PROSPECTS FOR IMPROVING RIPARIAN CANOPY AND PHYSICAL HABITAT FOR FISH ON ROSS CREEK

Geomorphic Reconnaissance Report
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Friends of Corte Madera Creek Watershed

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COVER: PHOTO DOWNSTREAM TO POTENTIAL WINTER AQUATIC HABITAT ENHANCEMENT SITE HAB-1 (OCT 25, 2006)

Purpose and Scope

This brief report summarizes the results of October 2006 geomorphic field investigations made for preliminary identification of potential stream restoration, physical fish habitat, and riparian canopy improvement project sites on Ross Creek downstream from Natalie Coffin Greene Park.

Four types of potential improvement projects were identified:

- Native riparian tree canopy enhancement;
- floodplain restoration and enhancement;
- stream restoration; and,
- winter fish habitat improvement (primarily by addition of physical habitat structures bordering existing pool habitats lacking adequate cover and habitat complexity).

This brief report only: (1) lists recommended project sites; (2) locates them according to stream distance measured from bridge crossings; and, (3) generally describes the recommended project actions. These preliminary data are thought to be sufficient for project conceptualization, discussions with property owners, and first-order cost estimates for grant proposals, as may need to be augmented by site maps, photos, site surveys, conceptual design drawings, and project construction cost estimates.

The site identification, specific recommended actions, and general technical rationale reported herein are made from fluvial geomorphic and civil and water resources engineering perspectives. They are also informed by review of separate, more comprehensive reports made on the subjects of potential fish passage barriers and fish population estimates (Alice Rich and Associates, 2000; Ross Taylor and Associates, 2003; Ross Taylor and Associates, 2006).

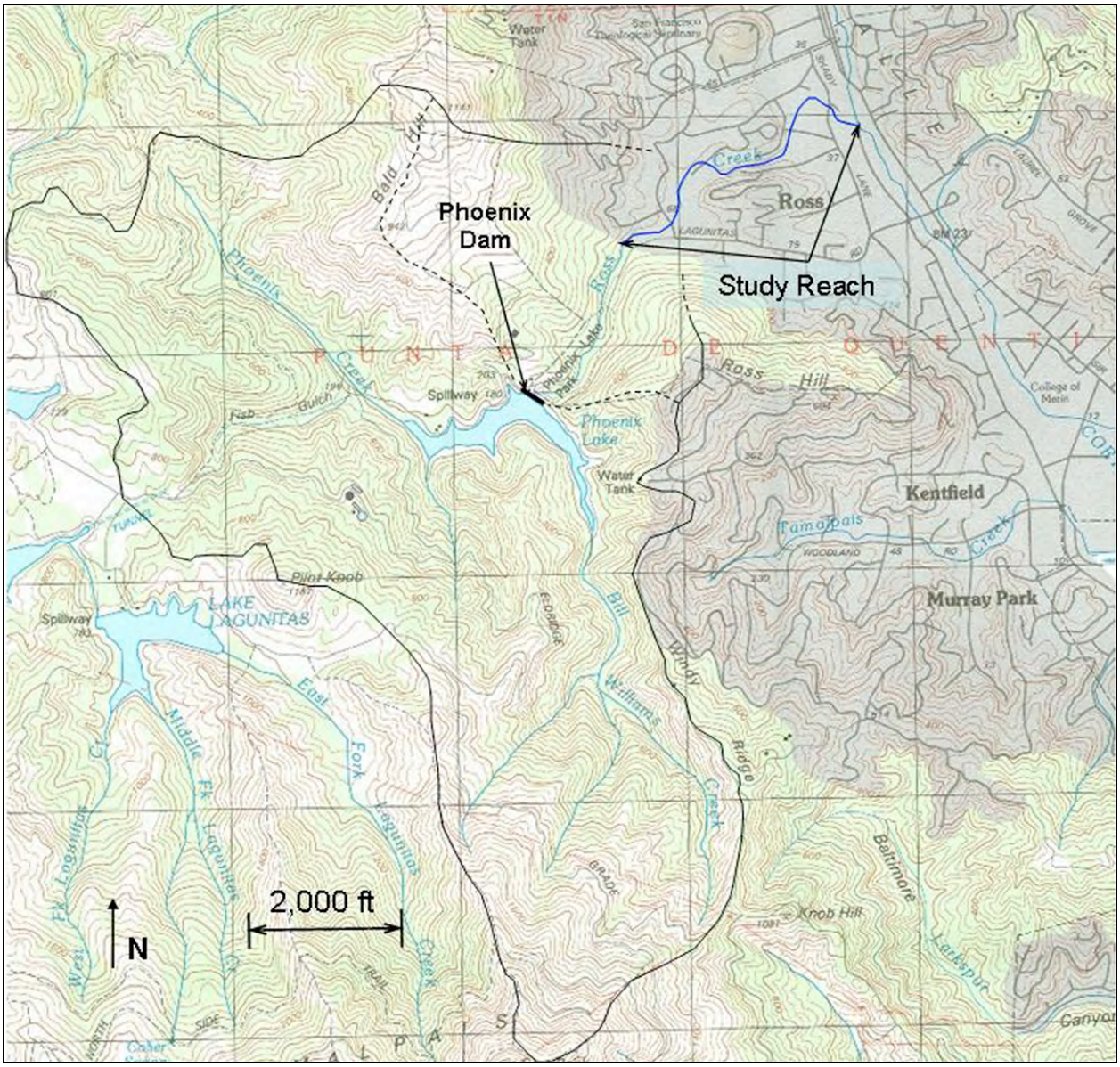
Making fish habitat improvements by modifying and reoperating MMWD's Phoenix Dam/Lake to increase spring and summer flows may be more beneficial to fish than the proposed physical habitat improvements, neither the minimum necessary seasonal flow improvements to benefit fish populations, nor the operational constraints and management costs of providing those improvements from Phoenix Reservoir are treated in this report.

