California Department of Fish and Game
East Marin County
San Francisco Bay Watersheds
Stream Habitat Assessment Reports

Cascade Creek

Surveyed 2009

STREAM INVENTORY REPORT
Cascade Creek

Surveyed 2009
Report Completed Feb, 2012

INTRODUCTION

A stream inventory was conducted during 7/23/2009 to 7/27/2009 on Cascade Creek. The survey began at the confluence with San Anselmo Creek and extended upstream 1.4 miles.

The Cascade Creek inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the habitat available to anadromous salmonids in Cascade Creek. The objective of the biological inventory was to document the presence and distribution of juvenile salmonid species.

The objective of this report is to document the current habitat conditions and recommend options for the potential enhancement of habitat for steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Cascade Creek is a tributary to San Anselmo Creek, a tributary to Corte Madera Creek, a tributary to San Francisco Bay, located in Marin County, California (Map 1). Cascade Creek's legal description at the confluence with San Anselmo Creek is T02N R07W S27. Its location is 37°58'53.4" north latitude and 122°37'11.6" west longitude, LLID number 1226188379815. Cascade Creek is a second order stream and has approximately 3 miles of blue line stream according to the USGS National Hydrography Dataset (NHD). Cascade Creek drains a watershed of approximately 1.06 square miles. Elevations range from about 233 feet at the mouth of the creek to 1,535 feet in the headwater areas. Mixed hardwood forest dominates the watershed. The watershed is primarily owned by local government which accounts for 99% of the land area. Ninety-nine percent of the land is considered natural and 0.4% is urban. Vehicle access exists via HWY 101 to Sir Francis Drake Boulevard to Bolinas road to Cascade drive.

METHODS

The habitat inventory conducted in Cascade Creek follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The California Conservation Corps (CCC) Technical Advisors and Watershed Stewards Project/AmeriCorps (WSP) Members that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two-person team.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the

survey reach. All habitat units included in the survey are classified according to habitat type and their lengths are measured. All pool units are fully measured. All other habitat unit types encountered for the first time in each reach are measured for all the parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the *California Salmonid Stream Habitat Restoration Manual*. This form was used in Cascade Creek to record measurements and observations. There are eleven components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) near the bottom of the stream survey reach using a Marsh-McBirney Model 2000 flow meter.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit and within one foot of the water surface.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1990). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Cascade Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to the nearest tenth. Habitat characteristics are measured using a clinometer, hip chain, and stadia rod.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out areas is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Cascade Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3) and 76 - 100% (value 4). Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like bedrock, log sills, boulders or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide juvenile salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition for prey. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Cascade Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs is recorded for each pool.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual*. Canopy density relates to the amount of stream shaded from the sun. In Cascade Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of coniferous or hardwood trees.

9. Bank Composition and Vegetation:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Cascade Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

10. Large Woody Debris Count:

Large woody debris (LWD) is an important component of fish habitat and an element in channel forming processes. In each habitat unit all pieces of LWD partially or entirely below the elevation of bankfull discharge are counted and recorded. The minimum size to be considered is twelve inches in diameter and six feet in length. The LWD count is presented by reach and is expressed as an average per 100 feet.

11. Average Bankfull Width:

Bankfull width can vary greatly in the course of a channel type stream reach. This is especially true in very long reaches. Bankfull width can be a factor in habitat components like canopy density, water temperature, and pool depths. Frequent measurements taken at riffle crests (velocity crossovers) are needed to accurately describe reach widths. At the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach.

BIOLOGICAL INVENTORY

Biological sampling during the stream inventory is used to determine fish species and their distribution in the stream. Fish presence was observed from the stream banks in Cascade Creek. In addition, one site was electrofished using a Smith-Root Model 12 electrofisher. These sampling techniques are discussed in the *California Salmonid Stream Habitat Restoration Manual*.

DATA ANALYSIS

Data from the habitat inventory form are entered into Stream Habitat 2.0.18, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Game. This program processes and summarizes the data, and produces the following ten tables:

- Riffle, Flatwater, and Pool Habitat Types
- Habitat Types and Measured Parameters
- Pool Types
- Maximum Residual Pool Depths by Habitat Types
- Mean Percent Cover by Habitat Type
- Dominant Substrates by Habitat Type
- Mean Percent Vegetative Cover for Entire Stream
- Fish Habitat Inventory Data Summary by Stream Reach (Table 8)
- Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
- Mean Percent Shelter Cover Types for Entire Stream

Graphics are produced from the tables using Microsoft Excel. Graphics developed for Cascade Creek include:

- Riffle, Flatwater, Pool Habitat Types by Percent Occurrence
- Riffle, Flatwater, Pool Habitat Types by Total Length
- Total Habitat Types by Percent Occurrence
- Pool Types by Percent Occurrence
- Maximum Residual Depth in Pools
- Percent Embeddedness
- Mean Percent Cover Types in Pools
- Substrate Composition in Pool Tail-outs
- Mean Percent Canopy
- Dominant Bank Composition by Composition Type
- Dominant Bank Vegetation by Vegetation Type

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of 7/23/2009 to 7/27/2009 was conducted by T. Macias, C. Bell and A. Villalobos (WSP). The total length of the stream surveyed was 7,181 feet.

Stream flow was measured near the bottom of the survey reach with a Marsh-McBirney Model 2000 flowmeter at 0.01 cfs on 07/27/2009.

Cascade Creek is a F4 channel type for 5,573 feet of the stream surveyed (Reach 1), and a B3 channel type for 1,608 feet of the stream surveyed (Reach 2).

F4 channels are entrenched, meandering, riffle/pool channels on low gradients with high width/depth ratios and gravel-dominant substrates. B3 channels are moderately entrenched, moderate gradient, riffle dominated with infrequently spaced pools, very stable plan and profile, with stable banks and cobble dominant.

Water temperatures taken during the survey period ranged from 58 to 64 degrees Fahrenheit. Air temperatures ranged from 73 to 87 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 29% pool units, 28% riffle units and 21% dry units, (Graph 1). Based on total length of Level II habitat types there were 63% dry units, 16% flatwater units and 14% riffle units(Graph 2).

Fourteen Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 21% Dry units, 19% Low Gradient Riffle units, 19% Mid-Channel Pool

units, (Graph 3). Based on percent total length there were 63% Dry units, 13% Step Run units and 11% Low Gradient Riffle units.

A total of 17 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 71%, and comprised 79% of the total length of all pools (Graph 4).

