Sheet XII-2.



REVISION		DATE		DESCRIPTION		BY	DT
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA							
DESIGNED: K. Wahl DRAWN: K. Wahl / R. Wagner CHECKED: D. Anderson SUBMITTED:				DATE APPROVED: 1/2/57 SCALE: SHEET: FILE NO.: CC-25-35			
CHIEF, SOIL DESIGN SECTION							

2 F 8 1 9

Depth	GR	SA	FI	LL	PI	MC	Gs	Description
El 26.0' 0"								CLAYEY GRAVEL, with cobbles, medium plasticity fines, gravel to 1-1/2" size, 3" to 6" cobbles, loose
2.4'								SILT, brown, small amounts of gray SANDY CLAY, soft
4.2'	5	95			MP	35	2.74	Water table at 4.2', 27 May 58
5.2'								SANDY SILT, brown, soft
6.2'								CLAY, blue-gray, high plasticity fines, soft, organic material with odor
								3.97 65 35 31
10.0'								CLAY, tan-blue, high plasticity fines, soft, some organics
								6 94 89 42 29 2.65
11.7'								CLAY, tan-brown, high plasticity fines, very stiff
								9 91 57 35 26
16.5'								SANDY CLAY, orange-brown, medium plasticity fines, very stiff
								46 54 42 25 19
17.8'								SANDY CLAY, orange-brown, medium plasticity fines, very stiff
								22 78 45 26 26
19.0'								CLAYEY SAND, orange-brown, medium plasticity fines, very stiff, dense
								58 42 35 17 24 2.71
20.0'								

2 D 8 1

Depth	GR	SA	FI	LL	PI	MC	Gs	Description
El 34.0' 0"								SILT-SANDY SILT, brown-tan, fine grained sand, firm, loose
								7 93 19 81 MP 12 17
3.6'								SANDY SILT, brown, firm, loose
								40 60 5 36 59 MP 13 2.71
6.8'								SILTY GRAVELLY SAND, gray-brown, firm, loose
								29 51 20 MP 5
10.0'								

2 B 8 2

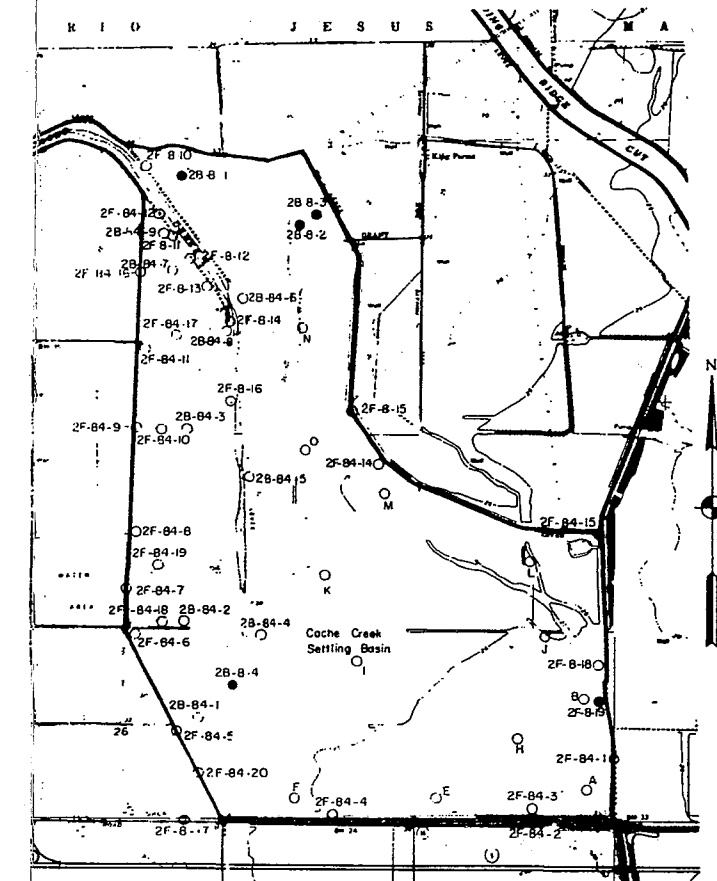
Depth	GR	SA	FI	LL	PI	MC	Gs	Description
El 32.1' 0"								SANDY SILT, brown, fine to medium grained sand, soft, loose
								43 57 41 54 MP 16 16
5.0'								SANDY SILT, as above
								38 62 MP 18 2.71
6.2'								SANDY CLAY, brown, medium plasticity fines, soft
								1 20 79 34 14 29
10.0'								

2 B 8 3

Depth	GR	SA	FI	LL	PI	MC	Gs	Description
El 30.0' 0"								GRAVELLY SILTY SAND, brown (old road)
0.8'								CLAY-SANDY CLAY, brown, low to medium plasticity fines, very fine grained sand, soft
								1 99 35 12 29 31 89 28 9 31
6.2'								SILT-CLAY, grayish dark brown, lenses of sandy silt, low plasticity fines, medium grained sand, very soft
								7 93 9 91 35 14 18 30
10.0'								CLAY, mottled bluish-gray and gray, medium to high plasticity fines, stiff, organic material
								11 89 65 36 39 2.68 11 89 40 19 21
15.0'								

2 B 8 4

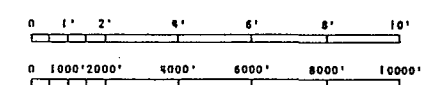
Depth	GR	SA	FI	LL	PI	MC	Gs	Description
El 31.4' 0"								CLAY, gray-black, high plasticity fines, slightly stiff
1.7'								CLAYEY SAND, brown, low to medium plasticity fines, soft, loose
3.0'								Water table at 3.0', 11 July 58
								50 50 28 13 22 2.67
8.0'								CLAY, brown, medium plasticity fines, medium to coarse grained sand, very stiff
								6 94 43 23 27
10.0'								CLAY, as above
								12 88 39 22 18
13.0'								CLAY, brown, very stiff
								3 97 51 32 24 2.74
15.0'								



LOCATIONS OF EXPLORATIONS

NOTE:
1. For additional notes and legend, see Sheet XII-2.

GRAPHIC SCALES



DESIGNED: K. Wahl		DRAWN: K. Wahl / R. Wagner		CHECKED: D. Anderson	
DATE: 1/1/58		DATE: 1/1/58		DATE: 1/1/58	
CHIEF, SOIL DESIGN SECTION		CHIEF, SOIL DESIGN SECTION		CHIEF, SOIL DESIGN SECTION	
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		CACHE CREEK BASIN CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN ELEMENT LOGS OF EXPLORATIONS 2F-8-19 & 2B-8-1 thru 2B-8-4		SCALE: 1" = 10'	
SHEET 1		FILE NO. CC-25-35		SPEC. NO. CC-25-35	

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than 50% or more retained on the No. 200 sieve.	GRAVELS More than 10% retained on the No. 10 sieve and No. 40 sieve.	GW	Well-graded gravel, gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravel, gravel-sand mixtures, little or no fines.
		GM	Silty gravel, gravel-sand mixtures.
		GC	Clayey gravel, gravel-sand mixtures.
		SW	Well-graded sands, gravelly sands, little or no fines.
		SP	Poorly-graded sands, gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
		ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts, Plasticity below "A" line.
		CL	Inorganic clays, gravelly clays, sandy clays, lean clays, Plasticity above "A" line.
FINE GRAINED SOILS More than 75% passing the No. 200 sieve.	SILTS AND CLAYS	OL	Organic silts and organic clays, Plasticity below "A" line.
		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, Plasticity below "A" line.
		CH	Inorganic fat clays, Plasticity above "A" line.
		OH	Organic clays or organic silts, Plasticity below "A" line.
		PT	Peat, organic content greater than 60%.

LEGEND:

● Bore Hole A-Location of Explorations on this Sheet.

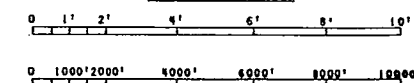
○ 2F-84-3 Location of Exploration:

- GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI Fines, percent by weight passing the No. 200 sieve.
- LL Liquid Limit.
- PI Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC Field Moisture Content in Percent of Dry Weight.
- ▽ Groundwater Level.
- G_s Specific Gravity.
- Y_d Dry Unit Weight.
- { } Visual Field Classification

NOTES:

- Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
- All sieve sizes on the chart are U.S. Standard.
- The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
- Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
- Bore holes A, B, E, F, and H thru O were drilled using a 5-inch diameter hand auger during 23 June thru 26 June 1975. The borings were done by the Civil Engineering Department, University of California, Davis.
- Depth to groundwater is shown if measured.

GRAPHIC SCALES



BORE HOLE A

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 28.0' 0									SILTY SAND, light brown to brown, Y _d =82.1 pcf
3.6'	SM	68	32	-	13	2.68			At 1.8', 1/2" layer of dark blue clay
									At 2.6', dark gray mottling begins
5.0'	(ML)	-	-	-	-	-	-	-	SILT, brown, moist
6.3'	(SP)	-	-	-	-	-	-	-	SAND, dark brown, moist, poorly graded, medium grained
7.0'	CH	-	-	100	55	30	-	2.63	SILTY CLAY, blue-gray, moist, large amount of organic material

BORE HOLE B

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 24.0' 0									SANDY CLAY, light brown to blue-gray, some organic material, Y _d =89.3 pcf
2.5'	CL	-	10	90	45	32	24	2.50	Water table at 2.5', 23 June 76
5.5'									At 5.0', sulfurous odor, organic material increases

BORE HOLE E

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 28.0' 0									SANDY SILT, light brown, fine grained sand, Y _d =101.8 pcf
3.0'	ML	-	24	76	-	20	2.68		At 2.0' dark blue silt lense, 1/2" thick
5.0'	CL	-	2	98	45	32	-	2.63	CLAY, blue-gray, damp
									Becomes bluer in color and more damp

BORE HOLE F

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 28.0' 0									SANDY SILT, yellow-brown, fine grained sand, Y _d =107.2 pcf
2.0'	ML	-	33	67	-	20	2.68		At 1.3', 1/2" lense of silty clay, Y _d =106.2
3.0'									CLAYEY SILT, blue-gray, damp
3.5'									Water table at 3.0', 23 June 76

BORE HOLE H

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 28.0' 0									SILTY SAND, light brown, fine grained sand, Y _d =97.2 pcf
5.0'	SM	-	55	45	-	22	2.68		At 2.1' mottling begins of blue-gray and dark brown material
5.2'									Water table at 5.0', 26 June 76

BORE HOLE I

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 23.0' 0									SILTY SAND, light brown, dry to damp, poorly graded sand
3.6'	SP-SM	-	92	8	-	-	2.68		At 2.8' dark blue clay lense with organic material
4.0'	(SM)	-	-	-	-	-	-	-	SILTY SAND, brown to gray, damp to wet
5.0'									Water table at 4.0', 26 June 76

BORE HOLE J

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 23.0' 0									SANDY SILT, light brown to brown, fine grained sand, some organic material, Y _d =96.8 pcf
3.0'	ML	-	88	12	-	20	2.68		Water table at 3.0', 23 June 76
5.0'									

BORE HOLE K

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 33.0' 0									SILT, light brown, fine grained sand, Y _d =85.4 pcf
2.5'	ML	-	10	90	32	4	38	2.68	
3.5'	(SP)	-	-	-	-	-	-	-	SAND, gray, moist, poorly graded medium grained, trace of organic material, Y _d =76.3 pcf
5.0'	SM	-	59	41	-	-	2.68		SILTY SAND, gray, moist, fine grained sand, more organic material

BORE HOLE L

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 23.0' 0									SANDY SILT, brown, fine grained sand, Y _d =106.2 pcf
5.0'	ML	-	15	85	-	16	2.68		At 2.4', traces of clay and organic material

BORE HOLE M

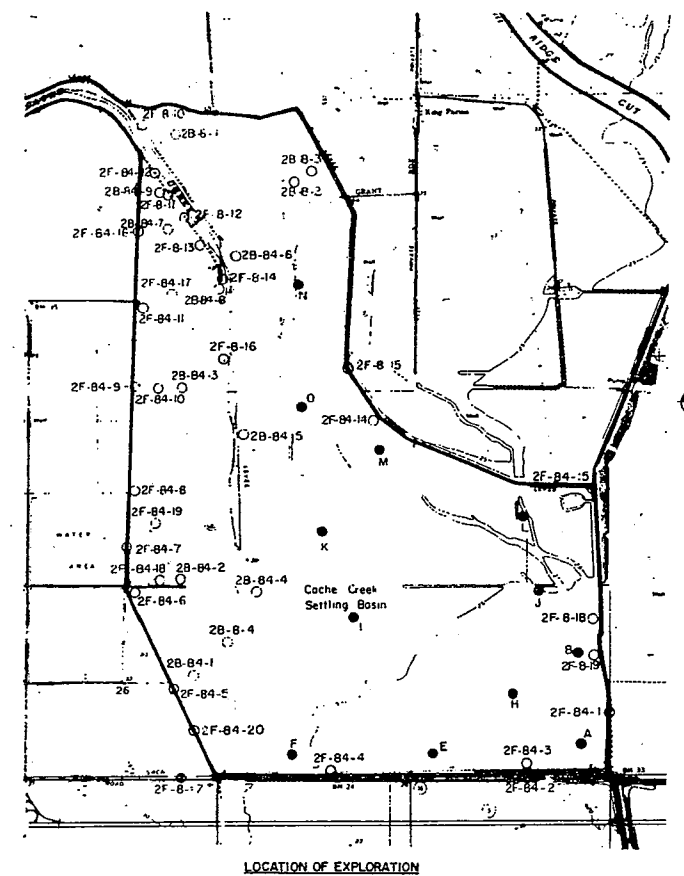
Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 30.5' 0									SANDY SILT, light brown to brown, fine grained sand, a clay lense with organic material, Y _d =89.1 pcf
2.2'	(SM)	-	-	-	-	-	-	-	SILTY SAND, gray, damp
3.0'	ML	-	3	97	-	-	2.63		CLAYEY SILT, brown
5.0'									

BORE HOLE N

Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 33.0' 0									SANDY SILT, light brown, Y _d =99.5 pcf
5.5'	ML	-	33	67	-	13	2.68		At 4.0' intermittent sand lenses
6.0'	(SM)	-	-	-	-	-	-	-	SILTY SAND, brown, damp
7.5'	ML-CL	-	2	98	40	15	-	2.54	SILTY CLAY, brown, damp, clay content increases with depth

