6. RECOMMENDATIONS

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Introduction

The three studies presented in Chapters 3, 4 and 5 of this report provide the technical basis from which a Cache Creek Resources Management Plan (CCRMP) can be developed. The following chapter discusses the proposed objectives of the CCRMP as described in the Yolo County Statement of Goals, Objectives and Policies for the Cache Creek Resources Management Plan (June 1994) and presents recommendations designed to assist the County in creating the means to achieve those objectives.

The recommendations related to streamway management are based on the analysis of existing conditions and problems as described in the channel dynamics section of Chapter 3 (Section 3.5). Analyses presented in Sections 4.5 and 5.6 provide the basis for the groundwater and riparian habitat recommendations, respectively. Because these recommendations are provided to meet multiple objectives, they may in some instances or specific applications be in conflict with each other. This report does not attempt to resolve conflicts between multiple objectives, but rather describes the steps necessary to achieve each of the County's objectives. Potential conflicts are described in general terms in anticipation of the County's need to resolve these issues during development of the CCRMP and Off Channel Mining Ordinance.

The creek is a dynamic system that is currently severely impacted by a variety of influences. Therefore, its response to management changes can not be accurately predicted. It would be premature to develop a recommended plan for the channel during this study and attempt, through maintenance, to force the creek to conform to the plan. Instead, the recommendations included here are intended to promote adjustments in the creek which meet the stated objectives while allowing flexibility for the creek to shape its own recovery and restoration over time.

Chapter 6 describes objectives for creek management, provides specific recommendations for achieving these objectives, and briefly discusses implementation options. All recommendations are tabulated in Table 6-1 at the end of this chapter. In that table, each recommendation is given a priority ranking indicating the relative importance and effectiveness of the specific recommendation to achieve the stated objective with "1" having the highest priority and "3" having the lowest.

Objectives

The starting point for establishing creek management objectives for this study is the set of goals described in the Yolo County Statement of Goals, Objectives and Policies for the Cache Creek Resources Management Plan. During the course of this study, an understanding of creek dynamics has been developed that can be used to refine and augment the stated goals from the Conceptual Study with respect to the Streamway Study. The following objectives were used to develop recommendations:

- Increase channel stability
- Improve riparian habitat
- Protect groundwater resources
- Provide opportunities for aesthetic, recreational, and educational enhancement
- Preserve flood carrying capacity
- Provide for managed aggregate extraction
- Protect County infrastructure
- Protect adjacent agricultural lands
- Promote a self sustaining fluvial system

In many instances, these objectives are not mutually compatible. For example, increased riparian vegetation may reduce flood carrying capacity, or aggregate extraction may limit the extent of riparian habitat feasible. Similar conflicts exist between other objectives. Nevertheless, the recommendations presented below are intended to meet these objectives individually, recognizing that priorities for objectives and timing of changes in management of the creek's various resources will need to be determined as part of the County's planning process.

Recommendations

General recommendations to meet each of the objectives are summarized in Table 6-1 and are discussed individually below.

Channel Stability

The methods used to extract aggregate from the creek up to the present time have contributed to channel instability by changing the channel's natural morphology, altering hydraulic characteristics, and affecting sediment transport through the study area. These changes have made the channel more susceptible to major adjustments during large floods, including bank erosion and incision of the bed. The hydraulic and sediment transport characteristics of each reach are now principally controlled by aggregate mining. As demonstrated in Section 3.6, variability in hydraulic characteristics between subreaches causes a progressive channel response that may be out of phase temporally and spatially with actual aggregate extraction operations. Continued extraction maintains the state of imbalance between subreaches and precludes recovery of the creek by natural channel forming processes.

In order to improve channel stability and protect bridges, banks, and adjacent agricultural land it is necessary to substantially change the present methods used to regulate aggregate extraction in the channel. In addition, the average annual extraction rates must be significantly reduced to more nearly match the estimated annual supply of sand and gravel to the study reach. The following recommendations related to aggregate extraction are designed to promote increased channel stability:

1) Define a streamway influence channel boundary for regulating aggregate extraction based on the historical extent of the channel defined by early topographic mapping. Figure 6-1 shows the recommended streamway boundary.

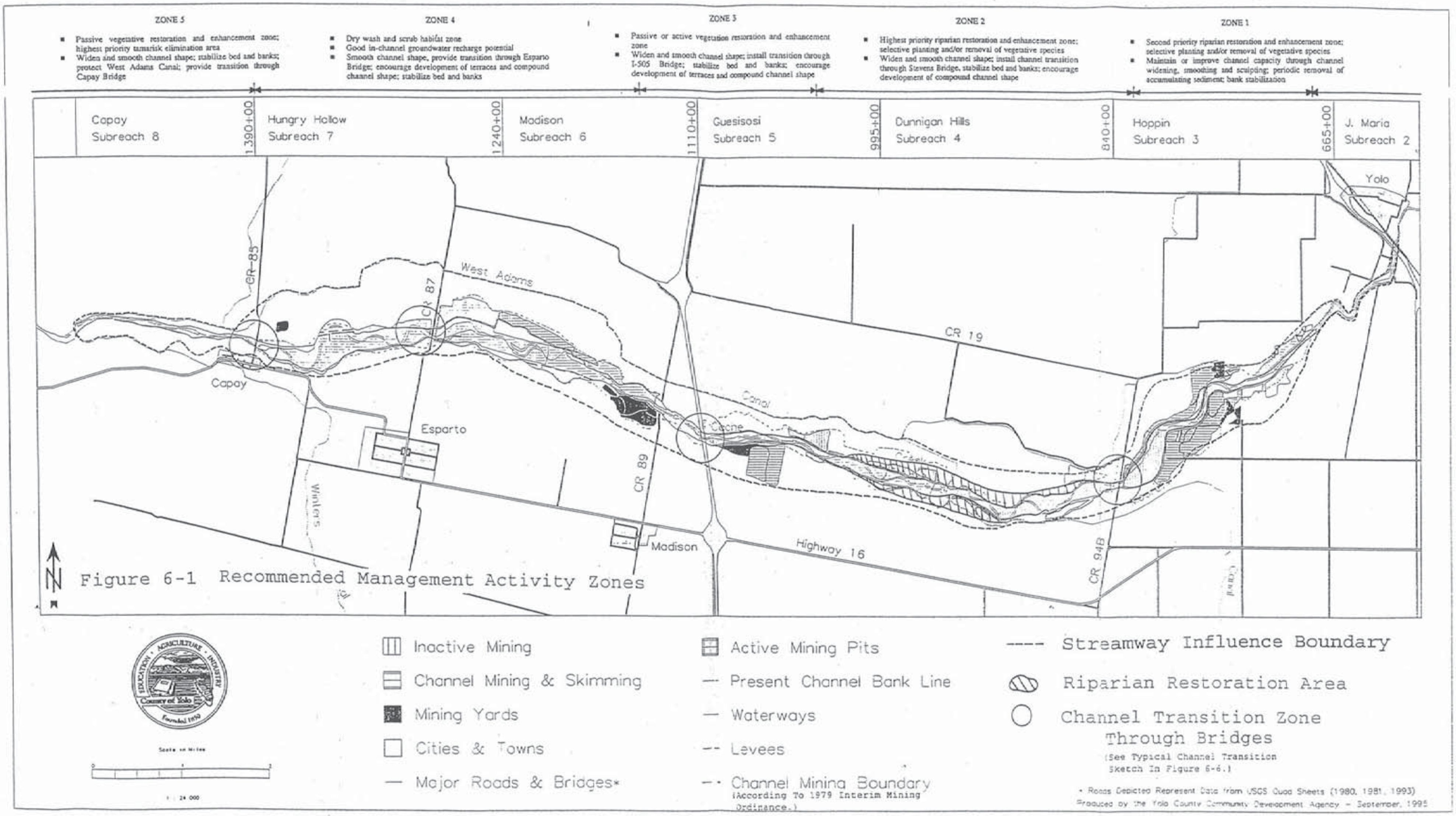

Figure 6-1 Recommended Management Activity Zones

2) In the long term, limit in-channel aggregate extraction to approximately the volume of sand and gravel delivered annually to the study reach. This amount is currently estimated to average 210,000 tons of sand and gravel per year. Individual years and flood events will vary in supply, and extraction should follow this variability based on a monitoring program (see below). In addition, aggregate extraction in local areas may be necessary on a one-time basis to provide bank protection or flood control benefits.

3) In the near term, allow regulated aggregate extraction to reshape and smooth the channel at rates greater than the supply to the study reach. This will return the channel (on a reach by reach basis) to a form more similar to its historical morphology. See Recommendation 6.

4) Discontinue mining activities within an active low flow channel area to avoid disturbance of the armor layer. A minimum width of 300 feet centered on the low flow channel is recommended in areas with a single thread channel. Extraction, haul roads, and all other mining activities should be prohibited in this area. Where braided or multiple channel exist, the protected width may be reduced to 250 feet for each channel. The low flow channel may be allowed to establish its own location, or may be created as part of an approved reclamation plan.

5) Abandon the theoretical thalweg concept and 1979 in-channel mining boundary. Establish initial management targets for channel slope and sinuosity. These targets may need to be adjusted over time based on monitoring (see below). Table 6-2 lists channel slopes and sinuosities by reach. Significant modification of existing thalweg elevations by grading or other management techniques is not anticipated. Management should focus on maintaining appropriate channel slopes rather than specific elevations. Every effort should be made to stop further bed lowering in all subreaches.

6) Restrict aggregate extraction using general or reach specific cross section templates. A recommended general cross section template is shown in Figure 6-2. This template is based on historical channel morphology. The application of the template to three typical cross sections is shown in Figures 6-3 to 6-5. Monitoring results and resource management considerations should guide development of reach specific cross sections in the future. Local variations will be necessary based on property ownership, protection of biological resources, and other existing conditions.

7) Synthesize individual in-channel mining reclamation plans into a single regional plan to achieve integrated (system-wide) management objectives. Utilize the regional reclamation plan to reduce changes in hydraulic and sediment transport capacities between reaches. Provide for coordinated phasing of aggregate extraction/reclamation between operators. Where significant changes in conveyance capacity presently exists between reaches, promote smooth transitions between reaches through the reclamation process.

