ARCADE CREEK
FEASIBILITY STUDY

Prepared for:

Department of Parks and Recreation
City of Sacramento
1023 J Street, Room 200
Sacramento, California

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Submitted by:

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1.0 EXECUTIVE SUMMARY

Background

This study examines the health and status of the Arcade Creek corridor from Marysville Boulevard upstream to the Sacramento City limits and makes recommendations for improving the corridor in four areas: water quality, flood damage mitigation, riparian and aquatic habitat, and recreation. The corridor investigated includes the creek channel and the area immediately surrounding the channel, including open space or undeveloped land, and bounded by development, roads or other constraining land use. The study was limited to the corridor upstream of the Marysville Boulevard Bridge because levees control flooding downstream of this point, limiting the benefits of restoration in that segment.

Data was collected on approximately 4.5 miles of stream corridor in June through August of 2002 using field collection sheets adapted from standard protocols. Analysis utilized both overlay-type methodology to rank potential restoration sites and in-field observations of opportunities. A working session was held to synthesize the data, analysis and observations into a series of potential projects that were further refined into the recommendations presented in Chapter 6.

Problems

As in many western urban watersheds, the Arcade Creek basin has undergone an enormous change in the past 60 years. Land that was once predominantly agricultural has been developed into residential, commercial, and industrial uses and transportation corridors including roads and railroads. Stormwater runoff that previously soaked into the ground or slowly filtered to the creek now flows quickly into storm drains and thence into the stream channel. Peak flows in the creek have increased dramatically in volume, with peak flows measured in 1992 more than 100 times the base flow (17). The result has been incision of the creek channel an average of 16 feet in the study area, intentional armoring of the streambanks to prevent erosion, reduction in water quality and a greatly increased probability of downstream flood damage.

The section of Arcade Creek that is the focus of this study is in the lower watershed and thus exhibits the largest impacts from the changes to the watershed. Residential development is the primary land use in a drainage basin that includes little undeveloped land, so the lower reaches of the creek experience serious problems with flooding and water quality.

One location in the study area that frequently floods is upstream of the Roseville Road and Union Pacific Railroad Bridges. During major storm events, water backs up behind these structures and overflows south and west into residential neighborhoods. The streambanks below this point are mostly armored with gunite, asphalt or gabions to lower channel roughness and prevent erosion. Armoring of the banks has consequences of lowering habitat quality through reduction of riparian vegetation and reduced instream structure, as well as decreasing the appeal of recreating along the stream.

Problems with water quality in a residential area typically come from improper use of household chemicals, vehicle use and unmanaged animal wastes, and this is the case with Arcade Creek. Diazinon and Malathion are two of the major toxins found in the creek that exceed water quality standards (18). Direct and indirect impacts of poor water quality include decreased aquatic life in the creek and corresponding decreased wildlife that feed on that aquatic life, potential danger to all users of the creek including local residents and anglers, decreased water quality in American and Sacramento Rivers, and decreased desire of residents to recreate along the creek corridor.

Another consequence of development on the watershed is the loss of wetlands. Wetlands detain stormwater and filter pollutants, so loss of these resources results in increased floodwater peak flows and diminished water quality. They also provide high-quality habitat for migratory waterfowl and other wildlife, so loss of wetlands means a reduction in habitat values.

Other significant problems found in the study area include a large homeless population along the creek, primarily under the bridges, which leads to reduced water quality due to the presence of bodily wastes and washing and cleaning in the creek. This also diminishes the recreational use of the nearby trails. Additionally, several areas within Haggin Oaks Golf Course exhibit poor riparian habitat with little buffer between the golf course and the stream. The presence of invasive plant species that supplant healthy native populations is also an important issue.

Recommendations

The recommendations of this report are organized into the four goal areas as listed below. While some of these suggestions can be implemented through the recommended projects outlined in Chapter 6, many are directed at watershed-wide measures to control the source of the problems, rather deal with the effects. The results of this study should be combined with the watershed plan for Arcade Creek to develop a comprehensive vision for improving the health of this critical system.

<u>Water Quality</u>

Source controls are likely to be the most effective and least costly means for improving the water quality on Arcade Creek. The existing Department of Utilities' programs of homeowner education and outreach should be directed towards reduction of household chemical use, particularly pesticides and herbicides. An important first step in source identification for pollutants entering the creek is mapping of the storm drainage system and focused water quality and flow monitoring. Another important source control may be retrofitting large parking lots such as those found at American River College and Sunrise and Birdcage Malls with oil/water separation vaults or, if space is available, above ground vegetated filtration swales.

Several outfalls in the study area are located in sufficient open space with topography such that detention ponds combined with filtration wetlands could be built to detain and filter runoff. This would help to improve water quality, as well as mitigate flooding and create beneficial habitat.

Cleanup of homeless camps would benefit water quality by removing sources of fecal bacteria and cleaning chemicals, however, without a larger city-wide solution to the homeless issue, these problems are likely to reoccur. Development of recreational resources along the creek will increase public usage which may reduce the likelihood of camp reestablishment; however, without sufficient shelters, the homeless population will relocate to other creeks and other watersheds.

<u>Flood Damage Mitigation</u>

Reduction of flood peak flows requires increased detention in the entire watershed. New construction and redevelopment projects should be required to detain stormwater onsite to meet pre-development runoff rates. Some increase in detention capacity can be retrofit in the study area. As mentioned in the above paragraphs on water quality, detention basins and wetlands should be constructed in several places on outfalls and tributaries to the creek. An additional technique that should be considered along this stretch of Arcade Creek is laying back the streambanks. This would increase the capacity of the channel to handle peak flows and allow woody vegetation to grow within the floodplain without increasing upstream flooding.

<u>Fish and Wildlife Habitat</u>

Habitat improvements should also be undertaken at both a regional and a local scale. At the watershed level, goals should be established to improve the connectivity of regional corridors for fish and wildlife. The open space corridors along the American River Parkway, the Ueda Parkway and the Dry Creek Greenway form a framework for these regional connections which benefit fish, migratory birds, songbirds, mammals and other wildlife. Arcade Creek should be part of this system.

Improving the water quality within the watershed and the creek will benefit aquatic species. The current level of toxicant loading to the creek is one of the primary limiting factors to fish populations. Another limiting factor is summertime water temperatures, which improvements within the study area can help to mitigate.

At a site-scale, stream reaches that lack good canopy cover should be revegetated with native trees capable of shading the surface of the creek. This will benefit both terrestrial and aquatic wildlife, including birds. Root masses from riparian vegetation also provide shelter for aquatic species. Invasive plant species should be removed where present and replaced with native trees and shrubs. Improvements to the riparian vegetation along the creek will benefit both wildlife and recreational users.

<u>Recreation</u>

As with habitat corridors, Arcade Creek should be part of the regional recreational system currently either built or being planned for the Sacramento metropolitan area. This includes the American River Parkway, the Ueda Parkway, the Dry Creek Greenway and

Parkway, and the Folsom Lake State Recreation Area. Bicycle and equestrian trails should follow the Arcade Creek corridor through the study area, eventually connecting the American River College campus, and if possible, Citrus Heights with the Ueda Parkway and the regional system. This study identifies several key nodes along the proposed trail for trailheads, rest stops and picnic sites. The location of the Sacramento Horseman's Association adjacent to Arcade Creek reinforces the importance of equestrian trails as part of this regional system.

Key Projects

Several key projects are recommended in Chapter 6 of this report. These include the Auburn Park Detention Basin northeast of Renfree Park, the Softball Complex Wetlands adjacent to the Sacramento Softball Complex, and the Arcade Creek Trail Corridor between Marysville Boulevard and Del Paso Boulevard. These projects were chosen for their integration of multiple restoration or improvement goals. They are presented in the report at a conceptual level and should be studied in greater detail to determine the full feasibility of the recommendations, including costs and benefits.

The Auburn Park Detention Basin combines a settling basin, a filtration wetland, a detention basin, and bicycle and equestrian trails with interpretive signage and a trailhead at Renfree Park. The settling basin and filtration wetland function to polish the stormwater first-flushes from an outfall emptying into the site from south of Auburn Boulevard. These initial stormwater flows are often the most toxic and the most important to treat. The detention basin, designed for the 100 year storm, catches the highest flows from the outfall, mitigating the contribution of this drainage to Arcade Creek flooding. Recreation trails connect the site to the proposed regional system along Arcade Creek, and a trailhead and information kiosk at Renfree Park provide access and educational opportunities to visitors.

The Softball Complex Wetlands project includes creation of wetlands on a site where they were likely to have been before the region was developed. Additionally, it may be feasible, depending upon site topography, to connect these wetlands back to Arcade Creek via a high water flow channel that would replenish the water in this system during flood events. Even if this is not possible, a perennial pond might be established northeast of the softball fields that would provide high-quality habitat to migratory birds and local wildlife. Such an amenity, in proximity to the softball complex, would offer educational and recreational benefits to visitors via interpretive signs and a system of trails that connect to the regional system. One of the challenges to improving this site that is also an asset to the proposed program elements is the need to protect the existing vernal pools and mature oak trees.

The Trail Corridor improvements between Marysville and Del Paso Boulevards include two main ideas: developing a regional trail system and laying back the creek banks. The benefits of connecting a trail along Arcade Creek with the Ueda Parkway have already been discussed. Two important linkages that would be made by this trail are connecting the Ueda Parkway to Del Paso Park and to the light rail station. Widening the stream channel by laying back the banks would allow replacement of the existing bank armoring with bioengineered solutions that reduce erosion while providing wildlife habitat. This would help reintroduce woody vegetation to shade the stream and reduce summertime water temperatures. The increased flood capacity would also allow the introduction of in-channel structures such as boulders to redirect the low-channel flow and provide shelter and diversity to fish and other aquatic wildlife. Improving the natural aesthetics of this segment of the creek would also promote additional recreational users of the trail.

These projects, if implemented will make significant contributions to the wildlife habitat and recreational opportunities within the study area. While they may not result in major improvements to the water quality or flood capacity by themselves, combined with concerted efforts in the watershed targeted at pollution source control and floodwater detention, they will help to return this stream system to a healthier and more stable regime.

2.0 INTRODUCTION

2.1 Feasibility Study Objectives

The original scope of this feasibility study was to examine a section of the Arcade creek Main Stem within the Sacramento City limits to determine the measures needed to reduce channel, bank and invert erosion and failure and debris dams at bridges. During the course of this study, the scope was refined to include only the stretch of Arcade Creek from Marysville Boulevard to the City limits. The reason for this was that the levees downstream of this crossing severely limit the opportunities for meaningful restoration.

The study was also expanded to examine factors that may negatively impact water quality, investigate opportunities and constraints for flood control, evaluate the quality of riparian and aquatic habitat, and identify recreational opportunities. One primary objective was to develop recommendations for potential restoration sites and techniques for improving the stream corridor with respect to the above factors, and finally, to recommend one key restoration site for further development of design and construction drawings and eventual implementation.

Throughout this report, reference is made to "restoration," "restoration projects," and "restoration sites." These terms are not meant to imply restoration of the system to a previous condition, such as pre-settlement times, which is a benchmark often used in restoration planning. Rather, for this study, restoration is used to mean improvement of the health of the stream system that benefits the ecological functioning of that system. The reason for this change of terminology is simply that the Arcade Creek watershed is so perturbed from its natural, undeveloped, state that it would be impossible to restore the creek to a pre-development condition that was stable. What is needed instead is to determine how the system should function ecologically under the current hydrologic regime and development patterns and to design restoration projects that work towards a healthy system.

2.2 The Arcade Creek Watershed

The Arcade Creek watershed drains approximately 24,800 acres, most of which is highly urbanized. Land use includes commercial roads, parking lots, open space, and residential neighborhoods, with residential being the dominant land use. The watershed includes portions of the cities of Sacramento, Citrus Heights and Roseville, with the majority falling within Citrus Heights and unincorporated areas of Sacramento County. Major contributors to stormwater runoff in this area may include paved streets and roads, American River College, Sunrise Mall, residential neighborhoods and various pockets of industrial and commercial development.

Topography in the watershed is relatively flat, ranging from 270 feet above mean sea-level at the east edge to 20 feet at the mouth of the stream. The watershed contains the following streams: Arcade Creek, Cripple Creek, Kohler Creek, Verde Creek, Brook Tree

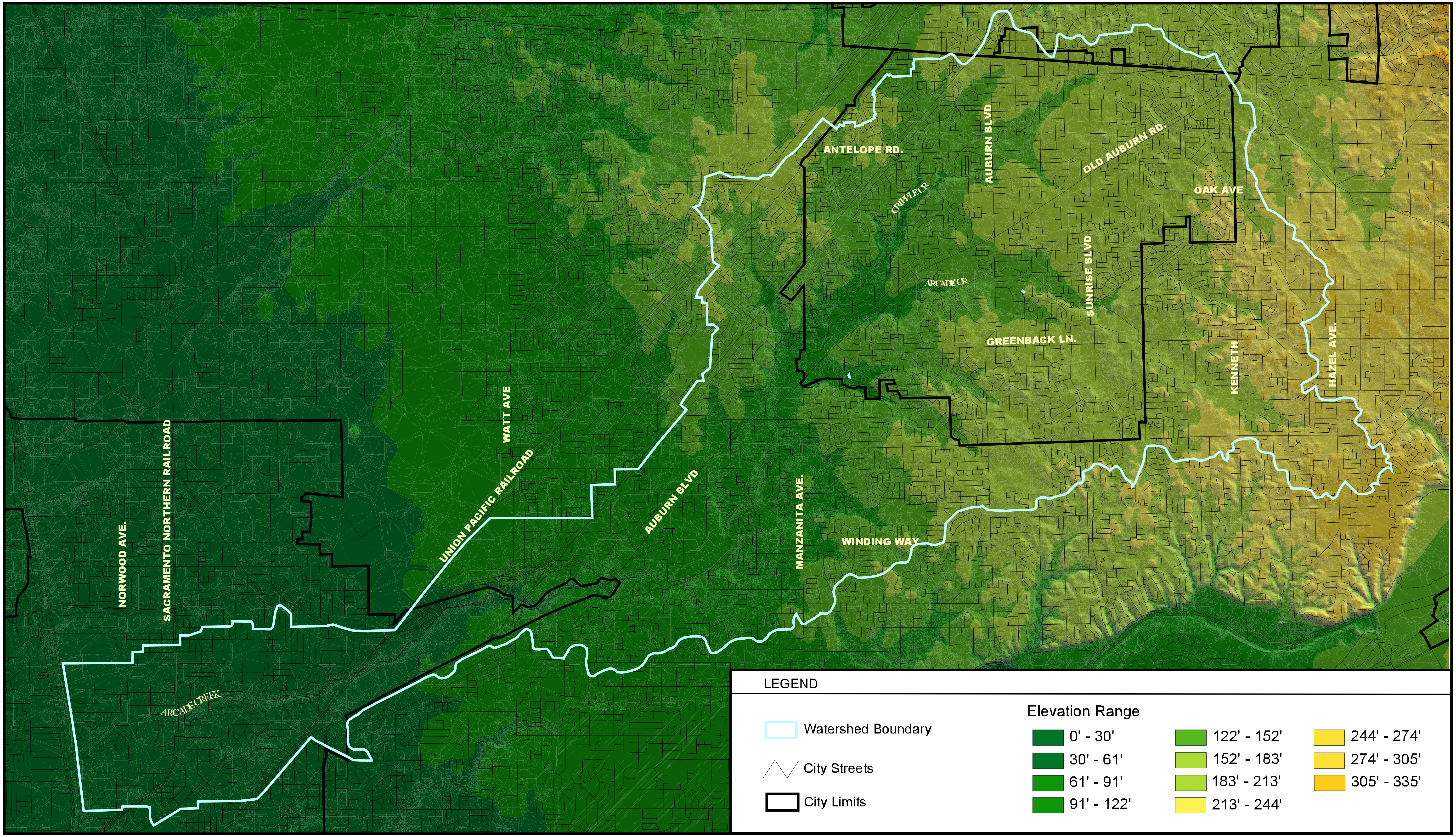
Creek, Coyle Creek, San Juan Creek, Mariposa Creek and several smaller unnamed streams. Of these, Arcade Creek and Cripple Creek are the primary tributaries. The watershed boundary is primarily controlled by the stormwater system and other infrastructure, such as streets and levees. Major influences along its northwest boundary are Highway 80 and the Union Pacific Railroad, which crosses the creek just west of the Roseville Road bridge. A low ridge between Arcade Creek and the American River forms much of the southern watershed boundary, which extends east to just beyond Hazel Boulevard. Figure 2-1 illustrates the topography of the watershed and the approximate watershed boundary. An accurate assessment of the watershed boundary will require a GIS network analysis of the various and extensive city and county storm sewer systems. This relatively large effort will need to be undertaken before we truly understand the geographic extent of the stormwater and pollution inputs to the creek.

2.3 The Watershed Group

An Arcade Creek Watershed Group was formed in spring of 2002. Organization of this group was funded by the Sacramento City Department of Parks and Recreation through an Environmental Protection Agency (EPA) grant.

The watershed group includes public and private agencies, community groups, local citizens and homeowners. Local public agencies include the City of Sacramento Departments of Utilities, Stormwater Management and Parks and Recreation, the City of Citrus Heights, California Integrated Waste Management Board and the Haggin Oaks Golf Course. Multiple Agencies concerned with flooding and water quality were present such as the American River Flood Control District (ARFCD), Sacramento Area Flood Control Agency, State Water Board Clean Water Team, Central Valley Regional Water Quality Control Board, and the County of Sacramento Department of Water Resources. Representatives from Councilmember Sandy Sheedy’s office, Sunrise Park and Recreation District, Citrus Heights Area #5, State Water Resources Control Board and American River College also participated in the meetings. Private firms included Russick Environmental Consulting, and Foothill Associates. Many community groups were involved in the meetings, including Sacramento SPLASH, Urban Creeks Council, California Native Plant Society, Sacramento Horseman’s Association, and the Arcade Creek Neighborhood Association from Citrus Heights. Additionally, several local homeowners participated.

The watershed group met six times starting in Spring of 2002, during which the members identified four primary goals for Arcade Creek: 1) improve water quality, 2) reduce flood damage, 3) enhance habitat, and 4) increase recreational opportunities. The group also defined four subcommittees, one for each primary goal. The mission of the subcommittees was to examine the existing data on the Creek with respect to their goal, determine the existing state of the creek and develop recommendations for actions to improve the creek. These recommendations and findings are integrated into another document: the Arcade Creek Watershed Management Plan. The watershed group currently meets every 6 weeks to discuss issues and concerns in the watershed.



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LANDSCAPE ARCHITECTURE

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TOPOGRAPHIC RELIEF

2.4 Feasibility Study Focus Area

Arcade Creek and its tributaries extend from Citrus Heights and Orangevale through Sacramento to the mouth at Steelhead Creek, for a total length of approximately 16.5 miles on the main-stem. This feasibility study looked at the 4.7-mile stretch defined by the Sacramento city limits on the east and Marysville Boulevard on the west. The study is focused on the land immediately adjacent to the creek, either encompassing the riparian buffer around the creek or bounded by a natural or constructed feature, such as the Haggin Oaks Golf Course, adjacent residential communities, or roads.

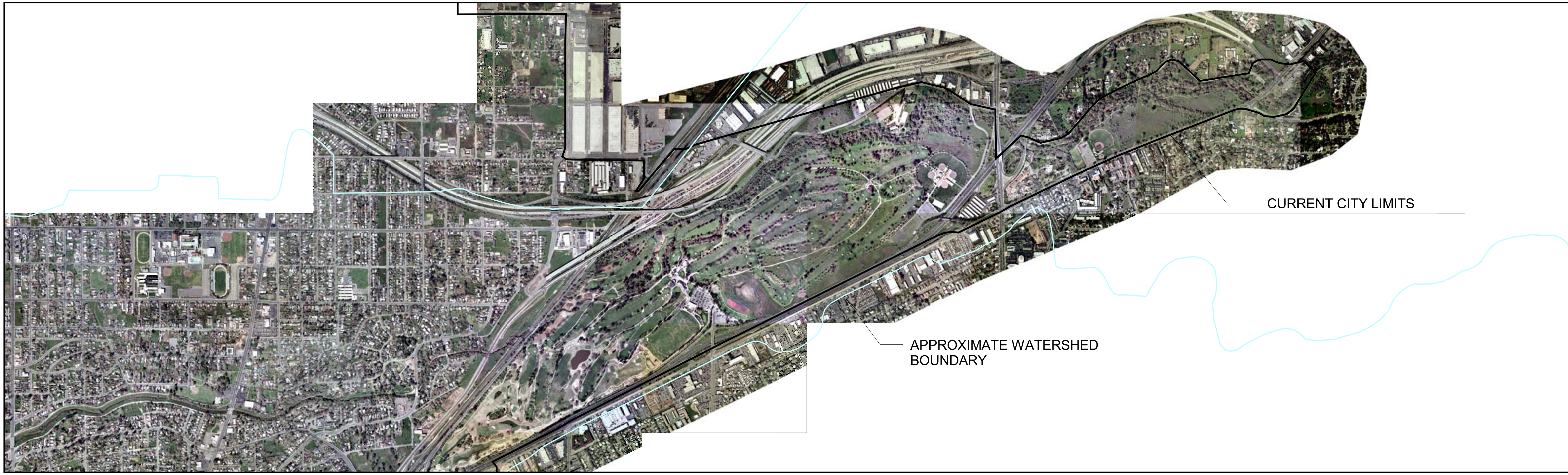
Figure 2-2 illustrates the changes to the study area over the past 60 years. The top image in the figure is circa 1998, and the bottom image was taken in 1937. As can be seen, Arcade Creek in this area has undergone a significant transformation from a largely agricultural landscape with a healthy, mostly contiguous riparian buffer to a fragmented stream crossed by roads and bridges and surrounded by residential communities. Several features are common between the two images: the Roseville Road and Union Pacific Railroad bridges, the Haggin Oaks Golf Course, Grant Union High School, Auburn and Del Paso Boulevard bridges, and various other local streets. Some of the small drainages seen on the 1937 photograph that join with Arcade are visible as remnants on the c1998 aerial. The most obvious changes between the two images are the construction of Interstate-80, extension of Watt Avenue north of the creek, widening of Auburn Boulevard and Roseville Road, the development of the industrial land uses north of I-80, expansion of the golf course, and the vast conversion of the landscape to residential land use. Interestingly, the course of the stream channel has remained relatively unchanged, although little riparian vegetation is left between Roseville Road and Marysville Boulevard.

2.5 Primary Goals

In accordance with the goals adopted by the watershed group, four primary goals were established for the improvements to be recommended by this study. In many cases these goals overlap and actions toward meeting one goal will, perforce, advance another goal as well. The four primary goals are:

- decrease floodwater damage,
- improve water quality,
- enhance riparian and aquatic habitat,
- provide additional recreational opportunities.

Decreasing floodwater damage is important to home and business owners along the creek, for the protection of roads, bridges, utilities and other public works, and for the overall economy of the region.



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HISTORIC CHANGES TO THE STUDY AREA

Improving water quality is important for protecting and enhancing the beneficial uses of the watershed and downstream resources in the Sacramento River and the Bay Delta.

These include fish and wildlife habitat, aesthetics, recreational and educational opportunities. Water quality also indirectly supports property values and human health. The water quality of Arcade Creek is currently far below standards, thus this goal is of primary importance in the watershed planning effort.

As the greater Sacramento area becomes more urbanized suitable habitat for many native species is rapidly disappearing. This is particularly true along Arcade Creek, due to the urban nature of the entire watershed. Improving the remaining habitat will be a significant factor in retaining many species in the area.

Arcade Creek fills a special need for recreation opportunities in a natural setting, within the urban context. This may encourage residents to recreate close to home rather than traveling to the mountains or coast, which leads to fewer car trips and a corresponding reduction in environmental impacts.

Keeping habitat intact, and thus keeping wildlife visible and audible, is an important part of creating a positive recreation experience on the creek. Recreational opportunities are both increased and improved by providing additional access and by educating the general public on these opportunities and the resources that exist in the watershed.

2.6 Process Outline

The following is an outline of the steps utilized in this study:

1. **Develop Protocols.** Several existing protocols were examined and modified to create the protocols used in this study. The primary objectives in development of the protocols were that they could be easily completed by citizen-based volunteer groups yet provide a qualitative assessment of the general health of the riparian corridor.

2. **Develop Base maps.** Aerial imagery was obtained from the City of Sacramento for the study area. Numbered station-points were located at approximately 200 foot intervals to provide reference locations for observations, and field maps were indexed and printed at 1"=50'. A Geographic Information Systems (GIS) database was created to contain the images, approximate watershed boundary, station points, and field survey notes.

3. **Initial Field Visit.** An initial visit was conducted with the Department of Parks and Recreation and Department of Utilities to walk the section of the creek along Haggin Oaks Golf Course from the Clubhouse downstream to Roseville Road. The purpose of this creek-walk was to introduce the team to the creek and riparian systems and to talk with public officials familiar with the waterway and flood control and water quality issues in the area.

4. **Test Protocols.** The data collection team took the draft protocol forms into the field and surveyed the section of the creek that was walked in the initial field visit. The forms were redlined and updated based upon this fieldwork and a database was created to manage the data.

5. **Perform Field Surveys.** Data was collected by two teams. The basic unit for data collection was the stream reach (see the section on *Data Collection Methodology* for additional information). Data collection was performed during the months of May, June, July and August.

6. **Develop Site Photographic Record.** Photographs were taken by the survey teams to document general characteristics of the stream corridor at each reach. Additionally, pictures were taken of outfalls.

7. **Update Geographic Information Systems (GIS) Database**. Stream reaches were coded into the database. Photographs were linked to location, and outfalls were added. Field notes were entered into the database as graphic overlays.

8. **Develop Rating Criteria and Assessment Methodology.** The study team developed the criteria to rate the data collected based upon the four goal areas defined by the Watershed Group. See section 3.3 *Analysis* and *Appendix B* for additional information. A rating matrix was created to quickly identify reaches that had high potential for restoration in each of the goal areas except for Recreation. For this goal, a map was created to identify opportunities for enhancing recreation.

9. **Check Data for Consistency (Quality Control)**. The field collection sheets were evaluated for inconsistencies and updated based upon rational checks and clarification with the data collection team.

10. **Conduct Work Session to Identify Restoration Sites.** A work session was held with the team members to examine the rating matrix, site photographs, field notes, data sheets and aerial images and develop recommendations for restoration opportunities. For each goal area, the team developed a list of techniques and potential projects.

11. **Refine Projects**. Project sites were visited to refine ideas, and additional detail was developed. Several projects were eliminated from the initial list based upon topography or other limiting factors.

12. **Draft Report**. This report was drafted with input from the team and reviewed by internal members of the group as well as professionals in the field of flood control, fisheries habitat, water quality, wetlands, and riparian habitat.

3.0 METHODOLOGY

3.1 Data Collection Protocols

3.1.1 Source selection and objectives

The following sources were used in development of the protocols for this study:

1. The Field Guide for Stream Classification, Dave Rosgen and Lee Silvey.

2. California Salmonid Stream Habitat Restoration Manual, State of California, Resources Agency, Department of Fish and Game, Second Edition, 1994.

3. California Native Plant Society – Vegetation Rapid Assessment Protocol, CNPS Vegetation Committee, 2001.

4. Adopt a Stream, Shoreline Surveys, Riverways/Adopt-A-Stream Program Staff, Joan Channing Kimball, et al.

As stated earlier, the following factors contributed to the protocols developed for this study:

- Designed for citizen-based volunteers. In other words, expertise in the fields of riparian ecology, fisheries or fluvial geomorphology was not required to collect the data.

- Provided a general qualitative assessment of the health of the riparian corridor, stream channel, and flood plain within the budget of this project.

- Adaptable from existing protocols.

The final draft of the protocol included qualitative assessments in the areas of stream channel morphology (width of corridor, height of banks, width of floodplain, etc.) riparian habitat (vegetation types, width of corridor, terrestrial species observed, riparian canopy cover, etc.) aquatic habitat (aquatic species observed, woody debris presence, streambed material, channel canopy cover), adjacent land uses and restoration opportunities.

3.1.2 Data sheets

Draft data sheets were developed from the existing protocols to record observations of the factors noted above. These data sheets were refined in the first day of field surveys into the forms shown in Figure 3-1 and 3-2. The final data sheets are based on the Access database for ease in entering field data into digital format.

Creek Inventory Field Form

Creek and Reach Identification

Reach ID: 11
Creek Name: Arcade Creek
Reach Begin Station: 20.2
Reach End Station: 18.2
Reach Beg GPS Lat: 38.62966
Reach Beg GPS Long: 121.41862
Reach End GPS Lat: 38.62880
Reach End GPS Long: 121.41898

Weather Past 24 hr: Sunny, clear
Weather Current: Sunny, clear
Date: 6/27/2002
Time: 11:00 AM
Observer: JFB, PJW
Photo ID Numbers: 113-106

Channel Characterization

Single or Multiple Channel: Single
Sinuosity Bankfull: None
Number of Pools: 0
Number of Riffles: 0
Number of Runs: 1
Odor: None
Color: Clear

Width Available Floodplain (ft): 0
Bankfull Width (ft): 50
Mean Bankfull Depth (ft): 17
Observed Width (ft): 12.5
Observed Depth (ft): 0.5
Velocity Estimated fps: 0.5
Channel Canopy Cover %: 30

Obstructions: Sedimented banks forming

Streambed consists of (rank from most typical (1) to least typical (6)):

Streambed Organic Debris: 4
Streambed Silt: 3
Streambed Gravel: 0
Streambed Sand: 5
Streambed Cobbles: 6
Streambed Boulders: 0

Restoration Opportunities:

- [ ] Channel Widening
- [x] Invasive Removal
- [x] Bank Stabilization
- [ ] Overflow/Detention Structures
- [x] Revegetation
- [ ] Remove Structures
- [ ] In-Channel Structure
- [x] Trash Cleanup

RestorationComments: Trash, large chunks of concrete rip-rap, asphalt channelized in places

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Figure 3-1 Page One of the Data Collection Protocol

Bird Species Observed:

Aquatic Species Observed:

fingerling

Vegetation - Left and Right Bank (GF - grass/forbs, SB - shrubs/brambles, TS - trees/shrubs, W - wetland)

L Veg Type: Trees/Shrubs

R Veg Type: Shrubs/Brambles

Plant Species Observed Left Bank:

- Box Elder
- California Black Walnut
- English Ivy
- Interior Live Oak
- Tree of Heaven
- Common Fig
- Privet
- Valley Oak
- Willow species
- Oregon Ash
- American Elm

Plant Species Observed Right Bank:

- Valley Oak
- Catalpa
- Privet
- Common Fig
- Willow species
- Almond
- Scarlet Firethorn
- Red Sesbania
- Rush
- Silktree
- Sedge
- American Elm

L Canopy Cover %	90	R Canopy Cover %	10
L Canopy Structure	Fair	R Canopy Structure	Poor
L Canopy Primary	☑	R Canopy Primary	☐
L Canopy Secondary	☑	R Canopy Secondary	☐
L Herbaceous	☑	R Herbaceous	☑
L Width (ft) Riparian Veg:	40	R Width (ft) Riparian Veg:	18

Vegetation Comments: Thick and overgrown on left bank. Evidence of higher flows (build up of driftwood on banks).

Landuse - Left and Right Bank

L Bank Adjacent Landuse:	Residential	R Bank Adjacent Landuse:	Residential
L Surrounding Landuse:		R Surrounding Landuse:	

Runoff and Bank Condition - Left and Right Bank

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Figure 3-2 Page Two of the Data Collection Protocol.

3.2 Data Collection

3.2.1 Methodology

Field data was collected by a total of five people working in teams of two or three. Teams went out on the following dates in the spring and summer of 2002: May 22nd, June 25th, June 27th, June 28th, July 17th and August 2nd. The field surveyors had backgrounds in landscape architecture, wildlife biology and hydrology, but did not have specific expertise in fluvial geomorphology or stream assessment/ restoration, and none was required to complete the forms.

The data collectors walked sections of the creek, recorded data, noted restoration opportunities and took digital photographs at key locations. Each team carried a set of aerial photographs marked with station points. These maps were used to track their progress and record locations of photographs, outfalls, reach endpoints, and spatial issues not captured completely in the protocols (usually related to restoration opportunities or constraints.) See Appendix C for an index, sample and copies of the field maps. While walking a reach the teams noted flora and fauna present in that segment and a variety of factors relating to the stream condition. A handheld GPS (Global Positioning System) was utilized to record coordinates at the beginning and end of each reach and at other important places such as large obstructions and outfalls. These coordinates were used in creation of the opportunities and constraints maps of the creek (Figures 5-1 through 5-4) and are available in the database.

Horizontal distances such as the width of the creek channel were measured with a laser rangefinder. When taking a measurement of a feature on the opposite side of the creek such as the width of the riparian buffer, distance was typically shot to the furthest visible tree on the opposite bank across the channel from the viewer, and the width of the channel was subtracted. Alternately, if the buffer was narrow (typically less than 20 feet) the data collector may have estimated the distance. Vertical distances such as height of stream banks were estimated by the field surveyor. Measurements for a stream reach were usually taken at the start or end of a reach. A significant variation in a measurement typically resulted in definition of a new reach.

Protocol data was collected and organized based upon left and right bank location. As a general rule in stream assessment, and for the purposes of this study, left bank is defined as the bank on the left when facing downstream.

3.2.2 Reach definition

The extent of the stream reaches was determined by the team-members in the field. Reaches were defined by changes in the morphology of the creek environment. These may have been changes in the creek itself such as from a uniform run to a pool/riffle structure or a change in bank material and condition. Changes in the surrounding vegetation, for instance from a grassy area to a tree-covered one, were also used to define reaches. Additionally changes in surrounding land use such as road over-crossings or a transition from parkland to residential neighborhoods served as reach separations. When a significant change was noted the coordinates were recorded, and photographs were taken.

3.2.3 Channel Characterization

Stream channels were characterized based upon their average statistics within that reach. A significant change in channel characteristics was recorded as a new reach. Numbers of pools and riffles were recorded based upon observation. If no pools or riffles were noted, the observer typically recorded one run. If multiple pools and riffles were recorded, a run was noted for each pool/riffle pair. Odor and color were mostly the same for all reaches. Methodology for noting widths has already been discussed. Depth of water was estimated, but not measured. Velocity was estimated based upon floating foam or debris. Channel canopy cover was recorded as a percentage of the channel that would be shaded at high noon based upon a visual assessment of canopy closure. Streambed material was ranked from most common to least common. Generally silt was the most common material.

3.2.4 Restoration notes

The field crews made note of important restoration opportunities or constraints along the stream. The data collection protocol had selections for several common restoration techniques as follows: channel widening, revegetation, invasive removal, structure removal, bank stabilization, in-channel structures, overflow or detention structures, and trash cleanup. A place to record other comments was also available. These suggestions and firsthand impressions can be found in the Restoration Opportunities section of the Reach Summaries in Appendix A.

3.2.5 Riparian Structure and Habitat

Predominant tree, shrub and herbaceous species were noted for both left and right bank riparian buffers. Other factors recorded included canopy cover, canopy structure and width of the riparian buffer. Canopy structure was defined as the number of layers of riparian vegetation present combined with diversity of vegetation. Good canopy structure would exhibit herbaceous, shrub and tree layers with diverse native species. Poor canopy structure would exhibit missing layers, poor coverage, poor diversity, or an abundance of invasive exotic plants. Bird and aquatic species were noted based upon the experience of the field surveyors, and thus identification varies from accurate to generalized.

3.2.6 Digital photography

Collection of data involved taking digital photographs to record important features. At a minimum, photographs were recorded at the ends of every reach and at each outfall. These pictures are indexed based upon date and photograph number (an internal number tracked by the digital camera and noted on the field collection sheets) and are linked to the GIS project map. They are also reprinted in Appendix D.

3.2.7 Data Processing

After completion of a day's field reconnaissance, the data collected was entered into the Access database. Points of interest marked on the maps, along with photograph locations and outfalls were transferred to a master GIS file of the study area. Features were generally referenced either to their location with respect to the station points or to their GPS coordinates, or both.

3.3 Analysis

3.3.1 Rating factors

Each reach was analyzed based on data from field visits, GIS maps, and aerial photographs and then rated for overall opportunity for restoration. A number of factors were identified for each of the four major goals of this study: reducing flood damage, improving water quality, enhancing habitat, and increasing recreation opportunities. A rating scale was established for each factor (see Appendix B) to distinguish between low, medium, and high opportunity for restoration to achieve one of the goals in the reach under consideration. The factors in each category were selected based on the available data and the experience of the design team.

It is important to note in reviewing the rating factors that they were developed as an aid in identifying opportunities, and not as a comprehensive system for overlay analysis. The factors and criteria were chosen to indicate potential for opportunity with respect to other reaches, and were not meant to provide accurate numerical results on any kind of absolute scale.

The following is a list of factors and a brief explanation of that factor's importance in determining restoration opportunities.

Flood Control

1. **Width of open space adjacent to channel:** Generally, the wider the open space, or undeveloped potential floodplain the greater the opportunity to detain additional water via overflow basins and detention structures. Additionally, greater floodplain width may allow improvement of groundwater recharge/infiltration areas. Three-to-one was chosen as the juncture between the moderate and high classification because this allows an area on each side of the stream equal to the channel width for overflow (or alternately a wider area on one side if not equally distributed). This was thought to be sufficient for the topographic changes that would be necessary to provide this type of remediation.

2. **Width of left and right bank riparian corridor:** Similar to the width of the potential floodplain, a wider riparian corridor allows for channel widening techniques or off-channel diversion structures. The riparian corridor is measured from the edge of the stream to the outside of the riparian area on each bank. Ten feet was selected as the cutoff from low to medium potential, because a riparian

corridor of less than ten feet occupies little more than the stream bank and presents little opportunity for improvement of flood control. From ten feet to thirty feet was classified as a moderate opportunity, since channel widening techniques could be used in this space to improve the capacity of the channel to handle peak flows, which may allow introduction of vegetation into the channel to slow discharge. Thirty feet was the lower limit for high potential for restoration to reduce flood damage, because at widths greater than 30 feet off-channel detention and infiltration mitigation techniques become possible.

3. **Adjacent land use/open space:** Open space adjacent to the creek may provide additional opportunity for overflow, detention structures or prescriptive flooding. Additionally, some land uses such as the golf course or city parks are used seasonally and thus could be collocated with seasonal detention structures.

