FINAL

CACHE CREEK IMPROVEMENT PROGRAM

for LOWER CACHE CREEK

Yolo County

Adopted
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CHAPTER 1.0 INTRODUCTION

1.1 PURPOSE

The Cache Creek Improvement Program (CCIP) was developed by the Yolo County Community Development Agency to implement the goals, objectives, actions, and performance standards of the Cache Creek Resource Management Plan (CCRMP) as it relates to the stabilization and maintenance of the Cache Creek channel. It has been adopted as a component part of the CCRMP. The CCIP provides the structure and authority for a Technical Advisory Committee (TAC), defines the procedures and methodologies for stream monitoring and maintenance activities, and identifies initial high priority projects for stream stabilization.

1.2 REGULATORY FRAMEWORK

One of the primary actions of the CCRMP is the elimination of commercial mining within the Cache Creek channel. Mining activities permitted in the past, under in-channel mining permits approved under the provisions of the Yolo County Mining Ordinance and the State Mining and Reclamation Act (SMARA), have contributed to streambed lowering and the loss of riparian vegetation. Since creek instability will only be partially addressed by the elimination of in-channel commercial aggregate mining, the CCRMP recognizes the need for channel maintenance and improvement projects to promote stabilization of the creek channel and the protection of infrastructure elements along the creek. The CCRMP also acknowledges that the elimination of in-channel mining could result in sediment accumulation in the channel which may cause a reduction of channel capacity and increase flooding hazards. Modifications and maintenance of the Cache Creek channel would be managed by the County and the TAC and would occur under the review and guidance procedures described in the CCIP. The improvements and maintenance projects recommended as a result of the CCIP process could require excavation and filling of areas under the jurisdiction of the following local, State, and Federal authorities:

Yolo County Community Development Agency (YCCDA)

Any proposed improvements resulting in channel modifications within the 100-year flood hazard zone as defined by the National Flood Insurance Program shall require a Floodplain Development Permit from the Yolo County Floodplain Administrator (YCCDA Director).

U.S. Army Corps of Engineers (COE)

Any proposed channel improvement project resulting in filling or excavation within "waters of the United States" shall require a Section 404 permit from the COE.

California Department of Fish and Game (CDFG)

Any proposed channel improvement project resulting in disturbance of areas below the high water level of the creek shall require the applicant to negotiate a Streambed Alteration Agreement with CDFG (Section 1601).

California Regional Water Quality Control Board (RWQCB)

Construction activities associated with channel improvement projects performed under the CCIP may require compliance with the requirements of the statewide General Permit for Storm Water Discharges Associated with Construction Activities. For projects meeting the criteria for permitting under the General Permit, the project sponsors would be required to file a Notice of Intent (NOI) with the State Water Resources Control Board (SWRCB) to comply with the requirements of the General Permit.

The County is currently working with the State and Federal agencies noted above to determine the feasibility of obtaining regional or "blanket" permits for the CCRMP area. If obtained, the permits would be administered by the YCCDA as part of the Floodplain Development Permit process.

CHAPTER 2.0 CACHE CREEK IMPROVEMENT PROGRAM DESCRIPTION

2.1 PROGRAM ELEMENTS

The Technical Studies for the Cache Creek Resource Management Plan (CCRMP) included an extensive evaluation of existing and current hydrologic and hydraulic conditions along Cache Creek from the Capay Dam to just upstream of the I-5 bridge at Yolo, California. The results of the evaluation indicated that the Cache Creek channel has been and is currently in a state of hydraulic disequilibrium throughout much of this reach of the creek. The instability of the channel has been caused by a combination of complex influences which have contributed to channel bed degradation and adverse lateral erosion. These influences include the reduction in channel width caused by the reclamation of floodplain areas to agriculture, construction of localized constrictions at bridge locations, in-channel aggregate mining of the channel bed, the diversion of stream flow for irrigation, and sediment deposition at dam sites. To reduce the adverse effects of current unstable hydraulic conditions, the Technical Studies proposed recommendations to improve channel stability along Cache Creek. The major recommendation proposed "reshaping" of the channel to develop more uniform hydraulic conditions and reduce the potential for adverse erosion. The Technical Studies proposed a conceptual channel configuration, referred to as the "Test 3" model, which reflects more uniform channel conditions. The Test 3 model would serve a general goal for developing a more stable channel for Cache Creek. Projects implemented under the CCIP would be designed to support the development of this more stable condition.

The three major elements of the CCIP intended to promote a more stable Cache Creek channel are as follows:

Identification of Major Channel Stabilization Projects

The CCIP shall identify major creek stabilization projects to be undertaken over the following five year period. Implementation of the projects is intended to guide development of a more stable channel form and reduce the adverse affects of channel migration, while providing protection for existing infrastructure components.

Identification of Expected Channel Maintenance Activities

Maintenance of the Cache Creek channel will be required to promote improvements related to channel stabilization projects and reduce the potential for development of unstable channel conditions. The CCIP shall identify expected short-term and long-term channel maintenance activities.

Establishment of a Hydrologic Monitoring Program

Monitoring of flow discharges and sediment transport in the Cache Creek channel is critical to designing and maintaining channel improvements. The CCIP shall provide a practical monitoring program for the evaluation of water flow in the creek and trends of sediment transport and deposition. The monitoring program shall also address changes in vegetation that could impact channel capacity and stability.

The hydrologic monitoring program shall also include those flooding events on Cache Creek which can result in major channel adjustments. The CCIP shall develop a program to mobilize technical personnel from the TAC during flood periods for inspection of channel conditions to monitor development of potential channel instabilities and flooding problems. Results from the flood watch program will also provide necessary information regarding project performance during floods and possible improved methods for maintaining and stabilizing the channel.

2.2 PROGRAM MANAGEMENT

Effective implementation of CCRMP requires coordinated management by an informed, experienced interdisciplinary group of professionals who are familiar with the processes and conditions within the Cache Creek system. Appropriate management structure and procedures are required to ensure continued collection of necessary information on channel conditions and prioritization of improvement and maintenance projects. The CCRMP establishes the need for a Technical Advisory Committee (TAC) for management of the CCIP. The following sections describe the management structure and responsibilities for the CCIP:

Resource Management Coordinator

The Resource Management Coordinator (RMC), assigned by the Director of the YCCDA, will be responsible for management of all activities conducted by the TAC. The RMC will have the responsibility for overall management and coordination of the CCIP. The duties of the RMC will include coordination of the TAC with the regulatory agencies having jurisdiction over activities performed under the CCIP and with other members of the Cache Creek Stakeholder Group (described below). The RMC will also have the responsibility to coordinate any necessary permit applications and maintenance of required permits for the CCIP. The RMC will oversee the review and issuance of permits for channel improvement and maintenance projects.

Technical Advisory Committee

The Technical Advisory Committee will be established to provide scientific and technical review and oversight for all projects conducted under the CCIP. The TAC will collect and evaluate scientific data on hydrologic, hydraulic, sediment transport, and biological conditions within the CCRMP area. These data and analyses will provide the basis for identification of annual maintenance needs and priority projects and critical review of the design and construction of improvement projects. The following tasks will be the responsibility of the TAC under the direction and supervision of the RMC:

1. Implementation of a creek monitoring program;
2. Review of annual monitoring data;
3. Annual recommendations for channel maintenance activities that promote channel stability and environmental restoration;
4. Annual establishment of priorities for major channel stabilization projects;
5. Review of the design of projects requiring Floodplain Development Permits within the CCRMP channel boundary;
6. Recommendations for periodic updates and refinements of existing hydraulic and sediment transport models;
7. Review of riparian habitat restoration proposals and designs;
8. Review of channel stabilization and annual maintenance activity performance;
9. Preparation of an annual report for submittal to the Board of Supervisors; and
10. Attend selected public meetings to describe channel management activities and the success of the improvement projects.

The science of river management is not so well advanced as to allow rigid formula-driven decision-making to dominate the planning and monitoring process in a dramatically changing river such as Cache Creek. The members of the TAC must have a blend of specialized knowledge and experience that will enable them to develop environmentally sound and flexible strategies for balancing a wide range of resource needs. They must also have the skills to work effectively with a variety of stakeholders and the develop a shared vision of the creek's future. The TAC will consist of a three-person interdisciplinary group comprised of the following:

1. A qualified river engineering specialist (hydraulic engineer);
2. A qualified fluvial geomorphologist; and
3. A qualified biologist with experience in riparian restoration.

Nominations for appointment to the TAC will be approved by the Board of Supervisors. The TAC members may be compensated under a time-and-materials contract with the County, with a not-to-exceed amount. The term of the TAC member contracts will be two years with the opportunity for unlimited extensions pending approval by the Board of Supervisors. The TAC will be required to submit a yearly budget to the RMC for review and submittal for approval by the Board.

The TAC will be responsible for making recommendations related to the supervision of all three elements of the CCIP, based on the activities conducted by the TAC. However, Yolo County will be responsible for implementation of the RMC recommendations.

Cache Creek Stakeholders Group

The RMC and TAC have broad responsibilities for decisions related to creek management. However, these decisions cannot be made without organized input from interested agencies, citizens groups, and industry. Therefore the CCIP includes the establishment of the Cache Creek Stakeholders Group (CCSG). The CCSG will consist of representatives from various agencies and organizations and will provide a forum for the discussion of site-specific and general concerns regarding the resource management of Cache Creek. A preliminary list of potential participants includes:

1. California Department of Fish and Game;
2. Central Valley Regional Water Quality Control Board;
3. Yolo County Flood Control and Water Conservation District;
4. Yolo County Public Works Department;
5. Yolo County Office of Agricultural Commissioner;
6. Yolo County RCD;
7. Yolo County Farm Bureau;
8. City of Woodland;
9. California Department of Water Resources;
10. Cache Creek Conservancy;
11. California Department of Transportation;
12. California Resources Agency;
13. California Department of Conservation;
14. Cache Creek Basin Coalition;
15. League of Women Voters;
16. Yolo County Aggregate Producers Association;
17. U.S. Army Corps of Engineers;
18. Property Owners along Cache Creek;
19. Communities of Capay, Esparto, and Madison;
20. Friends of Cache Creek;
21. U.S. Bureau of Land Management; and
22. Western Yolo Grange.

Agencies or organizations identified in the above list which do not wish to participate in the CCSG should contact the YCCDA. Other groups not identified on the list which would like to participate should also contact the YCCDA.

2.3 PROGRAM IMPLEMENTATION

Implementation of the CCIP will require several important programmatic and procedural steps. The following sections describe the implementation process and procedures:

Implementation of Monitoring Program

The TAC will initiate and perform the monitoring program described in Chapter 6. The monitoring program will consist of annual collection of stream discharge and sediment transport data and annual analysis of changes in channel morphology and riparian vegetation. All data and analysis will be summarized in an annual report submitted to the Board of Supervisors.

Notification for Recommended Channel Improvement Projects

On an annual basis, the TAC will identify priority channel improvement projects (separate from annual maintenance) on the basis of the results of the Cache Creek monitoring program. In an annual report to the Board of Supervisors, the TAC will describe the need for and purpose of identified priority projects. The report will describe the specific location of the projects (identifying landowners) and the general aspects of proposed improvements. With authorization by the Board, the RMC will submit a letter to landowners requesting participation in the implementation of the projects. The letters will describe the need and scope of the identified projects. The letters will also detail the type of permitting required for the projects and available resources for implementation of the project. Available resources may include hydrologic and hydraulic data compiled by the TAC which may be important for project design, design recommendations, or funding sources for implementation of all or parts of the recommended projects.

Permitting

All landowners proposing channel substantial modification projects within the CCRMP channel boundary will be required to submit applications to the YCCDA for a Floodplain Development Permit. The permit application will be reviewed by the TAC. The review will include consideration of potential effects of the proposed project on hydraulic conditions upstream and downstream of the proposed project site, as well as the consistency with the CCRMP, CCIP, and requirements of jurisdictional agencies that have issued "blanket permits" for the area. Following their review, the TAC will provide recommended changes in project design, if necessary. Upon incorporation of the TAC recommendations into the project design, a Floodplain Development Permit will be issued. Conditions of the permit will require that completed projects be surveyed to provide a record of as-built conditions.

Regulatory Coordination

During the first year of implementation of the CCIP, the YCCDA, with support from the TAC, will pursue issuance by the COE of a general Section 404 permit for improvement projects conducted under the CCIP. The YCCDA will also petition the CDFG for issuance of a general permit for Section 1601 Streambed Alteration Agreements and Section 2081 Permits for CCIP projects. In addition, the RWQCB will be approached for the issuance of a General Permit for Storm Water Discharge. The issuance of these general permits would streamline permitting process for channel improvement and habitat restoration projects. Under these conditions, the County would be given authority to approve projects that are consistent with the provisions of the CCRMP and CCIP.

Funding

The implementation of the CCIP would be funded initially through fees generated by a surcharge on the weight of aggregate resources sold (not mined) within the County. A $0.10 surcharge would be placed on each ton of processed aggregate in order to fund the CCIP. In addition, the County shall aggressively pursue other potential sources of funding, including user fees, benefit assessments, and state and federal grants for watershed management. The fees and other funding would be collected by the County Administrative Office (CAO) and placed in an interest-bearing account held by Yolo County, separate from the General Fund. The funds would be administered by the CAO with approval by the Board of Supervisors.

Implementation Schedule

The following preferred schedule will be met by the TAC for each year of program implementation unless high flow conditions preclude initiation of annual channel morphology monitoring:

15 January	Submittal of TAC annual progress report on previous year's monitoring results and completed channel improvement projects to Board of Supervisors.
15 March	Notification by TAC to landowners of high-priority recommended channel improvement projects.
1 April	Completion of annual aerocartography.
March/April	Discussions between TAC and interested landowners regarding potential projects, including maintenance activities.
1 May	Completion of Digital Terrain Model and channel cross-section and analysis of model by TAC.
31 May	Deadline for submittal of applications to YCCDA for Floodplain Development Permits (FDP) related to channel modifications within the CCRMP planning area during the summer and fall.

30 June	Completion of TAC and YCDPW review of channel modification designs and recommendations for approval of FDPs.
July/October	Construction of channel improvement projects.
1 November	Termination of in-channel improvement projects.
January-December	TAC monitoring of stream discharge, sediment load, flood conditions, and channel morphology.

CHAPTER 3.0 MAJOR STABILIZATION PROJECTS

3.1 INTRODUCTION

The following discussions outline a plan for improving the overall stability and maintainability of Cache Creek. The Cache Creek Improvement Program will be achieved through a series of steps orchestrated by the TAC. Steps include: 1) design and implementation of localized stabilization projects to promote "self improvement and increased stability" of the creek's morphology; 2) implementation of a comprehensive annual monitoring program (described in Chapter 6), and 3) implementation of channel maintenance activities (Chapter 4). The plan basically calls for the design and implementation of a series of localized stabilization projects integral to the initiation of a more stable and homogeneous channel configuration. The Technical Advisory Committee (TAC) will be responsible for collecting the required monitoring data and prescribing when and how further in-depth hydraulic engineering analyses and design activities will be carried out. As discussed in Chapters 2, 4, and 6 in this document, the TAC will identify and prioritize stabilization and maintenance projects along the creek. Engineering design of stabilization projects can be performed by the private land owners or public agencies. Through the processes of monitoring, maintenance and implementation of creek stabilization projects developed by the TAC, the CCIP intends to promote adjustments in the creek which meet the stated objectives of the CCRMP while allowing flexibility for the creek to fashion its own recovery and restoration over time.

The creek is a dynamic system that is currently substantially impacted by a variety of influences (NHC, 1995). Implementation of the CCRMP and CCIP will improve channel stability over the long term, but significant channel adjustments can be expected under present and future conditions, especially during periods of high flow. It is anticipated that channel maintenance requirements under the CCIP will decrease as the channel becomes more stable over time. However, some degree of channel maintenance will be required for the foreseeable future to ensure that flood carrying capacity is preserved, and to reduce the risk of bank erosion, lateral channel migration, and significant degradation or aggradation of the stream bed in specific locations.

3.2 SUMMARY OF EXISTING CONDITIONS BY REACH

From its origin near Clear Lake to its terminus in the settling basin, Cache Creek exhibits great diversity in geologic and physiographic characteristics with extreme swings in hydrologic and geomorphic processes from year to year. As described in the 1995 Technical Studies, the historical geomorphic characteristics of Cache Creek from Capay Dam downstream to the settling basin were considerably different from today. The Streamway Investigation (NHC,1995) identifies nine geomorphically distinct subreaches in the 35 miles from upstream of the Capay Dam to the Settling Basin, as shown in Figure 1. From upstream to downstream the nine geomorphic subreaches are referred to as follows:

1. Capay Valley (Subreach 9), upstream from the Capay Dam;

2. Capay (Subreach 8), from the Capay Dam to County Road 85;

3. Hungry Hollow (Subreach 7), from County Road 85 to County Road 87B;

4. Madison (Subreach 6), from County Road 87B to Interstate 505;
5. Guesisosi (Subreach 5), from Interstate 505 to a point upstream of Moore Crossing;

6. Dunnigan Hills (Subreach 4), from a point upstream of Moore Crossing to County Road 94B;

7. Hoppin (Subreach 3), from County Road 94B to County Road 97;

8. Rio Jesus Maria (Subreach 2), from County Road 97 to County Road 102; and

9. Settling Basin (Subreach 1), from County Road 102 to the Bypass.

The channel boundary, as defined in the CCRMP, extends from the Capay Dam downstream to the I-5 bridge near Yolo, a distance of approximately 14.5 miles. The approximate lateral extent of the channel boundary of the study area coincides with the 100-year floodplain boundary defined in the Corps of Engineers' *Westside Tributaries Study*, 1994. Therefore, the CCRMP channel boundary falls within Subreaches 8, 7, 5, 4, 3, and the uppermost portion of Subreach 2 (see Figure 1).

Table 1 summarizes the present reach-averaged characteristics of each of the main subreaches in the study area, including reach-averaged hydraulic characteristics for 100-year flow conditions. Figures 2 and 3 show how the average channel widths and thalweg elevations under the bridges have narrowed and deepened, respectively in each subreach since the turn of the century. Section 3.2 in the Streamway Study (NHC, 1995) summarizes the present geomorphic and hydraulic characteristics of each of the subreaches. Tables 2 through 9 below summarize present existing conditions for each of the major subreaches in the study area.

3.3 BACKGROUND

The present Cache Creek channel system is out of balance with the flow and sediment loads entering it. If there is too much water in a river system and not enough sediment, scour will lower the streambed and/or erode the adjoining banks. If there is too much sediment, and not enough water, the creek will meander and flood. Bridges and in-channel levees create significant hydraulic controls (constrictions) in the system. Flow velocities are significantly greater through constrictions than in the wider portions of the creek. This creates local high energy zones where scouring is common and channel bed lowering occurs due to scour. The present channel configuration confines the flow energy for large flood events to a much narrower channel than had occurred historically. Reduction of floodplain storage and blockage of natural flood water escape routes have altered the local hydrology (flood peaks and travel time). In most subreaches, the channel is attempting to adjust itself to be wider than the current widths.

River discharge within the confined banks, flow depths and velocities have increased through the study reach since the early 1900s, thus increasing the hydraulic stresses on the bed and banks. Increased hydraulic stresses within the channel may limit the type and survival rate of some vegetative species formerly found in the channel. Continuous long-term sediment transport simulations indicate that the creek will work on its own toward a more stable configuration (channel slope and compound cross sectional shape), but that the new equilibrium may take decades to establish itself. To improve channel stability in a shorter period of time, it is necessary to change the present in-channel mining procedures (see recommendations 1 through 8 in Chapter 6 of the Technical Studies) and reconfigure the channel to smooth out abrupt changes in capacity and to reduce constrictions. Once major constrictions are removed or improved and channel smoothing and widening projects are complete, annual anticipated channel maintenance requirements will decrease as the creek becomes more stable over time. This chapter of the CCIP describes types of channel improvement projects that will be considered by the TAC.

3.4 EXPLANATION OF THE TEST 3 CONCEPT

The Streamway Studies (NHC, 1995) describe a series of numerical (computer modeling) sensitivity analyses that were performed to test the effects of widening and smoothing the channel. The Test 3 conceptual configuration was ultimately recommended by the Technical Studies and the CCRMP. The Test 3 channel configuration is conceptual at this time and the sensitivity results presented in the Technical Studies are not intended for design purposes. By resculpting the present channel shape to slightly widen constrictions, smooth out irregular bank lines, and eliminate abrupt changes in channel widths (see Figure 4), the hydraulic capacity and sediment transport characteristics are smoothed to create a more stable and balanced creek system. Bridge crossings tend to be the most constricting features along the creek. The Test 3 concept also calls for smooth channel transitions into and out of the bridges to reduce energy losses and local scour. The Test 3 Conceptual Boundary provides a target channel shape for future stabilization plans. Reshaping and smoothing of the channel will help return the channel (on a reach-by-reach basis) to a form more similar to its historical morphology. In the long term, the Streamway Studies and CCRMP recommend that in-channel extraction be limited to the volume of sand and gravel delivered annually to the study reach. Also recommended as part of the Test 3 concept is abandonment of the theoretical thalweg concept and 1979 in-channel mining boundary. It is suggested that the old creek management criteria be replaced with target channel slopes and sinuosities listed in Table 10. Target slopes and sinuosities may change over time as the channel adjusts to reshaping projects and regular maintenance. Recommendations regarding where, when, and how adjustments to specific channel dimensions and hydraulic characteristics might be implemented will be made by the TAC following the evaluation of long term monitoring information (refer to Chapters 2, 4 and 6 below). Fixed standards and channel shapes should be avoided. It is impossible to anticipate exactly where and how the creek will respond to resculpting and smoothing projects as well as reduced in-channel mining. Management will focus on maintaining appropriate stable slopes and channel capacity rather than specific elevations.

A complete systems approach for the development of a channel improvement and stabilization plan is essential. All of the subreaches must be assessed as integral parts of the creek system, all connected together hydraulically with feed forward and feed back mechanisms relating to what has, or is occurring upstream or downstream from a particular location on the creek. The need and benefits of applying a complete systems approach for project design, monitoring and maintenance was described thoroughly in the Technical Studies (NHC, 1995). Current unstable channel conditions reflect the consequences of not having an integrated management program of channel modification activities.

Major channel smoothing and shaping projects may be too extensive to implement simultaneously and may require phased implementation. Starting with the highest priority projects first, the overall creek improvement plan should be carefully implemented, phase by phase, with ongoing monitoring to record how well the various phases and projects work towards improving channel stability. The CCRMP establishes a mechanism for implementation of large segments of the channel improvements proposed under this program, through Development Agreements or other arrangements with off-channel aggregate producers. Through the notification process described in Chapter 2, the TAC will promote and facilitate localized channel improvement projects.

3.5 DESIRABLE (TARGET) CHANNEL CHARACTERISTICS BY REACH

The 100-year channel characteristics for each subreach were developed in the Streamway Investigation for the Conceptual Test 3 channel configuration. These hydraulic characteristics, along with recommended channel slopes and sinuosities are listed in Table 10 as initial target channel characteristics recommended under the CCIP. As previously stated, these target values may be adjusted over time by the TAC, depending on how the creek responds to projects that are implemented under the CCIP. Regular monitoring and analysis is required (see Chapter 6). Creek management and maintenance will focus on maintaining the targeted channel slopes and sinuosities rather than specific elevations. Significant efforts will be made to stop further channel bed lowering in all subreaches. Suggested adjustable mining templates for areas where the channel is wide, narrow channel areas with adjacent off-channel aggregate extraction pits, and areas where the channel is narrow are shown in Figures 5, 6 and 7, respectively.

The template shown in Figure 5 is applicable to channel sections found in subreaches 6, 7, and 8. The template shown in Figure 6 is applicable to channel sections found in subreaches 3, 4 and 5, while the Figure 7 template is applicable to conditions found in subreaches 2 and 8.

All of the bridges within the CCRMP study area, with the exception of those bridges that cross the narrow channel near Yolo, have experienced damage due to channel degradation and other problems. Several bridges have had multiple failures. Structural damage to the Capay bridge resulted in closure of the bridge to all traffic and pedestrians following high flows in March of 1995. The Madison bridge collapsed in 1978 and has not been replaced. All of the bridges in the CCRMP study area are critical components of the County's transportation system and damage to them represents substantial inconvenience to residents and significant economic impacts to the County. As described in the Technical Studies, bridges have an effect on the overall channel stability throughout the study area. They form high flow constrictions in the channel resulting in localized rapid changes in channel conveyance and sediment transport capacity. These abrupt changes in flow and sediment capacity result in alternating areas of scour and deposition that lead to progressive changes in the channel well beyond the immediate area of the bridge.

The Technical Studies demonstrated the benefits of widening narrow bridge openings but acknowledged the financial constraints on the feasibility of lengthening several bridges. Therefore, the CCRMP recommends design and construction of smooth channel transitions into and out of bridge openings to improve local hydraulic conditions and reduce the abrupt changes that presently occur. An example of a generalized transition treatment for bridges is presented in Figure 8. The TAC will coordinate the design of individual bridge treatments with County, State, and Federal interests.

3.6 PRIORITY PROJECTS

Chapter 6 presents program descriptions for flood watch and annual monitoring activities. Perhaps the most important CCIP project is the installation of flow gages and the implementation of the annual monitoring program. Dependable data are critical to the design and implementation of any major channel stabilization project. It is therefore suggested that the tasks and program components described in Chapter 6 be considered as components of a high priority project.

Present and future channel stability problems continue to occur where channel capacity and hydraulic conditions change abruptly. Noticeable scour occurs through narrow constrictions and significant deposits of sediment occurs immediately upstream or downstream from constrictions resulting in potential deflection of flows at banks or important structures. The primary locations where these problems occur are in the vicinity of bridges. Therefore, all bridge locations are considered high priority sites for major stabilization projects.

Figures 9 through 12 present sketches of four different channel transition and stabilization projects prepared for the Capay bridge (Road 85). Figures 9, 10 and 11 show different methods of protecting the bridge abutments and providing three different methods for stabilizing the eroding north bank. Alternatives shown in Figures 9 through 11 are for an assumed bridge of the same length (opening) as the present bridge (Alternatives EBL1 - EBL3: *existing bridge length*). A key component of these project alternatives is the selective bar excavation along the right bank, upstream from the bridge. The point bar continues to grow in size and elevation, thus encouraging the creek to attack the left bank upstream from the bridge. Figure 12 presents a sketch of a channel transition project at the Capay bridge for a bridge lengthened by 150 feet to the north. As demonstrated in the Streamway Report (NHC, 1995) enlargement of bridge openings greatly improves the hydraulic characteristics and channel stability in the vicinity of the bridge.

Figures 13, 14, and 15 present generalized sketches of channel transition projects for the I-505 bridge, Stephens bridge (Road 94B), and Esparto bridge (Road 87), respectively. Each bridge transition project consists of channel smoothing upstream and downstream from the bridge. Channel transitions are created by building flow deflection works (spur dikes or groins) and/or biotechnical features that will equally guide high energy water to the bridge without an abrupt change in channel conveyance upstream or downstream from the bridge. Scour control (sills, aprons, rock donuts or mattresses) in the immediate vicinity of the bridges may be required for some sites, but design analyses are required to determine where and to what extent scour controls are required.