8) Develop regular and emergency channel bank maintenance and repair agreements with aggregate operators, land owners, and government agencies. These agreements could provide for extraction of detrimental channel deposits, construction of bank protection measures, and provision of emergency labor, equipment and materials during and/or after flood events.

TABLE 6-2

REACH CHARACTERISTICS

Reach	Year	Channel Slope	Sinuosity[1]
Rio Jesus Maria Subreach 2	1905 1995 Target	0.16% 0.12%-0.13% 0.12%-0.14%	1.18 1.18 1.18
Hoppin Subreach 3	1905 1995 Target	0.10% 0.14%-0.15% 0.12%-0.14%	1.20 1.08 1.15
Dunnigan Hills Subreach 4	1905 1995 Target	0.14% 0.19%-0.20% 0.15%-0.18%	1.05 1.00 1.05
Guesisosi Subreach 5	1905 1005 Target	0.14% 0.12%-0.14% 0.12%-0.14%	1.05 1.01 1.05
Madison Subreach 6	1905 1995 Target	0.18% 0.21%-0.23% 0.19%-0.21%	1.17 1.03 1.15
Hungry Hollow Subreach 7	1905 1995 Target	0.15% 0.21%-0.24% 0.19%-0.21%	1.16 1.02 1.10
Capay Subreach 8	1905 1995 Target	- 0.18%-0.20% 0.18%-0.20%	- 1.04 1.04

[1]Sinuosity is channel length divided by valley length.

SOURCE: NHC, 1995.

