NORTH COAST RESOURCE PARTNERSHIP

2014 IRWM Drought Project Grant Application

ATTACHMENT 3:

Project Justification Appendix

Integrated Regional Water Management Program
Applicant: Humboldt County

North Coast Resource Partnership 2014 IRWM Drought Project Grant

Attachment 3. Project Justification Appendix

Supporting Documentation

1. California Water Service Meter Conservation Estimate (2009)
2. Article about impacts of no water meters statewide (Rogers 2014)
3. LPMWC well production data
4. Design specifications for water meters
5. LPMWC Water and Wastewater Systems Important Infrastructure
6. Flat Rate causes Water Users to use more (2014)
7. SWRCB Report Submittal

Marysville Flat to Meter

Appendix A

April 2009

Dear Marysville Customers,

California Water Service Company will begin installing water meters on its 2,617 existing flat-rate services this month as required by state law. Conversions must be completed by 2025, but the company estimates that it will complete the project by 2018, converting about 260 flat-rate services per year.

The law requiring all customers to have water meters is designed to promote water conservation, according to Marysville District Manager Lee Seidel. During the summer, for example, the average water usage for metered customers is 27 Ccf per month (1 Ccf equals 748 gallons); for flat-rate customers, average summer usage is estimated to be 42 Ccf per month.

Studies have shown that introducing meters generally encourages water conservation in the 10-12% range. Customers will be able to manage and monitor their water consumption, and can benefit from a reduced water bill in some instances.

"Our population is increasing, but water supply is a finite resource. I would encourage all of our customers — flat-rate and metered — to take advantage of the conservation programs we offer," said Seidel. "It's critical that we use water efficiently, and water meters are one way to help customers be more accountable for the water they use."

To maximize efficiency and minimize the impact to customers, the meter installation and conversion schedule is based on current meter-reading routes for the company. Meters will be installed at no additional direct cost to customers, as the costs of the conversion are accounted for in water bill fees.

Cal Water serves about 12,800 people through 3,700 connections in the Marysville area. The company has provided water service in the area since 1930.

Appendix C

California drought: More than 255,000 homes and businesses still don't have water meters statewide

By Paul Rogers progers@mercurynews.com
Updated: 03/11/2014 05:18:56 PM PDT

MercuryNews.com

- Mar 12:
- Mercury News editorial: From Sacramento to Bakersfield, install water meters

Despite urgent calls for water conservation amid one of California's worst droughts, more than 255,000 homeowners and businesses across the state can still use all the water they want without paying higher bills.

And nobody even knows how much water they are using.

From Bakersfield to Sacramento to Shasta County, 42 communities in California have not installed the most basic tool of water management -- water meters -- for all of their connections. People without meters are charged a flat monthly rate in those areas for water, usually between $20 and $35 a month. And those communities use 39 percent more water per capita than the state average, according to an analysis of state Department of Water Resources records by this newspaper.

Meter reader Laura Rodelas of the Alameda County Water District works along South Grimmer Boulevard on Friday afternoon, March 7, 2014, in Fremont, Calif.

"Everybody I talk to about this is shocked," said Peter Gleick, president of the Pacific Institute, a nonprofit group in Oakland that studies water issues. "I get calls from Europe saying, 'What? You still don't meter everybody in California?' A rational water system would measure and monitor everyone's water use so it can be properly managed."

Most California residents have had water meters for generations.

Los Angeles finished installing them in the 1920s. San Jose has had meters on every home since the 1930s. Oakland began installing them in 1906 and was fully metered by 1940.

State law looming

Communities that have been holdouts are now slowly installing meters after years of resisting for reasons that ranged from political ideology to financial hardship.

But they have another 10 years to finish the job: Under a law signed a decade ago by former Gov. Arnold Schwarzenegger, all urban water providers are required to install meters on all connections by 2025.

Appendix C

"We know from experience that people with metered connections are more careful with their water use and use less water than people without meters," said Gleick, who thinks lawmakers should move the deadline to 2020. "It's long past time that 100 percent of California users were metered."

Unmetered water connections

In places where water meters are not universal, customers consume more water. Here are the top 10 water suppliers with the most unmetered connections and their average water use, compared with the statewide average.

Water provider	Percent of connections unmetered	Number of connections unmetered	Gallons used per capita per day
City of Sacramento	49%	66,245	279
California Water Service, Bakersfield	37	26,441	298
City of Modesto	24	18,064	285
Sacramento Suburban Water District	32	15,004	242
City of Lodi Public Works Department	79	14,846	248
City of Merced	52	10,746	310
Sacramento County Water Agency	21	10,472	278
South Tahoe Public Utilities District	61	8,428	201
Golden State Water Co., Rancho Cordova	51	7,440	369
City of Galt	89	6,429	215
STATE TOTAL (42 providers)	35	255,057	273

Source: California Department of Water Resources

Statewide average: 196

BAY AREA NEWS GROUP

Most of the communities that haven't installed meters for all water customers are in the Central Valley. Sacramento still has 66,245 connections without meters -- 49 percent of its connections. Bakersfield has 26,441, or 37 percent, and Modesto has 18,064, or 24 percent.

Some areas are much further behind. Small towns with struggling economies, including Galt, Shafter, Rio Vista and the city of Mount Shasta, all have 80 percent or more of their connections without meters.

But even in a large, prosperous city like Sacramento, plans to require water meters sparked controversy for decades.

"For some people, it's like going to Alabama and saying you are going to register their guns," said Barbara O'Connor, director emeritus of the Institute for the Study of Politics and the Media at Cal State Sacramento.

"It's a visceral reaction," she said. "People in some places view it as a birthright that they have big trees and green grass. They see the water in the rivers, they walk along it, and they raft on it. It's part of the right of being a Sacramentan."

O'Connor, who has lived in Sacramento since 1972, said she supports the law requiring meters. Over the years, when state lawmakers suggested that the city be forced to install meters, city officials argued that the cost was too high, or that water they saved would just be sent to Los Angeles.

When the bill mandating meters, carried by former state lawmaker Christine Kehoe, D-San Diego, passed in 2004, the only Democrat to vote against it was Darrell Steinberg, a former Sacramento city councilman.

"I was voting my district," said Steinberg, now president pro tem of the state Senate. "Ten years later, it's good policy, it's the right policy, and Sacramento is half way done."

Steinberg said he isn't hearing calls in the Legislature to move up the 2025 deadline.

Most Sacramento residents, he added, have come to terms with meters.

Appendix C

"Once meters became a reality and we phased it in, I think people are fine with it," he said. "If we're serious about conservation, then we have to create an incentive to help people use less water."

Sacramento officials are still touchy about the subject, however. Neither the city utilities director, Dave Brent, or the city spokeswoman, Linda Tucker, would agree to be interviewed about why Sacramento is so far behind other big California cities.

"Monday morning quarterbacking isn't helpful," Tucker said in an e-mail.

She noted that Sacramento is spending $416 million to install its meters, which can cost $1,000 each or more because of issues surrounding older homes and neighborhood configurations. The costs were paid for with rate increases and federal stimulus funds, among other sources. The city, now 51 percent finished, expects to be done by 2025.

In January, Sacramento city leaders asked residents to cut water use 20 percent because of the drought. They put in place rules that limit lawn watering to two days a week -- and only before 10 a.m. or after 7 p.m., with "water cops" ticketing violators. So far, they have seen a 12 percent drop in water use -- largely because of the new drought rules and the fact that half the homes now have water meters.

Conservation results

Communities have different explanations for why they've been slow to install meters. In South Lake Tahoe, officials had to upgrade sewer systems that were in danger of polluting the lake, and they still need to modernize water systems for fire protection, said Richard Solbrig, general manager of the South Tahoe Public Utility District.

"Basically our community had other priorities that were a lot more important," he said. "A lot of people get upset when we say Lake Tahoe is different than other places. But the reality is that it is."

One thing is clear: In places where meters have gone in, water use has substantially dropped.

Fresno, where voters 20 years ago passed a city ballot measure banning meters on homes, finished installing them last year because of the state law. Daily water use has fallen from 313 gallons per person in 2010 to 245, a decline of 22 percent.

Some Fresno residents, however, are not happy.

"With the old flat-rate system you could have a nice yard, and you didn't abuse it or your neighbors would let you know," said former Fresno County Supervisor Doug Vagim, now a anti-tax activist. "It was an esprit de corps. The bureaucrats want a guaranteed method of a cash register that they can manipulate."

In Folsom, where voters banned meters in 2002, the city finished putting them in by 2011 and has seen daily water use fall from 429 gallons per person to 367, a drop of 15 percent.

Appendix C

"We were worried that our bills were going to go up," said Folsom resident Karen Forster, who helped run the campaign against meters. "Our bills are up, but not as much as I expected. You have to watch it. You have to make sure you don't water your yard too much. But so far, I'm OK with it."

Paul Rogers covers resources and environmental issues. Contact him at 408-920-5045. Follow him at Twitter.com/PaulRogersSJMN

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Month/Year: January 2011								Operator	Gary Norder		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						68800		61690	0		130490
2						65100		58960	0		124060
3						71100		56360	0		127460
4						72000		56000	0		128000
5						67100		51780	0		118880
6						70100		54180	0		124280
7						66000		56280	0		122280
8						71100		52710	0		123810
9						66200		51810	0		118010
10						66500		53220	0		119720
11						65300		55400	0		120700
12						63100		53150	0		116250
13						68000		540	0		68540
14						68100		66250	0		134350
15						66000		65030	0		131030
16						59400		59280	0		118680
17						64200		62910	0		127110
18						66200		65400	0		131600
19						70200		63390	0		133590
20						70500		0	0		70500
21						68800		0	49950		118750
22						65500		0	38040		103540
23						61800		0	45610		107410
24						64400		0	36260		100660
25						65400		0	38240		103640
26						64400		0	35140		99540
27						64900		0	31570		96470
28						66800		0	41420		108220
29						67700		0	48280		115980
30						55800		0	30770		86570
31						67700		0	47740		115440

Lewiston Park Mutual Water Company

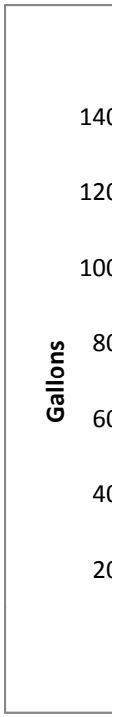
2014 IRWM Drought Solicitation Project Application

Total Gallons:	3545560

Month/Year: February 2011								Operator	Gary Norder		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						62000		0	33420		95420
2						64600		0	44760		109360
3						64500		0	28890		93390
4						65300		0	34310		99610
5						63600		0	34310		97910
6						60900		0	41210		102110
7						64000		0	32180		96180
8						63600		0	36460		100060
9						63900		0	38160		102060
10						67100		0	33300		100400
11						73100		61320	0		134420
12						63200		39420	0		102620
13						61100		38760	0		99860
14						67900		27030	0		94930
15						65700		25230	0		90930
16						70600		23500	0		94100
17						56800		43640	0		100440
18						67200		17270	0		84470
19						64700		23750	0		88450
20						58900		30680	0		89580
21						65700		24870	0		90570
22						65000		26540	0		91540
23						61600		31240	0		92840
24						67700		44140	0		111840
25						62000		39770	0		101770
26						49800		52160	0		101960
27						46600		44080	0		90680

28						58900		50390	0		109290
29											
30											
31											
									Total Gallons:		2766790

Month/Year: March 2011								Operator	Gary Norder		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						53100		47350			100450
2						62200		50720			112920
3						5540		48230			53770
4						69800		36340			106140
5						66900		29100			96000
6						62700		25480			88180
7						63600		0			63600
8						63000		54270			117270
9						59700		42550			102250
10						65300		28390			93690
11						64300		51020			115320
12						59500		43800			103300
13						55300		41130			96430
14						64700		57790			122490
15						63900		38150			102050
16						65600		26740			92340
17						59600		51780			111380
18						60800		35850			96650
19						65430		30260			95690
20						59200		28890			88090
21						65500		31110			96610
22						67600		27560			95160
23						66300		36860			103160
24						62600		48380			110980
25						74600		23680			98280
26						67300		26000			93300
27						66200		38750			104950
28						66900		28710			95610
29						68300		17740			86040



30						68700		20680			89380
31						68900		23030			91930
									Total Gallons:		3023410

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Month/Year: April 2011								Operator	Gary Norder		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						70100		19160			89260
2						58000		48370			106370
3						65000		27430			92430
4						69800		23670			93470
5						66900		19920			86820
6						67800		22800			90600
7						64500		39600			104100
8						69900		290			70190
9						72900		52230			125130
10						65400		45770			111170
11						6420		35310			41730
12						67800		25530			93330
13						67800		23040			90840
14						55300		27590			82890
15						57200		52100			109300
16						55800		49780			105580
17						58900		52480			111380
18						72500		3590			76090
19						5900		55320			61220
20						66100		38500			104600
21						65900		32200			98100
22						70500		32960			103460
23						62300		31220			93520
24						60500		23460			83960
25						67200		23450			90650
26						66700		35020			101720
27						66200		36830			103030
28						68800		32110			100910
29						58000		39570			97570
30						54700		40630			95330
31											

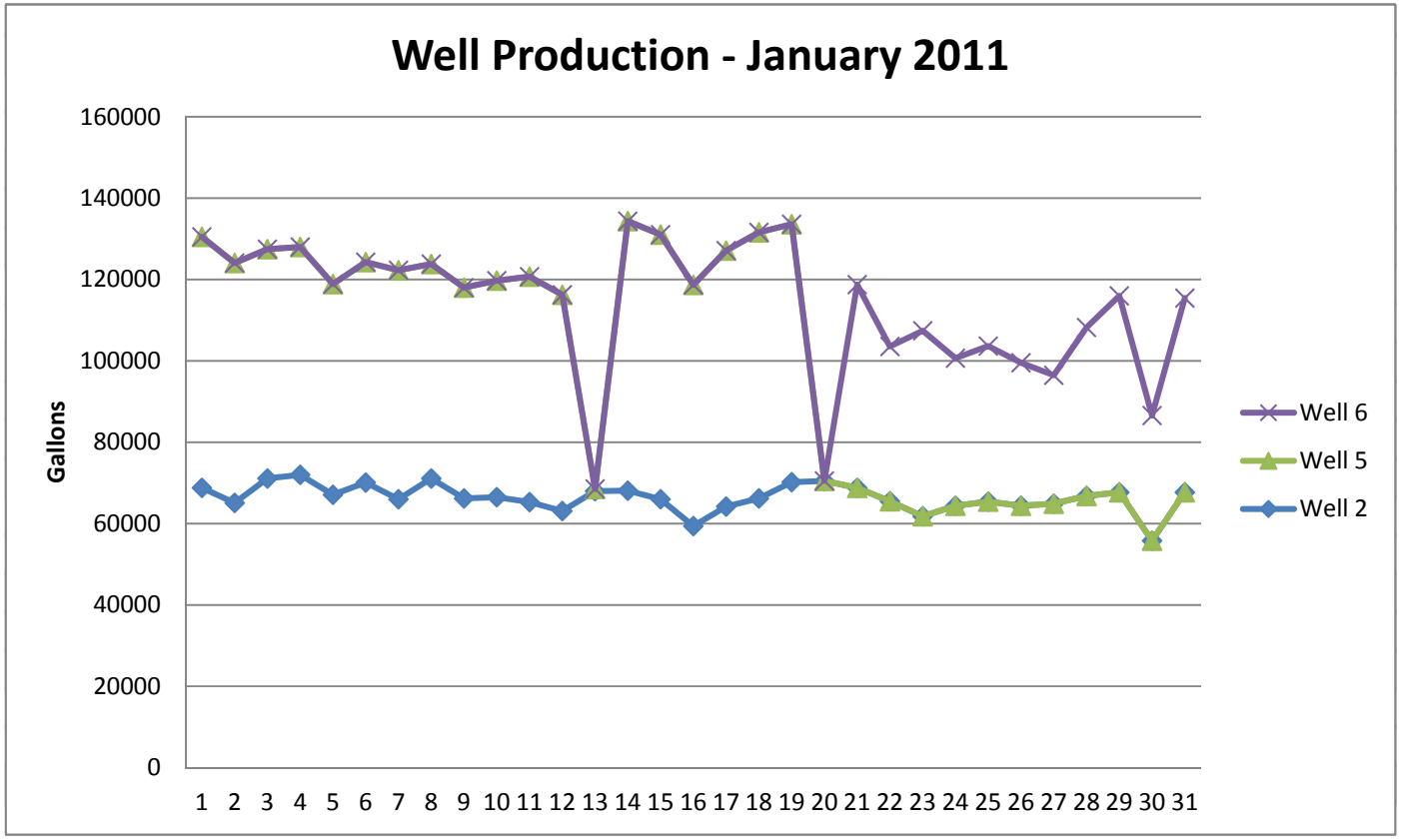
Total Gallons:	2814750

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Month/Year: May 2011								Operator	Gary Norder		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						67900	1450	1500	0	0	70850
2						66000	0	50200	0	0	116200
3						68500	0	51310	0	0	119810
4						70400	0	54920	0	0	125320
5						60100	93090	30940	0	0	184130
6						60400	86510	17000	0	0	163910
7						69400	96020	14410	0	0	179830
8						55400	82930	47210	0	0	185540
9						78300	86570	84200	0	0	249070
10						68800	79430	88580	0	0	236810
11						62500	84430	46450	0	12100	205480
12						66300	88890	14940	0	27200	197330
13						66600	86790	24770	0	25000	203160
14						71000	92780	200	0	27300	191280
15						63600	86110	0	80	0	149790
16						63700	70	90	68730	0	132590
17						59400	0	30	68280	0	127710
18						63200	0	30	83980	0	147210
19						65200	0	0	93290	0	158490
20						63300	0	0	83130	0	146430
21						69800	0	62460	102750	0	235010
22						63400	0	40030	77350	0	180780
23						65900	0	31100	77350	0	174350
24						66200	0	39870	80510	0	186580
25						64200	0	16870	68630	0	149700
26						64800	0	12190	65120	0	142110
27						53800	0	51750	36600	0	142150
28						69400	0	90	69140	0	138630
29						60500	0	19140	60330	0	139970
30						66300	0	380	63160	0	129840
31						63400	0	6890	60400	0	130690

Total Gallons:	5040750


Well Production - January 2011
Gallons
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140000
120000
100000
80000
60000
40000
20000
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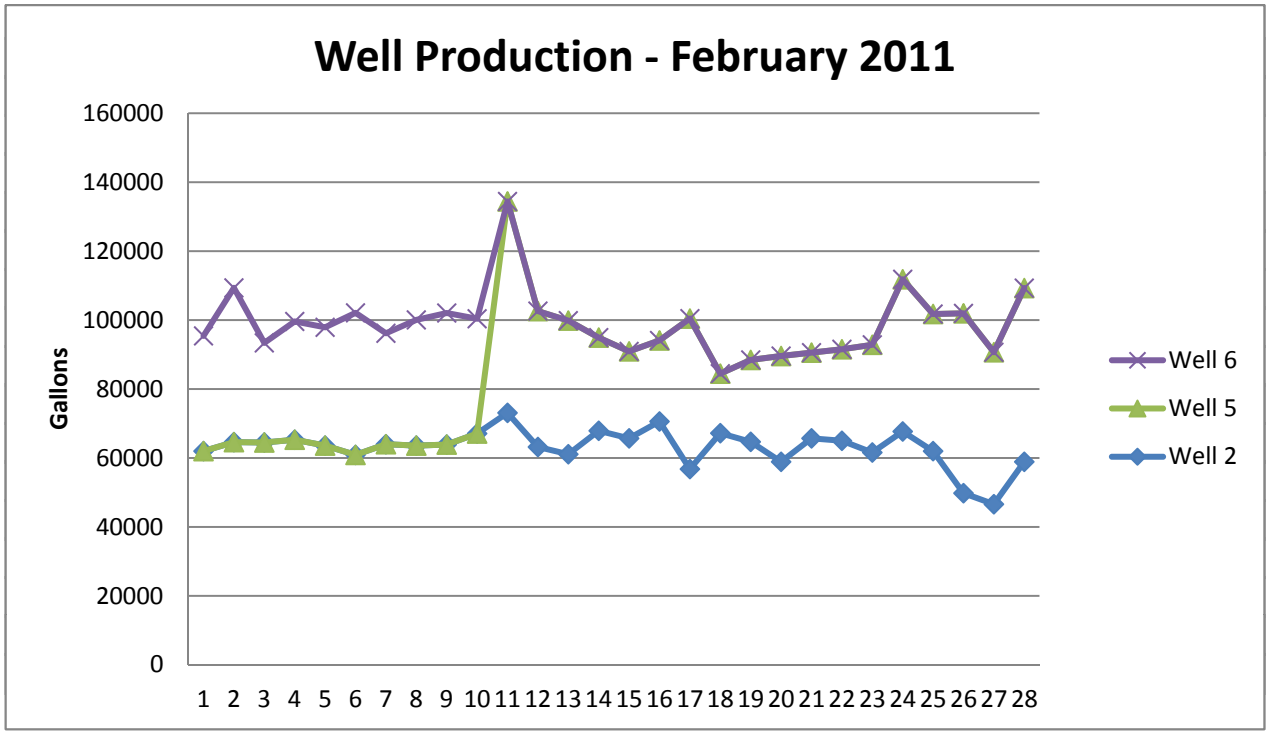
Well 6
Well 5
Well 2


Well Production - February 2011
Gallons
160000
140000
120000
100000
80000
60000
40000
20000
0
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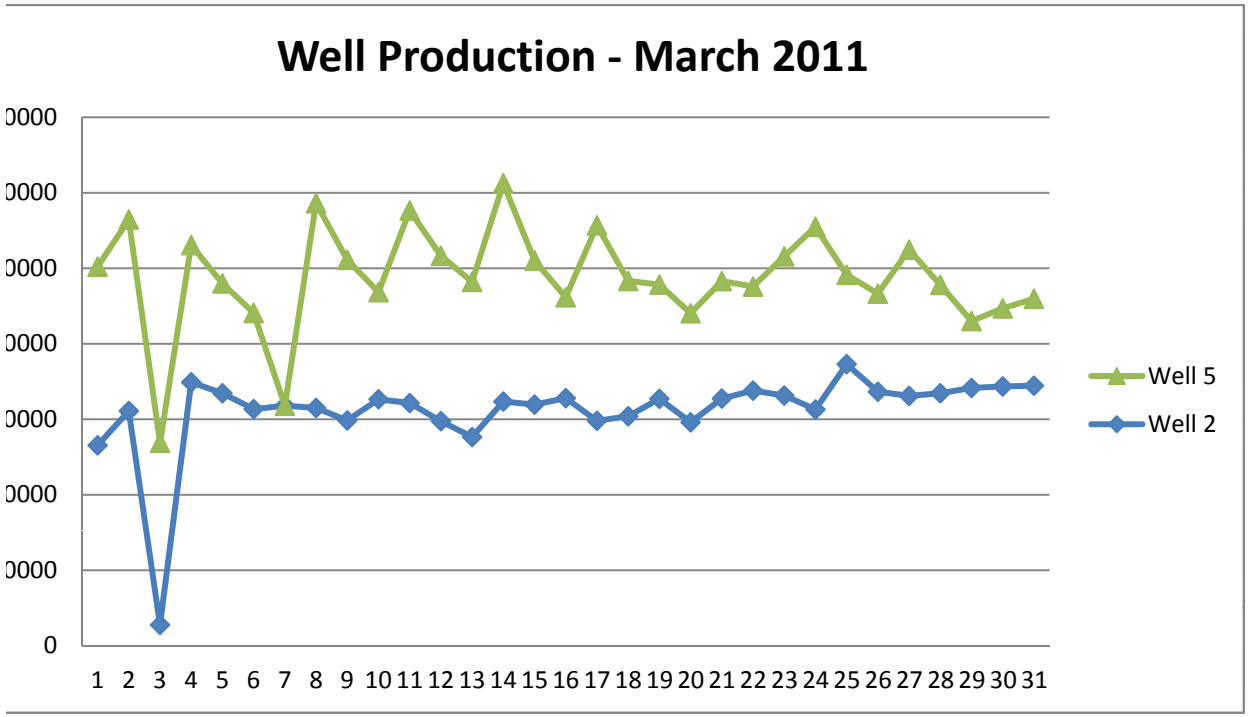
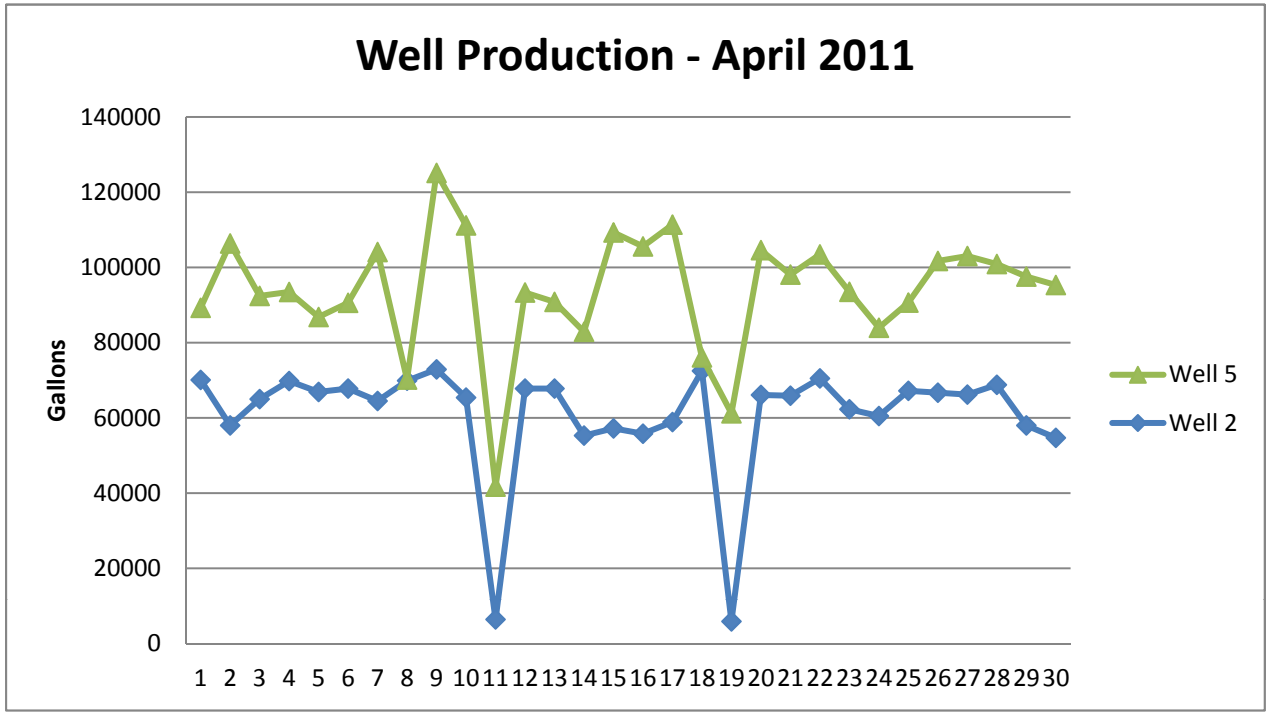
Well 6
Well 5
Well 2


Well Production - March 2011
0000
0000
0000
0000
0000
0000
0000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Well 5
Well 2


Well Production - April 2011
Gallons
140000
120000
100000
80000
60000
40000
20000
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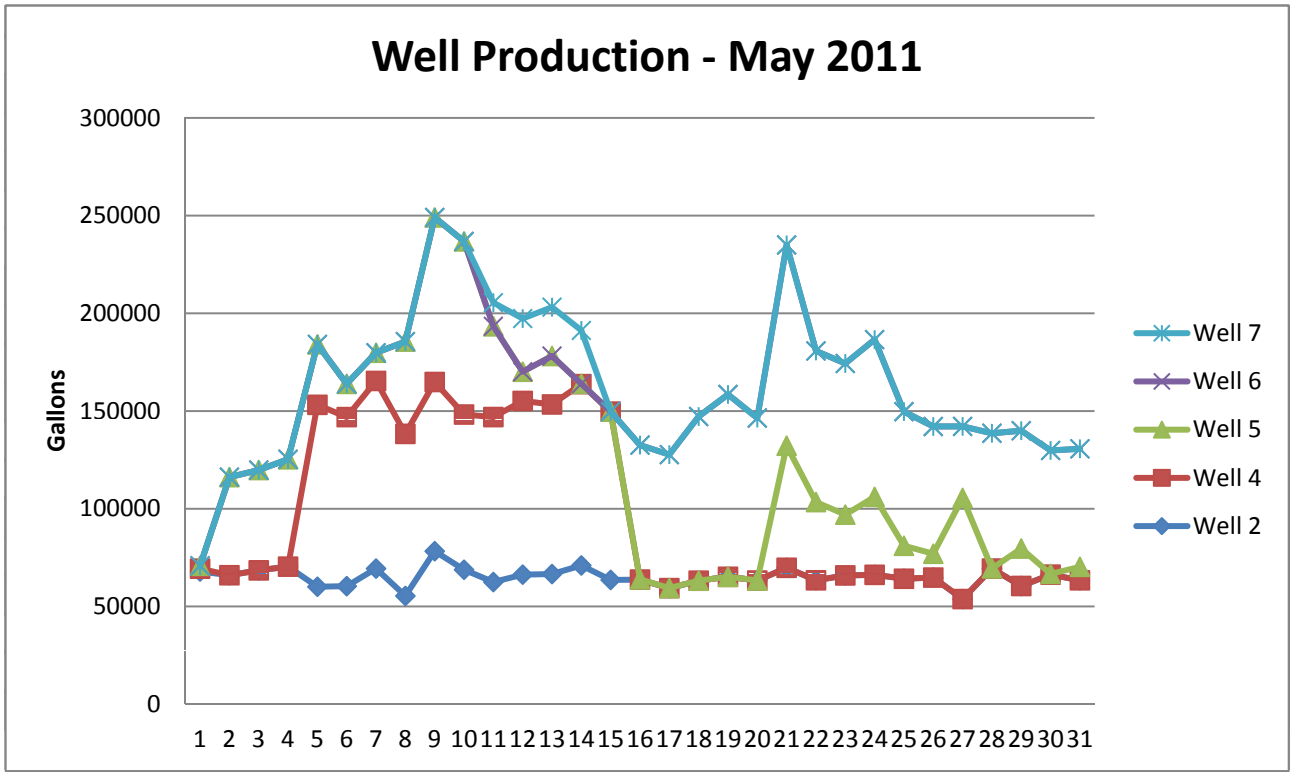
Well 5
Well 2


Well Production - May 2011
Gallons
300000
250000
200000
150000
100000
50000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Well 7
Well 6
Well 5
Well 4
Well 2

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Month/Year: January 2012								Operator	Gary Norder		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						70300			49230		119530
2	**Due to erratic record keeping, there is no data**					64300			46190		110490
3	**for 2013 prior to September. Included is data from**					68800			48490		117290
4	**2012 and 2011. No meter reads were available;**					68600			48500		117100
5	**only production figures.**					64900			36010		100910
6						64900			34980		99880
7						64100			22550		86650
8						67000			43520		110520
9						65800			48510		114310
10						68100			49280		117380
11						64600			48110		112710
12						65000			32170		97170
13						65800			33840		99640
14						64100			45000		109100
15						69200			49700		118900
16						62300			47720		110020
17						68800			50380		119180
18						52100			36900		89000
19						48900			4760		53660
20						52500			26180		78680
21						67400			48310		115710
22						66400			48490		114890
23						66500			48630		115130
24						62200			49830		112030
25						63400			50720		114120
26						65200			50140		115340
27						48800			49780		98580
28						54600			41740		96340
29						55000			51580		106580
30						65400			50750		116150
31						60700			49040		109740

Total
3296730

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Month/Year: February 2012								Operator	Gary Norder		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						20700			49390		70090
2						52700			40610		93310
3						53100			31470		84570
4						61600			34280		95880
5						59700			47700		107400
6						64400			41720		106120
7						65100			23060		88160
8						62900			42930		105830
9						56700			34840		91540
10						70700			47090		117790
11						59000			38810		97810
12						65500			44310		109810
13						66000			49500		115500
14						56800			49510		106310
15						56700			48620		105320
16						58600			49190		107790
17						69100			50240		119340
18						67100			50340		117440
19						63100			49980		113080
20						65600			50030		115630
21						62900			48820		111720
22						66400			49460		115860
23						56100			47460		103560
24						60600			51330		111930
25						64300			48910		113210
26						55700			52400		108100
27						54000			48840		102840
28						60600			49710		110310
29						59600			49880		109480
30											
31									Total Gallons:		3055730

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Month/Year: March 2012								Operator	Gary Norder		
		Meter Read			System No. 5301003	Gallons					Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						60900			47770		108670
2						53900			50960		104860
3						46800			47661		94461
4						63800			42580		106380
5						64000			50120		114120
6						54900			48710		103610
7						58400			49190		107590
8						66700			49180		115880
9						60300			46760		107060
10						55400			50960		106360
11						57000			46560		103560
12						50200			48550		98750
13						64000			50100		114100
14						55100			45510		100610
15						51100			50170		101270
16						51800			45350		97150
17						57500			46900		104400
18						58400			47670		106070
19						53100			48690		101790
20						49800			48680		98480
21						62000			47930		109930
22						51800			49110		100910
23						45400			46890		92290
24						45900			48920		94820
25						48400			50890		99290
26						46600			48200		94800
27						45400			47290		92690
28						45500			36480		81980
29						47000			5785		52785
30						49100			44420		93520
31						51300			46200		97500

Total
3105686

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

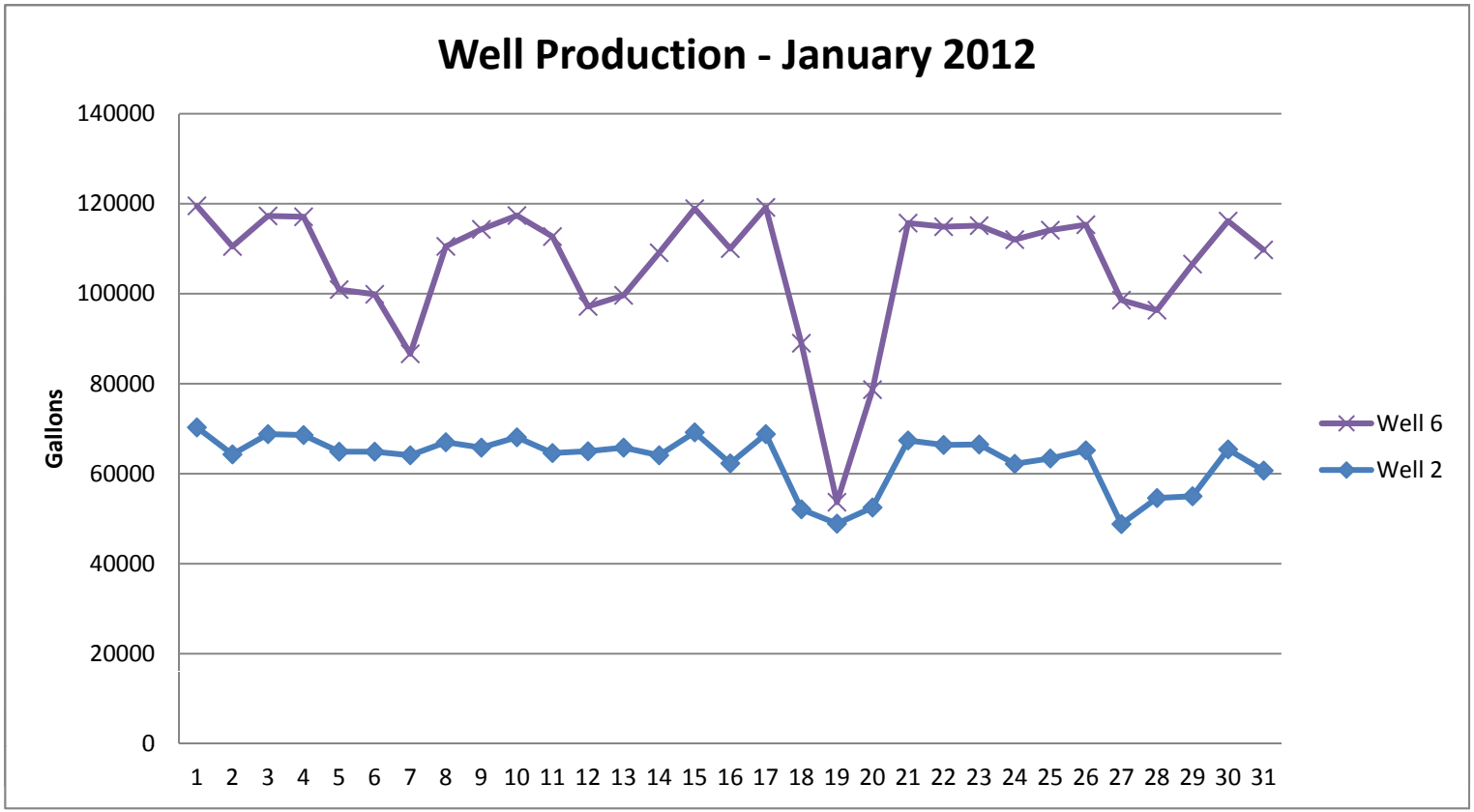
	Month/Year: April 2012							Operator:	Gary Norder		
		Meter Read			System No. 5301003			Gallons			Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						46000			39840		85840
2						48600			3826		52426
3						60000			55460		115460
4						51100			45720		96820
5						43600			45260		88860
6						50100			43850		93950
7						48700			46230		94930
8						53500			47330		100830
9						66900			46310		113210
10						45900			47110		93010
11						46000			48010		94010
12						51100			46680		97780
13						44100			45490		89590
14						42900			29400		72300
15						46800			32300		79100
16						60000			44520		104520
17						49500			43500		93000
18						46800			47790		94590
19						47900			40850		88750
20						48200			40880		89080
21						54800			45200		100000
22						52600			46350		98950
23						58800			45270		104070
24						63300			45870		109170
25						59700			46610		106310
26						46300			45540		91840
27						55400			49500		104900
28						66200			46830		113030
29						50000			40650		90650
30						56800			45000		101800
31									Total Gallons:		2858776

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Month/Year: May 2012								Operator	Gary Norder		
		Meter Read			System No. 5301003	Gallons					Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1						57100	0	0	48290	0	105390
2						47600	0	0	44220	0	91820
3						60700	0	0	44590	0	105290
4						61800	0	0	46560	0	108360
5						53900	92530	50300	44610	0	241340
6						52900	28590	29080	32520	0	143090
7						59200	6390	32790	40820	0	139200
8						45100	630	42220	41020	0	128970
9						56700	96250	47050	44380	0	244380
10						43100	98150	31020	30160	0	202430
11						56300	16530	9490	29660	0	111980
12						60900	0	20910	36810	0	118620
13						53300	0	49420	46510	0	149230
14						47000	88290	21890	21190	28100	206470
15						0	89870	28000	37370	21800	177040
16						49500	89080	8730	13460	21500	182270
17						36200	90140	4990	20160	20500	171990
18						39000	88070	16270	25680	19400	188420
19						43700	88630	21730	29560	20800	204420
20						54500	89110	27420	32240	22000	225270
21						56300	88790	0	120	21700	166910
22						42900	87330	0	20550	21100	171880
23						41000	87400	17320	31080	19500	196300
24						41600	89720	0	5130	18500	154950
25						37700	87580	170	4	16700	142154
26						38100	88040	36	15780	21300	163256
27						40500	87830	11774	21690	21400	183194
28						49700	88360	26330	3114	20600	188104
29						52700	90470	30880	37050	20600	231700
30						44900	84440	31780	40060	18900	220080
31						49800	89970	38950	44400	21000	244120

Total
5308628


Well Production - January 2012
Gallons
140000
120000
100000
80000
60000
40000
20000
0
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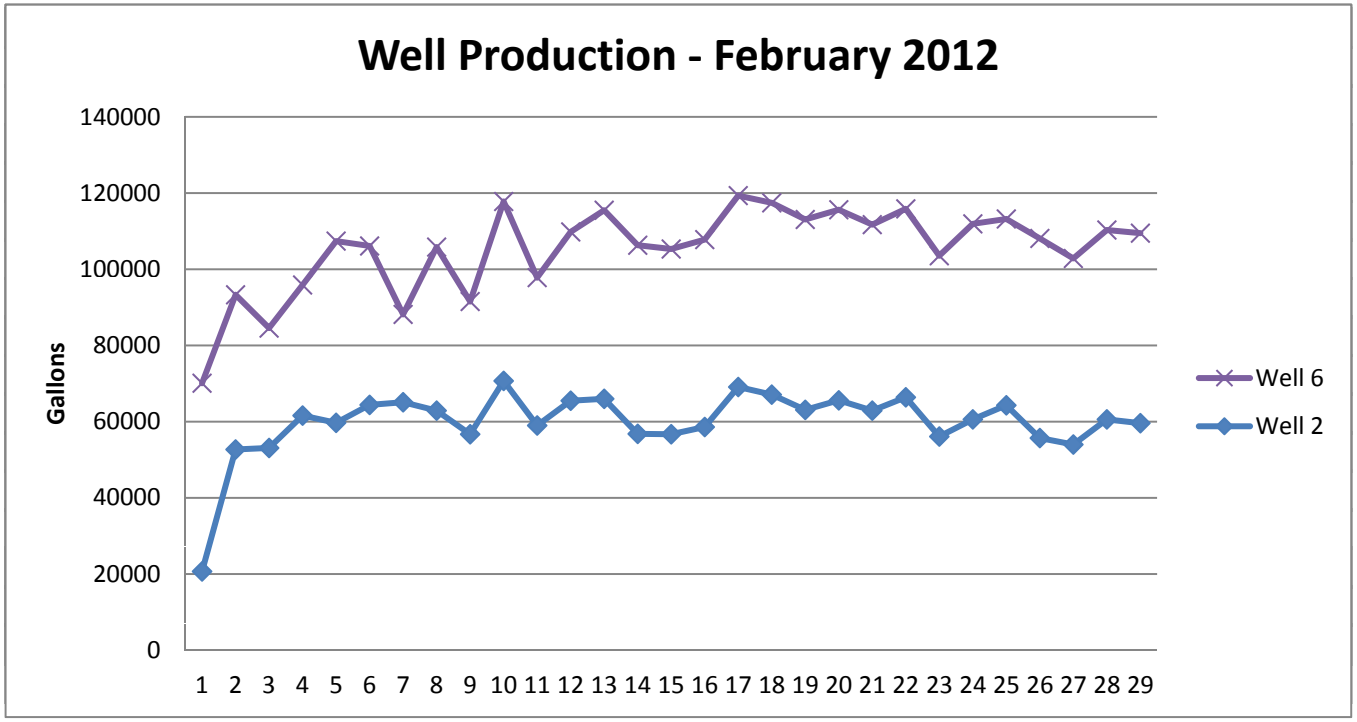
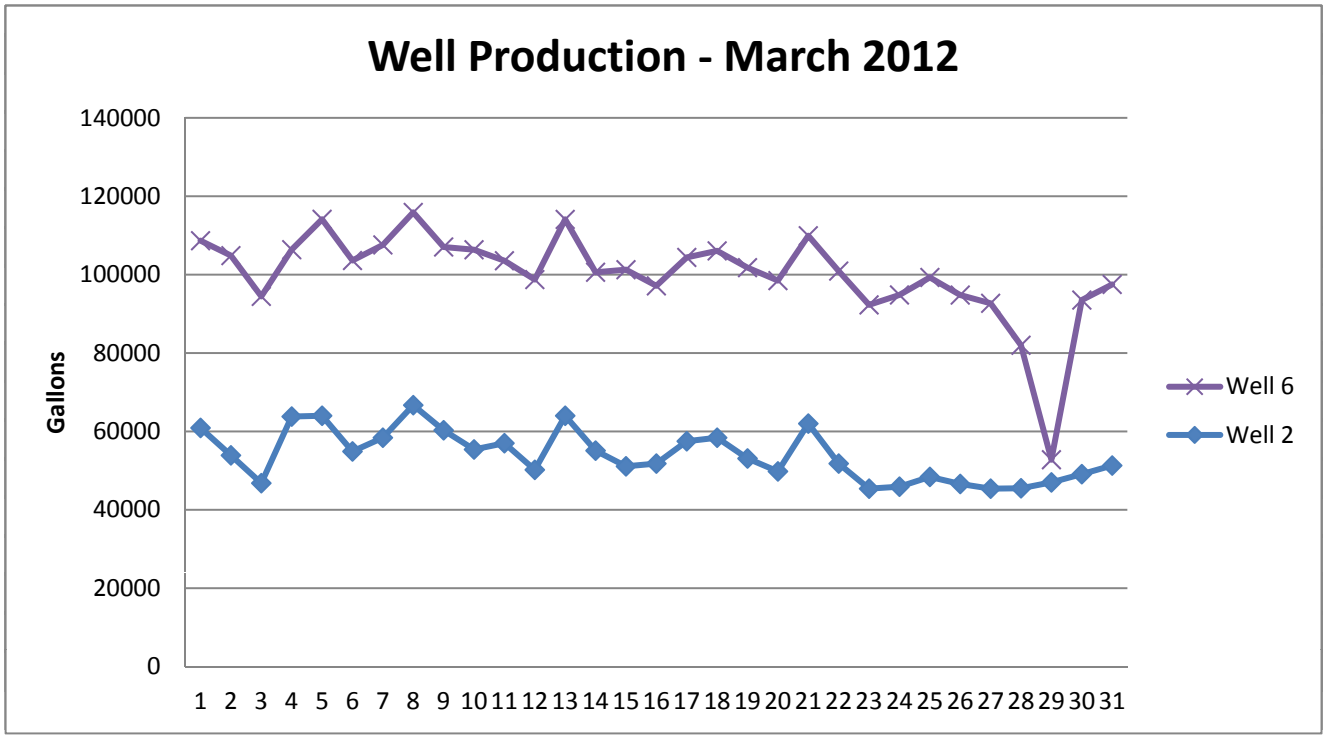
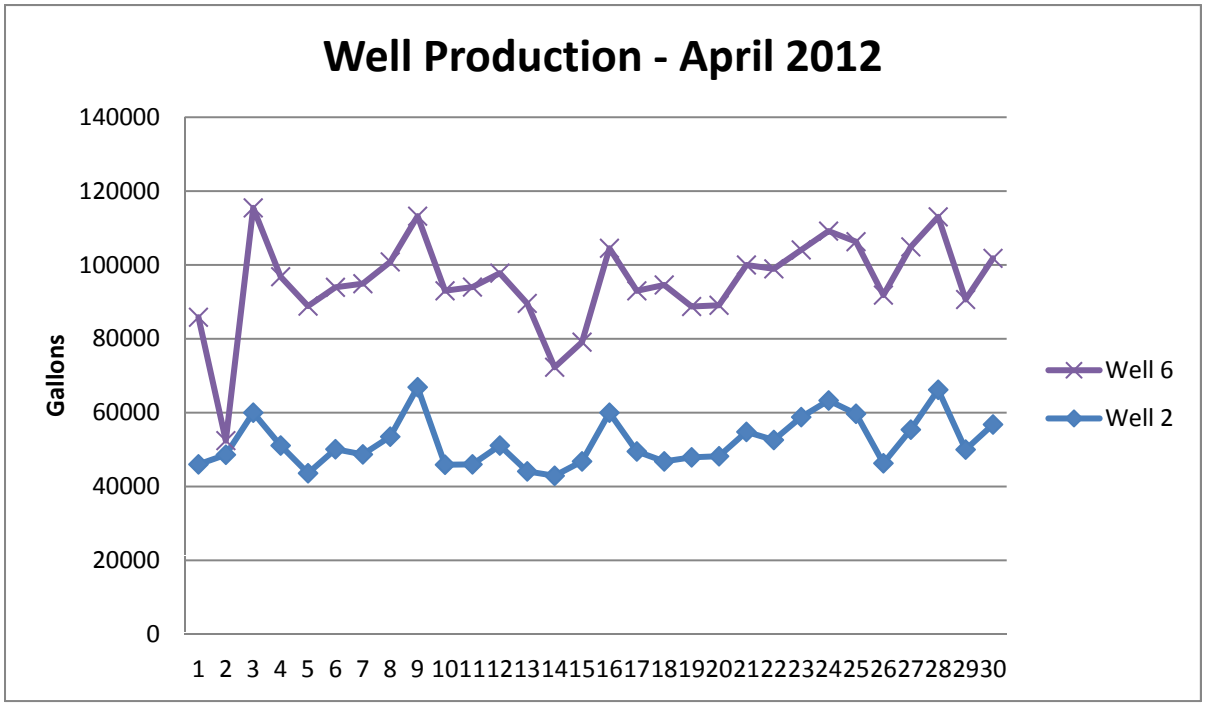
Well 6
Well 2


Well Production - February 2012
Gallons
140000
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Well 6
Well 2


Well Production - March 2012
Gallons
140000
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Well 6
Well 2


Well Production - April 2012
Gallons
140000
120000
100000
80000
60000
40000
20000
0
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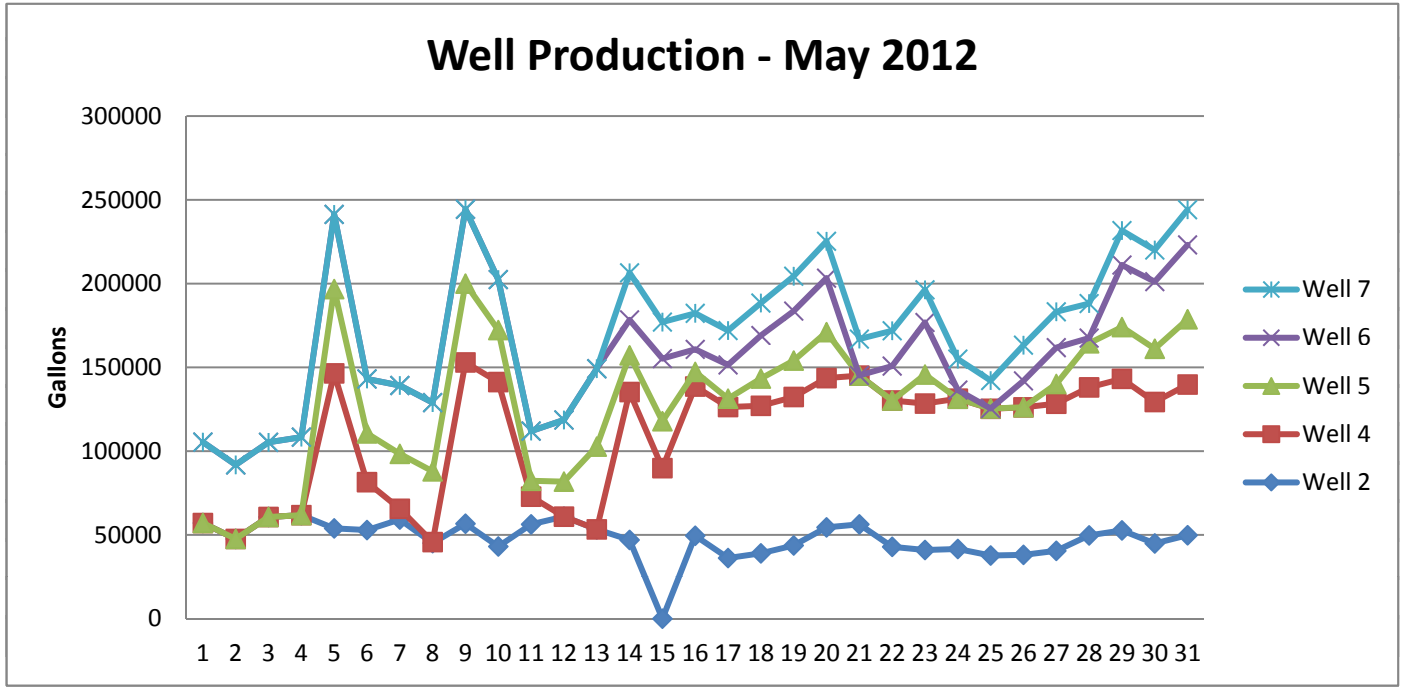
Well 6
Well 2


Well Production - May 2012
Gallons
300000
250000
200000
150000
100000
50000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Well 7
Well 6
Well 5
Well 4
Well 2

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

	Month/Yea	Jan-14			Lewiston Park Mutual Water Co.			Operator	Wayne Carlson		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1	18979800	3954990	6869240	8568440	26769300	64100	24510	0	0	0	88610
2	19056700	3981540	6869240	8568440	26769300	76900	26550	0	0	0	103450
3	19126200	4006570	6869240	8568440	26769300	69500	24200	0	0	0	93700
4	19190000	4030770	6869240	8568440	26769300	63800	15190	0	0	0	78990
5	19232600	4045960	6869240	8568440	26769300	42600	29760	0	0	0	72360
6	19313800	4075720	6869240	8568440	26769300	81200	19560	0	0	0	100760
7	19357700	4095280	6869240	8568440	26769300	43900	28740	0	0	0	72640
8	19440300	4124020	6869240	8568440	26769300	82600	20720	0	0	0	103320
9	19491200	4144740	6869240	8568440	26769300	50900	25380	0	0	0	76280
10	19565100	4170120	6869240	8568440	26769300	73900	23680	0	0	0	97580
11	19624400	4193800	6869240	8568440	26769300	59300	21510	0	0	0	80810
12	19683600	4215310	6869240	8568440	26769300	59200	22610	0	0	0	81810
13	19745800	4237920	6869240	8568440	26769300	62200	25170	0	0	0	87310
14	19814700	4263090	6869240	8568440	26769300	68900	20060	0	0	0	88960
15	19866100	4283150	6869240	8568440	26769300	51400	23020	0	0	0	74420
16	19923000	4306170	6869240	8568440	26769300	56900	27430	0	0	0	84330
17	19997800	4333600	6869240	8568440	26769300	74800	16720	0	0	0	91520
18	20037000	4350320	6869240	8568440	26769300	39200	24380	0	0	0	63580
19	20098700	4374700	6869240	8568440	26769300	61700	21300	0	30	0	83000
20	20158500	4396000	6869240	8568470	26769300	59800	25030	0	0	0	84830
21	20222700	4421030	6869240	8568470	26769300	64200	23930	0	0	0	88130
22	20287200	4444960	6869240	8568470	26769300	64500	19910	0	0	0	84410
23	20328900	4464870	6869240	8568470	26769300	41700	24800	0	0	0	66500
24	20381600	4489670	6869240	8568470	26769300	52700	25870	0	0	0	78570
25	20437100	4515540	6869240	8568470	26769300	55500	22210	0	0	0	77710
26	20492100	4537750	6869240	8568470	26769300	55000	22230	0	0	0	77230
27	20538900	4559980	6869240	8568470	26769300	46800	24290	0	0	0	71090
28	20587600	4584270	6869240	8568470	26769300	48700	25020	0	0	0	73720
29	20638500	4609290	6869240	8568470	26769300	50900	20940	0	0	0	71840
30	20685500	4630230	6869240	8568470	26769300	47000	22530	0	11200	0	69530
31	20732700	4652760	6869240	8579670	26769300	47200	24130	0	11540	0	71330

Lewiston Park Mutual Water Company

2014 IRWM Drought Solicitation Project Application

Total Gallons	2538320

	Month/Year FEB-2014		Lewiston Park Mutual Water Co.					Operator	Wayne Carlson		
			Meter Read		System No. 5301003			Gallons			Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1	20786600	4676890	6869240	8591210	26769300	0	20610	0	34900	0	55510
2	20786600	4697500	6869240	8626110	26769300	700	21470	0	35800	0	57970
3	20787300	4718970	6869240	8661910	26769300	23500	24180	0	40280	0	87960
4	20810800	4743150	6869240	8702190	26769300	0	21850	0	37380	0	59230
5	20810800	4765000	6911720	8739570	26769300	0	17770	34900	31040	0	83710
6	20810800	4782770	6946620	8770610	26769300	0	23170	46050	41790	0	111010
7	20860400	4805940	6992670	8812400	26769300	0	17180	34340	0	0	51520
8	20900400	4823120	7027010	8812400	26769300	70300	26100	53350	0	0	149750
9	20970700	4849220	7080360	8812400	26769300	35300	16000	32880	0	0	84180
10	21006000	4865220	7113240	8812400	26769300	64000	21690	45670	0	0	131360
11	21070000	4886910	7158910	8812400	26769300	37200	19100	40300	0	0	96600
12	21107200	4906010	7199210	8812400	26769300	68500	17520	36290	0	0	122310
13	21175700	4923530	7235500	8812400	26769300	39800	17680	38590	0	0	96070
14	21215500	4941210	7274090	8812400	26769300	65200	21240	45910	0	0	132350
15	21280700	4962450	7320000	8812400	26769300	49900	16950	36550	0	0	103400
16	21330600	4979400	7356550	8812400	26769300	59100	21020	45950	0	0	126070
17	21389700	5000420	7402500	8812400	26769300	45500	163230	34200	0	0	95930
18	21435200	5016650	7436700	8812400	26769300	54300	19500	44200	0	0	118000
19	21489500	5036150	7480900	8812400	26769300	50900	18250	40400	0	0	109550
20	21540400	5054400	7521300	8812400	26769300	57800	20820	46600	0	0	125220
21	21598200	5075220	7567900	8812400	26769300	54000	18920	42360	0	0	115280
22	21652200	5094140	7610260	8812400	26769300	36900	16450	36810	0	0	90160
23	21689100	5110590	7647070	8812400	26769300	36800	15970	36430	30	0	89230
24	21725100	5126560	7683500	8812430	26769300	49500	18100	40600	36670	0	144870
25	21775400	5144660	7724100	8849100	29771300	39800	17160	37680	0	0	94640
26	21815200	5161820	7761780	8849100	26769300	26500	21310	46310	6460	0	100580
27	21841700	5183130	7808090	8855560	26769300	7300	15770	34480	32450	2100	92100
28	21849000	5198900	7842570	8888010	26771400	0	16270	35700	34120	16300	102390
29											

30											
31											
									Total Gallons		2771440

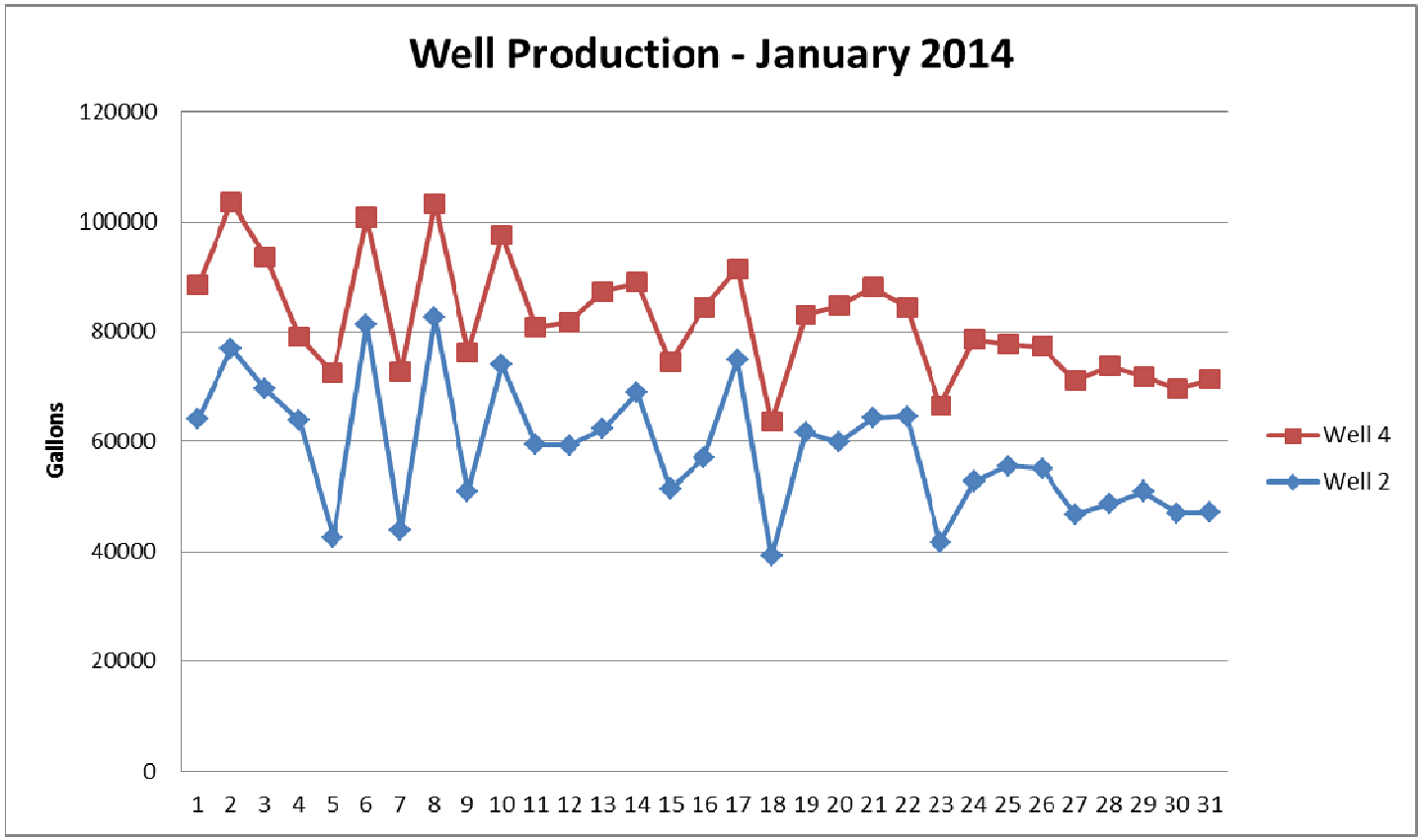
	Month/Year March 2014							Operator	Wayne Carlson		
			Meter Read			System No. 5301003		Gallons			Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1	21849000	5215170	7878270	8922130	26787700	0	22070	41810	40460	18800	123140
2	21849000	5234240	7920080	8962590	26806500	13500	16260	35680	33750	15300	114490
3	21862500	5250500	7955760	8996340	26821800	30600	17660	39470	11480	13600	112810
4	21893100	5268160	7995230	9007820	26835400	52800	20870	46250	0	15700	135620
5	21945900	5289030	8041480	9007820	2685110	34500	14010	31160	0	12000	91670
6	21980400	5303040	8072640	9007820	26863100	4400	14390	32140	22780	14700	88420
7	21984800	5317430	8104780	9030600	26877800	0	21490	48120	34890	22800	127300
8	21984800	5338920	8152900	9068490	26900600	0	8460	24270	17980	16200	66910
9	21984800	5347380	8177170	9086470	26916800	38900	15290	51900	19590	9900	135580
10	22023700	5362670	8204800	9106060	26929700	0	21290	48420	32200	2010	122010
11	22023700	5383960	8253220	9138260	26949800	0	13520	31490	28200	13800	87010
12	22023700	5397480	8284710	9166460	26963600	0	17960	30170	27450	20500	96080
13	22023700	5415440	8314880	9193910	26984100	0	19310	38330	45580	800	104020
14	22023700	5434750	8353210	9239490	26984900	0	24440	18203	31000	14000	87643
15	22023700	5459190	8535240	9270490	26998900	0	13890	31170	39190	12300	96550
16	22023700	5473080	8353240	9309680	27011200	1640	35810	0	39030	28300	119540
17	22040100	5492490	8353240	9348710	27039500	0	0	0	20280	17000	37280
18	22040100	5492490	8353240	9368990	27056500	0	70090	0	31750	0	101840
19	22040100	5526770	8353240	9400740	27056500	0	20130	0	38740	0	58870
20	22040100	5546900	8353240	9439480	27056500	0	17510	0	40810	0	58320
21	22040100	5564410	8353240	9480290	27056500	0	18650	0	26950	0	45600
22	22040100	5583060	8353240	9507240	27056500	0	19370	0	36160	0	55530
23	22040100	5602430	8353240	9543400	27056500	10	19380	310	35910	0	55610
24	22040110	5621810	8353550	9579310	27056500	0	20410	31200	38130	0	89740
25	22040110	5642220	8384750	9617440	27056500	0	19910	820	28880	0	49610
26	22040110	5662130	8385570	9646320	27056500	0	19320	0	37620	0	56940
27	22040110	5681450	8385570	9683940	27056500	0	0	31250	35220	0	66470

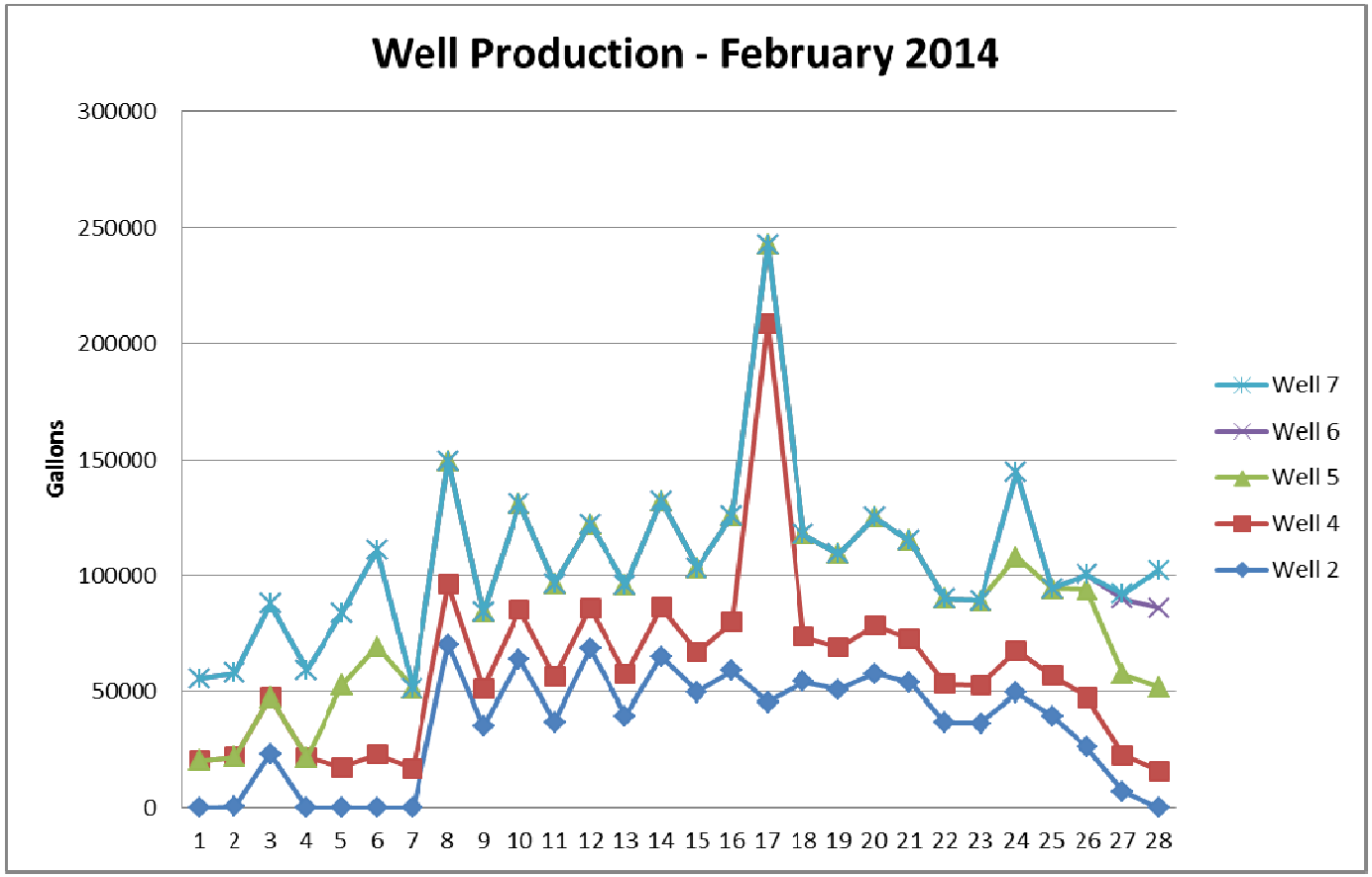
28	22040110	5681450	8416820	9719160	27056500	0	0	32530	36250	0	68780
29	22040110	5681450	8449350	9755410	27056500	0	0	35680	40250	0	75930
30	22040110	5681450	8485030	9795660	27056500	0	0	28990	32780	0	61770
31	22040110	5681450	8514020	9828440	27056500	0	0	37210	0	0	37210
									Total Gallons		2628293

	Month/Year: April 2014							Operator	Wayne Carlson		
			Meter Read			System No. 5301003		Gallons			Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1	22040010	5681450	8551230	9828440	27056500	0	18610	28340	0	0	46950
2	22040010	57000160	8579570	9828440	27056500	0	19680	31510	0	0	51190
3	22040010	5719740	8611080	9828440	27056500	0	0	30620	34530	0	65150
4	22040010	5719740	8641700	9862970	27056500	0	22870	35090	39520	0	97480
5	22040010	5742610	8676790	9902490	27056500	64500	19610	31650	0	0	115760
6	22104600	5762220	8708440	9902490	27056500	0	18090	29560	0	0	47650
7	22104600	5780310	5738000	9902490	27056500	63500	22080	36090	41030	0	162700
8	22168100	5802390	8774090	9943520	27056500	0	23050	0	37340	0	60390
9	22168100	5825920	8774090	9980860	27056500	0	18070	30590	8550	0	57210
10	22168100	5843990	8804680	9410	27056500	0	16990	28980	9890	0	55860
11	22168100	5860980	8833660	19300	27056500	0	3550	5920	38780	0	48250
12	22168100	5864530	8839580	580820	27056500	0	21430	33000	35780	0	90210
13	22168100	5885960	8872580	93860	27056500	0	26610	42880	47090	0	116580
14	22168100	5912570	8915460	140950	27056500	0	12060	20180	22490	0	54730
15	22168100	5924630	8365640	163440	27056500	0	20260	23350	3533	0	78940
16	22168100	5944890	8958990	198770	27056500	0	22020	4522	27760	0	95000
17	22168100	5966910	9004210	226530	27056500	0	18860	31030	19640	0	69530
18	22168100	5985770	9035240	246170	27056500	0	20440	34030	32140	0	86610
19	22168100	6006210	9069270	278310	27056500	0	52230	37570	41280	0	13180
20	22168100	6028440	9106840	319590	27056500	0	16500	27580	30400	0	74480
21	22168100	6044940	9134420	349990	27056500	0	21100	35650	29290	0	86040
22	22168100	6066040	9170070	379280	27056500	0	21180	35740	32420	0	89340
23	22168100	6087220	9205810	411700	27056500	0	19880	34190	36530	0	90600
24	22168100	6107100	9240000	448230	27056500	0	18220	31170	17590	0	66980

25	22168100	6125320	9271170	465820	27056500	0	17870	30440	17910	0	66220
26	22168100	6143220	9301610	483730	27056500	0	22510	38200	354100	0	96120
27	22168100	6165730	9339810	519140	27056500	0	16370	28130	31680	0	76180
28	22168100	6182100	9367940	550820	27056500	0	20300	34570	38490	0	93360
29	22168100	6202400	9402510	589310	27056500	0	21400	34680	37980	0	92760
30	22168100	6222500	9437190	627290	27056500	0	16400	28050	30470	0	74920
31											
									Total Gallons:		2320370

	Month/Year: May 2014							Operator	Wayne Carlson		
			Meter Read			System No. 5301003		Gallons			Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1	22168100	6238900	9465240	657760	27056500	0	23270	40200	16910	0	80380
2	22168100	6262170	9505440	674670	27056500	99900	16160	27890	0	0	143950
3	22268000	6278330	9533330	674670	27056500	55300	21010	36460	0	0	112770
4	22323300	6299340	9569790	674670	27056500	51100	19320	33810	0	0	104230
5	2237440	6318660	9603600	674670	27056500	0	18140	31700	31570	0	81410
6	22374400	6336800	9635300	706240	27056500	0	15420	27260	30640	0	73320
7	22374400	6352220	4662560	736880	27056500	62100	18880	33040	28110	0	142130
8	22436500	6371100	9695600	764990	27056500	0	21610	37870	37010	0	96490
9	22436500	6392710	9733470	802000	27056500	0	14700	25850	29170	0	69720
10	22436500	6407410	9759320	831170	27056500	0	22900	40630	40540	0	104070
11	22436500	6430310	9799950	871710	27056500	55000	14710	24340	27810	0	121860
12	22491500	6445020	9824290	899520	27056500	5600	19150	32850	37990	0	95590
13	22497100	6464170	9857140	937510	27056500	73000	20030	34380	39690	15400	182500
14	22570100	6484200	9891520	977200	27071900	45300	14460	25220	23150	11900	120030
15	22615400	6498660	9916740	1000350	27083800	6720	18770	33280	3630	14500	137380
16	22682600	6517430	9950020	1003980	27098300	81400	23280	40540	0	17600	162820
17	22764000	6540710	999560	1003980	27115900	62000	31620	61820	0	13200	168640
18	22826000	6572330	28740	1003980	27129100	32800	730	18970	0	10900	63400
19	22858800	6573060	47710	1003980	27140000	70300	0	32630	40920	200	144050
20	22929100	6573060	80340	1044900	27140200	63700	0	37880	36520	0	138100
21									Total Gallons:		2342840