Water Quality

1. **Size of outfall:** Larger outfalls have greater potential to adversely impact water quality than small outfalls, given ordinary urban non point-source runoff, due to the greater volume of water discharged. Smaller outfalls can also be significant sources of pollutants if the origin is a highly polluting source. Sizes chosen for the divisions between categories were selected as approximations for small, medium and large catchment areas.

2. **Source of outfall:** Outfalls from different sources have varying levels of toxicity. Open space and natural areas have low potential for introducing toxic substances to the creek. Golf courses and residential areas have medium potential for toxic runoff, primarily due to fertilizers, herbicides and pesticides. Industrial areas, commercial areas, and roads have high potential for carrying toxic constituents from automotive emissions and industrial byproducts. Sources of outfalls were recorded during data collection based upon adjacent land uses and locations of outfalls. Additional analyses of storm sewer systems and land use are necessary to definitively map sources.

3. **Distance from outfall to creek channel:** The greater the distance from the outfall to the creek channel, the better the chance that the effluent can be treated at the discharge location. If the outfall drains directly into the creek, then mitigation must occur at the source or at a point in the storm drainage system prior to the outfall. Outfall mitigation methods are described in Section 5.1. If an outfall does not dump directly into the creek, but a small buffer exists, from 10’ to 50’, it may be possible to introduce a diversion structure parallel to the creek to redirect runoff and filter pollutants via some form of filtering mechanism. If additional space is available, techniques such as detention basins or wetlands can be utilized to settle sediments and filter pollutants. This can be particularly effective for treating road and parking lot runoff.

4. **Width of riparian corridor at outfall:** The width of the riparian corridor is important for the same reason the outfall distance to the channel is important. Given the necessary space, an outfall could be potentially redirected into a filter or stormwater wetland to help mitigate pollutants. Even if insufficient space exists between the outfall and the creek channel, given a sufficiently wide riparian zone, the outfall may be modifiable to accommodate a mitigation structure. This factor considered only the width of the riparian corridor on the bank that held the outfall.

5. **Presence of trash:** Trash has the potential to leach contaminants into the water. It also indicates a lack of stewardship and maintenance which can lead to additional negative water quality impacts such as homeless camps and additional trash.

6. **Adjacent land use:** Overland and subsurface flow from adjacent areas may have a direct impact on water quality in the creek. More intensive land uses may have a greater potential for water quality impacts, including increased loading of toxicants and nutrients, and increases to conventional parameters such as temperature and pH. Vegetated buffers can reduce the direct water quality impacts of adjacent land use. A buffer can be a vegetated riparian zone, swale, or wetland.

7. **Visible runoff:** Visible runoff, especially with a foul odor or foam may be an indication of a water quality problem.

8. **Presence of algae:** Presence of algae may mean higher than normal nutrient loading in the runoff, primarily nitrate and phosphate. This may have a negative affect on both water and habitat quality.

Recreation

1. **Adjacent land use:** Undeveloped or existing open space and parklands are opportunities for expanded recreation along the creek. Adjacent land use can be classified as "encouraging recreation," "compatible with recreation" or "incompatible with recreation." Open space or existing parks are examples of land uses that encourage additional recreation. Residential or commercial land uses, particularly office parks, are often compatible with recreation, because people living or working in an area use recreation facilities such as biking and walking trails for exercise. Industrial sites or heavily trafficked roadways may fall into the "incompatible" land use category because they may make use of a natural site less desirable.

2. **Width of left and right bank riparian corridor:** A wider corridor provides greater opportunities for trails, rest stops, staging areas, interpretive sites, or other recreation opportunities.

3. **Presence of existing trails:** Existing trails, whether planned or unplanned, provide an opportunity for expanded recreational use such as interpretive signage, improved pedestrian, bicycle or equestrian trails, or staging areas.

4. **Proximity to residential areas:** Studies have shown that people are more apt to walk to recreational facilities that are within ¼ mile of their residence. Recreational facilities that are not near residential areas are less likely to be used than those within a ¼ mile radius.

5. **Proximity to existing recreational facilities:** Recreational facilities near other existing recreational facilities are more likely to be used that those that are not. Certain recreational uses work particularly well together, such as trails that connect to local and regional parks, parks that are near schools, etc.

6. **Accessibility:** Recreational facilities near existing roads are more likely to be used and easier to develop than those that cannot be accessed by car; however, recreational facilities that are near major highways should be set back or buffered from the high-traffic use areas. It is often beneficial to locate recreational nodes near a high-traffic area, but set back on a local feeder street. It is also important to avoid using residential neighborhoods as access routes to a node that provides connection to a regional system.

7. **Ownership:** Public land within the riparian corridor provides a greater opportunity for development of a recreational staging facility or other amenity than private land. While it is possible to acquire lands from private entities for locating public facilities, this can lead to extra expenses that make the site less desirable.

Aquatic and Riparian Species Habitat

Aquatic Habitat:

1. **Sinuousity:** Stream sinuosity is defined as the channel length, measured along the watercourse, divided by the valley length. Generally, streams with higher sinuosity provide better aquatic habitat than those with low sinuosity (1, p.2-59). This is because a higher sinuosity stream typically has more pools and riffles, which results in improved feeding, spawning and shelter habitat. Additionally, degraded streams with greater percentages of impervious surfacing in their watersheds (and correspondingly higher stormwater flows) exhibit lower sinuosity. Often streams that have been armored and channelized for flood control have also been straightened. A stream reach in a flat valley-bottom regime that exhibits low sinuosity means that there is likely a greater need for restoration that increases sinuosity. Such restoration techniques may include in-channel structures or boulders to constrain the stream to a low-flow channel and cause it to flow around the obstruction. The cutoff for stream classification from sinuous to meandering is a channel length to valley length ratio less than 1.5 (2, p.45). Since Arcade Creek is in a valley bottom with gradient of less than 1%, its

undisturbed state can be assumed to be meandering; therefore, stream reaches with sinuosity less than 1.5 may benefit from restoration.

2. **Presence of pools and riffles:** Pools provide hiding and feeding places for fish. Riffles provide spawning habitat for salmonids. While salmonids are not the target for the restoration efforts on Arcade Creek, primarily due to water temperatures, improving diversity of in-stream habitat will be beneficial to other aquatic wildlife. Therefore, reaches with no pools or riffles may have a greater need for restoration than those reaches containing some pool/riffle structure.

3. **Channel canopy cover:** Shade on the surface of the stream is good for both salmonids, which are unlikely to be found in significant numbers in Arcade Creek, and warm water game fish such as Largemouth Bass and Bluegill, because it helps reduce water temperature in the summer. Largemouth Bass are generally found in water under 80 degrees Fahrenheit, and spawn in water between 64 degrees and 67 degrees. Arcade Creek has not been measured for water temperature, but according to an ecologist with the California Department of Fish and Game, other valley streams that are poorly shaded have exhibited temperatures between 80 and 86 degrees Fahrenheit. Measurements on Alder Creek above and below a shaded section of the stream have shown a 4 degree reduction in temperature due to improved canopy cover.

   Additionally, roots from overhanging trees shelter young fish from predators, primarily other fish, humans, and raptors. Forty percent has been noted as indicative of good stream shading for salmonids (2, p.78), thus stream reaches with less than 40% cover may benefit from restoration that improves canopy closure.

4. **Streambed material:** Heterogeneous substrate material provides better habitat than uniform material (1, pg. 2-59). A mixture of boulders, cobbles, gravel and sand is preferable to a bed composed entirely of silt. Large woody debris and boulders provide cover for fish species, as well as promote better stream structure.

5. **Fish observed:** The presence of some fish species indicates that some level of suitable habitat exists. While the failure to observe fish does not indicate that habitat is unavailable, it may be indicative that habitat quality is poor. If salmonids were observed, this indicates that the creek is capable of supporting a species that is more sensitive to disturbed systems than other local species and indicative of good habitat in the creek. Incidentally, there were no salmonids observed during the survey, and current water conditions make their presence unlikely.

6. **Turtles and/or frogs observed:** If turtles and/or frogs were observed, some habitat exists to support aquatic life other than fish. While the failure to observe turtles and/or frogs does not indicate that habitat is unavailable, it may be indicative that habitat quality is poor.

7. **Left and right bank condition:** Stream banks in good condition provide shelter for fish due to overhanging roots and cut-back sides greater than 90 degrees. Stream banks in poor condition, in this study typically either eroding, armored or both, provide little shelter for fish, as well as increased sediment loading of the stream, and in the case of armoring, increased reflectivity and water temperature. Sedimentation degrades the quality of the streambed, and warmer water, as has been stated, reduces the quality of the fish habitat.

Riparian species wildlife habitat:

8. **Bird species observed:** Certain species of birds are indicators of healthy riparian systems. Presence of these species may indicate that high quality habitat is nearby. Note that the failure to observe a species from this list does not indicate that high quality habitat is absent. The riparian indicator species are as follows:

    Red-shouldered Hawk (roosts and nests in riparian vegetation) (3, p.2),
    American Kestrel (roosts and nests in riparian vegetation) (3, p. 2),
    Acorn Woodpecker (requires large standing dead snags) (3, p.4),
    Northern Rough-winged Swallow (associated with riparian zones) (3, p.5)
    Yellow-billed Cuckoo (4),
    Swainson's Hawk (4),
    Wilson's Warbler (4),
    Orange-crowned Warbler (4),
    Hermit Thrush (4),
    Swainson's Thrush (4),
    Nuttall's Woodpecker (4),
    Downy Woodpecker (4).
    Cooper's Hawk (4)
    Sharp-shinned Hawk (4)
    Kingfisher (4)

9. **Left and right bank vegetation type:** More complex canopy cover, such as a stand of mature trees, immature trees and shrubs, or more diverse vegetation systems, such as wetlands, provide better habitat for riparian species wildlife. The vegetation classification of shrubs/brambles provides moderate habitat for riparian species, because many species can still find cover and forage within the shrubs. Even though some riparian species will forage in grasses and forbs, these areas generally provide poor habitat for riparian species wildlife.

10. **Left and right canopy cover:** Better canopy cover indicates the presence of large and medium size trees, which generally benefits riparian species fish and wildlife. Low canopy cover suggests a degraded riparian system and an opportunity to restore it by introducing larger woody vegetation.

11. **Left and right canopy structure:** A denser, more complex canopy structure is of greater benefit to riparian species than a sparser, simpler structure because of greater opportunities for shelter, nesting, and foraging. In the data collected,

structure is classified as “good”, “moderate” and “poor” with “good” indicating the presence of multiple canopy tree/shrub/herbaceous layers and “poor” indicating herbaceous-only, barren or sparse.

12. **Total riparian width:** Wider corridors provide better habitat for more riparian species than narrow corridors. According to one local wildlife biologist, if the riparian vegetation is healthy and the total riparian corridor (L riparian width + channel width + R riparian width) is greater than 4 times the channel width, the riparian system is probably not in need of restoration (unless it is composed of a significant number of non-native plants).

13. **Left and right bank land use:** Certain land uses are more compatible with restored natural areas than others. For instance, a riparian vegetation restoration adjacent to open space is more likely to successfully attract desired species than one adjacent to an industrial manufacturing site. The left and right sides of the creek were rated individually.

14. **Presence of invasive plant species:** The presence of invasive plant species degrades the habitat value of the riparian system. If invasive plant species are present, they should be replaced with appropriate native plants.

Other Restoration Opportunities

In addition to the specific factors discussed above, eight general restoration techniques were considered. During site visits it was noted whether a particular technique would be beneficial and applicable to the stream reach under consideration. Special note should be made of those reaches where restoration opportunities were indicated, and these opportunities should be considered when evaluating sites for restoration. Restoration opportunities were recorded in the following categories:

1. *Channel widening*. Laying back the banks of a channelized stream system has several benefits. Firstly, it increases the flood capacity of the channel which allows introduction of larger woody vegetation without increasing upstream flooding. Secondly, this technique can be combined with creation of a low-flow channel to improve in-stream structure and sheltering opportunities for aquatic species fauna. Thirdly it creates an artificial floodplain into which first-terrace tree and shrub species can be reintroduced. This improves the value of the riparian habitat by potentially supporting floodplain species that may have been lost due to changes in the hydrologic regime (primarily channel incision). Due to the potential impact of channel widening on downstream flooding, detailed hydrologic modeling must be done prior to implementing this technique.

2. *Revegetation.* Planting of native riparian trees and shrubs in stream reaches where they are sparse helps to lower summertime water temperature and provides habitat to riparian wildlife species. Tree and shrub roots help to stabilize the banks, reducing erosion and the associated degradation of the aquatic habitat.

3. *Invasive plant removal*. Invasive, non-native plants replace native trees and shrubs in the ecosystem, thereby resulting in lower quality habitat for local species fauna that are adapted to the native systems. In general, invasive plants should be replaced by appropriate native flora.

4. *Structure removal*. This restoration technique involves removal of existing gabions and bank armoring and must be performed in conjunction with additional bank stabilization using more environmentally benign methods. The removal of culverts or replacement with more permeable structures such as bridges, where appropriate, is also a widely accepted method of urban stream restoration.

5. *Bank stabilization*. Where banks are eroding or currently unstable, they can be stabilized with a number of techniques. Methods should be chosen that are environmentally beneficial to the riparian system. For example, bio-engineering techniques utilize native vegetation to provide habitat functions in addition to greater bank stability.

6. *In-channel structure*. Both salmonids and warm-water gamefish benefit from improved stream structure for feeding and sheltering, so use of in-channel structures such as boulders, LWD (large woody debris), pallets or splash-dams may improve fish habitat. Boulders and LWD deflect the stream flow and increase structure in the channel. A pallet is a construction placed in the creek and covered with soil that provides fish shelter from predators and narrows the low-flow channel. Splash-dams are low structures often built of LWD that force water to spill over the front side, resulting in a plunge-pool immediately downstream of the dam. Pallets or splash-dams may not be appropriate in Arcade Creek given the high volume of water in the channel during storm events, however, if appropriate, they can be an effective means for creating shelter for fish. Due to the potential impact of in-channel structures on stream dynamics, hydrologic studies should be performed as part of the design of such remediation techniques.

7. *Overflow/detention structure*. Areas that have sufficient space may be useful either for overflow and detention of floodwaters, or in providing detention and water quality improvement for runoff. Careful consideration must be given to stream channel morphology and hydraulics when designing any in-stream structures.

8. *Trash cleanup*. In general, cleaning up trash benefits all users of the stream system. In some cases, trash such as detergents, found in homeless camps, is directly impacting the water quality of the stream.

The opportunity for using each technique in restoration was recorded as either “Yes” or “No” for each reach. Recommendations for restoration opportunities are found in the Reach Summaries (Appendix A) and on the Analysis Matrix (Appendix B).

3.3.2 Work session

Following the data collection phase of the project, a group from Foothill Associates including landscape designers and planners, a stormwater specialist, and a biologist participated in a work session to identify strategies and locations for restoration along the creek. Each of the four main goals (flood damage mitigation, water quality improvement, habitat enhancement and recreation improvement) were addressed independently. Strategies that could be used to meet a goal were developed and potential places to employ these strategies were identified on a map of the study area. Special consideration was given where multiple opportunities overlapped on a site, such as proximity of a potential wetland for improving water quality and flood detention to a recreational node. The reach reports provided additional information to refine the potential restoration projects and the Analysis Matrix (Appendix B) helped to identify opportunities and constraints.

Following the work session, the proposed restoration sites were revisited to evaluate the feasibility of the proposed projects, ascertain constraints and note other opportunities. With this additional information the proposed projects were further developed and fine-tuned.

4.0 REACH SUMMARIES

4.1 Overview

Appendix A contains reach reports for each reach based on the information collected during field visits. The data is divided into five categories: Channel Character, Vegetation and Wildlife, Land Use, Outfalls, and Restoration Opportunities.

Channel Character deals with width and depth of the stream, water quality issues, the condition of the banks and streambed, and width of the floodplain.

The *Vegetation and Wildlife* section discusses the amount and condition of tree canopy on both the left and right banks. This section includes a list of major plant species observed. This list is by no means an exhaustive inventory of the plants along Arcade Creek, instead it includes the dominant or most common plants in the each reach. Invasive species that should be removed or contained are highlighted in this section. Any animals observed are also listed in this section.

Land Use encompasses information gathered in the site visits as well as from aerial photographs and maps. It describes the dominant land uses in areas adjacent to the creek.

Any outfalls located during site visits are described in the *Outfalls* section. This includes any pipe, swale, gully, or feeder stream that empties into the stream channel.

The *Restoration Opportunities* section lists techniques that were recommended for each reach during the data collection phase. This section also offers additional recommendations based on the information provided in the previous four sections. Some recommendations for restoration occurred repeatedly throughout all reaches:

- Areas with wide floodplains or adjacent open green space offer opportunities for constructing detention structures to reduce the affects of flooding and to improve water quality or for stream widening to improve habitat and increase bank stability.

- Throughout the creek trash was a problem, particularly in area where homeless people camp. In these areas presence of both typical trash and human body wastes is a problem that negatively impacts water quality, recreation possibilities, and habitat value.

- The discharge from outfalls located more than ten feet from the stream has the potential to be treated in a variety of ways. Treating these discharges, particularly from large stormdrains that service residential or industrial land uses or major highways, can improve water quality as well as offer educational opportunities.

- Finally, in many areas of the creek, the riparian forest is severely degraded and in some places non-existent. Restoration of riparian vegetation will improve both habitat quality and recreation opportunities. It can also help stabilize banks and improve water quality. In addition, there are many exotic plant species in the riparian corridor. Not all exotic plants spread aggressively thereby crowding out native species. However, this behavior is documented in some species such as Yellow Star Thistle, Giant Reed, Tree of Heaven, and Common Fig. These highly invasive species should be contained and, wherever possible, removed.

Stream reaches in the Reach Report are delineated by station points. Please refer to the Feasibility Field Maps, Appendix C, to locate the reaches within the study area and with respect to local streets.

5.0 ENHANCEMENT STRATEGIES AND TECHNIQUES

GENERAL CONCEPTS

The following sections outline strategies for making progress towards the goals defined by the watershed group. The techniques presented primarily address the areas adjacent to Arcade Creek and within the study area. Although this is a first step in meeting the goals set forth, a comprehensive watershed plan is necessary that addresses the issues of water quality, flood damage mitigation, habitat and recreation at a basin-wide level before significant progress is possible.

The Arcade Creek watershed is primarily composed of residential land use. Several large paved and/or roofed areas exist in the watershed, including American River College and the Sunrise-Birdcage shopping malls. Interstate 80 crosses one edge of the watershed, and numerous arterial and collector streets crisscross the landscape. Primary sources of water quality pollutants in an urban system such as this include pesticides, herbicides and fertilizers used in residential landscapes, hydrocarbons and automobile byproducts that are deposited and run off of roadways and parking lots, and fecal coli form bacteria from pet wastes. Due to the scope and nature of this study, water quality recommendations focus on end-of-pipe strategies, however, changes at the source may be more effective and cost less in the long run. Therefore, some general recommendations are included in this report for source controls.

In planning the projects recommended in this report, a multi-scale approach was used. The suggested projects include both larger, long term and smaller, short-term projects. It is suggested that a plan be developed to implement both types of projects. Implementation should be prioritized to get the greatest results from each investment of time and money. Additionally, to reap the greatest rewards implementation should focus on projects that address multiple goals. The final chapter of this report includes recommended prioritization and integration of projects.

STRATEGIES

The following strategies were used in developing and evaluating the techniques and projects that are proposed.

- Use an ecosystem approach. This includes the recognition that all actions in the watershed, including restoration and enhancement, affect other watershed functions. Other important concepts include the awareness that stream channel morphology is a response to the hydrologic regime, riparian forests proceed through a natural succession, including the generation of snags and LWD, fish and wildlife populations are largely a response to the habitat available to them, and that building long-term sustainability into the landscape is the only strategy that will work.

- Work with the landscape. This means using naturally occurring depressional areas for constructing detention storage to minimize excavation costs and impacts.

- To the extent possible, develop projects that provide benefits in meeting at least two of the four goals, as opposed to narrowly focused projects. All too often, projects to minimize flood damage negatively impact habitat.

- Recognize that both flooding and erosion are natural processes that have been exacerbated by human activities. The goal should be to minimize the negative aspects (i.e., flood damage), rather than control the natural process of flooding itself.

- Maximize cost-effectiveness and minimize maintenance requirements.

OVERVIEW OF ISSUES AND TECHNIQUES

Water Quality Improvement

Arcade Creek is consistently referred to as one of the most polluted creeks in the Sacramento area. Measurements of pesticides, metals, and other chemicals are often higher in Arcade Creek than in the Sacramento River itself. Many pesticides are found in higher concentration in Arcade Creek than in canals draining agricultural runoff. Water quality analyses conducted in the past several years by USGS, Sacramento River Watershed Program, and Sacramento Stormwater permittees indicated the presence of diazinon and chlorpyrifos concentrations in discharges in the Sacramento urban area were consistently higher than water quality criteria. Levels of carbaryl were sometimes in excess of water quality criteria in discharges and Arcade Creek. Mercury was also noted in levels exceeding human health standards. Water in discharges and Arcade Creek was frequently toxic to bioassay species, particularly *Ceriodaphnia,* a species of daphnia that are food to fish. Diazinon and chlorpyrifos were present in Arcade Creek at levels toxic to *Ceriodaphnia*, throughout the year. USGS, in particular, noted the following chemicals as exceeding water quality criteria: carbaryl, chlorpyrifos, DCPA, diazinon, malathion, and diuron. Most organic compounds detected do not have water quality criteria.

Overall, improving water quality may be the most important goal for Arcade Creek because water quality affects so many other aspects of the stream system. Improving water quality also improves habitat quality for aquatic species and thus the terrestrial species that prey upon them. This in turn increases the recreational value to people. Aside from increasing the presence and diversity of wildlife, clean water in and of itself is more appealing to recreational users. Additionally, poor water quality may be detrimental to the health of the users of the creek system, whether human or wildlife. It is possible that there currently exists a real danger from eating fish or waterfowl taken from the stream.

While this study did not include an investigation of the causes of poor water quality in the creek, it is likely that sources contributing to degraded water quality include the following:

- Runoff from residential properties containing fertilizers, pesticides and herbicides,
- Runoff from roadways laden with automotive byproducts such as hydrocarbons, rubber, etc.
- Dumping of household wastes where they can drain into storm sewers or migrate into the water table,
- Runoff from homeless camps or direct input into the water through washing and bathing.

The techniques that should be implemented at the watershed level to improve water quality in the stream system include:

- Educating people that live and work in the watershed to be more water friendly by using fewer chemicals, properly disposing of left-over toxins, and cleaning up after their pets.
- Encouraging the practice of Integrated Pest Management (IPM) through incentive programs, education and/or regulation,
- Filtering runoff from roads and parking lots using detention ponds, grassed swales, filter strips, constructed wetlands, water quality basins, and/or phyto-remediation techniques,
- Prohibiting development adjacent to the creek to prevent direct runoff of potential pollutants and encouraging or requiring the planting of vegetative buffers for development already adjacent to the creek,
- Ensuring that Storm Water Pollution Prevention Plans are followed,
- Establishing regulations for new and re-development that require the capture and filtering of the initial runoff from a storm, which typically carries the majority of the water pollution.

Flood Damage Mitigation

Mitigation of damage to adjacent properties from stormwater flooding must also be addressed at the watershed level to effectively decrease the potential for damage when major storm events occur. High flows are the primary force that determines stream channel morphology. Compared to non-urban streams, some reaches of Arcade Creek are deeply incised by greatly increased volumes and velocities of peak flow. The desire to control flooding results in armoring of stream banks, straightening of channels, removal of woody vegetation and debris, and other techniques that significantly degrade the quality of the habitat and water quality in the stream corridor. The increase in flood waters and correspondingly greater impacts to the stream system arise from the decreased permeability of the landscape in an urban environment and the stormwater conveyance system itself, which increases the rate of runoff and decreases the time for floodwater to enter the creek channel.

One area that has had recurring problems with flooding is upstream of the Roseville Road and Union Pacific Bridges. Floodwaters have historically built up behind these obstructions and spilled south to flood some communities away from the creek. Reduction of flood volumes through detention in the upper watershed is probably the best opportunity to mitigate this damage.

The following techniques should be considered to better mitigate the impacts of flooding on surrounding communities:

- Increasing detention of storm water away from the creek to help lower peak flows, especially if done at a variety of scales from onsite detention ponds to regional detention facilities. All new development should include the requirement of attenuating runoff and, at minimum, retaining onsite the additional stormwater generated by the site improvements so that runoff entering the system is maintained at pre-development levels.

- Allowing flooding to occur on sections of the creek to lower peak flood levels and benefit riparian vegetation. Vacant sites and public open space along the creek should be considered for prescriptive flooding, particularly in those areas where flooding is compatible with an existing or proposed conjunctive use, such as sports fields that are not utilized during the rainy season. While this technique is more suitable to a system where levees confine the floodwaters, there may be locations along Arcade Creek where minor topographic modifications can be used to reintroduce flooding into disconnected backwater channels or sloughs.

- Adopting building and planning strategies to minimize the economic impact of floods. For instance, building on the floodplain should be prohibited, and existing buildings should be retrofitted to better withstand floodwater damage.

Habitat

Improving fish and wildlife habitat along Arcade Creek is important to preserving these natural resources in the region. Equally important is connecting this riparian corridor to others in the area. In order to retain diversity and healthy populations, fish and wildlife must be free to move and disperse between habitats. This allows fauna to take advantage of the range of habitats available to them. Similarly, restoring aquatic habitat enhances the value of the stream, both from a biodiversity standpoint and for the recreation value to anglers. Two major issues in improving fish habitat in the stream are poor water quality and excessive stream temperatures. Of these, water quality is probably the current limiting factor and the more difficult to address. Other fisheries habitat issues include eroding stream-banks, lack of structure in the channel, and lack of shelter.

The major problems in the quality of riparian wildlife habitat include discontinuities in riparian vegetation, insufficient buffer widths, preponderance of invasive plants and poor water quality which contributes to reduced aquatic food sources.

Several techniques for restoring habitat include:

- Planning on a regional level to conserve or restore an interconnected web of open space and wildlife corridors. This effort needs to include not just the Arcade Creek watershed, but watersheds throughout the region reaching into the Sierra Nevada Mountains and across the valley to the Coast Range;

- Improving water quality in the regional stream system. Existing data on the current condition of the creek suggests that its ability to support a healthy fish population is significantly degraded. Focused fisheries studies of the creek should be done to establish acceptable water quality goals for target species.

- Restoring stream connectivity where it is compromised by culverts, weirs, and other structures;

- Developing realistic enhancement goals for fisheries management at the watershed level.

INVASIVE PLANTS

Some plants are considered invasive weeds, in that they spread aggressively, quickly, and easily, once established in a new area. Although some invasive plants offer habitat or food resources to wildlife, they crowd out all other species leading to unhealthy stands of a single species. These plants should be removed as soon as they are found because, if left, they will multiply and be more expensive and time consuming to remove in the future. Ten species of this nature were found along Arcade Creek.

Two species observed along Arcade Creek are on the California Department of Food and Agriculture Noxious Weed List. Those are Yellow Starthistle (*Centaurea solstitialis*) and Scotch Broom (*Cystisus sp*.). However, both of these plants are on the C list meaning that they are so widespread that containment or eradication efforts are not endorsed except in seed lots and nurseries. There are introduced biological control species but no noticeable results have been observed. Both plants can be controlled with herbicide application or goat grazing. Where possible, small infestations of these species should be removed to prevent them from spreading.

Yellow Star Thistle near Arcade Creek

Scotch Broom (courtesy of BLM)

There are six other plants observed on Arcade Creek that are on the California Exotic Pest Plant Council's invasive wildland pest plant list. Although not listed by state or federal governments these are all plants that can seriously harm the ecosystem if not controlled and eradicated. The Plant Conservation Alliance names two additional trees found along Arcade Creek on their Alien Plant Invaders list.

Giant Reed (*Arundo donax)* is a highly invasive grass introduced from India. It can grow to a height of 30 feet and forms large clumps along banks and in the channel. Clumps growing in the creek channel often block water flow causing erosion of the banks around them and promoting flooding. Giant Reed often propagates itself vegetatively from stems or small clumps washed downstream. Giant Reed seemed to be spreading from the east of Reach #41. Eradication efforts must be coordinated along the entire creek or upstream infestations will recolonize the lower creek. It is hard to eradicate and often the rootmass must be dug out. Giant Reed was recorded in nine reaches.

(John M. Randall, The Nature Conservancy)

Red Sesbania (*Sesbania punicea*) is a small tree, up to 15 feet tall, from South America. It is easily identified by its bright red flowers and dry hanging seedpods. It is a member of the legume family, but eating its pods can cause serious illness and even death. It spreads by waterborne seeds. It can be controlled with pesticides and biological controls were highly successful in South Africa. Red Sesbania was recorded in twelve reaches.

Tree of Heaven (*Ailanthus altissima*) originates in China. This tree can grow to 80 feet in height. A nutty odor from all parts of the tree and pinnate leaves up to four feet long can help identify Tree of Heaven. Female trees can produce over 320,000 seeds per year. Tree of Heaven is susceptible to herbicides, but sprouts readily from stumps and roots when cut. It was recorded in nine reaches.

(picture courtesy of Floridata)

Edible or Common Fig (*Ficus carica*) originated in the eastern Mediterranean and escaped from orchards and gardens in California. Fig trees can reach a height of 30 feet. The lobed leaves are covered with bristly hairs. Fig trees were recorded in 14 reaches.

English Ivy (*Hedera helix*) is an invasive vine native to Europe, western Asia, and northern Africa. It affects all layers of the canopy because it grows along the ground as well as climbing trees. In both cases it kills other plants by shading them out. The added weight on trees makes them more susceptible to blowing over in heavy winds. English ivy can be controlled by mechanical pulling or with the use of herbicides. English Ivy was documented in six reaches.

(Pietro Pavone, University of Catania)

Black Locust (*Robinia pseudoacacia*) is another tree in the legume family. This sun loving tree grows quickly to between 40 to 100 feet and often shades out other sun-loving species such as our native oaks. It reproduces primarily through root suckers and a stand may share one large fibrous root mass. Herbicide is the most effective eradication technique. Black Locust was seen in three reaches.

Himalayan blackberry (*Rubus discolor*) is widespread evergreen trailing thorny shrub. Contrary to its name it originated in western Europe. It forms dense thickets along waterways. The fruit is edible but the dense growth may prevent medium and large mammals from reaching water. It reproduces by seeds, often dispersed by birds, and vegetatively from root suckers and forming roots where canes touch the ground. It is very hard to eradicate due to its multiple reproductive strategies but both mechanical and chemical means may be used. Blackberry thickets were observed in 13 reaches.

Mimosa, or Silktree (*Alibizia julibrissin*) is a medium sized tree native to Asia. It prefers full sun and can grow three feet per year. It forms dense stands and may crowd out other species. When growing in riparian area, its seeds are often spread by water. Silktree can be killed by herbicides or girdling, although suckers may grow from cut stumps. Silktree was observed in seven reaches.

Recreation

Similar to habitat planning, recreational uses should be connected across a larger area. Integrating bike, pedestrian, and horse trails with other regional trails is particularly crucial to the success of the trails along the creek. The Sacramento region is rich with long trails such as the American River Parkway, Ueda Parkway, and Sacramento Northern Bikeway. Within the watershed, unofficial and official trails exist along some parts of Arcade Creek. Efforts should be made to connect these to the regional system and perhaps create a continuous bike and equestrian trail corridor from one end to the other.

The following sections discuss objectives, techniques and projects for the four goal areas in greater detail. The section on objectives presents to overriding purpose for the recommended techniques and projects. The section on techniques discusses specific strategies for addressing the major issues in the goal area under discussion. The potential projects section presents areas where restoration or improvement should be considered. Chapter 6 discusses some of these potential projects in greater detail, integrating recommendations from the goal areas into several key restoration sites.

5.1 Water Quality

5.1.1 Objectives

Improving water quality was identified as the primary goal for Arcade Creek by the Watershed Group. This entails reducing pesticides, metals, and nutrients from fertilizers and bacteria from fecal and other sources. Water quality will also be improved by decreasing the sediment load of the creek, particularly during high flows.

5.1.2 Techniques

There are a variety of techniques that can be utilized to meet the objectives in this area, however as noted earlier, a comprehensive program must be undertaken in the watershed to target the sources of the pollutants. Treating the outflows before they enter the creek is a temporary and less effective means than addressing the sources. Recommended techniques include filtration methods to clean water entering the creek as well as techniques to prevent pollutants from reaching the creek in the first place.

Treatment of stormwater "first-flushes", the stormwater resulting from the first 1" or so of rain, is the most critical in improving water quality in the creek, since this runoff typically carries the greatest concentration of pollutants.

The table on the following pages presents an overview of water quality improvement techniques taken from the Sacramento Stormwater Management Program's <u>Guidance Manual for On-Site Stormwater Quality Control Measures.</u> Techniques are summarized based upon cost, effectiveness, space required, typical use and maintenance requirements. Following the table, some of the techniques are discussed in greater detail as they apply to Arcade Creek.

Water Quality Improvement Techniques					
Technique	**Cost**	**Effectiveness**	**Space Required**	**Typical Use**	**Maintenance Requirements**
Vegetated Swale	Low	Moderate for sediment and pollutants that adhere to grass and soil	Moderate relative to runoff area Must be in low gradient area	Treatment of moderate water volumes in public parks, office and retail complexes	Low
Filter Strip	Low	Moderate for water quality No detention function	Moderate relative to runoff area Must be in low gradient area	Adjacent to parking lots and business parks	Low
Media Filters	Very high	Good; Depends on media Sand is effective on suspended solids and suspended metals	Small	In vaults at retail and commercial centers and public parking areas	High
Infiltration Basins	Moderate	Low* for bacteria, suspended solids, nutrients, oil and grease, and floating waste Requires pre-treatment may contaminate groundwater	Large	In large residential developments	Moderate
Infiltration Trenches	Moderate	Low* for suspended sediments, floating debris, and bacteria May contaminate groundwater	Small	Retail centers, business parks, green belts and public parks	Moderate to high
Infiltration Paving	Moderate to high	Low* Requires gentle slopes May contaminate groundwater	Varies	Maintenance roads, pedestrian walkways and patios	Moderate to high
Detention Pond	moderate to high	Moderate to good Must be appropriately sized	Moderate	Treatment of urban runoff where both water quality and flow attenuation are required	Moderate

* Generally infeasable on soil types in the Arcade Creek watershed.
taken from the Sacramento Stormwater Management Program's <u>Guidance Manual for On-site Stormwater Quality Control Measures</u>

Source Control Techniques

Technique	Cost	Effectiveness	Space Required	Typical Use	Maintenance Requirements
Commercial/ Industrial Material Storage Shelters	Moderate	High; Protects materials from rain and prevents pollutants from entering runoff	Varies; May be constructed in existing storage footprint	In industrial complexes and transportation hubs	Low
Commercial/ Industrial Outdoor Loading/ Unloading Protection	Low	High; Preventing spills keeps potential pollutants out of stormdrain and river systems Containing and covering loading area prevents spills from spreading.	Low	At retail stores, industrial sites, and transportation hubs	Low to moderate
Commercial/ Industrial Vehicle and Equipment Fueling Protection	Moderate	Moderate* Should be covered if vehicle size permits Prevents oil, fuel, and heavy metals from entering storm drains	Low Equal to that required for fueling	At gas stations and transporation hubs	Moderate
Commercial/ Industrial Vehicle Repair, Maintenance, and Washing Containment	Moderate	Moderate* Controlling runoff prevents oil, paint, fuel, and cleaning agents from entering stormdrains	Moderate	In industrial complexes, golf course	Low
Commercial/ Industrial Outdoor Process Equipment Operations and Maintenance	Moderate	Moderate* Containing runoff prevents heavy metals, toxic materials, oil and grease from entering storm drains	High	Industrial complexes, construction, and deconstruction projects	Low
Commercial/ Industrial Waste Handling	Low	High* Properly managing hazardous waste ensures safety of people and the environment	Low	Industrial and commercial developments	Low

Multi-Family Vehicle Wash Areas	Moderate	Moderate Draining to sanitary sewer prevents detergents, grease, oil, anifreeze, and heavy metals from entering stormdrains	Moderate	In multi-family housing and mobile home parks	Low
Multi-Family Waste Handling Areas	Low	High* Proper diposal of household waste can prevent paints, solvents, batteries, cleaning agents, and garden chemicals from contaminating water supplies.	Low	In multi-family housing and mobile home parks	Low
Storm Drain Message	Moderate	Low; Educates public about effects of pollutants on storm drain system but has no physical effects	Very Low	Painted or stamped onto storm drain inlet	Moderate
Household Hazardous Waste Roundups	Low	High; Prevents toxicants from entering surface water	Low; Can be done on annual basis	Combined with environmental education in residential neighborhoods	Moderate
Promoting non-toxic alternatives to pesticides	Low	High; Prevents toxicants from entering surface water	N/A; Actually a management measure	Integrated Pest Management (IPM) can be implemented at golf courses, parks, roadsides and medians, and residential projects	Moderate; May require monitoring if target pests and other measures to more carefully manage landscapes

*Pave with impervious surfaces to avoid contaminating groundwater
Areas should be designed to prevent runon and runoff
Drain to dead end sump or sanitary sewer rather than storm drain
taken from the Sacramento Stormwater Management Program's Guidance Manual for On-site Stormwater Quality Control Measures

- *Detention/Retention Basins*
  Detention basins improve water quality because they trap sediments and many contaminants adsorbed to them. A detention basin is typically designed to hold water briefly during and after a storm event, and meter it out slowly. A retention basin is designed to retain water until it evaporates or infiltrates. In either case, the ultimate fate of large quantities of metals, petroleum products, nutrients, sediments and other pollutants depends upon the design and maintenance of the facility.

- *Filtration structures*
  Filtration structures can take many forms. In small spaces, sand filtration systems can be built. These are particularly useful for point sources of pollution or outfalls that are known to be especially polluted. However, sand filters can be very expensive and require regular maintenance. The addition of wetland and riparian plants to a swale or drainage can also act as a filtration structure. Where sufficient space exists, outfalls can be diverted into adjacent detention wetlands to help scrub pollutants. Additional information on sand filters can be found at the end of this section.

