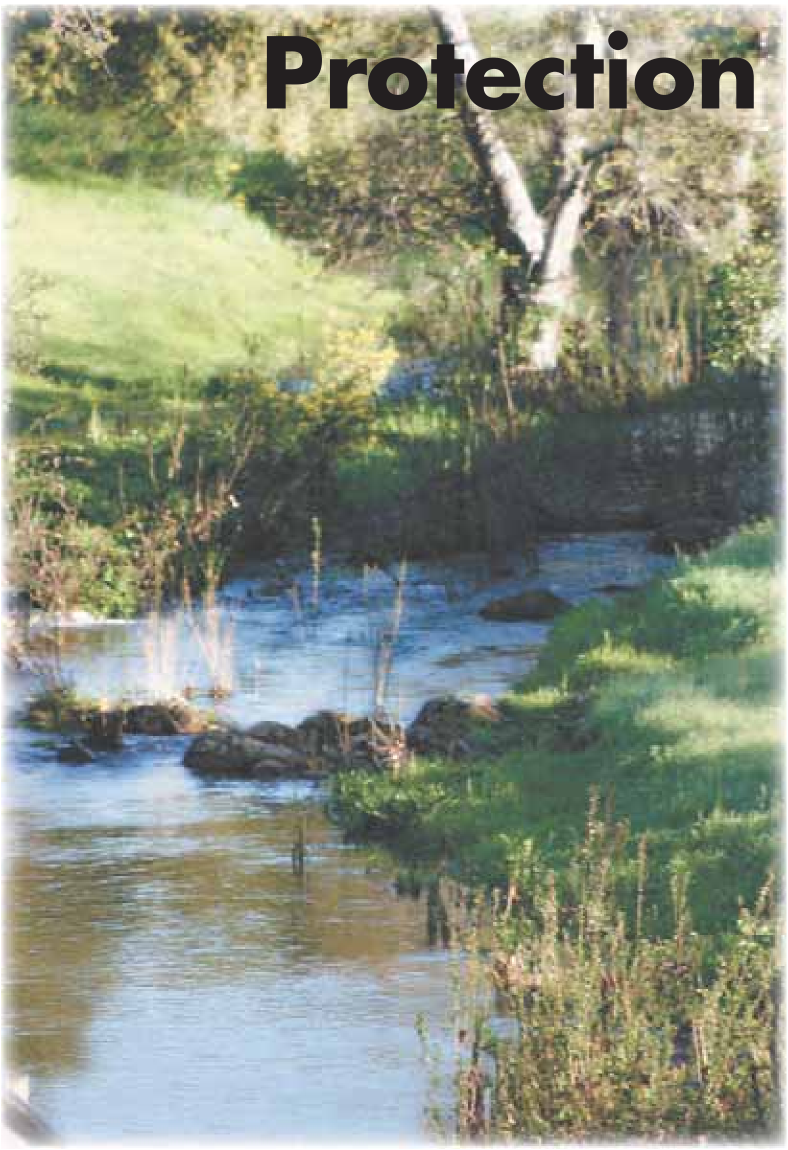
Water Resources Protection Manual



August 22, 2006

Santa Clara Valley Water District

RESOLUTION NO. 2006- 75
A RESOLUTION OF THE SANTA.CLARA VALLEY WATER DISTRICT ADOPTING A WATER RESOURCES PROTECTION MANUAL CONCERNING EVALUATION OF ENCROACHMENT PERMIT APPLICATIONS AND ESTABLISHMENT OF CONDITIONS FOR SUCH PERMITS

WHEREAS, the Santa Clara Valley Water District (District) desires to implement standards to accomplish District purposes described in the District Act and in Ordinance and to facilitate the implementation of District policies of providing a reliable supply of healthy and clean water; reducing the potential for flood damages; protecting and when appropriate enhancing and restoring natural resources of streams and watersheds; and providing additional open spaces, trails, and parks along creeks and in the watersheds when reasonable and appropriate.

WHEREAS, District staff, along with staff representatives of the County of Santa Clara, the Cities in Santa Clara County, the Guadalupe-Coyote Resource Conservation District, the San Francisco Bay Regional Water Quality Control Board (RWQCB), various business and development interests, environmental, agricultural, community, and property owners' interests have formed and are members of the Santa Clara Valley Water Resources Protection Collaborative (Collaborative).

WHEREAS, the Collaborative developed a set of model guidelines, standards, procedures, and recommendations to apply to land use activities near streams and on streamside properties, and to protect streams and streamside resources.

WHEREAS, the District desires to adopt a Water Resource Protection Manual containing standards and illustrative guidelines, drawing from the Collaborative's model guidelines and standards, which-will be used for the evaluation of permit applications and establishment of permit conditions under Ordinance 06- 01

WHEREAS, the Water Resource Protection Manual contains streamside and facility protection requirements and recommendations (Chapter I) , and a Design Guide (Chapter 3) intended to provide further detail, illustrations, and clarification on the application of the requirements and recommendations.

WHEREAS, in addition to the requirements contained in the Water Resource Protection Manual, there may be additional applicable requirements for District encroachment permits which are hereby incorporated by reference (Chapter 2).

WHEREAS, the guidance in the Water Resource Protection Manual is intended to compliment existing local, state, and federal regulations.

WHEREAS, additional requirements beyond what is contained in the Water Resource Protection Manual may be needed to comply with the California Environmental Quality Act or any regulatory permits in which case those requirements shall control.

NOW, THEREFORE BE IT RESOLVED that the attached Water Resources Protection Manual dated August 22, 2006, to be used in the evaluation of encroachment permit applications, and establishment of permit conditions is hereby adopted.

PASSED AND ADOPTED BY THE BOARD OF DIRECTORS OF THE SANTA CLARA VALLEY WATER DISTRICT ON October 24,2006, by the following vote:

AYES: Directors R. Kamei, T. Estermera, S. Sanchez, R. Santos, G. Zlotnick, L. Wilson

NOES: Directors None

ABSENT: Directors J. Judge

SANTA CLARA VALLEY WATER DISTRICT

LARRY WILSON
Board of Directors/Chairperson

ATTEST:

Lauren Keller
Clerk of the Board

APPROVED AS TO FORM AND LEGALITY

Debra L. Cauble
District Counsel

Contents

Water resources Protection Manual

Requirements and Recommendations

The following requirements will be used to determine compliance with Section 2.3.3 (6) of the Water resources Protection Ordinance (Ordinance 06-1). Recommended practices are outlined at the end of each section as appropriate. Illustrative detail and clarification on the specific application of the requirements and recommendations can be found in the Design Guide contained in Chapter 3.

I. Riparian Corridor Protection

A. Existing native riparian vegetation is retained unless it presents a threat to public health and safety, including an imminent danger of induced flooding, and/or a biologist/arborist confirms that removal will improve the stream ecology or habitat or it is deemed that removal is unavoidable.
B. When riparian vegetation is removed, required mitigation is provided.
C. Non-native species are not planted between the top of banks of a stream or within an existing riparian corridor.
D. Planting of non-native invasive species is not taking place adjacent to an existing riparian corridor.
E. Invasive species are not planted.

<u>Recommendations:</u>

1. Preserve in and near-stream existing riparian vegetation whose canopies provide shade and nutrients to aquatic life.
2. Protect stream characteristics suitable for fish habitat when a modification is proposed to influence these characteristics including riffles, pools, gravel beds, stable undercut banks, overhanging vegetation and in-stream woody debris.
3. Use watershed specific native species for major development restoration landscaping.
4. Locate loading docks, trash enclosures, chemical storage areas, and stationary noise producing mechanical equipment away from streams and riparian corridors.
5. Locate new paved areas, active recreational areas, agricultural growing areas, and grazing activities outside riparian corridors.
6. Avoid nighttime lighting in riparian corridors.
7. Locate trash bins away from streams.
8. Avoid bright colors and glossy or glare producing building finishes on structures facing the stream or riparian areas.
9. Direct nighttime lighting away from the riparian corridor.
10. Maximize the distance between nighttime lighting and the riparian corridor.

II. Levee and Pipeline Protection

A. A slope stability analysis shows the integrity of the levee is maintained related to any modification to a levee.
B. Replacement of fill in levees is designed according to District specifications.
C. Trees are not planted on levees unless additional fill is placed against the levee.
D. Bubbler or drip-system irrigation is used within the outboard levee slope, and only for plant establishment purposes.
E. Main irrigation lines are not installed on levees.
F. Any structure providing support to levees is designed for a 50 to 100-year life span.
G. Water pipelines are outside District levees.
H. Trees are not planted within easements or right-of-way of District water supply pipelines.

Recommendations:

1. Provide a building setback for levee sections of 18 to 25 feet from the toe of the levee.
2. Place fill adjacent to the dry side of the levee to minimize the levee height unless it causes drainage problems, disturbs wetlands, creates safety concerns, or impacts aesthetics of properties.

III. General Landscaping

A. Irrigation systems are designed such that runoff will not cause erosion.
B. Use of pesticides on District property or easements is conducted according to District's pesticide policy.

Recommendations:

1. Follow efficient water use landscape ordinance requirements for drought tolerant plants and water conservation.

IV. Streambank Stability and Streambed Conditions

A. Projects are located outside the slope stability area, defined as the greater of 1 or 2, below:
   1. Two to one (2:1) slope stability requirement. Please note that distance may need to be increased depending on whether the stream is deeply incised or have highly erodible banks.
   2. Twenty (20) feet from top of bank.

B. Projects which are within the slope stability area have a geotechnical analysis demonstrating that:
   1. The development would not require introduction of hardscape in order to maintain active floodplain or active channel slope.
   2. Maintenance or repair of the stream can be provided.
   3. The location of the proposed structure will not threaten bank stability.
   4. Bank instability will not threaten existing structures and/or potentially cause a health and safety hazard.

V. Encroachments between the Top of Bank

A. Decks, pathways, and buildings or any other structures do not overhang or encroach beyond or within the top of bank.
B. New and replacement bridges are constructed as clear span structures unless length of the span makes clear span infeasible, then
   1. Footings and pile caps are designed based on channel scour to prevent erosion.
   2. Foundation depth is a minimum of three (3) feet below the active channel invert.
   3. The clearance under the bridge is a minimum of 12 feet unless access to the stream is to be provided from the road.
C. Structures proposed between the top of bank do not reduce the active channel or active floodplains' conveyance area or re-direct flow to the detriment of another bank or the river bed unless a hydraulic analysis indicate no increase in erosive velocity or flood elevations will result.
D. Any required hydraulic analysis:
   1. Is prepared using HECII or HEC-RAS format (small rural streams may utilize simpler hydraulic analysis methods).
   2. Models debris loading on piers (3 times the pier width).
   3. Includes a scour analysis.
E. Structures proposed between the top of bank along jurisdictional creeks comply with District freeboard requirements.
F. Proposed encroachments in the active channel and active floodplains provide for fish passage and do not impact aquatic life.
G. Proposals to place structures in the active channel due to structural requirements, feasibility, or otherwise, include the appropriate accepted feasibility, geomorphic, biological, and/or hydraulic analyses.

Recommendations:
1. Mitigation for loss of riparian habitat or aquatic habitat impacts related to construction of new structures is located as close to the new structure as possible.

VI. Erosion Prevention and Repair

A. Remediation of onsite existing erosion is provided.
B. Erosion repair projects have an evaluation of the project on potential impacts and no negative impacts are found relating to
   1. Upstream and downstream banks.
   2. Post-construction erosion potential.
   3. Flood elevations.
   4. Or, mitigation is identified and provided as part of the project.
C. Construction on slopes greater than 5 percent include plans for implementation of erosion and sediment control measures.
D. Hardscape or retaining wall proposals have an analysis demonstrating that
   1. All softer methods have been evaluated
   2. The proposed method will reduce erosion
   3. The proposed method will not cause erosion or negatively impact proper stream function in other areas
   4. Or, mitigation is identified and provided as part of the project.
E. Channel repairs match the contours of the upstream and downstream banks.

F. Treatment of bare earthen slopes to minimize erosion and sedimentation resulting from work is provided.
G. Design cutoff walls or keys anticipate scour depth and have a minimum depth of three (3) feet.
H. Design of erosion protection utilizes the softest possible method.

Recommendations:

1. Include guidance provided in the Bank Protection and Erosion Design Guide for any erosion prevention and repair design work.
2. Appropriate vegetation is planted between the top of banks as an alternative to hardscape bank protection while maintaining design channel capacity.
3. Encourage drainage designs that avoid the need for outfalls or reduce the size and/or number of outfalls.
4. Lay back over-steepened banks to a more stable configuration whenever possible.

VII. Grading

A. Grading adjacent to streams provides for buffer areas and vegetated swales between the stream and graded areas.
B. Erosion and sediment control measures are taken to prevent sediment contribution from any construction area into Calero, Anderson, Lexington, Coyote, and Almaden reservoirs.

Recommendation:

1. Consider protective measures in source water protection zones and sensitive areas of reservoir watersheds.

VIII. Outfalls, Pump Stations and Site Drainage

A. Runoff is directed to the same watershed where the project is located.
B. Site drainage is directed through vegetated areas or stilling basins prior to discharge or collection in storm drain systems.
C. Concentrated drainage (i.e. roof overhangs or downspouts) is directed away from the stream or overbank drainage is directed to vegetative buffer strips or landscape areas prior to reaching the stream.
D. The minimum number of outfalls is used.
E. New channel outfalls conform to the municipality's drainage master plan.
F. Slope protection for outfalls meet District minimum engineering standards.
G. Outfalls do not overhang the stream bank or bed.
H. The minimum outfall diameter is 12 inches.
I. Outfall discharge is oriented downstream and pipe invert is at least 2 feet above the stream bottom in areas where sediment deposition is anticipated.
J. Flap gates are installed whenever 100-year surface water elevation is above adjacent ground at inlet.
K. Dormers in outfalls are provided with flap gates to isolate the flap gates and keep them out of flow area.

L. In conjunction with new or redevelopment, abandoned outfall pipes and slope protection are removed and the stream bank restored to similar condition existing upstream and downstream of site.
M. Outfall discharge does not pollute receiving water or cause channel erosion.
N. A discharge management plan is developed to manage pump operations during high water (flood) events for development projects requiring a pump station that discharges to a stream.

Recommendations:
1. Limit pump discharges to the extent feasible during peak flows to minimize potential impacts from flooding.
2. Prefer that there are no new outfalls

IX. Channelization

A. On-site surface streams are not buried.
B. On-site surface streams are not in culverts except for road crossings in which case the crossing is clear span and:
   1. Carries the bank full flow.
   2. Accommodates a modified floodplain drainage.
   3. Accommodates the 100-year flow, if feasible.
C. Regional debris or sediment basins that will be owned or maintained by the District are designed for 50-year sediment capacity.
D. Modifications to open channels have an accepted hydraulic analysis including stream dynamics and induced flooding.
E. Stream conveyance area is designed for 100-year design flow with freeboard, unless the active channel and floodplain will not contain the designed 100-year flow.
F. Creeks are not filled to accommodate grading and construction until impact avoidance and minimization efforts are maximized.
G. Impacts to habitat are demonstrated to be avoided.

Recommendation:
1. Dedicate an 18 to 22-foot wide maintenance area to the District for stream modification projects.
2. Recommend restoration of natural stream processes if possible.
3. Use multi-stage culverts with cross-sections designed to carry different flows for meeting IX.B.1,2 and 3.

X. Utility Encroachments

A. Proposals do not include longitudinal (parallel) encroachments within District right of way.
B. Utility pipes or conduits are under the stream or placed inside of, or attached to, the downstream face of a bridge, and go under any levee (no cuts in levees). If it is unfeasible to go under or attach to the downstream face of bridge, the utility crossing is located on the upstream face of bridge and the design provides the following features:
   1. Would not catch debris,
   2. Would be capable of surviving impacts from floating debris in high flow,
   3. Would not hinder emergency debris removal or maintenance operations.
C. New or replacement bridges provide locations for future utility crossings.

D. Utilities proposed under the stream are concrete encased or placed in a sleeve.
E. Borings are five (5) feet below lined channels and eight (8) feet below unlined channels.
F. The minimum clearance for cut and cover is three (3) feet and is based on scour depth.
G. A fracout prevention and response plan (describing how water quality will be protected in the event of fracout) is prepared for directional drilling projects using bentonite or other lubricants to go beneath or near streams and aquatic habitats.

<u>Recommendations:</u>
1. Utilize directional bore to install under-channel utilities.

XI. Trail Construction

A. Trails are located so as to avoid impacts to stream and riparian areas unless unfeasible.
B. Deep excavation for trail construction takes place outside tree root zones unless unfeasible.
C. Trails on District right of way have an agreement defining maintenance, management, and liability responsibilities of facilities.

<u>Recommendations:</u>
1. Encourage joint use of pedestrian/bicycle paths along creeks.
2. Place paved multi-use trails so as to maximize the distance between the stream and the riparian areas.

XII. Septic Systems

<u>Recommendations:</u>
1. Consult with District to determine whether land feature is an active floodplain or swale and assist in determining high water marks at reservoirs.

XIII. Groundwater Protection

A. Groundwater resource assessments acceptable to the District are prepared when there is potential for significant groundwater supply or groundwater quality impacts.

B. Wells are shown on plans and are registered with the District and either be maintained or destroyed in accordance with District standards.

<u>Recommendations:</u>
1. Manage (limit, monitor and implement best management practices) existing high risk activities in recharge areas of basin.

XIV. Flood Protection

A. In special flood hazard zone A (areas where base flood elevations have not been determined) hydraulic analyses are prepared to determine the base flood elevation for subdivisions greater than 5 acres or 50 lots whichever is lesser.
B. For major developments near streams subject to California Environmental Quality Act (CEQA) review that are compatible with the General Plan utilized for developing District hydrology

and the Federal Emergency Management Agency (FEMA) floodmaps, development does not increase site runoff so as to increase depth (0.1 foot increase in water surface) or lateral extent of flooding or increase discharge in local streams.

C. A hydraulic analysis, prepared by registered civil engineer, is prepared to demonstrate that there will not be flood impacts created in relation to XIV.B.

Recommendations:

1. Recommend increased levels of protection as described in the Department of Water Resources Model Floodplain Ordinance, recommendations of California Floodplain Management Task Force (Dec 2002), and FEMA's Community Rating System Program.
2. Utilize any other available base flood elevation data as criteria for meeting National Flood Insurance Program requirements for construction and substantial improvements for subdivisions other than those covered under XIV.A.

Additional Standards for District Encroachment Permits

Additional standards to evaluate District encroachment permits and to establish related permit conditions may be found in the following documents. The standards may be found at the Clerk of the Board of the Santa Clara Valley Water District; 5750 Almaden Expressway, San Jose, CA 95118-3686.

1. District's administration policies.

2. District's design guide.

3. Best Management Practices Handbook, ISO Document WW75109, for construction activities near streams.

4. United States Corps of Engineers guidelines for levee stability and safety.

CHAPTER 3

DESIGN GUIDES

INTRODUCTION TO THE DESIGN GUIDE

THE PURPOSE OF THE DESIGN GUIDE IS TO PROVIDE FURTHER ILLUSTRATIVE DETAIL AND CLARIFICATION ON THE SPECIFIC APPLICATION OF THE REQUIREMENTS AND RECOMMENDATIONS OUTLINED IN CHAPTER 1, AND TO DETERMINE COMPLIANCE WITH SECTION 2.3.3(6) OF THE WATER RESOURCES PROTECTION ORDINANCE (ORDINANCE 06-1).

WHERE THERE IS A VARIETY OF OPTIONS, THE PREFERRED OPTION IS INDICATED. IT IS NOTED, HOWEVER, THAT THE PREFERRED OPTION MAY NOT ALWAYS BE FEASIBLE OR PREFERRED DEPENDING ON THE CIRCUMSTANCES, OTHER OPTIONS, WHICH ARE ALLOWABLE NOT TYPICALLY RECOMMENDED HAVE BEEN INCLUDED AS WELL.

IF THERE IS A CONFLICT BETWEEN INFORMATION IN THE DESIGN GUIDE AND THE REQUIREMENTS AND RECOMMENDATIONS IN CHAPTER 1, PLEASE DEFER TO CHAPTER 1.
ALSO, SOME JUDGEMENT WILL NEED TO BE MADE BASED ON SITE-SPECIFIC CONDITIONS AND THE DYNAMIC NATURE OF THE STREAM SYSTEMS.

PROTECTION OF EXISTING RIPARIAN VEGETATION

INTRODUCTION

This Design Guide was assembled in order to provide more detail on protection of native riparian plants. The sections that follow provide more detail on how to best implement these requirements. They also serve as helpful guidelines for single family home owners involved in landscaping and revegetation projects.

THE IMPORTANCE OF RIPARIAN VEGETATION

Riparian vegetation plays a vital role in maintaining stream stability, providing valuable wildlife habitat, and moderating downstream flooding. In addition, the presence and/or absence of riparian areas is directly correlated to water quality as the riparian vegetation serves to filter pollutants from stormwater, such as oil and grease from roadways, fertilizer runoff from lawns, and excess sediments from upstream.

Due to the importance and relative lack of riparian vegetation in Santa Clara County, particularly in urban areas, one goal of any planning project is **to avoid removal of any native riparian vegetation and to prevent the types of conditions that would threaten or degrade existing riparian habitat and/or contribute to soil loss** critical to the continued health and regeneration of riparian trees. To this end, all development activities need to be outside this riparian corridor where at all possible. Any exceptions to this rule need to be justified and mitigated.

VALUE OF ESTABLISHING RIPARIAN BUFFERS

The amount and condition of the riparian habitat has been significantly reduced in Santa Clara County over time, primarily due to channel encroachment and modification. This has led to incised channels, as well as a lowering of the water table, loss of riparian vegetation, decline in water quality and most beneficial uses, as well as increased risk of erosion, bank failure and flooding. To stop and reverse this trend, an additional buffer area should be established between the edge of the existing riparian zone and any development, where feasible. This buffer should be planted with native vegetation in order to better protect the riparian corridor and the watercourse. The goal is to eventually establish and increase the riparian buffer area all along the riparian corridor. The value of riparian buffers areas has been well documented, in addition to reducing flash runoff and improving water quality, they provide supplemental foraging resources and corridors for wildlife to access the streams and even increase streamside property values.

This Design Guide describes standard criteria for determining how far from existing riparian habitat to locate construction and development activities in order to help ensure its protection. The Design Guides that follow provide more detail on the types of plants to use in landscaping and revegetation of areas, in or adjacent, to riparian areas. For more information on design of trails in specific, see Design Guide number 16.

CALCULATING RECOMMENDED TREE PROTECTION ZONES

Calculation of the recommended distance between an existing riparian tree and closest construction, staff need to consider the following variables:

1. Evaluate the species tolerance of the tree: good, moderate, or poor.

2. Identify tree age: young, mature or overmature.

3. Using the table below, "GUIDELINES FOR OPTIMAL TREE PRESERVATION ZONES", find the distance from the trunk that should be protected per inch of trunk diameter.

4. Multiply the distance by the trunk diameter to calculate the optimum radius (in feet) for the tree protection zone.

If excavation occurs inside the identified "Tree Protection Zone", roots will be severed, the tree's health will decline, the incidence of insect and diseases will increase and people may be endangered by eventual failure of the destabilized tree. Where there are other site constraints, anticipated encroachment within the recommended tree protection zone, an arborist should be consulted to determine the appropriate protection measures or alternative setbacks.

GUIDELINES FOR OPTIMAL TREE PRESERVATION ZONES

Species Tolerance	Tree Age	Distance from trunk feet (per inch trunk diameter)
Good	Young*	.05'
	Mature*	.75'
	Overmature*	1.0'
Moderate	Young	.75'
	Mature	1.0'
	Overmature	1.25'
Poor	Young	1.0'
	Mature	1.25'
	Overmature	1.5'

*Young (<20% life expectancy)
*Mature (20-80% life expectancy)
*Overmature (>80% Life expectancy)

EXAMPLE TREE PROTECTION ZONES

Western Cottonwood (*Populus fremontii*): Poor Tolerance
The Western Cottonwood has a poor tolerance to root disturbance. The tree protection zone for an overmature tree is 1.5′ per inch of tree diameter or a 45 foot radius for a 30 inch diameter tree. Other trees with a poor tolerance include the black cottonwood and bigleaf maple.

Western Sycamore (*Platanus racemosa*): Moderate Tolerance
A Western Sycamore has a moderate sensitivity to impacts around its roots. The tree protection zone for an overmature tree measured from its trunk is 1.25 feet per inch of trunk diameter. A 30″ diameter mature Western Sycamore needs a tree protection zone with a 37.5′ radius. Other species with a moderate tolerance include the valley oak, California bay and willows.

Coast Live Oak (*Quercus agrifolia*): Good Tolerance
The Coast Live Oak has a good tolerance to disturbance. The species is sensitive to the addition of fill around its trunk and does not tolerate frequent summer watering. The tree protection zone for a mature tree is one foot per inch of trunk diameter. A 30 inch diameter tree needs a protection zone with a 30 foot radius. Other trees with a good tolerance include alders, box elders, and California buckeye.

USE OF LOCAL NATIVE SPECIES

INTRODUCTION

The use of locally native plants for all landscaping and revegetation projects adjacent to streams and riparian areas is required for new and major redevelopment. It should also be the preferred choice for homeowners involved in any landscaping and revegetation projects within the riparian corridor since native plants are ecologically best suited to a particular creek environment and will provide the most habitat and slope protection with the least amount of maintenance over time.

HOW TO FIND AND SELECT NATIVES IN THE WATERSHED

When vegetating the creek, choose species growing nearby and make sure the plants used were propagated from seeds, cuttings or divisions collected from the same local creek or watershed. Try local home-grown native plants via direct installation of seeds, divisions and cuttings on the creek bank. Oaks, buckeye and bay trees are easy to grow from seed planted directly into moist creek bank soil. Cottonwood and willow are easy to grow from cuttings stuck directly into moist sandbars. California rose, California blackberry, snowberry, mugwort, beardless wildrye and others can be propagated readily from vegetative offsets and division.

GUIDELINES FOR PLANTING NATIVE SPECIES

- Geared toward establishing or enhancing the native habitat.
- **Ensure that the initial planting density is high,** averaging 6 to 12 feet on center, to create canopy coverage and closure quickly. Include a range of species in the plant palette to fill in the understory, mid-story and overstory.
- **Avoid hardscape** such as patios, walkways and decks within these areas to minimize human impacts and maximize habitat value.
- **Maintain and monitor plantings** for a 3 to 5 year period to ensure healthy establishment. Performance and success criteria include percentage of allowable mortality and goals for an annual percentage of vegetative cover.
- Slowly eliminate the need for human intervention, including irrigation, weed control, replanting, pruning, etc. The final goal is to discontinue maintenance activities when habitat is self sustainable.

California Native Plant Society's Web site:
www.cnps.org

LIST OF NATIVE PLANT SPECIES

The following list is a conglomerate of riparian plant species that exist within the boundaries of Santa Clara County. The distribution of one plant may or may not overlap with the next one on the list. Some of them would never be seen together in the wild due to preferences for different microclimates, soil substrates and hydrologic regimes. If you are unfamiliar with local native plant ecology, consult local experts for help selecting the best plant palette for your particular creek or follow Nature's example and copy what you see in a wild area located close to your project site.

TREES:

Big Leaf Maple
Acer macrophyllum

California Box Elder
Acer negundo var.californicum

California Buckeye
Aesculus californica

White Alder
Alnus rhombifolia

Western Sycamore
Platanus racemosa

Fremont Cottonwood
Populus fremontii ssp. fremontii

Black Cottonwood
Poplus trichocarpa

Coast Live Oak
Quercus agrifolia

Valley Oak
Quercus lobata

Narrow-leaved Willow
Salix exigua

Red Willow
Salix laevigata

Yellow Willow
Salix lucida ssp. lasiandra

Arroyo Willow
Salix lasiolepis

Blue Elderberry
Sambucus mexicana

California Bay Laurel
Umbellularia californica

SHRUBS AND VINES:

California Sagebrush
Artemisia californica

Mule Fat
Baccharis salicifolia

Virgin's Bower
Clematis ligusticifolia

Toyon
Heteromeles arbutifolia

Coffeeberry
Rhamnus californica

California Wild Grape
Vitus californica

Brown Dogwood
Cornus glabrata

California Rose
Rosa californica

California Blackberry
Rubus ursinus

Snowberry
Symphoricarpos albus var. laevigatus

GROUND COVERS AND HERBACEOUS PERENNIALS:

Mugwort
Artemisia douglasiana

Western Aster
Aster chilensis

Douglas' Baccharis
Baccharis douglasii

Western Goldenrod
Euthamia occidentalis

Beardless Wildrye
Leymus triticoides

Sticky Monkey Flower
Mimulus aurantiacus

California Figwort
Scrophularia californica

California Native Plant Society's Web site:
www.cnps.org

USE OF ORNAMENTAL OR NON-NATIVE LANDSCAPING

INTRODUCTION

If the use of local native plants propagated from local stock does not fit your landscaping goals, choose:

- **Non invasive drought-tolerant, non native ornamental plants** having no potential to cross pollinate native riparian species. For example, if native valley and coast live oaks, willows, sycamores or cottonwoods exist in the riparian corridor, don't plant ornamental oaks, willows, sycamores or poplars.
- **Non invasive, drought tolerant, non-local California natives** (aka ornamental natives), with no potential to cross-pollinate local native species; for example- Fremontodendron or Romneya.

When selecting plants and choosing their location in an ornamental landscape, the project design goals are generally geared to human aesthetics. In choosing ornamental landscaping, hardscape features, such as patios, decks, and walkways, are design components. **These features should be avoided within the riparian habitat area at all locations.**

PLANT SELECTION GUIDE

The choices of plants that meet the criteria described above for ornamental landscaping is vast. Selection of a plant species for a particular site will depend on goals of the landscape plan, site constraints, the owner's desires and budget. There are a variety of resources available from which selections can be made. Cities generally have plant lists available that were assembled for water conservation purposes. The East Bay Municipal Utility District has prepared a book, entitled "Plants and Landscapes for Summer Dry Climates" and the Sunset Western Garden Book, commonly available at most nurseries, has plant selections identified that are suitable for dry places. **Select plants from these sources as long as you avoid invasive plants and take the caution provided above for selecting native species that have not been propagated from your local watershed.**

REFERENCES

The California Native Plant Society's 'Guidelines for Protecting Native Plants from Genetic Degradation' is a helpful reference on the subject.

Find it at: http://www.cnps.org/archives/archives.htm

Scroll down to:

1) Policies and Guidelines
2) Conservation Policies
3) Guidelines for Landscaping to Protect Native Vegetation from Genetic Degradation.

NON – LOCAL CALIFORNIA NATIVE PLANTS

The following California native plants have a very low potential of hybridizing with our Santa Clara County natives since they do not naturally occur in northern California

TREES

Chilopsis linearis, (Desert Willow), Lyonothamnus floribundus, (Catalina Ironwood), Prosopis glandulosa var. torreyana, (Mesquite)

SHRUBS

Fremontodendron californicum or Fremontodendron mexicanum, (Flannel Bush), Galvesia speciosa, (Island Bush Snapdragon) Rhus integrifolia, (Lemonade Berry), Rhus ovata, (Sugar Bush), Romneya coulteri, Matilija Poppy, Simmondsia chinensis, (Jojoba)

California Invasive Plant Council Web site: www.cal-ipc.org

COMMONLY FOUND INVASIVE SPECIES TO BE AVOIDED

Acacia
Acacia spp.

Almond
Prunus dulcis

Ash, evergreen
Fraxinus uhdei

Bamboo, running types
Arundinaria, chimonobambusa, phyllostachys, etc.

Black locust
Robinia pseudoacacia

Broom, french
Genista monspessulana, previously cytisus monspessulanus

Broom, scotch
Cytisus scoparius

Broom, spanish
Spartium junceum

Cape weed
Arctotheca calendula

Cotoneaster
Cotoneaster spp.

Elm
Ulmus spp.

Eucalyptus
Eucalyptus spp.

Fig
Ficus carica

Flowering plum, fruitful varieties
Prunus spp.

Fountain grass
Pennisetum setaceum); purple variety "cupreum" is sterile and acceptable

Foxglove
Digitalis purpurea

Giant reed
Arundo donax

Glossy privet
Ligustrum lucidum

Gorse
Ulex europaea

Himalayan blackberry
Rubus discolor

Holly oak
Quercus ilex

Iceplants
Carpobrotus edulis, c. Chilensis, mesembryanthemum spp.

Ivy, algerian
Hedera canariensis

Ivy, cape
Delairea odorata, previously senecio mikanioides

Ivy, english
Hedera helix

Kikuyu grass
Pennisetum clandestinum

Lemon balm
Melissa officinalis

Lombardy poplar
Populus nigra 'italica'

London plane tree
Platanus acerifolia

Mint, any kind including pennyroyal, peppermint, spearmint
Mentha spp.

Monterey pine
Pinus radiata

Myoporum
Myoporum laetum

Olive
Olea europaea

Pampas grass, jubata grass
Cortaderia selloana, C. Jubata

Pepper trees
Schinus spp.

Periwinkle
Vinca major

Pyracantha
Pyracantha spp.

Tamarisk, salt cedar
Tamarix spp.

Tree of heaven
Ailanthus altissima

Walnut, english or black
Juglans regia, juglans californica var. Hindsii

California Invasive Plant Council Web site:
www.cal-ipc.org

RIPARIAN REVEGETATION OR MITIGATION PROJECTS

INTRODUCTION

This Design Guide is most applicable for larger scale revegetation or mitigation projects but also provides helpful information for anyone planning a revegetation project. Because of the complexity of revegetation design and the variety of ecosystems that exist within the county, it is nearly impossible to create succinct detailed Design Guidelines. Instead, a list of general, broad brush design planning guidelines is included below for riparian revegetation projects in Santa Clara County. Each individual project should be mentored through all stages of project planning and design by experienced biological staff on a case by case basis.

WATERSHED FIDELITY

- **To preserve genetic integrity in county watersheds, propagation material (seeds, cuttings, divisions) must originate from local native stock, i.e. individuals found as close as possible to the project site and within the same watershed.**
- If propagation material cannot be obtained from within the watershed, material may be collected from an immediately adjacent watershed that shares common ecological characteristics (climate, elevation, soil type, headwaters in the same mountain range, etc.).
- An ecological justification is required before any species may be planted using container stock grown from propagules that originate outside Santa Clara County.

SEED AND CONTAINER PLANTS

- Direct seeding should be used when possible. Quercus sp. and Aesculus californica have high success rates when installed in this manner.
- Direct stuck cuttings of willows, cottonwoods and mule fat is encouraged.
- Containerized native plants for revegetation or landscape plantings should be grown and installed in the smaller, deeper container sizes typically offered by revegetation nurseries rather than commercial nurseries to ensure they are healthy. For that reason, quality native plants will normally be smaller and younger than conventional nursery container stock, usually 1-gallon equivalent or smaller size. **Contract nursery production takes one-year minimum lead time before installation. Designers should take these factors into account when commitments are made to project stakeholders.**

SPECIES SELECTION

- Select plant species that are historically and ecologically appropriate to the project area unless site conditions have been radically modified. The plant palette should be well-suited to these conditions and blend with the existing native vegetation types.
- Non-local, showy, native **"landscape" species should not be intermingled with native revegetation species on projects where habitat restoration is the goal.**
- Do not plant invasive, non-native species near streams.

DESIGN CRITERIA

- Revegetation design should be predicated upon thorough analysis of groundwater and surface water hydrology, soil profiles, and other physical information obtained from direct site investigations. Existing site conditions should be preserved and modification into an artificially sustained condition should be discouraged.
- Revegetation projects should be designed to quickly attain sustainability rather than to require long-term human intervention.
- Irrigation, weed and pest control, soil manipulation, etc., should become unnecessary within one to three years.
- Land use on adjacent sites that could disrupt or damage the project goals should be factored into design decisions for revegetation projects.
- Experienced biological staff should be active participants during the entire design process for revegetation, native landscape, mixed (native & non-native) landscape, erosion control, etc. plans and specifications.

California Native Plant Society Web site:
www.cnps.org

TEMPORARY EROSION CONTROL OPTIONS

INTRODUCTION

This design guide provides more detail on G&S I.C.3 and GS IV.B.7 by explaining what steps can be taken during post construction to provide erosion control in short order on stream banks through temporary vegetative measures. These measures are typically employed:

- when the grading and/or construction is being done in phases,
- when it does not make sense to plant more permanent vegetation or
- if grading and/or construction has not been completed by the rainy season.

These temporary techniques are also sometimes used in conjunction with final more permanent revegetation. The following guidelines can be used to determine if and how erosion control seed mixes should be used.

SEED MIXES TO BE AVOIDED

Some commercially available seed mixes contain species, which are invasive weeds, aggressive competitors with native plants and/or future fire hazards. **These seed mixes should be excluded from streamside areas.** Examples are Blando brome, rose or red clover and annual rye.

EROSION CONTROL OPTIONS FOR WORK SITES WITH EXISTING NATIVE PLANTS

These erosion control options should be followed in most areas along natural creeks, where native trees, shrubs and herbs reside on or near the work site. A site visit or referral of a good series of photos to a landscape professional familiar with native plants or a revegetation specialist may be needed to determine the best approach.

If no irrigation is available, if the slope is very steep, or if it's late in the season

- Use a non-biological method, such as straw, straw with tackifier, erosion control blankets (jute netting with straw or coir filling), etc. instead of seeding.

Benefits:

- The blankets are functional immediately after installation.
- The adjacent native plants will fill in at their own pace.

Use if there is absolutely no time to investigate site conditions.

- Use a Failsafe mix with 50 lb/ac 'Regreen' sterile wheat (Triticum X Elymus 'Regreen'), with 95% minimum purity, and minimum germination of 85%.

Benefits:

- This plant mix makes few if any seeds, so it cannot become a weed, and it usually lives only one year.
- The adjacent native plants can seed in thereafter.

EROSION CONTROL OPTIONS FOR WORK SITES **WITHOUT** EXISTING NATIVE PLANTS

These erosion control options should be followed in areas where there is no remaining native vegetation for miles around. An example of such a site is the back slope of a levee in an urbanized area.

For Sunny Slopes 3:1 or Flatter

- **California Native Grass**
  Use a mix of:
  Prostrate Hordeum californicum (Prostrate California Barley) @ 16 lb/ac, minimum purity 90%, minimum germination 80%.

  Elymus glaucus 'Berkeley' ('Berkeley' Blue Wildrye) @12 lb/ac, minimum purity 95%, minimum germination 85%

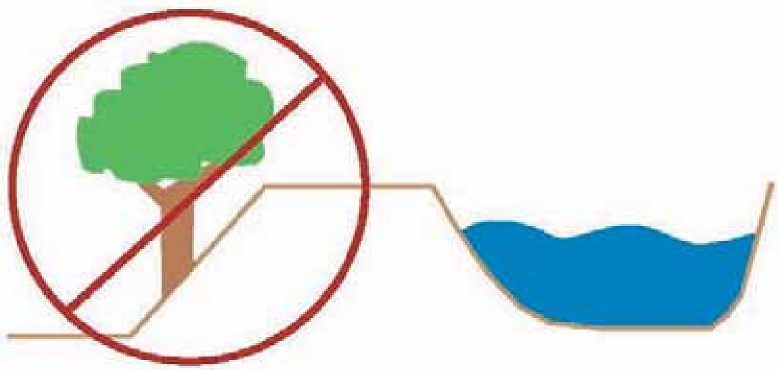
  Bromus carinatus 'S.F. Bay Area'('S. F. Bay Area'California Brome) @ 10 lb/ac, minimum purity 95%, minimum germination 85%
- **Failsafe mix**

  50 lb/ac 'Regreen' sterile wheat (Triticum X Elymus 'Regreen'), minimum purity 95%, minimum germination 85%
- **Non-biological method** as outlined above

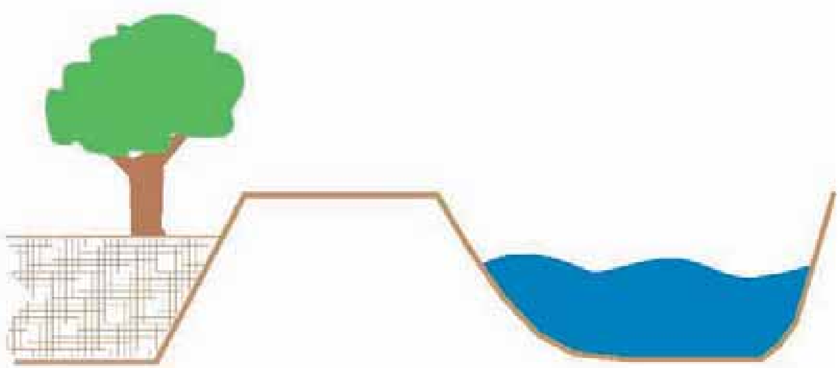
For Slopes 2:1 or Steeper

- **California Native Grasses PLUS Mix**
  Use the mix for Slopes 3:1 or Flatter PLUS Vulpia microstachys (Three Weeks Fescue) @ 5 lb/ac, minimum purity 95%, minimum germination 70%
- **Failsafe mix**
  50 lb/ac 'Regreen' sterile wheat (Triticum X Elymus 'Regreen'), minimum purity 95%, minimum germination 85%.
- **Non-biological method** as outlined above

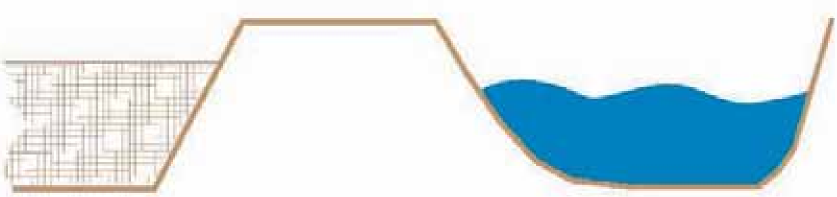
PLACEMENT OF FILL AND PLANTING OF TREES BY LEVEES



Plants with large root systems (trees and large shrubs) should not be placed on existing levees.