Well Production - January 2014
Gallons
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Well 4
Well 2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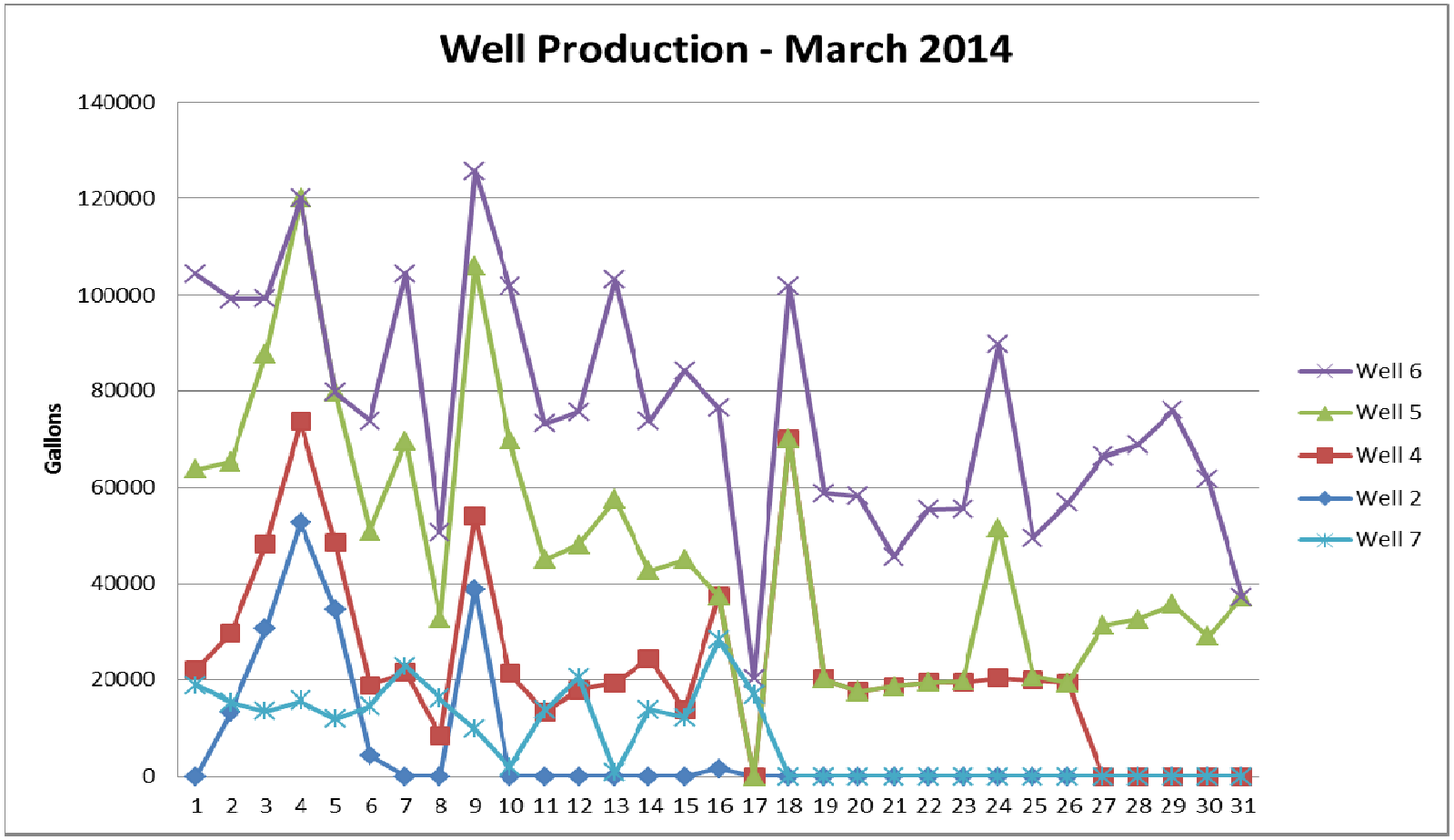
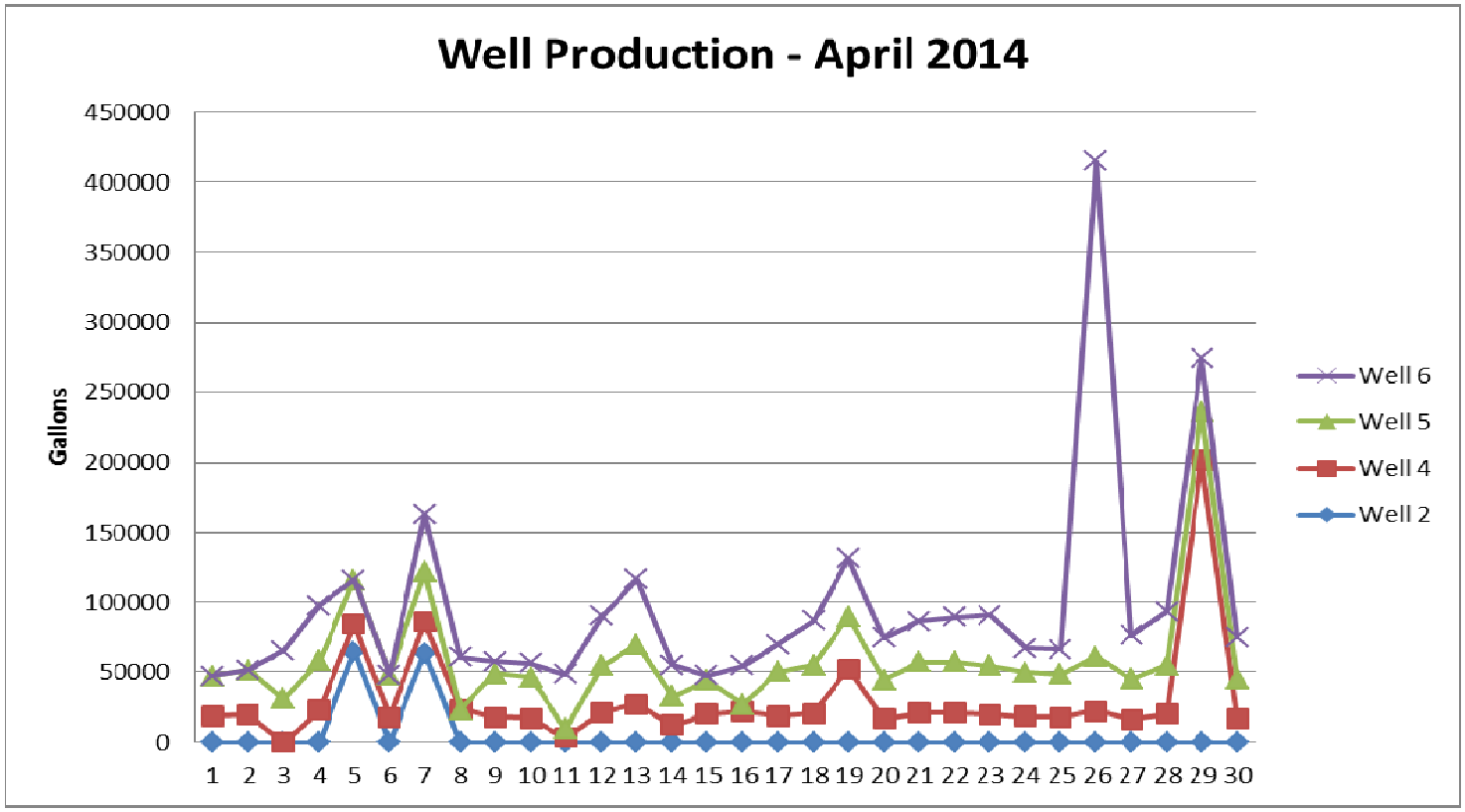
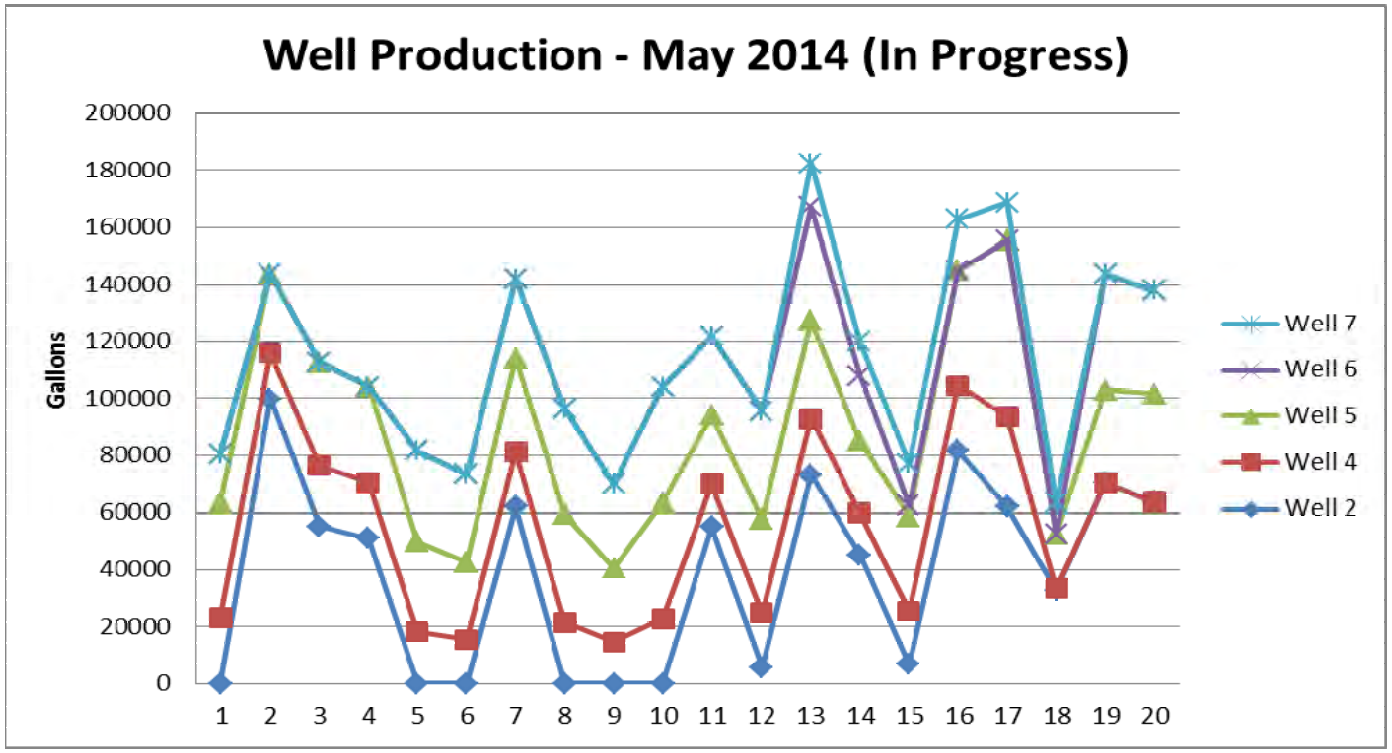
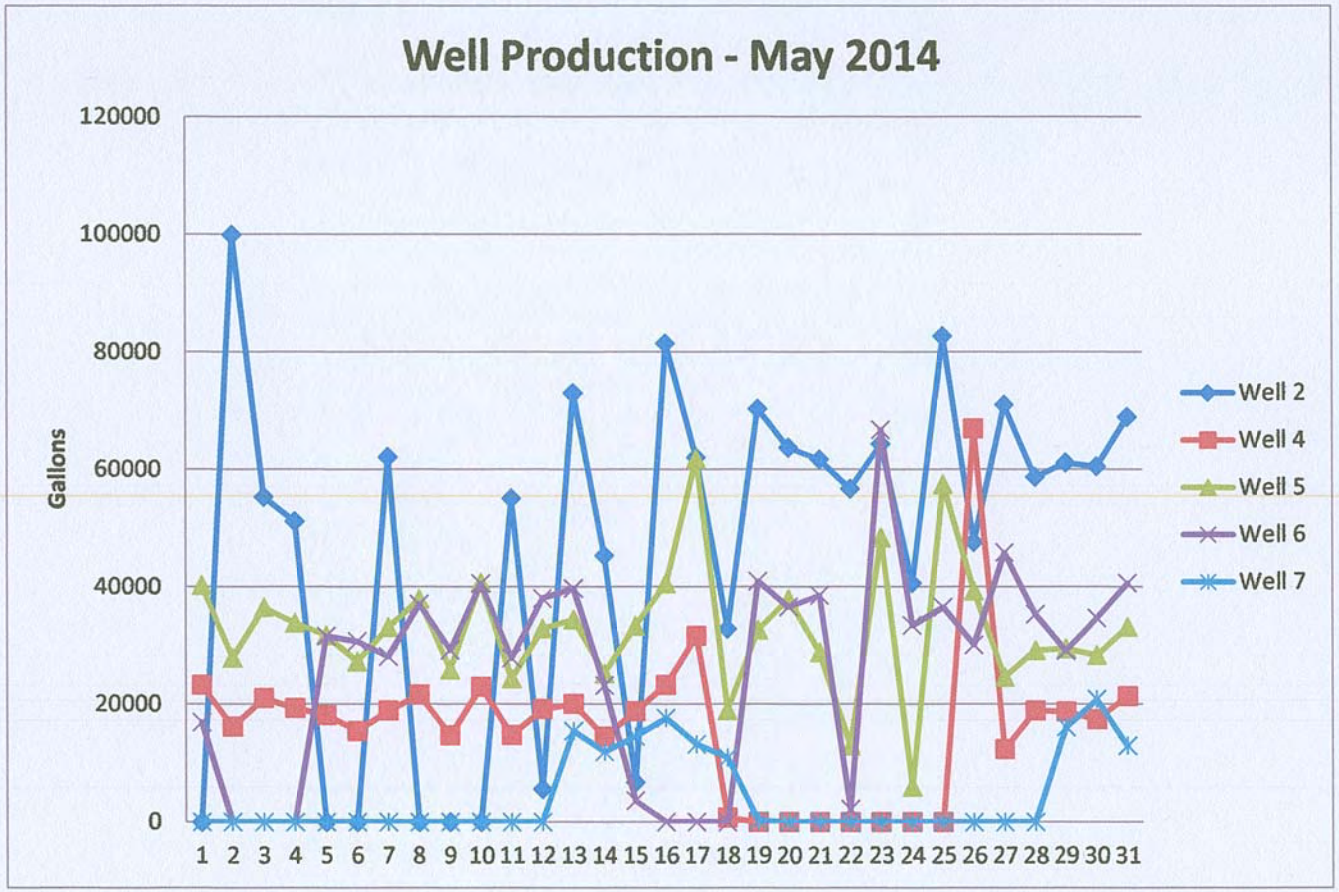
Gallons
300000
250000
200000
150000
100000
50000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Well 7
Well 6
Well 5
Well 4
Well 2


Well Production - March 2014
Gallons
140000
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Well 6
Well 5
Well 4
Well 2
Well 7

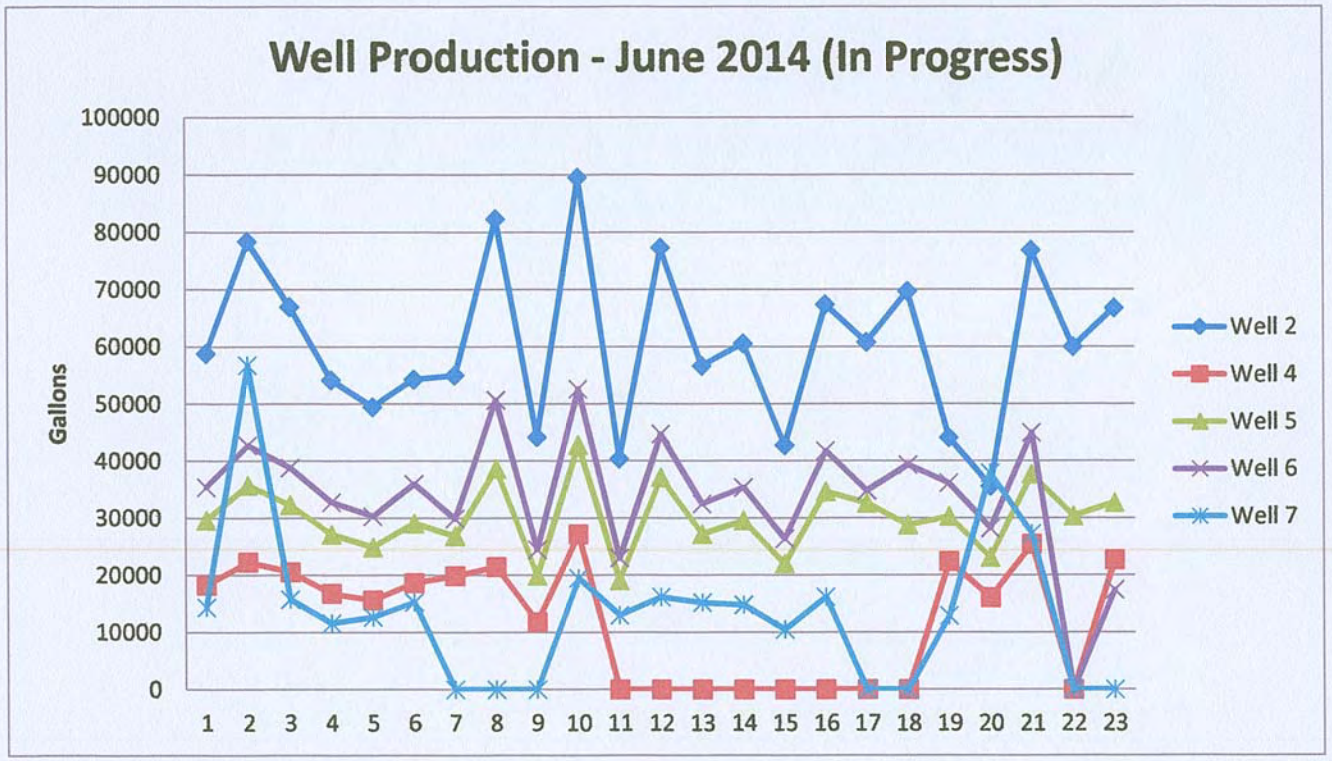

Well Production - April 2014
Gallons
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Well 6
Well 5
Well 4
Well 2


Well Production - May 2014 (In Progress)
Gallons
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Well 7
Well 6
Well 5
Well 4
Well 2

Month/Year: May 2014								Operator	Wayne Carlson		
		Meter Read			System No. 5301003		Gallons				Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1	22168100	6238900	9465240	657760	27056500	0	23270	40200	16910	0	80380
2	22168100	6262170	9505440	674670	27056500	99900	16160	27890	0	0	143950
3	22268000	6278330	9533330	674670	27056500	55300	21010	36460	0	0	112770
4	22323300	6299340	9569790	674670	27056500	51100	19320	33810	0	0	104230
5	22374400	6318660	9603600	674670	27056500	0	18140	31700	31570	0	81410
6	22374400	6336800	9635300	706240	27056500	0	15420	27260	30640	0	73320
7	22374400	6352220	4662560	736880	27056500	62100	18880	33040	28110	0	142130
8	22436500	6371100	9695600	764990	27056500	0	21610	37870	37010	0	96490
9	22436500	6392710	9733470	802000	27056500	0	14700	25850	29170	0	69720
10	22436500	6407410	9759320	831170	27056500	0	22900	40630	40540	0	104070
11	22436500	6430310	9799950	871710	27056500	55000	14710	24340	27810	0	121860
12	22491500	6445020	9824290	899520	27056500	5600	19150	32850	37990	0	95590
13	22497100	6464170	9857140	937510	27056500	73000	20030	34380	39690	15400	182500
14	22570100	6484200	9891520	977200	27071900	45300	14460	25220	23150	11900	120030
15	22615400	6498660	9916740	1000350	27083800	6720	18770	33280	3630	14500	137380
16	22682600	6517430	9950020	1003980	27098300	81400	23280	40540	0	17600	162820
17	22764000	6540710	999560	1003980	27115900	62000	31620	61820	0	13200	168640
18	22826000	6572330	28740	1003980	27129100	32800	730	18970	0	10900	63400
19	22858800	6573060	47710	1003980	27140000	70300	0	32630	40920	200	144050
20	22929100	6573060	80340	1044900	27140200	63700	0	37880	36520	0	138100
21	22992800	6573060	118220	1081420	27140200	61700	0	28790	38490	0	128980
22	23054500	6573060	147010	1119910	27140200	56700	0	12980	2190	0	71870
23	23111200	6573060	159990	1122100	27140200	64300	0	48340	66700	0	179340
24	23175500	6573060	208330	1188800	27140200	40600	0	5980	33400	0	79980
25	23216100	6573060	214310	1222200	27140200	82700	0	57410	36470	0	176580
26	23298800	6570360	271720	1258670	27140200	47600	66940	39280	30090	0	183910
27	23346400	6640000	311000	1288760	27140200	71000	12300	24610	45820	0	153730
28	23417400	6652300	335610	1334580	27140200	58700	18910	29160	35290	0	142060
29	23476100	6671210	364770	1369870	27140200	61100	18720	29430	29090	16100	154440
30	23537200	6689930	394200	1398960	27156300	60500	17390	28290	34650	20800	161630
31	23597700	6707320	422490	1433610	27177100	68900	21370	33090	40570	12900	176830
									Total Gallons:		3871810


Well Production - May 2014
Gallons
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Well 2
Well 4
Well 5
Well 6
Well 7

Month/Year: June 2014 (In Progress)								Operator	Wayne Carlson		
		Meter Read			System No. 5301003	Gallons					Total
Date	Well 2	Well 4	Well 5	Well 6	Well 7	Well 2	Well 4	Well 5	Well 6	Well 7	Gallons
1	23666600	6728690	455580	1474180	27190000	58800	18310	29650	35410	14400	156570
2	23725400	6747000	485230	1509590	27204400	78400	22290	35740	42770	56770	235970
3	23803800	6769290	520970	1552360	27218400	67000	20600	32320	38830	15800	174550
4	23870800	6789890	553290	1591190	27234200	54200	16780	27170	32800	11600	142550
5	23925000	6806670	580460	1623990	27245800	49500	15630	24940	30310	12700	133080
6	23974500	6822300	605400	1654300	27258500	54300	18660	29110	35990	15300	153360
7	24028800	6840960	634510	1690290	27273800	55000	19880	26890	29900	0	131670
8	24083800	6860840	661400	1720190	27273800	82300	21470	38640	50700	0	193110
9	24166100	6882310	700040	1770890	27273800	44200	11820	19920	24500	0	100440
10	24210300	6894130	719960	1795390	27273800	89600	27170	42840	52620	19500	231730
11	24299900	6921300	762800	1848010	27293300	40400	0	19110	22980	13000	95490
12	24340300	6921300	781910	1870990	27306300	77300	0	37150	44760	16200	175410
13	24417600	6921300	819060	1915750	27322500	56700	0	27240	32500	15200	131640
14	24474300	6921300	846300	1948250	27337700	60600	0	29570	35390	14800	140360
15	24534900	6921300	875870	1983640	27352500	42800	0	22060	26400	10500	101760
16	24577700	6921300	897930	2010040	27363000	67400	0	34670	41770	16200	160040
17	24645100	6921300	932600	2051810	27379200	60800	0	32610	34840	0	128250
18	24705900	6921300	965210	2086650	27379200	69700	0	28820	39330	0	137850
19	24775600	6921300	994030	2125980	27379200	44100	22390	30300	36120	12900	145810
20	24819700	6943690	124330	2162100	27392100	35600	16090	23090	28250	37900	140930
21	24855300	6959780	1047420	2190350	27430000	76900	25440	37700	45000	27300	212340
22	24932200	6985220	1085120	2235350	27419400	60000	0	30380	0	0	90380
23	24992200	6985220	1115500	2235350	27419400	66800	22680	32720	17450	0	139650
24											
25											
26											
27											
28											
29											
30											
31											
									Total Gallons:		3452940


Well Production - June 2014 (In Progress)
Gallons
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Well 2
Well 4
Well 5
Well 6
Well 7

Recordall® Disc Meters

Lead-Free Bronze Alloy, Sizes 5/8", 5/8" x 3/4", 3/4" & 1"
NSF/ANSI Standards 61 and 372 Certified

Model LP—5/8", 5/8" × 3/4"

Model 25—5/8", 5/8" × 3/4"

Model 35—3/4"

Model 55—1"

Model 70—1"

DESCRIPTION

The Recordall Disc Series meters meet or exceed the most recent revision of AWWA Standard C700 and are available in a lead-free bronze alloy. The meters comply with the lead-free provisions of the Safe Drinking Water Act, are certified to NSF/ANSI Standards 61 and 372 (Trade Designations: MLP-LL, M25-LL, M35-LL, M55-LL, M70-LL) and carry the NSF-61 mark on the housing. All components of the lead-free bronze alloy meter (housing, measuring element, seals, and so on) comprise the certified system.

Applications: For use in measurement of potable cold water in residential, commercial and industrial services where flow is in one direction only.

Operation: Water flows through the meter's strainer and into the measuring chamber where it causes the disc to nutate. The disc, which moves freely, nutates on its own ball, guided by a thrust roller. A drive magnet transmits the motion of the disc to a follower magnet located within the permanently sealed register. The follower magnet is connected to the register gear train. The gear train reduces the disc nutations into volume totalization units displayed on the register or encoder face.

Operating Performance: The Recordall Disc Series meters meet or exceed registration accuracy for the low flow rates (95%), normal operating flow rates (100 ± 1.5%), and maximum continuous operation flow rates as specifically stated in AWWA Standard C700.

Construction: Recordall Disc meter construction, which complies with ANSI/AWWA standard C700, consists of three basic components: meter housing, measuring chamber, and permanently sealed register or encoder. The meter is available in a lead-free bronze alloy with externally-threaded spuds. A corrosion-resistant engineered polymer material is used for the measuring chamber.

Magnetic Drive: Direct magnetic drive, through the use of high-strength magnets, provides positive, reliable and dependable register coupling for straight-reading or AMR/AMI meter reading options.

Tamper-Proof Features: Unauthorized removal of the register or encoder is inhibited by the option of a tamper detection seal wire screw, TORX® tamper-resistant seal screw or the proprietary tamper-resistant keyed seal screw. Each can be installed at the meter site or at the factory.

Maintenance: Badger Meter Recordall Disc Series meters are designed and manufactured to provide long-term service with minimal maintenance. When maintenance is required, it can be performed easily either at the meter installation or at any other convenient location.

To simplify maintenance, the register, measuring chamber, and strainer can be replaced without removing the meter housing from the installation. No change gears are required for accuracy calibration. Interchangeability of parts among like-sized meters and meter models also minimizes spare parts inventory investment. The built-in strainer has an effective straining area of twice the inlet size.

Connections: Tailpieces/Unions for installations of meters on various pipe types and sizes, including misaligned pipes, are available as an option.

Meter Spud and Connection Sizes

Model	Size Designation	×	"L" Laying Length	"B" Bore Dia.	Coupling Nut and Spud Thread	Tailpiece Pipe Thread (NPT)
LP	5/8"	×	7-1/2"	5/8"	3/4" (5/8")	1/2"
	5/8" x 3/4"	×	7-1/2"	5/8", 3/4"	1" (3/4")	3/4"
25	5/8"	×	7-1/2"	5/8"	3/4" (5/8")	1/2"
	5/8" x 3/4"	×	7-1/2"	5/8", 3/4"	1" (3/4")	3/4"
35	3/4"	×	7-1/2"	3/4"	1" (3/4")	3/4"
	3/4"	×	9"	3/4"	1" (3/4")	3/4"
	3/4" x 1"	×	9"	3/4"	1-1/4" (1")	1"
55	1"	×	10-3/4"	1"	1-1/4" (1")	1"
70	1"	×	10-3/4"	1"	1-1/4" (1")	1"

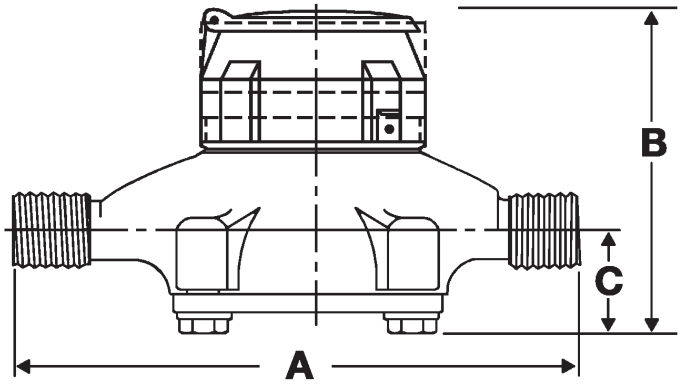
SPECIFICATIONS

	Model LP (5/8" & 5/8" × 3/4")	**Model 25 (5/8" & 5/8" × 3/4")**	**Model 35 (3/4")**	**Model 55 (1")**	**Model 70 (1")**
Typical Operating Range (100% ± 1.5%)	0.5…20 gpm (0.11…4.5 m^3/hr)	0.5…25 gpm (0.11…5.7 m^3/hr)	0.75…35 gpm (0.17…7.9 m^3/hr)	1…55 gpm (0.23…12.5 m^3/hr)	1.25…70 gpm (0.28…16 m^3/hr)
Low Flow	0.25 gpm (0.057 m^3/hr) Min. 95%	0.25 gpm (0.057 m^3/hr) Min. 98.5%	0.375 gpm (0.085 m^3/hr) Min. 97%	0.5 gpm (0.11 m^3/hr) Min. 95%	0.75 gpm (0.17 m^3/hr) Min. 95%
Maximum Continuous Operation	10 gpm (2.3 m^3/hr)	15 gpm (3.4 m^3/hr)	25 gpm (5.7 m^3/hr)	40 gpm (9.1 m^3/hr)	50 gpm (11.3 m^3/hr)
Pressure Loss at Maximum Continuous Operation	**5/8" size**: 2 psi @ 10 gpm (0.14 bar @ 2.3 m^3/hr) **5/8" × 3/4" size**: 1.5 psi @ 10 gpm (0.10 bar @ 2.3 m^3/hr)	**5/8" size**: 3.5 psi @ 15 gpm (0.24 bar @ 3.4 m^3/hr) **5/8" × 3/4" size**: 2.8 psi @ 15 gpm (0.19 bar @ 3.4 m^3/hr)	5 psi @ 25 gpm (0.37 bar @ 5.7 m^3/hr)	3.4 psi @ 40 gpm (0.23 bar @ 9.1 m^3/hr)	6.5 psi @ 50 gpm (0.45 bar @ 11.3 m^3/hr)
Maximum Operating Temperature	80° F (26° C)				
Maximum Operating Pressure	150 psi (10 bar)				
Measuring Element	Nutating disc, positive displacement				
Meter Connections	*Available in NL bronze and engineered polymer to fit spud thread bore diameter sizes:*				
	5/8" or 3/4" (DN 15 mm)	**5/8" size**: 5/8" (DN 15 mm) **5/8" × 3/4" size**: 3/4" (DN 15 mm)	3/4" (DN 20 mm)	1" (DN 25 mm)	1" (DN 25 mm)

MATERIALS

	Model LP (5/8" & 5/8" × 3/4")	**Model 25 (5/8" & 5/8" × 3/4")**	**Model 35 (3/4")**	**Model 55 (1")**	**Model 70 (1")**
Meter Housing	Lead-free bronze alloy				
Housing Bottom Plates	Lead-free bronze alloy, cast iron, engineered polymer		Cast iron, lead-free bronze alloy		
Measuring Chamber	Engineered polymer				
Disc	Engineered polymer				
Trim	Stainless steel				
Strainer	Engineered polymer				
Disc Spindle	Engineered polymer	Stainless steel	Stainless steel	Engineered polymer	Stainless steel
Magnet	Ceramic	Ceramic	Ceramic	Polymer bonded	Ceramic
Magnet Spindle	Engineered polymer	Stainless steel	Stainless steel	Engineered polymer	Stainless steel
Register Lid and Shroud	Engineered polymer, bronze				

DIMENSIONS



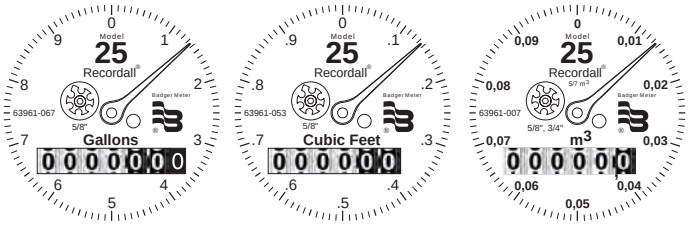
Meter Size	Model	A Laying Length	B Height Reg.	C Centerline Base	Width	Approx. Shipping Weight
5/8″ and 5/8″ × 3/4″ (15 mm)	LP	7-1/2" (190 mm)	3.70" (94 mm)	1.26" (32 mm)	3.75" (95 mm)	3 lb (1.4 kg)
5/8" (15 mm)	25	7-1/2" (190 mm)	4-15/16" (125 mm)	1-11/16" (42 mm)	4-1/4" (108 mm)	4-1/2 lb (2 kg)
5/8" × 3/4" (15 mm)		7-1/2" (190 mm)	4-15/16" (125 mm)	1-11/16" (42 mm)	4-1/4" (108 mm)	4-1/2 lb (2 kg)
3/4" (20 mm)	35	7-1/2" (190 mm)	5-1/4" (133 mm)	1-5/8" (41 mm)	5" (127 mm)	5-1/2 lb (2.5 kg)
3/4" (20 mm)		9" (229 mm)	5-1/4" (133 mm)	1-5/8" (41 mm)	5" (127 mm)	5-3/4 lb (2.6 kg)
3/4" × 1" (20 mm)		9" (229 mm)	5-1/4" (133 mm)	1-5/8" (41 mm)	5" (127 mm)	6 lb (2.7 kg)
1" (25 mm)	55	10-3/4" (273 mm)	6" (152 mm)	2-1/32" (52 mm)	6-1/4" (159 mm)	8-3/4 lb (3.9 kg)
1" (25 mm)	70	10-3/4" (273 mm)	6-1/2" (165 mm)	2-5/16" (59 mm)	7-3/4" (197 mm)	11-1/2 lb (5.2 kg)

REGISTERS / ENCODERS

Standard—Sweep-Hand Registration

The standard register is a straight-reading, permanently sealed magnetic drive register. Dirt, moisture, tampering and lens fogging problems are eliminated. The register has a six-odometer wheel totalization display, 360° test circle with center sweep hand, and flow finder to detect leaks. Register gearing is made of self-lubricating engineered polymer, which minimizes friction and provides long life. The multi-position register simplifies meter installation and reading. The register capacity is 10,000,000 gallons (1,000,000 ft^3, 100,000 m^3).

A Model 25 register is used in the following example:



Model	Gallon	Cubic Feet	Cubic Meter
LP	10	1	0.1
25 (5/8")	10	1	0.1/0.01
25 (5/8" × 3/4")	10	1	0.1/0.01
35	10	1	0.1
55	10	1	0.1
70	10	1	0.1

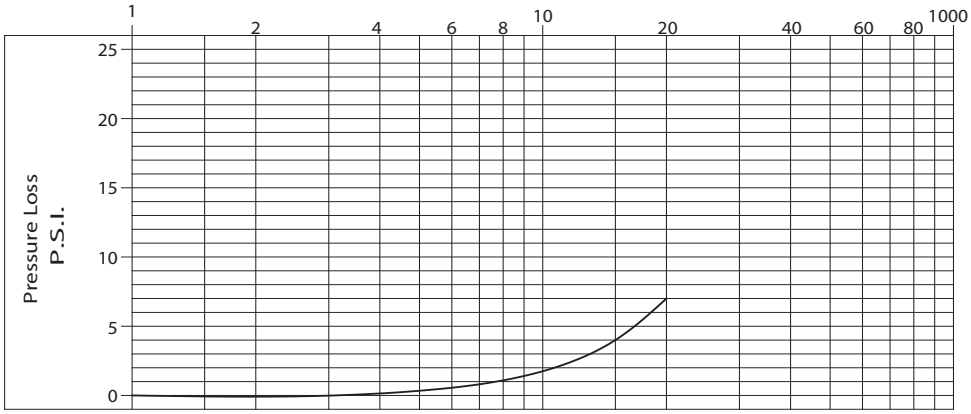
Optional—Encoders for AMR/AMI Reading Solutions

AMR/AMI solutions are available for all Recordall Disc Series meters. All reading options can be removed from the meter without disrupting water service. Badger Meter encoders provide years of reliable, accurate readings for a variety of applications and are also available pre-wired to Badger Meter approved AMR/AMI solutions. See details at **www.badgermeter.com**.

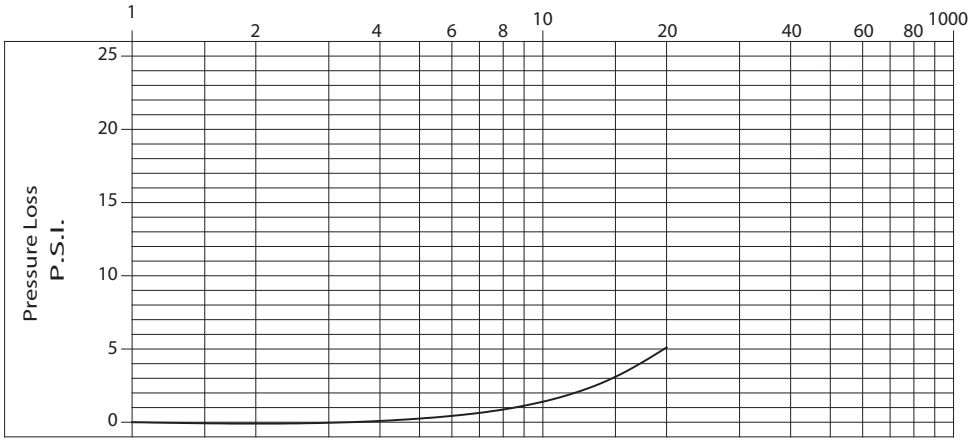
PRESSURE LOSS CHARTS

Rate of Flow in Gallons per Minute

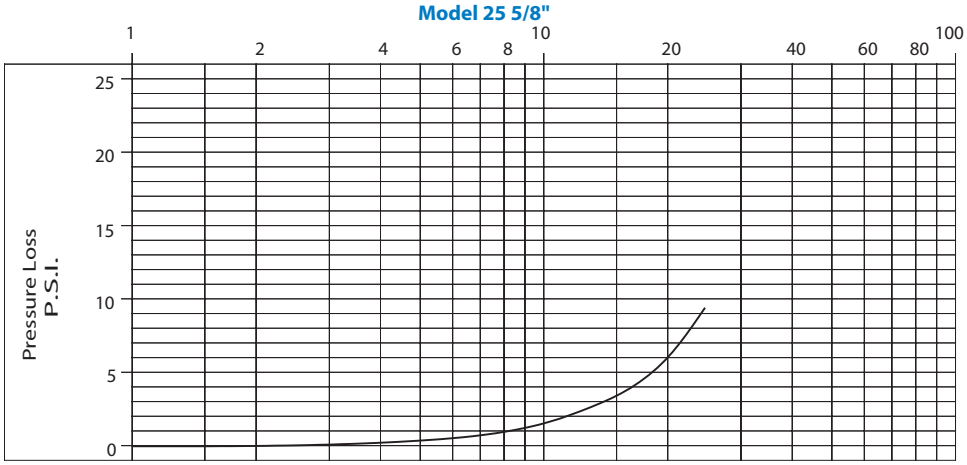
Model LP 5/8"



Model LP 5/8" × 3/4"



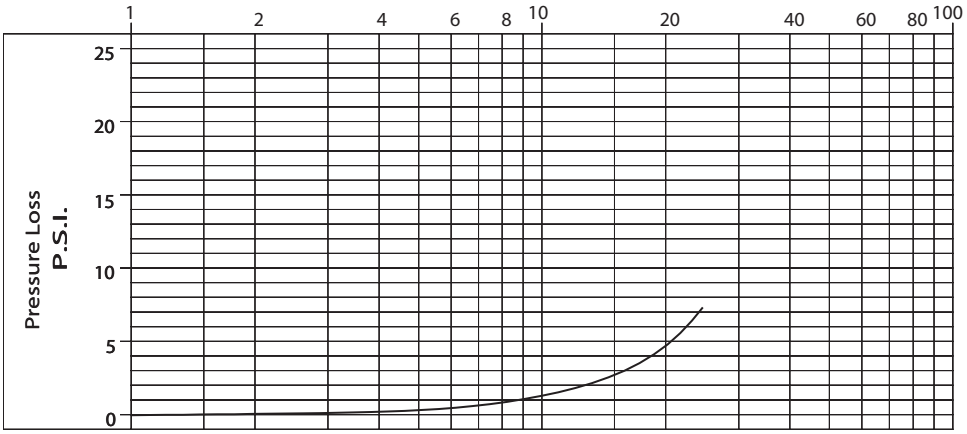
Model 25 5/8"



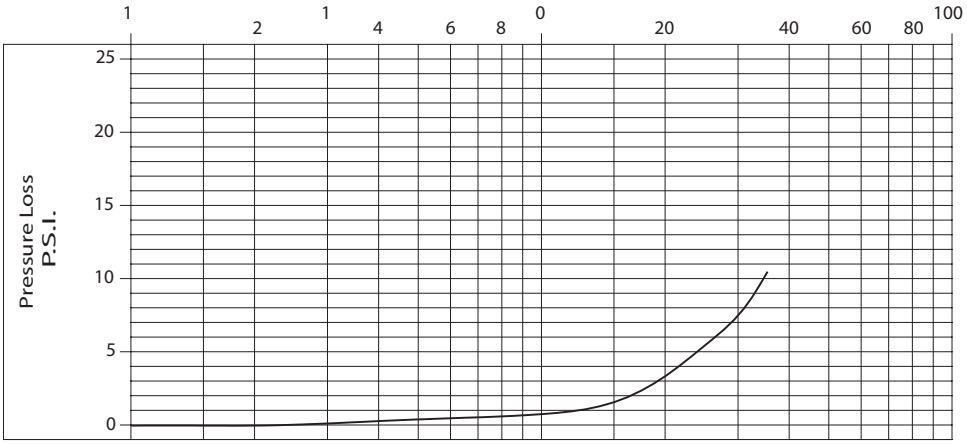
PRESSURE LOSS CHARTS (CONTINUED)

Rate of Flow in Gallons per Minute

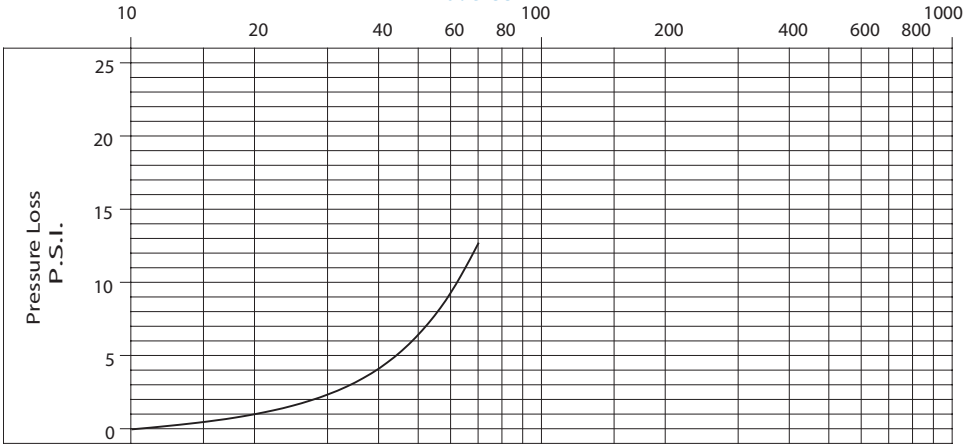
Model 25 5/8" × 3/4"



Model 35 3/4"



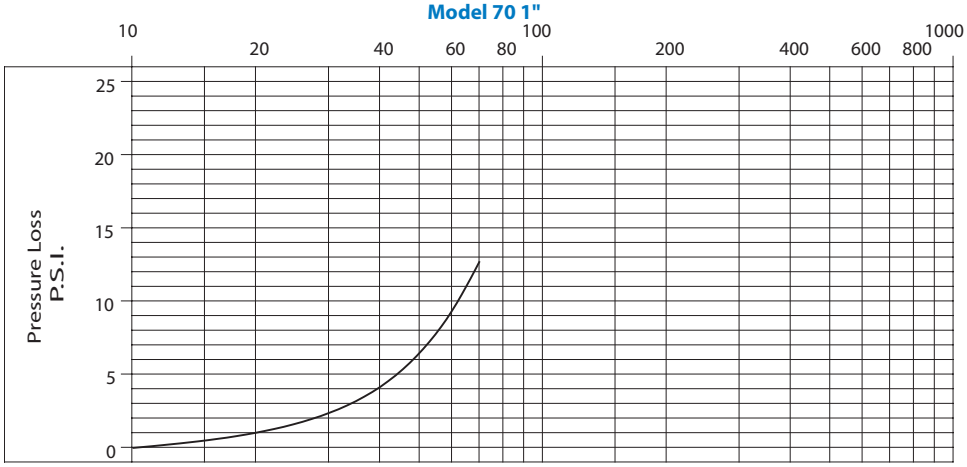
Model 55 1"



PRESSURE LOSS CHARTS (CONTINUED)

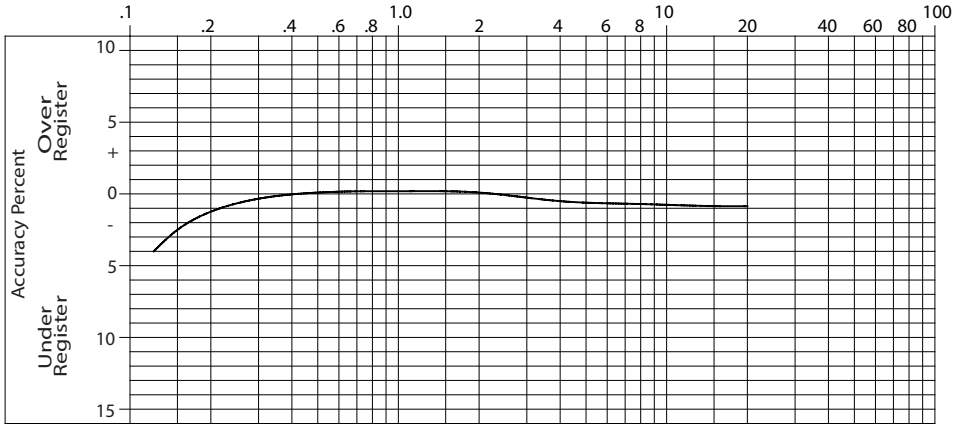
Rate of Flow in Gallons per Minute

Model 70 1"

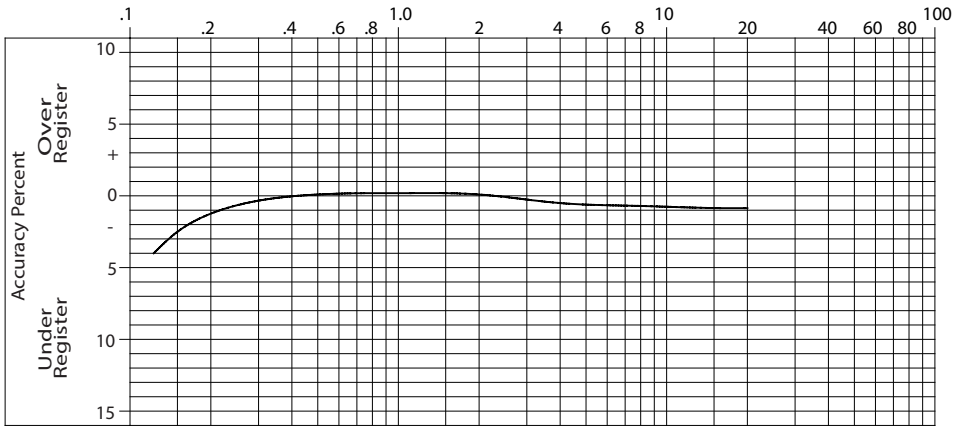


ACCURACY CHARTS

Model LP 5/8"



Model LP 5/8" × 3/4"



ACCURACY CHARTS (CONTINUED)

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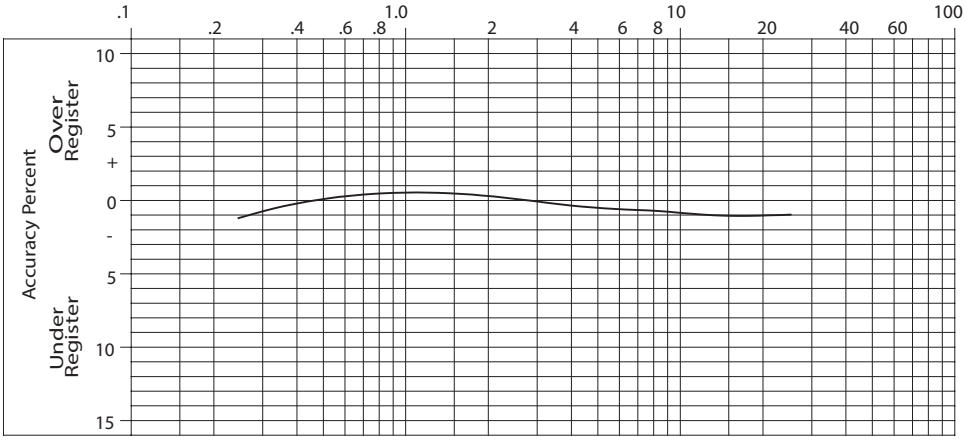

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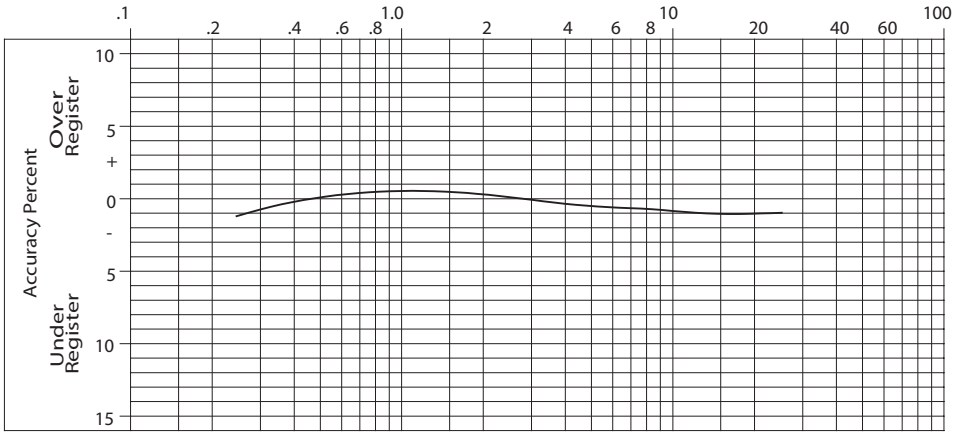
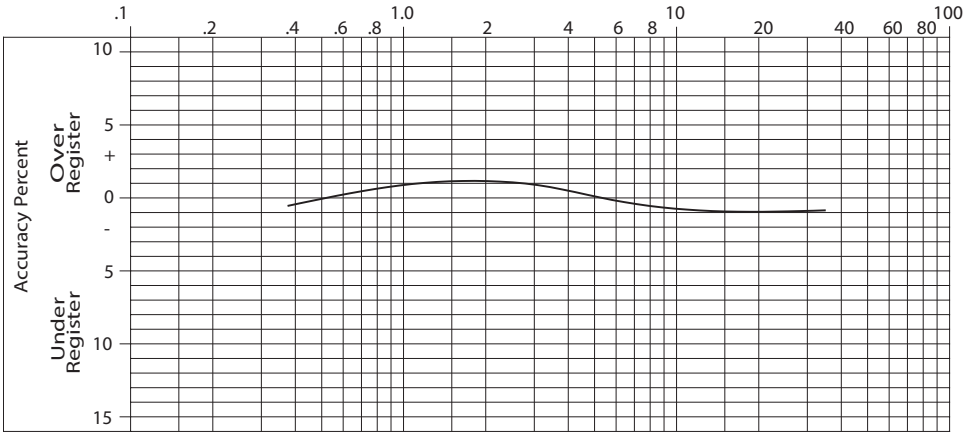
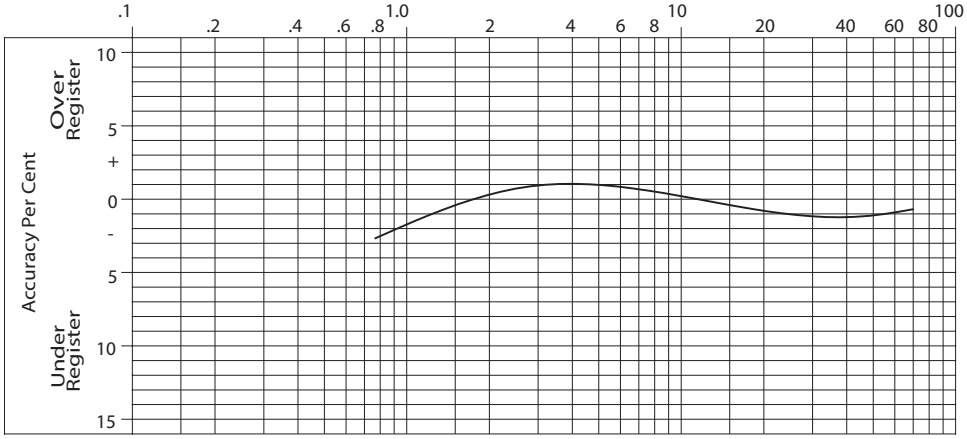


Model 35 3/4"

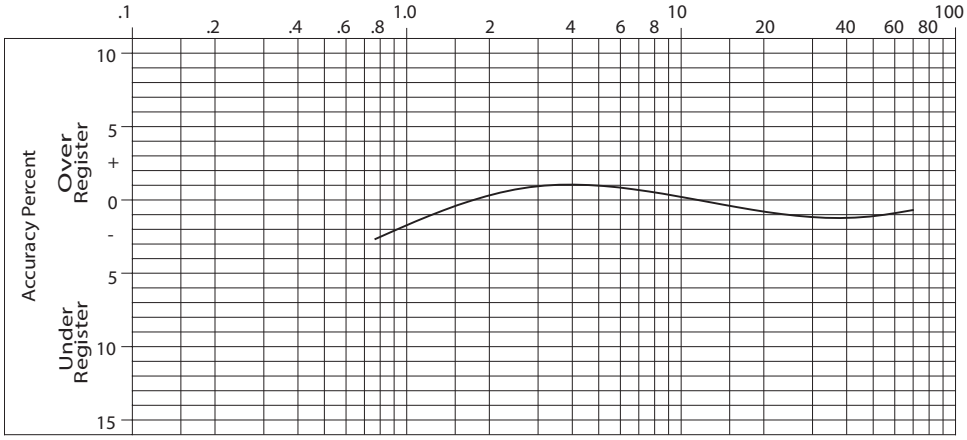


ACCURACY CHARTS (CONTINUED)

Model 55 1"



Model 70 1"



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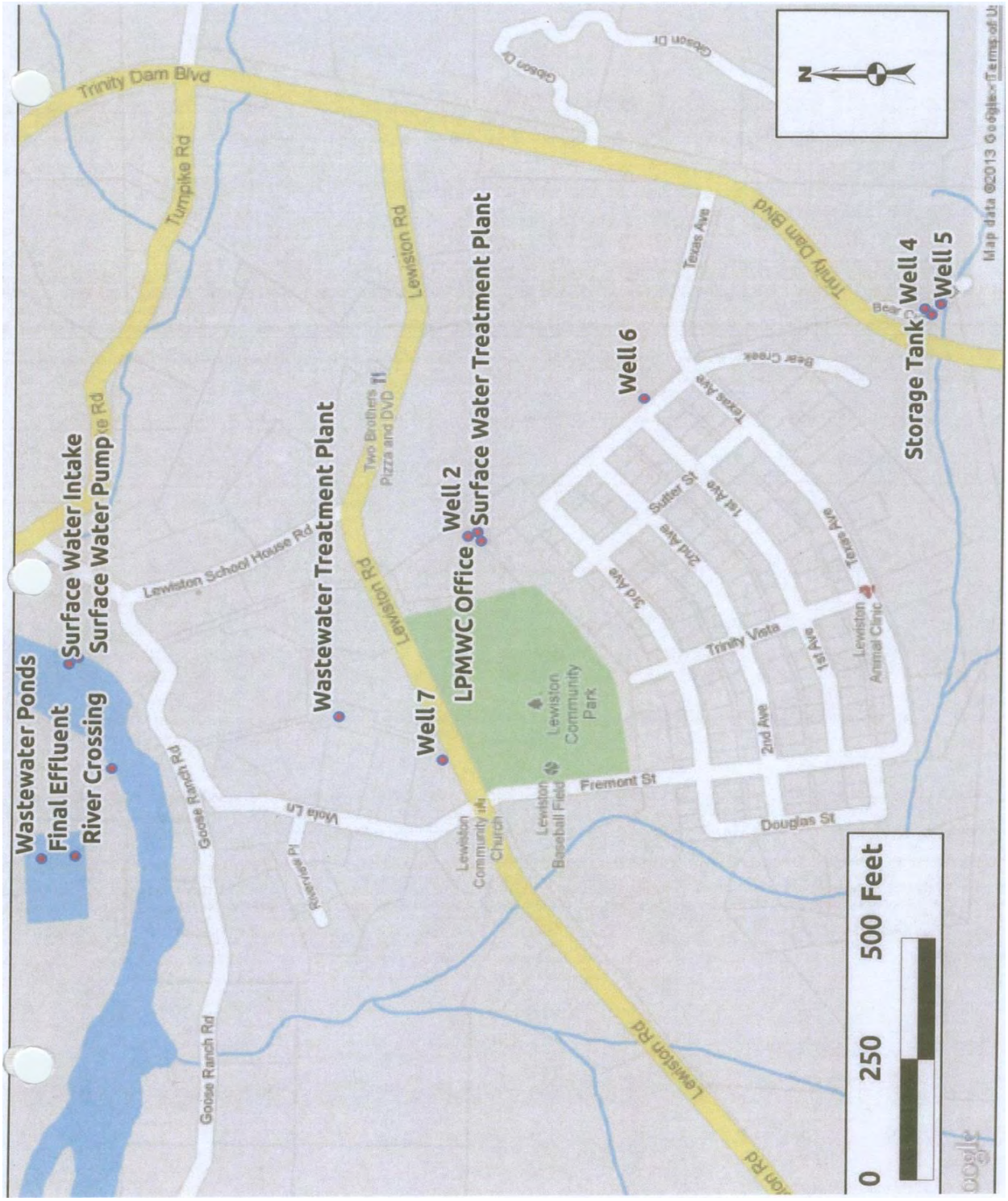
Asia Pacific | Badger Meter | 80 Marine Parade Rd | 21-06 Parkway Parade | Singapore 449269 | +65-63464836
China | Badger Meter | 7-1202 | 99 Hangzhong Road | Minhang District | Shanghai | China 201101 | +86-21-5763 5412

Legacy Document Numbers: RDM-DS-00062, 63, 64, 65, 66, and 73

Mutual Water Company (LPMWC)
Water and Wastewater Systems
Important Infrastructure
Final Effluent
Surface Water Intake
Surface Water Pump
River Crossing
Wastewater Treatment Plant
Well 7
LPMWC Office
Well 2
Surface Water Treatment Plant
Well 6
Storage Tank
Well 4
Well 5
0
250
500 Feet


Wastewater Ponds
Final Effluent
River Crossing
Surface Water Intake
Surface Water Pump
Wastewater Treatment Plant
Well 7
LPMWC Office
Well 2
Surface Water Treatment Plant
Well 6
Storage Tank
Well 4
Well 5
Trinity Dam Blvd
Turnpike Rd
Lewiston School House Rd
Lewiston Rd
Goose Ranch Rd
Two Brothers Pizza and DVD
Lewiston Community Park
Lewiston Baseball Field
Lewiston Community Church
Lewiston Animal Clinic
Fremont St
Douglas St
Trinity Vista
Texas Ave
Sutter St
1st Ave
2nd Ave
3rd Ave
Bear Creek
Gibson Dr
Viola Ln
Riverview Pl
0 250 500 Feet
N

blogs.kqed.org
http://blogs.kqed.org/science/2014/03/10/california-communities-that-pay-a-flat-rate-for-water-use-more-of-it/

California Communities That Pay a Flat Rate for Water Use More of It

Appendix B

Homes and businesses that pay a flat rate for their water use more of it per capita. (NVJ/Flickr)

By Mina Kim and Molly Samuel

For generations, water meters have been an important tool for measuring how much water we use in California, and the drought has intensified the significance of that measurement. But in 42 communities, homeowners and businesses don't have water meters installed. That adds up to more than 255,000 customers who pay a flat rate for their water.

Paul Rogers, the environment reporter at the San Jose Mercury News and managing editor of KQED Science, found that the flat-fee customers use more water, as he wrote in the Mercury News:

> *People without meters are charged a flat monthly rate in those areas for water, usually between $20 and $35 a month. And those communities use 39 percent more water per capita than the state average, according to an analysis of state Department of Water Resources records by this newspaper.*

"The city with the most unmetered connections is Sacramento," Rogers told KQED's Mina Kim. "Only half of Sacramento's connections have meters on them." Bakersfield, Modesto, Lodi and Merced also have a

Appendix B

significant number of unmetered connections. The first water meters began going in around World War I, so the communities with fewer meters lag far behind the rest of the state.

The list of California cities with unmetered water connections

"Most of the big cities in California, including San Francisco, San Jose, Oakland, Los Angeles have all had meters on all their water connections since at least the 1940s," Rogers said.

Part of the reason, he explained, is poverty. Farm towns like Hanford, Shafter and Corcoran in the Central Valley haven't had the money to put in meters. But that's not the case everywhere.

"The big cities, some of this is ideological. Over the years they have fought attempts to put in meters," he said. "Some people worried it would increase their bills. Other people, particularly in the Central Valley, were worried that if they saved water, more of it would go south to Los Angeles."

'It would be like going to the gas station and just paying $10 or $20, no matter how much gasoline you bought.'

In places where meters have gone in, water use has dropped. "Fresno finished putting in water meters last year and their daily water use per capita was 313 per person in 2012, and now it's 245 gallons per person," said Rogers.

"If you use more, you pay more, and that's something that is a really important incentive," he said. "It would be like going to the gas station and just paying $10 or $20, no matter how much gasoline you bought, whether you're driving a gas-sipping economy car or a Hummer."

All homes and business in California are required to have water meters by 2025, according to a law signed by Gov. Arnold Schwarzenegger. But, Rogers adds, there are other types of water users in California that don't have meters and don't fall under that law, including farms and individual units in apartment buildings.

Hear an edited version of their conversation, including an explanation of how Rogers figured out water use in places without water meters.

Related

Related

Drought Watch 2014

Bay Area: Do You Know Where Your Water Comes From?

California Drought: Town North of L.A. Could Run Out of Water

Icebergs and Green Paint: Lessons from California's Big Droughts

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Appendix F

CA.GOV CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
STATE WATER RESOURCES CONTROL BOARD

eWRIMS
Report Management System

Logged in as: A018177 | Reports | Log Out

Filter: Show all reports

Note: You can print your report(s) using your browser print function after selecting "View" in the Action column below.

Page **1**

Water Right ID	Primary Owner	Face Value (acre-ft/yr)	County	Source	Type	Year / Revision	Status	Date Submitted	Action
A018177	LEWISTON PARK MUTUAL WATER COMPANY, INC	311.3	Trinity	ALDER GULCH, TRINITY RIVER	Report of Licensee	2013 / 1	Submitted	06/16/2014	View Amend
A018177	LEWISTON PARK MUTUAL WATER COMPANY, INC	311.3	Trinity	ALDER GULCH, TRINITY RIVER	Report of Licensee	2012 / 1	Not Started		Start
A018177	LEWISTON PARK MUTUAL WATER COMPANY, INC	311.3	Trinity	ALDER GULCH, TRINITY RIVER	Report of Licensee	2011 / 1	Not Started		Start
A018177	LEWISTON PARK MUTUAL WATER COMPANY, INC	311.3	Trinity	ALDER GULCH, TRINITY RIVER	Report of Licensee	2010 / 1	Not Started		Start
A018177	LEWISTON PARK MUTUAL WATER COMPANY, INC	311.3	Trinity	ALDER GULCH, TRINITY RIVER	Report of Licensee	2009 / 1	Not Started		Start

Add a Report for a Previous Year

NORTH COAST RESOURCE PARTNERSHIP

2014 IRWM Drought Project Grant Application

ATTACHMENT 3:

Project Justification Appendix

Integrated Regional Water Management Program
Applicant: Humboldt County

North Coast Resource Partnership 2014 IRWM Drought Project Grant

Attachment 3. Project Justification Appendix

Supporting Documentation

1. Summers Lane Pond Plans (2010)
2. Preliminary Design Report (2009)
3. Timber Harvest Plan Summary of Work
4. Project Area Map

SUMMERS LANE POND

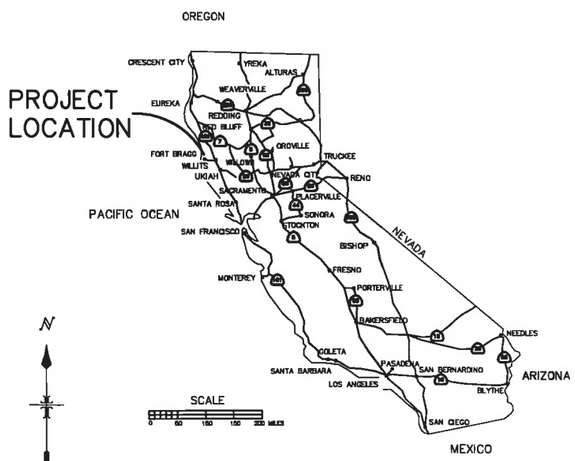
MARCH 2010

FINAL SUBMITTAL

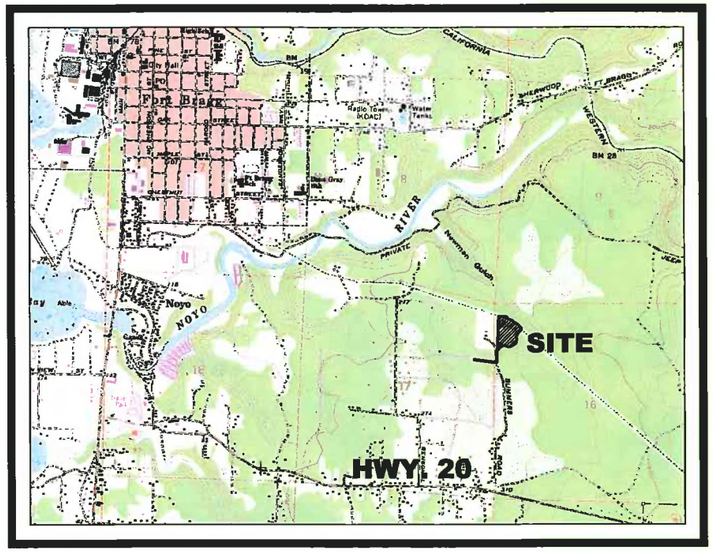
PROJECT DIRECTORY

OWNER: CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437
CONTACT: DAVE GOBLE
1-707-961-2824

CIVIL ENGINEERS: LAWRENCE & ASSOCIATES
3590 IRON COURT
SHASTA LAKE, CA 96019
CONTACT: JESSE SOLORIO
530-275-4800



VICINITY MAP



LOCATION MAP

1"=2000'

INDEX TO DRAWINGS

DRAWING	DRAWING TITLE
C1.0	SITE PLAN
C2.1	WATER PIPE PLAN AND PROFILE STATION 10+00 TO 15+50
C2.2	WATER PIPE PLAN AND PROFILE STATION 15+50 TO 21+00
C2.3	WATER PIPE PLAN AND PROFILE STATION 21+00 TO 26+00
C2.4	WATER PIPE PLAN AND PROFILE STATION 26+00 TO 31+50
C2.5	WATER PIPE PLAN AND PROFILE STATION 31+50 TO 35+28.37
C2.6	RESERVOIR EXIT PIPE PLAN
C2.7	PIPELINE DETAILS
C2.8	PIPELINE DETAILS
C2.9	PIPELINE DETAILS
C3.0	POND PLAN
C3.1	POND GRADING DETAILS
C4.0	ENTRANCE PLAN AND PROFILE
C5.0	OUTLET PLAN
C5.1	OUTLET DETAILS
C5.2	OUTLET DETAILS
C5.3	OUTLET DETAILS
C6.0	UNDERDRAIN PLAN
C6.1	UNDERDRAIN DETAILS
C7.0	FENCE PLAN
C7.1	FENCE DETAILS
C8.0	EROSION CONTROL GENERAL NOTES
C8.1	EROSION CONTROL SITE PLAN
C8.2	POND EROSION CONTROL PLAN
C8.3	EROSION CONTROL DETAILS

LEGEND

- RIGHT OF WAY
- PROPERTY BOUNDARY
- PROPOSED WATER LINE ALIGNMENT
- EXISTING WATER LINE
- EXISTING ELECTRICAL LINE
- EXISTING DRAINAGE SWALE
- EXISTING FENCE LINE
- 2800 — CONTOUR LINE (EXISTING)
- 2800 — CONTOUR LINE (NEW)
- F — FLOW METER
- GATE VALVE
- THRUST BLOCK
- CONCENTRIC INCREASER
- TRANSITION COUPLER
- (E) — EXISTING
- A/B — A – DETAIL NUMBER, B – SHEET NUMBER
- FT. — FEET
- MI. — MILE
- GAL. — GALLON
- ø — DIAMETER
- MIN. — MINIMUM
- EXISTING TREE

ABBREVIATIONS

MAX.	MAXIMUM
GSP	GALVANIZED STEEL PIPE
PVC	POLYVINYL CHLORIDE
CMP	CORRUGATED METAL PIPE
AC	ASBESTOS CEMENT
A/C	ASPHALT CONCRETE
GALV.	GALVANIZED
CU. YD.	CUBIC YARD
SCH.	SCHEDULE
O.C.E.W.	ON CENTER EACH WAY
IRRIG.	IRRIGATION
TYP.	TYPICAL
EQ.	EQUAL
W/	WITH
REQ'D.	REQUIRED
NO.	NUMBER
HWY.	HIGHWAY
L.F.	LINEAL FOOT
RSP	ROCK SLOPE PROTECTION
CAV	COMBINATION AIR VALVE

FORT BRAGG DEPARTMENT OF PUBLIC WORKS

Lindo Ruffing, City Manager

APPROVAL _____ SIGNED _____ DATE

FORT BRAGG CITY COUNCIL

Doug Hammerstrom, Mayor

APPROVAL _____ SIGNED _____ DATE

PLANS PREPARED BY: LAWRENCE & ASSOCIATES

Jesse Solorio, PE 65305

APPROVAL _____ SIGNED _____ DATE

GEOTECHNICAL REPORT:

GEOTECHNICAL ENGINEERING INVESTIGATION REPORT FOR SUMMERS LN. RESERVOIR
SUMMERS LN, FORT BRAGG,
MENDOCINO CO., CA
HOLDREGE & KULL FEB 5, 2010

ASSESSOR'S PARCEL NUMBER: 019-070-01

LATITUDE: 39°25'31"N

LONGITUDE: 123°46'04"W

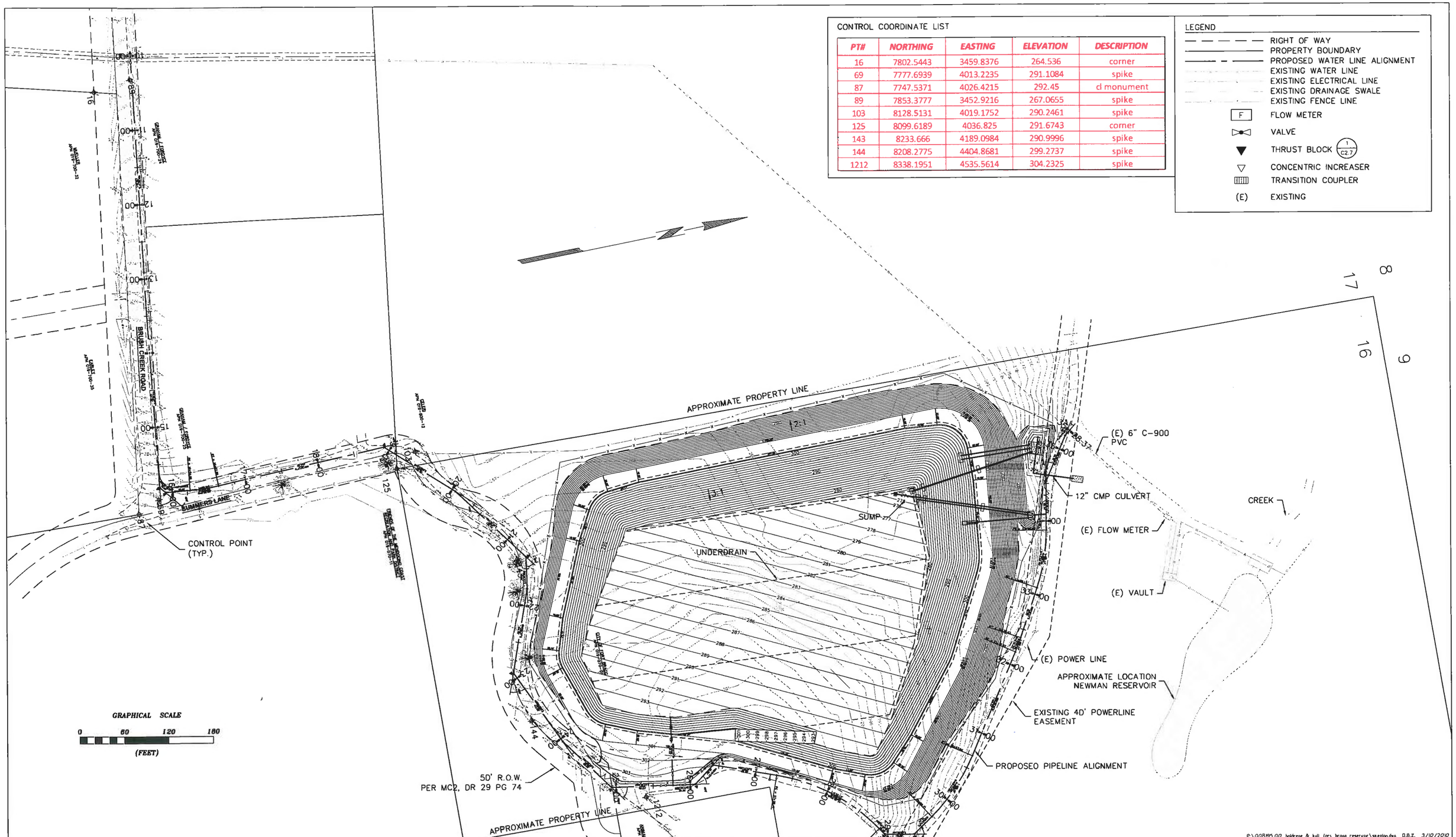
P:\00815.00_holdrege & kull_fort bragg reservoir\Coversheet.dwg D.B.I. 3/1/2010

CONTROL COORDINATE LIST

PT#	NORTHING	EASTING	ELEVATION	DESCRIPTION
16	7802.5443	3459.8376	264.536	corner
69	7777.6939	4013.2235	291.1084	spike
87	7747.5371	4026.4215	292.45	cl monument
89	7853.3777	3452.9216	267.0655	spike
103	8128.5131	4019.1752	290.2461	spike
125	8099.6189	4036.825	291.6743	corner
143	8233.666	4189.0984	290.9996	spike
144	8208.2775	4404.8681	299.2737	spike
1212	8338.1951	4535.5614	304.2325	spike

LEGEND

- RIGHT OF WAY
- PROPERTY BOUNDARY
- PROPOSED WATER LINE ALIGNMENT
- EXISTING WATER LINE
- EXISTING ELECTRICAL LINE
- EXISTING DRAINAGE SWALE
- EXISTING FENCE LINE
- F — FLOW METER
- VALVE
- THRUST BLOCK (1 / C2.7)
- CONCENTRIC INCREASER
- TRANSITION COUPLER
- (E) — EXISTING



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ENGINEER: J. SOLORIO	SCALE: 1"=60'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

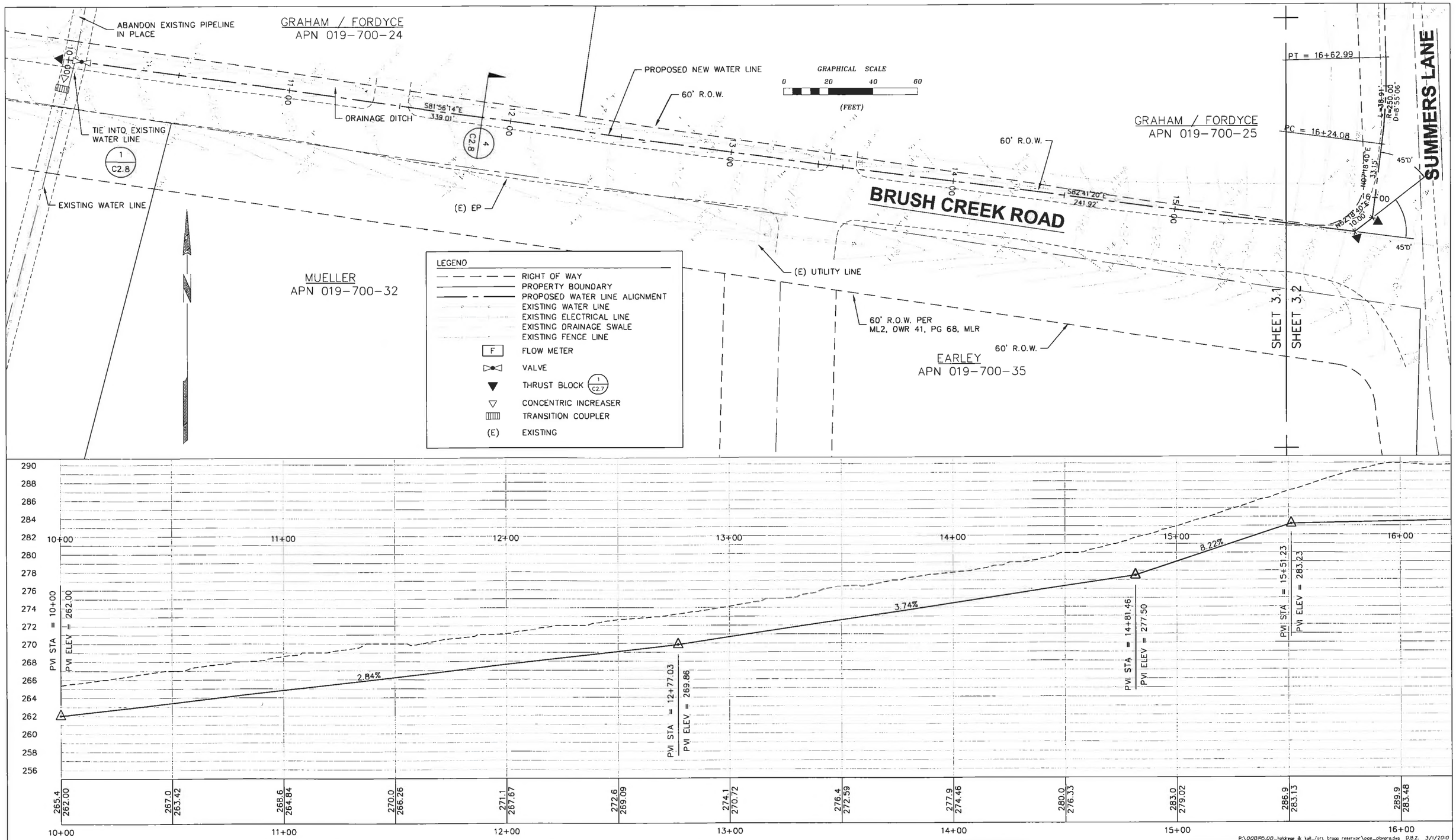
LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
3590 IRON CT.
SHASTA LAKE, CA 96019
(530) 275-4800
(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