Rationale and Limitations of Proposed Physical Habitat Improvements

Ross Creek is comprised of two physically distinct reaches (Figure 1). Upstream, the 3,200-ft long perennial flow reach within Natalie Coffin Greene Park is in relatively natural condition and provides fair to good fish habitat. Downstream, the 5,500-ft long intermittent reach extending from the park boundary to Corte Madera Creek (study reach) provides limited habitat because it ceases to flow in the late spring or early summer. The discontinuous flow in the spring, summer, and fall prevents the reach from providing juvenile rearing habitat and adequate connection to Corte Madera Creek for outmigration. And although the lower reach is continuously flowing in the winter, winter habitat quality is limited by the majority of streambanks being composed of

residential retaining wall structures that have reduced the active channel width and separate former active floodplains and gravel point bars from the creek. Bank stabilization structures also eliminated and now prevent reestablishment of native riparian tree root systems along the edges of run, glide, and particularly pool habitats. In addition, active removal of fallen trees from the channel bed and bank areas for flood management purposes reduces the potential for woody debris to restore some of the predevelopment habitat complexity and cover.

Figure 1. Watershed map of Ross Creek. The study reach is an approximately 5,500-ft long reach of Ross Creek downstream from Phoenix Dam and Natalie Coffin Greene Park.



Generally speaking, populations of rainbow trout and salmonids are known to be relatively low in Ross Creek in the study reach downstream from Natalie Coffin Greene Park and thought to be limited to various degrees by numerous factors, including:

- Low and zero spring streamflow downstream from park limits or prevents successful outmigration of juvenile fish to Corte Madera Creek;
- low and zero summer and fall streamflow limits the amount of juvenile rearing habitat;
- high summer and fall stream temperatures due to low and zero flow conditions and incomplete riparian canopy cover;
- low number of sites with a suitable combination of gravel substrate, flow depths, and velocities for successful spawning;
- lack of natural channel banks with adequate woody debris and riparian vegetation overhanging the stream for providing complex aquatic habitat and cover from predators, and lack of wide channel areas flanked by active floodplains accessible to fish during winter high flows;
- Phoenix Lake traps significantly more food than is produced in the 3,200-ft long reach within the park;
- fish passage migration barriers on Corte Madera Creek, particularly the Unit 3/4 fish ladder behind the Ross Post Office may reduce access by salmonids to Ross Creek;
- physical fish passage barriers and seasonally low flows on the Ross Creek mainstem, particularly the Park Street arch culvert and possibly also the concrete grade control weirs (both within the Branson School Campus), may reduce access by salmonids to the better habitat in Natalie Coffin Greene Park; and
- non-native, predatory fish (e.g., large-mouth bass) that are washed over the dam and into Ross Creek prey on young salmonids.

It is presently not known and would be difficult to determine which combination of the above factors most severely limits Ross Creek's rainbow trout and salmonid populations. Indeed, comprehensive limiting factors analyses are expensive, seldom completed, and usually inconclusive for want of still more years of monitoring. Even without the benefit of conclusive limiting factors analysis, it's reasonable to suggest that making *physical habitat improvements* on the downstream reach of Ross Creek without also making *flow improvements*, such as by releasing flow from Phoenix Lake in the late spring and summer to extend the period of continuous flow connectivity between the upper reaches of Ross Creek in the park and Corte Madera Creek, would probably only slightly improve fish populations, if at all.

The four types of projects recommended in this report would make physical habitat improvements in the downstream reach that would partially address only one to two of the limiting factors. Specifically, all four of the project types would improve the amount of quality winter physical habitat and add shading canopy cover that would theoretically reduce summer water temperatures and improve summer rearing habitat. But without spring flow enhancements

there will be no connectivity to Corte Madera Creek during the outmigration flow months , typically in the late spring and early summer. And without summer flow enhancements there will be no summer rearing habitat in the downstream reach for increased shading to reduce the water temperature. Therefore, it is also reasonable to suggest that the benefits of the physical habitat improvements embodied in the recommended projects will not be completely realized until "leveraged" by future potential flow enhancements, removal of fish passage barriers on Corte Madera Creek, and overall cumulative watershed-wide improvements that will enhance riparian and aquatic habitat and improve water quality.

This report does not include the biological and engineering analyses needed to determine if it is feasible to operate Phoenix Dam/Lake in a manner that would provide substantial spring and summer flow enhancements or if the flows would be beneficial to salmonids. Indeed, it may be premature to make these determinations without first beginning to collect year-round streamflow and spring-summer-fall temperature data, and monitoring progress of the Ross Valley Flood Protection and Watershed Program. If there turns out to be public interest, MMWD cooperation, and funding to evaluate the feasibility of reservoir modification and reoperation for flood control, then spring and summer flow enhancements may be more (or less) feasible as part of multi-objective reservoir operations.

Lastly, the recommended projects are all on private property such that owner permission and/or participation are prerequisite. With all of these limitations, the recommended projects were selected and should be viewed with an eye toward, in the short term, restoring the overall natural integrity of the riparian corridor, perhaps for its own sake and as part of a realistic symbiosis with the residential community. And combined with future potential flow enhancements and ongoing work to remove downstream fish passage barriers, the recommended physical habitat improvements should, in the long term, contribute to increased fish populations in Ross Creek below Phoenix Lake.

Methods

FGC first prepared 50-ft scale air photo field basemaps from the County of Marin 2004 digital orthophotos overlain by the 2004 5-ft interval topographic contours.[1] On October 3 and October 26, 2006, FGC walked the 5,500-ft length of the dry bed of Ross Creek from the outlet at Corte Madera Creek to the beginning of perennial flow at the downstream boundary of Natalie Coffin Greene Park. Using a "chainman" longitudinal distance measurement device, FGC delimited the length and position of each individual streambank stabilization structure and still natural streambank section along both banks. This way, FGC inventoried and characterized each streambank unit. FGC also delimited, inventoried, and characterized potential physical habitat improvement projects of four types:

- Native riparian tree canopy enhancement;
- floodplain restoration and enhancement;
- stream restoration; and,
- winter fish habitat improvement (primarily by addition of physical habitat structures bordering existing pool habitats lacking adequate cover and habitat complexity).

