

3.1 How Do Creeks Work?

Creeks form as the conduit to convey rainfall-runoff from the watershed to the sea. The channel form results from the complex combination of climatic conditions (rainfall amount, seasonality etc.), geology (underlying rock type, structure, topography) and ecology (vegetation type, patterns etc.). At any location, the creek channel shape (cross-sectional area, bank height, etc) forms primarily in response to the flow regime and underlying geologic conditions. While the shape may change over time, in a stable stream/watershed, these changes typically are slow and gradual, and often vary about a long-term equilibrium conditions.

From a geomorphic perspective, creeks are conveyor belts for sediment, transporting sediment eroded in the hills and ultimately depositing lower in the watershed or in the ocean. Landslides and soil erosion generate sediment in the **headwaters** of the creek, and the creek carries the material towards the sea. The amount of sediment a creek can transport depends on how steep it is and how deep and fast the water flows. If the creek has sediment carrying capacity to spare it will actively erode its banks, until it is carrying as much sediment as it can. Over time this process causes the land to become flatter, and creeks erode less and less. However, because the San Andreas Fault is still pushing up the Santa Cruz Mountains in the headwaters, Corte Madera Creek has never had the chance to become gentler and it is still a naturally highly erosive stream. Humans have added to this by changing the watershed, for example by increasing impermeable area such as buildings and parking lots, clearing woodland and constructing roads. As a result a naturally very dynamic (and possibly erosive) creek has become even more erosive. Where a buffer between the creek and structures can be maintained this is not a problem, as certain amounts of bank erosion are a natural process and provide important ecological niches. However, where homes or roads are sited close to the eroding creek bank there will be conflicts. This situation is not always easy to spot, since creeks are dynamic by nature. A bank may be stable for decades, and then start to erode because of either longer term changes reaching a critical threshold or more subtle changes such as a disruption in upstream sediment supply. For example, constructing a hard, smooth bulkhead to protect one reach of creek causes the water leaving the reach to accelerate, potentially creating greater erosion downstream.

Creek banks erode for two reasons. Firstly, they can erode because the creek migrates laterally into a bank, or water is directed from a straight reach onto a bank. This type of erosion can be controlled by increasing the erosion resistance of the bank, for example by planting vegetation on the bank toe or adding **toe** protection. Secondly, banks can slump because the creek channel cuts downwards (incises), leaving the bank too high and steep to remain stable. 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 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 treatment of an over-steepened bank is to reduce its slope to a stable angle, and protect the toe and face from future erosion so it doesn't become over-steepened again.

3.2 What is Riparian Habitat?

Riparian habitats are the plant communities (vegetation types) associated with the elevated soil moisture levels found within and adjacent to **watercourses**. The width of these areas depend on a number of factors including the size of the stream and contributing watershed, channel morphology, soil type, and topographic features, among others. Riparian areas are distinctly different from surrounding lands due to the unique soil and vegetation characteristics associated with the presence of water. They serve as the transitional zone between aquatic and terrestrial ecosystems. They are among the most important, diverse and productive ecosystems and support rich assemblages of wildlife. Unique water-loving, flood-tolerant trees and shrubs thrive along streams such as Corte Madera Creek and form a unique plant community referred to as riparian habitat. Corte Madera Creek supports a lush, diverse zone of riparian habitat along its watercourse.

Over 95% of the historic riparian vegetation in California has been lost to urbanization, agricultural conversion, livestock grazing, clearing for flood control, and invasion of non-native plant species. In the western United States, riparian areas comprise less than 1% of the land area, but are among the most valuable and productive natural resources. Accordingly, due to the critically important biological values that riparian habitat provides and the rarity of the habitat type, riparian areas are among the most sensitive habitat types in the region and extraordinary efforts are put into preserving, enhancing and restoring these areas.

The following section provides a general description of the riparian zone (typical) and the numerous ecological functions it performs.

3.3 Riparian Functions and Values

Riparian areas, such as those supported by Corte Madera Creek, provide the many important ecological functions of value to people as well as to fish and wildlife:

- **Maintain creek bank and channel stability**

Riparian vegetation is important in the prevention of stream bank erosion. Roots of riparian vegetation help to stabilize banks, reducing erosion by holding soil in place. Vegetation binds soil and creates "roughness" that reduces stream flow rates, particularly during floods. Vegetation at the "toe" of riverbanks is especially important to riverbank stability, particularly on outside bends of

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meanders and on other banks where flow is deflected. In addition, roots and rootballs allow the formation of overhanging banks, which provide high quality habitat for many aquatic organisms.



California bay, a component of the riparian habitat along Corte Madera Creek, provides bank protection and overhanging roots afford shelter for frogs and salamanders.