SITE PLAN

DRAWING: C1.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



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CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
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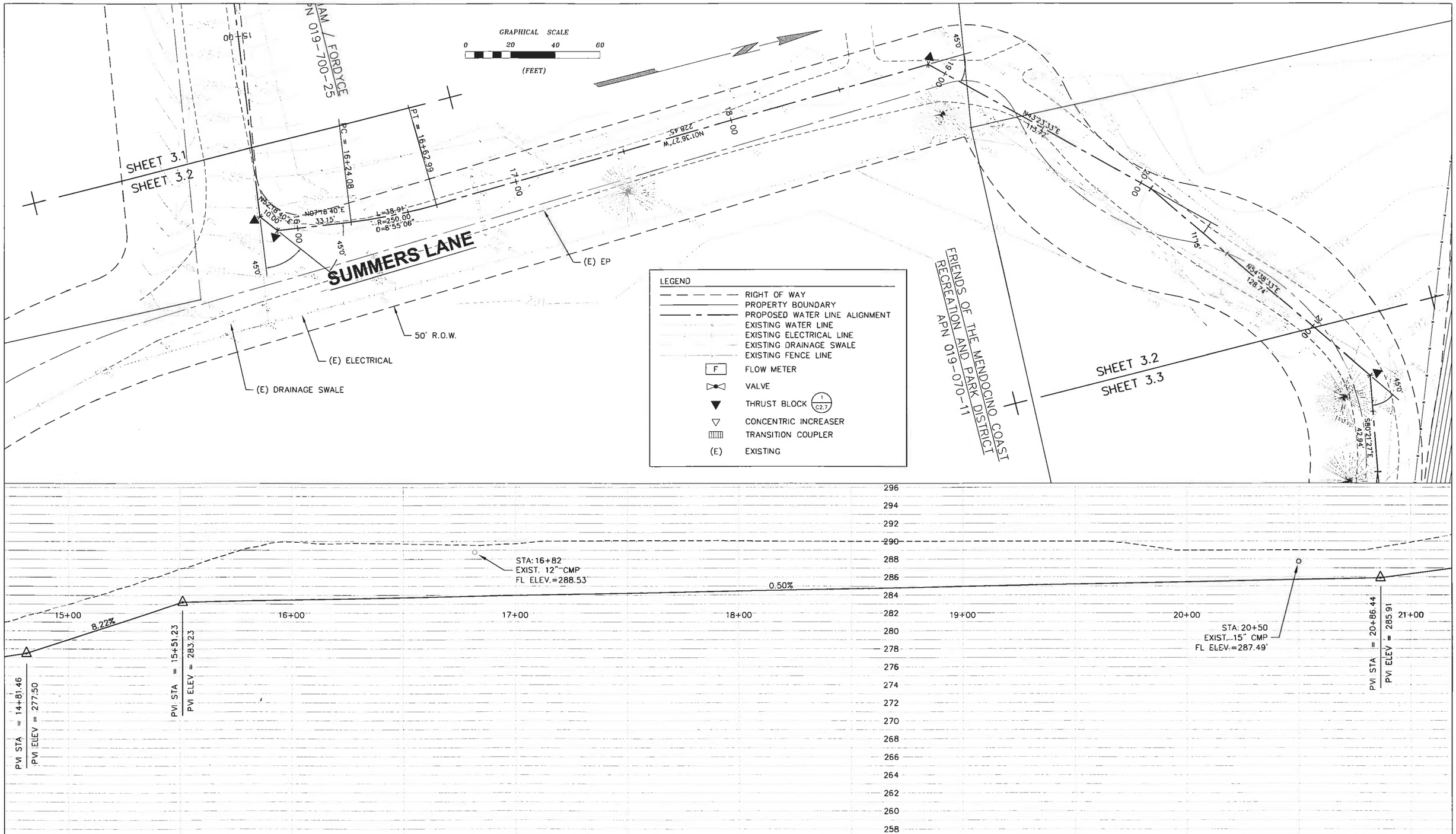
(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 10+00 TO 15+50

DRAWING: C2.1
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



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ENGINEER: J. SOLORIO
CHECKED BY:
DATE:
PROJECT NO: 008195.00
SCALE: 1"=20'
APPROVED BY:
DATE:

LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
3590 IRON CT.
SHASTA LAKE, CA 96019
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(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 15+50 TO 21+00

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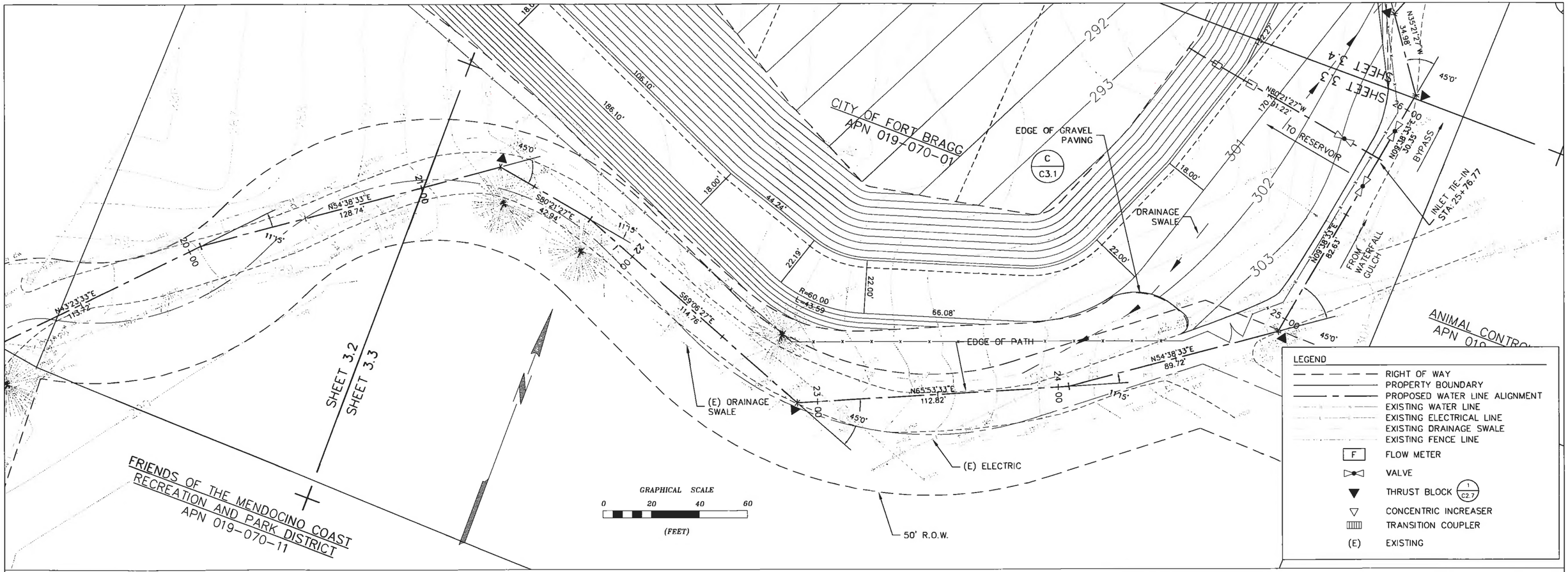

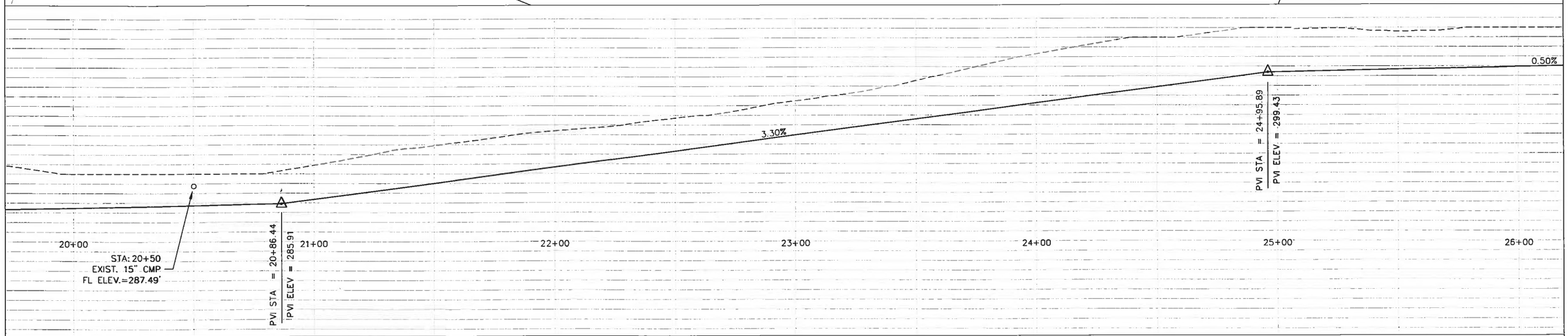

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CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
3590 IRON CT.
SHASTA LAKE, CA 96019
(530) 275-4800
(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 21+00 TO 26+00

DRAWING: C2.3
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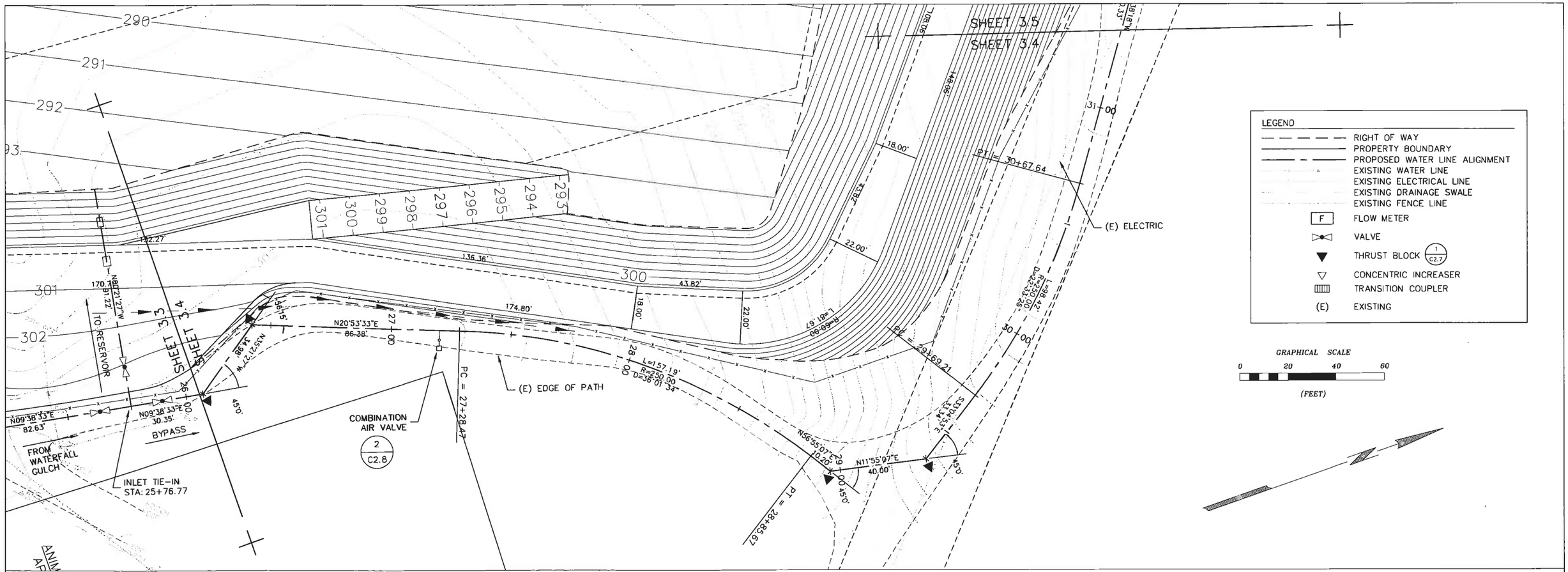
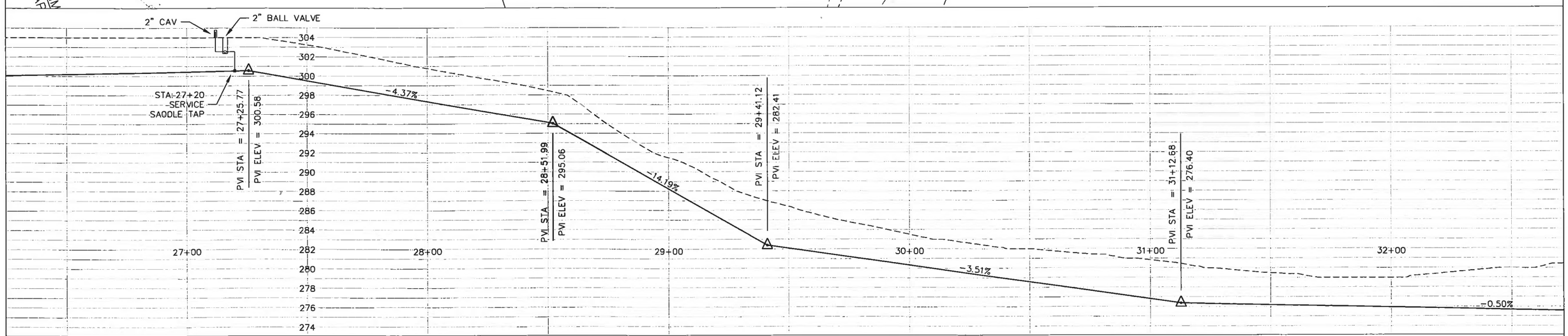
REVISION NO: REVISION 0
DATE: 12/1/09





P:\008195.00_baldrese & hull_fort bragg reservoir\pipe_planpro.dwg D.B.Z. 3/1/2010

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ
ENGINEER: J. SOLORIO
CHECKED BY:
DATE:
PROJECT NO: 008195.00
SCALE: 1"=20'
APPROVED BY:
DATE:

LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
3590 IRON CT.
SHASTA LAKE, CA 96019
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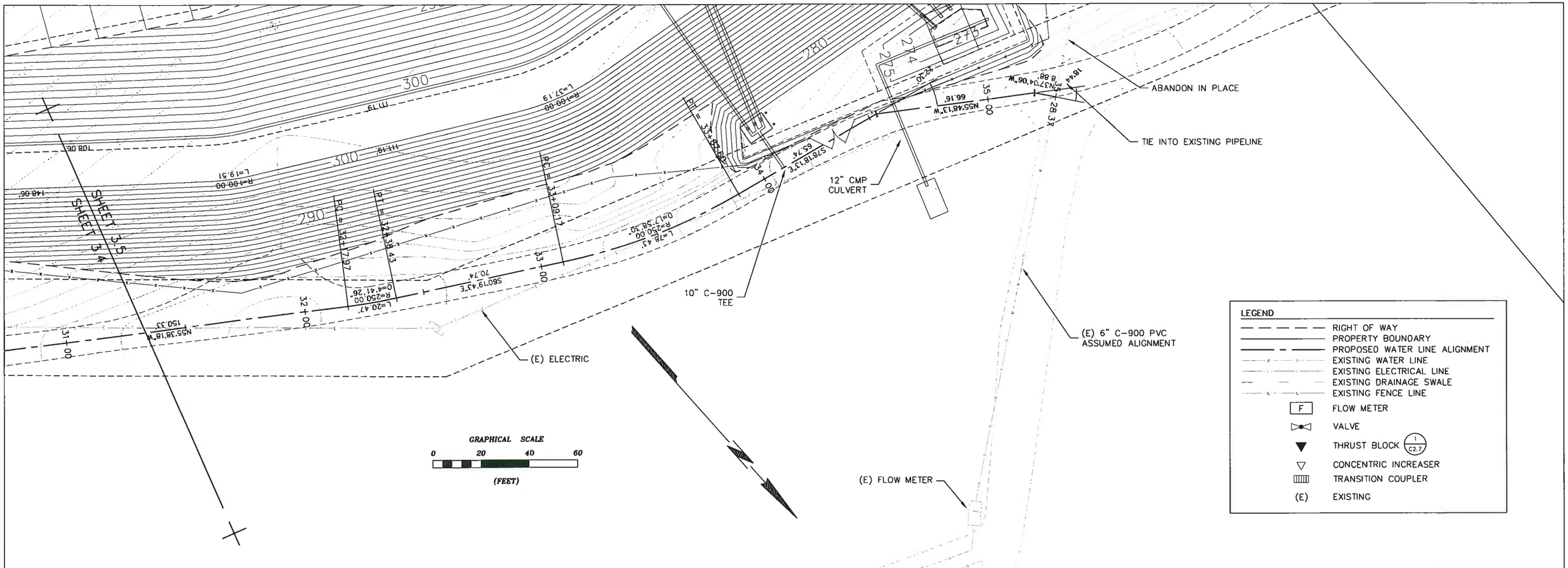
(530) 275-7970 FAX

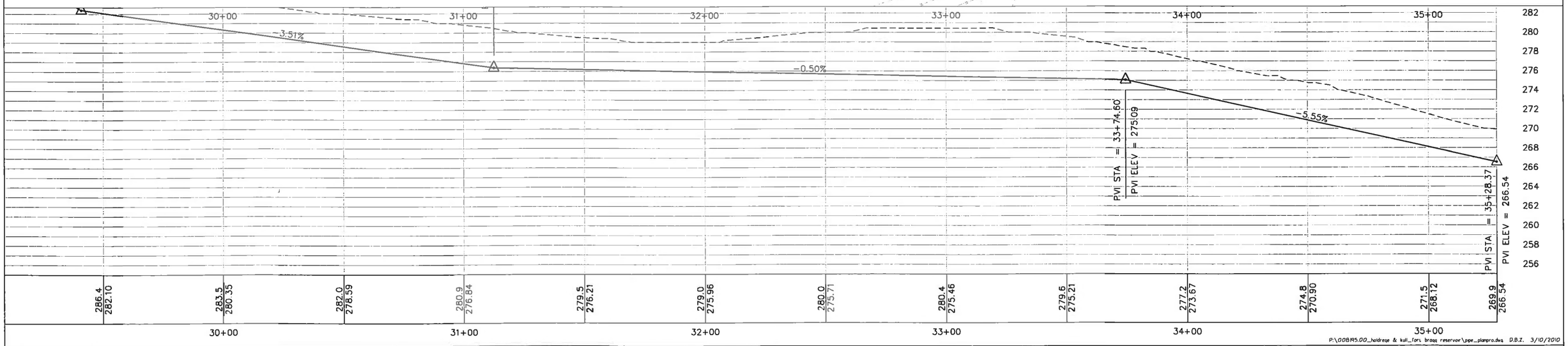
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 26+00 TO 31+50

DRAWING: C2.4
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09





P:\008195.00_haldrage & kull_fort bragg reservoir\pipe_planpro.dwg D.B.Z. 3/10/2010

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=20'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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SHASTA LAKE, CA 96019
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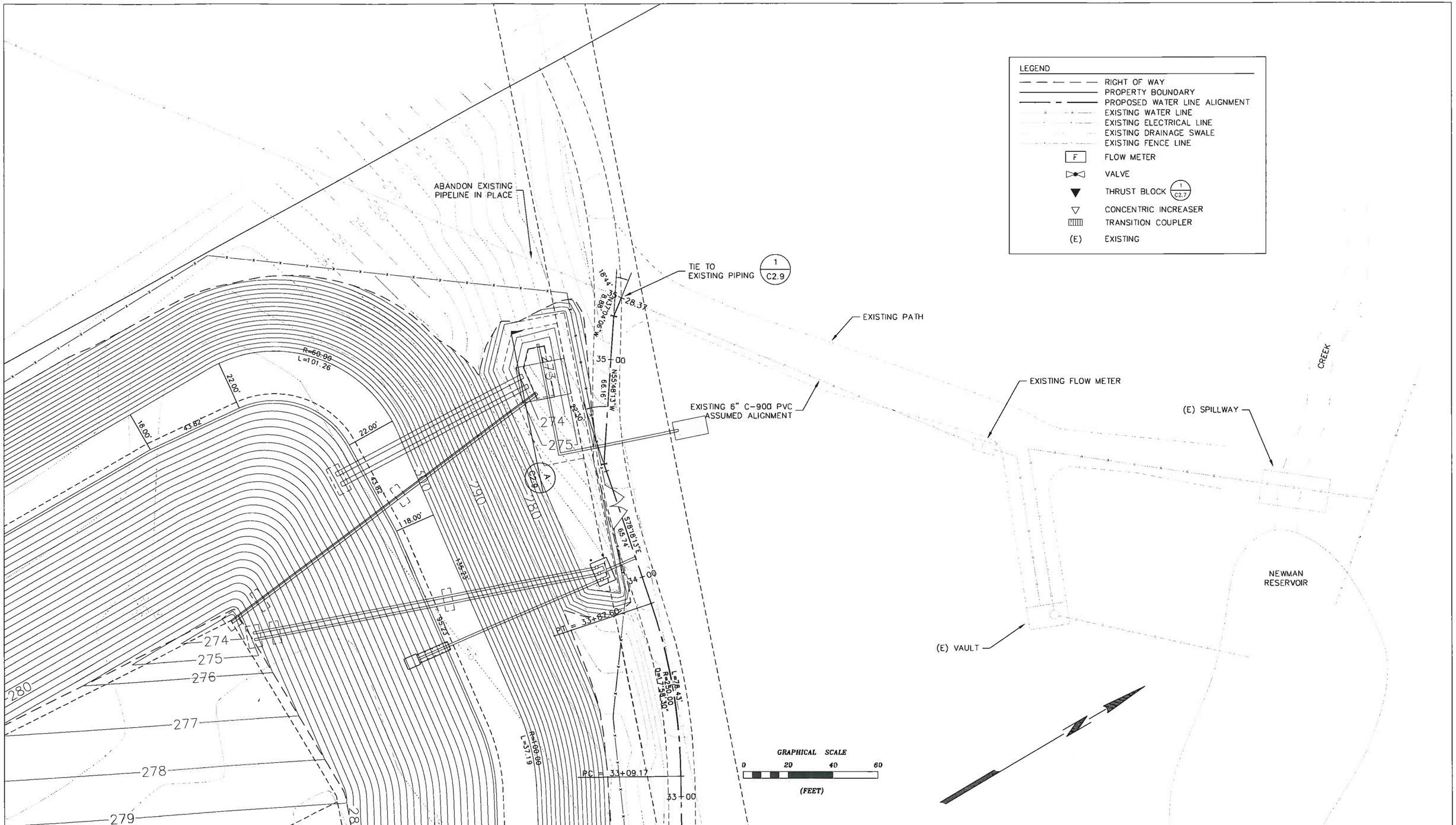
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 31+50 TO 35+29.13

DRAWING: C2.5
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



P:\008195.00_baldrace & hull_fort bragg reservoir\pipe_plans.dwg D.B.Z. 12/3/2009

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=20'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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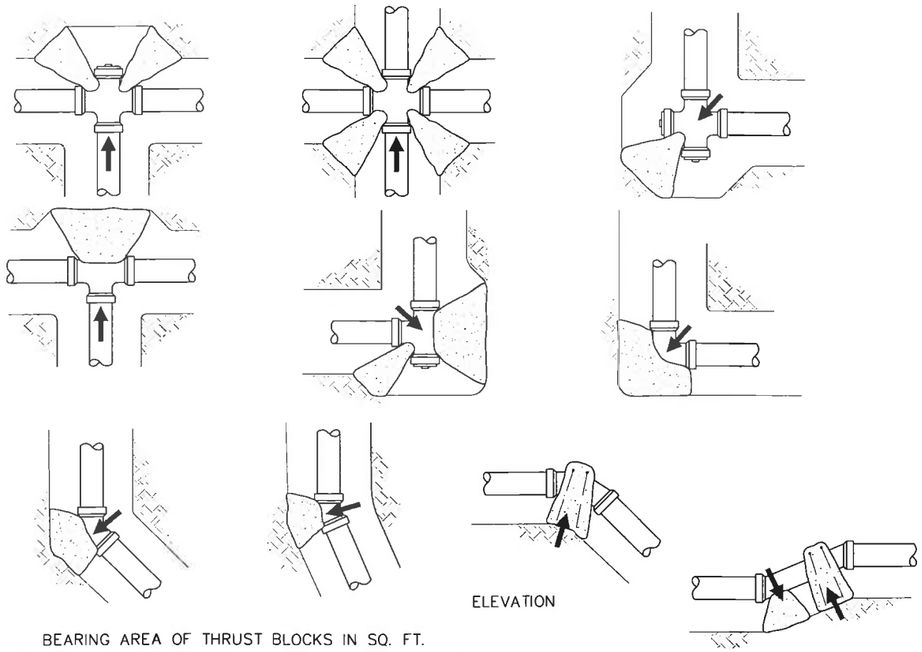
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

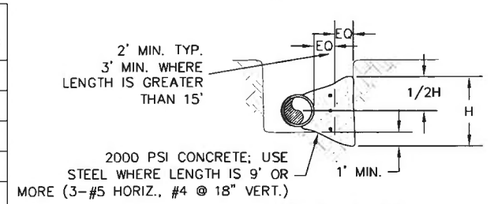
RESERVOIR EXIT PIPE PLAN

DRAWING: C2.6
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



BEARING AREA OF THRUST BLOCKS IN SQ. FT.

PIPE SIZE	TEE, WYE, PLUG OR CAP	90° BEND, PLUGGED CROSS	TEE, PLUGGED		45° BEND	22 ½° BEND	11 ¼° BEND
4	2	3			2	1	
6	5	6			4	2	
8	8	11			6	3	
10	12	17			10	5	
12	17	24			13	7	



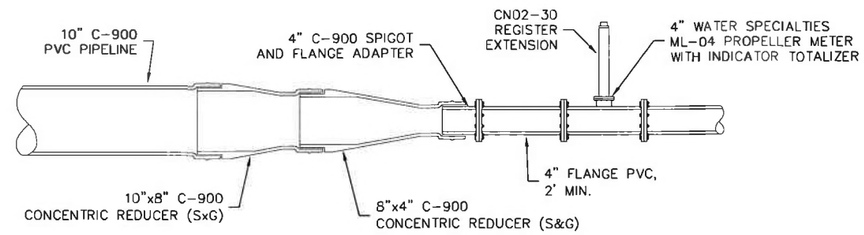
TYPICAL SECTION

NOTES:

1. CONCRETE THRUST BLOCKS ARE TO BE POURED AGAINST A UNDISTURBED EARTH OR STRUCTURAL BACKFILL.
2. KEEP CONCRETE CLEAR OF JOINTS AND ACCESSORIES.
3. VOLUMES AND SPECIAL BLOCKING DETAILS SHOWN ON THE PLANS TAKE PRECEDENCE OVER VOLUMES AND BLOCKING DETAILS SHOWN ON THIS STANDARD DETAIL.
4. ALL BURIED PIPE EXCEPT FLANGED, SCREWED, SOLVENT WELDED PVC OR WELDED STEEL PIPE SPECIFIED TO BE PRESSURE TESTED SHALL BE PROVIDED WITH CONCRETE THRUST BLOCKS AT ALL DIRECTIONAL CHANGES UNLESS OTHERWISE NOTED.
5. THRUST BLOCKS SHALL NOT BE LOCATED OR SIZED TO ENCASE ADJACENT PIPES OR FITTINGS.
6. THE SIZE AND WEIGHT OF ALL UPLIFE THRUST BLOCKS SHALL BE AS DETERMINED BY ENGINEER.
7. THE BEARING AREAS ARE BASED ON TEST PRESSURE OF 150 PSI AND ALLOWABLE SOIL BEARING STRESS OF 1000 POUNDS PER SQUARE FOOT. TO COMPUTE BEARING AREAS FOR DIFFERENT TEST PRESSURES AND SOIL BEARING STRESSES, USE THE FLLOWING EQUATION:
   BEARING AREA = (TEST PRESSURE/150) X (1000/SOIL BEARING STRESS) X (TABLE VALUE)

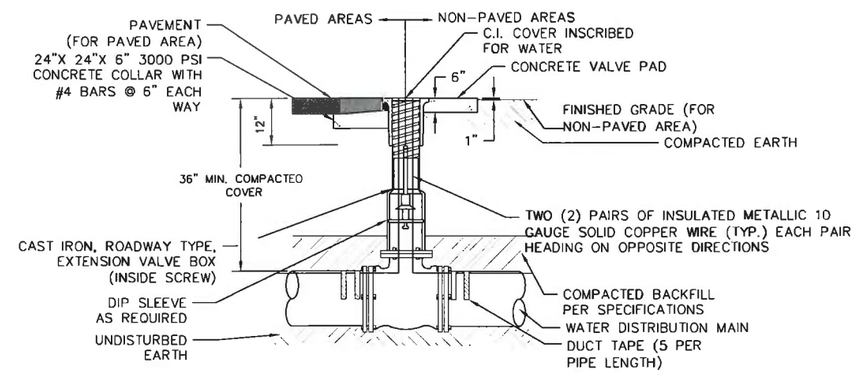
1 / – STANDARD THRUST BLOCK DETAILS

N.T.S.



2 / – POND INLET METER PIPING

N.T.S.



FOR EITHER PAVED OR NON-PAVED AREAS

NOTES:

1. PVC EXTENSIONS SHALL NOT BE USED.
2. EXTENSION ON VALVE BOX SHALL BE SET TO RESERVE 1/2 OF THE ADJUSTMENT LENGTH FOR FUTURE USE.
3. OPERATING NUT SHALL BE WITHIN 12" OF GRADE. EXTENSION TO BE PROVIDED AS REQUIRED.
4. VALVE EXTENSION SHALL BE MECHANICALLY ATTACHED AND SHALL HAVE A STAINLESS STEEL PIN AT THE VALVE AND SHEAR PIN ONLY AT THE OPERATING NUT.
5. ALL PVC PIPE SHALL REQUIRE TWO PAIRS OF INSULATED METALLIC LOCATING WIRES (10 GAUGE SOLID COPPER) TAPED WITH 2" WIDE DUCT TAPE TO TOP CENTERLINE OF THE PIPE AT EVERY JOINT AND AT 4 ADDITIONAL EQUALLY SPACED POINTS PER LENGTH OF PIPE.
6. LOCATING WIRES TO TERMINATE 4" ABOVE VALVE BOX AND FOLDED BACK INSIDE BOX AND PLUGGED PIPE AND PLUGGED.
7. LOCATING WIRES SHALL BE CAPABLE OF DETECTION BY A CABLE LOCATOR AND PASS A FIELD CONDUCTIVITY TEST, OBSERVED BY THE CITY, FROM END TO END OF WIRES.
8. SPLICES SHALL BE CAPABLE OF COMPLETE SUBMERSION, SUCH AS BUTT SPLICE WITH RAYCHEM HEAT SHRINK TUBING.
9. NO MORE THAN ONE SPLICE IN LOCATING WIRES BETWEEN VALVES IS ALLOWED.

3 / – RESILIENT SEATED GATE VALVE DETAIL

N.T.S.

P:\00B195.00_haldrew & kul_fort bragg reservoir\details.dwg D.B.Z. 12/3/2009

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 00B195.00
ENGINEER: J. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES
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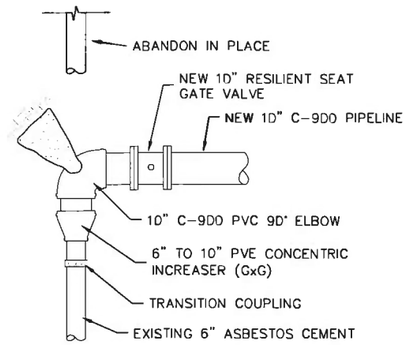
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

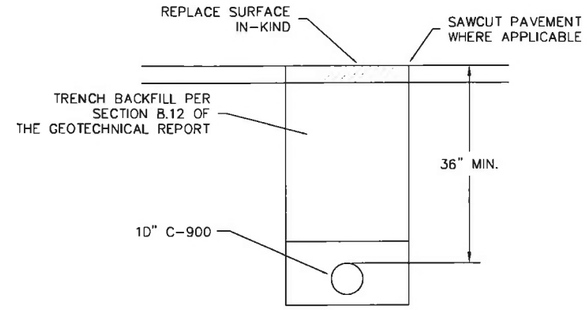
PIPELINE DETAILS

DRAWING: C2.7
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



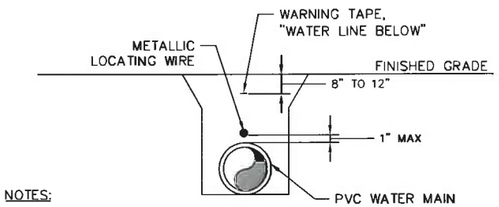
1 — NEW PIPEING TIE-IN

N.T.S.



4 — 10" WATER PIPELIN TRENCH

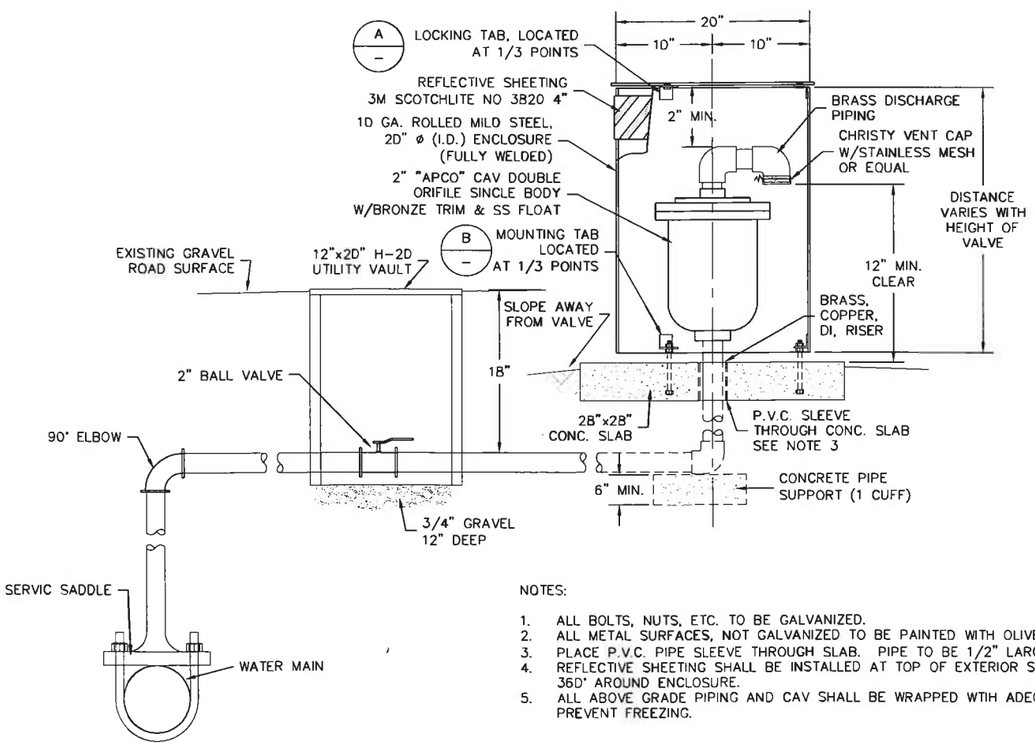
N.T.S.

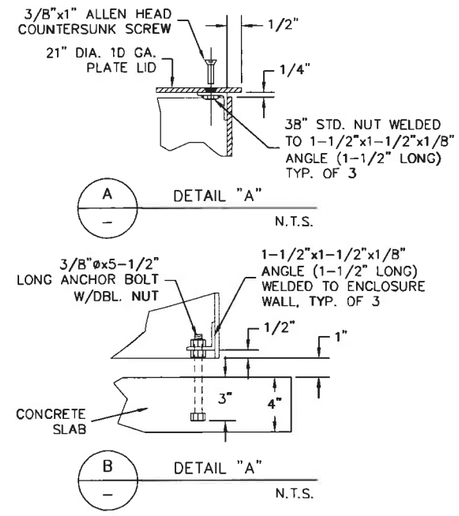


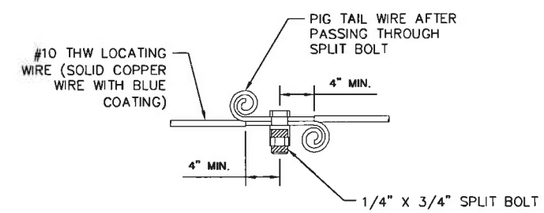
NOTES:

1. ALL PVC PIPE SHALL REQUIRE INSULATED METALLIC LOCATING WIRE (10 GAUGE COPPER/UF INSULATION) CAPABLE OF DETECTION BY A CABLE LOCATOR.
2. WIRE SHALL BE ATTACHED TO THE TOP OF PIPE WITH DUCT TAPE, AT LEAST FIVE TIMES PER JOINT. LOCATING WIRE SHALL TERMINATE AT THE TOP OF EACH VALVE BOX.
3. PROVIDE POTTING COMPOUND AT ALL TRACER WIRE JUNCTIONS AND SPLICES.
4. EXTEND TRACER WIRE INTO METER BOX.

PIPE LOCATING WIRE DETAIL







NOTES:

1. THE ENDS OF ALL LOCATING WIRES, WHETHER THEY ARE SPLICED, CONNECTED, OR TERMINATED, SHALL HAVE THE LAST THREE INCHES PIG TAILED AS DETAILED HEREON.
2. AFTER INSTALLATION OF THE LOCATING WIRE THE SYSTEM SHALL BE SUBJECTED TO TESTING, IN THE PRESENCE OF CITY UTILITIES STAFF PRIOR TO BACKFILL, IN ORDER TO INSURE THAT THE SYSTEM IS FUNCTIONAL.

LOCATING WIRE DETAIL

3 — PVC PIPE LOCATING WIRE DETAILS

N.T.S.

NOTES:

1. ALL BOLTS, NUTS, ETC. TO BE GALVANIZED.
2. ALL METAL SURFACES, NOT GALVANIZED TO BE PAINTED WITH OLIVE GREEN POWDER COAT PAINT.
3. PLACE P.V.C. PIPE SLEEVE THROUGH SLAB. PIPE TO BE 1/2" LARGER THAN RISER.
4. REFLECTIVE SHEETING SHALL BE INSTALLED AT TOP OF EXTERIOR SIDEWALL. WRAP SHEETING 360° AROUND ENCLOSURE.
5. ALL ABOVE GRADE PIPING AND CAV SHALL BE WRAPPED WTIH ADEQUATE PIPE INSULATION TO PREVENT FREEZING.

2 — COMBINATION AIR VALVE & ENCLOSURE

N.T.S.

P:\008195.00_haldrege & hull_fort bragg reservoir\details.dwg D.B.Z. 3/1/2010

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: O. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES ENGINEERING GEOLOGY
3590 IRON CT.
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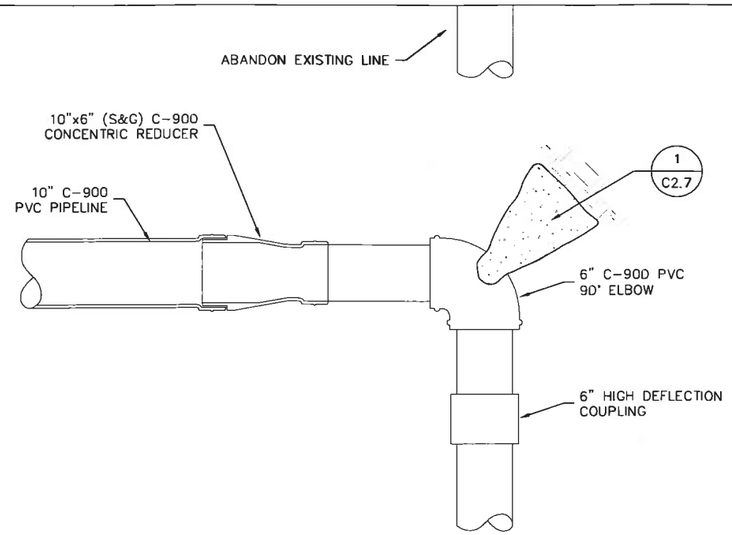
(530) 275-4800
(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

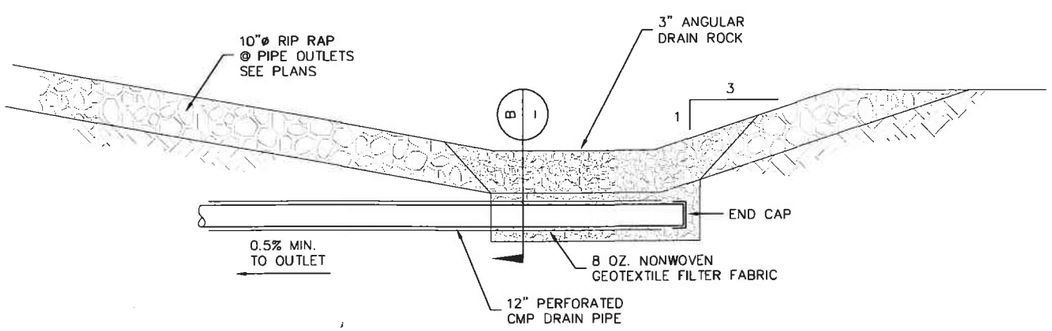
PIPELINE DETAILS

DRAWING: C2.8
SHEET: OF
REVISION NO: REVISION 0
DATE: 11/25/09



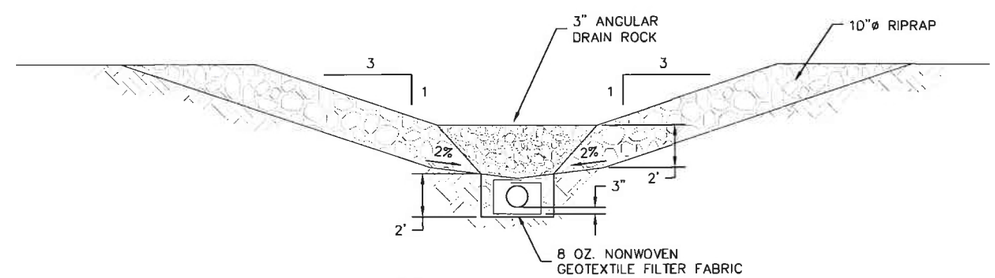
1 / – TIE TO OUTLET

N.T.S.



A / – OUTLET POND DRAIN SECTION

N.T.S.



B / – DRAIN SECTION

N.T.S.

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NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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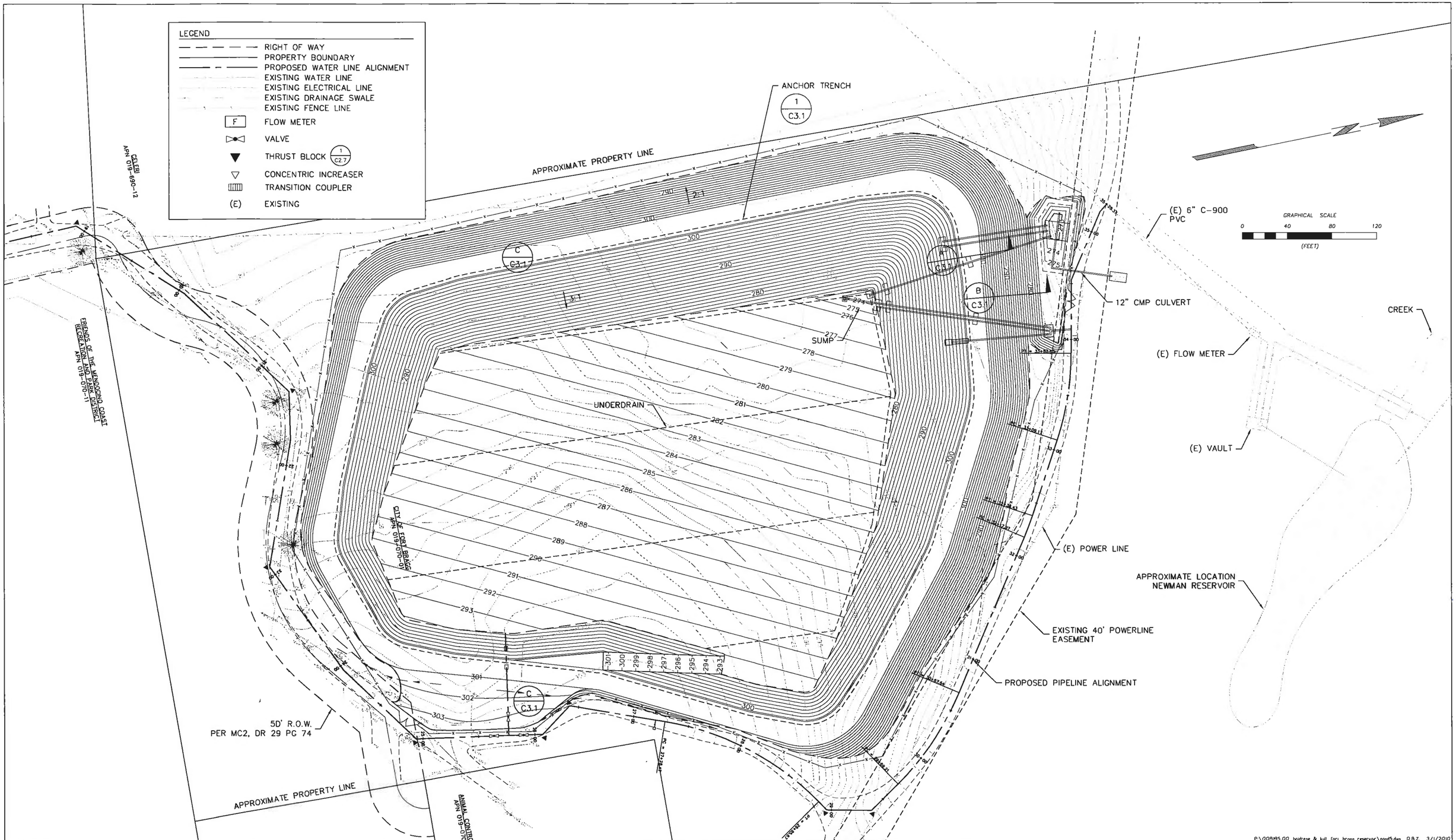
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

PIPELINE DETAILS

DRAWING: C2.9
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=40'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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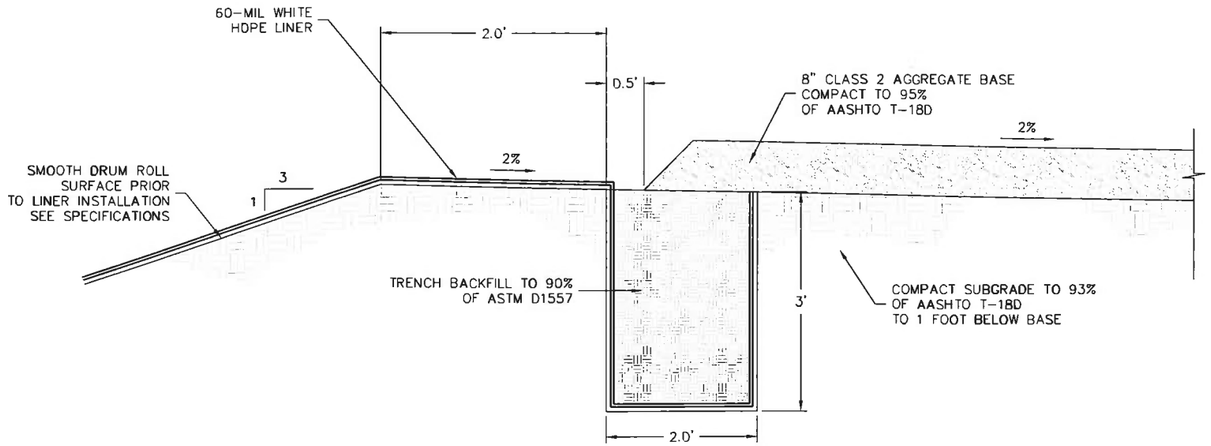
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

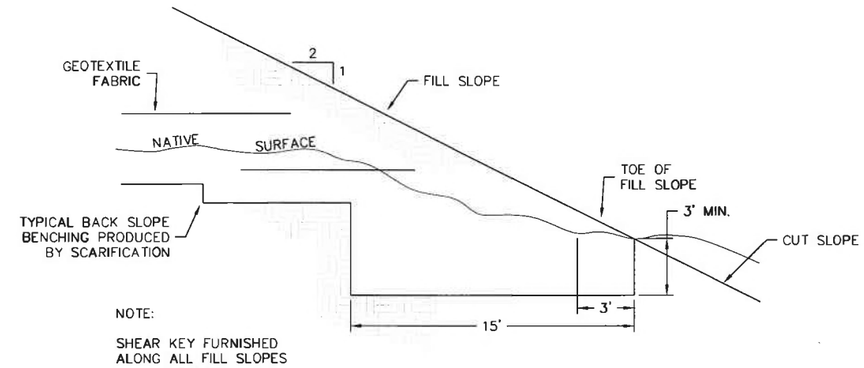
POND PLAN

DRAWING: C3.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



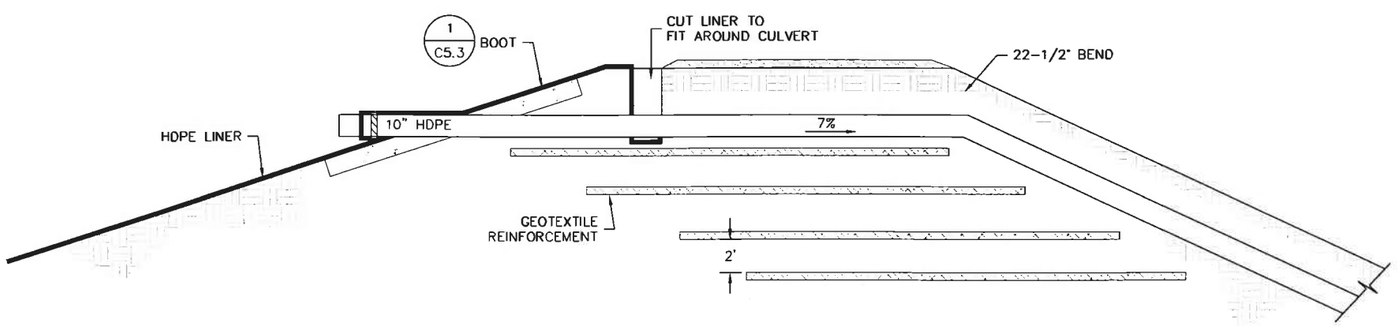
1 / – ANCHOR TRENCH FOR HDPE LINER

N.T.S.



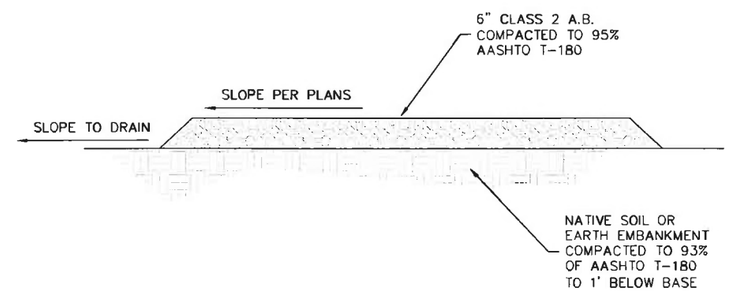
B / – SHEAR KEY DETAIL

N.T.S.



A / – OVERFLOW CULVERT OUTLET

N.T.S.



C / – GRAVEL PAVING – SECTION

N.T.S.

P:\008195.00_baldrege & kull_fort bragg reservoir\details.dwg D.B.Z. 1/27/2010

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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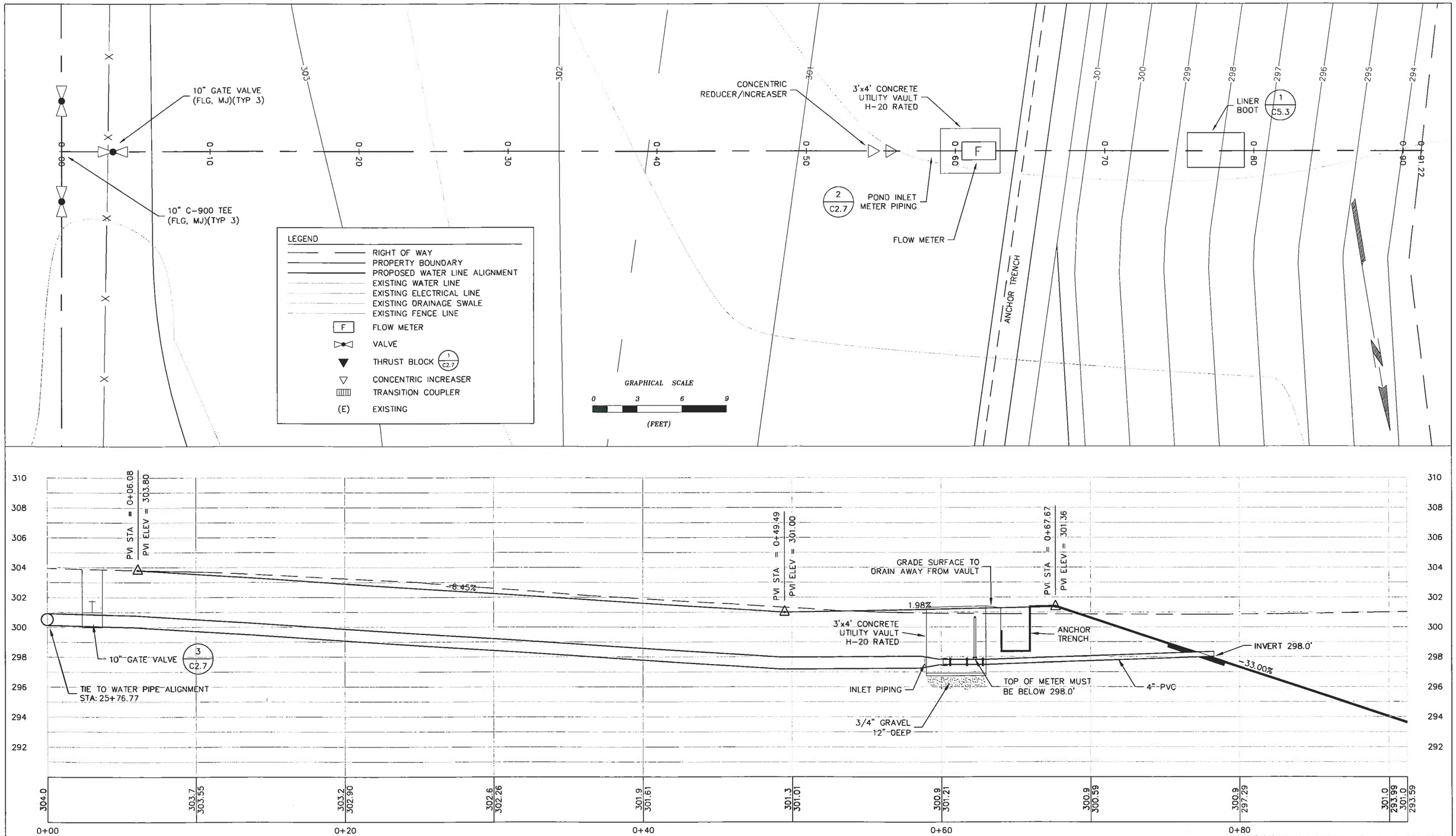
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

POND GRADING DETAILS

DRAWING: C3.1
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



P:\008195.00_holdrege & kull_fort bragg reservoir\elei_planpro.dwg D.B.Z. 3/1/2010

NO.	DATE	REVISIONS	BY	CHK

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=3' H & V
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

ENTRANCE PLAN AND PROFILE

DRAWING: C4.0
SHEET: - OF
REVISION NO: REVISION 0
DATE: 12/2/09

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ
ENGINEER: J. SOLORIO
CHECKED BY:
DATE:
PROJECT NO: 008195.00
SCALE: 1"=10'
APPROVED BY:
DATE:

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ENGINEERING GEOLOGY
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SHASTA LAKE, CA 96019
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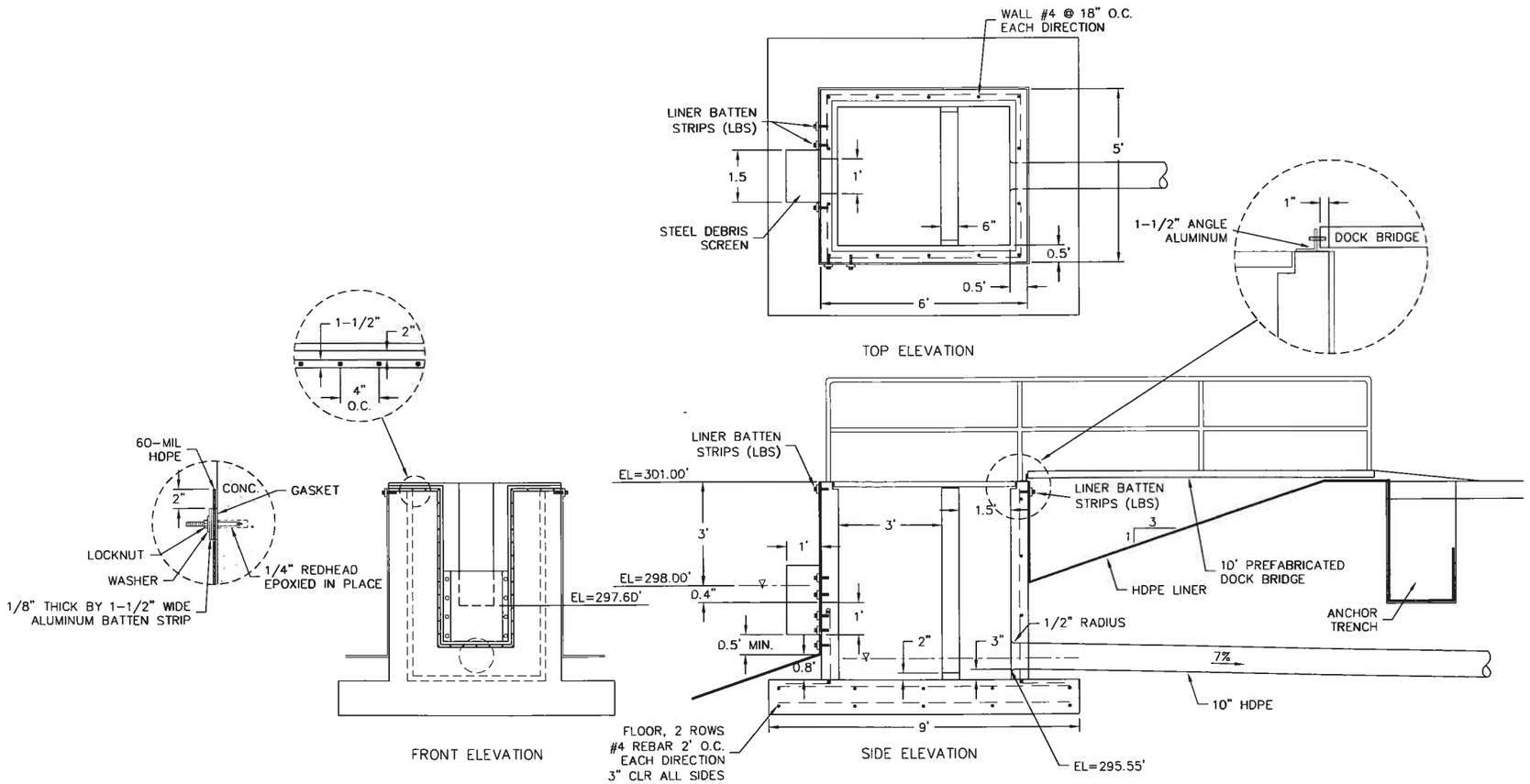
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

OUTLET PLAN

DRAWING: C5.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 11/20/09



1 — POND FULL OUTLET

N.T.S.

P:\008195.00_haldrese & kull_fort bragg reservoir\details.dwg D.B.Z. 1/27/2010

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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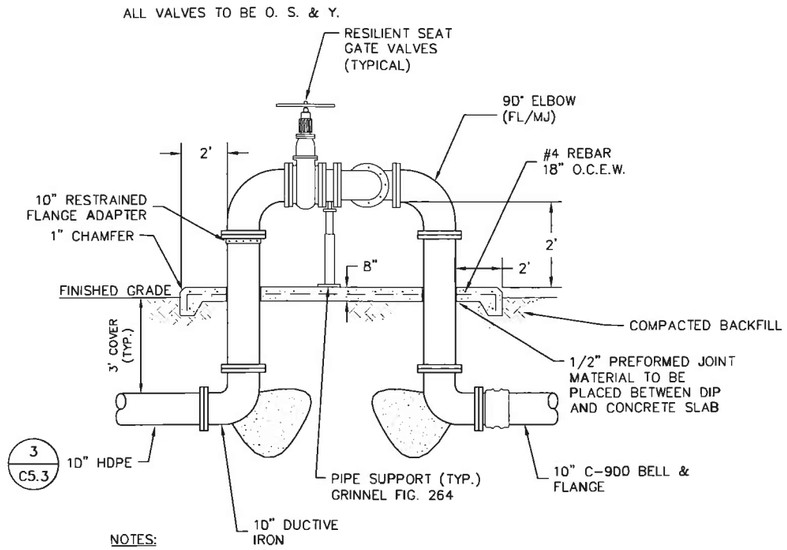
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

OUTLET DETAILS

DRAWING: C5.1
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09

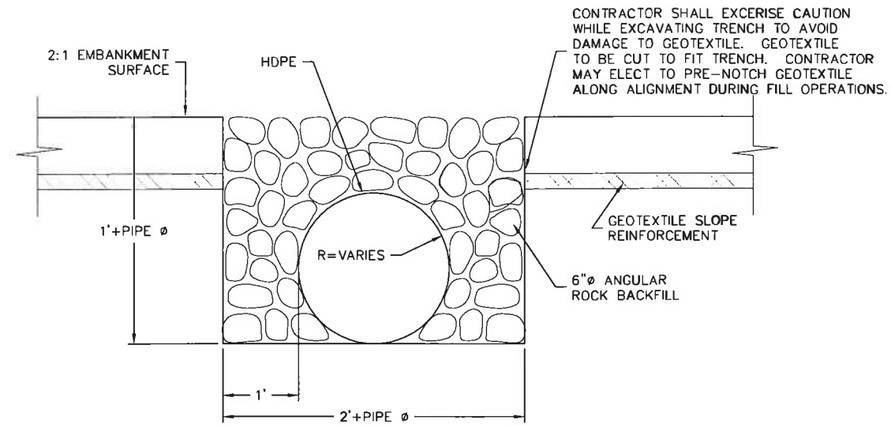


NOTES:

1. ALL PIPE AND FITTINGS SHALL BE ANSI/AWWA C115/A21.15 DUCTILE IRON, CLASS 125, CEMENT LINED INTERIOR WITH FLANGE FITTINGS FOR ABOVE GROUND USE. MANUFACTURERS RESTRAINED JOINTS SHALL BE USED FOR UNDERGROUND PIPING.

A / – OUTLET VALVE – ELEVATION

N.T.S.



3 / – DOWNDRAIN TRENCH

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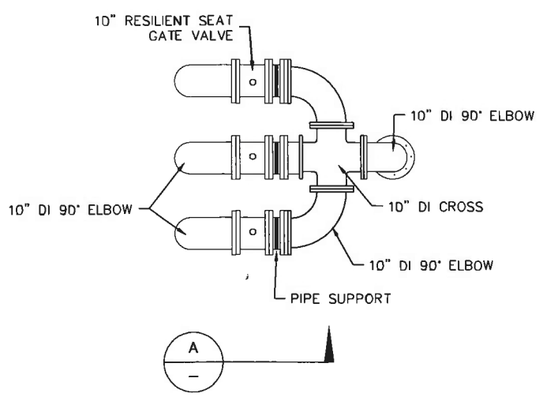
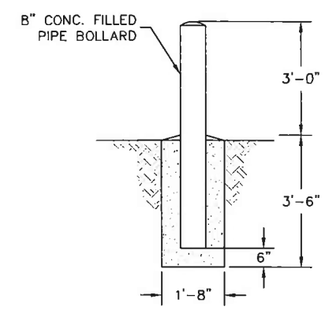


1 / – OUTLET VALVE – PLAN

N.T.S.



4 / – SINGLE BOLLARD DETAIL

N.T.S.

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NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: I. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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NEWMAN RESERVOIR

CITY OF FORT BRAGG
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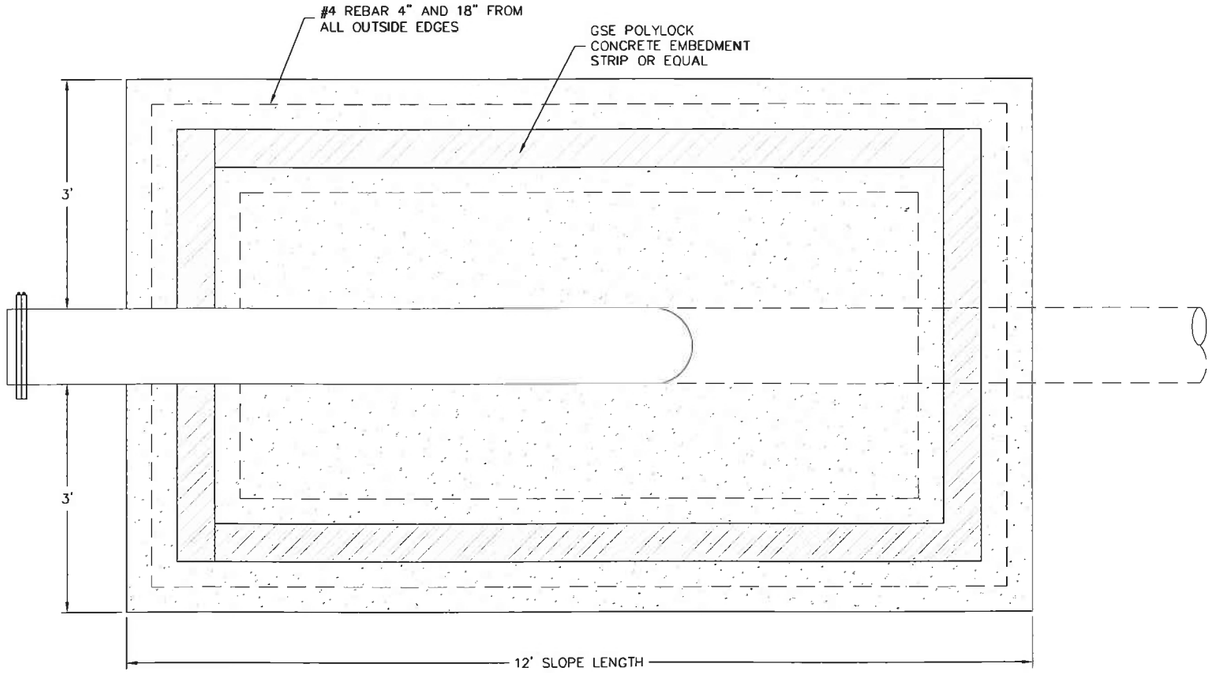
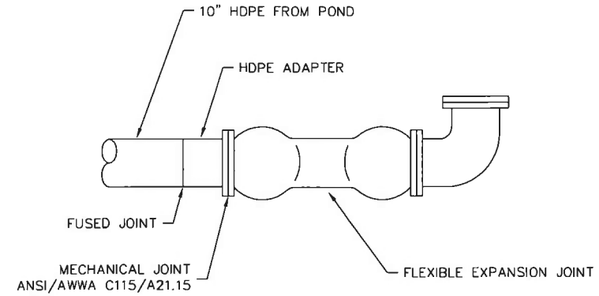
OUTLET DETAILS

DRAWING: C5.2
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09



PLAN VIEW

N.T.S.



3 / C5.0 BUTT FUSION WELD HDPE

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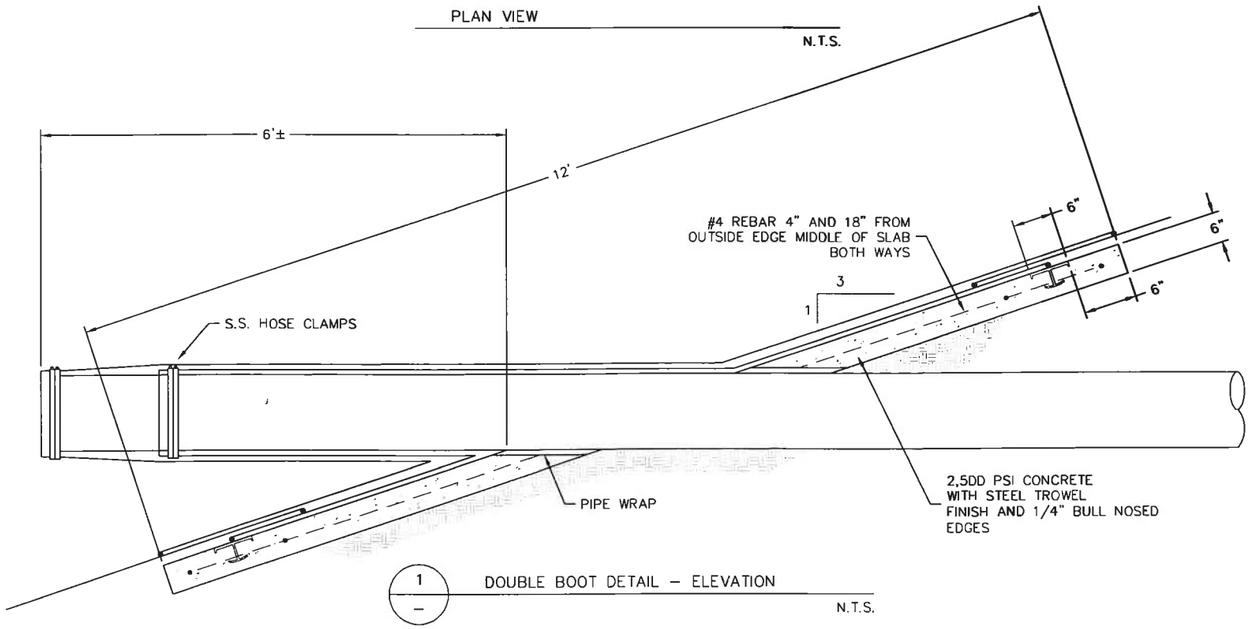
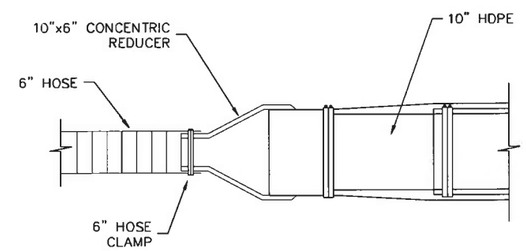


1 / – DOUBLE BOOT DETAIL – ELEVATION

N.T.S.



2 / C5.0 FAIRCLOTH SKIMMER CONNECTION

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ENGINEER: J. SOLORIO	SCALE: N.T.S.
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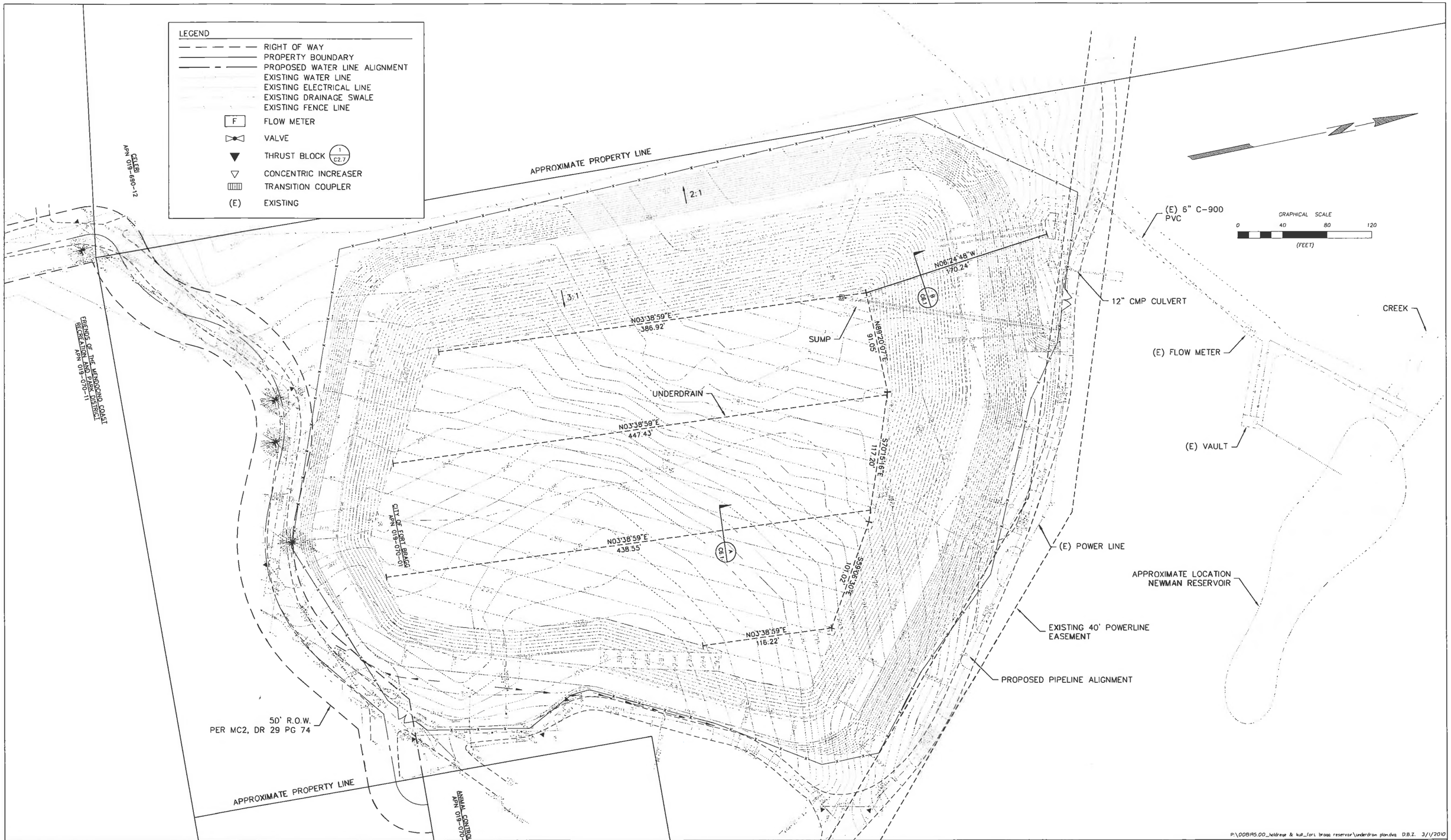
OUTLET DETAILS

DRAWING: C5.3
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09



NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=40'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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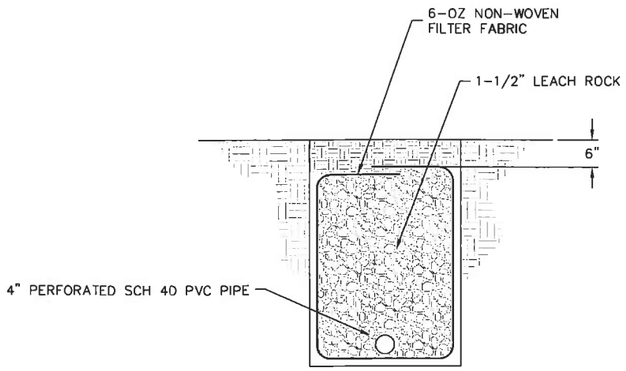
UNDERDRAIN PLAN

DRAWING: C6.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09



A
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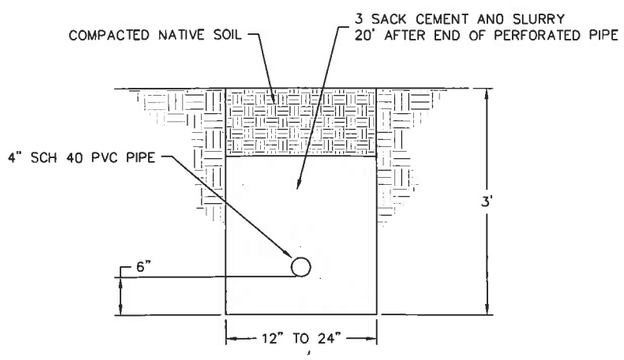
UNDERDRAIN DETAIL – PERFORATED
N.T.S.



B
–
UNDERDRAIN DETAIL – NONPERFORATED
N.T.S.

