STEELHEAD DISTRIBUTION AND ECOLOGY IN THE UPPER PAJARO RIVER SYSTEM
(with DRAFT preliminary restoration options, pages 33-34)

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I have investigated steelhead (*Oncorhynchus mykiss*) utilization of the Pajaro River watershed periodically for almost 30 years. In 1972-1976 sites throughout the watershed were sampled as part of Ph.D. investigations of Pajaro River system fishes (Smith 1982). Additional studies were undertaken in 1981-1983 to develop a steelhead management plan for the Pajaro River watershed (Smith et al. 1983 and 1984). Most steelhead and rainbow trout habitats were revisited in 1997 and/or 1998 to collect samples for a genetic study of Pajaro River steelhead and rainbow trout (Sundermeyer 1999). Regular site visits and limited fish sampling since 1982 have indicated that most recent habitat changes in the watershed have been associated with increasing urbanization of the valley floor and suburban encroachment upstream in the Uvas and Llagas creek watersheds. This report updates habitat conditions and steelhead status for the Santa Clara County portion of the Pajaro River system, based upon conditions observed prior to 1982-3 (Smith et al 1983 and 1984) and changes observed since that time. Steelhead access and rearing in the upper watershed were substantially impacted by the 1987-1991 drought, but most populations now appear to be generally similar to pre-drought conditions. The following habitat descriptions and steelhead status assessments are arranged from downstream to upstream.

Pajaro River

The Pajaro River serves as a migration pathway for steelhead, but because of low and warm summer streamflows and substrate dominated by sand or silt it provides almost no potential rearing habitat for steelhead. Even in wet years (1973, 1982) when summer streamflows were higher, the relatively high water temperatures and fine substrate still limited rearing steelhead to a few individuals at one site (Smith 1982). If the river were used to transport imported water downstream to Santa Cruz County summer streamflows and water quality would improve, but summer fish use would still probably be limited to warmwater species. The only significant habitat changes in the Pajaro River since the earlier AMBAG studies (Smith et al. 1983 and 1984) were the substantial increase in riparian vegetation in reach 2 in the 1980's through early 1990's, and the removal of most of those gains in 1995. Habitat descriptions by reach and an assessment of fisheries potential and steelhead limiting factors follow (limiting factors with * may be subject to modification).

1. Mouth to Highway 1: the Lagoon. A summer lagoon forms at the mouth of the Pajaro River, with partial or full closure of a sandbar at the beach. In most years the mouth is partially open all summer and tidal action in the brackish lagoon can occasionally penetrate as far upstream as Highway 1. In years when the sandbar fully closes, impounded water backs upstream to between the Watsonville Sewage Treatment Plant and Highway 1. The lagoon is generally shallow, with few portions deeper than 2 m. Inflows from the river and agricultural runoff to a closed lagoon are insufficient to convert the lagoon to freshwater (Swanson and Associates and Habitat Restoration Group 1993 A and B). The lagoon is generally stratified for salinity and temperature, with cooler freshwater at the surface and warmer saline water at the bottom. The reverse pattern of temperature stratification is because solar heat is trapped in the saline bottom water of the shallow lagoon, but the surface can lose heat to the air at night or on cool days. After full sandbar closure winds can gradually (6+ weeks) break up the stratification in the lower portion of the lagoon, but stratification persists in the narrow, tree-lined upper portion of the lagoon.

Lagoon Fish. Steelhead apparently do not rear in the lagoon because spawning areas are far upstream within Pajaro River tributaries; the closest good spawning habitat is 7 miles upstream in Corralitos Creek. However, the lagoon provides potentially important feeding habitat in spring for outmigrating smolts. The most common fish species of the lagoon are euryhaline saltwater fishes, including Pacific herring (*Clupea harengis*), topsmelt (*Atherinops affinis*), shiner surfperch (*Cymatogaster aggregata*), staghorn sculpin (*Leptocottus armatus*), starry flounder (*Platichthyes stellatus*) and striped bass (*Morone saxatilis*). Three resident estuarine fishes can also be present, threespine stickleback (*Gasterosteus aculeatus*), arrow goby (*Clevlandia ios*) and tidewater goby (*Eucyclogobius newberryi*); the endangered tidewater goby has not been captured in the lagoon since 1994.

When the sandbar forms early in summer and the lagoon substantially converts towards freshwater, stream fishes would be able to use the fresher portions of the lagoon. Studies in the Salinas River (Habitat Restoration Group, et al. 1992) have demonstrated that hitch (*Lavinia exilicauda*) and Sacramento blackfish (*Orthodon microlepidotus*) can tolerate salinities of up to 7 – 9 parts per thousand (PPT). Carp (*Cyprinus carpio*), Sacramento pikeminnow (=squawfish) (*Ptychocheilus grandis*) and Sacramento sucker (*Catostomus occidentalis*) can tolerate salinities of 4 PPT.

(Steelhead Limiting Factors: lack of fry recruitment from upstream spawning areas and inflows to the lagoon)

2. Highway 1 to About 1 Mile Downstream of Murphy Crossing. Summer streamflows are very low in this levee-lined reach of the Pajaro River. Salisipuedes Creek contributes some summer streamflow in the middle of the reach in all but the very driest years. Upstream of Salsipuedes Creek flow is from a shallow, perched aquifer, and the extent of surface flow varies substantially from year to year. In wet years the entire

reach has surface flow, but during the 1987-1991 drought surface water was restricted primarily to the area immediately upstream of Salsipuedes Creek. In the 1980's and early 1990's riparian vegetation was dense on and along the channel bed within the reach. Much of the channel vegetation was mechanically removed in spring 1995, following the floods of January and March 1995. High winter flows in 1997, 1998 and 1999 have prevented reestablishment of dense vegetation in the channel bed. The channel bed is sand, and pools are very shallow within the reach. The sandy bed tends to form a defined low flow channel around bends and along channel bed vegetation, allowing reasonably good low flow (at 10 cfs) passage for smolts in spring though much of the reach. The few shallow riffles tend to be relatively narrow, flat and short. Summer water temperatures exceed 80 degrees F, and were probably quite warm even when riparian vegetation along the low flow channel was dense. Spring water temperatures for smolts may be a problem, although temperatures cool substantially at night, when most smolt migration takes place.

(Steelhead Limiting Factors: spring and summer streamflow and water temperature)

3. 1 Mile Below and Above Murphy Crossing. This reach is normally dry by mid summer, and can be shallow enough to block smolt migration in April or May of dry years. Since perennial flows are absent, willows grow too slowly to significantly establish in the channel bed between storm years. Therefore, vegetation is restricted to the levee and toe of the levee slope, and winter and spring streamflows flows are spread over a wide, flat channel. Even when adult or smolt steelhead can negotiate reaches up or downstream of this reach, broad shallow riffles within this reach can block passage.

(Steelhead Limiting Factors: spring streamflow and water temperature and wide flat channel* for smolt passage)

4. 1 Mile Above Murphy Crossing to the Mouth of the San Benito River. This reach normally has perennial flows except in extreme droughts (1976 and 1977). The channel bed is dominated by sand, but some gravel and cobble riffles occur in the Aromas to Chittenden Pass area. Patches of marginal steelhead spawning gravels also occur in the Aromas to Chittenden Pass area. Large deep pools are found around fallen trees or at channel bends, but riffles or runs capable of providing fast-water feeding habitat for juvenile steelhead are very scarce. The corridor of riparian vegetation is generally dense, tall and wide along the stream, but afternoon summer water temperatures regularly exceed 72-74 degrees F.

(Steelhead Limiting Factors: summer streamflow and water temperature, spawning habitat and food production)

5. Mouth of the San Benito River to the Mouth of Llagas Creek. This reach has perennial flows and is generally bordered by a dense, tall, and wide riparian forest.

Major portions of the forest on the Santa Clara County side of the river, primarily between Highway 101 and the mouth of Carnadero Creek, were cut for flood control in 1982, but have regrown. Historically (1908) this reach was deep and lake-like, backed up behind a dam of sand pushed in from the San Benito River (Snyder 1913). Large pools still dominate the reach, but they are substantially filled with fine sediment (silts and clays) from the agricultural fields in the Gilroy area. Turbidity is high (50-80+ JTU), due to the fine sediment and its constant stirring by feeding carp. Filamentous algae is generally absent, but part of water column turbidity in summer is due to blooms of phytoplankton. Summer water temperatures are high (75-80 degrees F), and early morning dissolved oxygen levels can be low, due to the extreme scarcity of riffles for mechanical mixing.

(Steelhead Limiting factors: summer flow, water temperature and water quality (turbidity, oxygen))

6. Mouth of Llagas Creek to San Felipe Lake. This reach is the Pajaro River in name only, and the actual outflow of San Felipe Lake to the Pajaro River is through Miller Canal. The canal is a ditch dug early in the 20th century to speed the drainage of agricultural lands surrounding San Felipe Lake. The remnant Pajaro River Channel receives only local runoff from agricultural fields and pastures, and is often dry in summer.

(Steelhead Limiting Factor: local drainage ditch only)

Fisheries in the Pajaro River. Steelhead occasionally spawn in the Chittenden Pass to Aromas area, but high summer water temperatures, scarcity of fast-water feeding riffles and lack of suitable substrate for aquatic insects probably prevents significant rearing success anywhere in the Pajaro River, even in wet years. The river is the migration pathway to and from spawning and rearing habitat in Pescadero, Uvas, Llagas and Pacheco creeks. The major migration problem in the Pajaro River is getting smolts downstream through the Murphy Crossing area (reach 3), where the wide channel and early streambed drying can block all or some migrating fish in spring of many years. Adult carp, hitch, Sacramento blackfish and Sacramento suckers are abundant in the deeper pools of the Pajaro River, especially in reaches 4 and 5. Hitch, threespine stickleback and juvenile blackfish and suckers are widespread in the shallower habitats. Adult pikeminnow are common in larger, less turbid pools in the Chittenden Pass and Aromas area. Juvenile pikeminnow and prickly sculpin (*Cottus asper*) are found primarily in riffles and runs, where coarser substrate provides aquatic insects as food.

San Benito River

Hernandez Reservoir on the headwaters of the San Benito River provides substantial releases for groundwater percolation and downstream diversion, but is drawn down far

enough by late summer so that those releases are of warm water. Tributaries are small, except for Tres Pinos Creek, and all have low and warm summer streamflows. Much of the river upstream of the Highway 25 road crossing runs in the trace of the San Andreas fault, which provides for surface streamflows even in extreme drought years (1976-1977).