[1] Note that the topography data are derived from spot air photo altimetry elevation data and are completely inaccurate along the stream corridor because of the relatively dense canopy cover.

Floodplain restoration and enhancement project site inventory. FGC identified existing active floodplains – approximately flat, variably vegetated, gravelly or sandy alluvial bar deposits flanking the channel – that were apparently inundated by the December 31, 2005 flood. FGC also identified terraces – higher, former floodplain surfaces that are not currently inundated by floods because of historical channel incision. FGC identified where existing floodplain or terrace units appeared possible to restore or enhance by excavating the existing surface down to a lower level to promote more frequent inundation and use by fish as vegetated winter high-flow "refugia" habitat, without removing so much of the existing riparian canopy cover at the site as to increase solar exposure of the stream bed in the short term. FGC tabulated the beginning and endpoint creek station (ft) of individual floodplain restoration and enhancement sites, and described general considerations for project design, thought to be sufficient for project conceptualization and first-order cost estimates for grant proposals.

Streambed and streambank restoration site inventory. FGC identified reach-scale sections of the stream with unnatural bed slopes and bedforms as commonly influenced by relict grade control structures, and unnaturally steep, unstable streambanks commonly composed of emplaced fill and typically dominated by non-native vegetation or failing retaining wall structures. FGC tabulated the beginning and endpoint point creek station (ft) of individual streambed and streambank restoration sites, and described general considerations for regrading and stabilizing the site, thought to be sufficient for project conceptualization and first-order cost estimates for grant proposals.

Canopy enhancement site inventory. FGC identified voids in the existing riparian canopy cover that appear to allow direct solar penetration into the summer water column, and also appear to be mitigable in the long term by drip-irrigated riparian plantings on or along the top of the existing streambanks. FGC also considered reaches dominated by non-native and/or apparently senescent mature riparian trees as potential candidate canopy enhancement project sites. FGC tabulated the beginning and endpoint point creek station (ft) of individual canopy enhancement sites, and described general considerations for planting the site, thought to be sufficient for project conceptualization and first-order cost estimates for grant proposals.

Winter fish habitat improvement site inventory. Floodplain restoration and enhancement projects and streambed and streambank restoration projects can and should be designed to include physical habitat structures such as large woody debris along the waters edge to improve winter habitat at the sites. FGC also identified the location, estimated depth, and adjacent bank condition for all pool habitats in the study reach and identified the individual existing pool habitats where adding physical habitat structures along the edge of the pool habitat appeared structurally feasible and likely to substantially increase cover and habitat complexity during winter.

- *This report only lists and describes the highest priority potential physical habitat improvement projects. Budget constraints prevented FGC from also reporting on all of the below-listed inventory work made for the sake of completeness during the October 2006 field reconnaissance.*

December 31, 2005 high water marks inventory. FGC identified and measured the height above the water surface of existing December 31, 2005 flood HWMs.[2] FGC tabulated the creek station (ft) and HWM height above the average channel bed elevation. FGC did not inspect top of bank areas in floodprone reaches to identify any additional HWMs outside of the main channel.

Equilibrium channel bankfull width estimates. FGC identified creek segments that are wide enough to allow fine sediment to deposit along the channel margins, typically in straight reaches or along inside bends where there are narrow gravel bars and/or floodplain bench surfaces. FGC tabulated the channel width measured along a line approximately 2-3 ft above the water surface, from the opposite bank to the inside edge of the fine sediment deposition. The average of these data values can be taken as a proxy for "equilibrium" channel bankfull width, and used as a target, minimum design value for bank stabilization and other bank modification projects in the riparian corridor.

Flood flow constrictions. FGC identified reaches where the bankfull channel width was substantially narrower than the approximate "equilibrium" bankfull channel width and/or the top of bank channel width was substantially narrower than upstream and downstream channel sections – narrow sections that appeared by visual inspection to possibly cause a flood backwater effect similar to that of an undersized bridge/culvert opening. Examples of potential flood constriction sites included reaches where an existing bank stabilization structure(s) appeared to substantially reduce the width of the channel, and locations in relatively narrow or existing structure-constrained reaches where a group of mature riparian trees occupy more than approximately 25 percent of the cross-section area below flood stage. FGC tabulated the bankfull width at the apparent minimum width cross-section within the narrow reach.

Existing Storm Drain Outlet Inventory. FGC identified the location, dimensions, and general condition of stormwater drainage outlets and natural tributary streams discharging to the study reaches. FGC tabulated the creek station (ft) of the drain outlet, the approx. size and type of drainage structure, and noted the structural condition of the outlet. FGC also considered whether or not the drainage outlet design or structural condition appears to affect habitat or bank stability.

Existing bank stabilization structure delineation and classification. FGC delineated the length of the left bank and right bank[3] of the study reaches into either individual existing "structures" or existing potential project sites according to where there are existing bank stabilization structures and where there are not. FGC tabulated the creek station (ft) at the beginning and ending points of all existing bank stabilization structures, including distinguishing between adjacent bank stabilization structures of different construction types or apparent ownership.

FGC tabulated the estimated height of each individual structure (height above low flow water surface elevation) and its general structural condition. FGC also identified failed or failing portions of structures and considered whether or not modification or replacement of failed/failing structures would reduce erosion pressure on affected upstream and downstream sites or enhance aquatic habitat or riparian canopy in a canopy-limited reach.

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[2] HWMs are reliable indicators of maximum instantaneous flood water surface elevation, such as floated vegetative debris attached to stout tree limbs, or attached to existing bank stabilization structures.