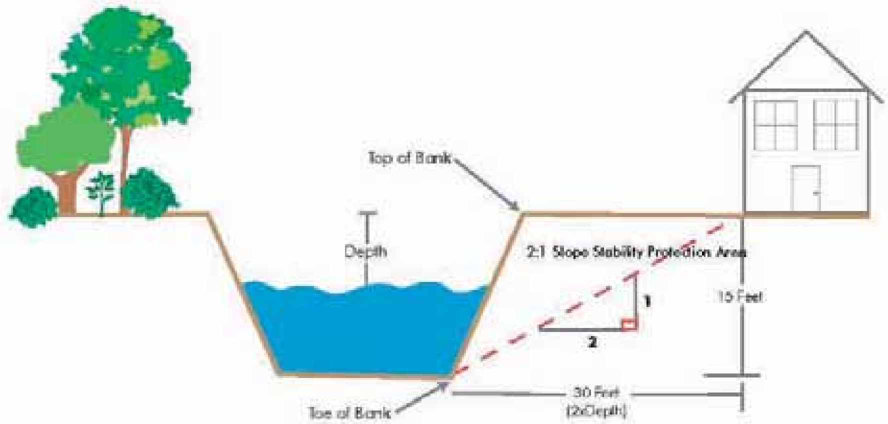


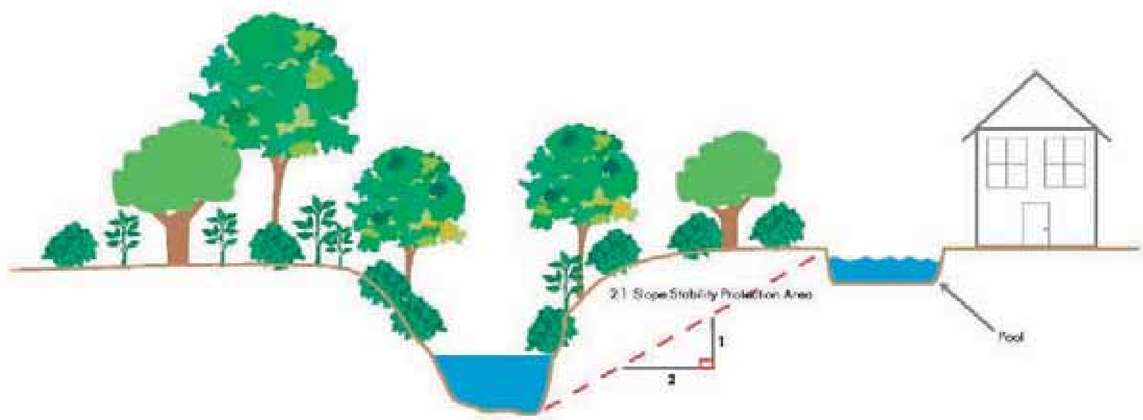
Trees may planted on a levee if additional fill is placed on the levee.

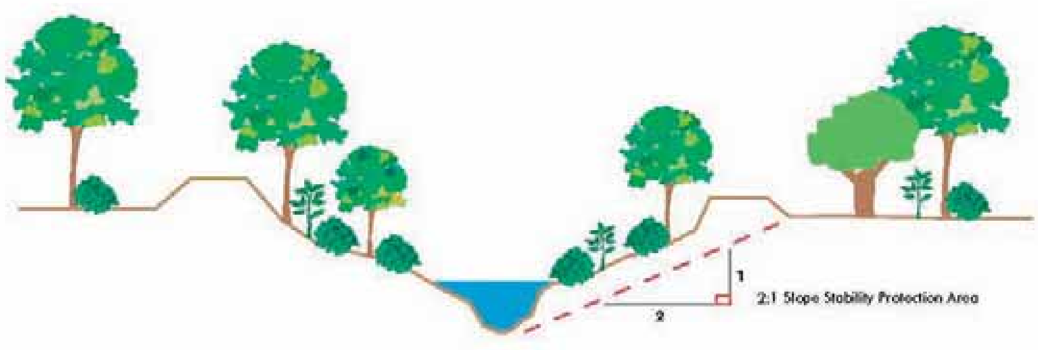


The placement of fill on/next to the out board slope of the levee will reduce the height of the levee for aesthetics and improves the safety of the levee system. The height of the fill may vary. Geotechnical analyses may be needed to determine the impacts of the fill to the levee slope.

SLOPE STABILITY PROTECTION AREA







Note: While accessory structures are typically exempt, it is still recommended to locate them outside the 2:1 Slope Stability Protection Area in order to protect the structures, creek bank, and habitat.

GUIDELINES FOR ESTABLISHING FREEBOARD FOR BRIDGE CROSSINGS AND FLOOD PROTECTION PROJECTS

BACKGROUND

Freeboard is the additional capacity in a stream above the calculated capacity required for the 1 percent flow. Freeboard provides a safety factor for such things as normal wave action, inaccuracies in determination of friction factors, and minor silt and debris deposits. **The freeboard guidelines should also be followed when streams are modified as part of major land development proposals.** The Federal Emergency Management Agency (FEMA) has set guidelines for the determination of freeboard. In order for an area to be removed from a flood zone designated by FEMA following completion of a flood control project, the project must meet the FEMA guidelines. These freeboard guidelines are followed by the SCVWD in the design of flood protection projects **and should be followed for the design of bridges and other street crossings.**

A. Where the design water surface[1] is above natural ground, the following criteria shall be considered a minimum:

1. Federal Emergency Management Agency (FEMA) guidelines. FEMA currently specifies that levees shall have a minimum of 3 feet of freeboard with an additional foot of freeboard required 100 feet on either side of structures that are within the leveed section of creek or where the flow is constricted such as at bridges. FEMA also requires an additional ½ foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee. To comply with these requirements, use as a minimum 3½ feet of freeboard within leveed sections and 4 feet within 100 feet of bridges or other constrictions.

2. For floodwalls, use the same freeboard criteria as for levees. (Basis—SCVWD guideline)

3. If two-tenths of the total energy (depth of flow + [v2/2g]) is greater than the freeboard requirement of A-1 or A-2 above, then the computed value shall be used for freeboard. (Basis—Natural Resource Conservation Service [NRCS] guideline)

B. Where the design water surface is below natural ground, the following criteria shall be considered a minimum:

1. One foot of freeboard shall be used for constructed, nonnatural channels where large amounts of vegetation are not anticipated in the channel. (Basis—Corps of Engineers guideline)

2. For all channels, if two-tenths of the total energy is greater than the freeboard requirement of B-1 above, then the computed value shall be used for freeboard. (Basis—NRCS guideline)

C. For bridges, the following criteria shall be considered minimum:

1. At new bridges, freeboard shall be the same as in the existing or proposed channel either upstream or downstream, whichever is greater. When the bridge structure encroaches into the freeboard area, there shall not be an increase in water surface for bank full flow. The intent is to define a system (bridge and channel) with a uniform level of protection. (Basis—SCVWD guideline)

[1] Defined by recent flood protection projects or determined according to local topography and site conditions. For more information, contact SCVWD.

2. Where an existing bridge or culvert can convey the design flow under pressure, it must be structurally sound and must be able to resist the resultant lateral and uplift forces.
(Basis—SCVWD guideline)

D. Other Considerations:

1. Evaluate all bridges with debris loads on the piers. (suggest Corps practice of three times pier diameter as blockage)
2. Freeboard should also contain the flow defined by the 80 percent confidence limit statistical parameter where practical to do so.
3. All channels with super-critical flow will use sequent depth plus freeboard.
4. All channels will include freeboard for super-elevation of water surface at curves in addition to requirements specified in Sections A, B, and C above.
5. In areas of the County where there is the possibility of continued land surface subsidence, additional freeboard allowances should be considered.

DESIGN GUIDE 9

GRADING OPTIONS NEXT TO STREAMS

INTRODUCTION

The details in this Design Guide are intended to provide clarification to G&S V.A, which calls for all grading next to streams to address drainage and avoid the concentration of flow over the stream bank. For all major redevelopment and new development, grading should be addressed in stormwater permit provisions. The applicants will have to observe urban runoff pollution prevention regulations during grading operations. In addition, the following grading guidelines would also be useful to single family homeowners interested in minimizing erosion and saturation of the streambank and maintaining slope stability and riparian habitat.

ADDITIONAL INFORMATION REQUIRED

In addition to the urban runoff pollution prevention regulations, permit applicants should also be asked to provide the following information:

- Existing trees that are to remain and those proposed to be removed
- The species of tree and its diameter at 4 feet from the ground
- Source of fill and hazmat certification

This will help in assess if the proposed grading method is the most appropriate for the site so as to avoid other impacts.

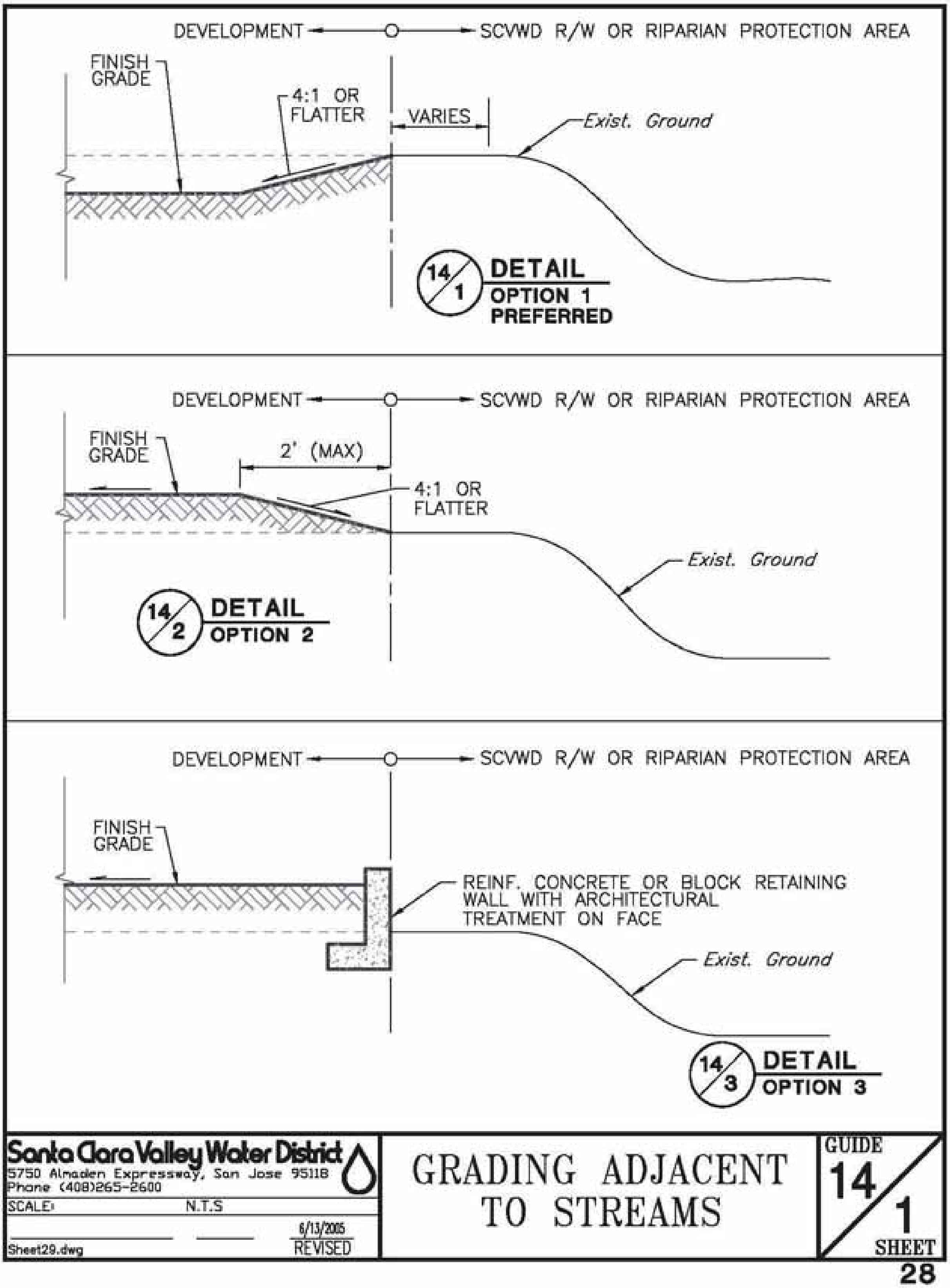
OPTIONS FOR GRADING

This Design Guide provides 5 options of how to design grading. Any other proposal which satisfactorily meets the goals of preventing over-bank drainage and the placement of fill along the riparian protection area by future lot owners may be considered. The selection of a particular option will be influenced by a site's finished grades needed to provide for streets, building pads and positive drainage to the storm sewer system.

Option #1 is the preferred option because it avoids disturbance to the riparian corridor and does not direct drainage over bank.

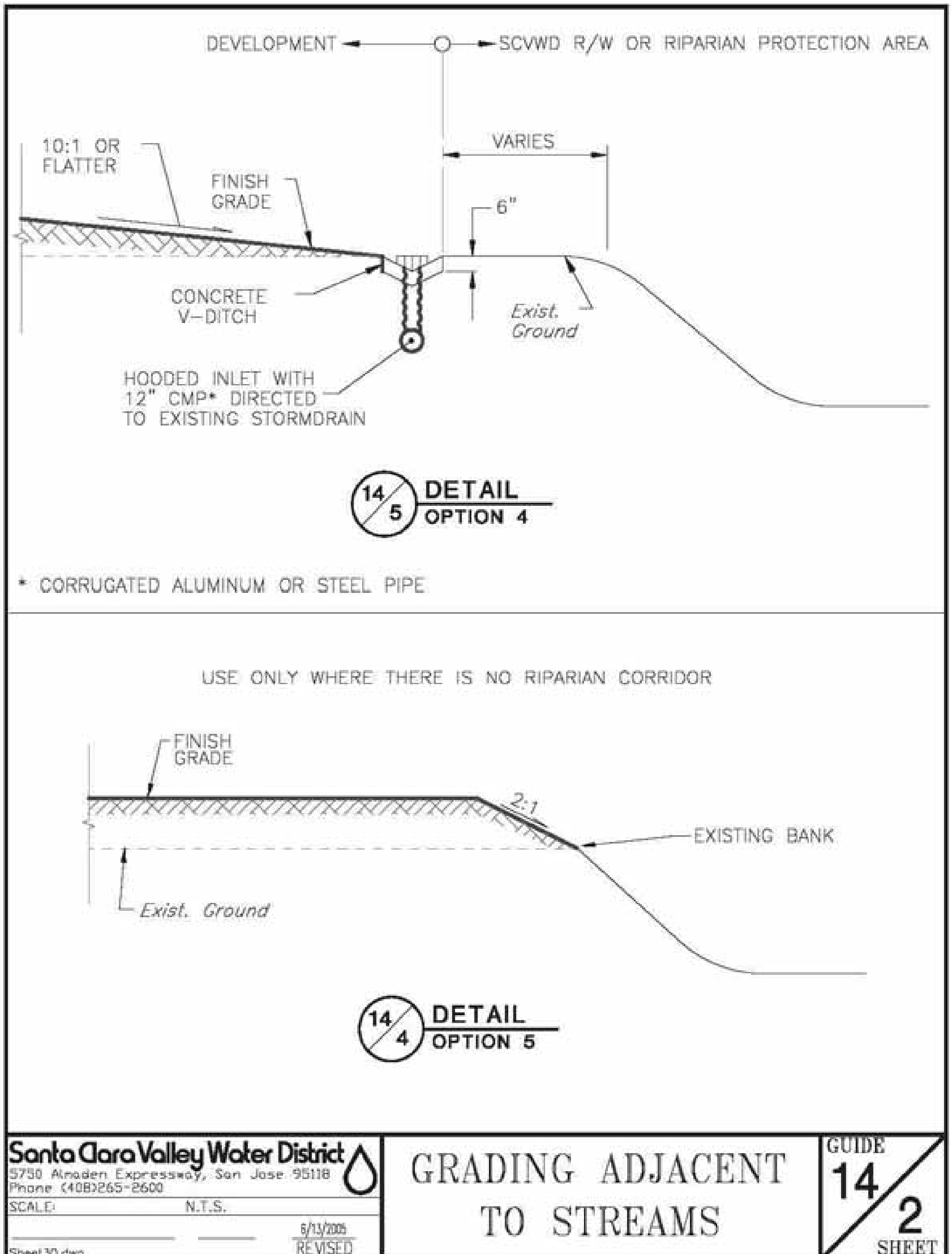
In other cases, applicants might need to use one of the Options 2- 5, because of the need to raise the site elevation. Option 2 avoids disturbance to the riparian corridor and minimizes the drainage directed over bank. Options 3 and 4 are similar but more costly. Option 5 would only be suitable if there is no riparian vegetation and it conforms to adjacent property upstream and downstream. **Fill placed within the riparian area should be suitable for planting.**

GRADING OPTIONS NEXT TO STREAMS



GRADING OPTIONS NEXT TO STREAMS

Option 5 is not the preferred option because placement of fill in riparian areas can damage stream side resources. If fill must be used in riparian areas, the type of fill used must support riparian vegetation and the area should be revegetated.



29

GRADING AND DRAINAGE

Use of Vegetated Swales or Buffer Strips

INTRODUCTION

The Guidelines and Standards Section V on Grading and Section VI on Outfalls and Site Drainage refer to the use of vegetated swales or buffer strips. A vegetated swale (a.k.a. grassed channel, dry swale, wet swale or biofilter) is a broad, shallow channel with a dense stand of vegetation designed to trap particulate pollutants (suspended solids and trace metals). Vegetated swales are fairly straight forward to design and can be easily incorporated into a project's site drainage plan. For all major redevelopment and new development, vegetated swales may be included in the stormwater permit; however, they are also a good practice for single family homeowners to consider incorporating in landscaping and design plans.

The benefits of using vegetated swales or buffer strips next to streams are that they:

1. Improve the quality of stormwater runoff and reduce or slow the velocity of runoff from hardened or paved areas
2. Allow for infiltration
3. Provide an opportunity for sediment and pollutants to be filtered and removed from the runoff.

The swales can be located within landscaped or turf areas and can collect runoff from patios, driveways, roof drains, parking lots. Discharge from the swale should be to a storm drain system, which will ultimately discharge to a stream.

DESIGN ELEMENTS

- Gentle side slopes: 3 horizontal to 1 vertical slope maximum
- Minimal longitudinal slope: 1% to 2% recommended. If greater, install check dams to reduce velocity. Do not use swales on slopes greater than 6%
- Flowpath length: Minimum of 10 feet
- Bottom width: 2 to 8 feet. Consider access with mowing equipment if turf grasses are used.

RECOMMENDED TYPES OF VEGETATION TO USE

There is a variety of vegetation, including trees, shrubs, groundcover and grasses that are suitable for periodic inundation. One goal is to select plants that will thrive at the site. Near streams, native plants and wetland vegetation are preferred to turf grasses as swale liners because they offer higher resistance to flow and provide a better environment for filtering and trapping pollutants from stormwater. However, turf grass, allowed to remain slightly high, can provide some benefits as well.

MAINTENANCE

Turf maintenance consists of mowing and removal of grass clippings. Swales should be cleaned of any sediment accumulation and monitored for erosion with subsequent reseeding or replanting as necessary. Fertilizers should be applied before the rainy season to minimize conveyance of pollutants to the stream.

PLANT SPECIES FOR VEGETATED BUFFERS AND SWALES

The following trees and shrubs tolerate wet soil and periodic inundation, and may be suitable for planting in basins and biofilters depending on regional hardiness and other factors. This list is not all-inclusive, and draws from both native and exotic species.

TREES

Box Elder (N)
Acer negundo

Red Maple (H)
Acer rubrum

Silver Maple (H)
Acer saccharinum

Alder (N)
Alnus spp.

Birch
Betula spp.

Pecan
Carya illinoensis

Buttonbush
Carya ovata

She-Oak
Casuarina spp.

Lily of the Valley
Clethra arborea

Redtwig Dogwood (N)
Cornus stolonifera

Persimmon
Diospyros virginiana

Oregon Ash (N)
Fraxinus latifolia

Honey Locust
Gleditsia triacanthos

Liquidambar
Liquidambar styrciflua

Tulip Tree
Liriodendron tulipifera

Southern Magnolia
Magnolia grandiflora

Sweet Bay
M. virginiana

Cajeput Tree
Melaleuca quinquenervia

Tupelo
Nyssa sylvatica

Sitka Spruce
Picea sitchensis

Sycamore (H)
Platanus occidentalis

California Sycamore (N)
P. racemosa

Fremont Cottonwood (N)
Populus fremontii

Wingnut
Pterocarya stenocarpus

Bur Oak (H)
Quercus macrocarpa

Pin Oak (H)
Q. palustris

Willow (N)
Salix spp.

Bald Cypress
Taxodium distichum

Arborvitae
Thuja occidentalis

SHRUBS

Salal (N)
Gaultheria shallon

Horsetail (N)
Equisetum hyemale

Fern (N)
Ferns (many spp.)

Iris (N)
Iris (many spp.)

Myoporum
Myoporum parvifolium 'putan creek'

Pacific Wax Flower (N)
Myrica

Willow (N)
Salix spp.

Huckleberry (N)
Vaccinium

GROUND COVER

Acorus
Acorus gramineus

Sedge (N)
Carex spp.

Tufted Hairgrass (N)
Deschampsia caespitosa

Sierra Laurel
Leucothoe davisiae

Bulrush
Scirpus spp.

Rush (N)
Juncus spp.

Spiderwort
Tradescantia Virginiana

Common Cattail (N)
Typha latifolia

SUITABLE TURF GRASS

Bentgrass (N)
Agrostis exerata

California Brome (N)
Bromus carinatus

Creeping wildrye (N)
Elymus triticoides

Idaho Fescue, (N) Blue Bunchgrass
Festuca idahoensis

Molate/Red Fescue (N)
Festuca rubra

Meadow Barley (N)
Hordeum brachyantherum

Meadow Barley salt (N)
Hordeum brachyantherum salt

Rushes (N)
Juncus spp.

N = Use plants grown from propagules collected locally

H = This species has a potential to hybridize with natives. Delete if native plants of the same genus exist nearby.

Table excerpted from BASMAA's Start at the Source Guide (2003) and adapted from Harris (1992), Sunset Western Garden Book (1998) and ABAG (1995b).

"Start at the Source" is available at http://www.scvurppp-w2k.com/basmaa_satsm.htm.
Other design guidance for pollution prevention is available at www.scvurppp.org

SPECIFICATIONS FOR PLACEMENT OF STRUCTURAL FILL ON SCVWD LEVEES

INTRODUCTION

This specification for structural fill is to be used where fill is placed on a levee in conjunction with projects that construct levees, raise levee heights or include cuts into levees for placement of outfalls or utilities.

FILL MATERIAL

Fill material for trench backfill of levees and for levee embankment may be either imported backfill material or suitable material from trench excavation blended with imported earthfill material. The fill material is to be free of debris, organic or deleterious material and not contain rocks or lumps over 4 inches in greatest dimension; no more than 15% of the rocks or lumps should be larger than 2 ½ ". The fill material shall contain at least 75% finer than the #4 U.S. Standard Sieve and 50% finer than the #200 Sieve. The liquid limit shall be less than 40 and the plasticity index shall be between 10 and 20. Levee fill material should be relatively impervious (permeability less than 10 to the minus 6cm/sec).

ADDITIONAL GUIDELINES

Surfaces exposed by stripping or excavation shall be scarified to a minimum depth of 6 inches and compacted to a relative compaction of not less than 95% based on (American Society of Testing Materials) ASTM D 1557 standard. The loose thickness of each layer of embankment material before compaction shall not exceed 8 inches, and each lift shall be compacted to at least 90% relative compaction based on ASTM D1557 standard. The field density and moisture content of compacted fill will be determined according to ASTM D 1556, D2922 and D3017 standard procedures. Any backfilled area not meeting the minimum test requirements shall be removed and recompacted until tests meet the minimum requirements. Jetting or ponding is not permitted

No thin, sliver fills will be accepted. Where compacted channel embankment is required or where replacement in over excavated areas must be accomplished, the new embankment must be placed in thin, maximum 8 inch thick horizontal layers with a minimum width of 6 feet. This specified width may be any combination of new fill plus cut into existing slope, except that a minimum cut of 2 feet into existing slope per layer of fill must be made. Slopes shall be trimmed to conform to existing section after placement of fill has been completed.

OUTFALL STANDARDS

INTRODUCTION

The details in this Design Guide are intended to provide clarification on slope protection standards for outfalls to be designed to meet SCVWD minimum engineering standards using softer slope protection methods wherever possible. This Design Guide also includes a plan view to show how the outfall would intersect with a natural channel so as to not impede surface flows or create a barrier to fish passage. The diagrams depicted are models and should be used unless stream conditions dictate otherwise. For placement of outfalls into streams with levees, floodwalls or structural linings, SCVWD will need to be consulted.

GENERAL GUIDELINES

1. Outfalls should not overhang the streambank or streambed as this can lead to excessive channel erosion.
2. Outfalls, bridge abutments and other structures should be placed within the first half of the straight section after the bend (page 3.24) in order to minimize erosion, prevent turbulence and prevent redirection of flow.
3. Outfalls should be aligned downstream in the direction of the flow, at an angle no greater than 30 degrees. **In natural streams where possible, a narrow channel should be created** for the outfall so that the discharge merges into the streams in order to minimize erosion, prevent turbulence and prevent redirection of flow.
4. Any outfall pipe should be cut off flush with the face of slope protection.
5. Outfalls with flap gates require dormers or similar designs to isolate the flap gate and keep them out of flow area. (See Detail #18/1 and 28/1).

TYPICAL MATERIALS TO USE

Where the pipe must be cut flush with the side slope (typically in engineered channels and on steep slopes where hard slope protection measures are needed, use corrugated metal or appropriate plastic pipes for outfalls. For outfalls, with rock slope protection, or where pipe is constructed into a concrete headwall, reinforced concrete pipe may be used.

TYPES OF OUTFALLS AND WHEN TO USE THEM

The selection of an outfall is dependent on the condition of the stream bank into which the outfall is directed. Below is a table that describes when certain outfalls would be most appropriate.

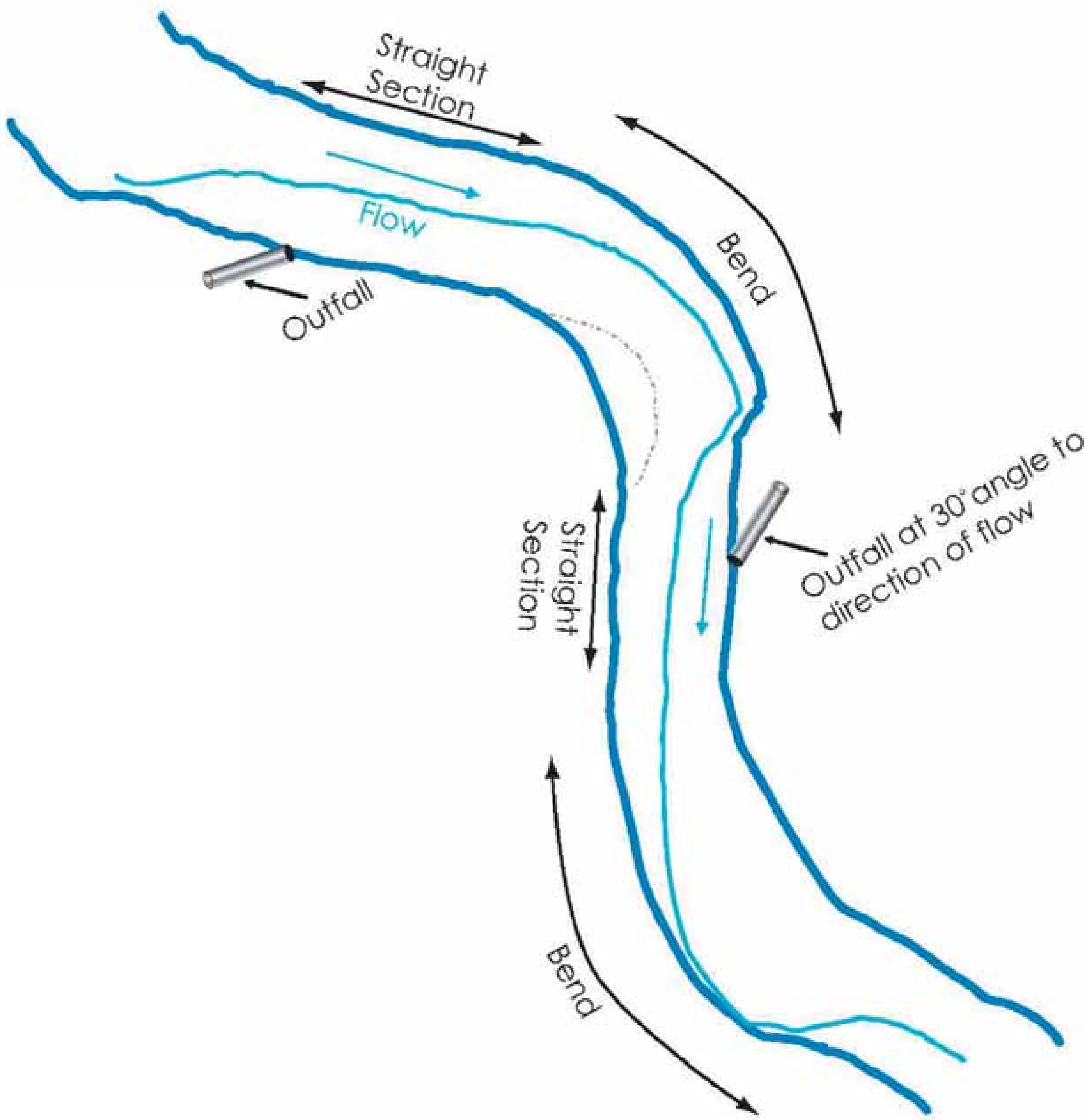
In addition to these measures, SCVWD has also developed model details for outfalls into mattress and stepped gabions, an emergency overflow into a stream, and an outfall into a deep ravine. These will be available on the District's web site. Other soft methods of slope protection that incorporate vegetation are shown in the Bank Protection section. An outfall may also be incorporated into a vegetated bank design provided there is sufficient slope protection to prevent bank erosion.

Type of Outfall	Detail Number	When to Use	Benefits/Limitations
Outfalls with rock slope protection	6-1, 6-2, 6-3	For unlined streams where slopes are flatter than 1.5:1 and where an incision into the bank is not possible.	Preferred option because vegetation can be re-established and rocks are more resilient to movement and stream degradation.
Outfall with a drainage swale	27-1	For natural streams where a bank incision can be made	Reduced potential for erosion from outfall but an incorrect placement in channel can increase turbulence and erosion
Outfall into RCB Wall with one or two steel curtains	1-1,1-2,1-3 2-1, 2-2	If the stream is contained in a Reinforced Concrete Box. The detail used will depend on the steel rebar configuration in the box	Reduced need for additional bank protection. Size of pipe is limited: larger pipes can impact hydraulics.
Pipe to Pipe Outfall	3-1	If the stream is contained in a reinforced Concrete or corrugated metal pipe	Outfall pipe is limited to ¼ the size of the stream pipe
Pipe Outfall into Channel Lining	4-1, 4-2	If the stream is contained in a concrete lined channel	
Pipe Outfall with Sacked Concrete Rip Rap	5-1, 5-2, 5-3, 5-4, 5-5, 5-6	For steep slopes 1.25:1 or greater where other measures will not be structurally sound	This treatment is not preferred ite it deflects flow, is not resilient in degrading channel

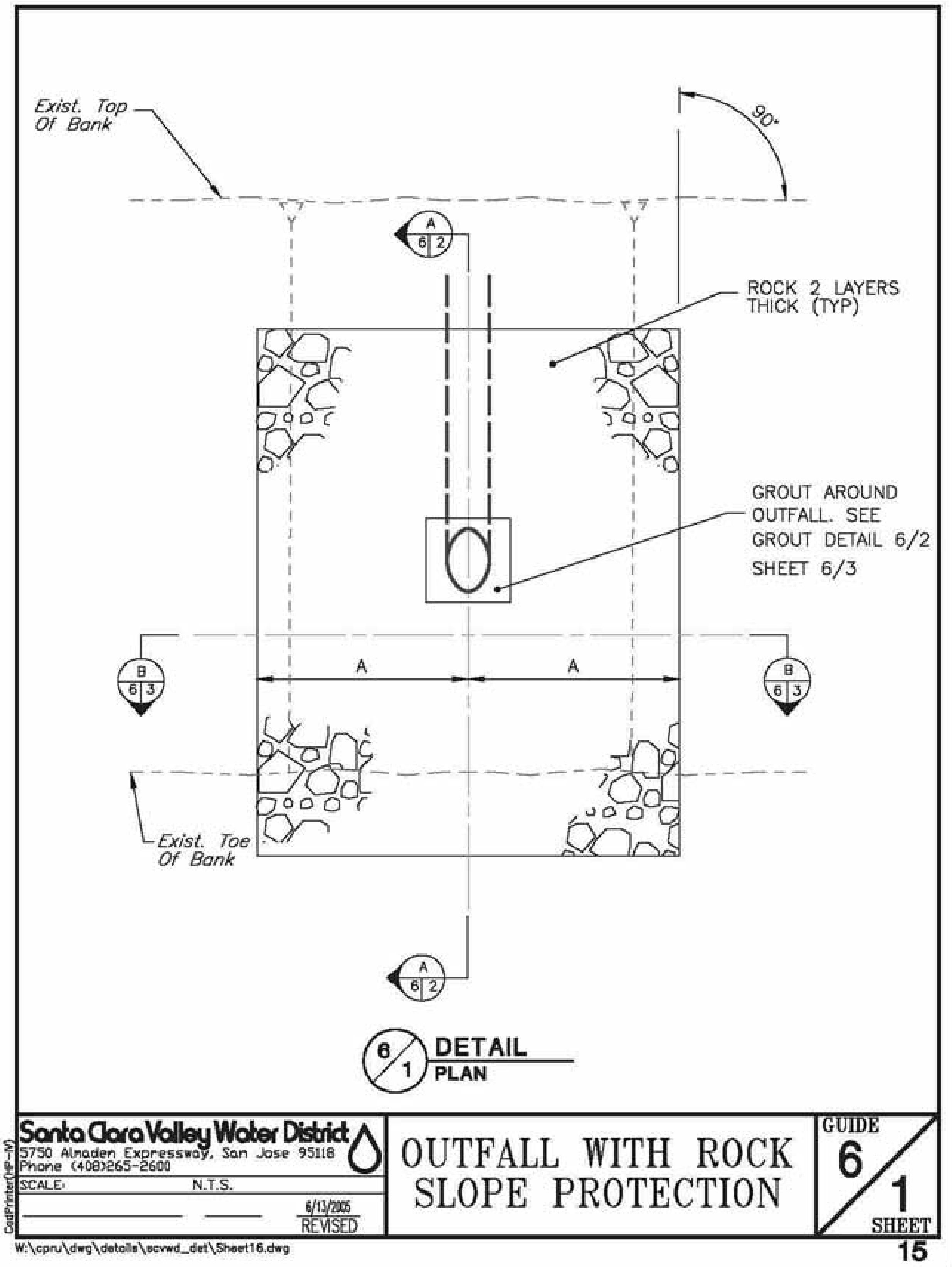
OUTFALL STANDARDS

Outfalls, bridge abutments and other structures should be placed within the first half of the straight section after the bend.

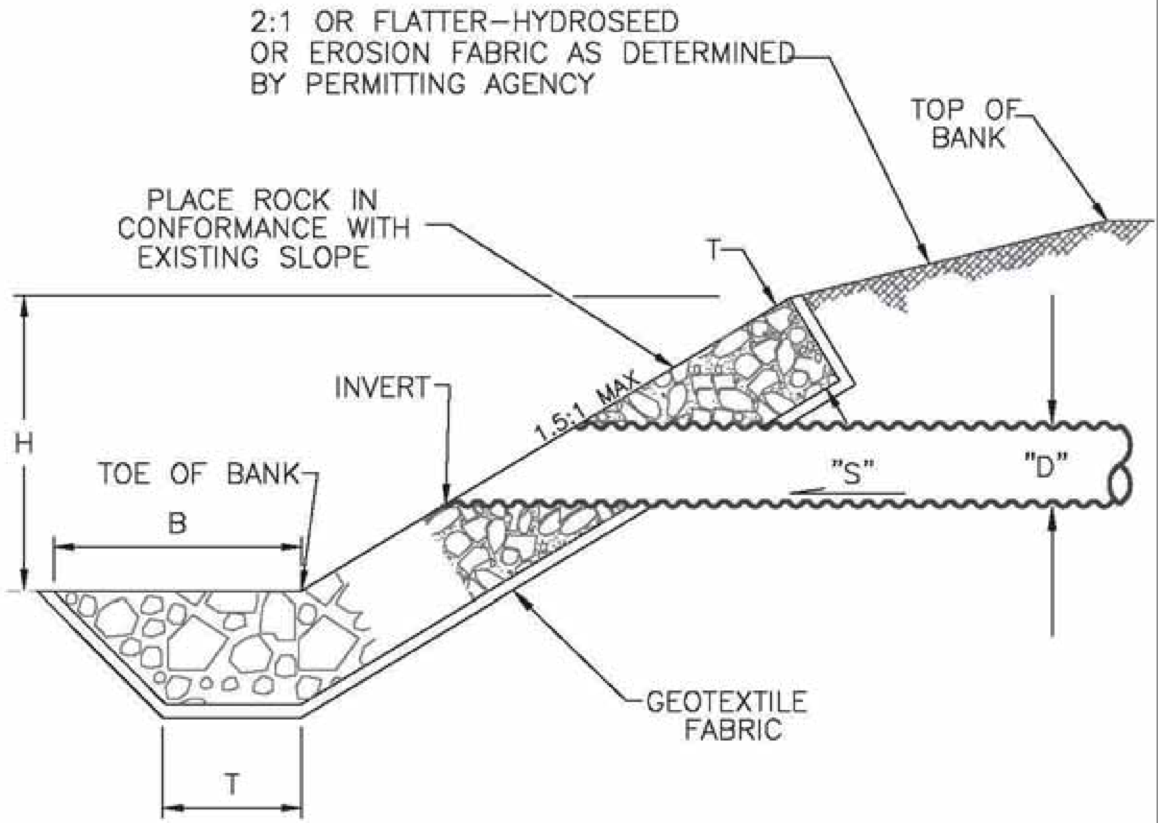
Outfalls should be aligned downstream in the direction of the flow, at an angleof less than 30 degrees.



OUTFALL WITH ROCK SLOPE PROTECTION



OUTFALL WITH ROCK SLOPE PROTECTION



A 6 2 SECTION

NOTE: Refer to notes on following page 4–28 for identification of lettered dimensions.

Santa Clara Valley Water District
5750 Almaden Expressway, San Jose 95118
Phone (408)265-2600

SCALE: N.T.S.

6/13/2005
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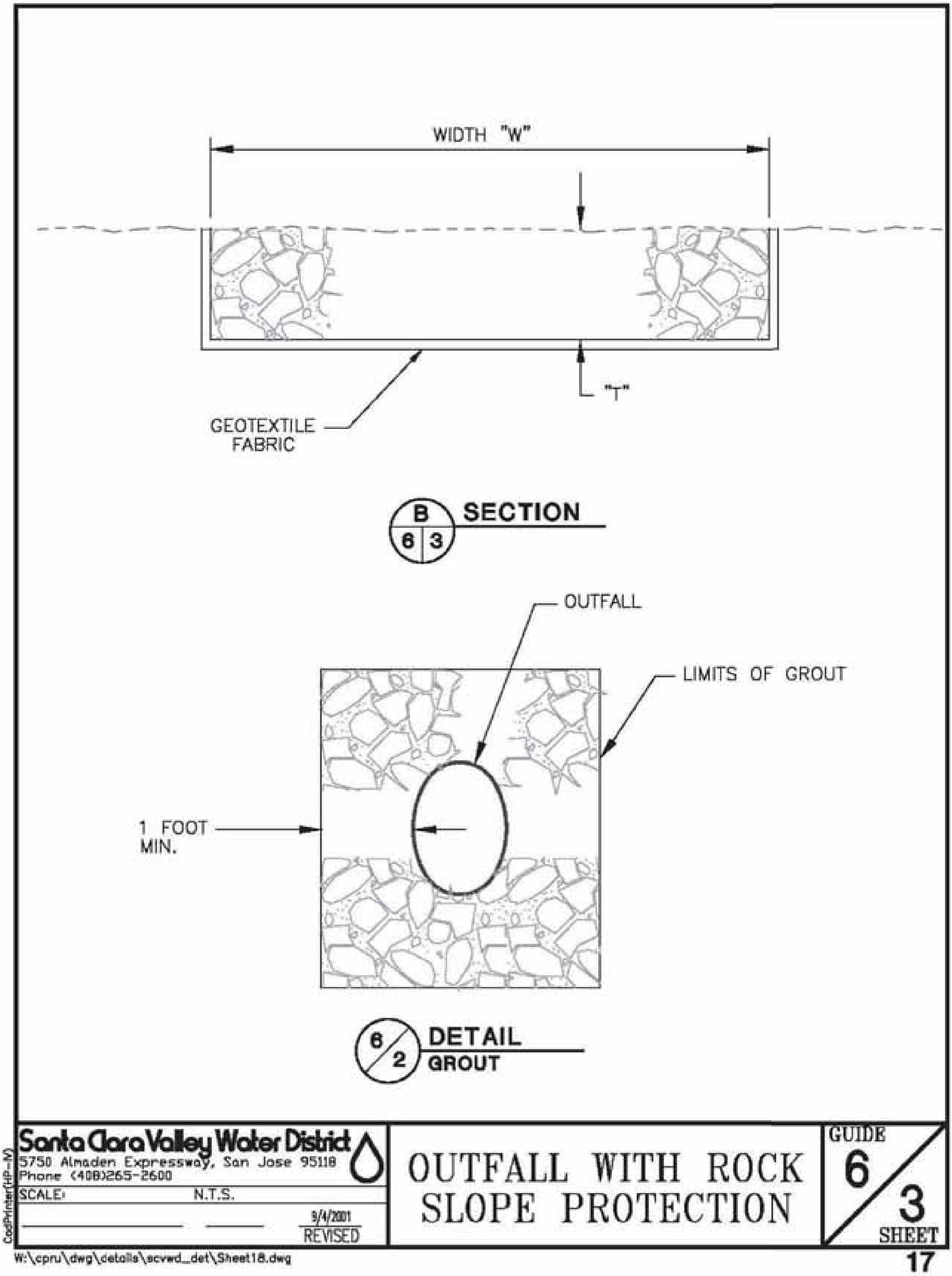
OUTFALL WITH ROCK SLOPE PROTECTION

GUIDE 6 / 2 SHEET

16

OUTFALL WITH ROCK SLOPE PROTECTION



NOTES FOR CONSTRUCTION OF OUTFALL

1. IT IS MANDATORY THAT THE SCVWD INSPECTOR BE NOTIFIED AT LEAST 48 HOURS PRIOR TO THE COMMENCEMENT OF CONSTRUCTION. COMPLETE REMOVAL OF PORTIONS OF THE WORK INSTALLED WITHOUT INSPECTION MAY BE REQUIRED IF THIS REQUIREMENT IS NOT MET.

2. ALL WORK IS TO BE IN ACCORDANCE WITH THE STATE STANDARD SPECIFICATIONS SECTION 72–2. NO WHITE ROCK MAY BE USED. METHOD B PLACEMENT SHALL BE USED. GROUT TO BE IN CONFORMANCE WITH PARAGRAPH 65–1.06 FOR CEMENT MORTAR.

3. THE OUTFALL PIPE IS TO BE CUT OFF FLUSH WITH THE SLOPE PROTECTION.

4. ANY BACKFILL NECESSARY FOR THE INSTALLATION OF THE OUTFALL SHOULD BE COMPACTED TO 90 PERCENT RELATIVE COMPACTION IN CONFORMANCE WITH ASTM STANDARD TEST METHOD D1557.