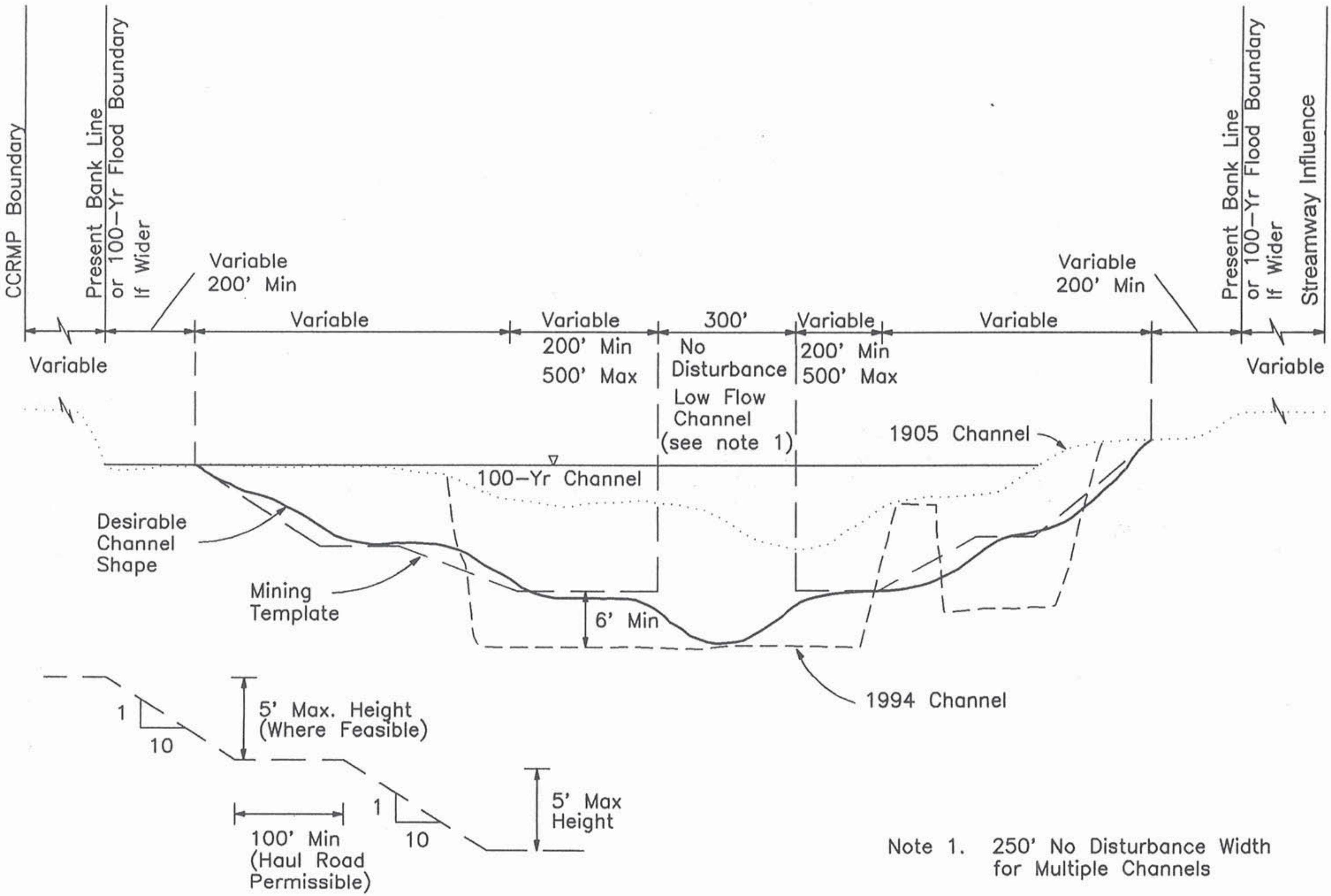

Figure 6-2 Generalized Cross Section Template

Not to Scale

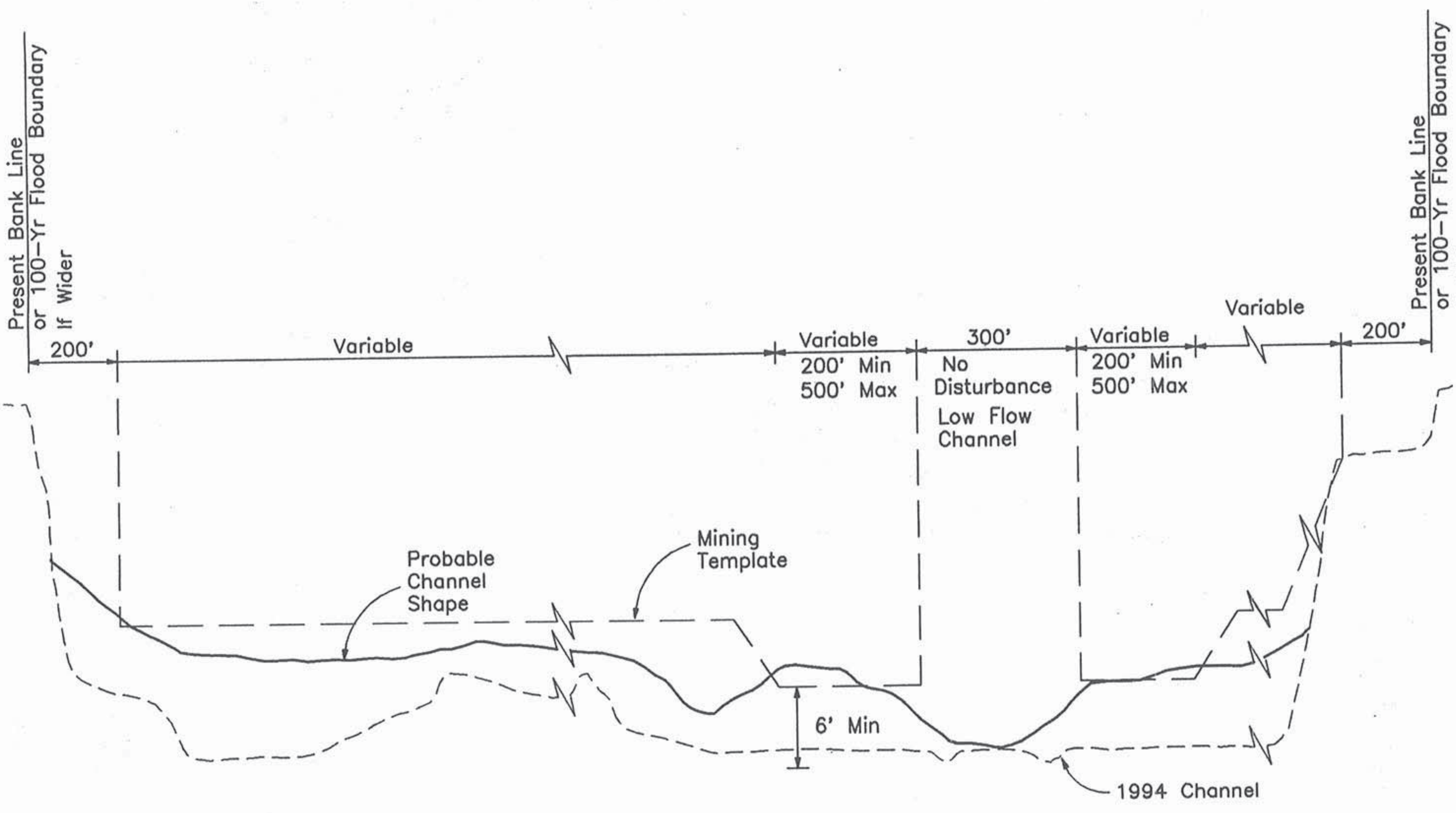

Figure 6–3 Wide Cross Section

Not to Scale

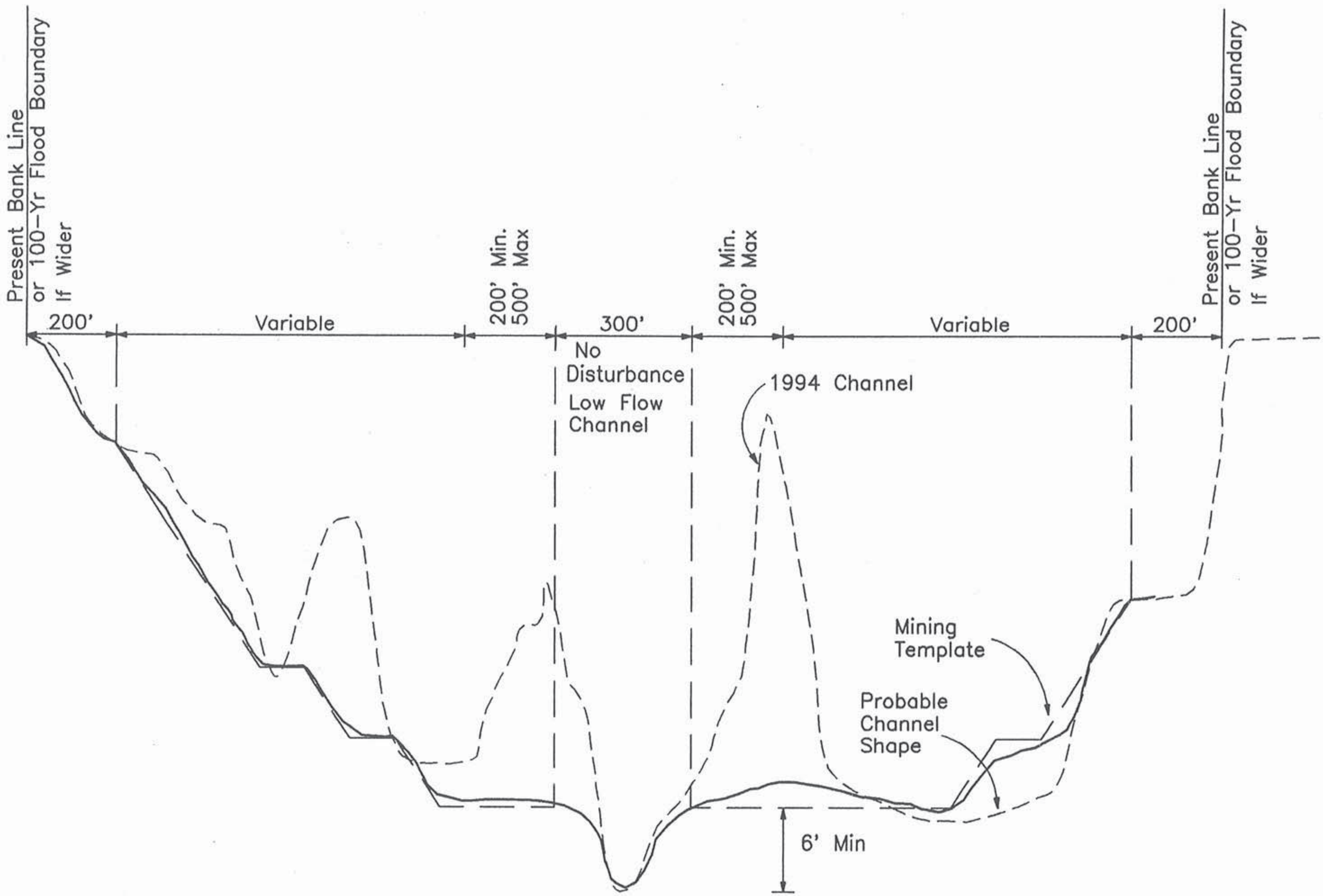

Figure 6-4 Narrow Cross Section with Adjacent Pits

Not to Scale

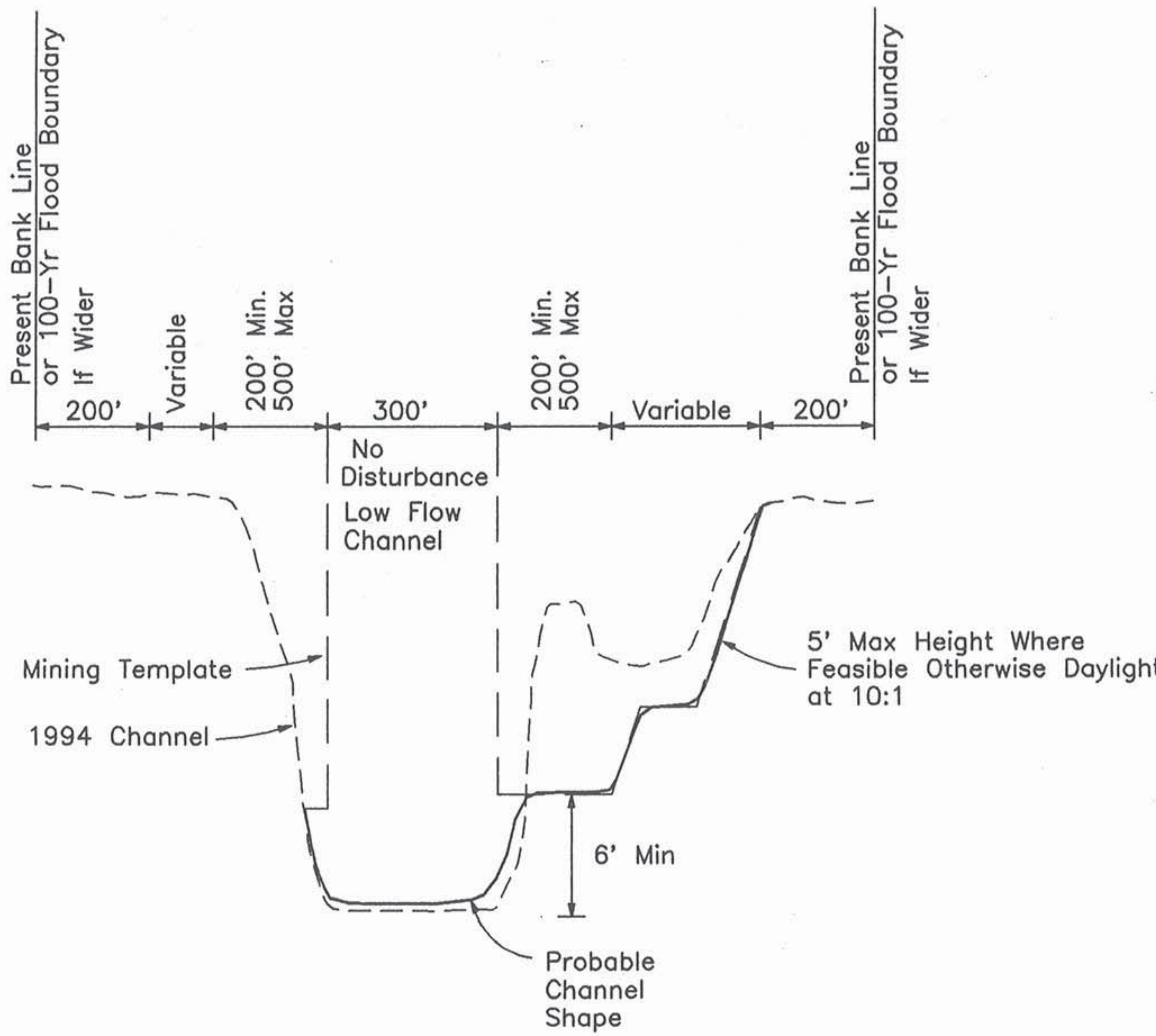

Figure 6–5 Narrow Cross Section

Not to Scale

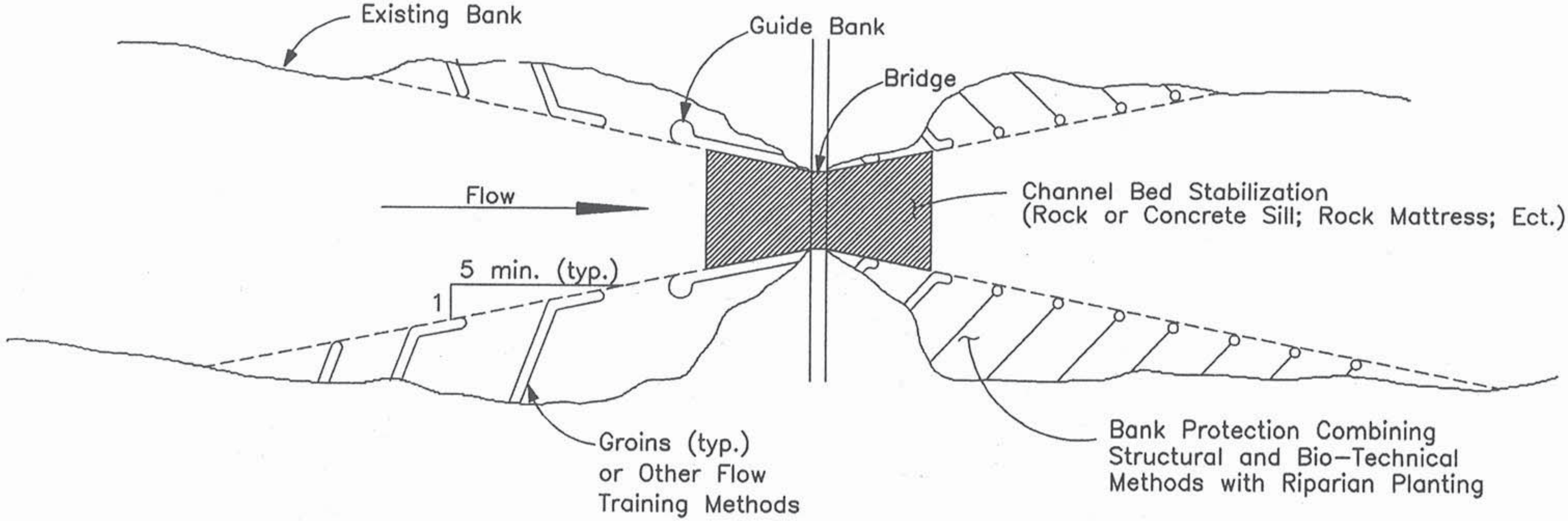

Figure 6-6 Typical Channel Transition at Bridges

Not to Scale

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

In addition to aggregate extraction, diversion of Cache Creek waters for irrigation has been a significant historical influence on channel morphology. Since the 1850s, portions of the study reach have had no summer flow. The irrigation season lasts about seven months in many years, and a large fraction of the creek's water is diverted during this period. The combined result of diversion and aggregate extraction is that no stable low flow channel can develop in most of the area downstream of Capay Bridge. This condition promotes instability in the channel as flows rapidly increase during the winter months and the diversion dam at Capay is lowered. Changes in flow-duration characteristics of the study reach could be used to promote a more stable low flow channel with a well developed armor layer.

