Existing Watershed Conditions

In the following discussion and throughout this management plan, the term *lower* reach refers to the portion of Carneros Creek from the Napa River to Old Sonoma Road Bridge, the *middle* reach is the portion from the Old Sonoma Road Bridge to the end of the public portion of Henry Road, and the *upper* reach is the portion from there to the headwaters (Figure 5).

Figure 5: Map of creek reaches within the Carneros Creek watershed.
Source: Napa County Resource Conservation District, 2004

This section is broken down into several resource topics including riparian function, upland ecology, salmonid habitat, soil erosion & excess sediment, flood hazards, and water supply. The relative importance of each resource issue depends upon specific watershed management goals and interests. Further detail regarding the existing condition of the watershed can be found in the Reference Document that accompanies this plan and in the various technical reports that were conducted as a part of the watershed assessment.

Riparian Function

Riparian vegetation along the creek provides an aesthetically pleasing channel corridor and is vitally important to the functioning of the creek. Riparian vegetation provides a myriad of benefits to the stream ecosystem including bank stabilization, erosion control, water temperature regulation, a source of nutrients, a source of large woody debris (fostering pool formation and creek channel complexity), in-stream cover for fish, and a means of filtering runoff (trapping sediment and contaminants) before it enters the channel. In addition, riparian vegetation also provides habitat, food, and a migration corridor for many terrestrial wildlife species.

The riparian corridor along Carneros Creek is fairly continuous and well-developed. It provides shade essential for maintaining adequate water temperatures for cold-water fish (such as steelhead) and provides a mechanism for pool formation through potential recruitment of large woody debris. The total length of the riparian corridor along the lower reach of the creek has increased by approximately 4,000 feet since 1858. Canopy cover is generally high (averaging 91%) and is comprised of 74% evergreen tree species and 26% deciduous tree species. Non-native species such as Himalayan Blackberry also occupy much of the riparian corridor and provide little benefit to the functioning of the creek and its corridor. Figure 6 shows a time-series view of the lower reach of Carneros Creek where it enters the Napa River. Evidence of the downstream riparian extension, past channels, and minor changes in a large meander are visibly comparable between the photos.

Although the riparian corridor is continuous, current observations show that the width of the riparian corridor is narrow, often comprised of a single row of trees, in many sections. Many of the trees are at risk of falling into the creek and younger trees have not been established to replace them. Streambank erosion is threatening the remaining riparian vegetation. In the lower reach, bank erosion has caused many of the mature bay trees to become severely undercut, putting them at risk for falling into the channel in the near future. Loss of these trees would not only create a large gap in canopy cover, but also potential flood hazards, decreased bank stability, and negative effects on water temperature and quality.