5. ANY EXCESS SOIL FROM EXCAVATION SHALL BE DEPOSITED OFF OF DISTRICT RIGHT OF WAY UNLESS APPROVED BY THE DISTRICT'S INSPECTOR.

CRITERIA TO BE USED FOR DESIGN OF OUTFALL

1. ROCK SLOPE PROTECTION FOR OUTFALLS MAY NOT BE USED FOR SLOPES STEEPER THAN 1.5:1.

2. THE PLAN VIEW, SECTION A 6/2 AND SECTION B 6/3 ARE TO BE DRAWN TO SCALE ON THE PLANS WITH SCALE PROVIDED AND SHOULD REFLECT EXISTING CONFIGURATION OF THE CHANNEL WHERE THE OUTFALL IS PROPOSED.

3. PLANS SHOULD SPECIFY THE FOLLOWING DIMENSIONS/ELEVATIONS:

PIPE DIAMETER "D"	TOP OF BANK ELEVATION
1/2 SLOPE PROTECTION WIDTH "A"	TOE OF BANK ELEVATION
ROCK THICKNESS "T"	PIPE INVERT ELEVATION
CHANNEL BOTTOM ROCK WIDTH "B"	PIPE OUTFALL SLOPE "S"
SLOPE PROTECTION WIDTH "W"	
HEIGHT OF ROCK "H"	

4. ROCK THICKNESS "T", HEIGHT OF ROCK PROTECTION "H" AND ROCK CLASS (gradation) ARE TO BE DETERMINED BY SCVWD BASED ON LOCATION OF OUTFALL AND FIELD CONDITIONS. ONE–HALF SLOPE PROTECTION WIDTH "A" IS TO BE THE GREATER OF TWICE THE PIPE DIAMETER "D" OR 2 FEET. CHANNEL BOTTOM ROCK WIDTH "B" IS TO BE 2 TIMES THE ROCK THICKNESS "T".

5. THE OUTFALL PIPE IS TO HAVE THE FOLLOWING CHARACTERISTICS:

MATERIAL:	CORRUGATED METAL PIPE
DIAMETER:	12–INCH MINIMUM
THICKNESS AND SLOPE:	SEE TABLE 5/1 ON SHEET 5/3

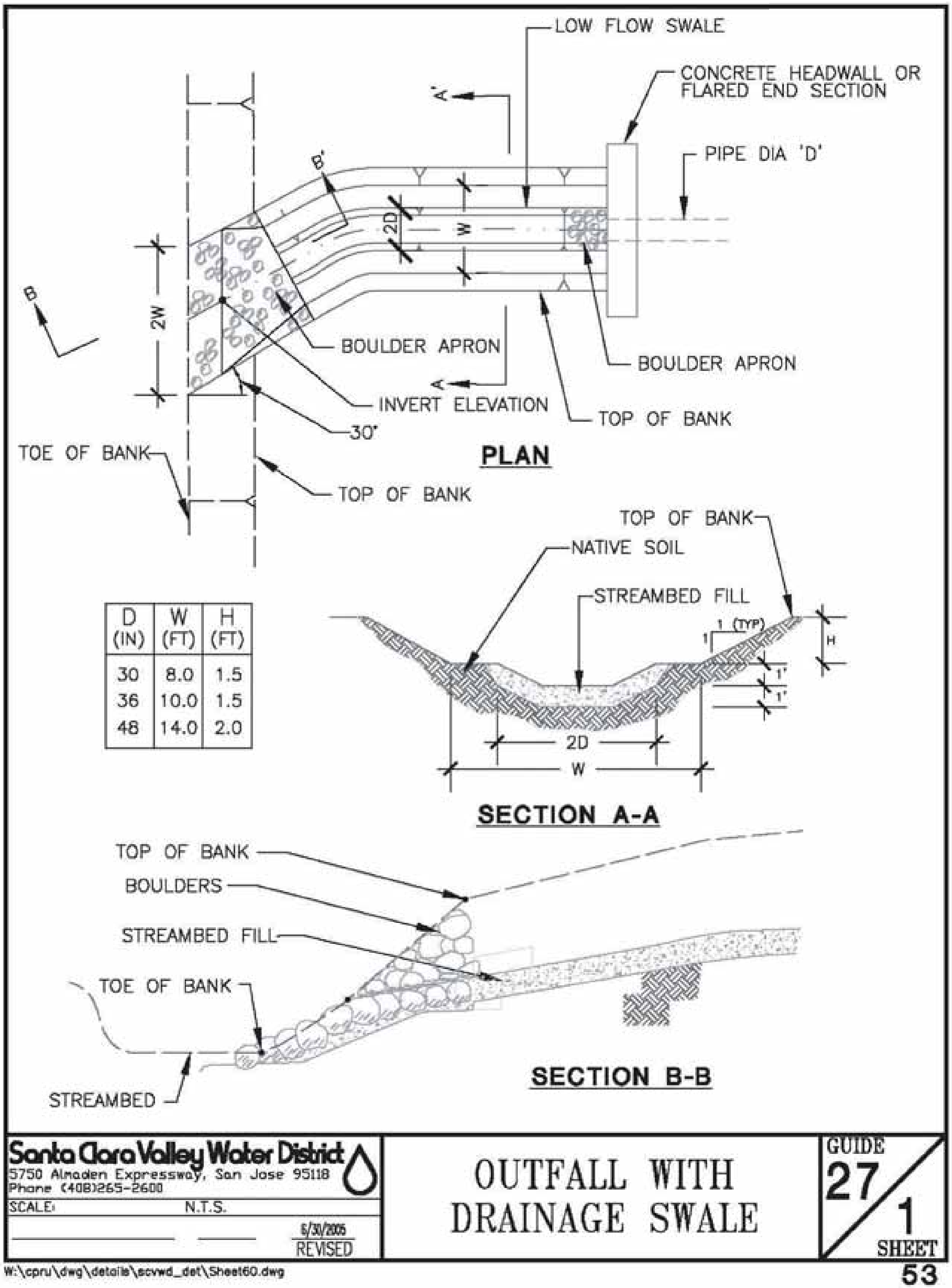
   REINFORCED CONCRETE PIPE MAY BE USED IN ROCK SLOPE PROTECTION.

6. GEOTEXTILE FABRIC SHALL BE MIRAFI 700X OR EQUAL.

7. ROCK SLOPE PROTECTION MAY BE COVERED WITH SOIL AND PLANTED.

8. THE OUTFALL PIPE SHOULD POINT DOWNSTREAM.

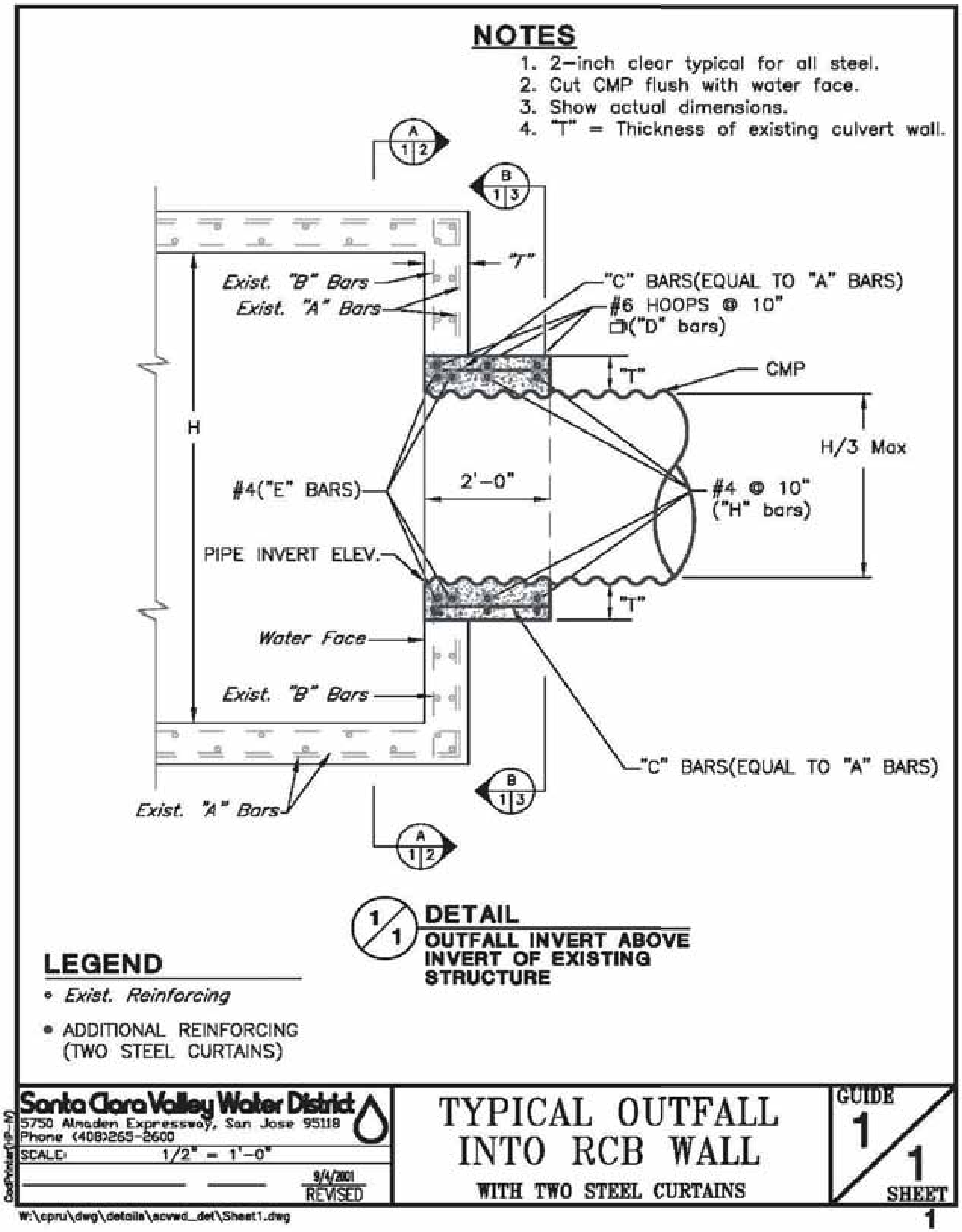
OUTFALL WITH DRAINAGE SWALE



D (IN)	W (FT)	H (FT)
30	8.0	1.5
36	10.0	1.5
48	14.0	2.0

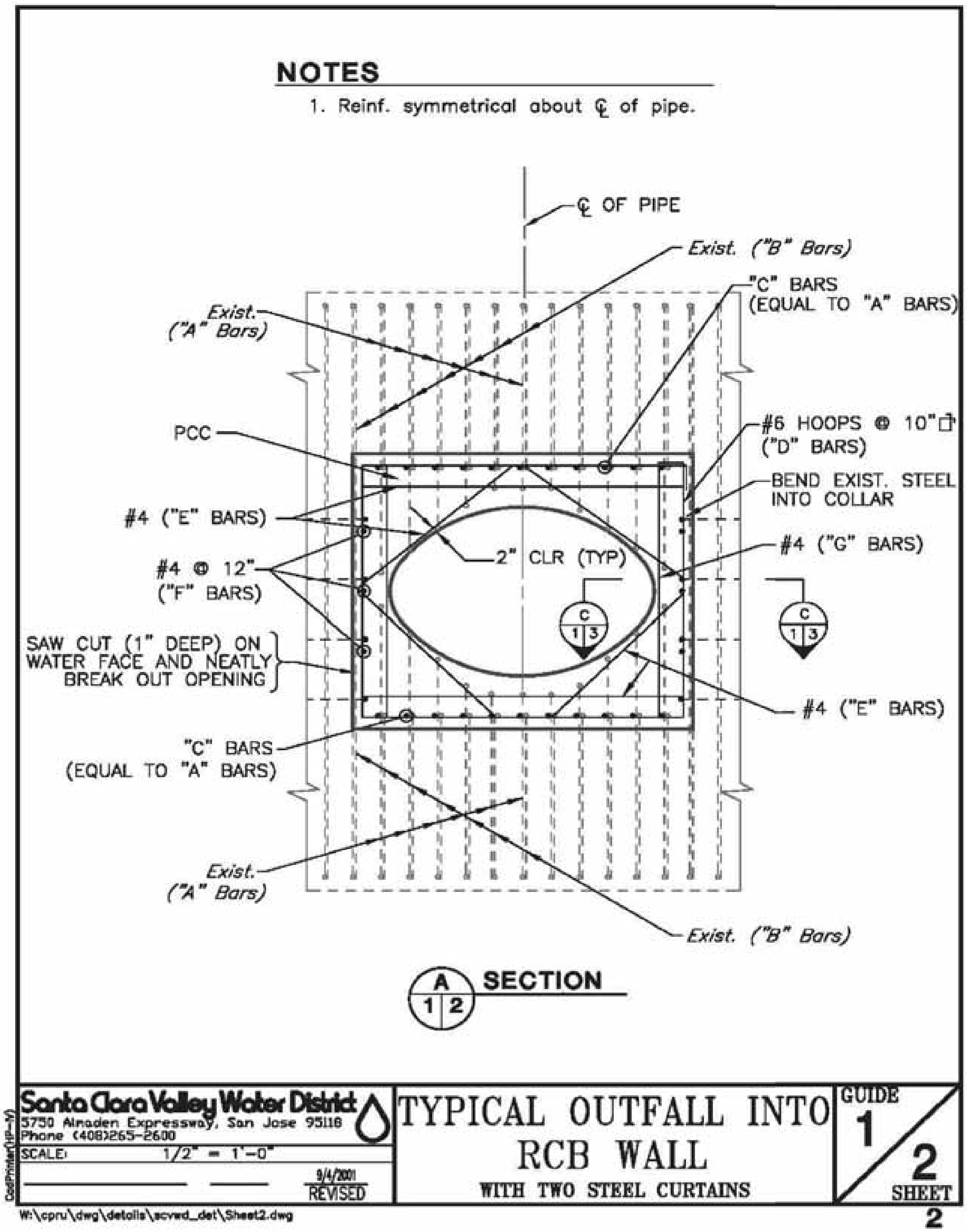
TYPICAL OUTFALL INTO REINFORCED CONCRETE BOX WALL

with two steel curtains

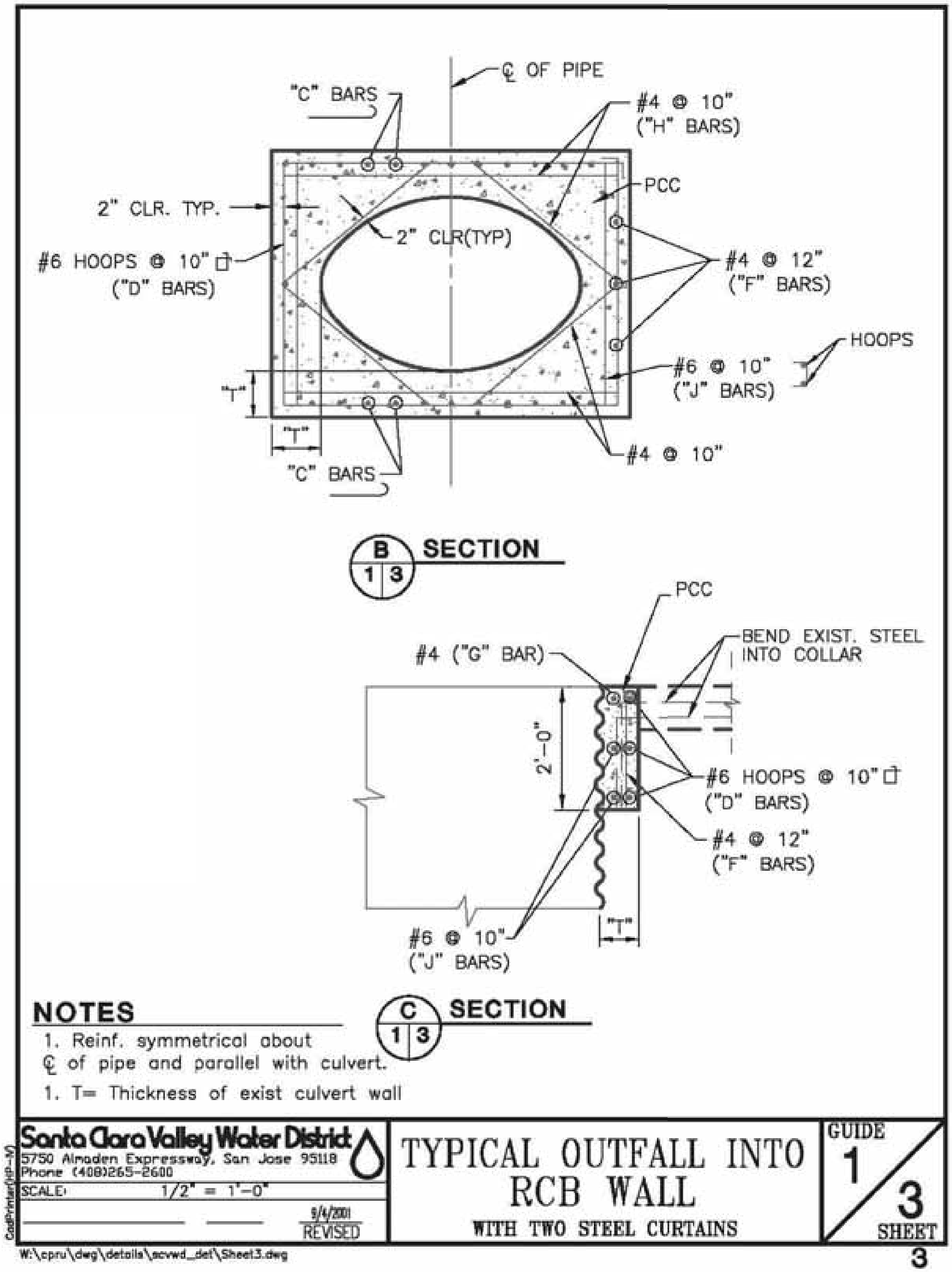


TYPICAL OUTFALL INTO REINFORCED CONCRETE BOX WALL

with two steel curtains

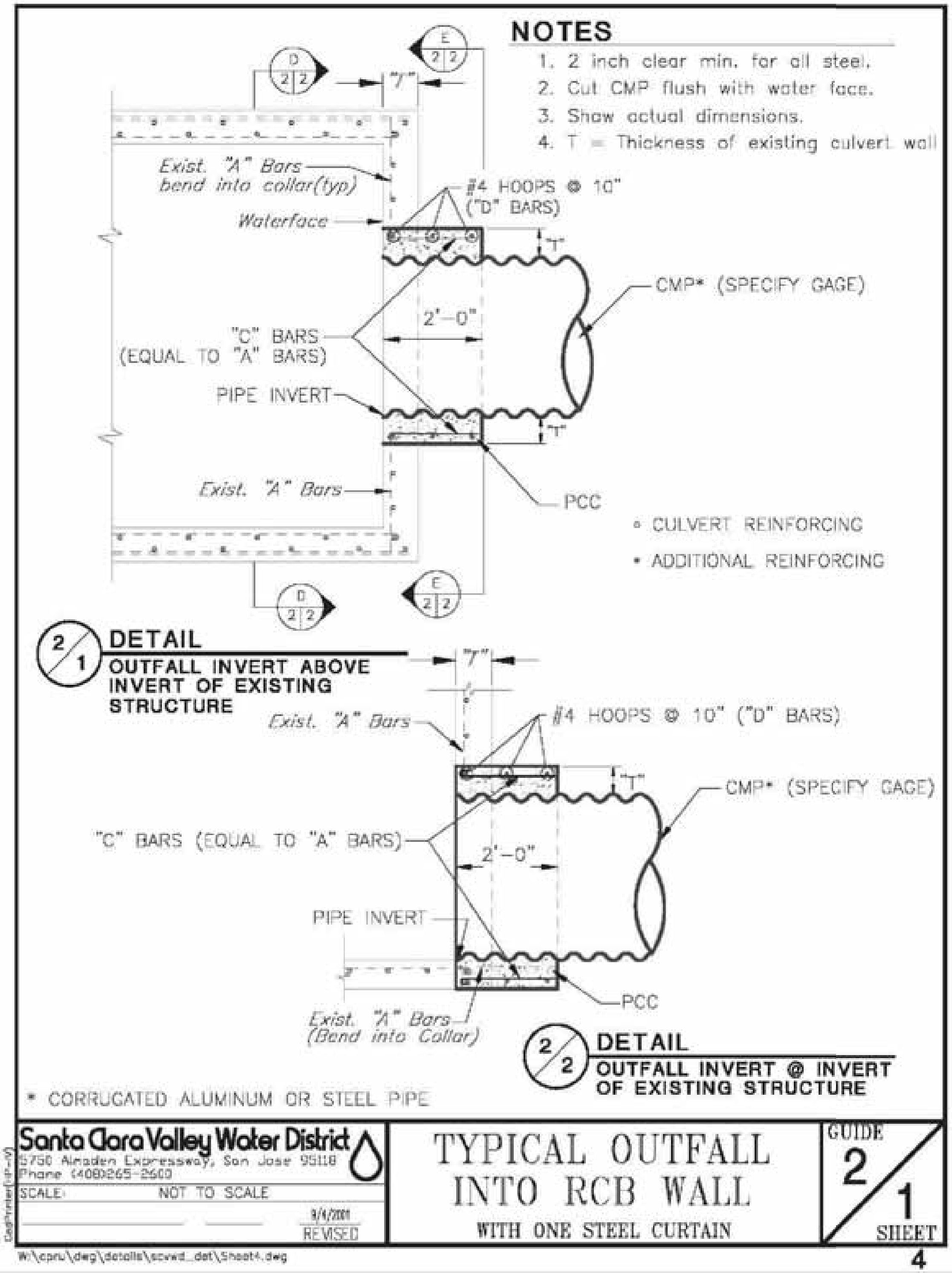


TYPICAL OUTFALL INTO REINFORCED CONCRETE BOX WALL
with two steel curtains



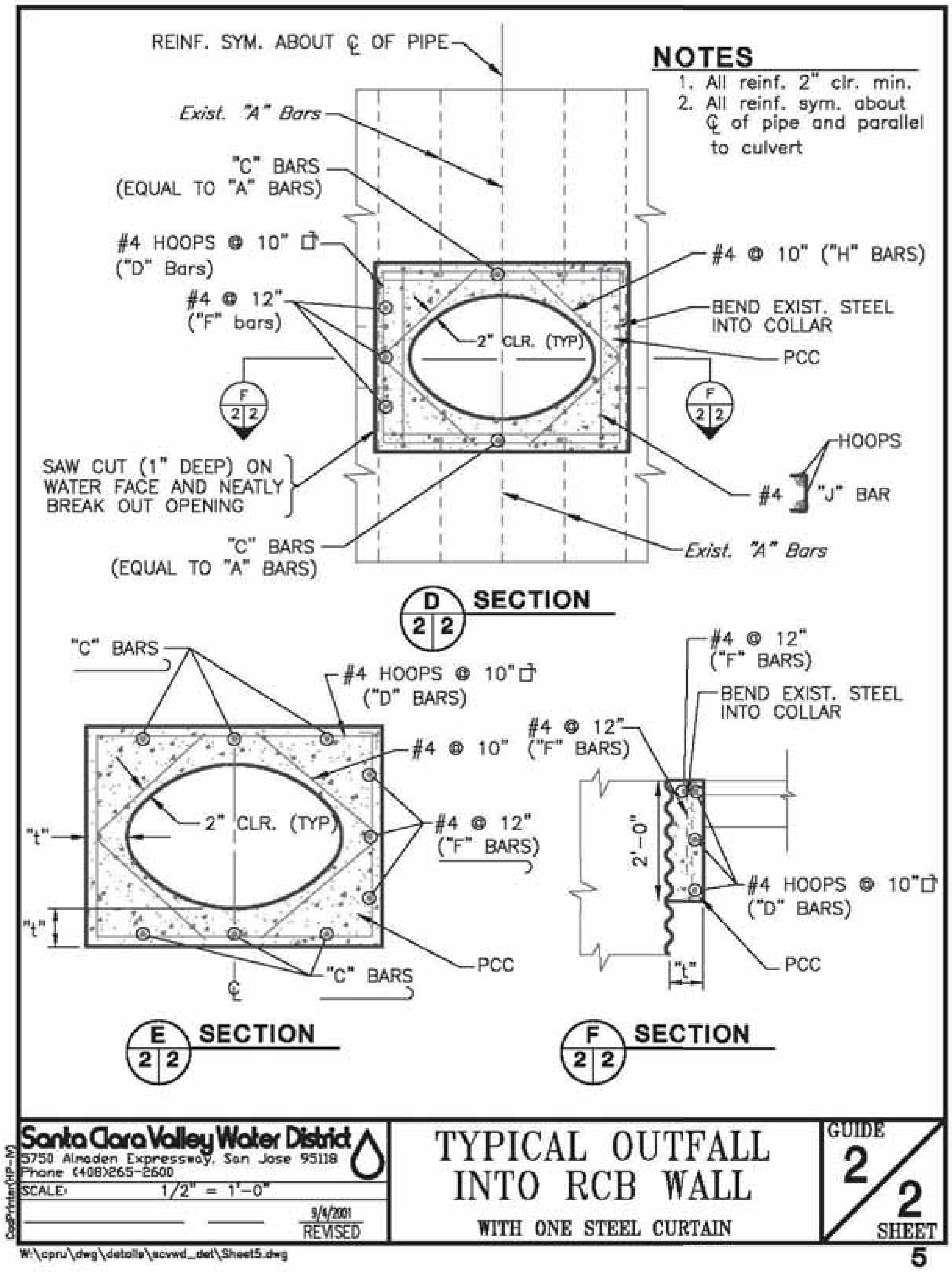
TYPICAL OUTFALL INTO REINFORCED CONCRETE BOX WALL

with one steel curtains



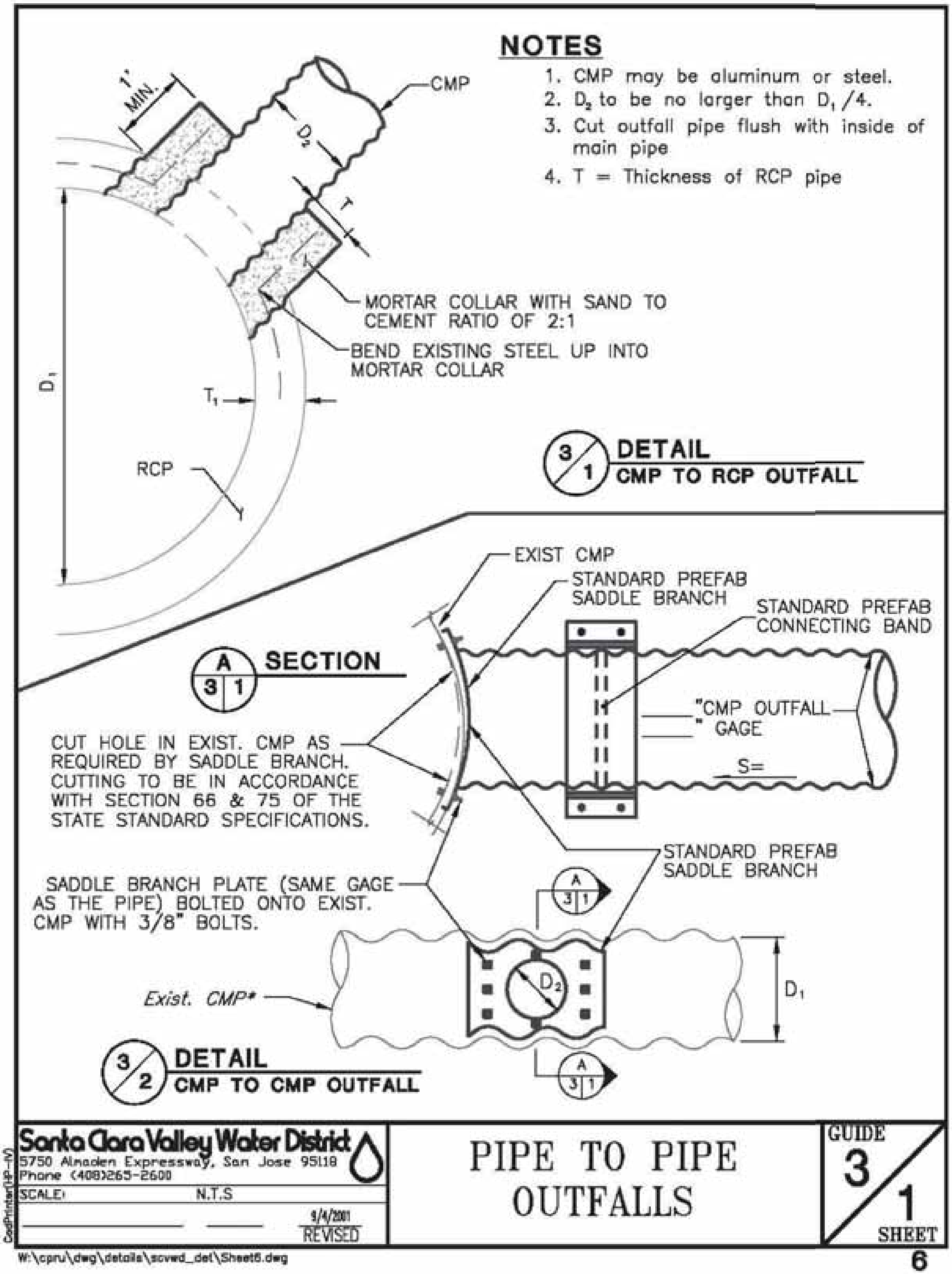
TYPICAL OUTFALL INTO REINFORCED CONCRETE BOX WALL

with one steel curtain

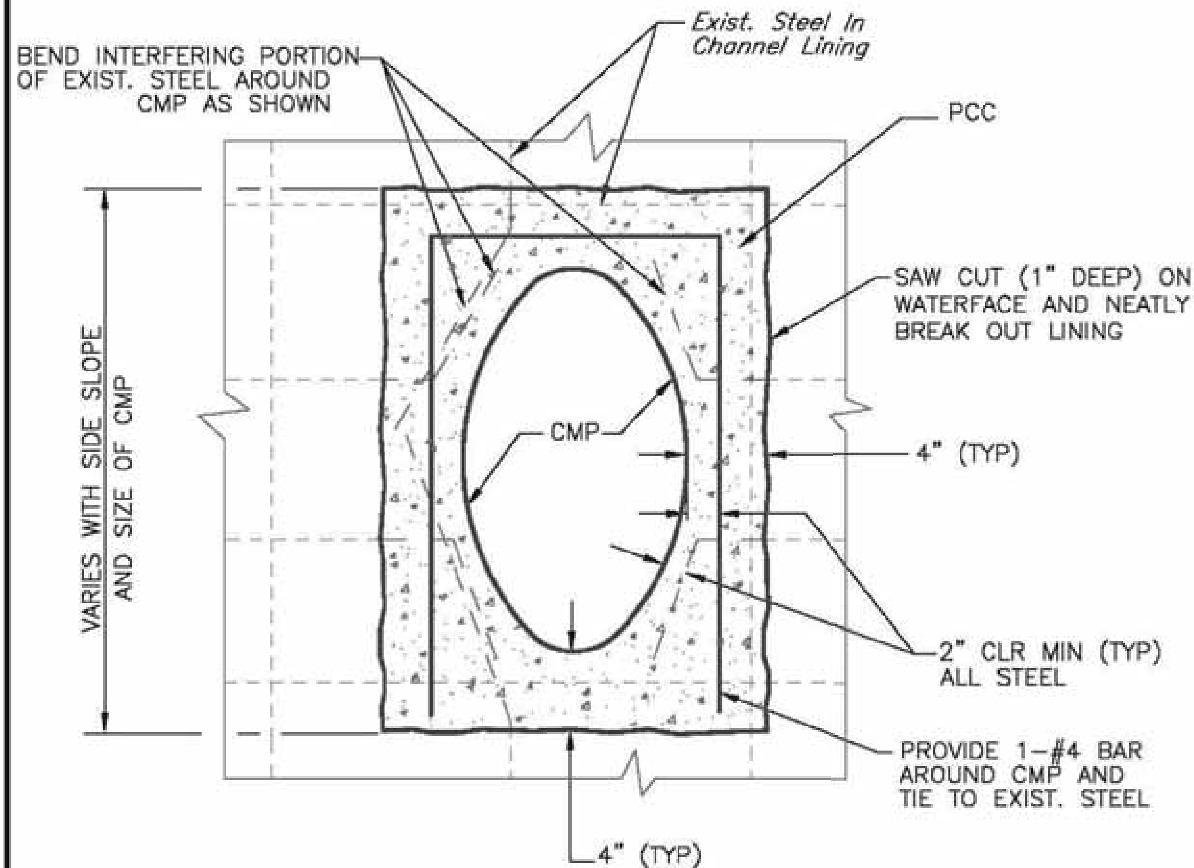


PIPE TO PIPE OUTFALLS

The size of the pipe is limited to 1/4 the diameter of the receiving pipe.



PIPE OUTFALL INTO CHANNEL LINING



4/1 **DETAIL**
CHANNEL SIDESLOPE 1:1 OR FLATTER

NOTES

1. Cut CMP flush with water face of lining.
2. CMP may be aluminum or steel.
3. This Detail is typical for both curtains of exist. steel.

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PIPE OUTFALL INTO CHANNEL LINING

GUIDE 4 / 1 SHEET

7

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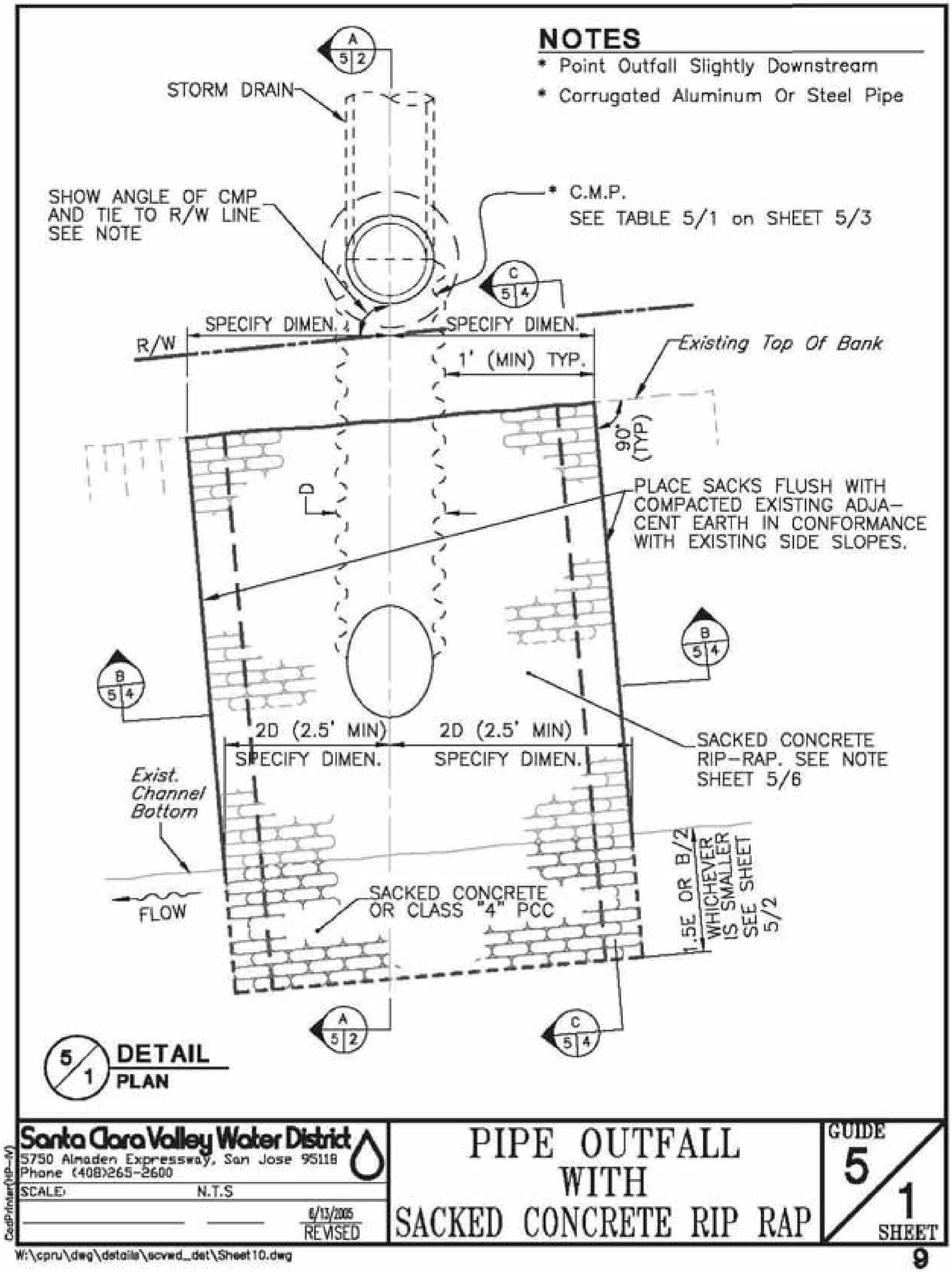
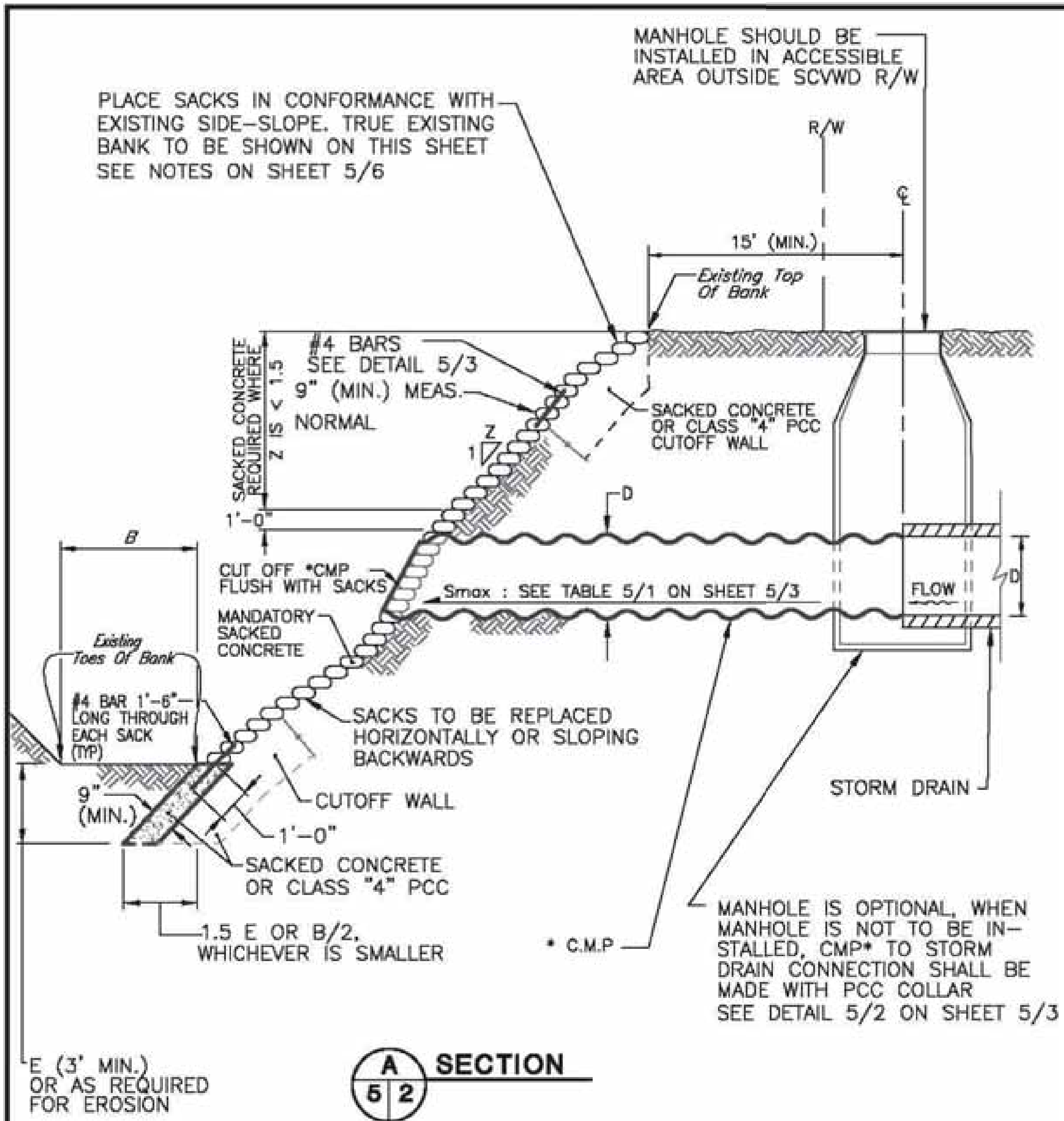
PIPE OUTFALL WITH SACKED CONCRETE RIP RAP



PIPE OUTFALL WITH SACKED CONCRETE RIP RAP



NOTES:

Place outfall invert 2-feet above stream bottom in locations where there is sediment deposition

* Corrugated Aluminum Or Steel Pipe

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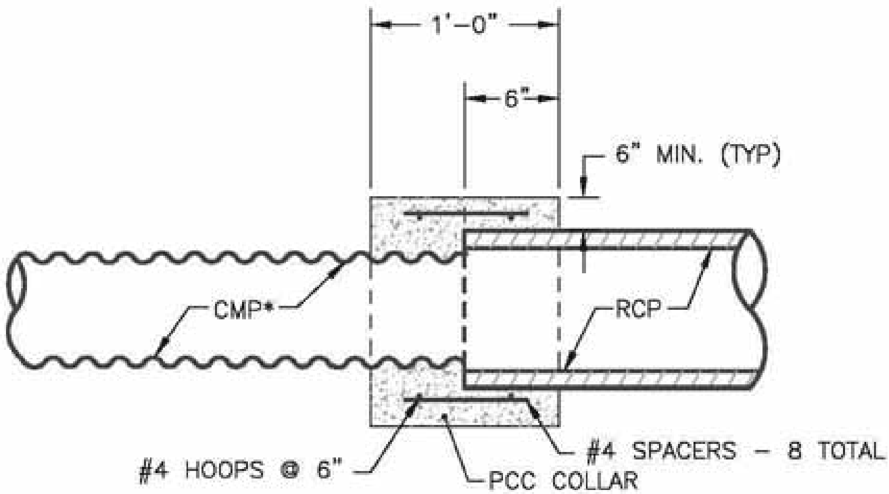
10

PIPE OUTFALL WITH SACKED CONCRETE RIP RAP



5/2 DETAIL
PCC COLLAR

* CORRUGATED ALUMINUM OR STEEL PIPE

CMP	GAGE	Smax.*
12"	16	.0778
18"	16	.0659
24"	14	.0580
30"	14	.0530
36"	12	.0491

CMP	GAGE	Smax.*
42"	12	.0459
48"	12	.0432
54"	12	.0411
60"	10	.0394
66"	10	.0379

CMP	GAGE	Smax.*
72"	10	.0365
78"	8	.0354
84"	8	.0343

5/1 TABLE

$$S_{max} = \frac{112\ n^2}{D^{1/3}}$$ (MEASURED. IN FT.)

