FINAL REPORT

Upper Pajaro River
Sediment Assessment

Prepared for:
Monterey Bay Sanctuary Foundation
299 Foam Street
Monterey, Ca 93940

February 2004

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Transmittal: **Technical Report – Upper Pajaro River Sediment Assessment**

Dear Katie and Larry:

Fall Creek Engineering, Inc. and Associates is pleased to present to you the final report for the Upper Pajaro River Sediment Assessment. This report summarizes and presents the results of a land use and stream sediment source and problem assessment conducted as part of a water quality attainment strategy for Llagas and Uvas Creek watersheds. This effort has been completed in collaboration with the Santa Clara County Farm Bureau Agricultural Water Quality Initiative community outreach effort within the Llagas and Uvas Creek basins.

The public outreach and project administration of the Monterey Bay National Marine Sanctuary, Central Coast Regional Water Quality Control Board, and the Santa Clara County Farm Bureau was critical to the successful completion of this study. Thank you for the opportunity to participate in this project. We look forward to future collaborative efforts with the Sanctuary and CRWQCB.

If you have any questions or comments, please do not hesitate to contact me at (831) 426-9054.

Sincerely,

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Final Report

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DISCLOSURE

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EXECUTIVE SUMMARY

E.S.1. Background

The Pajaro River Watershed is one of the largest riverine systems entering the Monterey Bay and drains an area of approximately 1,300 square miles of land on the Central Coast of California. The water quality of the Pajaro River and several tributary streams have been identified by the California Regional Water Quality Control Board (Regional Board) as being impacted by sediment, nutrients and other pollutants. Llagas Creek, a sub-watershed of the Pajaro has been designated by the Regional Board as a water quality impaired surface water body for both sediments and nutrients and is listed as required by Section 303(d) of the federal Clean Water Act on the Regional Boards' "303(d) list" of impaired water bodies. Under the provisions of the Clean Water Act Section 303(d), the State of California is required to develop and implement a water quality attainment strategy, including a Total Maximum Daily Load (TMDL) allocation to remedy impacts and improve water quality to ultimately restore the beneficial uses of the water body.

To better assess water quality impairments in the watershed, the Regional Board has funded a focused study in the Llagas and Uvas Creek watersheds to better characterize erosion and sedimentation problems in these areas. The study area includes approximately 202 square miles of the upper northeastern portions of the Pajaro River Watershed. The development of this pre-TMDL sediment assessment has been done in collaboration with the Santa Clara County Farm Bureau (SCCFB) and Fall Creek Engineering, Inc. (FCE). FCE conducted a field-based assessment of upland and stream conditions to evaluate erosion and sedimentation conditions in the study area. Throughout the course of the study the SCCFB Watershed Working Groups have been periodically updated and informed of the project and water quality planning process.

E.S.1.1. Water Quality Impairment of Surface Water Resources

There are many factors controlling the rate and extent of erosion and sedimentation in the study area including, soils, geology, topography, climate, vegetation and land use. Erosion and sedimentation can also be grouped into two principal categories, generally non-controllable and controllable sources. Many natural sources are considered to be non-controllable and may include catastrophic events such as landslides, floods and earthquakes that lead to substantial erosion and sedimentation. Historical and current land use and hydromodification activities have impacted water quality in the Llagas and Uvas Creek watersheds. Many of these water quality impacts are attributed to land use practices observed throughout the study area, including intensive agriculture, urbanization and loss of pervious surfaces, equestrian facilities, and other upland uses. These sources are typically "controllable" and can be identified and corrected to mitigate impacts to water quality.

E.S.1.2. Scope of Work

The focus of this study is the development of a pre-TMDL sediment assessment, which will support the development of a water quality attainment strategy and sediment TMDL. The problem assessment is an evaluation of sediment conditions, erosion risk, and potential impacts to beneficial uses within the study area. The field assessment also identified sediment sources and categorically ranked the erosion potential of sub-areas within the study area. As a result of the information collected in this study, data gaps can be directly linked to sediment source categories and agencies can prioritize projects to address areas with a high risk of erosion.

The major study tasks include:

- Preliminary problem and source assessments based on existing information, additional field surveys, and data collection in selected areas;
- Evaluation of impacts to beneficial uses and water quality objectives;
- Analysis of land use, particularly agricultural land uses;
- Regular outreach presentations to SCCFB Watershed Working Groups;
- Collation of existing information on sediment/suspended solids throughout the watershed;
- Determination of data gaps and recommendations to fill data gaps (sampling, data acquisition, etc.);
- Recommendations of priority actions and areas to reduce controllable sediment sources; and
- Develop a Technical Report.

E.S.2. Llagas Basin Study Area

The Llagas Basin study area comprises an approximate 202 square mile area in Southern Santa Clara County. The South Santa Clara Valley is on the eastern side of the Santa Cruz Mountains and extends from the north side of Morgan Hill south to Gilroy. The primary drainage systems in the Llagas Basin study area (study area) are Llagas Creek and Uvas-Carnadeross Creek. Surface water resources in the study area consist of a network of perennial and intermittent streams, engineered drainage channels, and reservoirs.

The activities and land uses in the region are diverse and generally transitioning from a historical agricultural and ranching base to a mix of urban, suburban, mixed commercial and industrial uses. The study area has two major urban jurisdictions, the cities of Morgan Hill and Gilroy.

E.S.2.1. Study Regions and Sub-areas

The Llagas Basin study area was first delineated and then divided into four smaller regions. These Regions were identified with the consideration and weighting of the following: landscape position, hydrologic sub-units or watersheds, current land uses, and previous investigations. These regions were further divided into additional sub-areas. These sub-area boundaries do not conform to precise sub-basin or sub-watershed units, but provide a structured and systematic approach to the description and analysis of land use practices, hydrology, and natural and anthropogenic sources of sediment. The following is a general description of the four Regions within the study area.

Upper West Basin Region - This area comprises most of the western mountain and foothill areas and is the largest Region in the study area. These areas have the largest amount of forest and scrublands in the study area. This area continues to be used for timber and grazing activities, but in recent years has had an increase in medium to large acre residential construction. Intensive agriculture is limited to a few, often small, wine grape vineyards. Many of the creeks in these upper watershed areas have experienced limited impacts related to recent human activities, and the channels remain generally unmodified.

North Valley Region - These areas include the City of Morgan Hill and the outlying and increasing western and eastern suburban areas around the city. These land areas have experienced significant residential and commercial development in the past 30 years. Until recently this was directly linked to agricultural land conversion in the Southern Santa Clara Valley floor; however, residential development has been increasing in the western and eastern foothill areas formerly utilized for rangeland, scrub, and forested land.

Mid-Valley Region - These areas include much of the unincorporated areas of South Santa Clara County devoted to rural residential lands, in addition to the northern portions of the City of Gilroy, and the remaining agricultural and rangelands on the eastern and western foothills. Much of this area has experienced land use conversions from agriculture and ranching, to urban and rural residential uses in the past thirty years. Recently, there have been a large number of residential developments in the eastern foothill areas on former rangeland.

Lower Valley Region - This area represents the majority of active agricultural lands in the study area, urban lands in the City of Gilroy, and rangelands on the eastern and western hills. Agricultural lands in this area have experienced significant conversion in the past thirty years from extensive crop systems like dry farmed wheat and pasture, and grazing of meat and dairy animals to intensive irrigated row crops. The continual expansion of urban limits in Gilroy has resulted in the conversion of former agricultural and rangelands to residential and commercial use.

E.S.3. Land Use and Channel Assessment

E.S.3.1. Channel Assessment Methods

A field assessment methodology was developed to identify in-channel erosion and rank channel conditions throughout the entire study area. Two methodologies were employed to assess the risk of erosion in channels: proper functioning condition (PFC) and bank erosion hazard index (BEHI). An aerial photograph of the southeastern portion of Santa Clara County, taken in August of 2000, was also used to supplement the PFC and BEHI channel assessment methodologies. Channel assessments were conducted from public access points within each sub-area, and in a few cases, on private lands where prior permission had been received for other related work. Average channel characteristics were used to derive PFC and BEHI ratings.

Proper Functioning Condition (PFC)- Index or functioning reaches were defined as those with no or little human disturbance within the past 40 years and no evidence of residual erosion or instability due to past human activity. Moderately disturbed or moderately functioning reaches were defined as reaches with recent management impacts but good protection over the stream course. Highly disturbed or non-functioning areas were defined as reaches with large areas of disturbed soil.

Bank Erosion Hazard Index (BEHI) - The Bank Erosion Hazard Index (BEHI) is an assessment developed by Wildland Hydrology, Inc. based upon quantitative measurements of bank characteristics.[1] The assessment compares measurements of bank characteristics to a relative risk of erosion. The five risk categories include a ratio of bank to bankfull height, a ratio of rooting depth to bank height, root density, slope steepness and percent surface area protected by vegetation. Categories of risk range from very low, low, moderate, high, very high and extreme.

[1] Rosgen, D.L, 'A Practical Method of Computing Streambank Erosion Rate', March 2001.

Assessment of Vegetation Density - A recent aerial photo of the southeastern portion of Santa Clara County was used to supplement the PFC and BEHI channel assessment methodologies. Specifically, the photo was used to assess the relative density of vegetation along stream reaches. Vegetation density was classified in three categories: low, moderate, and high. Generally the low vegetation density stream reaches do not have the root mass capable of withstanding erosion from high flow events and high vegetation stream reaches generally do.

E.S.3.2. Land Use Assessment Methods

The land use analysis was produced using a mixture of existing data bases, combined with ground-based and aerial photo truthing. The emphasis was to develop a robust and current quantification of the amount of agricultural land and it's distribution in the study area. This was achieved by utilizing a recent Santa Clara County Agricultural Commissioner GIS coverage and detailed ground-truthing of current croplands. A further step involved the development of a crop system category that provided a means to estimate the crop sediment risk potential in each sub-area. A California Department of Conservation (CDC) GIS database was used to determine developed urban, rural residential properties, and rangeland areas.

Agricultural Crop System Sediment Risk Categories - The Agricultural Commissioner's database was used to develop crop categories that were ranked based on their potential 'risk' as sediment sources.

The crop categories are:
- Short-term Row Crops – Annual irrigated vegetable crops, including strawberries
- Medium-term Row Crops – Bushberries (e.g. raspberries), asparagus
- Field Crops – Grass (forage and hay), alfalfa, turf
- Medium-term Perennial Crops – Perennial spice crops
- Long-term Perennial Crops – Vine (e.g. grape) and tree (e.g. cherry) crops
- Greenhouse Crops (Impervious Surface) - Greenhouse roofs and container areas

These crop categories (excluding Greenhouse) were then assigned to a sediment source risk category based on functional attributes (e.g. bare fallow periods, stormwater runoff potential). These categories were broadly defined as:

Low Risk – Field and Long-term Perennial[1]
Medium Risk – Medium-term Row and Medium-/Long-term Perennial[2]
High Risk – Short-term Row[3]
[1] Perennial crops typically planted on low slopes
[2] Long-term perennials typically planted on sloping land (e.g. grapes)
[3] Irrespective of soils or slope

E.S.3.3. Stream Channel Assessment Results

Sediment Source Categories - Observed in-channel sources of sediment, as described in the detailed channel descriptions can be divided into five categories: hydromodification, channel incision, bank failure, road ditches, vegetation, land use encroachment, and access. Two primary in-channel sediment source categories were identified in the course of the channel assessment program; channel incision and bank erosion/failure.

Within the study area, channel incision can generally be attributed to increased flow volumes associated with decreased access of high flows to the floodplain. This may result from increased flow volumes derived from decreased areas of infiltration associated with urban development. Increased flow volumes often occur with hydromodifications of channel geometry and form, which limit the ability of the natural channel form to dissipate erosive energy from high flows.

Within the project area, bank erosion/failure can generally be attributed to a lack of vegetation with root mass and cover capable of dissipating energy and stabilizing banks. This may be due to natural or anthropogenic causes. Bank destabilization is likely linked to changes in channel width to depth ratios as the stream system adjusts to compensate for changes in water and sediment supply.

Stream Channel Assessment - A natural stream channel is often defined as "*stable or in equilibrium*" when its cross section, and profile features are maintained with time such that the stream neither aggrades, degrades, or changes in dimension or meander pattern under average climatic conditions.[2] The channel is neither aggrading nor degrading the bed and it is maintaining the floodplain. Under these conditions, the river is said to be in "*dynamic equilibrium*". Channel instability occurs when scouring leads to degradation or when excessive deposition leads to aggradation. Both aggradation and degradation are often accompanied by bank failures, a change in channel dimension, meander pattern, and slope.

Analysis of the field data suggests that much of the Llagas Creek watershed does not exhibit the key characteristics of a system in "*equilibrium*". Conversely, the Uvas-Carnaderos watershed has a greater percentage of stream reaches and tributaries that can be characterized as "*stable or in equilibrium*". The upper reaches of both watersheds above the Chesbro and Uvas dams appear to be "*stable*" and can be considered properly functioning. This is in significant contrast to various ephemeral and intermittent reaches of the Llagas watershed in the eastern foothills and valley floor, as well as the lower southern portions of the Uvas-Carnaderos watershed. Channel modifications, both current and historic, are significant factors influencing channel stability in the entire study area. Several common modifications include residential and agricultural encroachment, removal or elimination of riparian vegetation, increased flow volumes arising from impervious surface runoff, and in some cases, storm runoff from row crop fields.

E.S.3.4. Land Use Assessment Results

Sediment Source Categories - Land use and land conversion are important dynamicss shaping the characteristics and magnitude of sediment sources in the study area. The study area area, with a long history of agriculture and ranching is increasingly becoming an urbanized community with closer

[2] GeoSyntec Consultants, "Hydromodification Management Plan Literature Review", Santa Clara Valley Urban Runoff Pollution Prevention Plan, September 2002.

connection to San Jose and Silicon Valley. This transition is far from complete, but the magnitude and speed of these land use changes implies that the drainage infrastructure, and stream and drainage channels are being forced to adjust to these land use changes.

Given the diversity of land use in the study area, potential sediment sources are numerous. The main controllable sediment sources related to land use are agriculture, rangeland, urban and rural residential stormwater runoff, and commercial and small equestrian facilities. Agricultural sources include historical and current channel modifications, riparian encroachment. bare winter fallow, and drainage practices. Rangeland sources are due to unimproved roads, riparian encroachment, and low residual biomass due to grazing practices. Urban land sources include hydromodifications, riparian encroachment, and firebreaks, while rural residential sources are related to roads and drainage, culverts, riparian encroachment, and firebreaks. Equestrian sources are due to poorly vegetated lots and pastures and riparian encroachment.

Land Use Analysis - Of the approximately 129,000 acres (202 square miles) in the project study area, about 12.5 percent (16,100 acres) are used for agriculture, approximately 46 percent (59,400 acres) are rangelands, and 14.8 percent (19,150) are urban and rural residential areas. The balance comprises forest and scrublands, surface water, mines, and other lands, including abandoned orchards and other non-developed land parcels.

E.S.4. Sediment Source Load Contributions

Sediment contributions from urban, rural residential, agriculture, and equestrian land uses combined are the most important controllable sources in the study area. Rangelands, forest, and scrubland in the Upper West Basin Region, due to their large area extent and topography, contribute a large portion of total sediment load, but represent only a small portion of the controllable sources. In the Valley Region portion of the study area, stream channels are in varying states of disequilibrium, leading to accelerated bank loss and channel incision and sedimentation. In-stream sediment sources may be significant due to the poor functional state and high bank erosion potential of many of the Valley Region ephemeral channels and portions of the mainstem Llagas and Uvas channels.

An estimate of sediment load contributions from the various land uses and in-stream processes has been developed to provide the basis for conclusions and recommendations for future priority actions in the study area. These estimates are based on a conceptual modeling approach, that combined the qualitative assessment results and modification of the sediment load rate estimates derived from the sediment load modeling of the entire Pajaro River watershed performed by the Central Coast Regional Water Quality Control Board.[3]

The following is a summary of the sediment load contribution estimates for various land use and in-stream sources in the Upper West, North Valley, Mid-Valley, and South Valley regions of the study area.

Upper West Basin Region - The Upper West Basin Region includes the Blackhawk, Bodfish, Chesbro Reservoir, Little Arthur, and Upper Llagas Creek sub-areas. The area historically yields significant quantities of sediment from natural or non-controllable sources. Due to limited

[3] Central Coast Regional Water Quality Control Board, *Draft Total Maximum Daily Load for Sediment in the Pajaro River Watershed, San Benito, Santa Cruz, Santa Clara*, and Monterey Counties, December 2003.

development and a small number of lower risk agricultural sources, there are only localized sedimentation problems due to controllable sources. Rangelands contribute the most significant portion (67.5 percent) of total sediment due to their large area. However controllable sources typically related to roads, riparian access or grazing are only a small portion of this total contribution. Agricultural sources (1 percent) are localized in one sub-area. Rural residential sources remain small (1.5 percent) but will most likely increase with continued development in the future. Observations of erosion and sedimentation within the Upper West Region agree with anticipated natural processes of erosion and sedimentation related to the geomorphic setting of the creeks. The estimated sediment load contribution from in-stream processes from creeks in the region is approximately 13.5 percent. The magnitude of this estimate is linked to the landscape or channel slope and topography of the region.

North Valley Region - The North Valley Region includes the Little Llagas, Madrone Channel, Tennant, Corralitos, Middle Llagas, and San Martin Creek sub-areas. The increasingly developed lands in the North Valley region are contributing to sediment loading (13.5 and 18.5 percent for urban and rural residential, respectively) related to impacts on in-stream processes and destabilization of banks and channels. Rangeland sources (38 percent) comprise a very small percentage of controllable sources. Agricultural sources (7.5 percent) related to row crop production are significant in a few sub-areas due to a number of management related factors and past hydromodifications that are controllable with specific practices.

Erosion and sedimentation related to channel hydromodification and encroachment into the channel and riparian zone, results in an estimated load contribution of approximately 19.5 percent. Observations of vegetation removal, channel incision, and bank failure within the region are associated with magnitude of this estimate.

Mid-Valley Region - The Mid-Valley Region includes the Church, Rucker Skillet, Panther, West Branch Llagas, Live Oak, and Lower Uvas Creek sub-areas. The newer eastern hill developments, older rural residential developments and their network of drainage and road ditches account for important and extensive, rather than locally intensive sediment sources (16.5 percent), in addition to impacts from urban runoff (12.5 percent). Additionally, the concentration of small and large equine lots and boarding facilities contribute to increased loading. Agricultural lands on the west side of the area are also significant source areas (10 percent). Generally, sediment contributions from rangelands (37 percent) account for the least significant controllable sources.

Historical and current land use patterns in the region have impacted channel processes. Increased flows from urban and rural residential areas have elevated the erosion potential in stream channels, and sediment load contributions from in-stream process are estimated at 21 percent. The erosion susceptibility of soils in the riparian zone and land use patterns contribute to this estimate.

South Valley Region - The South Valley Region includes the Jones, San Ysidro, Pajaro, Lower Llagas Creek, and Uvas Carnadeross sub-areas. Despite their location in the relatively flat, low-lying areas, the predominance of agricultural land uses, make these sediment sources most important (36.5 percent). Recent and historic hydromodifications related to soil drainage requirements in these contiguous agricultural parcels also contribute to sediment loading. Increased urban lands, although only representing two percent of the sediment load, has increased runoff that has impacted channel stability. Rangelands (33.5 percent), though accounting for a large percentage of the land area do not appear to be significant controllable sediment sources.

Increased flows from urban areas and land use encroachment from agriculture are related to observations of erosion and sedimentation in the region. In-stream sediment source contributions are estimated at approximately 25 percent, primarily linked to the erosion susceptibility of soils in the region and degradation of the riparian corridor.

E.S.5. Preliminary Problem Statement

Due to the diversity of land uses in this rapidly urbanizing area, a large number of controllable factors contribute sediment production and loading. Water quality concerns due to sediment increase when sediment is conveyed into creeks in amounts or locations that exceed the creeks ability to transport it. Additionally, in-stream sediment production may also be increased when existing natural or man-made channels experience rapid increases in upland runoff volumes. A large number of factors control the magnitude of in-stream erosion, including the composition of bed materials, stream flow duration, frequency and location of flow within an active channel, channel geometry, soil and geologic conditions and vegetation.

E.S.5.1. Water Quality and Impairment to Beneficial Uses

Surface water resources in the study area provide for various beneficial uses, ranging from municipal, agricultural and industrial water supply, cold and warm water habitat, wildlife habitat and several other uses listed in Table 8.1. The established narrative and numeric water quality objectives pertaining to sedimentation are limited and may not be fully protective of beneficial uses for surface water resources in the study area.

Other factors related to sediment, including stream geomorphology, sediment loads, riparian habitat, and flows are important factors to consider in the assessment of impairment to, and long term protection of water quality and beneficial uses. Alteration of stream geomorphology, increased fine sediment loads, loss of riparian vegetation, increased stream flows, and other factors have increased sedimentation related problems throughout the study area. These factors in turn are resulting in the impairment of several beneficial uses of streams in the study area, including cold and warm water and wildlife habitat, and migration and spawning for anadromous fish.

E.S.5.2. Beneficial Use Impact Assessment

Identified impacts to beneficial uses on Llagas and Uvas Creeks include impairment to cold and freshwater habitats, wildlife habitat, and migration and spawning of aquatic organisms. Impacts to beneficial uses on both surface water bodies are attributed to a combination of several activities:

1. Hydromodifications
    a. Channelization and channel relocation
    b. Culverts - undersized, collapsed and/or clogged culverts
    c. Creek crossings
    d. Channel disruption - Equipment in channel

2. Fine Sediment Loads
    a. Un-maintained or poorly designed/constructed ranch roads
    b. Placement of tail/stormwater discharge pipes

c. Hillside planting in ephemeral channels
d. Bare corral lots
e. Non-vegetated permanent ditches - steep unstable bank angles
f. Over grazed rangeland with low residual biomass
g. Bare winter fallowed fields
h. Unlined tail/stormwater ditches
i. Road ditches with bare-unstable shoulders, undersized ditch channels; steep unstable ditch banks; and insufficient setbacks from creeks

3. <u>High Flows</u>
    a. Concentrated flows from impervious land coverage

4. <u>Riparian Corridor Impacts</u>
    a. Land use encroachment into riparian corridor
    b. Riparian access
    c. Vegetation removal

E.S.6. Conclusions and Recommendations

E.S.6.1. Sediment Source Conclusions

Within the Upper West Basin Region, in-stream sediment sources are primarily linked to vegetation removal, land use encroachment, and access. Channels in the area are generally considered index or functioning reaches, with no or little human disturbance. Controllable sources of sedimentation from rangelands in the Upper West Basin are localized, not concentrated, and do not appear to contribute significantly to current sediment loads. Agricultural and rural residential sources are important in localized areas, but overall represent a small portion of the total sediment load.

Channels in the North Valley Region have been impacted by channel hydromodifications and land use encroachment related to urban and rural residential developments. Sediment contributions from urban and rural residential sources are related to concentrated hillside development, road ditches, and high runoff and thus comprise a majority of controllable sediment sources. Agriculture is a small, but still important portion of the controllable source loads in the region.

The Mid-Valley Region has been impacted by channel hydromodifications and land use encroachment related to a combination of urban, rural residential developments, and agriculture. Sediment contributions from urban and rural residential sources are related to concentrated hillside development, equestrian activities, road ditches, and high runoff and comprise a majority of controllable sediment sources. Agricultural sources are largely concentrated in the western portions of this valley region and comprise a significant portion of the controllable source load.

The South Valley Region has been impacted by channel hydromodifications and land use encroachment primarily related to agriculture. Sediment contributions from in-stream processes are, in part, related to past loading and impacts from land uses, but also due to the rather poor condition of riparian zones, stream banks, and channel beds. Agriculture land uses comprise the largest portion of controllable sediment sources.

Streams and channels in the valley portion of the study area are in varying states of disequilibrium leading to accelerated bank loss, channel incision, and sedimentation. In-stream sediment sources comprise a significant contribution to sediment load estimates in the study area, due to the poor functional state and high bank erosion potential of ephemeral channels and portions of Llagas and Uvas Creeks. Agriculture comprises an important source of the total controllable sediment load (including in-stream sources) in the study area. Runoff impacts on channels and sediment loading from urban and rural residential comprise the remaining important portion of controllable sources.

E.S.6.2. Recommendations

1. Coordination with Other Pajaro and Central Coast Region Watershed Activities

Coordination between various local agencies has historically been ineffective to address watershed management issues, and requirements pertaining to water quality and flood control. Recent efforts like the South Santa Clara County Joint Area Plan have provided a model and opportunity for more effective cooperative planning and implementation efforts between local agencies. Current assessment and water quality monitoring efforts across the entire Pajaro River watershed are not well coordinated, many agencies or research groups work in isolation and are disjointed with variable financial resources and monitoring methodologies.

2. Watersheds and Creek Management Planning and Outreach

Several management and outreach activities should be undertaken to address sedimentation and water quality issues in the study area. The stream assessment conducted for this project identified five in-stream sediment sources categories, the combined effects of these sediment sources influence the impairment to beneficial uses within the Llagas and Uvas Creek systems. To reduce in-stream and off-stream sediment sources, a cohesive management planning effort with a combined focus on restoration, land use encroachment, and flood control planning is proposed. The following is a preliminary list of recommended actions pertaining to watershed and creek management planning:

- Develop a ‘forum’ series bringing federal, state and local regulators together with local representatives from community organizations (e.g. Pajaro Watershed Council), agriculture, resource conservation groups, business, and appropriate local agencies to address sedimentation and water quality protection in the study area.

- From this initial effort, develop a stakeholder based action plan prioritizing efforts to reduce controllable sediment sources. Identify priority projects on a regional basis and sources for project funding.

- Provide watershed and water quality protection workshops similar to the Farm Bureau water quality meetings (at least once per year) for individuals/representatives of the above-mentioned stakeholders. Develop an incentive-based program to stimulate participation, similar to the RWQCB and SCCFB agreement to develop farm and water quality plans within the study area. An incentive based program requires a unique collaboration with stakeholders, and would encourage a voluntary approach to water quality protection.

- Current creek channel maintenance efforts by the Santa Clara Valley Water District (SCVWD) could be enhanced by integrating sediment source identification and channel cross-section monitoring (refer to Appendix D) into annual assessment efforts.

- Enhance outreach to local residents, homeowner's associations, community groups and special interest organizations like equestrian clubs, Santa Clara Cattlemen's, and schools (e.g. Live Oak High School).

The San Francisco Bay Regional Water Quality Control Board (Region 2) has required the development and implementation of a Hydromodification Management Plan (HMP) in the Santa Clara Valley. An HMP would describe how dischargers plan to manage changes in urban runoff, specifically from new and significant redevelopment projects, to protect the beneficial uses of streams.[13]Considering the effects of hydromodification within the study area on sediment sources in streams and impacts to beneficial uses, it is recommended that the CCRWQCB require the local cities and county to develop an HMP plan for the Llagas and Uvas Creek basins.

3. Loss of Riparian Habitat and Vegetation

Throughout the study area various land use practices are impacting the riparian corridor of many streams. Riparian vegetation has been removed along many miles of streams, resulting in channel destabilization, accelerated bank erosion, and degradation or loss of habitat. Stream channel destabilization is often attributed to a loss of woody vegetation, as dense vegetation adds roughness, slows flow velocity, reduces shear stress on stream banks, adds soil cohesion through root structure, and creates habitat benefits. Removal of large woody debris (LWD) as a management practice is known to contribute to bank erosion[14].

Based on the loss of riparian habitat and the direct link to erosion and sedimentation impacts to surface water resources in the study area, FCE recommends the following:

- Ecological restoration activities should be an integral component of the sedimentation TMDL for the study area. Implementation of stream restoration projects to re-establish native vegetation and buffers along streams will reduce erosion and sedimentation, improve habitat value, and protect or restore beneficial uses.

- Landowner and local agency workshops pertaining to stream restoration practices, including the use of biotechnical bank stabilization methods should be supported as part of the water quality attainment strategy for the Llagas Creek and Pajaro River watershed areas.

[13] GeoSyntec Consultants, *Santa Clara Valley Urban Runoff Pollution Prevention Program, Hydromodification Management Plan Literature Review*, September 2002.
[14] Ibid.

4. Water Quality Target Values

Presently, the Central Coast Regional Water Quality Control Board and the US Environmental Protection Agency are developing water quality attainment srategies as part of the sediment TMDL process. The main emphasis of this process is to develop numerical target values of surrogate parameters, such as total suspended solids and turbidity, with action levels established for the protection of cold water fisheries.

The development of a numerical target value of TSS or turbidity will be difficult, and may not be defensible nor attainable within the study area for several reasons:

a. Available water quality data for Llagas Creek and the Pajaro River are limited, and determination of background sediment concentration levels are unknown.

b. The poor correlation of turbidity to TSS data previously collected in the study area, suggest that use of turbidity as a surrogate parameter for sediment loading may not be protective of beneficial uses.

c. The Pajaro River Watershed is in a semi-arid region where many streams are ephemeral. As a result application of numeric and threshold criteria originating from research conducted in the Pacific Northwest or North Coast Region of the state, may not be applicable or even attainable in this region.

d. Current efforts by the USEPA to develop target values for the TMDL are being implemented from a “top down” perspective and may, as a result carry little weight with the local communities or personnel charged with effecting watershed improvements on private lands.

Based on these conditions, FCE recommends the following:

- Target values for the sediment TMDL should be based on several factors, including both numerical and narrative goals, including target values for ecological restoration, as well as numerical target values for sediment.

- Target values should take into consideration the semi-arid and geologic setting of the watershed areas.

The sediment TMDL should clearly integrate watershed/ecological restoration initiatives currently supported by the local communities as part of the TMDL process.

5. Suspended Sediment Monitoring

Additional water quality monitoring efforts are required to better address sediment discharge and loading throughout the study area. As a first step towards this effort an Integrated Water Quality Monitoring Plan has been developed and is presented in Appendix D. The following are recommend efforts for implementing a broader water quality monitoring program in the study area:

- Develop a coordinated region-wide effort to supplement the existing Central Coast Ambient Monitoring Program (CCAMP) with focused local efforts.
- In collaboration with Farm Bureau Watershed Working Groups and other cooperators, establish targeted baseline sediment monitoring efforts in known problem areas, rather than exclusively at traditional public access points (refer to Appendix D for an Integrated Water Quality Monitoring Program outline).
- When possible, expand the technical resources for CCAMP to collect appropriate data to improve sediment load estimates in the study area.
- Develop targeted research projects in coordination with local colleges and/or university personnel to monitor sediment loads from specific agricultural areas, fields, or ranches to quantify the impact of BMP adoption.
- Encourage and coordinate voluntary local efforts for storm water sample collection.

6. Agricultural Lands

Agricultural lands continue to be a sediment source to Llagas and Uvas Creeks and the Pajaro River. Further efforts are recommended to continue outreach efforts and to encourage agricultural management practices to control sediment sources. The following is a preliminary list of recommended actions to control of sediment from agricultural lands:

- Continue to provide adequate funding to the Farm Bureau Water Quality Programs for coordination of regular informational and educational meetings, self-monitoring training and evaluation, and farm water quality planning.
- Develop additional technical assistance resources through grants and strategic alliances with public technical resource providers like National Resource Conservation Service (NRCS), non-profits (e.g. Resource Conservation Districts), and the private sector to provide services on an individual basis.
- Continue to expand the outreach and educational effort to non-Farm Bureau growers via annual UCCE Irrigated Agriculture Water Quality Short Courses.

- Coordinate with the Santa Clara County Agricultural Commissioner's office to provide at least one surface water quality presentation at the annual "rules and regulation update" meeting.

7. Urban and Rural Residential

Throughout the study area sediment sources related to stormwater runoff from urban and rural residential areas were observed. The impervious surfaces in residential developments result in increased flow volumes and an altered hydrologic response. This combined with concentrated flows and land use encroachments have created sediment sources. In many areas it was also observed that the rate of increased urban and residential developments in the study area out paced the renovation of drainage infrastructure. The following is a preliminary list of recommended actions pertaining to control of sediment from urban and rural residential areas:

- Local municipalities should implement more stringent stormwater runoff management plans to reduce the potential for channel destabilization and in-stream sediment production.

- A region-wide drainage infrastructure assessment should be planned and implemented to identify and prioritize projects to restore and 'modernize" drainage infrastructure both within urban planning areas and unincorporated areas. The drainage plan should explicitly examine the impacts from erosion and sedimentation resulting from runoff from urban and rural residential land uses and aged, undersized, or un-maintained drainage channels.

- Continue to offer community workshops to rural residential owners concerning methods to restore and maintain drainage ditches and creek channels using established practices to restore channel stability and minimize erosion and sediment production.

1. Develop and implement a Hydromodification Management Plan to address the effects of development within the study area on in-stream processes, erosion and sedimentation, and impacts to beneficial uses.

8. Rangelands

Sediment sources from rangelands are primarily related to roads and animal access into stream channels. The extent of rangelands in the study area is large and current outreach and implementation of management practices to control sediment sources should continue. The following outreach and technical assistance efforts should continue and/or be expanded:

- Continue to expand the outreach and educational effort via annual UCCE Rangeland Water Quality Short Courses and Santa Clara County Cattlemen's Association (SCCCA). Continue to reinforce these training efforts to the Farm Bureau Water Quality Programs for coordination of regular informational and educational meetings, self-monitoring training and evaluation, and ranch water quality planning.

- Develop additional technical assistance resources through grants and strategic alliances with public technical resource providers like National Resource Conservation Service, non-profits (e.g. Resource Conservations Districts), and the private sector to provide services on an individual basis.

- Coordinate with the Santa Clara County Agricultural Commissioner's office to provide at least one surface water quality presentation at the annual "rules and regulation update" meeting.

9. Equine Facilities and Small Lot Grazing

Equestrian facilities and small lot grazing are widespread, and in some locations, concentrated within the study area. Sediment sources from these equine facilities and small lots originate from poorly vegetated lots and pastures, and animal access into streams and riparian corridors. The following outreach and technical assistance efforts should be implemented or expanded:

- Continue to develop outreach and educational efforts via the Farm Bureau Water Quality Programs, UCCE Resource Conservation Program, Loma Prieta RCD, and local equestrian clubs for coordination of regular informational and educational meetings, self-monitoring training and evaluation, and small lot and boarding facility water quality planning.

- Develop additional technical assistance resources through grants and strategic alliances with public technical resource providers like National Resource Conservation Service, non-profits (e.g. RCDs), and the private sector to provide technical assistance services on an individual basis.

1. INTRODUCTION

1.1. Background

The Pajaro River Watershed is one of the largest riverine systems entering the Monterey Bay and drains an area of approximately 1,300 square miles of land on the Central Coast of California. The water quality of the Pajaro River and several tributary streams have been identified by the California Regional Water Quality Control Board (Regional Board) as impacted by sediment, nutrients and other pollutants.

To better assess water quality impairments in the watershed, the Regional Board has funded a focused study in the Llagas and Uvas Creek watersheds to better characterize erosion and sedimentation problems in these areas. The study area includes approximately 202 square miles of the upper northeastern portions of the Pajaro River Watershed. The study area encompasses a substantial portion of Southern Santa Clara Valley, including the cities of Gilroy and Morgan Hill.

The Monterey Bay Sanctuary Foundation has administered this project as part of the Agricultural and Rural Lands Plan of the Monterey Bay National Marine Sanctuary Water Quality Protection Program. The Sanctuary's Agricultural and Rural Lands Plan was created in collaboration with the Coalition of Central Coast County Farm Bureaus and other agencies.

The development of this pre-TMDL sediment assessment has been done in collaboration with the Santa Clara County Farm Bureau (SCCFB) and Fall Creek Engineering, Inc. (FCE). FCE was retained to conduct a technical assessment study and to participate with the SCCFB to carryout a public outreach and education program focused on agricultural land management impacts on erosion and sedimentation problems in the watershed. FCE conducted a field-based assessment of upland and stream conditions to evaluate erosion and sedimentation conditions in the watershed areas.

This project is unique in its incorporation of the SCCFB and has been developed in a manner to support the development and implementation of Farm Bureau Watershed Working Groups as integral to the long-term water quality attainment strategy. Throughout the course of the study the Watershed Working Groups have been periodically updated and informed of the project and water quality planning process. FCE also assisted the SCCFB with several workshops in the watershed. At these meetings the preliminary results of the study were presented and critical drainage, erosion, and potential mitigation options were discussed.

1.2. Water Quality Impairment of Surface Water Resources

The sources of sediment in the Llagas and Uvas river systems are variable, some would be found in the system naturally and others are the result of land use in the Southern Santa Clara Valley. There are many factors controlling the rate and extent of erosion and sedimentation in the study area including soils, geology, topography, climate, vegetation, and land use. Erosion and sedimentation can also be grouped into two principal categories, generally non-controllable and controllable sources. Many natural sources are considered non-controllable and may include catastrophic events such as landslides, floods, and earthquakes that lead to substantial erosion and sedimentation. Alternatively, several land use and drainage modifications can accelerate and increase erosion and sedimentation in a watershed, but these sources are typically "controllable" and can be identified and corrected to mitigate water quality impacts.

Many of these water quality impacts are attributed to land use practices observed throughout the study area, including intensive agriculture, urbanization and loss of pervious surfaces, equestrian facilities, and other upland uses. Erosion and sedimentation problems are also attributed to modifications or alterations of various drainage ways and stream courses in the study area (generally termed "hydromodifications").

Historical and current land use and hydromodification activities have impacted water quality in the Llagas and Uvas Creek watersheds. Today many of the streams in the study area have been severely altered in an attempt to improve drainage and flood control, and to increase land area for agricultural and urban uses. These practices have transformed many of the streams to straight, non-vegetated drainage channels that are indistinguishable as natural watercourses void of habitat value. To a large extent many residents and to some degree public agencies working in the study area are not aware that these altered watercourses are streams at all. Awareness from landowners, residents and agencies of these streams, and their poor condition, could potentially change some land use practices and/or prioritize restoration efforts.

Under pressure from the State of California and the economy as a whole, many of the agricultural lands in the study area will continue be converted to urban use. To this point in time, conversion of rural lands to urban landscape has increased impervious surfaces and runoff to many of the valley streams. The increased rate and volume of runoff from these areas surcharges many aged drainage systems and stream courses, causing unstable and eroding watercourses, with the net-result that in-stream processes are a significant source of erosion and sedimentation in the study area. As acreage continues to be converted and covered by impervious surfaces, and unless stream enhancement and restoration measures become integral parts of these development projects, in-stream erosion and sedimentation problems area expected to continue and become more significant in the study area.

As a result of these impacts, Llagas Creek has been designated by the California Regional Water Quality Control Board as a water quality impaired surface water body and listed as required by Section 303(d) of the federal Clean Water Act on the Regional Boards' "303(d) list" of impaired water bodies. This list identifies water bodies determined by the Regional Water Quality Control Board to impact beneficial uses or do not satisfy water quality objectives. The list also describes the pollutants for each water body, which have impacted beneficial uses or prevent the attainment of water quality objectives. Under the provisions of the Clean Water Act Section 303(d), the State of California is required to develop and implement a water quality attainment strategy, including a Total Maximum Daily Load (TMDL) allocation to remedy impacts and improve water quality to ultimately restore the beneficial uses of the water body.

The initial phase of the water quality attainment strategy is to complete a comprehensive problem assessment to determine the principal causes, and if possible, loads attributing to water quality impairments. Once the problem assessment work has been completed, water quality attainment strategies can be formulated to address and control the release of sediment and silt from controllable sources.

A field based assessment study was undertaken to evaluate and identify major erosion and sedimentation problems in the watershed. The study emphasizes a systematic approach to assess and rank upland and in-stream processes associated with sedimentation problems in the watershed. The methodology is well suited for large watershed areas and provides a comprehensive initial assessment of land use and geomorphic conditions in a watershed that is fundamental in determining the primary mechanisms and sources of erosion and sedimentation in a watershed. Over a relatively short period of time, a substantial amount of upland and stream conditions can be evaluated, leading to a semi-quantitative source load assessment and more importantly to direct or focus subsequent water quality monitoring efforts to confirm or further substantiate findings in the initial survey study.

The focus of this study is the development of a pre-TMDL sediment assessment that will support the development of a water quality attainment strategy and sediment TMDL. This assessment is an evaluation of sediment conditions, erosion risk, and potential impacts to beneficial uses within the study area. The field assessment also identified sediment sources and categorically ranked the erosion potential of sub-areas within the study area. As a result of the information collected in this study, data gaps can be directly linked to sediment source categories and agencies can prioritize projects to address areas with a high risk of erosion.

1.3. Scope of Work

The major study tasks include:

- Preliminary problem and source assessments based on existing information, additional field surveys, and data collection in selected areas;
- Evaluation of impacts to beneficial uses and water quality objectives;
- Analysis of land use, particularly agricultural land uses;
- Regular outreach presentations to SCCFB Watershed Working Groups;
- Collation of existing information on sediment/suspended solids throughout the watershed;
- Determination of data gaps and recommendations to fill data gaps (sampling, data acquisition, etc.);
- Recommendations of priority actions and areas to reduce controllable sediment sources; and
- Develop a Technical Report.

Preliminary Problem and Source Assessment - The Study Team conducted a problem and source assessment in consultation with the Farm Bureau Watershed Working Groups. The source assessment involved a review of prior information, field survey work to rank erosion and sedimentation conditions in upland and riparian corridors, and an estimate of sediment sources. The fieldwork was limited to public right-of-ways and private lands where landowners agreed to provide access.

Problem Assessment – The Study Team evaluated impacts to all beneficial uses and impairments of water quality objectives within the selected study area. This included identification of temporal/seasonal issues affecting beneficial uses/water quality objectives, e.g., determining the time periods and conditions when sediment/suspended solids may cause a water quality problem, to determine where temporal/seasonal issues are significant and if particular beneficial uses have a sensitive or critical period.

Land Use Assessment – The Study Team performed a general area estimation of urban, rural residential, rangeland, and agricultural land uses. Determination of agricultural land uses was confirmed with detailed ground- and aerial-truth assessment of different crop systems. Sediment risk potential was determined on location basis.

Stream Channel Assessment – The Study Team conducted a visual assessment of stream conditions in the study area. Indicators of erosion risk and stream functioning condition, such as extent of vegetation cover, in-stream erosion and deposition, and channel geometry were recorded. The relative erosion and sediment source potential of each stream was determined based upon these observations.

Public Participation - In cooperation with the SCFB Program Coordinator, the Study Team provided a series of formal project presentations to the Llagas and Uvas-Carnaderos Watershed Groups to provide technical updates. The purpose of the meetings was to provide information describing the goals, objectives, and progress of the project. The meetings provided a forum to receive comments and answer questions from growers and other interested parties participating in the working groups.

Water and Sediment/Suspended Solids Data Review - The Study Team obtained and reviewed all existing sediment/suspended solids data from all known sources. The Study Team determined data gaps and if additional monitoring, information acquisition and review, and/or additional analysis are necessary.

Recommendations for Priority Actions - The Study Team provided recommendations for upland, riparian and stream enhancement projects on agricultural lands to address erosion and sedimentation problems in these areas. Additionally the Steering Committee will use this information to provide input on potential project sites for upland, riparian and stream enhancement projects in other land use areas.

1.4. Study Constraints

Based on the nature of the study, limited technical information, time and budgetary constraints, the project scope did not allow for certain tasks that would have provided a quantification of sediment load estimates in the study area. These included:

1. Targeted water quality monitoring activities,
2. Formal efforts to secure permission from landowners to visit many sites (particularly in the Upper West Basin Region),
3. More intensive contacts with various local, state and federal agency departments; and
4. Individual meetings with growers, residents, and other interested parties.

However, an estimate of sediment load contributions from various land uses and in-stream processes was developed using a conceptual modeling approach. A combination of the qualitative assessment results from this project and a modification of the sediment load estimates derived from a sediment load model for the entire Pajaro River watershed[4] were used to estimate sediment load contributions on a percentage basis. This approach was conceptual and limited by the available suspended sediment and loading data available, assumptions in the Pajaro River watershed sediment load model, and limits of best professional judgment.

Water Quality Monitoring. Due to budgetary constraints water quality monitoring activities were not conducted throughout the course of the study. Sediment samples were collected as part of the University of California Santa Cruz sampling effort, as described in Section 3, though the extent and frequency of sampling was not suitable for quantification of load estimates within the scope of this project. Therefore, quantification of water quality conditions in the surface waters during the field assessment component of the study was not possible.

Private Land Access. A substantial portion of private lands and stream corridors could not be surveyed due to access limitations. To obtain access to many private lands required a significant level of outreach beyond the scope and budget of the project.

Agency Contacts. Due to staff and work load commitments, the Study Team encountered significant barriers related to our ability to meet, discuss and review the project with several potentially key agencies responsible for management of drainage ways, stream courses and water quality planning activities in the study area.

Landowner Contacts. Based on the large size of the study area, the high number of individual landowners, and the budgetary constraints, conducting onsite visits with private landowners was limited.

[4] Central Coast Regional Water Quality Control Board Regional 3, *Draft Total Maximum Daily Load for Sediment in the Pajaro River Watershed, San Benito, Santa Cruz, Santa Clara and Monterey Counties, California*, December 2003.

2. LLAGAS BASIN STUDY AREA

The Llagas Basin study area (study area) comprises an approximate 202 square mile area in Southern Santa Clara County and is drained by two major watershed systems, Llagas and Uvas-Carnaderos Creeks. The activities and land uses in the region are quite diverse and in the past 30 years have experienced large changes in population, economy, and land use. Generally, the study area is transitioning from a largely agricultural base to a mix of urban, suburban, mixed commercial and industrial uses. Agricultural land areas have been declining since the 1970's and many of the prime agricultural lands exist as either patchwork parcels (northern areas) or in concentrated areas east and southeast of the City of Gilroy.

The study area has two major urban jurisdictions, the cities of Morgan Hill and Gilroy, that along with the community of San Martin continue to experience significant population increases resulting in more land being annexed into urban limits or city planning areas. In 1998 the planning areas were approximately 8,800 acres and 6,900 acres for Gilroy and Morgan Hill, respectively (FCE, 1999). The east side of the study area includes older rural residential development, while the western mountains outside of all urban centers have experienced significant residential development in recent years. This mix of rapid urbanization, abandoned farmland, and expansion of more intensive row-crop production has had a direct impact on drainage infrastructure influenceing the sources and magnitude of sedimentation in the study area.

2.1. Study Area Characteristics

The primary drainage systems in the study area are Llagas Creek and Uvas-Carnadeross Creek. Llagas and Uvas-Carnadeross Creeks and their tributaries drain mountain and valley lands situated in the Coast Range of Central California between the Santa Cruz and Diablo Mountain Ranges in Southern Santa Clara County (Figure 2.1). The South Santa Clara Valley is on the eastern side of the Santa Cruz Mountains and extends from the north side of Morgan Hill south to Gilroy. A large natural floodplain exists in the Southern Santa Clara Valley where the bottomlands from Tequisquita Slough through San Felipe Lake to Sargent constitute a natural flood lake, named Soap Lake. Historically, flood flows from Llagas and Uvas-Carnaderos Creeks were stored and impeded by flat channel gradients and floodplain storage in the Soap Lake area. Urbanization, agriculture, and flood control projects in the study area have combined to minimize the extent of Soap Lake and the natural flooding characteristics in the area south of the Llagas Creek and Pajaro River confluence.

2.2. Surface Water Resources

Surface water resources in the study area consist of a network of perennial and intermittent streams, engineered drainage channels, and reservoirs. Based on the location, topography, climate and geology of these systems, the hydrologic character of these surface waters vary significantly. Generally, there are two types of surface water bodies in the study area; mountain streams and valley rivers and streams.

Mountain Streams. Many of the mountainous streams in the Santa Cruz and Diablo Mountains are tributaries to Llagas and Uvas-Carnaderos Creeks. The channels are very steep, deeply entrenched and confined with cascading reaches. They are set in areas of high relief and the streambeds are both erosive and bedrock forms. A majority of the mountainous streams have relatively small watersheds, which have very short lag times between precipitation events and runoff, high peak

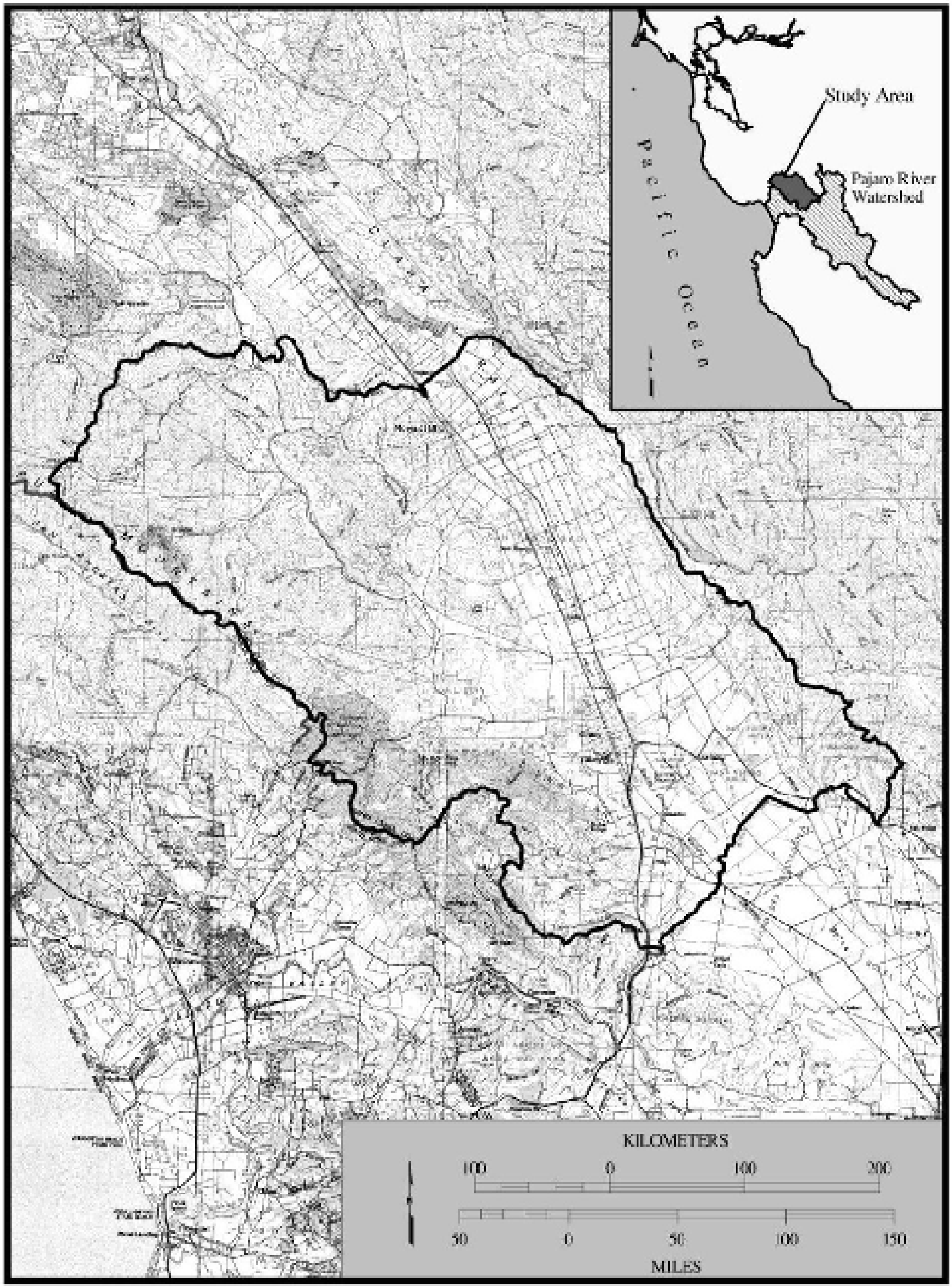

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FIGURE 2.1. VICINITY MAP OF STUDY AREA

runoffs, and limited seasonal baseflow. Many of the streams export high total sediment loads. This is caused by a combination of natural factors, including unstable rock and soils, high rates of uplift, and the occurrence of high-intensity rainfall events. Debris flows commonly occur in streams during periods of high runoff. Towards the Santa Clara Valley, these mountainous streams and the sediment they carry, enter either Llagas or Uvas-Carnaderos Creek.

Valley Streams. Llagas and Uvas-Carnaderos Creeks meander through valley riparian environments. Most of the rivers and streams in the valley have been modified in several locations by channelization and other flood control measures (levees). Sedimentation in the valley streams results from a variety of natural and anthropogenic processes.

2.2.1. Llagas Creek Watershed

The Llagas Creek channel is approximately 25 miles long, with its headwaters in the eastern side of the Santa Cruz Mountains, north of Uvas Creek in the Santa Clara Valley. Loma Prieta Mountain (elevation 3,791 feet) is at the crest of the 100- square mile watershed. Loma Prieta Mountain has a relatively higher average annual precipitation compared to the City of Gilroy lower in the watershed, which has an average annual precipitation of 21 inches per year. Numerous tributaries to Llagas Creek originate from the Diablo Mountain Range, which forms the general eastern boundary of the watershed. The main-stem of Llagas Creek flows south from Morgan Hill, through the floor of South Santa Clara Valley before entering the Pajaro River in the Soap Lake region approximately six miles south of Gilroy.

Chesbro Reservoir was constructed in 1955 on Llagas Creek on the eastern slope of the Santa Cruz Mountains west of Morgan Hill. The reservoir has a maximum storage capacity of 7,500 acre-feet and is managed for water supply and ground water recharge by the Santa Clara Valley Water District (SCVWD).

2.2.2. Uvas-Carnaderos Creek Watershed

Uvas-Carnaderos Creek drains the southeastern portion of the Santa Cruz Mountains. The channel is approximately 26 miles long with its headwaters in the Santa Cruz Mountains, south of Llagas Creek, in Southern Santa Clara County. The Uvas watershed drains an area of about 90 square miles, and generally Uvas-Carnaderos Creek flows southeast to join the Pajaro River about six miles south of Gilroy. The Uvas-Carnaderos Creek watershed is primarily mountainous, with approximately one-fifth occupying the valley floor and Soap Lake region.

Uvas Reservoir was constructed in 1957, approximately 17 miles upstream of the junction of Uvas-CarnaderosCreek and the Pajaro River. The reservoir covers about 280 acres with a storage capacity of about 10,000 acre-feet and a drainage area of about 30 square miles.

2.3. Study Regions and Sub-Areas

Prior to the initiation of the field assessment phase, the study area was delineated and a preliminary reconnaissance map was developed. The study area was defined, in part, by pre-existing lines for the western, northern, and eastern boundaries of the Santa Clara County portion of the Pajaro River watershed. The southern boundary was delineated by the Santa Clara County line and the Pajaro channel, from the San Felipe Lake area south to the confluence with Uvas-Carnaderos Creek. This approximately 202 square mile area includes forty-seven (47) named creeks and engineered drains.

The Llagas and Uvas-Carnaderos systems drains a large and diverse geographic region. During the preliminary reconnaisance phase, it became clear that smaller study units were essential to the description and analysis of existing conditions. The study area was first delineated and then further divided into four smaller regions. These Regions were identified with the consideration and weighting of the following: landscape position, hydrologic sub-units or watersheds, current land uses, and previous investigations. These regions were further divided into additional sub-areas. These sub-area boundaries do not conform to precise sub-basin or sub-watershed units, but provide a structured and systematic approach to the description and analysis of land use practices, hydrology, and natural and anthropogenic sources of sediment. Figure 2.2 shows the four study area regions and sub-areas. Refer to Appendix D for detailed sub-area figures.

A total of 26 sub-areas (Table 2.1) have been created as a basis for assessment and analysis of stream and riparian integrity/functioning, as well as, land use and sediment sources. Each sub-area is named for the highest order stream channel within the boundary. Some contain only one sub-watershed, while in other cases a number of named sub-watersheds may be included. Each sub-area will be described in more detail in the channel and land use sections of this report. The following is a general description of the four Regions within the study area.

2.3.1. Upper West Basin Region

These sub-areas comprise most of the western mountain and foothills and comprise the largest percentage of land in the study area. The region has the largest amount of forest and scrublands in the study area and continues to be used for timber and grazing activities. However, in recent years medium to large acre residential construction has increased in the region. Many of these new residential owners also keep horses. Intensive agriculture is limited to a few, often small, wine grape vineyards. Many of the creeks in these upper watersheds, have experienced limited impacts due to recent human activities, and have largely been left in their natural form and unmodified.

These sub-areas include the following watersheds:

Upper Llagas – Llagas Creek
Chesbro Reservoir – Llagas Creek
Upper Uvas –Uvas Creek
Blackhawk – Bodfish and Blackhawk Canyon Creeks
Little Uvas – Little Uvas Creek
Uvas Reservoir – Uvas Creek
Bodfish – Bodfish Creek
Little Arthur – Little Arthur Creek

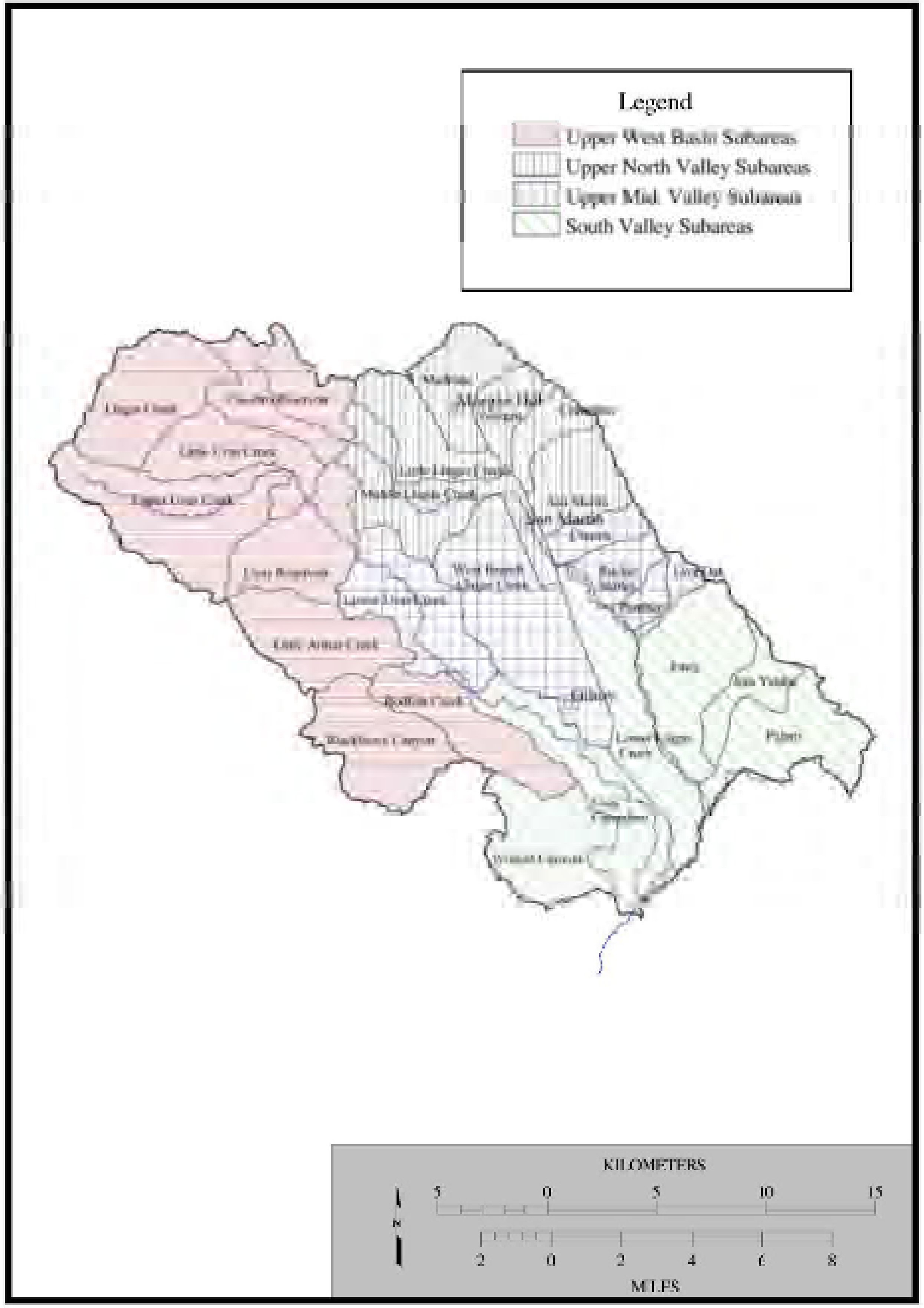

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FIGURE 2.2. STUDY REGIONS AND SUB–AREAS

2.3.2. North Valley Region

The region includes the City of Morgan Hill and the outlying and western and eastern suburban areas around the city. These land areas have experienced significant residential and commercial development in the past 30 years. Until recently this was largely agricultural land conversion in the valley floor; however, residential development has been increasing in the western and eastern foothills formerly utilized for rangeland, scrub, and forested land.

These sub-areas include the following watersheds:

Little Llagas – West and East Little Llagas, Dewitt, and Edmundson Creeks
Madrone – Madrone Channel
Tennant – Tennant and Foothill Creeks
Corralitos – Maple and Corralitos and South Corralitos Creeks
Middle Llagas – Llagas, Paradise, Machado, and Hayes Creeks
San Martin – San Martin, Center, and New Creeks

2.3.3. Mid-Valley Region

The Mid-Valley Region includes much of the unincorporated Southern Santa Clara County devoted to rural residential lands, in addition to the northern portions of the City of Gilroy, and the remaining agricultural and rangelands on the eastern and western foothills. Much of the region has also experienced land use conversions from agriculture and ranching, to urban and rural residential uses in the past thirty years. Recently, there have been a large number residential developments in the eastern foothills on former rangeland.

These sub-areas include the following watersheds:

Church – Church Creek
Rucker-Skillet – Rucker and Skillet Creeks
Live Oak – Live Oak Creek
Panther – Panther and South Panther Creeks
West Branch Llagas – West Branch Llagas, Day, and Lions Creeks, North and South Morey Channels, Upper Miller Slough
Lower Uvas – Uvas, Solis, Sycamore, and Burchell Creeks

2.3.4. South Valley Region

This region represents the majority of active agricultural lands in the study area, urban lands in the City of Gilroy, and rangelands on the eastern and western hills. Agricultural lands in the region have experienced significant conversion in the past thirty years from extensive crop systems like dry farmed wheat and pasture, grazing of meat and dairy animals to intensive irrigated row crops. The continual expansion of urban limits in Gilroy has resulted in significant conversion of former agricultural and rangelands to residential and commercial use. Much of the remaining agricultural land is situated in the low-lying areas that are prone to flooding, which present constraints for future conversion to other land uses.

These sub-areas include the following watersheds:

Jones – Alamias, Crews, Dexter, and Jones Creeks
San Ysidro - San Ysidro Creek
Pajaro – Pajaro River and Millers Canal
Lower Llagas – Llagas Creek, Princevalle Drain, and Lower Miller Slough
Uvas-Carnaderos – Uvas, Tick, Farman, Gavilan, and Babbs Creeks
Wildcat - Upper Tick, Farman, and Tar Creeks

2.4. Land Use

Land use in the study area is diverse and includes urbanized and rural residential lands, agricultural and rangelands, and timberlands. Of the approximately 129,000 acres (202 square miles) in the project study area, about 12.5 percent (16,100 acres) are used for agriculture, approximately 46 percent (59,400 acres) are rangelands, and 14.8 percent (19,150) are urban and rural residential. The balance comprises forest and scrublands, surface water, mines, and other lands, including abandoned orchards and other non-developed land parcels.

2.4.1. Agricultural Lands

For the purposes of this study agricultural lands do not include rangelands or other ‘abandoned’ or remnant lands not currently used for the production of annual or perennial ornamentals, vegetable, fruit, hay/pasture, and other food crops. Agriculture has historically been an important component of the overall land use and economy. However, residential and commercial development continues to reduce the extent and importance of agriculture. Accelerated development and annexation by the Cities of Morgan Hill and Gilroy place a variety of pressures on the regions growers. These changes, along with market forces, have direct and indirect impacts on production practices and the available technical and financial resources of local agriculture to respond to numerous issues, including water quality protection.

In the almost forty-year period from 1963 to 2002, Santa Clara County reported agricultural acreage has declined as follows (Table 2.2), total acreage by 34 percent, fruit and nut acreage by 91 percent, vegetable acreage by 23 percent, and field crops by almost 20 percent. The trend, as in most urbanizing areas of California, is to more high value (per unit area) and intensive crop production systems. Note the general disappearance of certain land extensive crops such as prunes, wheat, or sugar beets and the rise of intensive and higher value crops like peppers (315 and 930 percent increase in acreage and per acre gross dollar return, respectively), mushrooms (1590 and 1040 percent increase in acreage and per acre gross dollar return, respectively) and ornamentals (960 percent increase in acreage and per acre gross dollar return). These changes to more intensive uses have and will continue to influence sediment sources and quantities in the study area.

Table 2.1. Region and Sub-area Land Extent (acres) in the Study Area.

Region / Sub-area		Acreage	% of study area
Upper West Basin Region			
Blackhawk		6302	(4.9%)
Bodfish		4992	(3.9)
Chesbro Reservoir		5857	(4.5)
Little Arthur		5868	(4.5)
Little Uvas		4895	(3.8)
Upper Uvas		8911	(6.9)
Upper Llagas		6550	(5.1)
Uvas Reservoir		5725	(4.4)
	Total	**49,100**	**(38.0)**
North Valley Region			
Little Llagas		3955	(3.1)
Madrone		3824	(3.0)
Tennant		2215	(1.7)
Corralitos		1870	(1.4)
Middle Llagas		6857	(5.3)
San Martin		3973	(3.1)
	Total	**22.694**	**(17.6)**
Mid-Valley Region			
Church		1690	(1.3)
Rucker-Skillet		2183	(1.7)
Live Oak		814	(0.6)
West Branch Llagas		9997	(7.7)
Panther		1101	(0.9)
Lower Uvas		6412	(5.0)
	Total	**22,197**	**(17.2)**
South Valley Region			
Jones		7215	(5.6)
San Ysidro		2429	(1.9)
Pajaro		5828	(4.5)
Lower Llagas		6532	(5.1)
Uvas-Carnaderos		6899	(5.3)
Wildcat		6190	(4.8)
Total		**35,093**	**(27.2)**
TOTAL STUDY AREA		**129,074**	(100)

The continued conversion of agricultural lands in the study area influences farming due to the inevitable "sphere of influence" conflicts with non-compatible uses adjacent to agricultural parcels. The specific assessment of future sediment sources from agriculture is complex because of these land use conversions. Any attempt to "model" this dynamic process, based solely on Santa Clara County or local General Plans will not be able to account for the many other variables (including changing agricultural markets/prices, continued viability of required infrastructure, production loan funds, water availability and pricing etc.).

The County of Santa Clara currently supports the following policies intended to limit the conversion of prime farmlands to urban uses:

Santa Clara County General Plan

C-RC 37 Agriculture should be encouraged and agricultural lands retained for their vital contributions to the overall economy, quality of life, and for their functional importance to Santa Clara County.

C-RC 40.a Long term land use stability and dependability to preserve agriculture shall be maintained and enhanced by limiting the loss of valuable farmland from unnecessary and/or premature urban expansion and development.

C-RC 41 In addition to general land use and development controls, agricultural areas of greatest potential long-term viability should be identified and formally designated for permanent preservation.

The South Santa Clara County Joint Area Plan

14.04 Some prime agricultural lands in South Santa Clara County should be preserved for agricultural use through appropriate land preservation tools.

14.07 Santa Clara County and the Cities should plan for further urban growth to occur in areas which will encroach into those agricultural lands with the greatest long-term potential to remain economically viable.

14.09 The Cities should use their policies for urban service extensions and utility extensions to guide urban growth away from long-term agricultural areas.

2.4.2. Rangelands

Rangelands occupy a large portion of the western and eastern hillside and mountains. These lands are distributed among the remaining large contiguous ranches, smaller "patchwork' parcels closer to urban areas, and other parcels recently converted from cattle to equine grazing. Rangelands comprise the largest portion of all land use categories and, due to their topography, contribute significantly to the total natural sediment loading in the study area.

Table 2.2. Changes in Specific Crop Acreage and Value for Santa Clara County in the Period 1963 to 2002 .

CROP CATEGORIES	1963		1973		1983		1993		2002	
	Acreage	Gross*	Acreage	Gross	Acreage	Gross	Acreage	Gross	Acreage	Gross
FRUITS AND NUTS	54,918	28.3 million	25,511	23.2 million	7,431	13.1 million	4,990	11.2 million		
	8,723	706	3,587	844	975	2,400	685	1,938		
	27,514	419	11,749	720	2,000	2,240	700	2,438		
Apricots	7,453	306	4,373	417	1,460	600	925	1,365		
Prunes **VEGETABLES**	15,636	9.5 million	14,468	19.2 million	11,640	39.3 million	11,960	72.8 million	12,036	103.7 million
Walnuts	425	420	240	630	600	1,125	1,250	2,275	1,285	4,777
	1,105	1,000	630	2.046	200	3,300	600	4,200	106	2,801
Corn	8	34,848	28	59,628	90	175,500	105	267,800	127	362,960
Garlic [Bell]	640	742	400	1,470	1,250	2,860	2,000	3,995	2,015	6,901
Mushrooms	6,300	550	7,000	1,054	3,200	1,537	2,000	1,776	623	2,435
Peppers **FIELD CROPS**	247,430	2.3 million	243,900	2.3 million	242,415	6.2 million	236,320	5.7 million	198,700	4.7 million
Tomatoes	1,290	150	850	140	250	600			568	1,556
	2,590	286	850	509	165	930	~~210~~	~~805~~		
Alfalfa	4,000	125	1,500	150	2,000	200	2,500	250	790 <100	250 ??
CATTLE (#Head) Sugar Beets	34,725	3.3 million	37,000	7.4 million	15,000	5 million	12,400	6.7 million	15,340	6.4 million
ORNAMENTALS Irrigated Pasture	239	11.9 million	1,043	24.9 million	1,305	39.5 million	1,512	46.2 million		113.6 million

Between 1984 and 2002, there has been an approximate 5.5 percent decrease in rangeland throughout the study area. Much of this is related to growth and development of Morgan Hill and Gilroy, as well as, residential and commercial development in unincorporated areas. Some of this conversion is also related to conversion of grazing lands to row crop production in the South Valley Region. Table 2.3 shows the net changes in rangeland in the four major regions of the study area.