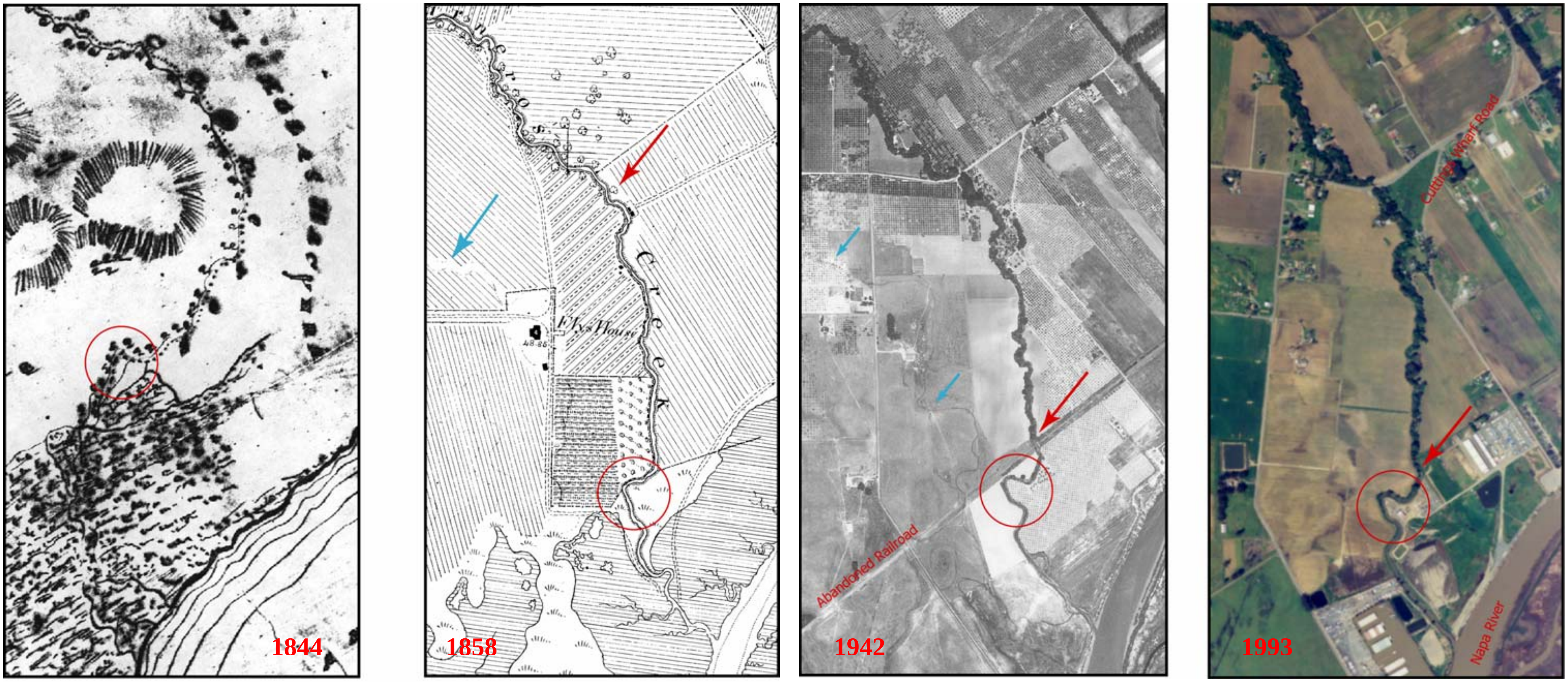

Figure 6: Time-series view of the lower reach of Carneros Creek. Note the change in the meander shape between 1858 and 1942, possibly due to the railroad (red circle), evidence of a former channel (blue arrows), and extension of riparian vegetation (from the red arrow in 1858 to the red arrow in 1942 and 1993).

Source: San Francisco Estuary Institute, 2002

Upland Ecology

Watershed health and function includes more than just the creek and its riparian corridor; many important physical processes occur in the surrounding upland landscape. Surrounding areas provide habitat for a diverse community of plant and animal species that help maintain the function of the natural ecosystem. Increased development, intensive land use, fire suppression, and altered hydrology of the watershed can all affect the functioning of terrestrial ecology. Potential watershed wide impacts include changes in vegetation patterns, amount and/or quality of habitat provided, and introduction of invasive species.

Historically, the lower portion of the Carneros watershed was open grassland with seasonal wetlands and the middle and upper watershed was a mix of grassland, brush, shrub, and woodland under native management (primarily burning), that supported native mammals. The watershed currently supports annual grasses and forbs and mixed hardwoods with smaller areas of California Bay and Pacific Douglas fir. Compared with historical records, a greater number and larger extent of invasive plant species are now found in the watershed. The change in vegetative composition coupled with vineyard and residential development has altered the types of habitat available to support various wildlife species; habitat has diminished for some species and expanded for others. For example, the open grasslands in the lower watershed historically supported Western burrowing owls and waterfowl. Vineyard and residential development in the lower watershed replaced a majority of the grassland habitat and this, in combination with an increase in the number of trees in the lower watershed, resulted in reduced habitat for grassland species and additional habitat for predatory birds that prey upon burrowing owls and waterfowl.

For species dependent upon riparian, woodland or chaparral (brush and shrub land) habitats, the change has been less dramatic. Although natural habitat areas are generally decreasing in the watershed, riparian, chaparral and woodland areas in the upper watershed are experiencing expansion into the grasslands. However, because the riparian corridor in the lower reach is dominated by a single row of mature bay trees, in the future, when these severely undercut trees fall into the channel, gaps in the habitat that connect the lower and upper watershed will be created and may negatively impact wildlife species that are dependent upon the corridor.