The Cache Creek channel has been subject to significant adjustments and bank erosion during major floods since at least 1940. Under present conditions, few bank erosion problems occur except during major runoff events. The bank loss, channel incision, and damage to the Capay Bridge during the 1995 floods are examples of the channel's response to major floods. Reduction of flood peaks would reduce the hazard of flooding downstream and bank erosion throughout the study area. Upstream storage at dam sites in Wilson Valley and on Bear Creek has been studied previously by the Corps of Engineers in 1994. Although probably not justified for this purpose alone, an upstream dam could be considered to have economic benefits associated with study reach channel stability. The benefits could include the avoided cost of bank protection, flood fighting, and damage to structures. If an upstream dam is reconsidered for combined water supply and flood control purposes, these benefits should be considered in the economic analysis, and the operation of the reservoir should be designed to promote channel stability by establishing desirable flow-duration characteristics. The following recommendations related to surface water supply are designed to promote channel stability:

9) Release channel forming flows in the operation of the Capay Diversion Dam. If feasible based on annual precipitation, maintain intermediate springtime flows to form an armored low flow channel and increase fall flows gradually up to a peak of approximately 2,000 cfs prior to November 15. The duration of flows exceeding 1,000 cfs should be at least one week, and the duration of 2,000 cfs flow should be at least one day. This discharge represents approximately 2.8 percent of the total annual average discharge of Cache Creek.

10) Consider the benefits of bank protection and bridge protection in economic analyses of upstream storage dams, if a dam is reconsidered for flood control and water supply purposes.

The existing riparian habitat conditions, loss of pre-historic and historical habitat, and potential methods for habitat preservation and enhancement are covered in detail in Chapter 5. Recommendations for enhancement of riparian habitat are presented under a separate heading below. However, channel morphology and riparian vegetation are closely interrelated, and preservation and re-establishment of riparian vegetation is briefly discussed in this section on channel stability. Riparian vegetation affects both the hydraulic and sediment transport capacity of the channel on both a regional and local scale. Suitable channel velocity, substrate, and ground moisture conditions must be present to allow establishment of vegetation. However, once established, vegetation can modify channel hydraulics, including changes to velocity and conveyance, and can promote deposition of fine sediments in vegetated areas.

In concert with the recommendations above, it may be feasible to use riparian vegetation to effect transitions between subreaches with differing hydraulic and sediment transport characteristics. It will also be necessary to manage a gradual shift in channel morphology associated with mining reclamation by simultaneously managing vegetation. The following recommendations, in addition to those above, are designed to allow for improved channel stability through the managed enhancement of riparian habitat in the study area:

11) Integrate riparian vegetation into overall channel hydraulic and sedimentation management.

12) Use riparian vegetation, where appropriate, to create smoother transitions between reaches with differing hydraulic capacities. For example, smoother contractions and expansions at bridge sites could be established using managed riparian vegetation and other dependable bio-technical river training methods.

13) Selectively remove vegetation where its establishment threatens channel stability. In particular, growth of tamarisk, giant reed, and willow on mid-channel or alternating bars should be controlled to prevent growth of the bars to the extent that could cause channel migration.

14) Encourage vegetation in newly established terrace areas within the channel near the banks. Vegetation should be established and maintained with highest density along the banks to result in a distribution of velocities in the channel, with the highest velocities centered over the thalweg or low flow channel.

Riparian Habitat Enhancement

The enhancement and/or expansion of riparian habitat within the study area depends upon the creation and maintenance of a channel morphology and hydrology that are conducive to the development of desired habitat types or mosaics. Specifically, frequent flooding is necessary to create seasonal saturation and to deposit fine-grained sediments, and near-surface ground water is necessary to sustain woody vegetation through dry seasons and years. Wherever surface flow is not perennial, the duration of the seasonal flow is very important in determining the character of the vegetation that can develop. Active habitat restoration efforts, such as removal of undesired weedy species or planting of desired native species, are only successful in the context of other actions that will maintain the proper soils and hydrologic regimes. Thus, achievement of habitat goals is realized primarily by improving the physical character of the streamway, and secondarily by specific vegetation-directed actions. The limitations imposed on re-establishment of extensive riparian habitat include narrowing of the floodway, diversion of surface flows, and surface disturbance due to aggregate mining. In general, the recommendations for establishing a wider channel morphology more similar to historical conditions and modifying aggregate extraction operations significantly would provide opportunities for establishment of riparian habitat (Recommendations 1, 2, 3, 6, and 7 above). Changes in flow-duration characteristics described in Recommendation 9 may also benefit riparian communities, although additional summertime flow may be required to support vegetation (see Chapter 5). The following recommendations are designed to provide for the long-term enhancement and management of riparian habitat within the study area:

15) Promote habitat stability by improving channel stability. In areas where significant existing riparian vegetation does not presently exist, smooth the channel banks by lowering the high banks at constrictions, as shown in Figure 6-1. In the stream segment including the Dunnigan Hills subreach and the upstream portion of Hoppin subreach, create terraced cross-sectional topography with gradual (10:1) transitions. Longitudinally smoothed, terraced creek topography will reduce erosion/sedimentation instability and promote the development of a variety of different riparian habitats.

16) Once desired channel configuration is achieved in the restoration reach(es), terminate in-channel mining in those areas in order to preserve the highest quality riparian habitat resources. Limited mining in specific areas may still be required to provide bank erosion and flood control benefits. This type of mining should be performed on freshly deposited bars prior to the development of significant vegetation.

17) Apply treatments similar to those presented in Recommendations 15 and 16 to the Capay reach.

18) Promote the development of stable habitat along losing reaches. Establish a low flow channel with an initial configuration similar to that seen in aerial photographs taken after the 1995 flood events. Discontinue all mining-related surface disturbance within a corridor 300 feet wide centered on this channel. Modify the width and location of the no-disturbance zone as the low-flow channel migrates and evolves. Require that no large piles of mined materials be left within the channel in places where they would tend to create highly erosive flows in the no-disturbance zone.

19) In gaining reaches of the riparian system, plant species appropriate to the substrate and hydrologic regime of each microsite (terrace, transition slope, etc.).

20) In all reaches where mining occurs, require that bar skimming be limited to the downstream portion (up to 3/4 of the length) of the bar, and require salvage of topsoil and woody plant material and their use in restoration planting.

21) Configure abandoned off-channel pits designated for habitat creation so as to favor the establishment and long-term survival of a diverse mixture of woody species, emphasizing those comprising mixed riparian forest. Place topsoil in abandoned pits to be reclaimed and plant with appropriate zones of riparian species.

22) Control weed invasion primarily by improving channel characteristics as described above.

23) Remove individual large clumps of giant reed in areas of highest flow velocities. The highest priority for removal should be given to the westernmost locations in the study area, upstream of Capay bridge.

24) Remove or exterminate tamarisk only where it competes with native species which would otherwise form "closed" vegetative communities. These closed communities would contain little open, unvegetated areas to allow for the establishment of tamarisk.

Groundwater Resources

As stated above, the protection of groundwater resources was presented as a primary objective in the June 1994 Yolo County Statement of Goals, Objectives and Policies for the Cache Creek Resources Management Plan. To achieve this objective, the following should occur:

- Protect groundwater from overdraft
- Protect groundwater recharge
- Protect aquifer transmissivity
- Protect usable groundwater storage capacity
- Preserve groundwater quality
- Improve riparian habitat
- Provide opportunities for recreation
- Enhance Yolo County water supply

<u>Protect Groundwater From Overdraft</u>

As documented in Section 4.4, concern about overdraft arose in Yolo County during the mid-1970's when sustained groundwater level declines occurred. These declines reflected an imbalance of groundwater discharge over groundwater recharge. However, such changes in groundwater levels historically in Yolo County have been the result primarily of groundwater irrigation. Aggregate mining has had only minor, localized impacts on groundwater levels. Nonetheless, mining potentially could have significant impacts on groundwater supply. This section focuses on potential impacts on groundwater supply from increasing discharge of groundwater. Discharge of groundwater can be increased substantially through dewatering of wet pits to facilitate mining. These impacts include local and even regional groundwater level declines, plus loss of discharged water. Minimization of impacts on wells would be challenging. Loss of discharge water could be lessened through planned routing and recovery of water, but would require careful water management.

An additional potential impact of aggregate mining on groundwater supply involves creation of wet pits and exposure of the water table to evaporation losses. These losses can be lessened by minimizing lake area, and particularly shallow lake areas. However, it is recognized that shallow lake areas are amenable to riparian vegetation.

25) Discourage dewatering of wet pits to facilitate mining.

26) Encourage design of relatively deep lakes with minimal shallow areas.

Protect Groundwater Recharge

The Yolo County statement of goals for the CCRMP calls for the maintenance of pervious ground surfaces and increase of recharge capability along Cache Creek. As indicated in Section 5, Aggregate Mining and Groundwater Resources, inappropriate disposal of fine sediments derived from aggregate mining can reduce recharge of groundwater.

27) Encourage disposal of fine sediments in reclamation to agriculture and habitat.

28) Where localized disposal of fine sediments is proposed, encourage minimization of the footprint of the deposit.

29) Discourage releases of fine sediments to the Cache Creek channel. This recommendation recognizes that intentional placement of fine sediments to provide suitable substrate for vegetation may provide benefits that offset localized losses of recharge capacity.

Protect Aquifer Transmissivity

Transmissivity describes the ease with which groundwater flows, and reflects the permeability of sediments through the full thickness of the aquifer. As indicated in Section 5, backfilling a pit introduces a zone of reduced permeability into the aquifer. To a lesser extent, localized disposal of fine sediments that penetrate the water table and clogging of a wet pit also introduce a zone of lesser permeability in the aquifer.