There are several locations in the CCRMP study area where past gravel excavation has occurred and low in-channel levees remain. Some of the levees are located downstream from significant high flow velocity areas at channel constrictions, creating hydraulic instability. The tendency for low-flow channels in these areas to braid or meander significantly presents potential streambank erosion hazards. Figures 5 through 7 present flexible maintenance mining templates which could be implemented in such locations. Partial removal of the low levees and regrading behind them provides the opportunity to establish the targeted compound channel shapes and dimensions recommended by the CCRMP. These areas are considered high priority project locations. Opportunities for groundwater recharge and reestablishment of valuable riparian features should be considered at all project sites. Figures 16 and 18 present plan view sketches of possible channel sculpting and smoothing projects located downstream from the Stephens and Esparto bridges, respectively. They consist of removal of portions of the existing low in-channel levees left from previous mining and the construction of terrace features adjacent to the channel banks. Figures 17 and 19 show cross section sketches of these two project areas. The proposed channel sculpting and smoothing complies with the target channel templates presented in Figures 5 and 6.

CHAPTER 4.0 CHANNEL MAINTENANCE

This section describes expected channel maintenance activities under the CCIP. Channel maintenance activities are in addition to the recommended activities described in the previous section as high priority channel improvement projects, and are based on the same objectives for stream stability. In general, channel maintenance activities are smaller in scale than improvement projects, and would be performed to address local conditions that need to be corrected to prevent larger stream stability problems.

4.1 ANTICIPATED NEED FOR CHANNEL MAINTENANCE

Implementation of the CCRMP and CCIP will improve channel stability over the long term, but significant channel adjustments can be expected under present conditions, especially during periods of high flow. It is anticipated that channel maintenance requirements will decrease as the channel becomes more stable over time. However, some degree of channel maintenance will be required for the foreseeable future to ensure that flood carrying capacity is preserved, and to reduce the risk of bank erosion, lateral channel migration, and significant degradation or aggradation of the stream bed in specific locations.

The Streamway Study (NHC, 1995) illustrated the non-uniformity in sediment transport capacities of the channel under present conditions. Even in the absence of aggregate extraction or other human influences, the channel can be expected to make significant adjustments by eroding or depositing sediments at various locations in the bed of the stream. These processes may lead to local changes in channel form and lateral instability. Although the channel might eventually adjust on its own to a more stable form, correction of the current imbalances in transport capacity would likely take a very long time. The improvement projects prioritized in Chapter 3 are intended to reduce the rapid changes in transport capacities that presently exist and thereby promote a more stable stream system. However, these projects will not immediately improve all areas of the stream, and the projects may not all be implemented for several years. During the first 5 to 10 years of CCIP implementation, fairly substantial requirements for channel maintenance should be anticipated to prevent sudden changes in the channel and erosion of its banks, and to help guide the stream toward a more stable form.

The monitoring program described in Chapter 6 is designed to provide information that will assist in making decisions regarding channel maintenance. Water and sediment discharge data will be collected to better understand creek hydrologic and sediment transport processes, topographic data will be collected to monitor changes in channel form and elevations, vegetation conditions will be monitored, and the TAC will make an annual evaluation of bed and bank stability in an annual monitoring report to the Board of Supervisors. This monitoring program will be used as the basis for making decisions regarding channel maintenance activities.

4.2 TYPICAL CHANNEL MAINTENANCE ACTIVITIES

The Streamway Study presented a Test 3 Concept (described in Chapter 3) to characterize the types of improvement projects that might be effective in improving channel stability. In addition, typical stream templates were presented that prescribed proposed limits on channel shaping and smoothing within the channel to improve stability. These templates have been incorporated into the Aggregate Resources Element of the CCRMP (refer to previous section of this report). Removal of in-stream sand and gravel beyond these purposes is precluded by the CCRMP. Use of the templates to guide channel maintenance activities will result in formation of a more compound channel than presently exists. Specific maintenance activities will be recommended by the TAC based on an annual inspection and analysis of monitoring data. However, it is possible to describe in general terms the types of activities anticipated:

Gravel Bar Skimming to Maintain Hydraulic Capacity or Reduce the Probability of Bank Erosion

The deposition of sediments in bars may reduce overall channel capacity, especially if dense vegetation develops on the bar. In some areas of the channel, reduction of capacity may not be adverse, or may even be beneficial. However, where channel capacity would become reduced below the level of the 100-year flow, or where it would be reduced from a present capacity below this level, aggradation in the channel would not be acceptable, unless the loss of capacity is compensated by other channel modifications. Bar formation also influences the distribution of flow in the channel, and growth of bars on the inside of a bend can result in erosion of the opposite bank. In this case, skimming of the bar to reduce its size and height can reduce erosive force on the opposite bank. Mid-channel bars can result in erosive pressure on both banks. Care must be taken to make relatively minor changes in bar size to avoid the possibility of major channel adjustment that could relocate erosion or capacity problems to another location.

Vegetation Removal to Maintain Hydraulic Capacity or Reduce the Probability of Bank Erosion, or to Remove Undesirable Species

Vegetation retards flow velocities and reduces hydraulic capacity. The effect of vegetation is normally beneficial in reducing velocities and protecting stream banks from erosion. However, the presence of vegetation in the center of a channel has a significant effect on hydraulic capacity and can adversely affect flow distribution in the channel in a manner similar to mid channel bars. Where hydraulic capacity is a concern, vegetation should be limited to the terraces of the channel, or to relatively narrow strips along the thalweg. Bar formation and vegetative growth are often interdependent. The formation of a bar provides sites for colonization by vegetation, which reduces flow velocities and promotes further development of the bar. This process is a normal part of creek behavior, but can in some instances result in undesirable reductions in capacity or erosion of channel banks. Removal of vegetation or reduction of vegetation densities may be sufficient to prevent further bar formation or to promote scour of the bar surface by the creek. Undesirable species such as giant reed and tamarisk are invasive in Cache Creek and are extremely resistant to scour. Control of these species by chemical means is necessary in any location where dense stands would result in adverse changes in hydraulic capacity or bank erosion potential.

Minor Bank Protection Works

It is expected that bank erosion will occur in multiple locations along the channel on a small scale, as well as in a few locations on a larger scale. The larger problems, especially in the Jesus Maria Reach, are beyond the scope of channel maintenance solutions. However, smaller scale problems can be addressed in the channel maintenance program. While revetment may be necessary in some instances, maintenance activities should focus on changing hydraulic conditions that lead to the problem by promoting lower velocities close to the bank, and protecting banks with vegetation or bio-technical erosion control techniques. Minor grading work, combined with strategic planting in suitable locations, can be used to promote the compound channel shape illustrated by the templates, reducing bank heights and resulting in lower velocities in the near-bank area. Maintenance activities need not always provide fail-safe protection against bank erosion, but rather should promote hydraulic conditions that reduce the potential for erosion. Experimentation with techniques that combine minor grading, revegetation, and bio-technical protection techniques should be promoted. These types of projects may provide opportunities for landowner or citizen group participation.

Removal of Debris at Bridges or Upstream of Bridges Susceptible to Debris Accumulation

Debris is transported downstream in the Cache Creek channel during high runoff. In major floods, debris collection on bridges can significantly reduce hydraulic efficiency of the bridge opening and result in locally high velocities and bed scour. Problems with the stability of bridge foundations, abutments, and channel banks can result. A small amount of debris collected on a bridge can promote rapid accumulation of additional debris during flood flows, resulting in a situation that prevents debris removal until after the event has passed. Normal maintenance activities should include removal of debris from the bridge area, and from channel areas upstream of bridges. Bridges with narrow spans between piers and which are skewed to the flow are particularly susceptible to debris accumulation.

Maintenance of a Defined Low Flow Channel

Under present conditions, the low-flow channel of the creek is often obliterated or modified by aggregate extraction operations. This situation results in instability of the channel as flows increase in the fall and winter. The Streamway Study recommends maintenance of a low flow channel through controlled releases of water from upstream locations and by avoiding disturbance within 300 feet of the low flow channel. In addition, excavation is not permitted by the templates below a level of six feet above the thalweg elevation. These recommendations will allow a more stable, naturally armored main channel to develop. In some areas, this low flow channel may be temporarily filled with sediment deposits or vegetation in response to hydrologic conditions or channel conditions upstream. In these cases, a low flow channel should be maintained by excavation, in a form similar to the templates.

Excavation is not permitted by the templates below a levee six feet above the thalweg elevation, except where the build-up of aggregate material would reduce channel capacity to below the 100-year flood capacity. Adjustments to the recommended cross-section templates may be necessary to permit aggregate removal under these circumstances.

Internal Levee Repair

Maintenance of Cache Creek flood control levees in the Hoppin and Jesus Maria reaches is the responsibility of the Department of Water Resources. In addition to these flood control levees, many internal levees are located on Cache Creek that were constructed to isolate gravel extraction pits from the main channel. Although it may be desirable to eventually remove or lower many of these levees as vegetated terraces are created in the restored pits, their immediate removal or failure could result in stream stability problems. Therefore, minor repair of these levees should be anticipated in the short term, to prevent rapid transitions in stream width at elevations associated with discharges less than the 2 to 5 year event.

Channel maintenance activities involve working in the creek with heavy equipment, and therefore are subject to permitting constraints. Typical activities may include grading with dozers, hydraulic excavators, or scrapers; removal of aggregate materials from the channel by truck or scraper; removal and disposal of vegetation; removal of debris; and planting or placement of bio-technical erosion control materials.

Rights-of-way or rights-of-entry will be required for channel maintenance work. The TAC will coordinate the necessary landowner agreements and easements. It is anticipated that most, if not all, channel maintenance work will be landowner initiated. The TAC will consider possibilities for cooperative design, financing, and construction of channel maintenance activities with interested landowners, and will serve as a technical resource for landowners planning these types of projects. The TAC will attempt to secure grants and other alternative funding for this and other components of the CCIP.

CHAPTER 5.0 DESIGN GUIDELINES FOR CHANNEL STABILIZATION AND MAINTENANCE

5.1 REVIEW PROCESS FOR CHANNEL STABILIZATION AND MAINTENANCE

The role of the TAC in the CCIP program is presented schematically in Figure 20. The TAC will meet regularly to discuss 1) information from the monitoring program, 2) feedback and requests from the CCSG, and 3) recommendations and concerns from the Board of Supervisors. Following review of annual maintenance activities, proposed improvement projects and annual monitoring information, the TAC will prepare recommendations for the coming construction and maintenance season. Depending on the amount of change in channel conditions observed from previous years, the TAC may recommend updating the County's numerical models and re-evaluating the hydraulic and/or sediment transport characteristics through the study area. Results from the TAC's annual inspection, review of the annual aerial photos and review of updated hydraulic and sediment transport information will support the TAC's recommendations to the Board for various maintenance and channel improvement projects.

Significant channel improvement projects, such as those described in Chapter 3, will require detailed engineering design. All projects proposed by individual landowners which would result in modifications to the channel within the 100-year flood hazard zone would require a Floodplain Development Permit (FDP). Designs for these projects would be submitted to the Yolo County Community Development Agency. The design of the projects would be reviewed by the TAC for conformance with the CCIP prior to approval of the FDP for the proposed project. Major projects may require the application of refined hydraulic and sediment transport models to specific creek reaches to develop design parameters. The TAC will make available flow and sediment discharge data collected under the CCIP, current versions of hydraulic and sediment transport models, and information on channel stability trends in the vicinity of the proposed project.

Annual channel maintenance activities will be smaller in scope than the significant channel improvement projects and can be accomplished based on the application of a set of adopted standards. The TAC will develop and adopt a set of standards within one year of its formation. The design guidelines described below will form the basis for development of the standards.

5.2 DESIGN GUIDELINES

This section describes design guidelines based on results of the Streamway Study and creek stabilization standards of practice. The section applies to both major stabilization projects and channel maintenance activities.

Channel Stabilization

Present conditions on Cache Creek involve radical changes in transport capacity along the stream's course. These changes and the constant disturbance induced by mining near the thalweg of the stream result in both vertical and lateral instability.

Many channel stabilization and erosion control techniques are available for controlling bed and bank erosion that occurs along alluvial streams. The literature is voluminous regarding these measures, often referred to as *erosion control countermeasures.* A countermeasure is defined as a technique used to control, inhibit, change, delay, or minimize stream stability problems. Countermeasures can be installed at the time of the initial development of a channel improvement project or retrofitted to resolve stability problems as they develop. Retrofitting and sound maintenance practices are practical because it is difficult to predict the location, magnitude and nature of potential instability problems. When selecting a countermeasure it is necessary to evaluate how the creek might respond to the countermeasure at the site and up- or downstream from the site. A very brief summary is presented here of some of the more viable methods for channel stabilization and erosion control for Cache Creek. Sketches of the some of the methods are provided for the convenience of the reader.

Stream stabilization and erosion control measures can be grouped into at least seven categories: *discharge control, revetments, dikes, vegetation (and biotechnical methods), alignment adjustments, bank drainage, and bed scour controls. Discharge control* requires that the erosive stream flow is routed through an upstream detention facility (dam or reservoir) to reduce the rate of flow thus reducing the flow's erosion power. *Revetments* (Figures 21 and 22) include placing stone or concrete on the channel bank to resist the erosive forces of the flow. *Dikes*, commonly referred to as groins or spur dikes (Figures 23 and 24), direct flow away from eroding surfaces or reduce the erosive forces along the channel bank by diverting the stronger currents. *Permeable dikes* and *groins* are often called *flow retarder structures* (Figure 25). *Vegetation* can be substituted in place of stone, concrete, timber or other materials for some erosion/stabilization sites (Figure 26). It is often advantageous to combine structural (stone or concrete) features with vegetative alternatives in the form of "*biotechnical solutions*" (Figure 27) to erosion and/or stabilization problems. The success of vegetative measures depends on the survival of the vegetation and substrate stability. The vulnerability of vegetation should be considered in site selection. For some problems *alignment adjustments* are appropriate. Care must be exercised, however, to ensure that the realignment does not result in the relocation of the problem elsewhere.

Creek realignments usually require placement of spur dikes, groin fields and revetments to encourage the main thread of the creek's flow path to relocate. There are many locations along the study area of Cache Creek where rather significant gully erosion is occurring at locations where floodplain drainage enters the creek. This situation can also contribute to further saturation of the banks which increases the likelihood of bank failure due to mass wasting. Upper bank drainage should be collected and allowed to enter the creek in erosion resistant channels or inlets. Channel incision and scour are very complex processes. Channel bed incision (erosion) occurs in locations where the hydraulic energy (flow) exceeds the ability of the bed to remain stable. Rock, concrete, soil cement or biotechnical bed armoring procedures can help control bed erosion. Applications of channel bed *erosion control mattresses* (Figure 28) are common at bridge crossings where rapid flow acceleration results in local bed scour.

Selecting Countermeasures

Selection of an appropriate countermeasure to resolve a specific channel stability problem is dependent on many factors, including the erosion mechanism causing the problem, local and regional creek characteristics, construction and maintenance requirements, potential for vandalism, and costs. Creek characteristics that most influence the selection of countermeasures include: channel width; bank height, configuration and material properties; vegetative cover; channel bed sediment transport characteristics; channel bend radii; channel velocities; and flow depth.

5.3 CONDITIONS, TECHNIQUES, AND COUNTERMEASURE DESIGN CONSIDERATIONS

Applicable repair and maintenance techniques for various problem types and physical/hydrologic settings are summarized in Table 11. For example, bank erosion due to contraction at bridges is a problem type, and guide banks, bank revetment, bridge widening, and smooth channel transitions are applicable techniques. Table 11 lists typical channel stability problems found on Cache Creek in the first column. The second column suggests different countermeasure techniques to correct erosion and stability problems. The third column lists specific references where design criteria and design procedures are specified. The last column indicates whether these problems and solutions are categorized as significant priority type projects, or projects of lesser magnitude that can be accomplished through the annual maintenance program. Specific design dimensions for stabilization countermeasures listed in Table 11 cannot be anticipated and will require site-specific design by the TAC. As described in Chapters 3 and 5, the TAC will review annual needs for maintenance and improvement projects. The TAC, with the assistance of consultants as needed, will develop specific project designs in accordance with the goals of the Test 3 concept and the CCRMP.

5.4 SUMMARY OF RECOMMENDED DESIGN GUIDELINES

Recommended design guidelines are presented in the Technical Studies Report and the CCRMP. The guidelines are summarized below.

1. Design and implement priority projects (see Chapter 3) that promote beneficial adjustments in the creek which meet the stated objectives of the CCRMP, while allowing flexibility for the creek to shape its own recovery and restoration over time.

2. The estimated average annual volume of annual sand and gravel delivered to the CCRMP study area is 210,000 tons per year. Individual years and flood events may vary the supply and aggregate extraction should follow that variability based on results from the annual monitoring program presented in Chapter 6. Aggregate extraction in local areas may be necessary on a one-time basis as part of priority channel stabilization projects (refer to Chapter 3). Extraction would be performed in accordance with the target stable channel characteristics listed in Table 9 and cross section templates shown in Figures 5 through 8.

3. In the near term, allow in-channel reshaping and smoothing at rates greater than the annual supply in locations identified by the TAC, in order to implement the Test 3 Model.

4. Individual landowners can propose reshaping and smoothing projects to mitigate local channel instabilities. Project designs must comply with the target channel characteristics summarized in Table 9 and Figures 5 through 8. Final designs will comply with local County design criteria, preserve channel stability and 100-year flood flow capacity without adversely affecting neighboring creek reaches. Final designs must be reviewed by the TAC and Department of Public Works.

5. Projects affecting the 100-year floodplain within the CCRMP plan boundary will require review by the Technical Advisory Committee and approval of a Floodplain Development Permit (FDP).

6. Revoke the theoretical thalweg concept and 1979 mining boundary. Use management targets for channel characteristics listed in Table 9.

7. Manage grading within the channel (for priority projects or annual maintenance) in compliance with the target stable channel templates shown in Figures 5 through 8.

8. Opportunities for groundwater recharge and reestablishment of valuable riparian features should be considered at all project sites.

9. Integrate riparian vegetation into overall hydraulic and sedimentation design, and management plans.

10. Use riparian vegetation, where appropriate, to provide bank stabilization and to create smoother transitions between reaches with differing hydraulic capacities.

11. Avoid channel bed lowering and permanent degradation through maintenance and channel management. Consider the design and installation of grade controls as major channel improvement projects if regular maintenance and channel management are unsuccessful in stopping further bed lowering in critical reaches or in the vicinity of bridges. Use vegetation and biotechnical measures wherever practical.

12. Limit changes in channel form and manage the channel toward a compound cross sectional shape. Establish vegetation and maintain at levels that will not result in overtopping of historical channel banks or increase in the 100-year flood elevation. Control weed invasion and adverse flow orientations by improving channel characteristics and performing regular maintenance.

13. Manage and maintain in-channel vegetation to ensure it is part of the solution to channel stabilization and not contributing to the problems. Annual maintenance will be guided by the TAC and will include selective clearing and thinning of in-channel vegetation, in a manner sensitive to the surrounding riparian habitat.

14. Use managed sand and gravel removal (bar skimming) to promote and maintain channel stability and flood capacity. Use managed clearing and thinning of vegetation to promote and maintain channel stability and flood capacity. Channel maintenance will be managed by the TAC based on annual monitoring and numerical analyses.

15. Plan, design, and implement priority projects listed in Chapter 3 to improve channel stability and promote more uniform hydraulic capacity with a stable compound shape.

16. Require completion of reconnaissance-level biological inventories before implementation of priority projects.

17. Promote the development of off-channel aggregate extraction to replace the present supply from the creek. If no flood protection or erosion control measures are proposed, a setback distance of 700 feet is recommended from the present bank line and the edge of off-channel pits. Where control measures are proposed, a minimum setback of 200 feet is recommended only if no adverse affects to bank stability and groundwater can be demonstrated. Project-induced creek capture must not be allowed.

18. Implement smooth transitions through the bridges to reduce bed and bank scour and improve the overall hydraulics of the system (refer to Figures 8 through 15). Smooth and sculpt the channel to remove or reduce abrupt channel changes.

19. Allow for flexible channel management of the creek so changes can be made to components of the CCIP, where and when necessary, based on new information in the future. Continuously collect monitoring data and analyze and document those data yearly. Review and revise the priority project list and maintenance management procedures every five years.

20. Some priority projects may require the construction of sections of levees to smooth and resculpt the channel to a more stable configuration. Levee design guidelines presented in the Corps, FHWA and Caltrans references listed in Table 11 should be used for design purposes. All levee designs will be based on thorough

geotechnical engineering analyses based on the local bed and levee materials at the project site. All levees designed to confine and control creek flows will be designed for 100-year flow conditions with no less than 3 feet of freeboard.

21. All levee projects must be reviewed by the TAC and the YCCDA and receive Floodplain Development Permit approval. Other State and Federal permits may also be required.

22. Bank revetments, spur dikes, groin fields, hard points, toe revetments, bridge transition projects, rock sill, grade controls, biotechnical bank protection projects, and channel shaping (smoothing and widening) must comply with the design guidelines summarized in Table 9 and Figures 5 through 8. Final designs must comply with County design criteria, and be reviewed by the TAC, and the County Floodplain Administrator if the projects require modification to the 100-year floodplain. An FDP permit may be required. Other State and Federal permits may also be required.

CHAPTER 6.0 MONITORING PROGRAM

This section describes a proposed monitoring program to collect and analyze data for the purpose of making resource management decisions for the Cache Creek channel on a continuing basis. A monitoring program is described to collect pertinent information regarding water and sediment discharge, changes in channel morphology, and changes in riparian vegetation. The monitoring program described herein is designed to be flexible and practical while assuring that essential data are regularly collected at key locations to support creek resource management decisions. Assuming the data collection program may be funded incrementally, allowing the monitoring program to possibly be expanded over time, the TAC will establish priorities for installation of gages and collection of data. The TAC will describe in their annual reports expected needs and recommended changes in the intensity and location of data collection activities as the channel adjusts over time. Data will be collected and analyzed under direction of the TAC, and the TAC will use the monitoring results to make decisions and recommendations for improvement projects, annual maintenance activities, and flood hazard reduction opportunities. In addition, the TAC will periodically review the monitoring program's effectiveness and costs, and make revisions as necessary to collect required quality information at minimum cost. The process by which monitoring results will be incorporated into TAC decisions was outlined in Chapter 2.

6.1 EXISTING DATA AND INFORMATION

Water and Sediment Discharge Data

The existing streamflow and sediment data available for Cache Creek were summarized in the Cache Creek Streamway Study (NHC, 1995). Figure 29 shows the location of existing stream gages for the portion of the Cache Creek basin upstream of Yolo. Table 12 summarizes existing streamflow data at several gages on lower Cache Creek (downstream of Clear Lake) and on Bear Creek, a major tributary of Cache Creek. Several gages have discontinuous records or are no longer in service. The gages of particular importance to the CCRMP area are the Rumsey, Capay, and Yolo gages. Data availability plays a role in limiting the current understanding of Cache Creek hydrologic and sediment transport processes. In spite of the importance of inflowing sediment loads to aggregate availability in the plan area, sediment discharge data on Cache Creek are extremely limited. The USGS (USGS, 1989) collected 56 suspended sediment samples at Capay and Brooks, and also collected six bedload samples. Inflowing loads were estimated in the Streamway Study using a water-sediment discharge relationship for suspended sediment developed by least squares regression of the USGS data. Due to the scarcity of bedload measurements, inflowing bedload was estimated as a percentage of suspended load according to practices documented by the USGS (1989) and Lustig and Busch (1967).

Comparison of streamflow data for gages at Rumsey, Capay, and Yolo indicate that the discharge is diminished in downstream progression, although tributary area increases. The explanation for this decrease was beyond the scope of the Streamway Study, but has important consequences for flood control, bank stability, and sediment transport through the plan area.

Topography and Channel Form

Since 1981, Yolo County has completed topographic mapping of Cache Creek between Yolo and Capay during the fall of the year. Mapping for the years 1981 to 1985 is available in hard copy format, and mapping for years 1986 to 1995 is available in digital form. The 1995 data has been incorporated into the County's GIS system. The Streamway Study used historical maps and aerial photography to characterize changes in channel form from 1937 to the present. The results of these comparisons have been entered into the County's GIS system. The Streamway Study modified stream cross-section data from the Westside Tributaries Study (COE, 1994) to generate hydraulic and sediment transport computer models. These cross-sections were updated from 1992 data during the Streamway Study, but have not since been updated with information available from the 1995 aerial topography. The Streamway Study also summarized existing channel geomorphic and hydraulic characteristics by reach. Existing channel characteristics were summarized in Chapter 3 (Tables 2 through 8).

Vegetation and Riparian Habitat

Existing riparian habitat in the CCRMP area was summarized in the Biological Resources Study (EIP, 1995). The extent of existing habitat types is shown on Figure 5.4-2 of the Technical Studies for the CCRMP (EIP, 1995). Table 13 summarizes habitat types and acreage within the plan area. These data have been incorporated into the County's GIS system. Information regarding the historical extent of riparian habitat is available from aerial photography (back to 1937) but has not been compiled in map form.

Bridges and Infrastructure

The Streamway Study summarized the history of bridges within the CCRMP area, and computed potential scour depths at all bridges. Plans are available for the present bridges through the Yolo County Public Works Department and Caltrans. Other infrastructure in the CCRMP area includes facilities operated by the Yolo County Flood Control and Water Conservation District (YCFCWCD) and Pacific Gas and Electric (PG&E). Plans are also available for the district facilities, and the district maintains operational records of diversions in various canals.

6.2 MONITORING PROGRAM OVERVIEW

The purpose of the monitoring program is to provide dependable, up-to-date channel condition data on which the TAC can base recommendations for management of the creek. In particular, the results of monitoring will be used to evaluate the need for improvement projects, annual channel maintenance, and hazard response. The data will be used directly in the design of these projects and activities. Due to the relative scarcity of existing data, analysis of monitoring program data will promote a better general understanding of Cache Creek processes, and their importance in channel stability. Therefore, changes in the recommended channel improvement program, and in the monitoring program itself, are expected based on this improved understanding. It is therefore anticipated that the annual monitoring program will be modified and refined over time as the TAC's understanding and management of the creek improves.

The objectives of the proposed monitoring program are to:

1. Improve present estimates of average annual inflowing sediment load;
2. Improve the present understanding of creek hydrology, including flood-frequency, flow- duration, and channel storage/loss relationships;
3. Estimate inflowing sediment load on an annual basis;
4. Monitor changes in channel form and topography, including those directly associated with improvement project and channel maintenance activities;
5. Monitor changes in vegetation and riparian habitat annually; and
6. Monitor bridges, levees, and other infrastructure to detect and prevent damage.

These data will be evaluated annually by the TAC in making designs and recommendations for channel improvements, channel maintenance and hazard response activities.

6.3 RECOMMENDED MONITORING PROGRAM

Water and Sediment Discharge

The water and sediment discharges of the creek, and their pattern over time, interact with biological and human influences to determine channel morphology. Except for discharge at Yolo, these key factors are presently not measured in the plan area. The locations of proposed monitoring points for normal and flood flow measurements of water and sediment discharge are shown in Figure 30. These measurements will allow development of improved water-sediment discharge relationships, and will assist the TAC in developing a better understanding than presently exists of hydrologic and sediment transport processes. The importance of a long-term monitoring record can not be overemphasized. Due to the high degree of variability in Cache Creek discharge from year to year and through each annual cycle, long-term data records are necessary to determine statistical relationships and to determine trends. The monitoring locations shown in Figure 30 have been selected to take fullest advantage of existing data in developing long term relationships.