BORE HOLE O

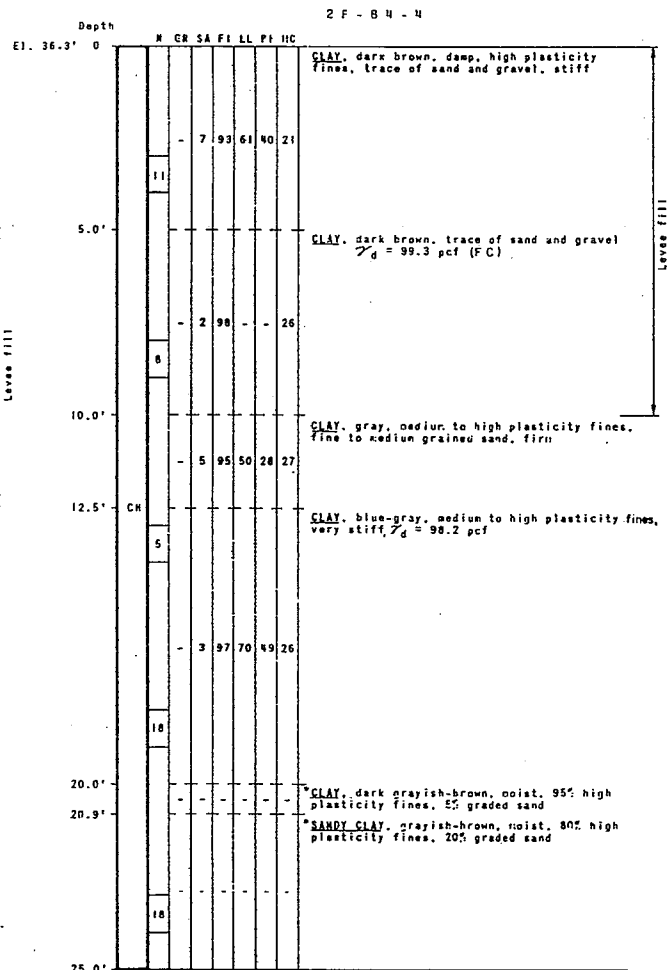
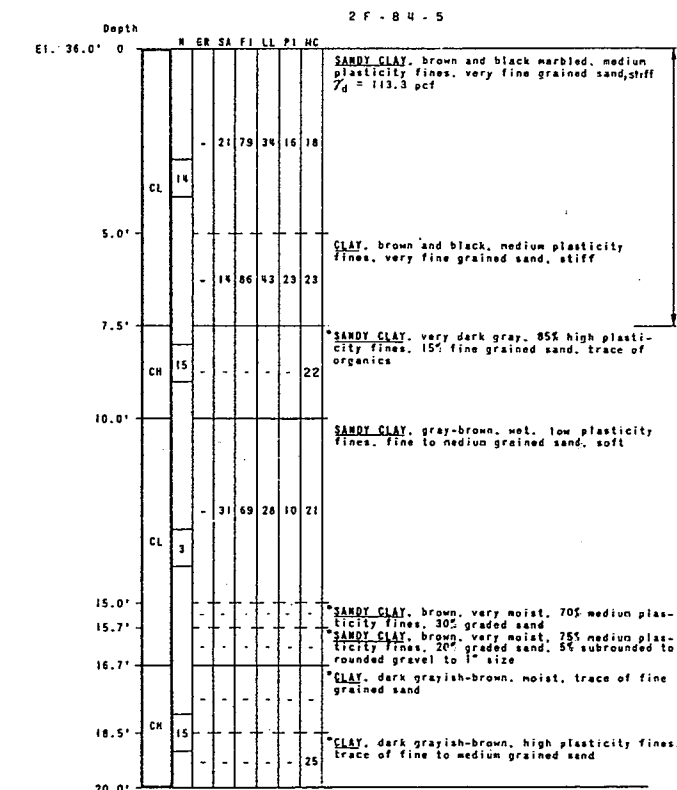
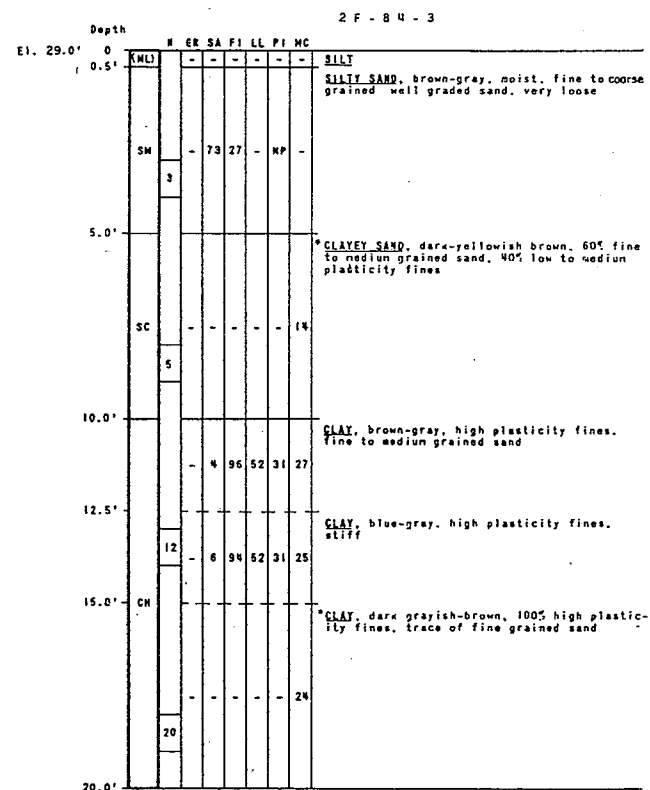
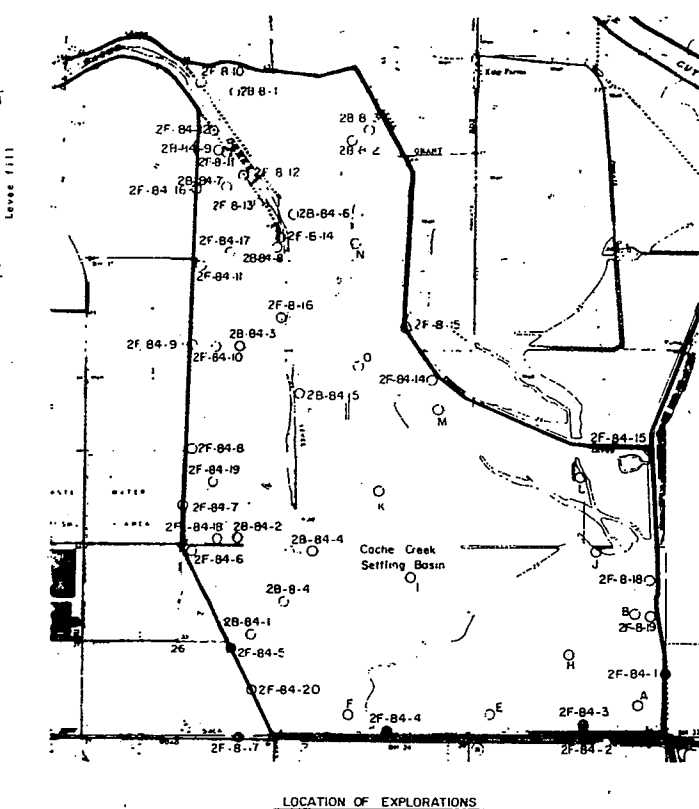
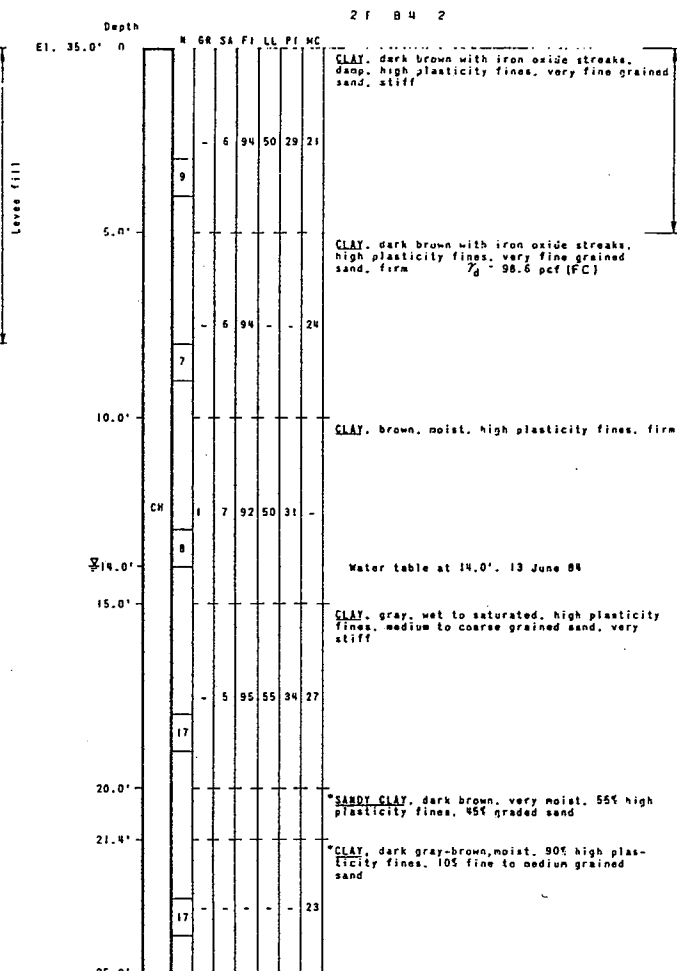
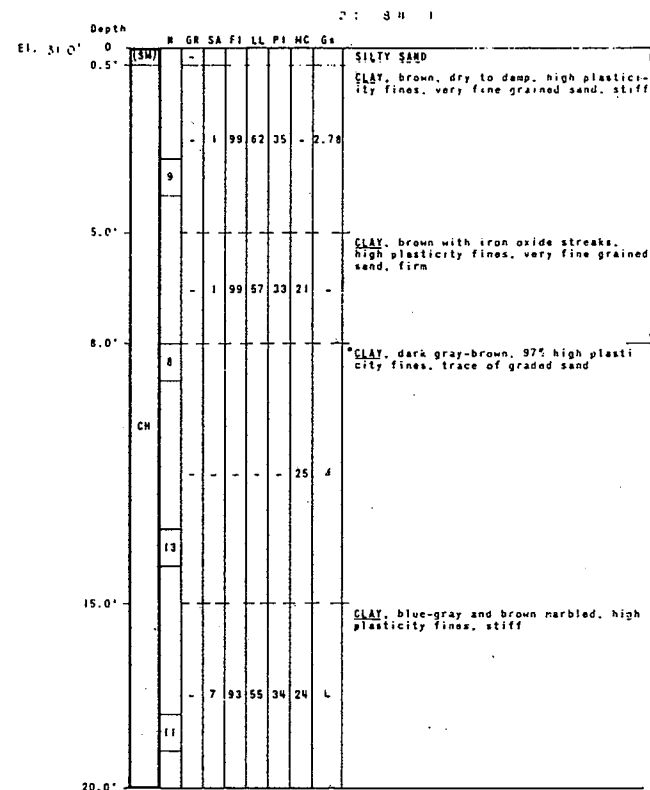
Depth	GR	SA	FI	LL	PI	MC	G _s	Y _d	Visual Field Classification
El. 30.0' 0									SILTY SAND, light brown to brown, Y _d =104.6 pcf
5.0'	SM	-	53	47	-	12	2.68		More mottling with depth



LOCATION OF EXPLORATION

ENVIRONMENTAL
ENGINEERING
DESIGN

FUNCTIONAL ANALYSIS - VE PAYS

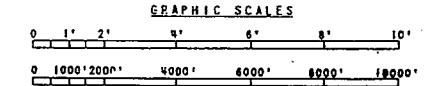


UNIFIED SOIL CLASSIFICATION SYSTEM			
MAJOR DIVISIONS	GROUP SYMBOLS	TYPICAL NAMES	
COARSE GRAINED SOILS More than 50% passing the No. 200 sieve.	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	
	GM	Silty gravels, gravel-sand mixtures.	
	GC	Clayey gravels, gravel-sand mixtures.	
	SW	Well-graded sands, gravelly sands, little or no fines.	
	SP	Poorly-graded sands, gravelly sands, little or no fines.	
	SM	Silty sands, sand-silt mixtures.	
	SC	Clayey sands, sand-clay mixtures.	
	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.	
	CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.	
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	OL	Organic silts and organic clays. Plasticity below "A" line.	
	MH	Inorganic silts, micaceous or distentionaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.	
	CH	Inorganic fat clays. Plasticity above "A" line.	
	OH	Organic clays or organic silts. Plasticity below "A" line.	
	Pt	Peat, organic content greater than 80%.	