Table 4 is a summary of maximum residual pool depths by pool habitat types. Pool quality for salmonids increases with depth. Five of the 17 pools (29%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 17 pool tail-outs measured, 9 had a value of 1 (52.9%); 4 had a value of 2 (23.5%); 4 had a value of 4 (23.5%); (Graph 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders, or other considerations.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 6, flatwater habitat types had a mean shelter rating of 21, and pool habitats had a mean shelter rating of 8 (Table 1). Of the pool types, the Main Channel pools had a mean shelter rating of 6, Scour pools had a mean shelter rating of 11 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover types in Cascade Creek. Graph 7 describes the pool cover in Cascade Creek. Boulders are the dominant pool cover type followed by undercut banks.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel dominance was observed in 41% of pool tail-outs, small cobble dominance was observed in 18% of pool tail-outs.

The mean percent canopy density for the surveyed length of Cascade Creek was 86%. The mean percentages of hardwood and coniferous trees were 100% and 0%, respectively. Fourteen percent of the canopy was open. Graph 9 describes the mean percent canopy in Cascade Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 50%. The mean percent left bank vegetated was 45%. The dominant elements composing the structure of the stream banks consisted of 30% bedrock, 6% boulder, 64% sand/silt/clay (Graph 10). Hardwood trees were the dominant vegetation type observed in 73% of the units surveyed. Additionally, 26% of the units surveyed had brush as the dominant vegetation type, and 1.4% had grass as the dominant vegetation (Graph 11).

BIOLOGICAL INVENTORY RESULTS

One site was electrofished for species composition and distribution in Cascade Creek on September 30, 2009. Water temperatures taken during the electrofishing period ranged from 57 to 59 degrees Fahrenheit. Air temperatures ranged from 71 to 72 degrees Fahrenheit. The sites

were sampled by Dan Resnik (DFG).

In reach 1, which comprised the first 5,573 feet of stream, one site was sampled. The reach site yielded twenty eight young-of-the-year steelhead/rainbow trout (SH/RT), three age 1+ SH/RT, three age 2+ SH/RT, and no coho salmon.

The following chart displays the information yielded from these sites:

2009 Cascade Creek e-fish observations

Date	Site #	Reference Point	Distance From Reference Point (ft.)	Steelhead/ Rainbow Trout			Non Salmonids Name species
				0+	1+	2+	
9/30/2009	731	N/A	N/A	28	3	3	0

DISCUSSION

Cascade Creek is an F4 channel type for the first 5,573 feet of stream surveyed and a B3 channel type for the remaining 1,608 feet. The suitability of F4/B3 channel types for fish habitat improvement structures is as follows: F4 channels are good for bank-placed boulders. They are fair for plunge weirs, single and opposing wing-deflectors, channel constrictors and log cover. They are poor for boulder clusters. B3 channels are excellent for plunge weirs, boulder clusters and bank placed boulders, single and opposing wing deflectors and log cover.

The water temperatures recorded on the survey days 7/23/2009 to 7/27/2009, ranged from 58 to 64 degrees Fahrenheit. Air temperatures ranged from 73 to 87 degrees Fahrenheit. To make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 16% of the total length of this survey, riffles 14%, and pools 7%. The pools are relatively shallow, with only 5 of the 17 (29%) pools having a maximum residual depth greater than 2 feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In first and second order streams, a primary pool is defined to have a maximum residual depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy, or where their installation will not conflict with the modification of any log debris accumulations (LDA's) in the stream.

Thirteen of the 17 pool tail-outs measured had embeddedness ratings of 1 or 2. Four of the pool tail-outs had embeddedness ratings of 3 or 4. None of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead.

Sediment sources in Cascade Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Ten of the 17 pool tail-outs measured had gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

The mean shelter rating for pools was 8. The shelter rating in the flatwater habitats was 21. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by boulders in Cascade Creek. Boulders are the dominant cover type in pools followed by undercut banks. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 86%. Reach 1 had a canopy density of 83%, Reach 2 had a canopy density of 95%, In general, revegetation projects are considered when canopy density is less than 80%

The percentage of right and left bank covered with vegetation was 50% and 45%, respectively. In areas of stream bank erosion or where bank vegetation is sparse, planting endemic species of coniferous and hardwood trees, in conjunction with bank stabilization, is recommended.

GENERAL RECOMMENDATIONS

Cascade Creek should be managed as an anadromous, natural production stream.

Winter storms often bring down large trees and other woody debris into the stream, which increases the number and quality of pools. This woody debris, if left undisturbed, will provide fish shelter and rearing habitat, and offset channel incision. Landowners should be sensitive about the natural and positive role woody debris plays in the system, and encouraged not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

RECOMMENDATIONS

1) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover in the pools is from boulders. Adding high quality complexity with woody cover in the pools is desirable.

2) Increase the canopy on Cascade Creek by planting appropriate native vegetation like willow, alder, redwood, and Douglas fir along the stream where shade canopy is not at acceptable levels. The reaches above this survey section should be inventoried and treated as well, since the water flowing here is affected from upstream. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.

3) Active and potential sediment sources related to the road system need to be identified, mapped, and treated according to their potential for sediment yield to the stream and its tributaries.

4) Access for migrating salmonids should be assessed at the falls at 1,450 feet into survey (HU 0028.00). Where needed and if appropriate barriers should be modified to improve fish passage.

COMMENTS AND LANDMARKS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

Position (ft.)	Habitat Unit #	Comments:
0	0001.00	Start of Survey: N37.98146 W122.62001
13	0002.00	Bio Sample: (Bank Observation) Steelhead 1+ observed.
49	0004.00	Bio Sample: (Bank Observation) Steelhead 0+ observed.
49	0004.00	Access Points / Location: (Bridge) Bridge #1. Footbridge in Elliot Nature Preserve 49' upstream from start of survey. Made of wood. Not retaining gravel. No downcutting. W=21' H=5' L=6'. Not a barrier.
70	0006.00	Access Points / Location: (Bridge) Bridge #2. Ford with cobble bottom in Elliot Nature Preserve 15' u/s from bridge #1. Not retaining gravel and no downcutting. W=11' H=na L=13'. Not a barrier.
188	0008.00	Bio Sample: (Bank Observation) Salamander observed.
379	0012.00	Bio Sample: (Bank Observation) Salmonid YOY observed.
1,029	0021.00	Bio Sample: (Bank Observation) Salamander observed.
1,418	0027.00	Tributaries: LB Trib #1. Flowing unnamed tributary. Discharge is <1cfs. Contributes an estimated 50% of flow to stream. Slope unknown Water temps downstream: 64F, upstream: 63F & tributary: 63F. Accessible to fish, checked 50' up tributary. No fish observed. N37.98394 W122.62148
1,450	0028.00	Fish Passage: (Falls) Trickling waterfall, approximately 20' high with an 88 degree angle at top of unit. No fish observed above this waterfall.
3,214	0029.00	General Comment: Salamanders observed
3,806	0036.00	General Comment: Salamanders observed