REQUIRED PIPE GAGE AND MAXIMUM ALLOWABLE SLOPES * FOR CMP OUTFALLS

* THE ABOVE SLOPES ARE BASED ON CMP WITH STANDARD CORRUGATIONS.

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PIPE OUTFALL
WITH
SACKED CONCRETE RIP RAP

GUIDE 5 / 3 SHEET

11

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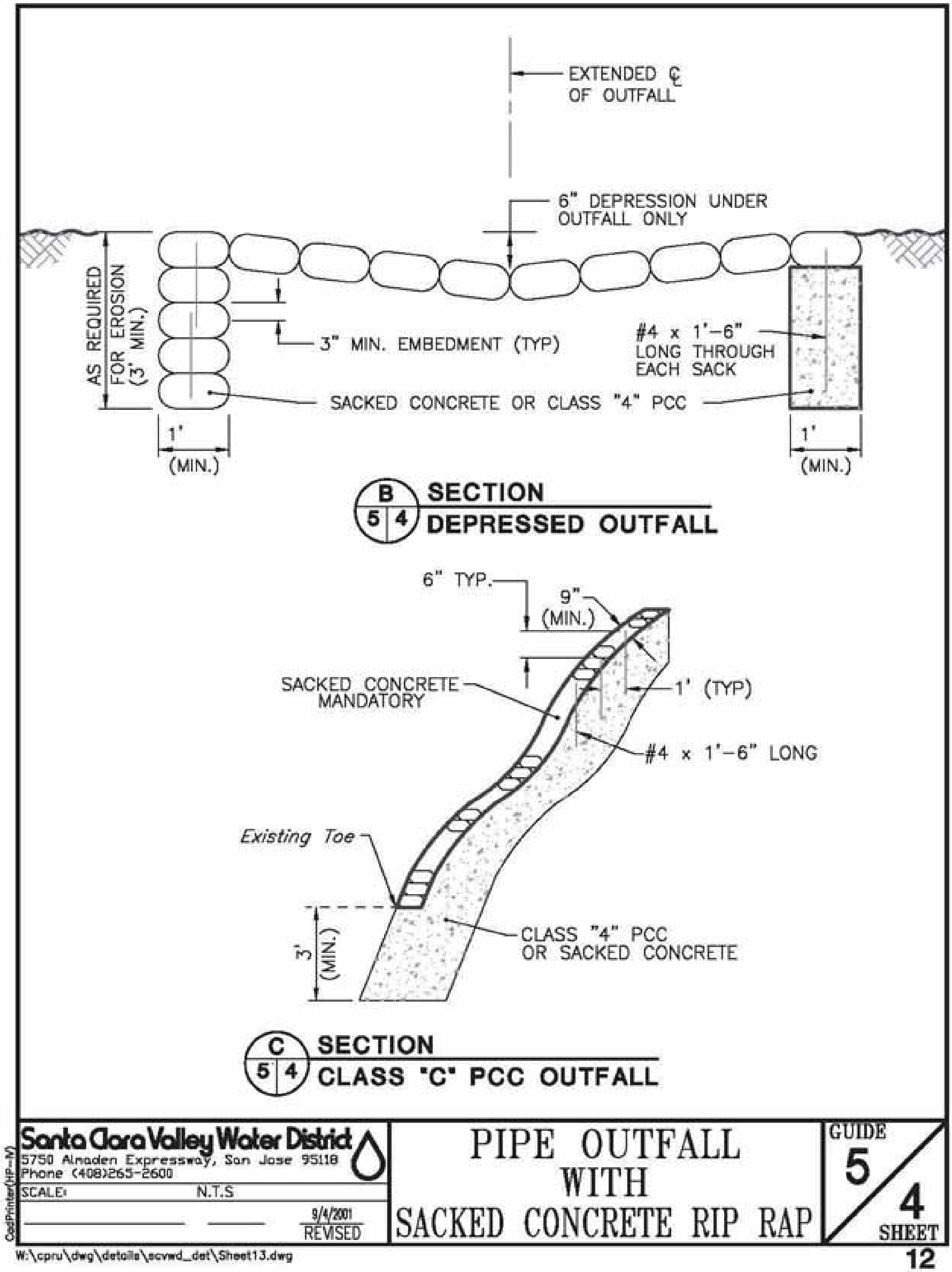
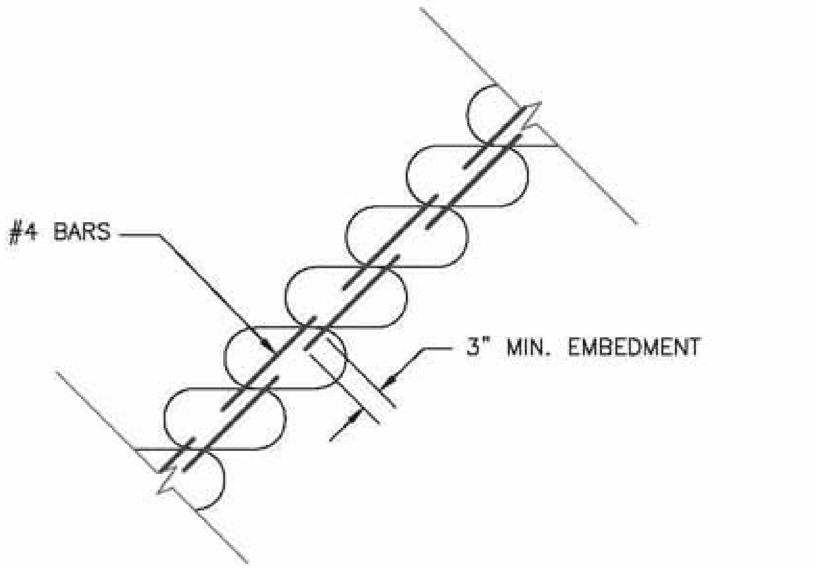
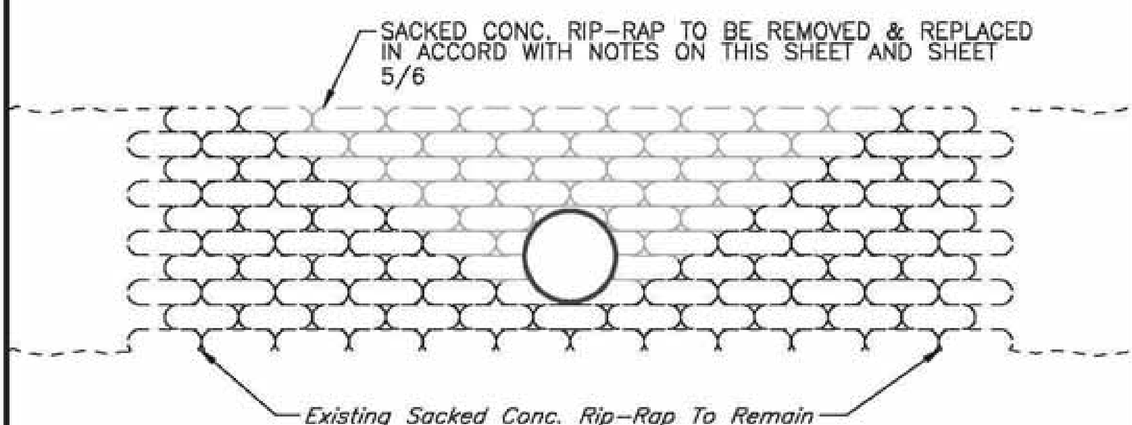
PIPE OUTFALL WITH SACKED CONCRETE RIP RAP



PIPE OUTFALL WITH SACKED CONCRETE RIP RAP



5/3 **DETAIL**
SACK REINFORCING



5/4 **DETAIL**
PIPE INSTALLATION IN EXIST. SACKED CONCRETE RIP-RAP

NOTES

1. The removal of only a portion of a sack is not allowed.

Santa Clara Valley Water District 5750 Almaden Expressway, San Jose 95118 Phone (408)265-2600 SCALE: N.T.S 9/4/2001 REVISED Sheet14.dwg	PIPE OUTFALL WITH SACKED CONCRETE RIP-RAP	GUIDE 5 / 5 SHEET 13

PIPE OUTFALL WITH SACKED CONCRETE RIP RAP

NOTES FOR SACKED CONCRETE RIP-RAP

THESE NOTES ARE TO APPEAR ON PLANS

1. SACKS FOR SLOPE PROTECTION SHALL BE 10oz. BURLAP MEASURING 19 1/2" BY 36" INSIDE THE SEAMS WHEN LAID FLAT. CONCRETE SHALL BE CLASS 4 IN ACCORDANCE WITH THE CURRENT STATE STANDARD SPECIFICATION. THE AMOUNT OF WATER ADDED AT THE TIME OF MIXING SHALL BE SUCH TO PRODUCE A MIXTURE WITH A MAXIMUM SLUMP OF 4 INCHES. SACKED DRY MIXES ARE NOT PERMITTED. THE VOLUME OF CONCRETE PLACED IN EACH SACK IS TO BE CONTROLLED BY A CHUTE MEASURING DEVICE AND SHALL BE APPROXIMATELY 1/2 CUBIC FOOT OF PLASTIC CONCRETE LOOSELY PLACED SO AS TO LEAVE ROOM FOR FOLDING AT THE TOP.
2. FACE OF RIPRAP TO BE COINCIDENT WITH EXISTING SIDE SLOPE OF CHANNEL. DO NOT PACK UNTIL SMOOTH; LEAVE AS ROUGH AS POSSIBLE.
3. EXTEND RIPRAP UP TO THE TOP OF BANK, UNLESS OTHERWISE SPECIFIED ON PLAN.
4. INSTALL CUTOFF WALL (3-FOOT MINIMUM DEPTH) AT UPSTREAM AND DOWNSTREAM ENDS. CUTOFF WALLS TO EXTEND UP SIDES OF CHANNEL.
5. DRIVE ONE #4 REINFORCING BAR THROUGH EACH SACK. MINIMUM LENGTH OF BARS TO BE 18 INCHES. DO NOT LEAVE ENDS OF BARS EXPOSED, NOR DRIVE INTO DIRT OR JOINT BETWEEN ENDS OF SACKS – SEE DETAIL 5/3
6. ALL BACKFILL SHALL BE WITH SUITABLE MATERIAL FROM EXCAVATION AND SHALL BE COMPACTED TO 90 PERCENT RELATIVE COMPACTION IN ACCORDANCE WITH ASTM TEST METHOD D1557
7. SACKS SHALL BE PLACED SO THAT THEY ARE HORIZONTAL OR SLOPING TOWARDS BANK. SACKS SLOPING AWAY FROM BANK WILL NOT BE ACCEPTED.
8. IT IS MANDATORY THAT SCVWD INSPECTOR BE NOTIFIED AT LEAST 48 HOURS BEFORE CONSTRUCTION BEGINS. COMPLETE REMOVAL MAY RESULT IF THIS REQUIREMENT IS NOT MET.

THE FOLLOWING NOTES ARE TO BE ADHERED TO BUT ARE NOT TO APPEAR ON THE PLANS

A. OBTAIN CONSTRUCTION/ENCROACHMENT PERMIT FROM THE SCVWD FOR ALL STORM OUTFALL BY SUBMITTING IMPROVEMENT PLANS BEFORE CONTRACT IS OUT TO BID.

B. ON PLAN SUBMITTALS SHOW SUFFICIENT INFORMATION SO THAT THE CROSS SECTION OF EXISTING CREEK AT THE OUTFALL AND FOR A MINIMUM DISTANCE OF 20 FEET BOTH UPSTREAM AND DOWNSTREAM OF OUTFALL CAN BE DETERMINED. ADDITIONAL CROSS SECTION INFORMATION MAY BE REQUESTED BY SCVWD.

C. SHOW ALL INFORMATION REQUIRED ON SHEET 5/1 & 5/2 AND INDICATE THE SIZE AND LOCATION OF TREES NEAR THE OUTFALL.

D. PLAN SUBMITTALS NOT SHOWING THE INFORMATION REQUIRED BY NOTES B AND C WILL NOT BE PROCESSED.

E. USE SAME HORIZONTAL AND VERTICAL SCALE FOR SECTION OF EXISTING CREEK AT OUTFALL.

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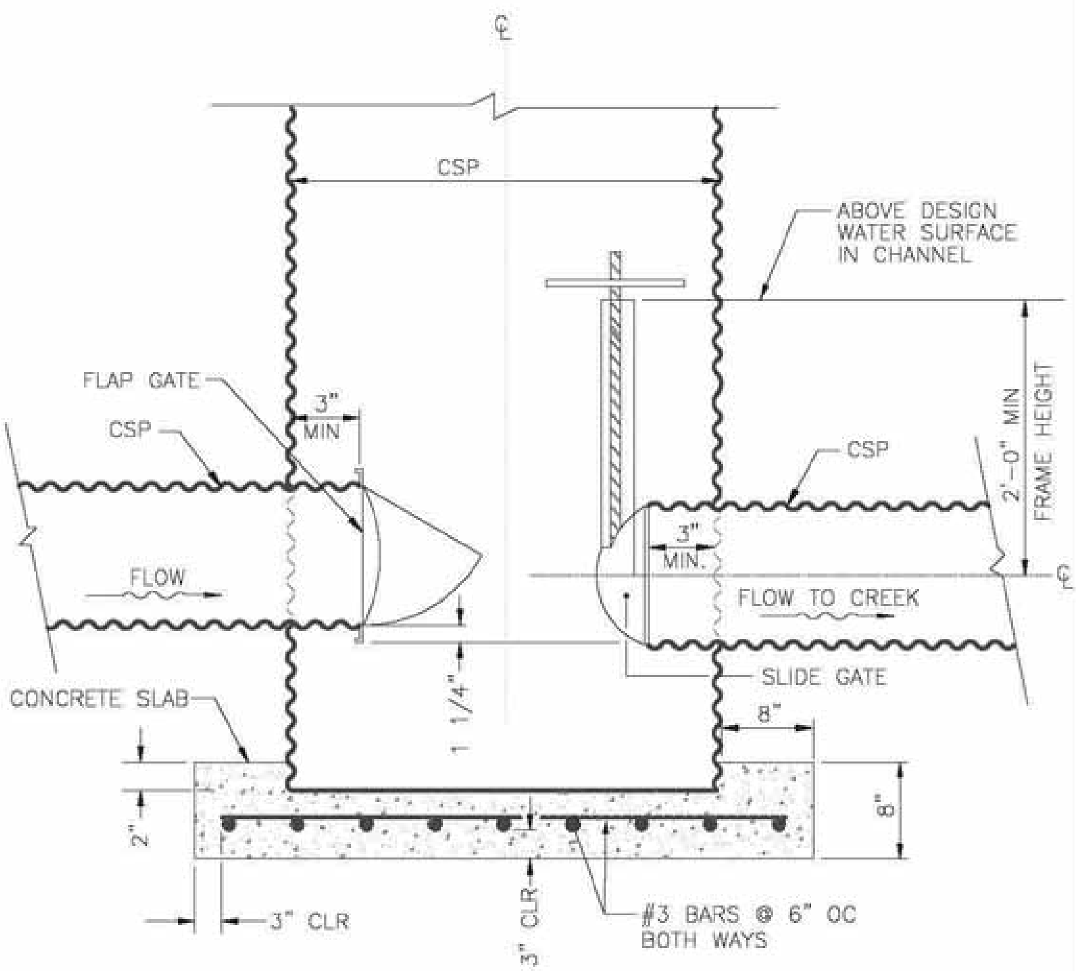
14

FLAP GATE STRUCTURE

Flap gates are needed on outfalls where the adjacent ground is below the high water level (usually 100 year water surface elevation). The flap gates will prevent the back flow of water from the stream on to the adjacent land. Where adjacent land at the stormdrain pipe inlet is higher in elevation than the high water level, a flap gate is not needed. Two options for the placement of a flap gate are shown.



18/1 DETAIL

NOTES

1. Structure to be installed outside SCVWD R/W in area that is easily accessible during rainy periods.
2. Specifications and details of design for the structure are subject to the standards of the local agency that will maintain the structure.

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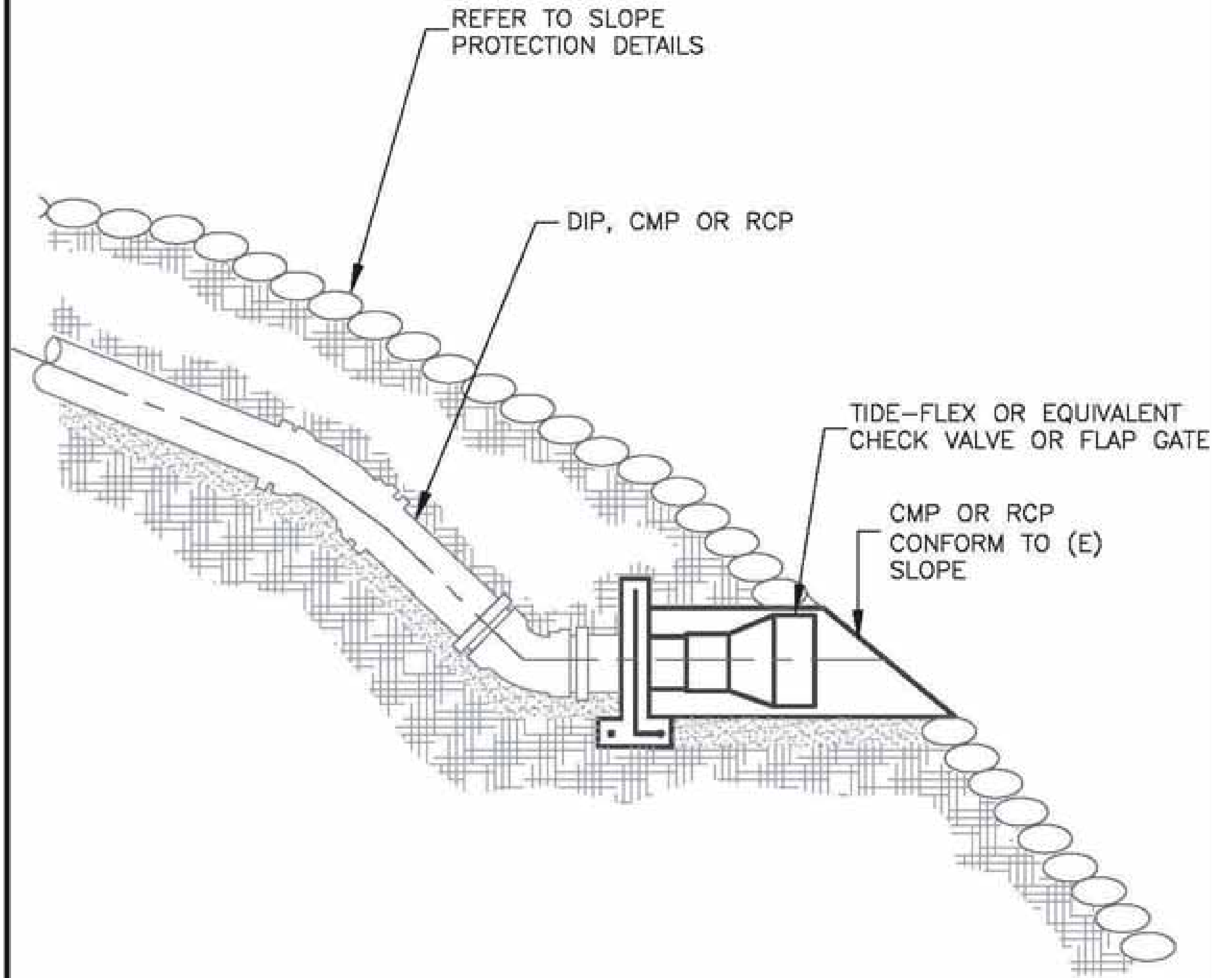
42

FLAP GATE IN DORMER PIPE



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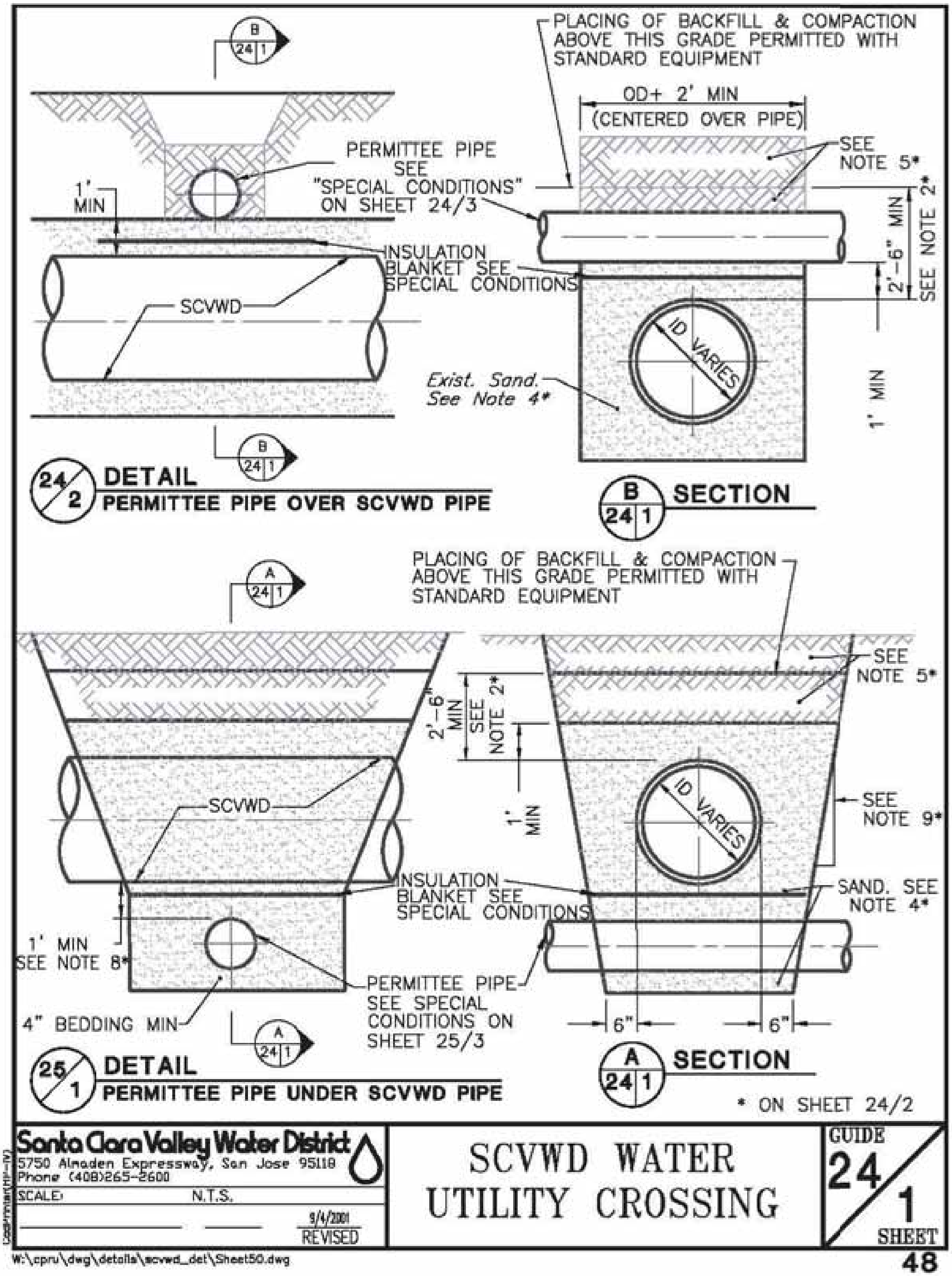
54

SCVWD WATER PIPELINE CROSSING

The following pipeline crossing design guides are for water, sewer and other utilities that may cross SCVWD raw (untreated) or treated water pipelines. These are generally large diameter high pressure water mains that supply drinking water to Santa Clara County residents. There may be variations to this guideline if pipeline is located under city/county streets.



SCVWD WATER PIPELINE CROSSING

THESE NOTES ARE TO APPEAR ON PLANS

1. THE CONTRACTOR SHALL COMPLY WITH THE RULES AND REGULATIONS OF "CAL OSHA" CALIFORNIA LABOR CODE SECTION 6300 AND FOLLOWING.
2. COMPACTION EQUIPMENT SHALL BE EITHER VIBRATORY COMPACTORS OR PNEUMATIC TAMPERS. JETTING MAY BE ALLOWED. STANDARD EXCAVATION AND COMPACTION EQUIPMENT IS NOT PERMISSIBLE WITHIN 30 INCHES OF DISTRICT PIPE. IF, IN THE OPINION OF THE DISTRICT, THE COMPACTION EQUIPMENT USED IS IMPROPER OR IMPROPERLY USED AND HAS DAMAGED THE PIPE, THE PIPE SHALL BE EXPOSED FOR INSPECTION AT THE CONTRACTOR'S EXPENSE. THE CONTRACTOR SHALL THEN REPAIR DAMAGE, IF ANY, AND PROCEED WITH THE BACKFILLING WITH EQUIPMENT APPROVED BY THE DISTRICT. IN GENERAL, HAND-OPERATED POWER EQUIPMENT WILL BE CONSIDERED SATISFACTORY FOR USE WITHIN 30 INCHES OF THE DISTRICT'S PIPE.
3. PIPE TRENCH EXCAVATION AND BACKFILL SHALL CONFORM TO THE PROVISIONS OF SECTION 19 OF THE STATE STANDARD SPECIFICATIONS EXCEPT AS HEREIN MODIFIED.
4. COMPACTED SAND BACKFILL MATERIAL SHALL BE CLEAN, HARD, SOUND AND DURABLE. IT SHALL HAVE A SAND EQUIVALENT VALUE OF NOT LESS THAN 30. THE PERCENTAGE COMPOSITION BY WEIGHT SHALL CONFORM TO THE FOLLOWING GRADATION:

SIEVE SIZE	PERCENT PASSING
3/4 Inch	100
3/8 Inch	75 TO 100
#4	60 TO 100
#20	0 TO 40
#200	0 TO 5

THE MATERIAL SHALL BE FREE FROM DELETERIOUS COATINGS, CLAY BALLS, ROOTS, BARK, STICKS, RAGS AND OTHER EXTRANEOUS MATERIAL. SAND BACKFILL SHALL BE COMPACTED BY APPROVED METHODS TO A DENSITY OF AT LEAST 90 PERCENT OF MAXIMUM DRY DENSITY.

5. BACKFILL AND COMPACTION REQUIREMENTS ABOVE THE NOTED LIMITS SHALL BE TO THE SPECIFICATIONS OF AGENCY HAVING JURISDICTION.
6. ALL EXCAVATION WITHIN 12 INCHES OF DISTRICT'S PIPE IS TO BE BY HAND METHODS.
7. CONTACT SANTA CLARA VALLEY WATER DISTRICT TWO WORKING DAYS PRIOR OF ANY WORK WITHIN_______FEET OF CENTER LINE OF THE DISTRICT PIPE. PHONE 265-2600, CONSTRUCTION ADMINISTRATION UNIT.
8. FOR UNDERCROSSING, SANTA CLARA VALLEY WATER DISTRICT PIPE SHALL BE SUPPORTED DURING TRENCHING OPERATIONS IF DEEMED NECESSARY BY THE DISTRICT INSPECTOR. ANY TYPE OF PIPE COULD BE USED IF CLEARANCE TO DISTRICT PIPE BOTTOM IS AT LEAST 2 FEET. BACKFILL AND COMPACTION OF PERMITTEE'S PIPE TO BE COMPLETED BEFORE BACKFILLING SCVWD PIPE.
9. SLOPES SHOWN ARE NOT TO SCALE AND ARE INTENDED TO INDICATE NATURAL ANGLE OF REPOSE OF BACKFILL MATERIAL.

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49

SCVWD WATER PIPELINE CROSSING

SPECIAL CONDITIONS FOR PIPE CROSSINGS OF DISTRICT UNDERGROUND FACILITIES

A. PIPELINES

1. WITHIN______FEET OF CENTER LINE OF SCVWD PIPELINE, PERMITTEE IS TO INSTALL RIGID STEEL, CAST IRON, OR REINFORCED PLASTIC MORTAR PIPE WITH WELDED, FLANGED, OR MECHANICAL JOINTS AND ENCLOSE ALL CABLES (TELEPHONE, ELECTRIC, etc.) IN RIGID STEEL CONDUIT. BY ELECTING TO DO OTHERWISE, PERMITTEE THEREBY AGREES THAT THE SCVWD HAS NO RESPONSIBILITY FOR DAMAGE OF ANY KIND TO THE CROSSING, INCLUDING THAT WHICH MAY OCCUR DURING FUTURE MAINTENANCE, REPAIR OR REPLACEMENT OF DISTRICT'S FACILITY. FOR EXCEPTION, SEE NOTE 8 ON SHEET 24/2.
2. WHEN THE PERMITTE PIPE CROSSING OVER A SCVWD TREATED WATER PIPELINE IS A SEWAGE PIPE OR UNDER WITH A SEWAGE FORCE MAIN, THE SEWAGE PIPE MUST BE ENCLOSED IN A CONTINUOUS SLEEVE FOR A DISTANCE OF 10', MEASURED HORIZONTALLY AND PERPENDICULAR FROM SCVWD'S TREATED WATER PIPELINE (BOTH SIDE). THE SLEEVE SHALL BE STEEL WITH A MINIMUM WALL THICKNESS OF 1/4".
3. IF THE SEWAGE PIPE IS 24" IN DIAMETER OR GRATER, THE INSTALLATION SHOULD BE REVIEWED AND APPROVED BE THE STATE DEPARTMENT OF HEALTH SERVICES PRIOR TO CONSTRUCTION.

B. CORROSION CONTROL – CATHODIC PROTECTION:

1. PERMITTEE HEREBY WAIVES ALL CLAIMS FOR DAMAGES TO FACILITIES BEING INSTALLED UNDER THIS PERMIT, FROM ELECTRICAL INTERFERENCE OR SIMILAR ACTION, RESULTING FROM OR CONNECTED WITH THE SCVWD OPERATION OF ANY EXISTING OR FUTURE CATHODIC PROTECTION SYSTEM ON OR IN VICINITY OF EASEMENTS OWNED BY THE DISTRICT.
2. BY EXERCISE OF THIS PERMIT, PERMITTEE AGREES TO BE RESPONSIBLE FOR ANY DAMAGE TO THE SCVWD FACILITIES WHICH MAY OCCUR AS THE RESULT OF THE INSTALLATION OF THE PERMITTEE'S CATHODIC PROTECTION FACILITIES.
3. PERMITTEE HEREBY AGREES TO REMOVE BY ELECTRICAL DRAINAGE OR OTHER METHOD APPROVED BY SCVWD, AT NO COST TO THE DISTRICT, CATHODIC INTERFERENCE OCCURING ON THE SCVWD FACILITIES WHICH, IN THE OPINION OF THE DISTRICT, RESULTS IN DAMAGE TO ITS STRUCTURES AND WHICH OCCURS AS A RESULT OF THE HEREIN PERMITTED INSTALLATION OF UNDERGROUND STRUCTURES OR CATHODIC PROTECTION DEVICES. THE AMOUNT OF ELECTRICAL DRAINAGE REQUIRED TO REMOVE SAID CATHODIC INTERFERENCE SHALL BE DETERMINED BY FIELD TESTS MUTUALLY CONDUCTED BY SCVWD AND PERMITTEE.
4. WHEN THE CLEARANCE SEPARATING METALLIC PIPELINES IS 24" OR LESS, AN INSULATING BLANKET IS TO BE INSTALLED. THE BLANKET SHALL BE SQUARE AND 2' LARGER THAN THE DIAMETER OF THE LARGER PIPE. THE BLANKET SHALL BE 1/4" THICK AND SHALL BE NEOPRENE, BUTYL RUBBER, PVC OR MICARTA INSULATING BLANKET.
5. BLANKET SHALL BE INSTALLED ON SOIL BACK FILL AND CENTERED BETWEEN PIPES.

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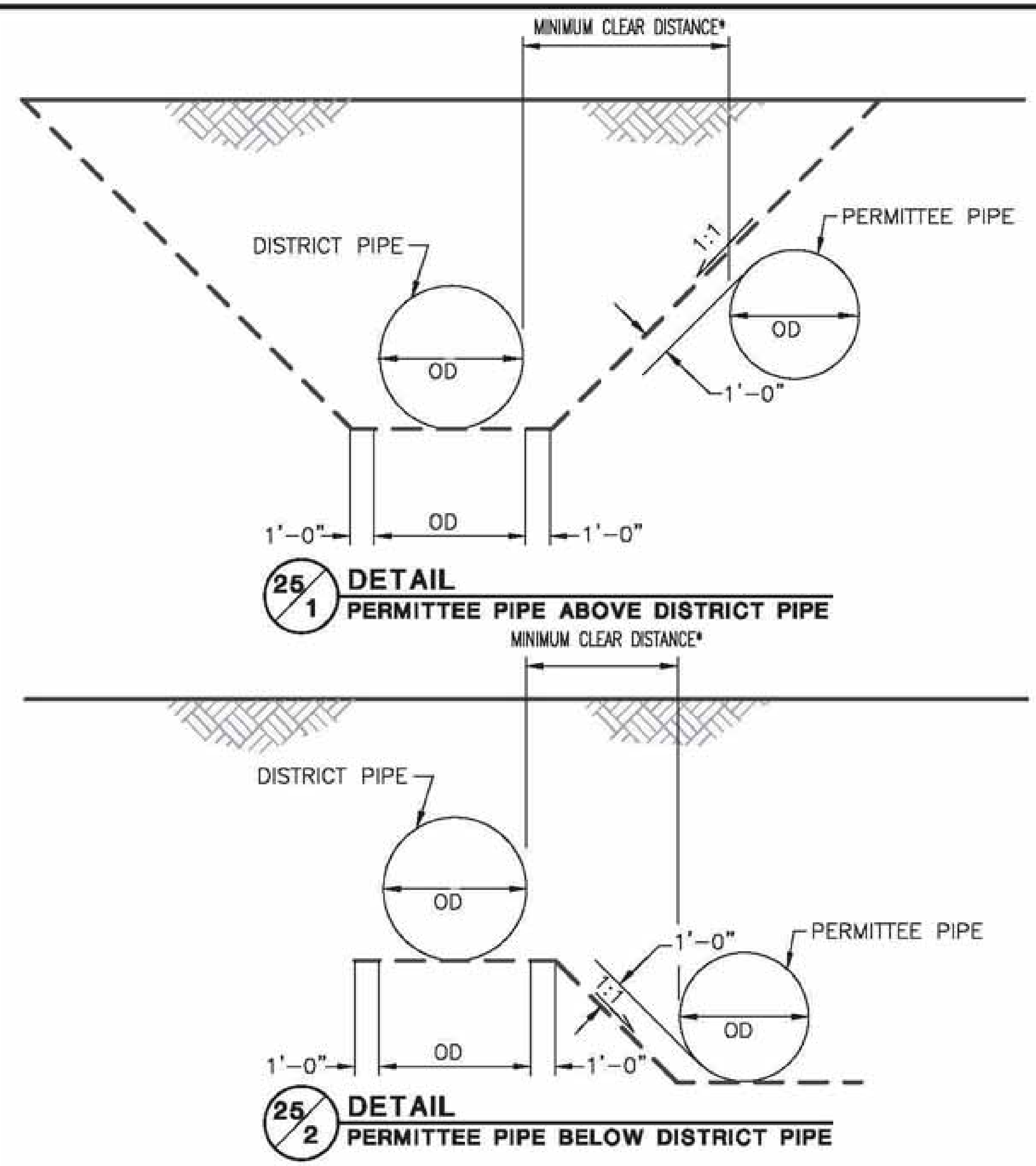
50

PIPELINE PARALLEL TO SCVWD WATER PIPELINE



* FOR INSTALLATION OF SEWAGE OR NON-POTABLE WATER PIPES PARALLEL WITH SCVWD'S TREATED WATER LINES, THE MINIMUM CLEAR DISTANCE IS 10 FEET. INSTALLATIONS WITH PROPOSED CLEAR DISTANCES LESS THAN 10 FEET MUST BE REVIEWED AND APPROVED BY THE DEPARTMENT OF HEALTH SERVICES. SEWAGE AND NON POTABLE WATER PIPES SHOULD BE INSTALLED BELOW SCVWD'S TREATED WATER LINE.

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CLEARANCE FOR PIPELINES PARALLEL TO WATER UTILITY PIPE

GUIDE 25 / 1 SHEET

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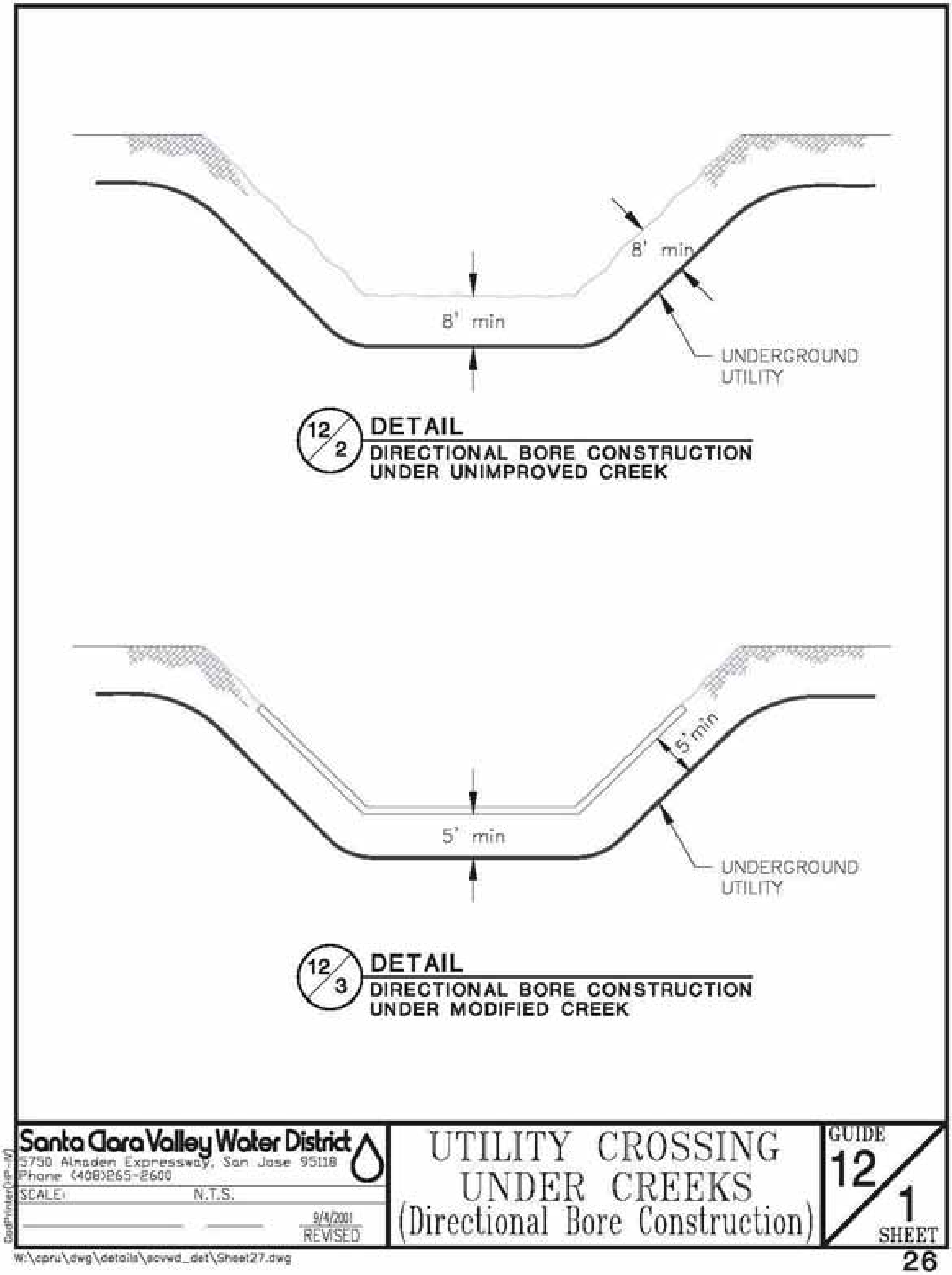
51

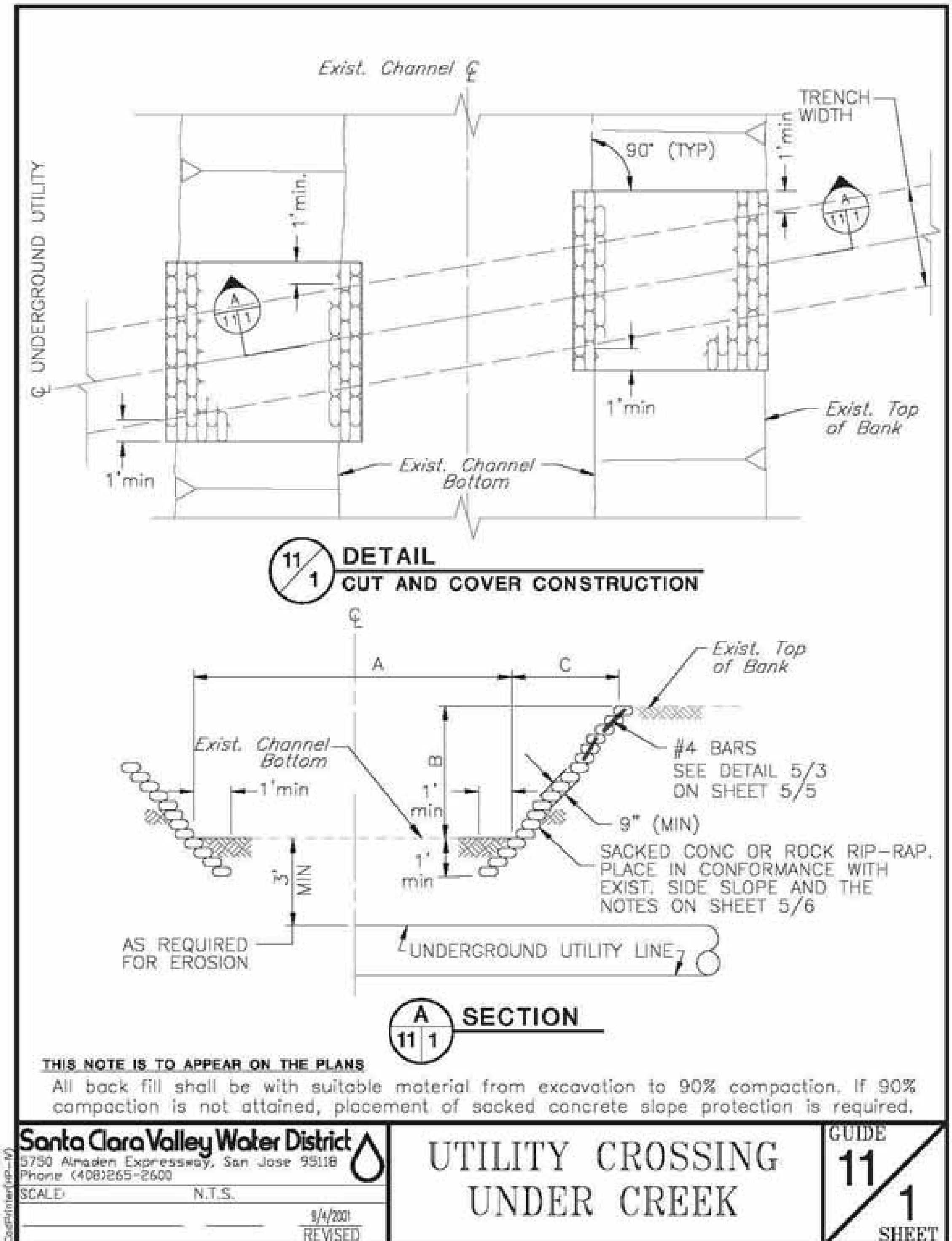
UTILITY CROSSING UNDER CREEKS

Place utilities on the downstream face of bridge and culvert crossings. Downstream face is preferred so as to not be damaged during debris removal activities. Exposed sanitary sewer, gas lines and treated water lines should be sleeved or otherwise protected to prevent breakage. Utilities may not be placed within the waterway, opening of the bridge or culvert. Utility crossings using direction bore or jack and bore methods are the preferred methods for under stream crossing.