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NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
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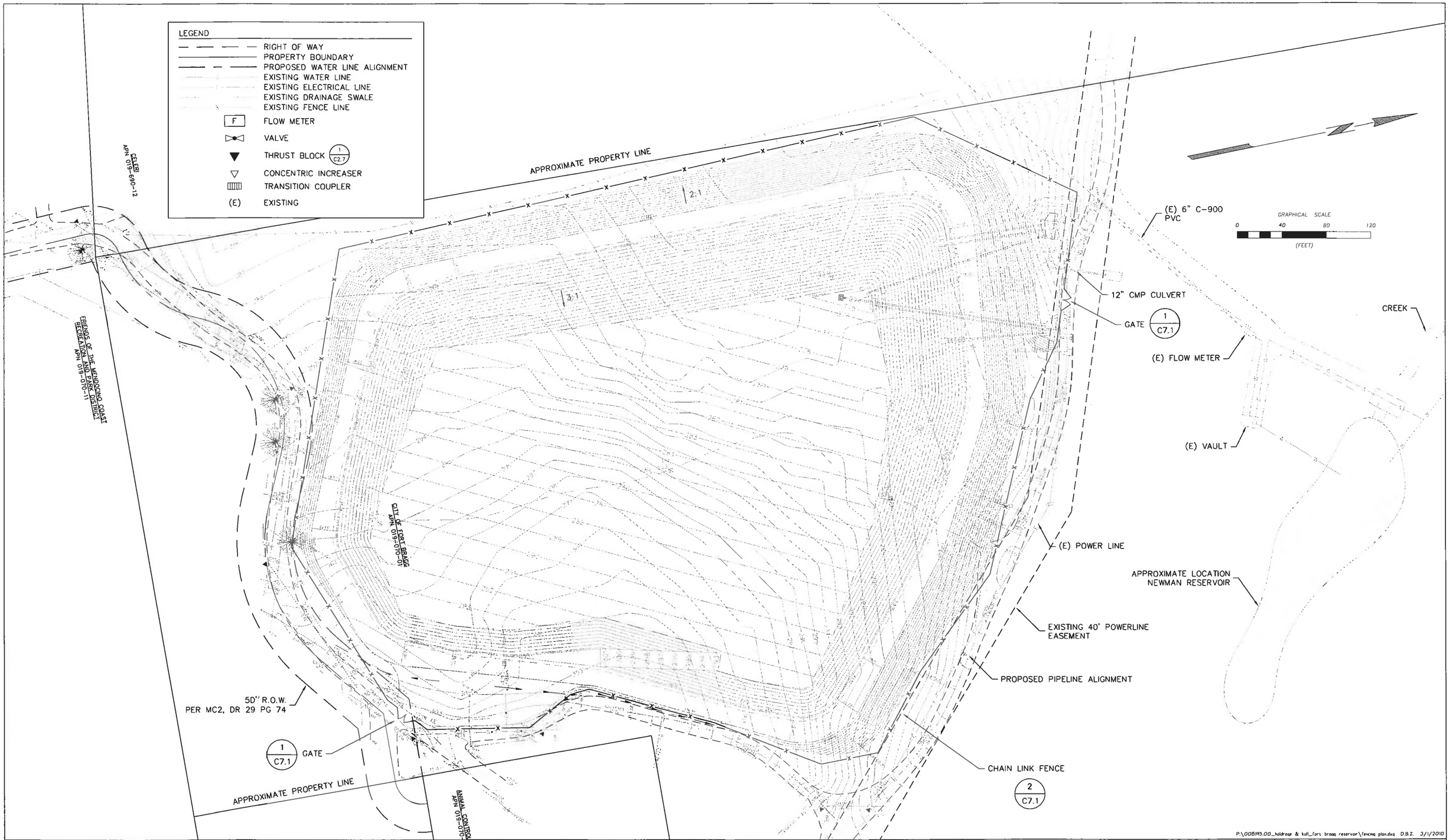
UNDERDRAIN DETAILS

DRAWING: C6.1
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09



P:\008195.00_haldrage & kull_fort bragg reservoir\fence plan.dwg D.B.Z. 3/1/2010

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=40'
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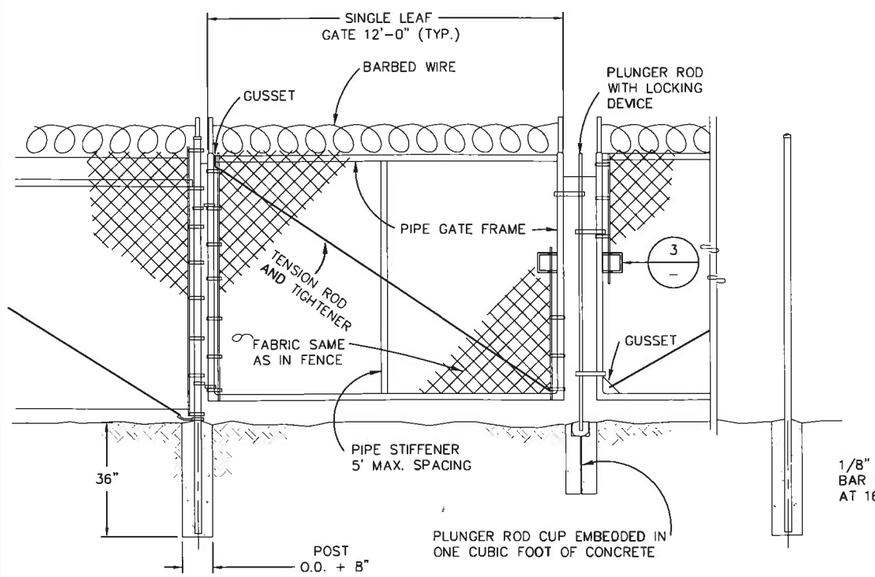
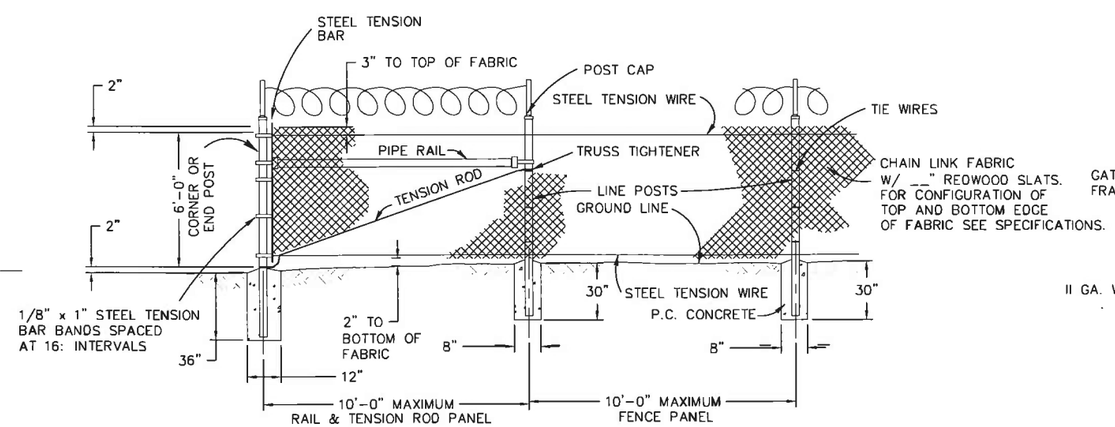
FENCE PLAN

DRAWING: C7.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09



1 — TYPICAL GATE ELEVATION

N.T.S.



3 — TYPICAL FENCE ELEVATION

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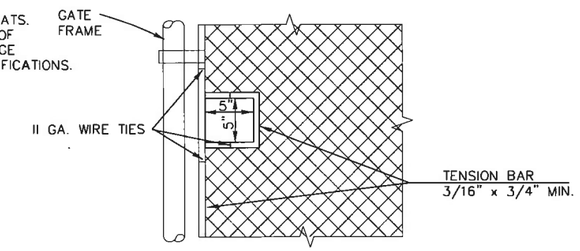

3 — CUT-OUT FOR CHAIN & LOCK

N.T.S.

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NO.	DATE	REVISIONS	BY	CHK
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ENGINEER: J. SOLORIO	SCALE: N.T.S.
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FENCE DETAILS

DRAWING: C7.1
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09

GENERAL CONDITIONS

GENERAL NOTES

1. THIS EROSION CONTROL PLAN PERTAINS SOLELY TO THE AREAS SHOWN ON THE ACCOMPANYING PLANS.
2. ALL EROSION AND SEDIMENT CONTROL DEVICES MUST BE IN PLACE BY OCTOBER 31.
3. EROSION AND SEDIMENT CONTROL DEVICES SHALL BE INSTALLED BY A CONTRACTOR LICENSED IN THE STATE OF CALIFORNIA WITH EITHER A CLASS A OR APPROPRIATE SPECIALTY LICENSE.
4. ALL AREAS THAT WILL ACCEPT FILL SHALL BE CLEARED, AND SCARIFIED AND BENCHED TO PROVIDE BONDING FOR THE FILLED SOIL.
5. FILL SLOPES SHALL BE COMPACTED AND GRADED TO A SMOOTH EVEN SURFACE. DO NOT FILL WITH LOOSE SOIL OR LEAVE SIDE CAST SOIL UNCOMPACTED.
6. AVOID ROUTING DRAINAGE ACROSS FILL SLOPES WHERE POSSIBLE.
7. PROVIDE ENERGY DISSIPATION AT THE OUTLETS OF ALL CULVERTS AND PIPES.

PERMANENT SEEDING & MULCHING

PERMANENT SEEDING & MULCH WILL BE REQUIRED ON ALL COMPLETED CUT AND FILL SLOPES.

1. TRACK-WALK UP AND DOWN SOIL SLOPES THAT ARE STEEPER THAN 4 TO 1 AND FLATTER THAN 2 TO 1.
2. APPLY SEED AND MULCH NO LATER THAN OCTOBER 31.
3. APPLY 40 LB/ACRE:

   NATIVE SEED EROSION CONTROL MIX.

4. APPLY 200 LB PER ACRE:

   B-10-10, (N-P-K), 10% SULFUR IS OPTIONAL, OR AS APPROVED BY THE ENGINEER.

5. APPLY 1.5 TONS PER ACRE:

   WHEAT OR RICE STRAW MULCH

6. IMMEDIATELY AFTER STRAW PLACEMENT, APPLY TACKIFIER/MULCH MIX:

   150 LB/ACRE TACKIFIER
   1,200 LB/ACRE CELLULOSE FIBER
   WATER NEEDED FOR OPTIMAL APPLICATION

7. OR EQUAL APPROVED BY CERTIFIED EROSION CONTROL SPECIALIST OR REGISTERED PRACTICING FORESTER.

VTC	VEHICLE TRACKING PAD		A GRAVEL PAD, LOCATED AT THE POINTS OF VEHICULAR INGRESS AND EGRESS ON A CONSTRUCTION SITE, TO REDUCE THE MUD TRANSPORTED ONTO ROADS AND PAVED AREAS.
STB	STRAW BALE BARRIER		A TEMPORARY SEDIMENT BARRIER COMPOSED OF ANCHORED STRAW BALES PLACED ACROSS OR AT THE TOE OF A SLOPE TO INTERCEPT AND DETAIN SEDIMENT AND DECREASES FLOW VELOCITIES FROM SMALL DRAINAGE AREAS; APPLICABLE WHERE SHEET AND RILL EROSION POTENTIAL IS LOW TO MODERATE.
SBB	SANDBAG BARRIER		TEMPORARY STABILIZATION OF DITCHES BY PLACEMENT OF SANDBAGS PERPENDICULAR TO FLOW. ACCOMPANIED BY A DEPRESSION UPSTREAM FOR SEDIMENT RETENTION. GOOD FOR USE WHERE SOILS ARE DIFFICULT TO EXCAVATE, IN AREAS OF SHALLOW BEDROCK, AND IN STEEP DRAINAGES.
SF	SILT FENCE	SF SF	A TEMPORARY SEDIMENT BARRIER CONSTRUCTED OF POSTS, FILTER FABRIC AND IN SOME CASES, A WIRE SUPPORT FENCE, PLACED ACROSS OR NEAR THE TOE OF A SLOPE OR IN A MINOR DRAINAGEWAY TO INTERCEPT AND DETAIN SEDIMENT AND DECREASE FLOW VELOCITIES FROM DRAINAGE AREAS OF LIMITED SIZE; APPLICABLE WHERE SHEET AND RILL OR SMALL CONCENTRATED FLOWS MAY BE A PROBLEM.
SW	STRAW WATTLE		TEMPORARY STABILIZATION OF SLOPES BY PLACEMENT OF STRAW WATTLES.
SB	SEDIMENT BASIN		A BASIN WITH A CONTROLLED STORMWATER RELEASE STRUCTURE, FORMED BY CONSTRUCTING AN EMBANKMENT OF COMPACTED SOIL ACROSS A DRAINAGEWAY, TO DETAIN SEDIMENT-LADEN RUNOFF FROM DISTURBED AREAS GREATER THAN 5 ACRES FOR ENOUGH TIME TO ALLOW MOST OF THE SEDIMENT TO SETTLE OUT CAN BE CONSTRUCTED ONLY WHERE THERE IS SUFFICIENT SPACE AND APPROPRIATE TOPOGRAPHY. TEMPORARY UNLESS DESIGNED AS A PERMANENT POND.
BB	BRUSH BARRIER		A TEMPORARY SEDIMENT BARRIER COMPOSED OF LIMBS, WEEDS, VINES, ROOT MATTER, SOIL, ROCK AND OTHER CLEARED MATERIALS PUSHED TOGETHER TO FORM A BERM; LOCATED ACROSS OR AT THE TOE OF A SLOPE TO INTERCEPT AND DETAIN SEDIMENT; AND DECREASE FLOW VELOCITIES DURING GRADING OPERATIONS AND REMOVED AT THE TIME OF FINAL GRADING.
CD	CHECK DAM	CD	SMALL, TEMPORARY BERMS CONSTRUCTED ACROSS DRAINAGEWAYS TO REDUCE THE VELOCITY OF CONCENTRATED FLOWS, REDUCING EROSION OF THE SWALE OR DITCH. LIMITED TO USE IN SMALL OPEN CHANNELS WHICH DRAIN SMALL AREAS; SHOULD NOT BE USED IN LIVE STREAMS.
TP	TREE PRESERVATION & PROTECTION	TP	PROTECTING EXISTING TREES FROM MECHANICAL AND OTHER INJURY DURING LAND DISTURBING AND CONSTRUCTION ACTIVITIES TO INSURE THE SURVIVAL OF TREES WHERE THEY ARE EFFECTIVE FOR EROSION AND SEDIMENT CONTROL AND PROVIDE OTHER ENVIRONMENTAL AND AESTHETIC BENEFITS.
GS	GRASS LINED SWALE		THE ESTABLISHMENT OF APPROPRIATE VEGETATION IN CONSTRUCTED CHANNELS TO LIMIT CHANNEL EROSION AND STABILIZE CHANNEL BOTTOMS.
PS	PERMANENT SEEDING	PS	ESTABLISHMENT OF PERENNIAL VEGETATIVE COVER BY PLANTING SEED ON ROUGH-GRADED AREAS THAT WILL NOT BE BROUGHT TO FINAL GRADE FOR AN EXTENDED TIME OR WHERE PERMANENT, LONG-LIVED VEGETATIVE COVER IS NEEDED ON FINE-GRADED AREAS. USED IN CONJUNCTION WITH HEAVY MULCHING.
PP	PERMANENT PLANTING	PP	ESTABLISHMENT OF WOODY VEGETATION ON ROUGH-GRADED AREAS THAT HAVE BEEN PERMANENTLY SEEDED OR SODDED WHERE PERMANENT, LONG-LIVED VEGETATIVE COVER IS DESIRED ON FINE-GRADED AREAS. USED IN CONJUCTION WITH MULCHING.
TM	TEMPORARY MULCHING	TM	USE OF CRIMPED STRAW, WOOD CHIPS, SAWDUST, ETC., TO COVER THE DENUDED SURFACE SHORTLY AFTER CLEARING AND GRUBBING, GRADING, AND CONSTRUCTION ACTIVITIES. MULCHING IS THE MOST EFFECTIVE AND IMPORTANT EROSION CONTROL PRACTICE TO BE USED.
PM	PERMANENT MULCHING	PM	USE OF WOOD CHIPS, STONE, BARK ETC., TO COVER THE FINISHED GRADED SURFACES AFTER CONSTRUCTION ACTIVITIES. MULCHING WITHIN 3 DAYS OF OPERATIONS TO ELIMINATE EROSION AND CONSERVE MOISTURE FOR PLANTINGS TO ENHANCE GROWTH. PART OF THE FINAL LANDSCAPING INCLUDING DRAINAGEWAYS, SWALES, ETC. USED WITH PERMANENT PLANTING.
IP	INLET PROTECTION		THE INSTALLATION OF VARIOUS KINDS OF SEDIMENT TRAPPING MEASURES AROUND INLETS, CULVERTS AND STRUCTURES PRIOR TO PERMANENT STABILIZATION OF THE DISTURBED AREA; LIMITED TO SMALL DRAINAGE AREAS AND NOT INTENDED TO CONTROL LARGE, CONCENTRATED STORMWATER FLOWS.
SS	STREAM SEEDING	SS	ESTABLISHMENT OF VEGETATIVE COVER WITHIN THE STREAM CHANNEL.
WB	WATER BAR		SMALL BERM AND DITCH COMBINATION APPROXIMATELY 18 INCHES IN HEIGHT AND LAID ACROSS A SLOPE AT 45° TO 60° TO REDUCE THE VELOCITY OF CONCENTRATED FLOWS, REDUCING EROSION OF A SLOPE, SWALE OR DITCH. FOR USE AS A SEMI-PERMANENT STRUCTURE ON TRAILS, SKI RUNS, AND SEASONAL ACCESS ROADS.
TS	TEMPORARY SEEDING	TS	ESTABLISHMENT OF SINGLE SEASON VEGETATIVE COVER ON ROUGH-GRADED AREAS. USED IN CONJUNCTION WITH HEAVY MULCHING.

GM	GEOTEXTILE MATTING	GM	STRONG MAN-MADE MATTINGS USED TO STABILIZE THE FLOW ON HIGH VELOCITY CHANNELS AND SWALES AND RECENTLY PLANTED SLOPES. ALSO USED AS A REINFORCEMENT BETWEEN COURSES ON ROAD WORK OVER SOFT AREAS. RECOMMENDED FOR USE IN RETAINING WALL AND FILL SLOPE CONSTRUCTION AS A TIE-BACK INTO NATIVE MATERIALS.
NM	NATURAL MATTING	NM	BIODEGRADEABLE MATERIALS, SUCH AS STRAW AND EXCELSIOR BOUND IN NETTING AND IMPREGNATED WITH SEED, ARE USED ON SLOPES WHERE RILL AND SHEET EROSION MAY BE A PROBLEM AND WHERE SEED AND MULCH WILL NOT BE EFFECTIVE. CAN BE UTILIZED IN TEMPORARY AND PERMANENT SEEDING SOLUTIONS AS NECESSARY.
SC	TEMPORARY STREAM CROSSING	SC	A TEMPORARY STRUCTURAL SPAN ACROSS A STREAM TO PROVIDE VEHICULAR ACCESS TO CONSTRUCTION ACTIVITY ON EITHER SIDE OF STREAM WHILE KEEPING SEDIMENT OUT OF THE STREAM AND PREVENTING DAMAGE TO THE CHANNEL AND BANKS. USED IN CONJUNCTION WITH OTHER MEASURES TO AVOID SEDIMENTATION OF THE RECEIVING WATER.
SR	SURFACE ROUGHENING	SR	GRADING PRACTICES SUCH AS STAIR-STEPPING, GROOVING SLOPES OR LEAVING SLOPES IN A ROUGHENED CONDITION BY NOT FINE-GRADING THEM. REDUCES RUNOFF VELOCITY, PROVIDES SEDIMENT TRAPPING AND INCREASES INFILTRATION; ALL OF WHICH FACILITATE ESTABLISHMENT OF VEGETATION ON EXPOSED SLOPES.
TRR	TEMPORARY ROCKLINED SWALE		A TEMPORARY ROCK LINED SWALE WILL PROVIDE DRAINAGE TO THE TEMPORARY GRADING OPERATIONS. A SECTION OF STRAW WATTLE IS PLACED ACROSS THE SWALE TO SLOW THE VELOCITY OF THE DRAINAGE.
SL	SLOPE DRAIN		A FLEXIBLE CONDUIT, USED BEFORE PERMANENT DRAINAGE STRUCTURES ARE INSTALLED; INTENDED TO CONVEY CONCENTRATED RUNOFF SAFELY FROM THE TOP TO THE BOTTOM OF A DISTURBED SLOPE WITHOUT CAUSING EROSION ON OR BELOW THE SLOPE.
DV	PERMANENT DIVERSION		A PERMANENT CHANNEL WITH A RIDGE ON THE LOWER SIDE CONSTRUCTED ACROSS A SLOPE TO REDUCE SLOPE LENGTH AND INTERCEPT AND DIVERT STORMWATER RUNOFF TO A STABILIZED OUTLET TO PREVENT EROSION ON THE SLOPE.
OP	OUTLET PROTECTION		THE INSTALLATION OF PAVED OR RIP-RAP CHANNEL SECTIONS AND/OR STILLING BASINS BELOW STORM DRAIN OUTLETS TO REDUCE EROSION FROM SCOURING AT OUTLETS AND TO REDUCE FLOW VELOCITIES BEFORE STORMWATER ENTERS RECEIVING CHANNELS BELOW THESE OUTLETS.
RR	RIP-RAP PROTECTION (ROCK LINED SWALE)		A PERMANENT, EROSION-RESISTANT GROUND COVER OF LARGE, LOOSE, ANGULAR STONE INSTALLED WHEREVER SOIL CONDITIONS, WATER TURBULANCE AND VELOCITY, EXPECTED VEGETATIVE COVER, ETC., ARE SUCH THAT SOIL MAY ERODE UNDER DESIGN FLOW CONDITIONS.
CRS	CONSTRUCTION ROAD STABILIZATION	CRS	TEMPORARY STABILIZATION WITH STONE HIGH TRAFFIC AREAS PRONE TO EROSION IMMEDIATELY AFTER GRADING TO REDUCE EROSION POTENTIAL DAMAGE CAUSED BY VEHICLES DURING WET WEATHER AND TO PREVENT HAVING TO REGRADE PERMANENT ROADBEDS BETWEEN INITIAL GRADING AND FINAL STABILIZATION.
DC	DUST CONTROL	DC	REDUCING SURFACE AND AIR MOVEMENT OF DUST DURING LAND DISTURBANCE, DEMOLITION OR CONSTRUCTION ACTIVITIES IN AREAS SUBJECT TO DUST PROBLEMS IN ORDER TO PREVENT SOIL LOSS AND REDUCE THE PRESENCE OF POTENTIALLY HARMFUL AIRBORNE SUBSTANCES. INCLUDES THE COVERING OF SOIL STOCK PILES AND CONSTRUCTION MATERIALS.
TSP	TOPSOIL PROTECTION	TSP	STRIPPING, STOCKPILING AND PROTECTING TOPSOIL FOR LATER USE IN PERMANENT LANDSCAPE ACTIVITIES. STOCKPILES ARE COVERED WITH SHEETING, MULCH AND/OR SEED AND SURROUNDED BY A CONTAINMENT BERM TO PROTECT THEM FROM EROSIVE FORCES. PERIODIC "TURNING" OF THE PILES IS REQUIRED TO MAINTAIN ENDEMIC MICROBIAL SOIL ORGANISMS.
LS	LEVEL SPREADER		AN OUTLET FOR DIKES AND DIVERSIONS CONSISTING OF AN EXCAVATED DEPRESSION CONSTRUCTED AT NEAR ZERO GRADE ACROSS A SLOPE TO CONVERT CONCENTRATED, SEDIMENT-FREE RUNOFF TO SHEET FLOW AND RELEASE IT ONTO AREAS OF UNDISTURBED SOIL STABILIZED BY EXISTING VEGETATION.
CWD	CLEAR WATER DIVERSION	CWD CWD	A TEMPORARY RE-ROUTING OF A WATERCOURSE THROUGH A SLUICE OR TUBE TO REDUCE THE AMOUNT OF CLEAN WATER COLLECTING SEDIMENTS FROM ACTIVE CONSTRUCTION OPERATIONS.
INF	INFILTRATION TRENCH	INF INF	A SEMI-PERMANENT SUB-SURFACE DRAIN THAT ALLOWS FOR STORM WATER TO BE ABSORBED BY THE GROUND IN A PONDED AREA. TYPICALLY A ROCK AND FABRIC LINED TRENCH ON THE DOWN GRADIENT SIDE OF A ROAD FILL OR IN AN OPEN AREA AWAY FROM THE ROADWAY.
SD	SUB-SURFACE DRAINS		A PERFORATED CONDUIT INSTALLED BENEATH THE GROUND TO INTERCEPT AND CONVEY GROUNDWATER PREVENTS SLOPING SOILS FROM BECOMING EXCESSIVELY WET AND SUBJECT TO SLOUGHING.
WDS	WATERWAY DROP STRUCTURE		A PERMANENT STRUCTURE OR SERIES OF STRUCTURES DESIGNED TO "STEP" WATER FLOW DOWN A SLOPE WITHOUT CAUSING CHANNEL EROSION; APPLICABLE IN NATURAL OR MAN-MADE CHANNELS WITH LONG, RELATIVELY STEEP REACHES.

NOTE: ADDITIONAL PRACTICES NOT SHOWN HERE CAN BE IMPLEMENTED BASED ON FIELD OBSERVATIONS AND ADJUSTMENTS FOR WEATHER, SEASON AND UNFORESEEN SITE CONDITIONS. CONTACT YOUR LOCAL PLANNING OFFICE FOR SPECIFIC SITE RECOMMENDATIONS AND FURTHER ASSISTANCE.

USE THESE CONVENIENT SYMBOLS AND DESCRIPTONS WHEN DEVISING AN EROSION CONTROL PLAN FOR THE INTENDED PROJECT. THE SYMBOLS ARE NATIONALLY ACCEPTED WHILE THE DESCRIPTIONS ARE TAILORED FOR MOUNTAIN DRIVEWAY CONSTRUCTION.

A SMALL PONDING AREA, FORMED BY CONSTRUCTING AN EARTHEN EMBANKMENT WITH A GRAVEL OUTLET ACROSS A DRAINAGE SWALE, TO DETAIN SEDIMENT-LADEN RUNOFF FROM SMALL DISTURBED AREAS FOR ENOUGH TIME TO ALLOW MOST OF THE SEDIMENT TO SETTLE OUT.

P:\008195.00_haldrear & hull_fort bragg reservoir\erosion notes.dwg D.B.Z. 12/2/2009

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EROSION CONTROL GENERAL NOTES

DRAWING: C8.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09

NOTES:

1. THESE REQUIREMENTS ARE MINIMUMS, CONTRACTOR IS RESPONSIBLE FOR FINAL PLANS.
2. FOR ROADSIDE DITCH, PLACE (SW) (PS) (PH) WHERE DITCH HAS BEEN DISTURBED AND REHABILITATED.

PLACE STRAW WATTLES EVERY 100' MIN. ACROSS FLOWLINE OF DITCH FROM 10+00 TO 16+80 (SW) 3/C8.3

(PS) (PM) ALONG DITCH WHERE DISTURBED

BRUSH CREEK ROAD

SUMMERS LANE

STRAW WATTLE @ ELEV. 288' & 298' (SW) 2/C8.3

1/C8.3 (SF)

APPROXIMATE PROPERTY LINE

2:1

3:1

(PS) (PM)

35+28.37

36+00

(OP)

18" CMP CULVERT

CREEK

SUMP

UNDERDRAIN

STRAW WATTLE @ ELEV. 278' (SW) 2/C8.3

PLACE STRAW WATTLES EVERY 100' MIN. ACROSS FLOWLINE OF DITCH FROM 20+50 TO 25+50 (SW) 3/C8.3

APPROXIMATE LOCATION NEWMAN RESERVOIR

STRAW WATTLE @ ELEV. 288' & 298' (SW) 2/C8.3

APPROXIMATE PROPERTY LINE

GRAPHICAL SCALE

0 60 120 180

(FEET)

P:\008195.00_baldrege & kull_fort bragg reservoir\skeplan_erosion.dwg D.B.Z. 12/3/2009

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=60'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
3590 IRON CT.
SHASTA LAKE, CA 96019
(530) 275-4800
(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

EROSION CONTROL SITE PLAN

DRAWING: C8.1

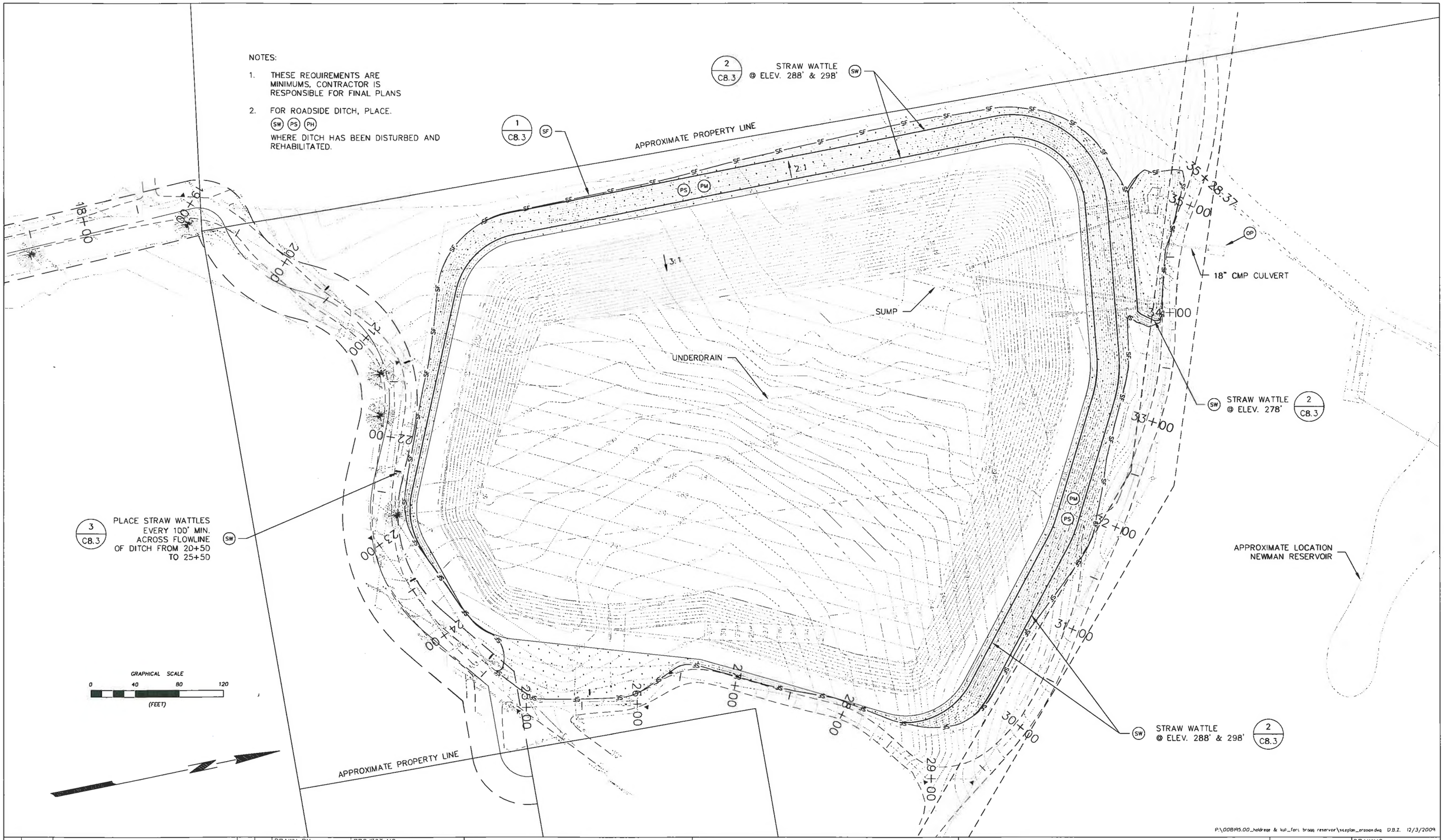
SHEET: OF

REVISION NO: REVISION 0

DATE: 12/1/09

NOTES:

1. THESE REQUIREMENTS ARE MINIMUMS, CONTRACTOR IS RESPONSIBLE FOR FINAL PLANS
2. FOR ROADSIDE DITCH, PLACE. (SW) (PS) (PH) WHERE DITCH HAS BEEN DISTURBED AND REHABILITATED.



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NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=60'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
3590 IRON CT.
SHASTA LAKE, CA 96019
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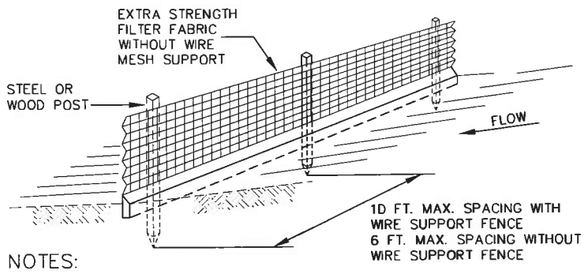
(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

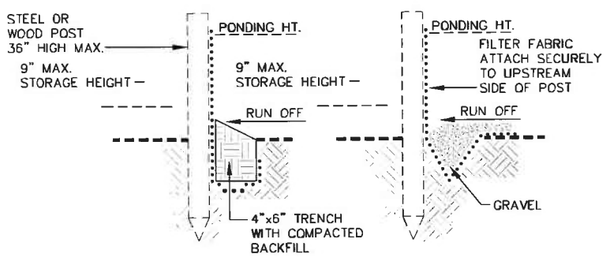
POND EROSION CONTROL SITE PLAN

DRAWING: C8.2
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/1/09



NOTES:

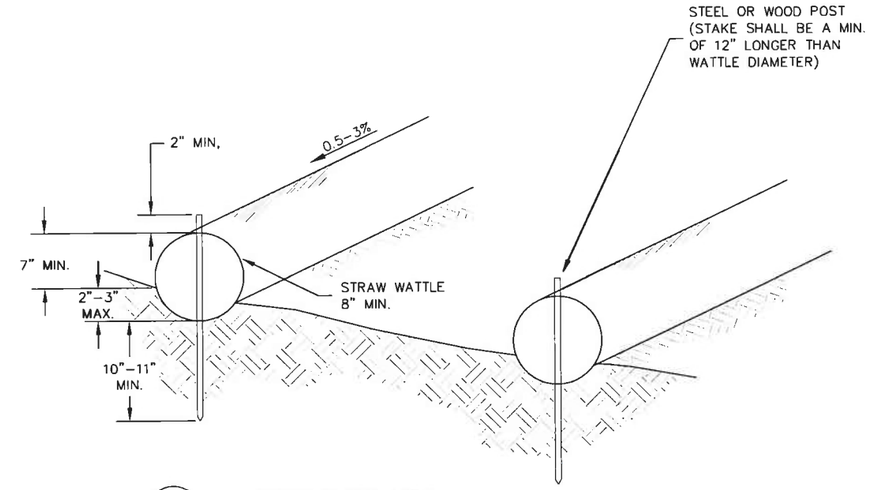
1. THE CONTRACTOR SHALL INSPECT AND REPAIR FENCE AFTER EACH STORM EVENT AND REMOVE SEDIMENT WHEN NECESSARY.
2. REMOVED SEDIMENT SHALL BE DEPOSITED TO AN AREA THAT WILL NOT CONTRIBUTE SEDIMENT OFF-SITE AND CAN BE PERMANENTLY STABILIZED.
3. SILT FENCE SHALL BE PLACED ON SLOPE CONTOURS TO MAXIMUM PONDING EFFICIENCY.



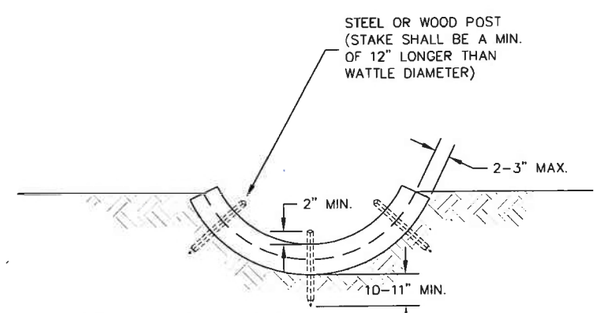
STANDARD DETAIL
TRENCH WITH NATIVE BACKFILL

ALTERNATE DETAIL
TRENCH WITH GRAVEL

1 — SILT FENCE
NOT TO SCALE



2 — STRAW WATTLE DETAIL
NOT TO SCALE



3 — STRAW WATTLE IN DITCH
NOT TO SCALE

P:\00B195.00_baldrage & kull_fort bragg reservoir\DETAILS-EROSION.dwg D.B.Z. 12/2/2009

NO.	DATE	REVISIONS	BY	CHK

DRAWN BY: D. ZAITZ	PROJECT NO: 00B195.00
ENGINEER: J. SOLORIO	SCALE: 1"=3' H & V
CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES
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3590 IRON CT.
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NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

EROSION CONTROL DETAILS

DRAWING: C8.3
SHEET: OF
REVISION NO: REVISION 0
DATE: 12/2/09

LAWRENCE
& ASSOCIATES
ENGINEERS & GEOLOGISTS

008195.00

July 2, 2009

Ms. Katryna Baker
City of Fort Bragg
416 North Franklin Street
Fort Bragg, CA 95437

Dear Ms. Baker:

SUBJECT: PRELIMINARY DESIGN REPORT FOR THE PROPOSED SUMMERS LANE 45 ACRE-FOOT RESERVOIR, CITY OF FORT BRAGG

Enclosed are three copies of our preliminary design report for a 45-acre-foot reservoir near Newman Gulch.

Please contact me at (530) 275-4800 if have any questions regarding the proposal or would like to schedule a meeting.

Sincerely,

Jesse Solorio, PE
Senior Engineer

enc.: 3 copies of report (duplicated on recycled paper)

3590 Iron Court • Shasta Lake, California 96019 • (530) 275-4800 • fax (530) 275-7970 www.lwrnc.com
2619 Forest Avenue • Chico, California 95928 • (530) 343-8857 • fax (530) 343-8879 info@lwrnc.com

LAWRENCE
& ASSOCIATES
ENGINEERS & GEOLOGISTS

008195.00

PRELIMINARY DESIGN REPORT
FOR THE
PROPOSED SUMMERS LANE
45 ACRE-FOOT RESERVOIR,
CITY OF FORT BRAGG

REGISTERED PROFESSIONAL ENGINEER
JESSE I. SOLORIO
No. 65306
Exp. 9/30/09
CIVIL
STATE OF CALIFORNIA

PREPARED FOR:

CITY OF FORT BRAGG
416 NORTH FRANKLIN STREET
FORT BRAGG, CA 95437

3590 Iron Court • Shasta Lake, California 96019 • (530) 275-4800 • fax (530) 275-7970 www.lwrnc.com
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A. Hydraulic Calculations
B. Engineers Estimate
C. Project Schedule

1. PROJECT DESCRIPTION

A. **Project Name**: Summers Lane Reservoir

B. **Project Location**: The proposed project is located in the City of Fort Bragg, California. The City is located on the North Coast along Highway 1 in Mendocino County. The property is located approximately 2.5 miles inland at the north end of Summers Lane. The site is bounded by a farm and residence to the West, an existing City reservoir to the North, and an existing animal shelter to the South-East.

- Latitude: 39° 25' 31" N (39.4252°)
- Longitude: 123° 46' 04" W (123.7678°)

C. **Type of Application(s)**: Development by the City of Fort Bragg.

D. **Assessor's Parcel Number**: 019-070-01

E. **City of Fort Bragg Zoning**: Public Facilities Zoning District

F. **City of Fort Bragg General Plan Designation**: Public Facilities and Services

G. **Project Description**: The proposed project consists of the construction of a 45 acre-foot reservoir on a 40-acre site, plus associated off-site piping and controls. **Figure 1** shows a site location map.

a. **Grading** – The project site will be altered to accommodate the proposed reservoir. A total of approximately 7.5-acres will be cleared and grubbed for the footprint of the reservoir and associated piping. Approximately 7,000-cubic yards (cy) of topsoil will be removed from the site to a location not yet determined. An additional 34,000-cy of subgrade soil will be graded on site to create the embankment of the reservoir. **Figure 2** shows a conceptual plan view of the proposed grading.

b. **Liner** – The reservoir will be lined with a 60-mil high-density polyethylene (HDPE) liner. The top of the liner will be white in color.

c. **Security** – The site will be enclosed with a locking gate and 6-foot high chain link fence.

d. **Piping Inlet** – The inlet for the pipe that will deliver water to the reservoir is located at Waterfall Gulch, approximately 2 miles south of the proposed reservoir. This inlet currently serves as the inlet for the pipe that delivers water to the City of Fort Bragg and the existing Newman Reservoir. The inlet has a mesh sand screen of unknown size. The existing inlet will not be altered for this project. We understand that the inlet basin has recently been cleaned to prevent sand from entering the pipe intake.

e. **Point of Connection to Existing Piping** - The new pipeline for the reservoir will connect to an existing 6-inch diameter asbestos-concrete pipeline approximately 280-feet west of the intersection of Brush Creek Road and Summers Lane. We assume that the metal pipe that currently connects to the asbestos pipe will be cut at its connection with the asbestos pipe, and removed to the adjoining Celeri property and abandoned in place. To reduce friction, a sweeping elbow will be installed. An isolation valve can be specified at the point of connection, if desired.

f. **Route of New Piping** - The new section of 8-inch PVC pipe will be routed from the point of connection east on Brush Creek Road to Summers Lane along the north shoulder of Brush Creek Road within the existing 60-foot Mendocino County right-of way. From the intersection, the pipeline will trend north along the 50-foot Mendocino County right of way easement of Summers Lane into the project property. The pipeline will discharge into the south end of the reservoir. A bypass line will continue around the reservoir and tie to the outlet. The total length of inlet piping will be approximately 1,550-ft. See **Figure 3.1, 3.2, and 3.3** for the approximate pipeline alignment.

g. **Depth of Trench** – Based on head calculations, there is sufficient head to route the pipe in a conventional manner (generally between 3- and 8-feet deep).

h. **Reservoir Inlet** – The force main will enter the reservoir at the south end. It is possible that a small forebay or buried tank could be added to remove sediment before entering the reservoir.

i. **Reservoir Bypass Pipe** – A bypass pipe will tee into the reservoir inlet pipe and can be used to route water around the reservoir. The other end of the pipe will tee into the reservoir outlet pipe. Valves will be used to route water around the reservoir. The bypass pipe would be used during periods when the pond is being maintained or if increased flow was required from Waterfall Gulch.

j. **Reservoir Outlet Pipe** - The pipeline will exit the reservoir at the northeast corner and then tie into the existing Newman Reservoir pipeline near the existing path to Newman Reservoir from the PG&E right of way (**Figure 3.5**). The outlet piping will be approximately 100-feet long.

k. **Cleanout Basin** – The pond will have a drain at the bottom that will be used to retain sediment during cleaning. The basin will provide a location where sediment can accumulate and then be removed using equipment. Because the incoming water is relatively sediment free, it is anticipated that the cleanout basin will be used infrequently.

l. **Floating Cover** – While one is not specified at this time, the City may elect to install a floating cover in the future to reduce evaporation and wind-blown debris.

H. **Permits and Approvals Required**:

a. **CEQA** – The City of Fort Bragg will complete the California Environmental Quality Act (CEQA) document when the biological and archaeological reports are complete.

b. **Timber Harvest Permit** – A Timber Harvest Permit is required before the trees within the limits of construction can be cut.

c. **Stormwater Permit for Timber Harvest** - The California Regional Water Quality Control Board (RWQCB) requires a "General Permit" (WQ Order No. #97-03) to be obtained prior to commencement of construction activities. The General Permit regulates and monitors storm water discharge from a variety of construction activities, including timber harvesting, and is used to identify responsible parties, locations, and scope of operations. A Storm Water Pollution Prevention Plan (SWPPP) is required to be submitted with the Notice of Intent (NOI).

d. **Grading Permit** – A grading permit will need to be submitted to, and approved by, the City of Fort Bragg Public Works Department prior to grading operations.

e. **Stormwater Permit for Construction** – The RWQCB requires a "General Permit" (WQ Order No. 99-08-DWQ) to be obtained prior to commencement of construction activities. The General Permit regulates and monitors storm water discharge from a construction site and is used to identify responsible parties, locations, and scope of operations. A SWPPP is required to be submitted with the Notice of Intent (NOI).

f. **Encroachment Permit** – An encroachment permit from Mendocino County is required for installation of a driveway from the reservoir property to Summers Lane.

g. **Point of Diversion** - The description of an existing Point of Diversion permit will need to be revised by the City of Fort Bragg and approved by the State Water Resources Control Board.

h. **ACOE 404 Permit** - An Army Corps of Engineers Permit (ACOE) will be required if a designated "water of the US" is found within the limits of construction. As it is not yet known if one is within the construction area, if one is found the City may elect to redesign the project to avoid the wetland or may mitigate removal of the wetlands either on site or by purchase of an off site mitigation.

I. **Initiated By**: City of Fort Bragg
416 North Franklin Street
Fort Bragg, CA 95437

J. **Owner**: City of Fort Bragg

K. **Prepared By**: Lawrence & Associates (L&A)
3590 Iron Court
Shasta Lake, CA 96019

2. SITE DESIGN

2.1. Grading

Approximately 43,000-cy of soil will be graded on the reservoir property to provide the planned 45-acre feet (af) of water storage. Approximately 7,000-cy of topsoil will be removed from the site and taken to a location not yet determined. An additional 34,000-cy will be cut, moved, and then compacted to create the embankment for the reservoir. The reservoir will cover approximately 6.5-acres. An additional one acre will likely be cleared to provide clear area for access, construction staging, the outlet basin, and reservoir piping.

Two-to-one (2 horizontal:1 vertical) outside (opposite impounded water), and three-to-one (3:1) inside slopes are planned for the reservoir embankment. The preliminary plan calls for 10-foot maximum cuts, and 17-foot thick fills, although these dimensions will vary with the final design. The maximum reservoir depth (from the water surface to the deepest point) will be 24-feet which is below the 25-foot jurisdictional limit for the California Division of Dam Safety. A geotechnical investigation has not been completed as of the time of this report, and the results of the geotechnical investigation may require changes to the embankment geometry.

A total of three feet of freeboard has been assumed for the reservoir. Freeboard is additional embankment height that is provided above a water surface level to assure that failure of the dam will not result from overtopping because of factors that may permanently or temporarily increase the water surface elevation in the reservoir. Freeboard also provides a safety factor to account for uncertainties in operational procedures and the function of the facility in critical situations. The total amount of freeboard may increase or decrease depending on calculations to be performed during the design phase of the project.

No camber has been assumed in the preliminary design. Camber is the extra height added to the crest of embankment dams to ensure that the freeboard will not be diminished by foundation settlement or embankment consolidation. Camber may be added to the final design following the results of the geotechnical investigation.

Figure 2 shows a conceptual plan view of the proposed grading.

2.2. Diversion/Piping

The source piping for the reservoir will tie into the existing pipeline to Newman Gulch Reservoir approximately 280-feet west of the intersection of Brush Creek Road and Summers Lane. The existing pipeline that continues north to Newman Gulch will be disconnected and abandoned in place. All water which used to flow to the City and Newman Gulch Reservoir will be diverted to the new reservoir.

The piping system will to use approximately 10,560-feet of existing piping. Of this total, approximately 3,178-feet were replaced in or around the year 1990. **Table 1** below lists the assumed pipeline characteristics based on historical data provided by the City on April 14, 2009.

Table 1
Existing Diversion Piping

STATION (STARTING AT WATERFALL INLET)	PIPE MATERIAL	APPROXIMATE YEAR INSTALLED
0 – 0+43	12" C150 PVC	1990
0+43 – 3+40	8" ASBESTOS CEMENT (AC)	UNKNOWN
3+40 – 34+75	10" C150 PVC	1990
34+75 – 105+60	6" AC	UNKNOWN
105+60 – 121+44	6" SPIRAL STEEL/6" AC/6" C300 PVC	UNKNOWN/1990

Notes: PVC: polyvinyl chloride. The 6" spiral steel section will be abandoned in place.

The current outlet from Waterfall Gulch consists of an embankment, less than 10-feet tall, through which a discharge pipe and an overflow culvert pass. The inlet to the discharge pipe is fitted with a stainless-steel sand filter. A gate valve is used to regulate the amount of water entering the pipeline. A vacuum relief valve is located on top of the embankment to prevent a vacuum from forming inside the pipe. The City's permit to operate allows them to take up to 300 gallons per minute (gpm) from the spring. City personnel typically let a small amount of water spill through the overflow culvert so that they don't risk drawing down the water level to the intake and introducing air to the pipe.

Historical data[1] show that the average flow from Waterfall Gulch is approximately 155 gpm. The flow has ranged from a high of 381 gpm to no flow in some months. The value of 381 gpm may be suspect as the next highest measured flow rate was 256 gpm. Flow through a pipeline is a function of the head loss and differential elevation of water surfaces. For any given pipe configuration, the greater the head (elevation) between the entrance and exit, the greater the velocity and hence flow through the pipe.

---

1 Facsimile transmission from Mike Heath, City of Fort Bragg. April 24, 2009.

The difference in elevation between the inlet at Waterfall Gulch and Newman Gulch Reservoir is about 108-feet. The inlet into the new reservoir will be 62-feet higher than the current discharge location, and hence the flow through the pipe will be lower than the current flow. One goal of design process is to evaluate whether there will be sufficient flow (*e.g.* have enough flow to fill the pond, compensate for evaporation, and leave water for use) with water discharging into the reservoir at its design elevation. It is the City's preference not to use pumps; therefore, our evaluation is based on gravity flow without booster pumps.

To evaluate flow, L&A calculated both the "ideal" and "actual" roughness and resulting flow velocity of the existing pipeline from Waterfall Gulch to Newman Reservoir. The "energy equation" was used to calculate the flow rate in the pipeline with Manning's equation used to calculate friction losses. Minor losses were neglected because of the length of the pipeline. The ideal roughness was calculated using typical pipe diameter text-book values of Manning's *n* (roughness coefficient). Actual roughness was back calculated using the known head and reported flow rates. **Appendix A** presents the calculations.

With the inlet valve at Waterfall Gulch fully open, ideal peak flow to the existing flow meter at Newman Reservoir was calculated to be approximately 300-gpm. This value was derived using the assumed pipeline data in Table 1, and estimated roughness coefficients.

To verify this flow rate, on May 25, 2009, City personnel opened the valve at Waterfall Gulch all the way, and then measured the actual flow at the Newman Reservoir flow meter and the water level at the intake. Unfortunately, the day of the test, Waterfall Gulch was producing less than 200-gpm and the inlet basin level began drawing down with the valve wide open. The test was stopped after 3 hours when the water level in the basin dropped to near the top of the intake. While the pipeline may be theoretically capable of supporting the ideal flow of 300-gpm, the maximum flow during the test was only 200-gpm. This result would indicate that there may be damage, corrosion, leakage, sediment in the pipeline, or a combination thereof. One possibility is that there may be solids deposited at a valley in the pipeline, reducing the pipe cross section area and choking off the flow is some locations. It may be prudent for the City to install a bleed valve at low points on the pipeline to shed off any deposited solids.

Appendix A presents the results of the field test and calculations of the expected flow to the new Reservoir assuming similar pipe roughness to the values derived from the field test.

Using this test as a baseline, we calculated flow into the new reservoir at an elevation of 298-feet MSL, and using the existing pipe, to be 132-gpm when full, and 162-gpm when empty (based on assumed elevations 298' full, and 275' empty). To minimize friction losses and optimize the flow, a larger 10-inch diameter C-900 PVC pipe was assumed for the 1,373-feet of pipe from the point of connection on Summers Lane to the new reservoir (the existing pipe is 6-inch diameter steel).

A final calculation (**Appendix A**) was made to determine the expected flow from Waterfall Gulch to the proposed reservoir based on the assumed existing pipe material, and published roughness coefficients for in-service pipelines. This calculation assumed that the last 1,373' of pipeline would be replaced with 10" diameter C-900 PVC. The results show that the expected flow rate to the proposed reservoir would be approximately 225-gpm.

Assuming 135-gpm, it would take approximately 70 days to fill the reservoir. Assuming 225-gpm flow rates based on published roughness, it would take approximately 40 days.

2.3. Overflow (Spillway)

An overflow path, commonly referred to as a spillway, is provided on reservoirs to provide a safe release in the event that inflow exceeds outflow during a condition when the water surface elevation is at full pool. The design of the overflow is driven by factors such as inlet flows, tributary area, rainfall rates, and safety. In the case of the proposed reservoir, surrounding surface drainage will be routed around the reservoir; therefore, the only tributary will be the pond surface. Therefore, the outlet must be designed for the maximum anticipated inflow, which is rainfall from a 100-year storm event, and additional factor of safety (in this case, a factor of safety of 1.5 is recommended).

Historical data provided by the City Water Treatment Plant dating back 12 years show a maximum flow in the existing pipeline to be 350-gpm (less than 1-cfs). Using the Rational Method, rainfall data from DWR Bulletin no. 195, and assuming an impermeable surface, the peak flow rate from the reservoir would be approximately 20-cfs for a 100-year storm of 5 minutes duration (flows from longer duration storms would be significantly less). Adding the inflow from the pipeline and applying a 1.5 factor of safety, the design overflow will be 32 cfs.

There are various methods of providing overflow capacity, including glory holes and spillways. For this application we are specifying a spillway because it is the least likely method to clog with floating debris (such as windblown branches). **Figure 4** shows a conceptual detail of the proposed spillway. The spillway will consist of two stages - a low-flow orifice, and an overflow spillway. The low-flow orifice, will allow the water level to rise up to one foot above full and then release the excess water at 1 cfs. The purpose of this orifice is to minimize the flow from smaller rainfall events and to allow the City some flexibility to collect the water rather than allowing to spill. The spillway will provide a controlled overflow for larger storms, and will be designed for the peak design flow of 31 cfs.

The spillway will route the water down the side of the pond via an HDPE lined and rip-rapped swale. The water will be discharged into an existing swale downstream. The swale travels northeast to Newman Gulch and subsequently into the Noyo River. The current peak flow from the reservoir footprint into the existing drainage swale is calculated to be 4.9 cfs. Using the low-flow orifice, the peak flow will be less after the reservoir is constructed.

There are no buildings between the reservoir spillway and the Noyo River. At the design discharge of 1 cfs, the flow into Newman reservoir and the Noyo River will be less than pre-project flow and will not contribute to flooding. Any discharge from the spillway is likely to last only the duration of the design storm for peak flow of 5 minutes. It is anticipated that this short term flow would not contribute to downstream flooding.

2.4. Outlet

Large reservoirs tend to develop a thermalcline with higher temperature water on top and lower temperature water on the bottom. This separation is called "stratification". Stratification can lead to stagnant water. In larger reservoirs, multiple outlets may be used to draw water from different levels to minimize the affects of stratified water.

Because the reservoir is relatively small and shallow, the likelihood for stratification is low, so discharge points and multiple depths are not specified. A single 8-inch diameter, outlet from near the bottom of the reservoir is assumed. The outlet will be located approximately two feet above the bottom of the pond to avoid in taking sediment. A second pipe will be provided near the bottom of the pond to be used as a drain for maintenance, and as a redundant discharge pipe. These outlets would tie to the existing pipeline which leads to Newman Reservoir (**Figure 4**). Both outlets also will be provided with a discharge basin so that sediment can be collected during maintenance.

Also, having a continuous line from the City to Waterfall Gulch provides the opportunity to increase head, and consequently, flow rate, from Waterfall Gulch with both Waterfall Gulch and Newman Gulch Reservoir off line.

2.5. Liner

Underdrain

To prevent groundwater from saturating the soil beneath the embankment, and to prevent groundwater from accumulating beneath the liner, an underdrain consisting of 2- to 3-inch perforated schedule 40 PVC pipe bedded in gravel, and filter fabric, shall be installed in the native soil installed beneath the liner. The underdrain should be installed to a depth of 3-feet below ground surface, be spaced every 100-feet along the reservoir bottom, and gravity drain downhill to an erosion-protected discharge point. For the last 20-feet of piping before it exits the slope, blank pipe and 3-sack sand-cement slurry backfill must be used.

Reservoir Outlet Pipes

The reservoir outlet pipes shall consist of 8-inch HDPE SDR-17 welded pipe. As described above, two pipes should be installed; one near the bottom of the reservoir that allows the reservoir to be drained completely, and one approximately 2- to 3-feet off the bottom that will

collect water that is unaffected by sediment. Two pipes also provide redundancy in case of a valve failure.

The locations where the pipes enter the reservoir shall have an approximately 48-inch tall by 46-inch wide by 6-inch thick reinforced concrete collar into which HDPE batten strips are installed. The "boot" (connection with the liner) will be attached to this collar. Boots are the most common cause of minor reservoir leakage, therefore it is essential that proper "piping" (movement of water along a pipe in trench backfill that creates a void that could cause failure of the embankment) prevention is provided.

Depending upon the amount of clay in the native soil, seepage collars may or may not be required. Seepage collars are concrete walls installed perpendicular to the pipe, extending into the native soil along the trench. Their purpose is to prevent water from piping. The current standard of practice is that in clayey soils, seepage collars do not provide a benefit, and that properly compacted clayey backfill provides better prevention of piping than seepage collars. However, if sandy soil is used for the pipe backfill, seepage collars likely will be required. The results of the geotechnical report should indicate the soil characterizes.

Surface Preparation

All roots, sticks and angular rocks must be removed from the compacted subgrade prior to installation of the liner. The surface compacted to 90 percent of maximum dry density per ASTM D1557 prior to finishing. The surface must be bladed smooth, and smooth-drum rolled to provide a smooth surface with non-protruding angular rocks or round rocks protruding more than ½-inch above the surrounding surface. The liner installer must inspect the prepared surface and approve it as ready for liner placement before placing the liner. All voids or cracks in the finished subgrade with sharp edges greater that ½-inch in diameter shall be filled with sand prior to installing the liner.

Anchor Trench

Appendix B is an anchor trench calculation. Assuming the worst case scenario of an empty reservoir, and anchor trench that is 3-feet deep, two feet wide and located 3-feet back from the top of slope has a pseudostatic factor of safety of greater than 1.5. The liner must be placed in the anchor trench so that it laps down the side of the trench, across the bottom and at least half-way up the other side. The anchor trench should be backfilled with native soil that is free of angular rocks over 1-inch in diameter and free of sticks or roots that could puncture the liner.

Liner Material

For the Newman Reservoir Project, a liner should have the following characteristics:

(1) Available in a light color to reduce the potential for water heating.
(2) Be suitable for drinking water applications.
(3) Be resistant to the affects of UV.
(4) Be resistant to physical damage.

(5) Have seams that are resistant to physical damage.

There are numerous liner materials including high density polyethylene (HDPE), low density polyethylene (LDPE), scrim reinforced polyethylene (SRPE), Polyvinylchloride (PVC), and polypropylene. While polyethylene and PVC liners cost as little as 40 percent less than HDPE liners and have a lower coefficient of thermal expansion, their longevity, and seam durability are lower than that of HDPE. The lifespan of HDPE is not known but is generally longer than 30 years. L&A has observed reservoir liners that have been in place for 15 years with no visible evidence of wear. For this application, we recommend using 60-mil smooth white liner.

Liner Installation and Inspection

HDPE Liners are installed using the double wedge weld continuous seams and extruded bead seams in locations of tests, repairs, and commonly at boots. Installation requires specialized tools and equipment. We recommend that the foreman have experience in at least one million square feet of liner installation, and that the liner company have experience in at least 5 million square feet of liner area within the last 5 years.

L&A will prepare specifications and construction quality assurance (CQA) plan describing materials testing and approval, installer experience requirements, nondestructive and destructive testing, observation, and record keeping.

To ensure a leak-free reservoir L&A recommends that a geoelectric leak test be required at the conclusion of installation. In a geoelectric leak test, a testing company places an electrode in the soil outside of the reservoir and runs an electrode that discharges water to complete the circuit over the bottom of the reservoir. This method can find tiny leaks, not detected with other CQA methods.

Valve Configuration

It is common to locate gate valves on the inlet side of reservoirs, although installing inlet valves will require additional boots and fastening points that can be prone to leakage. We recommend, therefore, that valves be placed on the outlet side of the pipe as shown on **Figure 4**.

Emergency Egress

On a 3 to 1 slope, a wet HDPE liner is very slippery and difficult to climb; therefore, we recommend installing an emergency egress ladder or strip of textured HDPE on each side of the reservoir. We also recommend that the reservoir be fenced to keep wildlife out.

Drive-In Access

A drive-in ramp is not currently shown on the drawings. Installation equipment can operate on a 3 to 1 slope; therefore a ramp is not necessary for installation. We assume that it is likely sediment will enter the reservoir, and that for cleaning, sediment will be hosed down to the lower outlet and washed through the pipe. We will provide a stand pipe so that City staff can connect

to the water from Waterfall Gulch, add a pump, and use the water for washdown. If the City would like a ramp, one can be added to the drawings, although, a ramp will reduce the reservoir capacity.

Thermal Shrinkage and Wrinkle Management

All liners shrink with decreasing temperature; therefore, the contractor must allow enough slack in the liner so that it does not create excessive tension during colder weather. Accommodating shrinkage is termed "wrinkle management". The coefficient of thermal expansion for 60-mil HDPE liner is 5.3×10^{-5} inches per inch length per degree F (in/in/deg F) from -100 to100 degrees F and 8×10^{-5} in/in/deg F from 100 to 180 degrees F[2]. This means that if a liner is installed at a temperature of 70 degrees and the temperature drops to 32 degrees, the liner will shrink 0.2%, or about 1-1/2 inches in 100 feet. With increasing installation temperature, more slack must be added.

The contractor will be required to submit a wrinkle management plan. Because this reservoir will contain water most of the time, fewer wrinkles will occur than a reservoir that is frequently empty. We recommend that the liner provide enough slack so that it can contract to a low temperature of 32 degrees F. The reservoir should not be emptied below this temperature. If the City of Fort Bragg feels that the reservoir could be emptied at a lower temperature, L&A can specify a lower temperature.

Wind Uplift

Wind blowing across the top of an empty reservoir causes suction on the downhill side of an embankment. Wind also can cause the wrinkles to be pushed to one end of an empty reservoir, so that they are not evenly distributed, resulting in undue stress on a liner. Reservoirs that will be emptied regularly will require ballast to prevent wind uplift. Ballast typically consists of HDPE tubes filled with sand. Typically a few inches of water over the reservoir surface is all that is needed to provide sufficient ballast to prevent wind uplift. L&A understands that the reservoir will always contain water unless it is drained for cleaning or maintenance; therefore, we have not specified ballast. If the reservoir will be emptied frequently or for extended periods of time, ballast should be specified.

2.6. Storage/Supply Relationship

The reservoir is to be used as an emergency source to supplement the Noyo River supply during times when that source is restricted. The proposed reservoir is to remain full during normal operating conditions, and only drained when supplemental storage is required (or for cleaning).

---

[2] Personal Communication, January 3, 2002, from Mr. Boyd Ramsey, Technical Engineering, GSE Lining Systems, Houston, Texas.

To evaluate (a) the flow that would be required to maintain the reservoir full and (b) whether the reservoir would support more use of the Waterfall Gulch (Simpson Lane) source (rather than the Noyo River), we developed a hydraulic-capacity model of the reservoir (**Figures 5 through 7**).

The model uses average monthly values for inflow and outflow to calculate the water level in the reservoir, based on given reservoir geometry. Inflow consisted of water from Waterfall Gulch and direct precipitation. Values for Waterfall Gulch were based on measurements of flow from Waterfall Gulch (Simpson Gulch) made by City staff. Inflow values from waterfall gulch were all lower than the maximum theoretical flow calculations described in **Section 2.2**. Precipitation data was from the last extended drought (1987 through 1992), so that inflow would not be overestimated (and, subsequently, the potential use overestimated). Evaporation data was calculated based on typical summer and winter values for the north coast area.

The model shows that in an extended drought period and with inflows similar to those measured from Waterfall Gulch, the reservoir will remain full year round, with only slight decreases in water levels during the summer (**Figure 5**). Overflow would be common throughout the year.

Increasing the water use 5% from the Waterfall Gulch source would cause the water level to decline about two feet during the summer, with only a few days of overflow during the winter (**Figure 6**). The reservoir would fill during the winter, and then gradually decline during the summer as water is used and evaporation increases. Winter water levels would be similar year to year.

Using the reservoir to make up 60% of the current Noyo River extraction would cause the water level to decline about four feet during the summer, with only an occasional overflow during the winter (**Figure 7**). The reservoir would fill during the winter, and then rapidly decline during the summer. Winter water levels would **not** be similar year to year in this operating scenario – the reservoir level would gradually decline about two feet. That is, this operating scenario would not be sustainable in the long term, but could be used for a few years at a time to augment the supply from the Noyo River.

2.7. Water Quality

The main water source for the reservoir will be from Waterfall Gulch. This water source currently is one of the sources for Newman Reservoir, and is of good quality (meets State drinking water standards).

Because uncontrolled surface water will not flow directly into the reservoir, as currently occurs with Newman Reservoir, the water quality will be better than in Newman Reservoir. Surface water in the vicinity of Newman Reservoir can be of poor quality, containing elevated tannins & lignins and having a low pH. The lack of uncontrolled surface water runoff into the new reservoir also will reduce the amount of extraneous material that enters. The only extraneous

material that will enter the new reservoir will be wind-blown material, such as dust and organic debris. The source water from Waterfall Gulch has low turbidity (1.5 NTU measured on 10/10/07). Therefore, it is expected that suspended solids should be low within the reservoir. Because the proposed reservoir is relatively small, it is not anticipated that stratification will occur, leasing to stagnation and reduced oxygen content. Generally, reservoirs less than 20-feet deep stay mixed through wind action.

It is expected that the reservoir will be oligotrophic (have low nutrient/low productivity).

Temperature increases, caused by low through-flows and shallow depth could be a concern. We have specified a white liner to help reduce the effects of reservoir warming.

3. FUNDING

The form of funding for the project has not yet been decided. The City has some capital funds that may be used, but they are not sufficient for the entire project. The State of California has programs for both low-interest loans (State Revolving Fund loans) and grants that can be used for improvements to drinking water systems. To apply for these programs, the design plans and environmental review must be complete. Other funding programs, such as the recent Federal "economic stimulus" monies may become available.

4. MAINTENANCE

The proposed reservoir will be designed to require minimal maintenance. As with all sites, clearing of weeds, upkeep of fencing, and general site maintenance will be required. A properly installed HDPE liner should provide a service live well in excess of 30 years.

Although the inlet at Waterfall Gulch has a sand screen, it is possible during winter storms or during maintenance for sediment that is finer than fine sand to enter the pipeline and settle in the pond. Because the pond is surrounded by trees, windblown floating debris may also enter the pond; some of the debris will be skimmed off and some will eventually sink to the bottom of the pond. It is difficult to predict the amount of debris that will enter the pond and accumulate on the bottom. For budgeting purposes, however, it should be assumed that the pond will be drained once every 5 years, inspected, and cleaned.

Ponds of this size are typically cleaned using fire hoses that wash the sediment to the low end. Larger branches are picked up by hand and smaller sediment is hosed through the cleanout drain and into the cleanout basin where it is collected and transported to a disposal site. Equipment must not drive on an unprotected liner, and sharp tools must not be used to collect or move sediment. Dull edged aluminum grain shovels are generally recommended in scooping up sediment if required. We also recommend periodic inspections for vandalism, signs of leakage, and clogging of the low flow spillway, and operating the valves to ensure functionality.

5. Right of Way

All proposed work is to be completed either on City property, or Mendocino County right of way. 280-feet of pipeline will be installed along Brush Creek Road, requiring an encroachment permit from the County. Mr. Paul Tiner from Mendocino County was contacted regarding the proposed pipeline. He stated that the County preference would be to have the pipeline installed in the shoulder of Brush Creek Road. The City will be required to submit an encroachment permit application and a fee. During construction, a County Road Foreman will be on site to direct the alignment of the pipeline, and trench backfill.

6. CQA and Control During Construction

Liner systems require specific inspection and testing to ensure that they will be leak- free after construction. A construction quality assurance (CQA) plan will be prepared that describes the specific steps of inspection and number and types of tests required.

The CQA plan also will include steps to minimize disturbance of neighbors by dust, noise and other nuisances typically associated with construction. Requirements will include watering during construction to reduce dust, working during daylight hours only (no earlier than one hour before sunrise to no later than one hour after sunset), reduction of speed on local roads, mud clear-off area to prevent tracking of mud onto local streets, street sweeping where required, and other nuisance control methods.

The CQA plan will require flagging and temporary fencing around critical habitat areas or waters of the US that must not be disturbed (if any). The plan will also require that work stop if any archaeological or cultural sites are found during the work, until mapped by an appropriately trained professional.

7. Cost Estimate

The engineer's estimate for the proposed reservoir (**Attachment B**) provides a general estimate of the construction costs associated with completing this project. No permit fees were considered in this estimate.

a. Mobilization – The cost of mobilization includes preparatory work and operations necessary for the movement of personnel, equipment, supplies and incidentals to the project site.

b. Timber Harvest – The timber harvest is an unknown quantity. The value assumed in the engineer's estimate includes the cost of tree cutting, storage, tree spoils removal, timber removal and sale of all merchantable pieces.

c. Field Engineering – The cost of field engineering includes basic site engineering requirements for which the Contractor will be responsible during construction. This includes grade setting, construction staking, and protection of Owner supplied survey control points and limits of work flagging.

d. Clearing & Grubbing – This includes the removal of non-merchantable trees, shrubs, boulders, and other objectionable material within the established work area. The Reservoir site is a heavily wooded and brushed area, extensive work will need to be accomplished prior to grading operations.

e. Grading – The grading will include the construction cost for creating the embankment of the Reservoir.

f. Off-Haul Excess Cut – This includes the grubbing and removal of the top 6- to 8-inches of organic topsoil.

g. Subdrain System – Includes cost for installation of a subdrain system under the reservoir.

h. Liner Anchor Trench – This includes the cost for providing a trench for the HDPE Liner to be anchored in.

i. HDPE Liner – This consists of providing all operations pertaining to the furnishing, installing, and testing of the high-density polyethylene (HDPE) geomembrane liner.

j. Spillway and Sediment Basin – Cost assumes concrete spillway with HDPE liner and sediment basin prior to entering culvert.

k. Culvert Under Existing Access Road – Assumed 18" HDPE culvert.

l. Trenching & Backfilling of Water Line – This includes the cost of trenching and backfilling for the construction and installation of the water pipeline.

m. 10" Water Line (C900) – This includes the cost for furnishing and installing pressure water lines, appurtenances, and pressure testing.

n. Erosion Control – The cost of erosion control includes furnishing materials required for erosion control, including silt fences, mulching and other erosion control devices. The Contractor is also responsible for providing a SWPPP prior to construction.

o. Chain Link Fence & Gate – This includes the cost for installing a new six-foot high chain link fence and gate.

p. Pavement Repair – The Contractor will be responsible for repairing any existing pavement damaged during the course of construction.

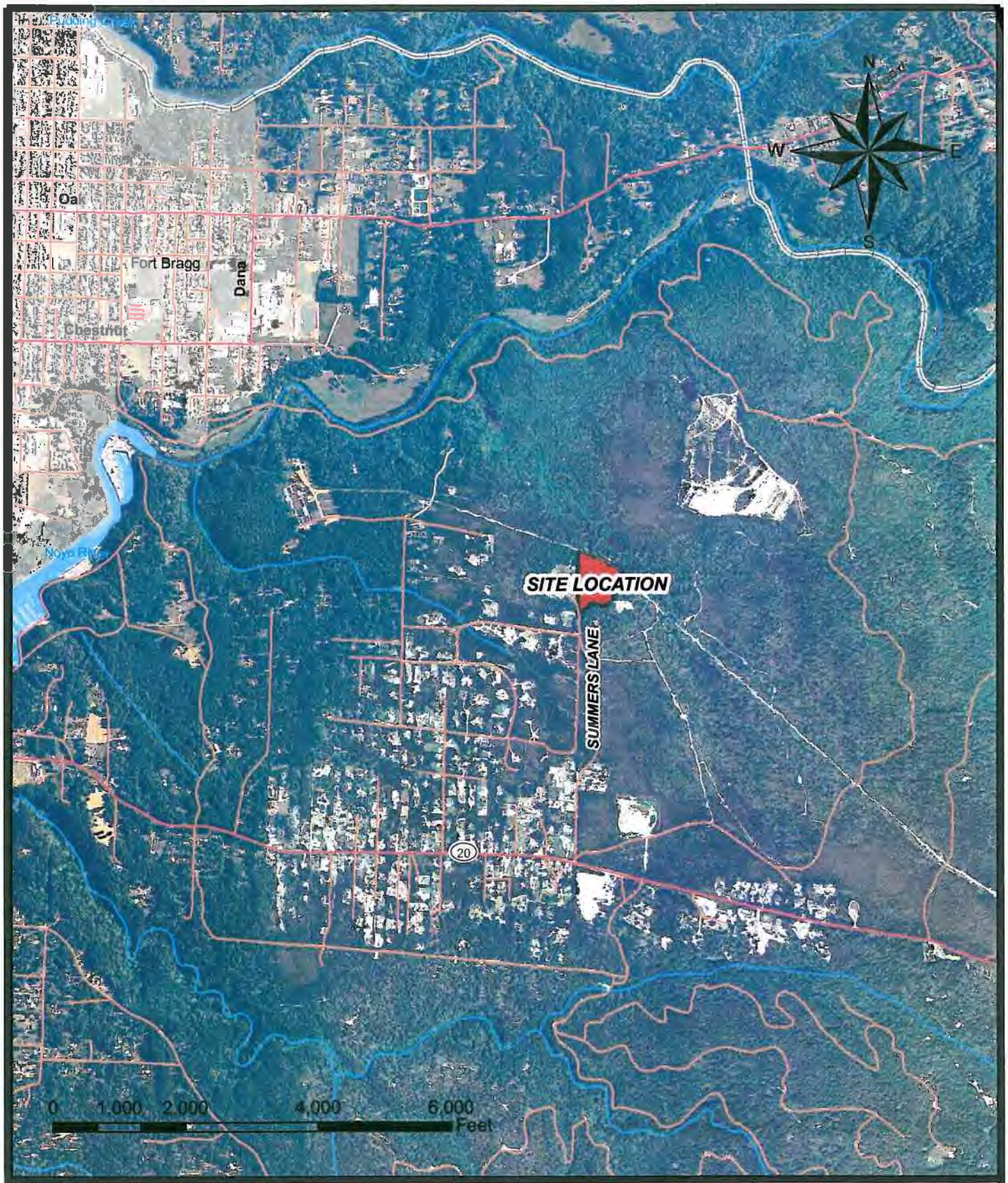
8. PROJECT SCHEDULE

The project schedule (**Appendix C**) assumes an early May 2010 construction start.

a. Permits – The necessary permits required for this project are still being determined. The completion and review of the CEQA document will indicate whether or not a 404 Army Corp of Engineers (ACOE) permit is necessary. Regardless of what permits are ultimately required, all permits should be complete and accepted by mid-March 2010.

b. Civil Design – The preliminary design has already begun. At design milestones of 75, 90, and 100 percent, the City will have an opportunity to review the design and provide suggestions for changes. The 100 percent design is scheduled to be completed in mid-August.

c. Bidding – The bidding process will begin with project advertisement and end with choosing a contractor at least 10 days prior to construction.