Position (ft.)	Habitat Unit #	Comments:
3,820	0037.00	Tributaries: LB Trib #2. Flowing unnamed tributary. Discharge is <1cfs. Contributes An estimated 50% of flow to stream. Slope is not available. Accessible to fish, checked 50' up tributary. No fish observed. N37.98757 W122.62948
5,149	0038.00	General Comment: Salamanders and gastropods observed
5,388	0042.00	General Comment: Salamanders and garter snakes observed
5,522	0043.00	General Comment: Channel type change: F4 to B3, R1 to R2.
6,432	0051.00	Tributaries: LB Trib #3. Dry unnamed tributary. Discharge is 0. Contributes 0% of flow to stream. Slope is unknown. Water temps downstream: 58F, upstream: 58F & tributary: dry. Accessible to fish, checked 50' up tributary. No fish observed. N37.99007 W122.63437
7,181	0058.00	End of Survey is at the confluence of LB tributary #4 and RB tributary # 1. N37.99006 W122.63657. RB Trib #1. Flowing unnamed tributary. Discharge is <1 cfs. Slope is unknown. Contributes an estimated 50% of flow to stream. Water temps downstream: 65F, upstream dry & tributary: 69F. Accessible to fish, checked 50' up tributary. No fish observed. LB Trib #4. Flowing unnamed tributary. Discharge is <1. Contributes an Estimated 50% of flow to stream. Water temps downstream: 65F, upstream: dry & tributary: 61F. Accessible to fish, checked 50' up tributary. Slope is unknown. No fish observed.

REFERENCES

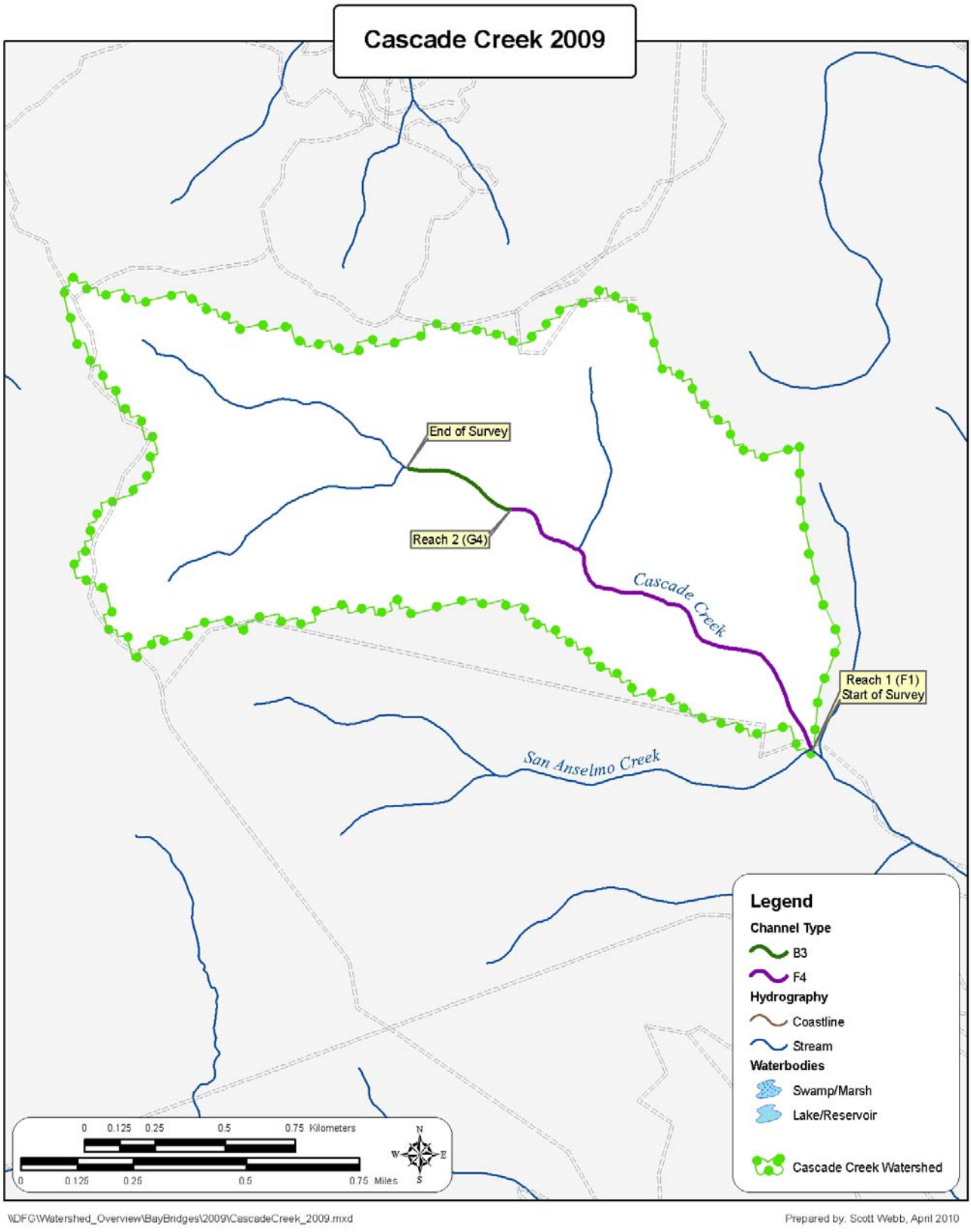
Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and Collins, B. 1998. *California Salmonid Stream Habitat Restoration Manual*, 3rd edition. California Department of Fish and Game, Sacramento, California.

McCain, M., D. Fuller, L. Decker and K. Overton. 1990. Stream habitat classification and inventory procedures for northern California. FHC Currents. No.1. U.S. Department of Agriculture. Forest Service, Pacific Southwest Region.

Rosgen, D.L., 1994. A Classification of Natural Rivers. Catena, Vol 22: 169-199, Elsevier Science, B. V. Amsterdam.