■ Provide vital habitat for many wildlife species

Riparian habitats in California provide critical habitats for wildlife, supporting a great diversity and abundance of fish, mammals, birds, amphibians, insects and reptiles. In the western United States, riparian habitats occupy less than 1% of the total land area and are particularly important for migratory songbirds. Remaining riparian areas are crucial for bird species that have migrated through California for many thousands of years. Migratory birds use riparian habitats for resting, nesting, and most importantly, for foraging. Many songbird species forage on small insects and spiders that are abundant in the moist habitats along streams. Many other species of wildlife use riparian habitats as well. The complex vegetation structure, usually with a dense under-story of shrubs and a higher canopy of trees, provides numerous nesting, resting, and foraging habitats for wildlife. Riparian habitats provide critical habitat for fish and other aquatic organisms by regulating water temperature, providing food and nutrient input, as well as coarse woody debris to enhance in-stream structure. Streams, such as Corte Madera Creek, provide year-round drinking water for a variety of wildlife

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species, and moist habitats provide habitat for amphibians, and for numerous invertebrates, which provide prey for larger animals. Particularly in developed areas, like the San Francisco Bay area, riparian corridors also provide pathways for wildlife movement and dispersal.

- **Provide nutrient and food input to the aquatic ecosystem**

Fine material produced by the breakdown of decaying plants and animals provides the foundation of the aquatic food chain within the creek.

- **Reduce stream water temperature**

Riparian vegetation, especially the portion overhanging or shading the water, regulates water temperature. Even small increases in water and air temperature may lead to substantial changes in the population structure of fish, aquatic insect, and other riparian species.



Deep shade cast by dense riparian vegetation keeps the creek water cool benefiting aquatic organisms.

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▪ Provide input of coarse woody debris to enhance in-stream habitat

As riparian vegetation along the stream dies and falls into the channel it provides **coarse woody debris** adding diversity to the ecosystem. This helps create and maintain pools within the creek channel that provide hiding places for many aquatic organisms from predators, reduce stream velocities providing shelter during high flows, and form areas of slower moving water where prey for fish and amphibian predators are concentrated.



In-stream habitat formed by accumulation of coarse woody debris.

▪ Moderate downstream flooding

A well-vegetated riparian corridor serves a number of valuable functions for flood control. Low-lying floodplain areas next to stream channels combined with riparian vegetation reduce the water velocity and allows floodwaters to spread out through the riparian corridor and re-enter the main channel slowly, thus reducing downstream flood potential. Additionally, floodplain soils are often quite porous and roots of riparian vegetation further increase the porosity of the soil allowing large amounts of water to infiltrate and reduce the overall volume of water moving downstream. Furthermore, riparian vegetation uses large amounts of water in the process of transpiration, pulling water out of the soil, which increases the overall water holding capacity of the floodplain soil.

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▪ **Provide water storage (groundwater recharge) and conservation**

Non-compacted soil along with passageways created by decaying roots and animal burrows within the riparian corridor provides a porous medium with very high infiltration rates. This allows for large volumes of water to percolate relatively deeply into the ground, recharging the local groundwater table as well as providing slow groundwater releases from upstream areas to the channel later in the year, increasing the base flow volume in the creek. This phenomenon of high infiltration rates replenishing the groundwater and recharging aquifers is important to both groundwater driven public water supplies as well as private wells.

▪ **Improve water quality/water filtration**

Excessive nutrients (nitrates, phosphates, etc.) can cause aquatic environments to become unbalanced. Manure and/or commercial fertilizer applied to adjacent lands as well as septic system leachate entering streams can cause excessive algal and plant growth which depletes the dissolved oxygen in the water. Too little oxygen is harmful and potentially fatal to many aquatic organisms. Nitrates in excessive concentrations can result in making water unhealthy for animal or human consumption.

A healthy riparian corridor acts as a filter to maintain and/or improve overall water quality, including groundwater quality. Vegetation, both living and dead, will trap suspended materials and reduce water velocity. This allows time for other functions to occur such as deposition of sand and silt, filtration of pathogens and pollutants as the water passes through floodplain soils, reduction of excess nutrients via assimilation by vegetation and microorganisms, and breaking down of pollutants by soil bacteria.

▪ **Provide sediment filtering and erosion control**

Sediment suspended in the water can reduce or block the penetration of sunlight, adversely affecting the growth and reproduction of beneficial aquatic plants. Sediment deposited on the stream bottom can interfere with the feeding and reproduction of bottom dwelling fish and aquatic insects, weakening the food chain. Large deposits of sediment can fill stream channels and floodplains, greatly increasing the potential for downstream flooding. Several mechanisms of sediment removal are at work in the streamside forest. Some sediment settles out as the speed of the flow is reduced by the many obstructions encountered in the forest litter. Sediment is also filtered out by the porous soil structure, vegetation and organic litter as the runoff flows over and onto the floor of the streamside forest.

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- **Provide aesthetic and recreational values**

People are naturally drawn to water for a number of reasons including fishing, boating, swimming or just to be near the water to contemplate its life-giving force. Riparian vegetation has an inherent aesthetic and intrinsic worth that is difficult to value in monetary terms.

3.4 Creek Terminology/ Glossary

Anthropogenic – Changes related to human actions.