In addition to altering wildlife habitat, the change in vegetation and increase in development have also altered the way in which precipitation is intercepted, infiltrated and stored in the watershed. Existing grasslands in the watershed are predominantly comprised of exotic Mediterranean annuals, which are tolerant of grazing and drought and are able to suppress the growth of native perennial grasses. Native perennial grasses provide the benefit of maintaining a large living root mass through time, thus increasing soil stability and precipitation infiltration, whereas exotic annuals reproduce by seed and do not maintain the same beneficial living mass of roots. Remnants of native grassland still exist and with proper expansion and restoration, possibly including careful application of grazing and fire, could provide benefits to the chemical and physical make-up of the soil and the infiltration capacity of the hillslopes.

The factors limiting the maintenance of a healthy, functioning terrestrial ecology are historic and current development and land management practices. Changes from natural vegetation patterns and densities occurred with the advent of suburban residential development, vineyards, agriculture, and grazing. Remaining habitat is fragmented and altered by non-native tree and grass species. Important land management practices that have significant effects on terrestrial ecology include the volume of water diverted from the creek, active fire suppression, and riparian corridor management. In addition, although the topic of groundwater will be discussed in a later section, the groundwater table is sensitive to withdrawals in some areas and a lowered groundwater table will reduce the amount of water provided to the creek from groundwater storage, thus reducing the amount of water available for animal and riparian plant species, especially during the late summer and fall.

Salmonid Habitat

Many physical processes combine to create suitable aquatic habitat. Different life stages of salmonids require various habitat elements, but several elements are universal to the different stages and will benefit many other aquatic species. Steelhead trout require cool water temperatures (below 68°F), access to the ocean, year-round water, a source of food, channel complexity, pools and velocity shelters, cover from predators, adequately sized spawning gravels, and a healthy riparian corridor, amongst other factors.

The Carneros Creek watershed currently supports one species of salmonid, steelhead trout, which is a federally listed threatened species (Figure 7). Historical records go back as far as the mid-19th century, when Menefee (1873: 36), described Carneros: "The writer has caught several [trout] that weighed from 7 to 10 ½ pounds, in the Carneros, five miles from its mouth, where the water was not a foot deep." Although it is likely that Carneros Creek never supported an exceptionally large steelhead population, its relative importance, compared to other streams of similar size in the North Bay, has probably increased. This is due to the maintenance of fairly rural land uses, lack of complete migration barriers, and direct connection and relative proximity to the Bay.

Figure 7: Steelhead Trout
Source:

The middle reach is the only reach suitable for steelhead spawning and rearing. This reach contains multiple areas for spawning with appropriately sized gravels, relatively high amounts of large woody debris, suitable channel complexity, the highest number of pools, the closest average pool spacing, consistently cool water temperatures, good cover, and relatively low volumes of sediment within pools. Most importantly, the middle reach is the only part of Carneros Creek with year-round water needed to support juvenile fish. Comparatively, the lower reach acts primarily as a migration corridor and provides only very limited year-round habitat due to lack of surface flow. Many negative sediment-related impacts on salmonid habitat are also observed in the lower reach and include: deficient pool frequency and quality, and moderate sediment embeddedness. The upper reach may support steelhead spawning but it does not support rearing because it is completely dry in the summer.

As discussed above, portions of the riparian corridor are at risk, particularly along the lower reach of Carneros Creek, below the Old Sonoma Bridge. In this reach, a single row of mature trees comprises the only riparian corridor, and it is severely undercut and in danger of toppling into the creek. Bank erosion and associated channel widening are the cause of this riparian instability. Although limited, the riparian corridor in this reach does provide many benefits, including shade for the maintenance of cool water temperatures. The riparian corridor in the middle and upper reaches are not nearly so vulnerable. However, some creek reaches in the upper watershed, where cattle are not fully fenced out, are showing damage to banks and riparian vegetation. Overall, the riparian corridor is not presently a limiting factor for steelhead success, but it could become a factor when several of the larger trees fall.