[3] Note that the engineering/geomorphology convention for determining left bank and right bank is looking downstream, whereas the fisheries biology convention is looking upstream.

Where there were multiple structures on one section of creek bank, the delineation is according to the structure type nearest to the water surface. Typical structures appear to consist of materials placed directly on the pre-project creekbank surface, such that the structure would have encroached into then-existing waters of the U.S. by a minimum amount comparable to its thickness, typically 3-4 ft. FGC noted instances where individual structures appeared to encroach more than that typical amount, and characterized the physical effects of encroachment on upstream and downstream sites, if any.

The individual structures are numbered sequentially increasing from the outlet at Corte Madera Creek to the downstream boundary of the park (e.g., S-1, S-2, etc.).

Site stability delineation and classification. Wherever there were not structures, the still natural banks were considered potential project sites that were delineated according to apparent recent and immediate future erosion/stability conditions. FGC tabulated the creek station (ft) at the beginning and ending point of each site according to the following classification:

BEDROCK	Stable native bedrock (sandstone, shale, and sometimes also dense clay) exposed in bank to a height typically exceeding approx. 3 ft above the adjacent water surface.
CLASS A	Creek channel banks show none or negligible recent bank erosion or upper bank slump failures (i.e., stable).
CLASS B	Creek banks show frequent and/or recent minor bank erosion and/or upper bank slump failures that overall appear self-stabilized or self-stabilizing and *do not* appear subject to additional major erosion that would damage existing public or private property or threaten to erode mature riparian trees important to the existing tree canopy cover in the reach.
CLASS B*	Creek banks show recent major bank erosion and/or upper bank slump failures that *do not* appear self-stabilized or self-stabilizing and instead appear subject to additional major erosion in the event of moderate and large floods in the immediate future, especially as would damage existing public or private property and/or threaten to erode mature riparian trees important to the existing tree canopy cover in the reach.
CLASS C	Creek banks with isolated severely undermined existing mature riparian tree(s) at mid-bank or near top of bank that, if not structurally stabilized and/or heavily pruned, appear likely to topple or erode into the channel in the immediate future, and as a result significantly reduce the existing tree canopy cover in the reach, and/or threaten to form flood constricting debris jams, and/or damage public or private property.
CLASS B/C	Creek banks show frequent and/or recent minor bank erosion and/or upper bank slump failures that overall appear

somewhat self-stabilized or self-stabilizing and *do not* appear subject to additional major erosion that would damage existing public or private property, and there are one or more severely undermined existing mature riparian trees at mid-bank or near top of bank that, if not stabilized and/or severely pruned, appear likely to erode into the channel in the immediate future, and as a result significantly reduce the existing tree canopy cover in the reach, and/or threaten to form flood constricting debris jams, and/or damage public or private property.

The individual sites are numbered sequentially increasing from the outlet at Corte Madera Creek to the downstream boundary of the park (e.g., A-1, A-2, etc.).

ACTION / NO-ACTION recommendations. FGC considered the overall watershed-scale physical effects of the December 31, 2005 flood and multiple reach-scale and site-specific factors to provide a best available information ACTION or NO-ACTION recommendation for each of the more than approximately 135 individual structures and sites delineated in the residential section of Ross Creek (study reach). ACTION was generally recommended at sites or existing severely failed or failing structures where bank stabilization appeared necessary to prevent against immediate future bank erosion of such a severe nature that the erosion would likely significantly damage existing public infrastructure or private property, reduce existing riparian tree canopy cover in canopy limited reaches, and/or increase bank erosion pressure at nearby vulnerable sites. ACTION was also generally recommended at structures and sites if it would feasibly eliminate flood flow constrictions that appeared from HWM measurements and other field observations to cause a local backwater effect contributing to flooding of public and private property adjacent to the riparian corridors on December 31, 2005. ACTION* was recommended at either lower priority repair sites, or where repair work would only be warranted if and when work would be completed at higher priority adjacent sites, or where site improvement design and success would be dependent on and part of a multiple-site (reach-scale) cooperative project.

NO-ACTION was almost always recommended at stable sites and existing bank stabilization structures in overall fair to good condition. NO-ACTION was also generally recommended at sites with frequent minor or recent erosion or failing structures that appeared to be self-stabilizing and therefore not threatening to existing public or private property, or canopy-forming trees. NO-ACTION was also sometimes recommended at severely eroding sites in cases where no property or important canopy-forming trees appeared threatened – i.e., stabilization projects that appeared to only reduce chronic sediment delivery to the channel. NO-ACTION was recommended at sites where stabilization appeared infeasible due to limited construction equipment access or difficult geotechnical conditions, such as streambanks cut in steep landslide deposits.

Results

The October 25, 2006 geomorphic reconnaissance delineated the 5,505-ft long study reach (combined total 11,010 lineal feet of creek bank) into 135 individual sites and structures (Table 1). Approximately 50 percent of the creek banks are comprised of existing bank stabilization structures, primarily vertical concrete and timber retaining walls and secondarily rip-rap bank

protection structures. About half of the still unprotected banks are in stable condition. Therefore, about one-quarter of the creek banks show varying degrees of recent and ongoing bank erosion. But only about 2-3 percent of the creek banks, about 250 lineal ft) appear likely to continue to undergo severe bank erosion (Class B* Sites). This percentage is lower than other Corte Madera Creek tributaries (e.g., Sleepy Hollow Creek, Fairfax Creek, Upper San Anselmo Creek), probably for at least four reasons: (1) less severe incision; (2) less dense residential development (i.e., much larger residential lots); (3) partial attenuation of flood flows by Phoenix Reservoir; and (4) more complete coverage by bank stabilization structures.

Table 1. Summary Bank Stability Classification of Ross Creek Downstream from Natalie Coffin Greene Park.