The monitoring program outlined here is intended to focus on specific needs of the CCRMP. In the long term, Yolo County may wish to implement an automated, "real-time" system of precipitation and runoff gage measurement. While the program described here is not a comprehensive automated system, its elements would be compatible with implementation of such a system.

The following data will be collected at the proposed monitoring locations:

Water Discharge, Continuous - A continuous creek stage recording gage is located at the Rumsey bridge. This gage is currently maintained by the Department of Water Resources, and has telemetry capabilities. As part of the CCIP, the TAC would arrange to obtain real time data telemetered to Yolo County from the Rumsey gage.

Water Discharge, Continuous and Sediment Discharge, Sampling Program - In addition to continuous water discharge monitoring, periodic sampling of suspended sediments, bed material, and bed load over a range of flow conditions are required to develop a sediment discharge rating curve. Real time discharge data would be telemetered to Yolo County. Approximately five measurements per year are anticipated to be performed by field crews. Two gaging stations would be used to characterize inflow (Capay) and outflow (Yolo) from the CCRMP area.

In the future a possible third station located at Madison to define changes in discharge and sediment transport through the CCRMP area would be installed. Flow and sediment load data at Madison are important because there are presently no data available to indicate channel hydraulics and sediment transport conditions in the main CCRMP study reach. Data from the Capay and Yolo gage sites will provide information at both inflow and outflow boundaries to the study reach only.

The gage at Yolo is currently maintained by the USGS, but does not have telemetry capability. The new gage at Capay, including a cableway, would be installed and maintained by the County (or by agreement with another agency).

High Flow Water and Sediment Discharge - Monitoring of water and sediment discharge during high flow events requires mobilization of field crews during winter runoff events to measure discharge, suspended sediment and bed load. A staff gage and peak recording gages would be installed at each monitoring location. Comparison of high flow discharge and sediment measurements to continuous gaging location results would yield information regarding the relative timing and magnitude of peak flows at various points, transport of sediments through the Cache Creek system, and general channel sediment storage/losses. In addition to two stations on Cache Creek, one future station is proposed on Goodnow Slough to characterize inflows from this source. An average of approximately five measurements per high flow year at each site are anticipated.

Bed Material Sampling - In addition to the samples collected during discharge and high flow measurements, bed material grab samples will be collected annually in each of the seven reaches identified in the Streamway Study within the CCRMP area. Two samples per reach will be collected. These samples will be collected at the time of the TAC's annual inspection (see below). Samples will be taken from exposed bar areas that are representative of the material being transported along the stream's bed during higher flows. Grain size distribution curves will be prepared for all samples annually.

Topography and Channel Form

Changes in channel form will be monitored by comparison of annual aerial topography and cross-section surveys. A set of cross-sections will be generated by aerial methods each year at fixed locations, selected by the TAC. Aerial survey data may be supplemented with additional field or aerially surveyed cross-sections in areas where increased accuracy is determined to be necessary by the TAC. Aerial survey data will be compiled in Digital Terrain Model (DTM) format (or files compatible with terrain model generation in the County's GIS system) to facilitate cross-section generation for use in hydraulic and sediment transport modeling, for use in volumetric comparisons, and for use in design of improvement projects and maintenance activities. Aerial surveys will have a contour interval of 2 feet, and be prepared in hard copy format at a scale of 1 inch = 200 feet. Horizontal coordinates will be based on the California Coordinate System, Zone 2. Existing survey control points will be used in performance of the aerial surveys, with annual checks to repaint and reset, where necessary, disturbed control points. Every five years the control net will be checked (resurveyed by the County surveyors or survey contractor) for vertical accuracy to detect variations due to land subsidence.

Aerial photography and compilation of the DTM will be performed once a year in the late spring (exact timing will depend on flow conditions). The TAC will specify locations for additional cross sections, if any, based on annual inspections (see below). In addition to the spring surveys, portions of the channel affected during the summer season by significant channel improvement or maintenance activities will be surveyed by the people performing the improvements or maintenance upon completion of those activities.

The aerial photography used for topographic mapping will be used to generate halftone mylar photo enlargements of the Cache Creek channel at a scale of 1 inch = 200 feet. These enlargements will be used by the TAC in annual inspections and for the purpose of monitoring changes in vegetation and riparian habitat.

Vegetation and Riparian Habitat

Every five years, the TAC will prepare a riparian habitat survey and map for incorporation into the County's GIS system. The riparian habitat survey will present measurements or estimates by subreach or subarea of the following:

1. Percent cover;
2. Crown height of trees (by age or size class);
3. Vigor;
4. Invasion by exotic species (or particular problem species);
5. List of special status species present;
6. Natural recruitment/regeneration; and
7. Changes in vegetative and habitat characteristics from previous evaluation.

These measurements will be recorded on maps in a format suitable for incorporation into the County's GIS system. Maps will be produced through a combination of field inspection and use of aerial photo enlargements.

As part of the vegetation monitoring program, the TAC will install a series of piezometers in the creek channel to measure groundwater levels. At least one piezometer per stream reach is recommended, with locations to be determined by the TAC. Piezometers will be monitored twice each dry season (June through October).

Annual Inspections

At the end of each runoff season, the TAC will make an annual inspection of the creek to document channel conditions. Conditions that will be noted include:

1. Evidence of changes in channel dimensions or bank erosion;
2. Evidence of bed degradation or aggradation;
3. Significant changes in the locations or sizes of bars and other channel features;
4. Degree of channel armoring and bed material imbrication;
5. Vegetation located within the center portion of the channel (within 100 feet of the low flow channel), including type, density, and size;
6. Conditions at bridges along levees and other major infrastructure;

7. Potentially hazardous conditions involving public safety or property damage;

8. General hydraulic condition of the channel based on qualitative comparison with previous years (e.g., restrictions due to vegetative growth, changes in bed form, etc);

9. General evaluation of channel and bank stability on a reach-by-reach basis;

10. Identification of areas where vegetation may be getting so thick as to adversely alter flow direction or reduce channel capacity; and

11. Areas where the existing capacity of the channel can no longer contain a 100-year flood event, or is nearing the loss of such capacity.

Notes from the annual inspection will be prepared on the photo base.

Flood Monitoring

Significant channel changes have historically occurred on Cache Creek during major floods. During periods of major floods in which the discharge at Rumsey exceeds 20,000 cfs, more intensive data collection is warranted to collect important water and sediment discharge data. Although an average of five high flow monitoring measurements at each site is anticipated, adequate monitoring of a single flood might require more than this number of measurements. If possible, water and sediment discharge measurements should be made at all stations at least once a day for each day that the flow exceeds 20,000 cfs. Depending on access and safety, efforts should be made to measure rising limits, peak flows and recession flow periods.

The Cache Creek channel has historically responded to major floods by making major lateral and vertical adjustments in channel form. Bank migration, loss of riparian vegetation, damage to bridges and other infrastructures, overbank flooding, and channel incision are problems that occur during large floods. At the present time, there are no procedures in place for monitoring and responding to flood events on Cache Creek. Both Yolo County and the Yolo County Flood Control and Water Conservation District are typically involved in monitoring flood situations that could threaten infrastructure or private property, but a coordinated proactive program for response to floods is lacking.

This section does not prescribe a comprehensive flood management plan, but outlines the participation of the TAC in flood watch activities and a high flow monitoring program. Such a program can become an integral component of a more comprehensive, County-wide flood management plan. The TAC will not have responsibility or authority for flood hazard response, but will be available to participate, on behalf of the County, to monitor and respond to Cache Creek floods. Several elements of the monitoring program described will assist the County in monitoring flow conditions on a real time basis, and preparing for potential flood conditions.

Observation and measurement of how Cache Creek responds to high flow events is critical to the CCIP. Understanding how the creek responds during high flows is important for proper creek resource management and maintenance activities. Flood watch activities include monitoring creek flows, precipitation, and watershed conditions to determine when flood flows are likely to occur in the CCRMP area, mobilizing personnel and equipment to monitor conditions in the area, and coordinating the activities of these personnel. The TAC will develop a plan to accomplish these objectives, including the following basic elements:

1. Procedures for monitoring discharge at the Rumsey gage and precipitation in the upper watershed to determine when flood flows are likely. For the purposes of this program, a discharge greater than 25,000 cfs is considered a flood flow. This discharge has about a 20 percent chance of occurring in any year (5-year flood). Procedures must include assignment of staff for 24-hour availability, and establishment of contact procedures with the National Weather Service for flood watch and flood forecast information.

2. Procedures for TAC contact with the Yolo County Public Works Department and YCFCWCD on a 24-hour basis to mobilize personnel and equipment necessary for monitoring purposes.

3. Selection of a TAC flood watch coordinator and an alternate to manage observations and monitoring of high flows .

4. Procedures for notification of other agencies (e.g., City of Woodland, Caltrans, DWR, USGS, etc.) of identified hydraulic problems or hazards, and advance notification of these agencies of flood watch and contact procedures. Although the CCIP has no authority or responsibility for flood hazard warning, the intent is that monitoring personnel will cooperate with other County emergency groups and notify them if problems are observed.

5. Establishment of flood flow monitoring and record keeping procedures for flood watch activities.

Data Analysis

Data compilation and analysis will be under the direction of the TAC. Data will be stored in a database integrated into the County's GIS system. Retrieval of data for use by the private sector will be billed at standard rates or by hourly charge for the time spent by County employees. Collection of the data is the first step in assembling the database. However, data checking, compilation, and analysis must also be performed on an ongoing basis to result in useful long term data. This section describes the procedures for compiling the data into a database system and making preliminary analyses for use by the TAC.

Water and Sediment Discharge - Water discharge at continuous gages is computed by means of a stage-discharge rating curve. This curve relates stage in the stream (water surface elevation) to discharge. Changes in the channel at or in the vicinity of the gage will result in changes in the rating curve. Streams that are in the process of incising (like Cache Creek) may require annual adjustments in the rating curve. The rating curve is established and maintained with actual discharge measurements, usually involving measurement of velocity and flow area in segments of the stream's cross-section. To develop a rating curve, multiple measurements are required over a range of discharges. Therefore, initial installation of a continuous gage requires many measurements in the first few years to establish a reliable rating curve, and measurement of high flows continues to be important to the accuracy of the rating curve throughout the gage's service life. Data collected by continuous recorders or via telemetry must be checked to eliminate errors. In addition, the gage equipment itself must be periodically checked and maintained to ensure proper operation and to collect recorded data.

Sediment data collection requires field sampling and laboratory analysis. The field sampling work involves collection of suspended and bed sediment samples, organizing and labeling the samples, and transporting samples to a laboratory for analysis. Suspended sediment samples are analyzed for total weight of sediment per unit weight or volume of water, and for gradation of the sediment by size. Bed load samples may be analyzed for weight collected per unit time and for gradation. Laboratory analysis may be performed, as needed, to yield gradation of the collected samples. Bed load transport supplies aggregate to the CCRMP area in the sizes that have been commercially mined. Bed load samples are useful in confirming the ratio of bed load to suspended load transport at various discharges (necessary to compute total load), and to confirm the accuracy of transport functions used in sediment transport modeling. However, at very high flows, bed load sampling may not be practical due to limitations in field equipment and methods. In addition to bed load samples taken from the flowing stream, dry bed material samples collected in each reach at the time of the annual inspection will be analyzed in the laboratory for gradation. Bed load transport can be calculated from stream properties and bed material size. Table 14 lists the type of compilation, analysis, and data storage required for each measurement type.

Topography and Channel Form - Changes in channel topography and form will be determined primarily from annual Digital Terrain Models (DTM) produced annually by aerial photogrammetry. The completed terrain model will be used to record key channel characteristics for comparison to previous years. In addition, a longitudinal profile of the stream within the entire CCRMP area will be made and compared to previous years.

The DTM will be used to locate areas of aggradation and degradation in the stream by comparing DTM surface elevations for the current year with that of the previous year. A grid plot of elevation differences will be produced for areas within the channel. Where significant elevation differences (e.g., greater than two feet over areas exceeding one acre) are identified or suspected, the two surfaces will be compared digitally and a volumetric estimate of aggradation or degradation made. This type of volumetric comparison is not required or recommended over the entire stream surface. In addition to comparison of terrain model surfaces, the TAC will establish cross-section locations for annual comparisons. Data for these cross-sections will be generated primarily from aerial photogrammetry, but a portion of the data may need to be produced by field survey in areas of vegetative cover or below the water surface. In addition to regularly measured cross-sections, the TAC may request additional cross-sections in areas of interest for channel improvement projects or problem areas.

Vegetation and Riparian Habitat - Data generated in vegetation and riparian habitat monitoring will be compiled and stored in the County's GIS system. The TAC will review monitoring data to determine trends by subreach. Data will be compiled and plotted to illustrate changes in acreage by habitat type over the entire CCRMP area, and changes in specific characteristics by subreach. Data comparisons to be tabulated or plotted include percent cover, crown height of trees, number of species present, and level of invasion by exotic species. Piezometer data will be recorded in the County's database.

Annual Inspection - Maps and notes from annual inspections will be stored in hard copy format. Additional analysis of annual inspection results is not required. The observations of the annual inspections will be supplemented by analysis of digital terrain model data for the purpose of identifying and quantifying changes in the channel.

Flood Monitoring - Data from flood monitoring will not normally require analysis, unless requested by the TAC. Discharge measurements will be compiled, stored, and analyzed as described for other water and sediment discharge measurements.

6.4 HYDRAULIC AND SEDIMENT TRANSPORT MODELING

The Streamway Study used hydraulic (HEC-2) and sediment transport (HEC-6) models to evaluate current conditions in the Cache Creek channel. As changes occur in the creek's channel, additional modeling will be required to maintain sufficiently accurate quantitative tools for making management decisions on the creek. Modeling is necessary both to support long-term management decisions and for use in the design of specific improvement projects or maintenance activities. Topics which can be addressed using numerical modeling include flood carrying capacity, bridge scour potential, channel stability, sediment transport characteristics, channel hydraulic characteristics (e.g., width, average velocity, and depth at two year flow frequency), and location of hydraulic constrictions or controls. As monitoring data are collected, the ability of numerical models to duplicate and predict observed conditions will improve.

The use of numerical modeling in the future will be at the discretion of the TAC, as necessary to evaluate significant changes in the creek's morphology (including changes in channel roughness due to vegetation and bar and terrace formation) or evaluate specific projects. The TAC will be responsible for maintaining current versions of both hydraulic and sediment transport models for the entire CCRMP area. The public will have access to these models (at a nominal cost to cover record keeping and reproduction) for use in evaluating specific channel improvement projects.

6.5 PROJECT PERFORMANCE EVALUATION

The TAC will be responsible for evaluating the performance of improvement projects in the creek. Projects may be evaluated using normal annual monitoring data, or additional data may be collected for evaluation of specific projects. The TAC will include special monitoring requirements in the estimated budgets for improvement projects.

6.6 ANNUAL MONITORING REPORT

The TAC will produce an annual report in January of each year for the Board of Supervisors that describes the data collected and analysis conducted as part of the monitoring program. The annual report serves as a regular opportunity for the TAC to step back and take a larger perspective in looking at both the creek and at the CCRMP with a critical eye for improvement. Although this is a complex and ambitious project, it is designed to be adaptive, so that monitoring requirements and management techniques can appropriately address the ever-changing riparian environment. In order to be effective, the annual report should not be seen as a chronicle of recent success or a lackluster recitation of dry data, but must reflect thoughtful self-evaluation. Is information being used? Are other forms of monitoring needed? Is there unnecessary or less-than-useful monitoring that can be eliminated or consolidated? Given the limited budget of the CCIP, are activities being carried out in a cost-effective manner and are the most important priorities being emphasized? Are objectives being met? Are the policy and technical assumptions still valid? Fundamental questions such as these should underlie the annual report, so that recommendations made by the TAC take into account the long-term benefit of both the creek and the community. Review of the report by the Board of Supervisors will provide the necessary policy direction, as well as provide an ongoing public forum for focussing the County's attention on the unique issues that concern Cache Creek. The format of the report will be as follows:

1. Brief description of annual monitoring activities, changes from previous years, and costs. Summary of significant findings, problems, and needs for upcoming year; chapter executive report
2. Summary of annual water and sediment discharge data and notable variations from previous years or period of record; chapter
3. Summary of changes in channel topography and form, including identification of problem areas and summary of desirable and undesirable trends, including any areas where existing channel capacity can no longer contain a 100-year flood event; part of ch. 3
4. Estimate of location and volume of annual sediment replenishment; part of chapter 3
5. Summary of changes in vegetation and riparian habitat; chap 4
6. Summary of flood monitoring results, if applicable;

7. Chap 3 Evaluation of bed and bank stability in the CCRMP area, considering data summarized above. A description of the relationship of problem areas to recommended improvement projects and maintenance activities (see Chapter 2);

8. Chapt 3 Recommendations for changes in prioritization of channel improvement projects; and

9. Chap 5 Recommendations for changes in monitoring program in coming year.

Figure 31 schematically shows the annual schedule for the monitoring program.

REFERENCES

1. EIP, 1995, Biological Resources Study, *Technical Studies and Recommendations for the Lower Cache Creek Resource Management Plan*, prepared for the Yolo County Community Development Agency, October.

2. Lustig, Lawrence K., and Busch, Robert D., 1967, *Sediment Transport in Cache Creek Drainage Basin in the Coast Ranges West of Sacramento, California*, Geological Survey Professional Paper 562-A.

3. Harmon, Jerry G., 1989, *Streamflow, Sediment Discharge, and Streambank Erosion in Cache Creek, Yolo County, California, 1953-86*, U.S. Geological Survey Water Resources Investigations Report 88-4188.

4. NHC, 1995, Cache Creek Streamway Study, *Technical Studies and Recommendations for the Lower Cache Creek Resource Management Plan*, prepared for the Yolo County Community Development Agency, October.

5. U.S. Army Corps of Engineers, 1994, Reconnaissance Report, Westside Tributaries to Yolo Bypass, California, June.

ACKNOWLEDGEMENTS

Cache Creek has historically been a dynamic system, influenced by high flood flows, large sediment supplies, and steep slopes in the upper watershed. These dynamics have been exaggerated by the multiple demands placed upon the creek in the past few decades, as mining, agriculture, and infrastructure have intruded into the floodplain. As a result, the creek has become increasingly degraded and imbalanced. Left on its own, the creek will eventually heal itself and adjust to the artificial constraints placed upon it, but the healing would take decades and may threaten property and lives in the process. Instead, the CCIP provides a program for managing riparian resources in a responsible and sensitive manner, that allows the creek to establish a new, more natural equilibrium. As the process of reshaping the channel and restoring in-stream habitat progresses, the creek will respond to these changes, requiring adjustments in the CCIP to account for these changes. This process will be guided by professional judgement, science, and an extensive monitoring program to keep abreast of Cache Creek as it evolves. The elimination of commercial in-stream mining is an important first step in solving the serious concerns currently associated with the creek, but other problems will continue. In order to properly manage riparian resources, the County must take a larger perspective and look at all of the components of the creek as an integrated system. The CCIP is a broad-based and flexible program, that provides the County with such a perspective, and the means, for enhancing the precious natural resources of Cache Creek.

Yolo County Board of Supervisors

Mike McGowan	District 1
Helen Thomson	District 2
Tom Stallard, Chair	District 3
Betsy Marchand	District 4
Frank Sieferman	District 5

Yolo County Planning Commission

Bob Heringer	District 1
Barbara Webster	District 2
Harry Walker	District 3
Jim Gray, Chair	District 4
Henry Rodegerts	District 5
Nancy Lea	At Large
Kent Lang	At Large

Key Members of Staff

Roy Pederson	County Administrative Officer
David Morrison	Resource Management Coordinator

Project management was provided by Heidi Tschudin of TSCHUDIN CONSULTING GROUP, under contract to the County as an extension of staff.

The primary technical basis for this Plan was provided by the *Technical Studies and Recommendations for the Lower Cache Creek Resource Management Plan* (October, 1995). Kevin O'Dea of Baseline Environmental Consulting was the primary author of this report, with assistance from Bob MacArthur of Northwest Hydraulic Consultants, Inc. The County is grateful for their involvement in this process.

Funding for this project was provided by R.C. Collet, Solano Concrete Company, Syar Industries, and Teichert Aggregates.

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To find out more about this Program, or the process through which it was developed, please contact:

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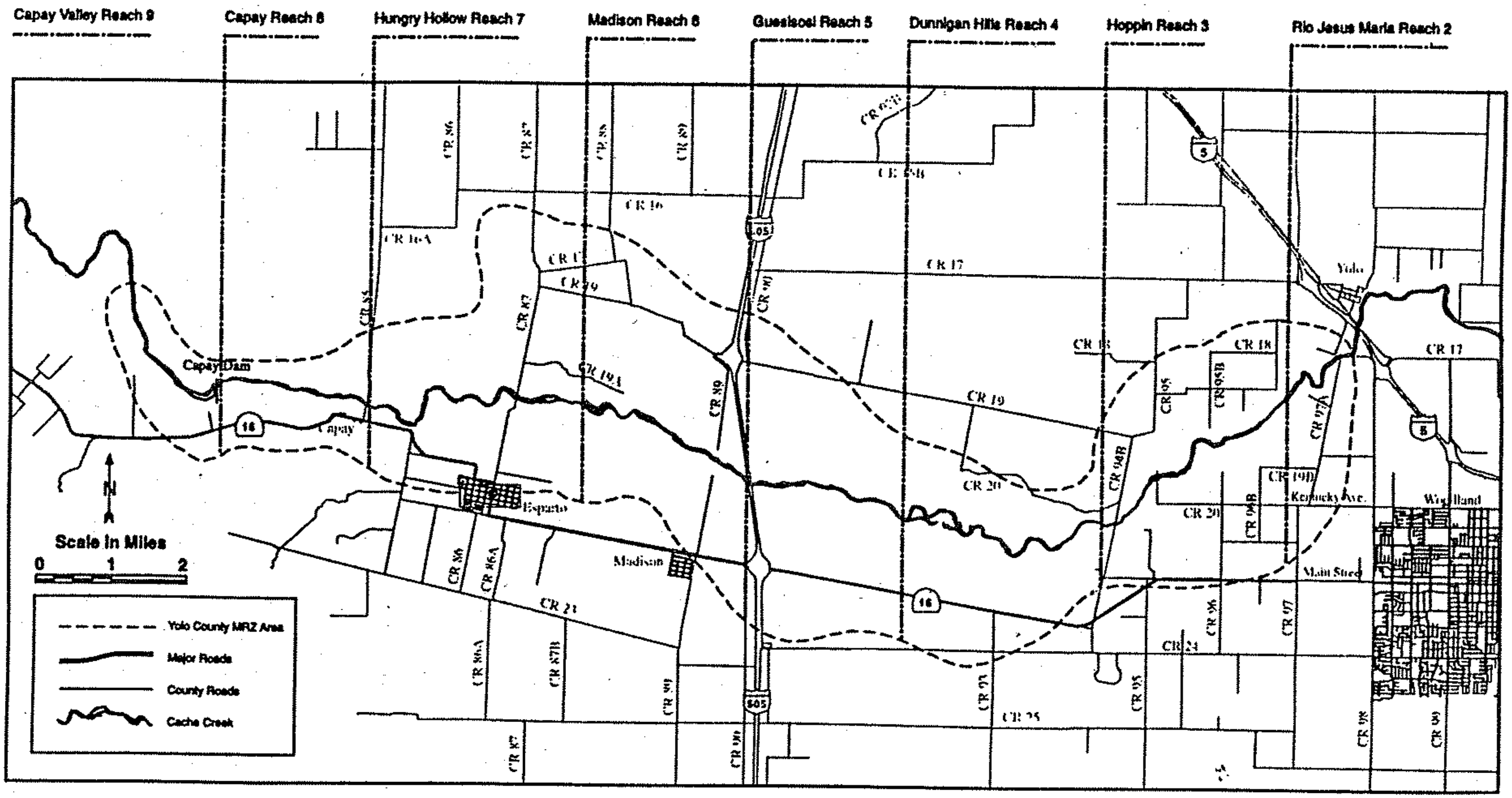
710 21st Street
Sacramento, CA 95814
(916) 447-1809