Multiple factors are limiting the success of steelhead in Carneros Creek. The most important factor appears to be low stream flow. Although the middle reach maintains year-round flow, the upper and lower reaches do not, and therefore, do not provide adequate rearing habitat. Evidence suggests that much of Carneros Creek did not flow year-round during historic times and that flow was historically negligible or intermittent in the summer. There are some anecdotal descriptions that the amount of intermittent flow and persistent pools has decreased over the past several decades. A number of residents independently describe a reduction in the extent of pools and seasonal flow, reporting that: "it ran more" and "used to visibly run ... enough to get over the rocks, when I came here." Additionally, several landowners suspect that stream flow may be influenced by the geologic fault that exists in the watershed. Several landowners have noted increases in stream flow that coincide with local earthquake activity.

Secondary limiting factors are lack of channel complexity in the lower reach, important for shelter during migration and cover from predators, as well as some partial migration barriers limiting the extent of available habitat. The most extensive barrier is the dry lower reach, where reduced flow during late spring and early summer limits the movement of young steelhead out of the creek and into the Bay and ocean (outmigration). In the middle reach of the creek, three dams and a small bedrock cascade are identified as likely obstacles during low flows, limiting both up and downstream migration. Nineteen on-stream reservoirs were also identified on tributaries to Carneros Creek, each preventing further upstream migration. However, steelhead do not appear to use these tributaries due to seasonal drying and other unfavorable conditions, so the impacts of these dams in terms of limiting habitat availability is likely very minor. Despite several partial barriers, the creek still maintains a direct path from the upper watershed to the Napa River, with no complete barriers.

Soil Erosion and Excess Sediment

Erosion is a natural process that acts to keep the landscape and stream channel in equilibrium. Some erosion is beneficial and essential to the watershed; for example, landslides and bank erosion provide sources of fresh sediment and gravel to the channel that can be utilized by spawning fish. However, intensive use of the land has the potential to increase rates of erosion and tends to supply more sediment to the creek than the system can handle, thus altering the natural balance. Excessive soil erosion can lead to costly property loss and resource degradation.

Soil erosion is a process that can take many forms including: bank erosion, gully erosion, sheet and rill erosion, and landsliding; all of which are currently occurring in the Carneros Creek watershed to varying degrees. Much of the erosion occurring on Carneros Creek is caused or aggravated by human activities. Finding solutions to minimize erosion induced by human disturbance is essential because property and soil resources are valuable and because excess erosion and the resultant sediment input to the creek can have negative impacts on channel functioning and aquatic habitat. Figure 8 shows examples of bank and gully erosion.

Figure 8: Examples of bank and gully erosion in the Carneros Creek watershed.
Source: Napa County Resource Conservation District, 2002

In the lower watershed, the change from grasslands, hay/grain production, and orchards to vineyards has, in some cases, led to more intensive soil disturbance and therefore increased the potential for surface erosion. Vineyard and road runoff controls such as pipelines and ditches concentrate runoff and provide ready transport of any surface erosion to the channel system. In addition, drainage pipes that discharge concentrated runoff onto channel banks without proper energy dissipation often cause bank collapse or gullying. Most of the lower watershed has been subject to some type of agricultural activity for well over a century, resulting in an increase in the erosion potential. In the middle and upper reaches, both historic and recent grazing practices cause the largest impacts to the hillslopes and banks.

Accelerated bank erosion caused by changes in land use and management is contributing substantial amounts of sediment to the creek. Localized areas in the middle reach, upstream from the Old Sonoma Road Bridge, are contributing the largest volume of sediment per unit channel length, with half occurring in the past 20 years. Tributary banks are also experiencing erosion but at a much slower rate. Most measured erosion is chronic, occurring over the past 50 to 100 years. However, bank erosion rates appear to have increased in the past 10 years. Bank material and vegetation cover determine the stability of channel banks in the watershed. Although bank material along the mainstem and tributaries is variable (ranging from bedrock to silt/clay), nearly the entire channel bank length contains at least some vegetation, including areas of dense vegetation. However, there are a few locations, especially in the lower reach, that contain bare banks with only exposed roots from the trees growing on the top of the bank. Areas with silt/sand banks and/or banks with minimal vegetation are at higher risk of eroding.