STANDARD PENETROMETER DESCRIPTIVE DATA

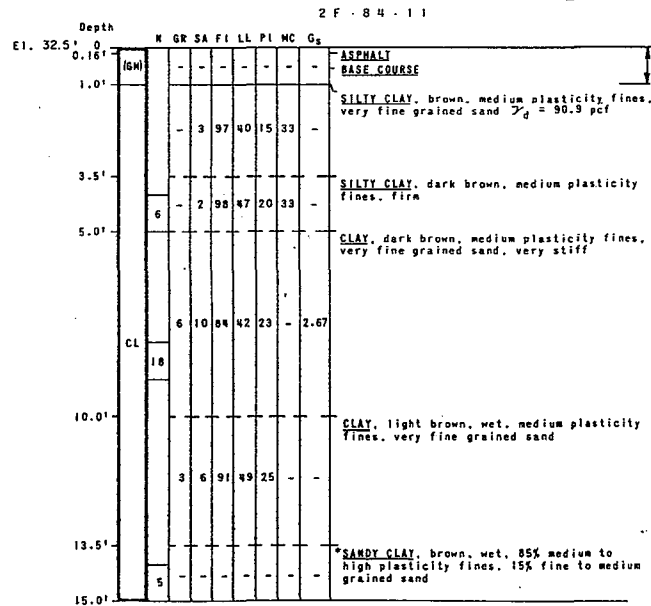
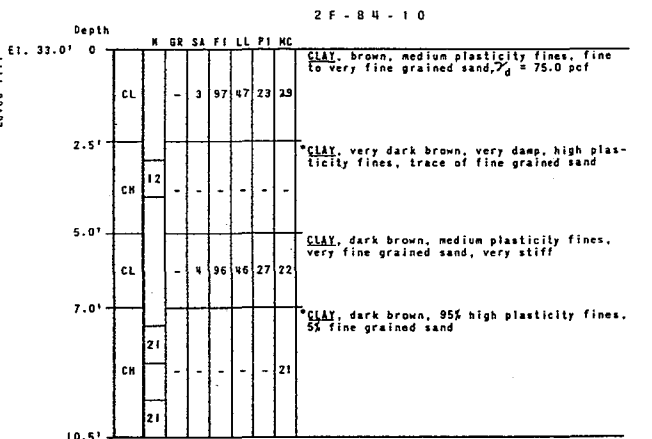
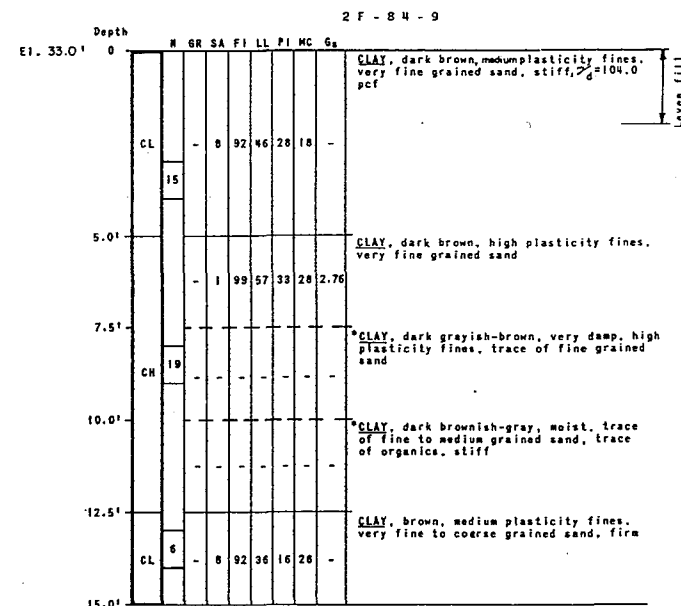
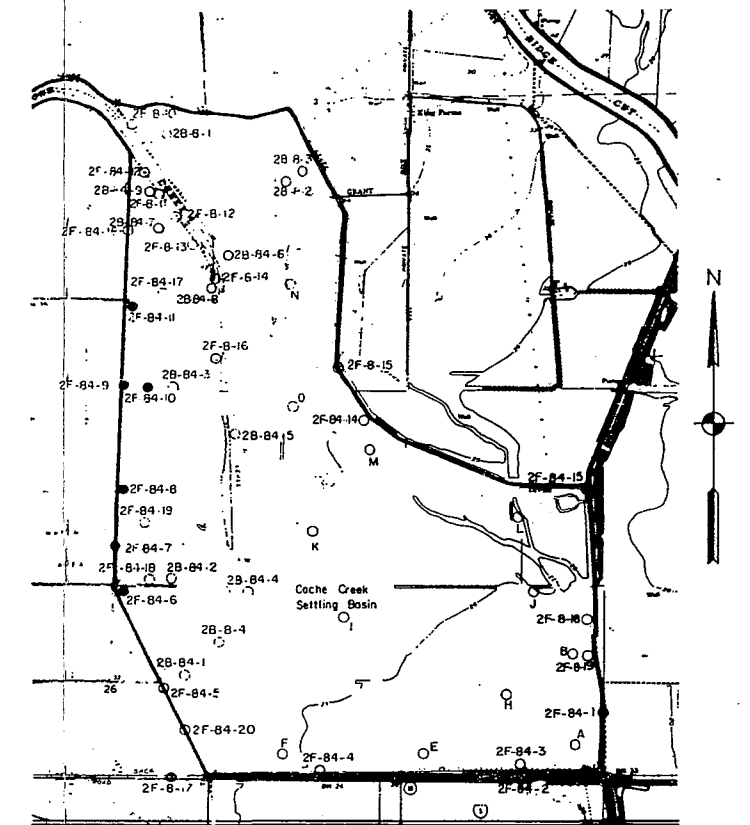
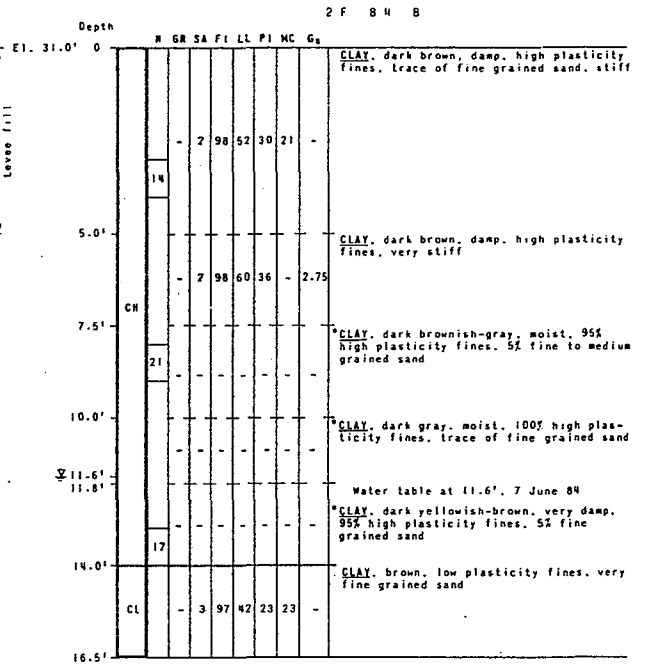
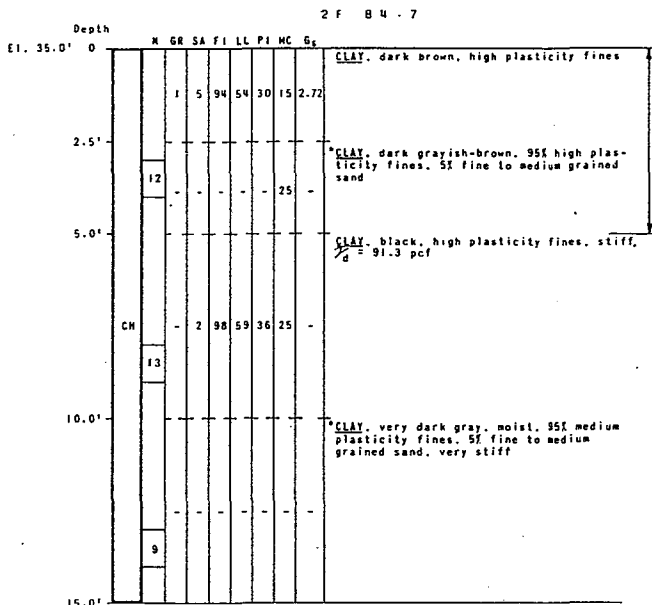
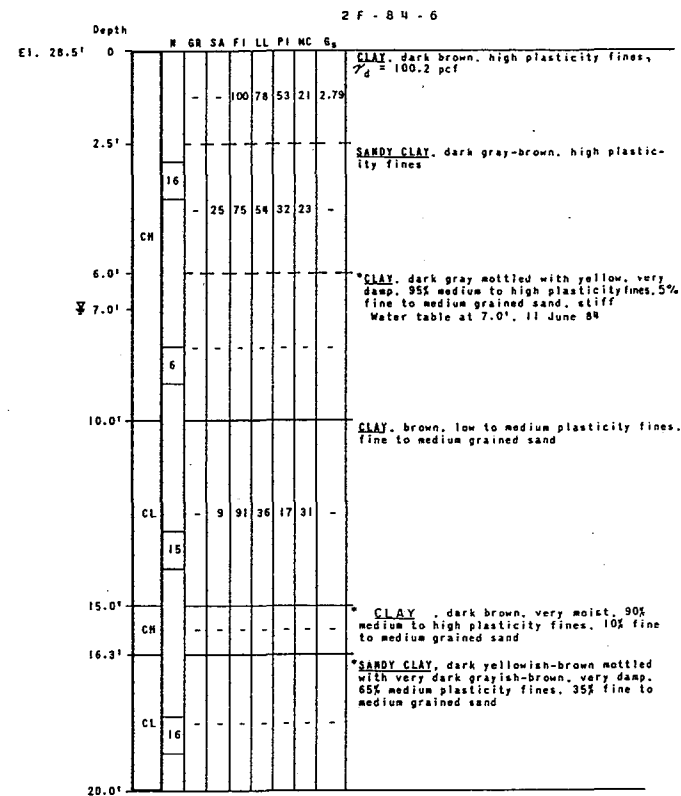
COHESIONLESS		COHESIVE	
Blows*	Relative Density	Blows*	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-20	Firm	5-8	Firm
21-30	Very Firm	9-15	Stiff
31-50	Dense	16-30	Very Stiff
51+	Very Dense	31+	Hard

- LEGEND:**
- 2F-84-1 Location of Exploration on this Sheet
 - 2F-84-19 Location of Exploration
 - GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
 - SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
 - FI Fines, percent by weight passing the No. 200 sieve.
 - LL Liquid Limit.
 - PI Plasticity Index (Liquid Limit Minus Plastic Limit).
 - MC Field Moisture Content in Percent of Dry Weight.
 - (F.C.) Field Classification.
 - * Laboratory Visual Classification.
 - N Number of Blows of Standard Penetrometer.
 - W Groundwater Level.
 - γ_d Dry Unit Weight.
 - Gs Specific Gravity.
- NOTES:**
- Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
 - All sieve sizes on the chart are U.S. Standard.
 - The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
 - Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
 - Borings 2F-84-1 through 2F-84-20 were drilled to required depths with a Mobile 8-40 drill rig using a 6" hollow stem auger during the period 7 June through 13 June 1988.
 - Depth to groundwater shown if encountered.

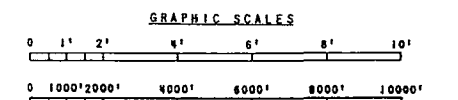


DESIGNED: K. Wahl		DRAWN: K. Wahl/K. Elliott		CHECKED: D. Anderson	
DATE: 1/1/87		SCALE: 1"=10'		SHEET: 1	
CHIEF, SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		CACHE CREEK BASIN CACHE CREEK, CALIFORNIA LOGS OF EXPLORATIONS 2F-84-1 thru 2F-84-5	
FILE NO. CC-25-35		PLATE XII 6 OF 16			

FUNCTIONAL ANALYSIS - VE PAYS

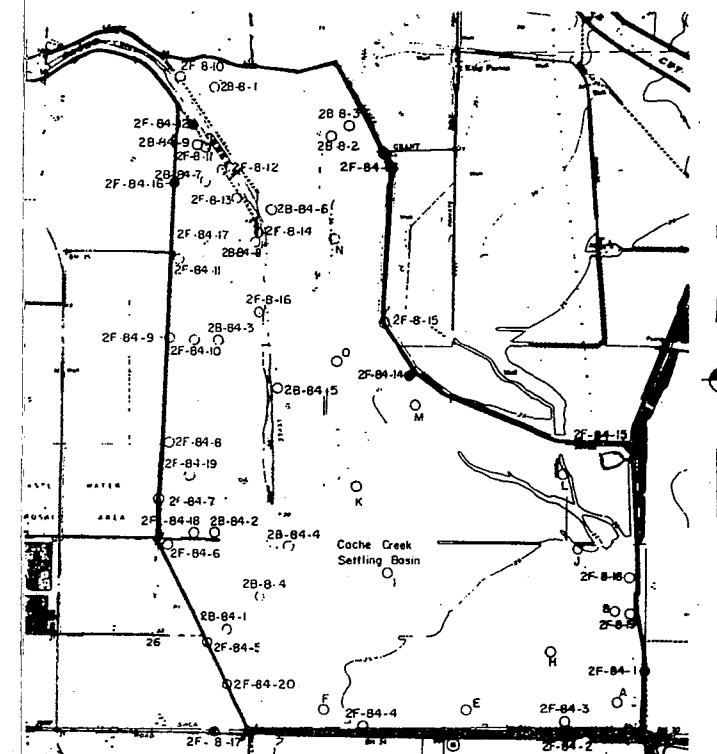
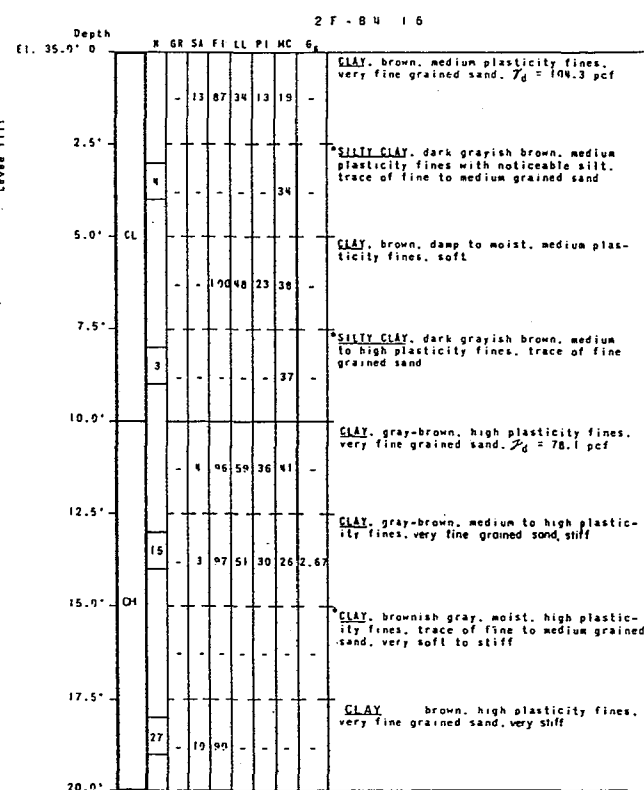
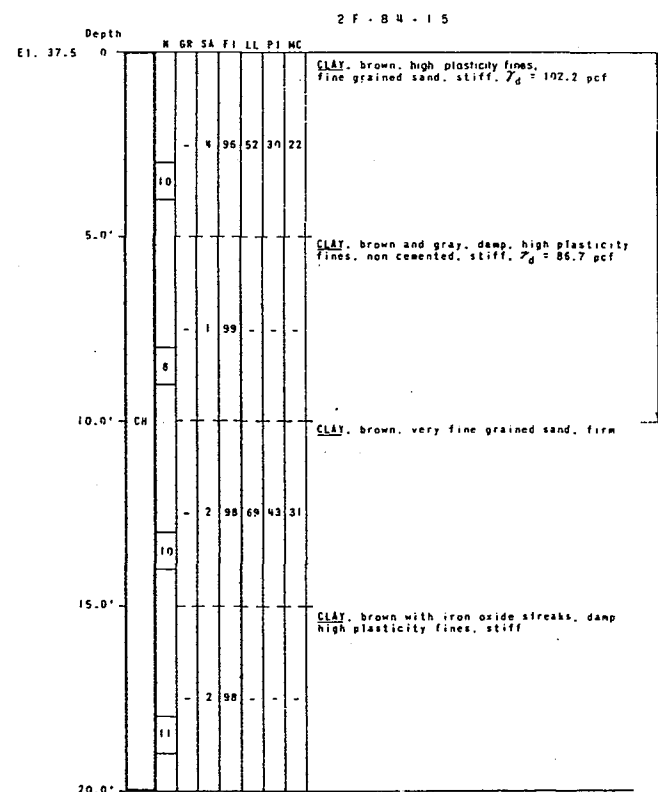
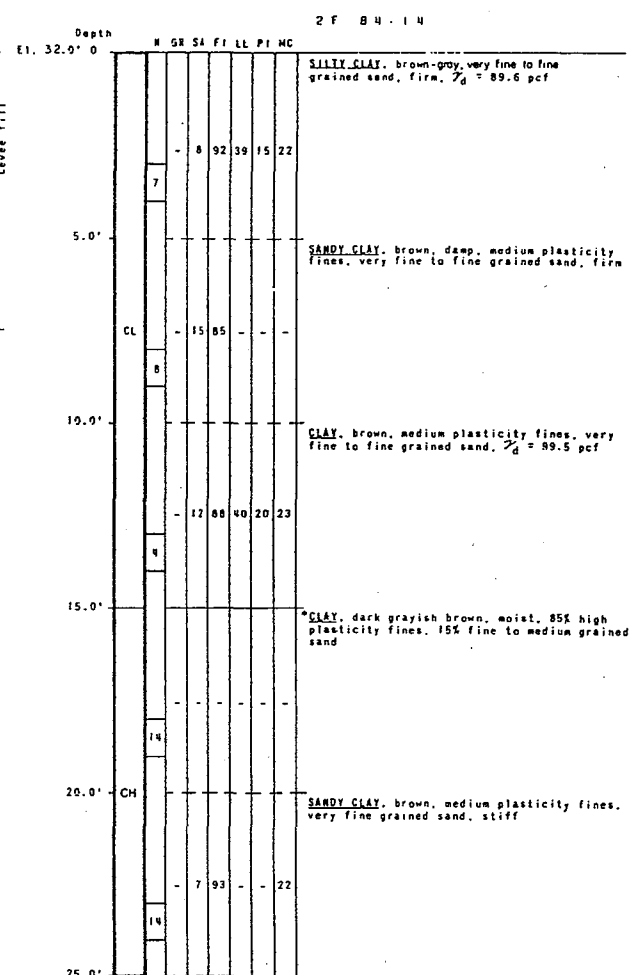
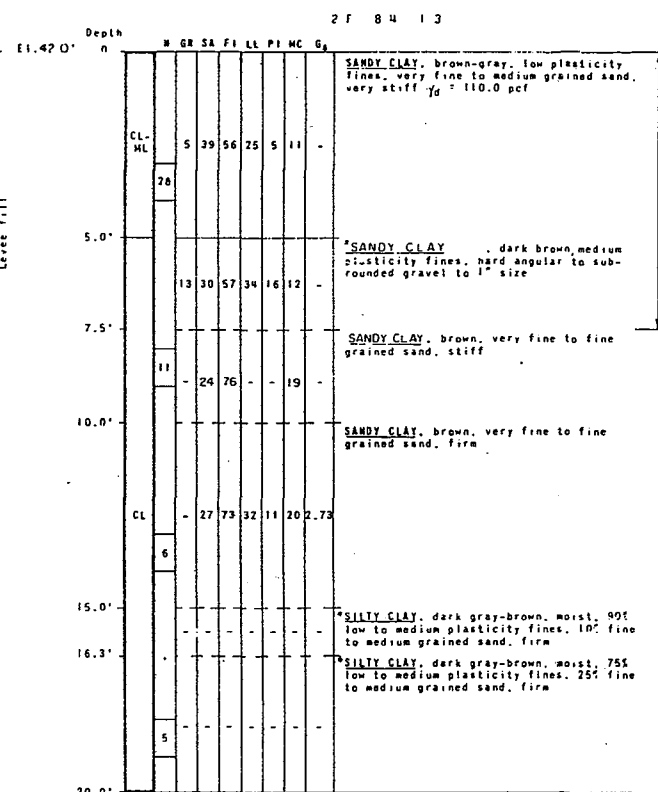
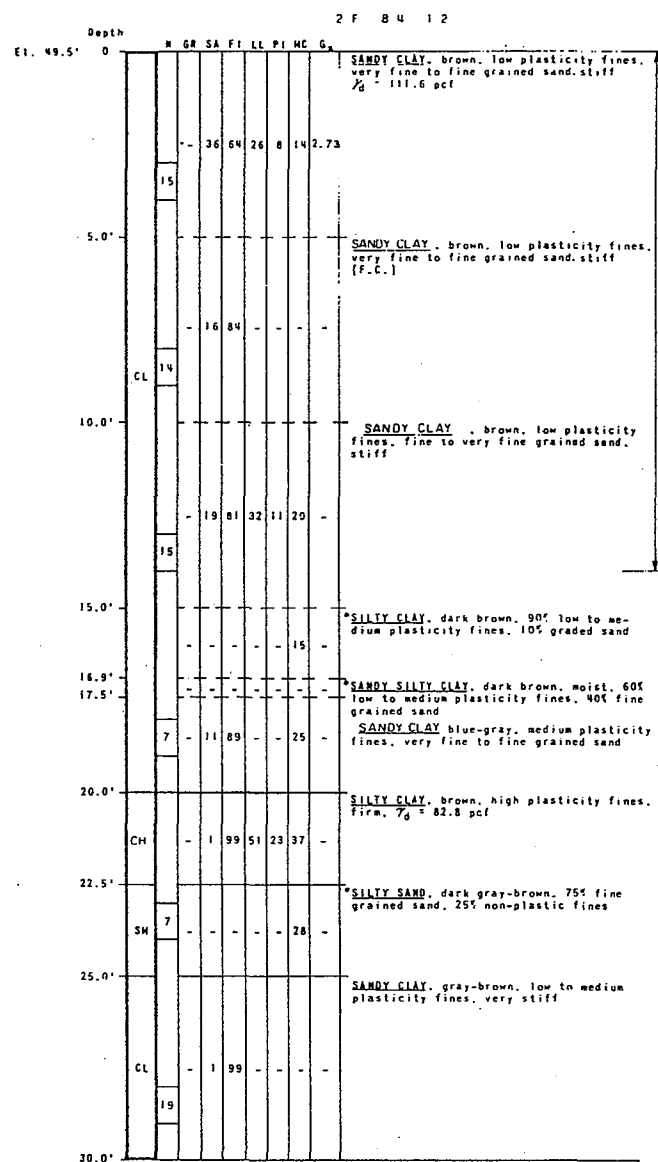