FIGURES

CACHE CREEK GEOMORPHIC SUBREACHES

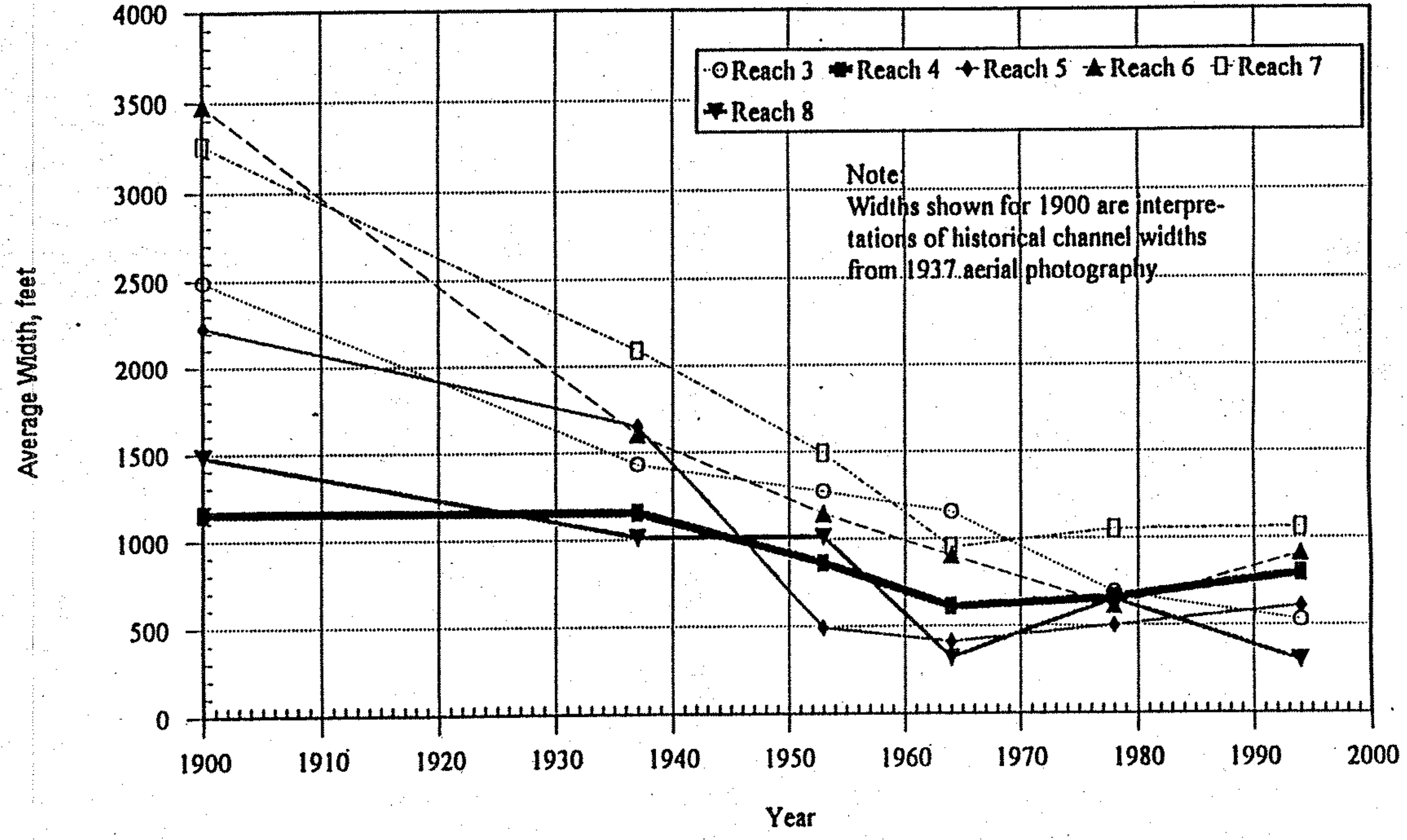
Figure 1



SOURCE: NHC, 1995

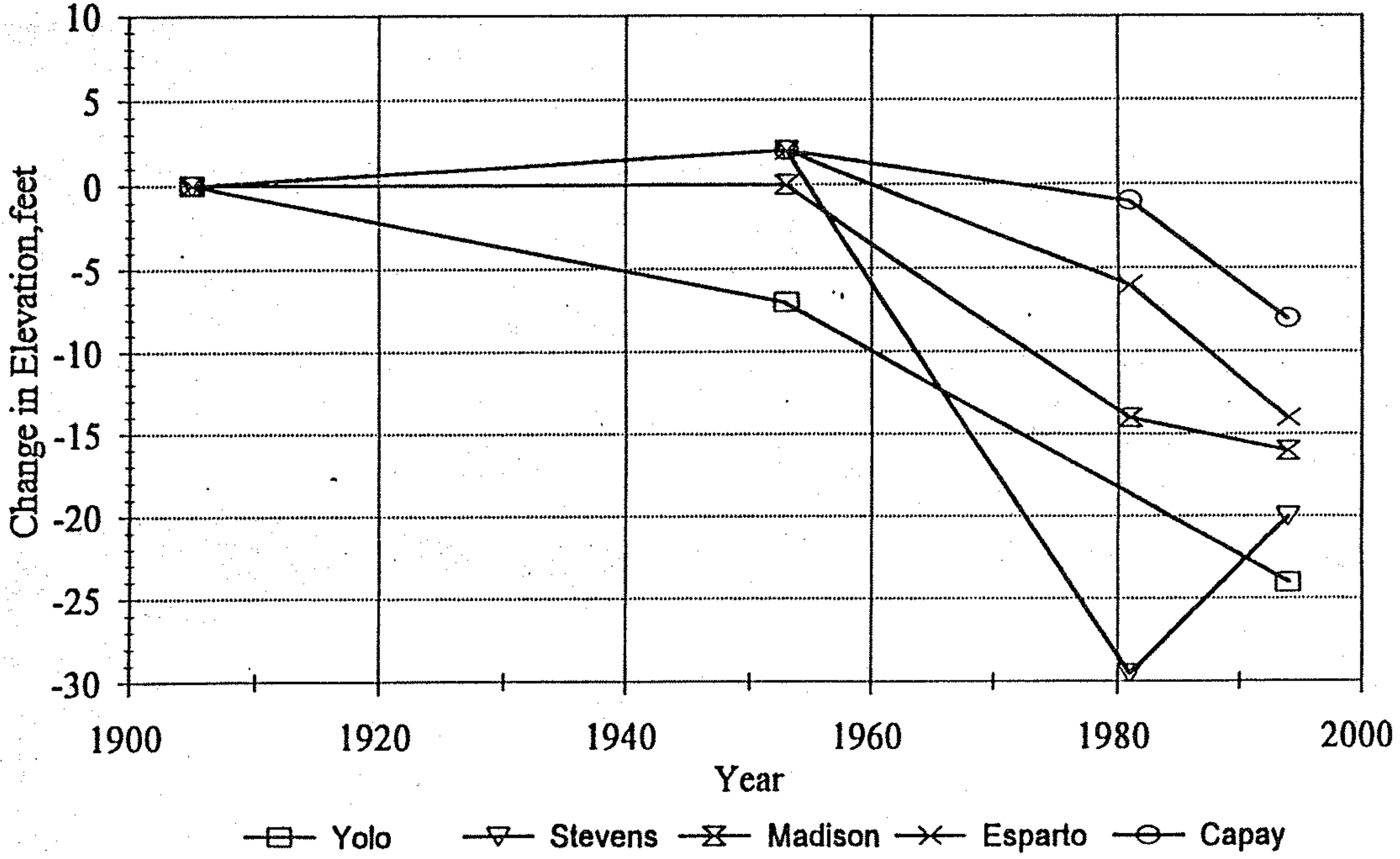
Reach Boundary

CHANGES IN CHANNEL WIDTH OF CACHE CREEK SUBREACHES Figure 2



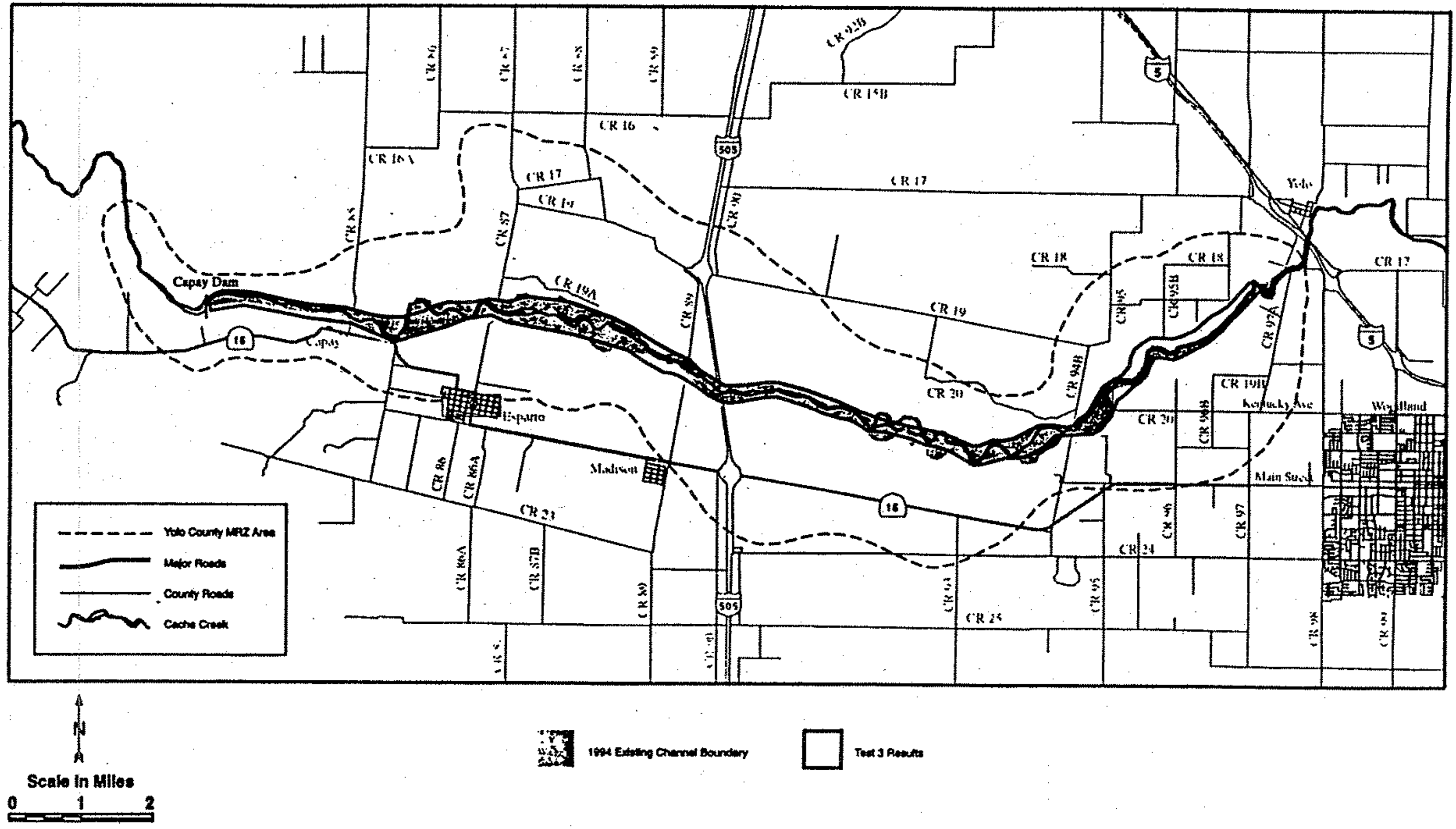
CHANGES IN CHANNEL THALWEG ELEVATION AT BRIDGE LOCATIONS

Figure 3



TEST 3 MODEL BOUNDARY

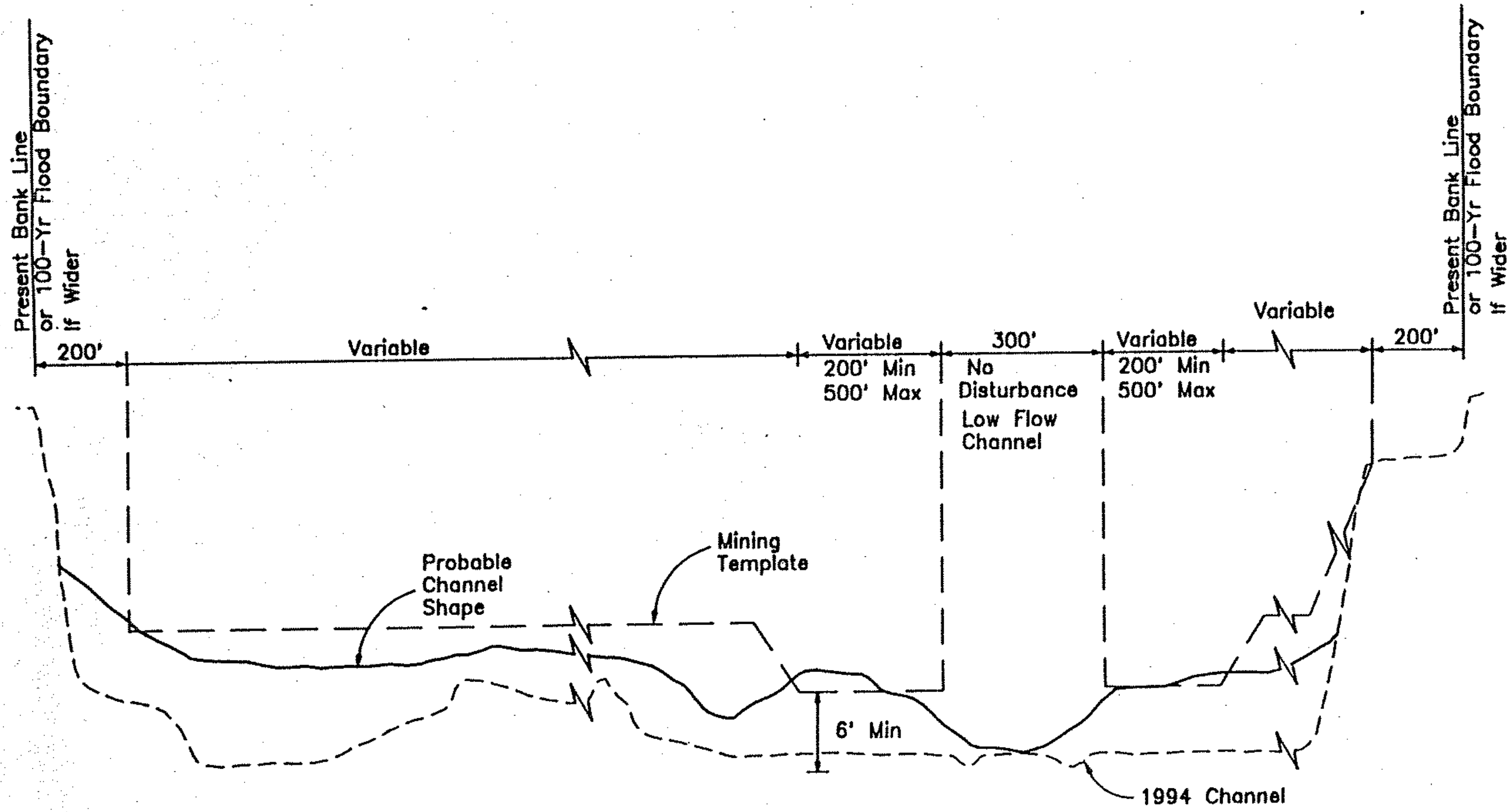
Figure 4



SOURCE: YOLO COUNTY COMMUNITY DEVELOPMENT AGENCY

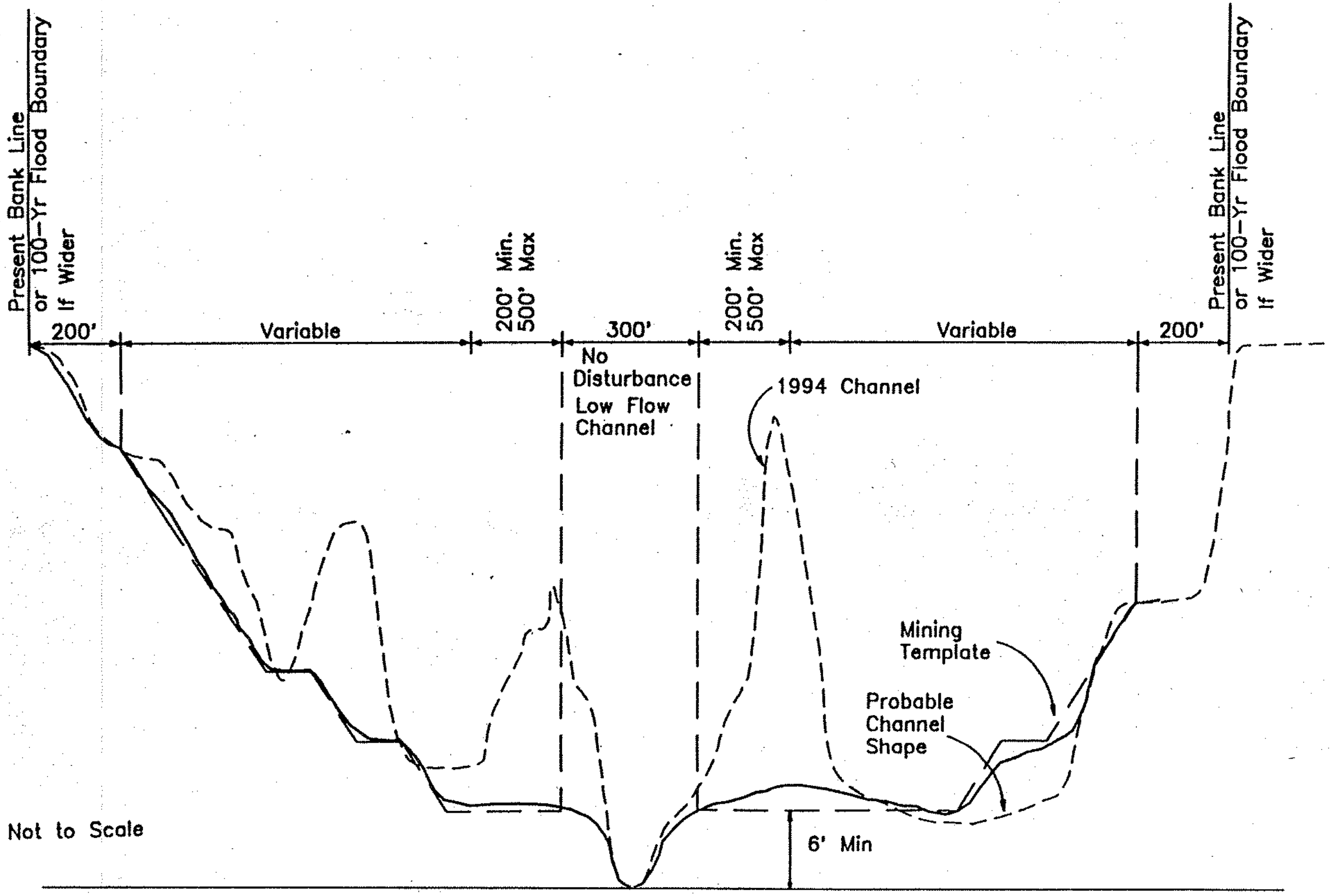
CROSS-SECTION TEMPLATE, WIDE CHANNEL

Figure 5



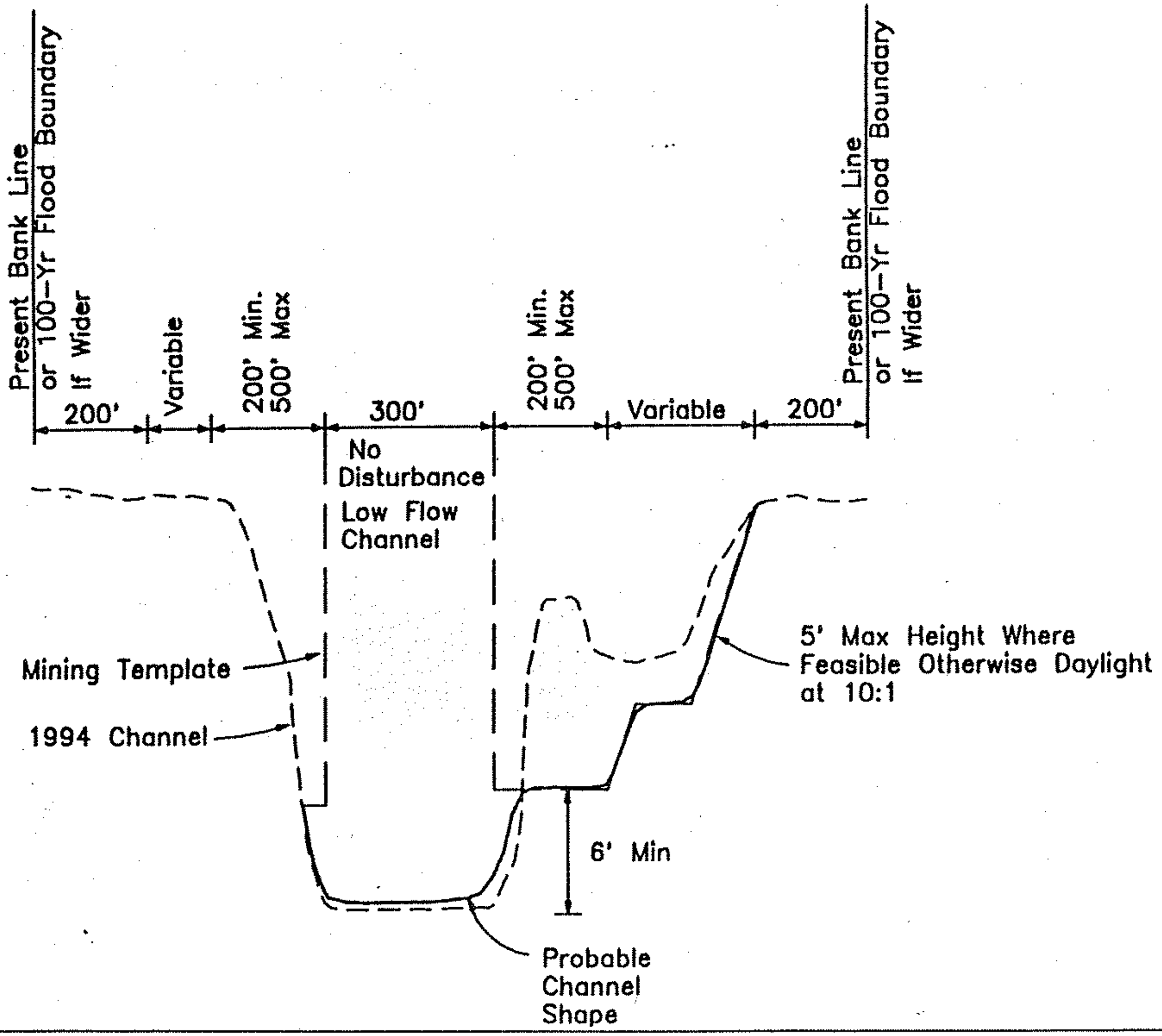
CROSS-SECTION TEMPLATE, NARROW CHANNEL WITH ADJACENT MINING PITS

Figure 6



CROSS-SECTION TEMPLATE, NARROW CHANNEL

Figure 7



TYPICAL CHANNEL TRANSITION AT BRIDGES Figure 8

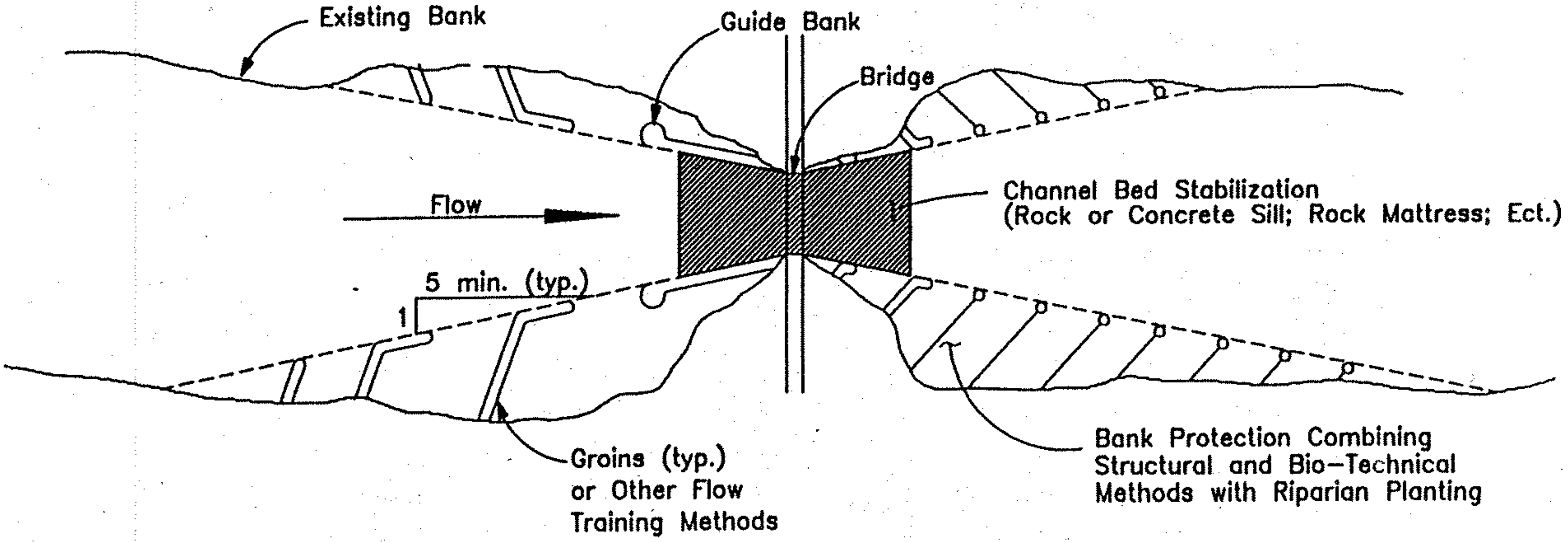


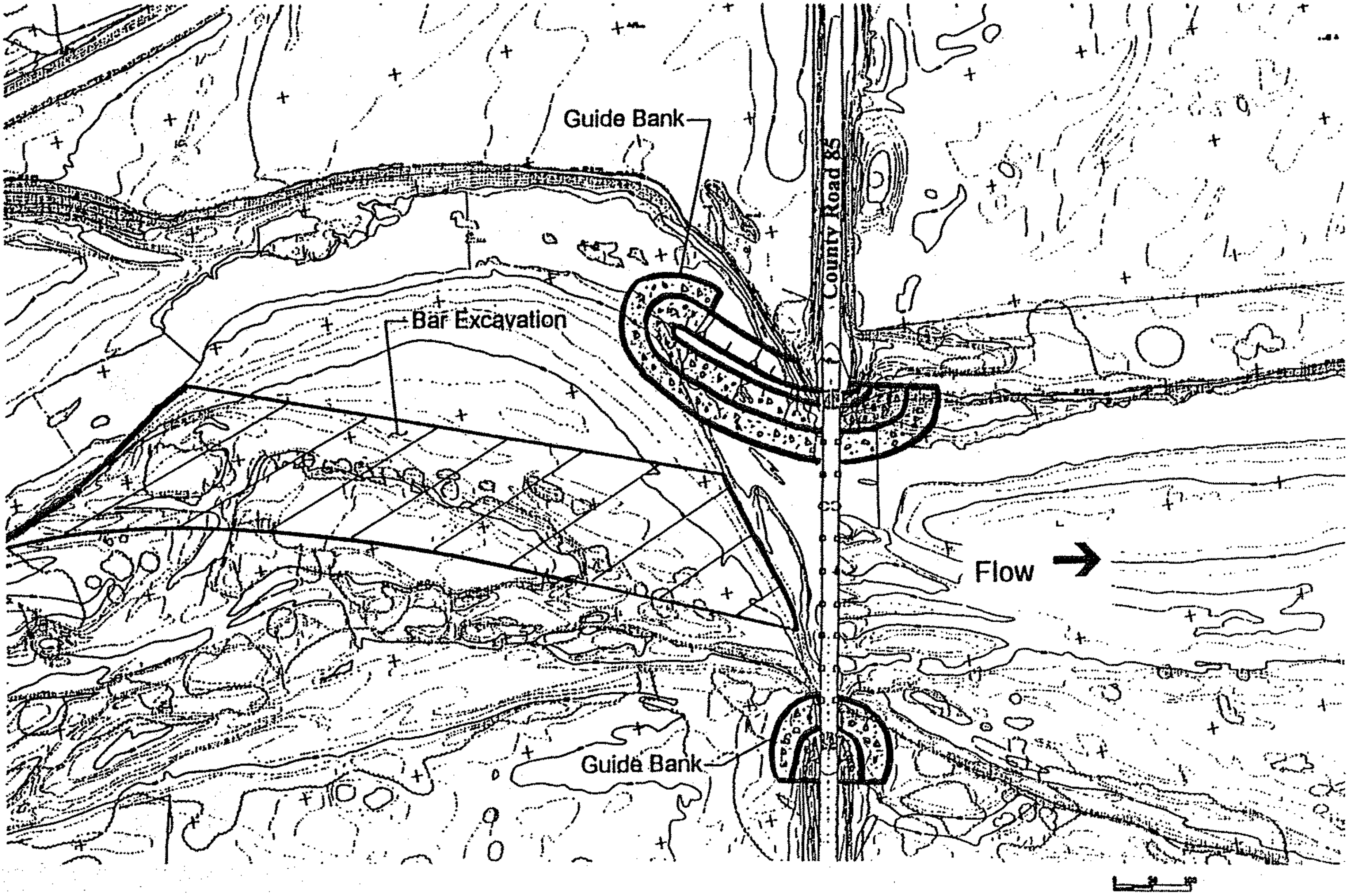
Figure 3-8. Typical Channel Transition at Bridges

Not to Scale

Note: Drawing Provides Graphical Representation Only and Is Not To Be Used For Design.