Fish Resources of the San Benito River Watershed. Steelhead have occasionally entered tributaries of the San Benito River in recent wet years (1995-1998). Juveniles were observed in Bird Creek in early summer 1995 and dead adults were observed in Pescadero Creek in spring 1997. However, no juvenile steelhead were captured in those streams in summer 1997. Summer water temperatures are probably sufficiently high within the watershed to preclude successful steelhead rearing. The observed steelhead were probably the result of adult straying by hatchery-reared smolts planted in the Pajaro River and Uvas Creek.

Sacramento sucker, hitch and California roach (*Lavinia symmetricus*) are found throughout the watershed. Threespine stickleback are present in Tres Pinos Creek, including in headwaters, where they were the only fish present in 1972-1974 (Smith 1982). Speckled dace (*Rhinichthyes osculus*) are present upstream of Hernandez Reservoir (including in Clear Creek) and in the San Benito River downstream to below the Highway 25 road crossing. Dace have been lost from other Pajaro River watershed locations (Pajaro River and Llagas Creek) since 1908 (Smith 1982) and from Coyote Creek and the Alameda Creek watershed (Scoppettone and Smith 1978). The San Benito River and the San Lorenzo River are now the only San Francisco Bay area watersheds with speckled dace.

(Steelhead Limiting Factor: water temperature)

Tar (La Brea) Creek

Tar Creek is a small tributary that enters Carnadero Creek immediately upstream of its confluence with the Pajaro River. During flood periods a lake, formed by Pajaro River backwaters, inundates the mouths of both creeks. There is no public access in its watershed, and no surveys have been done since 1981. However, the reaches upstream of Highway 1 are in ranch land, where habitat conditions are probably unchanged since the 1980's. Habitat descriptions by reach and an assessment of fisheries potential follows:

1. Mouth to Highway 101. This reach is a narrow channelized ditch, surrounded by irrigated crop agriculture. The silty ditch has only occasional agricultural runoff in late summer, so is unsuitable for steelhead spawning or rearing. However, since the ditch is flat and narrow, it provides easy adult winter passage, even between storms. The upper

watershed is relatively dry, so flows for smolt outmigration in spring can be quite low in dry years.

(Steelhead Limiting Factor: spring streamflow for smolt outmigration)

2. Highway 101 Upstream 2 Miles (Ranch Road Bridge). The stream banks are lined with relatively natural riparian vegetation, but streamflows are very low. The reach was dry in 1981, a year of below average rainfall. However in very wet years (1983,1995, 1998) surface flow is apparently present throughout the reach. The substrate in 1981 was relatively silty, and there are some oil seeps at the upstream end of the reach.

(Steelhead Limiting Factor: flow (usually dry in summer))

3. From Bridge Upstream 1.2 Miles. The stream was intermittent in 1981, with silty substrate and limited pool development. Steelhead rearing would be possible only in wet years, but spawning would probably have to occur upstream of the reach.

(Steelhead Limiting Factors: flow and substrate)

4. From 1.2 to 2.6 miles Upstream of Bridge (to Concrete Dam). Very tiny, mostly entrenched stream (Rosgen B4C) with dense riparian border. Pools are scarce and shallow, and silty-bottomed. Riffles have primarily angular gravels. The flow declines downstream within the reach, but flow is probably present in all but the driest years (like 1976-77); a small tributary from a farm pond enters from the west 0.8 miles upstream in the reach.

(Steelhead Limiting Factors: flow, substrate, pool development)

Steelhead in Tar Creek. This small tributary provides spawning and rearing in most years, but the small size of the stream, low streamflows, dense shading, and shallow pools probably limit young-of-year steelhead density and growth rate. The shallow pools may also limit overwintering survival and yearling abundance, although flood peaks may be small in this relatively small, dry watershed. The relatively easy adult access and the stream's location downstream of other upper basin steelhead tributaries probably results in regular straying of adult steelhead, especially of hatchery-origin fish. Threespine stickleback is the only other fish species present in the stream.

Uvas/Carnadero Creek Downstream of the Reservoir

The name of this stream changes from Carnadero to Uvas Creek upstream of Highway 101. The majority of spring and summer streamflow in Uvas/Carnadero Creek is

regulated by Uvas Reservoir, but two tributaries with perennial headwater reaches enter Uvas Creek downstream of the reservoir, Bodfish and Little Arthur creeks. All three streams support spawning and rearing by steelhead. Uvas Reservoir is the only reservoir in the Pajaro River watershed (or the remainder of Santa Clara County) whose water right specified minimum winter releases and summer releases (usually 10 cfs, except in drought years) for maintaining fish resources. However, a substantial part of Uvas Reservoir storage is transferred by pipeline to Llagas Creek for groundwater percolation in that watershed. Habitat descriptions by reach downstream of the reservoir and an assessment of fisheries potential follows:

1. Mouth Upstream to Thomas Road. This reach is normally dry in summer, although portions may have occasional surface flow due to agricultural runoff. Most of the reach apparently has a relatively low percolation rate, and there is little change in spring streamflows within the reach. The channel is incised (Rosgen G channel), with a narrow, but generally dense riparian/terrace vegetation border. Spawning gravels are common and of good quality. Steelhead regularly spawn in the reach, even though it goes dry. An apron at the Southern Pacific Rail Crossing downstream of Highway 101 was a major barrier to adult steelhead access until the mid 1980's. A concrete curb was then installed across half of the apron, and a curb and denil fishway was installed on the other half of the apron. The modifications greatly improved passage for both upmigrating adults and downmigrating adults and smolts, although debris occasionally clogs the fish ladder, restricting adult passage at low flows.

(Steelhead Limiting Factors: spring streamflow for smolt outmigration*, summer streamflow)

2. Thomas Road to ¼ Mile Upstream of Miller Avenue. This reach is now usually dry in summer, although in the 1970's and early 1980's summer flow was sufficient to maintain flow downstream to below Miller Avenue. A seasonal, onchannel lake was regularly created by constructing a gravel dam across the channel. However, the dam installation required a streamflow dryback prior to installation, and efforts were made to replace the gravel dam and dryback with a flashboard dam that might create a percolation pond. The reach is dominated by pool habitat when flow is present, and most of the streambed is dominated by fine substrate. Potential steelhead spawning gravels are very scarce. Vegetation is primarily confined to the levees, and stream shading is minimal. When the reach had summer flow in the 1970's and early 1980's, summer afternoon water temperatures were warm (75+ degrees F), and almost no fast-water feeding habitats suitable for maintaining steelhead at those temperatures were present.

The Uvas Reservoir water right requires a summer release of 10 cfs when the reservoir is full by the end of winter. That flow was judged at the time of the water right to be sufficient to maintain surface flow downstream to Monterey Road (now Highway 101), within reach 1. However, that amount was insufficient to reach Monterey Road in the 1970's and falls more than 2 miles short at the present time, even in wet years.

(Steelhead Limiting Factors: Summer streamflow (and water temperature if streamflow restored) and spring streamflow for smolt outmigration)

3. ¼ Mile upstream of Miller Avenue to Highway 152. In years when Uvas Reservoir fills or nearly fills in winter, summer releases from the reservoir are sufficient to maintain surface flow through this reach. However, percolation rate is heavy (5+ cfs) in the reach, and streamflows rapidly decline and water temperatures rapidly increase (70+-78+ degrees F) downstream within the reach. Streamside vegetation is primarily short willows and mulefat, which provide some overhead escape cover, but little stream shading. Downstream of Santa Teresa Boulevard the channel is quite wide through former (1970's) onchannel gravel quarries. An attempt to construct a "Rosgen Type C" channel by regrading and armouring meanders in that portion of the channel failed in the first wet winter.

Gravel and cobble substrates in riffles and runs and abundant algae throughout the reach support abundant aquatic invertebrates. Pools are relatively shallow within the reach, because of the broad channel and lack of very large scour objects. However, rearing steelhead would have to use fast-water feeding habitats in summer anyway in order to meet the high metabolic demands of the warm water. Good spawning gravels are common, but steelhead rearing potential declines rapidly downstream within the reach with rising temperatures and declining streamflows. In dry years (1972, 1976, 1977, 1989) when Uvas Reservoir fails to fill, releases are cut back sharply, and this reach goes dry.

(Steelhead Limiting Factors: summer streamflow and water temperatures*)

4. Highway 152 to the Mouth of Little Arthur Creek (Watsonville Road Crossing). This reach also is relatively sparsely shaded with willows, mulefat and sycamores. The channel tends to braid immediately upstream of Highway 152, at least partly due to gravel extraction in the 1960's and 1970's. From a mile upstream of Highway 152 upstream to the dam the channel is generally a Rosgen C4 channel. Streamflows decline due to heavy percolation (4+ cfs), and water temperatures increase sharply within the reach. Pools are sandy, but clean gravels and cobbles dominate riffles, runs and glides. Gravels are recruited from Little Arthur Creek and spawning habitat is good within the reach. Algae is common on coarser substrates, and aquatic insects are abundant. Juvenile steelhead are restricted to fast-water feeding habitats in riffles, runs and heads of pools in summer, but grow quickly, reaching smolt size in one year. Portions of this reach can go dry in years when reservoir releases are sharply reduced (<5 cfs).

(Steelhead Limiting Factors: summer streamflow and water temperatures*, fast-water habitats)

5. Little Arthur Creek to Uvas Road Crossing. This reach has perennial flow, except in the most extreme drought years (such as 1977, when Uvas Reservoir went dry). The stream is generally well-shaded (60-80+ percent canopy) by riparian (willows, alders, sycamores) and terrace (live oak) trees. Pools are frequent, deep and complex, and generally are dominated by sandy substrate. Riffles and runs are gravel and cobble. However, fine sediment captured with storm runoff in Uvas Reservoir is released throughout the winter and early spring. This results in persistent winter and early spring turbidity, reducing potential feeding by juvenile steelhead during these important growth periods. It also results in substantial amounts of fine silt within the coarser substrates, reducing the quality of the spawning gravels. Suitable-sized spawning gravels also decline in abundance upstream within the reach, reflecting the gradual loss of smaller gravels in storms and their lack of replacement due to trapping in Uvas Reservoir. Aquatic insects are relatively scarce, apparently due to the fine sediment and possibly to the heavy shading and scarcity of algae. Streamflows are relatively high and decline little through this reach, and water temperatures are usually below 70 degrees F in summer. Juvenile steelhead mostly use fastwater habitats (riffles, runs and heads of pools) for summer rearing within the reach.