Conversion of rangelands in the Upper West Basin Region has largely been due to single-family developments on parcels greater than one acre, thus reducing rangelands by approximately 430 acres or 1.5 percent between 1984 and 2002. The largest amount of conversion has occurred in the Bodfish sub-area that accounted for approximately 43 percent of that reduction.

In the North Valley Region rangelands decreased approximately 630 acres or an 8 percent reduction in the same time interval. The largest land area conversions have occurred in the Little Llagas (41 percent), Madrone (27 percent), and San Martin (10 percent) sub-areas. The decreases in these sub-areas accounted for approximately 87 percent of the total region's rangeland area conversion.

Rangelands decreased approximately 1,460 acres or 15 percent in the Mid-Valley Region. The Panther (91 percent), Rucker-Skillet (55 percent), and West Branch Llagas (12 percent) sub-area, accounted for 91 percent of the change.

Development in the South Valley Region between 1984 and 2002 has largely been related to conversion of former valley floor grazing lands to row crop agriculture. This conversion has likely been driven by the expansion of farming companies from San Benito, Monterey, and Santa Cruz Counties that have found favorable microclimates and land lease costs in this region. In this period approximately 975 acres have been converted in the lower portions of the Uvas-Carnaderos (35 percent) and the Pajaro (4 percent) sub-area that account for approximately 82 percent of the land area conversion.

Table 2.3. Estimated Decrease in Rangelands in the Study Area Between 1984 and 2002.

	Converted area [acres]	% change
Upper West Basin Region	428	-1.5
North Valley Region	631	-43.0
Mid-Valley Region	1,456	-57.0
South Valley Region	972	- 6.0
TOTAL STUDY AREA	**6,003**	**-5.5**

*Derived from analysis of Calif. Dept. of Conservation Farmland data bases

2.4.3. Developed Lands

For purposes of this discussion, developed lands combine urban, suburban, and rural residential uses due to constraint of the database employed. The rate of development has significant impacts on sediment sources and hydrological impacts. Urbanization modifies natural watershed and stream processes by altering the terrain, modifying the vegetation and soil characteristics, introducing pavement and buildings, and installing drainage and flood control infrastructure, and altering the condition of stream channels through straightening, deepening, smoothing, and sometimes armoring. These changes affect rainfall interception, infiltration, runoff and stream flows (i.e., modifies the hydrologic characteristics), and affects sediment supply and transport of sediment in the stream system.

Between 1984 and 2002, the Cities of Morgan Hill and Gilroy have expanded their urban limits and planning areas, and this comprises a large portion of the increased development. There has also been a concurrent increase in residential development in the unincorporated portions of the study area. Table 2.4 shows the net changes in developed land areas in the four major regions of the study area. Development in the Upper West Basin Region has largely been limited to single-family developments on parcels greater than one acre, and this increase of approximately 140 acres reflects only a 10 percent increase in developed lands between 1984 and 2002. The largest amount of development has occurred in the Bodfish sub-area that accounted for approximately 70 percent of that increase. In the North Valley Region developed lands increased approximately 2,600 acres or a 43 percent increase in the same time interval. The largest increases have occurred in the Madrone (95 percent), Little Llagas (28 percent), Tennant (38 percent), and Middle Llagas (30 percent) sub-areas. The increases in these sub-areas accounted for approximately 65 percent of the total region's land conversion. Developed lands increased approximately 2,950 acres or 57 percent in the Mid-Valley Region. The West Branch Llagas sub-area, that includes portions of the town of San Martin alone accounted for 40 percent of the change.

Development in the South Valley Region between 1984 and 2002 has largely been related to expansion of the Gilroy planning area that incorporates retail and industrial development east of Highway 101. In this period approximately 1,000 acres have been converted, much of that (approximately 70 percent) has occurred in the Lower Llagas sub-area.

Table 2.4. Estimated Increase in Developed Lands in the Study Area Between 1984 and 2002.

	Added area [acres]	% change
Upper West Basin Region	141	10
North Valley Region	2,566	43
Mid-Valley Region	2,946	57
South Valley Region	978	127
TOTAL STUDY AREA	**6,631**	**50**

*Derived from analysis of Calif. Dept. of Conservation Farmland data bases

3. LITERATURE AND DATA REVIEW

3.1. Literature Review

The cited data and/or narrative sources below provided general and specific background, comparisons of methodologies, and limitations common to watershed sediment load assessment. There are no significant studies specific to sediment loading and transport in the Llagas Basin study area. At the time of this report, the lack of data and studies specific to the study area were a significant limitation to this study.

***Draft Report Feb. 2004 - Total Maximum Daily Load for Sediment in the Pajaro River Watershed* (Central Coast Regional Water Quality Control Board)**
This modeling study developed sediment loading rates and estimated total annual sediment loads for sub-watersheds of the Pajaro River system by calibration of the USDA Soil and Water Assessment Tool (SWAT) model. The report provides estimates of source load contributions driven by land use, topography, soils, and weather. The Llagas Basin study area was divided into 4 distinct hydrological units for purposes of load estimation and TMDL allocations. Load estimates were determined for agricultural, rangelands, urban, forest, and mining lands in the Llagas and Uvas watersheds.

***Llagas Creek Watershed: Environmental Impact Report* (USDA Soil Conservation Service)**
This study was prepared in the early 1980's for the substantial and, yet to be fully constructed, flood control project covering many reaches in the Llagas Creek watershed. The report describes planned hydromodifications in all reaches; specifies channel cross-section dimensions; use and location of concrete linings; use and location of riprap; location of grade stabilization structures and fish ladders, preservation of existing; riparian vegetation; and maintenance practices to maintain steelhead habitat.

***Pajaro River Watershed Water Quality Management Plan* (Applied Science and Engineering, Inc.)**
This study and plan identified and recommended prioritized management strategies to reduce non-point sources of pollutants in the entire Pajaro River Watershed. This study included a review of existing water quality, hydrologic, biologic and land use data pertaining to the watershed. Further, it identified the most significant non-point sources and site-specific management strategies and practices to reduce contributions from these sources.
Agriculture, groundwater pumping, urbanization, unimproved roads, hydromodifications, grazing, and gravel mining were identified as the most significant controllable sources in the watershed. Urbanization in the Llagas watershed was identified as an increasing potential source at that time (1999) and in the future. Elevated levels of nitrate in surface and groundwater resources in Southern Santa Clara County, due to agricultural fertilization, were also identified as a priority concern. For the study area, recommendations were made to increase technical and educational outreach to the agricultural, ranching, and equestrian communities; develop a short course curriculum for irrigated agriculture; continue short course offerings to the ranching community; adopt urban stormwater BMPs; adopt policies to reduce the percentage of building-related impervious surface on new projects; restore and protect the riparian zone; and deter illicit waste dumping.

Lower Pajaro River Sediment Assessment **(Philip Williams and Associates)**
This study was part of a larger effort to develop solutions for flooding problems in the Pajaro River watershed. The study examined 12 miles of the lower Pajaro channel from the river mouth at Monterey Bay to Murphy's Crossing, and determined potential sediment transport impacts to the lower river reach. The study reviewed hydrology in the watershed; describe the geomorphic characteristics of the study reach; estimated sediment yield for the study reach; developed a sediment mass balance model; and evaluated scour at four bridges in the study reach. The authors found long-term trends of channel incision and channel narrowing, significant bank erosion due to removal of riparian vegetation removal and; an estimated sediment yield ranging from 93 to 1950 tons/mi^2/yr. The study recommended alternatives to proposed flood control plans; improvement of the riparian vegetation system; long-term monitoring of cross-sections, erosion, and scour, particularly at bridges; and an expansion of field data collection.

Hydromodification Management Plan Literature Review: Santa Clara Valley Urban Runoff Pollution Prevention Program **(GoeSyntec Consultants)**
This detailed literature review identifies all of the hydrological impacts related to channel modifications and increased runoff due to urbanization. These changes have altered the character of many stream systems in the northern portions of Santa Clara County. Many of these sub-watersheds have experienced significant erosion and channel instability due to increased and "flashy" discharge peaks. The authors also provided a detailed review of various assessment methods and management practices to mitigate the impacts of urbanization on stream systems in northern Santa Clara County.

Establishment of Nutrient Objectives, Sources, Impacts and Best Management Practices for the Pajaro River and Llagas Creek **(San Jose State University and Meritt Consulting)**
This study focused on nitrogen and sediment loading within the Pajaro and Llagas systems and establishment of numerical water quality objectives. The study made numerous observations concerning agricultural impacts in specific creek reaches and also provided recommendations on Best Management Practices (BMPs) to reduce these nutrient and sediment loads. The authors found consistently elevated levels of nitrate and phosphate levels in both the Pajaro and Llagas systems. Mean nitrate-nitrogen levels often exceeded the drinking water standard. The study determined with lab and field measurements that algal growth potential and fluctuations in growth rate was controlled by phosphate levels, rather than nitrate-nitrogen. Agricultural nutrient loading sources were determined the most significant source in the Llagas Creek watershed.

Sediment Source Investigation for the Van Duzen River Watershed **(Pacific Watershed Associates)**
The objective of this study was to conduct a sediment source analysis for the Van Duzen River Basin, identifying relative sediment contributions from various sources, including in-stream processes. They reviewed a substantial body of prior work and data directly related to historical watershed assessments and sediment load estimates; utilized field sampling program of eighty 42 acre plots to measure all past erosion and sediment delivery and; combine plot sampling with aerial photos to develop a statistically derived load estimate. An important aspect of this study was that the authors were able to negotiate access to many private lands to conduct a detailed field assessment and source identification.
With a substantial existing database on watershed landforms, past channel cross-sections, land use, and the detailed quantitative sampling completed during the field assessment phase, sediment load estimates were made for three distinct portions or regions of the watershed and load contributions were developed for controllable and natural sources. Due to past timber harvest practices, road

construction and, significant flood events, that has disrupted the hydraulic equilibrium, it was determined that in-stream processes or channel migration zones may account for over thirty percent of the sediment yield in certain areas of the watershed.

Van Duzen River and Yager Creek Total Maximum Daily Load for Sediment **(USEPA)**
This Total Maximum Daily Load (TMDL) plan was built upon the afore-mentioned pre-TMDL assessment by Pacific Watershed Associates developing load estimates in three distinct regions of the Van Duzen watershed. The primary beneficial use was salmon and steelhead habitat, that was previously found to be impacted by strong pulses of sediment from land and in-stream sources. Land use practices and timber management practices were determined the principle controllable sources of sediment and in-stream processes are a significant source that could be reduced with targeted riparian enhancement efforts. Recommendations stressed the need for resource managers to continue identification and prioritization of controllable sediment sources and implement management measures in a timely fashion. A comprehensive monitoring program was recommended to provide evaluation of resource manager's efforts in implementing sediment control practices; BMP effectiveness; and determine if physical and biological indicators changing with time.

Garcia River Sediment Total Maximum Daily Load **(U.S. Environmental Protection Agency)**
A prior sediment source analysis, supported by significant sediment production data provided by private timber companies, the California Department of Forestry, the Mendicino County Resource Conservation District and Water Agency allowed an evaluation of changes in sediment yield between 1952 and 1997. Comparisons of prior sediment loading estimates for similar heavily timbered coastal watersheds in the region confirmed load estimates. Qualitative linkages between land sources and in-stream conditions provided estimates of various source contributions. Roads, loss of woody in-channel debris, storm channel instability and past timbering practices were significant concerns.

3.2. Sediment Data Sources and Analysis

3.2.1. Overview

Existing water quality data has been compiled from a variety of sources, including existing federal databases, and special studies conducted in the Llagas Creek watershed. The sediment related data has been compiled and tabulated for the four principal data sources, including:

a. The ongoing University of California Santa Cruz nutrient water quality study;
b. A Regional Water Quality Control Board water quality study conducted in 1997-98;
c. The US Environmental Protection Agency STORET Database; and
d. A San Jose State University water quality study conducted in 1992-93.

Each data set for the respective sources covers a discrete time period and in many instances sampling locations are not the same from one study to the other, so site specific comparison of water quality over time at individual locations is not permitted.

The following is a brief description of each data set.

2002-2003 University of California Santa Cruz Nutrient TMDL Sampling

The University of California Santa Cruz (UCSC) is under contract with the Regional Water Quality Control Board to conduct a water quality study to assess nutrient levels in surface waters in the Pajaro River Watershed. As part of the sampling effort, UCSC analyzed samples in the upper Pajaro watershed for concentrations of fine sediment (g/L), dissolved sediment (g/L), and coarse sediment (g/L). Samples were collected from Llagas Creek at Bloomfield Avenue, Llagas Creek below Chesbro Reservoir, Llagas Creek at Monterey Road, West Branch Llagas Creek at Day Road, West Branch Llagas Creek at Highland Road, Uvas Creek at Highway 152, and Uvas Creek at Bloomfield Avenue. The results of fine, dissolved and coarse sediment concentrations for samples collected at these locations are presented in Table A.4.

1997-1998 Regional Water Quality Control Board

As part of the Pajaro River Watershed Water Quality Management planning study, the Regional Water Quality Control Board collected water quality samples from various locations on Llagas Creek and Uvas Creek from February 1998 through January 1999. Analyses of the water quality samples included measurements of turbidity, total suspended solids, total dissolved solids, and volatile solids. Samples were collected from Llagas Creek at Chesbro Reservoir, Llagas at Oak Glen Avenue, Llagas at Monterey Road, Llagas at Buena Vista Avenue, Llagas at Holsclaw Road, Llagas at Luchessa Avenue, Llagas at Bloomfield Avenue, and Uvas at Bloomfield Avenue. Turbidity, total suspended solids, total dissolved solids, and volatile solids results are also presented in Table A.3.

USEPA STORET Database

The US Environmental Protection Agency (EPA) manages a database for the storage and retrieval of water quality data from information collected across the country. The database commonly referred to as STORET has two parts, a Legacy Data Center (LDC) and STORET. As part of the Pajaro River Watershed Water Quality Management Plan (ASE, 1999)[5] water quality data from STORET was retrieved for the Upper Pajaro area, including the Pajaro River, Llagas Creek and Uvas Creek. The database did not clearly identify sample location on Uvas Creek. Suspended sediment (mg/L) and suspended sediment discharge (tons/day) data was collected intermittently on Uvas Creek from November 1965 to February 1976. Suspended sediment (mg/L) and suspended sediment discharge (tons/day) data was collected intermittently on Llagas Creek at Chesbro Reservoir from March 1974 to March 1978. The same data was collected on the Pajaro River, from Chittenden Pass, from February 1978 to September 1992. The data retrieved from STORET is summarized in Table A.1.

1992-1993 San Jose State University Study

From June 1992 to July 1993 San Jose State University in collaboration with Merritt Smith Consulting conducted a water quality study and collected water quality samples on the Pajaro River and on Llagas Creek for a study entitled 'The Establishment of Nutrient Objectives, Sources, Impacts and Best Management Practices for the Pajaro River and Llagas Creek'. Water quality samples were analyzed for nitrate and phosphate concentrations, water temperature, flow rate,

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[5] Applied Science and Engineering, Inc. 1999. *Final Pajaro River Watershed Water Quality Management Plan*, Association of Monterey Bay Area Governments

turbidity, conductivity, pH and dissolved oxygen. Samples were collected at various locations including Llagas Creek at Bloomfield Avenue, Llagas Creek at Luchessa Avenue, Llagas Creek at Highway 152, Llagas Creek near California Street, and the Pajaro River at Frazier Lake. The results of flow rate and turbidity measurements are presented in Table A.2.

3.2.2. Data Analysis

Using sediment data collected by UCSC and the RWQCB, FCE performed a limited data analysis to evaluate sediment concentrations and turbidity measurements collected in the main stem of Llagas and Uvas Creeks.

UCSC Sediment Data (2002-2003 Sampling Events). Sediment data was generated by the University of California Santa Cruz (UCSC) Environmental Studies Program for samples collected from December 2002 through May 2003. Over the monitoring period six stations were monitored on Llagas Creek and two stations on Uvas Creek. The samples were analyzed for filterable (or dissolved) solids, fine solids (>1.2 micron and <63 micron), and coarse sediments (>63 microns). The results of the sediment monitoring are presented graphically in Figures 3.1 through 3.8.
The results of the monitoring indicate that a majority of sediment in the water column is composed of very fine or filterable solids (< 1.2 microns). During peak storm events fine sediment (>1.2 micron particles) is measured at relatively high concentrations. The monitoring results indicate that sediment concentrations immediately below Chesbro Reservoir in Llagas Creek are relatively slow as compared to monitoring points measured in the valley floor and near the Pajaro River confluence. The higher sediment concentrations measured in the downstream stations is attributed to several factors, including more intensive agricultural and urban land use activities, as well as higher instances of in-stream sediment sources, primarily from bank and bed erosion. Sediment concentrations measured in Uvas Creek are relatively high, but lower than those measured in the lower reaches of Llagas Creek, which is attributed to the fact that Uvas Creek is geomorphically more stable than Llagas Creek. Sediment data collected from the West Branch of Llagas Creek also contains relatively high sediment concentrations, but also appears lower than the main stem of Llagas Creek.

Figure 3.1. Sediment Concentration at Llagas Creek below Chesbro Reservoir

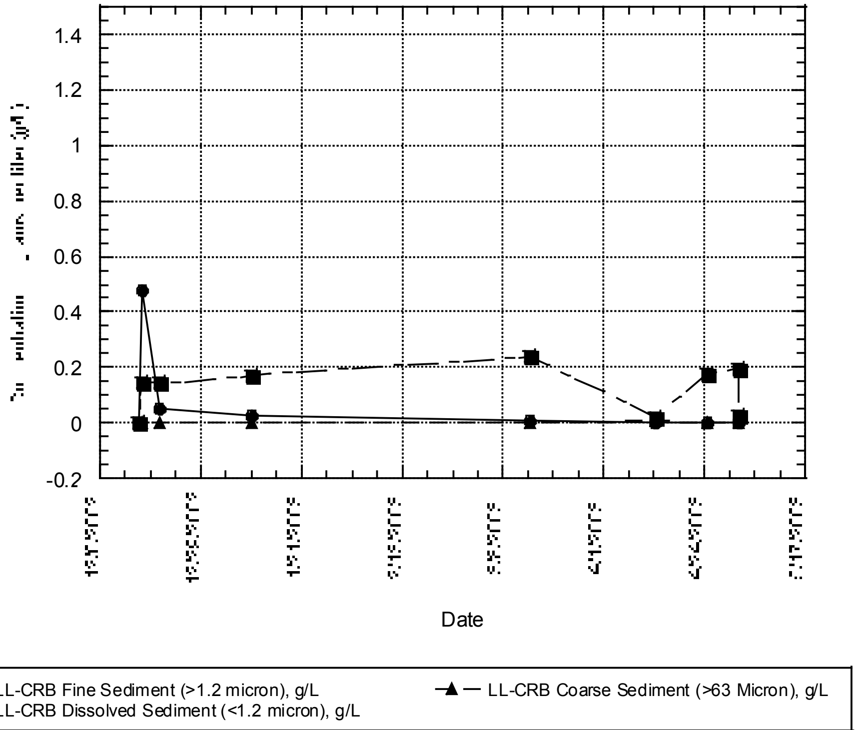


Figure 3.2. Sediment Concentration at Llagas Creek Monterey Avenue

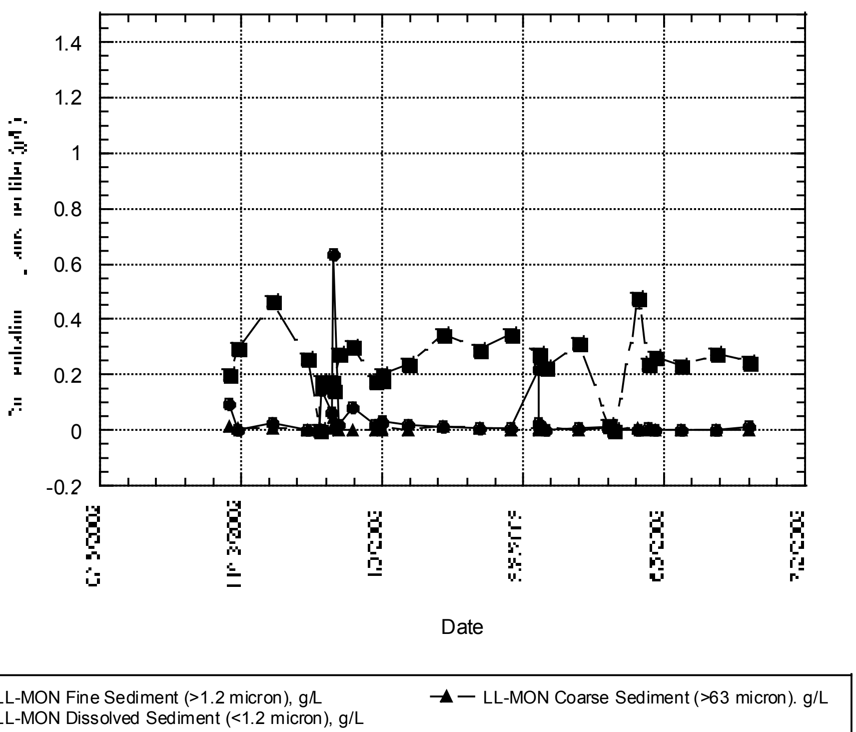


Figure 3.3. Sediment Concentration at Llagas Creek at Bloomfield Avenue Bridge

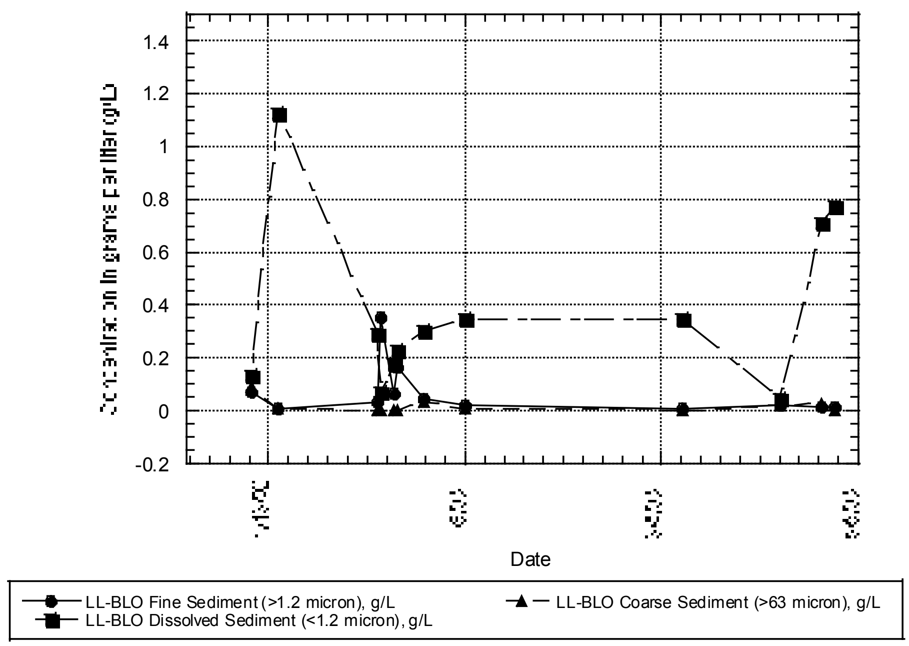


Figure 3.4. Sediment Concentration at Llagas Creek at Bloomfield Avenue Confluence

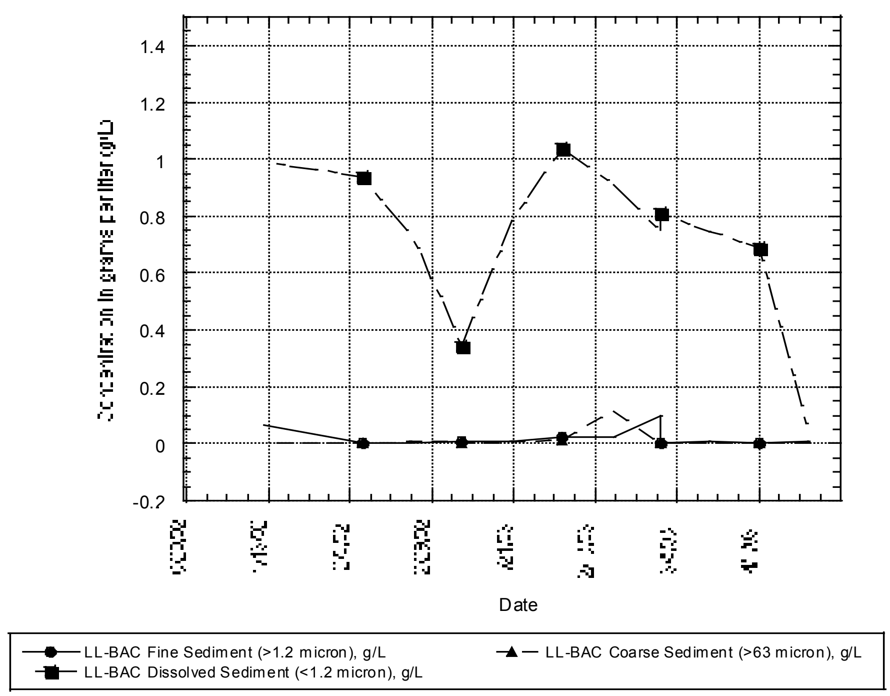


Figure 3.5. Sediment Concentration at West Branch of Llagas Creek at Day Road

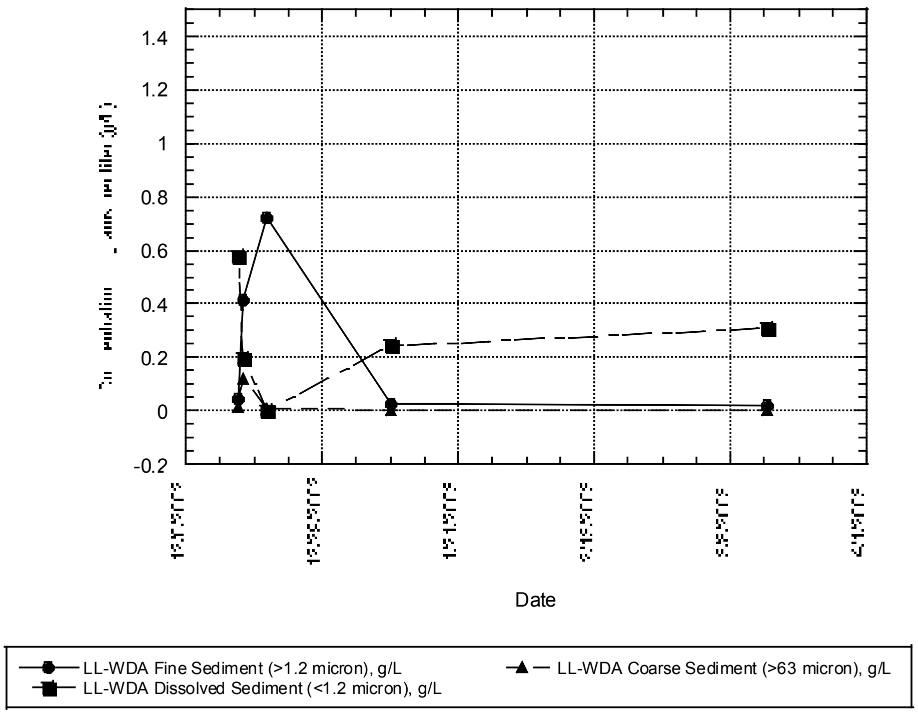


Figure 3.6. Sediment Concentration at West Branch of Llagas Creek at Highland Avenue

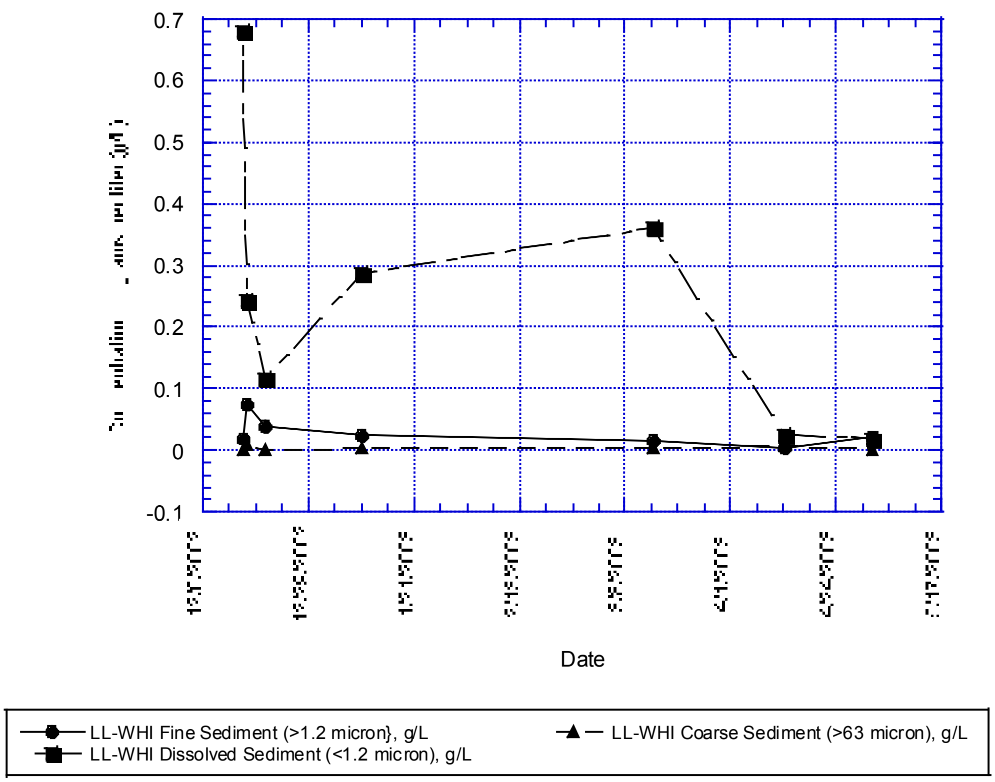


Figure 3.7. Sediment Concentration in Uvas Creek at Bloomfield Avenue

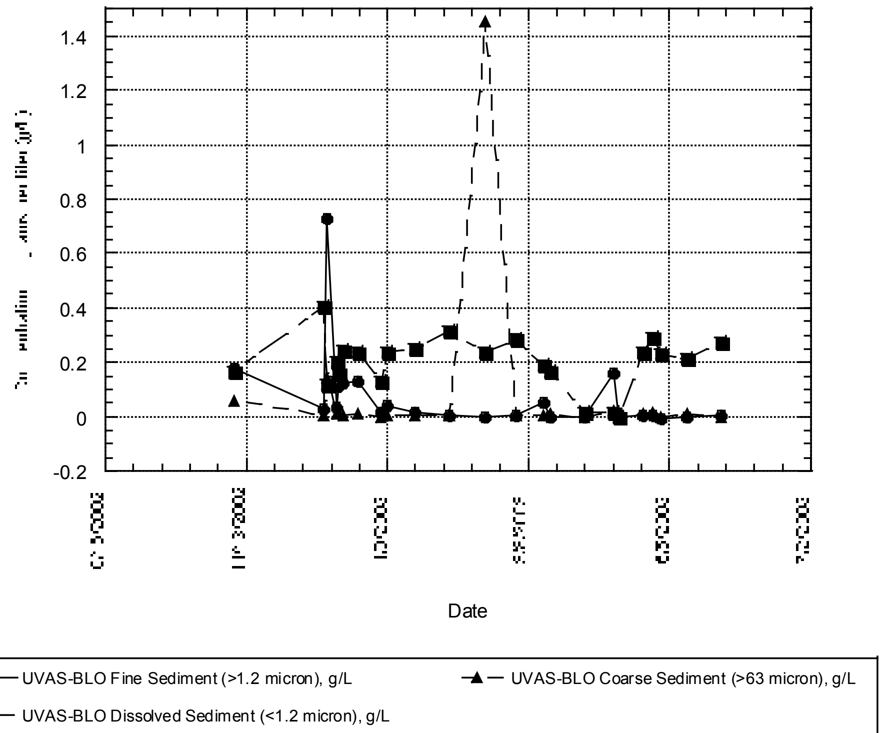
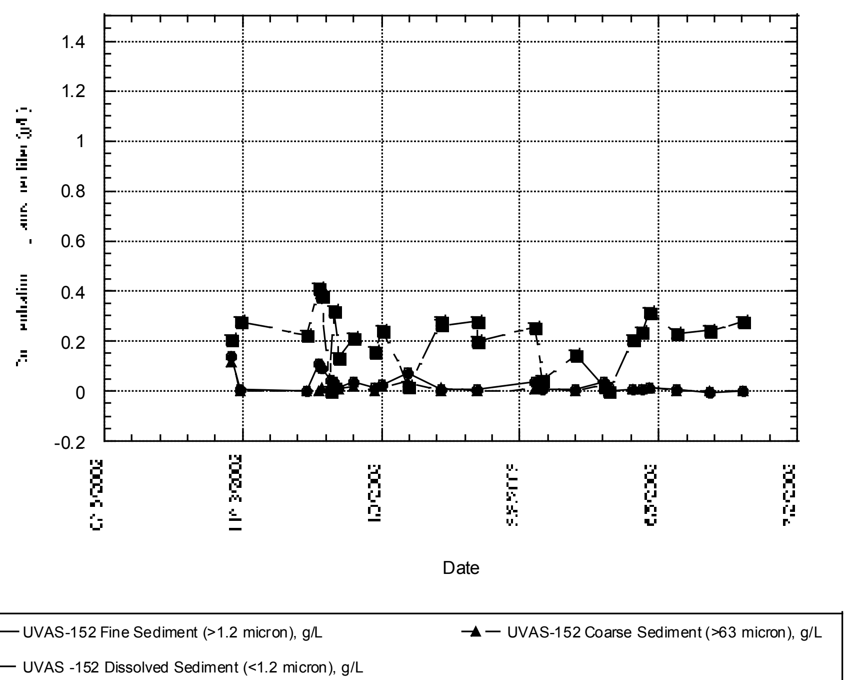


Figure 3.8. Sediment Concentration in Uvas Creek at Highway 152



RWQCB Sediment Data (1997-98 Sampling Events). During the 1997 through 1998 water year, the Central Coast Regional Water Quality Control Board (RWQCB) conducted a 13 month water quality monitoring program throughout the entire Pajaro River Watershed. During the project, turbidity measurement and water samples were collected for analysis of total suspended sediment from four monitoring points on Llagas Creek and one on Uvas Creek. The results of the testing are presented graphically in Figures 3.9 through 3.14.

The results of the monitoring event are summarized as follows:

- Above Chesbro Reservoir the concentration of total suspended solids (TSS) is typically higher than the TSS concentration below the reservoir. This likely occurs because sediment is trapped behind the Chesbro Reservoir dam.

- The data set shows that turbidity and TSS are poorly correlated, in many instances turbidity levels may remain relatively low, while TSS concentrations increase substantially. This data set indicates that turbidity, as a surrogate measurement, is not representative of sediment loads in the stream.

- Similarly, in the UCSC data set, the concentration of TSS increases from up to downstream stations, most notably in the last two monitoring points located at Luchessa and Bloomfield Avenues, shown in Figures 3.12 and 3.13, respectively.

- The TSS concentration in Uvas Creek is also relatively low, as compared to the Main Stem of Llagas Creek.

Figure 3.9. Turbidity (NTU) and Total Suspended Solids Concentrations (mg/L) in Llagas Creek above Chesbro Reservoir

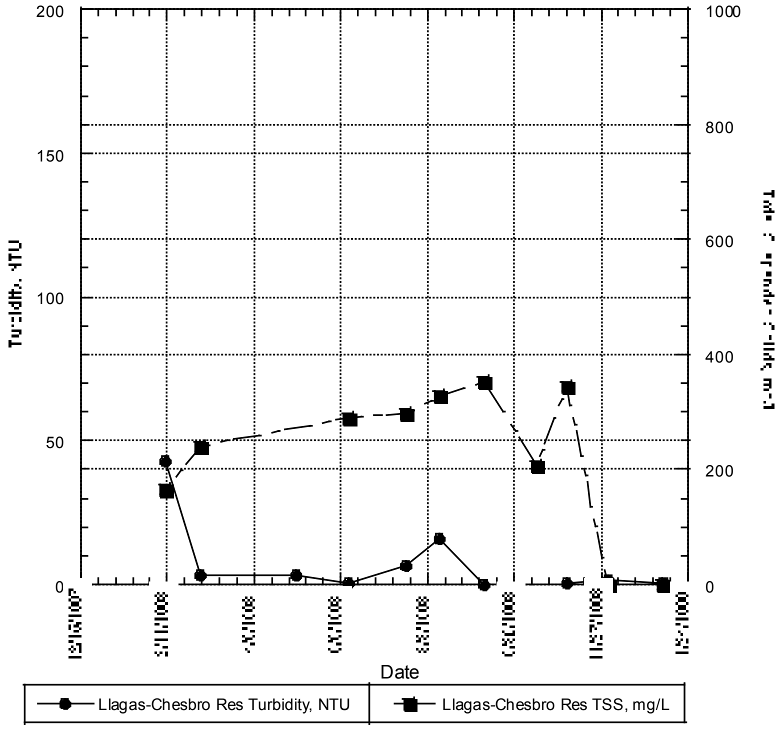


Figure 3.10. Turbidity (NTU) and Total Suspended Solids Concentrations (mg/L) in Llagas Creek at Oak Glen Avenue

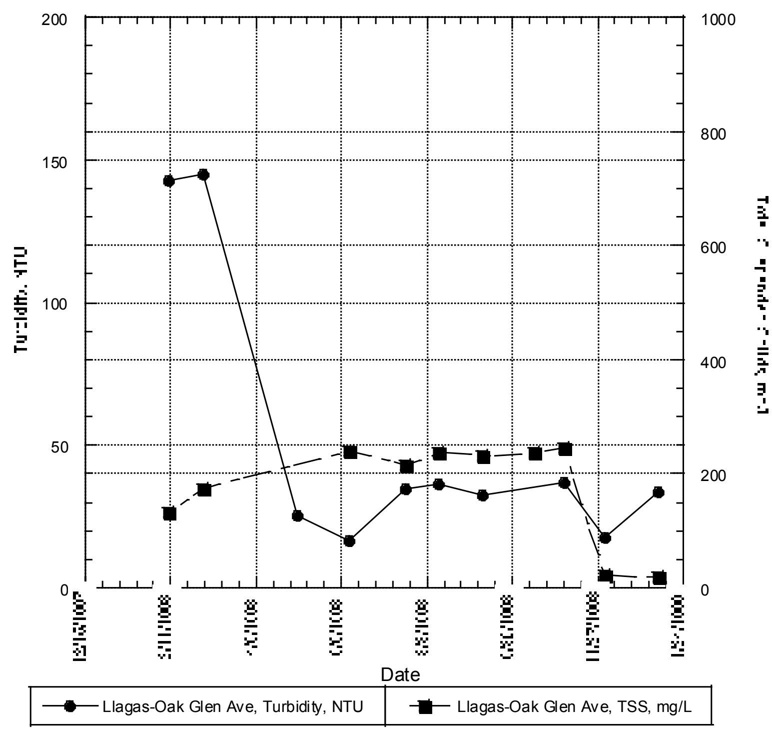


Figure 3.11. Turbidity (NTU) and Total Suspended Solids Concentrations (mg/L) in Llagas Creek at Monterey Avenue

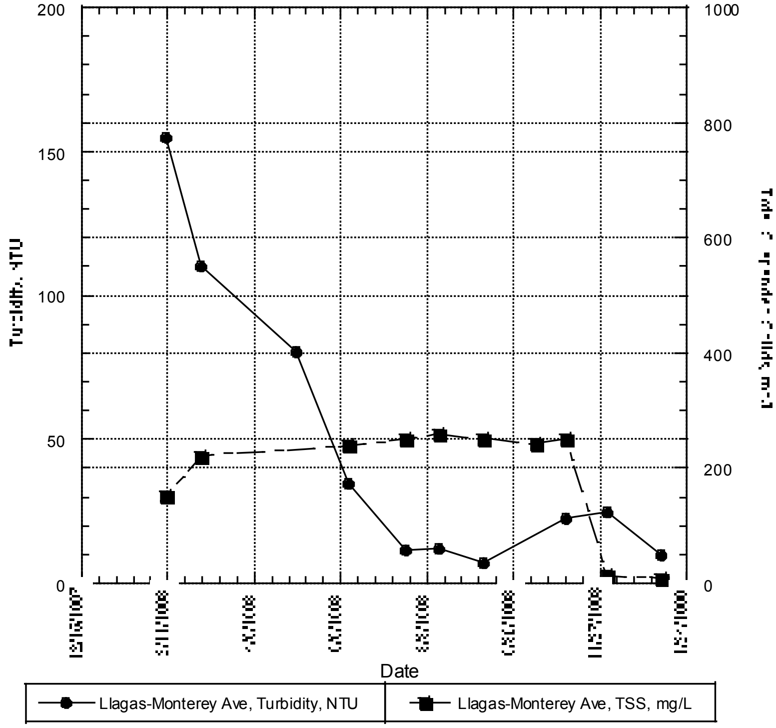


Figure 3.12. Turbidity (NTU) and Total Suspended Solids Concentrations (mg/L) in Llagas Creek at Luchessa Avenue

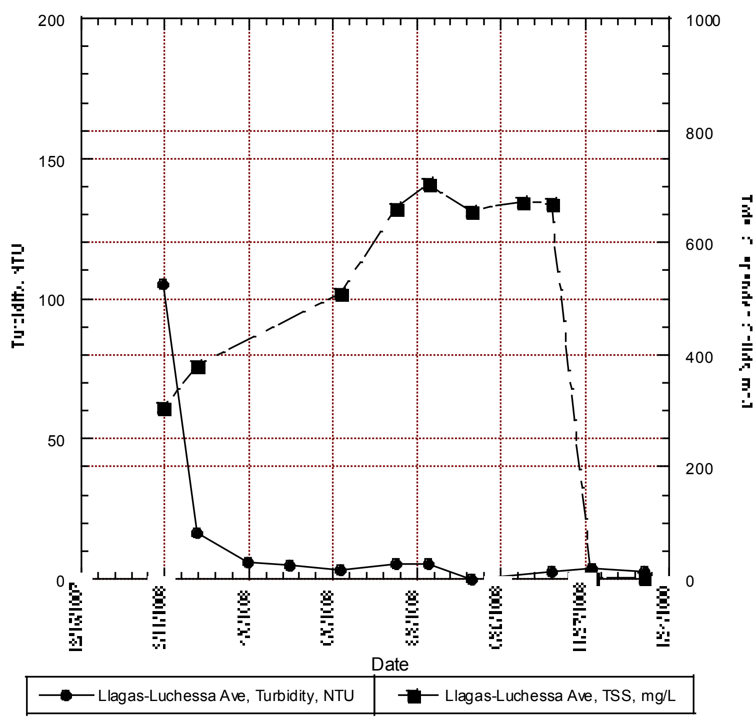


Figure 3.13. Turbidity (NTU) and Total Suspended Solids Concentrations (mg/l) in Llagas Creek at Bloomfield Avenue

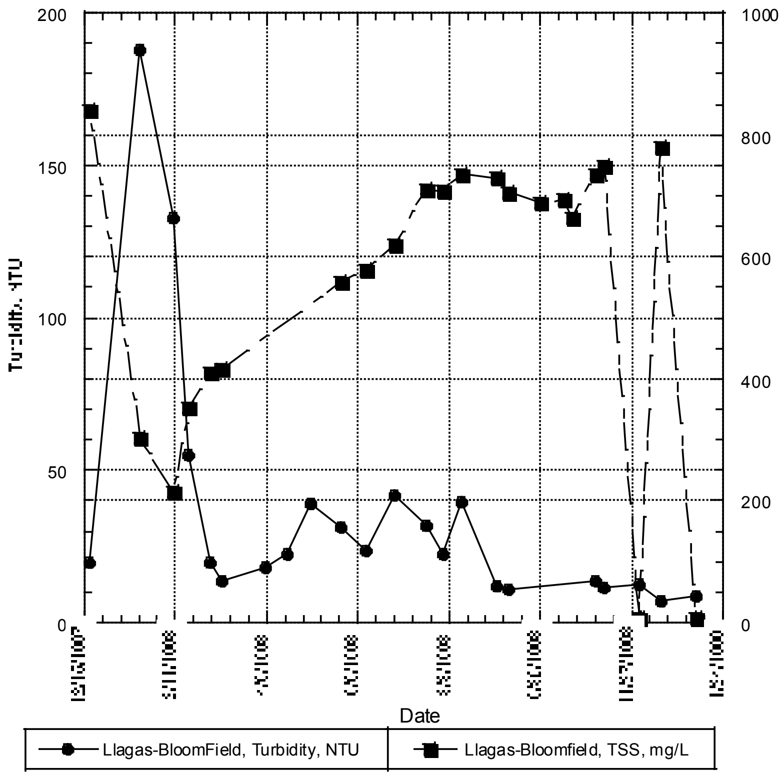
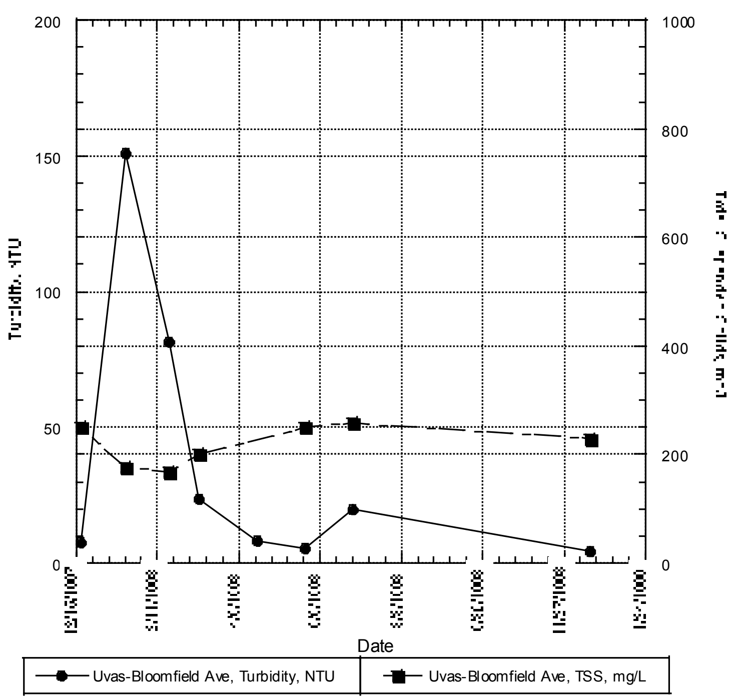


Figure 3.14. Turbidity (NTU) and Total Suspended Solids Concentrations (mg/L) in Uvas Creek at Bloomfield Avenue



4. STREAM CHANNEL ASSESSMENT

4.1. Introduction

When considering potential sediment sources and load allocations for the sediment TMDL process it is important to assess natural and manmade features that affect the stream course geomorphology and sediment transport. In-stream erosion can be a significant non-point source for sediment within a riverine system. A large number of factors control the magnitude of in-stream erosion, including the composition of bed materials, streamflow duration, frequency and location of flow within an active channel, channel geometry, soil and geologic conditions and vegetation.

Channel form and morphology will change in response to watershed modifications as well as large storm events. Land use changes, such as increased impervious surfaces can increase stream flows over a short duration of time causing excessive bank and channel erosion. Hydromodifications to streams, such as channel straightening, installation of bank linings, and culverts can concentrate and increase flow velocities and shear stress on banks and channels resulting in excessive scour, erosion, and downcutting of stream channels. Removal of natural vegetation along stream banks can result in unstable and easily erodable banks. Assessment of stream bank and channel conditions is critical to assess erosion and sedimentation conditions in a watershed. A field assessment methodology was developed to identify in-channel erosion and rank channel conditions throughout the study area. The following sections describe the methodology employed in this study.

4.2. Channel Assessment Methodology

Two methodologies have been developed to assess the risk of erosion in channels in the study area: proper functioning condition (PFC) and bank erosion hazard index (BEHI). These assessment methods have been applied over a large study area (~200 square miles) to understand the relative condition of stream corridors and their potential risk of erosion and contribution to sediment loads.

An aerial photograph of the southeastern portion of Santa Clara County, taken in August of 2000, was also used to supplement the PFC and BEHI channel assessment methodologies. This tool was used to provide a more detailed visual assessment of vegetation density in each sub-watershed.

Channel assessments were conducted from public access points within each sub-area, and in a few cases, on private lands where prior permission was received. The number of observation points varied, based on reach length and access. Therefore, in many instances, average channel characteristics were used to derive a PFC and BEHI rating. In combination with the aerial photograph, it was determined that, in some limited number of cases increased visual access and observations points might change the result of the PFC and BEHI rating. These specific streams are noted in the later descriptions of this section. PFC and BEHI ratings were not developed in sub-areas where limited public access prevented an adequate channel assessment.

4.2.1. <u>Proper Functioning Condition (PFC)</u>

The Proper Functioning Condition (PFC) is a qualitative assessment method and refers to 'a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the conditions of riparian-wetland areas'.[6] The PFC method was developed as a collaborative effort between the Bureau of Land Management (BLM), the Fish and Wildlife Service (FWS), and the Natural Resource Conservation Service (NRCS). The PFC assessment method compares observed channel conditions to channel features characteristic of a functioning stream system.

Stream characteristics indicating that a stream is properly functioning include; an established riparian vegetation community capable of providing aquatic cover, dissipating stream energy and protecting channel banks; a channel geometry that is widening or has achieved its potential extent and includes sinuosity, gradient, and floodplain characteristics in balance with the landscape setting; and erosional and depositional features that indicate a stable riparian system. Included in this assessment are the potential effects of increased or decreased sediment and water contributions from upland watersheds and information about vegetation diversity, channel substrate characteristics and adjacent land use.

The assessment information is summarized in a checklist system separated into three primary categories: riparian vegetation, erosion/deposition, and hydrology (Table 4.1). The checklist system provided a consistent and systematic evaluation of the drainages within the twenty-six sub areas in the study area. The checklist included questions designed to return an affirmative answer if the system is properly functioning, and a negative answer if the system is not functioning properly. If a question was not relevant to a specific assessment area then it was noted as not applicable.

A final checklist tally of the twenty questions revealed if the system could be characterized as properly functioning, moderately functioning or non-functioning. Index or functioning reaches were defined as those with no or little human disturbance within the past 40 years and no evidence of residual erosion or instability due to past human activity. Moderately disturbed or moderately functioning reaches were defined as reaches with recent management impacts but good protection over the stream course. Highly disturbed or non-functioning reaches were defined as reaches with large areas of disturbed soil.

The following figures are graphical representations of properly functioning, moderately functioning, and non-functioning systems in the study area. Figure 4.1 is a picture of Little Arthur Creek, a stream system identified as proper functioning in the stream assessment program. Figure 4.2 is a picture of Tennant Creek, a stream system identified as moderate to non-functioning in the stream assessment program. Figure 4.3 is a picture of Jones Creek, a stream system identified as non-functioning in the stream assessment program.

[6] BLM, NRCS, USDA, "A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas", TR 1737-15, 1998

Upper Pajaro PFC Checklist

Stream Name: ______________ Photo #: ______________

Date: ______________ Roll/Photo ID: ______________

Observer: ______________

Response				Riparian Vegetation
YES	NO	N/A		
			A	Is there an established riparian vegetation community? What are the community structures?
			B	Is there low bank riparian vegetation that provides shaded riverine aquatic (SRA) cover?
			C	Is there diverse age-class distribution of riparian-wetland vegetation?
			D	What is the dominant riparian vegetation type?
			E	Is there a diverse height distribution of the riparian-wetland vegetation?
			F	Is there a diversity of vegetation species? (species in common name?)
			G	No evidence of excessive loss of riparian vegetation.
			H	Is stream bank vegetation present with root mass capable of withstanding erosion from high flow events?
			I	Is riparian-wetland vegetative cover adequate to protect banks and dissipate energy during high flows?

Comments:
(bank/channel/floodplain) (tall/short grasses, deciduous/evergreen, broad/narrow leaves, shrubs/grasses/small plants)

Rank: ______

Response				Erosion/Deposition
YES	NO	N/A		
			A	Are floodplain and channel characteristics adequate to dissipate energy during high flows?
			B	Is the system vertically stable?
			C	Is the stream in balance with the water and sediment being supplied by the watershed (upstream)?
			D	Does the channel have mid-channel bars?
			E	Are stream banks stable? (obvious rills/gullies, mass wasting)
			G	What is the distribution of substrate types in the channel bed?
			H	What are bank characteristics? (material size/sorting/loose/armored/veg)
			I	What is the adjacent land use?
			J	No evidence of recent erosion. If no, streambed downcutting or bank erosion?
			K	Is there evidence of recent sediment deposition?

Comments: ______________

Rank: ______

Response				Hydrology
YES	NO	N/A		
			A	Riparian-Wetland area is widening and has achieved potential extent.
			B	Sinuosity in balance with the landscape setting? (channelized?)
			C	Gradient in balance with the landscape setting?
			D	Floodplain above bankfull is inundated in "relatively frequent" events.
			E	Upland watershed is not contributing to riparian wetland degradation.
			F	What is the depth of visibility? (turbid, eutrophic, suspended sediment?)

Comments: ______________

Rank: ______

Response		Dimensions
	A	Bank Height
	B	Bank Angle
	C	Channel Width
	D	Average bankfull depth/depth of Low Flow Channel
	E	Channel Shape (Narrow/Deep, Wide/Shallow)

Table 4.1. Upper Pajaro Proper Functioning Condition Checklist

Figure 4.1. The stream assessment identified Little Arthur Creek as an example of a Proper Functioning system.

Figure 4.2. The stream assessment identified Tennant Creek as an example of a Moderately Functioning system.

Figure 4.3. The stream assessment identified Jones Creek as an example of a non-Functioning system.

4.2.2. Bank Erosion Hazard Index (BEHI)

The Bank Erosion Hazard Index (BEHI) is an assessment developed by Wildland Hydrology, Inc. based upon quantitative measurements of bank characteristics.[7] The assessment compares measurements of bank characteristics to a relative risk of erosion. The five risk categories include a ratio of bank to bankfull height, a ratio of rooting depth to bank height, root density, bank slope, and percent surface area protected by vegetation. These measurements are scaled to values from 1 to 10 to determine the relative risk of bank erosion (Table 4.2). Categories of risk range from very low, low, moderate, high, very high to extreme.

[7] Rosgen, D.L, 'A Practical Method of Computing Streambank Erosion Rate', March 2001.

Table 4.2. Stream Bank Characteristics and Rating Values for Bank Erosion Hazard Index

RISK RATING		Bank Height / Bankful Height	Root Depth/ Bank Height	Root Density %	Bank Angle (degrees)	Surface Protection %	TOTALS
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80	
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	5-9.5
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55	
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	10-19.5
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30	
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	20.29.5
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15	
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	30-39.5
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10	
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	40-45
EXTREME	Value	>2.8	<0.05	<5	>119	<10	
	Index	10	10	10	10	10	46-50

In other watershed research and assessment projects, the results of the BEHI have been correlated to near bank stress (NBS) and velocity gradients to determine rates of bank erosion. These correlations are unique to different geologic and hydrologic regions and therefore need to be developed specific to each study area to make predictions of sediment loads based upon bank erosion. Therefore, for the purposes of this study the BEHI was used independently from the NBS to understand the relative erosion risk of channel banks in different sub-areas.

In some sub-areas bank characteristics change considerably over the entire stream length. Best professional judgment was used to select BEHI assessment locations that represent average channel characteristics observed over the entire stream length.

4.2.3. Assessment of Vegetation Density

A recent aerial photo of the southeastern portion of Santa Clara County was used to supplement the PFC and BEHI channel assessment methodologies. The aerial photo was used to verify or expand upon field observations. Specifically, the photo was used to assess the relative density of vegetation along stream reaches. Vegetation density was classified in three categories: low, moderate, and high. It was also noted where banks were devoid of vegetation or mostly grassed. These vegetation density assessments were combined for each reach and, depending upon the total percent of the channel that was vegetated the reach, was rated as minimal, moderately, or well vegetated.

For the purposes of this assessment a low vegetation density was defined as riparian vegetation that includes grasses, in-channel vegetation, and other low canopy vegetation that does not provide shaded riverine aquatic (SRA) cover. A moderate vegetation density was defined as riparian vegetation that includes grasses, in-channel vegetation, low canopy vegetation and sparsely distributed higher canopy vegetation that provides intermittent SRA cover. A high vegetation density was defined as riparian vegetation that includes grasses, in-channel vegetation, low and high canopy vegetation that provides contiguous SRA cover. Examples of low, moderate and high vegetation densities as determined in the aerial photograph are shown in Figures 4.4, 4.5 and 4.6. Generally the low vegetation density stream reaches do not have the root mass capable of withstanding erosion from high flow events and high vegetation stream reaches do.

Figure 4.4. Example of a stream reach with a low vegetation density that does not provide SRA or root mass capable of withstanding erosion during high flow events.

Figure 4.5. Example of a stream reach with a moderate vegetation density that provides intermittent SRA.

Figure 4.6. Example of a stream reach with a high vegetation density that provides continuous SRA and root mass capable of withstanding erosion during high flow events.

4.3. Channel Assessment Parameters

This assessment approach was partially constrained by limited public access points and/or the ability to site along full stream reaches. Most of the survey work occurred between mid-December 2002 through May 2003. Representative locations were chosen following a preliminary reconnaissance survey of the entire study area. At every observation point, the project team collected qualitative and quantitative descriptors of channel conditions. These included descriptions of riparian vegetation, channel erosion and deposition, channel hydrology, and cross section measurements.

4.3.1. Riparian Vegetation

Information about riparian vegetation was collected as part of the PFC analysis. This section of the analysis was developed to assess the extent and type of vegetation found within the creek channel, banks and floodplain. Vegetation is generally considered beneficial for a 'functioning' system because it stabilizes bank soils, slows flood flows and provides habitat.

Riparian vegetation was first assessed to determine if an established riparian vegetation community existed. For the purposes of this study an established community had general characteristics of diverse height and age distribution of vegetation, multiple levels on the stream corridor, including bank, channel, and floodplain.

Observations were then made to determine if the existing vegetation was capable of providing shaded riverine aquatic cover (SRA). SRA occurs where bank vegetation extends into and over in-channel habitat. The Fish and Wildlife Service has described this zone as an area where channel banks "composed of natural, eroding substrates support riparian vegetation that overhangs or protrudes into the water". The cover or shade created by this overhanging vegetation provides habitat and temperature regulation for aquatic species.

Observations were collected regarding the age-class distribution and height diversity of vegetation in the channel, bank and floodplain of the stream. A diversity of vegetation age-classes (2+) is important for the maintenance and recovery of a channel. Vegetation can generally be classified as either recruitment, replacement or mature. A recruitment species is young, a replacement species is middle aged, and mature species are in older age-classes. Established recruitment and replacement species are generally important for the recovery and maintenance of a channel because of their ability to propagate and establish following a channel disturbance such as flood or bank failure.[8] Height diversity of vegetation can be important for development of SRA as well as an indicator of age-class variation.

Throughout the field assessment, notes were collected on the types of vegetation present as well as if a diversity of species existed. Along with a diverse age-class distribution, species diversity is also important for channel maintenance and recovery. A diversity of riparian species can accommodate short-term changes in climate or disease that may affect certain species but not others. The determination of sufficient diversity was not based on a standard of every possible plant species that area could sustain was present, but whether the species present were adequate for maintenance and recovery of the riparian vegetation[9].

Observations were made regarding any visible loss of vegetation from stream banks, specifically due to erosion and bank failure. Observations were also made regarding the predicted ability of existing vegetation to protect banks and dissipate energy during high flows. Vegetation protects stream banks and filters sediment, but only if adequate amounts of surface cover exists to perform these functions. Similarly, to protect banks vegetation must have a root mass capable of withstanding erosion. If existing vegetation does not have sufficient root mass, banks can become undercut and collapse.

The combined response to these descriptors of riparian vegetation were used to determine if the system was properly functioning, moderately functioning, or non-functioning in regards to riparian vegetation.

4.3.2. Erosion/Deposition

Information about erosion and depositional features from each stream was collected as part of the PFC analysis. Observations were made to assess the extent of erosion and/or deposition in the creek, and the ability of the channel to prevent erosion and transport excess sediment.

Observations of channel characteristics related to energy dissipation were collected. Typical channel features related to energy dissipation are floodplains, long channel lengths or channel sinuosity, and in-channel coarse debris that slow flows. Floodplains are important features for energy dissipation because in high flow events water overtops channel banks and diffuses across broader areas at slow velocities and shallow depths. Sinuosity increases overall channel length, decreasing channel slope and channel velocity, compared to a straightened channel. Coarse debris such as rock or wood in a channel increases channel roughness, which slows channel velocities and decreases energy.

Observations were also collected about possible in-channel erosion, specifically whether the channel appeared to be vertically stable and the stream banks appeared stable. The process of sediment transport in rivers continually lowers the bottom channel elevation, though typically on a scale of hundreds of years or more. In a stream that is not vertically stable, the channel bottom is eroding, or

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[8] "A user Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas", Bureau of Land Management, U.S Forest Service, Natural Conservation Service, 1998.
[9] Ibid.

incising, at a rate faster than the natural cycle.[10] Unstable stream banks can be associated with anthropogenic disturbances, channel incision, loss of vegetation, and the overall adjustment of a stream system to achieve equilibrium with its water and sediment supply. An attempt was also made to infer, based upon adjacent and upstream land uses, whether the stream appeared to be in balance with its water and sediment supply, or if it was seeking a new state of equilibrium.

Information was also collected regarding the characteristics of in-channel and bank substrate. Specifically, in-channel substrate was categorized as combinations of cobble, gravel, sand, silt and clay. The occurrence of mid-channel bars was also noted, as they represent a sedimentation process typically observed in systems in equilibrium with sediment and water sources. Where possible the size and degree of sorting of bank material was described along with the extent of bank armoring, if present. General observations were also made if visual evidence of in-channel or bank erosion and/or sedimentation was identified.

The combined response to these descriptors of erosion and depositional features were used to determine if the system was properly functioning, moderately functioning, or non-functioning in regards to erosion and deposition.

4.3.3. Hydrological Characterization

Information about hydrologic features was collected as part of the PFC analysis. This section of the analysis assesses some of the visible hydrologic characteristics of the river system as reflected in the channel and floodplain geometry. These are largely subjective observations, based upon best professional judgment of the general structure and setting of the streams.

Observations were made to determine if the riparian-wetland area of the stream was widening or had achieved its potential extent. The widening of a riparian-wetland area along a stream corridor, and a riparian-wetland area achieving its potential extent are both positive indicators of stream functioning. It conveys that the stream is not being encroached upon by adjacent land uses, the system is in equilibrium with its sediment and water supply, and the riparian vegetation is vigorous and diverse.

Observations were also made comparing the sinuosity of the stream with the general sinuosity of natural streams in a similar landscape setting. Sinuosity is a ratio of stream length to valley length, and for valleys and streams with few anthropogenic influences, characteristic values of sinuosity are generally observed in specific landscape positions, such as upper watershed, foothills and valley. Decreasing sinuosity increases the stream gradient, or slope, which also increases velocity and the erosive energy of a stream. Therefore observations of stream sinuosity and gradient in balance with the landscape position can indicate if the stream is susceptible to increased rates of erosion.

Channel characteristics were observed to consider if the channel floodplain above bankfull is inundated in “relatively frequent” events. Determining if the floodplain, above bankfull was frequently accessed required the identification of the bankfull channel and the floodplain. The bankfull channel is the channel created by flood flows occurring once every 2 to 2.5 years. This intermediate flow has the ability to transport and erode sediment and occurs frequently enough to have the greatest influence on channel geometry. Water above the bankfull channel can flow onto

[10] Ibid.

an intermediary terrace or onto the channel floodplain. The floodplain is 'topographically' flat and lies adjacent to the stream. Geomorphically, it is a landform composed primarily of unconsolidated depositional material derived from the streams. Hydrologically, it is a landform subject to periodic flooding by the stream."[11] If channel geometry has been altered by anthropogenic influences such as hydromodifications, high flows may no longer access the floodplain and the associated benefits of energy dissipation and sediment deposition. As a result, water stays in the stream system and continues to erode and downcut the channel to accommodate increased flow volumes. In natural systems, high flows on the floodplain are also important, and in some cases necessary, to sustain riparian vegetation.

An attempt was also made to infer, based upon upstream land uses, whether the stream appeared to be in balance with its water and sediment supply, or if it was degraded and seeking a new state of equilibrium. If water was present in the channel at the time of the assessment notes on water clarity were taken.

The combined response to these descriptors of hydrological features were used to determine if the system was properly functioning, moderately functioning, or non-functioning in regards to hydrological functioning.

4.3.4. Channel Cross-Section Analysis

Measurements of channel cross sections were collected as part of the BEHI analysis. This section of the analysis estimates features of the channel geometry. Measurements collected as part of the channel cross-sectional analysis included:

- ✓ Bank Height
- ✓ Bank Angle
- ✓ Channel Width
- ✓ Average bankfull depth/depth of Low Flow Channel
- ✓ Channel Shape (Narrow/Deep, Wide/Shallow)

These measurements were used to verify observations such as bank steepness and channel down cutting. The channel cross-section analysis is a critical tool in assessing the relative stability and erosion potential in a stream.

4.4. In-Channel Sediment Source Categories

Observed in-channel sources of sediment, as described in the detailed channel descriptions can be divided into five categories: hydromodification, channel incision, bank failure, road ditches, vegetation, land use encroachment, and access. The relative impact of these in-stream sediment sources by study sub-area is summarized in Table 4.3.

Two primary in-channel sediment source categories were identified in the course of the channel assessment program; channel incision and bank erosion/failure.

Within the study area, channel incision can generally be attributed to increased flow volumes associated with decreased access of high flows to the channel floodplain. This may result from increased flow volumes derived from decreased infiltration associated with urban development.

[11] Ibid.

Table 4.3 Relative Ranking of Observed In-Stream Sediment Sources by Study Sub-Area

Upper West Basin Region	**Hydro-modification**	**Channel Incision**	**Bank Failure**	**Road Ditches**	**Vegetation**	**Land Use Encroachment**	**Access**
Blackhawk	○	○	○	○	○	○	○
Bodfish	○	○	○	○	◉	◉	○
Chesbro Reservoir	○	○	◉	○	◉	◉	◉
Little Arthur	○	○	○	○	○	○	○
Little Uvas	N	N	N	N	N	N	N
Upper Uvas	○	○	○	○	○	○	○
Upper Llagas	○	○	○	○	○	○	○
Uvas Reservoir	○	○	○	○	○	○	○
North ValleyRegion							
Little Llagas	●	●	●	◉	●	●	◉
Madrone	●	○	○	○	◉	◉	○
Tennant	●	◉	◉	◉	●	◉	○
Corralitos	●	◉	●	●	●	●	◉
Middle Llagas	●	●	●	◉	●	●	◉
San Martin	◉	●	●	◉	●	◉	○
Mid-Valley Region							
Church	●	●	◉	●	◉	◉	◉
Rucker-Skillet	●	●	●	●	●	●	◉
Live Oak	◉	◉	◉	◉	◉	◉	◉
West Branch Llagas	●	●	●	●	●	●	◉
Panther	◉	◉	◉	◉	◉	◉	●
Lower Uvas	◉	◉	◉	○	◉	◉	◉
South Valley Region							
Jones	●	●	●	●	●	●	◉
San Ysidro	●	●	●	●	●	●	◉
Pajaro	●	◉	◉	●	●	●	◉
Lower Llagas	●	◉	◉	○	●	●	○
Uvas-Carnadero	●	●	◉	◉	◉	●	○
Wildcat	N	N	N	N	N	N	N

○ = Low ◉ = Medium ● = High N = Not accessible

Increased flow volumes often occur concurrently with hydromodifications of channel geometry and form, which often limit the ability of the natural channel form to dissipate erosive energy from high flows.

Within the study area, bank erosion/failure can generally be attributed to a lack of vegetation with root mass and cover capable of dissipating energy and stabilizing banks. This may be due to natural or anthopogenic causes. Bank destabilization is likely linked to changes in channel width/depth ratios as the stream system adjusts to compensate for changes in water and sediment supply and develops a new equilibrium state.

4.5. Stream Channel Assessment Results

A natural stream channel is often defined as "*stable or in equilibrium*" when its cross section, and profile features are maintained with time such that the stream neither aggrades, degrades, or changes in dimension or meander pattern under average climatic conditions.[12] When a stream channel migrates laterally by eroding into its outer bank and depositing sediment on its inner bank, while maintaining its general shape, channel stability is maintained even though the channel is active. The channel is neither aggrading nor degrading the bed and it is maintaining the floodplain. Under these conditions, the river is said to be in "*dynamic equilibrium*". Channel instability occurs when scouring leads to degradation or when excessive deposition leads to aggradation. Both aggradation and degradation are often accompanied by bank failures, a change in channel dimension, meander pattern, and slope.