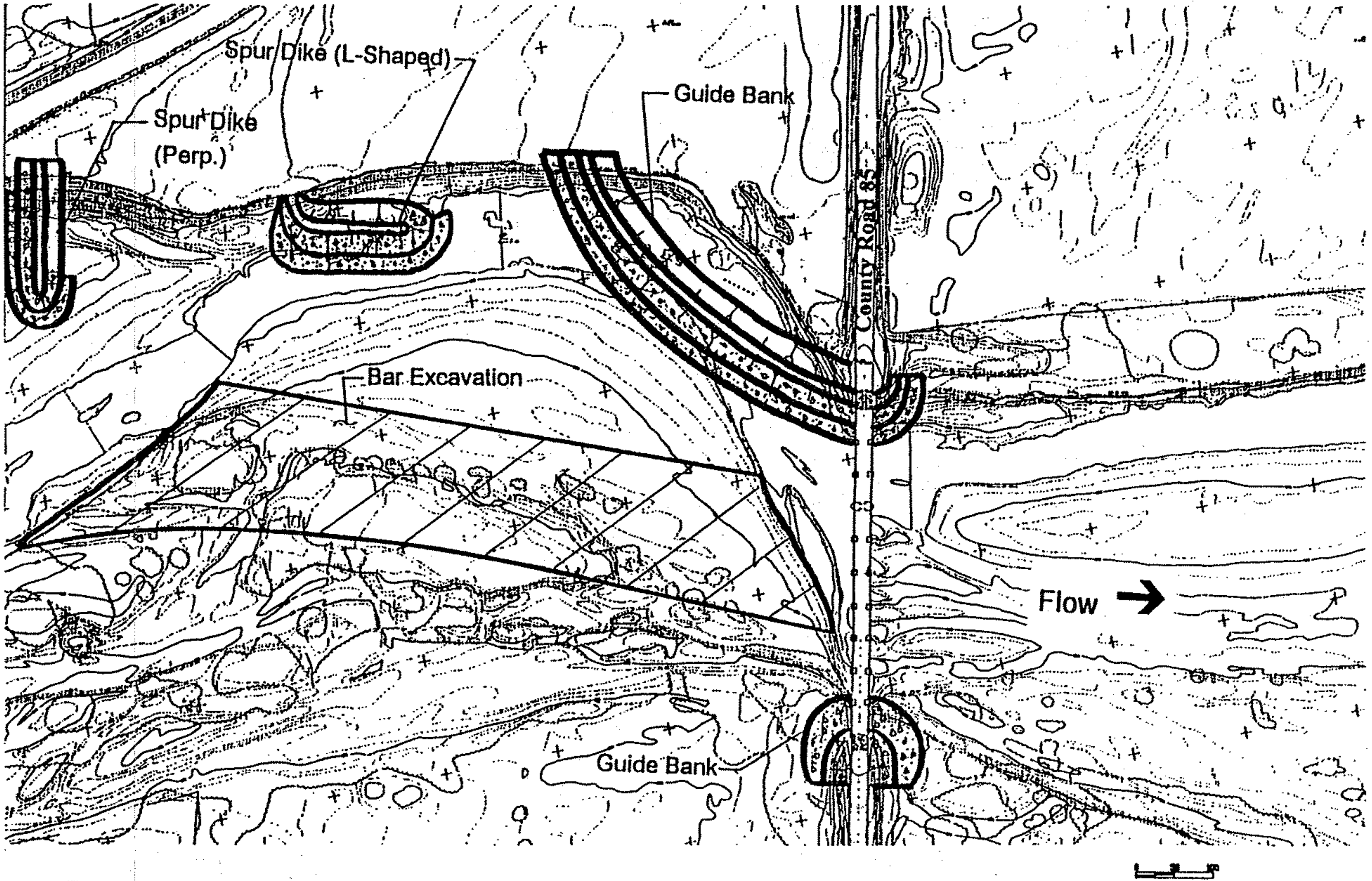
CAPAY BRIDGE CHANNEL TRANSITION PROJECT ALTERNATIVE EBL1

Figure 9



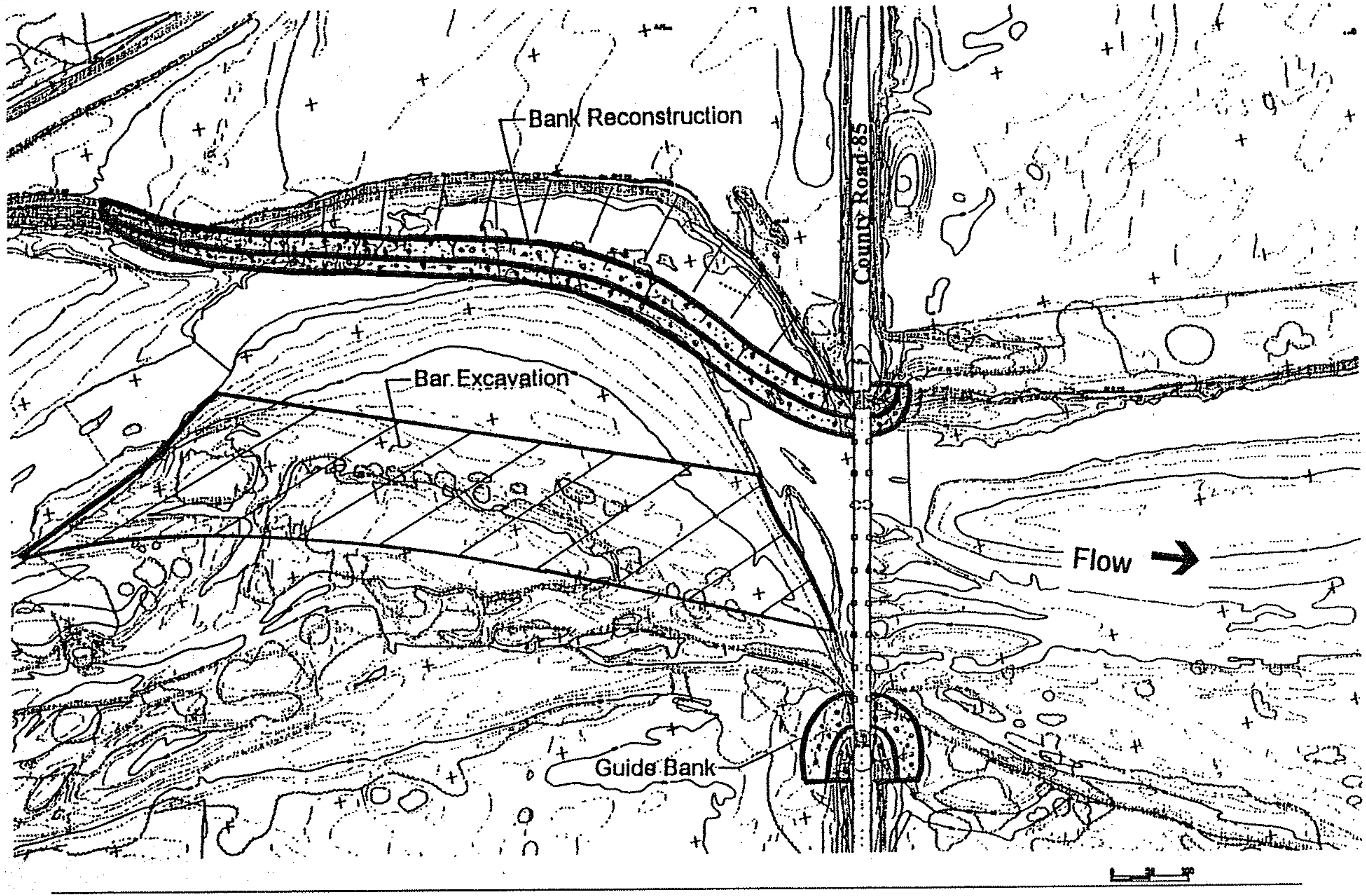
CAPAY BRIDGE CHANNEL TRANSITION PROJECT
ALTERNATIVE EBL2

Figure 10



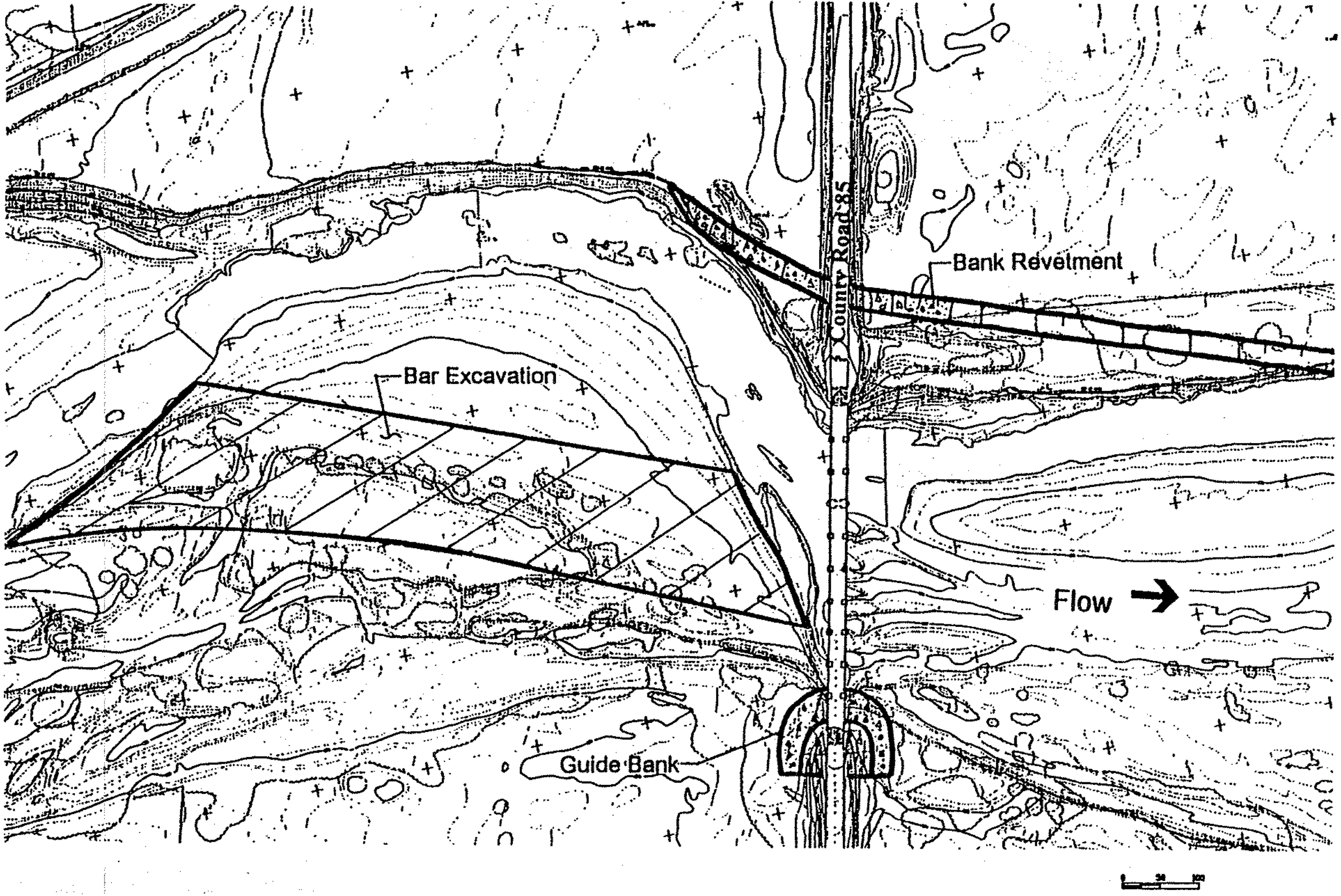
CAPAY BRIDGE CHANNEL TRANSITION PROJECT ALTERNATIVE EBL3

Figure 11



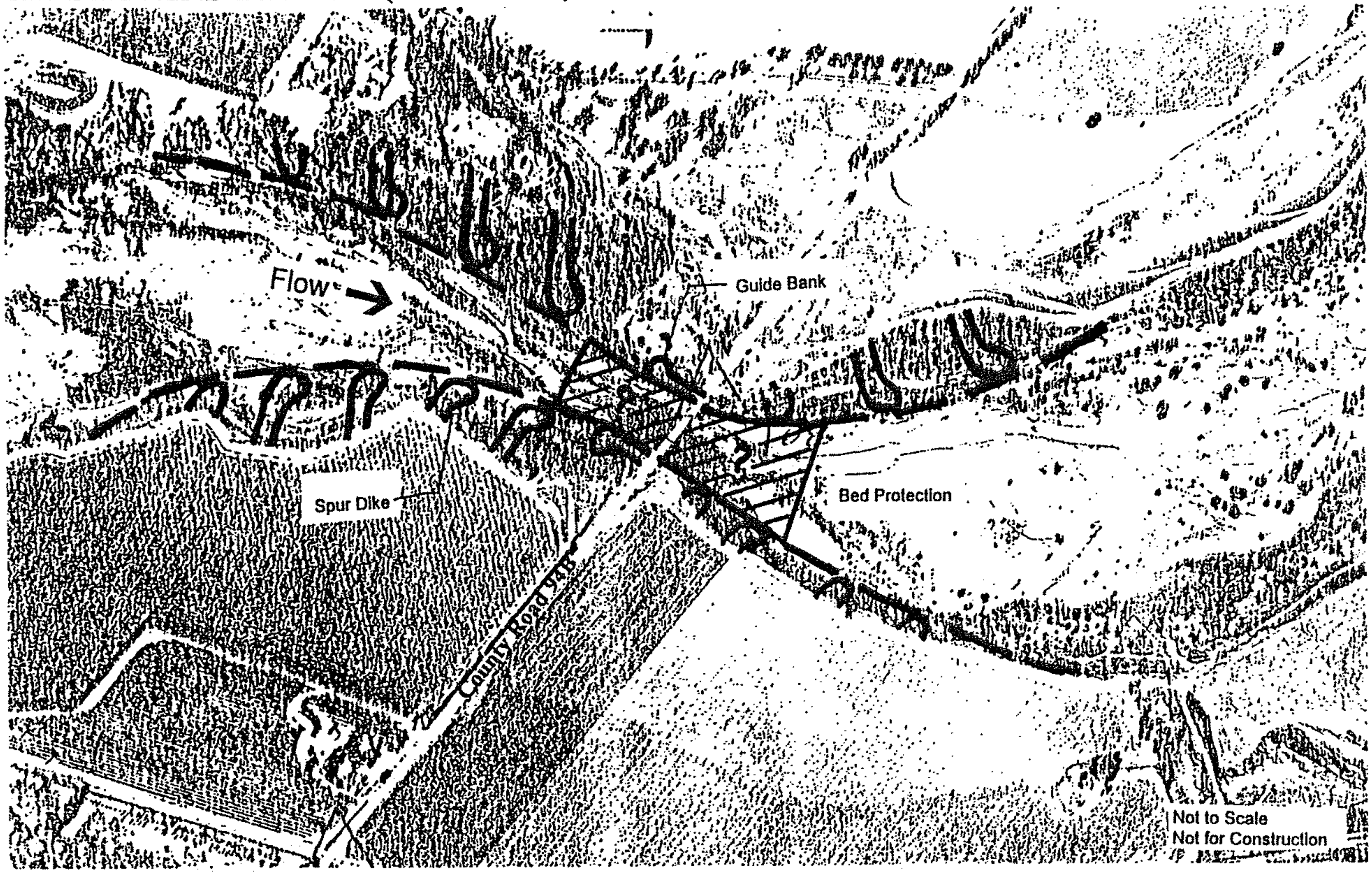
CAPAY BRIDGE CHANNEL TRANSITION PROJECT
ALTERNATIVE NBL1

Figure 12



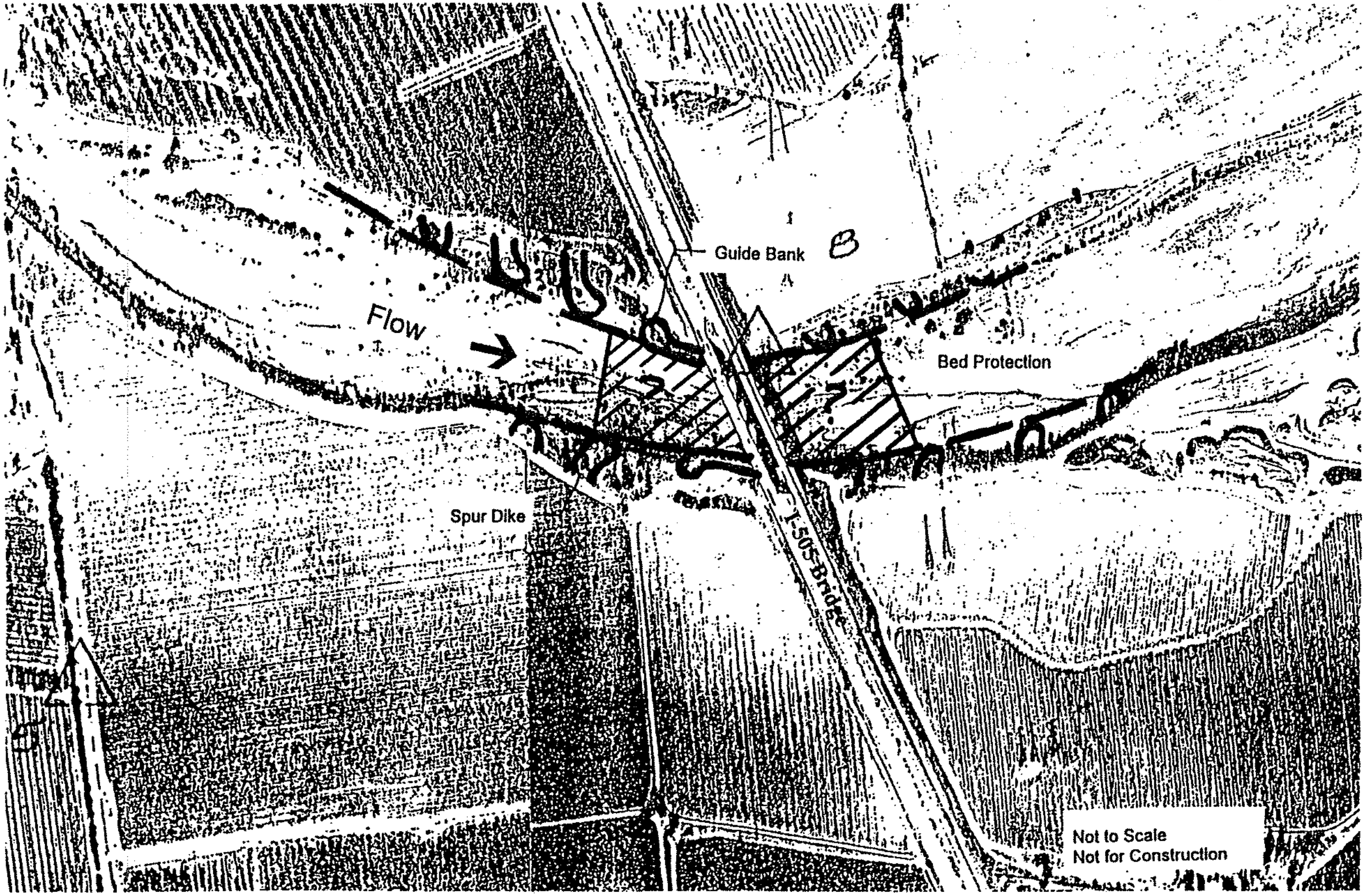
CHANNEL TRANSITION PROJECT AT STEVENS BRIDGE (ROAD 94B)

Figure 14



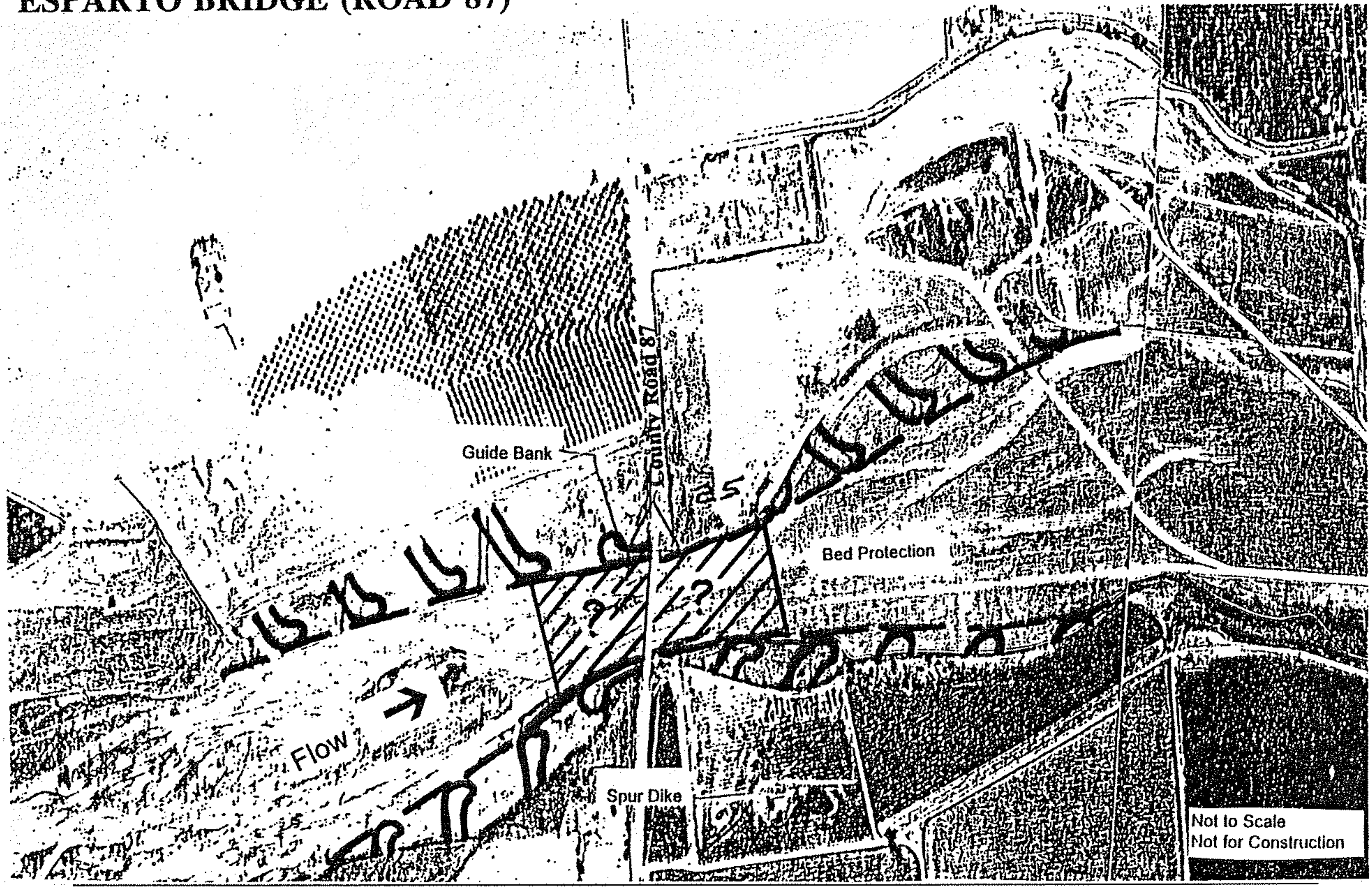
CHANNEL TRANSITION PROJECT AT I-505 Bridge

Figure 13



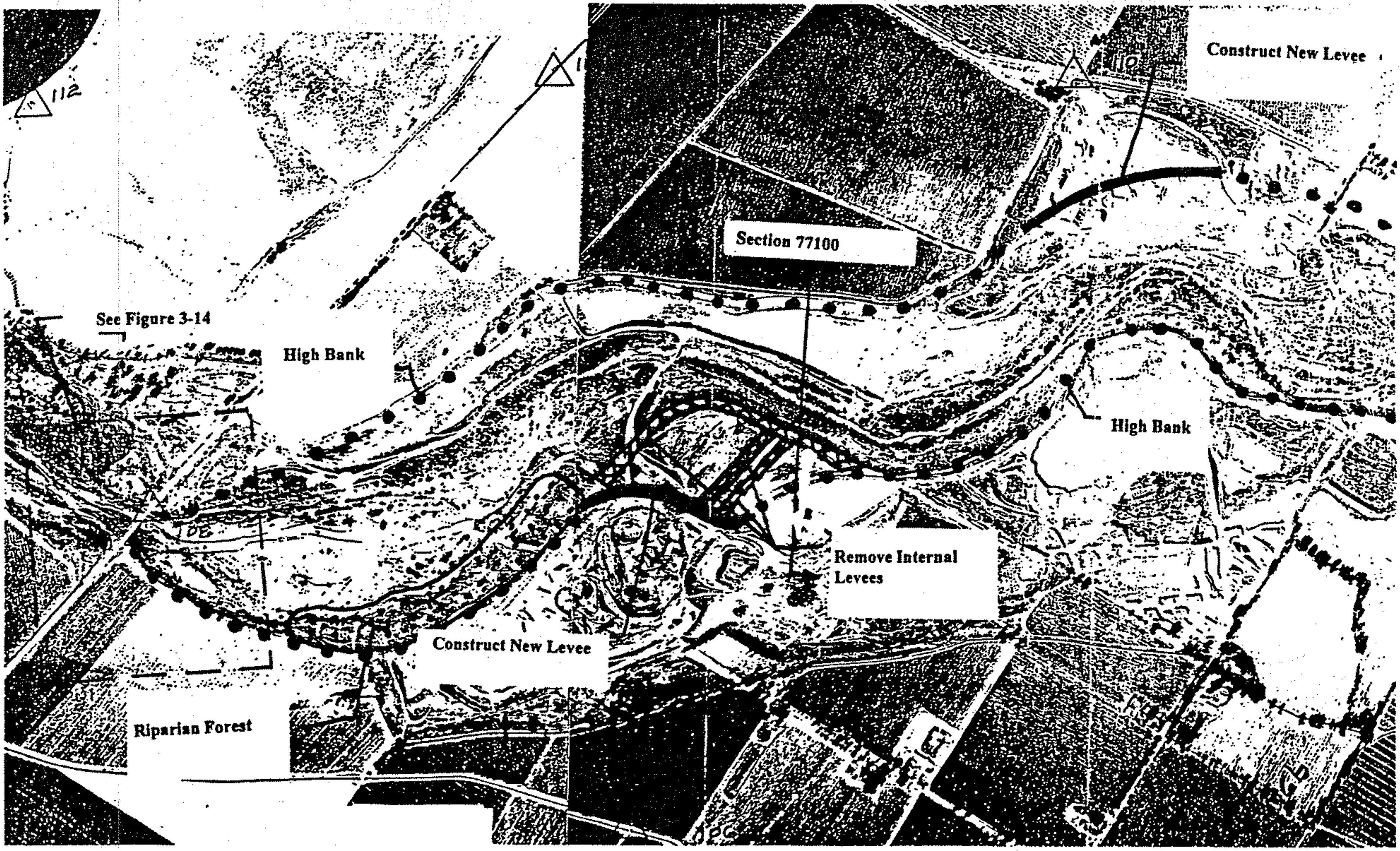
CHANNEL TRANSITION PROJECT AT ESPARTO BRIDGE (ROAD 87)