Armoring – The installation of impermeable walls or other hardened structures (rock, concrete, etc), including gabions, which prevent or substantially limit the growth of native trees and other desirable native vegetation.

Bank Stabilization – Securing of a creek bank through utilization of vegetation (dead and live materials) and/or built structures.

Bankfull – Channel dimension/ volume defined by a storm that occurs statistically once every 2 years.

Bioengineering Stabilization - Utilization of biological (plant and tree) materials to construct living structures for erosion control and revegetation (habitat enhancement).

Biotechnical Stabilization - Utilization of structural and biological (plant and tree) materials to construct integrated living structures for erosion control and revegetation (habitat enhancement).

Biological – Of or relating to living elements and systems such as plants and animals.

Brush Mat - Bioengineering technique for bank restoration and revegetation.

Bulkhead Wall – Vertical or battered structural wall built in constrained locations along a river or creek.

Coarse Woody Debris – Accumulations of fallen trunk and branch materials along the creek channel.

Conveyance – Flow capacity of a watercourse that depends on channel cross-section dimensions, slope and banks conditions such as friction created by vegetation and other bank materials.

Cutting – A section of plant/ tree stem, branch or root that will regenerate when planted.

Dynamic Equilibrium – A condition in which creek conditions change slightly throughout the year but return to the same average condition

Erosion – Removal of soil and rock by weathering, mass movement, and the action of creeks, glaciers, waves, and wind and groundwater.

Federal Endangered Species Act – Set of laws (enforced at the Federal level) that protect specific plant and animal species that are threatened with extinction and regulate human activities that potentially impact these species.

Flanking – Removal of soil and rock by creek flows moving around the edges/ sides of a structure along the creek bank.

Fluvial – Relating to moving/ flowing water in a river or creek.

Gabion – A large basket made of galvanized wire mesh filled with stone and/ or cobble materials often utilized to armor creek banks.

Geomorphology/ Geomorphic – The study of processes that shape landforms.

Geotechnical – Relating to the scientific and engineering principles and mechanical characteristics of soils and geologic materials.

Geotextile – Durable synthetic construction fabrics (high tensile strength) used in the installation of drainage and bank protection applications. Fabrics limit the movement of soils through bank stabilization measures. Biodegradable materials such as coir and jute can be used for temporary soil stabilization to allow and support vegetation establishment.

Grade/ Graded – Excavation and/ or reshaping of a specific area of land.

Guidelines – A written set of criteria or parameters that help to direct specific actions to achieve more comprehensive goals and objectives.

Headwaters – The highest areas in a watershed where channels begin to take shape and concentrate surface runoff into creeks.

Hydraulic – Pertains to how the water is behaving in the creek channel. Typical measures of hydraulics include: flow depth and velocity.

Hydrologic – Relating to the rainfall runoff process. Hydrology describes/predicts how water is converted from rainfall to runoff volume in the creek at any location.

H.T. Harvey & Associates (HTH) – Biological resources consulting firm.

Impinging – Concentrated flow that is directed straight onto a bank or structure.

Incise/ Incision – Downward erosion of a river or creek bed across an entire section or reach.

Joint Powers Authority (JPA) – A multi-jurisdictional agency consisting of the cities of Menlo Park, Palo Alto, and East Palo Alto, San Mateo County, and the Santa Clara Valley Water District formed to improve community storm preparation and flood management at San Francisquito Creek.

Keyed – To embed a structure into the bed and banks of the creek to encourage smooth transitions and reduce potential for scour and flanking.

Layback – Excavate or regrade creek banks to create flatter, more stable slope conditions.

Philip Williams & Associates (PWA) – Hydrologic and environmental restoration consulting firm.

Reach – A continuous section of river or creek channel defined by similar physical characteristics.

Revegetation – Planting/ installation of desired vegetation (native plants, trees, and seeds) in areas that have been cleared of existing non-native species and/ or targeted for habitat enhancement.

Riffle – A short section of steep, shallow water that is moving more rapidly than the water up or downstream of it. Often marked by coarser bed material such as cobbles or boulders.

Riparian – Of or relating to the environments, eco-systems and species that have evolved in association with rivers and creeks.

Riprap – A layer of rock placed on a creek bank to armor surface against erosion, scour and sloughing.

Rock Size – Dimension and weight of rock material specified to meet design.

Scour – Localized erosion of material from the creek bed by flowing water.

Shear Stress – Force acting over the wetted surface created by flows in a river or creek (measured by force/ area).

Setbacks – Defined dimension along the creek where certain activities are regulated to protect creek conditions and functioning.

Top of Bank – Top of creek bank where the slope and terrace conditions meet.

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Toe – Base of creek bank, slope protection or wall.

Vegetated Soil Lifts (VSL) - Biotechnical engineering technique for bank restoration and reconstruction.

Watercourses – Natural or human-made channels that convey water.

Watershed – The area draining into a river or stream.

3:1 – Definition of bank slope angle using relationship of horizontal to vertical dimensions (horizontal dimension: vertical dimension)

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