Analysis of the field data suggests that much of the Llagas Creek watershed does not exhibit the key characteristics of a system in "*equilibrium*". Conversely, the Uvas-Carnaderos watershed has a greater percentage of stream reaches and tributaries that can be characterized as "*stable or in equilibrium*". The upper reaches of both watersheds above the Chesbro and Uvas dams appear to be "*stable*" and can be considered properly functioning. This is in significant contrast to various ephemeral and intermittent reaches of the Llagas watershed in the eastern foothills and valley floor, as well as the lower southern portions of the Uvas-Carnaderos watershed. Channel modifications, both current and historic, are significant factors influencing channel stability in the entire study area. Several common modifications include residential and agricultural encroachment, removal or elimination of riparian vegetation, increased flow volumes arising from impervious surface runoff, and in some cases, storm runoff from row crop fields.

Table 4.4 summarizes the PFC and BEHI ratings of all watersheds and creeks in the study area. The following sections provide a more detailed description of each creek system supporting these results.

4.6. Summary

A total of 47 creeks were surveyed within the 202 square mile Llagas Basin Study Area. Two field methodologies were utilized to assess the risk of erosion in stream channels: proper functioning condition (PFC) and bank erosion hazard index (BEHI). The PFC is a qualitative assessment method that systematically guides observations of stream characteristics including riparian vegetation, erosion and deposition patterns, and hydrologic features. The BEHI assessment

[12] GeoSyntec Consultants, "Hydromodification Management Plan Literature Review", Santa Clara Valley Urban Runoff Pollution Prevention Plan, September 2002.

Table 4.4. Summary of Channel Assessment Results

Sub Area	Creek	Proper Functioning Condition	Bank Erosion Hazard Index	Vegetation Assessment (%)		
				High	Moderate	Low
Upper West Region						
Blackhawk						
	Bodfish	PF-MF	Mod	71	14	8
Bodfish						
	Bodfish	PF-MF	Mod	71	14	8
Chesbro Reservoir						
	Llagas	PF-MF	Mod	88	6	--
Little Arthur						
	Little Arthur	PF	Mod	100	--	--
Upper Llagas Creek						
	Llagas	PF	Very Low-Low	100	--	--
North Valley Region						
Little Llagas						
	West Little Llagas	NF-MF	Mod	11	9	25
	East Little Llagas	NF	High-Very High	--	1	--
	Dewitt	X	X	X	X	X
	Edmundson	MF	Mod-High	18	11	32
Madrone Channel						
	Madrone Channel	NF-MF	Mod	--	--	24
Tennant						
	Tennant	NF-MF	Mod-High	--	3	11
	Foothill	NF-MF	Moderate	28	20	10
Corralitos						
	Maple Creek	NF	Very High-Extreme	--	15	2
	Corralitos and South Corralitos	NF	High	--	22	11
Middle Llagas						
	Llagas	PF-MF	Mod-High	69	20	4
	Paradise	NF-MF	High	54	28	17
	Machado	NF-MF	High	68	22	--
	Hayes	MF	Mod-High	17	23	36
San Martin						
	San Martin	NF	Mod-High	12	30	15
	Center	NF-MF	Mod-High	31	20	31
	New	NF	Mod-High	4	24	39

Table 4.4. Summary of Channel Assessment Results

Sub Area	Creek	Proper Functioning Condition	Bank Erosion Hazard Index	Vegetation Assessment (%)		
				High	Moderate	Low
Mid-Valley Region						
Church						
	Church	NF	High	8	28	30
Rucker Skillet						
	Rucker	NF	Mod-High	--	4	33
	Skillet	NF-MF	High	8	28	17
Panther						
	Panther	PF-MF	Mod-High	31	20	18
	South Panther	NF-MF	Mod-High	--	11	10
West Branch Llagas Creek						
	West Branch Llagas	NF	High-Very High	--	15	18
	Day Creek	NF	High	--	6	--
	Lions	NF-MF	High	10	18	8
	North Morey Channel	NF-MF	High	8	31	--
	South Morey Channel	NF-MF	High	--	4	--
	Upper Miller Slough	NF-MF	Mod-High	--	6	41
Live Oak						
	Live Oak	MF	High	31	13	17
Lower Uvas Creek						
	Solis	PF	Low-Mod	100	--	--
	Sycamore	PF-MF	High	45	28	17
	Burchell	NF-MF	Low-Mod	4	33	22
	Uvas	PF-MF	Low-Mod	100	--	--
South Valley Region						
Jones						
	Alamias	MF	High	56	24	3
	Crews	NF-MF	Mod-High	14	14	17
	Dexter	NF-MF	Very High-Extreme	--	--	--
	Jones	NF-MF	Very High-Extreme	1	8	25
San Ysidro						
	San Ysidro	NF-MF	Mod-High	38	31	7
Pajaro						
	Pajaro River	NF	High-Very High	1	8	7
	Millers Canal	NF	High-Very High	--	2	40
Lower Llagas Creek						
	Princevalle Drain	NF	High	--	--	77
	Lower Miller Slough	NF	Mod-High	--	--	65
	Llagas	NF	Mod-High	25	3	32
Uvas Carnaderos						
	Uvas	PF-MF	Mod-High	39	34	26
	Tick	NF	Mod-High	34	12	21
	Farman	MF	Low-Mod	50	18	3
	Gavilan	NF	High-Very High	21	5	26
	Babbs	NF-MF	High-Very High	54	28	7

compares measurement of bank characteristics to a relative risk of erosion. An aerial photo was employed to supplement the PFC and BEHI, providing a visual assessment of vegetation density along stream channels.

A summary of the assessment results is provided below for the Upper West, North Valley, Mid-Valley, and South Valley regions in the study area.

Upper West Region. The Upper West Region includes the Blackhawk, Bodfish, Chesbro Reservoir, Little Arthur, and Upper Llagas Creek sub-areas. Creeks in these sub-areas are generally well-vegetated and considered index or functioning reaches, with no or little human disturbance. Systems in this region appeared at risk of erosion where human or animal access to the creek channel was permitted, and where road or urban runoff flowed over creek banks into the channel.

North Valley Region. The North Valley Region includes the Little Llagas, Madrone Channel, Tennant, Corralitos, Middle Llagas, and San Martin Creek sub-areas. This region includes the area east and west of Morgan Hill into the Santa Cruz and Diablo Mountain Ranges. Channels in the region have been impacted by urban development encroaching into the riparian zone along with large-scale channel modifications. Erosion was observed where vegetation has been removed from the channel, banks, and floodplain, and where channel incision is occurring as a result of hydromodifications associated with increased runoff from urban areas. On the eastern portion of the region, erosion was observed where road ditches enter the channel, or where stream courses have been redirected to road ditches. Erosion was also observed where human or animal access to the creek channel was permitted.

Mid-Valley Region. The Mid-Valley Region includes the Church, Rucker Skillet, Panther, West Branch Llagas, Live Oak, and Lower Uvas Creek sub-areas. This region includes the area east and west of San Martin into the Santa Cruz and Diablo Mountain Ranges, to the northern portion of the City of Gilroy. Streams in the region range from properly functioning channels with a low to moderate bank erosion risk to non-functioning channels with high to very high bank erosion risk. Impacts to streams on the west side of the region are generally related to rural residential developments, whereas impacts to streams on the east side of the region are generally related to urban development and large scale channel modification and flood control projects. Erosion was observed as a result of vegetation removal, altered flow regimes, and channel modification.

South Valley Region. The South Valley Region includes the Jones, San Ysidro, Pajaro, Lower Llagas Creek, and Uvas Carnadeross sub-areas. This region includes the area east and west of Gilroy into the Santa Cruz and Diablo Mountain Ranges, to the boundary between Santa Clara and San Benito Counties. Increased runoff from the City of Gilroy, associated with increased urban development, moves south through the region within the Lower Llagas Creek sub-area. Erosion was observed in these channels as a result of channel hydromodification, specifically related to increased runoff volumes. Agricultural lands that encroach into the riparian zone along with associated channel modification have impacted channels in the region. Erosion was observed where vegetation has been removed from the channel, banks, and floodplain. Observations of erosion related to agricultural development in the region included bank failure and channel incision, specifically where vegetation was removed from the channel or the channel alignment was modified.

Observed in-channel sources of sediment, as described in the detailed channel descriptions can be divided into five categories: hydromodification, channel incision, bank failure, road ditches, vegetation, land use encroachment, and access. The relative impact of these in-stream sediment sources by study sub-area is summarized in Table 4.3.

Hydromodification. Hydromodification is a change in runoff characteristic caused by a change in land use conditions. Channel hydromodifications were observed as changes in flow regimes caused by increased impervious surface areas and reservoir releases. Hydromodifications were also observed in channel realignments, levee development, and changes in channel geometry that alters stream flow characteristics. In general, hydromodifications may decrease sinuosity, thereby increasing channel slope and stream flow velocity and in most instances result in oversteepened, unstable banks with scour at instream structures.

Channel Incision. Channel incision is a form of erosion whereby the elevation of the channel bed decreases. Channel incision was observed throughout the study area in non-functioning and moderately functioning reaches. Observations of channel incision were generally linked to reaches with a low to moderate vegetation density and areas with adjacent hydromodification, specifically increased flow volumes.

Bank Failure. Bank failure is a form of mass wasting where bank materials slump or erode into channel. Bank failure was observed throughout the study area in non-functioning and moderately functioning reaches. Bank failure was generally linked to reaches with a low vegetation density, lcoations where overland flow enters the channel, and where channel incision or land use has created over-steepened banks susceptible to failure.

Road Ditches. Erosion associated with road ditches was observed throughout the study area, but principally in the eastern portion of the study area. Where unlined road ditches enter creek channels erosion and bank failure were typically observed. Road ditches were generally devoid of vegetation and are potential sources of sediment.

Vegetation. A decreased vegetation density was generally linked to the susceptibility of a channel to erode. The roots of vegetation cohesively bind soils on the banks and floodplains of creek channels. Vegetation also increases the 'roughness' of a channel, effectively slowing water and therefore reducing its erosive potential. Vegetation density was most intact in the upper reaches of sub-areas, were human impact and access was limited, with decreasing density in urban areas and adjacent to agricultural land use.

Land Use Encroachment. Land use adjacent to creeks physically limits the extent of the riparian corridor and the potential for creek access to the floodplain.

Access. Erosion was observed in channels throughout the study area where animal or human access to the channel was permitted. As a result, where access is possible, the channel or banks are devoid of vegetation and soils were disturbed.

Summary of Conclusions

1. Streams and channels in the valley portion of the study area are in varying states of disequilibrium leading to accelerated bank loss, channel incision, and sedimentation. In-stream sediment sources may be a significant contribution to sediment load estimates in the study area, due to the poor functional state and high bank erosion potential of ephemeral channels and portions of Llagas and Uvas Creeks.

2. Within the Upper West Basin Region, in-stream sediment sources are primarily linked to vegetation removal, land use encroachment, and access. Channels in the region are generally considered index or functioning reaches, with no or little human disturbance.

3. Channels in the North Valley Region have been impacted by channel hydromodifications and land use encroachment related to urban and rural residential developments.

4. The Mid-Valley Region has been impacted by channel hydromodifications and land use encroachment related to a combination of urban, rural residential developments, and agriculture.
5. The South Valley Region has been impacted by channel hydromodifications and land use encroachment primarily related to agriculture.

4.7. Stream Assessment

Upper West Region

4.7.1. Blackhawk Sub-Area

The Blackhawk sub-area includes the upper portions of Bodfish Creek and its smaller tributaries. The channel is generally very well vegetated and in a properly functioning condition.

4.7.1.1. *Bodfish*

Channel Location and Description. Bodfish Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Bodfish Creek flows in an easterly direction, along Highway 152, until its confluence with Uvas Creek north of Highway 152 and south of Burchell Road. Observations of Bodfish Creek were limited to public access points along Whitehurst Road and views from the aerial photography.

The upper watershed of Bodfish Creek is well vegetated in a mountainous canyon setting. Highway 152 parallels the sinuous stream channel into the foothills of the Santa Cruz Mountains. Approximately 15,820 feet upstream of the confluence of Bodfish Creek with Uvas Creek, the channel enters a valley, likely formed by the evolution of Bodfish Creek. As the creek enters the valley, Bodfish Creek is south of Highway 152 and agricultural and residential development on the floodplain begins. Coincident with development on the floodplain, the extent of riparian vegetation on the channel floodplain diminishes, though the banks and channel vegetation density remains high. Approximately 2,500 feet east of this transition point Bodfish Creek crosses Whitehurst Road, and enters the Bodfish sub-area.

4.7.2. Bodfish Sub-Area

The Bodfish sub-area includes Bodfish Creek and its smaller tributaries. Bodfish Creek is generally well vegetated throughout much of the sub-area. The density and extent of riparian vegetation decreases as the channel progresses east into the valley. Erosion on Bodfish Creek was observed at access points and where vegetation had been removed from the channel, and banks were eroding.

4.7.2.1. *Bodfish*

Channel Location and Description. Bodfish Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Bodfish Creek flows in an easterly direction, along Highway 152, until its confluence with Uvas Creek north of Highway 152 and south of Burchell Road. Observations of Bodfish Creek were limited to public access points along Highway 152, Rancho Vista Drive, Bodfish Ranch, and Whitehurst Road.

At Whitehurst Road the channel was well vegetated and the channel geometry consisted of a bankfull channel with access to the channel floodplain. At the time of the survey, adjacent properties did not appear to be encroaching on the creek channel. Surface cover was disturbed at access points adjacent to the creek crossing at Whitehurst Road. A United States Geological Survey (USGS) gaging station is also located on Bodfish Creek, downstream of Whitehurst Road.

The vegetation density on Bodfish Creek decreases as the stream progresses east into the valley. At Bodfish Ranch Road, approximately 11,880 feet downstream of Whitehurst Road, the vegetation density is moderate to high. Algal mats were observed in the pools of standing water upstream and downstream of Bodfish Ranch Road. The sinuosity of the channel remained intact and floodplain development was not encroaching onto the creek channel.

Approximately 1,370 feet downstream of Bodfish Ranch Road, Bodfish Creek parallels Rancho Vista Road, south of Highway 152. Along Rancho Vista Road the vegetation density is moderate to low and rock and concrete rubble was observed on channel banks. Yard waste was also dumped onto channel banks. At Rancho Vista Road the road, adjacent residencies, and agricultural land were encroaching onto the channel and floodplain. Stream encroachment was also observed up and downstream of Highway 152.

Observations of Erosion and Sedimentation. Erosion on Bodfish Creek was observed at access points adjacent to roads and where channel banks with poor surface cover had eroded or slumped into the channel. The channel bed generally consisted of fine to cobble material.

Point bar development was observed downstream of Whitehurst Road as well as sediment deposition on the inside turn of a channel bend.

Observations of Riparian Vegetation. Observed vegetation types on Bodfish Creek included oak, willow, bramble, fern, african violet, grasses, thistle, poppy. Overall the vegetation distribution on Bodfish Creek (approx. 34,000 feet) is good, with approximately 8% of the channel characterized as low vegetation density, 14% characterized as moderate vegetation density, and 71% characterized as high vegetation density.

Based upon qualitative indices, Bodfish Creek can generally be characterized as properly functioning to moderately functioning (PFC), with a moderate risk of erosion (BEHI).

4.7.3. <u>Chesbro Reservoir Sub-Area</u>

The Chesbro Reservoir sub-area includes Llagas Creek and its smaller tributaries. Llagas Creek in the Chesbro Reservoir sub-area has been impacted by adjacent rangelands and associated animal access to the creek channel.

4.7.3.1. *Llagas Creek*

Channel Location and Description. Llagas Creek in the Chesbro Reservoir sub-area originates at the base of the Upper Llagas Creek sub-area, at Casa Loma Road. Llagas Creek at this location flows in a southeasterly direction, until it drains into Chesbro Reservoir approximately 1,200 feet south of Oak Glen Road. Observations of Llagas Creek in the Chesbro Reservoir sub-area were limited to public access points on Oak Glen Road , Uvas Road and along Oak Glen Road.

In the Chesbro Reservoir sub-area Llagas Creek appears well vegetated and the majority of the land use adjacent to the channel is residential or range land. Animals appear to have unlimited access to a majority of the creek channel in rangelands. At animal access points, the channel banks were devoid of vegetation. Bank erosion was also observed where the density of bank vegetation decreased and channel migration appeared to be eroding the outside bank of a river bend.

Figure 4.7. Animal access location observed upstream of Oak Glen Road on Llagas Creek.

Observations of Erosion and Sedimentation. Erosion on Llagas Creek in the Chesbro Reservoir sub-area was observed at locations where animals access the channel and where the density of bank vegetation was low. The channel bed generally appeared armored with gravel and cobble material with a sand to cobble substrate.

Sedimentation was observed as point bar development and in finer sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Llagas Creek in the Chesbro Reservoir sub-area included grasses, oak, willow, bramble, redwood, and ivy. Overall the vegetation cover on Llagas Creek (approx. 10,025 feet) is very good, with approximately 6% of the channel characterized as moderate vegetation density, 88% characterized with a high vegetation density.

Based upon qualitative indices, Llagas Creek can generally be characterized as properly functioning to moderately functioning (PFC), with a moderate risk of erosion (BEHI).

4.7.4. Little Arthur Sub-Area

The Little Arthur sub-area includes Little Arthur Creek and its smaller tributaries. Little Arthur Creek is a properly functioning system with limited disturbances observed adjacent to residential developments and access points

4.7.4.1. *Little Arthur*

Channel Location and Description. Little Arthur Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Little Arthur Creek flows in an easterly direction, until its confluence with Uvas Creek west of Watsonville Road and north of Redwood Retreat Road. Observations of Little Arthur Creek were taken from three points on Redwood Retreat Road.

The floodplain along Little Arthur Creek is primarily used for agriculture with a recent conversion of some properties from rangeland to vineyards. The first location on Redwood Retreat Road is approximately 1,200 feet west of the intersection of Watsonville Road and Redwood Retreat Road. At this location the riparian vegetation adjacent to the channel is in very good condition with SRA intact. Surface cover was disturbed at access points adjacent to the road and where herbicide was used on bank and floodplain vegetation. A USGS gaging station is installed but inoperable, at this first location on Redwood Retreat Road.

The second location on Redwood Retreat Road, approximately 12,635 feet west of Watsonville Road, also has very good vegetation density with SRA intact. The channel has developed pool-riffle sequences, and the only surface cover disturbance was observed at channel access locations.

The third location on Redwood Retreat Road, approximately 13,510 feet west of Watsonville Road, also has very good vegetation density, with established channel and bank vegetation, and intact SRA. The channel has developed pool-riffle sequences, and the only surface cover disturbance was observed along the bridge wingwalls where some erosion was observed.

Figure 4.8. A view of Little Arthur Creek taken from the third observation point on Redwood Retreat Road.

Observations of Erosion and Sedimentation. The visual assessment of Little Arthur Creek showed little signs of excessive erosion or sedimentation occurring in the creek system. Erosion on Little Arthur Creek was observed adjacent to a bridge on Redwood Retreat Road where exposed and loose soil was observed. The channel bed generally appeared armored with coarse gravels and cobbles with substrate materials consisting of fine to cobble material.

Sedimentation was observed as point bar development and in finer sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Little Arthur Creek included oak, willow, grass, poison oak, african violet, maple, and eucalyptus. Overall the vegetation distribution on Little Arthur Creek (approx. 9,625 feet) is excellent, with approximately 100% of the channel characterized as high vegetation density.

Based upon qualitative indices, Little Arthur Creek can generally be characterized as properly functioning (PFC), with a moderate risk of erosion (BEHI).

4.7.5. Upper Llagas Creek Sub-Area

The Upper Llagas Creek sub-area includes Llagas Creek and its smaller tributaries. The observations of Llagas Creek in the Upper Llagas Creek sub-area are observations from the uppermost portions of the Llagas Creek watershed. The system is properly functioning, though impacts to the channel were observed where adjacent land use encroached upon the channel corridor.

4.7.5.1. *Llagas Creek*

Channel Location and Description. Llagas Creek in the Upper Llagas Creek sub-area originates in the Santa Cruz Mountains in Santa Clara County. Llagas Creek in the Upper Llagas Creek sub-area flows in a northeasterly direction. Observations of Llagas Creek in the Upper Llagas Creek sub-area were limited to public access points along Casa Loma Road.

The upper watershed of Llagas Creek along Casa Loma Road is very well vegetated in a coastal redwood canyon. Animal grazing was observed along much of the riparian corridor and floodplain in the lower portions of the sub-area. The creek also appeared to have some localized incision, likely induced from the proximity to the road and the steep landscape position. An in-stream road crossing was observed in one location, with riprap positioned downstream of the crossing. Clearing of bank vegetation was also observed adjacent to one residential property.

Figure 4.9. In-stream road crossing with animal grazing in the background, on Upper Llagas Creek.

At one location a landslide in the channel was observed. It appeared to have removed three (3) to four (4) large trees and deposited a large amount of soil into the creek channel.

Figure 4.10. Landslide adjacent to Llagas Creek and Casa Loma Road in the Upper Llagas Creek Sub-Area.

Observations of Erosion and Sedimentation. Erosion was observed as localized incision and bank failure between Casa Loma Road and the Llagas Creek channel. Erosion was also observed at animal access points along the creek. The channel bed generally appeared armored with gravel and cobble material with a sand to cobble substrate.

Sedimentation was observed downslope of a landslide in the Llagas Creek channel.

Observations of Riparian Vegetation. Observed vegetation types on Llagas Creek in the Upper Llagas Creek sub-area included grasses, oak, willow, bramble, redwood, and ivy. Overall the vegetation cover on Paradise Creek (approx. 20,100 feet) is excellent, with approximately 100% of the channel characterized with a high vegetation density.

Based upon qualitative indices, Llagas Creek can generally be characterized as proper functioning (PFC), with a very low to low risk of erosion (BEHI).

North Valley Region

4.7.6. Little Llagas Sub-Area

The Little Llagas sub-area includes West Little Llagas Creek, East Little Llagas Creek, Dewitt Creek, and Edmundson Creek. East and West Little Llagas Creek are the same drainage system, with West Little Llagas Creek becoming East Little Llagas Creek east of the Southern Pacific Railroad. The system has been impacted by urban development in the upper watershed and modifications to the stream channel in the valley. Edmundson Creek is also one example of a creek in an urban environment where community access was integrated into the stream management plan.

4.7.6.1. *West Little Llagas Creek*

Channel Location and Description. West Little Llagas Creek originates in the foothills of the Santa Cruz Mountains in Santa Clara County. West Little Llagas Creek flows in a southeasterly direction, until crosses it crosses the Southern Pacific Railroad Tracks and becomes East Little Llagas Creek. East Little Llagas Creek continues in a southeasterly direction until its confluence with Llagas Creek approximately 2,000 feet north of Masten Avenue and 1,350 feet east of Highway 101. The SCVWD jurisdiction of West Little Llagas Creek is approximately 2,000 feet upstream of Llagas Road. Observations of West Little Llagas Creek were limited to public access points on Llagas Road, Hale Avenue, West Main Street, Del Monte Avenue, West Dunne, Cosmo Avenue, Edmundson Avenue, Vineyard Avenue, La Crosse Drive, and Watsonville Road.

West Little Llagas Creek begins in the foothills of the Santa Cruz Mountains in the City of Morgan Hill. The area adjacent to the creek has recently converted into residential developments and the creek drainage and runoff patterns have changed as a result of the urbanization. For example the channel flow has increased as a result of the impervious surfaces and in anticipation of these increases sections of the channel have been modified, widened, or maintained to accommodate the increased flows. The observed channel modification and maintenance, upstream of Llagas Road, included channel shaping and the regular cutting of in-channel vegetation.

South of Llagas Road, West Little Llagas Creek parallels Hale Avenue. At one observation point the channel was unleveed and appeared to have access to the floodplain, though at the time of the survey this section of the channel was adjacent to multiple residential developments in construction that could impact the design of the channel. In-channel vegetation was observed though the extent of mature riparian vegetation was limited, and herbicide maintained channel banks were noted at one location. The banks where herbicide had been applied were loose and exposed and a potential sediment source.

As the channel continues south, straight and parallel to Hale Avenue, the channel functions as a road ditch. There is intermittent vegetation, concrete and trash debris in the channel, and exposed soils at access points and where vegetation cover is absent. Approximately 300 feet south of West Main Avenue West Little Llagas Creek makes a 90-degree bend east, towards downtown Morgan Hill. The channel south of West Main Avenue has mature vegetation scattered on the channel banks and grass and cattails in the channel bottom. Residential developments and fences encroach upon the channel and channel banks and at some locations their proximity appeared to be the cause of loose and bare channel bank soils.

As the channel continues south it parallels Monterey Highway and the city center of Morgan Hill. The channel passes behind or under many of the shops and buildings facing towards Monterey Highway. Where the channel surfaces the vegetation density is moderate and the channel bank soils adjacent to road or parking lot culverts showed signs of erosion. The channel infrastructure in the City of Morgan Hill is undersized for the increased runoff the channel is receiving from adjacent and upstream development.

Beginning near Spring Avenue and continuing south towards Watsonville Road the channel enters a wide corridor is actively managed by the SCVWD. The channel has been modified in some locations, but at the time of the survey it was understood that channel redevelopment was planned for this stretch of West Little Llagas Creek. As it exists now the creek is channelized with a low vegetation density.

At Edmundson Avenue West Little Llagas Creek transitions into a larger modified channel with a similar engineered channel profile as observed in the West Branch Llagas sub-area. This channel shape includes a low flow channel with adjacent access roads, and south of Edmundson Avenue a foot and bike path exists on the right bank of West Little Llagas Creek. The channel is mostly grassed with some cattails in the channel and intermittent mature woody vegetation on the channel banks. Approximately 350 southeast of Vineyard Avenue is the confluence of Edmundson Creek with West Little Llagas Creek. At the confluence both Edmundson Creek and West Little Llagas Creek are concrete lined, and some grass and sediment accumulation was observed at the bottom of the concrete channel.

South of LaCrosse Drive approximately 1000 feet West Little Llagas Creek makes a 90-degree bend east, leaving the engineered channel that continues another 800 feet to Watsonville Road. This continuation of the engineered channel and a bridge on Watsonville Road are to be used in the future modification of West Little Llagas Creek. Where the creek turns away from the engineered channel it is channelized around a residential development and fallow agricultural fields until crossing Watsonville Road, approximately 180 feet west of Monterey Highway. In this stretch of creek the channel narrows and deepens and is primarily grassed with no upper canopy vegetation. At Watsonville Road, the creek channel is narrow and showed evidence of channel incision and erosion downstream of the road culvert. In discussions with stakeholders it was learned that this location is also known as an area of regular flooding.

Figure 4.11. Bank erosion and scour pool development south of Watsonville Road on West Little Llagas Creek.

West Little Llagas Creek continues east under Monterey Highway through row crop fields and a trailer park and then under the Southern Pacific Railroad tracks. The channel in this stretch has a low vegetation density and has some sinuosity. Adjacent to agricultural fields, west of the railroad, portions of the channel appear to have been buried. East of the railroad, West Little Llagas Creek becomes East Little Llagas Creek.

Observations of Erosion and Sedimentation. Erosion on West Little Llagas Creek was observed where vegetation had been cleared as a result of adjacent land use, road or residential. Erosion was also observed as channel incision, between one (1) and two (2) feet, with associated bank failure and bank steepening. Bank scour was also observed downstream of road crossings and culverts. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed in finer sediments deposited amongst in-channel vegetation and in finer sediments deposited in channel pools. Accumulations of sediments were also observed downstream or downslope of bank failures, where sediments slumped into the channel. Soils in these areas are likely to re-suspend during high flow events.

Observations of Riparian Vegetation. Observed vegetation types on West Little Llagas Creek included grasses, sedge, cattail, oak, willow, bramble, and ivy. Overall the vegetation cover on West Little Llagas Creek (approx. 6,175 feet) is moderate, with approximately 25% of the channel characterized as low vegetation density, 9% characterized as moderate vegetation density, and 11% characterized as high vegetation density. Approximately 55% of the West Little Llagas Creek channel was devoid of vegetation.

Based upon qualitative indices, West Little Llagas Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a moderate risk of erosion (BEHI).

4.7.6.2. *East Little Llagas Creek*

Channel Location and Description. East Little Llagas Creek originates on the eastern side of the Southern Pacific Railroad Tracks, east of Monterey Highway, at the terminus of West Little Llagas Creek. The SCVWD Jurisdiction of East Little Llagas Creek begins on the eastern side of the Southern Pacific Railroad Tracks, east of Monterey Highway, at the terminus of West Little Llagas Creek. Observations of East Little Llagas Creek were limited to public access points on Seymour Avenue, Llagas Avenue, East Middle Avenue, Sycamore Avenue, San Martin Avenue, and Church Avenue.

East of the Southern Pacific Railroad Track the East Little Llagas Creek channel meanders through agricultural fields and a trailer park community. In discussions with stakeholders it was learned that this location is also known as an area of regular flooding. The channel in this reach has a low vegetation density and concrete debris has been placed on channel banks for armoring in some locations. Levees have also been built up to prevent flooding into fields. West of Llagas Avenue, East Little Llagas Creek passes through a residential property with equestrian facilities. The creek channel bisects a number of pastures and the animals are not prevented from accessing the channel. The channel has a very low profile and vegetation density and diversity. In some locations in this reach the channel banks are bare and incised approximately one (1) foot, potential sediment sources.

Figure 4.12. East Little Llagas Creek in pastures west of Llagas Avenue.

East of Llagas Avenue, East Little Llagas Creek crosses Highway 101 and turns abruptly south, parallel to the highway, joining Madrone Channel. East of Highway 101 the channel and banks are covered with large riprap to armor the channel approximately 75 feet upstream and downstream of the culvert outlet. As the creek continues south, the channel is vegetated with cattatils, sedges, and grasses, and the banks with grasses. The channel is modified with shaped and straight channel and the vegetation appears to be regularly maintained. This general channel shape and description of the creek continues until the confluence with Corralitos Creek.

East Little Llagas Creek parallels Highway 101 for approximately 4,750 feet before making a 90-degree bend east approximately 2,550 feet north of San Martin Avenue. The channel is covered with large riprap at the bend, and approximately 930 feet east is the confluence with Corralitos Creek. The channel and banks in this section are armored with large riprap. Where the riprap ends, approximately 160 feet downstream of the confluence, the channel has scoured banks and signs of channel incision. Downstream of this location other vertical and bare banks were observed along with a sinuous low flow channel at the bottom of the larger engineered channel. This general channel shape and description of the creek continues until the confluence with Church Creek.

Figure 4.13. Bank and channel erosion on East Little Llagas Creek downstream of the confluence with Corralitos Creek.

At the confluence with Church Creek, approximately 9,250 feet south of Church Avenue, the channel bank opposite Church Avenue is vertical and bare. It appears this bank, in an approximately 40 feet long stretch, has eroded approximately six (6) to twelve (12) inches into an adjacent access road and agricultural field. Approximately 350 feet downstream of Church Creek is the confluence of East Little Llagas Creek with Llagas Creek.

Observations of Erosion and Sedimentation. Erosion on East Little Llagas Creek was observed where animals access the channel, concentrated flows enter the channel, and at the transition between 'hard' and 'soft' landscapes. Where concentrated flows enter the channel, specifically at the confluence with Church Creek, the channel banks were bare and vertical, a change in channel geometry likely associated with the increased flows at this location. At the confluence with Corralitos Creek erosion was also observed as headcut migration, channel incision and bank erosion. This erosion was possibly associated with an elevation change caused by in-stream riprap additions. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed in finer sediments deposited amongst in-channel vegetation, as point bar development and in finer sediments deposited in channel pools. Accumulations of sediments were also observed downstream or downslope of bank failures, where sediments slumped into the channel. Soils in these areas are likely to re-suspend during high flow events.

Observations of Riparian Vegetation. Observed vegetation types on East Little Llagas Creek included grasses, cattail, oak, thistle and sedge. Overall the vegetation cover on East Little Llagas Creek (approx. 22,525 feet) is low, with approximately 1% of the channel characterized as moderate vegetation density. Approximately 99% of the East Little Llagas Creek channel was devoid of vegetation.

Based upon qualitative indices, East Little Llagas Creek can generally be characterized as non-functioning (PFC), with a high to very high risk of erosion (BEHI).

4.7.6.3. *Dewitt Creek*

Channel Location and Description. Dewitt Creek originates in the foothills of the Santa Cruz Mountains in Santa Clara County. Dewitt Creek flows in an easterly direction, until its confluence with West Little Llagas Creek approximately 670 feet north of Spring Avenue and 400 feet west of Monterey Highway. The SCVWD jurisdiction of Dewitt Creek is approximately 2,200 feet west of the confluence of Dewitt Creek with East Little Llagas Creek. The survey team was unable to locate any locations for public observation on Dewitt Creek.

4.7.6.4. *Edmundson Creek*

Channel Location and Description. Edmundson Creek originates in the foothills of the Santa Cruz Mountains in Santa Clara County. Edmundson Creek flows in an easterly direction, until its confluence with West Little Llagas Creek approximately 145 feet west of La Crosse Drive. The SCVWD jurisdiction of Edmundson Creek begins approximately 760 feet south of Edmundson Avenue and approximately 325 feet east of Sunnyside Avenue. Observations of Edmundson Creek were limited to public access points on Edmundson Avenue along La Crosse Drive.

The upper watershed of Edmundson Creek is agricultural and rangeland in the process of converting to large residential developments. The creek channel has a low vegetation density, likely a result of previous land use. At Edmundson Road, there are signs of channel incision where vegetation was sparse the banks appeared vulnerable to erosion. Downstream of Edmundson Road approximately 1,200 feet Edmundson Creek enters a modified engineered channel as the creek enters an urban residential neighborhood. This channel continues east, across La Crosse Drive to the confluence with West Little Llagas Creek. The channel is mostly grassed with large woody vegetation on the banks of the wider modified channel. The vegetation on the creek channel appears to be maintained regularly. The center of the channel has a sinuous low flow channel and the banks have a foot and bike path accessible to the adjacent neighborhoods. At the confluence with West Little Llagas Creek the channel is lined with concrete approximately 200 feet upstream of the confluence.

Figure 4.14. Confluence of Edmundson Creek with West Little Llagas Creek.

Observations of Erosion and Sedimentation. Erosion on Edmundson Creek was observed as channel incision and bank failure where flows were channelized and bank vegetation was poor. The channel bed generally consisted of fine to gravel material.

No observations of sedimentation were recorded.

Observations of Riparian Vegetation. Observed vegetation types on Edmundson Creek included grasses, oak, and cottonwood. Overall the vegetation cover on Edmundson Creek (approx. 9,090 feet) is good, with approximately 32% of the channel characterized as low vegetation density, 11% characterized as moderate vegetation density, 18% well vegetated.

Based upon qualitative indices, Edmundson Creek can generally be characterized as moderately functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.7. Madrone Sub-Area

The Madrone sub-area includes Madrone Channel and its smaller tributaries. Madrone Channel is an engineered system designed to optimize the percolation of water received from the San Luis Pipeline. The channel has a low vegetation density and observations of erosion in the channel were limited.

4.7.7.1. *Madrone Channel*

Channel Location and Description. Madrone Channel originates southeast of Cochrane Avenue at Highway 101. Madrone Channel flows south, until its confluence with East Little Llagas Creek approximately 665 north of East Middle Avenue. The SCVWD jurisdiction of Madrone Channel begins southeast of Cochrane Avenue at Highway 101. Observations of Madrone Channel were limited to views along Highway 101 and views from the aerial photography.

Madrone Channel is an engineered percolation channel managed by the SCVWD. Theoretically the flow of percolation waters from the San Luis Pipeline are managed to limit outfalls into the Llagas Creek system. The water and channel are managed as part of a water reclamation program managed by the SCVWD. Channel vegetation includes grasses, sedges and cattails and channel banks are grassed and appear to be regularly maintained. The amount of water in the Madrone Channel decreases as the channel continues south and water infiltrates into the valley groundwater system. The engineered channel collects water from road ditches to the east of Madrone Channel and Highway 101, as well as collecting water directly from parking lots and hotels adjacent to the highway. These outfalls are usually rocklined and no observations of erosion were recorded.

Observations of Erosion and Sedimentation. No observations of erosion were made on Madrone Channel.

No observations of sedimentation were recorded on Madrone Channel.

Observations of Riparian Vegetation. Observed vegetation types on Madrone Channel included grasses, sedge, and cattail. Overall the vegetation cover on Madrone Channel (approx. 22,290 feet) is low, with approximately 24% of the channel characterized as low vegetation density. Approximately 76% of the Madrone Channel was devoid of vegetation.

Based upon qualitative indices, Madrone Channel can generally be characterized as non-functioning to moderately functioning (PFC), with a moderate risk of erosion (BEHI).

4.7.8. Tennant Creek Sub-Area

The Tennant sub-area includes Tennant Creek and a tributary, Foothill Creek. Tennant and Foothill Creeks have been affected by past and recent channel modifications, agricultural and residential encroachment, and higher flows due to increases in impervious surface runoff. The riparian corridor and vegetation along Tennant Creek has been substantially altered and established vegetation covers only 14% of the stream channel. Modifications have been made to the channel, such as channelization and levee development, and the channel is experiencing localized incision and bank failure. These features combined with increased flow volumes have forced the system into a state of disequilibrium. The observed reaches of Foothill Creek show the results of stream channelization, evidence of incision in the creek channels, and decreased vegetation density in the downstream portions of the sub-area.

4.7.8.1. *Tennant Creek*

Channel Location and Description. Tennant Creek originates from a number of ephemeral streams in the Diablo Mountain Range that have been rerouted into a series of road ditches. Observations of Tennant Creek were limited to access points along Hill Road, East Dunne Avenue, Barrett Avenue, Tennant Avenue, and Maple Avenue.

The Tennant Creek road ditch is approximately 7,200 feet long and is mostly bare or covered with grass and gravel, and a few are cobble lined. Where vegetation is present it consists mostly of non-native grasses with no height diversity. The road ditch is channelized parallel to Hill Road until East Dunne Avenue, where the creek transitions into a wider channel adjacent to a residential development. It appears that this portion of Tennant Creek was modified, and its flood flow capacity increased to accommodate the adjacent residential development. At the channel transition between the road ditch and the modified channel a one to two foot high knick-point is moving upstream towards East Dunne Avenue. It appears the knick-point has developed as a result of the difference in channel elevations between the road ditch and the modified channel. The transition into the wider channel has also created an area of aggradation where the channel broadens. The broad channel causes flow velocities to decrease, initiating the deposition of sediments out of the water column. Downstream of the residential development the modified channel ends and transitions again into a smaller channel, with an approximate low flow channel width of four feet.

The smaller channel, which begins approximately 1,330 feet southeast of East Dunne Road, continues parallel to Hill Road and around various property boundaries. The land to the east of Tennant Creek in this stretch between East Dunne Avenue down to Maple Avenue is primarily agricultural. Where levees have not been built up adjacent to the creek the channel has access to the floodplain, and where the channel has not been previously channelized around property bounders, it is slightly sinuous.

Between East Dunne and Maple Avenues Tennant Creek crosses Barrett Avenue, Tennant Avenue, and Hill Road. The most notable of these access points is Barrett Avenue. During high flows at Barrett Avenue it was observed that water from Tennant Creek backed up and over Barrett Avenue. The cause of the back up could be restrictions downstream of the Barrett Avenue culvert in combination with increased flow volumes originating from a residential development to the east of the Tennant Creek channel on Barrett Avenue. The confluence of Tennant Creek with Foothill Creek is east of the intersection of Fisher Avenue and Hill Road.

Figure 4.15. Tennant Creek upstream of Barrett Avenue.

Observations of Erosion and Sedimentation. The Tennant Creek channel shows evidence of some mild incision (1-2 feet) and localized bank failure, particularly adjacent to road crossings and at knick-points developed from channel transitions. Evidence of erosion was also observed along the bare portions of the Tennant Creek road ditch and adjacent to agricultural fields and access roads that encroach on the channel. The channel bed generally appeared armored with coarse gravels with substrate materials consisting of fine to cobble material.

There were limited observations of sedimentation presumably because increased flow volumes also increased the sediment carrying capacity of the creek. The most substantial increases in flow volumes appear to originate from developments at the intersection of East Dunne Avenue and Hill Road and from the development at Barrett Avenue. At the modified channel at East Dunne Road, sedimentation was observed amongst in-channel vegetation. The sedimentation likely occurred because the wider channel and the vegetation slowed flows, decreased energy levels, and decreased the carrying capacity of the water, allowing suspended sediments to drop out of the water column.

Observations of Riparian Vegetation. Riparian vegetation along Tennant Creek primarily consists of non-native grasses and in-channel sedges, with instances of oak and bramble. The overall vegetation distribution along the entire length of Tennant Creek, (approx. 17,900 feet) was minimal, with approximately 11% of the channel being characterized with a low vegetation density and approximately 3% of the channel characterized with a moderate vegetation density. Approximately 86% of the Tennant Creek channel was devoid of vegetation.

Tennant Creek can generally be characterized as non-to moderately functioning (PFC), with a moderate to high risk of bank erosion (BEHI).

4.7.8.2. *Foothill Creek*

Channel Location and Description. Foothill Creek originates from an ephemeral stream in the Diablo Mountain Range. Observations of Foothill Creek were limited to access points on Foothill Road and Hill Road. It is useful to describe Foothill Creek in terms of three general reaches. The first reach is the uppermost watershed in the foothills of the Diablo Mountain Range. The second reach is between the beginning of the valley at the base of the Diablo Mountain range foothillls and Foothill Road. The third reach is between Foothill Road and the confluence of Foothill and Tennant Creeks, just north of Hill Road.

The first reach of Foothill Creek is relatively undisturbed and well vegetated. In the second reach, row crop fields are on both sides of the channel, but it appears from the aerial photograph that the vegetation density remains high. Closer to Foothill Road the creek channel has been channelized between property boundaries. In this reach the channel has been straightened adjacent to a nursery and row crop fields. The channel in this reach is sparsely vegetated and there is evidence of bank failure adjacent to the greenhouse. During the wet season, in the fields to the north of the creek channel, there is evidence of a channel that develops in the fields. It appears that this channel was possibly the original creek channel, prior to the creation of the existing channelized channel. What is assumed to be the original channel is bare of vegetation and sinuous. The straightened portion of Foothill Creek is approximately 2,160 feet long and is mostly covered with grass and thistle with some mature vegetation remaining along the channel.

Figure 4.16. Foothill Creek adjacent to a nursery west of Foothill Road.

Observations of Erosion and Sedimentation. Upstream and downstream of Foothill Road, the channel shows approximately six inches to one foot of channel incision. The reach of Foothill Creek downstream of Foothill Road (described as reach three) shows signs of bank failure, likely associated with stream access or crossing locations. Channelization of the creek, immediately upstream and downstream of Foothill Road, does not dissipate energy from high flows, which increases the possibility for channel erosion. The channel bed generally appeared armored with coarse gravels with substrate materials consisting of fine to sandy material.

Sedimentation was observed downslope of access locations and eroded channel banks.

Observations of Riparian Vegetation. The observed riparian vegetation along Foothill Creek primarily consists of non-native grasses, eucalyptus, and oak species. The overall vegetation distribution along the entire length of Foothill Creek, (approx. 4,360 feet) is moderate. The vegetation density varies depending upon landscape position and associated land uses, but can generally be described according to the three previously defined reaches. The first reach appears to have high vegetation density, reach two high to moderate vegetation density, and reach three has low to no vegetation density. Overall, approximately 28% of the channel can be described as having a high vegetation density, approximately 20% of the channel has moderate vegetation density, and approximately 10% of the channel has a low vegetation density.

Foothill Creek can generally be characterized as non-to moderately functioning (PFC), with a moderate risk of bank erosion (BEHI).

4.7.9. Corralitos Sub-Area

The Corralitos sub-area includes Corralitos Creek and two tributaries, Maple Creek and South Corralitos Creek. Maple Creek has numerous channel modifications, including channelization and channel realignment, which have limited the extent and diversity of riparian vegetation in the channel. Corralitos and South Corralitos Creek have portions of the channel devoid of vegetation. The channels have been modified, including channelized reaches and stream crossings. The creek system has increased flow volumes because of increased impervious surfaces associated with development in the upper watershed. The combination of increased flow volumes and channel modifications have forced the system into a state of disequilibrium.

4.7.9.1. *Maple Creek*

Channel Location and Description. Maple Creek begins from ephemeral streams in the Diablo Mountain Range and progresses into the valley. Observations of Maple Creek were limited to access points on Foothill Avenue, Center Avenue, and along Maple Avenue.

Maple Creek flows from the Diablo Mountain Range west to Foothill Avenue. Maple Creek east of Foothill Avenue is bordered by agricultural fields and is channelized around property boundaries. Maple Creek crosses Foothill Avenue and enters an agricultural field where the evidence of a channel is minimal. It appears that water from above Foothill Avenue diffuses across a row crop field and is conducted into a series of road ditches on Maple Avenue via tailwater drains from agricultural fields.

From the road ditch on Center Avenue, Maple Creek crosses Center Avenue to the west and enters an agricultural field. At the time of the survey the channel had been disced approximately 400 feet into the agricultural field, and during the wet season water from Maple Creek (and possibly Corralitos Creek) was pooling in the field, where the channel once existed. To the west of the field is the confluence of Maple, Tennant, and Corralitos Creeks.

Figure 4.17. The Maple Creek road ditch on Maple Avenue.

Maple Creek to the east of Foothill Avenue appears to be poorly vegetated and channelized around property boundaries. The channel west of Foothill Avenue has been completely destroyed with little evidence of the original channel. The road ditches adjacent to Maple Avenue and Center Avenue are mostly bare with some non-native grass cover. The road ditches appear to receive regular maintenance from the Santa Clara County Road Maintenance Crew.

Observations of Erosion and Sedimentation. During the rainy season there is evidence of erosion along the road ditches on Maple and Center Avenues. The ditch banks are bare and appear to be regularly disturbed by road maintenance. The areas upstream and downstream of the culvert crossings show evidence of scour pool development, specifically at 90-degree bends. The channel bed generally consisted of fine to gravelly material.

Sedimentation was observed inside and downstream of road culverts on Maple Avenue. There was also evidence of sedimentation where water was pooling in the agricultural field west of Center Avenue. At this location the water velocity decreased because of an increased channel width. As a result, the carrying capacity of the water decreased and suspended sediments were deposited. Sedimentation was also observed upstream of the culvert on Center Avenue, likely because the downstream pooling created a backwater effect that also decreased the velocity and carrying capacity of the water allowing sediments to be deposited.

Observations of Riparian Vegetation. Riparian vegetation along Maple Creek below Foothill Avenue is mostly absent before the confluence with Corralitos and Tennant Creeks. From the aerial photograph the vegetation above Foothill Avenue appears to consist mostly of grasses with the development of more mature woody vegetation closer to the Diablo Mountains. Overall the vegetation distribution on Maple Creek (approx. 7,320 feet) was low, with approximately 2% of the channel characterized with a low vegetation density and 15% of the channel characterized as a moderate vegetation density. Approximately 83% of the Maple Creek channel was devoid of vegetation.

Based upon qualitative indices, Maple Creek can generally be characterized as highly disturbed (PFC), with a very high risk of erosion (BEHI).

4.7.9.2. *Corralitos Creek and South Corralitos Creek*

Channel Location and Description. Corralitos Creek originates in the Diablo Mountain Range and progresses into the valley where it joins Tennant and Maple Creek and eventually East Little Llagas Creek north of San Martin Avenue, south of East Middle Avenue, and east of Sycamore Avenue. There are no pubic observation points for South Corralitos Creek, therefore the description of Corralitos Creek includes the tributary South Corralitos Creek. Observations of Corralitos Creek were limited to access points on Foothill Avenue, Center Avenue, Columbet Avenue, East Middle Avenue, and downstream of Center Avenue, and upstream of the confluence with East Little Llagas Creek.

In the last ten to fifteen years, large residential developments have been constructed in the upper watershed of both Corralitos and South Corralitos Creeks. These developments have increased impervious surfaces and have likely increased overall flow volumes in Corralitos Creek. The confluence of Corralitos and South Corralitos Creeks occurs in one of the largest of these developments. In conversations with a resident downstream of this development, large flows are observed outside of the rainy season in the Corralitos Creek channel, presumably from golf course ponds located on this development that are periodically emptied and refilled. This resident has also observed uncharacteristic water coloring during these flush periods, possibly from nutrient leaching from upstream equestrian centers that store manure adjacent to the stream.

Figure 4.18. Corralitos Creek downstream of Columbet Avenue.

West of the residential developments, Corralitos Creek is surrounded by agricultural fields and smaller residential developments. These developments and fields often encroach upon the channel, leaving less than 10 feet of space from the low flow channel. General observations along Corralitos Creek included; remnant in-stream crossings, yard cuttings disposed of on creek banks, and concrete and/or roof tile debris placed in the channel to prevent channel erosion. From the observation points, the channel has an approximate low flow channel width of four feet and is mostly sinous though the last 3,130 feet before the confluence of East Little Llagas and Corralitos Creek is channelized around property boundaries.

At the confluence of Corralitos Creek, East Little Llagas Creek, the East Little Llagas Creek channel is engineered and the banks and channel are lined with approximately two to three feet diameter boulders. As a result of these channel modifications in East Little Llagas Creek, Corralitos Creek above the confluence appears to be aggrading, with up to one foot of sediment deposition occurring in the lower reaches of the Corralitos Creek channel.

Observations of Erosion and Sedimentation. The most common observation of erosion occurred adjacent to crossings and in-stream channel modifications, specifically in scour pools downstream of road culverts and where concrete debris had been placed in the channel. The scour pools were generating downstream bank instability and also erosion adjacent to culverts. Where concrete debris had been placed in the channel, bank failure and downstream channel incision was observed. At one location the concrete was failing and downstream bank failure was occurring, likely derived from incision and bank steepening. There were also observations of erosion at in-stream foot crossings and channel incision of approximately one foot or more was observed in some locations. The channel bed generally consisted of fine to fine gravel material.

There was approximately one foot of aggradation, or sedimentation, observed at the confluence of Corralitos Creek with East Little Llagas Creek. It is possible that the rock riprap in East Little Llagas Creek is creating a sediment wedge stretching upstream of the confluence approximately 300 feet. Sedimentation was also identified adjacent to one observed bank failure location, where sediment from the bank had fallen into the channel and flows had not yet eroded the bank materials.

Observations of Riparian Vegetation. In the Corralitos sub-area there was a direct visual correlation between bank failure and vegetative cover. Where vegetation was not present bank slumping was observed. Vegetation provides support and stability to creek banks, increasing bank stability and protecting them from erosion during high flows. Where riparian vegetation is present along Corralitos Creek it includes non-native grasses, with instances of fennel, mustard, sedges, oak and walnut. Overall the vegetation distribution on Corralitos Creek (approx. 14,170 feet to the confluence with East Little Llagas Creek) was moderate, with approximately 11% of the channel characterized with a low vegetation density and approximately 22% of the channel characterized with a moderate vegetation density. Approximately 78% of the Corralitos Creek channel was devoid of vegetation.

Based upon qualitative indices, Corralitos Creek can generally be characterized as highly disturbed (PFC), with a high risk of erosion (BEHI).

4.7.10. Middle Llagas Creek Sub-Area

The Middle Llagas Creek sub-area includes Llagas Creek, Paradise Creek, Machado Creek and Hayes Creek. Land use in the sub-area generally consists of rangelands in the upper watershed with agricultural and residential lands in the valley. The creeks in the Middle Llagas Creek sub-area are moderately to well vegetated. Erosion was observed in the channels where adjacent land use encroaches on the channel or the channel system has been modified.

4.7.10.1. *Llagas Creek*

Channel Location and Description. Llagas Creek in the Middle Llagas Creek sub-area begins at the outlet of Chesbro Reservoir. Llagas Creek flows in a southeasterly direction, until its confluence with the Pajaro River approximately 4,680 feet south of Bloomfield Avenue. The SCVWD jurisdiction of Llagas Creek is unknown. Observations of Llagas Creek in the Middle Llagas Creek sub-area were limited to access points on Church Avenue, Llagas Avenue, Murphy Avenue, San Martin Avenue, Monterey Road, Santa Theresa Boulevard, Bowden Road, Sycamore Avenue, and Edmundson Road.

Llagas Creek in the Middle Llagas Creek sub-area begins downstream of the Chesbro Reservoir. The adjacent land use is agricultural or residential, and the creek channel and banks are well vegetated. The channel is sinuous though the adjacent land use limits the lateral extent of the riparian corridor. At Monterey Road the vegetation density begins to decrease and the channel appears to have been altered with the installation of the road and the Southern Pacific Railroad tracks, east of Monterey Road.

Figure 4.19. Llagas Creek east of Santa Theresa Boulevard at the Southern Pacific Railroad trestle.

At Llagas Avenue, approximately 1,700 feet east of Santa Theresa Avenue, the channel transitions into a modified channel with moderate to high vegetation density. Approximately 4,600 feet southeast of Llagas Avenue at San Martin Avenue the channel appeared to have a moderate vegetation density with large groups of *Arondo donax* in the channel. Encroachment of adjacent residential properties into the creek channel was also observed from San Martin Avenue.

Llagas Creek continues south approximately 7,560 feet, parallel to the airport, to Church Avenue. At Church Avenue the SCVWD has established a series of percolation ponds designed to recharge groundwater adjacent to Llagas Creek. The Llagas Creek channel at Church Avenue has a medium to low vegetation density with algal growths observed in pools of water exposed to sunlight. The vegetation density and diversity continue to decrease towards the confluence with East Little Llagas Creek.

Llagas Creek continues southeast from Church Avenue approximately 3,500 feet, passing beneath Highway 101 to the confluence with East Little Llagas Creek. At the confluence, bank erosion and channel incision on both channels was observed.

Observations of Erosion and Sedimentation. Erosion on Llagas Creek in the Middle Llagas Creek sub-area was observed as localized channel incision and bank erosion. The channel bed is generally armored with gravels with substrate consisting of fine to gravel material.

Sedimentation was observed as point bar development and in finer sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Llagas Creek in the Middle Llagas Creek sub-area included sedges, willows, oaks, eucalyptus, *Arondo donax*, fennel, walnut and star thistle. Overall the vegetation cover on Llagas Creek (approx. 49,000 feet) is very good, with approximately 4% of the channel characterized as low vegetation density, 20% characterized as moderate vegetation density, and 69% characterized as high vegetation density.

Based upon qualitative indices, Llagas Creek in the Middle Llagas Creek sub-area can generally be characterized as properly to moderately functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.10.2. *Paradise Creek*

Channel Location and Description. Paradise Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Paradise Creek flows in a southerly direction, until its confluence with Llagas Creek approximately 2,000 feet east of Chesbro Reservoir. The SCVWD jurisdiction of Paradise Creek is approximately 2,825 feet north of the confluence of Paradise Creek with Llagas Creek. Observations of Paradise Creek were limited to public access points at Llagas Road.

Paradise Creek borders rural residential developments and roads for most of its length. The vegetated cover and SRA in most locations appear intact, though erosion and diminished vegetation density were observed in proximity to adjacent land uses. Exposed bank and channel areas were observed in proximity to Llagas Road and where adjacent land uses encroached onto the channel.

Figure 4.20. Bank failure on Paradise Creek on Llagas Road.

Observations of Erosion and Sedimentation. Erosion on Paradise Creek was observed where vegetation was cleared as a result of adjacent land use, road or residential developments. Erosion was also observed where concentrated runoff entered the channel from the adjacent roads, pasture or residential developments. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed as finer sediments deposited amongst in-channel vegetation. Sedimentation was also observed as point bar development and in finer sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Paradise Creek included grasses, bamboo, oak, willow, bramble, and ivy. Overall the vegetation cover on Paradise Creek (approx. 6,175 feet) is very good, with approximately 17% of the channel characterized as low vegetation density, 28% characterized as moderate vegetation density, and 54% characterized as high vegetation density.

Based upon qualitative indices, Paradise Creek can generally be characterized as properly functioning to moderately functioning (PFC), with a moderate risk of erosion (BEHI).

4.7.10.3. *Machado Creek*

Channel Location and Description. Machado Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Machado Creek flows in a northeasterly direction, until its confluence with Llagas Creek approximately 1,375 feet east of Sycamore Avenue. The SCVWD Jurisdiction of Machado Creek is parallel to Armsby Avenue, approximately 2,000 feet north of Sycamore Avenue. Observations of Paradise Creek were limited to public access points along Ashby Road and at Oak Glen Avenue.

The upper watershed of Machado Creek is well vegetated with some rural residential developments on the eastern portion of the upper watershed, adjacent to Ashby Avenue. Where drainage from these developments accumulates and enters the Machado Creek channel, channel disturbances were observed. These disturbances included bare banks, likely the result of channel downcutting. Channel incision is likely caused by the proximity of the adjacent land use, depletion of the riparian corridor and/or effects of increased flow volumes.

Downstream of Ashby Avenue and west of Sycamore Avenue, Machado Creek crosses land used for animal grazing. Animals access the channel in some locations. At these locations channel degredation and depletion of riparian vegetation density was observed. Further downstream Machado Creek enters lands used for vines and row crops. The vegetation density of the channel in this reach is high, though occasional channel disturbances were observed from Oak Glen Avenue. For example, at one location it appeared that channel bank vegetation had been cleared and herbicide applied. As a result the soils were left bare and loose. At this location a fence has been installed directly above the channel, encroaching on the channel bank.

Figure 4.21. Machado Creek upstream of Oak Glen with bare banks with loose soils.

Observations of Erosion and Sedimentation. Erosion on Machado Creek was observed in the upper watershed as channel incision and bank steepening. Erosion was also observed on channel banks exposed to grazing, and where banks had been cleared due to agricultural practices. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed as point bar development and in finer and medium sized sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Machado Creek included grasses, oak, willow, bramble, and ivy. Overall the vegetation cover on Paradise Creek (approx. 10,460 feet) is very good, with approximately 0% of the channel characterized as low vegetation density, 23% characterized as moderate vegetation density, and 68% characterized as high vegetation density.

Based upon qualitative indices, Machado Creek can generally be characterized as moderately functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.10.4. *Hayes Creek*

Channel Location and Description. Hayes Creek originates in the foothills of the Santa Cruz Mountains in Santa Clara County. Hayes Creek flows in a northerly direction, until its confluence with Llagas Creek approximately 485 feet east of Watsonville Road. The SCVWD jurisdiction of Hayes Creek is approximately 5,150 feet south of the confluence of Hayes Creek with Llagas Creek. Observations of Hayes Creek were limited to public access points on Watsonville Court and Watsonville Road.

The upper watershed of Hayes Creek has numerous rural residential developments, animal pasture and facilities, and agricultural lands. At the first access to Hayes Creek, on Watsonville Road, the channel is adjacent to a new winery development. During the construction of the facility, or prior to it, the Hayes Creek channel was realigned and modified. The modified channel is low profile with access to the floodplain above bankfull stage. At the time of the survey the vegetation density was low, and grass was observed in the channel and some younger shrubbery on the channel banks. Bare and loose soils were observed along the channel banks in this channel reach.

Figure 4.22. Hayes Creek downstream of Watsonville Road.

Below Watsonville Road, Hayes Creek passes through this newly converted winery property and then into property used for equestrian facilities. Adjacent to the equestrian facilities, one in-stream crossings was observed across Hayes Creek. At this crossing the soil appeared bare and loose, susceptible to erosion.

Hayes Creek crosses Watsonville Court twice, the first approximately 4,025 feet north of Watsonville Road. At the first location on Watsonville Court, a scour pool was observed downstream of the road culvert and bank erosion was observed at the culvert inlet. Concrete debris in and adjacent to the channel was also observed. Similar observations were recorded at the second location on Watsonville Court. At the second location it also appeared the channel was incising approximately one (1) to two (2) feet.

Observations of Erosion and Sedimentation. Erosion on Paradise Creek was observed where vegetation had been cleared as a result of adjacent land use, specifically equine access or residential developments. Erosion was also observed as channel incision, likely caused by minimal floodplain access and the concentration of flood flows in the creek channel. The channel bed generally consisted of fine to gravel material.

Sedimentation was also observed as point bar development and in finer sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Hayes Creek included grasses, oak, willow, bramble, walnut, and ivy. Overall the vegetation cover on Hayes Creek (approx. 10,520 feet) is good, with approximately 36% of the channel characterized as low vegetation density, 23% characterized as moderate vegetation density, and 17% characterized as high vegetation density.

Based upon qualitative indices, Hayes Creek can generally be characterized as moderately functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.11. San Martin Sub-Area

The San Martin sub-area includes San Martin Creek and two tributaries, Center Creek and New Creek. Adjacent land uses, including equestrian facilities, cattle grazing, and agriculture, have encroached and impacted the creek. These land uses have resulted in riparian instability; however the well established riparian vegetation has reduced channel erosion. Center Creek has adequate riparian vegetation and has primarily been impacted by residential, agricultural and ranching practices that have disturbed the watershed and channel characteristics. On New Creek bank failure including rills, gullies, vertical or near vertical bank angles, channel incision, and bare bank slopes were observed and documented.

4.7.11.1. *San Martin Creek*

Channel Location and Description. San Martin Creek originates in the Diablo Mountain Range and progresses into the southern portion of the valley. San Martin Creek is a tributary to East Little Llagas and the confluence with East Little Llagas occurs between Sycamore and Colombet Avenue, north of Church Avenue and south of San Martin Avenue. Before the confluence with East Little Llagas Creek, the Center and New Creek tributaries enter the San Martin channel. Observations of San Martin Creek were limited to access points on Foothill Avenue, San Martin Avenue, Center Avenue, and Colombet Avenue. The upper portion of the watershed is primarily rangelands used for cattle grazing. From the rangelands in the foothills, San Martin Creek continues into the valley until its confluence with East Little Llagas Creek.

In the rangelands, there is visual evidence of cattle entering the creek, these signs included: slumped banks, vegetation development limited to grass species, and low angle banks with limited bankfull development. At one location where equine creek access was observed, a retaining wall was built in the channel, in an attempt to mitigate the bank failure.

Downstream of the rangelands, San Martin Creek is channelized in some locations around property boundaries, and in other locations retains what appears to be its original pattern of sinuosity. Some impacts to the San Martin channel were observed adjacent to row and tree crop fields, these included channel backfilling, farm road and field encroachment, and levee construction. In some locations, erosion was observed adjacent to bank failures or scour holes created by culverts, and where rock, concrete and tile debris had been placed in the channel in an attempt to stabilize the bank.

Observations of Erosion and Sedimentation. Erosion was observed as bank failure and channel incision. The bank failure was generally associated with animal access and culverts. Erosion associated with culverts was observed at scour pools downstream of culverts or at locations where the capacity of the culvert was exceeded. In one location the capacity of a culvert was exceeded causing flows to back up and eventually flow over the road and re-enter the channel. At the location where the water re-enters the channel the right and left channel bank were bare, vertical and eroded. On the right channel bank, rip-rap had been installed for bank protection. Channel incision was observed in San Martin Creek downstream of San Martin Avenue to the confluence with East Little Llagas Creek. The channel incision ranged from one to three feet. The channel bed generally appeared armored with gravel with substrate material consisting of fine to gravel material.

Figure 4.23. Bank erosion downstream of Columbet Avenue where water re-enters the channel from upstream into San Martin Creek.

Sedimentation was observed in locations where water had pooled behind culverts or in scour pools downstream of culverts. At these locations water velocities decreased, decreasing the carrying capacity of the water, which allowed sediment to be deposited.

Observations of Riparian Vegetation. Observed vegetation types on San Martin Creek included grasses, oak, walnut, eucalyptus, and sedges. The overall vegetation distribution on San Martin Creek (approx. 13,325 feet) was good, with approximately 15% of the channel characterized with a low vegetation density, 30% characterized with a moderate vegetation density, and 12% with a high vegetation density.

Areas with no riparian vegetation or with low vegetation density could be impacted by one of the following observed practices: riparian access and grazing, channel clearing adjacent to agricultural fields, channel encroachment from residential developments, or bank erosion and destabilization.

Based upon qualitative indices, San Martin Creek can generally be characterized as highly disturbed (PFC), with a moderate risk of erosion (BEHI).

4.7.11.2. *Center Creek*

Channel Location and Description. The first creek south of San Martin Creek is Center Creek. Center Creek originates in the Diablo Mountain Range and progresses into the southern portions of the valley until its confluence with San Martin Creek between Center and Foothill Avenue, north of Church Avenue and south of San Martin Avenue. Observations of Center Creek were limited to access points on San Martin and Foothill Avenues.

The upper portions of the watershed are primarily rangelands. The lower portion of Center Creek meanders through a combination of residential and agricultural developments. Typically, setbacks between the stream channel and residential developments is minimal and at some locations levees have been constructed adjacent to both residential and agricultural developments.

At the time of this survey the upper portion of the Center Creek watershed was being grazed and animals were accessing the creek channel. Animal access in the creek channel had caused bank degradation, slumping and poor recruitment of vegetation. At one location downstream of the ranch lands, concrete retaining walls were constructed on both channel banks and concrete debris had been dumped into the channel. The retaining walls could be the remaining abutments from an old farm road or installed for channel stability.

Figure 4.24. Center Creek in the upper watershed, above San Martin Avenue.

At the intersection of Center Creek and Foothill Avenue, the Foothill Avenue road ditch enters the Center Creek channel. At this location the ditch was eroding the channel bank and riprap rock was placed in the ditch to prevent further erosion. The road ditch on Foothill Avenue is bare, grassed and rock lined in various locations, but combined with increased impervious surfaces from new developments is a potential source of sediment. At the point where the road ditch merges with the channel, downstream of Foothill Avenue a scour pool is developing, also a potential sediment source.

Observations of Erosion and Sedimentation. Road ditch erosion, scour pool development downstream of culverts, channel incision and bank slumps are potential sources of sediment in the Center Creek watershed. Channel incision up to one foot was observed in the Center Creek channel. The incision was likely caused by channel levees that prevent floodplain access. This focuses flows, preventing energy dissipation over a broad floodplain area. The channel bed generally consisted of fine to fine gravel material.

Observations of sedimentation were recorded downslope of slumped or eroding channel banks.

Observations of Riparian Vegetation. Observed vegetation types on Center Creek included grasses with instances of oak, walnut, willow, cattail, bramble and sedges. Overall the vegetation distribution on Center Creek (approx 5,870 feet) is good, with approximately 31% of the channel characterized as low vegetation density, 20% characterized as moderate vegetation density, and 31% characterized as high vegetation density.

Based upon qualitative indices, Center Creek can generally be characterized as moderately to highly disturbed (PFC), with a moderate risk of erosion (BEHI).

4.7.11.3. *New Creek*

Channel Location and Description. New Creek originates in the Diablo Mountain Range and progresses into the southern portion of the valley until its confluence with San Martin Creek east of Columbet Avenue, west of Center Avenue, north of Church Avenue, and south of San Martin Avenue. Observations of New Creek were limited to access points on New Avenue, Foothill Avenue, and Center Avenue.

The New Creek channel has maintained most of its original sinuosity, though it is channelized in some locations with channel encroachment from adjacent land use, which is primarily agricultural. The channel profile is generally deep and narrow with intact sinuosity. Bank slumping and channel incision were observed at a number of locations resulting in bare and vertical or near vertical channel banks.

Figure 4.25. Bank erosion on New Creek at Foothill Avenue.

Observations of Erosion and Sedimentation. The channel appears to be incised approximately three to four feet and the banks show signs of slumping. In some locations the combination of high flows, channel incision, and inadequate energy dissipation have caused considerable bank failure, leaving the channel banks bare and steep. Levees and the effects of channel incision prevent New Creek from regularly accessing the floodplain. As a result high energy flows continue to erode the channel features. The channel bed generally consisted of fine to fine cobble material.

Observations of sedimentation were recorded downslope of slumped or eroding banks and on the inside of channel bends. Sedimentation was also observed amongst in-channel vegetation and debris.

Observations of Riparian Vegetation. Observed vegetation types included grass with occasional mature eucalyptus and oak. However, from the aerial photograph it appears that portions of the channel have consistent cover of mature vegetation. Overall the vegetation distribution on New Creek (approx 10,770 feet) is good, with approximately 39% of the channel characterized as low vegetation density, 24% characterized as moderate vegetation density, and 4% characterized as high vegetation density.

Based upon qualitative indices, New Creek can generally be characterized as highly disturbed (PFC), with a moderate to high risk of erosion (BEHI). If more visual access to New Creek were possible, the characterization would likely change because of the improved riparian habitat observed in some locations from the aerial photograph.

Mid-Valley Region

4.7.12. Church Sub-Area

The Church sub-area includes Church Creek and its smaller unnamed tributaries. The land use in this region primarily consists of rangeland in the upper portion of the sub-area and mixed residential and agricultural land use in the valley. Along Church Creek observations of bank failure including rills, gullies, channel incision, and bare bank slopes were noted.

4.7.12.1. *Church Creek*

Channel Location and Description. Church Creek begins in the Diablo Mountain Range and progresses into the southern portion of the valley until its confluence with East Little Llagas Creek. The stream confluence is just north of the confluence of East Little Llagas Creek with Llagas Creek, north of Masten Avenue, and west of Colombet Avenue. Observations of Church Creek were limited to access points on New, Foothill, Center, and Colombet Avenues.