Figure 15



CHANNEL STABILIZATION PROJECT DOWNSTREAM FROM 94B BRIDGE

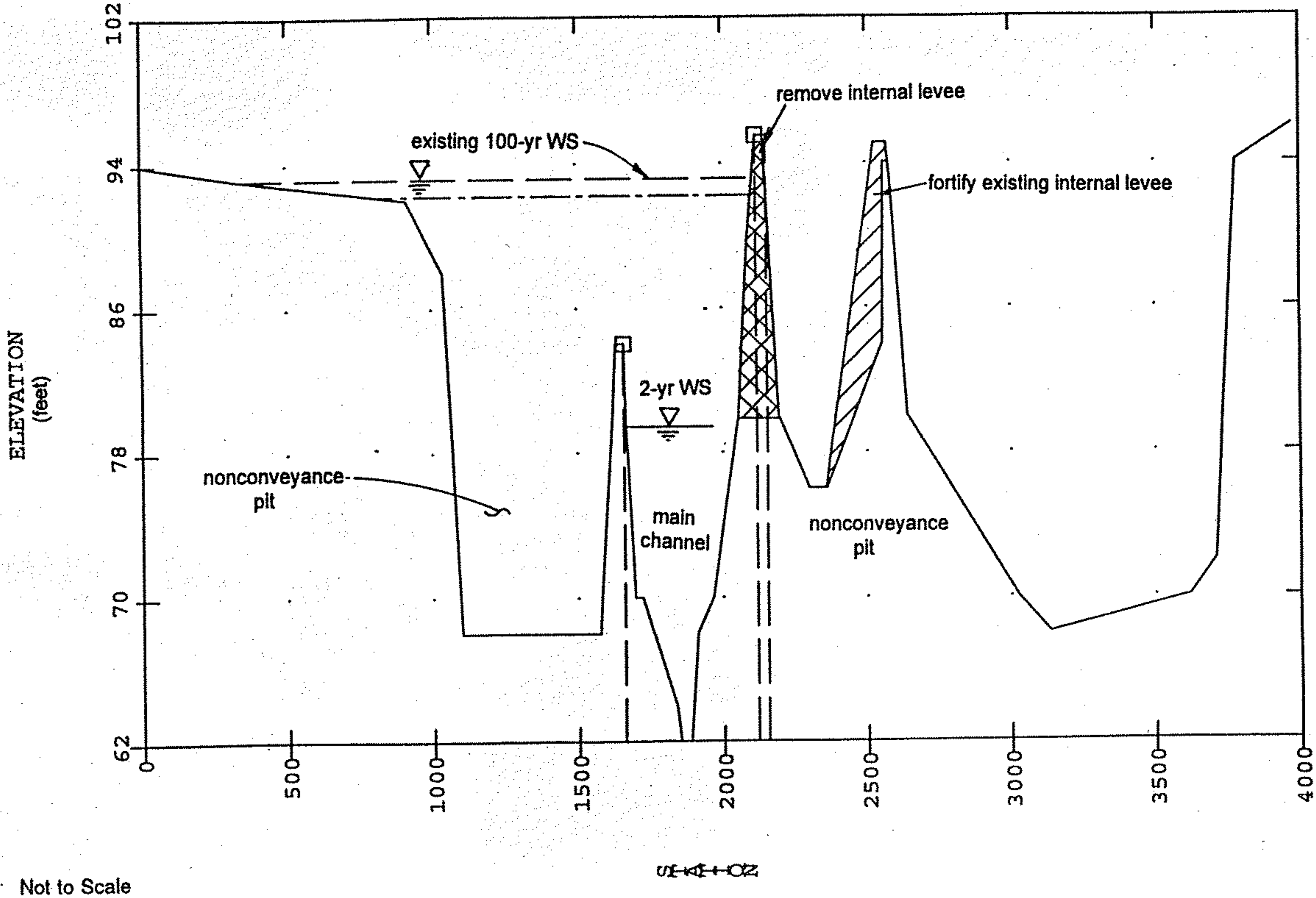
Figure 16



Not to Scale
Not for Construction

CROSS-SECTION CHANNEL STABILIZATION PROJECT DOWNSTREAM OF ROAD 94B BRIDGE

Figure 17



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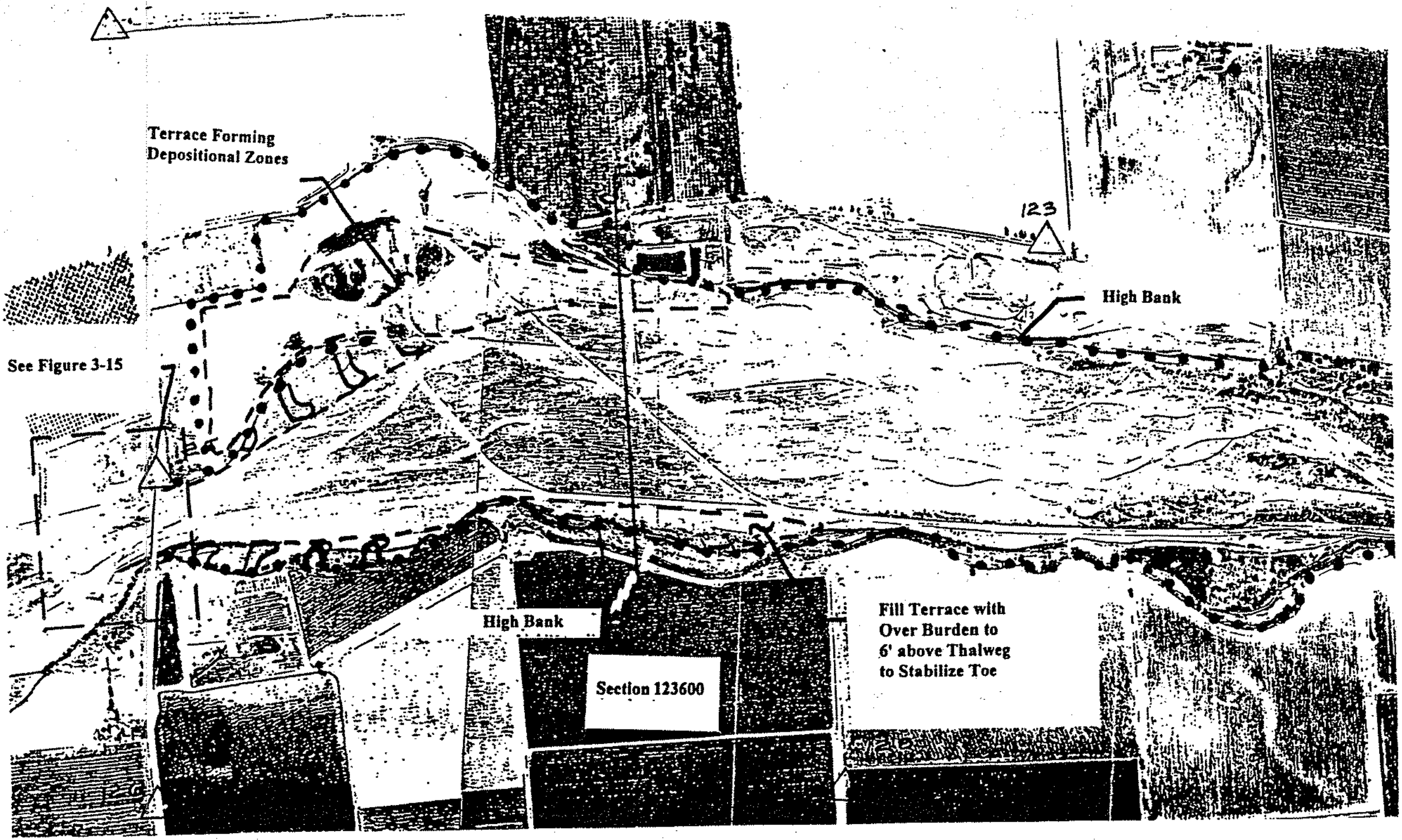
Not for Construction

CHANNEL STABILIZATION PROJECT DOWNSTREAM FROM ESPARTO BRIDGE

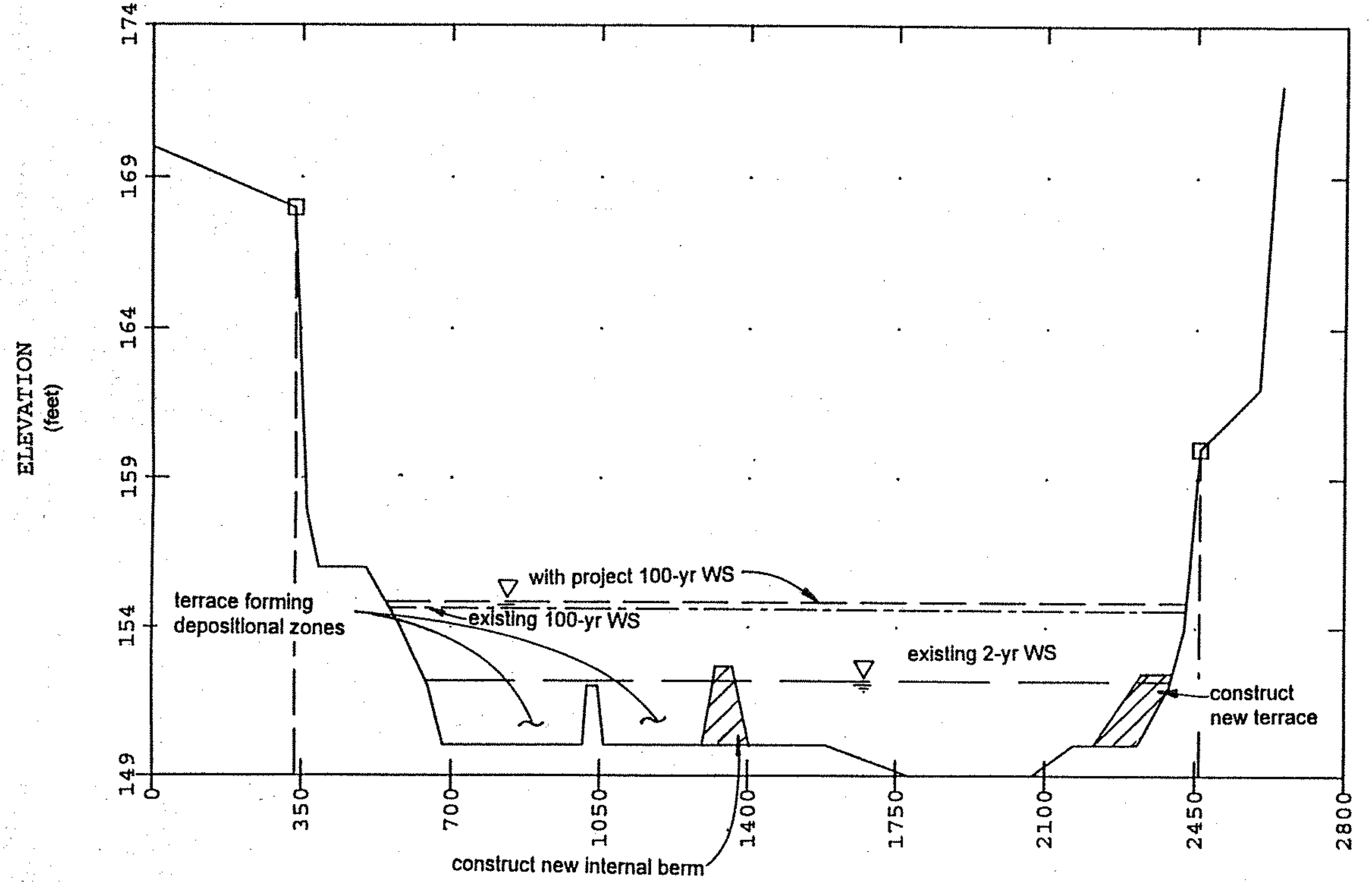
Figure 18



Not to Scale
Not for Construction

CROSS-SECTION PROPOSED STABILIZATION PROJECT DOWNSTREAM OF ESPARTO BRIDGE

Figure 19



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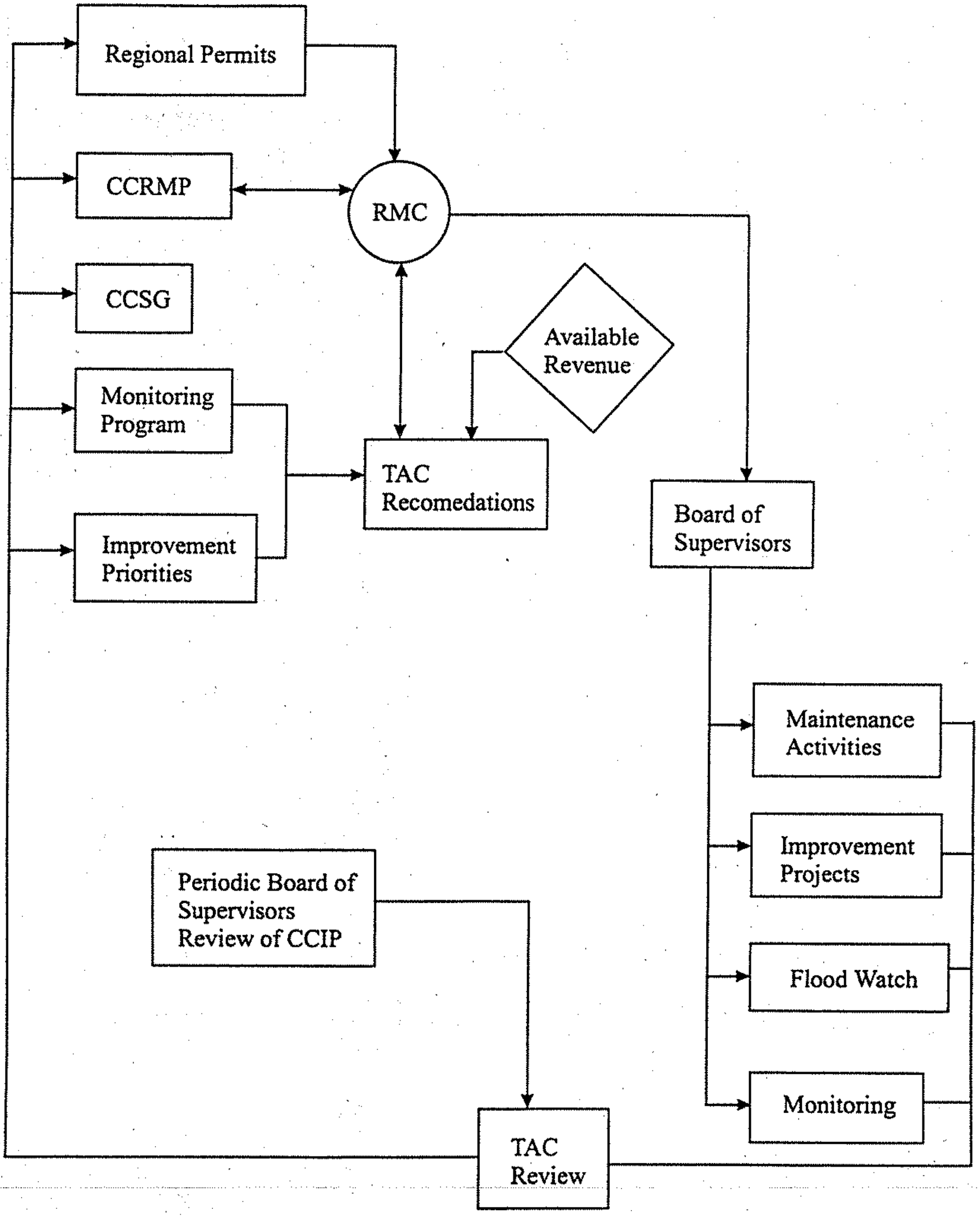
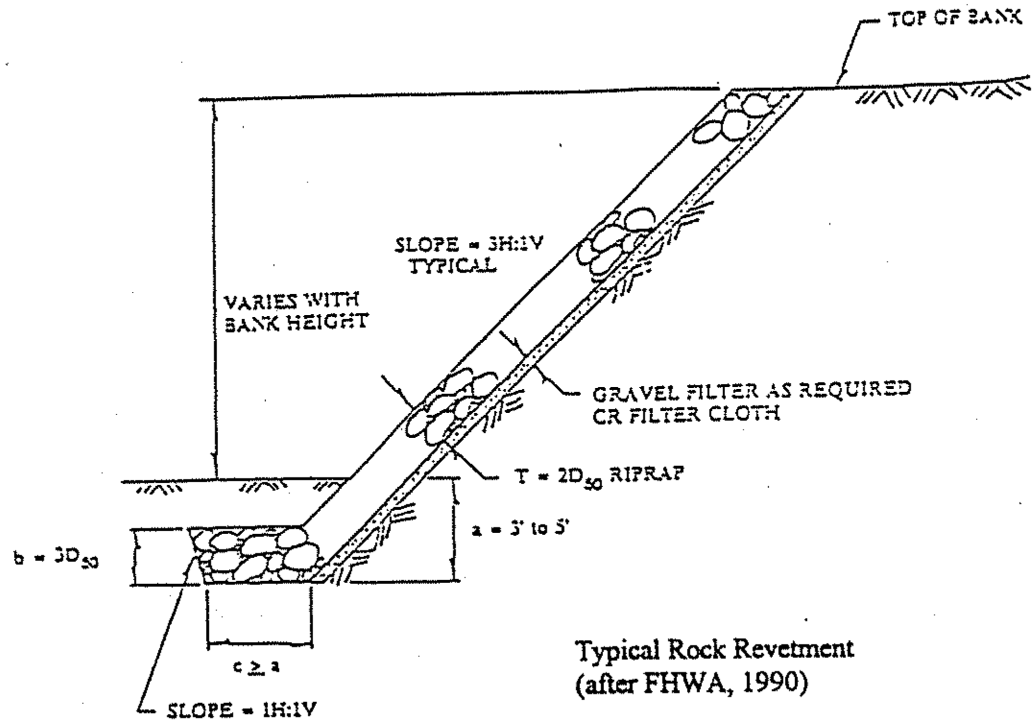
SCHEMATIC OF TAC'S ROLE IN CCIP PROCESS

Figure 20

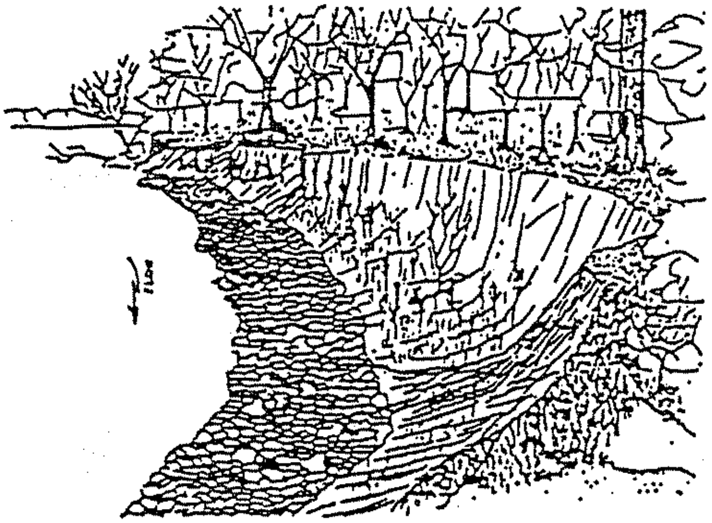


ROCK BANK REVETMENT AND TOE STABILIZATION

Figure 21



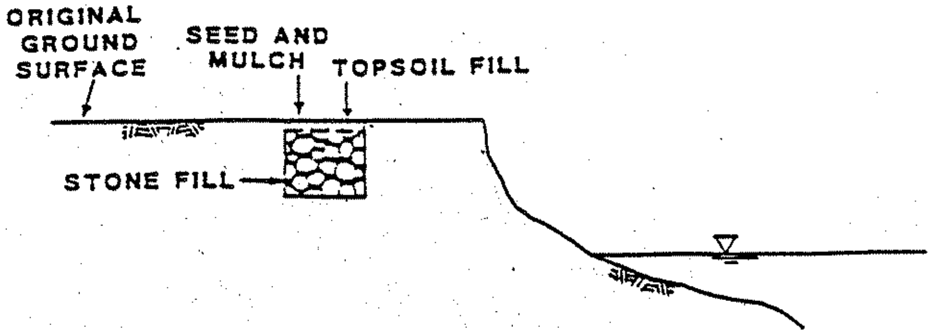
Typical Rock Revetment
(after FHWA, 1990)

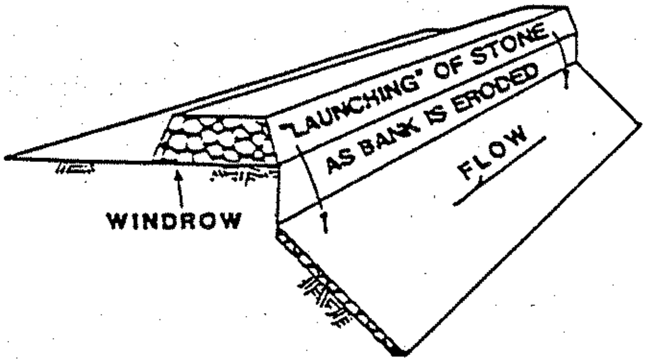


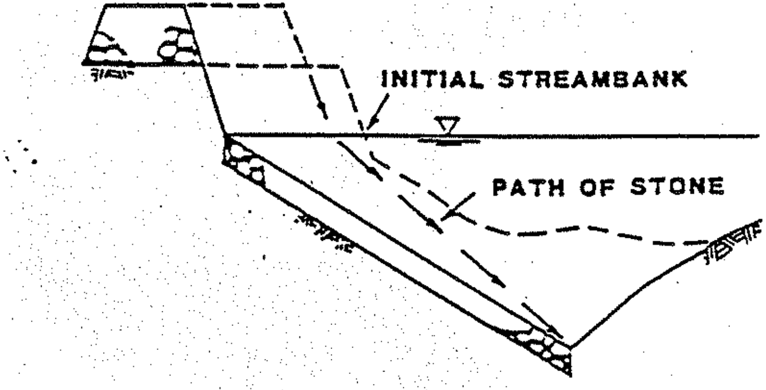
Rock Toe Stabilization
(COE, 1981)

WINDROW REVETMENT

Figure 22

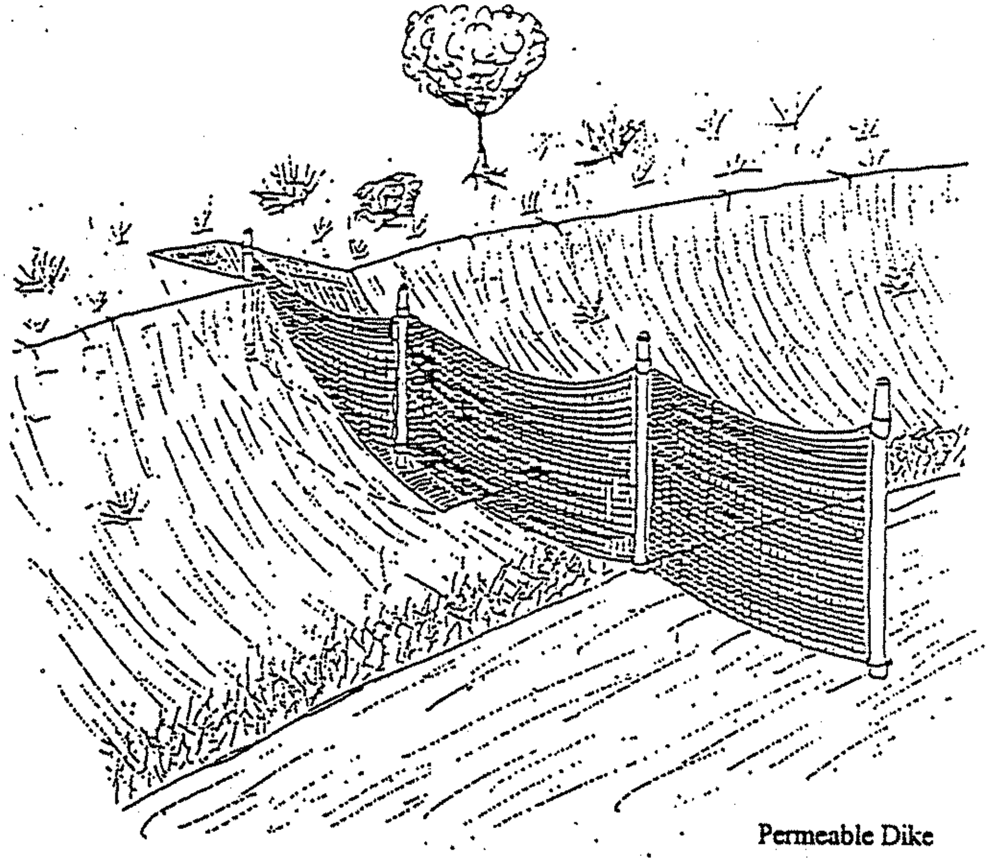




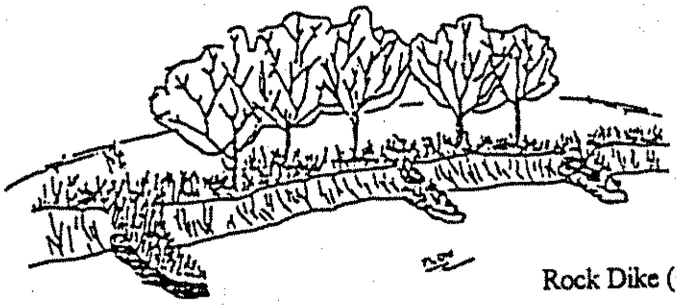


PERMEABLE AND SOLID DIKES

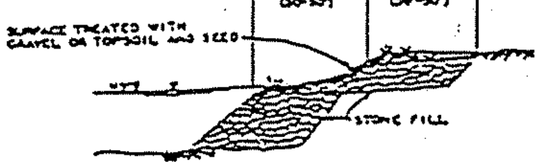
Figure 23



Permeable Dike



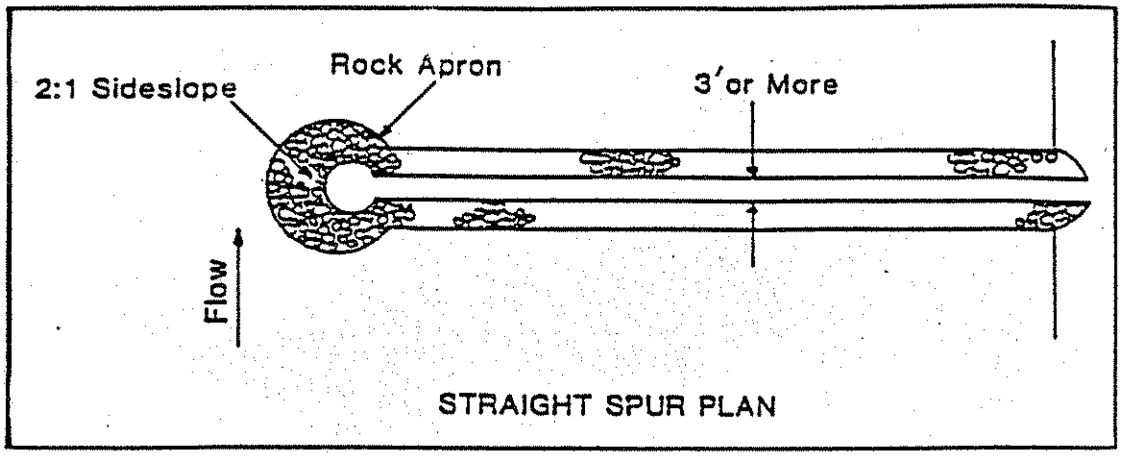
Rock Dike (Groin)