Landslides and other hillslope mass movements also contribute sediment to the creek. Approximately120 current and historic landslides have been mapped since 1942 and are contributing sediment to the creek system. Due to different underlying rock types, the east side of the watershed is more prone to hillslope failures. Most slides occur in the grasslands and appear to be associated with the underlying geology, rather than with changes in land use. Large storm events or prolonged, above-normal seasonal rains that saturate the soil are the likely triggering mechanisms. . Erosion control is recommended for seven landslide sites.

Sheet and gully erosion is occurring. The largest gullies are forming downstream of poorly designed outlets of existing reservoirs. Rilling and gullying are observed in vineyards planted perpendicular to contour before cover crop growth in the fall and especially on hillslopes steeper than 10%. However, most vineyards have existing cover crop growth, significantly reducing the amount of observed erosion. Gullies are also observed in areas grazed by cattle, on hillslopes receiving road runoff, and on stream bank slopes below culverted drainage outlets. Sheet erosion occurs primarily on bare soil areas throughout the watershed and on long stretches of unpaved rural road with poorly designed drainage and ditches that are connected with, and flow into streams.

Over 11 miles of road surface in the watershed drains directly to the channel system, delivering runoff and fine sediment. Undersized or plugged culverts and diverted streams also have the potential to contribute eroded sediment. Erosion control efforts are recommended for 10.3 miles of road, 16 of 23 ditch relief culverts, and 90 of 101 stream crossings. The erosion- and storm-proofing recommendations include a combination of such preventative treatments as re-grading roads to include rolling dips; installing wet crossings; removing or replacing undersized or damaged culverts; realigning culverts to the channel gradient; retrofitting pipes with a downspout, trash rack and/or flared inlet; and rock armoring outlets.

Many locations and types of erosion are observed throughout the watershed. Although some is attributable to natural physical conditions and processes, a portion is due to human modifications or land uses. Of the identified erosion causes, grazing practices (both historic and current), altered runoff patterns and timing created by intensive land use, road drainage and viticulture appear to be the critical causes.

Flood hazards

Floods can damage streamside property, bridges, and roads, and they often cause high rates of bank erosion and sediment transport. However, periodic flooding is also important to maintain channel function and steam ecology. Flooding occurs naturally in fluvial systems in response to climate and stream conditions with some degree of regularity over time. Reducing the damage caused by floods is possible with careful planning and implementation of key prevention strategies throughout the watershed. Human activity can alter the frequency and force of flood events through modification to the stream system. Natural and anthropogenic factors are contributing to the flood hazard in Carneros Creek. Addressing current management practices that increase the likelihood of flood hazards is important.

Overall, flood conveyance in Carneros Creek appears to be effective. Recent floods have not topped the terrace banks, even in the lower entrenched reaches. However, localized flooding does occur in the watershed and factors that contribute include: increased surface and subsurface drainage and time to peak flow associated with high intensity land use; a large number of inadequate culverted stream crossings; the large amount of woody debris in the creek and/or available for recruitment to the creek; and potentially some stream stabilization projects. In addition, catastrophic failure of an on-channel reservoir could potentially cause flooding, property damage, downstream sedimentation, bank erosion, habitat loss and widespread channel morphology changes. Limitations on building structures within flood-prone areas of the creek will assist in preventing future damages that may be caused by localized flooding.

Land use intensity is increasing and having an impact on localized flooding. Although historic cultural burning had some effect upon infiltration and evapotranspiration, recent changes in land use are having a larger impact by routing more water to the channel system in less time and increasing the likelihood of localized flooding. Land use changes include increases in agriculture, impervious surface areas, vineyard-related engineered subsurface and surface water drainage systems, and road density.

Multiple channel crossings and constrictions exist in the watershed and may also pose a flooding hazard. The mainstem of Carneros Creek has eight major crossings, either bridges or culverts, all of which appear to be large enough to accommodate flood flow. There are also several crossings located on tributaries; many of these are undersized and have the potential to constrict high water flows and cause localized flooding. Additionally, because the potential for wood recruitment to the creek is high and because the channel already contains many large woody debris pieces, plenty of debris is available to catch on bridge pilings and culvert inlets, causing a backup of floodwaters.