The upper reaches of the Church Creek watershed have a grazing history, but have been left relatively undisturbed. The channel has retained much of its original sinuosity in the upper reaches though it has been channelized or conducted into road ditches in the lower reaches. The channel has small levees in some locations and the banks are mostly well covered with vegetation. In some instances rock and concrete debris have been placed on banks to protect adjacent property from erosion. In some locations, bare and steep banks were observed at outside meander bends.

At New Avenue where a road ditch enters the channel, an observed elevation difference, up to four feet, separate the channel bed and the road ditch. As a result of this elevation difference the channel bank and road ditch show signs of rill and gully development. The erosion at this location resembles the slow migration of a head cut up the road ditch, an attempt to reduce the slope between the two channels. At some locations riprap or rock weirs have been placed over these head cuts in an attempt to strengthen the slopes, act as grade control structures, reduce water velocities, and reduce the slope between the road ditch and creek channel.

Figure 4.26. A road ditch on New Avenue entering Church Creek.

At one location a cattle guard was observed across the channel, blocking trash and collecting debris. Fencing along creek banks was observed at some locations, likely associated with property boundaries or remnants of cattle grazing. Most fences adjacent to property boundaries encroach upon the creek channel or are built on top of channel banks.

Observations of Erosion and Sedimentation. The channel appears to have incised one to two feet and up to five or six feet in some locations. Bank erosion and gully formations were observed where road ditches were entering the channel. These erosion features are likely attributable to a number of recent changes in and around the Church Creek watershed, including: increased impervious surfaces associated with five acre residential developments, bare and channelized road ditches, and road ditches that collect and concentrate flow from over a large area. The channel bed material appeared armored with cobble and gravel material with a fine to fine gravel substrate.

Bare ditches are susceptible to erosion and also do not possess channel features, such as vegetation and woody debris, that can slow flows and reduce the ability of water to transport sediment and further erode road ditches and creek channels. Road ditches in the Church Creek watershed collect and channelize stormwater over a relatively large area that is experiencing a wide spread conversion of agricultural lands to residential developments. These developments tie into a grid of channelized road ditches that conduct stormwater into Church Creek. Other observations of erosion included: scour around in-channel concrete supports, development of scour pools downstream of culverts, and exposed channel banks on the outside of meander bends.

Sedimentation, primarily as fines to sandy material, was observed upstream of road crossing abutments and in point bars downstream of vertical banks. Sedimentation at high water locations, where sediment was deposited as high water levels were falling, was also observed.

Observations of Riparian Vegetation. Observed vegetation types in Church Creek included grasses, oak, walnut, and jubata grass. Floodplains are bare of mature vegetation, and the floodplain is principally being used for residential or agricultural uses. Overall the vegetation distribution on Church Creek (approx 11,000 feet) is good, with approximately 30% of the channel characterized as low vegetation density, 28% characterized as moderate vegetation density, and 8% characterized as high vegetation density.

Based upon qualitative indices, Church Creek can generally be characterized as moderately to highly disturbed (PFC), with a high risk of erosion (BEHI). If more access to Church Creek were possible, the characterization would likely change because of the improved riparian habitat observed in some locations from the aerial photograph.

4.7.13. Rucker Skillet Sub-Area

The Rucker Skillet sub-area includes Rucker Creek and Skillet Creek and their tributaries. The land use in this region primarily consists of rangeland in the upper portion of the sub-area and mixed residential and agricultural land use in the valley. Portions of the upper watershed have also experienced a transition from rangeland to large residential developments. These developments have increased impervious surfaces and increased flow volumes entering the lower sub-area. The channels in the lower sub-area, on Rucker and Skillet Creeks, have been impacted by adjacent land use and in combination with the increased flow volumes from upstream, the system is in a state of disequilibrium.

4.7.13.1. *Rucker Creek*

Channel Location and Description. Rucker Creek originates in the Diablo Mountain Range and progresses into the southern portion of the valley until its confluence with East Little Llagas Creek, west of Foothill, east of Center Avenue, north of Buena Vista Avenue, and south of Omar Street. From the Diablo Mountains to the confluence with East Little Llagas Creek, Rucker Creek flows in a south westerly direction adjacent to residential, agricultural and equestrian developments. Observations of Rucker Creek were limited to access points on New Avenue, Guibal Avenue, Rucker Avenue, and Omar Avenue.

The upper portions of the watershed have a history of grazing, but more recently large residential developments have been built on sub-divided rangelands. Rucker Creek has maintained some of its original sinuosity in the upper reaches but has been mostly channelized in the lower reaches. At one location where a road ditch enters the channel at New Avenue an observed elevation difference of three or four feet separate the channel bed and the road ditch. As a result of this elevation difference the channel bank and road ditch show signs of rill and gully development. Various management strategies were observed in an attempt to prevent further bank erosion at this location and others, including: flared culvert outlets with concrete aprons, concrete sack retaining walls, and concrete slabs placed along the road ditch entrance. The channel is leveed in some locations, ranging from one to two feet in height, which has limited creek access to the floodplain. As a result of channelization and levee construction the channel has incised one to two feet resulting in bank over-steepening and failure at a number of locations.

At one location it was observed that water overtopped the road and re-entered the channel on the downstream side of the road. As part of road maintenance at this location it appears the downstream creek channel was excavated to prevent flooding over the road caused by culvert blockages.

The distance between the channel and fences along Rucker Creek was variable. At Rucker Avenue a fence adjacent to an equestrian area encroaches onto the creek. As a result the bank is steepening and over time the fence will likely slump into the creek. Fencing crossing the channel was observed in a number of locations.

Figure 4.27. Fence adjacent to Rucker Creek upstream of Rucker Avenue.

It was characteristic that the creek channel was leveed and channelized adjacent to agricultural fields. At one location where the Rucker Creek floodplain is being used for field crop production, the creek channel is channelized, devoid of vegetation, and has three-foot high banks at 90-degree angles. At another location, what is believed to be a remnant irrigation, recreation, or stock watering pond is in the creek channel. The pond was created by a concrete dam that is now filled-in with sediment. Rucker Creek currently flows in a braided pattern through the sediments accumulated upstream of the structure, and then drops approximately two feet over the structure onto a concrete apron.

The Rucker Creek channel is incised near the confluence with East Little Llagas approximately five feet. This incision continues upstream of the confluence. The Rucker channel in this reach can generally be characterized as narrow and deep with limited access to the channel floodplain.

Observations of Erosion and Sedimentation. The channel has incised approximately one to two feet in some locations. The banks also show evidence of mass wasting and erosion, particularly where road ditches enter the creek channel or at stream access points. Erosion was also observed in scour pools downstream of road crossings and culvert outlets, as well as at the transition between hardscape features, such as concrete abutments and retaining walls, and the natural channel. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed at the base of bank slumps, in point bar development downstream of slumped banks, and adjacent to the convergence of road ditches and the creek channel. Sedimentation was also observed downstream of an in-channel dam.

Observations of Riparian Vegetation. The observed vegetation types on Rucker Creek included grasses with instances of eucalyptus, oak, cherry, walnut, pine, jubata grass, and bramble. The banks are primarily covered with grasses but are bare in some locations. Overall the vegetation distribution on Rucker Creek (approx 11,300 feet) is moderate, with approximately 33% of the channel characterized as low vegetation density and 4% characterized as moderate vegetation density. Approximately 63% of the Rucker Creek channel was devoid of vegetation.

Based upon qualitative indices, Rucker Creek can generally be characterized as non-functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.13.2. *Skillet Creek*

Channel Location and Description. Skillet Creek originates in the Diablo Mountain Range and progresses into the southern portion of the valley until its confluence with Rucker Creek, west of Foothill, east of Center Avenue, north of Buena Vista Avenue, and south of Omar Street. Observations of Skillet Creek were limited to access points on Foothill Avenue, New Avenue, Duke Avenue, and along Bridle Path Drive in the upper watershed.

The upper portions of the watershed are rangelands, and had been left relatively undisturbed until recently. In the last 10 to 15 years approximately 15 large residential developments have been constructed in the upper watershed. In these upper reaches the creek channel shows evidence of the impact left by grazing in and around the creek, specifically, slumped banks and a limited riparian vegetation community. In these areas the vegetation consists primarily of grasses with scattered mature woody vegetation and the banks have a low profile with evidence of small banks slumps likely caused by large animal foot traffic. Though the stream channel has been impacted, the sinuosity of the channel remains mostly intact and floodplain access likely occurs during high flow events.

Figure 4.28. Riparian grazing and residential developments in the upper watershed of Skillet Creek.

From the foothills of the Diablo Mountains, Skillet Creek crosses Duke Avenue and enters the valley floor. In the valley, the creek retains some of its original sinuosity but has been channelized in some locations around agricultural fields and property boundaries. In the lower reaches the creek channel has incised one to two feet in some locations. Property owners in the watershed related observations of increased flows in the creek channel in the last five to ten years. It is possible that downstream incision and increased runoff volumes are linked to recent developments in the upper watershed.

The creek has been leveed in some locations and has some locations where adjacent developments and fences encroach upon the creek channel. Adjacent developments can limit floodplain access and therefore concentrate flows within the channel. In one location a footbridge and series of pipes were observed crossing the channel.

Observations of Erosion and Sedimentation. The banks are generally grassed with instances of bank slumping, especially near road crossings. Erosion was observed in scour holes developing at culvert outlets, particularly culverts that are perched (the invert elevation of the culvert is above the elevation of the channel bed). Rill and gully development was also observed where road ditches and overland flow enter the creek channel. Bank slumps were identified at a number of locations along Skillet Creek. The channel bed generally consisted of fine to fine cobble material.

Sedimentation was observed in channels downstream of scour pools. Sedimentation was also identified upstream of Duke Avenue, the first significant observation point for Skillet Creek as the channel leaves the foothills of the Diablo Mountain Range. At this location sediment is accumulating, sediment that is possibly originating from bank slumping and decreased vegetation density in the upper watershed.

Observations of Riparian Vegetation. Observed vegetation types on Skillet Creek included non-native grasses with instances of cherry, oak, walnut, pine, and mustard. Clearing of channel vegetation adjacent to agricultural fields was a common practice observed throughout the sub-area. Overall the vegetation distribution on Skillet Creek (approx 15,400 feet) is good, with approximately 17% of the channel characterized as low vegetation density, 28% characterized as moderate vegetation density, and 8% characterized as high vegetation density.

Based upon qualitative indices, Skillet Creek can generally be characterized as moderately disturbed (PFC), with a high risk of erosion (BEHI).

4.7.14. Panther Sub-Area

The Panther sub-area includes Panther Creek and South Panther Creek and their tributaries. The land use in this region primarily consists of rangeland and residential developments in the upper portion of the sub-area and mixed residential and agricultural land use in the valley. The vegetation density and sinuosity on Panther Creek decrease from the upper to lower watershed, with bare banks and channelization occurring in the lower watershed. On South Panther Creek observations of bank failure and depleted bank and floodplain vegetation was observed. The creek also appeared modified adjacent to residential developments and impacted by animal access, where allowed.

4.7.14.1. *Panther Creek*

Channel Location and Description. Panther Creek originates in the Diablo Mountain Range and progresses into the southern portion of the valley until its confluence with Llagas Creek, west of New Avenue, east of Marcella Avenue, north of Leavesley Avenue, and south of Buena Vista Avenue. Observations of Panther Creek were limited to access points on New Avenue and Estates Drive.

In the upper watershed of Panther Creek, in the foothills of the Diablo Mountain Range, many large residential developments have been built in the last 10 years. It appears that Panther Creek has maintained many of its physical characteristics, such as sinuosity and channel depth, however it does appear that construction and land use encroachment have reduced vegetation in the channel and on the floodplain. These characteristics could also be the result of previous land uses in the Panther Creek watershed.

As Panther Creek transitions from the foothills onto the Llagas floodplain, the vegetation density and channel sinuosity decrease. West of New Avenue, Panther Creek passes through agricultural fields, from which all vegetation has been removed from the creek and the channel straightened around the fields. The confluence of Panther Creek with Llagas Creek occurs north of Leavesley Avenue, south of Buena Vista Avenue, east of Marcella, and west of New Avenue. Panther Creek enters Llagas Creek via two large concrete culverts with concrete riprap placed at the outfall into Llagas Creek.

Figure 4.29. Panther Creek south of New Avenue.

Observations of Erosion and Sedimentation. Erosion was observed on Panther Creek at locations related to channel incision and subsequent bank failure. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed in the channel upstream and downstream of culverts under road crossings. Sedimentation was also observed at the bottom of slumped or eroding channel banks.

Observations of Riparian Vegetation. Observed vegetation types on Panther Creek included sedges, cattails, iceplant, grasses, eucalyptus, oak and thistle. The floodplains on Panther Creek are mostly bare of mature vegetation, and principally being used for residential or agricultural uses. Overall the vegetation distribution on Panther Creek (approx. 12,000 feet) is good, with approximately 18% of the channel characterized as low vegetation density, 20% characterized as moderate vegetation density, and 31% characterized as high vegetation density.

Based upon qualitative indices, Panther Creek can generally be characterized as moderately disturbed (PFC), with a moderate risk of erosion (BEHI).

4.7.14.2. *South Panther Creek*

Channel Location and Description. South Panther Creek originates in the Diablo Mountain Range and progresses into the southern portion of the valley until its confluence with Panther Creek, west of New Avenue, east of Marcella Avenue, north of Leavesley Avenue, and south of Buena Vista Avenue. Observations of South Panther Creek were limited to access points on Sugar Babe Road and New Avenue and views from an aerial photo of Santa Clara Valley.

Land use in the upper watershed consists mostly of large residential developments with small equestrian lots. South Panther Creek at these locations is devoid of vegetation, other than grasses, and at two locations in-stream dams have been built to capture water. In the vicinity of these locations the creek banks show signs of slumping possibly due to animal access or previous access when the land was likely used for grazing. Downstream of Sugar Babe Road below the two in-stream water impoundments, the creek enters a large residential development that has restored the vegetation adjacent to South Panther Creek for approximately 450 feet. As part of this residence a third water impoundment was created on the western boundary of the property. Downstream of the development where portions of South Panther appear to be restored, the creek is devoid of vegetation, except for grasses. This area is used as animal pasture and animals have access to the channel. As a result, the channel banks are slumped, bare, and the overall channel profile degraded.

Downstream of New Avenue, South Panther Creek passes through agricultural fields, and similar to conditions on Panther Creek, vegetation has been removed from South Panther Creek and the channel straightened around row crop fields. The confluence of South Panther Creek with Panther Creek occurs to the southwest of the agricultural fields approximately 325 feet before the confluence of Panther and Llagas Creek, in a seemingly moderately to well vegetated reach.

Observations of Erosion and Sedimentation. Erosion on South Panther Creek was observed adjacent to equestrian activities. At locations where horses accessed to the channel, the banks had extremely low profiles, to the point where the creek was almost indiscernible from the adjacent floodplain. Soils in these areas were also bare or covered with very short grasses. The channel bed generally consisted of fine to gravel material.

Sedimentation on South Panther Creek was observed where animals accessed the channel and bank slumping and erosion had occurred.

Observations of Riparian Vegetation. Observed vegetation types on South Panther Creek included grass, cattails, and oak. The floodplains on South Panther Creek are mostly bare of mature vegetation, and principally being used for residential, agricultural or equestrian uses. Overall the vegetation distribution on South Panther Creek (approx. 12,000 feet) is low, with approximately 10% of the channel characterized as low vegetation density and 11% characterized as moderate vegetation density. Approximately 79% of the South Panther Creek channel was devoid of vegetation.

Based upon qualitative indices, South Panther Creek can generally be characterized as moderately disturbed to highly disturbed (PFC), with a moderate to high risk of erosion (BEHI).

4.7.15. <u>West Branch Llagas Sub-Area</u>

The West Branch Llagas sub-area includes West Branch Llagas Creek, Day Creek, Lion’s Creek, North Morey Channel, South Morey Channel, and Upper Miller Slough. The creeks in the West Branch Llagas sub-area have been impacted by urbanization and hydromodifications to the creek channels. Day Creek is maintained as a road ditch along Day Road. Towards Gilroy, the Lion’s

Creek channel is in an engineered channel with minimal vegetation density. South Morey Channel, North Morey Channel and Upper Miller Slough are storm drains for the City of Gilroy, and where they surface, the channels are modified with a minimal vegetation density. Portions of the West Branch Llagas Creek channel have been modified, while it appears other portions are in transition while the SCVWD continues with the channel modifications and realignments. These channels are vulnerable to erosion because of the flashy and high volume flows they receive from urban and residential developments.

4.7.15.1. *West Branch Llagas Creek*

Channel Location and Description. West Branch Llagas Creek originates in the foothills of the Santa Cruz Mountains in Santa Clara County. West Branch Llagas Creek flows in a southeasterly direction, until its confluence with Llagas Creek approximately 1340 feet north of Pacheco Pass Road. The SCVWD jurisdiction of West Branch Llagas Creek begins approximately 8,545 feet west of Santa Theresa Boulevard. Observations of West Branch Llagas Creek were limited to public access points on Santa Theresa Boulevard, Highland Avenue, Fitzgerald Avenue, Golden Gate Avenue, Day Road, Farrell Avenue, Murray Avenue, Leavesley Road, and along Highway 101.

The upper watershed of West Branch Llagas Creek has been converted into an area that includes a golf course, resort, vineyards, and private residencies. This reach has a low to moderate vegetation density and it appears the channel has maintained its sinuosity in this reach. Though in many reaches it appears the golf course landscaping encroaches upon the West Branch Llagas Creek channel. At the first public observation point on West Branch Llagas Creek the vegetation cover is good with a medium to low density, consisting primarily of willow and grasses. Cobble rip-rap was observed in the channel and on channel banks. The channel geometry near Santa Theresa Boulevard likely allows for floodplain access during high flow events.

East of Santa Theresa Boulevard, West Brach Llagas Creek parallels Highland Avenue crossing multiple residential properties, each different practices for managing the creek on their property. Some have small levees, crossings, and bare banks in variable condition. Visual access to the channel in this reach was poor, but from a distance it appeared likely the channel was experiencing incision.

Approximately 1,015 feet east of Santa Theresa Avenue West Branch Llagas Creek crosses to the south of Highland Avenue. Downstream of this location significant scour and bank erosion was observed downstream of the road culvert outlet where the channel makes a 90 degree bend east along Highland Avenue. The apron downstream of the culvert also showed signs of erosion, and large rip-rap cobbles had been placed downstream of the culvert and along the eroding channel banks. Bank erosion is threatening existing tree roots.

Figure 4.30. Bank scour on West Branch LLagas Creek downstream of Highland Avenue.

The West Branch Llagas Creek channel parallels Highland Avenue and has been leveed on the right bank to prevent flooding into row crop fields to the south of the channel. The channel continues parallel to Highland Avenue for approximately 540 feet and then makes a 90-degree bend south. The channel south of Highland Avenue is approximately 50 feet wide, approximately 5 times wider than the channel that parallels Highland Avenue. The banks in the wider channel have low slopes (20-45 degrees) and are covered mostly with grass and some emergent oaks appear to have been planted on the banks of the modified channel. West Branch Llagas Creek and other tributary drainages have carved smaller low flow channels within the larger modified channel. West Branch Llagas Creek continues in the wide modified channel for approximately 1,365 feet before narrowing and continuing south for approximately 1,410 feet before making a 90-degree bend to the east. West Branch Llagas Creek continues east adjacent to row crop fields for approximately 900 feet before making another 90-degree bend to the south. The channel continues south for approximately 5,200 feet, mostly grassed or bare with sections of sinuous channel with medium to low vegetation density channel. The channel then makes another 90-degree bend, paralleling Fitzgerald Avenue for approximately 270 feet. Where West Branch Llagas Creek parallels and crosses Fitzgerald Avenue the channel appears incised one (1) to two (2) feet and scoured banks were observed at the 90-degree bend where the channel turns south under Fitzgerald Avenue.

West Branch Llagas Creek crosses Fitzgerald Avenue and bisects row crop fields for approximately 7,000 feet south towards Day Road. The channel in these fields appears to be incised one (1) to two (2) feet and the channel and banks are mostly devoid of vegetation. The channel has been straightened for most of it length and in-stream channel crossings occur in this stretch. Concrete debris was observed along channel banks to provide armoring and bank protection. Bank erosion was observed at locations where water exiting fields drained overland and into West Branch Llagas

Creek creating rill and gully formations on the chanel banks. Loose soil was also observed downslope of animal burrows in the channel banks.

Figure 4.31. Bank armoring on West Branch Llagas Creek in dry and wet conditions.

At Day Road West Branch Llagas Creek makes a 90 degree bend east, paralleling Day Road for approximately 750 feet. Along Day Road, West Branch Llagas Creek passes through three large culverts and a configuration of vertical posts placed in the centerline of the channel which act as debris traps. Rock riprap has also been placed in the channel and on the channel banks. Bank erosion was observed at points were agricultural runoff entered the channel. West Branch Llagas Creek crosses Day Road, via an engineered riprap and concrete lined channel with a concrete basin functioning as a sediment basin. Downstream of Day Road, the channel transitions from riprap and concrete lining to riprap and then earth. Downstream of Day Road the channel is highly modified and shaped with a low flow channel and access road/low flow floodplain. The channel shape is similar to that observed at Highland Avenue. The vegetation diversity is very low, consisting only of grasses on the banks and in the channel.

At some locations rip-rap has been placed along the channel and banks, though the general channel shape and vegetation observed at Day Road continues until the confluence of West Branch Llagas Creek and Llagas Creek. Approximately 3,900 feet south of Day Road is the confluence of Lions Creek and West Branch Llagas Creek. At this location West Branch Llagas Creek makes a 90-degree bend east towards Monterey Road. The channel continues southeast, paralleling and then crossing Highway 101 and joining Llagas Creek approximately 1340 feet north of Pacheco Pass Road.

Observations of Erosion and Sedimentation. Erosion on West Branch Llagas Creek was observed downstream of road culverts and at locations where the channel makes 90-degree bends. Erosion was also observed as rill and gully formation where runoff from agricultural fields flows overland and into the creek channel. Channel incision was also observed where flows concentrated in the channel without access to a floodplain or increased flow volumes have disrupted the equilibrium of the stream system. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed as finer sediments deposited in channel pools and downstream or downslope of scoured channel banks.

Observations of Riparian Vegetation. Observed vegetation types on West Branch Llagas Creek included grasses, oak, and willow. Overall the vegetation cover on West Branch Llagas Creek (approx. 52,800 feet) is moderate, with approximately 18% of the channel characterized as low vegetation density, and 15% characterized as moderate vegetation density. Approximately 67% of the West Branch Llagas Creek channel was devoid of vegetation.

Based upon qualitative indices, West Branch Creek can generally be characterized as non-functioning (PFC), with a high to very high risk of erosion (BEHI).

4.7.15.2. *Day Creek*

Channel Location and Description. Day Creek originates in the foothills of the Santa Cruz Mountains in Santa Clara County. Day Creek flows in an easterly direction, until its confluence with Lions Creek approximately 200 feet east of Santa Theresa Boulevard and approximately 40 feet south of Day Road. The SCVWD jurisdiction of Day Creek is approximately 3,000 feet west of Santa Theresa Boulevard on Day Road. Observations of Day Creek were limited to public access points along Day Road.

For most of its length Day Creek parallels Day Road. The upper watershed of Day Creek has a low to moderate vegetation density and appears to be an area of historic grazing. Along Day Road, Day Creek resembles a road ditch with no riparian corridor or developed channel geometry. From observations at the time of the survey it appears as though Day Creek is managed as a road ditch; regularly cleared and shaped to conduct runoff from the road and adjacent developments. The channel and banks of the creek were bare and exposed where maintenance had been conducted.

Figure 4.32. Day Creek road ditch on Day Road.

Observations of Erosion and Sedimentation. Erosion on Day Creek was observed at locations where the channel and banks were devoid of vegetation. The channel bed generally consisted of fine to gravel material.

Sedimentation on Day Creek was observed at locations in the channel where bare banks had slumped or eroded.

Observations of Riparian Vegetation. Observed vegetation types on Day Creek included grasses. Overall the vegetation cover on Day Creek (approx. 7,600 feet) is low, with approximately 6% of the channel characterized as moderate vegetation density. Approximately 94% of the Day Creek channel was devoid of vegetation.

Based upon qualitative indices, Day Creek can generally be characterized as non-functioning (PFC), with a high risk of erosion (BEHI).

4.7.15.3. *Lions Creek*

Channel Location and Description. Lions Creek originates in the foothills of the Santa Cruz Mountains in Santa Clara County. Lions Creek flows in a southeasterly direction, until its confluence with West Branch Llagas Creek approximately 1,050 feet east of Wren Avenue. The SCVWD jurisdiction of Lions Creek is approximately 1,200 feet north of Day Road and approximately 1.6 miles west of Santa Theresa Avenue. Observations of Lions Creek were limited to public access points on Lucky Court, Day Road, Geri Lane, Santa Theresa Boulevard and Wren Avenue.

The upper watershed of Lions Creek has a low to moderate vegetation density and appears to be an area of historic grazing. Two in-line reservoirs on Lions Creek were observed in the upper watershed. Towards Day Road, the adjacent land use on Lions Creek transitions from pasture to rural residential developments and row crop agriculture. Adjacent to the residential developments the channel has a high to moderate vegetation density and intact channel sinuosity.

It was observed that Day Road encroached upon the Lions Creek channel, and bank erosion was observed adjacent to the road. Landscape cuttings were also deposited into the channel from a Day Road access point. As the channel continues south the vegetation density decreases and channel incision of approximately one (1) foot was observed. At locations where channel incision was identified bare and vertical, or near vertical, channel banks were observed.

Lions Creek abruptly transitions into a straight engineered and primarily grassed channel approximately 3,800 feet west of Santa Theresa Boulevard. The channel profile resembles the engineered channel on West Branch Llagas Creek to the east, with a low flow channel and adjacent access roads. The general shape of this engineered channel continues until the confluence of Lions Creek with West Branch Llagas Creek approximately 1,050 feet east of Wren Avenue.

Figure 4.33. The engineered Lions Creek channel west of Santa Theresa Boulevard.

South of Day Road approximately 3,325 feet, North and South Morey Channels join Lions Creek and Lions Creek makes a 90-degree bend east. Approximately 3,000 feet further to the east is the confluence of West Branch Llagas Creek and Lions Creek. At the confluence of West Branch Llagas Creek and Lions Creek the channel is heavily armored with rock rip-rap in the channel and on the banks of both creeks.

Observations of Erosion and Sedimentation. Erosion on Lions Creek was observed as channel incision with associated bank failure and bank steepening. Bare and loose soils were also observed adjacent to Day Road. Scour was also observed downstream of culverts. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed as finer sediments deposited amongst in-channel vegetation, and as point bar development in the upper watershed.

Observations of Riparian Vegetation. Observed vegetation types on Lions Creek included grasses, oak, willow, bramble, Arondo Donax, thistle, and ivy. Overall the vegetation cover on Lions Creek (approx. 22,703 feet) is moderate, with approximately 8% of the channel characterized as low vegetation density, 18% characterized as moderate vegetation density, and 10% characterized as high vegetation density. Approximately 64% of the Lions Creek channel was devoid of vegetation.

Based upon qualitative indices, Lions Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a high risk of erosion (BEHI).

4.7.16. North Morey Channel

Channel Location and Description. Water entering North Morey Channel originates in the foothills of the Santa Cruz Mountains in Santa Clara County and from urban developments within the city of Gilroy. North Morey Channel flows in an easterly direction, until its confluence with Lions Creek approximately 1,350 feet east of Santa Theresa Boulevard. The SCVWD Jurisdiction of North Morey Channel is at Santa Theresa Boulevard. Observations of North Morey Channel were limited to public access points on Santa Theresa Boulevard and Hirasaki Avenue.

North Morey Channel is an urban drainage system in the northern portion of the City of Gilroy. The drainage receives runoff from residencies, roads, schools, and parking lots. At the time of the survey portions of the upper watershed were being converted into large residential developments.

The channel is mostly a series of underground pipes, though the channel does surface, east of Santa Theresa Boulevard. The channel at Santa Theresa Boulevard is straight with a characteristic channel geometry (observed on both Lions Creek and West Branch Llagas Creek), which includes a low flow channel, adjacent access roads, and limited development of riparian vegetation.

Observations of Erosion and Sedimentation. No observations of erosion were made on North Morey Channel. The channel bed generally consisted of fine to gravel material.

No observations of sedimentation were made on North Morey Channel.

Observations of Riparian Vegetation. Observed vegetation types on North Morey Channel included grasses and cattail. Overall the vegetation cover on North Morey Channel (approx. 6,175 feet) occurs only in the upper watershed and is moderate, with approximately 31% of the channel characterized as moderate vegetation density, and 8% characterized as well vegetated. Approximately 61% of the North Morey Channel was devoid of vegetation.

Based upon qualitative indices, North Morey Channel can generally be characterized as non-functioning to moderately functioning (PFC), with a high risk of erosion (BEHI).

4.7.17. South Morey Channel

Channel Location and Description. Water entering South Morey Channel originates in the foothills of the Santa Cruz Mountains in Santa Clara County and from urban developments within the city of Gilroy. South Morey Channel flows in an northeasterly direction, until its confluence with Lions Creek approximately 3,300 feet east of Santa Theresa Boulevard. The SCVWD Jurisdiction of South Morey Channel is at Santa Theresa Boulevard. Observations of South Morey Channel were limited to public access points on Santa Theresa Boulevard and Hirasaki Avenue.

South Morey Channel is an urban drainage system in the northern portion of the City of Gilroy. The drainage receives runoff from residencies, roads, schools, and parking lots. At the time of the survey portions of the upper watershed were being converted into large residential developments.

The channel is mostly a series of underground pipes, though the channel does surface, east of Santa Theresa Boulevard. The channel at Santa Theresa Boulevard is straight with a characteristic channel geometry (observed on both Lions Creek and West Branch Llagas Creek), which includes a low flow channel, adjacent access roads, and limited development of riparian vegetation. At the confluence of South Morey Channel and Lions Creek a band of rock rip-rap was placed across the channel and banks.

Figure 4.34. South Morey Channel upstream of the confluence with Lions Creek.

Observations of Erosion and Sedimentation. No observations of erosion were made on South Morey Channel. The channel bed generally consisted of fine to gravel material.

No observations of sedimentation were made on South Morey Channel.

Observations of Riparian Vegetation. Observed vegetation types on South Morey Channel included grasses and cattail. Overall the vegetation cover on South Morey Channel (approx. 7,770 feet) occurs only in the upper watershed and is low, with approximately 4% of the channel characterized as moderate vegetation density. Approximately 96% of the South Morey Channel was devoid of vegetation.

Based upon qualitative indices, South Morey Channel can generally be characterized as non-functioning to moderately functioning (PFC), with a high risk of erosion (BEHI).

4.7.17.1. *Upper Miller Slough*

Channel Location and Description. Upper Miller Slough is an urban drain in the center of the City of Gilroy in the Santa Clara Valley. Upper Miller Slough flows in a southeasterly direction, until its confluence with West Branch Llagas Creek approximately 130 feet west of Highway 101. The SCVWD jurisdiction of Upper Miller Slough begins at Monterey Road approximately 1,800 feet north of IOOF Avenue. Observations of Upper Miller Slough were limited to public access points on Monterey Road, Church Street, Welburn Avenue, Las Animas Veterans Park, Kern Street, IOOF Avenue, Forrestt Avenue, Lewis Avenue, and Roger and Gilman Roads.

Upper Miller Slough originates in a series of active and fallow agricultural lands south of Lions Creek and west of Wren Avenue. Drainage from this area and the surrounding urban developments flow south towards Las Animas Veterans Park. The channel flows through the park in a sinuous low profile channel with occasional pools that have been developed as part of the park landscaping. The vegetation consists primarily of grasses with some channel cattails and mature oaks.

Upper Miller Slough exits the park in the southeast corner and transitions into a straight channel, bordered on both right and left banks by residential developments. Upper Miller Slough crosses Welburn Avenue approximately 725 feet south of Las Animas Veterans Park. At the time of the survey construction was occurring at Upper Miller Slough at Welburn Avenue and Church Street. The construction exposed street storm drains and bare channel banks up and downstream of the bridge. Beyond the zone of construction the channel was grassed with cattails and sedges, with intermittent mature vegetation on the channel banks. The adjacent roads and residential developments encroach upon the channel and riparian corridor of Upper Miller Slough.

Approximately 1,000 feet south of Welburn Avenue, Upper Miller Slough makes a 90-degree bend east and continues straight towards Monterey Road, crossing Church Street. At Monterey Road, Upper Miller Slough crosses beneath a restaurant and then east beneath the Pacific Railroad Line. The restaurant, on the east side of Monterey Road, appears to have been built on pilings over Upper Miller Slough. Trash and a possible homeless dwelling were observed in the channel beneath the restaurant. Portions of Upper Miller Slough upstream of the restaurant were bare and covered with soil, possibly deposited during the construction of an adjacent parking lot. Downstream of Monterey Road, some erosion was observed where parking lot runoff entered the Upper Miller Slough channel and was eroding some of the parking lot built on the bank of the channel.

Figure 4.35. Bank and parking lot erosion east of Monterey Road on Upper Miller Slough.

Upper Miller Slough makes a 90-degree bend east of the railroad tracks and continues for approximately 1,700 feet south to IOOF Avenue. At IOOF Avenue the shape of the channel appears modified and engineered with a low flow channel and bankfull floodplain, similar to modified channel shapes observed on other creeks in the sub-area. This channel shape continues until the confluence with West Branch Llagas Creek west of Highway 101. At the confluence, West Branch Llagas Creek also receives runoff from Highway 101 which collects in a channel on the west side of the highway. The two most common observations on Upper Miller Slough were of trash and encroachment of residential properties on to the creek channel.

Figure 4.36. Encroachment of residential properties on the banks of Upper Miller Slough downstream of Lewis Avenue.

Observations of Erosion and Sedimentation. Erosion on Upper Miller Slough was observed where runoff from adjacent roads and parking lots entered the channel. The channel bed generally consisted of fine to gravel material.

No observations of sedimentation were recorded.

Observations of Riparian Vegetation. Observed vegetation types on Upper Miller Slough included grasses, oak, sedge, cattail, willow, bramble, and ivy. Overall the vegetation cover on Upper Miller Slough (approx. 12,000 feet) is moderate, with approximately 41% of the channel characterized as low vegetation density and 6% characterized as moderate vegetation density. Approximately 53% of Upper Miller Slough was devoid of vegetation.

Based upon qualitative indices, Upper Miller Slough can generally be characterized as non-functioning to moderately functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.18. <u>Live Oak Sub-Area</u>

The Live Oak sub-area includes Live Oak Creek and its smaller tributaries. In general, land use in the region primarily consists of rangeland in the upper portion of the sub-area and mixed residential and agricultural land use in the valley. The extent of the riparian corridor diminishes on Live Oak Creek towards the bottom of the sub-area, adjacent to agriculture, and in some portions of the upper rangelands.

4.7.18.1. *Live Oak Creek*

Channel Location and Description. Live Oak Creek originates in the Diablo Mountain Range and progresses into the southern portion of the valley until its confluence with Llagas Creek, west of New Avenue, east of Marcella Avenue, north of Leavesley Avenue, and south of Roop Road. Observations of Live Oak Creek were limited to access points along Roop Road and New Road.

The upper Live Oak watershed is mostly well vegetated with established mature vegetation. In the upper watershed west of Leavesley Road, the creek channel is bordered by Roop Road to the north and an old ranch or mining road to the south. The creek channel has bare steep banks in some locations, adjacent to both of these roads. At some locations adjacent to Roop Road, sheet flow from the road has created rill and gully features on the channel banks. The channel banks also show signs of grazing, either currently or historically.

Figure 4.37. Location where runoff from Roop Road enters Live Oak Creek.

The lower watershed, in the foothills of the Diablo Mountain Range is currently or was historically used as rangeland for animal grazing. The banks are grassed, with little to no diversity in vegetation species or vegetation height. Slumped banks were observed where animals directly accessed the creek channel. Some mature oak trees, intermittently spaced, exist adjacent to the channel. Further into the valley, residential developments encroach into the stream corridor, and in a couple of locations private roads cross the creek. From observation points, it appears the channel is incising as a result of the encroachment of residential development. The channel deepening decreases the chances of water accessing the floodplain in events other than extreme flood flows.

Closer to the confluence of Live Oak Creek with Llagas Creek the oak trees adjacent to the channel and in the floodplain are replaced with eucalyptus trees. In one location at New Road one section of the channel bank was treated with herbicide and the larger vegetation felled. The bank material, a sandy gravel, was bare and exposed adjacent to a residential parking lot and bank slumping was observed. This bank condition was sharply contrasted with conditions on the opposite bank that had not been treated with herbicide; the bank had mature oaks, grasses, ivy and shrubbery. Cement debris and trash were also observed in this and other portions of the Live Oak channel.

Observations of Erosion and Sedimentation. Erosion on Live Oak Creek was observed adjacent to residential developments, adjacent to paved roads, and in areas used for animal grazing, specifically where animals directly access the creek channel. Erosion as channel incision was observed at locations where residential developments on the floodplain encroach on the creek channel. Rills and gullies were observed adjacent to Roop Road in the upper porting of the Live Oak watershed. Rills and gullies form as water concentrates and sheet flows across Roop Road and into Live Oak Creek. These features displace soil and have the potential to destabilize portions of the channel banks. The channel bed generally consisted of fine to gravel material.

Observations of Riparian Vegetation. Observed vegetation types on Live Oak Creek included oak, willow, eucalyptus, and grasses. Overall the vegetation distribution on Live Oak Creek (approx. 17,720 feet) is good, with approximately 17% of the channel characterized as low vegetation density, 13% characterized as moderate vegetation density, 31% characterized with a high vegetation density. The vegetation density was lowest at locations where the channel and floodplain were exposed to animal grazing; at these locations the channel has low species and height diversity, consisting mostly of short grasses.

Based upon qualitative indices, Live Oak Creek can generally be characterized as moderately functioning (PFC), with a high risk of erosion (BEHI).

4.7.19. Lower Uvas Creek Sub-Area

The Lower Uvas Creek sub-area includes Solis Creek, Sycamore Creek, Burchell Creek, and Uvas Creek below Uvas Reservoir. The creeks in the sub-area are generally well vegetated in their upper portions with decreasing vegetation density adjacent to roads and developments. Erosion was observed adjacent to roads, at access points, and where vegetation had been removed from the channel.

4.7.19.1. *Solis Creek*

Channel Location and Description. Solis Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Solis Creek flows in a northerly direction, until its confluence with Uvas Creek approximately 500 feet below Uvas Reservoir, north of Uvas Road. Observations of Solis Creek were limited to public access points at Uvas Road and Kell Road. Visibility from Uvas Road was poor therefore observations were only taken at Kell Road and from the aerial photography.

At Kell Road, approximately 800 feet upstream of the confluence of Solis Creek with Uvas Creek, the riparian corridor and stream system appear intact, with very good surface cover and SRA. Disturbed soils were observed at access points, and at a location downstream of the road culvert where a scour pool had developed. Downstream of Kell Road, it appeared that a pasture was encroaching into the creek channel.

Observations of Erosion and Sedimentation. Erosion on Solis Creek was observed at locations where stream access was possible, and where scour below a road culvert accelerated the erosion on a downstream bank. The exposed bank had some recovery species though the bank angle was near vertical. The channel bed generally appeared armored with coarse gravels and cobbles with substrate materials consisting of fine to cobble material.

Sedimentation was observed as point bar development and in finer sediments deposited in channel pools.

Figure 4.38. A view of Solis Creek taken upstream of Kell Road.

Observations of Riparian Vegetation. Observed vegetation types on Solis Creek included grasses, bramble, oak, willow, and maple. Overall the vegetation distribution on Solis Creek (approx. 6,330 feet) is excellent, with approximately 100% of the channel characterized as high vegetation density.

Based upon qualitative indices, Solis Creek can generally be characterized as properly functioning (PFC), with a low to moderate risk of erosion (BEHI).

4.7.19.2. *Sycamore Creek*

Channel Location and Description. Sycamore Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Sycamore Creek flows in a southerly direction, until its confluence with Uvas Creek south of Uvas Road and north of Heritage Way. The SCVWD jurisdiction of Sycamore Creek is approximately 125 feet south of Sycamore Avenue and west of Watsonville Road. Observations of Sycamore Creek were limited to public access points at Uvas Road, Chaparral Avenue, and along Sycamore Avenue.

In the upper watershed, Sycamore Creek flows southeasterly towards Sycamore Avenue. In this stretch, the creek is moderately to well vegetated with vegetation density alternating between high and low in relationship to proximity to rural residential developments. At Sycamore Avenue the channel turns south and parallels the road for approximately 2,750 feet. The condition of Sycamore Creek along Sycamore Avenue is variable, depending mostly on the various management strategies of landowners adjacent to the road. For example, at some locations the channel has been cleared of vegetation and the channel geometry modified for drainage or the creation of water features. Other examples of the creek condition include, the construction of cobble and concrete debris lined channel banks, concrete lining of the channel, or animal grazing in and adjacent to the creek. Other portions of the channel appear relatively undisturbed other than that caused by the proximity to the road.

Figure 4.39. A view of Sycamore Creek taken at a site adjacent to Sycamore Avenue.

Approximately 2,400 feet southeast of Sycamore Avenue, Sycamore Creek crosses Chaparral Avenue. At Chaparral Avenue the banks are moderately to well vegetated with intact SRA. Disturbed soils were observed at access points, some possibly associated with historic animal access locations. The land adjacent to Sycamore Creek and the Sycamore Creek floodplain appear to be recently converted residential properties, which in some locations encroach upon the Sycamore Creek channel.

South of Chaparral Avenue, approximately 2,620 feet, Sycamore Creek crosses Uvas Road. The vegetation density decreases from Chaparral Avenue towards Uvas Road, and south of Uvas Road a low vegetation density was observed. South of Uvas Road Sycamore Creek enters a property used primarily for vines and winery facilities. At this location the channel vegetation appears regularly managed by mowing and some herbicide use. A retaining wall, designed to protect the riverbank and direct flow, was also observed at this location with significant erosion observed in the transition area between the retaining wall and adjacent soils. Approximately 1,340 feet downstream of Uvas Road is the confluence of Sycamore Creek with Uvas Creek.

Observations of Erosion and Sedimentation. Erosion on Sycamore Creek was observed adjacent to residential developments, where animals accessed the channel, and where bare banks had failed. In the upper portion of Sycamore Creek adjacent to Sycamore Avenue channel modification in some locations created easily erodible bare banks. Also in the vicinity of Sycamore Avenue, animal grazing in and adjacent to the channel had caused a depletion of channel vegetation combined with bank slumping caused by the weight and movement of the animals. The channel bed generally appeared armored with coarse gravels with substrate materials consisting of fine to gravel material.

Sedimentation was observed as point bar development and in finer sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Sycamore Creek included bramble, ivy, oak, grasses, thistle, african violets, and jubata grass. Overall the vegetation distribution on Sycamore Creek (approx. 12,460 feet) is very good, with approximately 17% of the channel characterized as low vegetation density, 28% characterized as moderate vegetation density, and 45% characterized as high vegetation density.

Based upon qualitative indices, Sycamore Creek can generally be characterized as properly functioning to moderately functioning (PFC), with a high risk of erosion (BEHI).

4.7.19.3. *Burchell Creek*

Channel Location and Description. Burchell Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Burchell Creek flows in a southerly direction, until its confluence with Uvas Creek south of Burchell Road, north of Highway 152, and upstream of the confluence of Bodfish Creek with Uvas Creek. The SCVWD jurisdiction of Burchell Creek is approximately 2,500 feet north of Burchell Road. Observations of Burchell Creek were limited to public access points along Burchell Road.

The upper watershed of Burchell Creek is primarily rangelands, and the animals appear to have unlimited access to the creek channel. The resulting channel geometry is typical for those with animal access. The vegetation in this reach, generally north of Burchell Road, has a low to moderate vegetation density, and one in-stream water impoundment was identified on the aerial photograph.

Burchell Creek crosses Burchell Road in three locations. At the northern most of these locations the creek enters a rural residential development and the channel has been channelized around property boundaries. Vegetation along the upstream creek channel has been removed and the banks are loose and bare. Downstream of this location the vegetation cover returns. At this location encroachment of adjacent land use (animal pasture and residential) to the channel was observed.

Burchell Creek crosses Burchell Road a second time, approximately 850 feet southeast of the first crossing. At this location the vegetation in the upstream channel has a low density and the channel geometry appears to have been modified, likely when the adjacent properties were developed and the channel redirected. East of Burchell Road at this location the creek reenters lands connected to the upland pasture. The channel banks at these locations are significantly diminished because of animal access. Algal growth was observed at all locations with standing water.

Burchell Creek enters a reservoir approximately 2,050 feet southeast of the second Burchell Road crossing, and approximately 375 feet southeast of the reservoir Burchell Creek crosses Burchell Road for a third time. At this location the vegetation density was high and the road appeared to be restricting channel migration and contributing some material from the road shoulder into the channel. Towards to the confluence with Uvas Creek the channel appears moderately to well vegetated.

Observations of Erosion and Sedimentation. Erosion on Burchell Creek was observed where runoff from private driveways entered the channel over bare slopes. General channel erosion and degradation was observed adjacent to property used for animal grazing. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed as point bar development and in finer sediments deposited in channel pools.

Observations of Riparian Vegetation. Observed vegetation types on Burchell Creek included bramble, ivy, willow, grasses, and oak. Overall the vegetation distribution on Burchell Creek (approx. 11,660 feet) is good, with approximately 22% of the channel characterized as low vegetation density, 33% characterized as moderate vegetation density, and 4% characterized as high vegetation density.

Based upon qualitative indices, Burchell Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a low to moderate risk of erosion (BEHI).

4.7.19.4. *Uvas Creek*

Channel Location and Description. The section of Uvas Creek in the Lower Uvas Creek sub-area begins below Uvas Reservoir. Uvas Creek flows in a southeasterly direction until its confluence with the Pajaro River approximately 2,000 feet east of Highway 101 and the Southern Pacific Railroad. The SCVWD Jurisdiction of Uvas Creek is upstream of the Lower Uvas Creek sub-area, and the exact location is unknown. Observations of Uvas Creek in the Lower Uvas Creek sub-area were limited to public access points on Watsonville Road and Heritage Way along with views from the aerial photography.

Downstream of Uvas Reservoir the land use adjacent to Uvas Creek, on the Uvas Creek floodplain, is primarily residential and agricultural. The extent of the riparian corridor is not at its potential extent as a result of this land use encroachment. However, the channel is well vegetated with a high vegetation density. Bank erosion was observed where vegetation had been removed from the channel as part of residential landscaping.

Observations of Erosion and Sedimentation. Erosion on Uvas Creek in the Lower Uvas Creek sub-area was observed riparian vegetation had been removed as part of residential landscaping.

Sedimentation was observed as finer sediments deposited amongst in-channel vegetation, and as point bar development.

Observations of Riparian Vegetation. Observed vegetation types on Uvas Creek in the Lower Uvas Creek sub-area included willow, oak, grass, *Arondo donax*, bramble, and ivy. Overall the vegetation distribution on Uvas Creek in the Lower Uvas Creek sub-area (approx. 30,100 feet) is very good, with approximately 100% characterized as high vegetation density.

Based upon qualitative indices, Uvas Creek can generally be characterized as proper to moderately functioning (PFC), with a moderate to low risk of erosion (BEHI).

4.7.20. Jones Sub-Area

The Jones sub-area includes Jones Creek, Alamias Creek, Dexter Creek, Crews Creek and their smaller unnamed tributaries. In general, land use in the region primarily consists of rangeland in the upper portion of the sub-area and mixed residential and agricultural land use in the valley. The impacted portions of the creeks in the sub-area occur adjacent to agricultural lands in the lower portion of the sub-area, in these areas the creeks are channelized and a majority devoid of vegetation. Erosion was observed where water from adjacent fields or roads entered these modified channels.

4.7.20.1. *Alamias Creek*

Channel Location and Description. Alamias Creek originates in the Diablo Mountain Range and progresses into the valley. Observations of Alamias Creek were limited to access points along Leavesley Road, Crews Road, and Ferguson Road. Towards the Santa Clara Valley the channel vegetation and sinuosity decrease where the creek is adjacent to agricultural fields and commercial greenhouses. At the confluence of Alamias Creek with Jones Creek the channel is devoid of vegetation and straight.

In the upper watershed of Alamias Creek, below the reservoir, the vegetation density is high and consists mostly of oak trees, willow, grasses, malva, thistle, ivy, and bramble. Shaded riverine aquatic (SRA) habitat in this reach is present. In this section the channel has maintained its sinuosity and access to the floodplain in some locations. Cobbles in this section also contribute to a sequence of pool-riffle features in the channel. Upstream of Crews Road an abandoned in-stream water impoundment was identified. The impoundment appeared to be open and water was not accumulating behind it.

In the lower reaches of Alamias Creek, the encroachment of agriculture, commercial greenhouses, and rural residential development has limited the movement of the creek and diminished the vegetation canopy. Where various land uses have encroached on the floodplain, the concentration of flows in the channel has caused approximately one foot of channel incision. At other locations, where development has encroached on the channel, bank failure and slumping was observed.

West of Ferguson Road the channel is between row crop fields and Leavesley Road. In this section, of approximately 2,000 feet of stream channel, a majority of the vegetation has been cleared from the channel and in some locations the channel geometry appears modified. The confluence of Alamias Creek and Jones Creek occurs below this 2,000-foot section of cleared vegetation, south of Leavesley Road and West of Ferguson Road.

Figure 4.40. Jones Creek south of Leavesley Road.

Observations of Erosion and Sedimentation. Erosion on Alamias Creek was observed in scour pools below road culverts, as channel incision, and localized bank failure. Scour pools were identified downstream of culverts where high volume, and high velocity water discharging from the culvert scoured and transported downstream. Localized bank failure was observed where channel incision created oversteepened banks and where runoff from roads destabilized bank soils. The channel bed generally consisted of fine to gravel material.

Some areas of sedimentation were observed adjacent to slumped banks, where sediments had deposited at the base of, or adjacent to, the area of disturbed soil.

Observations of Riparian Vegetation. Observed vegetation types on Alamias Creek included oak trees, willow, grasses, malva, thistle, ivy, and bramble. The vegetation density decreases as the channel moves from the Diablo Mountain Range into the southern portion of Santa Clara Valley. Overall the vegetation distribution on Alamias Creek (approx. 18,160 feet) is very good, with approximately 3% of the channel characterized as low vegetation density, 24% characterized as moderate vegetation density, 56% characterized with a high vegetation density.

Based upon qualitative indices, Alamias Creek can generally be characterized as moderately functioning (PFC), with a high risk of erosion (BEHI).

4.7.20.2. *Crews Creek*

Channel Location and Description. Crews Creek originates in the Diablo Mountain Range and progresses into the valley. The upper watershed is well vegetated and the vegetation density of the channel decreases towards the valley and the confluence of Crews Creek and Jones Creek. The land use along Crews Creek consists mostly of agricultural, equestrian and rural residential developments.

At locations where the creek is adjacent to rural residential developments, beginning at Crews Road, the density of larger woody vegetation adjacent to the channel begins to decrease. At these locations vertical or near vertical banks were observed and concrete rubble, yard waste, and other debris has been placed on the banks and in the channel. At these locations with vertical or near vertical banks, bank slumping was also observed. The sinuosity in this section, west and north of Crew Road, is fairly continuous and vegetation includes oak, willow, pine, thistle, grasses and bramble.

South of Crews Road, Crews Creek enters an animal pasture. The creek channel appears mostly bare with some short grasses. The animals have unrestricted access to the channel, which bisects the pasture. The effects of this channel access included; low angle banks where animals cross the channel, vertical bare banks where the channel has incised and the channel banks have slumped, and a low vegetation diversity. Vegetation includes oak trees in and adjacent to the channel as well as a mixture of grasses with a minimum of residual biomass. Sinuosity in this reach matches that expected in the landscape setting.

Figure 4.41. An equine pasture on Crews Creek south of Crews Road.

Downstream of the pasture, Crews Creek parallels land used primarily for row crop agriculture. The vegetation density thins and disappears as the channel progresses southeast towards Pacheco Pass Road. The sinuosity of the channel also decreases and eventually diminishes into a straightened channel adjacent to row crop fields. Crews Creek enters a culvert beneath Pacheco Pass/Ferguson

Road. Crews Creek continues in the culvert until its confluence with Jones Creek approximately 1,450 feet east of Pacheco Pass/Ferguson Road, parallel to Pacheco Pass Road.

Observations of Erosion and Sedimentation. Erosion on Crews Creek was observed adjacent to vertical or near vertical banks where soils had slumped into the channel. Where animal access was observed, the channel and banks of Crews Creek were eroded as a result of animal traffic across the channel. The erosion included both channel incision and bank slumping. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed downslope and downstream of bank failures. Limited sedimentation was also observed downstream of road culverts.

Observations of Riparian Vegetation. Observed vegetation types on Crews Creek included oak, willow, pine, thistle, grasses and bramble. The vegetation density decreases as the channel moves from the Diablo Mountain Range into the southern portion of Santa Clara Valley. The lowest and eventual elimination of vegetation on Crews Creek occurs west of Pacheco Pass Road adjacent to agricultural fields. Vegetation density on Crews Creek is also diminished where the creek passes through an equestrian pasture. Overall the vegetation distribution on Crews Creek (approx. 15,770 feet) is moderate, with approximately 17% of the channel characterized as low vegetation density, 14% characterized as moderate vegetation density, 14% characterized with a high vegetation density. Approximately 55% of the Crews Creek channel was devoid of vegetation.

Based upon qualitative indices, Crews Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.20.3. *Dexter Creek*

Channel Location and Description. Dexter Creek originates in the valley, west of Jones Creek and east of Llagas Creek. Observations of Dexter Creek were limited to an access point on Pacheco Pass Road and views from and aerial photo of Santa Clara Valley. Dexter Creek originates as a series of agricultural ditches to the north of Pacheco Pass Road. These ditches, which are mostly bare of bank and channel vegetation, continue to the south of Pacheco Pass Road. Dexter Creek joins Jones Creek approximately 5,435 feet south of Pacheco Pass Road.

The entire length of Dexter Creek, approximately 7,940 feet, has mostly bare banks and channel. The floodplain consists mostly of agricultural fields with access roads adjacent to the channel above the right and left channel banks. The entire length of the channel appears to have an engineered and regularly maintained channel geometry. The bare soils on the bank and channel had evidence of rill and gully erosion where water from adjacent fields was either conducted into the channel via tailwater ditches, or via overland flow across the access roads. Erosion was also observed where road ditches from Pacheco Pass Road entered the Dexter Creek channel. Other debris and trash was also observed in Dexter Creek from Pacheco Pass Road.

Figure 4.42. Dexter Creek south of Pacheco Pass Road.

Observations of Erosion and Sedimentation. Erosion on Dexter Creek was observed along the channel where water from adjacent fields enters the channel. Water enters the channel either via tailwater ditches or from adjacent access roads. At these locations, concentrated flows appear to form rill and gully erosion in the channel. Erosion was also observed at points adjacent to Pacheco Pass Road where road ditches, or runoff from the road, enters the channel. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed in Dexter Creek above and below the bridge crossing at Pacheco Pass Road. It appears that sediments from the Pacheco Pass Road ditch and from the upstream agricultural fields deposit at this location.

Observations of Riparian Vegetation. Observed vegetation types on Dexter Creek included only grasses. The vegetation density was consistently absent along the entire channel reach and all observed channel sections had bare and exposed soils. Overall the vegetation distribution on Dexter Creek (approx. 7,940 feet) is low. Approximately 100% of the Dexter Creek channel was devoid of vegetation.

Based upon qualitative indices, Dexter Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a very high to extreme risk of erosion (BEHI). If more visual access to Dexter Creek were possible, the characterization would likely change because of the extent the riparian corridor has diminished.

4.7.20.4. *Jones Creek*

Channel Location and Description. Jones Creek begins south of Leavesley Road, where Alamias Creek changes its direction of flow from westerly to southerly. Observations of Jones Creek were limited to public access points on Leavesley Road, Dunlap Road, Furlong Avenue, Pacheco Pass Road, Frazier Lake Road and Bloomfield Avenue.

Jones Creek is adjacent to predominantly row crop fields along its entire length until the confluence of Jones Creek and Llagas Creek north of Bloomfield Avenue. The channel has been straightened and channelized around fields and roads along most of its length. In some locations it also appears the channel geometry has been modified and is maintained, or re-shaped, regularly. The vegetation distribution on Jones Creek is variable, and in some locations the channel is devoid of vegetation.

Figure 4.43. Jones Creek in a modified channel adjacent to row crop agriculture.

The SCVWD has plans for a channel realignment of Alamias and Jones Creek, which includes extending Alamias Creek to Llagas Creek, south of Leavesley Road. This channel modification would remove the existing Jones Creek channel south of Leavesley Road and north of Dunlap Road. These changes to the channel geometry and location could alter the observed sedimentation and erosion patterns within the existing channel.

Observations of Erosion and Sedimentation. Erosion on Jones Creek was observed adjacent to agricultural fields and roads. Erosion adjacent to fields occurs at locations where tail and stormwater runoff drains from fields or adjacent farm roads enter the channel. No substantial rill or gully formations were observed at the time of this survey, though the bare bank and loose soil conditions seemed likely to erode when high flows occurred. At one location it appears the channel profile of Jones Creek had been eroded as a result of agricultural practices and a redirection of flow west of

Frazier Lake Road and north of Bloomfield Avenue. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed where in channel vegetation, such as reeds and cattails were present to slow flows, allowing for sediment deposition.

Observations of Riparian Vegetation. Observed vegetation types on Jones Creek included cattails, reeds, grasses and willow. Overall the vegetation distribution on Jones Creek (approx. 25,550 feet) is moderate, with approximately 25% of the channel characterized as low vegetation density, 8% characterized as moderate vegetation density, and 1% characterized as high vegetation density. Approximately 66% of the Jones Creek channel was devoid of vegetation.

Based upon qualitative indices, Jones Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a very high to extreme risk of erosion (BEHI).

4.7.21. San Ysidro Sub-Area

The San Ysidro sub-area includes San Ysidro Creek and its smaller tributaries. In general land use in the region primarily consists of rangeland in the upper portion of the watershed and agricultural land use in the valley. The rangelands in the upper portion of the sub-area are mostly well vegetated with decreasing vegetation density and sinuosity towards the valley. The creek is channelized with a low vegetation density, or devoid of vegetation, adjacent to agricultural lands.

4.7.21.1. *San Ysidro Creek*

Channel Location and Description. San Ysidro Creek originates in the Diablo Mountain Range and progresses into the valley. Observations of San Ysidro Creek were limited access points on and along Canada Road, and at Pacheo Pass Road. The upper watershed is well vegetated and the vegetation density of the channel decreases towards the valley and the confluence of San Ysidro Creek and Jones Creek. The land use along San Ysidro Creek consists mostly of rangeland and rural residential developments in the upper watershed and agricultural and rural residential developments in the lower watershed.

San Ysidro Creek parallels Canada Road for one mile. In this stretch the channel stays within a canyon that is well vegetated with some bare banks associated with channel downcutting and runoff from Canada Road. The channel appears to be disturbed adjacent to rural residential developments where channel modifications have been made or access to the channel is possible.

San Ysidro Creek in southern Santa Clara Valley crosses to the south of Canada Road and enters land primarily used for grapes and row crop. Downstream and south of Canada Road, the density of vegetation along the creek and the channel sinuosity decrease. The confluence of San Ysidro Creek and Jones Creek occurs in an agricultural setting. A farm road crosses San Ysidro Creek approximately 15 feet upstream of the confluence, at which point both channels have no established riparian vegetation and the creek banks are mostly bare and appear to be regularly cleared.

Figure 4.44. San Ysidro Creek in a modified channel adjacent to row crop agriculture.

Observations of Erosion and Sedimentation. Erosion on San Ysidro Creek was observed adjacent to agricultural fields, roads, and rural residential developments. Erosion in the vicinity of agricultural fields occurred at locations where drainage from fields or adjacent farm roads entered the channel. No substantial rill or gully formations were observed at the time of this survey, though the bare bank and loose soil conditions seemed likely to erode when high flows occurred. At locations where rural residential developments encroached upon San Ysidro Creek hydromodifications made to the creek channel were observed. At one location these resulted in bare and steep banks adjacent to the property. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed where channel slopes decreased with changes in landscape setting and where in-channel vegetation, such as reeds and cattails, were present to slow flows, allowing for sediment deposition.

Observations of Riparian Vegetation. Observed vegetation types on San Ysidro Creek included grasses, oak, willow, bramble, ivy, and iceplant. Overall the vegetation distribution on San Ysidro Creek (approx. 18,650 feet) is very good, with approximately 7% of the channel characterized as low vegetation density, 31% characterized as moderate vegetation density, 38% characterized with a high vegetation density.

Based upon qualitative indices, San Ysidro Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.22. Pajaro Sub-Area

The Pajaro sub-area includes the Pajaro River and Millers Canal. The sub-area is primarily rangelands in the upper portion of the sub-area and agricultural lands towards the valley. The sub-area also includes San Felipe Lake, a reservoir from which both the Pajaro River and Millers Canal originate. The water from San Felipe Lake is channelized into the Pajaro River and Miller Canal. These channelized systems are impacted by grazing adjacent to the channel or where tail and storm drains enter from adjacent fields.

4.7.22.1. *Pajaro River*

Channel Location and Description. The current configuration of the Pajaro River originates in agricultural fields southwest of the intersection of Bloomfield Avenue and Pacheco Pass Road and continues to the confluence with Llagas Creek. Observations of the Pajaro River were limited to Frazier Lake Road and views from aerial photography.

Water enters the Pajaro River channel via a release from San Felipe Lake, the remnant of Soap Lake, the historic flooding area with its eastern boundary at Chittenden Pass. The land use adjacent to the Pajaro River channel is primarily agricultural, and field drains enter the channel in numerous locations west of Frazier Lake Road and east of San Felipe Lake. The Pajaro River channel is mostly bare or grassed above Frazier Lake Road with cattle having riparian access in some sections. The vegetation density and diversity increase towards the confluence of Llagas Creek with the Pajaro River, approximately 4,000 feet east of Frazier Lake Road. The channel appears to have been straightened east of Frazier Lake Road and in some reaches west of Frazier Lake Road.

Figure 4.45. The Pajaro River at the Southern Pacific Railroad tressel, south of the confluence with Llagas Creek.

Observations of Erosion and Sedimentation. Erosion was observed on the Pajaro River where tail and storm drains entered the channel banks, creating localized rill and gully formations. The channel bed generally consisted of fine to gravel material.

Evidence of sedimentation was not observed at the time of the survey, though if more visual access were possible sedimentation would likely be observed.

Observations of Riparian Vegetation. Observed vegetation types on the Pajaro River includes grass, willow, bramble, sedge, cattail, and oak. Overall the vegetation distribution on the Pajaro River (approx. 19,460 feet) is low, with approximately 7% of the channel characterized as low vegetation density, 8% characterized as moderate vegetation density, 1% well vegetated. Approximately 84% of the Pajaro River channel down to the confluence with Llagas Creek was devoid of vegetation.

Based upon qualitative indices, the Pajaro River can generally be characterized as non-functioning to moderately functioning (PFC), with a high to very high risk of erosion (BEHI).

4.7.22.2. *Millers Canal*

Channel Location and Description. Water enters Millers Canal channel via a release from San Felipe Lake, the remnant of Soap Lake, and continues to the confluence with the Pajaro River south of Llagas Creek. Observations of Miller Canal were limited to Frazier Lake Road and views from aerial photography.

The land use adjacent to the Millers Canal channel is primarily agricultural, and field drains enter the channel in numerous locations west of Frazier Lake Road and east of San Felipe Lake. The Miller Canal channel is mostly bare or grassed above Frazier Lake Road. The vegetation density and diversity increase towards the confluence of the Pajaro River with Millers Canal, approximately 7,250 feet east of Frazier Lake Road. Millers Canal is a manmade channel, the entire length of which is straight with a consistent channel shape approximately 60 feet wide with bank slopes of approximately 60 degrees.

Figure 4.46. Water draining into Millers Canal via tail and stormwater drains.

Observations of Erosion and Sedimentation. Erosion was observed on the Pajaro River where tail and stormwater drains entered the channel banks, creating localized rill and gully formations. The channel bed generally consisted of fine to gravel material.

No observations of sedimentation were recorded at the time of the survey, though if more visual access were possible sedimentation would likely be observed.

Observations of Riparian Vegetation. Observed vegetation types on Millers Canal include grass, willow, bramble, sedge, cattail, and oak. Overall the vegetation distribution on Millers Canal (approx. 19,460 feet) is moderate, with approximately 40% of the channel characterized as low vegetation density and 2% characterized as moderate vegetation density. Approximately 58% of the Millers Canal channel was devoid of vegetation.

Based upon qualitative indices Millers Canal can generally be characterized as non-functioning to moderately functioning (PFC), with a high to very high risk of erosion (BEHI).

4.7.23. Lower Llagas Creek Sub-Area

The Lower Llagas Creek sub-area includes Princevalle Drain, Lower Miller Slough, Ronan Channel, and Llagas Creek. Princevalle Drain, Lower Miller Slough, and Ronan Channel are best described as urban storm channels originating from the City of Gilroy. The channel had low to moderate vegetation densities and some locations of bank failure were observed. Llagas Creek in the Lower Llagas Creek sub-area has been heavily modified; both the channel geometry and the flow regime have been altered. As a result the system is in disequilibrium and channel erosion was observed, particularly where the extent of vegetation was managed and/or cleared.

4.7.23.1. *Princevalle Drain*

Channel Location and Description. Princevalle Drain originates in the central portion of the City of Gilroy in southern Santa Clara County. Princevalle Drain flows in an easterly direction, until its confluence with Lower Miller Slough approximately 4,000 feet upstream of the confluence of Lower Miller Slough with Llagas Creek. The SCVWD Jurisdiction of Princevalle Drain begins along Princevalle Street, east of the Gilroy High School, and south of Tenth Street. Observations of Princevalle Drain were limited to public access points at and along Princevalle Street, Rosana Drive, Church Street, Monterey Road, and Chestnut Avenue.

Princevalle Drain is the outlet for a network of urban storm drains that surface in the Princevalle Drain channel downstream of Princevalle Street, east if Gilroy High School. Princevalle Drain continues in a straight channel for approximately 2,675 feet east of Princevalle Street to Monterey Highway, crossing Rosana Avenue, and Church Street. The channel description along this reach is relatively uniform. Princevalle Drain is an urban stream channel primarily used as a storm drain for adjacent residential developments in south Gilroy.

The channel is encroached upon by residential developments and is regularly maintained to maximize flow conveyance. The bank vegetation is regularly cut and at the time of the survey in-channel vegetation, cattails and grasses were thriving within the creek channel, though these are likely cut once a year as part of routine channel maintenance. Concrete sandbags had also been placed in some locations along the channel, to reinforce banks, particularly downstream of culverts and concentrated storm flows from storm drains, which periodically enter the channel. Algal growth on Princevalle Drain was observed at all locations with standing water.

Figure 4.47. A view of Princevalle Drain taken downstream of Princevalle Street.

The channel geometry resembles a v-ditch with an elevated and maintained access road adjacent to Princevalle Drain along most of the channel length. At Monterey Road rip-rap has been placed on channel banks. A portion of the rip-rap has slumped into the channel and is accumulating at the entrance to the downstream culvert. The exposed banks appear loose and susceptible to erosion. The vegetation in Princevalle Drain does not have the root mass capable of withstanding erosion from high flow events.

Figure 4.48. Riprap slumping into Princevalle Drain upstream of Monterey Highway.

East of Monterey Highway, Princvalle Drain crosses the Southern Pacific Railroad and then Chestnut Street and Highway 101. Scattered emergent oak, walnut, and willow trees were observed between the railroad and the highway. East of Highway 101, Princevalle Drain passes through a strip of industrial/commercial land and then parallels agricultural fields. Approximately 4,650 feet east of Highway 101, Princevalle Drain enters Lower Miller Slough.

Observations of Erosion and Sedimentation. Erosion on Princevalle Drain was primarily observed as slumping of soils on channel banks. The channel banks have very limited vegetation, with extent of riparian vegetation limited by adjacent land use and maintenance. Banks also appear unstable in some locations, possibly due to the high volume, flashy flows contributed to the channel via the adjacent urban properties. The channel bed generally consisted of fine to gravel material, with large cobble riprap.

Sedimentation was observed as finer sediments deposited amongst in-channel vegetation.

Observations of Riparian Vegetation. Observed vegetation types on Princevalle Drain included grasses, cattails, oak, willow, and walnut. Overall the vegetation cover on Princevalle Drain (approx. 8,890 feet) is good, with approximately 77% of the channel characterized as low vegetation density.

Based upon qualitative indices, Princevalle Drain can generally be characterized as non-functioning (PFC), with a high risk of erosion (BEHI).

4.7.23.2. *Lower Miller Slough*

Channel Location and Description. Lower Miller Slough originates in the southern portion of Santa Clara County. Lower Miller Slough flows in a southereasterly direction, until its confluence with Llagas Creek approximately 4,700 feet south of Pacheco Pass Road. The SCVWD jurisdiction of Lower Miller Slough is approximately 565 feet south of Pacheco Pass Road. Observations of Lower Miller Slough were limited to public access points along an access road paralleling the channel.