	5,505-ft long Study Reach		
Site/Structure Classification	**Total Number**	**Total Length (ft)**	**Percent of Total (%)**
Bridges & Culverts	10	302	2.7%
Class A Sites	33	3,074	27.9%
Class B Sites	17	1,579	14.3%
Class B* Sites	5	255	2.3%
Class B/C Sites	2	271	2.5%
Class C Sites	1	32	0.3%
Existing Structures	61	5,152	46.8%
Bedrock Banks	6	345	3.1%
	135	11,010	100.0%

If the only management objectives were to prevent against continuing severe bank erosion and to protect private property, then priority stabilization work would only be recommended at the 5 Class B* sites comprising 255 lineal ft. Instead, thirteen individual recommended projects were formulated to achieve multiple objectives, including enhancement of riparian canopy cover, aquatic habitat, fish passage, floodplain connectivity, water quality, bank stability, and native vegetation (Table 2). The locations, existing conditions, and recommended treatment actions for each of these projects are summarized in Tables 3-7, and the locations are mapped on Figure 2.

Table 2. Summary Recommended Canopy and Physical Habitat Enhancement Projects on Ross Creek Downstream from Natalie Coffin Greene Park.

Project Type	**Total Number**	**Total Length (ft)**	**Total Length w/Options (ft)**
Canopy Enhancement	7	721	0
Floodplain Restoration	2	223	0
Stream Restoration and Fish Passage Improvement	1	472	490
Bridge Replacement and Fish Passage Improvement	1	180	0
Aquatic Habitat Enhancement	2	236	300
	13	1,832	790

Table 3 Recommended Riparian Canopy Enhancement Projects for Reducing Solar Exposure and Reducing Summer Water Temperatures on Ross Creek.

Ross Creek Project Site ID/ Subreach	Right/ Left Bank	d/s Station (ft)	u/s Station (ft)	Proj Site Length (ft)	Project Site Description	Recommended Project Actions
CAN-1 MOUTH-SHADY	RB	426	456	30	LACK OF CANOPY FORMING TREES ALONG RIGHT TOP OF BANK (RESIDENTIAL LANDSCAPING AND FENCE)	PLANT AND IRRIGATE CANOPY FORMING TREES ALONG TOB (E.G. 3-4 REDWOODS). UPPER 6-FT HORIZON OF BANK FAILING AT 1(H):1(V) SLOPE BUT CONSTRUCTION EQUIPMENT ACCESS APPEARS LIMITED (SITE RB B*1; STA 424-486).
CAN-2 NORWOOD-PARK AVE	LB	1,768	1,836	68	EXISTING 20-25-FT WIDE APPROX. 100-FT LONG RECENTLY INUNDATED INSIDE BEND FLOODPLAIN BENCH WITH FINE SEDIMENT DEPOSITION BUT LACKING MATURE WOODY VEGETATION.	PLANT AND IRRIGATE CANOPY FORMING TREES ON SANDY BENCH AREA (E.G. 5-6 ASH) AND PROTECT FROM DEER BROWSING
CAN-3 NORWOOD-PARK AVE	RB	1,836	1,947	111	LACK OF CANOPY FORMING TREES ALONG RIGHT TOP OF BANK FENCE ABOVE EXISTING SHOTCRETE WALL (RESIDENTIAL LANDSCAPING AND FENCE)	PLANT AND IRRIGATE ADD'L 6-8 REDWOODS ALONG EXISTING TOB FENCELINE
CAN-4 NORWOOD-PARK AVE	LB	2,913	3,087	174	LACK OF CANOPY FORMING TREES ALONG APPROX. 170-FT LONG SECTION OF LEFT (NORTH) BANK ALONG BOUNDARY OF BRANSON SCHOOL RECREATION FIELDS. BANK COMPOSED OF MIXED GRADING SIDECAST AND CONCRETE RUBBLE AND DOMINATED BY NON-CANOPY FORMING EXOTIC VEGETATION.	REGRADE BANK TO MORE GRADUAL STABLE SLOPE AS FAR AS FEASIBLE. STABILIZE AND/OR COVER WITH GEOFABRIC, AND PLANT AND IRRIGATE NATIVE CANOPY FORMING TREES AND SHRUBS TO RESTORE OVERHANGING NATIVE RIPARIAN CANOPY AND HABITAT FORMING ROOT SYSTEMS NEAR CHANNEL EDGE (SITE IS PART OF PROJECT SR-1)
CAN-5 GLENWOOD-GREENE PK	RB	4,782	4,892	110	LACK OF CANOPY FORMING TREES ALONG RIGHT TOP OF BANK (TENNIS COURT) INCREASES SOLAR EXPOSURE IN ADJACENT STREAM REACH	PLANT AND IRRIGATE 8-10 NATIVE RIPARIAN CANOPY FORMING TREES ALONG TOP OF BANK
CAN-6 GLENWOOD-GREENE PK	LB	4,892	4,962	70	LACK OF CANOPY FORMING TREES ALONG LEFT TOP OF BANK (SWIMMING POOL) INCREASES SOLAR EXPOSURE IN ADJACENT STREAM REACH	PLANT AND IRRIGATE 5-8 NATIVE RIPARIAN CANOPY FORMING TREES ALONG TOP OF BANK
CAN-7 GLENWOOD-GREENE PK	RB	5,224	5,382	158	LACK OF CANOPY FORMING TREES ALONG RIGHT TOB (RESIDENTIAL LANDSCAPING) INCREASES SOLAR EXPOSURE IN ADJACENT STREAM REACH	PLANT AND IRRIGATE 12-15 NATIVE RIPARIAN CANOPY FORMING TREES ALONG TOP OF BANK (SITE BEGINS IMMEDIATELY UPSTREAM OF PROJECT FP-2)

Table 4. Recommended Floodplain Restoration/Enhancement Projects for Increasing Winter Aquatic Habitat on Ross Creek.