SITE VICINITY MAP

LAWRENCE & ASSOCIATES
3590 IRON COURT
SHASTA LAKE, CA 96019
(530) 275-4800
FAX (530) 275-7970

SCALE: 1"=2000'

DATE: 6-25-09

JOB NUMBER: 008195.00

CLIENT: CITY OF FORT BRAGG

PROJECT: POND DESIGN

DRAWN BY: D. ZAITZ

FIGURE 1

Z:\p\008195.00_holdrege & kull_fort bragg reservoir\site vicinity map8.5x11.mxd

LEGEND

- RIGHT OF WAY
- PROPERTY BOUNDARY
- PROPOSED WATER LINE ALIGNMENT
- EXISTING WATER LINE
- EXISTING ELECTRICAL LINE
- EXISTING DRAINAGE SWALE
- EXISTING FENCE LINE
- F — FLOW METER
- VALVE
- THRUST BLOCK
- (E) — EXISTING

APPROXIMATE PROPERTY LINE

GRAPHICAL SCALE 0 40 80 120 (FEET)

(E) 6" C-900 PVC

18" CMP CULVERT

CREEK

(E) FLOW METER

(E) VAULT

(E) POWER LINE

APPROXIMATE LOCATION NEWMAN RESERVOIR

PROPOSED PIPELINE ALIGNMENT

SUMP

UNDERDRAIN

2:1

3:1

50' R.O.W. PER MC2, DR 29 PG 74

APPROXIMATE PROPERTY LINE

CITY OF FORT BRAGG APN 018-070-01

ANIMAL CONTROL APN 018-070-

BOARD OF THE MENDOCINO COAST RECREATION AND PARK DISTRICT APN 018-010-11

CITY APN 018-090-12

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: O. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=40'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

PROPOSED POND

DRAWING: 2.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 7/2/09

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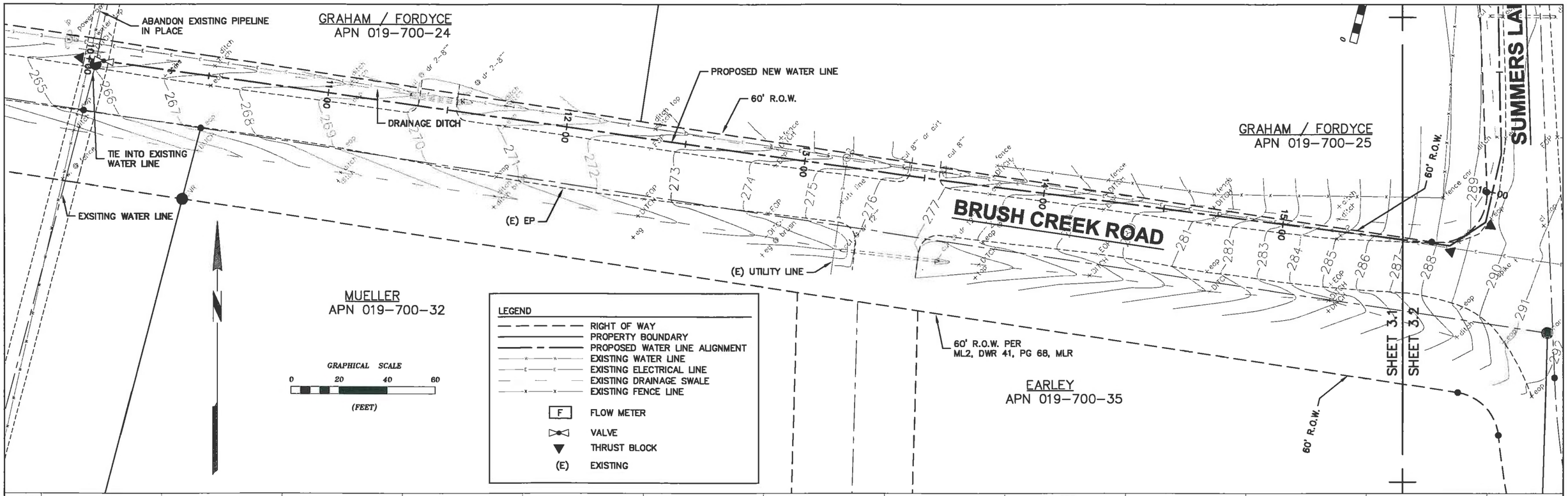

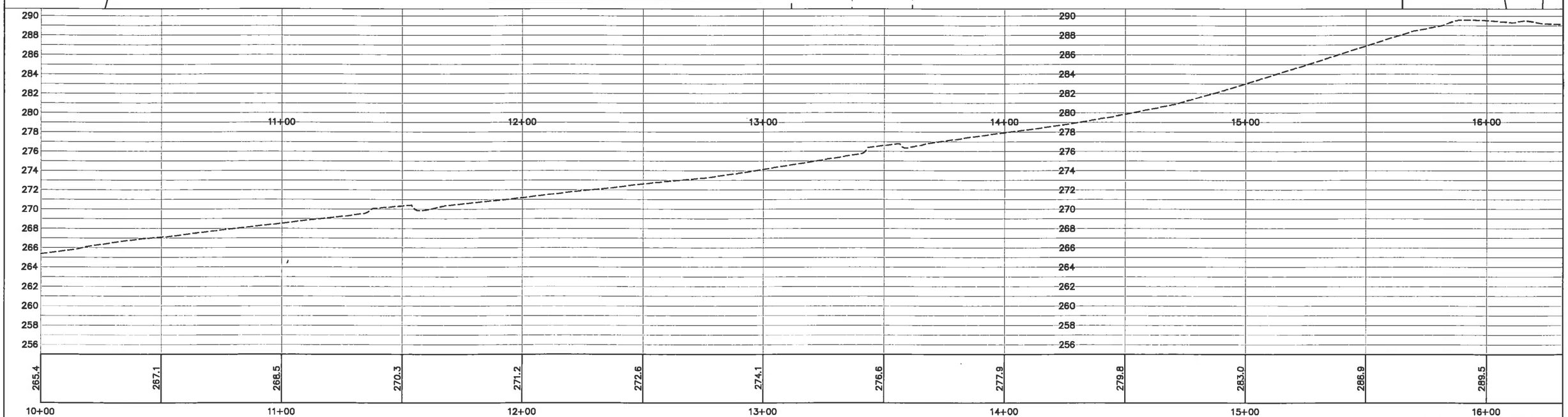

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ENGINEER: J. SOLORIO
CHECKED BY:
DATE:
PROJECT NO: 008195.00
SCALE: 1"=20'
APPROVED BY:
DATE:

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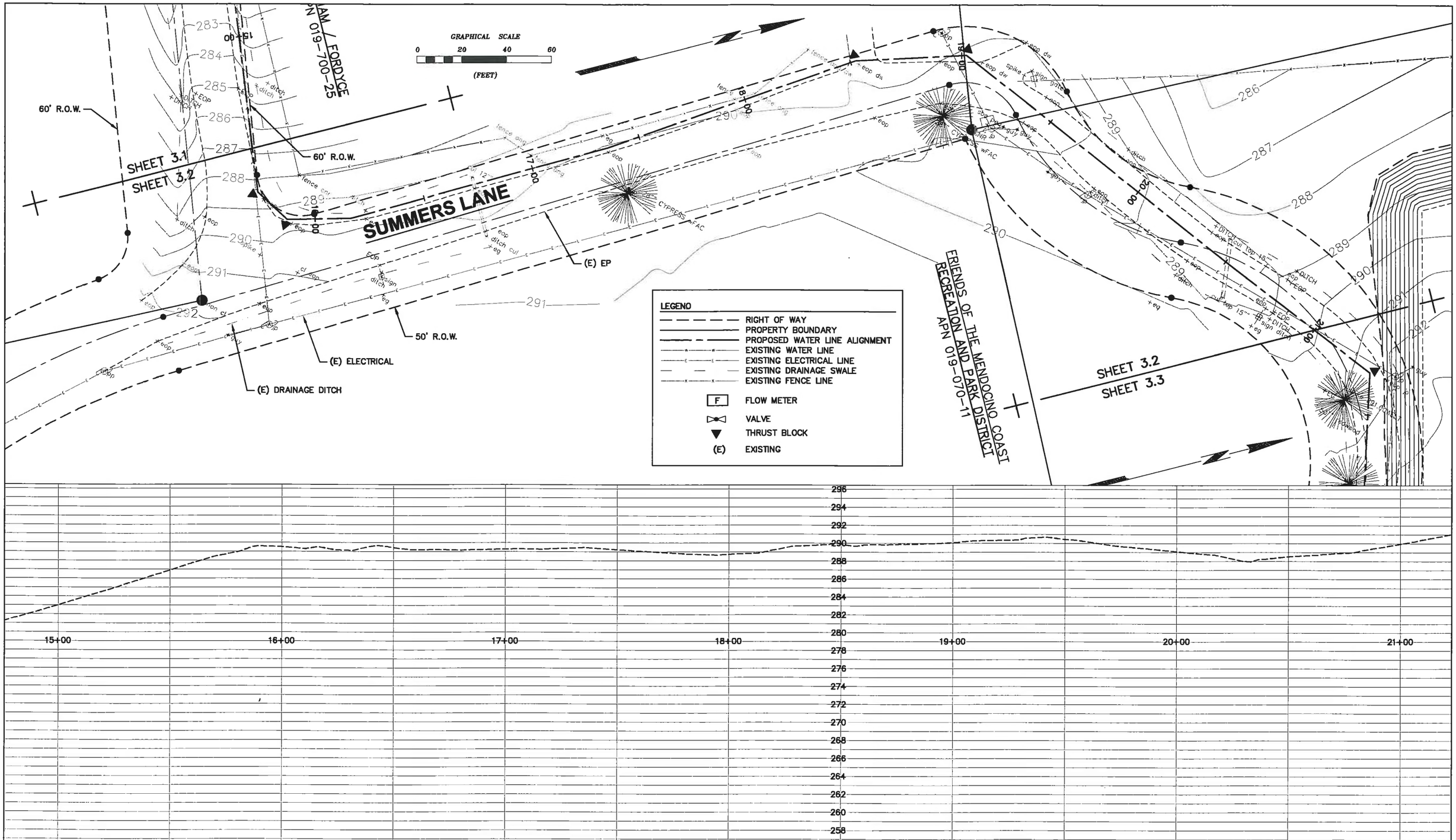
NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 10+00 TO 15+50

DRAWING: 3.1
SHEET: OF
REVISION NO: REVISION 0
DATE: 6/29/09



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ENGINEER: J. SOLORIO
CHECKED BY:
DATE:
PROJECT NO: 008195.00
SCALE: 1"=20'
APPROVED BY:
DATE:

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NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 15+50 TO 21+00

DRAWING: 3.2
SHEET: OF
REVISION NO: REVISION 0
DATE: 6/29/09

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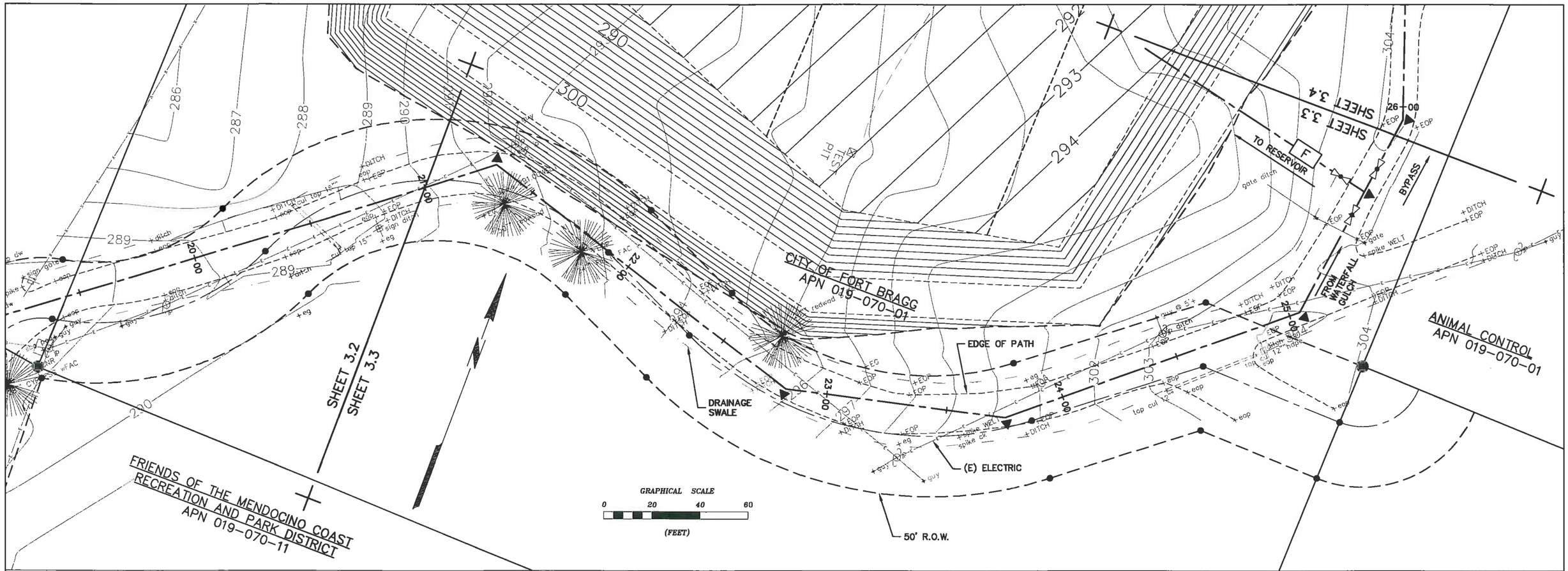

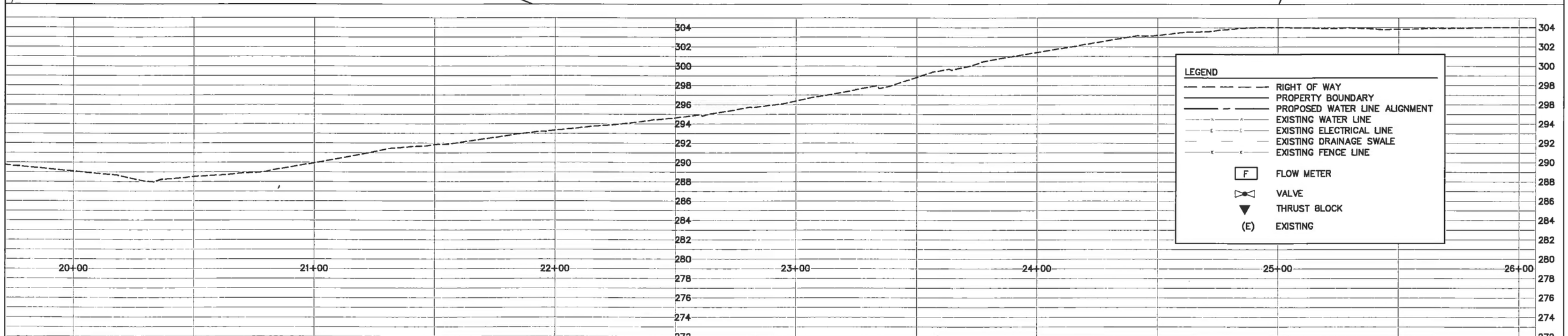

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1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=20'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 21+00 TO 26+00

DRAWING: 3.3
SHEET: OF
REVISION NO: REVISION 0
DATE: 6/29/09

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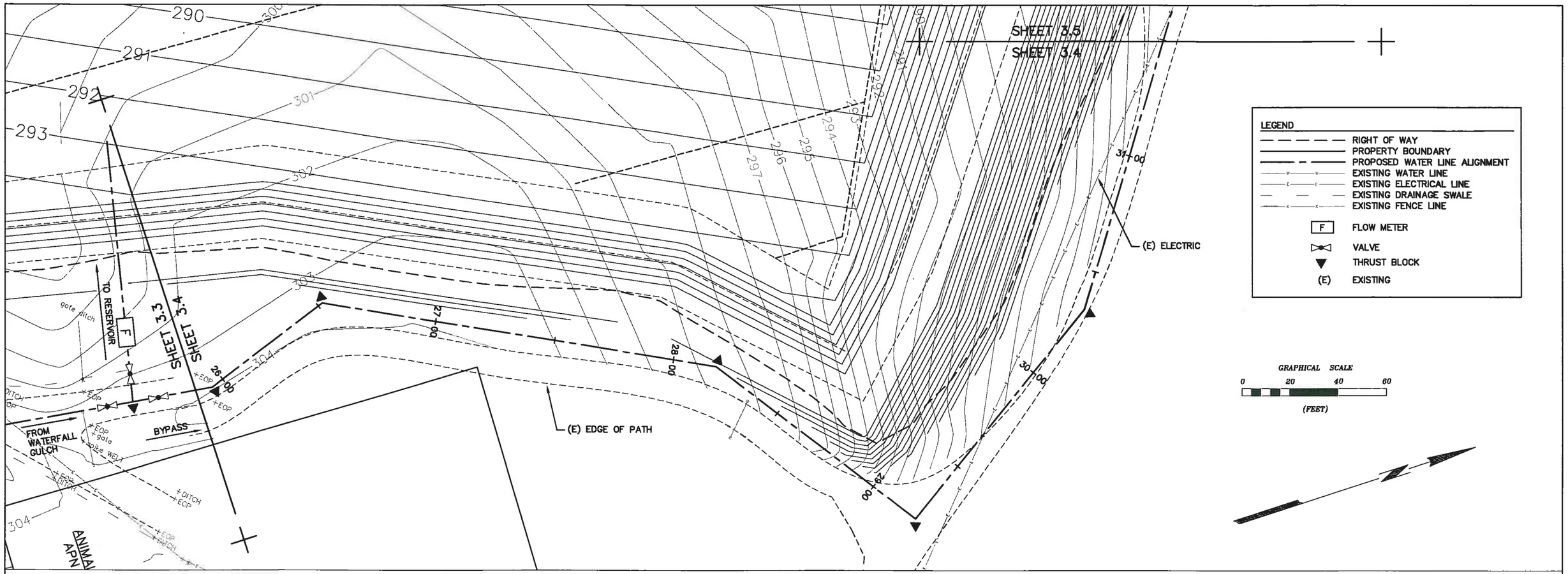

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1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: D. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: 1"=20'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 26+00 TO 31+50

DRAWING: 3.4
SHEET: OF
REVISION NO: REVISION 0
DATE: 6/29/09

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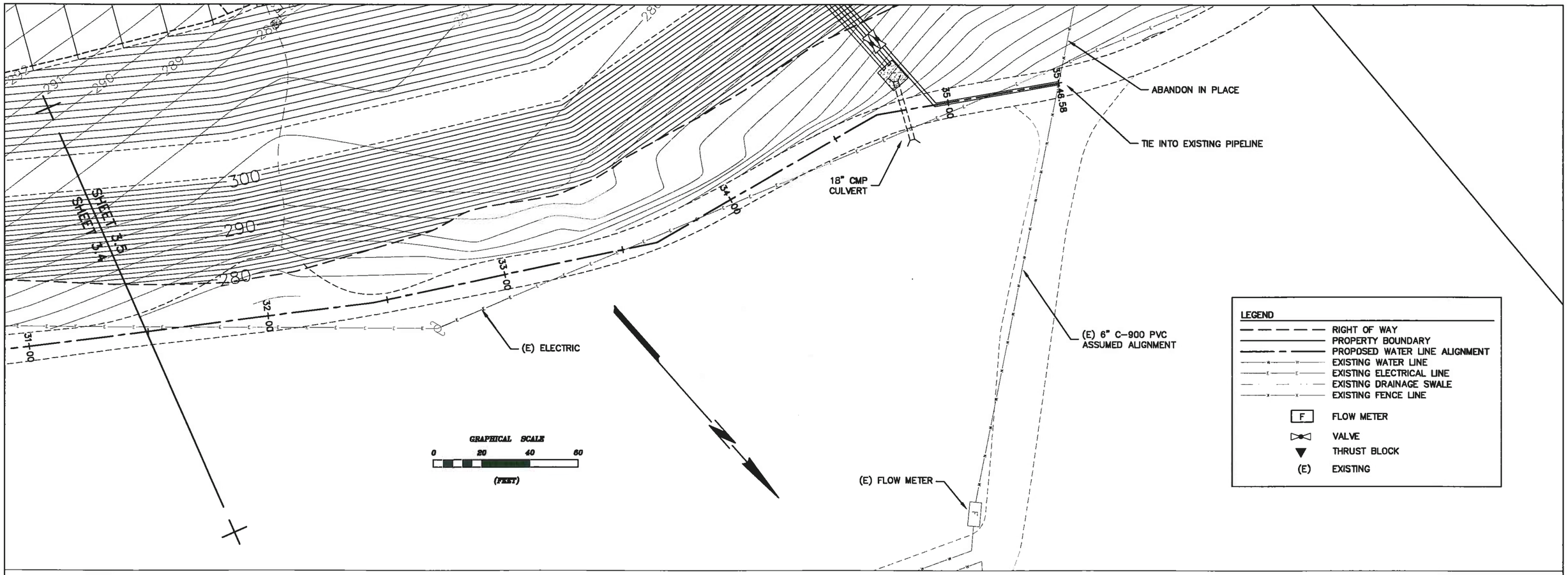

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1	7/2/09	PRELIMINARY	JS	CC

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ENGINEER: J. SOLORIO	SCALE: 1"=20'
CHECKED BY:	APPROVED BY:
DATE:	DATE:

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NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

WATER PIPE PLAN AND PROFILE STATION 31+50 TO 35+46.58

DRAWING: 3.5
SHEET: OF
REVISION NO: REVISION 0
DATE: 6/29/09

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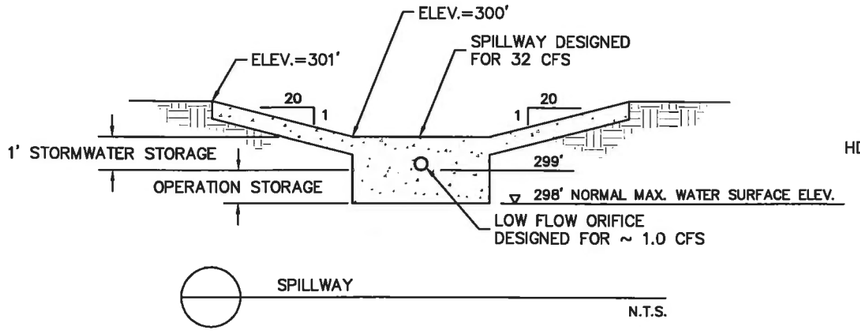

SPILLWAY

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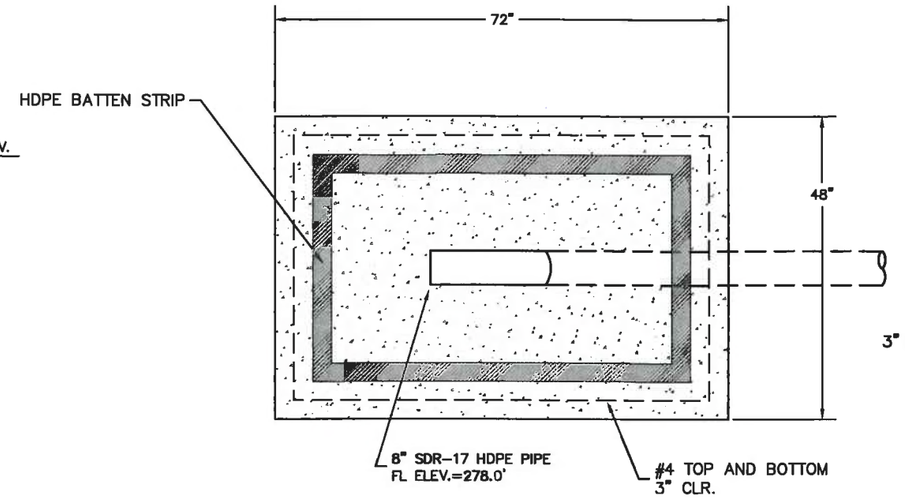

BOOT DETAIL – PLAN

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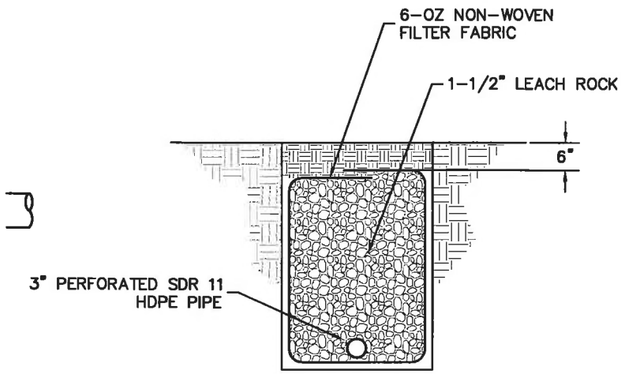

UNDERDRAIN DETAIL – PERFORATED

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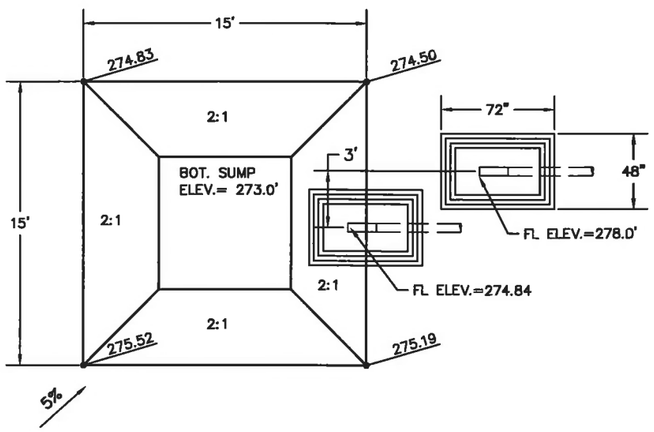

SUMP DETAIL

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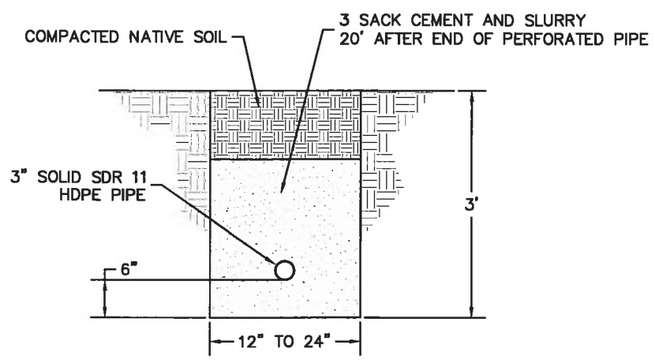

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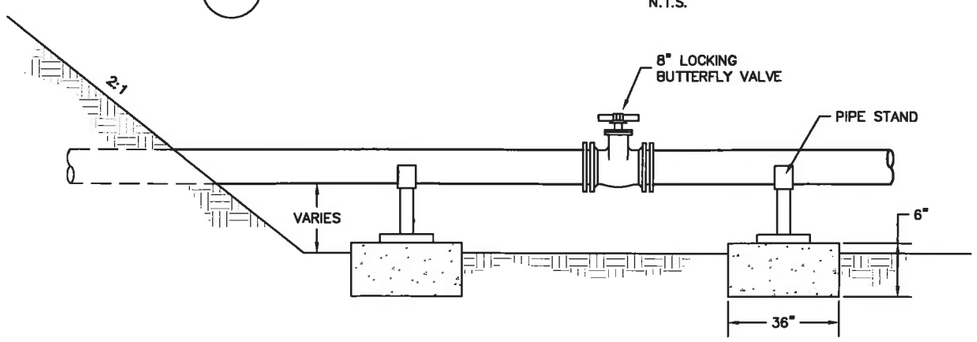
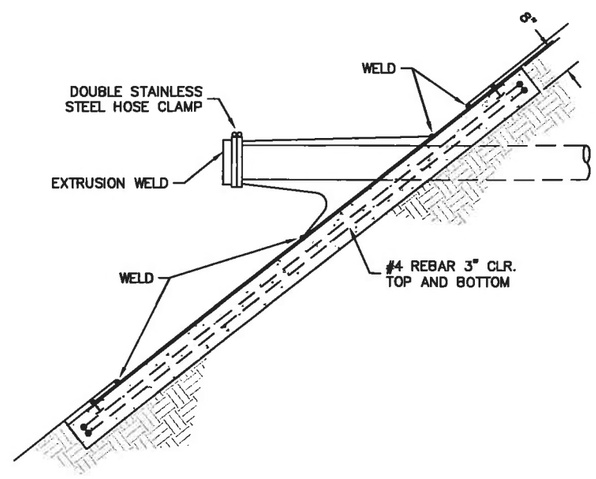


OUTLET VALVE DETAIL

N.T.S.



BOOT DETAIL – SECTION

N.T.S.

P:\008195.00_baldrige & kull_fort bragg reservoir\details.dwg D.B.Z. 7/2/2009

NO.	DATE	REVISIONS	BY	CHK
1	7/2/09	PRELIMINARY	JS	CC

DRAWN BY: O. ZAITZ	PROJECT NO: 008195.00
ENGINEER: J. SOLORIO	SCALE: N.T.S.
CHECKED BY:	APPROVED BY:
DATE:	DATE:

LAWRENCE & ASSOCIATES
ENGINEERING GEOLOGY
3590 IRON CT.
SHASTA LAKE, CA 96019
(530) 275-4800
(530) 275-7970 FAX

NEWMAN RESERVOIR

CITY OF FORT BRAGG
416 NORTH FRANKLIN ST.
FORT BRAGG, CA 95437

DETAILS

DRAWING: 4.0
SHEET: OF
REVISION NO: REVISION 0
DATE: 6/25/09

City of Fort Bragg - Proposed Summers Lane Reservoir - Hydraulic Capacity Model

5.5 Acre Pond (outer dimensions 514 feet x 464 feet); 18 Feet Deep, 3:1 Side Slopes

4 feet Freeboard; Total Volume = 58 af; Effective Volume = 45 af

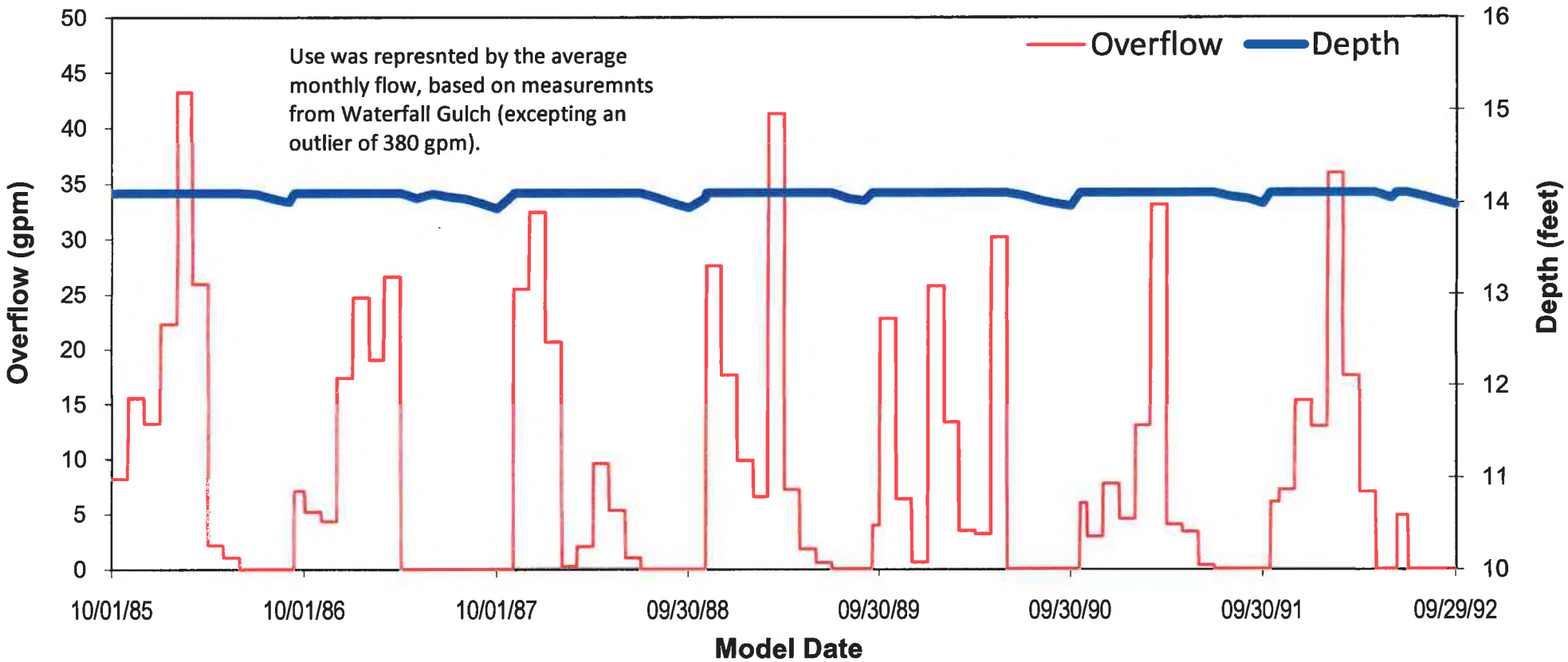


FIGURE 5

City of Fort Bragg - Proposed Summers Lane Reservoir - Hydraulic Capacity Model

5.5 Acre Pond (outer dimensions 514 feet x 464 feet); 18 Feet Deep, 3:1 Side Slopes

4 feet Freeboard; Total Volume = 58 af; Effective Volume = 45 af

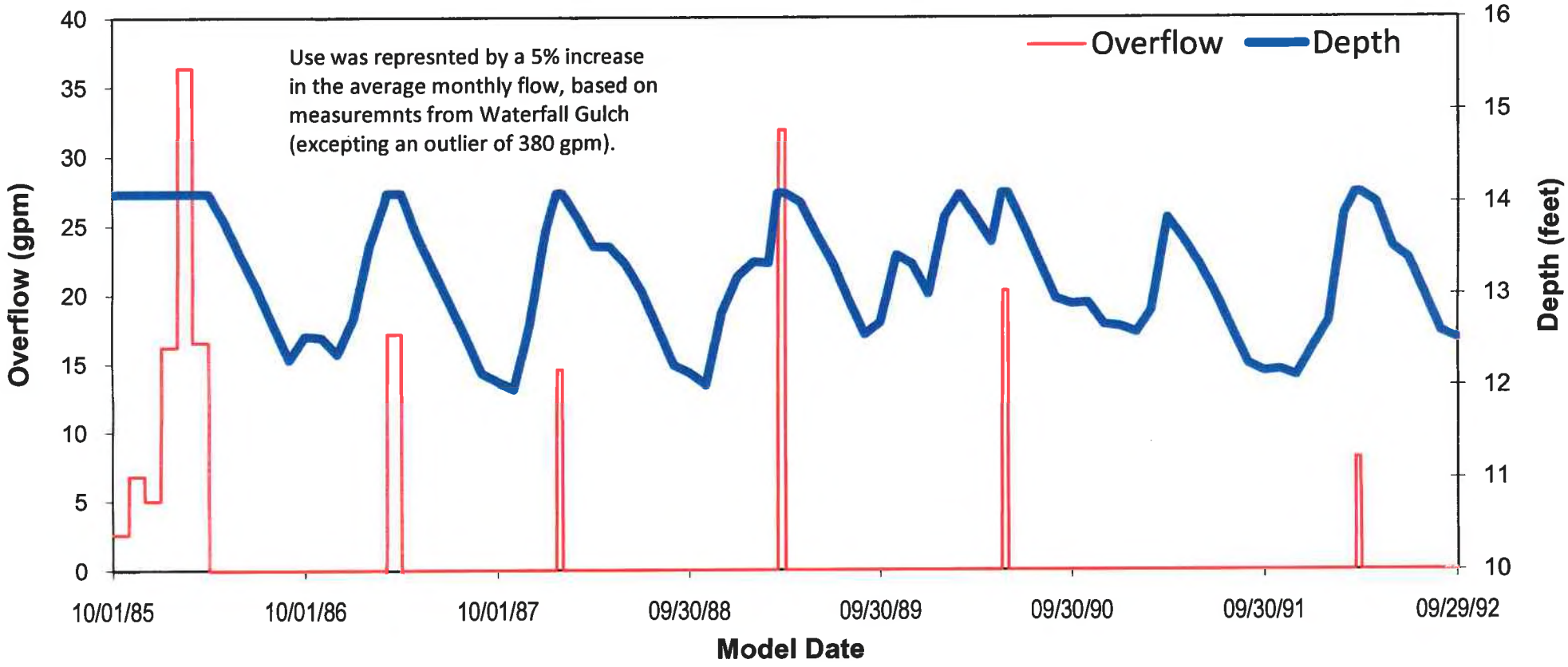


FIGURE 6

City of Fort Bragg - Proposed Summers Lane Reservoir - Hydraulic Capacity Model

5.5 Acre Pond (outer dimensions 514 feet x 464 feet); 18 Feet Deep, 3:1 Side Slopes

4 feet Freeboard; Total Volume = 58 af; Effective Volume = 45 af

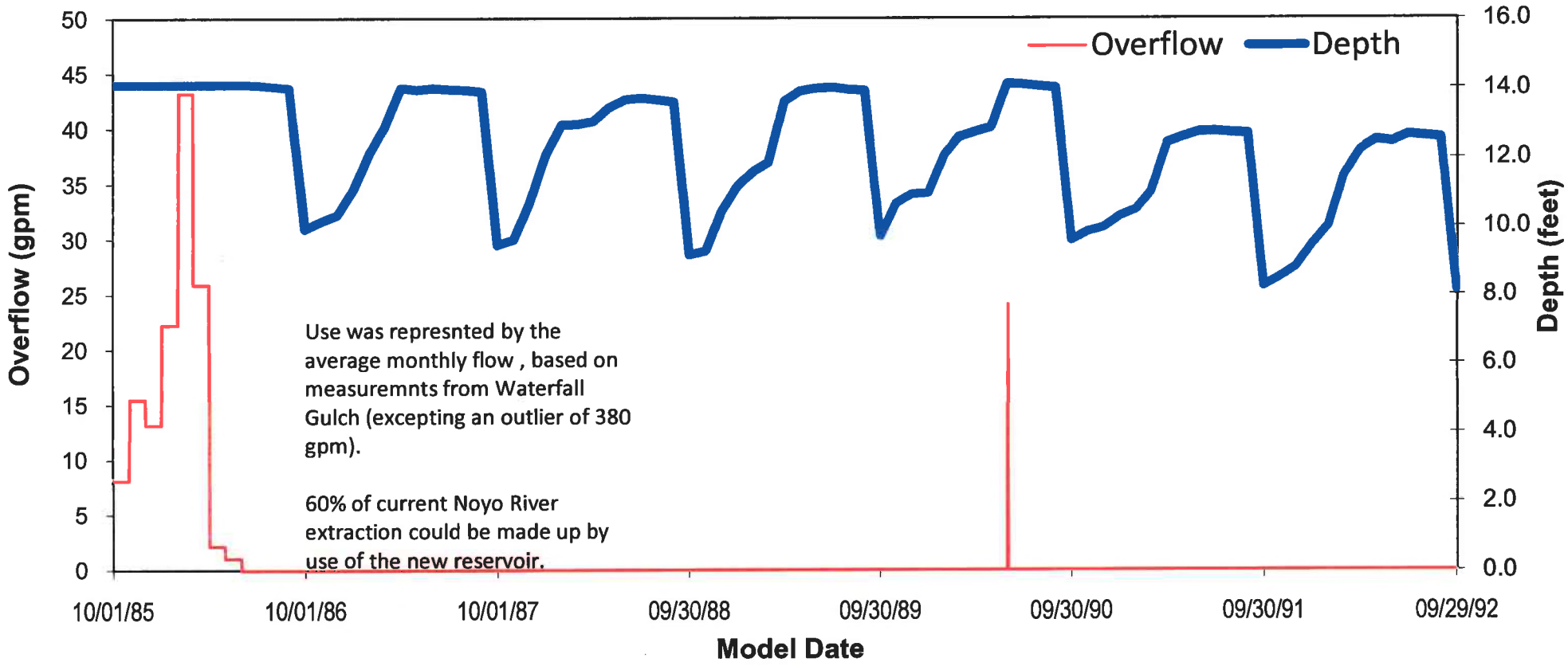


FIGURE 7

Appendix A:
Hydraulic Calculations

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ENGINEERS & GEOLOGISTS
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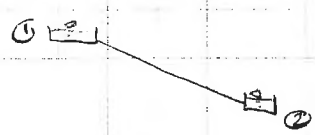
2619 Forest Ave., Suite 120, Chico, CA 95928 (530) 343-8857

SUBJECT NEWMAN RESERVOIR
SHEET NO. 1 OF 4
CALCULATED BY JTS DATE 5-14-09
CHECKED BY DATE
SCALE

1) DETERMINE APPROXIMATE FLOW FROM SIMPSON CREEK GIVEN EXISTING PIPELINE.

APPLY ENERGY EQUATION TO TWO RESERVOIRS 1 WATERFALL GULCH
2 SUMMERS LANE RESERVOIR

$$\frac{P_1}{\gamma} + WSEL_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + WSEL_2 + \frac{V_2^2}{2g} + \Sigma h_E$$



Q.) NEGLECT MINOR LOSSES?

$\frac{L}{D}$ L = 2.3 miles = 12,144 ft

D - VARIES ALONG PIPELINE. FROM HISTORICAL RECORDS IT IS EVIDENT THAT THE EXISTING PIPELINE IS A COMBINATION OF 6", 8" & 10" PIPE OF VARYING MATERIALS. BELOW REPRESENTS THE ASSUMED ALINGMENT CHARACTERISTICS.

0 - 0+43	12" C150 PVC	1990
0+43 - 3+40	8" ASBESTOS CEMENT	? OLD
3+40 - 34+75	10" C150 PVC	1990
34+75 - 105+60	6" AC	? OLD
105+60 121+44	6" SPIRAL STEEL	? OLD

USE LARGEST Ø TO BE VERY CONSERVATIVE

$$\frac{L}{D} = \frac{12{,}144 \text{ ft}}{12'' \text{ Ø}} = 1{,}012 > 1000 \Rightarrow \text{NEGLECT MINOR LOSSES}$$

$\frac{P_1}{\gamma} = \frac{P_2}{\gamma}$ = ATM. PRESSURE = 0 GUAGE

$V_1 = V_2 = 0$

$$\therefore WSEL_1 = WSEL_2 + \frac{Q^2 n^2 L}{2.21 A^2 R^{4/3}}$$

CONT.

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ENGINEERS & GEOLOGISTS
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2619 Forest Ave., Suite 120, Chico, CA 95928 (530) 343-8857

SUBJECT: NEWMAN RESERVOIR
SHEET NO. 2 OF 4
CALCULATED BY: JJS DATE: 5-14-09
CHECKED BY: DATE:
SCALE:

WSEL$_1$ = 340' (THIS IS MINIMUM ELEVATION IN RESERVOIR, MAY BE HIGHER = GREATER HEAD)

WSEL$_2$ = ASSUME 300 (WILL BE ADJUSTED DURING GRADING DESIGN, MOST LIKELY LOWER)

HEAD LOSS WILL BE CALCULATED USING 4 INDEPENDENT SECTIONS. WE WILL NEGLECT NEW 43' LONG 12" PVC AT INLET

ASSUME FULL

	PIPE SECTION	L (ft)	DIAM'N	A (ft²)	R	n	MATERIAL
A)	0+43 - 3+40	297	8"	0.349	0.167	0.011	AC
B)	3+40 - 34+75	3,135	10"	0.545	0.208	0.009	PVC
C)	34+75 - 105+60	7,085	6"	0.196	0.125	0.011	AC ← FIELD TEST YIELDS 0.020
D)	105+60 - 11,933	1,373	10"	0.545	0.208	0.009	PVC
		Σ 11,890 ft					

THIS WILL BE NEW PIPELINE FROM BRUSH CREEK ROAD TO THE NEW RESERVOIR

A) B) C) D)

$$340' = 300' + \frac{Q^2 \cdot .011^2 \cdot 297}{2.21 \cdot 0.349^2 \cdot 0.167^{1.333}} + \frac{Q^2 \cdot .009^2 \cdot 3135}{2.21 \cdot 0.545^2 \cdot 0.208^{1.333}} + \frac{Q^2 \cdot .011^2 \cdot 7085}{2.21 \cdot 0.196^2 \cdot 0.125^{1.33}} + \frac{Q^2 \cdot .009^2 \cdot 1373}{2.21 \cdot 0.545^2 \cdot 0.208^{1.333}}$$

$$340 = 300 + 1.44\,Q^2 + 3.14\,Q^2 + \boxed{161.0\,Q^2} + 1.37\,Q^2$$

96% OF HL

$$40 = 167.0\,Q^2$$

$$Q = 0.489 \text{ cfs} \Rightarrow \boxed{219 \text{ gpm}}$$

TRY POND @ 290

$$50 = 167\,Q^2$$

$$Q = 0.547 \text{ cfs} = 246 \text{ gpm}$$

TRY POND @ 298 $\boxed{Q = 225 \text{ gpm}}$

MINIMUM WSEL$_2$ TO MAINTAIN 250 gpm

$$250 \cdot .00222 = 0.557 \text{ cfs}$$

$$WSEL_1 - WSEL_2 = 167 \cdot 0.557^2$$

$$340 - WSEL_2 = 51.8'$$

$$WSEL_2 = 288.2'$$

cont

LAWRENCE & ASSOCIATES
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2619 Forest Ave., Suite 120, Chico, CA 95928 (530) 343-8857

SUBJECT NEWMAN RESERVOIR
SHEET NO. 3 OF 4
CALCULATED BY JIS DATE 5-14-09
CHECKED BY DATE
SCALE

BY USING HAZEN WILLIAMS C VALUES TO APPROXIMATE THE HEAD LOSS IN THE EXISTING PIPELINE, IT WAS DETERMINED THAT AN ELEVATION DIFFERENCE OF 51.5' IS NEEDED BETWEEN THE TWO RESERVOIRS. BELOW IS A LIST OF ADDITIONAL CONSIDERATIONS.

1) HAZEN-WILLIAMS IS AN APPROXIMATION. THE ROUGHNESS VALUES USED FOR THIS ANALYSIS ARE FOR DESIGN USE & MAY NOT ACCOUNT FOR OLD OR DAMAGED PIPE.

2) THE CONDITION OF THE PIPELINE IS UNCERTAIN. THERE MAY BE DIFFERENT DIAMETERS, DAMAGE, OR AIR POCKETS WHICH COULD ALL INCREASE THE HEAD LOSS.

3) THE WSEL AT WATERFALL GULCH WAS ASSUMED A MINIMUM. IT IS LIKELY THAT THE TRUE WSEL WOULD BE 2-4 HIGHER. THE OPERATOR CAN ASSURE THIS BY REGULATING FLOW.

4) WE DO NOT HAVE ACCESS TO VERY RELIABLE SURVEY DATA. A COMBINATION OF USGS, GOOGLE EARTH, & OLD CONSTRUCTION DOCUMENTS W/O DATUM OR SURVEY SOURCE. WHAT DATA WE DO HAVE IS CONSISTANT TO WITHIN ± 5'.

5)

APPENDIX 19.A
Manning's Roughness Coefficient,[a] n
(design use)

channel material	n^b
plastic (PVC and ABS)	0.009
clean, uncoated cast iron	0.013–0.015
clean, coated cast iron	0.012–0.014
dirty, tuberculated cast iron	0.015–0.035
riveted steel	0.015–0.017
lock-bar and welded steel pipe	0.012–0.013
galvanized iron	0.015–0.017
brass and glass	0.009–0.013
wood stave	
small diameter	0.011–0.012
large diameter	0.012–0.013
concrete	
average value used	0.013
typical commercial, ball and spigot rubber gasketed end connections	
– full (pressurized and wet)	0.010
– partially full	0.0085
with rough joints	0.016–0.017
dry mix, rough forms	0.015–0.016
wet mix, steel forms	0.012–0.014
very smooth, finished	0.011–0.012
vitrified sewer	0.013–0.015
common-clay drainage tile	0.012–0.014
asbestos	0.011
planed timber (flume)	0.012 (0.010–0.014)
canvas	0.012
unplaned timber (flume)	0.013 (0.011–0.015)
brick	0.016
rubble masonry	0.017
smooth earth	0.018
firm gravel	0.023
corrugated metal pipe (CMP)	0.024 (see App. 17.F)
natural channels, good condition	0.025
rip rap	0.035
natural channels with stones and weeds	0.035
very poor natural channels	0.060

[a]Compiled from various sources.
[b]Values outside these ranges have been observed, but these values are typical.

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ENGINEERS & GEOLOGISTS

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SUBJECT: NEWMAN RESERVOIR
SHEET NO. 1 OF 2
CALCULATED BY: JTS DATE: 5-26-09
CHECKED BY: DATE:
SCALE:

1) DETERMINE FLOW FROM SIMPSON LANE (WATERFALL RIGHT) TO NEWMAN RESERVOIR IN PERFECT CONDITION.

USEL SIMPSON = 344'
USEL NEWMAN = 236'
108'

* SEE PREVIOUS FLOW FROM SIMPSON USING FULL PIPE CHARACTERISTICS
8" AC 10" PVC 6" AC 6" SPIRAL STEEL

$$344 = 236 + 1.44Q^2 + 3.14Q^2 + 161.0Q^2 + \frac{Q^2 \cdot 0.016^2 \cdot 1584}{2.21 \cdot 0.196^2 \cdot 0.125^{1.33}}$$

$$108 = 1.44Q^2 + 3.14Q^2 + 161Q^2 + 75.9Q^2$$

$$108 = 241.5\,Q^2$$

$$Q = 0.669 \text{ cfs} = \boxed{300 \text{ gpm}}$$

MAX FLOW TO NEWMAN SHOULD BE CLOSE TO THIS VALUE.
MAX HISTORICAL VALUE = 381 gpm - VALUE IS SUSPECT
≈ 16 DATA POINTS ALL ABOVE 200 gpm

5-22-09 MIKE CHARLINO TELECON

FIELD TEST
CONDITION
NORMAL - DIVERTED TO CITY — Q = 100 gpm
DIVERT TO NEWMAN RES — Q = 105 gpm
FULL OPEN @ SIMPSON — USEL DROP FROM ½" ABOVE CULVERT TO 1' BELOW — 11:15 AM Q = 160 gpm
SOLVE — USEL 2' BELOW CULVERT — 1:20 PM Q = 200 gpm

~~$108 = X \cdot 0.445^2$~~
~~$X = 545.39$~~

~~ASSUME L = 12,144~~
~~D = 8"~~
~~A = 0.545~~
~~R = 0.208~~
~~Find n~~

~~$545.39 = \frac{n^2 \cdot 12144}{2.21 \cdot 0.545^2 \cdot 0.208^{1.33}}$~~

~~n = 0.0604 ≈ VERY POOR NATURAL CHANNEL~~

LAWRENCE & ASSOCIATES
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REDDING, CA 96001
(530) 244-9703

JOB NO. NEWMAN RESERVOIR
SHEET NO. 2 OF 2
CALCULATED BY JLS DATE 5-27-09
CHECKED BY _____ DATE _____
SCALE _____

GIVEN:

- APPROXIMATELY 96% OF HL IN PIPE OCCURS IN 6" AC SECTION.

1) CALCULATE n OF EXISTING PIPE USING ONLY 6" AC SECTION, THEN USING THIS n, FIND FLOW TO NEW RESERVOIR

USE SIMPSON USE NEWMAN

$$344 = 236 + Q^2 \cdot x$$

$$108 = Q^2 x$$

200 gpm = 0.445 cfs

$$108 = 0.445^2 \cdot x$$

ROUGHNESS OF STEEL PIPE

$$545.4 = \frac{n^2 \cdot 7085}{2.21 \cdot 0.196^2 \cdot 0.125^{1.33}}$$

$$n = 0.020$$

RES FULL

$$344 = 298 + \frac{Q^2 \cdot 0.020^2 \cdot 7085}{2.21 \cdot 0.196^2 \cdot 0.125^{1.33}}$$

$$46 = Q^2 \cdot 530.4$$

$$Q = 0.29 \text{ cfs} \Rightarrow 132 \text{ gpm}$$

$$344 - 275 = Q^2 \cdot 530.4$$

RES EMPTY

$$Q = 0.36 \text{ cfs} \Rightarrow 161.9 \text{ gpm}$$

Appendix B:
Engineers Estimate

NEWMAN GULCH 45-ACRE RESERVOIR
Preliminary Engineer's Estimate

July 2, 2009

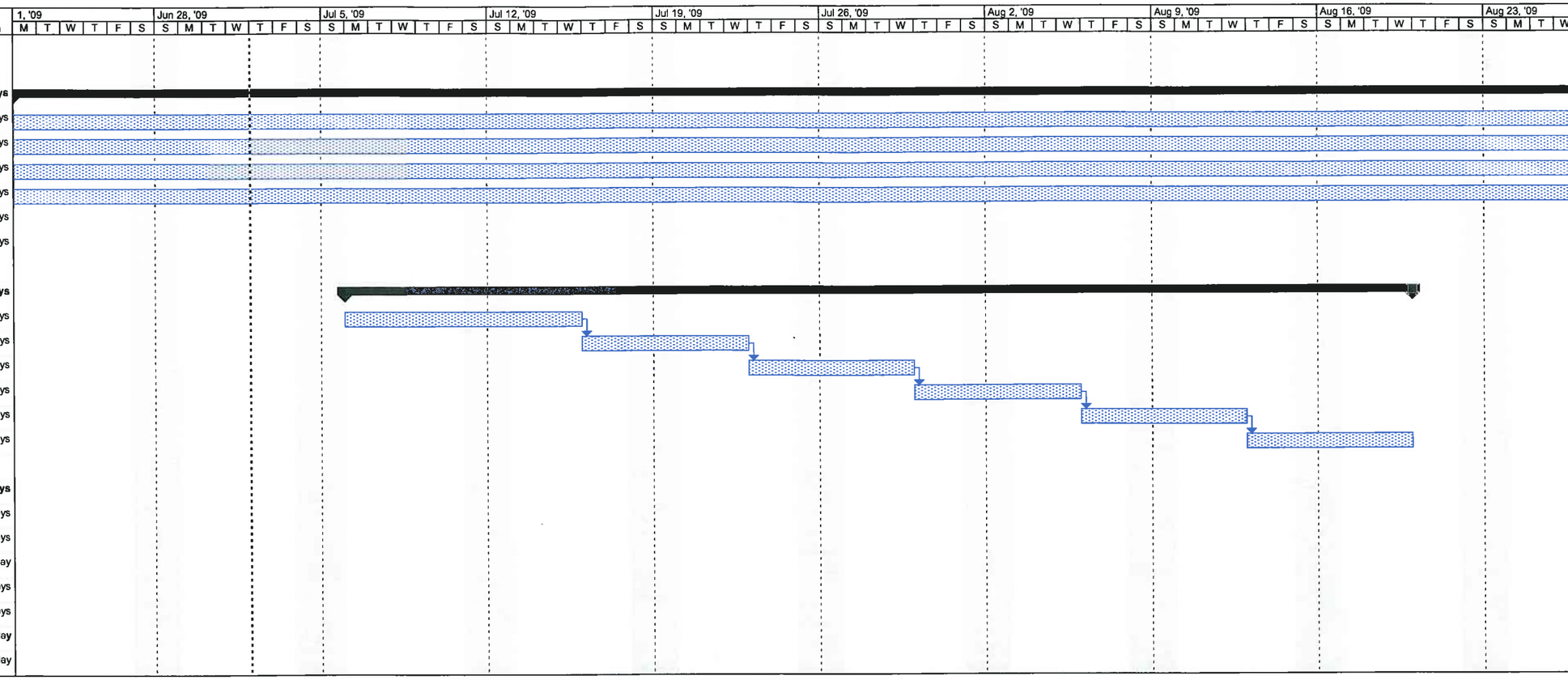
Item	Description	Unit	Quantity	Unit Price	Extension	
1	Permits	%	0.1	$1,187,148.06	$118,714.81	
2	Mobilization	LS	1	$10,000.00	$10,000.00	
3	Traffic Control	LS	1	$10,000.00	$10,000.00	
4	Timber Harvest	LS	1	$50,000.00	$50,000.00	Assumed Value
5	Field engineering	LS	1	$10,000.00	$10,000.00	
6	Clearing & Grubbing	LS	1	$60,900.00	$60,900.00	See Detail Sheet
7	Rough Grade Reservoir	CY	34,000	$8.00	$272,000.00	
8	Fine Grade Surface For Liner	Acre	6	$2,000.00	$12,000.00	
9	Off-haul Excess Cut (Top 6 to 8")	CY	7,032	$12.00	$84,384.00	RS pg.545
10	Subdrain System	LS	1	$38,541.75	$38,541.75	
11	Liner Anchor Trench	LF	1,680	$10.50	$17,640.00	
12	HDPE Liner	LS	1	$250,000.00	$250,000.00	See Detail Sheet
13	Spillway & Sediment Basin	LS	1	$14,340.00	$14,340.00	
14	Piping Manifolds & Connection	LS	1	$5,000.00	$5,000.00	Assumed Value
15	18" Culvert Under Existing Road	LF	30	$36.06	$1,081.88	Bni pg. 51
16	Trenching & Backfilling - Water Line	LF	2,500	$9.41	$23,515.00	See Detail Sheet
17	10" Water Line - C900	LF	2,500	$32.66	$81,640.63	See Detail Sheet
18	Erosion Control	LS	1	$28,750.00	$28,750.00	
19	Gravel Perimeter Road	LS	1	$61,600.00	$61,600.00	
20	Chain Link Fence & Gate	LS	1	$32,040.00	$32,040.00	See Detail Sheet
21	Pavement Repair	LS	1	$5,000.00	$5,000.00	
				Total	**$1,187,148.06**	

NEWMAN GULCH 45-ACRE RESERVOIR
Preliminary Engineer's Estimate
July 2, 2009

Item	Description	Unit	Quantity	Unit Price	Extension		Trench	Bedding	Backfill	Pipe	Fittings Allowance	Area Mult.
Clearing & Grubbing												
1	Clear & Grub	Acre	7.5	$8,120.00	$60,900.00	Bni pg.21						
				Total	**$60,900.00**							
HDPE Liner												
1	Liner	SF	240,000	$1.00	$240,000.00							
2	Piping Boots	EA	2	$5,000.00	$10,000.00							
			Total		**$250,000.00**							
Spillway & Sediment Basin												
1	6" Dia. Pipe	LS	1	$100.00	$100.00							
2	Concrete Wier	CY	10	$700.00	$7,000.00							
3	Rip-Rap	Ton	70	$100.00	$7,000.00							
4	Geotextile	SF	1,200	$0.20	$240.00							
				Total	**$14,340.00**							
Subdrain System												
1	3" Perf. Pipe	LF	3000	$12.39	$37,173.75	Bni pg.53	$1.25	$1.50	$0.72	$5.15	25.00%	15.00%
2	6 oz. Non-woven fabric	SF	3,600	$0.38	$1,368.00	Bni pg.28						
				Total	**$38,541.75**							
Gravel Perimeter Road												
1	Agg. Base	SF	28,000	$2.00	$56,000.00							
2	Geotextile	SF	28,000	$0.20	$5,600.00							
				Total	**$61,600.00**							
Trenching & Backfilling Water Line												
1	Trenching	LF	2,500	$7.41	$18,515.00	Bni pg.25	$5.00	$0.72	$0.72			15.00%
2	Pavement Cutting	LF	2,500	$2.00	$5,000.00							
			Total	**$9.41**	**$23,515.00**							
Water Line												
1	10" Water Line - C900	LF	2,500	$30.91	$77,265.63	RS pg. 586				$21.50	25.00%	15.00%
2	Water Line Testing	LF	2,500	$1.75	$4,375.00	Assumed Cost						
			Total	**$32.66**	**$81,640.63**							
Erosion Control												
1	Erosion Control	Acre	7.5	$3,500.00	$26,250.00							
2	SWPPP	LS	1	$2,500.00	$2,500.00							
				Total	**$28,750.00**							
Chain Link Fence												
1	Chain Link Fence	LF	2,200	$14.20	$31,240.00	Bni pg.58						
2	Double Gate 12'	LS	1	$800.00	$800.00	Bni pg.60						
				Total	**$32,040.00**							

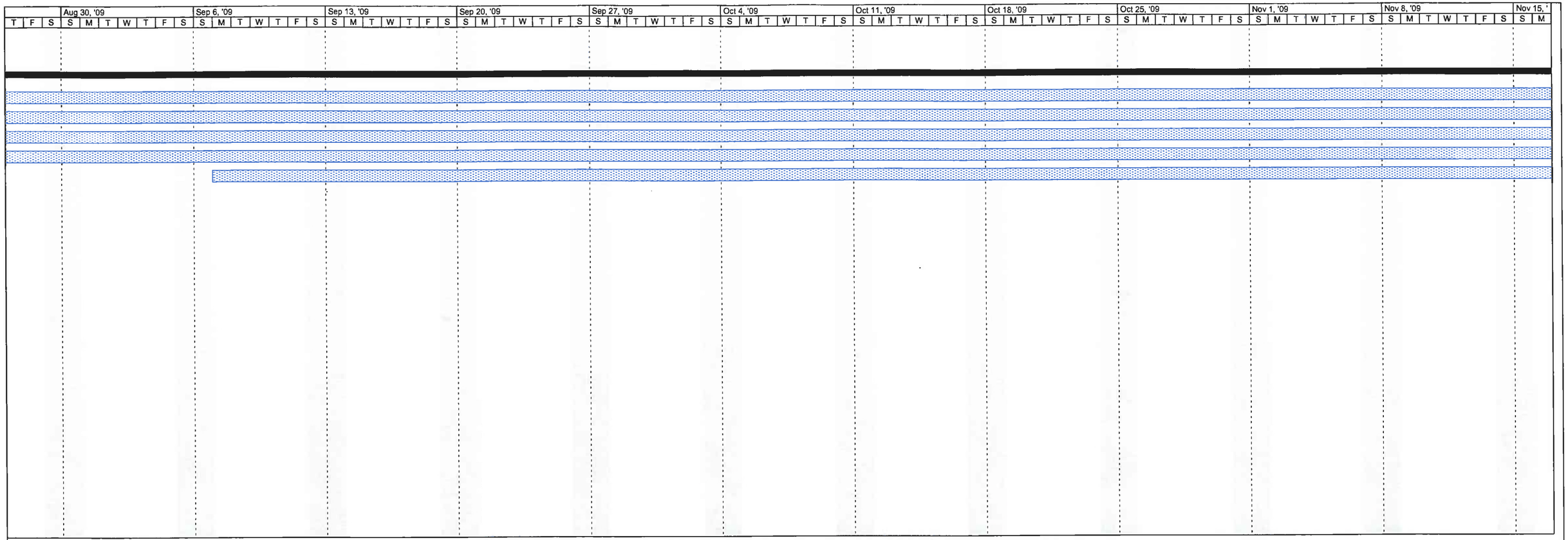
Appendix C:
Project Schedule

ID	Task Name	Duration
1		
2		
3	**Permits**	**190 days**
4	Army Corps. 404 Permit	190 days
5	Timber Harvest Permit	190 days
6	Timber Harvest NOI	190 days
7	Modify Permit - Drinking Water System	190 days
8	Grading Permit	135 days
9	Construction NOI	30 days
10		
11	**Civil Design**	**33 days**
12	75% Design	8 days
13	75% Design Review	5 days
14	90% Design	5 days
15	90% Design Review	5 days
16	100% Design	5 days
17	100% Design Review	5 days
18		
19	**Bidding**	**62 days**
20	Advertise Project	20 days
21	Contractor Bid Period	30 days
22	Pre-Bid Conference	1 day
23	Bid Review	10 days
24	City Approval of Winning Bid	10 days
25	Award Contract	1 day
26	Begin Construction	1 day



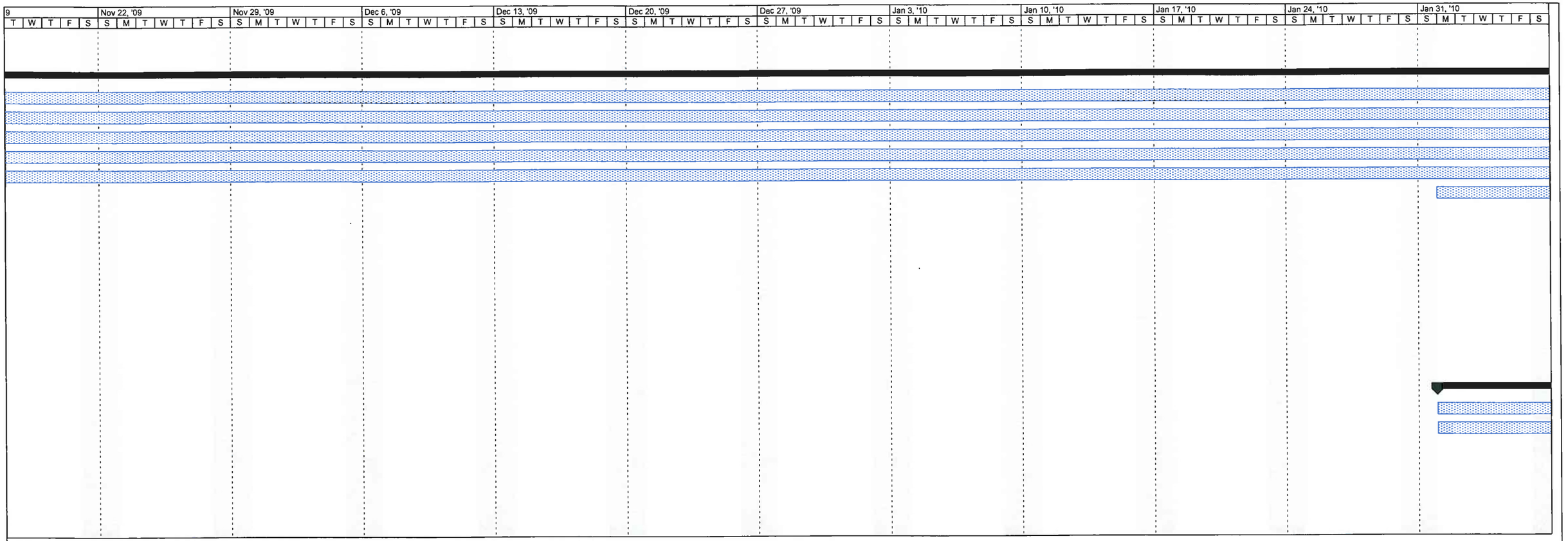
Project: Construction Start **MAY 2010**
Date: Thu 7/2/09

Task | Progress | Summary | Rolled Up Split | Rolled Up Progress | Project Summary
Split | Milestone | Rolled Up Task | Rolled Up Milestone | External Tasks



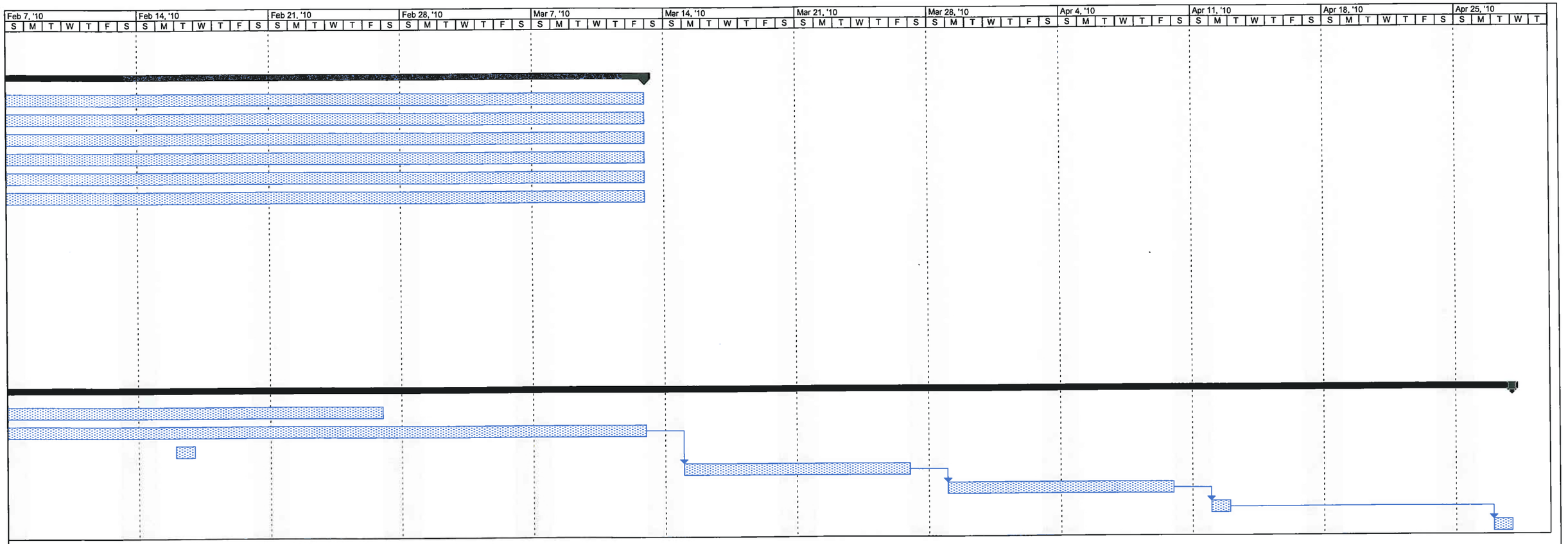
Project: Construction Start **MAY** 2010
Date: Thu 7/2/09

Task		Progress		Summary		Rolled Up Split		Rolled Up Progress		Project Summary	
Split		Milestone	◆	Rolled Up Task		Rolled Up Milestone	◇	External Tasks			



Project: Construction Start **MAY 2010**
Date: Thu 7/2/09

Task		Progress		Summary		Rolled Up Split		Rolled Up Progress		Project Summary	
Split		Milestone		Rolled Up Task		Rolled Up Milestone		External Tasks	



Project: Construction Start **MAY 2010**
Date: Thu 7/2/09

Task		Progress		Summary		Rolled Up Split		Rolled Up Progress		Project Summary	
Split		Milestone	◆	Rolled Up Task		Rolled Up Milestone	◇	External Tasks			

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Summary of work.

B. Contractor use of site and premises.

C. Work sequence.

1.02 RELATED SECTIONS

A. Standard General Conditions.

B. Supplementary Conditions.

1.03 SUMMARY OF WORK

A. The work to be performed by Contractor shall conform to the requirements of the General Conditions, Supplementary Conditions, Specifications, Drawings, and other related documents, and include the furnishing of all labor, materials, tools, equipment, plant, and services necessary and therefore incidental thereto to complete the project.

B. Purpose: The purpose of the work described herein is to construct a 48-acre-foot water storage reservoir and associated piping near Newman Gulch, on property at the end of Summers Lane that is owned by the City of Fort Bragg. The Summers Lane reservoir will be constructed of sandy dune deposits and, therefore, must be reinforced with geotextile fabric and lined with a synthetic liner to prevent leakage.

C. Routing of Water: Water is currently piped from Waterfall Creek via a 6-inch asbestos concrete pipe to the existing Newman Reservoir. The existing 6-inch asbestos concrete pipe will be intercepted at Brush Creek Road. A new pipe will be installed and routed East on Brush Creek to Summers Lane and again intercepting the existing 6-inch pipe on City property.

1.04 ORDER OF WORK

A. The order of work shall roughly follow the order listed below, although it is assumed that many tasks will be performed concurrently on different portions of the site.

B. Order Of Work

1. Harvest trees and remove stumps.
2. Clear vegetative materials off work area.
3. Grade reservoir and install geosynthetic fabric, and remove excess cut from site.
4. Construct outlet structures and pipe boots.
5. Install synthetic (HDPE) liner in the reservoir.
6. Trench and install new water pipe without disturbing the existing 6-inch pipe.
7. Temporarily shut off water flowing in existing water pipe and connect new line at both ends. Reestablish flow of water after installation.
8. Disinfect new pipeline.
9. Seed and mulch disturbed areas.
10. Repair any damaged road sections.
11. Install permanent fencing and gate.

C. The Contractor shall submit a work schedule indicating sequence and dates for various phases of construction. The work schedule shall be updated on a weekly basis, as necessary.

1.04 COORDINATION

A. The work included in this contract will be performed by a single general contractor and his or her subcontractors. The Contractor shall be responsible for timely coordination of his or her subcontractors.

1.05 CONTRACTOR USE OF SITE AND PREMISES

A. Temporary power for Contractors to use during construction, if needed, shall be the responsibility of the Contractor.

B. Construction water shall be the responsibility of the contractor. With prior approval from the City of Fort Bragg, the Contractor can possibly pump water from the existing Newman Reservoir into a water truck for use during construction.

C. Construction camping within the site will not be allowed.

D. Storage of construction materials shall be limited to those areas designated and approved by the Owner.

E. The Contractor shall take precautions to locate and protect all existing utility lines. Notify utility companies and the Project Engineer prior to excavations in the vicinity of known utilities.

1. Should damage occur to an unknown utility, repairs shall be performed as directed by the Project Engineer. Equitable adjustments shall be made under the terms of the changes provisions.

F. The Contractor shall comply with all legal load requirements of the State of California and City and County Jurisdictions when operating on area access roads. Damage to existing roadways from equipment operation or excessive loads shall be repaired by the Contractor at no additional cost to the Owner.

1.06 INSPECTION/CQA

A. The Owner will provide an inspection/testing company to provide CQA Inspector.

B. Regardless of the inspection activities or review of submittals, it will be the responsibility of the Contractor to construct the project in compliance with these contract documents. The Contractor shall not expect the CQA Inspector to provide continuous inspection, nor will the CQA inspector provide grade setting work for the Contractor.

1.07 CONTRACTOR-FURNISHED ITEMS

A. The Contractor shall furnish all labor, materials and equipment necessary for the completion of the work, as specified.

PART 2 - MATERIALS

Not used

PART 3 - EXECUTION

Not used

PART 4 – MEASUREMENT AND PAYMENTY

4.1 MEASURMENT AND PAYMENT

A. Mobilization and Coordination: Payment for Mobilization will be on a lump-sum basis as described in the Bid Schedule under "Mobilization."

B. Other: No additional payment will be made for the other items described in this Section.

END OF SECTION

SECTION 01050

FIELD ENGINEERING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General Conditions: Basic site engineering requirements may also be described in other sections of these Specifications.

B. Contractor's use of survey control.

C. Contractor's grade setting.

D. Project record documents.

E. Owner's survey and layout.

1.02 RELATED SECTIONS

Section 02210 - Site grading.

1.03 QUALITY ASSURANCE

A. The Contractor shall retain the service of California Licensed Surveyor to stake cuts and fills for earthwork.

B. The Contractor shall employ an experienced grade setter to maintain the construction stakes and ensure that the earthwork portion of the project is being constructed to the design grades.

C. Provide copies of all grade sheets to the Project Manager immediately after compiling each phase of project layout as described above.

D. Minimum accuracy for required work is as follows:

1. Grade: Vertical: +/- 0.05 ft. Horizontal: +/- 0.5 feet.
2. Culverts and ditches: Horizontal +/- 0.5 ft., Vertical +/- 0.05 ft.
3. Structures: Horizontal +/- 0.5 ft. (location), Vertical +/- 0.05 ft.

1.04 SUBMITTALS

A. Contractor's plan, if requested, including ASCII file of point coordinates, elevation and descriptions.

B. Contractor' staking notes, if requested.

C. Staking notes shall be submitted within two days of request by the Project Manager.

1.05 PROJECT RECORD DOCUMENTS

A. The Contractor's grade setter shall maintain a complete and accurate log of control, grid coordinates, and locations of the edges of work. The survey notes shall be made available to the Project Manager's upon request.

1.06 OWNER SUPPLIED SURVEY

A. The Project Manager will provide the coordinates and elevations of the temporary control used by the Owner's surveyor to perform the topographic surveys used for design. The Project Manager also will provide the digital terrain model or the design for the Contractor's use.

B. The Contractor shall flag the clearing limits. The Project Manager must accept the clearing limits before commencing work.

PART 2 – PRODUCTS

Not Used

PART 3 - EXECUTION

3.01 EXAMINATION

A. The Contractor shall verify locations of survey control points prior to starting work.

B. The Contractor shall promptly notify the Project Manager of any discrepancies that are discovered.

3.02 CONSTRUCTION STAKING

A. Construction Staking: The contractor shall provide construction and layout staking for all work in accordance with these specifications. The contractor shall protect and preserve all marks set by others and shall be liable for replacement of marks destroyed during construction. The Project Manager shall be given 48 hours notice of subgrade, and aggregate base completion so that finished grades may be checked. No direct

payment will be made for this work. The contractor shall include the associated costs in the construction staking item.

B. Measurement: All measuring for quantity calculations, if applicable, shall be made by the contractor and are subject to verification and approval by the Project Manager. All survey data shall be available to the engineer for review upon request.

C. Checks: The Project Manager may perform such checks as deemed necessary to verify the accuracy of the contractor's layout work and ensure that the completed work complies with the Drawings and Specifications. The control staking provided by the contractor shall be preserved and left undisturbed until the Project Manager has completed any checks deemed necessary. Staking that has been destroyed or disturbed prior to completion of the Project Manager's checks shall be replaced by the contractor.

D. Redesign: If unforeseen difficulties, not due to the contractor's operations, necessitate minor redesign of some portion of the work, the survey effort necessary to gather additional information for the redesign will be provided by the Project Manager.

E. Control Points: The Project Manager will provide vertical and horizontal reference control points in the vicinity of the work, as shown.

F. Reference Survey: The contractor shall furnish all stakes, templates, platform and equipment, and labor as are required to layout and control every part of the work from the reference control points.

G. Standard methods: Recognized and established construction survey practices and orders of accuracy shall be followed in all cases. Surveying equipment shall be in good operating order and kept in proper adjustment during the course of the work.

H. Reference point integrity: It shall be the responsibility of the contractor to maintain and preserve reference control points established by the Project Manager until authorized to remove them. If such marks are destroyed by the contractor or disturbed through his negligence prior to their authorized removal, they may be replaced by the Project Manager. The expense of replacement will be deducted from any amounts due, or to become due the contractor.

3.03 OWNER PROVIDED SURVEY

A. The Owner's surveyor will stake various control points that are tied to the design database. The control coordinates, elevations and point descriptions will be provided to the Contractor's Surveyor.

B. The Project Manager will provide the AutoCAD file to the Contractor and Contractor's Surveyor for their use in construction staking.

3.04 CONTRACTOR PROVIDED SURVEY

A. The Contractor shall provide construction staking, and grade setting. The Contractor shall replace any lost or damaged stakes at his or her own cost.

PART 4 – MEASUREMENT & PAYMENT

4.01 MEASUREMENT AND PAYMENT

A. Payment for field engineering shall be included in the bid schedule as a lump-sum item. All surveying shall be included in the cost for the "Field Engineering".

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.1 DESCRIPTION: The work of this section consists of submittal requirements before and during construction.

1.2 RELATED REQUIREMENTS: None.

1.3 SCHEDULES: As soon as possible after Notice of Award and before beginning any work, submit Progress Schedule and Schedule of Values as a package. The Project Engineer will review the Progress Schedule and the Schedule of Values for format and content.

A. Progress Schedule: Submit two copies of progress schedule (normally in bar chart form) showing estimated starting and completion dates for each part of the work. The first progress payment will not be issued until an acceptable progress schedule is submitted.