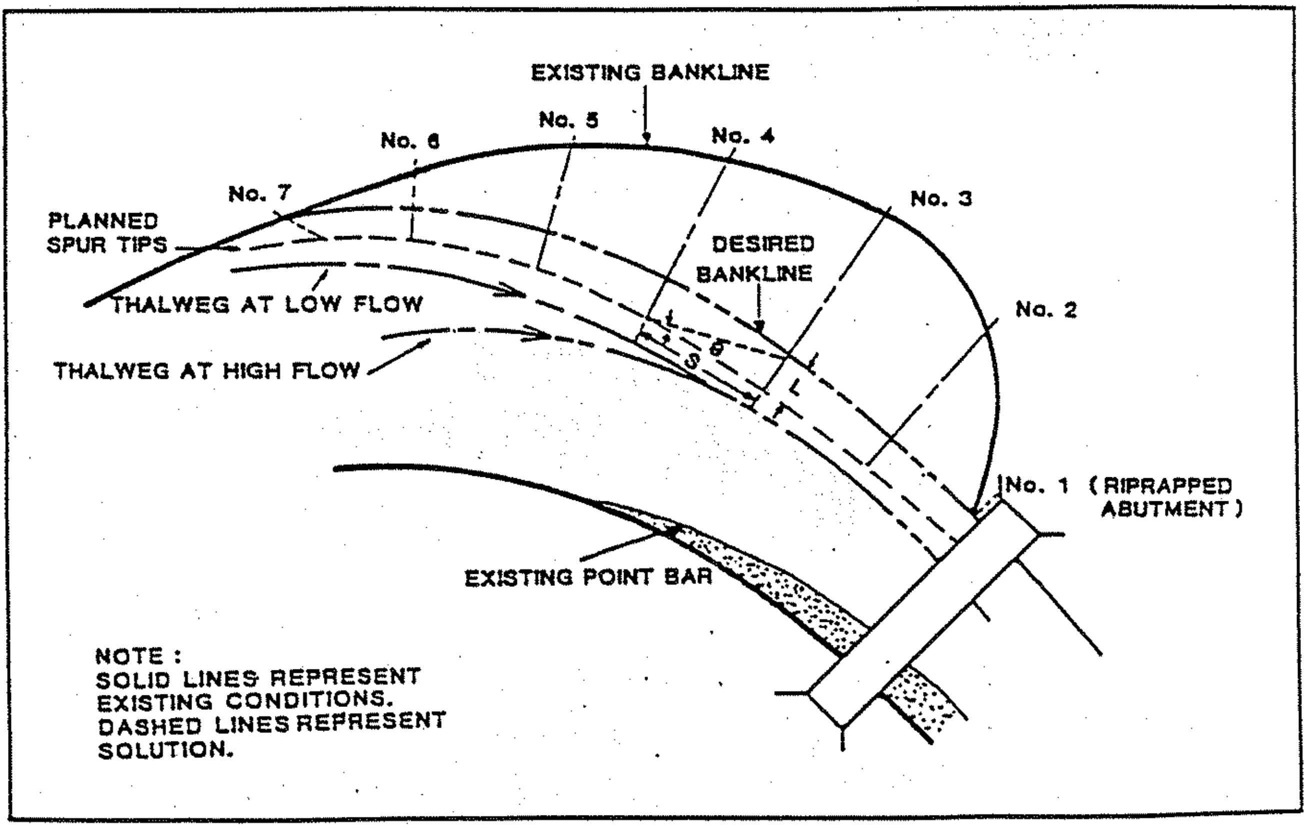
TYPICAL SECTION

SPUR DIKE DESIGN

Figure 24

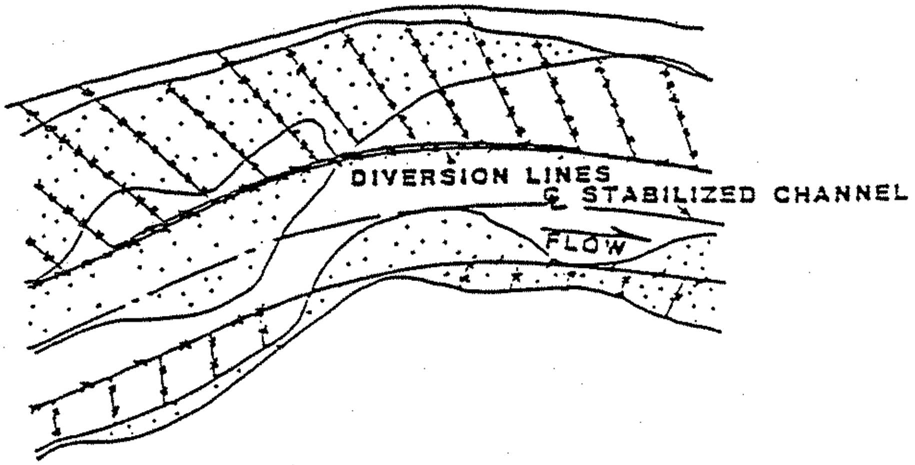


Typical straight, round nose spur.

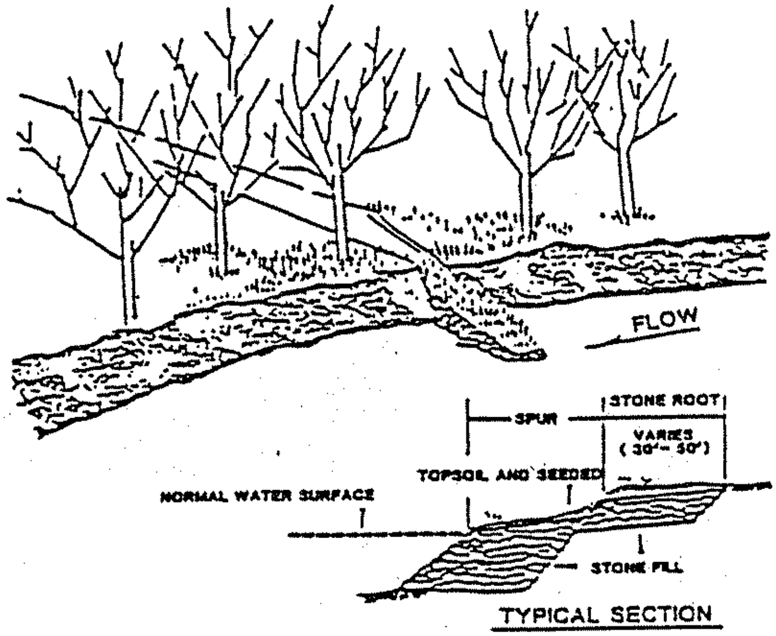


RETARDER FIELD AND HARDPOINTS

Figure 25



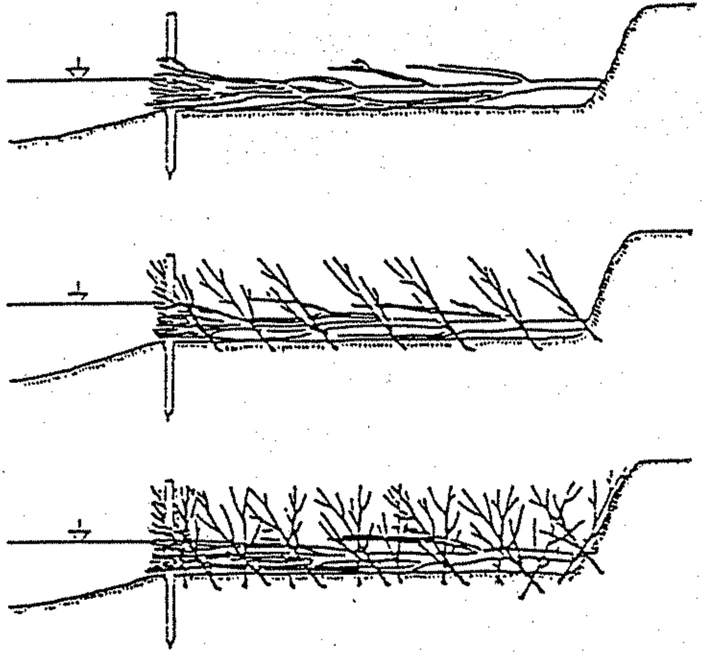
Retarder field schematic

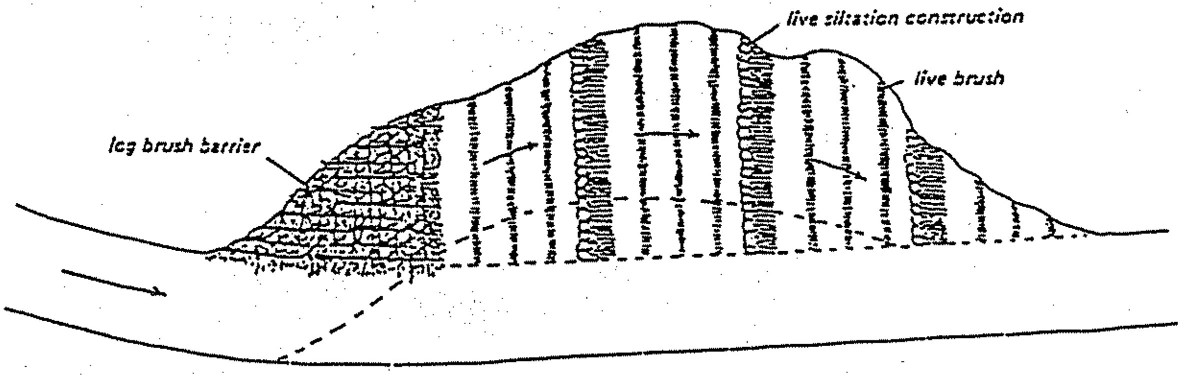


Perspective view of hardpoint installation with section detail

VEGETATIVE STABILIZATION

Figure 26





TYPICAL BIOTECHNICAL BANK STABILIZATION DESIGN

Figure 27

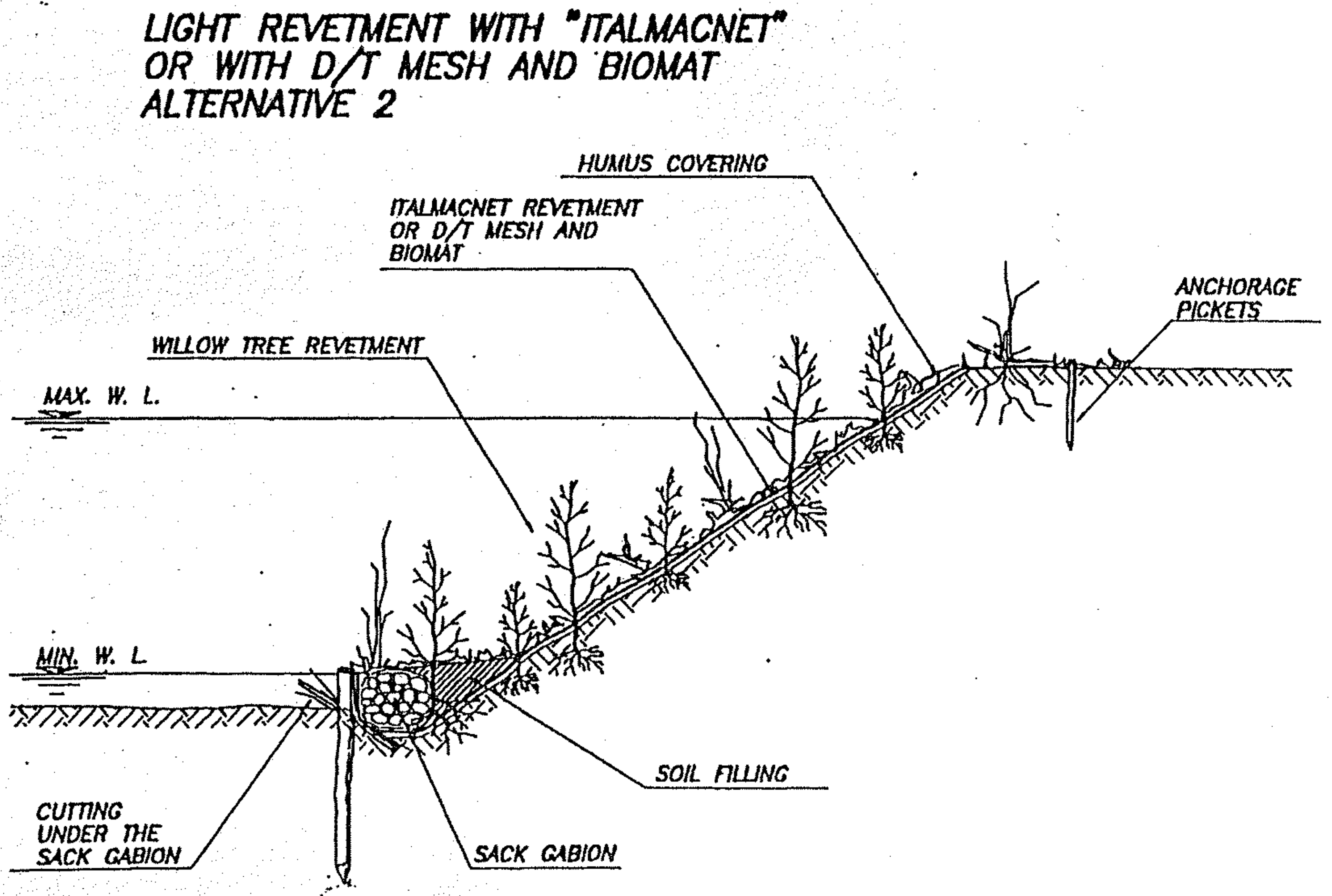
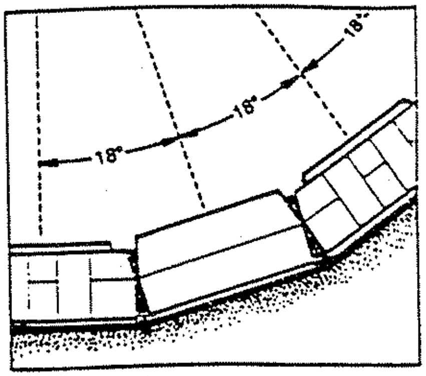
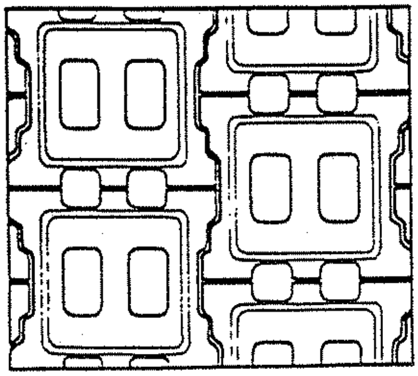
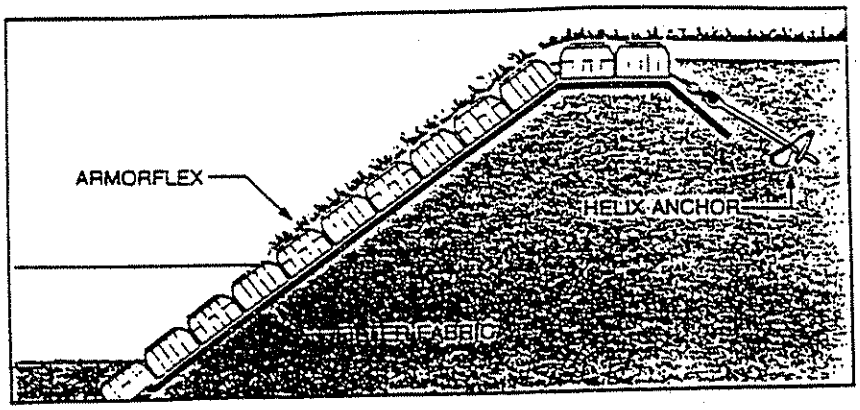


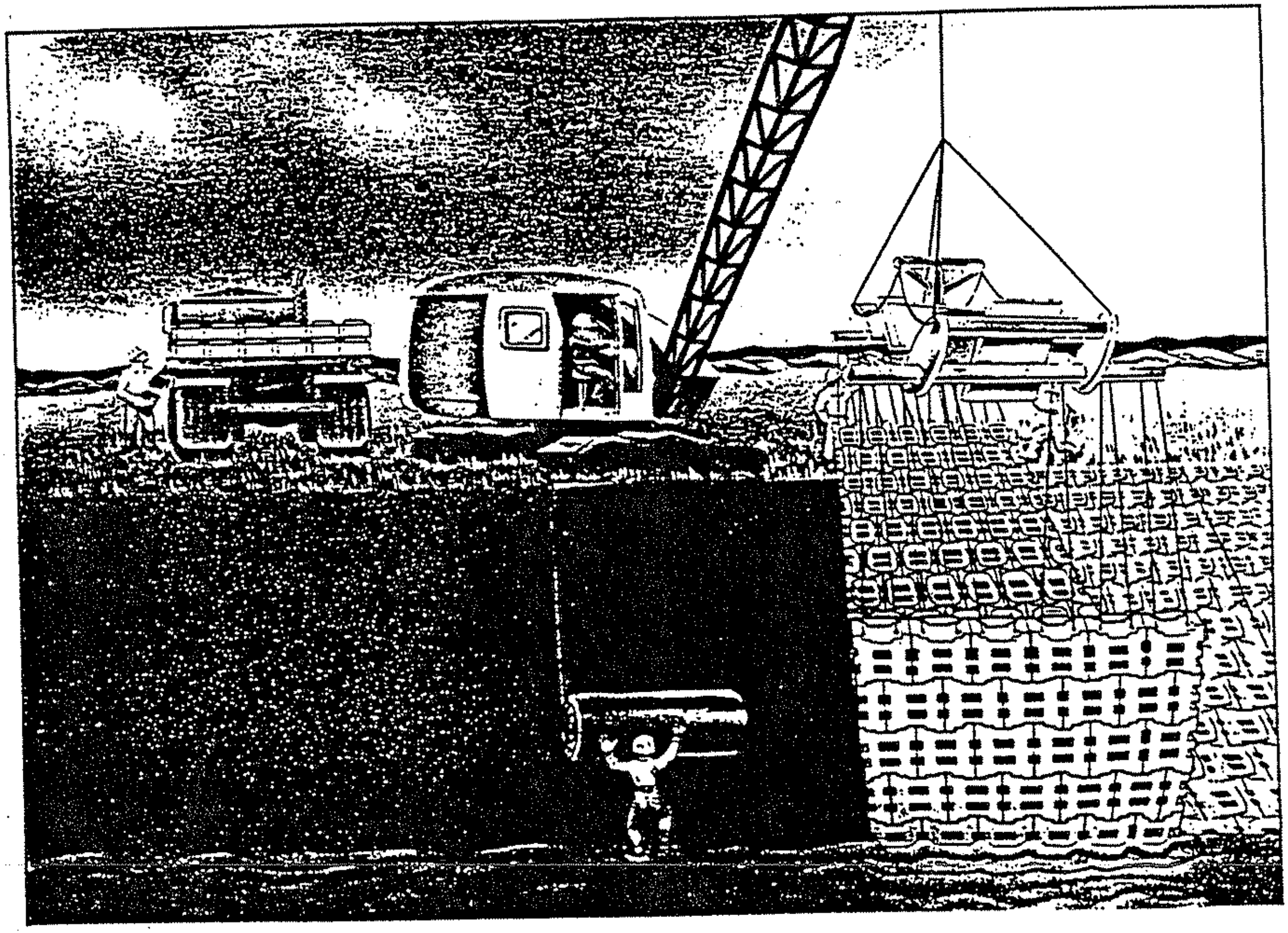
Figure 28

CHANNEL BED AND/OR BANK STABILIZATION WITH ARTICULATING MATTRESSES



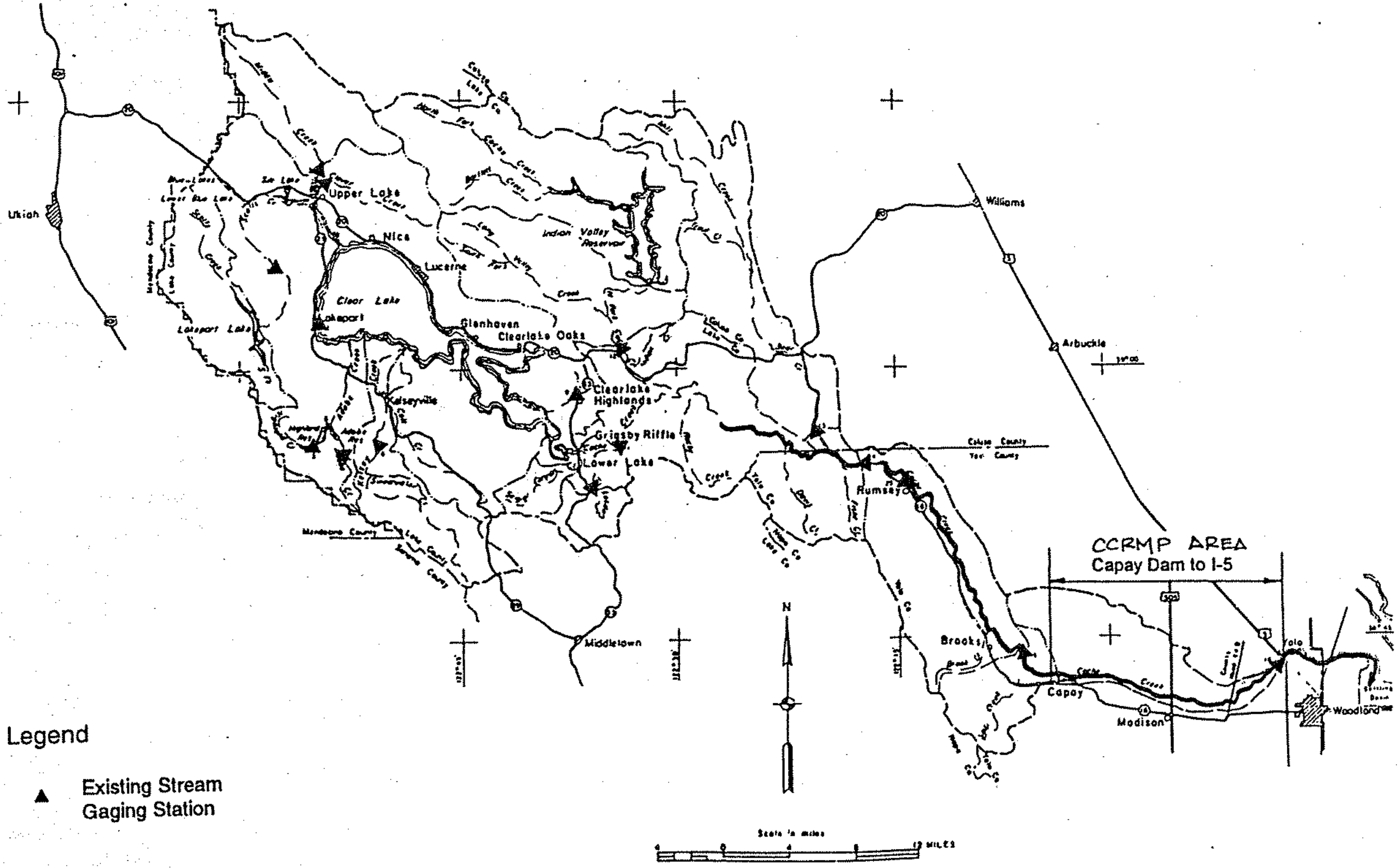






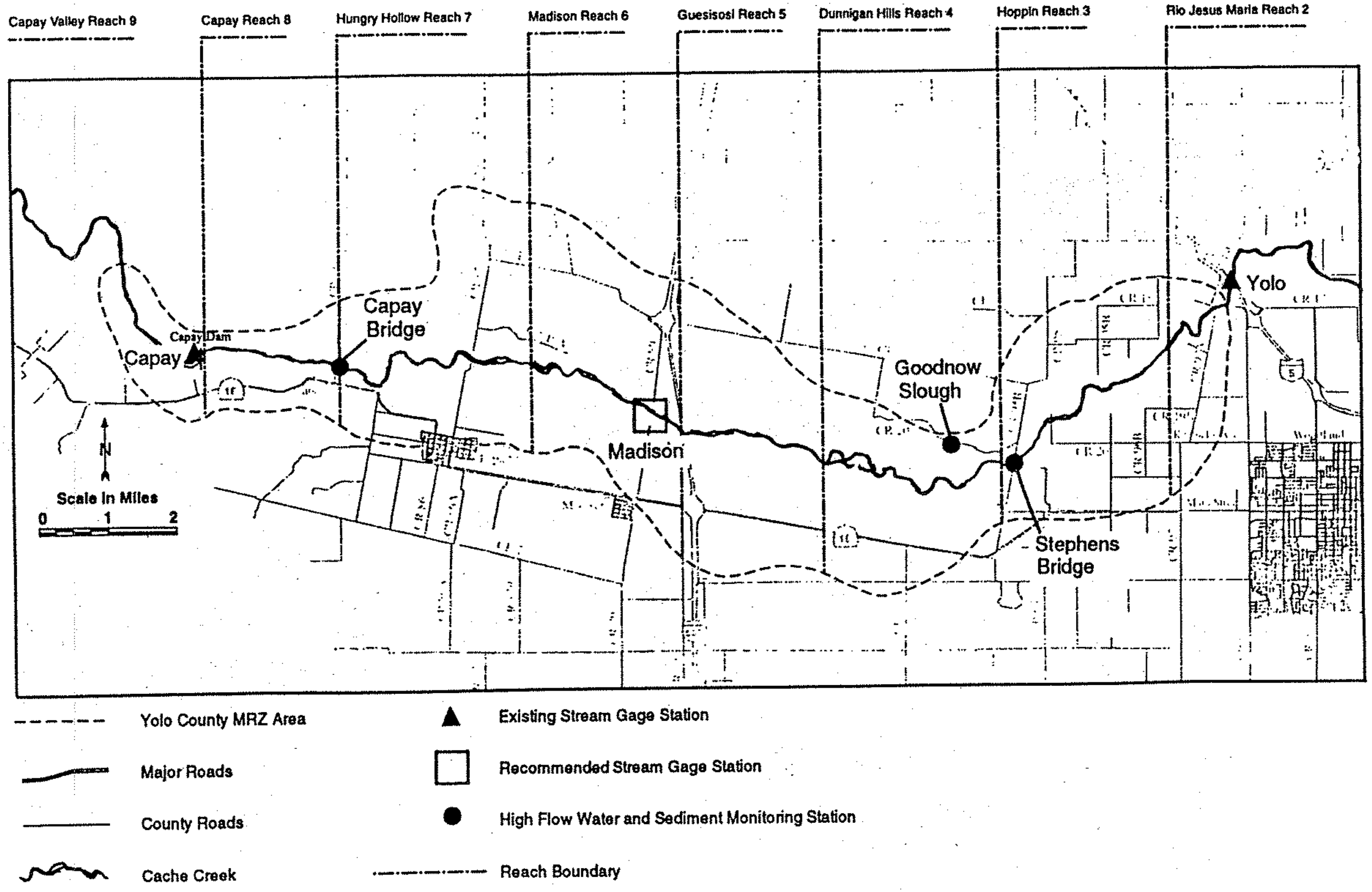
REGIONAL STREAM GAGE LOCATIONS

Figure 29



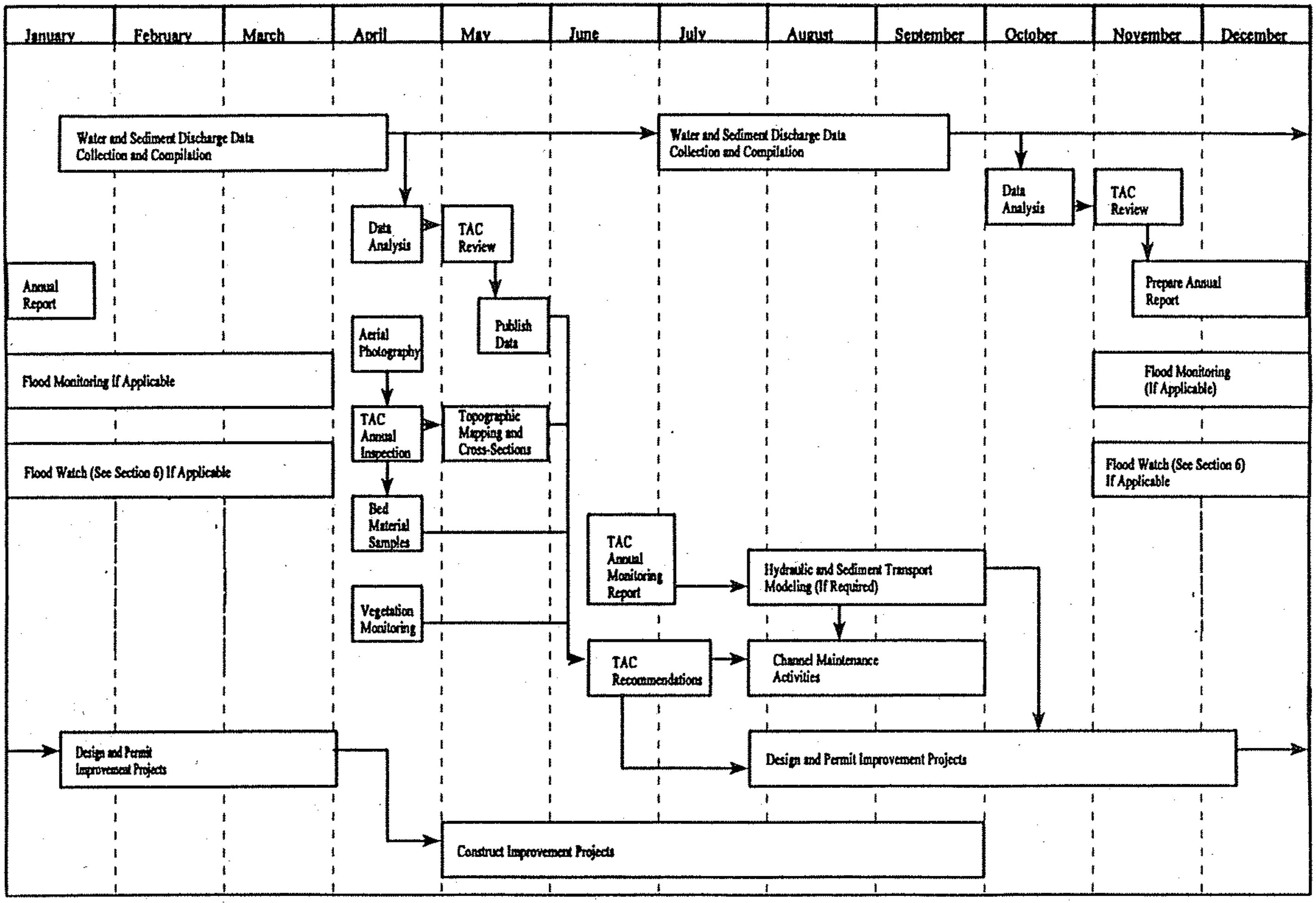
WATER AND SEDIMENT DISCHARGE MONITORING STATIONS