Vineyards have replaced orchards and pastures in the last decade. Homesites have also increased within the reach since the early 1980's. Substantial modification of streamside vegetation and stream banks has occurred on some lots (especially near Heritage Road), reducing escape and overhead cover and modifying natural pool/riffle sequences. In addition, street runoff has increased the amount of fine sediment going into the creek.

(Steelhead Limiting Factors: summer water temperatures, substrate quality (fine sediment*), food production)

6. Uvas Road to Uvas Dam. Large pools are the most common habitats within this reach, so shading is somewhat limited despite the good riparian border of willow, alders and sycamores. Riffles and pools tail crests are dominated by cobbles. Gravels, including potential spawning gravels are scarce, due to lack of recruitment below the dam and gradual loss since the dam was built more than 40 years ago. Since the reach is immediately downstream of the dam, summer water temperatures are cooler than elsewhere. Juvenile steelhead are still mostly confined to riffles and heads of pools, where drifting aquatic insects are most abundant.

(Steelhead Limiting Factors: spawning gravels*, fast-water habitat)

Uvas Creek Steelhead and other Fish Resources downstream of Uvas Reservoir. The summer releases from Uvas Reservoir for ground water percolation provide relatively good rearing habitat for steelhead, despite high water temperatures by late summer in most of the stream. Uvas Creek steelhead use only fast-water habitats (riffles, runs and heads of pools) for summer rearing (Smith and Li 1983), and these habitats make up only 10-15 % of available habitat upstream of Little Arthur Creek.

Riffle habitats are more common downstream of Little Arthur Creek, but streamflows decline due to percolation and water temperatures increase in the generally less-shaded habitat between Little Arthur Creek and Miller Avenue. Shading upstream of Little Arthur Creek slows the downstream increase in water temperature, but also may interfere with the ability of drift-feeding steelhead to feed. Fish densities appear to be higher in sunlit riffles. Warm temperatures and low streamflows presently prevent much steelhead rearing downstream of Highway 152.

Although overall densities of steelhead in Uvas Creek may be low compared to cooler, shaded tributaries, their rapid growth in fast-water habitats resulted in smolting after one year in the 1970's and 1980's (Smith 1982). However, fish captured during recent late summer sampling (1997-2000) have generally been substantially smaller and scarcer than in the past, apparently due to declines in substrate quality and food availability due to development along the stream.

The export of part of Uvas Reservoir storage to Llagas Creek reduces the potential summer streamflows in Uvas Creek and both the downstream extent of potential steelhead rearing and the amount of fast-water habitat within rearing reaches. In addition, the faster draw down of Uvas Reservoir due to the export results in the earlier release of warmer epilimnion water in late summer. This temperature effect is also very important, as higher water temperatures raise fish metabolisms and restrict them to even faster habitats to satisfy their food demands (Smith and Li 1983).

Genetic samples from Uvas Creek steelhead and from steelhead in accessible portions of Bodfish and Little Arthur creeks indicate that past stocking of steelhead smolts from the San Lorenzo River (and elsewhere) has apparently eliminated any original distinctive steelhead from the watershed (Sundermeyer 1999). Fish upstream of barriers on Bodfish and Little Arthur creeks and upstream of the reservoir on Uvas Creek appear to be native strains, but they are resident rainbow trout, rather than anadromous steelhead. In addition, removal of barriers on Little Arthur Creek is likely to eliminate the native strain there.

Uvas Creek downstream of the reservoir has healthy populations of warm-water native fish, including Sacramento sucker, California roach and Sacramento pikeminnow. Riffle sculpin (*Cottus gulosus*) are common in fastwater habitats from the dam to a mile below Little Arthur Creek, but decline downstream, apparently because of high summer water temperatures. Hitch, normally a "downstream" species, have been common in the larger pools in the past (Smith 1982), but are now scarce, apparently due to the frequent floods since 1992.

Uvas Creek Upstream of the Reservoir

The original water right for Uvas Reservoir specified that adult steelhead passage would be provided by construction of a fish ladder or by trucking fish around the reservoir if

they could not ascend the spillway. The spillway is clearly impassable to steelhead (although Pacific lampreys do ascend the spillway). However, the specified steelhead passage has not been provided in the 40+ years since reservoir construction. Most of the perennial, cool-water habitat upstream of the reservoir has not been surveyed in detail, but general reach descriptions are given below to help indicate the potential value of upstream habitats, if steelhead access was to be provided.

1. Uvas Reservoir. This reservoir is generally drawn-down to about 20-30% or less of its 10,000 acre-foot capacity by November. During the drought of 1976-77, it was reduced to the minimum pool below the outlet by late summer of 1977. The northwest to southeast orientation of the reservoir (with the dam to the south) is in line with prevailing summer winds, and the warm surface layer (epilimnion) of the reservoir mixes relatively deeply by the end of summer. By late summer the cool bottom layer (hypolimnion) is anoxic. Therefore, there is no oxygenated, cool-water habitat in late summer of most years, resulting in little or no survival of wild or planted rainbow trout. Introduced warm-water fishes dominate the reservoir, although native Sacramento suckers and Sacramento pikeminnows are also common. A two-step (3 foot, plus 2 foot) concrete abutment for an unused flashboard dam is located immediately upstream of the full reservoir and is a barrier to adult sucker and pikeminnow spawning migrations in spring. The barrier would also block upstream movement of steelhead or rainbow trout, except during winter floods.

(Potential Steelhead Limiting Factors: summer water temperatures and competition with warm-water fish)

2. From the Flashboard Dam Abutment Upstream to Uvas Road. Shading by alders and willows is relatively sparse in most of this reach, because of the channel alignment with respect to the sun and the relatively wide (Rosgen C3) channel downstream of Little Uvas Creek. Several pools are large and deep. The reach was reduced to several small, isolated pools during the 1977 drought, but otherwise has been perennial. Bedrock outcrops are common at the upstream end of the reach, but pools are mostly dominated by sand. Resident rainbow trout increase upstream within the reach, and are primarily associated with riffles and heads of pools.

(Potential Steelhead Limiting Factors: summer water temperatures and fast-water feeding habitat).

3. From Uvas Road to Uvas County Park. This reach has been perennial, even during severe droughts. The reach is well shaded by alders at the bottom of the reach, with redwoods increasingly common upstream. Water temperatures decrease upstream, and are generally less than 70-72 degrees in summer, even at the bottom of the reach. The channel grades from a low to moderately entrenched bedrock or cobble channel (Rosgen C/B1 or 3) at the bottom of the reach to moderately to well-entrenched cobble/boulder

channels (B3 to A2) in the upper half of the reach. Pools are generally associated with bedrock, boulders or alder roots, and are mostly relatively shallow and simple. Severe floods in 1995 and 1997 rearranged many pools in the steeper portions of the reach, and fish were relatively scarce in June 1997. There are probably some flashboard dams present in the reach, but they have not been inventoried. The upstream natural limit of potential steelhead access is not known.

(Potential Steelhead Limiting Factors: large, complex pools* for overwintering habitat and possible flashboard dams as barriers*)

4. Little Uvas Creek. Willows and oaks sparsely shade this tributary, which is dry or intermittent by late summer, even in wet years. The riparian border in the lower portion of the reach is sparse compared to upstream of Uvas Road, because of cattle grazing.. The channel is lightly to moderately entrenched and dominated by gravel and small cobbles (Rosgen C3/4 channel).

(Potential Steelhead Limiting Factor: streamflow—seasonally dry)

Fish Resources of Uvas Creek Upstream of the Reservoir. In the 1970's resident rainbow trout were usually quite abundant upstream of Uvas Road, but decreased in the flatter, wider, warmer reach downstream of the road (Smith 1982). Genetic studies (Sundermeyer 1999) indicate that the trout are probably native, and are likely the non-migratory remnants of the steelhead run blocked by the construction of Uvas Dam. If adult steelhead access was provided past Uvas Dam and the flashboard dam abutment upstream of the reservoir, spawning and rearing conditions for steelhead would be good, although juveniles would take two years to reach smolt size in the cool, heavily shaded habitat upstream of Uvas Road. An inventory of flashboard dams would be necessary to determine if possible migration barriers are present. The upper potential natural limit of steelhead access in Uvas Creek and several small tributaries, including Croy Creek, is not known.

The biggest potential problem for steelhead would probably be spring outmigration of smolts through the reservoir (with its warmwater predatory fish) and over the spillway or through the bottom release port. In many years the reservoir would stop spilling early in the outmigration period (April and May), trapping smolts in the reservoir. It is uncertain whether smolts could use the bottom release port, because of hypoxia of the bottom waters by May. Smolts are also likely to be injured or killed, even if they used either the spillway or bottom port. Closing the bottom port and spilling all spring releases would also result in discharging relatively warm surface water down Uvas Creek.

Sacramento pikeminnows are common in the reservoir and in the stream downstream of Uvas Road, but rapidly decline in the heavily shaded reach upstream of Uvas Road (Smith 1982). Sacramento suckers and California roach are found more than 3 miles further upstream, but are generally confined to larger pools with somewhat more open

canopy. Riffle sculpins are found throughout Uvas Creek upstream of the reservoir. Pacific lampreys ascend the spillway at Uvas Reservoir, and larval lampreys have been found upstream as far as Croy Creek.

Sacramento suckers, California roach and rainbow trout seasonally use Little Uvas Creek for spawning, but its importance may be small because of the early drying. Foothill yellow-legged frog (*Rana boylei*) larvae have been observed in Little Uvas Creek, and adults have been observed in Uvas Creek.

Bodfish Creek

The Bodfish Creek watershed is wetter than the Little Arthur Creek watershed and is presently the most important steelhead tributary to Uvas Creek. Bodfish Creek is largely paralleled by Highway 152, with two small tributaries entering from the south, (at and upstream of Whitehurst Road) and the main branch of the creek also coming from the south less than a mile upstream of the impassable barrier falls. The outflow of Sprig Lake enters Bodfish Creek from the north about ¾ of a mile downstream of the falls. Homesite development has substantially expanded along the lower two reaches since the AMBAG study (Smith et al. 1983 and 1984). Habitat descriptions by reach for Bodfish Creek and a description of steelhead ecology follow:

1. Mouth to Mile 1.5. The lower 1.5 miles of Bodfish Creek provide migration passage for steelhead, but are dry in summer. Percolation of streamflows is apparently heavy in the reach, and the stream bed closest to the mouth can be dry in late spring, severely impacting outmigration by steelhead smolts. In 2001, at least the lower ¼ mile was dry by the last week in April, although flow immediately downstream of the tributary from Sprig Lake was about 3-4 cfs. Homesite and vineyard expansion in the reach may be affecting groundwater levels and streamflow. The lower ½ mile of stream channel is incised (Rosgen channel type G4), in response to the lowering of the Uvas Creek channel in the 1970's by gravel extraction.