- *Homeless camp control*
  The presence of homeless camps along Arcade Creek negatively impact the water quality of the creek. This is primarily due to trash left around the camp and detergents used in the creek for cleaning and bathing. Initially, the existing camps should be relocated to permanent shelters and the waste removed. For long-term control, problem areas should be redesigned to increase public visibility by incorporation of staging areas, trails, and other recreational amenities near those areas favored by the homeless.

- *Animal waste control*
  Runoff from animal waste left on the ground can carry bacteria and parasites into Arcade Creek. In addition to these biological problems animal waste runoff can affect the nutrient balance of the creek. Pet owners should be educated about cleaning up after their pets, and periodic maintenance of equestrian trails should be performed to remove horse droppings. Animal facilities such as pastures adjacent to the creek or its tributaries should be evaluated for potential impact of runoff and requirements for vegetative buffering of the stream and other pasture management Best Management Practices (BMPs). The Sacramento County Resource Conservation District can assist with the design and implementation of a farm management plan and associated BMPs.

- *Homeowner education*
  Homeowner education is a multi-faceted tool to improve water quality. It can be used to address the overuse of pesticides in the Arcade Creek watershed, pet waste management, or the importance of properly disposing of hazardous materials. Educating local homeowners about the steps being taken to restore Arcade Creek can also increase their feeling of stewardship for the creek and support for government efforts and projects. Increased recreational use of the creek can also foster a sense of responsibility, and interpretive signage can be

used at staging locations to point out potential homeowner and user impacts to water quality as well as solutions.

- *Trash cleanup*
  A basic technique for improving water quality is cleaning up trash, both along the creek corridor and throughout the watershed. Trash often leaches chemicals into soil or groundwater. Additionally, hazardous chemical containers, such as oil or bleach, or appliances are often dumped into or adjacent to the creek and may leak contaminants.
- *Bank stabilization*
  Both banks along most of the length of Arcade Creek in the study area are unstable. This means that they are easily eroded during high flows and add large volumes of soil particles to the water. This degrades water quality as well as habitat quality. Stabilizing the banks with bio-engineering solutions will decrease erosion and lower sediment load in the creek while preserving or enhancing natural habitat.

Sand Filters

The use of sand filters as stormwater treatment devices is growing in popularity and is common in some metropolitan areas, but can still be considered as having a limited application across much of the country. There are several types of sand filters including surface, underground, and perimeter, each has its own design, operational, and cost considerations.

Regardless of the type, generically sand filters have two-chambers, the first chamber is for settling of solids, trash, and other coarse material, and the second is a filter bed filled with sand or another filtering media (usually organic in nature). As stormwater flows into the first chamber, large particles settle out, and the finer particles and other pollutants are removed as stormwater flows through filtering media. Modifications to the traditional surface sand filter were made primarily to fit sand filters into more challenging design sites (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).

Surface sand filters are often limited by their size and the amount of open space need for their implementation, whereas underground and perimeter sand filters are well suited for urban watersheds as they require no surface space. Sand filters have traditionally been used adjacent to stormwater "hotspots" such as parking lots or industrial areas that receive contaminated runoff, but from a limited area. Sand filters are a good option to achieve water quality goals in retrofit situations where space is limited, because they consume very little surface space and have few site restrictions. It is important to note, however, that sand filters cannot treat a very large drainage area. Using a small site practice to retrofit an individual site may be the only option, but it is expensive to treat an entire watershed with many small practices (compared to using larger practices such as a detention pond).

Siting and Design Considerations

Important considerations for the implementation of a sand filter: drainage area, slope, soil and substrate conditions, and depth and seasonal variability in the water table. To prevent structural degradation and contamination of the medium, two feet elevation difference is needed between the bottom of the sand filter and the top of the seasonally high water table. Literature indicates that sand filters are functional when the drainage area is at most 5 acres for surface sand filters, and 2 acres for perimeter or underground filters. Filters have been used on larger drainage areas in the past (up to one hundred acres), but these systems often clog, due to the large amount of trash, debris and sediment collected over the drainage area. Generally the site where a sand filter is to be installed should not be flat as a five to eight foot difference in head is needed, but slopes should also not exceed six percent. Sand filters can be used on almost any soil, because they rely on an artificial soil as a treatment medium.

Some pilot studies have investigated the cost and effectiveness of sand filters including a retrofit pilot study conducted by the California Department of Transportation (Caltrans). Caltrans constructed five sand filters in southern Californian metropolitan areas as retrofit projects for maintenance yards and park and rides

The nature of the project limited the contributing area of each sand filter to less than 2 acres, which contributed to a relatively high cost of about $150,000 per acre treated. Pollutant removal was reported as generally excellent, whereby suspended solids removal was 89%, total metals removal varied between 58% and 84%, while dissolved metals removal varied between 27% and 68%. Removal was lowest for nutrients, especially nitrate, which was generally negative. Low average rainfall totals (10 – 12" / year) resulted in no major maintenance requirements, however, required maintenance is expected to increase with higher rainfall amounts. Maintenance activities have consisted mainly of vegetation and litter management. The study concluded that the sand filters are appropriate for treating stormwater runoff where the highest quality discharge is required, and that the main impediment to widespread implementation is the initial construction costs.

Types of Sand Filters

Surface Sand Filter

The surface sand filter is the original sand filter design. In this practice both the filter bed and the sediment chamber are above ground. The surface sand filter is generally designed as an off-line practice, where only the first-flush is directed to the filter. The surface sand filter is the least expensive filter option, and has been the most widely used.

A surface sand filter has high community acceptance but also a high cost. It meets the water quality requirement and may meet the recharge requirement if it is designed to exfiltrate into the soil. A surface sand filter removes 87% of Total Suspended Solids (TSS), 59% of Total Phosphates (TP), and 32% of Total Nitrates (TN).

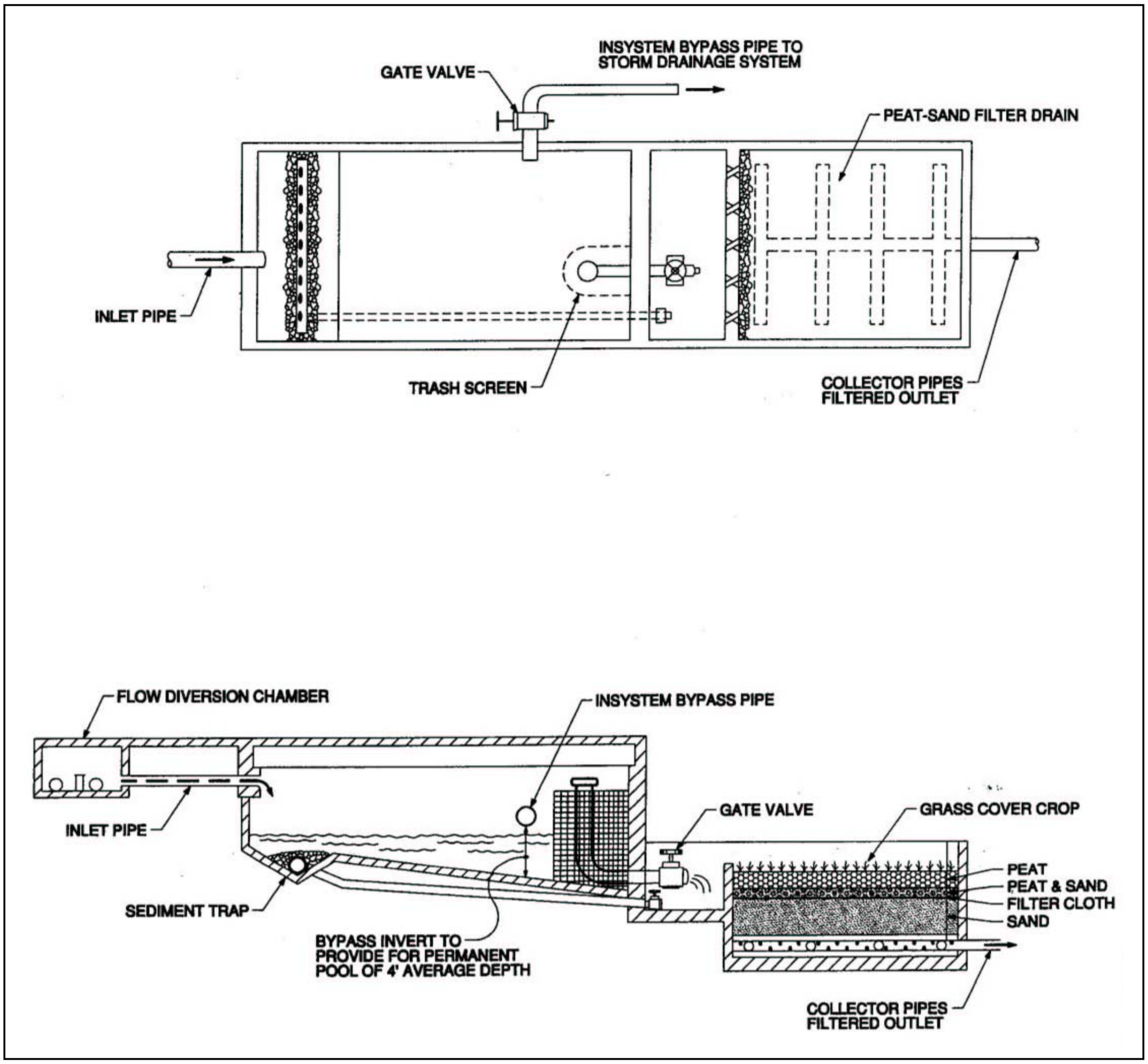
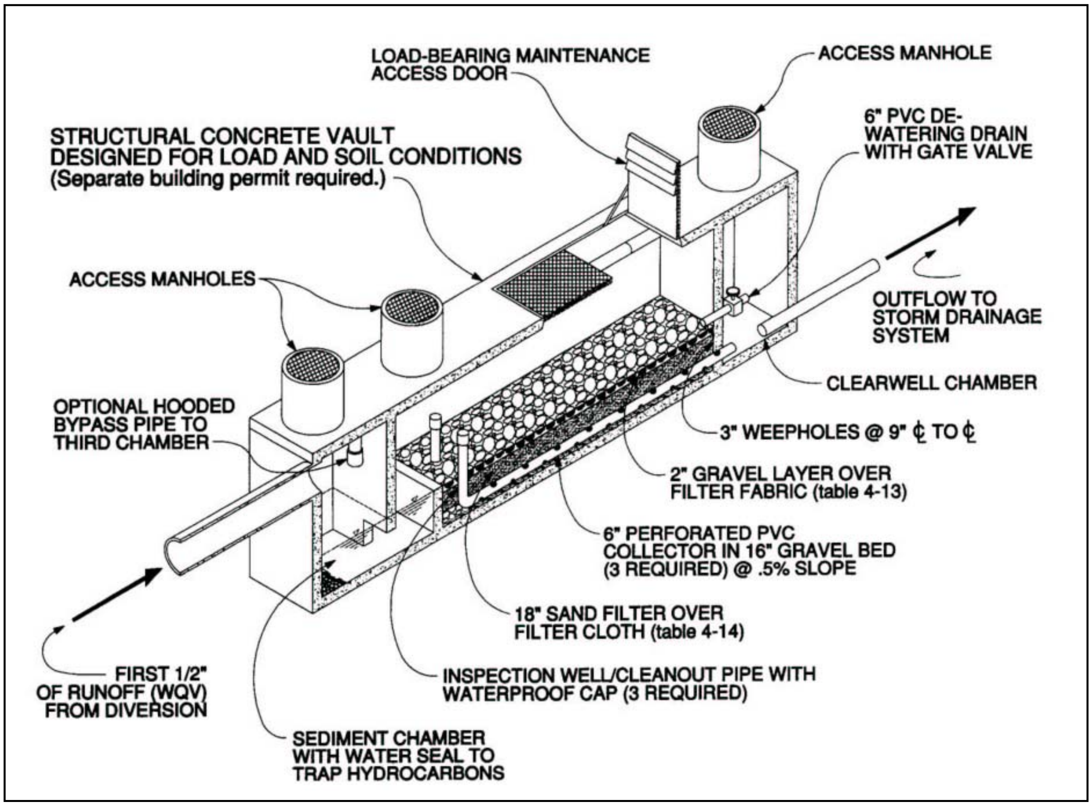


Figure 5-1 Surface Sand Filter

Sacramento Stormwater Management Program, Guidance Manual for On-Site Stormwater Quality Control Measures

Underground Sand Filter

An underground sand filter provides water quality storage and removes 80% of TSS, 50% of TP, and 35% of TN, although these numbers are based on limited data. This filter is highly accepted by the community, but is expensive to construct and requires a high level of maintenance.



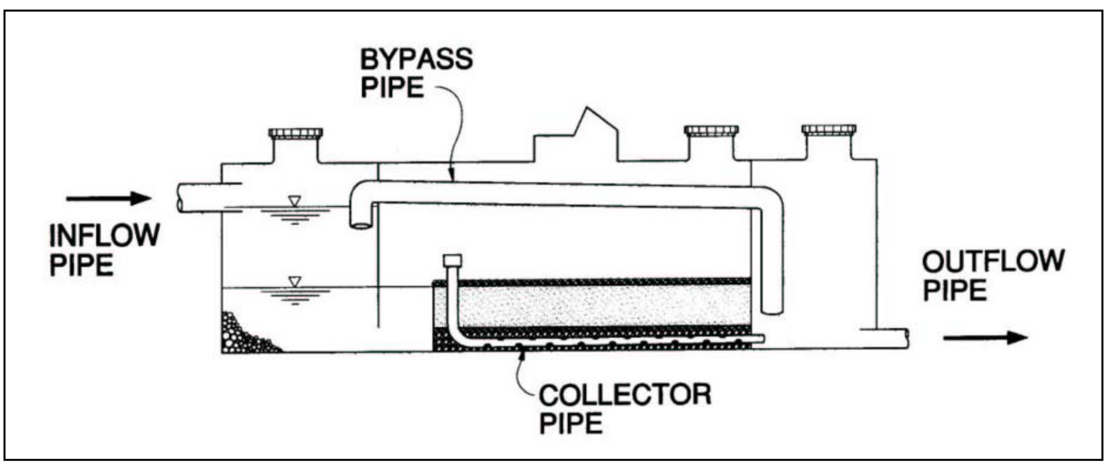


Figure 5-2 Underground Sand Filter

Sacramento Stormwater Management Program, Guidance Manual for On-Site Stormwater Quality Control Measures

Perimeter Sand Filter

The perimeter sand filter includes the basic design elements of a sediment chamber and a filter bed. In this design, however, flow enters the system through grates, usually at the edge of a parking lot. The perimeter sand filter is designed as an on-line practice, with all flows entering the system, with larger events bypassing treatment by entering an overflow chamber. One major advantage to the perimeter sand filter design is that it requires little hydraulic head, and thus is a good option in areas of low relief.

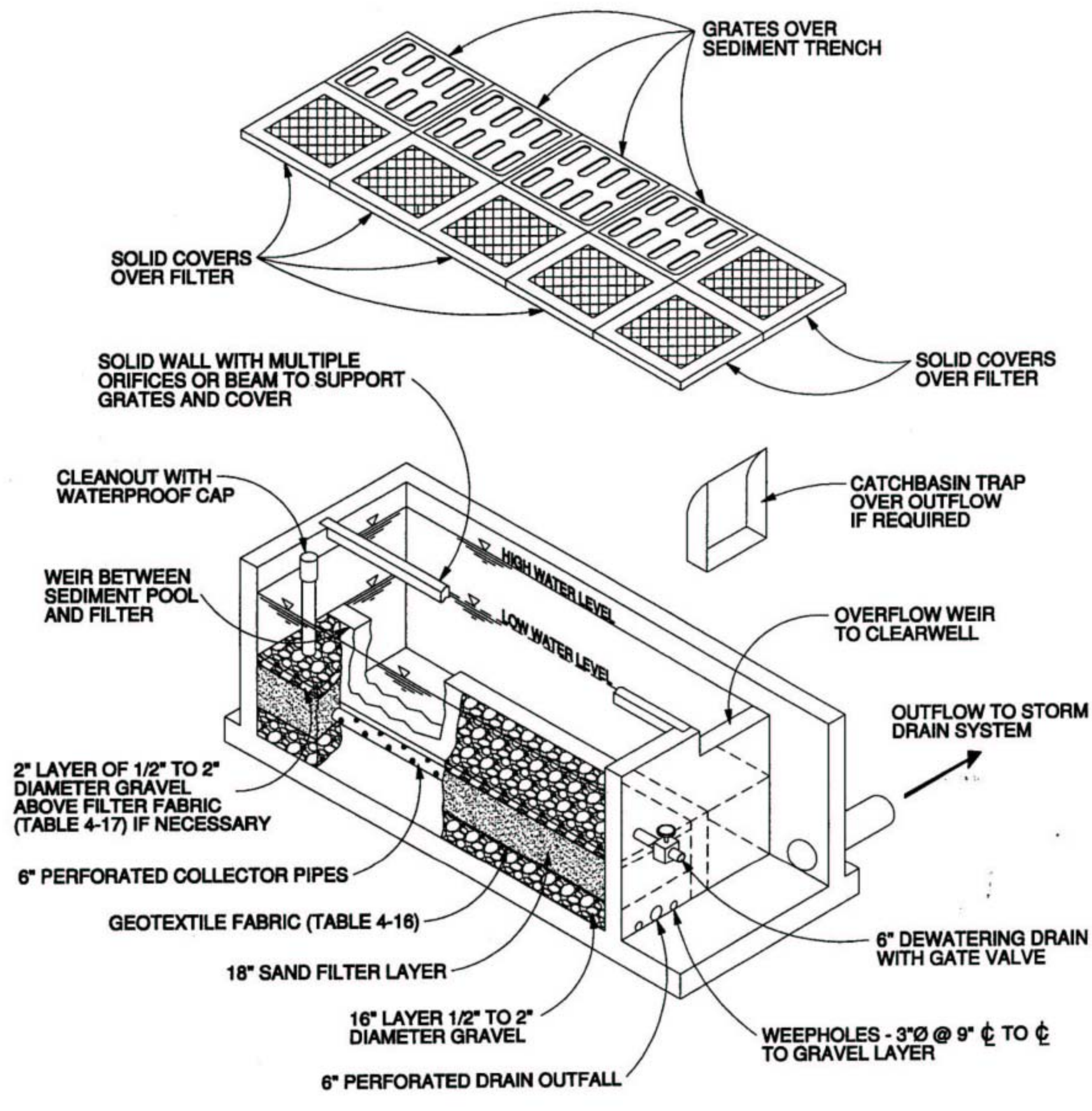


Figure 5-3 Perimeter Sand Filter

Sacramento Stormwater Management Program, Guidance Manual for On-Site Stormwater Quality Control Measures

Some pilot studies have investigated the cost and effectiveness of sand filters including a retrofit pilot study conducted by the California Department of Transportation (Caltrans). Caltrans constructed five sand filters in southern Californian metropolitan areas as retrofit projects for maintenance yards and park and rides

The nature of the project limited the contributing area of each sand filter to less than 2 acres, which contributed to a relatively high cost of about $150,000 per acre treated. Pollutant removal was reported as generally excellent, whereby suspended solids removal was 89%, total metals removal varied between 58% and 84%, while dissolved metals removal varied between 27% and 68%. Removal was lowest for nutrients, especially nitrate, which was generally negative. Low average rainfall totals (10 – 12" / year) resulted in no major maintenance requirements, however, required maintenance is expected to increase with higher rainfall amounts. Maintenance activities have consisted mainly of vegetation and litter management. The study concluded that the sand filters are appropriate for treating stormwater runoff where the highest quality discharge is required, and that the main impediment to widespread implementation is the initial construction costs.

5.1.3 Potential Projects

See Figure 5-4 to review the opportunities and constraints for the potential water quality improvement projects.

- *Sacramento Trapshooting Club detention facility,*
  The Sacramento Trapshooting Club leases 20 acres of Del Paso Park. Urban runoff that appears to originate from the south forms a drainage that flows through the target drop zone. Although trap shooting can take place in any weather, shooters only need access to the blocks, not the area over which they shoot. This creates the potential for building a seasonal stormwater detention basin in the target area. This would probably be the most cost-effective site for a regional detention facility in the study area. See Chapter 6 for additional information.

  Lead shot can be used in trapshooting and has the potential to impact water quality whether a stormwater detention structure is built or not. Lead and other metals in the watershed should be prioritized for source controls; rules at the trapshooting club should require the use steel-shot instead of lead, if such a policy is not currently in effect.

- *Parking lot improvements*
  Parking lots are one of the main contributors of poor quality urban runoff. In areas that are prone to seasonal use, such as ballfields and golf courses, parking lots could be modified to serve as temporary detention basins to slow stormwater runoff.

  Additionally, parking lots can be built or retrofitted with above-ground filtration and detention structures, either in the parking lot medians or adjacent to the lots.

These areas can act to filter pollutants prior to their entering the storm drain system.

The parking lot at the Sacramento Trapshooting Club is slated to be repaved in 2003. This offers a prime opportunity to modify the parking lot to detain runoff and filter pollutants in storm events.

- *Outfall mitigation*

  The stormdrains, swales, feeder creeks, and other pipes that drain into the creek channel are suspected of being the principal conveyors of chemicals, nutrients, and metals to Arcade Creek. However, the volume of runoff and pollutant loading from overland flow should not be underestimated.

  There are two aspects to cleaning the water entering Arcade Creek. Water quality can be improved before it enters the pipe by using source controls such as cleaner technologies and fewer pesticides. Dirty water can be filtered using a variety of techniques after it leaves the pipe but before it enters the creek.

  It is sensible to focus on source controls first because they are typically the most cost-effective. Once toxicants enter large volumes of water, they are more difficult to remove and more likely to either enter the stream or negatively affect wildlife.

  After source controls, the second priority should be larger diameter pipes, because they move a much greater volume of water and thus probably more pollutants than pipes with smaller diameters. This means filtration measures have a greater potential benefits. This study considered outfalls greater than two feet (2') in diameter for potential mitigation. Overall, fifty five (55) outfalls were located in the study area but only nineteen (19) were two feet (2') or greater in diameter.

  There are three filtration options depending on how much space is available between the end of the pipe and the creek. If the outfall ends less than ten feet from the creek channel there is no opportunity for detention wetlands or diversion structures. One method of filtering this water is to put a sand filter on the end of the pipe. Another option is to excavate the outfall further from the creek and employ mitigation measures at that point, if space is available in the riparian buffer. As has been stated and is discussed in additional detail in the Sacramento Stormwater Management Program Guidance Manual, solutions should be designed to treat the first-flush from a storm event.

The following text discusses mitigation for outfalls depending upon their proximity to the creek:

- Outfalls greater than two feet (2') diameter and less than ten feet (10') from the creek channel: These are unlikely candidates for sand filters due to drainage basin size and cost of treatment and maintenance. Outfalls in this category should be a high priority for mapping of their drainage basins and targeting of source controls. End-of-pipe treatments are typically not possible or very expensive due to proximity of the outfalls to the creek.

  A six foot (72") diameter metal pipe is located at stationpoint 0.0 in the right bank of Reach 1 (see photograph 080202-127). It drains Marysville Boulevard and empties directly into the creek channel. Although there is little room for mitigation structures presently, the outfall could potentially be redirected into a detention basin in Haggin Oaks Park (see Chapter 6). To do this, the pipe would have to be reengineered and Haggin Oaks Park redesigned, which would likely be very expensive. Source controls are recommended.

  In the right bank of Reach 4 is a three foot (36") concrete pipe located at stationpoint 10.8 (see photograph 080202-147/148). It appears to drain a residential neighborhood. When observed, some clear water was flowing through it and algae was present. Algae and aquatic plants near the mouth may be a sign of heightened nutrients in the water. This outfall should be a priority for source mapping and control of nutrients and sediments.

  A four foot (48") reinforced concrete pipe is located on the right bank of Reach 9 at stationpoint 22 (see photographs 062702-123, 126-127). It juts out of the concrete bank and is capped with a metal grate. Observers noted a trickle of water flowing out of the pipe, which probably drains a street. There are definitely excess nutrients and fertilizers in the discharge as shown by the abundant mass of aquatic plants beginning at this pipe. Both treating the outfall and preventing contamination of the water before it reaches the storm sewer system would be useful techniques here

  At stationpoint 51.25 in Reach 25 there is a two foot (24") reinforced concrete pipe emerging from the left bank. Water flowing from the pipe drains overland to the creek. There was a trickle of water running from the pipe when it was observed. It is unclear what this pipe drains. Again, source identification and control are the most likely techniques to be successful here.

  At stationpoint 87, in Reach 36, two pipes drain into the channel from Business 80, one on each side of the creek. They are both two foot (24") metal pipes (see photograph 062802-9). Due to the heavy traffic on the road, water from these drains is probably highly contaminated with metals and oils that are washed off of the road. A vault with an oil/water separator at this location may help to reduce the contaminants entering the creek from the road.

On the left bank of Reach 41, at stationpoint 112 is a two foot (24”) metal pipe draining Auburn Boulevard and Winding Way (080202-98). The bank below the opening is armored with a cobble and concrete pad. Some water was observed draining from the pipe and algae was present. As in the previous outfall, a vault with an oil/water separator may help to mitigate the road runoff.

- Outfalls greater than two foot (24”) in diameter and ten feet (10’) to fifty feet (50’) from the creek channel. The techniques that are likely to be effective on outfalls in this category include source controls, grassed swales parallel to the stream channel, and small-scale engineered systems to redirect first-flush to catchment and filtration areas.

  A two foot (24”) metal pipe protrudes from the right banks of Reach 6 at stationpoint 14.75 (see photograph 080202-157). It appears to drain residential areas but had no water running from it at the time of observation. Although it is more than ten feet from the current stream edge, the pipe empties onto a concrete lined bank. This precludes any filtering of runoff water before it joins the main creek channel. Techniques to mitigate this outfall may include replacement of the concrete bank with a vegetated bio-engineered solution combined with redirection of the outfall into a vegetated swale parallel to the stream. Source controls would also be effective.

  At stationpoint 16.7 in Reach 7, two six foot (72”) diameter concrete pipes empty into the creek from the left bank (see photograph 080202-162). Each pipe has a waterman gate over the mouth. They drain into a concrete inlet and, from there, directly into the stream. There is currently no filtering of water between the mouth of the pipes and Arcade Creek. These are very large outfalls. Propose investigating the feasibility of retrofitting the adjacent parking lot for detention and/or source controls.

  Another six foot (72”) pipe empties into Arcade Creek at stationpoint 46.75 in Reach 24 (see photograph 062502-9). This metal pipe opens into its own backwater channel on the right bank and appears to be a storm sewer outlet. When observed, there was a small amount of water flowing out of it at a rate of approximately 5 gallons per minute. There are good opportunities for detaining or filtering water from this outfall because it flows almost 50 feet in its own channel before joining the creek. Recommend examining the feasibility of directing the first flush and low flows to the abandoned channel to the west-southwest, located 160’ to 200’ north of the channel between stationpoints 40 and 43.

  There are two large outfalls in the right bank of Reach 34, both of which contained water when they were observed. The first is located at stationpoint 77.5. It is a seven foot (84”) concrete pipe, which is a storm drain outlet (see photograph 071502-5). It flows from areas to the north, including Industry Drive, Orange Grove Avenue, Interstate 80, possibly an area of rail beds, and a CalTrans lift station.

Foam was observed floating on the surface of the turbid water, and the effluent may be highly contaminated. This pipe is setback from the main channel approximately twenty feet (20') by a ten foot (10') wide rocky channel (see photograph 071502-6). The recommendation is to investigate of the installation of retrofit treatment options upstream of the outfall, including a vault with oil/water separators at the lift station and other locations. Low flows should be treated along with the first flush. Some of the sources should possibly be directed to the Waste Water Treatment Plant.

The second outfall is located at stationpoint 79.0. It is a reinforced concrete culvert under Longview Road with two two foot (24") pipes (see photograph 071502-4). The storm drain conveys runoff from the area of Longview and Airport Drives.

In order to reach Arcade Creek water from this outfall must flow across the trail. In the dry season the trail is higher than the adjoining land (see photograph 071502-1-2), which causes the water to form a pond with an abundance of algae that probably breeds mosquitoes. Water from this outfall flows a great distance overland. With some modifications to the trail to ensure summer drainage, this outfall offers good opportunities for filtering storm water. It might be possible to create a grassed swale between the outfall and the creek, and construct a trail crossing.

- Outfalls greater than fifty feet (50') from the creek channel:

  Creating detention ponds, grassed swales, or constructed wetlands are effective ways to treat large outfalls that are over 50 feet from the creek channel. There are five outfalls on Arcade Creek that have this potential.

  On the left bank of Reach 29, at stationpoint 61, is a two foot (24") diameter concrete pipe (picture 062502-20). No water was flowing through it at the time of observation. The source of this outfall is unknown. This pipe extends out from the bank over ten feet and then empties into a backwater channel. Water flowing from it drops a few feet after emerging from the pipe. The pipe could be cut back to its emergence from the bank and the area directly under the outfall cobbled or otherwise armored to diffuse the force of the impact and reduce erosion. Additionally, the backwater should be revegetated and possibly widened to improve flow dynamics. Establishing a healthy wetland flora in the backwater will help filter out soil, nutrients, and other pollutants. It may be possible to direct the first flush to the overflow channel 50' downstream and stabilize the discharge location for high flows.

  At stationpoint 91, in Reach 37, a two foot (24") metal pipe empties into the channel from the left bank (pictures 071502: 18-19). It drains the residential area south of Auburn Boulevard, including Annadale Lane, Brownson Street, and Merrily Way. It is conveyed north of Auburn Boulevard to the Discovery Museum Learning Center grounds.

Just downstream is a backwater channel with a paved path, formerly used as an interpretive trail, winding through it. This outfall is a good place to construct filtration wetlands. The existing path can be reclaimed, and used to educate people about the purpose of the wetlands. Additionally, education programs should be developed and coordinated with the adjacent Discovery Museum. Education at the museum will help improve water quality before it enters the wetlands.

Water was flowing out of a two foot (24") diameter metal pipe in the left bank of Reach 39, at stationpoint 101.5 (picture 071502:32-34). This pipe drains a stream feeding into Arcade Creek. At the time of observation water was flowing at approximately five gallons per minute. The water drops approximately three feet from the pipe into a scour pool before flowing into Arcade Creek. The area under the outfall should be armored to dissipate the force of the falling water and decrease further erosion. The sides of the channel between the outfall and the creek are steep and the channel is narrow. The banks could be cut back and the channel widened to allow greater flows. This would compensate for increased roughness resulting from the introduction of wetland plants. The flow originates in the residential neighborhood of Norris and Edison Avenues and includes Mira Loma High School. This sub-basin appears to be over 700 acres in size. Recommendations for this outfall are as follows: Construct a detention pond approximately 5 acres in size followed downstream by a filtration wetland approximately 15 acres in size. From the basin and wetland, the water would then discharge to the existing tributary channel. High school students could conduct water quality monitoring above and below the pond and below the wetland. The wetland should be designed as a retention/detention facility and a palustrine emergent/open water/forested wetland. The wetland would serve to polish water quality, provide waterfowl and other wildlife habitat, attenuate flows, and anchor the interpretive trails and signs on the site. The planning team rates this project as highest in the study area. See Chapter 6 for additional information and conceptual designs.

There are two large outfalls in the right bank of Reach 40, both of which are located over 300 feet from the main creek channel. At stationpoint 104.25 are two parallel thirty-three inch (33") metal pipes forming a culvert under Park Road (picture 071502-46). This culvert drains a small stream running through large residential lots and pastures. There are dense blackberries growing between the road and the creek. This outfall already has a significant amount of aquatic vegetation helping to filter out pollutants. This may be a good location for educating local landowners about the importance of keeping pesticides and animal waste out of the waterways To improve filtration and increase diversity some blackberries could be removed and replaced with native vegetation. However, blackberries are extremely aggressive and keeping them contained may take continued maintenance. Suggest pasture management BMPs and grassed swales or buffer strips.

The other outfall in Reach 40 is the confluence of a tributary with Arcade Creek at stationpoint 110 (picture 071502-44). The feeder creek flows under Park Road in a ten foot by ten foot concrete channel. The source appears to be runoff from the Interstate 80 off-ramp near the intersedtion with Auburn Boulevard. Shortly after the road-crossing, the stream bottom reverts to a natural substrate.

This creek has moderately healthy vegetation, although the riparian canopy is sparse in places. Planting of additional large woody tree species such as Live Oak, Valley Oak, Boxelder, will help to further shade the surface of the stream and reduce summertime temperatures. Additionally, the stream runs through Del Paso Park and thus it may be possible to lay back the almost-vertical banks to create a more gradual flood plain and allow introduction of additional woody vegetation or debris to the stream channel. Additional wetland plantings in the stream channel will also increase filtration of potential pollutants. Source controls are also recommended.

Reach 41 has a three foot (36") diameter corrugated metal pipe on the left bank that was causing serious erosion at stationpoint 114 at the time of data collection (pictures 080202: 111, 107). Erosion had also been caused by overland drainage from three smaller pipes (14" diameter) draining the pump station, but has apparently been rectified. Eliminating this erosion through bio-engineering techniques will improve water quality be reducing the amount of sediment and nutrients being carried downstream. Monitoring should be done on the recent erosion control improvements to determine their effectiveness and impact on the creek and take additional corrective action if required.

- *Homeless camp cleanup:*
  The current environment of Arcade Creek makes it a frequently used locale for homeless camps. The presence of few recreational users on the trails, combined with the dense tree cover, allows homeless people to stay secluded and undisturbed. Additionally, the many road overpasses provide shelter from summer heat and winter rains.

  These camps are a problem for many reasons. Probably the most significant impact on water quality is the large amount of human bodily waste. Besides contributing to total fecal coliform bacteria through drainage of wastes into the creek, the sight and smell of feces dramatically diminishes the value of the creek's recreation value. The presence of soap, detergent, and bleach bottles observed during site visits (see photograph 062702-162) indicates that some transients are washing their clothes and bodies in the creek. The direct input of these chemicals into the stream degrades water quality and may have a serious impact on creek biota. Additionally, the presence of transients may discourage other recreational users due to safety concerns. This creates a self-reinforcing problem.

Major homeless camps were found at the following locations:

- Watt Avenue Bridge,
- Roseville Road, Union Pacific RR and Light Rail bridges,
- Del Paso Park at Reach 40,
- Marysville Blvd overpass.
- Auburn Blvd Bridge

The existence of homeless people is a larger social issue that must be addressed at a city and regional level. However, their continued presence should not be tolerated in its current form along Arcade Creek. By changing the qualities that make Arcade Creek a desirable location, camping by transients can be reduced. Techniques to address the homeless problem at a local level include:

- Siting of formal, constructed, trails in locations that are favorable to homeless to increase public use of these areas,
- Increasing patrols by security or police officers,
- Developing public use areas such as staging areas, parks or restrooms near overpasses where homeless tend to congregate,

- *Animal Waste Management:*
  Runoff from areas with large amounts of animal waste can contaminate the creek if not properly managed. Improvements in waste management to prevent runoff from such areas from entering the creek can help prevent contamination. In addition, implementing a biofiltration system between the animal or animal-waste facility and the creek can help filter any runoff that does occur.

  The largest potential of waste contaminated runoff adjacent to the creek in the study area is the Sacramento Horseman's Association. Several techniques should be investigated to minimize impacts of this facility on the water quality of the creek:

  - Ensuring that their manure collection and storage facilities are under cover will reduce the possibility of contaminated runoff.
  - Constructing vegetated buffers between the Association and Arcade Creek where it is not possible to prevent runoff. These areas should be off-limits to grazing.
  - Ensuring a healthy riparian buffer is maintained between the facility and the stream.

Another related source of animal waste is the horses that are ridden along the trails bordering the creek. Although this may not be preventable, perhaps a routine cleaning of the trails can be performed. This may be a volunteer activity by members of the Horseman's Association, or a contracted service that they help support. Similarly, dog-walking along the creek may contribute to fecal coliform bacteria counts through improper disposal of dog waste. This has been successfully addressed in other locations through education of pet-owners, posting of signs requiring proper clean up of pet droppings, and supplying of pet waste disposal bags and storage containers at trail heads and staging locations.