NOTE:
1. For additional notes and legend, see Sheet XII-6.



DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY: X. WAHL	CACHE CREEK BASIN CACHE CREEK, CALIFORNIA
DRAWN BY: X. WAHL/R. WAGNER	CACHE CREEK SETTLING BASIN ELEMENT
CHECKED BY: D. ANDERSON	LOGS OF EXPLORATIONS
SUBMITTED BY:	2F-84-6 thru 2F-84-11
DATE APPROVED:	SCALE:
1/1/77	FILE NO. CC-25-35

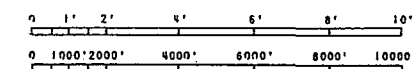
FUNCTIONAL ANALYSIS - VE PAYS



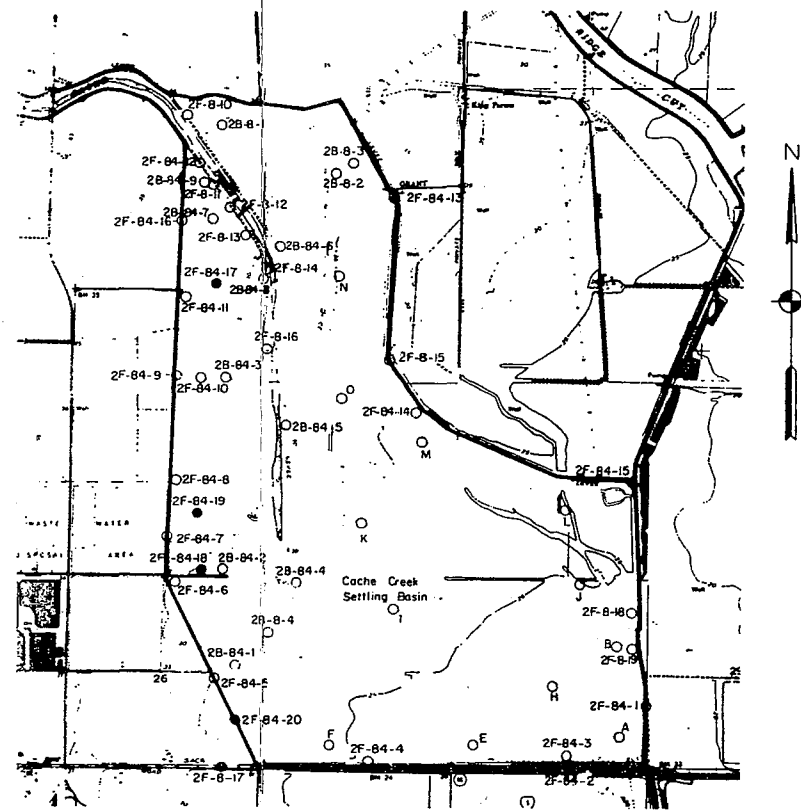
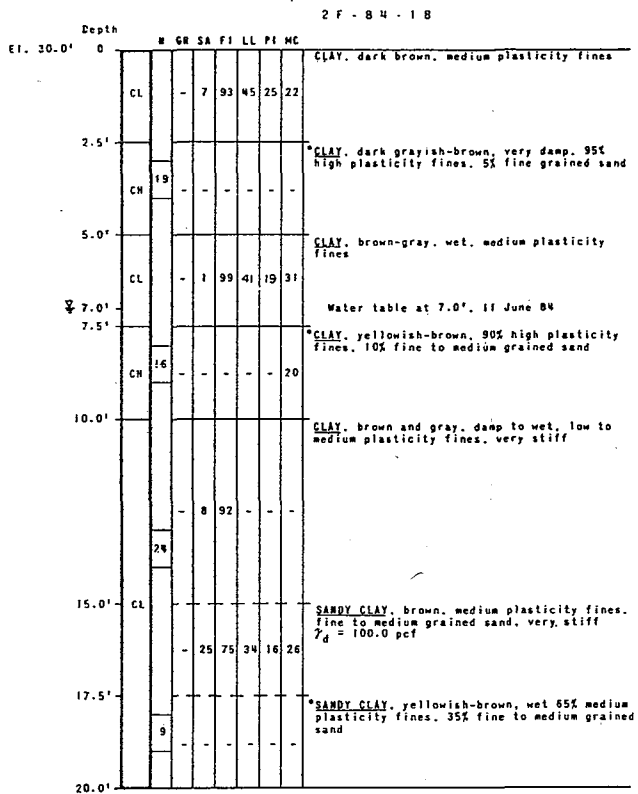
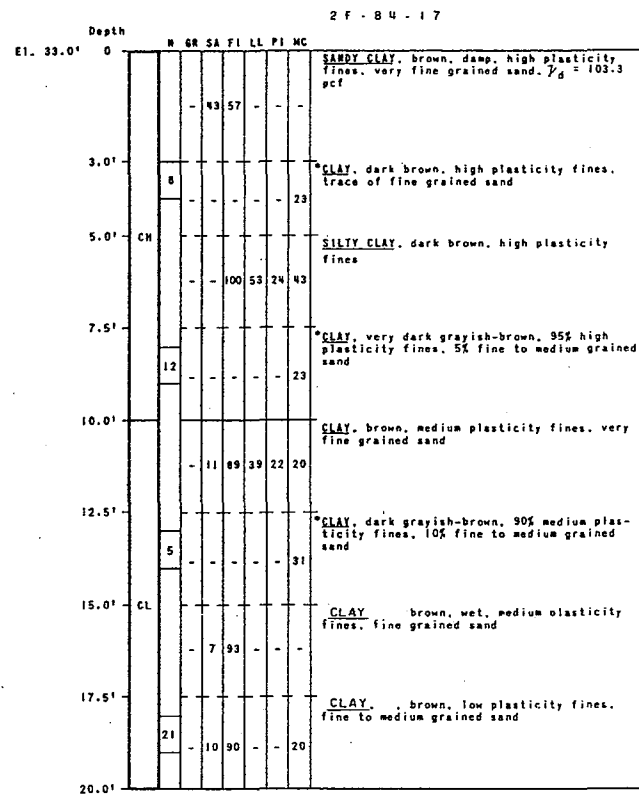
LOCATION OF EXPLORATIONS

NOTE:
1. For addition notes and legend, see Sheet XII-6.

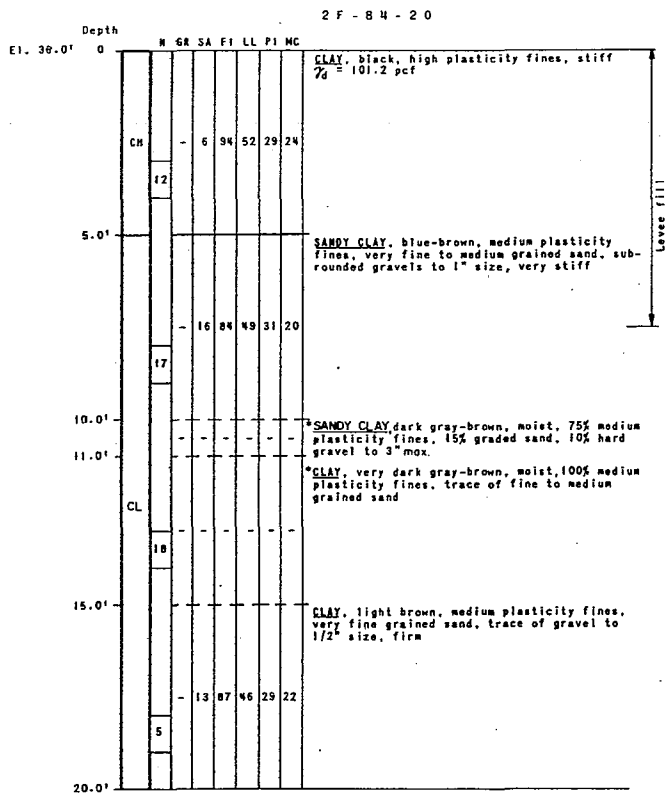
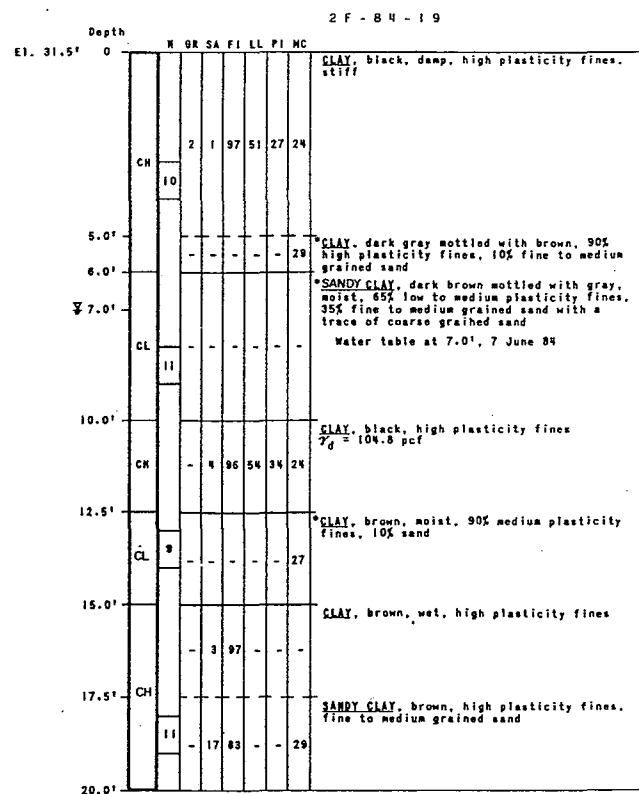
GRAPHIC SCALES



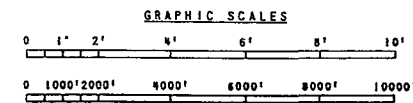
REVISION		DATE		DESCRIPTION		BY	BY
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA							
DESIGNED: K. Wahi				DRAWN: K. Wahi/V. Narino			
CHECKED: D. Anderson				SUBMITTED:			
DATE APPROVED:				SCALE:		SHEET:	
FILE NO.:				SPEC. NO.:		CC-25-35	
CHIEF SOIL DESIGN SECTION							