UTILITY CROSSING UNDER CREEKS

This type of utility crossing under a creek is not preferred because of the damage it can cause to riparian areas, bank soil structure and impacts to water quality. Permits are needed from resource agencies. This option may be permissible only in rare cases for small, rural streams.



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25

GUIDANCE FOR TRAIL DESIGN

For Trails next to Streams and Streamside Resources

INTRODUCTION

The guidelines and details in this Design Guide are intended to provide clarification to G&S IX.A and IX.A.2, which discuss design and construction of trails next to streams and riparian areas. Most of the guidelines and details, which are specifically related to streams, grading and riparian resources, have been excerpted from the document, Uniform Interjurisdictional Trail Design, Use and Management Guidelines (UD) (April 15, 1999), which was prepared by the Santa Clara County Parks and Recreation Department.

GENERAL GUIDELINES FOR PROTECTION OF RIPARIAN HABITAT

While trails are often located near natural and streamside areas for recreation and enjoyment purposes, it is important that the construction, design and use of the trail not negatively impact the nearby stream and stream resources that users of the trail want to enjoy. A biological resource assessment will be required for trail routes along streams or creeks. While there is no standard setback, the general guideline is to locate the trail adjacent to - not within - the riparian corridor.

In designing the trail, **the goal is to remove the minimum amount of vegetation as necessary** to accommodate the trail clearing width and to mitigat and restore riparian habitat. Consideration should be given to acquiring additional land rights, where feasible, to place the trail outside of the riparian corridor. In addition, the following guidelines should be followed:

- To control trail use and prevent environmental damage, the design should include barriers such as fences, vegetation, stiles and fallen trees. (UD – 1.3.1.3)
- To the maximum extent feasible, trail alignment should avoid impacts to known special status plants and animal habitats. In special status species areas, trail use may be limited as appropriate to ensure protection of these resources. (UD – 1.3.2.1)
- Revegetation or enhancement will be undertaken where any sensitive habitat or special status species habitat will be disturbed by construction. The design of an appropriate revegetation program shall fully compensate for the lost habitat and shall be designed by a qualified biologist. Riparian and wetland habitat will typically be mitigated at a 3:1 ratio for high quality habitat areas and at a lower ratio where lower habitat quality justifies a lower ratio. Locally native plants will be utilized in all mitigation work. (UD – 1.3.3.6)
- Any cut or fill slopes adjacent to the trail shall be immediately reseeded or replanted. Vegetation will vary by location and surrounding landscape context.

FOR MORE INFORMATION

Refer to sections in this Design Guide for protection riparian vegetation and planting guidelines.

GENERAL GUIDELINES FOR SITING OF TRAILS NEXT TO STREAMS/STREAM CROSSINGS

The objective is to set trails back from the top of bank to avoid erosion over time and protect the existing riparian area.

- Use existing maintenance trails, access route and levees wherever possible to minimize impacts of new construction in riparian zones (UD – 1.3.2.3)
- When parallel to a stream or riparian zone and not located on a levee, new trails should be located behind the top of bank or at the back or outside edge of the riparian zone – except where topographic, resource management, or other constraints make this infeasible or undesirable. (UD – 1.3.3.1)

- Trails in areas of moderate or difficult terrain and adjacent to a riparian zone shall be composed of natural materials or shall be designed to minimize disturbance, and the need for drainage structures. (UD – 1.3.3.2)
- Trail crossings of streams and drainages shall be designed to minimize disturbance through the use of bridges or culverts, whichever is least environmentally damaging. Bridges and culverts should be designed so that they visually and functionally blend with the environment. (UD – 1.3.3.3)
- New native riparian vegetation should be planted in the setback zone, where practical, to complement existing vegetation (UD – 1.3.3.4)
- Trails will avoid wetlands, including seasonal wetlands, wherever possible. Trails adjacent to wetlands will be constructed so that trail fills avoid wetland impacts. (UD – 1.3.3.5)
- Locate trail alignment and crossings under bridges above the 100 year or 1% flood water surface elevation.
- Trail alignment will be limited to one side of the stream to minimize impacts to habitat.
- Trail use will generally be limited to the hours between dawn and dusk to minimize impacts to wildlife.
- Lighting of trails should be avoided. Exceptions include security lighting in downtown commercial and entertainment areas where lighting should be minimized.

GENERAL GUIDELINES FOR GRADING AND DRAINAGE

- No significant grading as defined by local ordinances will be used for trail construction unless in conjunction with an approved development project. (UD – 3.5.1)
- The degree of cut allowed on a slope depends on the soil type, hardness and surrounding natural resources. Cuts should be contoured to blend with the natural slopes. Berms of earth, rocks or wood may be necessary. (UD – 3.5.2)
- Use limited terracing or building steps to avoid large-scale grading. Reinforce steps with stone or wood. (UD – 3.5.3)
- Surface water shall be diverted from trails by cross sloping the trail tread between 2 and 3%. (UD – 3.5.4)
- Where there is potential for significant soil erosion, require a specific erosion control plan. (UD – 3.5.5)
- Do not locate irrigation systems within 2 feet of the edge of the trail. Irrigation for turf areas around a trail should use only a pop-up variety of irrigation head. To avoid erosion and undercutting of the trail, the irrigation system should be controlled so that only incidental spray might reach the trail surface and edge. (UD – 3.5.6)
- Select plants for streamside areas that do not require irrigation beyond an establishment period.
- Use permeable pavements where possible.
- Where overland direction of drainage away from the creek is constrained, provide positive drainage.

GENERAL DESIGN AND AESTHETIC PLANS AND SECTIONS

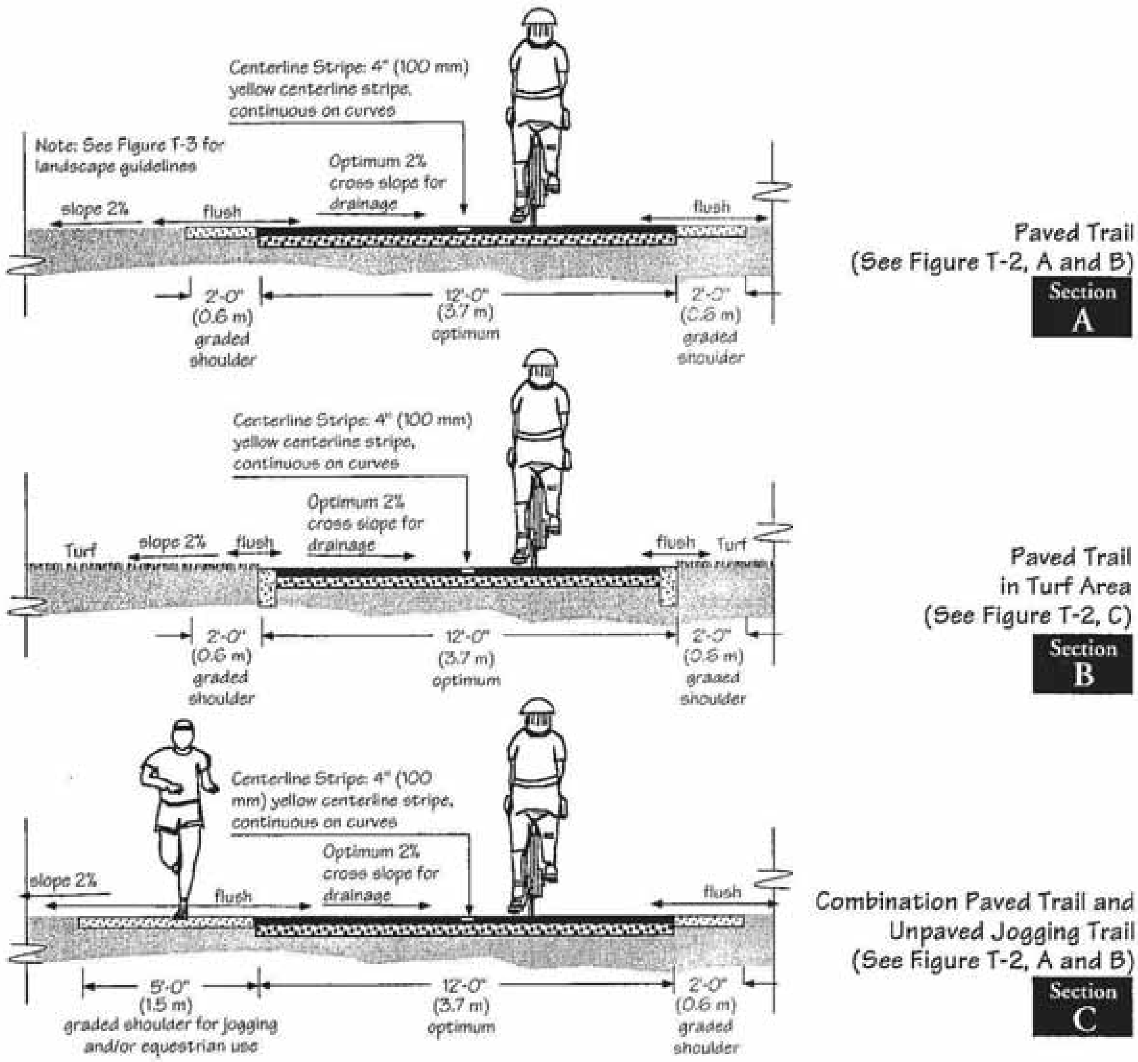
In addition to the excerpted guidelines above, this section also includes 7 plans and/or sections to help guide the design and placement of trails taken from the Santa Clara County Parks Departments Uniform Interjurisdictional Trail Design manual.

- Design of Urban Shared-Use Trails (T-1)
- Section: Trail Adjacent to Creek, Park, or Open Space (T-5A)
- Plan: Trail Adjacent to Creek, Park or Open Space (T-5B)
- Plan: Design of a Trail on a Levee (T-15)
- Plan and Section: Levee Trail Undercrossing (T-16)
- Creek Crossings and Water Quality (T-17)
- Trail Placement Adjacent to Streams (T-18)

DESIGN OF URBAN SHARED-USE TRAILS

Urban Shared-Use Trail Sections T-1

Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
Santa Clara County Interjurisdictional Trails Committee



Related Policies: UD-2.2.2; UD-3.5.4; UD-4.11.1; UM-3.4

Notes:

- For natural-surfaced trail cross-sections and urban Shared-Use Trails that include an equestrian shoulder, refer to the *1995 Countywide Trails Master Plan, Figures G-2 and G-3.*
- Trail shoulders: 2' (0.6 m) graded shoulder; 2' (0.6 m) minimum vegetation clearance; prune all brush over 12" (0.3 m) in height and 1/2" (12 mm) dia. that extends into trailway.
- Centerline stripes should be used along trails. Solid centerline stripes should be used where there is heavy use, on curves greater than 100 feet long (30.5 m) with restricted sight distances, and where the path is unlighted and nighttime riding is expected. Dashed stripes should be used where there is heavy use but only where sight distances permit.
- "Optimum": The best or most favorable condition for a particular trail situation from the perspective of responsible management.
- Reference Also: *Highway Design Manual, Chapter 1000 Bikeway Planning and Design; Topic 1003 - Design Criteria; and Topic 1004 - Uniform Signs.* California State Department of Transportation.

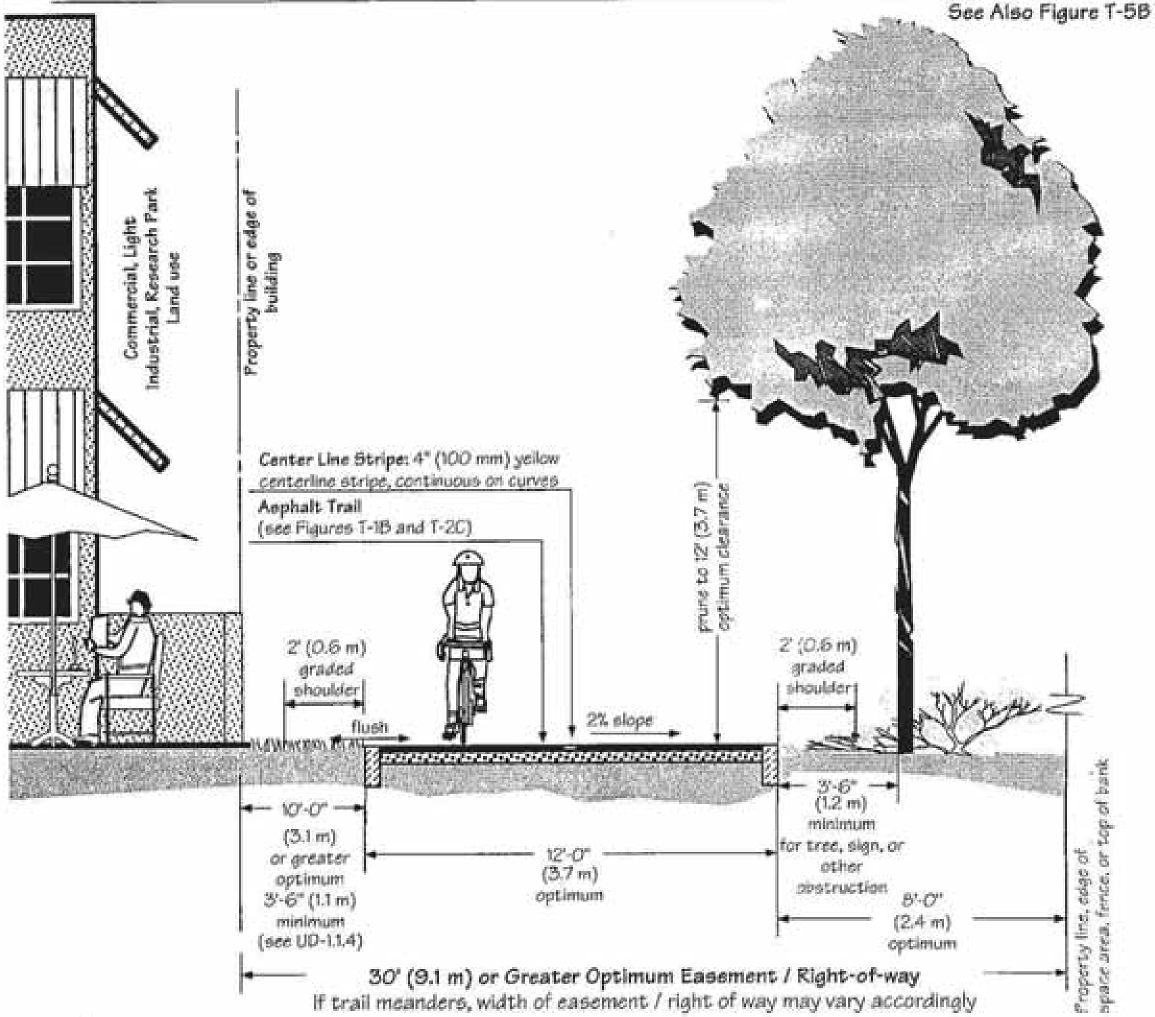
Final: April 15, 1999

SECTION: TRAIL ADJACENT TO CREEK, PARK OR OPEN SPACE

Trail Adjacent to Creek, Park, or Open Space T-5A

Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
Santa Clara County Interjurisdictional Trails Committee

See Also Figure T-5B



Related Policies: UD-1.1.1; UD-1.1.4; UD-2.2.2; UD-3.5.6; UD-4.11.1; UM-3.4

Notes:

- Maximum grade of 5% is optimum; 8.33% maximum for short sections.
- Trail shoulders: 2' (0.6 m) graded shoulder / 2' (0.6 m) minimum vegetation clearance; prune all brush over 12" (0.3 m) in height and 1/2" (12 mm) dia. that extends into trailway.
- Centerline stripes should be used along trails. Solid centerline stripes should be used where there is heavy use, on curves greater than 100 feet long (30.5 m) with restricted sight distances, and where the path is unlighted and nighttime riding is expected. Dashed stripes should be used where there is heavy use but only where sight distances permit.
- "Optimum": The best or most favorable condition for a particular trail situation from the perspective of responsible management.
- Reference Also: *Highway Design Manual, Chapter 1000 Bikeway Planning and Design; Topic 1003 - Design Criteria; and Topic 1004 - Uniform Signs.* California State Department of Transportation.

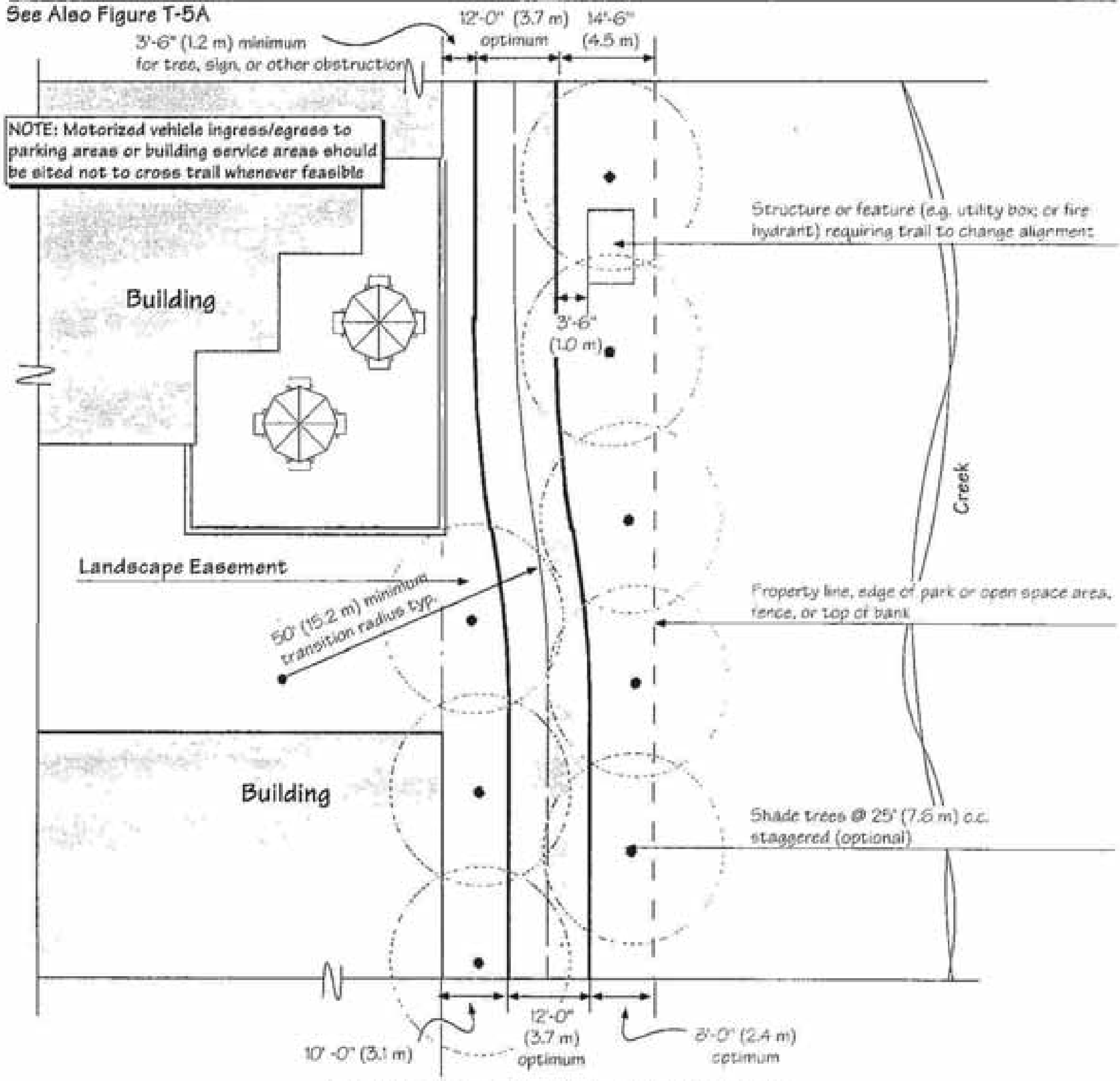
Final: April 15, 1999

PLAN: TRAIL AJACENT TO CREEK, PARK OR OPENSPACE

T-5B Plan: Trail Adjacent to Creek, Park, or Open Space

Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
Santa Clara County Interjurisdictional Trails Committee

See Also Figure T-5A



30' (9.1 m) or Greater Optimum Easement / Right-of-way
If trail meanders, width of easement / right-of-way may vary accordingly

Related Policies: UD-1.1.1; UD-1.1.4; UD 2.2.2; UD-4.11.1

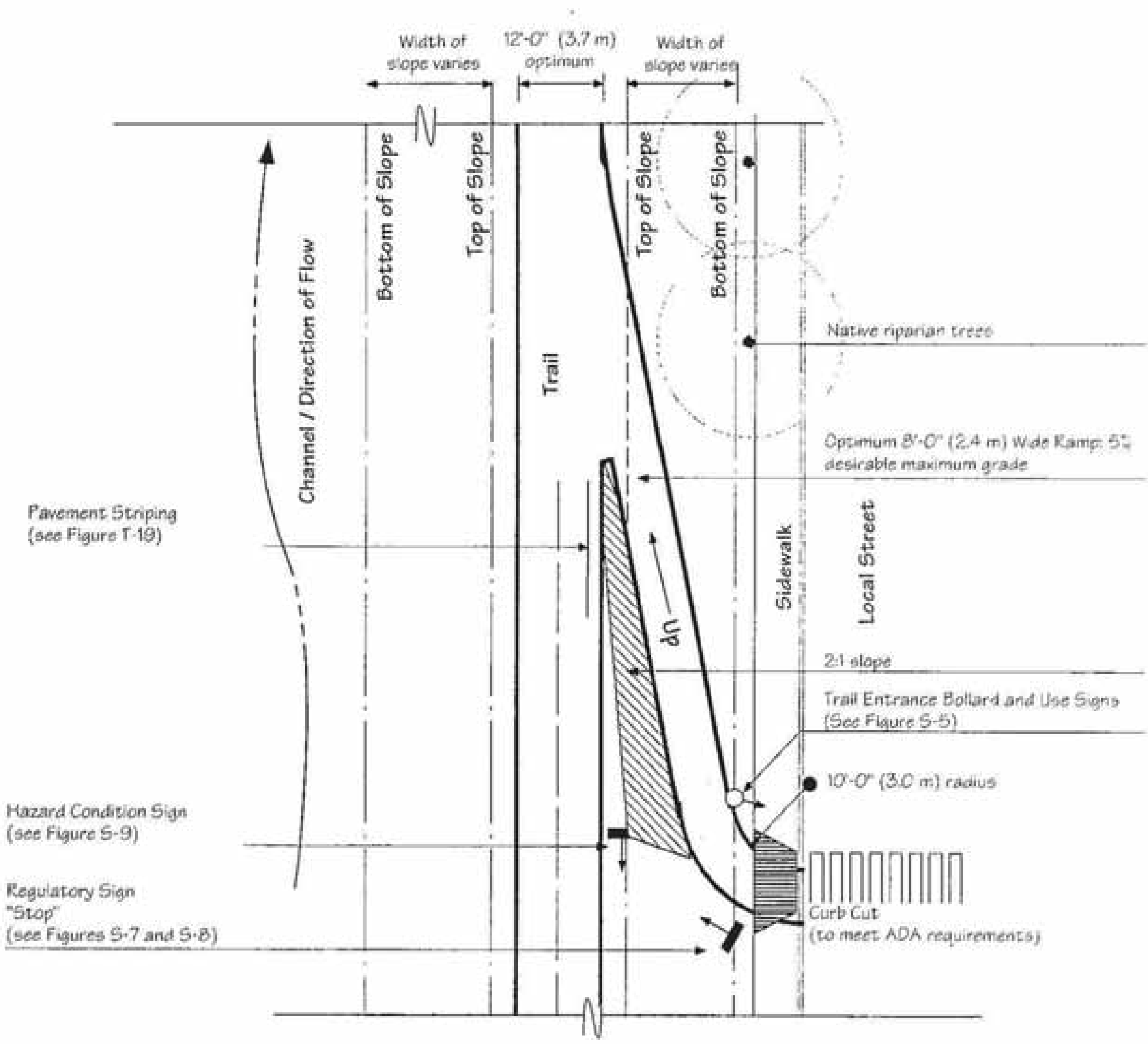
- "Optimum": The best or most favorable condition for a particular trail situation from the perspective of responsible management
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design; Topic 1003 - Design Criteria; and Topic 1004 - Uniform Signs. California State Department of Transportation.

Final: April 15, 1999

PLAN: DESIGN OF A TRAIL ON A LEVEE

T-15 Plan: Trail on Levee

Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
Santa Clara County Interjurisdictional Trails Committee



Related Policies: UD-1.3.2.3

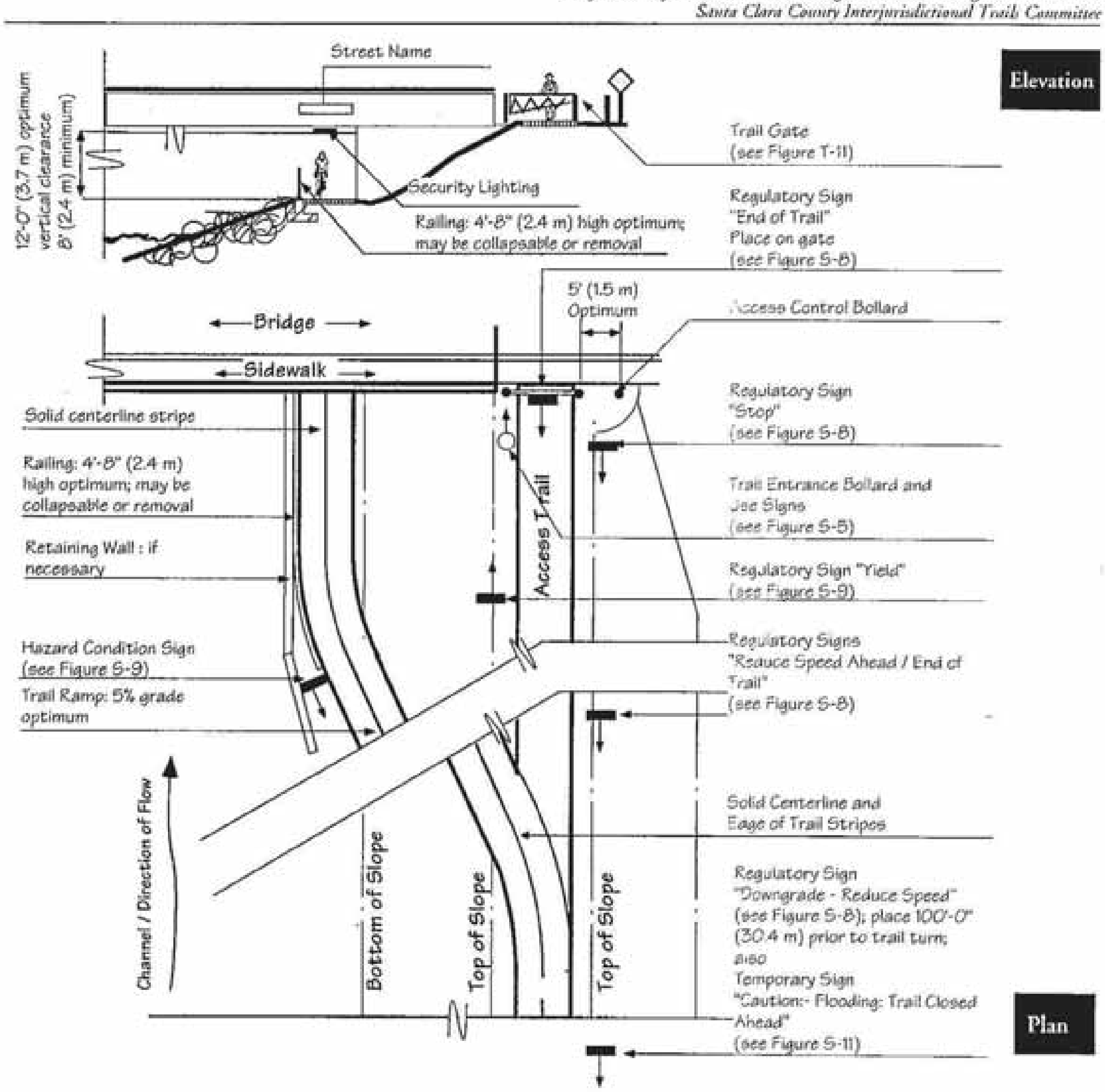
- "Optimum": The best or most favorable condition for a particular trail situation from the perspective of responsible management.
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design; Topic 1003 - Design Criteria; and Topic 1004 - Uniform Signs. California State Department of Transportation.

Final: April 15, 1999

PLAN AND SECTION: LEVEE TRAIL UNDERCROSSING

Plan and Section: Levee Trail Undercrossing **T-16**

Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
Santa Clara County Interjurisdictional Trails Committee



Related Policies: UD-2.6; UD 4.1.5

Notes

- Trail connections will likely occur on both sides of road bridge

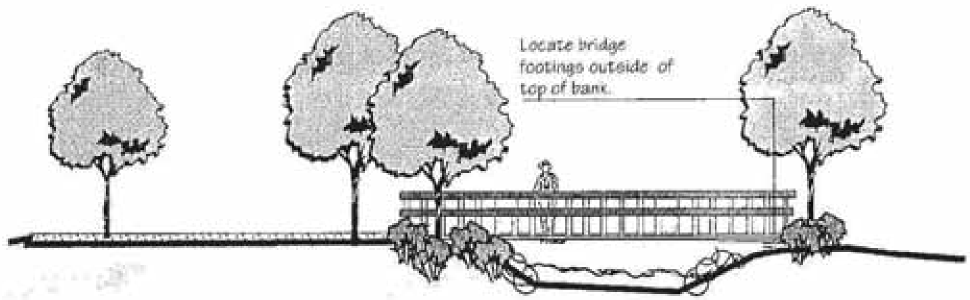
- "Optimum": The best or most favorable condition for a particular trail situation from the perspective of responsible management
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design: Topic 1003 - Design Criteria; and Topic 1004 - Uniform Signs. California State Department of Transportation.

Final: April 15, 1999

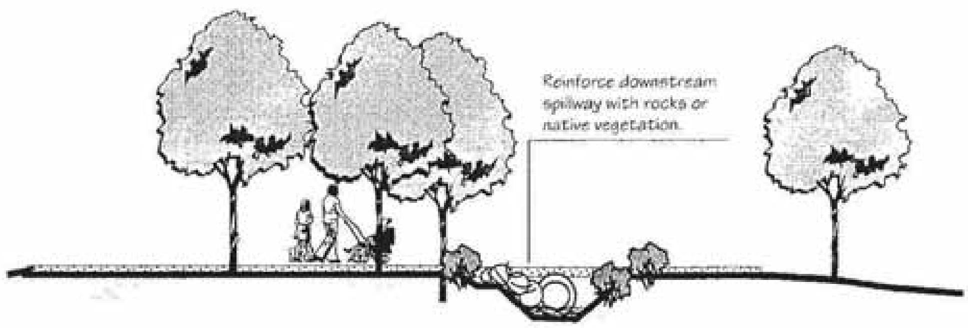
CREEK CROSSINGS AND WATER QUALITY

T-17 Creek Crossings & Water Quality

Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
Santa Clara County Interjurisdictional Trails Committee



Bridge major streams and drainages **A**



Culvert crossings of small streams and drainages **B**

Related Policies: UD-1.3.3.14

- "Optimum": The best or most favorable condition for a paticular trail situation from the perspective of responsible management.
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design; Topic 1003 - Design Criteria; and Topic 1004 - Uniform Signs. California State Department of Transportation.

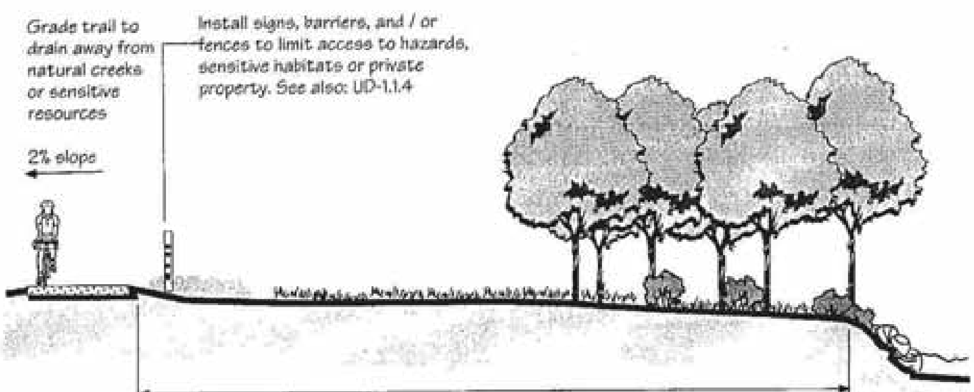
Final: April 15, 1999

TRAIL PLACEMENT ADJACENT TO STREAMS

Trail Placement Adjacent to Streams T-18

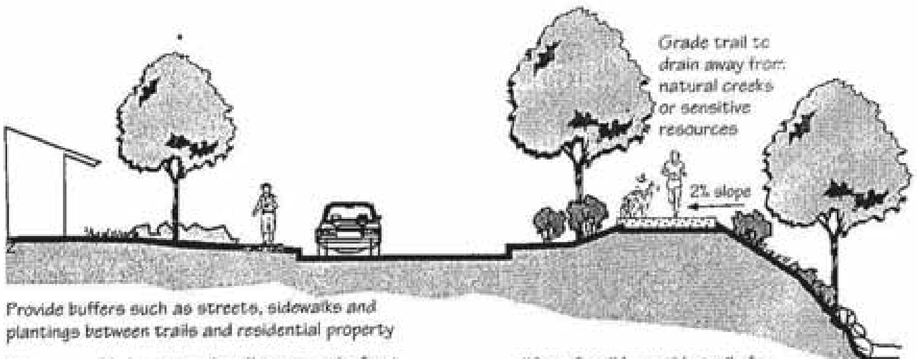
Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
Santa Clara County Interjurisdictional Trails Committee

Relationship to property lines, environmentally sensitive areas & residences



For shared-use trails, provide 150' (46.0 m) setback buffer, where possible, from the top of bank (where the stream is predominantly in its natural state) or 100' (30.4 m) from the outside edge of the riparian zone where there are no opportunities for shared use of levees or existing roadways.
See also: Design Guideline UD 1.3.3.1.

A



Provide buffers such as streets, sidewalks and plantings between trails and residential property

Where possible locate trails adjacent to the front yards, streets and public open spaces, rather than adjacent to private backyards, storage areas, or utility areas.

See also: Design Guideline UD 2.1, Tables UD-1 and UD-2

Where feasible provide trails for shared use of levees or other linear open spaces.
See also: Figures T-15 and T-16.

B

Related Policies: UD-1.1.1; UD-1.3.3.14; UD 1.1.4

- "Optimum": The best or most favorable condition for a paticular trail situation from the perspective of responsible management
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design; Topic 1003 - Design Criteria; and Topic 1004 - Uniform Signs. California State Department of Transportation.

Final: April 15, 1999

GROUNDWATER RESOURCE ASSESSMENT CRITERIA

INTRODUCTION

Any proposed project subject to CEQA where the District finds that there is potential for groundwater quantity or quality impacts should provide a groundwater assessment that will need to be reviewed. Examples of land use decisions that could impact groundwater and may require a groundwater assessment include:

- Increases in water demand (whether that demand will be served by on-site wells or potentially change the quantity of water pumped by retail water suppliers)
- Land use changes that could impact the quantity or quality of water percolating into the groundwater resource on site such as changes in impervious surface area or the use of dry wells or other stormwater infiltration facilities
- Use of on-site wastewater treatment
- Use of underground chemical storage facilities.

SUBMISSION OF GROUNDWATER ASSESSMENT

The groundwater assessment should be submitted to the District for review. Groundwater assessment before a project starts will help the District anticipate groundwater management impacts and ensure that groundwater resources, both quantity and quality, are sustained and protected. The required groundwater assessment should include:

General:

- A description of the groundwater basin or basins over which the project lies;
- Identify whether the site is located in a recharge area of the groundwater basin;
- Identify any existing active or abandoned wells on site.

Water Supply:

- Is groundwater expected to be a source of supply to meet the water demand for the project? If so, provide pumping locations and quantities for the proposed project;

    - Describe potential impacts to groundwater recharge on site (due to changes in pervious and impervious surfaces for example);

- Is there currently or will the proposed project be using recycled water? For what uses?

Water Quality:

- Are there any existing contamination sites or plumes?
- Information on the geo-hydrology of the site, including historical depth to water at the site (in different years, seasons, or different hydrologic conditions if known); is the shallowest groundwater part of the drinking water aquifer or perched water above a confining lens or confining layer?
- Identify active drinking water sources and protection zones within the proposed project limit;

    - If known, the vulnerability of the local groundwater to any possible contamination that might occur at the site (the physical barrier effectiveness to use the Drinking Water Source Assesment and Protection Program terminology): what the groundwater gradient is on site, the ability of the soil materials to transmit or delay the movement of contamination to the water table;

- Identify locations and risk rankings of possible contaminating activities within the limit of the proposed project area. These include storm runoff devices, other infiltration devices (such as septic or leach fields), chemical storage tanks (for example, dry cleaners and gas stations);
- Provide the information on Best management practices (BMPs) applied within the proposed project area for protecting groundwater and surface water that are used or potentially used as sources of drinking water.

SCVWD FLOOD PROTECTION DETENTION BASIN DESIGN CRITERIA

SCVWD FLOOD PROTECTION DETENTION BASIN DESIGN CRITERIA

This guidance is intended to provide an overview and is to be supplemented with engineering analysis and design. Engineering professionals should refer to the SCVWD Hydrology Manual, the Santa Clara County Drainage Manual, and any design requirements made by permitting agencies.

These design criteria are recommended to be used when detention basins are required to mitigate for impacts to flood conveyance capacity. Separate criteria have been developed for implementing NPDES permit requirements for hydro-modification. There may be some instances where stormwater runoff rates need to be regulated for both flood protection and hydro-modification (HMP) purposes. In those cases, the recommended method of design needs to be as follows: (a) design the basin for the HMP requirements, (b) test the HMP basin design against the flood protection requirements outlined in this section. If the HMP design meets the flood protection requirements, the HMP design achieves both functions. If not, the HMP design would need to be modified by the engineer to accomplish both functions. This may require modifying the storage volume and the orifices/weirs of the HMP basin.

GENERAL DESIGN CRITERIA

The frequency, lateral extent and elevation of flooding should not substantially increase under post development conditions.

The 100-year flood according to pre-development and post-development conditions shall be analyzed and routed through the pond. The 100-year outflow hydrograph shall not be more than the pre-development condition. If there is an existing flooding condition downstream, then the design should also be based on the flow rate and frequency at which flooding occurs.

In general the design of detention facilities should be based on the differential storage between the inflow and the outflow hydrographs. The peak of the outflow hydrograph for the post-design condition shall not exceed that of the pre-design condition.

DEFINITIONS AND DESIGN IMPLICATIONS OF SOME TERMINOLOGIES

Pre-development condition: This is the existing land uses within the tributary watershed, which may be completely rural, and it includes pervious and impervious areas. Using appropriate procedures, the total flow peak and volume may be determined by calculating the flood hydrographs from the pervious and impervious areas and then subsequently combining these two hydrographs.

Post-development condition: With an increase in imperviousness, urbanization within the watershed will result in a higher runoff volume and a different peak flow rate which, again, are obtained by combining the pervious area and impervious area hydrographs from the post-development land use conditions.

Differential peak flow rate and volume: The differential flow values, between the pre- and post-development conditions, represent the effect of urbanization. In order to minimize impacts from flooding, no increase in flow rate or volume is allowed. Thus, mitigation measures are needed. One of the mitigation measures is to achieve peak shaving and volume reduction via a detention basin.

Detention basin routing: The routing (passing-through) of floodwaters through the detention basin could effectively reduce the peak flow and volume at its downstream end due to storage effects. The use of a detention basin is desired to reduce flood peaks.

OPERATION MANUAL AND RULE CURVES

For every stormwater detention facility that is designed to alleviate flood damages or other natural emergencies, guidelines must be established to assure the proper maintenance and safety of the facility. These guidelines should identify whom, when, and how the facility will be managed. The safety elements of operating the facility should be addressed, as should recommendations relating to the ingress-egress to and from the facility.

It is recommended that detention basins be designed to function as multipurpose facilities for recreation as well as for flood attenuation. For this purpose, the facility should be designed with minimum depths of water and relatively flat slopes for the sides of the pond. In the case where detention facilities are designed as multipurpose facilities for recreation, flood and pollution control, a rule curve that specifies the allowable maximum water surface elevations over time should be defined and made as a part of the final operating manual.

SITING OF DETENTION BASINS

- Recommend situating the detention basin closer to the middle of a watershed to provide efficient peak flow and volume reductions.
- Avoid locations near San Francisco Bay or at the lower/downstream end of a watershed.
- Utilize existing topography, such as the selection of a low depressed area to reduce the amount of excavation and the selection of a narrow necking area for outlet control or dam sites, could result in significant savings.
- Avoid locations where the seasonal ground water level may rise above the basin bottom. Ground water flow can have significant effect in the construction and operation of the basin.
- Where multiple detention facilities are on one creek, synchronize operations of these facilities so as not to expand the impact and increase the flow rather than reducing it.

PROTECTION OF RIPARIAN HABITAT AND GROUNDWATER

Detention basins should not be located within the riparian corridor, but may be located beyond the riparian corridor. Geotechnical evaluation may be needed for basins in close proximity to a creek bank. To protect the groundwater from surface water contamination, it is preferable that the stormwater detention facilities be located in impervious areas. Investigations should also be made into the proximity of existing groundwater contamination. Infiltration from an unlined detention basin can exacerbate the movement of a groundwater contamination plume. Groundwater or geologic conditions may require the inclusion of a lining to ensure that the underground water is not contaminated.