Some private land adjacent to Arcade Creek and its tributaries is used for pasturing animals. As at the Horseman's Association, manure and used bedding should be protected from direct exposure to rainfall. Runoff from waste storage areas should be filtered where possible. Education of all animal owners about the proper handling of animal waste may help reduce the amount ending up in the creek

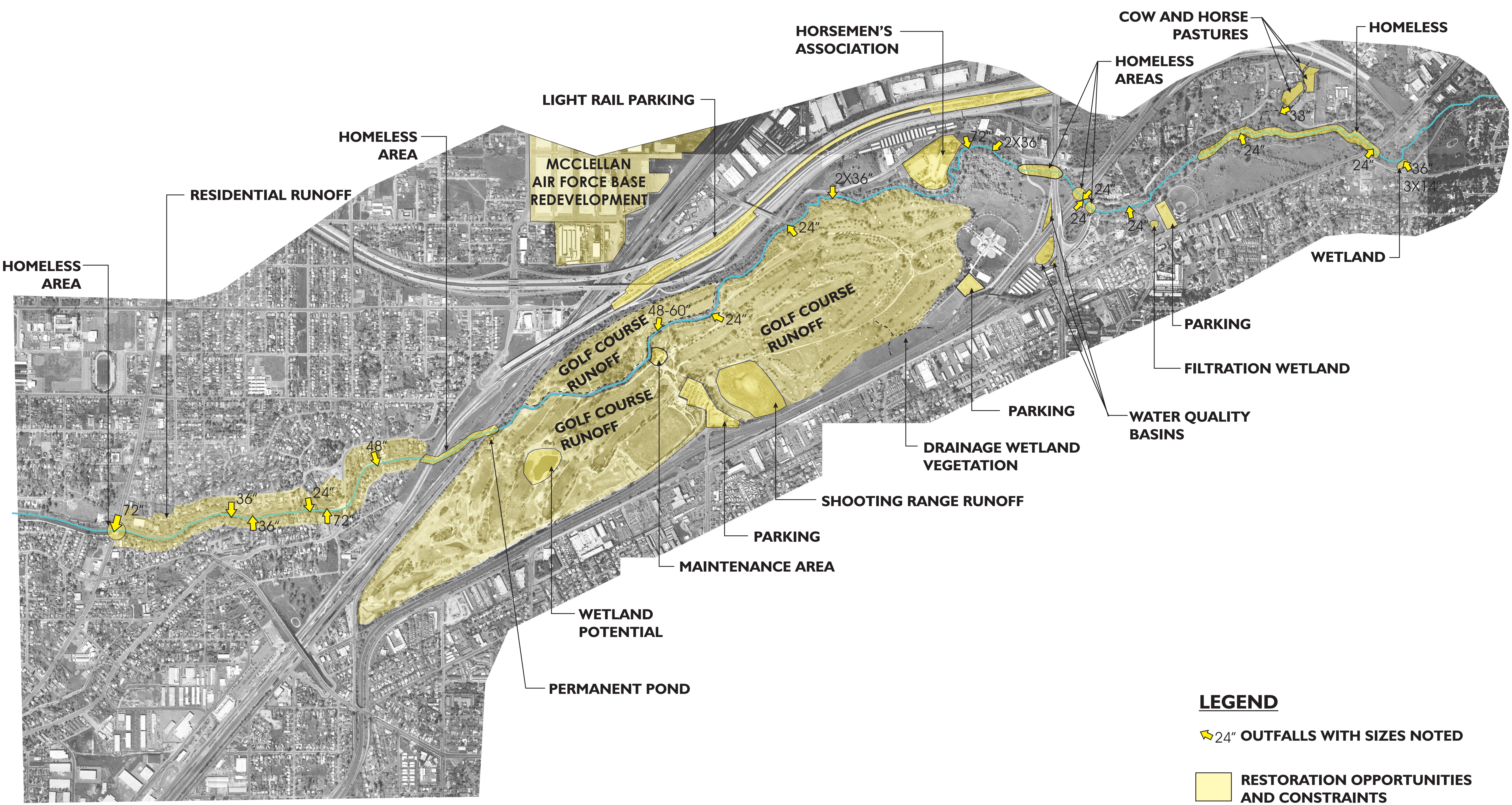
- *Residential runoff*

In areas where residential neighborhoods back directly onto the creek two mechanisms can be implemented to improve water quality. First, educating homeowners on the effects of fertilizers, pesticides and herbicides on the creek and how to reduce toxicant runoff from their properties will help stop the problem at its source. In addition, buffers should be constructed between residences and the creek to cleanse runoff. Grass swales are the most practical filtration technique because they are inexpensive to construct and require low maintenance. Grass swales do not need a large area, which makes them feasible in the generally limited space between residences and Arcade Creek.

- *Golf Course runoff*

Haggin Oaks Golf Course already practices Integrated Pest Management (IPM) strategies. Although steps are already being taken to control contamination of surface water, improvements may be possible. A more detailed study is recommended to examine the effects of the IPM plan, irrigation, and fertilization practices on Arcade Creek. One simple improvement that may be effective is creating buffers between the fairways and Arcade Creek. This will help reduce the amount of runoff directly entering the creek. These buffers may take the form of grassy swales or shrubby filter strips.

Currently the cart washing area drains overland into Arcade Creek through grassy swales perpendicular to the creek. Runoff from this area may contain oils and grease in addition to detergents. The washing area should be contained with curbs or berms and runoff should be treated before reaching the creek, possibly through a filtration wetland. Realigning the swales parallel to the creek would also help filter the phosphates prior to their entering the water body. Using biodegradable phosphate free detergents would dramatically decrease the toxicants from this source.



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SCALE IN MILES

ARCADE CREEK FEASIBILITY STUDY

WATER QUALITY IMPROVEMENT OPPORTUNITIES

5.2 Flood Damage Mitigation

5.2.1 Objectives

The Arcade Creek watershed is urbanized and the majority of the land is already developed. This has multiple implications on the flood behavior of the creek. The urban environment dramatically increases runoff due to the vast amounts of impervious surfaces such as asphalt, roofs, and other pavements. Flooding is exacerbated by the many road and railroad crossings of the creek that constrain flow volume during high flow events. Many over-crossings were built without sufficient capacity to handle the amount of water traveling through Arcade Creek in major flood events. This may have resulted from the continued urbanization of the watershed following construction of the bridges, with the consequence that they now constrict the channel, causing water to back up and overflow the banks.

Flooding has significant economic and social impacts in this highly urbanized area because homes and businesses may be damaged or destroyed. While flooding cannot be eliminated in the Arcade Creek watershed without changing the fabric of the city, the effects of flooding can be diminished to reduce property damage.

As with water quality improvement, comprehensive flood damage mitigation must be done at a watershed level. Detention structures and wetlands should be used to retain stormwater that in the absence of development would have filtered into the soil and slow overland flow. Regulations should be adopted by city and county agencies where not already in place to require such structures in new construction and redevelopment projects.

Local techniques to mitigate flood damage are listed below.

5.2.2 Techniques

The following techniques may be used to mitigate high flows and thus reduce property damage from flooding:

- *Off channel detention*
  Off channel detention is typically used along tributaries and outfalls to detain stormwater before it enters the creek. Detention basins are usually sized for specific design storms, such as the 25 year or the 100 year flood and may be engineered or natural. An important consideration when designing detention basins is how to manage the potentially toxic sediments that accumulate over time. These can be captured in a separate vault structure, periodically dredged or scraped from the basin with heavy equipment, or just allowed to accumulate. If plants are allowed to grow in the basin, they may need periodic cutting and special disposal. Detention basins can be used in combination with wetlands to detain and scrub pollutants contained in runoff.

- *Erosion control*
  Erosion of banks not only impacts water quality, but can increase flooding problems. Soil picked up by floodwaters is deposited downstream and over time aggrades the stream channel. This actually reduces the channel capacity and increases the frequency of an overbank discharge. Slowing water velocities and stabilizing banks will help slow erosion and decrease flood related damages. Erosion control should involve bio-engineering techniques to develop environmentally sound solutions.

- *Channel widening*
  Laying back the stream banks allows the creek to carry a greater volume of water. The greatest benefit of channel widening is that woody vegetation can be reintroduced to the channel without diminishing the capacity of the channel to carry floodwater. This introduction of trees and shrubs can actually slow the floodwaters, detaining more water in the channel and decreasing downstream flooding. In many areas of the creek the banks can be cut back and terraced to provide a wider channel with sloping, rather than vertical, banks. This increases the stability of the banks and provides a more natural first-terrace that is better connected to the low-flow channel. This is beneficial for riparian vegetation and also for aquatic species if combined with in-channel structures such as boulders. When used in combination with revegetation, channel widening can help improve water quality and habitat value.

  Channel widening must be used with care. While the benefits are many, it is highly disruptive to the creek and the existing riparian vegetation and should be utilized only where the natural creek system is already highly disrupted and/or degraded. Planning for channel widening requires detailed hydrologic modeling to evaluate the overall effect of the widening and introduction of vegetation into the channel.

- *Channel diversions and prescriptive flooding*
  Where sufficient open space exists and the topography permits, flooding can be allowed to happen in some areas of the creek system through the use of channel diversions or overflow areas. Since levees are absent from the section of the creek examined in this study, rather than breaching levees, topography will likely require modification to reconnect old channel remnants or to create depressions for flooding to occur. Benefits of reintroduced flooding include increased backwater area for sediment deposition, better riparian habitat, and reduction of floodwater peaks downstream.

- *Debris removal*
  Large debris, such a LWD, trash, or pipes, in the creek channel can impede flows and cause water to back up and overflow the banks. However, woody debris is important in developing good habitat for fish and other aquatic animals. Selectively removing large debris, especially trash and non-natural obstructions, prior to the rainy season in October may help reduce flooding, however, before such removal occurs, a debris removal plan should be developed addressing the

various types of debris and the benefit of the debris vs. the potential for impact on flooding and hazard to downstream structures. LWD in the stream should be allowed to remain, unless it poses a hazard to downstream structures or significantly increases the likelihood of flood damage to neighboring properties.

- *Multi-scale detention strategies*
  Water can be detained in many places during storms to allow it to flow to the creek over a longer period. This reduces the probability of flooding by reducing the total amount of water flowing through the creek at any one time. Multi-scale detention strategies include using detention basins on rooftops or parking lots, French drains to catch water and allow percolation, as well as larger basins in parks, open spaces, or ballfields.

5.2.3 Potential Projects

See Figure 5-5 to review the opportunities and constraints for the potential flood damage mitigation projects.

- *Hagginwood Park detention basin*,
  A large stormdrain empties into Arcade Creek under Marysville Boulevard. Just downstream of this overcrossing is Hagginwood Park. Filtration of the water from this stormdrain is difficult in its present configuration because it empties directly into the creek. The adjoining Hagginwood Park provides open space that could be used as a stormwater detention and filtration basin. However, the stormdrain must be altered to empty into the park rather than under Marysville Boulevard. The feasibility of this realignment will take further study and engineering calculations to ensure that raising the outlet does not cause backup in the pipe and subsequent flooding in another location. Additionally the costs of altering the stormdrain, and thus doing construction on Marysville Boulevard as well as the potential modifications to Hagginwood Park, may be prohibitive.
- *Large detention pond at Reach 38-40*
  In Reach 38 through Reach 40 Arcade Creek is bordered on the left side by a large open space. This is an ideal location for constructing a large detention basin. This basin could be a seasonal or temporary wetland or it could be transformed into a permanent shallow lake. See Chapter 6 for additional information.
- *Detention in spandrelles at Watt/Longview/Bus-80*
  Spandrelles are the landscape areas inside cloverleaf loops at a highway interchange. Though often forgotten space, these areas can be used to detain water that flows off the adjoining roads. This water usually has very high pollutant levels because of the high vehicular traffic. Detaining this runoff in spandrelles can filter and settle many of these pollutants out of it before it reaches the creek.

Due to the construction of the cloverleaf the northwest and southwest spandrelles already have significant cross slopes. Water can be detained in this area by excavating a slight depression and then building up a berm on the lower end. This depression can then be planted with a variety of native wetland plants and trees.

- *Channel widening at Reach 31*
  While there is much valuable healthy riparian habitat in this reach, there may be areas where channel widening is possible without significant impact to the native vegetation. This would increase the stability of the banks without requiring armoring. This reach should be studied in greater detail to determine the feasibility of this approach.

- *Redesign of Roseville Road and Union Pacific RR Bridges*
  Currently some of the worst flooding on Arcade Creek occurs at the Roseville Road and Union Pacific Railroad Bridges. During large storm events water backs up at these bridges, overflows the stream banks, and spills south along the road embankment. Flood waters eventually turn west and may damage residential areas before rejoining the creek. This flooding is caused by combination of circumstances, including a severe lack of detention capacity in the upper watershed. The bridge over-crossings are too narrow and constrict the volume of water that can flow through the channel at this point. Additionally, Arcade Creek bends naturally at this point, which predisposes it to flood here. The Roseville Road over-crossing is the first of three set very close together. All three constrict the creek during high flow and this probably increases flooding.

  Detailed hydrologic analysis of the water system and flood response in this area is necessary before detailing restoration or mitigation solutions, however some general conclusions can be made. Although redesign of the over-crossings to allow greater flows is the preferred solution to this problem, this may not be financially possible. Other strategies might be used to mitigate the back up of water. Detention basins could be created in the open spaces well above the area that floods to provide the most benefit. Analysis of topographical maps shows that the floodwaters partially follow a historic creek channel that runs south of the current Arcade Creek. This channel might possibly be reconnected to Arcade Creek further downstream and serve as a secondary channel to safely contain high flows.

  Additional projects that may help to reduce the flooding in this area include:

  - *Create detention in the spandrelle between the light rail tracks and the Union Pacific RR tracks*. This would help to provide low flow filtration of runoff coming from tracks and road, as well as provide additional habitat.
  - *Reconnect historic creek south of Arcade Creek and Roseville Road.* Although this is possible, the potential is limited by the need to provide flood protection in the lower watershed. The lower watershed has already been highly engineered and almost fully built out, including areas that were originally in the floodway prior to the construction of extensive flood protection measures.

- *Detention in the Trap Shoot range.* Since the Trap Shoot site can provide 20 to 40 acre-feet of stormwater storage at relatively low cost, this is much more likely to be cost-effective. Moreover, the Trap Shoot option would have little potential to be in conflict with existing land use.
- *Detention and wetland along Reach 39.* A large constructed wetland and detention pond south of station point 101 would likely confer more flood damage mitigation benefit than reconnection of the relict channel below Roseville Road. In addition, the constructed wetland and detention pond would provide significant water quality and habitat functions in addition to recreational and educational opportunities.

▪ *High flow overbank spillage and detention*

In several locations within the study area, the potential exists to reconnect old channel segments or sloughs. Additionally, an option might exist to create an area for overbank spillage during big-storm events. Within the golf course, from reaches 21 and 28, an old remnant channel is still present north of the mainstem. During data collection, water was noted in this channel, so it may already receive floodwater from the creek. A study should be done on this channel remnant to examine its functioning and determine if minor topographic changes could result in additional storage area or better conveyance for floodwater.

Additionally, this study is recommending the area adjacent to the Sacramento Softball Complex (see Chapter 6) as a potential for detention and filtration wetlands. It is also possible that through minor topographic changes, floodwater from the creek could be diverted into this sizable area to detain additional water. Detailed topographic analysis and hydrologic modeling would be required to determine the feasibility of this approach.

▪ *Debris Removal*

Almost every reach was listed as having debris in the creek. However, not all of it causes potential flooding hazards or water quality issues. In fact, some organic debris helps create a healthy fish habitat. Eighteen reaches had large obstructions that could increase flooding potential.

Floating vegetation or Giant Reed obstructs the channel in Reach #1, 2, 9, 10, and 11. These plants should all be removed using a combination of mechanical and chemical means. Care must be taken to choose appropriate herbicides that will not harm the creek. Giant Reed may take multiple years to eradicate. It is also located elsewhere in the riparian corridor where it has not yet grown into the channel. It should be removed in these locations as well to prevent channel obstruction in the future. Outfalls that add many nutrients to the creek encourage the growth of vegetation to the point of obstruction. Improving water quality in these outfalls may slow the regrowth of aquatic vegetation after initial removals.

LWD is partially blocking the channel in many of the upper reaches. Reaches 31, 32, 34, 35, 36, 38, 39, and 40 were all noted to have LWD that should be removed. The one in Reach 31 should have high priority because it is causing erosion of the banks (see photograph 062802-2). In addition, two beaver dam type structures were observed, one in Reach 40 and one in Reach 41 (see photographs 071502-40, 080202-112), although no beavers were sighted. These structures should be examined and, if not built by beavers, removed. A transient's house was located on a sandbar in the channel in Reach 38 (see photograph 071502-25). During winter high flows it will be demolished and the large pieces of wood may dam the stream in narrow areas.

In the middle reaches Arcade Creek is blocked by a variety of smaller objects. Pipes are located in the stream channel in Reaches 18, 23, and 24, and a concrete structure is in Reach 16. Reach 20 is split by a cobble check dam (see photographs 052202-62, 65). These obstructions are generally smaller than those found in the upper reaches and thus should be a lower priority.

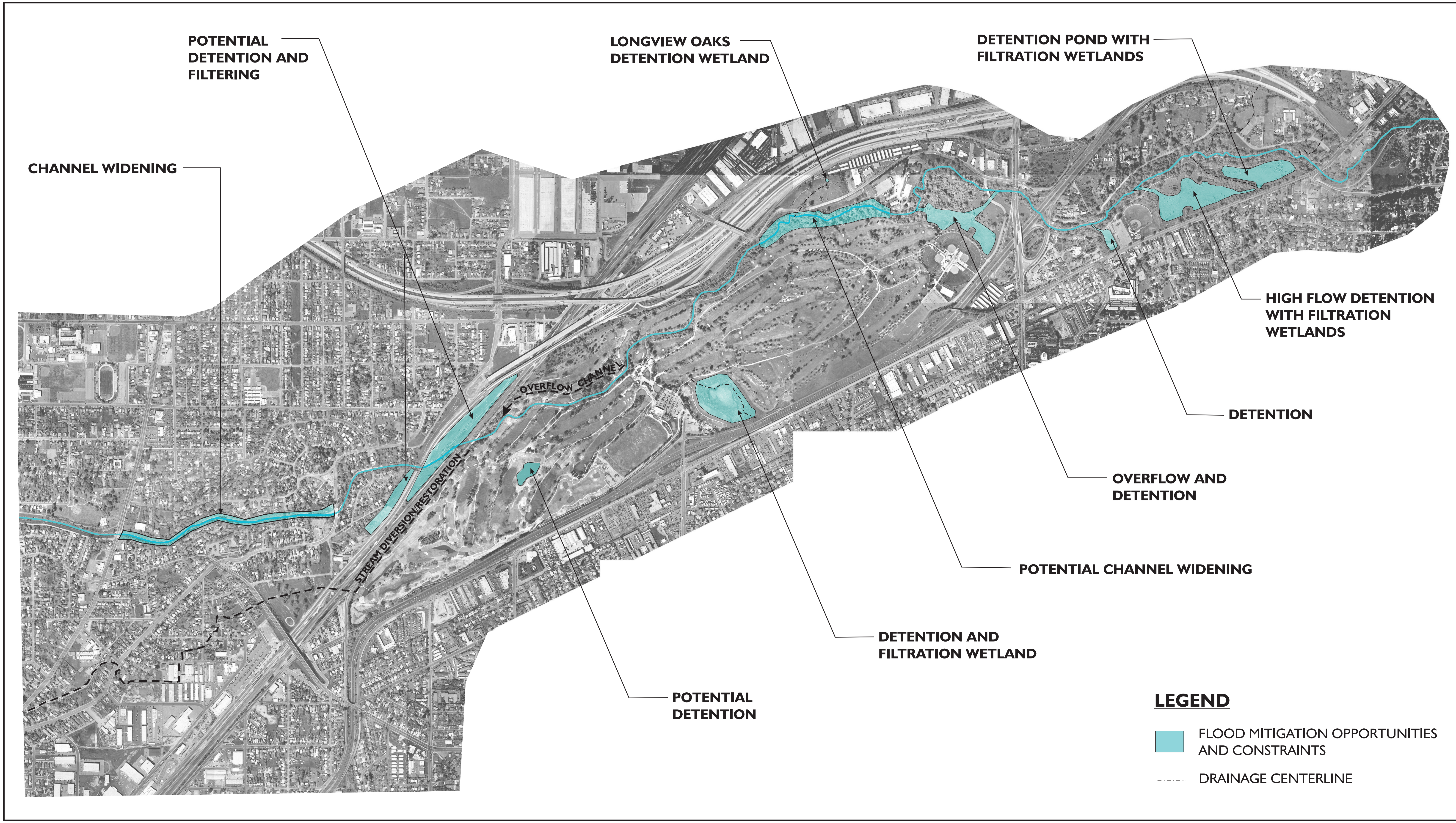
- Multi-scale Detention Basins
  Using detention strategies at multiple scales from site to regional levels can slow water before it ever reaches the creek. This will decrease the total volume flowing through the creek at any one time and thus reduce the chance of flooding. Overall, creating detention structures throughout the watershed will ease flooding by allowing more water to stay where it falls and help replenish aquifers on site. Generally, detention rather than retention basins should be used within this watershed, since the soils in the region may not support much infiltration.

  There are many opportunities for developing small scale stormwater detention. On residential lots ponds or swales can be constructed to slow water flow and allow some of it to percolate into the ground. Rooftop detention basins can be incorporated into both residential and commercial buildings in new construction, but would be difficult as a retrofit. Downspout detention structures could potentially be used on existing structures.

  Parking lots offer the potential opportunity for increasing detention of stormwater because they are large and flat and are also one of the primary producers of runoff. Parking lots for land uses that are not used during storms, such as parks and ballfields, can be designed to flood temporarily and then drain slowly as the storm subsides. Even parking lots used year round can be modified to better control stormwater. Grading paved surfaces to drain into planted median swales instead of directly into stormdrains is one technique. Alternately, the parking lot could drain into a detention wetland adjacent to the lot or site.

  Another approach to reducing runoff from parking lots, driveways, and other such structures is to use permeable pavings that allow some water to percolate into the soil. Unit pavers, permeable asphalt, and a variety of other techniques are available to decrease runoff but produce a hard, drivable surface, however, all infiltration techniques will be difficult in this watershed due to impermeability of the soils.

  Educating property owners, builders, and developers about the importance of and possibilities for incorporating stormwater detention structures is an important part of implementing this technique. Additionally, changes to building codes in the area to require less runoff from built areas can encourage implementation of these techniques. Legislative and regulatory means may be called for because the watershed is already so built out.



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ARCADE CREEK FEASIBILITY STUDY

FLOOD DAMAGE MITIGATION OPPORTUNITIES

5.3 Habitat

5.3.1 Objectives

Arcade Creek has been heavily impacted by humanities activities over the past 150 years. The riparian corridor of trees, shrubs, and vines, has been cut from miles wide to a few hundred feet wide, and in places totally obliterated. This removed habitat for terrestrial animals such as ringtail cats, raccoons, many songbirds, and raptors. It also affected the aquatic habitat by warming the creek due to reduced shade. Fish, amphibians, and reptiles were also affected by an influx of chemicals and toxins from mining, industrial and residential runoff, and automotive waste. Additionally both the terrestrial and aquatic environments have been impacted by the spread of invasive exotic plants. Many invasive plants provide no food or shelter to wildlife and often exclude valuable native plants that do. Restoring good riparian habitat in and along Arcade Creek can help preserve endangered species as well as attract species back into the area. This is important in that it helps maintain biological diversity and also because many people enjoy watching wildlife. Thus a healthy riparian ecosystem will enhance the recreational value of Arcade creek.

5.3.2 Techniques

- *Revegetation and channel shading*
  Some reaches, particularly those farthest downstream, have little to no riparian canopy cover. These areas should be replanted with native riparian trees and shrubs. This will provide habitat for terrestrial animals and also shade the channel. Many fish species are sensitive to small changes in water temperature. Some, such as salmonids, will only live in cold water. Unshaded water becomes too warm to support these species. In addition, as water warms its oxygen holding capability decreases, making it harder for aquatic animals to survive. Even warm water fish such as Large Mouth Bss prefer colder temperatures than are normally found in unshaded valley streams. Slow moving water in mostly full sun also tends to support more water weeds and algae which can further degrade the environment or even block the channel.

- *Replace gunite with more ecologically sensitive erosion control methods and restore banks,*
  In many reaches along the lower creek gunite, concrete, or asphalt coat the banks and sometimes the bottom as well. These reaches are almost completely inhospitable to life. The coatings should be removed and other erosion methods implemented that allow a healthy riparian habitat to exist.

- *Removal of invasive plants,*
  There are many exotic plants in the Arcade Creek riparian corridor. However, only some of them are aggressively invasive and therefore must be removed. These invasive plants out compete natives for a variety of reasons and without human intervention could turn Arcade Creek into a virtual monoculture with few species and little habitat value.

- *In-channel structures such as boulders*
  The creation of in-channel structures improves the aquatic habitat by providing a variety of environments for different species. Presently much of Arcade Creek is one large run with no change in depth or substrate. Adding in-channel structures such as boulders creates riffles and breaks up the creek into smaller pools. As water is forced to flow around the boulder, it begins to shape a meandering, low flow channel. Water undercutting boulders adds sheltering habitat for fish. Another benefit is that the water is aerated while going over a small drop or gravel bed. Additionally, creating in-channel structures creates recreation opportunities in that there are more places to access the water, and improves aesthetics. This technique should be used in tandem with reshaping and stabilizing banks and revegetation projects.

  Boulders are good for creating in-channel structure because they will not be washed downstream or moved, even in high flows. Large debris, such LWD and pipes currently in the stream create riffles but can catch other smaller detritus and form dams, blocking water flow and acerbating flooding. In high flows LWD can also be dislodged and carried downstream, potentially damaging bridges. In high volume situations water will simply flow over boulders. Boulders must be carefully sized to ensure that they aren't susceptible to downstream migration.

  Pallets and splash-dams, mentioned earlier, may be useful in adding structure to the stream, however, detailed studies must be done to ensure that these constructions don't become a problem to hydrodynamics or downstream structures.

5.3.3 Potential Projects

See Figure 5-6 to review the opportunities and constraints for the habitat improvements.

- *Revegetate according to channel morphologies and ideal vegetation communities*
  Many areas of Arcade Creek would benefit from revegetation, particularly in the golf course and downstream. The vegetation planted in a certain area depends upon its proximity to the water. Areas directly adjacent to the water, or which will be inundated every year should be planted with plants that prefer, or need, large quantities of water. Revegetated upland areas, which only flood in very large storm events, should have a different suite of plant species. Some areas of the creek needing revegetation are permanent uplands and will not be flooded.

  Riparian species should include:

  - White Alder, *Alnus rhombifolia*,
  - Fremont Cottonwood, *Populus fremontii*,
  - Willow, *Salix goodingii,*
  - Red Willow, *Salix laevigata*,
  - Black Willow, *Salix lasiandra*,
  - Sandbar Willow, *Salix hindsiana*
  - Willow, *Salix lasiolepis*

- Willow, *Salix melanopsis*
- Button-willow, *Cephalanthus occidentalis*
- Dutchman's Pipe Vine, *Aristolochia californica*
- Wild Grape, *Vitus californica*

Second tier species should include:

- Box Elder, *Acer negundo californicum*
- California Sycamore, *Platanus racemosa*
- Valley Oak, *Quercus lobata*
- California Buckeye, *Aesculus californica*
- Oregon Ash, *Fraxinus latifolia,*
- California Black Walnut, *Juglans hindsii*,
- Elderberry, *Sambucus mexicanus*
- Wild Grape, *Vitus californica*

Upland species should include:

- Valley oak, *Quercus lobata*,
- Interior Live Oak, *Quercus wislizenii*,
- Coyote Bush, *Baccharis pilularis*,
- Wild Rose, *Rosa californicus*,
- Toyon, *Heteromeles californicus*

- *Bank restoration/gunite replacement in lower reaches*

The banks in twelve of the lower reaches of Arcade Creek are covered with concrete, gunite, and asphalt. These bank stabilization methods are bad for habitat because they cannot support healthy riparian vegetation. Some plants do grow through cracks in the coating but these are often invasive exotics (see photographs 080202-165, 168). Gabions, large wire cages filled with stones, reinforce the banks in four reaches, particularly near the lower golf course. However, the gabions are being undercut in some places (see photograph .052202-61). Most of these reaches can be reworked to provide better habitat and still prevent erosion.

Many of these reaches have a moderate floodplain available. This would allow the banks to be cut back and the channel reconfigured. The first step of restoration in these cases is to remove the manmade bank lining. Then, the banks can be reformed to become less steep by cutting the top back. Ideally, this cut can be used to form midlevel tiers along the banks. The midlevel banks will delineate the low flow channel. Willows, cottonwoods, and other native riparian species should be planted along these banks. In high flows the water can overflow the midlevel banks but still be contained by the full banks. The addition of riparian vegetation will be offset by the greater capacity of the widened streambed, so there should be no increase in flooding. See Chapter 6, Hagginwood Park for an example of this technique. This technique should be combined with improvements in stream structure and revegetation.

The following lists the stream reaches that have bank armoring or riprap:

The right bank of Reach 3 is coated in gunite. The floodplain is 30 feet on the right side and 20 feet on the left side. The mean bank height is 15 feet.

Concrete rip rap covers the left bank of Arcade Creek from stationpoint 13.2 in Reach 5 through Reach 4. The width of the right bank floodplain narrows from 80 feet to 25 feet as you move downstream. The left bank floodplain remains narrow at 20 to 30 feet. The average observed bank depth is 18 feet.

Both the left and right banks of Reach 6 are coated in gunite. The floodplain is wide enough to nicely reshape the banks with 40 feet available on the right and 30 feet on the left.

Reach 7 is entirely contained within an asphalt channel. There is a large parking lot located approximately 10 feet from the creek on the left bank and an empty lot on the right bank. This reach is crossed by Del Paso Road and large powerlines.

Asphalt is used to reinforce the banks in some places along Reach 8 on both the left and right banks. Residences on both sides infringe heavily on the floodplain. In places there are only a few feet between the top of the concrete-coated banks and backyard fences.

Reaches 9 and 10 both have concrete banks on both sides. The undeveloped areas on both sides are approximately 30 feet. However in Reach 10, just past the light rail line is a large open space on both sides that may be used as a detention structure.

Reaches 11 through 14 are all severely constrained by the light rail, Union Pacific Railroad tracks, and Roseville Boulevard overcrossings. Concrete rip rap coves the right bank in Reach 11, 12, and 14. Reach 13 is not lined with concrete but is instead heavily eroded. However, the floodplain is wide in the areas between the roads and the creek can be restructured to improve bank stability here.

Gabions are in place on the left bank in Reaches 17 through 20 and on the right bank as well in Reaches 19 and 20. The golf course is built tightly against the creek in these reaches and there is not much space for reshaping the banks. Presently canopy cover ranges from none to 20%, with an average of 3%, so a tradeoff may need to be made between changing the channel and improving riparian vegetation due to the lack of space. Perhaps negotiations with the golf course could yield a better solution, such as wider buffers that would allow bank reshaping.

The left bank is armored with concrete directly across from a large outfall in Reach 24. This should be removed and the outfall modified to prevent it from eroding the far bank. Bioengineering techniques should be investigated for replacing the concrete armoring.

- *Restoration of relict wetlands and stream channels*,
  Mentioned in the prior section on Flood Damage Mitigation, there are several opportunities to restore historic stream channels. Additionally, further analysis of the historic aerial photographs presented in Appendix E can help to identify relict wetlands such as vernal pools for restoration.
- *Enhancement of golf course pond.*
  The golf course pond is one of several relict wetlands that are extant in a 1937 aerial photograph of the lower watershed. The original functions of the wetland

were attenuation of surface water flows, water quality improvement, aesthetics, and wildlife habitat.

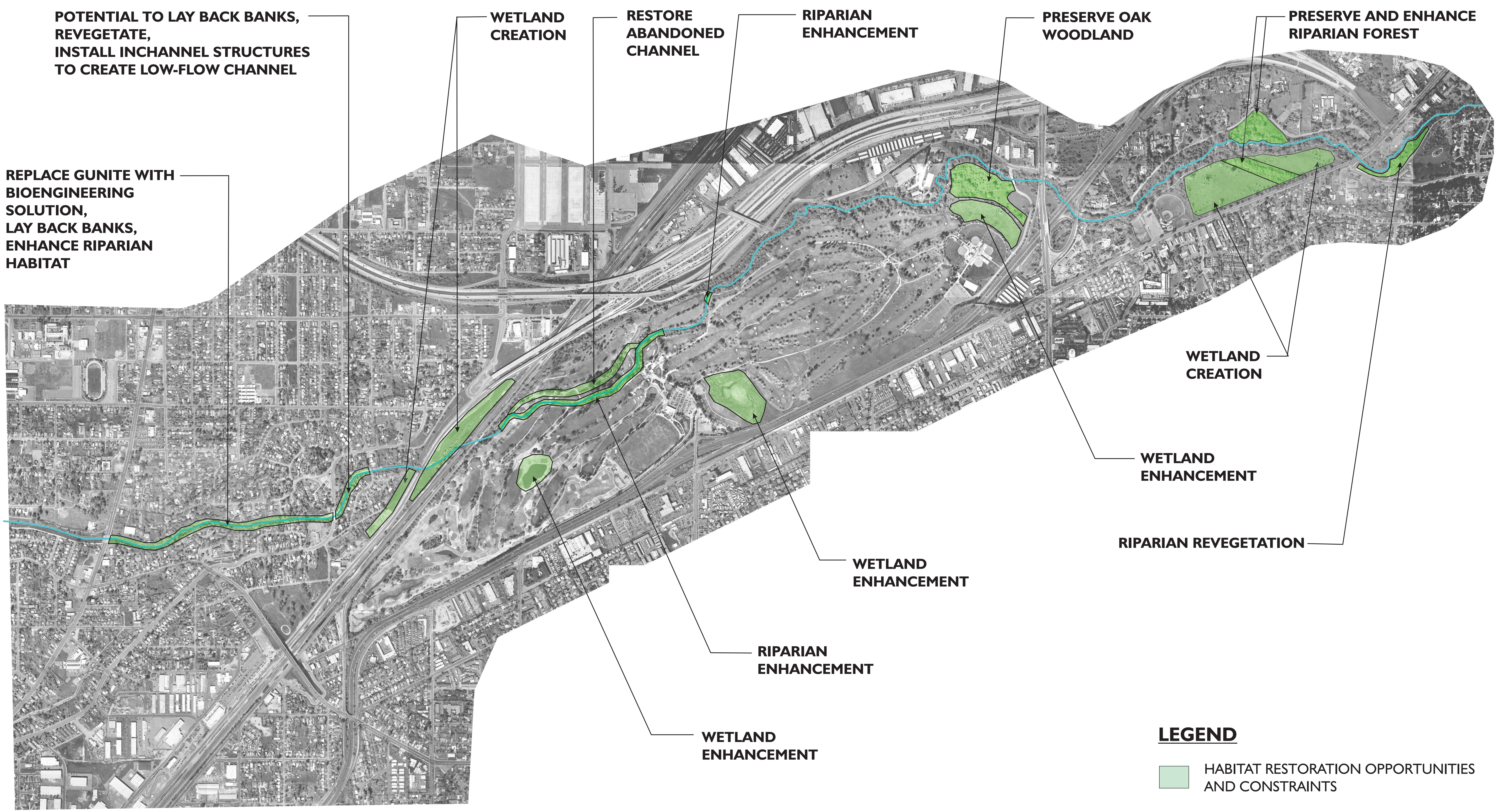
At present, the wetland is negatively impacted by the presence of invasive aquatic vegetation, degraded water quality, a lack of structural diversity, and an outlet that is a 12” culvert; the pond appears to provide very limited live storage of runoff volumes. It is also possible that the pond is used to store irrigation water, but additional research on this topic would be required. Several pumps are used to provide aeration, which indicates that the pond suffers from both low dissolved oxygen and eutrophic conditions.

All of these functions could be enhanced, even while maintaining the functionality of the golf course. For example, the outlet structure could be modified to provide additional live storage by lowering the water level prior to the rainy season. The average water level could be allowed to fluctuate up to 8” without compromising the value of plant communities that could thrive there. Given the size of the pond, this would provide approximately 0.9 to 1.0 acre-feet of detention storage for minimal cost.

The habitat value could be greatly increased by providing structural diversity, even without trees or any other features that would be taller than 6 feet. For example, emergent vegetation such as cattails and bulrushes could be planted around the perimeter of the pond. This would provide cover and nesting opportunities for bird species attracted to emergent wetlands. If portions of the pond have sufficient depth (6feet), these areas would remain open water. Other structural improvements to the pond could be in the form of logs or stumps in the water and/or an island to provide nesting habitat for birds that would be free of predation by mammals such as raccoons and feral cats.

Improvement of the water quality with source controls would provide better feeding habitat for waterfowl. The water quality would be improved if mowing, fertilization, and other measures were not conducted within 20 feet of the pond edge. Manual removal of invasive aquatic vegetation and litter would improve both water quality and aesthetics.

- *Removal of invasive plants*
  Invasive plants were discussed earlier under Section 5.0. Refer to the reach summaries to identify the reaches that have problems with invasive plants.



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ARCADE CREEK FEASIBILITY STUDY

HABITAT RESTORATION OPPORTUNITIES

5.4 Recreation

5.4.1 Objectives

Urban creeks offer an important recreation opportunity to the people living and working around them. To the many people in the area for whom long trips to the coast or mountains is not an option, Arcade Creek can provide a link to the natural world. This creek may be their only opportunity to escape their urban surroundings. Even for people who can travel, having an opportunity for natural recreation close to home is a valuable option.

Constructing a bike trail along Arcade Creek would provide a recreational resource and help improve bicycle transit in the Sacramento area. Most importantly this trail would connect with others in the region to allow easy access and thus increase use and functionality. A connection with the Ueda Parkway at Marysville Boulevard would extend this trail system to the Sacramento City limits.

Equestrians form another important group of trail users along Arcade Creek. Formalizing the horse trails already in use along the creek, if not already part of the City plan, would allow the City to maintain the trail system and keep them clean and safe. Horse and bicycle trails should be separated whenever possible. In addition to connecting trails, recreation sites along Arcade Creek should connect with other opportunities in the area such as parks and schools.

5.4.2 Techniques

- *Construction of Creekside Bike Trails*
  A bike trail along Arcade Creek can be used for recreation or commuting. The Ueda Parkway runs along Arcade Creek from Marysville Boulevard, the western end of the study area, to the mouth of Arcade Creek at Steelhead Creek. The Ueda Parkway links with the American River Parkway and the Dry Creek Parkway (in planning phase). Continuing the bike trail upstream along Arcade Creek will connect Arcade Creek with the large recreation loop surrounding the Sacramento area.

  Upstream of the study area are creekside trails managed by the Arcade Creek Recreation and Park District. Additionally, American River College is located adjacent to Arcade Creek upstream of the study area. Although not within the City's jurisdiction connecting the creekside trail to these existing trails would increase the value of all trails. The only existing bicycle lane is along Auburn Boulevard. Installing bicycle lanes along other major streets in the area such as Marysville Boulevard, Watt Avenue, Del Paso Road, and Grant Avenue as planned in the County of Sacramento Bikeway Plan, will create a network allowing access to Arcade Creek and many other areas of the city. Another important connection is connecting bikes to the light rail line. This may increase the use of bicycles by commuters as well as recreationalists, which can help decrease traffic congestion.

It is recommended that the bike trail should consist of 12 feet of paving to allow bi-directional traffic with a 2 foot shoulder for pedestrians. When located next to an equestrian trail, they should separated by a five foot buffer when possible.

- *Construction of and Improvements to Equestrian Trails*
  There is currently a large network of equestrian trails between Roseville Road and Auburn Boulevard on both sides of Arcade Creek. It is unclear which of these trails are officially sanctioned. Some are marked as bridle trails, but others are unmarked and have simply been created by the passage of horses and pedestrians over time. The full extent of the trails should be analyzed and decisions made on which ones to keep and improve and which, if any, to close off and revegetate.

  The recommended width of an equestrian trail is five feet. It should be surfaced with decomposed granite or bare dirt. Small turnouts every few hundred feet allow horses to pass each other or pedestrians. Most equestrian traffic emanates from the Sacramento Horseman's Association barn and paddock complex. This should be the central node in the equestrian trail system. Some equestrian traffic does originate from private owners and a stable on Park Road. Current access routes should be maintained for this group of users as well.