Figure 30



ANNUAL SCHEDULE FOR MONITORING PROGRAM

Figure 31



TABLES

Table 1 Summary of Reach Characteristics

Reach	Length (mi)	Stationing	Water Surface Slope[1] (ft/mi)		Channel Width[1] (ft)		Flow Depth[1] (ft)		Comments
			2 Yr	100 Yr	2 Yr	100 Yr	2 Yr	100 Yr	
Capay	2.1	1500+00 - 1390+00	10.8	10.8	328	1759	11.4	19.7	steep, confined and incised with bedrock controls
Hungry Hollow	2.8	1390+00 - 1240+00	11.3	11.3	1159	1548	5.9	11.5	channel widens; braided plan form; active gravel mining; depositional reach; avulsion potential
Madison	2.5	1240+00 - 1110+00	12.4	12.4	489	692	9.3	19.3	downstream portion of reach narrows and not actively mined
Guesisosi	2.3	1110+00 - 990+00	6.2	6.2	490	614	9.1	18.6	channel initially confined by levee, reasonably straight but meanders further downstream; some in-channel levees
Dunnigan Hills	2.8	990+00 - 840+00	9.9	9.9	690	879	7.4	16.1	well-developed low-flow meanders; significant riparian vegetation; site of former Moore diversion dam; bedrock controls along Dunnigan Hills; some in-channel levees; West Adams Canal drain and Goodnow Slough enter upstream from road 94B
Hoppin	3.3	840+00 - 665+00	7.4	7.4	672	1584	18.4	32.6	some meander development; bedrock controls upstream from Stevens Bridge; extensive gravel mining; dense vegetation downstream from Stevens Bridge; some in-channel levees
Rio Jesus Maria	7.5	665+00 - 590+00	7	7	210	384	27.6	41.6	upper 1.4 mi included in study area; channel considerably narrower and constricted with steep banks; some riparian vegetation; contains COE flood control levees; four bridge crossings near station 60000, at Yolo

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[1] Reach-averaged values.

Table 2 Cache Creek, Capay Subreach, February 1996

Subreach 8, Capay, Station 1500+00 to 1390+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	328	11.44	6.32	.0022	.00205	30	Relatively straight, steep, swift, low alternating bars, some bedrock controls, some cut banks, cobble and gravel bed materials,	Narrow & limited riparian vegetation primarily on high banks; variable density vegetation on alternating bars; due to channel incision reach may contain insufficient substrate for native riparian tree or shrub species
10 yrs	37000	1434	16.54	7.99	.0023	.00205	30	same as above	same as above
100 yrs	63500	1759	19.65	8.81	.0021	.00205	30	During high flows significant portions of the high terrace south of the main channel is inundated	During high flows substantial erosion and loss of vegetation occurs; during the 1995 event significant losses of trees and shrubs occurred

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the amount and size of in flowing load from upstream, local velocities, bed material size (armoring), local flow obstructions and the location of bedrock outcrops.	The NRCS and PG&E have recently installed bank protection works that may affect local bed and bank stability. Additional home made revetment works exist along the south bank downstream from the dam.	Controlling influences include: 1. in flowing sediment load and size, 2. location of bedrock and/or man-made stabilization works 3. location and extent of gravel bars and vegetation density on the gravel bars 4. Seasonal water diversions at the Capay Dam 5. Capay bridge 6. Seasonal rate and magnitude of in-channel gravel extraction downstream 7. Cumulative extraction volume removed downstream from reach 8	Periodic instability results from channel narrowing and deepening due to sediment starvation and lateral confinement (narrowing) of the active channel. Local instabilities occur due to the growth and stabilization of large - heavily vegetated gravel bars capable of redirecting flows at the banks. Prolonged removal of gravel downstream from the Capay Bridge has resulted in the upward migration of a significant nick point resulting in channel bed lowering and bank attack.

Table 3 Cache Creek, Upper Hungry Hollow Subreach, February 1996

Subreach 7, Upper Hungry Hollow, Station 1390+00 to 1300+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	865	6.87	4.57	.0028	.0022	25	Multiple low relief low flow channels at end of runoff season; following mining season there is no readily definable low flow channel; the reach between Capay and Esparto Bridges is wide with a relatively flat bottom; some cut banks and cobble and gravel bed materials. Channel form is artificially maintained by annual mining .	This reach is actively mined and characterized by large gravel and cobble substrate. Lack of adequate fines and water make this reach essentially devoid of vegetation
10 yrs	37000	1038	10.25	6.01	.0029	.0022	25	same as above	Without spring and summer flows, re-establishment of a stable low flow channel and riparian vegetation cannot occur
100 yrs	63500	1247	12.94	6.96	.0028	.0022	25	Same as above. Because of extensive excavation of materials from this reach, there is significantly greater in-channel flow capacity than the channel had historically, therefore, hydraulic energies are greater today	During high flows the channel bottom is resculpted to a new configuration; erosion and loss of vegetation occurs

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the amount and size of in flowing load from upstream, local velocities, bed material size, armoring, gravel extraction activities, the location and characteristics of local obstructions such as bars, haul roads, debris, vegetation and bridges	Bank stability is influenced by aggregate extraction activities, construction of berms and jetties, placement of localized revetments, size and location of haul roads, existing bridges and the size and amount of bed load delivered to the reach during a large event.	Controlling influences include: 1. in flowing sediment load and size, 2. location of bedrock and/or man-made stabilization works 3. location and extent of gravel bars and vegetation density on the gravel bars 4. Seasonal water diversions at the Capay Dam 5. Capay and Esparto Bridges 6. Seasonal rate and magnitude of in-channel gravel extraction upstream and downstream 7. Cumulative extraction volume removed upstream and downstream from reach 7.	Annual gravel removal within subreach 7 and upstream water diversions affect channel stability. The present system is artificially controlled in a state of disequilibrium through annual skimming. If annual extraction and regrading were to stop abruptly, it is difficult to predict where primary problems related to channel instability would occur. Abrupt changes in channel dimensions resulting in abrupt changes in hydraulic conditions.

Table 4 Cache Creek, Lower Hungry Hollow Subreach, February 1996

Subreach 7, Lower Hungry Hollow, Station 1300+00 to 1240+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	1455	4.98	4.01	.0030	.0022	23	Multiple low relief low flow channels at end of runoff season; following mining season there is no readily definable low flow channel; the reach downstream from the Esparto Bridge is wide with a relatively flat bottom; some cut banks and cobble and gravel bed materials. Channel form is artificially maintained by annual mining	This reach is actively mined and characterized by large gravel and cobble substrate. Lack of adequate fines and water make this reach essentially devoid of vegetation.
10 yrs	37000	1558	7.61	5.13	.0028	.0022	23	same as above	Without spring and summer flows re-establishment of a stable low flow channel and riparian vegetation cannot occur
100 yrs	63500	1860	10.09	5.71	.0022	.0022	23	Same as above. Because of extensive excavation of materials from this reach, there is significantly greater in-channel flow capacity than the channel had historically, therefore, hydraulic energies are greater today.	During high flows the channel bottom is resculpted to a new configuration; erosion and loss of vegetation occurs;

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the amount and size of in flowing load from upstream, local velocities, bed material size, armoring, gravel extraction activities, the location and characteristics of local obstructions such as bars, haul roads, debris, vegetation and bridges	Bank stability is influenced by aggregate extraction activities, construction of berms and jetties, placement of localized revetments, size and location of haul roads, existing bridges and the size and amount of bed load delivered to the reach during a large event.	Controlling influences include: 1. in flowing sediment load and size, 2. location of haul roads and/or man-made stabilization works 3. location and extent of gravel bars and vegetation density on the gravel bars 4. Seasonal water diversions at the Capay Dam 5. Esparto Bridge 6. Seasonal rate and magnitude of in-channel gravel extraction upstream and downstream 7. Cumulative extraction volume removed upstream and downstream from reach 7.	Annual gravel removal within subreach 7 and upstream water diversions affect channel stability. The present system is artificially controlled in a state of disequilibrium through aggregate extraction and annual skimming. If annual extraction and regrading were to stop abruptly, it is difficult to predict where primary problems related to channel instability would occur. Abrupt changes in channel dimensions result in abrupt changes in hydraulic conditions between the bridges.

Table 5 Cache Creek, Madison Subreach, February 1996

Subreach 6, Madison, Station 1240+00 to 1110+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	489	9.25	5.74	.0015	.00235	23	Same as reach 7, except the channel width is significantly reduced in the downstream direction. The upstream most portion of the reach is influenced by active gravel mining, however the downstream end is not actively mined	The creek plan form and vegetation vary throughout this reach. The upstream half of the reach has a poorly defined channel that is actively mined. The lower portion of the reach is not mined; vegetation occurs in patches along the banks and on small islands bars
10 yrs	37000	592	14.68	7.35	.0013	.00235	23	Same as above. Flows greater than the 2-year event are influenced by the presence of the I-505 bridge complex The reach is characterized by high near-vertical cut banks upstream from the I-505 bridge	Same as above. Vegetation in the reach is a mix of species, with high competition from tamarisk and giant reed.
100 yrs	63500	692	19.26	8.44	.0012	.00235	23	Same as above. Because of extensive excavation of materials from this reach, there is significantly greater in-channel flow capacity than the channel had historically, therefore, hydraulic energies are greater today.	During high flows the channel bottom is resculpted to a new configuration; erosion and loss of vegetation occurs;

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the amount and size of in flowing load from upstream, local velocities, bed material size, armoring, gravel extraction activities, the location and characteristics of local obstructions such as bars, haul roads, debris, vegetation and the effects of bridges	Bank stability is influenced by aggregate extraction activities, construction of berms and jetties, placement of localized revetments, size and location of haul roads, existing bridges and the size and amount of bed load delivered to the reach during a large event. Bank stability is also controlled by the geotechnical characteristics of the bank material, the bank height, its slope, and degree of saturation.	Controlling influences include: 1. in flowing sediment load and size, 2. location of haul roads and/or man-made stabilization works 3. location and extent of gravel bars and vegetation density on the gravel bars 4. Seasonal water diversions at the Capay Dam 5. I-505 Bridge and the old Madison bridge right abutment 6. Seasonal rate and magnitude of in-channel gravel extraction upstream and downstream 7. Cumulative extraction volume removed upstream and downstream from reach 6.	Annual gravel removal within subreach 6 and upstream water diversions affect channel stability. Cumulative gravel extraction upstream and downstream from the reach may also affect its stability. Reach 6 narrows and flows accelerate through the I-505 bridge leading to abrupt changes in local channel hydraulic conditions. The present system is artificially controlled in a state of disequilibrium through aggregate extraction and annual skimming. If annual extraction and regrading were to stop abruptly, it is difficult to predict where primary problems related to channel instability would occur. Abrupt changes in channel dimensions result in abrupt changes in hydraulic conditions in between bridges.

Table 6 Cache Creek, Guesisosi Subreach, February 1996

Subreach 5, Guesisosi, Station 1110+00 to 990+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	490	9.10	4.78	.0015	.00117	17	Active aggregate skimming occurs in this reach. Because of skimming the channel cannot establish a well defined low flow channel.	Vegetation is present on both banks but not present on the channel bottom until the lowe end of the reach.
10 yrs	37000	546	14.24	6.62	.0016	.00117	17	Significant bank revetment works occur through this reach. The channel width is narrower than it was historically and much deeper	Same as above. Vegetation in the reach is a mix of species, with less tamarisk and giant reed than in upstream reaches. In the downstream end more willow and other native riparian species are attempting to reestablish. Depth to groundwater is shallow, thus providing more perennial water for the support of vegetation.
100 yrs	63500	614	18.59	8.02	.0017	.00117	17	Same as above. Because of extensive excavation of materials from this reach, there is significantly greater in-channel flow capacity than the channel had historically, therefore, hydraulic energies are greater today.	During high flows the channel bottom is resculpted to a new configuration; erosion and loss of vegetation occurs

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the amount and size of in flowing load from upstream, local velocities, bed material size, armoring, gravel extraction activities, the location and characteristics of local obstructions such as bars, haul roads, debris, vegetation and the effects of bridges. Bed material size decreases in the downstream direction below I-505.	Bank stability is influenced by aggregate extraction activities upstream, the presence of berms and jetties, placement of localized revetments, size and location of haul roads, existing bridges and the size and amount of bed load delivered to the reach during a large event. Bank stability is also controlled by the geotechnical characteristics of the bank material, the bank height, its slope, and degree of saturation.	Controlling influences include: 1. in flowing sediment load and size, 2. location of haul roads and/or man-made stabilization works 3. location and extent of gravel bars and the height and vegetation density on the gravel bars 4. The presence of perennial water in the lower portion of the reach 5. I-505 Bridge and the old Moore Canal crossing (narrows) 6. Seasonal rate and magnitude of in-channel gravel extraction upstream and downstream 7. Cumulative extraction volume removed upstream and downstream from reach 5. 8. Bed material size decreases in the downstream direction below I-505.	Annual gravel removal within subreach 5 and the existence of annual low flows in the downstream portion of the reach affect material size, vegetation density and channel stability. Cumulative gravel extraction upstream and downstream from the reach may also affect its stability. Reach 5 narrows and flows accelerate through the Moore Canal syphon area. The invert of the syphon is exposed at the surface of the creek bed and is probably functioning as a defacto grade control for the reach downstream. The present system is artificially controlled in a state of disequilibrium through aggregate extraction and annual skimming in the upstream reach. If annual extraction and regrading were to stop abruptly, it is difficult to predict where primary problems related to channel instability would occur. Abrupt changes in channel dimensions result in abrupt changes in hydraulic conditions.

Table 7 Cache Creek, Dunnigan Hills, February 1996

Subreach 4, Dunnigan Hills, Station 990+00 to 840+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	690	7.38	4.49	.00110	.0019	15	The reach is not actively mined but has been in the past. There are multiple low flow channels separated by heavily vegetated islands and midchannel bars. Bed material consists of gravel, sands and finer materials trapped by the vegetation.	The reach represents the most significant area of groundwater gain, and has the largest and highest quality contiguous native riparian vegetation within the study area.
10 yrs	37000	761	12.22	5.97	.00192	.0019	15	Several in-channel berms and levees remain from past mining operations. Many of the pits behind the in-channel levees have riparian vegetation establishing or have the potential to establish riparian vegetation.	Many of the pits behind the in-channel levees have riparian vegetation establishing or have the potential to establish riparian vegetation.
100 yrs	63500	879	16.10	7.07	.00189	.0019	15	Same as above. Because of extensive excavation of materials from this reach in the past, there is significantly greater in-channel flow capacity than the channel had historically, therefore, hydraulic energies are greater today.	During high flows the channel bottom is resculpted to a new configuration; erosion and loss of vegetation occurs

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the size and volume of in flowing sediment load, the size, density and age of riparian vegetation, local depths and velocities during high flow, the location and characteristics of obstructions, revetments and bridges	Bank stability is influenced by regional aggregate extraction activities upstream and downstream; the presence of berms and jetties, placement of localized revetments, size and location of haul roads, existing bridges and the size and amount of bed load delivered to the reach during large events. Bank stability is also controlled by the geotechnical characteristics of bank materials, the bank height, its slope, and degree of saturation.	Controlling influences include: 1. in flowing sediment load and size, 2. location of haul roads and/or man-made levees and stabilization works 3. location and extent of gravel bars and the height and density of vegetation on the gravel bars 4. The presence of perennial water in the lower portion of the reach 5.Road 94-B Bridge and the old Moore Canal crossing and narrows upstream 6. Seasonal rate and magnitude of in-channel gravel extraction upstream and downstream from the reach 7. Cumulative extraction volume removed upstream and downstream from reach 4. 8. Bed material decreases in diameter in the downstream direction below I-505. 9. The downstream portion of reach 4 is influenced by backwater controls downstream near I-5 during high flows.	Reach 4 is the most significant area of groundwater gain. This significantly affects channel stability because vegetation is capable of re-establishing itself along the bed and banks. Cumulative gravel extraction upstream and downstream from the reach may also affect its stability. Reach 4 is relatively narrow. The present reach is attempting to recover from past mining and appears to be stabilizing well. If annual extraction outside of the reach were to stop abruptly, it is difficult to predict where primary problems related to channel instability would occur, however, reach 4 appears to be well on its way to restabilizing itself. Abrupt changes in channel dimensions result in abrupt changes in hydraulic conditions.

Table 8 Cache Creek, Hoppin Subreach, February 1996

Subreach 3, Hoppin, Station 840+00 to 665+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	672	18.37	2.89	.0004	.0013	7	The reach is not actively mined but has been in the past. There are multiple low flow channels separated by heavily vegetated islands and midchannel bars. Bed material consists of gravel, sands and finer materials trapped by the vegetation.	The reach has relatively high groundwater and has the potential to support high quality contiguous native riparian vegetation. Although mined in the past, the reach has dense patches of riparian vegetation. Exotic plant species competition is very high in this reach and tamarisk dominates the upper banks.
10 yrs	37000	1422	29.00	2.72	.0002	.0013	7	Several in-channel berms and levees remain from past mining operations. There are several in locations where mining has occurred recently behind levees adjacent to the main channel. Many of the pits behind the in-channel levees have riparian vegetation establishing or have the potential to establish riparian vegetation.	Many of the adjacent mining areas and pits behind the in-channel levees have riparian vegetation establishing or have the potential to establish riparian vegetation. This reach tends t be depositional during large events and has a high percentage of fine-grained bed materials.
100 yrs	63500	1584	32.57	3.55	.0003	.0013	7	Same as above. Because of extensive excavation of materials from this reach in the past, there is significantly greater in-channel flow capacity than the channel had historically, therefore, hydraulic energies are greater today.	During high flows the channel bottom is resculpted to a new configuration; erosion and loss of vegetation occurs. Reach 3 is significantly affected by backwater from the narrows at I-5, resulting in substantial deposition of sediment materials during large events

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the size and volume of in flowing sediment load, the size, density and age of riparian vegetation, local depths and velocities during high flow, the location and characteristics of obstructions, revetments and bridges. Because the reach is in a backwater zone, significant deposition of sediment materials occurs during large events.	Bank stability is influenced by regional aggregate extraction activities upstream; the presence of berms and jetties, placement of localized revetments, size and location of haul roads, existing bridges and the size and amount of bed load delivered to the reach during large events. Bank stability is also controlled by the geotechnical characteristics of bank materials, the bank height, its slope, amount of vegetative cover and degree of saturation.	Controlling influences include: 1. in flowing sediment load and size, 2. location of haul roads and/or man-made levees and stabilization works 3. location and extent of gravel bars and the height and density of vegetation on the gravel bars 4. The presence of perennial water in the lower portion of the reach 5.Road 94-B Bridge and the I-5 Bridge complex control both ends of the reach. The channel section near I-5 causes backwater control during high flows. 6. Seasonal rate and magnitude of in-channel gravel extraction upstream from the reach 7. Cumulative extraction volume removed upstream from reach 3. 8. Bed material size fines (decreases diameter) in the downstream direction below I-505. 9. Reach 3 is influenced by backwater controls downstream near I-5 during high flows.	Reach 3 typically has high groundwater and low flows most of the year. This significantly affects channel stability because vegetation is capable of re-establishing itself along the bed and banks. Cumulative gravel extraction upstream from the reach may also affect its stability. Reach 3 is relatively narrow. The present reach is attempting to recover from past mining and appears to be stabilizing. If annual extraction outside of the reach were to stop abruptly, it is difficult to predict where primary problems related to channel instability would occur. Abrupt changes in cross section dimensions result in abrupt changes in hydraulic conditions.

Table 9 Cache Creek, Rio Jesus Maria, February 1996

Subreach 2, Rio Jesus Maria, Station 665+00 to 590+00									
Return Period	Reach Average Hydraulic Characteristics						Sediment	Channel Form	Vegetation Condition
	Discharge (cfs)	Width (ft)	Depth (ft)	Velocity (ft/sec)	Energy Slope	Bed Slope	Bed Mat'l d_{50} (mm)		
2 yrs	14500	210	27.62	4.94	.0006	.0013	10	This is the narrowest reach in the study area. The reach is not actively mined but has been in the past. There are multiple low flow channels separated by heavily vegetated islands and midchannel bars. Bed material consists of gravel, sands and finer materials trapped by the vegetation.	The reach has relatively high groundwater and has the potential to support high quality contiguous native riparian vegetation. Although mined in the past, the reach has dense patches of riparian vegetation. Exotic plant species competition is very high in this reach and tamarisk dominates the upper banks and sand bars.
10 yrs	37000	357	39.63	6.40	.0008	.0013	10	The banks are extremely steep and approximately 30 to 40 feet high. Bed materials are comprised primarily of sands and some gravels	Vegetation is present in a narrow band along the banks, but tamarisk and other invasive species are dominant along the reach.
100 yrs	63500	383.85	41.55	7.47	.0011	.0013	10	Channel features slow water velocities during high flows and reduce channel capacity as well as the ability of flows to carry sediment through the reach	Valley oaks and sycamores are scattered along the uppermost portions of the banks

Bed Stability	Bank Stability	Controlling Influences and Location	Process resulting in Instability
Bed stability is controlled by the size and volume of in flowing sediment load, the size, density and age of riparian vegetation, local depths and velocities during high flow, the location and characteristics of obstructions, revetments and bridges. Because the reach is in a backwater zone, significant deposition of sediment materials occurs during large events.	Bank stability is influenced by regional aggregate extraction activities upstream; the presence of localized revetments and the Corps of Engineers levees, existing bridges and the size and amount of bed load delivered to the reach during large events. Bank stability is also controlled by the geotechnical characteristics of bank materials, the bank height, its slope, amount of vegetative cover and degree of saturation.	Controlling influences include: 1. in flowing sediment load and size, 2. location of man-made levees and stabilization works 3. location and extent of gravel bars and the height and density of vegetation on the gravel bars 4. The presence of perennial water in the reach 5. The I-5 Bridge complex and narrow channel dimensions control the hydraulic capacity of the reach. The channel section near I-5 causes backwater control during high flows. 6. Seasonal rate and magnitude of in-channel gravel extraction upstream from the reach 7. Cumulative extraction volume removed upstream from reach 3. 8. Bed material size fines (decreases diameter) in the downstream direction below I-505. 9. Reach 2 is influenced by backwater controls near I-5 during high flows. 10. There is evidence of some bedrock control (probably old Sacramento Valley formation materials) near the toe of the present high bank line that is contributing to the stability of the bed and banks through the reach.	Reach 2 typically has high groundwater and low flows most of the year. This significantly affects channel stability because vegetation is capable of establishing itself along the bed and banks. Cumulative gravel extraction upstream from the reach may also affect its stability. Reach 2 is the narrowest reach in the study area. The present reach is attempting to recover from past mining and channel incision. If annual extraction outside of the reach were to stop abruptly, it is difficult to predict where primary problems related to channel instability would occur. Abrupt changes in channel dimensions result in abrupt changes in hydraulic conditions.

Table 12
CACHE CREEK BASIN STREAM GAGING STATIONS

Location	Drainage Area (mi^2)	Period of Record Used	Length of Record Used (year)	Average Annual Runoff (acre-ft)	Average Annual Yield (acre-ft/mi^2)	Average Annual Discharge (cfs)	Station Operator
Cache Creek near Lower Lake	528.0	1944-1991	47	256,000	484.8	350	USGS
North Fork Cache Creek at Hough Springs near Lower Lake	60.2	1971-1991	20	67,900	1127.9	95	USGS
North Fork Cache Creek near Lower Lake[1]	197.0	1930-1981	52	136,500	692.9	185	USGS
Bear Creek near Rumsey[1]	100.0	1958-1980	23	35,760	357.6	50	DWR, CA
Cache Creek above Rumsey[1]	955.0	1965-1986	19	541,200	566.7	755	DWR, CA
Cache Creek near Capay[1]	1044.0	1942-1976	35	556,900	533.4	770	USGS
Cache Creek at Yolo	1139.0	1903-1993	91	378,900	332.7	520	USGS

Source: COE, 1994, Westside Tributaries Study, August.

[1] Stream gage recorder discontinued.