Lower Miller Slough begins south of Pacheco Pass Road, receiving runoff from the road and adjacent industrial and commercial properties. The channel and banks are mostly grassed with interspersed larger shrubery. Approximately 2,000 feet south of Pacheco Pass Road is the confluence of Princevalle Drain and Lower Miller Slough. At the time of the survey the channel vegetation at the confluence, and in the channel downstream of Princevalle Drain, had evidence of high volume, high velocity flows. The channel receives water from the City of Gilroy and both the east and west sides of Highway 101, areas transitioning from agricultural to commercial land use. Agricultural drainpipes enter the channel at a couple of locations, and localized rill and gully formations were observed where overland flow entered and the channel. Bank slumping was also observed along the Lower Miller Slough Channel. The channel is leveed and channelized and access to the floodplain from Lower Miller Slough is prevented.

Figure 4.49. Bank slumping on Lower Miller Slough channel.

Observations of Erosion and Sedimentation. Erosion on Lower Miller Slough was observed as channel incision and rill and gully formations on channel banks. The channel banks have very limited vegetation likely limited by adjacent land use and maintenance. The channel bed generally consisted of sand to gravel material.

Sedimentation was observed in Lower Miller Slough downslope of bank erosion and amongst in channel vegetation and debris.

Observations of Riparian Vegetation. Observed vegetation types on Lower Miller Slough included grasses, willow, and black walnut. Overall the vegetation cover on Lower Miller Slough (approx. 5,755 feet) is good, with approximately 65% of the channel characterized as low vegetation density.

Based upon qualitative indices, Lower Miller Slough can generally be characterized as non-functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.23.3. *Llagas Creek*

Channel Location and Description. Llagas Creek in the Lower Llagas Creek sub-area begins south of the confluence of East Little Llagas Creek and Llagas Creek. Llagas Creek flows in a southerly direction, until its confluence with the Pajaro River approximately 4,680 feet south of Bloomfield Avenue. The SCVWD jurisdiction of Llagas Creek is unknown. Observations of Llagas Creek were limited to access points on Bloomfield Avenue, Pacheco Pass Road, Gilman Avenue, Holsclaw Road, Leavesley Road, Buena Vista Avenue, Rucker Avenue and Masten Avenue.

Above the confluence of Llagas Creek and the Pajaro River, Llagas Creek is channelized in an approximately 200 feet wide channel adjacent to agricultural fields. The channel has approximately 10 foot high levee roads on each channel bank. In this reach of Llagas Creek the channel is very well vegetated with a 3-foot wide sinuous low flow channel with in-channel sedges and intermittent flow.

Riparian vegetation in the channel is well established, with a diversity of species and canopy heights in most locations. Observed vegetation included sedges, willows, oaks, *Arondo donax*, fennel, walnut and star thistle. Riparian vegetation appears adequate to provide adequate SRA. Algae cover was also observed in pools of standing water, evidence of eutrophication in the riparian system.

A quarter of a mile upstream of Bloomfield Avenue on Llagas Creek the levee/channel banks are covered with rip-rap with a cement anchor down to the channel bottom where a fish ladder is installed. The creek is devoid of vegetation other than in the channel bottom. A similar riprap fish ladder structure is located approximately 1.2 miles upstream of Bloomfield Avenue. At this site begins a series of managed percolation ponds, adjacent to the channel, and downstream of this site water enters Llagas Creek from an adjacent property. At this location is a well-developed pond that appears to receive regular flows from the treatment facility. The pond was easily accessed from a road down to the pond, around which was scattered various trash and debris. Upstream of both the pond and the fish ladder the riparian vegetation is well established and dense.

Approximately 1.5 miles upstream from Bloomfield Avenue is the confluence of Ronan Channel and Llagas Creek. Upstream of the confluence it appears that in-stream weirs have been built to create a pool riffle sequence downstream of the third fish ladder observed in the channel. A fourth fish ladder was observed approximately 400 feet downstream of Pacheco Pass Road.

Figure 4.50. One of four fish ladders in Llagas Creek south of Pacheco Pass Road.

At the location of the fourth fish ladder the vegetation density in Llagas Creek decreases from high to low, with no SRA cover. North of Pacheco Pass Road the Llagas Creek channel is grassed and the vegetation appears regularly maintained. At the time of the survey a crew of workers was clearing emergent woody vegetation, primarily willows, from the channel and banks. The cut vegetation was cut into smaller segments and dispersed across the channel.

A sinuous low flow channel was observed within a larger engineered and leveed Llagas Creek channel. The low flow channel had evidence of incision, a possible indication the channel is attempting to reestablish a equilibrium geometry.

At the confluence of Llagas Creek and West Branch Llagas Creek, approximately 1,400 feet north of Pacheco Pass Road, a large debris bar had developed between the two channels. The debris bar included woody vegetation, sediment, and trash. It also appeared that a knick-point was moving up the West Brach Llagas Creek channel from Llagas Creek. The knick-point has created localized incision, and riprap had been placed in a downstream scour pool in an attempt to prevent further erosion.

Approximately 300 feet upstream of West Branch Llagas Creek, a fifth fish ladder was identified in the Llagas Creek channel. At this location vegetation in the channel was only observed where riprap did not cover the channel and banks. A low flow channel had been created downstream of the ladder, within a larger pool that appeared to be an area of sediment accumulation. Upstream of the fish ladder the channel had signs of incision, up to three feet, with near vertical channel banks. Bank slumping was observed for approximately 300 feet upstream of the fish ladder. Where vegetation had not yet been cleared from the channel and banks, cottonwood, willow, and maple species were observed.

Figure 4.51. Examples of the nine fish ladders, with the sculpted low flow channel, in Llagas Creek north of Pacheco Pass Road.

The engineered channel north of Pacheco Pass Road and south of Buena Vista Avenue continues with a total of nine fish ladders. Each with similar attributes as those described at the first fish ladder. Downstream of some of the fish ladders equipment has been used to shape a low flow channel in the sediments that have accumulated downstream of the fish ladders. The resulting low flow channel is devoid of vegetation and appears loose and at risk of erosion. The channel has some sinuosity and an access road adjacent to the low flow channel appears in some sections of the creek. Riprap has been placed in the channel and on channel banks in some locations.

Figure 4.52. Example of engineered Llagas Creek channel with low flow channel, access road, and riprap on channel banks.

North of Buena Vista Avenue the channel shape transitions from the engineered channel into what appears to be a 'natural' channel geometry with levees built onto the channel banks. The channel has established eucalyptus vegetation providing a low to moderate vegetation density north to Masten Avenue. Channel incision between one and three feet was observed on the channel banks, which are vertical at some locations.

At the time of the survey a motorbike trail was observed within the main channel and concrete, riprap, and other debris were identified in the channel from current and historic land use. North of Rucker Avenue a paintball park was also located, with paintball debris and other paraphernalia deposited in the channel.

Observations of Erosion and Sedimentation. Erosion on Llagas Creek in the Lower Llagas Creek sub-area was observed as channel incision and bank erosion. Both current and historic land managers have extensively modified the channel. The channel geometry has been altered and fish ladders positioned in the channel at various locations. The channel system does not appear to have an established equilibrium with the new channel geometry. The channel system has also been modified by increased flow volumes received from tributaries and from increases to adjacent impervious surfaces. As a result of these hydromodifications to the Llagas Crek channel the system is vulnerable to erosion. The channel bed is generally armored with gravels with substrate consisting of fine to gravel material.

Sedimentation was observed upstream of road crossings, adjacent to in-channel vegetation and in standing pools of water. Depositional areas were also observed on the inside of meander bends.

Observations of Riparian Vegetation. Observed vegetation types on Llagas Creek included sedges, willows, oaks, eucalyptus, *Arondo donax*, fennel, walnut and star thistle. South of Pacheco Pass Road to the Pajaro River, Llagas Creek is very well vegetated, with decreasing vegetation density north towards Buena Vista Avenue from Pacheco Pass Road. At Buena Vista Avenue the channel vegetation consists mostly of eucalyptus trees with a low to moderate vegetation density continuing north towards Masten Avenue. Overall the vegetation cover on Llagas Creek (approx. 50,700 feet) is good, with approximately 25% of the channel characterized as low vegetation density, 3% characterized as moderate vegetation density, and 32% characterized as high vegetation density.

Based upon qualitative indices, Llagas Creek in the Lower Llagas Creek sub-area can generally be characterized as non-functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.24. Uvas Carnaderos Sub-Area

The Uvas Carnaderos sub-area includes Uvas Creek, Gavilan Creek, Farman Creek, Tick Creek and Babbs Creek. The general land use in the upper watershed of the Uvas Carnaderos sub-area is open space or rangeland with residential and agricultural land towards the valley. Gavilan, Farman, Tick and Babbs Creek are well vegetated in their upper reaches, with decreasing vegetation density in the lower valley where the creeks are adjacent to agriculture and urban areas. Erosion on these creeks was identified where water entered the channel from agricultural drains, where urban developments increased runoff volumes, or where vegetation was removed from channel banks or floodplain. Uvas Creek is well vegetated throughout most of the sub-area with erosion occurring in some locations where vegetation has been removed or channel modifications forced the system out of equilibrium.

4.7.24.1. *Uvas Creek*

Channel Location and Description. The section of Uvas Creek in the Uvas Carnaderos sub-area begins southeast of the confluence of Bodfish Creek and Uvas Creek. Uvas Creek flows in a southeasterly direction until its confluence with the Pajaro River approximately 2,000 feet east of Highway 101 and the Southern Pacific Railroad track. Observations of Uvas Creek in the Uvas Carnaderos sub-area were limited to public access points on Highway 152, Santa Theresa Boulevard, Christmas Hill Park, West Luchessa Road, along Bolsa Road, and at Bloomfield Avenue.

At Highway 152, approximately 1,230 feet downstream of Bodfish Creek, Uvas Creek has a moderate to low vegetation density. The vegetation primarily consists of *Arondo donax*, willow and grass, which provides a limited extent of bank vegetation and shaded riverine aquatic habitat. The channel appears to have a low flow and bankfull channel that are regularly overtopped by flood flows, though levee development prevents flows from regularly accessing the floodplain terrace.

Approximately 8,800 feet southeast of Highway 152, Uvas Creek crosses Santa Theresa Boulevard. At Santa Theresa Boulevard the channel width is four to five times wider than the channel at Highway 152. Some sections of the channel in this reach are braided and others have a sinuous and well-established low flow channel migrating within the boundaries of the channel levees. Where the low flow channel has migrated to the levee boundaries, bank erosion was observed. The SRA is low to moderate in this reach and the bank vegetation was not developed to its possible extent.

Uvas Creek enters Christmas Hill Park approximately 5,200 feet downstream of Santa Theresa Boulevard. The creek passes beneath Miller Avenue via multiple in-stream culverts. The road has a very low profile and in high flows is inundated. The channel in Christmas Hill Park showed signs of bank erosion, and vertical or near vertical banks devoid of vegetation were observed at numerous locations. The vegetation density, similar to upstream locations, is moderate to low.

Approximately 5,000 feet southeast of Christmas Hill Park Uvas Creek crosses West Luchessa Road. At West Luchessa Road, the channel geometry and vegetation has been heavily modified with riprap on both channel banks, up and downstream of West Luchessa Road. The riprap prevents the growth of vegetation on the banks, and as a result the riparian corridor is discontinuous where riprap has been installed. A low flow channel exists in the channel at this location, and showed signs of incision at the time this survey was conducted.

Figure 4.53. Riprap and low flow channel observed on Uvas Creek upstream of West Luchessa Avenue.

Uvas Creek continues southeast for another 11,400 feet to Highway 101, in a sinuous channel adjacent through agricultural fields. The channel is leveed and well vegetated along this reach. Downstream of Highway 101, Bolsa Road parallels Uvas Creek, and the channel is well vegetated with a deep channel geometry. At Bloomfield Avenue and along Bolsa Road bare channel banks were observed where adjacent land uses encroached upon the channel and developed levee system. Uvas Creek continues in a well vegetated and leveed channel for approximately 3.2 miles (17,000 feet) until the confluence of Uvas Creek and the Pajaro River.

Observations of Erosion and Sedimentation. Erosion on Uvas Creek in the Uvas Carnaderos sub-area was observed where migration of the creek channel was eroding into levees and/or channel banks. Bank erosion was also observed where vegetation cover and density was reduced because of access or management. The channel bed generally appeared armored with coarse gravels and cobbles with substrate materials consisting of fine to cobble material.

Sedimentation was observed as finer sediments deposited amongst in-channel vegetation, and as point bar development in the upper watershed. Sedimentation was also observed at one location, on the inside of a meander bend.

Observations of Riparian Vegetation. Observed vegetation types on Uvas Creek in the Uvas Carnaderos sub-area included willow, oak, grass, *Arondo donax*, bramble, and ivy. Overall the vegetation distribution on Uvas Creek in the Uvas Carnaderos sub-area (approx. 57,500 feet) is good, with approximately 26% of the channel characterized as low vegetation density, 34% characterized as moderate vegetation density, and 39% characterized as high vegetation density.

Based upon qualitative indices, Uvas Creek can generally be characterized as moderately to properly functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.24.2. *Tick Creek*

Channel Location and Description. Tick Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Tick Creek flows in an easterly direction, crossing Old Monterey Road and Highway 101. Tick Creek is a tributary to Carnedero Creek, and the confluence of the two occurs approximately 5,500 feet southeast of where Tick Creek crosses Highway 101. The SCVWD Jurisdiction of Tick Creek is unknown. Observations of Tick Creek were limited to public access points on Old Monterey Highway and Highway 101.

The upper portions of the Tick Creek watershed are densely vegetated. Below this vegetated reach, in the foothills of the Santa Cruz Mountains towards the valley and adjacent to the creek are rangelands. Where animals access Tick Creek the channel is shallow and narrow and the vegetation density and diversity are low. The vegetation in this reach of Tick Creek primarily consists of grasses and provides no shaded riverine aquatic habitat. The sinuosity of the channel upstream of Old Monterey Highway appears to match that expected for the geomorphic setting.

Figure 4.54. Tick Creek west (upstream) of Old Monterey Highway.

Downstream of the Old Monterey Highway the channel elevation drops approximately ten feet from the upstream channel elevation. As a result of this apparently recent elevation change and channel erosion, a concrete apron below the road culvert has eroded and fallen into the channel. At the time of the survey standing water in the downstream channel was exposed to direct sunlight, and contained dense algal mats.

East of the Old Monterey Highway and Highway 101, Tick Creek parallels row crop fields. The channel in this reach has been straightened in some locations, while at others the channel maintains a sinuosity and vegetation density expected for the valley stream. At locations where the encroachment of agricultural fields has impacted Tick Creek, the channel has steep banks with failing vegetation.

Observations of Erosion and Sedimentation. Erosion on Tick Creek was observed on rangelands and adjacent to agricultural fields and roads. In areas used for animal grazing, specifically where cattle directly access the creek channel, bank slumping was observed. On Tick Creek, the result of this channel access was a very low profile creek channel, approximately one foot deep and 3.5 feet wide. At the Old Monterey Highway, concentrated flows beneath the road have damaged and incised the downstream channel. The incision, in combination with the removal of riparian vegetation adjacent to agricultural fields and levee development, has caused bank steepening, the destabilization of remaining vegetation, and bank failure. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed downstream of bank failure where soil had fallen into the channel and accumulated.

Observations of Riparian Vegetation. Observed vegetation types on Tick Creek include grasses, willow, and fennel. Overall the vegetation distribution on Tick Creek (approx. 17,700 feet) is moderate, with approximately 21% of the channel characterized as low vegetation density, 12% characterized as moderate vegetation density, and 34% of the channel characterized as high vegetation density.

Based upon qualitative indices, Tick Creek can generally be characterized as non-functioning (PFC), with a moderate to high risk of erosion (BEHI).

4.7.24.3. *Farman Creek*

Channel Location and Description. Farman Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Farman Creek flows in an easterly direction, parallel to Castro Valley Road and crossing Santa Theresa Boulevard. Farman Creek is a tributary to Gavilan Creek, and the confluence of the two occurs east of Santa Theresa Boulevard, west of Highway 101 and just north of Castro Valley Road. Observations of Farman Creek were limited to public access points on Santa Theresa Boulevard and views from the aerial photography.

The upper watershed of Farman Creek is very densely vegetated. In the foothills of the Santa Cruz Mountains, Farman Creek flows adjacent to a rural residential development and into an in-stream reservoir. Below the reservoir Farman Creek passes through a golf course and then beneath Santa Theresa Boulevard and into Gavilan Creek. The portion of the creek in the golf course is almost indiscernible from the golf course landscaping. The channel profile is very low and the vegetation consists mostly of grass with intermittent stands of large woody vegetation.

Figure 4.55. Farman Creek in the golf course west (upstream) of Santa Theresa Boulevard.

Observations of Erosion and Sedimentation. Due to limited visual access observations of erosion and sedimentation on Farman Creek were not recorded.

Observations of Riparian Vegetation. Observed vegetation types on Farman Creek included grass and oak. Overall the vegetation distribution on Farman Creek (approx. 8,130 feet) is moderate to good, with approximately 3% of the channel characterized as low vegetation density, 18% characterized as moderate vegetation density, and 50% characterized as high vegetation density.

Based upon qualitative indices, Farman Creek can generally be characterized as moderately functioning (PFC), with a low to moderate risk of erosion (BEHI).

4.7.24.4. *Gavilan Creek*

Channel Location and Description. Gavilan Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Gavilan Creek flows in an easterly direction, parallel to Santa Theresa Boulevard until it passes beneath Highway 101 and eventually joins Carnaderos Creek. The confluence of Gavilan Creek and Carnaderos Creek occurs approximately 8,850 feet downstream of where Gavilan Creek passes under Highway 101. Observations of Gavilan Creek were limited to public access points at Mesa Road, Santa Theresa Boulevard, Castro Valley Road, and Highway 101.

The upper watershed of Gavilan Creek is well vegetated. In the foothills of the Santa Cruz Mountains, Gavilan Creek enters an urban development between Gavilan College and a residential area. The development has encroached upon the channel and the vegetation density decreases in this reach. Larger woody vegetation remains directly adjacent to the channel, though smaller intermediate height vegetation is absent. Gavilan Creek in this area also shows signs of channel deepening, possibly caused by higher flows resulting from increasesed impervious surfaces and runoff voulumes associated with residential development.

East of Santa Theresa Boulevard, Gavilan Creek passes through an infrequently used agricultural field. At this location the channel has incised approximately five feet and the banks are bare and vertical or near vertical in most locations throughout this approximately 460 feet stretch. Gavilan Creek then passes south beneath Mesa Road and begins a very well vegetated stretch of the creek, approximately 2,560 feet long. The adjacent land use in this reach is primarily row crop agriculture planted in the creek floodplain.

Below this stretch of creek the channel runs parallel to Santa Theresa Boulevard and bisects fields used for cultivation of row and tree crops. The vegetation has been removed and the banks appear bare in most locations. Gavilan Creek passes south beneath Castro Valley Road, and vegetation on the banks was primarily grasses and shrubs with occasional large woody vegetation. The vegetation density south of Castro Valley Road is not as dense as was observed south of Mesa Road.

Figure 4.56. Gavilan Creek transitioning between a well vegetated and poorly vegetated section, east of Santa Theresa Boulevard.

Gavilan Creek passess southeasterly beneath Highway 101 through a concrete box culvert. Downstream of Highway 101, trash and other debris were observed in a modified and straightened channel. Concrete rubble was placed in the channel at some locations, possibly as an attempt to prevent channel erosion or the lateral migration of the channel into adjacent row crop fields. Vegetation downstream of Highway 101 was intermittent and where present consisted mostly of grasses and other shrubs.

Gavilan Creek parallels Highway 101 and row crop fields, flowing south for approximately 1,970 feet, then turns east and bisects row crop fields. The straightened channel passes beneath railroad tracks approximately 2,100 feet east of Highway 101, and appears to be mostly bare of vegetation for approximately 4,700 feet. Approximately 2,325 feet upstream of the confluence of Gavilan Creek with Carnaderos Creek the vegetation increases to a low density with intermittent SRA cover.

Where Gavilan Creek parallels or is adjacent to agricultural fields, ditches and field drains have been constructed to conduct tail water away from fields and into the creek channel. These drains connect laterally to the main channel, and most appear well established with grass and other shrub vegetation. However, the source water that was observed entering these lateral channels was laden with sediment leaving fields.

Observations of Erosion and Sedimentation. Erosion on Gavilan Creek was observed adjacent to agricultural fields and urban developments. Erosion on Gavilan Creek was observed adjacent to urban developments as channel incision and bank failure. This erosion is likely caused by the combination of increased flow volumes and a decrease in vegetation that stabilizes bank material and prevents erosion and bank failure from occurring. Erosion was observed adjacent to agricultural fields where vegetation had been removed and soils appeared to be bare and loose. The channel bed generally consisted of fine to gravel material.

Sedimentation was observed adjacent to and downstream of urban development where sediments collected downstream of bank slumps. Sedimentation was also observed adjacent to some field drains, where water had slowed and sediments deposited.

Observations of Riparian Vegetation. Observed vegetation types on Gavilan Creek included oak, grasses, willow, fennel, mustard, and sedges. Overall the vegetation distribution on Gavilan Creek (approx. 21,710 feet) is good, with approximately 26% of the channel characterized as low vegetation density, 5% characterized as moderate vegetation density, and 21% characterized as high vegetation density.

Based upon qualitative indices, Gavilan Creek can generally be characterized as non-functioning (PFC), with a high to very high risk of erosion (BEHI).

4.7.24.5. *Babbs Creek*

Channel Location and Description. Babbs Creek originates on the eastern side of the Santa Cruz Mountains in Santa Clara County. Babbs Creek flows in an easterly direction, until its confluence with Uvas Creek east of Thomas Road, west of Highway 101, north of Mesa Road, and south of Luchessa Avenue. Observations of Babbs Creek were limited to public access points at Millers Avenue, Santa Theresa Boulevard, Babbs Creek Road, and Thomas Road.

The upper watershed of Babbs Creek is very well vegetated. The land adjacent to Babbs Creek at Miller Avenue, is used as animal pasture. In some locations equine access to the creek is permitted, though these occurrences are localized and appear to have generated minimal in-stream impacts at the time the survey was conducted. Downstream of Miller Avenue, west of Santa Theresa Boulevard and adjacent to the pastures is one in-stream reservoir on Babbs Creek. Another off-stream reservoir is located to the south of the Babbs Creek channel, west of Santa Theresa Boulevard.

Approximately 235 feet upstream of Santa Theresa Boulevard, Babbs Creek transitions from a well-vegetated riparian corridor into a channelized, rip-rap lined channel parallel to Santa Theresa Boulevard. In this section the vegetation density is low. Downstream of Santa Theresa Boulevard, the sinuosity and vegetation density of Babbs Creek appear to increase to between low and moderate levels. The land directly east of Santa Theresa Boulevard appears to be an abandoned orchard that is setback approximately 35 feet from the Babbs Creek channel. East of the orchard Babbs Creek enters an urban development, likely recently converted from row or tree crops. Babbs Creek bisects this urban area and is maintained as "Babbs Creek Park Preserve". The houses in the neighborhood are set back from the channel, instead trails and roads parallel the channel. The set back between the channel and the adjacent land use has allowed the establishment of channel and riparian vegetation.

Vegetation in Babbs Creek Park Preserve varies in density and type. Young oak trees have been planted on the floodplain as part of the park revegetation effort and a variety of exotic species appear in the channel and the banks. Large cobbles and boulders have also been placed in the channel at some locations, specifically downstream of urban stormwater outfalls.

Figure 4.57. Babbs Creek in the Babbs Creek Park Preserve where young oak trees have been planted on the channel banks and riprap has been placed downstream of stormwater outfalls.

The channel in Babbs Creek Park Preserve showed evidence of channel incision and is more than ten feet below the elevation of the adjacent road surface, the floodplain is therefore rarely accessed and as a result the majority of high flows are concentrated within the channel. The channel had no obvious bankfull channel, implying the channel is in disequilibrium with its increased inputs (from stormwater outfalls) and the channel geometry.

Downstream of the Babbs Creek Park Preserve drainage enters a large cobble lined detention basin before entering the downstream channel, east of Thomas Road. East of Thomas Road, the creek parallels row crop fields for approximately 1655 feet upstream of the confluence of Babbs Creek and Carnaderos Creek. The channel in this reach has been cleared and modified in some locations. Mature oak trees exist, though the surface vegetation has been removed.

Observations of Erosion and Sedimentation. Erosion on Babbs Creek was observed as channel downcutting and rill and gully formations adjacent to agricultural fields. Increased runoff, likely associated with increases in impervious surfaces in combination with limited access to the channel floodplain, has generated channel incision. The channel deepens as a result of concentrated flows with high erosive energy contained within the creek channel. Localized rill and gully formations were observed adjacent to agricultural fields where vegetation was removed from the creek banks. The channel bed generally consisted of fine to cobble material.

Point bar development, a form of in-channel sedimentation was observed downstream of Miller Avenue. Sedimentation was observed at Millers Avenue where in channel vegetation, such as reeds and cattails were present to slow flows, allowing for sediment deposition. During the dry season, sedimentation was also observed where loose soils from bare banks had eroded into the channel and deposited on the channel bottom and lower banks. It is likely that these sediments are flushed out of the channel during the wet season.

Observations of Riparian Vegetation. Observed vegetation types on Babbs Creek included oak, bramble, grasses, ivy, thistle, accacia and willow. Overall the vegetation distribution on Babbs Creek (approx. 10,650 feet) is moderate to good, with approximately 7% of the channel characterized as low vegetation density, 28% characterized as moderate vegetation density, and 54% characterized as high vegetation density.

Based upon qualitative indices, Babbs Creek can generally be characterized as non-functioning to moderately functioning (PFC), with a high to very high risk of erosion (BEHI).

4.8. Hydromodification

Hydromodification is defined as the change in runoff characteristics caused by changes in land use conditions. Most land use changes (agriculture, grazing, forestry, residential and commercial development) result in hydromodification. These land use changes generally have the effect of modifying natural stream and watershed processes by 'altering the terrain, modifying the vegetation and soil characteristics, introducing pavement and buildings, and installing drainage and flood control infrastructure, and altering the condition of stream channels through straightening, deepening, smoothing and sometimes armoring'.[13]

Within the study area the principal land uses, current and historical agriculture and urbanization have altered stream and watershed processes. The result of these modifications has changed the equilibrium of these systems and as a result the streams must adjust to balance altered sediment loads, grain size distribution, stream discharge, and channel slope.

Uvas and Llagas Creeks show varying extents of hydromodification and states of equilibrium or disequilibrium originating from current and past land use. Beginning in the 19th century the lands in southern Santa Clara Valley changed from primarily natural lands to agriculture. This land use conversion ignited an era of channel hydromodification as water was diverted from streams, and levees and other flood control projects were constructed to prevent flooding of farms and settlements in the valley.

The current location of San Felipe Lake is a remnant of a larger lake, Soap Lake, which formed seasonally above Chittenden Pass in the Santa Cruz Mountains back towards the Diablo Mountain Range and San Felipe Lake. Upstream flood control projects, channel hydromodifications, and the conversion of lands in Soap Lake to agriculture uses have altered the historic flooding, lake, and wetland conditions at the confluence of San Ysidro, Llagas, and Uvas Creeks with the Pajaro River. These channels have been realigned or levees built adjacent to the modifiedchannels to prevent high flows from overtopping banks. Historic maps of Santa Clara County indicate that San Ysidro Creek was once a tributary to the Pajaro River though it is currently a tributary to Jones Creek. These maps also detail Uvas Creek emptying into 'Willow Swamp' before entering the Pajaro River, though currently that swamp system does not exist and the channel connects directly to the Pajaro. As urbanization and agriculture intensity increased, the effects of these and other hydromodifications include; increased inputs to stream systems associated with increased impervious surfaces which cause alterations to flow regimes to flashy, high volume flows, and the alteration of channels which includes the removal of vegetation, straightening, levee development and channel realignment.

The construction of Uvas Reservoir, in the upper Uvas Carnaderos Creek watershed, and Chesbro Reservoir, in the upper Llagas Creek watershed are examples of large scale hydromodifications that have altered the flow and sediment regimes in these creeks. In the last approximately 50 years the land use changes in the Uvas Carnaderos system have been less dramatic than in the Llagas system and the realease of water from Uvas Reservoir is also more consistent then from Chesbro Reservoir. As a result the Uvas Carnaderos Creek system has established a more stable equilibrium condition than the Llagas Creek system.

[13] GeoSyntec Consultants, "Hydromodification Management Plan Literature Review", Santa Clara Valley Urban Runoff Pollution Prevention Plan, September 2002.

5. LAND USE ASSESSMENT

5.1. Land Use and Sediment Source Summary

The land use analysis was produced using a mixture of existing land use data bases, combined with ground-based and aerial photo truthing. The focus was on developing a current quantification of the amount of agricultural land and its distribution throughout the study area. This reflects the project's emphasis on agricultural land use as the RWQCB has determined that agriculture is the predominant non-point contaminant source in the Central Coast Region. A further step involved the development of a crop system category that provided a very coarse, yet useful means to estimate the sediment risk potential in each sub-area.

A similar ground- and aerial photo truthing for more robust estimates of urban and residential land use was not possible due to time limitations. Rangeland area analysis by ground-based truthing was not feasible due to limitations of access required to survey private lands. Similarly, a quantification of equine lots and boarding facilities and their area extent would also have required a similarly significant effort and therefore is discussed only quite generally in this section.

Table 5.1 provides a broad overview of land use in the study area. The two major watersheds have slightly differing characters, largely related to topography and proximity to Highway 101, the major 'development corridor". The Llagas Creek watershed has the larger portion of developed land, related to the Cities of Morgan Hill and Gilroy and the San Martin community. While the differences in the percentage of land in agriculture is not as great, the actual agricultural land area in the Llagas Creek watershed is almost three times that of the Uvas-Carnadeross watershed. In both watersheds the foothill and mountain lands still have a large percentage of potential rangeland.

Table 5.1. Land Use in the Llagas and Uvas-Carnadeross Creek Watersheds

Watershed	Acreage	Developed	Agric.	Range
Llagas Creek	79,769	17,704	11,746	34,594
(% of area)		(22.2)	(14.7)	(43.4)
Uvas-Carnadeross Creek	49,305	1,414	4,115	24,824
(% of area)		(2.9)	(8.3)	(50.3)
TOTAL STUDY AREA	**129,074**	**19,118**	**15,851**	**59,418**

Table 5.2 provides an overview of land use based on four Regions within the study area, defined in Section 2.4. The Upper West Basin Region has the largest area extent, as well as, the major portion of rangelands. Development and agriculture represent a small portion of land uses in this region. The North Valley Region is the most developed (Morgan Hill), and as a result the land areas utilized for grazing and agriculture comprise a smaller portion of the total land area. The Mid-Valley Region has a similar distribution of land use as the North Valley Region, where developed lands (Gilroy and San Martin) dominate. Finally, the South Valley Region is the least developed region in the valley floor, and supports the bulk of the agricultural land in the study area, along with a number of larger intact ranches.

Table 5.2. Land Use in the Study Area Regions

Study Area Region	Acreage	Developed	Agric.	Range
Upper West Basin Region	49,100	158	478	28,371
(% of area)		(0.3)	(1.0)	(58.8)
North Valley Region	22,694	8,684	2,194	7,468
(% of area)		(38.3)	(9.7)	(32.9)
Mid-Valley Region	22,197	6,927	2,172	8,423
(% of area)		(31.2)	(9.8)	(37.9)
South Valley Region	35,093	3,386	11,262	15,157
(% of area)		(9.6)	(32.1)	(43.2)
TOTAL STUDY AREA	**129,074**	**19,118**	**15,851**	**59,418**

5.1.1. Sediment Sources in Study Area Regions

The following generally summarizes the important sediment sources in the four study area regions.

Upper West Basin Region. The region historically yields significant quantities of sediment from natural or non-controllable sources. Due to limited development and a small number of lower risk agricultural sources, there are only localized sedimentation problems due to controllable sources. Rangeland sources are typically related to roads, riparian access and grazing, rather than over grazing of large areas. Agricultural sources are localized in one sub-area, but limited row crop acreage likely contributes significantly less sediment than other valley regions. There will continue to be increased rural residential development in the upper watershed and this will be one area to focus efforts at minimizing future sediment sources and loading.

North Valley Region. The increasingly developed areas in the North Valley Region are likely significant sediment sources due to impacts on in-stream process and destabilization of banks and channels. Rangeland sources appear to comprise a very small percentage of controllable sources. However, as these areas continue to be converted to multi-home development or are incorporated into larger residential parcels, substantial erosion problems may result without major improvement to drainage infrastructure. Agricultural sources related to row crop production are significant in a few sub-areas due to a number of management related factors and past hydromodifications that are controllable with specific practices.

Mid-Valley Region. The eastern hill developments, as well as, older rural residential developments and their network of drains and road ditches account for important and extensive, rather than locally intensive sediment sources. Additionally, the concentration of small and large equine lots and boarding facilities are likely contributors to increased sediment loading. Agricultural lands on the west side of the region are also significant source areas. Generally problems related to rangelands are localized, and likely account for the least significant controllable sources.

South Valley Region. Despite its location in the relatively flat, low-lying areas, the predominance of agricultural land uses, particularly for sprinkler-irrigated row crop production systems that may generate tailwater and stormwater runoff, make the sediment sources in this region important. Recent and historic hydromodifications related to soil drainage requirements in these contiguous agricultural parcels also contribute to sediment loading. Extensive removal and disturbance of riparian vegetation are particularly important in the lower sub-areas of the Llagas and Uvas-Carnadeross systems. Increased urban runoff introduces significant flow volumes and energy that have impacted channel stability, but can effectively transport significant quantities of accumulated sediments downstream. Rangelands, though accounting for a large percentage of the land area do not appear to be significant sediment sources.

Table 5.3 summarizes the importance of sediment sources by land use categories in all of the study sub-areas

Table 5.3. Land Use Sediment Sources by Study Area Regions and Sub-areas

Upper West Basin Region	**Agric.**	**Range**	**Urban**	**Rural**	**Eques.**
Blackhawk	○	○	○	○	N
Bodfish	◉	○	○	○	○
Chesbro Reservoir	○	○	○	○	○
Little Arthur	○	○	○	○	◉
Little Uvas	○	○	○	○	○
Upper Uvas	○	○	○	○	◉
Upper Llagas	○	○	○	○	○
Uvas Reservoir	○	○	○	○	N
North Valley Region					
Little Llagas	○	○	●	◉	○
Madrone	○	○	○	◉	○
Tennant	◉	○	◉	◉	◉
Corralitos	◉	◉	○	◉	◉
Middle Llagas	○	○	◉	◉	◉
San Martin	○	○	○	◉	◉
Mid-Valley Region					
Church	○	○	○	◉	●
Rucker-Skillet	○	◉	○	◉	●
Live Oak	○	◉	○	○	◉
West Branch Llagas	●	○	●	◉	○
Panther	◉	○	○	◉	◉
Lower Uvas	◉	◉	○	◉	◉
South Valley Region					
Jones	●	○	○	◉	◉
San Ysidro	●	○	○	○	○
Pajaro	◉	◉	○	○	○
Lower Llagas	●	○	○	○	○
Uvas-Carnadeross	●	○	◉	○	○
Wildcat	○	○	○	○	○

○ = Low ◉ = Medium ● = High N = Not accessible

5.2. Summary of Conclusions

The results of the stream and land use leads to these general conclusions concerning sediment sources and problems in the study area.

1- Rangelands are the dominant land use in the study area and therefore, are a large portion of the natural or non-controllable sediment sources in the study.

2- Controllable sources of sedimentation from rangelands, comprising a large portion of the Upper West Basin are localized, and do not appear make a significant contribution to current sediment loads.

3- Agricultural sediment sources are numerous, however agricultural lands comprises only 12.5 percent of the land area and many fields and orchards do not have any direct connection to stream channels.

4 – Agricultural sediment sources are most significant in the South Valley Region where the largest acreage of row cropland is located. The majority of the sprinkler and surface-irrigated croplands occur in large contiguous parcels often with direct connection to channels.

5 – Past hydromodifications, including currently maintained agricultural drainage ditches, in the lowest-lying portions of the South Valley Region are important sediment source locations.

6 – In addition to riparian encroachment and vegetation removal, increased runoff volumes and velocities related to development in the valley and foothill areas, appear to be significant causes of channel and bank instability.

7 – Urban and rural development in the North Valley Region, particularly recent developments in the western foothills outside of Morgan Hill have increased flow volumes and sediment loads.

8- Equestrian and small animal lot impacts are significant sources in sub-areas where concentration and proximity to ephemeral creeks and other drainage ditches coincide.

9 – Erosion of road shoulders and ditches are important localized sources of sediment.

5.3. Historical Land Uses

The earliest known inhabitants in the study area were the Ohlone Indians who lived as hunter-gatherers until the arrival of the Spanish in the 1700s. Two later Spanish land grants, the Las Animas and the San Ysidro, and many subsequent Mexican land grants divided the study area into large ranches. Following the Gold Rush period, many people arrived in the study area and established diversified farming communities and economies. In 1850 the town of Gilroy was a stagecoach stop on the Monterey Road route to San Jose.

Until the 1950's the economy and land uses in the study area were dominated by agriculture and agricultural processing, while primary crops changed constantly in relation to markets and new immigrant arrivals. Even today, Gilroy Foods and Christopher Ranch remain the City of Gilroy's largest private employers (City of Gilroy, 2002). In the mid-19th century hay and grain crops were economically dominant, followed briefly by tobacco in the 1870's, then dairy and cheese in the 1870s. Late in the century orchard and row crops were planted on the divided large land parcels. Into the 20th century the City of Gilroy was alternately known as the Prune, then Garlic Capital of California.

As the northern portion of Santa Clara County grew in the post-WW II years and Highway 101 was completed in the early 1970's, the agricultural sector began to diminish in importance. The growth of the technology industry and influence of San Jose and South Bay Area has rapidly decreased the lands, infrastructure, and agricultural 'environment' in the study area. The City of Morgan Hill's population was 5,579 in 1970, but the number of residents more than tripled to 17,076 persons in 1980. Since 1990, Morgan Hill's population has increased at an average annual rate of 2.5% . The City of Gilroy's first General Plan in 1968 projected a 1985 planning population of 70,000 (actual was 27,000 in that year). By 1999 the State estimate for Gilroy was 39,050.

5.2.1. <u>Recent Trends in Land Use Conversion</u>

In the late 20th century, agricultural and rangelands continued to be converted at a significant rate to urban and residential uses. With this development, it is clear that there has been increased impact on the functioning of creeks and other related drainage infrastructure. Increased development (sic. impervious surfaces) has led to increased runoff volumes and energy in stream channels. Increased development in the foothill and hillside regions further increases the velocities and volumes of drainage waters that, to date, have typically been conveyed into natural and modified channels. The Cities of Morgan Hill and Gilroy have expanded their 'sphere of influence' that also reduces the viability of agricultural operations due to conflicts between these land uses.

As well the structure and markets in agriculture are undergoing rapid change, leading to consolidation by larger farming companies (as evident in the South Region) and increasingly smaller operations owned by recent foreign immigrants to the study area. More intensive agricultural practices are being employed today than in the past such that more recent hydromodifcations and other agricultural drainage practices can both decrease and increase the amount of tail and stormwater runoff and sediment conveyance into surface waters.

5.4. Land Use Analysis Methodology

The initial scope of work emphasized the potential contributions of agricultural land use to sediment loads in the study area, therefore a more intensive focus was placed on accurately quantifying the active agricultural land areas. Prior experience with a database maintained by the California Department of Conservation (CDC) and review of other land use databases indicated that these data sets did not provide an accurate estimate of agricultural lands for this study area. Therefore, an alternative approach was developed to create a more accurate and defensible assessment of agricultural land use. Conversely, the CDC database for land use was utilized to provide a general estimate of urban, commercial, and rural residential development, as well as, the estimated extent of rangelands. Trends in urban and residential land use were developed from the CDC database by comparing analyses for the years 1984 and 2002.

5.4.1. California Department of Conservation Land Use Database

The CDC database is updated on a bi-annual basis for California Counties. The data is derived from interpretations of aerial photos and then placed into specific use categories to track the conversion and loss (or gain) of farmlands in the state. As the data is derived from aerial photos, rather than ground-truthing, there is a potential for gross errors in certain categories (e.g. active versus fallow or abandoned agricultural lands). Additionally some of the categories may aggregate a few land uses into one category, thus making more specific judgment difficult. The following briefly describes the use categories defined by the CDC.

Prime Farmland. Farmland with the best combination of physical and chemical features able to sustain long-term agricultural production. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for irrigated agricultural production at some time during the four years prior to the mapping date to be added to this classification.

Farmland of Statewide Importance. Farmland similar to Prime Farmland, but with minor shortcomings, such as greater slopes or less ability to store soil moisture.

Unique Farmland. Farmland of lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated, but may include non-irrigated orchards or vineyards as found in some climatic zones in California.

Farmland of Local Importance. Land of importance to the local agricultural economy as determined by each County's board of supervisors and a local advisory committee.

Grazing Land. Land on which the existing vegetation is suited to the grazing of livestock. This category was developed in cooperation with the California Cattlemen's Association, University of California Cooperative Extension, and other groups interested in the extent of grazing activities. The minimum mapping unit for Grazing Land is 40 acres.

Urban and Built-up Land. Land occupied by structures with a building density of at least 1 unit to 1.5 acres, or approximately 6 structures to a 10-acre parcel. This land is used for residential, industrial, commercial, construction, institutional, public administration, railroad and other transportation yards, cemeteries, airports, golf courses, sanitary landfills, sewage treatment, water control structures, and other developed purposes.

Other Land. Land not included in any other mapping category. Common examples include low density rural developments; brush, timber, wetland, and riparian corridors not suitable for livestock grazing; confined livestock, poultry or aquaculture facilities; strip mines, borrow pits; and water bodies smaller than forty acres. Vacant and nonagricultural land surrounded on all sides by urban development and greater than 40 acres is mapped as Other Land.

Water. Perennial water bodies with an extent of at least 40 acres.

This database was utilized for an estimate of current (2002) rangeland, and urban-rural residential areas, and to estimate changes in these land areas between 1984 and 2002. The most important use of the land use conversion data was to provide additional support to the identification and analysis of sediment sources related to development in the study area. For example, the estimated conversion of lands to urban developments supported the hypothesis that increased runoff from impervious surfaces was impacting in-stream processes.

5.4.2. Agricultural Lands

There was a substantial effort made during the preliminary field assessment phase to visually identify as many agricultural parcels as possible. This was important as a number of former croplands had been recently converted to commercial and residential use. Field data was recorded directly onto maps provided by the Santa Clara Valley Water District (SCVWD) that indicated stream channels and roads, as well as, legal parcel boundaries (albeit somewhat dated).

An initial estimate of agricultural land areas was undertaken by utilizing the 2001 year Pesticide Permit database purchased from the Santa Clara County Agricultural Commissioner. This year was used because it was the most current data available as of December of 2001 at the original project start-up period.

The first step in the GIS-based analysis overlayed the study area map with the permit data imposed on a parcel layer. This initial map provided parcel data according to the Commissioner crop categories shown in Appendix C. The total active agricultural land area estimate developed from this analysis was substantially lower than a prior analysis using the CDC database for 2000. This analysis was then placed on hold, pending the further refinement of the study sub-area boundaries. Following the finalization of the study sub-area boundaries, an additional analysis of the Agricultural Commissioner data was completed to present data by sub-area. Smaller sub-area maps were printed to then ground- and aerial photo-truth the agricultural parcels, ultimately revising the land area estimates.

Ground- and aerial photo-truthing involved adding additional actively farmed parcel boundaries on the printed sub-area maps and indicating the appropriate crop category (e.g, short-term row crop). The corrected parcels were then added to the existing GIS-data layer and a new map set was printed and checked for accuracy. This information was tabulated and summarized as follows.

5.4.3. Rangelands

Estimates for rangeland areas were derived from the CDC data. These estimates reflect the CDC's interpretation of the potential for grazing use based on observed vegetation, and likely over-estimate the actual amount of actively grazed lands in the study area.

5.4.4. Urban and Rural Residential Lands

A land use analysis was completed using data from the CDC for 2002. Unfortunately, the CDC's process and categories for these land uses require some additional subjective judgments to develop the best approximation. As shown in Section 5.2.1, the CDC estimates for developed lands are placed in two categories (Developed and Other). Initially it was found that the developed land category in certain study sub-areas (particularly in the Upper West Basin Region) under-estimated new rural residential development. This was adjusted by contrasting changes in the Other Lands category between the years 1984 and 2002.

Concurrently a land use conversion analysis was completed using the CDC data for the period 1984-2002. The focus of this assessment has been to quantify the impact of agricultural land conversion to urban, suburban, commercial, and rural residential uses. This is providing some quantitative support to interpretation of sediment sources and channel instability related to increased runoff volumes.

5.5. Agricultural Crop System Sediment Risk Categories

In addition to developing estimates of agricultural land use in the study area, it was important to use this data to further identify and prioritize problem areas. Given the lack of specific monitoring data for critical locations and/or cropping systems specific to the study area and the significant and costly effort required to quantify sediment loading (e.g. modeling) from the diversity of agricultural parcels, a simple sediment source "risk potential" analysis was developed. Similar to the process used for agricultural land use, the first iteration was done using the 2000 Agricultural Commissioner database. Following the refinement of that data with ground- and aerial-truthing, the final estimates were completed.

The Agricultural Commissioner's database was revised by developing larger crop categories that could later be logically ranked based on their potential or 'risk' as sediment sources. While, inclusion of soil and slope data would provide further resolution, most of the High Risk crop category occurs on slopes of 0 to 3 percent. Also the USDA Soil Survey data for the study area is not currently available in a GIS coverage format.

The crop categories are:

- Short-term Row Crops – Annual irrigated vegetable crops, including strawberries
- Medium-term Row Crops – Bushberries (e.g. raspberries), asparagus
- Field Crops – Grass (forage and hay), alfalfa, turf
- Medium-term Perennial Crops – Perennial spice crops
- Long-term Perennial Crops – Vine (e.g. grape) and tree (e.g. cherry) crops
- Greenhouse Crops (Impervious Surface) - Greenhouse roofs and container areas

These crop categories (excluding Greenhouse) were then assigned to a sediment source risk category based on functional attributes (e.g. bare fallow periods, stormwater runoff potential). These categories were broadly defined as:

Low Risk – Field and Long-term Perennial[1]
Medium Risk – Medium-term Row and Medium-/Long-term Perennial[2]
High Risk – Short-term Row[3]
[1] Perennial crops typically planted on low slopes
[2] Long-term perennials typically planted on sloping land (e.g. grapes)
[3] Irrespective of soils or slope

5.6. Land Use Analysis

Land uses and land use conversion are an important dynamic shaping the characteristics and magnitude of sediment sources in the study area. The study area, with a long history of agriculture and ranching is now increasingly an urbanized commuter economy with closer connection to the San Jose and Silicon Valley. This transition is far from complete, but the magnitude and speed of these land use changes implies that the drainage infrastructure, and natural channels are being forced to adjust to changes on the land.

5.6.1. Agriculture

Table 5.3 gives the estimates of the agricultural lands in the study area. These lands comprise approximately 12.5 percent of the total land area and are concentrated in the South Valley Region. Agricultural land in the Upper West Basin comprises only a very small portion of that land area with some row and nursery crops grown on relatively flat fields, with wine grapes, pasture, and orchards on sloping areas. The North Valley Region supports a patchwork of hay, orchard, greenhouse, and row crop operations, largely in areas east of Highway 101. The Mid-Valley Region supports a similar mix of crops, however there are some larger contiguously farmed parcels, notably in the areas west of Highway 101. As noted, the South Valley Region comprises almost 70 percent of the total agricultural land area and is devoted largely to row crops, vineyards, orchards, and pasture. Farming operations vary widely in size, specialty and management practices. However, there is one important attribute shared with many of the row crop fields, vineyards, and, to a significant degree, the orchards. Growers large and small have adopted new irrigation technologies that have replaced traditional hand-move sprinkler, furrow, and flood irrigation practices with micro-sprinkler and drip technologies. In the past ten years, this has reduced summer season tailwater flows, and thus sediment generation dramatically. Furrow irrigation is now an alternative practice, used infrequently during the season, and only for minor crops. Sprinkler irrigation remains critical to hay and pasture production but generates little to no tailwater.

Table 5.4 gives the further analysis and classification of agricultural land use by grouping the crop systems by sediment source or risk potential. This data again points to the importance of the South Valley Region, while also indicating that high-risk croplands represent only 40 to 55 percent of the agricultural land area in the other valley regions.

5.6.2. Rangelands

Rangelands comprise almost 50 percent of the study area and are predominantly on the eastern and western hillside and mountain areas (Table 5.4). The Upper West Basin Region is the most important and, due to the steeper terrain, these lands are more susceptible to erosion related to practices. The western areas tend to have greater vegetative productivity potential due to higher precipitation that partially offsets the steeper terrain effects on sediment generation. The North and Mid-Valley rangelands are often on smaller, less contiguous parcels on the eastern hills, while some large contiguous ranches are found on both eastern and western areas. The South Valley rangelands are larger contiguous mountain and hillside parcels, although grazing lands are also present on the valley floor in the eastern portion of the region.

Table 5.4. Agricultural Land Use in the Study Sub-areas

Upper West Basin Region		**Acreage**	**% sub-area**	**% study area**
Blackhawk		0	0.0	
Bodfish		417	8.3	
Chesbro Reservoir		0	0.0	
Little Arthur		13	0.2	
Little Uvas		46	0.9	
Upper Uvas		0	0.0	
Upper Llagas		0	0.0	
Uvas Reservoir		2	0.0	
	Total	**478**	**0.1**	**(0.3)**
North Valley Region				
Little Llagas		353	8.9	
Madrone		426	11.1	
Tennant		461	20.8	
Corralitos		347	18.6	
Middle Llagas		382	5.6	
San Martin		222	5.6	
	Total	**2,194**	**9.7**	**(1.7)**
Mid-Valley Region				
Church		168	9.9	
Rucker-Skillet		307	14.1	
Live Oak		29	3.6	
West Branch Llagas		1161	11.6	
Panther		136	12.4	
Lower Uvas		371	5.8	
	Total	**2,172**	**9.8**	**(1.7)**
South Valley Region				
Jones		2903	40.2	
San Ysidro		687	28.3	
Pajaro		716	12.3	
Lower Llagas		3690	56.5	
Uvas-Carnadeross		3266	47.3	
Wildcat		0	0.0	
Total		**11,262**	**32.1**	**(8.7)**
TOTAL STUDY AREA		**15,861**		**(12.5)**

Table 5.5. Sediment Source Risk Potential from Agricultural Lands by Study Sub-areas

Upper West Basin Region		**HIGH**	**MEDIUM**	**LOW**
Blackhawk		0	0	0
Bodfish		44	128	238
Chesbro Reservoir		0	0	0
Little Arthur		0	6	7
Little Uvas		0	0	46
Upper Uvas		0	2	0
Upper Llagas		0	0	0
Uvas Reservoir		0	0	0
	Total	**44**	**136**	**291**
North Valley Region				
Little Llagas		138	10	201
Madrone		55	116	249
Tennant		198	125	123
Corralitos		253	52	26
Middle Llagas		141	92	145
San Martin		58	125	38
	Total	**843**	**520**	**782**
Mid-Valley Region				
Church		89	54	17
Rucker-Skillet		50	111	143
Live Oak		2	27	0
West Branch Llagas		812	288	52
Panther		84	40	5
Lower Uvas		130	218	18
	Total	**1,167**	**738**	**235**
South Valley Region				
Jones		2269	280	317
San Ysidro		260	359	42
Pajaro		232	313	162
Lower Llagas		3046	51	540
Uvas-Carnadeross		2465	283	475
Wildcat		0	0	0
Total		**8,272**	**1,286**	**1,536**
TOTAL STUDY AREA		**10,617**	**2,680**	**2,844**

Table 5.6. Rangelands in the Study Sub-areas

Upper West Basin Region		Acreage	% sub-area	% study area
Blackhawk		2335	37.1	
Bodfish		2684	53.8	
Chesbro Reservoir		5500	93.9	
Little Arthur		2612	44.5	
Little Uvas		4704	96.1	
Upper Uvas		2771	31.3	
Upper Llagas		5247	80.1	
Uvas Reservoir		2518	44.0	
	Total	**28,371**	**58.8**	**(22.0)**
North Valley Region				
Little Llagas		1411	35.8	
Madrone		301	7.9	
Tennant		231	10.4	
Corralitos		711	38.0	
Middle Llagas		3174	46.3	
San Martin		1640	41.3	
	Total	**7.468**	**32.9**	**(5.8)**
Mid-Valley Region				
Church		659	39.0	
Rucker-Skillet		377	17.3	
Live Oak		621	76.3	
West Branch Llagas		2165	21.7	
Panther		58	5.3	
Lower Uvas		4543	70.9	
	Total	**8.423**	**37.9**	**(6.5)**
South Valley Region				
Jones		2373	32.9	
San Ysidro		1529	62.9	
Pajaro		4229	72.7	
Lower Llagas		82	1.3	
Uvas-Carnadeross		1123	2518	
Wildcat		5821	94.0	
Total		**15,157**	**43.2**	**(11.7)**
TOTAL STUDY AREA		**59,418**		**(46.0)**

5.6.3. Urban and Rural Residential

Urban areas are largely within the city limits or urban planning areas of Gilroy and Morgan Hill and are limited to the valley regions. These urbanizing areas particularly increased recent construction of business and technology parks, as well, as major retail centers (with greater impervious surface ratios) will continue to impact the hydrology in the valley regions. Urban and rural residential lands comprise approximately 15 percent of the entire study area (Table 5.6).

The Upper West Basin Region will continue to experience development of rural residences, but will likely remain a small portion of the land area in the near future. The North Valley Region, that encompasses all of Morgan Hill and it's suburban areas has the highest proportion of developed (urban and rural residential) lands, followed by the Mid-Valley Region that includes Gilroy and it's larger commercial and retail areas. Developed lands in the South Valley Region are largely rural residences in the unincorporated areas of Santa Clara County.

Urbanization is implicated in the modification of natural watershed and stream processes by alteration of terrain and stream channels, modification of vegetation and soil characteristics, introduction of pavement and buildings, drainage and flood control infrastructure. However, suburban and rural development share these impacts, and their maginitude can be directly related to the percentage of associated impervious surface area (e.g. driveways, roof areas). A large part of the eastern portion of the Southern Santa Clara Valley has been subdivided into smaller one to five acre parcels. In the recent past, many of these parcels have been converted from orchards, pastures, etc. to residential uses, often large, homes with significant paved areas. This development occurs in a patchwork fashion often leading to localized drainage problems due to the lack of a designed or integrated drainage plan. This has led to the further degradation of publicly and privately managed drainage infrastructure and increased sediment generation.

5.6.4. Equestrian

Equestrian activities are part of the "culture" of Southern Santa Clara Valley and a have a long history in the study area. Many rural residential properties have equine barns, lots, and/or pasture and there are numerous boarding and training facilities in all portions of the rural areas. While time and budget limitations prevented an estimate of the land area devoted to horse keeping, it must be identified as an important land use with direct impacts on sediment generation in the study area. These impacts are most observable in areas with greater concentrations of small lots and pastures, and include; bare or low residual biomass ground cover in lots or pastures; concentrated runoff; riparian encroachment from animal access or grazing; and equestrian creek crossings.

Table 5.7. Urban and Rural Residential Lands in the Study Sub-areas

Upper West Basin Region		**Acreage**	**% sub-area**	**% study area**
Blackhawk		0	0.0	0.0
Bodfish		67	1.3	0.3
Chesbro Reservoir		37	0.6	0.0
Little Arthur[1]		13	0.2	0.01
Little Uvas[1]		4	0.1	0.04
Upper Uvas[1]		0	0.0	0.0
Upper Llagas[1]		37	0.6	0.0
Uvas Reservoir[1]		0	0.0	0.02
	Total	**158**	**0.3**	**(0.1)**
North Valley Region				
Little Llagas		2028	51.4	0.3
Madrone		1859	48.6	0.3
Tennant		883	39.9	0.4
Corralitos		347	18.6	0.3
Middle Llagas		2368	34.5	0.3
San Martin		1199	30.2	0.2
	Total	**8,684**	**38.3**	**(6.7)**
Mid-Valley Region				
Church		483	28.6	0.1
Rucker-Skillet		801	36.7	0.2
Live Oak		74	9.1	0.02
West Branch Llagas		4410	44.1	0.9
Panther		655	59.5	0.1
Lower Uvas		504	18.4	0.3
	Total	**6,927**	**31.2**	**(5.4)**
South Valley Region				
Jones		445	6.2	2.2
San Ysidro		21	0.9	0.5
Pajaro		100	1.7	0.6
Lower Llagas		1202	18.4	2.9
Uvas-Carnadeross		1616	23.4	2.5
Wildcat		2	0.03	0.0
Total		**3,386**	**9.6**	**(2.6)**
TOTAL STUDY AREA		**19,118**		**(14.8)**

5.7. Sediment Sources

Given the diversity of land use in the study area, potential sediment sources are numerous. The main controllable sediment sources related to land use are agriculture, rangeland, urban and rural residential stormwater runoff, and commercial and small equestrian facilities. In the following section, the important sediment sources are grouped by land use category and defined. Visual examples of many of these sources are also provided.

Figure 5.1. Agricultural Source

Figure 5.2. Rural Residential Source

5.7.1. Agriculture

Agricultural sediment sources are grouped by four categories: Hydromodifications, Riparian Encroachment. Bare Fallow, and Drainage Practices. While agricultural land areas comprise only about 12 percent of the entire study area, the large amount of routine soil disturbance related to crop production and drainage management leaves croplands prone to high rates of sediment generation.

Hydromodifcations [HYDRO]. This category includes historical and/or current farming activities that may alter or disrupt the functioning of ephemeral, intermittent, and perennial streams.

Channel modification – Within the study area channel modification falls into two categories. The first, is historical change to stream courses likely begun in the late 1800's by private land owners and continued well into the 20th century. The second category includes recent, engineered modifications to channels for flood control by the public sector. Channel straightening increases the velocity of flows, increasing energy for channel scouring and bank erosion. Increased erosion leads to loss of optimal channel cross-section, loss of floodplain, and bank steepening.

Channel bed disruption – Channel crossings, sediment removal practices and, in a few exceptional cases farm or related equipment operation in creek channels reduces and disturbed armoring and increases channel and bank instability. In the worst case, significant lengths of natural channels were found to have been tilled routinely or at least appeared to have been recently disturbed at the time of the survey.

Figure 5.3. Example of Channel Bed Disruption related to Agricultural Hydromodification.

Non-engineered levees – Historical and, in a few cases, current practices by growers to reduce flood risk to fields have left unstable, poorly or non-vegetated levees in adjacent to a number of channel reaches. Often these levees encroach into the riparian zone and alter channel cross-section and reduce or eliminate floodplain.

Riparian vegetation removal – Historical and current riparian vegetation removal is common. At some locations banks are kept clear of all vegetation by herbicide application and hoeing. The more common condition is poor or patchy vegetative cover that does not provide adequate protection to banks from erosive effects of stream flow.

Figure 5.4. Example of Channel Modification and Vegetation Removal related to Agricultural Hydromodification.

Riparian Encroachment [RIPAR]. Riparian encroachment is a common condition in fields adjacent to channels. Field margins may often extend right to the top of channel banks, thus leading to a loss of riparian habitat and bank failure. Riparian encroachment has degraded optimal channel cross-section dimensions, floodplain access and vegetation, leading to increased or regular bank failure.

Hillside planting in ephemeral channels – This condition is most commonly observed in rangeland, orchard (mostly residential/hobby), and vineyard lands. Planting across even insignificant ephemeral channels increases soil detachment and increases the velocity and erosive power of runoff.

Figure 5.5. Example of Hillside Planting in an Ephemeral Channel related to Riparian Encroachment of Agriculture.

In-stream creek crossings – Poorly constructed or maintained channel crossings disrupt the bed substrate (armor) and reduce bank stability.

Soil tillage and access roads – Soil disturbance immediately adjacent to channels can lead to disturbed soil deposited on bank surfaces, covering existing herbaceous vegetation, or eventually reaching the channel itself. Roads are commonly at field margins and the routine maintenance (scraping or blading) of these roads may lead to soil entering channels directly or subsequently being transported into the channel via road runoff. Disturbance of the top of creek banks increases bank instability, often leading to partial or substantial failure.

Figure 5.6. Examples of Soil Tillage and Access Roads related to Riparian Encroachment of Agriculture.

Bare Winter Fallowed Fields [FALLOW]. This common practice is critical to the flexibility and success of early season crop production for many vegetable and bush fruit farming operations. However under certain conditions (e.g. slope, soil type, specific drainage management practice), and without specific additional control measures, this contributes to excessive sediment loading from fields.

Listed beds, plastic mulched beds - Where planting beds are formed in fall prior to late winter/early spring planting, runoff generated during storm events is concentrated in the furrow (between beds) often with sufficient energy to suspend higher quantities of soil particles than "flat" tilled fields. Plastic mulch increases the total runoff volume and velocity, thereby increasing sediment loss from fields unless runoff is captured or detained.

Figure 5.7. Example of Stormwater Runoff related to Bare Winter Fallowed Fields.

Concentrated runoff volumes – Other farm drainage practices (e.g. tailwater collection ditches) may lead to concentrated runoff leaving the field, thereby increasing water velocity and the erosion potential of downstream drainage infrastructure and stream channels.

Drainage practices [DITCH]. There are numerous methods employed to convey tail and stormwater away from fallow and production fields. Many variables will influence the amount of soil suspended in runoff from any given field, however temporary and permanent bare soil ditches are typically the source of additional sediment transport from farm fields.

Placement of tail/stormwater discharge pipes – At some locations or fields tail and stormwater may be conveyed to either larger drains or creeks. These outfalls maybe located at excessive height above the receiving channel. As a result the velocity and concentrated flow often creates small to larger scour holes within the receiving channel, thus increasing suspended soil particles.

Non-vegetated permanent ditches – Larger drainage ditches are often kept bare for various reasons (e.g. pest management) or due to regular sediment removal and re-shaping operations. Bank angles are often steep, leading to localized bank slumping or failure under intense rainfall or drainage flows.

Encroachment on roadway easements – Many fields adjacent to roads may be tilled or cropped too close to road shoulders and road ditches. Loosened soil, destabilization of road ditch banks, and/or field runoff increase sediment conveyance.

Figure 5.8. Example of Encroachment to Roadway Easements related to Agricultural Drainage Practices.

Unlined tail/stormwater ditches – These types of 'structures' are temporary and typically have loosened soil with a high erodability potential. In many locations tail and stormwater is conveyed directly to road ditches or other drainage structure with direct connection to creeks, or directly to existing channels.

Figure 5.9. Examples of Runoff from Unlined Tail or Stormwater Ditches related to Agricultural Drainage Practices.

Direct discharge to channels – Fields that are adjacent to channels may represent the largest sources of agricultural sediment loads when tail and stormwater is conveyed directly via ditches, pipes, or overland flow into stream channels

5.7.2. Rangeland

Rangelands contribution to sediment loading is largely driven by their dominant area extent in the study area. While seasonal grazing practices do not appear to result in low or no residual vegetation (biomass) at most locations, unimproved ranch roads and permanent cattle paths are the most widely observed source of enhanced sediment delivery to channels. Rangeland sources are grouped into three categories: Roads, Riparian Encroachment, and Low Residual Biomass.

Roads [ROAD]. On sloping terrain ranch roads are often the most significant sediment source. The Study Team had limited visual access to ranch roads, but it can be reasonably assumed that many locations share similar problems related to non-surfaced roads.

Non-surfaced roads - In-slope grading typically directs runoff into ditches, which may often convey water to culverts that conduct concentrated flows downhill. Culvert outfall locations, when not armored may cause accelerated sheet or rill erosion and in the worst instances initiate gully formation. Unstable or slumping in-slope banks (particularly poorly vegetated), non-vegetated road ditches, and bare down slope road shoulders have been observed as sediment sources.

Figure 5.10. Example of Runoff from a Non-Surfaced Rangeland Road.

Riparian Encroachment [RIPAR]. Riparian encroachment by cattle, sheep, or goats was observed in many locations within the study area. Cattle access to perennial channels occurs to varying extents in the Upper West Basin Region. Numerous ephemeral channels on footslope and hillside locations are grazed with generally low impact. In the valley floor impacts are more likely due to smaller animals (e.g. sheep) on small lots or pasture. In these locations ephemeral and intermittent channels are often incised with little or poor vegetation cover.

Riparian access/grazing – Where animals have access to graze, drink, or simply walk in the riparian zone, the degree of disturbance may become significant enough to induce bank loss or channel scouring. Localized bank instability and evidence of accelerated erosion were noted in some locations thorough out the study area.

Figure 5.11. Example of Location where Rangeland Riparian Access and Grazing Permitted.

Creek crossings – Based on survey work, with only limited visual access, creek crossings do not appear to be a widespread occurrence. In fact, a few observed crossings exhibited few signs of significant impact. However, it is assumed that some crossings may cause significant localized disruption of channel substrate due to trampling along with increased bank erosion.

Figure 5.12. Example of In-Stream Crossing.

Low Residual Biomass [LOWVEG]. While there were only minor observations of cattle overgrazing in the upper western and eastern slopes, there were significantly more observations of overgrazing in some larger equine pastures and small lot pastures for goats and sheep. Significant localized impacts are most often due to excessive vegetation removal in, and adjacent to, ephemeral and intermittent channels.

5.7.3. Urban

Urban development increases runoff volumes and velocity, therefore increasing the erosion potential in unlined urban drains and stream channels. The accelerated rates of development in the past 15 years, with concurrent increases in impervious surfaces, has clearly resulted in localized and extensive impacts on the stability of certain channels. Change in the volume of water supplied, to stream channels requires adjustments to hydraulic or channel geometry, often accompanied by higher sediment transport. Urban land sources are grouped into three categories: Hydromodifications, Riparian Encroachment, and Firebreaks

Hydromodifications [HYDRO]. Increased runoff related to urbanization requires construction of drainage structures and, in some cases, alteration of existing natural channels. In the study area these changes have been occurring since the 19th century. However, the rapid increase in development during the late 20th century, concurrent with the development of large-scale flood control projects has led to localized and extensive destabilization of certain channel reaches.

<u>Urban drains and flood control channels</u> – All of the publicly constructed drains in the region share certain characteristics, largely earthen-linings, uniform channel cross-sections (at least initially), straight channels and occasional 90 degree bends, with vegetation (when present) limited to grasses or rank weed growth. While these features enhance the rapid conveyance of drainage waters and reduce flood risk, there are locations that exhibit scour and channel incision, past or recent bank loss/instability, or sedimentation related to high flows and increased erosive energy.


Figure 5.13. Example of Urban Drains and Flood Control Channel Hydromodifications.

Riparian Encroachment [RIPAR]. The high use and economic value of urbanized lands has led to the constriction of channel width or meanders by construction in former riparian zones and, in some cases, right to the top of channel banks.

<u>Building setbacks</u> – While current urban building codes require an adequate buffer between channels and buildings, work or parking areas, there are many locations where channel integrity continues to be compromised by encroachment of urban development. At these locations creeks or drainage ditches may have limited or no floodplain adjacent to the bankfull channel, limited vegetative cover,

or the channel width is constrained by concrete retaining walls. Even in certain older urban locations, evidence of current bank instability and channel incision was observed.

Figure 5.14. Example of Urban Riparian Encroachment.

Firebreaks [FIRE]

Disked bare breaks - While disked fire breaks were not observed as a common occurrence in urban areas, it was noted in some larger suburban developments. Where this practice is employed on sloping lands, and particularly when disking occurs across ephemeral channels, increased erosion potential exists.

5.7.4. Rural Residential

Rural residential parcels comprise a significant portion of some study sub-area sediment sources, ranging from the older areas on the eastern valley floor, to the more recent large developments and single-residence parcels on the western and eastern foothills and hillside areas. The design and condition of drainage infrastructure ranges greatly and is often where significant sediment problems are found. Rural residential sources are grouped into four categories: Roads, Culverts, Riparian Encroachment, and Firebreaks.

Roads [ROAD]. Increased development has placed a strain on the existing road drainage infrastructure in unincorporated areas as higher runoff volumes are conveyed. Road maintenance personnel have noted that increased urban and rural residential development is leading to the deterioration of drainage infrastructure. While runoff from paved roads causes only occasional localized problems, there are many areas where runoff flows across unstable road shoulders or into eroding ditches. In many cases land/home owners may routinely disturb the areas within roadway easements, including ditches. Along some roads the road ditch cross-section may change at every parcel frontage, may be eliminated, bare, concrete-lined, etc. This often creates localized instability, erosion, and sedimentation.

Road ditches – In many of the rural residential areas, roadway ditches may carry road, driveway, even roof runoff waters into existing creek channels. Many road easements have bare-unstable shoulders, undersized or incised 'channels' with unstable ditch walls, and/or improper setbacks from residential activities. In some cases road ditches are actually functioning as creek channels carrying natural upland, residential, and roadway drainage waters.

Figure 5.15. Examples of Road Ditches in Rural Residential Areas.

Culverts [CULV]. Given increased runoff volumes, the numerous public and private culverts represent significant sediment sources. Common problems are undersized roadway and creek culverts, poor placement of culverts in hillside locations, excessive scour due to high runoff volumes and velocities, partially collapsed culverts, and poor design and maintenance by residential owners.

Figure 5.16. Examples of Drainage Culverts in Rural Residential Areas.

Riparian encroachment [RIPAR]. Many stream channels pass through rural residential parcels and are subject to impacts related to animal lots, landscaping, drainage systems for conveyance of runoff from roofs and driveways, and other uses that encroach upon or otherwise impair the function of channels.