B. Schedule of Values: Submit a schedule of dollar values for bid items based on the Contract Bid Schedule. Break down into component parts each bid item involving a series of operations for which progress payments may be requested. The total costs for the component parts shall equal the bid amount for that item, and the total cost of all items shall equal the contract sum. The Project Engineer may request data to verify accuracy of dollar values. The schedule of values will form the basis for progress payments as provided for in the general provisions.

1.4 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES:

A. General Procedures:

1. As specified in the individual sections, forward submittals to the Project Engineer at least 15 days before need for approval. Unless a different number is specified, submit two copies of each shop drawing, two specimens of each sample, and two copies of all other submittals requested, all of which will be retained by the Project Engineer. Submit any additional copies that are to be returned.

2. Coordinate all submittals and review them for legibility, accuracy, completeness, and compliance with contract requirements. Forward submittals that are related to or affect one another as a package to facilitate coordinated review.

3. List submittals on a transmittal letter with date of submittal and content of submittal. Transmittal letter shall be on Contractor's letterhead or other approved format. All submittals shall be uniformly transmitted.

4. Submittals will not be accepted for review if an incorrect amount of submittals are submitted, the transmittal form is incorrectly filled out, submittals are not coordinated, or submittals do not show evidence of Contractor's approval.

5. Specific Procedures:

   a. Shop Drawings: Identify each copy of shop drawings with contract drawing number in lower right hand corner.

   b. Samples: Samples shall be large enough to illustrate clearly the functional characteristics and full range of color, texture, or pattern.

   c. Manufacturer's Literature: Submit only pertinent pages; mark each copy of standard printed data to identify products referenced in specification section.

   d. Aggregate Samples: Samples shall be large enough to perform the necessary tests and gradings required by the specifications. Twenty-five pound sample minimum.

B. Project Engineer's Review:

1. After approving submittals, Project Engineer will return Contractor's copies.

2. If submittals are not approved, Project Engineer will return all copies to Contractor with reasons for rejection. Resubmit, identifying changes.

3. Any work done before approval shall be at Contractor's own risk.

1.5 APPROVED EQUALS AND SUBSTITUTIONS:

A. For each item proposed as an 'approved equal', submit a separate request. With each request, submit supporting data, including:

1. Drawings and samples as appropriate.

2. Comparison of the qualities of the proposed item with that specified.

3. Changes required in other elements of the work because of the substitution.

4. Name, address, and telephone number of vendor.

5. Manufacturer's literature regarding installation, operation and maintenance, including schematics for electrical and hydraulic systems, lubrication requirements, and parts lists. Describe availability of maintenance service, and state source of replacement materials.

B. A request for approval constitutes a representation that the contractor:

1. Has investigated the proposed item and determined that it is equal or superior in all respects to that specified.

2. Will provide the same warranties for the proposed item as for the item specified.

3. Has determined that the proposed item is compatible with interfacing items.

4. Will coordinate the installation of an approved item and make all changes required in other elements of the work because of the substitution.

5. Waives all claims for additional expenses that may be incurred as a result of the substitution.

C. New Construction Materials: The Contractor is encouraged to submit for approval products made out of recycled or environmentally-responsible material. Every effort will be made by the Owner to approve these materials.

1.6 MANUFACTURER'S INSTALLATION INSTRUCTIONS: When contract documents require compliance with manufacturer's printed instructions, provide one complete set of instructions for the Project Engineer and keep another complete set of instructions at the project site until substantial completion.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 SUBMITTALS: Payment that relates to this work will be included in various items in the Bid Schedule. No separate payment shall be made.

END OF SECTION

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SECTION 01900

MOBILIZATION

PART 1 – GENERAL

1.1 DESCRIPTION: This work shall include preparatory work and operations necessary for the movement of personnel, equipment, supplies and incidentals to the project site, and for all other work and operations that must be performed prior to beginning work on various items on the project. This work also includes bonding costs and dust control, and close-out items.

1.2 RELATED SECTIONS

A. Section 02210 – Site Grading, regarding dust control during grading activities.

B. Section 02271 – Erosion Control, regarding mud and silt control.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 CONSTRUCTION TRAILER: The Contractor in not required to provide a construction trailer, but may provide one at his or her discretion at no additional cost.

3.2 RESTROOM FACILITIES: The Contractor shall provide temporary restroom facilities throughout the work.

3.3 CONSTRUCTION WATER: With prior approval from the City of Fort Bragg, the Contractor can possibly pump water from the existing Newman Reservoir into a water truck for use during construction.

3.4 POTABLE WATER: The Contractor shall provide a source of potable drinking water for his or her employees, the Owners representatives, and guests.

3.5 SECURITY: The Contractor shall restrict access to the work site to the public and provide access to the Contractor, his or her employees, subcontractors, the Project Manager, Owner, State and Federal Agencies.

3.6 TRASH: The Contractor shall provide trash receptacles for his or her employees or subcontractors. Trash must be disposed regularly shall not be allowed to accumulate on site. The Contractor will be responsible for collecting wind-blown trash generated from the construction site.

3.7 DUST CONTROL: The Contractor shall provide dust control as described Section 02210 – Site Grading. Dust control shall include sweeping adhered soil from the paved access road.

3.8 MUD CONTROL: The Contractor shall provide a means of removing mud from tires of trucks leaving the site. Methods can include a section of course rock at the site exit, and/or clearing mud and sweeping the paved entrance road.

3.9 TRAFFIC CONTROL: The Contractor shall provide a means of traffic control when working on any street. Methods can include providing personnel to direct traffic warning of construction work, and/or signs, flagging, and cones if personnel is not to be used.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT: Shall be lump sum for the job.

4.2 PAYMENT: Progress payments shall be made as follows:

A. 25% of mobilization will be paid during the first monthly pay request but shall not exceed 50% of the first invoice.

B. The next 50% will be paid in two 25% installments during the second and third monthly pay requests.

C. The last 25% will be paid upon successful completion of the project and demobilization.

D. Cost for Bonding will be included under this item.

E. The cost for mobilization shall not exceed 10% of the total contract price.

END OF SECTION

SECTION 02110

CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Removal of non-merchantable trees, shrubs, boulders, organic topsoil and other objectionable material within the work area.

1.02 RELATED SECTIONS

A. Section 02210 - Site Grading.

B. Section 02221 - Excavating, Trenching, and Backfilling for Utilities.

1.03 REFERENCES

A. Geotechnical Report – A geotechnical report titled Geotechnical Engineering Investigation Report for Summers Lane Reservoir, Summers Lane, Fort Bragg, Mendocino County, California, dated October 2, 2009, has been prepared for this project. Page 22 describes the requirements for clearing and grubbing related to areas of cut and fill.

1.04 REGULATORY REQUIREMENTS

A. Waste material removed from the site shall be disposed of in conformance with Federal, State, and local requirements. Any disposal shall be at the Contractor's expense.

B. Coordinate clearing work with other onsite construction.

C. All clearing shall not extend past the clearing limits without prior authorization from the Engineer.

D. Notify the Engineer immediately if any cultural sites are found during clearing.

1.05 COORDINATION

A. The Contractor will be responsible for tree, brush, root, stump, and organic topsoil removal in all working areas.

B. The Contractor shall not assume that burning will be allowable means of disposal.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. The site is covered with dense brush mixed with conifer forests.

3.02 PROTECTION

A. Locate, identify, and protect existing utilities and survey monuments from damage.

B. Protect trees, plant growth, and features designated to remain as final landscaping and outside of the clearing limit

C. Protection of persons and property:

1. Protect bench marks, survey control points, and existing structures from damage or displacement.
2. Barricade open depressions and holes occurring as part of this work and post warning lights on property adjacent to or having public access. Operate warning lights from dusk to dawn each day and as otherwise required.

D. Remove only trees designated for removal.

E. The contractor shall pay special consideration to the trees located on the West end of the property, neighboring the adjacent rhododendron farm. The goal is to minimize the trees removed in this area to maintain a visual buffer for the neighbors. The contractor shall meet with the Project Manager to devise a plan for tree protection.

3.03 CLEARING AND GRUBBING

A. <u>Brush and Small Tree Removal</u>

1. The Contractor shall select the most cost effective means of brush and small tree disposal. The Contractor may select a combination of methods:
   a. Brush chipping: The Contractor may elect to chip or grind brush and small trees, stockpile the material and for use as erosion control material on the pipeline or embankment fill. No more than 2-inches of chips shall be applied.

b. In-place brush chipping or shredding: The Contract may elect to grind the brush and small tree using mobile brush masticator. Chippings will be disposed with the top soil as described below.

c. Removal from site: The contractor may elect to remove the brush and small trees from the site. The brush and small trees shall be disposed of in conformance with Federal, State, and local requirements. Any disposal shall be at the Contractor's expense.

B. Stump Disposal: All stumps and root balls shall be excavated and removed. Stumps shall be disposed of one of the following methods:

1. Chipped and used for erosion control.
2. Removed from the site and chipped for biomass fuel.
3. Other method approved by Engineer.

C. Grubbing: For locations that will be cut or filled, strip and remove approximately the top 4 to 18 inches of soil containing shallow leaf matter, chipped brush (if chipped in place) vegetation, roots, and other deleterious materials. Stockpile some of this material for use as top dressing on fills and remove the remainder from the site entirely. Grub the underlying 6 to 8 inches to remove any large roots while leaving the soil in place. Rocks of all sizes may be left in place in locations that will receive more than one foot of cut or fill (excluding road base). In locations that will receive less than one foot of fill rocks greater than 3-inches in diameter shall be removed from the top 12-inches of soil. Rocks may be incorporated into fills exceeding 3 feet or retained for use as riprap or erosion control. Locations that do not contain significant organic matter such as existing road surfaces, shore areas, and bare outcrops will not require stripping of organic matter.

3.04 STOCKPILING AND DISPOSAL

A. Brush and small trees shall be mulched, or used for or removed from the site as described above.

B. Trash, if any shall not be burned and shall be disposed at a legal disposal location outside of the subject property.

C. Grubbed material shall not include trash, excessive soil or other deleterious matter.

D. The Contractor shall include landfill fees, if any, in the disposal cost.

E. In some cases relatively non organic top soil can be incorporated into fills. See Section 02210 for fills.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT AND PAYMENT: The cost for clearing & grubbing shall include all materials, equipment, labor, superintendence, disposal fees, and incidentals to complete the work. The work also includes hauling soil strippings to the point of use and temporarily stockpiling. "Clearing & Grubbing" will be paid by the following quantities:

A. General clearing, grubbing, stump removal, removing trees, or otherwise disposing of brush and small trees be paid on a lump-sum basis as described in the Bid Schedule under "Clearing and Grubbing".

B. The cost for grubbing and stripping 4 to 18" of organic material will be measured and paid for on a cubic-yard basis. The cost for clearing, stockpiling and/or additional handling of this material shall be included in the price for "Off-haul Excess Cut (Top 8")" on the Bid Schedule.

END OF SECTION

SECTION 02207

AGGREGATE MATERIALS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Aggregate materials.

1.02 RELATED SECTIONS

A. Section 02210 - Site Grading.

1.04 REFERENCES

A. ASTM C136 - Method for Sieve Analysis of fine and coarse aggregates.

B. ASTM D1557 - Test methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures using 10 lb (4.54 Kg) Rammer and 18-inch (457 mm) Drop.

C. ASTM D2487 - Classification of Soils for Engineering purposes.

D. ASTM D2922 - Test methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (shallow depth).

E. ASTM D3017 - Test method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

G. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and other gravity flow applications.

1.05 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals.

B. Samples: Submit 10 lb samples of each type of Type of aggregate for inspection.

C. Submit supplier-provided representative gradation (ASTM C136) and proctor curve (ASTM D1557), no more than 6 months old, or current tests performed by a City of Fort Bragg authorized testing laboratory for aggregates. One set of analyses will be required for each separate aggregate source. Additional analyses may be required if the Project Manager determines that the material provided differs from the proposed material.

1.06 SUBMITTALS FOR INFORMATION

A. Section 01300 - Submittals: Procedures and submittals.

B. Materials Source: Submit name of imported materials suppliers.

1.07 QUALITY ASSURANCE

A. Perform work in accordance with the California State Standard Specifications, "Aggregate Bases", and related sections of these specifications.

PART 2 - PRODUCTS

2.01 COARSE AGGREGATE MATERIALS

A. Aggregate ¾" Class II AB (crushed aggregate base) shall meet the following requirements:

1. Gradation: The aggregate shall be uniformly graded and shall conform to the requirements of standard specification (Cal-Trans) Section 26 for Class II base:

Sieve Size:	Percent Passing:
1"	100
3/4"	87-100
No. 4	30-65
No. 30	5-35
No. 200	0-12

2. Quality Requirements. The material shall conform to the following:

Test:	Test Method No.:	Requirement:
R-Valve	Calif. 301	78 Min.
Sand Equivalent	Calif. 217	22 Min.
Durability Index		35 Min.

B. Aggregate (Pipe Bedding): ASTM D2321, Class III material with the following additional requirement:

1. Well graded sand, free from clay or organic material. 90 - 100% passing No.4 sieve with no more than 5% passing No. 200 sieve, or as approved by the Project Manager.

C. Aggregate (Pea Gravel): Natural, rounded stone; washed, free of clay, shale, organic matter; graded in accordance with ASTM C136 and ASTM D2487 Group Symbol GP; to the following limits:

1. Minimum Size: 1/4 inch
2. Maximum Size: 5/8 inch

D. Aggregate ("leach rock"): Natural stone; washed, free of clay, shale, organic matter; graded in accordance with ASTM C136 and ASTM D2487 Group Symbol GP; to the following limits:

1. Minimum Size: 1/2-inch
2. Maximum Size: 3-inch
3. Nor more than 10% passing a 200 sieve
4. No more than 20% passing a #4 sieve
3. Or as approved by the Project Manager

2.02 SOURCE QUALITY CONTROL

A. Visually inspect samples for Aggregate for size distribution and uniformity.

B. Inspect submittals to assure material meets requirements listed above.

C. If tests indicate materials do not meet specified requirements, change material or material source and retest.

D. Provide materials of each type from same source throughout the work.

PART 3 - EXECUTION

3.01 STOCKPILING

A. Stockpile materials on site at locations approved by Project Manager.

B. Stockpile in sufficient quantities to meet project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.02 STOCKPILE CLEANUP

A. Remove stockpile, leave area in a clean and neat condition. Grade site surface to prevent free standing surface water.

PART 4 – MEASUREMENT AND PAYMENT

4.01 UNIT PRICES - MEASUREMENT AND PAYMENT

A. Measurement will be by the unit of measurement for which the aggregate is used.

B. Payment shall include the cost of testing for submittals, aggregate, transport, and installation, complete in place, and shall be included in payment for items described in the Bid Schedule:

1. Type A Aggregate (crushed aggregate base): The cost of Type A aggregate shall be included in the square foot price of "Gravel Road".

2. Type B Aggregate (Pipe Bedding): Shall be included in the linear-foot price of "Trenching & Backfilling".

END OF SECTION

SECTION 02210

SITE GRADING FOR EARTHWORK AND PREPARED SUBGRADE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The preparation of the areas for the cuts and fills to construct the cuts and fills for the base grades, ditches, and embankment of the reservoir.

1.02 RELATED SECTIONS

A. Section 01010 - Summary of Work.

B. Section 02110 – Clearing and Grubbing.

1.03 REFERENCES

A. ASTM D422 – Standard Test Method For Particle-Size Analysis for Soils.

B. ASTM D1556 – Test Method for Density of Soil in Place by the Sand-Cone Method.

C. ASTM D1557 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10 lb. (4.54 Kg) Rammer and 18 inch (457 mm) Drop.

D. ASTM D2922 – Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

E. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.04 DEFINITIONS

A. Finish Grade: Top of embankment, or other finished surface.

B. Subgrade or rough grade: Fill up to the bottom of the structural section or soil surface where no structural section will be added or cut down to within 0.1 feet of the top of the soil layer at the bottom of the aggregate base layer, or top of other cuts. Unless otherwise shown, the grading plans show the finish-grade elevations. Contact the Engineer for clarification in case of discrepancy.

C. Fine grading: Finish grading in locations that will receive a structural section.

D. Geotechnical Report: Geotechnical Engineering Investigation Report for Summers Lane Reservoir. Summers Lane, Fort Bragg, Mendocino County, California. Dated October 2, 2009 by Holdrege & Kull.

1.05 QUALITY ASSURANCE

A. Use adequate numbers of skilled personnel who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. A qualified engineer, engineering geologist, or testing laboratory will be retained by the City to perform all tests of fill and soil compaction, and for observation of the earthwork. Samples of all imported fill material (if any) shall be delivered to the Engineer at least 5 days prior to placement of such material. Written approval of material must be obtained.

C. Quality-assurance testing will be performed under the direction of the project engineer.

1.06 SUBMITTALS

A. No submittals are anticipated for this section.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. Borrow for fill area shall be obtained from on-site sources.

2.02 GEOTEXTILES

A. The pond embankment shall be reinforced with a woven geotextile such as Propex 2006 or approved equivalent.

PART 3 - EXECUTION

3.01 SUBGRADE PREPARATION

A. General: The subgrade shall be constructed to the lines and grade shown on the drawings. The final surfaces to accept liner material shall be smooth-drum rolled and unyielding. Surfaces that will be left open shall be track walked up and down the slope for placement of seeding and mulching.

B. All survey grade stakes shall be removed from the surface of the subgrade at the completion of subgrade construction prior to placement of the synthetic liner in those areas where synthetic liner is to be placed.

C. Ensure that rutting or raveling is not caused by installation equipment.

D. Ensure that no rocks shall protrude more than 1/2 inch from surface.

E. Unless otherwise stated (except for excavated and replaced soil described above), all soils in this section shall be compacted to no less than 90% of maximum dry density per ASTM D1557 (modified Proctor).

F. Subgrade shall be proof rolled per the Geotechnical Report.

3.02 ENGINEERED FILL

A. Fill of the pond embankment will include a combination of reinforced, and non-reinforced soil.
B. Fill shall be constructed per the constraints listed in Section 8.3 and 8.4 of the Geotechnical Report.

3.03 DUST CONTROL

A. Use means necessary to prevent dust from leaving the work site, becoming a nuisance to the public, to neighbors and to other work being performed on or near the site.

PART 4 – FIELD QUALITY CONTROL

4.01 FIELD QUALITY CONTROL

A. Field testing will be provided by the Project Manager or independent laboratory. Secure the Engineer's inspection, testing, and approval of each lift prior to subsequent construction.

B. Failed tests shall result in removal, manipulation, and recompacting of materials. Retesting shall be at the discretion of the Project Manager, and shall be at the Contractor's expense. It will be the Contractor's responsibility to provide equipment necessary to uncover completed portions of work for test pits when requested.

PART 5 – MEASUREMENT AND PAYMENT

5.01 UNIT PRICES – MEASUREMENT AND PAYMENT

A. Measurement of "Site Grading" will be on a cubic-yard basis.

B. Measurement of Geotextile Reinforcement shall be on a square yard basis.

C. Payment shall include the cost of compaction testing, transport, and placement, complete in place, and shall be included in payment for items described in the Bid Schedule for "Site Grading". The cost of site grading shall be paid in the cubic-yard price.

D. Payment for Geotextile Reinforcement shall be on a square yard basis as described in the Bid Schedule for "Geotextile Reinforcement".

END OF SECTION

SECTION 02221

UTILITY TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.1 DESCRIPTION: The work of this section consists of trenching and backfilling for the construction and installation of the water pipeline. All trenching will be open cut, except as specified in the drawings.

1.2 DEFINITION: Materials used in backfill and bedding, as shown in trench details, are defined as follows:

A. Bedding and Backfill: When rock, unstable material or wet trench is encountered at the excavated grade for utility installation, bedding is required. Materials shall be predominantly sand and gravel, meeting the requirements of Paragraph 3.3. Bedding may be omitted if, in the opinion of the Project Manager, the excavated trench bottom will adequately support and not damage the utility line (unlikely at this site).

1.3 RELATED SECTIONS:

A. Section 02229 – Utility Line Marking.

B. Section 02600 – Waterlines & Appurtenances.

1.4 QUALITY ASSURANCE:

A. All material gradation analysis shall be accomplished by an independent testing lab arranged and paid for by the Contractor.

B. All references to percent of maximum density shall be as determined by ASTM D1557, Method C, at a moisture content determined to be suitable for such density. Moisture-density curves shall be prepared in a certified soils testing laboratory.

C. In-Place Soil Density Testing: Procedures used be in accordance with ASTM D1556-82, Density of Soil in Place by the Sand-Cone Method, or ASTM D2922-81, Density of Soil and Soil-Aggregate in Place by Nuclear Methods (shallow depth). Testing shall be in accordance with Section 01050.

Test locations will be selected at the discretion of the Project Manager.

1.5 PROJECT CONDITIONS:

A. Arrange construction sequences to provide the shortest practical time that the trenches will be open to avoid hazard to the public and to minimize the possibility of trench collapse.

1.6 EXCAVATION CLASSIFICATION: Regardless of the nature of material excavated, all excavation will be considered unclassified.

PART 2 - PRODUCTS

2.1 GENERAL: All backfill material shall be approved before use and be free of cinders, ashes, ice, frozen soil, large hard clods, organic debris, or other deleterious items. Trench excavation materials may be used as approved by the Project Manager.

2.2 MATERIALS FOR BACKFILLING: Furnish required bedding, select backfill, and backfill materials listed under the appropriate types of utility line in the sections to which this work relates, and in accordance with Paragraph 3.4 of this Section.

2.3 UTILITY LINE MARKING: All utilities shall be marked for location and identified by marking tapes, as specified in Section 02229.

PART 3 - EXECUTION

3.1 TRENCH CLEARING:

A. The maximum width of clearing for utility trenches shall be 10 feet unless otherwise directed by the Project Manager. Trench spoils shall not be placed over or around uncleared vegetation unless specifically approved by the Project Manager.

3.2 TRENCH EXCAVATION:

A. All excavations must comply with the current requirements of Cal/OSHA. Additionally, all cuts greater than five feet (5') in depth and involving personnel within the excavation should be sloped and/or shored. Temporary excavations to ten feet (10') below surrounding grade may be sloped at ¾(h):1(v) or flatter. Flatter slopes will be required if clean/or loose sandy soils are encountered along the slope face. Temporary excavations adjacent to existing footings should not extend below a plane projected downward at a 45-degree angle from the closest edge of the footing.

1. Paved Areas: Areas paved with asphalt or concrete shall be marked for alignment and trench width. Asphalt and concrete paving, or sidewalks, shall be cut with a saw in neat parallel lines. The cut lines shall be at least 6" outside each edge of the trench width to prevent over-breaking and cracking of the paved surfaces.

2. Trench Configuration: The trench shall be excavated to allow the pipe to be aligned in the approximate center. Trench widths shall permit the pipe to be laid and joined properly and to allow for proper placement and compaction of backfill material. In no case shall the trench width be less than the pipe O.D. plus 16 inches. The trench side walls shall be as near vertical as possible, except where sloping is permitted by the Project Manager or required by OSHA standards. The trench bottom shall provide a firm, uniform and continuous bedding for the pipe. Properly sized and placed bell holes shall be provided at each joint. Mounding of trench bottom to support pipe will not be allowed.

3. Stockpiling: The Contractor shall exercise caution in stockpiling excavated and import materials so as not to interfere with public traffic and so as to maintain a clear distance from the trench sufficient to prevent collapse of the trench wall.

4. Underground Facilities: The Contractor shall proceed with caution in excavation and preparation of the trench so that the exact location of all underground facilities may be determined. It shall be the Contractor's responsibility to locate and protect all existing underground utilities. All damage to underground facilities due to the failure of the Contractor to have the facilities located or due to carelessness in excavation after the facilities are located, shall be the Contractor's responsibility. Location of existing underground facilities on the plans or in the field does not relieve the Contractor of his responsibility to determine their exact location.

5. Over Excavation: Trenches for all types of PVC pipeline materials shall be over excavated to provide for a minimum 6-inch sand (class 1) bedding.

   Trenches in areas of underground water shall be over excavated to allow for 6 inches or more of permeable backfill, as required for pipe trench backfill, as described elsewhere in this section.

   Any areas of trench over excavated beyond the lines and grades shown on the plans or specified herein shall be brought back up to proper grade using suitable materials as approved by the Project Manager. This material shall be compacted to the specified degree prior to placing any pipe or sand bedding in the trench.

6. Ground Water and Unsuitable Material: Material taken from excavations where excessive ground water, surface water, or other sources of water have rendered the soil material unsuitable for trench backfill material shall be removed from the site and replaced with suitable material. The over-wet material may, at the Contractor's option, be dried to a proper moisture content and reused in the work, provided the material meets all other requirements of these specifications.

3.3 SHORING AND SHEETING:

A. Construct and maintain all shoring, sheeting and slope layback necessary to protect the excavation, as needed for the safety of the employees and as required by applicable State and Federal laws.

B. For trenches over 5 feet deep, provide suitable barricades and shoring for worker protection. When work area is left open and unattended by the Contractor, provide suitable barricades for public safety, regardless of trench depth.

C. For trenches over 4 feet deep, provide suitable exit means in accordance with applicable provisions of OSHA.

D. As directed, remove all other sheeting and shoring when safe to do so.

3.4 BACKFILLING:

A. Backfill Selection:

1. Native material removed from the trench may be used for backfill material provided it meets all of the requirements set forth on the plans and in these specifications. Native backfill material may be mechanically screened to meet these requirements. Materials excavated from the trench which are found to be unsuitable for trench backfill shall be disposed of in a manner described elsewhere in this section.

2. The Contractor shall import the type and quantities of backfill materials not found on the job site at his own cost. The Contractor shall provide the equipment and materials necessary to collect samples of the native materials and proposed import material for testing, all as directed by the Project Manager.

B. Pipe Bedding and Backfill:

1. Three types of materials are acceptable for pipe bedding and envelope; 1) naturally occurring rounded sand, 2) crushed sand, 3) decomposed granite. All material shall be free from clay, organic, or other deleterious material, shall have a sand equivalent of at least 50, and shall meet the following percent passing by weight gradations:

Sieve Size	Natural Sand	Crushed Sand	Decomposed Granite
1-1/2"	100	---	
3/4"	75-100	100	100
No. 4	55-100	75-100	75-100
No. 200	0-5	0-15	0-5

2. Select excavated earth, free from stones or lumps exceeding 1" in greatest dimension, vegetable matter, or other deleterious material.

3. Aggregate base course material conforming to the requirements of Section 02207.

4. Select excavated earth, free from stones or lumps exceeding 4" in greatest dimension, vegetable matter or other deleterious material.

5. Permeable Backfill Material: Hard, durable, clean gravel or crushed stone, free from organic material, clay balls, or other deleterious substance, conforming to one of the following grades:

	Percentage Passing	
Sieve Size	1/2"	1-1/2"
2"	--	100
1-1/2"	--	95-100
3/4"	100	50-100
1/2"	95-100	
3/8"	70-100	13-55
No. 4	0-55	0-25
No. 8	9-10	0-5
No. 200	0-3	0-3

C. Backfilling Operations:

1. Native and imported backfill material shall be screened or otherwise prepared before placing the material in the trench. Backfill material shall be at or near optimum moisture content. Excessive moisture must be removed by windrowing and air drying. Dry soils shall be moistened and thoroughly mixed.

2. Compaction: Use vibratory compactors for sands and gravel (noncohesive soils). Use mechanical tampers for sand and gravel containing a significant portion of fine-grained material, such as silt and clay (cohesive soils). Hand tamp around pipe or cable to protect the lines until adequate cushion is attained. Puddling or water flooding for consolidation of backfill or compaction by wheel rolling with construction equipment will not be permitted.

3. Bedding: Compact the specified material to 95 percent of maximum density to the finished utility grade.

4. Utility Installation: Shape the trench bottom to ensure uniform contact with the full length of the installed line and remove any sharp-edged materials that might damage the line. Compaction shall be maintained beneath the line.

5. Install tape in backfill directly over each buried utility line as shown on the drawings. Place tape during final backfilling. See specification section 02229 – Utility Line Marking.

6. Select Backfill: Fill by hand placement around the utility to just over half depth, and compact in a manner to ensure against lateral or vertical displacement. Place select backfill to 12 inches above the utility line by hand placement in not more than 6-inch layers. Compact each layer to 98 percent of maximum density.

3.5 SURFACE FINISH WORK:

A. Paved Areas: Replace removed paving and base course with new material of equal or better quality and of the same texture and color as the adjacent paved areas. Saw cut pavement edge to a true line and broom as needed prior to paving.

B. Open Areas: Grade all disturbed areas to a finish ordinarily obtained from a blade grader, with no abrupt changes in grade or irregularities that will hold water.

C. Drainage Ditches: Restore drainage ditches to appropriate line and grade, using surface erosion-prevention techniques approved by the Project Manager.

D. Cleanup: Prior to final inspection and acceptance, remove all rubbish and excess material for disposal as approved, and leave area in a neat, satisfactory condition.

PART 4 - MEASUREMENT AND PAYMENT

4.1 UNIT PRICES - MEASUREMENT AND PAYMENT

A. Measurement shall be on a linear-foot basis.

B. Payment shall include the cost of trenching, shoring (if needed), bedding material, backfilling, utility line marking, pavement repair, and compaction on a linear-foot basis as listed under "Trenching and Backfilling" in the Bid Schedule.

END OF SECTION

SECTION 02229

UTILITY LINE MARKING

PART 1 - GENERAL

1.1 RESPONSIBILITIES AND COORDINATION: This section applies to the Utility Installation (underground) Contractor.

1.2 DESCRIPTION: The work of this section consists of furnishing and installing utility line marking.

1.3 RELATED SECTIONS:

A. Section 02221 – Utility Trenching & Backfilling.

B. Section 02600 – Waterlines & Appurtenances.

1.4 SUBMITTALS: As specified in Section 01300.

A. Samples: 24-inch strips of tape and two markers.

B. Certification that the materials used in the tape fabrication meet the requirements of this section.

PART 2 - PRODUCTS

2.1 MARKING TAPE: Capable of being inductively detected electronically.

A. Construction: Metallic foil laminated between two layers of impervious plastic film not less than 3 inches wide. Total thickness of tape shall not be less than 0.005 inch (5 mil) plus or minus 10 percent manufacturing tolerances.

1. Film: Inert plastic. Each film layer shall be not less than 0.0005 inch thick (0.5 mil).

2. Foil: Not less than 0.00035 inch thick (0.035 mil).

3. Adhesive: Compatible with foil and film.

B. Imprint: 3/4-inch or larger bold black letters.

C. Legend: Identify buried utility line tape with imprint such as 'Caution: Sewer Line Below'. Repeat identification at approximately 24-inch intervals.

D. Background Color: APWA color code and as specified below:

Color	Utility
Safety Red	Electric
Safety Precaution Blue	Water System
Safety Green	Sanitary Sewer, Storm Drain
Safety Yellow	LPG

E. Manufacturer: Lineguard, Inc., Wheaton, Illinois; Reef Industries, Inc., Houston, Texas; Thor Enterprises, Inc., Sun Prairie, Wisconsin; or approved equal.

PART 3 - EXECUTION

3.1 MARKING TAPE:

A. Install tape in backfill directly over each buried utility line as shown on the drawings. Place tape during final backfilling.

B. Where utilities are buried in a common trench, identify each line by a separate warning tape. Bury tapes side by side directly over the applicable line.

PART 4 - MEASUREMENT AND PAYMENT

4.1 UTILITY LINE MARKING: Payment will be included in the bid schedule item – "10" Water Line C-900".

END OF SECTION

SECTION 02271

DRAINAGE AND EROSION CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION: The work of this section consists of furnishing materials required for erosion control including silt fences, lined channels, mulching and other erosion control.

A. The Contractor will be responsible for submitting the Notice of Intent (NOI), to be covered under the State of California's Statewide National Pollution Discharge Elimination System (NPDES) permit for constriction activities.

B. The Contractor shall prepare a SWPPP for both temporary and post construction erosion control and obtain approval of the plan from the State of California Regional Water Quality Control Board. SWPPP is described in detail in Paragraph 3.02 of this specification

C. The requirements described herein are considered minimum standards. The Contractor and/or his preparer may recommend equivalent erosion control applications that provide equal or better performance.

D. The project is being performed as described in Section 01010 – Summary of Work. The contractor will be responsible for implementing and maintaining erosion control through the construction season.

1.02 SUBMITTALS:

A. Submit SWPPP as described in paragraph 3.02 of this specification within 15 days of Contract authorization.

B. Submit seed mix, fiber mulch cut sheet, mix proportions, and manufacturers cut sheet and instructions for tacking agent with SWPPP.

C. Submit source for weed free straw with SWPPP.

PART 2 - PRODUCTS

2.01 MULCH AND FIBER:

A. Straw for Mulching: Provide dry oat, wheat, or rice straw, free from weeds and foreign matter detrimental to plant life. Straw for erosion control work shall be sterile upland straw. The Contractor shall furnish evidence that clearance has been obtained from the County Agricultural Commissioner, as required by law, before straw obtained from outside the County is delivered to the site of the work. Straw

that has been used for stable bedding shall not be used. Hay or chopped cornstalks are not acceptable. Straw shall be chopped and uniformly applied at a rate specified in Paragraph 3.04 of this section.

B. Wood Fiber for Tacking: Softwood species, wood cellulose fiber which is free of growth or germination inhibiting ingredients and has the property of dispersing readily in water. The material shall contain no weed seed and shall be heat-processed to eliminate factors that inhibit growth and germination. The material shall have no toxic effect when combined with seed or other materials and shall have the following physical and chemical properties:

Moisture content	3 – 7 percent
Organic matter (oven-dried basis)	99.1 percent (minimum)
Ash content	0.9 percent (maximum)
PH @ 3% concentration	4.7 to 7.0 pH
Water holding capacity	200% by weight

The wood fiber shall readily blend with water, grass seed, fertilizer, and other additives to form a homogeneous slurry or mixture capable of application with power spray equipment. A colored dye that is noninjurious to plant growth and that fades rapidly with exposure to light may be used. Wood cellulose fiber shall be packaged in new, labeled containers in an air-dry condition.

C. Bonded Fiber Matrix (if required): Eco Aegis II as manufactured by Canadian Forest Products, LTD (Canfor).

2.02 PERMENANET SEED:

A. For permanent grass, a native seed mix as approved by the Project Manager. Seed for erosion control work shall consist of one or more of the following types:

California Bromegrass
Cucamonga Blue Wild Rye
Three Weeks Fescue
California Buckwheat
California Poppy
Arroyo Blue Lupine

The seedmix "Holdfast" has been preapproved for this project. Holdfast is available from LeBallister's Seeds in Santa Rosa (www.leballistersseed.com/Native erosion.htm)

B. Seed is required to be labeled under the California Food and Agricultural Code and shall be labeled by the vendors supplying the seed. Seed shall have been tested for purity and germination not more than 12 months prior to the application of the seed. Seed labels furnished by the vendors shall indicate the purity, germination and pure live seed as determined by testing. Results from testing the seed for purity and

germination shall be furnished to the Project Manager prior to applying seed. Seed shall be delivered to the job site in unopened separate containers with the seed tag attached. Containers without a seed tag will not be accepted.

2.03 The SWPPP preparer shall specify the seed application rate. For bidding assume 140 pounds per acre for single season, and 40 pounds per acre for permanent seeding.

2.04 FERTILIZER: 15-20-20 (N-P-K), 10% sulfur is optional. Fertilizer for erosion control work shall conform to the requirements of the California Food and Agricultural Code, shall be in pelleted or granular form and shall have a minimum guaranteed chemical analysis of 15 percent nitrogen, 20 percent phosphoric acid, 20 percent water soluble potash, and 10 percent sulfur. Fertilizer shall be a formulation suitable for hydroseeding purposes and soluble in water.

2.05 TACKING AGENT: Use nontoxic commercially produced tacking agent.

2.06 STABILZITING EMULSION: Stabilizing emulsion for erosion control work shall be a concentrated liquid chemical mixed with fiber that forms a plastic film upon drying and allows water and air to penetrate. The fiber shall be produced from natural or recycled (pulp) fiber, such as wood chips or similar wood materials or from newsprint, chipboard, corrugated cardboard or a combination of these processed materials, and shall be free of synthetic or plastic materials. Stabilizing emulsion shall be nontoxic to plant or animal life and nonstaining to concrete or painted surfaces. In the cured state, the stabilizing emulsion may be re-emulsifiable. The material shall be registered with and licensed by the State of California, Department of Food and Agriculture, as an "auxiliary soil chemical."

2.07 STRAW WATTLE: Straw wattles shall be a commercially manufactured mesh tube containing tightly packed straw or coconut fiber. Sizes may be 9-inch diameter or 12-inch diameter as specified in the drawings or erosion control plan. Stakes shall be at least 12-inches longer than the diameter of the roll. Provide one stake for each 4 feet of wattle.

2.08 SILT FENCE: Silt Fence shall have the following characteristics or as approved by the Project Manager:

A. Preassembled rolls.
B. Woven geotextile with grab tensile of 100 lb min and apparent opening size of # 20 to 70 sieve.
C. 36-inch or larger.
D. Sewing Cord at top or method to prevent fold over.
E. Pre-applied wood 2 x 2 inch stakes, 5-feet long, maximum spacing 6 feet.

PART 3 - EXECUTION

3.01 INTERPRETATION OF DRAWINGS

A. The erosion control measures shown on the drawings are considered the minimum required. The Contractor shall prepare their Storm Water Pollution Prevention Plan (SWPPP) as described herein and increase the amount of erosion and sediment control features as is needed to ensure compliance with state and federal regulations.

3.02 WATER POLLUTION CONTROL, SWPPP PREPARATION AND IMPLIMENTATION

A. CONFORMANCE WITH REGULATIONS: Water pollution control work shall conform to the provisions of the Standard Specifications and these special provisions. Prior to any construction activity, the Contractor shall prepare, submit, and obtain approval of a Storm Water Pollution Prevention Plan (SWPPP) in accordance with the NPDES General Construction Permit for storm water and non-storm water discharges associated with construction activities, entitled: "National Pollutant Discharge Elimination System (NPDES) Permit - Water Quality Order 99-08-DWQ. Approval of the SWPPP shall not relieve the contractor of any liability for violations of State or Federal law relating to water pollution.

B. PERMIT: Approval of the NPDES permit(s) that regulates this project, as referenced above, are hereafter collectively referred to as the "Permit(s)." This project shall conform to the Permits and modifications thereto. The Contractor shall maintain copies of the Permits at the project site and shall make the Permits available during construction. The Contractor shall know and fully comply with applicable provisions of the Permits and all modifications thereto, and Federal, State, and local regulations and requirements that govern the Contractor's operations and storm water and non-storm water discharges from both the project site and areas of disturbance outside the project limits during construction.

   The Permits shall apply to storm water and certain permitted non-storm water discharges from areas outside the project site which are directly related to construction activities for this contract including, but not limited to, asphalt batch plants, material borrow areas, concrete plants, staging areas, storage yards and access roads. The Contractor shall comply with the Permits for those areas and shall implement, inspect and maintain the required water pollution control practices.

C. EROSION CONTROL OUTSIDE OF DESIGNATED WORK AREA: Installing, inspecting and maintaining water-pollution control practices on areas outside the right-of-way not (or designated work area) specifically arranged and provided for by the City of Fort Bragg for the execution of this contract, will not be paid for.

D. PENALTIES: The Contractor shall be responsible for penalties assessed or levied on the Contractor or the City of Fort Bragg as a result of the Contractor's failure to comply with the provisions in this section "Water Pollution Control" including, but not limited to, compliance with the applicable provisions of the Permits, and Federal, State and local regulations and requirements as set forth therein. Penalties as used in this section, "Water Pollution Control," shall include fines, penalties and damages, whether proposed, assessed, or levied against the City of Fort Bragg or the Contractor, including those levied under the Federal Clean Water Act and the State Porter-Cologne Water Quality Control Act, by governmental agencies or as a result of citizen suits. Penalties shall also include payments made or costs incurred in settlement for alleged violations of the Permits, or applicable laws, regulations, or requirements. Costs incurred could include sums spent instead of penalties, in mitigation or to remediate or correct violations.

1. RETENTION OF FUNDS:

a. Notwithstanding any other remedies authorized by law, the City of Fort Bragg may retain money due the Contractor under the contract, in an amount determined by the City of Fort Bragg, up to and including the entire amount of Penalties proposed, assessed, or levied as a result of the Contractor's violation of the Permits, or Federal or State law, regulations or requirements. Funds may be retained by the City of Fort Bragg until final disposition has been made as to the Penalties.

b. The Contractor shall remain liable for the full amount of Penalties until such time as they are finally resolved with the entity seeking the Penalties.

c. Retention of funds for failure to conform to the provisions in this section, "Water Pollution Control," shall be in addition to the other retention amounts required by the Contract. The amounts retained for the Contractor's failure to conform to provisions in this section will be released for payment on the next monthly estimate for partial payment following the date when an approved SWPPP has been implemented and maintained, and when water pollution has been adequately controlled, as determined by the Project Manager.

d. When a regulatory agency identifies a failure to comply with the Permits and modifications thereto, or other Federal, State or local requirements, the City of Fort Bragg will retain money due the Contractor, in the amount of 10 percent of the work done to date or any fine whichever is greater, this amount is in addition to the retention specified in Section 9-3.2 of the general provisions under Final Payment, subject to the following. The City will give the Contractor written notice of the City's intent to retain funds from partial payments which may become due to the Contractor prior to recording of the Notice of Completion. During the first estimate period that

the Contractor fails to conform to the provisions in this section, "Water Pollution Control," the City of Fort Bragg may retain an amount equal to 25 percent of the estimated value of the contract work performed.

e. The Contractor shall notify the Project Manager immediately upon request from the regulatory agencies to enter, inspect, sample, monitor, or otherwise access the project site or the Contractor's records pertaining to water pollution control work. The Contractor and the City of Fort Bragg shall provide copies of correspondence, notices of violation, enforcement actions or proposed fines by regulatory agencies to the requesting regulatory agency.

E. SWPPP PREPARATION

1. SWPPP GENERAL: As part of the water pollution control work, a Storm Water Pollution Prevention Plan (SWPPP) is required for this contract. The SWPPP shall conform to the provisions in this section, "Water Pollution Control," the Standard Specifications, the requirements of the Permits, and these special provisions. Upon the Project Manager's approval of the SWPPP, the SWPPP shall be considered to fulfill the provisions in this section, "Water Pollution Control," of the Standard Specifications for development and submittal of a Water Pollution Control Program. No work having potential to cause water pollution shall be performed until the SWPPP has been approved by the Project Manager. Approval shall not constitute a finding that the SWPPP complies with applicable requirements of the Permits, the Manuals and applicable Federal, State and local laws, regulations, and requirements.

2. WATER POLLUTION CONTROL MANAGER: The Contractor shall designate a Water Pollution Control Manager. The Water Pollution Control Manager shall be responsible for the preparation of the SWPPP and required modifications or amendments, and shall be responsible for the implementation and adequate functioning of the various water pollution control practices employed. The Contractor may designate different Water Pollution Control Managers to prepare the SWPPP and to implement the water pollution control practices. The Water Pollution Control Managers shall serve as the primary contact for issues related to the SWPPP or its implementation. The Contractor shall submit to the Project Manager a statement of qualifications, describing the training, previous work history and expertise of the individual selected by the Contractor to serve as Water Pollution Control Manager. The Water Pollution Control Manager shall have a minimum of 24 hours of formal storm water management training or certification as a Certified Professional in Erosion and Sediment Control (CPESC). The Project Manager will reject the Contractor's submission of a Water Pollution Control Manager if the submitted qualifications are deemed to be inadequate.

3. SWPPP CONTENTS. The SWPPP shall apply to the areas within or outside of the right-of-way that are directly related to construction including, but not limited

to, material borrow areas, staging areas, storage yards, and access roads. The SWPPP shall incorporate water pollution control practices in the following categories:

a. Soil stabilization.
b. Sediment control.
c. Wind erosion control.
d. Tracking control.
e. Non-storm water management.
f. Waste management and materials pollution control.

The Contractor shall complete the "Construction Site BMPs Consideration Checklist" presented in the California Department of Transportation SWPPP and WPCP Preparation Manual, dated March 2003, and shall incorporate water pollution control practices into the SWPPP. Water pollution control practices include the "Minimum Requirements" and other Contractor-selected water pollution control practices from the "Construction Site BMPs Consideration Checklist" and the "Project-Specific Minimum Requirements" identified in the Water Pollution Control Cost Break-Down of this section.

4. SUBMITTAL AND REVIEW: Within 15 working days after the approval of the contract, the Contractor shall submit three (3) copies of the draft SWPPP to the Project Manager. The Project Manager will have five (5) working days to review the SWPPP. If revisions are required, as determined by the Project Manager, the Contractor shall revise and resubmit the SWPPP within five (5) working days of receipt of the Project Manager's comments. The Project Manager will have five (5) working days to review the revisions. Upon the Project Manager's approval of the SWPPP, four (4) approved copies of the SWPPP, shall be submitted to the Project Manager. To allow construction activities to proceed, the Project Manager may conditionally approve the SWPPP while minor revisions are being completed. In the event the Project Manager fails to complete the review within the time allowed, and if, in the opinion of the Project Manager, completion of the work is delayed or interfered with by reason of the Project Manager's delay in completing the review, an extension of time will be granted, in the same manner as provided for in the Standard Specifications.

5. SCHEDULE: The Contractor shall develop a Water Pollution Control Schedule that describes the timing of grading or other work activities that could affect water pollution. The Water Pollution Control Schedule shall be updated by the Contractor to reflect changes in the Contractor's operations that would affect the necessary implementation of water pollution control practices.

6. AMMENDMENTS: The Contractor shall prepare an amendment to the SWPPP when there is a change in construction activities or operations which may affect the discharge of pollutants to surface waters, ground waters, storm drain systems,

or when the Contractor's activities or operations violate a condition of the Permits or when directed by the Project Manager. Amendments shall identify additional water pollution control practices or revised operations, including those areas or operations not identified in the initially approved SWPPP. Amendments to the SWPPP shall be prepared and submitted for review and approval within a time approved by the Project Manager, but in no case longer than the time specified for the initial submittal and review of the SWPPP.

7. LOCATION OF SWPPP COPIES: The Contractor shall keep one copy of the approved SWPPP and approved amendments at the project site. The SWPPP shall be made available upon request by a representative of the Regional Water Quality Control Board, State Water Resources Control Board, United States Environmental Protection Agency, or the local storm water management agency. Requests by the public shall be directed to the Project Manager.

F. SWPPP IMPLIMENTATION

1. GENRAL: Unless otherwise specified, upon approval of the SWPPP, the Contractor shall be responsible throughout the duration of the project for installing, constructing, inspecting, maintaining, removing, and disposing of the water pollution control practices specified in the SWPPP and in the amendments. Unless otherwise directed by the Project Manager, the Contractor's responsibility for SWPPP implementation shall continue throughout temporary suspensions of work. Requirements for installation, construction, inspection, maintenance, removal, and disposal of water pollution control practices shall conform to the requirements in these special provisions.

2. CORRECTION OF DEFICIENCIES: If the Contractor or the Project Manager identifies a deficiency in the implementation of the approved SWPPP or amendments, the deficiency shall be corrected immediately unless requested by the Contractor and approved by the Project Manager in writing, but shall be corrected prior to the onset of precipitation. If the Contractor fails to correct the identified deficiency by the date agreed or prior to the onset of precipitation, the project shall be in nonconformance with this section, "Water Pollution Control." If the Contractor fails to conform to the provisions of this section, "Water Pollution Control," the Project Manager may order the suspension of construction operations until the project complies with the requirements of this section.

3. SEASONAL VARIATON:

   a. Implementation of water pollution control practices may vary by season. These special provisions shall be followed for control practice selection of year-round, rainy season and non-rainy season water pollution control practices.

b. Year-Round Implementation Requirements: The Contractor shall have a year-round program for implementing, inspecting and maintaining water pollution control practices for wind erosion control, tracking control, non-storm water management, and waste management and materials pollution control. The National Weather Service weather forecast shall be monitored and used by the Contractor on a daily basis. An alternative weather forecast proposed by the Contractor may be used if approved by the Project Manager. If precipitation is predicted, the necessary water pollution control practices shall be deployed prior to the onset of the precipitation. Disturbed soil areas shall be considered active whenever the soil disturbing activities have occurred, continue to occur or will occur during the ensuing 21 days. Non-active areas shall be provided within 14 days of cessation of soil disturbing activities or prior to the onset of precipitation, whichever occurs first.

4. MAINTENANCE:

a. To ensure the proper implementation and functioning of water pollution control practices, the Contractor shall regularly inspect and maintain the construction site for the water pollution control practices identified in the SWPPP. The construction site shall be inspected by the Contractor as follows:

i. Prior to a forecast storm.
ii. After a precipitation event which causes site runoff.
iii. At 24 hour intervals during extended precipitation events.
iv. Routinely, a minimum of once every two weeks from May 15th to October 15th.
v. Routinely, a minimum of once every week from October 15th to May 15th.

b. The Contractor shall use a Storm Water Quality Construction Site Inspection Checklist approved by the Project Manager. One copy of each site inspection record shall be submitted to the Project Manager within 24 hours of completing the inspection.

5. REPORTING REQUIREMENTS:

a. Report of Discharges, Notices or Orders: If the Contractor identifies discharges into surface waters or drainage systems in a manner causing, or potentially causing, a condition of pollution, or if the project receives a written notice or order from a regulatory agency, the Contractor shall immediately inform the Project Manager. The Contractor shall submit a written report to the Project Manager within 3 days of the discharge event, notice or order. The report shall include the following information:

i. The date, time, location, nature of the operation, and type of discharge, including the cause or nature of the notice or order.
ii. The water pollution control practices deployed before the discharge event, or prior to receiving the notice or order.
iii. The date of deployment and type of water pollution control practices deployed after the discharge event, or after receiving the notice or order, including additional measures installed or planned to reduce or prevent reoccurrence.
iv. An implementation and maintenance schedule for affected water pollution control practices.

b. Report of First-Time Non-Storm Water Discharge: The Contractor shall notify the Project Manager at least three (3) days in advance of first-time non-storm water discharge events, excluding exempted discharges. The Contractor shall notify the Project Manager of the operations causing non-storm water discharges and shall obtain field approval for first-time non-storm water discharges, Non-storm water discharges shall be monitored at first-time occurrences and routinely thereafter.

c. Annual Certifications: By June 15 of each year, the Contractor shall complete and submit an Annual Certification of Compliance, as contained in the California Department of Transportation SWPPP and WPCP Preparation Manual, dated March 2003, to the Project Manager.

3.03 TEMPORARY ROCK DRAINAGE SWALES:

A. Install geotextile over prepared area as shown on the Drawings. Coordinate earthwork to assure edges of geotextile are properly secured. Shingle and overlap seams across the flow line by three (3) feet.

B. Carefully place ¾" CLEAN rock on top of the geotextile to a depth of four (4) inches. Do not drive on the geotextile. Place material by loader bucket from side of the drainage. Level the material carefully to prevent tearing or puncturing of the geotextile or geotextile. Tears or punctures shall be replaced at the contractor's expense.

3.04 MULCHING AND TACKING

A. Seeding, General: When seed is required, seed and fertilize first, or incorporated seed and fertilizer in hydromulch mix at the rates described in Section 2.02 and 2.03 of this Specification. Prior to seeding ensure that the soil is loose enough to accept seed for germination.

B. One Season Straw Mulch (no seed): Straw mulch shall be applied at a rate of 2 tons per acre and shall cover no less than 90% of the surface on slopes flatter than 20

percent. Mulch shall be applied at 2-1/2 tons per acre on slopes steeper than 20% and cover at least 95% of the surface. Straw shall be track-walked into the surface in a direction up and down the slopes using the grousers of a dozer.

C. Seed and Straw Mulch (no tackifier): Prior to placing straw, broadcast fertilizer and seed at the rates described in Sections 2.02 and 2.03 of this specification. Straw mulch shall then be applied at a rate of 2 tons per acre and shall cover no less than 90% of the surface. Straw shall be track-walked into the surface in a direction up and down the slope using the grousers of a dozer.

D. Seed, Mulch & Tackify: Straw shall be applied at a rate of 1.75 tons per acre and be tacked using a tacking agent at the proportions of 150 pounds of tacking agent, 500 pounds of wood fiber and 300-gallons of water. Seed and fertilizer shall be applied at the rates described in Sections 2.02 and 2.03 of this specification.

E. Hydromulch only: Using a tacking agent at the proportions of 150 pounds of tacking agent, 800 pounds of wood fiber and 300-gallons of water or as approved by Project Manager. Seed and fertilizer shall be applied at the rates described in Sections 2.02 and 2.03 of this specification.

F. Steep Fill Slope Seed, Mulch and Tackify: Seed and fertilizer shall be applied at the rates described in Sections 2.02 and 2.03 of this specification. Incorporate seed and fertilizer into Eco Aegis II mixture and apply at a rate of rate of 3,000 lb/acre. The Contractor may substitute with a combination of jute netting and seeding and mulching or other stabilization methods.

3.05 STRAW WATTLES

A. Install wattles on the contour as shown on the erosion control drawings.

B. Tightly butt ends and pack with loose straw to prevent breakthrough at joints. Curl open ends 3 feet up slope.

C. First excavate a slight depression using a hoe or pick axe for good contact with the soil.

D Place the wattle firmly against the ground and stake every 2 to 3 feet.

E. Stake within a foot of butted ends.

F. On slopes flatter than 20% with forest litter still on the ground, space 9-inch wattles a minimum of every 40 feet (slope length). On bare soil space them a minimum of every 20 feet. Space wattles a minimum every 20 feet on all slopes steeper than 20 percent.

3.06 SILT FENCES

A. Install silt fences on the contour and curl the end 3 feet up slope.

B. First Excavate a 4- to 6-inch deep trench then pound the stakes into the trench with the fabric stretched tight and on the up hill side.

C. Bury the tail of the fabric and compact the soil in the trench.

PART 4 – MEASUREMENT & PAYMENT

4.01 GENERAL

A. Lump-sum and unit cost shall include all materials, equipment, shipping, sales tax, labor, superintendence, tools, overhead, and other costs to construct the materials complete in place.

B. The quantities shown on the drawings considered minimum scope and quantity to depict the general requirements. The Contractor shall determine the final quantities required and submit an itemized cost breakdown. The Contractor shall include a Water Pollution Control Cost Break-Down in the SWPPP which itemizes the contract lump sum for water pollution control work. The Contractor shall use the Water Pollution Control Cost Break-Down to identify items, quantities and values for water pollution control work. The Contractor shall be responsible for the accuracy of the quantities and values used in the cost break-down submitted with the SWPPP.

C. Partial payment for the item of Water Pollution Control will not be made until the Water Pollution Control Cost Break-Down is approved by the Project Manager. No adjustment in compensation will be made to the contract lump sum price paid for water pollution control due to differences between the quantities shown in the approved cost break-down and the quantities required to complete the work as shown on the approved SWPPP. No adjustment in compensation will be made for ordered changes to correct SWPPP work resulting from the Contractor's own operations or from the Contractor's negligence. The approved cost breakdown will be used to determine partial payments during the progress of the work and as the basis for calculating the adjustment in compensation for the item of water pollution control due to increases or decreases of quantities ordered by the Project Manager. If an ordered change requires a new item which is not on the approved cost break-down, the adjustment in compensation will be determined in the same manner specified for extra work in conformance with the appropriate section of the Standard Specifications.

4.02 MEASUREMENT

A. Measurement will be on a lump-sump basis for each item shown in the bid schedule. Measurement for partial payment will be based on the Water Pollution Control Cost Break-Down as described above. The Contractor shall indicate the quantities used in each pay request. The quantities shall be approved by the Project Manager prior to approval of the pay request.

4.03 PAYMENT

A. SWPPP: The contract lump sum price paid for prepare Storm Water Pollution Prevention Plan shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work involved in developing, preparing, obtaining approval of, revising, and amending the SWPPP, as specified in these special provisions, and as directed by the Project Manager. Payments for preparing the storm water pollution prevention plan shall be paid under the item "SWPPP Preparations" as follows:

1. After the SWPPP has been approved by the Project Manager, 75 percent of the contract item price for preparing the Storm Water Pollution Prevention Plan will be included in the monthly progress payment.

2. The payment for the remaining 25 percent of the contract item price for prepare Storm Water Pollution Prevention Plan will be made with the final progress payment.

B. SWPPP IMPLIMENTATION: The contract lump sum price paid for Water Pollution Control shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in installing, constructing, removing, and disposing of water pollution control practices, including non-storm water management, and waste management and materials pollution water pollution control practices, except those for which there is a contract item of work as specified in the Standard Specifications and these special provisions, and as directed by the Project Manager.

C. WATER POLLUTION CONTROL PRACTICES MAINTEANCE: Full compensation for maintenance costs of water pollution control practices, as specified in this section, shall be considered as included in the contract lump sum price paid for "Water Pollution Control" and no additional compensation will be allowed therefor. Water pollution control practices for which there is a contract item of work, will be measured and paid for as that contract item of work.

END OF SECTION

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SECTION 02272

ROCK CHANNEL PROTECTION AND RIP RAP

PART 1 - GENERAL

1.1 DESCRIPTION: The work of this section consists of furnishing and placing stone riprap to create an un-concreted rock-lined energy dissipater.

1.2 LIMITATIONS: Rock Reinforced channels and faces shall be used only on slopes equal to flatter than 1 horizontal to 1 vertical (1 to 1) and up to 15 feet tall, unless otherwise directed by the Engineer.

1.3 RELATED SECTIONS:

A. Section 02210 - Site Grading for coordination with fills.

B. Section 02217 - Erosion Control.

PART 2 - PRODUCTS

2.1 GENERAL: Rip-Rap Boulders shall be angular quarry stones, sound and hard, resistant to water and weathering.

2.2 ROCK FOR ENERGY DISSIPATER:

A. 10" poorly graded angular stone.

2.3 ROCK FOR SLOPE TRENCH BACKFILL:

A. 3" angular drain rock.

2.4 ROCK FOR OUTFALL BASIN:

A. 3" angular drain rock.

2.5 FILTER FABRIC: Fabric shall be a nonwoven 8-oz, geotextile fabric.

2.6 12 CMP Culvert: 12" perforated and non-perforated CMP H-20 rated culvert.

PART 3 - EXECUTION

3.1 EXCAVATION: Excavate subgrade to lines and grades, as shown on plans and as specified in Section 02210 – Site grading. Obtain Project Engineer's approval of foundation before placing rock slope protection.

3.2 FILTER FABRIC: Place filter fabric over prepared excavation and secure in place (if shown on the drawings). Use a 1-foot deep anchor trench at the top of the slope to secure the fabric from sliding down the slope.

3.3 SLOPE PROTECTION: Excavate toe trench where shown on the drawings. Place stones into place to form the proper cross section. The exposed surface of riprap shall be reasonably uniform and free from bulges, humps, or cavities.

3.4 CULVERT: Culvert shall be placed at the location and grades shown on the plan. The culvert shall have at least 36" of cover under the existing utility road. Culvert must maintain at least 1% slope.

PART 4 - MEASUREMENT AND PAYMENT

4.2 MEASUREMENT:

A. Measurement for "Channel Protection" will be on a tonnage basis. The cost for "Channel Protection 10" shall include the 12" CMP Culvert.

4.1 PAYMENT:

A. Payment for the rock lined overflow shall be lump sum for "Channel Protection 10", Channel Protection 3", and Trench Backfill 3".

END OF SECTION

SECTION 02444

CHAIN LINK FENCE AND GATES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. Work included:

1. Construction of new six-foot high security chain link fence and gate.

1.2 SUBMITTALS:

A. Submit for approval no less than 20 calendar days before use, in accordance with General Provisions Section: 'Submittals'.

B. Manufacturer's Data:

1. Framework (rail, post and gate).
2. Mesh.
3. Barbed wire and support arms.
4. Gate hardware.

PART 2 – PRODUCTS

2.1 MATERIALS:

A. Fence shall conform to Section 80 of the State of California Standard Specifications and these Special Provisions.

1. The fencing fabric shall be woven from No. 9 gauge wire conforming to Sections 3, 4, 7 and 8 of ASTM Designation: A 116, with Class Ill zinc coating. The fencing fabric shall be a chain link type fabric as defined in Section 3 of ASTM Designation: A 392.

   Where specified, pickets shall be 2-inch plastic tubular slats, colored brown, and shall be inserted vertically into each mesh of the chain link fabric. Each picket shall extend the full height of the chain link fabric. Any pickets with cracks, splits, or other blemishes shall be removed and replaced.

2.2 CONCRETE MIX:

A. Concrete: Conform to the requirements of ASTM C94 and Section 03306, normal Portland cement, 2000 psi @ 28 days, 2-inch to 3-inch slump.

2.3 COMPONENTS:

A. Cap and support arm: Combination post cap and barbed wire support arm shall be hot dip galvanized steel, sized to post dimension, set screw retained.

B. Fittings: Sleeves, bands, clips, rail ends, tension bars, fasteners and fittings, shall be galvanized steel.

C. Top rail framework: 1.66" O.D. pipe weighing not less than 2.27 lbs. per lineal foot.

D. Posts frameworks: Line posts shall be 2.375" O.D. pipe, weighing not less than 3.65 lbs. per lineal foot. Terminal, corner and pull posts shall be 2.875" O.D. pipe, and weighing not less than 5.779 lbs. per lineal feet. Gate posts shall be 4.00" O.D. pipe weighing not less than 9.1 lbs. per lineal foot.

E. Truss rods: Barbed wire shall conform to FS-RR-F-191 series and shall be provided with turnbuckles or other equivalent provisions for adjustment.

F. Miscellaneous wire: Miscellaneous wire shall conform to FS-RR-F-191 series and shall be zinc-coated steel. Reinforcing wire shall have minimum tensile strength of 75,000 psi, zinc-coated for use with zinc-coated fabric. Tie wire shall be aluminum alloy of 0.144-inch diameter for attaching fabric to zinc-coated posts. Steel wire may be used for attaching fabric to intermediate posts. Hog rings shall be aluminum wire of 0.110-inch diameter for attaching fabric to reinforcing wires.

G. Gate hardware: Hinges, drop rods, catches, gate stops and all other gate hardware shall be heavy duty 'bulldog' style. They shall be manufactured from malleable iron or pressed steel, hot-dipped galvanized per ASTM A123.

H. Weld Plates: Embed welding plates in concrete retaining wall at the Transfer building. The steel plates shall be a minimum 9 gauge metal plate large enough to properly weld the fence post base to the embedded steel plate.

PART 3 – EXECUTION

3.1 STANDARD INSTALLATION:

A. Chain link fence shall be constructed where shown on the plan. The line of the fence shall be cleared of all obstructions and surface irregularities and the bottom of the fence shall be to uniform grade, as may be established by the Inspector.

B. Unless otherwise set forth in the Plans or these Special Provisions, all fence shall be constructed with a top rail, and a bottom tension wire.

C. The posts shall be spaced not more than ten feet (10') apart and at points specifically shown by the Plans. Terminal posts and gate posts shall be set thirty-six inches (36") in concrete bases. Line posts shall be set thirty inches (30") in concrete bases.

D. Set post to within 6 inches from bottom of concrete footing. Slope top of concrete for water run-off. Set top of footing 2 inches maximum above finished grade.

E. Concrete base posts shall be allowed to cure for not less than seven (7) days before wire fabric is placed.

F. Fabric is to be fastened to line posts with fabric bands spaced approximately fourteen inches (14") apart and to top rail and bottom tension wire with 9 gauge galvanized tie wires spaced approximately twenty-four inches (24") apart.

G. Stretcher bar and truss bands shall be spread and slipped on end, corner, pull, brace, and gate posts before installation of top rails. Extension joints shall be provided from rails at intervals of one hundred feet (100'). Bottom tension wire shall be seven (7) gauge galvanized coil spring steel.

H. Pass top rail through line post tops to form continuous bracing. Install 7-inch long couplings midspan at pipe ends.

I. Brace each gate and corner post back to adjacent line post with horizontal center brace rail. Install brace rail, one bay from end and gate posts.

J. The placing of the rails, braces, and the wire fabric shall be accomplished in such a manner that the finished fence shall be taut, true, and of precise workmanship throughout. The fabric shall be stretched so that no slack sections remain at any point. The fabric shall be securely tied to posts and rails in a manner so that the fabric will remain tight and immovable.

K. Position bottom of fabric no more than 2 inches above finished grade with tension wire stretched taut between posts.

L. Attach fabric to end, corner, and gate posts with tension bars and tension bar clips.

M. Install gates in the locations shown on the Plans. Install 3 hinges per leaf, latch, catches, foot bolts and sockets, retainer and locking clamp.

N. Gates shall be so set that they are true and will swing freely in the direction indicated by the Plans.

O. Install center and bottom brace rail on corner and gate leaves.

PART 4 – MEASUREMENT AND PAYMENT

4.1 PAYMENT:

A. Payment for the fence shall be based on a lump-sum cost for "Security Chain Link Fence".

4.2 MEASUREMENT:

A. Measurement shall be on a lump-sum basis. Measurement includes hole boring, gates, latches, posts, concrete, fabric, labor and accessories necessary for the completed installation.

END OF SECTION

SECTION 02589

GEOELECTRIC LINER LEAK LOCATION SURVEY

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Requirements for performance of an electronically based liner leakage survey for post-construction liner interbred monitoring. Monitoring shall be performed where indicated on the plans.

B. Successful performance of an electrically-based liner leak survey requires the conductive media above and below the liner to be electrically isolated from each other except through the leaks being sought. It is also necessary to have a continuous electrically conducting pathway under the geomembrane from the leaks being sought to the point at which a current return electrode can be placed in the leaked liquid.

C. This test is intended to identify any potential defects in the primary lining system, which may cause the lining system to leak. As a result, the Leak Location Contractor shall identify defects equivalent to a hole with a diameter of =1/5" (=0.2 inches; 0.5 cm), or an overall area of =0.03 square inches (=0.20 square cm).

1.02 RELATED SECTIONS

A. Section 02750 – HDPE Geomembrane

1.03 SUBMITTALS

A. The firm retained for the project shall submit, all items described in the subsequent sections to the Project Manager for approval prior to commencement of the leak survey:

1. Qualifications of the proposed Leak Location Contractor to include the number of years the Leak Location Contractor has performed the proposed survey process.

2. Description of the proposed method for electrical leak location.

3. List of projects where the proposed Leak Location Contractor has performed the proposed method. The project list shall include the type of liner system surveyed, general description of what damage was located and identification of any modifications to the method that they were employed.

4. Sample of the final report or certification to be issued by the Leak Location Contractor following the completion of the survey.

B. Final certification or report from Leak Location Contractor that the entire designated area has been surveyed.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.01 INFORMATION REQUIRED

A. The firm shall provide the Leak Location Contractor with drawings showing:

1. All layers constituting the lining system.

2. Details of all liner penetrations.

3. Peripheral details, including welds between primary and secondary liners, and welds to adjacent lining systems.

4. Structures and obstructions above the liner.

5. Electrical equipment above the primary liner.

3.02 SITE PREPARATION

A. The Leak Location Contractor will identify actions required by Engineer to prepare the site for a survey, such as:

1. Plugging pipes with inflatable bungs.

2. Painting/covering metal and concrete.

3. Moving/disconnecting electrical equipment.

4. Cleaning/preparing soil surfaces.

5. Adjusting liquid levels.

6. Gridding a soil surface.

7. Providing electrode access to leak detection zone.

8. Removing/marking obstructions to the survey.

B. The Contractor shall provide an electrically conductive medium within the primary and secondary drainage blanket by ensuring an adequate moisture content therein. If the natural moisture content in the primary or secondary drainage blanket does not provide for an adequate conductive medium, then the Contract shall add sufficient water as directed by the Leak Location Contractor. The Contractor shall document the volume of any water introduced into the secondary collection system.

3.03 EXECUTION

A. Survey site to ensure electrical conditions are appropriate for a leak survey.

B. Confirm or establish required grid markings on cover soils. The initial grid shall be 5-foot by 5-foot spacing across the site, with additional grid points established as needed in suspected leak locations.

C. Disconnect electrical equipment within the lining system as required.

D. Activate lining system with an injector electrode in the medium above the liner, and a current electrode placed between the primary and secondary liners.

E. Perform calibration procedure with artificial hole, to determine voltage/current required, instrument settings, and spacing of survey traverses in liquids or distance between readings on soils. If required, an actual hole may be introduced into the primary lining system by the Leak Location Contractor in order to calibrate the electrical survey. This hole shall be repaired and tested as required. The Leak Location Contractor may only calibrate to an actual hole if equipment is on-site to immediately repair hole after calibration.

F. For soils, perform survey using dipole probe, or with static reference probe and roving search probe.

G. For uncovered liner, perform water lance survey, ensuring that water source is electrically isolated, and that run-off water remains contained on the liner.

H. The Leak Location Contractor shall inform the Engineer and mark the locations of all identified or indicated leaks with flags, spray paint, or written coordinates.

I. On soils, ensure meter shows equal plus/minus readings of commutated current.

J. On exposed liner, periodically direct water jet over known hole or on to surrounding soil at top of side slope, to assure a proper signal.

K. The Leak Location Contractor shall inform the Engineer and mark the locations of all identified or indicated leaks with flags, spray paint, or written coordinates.

3.04 REPORTING

A. Provide written report within 2 weeks of completion of survey outlining:

1. Principles of technique
2. Site activities
3. Map of leak locations
4. Description of leaks, if known

3.05 REPAIRS

A. If a leak is found, the leak then will be repaired by the geosynthetic contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.1 UNIT PRICES - MEASUREMENT AND PAYMENT

A. Measurement and payment shall be included in the square-yard price of installing the synthetic liner as listed under "60-mil HDPE Liner" in the bid schedule. No separate payment shall be made.

END OF SECTION

SECTION 02720

UNDERDRAIN

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Trenching, placement of a perforated 4-inch – PVC pipe, non-woven filter fabric, and backfill.

1.02 RELATED SECTIONS

A. Section 01050 - Field Engineering.

B. Section 01300 - Submittals.

C. Section 02221 – Utility Trenching & Backfilling.

1.03 FIELD MEASUREMENTS

A. Verify survey bench marks and that intended elevations are as indicated.

B. Provide construction control monuments for vertical and horizontal placement of underdrain line, and locations and grades on the drawings.

1.05 SUBMITTALS

A. Comply with Section 01300 of these Specifications.

B. The Contractor shall submit copies of brochures, samples, manufacturer's name, model number, ratings and any other pertinent information necessary for the installation, operation, and maintenance of the gas-header system. Items include, but not necessarily limited to: PVC lines and fittings.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe shall be of 4" inside diameter and shall be ASTM 3034 SDR 35 or Sch 40 PVC or better, with the exception that perforated pipe shall have a minimum wall thickness conforming to ASTM Standard 2729.

B. Gravel shall be Effective size 3/4 inch, uniformity coefficient 3.0, voids 40 percent by volume. The filter material shall have a cleanness value of at least 70 using test method No. Calif. 227-E method of test for evaluating cleanness of course aggregate, or equal approved by the engineer. "Effective size" for the purpose of these Standards is that size of grain which is larger than 10 percent of the material by weight. The uniformity coefficient for the purpose of these Standards is that sieve that passes 60 percent of the material divided by sieve size that passes 10 percent of the material.

C. Filter Fabric shall be 6-ounce or better nonwoven geotextile to line the trench around the drain rock.

2.02 OTHER

A. Provide other materials not specifically, described but required for a complete and proper installation as selected and submitted by the Contractor subject to approval by the Engineer.

PART 3 EXECUTION

3.01 CONSTRUCTION REQUIREMENTS

A. Excavation and backfill shall be to the depths shown on the Plans and shall conform to the requirements of Section 02221, and as directed by the Engineer.

B. Pipe shall be laid true to grade and line as indicated on the Plans. Pipe, fittings and appurtenances, shall be handled and stored in such a manner to avoid damage.

1. Pipe shall be cleaned of all foreign material such as dirt, grease, oil, or moisture prior to placement.

2. Geotextile fabric shall be protected from sunlight and handled per manufacturers specifications.

3.02 BACKFILL AND FINISH GRADING

A. Lines shall be backfilled in accordance with Section 02221. After completion of all pipe placement and backfill, the ground surface shall be graded to final contours and depressions and irregularities removed.

4.0 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Excavating, placement of bedding material, filter fabric, placement of 4-inch PVC pipe, and backfill shall be paid for as a lump sum under "Subdrain System".

END OF SECTION

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SECTION 02600

WATER LINES AND APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section describes the requirements for furnishing and installing pressure water lines (excluding HDPE), 18-inch and smaller, including the materials to be used, methods and requirements for installation and measurement for payment.

B. Work under this section shall include, but not be limited to, installing the pipe (including storing and handling), placing the pipe and fittings, installing protective wrap where required, completing joints, including application of corrosion protection materials, placing of reaction blocking, installing and testing the locating wire, connecting to existing mains, and installation of valves, fittings, and appurtenances associated with the water delivery system.

1.2 RELATED SECTIONS:

A. Section 01300 - Submittals

B. Section 02221 – Utility Trenching & Backfilling.

B. Section 02229 – Utility Tape.

C. Section 02602 – Waterline Testing.

1.3 SUBMITTALS:

A. Submittals supplied by the Contractor shall include: catalog information on pipeline material, fittings, mechanical couplings, restrained joints and flange insulation kits; samples of gravel, select backfill and sand; gravel, sand, sand-cement slurry, permeable backfill and ready-mix concrete; and laying diagrams for any sections of water main that cannot be laid with standard length material. The Contractor's attention is directed to the General Conditions of this contract under 'Submittals".

1.4 QUALITY CONTROL:

A. The Contractor shall make all water main materials available for inspection by the Engineer prior to their installation. The Contractor shall provide the necessary men and equipment to make these materials available. Each phase of work shall pass inspection by the Project Engineer before commencing work on the next phase. The

phases shall consist of, but not be limited to, pavement cutting, excavation, bedding, pipe laying, application of corrosion protection (including protective wrap of D.I. pipe, where required), shading around pipe, installing the locating wire, backfilling each layer, testing the locating wire, and trench restoration. Pressure and leak testing, and disinfection requirements are described elsewhere in these specifications.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Materials furnished for raw water pipeline shall include, but not be limited to, pipeline materials; fittings including bends, tees, wyes, crosses, reducers, caps, couplings, flanges and other special joints, flange insulating kits, polyethylene encasement, primers and solvents for use with PVC pipe, native and imported backfill, straw bales, concrete for reaction blocking and structure replacement, sand-cement slurry, water and palliatives for backfill conditioning and dust control, locating wire and materials used for restoration of the trench and work area.

B. Requirements for backfill materials, both native and imported, are included with installation procedures contained elsewhere in this section.

2.2 PIPELINE MATERIAL:

A. Pipeline materials shall be polyvinyl chloride pipe (PVC). The type of pipeline material, the nominal size; class, rating, or schedule, shall be as shown on the plans, or as further limited by the Special Conditions of this Contract. In no case shall the system working pressure exceed the maximum working pressure for the pipeline material, size, class, rating, or schedule listed below:
   a. 10" PVC shall be C-900 with ASTM F477 elostomeric gaskets.
   b. 10" Ductile Iron shall be ANSI/AWWA C110/A21.10 for Water or Other Liquids with flanged fittings. Gasket material shall be Styrene Butadiene (SBR).

B. The same type of pipeline material and manufacturer shall be used throughout the work unless specific types are listed for specific areas in the Special Conditions of this Contract.

2.3 PVC PRESSURE PIPE (POLYVINYL CHLORIDE)

A. PVC pressure pipe shall be furnished with iron pipe size equivalent outside diameters.

B. PVC pipe sections shall be supplied in 20-foot laying lengths. Pipe cut for closures shall be machined or otherwise rendered suitable for inserting into and making a tight joint with the coupling or fitting. At least 90% of pipe furnished shall be standard 20-foot lengths, except that shorter lengths may be required for horizontal and vertical curves, as described for installation elsewhere in this section. The remainder of pipe sections supplied may be of random lengths, but not less than 18-foot long. The Contractor shall not substitute multiple short lengths of pipe where one or more standard length will fit.

C. Pipe shall be supplied with plain ends suitable for use with PVC and mechanical couplings using two elastomeric gaskets, or supplied with one plain end and one bell end using one elastomeric 'O' ring gasket. Solvent weld joints for 4-inch or larger pipe will not be allowed. Restrained joints using clamp or other devices will not be allowed. PVC couplings used for plain end pipe shall be of the same type of material and equivalent to the class of pipe for which they are to be used and shall be appropriately marked.

D. Each section of pipe shall be clearly marked with the nominal size and OD base (for example, 8-CI), type of pipe, dimension ratio number (for example, DR18), AWWA Pressure Class (for example, PC150), AWWA Designation Number (AWWA C900), the manufacturer's name or trademark and production record code.

2.5 JOINT CONFIGURATIONS

A. Push-on joints for PVC pressure pipe and related fittings may not be substituted for mechanical joints where using mechanical joints are required.