LEVEL III and LEVEL IV HABITAT TYPES

RIFFLE			
Low Gradient Riffle	(LGR)	[1.1]	{ 1}
High Gradient Riffle	(HGR)	[1.2]	{ 2}
CASCADE			
Cascade	(CAS)	[2.1]	{ 3}
Bedrock Sheet	(BRS)	[2.2]	{24}
FLATWATER			
Pocket Water	(POW)	[3.1]	{21}
Glide	(GLD)	[3.2]	{14}
Run	(RUN)	[3.3]	{15}
Step Run	(SRN)	[3.4]	{16}
Edgewater	(EDW)	[3.5]	{18}
MAIN CHANNEL POOLS			
Trench Pool	(TRP)	[4.1]	{ 8 }
Mid-Channel Pool	(MCP)	[4.2]	{17}
Channel Confluence Pool	(CCP)	[4.3]	{19}
Step Pool	(STP)	[4.4]	{23}
SCOUR POOLS			
Corner Pool	(CRP)	[5.1]	{22}
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]	{10}
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]	{11}
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]	{12}
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]	{20}
Plunge Pool	(PLP)	[5.6]	{ 9 }
BACKWATER POOLS			
Secondary Channel Pool	(SCP)	[6.1]	{ 4 }
Backwater Pool - Boulder Formed	(BPB)	[6.2]	{ 5 }
Backwater Pool - Root Wad Formed	(BPR)	[6.3]	{ 6 }
Backwater Pool - Log Formed	(BPL)	[6.4]	{ 7 }
Dammed Pool	(DPL)	[6.5]	{13}
ADDITIONAL UNIT DESIGNATIONS			
Dry	(DRY)	[7.0]	
Culvert	(CUL)	[8.0]	
Not Surveyed	(NS)	[9.0]	
Not Surveyed due to a marsh	(MAR)	[9.1]	


Cascade Creek 2009
End of Survey
Reach 2 (G4)
Cascade Creek
Reach 1 (F1)
Start of Survey
San Anselmo Creek
Legend
Channel Type
B3
F4
Hydrography
Coastline
Stream
Waterbodies
Swamp/Marsh
Lake/Reservoir
Cascade Creek Watershed
0 0.125 0.25 0.5 0.75 Kilometers
0 0.125 0.25 0.5 0.75 Miles
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W
E
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Prepared by: Scott Webb, April 2010

Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

Stream Name: Cascade Creek **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: Quad: SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating
2	0	CULVERT	3.4	10	19	0.3									
12	0	DRY	20.7	376	4510	62.8									0
11	11	FLATWATER	19.0	104	1142	15.9	4.9	0.6	1.2	468	5148	277	3050		21
17	17	POOL	29.3	28	482	6.7	6.3	1.0	2.0	180	3067	247	4198	227	8
16	16	RIFFLE	27.6	64	1028	14.3	3.2	0.2	0.5	186	2973	43	681		6

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
58	44	7181	11187	7930

Table 2 - Summary of Habitat Types and Measured Parameters

Stream Name: Cascade Creek **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: Quad: SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating	Mean Canopy (%)
11	11	LGR	19.0	71	783	10.9	3.0	0.2	1.0	209	2302	45	500		10	86
2	2	HGR	3.4	48	96	1.3	4.0	0.3	0.5	146	293	34	69		0	95
1	1	CAS	1.7	6	6	0.1	0.0	0.1	0.3	3	3	0	0		0	97
2	2	BRS	3.4	72	143	2.0	4.0	0.3	0.8	188	375	56	113		0	0
3	3	GLD	5.2	40	121	1.7	7.0	0.8	1.3	264	792	234	703		8	95
2	2	RUN	3.4	32	64	0.9	4.0	0.4	1.0	118	236	47	94		0	95
6	6	SRN	10.3	160	957	13.3	4.0	0.5	1.8	687	4120	375	2253		45	97
11	11	MCP	19.0	23	248	3.5	6.0	0.9	2.8	138	1521	152	1674	137	4	92
1	1	STP	1.7	134	134	1.9	7.0	1.9	5.9	938	938	1876	1876	1782	30	0
1	1	LSR	1.7	17	17	0.2	5.0	0.8	1.4	81	81	73	73	65	0	96
2	2	LSBo	3.4	20	40	0.6	6.0	0.7	1.4	101	202	81	162	66	25	94
2	2	PLP	3.4	22	43	0.6	8.0	1.1	2.5	163	325	207	413	190	3	89
12	0	DRY	20.7	376	4510	62.8									0	100
2	0	CUL	3.4	10	19	0.3										

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume
58	44	7181	11187	7930

Table 3 - Summary of Pool Habitat Types

Stream Name: Cascade Creek **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: **Quad:** SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Residual Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Residual Pool Vol (cu.ft.)	Estimated Total Resid. Vol (cu.ft.)	Mean Shelter Rating
12	12	MAIN	71	32	382	79	6.3	1.0	205	2459	274	3284	6
5	5	SCOUR	29	20	100	21	6.2	0.9	122	608	115	577	11

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
17	17	482	3067	3861

Table 4 - Summary of Maximum Residual Pool Depths By Pool Habitat Types

Stream Name: Cascade Creek **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: **Quad:** SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Habitat Units	Habitat Type	Habitat Occurrence (%)	< 1 Foot Maximum Residual Depth	< 1 Foot Percent Occurrence	1 < 2 Feet Maximum Residual Depth	1 < 2 Feet Percent Occurrence	2 < 3 Feet Maximum Residual Depth	2 < 3 Feet Percent Occurence	3 < 4 Feet Maximum Residual Depth	3 < 4 Feet Percent Occurrence	>= 4 Feet Maximum Residual Depth	>= 4 Feet Percent Occurrence
11	MCP	65	0	0	9	82	2	18	0	0	0	0
1	STP	6	0	0	0	0	0	0	0	0	1	100
1	LSR	6	0	0	1	100	0	0	0	0	0	0
2	LSBo	12	0	0	2	100	0	0	0	0	0	0
2	PLP	12	0	0	0	0	2	100	0	0	0	0

Total Units	Total < 1 Foot Max Resid. Depth	Total < 1 Foot % Occurrence	Total 1< 2 Feet Max Resid. Depth	Total 1< 2 Feet % Occurrence	Total 2< 3 Feet Max Resid. Depth	Total 2< 3 Feet % Occurrence	Total 3< 4 Feet Max Resid. Depth	Total 3< 4 Feet % Occurrence	Total >= 4 Feet Max Resid. Depth	Total >= 4 Feet % Occurrence
17	0	0	12	71	4	24	0	0	1	6