- *Recreation Nodes*
  A node is a point where multiple activities come together. Recreational nodes along Arcade Creek are sites that provide parking, access to bike and pedestrian trails, interpretive signs, and possibly restroom facilities. Nodes are generally located at the intersection of bike routes. These make them important places for maps, kiosks, trail signs or other wayfinding amenities.

- *In-Channel Structures*
  In-channel structures such as boulders offer opportunities for recreation by allowing easier access to the creek and creating pools and ponds. In the future, as habitat and water quality improve, fishing may become a viable activity along Arcade Creek. Improving channel structure will not only provide habitat for fish but places from which anglers can fish. It also provides access to the water for school field trips and recreational trail users.

5.4.3 Potential Projects

See Figure 5-7 to review the opportunities and constraints for recreation improvements.

- *Bike Lanes and Trails*
  A network of bike lanes is planned to be created along the major streets in this area of Sacramento. On-street bike lanes are proposed in the Sacramento County Bikeway Plan for the following streets:
    - Marysville Boulevard
    - Del Paso Boulevard
    - Grant Avenue
    - Howe Avenue

- Auburn Boulevard
- Winters Street
- Watt Avenue
- Longview Drive
- Winding Way

A bike trail running the length of Arcade Creek should also be constructed. Due to bank conditions and existing bridges in the lower creek it is not possible to create a trail directly along the creek for the entire length. A trail can be added on the left bank from Marysville Boulevard to Pilgrim Court. At Pilgrim Court a pedestrian and bike bridge should be constructed to cross the stream. The trail should then run along the right bank to Del Paso Boulevard. Here it should join with the Del Paso bike lane, leaving Arcade Creek and turning north, then east along Del Paso Boulevard. Where Ripley Street diverges from Del Paso, it should follow Ripley to Roanoke Avenue and turn east to Winters Street. Here the trail should split with one branch leading south under the light rail tracks and returning to Arcade Creek. The other branch should continue along Winters Street east into the light rail station to make the connection to this regional transit system. After rejoining Arcade Creek, the bike trail should pass under the Union Pacific Railroad tracks and Roseville Road. The trail should then again diverge from the creek to follow the northern border of Haggin Oaks Golf Course. It should parallel the existing equestrian trail until reaching the Longview Oaks node, where it should cross over to the left bank of the creek. From this point on the bicycle trail should follows the left bank of the creek until it reaches the City limits, often paralleling existing equestrian trails.

- *Hagginwood Park*
  Hagginwood Park is located at the downstream end of the study area. It has a large parking lot, walking trails, a community center and restrooms. This is the intersection of the Ueda Parkway Bike Trail, the planned Marysville Boulevard bike lane, and the proposed Arcade Creek Bike Trail. Visitors can use this node as a staging area and jumping off point for bike rides or walks. One limitation of this node is that users will have to cross Arcade Creek and Marysville Boulevard to reach the trails.

- *Del Paso Boulevard*
  A small, undeveloped parcel lies on the north side of Arcade Creek at Del Paso Boulevard. Large powerlines cross overhead. This is a good location for a small parking area because it provides access to the proposed Arcade Creek Bike Trail and the Del Paso Boulevard bike lane. This node could be developed as a rest area with picnic tables or benches.

- *Longview Oaks*
  Current City plans for the Longview Oaks Vernal Pool Preserve include a low impact footpath through the site and a small interpretive area. Parking is currently limited to one on-street area at the western edge of the site. This node provides access to the creek in Del Paso Park, an area with good riparian forest. There is also a connection between the planned Longview Drive Bike Lane and the

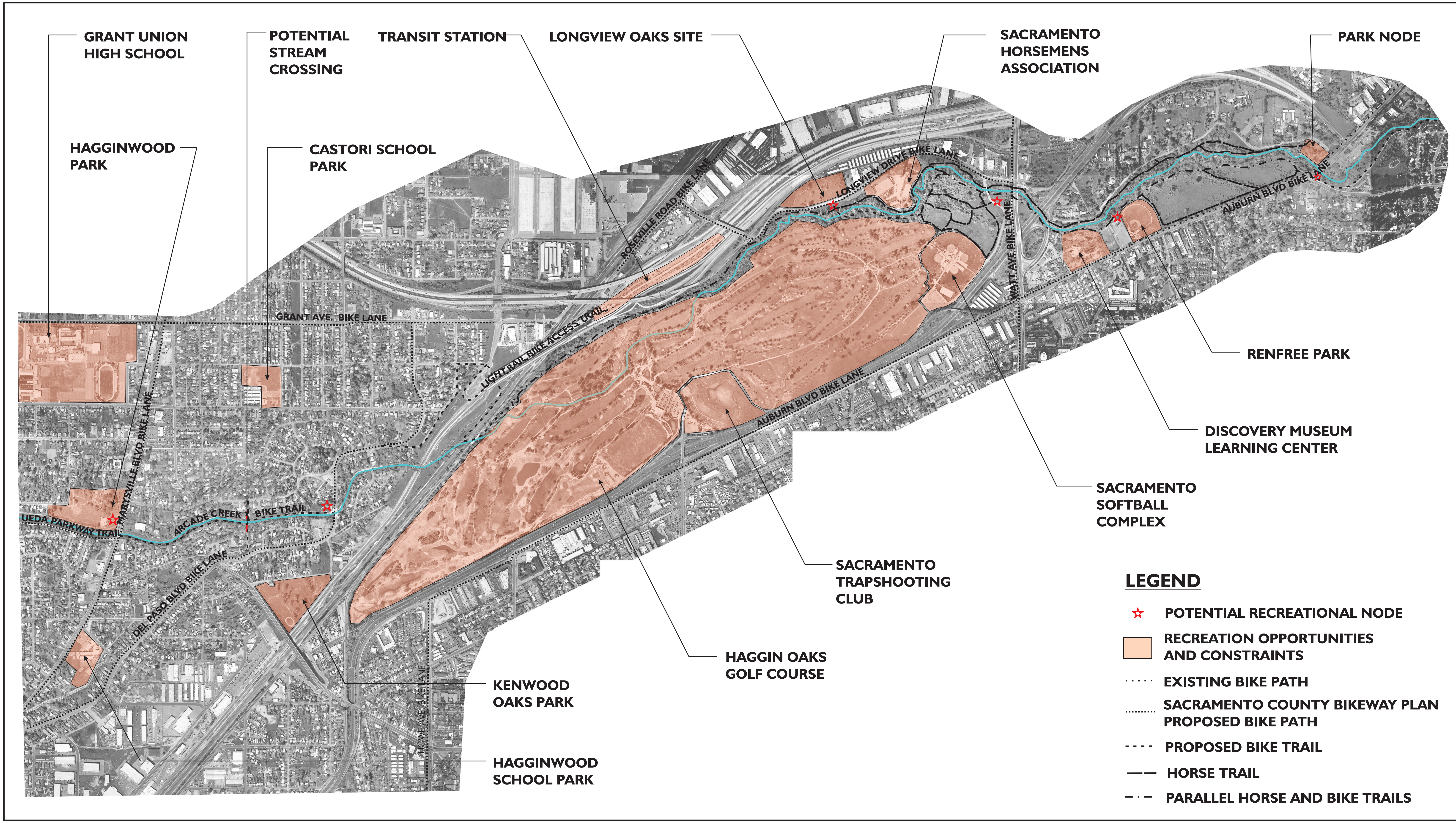
proposed Arcade Creek Bike Trail. This should be a low intensity node with limited parking, maps, and interpretive information.

Care should be taken in planning the trail crossing on Longview Drive due to the speed of traffic on this street. A traffic light, stop sign or other traffic calming techniques may be needed where the trail crosses the street.

- *Watt Avenue Detention*
  This is an important node because of its proximity to a major thoroughfare, bike and pedestrian trails, and proposed wetland enhancement. It is located next to the Sacramento Softball Complex and thus needs only a small parking area and no restrooms. This node would serve as a staging area for the existing trails winding through the oak woodland and proposed trails around the existing and proposed wetland areas. Interpretive elements should be added and incorporated to both sets of trails. The Arcade Creek Bike Trail would also be accessible from this node. See Chapter 6 for additional information.

- *Renfree Park*
  Renfree Park already has a parking lot that can be utilized as a staging area for activities along Arcade Creek. It is located between a large proposed filtration wetland and a smaller undeveloped lot that could be used to catch and filter runoff from the parking lot. Both of these bio-remediation sites would provide opportunities for education and interpretation. This node also adjoins the Discovery Museum Learning Center. An abandoned nature trail behind the Discovery Museum could be reclaimed and accessed from this node. Arcade Creek is crossed by Bridge Road at this point. Access to the bike, pedestrian, and equestrian trails is easy here because they must cross over the bridge.

- *Auburn and Winding Way*
  This small staging area is currently a small gravel lot at the corner of Auburn Boulevard and Winding Way. From this node people can access the proposed Arcade Creek Bike Trail and the Auburn Boulevard and Winding Way Bike Lanes.



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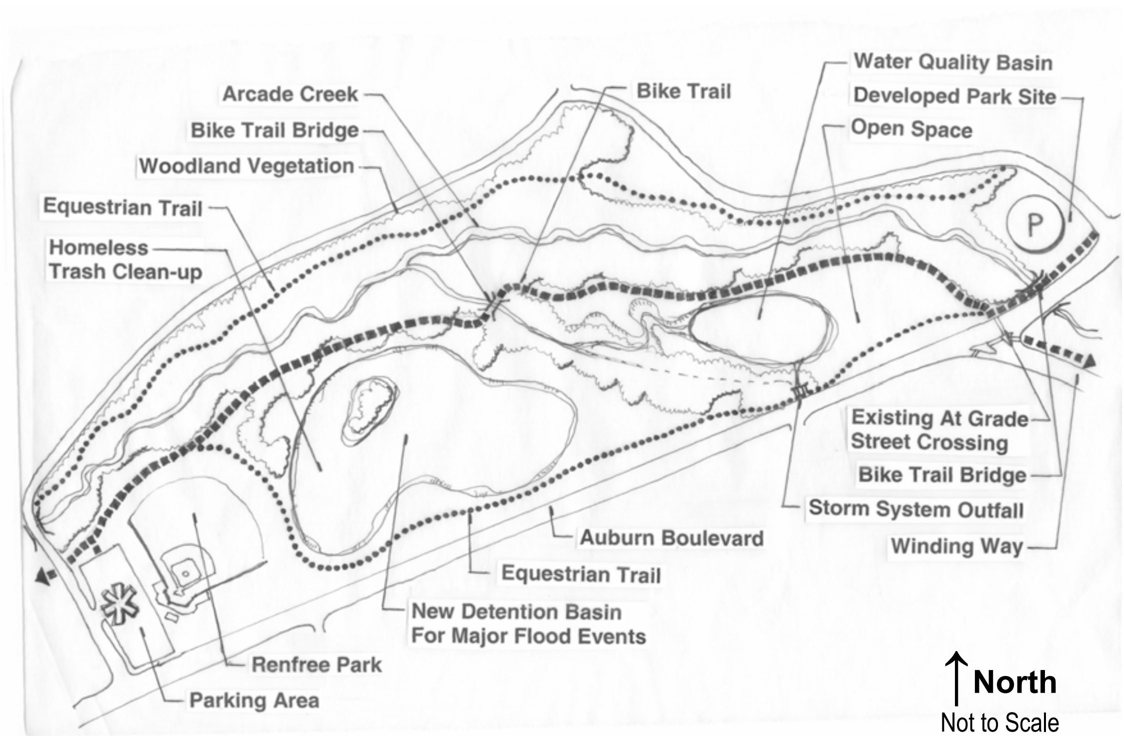
ARCADE CREEK FEASIBILITY STUDY

RECREATION OPPORTUNITIES

6.1Auburn Park Detention Basin

In Del Paso Park between Auburn Boulevard and Park Road Arcade Creek flows through approximately 30 acres of open space. On the south side of the open space at the intersection of Auburn Boulevard and Norris Avenue a large storm system outfall provides enough water to create a small stream that flows into Arcade Creek. This recommended project focuses on providing a water quality basin for this storm drainage, a detention area for large flood events, a bike path that transverses Del Paso Park, and equestrian trails that parallel the creek on the north and south sides of the park.

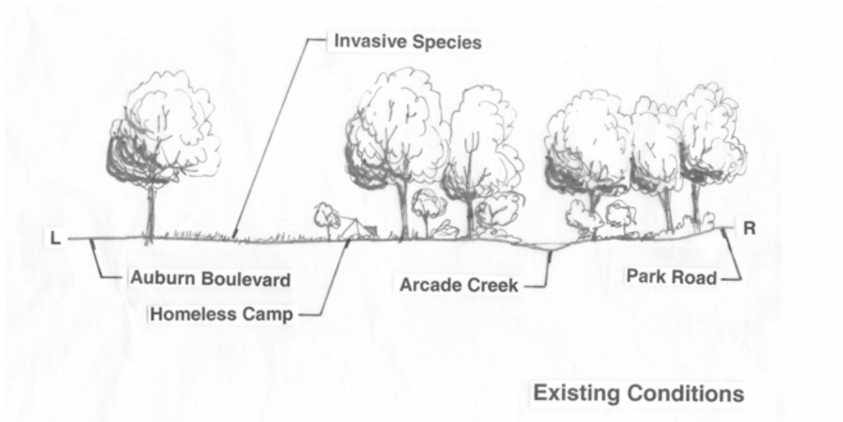


Water Quality

The large storm drain at Norris and Auburn carries mostly runoff from residential neighborhoods. Two of the main pollutants of Arcade Creek that exceed water quality criteria, Diazinon and Malathion, are commonly used household chemicals; therefore, treating residential runoff is critical to improving water quality in the stream. Given the space available on this site, it is a prime candidate for polishing the residential runoff from the outfall using wetland plants.

To create a bio-filtration system, the stream should be diverted near its outfall under Auburn Boulevard into a water quality basin located east of the current stream channel (see diagram above). In the basin, the pollutants and suspended particulates can settle out of the water and be taken up by the vegetation growing in the water. Following the settling pond, the water should flow though a filtration wetland where various plants filter additional pollutants out of the water. This wetland should empty back into the original channel close to the point where the water was initially diverted. The system should be designed to treat first-flush runoff from a storm, and work in conjunction with the detention basin discussed below.

High quality riparian vegetation exists along the subject stream and care should be taken to minimize disturbance to the existing trees and shrubs as well as the existing water course. Native plant species should be planted to replace the existing invasive star thistle field that occupies the site.



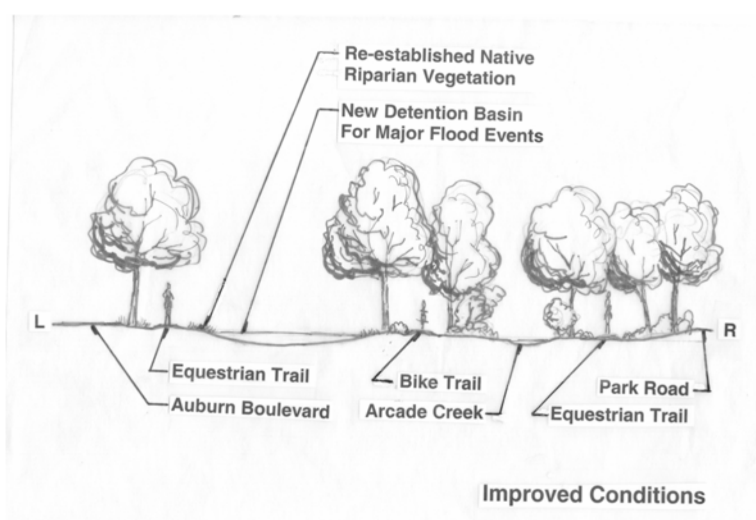
Not to Scale

Flood Mitigation

The large open space along Auburn Boulevard east of Renfree Park and West of the storm outflow channel mentioned in the water quality section is one of the largest undeveloped pieces of land in the Arcade Creek Feasibility Study Area. A large 6-8 acre detention basin could be built on this site. The basin would serve as an overflow area for the water from severe flood events, such as a 100 year flood, and be designed to work in conjunction with the water quality pond, so that the initial flush from a storm would pass into the pond, but additional runoff above a predefined level would flow into the basin. This basin could potentially be collocated with a passive recreation use space. The existing mature oaks within the proposed detention basin site can be saved by excavating around them leaving the trees on top of an island in the future basin.

Habitat

All woodland habitat that currently exists on this site is proposed to remain. The construction of the water quality pond, water quality wetland, and the detention basin will add approximately 14 acres of wetland habitat. Removal of the invasive plant species and the replanting with native plants will help increase biodiversity in plant life which will in turn



Not to Scale

increase the biodiversity in animal life.

Recreation

The existing Softball complex at Renfree Park and the adjacent large parking lot provide an excellent staging opportunity for a trail head for recreation trails that would parallel Arcade Creek. Interpretive signage along the trails and at a trailhead kiosk could explain the functioning of the water quality pond, wetland and detention basin and the impact of household pesticide and herbicide use on the creek system.

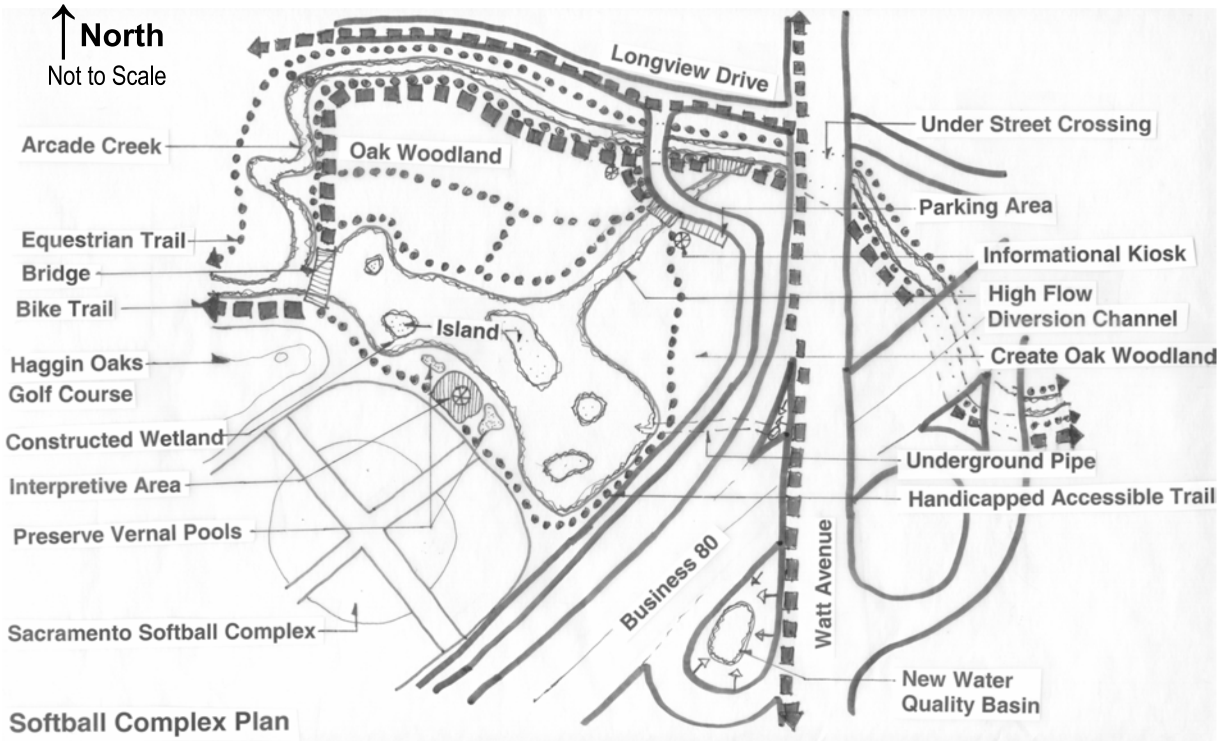
The large number of horses in the neighborhood and the neighborhood's significant historic equestrian ties to the region provide reason for adopting the existing trails in this area as standardized equestrian trails. An equestrian trail on the north side of creek and to the south of the proposed water quality and detention basins would form a loop around this portion of Del Paso Park. The bike trial on the south side of the creek would be part of the continuous trail that this report proposed to run from Marysville Boulevard East to the City of Sacramento City Limits. The bike and equestrian trails should be separated by a buffer strip as much as possible, but in areas where space is limited the users may have to share the trail.

Project Summary

This project is one of the most promising in the study area. The available space, proximity to Renfree Park, and location of the outfall and stream mean that significant issues in water quality, flood damage mitigation, recreation and habitat improvement can be addressed on this site. High priority should be given to further developing a plan for this site.

6.2 Softball Complex Wetlands

The Sacramento Softball Complex adjoins an open space that has the potential to be transformed into a filtration wetland and high water detention basin. This project offers opportunities for mitigating flood control while improving habitat and recreational opportunities. It addresses the goals of the Feasibility Study as follows:



Softball Complex Plan

Water Quality

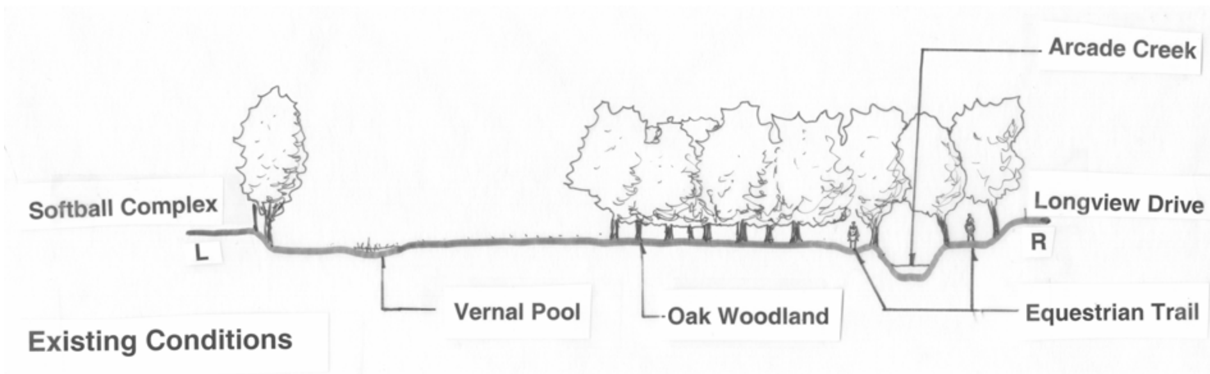
Improving water quality is not the primary goal of this project. Water flowing across this site is already filtered by the many grasses that currently occupy the site, thus the detention basin may not provide significant improvements. Some water quality benefits may be gained by draining the spandrelle between Watt Avenue and the Business 80 west on-ramp into the detention basin. This spandrelle collects runoff from two very busy roads. Directing this water overland and into a detention basin rather than into a storm drain and directly into the creek may improve water quality.

Flood Mitigation

Cutting a high flow channel from Arcade Creek to the wetland may allow it to serve as a floodwater detention structure while not impacting the creek during low flows. A detailed topographic survey of the site is required to determine if this is feasible, but if so, the basin could add new storage capacity to the creek. In addition to storing high flows, the wetlands would intercept runoff from the softball complex and freeway.

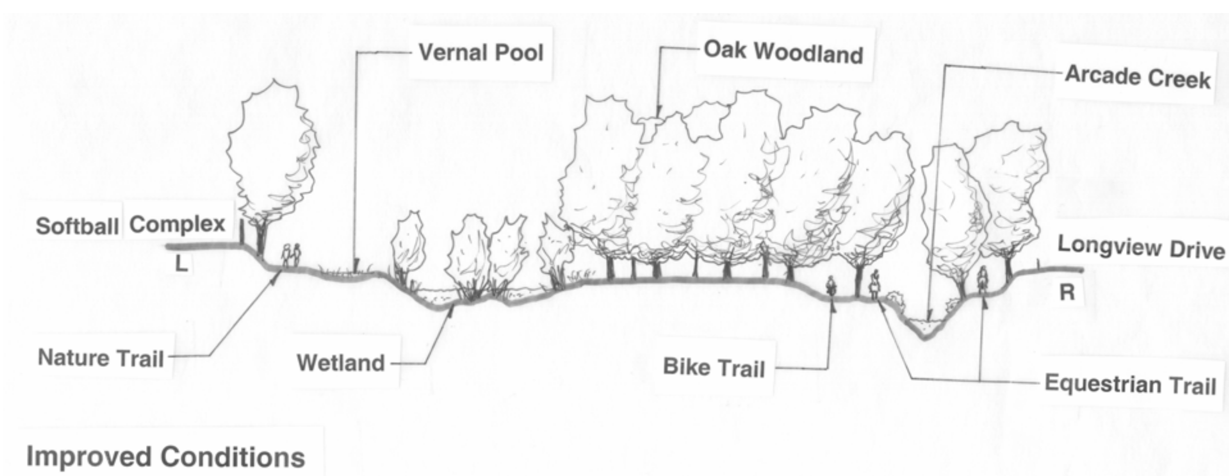
Habitat

This project has been designed to maximize habitat variety and recreation opportunities. The wetland is located away from the creek to preserve an existing oak woodland. Additionally, two existing vernal pools should be preserved. This project would construct a large wetland, a habitat that has been almost completely eliminated within the watershed. Existing annual grasses and starthistle should be replaced by oak woodlands near the softball complex access road.



Recreation

This project would serve as an important recreational node along Arcade Creek. Some parking would be added along the softball complex access road to allow hikers and bikers to park and access the creekside trail. This area currently has a number of equestrian and pedestrian trails winding through it. These trails should be retained wherever possible. The area between the two existing vernal pools, adjacent to the rear gate of the softball complex, would be an important interpretive point with seating and signage. This area could be utilized by visitors along the creek as well as by spectators and competitors at the softball complex. Interpretive elements should also be added at other locations around the wetlands and throughout the oak woodlands.

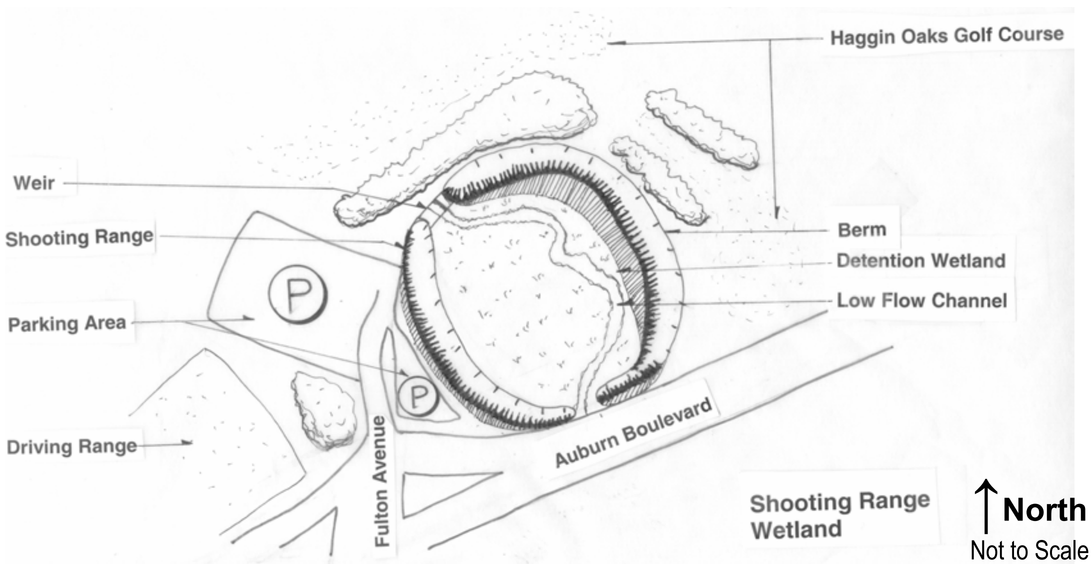


Project Summary

This project provides high quality habitat enhancements and recreation opportunities. The detention basin could be maintained as a perennial pond that would attract migrating waterfowl and provide a place where visitors to the softball complex could relax and stroll. Local schools could also use the site as an educational resource for thematic instruction. If topographically feasible, the basin could also function as an overflow area for the creek, providing additional benefits to flood control, as well as returning flooding to a site that most likely has been disconnected from the creek. This project should be a high-priority in the overall plan for this region.

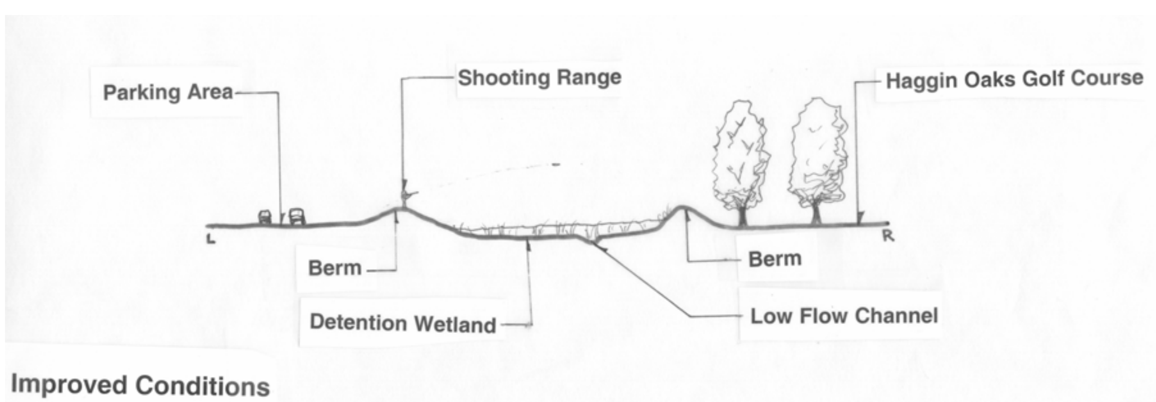
6.3 Shooting Range Detention Wetlands

The creation of detention wetlands at the Sacramento Trapshooting Club shooting range takes advantage of a naturally occurring drainage. A small creek runs through the down range area over which traps are shot. This project would build up the berms that surround this drainage and install a flow regulating structure, such as a weir, to control high flow runoff. Water currently flows into this area from a culvert under Auburn Boulevard and drains overland across the golf course into Arcade Creek. The overall flow of the drainage will remain unchanged.



Flood Control and Water Quality

The primary function of this project is to increase detention capacity during high flows. The drainage, fed by urban runoff, currently flows year-round and would continue to do so in the low flow channel defined in this project. During the wet season water would be detained in the large basin formed by the berms and slowly released to run into Arcade Creek. This drainage currently runs overland for a long distance before reaching Arcade Creek. Thus, many nutrients and pollutants may already be scrubbed from it before it



reaches the creek. The addition of other wetland plants may slightly improve water quality.

Habitat and Recreation

This project will result in the development of seasonal wetlands. However, due to the urban origins of the water entering the wetlands and the fact that they are under the target area for the trapshooting club their habitat value is questionable. The wetlands created may be suitable for reptiles, amphibians, and small mammals, but will probably be only marginal habitat for birds.

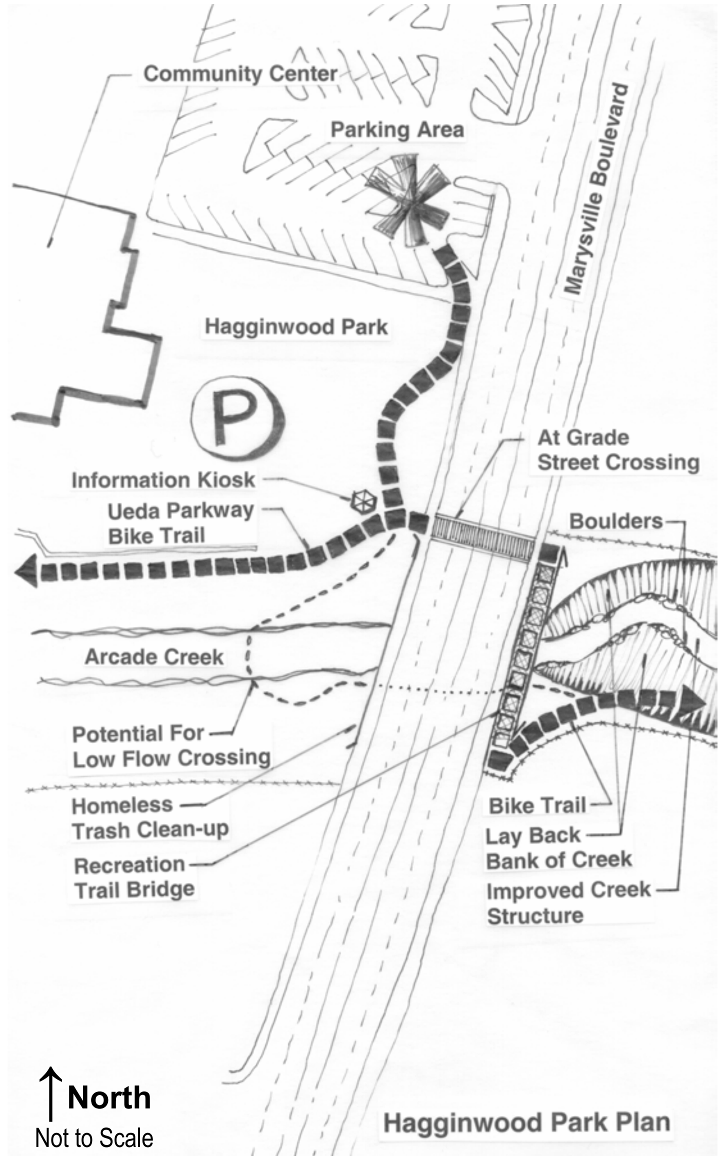
The trapshooting club holds shooting competitions throughout the year. One important influence on the habitat value, and water quality, is the type of shot used by its members. The use of lead shot should not be allowed, to prevent its being eaten by wildlife or contaminating the water. Due to the presence of the trapshooting club this wetland will not be accessible to the public or offer other recreational opportunities. It should not interfere with the activities of the club and may offer aesthetic appeal to the members.

Project Summary

This area provides approximately 9 acres of available land for additional detention. It could increase the detention capacity of the area by 9-18 acre-feet, depending upon the topographic variation between the north end of the site and the invert elevation of the outfall. It could also result in quality habitat for non-bird species, as well as an additional polisher for stormwater pollutants in the water. This project should receive a medium priority.

6.4 Hagginwood Park

The Hagginwood Park Project integrates habitat improvement and flood damage reduction through channel modification. The project offers the opportunity to link mass transit, the Ueda Parkway, and northeastern Sacramento neighborhoods together with a recreation trail. The project addresses the overall goals of the Arcade Creek Feasibility Study as follows:



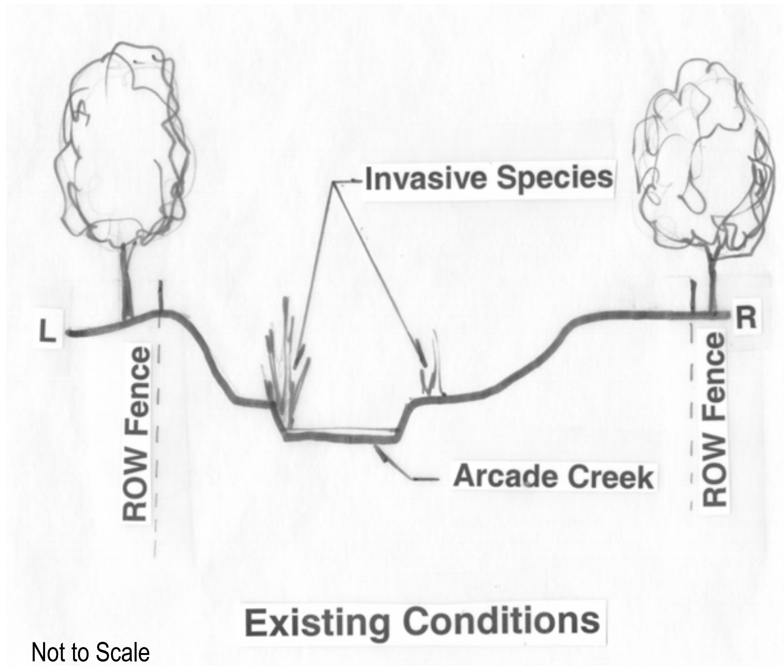
Water Quality:

The elevation difference between the large 72” outfall that flows into Arcade Creek underneath the Marysville Boulevard Bridge and the neighboring Hagginwood Park is approximately 10 to 15 feet. Because of the significant grade difference constructing a water quality detention basin in the park to capture the water from the outfall is not realistic without an elaborate pumping system and rerouting of the deep storm water pipe at the bridge. The cost of such an undertaking would be very high, but could improve the water quality from the outfall. Source identification and control is probably a better option for this outfall.

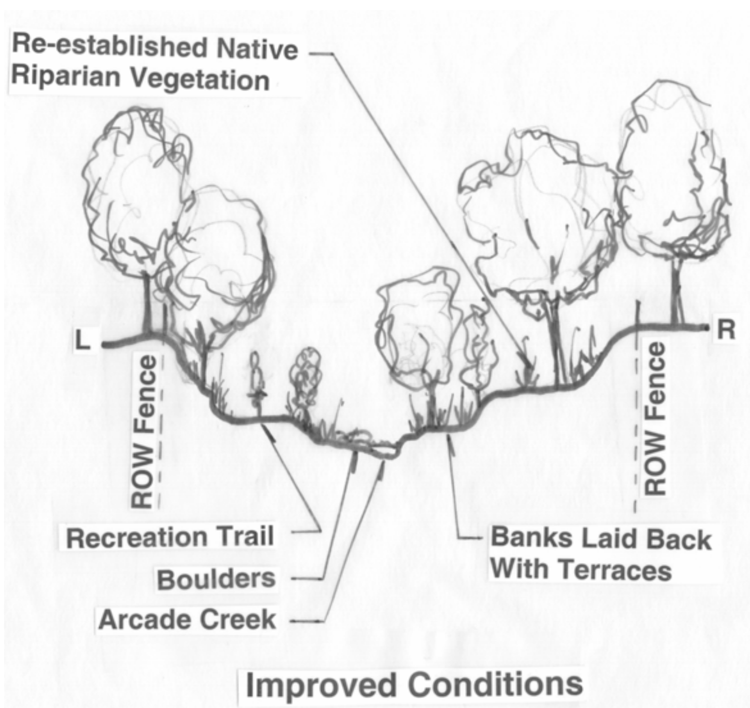
Wildlife Habitat and Flood Control:

Arcade Creek immediately east of Marysville Boulevard flows through a very wide right of way for approximately 800 feet which affords the opportunity for major regrading of the stream banks. The banks could be laid back and in-channel structures such as boulders utilized to narrow the low flow channel which in turn would begin to create structure in the creek. Boulders would also serve as shelter for warm water fish species such as large mouth bass. Laying back the banks also has the advantage of increasing floodwater capacity, which in turn allows the introduction of woody vegetation such as alders and willows to the stream channel (without increasing flood levels). Removal of invasive plant species and replanting with native plants will also help restore a healthy riparian system.