(Steelhead Limiting Factor: spring streamflows for smolt outmigration)

2. Mile 1.5 to Whitehurst Road. Very low summer flows are present in all or portions of this reach during average and wet years. The reach is dry during extreme droughts (1972, 1976-1977). The channel has a gradient of less than 2 %, but is moderately entrenched; Rosgen channel type is B4C. Pools are relatively shallow and make up about 35 percent of the habitat. Pools are usually sandy-bottomed, but escape cover, as undercut banks and alder roots, is common. The stream is well-shaded (80+ % canopy closure) with mostly deciduous trees, especially alders and willows. A small seasonal dam with a 2-step base was identified as a partial barrier to steelhead adults at low winter streamflows (Smith et al. 1983) and recommended for modification (Smith et al. 1984).

However, the California Department of Fish and Game took no action and no further observations have been made of the dam.

(Steelhead Limiting Factors: summer streamflow, spring streamflow for smolt passage in drought years, partial barrier to adult migration*)

3. Whitehurst Road to the Confluence with the Tributary from Sprig Lake. Summer flows are normally present, except in drought years (like 1987-1990), when portions of the channel (especially shallow riffles) may become intermittent. In extreme drought years (1972, 1976-1977) only larger pools retain water throughout much of the channel. The channel is generally a Rosgen B3, with gradient 2-3 % and cobbles the average channel substrate size. Pools are generally less than 2 feet deep and are associated with boulders, bedrock and rootwads of streamside trees; escape cover is good in the pools. Step-runs are the most common habitats, but pools are also common. The substrate is generally clean, but pools are largely sandy-bottomed. Shading is dense (85+ % canopy closure) and is provided by about equal amounts of evergreen (redwood, California bay) and deciduous trees (big-leaf maples, alders).

(Steelhead Limiting Factors: summer streamflow and food production and pool development)

4. Confluence Upstream 0.6 miles. The channel gradient is 3-5 % and the channel is mostly moderately-to-well entrenched (Rosgen channel types B3 to A2). Surface water is usually present, even during extreme drought years (1972, 1976-77). Pools are frequent (>40%), usually associated with boulders, sand or gravel-bottomed, and up to 3 feet deep. Shading is dense (90+ % canopy closure) and primarily evergreen (California bay, tanbark oak and redwood), with some deciduous trees (primarily big-leaf maple).

(Steelhead Limiting Factors: summer streamflow and food production)

5. Miles 0.6 – 0.75 Upstream of the Confluence. The channel is steep (5-10+ %) and entrenched, with several difficult or impassable boulder falls identified in 1982 (Smith et al. 1983). The impassable falls are at the top step of the reach, in the narrowest portion of the channel, immediately adjacent to Highway 152. The falls are the remains of landslide debris from both the south and the north (highway) side of the channel. Material from past slides on the highway was routinely pushed from the road into the channel in the 1960's to early 1980's. Pools are associated with large boulders, and the upper accessible pool is more than 4 feet deep. Shading is dense (90+ % canopy closure) and evergreen.

(Steelhead Limiting Factors: adult access and spawning gravels)

6. Upstream of the Barrier Falls. Much of the channel upstream of the falls is relatively flat (< 2 % gradient), with moderate entrenchment (Rosgen channel types B4C and B4). Substrate is silty to sandy gravel and pools are generally shallow. Shading is heavy (canopy closure 95+ %) and evergreen. Summer streamflows in the reach are very low, even in average to wet years. In severe drought years (1972, 1976-77) much of the channel is dry. Resident rainbow are present and appear to be of native genetic stock (Sundermeyer 1999), although hatchery-origin steelhead fry from the San Lorenzo River were planted above the falls in 1996.

(Steelhead Limiting Factor: impassable boulder falls)

Steelhead and Other Fish in Bodfish Creek. The lower portion of Bodfish Creek dries in early to late spring and presents a passage problem for outmigrating smolts in many years. Several miles of potential steelhead habitat in the headwaters are blocked to steelhead use by impassable boulder falls. Low summer streamflows and heavy stream shading result in poor steelhead growth in perennial portions of Bodfish Creek in mid to late summer. Steelhead fry usually emerge from the gravels beginning in early May. By then, streamflows are already declining and even reaches with deciduous trees are well-shaded. In most years young-of-year steelhead cease growing by July to August at lengths of 40 – 70 mm standard length (SL). In wetter years growth continues the longest, and fish are larger by the end of summer. Growth usually does not resume until the water warms and clears the following spring (in early March to April). Few steelhead are large enough to emigrate to the ocean after only one year in the stream, and most of the fish that survive the winter apparently spend a second summer (and winter) in the stream. Yearling steelhead are found primarily in the pools and other deeper habitats and make up 5 –15 % of juveniles by late summer. Yearlings and 2-year fish grow considerably in spring due to higher streamflows and insect abundance, especially prior to leaf out by deciduous trees. In April and early May, most 2-year olds and a few larger yearlings emigrate to the ocean. Some 2-year olds remain, but most of those are males, which mature and remain in the stream. Yearlings that remain for a second summer cease growth in midsummer (usually at 85 – 160 mm SL) and lose weight in late summer and fall (yearlings show poor "condition", becoming "skinny" in the fall).

Steelhead abundance changes among years because of summer and winter flow conditions. In drier years fish are smaller and young-of-year less abundant because of scarcer food and reductions in the amount of habitat; much of the run and riffle habitat becomes too shallow for steelhead use. Severe winters substantially reduce overwinter survival, reducing the abundance of yearlings and 2-year fish. The low abundance of smolt-size juveniles (yearlings and 2-year olds) in the 3 – 4 miles of accessible, perennial habitat in Bodfish Creek indicates that annual production of emigrating smolts is probably in the range of 500 - 2000 fish.

Riffle sculpin is the only other fish regularly found in Bodfish Creek, although threespine stickleback are occasionally present as far upstream as the tributary from Sprig Lake. Sculpin are also present upstream of the barrier falls.

7. Sprig Lake and Its Tributaries

Sprig Lake is a seasonal impoundment on a tributary immediately upstream of Highway 152. Two tributaries enter the lake. Habitat conditions and a description of steelhead ecology when the lake is operated follow:

7A. Confluence with Bodfish Creek Upstream to Sprig Lake. Seepage through the slide gate on the culvert at Sprig Lake maintains flow downstream in summer for the 250 feet of channel to the confluence with Bodfish Creek. The seepage rate decreases as the lake level lowers and algae and debris improve the seal on the gate in late summer. Much of the channel is under Highway 152, and a single deep pool is present immediately downstream of the culvert. A weir was installed downstream of the culvert in 1981 to raise pool height and maintain pool depth (4 feet) in order to allow steelhead adults to more easily jump through the culvert when it is open in winter (Smith et al. 1983). Prior to the construction of the weir the pool was as much as 1 foot shallower and the jump 1 foot higher.

(Steelhead Limiting Factors: summer streamflow and pool development)

7B. Tributary to Sprig Lake from the North, along Road. The small tributary to Sprig Lake which enters from the north goes dry in early summer. The channel is deeply incised (Rosgen channel type G3), and only about ¼ mile is accessible to steelhead. Pools are mostly less than 1 foot deep, but spawning gravels are relatively common. The stream is heavily shaded (85+ % canopy closure) by evergreen trees (live oak, California bay).

(Steelhead Limiting Factors: winter flows for spawning and spawning gravels; dry in summer)

7C. Tributary to Sprig Lake, Blackhawk Canyon Creek; upstream 0.5 Miles. The lower half mile of Blackhawk Canyon Creek is narrow, moderately entrenched, and has a gradient of 2-3 % (Rosgen channel type B3). The stream is perennial, except in extreme drought years (1972, 1976-77), but flows are very low (<0.05 cfs) by late summer of even wet years. The stream has a dense canopy (mostly 95+ % closure) of evergreen trees (redwoods, California bays, tanbark oaks). The dominant habitat type is step-run, and pools are relatively uncommon and mostly less than 1 foot deep. The stream is too narrow (mostly less than 4-6 feet) and steep for woody debris to provide much habitat structure. Spawning gravels occur as small pockets at the tails of pools.

(Steelhead Limiting Factors: pool development, summer streamflow, food production)

7D. Blackhawk Canyon Creek above Mile 0.5. Stream gradient sharply increases upstream, and the channel is well-entrenched (Rosgen channel type A2). The narrow, steep channel is blocked by several small (4-5 feet high) boulder falls (Smith et al. 1983), and adult steelhead probably rarely ascend the reach. The stream is perennial, except in drought years. Habitats consist mostly of cascades and shallow plunge pools. Spawning gravels are very scarce. The stream has a dense evergreen canopy.

(Steelhead Limiting Factors: adult access and spawning gravels)

7E. Sprig Lake. A slide gate at the culvert through the concrete dam has been used to impound this seasonal lake starting in March through May, depending upon runoff conditions. In drought years the gate has been closed earlier to ensure that sufficient water is impounded in the lake. In wet years closure has been delayed until after significant storms. When closed, the outflow (other than some seepage at the gate) is through two 2-foot diameter culverts at the lake surface; through the 1980's only a single smaller culvert was present. A major storm after closure would require reopening the dam to prevent the lake from overflowing the dam, but the two culverts can now accommodate inflow from smaller storms.

Since the opening in the dam is only a 3-foot diameter culvert, extreme storm flows occasionally back up in the lake and suspended and bedload sediments are deposited in the lake bed. The problem is aggravated when woody debris partially blocks the culvert. Declining flows at the end of the storm, and later storms, usually recut through the newly deposited sediments and remove much of them. However, significant portions of the lake's capacity are lost following severe storms such as in 1982, 1986 and 1995. Most of the loss is immediately downstream from Blackhawk Canyon, which has the larger watershed and steeper gradient and moves more sediment into and through the lake bed.