However, groundwater flow continues around the backfill. Impacts are a small, localized upgradient rise in groundwater levels and a downgradient decrease. The degree of impact depends on the extent of the aquifer, geometry and orientation of the backfill, local water levels, and location and depth of wells. For example, the larger the backfill, the greater the potential impact. A thinner section of aquifer would be more affected by backfilling than one that is thick relative to the backfill. Shallow nearby wells are more susceptible than deep, distant wells. Impacts can be minimized by limiting pit size and depth, and increasing distance from other backfilled pits and production wells. Pit-to-pit set backs will be roughly proportional to the size of the pits. However, the hydrogeology of the area is variable, and no single-value size limitation or setback is applicable to all sites.

30) Adopt procedures to determine appropriate site-specific size limitations and setbacks for backfilled pits. These procedures would include identification of potentially impacted wells, water level monitoring, documentation of aquifer characteristics, and application of analytical methods or small scale modeling to determine limitations and setbacks.

31) Minimize penetration into the water table of deposits resulting from localized disposal of fine sediments.

32) Maintain water quality in wet pits and lakes in pertuity to minimize clogging and prevent sedimentation of wet pits.

Protect Usable Groundwater Storage Capacity

Sections 4.4 and 4.5 identified thalweg lowering and the concomitant loss of groundwater storage capacity as one result of in-channel mining. These impacts are relatively limited, but permanent.

33) To prevent thalweg lowering, limit in-channel mining to that needed for streamway restoration and flood control.

Preserve Groundwater Quality

The portion of Section 5 concerning groundwater quality describes the potential impacts due to exposure of the water table to surface contamination, loss of filtration, and salts concentration. All of these pertain to wet pits. The small potential impact of salt concentration derives from lake evaporation; thus reduction of evaporation through the recommended minimization of shallow lake area (see above) also reduces salt concentration.

To avoid adverse impacts on groundwater quality, it is essential that the quality of the water in the wet pits or lakes be protected from sources of surface contamination. Such sources of contamination may include local runoff and erosion, byproducts of recreational use (septic effluent and trash), and illegal disposal of wastes (midnight dumping). Accordingly, the first line of defense against potential pollution is appropriate siting, design, and maintenance of the site and lake. The second line of defense is the natural ability of the lake and aquifer to provide dilution, filtration, and attenuation of pollutants. Third, installation and sampling of two or more monitoring wells downgradient of the wet pit allows detection of a groundwater quality problem.

34) Develop wet pit design parameters to protect lake and groundwater quality. Such parameters should include perimeter berms to prevent intrusion of local runoff into the lake. Promote design of wet pits with relatively steep slopes along a portion of the perimeter to minimize clogging and promote throughflow of water, while recognizing the offsetting riparian and recreational benefits of gentler slopes along a portion of the perimeter.

35) Define appropriate site use and maintenance. Wet pits reclaimed as lakes provide opportunities for natural habitat and recreation. If the site is to be remain private property, consider the maintenance of security, aesthetics, and habitat benefits of the site and lake. If accessible to the public, consider the ultimate ownership and responsibility for the site. In addition, define restrictions on site access and activities. Such restrictions may include fencing and gating of the site, establishment of site hours or curfew, regular inspection, security, and even policing of the site. Sanitary facilities will be required for public access. Restriction of site activities should include prohibition of motorized vehicles and watercraft to prevent erosion and pollution. Appropriate site activities may range from those including significant access to the water and site (e.g., non-motorized

boating, windsurfing, swimming) to those prohibiting water access and allowing, for example, only picnicking, pier fishing, and perimeter hiking in designated areas.

36) To ensure that nearby wells are provided protection through aquifer filtration and attenuation, outline procedures to identify and describe potentially affected wells, to evaluate wellhead protection areas, and determine appropriate setback. These procedures would include identification of nearby wells, documentation of local hydrogeologic conditions, including consideration of local occurrence of multiple aquifers, and analysis of wellhead protection areas, likely using small scale modeling.

37) Provide for detection of a groundwater quality change through installation and sampling of two or more monitoring wells downgradient of the wet pit or lake. Establish a site monitoring program that includes upgradient and downgradient wells, water level measurements, and regular sampling.

Establish Habitat Through Pit Reclamation

Riparian habitat relies on near-surface groundwater, typically in close proximity to a stream or other surface water feature. Promotion of riparian vegetation, with its associated evapotranspiration demands, involves dedication of a small portion of the area's groundwater supply. This dedication is expressed in the Yolo County goal "To assure an adequate water supply, both in quantity and quality, for the continuous maintenance of natural biological resources along Cache Creek." Creation of wet pits can provide benefits to riparian species. Although consideration of impacts of wet pits on groundwater alone would result in deep, steep-walled pits, pit design also can accommodate the needs of riparian vegetation for gentler slopes on a portion of the pit perimeter. In fact, establishment of shoreline vegetation provides erosion control and aesthetic benefits.

38) Consider evapotranspiration demands of restored riparian habitat as an appropriate demand on groundwater supply. Promote establishment of shoreline vegetation along the perimeter of wet pits where appropriate.

The interaction of groundwater and habitat also is an issue with disposal of fine sediments. Preservation of pervious surfaces for recharge would result in minimization of localized disposal of fine sediments. If pits are proposed for use for groundwater recharge basins, their use for habitat enhancement will be limited or nonexistent.

Provide Opportunities For Recreation

Generally groundwater provides opportunities for recreation only when exposed at the surface as a spring or perennial lake. Wet pits can provide an opportunity for water-related recreation, given the measures to protect the lake and groundwater quality described above. However, recreational (and riparian) benefits depend on a reasonable range of water table and lake level fluctuation to prevent an unattractive "bathtub ring," stranding of recreational facilities above the water line, and loss of vegetation. These undesirable effects can be minimized by siting wet pits in areas of relatively high or stable water levels, or design of deep, steep-sided pits.

39) If a wet pit is to be reclaimed for recreational uses or riparian habitat, document the range of expected water level fluctuations and adjust siting and design of the pit accordingly.

Enhance Yolo County Water Supply

The Yolo County statement of goals for the CCRMP repeatedly expressed the intention to enhance the water supply of the County, specifically to:

Continue evaluation of water resources,
Manage surface and groundwater supplies,
Coordinate groundwater and surface water supply systems,
Encourage conjunctive use,
Conserve and recycle water supplies, and
Adopt a County-wide water supply management program.

Evaluation of water resources, through monitoring and analysis, provides the basis for informed management of surface water and groundwater resources. Section 2, Available Data, provides an overview of water resource monitoring in the region and reveals data gaps. Section 5, Aggregate Mining and Groundwater Resources, presents specific suggested monitoring tasks and water related investigations. Specific monitoring tasks range from continued compilation of rainfall data to revision of the groundwater quality monitoring program. Specific evaluations include evaluation of the regional water and salt balances, study of subsidence, and regional consideration of potential groundwater contamination.

40) Consider establishment of a comprehensive water resources monitoring and data analysis program.

Site-specific monitoring and data analysis at aggregate mining sites with wet pits or backfilling already has been addressed. Information from specific sites will be a beneficial supplement to data generated by regional monitoring. In addition, as mining areas, particularly wet pits and artificial recharge areas, are reclaimed, their stewardship may pass into the hands of a water agency. Accordingly, responsibility for water-related monitoring at mining sites should be assumed by the water agency even as quarry operations continue. This should develop into an agency-conducted program of quarry area monitoring, and eventually into full integration in the water agency's monitoring and management practices.

41) Integrate site-specific monitoring of mining sites into a comprehensive water resources monitoring program. Recognize that this integration will be incremental: beginning initially with data sharing by mining companies, developing into a program of quarry area monitoring by an agency, and eventually including full responsibility by a water management agency for sites reclaimed with water management functions.

Several objectives concern coordinated management of surface and groundwater supplies, conjunctive use, and conservation and recycling of water supplies. In terms of aggregate mining and groundwater resources, these objectives are pertinent to use of pits for water storage and artificial recharge.

Use of wet pits for clean surface water storage would involve recovery of water from the pit through pumping. Although not as severe as dewatering, such use could cause adverse impacts on local groundwater levels, stream baseflow, nearby wells, and riparian vegetation. Such impacts can be minimized through pit siting and design, and operational guidelines. Storage of turbid streamflow could result in sedimentation of the pond, with adverse effects on groundwater levels and flow, and lake quality.

42) Use of a wet pit for clean water storage should include careful consideration of adverse impacts. Adopt procedures to determine appropriate setbacks for storage pits and operational limitations. These procedures would include identification of potentially impacted wells, water level monitoring, documentation of aquifer characteristics, and application of analytical methods or small scale modeling to determine limitations and setbacks.

Pits may be considered for retention of poor quality irrigation tailwater, entailing significant potential adverse impacts to groundwater quality and nearby wells.

43) Disallow use of pits for retention of poor quality water.

As documented in Section 5, aggregate mining can present opportunities for enhanced groundwater management through provision of ready-made or adaptable pits, basins, or channels for artificial recharge. Spreading grounds, channels, or basins situated above the water table provide considerable advantage over wet pits as methods of artificial recharge. The presence of an unsaturated zone below the recharge facility provides filtration for recharge water. In addition, recharge facilities above the water table can be dried out, reducing biological clogging and allowing scraping of the basin to cost-effectively remove clogging sediment.

44) Consider dedication to artificial recharge of areas in and adjacent to the Cache Creek channel that are permeable, situated 10 to 20 feet above the high water table, relatively flat, and accessible by equipment.

Lastly, County policy points toward adoption of a County-wide water supply management program. This goal is in accord with the finding that the Cache Creek region currently lacks a comprehensive water resources monitoring and management program. Given its scope, development of such monitoring and management program likely will progress in stages, beginning with identification of the appropriate water management agency. Options for this agency include extension of water management activities by the Yolo County Flood Control and Water Conservation District, expansion of the County's role, creation of a new water management agency, or a joint agency agreement. Subsequently, such a water management agency will assume water monitoring, data analysis, and management responsibilities, including incorporation of comprehensive quarry area monitoring. A regional groundwater model, developed hand-in-hand with the water monitoring and management effort, will be a valuable tool in assessing the impacts and opportunities of aggregate mining and in overall basin management.