B. Where angle points in the pipe alignment require two elbow fittings to be flanged and bolted together, the Contractor may substitute a single fitting of proper degree bend to match the required angle. Such substitute elbow fittings shall comply fully with these specifications.

2.6 CONCRETE:

A. Concrete for reaction blocking shall be 2,000 psi. Concrete for replacing sidewalks, curbs, gutters, driveways and road crossing caps shall be 3,000 psi, both conforming in all respects to the requirements for concrete work.

2.7 LOCATION TAPE:

A. Water line location tape shall be electronically detectable and conform to the requirements of Section 02229.

PART 3 - EXECUTION

3.1 GENERAL:

A. Installation shall be in conformance with AWWA C605-05.

B. This work shall consist of installing the pipe, fittings, appurtenances and locating wire.

3.2 HORIZONTAL ALIGNMENT

B. The Contractor shall follow the horizontal alignment as staked in the field, and/or as shown on the drawings. The Contractor's attention is directed to Section 01050 'Field Engineering' for staking requirements. The horizontal alignment shall follow the staked alignment with a maximum variation of plus or minus 6 inches on straight sections and plus or minus 12 inches on curved sections.

C. Pipe bends and curve radii shall not exceed the following values, or the limitations of the pipe manufacturer:

Pipe Size (inches)	Curve Radius (feet)
1-1/2	38
2	50
2-1/2	63
3	75
4	100
6	150
8	200

3.3 VERTICAL ALIGNMENT:

A. The vertical alignment shown on the plans shall be maintained within the limits described herein. If construction staking is required, the Contractor shall comply with requirements for construction staking, as described in Section 01050.

3.4 SEPARATION:

A. All water line installations shall conform to the 'California Waterworks Standards' contained in Section 64630, Title 22, California Administrative Code. Among others, these standards specify separation requirements between water mains and sanitary sewer lines.

3.5 PIPE LENGTHS:

A. Pipe lengths shall be selected so that pipe can be installed through horizontal or vertical curves, or any combination thereof, without exceeding the maximum joint deflection as recommended by the manufacturer, or maximum pipe barrel deflection, as allowed by these specifications. All curves exceeding these requirements shall be made with fittings, or by selecting shorter pipe lengths. Individual pipe lengths shall not be less than one half the standard length unless approved by the Project Engineer.

3.6 TEMPORARY EROSION CONTROL:

A. The Contractor shall take whatever measures necessary to prevent excessive erosion of areas disturbed by this work and shall prevent sediments from leaving the work areas. Measures may include, but not be limited to filter fabric fences, straw bail dikes, interceptor swales, or other methods, all as approved by the Project Engineer.

B. Straw bales shall be placed across streams downstream of the areas to be disturbed prior to working in the area. Enough bales shall be used so as to adequately cross and filter the stream. Bales shall be placed in a row with their ends tightly abutting the adjacent bale so as not to allow normal stream flows to pass around, between, or underneath the bales.

C. Each bale shall be staked in place with at least 3 No. 4 rebar stakes, each of which must penetrate firm ground by 18". The first stake in each bale shall be driven toward the previously laid bale to force the bales together.

3.7 FINAL CLEAN-UP:

A. All areas over and around the trench and appurtenances, and all other areas and surfaces disturbed by the construction activities shall be restored to an equal or better condition as existed prior to the start of construction.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT AND PAYMENT:

A. Measurement and payment for water piping shall be based on a linear-foot price. Measurement shall include backfill, valve enclosures, pipe, valves, valve boxes, and all necessary labor and materials for the completed installation.
B. Payment shall be paid under the per foot price of "10" Water Line C-900" in the bid schedule.

END OF SECTION

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SECTION 02602

TESTING WATER LINES

PART 1 - GENERAL

1.1 RESPONSIBILTIES AND COORDINATION: This work is the responsibility of the Contractor.

1.2 DESCRIPTION:

A. This section describes the requirements for pressure and leak testing of water mains and appurtenances, including but not limited to, air release valve assemblies, and all other appurtenances.

B. This work shall consist of making all connections to the water main for expelling air and for testing equipment; running the test, visually inspecting exposed appurtenances, locating and repairing all leaks, and re-testing.

D. Materials furnished for this work shall include, but not be limited to, pipe and fittings for connections to the main, and all other materials, fittings and pipelines required to perform the tests and make the necessary repairs.

1.3 REQUIRED WORK SEQUENCE:

A. The pressure test and the test for allowable leakage shall be performed simultaneously. Testing shall not commence until the water main and all appurtenances have been completely installed, up to and including compaction of road aggregate base. The Contractor may, at any time, perform his own pressure and leak test. However, these tests will in no way offset the requirement for a final pressure and leak test.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 GENERAL:

A. This section shall consist of testing the water main and appurtenances for both pressure and leakage requirements. These tests will be run simultaneously.

B. Prior to testing, the water main shall be slowly and carefully filled with water. All air shall be expelled slowly from the pipe and appurtenances in a manner so as not to

create excessive surge pressures. All appurtenances shall be left on during the testing procedure.

C. The Contractor may, at his own risk, test against new or existing valves. Suspected leaking of these valves will not be accepted as a reason for having not passed the leakage test requirements. These valves shall either be repaired or replaced prior to the start of another testing sequence. If an existing valve is suspected of leaking, the Contractor may repair or replace the valve at his own expense, or disconnect the water main from the valve, install a bulkhead, and retest.

3.2 TESTING EQUIPMENT:

A. The Contractor shall be responsible for supplying, maintaining, and operating all testing equipment. In general, the testing equipment configuration shall consist of a pump receiving water from a calibrated storage tank. The pump discharge shall enter the water main through a tap or appurtenance. A pressure sustaining valve capable of being adjusted within the required pressure ranges shall be placed on a tee located in the pump discharge line. Discharge from the pressure sustaining valve shall return to the calibrated storage tank. Other types or configurations of testing equipment shall be subject to the Project Manager's approval. The pressure pump and pressure sustaining valve shall remain in operation continuously throughout the test period.

3.4 TEST PRESSURE:

A. The test pressure shall be 150 percent of the working pressure, as calculated for the lowest elevation of the test section, or 150 psi, whichever is greatest. The pressure maintained at the pump shall be adjusted for the difference in elevation between the lowest elevation of the test section and the pump location.

3.5 TEST DURATION:

A. The test duration shall be 2 hours. Pressure in the water main shall be maintained as near the calculated test pressure as possible for the full two hour duration. The pressure pump and pressure sustaining valve shall remain in operation continuously throughout the duration of the test.

3.6 ALLOWABLE LEAKAGE:

A. The allowable leakage per test section shall be calculated from the formula contained in this subsection. Different sized water mains that might be contained within the same test section shall be calculated separately and their allowable leakage added together. This formula represents the allowable leakage regardless of the number of joints, couplings, fittings, valves, pressure reducing or pump station or any other appurtenances on the water main. The length of pipe contained in these appurtenances shall not be counted as adding to the length of water main being tested.

$$V = LD/148{,}000\ (P^{1/2})$$

V = Allowable leakage in gallons per hour
L = Length of water main in feet
D = Nominal diameter in inches
P = Average test pressure in psi**

** The average test pressure shall be calculated as the test pressure for the lowest elevation of the test section less one-half the elevation change to the highest point on the test section.

3.7 REPAIRS:

A. During the pressure and leakage test, all accessible appurtenances shall be inspected for visual signs of leakage. All visual leaks shall be corrected immediately, regardless of the amount of leakage and the test shall be run again for its full duration. Should the pressure and leakage test fail, the Contractor shall begin to investigate all areas of suspected leakage and shall make all repairs necessary in order to affect a successful test. All repair methods shall be subject to Project Manager's approval. All leaks detected shall be repaired to a water tight condition. All repairs made shall be re-tested in accordance with these specifications. All repairs shall be made and a successful test accomplished prior to taking bacteriological samples.

PART 4 - MEASUREMENT AND PAYMENT

4.1 TESTING OF WATER LINES: Payment shall be included in the lineal-foot price for the bid item 10" Water Line – C900. No separate payment shall be made for testing.

END OF SECTION

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SECTION 02610

HIGH DENSITY POLYETHYLENE (HDPE) PIPE

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Furnishing and installing HDPE pipe, fittings, and tees to the lines, grades, and locations indicated in the Contract Plans.

B. Backfill and slope protection at pipe ends.

C. Valves installed in conjunction with HDPE Pipe.

1.02 RELATED SECTIONS

A. Section 02210 – Site Grading.

B. Section 02207 – Aggregate Materials.

C. Section 10100 – Valves.

. Section 02752 – Geotextiles.

1.03 REFERENCES

A. ASTM D638 Standard Test Method for Tensile Properties of Plastics.

B. ASTM D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

C. ASTM D1248 Specification for Polyethylene Plastics Molding and Extrusion Materials.

D. ASTM D1505 Test Method for Density of Plastics by the Density Gradient Technique.

E. ASTM D1603 Test Method for Carbon Black in Olefin Plastics.

F. ASTM D1693 Test Method for Environmental Stress Cracking of Ethylene Plastics.

G. ASTM D2657 Standard Practice for Heat Joining Polyolefin Pipe and Fittings.

H. ASTM D3015 Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.

I. ASTM D3035 Standard Specification for Polyethylene Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter.

J. ASTM D3261 Standard Specification for Butt Heat Fusion Polyethylene Plastic Fittings for Polyethylene Plastic Pipe and Tubing.

K. ASTM D3350 Specification for Polyethylene Plastic Pipe and Fittings Materials.

L. ASTM F714 Specification for Polyethylene Plastic Pipe (SDR-PR) Based on Outside Diameter.

1.04 SUBMITTALS FOR REVIEW

A. Submittals shall be turned in during the mobilization phase.

B. Product Data: Provide data on pipe, fittings and accessories.

C. Manufacturer's Installation Instructions: Indicate special procedures required to install products specified.

1.05 SUBMITTALS AT PROJECT CLOSEOUT

A. Accurately record actual locations of pipe runs, connections, and invert elevations.

B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

PART 2 - PRODUCTS

2.01 PIPE MATERIALS

A. General: Pipe sizes referenced on the Drawings shall reference nominal diameter unless otherwise indicated. Pipes shall be in accordance with ASTM F714 and ASTM D3035. HDPE pipe shall contain no recycled compound except that generated in the manufacturer's own plant and from resin of the same specification and from the same raw material supplier.

B. HDPE Pipe Materials: The polyethylene pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other injurious defects. Any pipe with nicks, scrapes, or gouges deeper than 5 percent of the nominal wall thickness shall be rejected. Pipe shall be ductile iron pipe sizes (DIPS). Pipe shall be DR 17 (100psi WPR)

unless otherwise specified on the plans. All pipes shall be suitable for use as pressure conduits, listed as NSF 61 and per AWWA C906 Pressure Class (PC) 100 have a nominal burst value of three and one-half times the Working Pressure Rating (WPR) of the pipe.

1. The pipe shall be uniform in color, opacity, density, and meet the following physical properties:

Property	Test Method	Unit	Nominal Value
Material Designation	PPI/ASTM	--	PE 3408
Material Classification	ASTM D1248	--	MC5P34
Cell Classification	ASTM D3350	--	345434C
Density (3)	ASTM D1505	gm/cm3	0.941-0.955
Melt Index (4)	ASTM D1238 (216 kg/190°C)	gm/10 min.	< 0.15
Flex Modux (5)	ASTM D-790	psi	110,000-160,000
Tensile Strength (4)	ASTM D638	psi	3000-3500
ESCR (3)	ASTM D1693	hours	> 5,000
HDB @ 73°F (4)	ASTM D2837	psi	1,600
U-V Stabilizer (C)	ASTM D1603	%C	> 2.0

2. The following information shall be continuously marked on the pipe or spaced at intervals not exceeding 5 feet:
   (a) Name and/or trademark of the pipe manufacturer.
   (b) Nominal pipe size.
   (c) Standard Dimensional Ratio (SDR).
   (d) PE 3408.
   (e) Manufacturing Standard Reference. (A production code from which the date and place of manufacture can be determined.)
3. Compliance with the requirements of these Specifications shall be certified in writing by the pipe manufacturer.

C. Joints: Pipe jointing shall be by thermal butt fusion outlined in ASTM D2657. Butt fusion of pipes and fittings shall be performed in accordance with the pipe manufacturer's recommendations as to equipment and technique. The pipe shall be fused by an individual who has demonstrated ability to fuse polyethylene pipe in the manner recommended by the pipe supplier and/or the fusion machine manufacturer, as determined by the Engineer.

D. Fittings: Fittings shall be manufactured in accordance with ASTM D3261, except as modified herein. Fittings shall be of the same cell classification as pipe it is to be joined to. Fabrication fittings shall be manufactured from pipe at least one (1) SDR heavier than

the system piping, and shall be pressure rated to match the system piping. Butt fusion shall be in accordance with ASTM D3261 and the manufacturer's recommendations.

E. Bedding and cover: The pipes shall be bedded and covered as shown on the Drawings.

PART 3 - EXECUTION

3.01 STORAGE AND HANDLING

A. General: The pipe fittings and accessories shall be delivered, handled and stored in strict accordance with the manufacturer's recommendations.

B. Delivery:

1. Materials shall be delivered to the site only after the Engineer reviews and takes no exceptions to the materials.

2. Separate damaged or rejected pipe from undamaged pipe and store at locations designated by the Engineer until proper disposition of material is determined by the Engineer.

3. The Contractor shall identify damage of all damaged pipe and fittings.

4. The Contractor shall repair or replace damaged pipe, fittings and accessories at no cost to the City and to the satisfaction of the Engineer.

C. Storage: The pipe storage area at the construction site shall be prepared and reviewed for acceptability prior to the arrival of any material.

D. Handling:

1. Use appropriate handling of equipment recommended by the manufacturer to load, move and install HDPE pipe, fittings and accessories.

2. The HDPE Pipe Contractor is responsible for off-loading, storage and transporting material from storage area to installation site.

3.02 INSTALLATION OF PIPE

A. Follow the manufacturer's recommendations when hauling, unloading and stringing the pipe. Take precautions to prevent damage to the pipe and the geosynthetics.

B. The pipe shall be installed to the lines and grades shown on the Drawings.

C. The pipe, fittings, and accessories shall be inspected prior to installation for defects, buckles, cuts, gouges, or any other damage which in the opinion of the Engineer will affect the performance of the pipe and shall be removed from the site.

D. Any portion of the geosynthetics damaged during the installation of the pipe shall be removed and repaired in accordance with their respective specifications.

E. Carefully place pipe, fittings and accessories by means of derrick, ropes, belt slings, or other equipment authorized by the manufacturer.

3.03 PIPE CONNECTIONS

A. Join the polyethylene pipe by the method of thermal butt or side wall fusion, outlined in ASTM D2657. Perform fusion joining of pipe and fittings in accordance with the procedures established by the pipe manufacturer. Of particular importance is the use of proper interface pressures and heater plate temperatures.

B. Use fusion pressures, temperatures, and cycle times according to pipe manufacturer's recommendations. Use personnel adequately trained and qualified in the technique involved.

C. Do not perform pipe fusion in water or when conditions are unsuitable for the work. Secure open ends of pipe when work is not in progress, so that no water, earth, or other substance will enter the pipe or fittings. Plug, cap, or valve pipe ends left for future connections.

D. In order to allow the joining operation to continue in adverse weather conditions, a shelter may be required for the joining machine. Particular caution should be exercised to prevent water from entering the I.D. or O.D. of the pipe and from coming in contact with the heater plate.

E. Polyethylene Fusion Qualification: All pipe fusion should be performed by a supplier, or a factory supplied and/or certified fusion operator.

F. Provide instruction on polyethylene fusion machine operation for welding personnel and quality control personnel. Provide instruction on HDPE pipe installation and fitting fusion as applicable for the project. Only fully trained personnel will be allowed to perform the installation, supervision, or inspection of polyethylene-fusion joints. Prior to fusion welding, submit for review by the Engineer a listing of those authorized/instructed for polyethylene fusion. Make all onsite training sessions available to quality assurance personnel at no charge to the Engineer or City.

F. Training: Provide assistance from the manufacturer/supplier in instructing welding personnel in proper fusion procedures and techniques. Notifications will be required in writing, listing the names of those persons so certified.

3.05 PIPE BACKFILL:

A. The Contractor is responsible for all bedding and backfilling for HDPE pipe with rock specified in the Drawings.

B. Solid Pipe Sections: Solid pipe sections shall be backfilled with soil obtained on site. All rocks larger than 3 inches shall be removed from the backfill.

PART 4 – MEASURMENT AND PAYMENT

4.01 MEASUREMENT AND PAYMENT

A. General: Payment shall include all pipe, fittings, storage, shipping, labor, equipment, including fusion welders, superintendence, and incidentals to install the work complete in place.

B. Measurement for 10" HDPE Pipe shall be per linear-foot.

C. Payment for the HDPE pipe shall be included in the linear-foot price of "10" HDPE Pipe" as listed in the bid schedule.

END OF SECTION

SECTION 02750
HDPE GEOMEMBRANE (White)

PART 1 - GENERAL

1.01 WORK INCLUDED

A. General: The work described in this Section consists of providing all operations pertaining to the furnishing, installing, and testing of the high-density polyethylene (HDPE) geomembrane, in accordance with the Specifications and in conformity with the lines and grades shown on the Drawings, and as directed by these Specifications.

B. Work provided under this Section shall be included as work being performed by the "Geosynthetic Contractor," as referenced in other Sections.

1.02 RELATED SECTIONS

A. Section 02210 - Site Grading.

1.03 REFERENCES

A. ASTM D638 Test Method for Tensile Properties of Plastics.

B. ASTM D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics.

C. ASTM D746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.

D. ASTM D751 NSF Modified, Method of Testing Coated Fabrics.

E. ASTM D792 Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.

F. ASTM D882 Test Methods for Tensile Properties of Thin Plastic Sheeting.

G. ASTM D1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

H. ASTM D1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.

I. ASTM D1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

J. ASTM D1505 Test Method for Density of Plastics by the Density-Gradient

Technique.

K. ASTM D1593 Specification for Nonrigid Vinyl Chloride Plastic Sheeting.

L. ASTM D1603 Test Method for Carbon Black in Olefin Plastics.

M. ASTM D1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics.

N. ASTM D2103 Specification for Polyethylene Film and Sheeting.

O. ASTM D3015 Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.

P. ASTM D3083 Specification for Flexible Plastic Sheeting for Pond, Canal, and Reservoir Lining.

Q. ASTM D4437 Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

R. ASTM F88 Test Methods for Seal Strength of Flexible Barrier Materials.

S. The latest revision of Federal Test Method Standard 101 C, Puncture Resistance, is hereby made a part of these Specifications.

T. The latest revision of National Sanitation Foundation (NSF) Standard NSF 54, Flexible Membrane Liners, is hereby made a part of these Specifications.

U. The latest revision of Geosynthetic Research Institute (GRI) Standard Test Method GM-4, is hereby made a part of these Specifications.

1.04 MANUFACTURER QUALIFICATIONS

A. The manufacturer shall have at least 5 years continuous experience in the manufacturing of HDPE Geomembranes totaling more than 5,000,000 square feet of manufactured HDPE geomembrane for no less than 10 completed facilities. At least 5 projects shall have involved 60-mil or thicker HDPE membrane. No later than 10 days after Notice to Proceed, submit manufacturer's statement that their experience meets this requirement.

1.05 CONTRACTOR QUALITY-ASSURANCE QUALIFICATIONS

A. Installation of the geomembrane shall be performed by a geomembrane-installation Contractor that has:

1. Previously installed a minimum of 5,000,000 square feet of the material (HDPE) within the past 5 years, in similar landfill installations.

2. Completed at least 10 facilities, at least 5 with 60-mil or thicker HDPE membrane.

B. Installation shall be performed under the continuous direction of a single field-installation supervisor who shall remain onsite and be in responsible charge throughout the HDPE-geomembrane installation, including subgrade acceptance, layout, seaming, patching, testing, repairs, and all other activities by the Contractor. The field-installation supervisor shall have installed and/or supervised the installation and seaming of a minimum of 2,000,000 square feet of the material (HDPE), including at least 500,000 square feet of 60-mil or thicker HDPE, within the past 3 years.

C. All seaming shall be performed under the direction of a master seamer (who may be the same person as the installation supervisor) who has seamed a minimum of 2,000,000 square feet of 60-mil HDPE or thicker, using the same seaming apparatus that is specified for this project. The supervisor and/or master seamer shall be present whenever seaming is performed.

D. All welding-machine operators shall have shown proven performance on previous geomembrane installations and shall have seamed a minimum of 500,000 square feet of HDPE in the last 3 years. All welding-machine operators shall perform a demonstration of their welding technique and a test of the welds which they have performed, prior to any welding on the project.

E. The installer shall, at their own expense, provide a technical representative of the geomembrane manufacturer at the job site to ensure compliance with the manufacturer's directions for handling and installing the geomembrane. The technical representative must be present when the geomembrane installation is started, and whenever geomembrane is installed, unless this requirement is waived by the Project Manager. The technical representative shall instruct and observe the work, report unsatisfactory conditions, and make recommendations for improvement in procedures to the Contractor.

F. The Owner will engage and pay for the services of: (1) a construction quality-assurance consultant to monitor the the liner installation, and (2) construction quality-assurance (CQA) laboratory to perform destructive tests on the liner sheet goods and seam samples, unless otherwise specified.

G. The Contractor shall provide and make available all testing equipment required by these Specifications.

H. Manufacturer/fabricator/installation qualifications: The following are prequalified. Substitutions will be considered provided they are "an equal."

1. GSE, Inc., 19103 Gundle Road, Houston, Texas 77073, (800) 435-2008.
2. Poly-Flex, Inc., 2000 W. Marshall Dr., Grand Prairie, TX 75051, 888-765-9359

3. Agru America, Inc. 500 Garrison Road, Georgetown, South Carolina, 29440 (800) 321-1379.

1.06 WARRANTY

A. The Contractor shall furnish to the Owner a warranty from the installer of the HDPE geomembrane which warrants their workmanship to be free of defects on a nonprorata basis for 3 years after the final acceptance of the work. This warranty shall include, but not be limited to, all field-welded seams, anchor trenches, attachments to appurtenances, and penetration seals. The installer shall provide all warranty work required by the Owner at the Contractor's sole expense.

B. The Contractor shall furnish the Owner a warranty from the HDPE-geomembrane manufacturer for the materials used. The material warranty shall be for defects or failures related to manufacture on a nonprorata basis for 3 years after the date of shipment.

C. Should a defect that is covered under warranty occur within the aforesaid periods, the Contractor shall bear all costs for repair and/or relocation and replacement of the HDPE geomembrane. The Contractor shall, in addition, bear all costs associated with the excavation, removal, relocation and replacement of any liner section, foundation material, and drainage material that is required in order to repair and/or replace the HDPE geomembrane. All materials removed to allow for repairs shall be reinstalled by the Contractor, at the Contractor's sole expense, in accordance with these Contract Documents.

1.07 SUBMITTALS

A. Submittals shall be made before commencing the work specified in this Section. Copies of the following information and material shall be provided as indicated. Submit four copies of each of the following to Project Manager; one copy each to be retained by Owner, Contractor, Project Manager, and Design Engineer.

B. Product data and factory test results:

1. Published product properties.
2. Specifications and seaming techniques for the proposed HDPE, including, but not limited to resin, roll information, and extrudate, as well as factory test results of materials, certified by the HDPE-geomembrane manufacturer, shall be submitted showing conformance with the requirements of these Specifications.
3. Manufacturer's certification stating that the material proposed is similar to and of the same formulation as that for which test results are submitted, and by which actual usage has been demonstrated to be satisfactory for the intended application.

C. Samples:

1. Geomembrane sheeting.

2. Seams: Width of 6 inches plus the seam width, and a length of 10 inches.

D. Quality assurance/quality control:

1. Copies of the manufacturer's recommendations for quality assurance/quality control addressing each item in the material Specification and address procedures for quality control.

E. Qualifications:

1. Submit list of equipment and personnel proposed for the project. Include equipment type and quantities. Include personnel experience on similar projects.
2. Submit resume and references of installation supervisor to be assigned to the project, including dates and duration of employment and pertinent experience information. Experience information shall include the number of square feet HDPE including the total square feet of material thicker than 60-mil.
3. Submit resume and references of master seamer if different than installation supervisor to be assigned to the project, including dates and duration of employment and pertinent experience information. Experience information shall include the number of square feet HDPE including the total square feet of material thicker than 60-mil.
4. Submit resumes and references of installation welders who will perform seaming operations, including dates and duration of employment and pertinent experience information. Experience information shall include the number of square feet HDPE including the total square feet of material thicker than 60-mil.

F. Delivery, storage and handling instructions: The manufacturer's recommendations for delivery, storage and handling shall be submitted to the Project Manager for review.

G. Delivery date: The Project Manager shall be notified of the scheduled delivery dates for the materials.

H. Installation drawings, procedures and schedules:

1. Geomembrane sheet layout plan with:
   (a) Proposed size, number, position, and sequence of placing sheets/rolls.
   (b) Wrinkle management plan.
   (c) The location of all field joints.
   (d) Direction of shop joints on each sheet.
   (e) Details and/or methods for anchoring the geomembrane at the edges of the geomembrane, making field seams, and making seals around pipes and structures penetrating the geomembrane.
2. Following review, these drawings will be used for installation of the geomembrane.

3. Procedures addressed by the Contractor shall include, but not be limited to material unloading, storage, installation, repair, and protection to be provided in the event of rain.

J. Field quality control documents: Submit daily quality-control documentation prepared during installation.

K. Post-installation requirements: Upon completion of the installation, the Contractor shall submit the following:

1. Certificate stating that the geomembrane has been installed in accordance with the Plans, Specifications, and the manufacturer's recommendations.
2. Manufacturer's and installer's warranties.
2. Record drawing information: Record drawings including, but not limited to, drawings showing the true panel dimensions, location and coordinates of all seams, panels with roll numbers, repairs, patches, destructive test locations, anchor trenches, pipe penetrations and other appurtenances, including measurements and dimensions, shall be prepared by the Contractor and submitted to the Project Manager following completion of the project.

1.08 PRE-APPROVED INSTALLERS

A. Pre-approved installers include:

1. D&E Construction, 14175, Avenue 344, Visalia, CA (559) 732-1601
2. The Barber Webb Company, Barber-Webb Company Inc., 3833 Medford, Los Angeles, CA, 323-264-4800.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Material shall be smooth/textured polyethylene geomembrane as shown on the drawings.

B. Resin
1. Resin shall be new, first quality, compounded and manufactured specifically for producing geomembrane.
2. Natural resin (without carbon black) shall meet the following requirements:

Table 1
Raw Material Properties

Property	Test Method	HDPE	LLDPE
Density (g/cm3)	ASTM D 1505	≥0.932	≥0.915
Melt Flow Index (g/10 min)	ASTM D 1238 (190/2.16)	≤1.0	≤1.0
OIT (minutes)	ASTM D 3895 (1 atm/200^{0}C)	≥100	≥100

C. Geomembrane Rolls

1. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
2. Geomembrane shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.
3. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width and MANUFACTURER.
4. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements listed in this section and be tested by an acceptable method of inspecting for pinholes. If pinholes are located, identified and indicated during manufacturing, these pinholes may be corrected during installation.

D. Smooth surfaced geomembrane shall meet the requirements shown in the following data sheets below:

1. Table 2 for white-surfaced HDPE
   a) The geomembrane shall be a white-surfaced, coextruded geomembrane.
   b) The white surface shall be installed upwards.
   c) The white surface shall be installed upwards.

F. Extrudate Rod or Bead

1. Extrudate material shall be made from same type resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Materials shall be free of contamination by moisture or foreign matter.

Table 2
White Smooth Geomembrane

Tested Property Value	Tes Method	Frequency	Minimmum Average				
			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, (minimum average) mil (mm) Lowest individual reading (-10%)	ASTM D 5199	every roll	30 (0.75) 27 (0.69)	40 (1.00) 36 (0.91)	60 (1.50) 54 (1.40)	80 (2.00) 72 (1.80)	100 (2.50) 90 (2.30)
Density, g/cm^3	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction) Strength at Break, lb/in-width (N/mm) Strength at Yield, lb/in-width (N/mm) Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbell, 2 ipm G.L. 2.0 in (51 mm) G.L. 1.3 in (33 mm)	20,000 lb	120 (21) 66 (11) 700 13	152 (26) 84 (14) 700 13	243 (42) 132 (23) 700 13	327 (57) 177 (30) 700 13	410 (71) 212 (37) 700 13
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (124)	42 (186)	58 (257)	73 (324)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	65 (289)	85 (378)	125 (556)	160 (711)	195 (867)
Carbon Black Content[(1)], % (Range)	ASTM D 1 603*/421 8	20,000 lb	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]
Notched Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lb	1000	1000	1000	1000	1000
Oxidative Induction Time, min	ASTM D 3895, 200° C; O_2, 1 atm	200,000 lb	>140	>140	>140	>140	>140

NOTES:

- [(1)]. These values apply to the black layer only.
- [(2)] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

Table 3
Factory Quality-Control Requirements

Property	Test Method	Test Frequency
Thickness (nominal)	ASTM D 5199	20 per roll
Thickness (minimum)	ASTM D 1593	20 per roll
Density	ASTM D 1505	1 per 50,000 ft^2 (1)
Carbon Black Content	ASTM D 1603	1 per 50,000 ft^2 (1)
Carbon Black Dispersion (min.)	ASTM D 5596	1 per 50,000 ft^2 (1)
Tensile Properties:	ASTM D 6693:	
Tensile Strength at Yield (min.)		1 per 50,000 ft^2 (1)
Tensile Strength at Break (min.)		1 per 50,000 ft^2 (1)
Elongation at Yield (min.)		1 per 50,000 ft^2 (1)
Elongation at break (min.)		1 per 50,000 ft^2 (1)
Tear Resistance (min.)	ASTM D 1004	1 per 50,000 ft^2 (1).
Environmental Stress Rack (min.)	ASTM D 1693	1 per 50,000 ft^2 (1)

(1) Or one per resin batch, whichever results in the greater number of tests.

PART 3 - EXECUTION

3.01 PANEL MARKING, PACKAGING, DELIVERY, STORAGE, AND HANDLING

A. General: The HDPE geomembrane shall be delivered, stored and handled in strict accordance with the manufacturer's recommendations.

B. Marking, packaging: Each roll of the geomembrane shall be given prominent, unique, indelible identifying markings indicating the sheet number and date of fabrication.

C. Delivery: Geomembrane shall be shipped in rolls. Folded HDPE geomembrane shall not be accepted. Any evidence of folding shall be cause for rejection of the material by the Project Manager.

D. Materials shall be delivered to the site only after the Project Manager reviews and takes no exception to the materials and manufacturer proposed by Contractor.

E. Separate damaged rolls from undamaged rolls, and store at locations designated by the Project Manager until proper disposition of material is determined by Project Manager. Project Manager will designate damaged rolls.

F. Storage: The geomembrane storage area at the construction site shall be prepared and reviewed for acceptability prior to the arrival of any material. The area shall be secured from the following:

1. Man or animal: The storage area shall not be near or adjacent to areas frequented by the general public, unless a security fence is provided.
2. Puncture, dirt, dust, grease or water: Store HDPE-geomembrane rolls to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions or other damage. Do not store where bonding may occur.
3. Extreme heat: The geomembrane shall be protected from extreme heat.
4. The geomembrane shall be stacked no more than 3 rolls high.

G. Handling: Use appropriate handling equipment recommended by the manufacturer to load, move, and deploy HDPE-geomembrane rolls. Appropriate handling equipment may include, but not be limited to, cloth chokers, spreader bar, and roll bars for deployment. Dragging panels on ground surface will not be permitted.

1. The HDPE-geomembrane material shall not be folded; folded material will be rejected.
2. Contractor is responsible for off-loading, storage, and transporting material from storage area to installation site.

3.02 MANUFACTURER'S SERVICES

A. The geomembrane installer's representative shall inspect the subsurface for acceptability and provide onsite technical supervision and assistance at all times during the installation of the geomembrane and placement of the overlying materials.

B. The installer's representative shall furnish the Project Manager with certification that the geomembrane was installed in accordance with manufacturer's recommendations.

3.03 PRECONSTRUCTION SHEET GOODS CONFORMANCE TESTING

A. Conformance testing – The Project Manager or the testing laboratory will obtain samples of the sheet goods from the factory as described below:

1. Obtain one sample per 100,000 square feet and per every resin lot of material supplied. Project Manager will obtain samples.
2. Forward samples to construction quality assurance laboratory.
3. Perform, as a minimum, the following tests for conformance with design Specifications and guaranteed properties.

(a) Density: ASTM D1505 or ASTM D792
(b) Sheet thickness: ASTM D1593
(c) Tensile properties: ASTM D882
(d) Tear resistance: ASTM D1004
(e) Carbon black content: ASTM D1603
(f) Carbon black dispersion: ASTM D5596

4. Sampling procedures:
   (a) Sample across the entire width of the roll excluding the first 3 feet.
   (b) Cut sample 3 feet by the width of the roll.
   (c) Mark machine direction of the roll on the sample.

B. The Project Manager will review the laboratory reports and evaluate whether the materials meet the specifications. If not, the materials will be rejected and resampled at the Contractor's Expense.

C. The sheet goods delivered to the site shall have the same lot/and.or roll numbers as those sampled at the factory.

3.04 SUBGRADE INSPECTION

A. Immediately prior to placement of each panel, the area to be covered shall be walked by the Project Manager and the installer's technical representative to determine the acceptability of the subsurface. No debris, rocks, survey stakes, or any other objects that protrude will be allowed.

B. The manufacturer's technical representative and installer shall verify daily in writing to the Project Manager that the subgrade on which the HDPE geomembrane will be installed is acceptable. HDPE Installed without written subgrade acceptance from installer/manufacturer will be subject to replacement at the sole expense of the manufacturer and Contractor.

3.05 PREPARATION

A. Repair damage caused to subgrade during deployment.

B. Excavate anchor trenches prior to deployment.

C. Round edges of anchor trenches or cushion with geotextiles.

3.06 INSTALLATION OF HDPE GEOMEMBRANE

A. The geomembrane shall be placed over the prepared surfaces to be covered in such a manner as to ensure minimum handling necessary. The geomembrane shall be installed as shown on the drawings and in accordance with reviewed panel-layout drawings. The

Contractor shall make necessary field measurements prior to start of fabrication to ensure proper fit of the geomembrane.

B. Any portion of HDPE damaged during installation by any cause shall be removed and repaired by using an additional piece of HDPE, as specified hereinafter.

C. All field joints, joints to structures, and repairs to HDPE geomembrane shall be performed during dry-weather conditions with a minimum air temperature of 40°F and a maximum of 100°F without extra trial welds. For temperatures between 100 and 120 additional trial welds shall be performed to demonstrate conformance during the period of temperature over 100 degrees.

D. Assign each panel an identifying code number or letter consistent with the Contractor's submitted panel-layout drawing. The coding is subject to review by the Project Manager. All panels shall be marked at the toe, midpoint, and top of the slope with the panel-identification number.

E. Deploy no more panels in one shift than can be bonded and secured during that same day.

F. Do not damage the HDPE geomembrane by handling, traffic, leakage of hydrocarbons, or any other means. Do not smoke, wear damaging shoes or engage in activities that could damage the HDPE. Unroll the HDPE geomembrane panels using methods that will not damage, stretch or crimp the HDPE. Use deployment methods that will minimize panel wrinkles and differential wrinkles between adjacent panels.

G. Place ballast on HDPE that prevents uplift from wind, but will not damage the HDPE geomembrane. The use of tires for anchoring shall not be allowed.

H. Protect the HDPE in areas of heavy traffic by placing a protective cover which is compatible with and will not damage the HDPE. Do not allow vehicular traffic directly on the HDPE.

I. Visually inspect the HDPE geomembrane for imperfections and mark areas for repair.

J. Backfill all anchor trenches.

3.07 SEAM LAYOUT

A. Orient the seams parallel to a line of maximum slopes (*i.e.,* orient down, not across slope).

B. Maintain horizontal seams (seams running perpendicular) at least 5 feet away from toe or crest of slope.

C. Minimize the number of field seams in the corners, odd-shaped geometric locations and outside corners.

D. The seams shall be identified with a numbering/labeling system that is compatible with the panel-identification system.

3.08 FIELD SEAMING

A. Weather conditions: The required weather conditions for seaming are as follows:

1. Weld only when ambient temperature, measured 6 inches above the HDPE is between 40°F and 100°F, unless other limits are accepted, by the Project Engineer.
2. If the installer wishes to use methods which may allow seaming at ambient temperatures below 40°F or above 100°F, then the installer must demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures above 40°F and below 100°F, and that the overall quality of the HDPE is not adversely affected. In addition, a change order to the Contract between the Owner and the installer is required which specifically states that the seaming procedure does not cause any physical or chemical modification to the HDPE that will generate any short- or long-term damage to the HDPE. Then, the temperatures in the above quality-assurance procedure shall be modified accordingly.
3. Should the well being of the crew become uncertain at any temperature below 100°F, that temperature shall become the high-temperature limit for geomembrane seaming.
4. No field seaming shall be performed in the presence of rain, dust in the air, and/or excessive wind.

B. Seam welding personnel shall have experience as listed above.

C. Trial seams: Test welds shall be prepared and tested before seaming in order to gauge appropriate welding conditions (Example: welding machine temperatures set higher and/or welding rates slowed down).

1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions and equipment are adequate. Such trial seams shall be made at the beginning of each seaming period (start of day, midday, and anytime equipment is turned off and allowed to cool) for each seaming apparatus used. Trial seams shall be made under the same conditions as actual seams.
2. The trial-seam sample shall be approximately 3 feet long by 1 foot wide (after seaming) with the seam centered lengthwise. Seam overlap shall be nominally 4 inches and 3 inches minimum.
3. Two adjoining specimens each 1-inch wide, shall be cut from the trial-seam sample by the installer. The specimens shall be tested respectively, in shear and peel using a field tensiometer, and they should not fail in the seam. If the additional specimen fails, the entire operation shall be repeated. If the second set of specimens fail, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming

until the deficiencies are corrected and two consecutive successful full-trial welds are achieved.

D. Seaming equipment: The approved processes for field seaming are extrusion welding and fusion (hot-wedge) welding. Proposed alternate processes shall be documented and submitted to the Project Manager for his approval.
   1. The extrusion-welding apparatus shall be equipped with gauges giving the temperature of the apparatus at the nozzle and extruder barrel.
   2. The fusion-welding apparatus must be an automated vehicular-mounted device which produces a double seam within an enclosed air space.
   3. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures.
   4. The geomembrane installer shall provide an equipment list outlining quantity and types, as well as maintaining adequate quality of welding apparatus in order to avoid delaying the project.
   5. The geomembrane installer shall verify and ensure that:
      (a) equipment used for seaming is not likely to damage geomembrane;
      (b) the extrusion welder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;
      (c) the electric generator is placed on a smooth base such that no damage occurs to the geomembrane and that the power source is capable of providing constant voltage under combined line load;
      (d) buffing and grinding shall be completed no more than one (1) hour prior to extrusion welding (buffing is not necessary for hot-wedge welding);
      (e) a smooth insulating plate or fabric is placed beneath the hot-welding apparatus after usage; and
      (f) the geomembrane is protected from damage in heavily trafficked areas.

E. Seaming procedures: All major seams shall be performed using a double hot-wedge welder. Extrusion welding shall be used only on cap strips, butt seams, pipe penetrations and berm details.

   1. Seaming of the geomembrane shall be performed by a certified welder using the manufacturer's welding system, equipment, and techniques. All field seams will be performed on a firm foundation with a supporting smooth surface.
   2. The panels of geomembrane shall be overlapped by a minimum of 4 inches for hot-wedge welding and 3 inches for extrusion welding.
   3. Provide adequate material on weld to allow peel testing of both sides of double wedge weld. Inadequate overlaps which do not allow for peel testing shall be repaired by a cap strip.
   4. All cross seams are to be extrusion welded where they intersect. The top flap of geomembrane is removed in the area to be extrusion welded and the weld area is ground parallel to the seam prior to welding.
   5. If required, provide a firm substrate by using a flat board, a conveyor belt, or similar hard surface directly under the weld overlap to achieve firm support. For hot-wedge

welding, a movable protective layer of plastic may be required to be placed directly below the overlapped membranes being seamed. This is to prevent any moisture or dirt buildup between the sheets to be welded and/or to provide consistent rate of speed for the wedge-welding device.

6. The contact surfaces of the sheets shall be wiped clean to remove all dirt, dust, moisture, or other foreign materials prior to welding.
7. Cut fishmouths or wrinkles along the ridge of the wrinkle in order to achieve a flap overlap. Extrusion-weld the cut fishmouths or wrinkles where the overlap is more than 3 inches. When there is less than 3-inches overlap, patch with an oval or round patch extending a minimum of 8 inches beyond the cut in all directions.
8. Seaming shall extend up the panels to the outside edge and to the bottom of the anchor trench.
9. All bonded seams and joints, on completion of work, shall be sealed smooth, and provide a bonded seam with tensile and peel strength in accordance with these Specifications. Any geomembrane surface showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade shall be replaced, or covered and sealed with an additional layer of the geomembrane.
10. Polyethylene pipe sleeves and boots shall be used for pipe sleeves penetrating through the lined area. Pipe boots shall conform to the contract drawings and these Specifications. When the pipe composition is polyethylene, the sleeve shall be extrusion-welded directly to the pipe if space permits. Furthermore, the sleeve should be fastened by mechanical means and sealant applied between the pipe and sleeve.

3.09 ANCHOR TRENCH

A. The geomembrane-anchor trench shall be constructed around the perimeter of the reservoir. The geomembrane-anchor trench shall be left open until seaming in that particular area is completed. Expansion and contraction of the geomembrane shall be accounted for in the geomembrane placement. Lining compensators at the toe of the side slope will not be allowed. The anchor trench shall be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

3.10 FIELD QUALITY CONTROL

A. General: Manufacturer, fabricator, and installer shall participate in and conform with all terms and requirements of the Quality Assurance Plan. The Contractor shall be responsible for assuring this participation. Quality assurance requirements are specified in this Section.

C. Nondestructive field testing (performed by installer):

1. General: The installer shall nondestructively test all field seams over their full length using a vacuum-test unit, air pressure (for double-fusion seams only), or other methods. Perform testing within 24 hours of the time that each field seam was

completed. Complete all required repairs in accordance with this Specification. Testing shall be performed in the presence of the Project Manager.

2. Vacuum-testing equipment:
   (a) A vacuum-box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge.
   (b) A vacuum pump assembly equipped with a pressure control.
   (c) A rubber pressure/vacuum hose with fittings and connections.
   (d) A soapy solution and an applicator.
3. Vacuum-test procedures:
   (a) Project Manager shall be present during all vacuum testing of seams.
   (b) Place the box over the wetted seam area (soapy solution).
   (c) Ensure that a leak-tight seal is created.
   (d) Energize the vacuum pump and reduce the vacuum-box pressure to approximately 10 inches of mercury (i.e., 5 psi gauge).
   (e) Examine the HDPE through the viewing window for the presence of soap bubbles for a period of not less than ten (10) seconds.
   (f) Where soap bubbles appear, mark and repair in accordance with repair procedures described in this Specification.
4. Air-pressure-testing equipment:
   (a) An air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining a pressure over 70 psi and mounted on a cushion to protect the HDPE.
   (b) A rubber hose with fittings and connections.
   (c) A sharp hollow needle, or other pressure feed device.
   (d) A pressure gauge with an accuracy of 1 psi.
5. Air-pressure-test procedure:
   (a) Seal both ends of the welded seam to be tested.
   (b) Insert needle or other pressure-feed device into the channel created by the weld.
   (c) Energize the air pump to a minimum pressure of 25-30 psi. Allow a 2 minute relaxing period to equilibrate channel. Sustain pressure for at least an additional 5 minutes.
   (d) If loss of pressure exceeds 3 psi, or does not stabilize, locate faulty area and repair in accordance with repair procedures described in this Specification.
   (e) Puncture opposite end of seam to release air. If blockage is present, locate and test seam on both sides of blockage.
   (f) Remove needle or other pressure-feed device and seal the penetration holes.

D. Destructive-seam testing (performed independently by the Project Manager and the installer):

1. Location and frequency of testing:
   (a) Collect destructive test samples at a minimum frequency of one test location per 500 feet of seam length or one per seam, whichever results in the larger amount of samples.

(b) Determine test locations after seam bonding. Locations may be prompted by suspicion or excess crystallinity, contamination, offset welds, or suspected defect. The Project Manager will be responsible for choosing the locations. The Project Manager will not notify installer in advance of selecting locations where weld samples will be taken.
(c) The Project Manager may increase the test frequency at his/her discretion.

2. Sampling procedures:
   (a) Contractor shall cut samples at locations designated by the Project Manager as the welding progresses in order to obtain laboratory test results before the HDPE is covered by another material and within 24 hours of the request or seam welding.
   (b) The Project Manager will number each sample and mark sample number and location.
3. Immediately repair all holes in the HDPE resulting from destructive sampling. Repair in accordance with repair procedures described in these Specifications. Test the continuity of the repair in accordance with these Specifications.
4. Size of samples: Minimum 12-inches wide by 44-inches long with the seam centered lengthwise. Cut a 1-inch wide strip from each end of the sample and test for bonded-seam strength in the field. Cut the remaining sample into 3 parts for distribution as follows:
   (a) One portion for the installer: 12 inches by 12 inches.
   (b) One portion for testing by the laboratory: 12 inches by 18 inches.
   (c) One portion to the Owner for archive storage: 12 inches by 12 inches.
5. Field Testing:
   (a) Test the 2, 1-inch wide samples specified in Paragraph 4 above by tensiometer for bonded-seam strength and peel adhesion.
   (b) Test specimens must meet bonded-seam strength and peel-adhesion requirements for bonded seams specified in this Specification.
   (c) If any field test specimen fails, follow procedures outlined in this Specification.

E. Laboratory testing by laboratory and installer (installer testing performed onsite):

1. Test bonded-seam strength (ASTM D6693).
2. Test peel adhesion (ASTM D413).
3. Test at least 5 specimens for each test method. Select specimens alternately by test from the samples (i.e., peel, shear, peel, shear...). For double-wedge-welded samples, test both sides in peel.
4. A sample passes if 4 of the 5 specimens for each test method meet the following requirements:
   (a) The break is a film tearing bond.
   (b) The break is ductile.
   (c) The peel strength is 70% minimum of the specified sheet strength at yield for wedge-welded or flat welded seams and 60% minimum of the specified sheet strength at yield for extrusion-welded seams.
   (d) The shear strength is 90% minimum of the specified strength at yield for all welded seams.

(e) No more than 25% partial peel per GM-17.

5. Provide test results no more than forty-eight hours after receiving samples.
6. The laboratory shall forward a 12-inch x 12-inch sample to the geosynthetic laboratory for confirmation testing (in accordance with this Specification). Sample frequency shall be 1 for every 20 destructive samples taken.

F. Failed-seam procedures:

1. Follow these procedures when there is a destructive test failure. Procedures apply when test failure is conducted by the construction quality assurance laboratory, the fabricators laboratory, or by field tensiometer. Follow 1 of the following 2 options:
   (a) First option: Recap the seam between any 2 passed-test locations.
   (b) Second option:
      (1) Trace the seam to a location at least 10 feet in both directions from the failed test location, or to where the welded seam ends.
      (2) Obtain a small sample at both locations for an additional field test.
      (3) If these additional test samples pass field tests, then take laboratory samples.
      (4) If the laboratory samples pass, then recap the seam between the test sample locations.
      (5) If any sample fails, then repeat the process to establish the zone in which the seam must be recapped.

G. Acceptable bonded seams:

1. Bounded by 2 locations from which samples have passed destructive tests and seam has been repaired as required by this Specification.
2. For recapped seams exceeding 50 feet, a sample taken from within the recapped seam passes destructive testing.
3. Whenever a sample fails, provide additional testing for seams that were welded by the same welder, welding apparatus or welded during the same time shift.
4. No seam can be recapped more than 2 times. The HDPE sheet will then be considered damaged and shall be replaced with acceptable HDPE material.

3.11 REPAIR PROCEDURES

A. Remove damaged HDPE and replace with acceptable HDPE materials if damage cannot be satisfactorily repaired.

B. Repair, removal, and replacement shall be at Contractor's expense if the damage results from the Contractor's, installer's, or the Contractor's subcontractor activities.

C. Repair any portion of the HDPE geomembrane that has had a sample removed, exhibited a flaw, failed a destructive test, or failed a nondestructive test. Installer shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate

repair method shall be decided between the Project Manager and the installer. Do not commence welding on geomembrane until trial weld-test sample, made by that equipment and operator, passes the trial test. Repair procedures available include:

1. Patching: Used to repair all holes, tears, undispersed raw materials, and contamination by foreign matter.
2. Abrading and rewelding: Used to repair small sections of seams.
3. Spot welding or seaming: Used to repair pin holes or other minor, localized flaws such as where HDPE thickness has been reduced by more than 4 mils by over abrading, etc.
4. Capping: Used to repair large lengths of failed seams.
5. Removing the seam and replacing with a strip of new material.

D. Repair procedures:

1. Abrade HDPE surfaces to be repaired (extrusion welds only) no more than 1 hour prior to the repair.
2. Clean and dry all surfaces at the time of repair.
3. The repair procedures, materials, and techniques shall be accepted in advance of the specific repair by the Project Manager.
4. Extend patches or caps at least 8 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel top edges of patches before extrusion welding.
5. Unless otherwise instructed by the Project Manager, cut HDPE below large caps to avoid water collection between the sheets.

E. Verification of repair:

1. Number and log each repair.
2. Nondestructively test each repair using methods specified in this Specification.
3. Destructive tests may be required at the discretion of the Project Manager and will be at the Contractor's expense.
4. Reconstruct repairs until tests indicate passing results.
5. Technician making repairs shall initial each repair.
6. The Project Manager shall initial each repair upon acceptance.

3.12 POST-INSTALLATION INSPECTION

A. Inspection: Upon completion of the installation of the geomembrane, representatives of the manufacturer, Contractor, and Project Manager jointly shall inspect the geomembrane to satisfy themselves that material, factory seams, field seams, repairs, fitments, and anchors are in accordance with these Specifications.

B. Certification: Following inspection, the geomembrane manufacturer's authorized representative shall furnish the Project Manager with certification that the geomembrane was installed in accordance with the manufacturer's recommendations.

3.13 HDPE GEOMEMBRANE ACCEPTANCE

A. Contractor retains all ownership and responsibility for the HDPE geomembrane until acceptance by the Owner. Owner will provide written noification of acceptance.

B. The HDPE geomembrane installation shall be accepted by the Owner after:

1. Conformance-test results meet project Specifications.
2. All required documentation from the manufacturer, fabricator, and installer has been received and accepted including the final report of the Owner's testing lab.
3. The installation is finished.
4. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.
5. Written certification documents, including record drawings, have been received by the Owner.

C. Wrinkles and folds: Wrinkles over 2-inches high shall be cut out and repaired in accordance with this Section prior to cover placement. Under no circumstances will cover material be allowed to be placed over folded geomembrane. Areas of folded material shall be cut out and repaired in accordance with this section prior to cover placement.

D. Installation conditions: Placement of cover material shall only be performed when geomembrane surface temperature is lower than the geomembrane surface temperature were when the geomembrane was welded. The geomembrane is extremely sensitive to changes in temperature. Increases in temperature will cause the length and width of each individual sheet to expand significantly, and will cause a wave to be formed in the geomembrane during placement of the cover material. Geomembrane surface temperatures shall be recorded on both the geomembrane sheet and in the field records by the Contractor at the start and finish of each weld.

3.15 SANDBAG PLACEMENT OVER LINER

A. Extend the liner one panel width past the edge of the bottom liner at the termination on the side slope. Secure the edge on the liner using UV Resistant sand bags supported by a 3/16" stainless steel chain suspended from post at the top of the slope. Space bags every 50 feet in width and every 10 feet down the slope.

PART 4 – MEASUREMENT & PAYMENT

4.01 MEASUREMENT & PAYMENT

A. Field Liner: Payment for HDPE geomembrane liner shall be as listed in the Bid Schedule under "60-mil HDPE Liner". Payment shall include all materials, equipment, labor, superintendance, Contractor-supplied testing, and incidentals to perform the work, complete in-place. Measurement of the square-yard area will be on a surface area basis measured from the as-built plans and corrected for side slope. An additional 10 feet width multiplied by the length of the anchor trench will be added for material past the edge of the trench.

B. Anchor Trench: Payment for the excavation and backfilling if the anchor trench will be based on a linear-foot price per as described in the Bid Schedule under "Liner Anchor Trench".

END OF SECTION

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SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION:

A. Section Includes:

1. Concrete formwork.
2. Concrete reinforcement.
3. Concrete placing, curing, finishing.

B. The work of this section consists of furnishing and placing cast-in-place concrete for:

1. Pond outlet structure.
2. Liner boots.
3. Outlet valve structure.

1.2 SUBMITTALS: As specified in Section 01300.

A. In compliance with Paragraph 5.3.2 of ASTM C94-90, furnish statement of composition of concrete mix for each strength and type of concrete and evidence that mix meets specified quality. Submit mix design at least 7 days prior to placement of concrete.
   1. Submit separate mix design for:
      a. Each concrete strength.
      b. Each specified or range of air content.
      c. Concrete with identifiable admixtures.
   2. Include the following information with each design:
      a. Quantity of water.
      b. Type, brand, certification, and quantity of cement.
      c. Type, brand, sources, certification and quantity of admixture, if used.
      d. Source, certification, and quantity of each nominal maximum size of aggregate.
      e. Water/cement ratio.
      f. Air-content.

B. Description of machines proposed for concrete extruding or slip-forming.

1.3 QUALITY ASSURANCE:

A. All concrete for the project shall be controlled concrete of specified strengths, of uniform color, and free from defects liable to adversely affect strength, durability or appearance of the structure or its components.

B. Requirements of Regulatory Agencies: The quality and design of structural concrete shall comply with the requirements of the California Building Code.

C. Workmanship: Materials and methods used for the production and placement of concrete shall be such as to assure the specified quality and shall conform to applicable requirements of the Building Code for Reinforced Concrete (ACI 301, 318, and 347) of the American Concrete Institute, except as otherwise specified in this Section.

D. Repair of Defective Concrete Surfaces shall be done in the following manner when, in the opinion of the Engineer, such defects may be repaired and at no additional cost to the Owner.

1. Rock pockets, voids, spalls, cracks and exposed reinforcing shall be repaired with 1:2 cement mortar of cut out and patched. Prepare surfaces and bond cement mortar with concrete adhesive as hereinafter specified.

2. Surfaces which are not plumb and square or which do not conform to the lines and levels indicated shall be chipped, ground, filled or trued as required to obtain the desired results.

E. Uniformity of Concrete: All aggregates shall be measured by weight and the proportion of water to cement shall be accurately controlled by either automatic measuring devices or calibrated containers. All concrete placed shall be uniform in strength and color appearance as well as surface texture.

F. Screeds shall be provided at all construction joints as required to ensure installation of concrete to lines and elevations noted.

G. Ready-Mixed Concrete: ASTM C94 except as otherwise specified herein.

1.6 PROJECT CONDITIONS: Place concrete only when nighttime temperatures are above 35 degrees F., unless it is protected from freezing.

PART 2 - PRODUCTS

2.1 FORMS AND MATERIAL:

A. Softwood plywood: PS 1, Grade B-B, Class 1 plyform, mill-oiled and sanded on both sides. Plywood shall be of adequate thickness to support imposed loads, but in no case be less than 5/8" thick.

B. Lumber: Douglas Fir-Larch, No. 2 grade, S4S, or Southern Yellow Pine, No. 2, S4S. Boards shall be 6 inches or more in width. Grade stamp shall be clearly visible. Dimension lumber forms may be used only in unexposed areas.

C. Form Coating: Form shall be coated with nongrain-raising and nonstaining types of form coating that will not leave a residual matter on the face of the concrete or adversely affect proper bonding of any subsequent paint or other surface applications.

1. Form coating containing mineral oils or other nondrying materials will not be permitted for any concrete work.

D. Round Column Forms: Sonotube; Burke tube or equivalent product of other manufacturer's.

2.2 CONCRETE REINFORCEMENT:

A. Reinforcing steel: ASTM A615; reinforcing bars of size No. 3 may be 40 grade or 60 grade, while bars size No. 4 or larger shall be 60 grade. All rebar to be deformed billet steel bars, unfinished. All splices shall not be less than 30 bar diameters or the larger bar. Horizontal laps in adjacent bars shall be staggered 5 foot, 0 inch minimum.

B. Wire ties for tying reinforcing steel shall be minimum 16 gage annealed wire.

C. Spacers and Chairs: As manufactured by Kalman Steel Company, Concrete Engineering Company, or equal.

2.3 CEMENT: ASTM C150, Type II or IIA, low alkali Portland Cement, free from lumps and other defects. All cement shall be from one manufacturer.

2.4 AGGREGATE: Free from oil, alkali, organic matter, or other deleterious substances. Aggregate may consist of sand and gravel separately batched at construction site, central batching plant combined sand and gravel, or pit-run gravel, as approved. Well graded in accordance with the following table:

Percentage by Weight Passing Laboratory Sieves Having Square Openings with Dimensions in Inches as Shown

Screen Size	No. 4 to 1-1/2 Inch	No. 4 to 1 Inch	Sand	Combined (or Pit Run)
1-1/2 inch	95-100			95-100
1 inch		90-100		90-100
3/4-inch	35-70			60-80
1/2-inch		25-60		55-75
3/8-inch	10-30			45-60
No. 4	0-5	0-10	95-100	40-50
No. 16			45-80	15-30
No. 30			25-55	10-20
No. 50			5-30	2-10
No. 100			0-10	0-4
No. 200			0-5	0-2
	For Use In: Sections greater than 6 inches or flat slabs	For Use In: Sections 6 inches or under or flat slabs		For Use In: Any sections or flat slabs

2.5 WATER: Potable.

2.6 AIR ENTRAINMENT:

A. Air entraining agents shall be used in all exposed concrete and pumped concrete. Approved agents are Sika AET, Master Builders MBAE-10, Darex AERA and Protex AEA. Entrained air content shall be 6 percent (± 1 percent) by volume except for floor slabs where it shall not exceed 3 percent by volume.

2.7 FLY ASH: Conform to ASTM C618, type F.

2.8 ADMIXTURES:

A. Except for air entraining agents and water-reducing admixtures, no other admixtures shall be used without written approval from the Engineer. Where such agents are permitted, they shall be a type approved and used only as directed by the Engineer and at no increase in cost to the Owner. Where water reducing admixtures are specified, they shall be Master Builders Pozzolith 322-N, used at the rate of 5 + 2 fluid ounces per 100 pounds of cement, or Konset I-R as manufactured by Conrad Sovig Company, San Francisco, California, and used at the rate of 2 ounces per sack of cement.

1. Calcium chloride will not be permitted for use in concrete under any circumstances.

2.9 RELATED MATERIALS:

A. Concrete Adhesive and Bonding Agent: "Concresive #1001-LPL" (1-1/2 hour maximum pot life), an epoxy polysulfide type concrete adhesive as manufactured by Adhesive Engineering, San Carlos, California, or an approved equal.

B. Liquid Curing Compound: Burke "Res-X", as manufactured by the Burke Company, or equivalent product.

C. Capillary Break: Gravel or crushed rock of 1" maximum size, with no material passing a No. 4 sieve.

D. Sand Cushion: per CBC, ASTM C33, or Local building code.

E. Chemical Floor Hardener: "Burk-O-Lith", as manufactured by the Burke Company or "Lapidolith", as manufactured by Sonneborn Corporation.

F. Curing and Concrete Protective Cover: Orange Label Sisalkraft as manufactured by Fortifiber-Sisalkraft Corporation. Materials shall consist of two outer layers of high wet strength kraft paper treated to resist scuffing and shrinkage. Paper sheets shall be laminated together with a double coating of high melting point asphalt laminate having embedded, cross reinforcing fibers.

G. Metal Construction Joints: Burke "Keyed Kold Joint" tongue and groove joint key with "Keyed Kold Stakes", as manufactured by the Burke Company.

H. Corners: Chamfered, wood strip type; ¾ x ¾ in. size.

I. Form Release Agent: Colorless mineral oil which will not stain concrete, absorb moisture, or impair natural bonding or color characteristics of coating intended for use on concrete.

J. Waterstops: Polyvinyl chloride, minimum 1750 psi tensile strength with appropriate temperature range for Yreka, maximum possible lengths, ribbed profile, preformed corner sections.

2.10 CONCRETE DESIGN AND COMPRESSIVE STRENGTH:

A. For purposes of bidding, the concrete mixes shall be proportioned as follows:

Maximum		Minimum Sacks	Maximum Water-Cement	Minimum Ultimate
Concrete Type	Aggregate Size	Cement Per Yard of Concrete	Ratio in Gallons Per 94 lb. Sack Cement	28-Day Compressive Strength of Concrete
Class A	¾" & 1"	6.0	5.0	3,500 psi

B. Ready-Mixed Concrete: ASTM C94 except as otherwise specified herein.

1. Transit-mixed concrete shall be mixed for a period of not less than ten minutes at a peripheral drum speed of approximately 200 feet per minute, and mixing shall be continued until discharge is complete. At least 3 minutes of the mixing period shall be at the job. Transit mixers shall be equipped with water measuring devices consisting of either accurately calibrated water tanks or water meters.

2. Maximum transit time shall be 1-1/2 hours after introduction of cement to the aggregates. When concrete is 85 deg. or higher, maximum delivery time is 45 minutes.

PART 3 - EXECUTION

3.1 PREPARATION OF SUBGRADE: Excavate to required depth. Remove soft, yielding material and replace with select fill. Compact to a density of not less than 95 percent of the maximum density, as determined by ASTM 1557, Method C.

3.2 BASE COURSE: Place and compact base course to a density of not less than 95 percent of the maximum density, as determined by AASHTO T180, Method D.

3.3 FORMS:

A. Build and erect forms to conform to the required shapes, patterns, lines, grades and dimensions indicated. Forms shall be substantial and tight to prevent any leakage, of mortar, properly braced and tied together to maintain their position and shape. Forms shall not deflect under the dead load weight of the plastic concrete or construction loads. Joints in forming material shall be butted tightly and shall bear on solid construction. Provide tool edges where indicated.

B. Cast-in Items: Set in formwork all new sleeves, inserts, anchors, and similar items furnished and required under the work of other sections. Brace, anchor and support cast-in-items to prevent displacements and distortions.

3.4 REINFORCING STEEL: Clean, place and secure, using metal chairs, spacers, or other approved devices. Tie wire, 16-gauge minimum, black annealed wire. Bending, splicing and protection, ANSI/ACI 318-83. Provide dowels in foundations for all vertical bars. Place reinforcement as indicated and shown on the plans. Dowels shall not be driven through the vapor barrier (where used). An adequate number of concrete dobies shall be used to support reinforcement above the sand layer in slabs.

A. Maintain minimum concrete cover around reinforcing as follows:

Item	**Minimum cover, in.**
Formed Concrete Surfaces Exposed to Earth/Water Weather:	
No. 5 bars and smaller, W31 or D31 wire and smaller	1-½
No. 6 through No. 18 bars, W45 or D45 wire	2
Walls:	
Dry Conditions –	
No. 11 bars and smaller	¾
No. 14 and 18 bars	1-½
Exposed to earth, water, weather –	
All bars	2
Footings:	
At unformed surfaces and bottoms in contact with earth	3
Top of footings	2

3.5 PROPORTIONING AND CONTROL: Concrete, minimum of six 94-pound sacks of cement per cubic yard of concrete. Maximum allowable net water content, including water in aggregate, 5 gallons of water per sack of cement.

3.6 MIXING CONVEYING AND PLACING:

A. Ready-mixed concrete shall be mixed and delivered I accordance with ASTM C94. A delivery ticket shall be furnished for each load of ready-mix or transit-mix concrete. A copy of each delivery ticket shall be handed to the job superintendent at the time of delivery and unloading. A record copy of the delivery tickets shall be forwarded to the Engineer for his files.

B. Conveying equipment shall be of a sufficient capacity to ensure a practically continuous flow of concrete to the placing point without separation or loss of materials. Carts and buggies shall be equipped with pneumatic tires. Runway supports shall not bear on reinforcing or fresh concrete. All conveying equipment shall be thoroughly cleaned before beginning and at frequent intervals during the placing of the concrete.

1. Chutes, if employed, shall slope not less than 4" or more than 6" per foot of horizontal run.

3.7 PLACING:

A. Notify the Engineer 48 hours in advance of concrete placement.

B. With minimum handling, place concrete within 30 minutes after mixing. Do not drop freely more than 5 feet. Place concrete footings on surfaces free of mud, loose or unsound rock, or other detrimental substances. Thoroughly tamp or vibrate concrete in forms.

C. Reinforcing steel exposed to the sun shall be cooled by a water spray prior to the placing of concrete.

D. No adjustment of steel reinforcement will be permitted during the placement of concrete.

E. Concrete shall be scheduled so that the placing is a continuous operation for the completion of each section between predetermined construction joints. If a planned concreting operation cannot be carried on continuously, the concreting shall stop at temporary bulkheads. Locate where resulting construction joints shall be as shown on drawings or as approved by the Engineer. Prior to placing of concrete for any concrete slabs, the moisture content of the subgrade below the slabs shall be adjusted to at least optimum moisture.

F. Deposit the concrete in forms as nearly as practicable in its final position to avoid flowing and maintain until completion of the unit an approximate horizontal plastic surface. Thoroughly compact all concrete during placing operations, thoroughly around reinforcement, embedded fixtures or accessories, and into the corners of forms to eliminate air pockets and honeycombing. Compacting shall be done with mechanical vibrators. Vibrators shall not be used to cause concrete to flow horizontally. Thoroughly compact concrete to the forms to release the air and secure full contact of the concrete with the forms.

3.8 CONCRETE FINISHES:

A. All concrete work, except as otherwise specified, shall be of a quality that will present a finished appearance upon the stripping of the forms. Only a minimum of patching and finishing should be necessary as required to fill holes left by form ties and to remove any fins or minor irregularities left by the joints in the forms. Except as otherwise specified, all concrete surfaces shall be finished as follows:

1. Exterior slab and aprons – smooth steel trowel, with medium broom finish.

2. Walkways and ramps – smooth steel finish with medium broom finish. Groove where specified per Title 24.

3.9 FORMS REMOVAL: After concrete has set minimum of 12 hours, remove forms when and as directed.

3.10 CURING: Prevent rapid drying by covering exposed surfaces with craft paper, mats, earth, wet burlap or an approved membrane curing compound for at least 7 days. Protection and curing of concrete shall conform to provisions of ACI 301 Section 5.3.6.

A. ACI 305R shall be used when ambient daytime temperature at any time is 75 degrees F or more.

B. All applicable practices for production control and delivery including but not limited to temperature control, water content, slump, admixtures, and batching and mixing shall be employed. Protection shall be provided from the sun and wind and all practice from ACI 305R Chapter 4 shall be followed in placing and curing.

C. ACI 306R shall be used shall be used for cold weather applications. Comply with recommended concrete temperatures "as mixed" and "as placed and maintained" from Table 3.1 of ACI 306R. Comply with Table 7.6.1.1 of ACI 301 for temperatures of delivered concrete.

3.11 PROTECTION: After placement in forms, maintain concrete at a temperature of <u>no less than</u> 50 degrees F. for a period of 72 hours, and at a temperature above 32 degrees F. for an additional period of 3 days.

3.12 JOINTS: Construct joints true to line with faces perpendicular to surface.

A. Isolation joints: Separate walks and slabs from walls, stairways and other structures, using expansion joint fillers.

B. Contraction (control) joints: Space building slab joints where detailed on the construction documents. Space walk joints at intervals about equal to width of walk to a depth of one-fourth the slab thickness. Space curb and gutter joints not over 12 feet 6 inches on center, and align them with sidewalk joints. Contraction joints may be either sawn or tooled.

1. Sawn: Cut with a power saw fitted with an abrasive or diamond blade within 4 to 12 hours after walk has been placed and finished. Use sawn joints on exposed aggregate.

2. Tooled: Form plane of weakness by inserting and later removing a metal divider, finish with an edger or a groover, or by saw cutting a previously tooled joint.

PART 4 - MEASUREMENT AND PAYMENT

4.1 PAYMENT: Payment will be included in the bid schedule under the item where concrete was placed.

4.2 MEASUREMENT: Measurement shall be as follows:

A. Concrete for the outlet structure shall be on a Lump Sum basis for "Outlet Structure"

B. Concrete for the liner boots shall be included in the per Each item price for "Liner Boots".

C. All other concrete shall be incidental and included in the cost of other items.

END OF SECTION

SECTION 15100

VALVES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes general duty valves and meters common to piping systems and valves. This section includes the following special valves:

1. Miscellaneous valves for raw water supply line.
2. Flow meter.
3. Combination air valve.
4. Faircloth Skimmer.

1.02 SUBMITTALS

A. General: Follow the procedures specified in Division 1 and Section 15050 – Piping Systems.

B. For flow meter and combination air valve, submit product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

C. Submit valve information for valves over 4 inches for approval 4 weeks before use and at least 2 weeks prior to approval.

1.03 QUALITY ASSURANCE

A. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Preparation For Transport: Prepare valves for shipping as follows:

1. Ensure valves are dry and internally protected against rust and corrosion.
2. Protect valve ends against damage to threads, flange faces, and weld-end preps.
3. Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces;

set butterfly valves closed or slightly open; and block swing check valves in either closed or open position.

B. Storage: Use the following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.
2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

C. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products from one of the following:

1. Grinnell
2. Powell
3. Stockham
4. Nibco
5. Apollo

2.02 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems.

B. Pressure and Temperature Ratings: As scheduled and required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:

1. Handwheels, fastened to valve stem, for valves other than quarter turn.

2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves. Provide plug valves with square heads; provide one wrench for every 10 plug valves. Chain-wheel operators, for valves 2-1/2-inch and larger, installed 96 inches or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.

3. Gear drive operators, on quarter-turn valves 8-inch and larger.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.

1. Threads: Comply with ANSI B1.20.1.

2. Flanges: Comply with ANSI B16.1 for cast iron, ANSl B16.5 for steel, and ANSI B16.24 for bronze valves.

3. Solder-Joint: Comply with ANSI B16.18.

a) Caution: Where soldered end connections are used, use solder having a melting point below 840°F for gate, globe, and check valves; below 421°F for ball valves.

2.03 GATE VALVES

A. Gate Valves, 2-Inch and Smaller: MSS SP-80; Class 150, body and union bonnet of ASTM B62 cast bronze; with threaded ends or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Do not use solder end valves for hot water heating or steam piping applications.

B. Gate Valves, 2-Inch and Smaller (High Pressure Steam and Condensate Service): MSS SP-80; Class 300, body and union bonnet of ASTM B 61 cast bronze; with threaded ends, solid disc, copper-silicon alloy stem, brass packing gland, and malleable iron hand wheel.

C. Gate Valves, 2-1/2-Inch and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends, "Teflon" impregnated packing, and two-piece backing gland assembly.

D. Gate Valves, 2-1/2-Inch and Larger (High Pressure Steam and Condensate Service): MSS SP-70; Class 300 cast steel body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends.

2.04 BALL VALVES

A. Ball Valves, 1/2-Inch to 2-Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, full port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout

proof stem, and vinyl-covered steel handle. Provide solder ends for chilled water and domestic hot and cold water service; threaded ends for heating hot water.

2.05 GLOBE VALVES

A. Globe Valves, 2-Inch and Smaller: MSS SP-80; Class 125; body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron hand wheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Globe Valves, 2-Inch and Smaller (High Pressure Steam and Condensate Service): MSS SP-80; Class 300; body and screwed bonnet of ASTM B 61 cast bronze; with threaded ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, and malleable iron hand wheel.

C. Globe Valves, 2-1/2-Inch and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; with outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing, and two-piece backing gland assembly.

2.06 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated bubbletight at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPT sleeve, aluminum bronze disc, stainless steel stem, and EPT stem seals. Provide lever operators with position indicator and lock for sizes 2½ through 6 inches and gear operators with position indicator for sizes 8 through 24 inches. Provide lug type body. Drill and tap valves on dead-end service or requiring additional body strength.

2.07 CHECK VALVES

A. Swing Check Valves, 2-Inch and Smaller: MSS SP-80; Class 125, cast-bronze body and cap conforming to ASTM B 62; with horizontal swing, Y-pattern, and bronze disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.

B. Swing Check Valves, 2 Inch and Smaller (High Pressure Steam and Condensate Service): MSS SP-80; Class 300, cast-steel body and cap conforming to ASTM B 61; with horizontal swing, Y-pattern, and bronze disc; and having threaded ends.

C. Swing Check Valves, 2½ Inch and Larger: MSS SP-71; Class 125, cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line. Check valves shall be quiet closing.

D. The check valve for the main well shall be a Val-Matic "Surge Buster" 10" check valve available from Val-Matic Valve & Manufacturing Corp. 905 Riverside Dr. Elmhurst, IL 60126, Phone: (630) 941-7600, or approved equal.

E. The check valve from the back-up well shall be a 4" ASI 125 Wafer Style Silent Check valve available from Val-Matic as described above, or approve equal.

2.08 AIR/VACUUM RELEIF VALVES

A. Provide combination air valves designed to fulfill functions of air release (permit escape of air accumulated in the line at high point of elevation while line is under pressure) and vacuum relief.

B. Air and vacuum valve materials: body and cover, ASTM A 48, Class 35, cast iron; float, ASTM A 240 stainless steel; seat, Type 304, stainless steel; other valve internals, stainless steel or bronze.

2.09 Flow Meter

A. The flow meter shall be a 4" Water Specialties ML-04 Propeller Meter with Indicator Totalizer with a CN02-30 Register Extension. No exceptions will be made.

2.10 Faircloth Skimmer

A. Pond outlet shall be outfitted with an 8" Faircloth Skimmer. Contractor shall supply a 30' 6' diameter Sch 40 PVC barrel.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine valve interior through the end ports for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks used to prevent disc movement during shipping and handling.

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.

C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Replace defective valves with new valves.

3.02 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-Inch and Smaller: Solder ends.
2. Steel Pipe Sizes, 2-Inch and Smaller: threaded end.
3. Steel Pipe Sizes 2-1/2 Inch and Larger: flanged.

3.03 VALVE INSTALLATIONS

A. Locate valves for easy access and provide separate support where necessary.

B. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

C. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

D. Install valves in horizontal piping with stem at or above the center of the pipe.

E. Install valves in a position to allow full stem movement.

F. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.
2. Wafer Check Valves: Horizontal or vertical position, between flanges.

3.04 SOLDER CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to full open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

3.05 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.06 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.07 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.08 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

3.09 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

A. Valves, 2-inch and smaller service, gate, globe, ball, check

Chilled Water 125 125 150 125
Domestic Hot and Cold Water 125 125 150 125
Heating Hot Water 150 150 150 150
Low-Pressure Steam 50 150 150 150

High Pressure Steam 300 300 300 300

B. Valves 2-1/2-inch and larger service gate, globe, butterfly, check

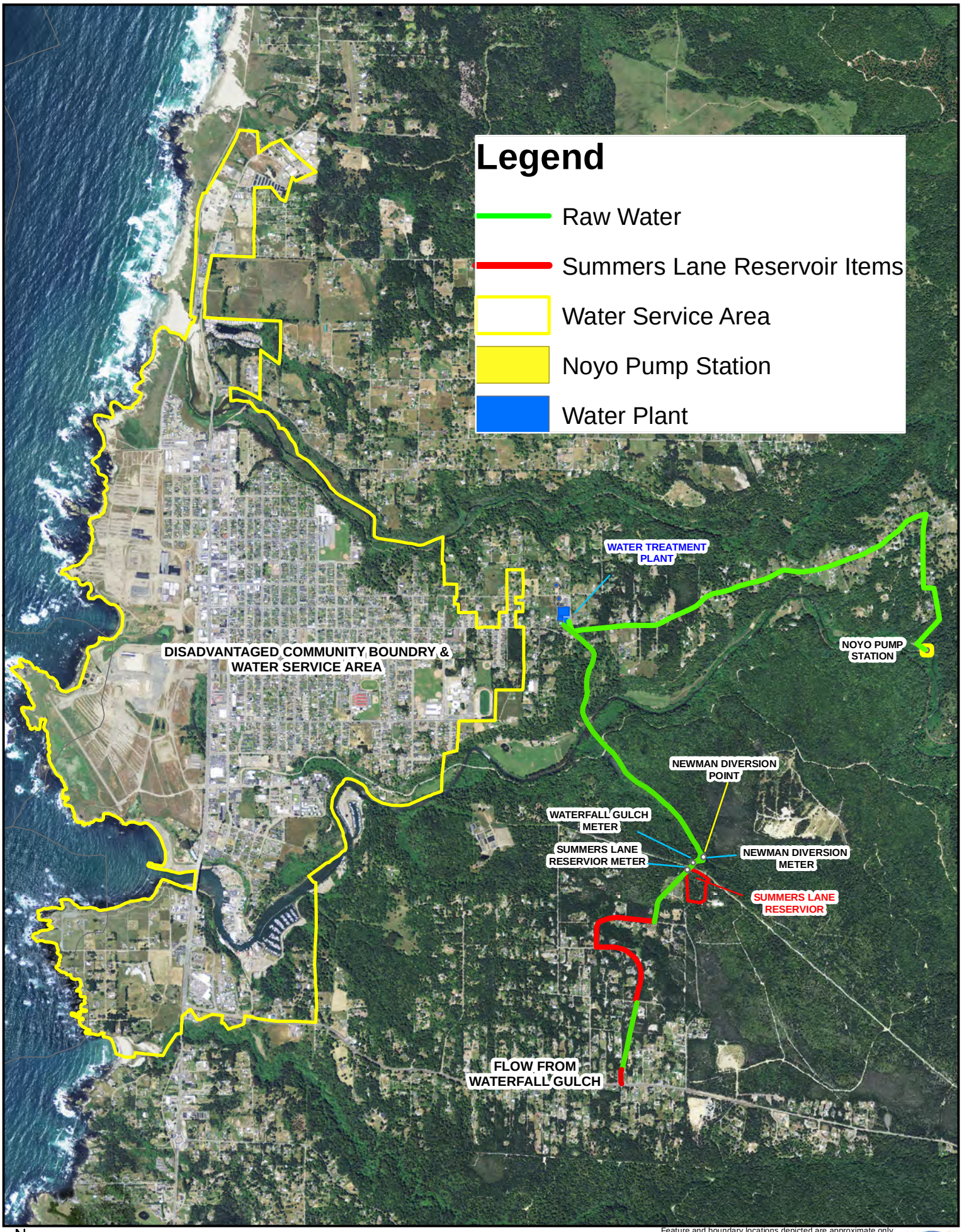
Chilled Water 125 125 200 125
Domestic Hot and Cold Water 125 125 200 125
Heating Hot Water 125 125 200 125
Low-Pressure Steam 125 125 N/A 125
High Pressure Steam 300 300 N/A 300

PART 3 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT: Measurement will be on a lump-sum basis.