LOCATION OF EXPLORATIONS

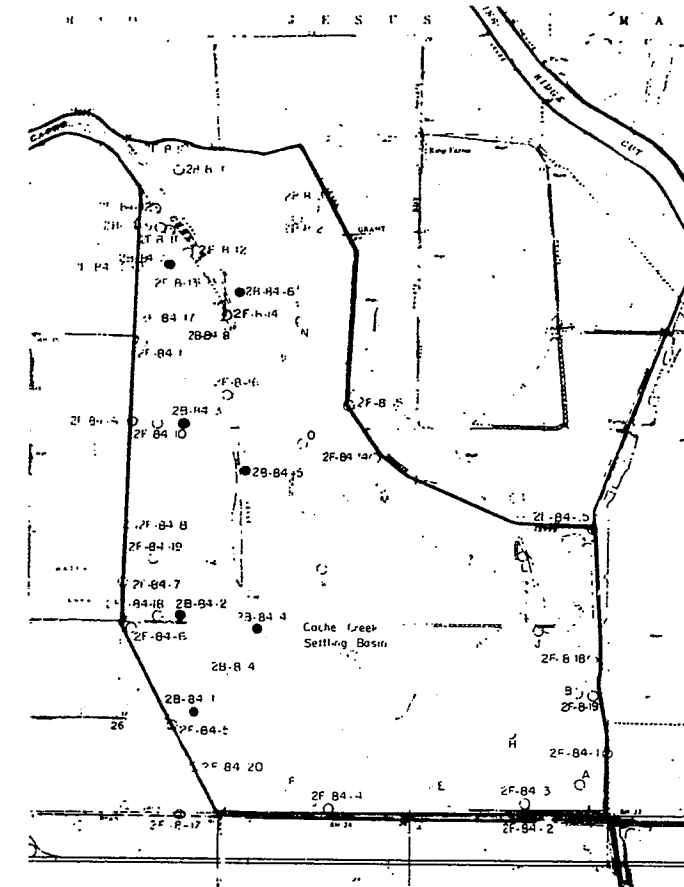
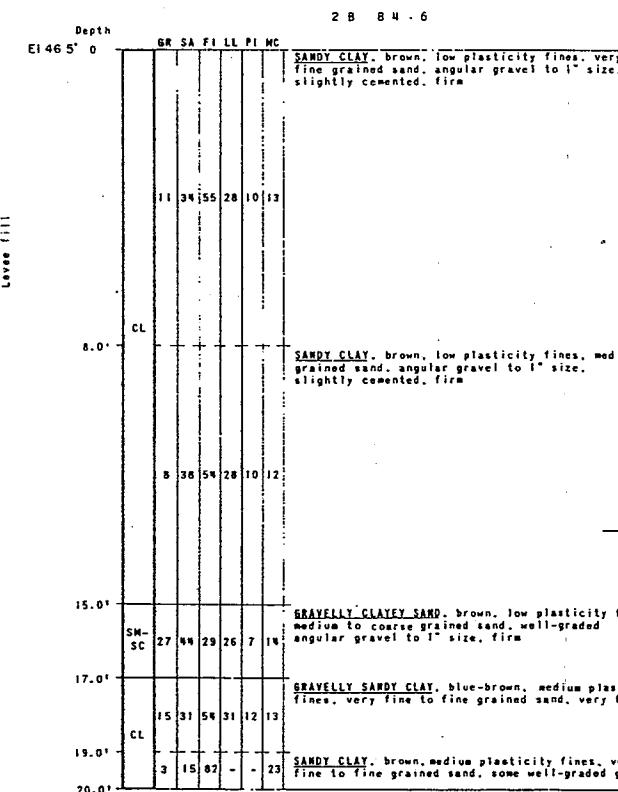
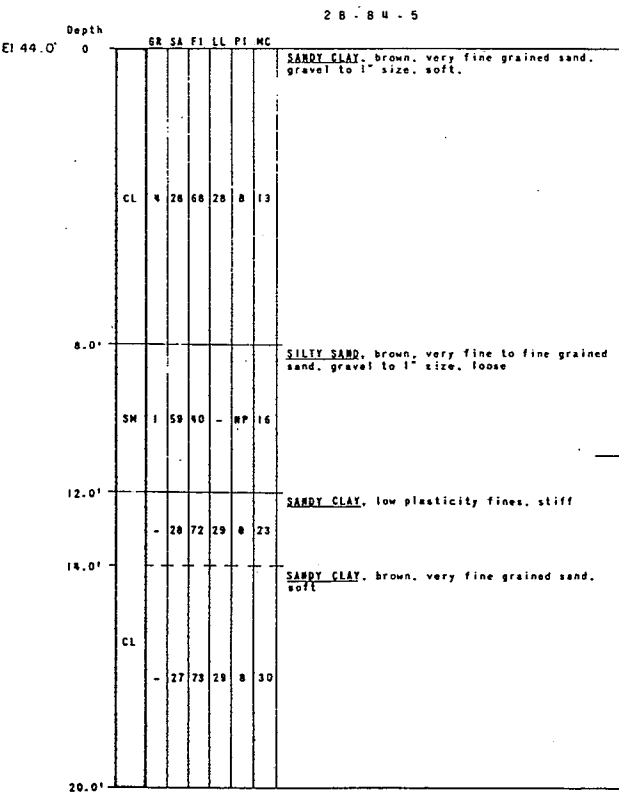
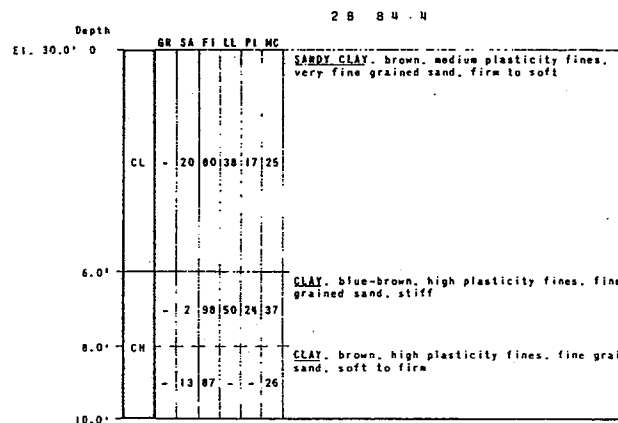
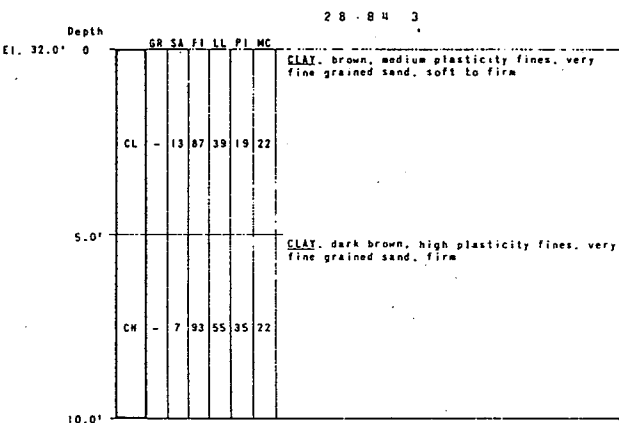
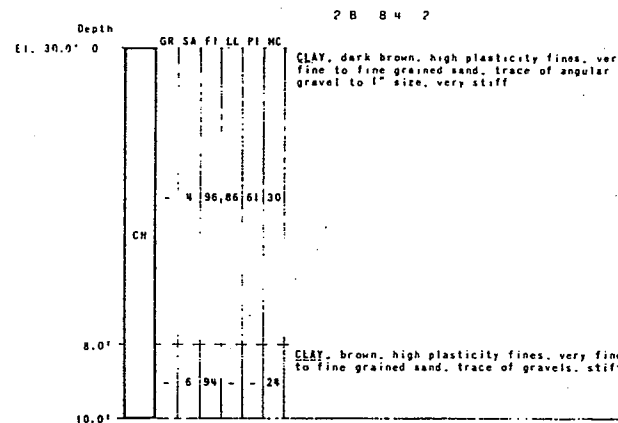
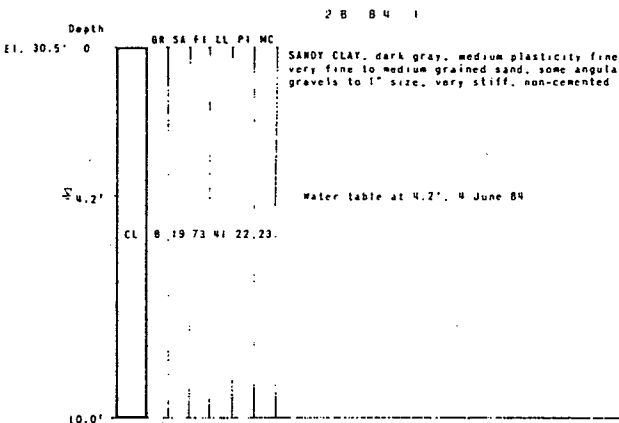


NOTE:
1. For additional notes and legend, see Sheet XII-6.



REVISION		DATE	DESCRIPTION	BY	BY
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA					
CACHE CREEK BASIN CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN ELEMENT LOGS OF EXPLORATIONS 2F-84-17 thru 2F-84-20					
DESIGNED: K. WAHL		DATE APPROVED: 1/2/87		SCALE: FILE NO. SPEC. NO.	
DRAWN: K. WAHL/R. WAGNER		CHECKED: D. ANDERSON		SUBMITTED: 1/2/87	
ENGINEER: D. ANDERSON		DESIGN SECTION		CC-25-35	

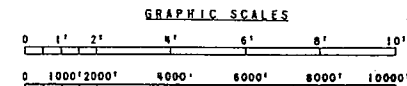
FUNCTIONAL ANALYSIS - VE PAYS



UNIFIED SOIL CLASSIFICATION SYSTEM					
MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	
COARSE GRAINED SOILS 50% of more retained on the No. 200 sieve.	SANDS More than half of coarse particles retained on the No. 4 sieve.	Gravel with fine	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	
			GM	Silty gravels, gravel-sand mixtures.	
			GC	Clayey gravels, gravel-sand mixtures.	
	SANDS More than half of coarse particles passing on the No. 4 sieve.	Clean with fine	SW	Well-graded sands, gravelly sand, little or no fines.	
			SP	Poorly-graded sands, gravelly sand, little or no fines.	
			SM	Silty sand, sand-silt mixture.	
			SC	Clayey sand, sand-clay mixture.	
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit above 50% and above	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.	
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.	
			OL	Organic silts and organic clays. Plasticity below "A" line.	
			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.	
			CH	Inorganic fat clays. Plasticity above "A" line.	
			OH	Organic clays or organic silts. Plasticity below "A" line.	
			PT	Peat, organic content greater than 80%.	
			Highly organic soils		

- LEGEND:
- 2B-84-1 Location of Explorations on this Sheet.
 - 2F-84-1 Location of Exploration in the Cache Creek Settling Basin area.
 - GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
 - SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
 - FI Fines, percent by weight passing the No. 200 sieve.
 - LL Liquid Limit.
 - PI Plasticity Index (Liquid Limit Minus Plastic Limit).
 - MC Field Moisture Content in Percent of Dry Weight.
 - Groundwater Level.

- NOTES:
- Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
 - All sieve sizes on the chart are U.S. Standard.
 - The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
 - Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
 - Borings 2B-84-1 thru 2B-84-10 were drilled to required depths with a 28" auger Highway Drill Rig during 4 June - 6 June 1984.
 - Depth to groundwater is shown if measured.



DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

CACHE CREEK BASIN
CACHE CREEK, CALIFORNIA
CACHE CREEK SETTLING BASIN ELEMENT
LOGS OF EXPLORATIONS
2B-84-1 thru 2B-84-7

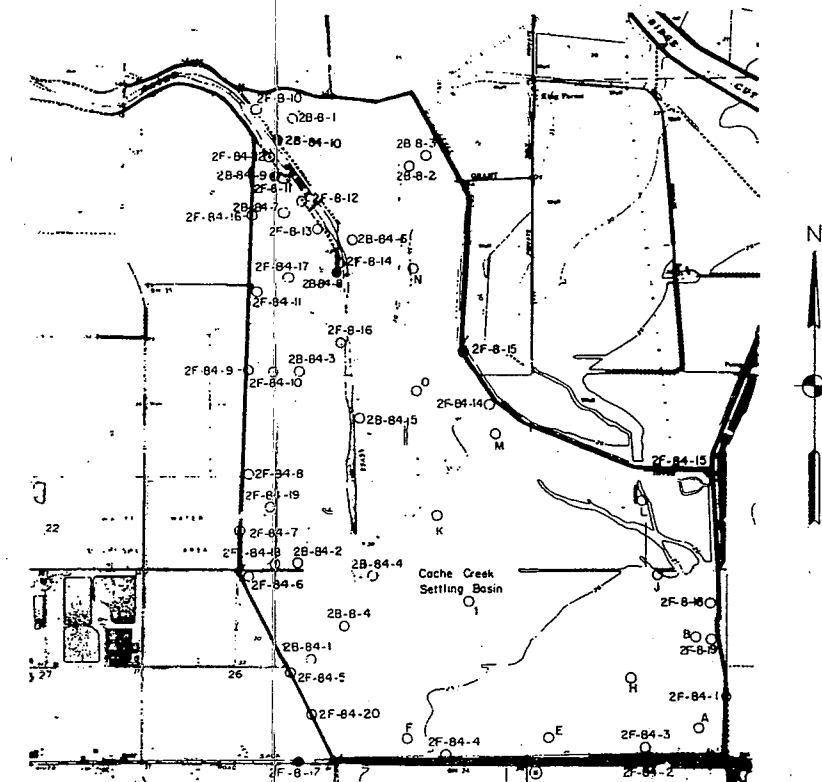
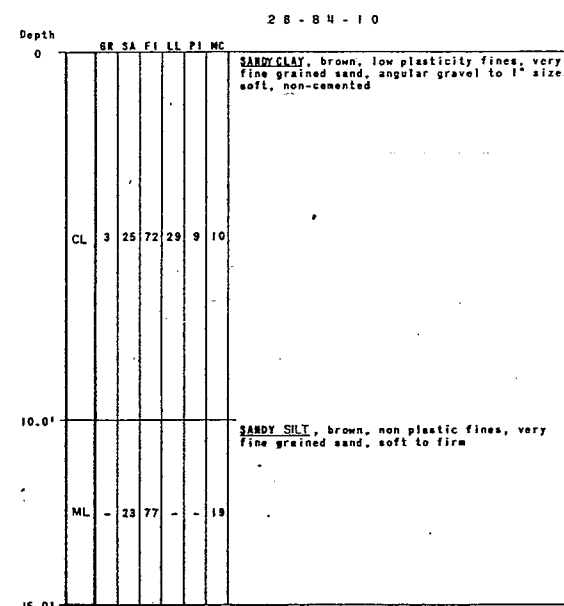
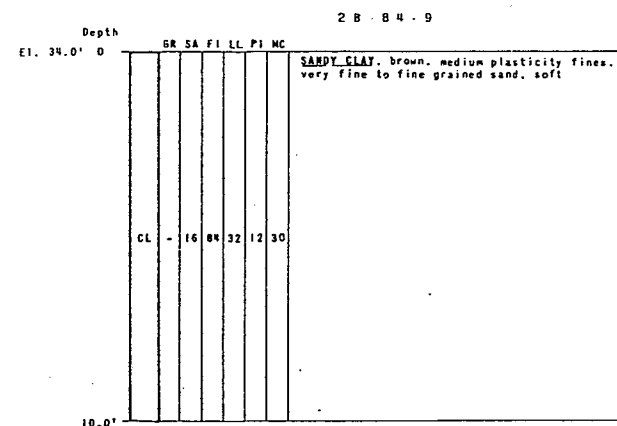
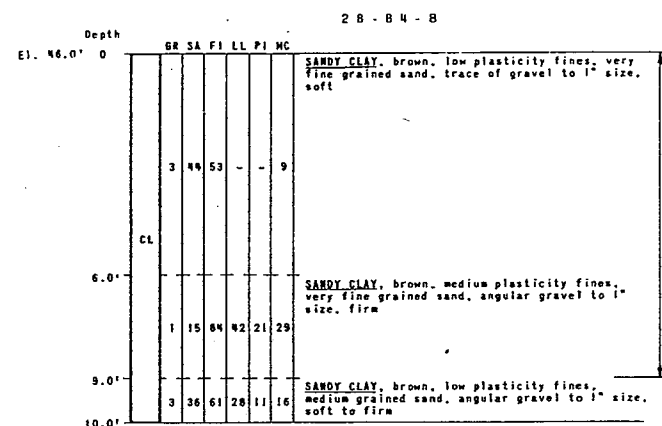
DESIGNED: K. Wahl
DRAWN: K. Wahl/V. Marino
CHECKED: D. Anderson

DATE: 11-13-77

SCALE: 1" = 100'

SHEET: 11 OF 12

FILE NO.: CC-25-35

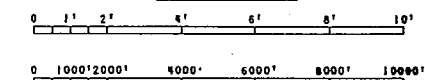


LOCATION OF EXPLORATIONS

NOTE

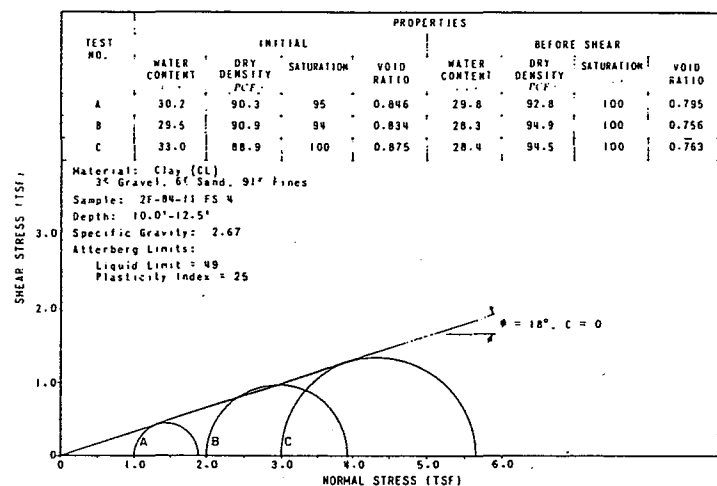
1. For additional notes and legend, see Sheet XII-10.