Ross Creek Project Site ID/ Subreach	Right/ Left Bank	d/s Station (ft)	u/s Station (ft)	Proj Site Length (ft)	Project Site Description	Recommended Project Actions
FP-1 MOUTH-SHADY	RB	133	254	121	20-35-FT WIDE INFREQUENTLY AND SHALLOWLY INUNDATED FLOODPLAIN AREA AT REAR OF DEEP RESIDENTIAL PROPERTY WITH PRIMARILY NON-NATIVE VEGETATION	RECOMMEND REMOVING EXISTING TREES AND GRADING 95-FT LONG 20-35-FT WIDE AREA DOWN TO BANKFULL ELEVATION MINUS 0.5 FT TO ALLOW FOR INUNDATION DURING TYPICAL ANNUAL FLOODS, AND PLANTING AND IRRIGATING ALDERS ON THE FINISHED FLOODPLAIN/BAR ELEVATION. CONSIDER POSSIBLE FLOOD BACKWATER EFFECT CAUSED BY CORTE MADERA CREEK WATER SURFACE ELEVATION 159 FT DOWNSTREAM. FREQUENT MINOR BANK EROSION AT SITE, HEADING INTO D/S OUTSIDE BEND CH POSITION.
FP-2 GLENWOOD-GREENE PK	RB	5,122	5,224	102	15-25-FT WIDE INFREQUENTLY AND SHALLOWLY INUNDATED FLOODPLAIN AREA AT REAR OF RESIDENTIAL PROPERTY WITH EXISTING MATURE NATIVE RIPARIAN VEGETATION	RECOMMEND REMOVING VERT CONC RET WALL AND REPLACING WITH BIOTECHNICAL BANK STABILIZATION STRUCTURE INCLUDING MINOR REGRADING TO LOWER OVERALL FP GRADE CONSISTENT WITH OBJECTIVES OF RETAINING EXISTING NATIVE RIPARIAN TREES ON RELICT FP SURFACE AND CREATING SUITABLE RESIDENTIAL LANDSCAPE; PROTECTING RESIDENTIAL INFRASTRUCTURE (SWIMMING POOL) MAY LIMIT AMOUNT OF RELICT FP BAR THAN CAN BE RESTORED; VERT CONC RET WALLS MAY BE NEEDED ALONG PROPOSED NEW BORDER OF RESIDENTIAL AREA

Table 5. Recommended Stream Restoration Projects for Improving Bank Stability, Native Riparian Vegetation Cover, Fish Passage, and Winter Aquatic Habitat, and Water Quality at the Reach Scale