When full, the deepest portions of the lake exceed 5 meters. The lake has limited shade, and summer daytime water temperatures can be quite warm. In late afternoon on 7 August 1993 (during a heat wave) the upper meter of the lake was 23.6 – 24.4 degrees C (75-77 degrees F), and the rest of the water column (to 2.6 m deep) was warmer than 22.5 degrees C (73 degrees F). Earlier in the summer, and when the lake is deeper, water temperatures are lower. Even during the warmest periods of summer, the lake usually cools off 5+ degrees C over night, and early in the summer inflows from Blackhawk Canyon provide a cooler refuge. Submerged aquatic plants (coontail and others) become abundant about 1-2 months after lake closure, and provide escape cover for small fish. They also support epiphytic algae and abundant invertebrates (insects and amphipods). The rooted plants utilize most of the lake nutrients and water is clear (secchi depths 3-4 meters) because of a lack of phytoplankton algae blooms.

The gate on the dam is usually opened in late fall, prior to large storms, but after leaf drop and cooler weather have increased the streamflow in Bodfish Creek.

(Steelhead Limiting Factors: lake depth* (due to inflows, seepage and sediment filling), water temperatures, and possible fishing harvest*)

Sprig Lake Watershed Steelhead. In all years that steelhead are able to access Bodfish Creek, they apparently spawn in Blackhawk Canyon Creek. In many of those years they also spawn in the other (seasonally dry) tributary to Sprig Lake. Spawning apparently occurs almost exclusively during and immediately following storms, when streamflows are still high and turbid. The two streams have been walked over 20 times between storms, rarely encountering adult steelhead; they apparently enter the tributaries, spawn quickly and emigrate immediately after spawning. Even males, which often linger on spawning grounds elsewhere, apparently emigrate from the shallow tributaries quickly. Even in years when the dam has been closed early it is very unusual for an adult fish to be trapped in the lake.

In the seasonal tributary, which is warmer, fry emerge by May. In cooler Blackhawk Canyon Creek, recently emerged fry are present throughout May and early June. In the seasonal tributary the lake inundates the lower half of the stream, and declining flows appear to cause the fry to move into the lake. In Blackhawk Canyon Creek many fry apparently actively move downstream in response to competition or food, despite the perennial nature of the stream.

Fish remaining in Blackhawk Canyon Creek grow slowly, reaching only 30 - 55 mm SL by the end of the summer; low summer streamflows and dense evergreen shading (which reduces algae and insect production) are apparently responsible. The shallow nature of the stream also apparently prevents fish from overwintering in the stream. Poor overwinter survival and/or winter emigration results in few yearling fish being present in summer. In August 1981 (following a *mild* winter) all pools were sampled in the lower ½ mile of Blackhawk Canyon, and only 3 yearling fish were caught, compared to hundreds of young-of-year fish. Therefore, almost no smolts are probably produced in the tributary itself. This fact accounts for the lack of observations of smolts trapped in the lake, even when the gate is closed early in the spring.

Fry are common in Sprig Lake after the dam is closed, and grow rapidly. By late summer visual observations indicate that the lake usually contains 500-2000 young-of-year steelhead, which mostly exceed 150 mm SL. Thus the production of smolt-sized fish in the lake is probably roughly equivalent to the smolt production in the remainder of the Bodfish Creek watershed. It is likely that the fish that spawn and rear in the Sprig Lake watershed are adapted to use its unique habitat features.

No other fish species are regularly present in the Sprig Lake watershed, although golden shiners, carp, and other species have occasionally been dumped in the lake.

Sprig Lake Catchable Trout Fishery. Sprig Lake has traditionally also been used to provide a children's fishery for catchable rainbow trout. Hatchery-reared catchables have

been stocked in May through early July or later. Most fish have been quickly caught and few remain more than several weeks after stocking ceases.

The steelhead management plan for the Pajaro River (Smith et al. 1984) called for ending fishing in the lake by early to mid-July. By then some of the wild steelhead had grown to 100 mm SL, and were big enough to be caught by fishermen. Fishing after mid-July could seriously reduce the number of steelhead successfully raised in the lake.

Concern also existed for the possible impact of catchables on the genetics of the steelhead and for possible predation of the catchables on steelhead fry. Since few catchable trout survive the summer in the lake, the likelihood that they could interbreed with adult steehead in the following or subsequent winters is small. In genetic samples from catchables stocked in 1997, the most common allele at one microsatellite locus was unique compared to samples from throughout the Pajaro River watershed (Sundermeyer 1999). If the source of catchables is the same from year to year, it appears that no interbreeding with steelhead has occurred, and the marker allele could be used to detect any future interbreeding.

Only a limited food habits study has ever been made of the catchables in the lake. In June 1984, stomachs from freshly caught catchables (n = 23) were obtained by offering to clean the fish caught by fishermen. The stomachs of the fish were empty, with the exception of bait (salmon eggs, worms, marshmallows) used by fishermen. It may be that the catchables require a more extended period in the lake before they "learn" to eat wild food. It is likely that most would be caught before they presented any potential predation threat to steelhead fry.

Little Arthur Creek

Much of the accessible watershed on Little Arthur Creek is quite dry. Residential development and vineyards have greatly expanded in the watershed since the AMBAG studies (Smith et al. 1983, 1984). In September 2001 most of the streambed was dry upstream to ½ mile above Mt. Madonna Road (formerly Old Watsonville Road), although similar rainfall in the 1970's or 1980's would have maintained perennial flows for 2 additional miles. A fish ladder was installed at Pickels Dam in the late 1980's, allowing potential steelhead access to the perennial reaches of the stream. Habitat descriptions by reach and an assessment of fish resources follow:

1. Mouth Upstream to Pickels Dam. Most of this reach is dry in summer in most years. In wetter years surface flow is maintained for about 0.2 miles downstream of the small reservoir by seepage. The channel is low gradient, but somewhat entrenched (mostly Rosgen B4C). The channel is generally well-shaded (65-80 % canopy closure) by riparian (willows, alders) and terrace (oaks) trees. Substrate is clean, with pools of sand and fine gravel, and with cobbles and gravels in the riffles. The reach provides good

spawning habitat for steelhead, but dries quickly near the mouth in late spring, so few fish, except those produced near the mouth, can move to rearing habitat in Uvas Creek in most years. Little Arthur also delivers good quality spawning gravels to Uvas Creek in the stretch immediately downstream of the tributary. Little Arthur Creek clears quickly after storms, compared to the turbid winter and early spring releases from Uvas Reservoir, and is probably relatively attractive to migrating adult steelhead.

(Steelhead Limiting Factor: spring streamflow for smolt and fry outmigration; dry in summer)

2. Pickels Reservoir. Access through this dam is provided by a steep-pass fishway installed in the late 1980's. The narrow fishway is steep and probably prone to frequent clogging; it should be regularly checked for passage problems. However, the ladder should provide for adult steelhead access to upstream reaches of Little Arthur Creek in most years. The square opening in Pickels Dam is seasonally closed by placing boards over the opening. This crude method of closure requires that the lake be almost fully drawn down prior to winter rains in order to remove the boards. Early board removal could result in the loss of many steelhead reared in the lake, as they would be confined to a small (and potentially drying) stream area downstream of the dam for several (or many) weeks prior to rains. Installation of a screw-operated slide gate over the hole in the dam (similar to the one used at Sprig Lake) would allow for easy opening and closure. The lake could then be maintained longer and opened with the first substantial rains.

Pickels Reservoir provides water for agricultural use and also loses water to evaporation and seepage through the dam (which can exceed ¼ cfs). The water level drops in all years, and drops substantially in years when surface inflows cease in early summer. On 7 August 1993 inflow was only 0.15 cfs, and no inflow was present by 30 September. The water level of the lake dropped over 4 feet during that period (Smith 1993). However, on 7 August the reservoir was approximately 1100 feet long and over 5 meters deep at the dam (more than 3 times the potential volume of Sprig Lake in the Bodfish Creek watershed). On the same day the maximum depth at Sprig Lake was only 2.6 meters. Afternoon water temperatures were similarly warm (72 - 76 degrees F) on 7 August 1993 (Smith 1993). The lake is lined with riparian and terrace trees and is moderately well-shaded. Pondweed and coontail were common in shallower portions of the reservoir, but dissolved oxygen levels were generally found to be good, even in sampling done in the morning (8:45-9:30). The reservoir was not operated in 2001.

(Steelhead Limiting Factors: draw down and early draining to open dam*, inflows and lake size, water temperatures, adult access above the dam*, lack of extensive spawning gravels immediately upstream of the lake*).

3. Pickels Reservoir to Mt. Madonna Road Crossing. This stream reach is likely to be intermittent in all but the wettest years. In 1993, a wet year following a multiyear drought, flow at the upstream end of the reach was only about 0.01 cfs at the end of

September, and the lower half of the reach was dry. In September 2001 the reach was dry except for a few scattered pools. The stream is generally well-shaded by riparian (willows, alders) and terrace (oaks, California bays) trees and has generally clean substrate, including spawning gravels. The substrate is often rather silty immediately downstream of Old Watsonville Road, apparently from runoff from that road or from further upstream on the creek. The channel has low to moderate entranchment (primarily Rosgen C4 and B4C channels), with some bedrock outcrops. The reach consists primarily of shallow pools (averaging less than 1 foot deep) and runs.

(Steelhead Limiting Factors: summer streamflow, pool development, fine sediment*)

4. Mt. Madonna Road to End of Paved Road. Summer flows used to be present in this reach, even during droughts. However, in 2001 the lower ½ mile was dry, apparently due to increased water use by homes and vineyards. The reach is well-shaded by alders and redwoods (65-95 % canopy), but flows along numerous homesites and horse pastures. There are 6 flashboard dams within the reach, 5 of which were used to create seasonal ponds in 1981. A substantial portion of the reach is inundated by these seasonal ponds, which provide deep habitat. Substrate in the stream habitat between the ponds is often rather silty, but winter spawning gravel conditions should be good. The potential rearing value of the seasonal ponds for steelhead is unknown, and would be dependent upon food production. However, the ponds maintained resident rainbow trout, California roach and Sacramento sucker populations through the droughts of 1972 and 1976-77 (Smith 1982). The dams have not been revisited since 1981-2, but at that time 3 of the dams presented potential winter passage problems (Smith et al. 1983). The timing of flashboard installation is not known and is presently not regulated by the California Department of Fish and Game streambed alteration agreements.

(Potential Steelhead Limiting Factors: summer streamflow, food production in the seasonal ponds, adult steelhead access between storms and potential flashboard installation prior to smolt outmigration*).