Mean Maximum Residual Pool Depth (ft.): 2

Table 5 - Summary of Mean Percent Cover By Habitat Type

Stream Name: Cascade Creek **Dry Units:** 12 **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: Quad: SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Habitat Units	Units Fully Measured	Habitat Type	Mean % Undercut Banks	Mean % SWD	Mean % LWD	Mean % Root Mass	Mean % Terr. Vegetation	Mean % Aquatic Vegetation	Mean % White Water	Mean % Boulders	Mean % Bedrock Ledges
11	7	LGR	0	0	0	0	14	0	0	0	0
2	1	HGR	0	0	0	0	0	0	0	0	0
1	1	CAS	0	0	0	0	0	0	0	0	0
2	2	BRS	0	0	0	0	0	0	0	0	0
16	11	TOTAL RIFFLE	0	0	0	0	9	0	0	0	0
3	2	GLD	0	0	0	0	0	0	0	50	0
2	1	RUN	0	0	0	0	0	0	0	0	0
6	2	SRN	0	0	0	0	0	40	0	60	0
11	5	TOTAL FLAT	0	0	0	0	0	16	0	44	0
11	10	MCP	10	0	0	0	0	0	0	40	0
1	1	STP	0	0	0	0	100	0	0	0	0
1	1	LSR	0	0	0	0	0	0	0	0	0
2	2	LSBo	0	0	0	40	0	0	0	60	0
2	2	PLP	38	0	0	0	0	0	0	13	0
17	16	TOTAL POOL	11	0	0	5	6	0	0	34	0
2	0	CUL									
58	33	TOTAL	5	0	0	2	6	2	0	23	0

Table 6 - Summary of Dominant Substrates By Habitat Type

Stream Name: Cascade Creek **Dry Units:** 12 **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: **Quad:** SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Habitat Units	Units Fully Measured	Habitat Type	% Total Silt/Clay Dominant	% Total Sand Dominant	% Total Gravel Dominant	% Total Small Cobble Dominant	% Total Large Cobble Dominant	% Total Boulder Dominant	% Total Bedrock Dominant
11	7	LGR	0	43	29	0	29	0	0
2	1	HGR	0	0	0	0	0	0	100
1	1	CAS	0	0	0	0	0	0	100
2	2	BRS	0	0	0	0	0	0	100
3	2	GLD	0	0	50	0	50	0	0
2	1	RUN	0	0	0	0	0	0	100
6	2	SRN	0	0	50	0	0	0	50
11	11	MCP	0	45	18	0	0	9	27
1	1	STP	0	0	0	0	0	0	100
1	1	LSR	0	100	0	0	0	0	0
2	2	LSBo	0	50	0	0	0	50	0
2	2	PLP	0	50	50	0	0	0	0
2	0	CUL	0	0	0	0	0	0	0

Table 7 - Summary of Mean Percent Canopy for Entire Stream

Stream Name: Cascade Creek **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: **Quad:** SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Hardwood	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
86	0	100	9	50	45

Note: Mean percent conifer and hardwood for the entire reach are means of canopy components from units with canopy values greater than zero.

Open units represent habitat units with zero canopy cover.

Table 8 - Fish Habitat Inventory Data Summary

Stream Cascade Creek LLID: 1226188379815 Drainage San Rafael

Survey Dates: 7/23/2009 to 7/27/2009 Survey Length (ft.): 7181 Main Channel (ft.): 7181 Side Channel (ft.): 0

Confluence Location: Quad SAN RAFAEL Legal Description: T02NR07WS27 Latitude: 37:58:53.4N Longitude: 122:37:11.6W

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 1

Channel Type: F4
Reach Length (ft.): 5573
Riffle/Flatwater Mean Width (ft.): 3.7
BFW:
Range (ft.): 12.00 to 20.00
Mean (ft.): 14.78
Std. Dev.: 3.34
Base Flow (cfs): 0.01
Water (F): 58 - 64 Air (F): 73 - 87
Dry Channel (ft.): 3560

Canopy Density (%): 83.2
Coniferous Component (%): 0.0
Hardwood Component 100.0
Dominant Bank Hardwood Trees
Vegetative Cover (%): 49.1
Dominant Boulders
Dominant Bank Substrate Sand/Silt/Clay
Occurrence of LWD (%): 0.0
LWD per 100 ft.:
Riffles: 0
Pools: 2
Flat: 1

Pools by Stream Length 6.5
Pool Frequency (%): 27.9
Residual Pool Depth (%):
< 2 Feet Deep: 66.7
2 to 2.9 Feet Deep: 25.0
3 to 3.9 Feet Deep: 0.0
>= 4 Feet Deep: 8.3
Mean Max Residual Pool Depth 2.09
Mean Pool Shelter 10

Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 8.3 Gravel: 33.3 Sm Cobble: 25.0 Lg Cobble: 16.7 Boulder 0.0 Bedrock: 16.7

Embeddedness Values (%): 1. 58.3 2. 25.0 3. 0.0 4. 16.7 5. 0.0

STREAM REACH: 2

Channel Type: B3
Reach Length (ft.): 1608
Riffle/Flatwater Mean Width (ft.): 4.8
BFW:
Range (ft.): 12.00 to 18.00
Mean (ft.): 16.29
Std. Dev.: 2.71
Base Flow (cfs): 0.01
Water (F): 58 - 58 Air (F): 87 - 87
Dry Channel (ft.): 950

Canopy Density (%): 95.2
Coniferous Component (%): 0.0
Hardwood Component 100.0
Dominant Bank Hardwood Trees
Vegetative Cover (%): 42.8
Dominant Undercut Banks
Dominant Bank Substrate Sand/Silt/Clay
Occurrence of LWD (%): 0.0
LWD per 100 ft.:
Riffles: 1
Pools: 1
Flat:

Pools by Stream Length 7.4
Pool Frequency (%): 33.3
Residual Pool Depth (%):
< 2 Feet Deep: 80.0
2 to 2.9 Feet Deep: 20.0
3 to 3.9 Feet Deep: 0.0
>= 4 Feet Deep: 0.0
Mean Max Residual Pool Depth 1.66
Mean Pool Shelter 1

Pool Tail Substrate (%): Silt/Clay: 20.0 Sand: 20.0 Gravel: 60.0 Sm Cobble: 0.0 Lg Cobble: 0.0 Boulder 0.0 Bedrock: 0.0