Recreation:



Located at the downstream end of the project, Hagginwood Park provides an excellent staging point for a potential recreation trail that could link up with the Ueda Parkway Bike Trail and follow the creek east to the city limits. Due to the topography and geographic constraints the trail would need to be located on the south bank of the creek in this area. The Ueda Parkway Bike Trail is slated to be on the north side of the creek, therefore a bridge would be required to link the paths. This may utilize the existing bridge at Marysville Boulevard or a separate structure. Alternately, a low flow crossing in lieu of a bridge over the creek is a less expensive option and should be investigated.



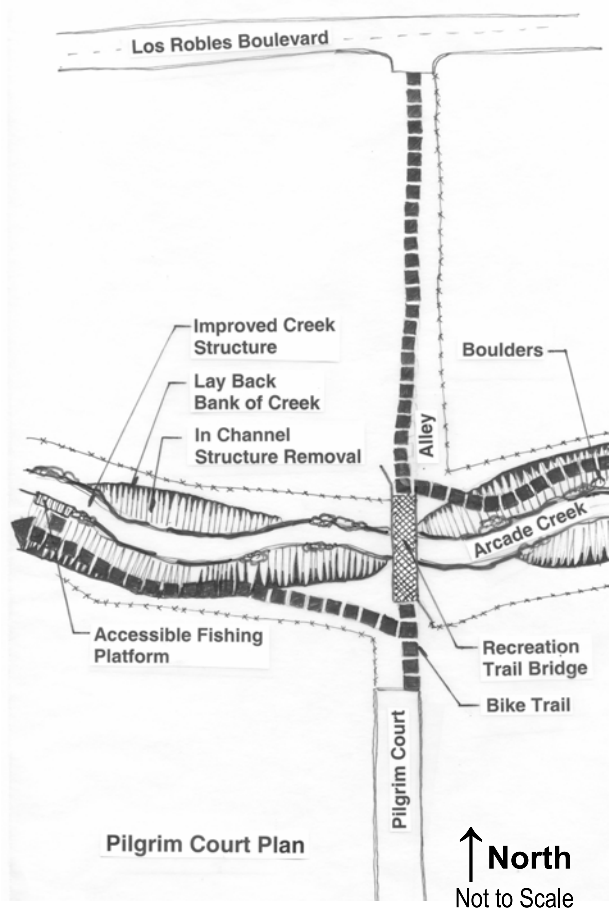
If this is to be a primary commuter route, however, it should be accessible year-round. Another challenge would be constructing an at grade street crossing across Marysville Boulevard, a major thoroughfare. This crossing may use a traffic light, although a low-flow path underneath the bridge might be possible.

An interpretive kiosk illustrating the current conditions of Arcade Creek and the creek after the proposed improvements would be a great addition to Hagginwood Park. The kiosk could chart the conditions of the creek, historic changes of the region, the impact of development on the creek and provide educational information about urban creeks in general. The kiosk could also serve as a mile marker for the overall Arcade Creek Recreation Trail.

Project Summary

This project combines valuable recreation trail linkages with a node for a trailhead containing interpretive signage. Laying back the creek banks would provide habitat enhancements and greater floodwater capacity as well as increasing educational opportunities and significantly improving the aesthetics of this highly modified and armored section of the creek. The proximity of residential neighborhoods to the creek in this section increases the importance of a natural stream corridor and should ensure the heavy usage of a trail in this area. This project should have a medium to high priority.

6.5 Pilgrim Court



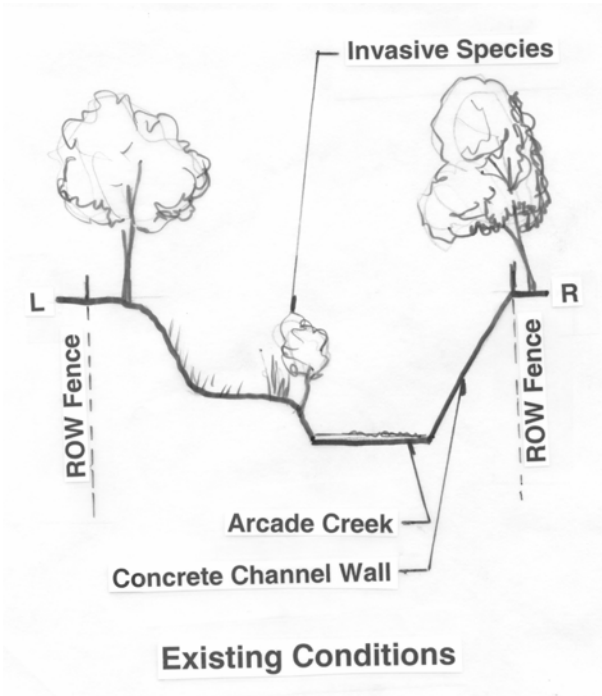
Pilgrim Court is a short residential street located approximately halfway between Marysville and Del Paso Boulevards. This project's main accomplishments would be improved wildlife habitat through removal of the impervious materials on the streambanks and the construction of a bridge for the recreation trail that could also be used by local residents for better pedestrian access within the neighborhood. The goals of the Arcade Creek Feasibility Study are addressed as follows:

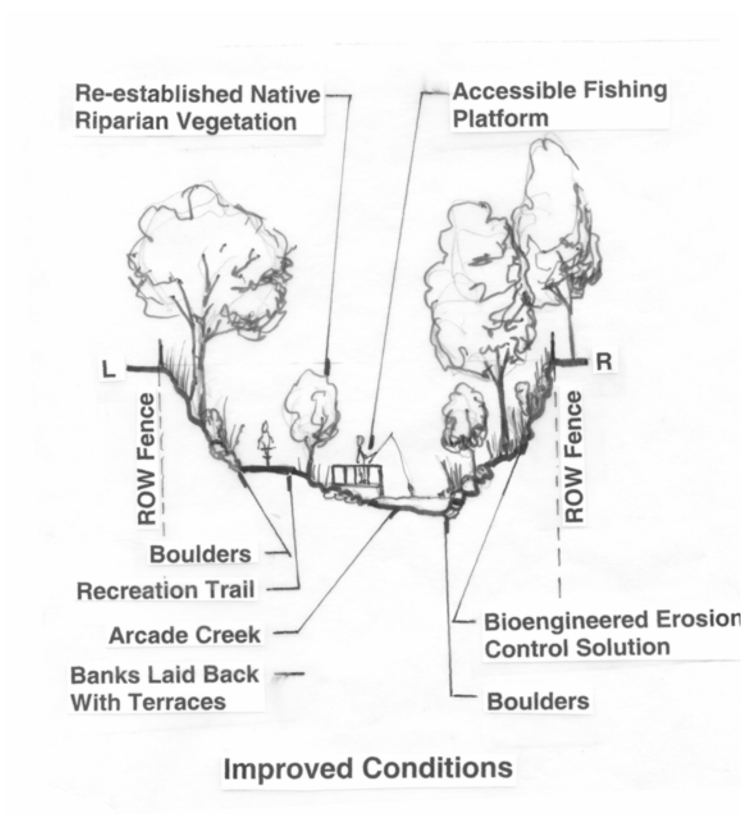
Water Quality

The narrow right of way of Arcade Creek through the Hagginwood Neighborhood physically limits what can be done to improve the water quality in this segment of creek. Perhaps the best way to improve water quality is to develop a program of informing and educating residents in the neighborhood about the effects that common household chemicals and products can have on the creek system. Residents who own property that backs up directly to the creek should be educated not to dump trash over the top of the fence. Additionally, if sufficient room exists, a narrow grassed swale could be built at the top of the slopes to catch runoff coming from the adjacent properties. This swale could be built into the banks of a redesigned stream channel.

Wildlife Habitat and Flood Control:

In the past, flood control along Arcade Creek in the vicinity of Pilgrim Court has been accomplished by paving the channel to reduce erosion and channel roughness. Most of the creek banks up and downstream of Pilgrim Court are completely or partially covered in gunite, concrete, asphalt, and/or other impervious surfaces. Much of the creek in this section is essentially a paved canal. To restore this section of the creek to a more natural state, while maintaining erosion control and floodwater conveyance capacity, the current bank armoring should be replaced with ecologically sensitive erosion control methods. Bioengineered solutions would allow for plant material to grow on the banks of the stream while providing comparable erosion protection. Using environmentally sound





bank stabilization methods, the creek bed could serve as rich habitat for an array of wildlife. In-channel structures and the addition of boulders to the stream banks would provide improved habitat for aquatic life. Removal of invasive plant species from this section of Arcade Creek would help to prevent competition with the existing native vegetation. If not removed, invasive aquatic plant species may eventually replace native species and create a monoculture within the creek – a monoculture of plants that provide little to no habitat value for a diverse community of wildlife.

Recreation:

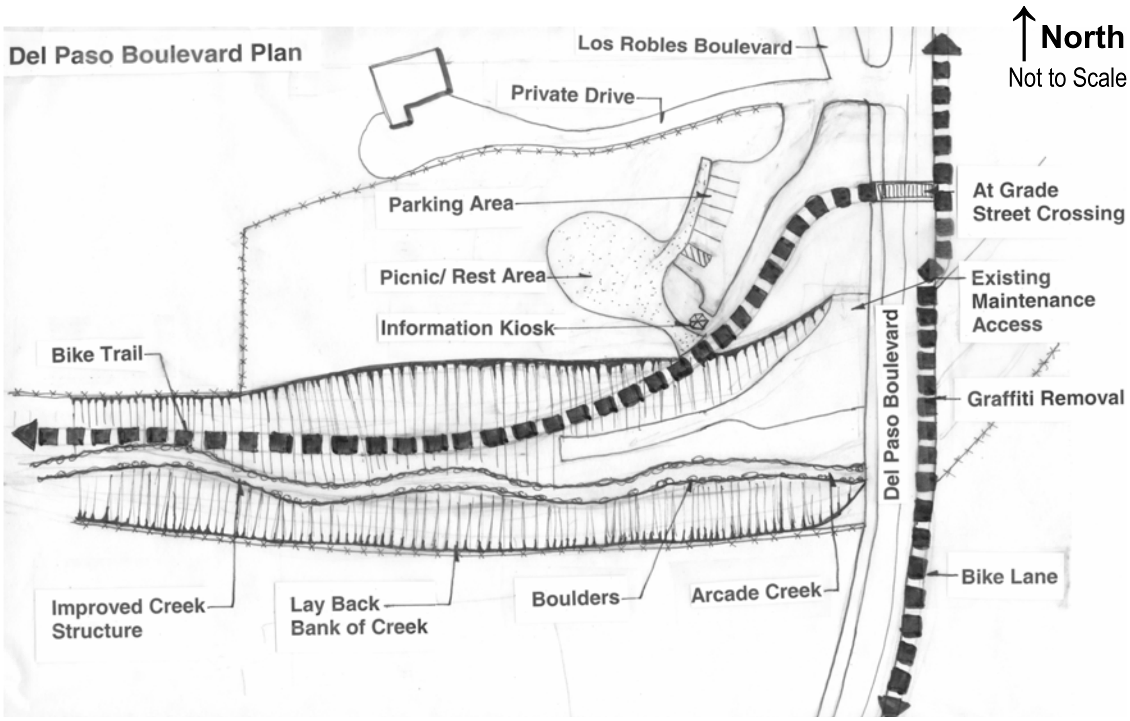
The Arcade Creek right of way should cross the creek at Pilgrim Court. West of where Pilgrim Court dead ends into Arcade Creek the south side of the stream has a wider bank than the north, however, east of the intersection the north side of the stream has the wider bank. Across the stream from Pilgrim court is a wide alley corridor that links up to Los Robles Boulevard. A bridge linking Pilgrim Court to the alley across Arcade Creek would also allow the bike trail to cross at that point while remaining on the side with the widest bank. The bridge crossing would also provide access to the residents on the south side of the creek via Pilgrim Court and to residents on the north side of the creek via Los Robles Boulevard. As the health of Arcade Creek improves following recommendations in this plan and in the watershed plan currently under development, fishing may once again become a viable sport along its banks. Wooden pallets in the stream along the edges of the creek combined with boulders and revegetation would provide shelter from predators to fish and other aquatic life, such as crayfish. Fishing platforms could be constructed along the path that are ADA accessible and close to or overhanging the creek edge. All structures placed in the creek would require engineering to withstand the high water flows.

Project Summary

This project provides key habitat improvements such as replacement of bank armor with connection of recreation trails. It is a moderate to high priority and should be combined with the Hagginwood Park improvements.

6.6 Del Paso Boulevard Staging Area

The intersection of the Del Paso Boulevard Bike Lane and the Arcade Creek Bike Trail is an important recreational node. There is a vacant lot adjoining the creek on the north side with power lines running over it. At this point, the Arcade Creek trail should leave the creekside to bypass the constriction of the corridor at the light-rail bridge and connect to a spur that links the trail system to the light rail station. This project provides these trail linkages, parking, and a picnic and rest area for people using the trails.



Water Quality

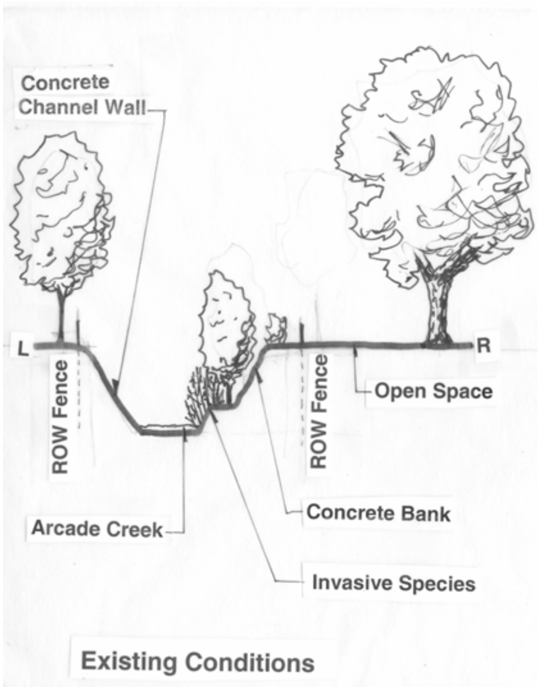
The right of way along this section of the creek is very narrow, limiting the techniques that can be used to improve water quality. As in previous projects, the most effective technique for improving water quality is probably to educate local residents about proper management of household wastes and toxins.

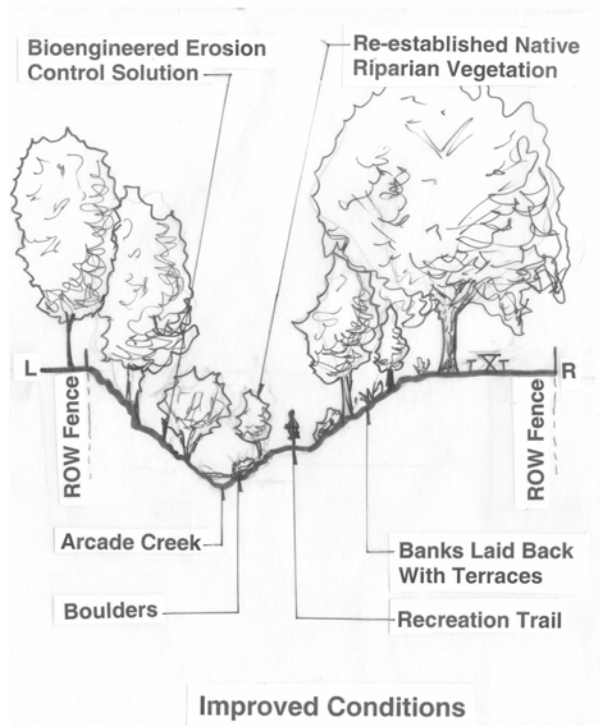
Flood Control and Habitat

As discussed previously, both banks in this area are partially covered in asphalt and concrete, which stabilizes the banks but provides little wildlife or aquatic habitat. Due to the narrowness of the corridor, the creek channel cannot be widened, however, it can be reformed to improve the habitat value and maintain stable banks and flood capacity. A deeper, but narrow low-flow channel should be cut to improve habitat quality for aquatic species. This channel should meander through the creek bottom and around boulders to improve the diversity of aquatic habitat. The banks should be reshaped to create terraces, which would increase biodiversity. These terraces should be planned to flood in high-flow events. This will improve habitat while maintaining flood capacity. The removal of invasive plant species will also help improve habitat quality and biodiversity.

Recreation

This would be an important recreational node on Arcade Creek, because it would serve as a jumping off point for people wishing to use the trails for hiking or biking. A small parking area would allow users to easily access the trails. In addition, this area should have a small picnic area with tables and benches for trail users to rest stop and rest. An information kiosk with maps of the trail system and information on the restoration of Arcade Creek is another important feature that should be located at this site.





Project Summary

While the majority of the benefits of this project come from the recreational linkages, removal of bank armoring and revegetation would have significant habitat value. This project should be planned with the previous two as part of a bike trail improvement plan for this region.

7.0 GLOSSARY

Detention Wetland	A wetland designed to detain stormwater and filter pollutants. Compared to a detention basin, which is just designed to store stormwater and possibly to filter sediments, the main goal of the detention wetland is to filter pollutants from the water.
Constructed Wetland	A wetland designed to detain runoff and filter pollutants from the water. Typically shallower than a detention basin, its primary purpose is the filtering and uptake of impurities.
First-flush	The stormwater resulting from the initial rain in a storm. This runoff typically carries the greatest concentration of pollutants and is the most important to treat prior to entry into the stream system.
GIS	Geographic Information Systems are computer-based tools that allow spatial mapping, analysis and organization of data. ESRI's ArcView 3.2 was used as the GIS for this project.
GPS	Global Positioning Systems are hand-held or backpack satellite based positional systems that record coordinates for a users location to an electronic file, as well as depict the users location on a digital map. The complexity of the GPS System determines its accuracy and ability to integrate with GIS maps. For this study, a simple hand-held Garmin GPS was used, and coordinates were manually copied into an Excel Spreadsheet and transferred to the GIS.
LWD	Large Woody Debris is any large piece of relatively stable woody material having a diameter greater than ten centimeters and a length greater than one meter that intrudes into the stream channel.(2)
Run	A section of the stream without pools or riffles, or between two pools/riffle sequences. This is typically defined as a "reach", but since this study uses "reach" to apply to changes in the broader stream-corridor, "run" was used instead.
Sinuosity	The length of the stream channel divided by the valley length. For the purpose of this study, stream sinuosity was classified as Low, Moderate or High, with low being less than 1.5, moderate being 1.5 to 2 and high being greater than 2.
Spandrelle	The left-over spaces in between the on and off ramps of a freeway or major highway interchange. These spaces are typically left-over land that may be ideal for catching and filtering runoff from the adjacent roadways.
Water Quality Basin	A detention basin designed to catch the first-flush during a storm and settle out sediments prior to the water being filtered by a constructed wetland.

Reach ID: 1

Starting Stationpoint: 0.0
Ending Stationpoint: 4.0
Photographs: 080202: 126-132, 126b

Channel Characteristics

The stream channel in this reach has low sinuosity. Streambed is mostly silt with some organic debris but no sand, gravel, cobbles, or boulders. The banks are well laid back with a bankfull width almost five times the observed width. The available floodplain is 105 feet wide. Water velocity is very slow at .2 feet per second. There is no canopy cover. Stream structure is poor with no riffles occurring in this reach.

Vegetation and Wildlife

Left bank vegetation was rated poor with only primary canopy and herbaceous vegetation forming a 15% canopy cover. Dominant trees on the left bank include Valley Oak, Willow species, Catalpa, Oregon Ash, Box Elder, Chinese Elm, and Silver Maple. Understory species include Chicory, Tule, Canary Grass, Prickly Lettuce, Curly Dock, Cocklebur, Fennel, and the invasive species Yellow Star Thistle. Right bank vegetation is rated as poor and has a canopy cover of only 5%. Species observed on the right bank are Valley Oak, Willow species, and Tule. Invasive species include Tree of Heaven and Giant Reed.

No birds or aquatic animals were observed in this reach.

Land Use

The left bank is bordered entirely by residential developments. Right bank land use is a mix of residential and commercial areas.

Outfalls

There are three outfalls in this reach. Two are 12” in diameter. One of these drains a residential development and is located less than 10 feet from the creek. The other drains a commercial development and is located between 10 and 50 feet from the creek. The third outfall is 72” in diameter and drains Marysville Boulevard. It is located between 10 and 50 feet from the creek, and has black growths in the pipe.

Restoration Opportunities

Restoration opportunities in this reach include removing invasive species and revegetation as well as trash cleanup. There is also a homeless camp on the left bank at Marysville Boulevard that should be cleaned up. Water quality may be improved by diverting water into a detention basin or filtering outflows from the pipe draining Marysville Boulevard.

Reach ID: 2

Starting Stationpoint: 4.0
Ending Stationpoint: 7.0
Photographs: 080202: 125, 133-140, 137b

Channel Characteristics

The stream channel has medium sinuosity. Streambed is mostly silt with some organic debris and no sand, gravel, cobbles, or boulders. Bankfull width is slightly over two times the observed width. The left bank has a ten-foot terrace while the right bank is cut at points and has sandbags scattered along it. Obstructions in the stream include *Arundo* clusters, which in places block almost the entire channel. Available floodplain width is 60 feet. The creek is very slow moving with a velocity of .2 feet per second and has a canopy cover of 10%. Stream structure is poor, being one continuous pool.

Vegetation and Wildlife

Left bank vegetation is rated as poor with no secondary canopy and only 20% canopy cover. Dominant tree species include Valley Oak, Almond, Catalpa, White Mulberry, Willow Species, and Chinese Pistache. The understory includes Sedges, Tule, Canary Grass, Marsh Marigold, Chicory, and Morning Glory. Invasive species include Silktree and Common Fig. Right bank vegetation is rated poor. It has an 80% canopy cover but a width of only 10'. Invasive species include Black Locust, Tree of Heaven, Giant Reed, and Himalayan Blackberry. Other species present are Valley Oak, Canary Island Date Palm, California Black Walnut, Wisteria, Acacia, Plum, and Privet. Scrub Jays and a Kingfisher were observed in this area.

No animals were observed in the water.

Land Use

Land use on both sides of the creek is residential.

Outfalls

There is one 8" outfall draining a residential area that is located between ten and fifty feet from the creek.

Restoration Opportunities

Restoration opportunities in this reach include removing invasive species and revegetation, trash cleanup, and removing concrete box and metal grate on the bank. Removing *Arundo* from the channel will help prevent further erosion of the banks and improve flows, particularly during storm events.

Reach ID: 3

Starting Stationpoint: 7.0
Ending Stationpoint: 8.3
Photographs: 080202: 141

Channel Characteristics

The stream channel in this reach has a low sinuosity. The streambed is made up exclusively of silt. The bankfull width is 2.5 times the observed width. Overall bank condition is poor. The left bank is steep with a vegetated access road while the right bank is steep and covered with gunite to a boundary fence. The available floodplain is fairly narrow at 50 feet wide. Water moves very slowly through this reach at a velocity of .2 feet per second. Canopy cover is only 5%. Stream structure is poor, with no riffles in this reach.

Vegetation and Wildlife

The left bank vegetation is rated as poor with trees and herbaceous vegetation making up the 30% canopy cover. Primary species are Tule, Interior Live Oak, Almond, Plum, Beefwood, Catalpa, and Valley Oak. Invasive species include English Ivy and Red Sesbania. Right bank vegetation is rated as poor with no secondary canopy. It has a 50% canopy cover but only a two-foot width. The only species observed on the right bank were Valley Oak, Oregon Ash, and Periwinkle.

Mallards and a hummingbird were observed in this reach but no aquatic species were seen.

Land Use

Residential areas border both sides of the creek.

Outfalls

There are no outfalls in this reach.

Restoration Opportunities

Removing the gunite covering of the bank and subsequent bank stabilization using other techniques are the primary restoration opportunities. Other improvements include removing invasive plant species, revegetation, and trash cleanup.

Reach ID: 4

Starting Stationpoint: 8.3
Ending Stationpoint: 11.0
Photographs: 080202: 142-148, 145b

Channel Characteristics

The stream channel in this reach has very low sinuosity. Streambed is mostly silt with some organic debris and no sand, gravel, cobbles, or boulders. At four times the observed width, the bankfull width is good. Overall condition of banks is poor with the left bank covered with concrete rip rap and terraced with an access road that is covered in herbaceous vegetation. The right bank is very steep and covered with grass and weeds. Available floodplain width is 80 feet. The creek is slow moving with a velocity of .2 feet per second and has a channel canopy cover of 20%. Stream structure is poor, consisting of one continuous pool.

Vegetation and Wildlife

Left bank vegetation is rated as poor, composed mainly of trees and herbaceous plants, creating a 30% canopy cover. Dominant trees on the left bank include Valley Oak, Fremont Cottonwood, Oregon Ash, Box Elder, London Plane Tree, White Mulberry, Silver Maple, and Interior Live Oak. Invasive species include English Ivy and Himalayan Blackberry. The understory consists of Sedge, Tule, Chicory, Fennel, and Scarlet Firethorn. Right bank vegetation is also poor, composed mainly of trees and herbaceous plants, and has a canopy cover of only 20%. Dominant trees on the right bank include Valley Oak, Willow species, Almond, and California Black Walnut. Invasive species include Common Fig and Himalayan Blackberry. The understory includes Oleander, Privet, Tule, and Fennel.

Mallards and an American Robin were observed in this reach, as well as fingerlings in the water.

Land Use

Residential land use was noted on both sides of the stream.

Outfalls

There are two 36” outfalls located in this reach, both draining residential areas. One is less than ten feet from the creek and had some clear water flowing out of it. The other is between ten and fifty feet from the creek and is not connected to a drainage pipe system, instead the observers could see through it to the other side. There was no outflow from the second pipe.

Restoration Opportunities

Due to the bankfull and floodplain width this reach offers an excellent location for removing the concrete bank and using other stabilization techniques to improve habitat, recreation value, and flow. Other restoration opportunities on this reach include revegetation, invasive species removal, and trash cleanup.

Reach ID: 5

Starting Stationpoint: 11.0
Ending Stationpoint: 14.5
Photographs: 080202: 149-155

Channel Characteristics

The stream channel in this reach has a low sinuosity. The streambed is consists mostly of streambed silt with some organic debris. The bankfull width is excellent at five times the observed width. However, bank conditions are poor. The left bank is eroding and covered with concrete for one third of the reach. There is a 16-foot wide terrace on the right bank. The available floodplain is 60 feet wide. The stream is very slow moving at .2 feet per second and has a channel canopy cover of 50%. Stream structure is poor with only one large pool and no riffles.

Vegetation and Wildlife

Left bank vegetation is rated fair with a 30% canopy cover. Dominant species include Oregon Ash, Valley Oak, Willow species, Fremont Cottonwood, and American Elm. The understory includes privet and Virginia Creeper. Invasive species on the left bank are Silktree, Common Fig, and English Ivy. Right bank vegetation is rated poor with only 5% canopy cover and no secondary canopy. Dominant species on the right bank include Willow species, Box Elder, Valley Oak, Siberian Elm, Catalpa, and London Plane Tree. The understory is made up of Tule, Sedges, March Marigold, Cocklebur, *Polygonum*, Prickly Lettuce, Wild Rose, Canary Grass, and Morning Glory. Invasive species on the right bank are Common Fig, Silktree, Himalayan Blackberry, Mustard, and Honey Locust. Acorn Woodpeckers and Scrub Jays were observed along with potential roosting sites in dead trees.

Fingerlings were observed in the water.

Land Use

Residential land use was noted on both sides of the stream.

Outfalls

One 8" concrete outfall is located between 10 and 50 feet from the stream.

Restoration Opportunities

Restoration opportunities in this reach include removing invasive species and revegetation and trash cleanup. Removal of the concrete bank lining and bank stabilization are also potential restoration projects.

Reach ID: 6

Starting Stationpoint: 14.5
Ending Stationpoint: 15.5
Photographs: 080202: 156-160, 159b

Channel Characteristics

The stream channel in this reach has low sinuosity. The streambed consists mostly of silt with some organic debris. The bankfull width is five times the observed width. Both the left and right banks are coated with gunite, although the left bank is eroded. The width of the available floodplain is 60 feet. The stream flows slowly at .5 feet per second. There is 70% channel canopy cover. Stream structure is poor consisting of only one large pool.

Vegetation and Wildlife

Left bank canopy structure is good with trees and shrubs creating 100% canopy cover. Dominant trees include Oregon Ash, Canary Island Date Palm, Interior Live Oak, Valley Oak, and Siberian Elm. The understory includes Marsh Marigold and Oleander. Invasive species on the left bank are Common Fig, Himalayan Blackberry, English Ivy, and Loquat. Right bank vegetation is poor with only 5% canopy cover. Trees observed are California Black Walnut, Box Elder, Catalpa, and Willow species. Understory plants include Annual Sunflower, cocklebur, and Tule. Honey locust is also present on the right bank.

Fingerlings were observed in the water but no birds were seen in this reach.

Land Use

Residential land use was observed on both the right and left sides of the stream.

Outfalls

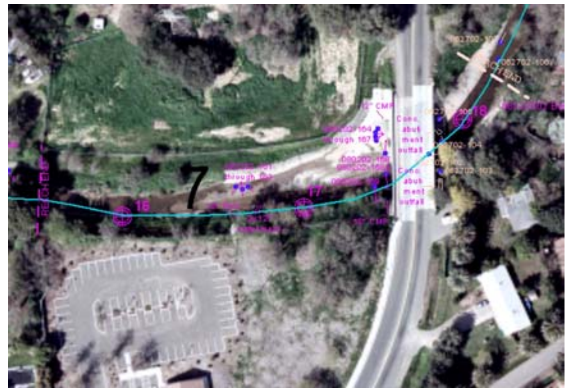
There are two outfalls in this reach. One is 8” and the other 24” in diameter. Both are located between ten and fifty feet from the stream.

Restoration Opportunities

Possible restoration projects include removing gunite from the banks and using environmentally friendly forms of bank stabilization, along with invasive species removal and revegetation. Filtering or detaining water from the outfalls may improve water quality and thus increase habitat value.

Reach ID: 7

Starting Stationpoint: 15.5
Ending Stationpoint: 18.2
Photographs: 062702: 102-105, 080202: 161-169, 168b



Channel Characteristics

The stream channel in this reach has low sinuosity. The stream is entirely contained in an asphalt channel. There is a small amount of organic debris in the streambed. The bankfull width is five times the observed width. Both banks are asphalt reinforced. Seven bridge piers obstruct the creek. Available floodplain width is 60 feet. The stream is very slow moving with a velocity of .2 feet per second. Only 5% of the channel has canopy cover. The stream structure is poor, consisting of one large pool and no riffles. Observed depth is very shallow (<1').

Vegetation and Wildlife

Left bank canopy structure is poor with trees and herbaceous plants making up the 30% canopy cover. Trees observed on the left bank were Blue Oak, Valley Oak, California Sycamore, Almond, White Mulberry, and Oregon Ash. Invasive Giant Reed was also recorded. Right bank vegetation was rated poor also with 30% canopy cover. Blue Oak, Interior Live Oak, and Willow species were observed with an understory including Marsh Marigold, Fennel, Polygonum, Annual Sunflower, Chicory, Cocklebur, Curly Dock, Prickly Lettuce, and Nettle. Invasive species included Yellow Star Thistle, Giant Reed, Red Sesbania, Tree of Heaven, and Scotch Broom. There are many algae and other aquatic vegetation in the stream channel.

A Northern Mockingbird and domestic cat were seen on the banks and fingerlings were observed in the water.

Land Use

Residential land use was noted on both sides of the stream.

Outfalls

There are six outfalls in this reach. One with a 72" diameter is located between ten and fifty feet from the creek and the source is unknown. Another three are 12" in diameter and drain street or parking lot areas. Two are located between ten and fifty feet from the stream while the third is less than ten feet from the stream. The final two are 12" concrete pipes, one of which is less than ten feet from the stream and the other between ten and fifty feet from the stream. Some of the outfalls discharge directly into the stream channel.

Restoration Opportunities

Due to the large bankfull width and moderate floodplain the stream could be naturalized by removing the asphalt lining and reshaping the banks to create more natural flow, resulting in improved recreation and habitat value and water quality. Restoration opportunities in this reach also include invasive species removal and trash clean up. Improvement of the quality of the water discharged from the outfalls is recommended where possible.

Reach ID: 8

Starting Stationpoint: 18.2
Ending Stationpoint: 20.2.
Photographs: 062702: 106-113

Channel Characteristics

The stream channel in this reach has very low sinuosity. Streambed is mostly silt, with some organic debris and sand. Banks are well laid-back, with bankfull width being 4 times observed width. Overall condition of the streambanks is poor, being steep, overgrown, and weedy with asphalt used for bank reinforcement in places. Silt is accumulating in the channel and beginning to obstruct water flow. Stream velocity is very low at .5 feet per second. The channel had a canopy cover of 30%. Stream structure is poor, with no riffles or pools occurring in this reach. Observed depth was very shallow (<1').

Vegetation and Wildlife

Left bank vegetation is rated fair, with trees and shrubs creating dense 90% canopy cover. Dominant trees on the left bank include Box Elder, Black Walnut, Interior Live Oak, Valley Oak, Oregon Ash and willows. Invasives include English Ivy and Tree of Heaven. Left bank width is moderate at 40' wide. Right bank vegetation is poor, being mostly shrubs and brambles, and narrow, 18' wide. Canopy cover is low at 10%. Of the few trees on the right bank, Valley Oak, Catalpa, Privet, Almond, Common Fig, American Elm, Silktree and Willow species were observed. Understory includes Scarlet Firethorn, Red Sesbania, Rushes and Sedges. Vegetation is thick and overgrown on the left bank, with build-up of driftwood indicating higher flows.

Few birds were observed in this area. Fingerlings were noted in the creek.

Land Use

Residential land use was noted on both sides of the stream.

Outfalls

One outfall is located in this reach, a single PVC pipe, 12" in diameter, which empties directly into the channel. No large outfalls are located in this area.

Restoration Opportunities

Revegetation, invasive species removal, bank stabilization, in particular by removing concrete from the banks and utilizing softer stabilization methods, and trash cleanup would all be appropriate for this reach.

Reach ID: 9

Starting Stationpoint: 20.2
Ending Stationpoint: 23.2
Photographs: 062702: 114-132, 122b

Channel Characteristics

The creek in this reach exhibits low sinuousity. Banks are lined with concrete or gunite with a trapezoidal cross section. Bankfull width is approximately twice the observed width. No pool or riffle structure exists in this reach. Flow is very slow. Silt is the primary streambed component. Observed depth was very shallow (< 1'). There is virtually no shade on the channel from overhanging vegetation.

Vegetation and wildlife

Floating vegetation and invasives were noted in this section. Riparian vegetation structure and cover for both banks are poor, generally due to the use of gunite and proximity of residential development. Canopy coverage is low to moderate, being approximately 30% for both banks. Trees noted on the left bank include Willows, Oregon Ash, Valley Oak, California Black Walnut, Mexican Fan Palm, as well as invasive Black Locust, Tree of Heaven, and Common Fig. Understory species include Cattail, Rush, Marsh Marigold. In addition invasive Red Sesbania, Giant Reed,and Himalayan Blackberry are found on the left bank. Right bank trees include Willow, California Black Walnut, Box Elder, Fremont Cottonwood, and Valley Oak. Shrubs include China Berry and Red Sesbania, non-native ornamentals. Groundcovers include Cattail, Rush, and invasive English Ivy.

Acorn Woodpecker, Black Phoebe and the ubiquitous Scrub Jay were found in this reach. Fingerlings and tadpole were noted in the creek.

Land Use

Residential development occurs on both banks of the stream.

Outfalls

Two outfalls are in this reach, one of which is a 48" Reinforced Concrete Pipe that dumps directly into the channel. A large colony of aquatic vegetation begins at this pipe that could indicate high nitrate or phosphate levels in the water coming from the outfall. Algae forming at this pipe also support this hypothesis. Our field crews noted that this outfall appears to be a street drain. At the time of observation, there was a trickle coming from this pipe. There is little opportunity to mitigate the runoff coming from this structure without source controls. The second outfall is a 12" corrugated metal pipe.

Restoration Opportunities

Noted restoration opportunities include revegetation to increase channel cover and riparian structural diversity and a potential for in-channel structures to increase diversity of aquatic habitat, although this might be difficult given the constrained channel.

Reach ID: 10

Starting Stationpoint: 23.2
Ending Stationpoint: 26.1
Photographs: 062702: 134-143, 139b, 144b

Channel Characteristics

Sinuousity is very low. Silt is the primary streambed material, with organic debris also noted. Channel banks are well laid back with bankfull width being four times observed width. Flow is very slow. Floodplain width is 1.5 times bankfull width. Condition of the banks is poor, being armored with concrete on both sides. The channel is bordered by a moderate floodplain of 72 feet. The channel was approximately 60% shaded by riparian vegetation. Some stream structure exists in this area: crews observed one pool and one riffle. A beaver dam in this area forms the pool.

Vegetation and Wildlife

Riparian vegetation structure in this reach is fair to moderate. Left bank structure was missing the shrub/secondary layer, but the right bank had all three: primary, secondary and herbaceous. Left bank species include White Alder, Valley Oak, Box Elder, Blue Oak and Willows. Invasives and non-natives include Tree of Heaven, Common Fig, Catalpa, Beefwood and Privet. Poison Oak was noted in the area. The herbaceous layer included Yellow Starthistle, and Verbena. Right bank species were similar to the above, adding White Cottonwood, Oregon Ash, Canary Island Palm, White Mulberry and California Sycamore to the trees, Scotch Broom and Red Sesbania, all of which can be very invasive, to the shrubs, and Rush, Fennel, and invasive English Ivy to the groundcover. Canopy coverage on the left bank is marginal, but very good on the right bank, approaching 90%. Riparian width is poor, approximately 15’ on both banks. The vegetation in this reach is characterized by many weedy invaders, floating vegetation, and algae.