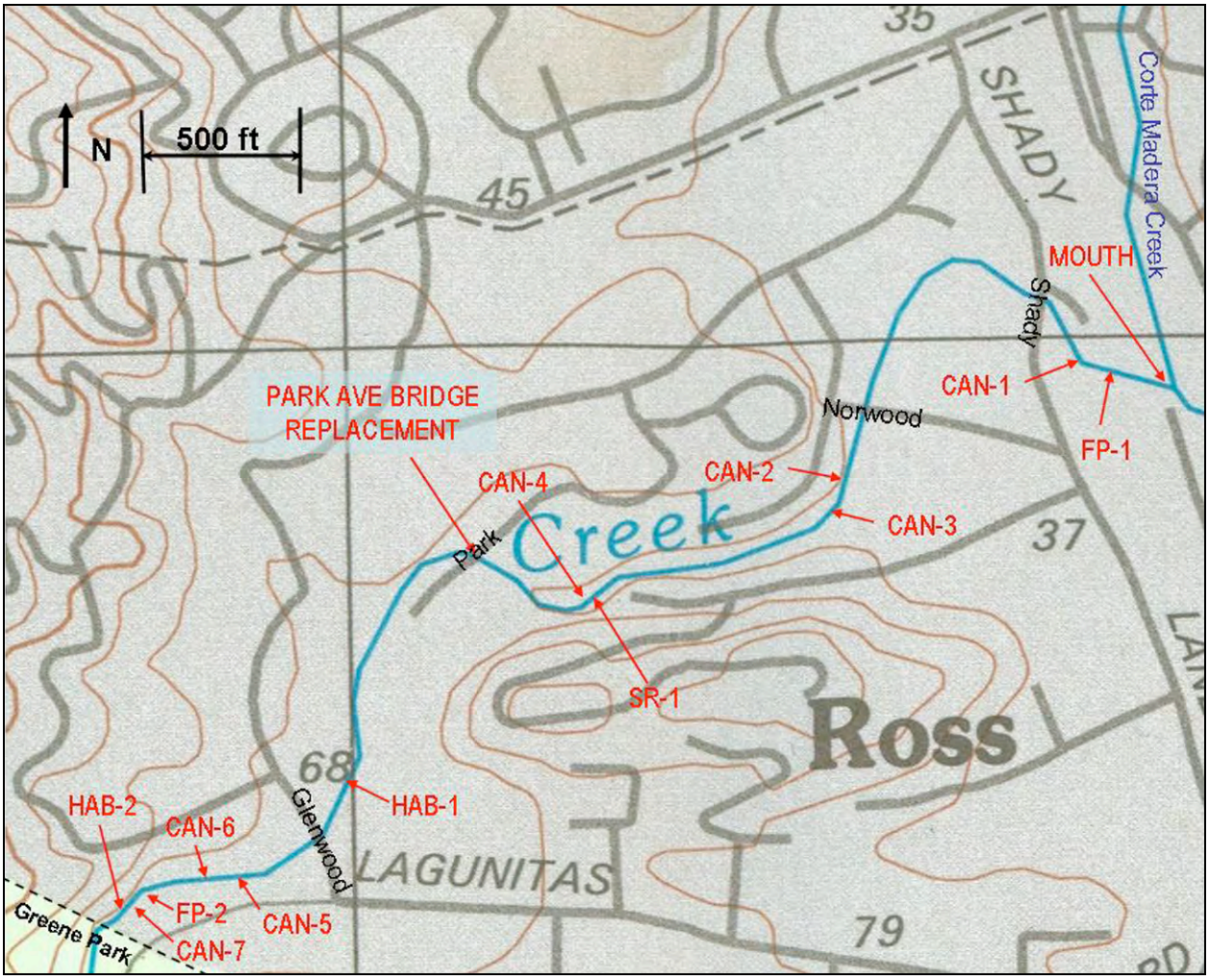
Ross Creek Project Site ID/ Subreach	Right/ Left Bank	d/s Station (ft)	u/s Station (ft)	Proj Site Length (ft)	Project Site Description	Recommended Project Actions
SR-1 NORWOOD-PARK AVE	BOTH	2,860	3,096	236	UNNATURALLY SLOPED AND ARTIFICIALLY NARROW CHANNEL REACH CAUSED BY INSTALLATION OF CONCRETE CHECK DAMS IN REACH WITH NATURAL HILLSLOPE PROCESSES	REMOVE CONCRETE AND ROCK CHECK DAMS IN REACH AND REGRADE CHANNEL TO QUASI-STABLE SLOPE, WIDTH, AND PLANFORM WITH HABITAT ENHANCEMENT STRUCTURES AT CORRECT POSITIONS TO ENCOURAGE OUTSIDE BEND SCOUR POOL FORMATION; COMBINE WITH LB REGRADING AND CANOPY ENHANCEMENT
SR-1 OPTIONAL ADD-ON: SITE LB A11	LB	3,096	3,272	176	STABLE INSIDE BEND CH POSITION WITH GR BAR TOE AND HIGH FP BAR WITH FINE SED DEP;	(OPTIONAL) RECOMMEND REPLACE RHUS AND OTHER NON-NATIVE VEGETATION AS PART OF D/S STREAM RESTORATION PROJECT
SR-1 OPTIONAL ADD-ON: SITE RB S22	RB	3,096	3,166	70	12-FT HIGH APPROX. 1(H):1(V) SLOPED GROUTED RR BANK LINING PROBABLE LANDSLIDE BODY ALONG TOE OF HILLSLOPE;	(OPTIONAL) CONSIDER REMOVAL OF GROUTED RR BANK AND REGRADING AND STABILIZATION BANK WITH BIOTECHNICAL STABILIZATION MATERIALS AS PART OF DESIGN FOR D/S STREAM RESTORATION PROJECT (OR DESIGN D/S RESTORATION PROJECT WITH GROUTED RR BANK AS IS)
SR-1 OPTIONAL ADD-ON: SITES LB B3, LB C1	LB	3,272	3,340	68	8-9 FT-HIGH 1(H):2(V) TO 1(H):3(V) SLOPED BANK BETWEEN SITE LB A11 (DESCRIBED ABOVE) AND SITE LB S14 (EXISTING NEW CONSTRUCTION RR RET WALL) COMPRISED OF RELATIVELY UNSTABLE CLASS B AND CLASS C SITES	(OPTIONAL) CONSIDER BIOTECHNICAL STABILIZATION OF STEEP VEGETATED BANKS AS PART OF OVERALL STREAM RESTORATION PROJECT; STREAM REACH IS AFFECTED BY BOTH THE D/S STREAM RESTORATION PROJECT DESIGN AND THE U/S PARK AVE CULVERT REPLACEMENT DESIGN
SR-1 OPTIONAL ADD-ON: SITES RB S23, RB B5, RB B6	RB	3,247	3,423	176	8-9 FT-HIGH 1(H):2(V) TO 1(H):3(V) SLOPED BANK SECTION BETWEEN OUTSIDE BEND BEDROCK BANK AND EXISTING PARK AVE BDGE D/S VERT CONC WINGWALL COMPRISED OF CLASS B SITES AND 5-FT HIGH STACKED RUBBLE RET WALL IN FAIR CONDITION	(OPTIONAL) CONSIDER BIOTECHNICAL STABILIZATION OF STEEP VEGETATED BANKS AS PART OF OVERALL STREAM RESTORATION PROJECT; STREAM REACH IS AFFECTED BY BOTH THE D/S STREAM RESTORATION PROJECT DESIGN AND THE U/S PARK AVE CULVERT REPLACEMENT DESIGN
PARK AVE CULVERT REPLACEMENT	BOTH	3,423	3,522	180	PARK AVE BDGE ARCH CULVERT (~16-FT WIDE BY ~14-FT HIGH) IN POOR STRUCTURAL CONDITION AND IDENTIFIED AS FISH PASSAGE BARRIER BY ROSS TAYLOR (2006); SITE LENGTH INCLUDES BOTH EXISTING U/S AND D/S VERT CONC WINGWALLS; BEDROCK OUTCROP IN BED AT U/S END OF CULVERT	RECOMMEND REPLACEMENT OF STRUCTURE WITH OPEN-BOTTOM ARCH CULVERT AND PROVIDING FISH PASSAGE WITH ENGINEERED GRADE CONTROL STRUCTURE OR 133-FT LONG APPROX 2-PERCENT SLOPED ROUGHENED ROCK RAMP EXTENDING TO D/S END OF EXISTING NEW CONSTRUCTION LB RET WALL (SITE LB S14); CONSIDER COMBINING WORK WITH DOWNSTREAM STREAM RESTORATION PROJECT SR-1

Table 6. Recommended Aquatic Habitat Enhancement Projects for Increasing Quality Summer and Winter Physical Habitat for Fish on Ross Creek.