TYPES OF ATTENUATION FACILITIES

Off-Stream Facilities: Off-stream basins are preferable because they are generally smaller than in-stream types and, hence, more economical. In-stream basins have more restrictions due to environmental concerns. An off-stream detention basin is designed to take the excess flow above a certain prescribed threshold. Stormwater runoff from a watershed is generally collected and transported via storm drains or channels to the detention basin. The outlet of the off-stream basin should be designed to drain flow back to the main stream either by gravity or by pumping if gravity flow is not feasible.

In-Stream Facilities: Instream facilities are not preferred because of the impacts structural modifications may have on the stream. Flow through ponds or detention basins that intercept flow from development with a discharge outlet draining back to the creek to mitigate induced flooding can both be categorized as in-stream facilities. The modified puls or storage-indication method is frequently used as the routing method for the in-stream facility routing. Usually the in-stream facility attenuates the flows through the creek; therefore, the outlet structure should be designed to accommodate the required capacity of the creek. At times, minimum inflows are permitted to flow unimpeded through the detention facility. The design of in-stream detention facilities shall be consistent with the design of the ultimate flood control project on that stream.

SIZING OF AN OFF-STREAM DETENTION BASIN

The sizing of an off-stream detention basin involves an iterative design process. Flow over a preset level is diverted through a diversion and control structures such as an overflow weir discharging via either an open channel or a closed conduit into the detention basin. At the lower end of the basin, an outlet draining the flow back into the main stream may be needed. The flow conveying hydraulics for both inflow and outflow of the detention basin must be determined in order to meet the objectives of the flow attenuation in the main stream. This involves a trial and error design process of sizing the basin with its associated storage-discharge relationship to optimize the combined flow at the downstream end.

OUTLET STRUCTURE

The outlet structure should be designed to evacuate the storage volume incidental to flood control (excluding the initial storage) within a short time period to allow for the next incoming storm.

SPILLWAY DESIGN

Every stormwater detention facility should be designed to prevent damages from embankment failure due to overtopping or other causes. Good engineering principles should be implemented in the construction of the embankment and the spillway should be designed to prevent the possibility of over-banking from the spillway design flood.

If the pond volume is less than 15 acre-feet and the depth of water in the pond is less than 6 feet, then the spillway shall be designed for the 100-year flood. If the volume of the pond is between 15 and 50 acre-feet and the depth is between 6 and 25 feet, then the spillway design flood may be based on the 200-year flood. All other impoundments that are larger than defined above should comply with the design criteria of the State of California Division of Safety of Dams (DSOD).

BASIN SLOPES AND LOW FLOW CHANNEL

The recommended side slopes for flood control storage areas within a stormwater detention basin vary with the design of the basin. Earthen slopes or passive vegetated areas should be at a maximum of 3 horizontal to 1 vertical. Turf areas should be at a 4 to 1 or flatter slope to facilitate mowing. The basin floor shall be sloped towards the low flow channel with a minimum slope of 1%. The low flow channel is recommended to carry 1 to 3 percent of the 100-year peak flow.

CHECKLIST FOR DETENTION BASIN DESIGN

- Hydrology map of watershed boundaries, basin layout with contours.
- Summary tables of watershed parameters.
- Inflow hydrographs at key locations.
- Stage, storage, discharge curves.
- Outflow hydrographs after basin routing.
- Basin design drawings with inlet and outlet designs.
- Summary tables of peak flow and volume for pre- and post- conditions.

Bank Protection/Erosion Repair Design Guide

INTRODUCTION AND PURPOSE OF DESIGN GUIDE

This Design Guide is intended to clarify the Chapter 1 of the Water Resources Protection Manual, section VIII, articles D-H (Outfalls, Pump stations and Site Drainage). This Design Guide describes how to address streambank erosion problems, and how to use bioengineered methods of bank protection and erosion repair.

This Design Guide is to be used by local permitting agencies, property owners and professionals who design projects on streamside parcels (i.e. civil engineers, land use planners, landscape architects, etc..) It is intended to:

- Provide guidance for how to design a variety of bank protection projects, in places where streambanks are, have, or may be eroding
- Promote proactive approach to preventing and resolving serious erosion problems

This document is a guide, not an instruction manual. Erosion repair activities within a stream channel will impact water quality, flood protection, the stability of adjacent properties, and the habitats of many stream-dependant species. It is for these reasons that these activities require several state and federal permits, as well as the involvement of qualified professionals to help design and construct the project in a way that addresses stability and long-term water resource protection. Examples of more detailed guidance manuals are listed at the end of this document for reference.

Moving Toward Soft, More Systemic Methods of Bank Protection/Erosion Repair

Traditional methods of controlling erosion have relied on "hard" structural practices such as covering banks with interlocking concrete blocks and building retaining walls. However, these techniques often have negative impacts on streams. In many cases, these methods are also expensive and ineffective in the long run. Recommended instead are "soft" or bioengineered bank stabilization methods. A bioengineered approach involves the planting of native streamside or riparian vegetation combined with the strategic placement of logs or minimal rock, where necessary, and regrading of steep slopes wherever possible in order to produce living systems that minimize erosion, control sediment, and provide habitat. The natural attributes of plants, when combined with stabilized bank slopes, provide better dynamic stream systems than stationary hard structures.

An objective of this Design Guide is to protect, and where appropriate, restore streambanks and related stream resources. Where suitable, it encourages a systemic approach to streambank protection and stream restoration. This Design Guide starts by describing how streams function, typical features of a stream and importance of riparian vegetation. It then discusses typical causes of streambank erosion and recommends basic measures to be considered when planning and designing a bank protection erosion repair project. Finally, alternative methods of protecting a streambank are presented, starting with how to treat a reach of a stream in a more rural setting where there is room to use a more systemic approach, and continuing with a variety of treatments for smaller, urban parcels, which include a small reach of a stream.

Goals/Purpose of Streambank Protection Activities

In general, the goals of any bank protection/erosion repair activity should be to:

- Maintain or increase stream stability and facilitate transport of sediment and water;
- Avoid localized solutions that repair only a single erosion site but reduce the stability of neighboring stream banks and cause erosion problems on upstream or downstream properties;
- Enhance and increase native vegetation both in extent and diversity to provide habitat value and help ensure long-term bank stability.

With these goals in mind, this Design Guide delineates some general guidelines and issues to consider when embarking on a bank-protection/erosion-repair project, as well as a description of various erosion-repair techniques. This guidance also provides agency staff and streamside property owners with a brief overview of how streams are formed, their common characteristics and features, and typical causes of streambank erosion.

ORGANIZATION OF THIS DESIGN GUIDE

This Design Guide is organized into two parts and six subsections. The Technical Primer part includes useful background information that explains the causes of erosion. Homeowners and project developers will likely refer to the Techniques and Guidance part more frequently, because it outlines techniques and guidelines for erosion repair.

Contents **page**

BANK PROTECTION/EROSION REPAIR DESIGN GUIDE
PART ONE:
TECHNICAL PRIMER ON STREAM FUNCTION AND FORM

Introduction

Before considering bank protection or erosion repair, it is necessary to understand the process by which streams form and adjust to their surroundings. Streams are shaped by a combination of "forming forces" that include:

- *Gravity,* or the slope of the channel banks
- *Friction,* which is a function of vegetation, the soil's type and particle size, and the channel's pattern and profile.
- *Velocity*, the speed of the water flow.
- *Quantity*, the volume of water flowing and sediment moving through the stream.

Over time, streams move and shift in response to changes in these forming forces. That is why streams do not naturally tend to flow in a straight line. Instead, they meander in search of equilibrium with their forming forces, adjusting to changes in water flow and sediment transport. These changes can have both natural and non-natural causes.

Characteristics and History of Streams in Santa Clara County

Some streams in Santa Clara County are still in a natural condition, while others have been straightened or channelized in response to land development activities and flood control needs. Throughout the County, human-made channels were created to contain the flows that once naturally fanned out over the valley floor, carrying with them nutrients and sediment, and creating alluvial fans and fresh water marsh habitat. These human-made channels were created to accommodate the use of land for agriculture or urban development, and to ameliorate flooding conditions.

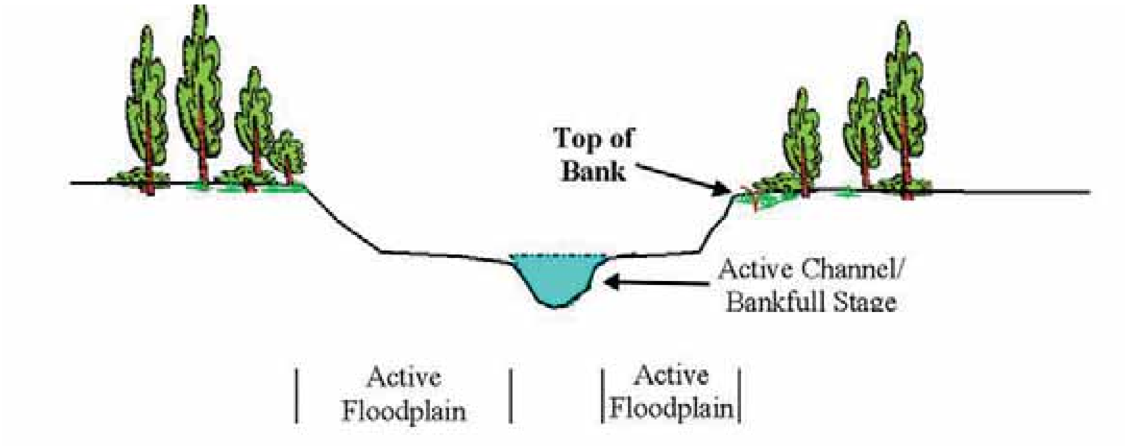
Experience has also shown, however, that significant problems arise when streams in the lower watershed are confined. By lining streams with levees or floodwalls, water that would otherwise slowly spread out over a large area of land in a beneficial way accumulates in the channel until it breaches its levee or floodwall, potentially causing catastrophic flooding. Even if this does not happen, a significant amount of sediment may be deposited in the channel after a storm event, raising the channel bed elevation. This sediment decreases the channel's capacity to handle subsequent storm flow. In other words, the chance of catastrophic flooding increases with every storm if the channel's sediment is not removed often enough.

Significant efforts are underway throughout the County to address these issues, and to maintain and enhance our remaining natural streams. There are also efforts being made to restore and enhance, where possible, channelized urban drainage ways. It is important to remember that even though a stream may be hardened or modified in a particular location, it may remain natural in other areas. Over time, it may be possible and even essential to restore these streams to a more natural state to improve stability and flood protection for nearby property owners. In addition, the protection of water quality is critical in all types of Santa Clara County streams, both natural and unnatural, because they eventually convey water to either Monterey Bay or San Francisco Bay.

Typical Stream Features

In a cross-sectional view, a stable natural stream can be defined by two significant features: the "bankfull" (or "active channel") and the "active floodplain." See Figure 1 below.

Figure 1: Cross-Sectional View of a Natural Stream



The bankfull or "active channel" can be defined by the elevation of the floodplain, which is formed by the most effective channel forming or "dominant" stream discharge. It is the part of the stream where sediment is actively transported and deposited, the part that is capable of containing the most frequent flows.

The active channel is an important feature because it transports the majority of the water and sediment in the stream system, and thus it influences the channel formation over time. As seen in Figure 1, the active channel is usually distinguished from the active floodplain by an abrupt change in the slope of the stream bank, usually from a vertically-sloped plane to the horizontally-sloped plane on top of the floodplain.

Active floodplains are the low-lying areas between Top of Bank (See Figure 1) and adjacent to the active channel that are subject to frequent inundation during moderate and high flows. This area is where sediment is deposited when the active channel's capacity is exceeded during high flows. In urban settings, active floodplains are often hard to identify, due to channel incision and erosion from increased urban runoff. On rural streams, the active floodplain normally fills approximately every year or two. Floodplain filling usually occurs more often in urban areas. Vegetation is typically present in the floodplain area, as it will become established between the alternating seasonal periods of inundation and sediment deposition.
(Section 2 of the Guidelines and Standards also includes more detailed definitions and sketches showing these features in a variety of settings).
Important Note: A stream's active floodplain is not to be confused with the delineation of floodplain used for flood insurance purposes. The floodplain defined for flood insurance purposes is the one percent (100-year) flood, or the area that has a one percent chance of being flooded to a depth of one foot or greater each year. For insurance purposes, this equates to a 26 percent chance of suffering some flood damage during the term of a 30-year mortgage.

Stream Beltwidth and Stream Meander Width

A channel has a certain beltwidth within which it naturally moves. This beltwidth can be determined by studying: sections of the channel which have not been straightened; pre-development photographs; or, adjacent similar channels. Levees should not, for example, be constructed in a way that does not accommodate the beltwidth. Doing otherwise increases erosion potential and maintenance costs. Meander width is the amplitude of the meander within the beltwidth. It is smaller than the beltwidth. At a minimum, the average meander width of a channel should not be compromised in the lower flood plains. In the mid to upper slopes above the valley floor, where the natural channel may be fairly straight, the beltwidth should also be respected.

Factors that Affect Stream Stability

Several factors affect stream stability. They include stream topography, the width-to-depth ratio, and extent of channel incision.

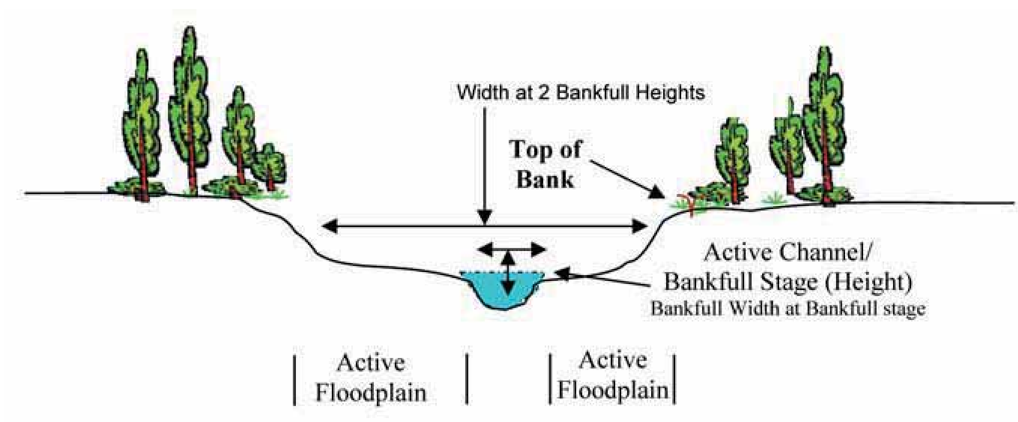
The quantity and movement of both water and sediment in a stream are two of the primary influences on the topography of a stream. These materials tend to balance each other within the confines of the stream channel. For example, erosion on one bank is typically balanced by sediment deposition on the other. While the location and extent of the erosion and resulting deposition may change over time, the width and depth of a stable stream does not change much. Thus, any type of erosion repair project must be designed to maintain width-to-depth ratio in order to ensure long-term stream stability, while also allowing the streambed to erode and fill naturally.

A channel's width-to-depth ratio is calculated by dividing the width of the stream channel (at the bankfull level) by the mean channel depth. Width-to-depth ratio is part of a more complicated concept called entrenchment ratio, which is important because it calculates a channel's stability. Generally speaking, it calculates its stability in terms of its floodplain—the larger the floodplain, the higher the entrenchment ratio. Specifically the entrenchment ratio is equal to the width of the stream channel (at twice the maximum bankfull depth) divided by the width-to-depth ratio of the bankfull channel.

In order to prevent channel incision and maintain a stable stream, the ratio of the width of the channel at 2 bankfull heights (see Figure 2) to the bankfull width should be a minimum of 2 where the channel is constrained. It should be a 3 to 4 ratio at other locations, both upstream and downstream.

This provides sufficient relief, and thus prevents excessive erosion of streambed and bank. It also prevents damage to bankside properties during 1 year–10 year storm events.

Figure 2. Determining the Appropriate Width to Depth Ratio



Effects of Water and Sediment Transport on Bank Stability

Streams adjust themselves to transport, as efficiently as possible, water and sediment from higher elevations to lower elevations. If the amount of sediment available to a creek is significantly increased or decreased, the creek adjusts its channel area or cross section to handle the change in sediment. In a normally-functioning gravel bed stream, for example, it is not uncommon for the stream channel (or portions of the stream channel) to downcut and refill significantly—from a few inches to 10 feet or more in a single storm event. This is one way streams transport their sediment loads, clean themselves, and temporarily increase their flow capacity.

With the expanded development in Santa Clara County, the time it takes for runoff to reach the streams has decreased, which leads to the increase in the amount of water in most streams. Some of the specific factors that have led to this increase in water flows are:

- Substantial increases in impervious surfaces such as pavement and roof tops.
- The routing of storm water runoff directly into streams through piped storm drain systems.
- Removal of large areas of streamside vegetation that would otherwise form buffers for runoff, and promote infiltration into the soil.

The stormwater management programs of local municipalities have efforts underway to address these long-term issues. In the interim, however, <u>it is important that armoring the channel be avoided on individual properties whenever possible</u>, for several reasons. First bank armoring prevents channels from adjusting to high flows, and can increase the probability of flooding. Bank armoring also causes accelerated flow velocities and turbulence along banks, which then induces more erosion on unarmored banks. Finally, because armored banks cannot adjust to changing stream conditions, they are prone to undercutting.

Importance of Vegetation and Riparian Buffers

The roots of well-established vegetation not only protect the surface of stream banks, but also penetrate deeply into the ground, helping to stabilizing it. Lack of vegetation close to a creek bank can contribute to slope instability and failure due to overbank drainage or soil saturation. In addition to providing bank stability, streamside vegetation filters pollutants; shades and cools the stream; increases infiltration; reduces flash runoff; and provides habitat for wildlife. <u>A variety of scientific studies of the minimum and optimum width of a vegetated buffer along a stream indicate that a width of 10 feet is not enough to provide adequate filtration or habitat.</u> A study by U.S. Fish and Wildlife indicates that in order to effectively remove pollutants, a buffer of 50 feet is needed. Other sources recommend a vegetated buffer that is 2 to 5 times the width of the stream channel. While there is ongoing discussion about the most appropriate width for vegetated buffers, it is conclusive that at least some adequate buffer is necessary to protect stream resources. <u>In terms of erosion repair projects, the use of live plants, either alone or in combination with dead or select rock materials, can be sufficient to prevent erosion, control sediment, and provide habitat.</u>

Stream Features That Are Important to Fish Habitat

The movement of water through a streambed creates certain natural characteristics or that benefit fish habitat. Some of these important features are riffles, runs, glides and pools. Riffles are located in shallow areas or bends in a stream where water flows over rocks. Runs are the straight sections between riffles. Glides are the transition areas between the downstream end of pools and a run or riffle. Pools are usually formed on the outside of bends in a stream. Deep pools are particularly import ant in providing critical fish habitat and refuge areas. When the flow in the stream decreases in drought, fish can retreat to these pools to wait for the return of higher flows.

These stream features described above differ from stream to stream depending on a stream's geometry and location. For example, at higher elevations, stream channels are steeper, narrower, and drop at faster rates, and may contain series of step-pool cascades. At a lower elevation, however, a channel tends to be less steep, wider, and more sinuous, making riffles and pools more common. The combination of riffles, runs and pools is extremely important for fish because it provides different feeding, spawning and/or nursery areas. These stream characteristics should be preserved, restored, and enhanced where possible, as appropriate to the stream topography, in any type of erosion repair effort.

SECTION 2 - CAUSES OF STREAM BANK EROSION

All streams erode to some extent as a part of natural processes. Natural erosion is typically caused by:
1) Hydraulic forces that remove bank material;
2) Geotechnical instabilities;
3) Or, most commonly, a combination of both these two forces.

Hydraulic Failures

Hydraulic failures occur when the force or velocity of the water is greater than the natural cohesion of the soil. In other words, the forces that bind the soil together are overcome by the water. Some visible features of hydraulic failures are erosion near the bottom, (or at the "toe,") of a stream bank, or alteration of the streambed. Changes in the direction of flow, constrictions, increases or decreases in the amount of sediment, and increased amount and duration of flow from impervious areas can all accelerate erosion of the stream bank or alteration of the streambed, and in turn, hydraulic failure. Some of the sediment that is introduced into the stream will naturally deposit on the bottom of the stream. Over time, this may raise the bottom of the stream and reduce the capacity of the active channel, forcing the water to spread out laterally. This causes erosion and steepening of the stream banks. This can also occur when a stream is starved of sediment (typically by dams or erosion control structures) and the excess energy that would have been used to transport sediment is now free to erode bed and banks. This condition typically occurs with the construction of hardened channel linings, or with the addition of other types of instream debris, sediment, or detention basins that trap sediment. In this case, the erosion (down-cutting and steepening) of the streambed and banks occurs below the lined section (or "instream basin"), causing the eroded sediment to settle farther downstream. Nonetheless, the impact on the stream is similar. Thus, for hydraulic failures, the most effective erosion repairs are accomplished by addressing the root cause of the failure, which may include installation of measures to redirect flow, increasing the erosion resistance of the bank, by planting vegetation on the bank or adding protection to the toe of the stream bank.

Geotechnical Failures

Geotechnical failures occur when gravitational forces are greater than the strength of the soil. These failures are usually caused by over steepened banks and/or excess moisture in the soil. This results in the movement of earth, better known as a landslide. Near a stream, the likely causes of this type of failure are a high groundwater table, poorly designed surface drainage systems (such as those that drain surface runoff directly over the top of the stream bank), leaking swimming pools, and leaking septic systems or water lines (which saturate the stream bank). Thus, for most geotechnical failures, what must be addressed is the source of the water that's causing excess moisture in the vicinity of the stream bank.

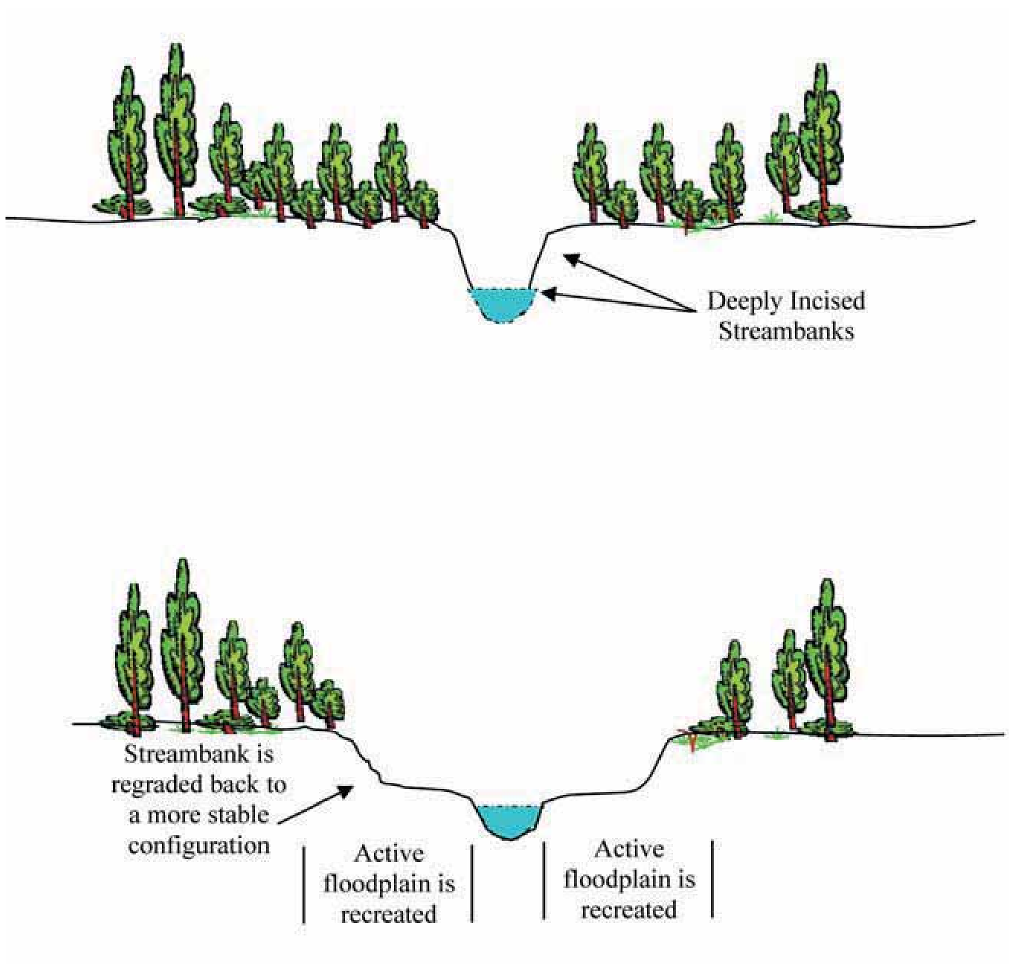
Combination Failures

The third type of failure is a combination of hydraulic forces and geotechnical instabilities. Hydraulic failures often lead to geotechnical failures. As the toe of the stream bank erodes, or the channel cuts downward because of hydraulic forces, the bank effectively increases in height and becomes too steep and unstable. Sometimes, the upper portion of the stream bank fails from lack of support, and slides into the stream. This process is well described in the document *Maintaining Corte madera Creek: A Citizen's Guide to Creek-side Property Protection*, which was prepared by Phil Williams and

Associates in Collaboration with H. T. Harvey and Associates for the San Francisquito Creek Joint Powers Authority. They write, "The higher a bank is, the flatter the angle must be to prevent slumping. For example, most soils will support a three-foot high vertical bank, but if the river cuts a deeper channel (say five feet) the bank will collapse under its own weight. A five-foot tall bank would need to be graded to a lower gradient to be as stable as a three-foot vertical bank, and a ten-foot high bank would have to be excavated to an even lower gradient to be stable. The higher the bank, the lower the stable gradient becomes." The best remedy for this problem—the problem of an over-steepened bank experiencing both hydraulic and geotechnical failures—combines several steps. The first step involves regrading the slope to a more stable angle, which is why it is called "laying it back." The second step involves reinforcing the toe, where necessary, with biotechnical methods such as logs and rocks. The third step involves reducing erosive energy on the bank by planting the bank, so that it does not become over-steepened again.

For an illustration, see figure 3 below.

Figure 3: Laying Back a Streambank to Increase Stability



BANK PROTECTION/EROSION REPAIR GUIDE PART TWO:

TECHNIQUES AND GUIDANCE FOR DEVELOPING A WATERSHED-FRIENDLY EROSION REPAIR PROJECT.

SECTION 3 - EMBARKING ON YOUR BANK PROTECTION/EROSION REPAIR PROJECT

This section describes five initial steps to consider in undertaking an erosion repair project. This text borrows extensively from the guidance manual developed for the Guadalupe and Alamitos Creeks entitled "Stream-bank Repair Guidance Manual for the Private Landowner," which is cited in the references section.

Initial Steps
Step 1: Establish the Purpose and Necessity of Your Project
Step 2: Hire Qualified Professionals
Step 3: Get to the Root of the Problem
Step 4: Seek Assistance from the Water District
Step 5: Secure Permits from the Appropriate State and Federal Agencies

Step 1. Establish the Purpose and Necessity of Your Project

Repairing a stream or bank erosion problem is not a simple or routine task. The root cause of the bank failure must first be identified. Then, the most probable stable channel form and dimensions must be determined, based on geomorphology and hydrology, as well as hydraulic analyses. Only then can a proper solution or repair be recommended.

Before embarking on any bank stabilization/erosion repair project, it is important to answer the following questions: What is the purpose of this project? What are its objectives? Is it necessary?

Some examples of objectives could include:

- Protecting property or structures
- Restoring eroded banks
- Protecting existing banks from erosion
- Restoring riparian habitat and improving stream function

Determination of the project's necessity must take into account the fact that some erosion is natural and acceptable. For example, the exposure of roots on a streamside tree is natural, and unless extreme, it will not hurt the tree. If the bank height is less than about eight feet, what is easily perceived as bank erosion may be only temporary, or even reverse itself as the stream meanders in its floodplain. Some erosion repair activities, such as bank armoring, can destabilize other areas erosive forces are transferred downstream, or onto opposite banks, eventually causing additional problems. <u>A qualified professional may be needed to help determine whether, and to what extent, erosion is in need of repair.</u>

Step 2. Hire a Qualified Expert to Determine the Appropriate Design

Designing an erosion repair project that maximizes stability and avoids unintended consequences is complicated. As noted earlier, a stream must have a properly dimensioned bankfull channel in order for it to have long-term stability. Other critical factors in proper channel design include: proper width to depth ratio, water velocity, sheer stress, and channel slope. Most property owners do not have the training or expertise necessary to incorporate all of these considerations into project design.
A walk along many Santa Clara County streams proves this point. It reveals many examples of

how individual property owners, without professional help, tried to control streambank erosion by armoring the bank. These measures often fail to address the need to reduce shear stresses in order to keep the bed and banks from eroding. Eventually, the channel will downcut, and in most cases, fail. Professionals can help avoid this kind of failure-prone approach to streambank repair and help identify and address the root cause of the problem.

Step 3. Identify the Source of the Problem

It is important to identify and, if possible, address that the source of streambank or bed erosion. If it is not addressed, the erosion repair project may either need to be repeated or expanded in the future, or cause other erosion problems upstream, downstream, or across the stream. To identify a potential source, one should look for:

- Flow constrictions like bridges or debris that increase downstream velocities and shear stress,
- Existing hardscape, or paved over areas, that may be increasing velocities downstream,
- Natural or non-natural debris that may have redirected the flow into the bank,
- Drainage features that may be directing flow onto, or saturating, the bank,
- Watershed-wide increases in amount and duration of runoff that may be causing systematic degradation of the creek channel (incision), which leads to toe failures and bank slumps.

These underlying causes of erosion could be natural features or constrictions, but most likely, they are non-natural, i.e., human-made. Oftentimes, the source of the problem is an earlier effort to address an erosion problem upstream or downstream. Depending on the extent of the problem, it may be worthwhile for the property owner to consider a collective effort with neighboring property-owners, perhaps even including government and/or public agencies who own land or rights-of-way in or near the stream.

Because actions taken to address erosion in one place can cause problems elsewhere, permit applicants should consider the potential impacts on both the downstream and upstream streambed and banks when determining the type of erosion repair measure to use. To this end, property owners may be asked to provide professional analyses of stream geomorphology and/or hydraulics to determine potential negative impacts, and recommend ways to prevent them.

Step 4. Seek Assistance From the Santa Clara Valley Water District (SCVWD)

For SCVWD's assistance in conducting repair or maintenance, contact the SCVWD's Watershed staff at 408.265.2600. There are three different scenarios related to ownership and easement that determine assistance eligibility:

SCVWD Right of Way: If the District owns the property where the stream is located, District staff will visit the site to inspect the erosion, determine if and how it should be addressed, and then, if need be, take appropriate measures to do so.

SCVWD Easement: If the District has an easement on the section of the stream needing repairs, District staff will visit the site to inspect the erosion. Easements generally provide the District with the necessary rights to perform the work. The District can make repairs within an easement after assessing the extent of the erosion, the infrastructure affected, the available funding, and the need to conduct other work on District property.

Private Ownership: If the stream is under private ownership, District staff is generally available for a visit to the site, however this availability will depend on the number of requests received and staff resources. Staff can provide advice on an approach to use but, the District will not design or construct the project.

Requests for technical assistance for minor erosion repair work can be submitted to the District via their web site at http://www.valleywater.org/Water/Watersheds_-_streams_and_floods/Taking_care_of_streams/Service_request_form.cfm. To negotiate an agreement for assistance on a substantial repair project, contact the District's Watershed staff at 408.265.2600.

Step 5. Secure Permits from Federal, State and/or Local Resource Agencies

Most erosion repair projects will require permits from federal, state and/or local regulatory agencies if they entail construction between the banks of a stream. Please refer to the Resource Agency Referral List in Section 6 of this Design Guide for a list of all the agencies, the types of activities for which they should be contacted, and their contact information. The San Francisco Bay Area Joint Aquatic Resource Permit Application (JARPA) consolidates the information that permitting agencies require into a single application. The JARPA application can be found at:
http://www.abag.ca.gov/bayarea/sfep/projects/JARPA/JARPA.html

The permitting process can take as little as a few weeks to complete, but typically takes a few months, depending on the complexity of the project and the presence (or potential presence) of federal of state listed endangered, threatened or special status species of plants or animals. Typically, the U.S. Army Corps of Engineers, the Regional Water Quality Control Board, and California Department of Fish and Game will issue permits under federal and state laws, while the Santa Clara Valley Water District or the local municipality acts as the local permitting agency.

Important Note: Bank repair designs that avoid or minimize hardscape and are based on sufficient analysis of the cause of failure and stable channel characteristics almost always receive permits more readily than those that do not. Do not hesitate to contact agency representatives early in the design process to determine whether you need a permit from their agency, and to discuss potential repair options if you do.

Use Vegetation to Restore and Maintain Stability

Revegetation of the streambank is one of the most common, and often the most effective, way to prevent erosion along a streambank. This is because roots bind soils together, which prevents erosion, while leaves provide protection from rain splash erosion. In addition, the exposed trunks and stalks provide resistance to stream flow because they slow the water and decrease its erosive energy. An added benefit is that vegetation provides ideal habitat for birds and other animals. Vegetation planting methods commonly used include cuttings, transplants, live staking, and direct seeding (including hydro-seeding).

- **Maintain streamside trees**. Avoid pruning trees unless it is necessary to the survival of the plant or the protection of existing property and/or infrastructure as trees can critical shelter and shade for stream wildlife.
- **Do not remove affixed logs**. Logs that have been permanently or securely affixed to the streambank provide valuable habitat. Their removal could negatively impact fish habitat, and might therefore require mitigation. However, downed trees and logs can often deflect high flows, causing serious bed and bank erosion, destroying fish habitat, and degrading water quality. For these reasons, downed trees and logs need to be removed quickly.
- **Plant between October 15 and March 15**. In order to minimize irrigation requirements and ensure that plants receive sufficient water for natural propagation, plant in the fall and early winter. Where soils are dry and water is limited, irrigate as needed until the rainy season.
- **Do not introduce invasive non-native vegetation species into the watershed.** Non-native invasive plants are a serious problem because they often inappropriately constrict water flows and overtake native plant species. (See Design Guide 2 for more on invasive non-natives.
- **Instead, use locally collected native species for revegetation and replacement plantings**. Plant selection and density should be informed by a survey of natural areas on the same creek that have a similar ecological setting. This can inform you as to what species would be found in the area and an approximate population density. See Design Guide 4 and 5.
- **Plant according to moisture needs, using different types of vegetation on the upper and lower sections of the stream bank**. Plants have different tolerances for the wet conditions at the toe of slope. They also vary in drought-tolerance and erosion-control effectiveness on the upper slopes. Some tree species, such as willows and cottonwoods, are more successful when they are closer to the stream. Others, like oaks, enjoy more success higher up the bank. Where stream capacity is an issue for flood protection purposes, choose vegetation that is flexible and that will not collect debris and slow high flows during flood events.
- **Use fast-sprouting grass species for more immediate erosion control**. A regraded slope can be seeded with fast-sprouting grass species such as sterile wheat, or better yet, a native grass/sedge seed mix combined with a biodegradable erosion control blanket. These species provide more immediate erosion control. See Design Guides 4 and 5 for plant species.

- **Do not use chemical fertilizers, herbicides or pesticides**. These chemicals can be easily transported to the creek by wind or rain and degrade water quality, endangering aquatic life.

Watershed-friendly Design: Best Management Practices

This section provides some tips for stream care during construction. Proper use of best management practices (BMPs) can have a tremendously beneficial impact on aquatic species and other wildlife, human health, environment, property, and public services.

Construction BMPs:

- When restoring a damaged section of a streambank, imitate natural stream features, such as channel meanders, appropriate width and depth, and vegetation. This will stabilize the channel. Details of this concept are included in Section 5 of this Design Guide.
- Observe work windows. In-channel work should generally be conducted during the dry season, between June 15th and October 15th, to minimize a negative impacts to plant and wildlife. Sometimes these dates will vary depending on the wildlife species in the area. Do not use heavy equipment during spawning or migration seasons, as it can destroy fish habitat. If construction during periods of stream flow can not be avoided, include measures to separate area of disturbance from stream flow to minimize turbidity in stream.
- Avoid removing in-stream gravel. Avoid disturbing the creek bed, particularly spawning gravel. After project completion, replace or restore any gravel that was moved or removed to maintain spawning areas for fish.
- Take special care when establishing stream access points, because these points can contribute undesirable sediment to the stream. So
    - Use established access point wherever possible.
    - If it is necessary to create a temporary access point for construction, do so as close to the work area as possible in order to minimize adverse impacts. When the project is complete, restore the access point to as natural and stable condition as possible.
    - Prevent soil at construction entrances from being tracked onto streets near work sites.
- Control dust. Dust can be a nuisance, and have an adverse impact on water quality. To control dust:
    - Water active maintenance areas so that they are sufficiently moist to prevent dust.
    - Sweep any paved access roads of visible soil material.
    - Cover trucks hauling sediment, ensure that their tailgates are closed, and brush off any excess dirt.
- Store and secure materials. Remove all building materials, debris, lumber, et cetera within 2 days of completing the project.
- Be wary of mercury and other contaminants. Disturbed or excavated soils in areas where soils are known to contain mercury or other contaminants should be removed or properly capped if the soil will be exposed to flood flows. In areas whose soils are known to contain mercury, remediate the disturbed or excavated soils if they are exposed to flood flows. Wear protective equipment.

Consult the Santa Clara Valley Water District for disposal guidance.

Follow-Up Maintenance:

Do not neglect stream-bank repair after construction is over. Minor maintenance activities help ensure a project's success.

- Remove trash and debris. Sometimes, the accumulation of debris in the channel causes erosion on nearby banks. So:
    - Regularly remove debris such as trash and human-caused debris.
    - Do not put yard waste in the creeks or on the banks, where leaves and clippings can wash into the stream.
- If mulching:
    - Use biodegradable erosion control blankets on bare slopes or if it is too late in the season to establish vegetation. The blankets will last for 1 to 3 years while natives reseed. Monitor the success of natural revegetation before taking aggressive action to revegetate.
    - Woody debris from the site might make for suitable mulch.
    - Use bark and other wood products or fabric blankets above the high water line to prevent erosion of bare soil after construction is completed.
    - Use weed-free certified mulch.
    - Do not use Eucalyptus, Walnut, or Tree of Heaven. They produce an allelopathic compound that can be toxic to plants and aquatic organisms.
- Be careful when trying to control rodents. Burrowing rodents may be a nuisance and can damage levees on streams, <u>but do not use rodenticides</u>. Their effect on the local habitat is too destructive. Instead, consult County Vector Control.
- Revegetate. In areas that have been revegetated, replace dead or dying plants and weeds. Remove non-native plant colonizers. Ensure that all plants receive sufficient water.

SECTION 5 - DETAILED DESCRIPTIONS OF EROSION REPAIR TECHNIQUES

Described in this section are 16 different types of erosion repair methods. Each description contains a brief overview of the repair method, the circumstances in which it is most appropriate, its anticipated environmental value, its relative costs, and its potential impacts. Descriptions are not exhaustive, and should only be used in conjunction with consultation from a qualified erosion repair professional, the Santa Clara Valley Water District, and relevant regulatory agencies.

Even the most well-meaning erosion repair designs can have negative impacts on a stream if they are not planned, designed, and constructed properly. Poorly placed rocks or woody material can cause bed and bank scour/erosion, excessive sediment deposition, and/or decreased channel capacity. For this reason, it is essential that the project is designed to accommodate the site's particular geomorphic location, channel form and depth, flow velocity, and site constraints. This typically requires a physical, or "geomorphic" assessment by a trained professional.

To protect both your property and its value, the goals of any streamside bank protection or erosion repair project should be to restore stability and leave the site in a better ecological condition than it was before. The first erosion repair method, the modified flood plain, will provide the best long term, ecologically friendly and most stable results. Methods 2 through 8 use bioengineering methods. Bioengineered bank stabilization methods typically involve two components:

- Regrading the upper streambank to establish or re-establish a floodplain, with terraces where possible.
- Planting native riparian vegetation on the streambank and terraces in order to restore and provide long-term stability.

If soft methods of protection are not feasible due to highly erosive forces, then there is probably a channel dimension, hydrology and/or morphology problem. Hard bank protection can cause more erosion and damage in the channel, along the downstream and/or upstream banks, as well as on the opposite bank of the repair site. Any consideration of the use of hardened materials should be with caution and with an assessment of the impacts that may occur.

Erosion repair methods 9 thorough 11, incorporate bank armoring which should be avoided. The use of log and rock flow deflecting structures as described in method 1 is less expensive and a more environmentally friendly way of protecting banks from erosion. Detailed guidance of these methods is beyond the scope of this Design Guide but should be considered by the design professional.

Erosion repair methods 12 through 16 are <u>NOT</u> recommended. However, they may be necessary when the site is constrained, or where the water volume, velocity, bank steepness, and resultant erosive forces necessitate the use of more extreme methods.

Table 1: Preferred Erosion Repair Methods

Repair Method	Appropriate Slope	Appropriate Water Velocity	Environ Value	Cost
1. Modified floodplain	Varies	Varies	Positive	Low
2. Slope Grading with Vegetation	2:1 or flatter for vegetation section, 1.5:1 or flatter for boulder section.	Low – typically up to 6 ft/sec	Positive	Low
3. Erosion Mats	2:1 or flatter for erosion mat section, 1.5:1 or flatter if boulders used.	Generally 1-7 ft/sec but can go up to12ft/sec if vegetated.	Positive, if planted.	Low
4. Contour Wattling		Low	Positive	Low
5. Brush Mattresses	2:1 or flatter for erosion mat section, 1.5:1 or flatter if boulders used.	Low	Positive	Low
6. Brush Layering	2:01	Medium	Positive	Low
7. Vegetated Geogrids or Soil Lifts	Up to 1:1	Medium	Positive	Low
8. Root wads and boulders		Medium: (10 ft/sec or less)	Positive, if planted	High
9. Boulder/ Rock Revetment	Up to 1:1, preferably 2:1.	High: up to 15 ft/sec; less where voids in boulders are planted.	Negative. Negative to Neutral, if planted	Medium
10. Cellular Confinement System	Up to 0.5 to 1	Medium to High:5-21 ft/sec depending on vegetation)	Neutral	Medium
11. Live Log Crib Walls	Up to 0.25:1	Medium: up to 12 ft/sec or less	Neutral to High, if planted	High

#1: Modified Floodplain

How to Create a Modified Floodplain

The modified flood plain design provides the optimum solution for long-term, ecologically-friendly, and less expensive stability. In urban areas property owners typically have short stretches of stream running through their property and often only on one side of the stream. The cooperative enlisting of neighbors to affect this approach is well worth the effort. The typical steps in creating a modified floodplain are:

Step 1: Identify the appropriate channel width and depth, at bankfull level. The active channel will contain flows resulting from small frequent rainfall events.
Step 2: Identify the appropriate elevation for the floodplain area, and determine how much space is available and appropriate for widening the banks.