Riparian vegetation removal – Removal of riparian vegetation removal is common, both historical and under current land use conditions. Often exotic weedy vegetation replaces a natural riparian vegetated corridor, or landscape designs alter the location or channel characteristics for aesthetic reasons. Where vegetation removal occurs due to intensive grazing, landscaping, recreational purposes, etc. this often results in widening or incision of channels with associated increases in sediment generation.

Channel disturbance – While visual access to large portions of rural residential lands was limited, when permission was attained the Study Team found evidence of channel disturbance. Disturbance is most often related to fencing, grazing, drainage, and landscaping activities. Scour pits from poorly designed drainage systems, and poorly sized or placed culverts were observed. Numerous and hasty bank stabilization attempts appear to have led to subsequent failures in other locations of the channel.

Riparian encroachment – Encroachment is very common where recreational uses, landscaping, driveways, animal lots, outbuildings, property line fences, etc. constrains channel width or natural channel meander, alters the natural channel cross-section dimensions, reduce bank stability, and/or increases in scouring and incision.

Figure 5.17. Examples of Riparian Encroachment, Channel Disturbance, and Riparian Vegetation Removal in Rural Residential Areas.

Firebreaks [FIRE]

Disked bare breaks - While this was not observed as a common occurrence, it was noted on individual parcels and some small residential developments. Where this practice is employed on sloping lands, and particularly when disking occurs across ephemeral channels, increased erosion potential exists.

Figure 5.18. Example of Disked Firebreaks in Rural Residential Areas.

5.7.5. Equestrian

Lands utilized for equine boarding, training, and/or small lot keeping are not identified as a specific land use category by this study due to the time required to ground-truth and estimate the land area devoted to equestrian activities. However, equestrian activities are widespread and, in some locations, concentrated in the study area. These sources have been grouped into two categories: Poorly Vegetated and Riparian Encroachment. These are assumed to be "embedded" in the larger rural residential land use category.

Poorly Vegetated Lots and Pastures [BARE]. Poorly vegetated pastures and small lots are a widespread condition in the study area. Many small private lots and paddocks, even with one animal, are not large enough to allow for adequate animal rotation to allow vegetation re-growth. Bare and often, compacted soil (those not with sawdust or woodchip applications) increases the potential erosion rate and volume and velocity of runoff, particularly on sloping pastures.

Bare or low residual biomass lots and pastures – This most often occurs in small lot situations when the allotted lot or pasture is too small for the number or size of horses. Numerous instances of completely bare corrals can be found in almost every sub-area. Lots and pastures with low amounts of residual vegetation (biomass) and compacted soil from trampling have high potential runoff and erosion rates.

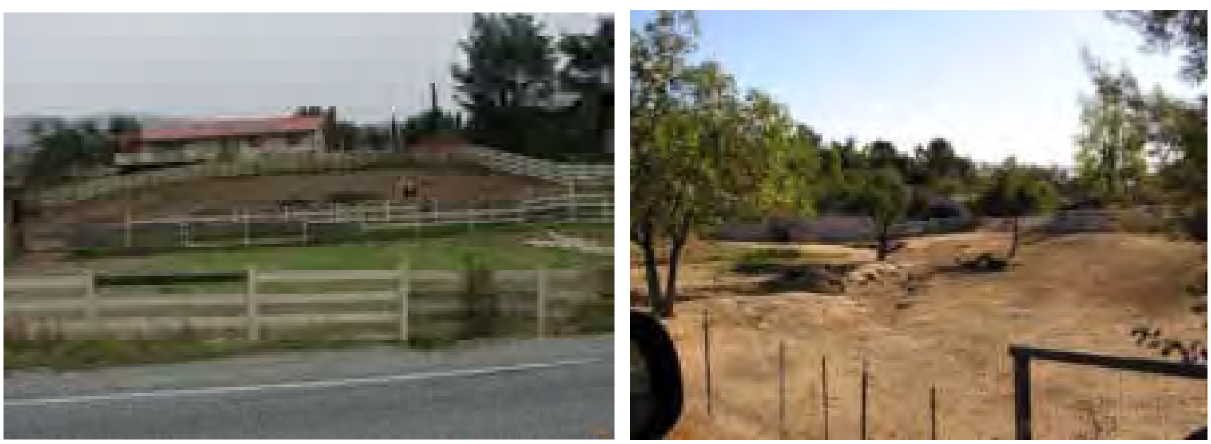

Figure 5.19. Example of Poorly Vegetated Equestrian Lots and Pastures.

Concentrated runoff flows – In some locations temporary or permanent ditches used to drain exercise paddocks or small lots may concentrated flow volumes increasing sediment transport.

Riparian Encroachment [RIPAR]. Riparian encroachment by horses occurs in many locations within the study area. Equine access and localized impact to the larger perennial channels was most often related to recreational riding, in or across stream channels. However numerous ephemeral channels in foothill and hillside locations are grazed. Where stock numbers or lack of rotation exceeds the productive capacity of the vegetation, increases in overland flow, sheet erosion, and channel incision are apparent.

Riparian access/grazing – When horses are allowed to graze, drink, or simply walk in the riparian zone, the degree of disturbance increases bank loss or channel scouring.

Creek crossings – Based on survey work, equine crossings are not a widespread occurrence. However, where observed most of the crossings had noticeable past and current impacts from hoof traffic. Channel and bank substrate at crossings is disrupted increasing bank erosion potential.

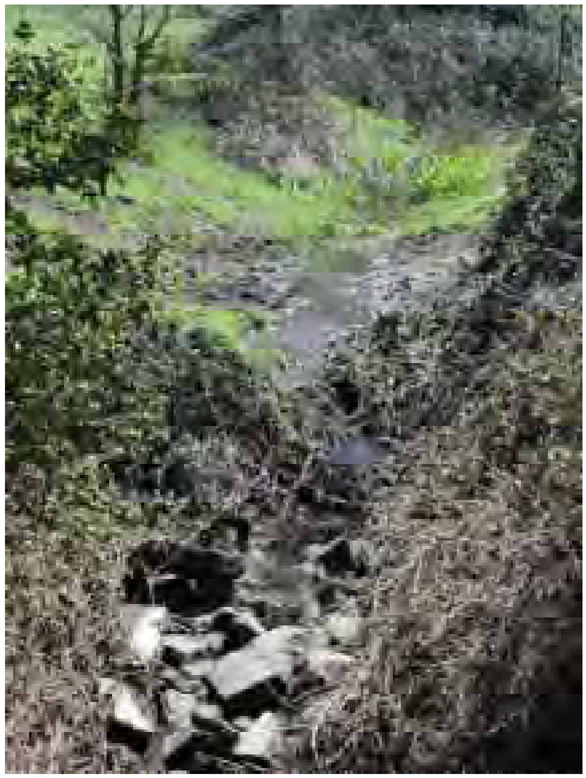

Figure 5.20. Example of Equestrian Creek Crossing.

5.8. Sediment Source Analysis

5.8.1. Upper West Basin Region

The Upper West Basin Region (38% of study area) is largely undeveloped with the majority of the land area is forest, scrubland, and potential or active rangelands. Restricted access in this, the largest portion of the study area, limited more detailed assessment of land use and channel conditions. Rural residential development is one of the most important land use conversions and has likely been underestimated in our analysis of the CDC data. Along with these developments has been an increase in the equine population including barns (impervious surfaces), corrals, pasture, and an expansion of existing or new boarding facilities. There are many timber and ranch roads in this Region, most of which could not be observed by the Study Team. Agricultural lands uses are limited, and are largely commercial or small home vineyards, along with nurseries and a small area of row crops. The Bodfish sub-area has the largest concentration of agricultural lands in the Upper Basin Region.

Figure 5.21. Rangelands and Mixed Oak Forest in the Upper West Basin Region

Sediment Sources in the Upper West Basin Region. Due to limited access to this extensive upland region, only brief discussion of field observations for selected sub-areas can be provided. The following sub-areas have limited public roads or private roads that prevented detailed assessments from the ground.

Upper Llagas – Llagas Creek
Chesbro Reservoir – Llagas Creek
Upper Uvas –Uvas Creek
Blackhawk – Bodfish and Blackhawk Canyon Creeks
Little Uvas – Little Uvas Creek
Uvas Reservoir – Uvas Creek
Bodfish – Bodfish Creek

The Bodfish sub-area encompasses a unique combination of ranches, rural residences, vineyards, and nurseries. There are no urban sources in this sub-area. Similar to other Upper West Basin Region, rangelands are the dominant land use category, generally distributed over smaller holding. Agricultural and residential land uses are somewhat concentrated along the Hecker Pass Road (Highway 152) corridor adjacent to the lower portions of Bodfish Creek. The vineyards and nurseries in this sub-area are largely on low slope to flat areas and little evidence (though visually limited) was found of significant erosion or direct discharges to channels. There is some evidence of historical hydromodifications to intermittent and ephemeral channels. In some locations there may be riparian encroachment from fields or plant container nurseries. Similarly there were only a few observations of riparian encroachment in some rural residential parcels as well. Other minor sources were observed related to small animal lots.

Little Arthur – Little Arthur Creek. The Little Arthur sub-area has historically been a ranching area and now is experiencing some conversion to vineyards, equestrian, and rural residential uses. Rangelands and forest comprise the greatest portion of the land area. Conversion of rangelands to equine pasture, vineyard, and rural residential uses appears to be causing some degradation of the existing road drainage infrastructure due to increased runoff. However, given the rather low concentration of these land uses in the sub-area, these sediment sources are currently insignificant.

Table 5.8. Sediment Sources in the Upper West Basin Region

Agriculture	**HYDRO**	**RIPAR**	**FALLOW**	**DITCH**
Blackhawk	na	na	na	na
Bodfish	○	○	○	○
Chesbro Reservoir	na	na	na	na
Little Arthur	na	na	na	na
Little Uvas	na	na	na	na
Upper Uvas	na	na	na	na
Upper Llagas	na	na	na	na
Uvas Reservoir	na	na	na	na

Rangeland	**ROAD**	**RIPAR**	**LOWVEG**
Blackhawk	N	N	N
Bodfish	○	○	○
Chesbro Reservoir	○	○	○
Little Arthur	○	○	○
Little Uvas	○	○	○
Upper Uvas	○	○	○
Upper Llagas	○	○	○
Uvas Reservoir	○	○	○

Urban	**HYDRO**	**RIPAR**	**FIRE**
NO URBAN LANDS PRESENT			

Rural Residential	**ROAD**	**RIPAR**	**CULV**	**EQUES**	**FIRE**
Blackhawk	N	N	N	N	N
Bodfish	○	◉	○	○	na
Chesbro Reservoir	○	◉	○	○	na
Little Arthur	○	○	○	○	na
Little Uvas	○	○	N	N	na
Upper Uvas	○	○	○	◉	na
Upper Llagas	○	○	○	◉	na
Uvas Reservoir	○	○	○	○	na

○ = Low ◉ = Medium ● = High N = Not accessible na = not applicable/observed

5.8.2. North Valley Region

The North Valley Region (17.6 percent of study area) is dominated by urban and rural residential development (38.3 percent) due to the growth of the City of Morgan Hill and the outlying unincorporated areas. In the past twenty years there has been significant conversion of agricultural and rangelands, particularly in the eastern and western portions of the region. Of particular significance has been the development of the foothill and hillside locations.
Rangeland is the second largest land use area, however many of these lands now form a "patchwork" of smaller holdings in some sub-areas. The majority of the more intact and larger rangeland holdings are in the western foothill areas. Often the smaller holdings in the eastern hills are bounded by development and, in some cases, are now part of the suburban drainage network.
Agricultural lands comprise less than 10 percent of the region and are largely found east of Highway 101. Much of the agricultural land exists as smaller "patchwork" parcels in rural residential areas. Crops include row, tree, field, greenhouse and specialty crops. Potential sediment loading from agricultural lands is substantially higher than in the Upper West Basin Region due to the majority of land being row cropped (Table 5.4).

There are a few equine boarding facilities, notably in the northeast portion of the region. The southeastern portion of this region has the highest concentration of small equine lots observed in the study area. In some cases these holdings have been found to be potentially significant sediment sources due to their proximity to riparian zones or creek and drain channels.

Figure 5.22. View to the Southwest of Upper Dunne Avenue in Morgan Hill

Table 5.9. Sediment Sources in the North Valley Region

Agriculture	**HYDRO**	**RIPAR**	**FALLOW**	**DITCH**
Little Llagas	○	●	●	◉
Madrone	◉	◉	◉	◉
Tennant	●	●	●	●
Corralitos	◉	◉	◉	◉
Middle Llagas	●	◉	◉	◉
San Martin	○	◉	◉	○

Rangeland	**ROAD**	**RIPAR**	**LOWVEG**
Little Llagas	○	○	○
Madrone	○	◉	○
Tennant	○	○	○
Corralitos	○	○	○
Middle Llagas	○	○	○
San Martin	○	◉	○

Urban	**HYDRO**	**RIPAR**	**FIRE**
Little Llagas	◉	●	○
Madrone	◉	○	na
Tennant	◉	○	◉
Corralitos	na	◉	○
Middle Llagas	◉	○	○
San Martin	na	○	○

Rural Residential	**ROAD**	**RIPAR**	**CULV**	**EQUES**	**FIRE**
Little Llagas	◉	◉	◉	○	na
Madrone	◉	○	○	○	na
Tennant	◉	◉	◉	○	◉
Corralitos	●	◉	●	◉	○
Middle Llagas	◉	●	◉	●	na
San Martin	◉	●	●	●	○

○ = Low   ◉ = Medium   ● = High   N = Not accessible   na = not applicable/observed

Sediment Sources in the North Valley Region.

Little Llagas – West and East Little Llagas, Dewitt, and Edmundson Creeks. Little Llagas sub-area is largely developed and includes the Morgan Hill City Center and other urban and residential areas north of Watsonville Rd, including Edmunson Rd north to Llagas Rd. and the rural residential areas east of Monterey Rd. to Middle Ave. Rangelands may be overestimated by the CDC database, as they largely exist as a "patchwork" of smaller parcels in the northern and western foothill areas. In many cases these are lands that have been converted to suburban and rural residential tracts in the 1990s. Increased runoff from these converted parcels appear to be destabilizing some portions of Edmunson and West little Llagas channels.

Agricultural lands are for the most part east of Monterey Rd. to Highway 101. A large portion of these lands have a high sediment risk potential during the rainy season, particularly due to routine high flows, localized flooding, and riparian encroachment.

Madrone – Madrone Channel. The Madrone sub-area is also a largely developed area, with a mix of older rural residential and newer multi-home developments east of Highway 101. Residential development in the foothills is significant and storm runoff waters are conveyed west via ditches and culverts to the portions of the Madrone Channel. Rangelands comprise less than 10 percent of this sub-area and largely exist as "patchwork" lands. Bounded by residential development in the eastern foothills. These lands are used for cattle and horses. It appears that much of the storm runoff from ephemeral channels is conveyed into the network of road ditches in the valley portions of the sub-area. The east-west roads often have stormwater culvert outfalls into the channel.

Agricultural lands are predominantly on the valley floor portions of the sub-area with very few large continuous parcels, except in the north and northeastern portions of the sub-area where there is a mix of tree and row cropping. Field crops are important thus the sediment source potential in this sub-area is lower in contrast to other more intensively farmed sub-areas.

Tennant – Tennant and Foothill Creeks. The Tennant sub-area is largely influenced by development. In general, land use in the sub-area has been transitioning from orchards, hay, row crop, to more intensive suburban development as the City of Morgan Hill develops eastward. Much of this more recent development is in the north and northeastern portions of the sub-area near East Dunne and upper Barrett Avenues. Much of the runoff from these developments ultimately is conveyed to Tennant Creek. Despite the presence and function of two detention structures, some portions of the channel appear to be impacted by these increased flows. The rangeland area is a small portion of the land area, in the eastern hills, which are also experiencing conversion to large home sites.

There is a large mixture of agricultural uses and much of it comprises small farm operations. There are some relatively large contiguous agricultural parcels, largely in row crops. Sediment risk potential is significant and there are a number of locations where excessive sedimentation is apparent, channels have been modified or routinely disturbed, and riparian encroachment, particularly adjacent to road crossings has destabilized creek banks.

Corralitos – Maple and Corralitos and South Corralitos Creeks. The Corralitos sub-area has a much smaller proportion of developed land area. Much of the sub-area has older rural residences, often with small to medium sized pasture and lots for horses and/or cows. The upper portion of Corralitos sub-area has new and large home developments, including a private golf course. These developments appear to have greatly increased runoff entering the channel. Potential and active rangelands above and around these hillside developments still represent a significant portion of the upper sub-area, but many exist as small 'patchwork' parcels bounded by development. Agricultural lands are well distributed from the foothills of upper Maple Avenue to the confluence of Maple and Corralitos Creeks. Sediment source potential is high in the Maple Avenue area due to row cropping and riparian encroachment where Maple Creek is essentially a road ditch. The lower reaches of Maple Creek and Corralitos Creek have been encroached and/or channel has been disrupted by row cropping and grazing. A number of agricultural parcels downstream of their confluence straddle the Corralitos channel all the way to the confluence with East Little Llagas Creek.

Middle Llagas – Llagas, Paradise, Machado, and Hayes Creeks. Middle Llagas is also a diverse sub-area with almost 40 percent of the area recently developed as multi-home developments or are older rural residential and suburban parcels. Much of the most concentrated development is west of Santa Teresa Boulevard including much of the San Martin community in the southern portion of the sub-area. In the upper portions of the sub-area in the vicinity of Paradise, Hayes, and lower Machado Creeks, there has been a significant amount of large home development. Many road ditches and culvert crossings show signs of destabilization due to increased runoff, particularly where creek channels (e.g. Paradise and Hayes) are adjacent to roads with limited setbacks. The upper portion of Machado Creek has a rural residential development with a mix of small animal lots, although there is little evidence of riparian encroachment.

Rangelands comprise over 45 percent of the sub-area and much of these lands still exist as large contiguous parcels in the upper reaches of Machado and Hayes Creek. Along Hayes Creek and Watsonville Road there are a number of larger equine boarding facilities and evidence of riparian access and creek crossings that locally disrupt the channels of creeks or ephemeral tributaries. Riparian encroachment occurs at some locations grazed by cattle.
Agricultural lands exist largely as smaller "patchwork" parcels south of Watsonville Rd. to California Avenue and west of Highway 101. Row and field crops (hay) are most important in the sub-area, however very few of the farmed parcels are adjacent to channels or appear to convey storm water to creek channels. Potential sediment risk is proportionately lower due to the higher percentage of hay and orchard crops in this sub-area.

San Martin – San Martin, Center, and New Creeks. The San Martin sub-area comprises a diverse area east of Highway 101 and is at the northern portion of the older rural residential developments associated with the community of San Martin. Many of the residential parcels have adequate land for small animals and there is a long history of an active equestrian community in this sub-area. The road ditch network in this sub-area is older and shows many signs of destabilization and incision due to increased runoff flows as more and more of the open parcels are developed, most often with larger homes and significant impervious "footprints".

The rangelands areas are significant (about 40 percent of sub-area), and where they are not divided by development in the foothills, they exist as larger intact parcels. The Bear Creek Ranch, east of Foothill Avenue in the upper San Martin Creek watershed is contiguous with other rangelands to the south and east of New Avenue that include the upper reaches of New Creek. These rangelands show some impact due to riparian access by animals, but generally do not appear to be significant sediment sources. However, encroachment of equine grazing on riparian zones and channels on both creek channels was observed. This is particularly important along the San Martin channel. Agricultural lands are relatively insignificant in this sub-area (less than 6 percent) and much of the land area has a lower sediment source potential related to a larger proportion of field (hay and pasture) crops, vines and trees.

5.8.3. Mid-Valley Region

The Mid-Valley Region (17.2 percent of the study area) also has a significant amount of developed lands. Some of these lands are in unincorporated areas as rural residences, but the majority of the development includes the City of Gilroy. Increased development is largely due to increasing city limits and planning areas for Gilroy and rural residential development in the western and eastern foothills.

Rangelands are slightly greater in extent than developed areas. There are still some larger intact ranches, although the lands in proximity of Gilroy will likely continue to be subdivided. In very recent years, development of the eastern foothills has also reduced active rangeland use. Agricultural lands account for less than ten percent of the land area, much of which is on smaller parcels bounded by rural residential and/or urban lands. There are a number of larger intact continuous agricultural tracts in the western portion of the region (west of Highway 101). Crops include row, field, and greenhouse crops, while tree crops are less important. Potential sediment loading from agriculture is similar to that for the North Valley Region (Table 5.4), although there are a larger number of row crop areas adjacent to riparian zones and channels.
Equine uses are mostly associated with smaller lots, although these holdings are often adjacent to riparian zones and channels. Of significance is the expansion of equine lots in the eastern hills associated with residential development.

Figure 5.23. View of the Southern Santa Clara Valley Northeast from Upper Masitelli Drive in Gilroy.

Table 5.10. Sediment Sources in the Mid-Valley Region

Agriculture	**HYDRO**	**RIPAR**	**FALLOW**	**DITCH**
Church	○	◉	○	◉
Rucker-Skillet	◉	◉	○	◉
Live Oak	○	○	○	○
West Branch Llagas	●	●	●	●
Panther	◉	◉	◉	◉
Lower Uvas	◉	◉	○	◉

Rangeland	**ROAD**	**RIPAR**	**LOWVEG**
Church	○	◉	○
Rucker-Skillet	○	◉	◉
Live Oak	◉	○	○
West Branch Llagas	○	○	○
Panther	○	○	○
Lower Uvas	○	○	○

Urban	**HYDRO**	**RIPAR**	**FIRE**
Church	○	○	○
Rucker-Skillet	○	◉	○
Live Oak	○	◉	○
West Branch Llagas	●	○	●
Panther	◉	○	○
Lower Uvas	◉	◉	○

Rural Residential	**ROAD**	**RIPAR**	**CULV**	**EQUES**	**FIRE**
Church	◉	◉	◉	●	○
Rucker-Skillet	●	◉	●	●	◉
Live Oak	◉	◉	○	○	○
West Branch Llagas	◉	◉	●	◉	○
Panther	●	◉	◉	◉	○
Lower Uvas	○	◉	◉	◉	○

○ = Low   ◉ = Medium   ● = High   N = Not accessible   na = not applicable/observed

Sediment Sources in the Mid-Valley Region

Church – Church Creek. The Church sub-area comprises the heart of the older rural residential areas associated with the community of San Martin. Many of the residential parcels have adequate land for small animals, and similar to the San Martin sub-area to the north, there is a long history of an active equestrian community. The road ditch network in this sub-area is older and shows many signs of destabilization and incision due to increased runoff flows as more and more of the open parcels are developed, often with larger homes and significant impervious "footprints". In particular the sub-area and road ditches along Church Avenue and south on Foothill Avenue to the Church Creek channel are a critical source area, where two significant ephemeral channels function as road ditches. This degradation appears also to be related to the development of upper Church Avenue where almost every residence has a horse lot and pasture.

Rangelands are all on the upper eastern hills, above the development on upper Church Avenue. While there is visual evidence of riparian access to ephemeral channels and the presence of ranch roads, there does not appear to be any significant sediment sources associated with the upper portion of the Church watershed. However, equine grazing associated with residential parcels often encroaches on riparian zones and channels on in the upper sub-area. This is particularly important in the development on upper Church Avenue.

Agricultural land uses comprise less than 10 percent of the area and generally form a "patchwork' of smaller parcels around rural residences. However, the largest proportion are row crops with a higher sediment source potential. The most concentrated agricultural activity is in the vicinity of the Church Creek confluence with East Little Llagas Creek. Here there is some localized sediment sources from fields adjacent to roads or channels and there is a significant amount of riparian encroachment on the channel along Columbet Avenue, which appears to be contributing to the significant channel incision.

Rucker-Skillet – Rucker and Skillet Creeks. The Rucker-Skillet sub-area has a mix of older rural residential parcels and more recent extensive hillside developments (almost 40 percent of area) that are clearly degrading the drainage infrastructure and some ephemeral channels. This sub-area also has a significant amount of small and large equine lots and pasture associated with valley floor and hill residences. It appears that the recent developments in the upper reaches of Rucker and Skillet have had a significant destabilizing effect on the lower channels. In this sub-area there are observable impacts related to road drainage and, in some cases elaborate landscape alterations associated with large home sites. This sub-area was formerly rangeland, but on soils that are more susceptible to slumping and erosion. Therefore, there are some notable historical sources that have been and are being enlarged by the increase in runoff from impervious surfaces in this highly sloping sub-area. Much of this former cattle-grazing land is now utilized for equine pasturing.
Due to the increased development in the upper portions of these two watersheds the rangeland area has been reduced to less than 20 percent of the sub-area. As mentioned, these lands show more historical grazing impacts, including riparian access, than other rangelands in the study area. This is due to erosion susceptible soils, and some historical evidence of over-grazing.

Agricultural lands in this sub-area comprise about 15 percent of the land area, are exclusively on the valley floor and are dominated by field (hay) cropping. Therefore the sediment source potential is proportionately lower than in other sub-areas. However, there are a few locations where riparian encroachment and riparian vegetation removal related to adjacent fields appear to contribute to sediment loading.

There are numerous small equine lots adjacent to the riparian zone and channel in the mid-portions of Rucker Creek. Much of this sub-area is not visible from public access points, but informal discussions with local community members and observations during major runoff events suggest that riparian access or encroachment may be contributing to bank and channel destabilization. This is much more apparent in the upper reaches of both watersheds associated with the newer development. Riparian access and overgrazing was noted in a number of hillside locations and appeared to be contributing to erosion.

Panther – Panther and South Panther Creeks. The Panther sub-area is a smaller sub-area distinguished by a high proportion of developed land area (almost 60 percent), mostly smaller rural residential parcels and recent multi-home developments in the upper reaches. Riparian encroachment is apparent, and in some new developments, there are water impoundments and some restoration of riparian vegetation. Increased runoff does appear to cause some localized bank and channel destabilization on downstream culvert locations.

There is only a small land area suitable for grazing (approximately 6 percent) in the upper reaches of the watershed. These lands appear to have little significant contribution to sediment loads.
While agricultural lands comprise only about 12 percent of the sub-area, much of this land is part of a larger tract in the lower reaches of the watershed. The sediment source potential in this sub-area is proportionately high due to the row cropping west of New Ave. Here riparian encroachment, modification of the channel, and stormwater runoff are contributing to elevated sediment loads at the confluence of both channels with Llagas Creek.

Equestrian uses appear to have some localized impacts, particularly in the newer developments in the south Panther watershed, where riparian access causes reduced vegetation and localized erosion. Some of the newer home sites have small and large equine lots and pasture, and there is at least one equine boarding facility in the foot slope portion of the watershed, and a facility adjacent to New Avenue.

Live Oak – Live Oak Creek. The Live Oak sub-area is the smallest (814 acres) of all the study areas and was not grouped with other watersheds, due to rather unique aspects of topography, channel characteristics, and land use. Less than 10 percent of the land area is developed and is concentrated in the lower reaches to the confluence with Llagas Creek.

Rangelands comprise over 75 percent of the sub-area and begin at the foot slope and continue to the upper reaches of the watershed. In many portions of this sub-area there appear to be some historical eroded locations in ephemeral tributary channels and localized soil destabilization associated with downstream culverts. Significantly there are some locations in the mid-reach area where a combination of slope and road encroachment have contributed to small and one large slope and bank failure. This is an active source of sediment in the Live Oak watershed.

Agricultural lands comprise less than 4 percent of the sub-area and are mostly in the vicinity of New Avenue near the confluence with Llagas Creek. There is some evidence of a small amount of sediment loading from these fields into road ditches that convey road, residential, and agricultural runoff into Live Oak Creek at the New Ave. crossing.

West Branch Llagas – W. Branch Llagas, Day, and Lions Creeks, North and South Morey Channels, Upper Miller Slough. West Branch Llagas is the largest valley floor sub-area. This is a diverse sub-area with many different types and scales of land uses, but is largely defined by the City of Gilroy, it's northern sphere of influence, as well as the community of San Martin. Urban and rural residential land use accounts for almost 45 percent of the sub-area with the greatest concentration in Gilroy, where urban runoff is conveyed into the lower portions of West Branch Llagas, Morey Channels, and Upper Miller Slough. These channels are engineered or historical urban drains. North of Gilroy, development is largely older rural residences or more recent and elaborate large home developments. West of Santa Teresa Boulevard and north of Fitzgerald Avenue, there have been numerous new large residential developments, some of them associated with vineyard plantings. In the upper reaches of West Branch Llagas there is a recent residential and golf course development. Conversion of the rangelands to the west of Santa Teresa Blvd. appears to be inevitable. Localized flooding is all ready an issue in the vicinity of Santa Teresa Boulevard. Many of the residential parcels east of Santa Theresa and south of San Martin Ave. have small equine lots and there is notable sediment loading from road ditches and locations of residential encroachment on the channel.

Rangeland areas are all in the western foothills above Turlock Avenue, but only comprise about 20 percent of the sub-area. Much of the rangelands were inaccessible.

Agricultural lands, while only comprising slightly more than 10 percent of the land area are an important contributor to sediment loads in West Branch Llagas Creek. Given the type of cropping systems, a high proportion (70 percent) of the agricultural land has a high sediment source potential. These row cropped lands are also concentrated and, in some cases, are adjacent to the channel. Stormwater runoff, creek crossings, hydromodifications, and riparian encroachment are related to sediment loads observed during major runoff events. In limited locations some of the newer vineyard plantings associated with new developments are encroaching on riparian zones, and some evidence of recent, but localized channel incision was noted. Day Road has some unique issues, as a large portion of Day Creek serves as the road ditch. As it passes by various rural residential properties, the size and cross-section of the channel changes, leading to destabilization at some sections. Additionally, there are locations where the ditch is maintained clear of vegetation with herbicides, and on a number of occasions failure of the bank and road shoulder were noted. Santa Clara County road crews were observed on two occasions removing loose or eroded soil to keep the ditch clear.

Equine lots are mostly small and associated with residential development between San Martin and Fitzgerald Avenues. There only appeared (although visual access was limited) to be limited localized problems related to bare corral lots.

Lower Uvas – Uvas, Solis, Sycamore, and Burchell Creeks. The Lower Uvas sub-area is still largely undeveloped and only 18 percent of the land area is in rural residential uses. However, there are some concentrated residential developments in the Burchell and Sycamore Creek watersheds, which have some localized problems that appear to contribute to bank destabilization and sediment loading. These residential developments also have numerous small equine lots.

Rangelands comprise over 70 percent of the sub-area and are represented by a few large contiguous ranches in the vicinity of Burchell Creek, just west of the Gilroy city limit, the Solis Creek area, and the above the Oak Dell Park residential area. In some locations problems related to riparian access were noted and in others localized over-grazing appeared to be contributing to limited erosion of ephemeral channels.

Agricultural lands comprise only a small portion of the land area (about 6 percent) and are largely vineyards. There has been recent expansion of the vineyard acreage in the sub-area. Newer plantings on sloping ground appear to be contributing to sediment loading, particularly when plantings are made across ephemeral channels. Generally established vineyards have a lower sediment source potential, but certain hillside locations show evidence of localized erosion due to incising drainage ditches. Evidence of sedimentation from vineyards was noted at some culvert locations at road crossings, as well as localized bank failure at culverts and road crossing abutments, attributed to increased runoff volumes. Generally the sediment loading derived from agriculture in this sub-area appears to be lower than other similarly sized sub-areas in the study area.

Localized problems related to riparian access and encroachment by equine corrals and buildings were noted in the Sycamore and Burchell Creek watersheds. There are numerous small lots and boarding facilities that are, in some cases, adjacent to riparian zones and channels. Localized destabilization of creek banks was noted.

5.8.4. South Valley Region

The South Valley Region (27.2 percent of the study area) includes some portions of southwestern Gilroy and it's outlying areas, but development comprises less than 10 percent of the land. The largest urban growth is currently in the western area south of Highway 152 along Santa Teresa Boulevard. Much of the sub-area is low-lying with a high flood risk, therefore development is limited to the foothills. Much of the eastern developed portion of this region has larger rural residential parcels with farmed acreage or older homes surrounded by agricultural land.

Rangelands in the Region are the dominant land use (43.2 percent) and occur in large contiguous holdings in the eastern and western foothills. There is also a substantial amount of intensive grazing in the lower valley portions of the eastern region on poorly drained soils with elevated water tables. Agricultural land area is significant (32.1 percent) in the region, and often occurs in large contiguous parcels. Crops include row, field, tree, greenhouse and specialty crops. Given the large portion of agricultural land devoted to row crops (73.5 percent), the potential for sediment loading from agriculture is the highest in the study area. Additionally, much of the agricultural land in this region occurs adjacent to riparian zones, creek, and drainage channels.

This region has perhaps, the lowest concentration of equine holdings in the entire study area. However, potential impacts from this land use can be quite significant in specific locations in the eastern portion of the region, particularly adjacent to riparian zones and creek channels.

Figure 5.24. Gavilan Creek East from Santa Theresa Blvd. near Castro Valley Rd.

Table 5.11. Sediment Sources in the South Valley Region

Agriculture	**HYDRO**	**RIPAR**	**FALLOW**	**DITCH**
Jones	●	●	●	●
San Ysidro	●	●	◉	●
Pajaro	●	◉	●	◉
Lower Llagas	●	●	●	●
Uvas-Carnadeross	●	●	●	●
Wildcat	na	na	na	na

Rangeland	**ROAD**	**RIPAR**	**LOWVEG**
Jones	○	○	○
San Ysidro	○	◉	○
Pajaro	○	●	○
Lower Llagas	○	○	○
Uvas-Carnadeross	○	○	○
Wildcat	N	N	N

Urban	**HYDRO**	**RIPAR**	**FIRE**
Jones	na	na	na
San Ysidro	na	na	na
Pajaro	na	na	na
Lower Llagas	na	na	na
Uvas-Carnaderos	○	○	na
Wildcat	na	na	na

Rural Residential	**ROAD**	**RIPAR**	**CULV**	**EQUES**	**FIRE**
Jones	◉	●	◉	◉	○
San Ysidro	○	○	◉	○	N
Pajaro	○	◉	○	○	N
Lower Llagas	◉	○	◉	○	na
Uvas-Carnaderos	○	○	○	○	na
Wildcat	N	N	N	N	N

○ = Low ◉ = Medium ● = High N = Not accessible na = not applicable/observed

Sediment Sources in the South Valley Region

Jones – Alamias, Crews, Dexter, and Jones Creeks. The Jones sub-area encompasses a major proportion of the contiguous agricultural lands in the southeastern portion of the study area. Developed land accounts for only 6 percent of the region and is mostly rural residences on large lots or acreage. In these residential developments there are still numerous actively farmed parcels. The most significant developments are in the northern portion of the sub-area just north of Leavesley Road and east to Crews Road. Some of the road ditches adjacent to these developments appear impacted by increasing runoff volumes and the varied landscaping and road easement alterations made by owners. The ephemeral tributary to Alamias Creek along upper Dryden Road has been impacted by riparian encroachment, intense runoff flows, and riparian access to the channel by small grazing animals. In places it also functions as a road ditch. Similarly the road ditch on Godfrey Ave. southwest to Jones Creek is badly incised in spots and was observed carrying significant sediment loads in major runoff events.

Rangelands occur in the eastern hills adjacent to Crews Road. Some of the rangelands have been slightly impacted by cattle access to major ephemeral channels, but most of the problems appear to occur where rangelands or drainages intersect with road ditches, specifically at the foot slope area of Crews Road and hillside portions of upper Leavesley Road.

Equine lots and pastures occur sporadically in this sub-area, but are not as concentrated (lower residential development) as the east valley sub-areas to the north. As noted previously, there are locations impacted by small animal grazing, particularly when lots or pastures are adjacent to channels. There has been significant incision of the Crews Creek channel in an equine pasture area where horse and cattle are kept continuously, as there is no riparian vegetation, and animals have full access to the channel.

Agricultural lands account for just over 40 percent of the sub-area and about 78 percent of this land is devoted to high sediment source potential row crops. Tree and field crops account for the remaining croplands. Most of the intensively farmed lands are to the west of Ferguson and Pacheco Pass (Highway 152) Roads. There are numerous locations where riparian encroachment and vegetation removal have destabilized banks. The low-lying and relatively flat topography does allow sediment to accumulate in many locations along Jones Creek. In this sub-area there are creek crossings and agricultural drains that convey sediment laden irrigation tail water and stormwater into the channel.

Sediment likely moves slowly through the lower reaches of Jones Creek, but during major runoff events sediment laden water can be seen at the intersection of Bloomfield and Frazier Lake Roads. Historical hydromodifications for flood control and drainage have left much of the riparian corridor devoid of vegetation. Riparian encroachment is perhaps the most widespread and significant practice impacting sediment loading from these agricultural lands. Jones Creek also receives water from a Cal Trans ditch along Pacheco pass Road which is first conveyed underground along the road then is conveyed in to a westward flowing ditch that enters Jones Creek approximately 2,000 feet upstream of Bloomfield Road.

Lower Crews and Dexter Creeks have been significantly impacted by hydromodification (straightening), vegetation removal, and in the case of Crews Creek incision due to levees constructed from sediment removal operations. West of Ferguson Road, Crews Creek is captured in a culvert flowing underground to its confluence with Dexter Creek. At the Dexter Creek crossing on Highway 152, large quantities of recent sediment deposits can be observed at the culvert outfall or confluence with Crews Creek. This location also shows evidence of riparian encroachment from adjacent row crop fields.

San Ysidro - San Ysidro Creek. The San Ysidro sub-area has very little development aside from rural residences, occasionally associated with small farm operations and typically surrounded by row, vine, tree crop, and pasture or rangeland. There were no observations of any significant problems contributing to excessive sediment loads in this sub-area. A new construction area along Canada Road, and what appeared to be riparian encroachment at one residential parcel may be potential sources in the future.

Rangelands comprise over 60 percent of the land area and are largely in the contiguous hill parcels of the sub-area adjacent to upper Canada Road. There were few problems observed in association with these lands other than some natural slumps associated with seasonal springs. West of Pacheco pass Road, a bare-lined drainage ditch was noted passing through a non-accessible pasture, which appeared to carry nutrient-rich and occasionally sediment-laden water.

Agricultural lands comprise almost thirty percent of the sub-area and begin at the bottom of the eastern hills. Much of the lands east of Pacheco Pass Road are vineyards, which have been farmed for a long period. Recent expansion of vineyards on the upper slopes have created some erosion problems observed during a tour of one of the operations. However, sediment is partly contained by a detention pond. Field drains running down slope towards Pacheco Pass Road show evidence of incision and bank instability. South of Pacheco Pass, the San Ysidro channel serves as an agricultural drain associated with intensive row cropping. At this location towards the confluence with Jones Creek, sediment loading is attributed to historical hydromodifications (channel straightening) riparian encroachment, tail and stormwater conveyance from adjacent croplands. The San Ysidro channel appears to be incised as the result of these current and historical practices.

Pajaro – Pajaro River and Millers Canal. The Pajaro sub-area is also largely undeveloped and consists primarily of rural residential holdings of varying size mostly along Pacheco Pass Road. There are no concentrated residential lands in the sub-area. There were few observations of any widespread problems resulting in significant sediment loading from these holdings.

Rangelands in the sub-area comprise over 70 percent of the area and are found largely in the eastern hills above Pacheco Pass Road and on the poorly drained, relatively flat lands southeast of Bloomfield Road to the Pajaro channel. Generally there is limited visual access to the hills and there were no observations of significant problems other than soil destabilization at ditches and culverts. The lower-lying lands are maintained with varied management practices and there are some important portions of the land adjacent to the Pajaro channel that appear impacted by riparian access and grazing. Sediment conveyance through the Pajaro sub-area (via the Pajaro channel) is likely slow due to the flat topography and the fact that Miller's Canal to the south carries much of the water from hillside rangelands. Generally, the Pajaro channel does not carry high flow volumes at a velocity necessary to rapidly transport the accumulating sediments. This sub-area still has some of the attributes of the historic Soap Lake, where sediments from the mountains and valleys deposit in this formerly large wetland environment.

Agricultural lands (about 12 percent of area) are diverse and almost equally distributed among the three sediment source potential classes. Field crops, including hay and pasture are important, tree and vine crops are grown east of Pacheco Pass Road, while row crops are grown closer to the Pajaro and Llagas channels. There are possibly some locations in the vicinity of Frazier Lake where drainage ditches from sprinkler-irrigated row crop fields may convey waters to Llagas Creek, however much of the area was inaccessible.

Lower Llagas – West Branch Llagas Creek, (Ronan Channel), Llagas Creek , Princevalle Drain, and Lower Miller Slough. The Lower Llagas sub-area has a long north-south extent from Masten Road south to the confluence of the Pajaro and Uvas-Carnaderos channels. This sub-area includes the largest extent of prime agricultural lands in the study area. Developed lands account for about 18 percent of the area although much of this is commercial and retail development within the current and planned city limits of Gilroy. The bulk of the residential devlopments are in the sections north of Leavesley Road, at the heart of the valley floor. Generally the SCVWD channel easement through almost the entire sub-area limits riparian encroachment to only a few locations in the channel along Holsclaw Road.

The only rangelands in this sub-area are dryland and irrigated pastures that occur sporadically. As some are not accessible, no problems were observed directly linked to grazing in the sub-area. Agricultural land accounts for over 55 percent of the land area and the majority of it (83 percent) are high sediment source potential row crops. In the portion of the sub-area, along Marcella Road a very large road ditch conveys drainage waters from row, field, and tree crop fields, where fields encroach on the ditch. However, the occasionally sediment laden water does not appear to be directly conveyed to any surface water bodies. The lower portion of Lower Miller's Slough is impacted in a few short reaches by older drain outfalls from adjacent agricultural fields, but to a greater degree where the relatively steep banks on this deep channel are kept clear of vegetation by herbicide applications. This is potentially important given the occasionally high volume and velocity of urban runoff from Gilroy conveyed in the channel.

There were no observed agricultural drain outfalls into the Llagas channel from Bloomfield Rd north to Masten Road. However, below the Llagas confluence with the Pajaro channel there are a number of major agricultural drains that discharge sediment into the Pajaro channel. While there was no ground-based visual access to the Pajaro channel south of Highway 25, the aerial photo suggests that tail and stormwater is conveyed into the Pajaro channel from the network of field drains on what is known as the Sargent Ranch.

Uvas-Carnaderos – Uvas, Tick, Farman, Gavilan, and Babbs Creeks. The Uvas-Carnaderos sub-area comprises a diverse area that includes parts of western Gilroy. Developed lands (mostly in the northern portion of the sub-area) account for almost 25 percent of the land area. Most of this is relatively recent multi-home developments and Gavilan College that appear to be tied to more modern subsurface drainage networks that, in some cases, have outfalls into the Uvas-Carnaderos Creek channel.

Rangelands account for 16 percent of the area largely on the western slopes above Santa Teresa Boulevard. There are numerous ephemeral channels that drain these locations, but no evidence of any significant sediment sources was observed.

Agricultural land accounts for these high potential sediment source cropping. These locations, with significant field drainage networks in the low-lying lands, may be important sediment sources. Unfortunately there was very little ground-based visual access to this large contiguous agricultural area. However, discussions with local growers who have farmed the area in the past confirmed that: annual sediment accumulation can be significant due to upstream transport and deposition as well as localized sources; a significant open drain network must be maintained to passively lower the water table to allow year-round farming and flood drainage and; most of the ditches have a steep 'V' cross-section similar to that observed for the historically modified portion of Gavilan Creek (visible from Highway 101) and are not vegetated. Gavilan Creek has undergone many hydromodifications, is non-vegetated for a substantial portion of its length through the row crop lands between Mesa Road and the confluence with the Pajaro River. The lower portions of Babbs Creek flow through row crop fields as well, and in some portions has been impacted and has incised due to riparian zone encroachment by farm roads and field tillage.

Generally the riparian zone vegetation of the Uvas-Carnaderos channel has remained intact and is often of diverse age, species, and height classes. Riparian encroachment from roads and tillage are limited, although some encroachment was observed adjacent to fields in the middle to lower portions of the sub-area. The locations with a high risk for direct discharge of field stormwater runoff are in the vicinity of Mesa Road and the end of the Monterey Frontage Road south of Gilroy.

Wildcat Canyon- Upper Tick, Farman, and Tar Creeks. Almost 95 percent of the Wildcat Canyon sub-area is contiguous rangelands, with only a limited number of structures accounting for all of the developed land (0.03 percent of sub-area). These rangelands are visible from a few locations along Highway 101, the Highway 25 ramp, and Castro Valley Road. Generally the only problems appear to be associated with culverts at road crossings, occasional soil slumps on the high slopes with thin soils that receive cattle traffic, and some limited rill erosion that occurs on some fall planted hay fields close to Highway 101.

6. SEDIMENT SOURCE SUMMARY

A total of 47 creeks were surveyed within the 202 square mile study area. Two field methodologies were utilized to assess the risk of erosion in stream channels: proper functioning condition (PFC) and bank erosion hazard index (BEHI). An aerial photo was employed to supplement the PFC and BEHI, providing a visual assessment of vegetation density along stream channels. Numerous in-channel sources of sediment have been described related to: hydromodification, channel incision, bank failure, road ditches, vegetation, land use encroachment, and access.

Current and historical land uses and land use conversion are an important dynamic shaping the characteristics and magnitude of sediment sources in the study area. This region, with a long history of agriculture and ranching is increasingly becoming urbanized as a bedroom community for San Jose and Silicon Valley.

Given the diversity of land use in the study area, potential sediment sources are numerous. The main controllable sediment sources related to land use are agriculture, rangeland, urban and rural residential stormwater runoff, and commercial and small equestrian facilities.

This section summarizes the findings of the field survey and provides an estimate of the sediment load contributions from the various land use and in-stream sources discussed in Sections 4 and 5. Sediment contributions from urban, rural residential, agriculture, and equestrian land uses are the most important controllable sources in the study area. Rangelands, forest, and scrubland in the Upper West Basin Region, due to their large area extent and topography, contribute a large portion of total sediment load, but represent only a small portion of the controllable sources. In the Valley Region portion of the study area, stream channels are in varying states of disequilibrium, leading to accelerated bank loss and channel incision and sedimentation. These sources are significant sediment sources. Figures 6.1 and 6.2 provide a graphic summary of relative in-stream and land use related erosion potential for each study sub-area.

6.1. Sediment Source Load Contributions

An estimate of sediment load contributions from the various land uses and in-stream processes have been developed to provide the basis for conclusions and recommendations for future priority actions in the study area. These estimates are based on a conceptual modeling approach, a combination of the qualitative assessment results, and modification of the sediment load rate estimates derived from the sediment load modeling for the entire Pajaro River watershed performed by Tetra-Tech.[12]

The sediment load modeling conducted for the CCRWQB uses the SWAT sediment model. The modeling appears to have assumed the following:

- A 1992 land use database from satellite images adequately represent current land uses
- The hydrological system is in equilibrium
- Land use and land area drive sediment loading in the study area
- Stream channels retain constant and uniform dimension

[12] Central Coast Regional Water Quality Control Board, *Draft Total Maximum Daily Load for Sediment in the Pajaro River Watershed, San Benito, Santa Cruz, Santa Clara*, and Monterey Counties, December 2003.

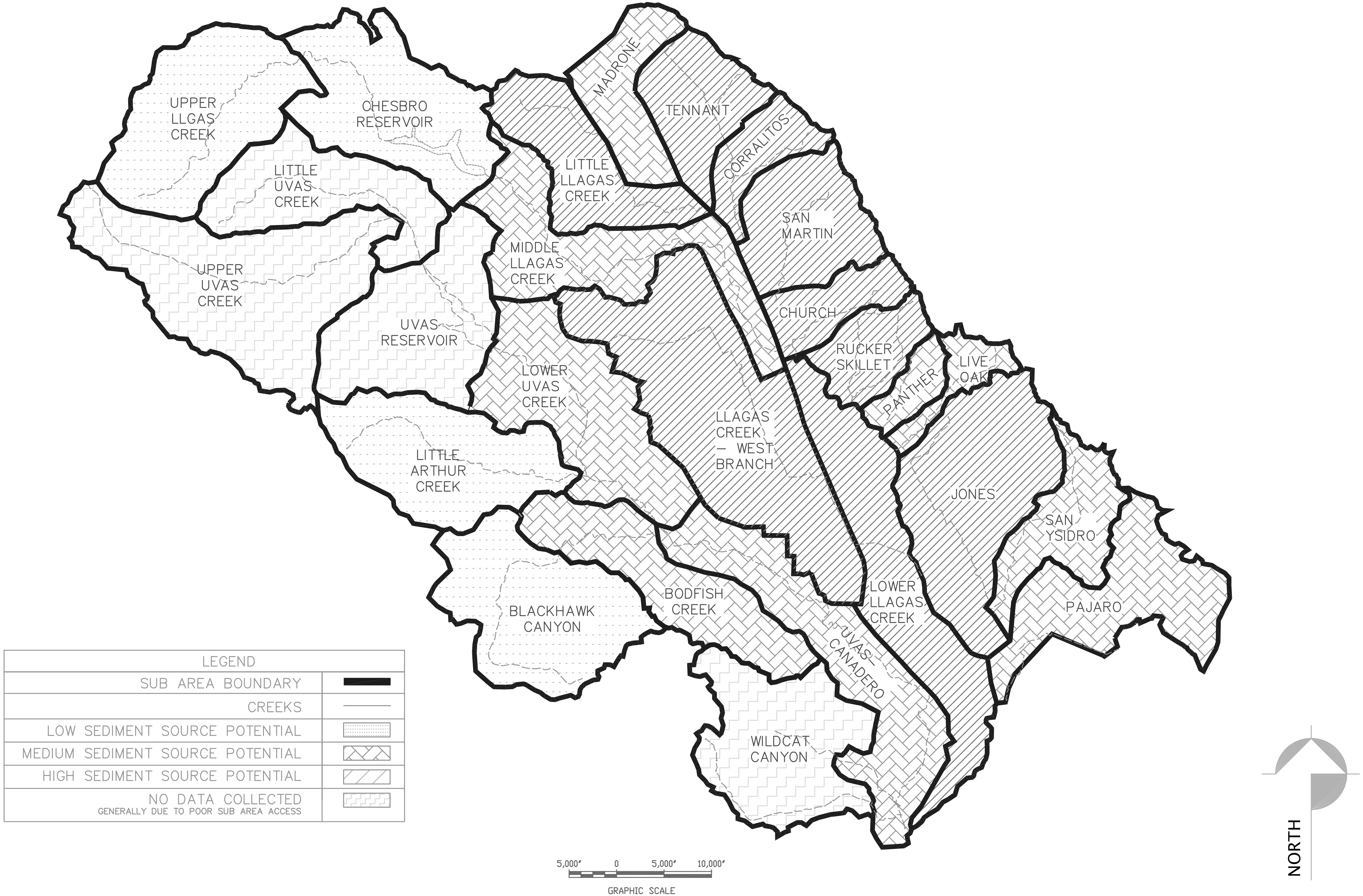

FIGURE 6.1. GRAPHIC SUMMARY OF RELATIVE STREAM EROSION RISK BY SUB-AREA

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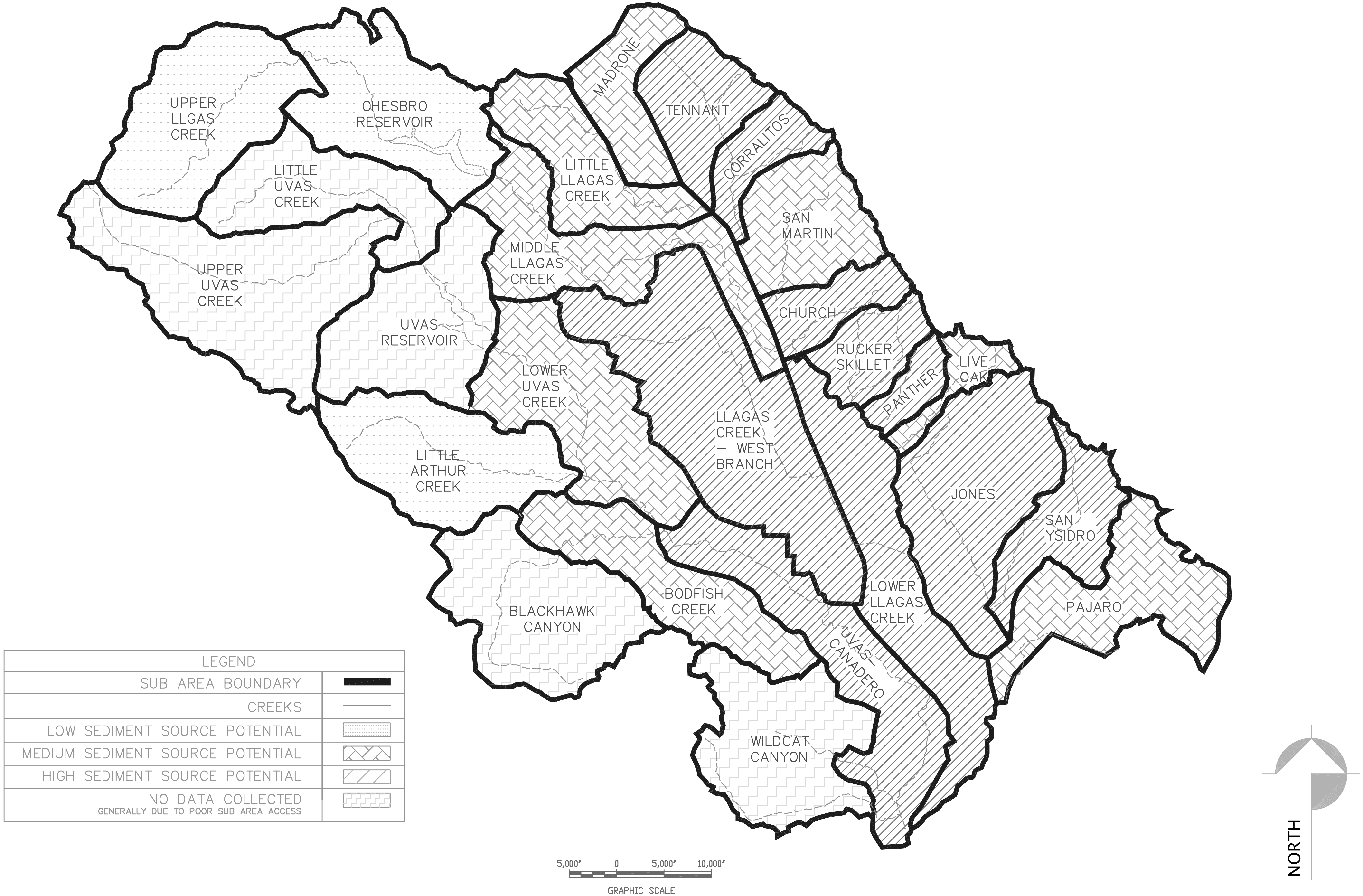

FIGURE 6.2. GRAPHIC SUMMARY BY SUB-AREA OF RELATIVE SEDIMENT SOURCE RISK ASSOCIATED WITH LAND USE

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Civil • Environmental • Water Resources Engineering

To develop a refinement of sediment load contributions in the study area, land use analysis results from this study were substituted for many of the categories developed in the SWAT model. As this project's study area was larger than defined by the Tetra-Tech and had been divided into more discrete study units, additional adjustments of load rates calculated by SWAT model runs was possible. The following assumptions drove these adjustments:

- Land use data derived in this study is more representative of existing conditions
- A large portion of land use identified by Tetra-Tech as 'orchard' is actually rural residential
- Rural residential lands share loading "traits" of urban impervious surfaces, orchards, and pasture
- Agricultural loading can be adjusted by the degree of "connectivity" to drainage and stream channels
- In-stream sources exist and are related to land use and riparian, stream bank and channel bed integrity

Utilizing the SWAT model output for Llagas and Uvas watersheds and the land use data derived from the field survey, sediment load contributions were then estimated on a percentage basis. This approach is largely conceptual and is limited, first by the limited suspended sediment and loading data available for calibration, the perceived assumptions used to calibrate the SWAT model, and the limits of best professional judgment. However, these professional judgments are well informed by detailed knowledge of study area characteristics acquired during the field phase of this study.

A summary of the sediment load contribution estimates for land use and in-stream sources in the Upper West, North Valley, Mid-Valley, and South Valley regions in the study area is provided in Table 6.1 and below.

6.1.1. Upper West Basin Region

The Upper West Basin Region includes the Blackhawk, Bodfish, Chesbro Reservoir, Little Arthur, and Upper Llagas Creek sub-areas. The area historically yields significant quantities of sediment from natural or non-controllable sources. Due to limited development and a small number of lower risk agricultural sources, there are only localized sedimentation problems due to controllable sources. Rangelands contribute the most significant portion (67.5 percent) of total sediment due to their large area. However controllable sources typically related to roads, riparian access, and grazing are only a small portion of this total contribution. Agricultural sources (1 percent) are localized in one sub-area. Rural residential sources remain small (1.5 percent) but will most likely increase with future development.

Observations of erosion and sedimentation within the Upper West Region agree with anticipated natural processes of erosion and sedimentation related to the geomorphic setting of these creeks. The estimated sediment load contribution from in-stream processes from creeks in the region is approximately 13.5 percent, related to natural geology, channel slope, and topography of the region.

6.1.2. North Valley Region

The North Valley Region includes the Little Llagas, Madrone Channel, Tennant, Corralitos, Middle Llagas, and San Martin Creek sub-areas. The increasingly developed areas in the North Valley region are contributing to sediment loading (13.5 and 18.5 percent for urban and rural residential, respectively) resulting in impacts to stream flows and destabilization of banks and channels. Rangeland sources (38 percent) comprise a very small percentage of controllable sources. Agricultural sources (7.5 percent) related to row crop production are significant in a few sub-areas, due to a number of management related factors and past hydromodifications that are controllable with specific practices.

Erosion and sedimentation was related to channel hydromodification and land use encroachment into the channel and riparian zone. As a result the estimated load contribution, approximately 19.5 percent, is higher than that expected for a non-impacted stream system. Observations of vegetation removal, channel incision, and bank failure within the region are associated with magnitude of this estimate.

6.1.3. Mid-Valley Region

The Mid-Valley Region includes the Church, Rucker Skillet, Panther, West Branch Llagas, Live Oak, and Lower Uvas Creek sub-areas. The newer hillside developments, older rural residential developments, and their network of drainage and road ditches account for important and extensive, rather than locally intensive sediment sources (16.5 percent), in addition to impacts from urban runoff (12.5 percent). The concentration of small and large equine lots and boarding facilities contribute to increased loading. Agricultural lands on the west side of the area are also significant source areas (10 percent). Generally, sediment contributions from rangelands (37 percent) account for the least significant controllable sources.

Historical and current land use patterns in the region have impacted channel processes. Increased flows from urban and rural residential areas have elevated the erosion potential in stream channels, and sediment load contributions from in-stream process are estimated at 21 percent. The erosion susceptibility of soils in the riparian zone and land use patterns contribute to this estimate.

6.1.4. South Valley Region

The South Valley Region includes the Jones, San Ysidro, Pajaro, Lower Llagas Creek, and Uvas Carnadeross sub-areas. Despite their location in the relatively flat, low-lying areas, the predominance of agricultural land uses, make these sediment sources most important (36.5 percent). Recent and historic hydromodifications related to soil drainage requirements in these contiguous agricultural parcels also contribute to sediment loading. Increased urban development (2 percent) and runoff introduces significant flow volumes that have impacted channel stability. Rangelands (33.5 percent), though accounting for a large percentage of the land area do not appear to be significant controllable sediment sources.

Increased flows from urban areas and land use encroachment from agriculture are related to observations of erosion and sedimentation in the region. In-stream sediment source contributions are estimated at approximately 25 percent, primarily linked to the erosion susceptibility of soils in the region and degradation of the riparian corridor.

Table 6.1. Sediment Load Contributions from Land Uses and In-stream Processes

	Agric.	Range	Urban	Rural	Stream	Other
Upper West Basin Area						
Total Land Area	478	28,371	0	158	--	20,013
Percent Study Area	1.0	58.0	0	0.5	--	40.5
Load Contribution (%)	**1.0**	**67.5**	**0.0**	**1.5**	**13.5**	**16.5**
North Valley Area						
Total Land Area	2,194	7,468	3,100	5.584	--	4,438
Percent Study Area	10.0	33.0	13.0	24.5	--	19.0
Load Contribution (%)	**7.5**	**38.0**	**13.5**	**18.5**	**19.5**	**3.0**
Mid-Valley Area						
Total Land Area	2,172	8,423	3,265	3,662	--	4,675
Percent Study Area	9.5	38.0	14.5	16.5	--	21.0
Load Contribution (%)	**10.0**	**37.0**	**12.5**	**16.5**	**21.0**	**3.0**
South Valley Area						
Total Land Area	11,262	15,157	930	2,496	--	5,248
Percent Study Area	32.0	43.0	2.5	7.0	--	15.0
Load Contribution (%)	**36.5**	**33.5**	**2.0**	**2.0**	**25.0**	**1.0**
STUDY AREA						
Total Land Area	16,106	59,779	7,295	11,900	--	34,374
Percent Study Area	12.5	46.3	5.7	9.2	--	10.5
Load Contribution (%)	**8.5**	**57.5**	**2.5**	**5.0**	**16.0**	**10.0**

6.2. Summary of Conclusions

1. Within the Upper West Basin Region, in-stream sediment sources are primarily linked to vegetation removal, land use encroachment, and access. Channels in the area are generally considered index or functioning reaches, with no or little human disturbance. Controllable sources of sedimentation from rangelands in the Upper West Basin are localized, not concentrated, and do not appear to contribute significantly to current sediment loads. Agricultural and rural residential sources are important in localized areas, but overall represent a small portion of the total sediment load.

2. Channels in the North Valley Region have been impacted by channel hydromodifications and land use encroachment related to urban and rural residential developments. Sediment contributions from urban and rural residential sources are related to concentrated hillside development, road ditches, and high runoff and thus comprise a majority of controllable sediment sources. Agriculture is a small, but still important portion of the controllable source loads in the region.

3. The Mid-Valley Region has been impacted by channel hydromodifications and land use encroachment related to a combination of urban, rural residential developments, and agriculture. Sediment contributions from urban and rural residential sources are related to concentrated hillside development, equestrian activities, road ditches, and high runoff and comprise a majority of controllable sediment sources. Agricultural sources are largely concentrated in the western portions of this valley region and comprise a significant portion of the controllable source load.

4. The South Valley Region has been impacted by channel hydromodifications and land use encroachment primarily related to agriculture. Sediment contributions from in-stream processes are, in part, related to past loading and impacts from land uses, but also due to the rather poor condition of riparian zones, streambanks, and channel beds. Agriculture land uses comprise the largest portion of controllable sediment sources.

5. Streams and channels in the valley portion of the study area are in varying states of disequilibrium leading to accelerated bank loss, channel incision, and sedimentation. In-stream sediment sources comprise a significant contribution to sediment load estimates in the study area, due to the poor functional state and high bank erosion potential of ephemeral channels and portions of Llagas and Uvas Creeks. Agriculture comprises an important source of total controllable sediment load (including in-stream sources) in the study area. Runoff impacts on channels and sediment loading from urban and rural residential comprise the remaining important portion of controllable sources.

7. OUTREACH ACTIVITIES

7.1. Santa Clara County Farm Bureau Watershed Groups

Critical to this study has been the effort to engage growers, ranchers, and equestrian interests in defining, clarifying, and discussing issues related to sediment problems, sources and management in the study area. Planning of this effort was in partnership with the Santa Clara and San Benito County Farm Bureau Water Quality Program Coordinator. One of the main objectives and activities of the Farm Bureau Program has been the formation of watershed workgroups that meet on an occasional basis to learn about and discuss local watershed and water quality protection issues. Three Watershed Workgroups were formed: Llagas, Uvas-Carnadeross, and Pacheco.

The outreach effort was somewhat hindered at the outset due to the lag time associated with re-establishing one of the watershed groups. The Llagas Watershed Workgroup had been formed initially, in anticipation of the sediment TMDL process, in 2001. However, momentum was lost given the delays in the start of this study and the possible perception on the part of growers that there was little immediate or compelling reason or benefit to participation.

In addition to presentations of the work progress by the Study Team, meetings also provided the opportunity for additional discussion and input with the Watershed Workgroup members. Each of these groups met bimonthly for the entire study period. Prior to each meeting, letters were mailed to each grower in the watershed, informing him/her of the topics to be discussed at the meeting. In addition, growers were called the day before most meetings to ensure they had the opportunity to attend and provide input to the discussion.

7.1.1. <u>Presentations to Llagas and Uvas-Carnaderos Watershed Workgroups</u>

The first presentation, made on February 25, 2003, was an introduction to the assessment scope, problem definition, and methodology as well as a presentation of preliminary field observations made during the rainy season. Unfortunately this meeting was poorly attended, but did allow for a detailed discussion and feedback. Meeting participants were provided a study area map with major roads included for quick reference. Much of this initial discussion focused on grower concerns over source definition, location, and the difficulties of actual quantification of sediment sources without good long-term data.

Additionally, there was animated discussion of sources and agricultural management practices when growers recognized a particular location from pictures on a PowerPoint slide. This inevitably led to valuable discussions concerning the grower's perception of the problem and, in some cases, providing direction to project personnel for additional areas of observation and assessment of problem sources. It became quite clear at the outset that these growers did not have a good familiarity with the many possible sources and causes of sedimentation. The small number of participants did allow for some in depth discussions concerning the nature of the problem, concepts related to beneficial use impairments, and in particular, responses to visual evidence of winter/rainy season examples provided by pictures from the study. Positive comments were received on this initial presentation, particularly related to the educational value of photo documentation of the types and relative or specific locations of agricultural sediment sources.

An edited version of the same presentation was made to the general Santa Clara County Farm Bureau (SCCFB) meeting of April 2, 2003. While there were many more members in attendance, the presentation and discussion was limited to 1/2 hour, restricting the opportunity for any detailed interaction. Meeting participants were given an updated study area map with preliminary sub-area boundaries and a very preliminary problem 'rating' (low, medium, high) by sub-area. The main objective, making a larger portion of the SCCFB membership aware of this project, was achieved.

On April 30, 2003, a revised and expanded presentation was made to the Uvas-Carnaderos Watershed Group. This meeting was well attended by members, from both the Uvas-Carnaderos watershed and the Llagas watershed, who were more consistently involved prior to this meeting. However, many of the questions also revealed that these growers were also just beginning to understand the scope of sediment sources and how typical production practices may contribute to the nature and magnitude of problems. Meeting participants were given the same study area map provided at the April 2 meeting. This map format appeared to be a good tool to 'locate' participants land and provide some 'food for thought' by comparing their sub-area risk 'rating' to others. Also added to this PowerPoint presentation was a small sediment monitoring data set from one of the study sub-areas. The monitoring data was collected by the University of California Santa Cruz (UCSC) as part of a Nutrient TMDL sampling program. The limited data collected from two locations in the West Branch Llagas sub-area provided a vivid indicator to the group of how land use changes, hydromodifications, eroding creek crossings, and poorly vegetated banks can result in extreme sediment loading. However, again, it was found that photos from 'known' locations were a very effective educational tool that stimulated detailed discussion of problems and possible mitigations.

A fourth presentation was made to the Uvas-Carnaderos work group on November 9, 2003. This meeting was attended by many growers who were new to water quality issues and the concept and function of watershed groups. Most of the growers were from the Llagas watershed. Consequently, there was a large amount of discussion prior to the presentation concerning updates on current activities in the region, including the scope and status of the Regional Baord's Agricultural Waiver. A presentation was made with handouts that contained information concerning the methodology and preliminary results from the channel assessment component, an updated study area map, and example descriptions and photos of creek channels rated by the PFC and BEHI methods. The focus on sub-area locations was helpful in eliciting comments, additional information, and questions concerning sediment sources in the study area. Due to the length of prior agenda items, this presentation and discussion was relatively brief; however, it appeared that growers were satisfied that the project scope, methods, and preliminary conclusions were fair and balanced.

A copy of a PowerPoint show presentation developed for the SCCFB outreach component is included in Appendix B.

7.2. Public Agency Contacts

At the outset of this study, it was assumed that a significant effort would be made to develop contacts with a number of the key public agencies and departments pertinent to drainage, creek and ditch management, flood control, and planning. During the winter of 2002-2003 a number of preliminary inquiries and mostly informal discussions were initiated with Santa Clara Valley Water District (SCVWD) and Santa Clara County Roads Operations staff. The most productive and meaningful public agency contacts were largely with field personnel. However in the spring of

2003, as advised by Regional Board staff, that further efforts, particularly with planning departments of the cities, were unnecessary and perhaps would be less fruitful, given the ongoing process and uncertainties related to new municipal storm water management plans currently in development by the local cities.

7.2.1. Santa Clara Valley Water District

At the onset of the project it was determined that the SCVWD was likely the most important source of information concerning watershed and creek management in the study area. However, due to time constraints and difficulties identifying the proper agency contacts, limited information concerning comprehensive watershed management plans and strategies was attained. It was clear that the SCVWD's watershed management effort in the study area is oriented towards flood control and channel maintenance for flood control.

Contact was made initially with the supervisor responsible for South Santa Clara Valley watersheds, including Llagas Creek. A brief interaction with the supervisor was possible, which resulted in securing access to the maintenance staff responsible for drainage systems in the study area. Two meetings with the staff manager provided very detailed information concerning the scope and activities of the annual creek maintenance program. The Study Team was provided field notes, maintenance priorities and pictures of channel conditions from the survey of 2002. Additionally, the staff manager took Study Team personnel on a short, but valuable field trip to observe and describe problems in the West Little Llagas watershed in downtown Morgan Hill. During this field trip, the District staff provided significant background concerning the development of the proposed West Little Llagas flood control project that will redirect a substantial amount of stream flow to a new channel to reduce flooding risk in unincorporated areas south of Morgan Hill.