GRAPHIC SCALES

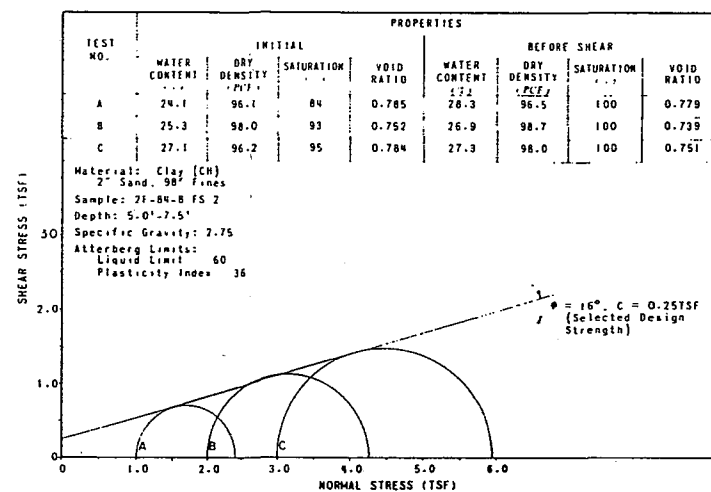


DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED: K. Wahl DRAWN: K. Wahl / R. Wagner CHECKED: D. Anderson	DATE: 1/1/77 SCALE: 1" = 100' SHEET: CC-25-35 FILE NO.: SPEC. NO.:
CACHE CREEK BASIN CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN ELEMENT LOGS OF EXPLORATIONS 28-B4-8 thru 28-B4-10	

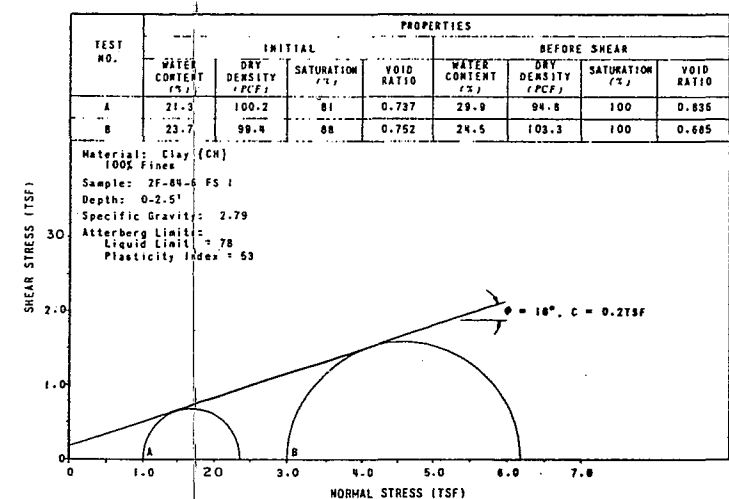
TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED ($\bar{\sigma}$)



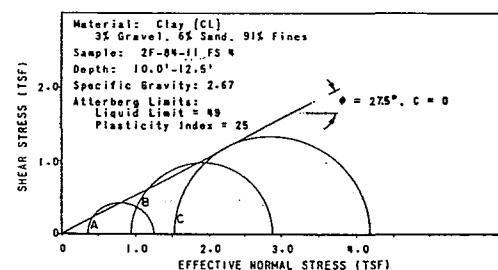
TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED ($\bar{\sigma}$)



TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED ($\bar{\sigma}$)

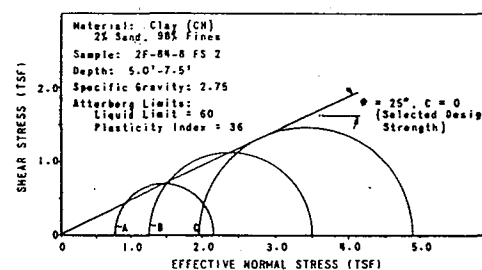


TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH⁽¹⁾

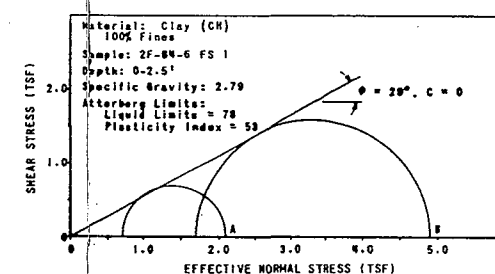


(1) Effective strength based on consolidated undrained strengths with pore pressure measurements.

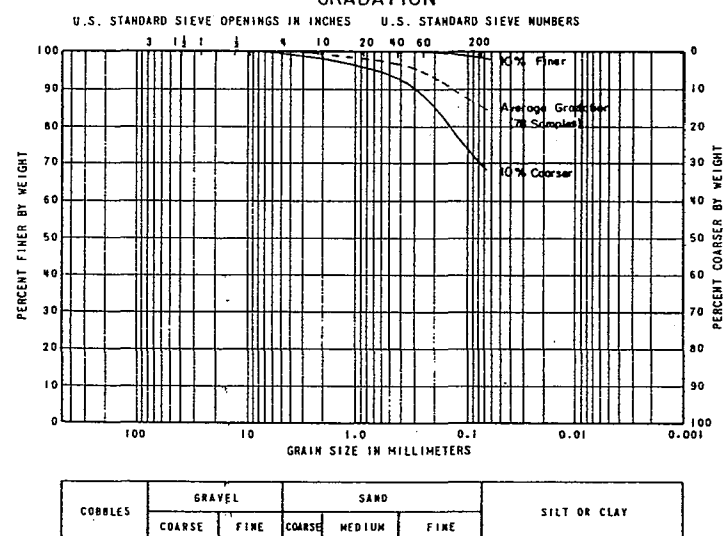
TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH⁽¹⁾



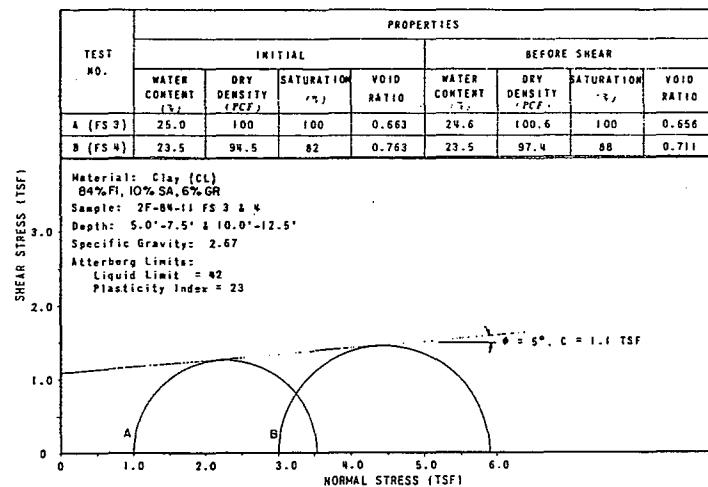
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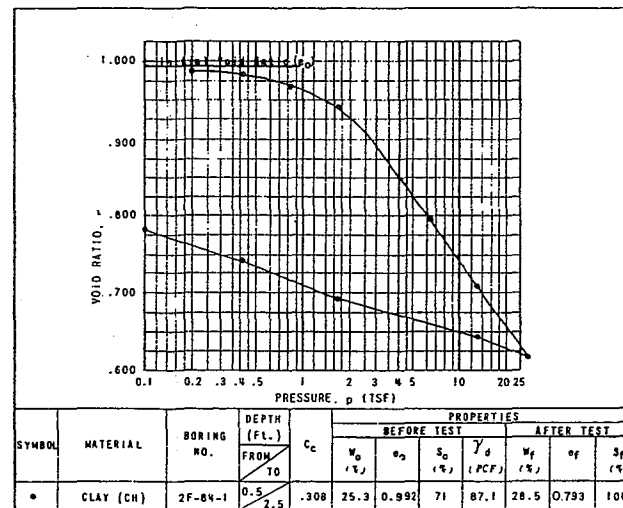
GRADATION



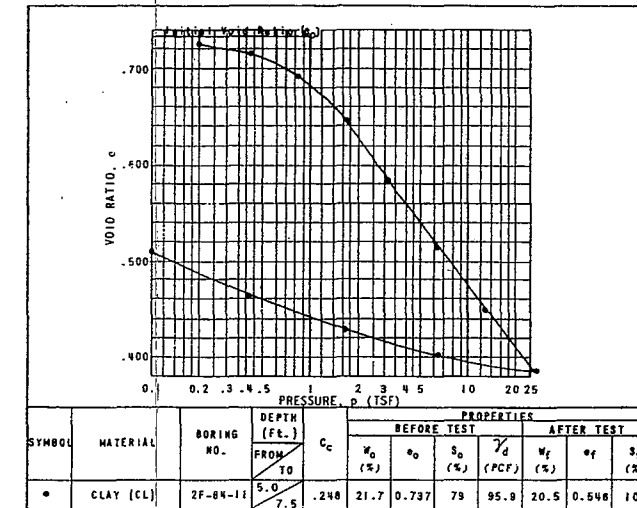
TRIAxIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)



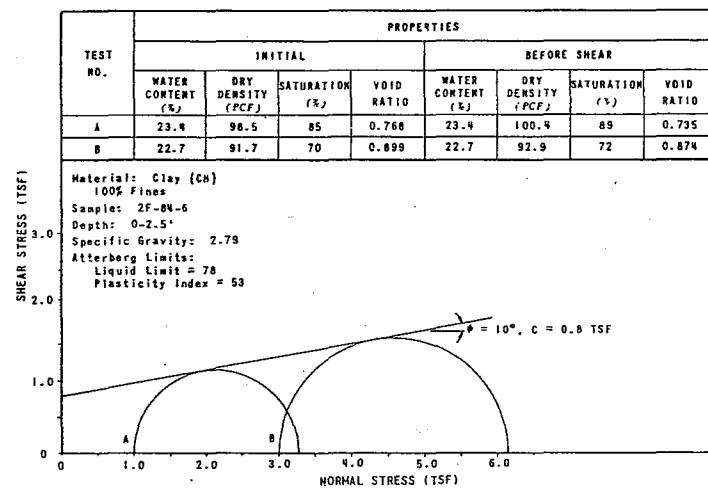
CONSOLIDATION



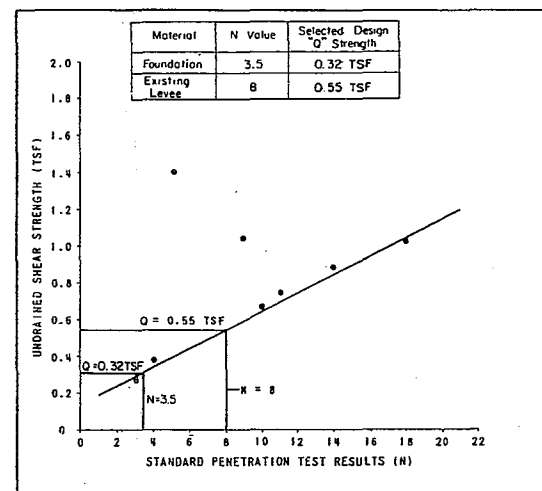
CONSOLIDATION



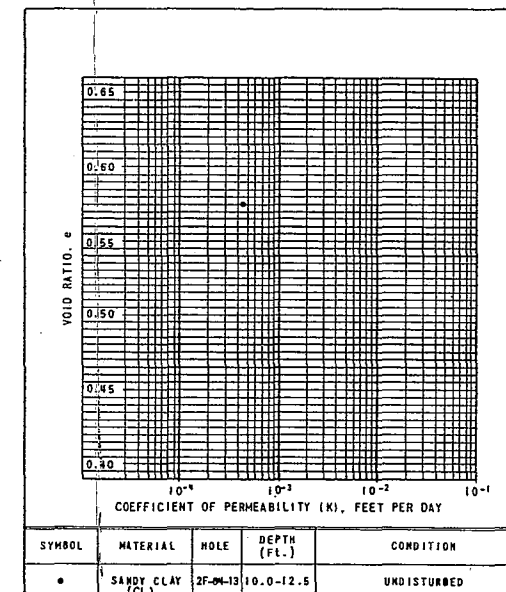
TRIAxIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)



UNDRAINED SHEAR STRENGTH vs. STANDARD PENETRATION TEST RESULTS

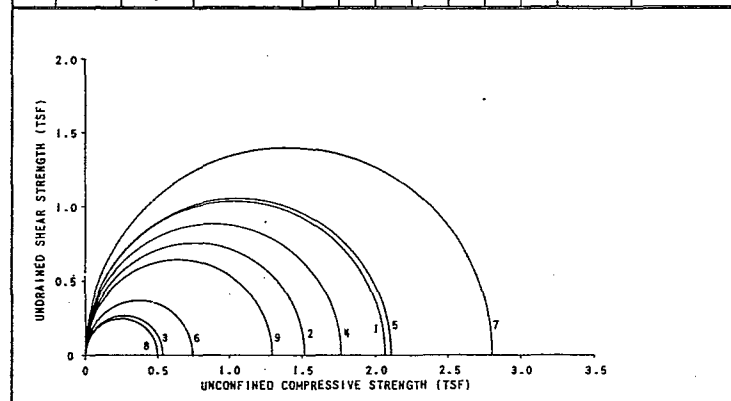


PERMEABILITY

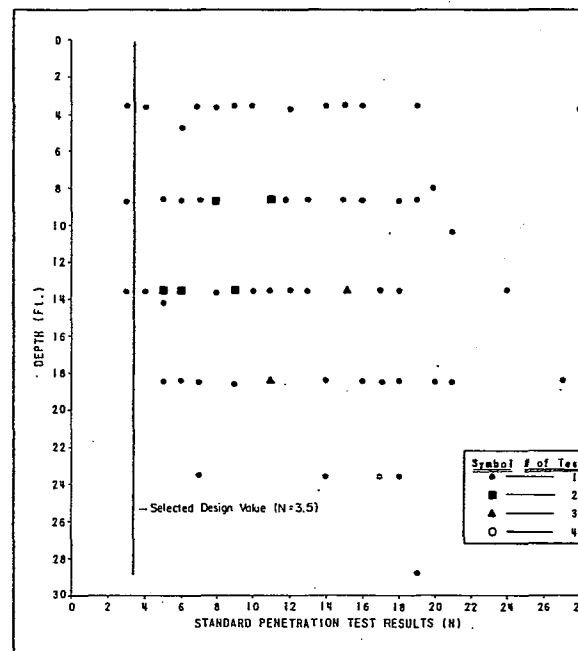


UNCONFINED COMPRESSION TEST

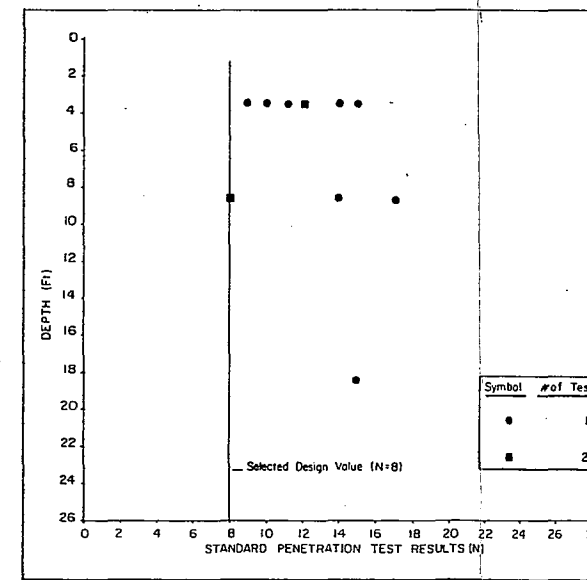
CURVE NO.	BORING NO.	DEPTH (FT.)	CLASSIFICATION	GR (%)	SA (%)	FI (%)	LL	PI	W ₀ (%)	S ₀ (%)	DRY UNIT WEIGHT (PCF)	UNCONFINED COMPRESSIVE STRENGTH (TSF)
1	2F-BN-2	2.5-5.0	CLAY (CH)	-	6	94	50	29	20.7	79	98.5	2.08
2	2F-BN-4	0-2.5	CLAY (CH)	-	7	93	61	40	21.2	78	97.8	1.52
3	2F-BN-5	10.0-12.5	SANDY CLAY (CL)	1	30	69	28	10	20.5	92	105.4	0.54
4	2F-BN-6	0-2.5	CLAY (CH)	-	2	98	52	30	20.9	67	92.1	1.77
5	2F-BN-11	5.0-7.5	CLAY (CL)	6	10	84	42	23	25.6	86	93.2	2.12
6	2F-BN-16	5.0-7.5	CLAY (CL)	-	-	100	48	23	37.5	96	82	0.74
7	2F-BN-17	10.0-12.5	CLAY (CL)	-	11	89	39	22	20.2	97	108.0	2.80
8	2F-BN-18	5.0-7.5	CLAY (CL)	-	1	99	41	19	30.6	99.6	92.1	0.50
9	2F-BN-19	0-2.5	CLAY (CH)	2	1	97	51	27	23.9	62	82.9	1.31