45) Implement a regional or County-wide water management program, including identification of the suitable water agency, initiation of comprehensive regional monitoring and management, and development of a regional computer model as a tool for management of surface water and groundwater supply and quality.

Groundwater and Chemical Stability

Channel morphology is indirectly related to groundwater and attached vegetation. Where suitable groundwater conditions exist, riparian vegetation is more prevalent and has an influence on channel form. These reaches are generally in locations where Tehama Formation outcrop occurs in the channel (see Chapter 4), and the presence of this more resistant bed material also influences channel morphology. Previous studies have theorized that incision of the channel has resulted in the lowering of the groundwater table by reducing the elevation of the groundwater dam formed by these less permeable materials. While the conclusions in Chapter 4 are somewhat different from those of previous studies with respect to the significance of the outcrops to overall groundwater management, continued incision of the channel would be detrimental to groundwater storage. Therefore, the recommendations regarding channel stability above will also serve to protect groundwater resources by arresting channel incision.

The development of off-channel groundwater recharge basins along Cache Creek may be pursued. The timing and quantity of diversions into these basins would determine their impacts on channel stability. If diversions further reduce the duration and frequency of intermediate channel forming flows, for example, they could adversely affect channel stability. Conversely, if the diversions are made only during peak runoff, they could be managed to promote channel stability in much the same way as an upstream storage reservoir (see Recommendation 10). In lieu of, or in combination with off-channel recharge basins, the county could consider development of in-channel recharge basins in appropriate reaches of the creek. The Hungry Hollow and the upper end of the Madison Reach appear to the most appropriate reaches for this application. These types of facilities are in use in Santa Clara, San Benito, San Bernardino, and Orange Counties. In-channel basins have the advantages of not requiring extensive diversion works, have high natural percolation rates, and could be associated with other channel maintenance activities. Construction of recharge basins in the channel represents a relatively high level of disturbance in the channel, and is probably not compatible with development of riparian habitat wherever the channel is relatively narrow. Seasonal wetland habitat might be developed in conjunction with recharge basins, although its quality would probably be limited by design constraints to maximize recharge and the level of maintenance activity required. However, in the wider portions of the reaches mentioned their use might be considered an acceptable alternative to off-channel basins. The following recommendations, in addition to the channel stability recommendations already described, are designed to benefit groundwater resources:

46) Consider the implications on channel stability of any future diversions from the creek associated with groundwater recharge. The timing and quantity of these diversions would determine their potential beneficial or detrimental impacts on channel stability.

47) Consider in-channel recharge basins in appropriate reaches of the creek as one component of a more intensively managed section of the creek. Compatible uses might include managed aggregate extraction and development of seasonal wetland habitat.

Aesthetic, Recreational, and Educational Enhancement

Cache Creek in the study area is presently known only to a relatively few landowners and aggregate operators. Additional public use of these lands would be incompatible with aggregate operations and adjacent agricultural and residential land uses under present conditions. However, the long term prospect of significant changes in aggregate operations and the restoration of the creek's riparian resources through an integrated regional reclamation plan provide an opportunity for increased public access to the creek. Reclamation of lands currently in use for aggregate extraction could provide the basis for development of a riparian corridor or parkway accessible to the public. In addition, the transition from extensive in-channel impacts of aggregate mining to management of all of the creek's resources could provide extensive public education and research opportunities as well as the long-term stewardship of the creek's resources. Conversion to public use poses difficult questions related to public safety and protection of private property rights, but may also provide additional potential sources of funding for restoration. The Corps of Engineers is presently studying Cache Creek to develop plans for environmental restoration incorporating flood control and sediment reduction benefits. This study includes detailed examination of opportunities for public recreation and education along Cache Creek, including the entire study area. The following recommendation, in addition to those listed above for channel stability and riparian habitat enhancement, are intended to provide opportunities for aesthetic, recreational, and educational enhancement along Cache Creek:

48) Develop a continuous corridor along Cache Creek accessible to the public as part of regional reclamation plans. In the near term, public access may be incompatible with many existing land uses. However, as reclamation plans are developed in phases, limited public access may be feasible, and could help to financially support additional reclamation and restoration. Increased public access, with a continuous parkway corridor, may be a feasible long term goal.

Flood Carrying Capacity

As described in Section 3.6, the flood capacity of the entire Cache Creek system is presently limited by channel capacities near the downstream end of the study area. In most of the study area upstream, adequate channel capacity presently exists to convey the 100-year storm without overtopping the channel banks. This capacity exceeds the historical capacity, which resulted in more frequent overflows of shallow flood waters onto adjacent agricultural lands. Many of these lands are still subject to flooding by local runoff and overflows from smaller tributaries. To some extent, the recommendations for improvement of channel stability are contrary to preservation of existing flood carrying capacity. That is, development of a compound channel could reduce total channel conveyance. However, widening of the channel within its historical limits will counteract this potential reduction. Computer modeling results described in Section 3.6 demonstrate that a channel with a form more similar to historical conditions could be developed that would preserve 100-year capacity in most of the study area while improving channel stability.

Near the downstream end of the study area, the channel capacity is inadequate to provide this level of protection under present conditions. This area is under study by the Corps of Engineers to develop alternatives for an increased level of protection. Implementation of flood control alternatives could potentially affect sediment transport characteristics of the lower end of the study reach, and could impact channel stability. Therefore, study of flood control alternatives should include analysis of sedimentation and channel stability impacts.

The following recommendations are designed to promote maintenance of adequate flood carrying capacity while improving channel stability in the study reach:

49) Limit changes in channel form (compound shape) and establishment of vegetation to levels that will not result in overtopping of historical channel banks in the 100-year flood.

50) Perform annual maintenance based on a monitoring program to maintain flood capacities (see Recommendation 8 for channel maintenance, and monitoring recommendations below).

51) Request that the Corps of Engineers make appropriate sedimentation and channel stability assessments in conjunction with development of flood control alternatives near the downstream end of the study area.

Aggregate Extraction

Recommendations 1 through 8 would substantially reduce in-channel aggregate extraction and improve channel stability. However, the County desires to promote managed aggregate extraction where appropriate as an important industry that contributes to the economic health of the area. Managed aggregate extraction also has the potential to protect channel stability by removing bars or portions of bars where their formation could threaten bank stability. This is particularly true in the near term if aggregate extraction operations are substantially modified, as the creek will likely respond to this change fairly unpredictably over a period of several years. Providing for continued aggregate extraction during this period provides an economically viable way to respond to these changes and maintain channel stability. In addition to the recommendations above for channel stability, the following recommendations are made with respect to managed aggregate extraction:

52) Manage extraction to promote and maintain channel stability and flood capacity. Aggregate extraction would primarily be from shallow excavations located on in-channel bars and terraces. Extraction would be guided by annual monitoring. Because extraction may be necessary outside of the limits of mining rights of individual operators, the County may wish to take bids for these removals under a new permit program.

53) Extract the aggregate presently located in levees constructed or remaining within the channel limits to create a wider channel with a compound form more similar to historical channel cross sections (see Recommendation 6).

54) In the long term, promote the development of off-channel aggregate extraction to replace the present supply from in-channel mining. Maintain a setback distance between the present channel bank line (see Figure 6-1) and the edge of off-channel pits. A setback of 700 feet or more is recommended unless engineering analysis indicates a smaller distance will not adversely affect channel stability or groundwater resources. A minimum setback of 200 feet is recommended for all excavations.

County Infrastructure

All of the bridges on Cache Creek in the study area, with the exception of the bridges across the narrow channel at Yolo, have experienced damage due to channel incision at some time in their history. Several bridges have had multiple failures, and the Capay Bridge is presently closed due to damage sustained in the March 1995 flood. The Madison Bridge collapsed in 1978 and has not been replaced. These bridges are important components of the County's transportation system and damage to them results in substantial financial loss as well as inconvenience to area residents and businesses. In addition, the bridges have an affect on overall channel stability in the study area as demonstrated in Section 3.6. By forming constrictions in the channel, the bridges cause rapid changes in channel conveyance and sediment transport capacity. These rapid changes 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 following recommendations, in addition to the general recommendations regarding channel stability above, are designed to protect the bridges from damage:

55) Widen or eliminate existing bridges to reduce hydraulic constrictions in the channel and the potential for scour damage at the bridges. (This recommendation, while technically sound for protection of the bridges, may not be justifiable or practical based on cost.)

56) In lieu of Recommendation 55, construct smooth transitions in channel capacity upstream and downstream from the bridges and construct guide banks and grade control structures at the bridges where determined necessary in a monitoring program. Transitions may use spur dikes, berms, vegetation or other means to gradually change channel capacity in the longitudinal direction. Transitions should be at least five times as long as the change in channel width at the bridge. Figure 6-6 shows a proposed typical channel transition through a bridge construction. Monitor and maintain transition areas.

Agricultural Lands

Agricultural lands are lost along the creek where bank erosion occurs. In the past aggregate operators have installed bank protection measures to protect various private properties from erosion. In general, the recommendations for channel stability above would provide protection of agricultural land by reducing bank erosion and providing maintenance and repair as necessary. Agricultural landowners may be involved in the regular and emergency bank maintenance work described in Recommendation 8, and would necessarily be involved in rights-of-way for these activities. Agricultural landowners should also be involved in the monitoring program recommended below. No additional specific recommendations are made for protection of agricultural lands.