Pictures and descriptions provided from the 2002 creek assessment provided a guide to conduct supplemental observations of sediment source problems in specific creek reaches. An important aspect of the meetings was to obtain an overview of the conceptual approach, practices and priorities of the SCVWD's channel maintenance program.

7.2.2. County of Santa Clara Roads Department

Contact with this Department was limited to three informal meetings with one field manager in the field. The meeting sites tended to occur at problem sites, which allowed for specific discussions of road and ditch maintenance issues. These conversations and problem locations were always concerning road and drainage infrastructure that was failing largely due to increased runoff volumes associated with development in the unincorporated areas of South Santa Clara County. These discussions assisted the study team to become aware of other problem sites in the study area.

Detailed discussions related to erosion and sedimentation issues, specifically sediment sourcing from Santa Clara County drainage infrastructure were typically very brief. However, in later conversations with a few private landowners, the Study Team learned that, as a result of those few conversations, the road staff awareness of erosion and sedimentation issues was greater as a result of our informal discussions.

7.3. Summary

The presentations to and work with the SCCFB work groups was useful and beneficial to both the Study Team and Workgroup members. As the SCCFB Water Quality Program is an evolving and growing effort, it could always be argued that additional time for more consistent interactions concerning sediment assessment and management would only increase positive outcomes and actions. Similarly, outreach to local agencies was important in confirming/validating observations and providing a “reality check” for the Study Team, but would have been enhanced with intaction with field staff and program supervisors.

8. PRELIMINARY PROBLEM STATEMENT

8.1. Introduction

The Llagas Basin study area is a diverse region comprising approximately 15 percent of the Pajaro River Watershed. The RWQCB has listed the Pajaro River and Llagas Creek as impaired due to elevated sediment levels.

The Llagas and Uvas Watersheds are impacted by elevated sedimentation due to tectonic activity and geologic instability in the Upper West Basin Region, as well as, past and present land use practices in the Upper and Valley Region. Sedimentation in the Upper Basin Region results primarily from the failure of the sandstone and shale materials on steeper slopes. Rock slides and bank slumping events are the main processes of mass wasting in the Upper West Basin Region and may occur more frequently in locations disturbed by timber activities, fires and/or scarified from roads or other slope cuts. In the Valley Regions of the Study Area, sheet and rill erosion from adjacent and distant land uses and bank and bed erosion in the streams are the predominant sources of sedimentation.

Due to the diversity of land uses in this rapidly urbanizing area, a large number of controllable factors contribute sediment production and loading. Water quality concerns due to sediment increase when sediment is conveyed into creeks in amounts or locations that exceed the creeks ability to transport it. Additionally, in-stream sediment production may also be increased when existing natural or man-made channels experience rapid increases in upland runoff volumes. A large number of factors control the magnitude of in-stream erosion, including the composition of bed materials, stream flow duration, frequency and location of flow within an active channel, channel geometry, soil and geologic conditions and vegetation.

8.2. Beneficial Uses of Surface Water Resources

The California Porter-Cologne Water Quality Control Act establishes the responsibilities of the State Water Resource Control Board and nine Regional Water Quality Control Boards in California. Under the Porter-Cologne Act each Regional Board is required to “formulate and adopt Water Quality Control Plans (Basin Plans) for each of the nine regions. The Basin Plan for the Central Coast Region defines the beneficial uses for each water body, the water quality objectives that protect those uses, and an implementation plan that attempts to accomplish those objectives.

Surface water resources in the study area provide for various beneficial uses, ranging from municipal, agricultural and industrial water supply, cold and warm water habitat, wildlife habitat and several other uses listed in Table 8.1.

8.3. Water Quality and Impairment to Beneficial Uses

The Basin Plan contains very general water quality objectives established to protect each beneficial use. Water quality objectives are developed for all inland surface waters, enclosed bays, estuaries, and ocean waters. Both general and more specific water quality objectives are established to protect beneficial uses.

General Water Quality Objectives as put forth in the Central Coast Region Basin Plan in relation to sedimentation state that:

Sediment

The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Turbidity

Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increase in turbidity attributable to controllable water quality factors shall not exceed the following limits:

1. Where natural turbidity is between 0 and 50 Jackson Turbidity Units (JTU), increases shall not exceed 20 percent.
2. Where natural turbidity is between 50 and 100 JTU, increases shall not exceed 10 JTU.
3. Where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent.

Allowable zones of dilution within which higher concentrations will be tolerated will be defined for each discharge in discharge permits.

The established narrative and numeric water quality objectives pertaining to sedimentation are limited and may not be fully protective of beneficial uses for surface water resources in the study area.

The narrative objective for suspended solids may be applicable to site specific projects, where ambient suspended solid concentrations can be measured up and downstream of a specific activity. However, based on the natural variability in suspended solid loads, discharge rates, and the lack of long-term water quality data, the determination of a background concentration from which to measure water quality impairment is not possible at this time.

Similarly, turbidity objectives outlined in the Basin Plan are numeric but address increases to natural turbidity. The objectives may not be directly applicable in this study since the natural turbidity levels for the Llagas and/or Uvas-Carnadero are unknown, and in reality other contaminant and biological sources other than suspended sediment have a strong influence on turbidity levels.

Other factors related to sediment, including stream geomorphology, sediment loads, riparian habitat, and flows are important factors to consider in the assessment of impairment to, and long term protection of water quality and beneficial uses. Alteration of stream geomorphology, increased fine sediment loads, loss of riparian vegetation, increased stream flows, and other factors have increased sedimentation related problems throughout the study area. These factors in turn are resulting in the impairment of several beneficial uses of streams in the study area, including cold and warm water and wildlife habitat, and migration and spawning for anadromous fish.

8.3.1. Altered Stream Geomorphology

Altering or severely changing geomorphological characteristics such as pool-riffle ratios, width/meander length ratios, width/depth ratios, and substrate composition can impact stream ecology and water quality. Throughout the study area many of the streams have undergone substantial alteration or hydromodification, including straightened channels, removal of vegetation, encroachment and loss of floodplains. All of these alterations are resulting in excessive erosion, sedimentation and water quality impairment.

As reported in the stream assessment section of the report, channelization or channel modification, which encompass activities such as straightening or relocating existing stream channels have occurred throughout the study area. In many instances, these activities have been undertaken to improve flood control or to increase acreage for agricultural and urban land uses. These forms of hydromodifications typically result in more uniform channel cross sections, steeper stream gradients and reduced average pool depths. Channel modifications typically change the stream systems natural ability to absorb hydraulic energy resulting in excessive erosion in some reaches, and sedimentation in others. A frequent result of channelization and channel modification is a diminished suitability of in-stream and riparian habitat for fish and wildlife. Hardening of banks along waterways has eliminated in-stream and riparian habitat, and decreased the quantity of organic matter entering aquatic systems, an important source of food and habitat for aquatic organisms.

One of the more significant changes to in-stream habitat associated with channelization and channel modification is sediment supply and delivery rates. Stream side levees have been linked to accelerated rates of erosion and decreased sediment supplies to coastal areas (Hynson et al., 1985). Sherwood and others (1990) evaluated the long-term impacts of channelization projects on the Columbia River estuary and found that changes to the river system have resulted in a substantial increase in erosion and sedimentation in the watershed. Schoof (1980) reported several other impacts of channelization, including drainage of wetlands, reduction of oxbows and stream meander, clearing of floodplain hardwood, lower of groundwater levels, and increased erosion. The correlations presented in these articles concur with observations made by the Study Team within the Llagas Basin study area.

8.3.2. Fine Sediment Loads

Excessive loads of fine sediments are detrimental to most stream systems because they can alter both substrate and water column conditions. Sources of fine sediment can result from upland sources, such as sheet and rill erosion from agricultural lands, and bank erosion from unlined road and drainage ditches. In-stream sources can also originate from bank failure and bed scour at downstream of hydraulic structures. Alterations in substrate contribute to a decline in fish spawning success, particularly for salmonids. Fine sediment can trap fry that are attempting to emerge; deplete intergravel oxygen levels, smothering eggs that have been laid; limit the aquatic invertebrate populations, a food source by predatory fish in rearing areas; and fill pools and pockets between rocks and boulders on which young fish depend upon for protection. Suspended fine sediments may also influence the survival of aquatic organisms by clogging and damaging respiratory organs. Increased turbidity increases water temperature (because turbid water absorbs heat more efficiently) and suppresses algal photosynthesis.

8.3.3. Abnormally High Stream Flows

High-energy flows can erode substrate and bank materials, destabilize the physical structure of aquatic habitats, kill resident aquatic organisms, and destroy eggs incubating in the benthic environment. Seasonal cycles of high-energy flow events are typical in most aquatic systems; however, urbanized and altered streams may exacerbate impacts of high-energy flows and contribute to impairment of beneficial uses. For example, in a channelized stream with minimal riparian vegetation, flow velocity and volume will likely be greater than expected in a "natural stream", thereby, increasing erosive potential.

8.3.4. Riparian Corridor and Vegetation

A well-developed riparian corridor provides natural habitat values encountered in undisturbed streams. An in tack or restored riparian zone preserves stream ecology, prevents flood damage and bank erosion, and provides important wildlife and aquatic habitat . Riparian vegetation is an integral part of the stream ecosystem. A network of deep tree roots consolidate floodplain soils, making them more resistant to erosive forces. Established vegetation prevents flood damage, bank erosion and improves fish and wildlife habitat. Riparian vegetation also provide critical shaded riverine aquatic (SRA) habitat. SRA cover provides valuable cover for fish and other aquatic organisms, providing a variety of microhabitats with various flow depths, cover and food production. In-stream cover such as woody debris provides a food source and spawning substrate for a variety of aquatic species. The majority of streams in the study area have been cleared of riparian vegetation, resulting in unstable, eroding banks. The remaining vegetative cover is fragmented and in many instances the extent and quantity of remaining SRA is insufficient to support native fish and wildlife.

8.4. Beneficial Use Impact Assessment

The following analyses identify the beneficial uses impacted by excessive erosion and sedimentation within in the Llagas and Uvas systems. These are based on field observations performed during the study period. It should also be recognized that many of these factors are flow dependent, and due to the climatic regime of the region, stream flow conditions can vary significantly depending on water year conditions.

8.4.1. Upper West Basin Region

Upper Watershed of Llagas Creek (Above Chesbro Resevior)

The results of the field assessment did not find any significant impacts to beneficial uses due to controllable or manageable sediment sources. Only in a few, small and localized instances were direct impacts to cold freshwater habitat (COLD) and wildlife habitat (WILD) observed. These impacts to beneficial uses were attributed primarily to impacts by residential development or land use encroachment into the riparian corridor and/or loss of riparian vegetation due to grazing activities and/or removal of vegetation.

Upper Watershed of Uvas Creek (Above Uvas Reservior)

The results of the field assessment did not find any significant impacts to beneficial uses due to controllable or manageable sediment sources. Similar to the upper watershed of Llagas Creek, in only a few, small and localized instances were direct impacts to cold freshwater habitat (COLD) and wildlife habitat (WILD) were observed. These impacts to beneficial uses were attributed primarily to impacts by residential development or land use encroachment into the riparian corridor and/or loss of riparian vegetation, due to grazing activities and/or removal of vegetation.

8.4.2. Mid and North Valley Region

Llagas Creek (North and Mid Valley Region)

The field assessment study encountered several controllable or manageable sediment source related activities resulting in various impacts to beneficial uses, including impairment to cold and warm fresh water habitats (COLD and WARM), wildlife habitat (WILD), and migration and spawning of aquatic organisms (MIGR and SPWN). These impacts to beneficial uses are attributed to several activities:

1. Hydromodifications
   a. Non-engineered levees
   b. Channelization and channel relocation
   c. Culverts - undersized, collapsed and/or clogged culverts

2. Fine Sediment Loads
   a. Un-maintained or poorly designed/constructed ranch roads
   b. Rangeland with low residual biomass
   c. Bare winter fallowed fields
   d. Unlined tail/stormwater ditches
   e. Bare corral lots
   f. Road ditches with bare-unstable shoulders, undersized ditch channels; steep unstable ditch banks; or insufficient setbacks from creeks
   g. Disked firebreaks

3. High Flows
   a. Concentrated flows from impervious land coverage

4. Riparian Corridor Impacts
   a. Land use encroachment into riparian corridors
   b. Vegetation removal

Uvas Creek

The field assessment encountered several controllable or manageable sediment related activities resulting in various impacts to beneficial uses, including impairment to cold and warm freshwater habitats (COLD and WARM), wildlife habitat (WILD), and migration and spawning of aquatic organisms (MIGR and SPWN). These impacts to beneficial uses are attributed to several activities:

1. Hydromodifications
    a. Channelization and channel relocation
    b. Culverts - undersized, collapsed and/or clogged culverts

2. Fine Sediment Loads
    a. Un-maintained or poorly designed/constructed ranch roads
    b. Placement of tail/stormwater discharge pipes
    c. Hillside planting in ephemeral channels
    d. Bare corral lots
    e. Rangeland with low residual biomass
    f. Bare winter fallowed fields
    g. Unlined tail/stormwater ditches
    h. Road ditches with bare-unstable shoulders, undersized ditch channels; steep unstable ditch banks; and insufficient setbacks from creeks
    i. Disked firebreaks

3. High Flows
    a. Concentrated flows from impervious land coverage

4. Riparian Corridor Impacts
    a. Land use encroachment into riparian corridor
    b. Riparian access
    c. Vegetation Removal

8.4.3. South Valley Region

Llagas Creek

The field assessment encountered several controllable or manageable sediment related activities resulting in various impacts to beneficial uses, including impairment to cold and warm fresh water habitats (COLD and WARM), wildlife habitat (WILD), and migration and spawning of aquatic organisms (MIGR and SPWN). These impacts to beneficial uses are attributed to several activities:

1. Hydromodifications
    a. Channelization and channel relocation
    b. Culverts - undersized, collapsed and/or clogged culverts
    c. Creek crossings
    d. Channel disruption - Equipment in channel

2. Fine Sediment Loads
    a. Un-maintained or poorly designed/constructed ranch roads
    b. Placement of tail/stormwater discharge pipes
    c. Hillside planting in ephemeral channels
    d. Bare corral lots
    e. Non-vegetated permanent ditches - steep unstable bank angles
    f. Rangeland with low residual biomass
    g. Bare winter fallowed fields
    h. Unlined tail/stormwater ditches

i. Road ditches with bare-unstable shoulders, undersized ditch channels; steep unstable ditch banks; and insufficient setbacks from creeks

3. High Flows
    a. Concentrated flows from impervious land coverage

4. Riparian Corridor Impacts
    a. Land use encroachment into riparian corridor
    b. Riparian access
    c. Vegetation removal

Uvas Creek

The field assessment encountered several controllable or manageable sediment related activities resulting in various impacts to beneficial uses, including impairment to cold and warm freshwater habitats (COLD and WARM), wildlife habitat (WILD), and migration and spawning of aquatic organisms (MIGR and SPWN). These impacts to beneficial uses are attributed to several activities:

1. Hydromodifications
    a. Channelization and channel relocation
    b. Culverts - undersized, collapsed and clogged culverts
    c. Creek crossings
    d. Channel disruption - Equipment in channel

2. Fine Sediment Loads
    1. Un-maintained or poorly designed/constructed ranch roads
    2. Placement of tail/stormwater discharge pipes
    3. Hillside planting in ephemeral channels
    4. Bare corral lots
    5. Non-vegetated permanent ditches - steep unstable bank angles
    6. Rangeland with low residual biomass
    7. Bare winter fallowed fields
    8. Unlined tail/stormwater ditches
    9. Road ditches with bare-unstable shoulders, undersized ditch channels; steep unstable ditch banks; and insufficient setbacks from creeks

3. High Flows
    a. Concentrated flows from impervious land coverage

4. Riparian Corridor Impacts
    d. Land use encroachment into riparian corridor
    e. Riparian access
    f. Vegetation Removal

Table 8.1. Beneficial Uses of Surface Waters

Beneficial Water Uses	Abbreviation	Description
Municipal and Domestic Supply	MUN	Uses of water for community, military or individual water supply systems including, but not limited to, drinking water supply.
Agricultural Supply	AGR	Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
Industrial Service Supply	IND	Uses of water for industrial activities that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.
Groundwater Recharge	GWR	Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers. Groundwater recharge includes recharge of surface water underflow.
Water Contact Recreation	REC-1	Use of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible.
Non-Contact Water Recreation	REC-2	Use of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible.
Wildlife Habitat	WILD	Uses of water that supports terrestrial ecosystems including, but not limited to preservation or enhancement of terrestrial habitats, vegetation, wildlife (e.g. mammals, birds, reptiles, amphibians, and invertebrates), or wildlife water and food sources.
Cold Fresh Water Habitat	COLD	Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Warm Fresh Water Habitat	WARM	Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Migration of Aquatic Organisms	MIGR	Uses of water that supports habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.
Spawning, Reproduction, and/or Early Development	SPWN	Use of water that supports high quality aquatic habitats suitable for reproduction and early development of fish.
Rare, Threatened, or Endangered Species	RARE	Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.
Freshwater Replenishment	FRESH	Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g. salinity), which includes a water body that supplies water to a different type of water body, such as, streams that supply reservoirs and lakes, or estuaries; or reservoirs and lakes that supply streams. This includes only immediate upstream water bodies and not their tributaries.
Navigation	NAV	Any stream, lake, or arm of the sea, or other natural body of water that is actually navigable and that, but itself, or by its connection with other waters, for a period long enough to be commercial value, is of sufficient capacity to float water craft for purposes of commerce, trade, transportation, and including pleasure.
Commercial and Sport Fishing	COMM	Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1. Summary of Issues in Study Area Regions

The following is a brief summary of sediment sources within the four study area regions.

9.1.1. Upper West Basin Region

The Upper West Basin Region includes the Blackhawk, Bodfish, Chesbro Reservoir, Little Arthur, and Upper Llagas Creek sub-areas. The area historically yields significant quantities of sediment from natural or non-controllable sources. Due to limited rural residential development and a small number of lower risk agricultural sources, there are only localized sedimentation problems due to controllable or manageable sources. Rangelands contribute the most significant portion (67.5 percent) of total sediment due to their large area. However controllable sources typically related to roads, riparian access or grazing are only a small portion of this total contribution. Agricultural sources (1 percent) are localized in one sub-area. Rural residential sources remain small (1.5 percent) but will most likely increase with continued development in the future.

Observations of erosion and sedimentation within the Upper West Region agree with anticipated natural processes of erosion and sedimentation related to the geomorphic setting of the creeks. The estimated sediment load contribution from in-stream processes from creeks in the region is approximately 13.5 percent. The magnitude of this estimate is linked to the landscape or channel slope and topography of the region.

9.1.2. North Valley Region

The North Valley Region includes the Little Llagas, Madrone Channel, Tennant, Corralitos, Middle Llagas, and San Martin Creek sub-areas. The increasingly developed lands in the North Valley region are contributing to sediment loading (13.5 and 18.5 percent for urban and rural residential, respectively) related to impacts on in-stream processes and destabilization of banks and channels. Rangeland sources (38 percent) comprise a very small percentage of controllable sources. Agricultural sources (7.5 percent) related to row crop production are significant in a few sub-areas due to a number of management related factors and past hydromodifications that are controllable with specific practices.

Erosion and sedimentation related to channel hydromodification and encroachment into the channel and riparian zone, results in an estimated load contribution of approximately 19.5 percent. Observations of vegetation removal, channel incision, and bank failure within the region are associated with magnitude of this estimate.

9.1.3. Mid-Valley Region

The Mid-Valley Region includes the Church, Rucker Skillet, Panther, West Branch Llagas, Live Oak, and Lower Uvas Creek sub-areas. The newer eastern hill developments, older rural residential developments and their network of drainage and road ditches account for important and extensive, rather than locally intensive sediment sources (16.5 percent), in addition to impacts from urban runoff (12.5 percent). Additionally, the concentration of small and large equine lots and boarding facilities contribute to increased loading. Agricultural lands on the west side of the area are also significant source areas (10 percent). Generally, sediment contributions from rangelands (37 percent) account for the least significant controllable sources.

Historical and current land use patterns in the region have impacted channel processes. Increased flows from urban and rural residential areas have elevated the erosion potential in stream channels, and sediment load contributions from in-stream process are estimated at 21 percent. The erosion susceptibility of soils in the riparian zone and land use patterns contribute to this estimate.

9.1.4. South Valley Region

The South Valley Region includes the Jones, San Ysidro, Pajaro, Lower Llagas Creek, and Uvas Carnadeross sub-areas. Despite their location in the relatively flat, low-lying areas, the predominance of agricultural land uses, make these sediment sources most important (36.5 percent). Recent and historic hydromodifications related to soil drainage requirements in these contiguous agricultural parcels also contribute to sediment loading. Increased urban lands, although only representing two percent of the sediment load, has increased runoff that has impacted channel stability. Rangelands (33.5 percent), though accounting for a large percentage of the land area do not appear to be significant controllable sediment sources.

Increased flows from urban areas and land use encroachment from agriculture are related to observations of erosion and sedimentation in the region. In-stream sediment source contributions are estimated at approximately 25 percent, primarily linked to the erosion susceptibility of soils in the region and degradation of the riparian corridor.

9.2. Coordination with Other Pajaro and Central Coast Region Watershed Activities

Coordination between various local agencies has historically been ineffective to address watershed management issues, and requirements pertaining to water quality and flood control. Recent efforts like the South Santa Clara County Joint Area Plan have provided a model and opportunity for more effective cooperative planning and implementation efforts between local agencies. Current assessment and water quality monitoring efforts across the entire Pajaro River watershed are not well coordinated, many agencies or research groups work in isolation and are disjointed with variable financial resources and monitoring methodologies.

One example of a collaborative alliance within the Pajaro watershed began with the Monterey Bay National Marine Sanctuary's Agriculture and Rural Lands Plan. The plan outlines voluntary strategies to reduce agricultural runoff in the form of sediments, nutrients and pesticides. The Sanctuary has been working to coordinate partnerships to implement the plan throughout the Central Coast. The Agriculture Water Quality Alliance (AWQA) is a regional collaboration of agriculture industry groups, federal, state, and local agencies, technical experts, environmental organizations and university researchers working to carry out the Agriculture Plan. This region-wide collaboration has brought additional funding for various agencies and organizations, resulting in increased staffing and assistance available to landowners for water quality protection work. As a result, there are now many more personnel and programs organized under the AWQA umbrella, this alliance represents an additional coordination model, that could be expanded to engage key local agency representatives, including the SCVWD staff associated with the Watershed Management Initiative.

9.3. Watershed and Creek Management Planning

Several management and outreach activities should be undertaken to address sedimentation and water quality issues in the study area. The stream assessment conducted for this project identified five in-stream sediment sources categories, the combined effects of these sediment sources influence the impairment to beneficial uses within the Llagas and Uvas Creek systems. To reduce in-stream and off-stream sediment sources, a cohesive management planning effort with a combined focus on restoration, land use encroachment, and flood control planning is proposed. The following is a preliminary list of recommended actions pertaining to watershed and creek management planning:

- Develop a 'forum' series bringing federal, state and local regulators together with local representatives from community organizations (e.g. Pajaro Watershed Council), agriculture, resource conservation groups, business, and appropriate local agencies to address sedimentation and water quality protection in the study area.

- From this initial effort, develop a stakeholder based action plan prioritizing efforts to reduce controllable sediment sources. Identify priority projects on a regional basis and sources for project funding.

- Provide watershed and water quality protection workshops similar to the Farm Bureau water quality meetings (at least once per year) for individuals/representatives of the above-mentioned stakeholders. Develop an incentive-based program to stimulate participation, similar to the RWQCB and SCCFB agreement to develop farm and water quality plans within the study area. An incentive based program requires a unique collaboration with stakeholders, and would encourage a voluntary approach to water quality protection.

- Current creek channel maintenance efforts by the Santa Clara Valley Water District (SCVWD) could be enhanced by integrating sediment source identification and channel cross-section monitoring (refer to Appendix D) into annual assessment efforts.

- Enhance outreach to local residents, homeowner's associations, community groups and special interest organizations like equestrian clubs, Santa Clara Cattlemen's, and schools (e.g. Live Oak High School).

The San Francisco Bay Regional Water Quality Control Board (Region 2) has required the development and implementation of a Hydromodification Management Plan (HMP) in the Santa Clara Valley. An HMP would describe how dischargers plan to manage changes in urban runoff, specifically from new and significant redevelopment projects, to protect the beneficial uses of streams.[13]Considering the effects of hydromodification within the study area on sediment sources in streams and impacts to beneficial uses, it is recommended that the CCRWQCB require the local cities and county to develop an HMP plan for the Llagas and Uvas Creek basins.

[13] GeoSyntec Consultants, *Santa Clara Valley Urban Runoff Pollution Prevention Program, Hydromodification Management Plan Literature Review*, September 2002.

<u>Implementation</u>:

To address localized sedimentation and erosion issues, the SCVWD could develop a more aggressive outreach effort within the study area (SCVWD Watershed Area 5), as part of the SCVWD Initiative effort. These efforts should include all local municipal planning and public works representatives.

The SCVWD's current Creek Maintenance Program could conduct regular in-stream and upland sediment source assessments as past of annual creek inspection activities.

9.4. Loss of Riparian Habitat and Vegetation

Throughout the study area various land use practices are impacting the riparian corridor of many streams. Riparian vegetation has been removed along many miles of streams, resulting in channel destabilization, accelerated bank erosion, and degradation or loss of habitat. Stream channel destabilization is often attributed to a loss of woody vegetation, as dense vegetation adds roughness, slows flow velocity, reduces shear stress on stream banks, adds soil cohesion through root structure, and creates habitat benefits. Removal of large woody debris (LWD) as a management practice is known to contribute to bank erosion.[14] The influence of vegetation on bank stability is greatest in low-gradient, unconfined reaches where a loss of vegetation can accelerate bank failures and channel widening. The removal of vegetation for flood control or other purposes can lead to stream bank erosion and sedimentation, ultimately reducing flood flow capacity.

Reduction of native vegetation along many streams has reduced and degraded habitat quality and complexity, habitat and species diversity, and species abundance. Establishment of evasive, non-native riparian vegetation, most notably the Giant Reed (*Arundo donax*), is endemic throughout the Llagas Creek stream corridor. The establishment of this vegetation has both direct and indirect impacts to water quality. Due to its relatively shallow rooting depth, plant morphology, and high water demand, the plant does not provide substantial bank stabilization, stream cover, and draws a substantial amount of water from the stream, reducing baseflow conditions. Collectively, these conditions exacerbate low flow conditions in many of the valley streams, leading to continued bank erosion and sedimentation, elevated stream temperatures, excessive algal blooms, and periods of low dissolved oxygen concentration.

Based on the loss of riparian habitat and the direct link to erosion and sedimentation impacts to surface water resources in the study area, FCE recommends the following:

- Ecological restoration activities should be an integral component of the sedimentation TMDL for the study area. Implementation of stream restoration projects to re-establish native vegetation and buffers along streams will reduce erosion and sedimentation, improve habitat value, and protect or restore beneficial uses.

- Landowner and local agency workshops pertaining to stream restoration practices, including the use of biotechnical bank stabilization methods should be supported as part

[14] GeoSyntec Consultants, *Santa Clara Valley Urban Runoff Pollution Prevention Program, Hydromodification Management Plan Literature Review*, September 2002.

of the water quality attainment strategy for the Llagas Creek and Pajaro River watershed areas.

<u>Implementation:</u>

Stream restoration projects carried out by the NRCS Environmental Quality Incentives Program (EQIP), the Loma Prieta RCD, the SCVWD and others should be recognized as integral to the sediment TMDL process. These programs should be supported and additional grant resources provided to assist and expand the implementation of restoration projects.

9.5. Water Quality Target Values

Presently, the Central Coast Regional Water Quality Control Board and the US Environmental Protection Agency are developing water quality attainment standards as part of the sediment TMDL process. The main emphasis of this process is to develop numerical target values of surrogate parameters, such as total suspended solids and turbidity, with action levels established for the protection of cold water fisheries.

The development of a numerical target value of TSS or turbidity will be difficult, and may not be defensible nor attainable within the study area for several reasons:

a. Available water quality data for Llagas Creek and the Pajaro River are limited, and determination of background sediment concentration levels are unknown.

b. The poor correlation of turbidity to TSS data previously collected in the study area, suggest that use of turbidity as a surrogate parameter for sediment loading may not be protective of beneficial uses.

c. The Pajaro River Watershed is in a semi-arid region where many streams are ephemeral. As a result application of numeric and threshold criteria originating from research conducted in the Pacific Northwest or North Coast Region of the state, may not be applicable or even attainable in this region.

d. Current efforts by the USEPA to develop target values for the TMDL are being implemented from a "top down" perspective and may, as a result carry little weight with the local communities or personnel charged with effecting watershed improvements on private lands.

It is recommended that a combination of information on watershed physical characteristics, habitat, land ownership, regulatory jurisdictions, and the preliminary analysis of the nature of impairment be used to select an appropriate strategy for stream restoration and water quality improvement. Based on these conditions, FCE recommends the following:

- Target values for the sediment TMDL should be based on several factors, including both numerical and narrative goals, including target values for ecological restoration, as well as numerical target values for sediment.

- Target values should take into consideration the semi-arid and geologic setting of the watershed areas.

- The sediment TMDL should clearly integrate watershed/ecological restoration initiatives currently supported by the local communities as part of the TMDL process.

Implementation:

The CCRWQCB should work closely with local, state and other federal agencies and stakeholders in the development of the sediment TMDL target values and goals. The sediment TMDL should attempt to identify and incorporate target values established by other agencies or watershed groups working on erosion and sedimentation problems in the study area.

9.6. Suspended Sediment Monitoring

Additional water quality monitoring efforts are required to better address sediment discharge and loading throughout the study area. As a first step towards this effort an Integrated Water Quality Monitoring Plan has been developed and is presented in Appendix D. The following are recommend efforts for implementing a broader water quality monitoring program in the study area:

- Develop a coordinated region-wide effort to supplement the existing Central Coast Ambient Monitoring Program (CCAMP) with focused local efforts.

- In collaboration with Farm Bureau Watershed Working Groups and other cooperators, establish targeted baseline sediment monitoring efforts in known problem areas, rather than exclusively at traditional public access points (refer to Appendix D for an Integrated Water Quality Monitoring Program outline).

- When possible, expand the technical resources for CCAMP to collect appropriate data to improve sediment load estimates in the study area.

- Develop targeted research projects in coordination with local colleges and/or university personnel to monitor sediment loads from specific agricultural areas, fields, or ranches to quantify the impact of BMP adoption.

- Encourage and coordinate voluntary local efforts for storm water sample collection.

Implementation:

The Central Coast RWQCB and SCVWD could work more intensively under the Watershed Management Initiative to develop and coordinate voluntary monitoring efforts with local community organizations, non-profits like the Loma Prieta Resource Conservation District (RCD), Farm Bureau Watershed Workgroups, and Cattleman’s Association.

9.7. Agricultural Lands

Agricultural lands continue to be a sediment source to Llagas and Uvas Creeks and the Pajaro River. Further efforts are recommended to continue outreach efforts and to encourage agricultural management practices to control sediment sources. The following is a preliminary list of recommended actions to control of sediment from agricultural lands:

- Continue to provide adequate funding to the Farm Bureau Water Quality Programs for coordination of regular informational and educational meetings, self-monitoring training and evaluation, and farm water quality planning.
- Develop additional technical assistance resources through grants and strategic alliances with public technical resource providers like National Resource Conservation Service (NRCS), non-profits (e.g. Resource Conservation Districts), and the private sector to provide services on an individual basis.
- Continue to expand the outreach and educational effort to non-Farm Bureau growers via annual UCCE Irrigated Agriculture Water Quality Short Courses.
- Coordinate with the Santa Clara County Agricultural Commissioner's office to provide at least one surface water quality presentation at the annual "rules and regulation update" meeting.

Implementation:

The SCCFB Water Quality Program, University of California Cooperative Extension (UCCE), and NRCS have developed an evolving partnership to provide outreach and planning assistance to growers. Based upon experience within the study area community, it is recommended this partnership be maintained for at least five years to adequately develop relationships with members of the agricultural community, provide follow-up with growers, and ensure practices, monitoring, or projects are successful.

The UCCE Irrigated Lands Short Course is the prime vehicle to recruit non-Farm Bureau growers and introduce them to public and private technical assistance providers.

9.8. Urban and Rural Residential

Throughout the study area sediment sources related to stormwater runoff from urban and rural residential areas were observed. The impervious surfaces in residential developments result in increased flow volumes and an altered hydrologic response. This combined with concentrated flows and land use encroachments have created sediment sources. In many areas it was also observed that the rate of increased urban and residential developments in the study area out paced the renovation of drainage infrastructure. The following is a preliminary list of recommended actions pertaining to control of sediment from urban and rural residential areas:

- Local municipalities should implement more stringent stormwater runoff management plans to reduce the potential for channel destabilization and in-stream sediment production.

- A region-wide drainage infrastructure assessment should be planned and implemented to identify and prioritize projects to restore and 'modernize" drainage infrastructure both within urban planning areas and unincorporated areas. The drainage plan should explicitly examine the impacts from erosion and sedimentation resulting from runoff from urban and rural residential land uses and aged, undersized, or un-maintained drainage channels.

- Continue to offer community workshops to rural residential owners concerning methods to restore and maintain drainage ditches and creek channels using established practices to restore channel stability and minimize erosion and sediment production.

- Develop and implement a Hydromodification Management Plan to address the effects of development within the study area on in-stream processes, erosion and sedimentation, and impacts to beneficial uses.

Implementation:

Local municipalities will be finalizing new Urban Runoff Programs identifying program development and implementation of strategies and practices to reduce contamination from runoff (http://www.swrcb.ca.gov/stormwtr/murp.html). These strategies will comply with the USEPA's NPDES Storm Water Program for Regulated Small Municipal Separate Storm Sewer Systems (MS4s) (http://cfpub1.epa.gov/npdes/stormwater/phase2.cfm).

The SCVWD's Watershed Area 5 managers could develop better working relationships with local planning and public works staff (including Santa Clara County Roads Department) to develop an integrated drainage infrastructure plan.

The University of California Resource Conservation Program and Loma Prieta RCD have organized, and should continue to, sponsor local outreach workshops for residents in incorporated and unincorporated areas.

9.9. Rangelands

Sediment sources from rangelands are primarily related to roads and animal access into stream channels. The extent of rangelands in the study area is large and current outreach and implementation of management practices to control sediment sources should continue. The following outreach and technical assistance efforts should continue and/or be expanded:

- Continue to expand the outreach and educational effort via annual UCCE Rangeland Water Quality Short Courses and Santa Clara County Cattlemen's Association (SCCCA). Continue to reinforce these training efforts to the Farm Bureau Water Quality Programs for coordination of regular informational and educational meetings, self-monitoring training and evaluation, and ranch water quality planning.

- Develop additional technical assistance resources through grants and strategic alliances with public technical resource providers like National Resource Conservation Service, non-profits (e.g. Resource Conservations Districts), and the private sector to provide services on an individual basis.

- Coordinate with the Santa Clara County Agricultural Commissioner's office to provide at least one surface water quality presentation at the annual "rules and regulation update" meeting.

Implementation:

The UCCE Resource Conservation Program, Farm Bureau, Loma Prieta RCD, NRCS, and SCCCA should continue the collaborative efforts that are currently in place. Additional grant resources should be developed to provide more intensive individual site consultations.

9.10. Equine Facilities and Small Lot Grazing

Equestrian facilities and small lot grazing are widespread, and in some locations, concentrated within the study area. Sediment sources from these equine facilities and small lots originate from poorly vegetated lots and pastures, and animal access into streams and riparian corridors. The following outreach and technical assistance efforts should be implemented or expanded:

- Continue to develop outreach and educational efforts via the Farm Bureau Water Quality Programs, UCCE Resource Conservation Program, Loma Prieta RCD, and local equestrian clubs for coordination of regular informational and educational meetings, self-monitoring training and evaluation, and small lot and boarding facility water quality planning.

- Develop additional technical assistance resources through grants and strategic alliances with public technical resource providers like National Resource Conservation Service, non-profits (e.g. RCDs), and the private sector to provide technical assistance services on an individual basis.

Implementation:

The UCCE Resource Conservation Program, Farm Bureau, Loma Prieta RCD, NRCS, and SCCA should develop a formal collaborative program to provide regular outreach and training events. Additional grant resources should be developed to provide more intensive individual site consultations.

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APPENDICES

Appendix A

Sediment Data Sources

USEPA STORET Database
San Jose State University
Regional Water Quality Control Board
University of California Santa Cruz

Table A1
EPA STORET Data

STREAMKEY	Date	Time	Suspended Sediment (mg/L)	Suspended Sediment Dishcarge (tons/day)
UVAS CREEK	11/14/1965	1230	324	10
UVAS CREEK	11/14/1965	1400	508	13
UVAS CREEK	11/16/1965	1000	33	0.28
UVAS CREEK	11/16/1966	1020	259	12
UVAS CREEK	12/2/1966	1330	935	959
UVAS CREEK	1/24/1967	1455	285	426
UVAS CREEK	12/5/1967	725	396	21
UVAS CREEK	1/18/1969	1730	2990	8890
UVAS CREEK	1/20/1969	1520	282	489
UVAS CREEK	1/21/1969	1625	294	583
UVAS CREEK	2/11/1969	1630	779	1490
UVAS CREEK	2/24/1969	1130	411	1000
UVAS CREEK	2/28/1969	1100	530	1250
UVAS CREEK	2/28/1969	1500	107	176
UVAS CREEK	12/19/1969	1330	303	13
UVAS CREEK	12/19/1969	1700	1710	716
UVAS CREEK	12/21/1969	1100	2440	4880
UVAS CREEK	12/24/1969	930	174	37
UVAS CREEK	1/9/1970	1400	93	9.8
UVAS CREEK	1/14/1970	1700	498	857
UVAS CREEK	1/16/1970	1110	1240	4190
UVAS CREEK	1/24/1970	955	83	62
UVAS CREEK	3/12/1971	1600	1210	833
UVAS CREEK	3/26/1971	930	74	29
UVAS CREEK	12/22/1971	1030	181	23
UVAS CREEK	12/24/1971	1100	455	115
UVAS CREEK	1/27/1972	1205	84	39
UVAS CREEK	11/15/1972	1255	17	6.4
UVAS CREEK	1/9/1973	1030	612	1880
UVAS CREEK	1/10/1973	1105	33	14
UVAS CREEK	1/17/1973	1205	86	75
UVAS CREEK	1/18/1973	1145	646	1760
UVAS CREEK	2/6/1973	1145	375	403
UVAS CREEK	2/7/1973	940	465	1020
UVAS CREEK	2/27/1973	1245	888	1820
UVAS CREEK	2/27/1973	1710	265	458
UVAS CREEK	12/1/1973	1015	113	120
UVAS CREEK	1/7/1974	1055	24	9.6
LLAGAS CREEK @ CHESBRO RESERVOIR	3/1/1974	830	1370	1940
LLAGAS CREEK @ CHESBRO RESERVOIR	3/2/1974	815	575	425
UVAS CREEK	3/5/1974	1230	21	8.5
LLAGAS CREEK @ CHESBRO RESERVOIR	3/28/1974	1415	16	2.1
UVAS CREEK	4/1/1974	1210	85	66
UVAS CREEK	12/3/1974	910	85	4.4
UVAS CREEK	2/1/1975	1415	201	104
UVAS CREEK	2/1/1975	940	30	6.7

Table A1
EPA STORET Data

STREAMKEY	Date	Time	Suspended Sediment (mg/L)	Suspended Sediment Dishcarge (tons/day)
LLAGAS CREEK @ CHESBRO RESERVOIR	2/4/1975	815	171	64
LLAGAS CREEK @ CHESBRO RESERVOIR	2/9/1975	750	260	120
UVAS CREEK	2/9/1975	1105	96	96
LLAGAS CREEK @ CHESBRO RESERVOIR	2/10/1975	825	63	21
UVAS CREEK	2/13/1975	845	115	169
LLAGAS CREEK @ CHESBRO RESERVOIR	3/7/1975	1150	470	326
LLAGAS CREEK @ CHESBRO RESERVOIR	3/7/1975	745	1890	1370
UVAS CREEK	3/7/1975	845	296	368
LLAGAS CREEK @ CHESBRO RESERVOIR	3/8/1975	825	114	53
UVAS CREEK	3/25/1975	915	35	16
CORRALITOS	1/9/1976	1040	43	0.06
UVAS CREEK	2/29/1976	1715	80	15
CORRALITOS	3/1/1976	1030	68	2
CORRALITOS	3/2/1976	1025	15	0.49
CORRALITOS	3/16/1977	1630	28	0.54
CORRALITOS	3/17/1977	1040	52	0.46
LLAGAS CREEK @ CHESBRO RESERVOIR	12/23/1977	1030	29	2.8
LLAGAS CREEK @ CHESBRO RESERVOIR	1/5/1978	1510	1790	1170
LLAGAS CREEK @ CHESBRO RESERVOIR	1/14/1978	1630	451	291
LLAGAS CREEK @ CHESBRO RESERVOIR	1/16/1978	1200	2500	4040
LLAGAS CREEK @ CHESBRO RESERVOIR	1/16/1978	1700	2920	4130
LLAGAS CREEK @ CHESBRO RESERVOIR	1/16/1978	930	4710	10800
LLAGAS CREEK @ CHESBRO RESERVOIR	1/19/1978	810	104	28
PAJARO-RIVER	2/1/1978	1035	36	3.9
LLAGAS CREEK @ CHESBRO RESERVOIR	2/9/1978	1225	121	44
PAJARO-RIVER	2/28/1978	1115	49	9.7
LLAGAS CREEK @ CHESBRO RESERVOIR	3/5/1978	800	1120	1210
PAJARO-RIVER	6/20/1978	1115	92	1
PAJARO-RIVER	7/25/1978	1345	34	0.74
PAJARO-RIVER	8/15/1978	1045	55	0.56
PAJARO-RIVER	9/21/1978	1400	18	0.12
PAJARO-RIVER	10/18/1978	1130	23	0.16
PAJARO-RIVER	11/14/1978	1225	17	0.04
PAJARO-RIVER	12/19/1978	1100	15	0.14
PAJARO-RIVER	1/16/1979	1300	355	242
PAJARO-RIVER	2/13/1979	1000	36	1.7
PAJARO-RIVER	3/13/1979	1200	47	4.9
PAJARO-RIVER	4/19/1979	1115	130	5.3
PAJARO-RIVER	5/17/1979	1015	95	2.8
PAJARO-RIVER	6/20/1979	1135	15	0.23
PAJARO-RIVER	7/11/1979	1220	34	0.63
PAJARO-RIVER	8/21/1979	1200	32	0.4
PAJARO-RIVER	9/11/1979	1120	44	0.39
PAJARO-RIVER	10/16/1979	1220	59	0.22
PAJARO-RIVER	11/20/1979	1200	22	0.19
PAJARO-RIVER	12/18/1979	1145	27	0.12

Table A1
EPA STORET Data

STREAMKEY	Date	Time	Suspended Sediment (mg/L)	Suspended Sediment Dishcarge (tons/day)
CORRALITOS	1/15/1980	1045	1540	911
PAJARO-RIVER	1/29/1980	1225	43	11
PAJARO-RIVER	3/11/1980	1510	266	397
PAJARO-RIVER	3/25/1980	1245	272	111
PAJARO-RIVER	4/3/1980	1100	53	12
PAJARO-RIVER	4/14/1980	1350	52	16
PAJARO-RIVER	5/21/1980	1330	69	4.1
PAJARO-RIVER	6/18/1980	1015	55	2.5
PAJARO-RIVER	7/22/1980	1215	88	2.9
PAJARO-RIVER	8/20/1980	1320	129	4.2
PAJARO-RIVER	9/9/1980	1220	75	2.8
PAJARO-RIVER	10/6/1980	1300	36	0.36
PAJARO-RIVER	1/14/1981	1330	18	0.38
CORRALITOS	1/23/1981	1045	754	63
CORRALITOS	1/23/1981	1145	949	82
CORRALITOS	1/23/1981	1300	778	84
CORRALITOS	1/23/1981	1500	882	95
CORRALITOS	1/27/1981	1020	518	113
CORRALITOS	1/27/1981	1135	1680	472
CORRALITOS	1/27/1981	1230	1480	611
CORRALITOS	1/27/1981	1330	2010	1270
CORRALITOS	1/27/1981	1425	3830	3410
CORRALITOS	1/27/1981	1545	3420	3800
CORRALITOS	1/27/1981	1735	1650	1560
CORRALITOS	1/27/1981	1810	1550	1310
CORRALITOS	1/27/1981	1820	1670	1360
CORRALITOS	1/28/1981	1215	161	30
CORRALITOS	2/27/1981	1220	20	0.22
PAJARO-RIVER	3/11/1981	1100	10	0.97
CORRALITOS	3/25/1981	1035	344	59
CORRALITOS	3/25/1981	1300	232	39
CORRALITOS	4/29/1981	1210	34	6.2
PAJARO-RIVER	5/13/1981	1445	63	2
PAJARO-RIVER	7/17/1981	1130	47	0.53
PAJARO-RIVER	1/26/1982	1340	129	
PAJARO-RIVER	3/8/1982	1400	30	
PAJARO-RIVER	5/18/1982	1200	53	
PAJARO-RIVER	7/13/1982	1330	82	
PAJARO-RIVER	9/14/1982	1320	75	
PAJARO-RIVER	12/14/1982	1315	17	3.1
PAJARO-RIVER	3/23/1983	1345	2230	16400
PAJARO-RIVER	6/20/1983	1345	279	
PAJARO-RIVER	9/14/1983	1300	135	
PAJARO-RIVER	3/21/1984	1115	163	
PAJARO-RIVER	6/14/1984	1020	169	
PAJARO-RIVER	9/11/1984	1155	112	

Table A1
EPA STORET Data

STREAMKEY	Date	Time	Suspended Sediment (mg/L)	Suspended Sediment Dishcarge (tons/day)
PAJARO-RIVER	12/10/1984	1230	122	11
PAJARO-RIVER	2/22/1985	1240	134	15
PAJARO-RIVER	6/11/1985	1215	84	3.2
PAJARO-RIVER	9/18/1985	1230	3	0
PAJARO-RIVER	12/17/1985	1130	29	
PAJARO-RIVER	2/6/1986	1325	46	
PAJARO-RIVER	2/18/1986	1325	1710	57300
PAJARO-RIVER	3/18/1986	1315	1210	
PAJARO-RIVER	3/18/1986	1325	1280	
PAJARO-RIVER	3/18/1986	1327	1340	
PAJARO-RIVER	3/18/1986	1330	1310	
PAJARO-RIVER	3/18/1986	1335	1340	
PAJARO-RIVER	3/18/1986	1340	1570	
PAJARO-RIVER	3/18/1986	1345	1320	
PAJARO-RIVER	6/17/1986	1205	97	
PAJARO-RIVER	9/10/1986	1135	44	
PAJARO-RIVER	12/15/1986	1245	48	
PAJARO-RIVER	3/10/1987	1420	30	
PAJARO-RIVER	6/15/1987	1410	24	
PAJARO-RIVER	9/15/1987	1200	10	
PAJARO-RIVER	12/15/1987	1310	12	
PAJARO-RIVER	3/15/1988	1115	23	
PAJARO-RIVER	6/14/1988	1240	15	
PAJARO-RIVER	12/12/1988	1205	2	
PAJARO-RIVER	3/14/1989	1415	16	
PAJARO-RIVER	3/14/1989	1416	16	
PAJARO-RIVER	3/14/1989	1417	15	
PAJARO-RIVER	3/14/1989	1419	13	
PAJARO-RIVER	3/14/1989	1421	20	
PAJARO-RIVER	3/14/1989	1423	16	
PAJARO-RIVER	6/13/1989	1345	20	
PAJARO-RIVER	6/13/1989	1355	25	
PAJARO-RIVER	6/13/1989	1357	22	
PAJARO-RIVER	6/13/1989	1359	13	
PAJARO-RIVER	9/25/1989	1140	17	
PAJARO-RIVER	12/11/1989	1220	3	
PAJARO-RIVER	2/21/1990	1335	15	
PAJARO-RIVER	3/19/1990	1300	11	
PAJARO-RIVER	3/19/1990	1305	12	
PAJARO-RIVER	3/19/1990	1306	12	
PAJARO-RIVER	3/19/1990	1307	10	
PAJARO-RIVER	6/5/1990	1315	21	
PAJARO-RIVER	9/10/1990	1230	8	
PAJARO-RIVER	12/10/1990	1200	28	
PAJARO-RIVER	3/7/1991	1302	118	
PAJARO-RIVER	3/7/1991	1304	116	

Table A1

EPA STORET Data

STREAMKEY	Date	Time	Suspended Sediment (mg/L)	Suspended Sediment Dishcarge (tons/day)
PAJARO-RIVER	3/7/1991	1305	115	
PAJARO-RIVER	3/7/1991	1306	117	
PAJARO-RIVER	3/7/1991	1308	113	
PAJARO-RIVER	3/7/1991	1310	111	
PAJARO-RIVER	6/12/1991	1330	12	
PAJARO-RIVER	9/9/1991	1515	9	
PAJARO-RIVER	12/9/1991	1240	4	
PAJARO-RIVER	3/16/1992	1245	14	
PAJARO-RIVER	6/9/1992	1430	36	
PAJARO-RIVER	7/21/1992	1120	26	
PAJARO-RIVER	9/8/1992	1130	14	

Table A2

1992-1993 San Jose State University

	Llagas @ Bloomfield		Llagas @ Luchessa		Llagas @ HWY 152		Llagas near California Street		Pajaro @ Frazier Lake Road	
Date	**Flow Rate (cfs)**	**Turbidity (NTU)**	**Flow Rate (cfs)**	**Turbidity (NTU)**	**Flow Rate (cfs)**	**Turbidity (NTU)**	**Flow Rate (cfs)**	**Turbidity (NTU)**	**Flow Rate (cfs)**	**Turbidity (NTU)**
6/18/1992	0.6	5.7	1.6	2.4	DRY	DRY	21.1	8.4	0.0	17.0
7/2/1992	0.6	17.0	1.7	3.7	DRY	DRY	15.5	16.0	0.1	15.0
7/16/1992	0.5	120.0	1.3	3.0	DRY	DRY	17.7	8.8	0.0	23.0
7/30/1992	0.5	14.0	1.0	1.0	DRY	DRY	24.2	4.3	0.0	84.0
8/12/1992	0.8	17.0	0.0	10.0	DRY	DRY	17.4	5.5	0.1	70.0
8/27/1992	0.0	6.1	0.0	4.0	DRY	DRY	19.5	6.3	0.0	96.0
9/24/1992	0.0	100.0	DRY	DRY	DRY	DRY	18.1	8.6	0.0	43.0
10/22/1992	DRY	DRY	DRY	DRY	DRY	DRY	10.0	8.5	0.0	25.0
11/19/1992	DRY	DRY	DRY	DRY	DRY	DRY	11.0	12.0	0.0	60.0
12/22/1992	0.0	2.9	0.5	1.0	DRY	DRY	7.3	3.6	0.0	9.9
1/20/1993	HIGH FLOW	43.0	HIGH FLOW	48.0	#	#	HIGH FLOW	41.0	HIGH FLOW	66.0
3/17/1993	HIGH FLOW	2.5	HIGH FLOW	2.7	#	#	HIGH FLOW	13.0	HIGH FLOW	16.0
4/7/1993	HIGH FLOW	2.4	8.2	1.5	#	#	17.6	52.0	0.0	66.0
4/28/1993	0.0	4.0	5.2	1.3	#	#	13.1	4.6	0.0	77.0
5/12/1993	0.0	3.0	3.7	2.2	#	#	6.2	8.0	DRY	DRY
5/27/1993	0.0	6.0	4.7	2.2	#	#	6.8	4.4	DRY	DRY
6/8/1993	0.0	10.0	4.2	3.1	#	#	10.1	5.3	DRY	DRY
6/23/1993	0.0	6.2	3.3	1.6	#	#	8.2	3.5	DRY	DRY
7/13/1993	0.0	3.5	3.3	3.2	#	0.6	8.4	5.5	DRY	DRY

= Information not available for this parameter

Table A3

Regional Water Quality Control Board

December 1997 through December 1998

Site Code	Station Location	Total Suspended Solids (mg/L)				
		# Tests	Mean	Min	Max	Std. Dev.
TRE	Tres Pinos Creek @ Southside Rd.	11	661	400	785	108
SAN	San Benito @ Y Rd.	12	992	306	1,540	365
PAC	Pacheco Creek @ San Felipe Rd.	13	489	146	1,260	262
TES	Tesquisquita Slough @ Shore Rd.	16	976	230	1,790	428
FRA	Pajaro @ Frazier Lake Rd	13	523	58	975	380
CHE	Llagas @ Chesboro Reservoir	10	223	0	353	125
OAK	Llagas @ Oak Glen Ave.	11	176	20	246	80
MON	Llagas @ Monterey Rd.	11	194	8	260	90
VIS	Llagas @ Buena Vista Ave.	4	238	157	370	88
HOL	Llagas @ Holsclaw Rd.	8	323	2	580	225
LUC	Llagas @ Luchessa	10	457	3	706	260
LLA	Llagas @ Bloomfield	24	536	7	840	237
UVA	Uvas @ Bloomfield	7	219	168	260	35
PAJ	Pajaro below Hwy 101	26	642	25	920	287
CHI	Pajaro @ Chittenden Bridge	22	721	40	1,130	340
MUR	Pajaro @ Murphy's Crossing	12	730	26	1,130	404
COR	Corralitos Creek	13	407	181	633	133
THU	Pajaro @ Thurwachter Rd.	23	1,664	43	9,450	2,186

Table A3
Regional Water Quality Control Board
December 1997 through December 1998

SiteTag	DateTime	Turb	TSS	TDS	VS
che	2/10/1998 13:40	43	166	36	72
che	3/5/1998 15:10	3.5	240	2.5	2.5
che	5/8/1998 14:43	3.2			
che	6/12/1998 16:27	0.6	290	2.5	2.5
che	7/20/1998 14:53	6.9	298	1.6	102
che	8/11/1998 13:12	16.1	328	7.2	108
che	9/10/1998 13:08	0	353	0.25	70
che	10/15/1998 16:53		208	0.25	94
che	11/4/1998 15:13	0.8	344	0.25	104
che	12/2/1998 15:34	1.7	0.25	292	116
che	1/7/1999 15:24	0.5	0.25	288	102
fra	2/10/1998 10:55	444	130	174	100
fra	3/5/1998 11:37	65.8	340	31	2.5
fra	4/9/1998 12:36	72.1			
fra	5/8/1998 12:00	133			
fra	6/12/1998 12:53	196	690	155	135
fra	7/20/1998 12:25	344	870	296	180
fra	8/11/1998 11:14	213	960	132	235
fra	9/10/1998 11:22	251	975	16	215
fra	10/15/1998 14:21		905	176	225
fra	11/4/1998 12:27	236	810	172	275
fra	12/2/1998 13:09	90	82	565	370
fra	1/7/1999 13:01	68.4	58	900	255
fra - dup	11/4/1998 12:27	236	835	174	255
fra - dup	12/2/1998 13:09	90	83	890	285
fra - dup	1/7/1999 13:01	68.4	59	890	215
hol	2/10/1998 11:40	143	178	84	108
hol	3/5/1998 12:56	20.5	310	2.5	2.5
hol	4/9/1998 13:46	13.4			
hol	5/8/1998 13:07	14.3			
hol	6/12/1998 14:00	1.4	400	2.5	2.5
hol	7/20/1998 13:22	7.6	580	2	227
hol	9/10/1998 12:20				
hol	10/15/1998 15:03		553	4.1	227
hol	11/4/1998 13:40	10.7	557	4.3	153
hol	12/2/1998 14:06	22.5	4	647	253
hol	1/7/1999 14:01	4.3	2.3	553	267
lla	12/18/1997 14:30	20	840	12	300
lla	1/19/1998 15:19	188	303	46	124
lla	2/10/1998 10:40	133	215	64	112
lla	2/19/1998 12:09	55.2	354	36	165
lla	3/5/1998 10:52	20	410	11	2.5
lla	3/12/1998 11:55	13.7	415	5	5
lla	4/9/1998 12:16	18.1			
lla	4/23/1998 12:30	22.4			
lla	5/8/1998 12:14	39.2			
lla	5/27/1998 12:45	31.7	560	33	27
lla	6/12/1998 12:35	23.5	580	27	27
lla	6/30/1998 13:56	42	620	17	17
lla	7/20/1998 12:08	32	710	16	203

Table A3
Regional Water Quality Control Board
December 1997 through December 1998

SiteTag	DateTime	Turb	TSS	TDS	VS
lla	7/31/1998 11:46	22.4	707	14	300
lla	8/11/1998 10:57	39.6	736	16	256
lla	9/3/1998 13:39	12	730	14	195
lla	9/10/1998 11:03	11.2	706	7.5	160
lla	9/30/1998 13:03		690	7.8	205
lla	10/15/1998 13:55		693	3.7	167
lla	10/21/1998 15:30		663	5.9	277
lla	11/4/1998 12:05	13.6	735	8.7	325
lla	11/10/1998 12:01	11.6	750	10	145
lla	12/2/1998 12:39	12.9	7.5	745	315
lla	12/16/1998 13:19	7	780	5.3	225
lla	1/7/1999 12:28	9.1	7.3	760	260
lla - dup	1/19/1998 15:19	188	298	65	132
lla - dup	2/19/1998 12:09	55.2	366	53	175
luc	2/10/1998 11:20	105	306	58	110
luc	3/5/1998 12:15	16.4	380	6	2.5
luc	4/9/1998 13:09	6.3			
luc	5/8/1998 12:44	5.2			
luc	6/12/1998 13:28	3.2	510	2.5	2.5
luc	7/20/1998 12:54	5.3	660	4	243
luc	8/11/1998 11:39	5.8	706	2	273
luc	9/10/1998 11:49	0	657	2	153
luc	10/15/1998 17:44		673	2.3	307
luc	11/4/1998 13:08	2.7	670	1.3	290
luc	12/2/1998 13:39	3.7	3.2	507	287
luc	1/7/1999 13:31	2.7	3.3	667	280
mon	2/10/1998 12:45	155	151	70	78
mon	3/5/1998 14:04	110	220	18	2.5
mon	4/9/1998 14:42				
mon	5/8/1998 14:01	80.7			
mon	6/12/1998 15:27	34.5	240	9	2.5
mon	7/20/1998 14:03	11.5	250	6	78
mon	8/11/1998 12:26	12.1	260	4.8	82
mon	9/10/1998 12:23	7.1	250	5.2	60
mon	10/15/1998 16:07		242	8.2	116
mon	11/4/1998 14:20	22.8	252	16	102
mon	12/2/1998 14:50	24.7	15	260	106
mon	1/7/1999 14:40	9.8	8	264	142
mon - dup	5/8/1998 14:01	80.7			
mon - dup	7/20/1998 14:03	11.5	242	6.8	74
oak	2/10/1998 13:20	143	133	37	68
oak	3/5/1998 14:42	145	175	23	2.5
oak	5/8/1998 14:27	25.1			
oak	6/12/1998 16:07	16.5	240	2.5	2.5
oak	7/20/1998 14:32	35	214	8.5	66
oak	8/11/1998 12:52	36.6	236	9.2	68
oak	9/10/1998 12:48	32.4	232	9.5	26
oak	10/15/1998 16:30		238	4	68
oak	11/4/1998 14:47	36.7	246	17	94
oak	12/2/1998 15:13	17.5	23	254	84

Table A3
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December 1997 through December 1998

SiteTag	DateTime	Turb	TSS	TDS	VS
oak	1/7/1999 15:04	33.7	20	248	110
oak - dup	3/5/1998 14:42	145	175	21	2.5
uva	12/18/1997 14:16	7.6	250	2.3	66
uva	1/19/1998 14:49	151	176	96	80
uva	2/19/1998 11:46	81.7	168	69	85
uva	3/12/1998 11:38	23.5	200	13	5
uva	4/23/1998 12:00	8.1			
uva	5/27/1998 12:25	5.4	250	44	44
uva	6/30/1998 13:25	19.6	260	2.5	2.5
uva	12/16/1998 12:57	4.5	228	0.25	98
vis	2/10/1998 14:30	147	157	68	72
vis	3/5/1998 13:33	32.2	265	11	2.5
vis	4/9/1998 14:23				
vis	5/8/1998 13:31	6.8			
vis	6/12/1998 14:48	2.2	370	2.5	2.5
vis - dup	2/10/1998 14:30	147	158	9	84

Table A4
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Nutrient TMDL Sampling

Waterway	Location	TripID	Abr	Longitude	Latitude
Pajaro River	Chittenden	1	PA-CHI	-121.5975133	36.9003992
Pajaro River	Murphy's	1	PA-MUR	-121.6767257	36.9057519
Pajaro River	Main	1	PA-MNS	-121.7513697	36.905189
Corralitos Creek	Salsipuedes	1	CO-SAL	-121.7451414	36.9126232
Corralitos Creek	Green Valley	1	CO-GVA	-121.7704467	36.9392434
Corralitos Creek	Varni Rd.	1	CO-VAR	-121.7987471	36.9677892
Corralitos Creek	Brown Valley Rd.	1	CO-BVR	-121.8025575	36.9890066
Corralitos Creek	Las Colinas Rd.	1	CO-LCR	-121.8094623	37.0079261
Carneros Creek	Dunbarton Rd.	1	CA-DUN	-121.639366	36.8542634
Carneros Creek	Corey Rd.	1	CA-COR	-121.6491239	36.8556008
Carneros Creek	San Miguel Canyon Rd.	1	CA-SMC	-121.6948486	36.85825
Carneros Creek	Johnson Rd.	1	CA-JNR	-121.7076628	36.8598537
Carneros Creek	Kirby Park	1	CA-KIR	-121.7435713	36.8399392
Gabilon Creek	Old Stage Coach Rd.	1	GA-OSC	-121.5853422	36.7804288
Gabilon Creek	Crazy Horse Rd.	1	GA-CHR	-121.602313	36.7713937
Gabilon Creek	Hebert Rd.	1	GA-HEB	-121.6102659	36.7558183
Carneros Creek	Bend in road	1	CA-BIR	-121.6622286	36.8624566
Carneros Creek	Maher Rd.	1	CA-MAH	-121.6850764	36.8575524
Corralitos Creek	129 Ditch	1	CO-129		
Beach Road Ditch	Tile end of BS #1	1	BR-TE1		
Pajaro River	Thurwatcher Rd.	1	PA-THU		
San Benito Creek	Y Road	2	SB-YRD	-121.5543535	36.8853087
Pajaro River	Betabel Road	2	PA-BET	-121.5498326	36.9166996
McGowan	Trafton	1	MG-TRA	-121.7824652	36.8735056
McGowan	McGowan Ditch #1	1	MG-MC1	-121.7866998	36.8725021
Watsonville Slough	Tile near San Andreas	1	WS-TSA	-121.8045234	36.8877937
Watsonville Slough	Ditch near San Andreas	1	WS-DSA		
McGowan	Tile near McGowan	1	MG-TMC	-121.7894457	36.8750667
San Lorenzo River	San Lorenzo	1	SL-SLR	-122.0232958	36.9756225
McGowan	McGowan Ditch #2	1	MG-MC2	-121.7894457	36.8750667
McGowan	Tile along Trafton	1	MG-TTF	-121.7824652	36.8735056
Beach Road Ditch	Tile end of BS #2	1	BR-TE2		
Watsonville Creek	Ag Ditch near RR	1	WC-ARR		
Watsonville Creek	Ag Ditch along Salinas	1	WC-ASR	-121.7466414	36.8816137
Watsonville Creek	Lewis Rd	1	WC-LEW	-121.7377772	36.8964189
Watsonville Creek	Below Warner Lake	1	WC-BWL		
Watsonville Creek	Confluence	1	WC-CON	-121.7469438	36.879705
Watsonville Creek	Hudson Landing	1	WC-HUD	-121.7451746	36.8738756
Pajaro River	Frazer Lake Rd.	3	PA-FLR	-121.501762	36.9720884
Llagas Creek	Above Chesbro Res.	3	LL-CRA	-121.7325291	37.1264217
Llagas Creek	Below Chesbro Res.	3	LL-CRB	-121.6904961	37.1144908
Llagas Creek	Monterey Rd.	3	LL-MON	-121.6164974	37.095565
Llagas Creek	Church Ave	3	LL-CHU	-121.595638	37.0692892
Llagas Creek	Little Llagas @ Church	3	LL-LLC	-121.5850419	37.0731364
Llagas Creek	Buena Vista Ave.	3	LL-BVA	-121.5589975	37.0487974
Llagas Creek	Leavesley Rd.	3	LL-LEA	-121.5435871	37.0310893
Llagas Creek	W. Branch @ 101	3	LL-WB1		
Llagas Creek	Southside Ave.	3	LL-SOU	-121.5319823	36.9904316
Llagas Creek	Bloomfield Av. Bridge	3	LL-BLO		
Uvas Creek	Above Uvas Reservoir	3	UV-URA	-121.7351059	37.1106729

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Waterway	Location	TripID	Abr	Longitude	Latitude
Uvas Creek	Below Uvas Reservoir	3	UV-URB	-121.673189	37.060065
Uvas Creek	Watsonville Rd.	3	UV-WAT		
Uvas Creek	152	3	UV-152	-121.6270734	37.011556
Uvas Creek	Thomas Rd.	3	UV-THO	-121.572235	36.9917355
Uvas Creek	101	3	UV-101		
Uvas Creek	Bloomfield Av.	3	UV-BLO	-121.5319741	36.9651568
Pacheco Creek	San Felipe Rd.	3	PC-SFR	-121.4185181	36.9598119
Pacheco Creek	156	3	PC-156	-121.3848999	36.9439302
Miller's Canal	Frazer Lake Rd.	3	MC-FLR	-121.4919075	36.9635242
Llagas Creek	Bloomfield Av. Confl.	3	LL-BAC	-121.5116861	36.9738591
San Juan Creek	101	3	SJ-101	-121.561026	36.8828863
Tesquitito Slough	Shore Rd.	3	TS-SHO	-121.4443355	36.9427413
Llagas Creek	West Branch @ Highland	3	LL-WHI	-121.6083013	37.0730068
Llagas Creek	West branch @ Day	3	LL-WDA	-121.5857396	37.0380504
Furlong Creek	Frazer Lake Road		FU-FLR		
San Benito Creek	101		SB-101	-121.5590792	36.8868862
Ditch	New Ave.		DI-NEW		
Ditch	San Martin Ave.		DI-SMA		
Cassery Creek	Cassery Road		CR-CAS		
Llagas Creek	Highway 25	3	LL-H25		

Table A4
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Nutrient TMDL Sampling

Abbreviation	Date	Sample Type	Sample mass (g)	Fine Sediment (>1.2 µm) (g/L)	Dissolved Sediment (g/L)	Coarse Sediment (>63 µm) (g/L)
LL-BAC	11/12/2002	Biweekly	316.87	0.0644	0.996	0.0035
LL-BAC	12/10/2002	Biweekly	335.17	0.0012	0.936	0.0033
LL-BAC	12/23/2002	Biweekly	354.27	0.0031	0.74	0.0088
LL-BAC	1/7/2003	Biweekly	335.88	0.0065	0.34	0
LL-BAC	1/21/2003	Biweekly	277.91	0.0083	0.788	0.0065
LL-BAC	2/4/2003	Biweekly	360.53	0.0236	1.036	0.0114
LL-BAC	2/19/2003	Biweekly	456.15	0.025	0.908	0.1138
LL-BAC	3/4/2003	Biweekly	386.97	0.0977	0.744	0
LL-BAC	3/4/2003	Biweekly	408.5	0.0024	0.808	0
LL-BAC	3/18/2003	Biweekly	368.13	0.0062	0.748	0.0005
LL-BAC	4/1/2003	Biweekly	394.6	0.002	0.688	0
LL-BAC	4/15/2003	Biweekly	387.76	0.0072	0.0495	0.0034
LL-BLO	11/8/2002	Storm	209.58	0.0725	0.132	0.0892
LL-BLO	11/16/2002	Storm	409.67	0.0088	1.124	0.0085
LL-BLO	12/15/2002	Storm	956.49	0.0358	0.288	0
LL-BLO	12/16/2002	Storm	393.87	0.3527	0.072	0
LL-BLO	12/20/2002	Storm	406.03	0.0655	0.18	0.0007
LL-BLO	12/21/2002	Storm	458.16	0.1674	0.228	0.0024
LL-BLO	12/29/2002	Storm	423.04	0.0433	0.304	0.0352
LL-BLO	1/10/2003	Storm	320.28	0.0215	0.348	0.0091
LL-BLO	3/15/2003	Storm	440.88	0.0084	0.348	0
LL-BLO	4/13/2003	Storm	278.41	0.0198	0.0471	0.0198
LL-BLO	4/25/2003	Storm	366.5	0.0109	0.712	0.024
LL-BLO	4/29/2003	Biweekly	335.91	0.0134	0.776	0
LL-BLO	5/2/2003	Storm	377.38	0.0042	0.336	0.0466
LL-BLO	5/13/2003	Biweekly	404.24	0.0074	0.688	0.0027
LL-BLO	5/27/2003	Biweekly	313.9	0.0051	0.092	0
LL-BLO	6/10/2003	Biweekly	442.21	0.0106	0.76	0.0088
LL-CRB	12/15/2002	Storm	288.89	-0.1731	-5.504	0
LL-CRB	12/16/2002	Storm	330.31	0.4786	0.148	0.0045
LL-CRB	12/20/2002	Storm	523.39	0.0525	0.144	0.0017
LL-CRB	1/10/2003	Storm	307.78	0.0276	0.172	0
LL-CRB	3/15/2003	Storm	427.95	0.007	0.24	0.0023
LL-CRB	4/13/2003	Storm	325.09	0.0028	0.0175	0.0046
LL-CRB	4/25/2003	Storm	390.28	0.0026	0.18	0
LL-CRB	5/2/2003	Storm	358.58	0.0039	0.196	0.0036
LL-CRB	5/2/2003	Storm	321.99	0.0062	0.0236	0.0013
LL-MON	11/8/2002	Storm	375.46	0.098	0.2	0.0152
LL-MON	11/12/2002	Biweekly	370.34	0.0005	0.296	0.0092
LL-MON	11/26/2002	Biweekly	327.43	0.0235	0.468	0.0098
LL-MON	12/10/2002	Biweekly	283.87	0	0.256	0
LL-MON	12/15/2002	Storm	371.91	-0.5197	-4.656	0
LL-MON	12/16/2002	Storm	316.53	0.1431	0.18	0.0041
LL-MON	12/20/2002	Storm	496.05	0.0645	0.18	0.0079
LL-MON	12/21/2002	Storm	455.07	0.6359	0.144	0.0431
LL-MON	12/23/2002	Biweekly	286.13	0.0178	0.276	0
LL-MON	12/29/2002	Storm	461.35	0.0817	0.304	0