FOUNDATION
DEPTH vs. STANDARD PENETRATION TEST RESULTS

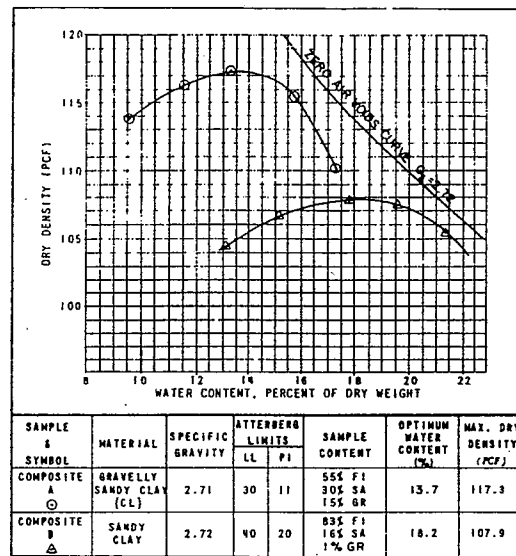


EXISTING LEVEE
DEPTH vs. STANDARD PENETRATION TEST RESULTS

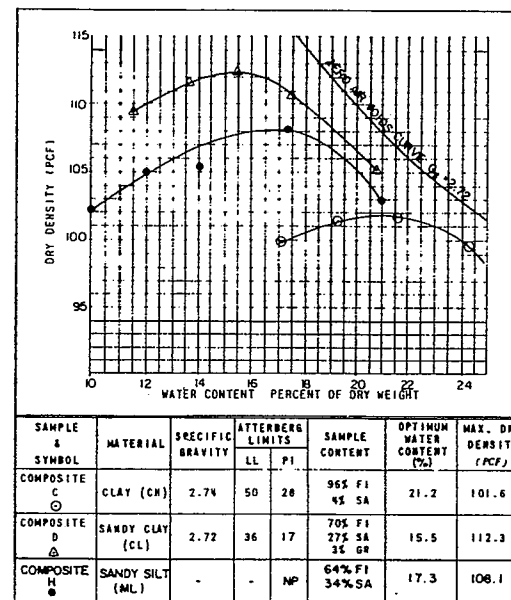


DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
CACHE CREEK BASIN CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN ELEMENT SUMMARY OF TEST RESULTS FOUNDATION & EXISTING LEVEE	
DESIGNED BY: K. WAHL	CHECKED BY: K. SWANSON
PREPARED BY: K. SWANSON	DATE: 1/1/37
SCALE: 1" = 1' 37"	FILE NO. CC-25-35

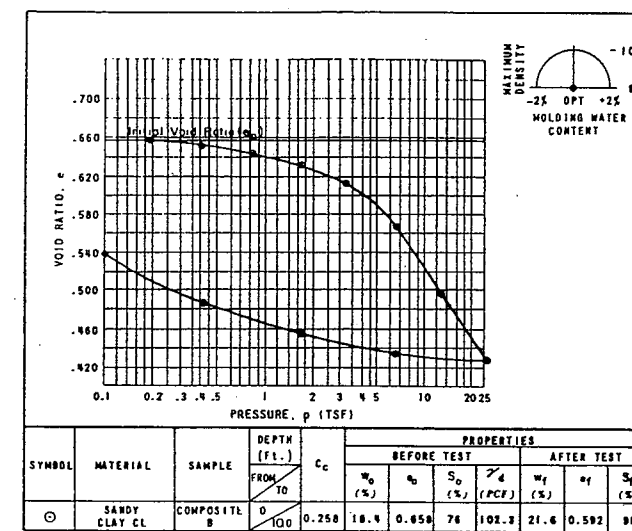
COMPACTION



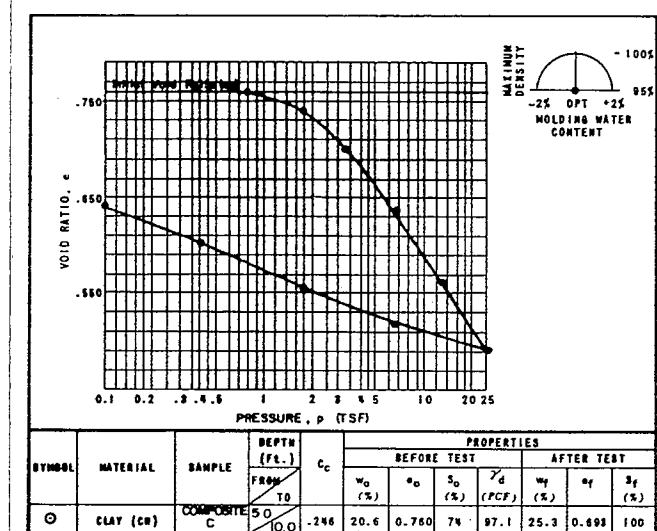
COMPACTION



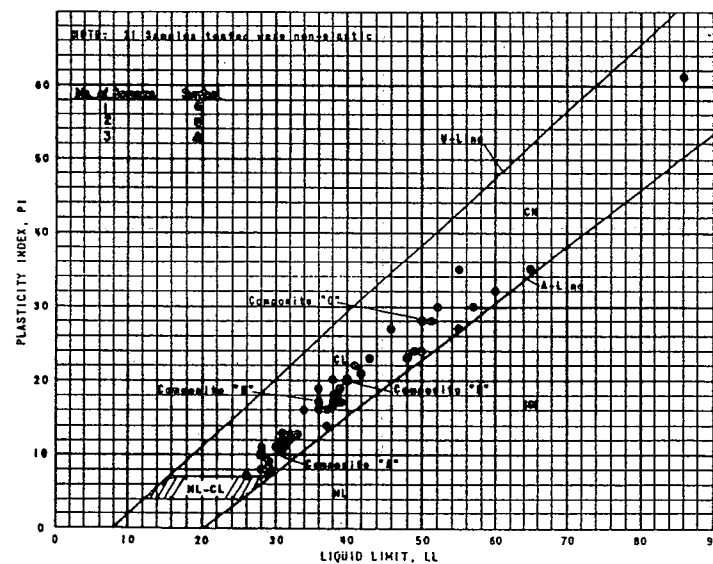
CONSOLIDATION



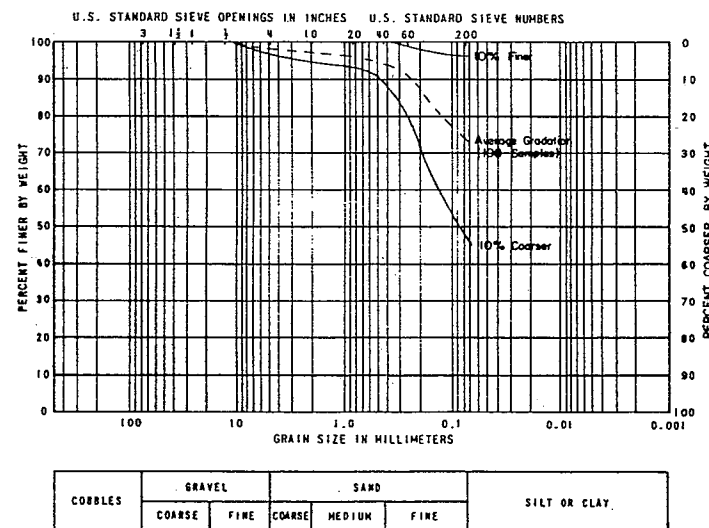
CONSOLIDATION



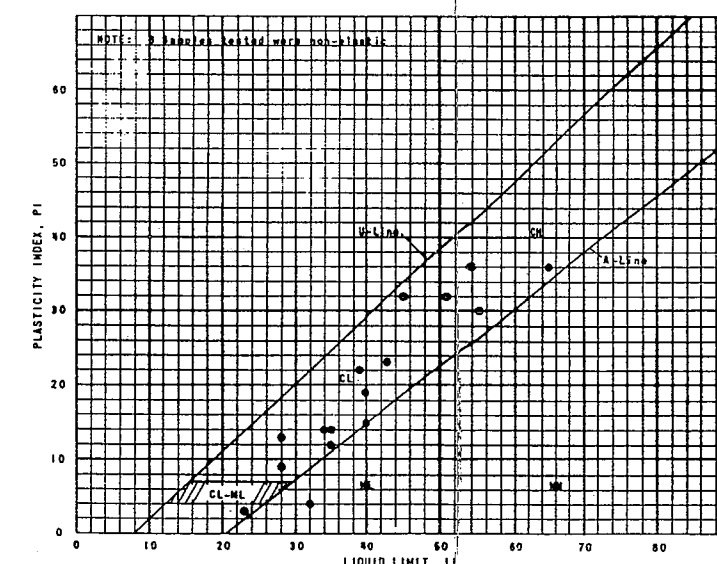
ATTERBERG LIMITS BORROW AREA



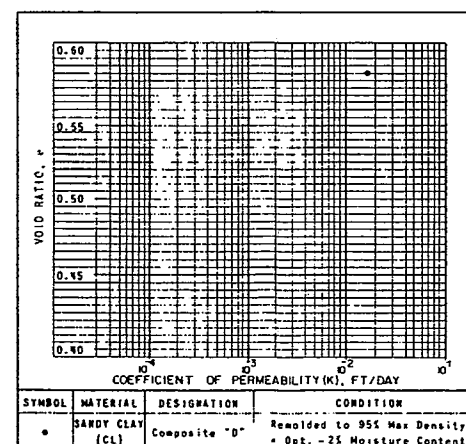
GRADATION



ATTERBERG LIMITS BASIN INTERIOR

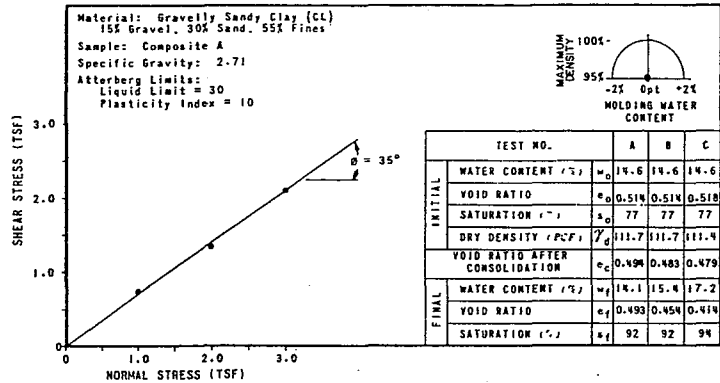


PERMEABILITY

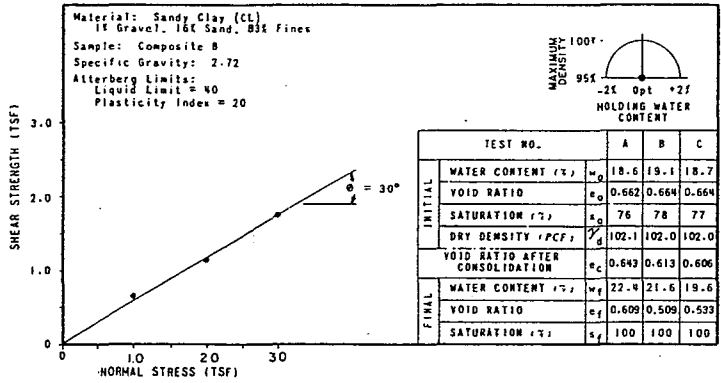


DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
CACHE CREEK BASIN CACHE CREEK, CALIFORNIA CACHE CREEK SETTLING BASIN ELEMENT	
SUMMARY OF TEST RESULTS BORROW MATERIAL	
DRAWN BY: K. WAHL, R. ELLIOTT CHECKED BY: D. ANDERSON PREPARED BY: K. SWANSON	DATE: 1/1/87 SCALE: SHEET: FILE NO.: CC-25-35