Self Sustaining Fluvial System

The creek is currently in a condition far removed from its natural or historic form due to a variety of human impacts. Although the channel can never be returned to its historical form, and will continue to be strongly influenced by human activity, this study recommends changes to aggregate extraction and other activities that will substantially affect the creek. The presence of bridges, irreversible changes in channel depth, changes in annual water delivery, land use, and other factors prevent restoration of pre-historical or historical conditions. However, recommendations in this study generally promote long term guidance of the creek towards its historical form, which is believed to be the most naturally sustainable condition of the creek. Management and monitoring of the creek will be necessary as changes are implemented. The following recommendations are designed to promote management of the creek towards a more self sustaining fluvial system, maintaining flexibility to change management strategies over time to respond to trends in the channel:

57) Institute a focused creek monitoring program to collect data necessary to make management decisions. This data collection should include water and sediment discharge data at the Capay and Yolo gage sites, water and sediment discharge data collection during high flows at additional sites, annual vegetation monitoring, and topographic data collection twice annually in areas of aggregate extraction and once annually in other areas. Substantial monitoring could be accomplished through a combination of forces, including federal and state government agencies (USGS, Corps of Engineers, DWR), local agencies (Yolo County, YCFCWCD), local residents and interest groups, and aggregate operators. The monitoring program could become a part of public education programs associated with the creek. The monitoring results should be integrated and maintained in the County's GIS database.

58) Establish a Technical Advisory Committee (TAC) composed of members with sound technical backgrounds to make management decisions on the creek. Provide monitoring data to the TAC to be used as the basis for decisions and recommendations to the Board of Supervisors. Synthesize annual monitoring data and TAC recommendations into scientifically-based management actions.

59) Allow for flexibility in management of the creek over time as conditions change. Establish desirable trends rather than fixed plans or specific dimensions. Monitor changes to confirm trends.

Prioritization of Recommendations and Resolution of Conflicts

The recommendations above are designed to meet individual objectives, and therefore could be mutually incompatible in specific applications. Implementation priorities for overall resources management will be established by the CCRMP. However, it is useful to establish priorities for the recommendations above based on their effectiveness in modifying current undesirable conditions or channel behavior. Implementation of recommendations that improve channel stability have secondary benefits consistent with the goals established by Yolo County for resource management on the creek. For example, increased channel stability improves riparian habitat by creating stable sites for vegetation establishment, protects groundwater resources by arresting incision, protects County bridges, and protects adjacent agricultural lands. Depending on the methods selected for improving channel stability, it can also provide opportunities for recreational and educational benefits, preserve flood carrying capacity, and provide for managed aggregate extraction. Therefore, implementation of recommendations that have the highest benefit for channel stability also have the greatest additional benefits to meet other objectives and should be given the highest priority.

This study recommends reestablishment of channel morphologies more similar to historic conditions as a means to improve channel stability and promote development of a self sustaining fluvial system in the long term. The highest priority is therefore given to widening of the conveyance area within the limits of the existing channel, improving hydraulic conditions and bridge crossings, and reducing the rapid changes in hydraulic and sediment transport capacities between reaches caused by human intervention. These river management recommendations require that the present methods used to regulate in-channel aggregate extraction (e.g., the 1979 Interim In-Channel Mining Regulations) be significantly modified. Proposed changes would ultimately limit extraction to a fraction of its present annual rate based on actual replenishment rates.

Substantial modification of the existing channel will be required to return the channel to a form closer to its historical morphology. These modifications, if undertaken by the County, would be prohibitively expensive. Therefore, the County should work with the aggregate industry to remove artificial channel confinement levees within the in-channel area and reshape the channel as part of a regional reclamation plan. A regional reclamation plan is necessary to remove the present rapid changes in conveyance between subreaches and avoid complex channel response to these changes. The CCRMP provides the opportunity to create a regional reclamation plan.

Because the channel is presently strongly influenced by aggregate mining, changes in aggregate mining can be expected to produce a series of adjustments in channel form over time. It is impossible to predict exactly what changes will occur in specific locations, although general trends can be predicted. It is therefore important that effective monitoring techniques be implemented with the flexibility to adjust management of the creek over time. Based on these principles, the highest priority recommendations (Priority Class 1) have been designated in Table 6-1. The table also shows second and third levels of priority for recommendation.

Resolution of Conflicts

Several of the recommendations described above could be mutually incompatible. For example, creation of a channel with a compound form more similar to historical conditions would reduce total flood capacity in individual subreaches. In addition, establishment of riparian vegetation would reduce flood capacity. This follows from the recommendations to return the channel to a form closer to historical conditions - over-bank flooding was much more common under historical conditions in most reaches. Management of the creek must be constrained by current conditions, including protection of public safety and private property in the study area. Therefore, channel management must not unduly increase flood risk. A reasonable standard is to prevent overbank flooding in developed areas for the 100-year flood. This standard should be applied to limit the extent of managed channel change over time. In the Hoppin and Rio Jesus Maria Reaches, this level of flood protection does not presently exist and proposed channel stabilization measures would not provide any increase in capacity. Some recommendations could potentially decrease flood carrying capacity. In these areas, in-channel excavation, establishment of riparian vegetation and management towards a more compound channel shape should be balanced to produce no net decrease in capacity. Flood control alternatives under development by the Corps of Engineers should consider impacts on channel sedimentation processes and stability upstream. Flood control and creek management must also address methods for correcting the existing limited channel capacity problems downstream from the present study reach and adjust management activities as those problems are corrected over time. In addition, sediment transport through the study reach and downstream to the sediment basin should be considered in the design of any flood control project.

The HEC-2 model used in this study provides a tool that can be periodically updated to evaluate the impacts of channel change on flood carrying capacity. Data needs for this work include topographic and vegetation mapping described in the monitoring recommendations.

Modification of operations at the Capay Dam (Recommendation 9) poses potential conflicts with irrigation water supplies to regional agricultural lands. The impact of this recommendation requires further evaluation with the assistance of the Yolo County Flood Control and Water Conservation District (YCFCWCD). This recommendation would assist in maintaining a stable channel form and could also supply water to support riparian habitat. This concept needs to be explored further in conjunction with the results of the Environmental Restoration Study by the Corps of Engineers. With the assistance of YCFCWCD, it may be possible to define operating schemes that are based on annual or seasonal hydrologic conditions in order to minimize impacts on agricultural water supplies.

The interaction of ground and surface waters in the study area is described in Chapter 4. Construction of in-channel or off-channel facilities to promote groundwater recharge (see Recommendations 46 and 47 could potentially impact stream stability and riparian habitat potential. These types of facilities would require intensive management, presumably funded through water sales. Implementation of a managed surface/groundwater program may be beneficial in protecting long-term water supply resources in the County. However, constructing in-channel basins or diversions also represents a shift away from the self-sustaining fluvial system recommended above. Evaluation of the benefits and costs of overall water management in the County is beyond the scope of this study. However, the implications of various water management strategies on the character of the streamway should be considered in the County's long-range planning.

This study recommends concepts for long-term implementation. It should be recognized that these concepts may not be feasible to implement in all locations due to various types of site-specific constraints. In addition, it will not be feasible to implement the recommendations immediately. Example constraints include private property rights, site-specific environmental impacts, and public safety considerations (including flood control). The recommendations of this should not be construed as fixed or site-specific recommendation. It is important that the creek be considered as an entire system, but it is not necessary to implement all recommendations in all areas in order to make substantial improvements in the system. Rather, it is important to begin implementation of recommendations in phases as site-specific conditions allow, and to monitor the system to determine its response over time. Flexibility in management is more important than fixed criteria. Resolution of site-specific conflicts can be effected by the recommended Technical Advisory Committee if monitoring data are collected and utilized based on sound scientific and engineering principles.

TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Objective	Recommendation	Priority Class
Increase Channel Stability	1. Define a regulatory boundary for streamway influence utilizing the historical extent of the channel as defined by early topographic mapping.	1
	2. In the long term, limit in-channel aggregate extraction to approximately the volume of sand and gravel delivered annually to the study reach. Vary extraction to match supply on an annual basis.	1
	3. In the near term, allow aggregate extraction greater than the supply to the study reach to return the channel to a form more similar to its historical morphology.	1
	4. Discontinue mining activities within active low flow channel areas to avoid disturbance to the armor layer. Recommended width of protection is 300 feet for single thread channels and 250 feet for multiple thread channels.	1
	5. Abandon the theoretical thalweg concept and 1979 in-channel mining boundary. Utilize valley slope and historical sinuosity to establish management targets for bed gradients.	1
	6. Restrict aggregate extraction using general or reach-specific cross section templates (see Figures 6-2 to 6-5).	1
	7. Synthesize individual in-channel mining reclamation plans into a single regional plan. Utilize the regional reclamation plan to reduce changes in hydraulic and sediment transport capacities between reaches.	1
	8. Develop regular and emergency channel bank maintenance and repair agreements with aggregate operators, land owners, and government agencies.	1
	9. Modify Capay Dam operation to provide channel forming flows during the Spring and Fall. If feasible based on annual precipitation, release flows of 1,000 cfs or more for a period of at least 1 week and flows of 2,000 cfs or more for a period of at least 1 day.	3
	10. Consider the benefits of bank protection and bridge protection in economic analyses of upstream storage dams, if a dam is reconsidered for flood control and water supply purposes.	3
	11. Integrate riparian vegetation into overall hydraulic and sedimentation management.	2
	12. Use riparian vegetation, where appropriate, to create smoother transitions between reaches with differing hydraulic capacities.	1

TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Objective	Recommendation	Priority Class
Increase Channel Stability (cont)	13. Selectively remove vegetation where its establishment threatens channel stability.	1
	14. Encourage vegetation in newly established terrace areas within the channel near the banks.	2
Improve Riparian Habitat	15. Promote habitat stability by improving channel stability. Smooth the channel banks by lowering the high banks at constrictions, as shown in Figure 6-1. In the stream segment including the Dunnigan Hills subreach and the upstream portion of Hoppin subreach, create terraced cross-sectional topography with gradual (10:1) transitions. Longitudinally smoothed, terraced creek topography will reduce erosion/sedimentation instability and promote the development of a variety of different riparian habitats.	1
	16. Once the desired channel configuration is achieved in the restoration reach(es), terminate in-channel mining in those areas in order to preserve the highest quality riparian habitat resources.	1
	17. Apply treatments similar to those presented in Recommendations 15 and 16 to the Capay reach.	2
	18. Promote the development of stable habitat along losing reaches. Establish a low flow channel with an initial configuration similar to that seen in aerial photographs taken after the 1995 flood events. Discontinue all mining-related surface disturbance within a corridor 200 feet wide centered on this channel. Modify the width and location of the no-disturbance zone as the low-flow channel migrates and evolves. Require that no large piles of mined materials be left within the channel in places where they would tend to create highly erosive flows in the no-disturbance zone.	2
	19. In gaining reaches of the riparian system, plant species appropriate to the substrate and hydrologic regime of each microsite (terrace, transition slope, etc.).	1
	20. In all reaches where mining occurs, require that bar skimming be limited to the downstream portion (up to 3/4 of the length) of the bar, and require salvage of topsoil and woody plant material and their use in restoration planting.	1
	21. Configure abandoned off-channel pits designated for habitat creation so as to favor the establishment and long-term survival of a diverse mixture of woody species, emphasizing those comprising mixed riparian forest. Place topsoil and plant abandoned pits to be reclaimed with appropriate zones of riparian species.	1

TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Objective	Recommendation	Priority Class
Improve Riparian Habitat (cont)	22. Control weed invasion primarily by improving channel characteristics as described above.	1
	23. Remove individual large clumps of giant reed in areas of highest flow velocities (in or near the thalweg).	1
	24. Remove or exterminate tamarisk only where it competes with native species which would otherwise form closed vegetative communities.	2
Protect Groundwater Resources	25. Protect groundwater from overdraft by discouraging dewatering of wet pits to facilities mining.	1
	26. Encourage minimization of lake area, especially shallow lake areas.	3
	27. Protect groundwater recharge by encouraging disposal of fine sediments in reclamation to agriculture and habitat.	1
	28. Where localized disposal of fine sediments is proposed, encourage minimization of the footprint of the deposit.	3
	29. Discourage releases of fine sediments to the Cache Creek channel. This recommendation recognizes that intentional placement of fine sediments to provide suitable substrate for vegetation may provide benefits that offset localized losses of recharge capacity.	1
	30. Protect aquifer transmissivity by adopting procedures to determine appropriate site-specific size limitations and setbacks for backfilled pits. These procedures would include identification of potentially impacted wells, water level monitoring, documentation of aquifer characteristics, and application of analytical methods or small scale modeling to determine limitations and setbacks.	1
	31. Minimize penetration into the water table of deposits resulting from localized disposal of fine sediments.	3
	32. Maintain wet pits and lakes in a clean condition to minimize clogging and prevent sedimentation of wet pits.	2
	33. Protect usable groundwater storage capacity by continuing limitations on in-channel mining to prevent thalweg lowering within the context of streamway restoration.	2

TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Objective	Recommendation	Priority Class
Protect Groundwater Resources (cont)	34. Preserve groundwater quality by developing wet pit design parameters to protect lake and groundwater quality. Such parameters should include perimeter berms to prevent intrusion of local runoff into the lake. Promote design of wet pits with relatively steep slopes along a portion of the perimeter to minimize clogging and promote throughflow of water, while recognizing the offsetting riparian and recreational benefits of gentler slopes along a portion of the perimeter.	1
	35. Define appropriate site use and maintenance. Wet pits reclaimed as lakes provide opportunities for natural habitat and recreation. If the site is to be remain private property, consider the maintenance of security, aesthetics, and habitat benefits of the site and lake. If accessible to the public, consider the ultimate ownership and responsibility for the site. In addition, define restrictions on site access and activities. Such restrictions may include fencing and gating of the site, establishment of site hours or curfew, regular inspection, security, and even policing of the site. Sanitary facilities will be required for public access. Restriction of site activities should include prohibition of motorized vehicles and watercraft to prevent erosion and pollution. Appropriate site activities may range from those including significant access to the water and site (e.g., non-motorized boating, windsurfing, swimming) to those prohibiting water access and allowing, for example, only picnicking, pier fishing, and perimeter hiking in designated areas.	1
	36. To ensure that nearby wells are provided protection through aquifer filtration and attenuation, outline procedures to identify and describe potentially affected wells, to evaluate wellhead protection areas, and determine appropriate setback. These procedures would include identification of nearby wells, documentation of local hydrogeologic conditions, and analysis of wellhead protection areas, likely using small scale modeling.	1
	37. Provide for detection of a groundwater quality problem through installation and sampling of two or more monitoring wells downgradient of the wet pit or lake. Establish a site monitoring program that includes upgradient and downgradient wells, water level measurements, and regular sampling.	1
	38. Improve riparian habitat by considering evapotranspiration demands of restored riparian habitat as an appropriate demand on groundwater supply. Promote establishment of shoreline vegetation along the perimeter of wet pits.	3

TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Objective	Recommendation	Priority Class
Protect Groundwater Resources (cont)	39. If a wet pit is to be reclaimed for recreational uses or riparian habitat, document the range of expected water level fluctuations and adjust siting and design of the pit accordingly.	1
	40. Enhance Yolo County water supply by considering establishment of a comprehensive, basin-wide water resources monitoring and data analysis program.	1
	41. Integrate site-specific monitoring of mining sites into a comprehensive, basin-wide water monitoring program. Recognize that this integration will be incremental: beginning initially with data sharing by mining companies, developing into a program of quarry area monitoring by an agency, and eventually including full responsibility by a water management agency for sites reclaimed with water management functions.	1
	42. Use of a wet pit for clean water storage should include careful consideration of adverse impacts. Adopt procedures to determine appropriate setbacks for storage pits and operational limitations. These procedures would include identification of potentially impacted wells, water level monitoring, documentation of aquifer characteristics, and application of analytical methods or small scale modeling to determine limitations and setbacks.	2
	43. Discourage use of pits for retention of poor quality water.	1
	44. Consider dedication to artificial recharge of areas in and beyond the Cache Creek channel that are permeable, situated above the high water table, relatively flat, and accessible by equipment.	1
	45. Implement a regional or County-wide water management program, including identification of the suitable water agency, initiation of comprehensive regional monitoring and management, and development of a regional computer model.	1
	46. Consider the implications on channel stability of any future diversions from the creek associated with groundwater recharge.	2
	47. Consider in-channel recharge basins in appropriate reaches of the creek as one component of a more intensively managed section of the creek. Compatible uses might include managed aggregate extraction and development of seasonal wetland habitat.	3

TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Objective	Recommendation	Priority Class
Provide Opportunities For Aesthetic, Recreational, and Educational Enhancement	48. Develop a continuous corridor along Cache Creek accessible to the public as part of regional reclamation plans. In the near term, public access may be incompatible with many existing land uses. However, as reclamation plans are developed in phases, limited public access may be feasible, and could help to financially support additional reclamation and restoration. Increased public access, with a continuous parkway corridor, may be a feasible long term goal.	3
Preserve Flood Carrying Capacity	49. Limit changes in channel form (compound shape) and establishment of vegetation to levels that will not result in overtopping of historical channel banks (in-channel mining boundary) in the 100-year flood.	1
	50. Perform annual maintenance based on a monitoring program to maintain flood capacities (see Recommendation 8 for channel maintenance, and monitoring recommendations below).	1
	51. Request that the Corps of Engineers make appropriate sedimentation and channel stability assessments in conjunction with development of flood control alternatives near the downstream end of the study area.	1
Provide For Managed Aggregate Extraction	52. Utilize managed extraction to promote and maintain channel stability and flood capacity. Aggregate extraction would primarily be from shallow excavations located on in-channel bars and terraces. Extraction would be guided by annual monitoring. Because extraction may be necessary outside the limits of mining rights of individual operators, the County may wish to take bids for these removals under a new permit program	1
	53. Extract the aggregate presently located in levees constructed or remaining within the channel limits to create a wider channel with a compound form more similar to historical channel cross sections (see Recommendation 6).	1
	54. In the long term, promote the development of off-channel aggregate extraction to replace the present supply from in-channel mining. Maintain a setback distance between the present bank line and the edge of off-channel pits. A setback of 700 feet is recommended unless engineering analysis indicates that a smaller setback will not adversely affect channel stability or groundwater resources. A minimum setback of 200 feet is recommended.	2
Protect County Infrastructure	55. Widen or eliminate existing bridges to reduce hydraulic constrictions in the channel and the potential for scour damage at the bridges. (This recommendation, while technically sound for protection of the bridges, may not be justifiable or practical based on cost.)	1

TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Objective	Recommendation	Priority Class
Protect County Infrastructure (cont)	56. In lieu of Recommendation 55, construct smooth transitions in channel capacity upstream and downstream from the bridges and construct guide banks and grade control structures at the bridges where determined necessary in a monitoring program. Transitions may use spur dikes, berms, vegetation or other means to gradually change channel capacity in the longitudinal direction. Transitions should be at least five times as long as the change in channel width at the bridge. Monitor and maintain transition areas.	1
Promote A Self Sustaining Fluvial System	57. Institute a focused creek monitoring program to collect data necessary to make management decisions. This data collection should include water and sediment discharge data at the Capay and Yolo gage sites, water and sediment discharge data collection during high flows at additional sites, and topographic data collection twice annually in areas of aggregate extraction and once annually in other areas. Substantial monitoring could be accomplished through a combination of forces, including federal and state government agencies (USGS, Corps of Engineers, DWR), local agencies (Yolo County, YCFCWCD), local residents and interest groups, and aggregate operators. The monitoring program could become a part of public education programs associated with the creek. The monitoring results should be integrated and maintained in the County's GIS database.	1
	58. Establish a Technical Advisory Committee (TAC) composed of members with sound technical backgrounds to make management decisions on the creek. Provide monitoring data to the TAC to be used as the basis for decisions and recommendations to the Board of Supervisors. Synthesize annual monitoring data and TAC recommendations into scientifically-based management actions.	2
	59. Allow for flexibility in management of the creek over time as conditions change. Establish desirable trends rather than fixed plans or specific dimensions. Monitor changes to confirm trends.	1