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Abbreviation	Date	Sample Type	Sample mass (g)	Fine Sediment (>1.2 μm) (g/L)	Dissolved Sediment (g/L)	Coarse Sediment (>63 μm) (g/L)
LL-MON	1/7/2003	Biweekly	300.56	0.0186	0.176	0
LL-MON	1/10/2003	Storm	324.34	0.0253	0.184	0
LL-MON	1/10/2003	Storm	329.03	0.0316	0.2	0.0055
LL-MON	1/21/2003	Biweekly	297.07	0.0215	0.24	0.004
LL-MON	2/4/2003	Biweekly	432.18	0.0125	0.348	0.0125
LL-MON	2/19/2003	Biweekly	426.78	0.0047	0.288	0.0075
LL-MON	3/4/2003	Biweekly	284.29	0.0053	0.348	0.0032
LL-MON	3/15/2003	Storm	390.72	0.2178	0.276	0.0077
LL-MON	3/15/2003	Storm	418.12	0.0258	0.268	0.0019
LL-MON	3/18/2003	Biweekly	205.8	0.001	0.228	0.0087
LL-MON	4/1/2003	Biweekly	305.57	0.0046	0.316	0.0026
LL-MON	4/13/2003	Storm	361.39	0.0116	0.0185	0.0111
LL-MON	4/15/2003	Biweekly	299.89	0	0.0017	0
LL-MON	4/25/2003	Storm	318.18	0.0028	0.48	0.0047
LL-MON	4/29/2003	Biweekly	368.25	0.0049	0.24	0.0022
LL-MON	5/2/2003	Storm	367.18	0.002	0.2652	0.0007
LL-MON	5/13/2003	Biweekly	429.64	0.0023	0.236	0.0012
LL-MON	5/27/2003	Biweekly	399.37	0.002	0.276	0.001
LL-MON	6/10/2003	Biweekly	367.16	0.0125	0.248	0.0027
LL-WDA	12/15/2002	Storm	822.47	0.0444	0.58	0.0157
LL-WDA	12/16/2002	Storm	823	0.418	0.196	0.1192
LL-WDA	12/20/2002	Storm	596.21	0.7254	0	0.0091
LL-WDA	1/10/2003	Storm	339.92	0.0265	0.244	0.0041
LL-WDA	3/15/2003	Storm	354.02	0.0201	0.308	0.0023
LL-WHI	12/15/2002	Storm	1037.7	0.0177	0.68	0.0008
LL-WHI	12/16/2002	Storm	890.5	0.074	0.244	0.0086
LL-WHI	12/20/2002	Storm	505.37	0.0398	0.116	0
LL-WHI	1/10/2003	Storm	305.22	0.0229	0.288	0.0023
LL-WHI	3/15/2003	Storm	346.48	0.0153	0.36	0.0023
LL-WHI	4/13/2003	Storm	382.56	0.0047	0.023	0.0078
LL-WHI	5/2/2003	Storm	394.1	0.0215	0.0196	0.0014
PA-BET	12/2/2001	Grab	843	0.207663108	0.7256	0.00221827
PA-CHI	11/29/2001	Grab	471	0.1301	1.0148	0.1396
PA-CHI	12/2/2001	Grab	852	0.559788732	0.8428	0.09312207
PA-CHI	12/4/2001	Grab	798	0.061942356	0.7144	0.00197995
PA-CHI	12/18/2001	Grab	1045	0.0275	1.0136	0.0099
PA-CHI	1/1/2002	Grab	1046	0.0314	0.5492	0.0046
PA-CHI	1/3/2002	Grab	822	0.0483	0.5064	0.0013
PA-CHI	1/16/2002	Grab	908	0.0177	0.7428	0.0006
PA-CHI	2/5/2002	Grab	765	0.0093	0.686	0
PA-CHI	2/28/2002	Grab	1040	0.0156	0.752	0
PA-CHI	4/10/2002	Grab	952	0.003697479	0.6996	0.00960084
PA-CHI	5/9/2002	Grab	849.39	0.00656942	0.854	0
PA-CHI	5/23/2002	Grab	171.47	0.026360296	1.1076	0.03901557
PA-CHI	6/6/2002	Grab	168	0.004166667	1.2412	0
PA-CHI	6/19/2002	Grab	982	0.016466395	1.2724	0.00387984
PA-CHI	7/2/2002	Grab	756	0.019920635	1.3408	0.01519841

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2002-2003 University of California Santa Cruz
Nutrient TMDL Sampling

Abbreviation	Date	Sample Type	Sample mass (g)	Fine Sediment (>1.2 μm) (g/L)	Dissolved Sediment (g/L)	Coarse Sediment (>63 μm) (g/L)
PA-CHI	7/17/2002	Grab	687	-4.351703057	1.5228	0.00716157
PA-CHI	7/31/2002	Grab	626	0.011325879	0.4264	0.00829074
PA-CHI	8/14/2002	Grab	896	0.003571429	1.352	0.00148438
PA-CHI	8/27/2002	Grab	778	0.006799486	1.3652	0
PA-CHI	9/10/2002	Grab	994	0.017937626	1.1144	0.00185111
PA-CHI	9/25/2002	Grab	585	0.001931624	1.6036	0.00167521
PA-CHI	10/8/2002	Biweekly	723.94	0.0062	5.464	0.0041
PA-CHI	10/22/2002	Trial	342.31	0.0012	1.456	0.0015
PA-CHI	10/22/2002	Trial	301.58	0.0056	1.452	0
PA-CHI	11/5/2002	Trial	223.3	0.0085	1.168	0
PA-CHI	11/12/2002	Biweekly	394.21	0.0134	1.244	0.0089
PA-CHI	11/19/2002	Biweekly	267.94	-0.3799	-4.456	0
PA-CHI	12/3/2002	Biweekly	273.05	-0.5633	-5.436	0
PA-CHI	12/10/2002	Biweekly	310.62	0.0064	0.868	0
PA-CHI	12/15/2002	Storm	972.26	0.1384	0.516	0.0073
PA-CHI	12/16/2002	Storm	359.48	0.2559	0.356	0.0337
PA-CHI	12/17/2002	Biweekly	325	0.124	0.296	0.0006
PA-CHI	12/20/2002	Storm	262.98	0.2418	0.42	0.0068
PA-CHI	12/21/2002	Storm	279.8	0.5179	0.316	0.0143
PA-CHI	12/23/2002	Biweekly	465.58	0.1207	0.448	0.0028
PA-CHI	12/29/2002	Storm	428.02	0	0.508	0.0089
PA-CHI	1/7/2003	Biweekly	360.65	0.0286	0.332	0
PA-CHI	1/10/2003	Storm	295.98	0.1264	0.388	0.0081
PA-CHI	1/14/2003	Biweekly	441.72	0.0217	0.34	0
PA-CHI	1/21/2003	Biweekly	365.43	0.0265	0.376	0.0027
PA-CHI	1/28/2003	Biweekly	469.96	0.0245	0.616	0
PA-CHI	2/11/2003	Biweekly	452.35	0.0117	0.828	0.0004
PA-CHI	2/19/2003	Biweekly	463.97	0.0237	0.84	0.015
PA-CHI	2/25/2003	Biweekly	283.9	0.043	0.408	0.006
PA-CHI	3/4/2003	Biweekly	349.3	0.0312	0.868	0.1801
PA-CHI	3/11/2003	Biweekly	291.13	0.0275	0.844	0.0017
PA-CHI	3/15/2003	Storm	358.22	0.0757	0.632	0.0123
PA-CHI	3/18/2003	Biweekly	405.624	0.0375	0.696	0.0106
PA-CHI	3/25/2003	Biweekly	424.6	0.0309	0.676	0.0184
PA-CHI	4/1/2003	Biweekly	430.57	0.0265	0.0418	0.0137
PA-CHI	4/8/2003	Biweekly	373.25	0.0319	0.0429	0.019
PA-CHI	4/13/2003	Storm	388.97	0.0244	0.0049	0
PA-CHI	4/15/2003	Biweekly	325.07	0.0129	0.0301	0
PA-CHI	4/22/2003	Biweekly	379.08	0.0349	0.0337	0.0161
PA-CHI	4/25/2003	Storm	457.84	0.0308	0.392	0.0295
PA-CHI	4/29/2003	Biweekly	393.98	0.036	0.352	0.0076
PA-CHI	5/6/2003	Biweekly	335.07	0.0221	0.556	0.0012
PA-CHI	5/6/2003	Biweekly	302.53	0.0228	0.584	0.003
PA-CHI	5/13/2003	Biweekly	281.97	0.0337	0.724	0.0064
PA-CHI	5/13/2003	Biweekly	324.97	0.0357	0.736	0.0157
PA-CHI	5/20/2003	Biweekly	411.23	0.0267	1.028	0.0041
PA-CHI	5/27/2003	Biweekly	347.63	0.0256	0.912	0

Table A4
2002-2003 University of California Santa Cruz
Nutrient TMDL Sampling

Abbreviation	Date	Sample Type	Sample mass (g)	Fine Sediment (>1.2 μm) (g/L)	Dissolved Sediment (g/L)	Coarse Sediment (>63 μm) (g/L)
PA-CHI	6/3/2003	Biweekly	431.15	0.0244	0.964	0.0051
PA-CHI	6/3/2003	Biweekly	423.78	0.0283	0.904	0.0012
PA-CHI	6/10/2003	Biweekly	381.52	0.0367	1.032	0.0024
PA-CHI	6/17/2003	Biweekly	387.56	0.0284	0.876	
PA-MUR	11/12/2001	Grab	782	0.0393	1.2712	0.0417
PA-MUR	11/12/2001	Grab	598.91	3.9325	1.2456	0.0141
PA-YRD	1/7/2003	Biweekly	305.09	0.0285	1.988	0.002
UV-152	11/8/2002	Storm	354.38	0.1408	0.208	0.1126
UV-152	11/12/2002	Biweekly	370.34	0.0057	0.276	0.0008
UV-152	12/10/2002	Biweekly	317.2	0	0.224	0
UV-152	12/15/2002	Storm	978.77	0.1076	0.412	0.0021
UV-152	12/16/2002	Storm	783.5	0.0883	0.384	0.0143
UV-152	12/20/2002	Storm	600.88	0.0404	0	0
UV-152	12/21/2002	Storm	1053.8	0.0343	0.32	0.0045
UV-152	12/23/2002	Biweekly	188.45	0.0111	0.136	0.008
UV-152	12/29/2002	Storm	444.16	0.0374	0.212	0.018
UV-152	1/7/2003	Biweekly	272.22	0.014	0.16	0
UV-152	1/10/2003	Storm	340.82	0.027	0.24	0.0185
UV-152	1/21/2003	Biweekly	306.39	0.0741	0.016	0.0379
UV-152	2/4/2003	Biweekly	372.66	0.0046	0.276	0.003
UV-152	2/4/2003	Biweekly	339.15	0.0077	0.264	0.0097
UV-152	2/19/2003	Biweekly	440.84	0.0061	0.276	0
UV-152	2/19/2003	Biweekly	444.37	0.0047	0.2	0
UV-152	3/15/2003	Storm	324.12	0.0336	0.252	0.0031
UV-152	3/18/2003	Biweekly	285.68	0.0053	0.04	0.013
UV-152	4/1/2003	Biweekly	264.06	0.0038	0.144	0.0023
UV-152	4/13/2003	Storm	358.6	0.036	0.0173	0.0218
UV-152	4/15/2003	Biweekly	416.56	0	-0.0014	0
UV-152	4/25/2003	Storm	307.74	0.0068	0.208	0.0032
UV-152	4/29/2003	Biweekly	273.58	0.0069	0.236	0.0048
UV-152	5/2/2003	Storm	358.52	0.0103	0.312	0.0137
UV-152	5/13/2003	Biweekly	379.53	0.0032	0.228	0.0024
UV-152	5/27/2003	Biweekly	436.23	-0.0048	0.24	0
UV-152	6/10/2003	Biweekly	407.13	0.0025	0.28	0.0017
UV-BLO	11/8/2002	Storm	360.57	0.1803	0.164	0.058
UV-BLO	12/15/2002	Storm	919.51	0.0249	0.404	0.0014
UV-BLO	12/16/2002	Storm	270.54	0.7274	0.116	0.139
UV-BLO	12/20/2002	Storm	351.67	0.035	0.2	0.0088
UV-BLO	12/21/2002	Storm	476.94	0.1103	0.16	0.0092
UV-BLO	12/23/2002	Biweekly	361.93	0.122	0.244	0.0022
UV-BLO	12/29/2002	Storm	422.23	0.1305	0.236	0.009
UV-BLO	1/7/2003	Biweekly	263.35	0.014	0.132	0
UV-BLO	1/10/2003	Storm	313.19	0.0415	0.236	0.0061
UV-BLO	1/21/2003	Biweekly	303.92	0.0132	0.252	0.0023
UV-BLO	2/4/2003	Biweekly	384.13	0.0029	0.316	0.0023
UV-BLO	2/19/2003	Biweekly	346.96	0	0.24	1.4552
UV-BLO	3/4/2003	Biweekly	415.38	0.0043	0.284	0.0055

Table A4
2002-2003 University of California Santa Cruz
Nutrient TMDL Sampling

Abbreviation	Date	Sample Type	Sample mass (g)	Fine Sediment (>1.2 μm) (g/L)	Dissolved Sediment (g/L)	Coarse Sediment (>63 μm) (g/L)
UV-BLO	3/15/2003	Storm	366.12	0.0494	0.188	0.0057
UV-BLO	3/18/2003	Biweekly	306.239	0	0.168	0.0085
UV-BLO	4/1/2003	Biweekly	327.04	0	0.0144	0
UV-BLO	4/13/2003	Storm	352.74	0.1599	0.0179	0.0196
UV-BLO	4/15/2003	Biweekly	303.05	0	0	0
UV-BLO	4/25/2003	Storm	324.23	0.0025	0.236	0.0086
UV-BLO	4/29/2003	Biweekly	359.08	0.0047	0.292	0.0178
UV-BLO	5/2/2003	Storm	265.14	-0.0053	0.232	0
UV-BLO	5/13/2003	Biweekly	420.29	0	0.216	0.0124
UV-BLO	5/27/2003	Biweekly	423.68	0.0019	0.276	0

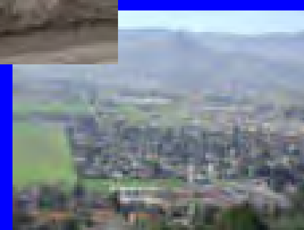
Appendix B

Presentation of
Pre-TMDL Sediment Assessment Project

to

Uvas Watershed Working Group
Farm Bureau Meeting
April 30, 2003

PRE-TMDL SEDIMENT ASSESSMENT STUDY IN THE LLAGAS AND UVAS WATERSHEDS



PROJECT TEAM

Fall Creek Engineering
Peter Haase P.E. and Emily Corwin

Buchanan Associates
Marc Buchanan Ph.D.

Santa Clara Farm Bureau
Mary Ellen Dick

Pajaro River and Llagas Creek water quality is impaired by excessive sediment

The Regional Water Quality Control Board seeks to involve the agricultural, ranching, and equestrian communities early in the development of the Sediment TMDL

This assessment study is a preliminary step in the TMDL process intended to identify the important controllable sources of sediment in the Llagas and Uvas-Carnadero watersheds

Project Elements

- ✓ **Establish study area boundaries**
- ✓ **Form Farm Bureau Watershed Groups**
- ✓ **Review existing sediment data**
  Determine data and information gaps
- ✓ **Problem-Source Assessment**
  Determine source locations/areas, verify land use
  Gather local historical information
- ✓ **Outreach**
  Agriculture, Equestrian, Ranching, Local Agencies
- ✓ **Recommendations (Data gaps, Monitoring, Watershed Groups)**
- ✓ **Mapping → Review Draft Report → Final Report**

The TMDL Allocates Responsibility for Sediment Loads in Llagas and Uvas Basins

Total Sediment Load = Natural + Controllable Sources

TSL = Natural + (Agriculture, Urban, Rural Residential, Ranching, Mgmt. Agencies, Other)

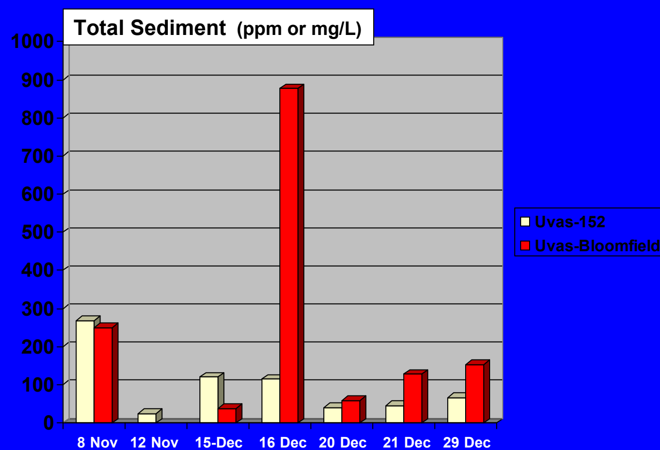
The estimation of these sediment loads is only as good as the information and data that goes in to them.

The load allocation and the targeted reductions could be done with poorly formed assumptions and incomplete data concerning land use, erosion sources, and sedimentation.

This pre-TMDL Project will allow growers, ranchers, and equestrians an opportunity to participate in the identification of problem areas, raise concerns, and demonstrate recognition and early response to this water quality issue

Baseline data collected in Winter 2003

Some trends can be inferred, but there is no reference data and very limited flow data



Identify sources and causes

Agriculture

Tailwater, bare ditch banks,
sheet erosion in winter fallow

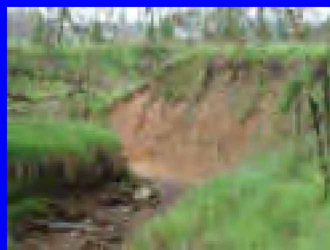
Equestrian

Sheet-rill erosion,
riparian grazing, impervious
surfaces (roof drains)

Rangeland and Pastures

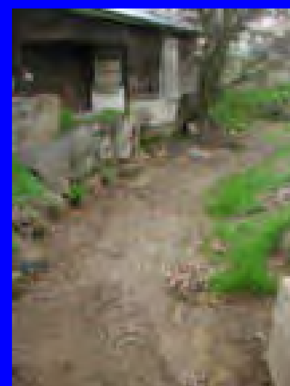
Riparian grazing, roads,
creek crossings

Identify sources and causes of sediment



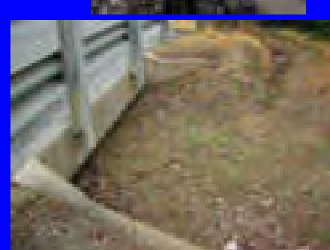
Unstable creek banks

Channel modification, ↑ flows vegetation removal, setbacks, creek crossings



Identify sources and causes of sediment

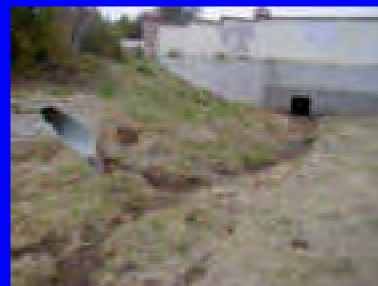
Road and other drain ditches

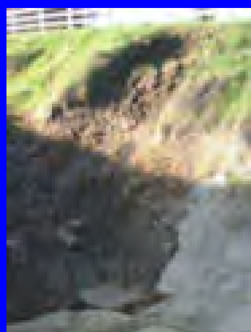


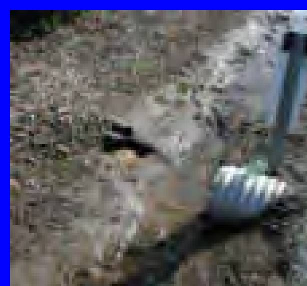
Identify sources and causes of sediment

Concentrated flows

Development, impervious surfaces, poorly designed residential drains



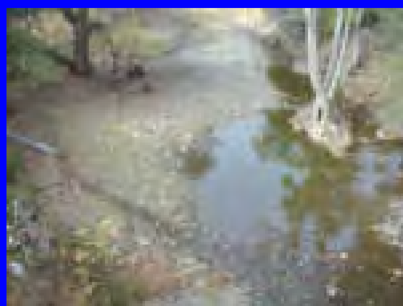




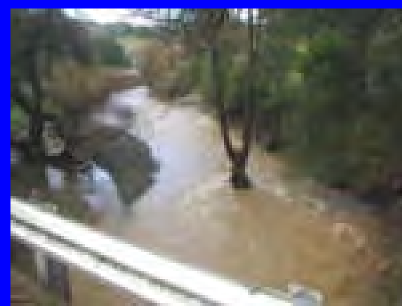
Identify sources and verify land use

Conduct multiple observations

Early October



Late December



Llagas Creek at Oak Glen and Uvas Rds.
(above Chesbro Reservoir)

Assess condition of creek channels

Bank angle

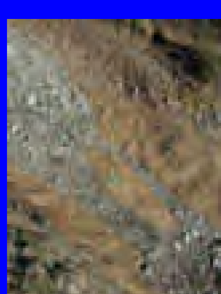
Channel depth (incision) and cross-section attributes

Riparian vegetation

Rooting depth and percentage

Creek bed material

Channel modified??



Agricultural Sources

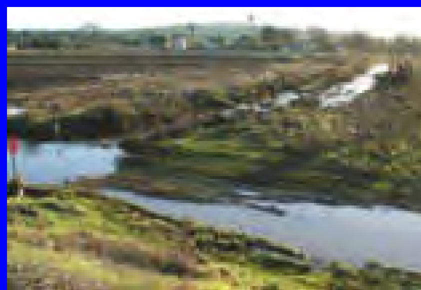
Agricultural Sources

Less than optimal winter stormwater management appears to be a widespread source of sediment

Typical drainage practices are resulting in significant sediment input to creeks

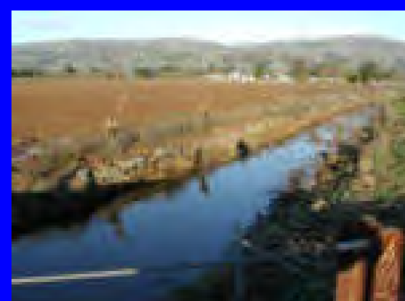
Inadequate setbacks without berms allow soil to fill ditches and/or creek channels

Creek channel and bank modifications

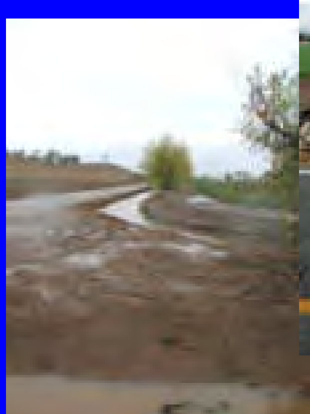


Creek channel was disked down prior to winter rains

Concrete rip-rap flood wall on left bank leads to destabilization of and flooding over right bank



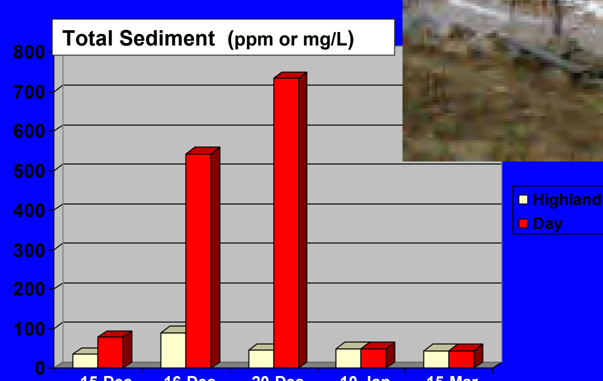
Removal of riparian vegetation and channel straightening increase bank instability and erosion



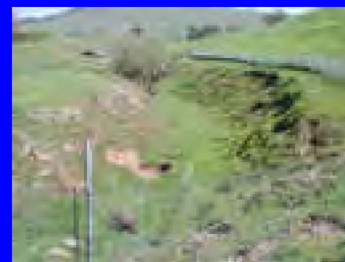
Steep bank angles on drainage ditches, yearly cleanout in late season, and no or sparse vegetation cover provides a continuous source of sediment

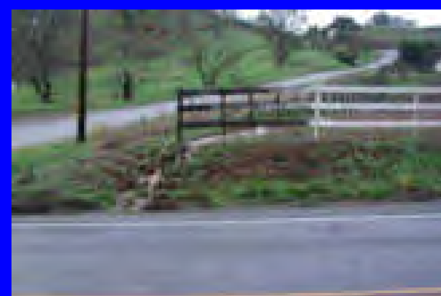
Impacts are quantifiable

Upstream and downstream measurements reveal increased sediment loads

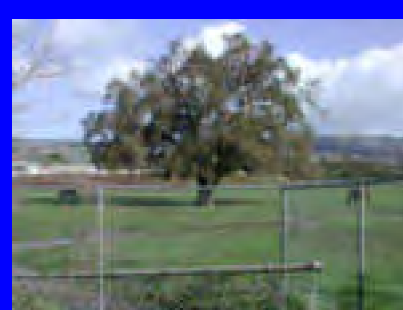


Equestrian sources



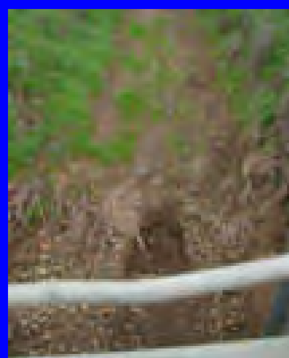


Exposed soil in corrals with little drainage control and riparian access increase sedimentation



Other Problem Sources

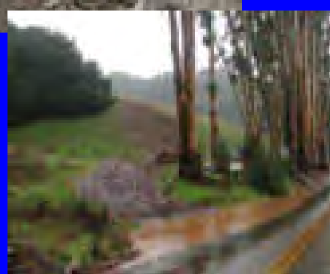
Increasing flow volumes from land use changes creates sediment “hungry drainage waters

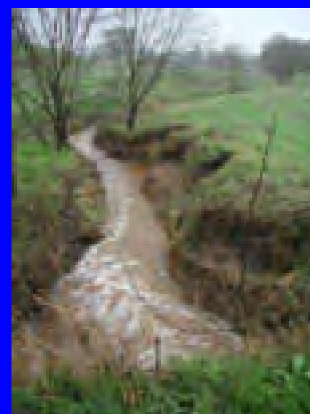


Other Problem Sources

Drainage system is not designed for flow volumes and intensity

More runoff + Bare soil = Higher TMDL Allocation





What does the Project Team need from FB members?

Provide additional information, local knowledge, and concerns

- Are there problem areas that we should be aware of?
- How have things changed in the last 10, 20, 30 or 50 years?
- Your feelings about the role of management agencies (e.g. SCVWD, City and County Roads, Parks, Planning)
- Give us your opinions about best ways to develop more sound quantitative data/info prior to the allocation process
- Participate in the review (anonymous if preferred) of project updates and draft report
- Access to private land for informal and confidential assessment?
- Help to reduce errors of judgement/assumptions in the process of load estimation and allocation

Future Questions, Comments, Concerns?

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Appendix C

Agricultural Commissioners
Crop Categories

Table C1
Agricultural Commissioners
Crop Categories

ST-ROW = Short-term row crop
MT-ROW = Medium-term row crop
FIELD = Field crop
MT-PERENNIAL = Medium-term perennial
LT-PERENNIAL = Long-term perennial
IMPERVIOUS = Greenhouse

COMMODITY	SEDIMENT SOURCE RISK	CROP CATEGORY
ALFALFA	LOW	FIELD
ALMOND	LOW	LT-PERENNIAL
APPLE	LOW	LT-PERENNIAL
APRICOT	LOW	LT-PERENNIAL
ASPARAGUS	MEDIUM	MT-ROW
BARLEY	MEDIUM	FIELD
BARLEY	MEDIUM	FIELD
BEAN SUCCULENT	HIGH	ST-ROW
BEAN SUCCULENT	HIGH	ST-ROW
BEAN UNSP SEED	HIGH	ST-ROW
BEAN UNSPECIFD	HIGH	ST-ROW
BLACKBERRY	MEDIUM	MT-ROW
BLUEBERRY	MEDIUM	MT-ROW
BOK CHOY LSE LF	HIGH	ST-ROW
BROCCOLI	HIGH	ST-ROW
CABBAGE	HIGH	ST-ROW
CAULIFLOWER	HIGH	ST-ROW
CAULIFLOWR SEED	HIGH	ST-ROW
CELERY	HIGH	ST-ROW
CELERY SEED	HIGH	ST-ROW
CHERRY	LOW	LT-PERENNIAL
CHINESE GREEN	HIGH	ST-ROW
CHRISTMAS TREE	LOW	MT-PERENNIAL
CILANTRO	HIGH	ST-ROW
CORN, HUMAN CON	HIGH	ST-ROW
CUCUMBER	HIGH	ST-ROW
FIG	LOW	LT-PERENNIAL
FORAGE HAY/SLGE	LOW	FIELD
FORAGE HAY/SLGE	LOW	FIELD
GARLIC	HIGH	ST-ROW
GF-CARNATION	LOW	IMPERVIOUS
GF-CHRYSANTHMUM	LOW	IMPERVIOUS
GF-CHRYSANTHMUM	LOW	IMPERVIOUS
GF-FLOWER SEED	LOW	IMPERVIOUS
GF-FLWRNG PLANT	LOW	IMPERVIOUS
GF-FOLIAGE PLNT	LOW	IMPERVIOUS
GF-FOLIAGE PLNT	LOW	IMPERVIOUS
GF-GROUND COVER	LOW	IMPERVIOUS

Table C1
Agricultural Commissioners
Crop Categories

COMMODITY	SEDIMENT SOURCE RISK	CROP CATEGORY
GRAPE	MEDIUM	LT-PERENNIAL
GRAPE, WINE	MEDIUM	LT-PERENNIAL
GT-CHRYSANTHMUM	LOW	IMPERVIOUS
GT-FLWRNG PLANT	LOW	IMPERVIOUS
HERB, SPICE	MEDIUM	MT-PERENNIAL
KIWI	LOW	LT-PERENNIAL
LEEK	HIGH	ST-ROW
LETTUCE HEAD	HIGH	ST-ROW
LETTUCE LEAF	HIGH	ST-ROW
LETTUCE ROMAINE	HIGH	ST-ROW
MINT	MEDIUM	MT-PERENNIAL
MUSHROOM	LOW	IMPERVIOUS
NAPA CBG TGHT H	HIGH	ST-ROW
NECTARINE	LOW	LT-PERENNIAL
N-GRNHS FLOWER	LOW	IMPERVIOUS
N-GRNHS PLANT	LOW	IMPERVIOUS
N-OUTDR FLOWERS	HIGH	ST-ROW
N-OUTDR PLANTS	HIGH	ST-ROW
N-OUTDR TRANSPL	HIGH	ST-ROW
OAT	MEDIUM	FIELD
OAT SEED	MEDIUM	FIELD
OF-CHRYSANTHMUM	HIGH	ST-ROW
OF-FLWRNG PLANT	HIGH	ST-ROW
OF-FLWRNG PLANT	HIGH	ST-ROW
ONION DRY ETC	HIGH	ST-ROW
OP-FOLIAGE PLNT	HIGH	ST-ROW
OP-TURF	LOW	FIELD
ORANGE	LOW	LT-PERENNIAL
ORCHARD FLOOR	LOW	LT-PERENNIAL
OT-FLOWER SEED	HIGH	ST-ROW
PASTURELAND	LOW	FIELD
PEACH	LOW	LT-PERENNIAL
PEAR	LOW	LT-PERENNIAL
PEPPER FRUIT SD	HIGH	ST-ROW
PEPPER FRUITNG	HIGH	ST-ROW
PEPPER SPICE	HIGH	ST-ROW
PERSIMMON	LOW	LT-PERENNIAL
PLUM	LOW	LT-PERENNIAL
POME FRUIT	LOW	LT-PERENNIAL
PRUNE	LOW	LT-PERENNIAL
PUMPKIN	HIGH	ST-ROW
RANGELAND	LOW	FIELD
RASPBERRY	MEDIUM	MT-ROW
RESEARCH COMMOD	?	?
RYE	MEDIUM	FIELD
SPINACH	HIGH	ST-ROW
SQUASH	HIGH	ST-ROW

Table C1
Agricultural Commissioners
Crop Categories

COMMODITY	SEDIMENT SOURCE RISK	CROP CATEGORY
STONE FRUIT	LOW	LT-PERENNIAL
STRAWBERRY	HIGH	ST-ROW
SUGARBEET	HIGH	ST-ROW
SUNFLOWER	HIGH	ST-ROW
TOMATILLO	HIGH	ST-ROW
TOMATO FRESH	HIGH	ST-ROW
TOMATO PROCESS	HIGH	ST-ROW
TOMATO SEED	HIGH	ST-ROW
TURF/SOD	LOW	FIELD
TURF/SOD	LOW	FIELD
UNCUL NON-AG	?	?
UNCUL NON-AG	?	?
UNCULTIVATED AG	LOW	FIELD
UNDECLARED COMM	?	?
VEGETABLE	HIGH	ST-ROW
VEGETABLE LEAF	HIGH	ST-ROW
WALNUT	LOW	LT-PERENNIAL
WHEAT	MEDIUM	FIELD
WHEAT FOR/FOD	MEDIUM	FIELD

Appendix D

Integrated Water Quality Monitoring Program

Appendix D

Integrated Water Quality Monitoring Program

Historical and current monitoring efforts (e.g. Central Coast Ambient Monitoring Program) do not provide sufficient data to develop reasonable sediment load estimates, nor provide sufficient detail of specific impacts from land uses and in-stream processes. Load estimates, derived from simulation modeling based on broad and generalized assumptions about the erosion rate potential from different land areas and contributions from in-stream sources, will provide gross estimates at best. There are currently no adequate local data sets accounting for the dynamics of land use conversion and arid drainage conditions.

FCE has developed an integrated water quality monitoring program outline, which provides a number of suggestions to address current data gaps for specific locations and to assess land use impacts in the Llagas and Uvas watersheds. The monitoring program outlines activities to expand on the pre-TMDL assessment of existing conditions. The intent of the program is to provide guidance for the collection of baseline data to develop sediment estimates for priority sub-watersheds, target land use related load contributions, and ultimately to assess source reduction progress.

Monitoring Stations

The current Central Coast Ambient Monitoring Program (CCAMP) effort utilizes historic public access points, typically located at public road crossings (bridges). In the Llagas Basin study area, numerous monitoring stations are located at logical and important points in the watershed. Expanding this monitoring program with additional locations will provide a more complete assessment of current and future conditions.

Monitoring locations have been selected to provide data related to land use specific sediment sources, in-steam sediment sources, and baseline information for the mainstem of the Uvas and Llagas Creek channels. Monitoring locations have been selected for stations throughout the four study area regions to generate information across a diversity of land uses, soil types, and geomorphic settings. Where possible the proposed locations complement information collected from existing CCAMP stations. The monitoring locations were selected based on the results of the in-stream and land use field assessment work. The locations, monitoring parameters and monitoring frequency are summarized in Table D1. The locations for the various stations are shown in Figures D1 through D6.

Monitoring locations have been selected based on the results of the land use and stream source assess. The locations have been selected to quantify sediment loads within proper, moderately, and non-functioning stream reaches. Monitoring stations have also been selected to quantify sediment loads from specific land uses within study sub-areas where a particular land use dominates either land area or estimated percentage of sediment load contribution. Selected monitoring locations focus on source contributions from agriculture, rangeland, rural residential, and urban land uses.

Several stations have been selected to provide more refined load contributions from both natural or controllable sediment sources. The sites have also been selected to evaluate future best management practice (BMP) efforts.

Implementation

It is recognized that the proposed monitoring program may exceed current or future financial and personnel resource availability. However, existing and new programs in the study area, undertaken by various watershed stakeholder groups, could collaborate in the implementation of monitoring activities. For example, the Santa Clara County Farm Bureau Watershed Working Groups in the Uvas and Llagas watersheds represent one potential partner in the implementation of a future monitoring program. Other local agencies (such as the SCVWD Creek Maintenance Group and County of Santa Clara Department of Roads) could potentially be integrated into a regional monitoring program, along with additional undeveloped resources, such as local volunteers and community groups. There are numerous examples of watershed monitoring programs implemented with public agency and community partnerships in small and large watersheds throughout the region.

Not all of the proposed monitoring locations are on publicly accessed lands, however it is suggested that coordination and collaboration with private landowners or land managers be pursued to develop relationships with various watershed stakeholders. Access to these locations would also enhance the ability of investigators to form defensible conclusions with collected data.

Methods

The proposed monitoring includes measurement of total suspended solids concentrations, stream flow, stream cross-sections, and regular photo documentation at all sites.

Total Suspended Solids. A majority of sediment transported in the local streams is composed of fine suspended solids. The movement of coarse sediment or bedload is typically very low in the streams in the Llagas and Uvas Creek systems. Total suspended solids monitoring could be conducted at several locations throughout the study area. Samples would be collected and taken to a certified laboratory for analysis of total suspended solids pursuant to EPA Test Method 160.2.

Stream Flow Measurements. In order to estimate sediment loads, stream flow data is imperative; however, many of the streams in the study area are ungaged. Therefore, stream flow measures should be taken when samples are collected. Use of a calibrated flow meter or stream gage is recommended to conduct routine measurements at fixed stations throughout the study area.

Stream Cross-Sections. Changes in channel form due to aggradation and degradation processes can be monitored with annual surveys at established or monumented cross-sections. Information indicating the change of channel form, specifically regarding channel incision and bank failure would improve estimates of in-stream sources.

Photo Documentation. Photo documentation of stream and riparian conditions should be an integral component of a water quality monitoring program. Establishing fixed photo points at the onset of the monitoring program is important to document baseline conditions and to visually monitoring changes overtime.

Monitoring Frequency

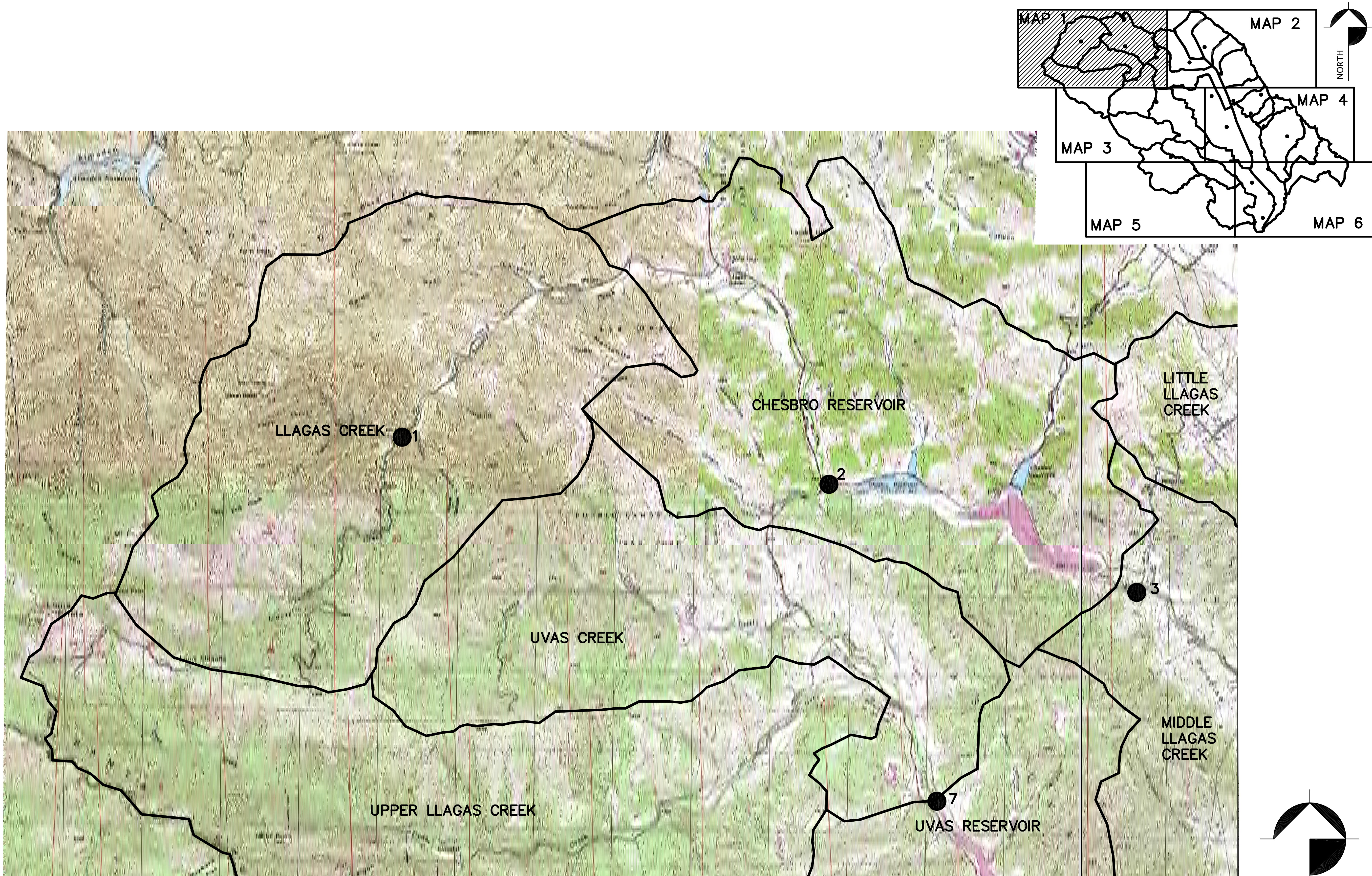
The frequency of monitoring for these parameters at the various locations is presented in Table D1.

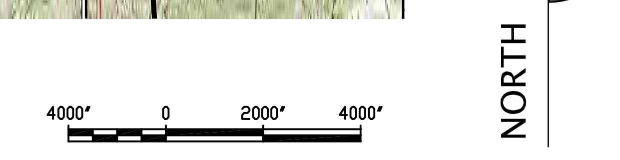
Table D1
Proposed Water Quality Monitoring Stations

Stream	Station Number	Access	Parameters			CCAMP Station	Targeted Land Use
			TSS	Stream	Cross		
Llagas Creek							
@ Casa Loma Road	1	Public	Q	Q			Baseline
@ Oak Glen Avenue above Chesbro	2	Public	Q	Q		X	Baseline/Rangeland
@ Oak Glen Avenue below Chesbro	3	Public	Q	Q		X	Baseline
Confluence w/ Little Llagas	4	SCVWD	M	M	A		North Valley
Confluence w/ Lower Miller Slough	5	SCVWD	M	M			South Valley/Urban
Confluence w/ Pajaro River	6	SCVWD/Private	M	M	A		South Valley/Agriculture
Uvas Creek							
Above Uvas Reservoir	7	SCVWD	Q	Q			Baseline/Rangeland
Below Uvas Reservoir	8	SCVWD	Q	Q			Baseline
Confluence w/ Bodfish Creek	9	Private	M	M			
Confluence w/ Gavilan Creek	10	Private	M	M			Western Sub-Areas/Non-Functioning
Below Miller Road	11	Public	M	M	A		South Valley/Baseline
@ South Monterey Road	12	Public	M	M			South Valley/Baseline/Urban
@ Bloomfield Road	13	Public	M	M	A	X	South Valley/Proper Functioning
Confluence w/ Pajaro River	14	Private	M	M			South Valley/Agriculture
Little Llagas Creek							
Confluence w/ Edmundson Creek	15	Public	M	M			North Valley Region/Urban
Downstream of Confluence w/ Corralitos Creek	16	SCVWD	M	M	A		North Valley Region/Rural Residential
West Branch Llagas Creek							
@ Highland Avenue	17	Public	M	M	A		Mid-Valley Region/Agriculture
@ Day Road	18	Public	M	M			Mid-Valley Region/Agriculture
@ Gilman Avenue	19	Public	M	M			South Valley
Skillet Creek							
@ Upper Bridle Path Road	20	Public	M	M			Mid-Valley Region/Rural Residential/Land Use Conversion
@ Center Avenue	21	Public	M	M			Mid-Valley Region/Rural Residential/Land Use Conversion
Live Oak Creek							
@ New Avenue	22	Public	M	M			Mid-Valley Region/Moderately Functioning
Little Arthur Creek							
@ Redwood Retreat Road	23	Public	M	M			Mid-Valley Region/Proper Functioning/Land Use Conversion
Crews Creek							
Crews Road	24	Private/Public	M	M	A		South Valley/Equestrian
Jones Creek							
Confluence w/ San Ysidro Creek	25	Private	M	M			South Valley/Agriculture
Corralitos Creek							
@ Sycamore Avenue	26	Unknown	M	M			Eastern Sub-Areas/Non-Functioning
San Ysidro Creek							
@ Canada Road	27	Public	Q	Q			Eastern Sub-Areas/Properly Functioning/Agriculture
Hayes Creek							
@ Watsonville Court	28	Private	M	M			Western Sub-Areas/Moderately Functioning
Bodfish Creek							
@ Whitehurst Road	29	Public	Q	Q			Western Sub-Areas/Properly Functioning
Tennant Creek							
@ Barrett Avenue	30	Public	M	M			North Valley/Urban/Land Use Conversion

Notes:

A = Annual Monitoring, Q = Quarterly Monitoring, M = Monthly Monitoring

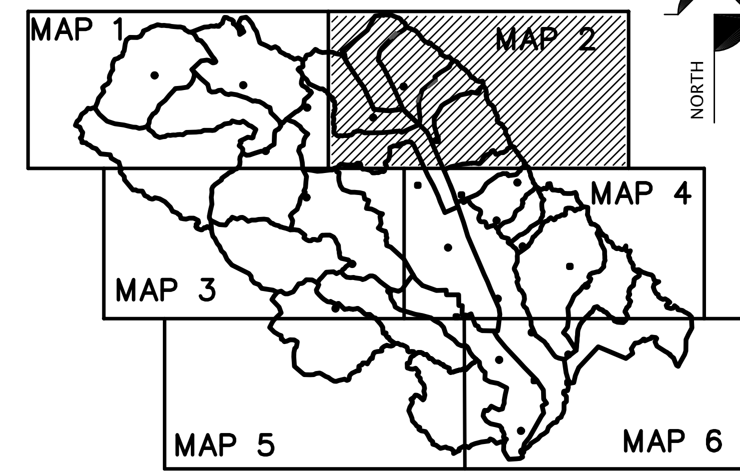


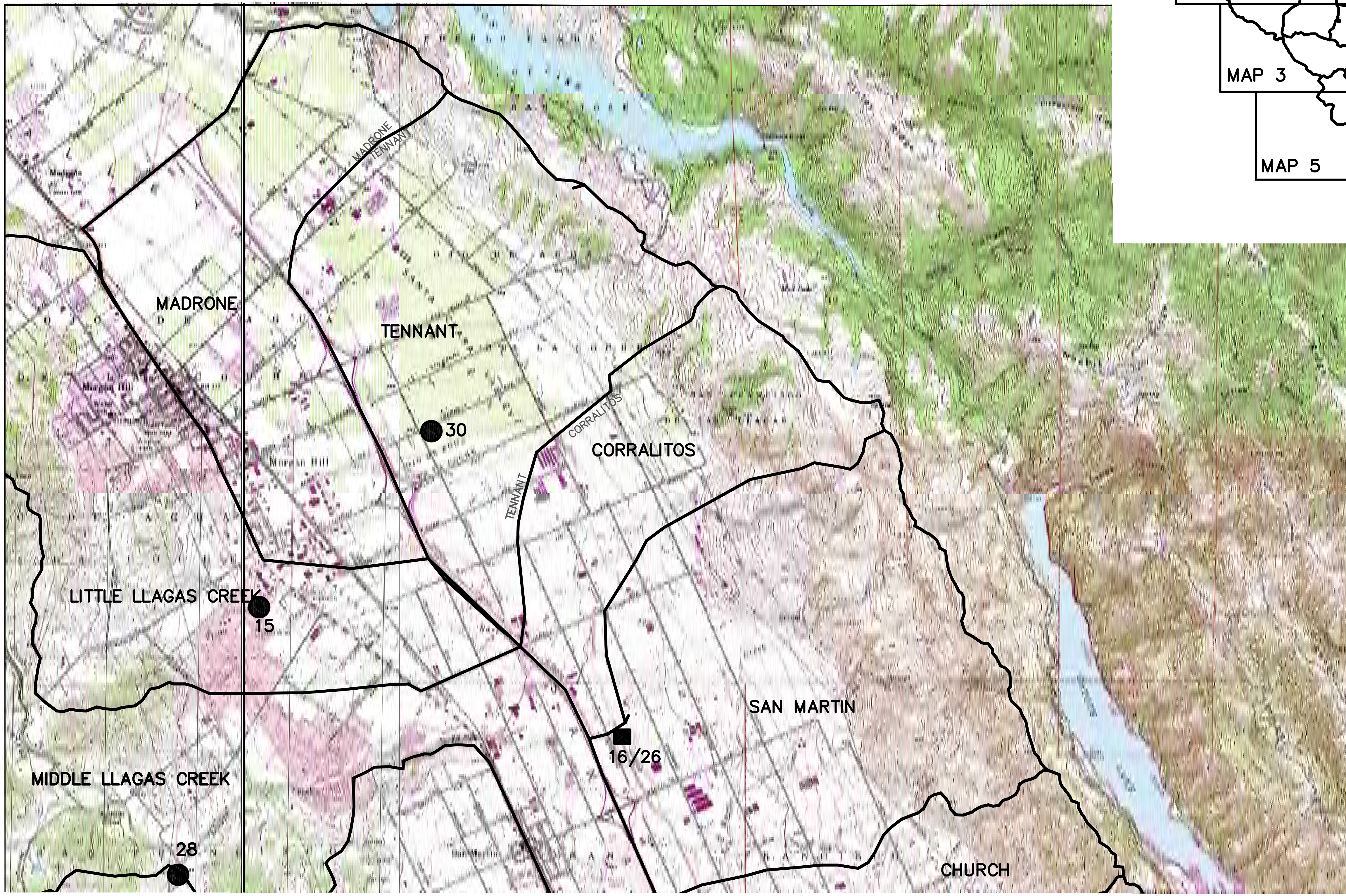


LEGEND
● WATER QUALITY MONITORING LOCATION
■ WATER QUALITY MONITORING AND CROSS SECTION ASSESSMENT LOCATION

FIGURE D1: MAP 1 OF 6

FALL CREEK ENGINEERING, INC.
Civil • Environmental • Water Resources Engineering





LEGEND	
●	WATER QUALITY MONITORING LOCATION
■	WATER QUALITY MONITORING AND CROSS SECTION ASSESSMENT LOCATION

4000' 0 2000' 4000'
GRAPHIC SCALE

NORTH

FIGURE D2: MAP 2 OF 6

FALL CREEK ENGINEERING, INC.
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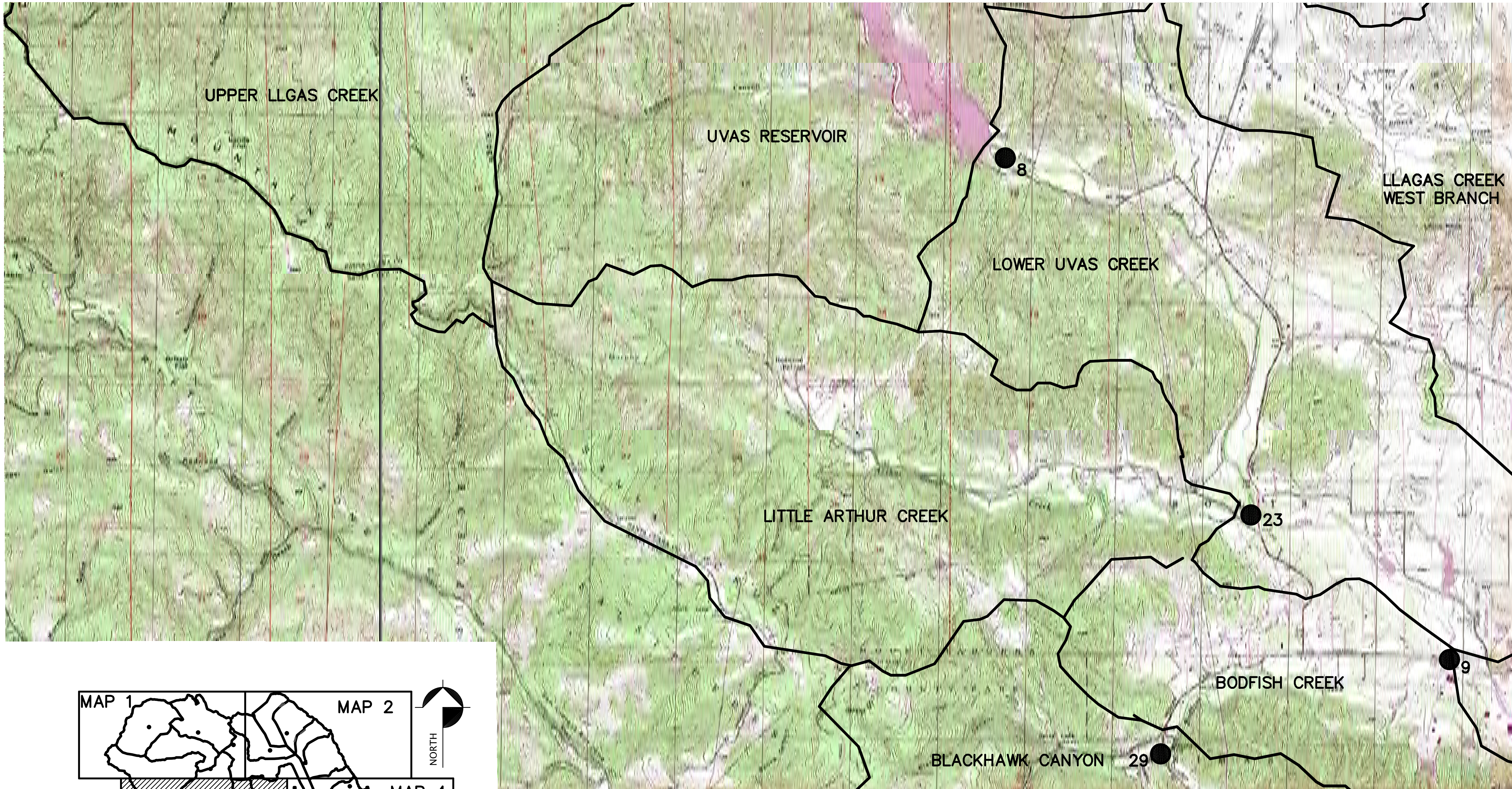
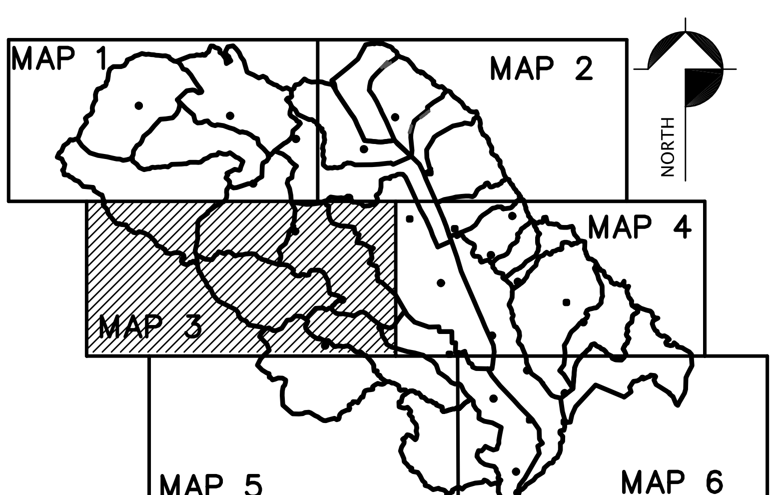




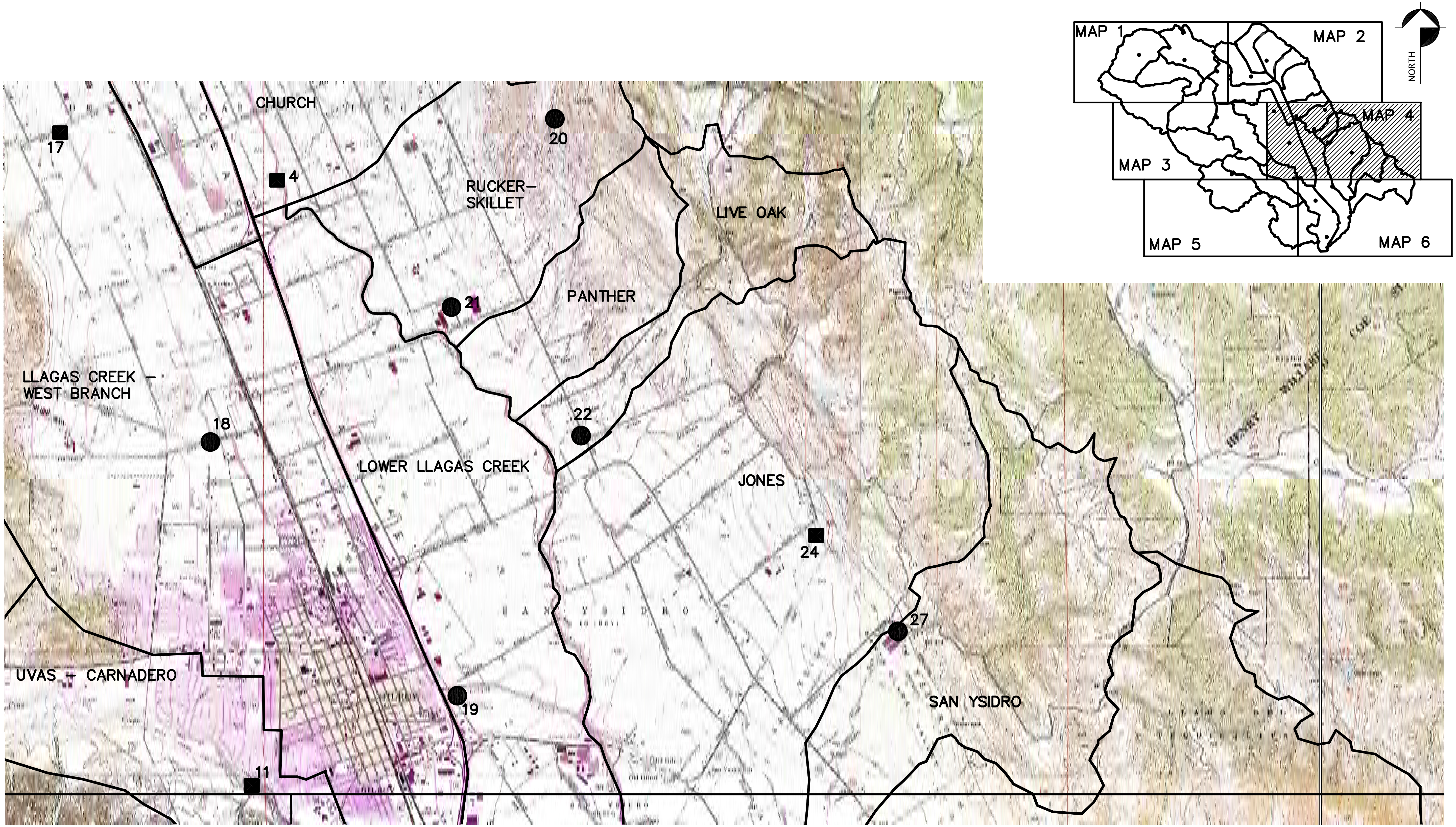
4000' 0 2000' 4000'
GRAPHIC SCALE

LEGEND	
●	WATER QUALITY MONITORING LOCATION
■	WATER QUALITY MONITORING AND CROSS SECTION ASSESSMENT LOCATION

NORTH

FIGURE D3: MAP 3 OF 6

FALL CREEK ENGINEERING, INC.
Civil • Environmental • Water Resources Engineering



LEGEND	
●	WATER QUALITY MONITORING LOCATION
■	WATER QUALITY MONITORING AND CROSS SECTION ASSESSMENT LOCATION

4000' 0 2000' 4000'
GRAPHIC SCALE

NORTH

FIGURE D4: MAP 4 OF 6

FALL CREEK ENGINEERING, INC.
Civil • Environmental • Water Resources Engineering

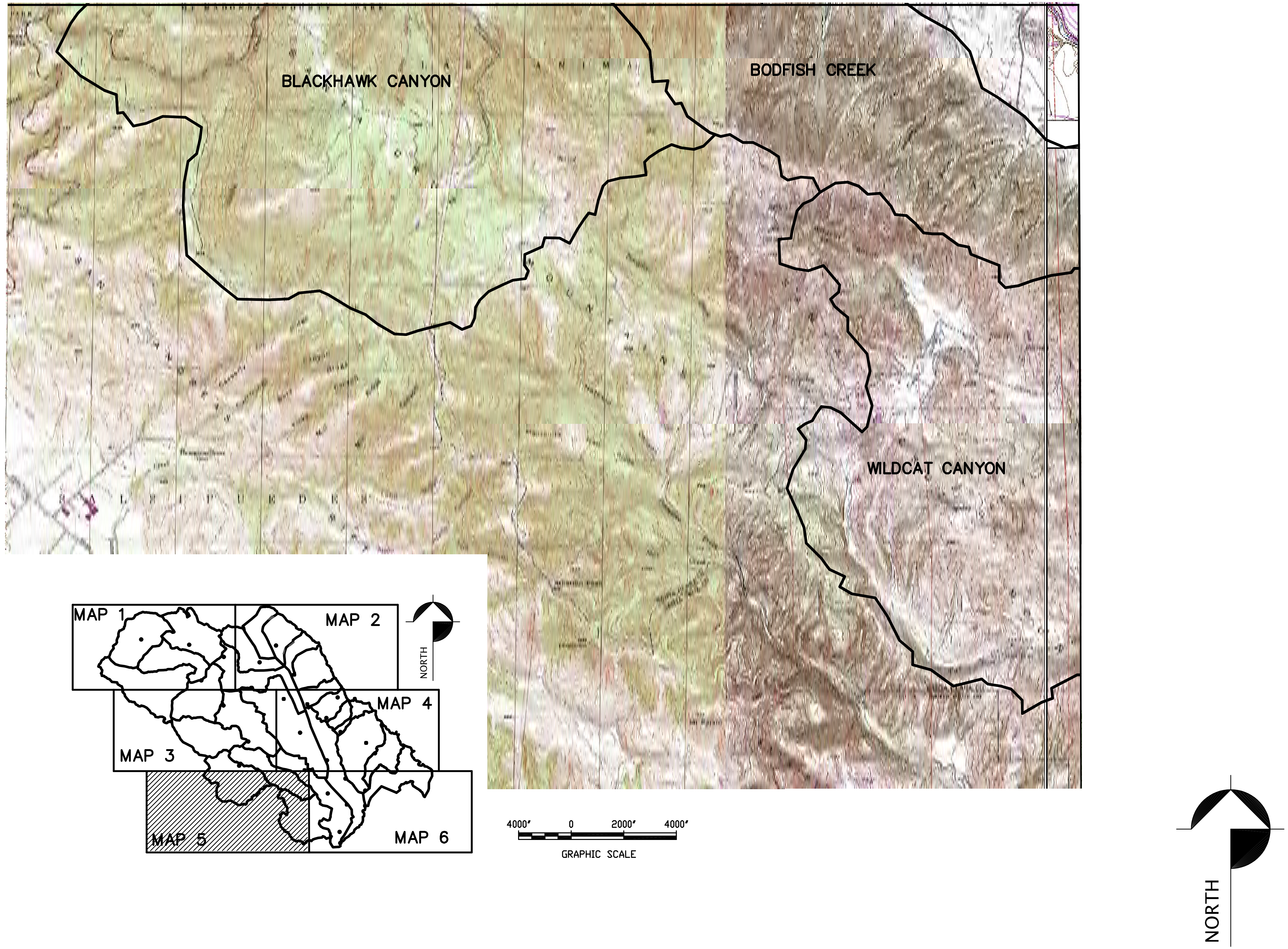


FIGURE D5: MAP 5 OF 6

FALL CREEK ENGINEERING, INC.
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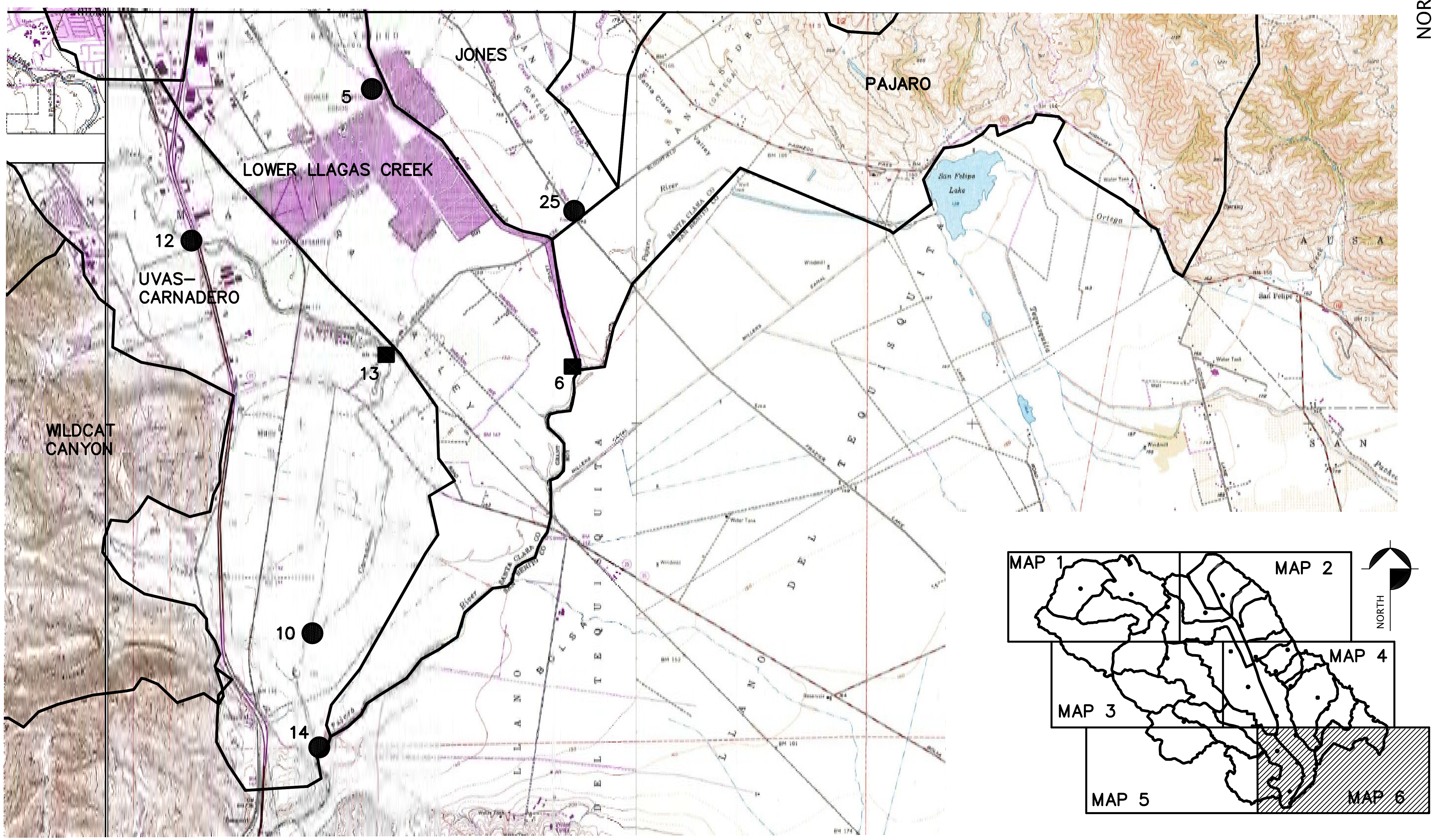

LEGEND
● WATER QUALITY MONITORING LOCATION
■ WATER QUALITY MONITORING AND CROSS SECTION ASSESSMENT LOCATION

4000' 0 2000' 4000'
GRAPHIC SCALE

FIGURE D6: MAP 6 OF 6

FALL CREEK ENGINEERING, INC.
Civil • Environmental • Water Resources Engineering