5. Upstream of End of paved Road. This reach is densely shaded by redwoods (95+ % canopy) and maintains surface flow even in extreme droughts (1976-77). The channel is entenched (Rosgen B3 to A2 channels) and rapidly becomes steep upstream. Potential steelhead access is blocked by boulder falls about ½ mile upstream of the paved road, but there are also 3 partial barriers (including 2 small dams) within the reach. Pool development is good within the stair-step channel, and the substrate is coarse and clean. Steelhead spawning habitat may be limited, because gravels are present, but mostly in the pools. Pool tail crests tend to be dominated by cobbles or boulders.

(Steelhead Limiting Factors: dry year adult access, food production, spawning habitat).

Little Arthur Creek Steelhead and Other Fish Resources. In dry years most of the habitat downstream of Mt. Madonna Road will go dry. Even in very wet years summer-long surface flow formerly did not extend much downstream of Pickels Dam, and most of the habitat between the reservoir and Mt. Madonna Road was shallow and able to support few yearling steelhead (Smith et al. 1983 and 1984). Summer streamflow conditions now appear to be worse, apparently due to increases in homesite and vineyards. These developments are also likely to degrade substrate conditions. The ladder at Pickels Dam and several of the flashboard dams upstream of Watsonville Road probably present some adult steelhead passage problems in most years.

Little Arthur Creek might be able to produce juvenile and smolt steelhead numbers similar to Bodfish Creek in wetter years, but that potential depends upon the operations and rearing habitat provided by the Pickels Reservoir and the much smaller seasonal ponds produced by flashboard dams upstream of Mt. Madonna Road. Pickels Reservoir is capable of producing several thousand smolt-sized steelhead, if large numbers of fry are produced in the reach immediately upstream of the reservoir. However, the present method of closing and opening the dam seriously curtails the potential length of the rearing season and the potential survival of steelhead after opening the dam in fall. A slide-gate similar to that of Sprig Lake is necessary to realize the full potential of the reservoir for steelhead rearing. Since the watershed is relatively dry, early closure of the reservoir is probably necessary to insure filling of the lake. Closure of the lake or installing the flashboards in the smaller dams prior to the end of May might trap some outmigrating smolts. However, without the reservoir this dry watershed is probably capable of producing very few steelhead smolts except during multiple wet years. The dam was not operated in 2001, and future use might be affected by regulations implemented to protect steelhead.

Prior to installation of the ladder at Pickels Dam in the late 1980's steelhead were unable to use the habitat above the dam, and few survived in the short perennial reach downstream of the dam. Resident rainbow trout, Sacramento suckers, California roach, riffle sculpin, and threespine stickleback were present upstream, but stickleback were eliminated during the severe drought in 1976-77 (Smith 1982). With the laddering of the dam, steelhead will replace the resident trout upstream to the boulder falls above the end of the paved road. Pikeminnow, prickly sculpin, threespine stickleback and hitch have been collected downstream of the dam, but would have difficulty negotiating the steep ladder. However, juvenile pikeminnow were present immediately upstream of the ladder in September 2001.

Foothill yellow-legged frogs and California red-legged frogs (*R. aurora draytonii*) have been observed upstream of Pickel Reservoir. Bullfrogs (*R. catesbeiana*) are abundant in several farm ponds in the watershed, including one near Pickel Reservoir. Bullfrog adults and tadpoles are also usually present in the reservoir and in the bedrock pool immediately downstream of the reservoir.

Llagas Creek Downstream of Chesbro Reservoir

The Llagas Creek watershed is drier than that of Uvas Creek, and none of the tributaries of Llagas Creek have perennial flow. Summer flow in Llagas Creek below the reservoir is dependent upon releases for groundwater recharge from Chesbro Reservoir and from a pipeline from Uvas Reservoir. Chesbro Reservoir has a larger bottom outlet than most other Santa Clara Valley Water District reservoirs, allowing relatively rapid draining. A portion of midwinter reservoir storage capacity is left empty by draining between storms to provide for some degree of flood protection in the urbanized watershed downstream of the reservoir. Urbanization has expanded substantially on the valley floor within the Llagas Creek watershed since the AMBAG study, increasing storm runoff to the lower portion of the watershed. The density of homesites has also increased in the reach between Watsonville Road and Chesbro Reservoir. Habitat descriptions by reach and an assessment of fish resources follow.

1. Mouth to Highway 152. Most of this reach has perennial flows due to a combination of agricultural irrigation runoff and wastewater treatment plant recharge to a shallow, perched aquifer. The reach has been channelized for flood control since the late 1970's. Shading is generally limited, although willows and cattails are abundant along portions of the silty-bottomed channel. Late spring and summer water temperatures are warm, with summer temperatures exceeding 78-80 degrees F. Dissolved oxygen levels are often low in the morning in summer in years of low stream flows and excessive algal respiration. With the string of recent wet years, summer stream flows have been higher, reducing potential water quality problems. However summer temperatures and silty substrate preclude use by juvenile steelhead. The reach does provide easy winter and spring passage for migrating steelhead compared to the seasonal channel upstream.

(Steelhead Limiting Factors: late spring water temperatures and water quality for emigrating steelhead smolts)

2. Highway 152 to Church Avenue. This largely channelized reach is dry in late spring and summer. In 2001 it was dry by late April and had less than 2 cfs of flow by early April. The channel is unshaded and has almost no channel riparian trees or shrubs. The streambed is very flat (<0.3 % gradient) and is primarily silt/clay and sand. Grade control structures with fish ladders are present between Highway 152 and Leavesley Avenue, and a center low flow channel is present within that portion of the reach. The low flow channel substantially reduces the amount of streamflow necessary to allow fish passage. Adults can probably migrate at flows of 10 cfs, and smolts can probably emigrate at flows of 3-5 cfs. There has been no apparent filling of the channel within that portion of the stream, and the low flow channel position and shape have been stable. Apparently only fine suspended sediment is transported into the reach, and that flushes through during high flows or in the low flow channel at lower flows.

(Steelhead Limiting Factor: spring streamflows to allow smolt emigration)

3. Church Avenue to Silveira Lake, Just Upstream of Monterey Road. Except in drought years, surface flow in summer is maintained downstream to Church Avenue, where most of the remaining flow can be diverted into a series of 3 offchannel percolation ponds. Substantial streambed percolation occurs within the reach; flows of 6-8 cfs at the upstream end of the reach can decline to less than ½ cfs at the bottom of the reach. Potential fast-water feeding habitat for juvenile steelhead declines downstream with gradually decreasing streamflows and channel gradient. Small willows, blackberries and patches of giant reed make up the riparian vegetation in much of the reach, and shading of the channel is generally minimal. Scarce riffles within the reach are of coarse to fine gravels, and the substrate in other habitats is generally silt, sand and fine gravel. Potential steelhead spawning gravels are scarce and relatively sandy. Pools are generally scarce and less than 2 feet deep. Willows, giant reed and filamentous algae along the stream margins provide escape cover. As might be expected, summer water temperatures are warm. In 2000, with relatively high summer reservoir and pipeline releases (7-9 ½ cfs), late July water temperatures at temperature logger stations at San Martin and Llagas Avenues generally ranged between 68-75 degrees F, and at Church Avenue they ranged between 68-78 degrees F (SCVWD temperature data). By late September temperatures had cooled somewhat and ranged between 62 and 73 degrees F at the 3 sites.

(Steelhead Limiting Factors: water temperature and fast-water feeding habitats)

4. Silveira Lake. This onchannel lake was created in the mid 1980's when a berm separating the creek from an offchannel gravel quarry was notched to divert the creek into the quarry. The lake is now the site of a park. The deepest portions of the lake are about 3.5 m (11 feet) deep, and most of the lake is 2-3 m (6-9 ½ feet) deep (Harvey and Stanley Associates 1988). Depth increases abruptly along the northwest and north shorelines, but the south shore is relatively shallow. There is little emergent plant development along the shore, because of the sharp shoreline depth increase. The lake is shallow and wide enough to allow generally good mixing. On 28 October 1987 midday water column temperatures ranged from 66 degrees F at the surface to 63 degrees F on the bottom in the deepest part of the lake. Dissolved oxygen levels were generally above 5 ppm in the upper 2 m (6 feet) of the lake. Summertime temperatures in the lake are probably 65-74 degrees F. During warm, calm periods in summer the outflow of surface water from the lake might reach 2-4 degrees warmer than inflow temperature, but on 28 October 1987 the difference was only about 1- 1 ½ degrees F (with an inflow of about 1 ½ cfs). The water temperature increases through the lake are potentially significant because water temperatures downstream are marginal for steelhead anyway. Large pikeminnows are common in the lake, and could prey on migrating steelhead smolts.

(Steelhead Limiting Factors: water temperature and competition for food with warmwater fishes, potential predation on migrating juvenile steelhead)

5. Silveira Lake to Pipeline from Uvas Reservoir. Summer streamflows in this reach can be substantially higher than upstream of the pipeline. In 2000 releases from Chesbro Reservoir were generally 3-4 cfs from Late April through late September, but the pipeline from Uvas Reservoir added 3 cfs in late May and gradually increased that amount to 4 ½ to 5 cfs in August and 5 ½ cfs in late September. The reach generally has a dense riparian (willows, sycamores) and terrace (oaks) forest border, with canopy closures of 50-90 %. The stream is surrounded by tract homes downstream of Santa Teresa Boulevard, but streamside vegetation is actually much denser now than when the stream was surrounded by farmland in the 1970's. Upstream of Santa Teresa Boulevard the surrounding landscape is primarily grazed grassland and low density homesites. The channel is somewhat entrenched, and substrate is generally silty gravels and sand. Spawning gravels are rather uncommon and contain significant amounts of sand and silt. Pools are frequent, deep (to over 3 feet) and have dense escape cover from overhanging willows and blackberries. Potential steelhead fast-water feeding habitat makes up less than 25% of the habitat. Summer water temperatures are moderately warm, and are dependent upon the depth of Uvas Reservoir in relation to the pipeline intake. In late July 2000 temperatures below the pipeline ranged between 60-62 degrees F and below the Santa Teresa Boulevard ranged between 60–64 degrees F (SCVWD temperature logger data). However, in late September temperatures had climbed to 67-69 degrees F at the pipeline and 64-73 degrees F at Santa Teresa Boulevard, despite cooler weather and the increased flow rate from the pipeline. Because Uvas Reservoir had been lowered the pipeline was transferring warmer water from nearer the reservoir surface. In drier years, when Uvas Reservoir starts the season at far less than capacity, the warming effect would be greater and occur earlier.