Birds observed in this reach include Kingfisher and Red Shouldered Hawk, both of which can be an indicator of healthy riparian structure, as well as Magpie and Black Phoebe. No aquatic species were noted for this section.

Land Use

Residential development was present on both banks, with the light rail corridor to the east.

Outfalls

One outfall dumps into this reach. It is a 15 inch corrugated metal pipe and appears to drain the area around the light rail tracks.

Restoration Opportunities

Revegetation, invasive removal, removal of structures, and trash cleanup were all noted as potential restoration opportunities for this reach.

Reach ID: 11

Starting Stationpoint: 26.1
Ending Stationpoint: 27.6
Photographs: 062702: 144-147, 148b, 148c

Channel Characteristics

Stream channel sinuousity is very low, although some beneficial structure exists in this reach: one pool, one riffle, and 3 runs were noted. A natural 24" drop or falls occurs, as captured in photograph 062702-147. This forms a natural pool just downstream of the falls, with a depth of approximately three feet (3'). Flow velocity is low. Bankfull width is good, 5 times the observed width, with laid-back natural banks forming a floodplain over 200 feet wide. This reach is upstream of the light-rail tracks, in an area of open space between the tracks and Roseville Road. Bank conditions are poor, with sloughing of bank into stream and a 12' cut bank on the left, and steeply cut, concrete riprap on the right. Channel canopy coverage is approximately 30%.

Vegetation and Wildlife

Left bank riparian vegetation structure is fair, right bank is poor. Both banks are fairly open, with grasses and forbs being the dominant vegetation. Left bank canopy cover is 40%, right bank is 10%. The left bank has more trees than the right, with dominant species being Valley Oak, Oregon Ash, American Elm and California Black Walnut. Right bank tree species include Valley Oak, White Alder and willow. Rushes, sedges, and fennel are the dominant herbaceous species. Overall riparian condition is fair to poor. The creek contains floating vegetation and quantities of algae.

Bird species observed include Scrub Jay, Kingfisher, and Pheasant. No aquatic species were observed.

Land Use

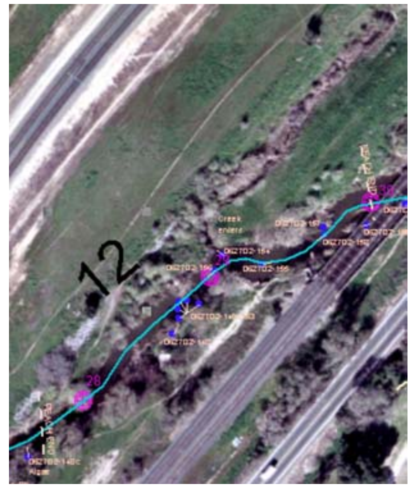
Open fields are on both sides of the channel. Surrounding land uses include light rail to the west and the Union Pacific railroad to the east.

Outfalls

No outfalls were noted in this reach.

Restoration Opportunities

Restoration activities in this reach might include revegetation to build up riparian canopy structure, invasive removal, bank stabilization and trash cleanup. The open space between the railroads might be an opportunity for some over-bank flooding and water storage areas. In addition removal of the current concrete riprap and stabilization of banks using other methods is an important restoration opportunity in this reach.



Reach ID: 12

Starting Stationpoint: 27.6
Ending Stationpoint: 30.0
Photographs: 062702: 148-159

Channel Characteristics

Sinuosity is very low, structure is poor, with no pools or riffles in this area. Streambed material is primarily silt, with some organic debris. Bankfull width is 2.7 times observed width. Bank condition is poor, with a significant cut bank on the left and eroded rip-rap on the right. Floodplain width is 154 feet, being between the light rail and Union Pacific railroad. Stream flow is very slow. Observed depth in this reach is 5’, which is deeper than average for this area. Channel canopy cover is poor at 15%.

Vegetation and Wildlife

Canopy cover is poor, less than 20% for left and less than 10% for right bank. Structure is fair, vegetation is primarily trees and shrubs. Primary tree species are the typical mix for the area: willow, Oregon Ash, Valley Oak, Interior Live Oak, Box Elder and California Buckeye for the left bank, and Valley Oak, Box Elder and Willow on the right. Invasives/ornamentals noted on the right bank include Siberian Elm, Catalpa, Common Fig and Silktree. Himalayan Blackberry was noted on the left bank. Width of the riparian vegetation is fair, being 50 feet on the left bank and 30 feet on the right. Many weedy invaders were noted in the survey.

Birds noted include Kingfisher, Scrub Jay and Mallard duck. Fingerlings were observed in the creek.

Land Use

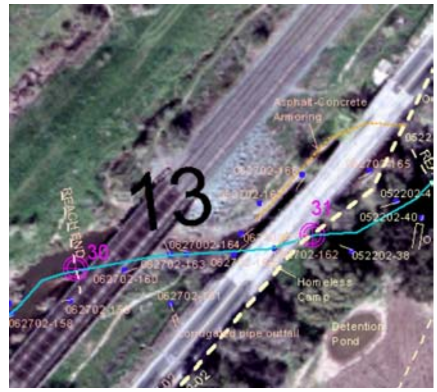
Union Pacific and Light Rail are the adjacent land uses.

Outfalls

There were no outfalls recorded for this reach.

Restoration Opportunities

Restoration opportunities noted include revegetation, invasive removal, bank stabilization and trash cleanup. Additionally, due to the adjacent open fields between the light rail and Union Pacific railroad, the opportunity exists for overbank flooding and detention.



Reach ID: 13

Starting Stationpoint: 30.0
Ending Stationpoint: 31.0
Photographs: 062702: 160-169

Channel Characteristics

Sinuosity is low, floodplain width is negligible. This stream reach lies between the Union Pacific Railroad and Roseville Road. The channel banks flare out in this section, being six to seven times wider at bankfull than at observed flow. Observed depth was shallow and flow was slow (1 fps). One pool and one riffle were noted in this area, most likely caused by the grading around the bridges. Bridge piers for both the railroad and Roseville Road sit directly in the channel and the water flows around them. It is very likely that the bridge abutments constrain peak flows and contribute to the upstream flooding problems. This is exacerbated by the two bridge crossings not being perpendicular to the channel reach.

Bank conditions are poor, with a concrete channel under Roseville Road and cut-banks and erosion downstream. There was no vegetative channel canopy cover, although the bridge shades a portion of this reach.

Vegetation and Wildlife

Canopy structure and cover is poor except for the bridge structures themselves. Tree species on the left bank include Siberian Elm, Interior Live Oak, Oregon Ash, Silktree, Tree of Heaven, and Beefwood, most of which are invasives or exotics. Right bank species include Siberian Elm, Willow, Tree of Heaven, and Box Elder. Herbaceous plants found in this reach are sedges, Red Sesbania, Verbena and Fennel. Shrubs include Himalayan Blackberry, Buttonbush, and Hackberry. Riparian vegetation in this reach consists primarily of weedy invaders.

Pigeons and Magpies were noted in this reach. No aquatic species were observed.

Land Use

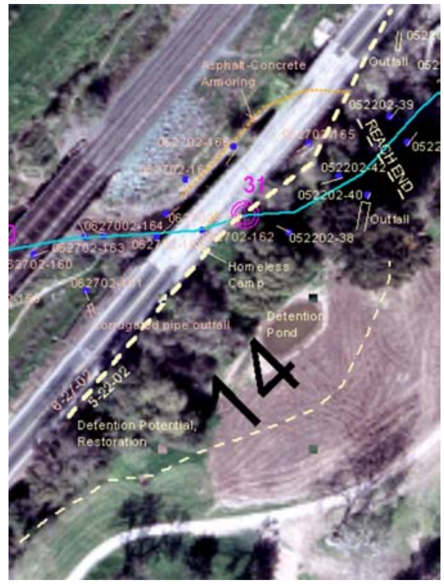
Adjacent land uses are Roseville Road and the Union Pacific Railroad. Upstream and to the east of Roseville Road is the Haggin Oaks Golf Course.

Outfalls

One 8” corrugated metal pipe was noted in this reach. It was blocked and full of debris, but appeared to drain from Roseville Road.

Restoration Opportunities

Removal of invasive plants was noted as a primary goal for this reach, as well as trash cleanup including shopping carts, trash and cleaning supplies from a homeless camp under Roseville Road. The need for bank stabilization and revegetation are also important considerations.



Reach ID: 14

Starting Stationpoint: 31.0
Ending Stationpoint: 31.5
Photographs: 052202: 38-42

Channel Characteristics

Sinuosity of the channel in this area is moderate, and the reach has some structure: the team noted three riffles but no pools. Observed stream width is 25 feet, bankfull width is 60 feet, and floodplain width is 90 feet. Flow is moderate at 2 fps. Bridge piers from Roseville Road partially obstruct the flow. It is very likely that the bridge abutments constrain peak flows and contribute to the upstream flooding problems. This is exacerbated by the two bridge crossings not being perpendicular to the channel reach.

Bank conditions are poor due to concrete armoring. Streambed material is primarily silt, although cobbles, organic debris, gravel and sand were also noted. The bridge provides a 40% canopy over the stream. Other than the bridge, there is little cover.

Vegetation and Wildlife

Canopy structure and cover are poor. The left bank has only tree cover of Live Oak, Oregon Ash and Siberian Elm. Right bank cover was primarily absent, with willows and Siberian Elm noted as the only species.

Yellow-billed Magpie was the only bird species recorded, with no aquatic species observed.

Land Use

Adjacent land uses are the Roseville Road bridge and Haggin Oaks Golf Course.

Outfalls

Two outfalls are located in this reach, a 12” corrugated metal pipe handling road runoff from Roseville Road, and a 12” steel pipe that perhaps handles stormwater flow.

Restoration Opportunities

Restoration of this area may include revegetation, invasive removal, replacing of the concrete bank armoring with a more ecologically friendly erosion control method, and trash cleanup from the homeless camp under the bridge. The detention pond could be enlarged and retrofit with an engineered control structure to maximize the potential for detention storage and water quality improvement.

Reach ID: 15

Starting Stationpoint: 31.5
Ending Stationpoint: 32.0
Photographs: 052202: 44-45

Channel Characteristics

The creek channel splits into multiple channels in this reach, and the floodplain widens. Sinuosity is high where the creek meanders through the trees. Two pools and two riffles were noted in this section. The floodplain is wide, approximately 200 feet, and the banks are laid back approximately 150 feet, greater than 10 times the observed width. Depth is moderate (2.5') and velocity is high (3.5 fps). There is some vegetation and woody debris in the stream. The streambed has better diversity of material than most reaches in the study area, containing high percentages of sand, cobbles and organic debris. The left streambank is in poor condition, having a high, eroding cut-bank. The right streambank is in fair condition. The channel has no canopy cover due to its extreme bankfull width.

Vegetation and Wildlife

Riparian structure in this area is moderate. Both banks had healthy tree and herbaceous layers, though shrubs were sparse. Left bank tree species includes Fremont Cottonwood, Willow, Interior Live Oak and Oregon Ash. Right bank species includes non-native Tree of Heaven and White Mulberry. Canopy coverage was good; 75 and 60 percent on left and right banks respectively.

Mallard duck was the only bird species observed. No aquatic life was noted.

Land Use

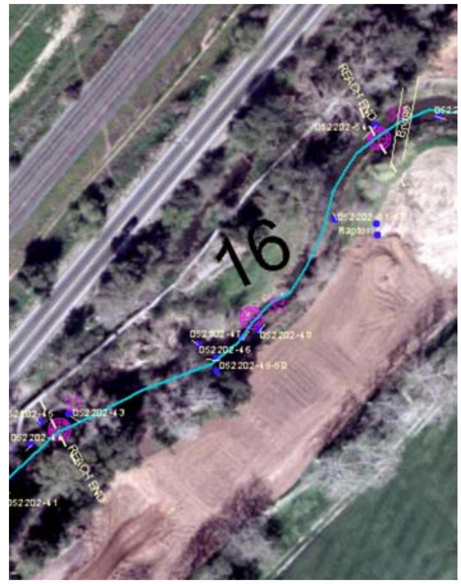
This reach is abutted by the Haggin Oaks Golf Course on both sides. Roseville Road is visible to the west.

Outfalls

No outfalls are located in this reach.

Restoration Opportunities

Overall, the health of the riparian and channel systems in this reach are better than average. Invasive plant removal and bank stabilization were the two restoration techniques noted that could be of benefit.



Reach ID: 16

Starting Stationpoint: 32.0
Ending Stationpoint: 34.0
Photographs: 052202: 43, 46-53

Channel Characteristics

Sinuosity in this reach is moderate. Stream structure is good, with 3 pools, 2 riffles and 5 runs. The riparian buffer and floodplain widen from this point downstream to Roseville Road and Reach 15. Average floodplain width is approximately 100 feet; bankfull width is the same. Observed width is approximately 20 feet, except in the riffles where it narrowed. Stream flow velocity is fast at 3 fps. Streambanks are approximately 17 feet tall in this reach. Streambed consists primarily of silt, although sand and cobbles were also noted. A concrete structure obstructs the streamflow at stationpoint 32, and reeds and a sandbar are located at 32.25. Streambanks were in fair condition, with no obvious erosional hot-spots. There was minimal channel canopy cover of 3%.

Vegetation and Wildlife

Canopy structure is moderate in this reach. Both banks have healthy tree, shrub and herbaceous layers, although canopy cover is poor, estimated at 5% for the left bank, and less than that for the right. Left bank riparian width is poor, 10 feet, but right bank width is good, 250 feet or more. Left bank species include willow, Oregon Ash, Camphor Tree and White Mulberry, with some Himalayan Blackberry undergrowth. Right bank species include Valley Oak, White Mulberry and False Cypress with pines and grasses to the Roseville Road. The riparian zone vegetated with trees and grasses is at least 100' wide.

A Red-shouldered Hawk was observed in this reach, see photographs 51-53. This bird species can be an indicator of a healthy riparian system. No aquatic species were noted.

Land Use

The golf course is adjacent to the left bank. The right bank riparian buffer extends to Roseville Road.

Outfalls

No outfalls were noted for this reach.

Restoration Opportunities

Opportunities noted include revegetation, invasive plant removal, structure removal and bank stabilization.

Reach ID: 17

Starting Stationpoint: 34.0
Ending Stationpoint: 35.0
Photographs: 052202: 54-58, 59b

Channel Characteristics

Sinuosity of this reach is high, and structure is poor. One riffle occurs in this area. Bankfull width is floodplain width and is twice observed width. Observed width varied considerably from areas downstream, being 40 feet here compared with 20 feet in the previous reach. Observed depth is 3.5 feet. Velocity is moderate at 2.5 fps. Silt is the primary streambed material, although sand and organic debris were also noted. Left bank condition was poor, with gabions for rip-rap. Right bank condition was fair, with some sand beaches. A moderate floodplain of 80 feet is available. The creek channel is completely unshaded.

Vegetation and Wildlife

Riparian structure is mostly absent in this reach, with the Golf Course coming virtually right down to the creek. Taller grasses and rushes form a 10’ wide buffer between the turf grasses and the creek channel, and are matted by higher flows. The few trees in this area include Oregon Ash, Siberian Elm, Mexican Fan Palm, Valley Oak, and the invasive Common Fig. Many tree suckers were seen in this area.

A Great Egret and a Black Phoebe were observed in this area.

Land Use

The Golf Course closely abuts the channel on both sides.

Outfalls

There are no outfalls in this area.

Restoration Opportunities

Restoration opportunities noted for this reach include revegetation of the banks to form a better riparian structure, removal of the weedy invaders, and replacement of the gabion structures with a more ecologically friendly alternative. Due to the poor condition of the riparian vegetation in this area, this reach should be a high priority for some level of restoration to buffer the creek from the golf course.

Reach ID: 18

Starting Stationpoint: 35.0
Ending Stationpoint: 36.0
Photographs: 052202: 59-60

Channel Characteristics

The overall stream structure of this reach is moderate with medium sinuosity and 2 separate pools. The streambed is composed primarily of silt with some sand and a small amount of organic debris. The bankfull width is over three times the observed width. On the left bank there is a gabion in place and erosion problems. A tire, pipe, and sandbar all partially obstruct water flow. The water is brown and turbid. The floodplain is 100 feet wide. The stream moves quickly at 3 feet per second and is well shaded with a 75% channel canopy cover.

Vegetation and Wildlife

Left bank vegetation is fair. Oregon Ash and Interior Live Oak contribute to the 20% canopy cover. Right bank vegetation is poor, with a sparse primary canopy and only 7% canopy cover. Interior Live Oak is the dominant tree on the right bank. Both banks have thin riparian vegetation of only 15 feet and no secondary canopy.

Birds seen in this reach are a Canada Goose, European Starling, Mallard, and another duck. No aquatic animals were noted.

Land Use

The golf course surrounds the stream on all sides.

Outfalls

There are no known outfalls in this reach.

Restoration Opportunities

Opportunities for restoration in this reach include revegetation, bank stabilization, removing structures, and trash cleanup. Due to the narrow riparian vegetation, this reach should be a focus of restoration in order to better buffer the effects of the golf course on the creek.

Reach ID: 19

Starting Stationpoint: 36.0
Ending Stationpoint: 37.2
Photographs: 052202: 61, 63, 64b

Channel Characteristics

Stream structure in this reach is fair with medium sinuosity and two runs. The streambed consists of mostly silt with some cobbles and small amounts of sand and organic debris. The bankfull width is 2.5 times the observed width. Both the left and right banks have gabions in place but the right bank is undercut. One hundred feet is the width of the available floodplain. The water is brown and turbid. The stream moves moderately at 1.5 feet per second. There is no channel canopy cover.

Vegetation and Wildlife

Both the left and right banks are rated poor and neither one has primary canopy. The left bank has 4% canopy cover in a 30 foot wide strip consisting of Box Elder and Siberian Elm. The narrow (15') right bank vegetation has 3% canopy cover consisting of Valley Oak and Oregon Ash. There are many invasive species present.

A Mallard and turtle were both observed in this reach.

Land Use

The golf course is present on both the left and right sides, with roads in the distance.

Outfalls

There are no known outfalls in this reach.

Restoration Opportunities

Invasive plant species removal and revegetation are the major restoration opportunities in this reach, although removing structures is also recommended.

Reach ID: 20

Starting Stationpoint: 37.2
Ending Stationpoint: 39.0
Photographs: 052202: 62, 64-70

Channel Characteristics

Although the sinuosity is low, the stream structure is moderate, having two runs. The streambed is silt with some cobbles and traces of sand, gravel and organic debris. The bankfull width is equal to the observed width. Both banks are cut, eroding, and covered with riprap. The width of the available floodplain is 100 feet. There is a cobble check dam in the stream. The water is brown and turbid. It is moving slowly at 1 foot per second. There is no channel canopy cover at all.

Vegetation and Wildlife

Both banks have very poor canopy structure, if any at all, on the 12 foot strips of vegetation. There are a few trees forming the 3% canopy cover, but mostly herbaceous growth. The sparse trees on the left bank include American Elm, Pine, White Mulberry, and invasive Common Fig. The right bank has Valley Oaks. There is red sesbania on both banks.

Land Use

Adjacent land use on both banks is the golf course, which is surrounded by roads.

Outfalls

There is a 4" plastic pipe from the golf course located less than ten feet from the stream.

Restoration Opportunities

Invasive plant species removal and revegetation is of prime importance in this reach. Other opportunities include removing structures, bank stabilization, and trash cleanup. However, this reach is tightly surrounded by the golf course and there is little open space for increasing the riparian vegetation.

Reach ID: 21

Starting Stationpoint: 39.0
Ending Stationpoint: 42.0
Photographs: 052202: 36-37, 71-74

Channel Characteristics

Stream structure is poor in this reach because there is low sinuosity and no riffles. The streambed is primarily silt with some organic debris. Bankfull width is slightly less than 1.5 observed stream width. The available floodplain is 250 feet wide. The water is brown and turbid. The water flows at very slowly at .5 feet per second. It is lightly shaded with 20% channel canopy cover.

Vegetation and Wildlife

Both the left and right bank have poor vegetation structure with trees and herbaceous plants but no shrubs or small trees. The left bank has 30% canopy cover dominated by American Elm, Interior Live Oak, Oregon Ash, and Blue Oak. The right bank has only 20% canopy cover consisting of Oregon Ash, Valley Oak, Interior Live Oak, Willow species, and the invasive Common Fig. There are many non-native, weedy grasses and forbs on both banks.

A Scrub Jay was the only wildlife observed in this reach.

Land Use

Immediately adjacent to both banks is the golf course. Further from the creek are roads.

Outfalls

There is one 8" pipe located between ten and fifty feet from the stream.

Restoration Opportunities

Restoration opportunities in this reach include bank stabilization, trash cleanup, invasive plant species removal and revegetation. The large floodplain on the right bank allows consideration of channel widening or in channel structure improvements.

Reach ID: 22

Starting Stationpoint: 42.0
Ending Stationpoint: 44.5
Photographs: 052202: 1-10

Channel Characteristics

Stream structure is poor in this reach as it contains only one large pool. The streambed is composed mostly of silt with some organic debris. The bankfull width is slightly under 1.5 times the observed width. The width of the available floodplain is 100 feet. The water is brown and turbid with a somewhat organic odor. Water velocity is a very low .5 feet per second. Channel canopy cover is 30%.

Vegetation and Wildlife

Left bank vegetation is rated moderate with no secondary canopy. It has 30% canopy cover. Dominant trees on the left bank include Interior Live Oak, American Elm, Oregon Ash, Blue Oak, and Valley Oak. The right bank is described as unhealthy with no primary canopy. Although mostly shrubs and brambles a few trees provide 20% canopy cover. Oregon Ash, Box Elder, and American Elm are all found on the right bank. There are lots of weeds and non-native grasses on both banks.

A turtle was seen in the water. Birds observed included a Magpie, Red-shouldered Hawk, Pigeon, Mallard, and Scrub Jay.

Land Use

Land on both sides of the creek is used as a golf course.

Outfalls

The one outfall in this reach is an eight-inch metal pipe, which empties between ten and fifty feet from the creek. However the creek does receive some runoff from a maintenance yard on both sides of the creek.

Restoration Opportunities

There are opportunities for channel widening, invasive species removal and revegetation, trash cleanup, removal of structures, and creation of overflow and detention structures in this reach. Backwaters and an overflow channel also offer restoration opportunities to increase water holding capacity.

Reach ID: 23

Starting Stationpoint: 44.5
Ending Stationpoint: 46.0
Photographs: 062502: 1-4

Channel Characteristics

Stream structure is poor in this reach due to low sinuosity and being composed of a single large pool with no riffles. The streambed is primarily composed of silt with lots of organic debris. The bankfull width is 1.3 times the observed width. The left bank is in good condition and the right bank in moderate condition but both are a little cut. The water is brown. The available floodplain is narrow at only 39 feet. Woody debris and a pipe crossing the stream partially obstruct the flow of water. Channel canopy cover is moderate at 45%.

Vegetation and Wildlife

Both the left and right bank vegetation is rated good with 45% cover, although vegetation widths are 20 feet and 10 feet respectively. Oregon Ash and Interior Live Oak are the dominant trees on both banks.

No birds or aquatic species were observed in this reach.

Land Use

On the left bank is a maintenance yard and the golf course while on the right are more golf course holes.

Outfalls

On the left side there is a 12" grassy swale near the cart barn that ends less than 10 feet from the channel. Runoff from cart maintenance activities runs directly into the creek.

Restoration Opportunities

This reach offers opportunities for channel widening, trash cleanup, construction of in-channel structure, and treatment of the runoff from the swale near the cart barn.

Reach ID: 24

Starting Stationpoint: 46.0
Ending Stationpoint: 48.0
Photographs: 062502: 5-7, 9

Channel Characteristics

Overall this reach has poor stream structure with low sinuosity and no riffles or runs. The bankfull width is only slightly larger than the observed width of the creek. There are erosion problems on the left bank directly across from the outfall. This part of the bank has been reinforced with concrete. There is some woody debris in the channel along with a rusty pipe. The available floodplain is 51 feet wide. The creek is slow moving and receives lots of sun due to the sparse channel canopy cover (5%).

Vegetation and Wildlife

Left bank vegetation is rated poor. It has 5% canopy cover and is only 5 feet wide. In this small strip are found American Elm, Blue Oak, White Mulberry, Interior Live Oak, and Oregon Ash. The right bank is rated moderate. The vegetation is 30 feet wide with 15% canopy cover. There is some good canopy structure located around the outfall. Dominant trees on the right bank are American Elm, Interior Live Oak, and Oregon Ash.

A Scrub Jay and fingerlings were noted in this reach.

Land Use

The creek is surrounded by golf course on all sides.

Outfalls

There is one outfall on the right bank that is 5 feet in diameter and located between ten and fifty feet from the creek. It is a storm sewer outlet.

Restoration Opportunities

Invasive plant species removal and revegetation, trash cleanup, and overflow and detention structures are all possible in this reach. Either bank stabilization, improving in-channel structure, or both can be used to treat the problems at the outfall.

Reach ID: 25

Starting Stationpoint: 48.0
Ending Stationpoint: 51.5
Photographs: 062502: 8, 10

Channel Characteristics

The stream channel has low sinuosity in this reach. The streambed is composed primarily of silt with some organic debris. The bankfull width is 1.5 times the observed width. Both banks are in good condition. A bridge partially obstructs water flow along with some large woody debris. Ninety feet of floodplain are available. Channel canopy cover is poor at only 15%. Overall stream structure is poor, but typical, being formed of one large continuous pool.

Vegetation and Wildlife

With 40% canopy cover and multi-layered structure both the left and right banks are rated good. On both the left and right bank Willow species, American Elm, Blue Oak, Interior Live Oak, Valley Oak, and Oregon Ash were the dominant tree species. Cattails were noted in a backwater and invasive Himalayan Blackberry is found in the understory.

Scrub Jays were seen and heard overhead while fingerlings were noted in the creek.

Land Use

The golf course surrounds this reach on all sides.

Outfalls

There are two outfalls into this reach. One 2' outfall is located less than 10 feet from the creek and drains overland to the creek. The other is a 1.5-foot outfall located between ten and fifty feet from the stream.

Restoration Opportunities

Restoration opportunities in this reach include invasive plant species removal, improving in-channel structure, building overflow and detention structures, and trash cleanup. The wide floodplain and large area of riparian vegetation on the left bank make this a good site for restoration projects.

Reach ID: 26

Starting Stationpoint: 51.5
Ending Stationpoint: 53.7
Photographs: 062502: 11-14

Channel Characteristics

The stream channel has low sinuosity in this reach. Silt composes the streambed almost exclusively, with some organic debris. The bankfull width is only slightly wider than the observed stream width. Overall bank condition is fair with some bank cut and some armoring already present. Some woody debris obstructs the stream. The available floodplain is 63 feet. Channel canopy cover is a very low 10%. This reach is composed of one large pool and so has poor stream structure.

Vegetation and Wildlife

Riparian vegetation is poor on both the left and right banks with only a 10% canopy cover. This is primarily due to the fact that the width of the riparian vegetation is only 8 feet and there are many bare spots where the fairways cross the creek. Oregon Ash and Interior Live Oak were noted on the left bank. The right bank vegetation is composed of Catalpa, Oregon Ash, and Blue Oak.

Fingerlings were observed in the water.

Land Use

The golf course occupies the land on both the left and right banks. Interstate 80 is visible in the distance to the north.

Outfalls

There are no known outfalls in this reach.

Restoration Opportunities

Revegetation and bank stabilization, particularly were the fairways cross the stream, are good restoration opportunities.

Reach ID: 27

Starting Stationpoint: 53.7
Ending Stationpoint: 56.0
Photographs: 062502: 15-16

Channel Characteristics

The stream channel in this reach has medium sinuosity. The streambed is made up mostly of silt with some organic debris, a little sand and a bit of gravel. The bankfull width is twice the observed width of the stream channel. The bankfull depth returns to 15 feet. Overall both the left and right banks are in good condition except for one large cut area on the left bank. Two bridges and a rock outcropping obstruct stream flow. The available floodplain is 120 feet wide. Water flows slowly at 1 foot per second under the shade of 67% canopy cover. Stream structure is again poor, consisting of only one large pool through out the reach.

Vegetation and Wildlife

Overall the vegetation is good with 75% cover on both banks. On the left bank Interior Live Oak and the invasive Tree of Heaven were observed. Box Elder, Oregon Ash, Interior Live Oak, and invasive Himalayan Blackberry characterize the right bank. Width of Riparian vegetation is a moderately good 50 feet on both banks.

No animals were observed in this reach.

Land Use

The golf course and trails occupy the land on both sides of the creek.

Outfalls

No outfalls are noted in this reach.

Restoration Opportunities

Restoration opportunities include removing invasive plant species, revegetation, bank stabilization, trash cleanup, creating overflow or detention structures, and channel widening, particularly just before the bridge.

Reach ID: 28

Starting Stationpoint: 56.0
Ending Stationpoint: 60.0
Photographs: 062502: 17-18

Channel Characteristics

The stream channel is highly sinuous in this reach. Silt, with some organic debris and sand, forms the streambed. The bankfull width is less than 1.5 times the observed width. Both the left and right banks have large cut sections. Tires, woody debris and sand bars all form obstructions to water flow in the stream channel. One hundred and eleven feet are available for the floodplain. The channel has good canopy cover of 78% and water moves slowly at .7 feet per second. There are no riffles in this reach and thus stream structure is poor.

Vegetation and Wildlife

Both the left and right bank vegetation is rated good and have 75% canopy structure. Dominant trees on the left bank include Oregon Ash, Valley Oak, and Box Elder. On the right bank Oregon Ash, Interior Live Oak, and Fremont Cottonwoods are the dominant trees. Overall this reach has good vegetation structure and good shade.

A duck and some fingerlings were observed in the water.

Land Use

Land on the left bank is incorporated into the golf course. On the right bank it is used as a freeway.

Outfalls

There are no known outfalls in this reach.

Restoration Opportunities

There is a wide area suitable for overflow and detention structures. In-channel structures can be used to improve habitat and stream structure. Channel widening, bank stabilization, and trash cleanup are also potential restoration activities.

Reach ID: 29

Starting Stationpoint: 60.0
Ending Stationpoint: 62.0
Photographs: 062502: 19-20, 22

Channel Characteristics

This reach is distinguished from many others by a highly sinuous stream channel helps. The streambed is composed of primarily silt with some organic debris, a small amount of sand, and a little bit of gravel. The bankfull width is only ~1.5 times the observed width. Both the left and right banks are in good condition. Some woody debris in the stream channel may cause an obstruction of flow. The available floodplain is 143 feet wide. The water flows slowly at 1 foot per second and is shaded by arching bows that form a 77% channel canopy cover.

Vegetation and Wildlife

Overall this reach has good vegetation structure. Both the left and right banks have 75% canopy covers consisting primarily of Oregon Ash, Interior Live Oak, Valley Oak, and Chinese Elm. The right bank has some invasive Silktree. The width of both the left and right bank vegetation is good, being 75 feet and 100 feet respectively.

No fauna were observed in this reach.

Land Use

The golf course and some trails lie on the left bank. On the right bank are trails and open space.

Outfalls

There is a 2' concrete pipe over 50 feet from the stream that may contribute to backwater flows.

Restoration Opportunities

Invasive plant species removal and revegetation, bank stabilization, improving in-channel structures and detention capacity, and trash cleanup are all restoration possibilities. The large floodplain and neighboring open space offer opportunities for detention structures and wetland construction.

Reach ID: 30

Starting Stationpoint: 62.0
Ending Stationpoint: 66.5
Photographs: 062502: 21, 23

Channel Characteristics

The stream channel in this reach has moderate sinuosity. The streambed is made up mostly of silt with some organic debris and a slight amount of sand. The bankfull width is only slightly wider than the observed stream width. Both the left and right side of the channel have big cut banks with large root masses. There is some trash and woody debris obstructing the channel. There is no flood plain available. The stream flows at the very slow pace of .5 feet per second under a dense, 90% canopy cover. Stream structure is poor, being composed of a single large pool.

Vegetation and Wildlife

Both left and right bank vegetation is classed as good with a 78% canopy cover. The left bank is characterized by Oregon Ash, Interior Live Oak, and Valley Oak, whereas the right bank has Oregon Ash, Valley Oak, and Blue Oak. Both sides have a healthy tree/shrub layer.

Fingerlings were the only wildlife observed.

Land Use

The land on the left bank is part of the golf course. A road borders the riparian area on the right side.

Outfalls

There is a 48" outfall coming under Longview Road that empties less than ten feet from the stream.

Restoration Opportunities

Restoration opportunities include channel widening, bank stabilization, developing in-channel structures and overflow or detention structures, and trash cleanup, particularly the big trash pile.

Reach ID: 31

Starting Stationpoint: 66.5
Ending Stationpoint: 69.2
Photographs: 062802: 1-3

Channel Characteristics

The creek channel in this reach has medium sinuosity. The streambed is composed primarily of silt with some sand and organic debris. The bankfull width is only slightly larger than the observed width. Both the left and right banks are cut and eroded. Obstructions include one large downed tree and miscellaneous woody debris. The width of the available floodplain is 222'. The water moves slowly through this reach at .5 feet per second. Canopy cover averages 50% over the channel. Stream structure is very good with four runs in this reach.

Vegetation and Wildlife

Both the left and right bank vegetations are classified as moderate and have 50% canopy cover. Left bank trees included Oregon Ash, Valley Oak, and Willow species, while Mugwort and cattails were among the herbaceous species. Invasive species were Red Sesbania and Yellow Star Thistle. Oregon Ash, Valley oak, California Black Walnut, and Willow species were observed on the right bank.

Pheasants, Hummingbirds, Scrub Jays and Fingerlings were all observed in this reach.

Land Use

Land on the left bank is used as a golf course, while the right bank is bordered by open space and a road. A horse trail crosses the creek at the end of this reach.

Outfalls

There are no known outfalls in this reach.

Restoration Opportunities

Channel widening, invasive species removal, bank stabilization, trash cleanup, improvement of in-channel structure, and creation of overflow/ detention structures are all potential restoration activities in this reach. In particular removing a large bramble midway through the reach will help reduce bank cutting and erosion.

Reach ID: 32

Starting Stationpoint: 69.2
Ending Stationpoint: 73.2
Photographs: 062802-4

Channel Characteristics

This reach's stream channel has low sinuosity. The streambed is composed mainly of silt with some organic debris and sand and a few cobbles. The bankfull width is slightly less than four times the observed width. Both the left and right banks are cut and eroding. There are a couple of snags in the stream channel, potentially obstructing flow. The available floodplain is 120 feet wide. The channel is 35% covered by tree canopy. Stream structure is poor as this reach consists of one large pool.

Vegetation and Wildlife

Left bank vegetation is rated fair and provides only 30% canopy cover. Valley Oak, Oregon Ash, and Interior Live Oak are the dominant trees amongst an understory that includes Mugwort, Thistle, and Poison Oak. Right bank canopy structure is good and canopy cover reaches 50%. Beefwood, Valley Oak, and Oregon Ash are the dominant trees and are scaled by Wild Cucumber vines. Many of the clearings are filled with invasive grasses.

Land Use

On the left bank lies a golf course and on the right bank horse stables and trails.

Outfalls

There are no outfalls in this reach.

Restoration Opportunities

Channel widening, invasive species removal, revegetation, bank stabilization, removal of structures, trash cleanup, and creation of in-channel and overflow or detention structures are all restoration opportunities.

Reach ID: 33

Starting Stationpoint: 73.2
Ending Stationpoint: 77.6
Photographs: 062802: 5-6, 071502: 5-6

Channel Characteristics

The stream channel in this reach has high sinuosity. The streambed is composed primarily of silt with some sand and small amounts of organic debris and gravel. The bankfull width is six times the observed width. Both banks are in fair condition and are cut and incised. There are some sand bars and organic debris obstructing the channel. There is no available floodplain. Water flows quickly at 2 feet per second under 70% canopy cover. Stream structure is excellent with five runs in this reach.

Vegetation and Wildlife

Vegetation on the left bank is rated good and has a canopy cover of 65%. Oregon Ash was observed as well as Poison Oak, Wild Grape, Mugwort, and Teasle. Right bank vegetation also rates good and has a 65% canopy cover. Poison Oak and a Canary island Date Palm were observed. There were probably also Interior Live Oaks and Valley Oaks on both banks. There were some non-native trees as well. Blue Jays, an Acorn Woodpecker and Nuthatch were observed in the trees while fingerlings were seen in the water.

Land Use

Land use on the left bank consists of open space and a golf course. On the right bank are horse stables, open space, and a road.

Outfalls

There is one very large, 84”, outfall on the right bank. It was discharging a trickle of foamy water. It discharges between approximately 20 feet from the stream.

Restoration Opportunities

Restoration opportunities include bank stabilization and construction of in-channel and overflow or detention structures. Water quality may be improved by treating runoff from the neighboring horse stables. The quality of the water discharged from the very large culvert needs to be addressed.

Reach ID: 34

Starting Stationpoint: 77.6
Ending Stationpoint: 82.0
Photographs: 071502: 1-4

Channel Characteristics

The stream channel in this reach has very low sinuosity. The streambed is primarily silt with some organic debris and sand and small amounts of gravel and cobbles. The bankfull width is equal to the observed stream width. The left bank is eroded and cut while the right bank is eroded. A few logs in the water obstruct flows in this reach. There is no floodplain available. Stream velocity is very slow at .5 feet per second. The channel is 60% covered by tree canopy. Stream structure is moderate with two runs in this reach.

Vegetation and Wildlife

Left bank vegetation is good and provides 65% canopy cover. Valley Oak, Interior Live Oak, and Oregon Ash shade the understory of mugwort, poison oak, fennel, and thistle. Thistles grow in dense patches, especially in the open areas. Right bank vegetation is classified as good and has 40% canopy cover. Valley Oak was the dominant tree observed in this reach.

Acorn Woodpeckers and Scrub Jays were observed in the trees while fingerlings were seen in the water.

Land Use

On the left bank is a park and softball complex. On the right bank is a road and commercial land use.

Outfalls

There are two 24” pipes forming a culvert under Longview Road. They are located over fifty feet from the stream and separated from it by a path. When observed the path had stopped water flowing into the creek resulting in nasty stagnant water full of algae and potential breeding grounds for mosquitos.