Step 3: Regrade or lay back the existing bank above the floodplain to a flatter, more stable angle (usually a 2 horizontal to 1 vertical slope, or greater);
Step 4: Create terraces above the active floodplain to accommodate vegetation
Step 5: Plant the terraces with appropriate local, native, riparian vegetation to stabilize the bank(s) and create habitat.

How to Create a Modified Floodplain in Deeply Incised Channels

A watershed-friendly design that recreates a natural floodplain is depicted in Figures 4 and 5 below:

Figure 4: Stream channel with deeply incised streambanks

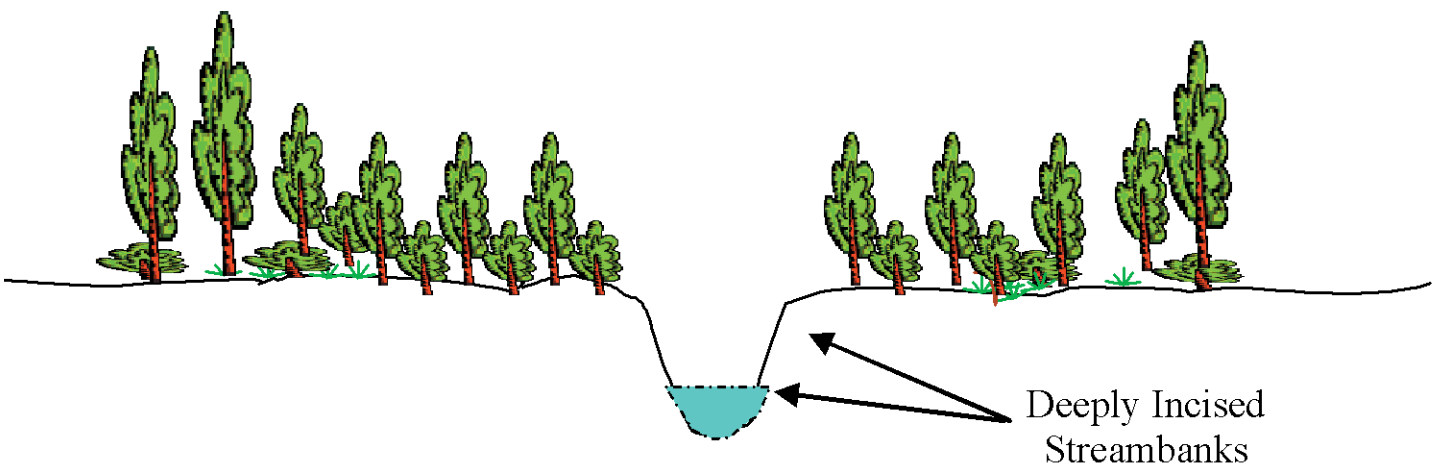
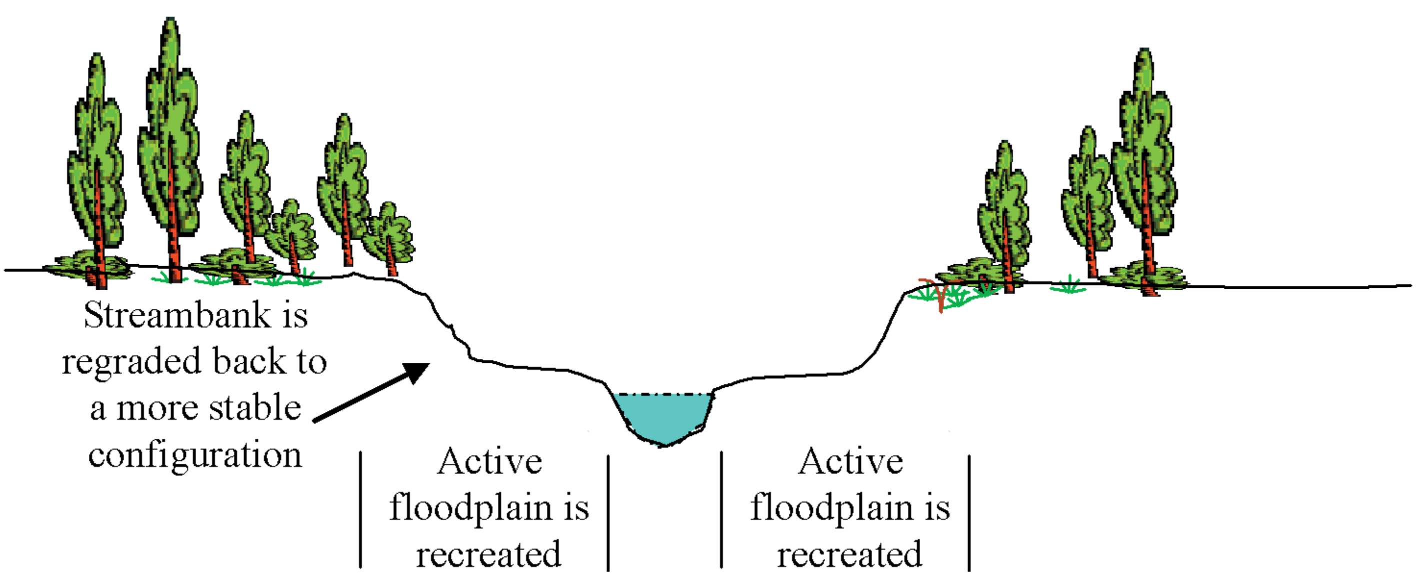


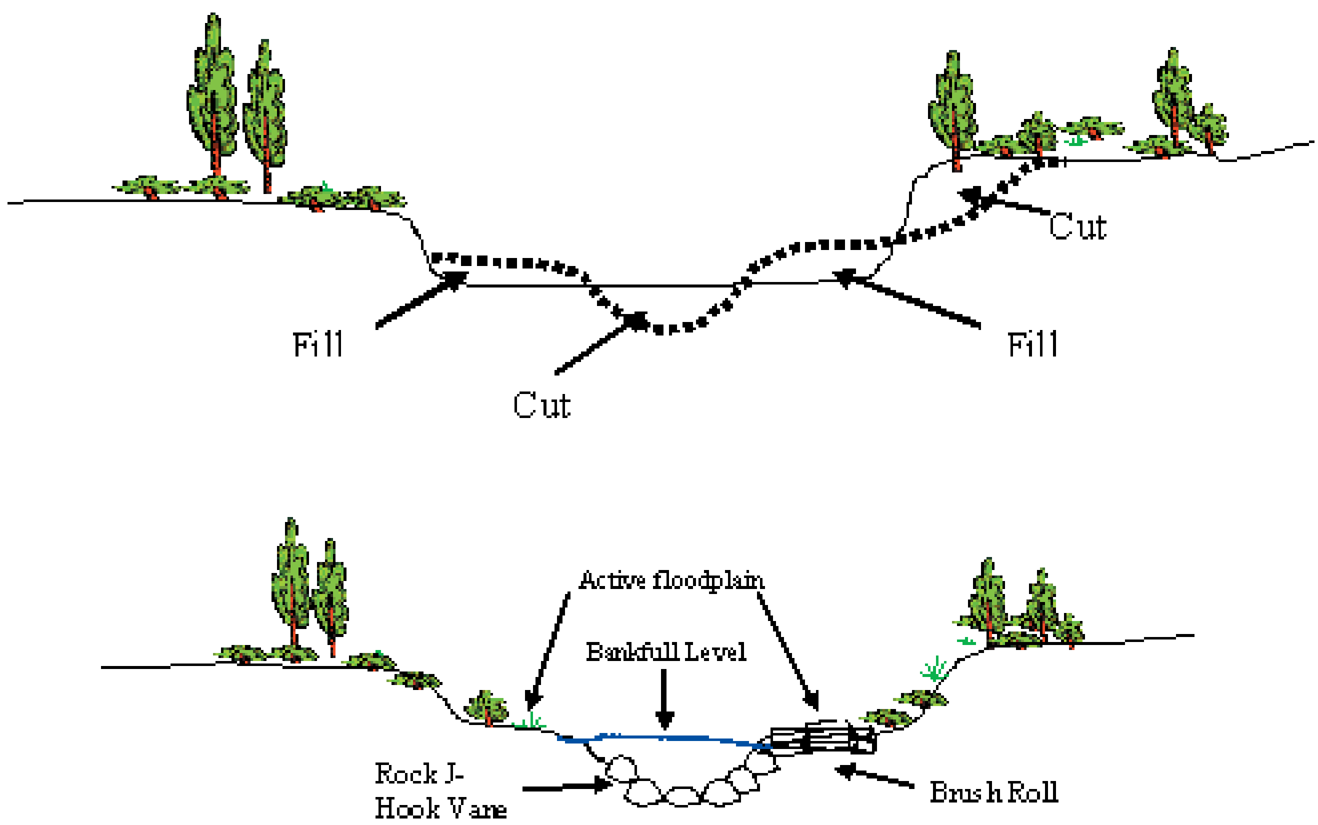
Figure 5: The same stream channel as Figure 4, but stream banks have been regrades to create terraces where vegetation can be planted



How to Create a Modified Floodplain In Broad Flat Stretches with Sediment Deposition

In some cases, a stream may have experienced heavy sediment deposition overthe years. In contrast to the deeply incised channels, with heavy sediment deposition tend to be wide, shallow and rather straight. Although there may have been fish present at one time, the shallow flows make it difficult for them to return. Where there is room, it is important to restore the nature meanders if possible.
Figures 6 below shows a stream prior to a stream restoration project. As you can see, the channel was wide, shallow and rather straight. The bottom drawing shows that the channel was made narrower and constructed with a proper width/depth ratio at the bankfull level. This helped assure the proper transport of sediment through the area by increasing velocities in the active channel. The active channel was moved away from the right bank and into the center of the channel corridor, creating deep pools for steelhead trout and salmon. Brush rolls were used on the top of the right floodplain to accumulate fine sediment and the right vertical stream bank was sloped back and vegetated.

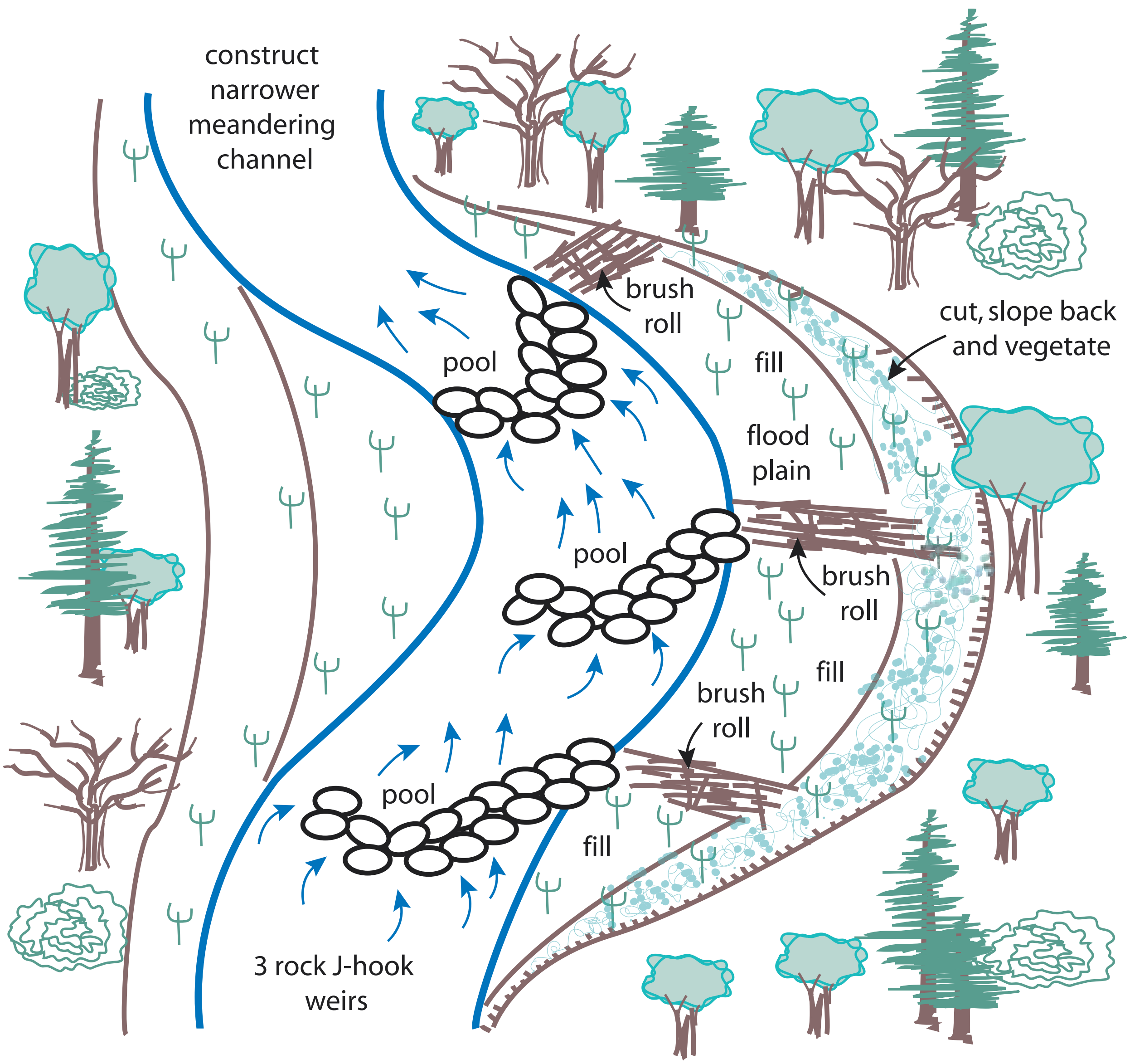
Figures 6: Stream Channel Cross Section View



Possible Variations on the Floodplain Approach

Restoring Natural Stream Meanders

Where there is sufficient room in the stream channel, it can be very helpful to modify the channel in a way that restores natural stream meanders. The diagram below shows how a creek channel can be narrowed and reformed with more meander. As noted earlier, a proper width/depth ratio at the bankfull level is created and a modified floodplain can be constructed. In this example, three J-Hook rock structures were installed with brush rolls on the right bank floodplain to divert the water away from the bank and into the center of the channel.



Additional Toe and Bank Protection for High Flow Velocities or Confined Areas

In the uncommon situations where water velocities are especially high, or where a structure is threatened by its proximity to the bank, additional protection or a hybrid approach may be desired. Placement of rock boulders at the toe of the slope, along with placement of riparian branch cuttings such as willows into the spaces between the boulders into the soil or earth-filled mats can accomplish this goal. Another hybrid approach is to use cellular confinement or rock on the lower slope, and the upper slope can be graded back to a less steep slope and revegetated The rock must be keyed into the streambed to prevent undercutting and failure of the rock slope protection.

In the cases noted above, the use of bank armoring is likely to cause more problems than it will solve, because it will not address the root cause of the problem. Instead, efforts should be made to reduce the water's velocity, or redirect it away from the bank using j-hook weirs or vanes.

Use of Grade Control Structures

While efforts should be made to construct floodplains/flood benches and to consider hybrid alternatives, it is also important to consider whether a project should be addressed using a grade control structure. For example, sometimes bank erosion is a result of channel bed incision, which increases the height of a bank and reduces vertical support. If a channel is highly incised, simply regrading the slope may not be sufficient in the long-term, and the project will need to address grade control in order to stabilize the bank effectively. A variety of structures can be used, such as log or rock weirs, Newberry weirs, and vanes, in order to encourage sediment deposition and stabilization of the bed.

Use of Deflectors

Finally, in some cases it may be most appropriate to use smaller structures designed to redirect high velocity flow away from eroding banks and into the center of the channel. Examples include spurs, kickers, deflectors, vane dikes, etc., and they should be considered as a way to train flows and reduce the amount of engineered bank protection. The photographs below provide some guidance on how and when these devices can be used. Detailed guidance of these methods, however, is beyond the scope of this Design Guide but should be considered by the design professional.

For a rock cross vane structure, boulders are placed in an upside down "V" shaped structure in the stream. This "V" shaped design serves to slow water velocities near the banks and direct the flow toward the center of the stream. The banks then become depositional areas, instead of erosion areas. At the same time, the increased velocities in the center of the channel actually increase the channel's flow and sediment transport capacity, reducing the risk for infrastructure flooding during high flow events. Finally, the rocks in the center serve as a channel grade control. The drop-off just downstream of the rocks creates a deep hole, which slows flows and can provide an excellent fish hold and hide habitat even at very low flows.

The rock J-hook structure is used to protect one side of the river bank by directing flows from that side to the center of the stream. As with the rock cross vane structure, the increased velocities in the center of the channel increase the channel's flow and sediment transport capacity and the deep hole is created for fish habitat.

Additional Toe and Bank Protection for High Flow Velocities or Confined Areas

In the uncommon situations where water velocities are especially high, or where astructure is threatened by its proximity to the bank, additional protection or a hybrid approach may be desired.

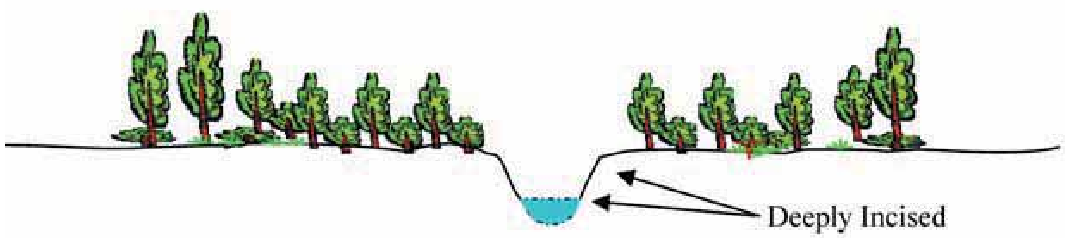
Photograph 1: Rock Cross Vane Structure:

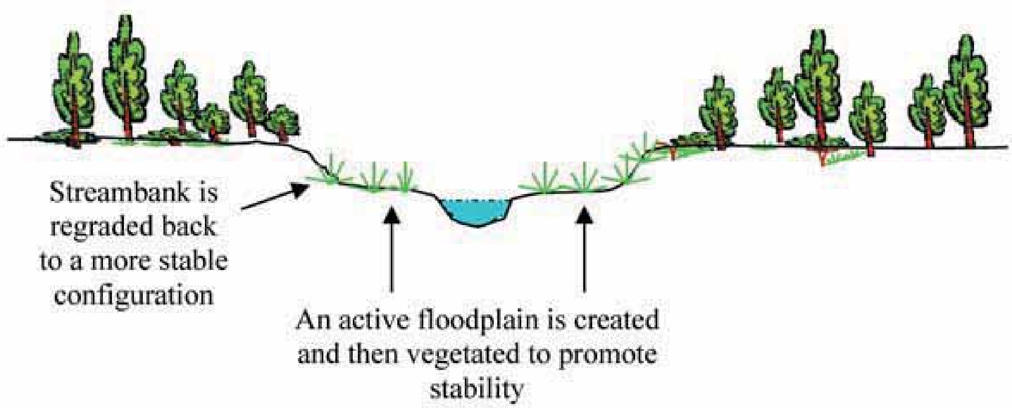
Photograph 2: Rock J-Hook Structure:

How to Create a Modified Floodplain In Broad Flat Stretches with Sediment Deposition

In some cases, a stream may have experienced heavy sediment deposition over the years. In contrast to the deeply incised channels, channels with heavy sediment deposition tend to be wide, shallow and rather straight. Although there may have been fish present at one time, the shallow flows make it difficult for them to return. Where there is room, it is important to restore the nature meanders if possible.

Figures 6a and 6b below shows a stream prior to a stream restoration project. As you can see, the channel was wide, shallow and rather straight. The bottom drawing shows that the channel was made narrower and constructed with a proper width/depth ratio at the bankfull level. This helped assure the proper transport of sediment through the area by increasing velocities in the active channel. The active channel was moved away from the right bank and into the center of the channel corridor, creating deep pools for steelhead trout and salmon. Brush rolls were used on the top of the right floodplain to accumulate fine sediment and the right vertical stream bank was sloped back and vegetated.





#2: Slope Grading with Vegetation and Floodplain Terraces Space Permitting

This is perhaps the least engineered, and often most effective, method of long-term bank repair, because it restores the natural contour and vegetative cover of the stream bank. If the bank is undercut or has slumped to a vertical face, consider matching the grade of a nearby stable slope. Usually a 2 horizontal to 1 vertical slope is considered stable for many soil types, and if space allows, a 3

How to Create a Modified Floodplain In Broad Flat Stretches with Sediment Deposition

In some cases, a stream may have experienced heavy sediment deposition over the years. In contrast to the deeply incised channels, channels with heavy sediment deposition tend to be wide, shallow and rather straight. Although there may have been fish present at one time, the shallow flows make it difficult for them to return. Where there is room, it is important to restore the nature meanders if possible.

Figures 6 below shows a stream prior to a stream restoration project. As you can see, the channel was wide, shallow and rather straight. The bottom drawing shows that the channel was made narrower and constructed with a proper width/depth ratio at the bankfull level. This helped assure the proper

Figure 9a: Slope Grading with Vegetation

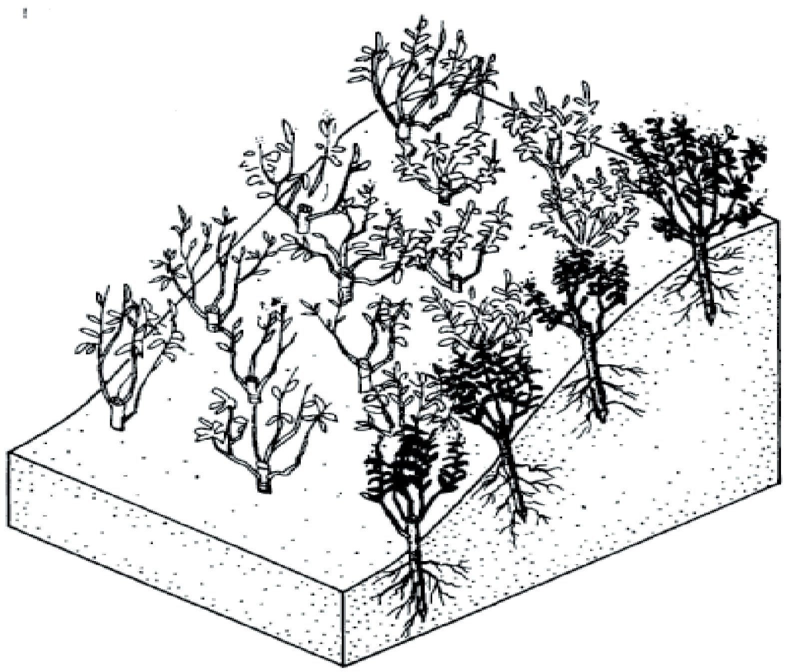
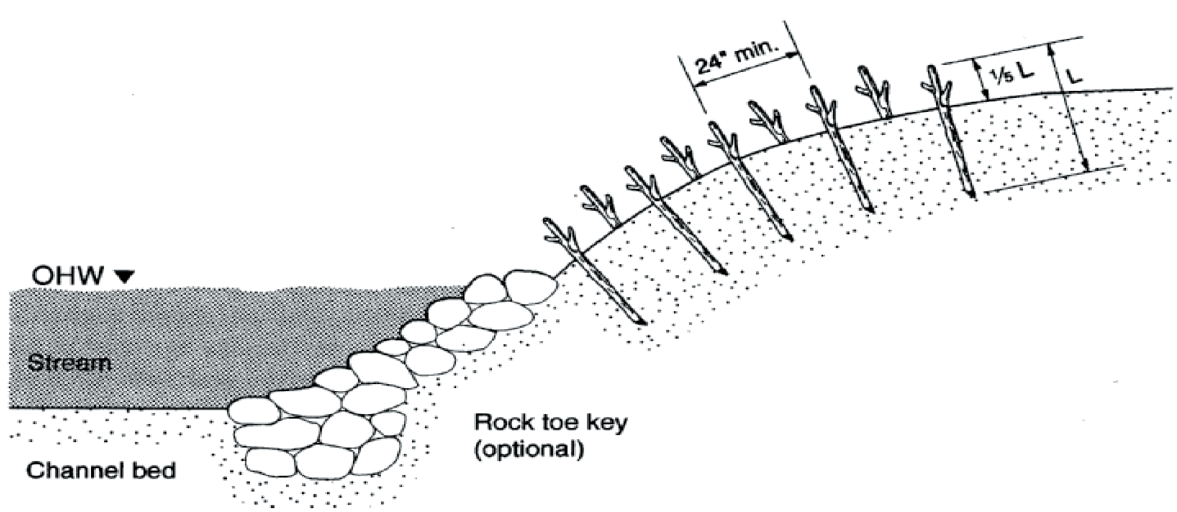


Figure 9b: Cross Section of Slope Grading with Vegetation and Rock Toe Protection



(for definitions and diagrams of bankful and other terms, see page 5)

#3: Erosion Mats

This method consists of securing geotextile blankets made of biodegradable materials like jute or coconut fiber to channel banks using stakes or staples. Biodegradable fabrics are preferable to plastic because they do not inhibit plant growth, or act like a net if they are dislodged during a storm. The erosion mats provide soft armor protection against erosive forces and are combined with live staking and direct seeding. Abrasive sediment, debris, foot traffic, and sunlight will slowly wear, snag, and tear these fabrics, potentially undermining the structure. That's why erosion mats are intended to be only the foundation of a *vegetated* erosion control system. In other words, the establishment of vegetation is crucial to the long-term success of erosion mats.

Design Considerations:

- Toe protection may be required where significant toe scour is anticipated.
- The bank must be smooth before installing blankets to ensure adequate contact and prevent subsurface erosion.
- The erosion mats must be installed according to manufacturer's instructions in order to prevent failure.

#3a: Erosion Mats with Boulder or Log Toe Protection

This method consists of grading the lower portion of the eroded slope at a maximum of 1.5:1. The upper portion of the slope is then graded at a minimum slope of 2:1 and smoothed to ensure that the whole erosion mat contacts the soil. Appropriately-sized boulders are placed at the toe of the rebuilt bank up to the bankfull discharge water elevation, or even slightly higher. Voids between the boulders can be planted using live stakes.

Design Considerations:

- Best for bank slopes of 3:1 or steeper
- Boulders must be keyed in (min. 3 feet) at the toe of the bank.
- Boulder placement must not constrict the channel cross section or reduce the width-to-depth ratio. Otherwise, the repair will likely destabilize the channel.
- The placement of boulders or armoring along the bank may increase turbulence in the area and other areas downstream. This could increase erosion.

#4: Contour Wattling (Fascines)

This method consists of tying long bundles of plant cuttings (typically willows or cottonwood) together with twine and anchoring them in shallow trenches, parallel to the stream, with wooden stakes. When the cuttings develop root systems and mature, the plants provide structural soil stability. This technique is generally used to manage surface erosion. It works well in straight stream sections and wherever flow velocity is low.

Design Considerations:

- The long bundles trap and hold soil on banks by creating small, dam-like structures, effectively segmenting the slope length into a series of shorter slope lengths.
- This method enhances the opportunities for locally native species to colonize and therefore should, where appropriate, be used with other soil bioengineering systems and live plantings.
- Reinforcement at the toe of bank may be a limiting factor.
- Contour wattling does <u>not</u> work well in locations where slopes are undergoing geotechnical failure.

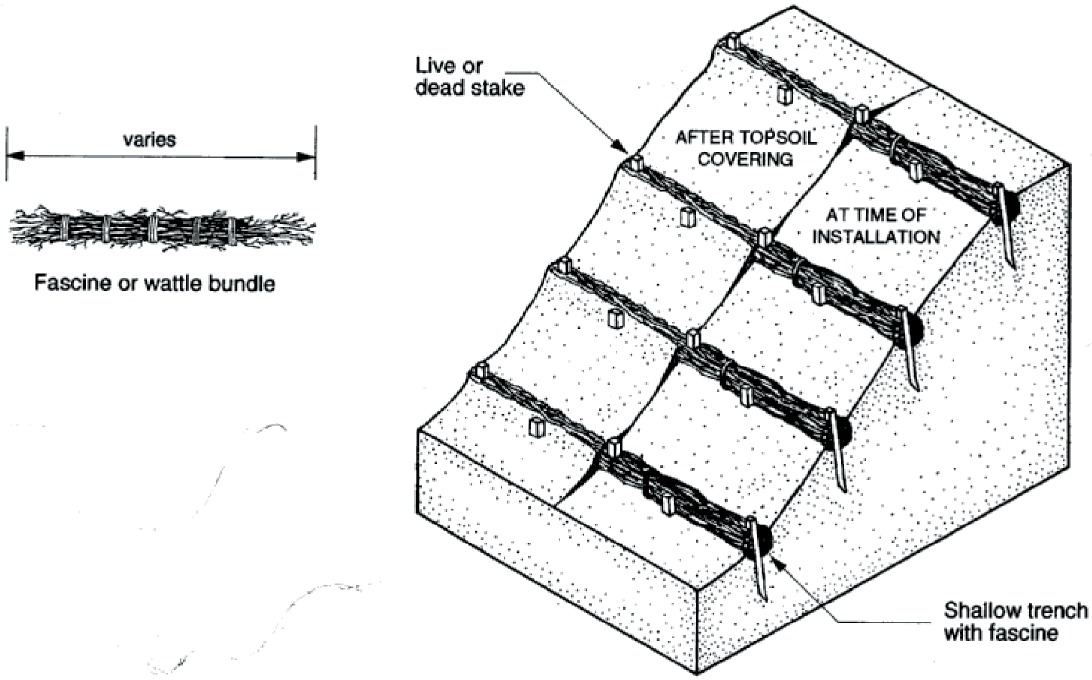
#4a: Contour Wattling with Boulder or Log Toe Protection

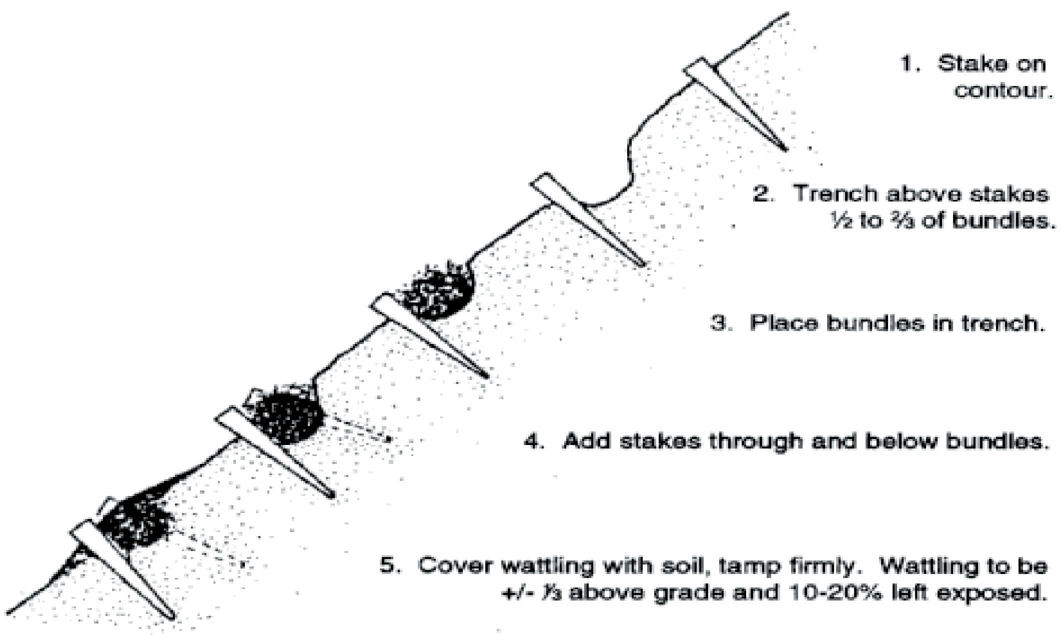
Appropriately-sized boulders are placed at the toe of the rebuilt bank up to the bankfull discharge water elevation or slightly higher. Voids between the boulders can be planted using live stakes.

Design Considerations:

- Boulder placement must not constrict the channel cross-section or reduce the width-to-depth ratio. Otherwise, the repair will likely destabilize the channel.
- The placement of boulders or armoring along the bank may increase turbulence in the area and other areas downstream, which could increase erosion.

Figure 10: Contour Wattling





#5: Brush Mattress

First, the bank must be prepared. The eroded slope is graded and smoothed to ensure that all willows are in contact with the soil. Then, a deep trench (2 ft. min) is dug at the toe of the bank for the butt ends of the willow branches. Wood, steel, or live willow stakes are partially driven into the soil in rows, on three foot centers, in the area that will be covered by the mattress. After the stakes have been placed, live willow branches are put on the bank with their butt ends in the trench. Straight branches no shorter than four-feet in length and .5 to 1" in diameter are used. If the branches are not long enough to reach the upper end of mattress, several layers may be used; however, it is necessary to "shingle" the layers by lapping each new layer over the one below by at least 18".

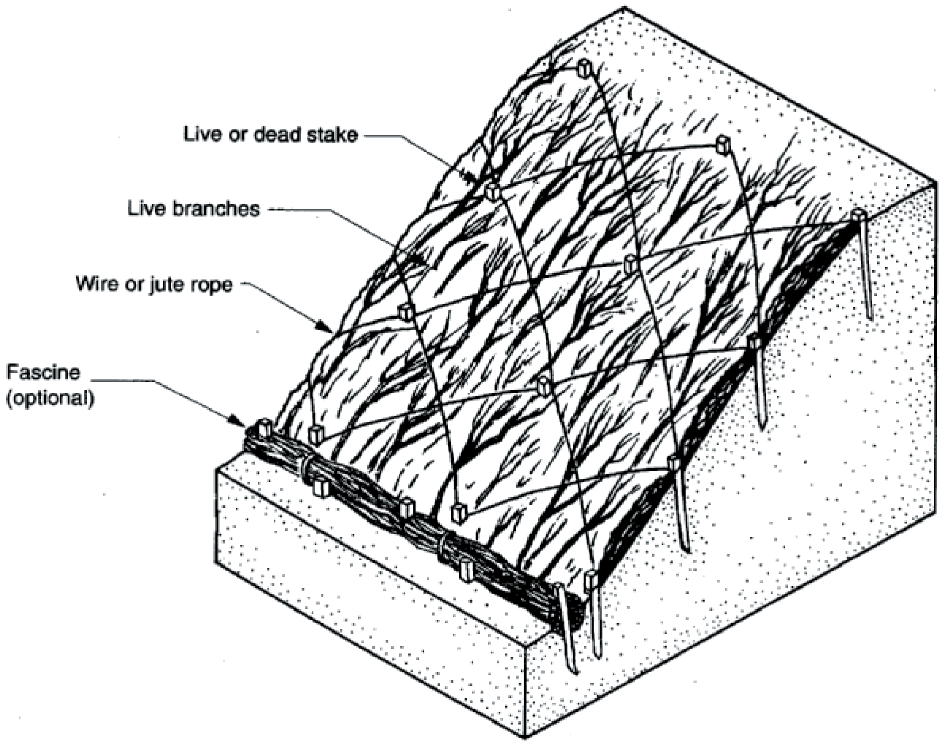
Once the bank is covered by a thick layer of willows, cross branches are placed horizontally over the bottom layer. These branches are placed against the stakes and then tied to the stakes using wire or string. The stakes are then driven into the bank at least two feet deep. After the completion of the mattress, the toe trench is filled with appropriately-sized boulders and rocks to anchor the butt ends of the branches. The brush mattress should be covered with an amount of soil sufficient to ensure a good contact surface between the mattress and the soil, leaving some buds and twigs exposed.

This method forms an immediate protective cover over the stream bank, captures sediment during flood flows, and rapidly restores riparian vegetation and streamside habitat. This measure is not appropriate where toe scour is anticipated, in which case boulders may need to be added at the toe.

Design Constraints and Considerations:

- Branches should be tamped down before tying to create a good contact surface between the soil and the mattress.
- Butt or basal ends of branches must be covered with soil so they can root and to prevent them from drying out.
- Branches should be partially covered with soil.
- **This method should not be used on slopes that are experiencing geotechnical failures or other slope instability.**

Figure 11: Brush Mattress



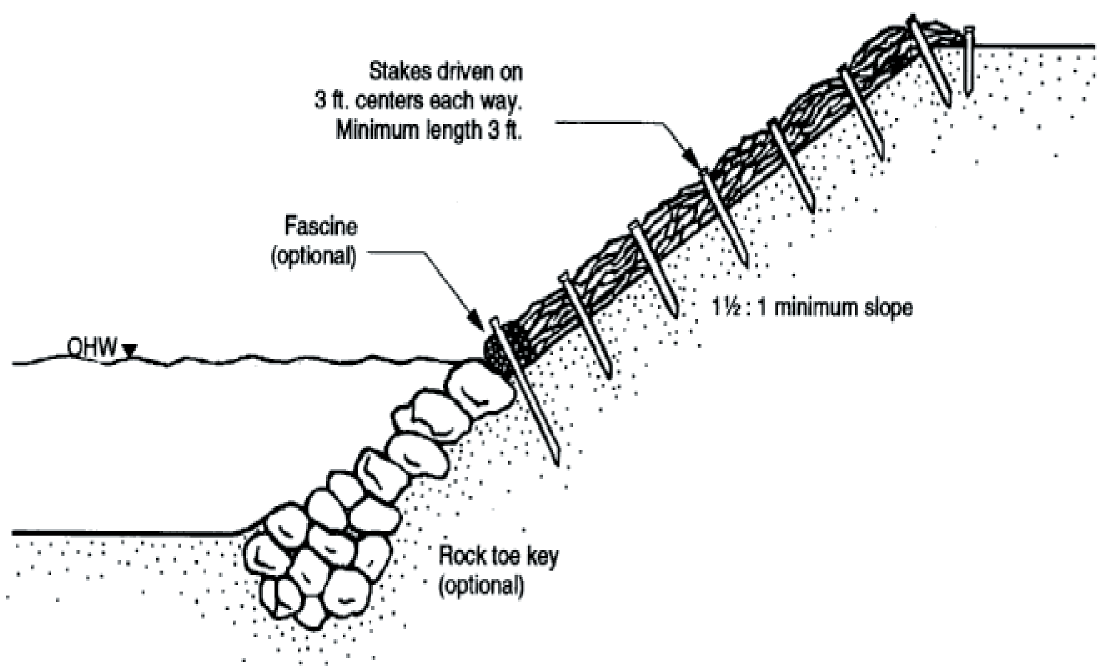
#5a: Brush Mattress with Boulder or Log Toe Protection

First, the lower portion of the eroded slope is graded at a maximum slope of 1.5:1. Then the upper portion of the slope is graded at a minimum of 2:1 and smoothed to ensure all willows are in contact with soil. Appropriately-sized boulders are placed at the toe of the rebuilt bank, up to the bankfull discharge water elevation or even slightly higher. Live stakes can be placed between the boulders to establish vegetation. This method requires a lot of branches. Therefore, needs to be installed during low flow conditions so that growth can be established. Otherwise, the branches will wash away.

Design Criteria:

- Boulders must be keyed in (min. 3 feet) at toe of bank.
- Boulders placement must not constrict the channel cross-section or reduce the width-to-depth ratio. Otherwise, the repair will likely destabilize the channel.
- The placement of boulders or armoring along the bank will increase turbulence in the area and downstream, which could cause increased erosion.

Figure 12: Brush Mattress with Boulder or Log Toe Protection



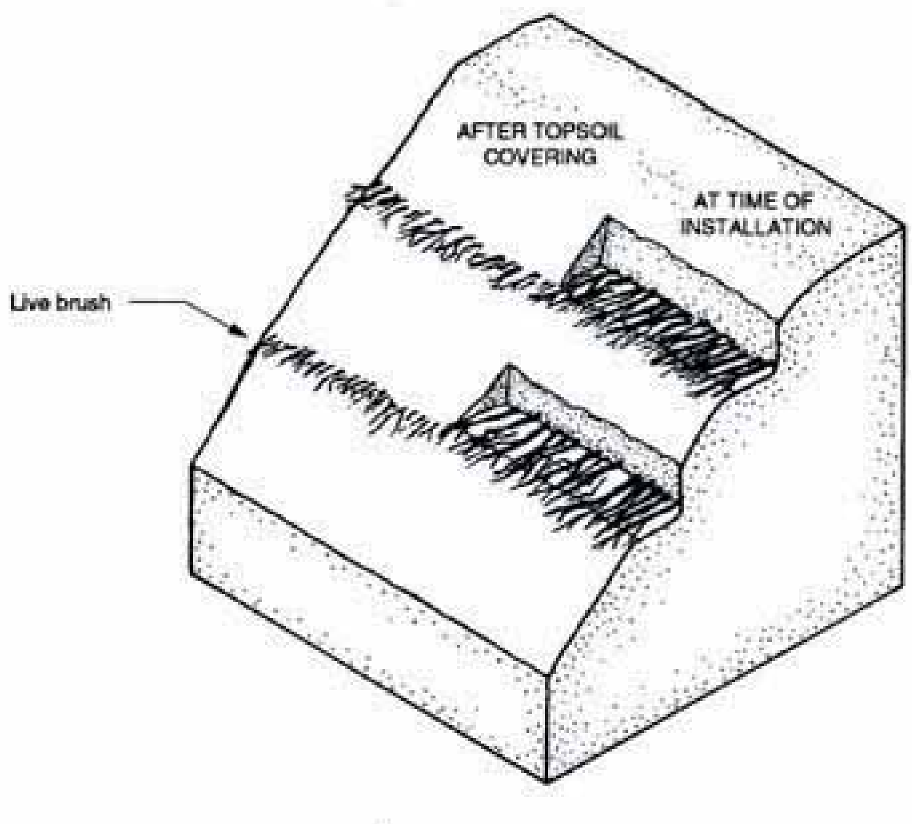
#6: Brush Layering

In this method, alternating layers of soil and live branches are installed in horizontal rows on the streambank. This method is more substantial than brush mattresses and can be used to repair erosion gullies, scour holes, and other significantly scoured areas. The buried branches take root to reinforce the substrate, while the tips produce vegetative top growth that protects the bank surface. This method can also be used in combination with a rock toe, vegetated geogrid or live cribwall as described later in this section.

Design Constraints and Considerations:

- Installation is best done during dry periods or low flow conditions since construction requires earthwork.
- A large amount of branches are needed for this method.