Ross Creek Project Site ID/ Subreach	Right/ Left Bank	d/s Station (ft)	u/s Station (ft)	Proj Site Length (ft)	Project Site Description	Recommended Project Actions
HAB-1 PARK AVE-GLENWOOD	RB	4,232	4,402	170	STRAIGHT 6-7-FT HIGH VERT AND NR VERT CONC RET WALL SUBDIVIDED INTO VARIOUSLY FAILING AND FAILED/ REPAIRED CONDITION CLASSES (SITES RB S30, RB S31, RB S32) ALONG RELATIVELY STRAIGHT REACH; EXISTING RB LATERAL SCOUR POOL FORMED AT AND ALONG U/S END OF WALL (SITE RB S32) (SEE REPORT COVER PHOTO); THE EXISTING RB NATIVE RIPARIAN TREE CANOPY COVER IS LIMITED IN THIS REACH.	RECOMMEND REMOVING ALL OR PART OF VERT CONC RET WALL BEGINNING AT UPSTREAM END AND GRADING BANK BACK TO TYP. 1.5(H):1(V) SLOPE VAR. AS NECESSARY TO SAVE MOST OR ALL EXISTING NATIVE RIPARIAN TREES; STABILIZE WITH COMB. OF BIOTECHNICAL TREATMENTS THAT INCORPORATE CABLED RR-LWD AQUATIC HABITAT ENHANCEMENT STRUCTURES ALONG THE TOE OF THE BANK AT EXISTING LATERAL SCOUR POOL LOCATIONS AND INCREASE CANOPY COVER;
HAB-1 OPTIONAL ADD-ON: SITE LB B8	LB	4301	4463	162	CHRONIC MINOR BANK TOE EROSION BELOW BKF DEPTH APPEARS SELF-STABILIZING IN RELATIVELY WIDE STRAIGHT CH REACH; NO TREES OR STRUCTURES THREATENED;	(OPTIONAL) RECOMMEND ALSO STABILIZING AND REVEGETATING OPPOSITE (LEFT) BANK CLASS B SITE (SITE LB B8) AS PART OF PROJECT BY EXCAVATING BANK BACK TO 1.5(H):1(V) SLOPE AND INSTALLING LIVE WILLOW BRUSH LAYERING BANK PROTECTION STRUCTURE.
HAB-2 GLENWOOD-GREENE PK	LB	5,314	5,380	66	EXISTING OUTSIDE BEND SCOUR POOL[1] FORMED ALONG APPROX. 15-FT HIGH 1(H):2(V) SLOPED AND LOCALLY SEVERELY OVERSTEEPENED CREEK BANK (66-FT LONG SITE LB B*4), BUT NO STRUCTURES OR CANOPY FORMING TREES APPEAR THREATENED BY ADDITIONAL BANK EROSION; CANOPY COVER LIMITED IN REACH BY LACK OF CANOPY FORMING TREES ALONG OPPOSITE (RIGHT) BANK RESIDENTIAL SITE (PROJECT SITE CAN-7);	RECOMMEND INSTALLING A CABLED RR-LWD AQUATIC HABITAT ENHANCEMENT STRUCTURE TO PROVIDE HABITAT COMPLEXITY AND COVER WITHIN EXISTING POOL; RECOMMEND ALSO CONSIDERING GRADING BACK AND STABILIZING SITE LB B*4 ESPECIALLY IN SO FAR AS IT INCREASES THE FEASIBILITY OF SUCCESSFUL POOL HABITAT ENHANCEMENT; CONSTRUCTION AND IRRIGATION ACCESS MAY BE LIMITING
HAB-2 OPTIONAL ADD-ON: SITE LB A16	LB	5,216	5,314	98	RELATIVELY STABLE SLIGHTLY INSIDE BEND CHANNEL POSITION WITH ATTACHED GRAVEL BAR DOMINATED BY EXOTIC VEGETATION (BROOM);	(OPTIONAL) IF BANK STABILIZATION WORK IS COMPLETED AT UPSTREAM SITE LB B*4 AS PART OF PROJECT HAB-2, THEN RECOMMEND ALSO CONSIDERING REMOVAL OF BROOM FROM SITE LB A16 AND STABILIZATION OF DEVEGETATED BANK WITH LIVE WILLOW BRUSH LAYERING AND/OR BRUSH MATTRESS, INCLUDING LIVE WILLOW POLE PLANTINGS ALONG THE EDGE OF WATER; SOLAR EXPOSURE APPEARS ADEQUATE TO SUPPORT BY IRRIGATION ACCESS MAY BE LIMITING
HAB-2 OPTIONAL ADD-ON: SITE LB B*3	LB	5,176	5,216	40	ONGOING BANK EROSION ALONG EDGE OF HIGH RELICT FP BAR, NO STRUCTURES OR CANOPY FORMING VEGETATION APPEAR THREATENED BY FUTURE EROSION	(OPTIONAL) IF BANK STABILIZATION WORK IS COMPLETED AT UPSTREAM SITES OR FLOODPLAIN RESTORATION WORK IS COMPLETED ON THE OPPOSITE BANK (PROJECT SITE FP-2), CONSIDER ALSO BIOTECHNICALLY STABILIZING THE TOE OF BANK ALONG SITE LB B*3, ESPECIALLY TO INCORPORATE SOME CABLED RR-LWD AQUATIC HABITAT ENHANCEMENT STRUCTURE AT THE DOWNSTREAM END OF THE SITE TO INCREASE HABITAT COMPLEXITY AND COVER IMMEDIATELY UPSTREAM FROM THE EXISTING BEDROCK BOUNDED OUTSIDE BEND SCOUR POOL; CONSTRUCTION AND IRRIGATION ACCESS MAY BE LIMITING

[1] DRY, NOT PERENNIAL POOL WITH MIN BED ELEV THAT APPEARS 5-6 FT LOWER THAN IN THE 60 FT U/S PERENNIAL POOL. OCTOBER 25, 2006 OBSERVATIONS INDICATE THAT THE DRY SEASON GROUNDWATER TABLE SLOPES MORE THAN 10 PERCENT TO EAST BEGINNING D/S FROM BEDROCK CANYON CONFINEMENT WITHIN NATALIE COFFIN GREENE PARK.

Figure 2. Detail map of Ross Creek study reach showing locations of recommended canopy and physical fish habitat improvement projects described in Tables 3-6.



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