Restoration Opportunities

Restoration opportunities include channel widening, revegetation, invasive species removal, removal of structures, bank stabilization, building in-channel and overflow/detention structures, and trash cleanup. This outfall is an ideal spot for treatment to improve water quality.

Reach ID: 35

Starting Stationpoint: 82.0
Ending Stationpoint: 87.0
Photographs: 062802: 7-9

Channel Characteristics

The stream channel in this reach has low sinuosity. The streambed is primarily silt with small amounts of organic debris, sand, and gravel. The bankfull width is 7.5 times the observed width. Both the left and right banks are cut, especially near the softball complex entrance. Obstructions in the creekbed consist of snags and other organic debris. The smell of human feces was strong in some areas of the creek. The available floodplain is 300 feet wide. The stream flows slowly at a rate of 1 foot per second. The average channel canopy cover is 40 feet per second. Stream structure is good with three runs in this reach.

Vegetation and Wildlife

Both the left and right bank vegetation is rated moderate with 40% canopy cover. The dominant species on both banks is Valley Oak, Willow species, and Poison Oak. Other grasses and forbs are also present on both banks. Decreased canopy cover is possibly due to large roads nearby.

Blue jays were the only wildlife observed.

Land Use

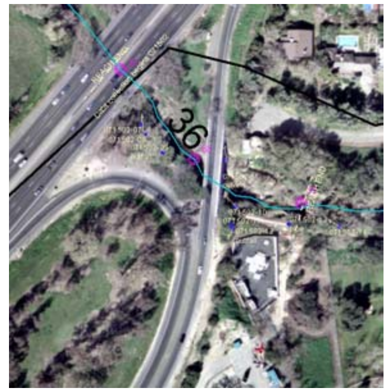
Roads and industrial land use were present on both banks.

Outfalls

There are two sets of outfalls, each one with both 12" and 4" holes draining Watt Avenue. One set is located less than ten feet from the stream and one set is located more than 50 feet from the stream.

Restoration Opportunities

The restoration opportunities in this reach include invasive species removal, bank stabilization and improving in-channel structure. Additionally there are a number of homeless camps that should be cleaned up.



Reach ID: 36

Starting Stationpoint: 87.0
Ending Stationpoint: 89.0
Photographs: 071502: 7-13, 51

Channel Characteristics

Sinuosity is low in this reach's stream channel. The streambed consists primarily of silt with some organic debris and small amounts of sand and gravel. The bankfull width is 3.5 times the observed width. Both banks are in fair condition, being somewhat incised and eroded. There are some trees and branches in the water but no major obstructions. The only distinct odors occurred due to a homeless camp. The available flood plain is 300 feet wide. The stream flows very slowly at .3 feet per second and has a channel canopy cover of 40%. Stream structure is poor, being only one continuous pool.

Vegetation and Wildlife

Left bank vegetation was rated good and has canopy cover of 50%. Willow species, Interior Live Oak, Valley Oak, Poison Oak, Oregon Ash, and Sedges were all observed on the left bank. Right bank vegetation was rated good with 50% canopy cover. Species observed include California Black Walnut, Interior Live Oak, Valley Oak, Poison Oak, and Sedges.

The birds observed in this reach are Blue Jays and Acorn Woodpeckers. Suckers, a frog, tadpoles, and a turtle were all observed in the water.

Land Use

Roads, industrial, and commercial land use were noted on both sides of the creek.

Outfalls

There are six outfalls in this reach. Two outfalls, one 12" and one 18", are located over fifty feet from the stream. Another 12" pipe is located less than ten feet from the stream but is set back enough that it may be a good place for a swale. One outfall is 18" in diameter, less than ten feet from the stream, and drains Del Paso Boulevard. The final two are 24" storm drains from Interstate 80 which are less than ten feet from the stream.

Restoration Opportunities

The restoration opportunities in this reach include invasive removal, bank stabilization, trash cleanup, and cleaning up homeless camps.

Reach ID: 37

Starting Stationpoint: 89.0
Ending Stationpoint: 92.7
Photographs: 071502: 14-22

Channel Characteristics

The stream channel in this reach has low sinuosity. The streambed consists primarily of silt with small amounts of organic debris and sand and a small amount of gravel. The bankfull width is three times the observed width. Both banks are in fair condition with erosion hazards and some cut. The available floodplain is 180 feet wide. At .5 feet per second the stream velocity is very slow. Channel canopy cover is 40%.

Vegetation and Wildlife

Left bank vegetation is rated good with a 50% canopy cover. Tree species include Interior Live Oak, Valley oak, Oregon Ash, and California Black Walnut. Poison Oak and Red Sesbania were also observed along with a marshy wetland area. Right bank vegetation is rated fair with 30% canopy cover. Valley Oak, Oregon Ash, Interior Live Oak, California Buckeye, and Red Sesbania were all recorded on the right bank.

Wildlife in this reach included Scrub Jays and a turtle.

Land Use

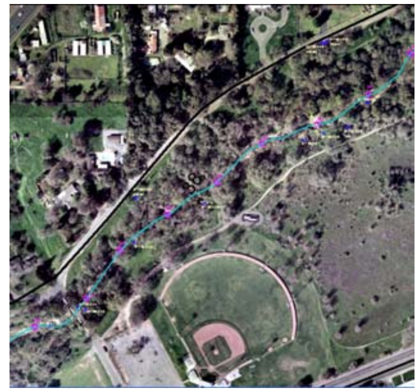
Land use on the left bank consists of a park. The right bank is used for a park and residential development.

Outfalls

The single outfall in this reach is a 24” metal pipe connecting to a culvert from the neighboring park. It is located more than fifty feet from the stream.

Restoration Opportunities

Restoration opportunities include invasive species removal and revegetation, bank stabilization, trash cleanup, and removal of structures. There is a homeless camp in this reach that should be cleaned up. An existing concrete trail adjacent to the park could be restored and used as an educational trail.



Reach ID: 38

Starting Stationpoint: 92.7
Ending Stationpoint: 98.0
Photographs: 071502: 23-27, 50

Channel Characteristics

The stream channel in this reach has low sinuosity. The streambed consists primarily of silt with some organic debris and sand and small amounts of gravel. The bankfull width is slightly over twice the observed width. Both banks are in poor condition with cut and eroded banks. There are some obstructions in the form of in-channel woody debris. The available floodplain is 600 feet wide. The stream flows slowly at .5 feet per second. Channel canopy cover averages 55%. Stream structure is moderate with two pools and one riffle.

Vegetation and Wildlife

Left bank vegetation is rated good and has 60% canopy cover. Dominant trees include Interior Live Oak, Valley Oak, California Black Walnut, Oregon Ash, Fremont Cottonwood, Willow species, and Almond. Invasive species observed were Common Fig and Giant Reed. Fennel was one of the understory plants. Right bank vegetation was rated good with 60% canopy cover. Interior Live Oak, Valley Oak, California Black Walnut, and Oregon Ash observed on the right bank, as was the invasive Giant Reed. Overall the vegetation in this reach consisted of many old growth natives and some exotic invasives.

A Blue Jay was the only wildlife observed in this reach.

Land Use

Land use on the left bank included roads, open space, and a ball field. The right bank is used for residential uses and roads.

Outfalls

There were a number of 6” holes draining from a road overpass. There was also a 12” storm drain outlet located less than 10 feet from the stream.

Restoration Opportunities

Restoration opportunities include invasive species removal, bank stabilization, removal of structures, creation of overflow and detention structures and trash cleanup. Removing debris from the channel is recommended.

Reach ID: 39

Starting Stationpoint: 98.0
Ending Stationpoint: 104.0
Photographs: 071502: 28-38, 47-49

Channel Characteristics

The stream channel in this reach has a low sinuosity. The streambed consists of mostly silt and gravel with small amounts of organic debris and sand. The bankfull width is 1.3 times the observed width. Both banks are in moderate condition with some cutting and erosion. There are some large snags and sandbars obstructing the channel. The available floodplain is 400 feet wide. Water flows quickly at 1 foot per second in this reach. Channel canopy cover is 30%. Stream structure is good with three runs in the reach.

Vegetation and Wildlife

Left bank vegetation is rated good with a 40% canopy cover. Dominant trees include Valley oak, Interior Live Oak, Oregon Ash, California Black Walnut, Bigleaf Maple, Willow species, and White Mulberry. Sedges and other plants make up a significant marshy wetland area. Invasive species include Giant Reed, Himalayan Blackberry, Common Fig, and Red Sesbania. Right bank vegetation is rated fair with 40% canopy cover. Valley Oak, Interior Live Oak, Oregon Ash, California Buckeye, and California Black Walnut were observed on the right bank along with invasive Himalayan Blackberry.

Mallards, Scrub Jays, and a Cooper's Hawk were observed in this reach. Fingerlings and tadpoles were seen in the water. A Striped Skunk was encountered next to one of the drainage swales.

Land Use

Residential land use was observed on both sides of the creek.

Outfalls

There are three outfalls in this reach. One is a 24" metal pipe which is the outflow of a naturally occurring drainage. It was flowing at about 0.7 cubic feet per second and there was a large pool at the outlet. It was located over 50 feet from the stream but connected by a long backwater channel. Two residential storm drains empty into this reach. Both are 12" in diameter and are located approximately 100 feet from the stream. These outfalls likely convey stormwater from the residential communities to the south, and as such are good candidates for mitigation design. Given the size of the open space between Auburn Boulevard and the stream, a water quality basin and filtration wetland could be used to filter storm first-flush. Additionally, a large detention basin could be constructed to hold the runoff from major events.

Restoration Opportunities

Restoration opportunities include invasive plant removal, revegetation, bank stabilization, removal of structures, and trash cleanup. There is a homeless camp with a latrine area in the bushes that should be cleaned up.

Reach ID: 40

Starting Stationpoint: 104.0
Ending Stationpoint: 112.0
Photographs: 071502-39-46

Channel Characteristics

The stream channel in this reach has a low sinuosity. The streambed consists mostly of silt with some organic debris and small amounts of gravel and sand. The bankfull width is slightly over two times the observed width. Both banks are in poor condition and are incised, cut, and eroding. There are many snags and woody debris obstructing the stream. There is also a large mid-channel bar midway in this reach. The width of the available floodplain is very large at 1200 feet. The stream flows slowly at .5 feet per second. Stream structure is good with three runs in this reach.

Vegetation and Wildlife

Left bank vegetation was rated good with 40% canopy cover. Tree species found on the left bank included California Black Walnut, Valley Oak, Oregon Ash, Willow Species, White Alder, Bigleaf Maple, and Interior Live Oak. Giant Reed, Himalayan Blackberry and Red Sesbania were two invasive species found on the left bank. Right bank vegetation was rated good. California Black Walnut, Interior Live Oak, Valley Oak, White Alder, Poison Oak, and Willow species were observed as well as the invasive species Red Sesbania and Himalayan Blackberry.

A Cooper's Hawk, Blue Jay, Mourning Dove, and Pheasant were seen in this reach. Fingerlings were observed in the water as well as a structure resembling a beaver dam.

Land Use

Land uses along the left bank included open space, a road, and a homeless camp. Land use along the right bank consisted of open space, a park, residential development, roads, and a homeless camp.

Outfalls

There are three outfalls in this reach all of which are located over fifty feet from the stream. One is a natural creek confluence, which is ten feet across. Another is a 33" concrete pipe located approximately 100 feet from the stream with large blackberry brambles in between. The third is a 12" drainage channel from a residential area.

Restoration Opportunities

Restoration opportunities in this reach include invasive species removal, structure removal, bank stabilization, the creation of in-channel structure and overflow and detention structures, and trash cleanup. There is a homeless camp on the left bank. Due to the large floodplain width there are many possibilities for setback restoration and creation of permanent or seasonal wetlands.

Reach ID: 41

Starting Stationpoint: 112.0
Ending Stationpoint: 118.7
Photographs:080202: 97-124, 106b, 117b

Channel Characteristics

The stream channel in this reach has very low sinuosity, being for the most part straight. Streambed is mostly silt with some streambed organic debris but no sand, gravel, cobbles, or rocks. Bankfull width is ten times the observed width. Overall bank condition is good but at the time of observation serious erosion was occurring at a pump station on the left bank. Work in the area has since been observed, so the damage may have been repaired. A garlic-like odor was noted during the site visit. Obstructions in the channel include a beaver dam type structure and a concrete structure. There is a dry channel running along part of this reach. The available floodplain reached a width of 150 feet. Stream velocity is very low at .2 feet per second and channel canopy cover is 95%. Stream structure is poor with no riffles occurring in this reach.

Vegetation and Wildlife

Left bank vegetation is rated good with trees, shrubs, and forbs creating a 95% canopy cover. Dominant trees on the left bank include Oregon Ash, Interior Live Oak, Willows, California Black Walnut, California Buckeye, Siberian Elm, and Valley Oak. Invasive species include Himalayan Blackberry, and Black Locust. Right bank vegetation is good with 85% canopy cover consisting of trees, shrubs, and forbs. Dominant trees on the right bank include Oregon Ash, Valley Oak, Fremont Cottonwood, California Black Walnut, Goldenrain Tree, Catalpa, and Willow species. Invasive species include Red Sesbania, Giant Reed, Black Locust, Himalayan Blackberry, and Silktree. Overall the vegetation was varied with and excellent structure.

A Red-shouldered Hawk and some scrub jays were observed in the area. Fingerlings were observed in the creek. There were several dead trees, which may serve as roosting sites and a wooden pile in the creek that resembles a beaver dam.

Land Use

On the left bank there is open land, an access road, and apartment buildings. A levee parallels the left bank of the creek about 100' to the south, and a pump station is located in this reach. The pump station appears to move stormwater from the residential communities on the other side of the levee into the creek. On the right bank is a hospital with turfgrass and a parking area.

Outfalls

There are six outfalls in this reach ranging from 12" to 36" in diameter. Three 14" concrete pipes at the pumping station are causing serious erosion. The 36" pipe is also causing serious erosion and is located more than fifty feet from the creek. A 24" concrete and cobble outfall is located less than ten feet from the creek but is not causing erosion problems. A 12" concrete and cobble outfall is located over fifty feet from the creek.

Restoration opportunities

Restoration opportunities include revegetation and removing invasive species, removing structures from the creek channel, trash cleanup in and along the creek, creating overflow/detention structures, and stabilization of the banks. Stopping bank erosion at the pumping station should be a restoration project of the highest priority. The large setback of the 36” pipe provides an opportunity for filtration techniques to be used to improve water quality.

Appendix B – Evaluation Criteria and Matrix

Rating methodology

The following rating system was used for evaluation of the factors listed in the Analysis section of the Methodology. Each factor was evaluated based on the descriptions provided in the previous section. For factors dealing with the left and right banks, each side was considered independently. The evaluation results in a rating number, typically from 0-2, which indicates a site's potential to meet the objective if restoration is performed, with 0 being lower and 2 being higher potential. This data is then displayed graphically in the Matrix (4.2).

Flood Control

1. Width of floodplain compared to channel.

   Criteria:

Rating	*Range*	*Description*
0	1:1 or less	Low opportunity for overflow structures
1	1:1>x>3:1	Moderate opportunity for overflow structures
2	>3:1	Good opportunity for overflow structures

2. Width of Left and Right Bank Riparian corridor.

   Criteria:

Rating	*Range*	*Description*
0	0-10'	No opportunity for structures
1	10'-30'	Moderate opportunity – techniques such as channel widening.
2	>30'	Good opportunity – channel widening and detention structures.

3. Adjacent land use.

Criteria:

Rating	*Range*	*Description*
0	Developed land	Poor opportunity for overflow structure
1	Golf course or Park	Moderate opportunity for restoration
2	Undeveloped land	Good opportunity for restoration structure

Water Quality:

1. Size of outfall.

Criteria:

Rating	*Range*	*Description*
0	<1'	Low potential for impact. Low need for mitigation.
1	1'-3'	Moderate potential for impact. Moderate need for mitigation.
2	>3'	High potential for impact. High need for mitigation.

2. Source of outfall.

Criteria:

Rating	*Range*	*Description*
0	Open space, natural areas,	Low potential to mitigate pollutants.
1	Residential, golf course, developed parks	Moderate potential to mitigate pollutants.
2	Industrial, commercial & roadways	High potential to mitigate pollutants.

3. Distance from outfall to creek channel.

Criteria:

Rating	*Range*	*Description*
0	<10’	Little to no opportunity to mitigate.
1	10’-50’	Moderate opportunity to mitigate using diversion structure parallel to creek and linear wetlands or sand filters.
2	>50’	Good opportunity to mitigate using stormwater wetlands.

4. Width of Riparian corridor at outfall location.

Criteria:

Rating	*Range*	*Description*
0	<10’	Low potential for mitigation structure
1	10’-50’	Moderate potential for mitigation structure
2	>50’	Good potential for mitigation structure

5. Presence of trash.

Criteria:

Rating	*Range*	*Description*
0	No	Low potential for impact.
1	Yes	Moderate potential for impact.

6. Adjacent land use.

Criteria:

Rating	*Range*	*Description*
0	Adjacent land has low intensity land use	Natural area, undeveloped park and/or open space.
1	Adjacent land has moderately intense land use	Parking lot, residential lawn, industrial site, roadway, with a vegetated buffer.
2	Adjacent land has intense land use	Parking lot, residential lawn, industrial site, roadway, without a vegetated buffer.

7. Visible Runoff

Criteria:

Rating	*Range*	*Description*
0	No runoff	Low need for mitigation
1	Runoff present, no odor or foam	May need mitigation
2	Runoff present, foul odor or scum.	Probably requires mitigation

8. Presence of Algae

Criteria:

Rating	*Range*	*Description*
0	No	Low need for mitigation
1	Yes	May need mitigation

Recreation

1. Adjacent Land Use

Criteria:

Rating	*Range*	*Description*
0	Incompatible with recreation	Industrial, etc.
1	Compatible with recreation	Residential, Commercial, etc.
2	Encourages recreation	Park or open space

2. Width of Left and Right Riparian Corridor

Criteria:

Rating	*Range*	*Description*
0	<20’	Opportunity for recreation very limited.
1	20’-50’	Opportunity for trails
2	50’-100’	Opportunity for meandering trails or small staging areas.
3	>100’	Opportunity for larger staging area, park, kiosk, etc.

3. Presence of Existing Trails

Criteria:

Rating	*Range*	*Description*
0	No or unknown	Lesser opportunity for recreation
1	Yes	Greater opportunity for recreation

4. Proximity to residential areas

Criteria:

Rating	*Range*	*Description*
0	Residential neighborhood more than ¼ away	Lesser opportunity for recreation
1	Residential neighborhood within a ¼ mile	Greater opportunity for recreation

5. Proximity to existing recreational facilities

Criteria:

Rating	*Range*	*Description*
0	Recreational facility more than ¼ mile away	Lesser opportunity for recreation
1	Recreational facility within ¼ mile of stream segment	Greater opportunity for recreation

6. Accessibility

Criteria:

Rating	*Range*	*Description*
0	Road not within or adjacent to riparian buffer	Lesser opportunity for recreation
1	Road within or adjacent to riparian buffer	Greater opportunity for recreation

7. Ownership

Criteria:

Rating	*Range*	*Description*
0	Private land within or adjacent to riparian buffer.	Lesser opportunity for recreation
1	Public land within or adjacent to riparian buffer.	Greater opportunity for recreation

Aquatic and Riparian Species Habitat

Aquatic Habitat

1. Sinuosity

Criteria:

Rating	*Range*	*Description*
0	>2	Good sinuosity, lesser need for restoration
1	1.5-2	Moderate sinuosity, may need restoration
2	<1.5	Poor sinuosity, greater need for restoration

2. Pools and Riffles

Criteria:

Rating	*Range*	*Description*
0	Pools and riffles observed in reach	Adequate aquatic habitat may be present already; reduced need for restoration.
1	Pools or riffles noted in reach, but not both	Some aquatic habitat present in reach; may benefit from restoration.
2	No pools or riffles noted in reach	Aquatic habitat would benefit from restoration that creates pools and riffles.

3. Channel Canopy Cover

Criteria:

Rating	*Range*	*Description*
0	≥40%	Excellent shading, no restoration necessary.
1	<40%	Poor to moderate shading, restoration could enhance habitat.

4. Streambed Material

Criteria:

Rating	*Range*	*Description*
0	Gravel and Sand less than or equal to 3 rating. Organic debris and cobbles present.	Good streambed habitat exists. Lesser opportunity for restoration.
1	Gravel or sand greater than or equal to 3 rating. Organic debris or cobbles present.	Moderate streambed habitat exists. Some opportunity for restoration schemes that improve streambed material.
2	Gravel, sand, cobbles or organic debris not present or present in insignificant quanitites (6 rating).	Streambed habitat generally poor. Restoration recommended.

5. Fish Observed

Criteria:

Rating	*Range*	*Description*
0	Yes – salmonids noted	Good habitat exists somewhere near the observation point, or salmonids are using the creek for spawning and/or migration. Lesser need for restoration.
1	Yes	Some habitat exists. Restoration may improve the existing habitat.
2	No	Habitat may be lacking. Greater need for restoration.

6. Turtles/Frogs observed

Criteria:

Rating	*Range*	*Description*
0	Yes	Some habitat exists. Lesser need for restoration.
1	No	Habitat may be lacking. Greater need for restoration.

7. Left and Right Bank Condition

Criteria:

Rating	*Range*	*Description*
0	Good	Good shelter habitat. Restoration not necessary
1	Fair	Moderate shelter habitat. Restoration that stabilizes bank and creates better overhands will probably help fish species.
2	Poor	Poor shelter habitat and increased sediment loading on stream. Restoration to stabilize banks should be considered.

Riparian Wildlife Species Habitat

8. Bird Species Observed

Criteria:

Rating	*Range*	*Description*
0	Species noted is within list above	Good riparian habitat present. Restoration may not be needed.
1	Species from above list not noted	May indicate a lack of good habitat. Restoration may be beneficial to these species.

9. Left and Right Bank Vegetation Type

Criteria:

Rating	*Range*	*Description*
0	Trees/shrubs or wetlands	Good habitat. No restoration necessary.
1	Shrubs/brambles	Riparian species may benefit from restoration of this reach with larger woody vegetation.
2	Grasses/forbs	Riparian species would benefit from introduction of trees and shrubs to this reach.

10. Left and Right Bank Riparian Canopy Cover

Criteria:

Rating	*Range*	*Description*
0	>50%	Good canopy cover. Restoration not necessary.
1	20-50%	Health of the riparian habitat may be improved by introducing more trees.
2	<20%	System should be enhanced by planting more large trees.

11. Left and Right Bank Riparian Canopy Structure

Criteria:

Rating	*Range*	*Description*
0	Good	No restoration needed
1	Moderate	Restoration may help improve habitat
2	Poor	Restoration needed to improve habitat.

12. Total Riparian Width

Criteria:

Rating	*Range*	*Description*
0	$R_T/C \geq 4$	Restoration not necessary
1	$R_T/C < 4$	Restoration maybe beneficial

R_T = Total width of the riparian corridor (L Riparian width + channel width + R Riparian width), C = Channel Width

13. Left and Right Bank Land Use

Criteria:

Rating	*Range*	*Description*
0	Incompatible LU	Lower probability for restoration success
1	Compatible LU	Higher probability for restoration success

14. Presence of Invasive Plant Species

Criteria:

Rating	*Range*	*Description*
0	No	Invasive species removal not necessary
1	Yes	Invasive species removal needed

The table on the following page is constructed from the preceding ratings. Red circles in this matrix indicate a high potential for restoration in this reach for the associated factor. Yellow circles indicate moderate potential, and green indicate low potential. Recreation opportunities are not noted, since it was determined during evaluation that recreation factors were better analyzed spatially. See the Recreation Opportunities map for additional information.

This table was used in the restoration opportunities and constraints work-session to quickly identify potential restoration sites. Reaches predominantly showing red in a goal area were likely candidates for restoration activities, and thus prompted a more in-depth examination of the physical factors on that reach.

	Reach ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Flood Control	1. Width of floodplain compared to channel,	M	L	L	M	L	L	L	L	L	M	M	M	L	M	M	L	L	L	L	L	M	L	L	L	M	L	H	H	H	L	H	M	L	L	H	H	H	H	H	H	L
	2. Width of riparian corridor,	L	L	L	M	H	H	L	M	L	M	M	M	L	L	H	H	L	M	M	M	M	M	L	M	M	L	H	H	H	H	H	M	H	H	L	H	H	H	H	H	L
	3. Adjacent land use R bank	L	L	L	L	L	L	L	L	L	L	H	L	L	M	M	M	M	M	M	M	M	M	M	M	M	M	M	L	L	L	H	L	L	L	L	L	M	L	L	H	L
	3. Adjacent land use L bank	L	L	L	L	L	L	L	L	L	L	H	L	L	M	M	M	M	M	M	M	M	M	L	M	M	M	M	M	M	M	M	M	M	L	L	L	M	H	L	H	H
	summ, land use (max L/R LU)	L	L	L	L	L	L	L	L	L	L	H	L	L	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H	M	M	L	L	L	M	H	L	H	H
Water Quality	1. Size of outfall,	H	M	N	M	L	M	H	L	H	M	N	N	L	L	N	N	N	N	N	L	L	L	L	H	M	N	N	N	M	N	N	N	H	N	M	M	M	L	M	H	M
	2. Source of outfall,	H	M	N	M	M	M	H	L	H	H	N	N	H	H	N	N	N	N	N	M	M	M	H	M	M	N	N	N	M	N	N	N	M	N	H	H	M	H	M	M	H
	3. Distance from outfall to creek channel,	M	M	N	M	M	M	M	M	L	M	N	N	M	M	N	N	N	N	N	L	M	L	M	M	H	N	N	N	L	N	N	N	L	N	L	H	H	H	H	H	H
	4. Width of riparian corridor at outfall,	L	M	L	M	M	M		M	L	M	M	M	L	L	H	H	L	M	M	M	M	M	M	M	M	L	N	H	H	H	H	M	H	H	L	H		H	H	H	L
	5. Presence of trash,	M	M	M	M	M	L	M	M	L	M	M	M	M	M	L	L	L	M	L	M	M	M	M	M	M	L	M	M	M	M	M	M	L	M	L	M	M	M	M	M	M
	7.a Adjacent land use, R bank	H	H	H	M	M	M	H	M	H	M	L	M	H	H	M	M	H	M	M	M	M	M	H	M	M	H	M	M	M	M	M	M	M	M	H	M	M	M	M	M	H
	7.b Adjacent land use, L bank	H	M	M	M	M	M	H	M	H	M	L	M	H	H	M	H	H	M	M	M	M	M	M	H	M	H	M	M	M	M	M	M	M	H	H	M	M	M	M	M	L
	7. Adjacent land use, MAX	H	H	H	M	M	M	H	M	H	M	L	M	H	H	M	H	H	M	M	M	M	M	H	H	M	H	M	M	M	M	M	M	M	H	H	M	M	M	M	M	H
	8. Visible runoff, Outfall	H	L	N	M	L	L	L	L	M	L	N	N	L	L	N	N	N	N	N	M	L	L	L	M	L	N	N	N	L	N	N	M	H	N	L	L	M	L	H	M	M
	9. Algae present, outfall	M	L	N	M	L	L	L	L	M	L	N	N	L	L	N	N	N	N	N	L	L	L	L	L	L	N	N	N	L	N	N	N	M	N	L	L	L	L	L	L	M
	10. Bank erosion	L	L	M	M	M	M	L	M	L	L	M	M	M	L	M	M	L	M	M	M	M	L	L	M	L	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Aquatic and Riparian Species Habitat	Aquatic:																																									
	1. Sinuousity,	L	M	L	L	L	L	L	L	L	L	L	L	L	M	H	M	H	M	M	L	L	L	L	L	L	L	M	H	H	M	M	L	H	L	L	L	L	L	L	L	L
	2. Presence of pools and riffles,	H	M	H	H	H	H	H	H	H	L	L	H	L	M	L	L	H	L	L	L	M	M	M	M	M	M	L	L	L	L	L	M	L	L	L	M	M	L	L	L	H
	3. Channel canopy cover,	M	M	M	M	L	L	M	M	M	L	M	M	M	M	M	M	M	L	M	M	M	M	L	M	M	M	L	L	L	L	L	M	L	L	L	L	L	L	M	M	L
	4. Streambed material,	H	H	H	H	H	H	H	M	H	H	H	H	H	M	M	M	M	M	M	H	H	H	H	M	H	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H
	5. Fish observed,	H	H	H	M	M	M	M	M	M	H	H	M	H	H	H	H	H	H	H	H	H	H	H	M	M	M	H	M	H	M	M	H	M	M	H	M	H	H	M	M	M
	6. Turtles and/or frogs observed,	M	M	M	M	M	M	M	M	L	M	M	M	M	M	M	M	M	M	L	M	M	L	M	M	M	M	M	M	M	M	M	L	M	M	M	L	L	M	L	M	M
	Riparian Species:																																									
	7. Bird species observed,	M	L	M	M	L	M	M	M	L	L	L	L	M	M	M	L	M	M	M	M	M	L	M	M	M	M	M	M	M	M	M	L	L	L	M	L	M	M	L	L	L
	8a. R bank condition	M	M	H	H	M	H	H	H	H	H	H	H	H	H	M	M	M	M	H	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H	M	M	H	M	H	L
	8b. L bank condition	L	M	H	M	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	M	M	M	H	M	M	H	M	M	M	M	M	M	M	H	M	M	H	M	H	L
	9a. Vegetation type, R Bank	NA	L	L	L	L	L	NA	M	NA	L	H	L	H	NA	L	NA	H	L	NA	NA	H	M	L	L	H	L	H	L	H	L	NA	L	H	L	H	L	NA	L	NA	L	L
	9b. Vegetation type, L Bank	NA	L	L	L	L	L	L	L	NA	L	H	L	H	L	L	NA	L	L	NA	NA	L	L	L	L	H	L	H	L	H	L	NA	L	H	L	H	L	NA	L	NA	L	L
	10a. R canopy cover,	H	L	M	H	H	H	M	H	M	L	H	H	H	H	L	H	H	H	H	H	H	H	M	H	M	H	L	L	L	L	M	M	L	M	M	M	M	L	M	H	L
	10b. L canopy cover	H	H	M	M	M	L	M	L	M	H	M	H	H	H	L	H	H	H	H	H	M	M	M	H	M	H	L	L	L	L	M	M	L	L	M	M	M	L	M	M	L
	11a. R canopy structure,	NA	H	H	H	H	H	H	H	H	M	H	M	H	H	M	NA	H	H	H	H	H	H	L	M	L	H	L	L	L	L	M	L	L	L	M	L	M	L	M	L	L
	11b. L canopy structure	NA	H	H	H	M	L	H	M	H	M	M	M	H	H	M	M	H	M	H	H	H	M	L	H	L	H	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L
	12. Riparian width,	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	L	M	M	L	L	M	M	L	M	L	M	L	L	L	M
	13a. R bank landuse	L	M	M	M	M	M	M	M	M	M	M	L	L	L	M	M	M	M	M	M	M	M	M	M	M	M	M	L	M	L	M	M	M	L	L	L	M	M	M	M	M
	13b. L bank landuse	M	M	M	M	M	M	M	M	M	M	M	L	L	L	M	M	M	M	M	M	M	M	L	M	M	M	M	M	M	M	M	M	M	M	L	L	M	M	M	M	M
	14. Invasive Species Presence.	M	M	M	M	M	M	M	M	L	M	M	M	M	M	M	M	M	L	M	M	M	M	L	M	M	L	M	L	M	L	M	M	L	M	M	M	M	M	M	M	M
Other Restoration Opportunities	Channel Widening																					H	H	H				H	H		H	H	H		H							
	Revegetation	H	H	H	H	H	H		H	H	H	H	H	H	H		H	H	H	H	H	H	H		H		H	H		H			H		H			H		H		H
	Invasive Removal	H	H	H	H	H	H	H	H		H	H	H	H	H	H	H	H		H	H	H	H		H	H		H		H		H	H		H	H	H	H	H	H	H	H
	Remove Structures		H	H			H				H				H		H	H	H	H	H		H									H	H		H			H	H	H	H	H
	Bank Stabilization			H	H		H		H			H	H	H		H	H		H		H	H			H		H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
	In-Channel Structure									H												H		H	H	H			H	H	H	H	H	H	H	H					H	
	Overflow/Detention Structure																						H		H	H		H	H	H	H	H	H	H	H						H	H
	Trash Cleanup	H	H	H	H	H		H	H		H	H	H	H	H				H		H	H	H	H	H	H		H	H	H	H	H	H		H		H	H	H	H	H	H

Key		
	High Opportunity/need for restoration	H (orange)
	Med Opportunity/need for restoration	M (yellow)
	Low Opportunity/need for restoration	L (green)
	No outfall in reach	N (white)
	data not available	NA (grey)

Appendix C – Field Maps

FOOTHILL ASSOCIATES
ENVIRONMENTAL CONSULTANTS
(916) 782-1011
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ARCADE CREEK FEASIBILITY STUDY

REACH MAP

N

SCALE:
50 0 50 100 Feet

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Environmental Consultants
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ARCADE CREEK
FEASIBILITY STUDY

REACH MAP

N

SCALE:
50 0 50 100 Feet

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ARCADE CREEK
FEASIBILITY STUDY

REACH MAP

N

SCALE:
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SCALE:
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ARCADE CREEK
FEASIBILITY STUDY

REACH MAP

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SCALE:
50 0 50 100 Feet

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ARCADE CREEK
FEASIBILITY STUDY

REACH MAP

N

SCALE:
50 0 50 100 Feet

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ARCADE CREEK FEASIBILITY STUDY

REACH MAP

N

SCALE:
50 0 50 100 Feet

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ARCADE CREEK FEASIBILITY STUDY

REACH MAP

N

SCALE:
50 0 50 100 Feet

Appendix D – Field Photographs


052202-03


052202-06


052202-09


052202-02


052202-05


052202-08


052202-01


052202-04


052202-07


052202-37


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052202-43


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052202-39


052202-42


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062502-09


062502-12


062502-05


062502-08


062502-11


062502-04


062502-07


062502-10


062502-15


062502-18


062502-21


062502-14


062502-17


062502-20


062502-13


062502-16


062502-19


062702-102


062702-105


062702-108


062502-23


062702-104


062702-107


062502-22


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062702-111


062702-114-120


062702-115


062702-110


062702-113


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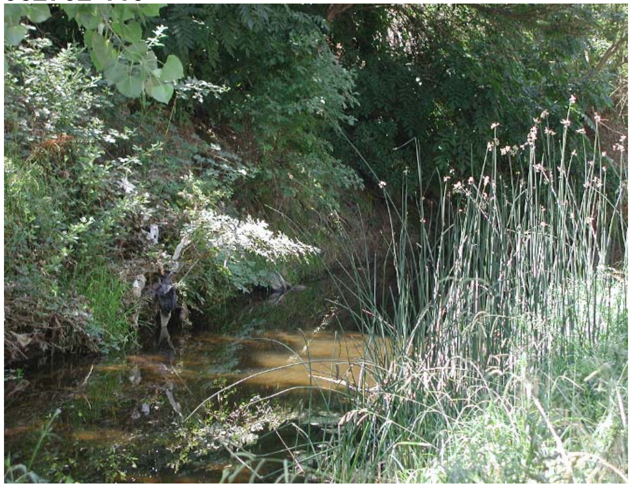
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062702-116


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062702-148b


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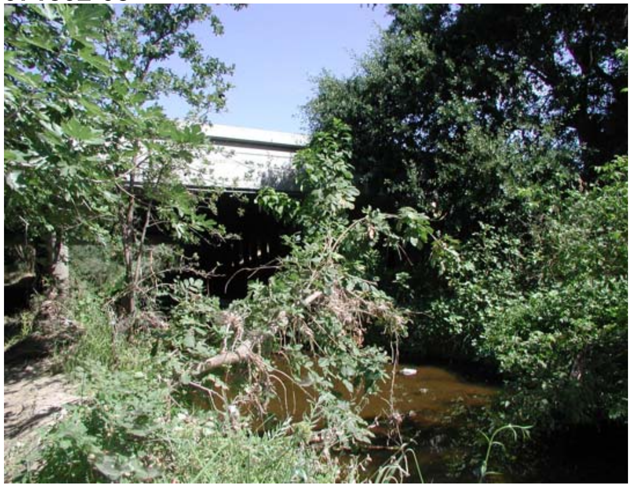
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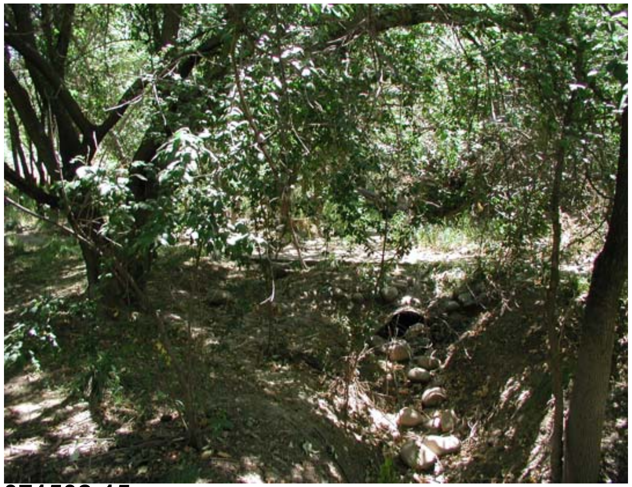
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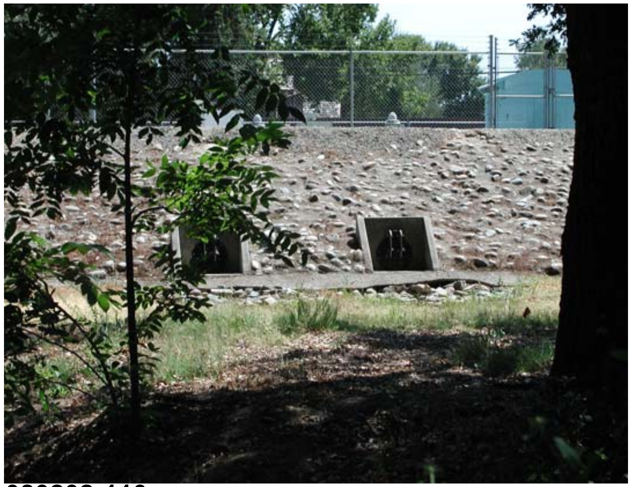
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Appendix E – Historic Changes to the Study Area

Appendix F – References

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