(Steelhead Limiting Factors: water temperature, fast-water feeding habitat, food production)

6. Pipeline Outfall to Chesbro Dam. The partially incised channel (Rosgen B4/5C) in this reach is generally well-shaded (mostly 60-95% canopy closure) by riparian (willows, sycamores) and terrace (oaks) trees. Substrate is generally cobbles and gravels in the riffles and silty sand and fine gravel in the pools. However, substrate is generally much finer in the lower half of the reach. Spawning gravels are somewhat scarce, except in the middle of the reach, and contain significant amounts of sand and silt. In the upstream portion of the reach gravels are very scarce, due to their gradual depletion since construction of the dam. Pools are frequent, relatively deep, and provide substantial escape cover from undercut banks and overhanging vegetation. Potential steelhead fast-water feeding habitat (riffles, runs, heads of pools) makes up about 15 percent of available habitat. Releases from Chesbro Reservoir vary substantially with year to year storage. In 2000 releases varied between 3 and 4 cfs from late April through late September. Flows were 5-6 cfs in 1998 and 1999. In drier years the releases can be only 1-2 cfs, but losses through the reach to percolation are minor. All of Llagas Creek downstream of the reservoir went dry in 1977, except immediately downstream of the dam. Water temperatures gradually increase downstream of the reservoir, and

temperatures of the releases from the reservoir increase seasonally as the reservoir is drawn down. In 2000 water temperatures in late July were 60-64 degrees F below the dam and 62-68 degrees F at Edmundson Avenue and Machado School temperature logger sites (SCVWD temperature data). At Bowden Court, immediately upstream of Watsonville Road, they were somewhat higher (62 –72 degrees). In early October water temperatures had increased to 66-68 degrees F immediately downstream of the reservoir, and were similar to July values at the other 3 sites, despite much cooler weather in October. A concrete pad and culvert stream crossing 1 mile downstream of the dam is a passage barrier to adult steelhead at most streamflows

(Steelhead Limiting Factors: summer streamflow and late summer water temperatures, food production, fast-water feeding habitat, spawning habitat near the dam*)

7. Little Llagas Creek and the Madrone Channel. Like all of the tributaries to Llagas Creek, Little Llagas goes dry in late spring or early summer. The Madrone Channel, a ditch along Highway 101, potentially drains into Little Llagas Creek. Water from Anderson Reservoir on Coyote Creek is fed by pipeline in summer into the Madrone Channel for ground water recharge in the Llagas Creek watershed. Gravel dams within the channel produce a series of percolation ponds and none of the surface water normally reaches Little Llagas Creek. The ponds are normally allowed to dry in late fall, but can be operated all year during drought years.

(Steelhead Limiting Factor: seasonally dry habitats)

Llagas Creek Steelhead and Fish Resources Downstream of the Reservoir. The biggest potential problem for maintaining steelhead in Llagas Creek is the difficulty of regularly getting smolts out in spring through the long, seasonally dry reach of stream downstream of Highway 101. The low flow channel within the flood control channel may allow smolt emigration at flows as low as 3 cfs, but the reach is dry in most years by mid April. Juvenile rearing within Llagas Creek is probably restricted in most years to the reach between the dam and Watsonville Road by low streamflows, high water temperatures, and food availability in fast-water habitats. However, some juvenile steelhead have been captured in late summer as far downstream as Santa Teresa Boulevard in wet years (Smith 1982). The few steelhead that do rear in the fast-water habitats of Llagas Creek are able to grow relatively quickly and reach smolt size in their first summer. In 1997 four sites between the dam and Monterey Road were sampled and only 7 juvenile steelhead and were captured at the first bridge downstream of the dam. Three additional sites had to be sampled in 1998 in order to collect a combined total of 30 fish for genetic analyses. The genetic analyses indicated low genetic variation, and the samples may have been produced from a single spawning pair of steelhead in each year (Sundermeyer 1999). The present steelhead run in Llagas Creek probably amounts to relatively few adult fish, possibly as strays, in wetter years only.

Sacramento suckers are common throughout the stream below the dam. Sacramento pikeminnow and hitch are also common, but occur primarily downstream of Watsonville Road, where pools are larger. Large pikeminnows are apparently common in Silveira Lake, where they could potentially prey on migrating juvenile steelhead. California roach were lost during the dry-back in 1977 (Smith 1982). Sacramento blackfish are common in Silveira Lake and were common in the Church Avenue percolation ponds. Prickly sculpins are present, but scarce, primarily downstream of the pipeline from Uvas Reservoir and may come through the pipeline. Pacific lamprey have occasionally been found near Santa Teresa Boulevard.

Llagas Creek Upstream of Chesbro Dam

Unlike Uvas Reservoir, the water right for Chesbro Reservoir never required adult steelhead passage at the dam. The descriptions of habitats upstream of Chesbro Dam are provided for comparison and in response to questions about potential steelhead habitat upstream, if passage was provided.

1. Chesbro Reservoir. The watershed upstream of Chesbro Reservoir is substantially drier than that upstream of Uvas Reservoir. In addition, since heavy releases are often made between storms during early winter to reserve some capacity for flood protection, Chesbro spills less frequently and for shorter duration than Uvas Reservoir. Chesbro Reservoir spilling rarely occurs in spring, during the potential steelhead smolt outmigration period. Chesbro Reservoir is relatively shallow, and is usually almost drained by late summer, except during very wet years. No cool, oxygenated habitat remains to support trout or to potentially support juvenile steelhead.

(Potential Steelhead Limiting Factors: too shallow and warm for juvenile rearing and very limited potential for smolt outmigration over the spillway)

2. Reservoir Upstream to the Locked Gate on Casa Loma Road. Summer stream flows decline downstream within this reach. In dry years (1972, 1987-1991) this reach is dry or intermittent. In very wet years stream flow would be very low by late summer and would likely be intermittent near the reservoir. Streamside vegetation is primarily sycamores, oaks and willows in the downstream two-thirds of the reach, but alders are present at the upstream end of the reach. The channel is flat, but moderately entrenched, with sandy pools and gravel to cobble riffles (Rosgen channel type B4C). Much of the shading comes from terrace trees, and canopy closure ranges from 30-80 percent. Summer water temperatures probably exceed 72-78 degrees (F) in the reach in most years.

(Potential Steelhead Limiting Factors: summer stream flows and water temperatures)

3. Upstream of the Locked Gate on Casa Loma Road. In average to wet years summer stream flow is usually present throughout this reach**,** but the lower portion of the reach is dry or intermittent in dry years. The stream is generally well-shaded by sycamores, alders, willows and oaks (canopy closures of 50 – 90 percent). The channel is moderately entrenched, with cobble riffles and with sand and bedrock outcrops in the pools (Rosgen B1/3 channel). Pools are relatively common, moderately deep and have good escape cover as undercut banks or ledges.

(Potential Steelhead Limiting Factors: summer stream flow in the lower portion of the reach and food production)

Fish Resources of Llagas Creek Upstream of the Dam. The perennial headwaters of Llagas Creek contain healthy populations of rainbow trout, riffle sculpin, California roach and Sacramento suckers, but the lower half of the stream is usually intermittent. In dry years only California roach and Sacramento suckers are found at the locked gate on Casa Loma Road, and much of the habitat downstream is dry. After a series of wet years (1997, 1998) rainbow trout were relatively common, but riffle sculpin were absent at the end of the public portion of Casa Loma Road. In wetter years, some roach and juvenile suckers can be found throughout most of the stream, and some rainbow trout are likely to be found more than a mile downstream of the locked gate. Foothill yellow-legged frogs (and some bullfrogs) were present at the locked gate on Casa Loma Road in 1998.

Miller Canal and San Felipe Lake

The head of the Pajaro River was originally wetlands associated with San Felipe Lake, a Calaveras Fault zone sag pond located near Highway 152 east of Gilroy. When the valley flooded, the lake and wetlands drained into the river. To facilitate agricultural development, Miller Canal was constructed from San Felipe Lake directly to a downstream portion of the Pajaro River near its confluence with Llagas Creek, bypassing the flat, meandering wetland channel. The canal allowed for quicker spilling of the lake at a lower elevation, allowing farming around the lake. The original upper Pajaro River channel is now a shallow, seasonal ditch.

Miller Canal. This canal provides for steelhead passage to and from San Felipe Lake and its tributaries. The canal is flat, narrow and relatively impermeable, and provides good fish passage when San Felipe Lake spills; only about 2-4 cfs is necessary to allow smolt passage. A bridge apron at Frazer Lake Road, which presented passage problems for adult steelhead at low flows, was removed in the late 1980's. The canal is dry for most of the year.

San Felipe Lake. This shallow, natural lake is too warm to allow for steelhead rearing, but may allow feeding by smolts migrating in winter or spring. The lake is normally turbid because it supports large carp and Sacramento blackfish populations, which have occasionally been commercially harvested. The lake dried in 1977, the second of two consecutive severe drought years. Two tributaries empty into San Felipe Lake from the east, Tequisquita Slough from San Benito County and Pacheco Creek primarily from Santa Clara County.

Tequisquita Slough Watershed

Tequisquita Slough partially occupies former wetlands near San Felipe Lake and drains runoff from 3 watersheds northeast of Hollister. Since the AMBAG studies (Smith et al. 1983, 1984) this generally dry watershed has begun receiving imported water to maintain ground water levels.

1. Tequisquita Slough. The "slough" is a realigned channel that flows through more than 5 miles of valley flatlands used for agriculture and grazing. Most of the channel is dry except during winter and early spring runoff. Portions remain as summer ponds, and the duration of runoff and ponding appears to have increased since the 1980's, apparently due to higher ground water levels. Riparian trees (willows) are limited to small patches along summer ponded areas, but the amount of cattails in the seasonally dry channel has expanded. Substrates throughout the channel are silt.

(Steelhead Limiting Factors: spring runoff for smolt outmigration)

2. Arroyo de las Viboras and Santa Anna Creek. These two tributaries drain relatively dry watersheds and have limited perennial flow. They may go completely dry during severe droughts.

3. Arroyo Dos Picachos, Mouth to 0.2 Miles Downstream of Lone Tree Road. This reach flows through crop agricultural land downstream of Fairview Road and grazing land upstream. The stream in the cropland is primarily a narrow, unshaded, silty-bottomed ditch. In the grazing land the channel is lined with mule sparse mule fat and a sparse parkland of sycamores. Substrate is sandy and gravel. Streamflows are present only in winter and early spring.