To some degree, bank stabilization efforts, particularly in the lower reach may also influence the likelihood of localized flooding. These hardscape revetments typically encroach upon the natural channel area, causing a decrease in the volume of flood flow that can pass, and increasing the likelihood of flooding.

The watershed currently contains 57 on- and off-stream reservoirs, which intercept and retain storm flow, acting to reduce the peak of the hydrograph and the likelihood of flooding, at least during the early part of the rainy season. However, some of these reservoirs have the potential to overflow, with the potential to cause either severe erosion or catastrophic failure of the dam and associated flooding.

Water Supply

Water is essential for all aspects of life, including agriculture, grazing, human habitation, aquatic and terrestrial habitat, and vegetation communities. Water availability is generally limited in the Carneros Creek watershed. There are many competing uses for the finite amount of water including flows for environmental benefits, diversion for storage, diversion for land uses or residential needs, and extraction from wells. Without continued maintenance of and/or increases in seasonal water flow in Carneros Creek, continued challenges for all water users will likely occur.

Precipitation is the primary source of surface water in the watershed and is driven by the natural regional flood/drought regime. Average annual precipitation in the watershed is 28 inches and it is estimated that approximately 52% of rainfall in an average year enters the creek as runoff; wetter and drier years have proportionally greater and less runoff, respectively. The rate at which the creek flows is seasonally dependent; water levels in the creek begin to rise in December and closely follow precipitation events, frequently ceasing to flow from September to November. The overall low levels of seasonal flow are likely the historical norm and are typical of many Napa region creeks. Historic stream surveys have noted lack of channel flow. However, there is evidence of recent decreases in flow. The entire channel has essentially no flow from September to November. The upper reach is completely dry throughout the summer and fall, the middle reach has perennial (year-round) surface flow that slows to a trickle in the late summer, and the lower reach contains only isolated pools, which quickly decrease in volume and quality throughout the summer. Aquatic habitat for cold-water fish is impacted by the naturally low summertime flows and exacerbated by additional decreases. Figure 9 shows an example of stream levels in the lower and middle reaches of Carneros Creek during the month of July.

Large volumes of water are being stored in reservoirs. A total of 57 on- and off-stream reservoirs exist, all having been built since 1940. Reservoir surface area ranges from 1,600 square feet to 31 acres. On-stream reservoirs intercept and retain storm flow, slowly releasing water for irrigation purposes over the growing season. Currently, over 30% of the average surface runoff is allocated for diversion.

Figure 9: Images from the lower and middle reaches of Carneros Creek. July, 2004.
Source: Napa County Resource Conservation District

Groundwater is also generally limited in some areas of the watershed. Based upon historic studies and current landowner observations, the groundwater table appears to be sensitive to overdraft. The incised nature of Carneros Creek, as well as localized use of groundwater for domestic and irrigation purposes, contributes to a localized drop in groundwater levels. Continued monitoring of well levels in Carneros and additional research are essential to establish a trend and to better understand the form and recharge characteristics of the groundwater aquifer.

A large portion of water is diverted/extracted for human uses. Although agricultural land was historically dry farmed, many diversions are apparent in historic channel surveys, presumably for grazing and household needs. Wells generally supply water for residential uses and for irrigation of some vineyards, many of which are located on the eastern side of the watershed because of a relatively higher groundwater table. The amount of groundwater being extracted and the effect that extraction is having on surface flows are unknown; groundwater pumping is not frequently monitored and permits are not needed for extraction.

To a lesser extent, changing vegetation patterns are also influencing surface flows and groundwater recharge by altering the infiltration/transpiration capacity of the watershed. This is primarily happening through expansion of chaparral/woody vegetation into grasslands and lengthening and expansion of riparian vegetation.

The factor most responsible for a limited water supply in Carneros Creek is the natural climatic and geologic characteristics of the watershed. Secondary factors are the increased population of the watershed and greater diversion and extraction associated with more water-intensive land uses.