Embeddedness Values (%): 1. 40.0 2. 20.0 3. 0.0 4. 40.0 5. 0.0

Table 9 -Mean Percentage of Dominant Substrate and Vegetation

Stream Name: Cascade Creek **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: Quad: SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

Mean Percentage of Dominant Stream Bank Substrate

Dominant Class of Substrate	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage (%)
Bedrock	12	9	30.0
Boulder	1	3	5.7
Cobble/Gravel	0	0	0.0
Sand/Silt/Clay	22	23	64.3

Mean Percentage of Dominant Stream Bank Vegetation

Dominant Class of Vegetation	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage
Grass	0	1	1.4
Brush	10	8	25.7
Hardwood	25	26	72.9
Coniferous	0	0	0.0
No Vegetation	0	0	0.0

Total Stream Cobble Embeddedness Values: 2

Table 10 - Mean Percent of Shelter Cover Types For Entire Stream

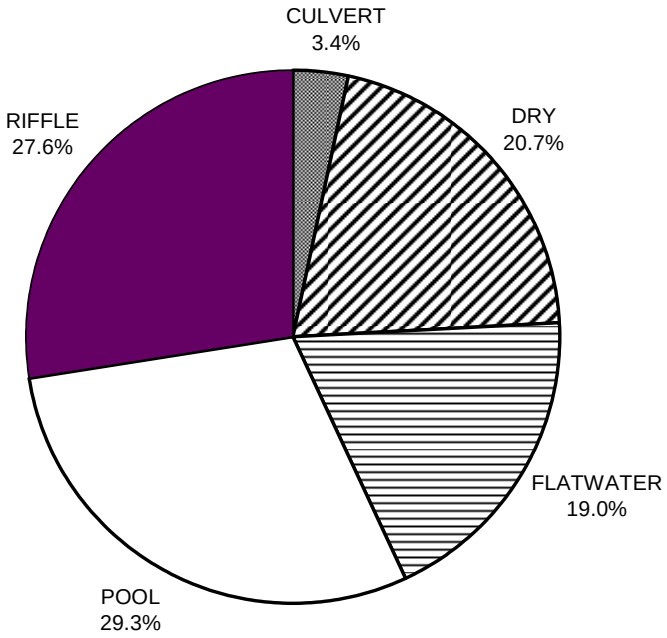
Stream Name: Cascade Creek **LLID:** 1226188379815 **Drainage:** San Rafael

Survey 7/23/2009 to 7/27/2009

Confluence Location: Quad: SAN RAFAEL **Legal Description:** T02NR07WS27 **Latitude:** 37:58:53.4N **Longitude:** 122:37:11.6W

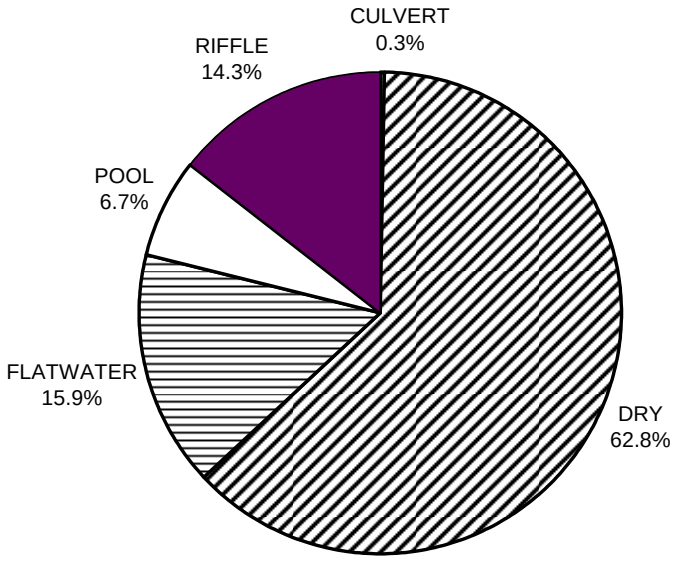
	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	0	11
SMALL WOODY DEBRIS (%)	0	0	0
LARGE WOODY DEBRIS (%)	0	0	0
ROOT MASS (%)	0	0	5
TERRESTRIAL VEGETATION	9	0	6
AQUATIC VEGETATION (%)	0	16	0
WHITEWATER (%)	0	0	0
BOULDERS (%)	0	44	34
BEDROCK LEDGES (%)	0	0	0