(Steelhead Limiting Factors: streamflows for adult access and especially for smolt outmigration in spring)

4. Arroyo Dos Picachos, from Below Lone Tree Road, Upstream 3+ Miles. This reach has perennial flow, even in severe droughts (1976-77). The stream is well-shaded (60-80+ % canopy closure) by riparian (willows) and terrace (oaks) trees. Summer water temperatures probably seldom exceed 70-72 degrees F. Pools are frequent, moderately deep (1-2+ feet), and associated with bedrock and rootwads. Substrate in pools is sand and fine gravel. Riffles and runs are gravel and cobble. Potential steelhead spawning gravels are common and of good quality. A small diversion dam is located at the bottom of this reach. The upper portion of this watershed is beneath spectacular volcanic peaks.

(Steelhead Limiting Factors: migration access to and from the reach)

Tequisquita Watershed Steelhead and Other Fish Resources. Arroyo de las Viboras and Santa Anna Creek are apparently too dry to support stream fishes, but Arroyo Dos Picachos has a healthy population of resident rainbow trout. Steelhead originally used this watershed for spawning and rearing, and may still use it in wet years. Abundant yearling "trout" captured in June 1997 above a diversion dam near the Lone Tree Road crossing may have represented steelhead smolts trapped by declining spring flows. However, smolt outmigration through the lower reaches of the stream and through Tequisquita Slough is limited to winter and early spring of wet years. In most years smolts could only successfully emigrate during storm periods. Genetic analysis indicates that the trout/steelhead present are probably the native strain (Sundermeyer 1999). The remoteness of the system, and its upstream position within the Pajaro River watershed, have apparently protected it from hatchery strays of San Lorenzo River origin.

California roach and Sacramento suckers are common in Arroyo Dos Picachos. Riffle sculpin, a frequent associate in wetter streams elsewhere in the Pajaro River system, are absent in both Arroyo Dos Picachos and in the Pacheco Creek watershed.

Pacheco Creek

Summer streamflow in Pacheco Creek comes from releases from North Fork Pacheco Reservoir, which is operated by the Pacheco Water District to supply agricultural irrigation water through streambed percolation. Significant releases from the reservoir normally don't begin until demand for water increases in late May or early June, so flows are often low and water temperatures high in late spring prior to the commencement of reservoir releases. Paradoxically, this is more likely to be true in relatively wet years, when early demands for flows for agricultural use are less.

1. San Felipe Lake to Highway 156. This flat (<0.5% gradient), gravelly, entrenched channel tends to dry fairly early in the spring of many years. A narrow, but generally dense, riparian (willow, box elder) and terrace (oaks) forest borders the channel, but because the channel is relatively wide, there is little midday shading. There is little deep

pool development, even on the outside of bends, but overhanging willows provide some escape cover. Even in wet years, all but the upstream portion of the reach is dry in summer.

(Steelhead Limiting Factor: this reach is the critical passage problem for outmigrating smolts from Pacheco Creek)

2. Highway 156 to Casa de Fruta. This flat, entrenched reach has a dense, but narrow, riparian and terrace border of trees that gives partial midday shade (25-60 % canopy closure). Fine gravel and sand dominate the streambed, and deep pools are scarce. Spawning gravels are common but sandy. Summer streamflow is very low and water temperatures warm (76+ degrees F) even in wet years. In drier years the site is dry in summer. Most of the channel is deeply entrenched (B4C or G/F 4). At the upstream end of the reach the channel has limited entrenchment (Rosgen C4 or D4 (braided) channel); the willow border there is usually denser than upstream, because it is fenced from cattle use.

(Steelhead Limiting Factors: spring and summer streamflow and water temperatures)

3. Casa de Fruta to North Fork Pacheco Reservoir. Stream shading by willows and sycamores is limited in most of the reach, and the dominant streamside plant along most of the (Rosgen C4) channel is mulefat, due to cattle grazing. Percolation rates are high, so streamflows decrease and water temperatures increase relatively rapidly downstream. Midsummer reservoir releases of 20-25 cfs and 58 degrees F become streamflows of 2-3 cfs and 76+ degrees F in the afternoon at the highway crossing upstream of the California Division of Forestry Fire Station. Late summer and fall water temperatures also increase as the reservoir is drained and "surface water" is released. In 1972, 1976-7 and 1987-1991 the stream was dry except for the first 1 –3 miles downstream of the dam. Pools tend to be sandy, but riffles and runs are of cobbles and gravels. Spawning gravels are relatively common, but sandy, except for the short reach between the dam and the South Fork. In that short reach gravels are scarce because of their gradual depletion after the construction of the dam.

(Steelhead Limiting Factors: spring* and summer streamflow and water temperatures, late spring flow cutoffs*, smolt outmigration).

4. South Fork Pacheco Creek. This very dry watershed has intermittent late summer flows in wet years and is probably mostly dry in other years. Pools are associated with bedrock outcrops, especially in the narrower, steeper upper portion of the stream.

(Steelhead Limiting Factor: summer streamflow)

5. Cedar Creek. The lower mile of this north bank tributary is dry in summer even in wet years, but the upper portion apparently has some surface water even in drought years. Stream shading is limited to sparse willows, sycamores and oaks. Pools are associated with bedrock outcrops. Substrate, including potential spawning habitat, is a generally clean mixture of gravels and sand.

(Steelhead Limiting Factor: summer streamflow)

Pacheco Creek Steelhead and Other Fish Resources. Adult steelhead access through Miller Canal and the lower portion of Pacheco Creek is greatly restricted in dry years. Even more important, the lowermost reach of Pacheco Creek has a wide, percolating channel, and is likely to block smolt outmigration by April or May of all but the very wettest years. In very dry years few smolts are likely to successfully emigrate. Rearing habitat in Pacheco Creek is almost completely dependent upon releases from North Fork Pacheco Reservoir. The stream is generally sparsely shaded and percolation rates are high, so streamflows decrease and temperatures increase rapidly downstream. Even with good summer reservoir releases, conditions are rarely suitable for significant juvenile steelhead rearing much further downstream than the CDF fire station. Rearing steelhead are all associated with fast-water feeding habitat (riffles, runs and heads of pools), and fish density increases upstream where flows are higher and temperatures lower. However, as for Uvas Creek, those steelhead that do successfully rear in the fast-water habitats grow rapidly and reach smolt size by the end of their first summer (Smith 1982). In many years in late spring, prior to reservoir releases for agriculture, low streamflows and high water temperatures severely impact steelhead fry and small juveniles. Later in summer the higher releases provide good potential rearing conditions, but many of the steelhead will have been already eliminated or reduced by the restricted, warm, earlier releases.

Two Pacheco Creek tributaries, Cedar Creek and South Fork Pacheco Creek, tend to have mostly intermittent flows in summer, but both were used by steelhead in the early 1970's (Smith 1982).

Sacramento suckers, prickly sculpin, and hitch are common throughout perennial portions of Pacheco Creek. California roach, which might be expected for such a stream, have been captured only in Cedar Creek and on the South Fork of Pacheco Creek. They have apparently been displaced by hitch, which now have a high flow refuge in the large pools downstream of North Fork Pacheco Reservoir.

PRELIMINARY RESTORATION AND ENHANCEMENT OPTIONS

Additional fieldwork and discussions with water management and regulatory agencies must be done to develop restoration and enhancement options for Pajaro River system steelhead. The following are very preliminary possibilities, and are presented with no priority ranking.

Barrier Modifications

1. Modify flashboard dam support structure on lower Bodfish Creek to improve adult migration passage.

2. Conduct regular winter inspections of the fish ladders for debris at the Carnadero Creek Southern Pacific Railroad Crossing and at Pickels Dam on Little Arthur Creek.

3. Use streambed alteration agreements to regulate timing of flashboard installation on seasonal dams on Little Arthur Creek.

4. Modify 3 of the flashboard dams on Little Arthur Creek to improve adult steelhead passage.

5. Modify concrete pad and culvert stream crossing downstream of dam on Llagas Creek.

6. Evaluate riparian plant or other methods to narrow the channel of the Pajaro River immediately up and downstream of Murphy Crossing to improve smolt low flow passage.

7. Provide adult steelhead passage at Uvas Dam by constructing a fish ladder at the dam and modifying a 2-step flashboard dam abutment upstream of the reservoir or by trapping adult fish and trucking them around the barriers.

Instream Habitat Improvement

1. Periodically remove sediment accumulations at Sprig Lake (Bodfish Creek) to maintain seasonal lake capacity.

2. Improve seal on outlet at Sprig Lake to reduce seepage loss and maintain lake depth through summer.

3. Install a slide gate on the outlet at Pickels Reservoir on Little Arthur Creek (similar to that at Sprig Lake) to improve flexibility in closing and opening the dam.

4. Install spawning gravels in the reaches immediately downstream of Chesbro and Uvas reservoirs to replace those gradually lost since dam construction. Include 10% marker rocks within installed gravels and monitor gravel movement. Gravel sources might include delta deposits at the head of Chesbro Reservoir.

5. Install spawning gravels in the stream reach immediately upstream of Pickels Reservoir to increase juvenile steelhead use of the rearing habitat in the reservoir. This might be used in combination with an instream structure to produce a holding pool attractive to adult steelhead.

6. Reroute Llagas Creek around Silveira Lake (in its original channel) to eliminate the increased stream temperatures caused by the onchannel lake and to reduce possible predation impact on migrating smolts by large pikeminnows and other predatory fish present in the lake. Maintain connection of the lake to the stream by culverts.

Water Management Changes

1. Modify spring releases at North Fork Pacheco Reservoir to reduce or eliminate flow cutbacks prior to the irrigation season.

2. Reduce the transfer of Uvas Reservoir water to the Llagas Creek watershed and release more water into Uvas Creek.

3. Install a flashboard dam downstream of Miller Avenue to create a percolation pond for Uvas Creek water.

4. Evaluate percolating more water from from Anderson Reservoir in the Llagas Creek watershed to compensate for reduced water transfers from Uvas Reservoir.

5. Evaluate water swaps with Santa Cruz County so that their importation allotment would come through the San Felipe Pipeline and be percolated in the Llagas Creek watershed in exchange for additional Uvas Reservoir releases through Uvas Creek and the Pajaro River for diversion in Santa Cruz County.

6. Improve spring releases in Uvas Creek during the smolt outmigration period.

Fishing Regulations

1. If catchable trout are to be stocked in Sprig Lake, close the fishing season in early July and enforce the closure to prevent harvest of juvenile steelhead.

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