Figure 13 : Brush Layering



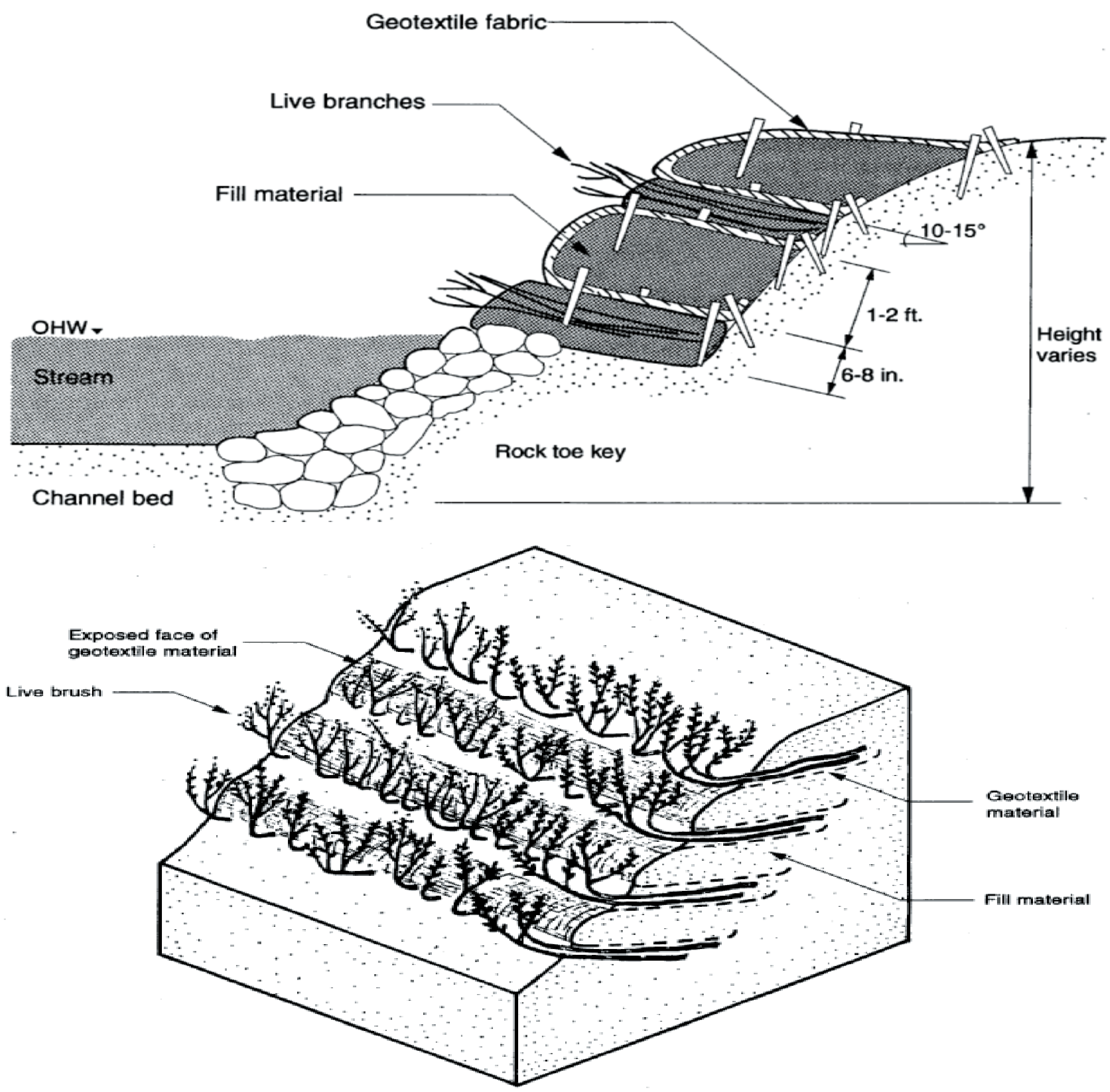
#7: Vegetated Geogrids or Soil Lifts

This method is similar to brush layering, but adds even more stability by wrapping engineered soil lifts in biodegradable erosion control fabric or geotextiles between layers of live branches. This method is useful where site constraints don't allow the slope to be laid back. Boulder or log toe-protection can also be incorporated into the design where site conditions warrant.

Design Considerations:

- Boulder placement must not constrict the channel cross-section or reduce the width-to-depth ratio. Otherwise, the repair will likely destabilize the channel.
- Armoring or the placement of boulders along the bank will increase turbulence in the area and other areas downstream, which could increase erosion.

Figure 14: Vegetated Geogrids or Soil Lifts



#8: Root Wads and Boulders

This method consists of using a combination of boulders, logs, and live plant material to armor a stream bank. It enhances fish habitat, and creates a natural-looking bank stabilization structure [1]. Footer logs are set in a toe trench below the thalweg line (the line of maximum depth in a stream), with the channel end pointed downstream and the butt end angled 45 to 60 degrees upstream. A second log (with a root wad) is set on top of the footer log diagonally, forming an "X".

The root wad end is set pointing upstream and the butt end lying downstream 45 to 60 degrees. The apex of the logs are anchored together using boulders, re-bar or cables. Large boulders are placed on top and between the logs at each apex. After all the logs and boulders are set in place, live plant material, such as willows, is placed within the spaces of the structure behind the boulders. Excavated gravel and stream materials can then be placed over the bank end portion of the structure[1].

This method will tolerate high boundary shear stresses if logs and root wads are well anchored. This method should, where appropriate, be used in conjunction with soil bioengineering or live vegetation plantings in order to stabilize the upper bank and ensure a regenerative source of streambank vegetation. The endurance of the structure depends on the species of logs used; it might need replacement if vegetative colonization does not take place.

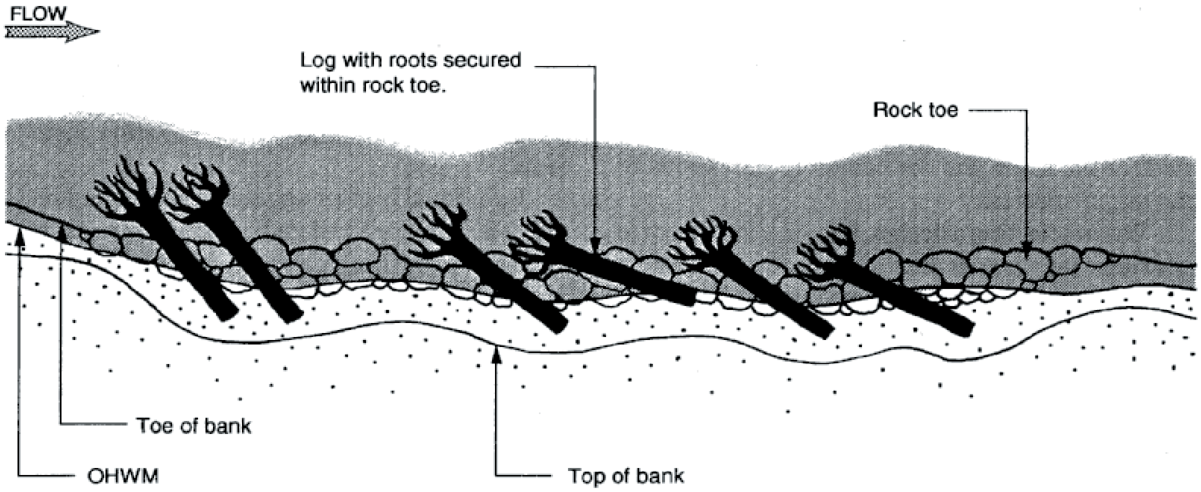
Design Considerations:

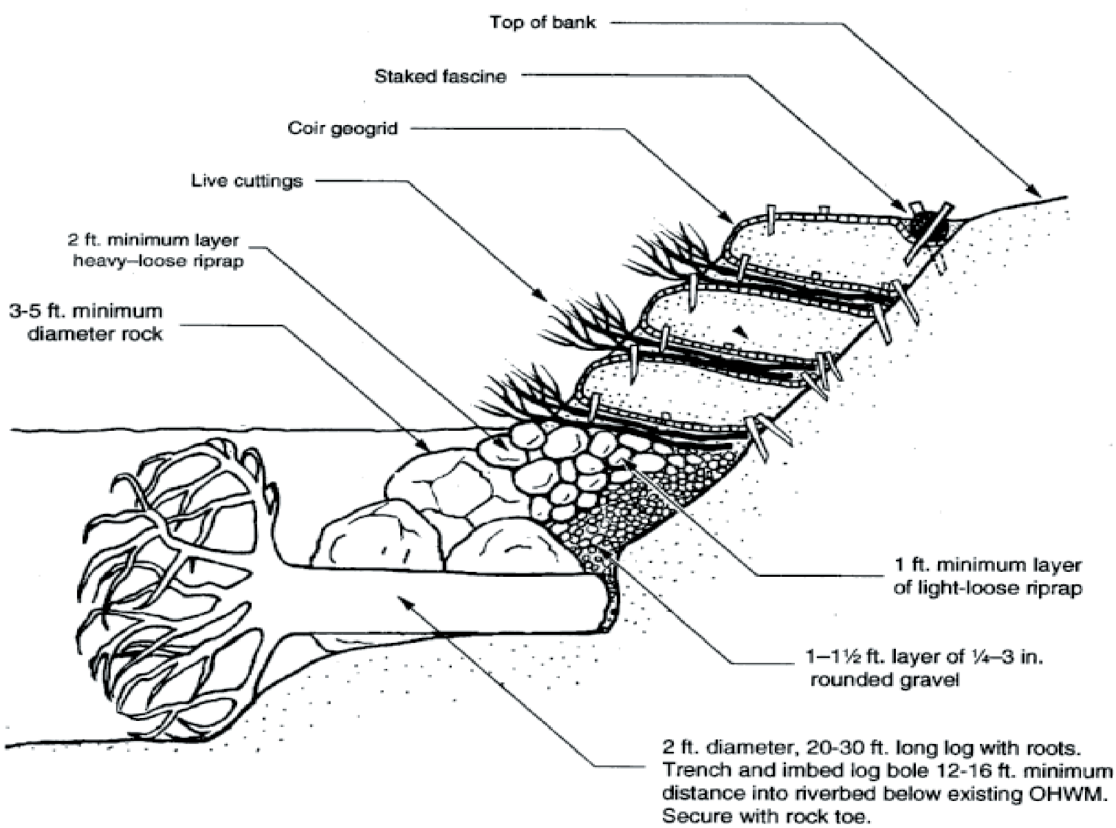
- This method may cause channel scour and erosion of downstream and opposite banks if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour. [2].

[1]Source: California Department of Fish and Game, California Salmonid Stream Habitat Restoration Manual

[2]Source: Natural Resources Conservation Service, Stream Corridor Restoration Principles, Processes and Practices

Figure 15: Root Watds and Boulders





#9: Boulder/Rock Revetment

Rock rip-rap is a method for armoring stream banks with boulders that prevent bank erosion. Rock riprap can be used at the toe of the slope in combination with other vegetative methods on the upper portions of the bank. Rock can also be used for drainage outfall structures. Rip-rap footing is laid in a toe trench dug along the base of the bank. The size of the rock is determined according to the expected velocity in the channel, and can vary from 6" to 18" for velocities up to 10 feet per second up to 24" minimum for higher velocities. Large angular boulders are best suited for this purpose because they tend to interlock. The rock's specifications must meet certain standards in order to assure that it is structurally sound.

A gravel blanket that is at least one foot thick should be placed under the rock rip-rap on slopes of 1:1 or greater. This prevents underlying soil from being washed out, which leads to slope slump and failure during periods of high flow. Geotextile fabrics should be avoided, since they prevent the natural establishment of vegetation[1].

This method should, where appropriate, be used with soil-bioengineering systems, or live vegetation, to stabilize the upper bank and ensure a regenerative source of streambank vegetation. A major benefit of this method is that the components are flexible and their function is not impaired by slight movement from settlement or other adjustments[2].

Design Criteria and Considerations:

- Rock should be keyed in approximately three feet below the bed elevation.
- Rock can be graded from larger at the toe to smaller at the upper banks.
- This method may cause channel scour and erosion, especially downstream and along opposite banks, if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour.

#9a: Boulder Revetment with Soil and Revegetation

This method consists of placing soil over the boulders and installing vegetation by staking and/or direct seeding. Biodegradable erosion control mats are placed over the soil to help control erosion until vegetation establishes itself. Special care must be taken while driving live stakes between boulders to avoid damage to the cambium layer of the woody material and to ensure good soil/water/stake contact. Thick rip-rap layers may require special tools for establishing staking pilot holes.[2]

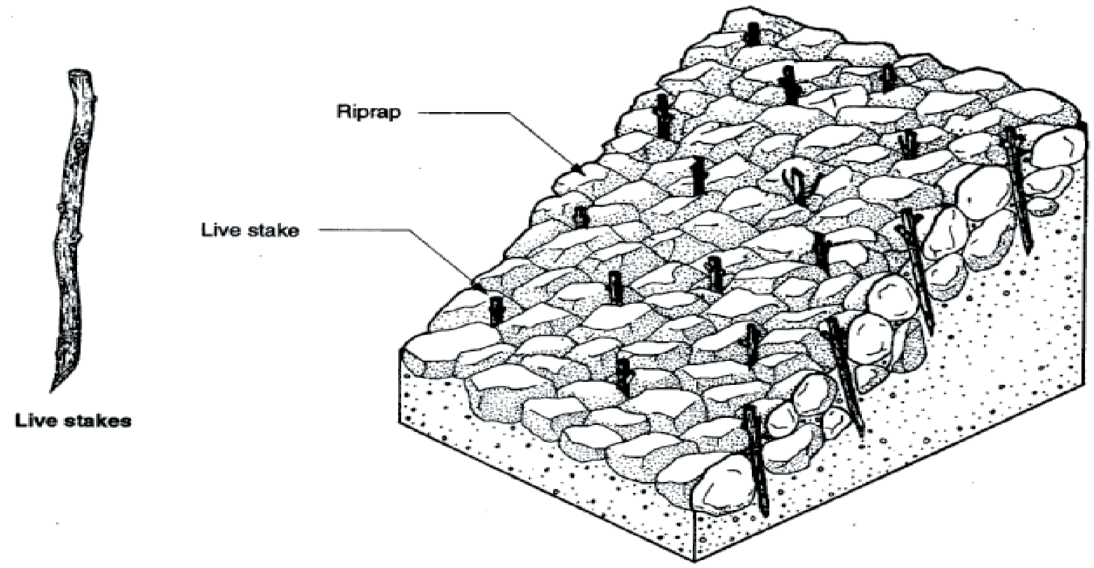
Design Considerations:

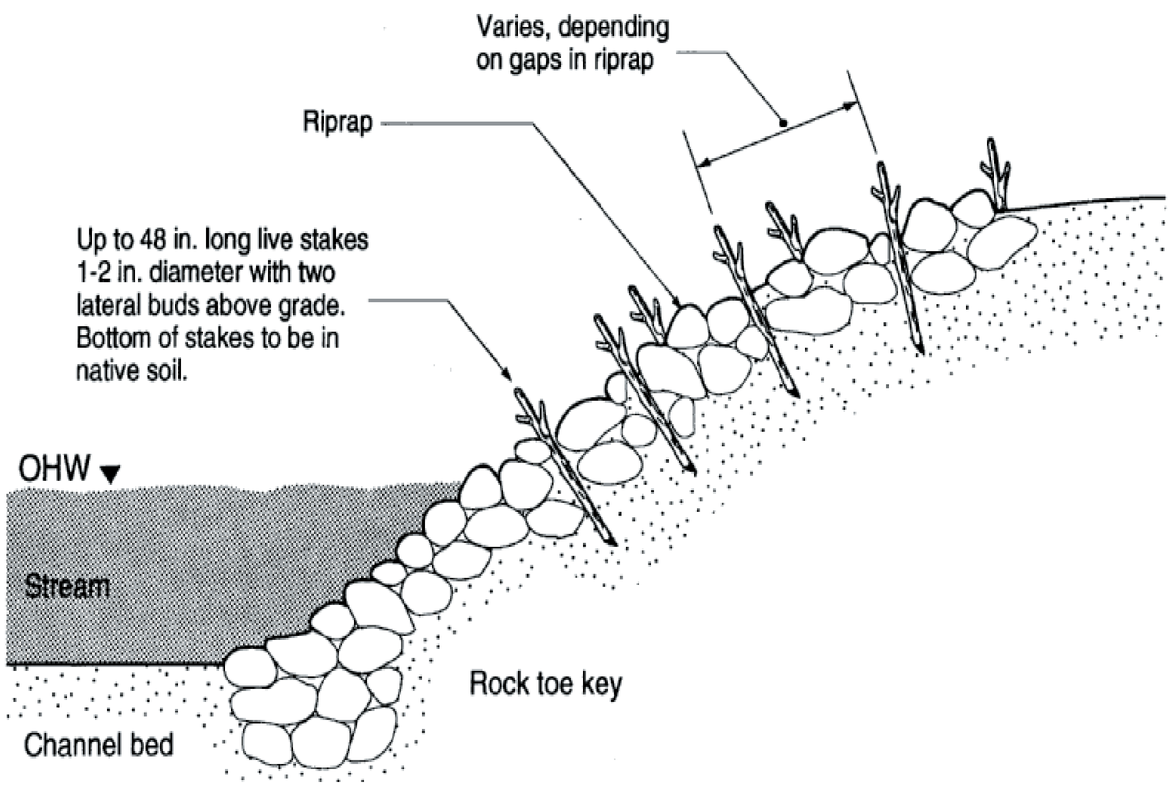
- Woody material can be placed using a backhoe with an auger attachment, or by driving a steel bar between boulders, or by placing rock around durable planting tubes.
- This method may cause channel scour and erosion of downstream and opposite banks if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour.

[1]Source: California Department of Fish and Game, California Salmonid Stream Habitat Restoration Manual

[2]Source: Natural Resources Conservation Service, Stream Corridor Restoration Principles, Processes and Practices

Figure 16: Boulder Revetment with Soil and Revegetation





#10: Cellular Confinement System

Soil cellular confinement system (geocell) is a polyethylene plastic cellular system where structural strength is developed by the composite design of soil, plant roots, and the plastic's cellular configuration. This system is available in eight-inch deep honeycomb mats that can be installed in offset vertical layers to create terraced planting areas. The honeycomb cells are filled with soil, moderately compacted, and planted with woody vegetation and grasses. The structure functions similarly to a crib wall structure. This method can also be used in combination with slope grading and vegetation on the upper slopes.

This method can foster the development of vegetation.

#11: Live Log Crib Walls

Live log crib walls are used to reduce sediment input and protect banks in areas where logs are available and boulders are not practical[1]. These temporary structures are designed to rot and degrade after live plant material has established itself. Cribbing provides protection in areas with near-vertical banks where bank sloping options are constrained by adjacent land uses.

In this method, two rows of base logs are placed parallel to the bank, in trenches below stream grade, to minimize undercutting of the structure. Tie-back logs are notched into the base logs and placed at regular intervals (typically 6 to 8 feet) along the base logs. Tie-back logs are attached to the base logs using re-bar pins or cables. There should be at least two tie-back logs connecting each pair of base logs. Once the first row of tie-back logs has been connected, a second set of face logs is placed on top of the tie-backs. This procedure is repeated until the desired level of bank protection is achieved. As each lift is constructed, the face logs and tie-backs are filled with a mix of gravel and cobbles to the top of the face log. It is not necessary to use topsoil in the fill material; but there should be sufficient fine-grain material to insure vegetation growth. Live cuttings are then laid in to form a complete cover layer. These live branches should be long enough to have their butt ends in the soil behind the crib wall. The tips should stick out of the crib wall no more than a quarter of the cutting total length. The branches are then covered with the gravel/cobble mix to the top of the tie-backs, and the next layer is continued.

This method is effective on the outside of bends where high velocities are present, and in situations where a low wall may be required to stabilize the toe and reduce slope steepness[2]. The use of crib walls in a specific location must be considered carefully in the context of the stream's function. If placed incorrectly relative to the active channel, the bends in a meandering stream can induce considerable damage downstream or on the opposite bank. This method does not adjust to toe scour and should be used in combination with soil bioengineering systems and live plantings to stabilize the upper slopes[2].

Design Criteria and Considerations:

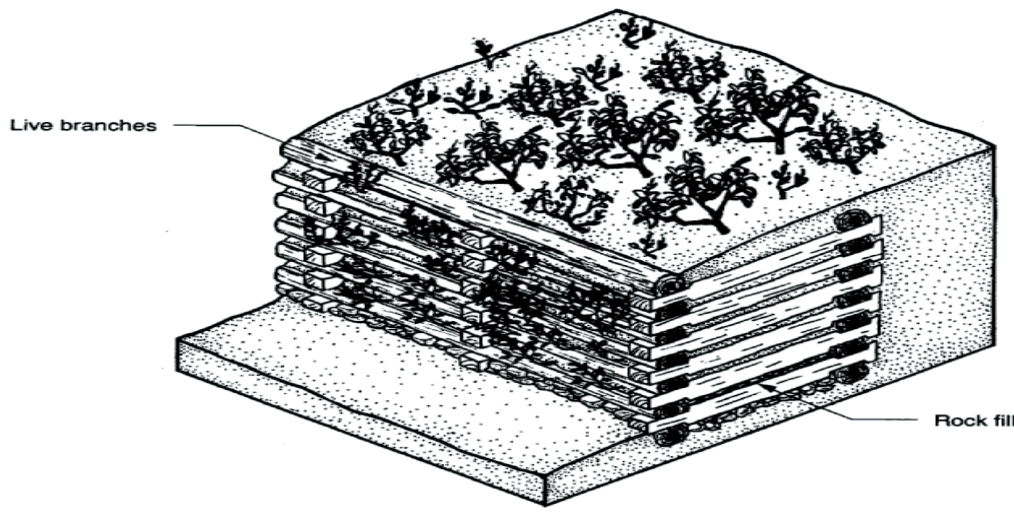
- This method may cause channel scour and erosion of downstream and opposite banks if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour.
- As the logs rot, the crib wall can be undercut and eventually fail. If the structure fails, hazardous rebar and steel cable can be deposited in the river along with the logs and other debris of the structure.

[1]Source: California Department of Fish and Game, California Salmonid Stream Habitat Restoration Manual

[2]Source: Natural Resources Conservation Service, Stream Corridor Restoration Principles, Processes and Practices

form mats that can be laid on the channel slope and/or channel bottom.

Figure 17: Live Log Crib Walls



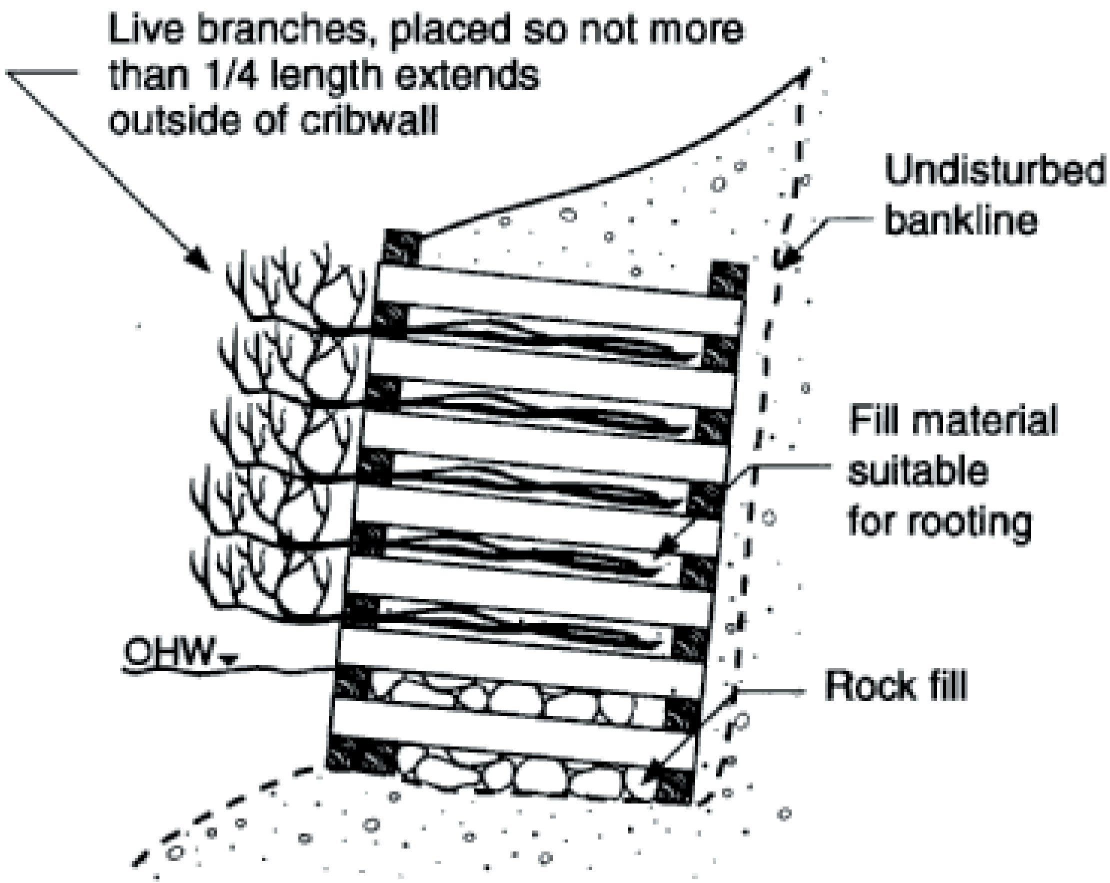


Table 2: Erosion Repair Methods that are NOT Recommended:

Repair Method	Appropriate Slope	Appropriate Water Velocity	Environ Value	Cost
12 Concrete Crib Walls	Up to 0.25:1	High: up to 15 ft/sec; depending on size of crib wall openings.	Negative	High
13: Articulated Concrete Blocks	Up to 1:1	High: up to 15 ft/sec; for closed cell ACBs, low to medium for open cell ACBs.	Negative	High
14: Gabions	From 0.75:1 up to 3:1	High: up to 15 ft/sec; lower velocity if planted, depending on size and number of planting pockets.	Negative	High
15: Sacked Concrete	Up to 0.5:1	High: up to 15 ft/sec;	Negative	High
16: Gunite Slope Protection	Up to 1:1.	High: up to 15 ft/sec	Negative	Medium

#12: Concrete Crib Walls

Concrete crib walls consist of stacked interlocking concrete frames that form a retaining wall. Its structural strength is due in part to the composite design of a concrete frame with compacted backfill. Crib walls are constructed with open face panels that are planted by live staking. This method restricts plant growth to the size of the panel opening. As the crib wall slope is flattened and the lattice becomes more open, the vegetation potential increases, and the allowable velocity decreases because of the exposed soil and vegetation. Concrete crib walls perform similarly to live log crib walls. Because the crib wall is a rigid structure, it is more prone to massive failure in the event of undercutting or settlement.

All crib walls tend to cause channel bed and bank erosion both in the immediate area and other areas downstream, and may also cause erosion upstream. Most crib walls eventually fail because they attempt to resolve a symptom of erosion, not its cause. The use of concrete crib walls is discouraged. This method is mentioned only for reference.

13: Articulated Concrete Blocks

Articulated concrete blocks (ACB) consists of concrete interlocking blocks that are cabled together to form mats that can be laid on the channel slope and/or channel bottom.

There are two styles of ACBs: open cell and closed cell. The open cell style allows for vegetation to be recruited into the soil filling each cell. Vegetation growth is restricted by the sizes of the cell openings and by the disconnection caused by the cell walls. In our arid climate, the long-term viability of vegetation within the restricted cell openings is problematic. However, open planting areas can also be constructed into the ACB mats by creating an opening in the mat by removing some of the blocks. The open areas can be revegetated with shrubs and trees. Irrigation is necessary to aid plant establishment.

This method will create channel and bank erosion both down and upstream of protected areas. It is environmentally unfriendly and prone to failure. When it fails, steel cables and stakes hazardously protrude from the mats into the channel. <u>This method is not appropriate for small erosion repair sites, and is discouraged because of the limited potential for biotic resources.</u>

#14: Gabions

This method consists of placing large wire baskets filled with rocks on channel banks, either as mattresses or stacked in layers that resemble steps. Gabions can sometimes naturally revegetate if adequate water and soil are available. Gabions can also be revegetated using planting boxes. (Planting boxes are gabion cells that are left open to bare soil and revegetated with shrubs and trees.) Temporary irrigation may be provided to the planted vegetation in order to aid its establishment. But, wire baskets can deteriorate over time and may be harmful to fish.

Gabions are very hazardous and unfriendly to native fish, especially salmonids, which often try to spawn in gabions below the water line. The basket wire deteriorates quickly, and the fish are injured on the baskets' sharp wire barbs.

Furthermore, the baskets used to line or armor the banks of streams cause bed and bank erosion. They often undercut or fail due to slumping of the soil on which they are constructed. <u>The use of gabions is discouraged and are rarely permitted by the Department of Fish and Game except in extreme situations. The material is included here for information.</u>

#15: Sacked Concrete

Sacked concrete slope protection consists of burlap bags filled with concrete and placed against channel banks. Sacked concrete does not provide any revegetation potential. However, it offers the opportunity to contour walls around existing vegetation such as tree wells.

<u>Sacked concrete should not be used because it causes erosion, degrades water quality, and destroys other beneficial uses</u>. It is included here for reference. There may, however, be extreme circumstances

where site constraints, vertical slopes, and high velocities preclude all other options.

#16: Gunite Slope Protection

Gunite slope protection consists of a pressurized concrete mixture sprayed over an eroded bank. The gunite can be textured, colored, and formed for aesthetics to mimic natural rock. Reinforcing steel may be placed against the bank prior to spraying. This is not an acceptable method of erosion repair, but is included here because it has been successfully used with soil nails to stabilize vertical slopes on upper banks where land use constraints preclude regrading of the slope. Sheet pile retaining walls have been used in a similar manner. Vegetation can be placed on the lower portions of the bank to enhance biotic resources.

Gunite slope protection causes erosion problems, degrades water quality and destroys other beneficial uses. Therefore, the use of gunite slope protection is discouraged and is included here only for reference.

SECTION 6 - OBTAINING PERMITS FOR STREAM-BANK REPAIR

(Taken from the Stream-Bank Repair Guidance Manual for the Private Landowner: Guadalupe and Alamitos Creeks)

Practical Points to Help You Obtain Permits for Your Project

As noted earlier, if you are working in or around a creek or stream, you will likely need permits from a local, state, and/or federal agency. Below are some practical points to help you obtain permits for your project as quickly and efficiently as possible. Following this list is a matrix of activities and the agencies, which may require permits for those activities.

- **Learn the rules.** Familiarize yourself with applicable state, local, and federal agency permitting requirements. Determine which agencies may be involved in your project. Take time to study the protocols and regulations of these agencies. Refer to their web sites. Read staff reports, permit conditions, and studies relating to your project or similar projects.
- **Contact the agencies in charge of granting permits for your project.** You may need to obtain different permits for your project from a number of agencies. Contact the agencies that may need to issue a permit for your project to determine who will be involved. Ask about the agency's permitting process, obtain relevant forms, and discuss potential timelines for obtaining your permits. Do not expect to get schedule commitments at this stage, but at least get an idea of the how the process works and a feel for how long it may take.
- **Write a complete project description.** A complete project description is crucial. Include drawings, photographs and other supporting materials to assist the regulatory agencies in understanding what your project entails. Photographs and descriptions enable them to provide guidance and direction before a site visit can be scheduled.
- **Consult early and become familiar with agency staff.** Consultation with permitting and regulatory agencies should begin as early as possible. An in-person meeting is the best way to discuss your project. Try to have plans, maps, photographs of the project location, and other information available at the meeting. You can also request that a staff person meet you at the site.
- **Reduce adverse environmental impacts.** Design your project to eliminate or reduce as many potential health concerns and environmental impacts as possible. Consider environmentally superior alternatives described in the previous section. These methods are also generally easier and much faster to permit. Incorporate the suggestions you receive during early consultation. Employ a qualified design consultant with specialized expertise in stream analysis and design.
- **Pay attention to details.** Follow all the rules and listen to agency staff guidance. Respond promptly to requests for information. Be on time for meetings with representatives of the regulating agencies. Do not cut corners. Get in writing all dates, procedures, fees, etc..
- **Be willing to negotiate.** Recognize that government regulators may have a great deal of authority over your project, but that they are willing to negotiate. You should be, too.
- **When in doubt, ask.** If you are not sure whether your project needs a permit or whether it is regulated at all, ask. Going ahead without following the proper guidelines will ultimately

cost you time, money, and goodwill.

- **Keep good records.** Keep notes of conversations and meetings. Ask for interpretations of rules to be written by the agency representatives. An easy way to do this is to confirm conversations by E-mail. Remember, agency staff time is limited; it is easier for them to review or comment on your understanding than for them to compose the correspondence.

Prohibited Activities

Before you decide to do work near a creek or river, you should consider that it is illegal to place, store, or dispose of materials of any kind on the banks of, or into, a watercourse. Prohibited materials include dirt, soil, and concrete; pool and spa water; paints, solvents, and soaps; yard and animal waste; automobile and machinery fluids; and firewood and building materials. Remember to comply with best management practices that prevent pollution from entering the waterway and damaging the ecosystem.

Agencies That May Require Permits

Use this chart to help you determine which agency may be involved in your project. A checked box indicates that an agency may be involved and should be contacted, but does not mean they definitely

	Santa Clara Valley Water District	Your City's Planning or Public Works Dept	NOAA	CalEPA DTSC	SWRCB Water Rights	Regional Water Quality Control Board	California Fish and Game	Army Corps of Engineers	U.S. Fish & Wildlife Service
Involve work on the bank of a river, stream, or lake?	X	X				X	X	X	X
Involve excavation of the bank?	X	X				X	X		
Involve placement of piers?	X		X	X		X	X	X	
stabilization or erosion control?	X	X				X	X	X	X
Require the removal of riparian or other wetland vegetation?	X	X	X			X	X	X	X
Involve planting riparian or wetland vegetation?	X		X			X	X	X	X
Affect native plants, wildlife, or fisheries?	X		X			X	X		X
Result in stormwater discharge into a creek or wetland?	X	X				X	X	X	X
Divert or obstruct the natural flow or change the natural bed or bank of a creek or wetland?	X	X				X	X	X	X
Involve repair, rehabilitation, or replacement of any structure or fill adjacent to a creek or wetland?	X	X				X	X	X	X
Involve placement of bank protection or stabilization structures or materials (e.g., gabions, riprap, concrete slurry/sacks)?	X	X				X	X		X
Involve building any structure adjacent to a creek or wetland?	X	X				X	X	X	X
Involve fish and wildlife enhancement, attraction, or harvesting devices and									

	Santa Clara Valley Water District	Your City's Planning or Public Works Dept	NOAA	CalEPA DTSC	SWRCB Water Rights	Regional Water Quality Control Board	California Fish and Game	Army Corps of Engineers	U.S. Fish & Wildlife Service
Use materials from a streambed (including but not limited to boulders, rocks, gravel, sand, and wood debris)?	X	X		X		X	X	X	X
Require the disposal or deposition of debris, waste, or any material containing crumbled, flaked, or ground pavement with a possibility that such material could pass into a creek or wetland?	X	X		X		X	X	X	X
Involve the removal of any materials from, or add fill to, a creek or wetland?	X	X	X	X		X	X	X	X
Involve grading or fill near a creek or wetland?	X	X	X			X	X		X
Involve a bridge or culvert?	X	X				X	X	X	X
Involve utility pipe lines?	X	X				X		X	
Involve a septic leach field near a creek or wetland?	X	X				X	X		
Require a water well near a creek or wetland?	X	X	X				X		
Involve work within historic or existing coastal wetlands?	X					X	X	X	X
Remove water from a creek for storage or direct use on non-riparian land?	X	X	X		X	X	X	X	X
Require that hazardous materials be generated and/or stored on site?	X	X		X		X			
Take place in, adjacent to, in a building adjacent to or near a river that has been designated as "wild and scenic" under state or federal law?	X					X	X	X	X

	Santa Clara Valley Water District	Your City's Planning or Public Works Dept	NOAA	CalEPA DTSC	SWRCB Water Rights	Regional Water Quality Control Board	California Fish and Game	Army Corps of Engineers	U.S. Fish & Wildlife Service
Require water to be diverted from a river, stream, or lake for the project or activity?	X	X			X	X	X	X	X
Affect water quality by the deposition of silt, an increase in water temperature, a change in the pH level, or in some other way?	X		X			X	X	X	X
Occur in an area where endangered or rare plant species are thought or known to occur?	X	X				X	X		X
Occur in an area where endangered or threatened fish, bird, or animal species are thought or known to occur?	X	X	X			X	X		X

will be involved.

San Francisco Bay Area Joint Aquatic Resource Permit Application

As discussed earlier, projects in or near creeks and even intermittent streams can be regulated by many agencies, the local city government, local agencies, such as the Santa Clara Valley Water District, state agencies, such as the San Francisco Bay Regional Water Quality Control Board, and California Department of Fish and Game, and federal agencies, such as the Army Corps of Engineers and U.S. Fish and Wildlife Service, to name a few. For projects with an aquatic component, such as work near a creek or stream, a single application called the San Francisco Bay Area Joint Aquatic Resource Permit Application (JARPA) has been designed to replace individual applications for state, regional, and federal agencies. As suggested earlier, consider taking advantage of this consolidated application to streamline the project permit application process.

If a project requires local approval, such as that of the local city government or Santa Clara Valley Water District, be sure to check with these agencies about what to include in the application, since the JARPA document does not consider local agency requirements.

California Environmental Quality Act

Prior to obtaining permits for a project, a California Environmental Quality Act (CEQA) review will be required if the project is undertaken by a public agency or if a public agency needs to issue a permit for a project. CEQA is found in Section 21000 et seq. of the Government Code, and the CEQA guidelines are found in Section 1500 et seq. of the California Code of Regulations. The Guidelines have the force of law, and lay out the way CEQA is administered.

(See http://ceres.ca.gov/topic/env_law/ceqa/)
The purpose of the CEQA review is to inform project decision-makers of the issues associated with the project, to identify significant environmental impacts and reduce them, and to disclose to the public the rationale for the decision to approve a project. The agency responsible for the CEQA review is called the lead agency, and it is usually the agency with the most involvement in the project. The local municipality's planning department usually handles the CEQA review, however, CDFG is also a lead agency for purposes of issuing a Streambed Alteration Agreement.

Once the lead agency is identified, all other agencies that require a permit to be issued for the project, whether state or local, become responsible. Responsible and trustee agencies must consider the environmental document prepared by the lead agency and do not, except in rare instances, prepare their own environmental documents.

There are four possible scenarios regarding CEQA requirements:

1. The project is exempt from CEQA. Exemptions are listed in the CEQA Guidelines. Specific rules should be consulted, but essentially, a categorical exemption cannot be used if the project has the potential for an individual or cumulative significant effect on the environment. Documentation of exemptions should be obtained from the lead agency. Unless a public hearing is required by the local agency for the project, a categorical exemption does not require a public hearing. The document is simply filed at the county for a specified period.
2. A **Negative Declaration** is issued by the lead agency for the project.

   A Negative Declaration can be issued if the project will have no significant impact on the environment without the need for mitigation measures to reduce a project impact to a less than significant level. A public hearing to adopt the findings and the Negative Declaration is required.

   Hint: If, at any time along the permitting or review process, you find that your proposed project can have a significant impact on the environment, and by redesigning your project, the impact can be eliminated or reduced to insignificant, you will save yourself time and money by redesigning your project.
3. A Mitigated Negative Declaration is issued for the project. This means that there are significant impacts from your project on the environment, but mitigation measures during implementation can be adopted to reduce these impacts to a less than significant level. A mitigation monitoring and reporting plan is required to identify, what, who, when and where for each mitigation measure, thus ensuring that all mitigation measures are implemented. A public hearing is required.
4. An **Environmental Impact Report (EIR)** is required to study the significant impacts of your project on the environment. Various alternatives to your project must be identified and evaluated and the environmentally preferred alternative must be selected unless there are overriding circumstances that make the project desirable, even though there are significant unmitigated impacts. This finding must be made by the approving body of the lead agency, along with the findings and MMRP. Because there are more alternatives to evaluate, there is a slightly longer review period and a requirement to specifically respond to comments. For this reason, an EIR can be the most

time-consuming and complicated scenario.

SECTION 7 - REFERENCE MATERIALS

There is a wide body of literature that provides more detailed information on these bank protection repair techniques. We have identified several of the more comprehensive documents. A more complete list can be found at http://www.4sos.org/wssupport/ws_rest/rest_con.asp.

A Citizen's Streambank Restoration Handbook – This 171 page handbook is a guide to restoring eroding streambanks using vegetation and flexible systems. It, features installation guidelines, sample budgets, case studies and tips on choosing the best restoration solution. $20 plus $5 shipping. To order call 800/284-4952 or E-mail sos@iwla.org.

How to Hold Up Banks: Using All the Assets – An informative, well-illustrated booklet on controlling stream erosion. Produced by the Boquet River Association (BRASS), a small nonprofit group with extensive experience in stream monitoring and restoration, the book helps citizen groups tap community resources and find success with low-cost techniques. Techniques covered include streambank shaping; grass, seedling, and live posts planting; log cribbing and stone riprap installation. To order send $8 to BRASS, c/o Essex County Government Center, Box 217, Elizabethtown, NY 12932, or call 518/873-3688.

Stream Corridor Restoration: Principles, Processes, and Practices – Developed by an interdisciplinary team of stream and watershed management specialists, hydrologists, engineers and other EPA, federal agency, and private group representatives. A printed document is available for $71, a CD-ROM version sells for $60. Available through the Center for Watershed Protection. at http://www.cwp.org.

The Practice of Watershed Protection: Techniques for Protecting and Restoring Urban Watersheds – At $80, 150 articles are included on all aspects of watershed protection. Drawn from past issues of *Watershed Protection Techniques* as well as a wealth of other Center papers and reports, this 800-page book is organized around the eight tools of watershed protection, and indexed for easy reference. Available through the Center for Watershed Protection. at http://www.cwp.org.

Urban Stream Restoration Practices: An Initial Assessment – This assesses the performance of 24 urban stream restoration practices from sites around the Mid-Atlantic and Mid-west, and provides recommendations for improving their application in a variety of urban stream environments. It costs $20. Available through the Center for Watershed Protection. at http://www.cwp.org.

Stream-bank Repair Guidance Manual for the Private Landowner – Guadalupe and Alamitos Creek – This focuses on erosion repair in mercury-contaminated streams, but it is relevant to a broad range of erosion repair projects. Some of the most relevant information from this document is contained in this Design Guide. This publication can be obtained from the Santa Clara Valley Water District.

Maintaining Corte Madera Creek: A Citizens' Guide to Creek-Side Property Protection – Created for the Town of Portola Valley and its residents to help guide bank stabilization and revegetation efforts along Corte Madera Creek, a tributary to San Francisquito Creek. The report was created to facilitate communications between the Town and private property owners who wish to address erosion and property loss. The document can be found at http://www.cityofpaloalto.org/public-works/jpa-projects.html.

Guidelines for Bank Stabilization Projects: in Riverine Environments of King County – Produced by the King County Department of Public Works Surface Water Management Division, Seattle, Washington in 1993. This report is an exceptional manual that clearly and comprehensively describes the planning, design, permitting, and construction aspects of bank erosion repair. From a technical perspective , it is very applicable to California streams. This resource, including some of its illustrations, was used to help prepare this Bank Protection Design Guide.