CASCADE CREEK 2009
HABITAT TYPES BY PERCENT OCCURRENCE



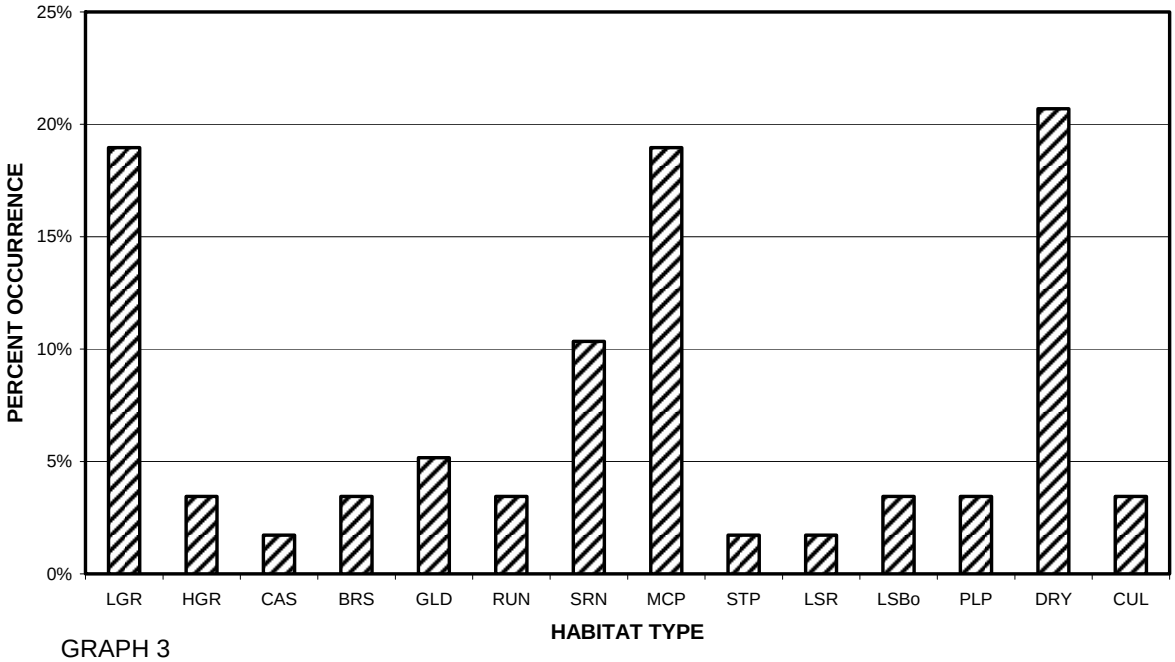
GRAPH 1

CASCADE CREEK 2009
HABITAT TYPES BY PERCENT TOTAL LENGTH



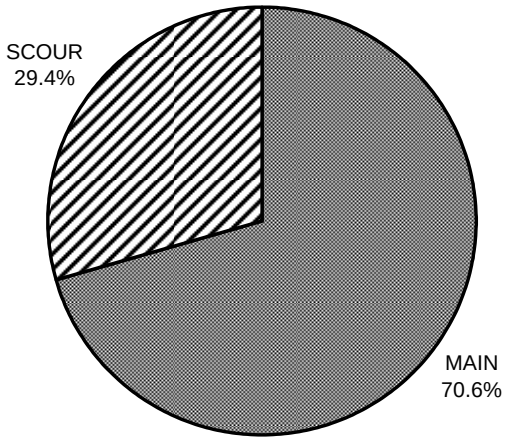
GRAPH 2

CASCADE CREEK 2009
HABITAT TYPES BY PERCENT OCCURRENCE

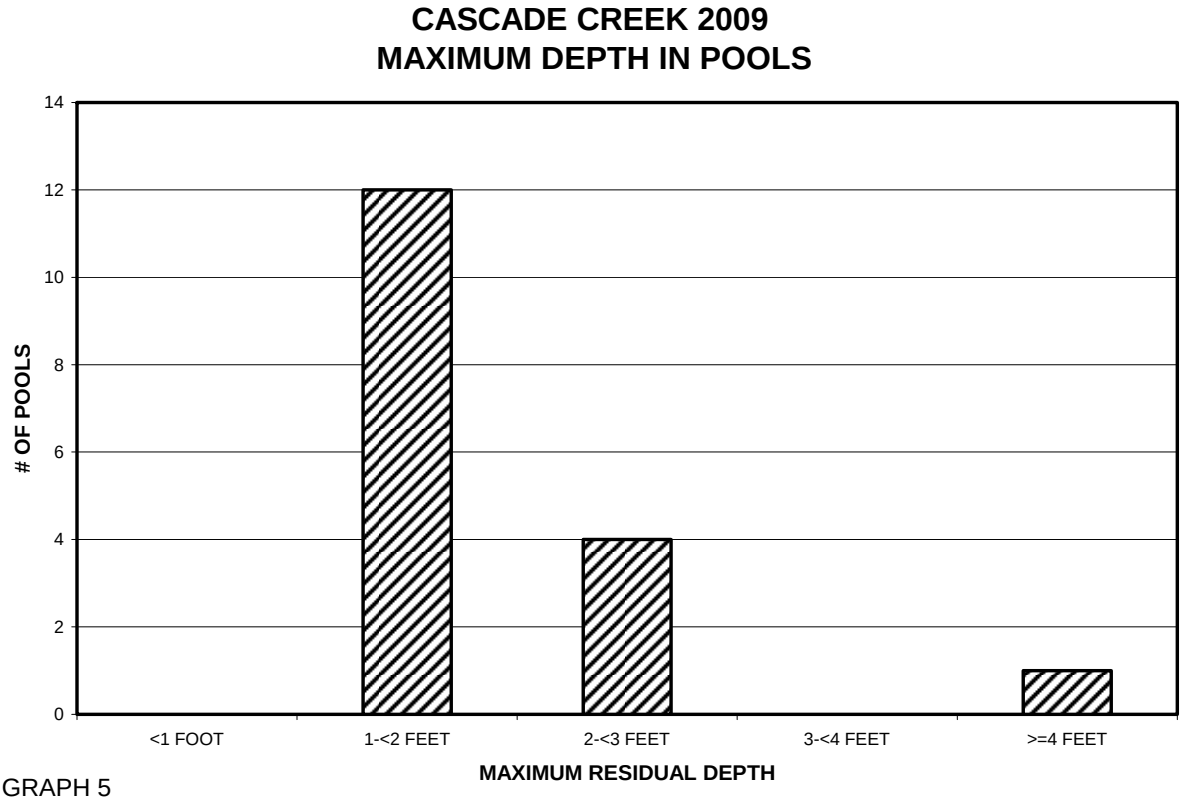


GRAPH 3

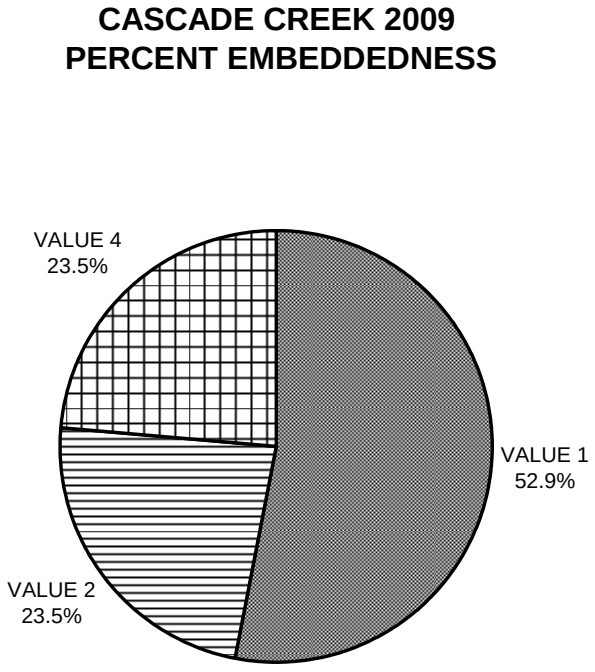
CASCADE CREEK 2009
POOL TYPES BY PERCENT OCCURRENCE



GRAPH 4

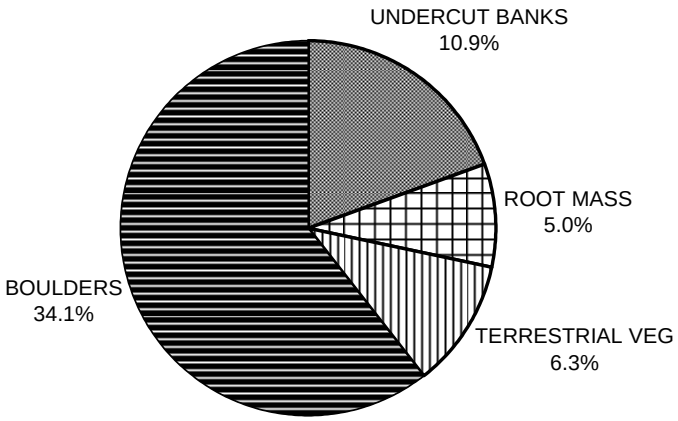


GRAPH 5