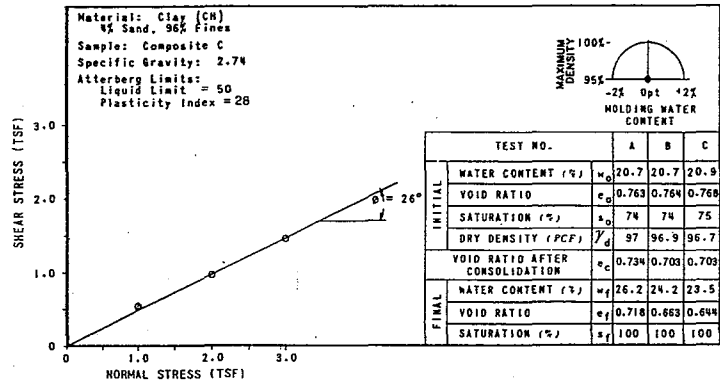
DIRECT SHEAR TEST



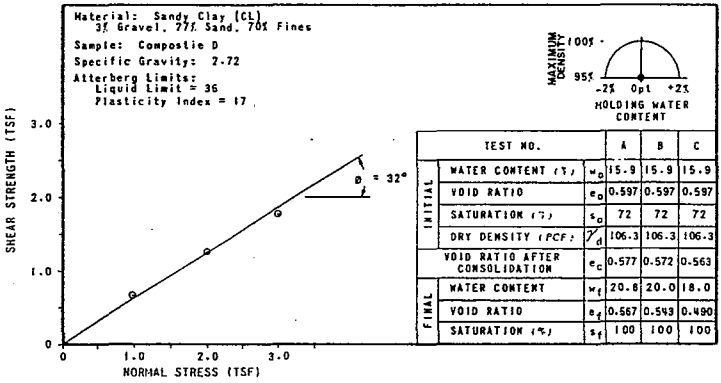
DIRECT SHEAR TEST



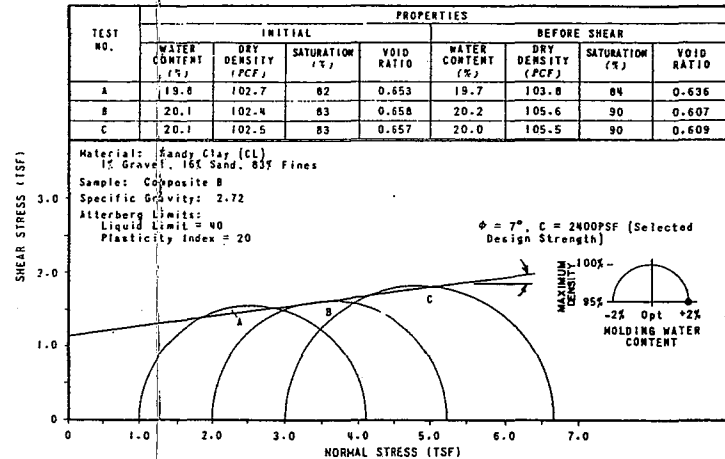
DIRECT SHEAR TEST



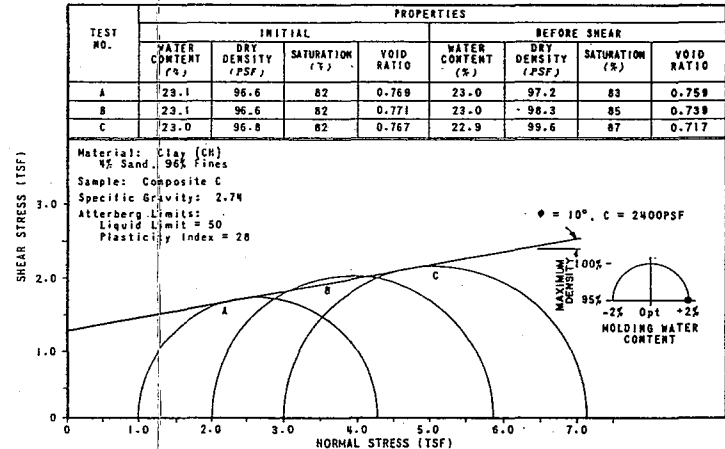
DIRECT SHEAR TEST



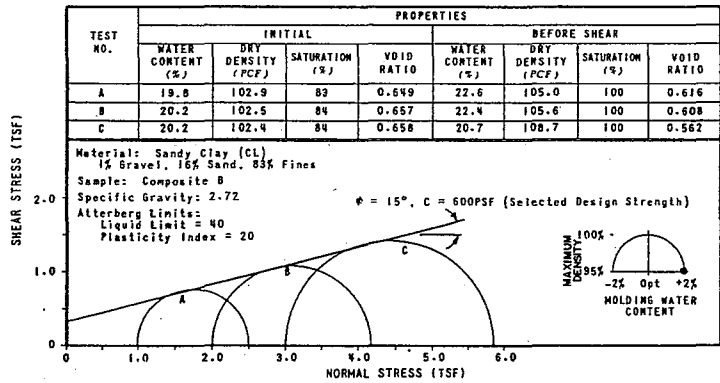
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)



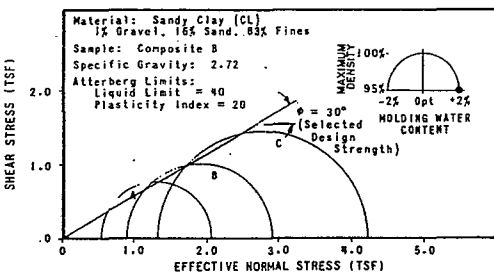
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)



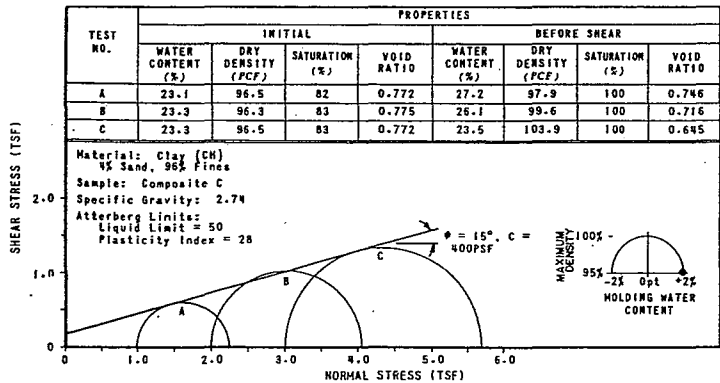
TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)



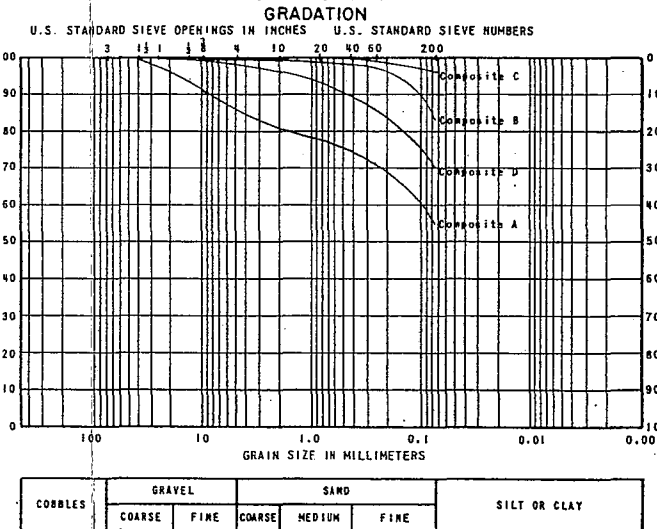
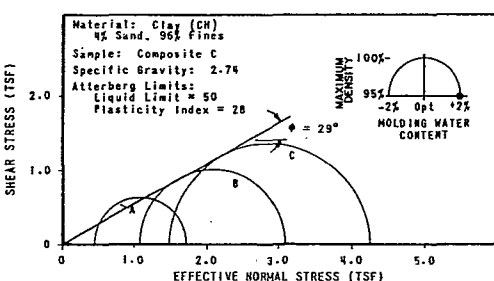
TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (I)



TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)



TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (I)



(I) Effective strength based on consolidated undrained strengths with pore pressure measurements

Slice No.	Segment No.	Segment Area (Sq. Ft.)	Moist Unit Weight (PCF)	Buoyant Unit Weight (PCF)	Segment Weight (Kips)	Slice Weight (Kips)	Base Length of Slice (Ft.)	C ΔL	C ΔL F.S.	φ°
1	1A	67.8	121.2	-	8.2	8.2	11.9	28.6	16.4	4.0
	2A	81.9	121.2	-	9.9					
2	2B	21.2	122.7	-	2.6	12.5	7.9	8.7	5.0	-
	3A	101.1	121.2	-	12.3					
3	3B	95.8	-	61.5	5.9	18.2	10.1	11.1	6.4	-
	4A	62.6	121.2	-	7.6					
4	4B	106.6	122.7	-	13.1	22.3	8.0	5.1	2.9	-
	4C	12.6	122.7	-	1.5					
	4D	1.0	-	61.5	0.1					
	5A	38.3	121.2	-	4.6					
5	5B	109.0	122.7	-	13.4	21.6	7.3	4.7	2.7	-
	5C	20.8	122.7	-	2.6					
	5D	16.0	-	61.5	1.0					
	6A	14.0	121.2	-	1.7					
6	6B	114.0	122.7	-	14.0	20.3	7.9	5.1	2.9	-
	6C	21.8	122.7	-	2.7					
	6D	30.8	-	61.5	1.9					
	7A	101.6	122.7	-	12.5					
7	7B	22.3	122.7	-	2.7	17.5	7.3	4.7	2.7	-
	7C	37.3	-	61.5	2.3					
	8A	69.7	122.7	-	8.6					
8	8B	20.9	122.7	-	2.6	13.4	7.1	4.5	2.6	-
	8C	35.6	-	61.5	2.2					
	9A	50.2	122.7	-	6.2					
9	9B	24.2	122.7	-	3.0	11.2	8.1	5.2	3.0	-
	9C	31.9	-	61.5	2.0					
	10A	16.7	122.7	-	2.0					
10	10B	32.7	122.7	-	4.0	6.9	15.1	9.7	5.6	-
	10C	14.0	-	61.5	0.9					

$\phi_0 = \text{Arc tan } \frac{\tan \phi}{F.S.} = \text{Arc tan } \frac{\tan 7^\circ}{1.74} = 4.0$

FIGURE 3 COMPOSITE FORCE POLYGON DATA

ADOPTED DESIGN DATA				
Material	Q STRENGTH		Unit Weight	
	φ Degree	Cohesion Kips/Sq. Ft.	γ _m	γ _s
FILL	7	2.4	121.2	127.2
EXISTING LEVEE	0	1.1	122.7	123.9
FOUNDATION	0	0.64	122.7	123.9

FIGURE 4 DESIGN DATA

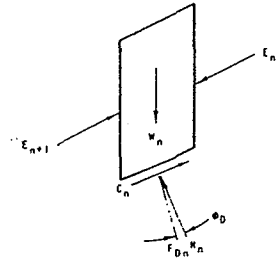


FIGURE 5 TYPICAL SLICE

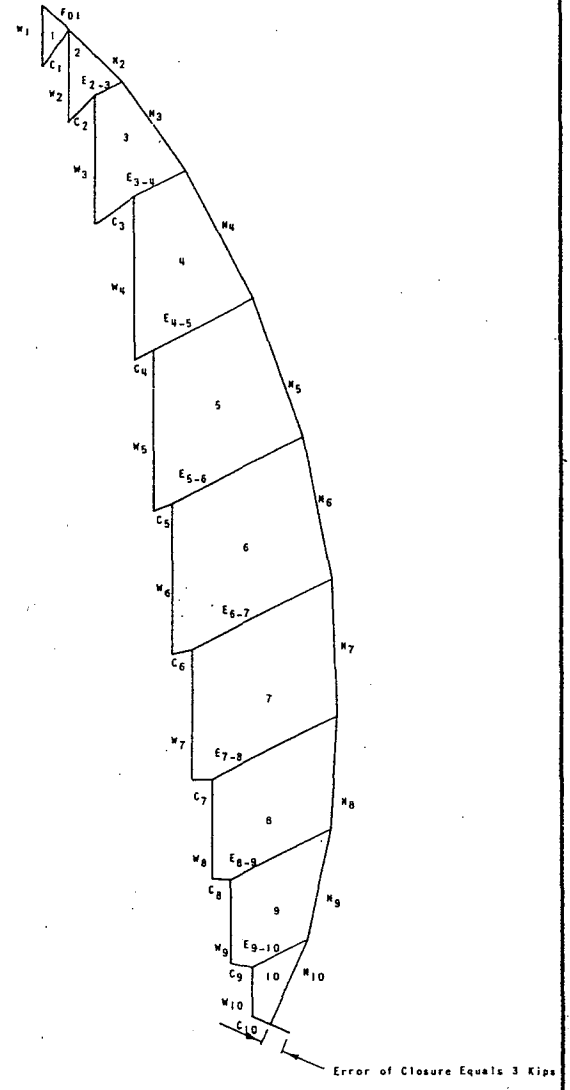


FIGURE 6 COMPOSITE FORCE POLYGON FOR TRIAL F.S. 1.74

- NOTES:
- For slice 1, it was assumed that the developed shear resistance on the base of the slice cannot be greater than that required to close the force polygon.
 - The End of Construction analysis using the Modified Swedish Method, Finite Slice Procedure, was performed on the Harris Computer System, Program no. 74186C2040, developed by St. Paul District, Corps of Engineers was used.
 - The computer solution for the critical arc shown was for a factor of safety equal to 1.74. The manual check of this solution agreed closely.
 - A tension crack was assumed to have developed to a depth of 6 feet below the crest of the expanded levee.

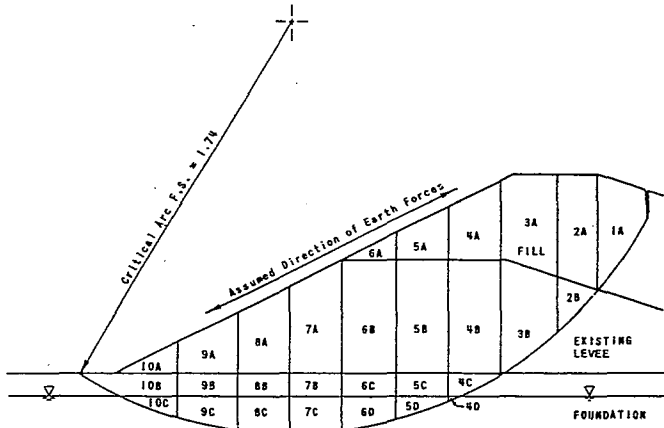


FIGURE 1 CRITICAL ARC

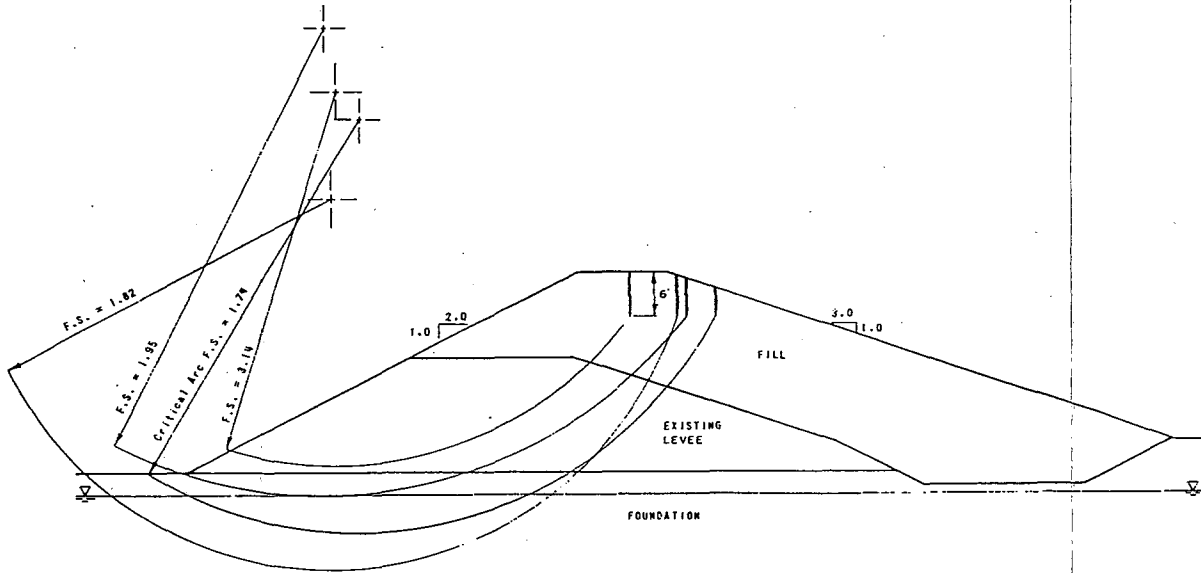


FIGURE 2 TYPICAL ARCS

REVISION		DATE		DESCRIPTION		BY	BY
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA							
DESIGNED K. SWANSON		CACHE CREEK BASIN CACHE CREEK, CALIFORNIA					
DRAWN R. WAGNER		CACHE CREEK SETTLING BASIN ELEMENT STABILITY ANALYSIS					
CHECKED K. SWANSON		END OF CONSTRUCTION					
SUBMITTED		DATE APPROVED		SCALE		SHEET	
CHIEF, SOFT DESIGN SECTION						FILE NO. CC-25-35	