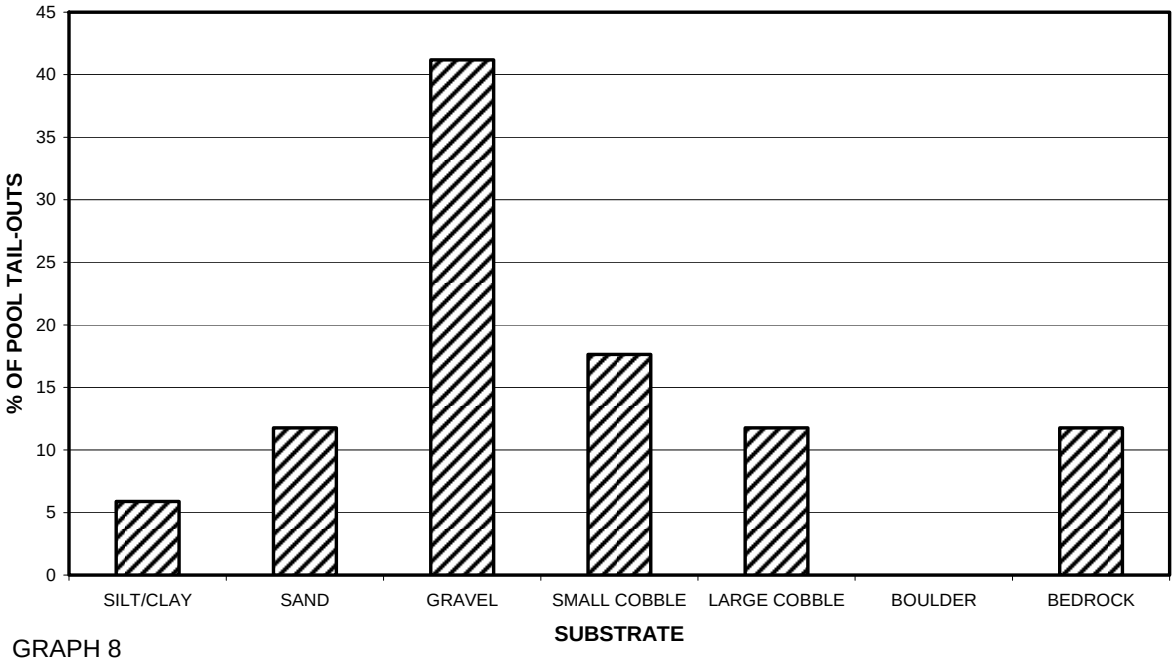
GRAPH 6

CASCADE CREEK 2009
MEAN PERCENT COVER TYPES IN POOLS



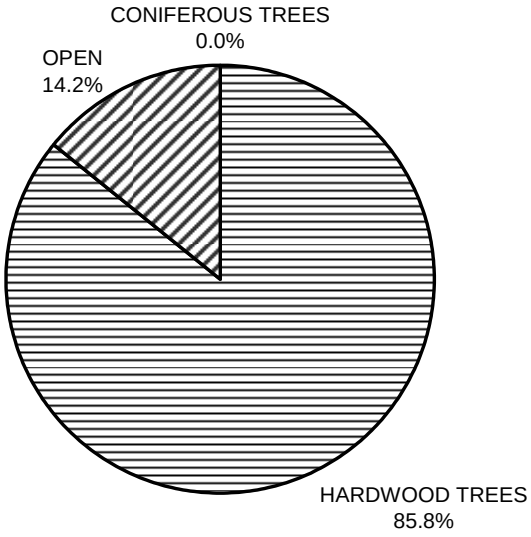
GRAPH 7

CASCADE CREEK 2009
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



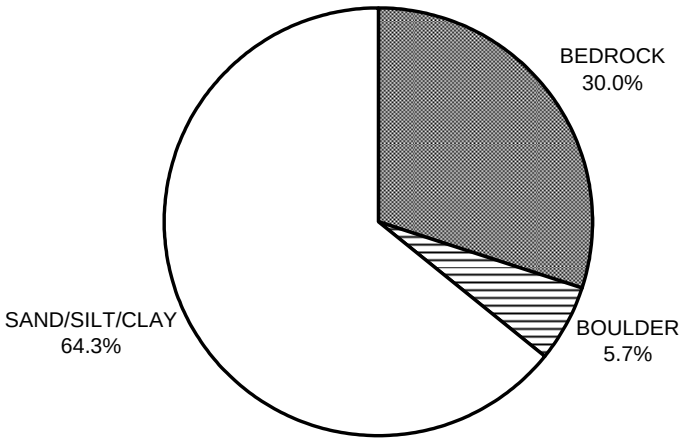
GRAPH 8

CASCADE CREEK 2009
MEAN PERCENT CANOPY



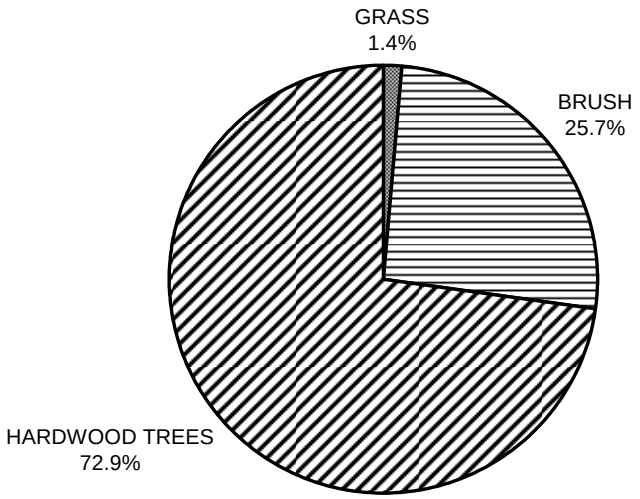
GRAPH 9

CASCADE CREEK 2009
DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 10

CASCADE CREEK 2009
DOMINANT BANK VEGETATION IN SURVEY REACH



GRAPH 11