4.2 PAYMENT: Payment shall be included in the lump sum cost for "Valves and Meters":

END OF SECTION



Feature and boundary locations depicted are approximate only.

N

0 1,800 3,600 Feet

City of Fort Bragg

NORTH COAST RESOURCE PARTNERSHIP

2014 IRWM Drought Project Grant Application

ATTACHMENT 3:

Project Justification Appendix

Integrated Regional Water Management Program
Applicant: Humboldt County

North Coast Resource Partnership 2014 IRWM Drought Project Grant

Attachment 3. Project Justification Appendix

Supporting Documentation

1. Gualala River Synthesis Report (2002)
2. Gualala River Estuary Study (2005)
3. Gualala River Watershed Council (GRWC) Strategic Plan (2010)
4. Final Recovery Plan for CCC Coho Salmon (2012)
5. GRWC QAPP
6. California Department of Fish and Wildlife News Release: Streamlined Domestic Water Tank Storage Permitting Process in Response to Drought
7. GRWC participant List
8. GRWC The Flow Bank Program Draft (2014)

North Coast Watershed Assessment Program

Gualala Watershed Synthesis Report

The mission of the North Coast Watershed Assessment Program is to conserve and improve California's north coast anadromous salmonid populations by conducting, in cooperation with public and private landowners, systematic multi-scale assessments of watershed conditions to determine factors affecting salmonid production and recommend measures for watershed improvements.

DRAFT

3rd Draft - Revised January 16, 2002

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Executive Summary of Findings and Conclusions

An Interdisciplinary and Interagency approach to Watershed Assessment on California's North Coast

Introduction

This report constitutes a first public review draft of the North Coast Watershed Assessment Program's (NCWAP) watershed assessment work on the Gualala River basin. The North Coast Watershed Assessment Program (NCWAP) was established in 2000 to provide a consistent scientific foundation for collaborative watershed restoration efforts and to better meet the State needs for protecting and restoring salmon. The program was developed as an interagency effort by the California Resources Agency and CalEPA, and includes the Departments of Fish and Game (DFG), Forestry and Fire Protection (CDF), Conservation's Division of Mines and Geology (DMG), and Water Resources (DWR), and the State Water Resources Control Board's North Coast Region (NCRWQCB). The Institute for Fisheries Resources is a contractor to CDF assisting in the development of a computerized database adapted from the Klamath Resource Information System (KRIS). The process also involved scoping and interaction with the Gualala River Watershed Council (GRWC), Gualala Redwoods, Inc. (GRI), and landowners in the watershed. This report is designed to begin to assess watershed conditions as they relate to a set of critical questions about suitability for salmon habitat, tailoring the assessment process to those that are most relevant to each watershed. Its contents should be considered preliminary and subject to review and revision. A final watershed assessment report is to be completed in May 2002.

Profile of the Gualala River Watershed Basin

The Gualala River flows through its 298 square mile watershed along the coast of southern Mendocino and northern Sonoma Counties, entering the Pacific Ocean near the town of Gualala. The Gualala River watershed is elongated, running over 32 miles long north to south . Elevations vary from sea level to 2,602 feet at Gube Mountain and terrain is most mountainous in the northern and eastern parts of the basin. The five principal subbasins of the Gualala are the Wheatfield Fork, South Fork and Gualala Mainstem, North Fork, Buckeye Creek, and Rockpile Creek.

Coastal conifer forests of redwood and Douglas fir occupy the northwestern, southwestern and central portions of the watershed while oak-woodland and grassland cover many slopes in the interior basin. Coho naturally inhabited the streams flowing from coniferous forest but were likely sub-dominant to steelhead in interior basin areas
A long history of movement along the San Andreas Fault and the Tombs Creek Fault has been a dominant force in the shaping of the basin. The climate is influenced by fog near the coast with seasonal temperatures ranging between 40 to 60 degrees F, but the interior basin can range from below freezing to over 90 degrees F seasonally. Rainfall also varies by location within the basin with 31 inches falling on average near the town of Gualala and totals reaching over 65 inches in some areas.

Ninety-five percent of the Gualala watershed is privately owned. The watershed has supplied timber since before 1900, the first wave of harvests occurring around the turn of the century. The next most significant wave occurred in the 1950s and 1960s with the advent of tractor yarders. Harvest operations concentrated in riparian areas. Logging roads often followed streams. Tractors pushed logs and dirt into streams to make road crossings and landings. Accelerated erosion from those logged areas was especially pronounced during the 1964 storm. Natural clearings as well as human-cleared areas on the eastern side of the watershed are used for grazing, though to a lesser extent since the 1980s. Residential development near the coast and vineyard development inland have become dominant land use activities since the late 1990s.

Salmon , Stream, Watersheds, and Land Use

Anadromous Pacific salmonids spend over half their life history in the marine environment, which is generally beyond man's control other than to regulate harvest. However, they are also dependent upon a high quality freshwater environment at the beginning and end of their life cycles. As such, they thrive or perish depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

The anadromous salmonid fisheries historically included coho (*Oncorhynchus kisutch*), possibly Chinook salmon (*Oncorhynchus tshawytscha*), and steelhead trout (*Oncorhynchus mykiss*). Surveys in 1970 found significantly higher numbers of salmonids in the streams surveyed as compared to current conditions. Electrofishing was used to sample presence and absence of salmonids in all the basins except Rockpile during September, 2001. Coho were not observed in the watershed in 2001 and were last observed in the Northfork subbasin in 1998.

Assessment and Analysis

The assessment process included defining the factors and corresponding ranges which could limit salmonid populations in the watershed, such as water temperature, spawning gravel composition, etc. Those ranges came from the literature, DFG's California Salmon Stream Habitat Restoration Manual, and the NCRWCB's *Water Quality Control Plan for the North Coast Basin* (1996) (Basin Plan). Instream data were compared to those ranges, and a decision support model was run with the data using those ranges to provide a perspective on overall stream reach and watershed conditions.

The California Department of Fish & Game inventoried over 100 miles of stream for salmonid habitat throughout the watershed from June-November, 2001. Streambed substrate and embeddedness varied by subbasin and was dominated by gravel. The earliest stream surveys recorded higher pool frequency and depth, and longer reaches of suitable spawning gravels. Post 1950's and 1960's era logging surveys documented a shallow pool structure, reduced pool frequency and water quality problems related to logging debris deposited into streams. Habitat inventories showed low pool frequency and shallow pool depth in most tributaries throughout all subasins where surveyed. Low stream pool frequency and shallow pool depth coincide with contemporary fisheries studies showing predominantly young of the year steelhead populations and absence of coho. This contrasts with the earliest fisheries studies showing deeper and more frequent pool structure with consistent coho observations and older steelhead found in many of these same areas.

Sediment conditions in the stream channels along with the declining anadromous salmonid fishery prompted a USEPA listing as impaired by sediment on the Clean Water Act Section 303(d) list in 1992, with the North Coast Regional Water Quality Control Board following suit during a subsequent listing. Sediment conditions in the Gualala River watershed appear to have recovered significantly from the 1964 flood event, however data from 1992-2001 show improvement in only a few of the areas sampled. Though data were limited in geographic area, and often insufficient to show temporal or spatial trends, streambed particle sizes are relatively small in the areas sampled. The data were not analyzed spatially to provide a broader perspective of the watershed, a limitation of the assessment due to staffing resources and timelines

Water temperature data provided by Gualala River Watershed Council and Gualala Redwoods Inc. from continuous recording devices were assessed from 1994-2001. Water temperatures expressed as the highest of the floating weekly average for the summer (MWAT) were within the proposed "fully suitable" range of 50-60 F (10 to 16 C) in many tributaries in the North Fork subbasin, and in some other small tributaries in other subbasins. Mainstem water temperatures for the larger streams (North Fork, Rockpile, Buckeye, Wheatfield Fork, and South Fork/Main Gualala) were above that range. In some areas, higher water temperatures were observed coming off the Franciscan Central Belt areas where open oak woodlands predominate, then cooling as the colder tributaries contributed their flow. The extent to which this is natural is unknown.

Canopy cover was complete in most tributaries as of 1942 indicating advanced regeneration from original old growth logging. Streams in the eastern portion of the Gualala basin have a naturally more open canopy even in 1942 photos. Aerial photos from 1961, 1963, 1965, and 1981 show canopy closure substantially reduced. In 2001, measurements taken during habitat inventory surveys showed greater and improved canopy closure. Aerial photos from 1999 and 2000 substantiate these findings. Most current riparian overstory conditions reflect shade canopy

in-growth of young conifer/ hardwood regeneration from riparian zones entirely cleared of all vegetation between 1952 and 1968.

The relative lack of large wood in the stream channels was noted, though landowners are adding wood under various local, state, and federal grant programs. Improved habitat complexity and sediment metering in the channels is expected to result from large-wood installation; thus enhancing the future suitability for salmonids.

EMDS: A Tool for Synthesis

The NCWAP team is using computer models called knowledge base or expert systems. The software allows scientists to combine data of different environmental factors, such as stream temperature and substrate composition, to produce a synthesis of watershed conditions for native salmonids. The data that is fed to the knowledge base network comes from GIS (Geographic Information Systems) layers developed for the program.

EMDS will rank the environmental factors by their influence on the overall habitat indicator values derived, and will show which factors, with more complete and comprehensive data, would improve the quality of the analysis in the most cost-effective manner. Maps depicting those factors that may be the largest impediments, as well as those areas where conditions are very good, can help guide protection and restoration strategies

The software assists open communication with the general public about how the scientists define suitable conditions for salmonids, and produces simple graphics and easily understood flow diagrams. Another feature of the system is that can be test the sensitivity to different assumptions about the environmental factors and how they interact.

Subbasin Issue Synthesis and Recommendations

Natural variation among subbasins is at least partially a product of natural and human disturbances. Other variables that can distinguish areas, or subbasins, in larger basins include differences in elevation, geology, soil types, aspect orientation, climate, vegetation, fauna, human population, land use and other social-economic considerations. The combined complexity of large basins makes it difficult to speak about them concerning watershed assessment and recommendation issues in other than very general terms. In order to be more specific and useful to planners, managers, and landowners, the Gualala River Basin has been subdivided into five parts: the estuary and four distinct subbasins.
Issues of the five subbasins are identified. Hypotheses regarding linkages of these various factors and processes along with supporting and contradictory findings are presented. Recommendations based on those hypotheses range from road abandonment /upgrades to expanding existing monitoring activities.

Gualala Estuary

Working Hypothesis: ***The present state of estuarine habitat is limiting the production of salmonids in Gualala River.***

Supporting Findings: In progress.

Contrary Findings: None noted.

Potential Recommendations:

- Encourage present estuary assessment program and provide technical assistance when necessary.
- Develop long term temperature monitoring program.
- Continue and/or expand monitoring anadromous salmonid population efforts.
- Work with responsible agencies, the Gualala River Watershed Council and landowners to improve physical structure and biologic function of the estuary.
- Continue efforts such as road improvements and decommissioning throughout the basin to reduce sediment delivery to Gualala River and its tributaries.
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Gualala River and its tributaries. Where current canopy is inadequate and site conditions are appropriate,

use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy.

North Fork Subbasin

Working Hypothesis: ***Water temperatures in the mainstem North Fork Subasin are not fully suitable for anadromous salmonids. Depleted overstory shade canopy cover along the North Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings**:**

- MWATs exceeded the fully suitable range of 50-60 F at all eight North Fork mainstem sites for the period of record (1994-1998, 2000-2001), ranging from 62-72 F.
- Seasonal maxima exceeded the 75 F lethal maximum 40% of the time during the same period of record, ranging from 66-80 F.
- The highest MWATs for the period of record presented on a LandSat vegetation layer (Figure xx) point out: Water temperatures are higher in the upstream areas draining the northeastern portion. Vegetation in the area upstream of those high temperatures (Franciscan melange) is open oak grasslands with poor canopy
- Two historical timber harvest eras eliminated riparian shade canopy throughout the lower and middle reaches of the North Fork: 1860 to 1900, and 1952 to 1968, elevating stream temperatures as measured today in the latter, and presumed in the former.
- There is partial riparian cover in the oak woodland melange in the upper basin reaches.

Contrary Findings**:** Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Limitations:

- Data from Gualala Redwoods Inc.'s eight mainstem sites in about the lower 9 miles were evaluated. The North Fork mainstem is about 10 miles long, with headwater tributaries extending about another 11 miles. Data represents about 50% of total blue line length.
- The extent of the thermal reaches for the sites is unknown.
- Three sites had only one year's data.
- Raw data were not evaluated for inconsistencies, thus assumptions were made that GRI and GRWC performed quality assurance and quality control.
- Individual canopy measurements for the entire watershed were not available, Landsat 1994 layers from the US Forest Service were used instead

Conclusions: The hypothesis is supported, given the limitations.

Recommendations:

- Investigate the availability and quality of other data for the northeastern area. Include and reevaluate the hypothesis.
- More temperature, monitoring and canopy ground-truthing on the northeastern area would assist in further describing the relationship.
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the North Fork and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.

Working Hypothesis: ***Stream reach conditions in the North Fork subbasin are limiting the suitability for sustaining healthy populations of native anadromous salmonids in specific areas.***

Supporting Findings:

The EMDS reach model results indicate the following:

- Pool Shelter Complexity is low in Doty Creek and the Little North Fork upstream of Log Cabin Creek; very low in the Dry Creek tributary and in the Little North Fork from (and including) Log Cabin Creek downstream to the confluence with the North Fork; extremely low in Dry Creek downstream of the three tributary

confluence and in the mainstem North Fork for the entire survey area from upstream of Dry Creek downstream to the confluence with the South Fork Gualala.

- Pool Quality rating is low in Robsinson Creek; very low in Dry Creek tributary, the little North Fork, Doty Creek; extremely low in Dry Creek below the three tributary confluence.
- Pool depth was rated extremely low in the Little North Fork watershed, Robinson Creek Dry Creek, and McGann Gulch.
- In-channel conditions were rated low in all watersheds within the subbasin, with the exception of the Mainstem North Fork.
- Embeddedness was high in the surveyed section of Robinson Creek, and very high in the surveyed section of Doty Creek.
    - Canopy Density is: Low in Dry Creek downstream of the three tributary confluence and in the surveyed section of Robinson Creek.Very low in the upper two-thirds of the surveyed section of the Dry Creek tributary.

Contrary Findings:
The EMDS reach model results indicate the following:

- Pool Shelter Complexity was rated barely suitable in the surveyed section of Robinson Creek.
- Pool Quality is somewhat suitable in the surveyed section of the mainsteam North Fork.
- Pool Depth is fully suitable in the surveyed section of the mainsteam North Fork.
- In-channel conditions are somewhat suitable in the surveyed section of the mainsteam North Fork.
- Embeddedness was low to very low in the subbasin, with the exception of Robinson Creek, Doty Creek, and McGann Gulch.
- Canopy Density is mostly suitable in the surveyed section of the mainsteam North Fork, and fully suitable in the Little North Fork subwatershed.

Limitations: Not all tributaries in the subbasin were surveyed.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

- Restoration activities should focus on areas needing improved pool quality, and on improving canopy density in Robinson and Dry Creeks.

***Working Hypothesis:* A lack of in-stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools)**

Supporting Findings:

- Heavy tractors which built roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed large woody debris in the basin.
- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, reducing the available recruitment supply of large woody debris.
- Although stream buffers are regenerating under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as large woody debris in channel formation processes have not yet been reestablished.
- Cleaning of streams to remove “fish barriers” made of large woody debris occurred throughout the subbasin.

Contrary Findings: None noted.

Limitations: None noted.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

- Gualala River Watershed Council and Gualala Redwoods Inc. are encouraged to do more large woody debris placement work throughout the N.F. basin. .
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Working Hypothesis: ***Due to the steep topography of the NF basin, many roads are located in erosion-prone areas, such as, adjacent to stream channels or across debris slide slopes.***

Supporting Findings:
- Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high.
- Road density and stream density in the upper NF basin is the highest in the Gualala watershed [EMDS results]. This combination results in a high number of stream crossings. The steep topography and high stream density result in intense, flashy runoff, and frequent debris flows that challenge poorly engineered stream crossings.
- Mapping and aerial photo analysis shows that legacy roads preferentially followed streams up the narrow valleys resulting in stream side canopy removal and in-stream and near-stream grading.
- The fast runoff of storm water produces high peak flows along major tributaries that challenge in-stream and near-stream road related structures.
- The 1981 photos show a high density of road and landing failures along streamside roads throughout the steep, deeply incised terrain in the Stewart Ck. Planning watershed.
- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records in Dry , Robinson, Stewart Creeks, and McCann Gulch. These sites are confirmed on ground by CDF and DMG field inspectors.

Contrary Findings: None noted.

Limitations: None noted.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:
- Evaluate the feasibility of abandoning streamside roads.
- Culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.
- Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Doty, Dry, Robinson, Stewart, and McCann Gulch.

Working Hypothesis: ***Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habitat.***

Supporting Findings:
- Comparison of historic stream survey and electrofishing show a decline in salmon populations.
- Comparison of historic stream surveys and current habitat inventory survey showed that pools of some tributaries have become shallower and some streambeds have become embedded with fine sediment over the last several decades. Both are limiting factors to salmonids.
- Both historic and modern aerial photos show that numerous debris flows and slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

Contrary Findings:
- Embeddeness is suitable on the Northfork, Little Northfork and Log Cabin creeks.
- Embeddeness may be suitable on additional tributaries which have not been surveyed.

Limitations: None noted.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravel. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Rockpile Creek Subbasin

Working Hypothesis: ***The Rockpile subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- Water temperatures in lower three miles of mainstem exceed suitable range for salmonids.

Contrary Findings:

- Improving canopy
- We have no temperature data for upstream nor for other tributaries.
- Water temperature at a tributary site was within suitable range.

Working Hypothesis: ***Many roads, in the lower Rockpile Creek basin, are located in erosion-prone areas; such as, adjacent to stream channels or across debris slide slopes. In the upper basin, active earthflow complexes are so abundant that they are unavoidably crossed by many roads.***

Supporting Findings:

- Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high.
- The large portions of the upper basin are underlain with the mélange of the Central Belt of the Franciscan Assemblage and vegetated with prairie and sparse oaks. Runoff from the prairie is rapid creating potentially high peak flows. Landsliding is especially abundant in the mélange. These high flows and landsliding challenge poorly engineered stream crossings.

Contrary Findings: None at this time.

Limitations: Field level analysis of sediment was limited.

Potential Recommendations:

- In the erosion-prone Rockpile Creek basin, careful road siting, design, and maintenance is necessary to avoid increased sedimentation of streams because poorly sited or engineered roads will likely produce sediment impacts to stream.
- Evaluate the feasibility of abandoning streamside roads.
- In steep terrain, culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.
- Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.

Working Hypothesis: ***Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.***

Supporting Findings:

- Comparison of modern and historic stream surveys show a decline in salmon populations.
- Comparison of modern and historic stream surveys show that some pools have become shallower and streambeds have become embedded with fine sediment over the last several decades. Both conditions are deleterious to salmon.

- Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

Contrary Findings: None at this time.

Limitations: Field level analysis of sediment delivery was limited.

Conclusions:

- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels.
- Careful engineering of new roads or repairs can reduce adverse sediment impacts

Potential Recommendations:

- Road managers should develop and adopt erosion control plans.
- Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

Working Hypotheses: Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting *in added degradation of salmon habit.*

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries.

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

- Most of the roads in the basin were built strictly to support logging operations.

- Most of the middle reaches of the Rockpile basin were clear-cut between 1952 and 1968 buillding roads in or along the major tributaries streams and mainstem Rockpile. Timber operations were particularly pronounced immediately prior to the 1964 flood. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground on steep slopes.

- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the Middle Rockpile Planning Watershed.

- Comparative 20 year stream channel width measurements between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.
- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.
- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings: None at this time.

Limitations: These conditions are well constrained within the scope of work performed thus far.

Conclusions:

- Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Red Rock Creek, Horsethief Canyon, and larger tributary watercourses in the middle reaches of the basin flanked by McGuire Ridge between Rockpile Peak and Robinson Ridge, downstream of Burnt Ridge Creek.

Working Hypothesis: ***Depleted overstory shade canopy cover along Rockpile Ck. and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Rockpile Creek and tributaries. There was near entire canopy elimination in the Middle Rockpile Planning Watershed, with operations especially pronounced during the late 1950s to 1964.

Contrary Findings:
- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Potential Recommendations:
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Rockpile Ck. and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.

Working Hypothesis: ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.
- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.
- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings: None noted.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Potential Recommendations:
- Artificial LWD installation projects vastly speed up in channel diversity development

- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Buckeye, Wheatfield and South Fork Subbasins

The following working hypotheses are still being explored for these subbasins. The NCWAP team will work with the public and stakeholders during the revision period to finalize analyses, draw conclusions about the level of support of findings, and develop appropriate recommendations.

Working Hypotheses: ***The subbasins provide unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Findings:

- EMDS results and temperature data still being analyzed.

Contrary Findings:

- Improving canopy for Buckeye subbasin.

Potential Recommendation:

- Survey ability was limited by landowner access. Agency Biologists and the Gualala River Watershed Council should consider training landowners to conduct habitat inventory and fisheries surveys.

Working Hypotheses: Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.
- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries.
- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.
- Most of the roads in the Buckeye basin were built strictly to support logging operations.
- Most of the middle reaches of the Buckeye basin and the lower and middle reaches of the Wheatfield were clear-cut between 1952 and 1968, building roads in or along the major tributaries streams and mainstem Buckeye. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground.
- Conifer block removal, followed by permanent conversion to pastureland, in mainstem subbasin was the dominant historical land use practice in the basin.. Prolonged cattle encroachment into streams prevented timely riparian canopy reestablishment, reducing vegetation barriers to erosion.
- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the middle reaches in the Buckeye basin and the lower reaches of the Wheatfield.
- Comparative 20 year stream channel width measurements in Buckeye and Wheatfield subbasins between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.
- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Contrary Findings:

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.
- Building fences along creeks, now highly encouraged by Resource Conservation Districts, is being implemented more widely on private ranches.

Limitations: Field work related to sediment delivery is limited.

Potential Recommendations

- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.
- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources:
    - Franchini, Grasshopper, and Osser Creeks in Buckeye
    - Lower reaches of House, Haupt and Tobacco Creeks, North Fork Wheatfield Fork Mckenzie Creek on South Fork main stem.

Working Hypothesis: ***Depleted overstory shade canopy cover along Buckeye Creek and Wheatfield Forks, and the higher reaches of Upper South Fork and Marshall Creek and their tributaries from legacy harvests continues to contribute to elevated water temperatures. In the mainstem these effects were followed by conversion to grazing.***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Buckeye Creek, Wheatfield Fork, Upper South Fork and Marshall Creek and tributaries.
- Vineyard development in recent times in the mainstem may have encroached into riparian zones.
- There was near entire canopy elimination in the middle Buckeye basin reaches with operations especially pronounced during the late 1950's to 1964, and in lower mainstem and main tributaries of Wheatfield, particularly in the 1950's.

Contrary Findings:

- Advanced conifer and hardwood regeneration since 1968 has reinstated canopy cover through out many of the highest tributary reaches.

Potential Recommendations:

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Buckeye Ck, Wheatfield Fork. and their tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.
- Exclude vineyard development from riparian areas on Mainstem.
- Encourage livestock exclusionary measures along streams in Mainstem.

Working Hypothesis**:** ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.

- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.
- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings: None noted at this time.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Potential Recommendations:

- Artificial LWD installation projects vastly speed up in-channel diversity development
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Program Introduction and Overview

North Coast Watershed Assessment Program (NCWAP)

Salmon / Stream / Watershed / Land Use Relationships

Anadromous Pacific salmonids are dependant upon a high quality freshwater environment at the beginning and end of their life cycles. As such, they thrive or perish depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirements must be provided by diverse and complex instream habitats as the fish move through their life cycles. If any of these elements are missing or in poor condition at the time a fish or stock requires it, their survival can be impacted. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

"In streams where fish live and reproduce, all the important factors are in a suitable (but usually not optimum) range throughout the life of the fish. The mix of environmental factors in any stream sets the carrying capacity of that stream for fish, and the capacity can be changed if one or more of the factors are altered. The importance of specific factors in setting carrying capacity may change with life stage of the fish and season of the year," (Bjorrn and Reiser, 1991).

Through the course of the years, natural climatic, watershed hydrologic responses, and erosion events interact to shape freshwater salmonid habitats. These include the kind and extent of the watershed's vegetative cover as well, and act to supply nutrients to the stream system. "In the absence of major disturbance, these processes produce small, but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions." (Swanston, 1991).

The results of a major disruption, which can be created over time by many smaller disruptions, can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, dependent relationships of salmon and steelhead with their natal streams during their freshwater life phases, and their streams' dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

"Protection and maintenance of high-quality fish habitats should be among the goals of all resource managers. Preservation of good existing habitats should have high priority, but many streams have been damaged and must be repaired. Catastrophic natural processes that occlude spawning gravels can reduce stream productivity or block access by fish (for example), but many stream problems, especially in western North America, have been caused by poor resource management practices of the past. Enough now is known about the habitat requirements of salmonids and about good management practices that further habitat degradation can be prevented, and habitat rehabilitation and enhancement programs can go forward successfully," (Meehan, 1991).

In general, natural disruption regimes do not impact larger watersheds, like the 300 square mile Mattole, in their entirety at any given time. Rather, they rotate episodically across the entire mosaic of their smaller subbasin, watershed, and sub-watershed components over long periods of time. This creates a shifting mosaic of habitat conditions over the larger watershed, (Reice, 1994).

Human disturbances, although individually small in comparison to natural events, are usually spatially distributed widely across basin level watersheds (Table 1), (Reeves, et al., 1995). That occurs because market driven land uses tend to function in temporal waves, like the California Gold Rush or the post-WWII logging boom in Northern California. The intense human land use of the last century, combined with the energy of two mid-century, record floods on the North Coast, created stream habitat impacts at the basin and regional scales. The result has overlain the natural disturbance regime and depressed stream habitat conditions across most of the North Coast region.

TABLE 1: WATERSHED DISTURBANCE REGIMES (REEVES, 2001)

	Natural Disturbance	**Anthropogenic Disturbance**
Magnitude	High	Low, Medium
Frequency	Low	High
Area Affected	Small to Intermediate	Large
Coupling of System	Maintains	Decouples
Legacy	Wood, Sediment	Sediment

No long term fish counts exist for the Gualala River. However, the information, although of differing quantity and quality reflects the absence of coho in all subbasins since 1998, with the rate of decline most evident in the late 60's and early 70's. Steelhead also appear to have decline, more in some subbasins than others.

ADD FIGURES OF HISTORIC CREEL CENSUS

ADD E-FISHING GRAPHIC

Factors Affecting Anadromous Salmonid Production

Coho salmon and steelhead trout all utilize headwater streams, larger rivers, estuaries and the ocean for parts of their life history cycles. There are several factors necessary for the successful completion of an anadromous salmonid life history.

A main component of the NCWAP is the analyses of these factors in order to identify whether any of them are at a level that limits production of anadromous salmonids in North Coast watersheds. This "limiting factors analysis" (LFA) provides a means to evaluate the status of a suite of key environmental factors that affect anadromous salmonid life history.[1] These analyses are based on comparing measures of habitat components such as water temperature and pool complexity to a range of reference conditions determined from empirical studies and/or peer reviewed literature. If the component's condition does not fit within the range of the reference values, it may be viewed as a limiting factor. This information will be useful to identify the underlying causes of stream habitat deficiencies and help reveal if there is a linkage to watershed processes and land use activities.

In the freshwater phase in salmonid life history, stream connectivity, stream condition, and riparian function are essential for survival. Stream connectivity describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity.

The concept that fish production is limited by a single factor or by interactions between discrete factors is fundamental to stream habitat management (Meehan 1991). A limiting factor can be anything that constrains, impedes, or limits the growth and survival of a population.

Stream condition includes several factors. They include adequate stream flow, suitable water quality, suitable steam temperature, and complex habitat. For successful salmonid production, stream flows should mimic the natural hydrologic regime of the watershed. A natural regime minimizes the frequency and magnitude of storm flows and promotes better flows during dry periods of the water year. Salmonids evolved with the natural hydrograph of coastal watersheds, and changes to the timing, magnitude, and duration of low flows and storm flows can disrupt the ability of fish to follow life history cues. Adequate instream flow during low flow periods is essential for good summer time stream connectivity, and is necessary to provide juvenile salmonids free forage range, cover from predation, and utilization of localized temperature refugia from seeps, springs, and cool tributaries.

Three important aspects of water quality for anadromous salmonids are water temperature, turbidity, and sediment load. In general, suitable water temperatures for salmonids are between 48° and 56° F for successful spawning and incubation, and between 50-52° and 60-64° F, depending on species, for growth and rearing. Additionally, cool water holds more oxygen, and salmonids require high levels of dissolved oxygen in all stages of their life cycle.

A second important aspect of water quality is turbidity, which is the relative clarity of water. Water clarity and turbid suspended sediment levels affect nutrient levels in streams that in turn affect primary productivity of aquatic vegetation, and insect life. This eventually reverberates through the food chain and affects salmonid food availability. Additionally, high levels of turbidity interfere with juvenile salmonids' ability to feed and can lead to reduced growth rates and survival (B. Trush, personal communication).

A third important aspect of water quality is stream sediment load. Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Eggs and embryos suffocate under excessive fine sediment conditions because oxygenated water is prevented from passing through the egg nest, or "redd." Additionally, high sediment loads can "cap" the redd and prevent emergent fry from escaping the gravel into the stream at the end of incubation. High sediment loads can also cause abrasions on fish gills, which may be susceptible to infection. At extreme levels, sediment can clog the gills causing death. Additionally, materials toxic to salmonids can cling to sediment and be transported through the downstream areas.

Habitat complexity for salmonids is created by a combination of deep pools, riffles, and flatwater habitat types. Pools, and to some degree flatwater habitats, provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas, particularly for young coho salmon. They are also necessary for adult resting areas. A high level of fine sediment fills pools and flatwater habitats. This reduces depths and can bury complex niches created by large substrate and woody debris. Riffles provide clean spawning gravels and oxygenate water as it tumbles across them. Steelhead fry use riffles during rearing. Flatwater areas often provide spatially divided "pocket water" units that separate individual juveniles which helps promote reduced competition and successful foraging (Flosi, et al., 1998).

A functional riparian zone helps to control the amount of sunlight reaching the stream, and provides vegetative litter and invertebrate fall. These contribute to the production of food for the aquatic community, including salmonids. Tree roots and other vegetative cover provide stream bank cohesion and buffer impacts from adjacent uplands. Nearstream vegetation eventually provides large woody debris and complexity to the stream (Flosi et al. 1998).

Riparian zone functions are important to anadromous salmonids for numerous reasons. Riparian vegetation helps keep stream temperatures in the range that is suitable for salmonids by maintaining cool stream temperatures in the summer and insulating streams from heat loss in the winter. Larval and adult macroinvertebrates are important to the salmonid diet and they are in turn dependant upon nutrient contributions from the riparian zone. Additionally, stream bank cohesion and maintenance of undercut banks provided by riparian zones in good condition maintains diverse salmonid habitat, and helps reduce bank failure and fine sediment yield to the stream. Lastly, the large woody debris provided by riparian zones shapes channel morphology, helps a stream retain organic matter and provides essential cover for salmonids (Murphy and Meehan 1991).

Therefore, excessive natural or man-caused disturbances to the riparian zone, as well as the directly to the stream and/or the watershed itself can have serious impacts to the aquatic community, including anadromous salmonids. Generally, this seems to the case in streams and watersheds in the north coast of California. This is borne out by the recent decision to include many North Coast chinook and coho salmon, and steelhead trout stocks on the Endangered Species Act list.

Policies, Acts, and Listings

Several federal and state statues have significant implications for watersheds, streams, fisheries, and their management. Here, we present only a very brief listing and description of several laws.

Federal Statutes

One of the most fundamental of federal environmental statutes is the **National Environmental Policy Act** (NEPA). NEPA is essentially an environmental impact assessment and disclosure law. Projects contemplated or plans prepared by federal agencies or funded by them must have an environmental assessment completed and released for public review and comment, including the consideration of more than one alternative. The law does not require that least impacting alternative be chosen, only that the impacts be disclosed.

The federal **Clean Water Act** has a number of sections relevant for watersheds and water quality. Section 208 deals with non-point source pollutants arising from silvicultural activities, including cumulative impacts. Section 303 deals with waterbodies that are impaired such that their water quality is not suitable for the beneficial uses identified for those waters. For water bodies identified as impaired, the US Environmental Protection Agency or its state counterpart (here, the North Coast Regional Water Quality Control Board and the State Water Resources Control Board) must set targets for "total maximum daily loads" (TMDLS) of the pollutants that are causing the impairment. Section 404 deals with the alterations of wetlands and streams through filling or other modifications, and requires the issuance of federal permits for most such activities.

The federal **Endangered Species Act of 1973** (FESA) addresses the protection of animal species whose populations are dwindling to critical levels. Two levels of species risk are defined. "Threatened" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. "Endangered" species means any species that is in danger of extinction throughout all or a significant portion of its range. In general, the law forbids the "take" of listed species. Where specially permitted through the completion and approval of a habitat conservation plan, take of a species listed as threatened may be allowed. Many of California's salmon runs are listed under FESA, including Mattole River chinook and coho salmon, and steelhead trout, which have been proposed for listing.

State Statutes

The state analogue of NEPA is the **California Environmental Quality Act** (CEQA). CEQA goes beyond NEPA in that is requires the project or plan proponent to select for implementation the least environmentally impacting alternative considered. When the least impacting alternative would still cause "significant" adverse environmental impacts, a statement of overriding considerations must be prepared.

The Porter-Cologne Water Quality Control Act establishes state water quality law and defines how the state will implement the federal authorities that have been delegated to it by the US EPA under the federal Clean Water Act. For example, the US EPA has delegated to the state certain authorities and responsibilities to implement TMDLS for impaired water bodies and NPDES (national pollution discharge elimination system) permits to point-source dischargers to water bodies.

Sections 1600 et seq. of the Fish and Game Code, implemented by the Department of Fish and Game, are required for any activities that alter the beds or banks of streams or lakes. While treated as ministerial in the past, the courts have more recently indicated that these constitute discretionary permits and thus must be accompanied by an environmental impact review per CEQA.

The **California Endangered Species** Act (CESA) … The California Endangered Species Act (CESA) (Fish & Game Code §§ 2050, *et seq.*) generally parallels the main provisions of the Federal Endangered Species Act and is administered by the California Department of Fish and Game (DFG). Coho salmon, found in the Mattole, is currently a candidate for listing under CESA. The State Fish and Game Commission is expected to make the final listing decision of this species in 2002.

The **Z'Berg-Nejedly Forest Practice Act** (FPA) and associated **Forest Practice Rules** establish extensive permitting, review, and management practice requirements for commercial timber harvesting. Evolving in part in response to water quality protection requirements established by the 1972 amendments to the federal Clean Water

Act, the FPA and Rules provide for significant measures to protect watersheds, watershed function, water quality, and fishery habitat.

Assessment Needs for Salmon Recovery and Watershed Protection

The North Coast Watershed Assessment Program (NCWAP) is an interagency effort between the California Resources Agency and CalEPA which was established in 2000 to provide a consistent scientific foundation for collaborative watershed restoration efforts and to better meet the State needs for protecting and restoring salmon species and their habitats under State and federal laws. The program was developed by a team of managers and technical staff from the following departments with watershed responsibilities for the North Coast: California Resources Agency, California Department of Fish and Game (DFG), California Department of Forestry and Fire Protection (CDF), California Department of Conservation/Division of Mines and Geology (DOC/DMG), California Department of Water Resources (DWR), and the North Coast Regional Water Quality Control Board (RWQCB) of the State Water Resources Control Board. The Institute for Fisheries Resources (IFR) is also a partner and participant in this program. The California Resources Agency in coordination with CalEPA, initiated this program in part in response to specific requests from landowners and watershed groups that the State take a leadership role in conducting scientifically credible, interdisciplinary assessments that could be used for multiple purposes. The need for comprehensive watershed information grew in importance with listings of salmonids as threatened species, the TMDL (total maximum daily load) consent decree, and the increased availability of assistance grants for protecting and restoring watersheds.

Listings under the federal Endangered Species Act for areas within the NCWAP region (the North Coast Hydrologic Unit) began with coho salmon in 1966, followed by Chinook salmon in 1999, and steelhead in 2000. In 2001, coho was proposed for listing under the California Endangered Species Act. Concerns about the potential impacts of salmonid listings and Total Maximum Daily Loads (TMDL) on the economy are particularly strong on the North Coast where natural-resource-dependent industries predominate. Cumulative impacts related to these activities, along with natural processes, can adversely affect watershed conditions and fish habitat, including landslides, flooding, timber harvest, mining, ranching, agricultural uses and development. In order to recover California's salmonid fisheries, it is necessary to first assess and understand the linkages among management activities, dominant ecological processes and functions, and factors limiting populations and their habitat.

NCWAP integrates and augments existing watershed assessment programs to conform with proven methodologies and manuals available from each department. The program also responds to recommendations from a Scientific Review Panel (SRP) which was created under the auspices of the State's Watershed Protection and Restoration Council as required by the March, 1998 Memorandum of Understanding (MOU) between the National Marine Fisheries Service (NMFS) and the California Resources Agency. The MOU required a comprehensive review of the California Forest Practice Rules (FPRs) with regard to their adequacy for the protection of salmonid species. In addition, the promise of significant new State and federal salmon restoration funds highlighted the need for watershed assessments to ensure those dollars are well spent.

NCWAP Program Goals

The NCWAP was developed to improve decision-making by landowners, watershed groups, agencies, and other stakeholders with respect to restoration projects and management practices to protect and improve salmonid habitat. It was therefore essential that the program took steps to ensure its assessment methods and products would be understandable, relevant, and scientifically credible. As a result, the interagency team developed the following goals:

1. Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;

2. Provide assessment information to help focus watershed improvement programs, and assist landowners, local watershed groups, and individuals to develop successful projects. This will help guide support programs, like DFG's Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and lead to improved salmonid populations;

3. Provide assessment information to help focus cooperative interagency, nonprofit and private sector approaches to "protect the best" watersheds and streams through watershed stewardship, conservation easements, and other incentive programs; and

4. Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

Program Objectives and Guiding Questions

During the assessment process, the NCWAP agencies will work together very closely at all stages to consider how man-caused and naturally occurring watershed processes interact and affect stream conditions for fisheries, and other uses, and also consider the implications for watershed management.

During the formulation of the NCWAP's Methods Manual, the participating agencies agreed upon a short list of critical questions with the key question being:

"What watershed factors are limiting salmonid populations?"

- What are the general relationships between natural event and land use histories, for example, fire, flood, drought, earthquake, etc.; and urban and rural land development, timber harvest, agriculture, roads, dams, and stream diversions. How is this history reflected in the current vegetation and level of disturbance in North Coast watersheds? How can these kinds of disturbances be meaningfully quantified?

- What is the spatial and temporal distribution of sediment delivery to streams from landsliding, bank, sheet and rill erosion, and other erosion mechanisms, and what are the relative quantities for each source?

- What are the effects of stream, spring, and groundwater uses on water quality and quantity?

- What role does large woody debris (LWD) have within the watershed in forming fish habitat and determining channel condition and sediment routing and storage?

- What are the current salmonid habitat conditions in the watershed, the aquatic/riparian zone, and the estuary (flow, water temperature/shade, sediment, nutrients, instream habitat, large woody debris and its recruitment); how do these compare to desired conditions (life history requirements of salmon, Basin Plan water quality objectives)?

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations and/or other aquatic community organisms within the watersheds?

- Does the status of these populations reflect current watershed and stream habitat conditions or does it indicate constraints beyond the watershed might exist. For example, a lack of stream connectivity that prevents free movement for adults or juveniles, or a poor marine life history, could affect a salmonid population.

These questions have guided the individual team members in data gathering and procedure assessment. The questions have provided direction for those analyses that required more interagency, interdisciplinary synthesis, including the analysis of factors affecting anadromous salmonid production.

Program Assessment Region and Agency Roles

The NCWAP assessment area includes all coastal drainages from Sonoma County north to Oregon. This area corresponds with the North Coast Water Quality Control Board's region. The region has been sub-divided into

thirty-one basins for NCWAP assessment purposes (Map XX). Thus, the program will organize existing information and provide limited baseline environmental and biological information for approximately 6.5 million acres of land over an estimated seven-year period. The administrative lead for the NCWAP is the California Resources Agency

The roles of the five participating agencies in these efforts are as follows:

- DFG will compile, develop, and analyze data related to anadromous fisheries habitat and populations. It will also lead an interagency evaluation of factors affecting anadromous fisheries production at the watershed level and provide recommendations for restoration and monitoring in the final synthesis report.

- CDF will compile, develop, and analyze data related to historical land use changes in the watersheds. It will also take the lead on preparing reports that synthesize information, findings and recommendations, and develop a framework for assessing cumulative impacts.

- DOC/DMG will compile, develop, and analyze data related to the production and transport of sediment. Tasks will include baseline mapping of landslides, landslide potential, and instream sediment, as well as an analysis of stream geomorphology and sediment transport.

- RWQCB will compile, collect, and analyze water quality data for the assessments.

- DWR will install and maintain stream monitoring gages where needed to develop and analyze stream flow information.

Assessment Strategy and General Methods

Because the NCWAP is intended to provide information useful for several purposes, its approach emphasizes close coordination with clientele groups. The NCWAP products are expected to provide both context and content for finer scale analysis, set priorities for detailed analysis and program planning, and identify areas for further work. Therefore, although a relatively uniform assessment process will be followed in each basin, key issues and information are custom to each watershed. Variability in watershed condition, public resource values and concerns, land use and ownership, and the availability of existing data shape each assessment within the context of the guiding, critical questions. Public review of products will provide additional opportunities to adapt and enhance assessments in the future.

The steps of the NCWAP process in each basin are:

Step One: Scoping. The basin assessment team will meet with stakeholders to identify watershed problems or concerns, local assessment interests, existing data and gaps, and opportunities to work with local interests to answer the critical questions.

Step Two: Data compilation. The team will compile and screen existing data according to the quality and usefulness for answering critical questions and application to the program's Ecological Management Decision Support system model (EMDS). This model accepts information about the study watershed and /or stream, and helps process and explains relationships among current conditions affecting fishery production. Quality control processes are described in greater detail in Chapter 4 of the NCWAP's draft Method Manual. Mapping and geographical information system (GIS) presentation will be coordinated among the several departments.

Step Three: Initial Analyses. The team will use the EMDS model (described in Chapter 3 of the NCWAP's Methods Manual) to help analyze the habitat factors affecting fish production. This initial model run with existing data will help to identify significant data gaps (categories, location, and scale) and to focus field data verification and collection by DFG and others. The model will be updated as run as new data is collected and/or developed.

Step Four: Fieldwork. Agencies will conduct necessary fieldwork, including validation of existing data, verification of imagery or photo-based analyses, and collection of new data to fill critical gaps. Throughout this process, there will be coordination with local groups and landowners on access to private property and validation of findings.

Step Five: Analyze data. This includes the generation of maps, databases, and the more integrative analyses. Data will be analyzed in an interdisciplinary fashion where needed, particularly when answering critical questions, applying the limiting factors analysis, and developing general management and cumulative efforts recommendations.

Step Six: Develop Assessment Reports for Public Review: Draft products will include data developed or compiled by all the agencies as licenses or agreements permit (including photos and imagery); analytical products such as maps, limiting factor analysis results, GIS analyses, topical reports, etc.; and the review summary report with recommendations. These products will be made available in hard copy from NCWAP offices in Fortuna, Santa Rosa, and Sacramento; and also through the Klamath Resources Information System CD and on-line. A public review process will be established for each basin. The NCWAP team will summarize comments and revise preliminary products to reflect comments as feasible.

NCWAP Products

The NCWAP will produce and make available to the public a consistent set of products for each basin assessed. They include the following:

- Databases of information that the NCWAP has used and collected for its analysis. The NCWAP will also provide a data catalogue which identifies all the information we considered, and evaluates its usefulness for the NCWAP assessment process, as well as a bibliography of other references cited in the assessment report.

- Maps showing geology, geomorphic features related to landsliding, instream sediment and transport zones, and relative landslide potential developed by the Department of Conservation/Division of Mines and Geology.

- An Ecological Management Decision Support system (EMDS) model that describes how watershed conditions interact at the stream reach and watershed scale to affect suitability for fish.

- GIS-based models and analyses such as timber harvest frequency, road-based erosion model runs, vegetation, stream buffers, roads, road density, road and stream interactions, and roads on unstable slopes.

- An interdisciplinary analysis of the results of fieldwork, historical analyses, EMDS data, and other analytical products about the suitability of stream reaches and the watershed for salmonids.

- An interagency description of historic and current conditions as they relate to suitability for salmonid fisheries. This will address vegetation cover and change, land use, geology and geomorphology, water quality, streamflow and water use, and instream habitat conditions for salmonids. It will also contain hypotheses about watershed conditions that contribute to factors affecting salmonids.

- Recommendations for management and restoration to address limiting factors.

- Recommendations for additional monitoring to improve the assessment process.

- A CD developed through the Institute for Fisheries Resources (IFR) which uses the Klamath Resources Information System (KRIS) tool to store data, provide a regional bibliography of watershed studies and reports, present the NCWAP analyses, maps and other products, and store community based data over time.

- A synthesis report describing the results and implication of the watershed assessment.

All products will be made available electronically through the NCWAP website and the IFR's KRIS tool on CD and on their website.

Assessment Report Conventions and Use

Calwater 2.2a Planning Watersheds

NCWAP is using the California Watershed Map (CALWATER version 2.2a) to delineate watershed units. CALWATER is a set of standardized watershed boundaries meeting standardized delineation criteria. The hierarchy of watershed designations consists of six levels of increasing specificity: Hydrologic Region (HR), Hydrologic Unit (HU), Hydrologic Area (HA), Hydrologic Sub-Area (HSA), Super Planning Watershed (SPWS), and Planning Watershed (PWS). The primary purpose of Calwater is the assignment of a single, unique code to a specific watershed polygon. The Calwater Planning Watersheds are generally from 3,000 – 10,000 acres in size.

Primary purposes for Calwater 2.2 include but are not limited to mapping, reporting, and statistical analysis of water resources, water supply, water quality, wildlands, agriculture, soils, forests, rangelands, fish habitat, wildlife habitat, cross-referencing state and federal hydrologic unit or watershed codes and names.

CALWATER version 2.2 is the third version of Calwater (after versions 1.2 and 2.0), and is a descendent of the 1:500,000-scale State Water Resources Control Board Basin Plan Maps drawn in the late 1970's.

Tierra Data Systems completed Version 1.2 in 1995 by Tierra Data Systems (Jim Kellog). Line work was captured by overlaying the Basin Plan Maps on 1:24,000-scale USGS quad sheets, redrawing and digitizing lines to match 1:24,000-scale watershed boundaries, and subdividing the 4th level Hydrologic Subareas (HSA's) into 5th level Super Planning Watersheds (SPWS) and 6th level Planning Watersheds (PWS).

Hydrology Hierarchy

Watershed terminology often becomes confusing when discussing the different scales of watersheds involved in planning and assessment activities. The conventions used in the Mattole assessment follow the guidelines established by the Pacific Rivers Council. The descending order of scale is from ***basin*** level (e.g., Mattole Basin) – ***subbasin*** level (e.g., Northern subbasin) – ***watershed*** level (e.g., Honeydew Creek) – ***sub-watershed*** level (e.g., West Fork Honeydew Creek).

The subbasin is the assessment and planning scale used in this report as a summary framework; subbasin findings and recommendations are based upon the more specific watershed and sub-watershed level findings. Therefore, there are usually exceptions at the finer scales to subbasin findings and recommendations. Thus, the findings and recommendations at the subbasin level are somewhat more generalized than at the watershed and sub-watershed scales. In like manner, subbasin findings and recommendations are somewhat more specific than the even more generalized, larger scale basin level findings and recommendations that are based upon a group of subbasins.

The term "watershed" is used in both the generic sense, as to describe "watershed" conditions at any scale, and as a particular term to describe the ***watershed*** scale introduced above, which contains, and is made up from multiple, smaller sub-watersheds. The watershed scale is often approximately 20 – 40 square miles in area; its sub-watersheds can be much smaller in area, but for our purposes contain at least one perennial, un-branched stream. Please be aware of this multiple usage of the term watershed, and consider the context of the term's usage to reduce confusion.

Gualala Watershed Profile

Introduction

The Gualala River drains 298 square miles along the coast of southern Mendocino and northern Sonoma Counties. The river enters the Pacific Ocean near the town of Gualala, 114 miles north of San Francisco and 17 miles south of Point Arena. The Gualala River watershed is elongated, running over 32 miles long north-south, with an average width of 14 miles. Elevations vary from sea level to 2,602 feet at Gube Mountain and terrain is most mountainous in the northern and eastern parts of the basin (Figure. 2). A long history of movement along the San Andreas Fault and the Tombs Creek Fault has been a dominant force in the shaping of the basin. The climate is influenced by fog near the coast with seasonal temperatures ranging between 40 to 60 degrees F, with the interior basin ranging from below freezing to over 90 degrees F seasonally. Rainfall also varies by location within the basin with 33 inches falling on average near the town of Gualala and totals reaching over 63 inches in some areas within the interior.

The five principal Gualala subbasins in order of size are the Wheatfield Fork (37% of drainage), South Fork and Gualala Mainstem (21%), North Fork (16%), Buckeye Creek 14%), and Rockpile Creek (12%), which also serve as subbasins for analysis in this study (Figure. 2). The mainstem Gualala extends only from the convergence of the North Fork and South Fork to the ocean, with much of this reach comprising the estuary or lagoon. Coastal conifer forests of redwood and Douglas fir occupy the northwestern, southwestern and central portions of the watershed while oak-woodland and grassland cover many slopes in the interior basin. Coho naturally inhabited the streams flowing from coniferous forest but were likely sub-dominant to steelhead in interior basin areas draining the mélange due to the more open nature of the channels, less suitable habitat, and naturally warmer stream temperatures. The interior basin is largely grassland with scattered oaks. Surface water in this area generally lack shade and are warmed with abundant sunshine.

Salmon / Stream / Watershed / Land Use Relationships

Anadromous Pacific salmonids are dependent upon a high quality freshwater environment at the beginning and end of their life cycles. As such, they thrive or perish depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirements must be provided by diverse and complex instream habitats as the fish move through their life cycles. If any of these elements are missing or in poor condition at the time a fish or stock requires it, their survival can be impacted. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

"In streams where fish live and reproduce, all the important factors are in a suitable (but usually not optimum) range throughout the life of the fish. The mix of environmental factors in any stream sets the carrying capacity of that stream for fish, and the capacity can be changed if one or more of the factors are altered. The importance of specific factors in setting carrying capacity may change with life stage of the fish and season of the year," (Bjorrn and Reiser, 1991).

Through the course of the years, natural climatic, watershed hydrologic responses, and erosion events interact to shape freshwater salmonid habitats. These include the kind and extent of the watershed's vegetative cover as well, and act to supply nutrients to the stream system. "In the absence of major disturbance, these processes produce small, but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions." (Swanston, 1991).

The results of a major disruption, which can be created over time by many smaller disruptions, can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, dependent relationships of salmon and steelhead with their natal streams during their

freshwater life phases, and their streams' dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

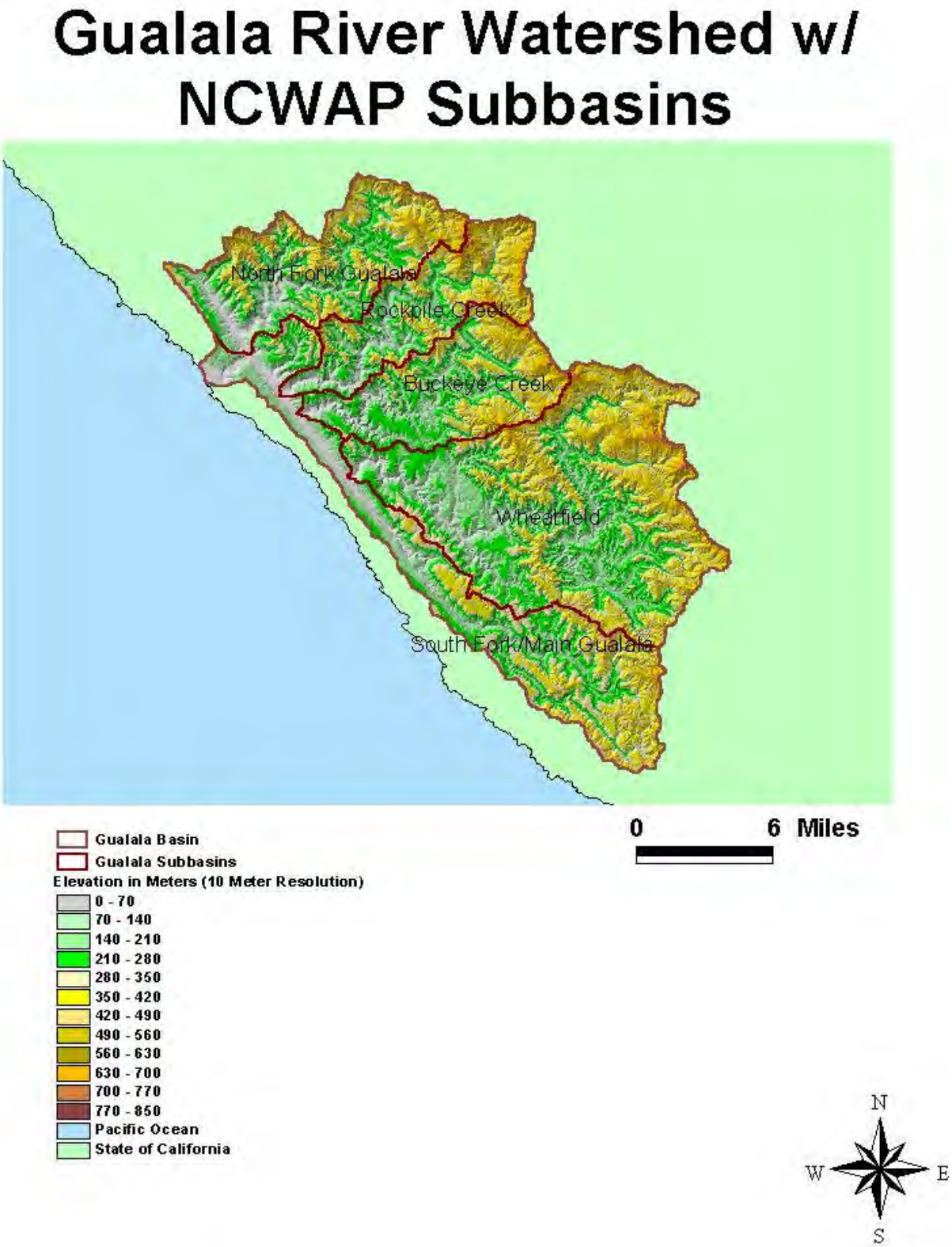


FIGURE 2: GUALALA RIVER WATERSHED W/ NCWAP SUBBASINS

"Protection and maintenance of high-quality fish habitats should be among the goals of all resource managers. Preservation of good existing habitats should have high priority, but many streams have been damaged and must be repaired. Catastrophic natural processes that occlude spawning gravels can reduce stream productivity or block access by fish (for example), but many stream problems, especially in western North America, have been caused by poor resource management practices of the past. Enough now is known about the habitat requirements of salmonids and about good management practices that further habitat degradation can be prevented, and habitat rehabilitation and enhancement programs can go forward successfully," (Meehan, 1991).

In general, natural disruption regimes do not impact larger watersheds, like the 298 square mile Gualala, in their entirety at any given time. Rather, they rotate episodically across the entire mosaic of their smaller subbasin, watershed, and sub-watershed components over long periods of time. This creates a mosaic of habitat conditions over the larger watershed, (Reice, 1994).

Human disturbances, although individually small in comparison to natural events, are usually spatially distributed widely across basin level watersheds, (Reeves, et al., 1995). That occurs because market driven land uses tend to function in temporal waves, like the California Gold Rush or the post-WWII logging boom in Northern California. The intense human land use of the last century, combined with the energy of two mid-century, record floods on the North Coast, created stream habitat impacts at the basin and regional scales. The result has overlain the natural disturbance regime and depressed stream habitat conditions across most of the region.

Subbasin Scale

Natural variation in subbasins is at least partially a product of natural and human disturbances. Other variables that can distinguish areas, or subbasins, in larger basins include differences in elevation, geology, soil types, aspect orientation, climate, vegetation, fauna, human population, land use and other social-economic considerations. The combined complexity of large basins makes it difficult to speak about them concerning watershed assessment and recommendation issues in other than very general terms. In order to be more specific and useful to planners, managers, and landowners, it is useful to subdivide the larger basin units into smaller subbasin units whose size is determined by the commonality of many of the distinguishing traits.

Hydrology

The watershed has a long history of land use, fire, and floods. With steep slopes and high rainfall amounts, alterations of the landscape can likely change the hydrologic curves, flood frequencies and stream flow peaks within the subwatersheds. Aggradation of the streambed in many areas has probably reduced surface water flow during dry years.

The main stem of the Gualala River flows from the confluence of the South Fork and North Fork to the Pacific Ocean. This reach is greatly influenced by seasonal closures of the river mouth, which typically occur in early summer and last until the first heavy rains of October or November, although it may also close briefly during the winter months (CDFG 1968 and EIP 1994).

Precipitation in the Gualala watershed is highly seasonal. Most precipitation occurs between the months of October through April. Average annual precipitation ranges from 33 inches at the lower elevations near the Pacific Ocean to 63 inches at the higher elevations in the southeastern upper watershed.

Few long-term precipitation stations exist within the basin. The longest gauge record near the basin is the Cloverdale gauge with a continuous period of record of 1903 through the present. Annual precipitation at the gauge during this period ranged from 13.54 inches in 1924 to 79.26 inches in 1983. Mean annual precipitation for this station is 40.89 inches. A list of long-term precipitation gauges within or near the Gualala watershed and a location map are included in Appendix 6.

Similar to other watersheds within the North Coast, only a few stream flow gauging stations have historically operated within the Gualala watershed. Stream flow data had not been collected by any agency since 1994. To gain additional stream flow data, three stream flow gauging stations (one on the North Fork Gualala, one on the Wheatfield Fork, and one on the South Fork Gualala above the Wheatfield Fork) were installed by NCWAP during the fall of 2000. Zero flow occurred at the new Wheatfield and South Fork gauges during the late summer months

of 2001, but the North Fork maintained a minimum base flow and was the major if not the only contributor of surface water flow to the estuary during low flow periods. A list of existing and discontinued stream flow gauging stations, their locations, and period of record along with a location map are provided in Appendix 6.

Only one stream flow gauge, USGS gauge #11467500 "South Fork Gualala River near Annapolis" was operated for a significant continuous period (October 1950 – September 1971). This station was located below the confluence with the Wheatfield Fork and measured the runoff from a drainage area of 161 of the 298 square mile Gualala watershed. The two highest peak flow events recorded for this station occurred in December 1955 at 55,000 cubic feet per second (cfs) and January 1966 at 47,800 cfs. While other North Coast rivers experienced near record flood flows in December 1964, the South Fork Gualala gauge recorded only 21,000 cfs. An examination of other stream flow gauges in the area indicates recent flood events at the South Fork Gualala gauge site of 30, 000 cfs or greater probably occurred in 1974, 1983, 1986, 1993, 1995, and 1997. A summary and statistical analysis of the flow data for this station are presented in Appendix 6.

A search of the SWRCB's Water Right Information System (WRIMS) was performed to determine the number and types of water rights within the Gualala watershed. The WRIMS database is under development and may not contain all post-1914 appropriative water right applications that are on file with the SWRCB at this time. Some pre-1914 and riparian water rights are also contained in the WRIMS database for those water rights whose users have filed a "Statement of Water Diversion and Use". A list of water rights and associated information contained within WRIMS for the Gualala watershed along with a location map are presented in Appendix 6.

SWRCB issued appropriative water rights for a total of about 4,500 acre-feet per year (ac-ft/yr) of water from the Gualala River watershed, at a maximum diversion rate of about 8 cfs. Because the watershed is sparsely populated, riparian extraction in the watershed is probably minimal. The potential peak demand from this use and additional future riparian uses in the watershed was estimated to be 2.5 cfs (EIP, 1994). Although municipal use is the dominant water use in the watershed, other uses of surface water include domestic, irrigation, stock watering, fish and wildlife enhancement, and fire protection.

Current water use in the Gualala River watershed by agricultural and rural development is probably minor. However, as stated in the Gualala River Watershed Literature Search and Assimilation (Higgins 1997): "While agricultural water use in the Gualala River watershed has been very low in the past, vineyards are now being developed in some areas. These" vineyards "may have a direct impact on tributary flow if surface water is used. If wells are drilled in upland areas, and if the aquifer is joined to headwater springs, flows in some tributaries could be affected". EIP Associates (1994) projected that development of vacation homes or residences could result in use of up to 2.5 cfs for the entire basin.

Two major municipal water users, the North Gualala Water Company (NGWC) and the Sea Ranch, currently extract water from the Gualala watershed. The SWRCB issued an appropriative water right permit to NGWC to divert water from the North Fork Gualala River. The permit stipulates a maximum diversion of 2.0 cfs, but when the natural flow of the North Fork falls below stipulated by-pass flows for fish, NGWC is prohibited from diverting any water from the North Fork. The by-pass flows vary with the time of year, but a minimum by-pass flow of 4.0 cfs is required at all times. In August 2000, the State Water Resources Control Board ruled that the by-pass flows applied to both surface water diversions and extractions from underground water from two NGWC off-set wells that had been previously found to fall under the SWRCB's jurisdiction as "subterranean streams flowing through known and definite channels". The SWRCB decisions regarding these water extractions are currently under litigation in the Superior Court of Mendocino County. The plaintiff, NGWC, is claiming the water extractions from their off-set wells do not fall under the jurisdiction of the SWRCB.

The Sea Ranch once drew surface water directly from the South Fork Gualala, but they currently draw water from the aquifer below the lower South Fork Gualala riverbed by off-set wells and have augmented storage with an off-site reservoir. The SWRCB again ruled that the water extractions from the aquifer are from "subterranean streams" and are therefore under the SWRCB jurisdiction. The Sea Ranch's appropriative water right permit allows for a maximum extraction of 2.8 cfs, although actual historic maximum diversions have been substantially less. These diversions are also dependent on minimum fish by-pass flows stipulated in the SWRCB permit. Current low flow constraints in the Gualala River will most likely prohibit future additional appropriative water allocations; however, greater use of the rights allocated to the Sea Ranch is expected in the future.

The NCRWQCB's Basin Plan designates ten existing and one potential beneficial use of water for the Gualala River watershed. The Water Board has responsibility for protecting all beneficial uses. Accordingly, the water quality parameters assessed in this report are compared to water quality objectives for the protection of all beneficial uses. However, the assessment is focused primarily on the salmonid fishery beneficial uses: COLD (cold freshwater habitat), SPWN (spawning, reproduction, and/or early development), MIGR (migration of aquatic organisms), EST (estuarine habitat), and REC-1 (water contact recreation-fishing). A complete list of beneficial uses is shown in Appendix 9.

Geology

The Coast Ranges in general and the Gualala Watershed in particular are areas of naturally high background levels of landslide activity due to geologic and climatic conditions; i.e., steep slopes, weak rock, high rainfall, seismic shaking, and uplift. The watershed resides wholly in the San Andreas Fault System and is bounded on the west and east by the San Andreas and the Maacama Faults. Drainage networks are largely fault controlled and vary from very long linear reaches (as along the Little North Fork and South Fork) to regions of simple zigzag patterns (Rockpile Creek), to high ordered convoluted patterns (eastern Wheatfield Fork). A disconnected series of northwest trending interior ridges subdivide the Gualala watershed into several sub-basins. The Geologic and Geomorphic Features Related to Landsliding Map (Plate 1) shows a complex pattern of lithology and landsliding.

The inland boundaries of the watershed and sub-basins are defined by the disconnected series of northwest oriented groups of ridges. Varying distributions of large earthflow and rockslide complexes are mapped (see Plate 1). Northwest oriented bands of poorly consolidated ancient marine terraces are concentrated in lower central and upper east reaches of the watershed. The Ohlson Ranch formation is subject to landsliding along the edges of terraces or along incised drainages.

The Gualala River system and surrounding topography evolved in response to rapid geologic changes along the west coast of North America over the past 30 million years, and especially in the last five million years. The drainage networks evolved along with the changing landscape. The landscape continues to actively change through the processes of erosion and mass wasting in ways that force the stream channels to continually adjust. It is unknown (and beyond the scope of the geologic portion of the assessment) to what degree land use has accelerated natural erosion levels and how long the residual effects will last. It is clear that past land-use practices that were indifferent to stream health triggered many landslides and directly placed large volumes of sediment in the stream channels.

Montgomery (2000) proposed that the geologic evolution of the Pacific coast created habitat diversity, which allowed for the evolution of the five species of Pacific salmon. It then follows that in the Gualala Watershed, the present ecology of the listed coho salmon and steelhead developed in sync with the geologic foundation, and modification to the landscape from historic time. Additional detail is presented in Appendix 7.

Land Use

The Gualala Watershed has one of the longest span of historical use compared to other North Coast watersheds. Logging of the virgin old growth redwood forest began during the mid 1800s. The first documented account dates to 1862 in lower portions of the watershed near coastal ramp and port facilities. This includes the lower reaches of the Little North Fork, North Fork, Pepperwood Creeks, and the lowest reaches of Rockpile and Buckeye Creeks at the confluence with the South Fork. There was concentrated demand of the resource after the 1906 earthquake and rebuilding of San Francisco. The first logging methods used oxen teams to move large old growth redwood logs to terminal points of lateral connecting rail lines, which extended along the South Fork to Gualala from the Santa Rosa Area. Watercourses were frequently used to move logs downslope including use of splash dams. Main rivers were used to float logs downstream. Fire was used extensively to reduce slash during logging and in attempts to convert redwood forest to grazing land after the logging.

Early logging activities left a legacy of impacts, some of which persist to the present. Splash dams and log drives tended to flatten and simplify stream channels. Rail line construction included massive cut and fill excavation along roadbeds which followed streams. Although wood trestles were built over larger watercourses, smaller

watercourses were crossed by wood and earth fill which later failed. The introduction of the steam donkey by the turn of the century reduced ground impacts by cable pulling arge logs from fixed locations but allowed much more widespread forest harvest. These operations did not disturb the ground to the extent of more recent tractor operations characterized by large-scale sideslope excavations and skid trail networks. The gasoline powered crawler tractors made their appearance in the north coast in the late 1920s, but logging in the Gualala was inactive during the Great Depression.

Increased demand for lumber products during the 1950s coincided with the widespread deployment of heavy tractors greatly improved by technology advanced during World War II. Early versions of the D-8 and D-10 tractors, using refined track mounts and suspension systems, and powered by diesel engines, were ideally suited for moving large diameter logs over difficult terrain. This equipment was readily maneuverable, enabling large areas to be worked over in short time periods. Rail line networks were quickly abandoned and diesel powered log trucks transported logs along seasonal roads. Between 1952 and 1960, tractor method harvesting extended in a broad sweep from the upper reaches of the North Fork, east through the central and upper reaches of Rockpile and Buckeye creeks, and throughout lower and middle reaches of Wheatfield Fork. Harvest operations followed straight parcel lines regardless of watercourse condition or difficult terrain. Roads often followed the stream channel to enable downslope skidding. Many roads had steep gradients designed to access all positions of the sideslope. Skid trails frequently followed or crossed ephemeral stream channels. Landings were often located in, or adjacent to, watercourses. These were built by pushing wood debris into channel, and overtopped by dirt fill. Across steep terrain, skid trials cut deep into the sideslope, creating a terraced effect. By 1964, tractor harvesting had continued at an active pace to comprise a majority, and in some areas, most of the timbered areas in the west and central reaches of the watershed (See Figures 3, 3a-b below).

The lack of any erosion control facilities installed throughout large areas of the watershed, coupled with the uncontrolled installation of fills and failure to remove fills adjacent to watercourses, left the entire watershed particularly vulnerable to the 1964 flood event. During a period of one week in December 1964, the intense prolonged runoff caused massive erosion from downcutting, slides, and washing of soil and debris into watercourses. The residual effects are still observed in some areas today. Cal Trans aerial photos taken in June 1965 at 1,200 scale show stream channel meandering through wide, flat areas of buried stream pools, indicating channel aggradations. Roads following the stream channel repeatedly failed as fill sidecast washed out during peak flows. Debris slides above and below roads were frequent. Deep blowouts through landings built over channel are numerous throughout the 1965 photos. There were numerous watercourse diversions onto roads and skid trails.

After 1964, harvest operations resumed at an active rate in the lower and middle reaches of the North Fork and entire Little North Fork areas to remove most of the available timber base in these areas by 1973. Other areas of mature Douglas fir in (1) higher elevation areas and (2) east reaches of the watershed were harvested during this time. Only pocket stands and scattered larger timbered blocks remained. Roads and landings continued to be located low on the sideslope, frequently following the stream channel. Subsequent landing blowouts and road failures have been documented along the Little North Fork and central North Fork. There were large storm events in 1972 and 1974. With ranching being the dominant use in mixed conifer –oak woodland areas, logging of Douglas fir was frequently followed by prolonged cattle grazing. This reduced, and in many locations prevented conifer reestablishment altogether. Grassland became permanently established throughout compacted ground. In addition, removal of Douglas fir in mixed conifer-hardwood forests converted these stands to pure tan oak and madrone. Prolonged cattle grazing in riparian areas after harvest prevented timely reestablishment of canopy cover over fish bearing watercourses, elevating stream temperatures.
After 1973, logging operations had slowed. Smaller selection method harvests were predominant. By this time, tractor-yarding methods changed to maintain equipment exclusion zones and minimum vegetation retention standards adjacent to watercourses per 1973 Forest Practice Rules. New road locations were moved upslope, but the practice of using existing roads located near streams continued. The new forest practice rules limited the cutblock size, creating smaller logged areas.

In the 1990s, harvest activity increased. Smaller but numerous clearcut blocks appear in the redwood lowland areas of the Gualala Redwoods ownership. Throughout the watershed, cable method yarding appears with new road construction now moved to upslope and ridgeline locations. Many sections of the older seasonal roads following the stream channel are either abandoned or removed. Numerous seasonal roads still exist in close proximity to streams, and are used as needed during timber harvest activities. During the mid 1990s, Coastal Forestlands (formerly R&J Timber Co.), purchased by Pioneer Resources in 1998, submitted numerous seed tree overstory removal/ dispersed harvest THPs, covering large areas but removing scattered single trees and remnant stands left from 1960s era entries. Agency review of these THPs clarified road upgrade work requirements to repair erosion

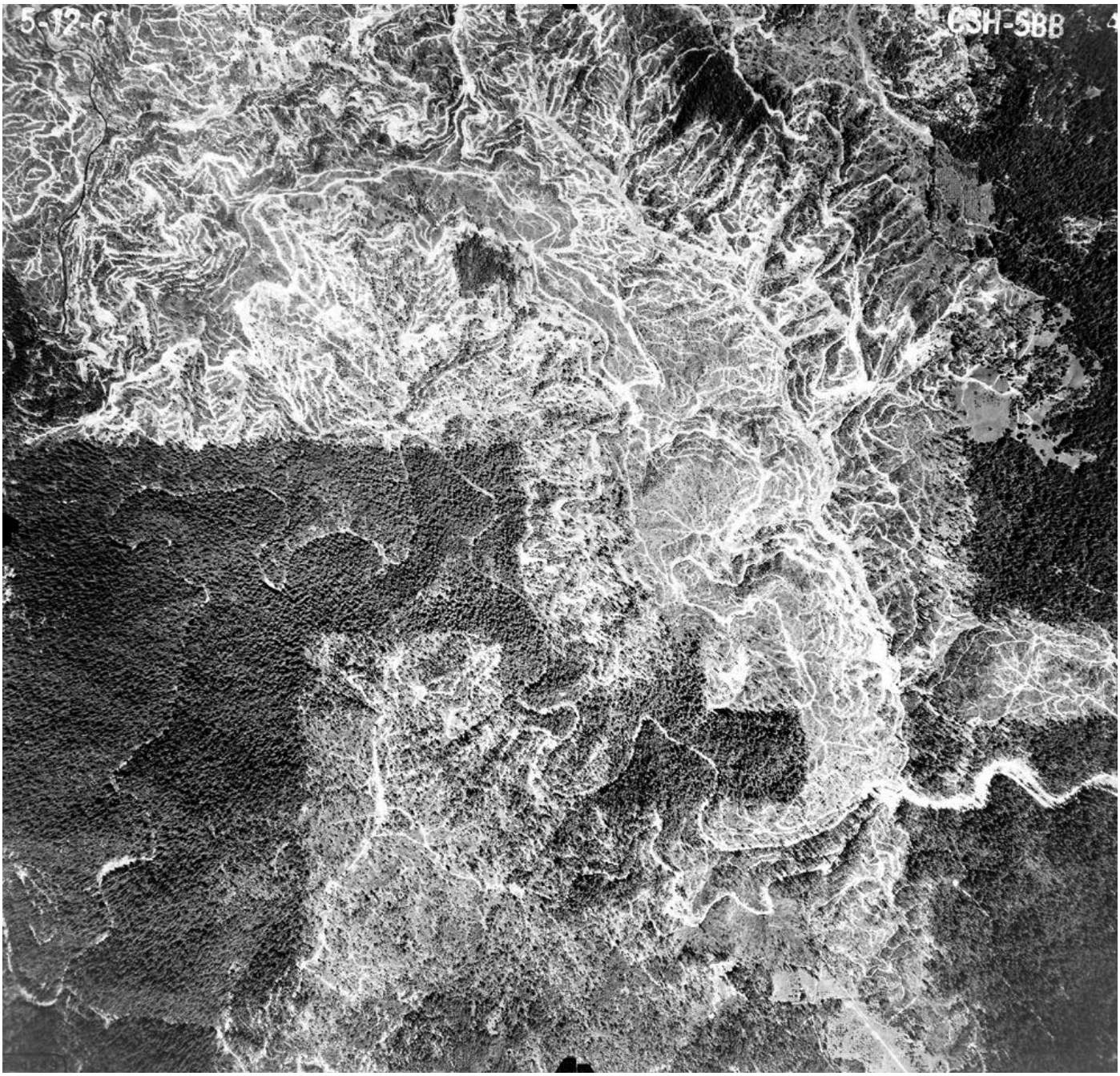
conditions of pre-1973 operations. There has been little harvesting in these areas since 1998. Residential development near the coast, and vineyard development inland, become dominant land use activities by the late 1990s. Ninety-five per cent of the Gualala watershed is privately owned.

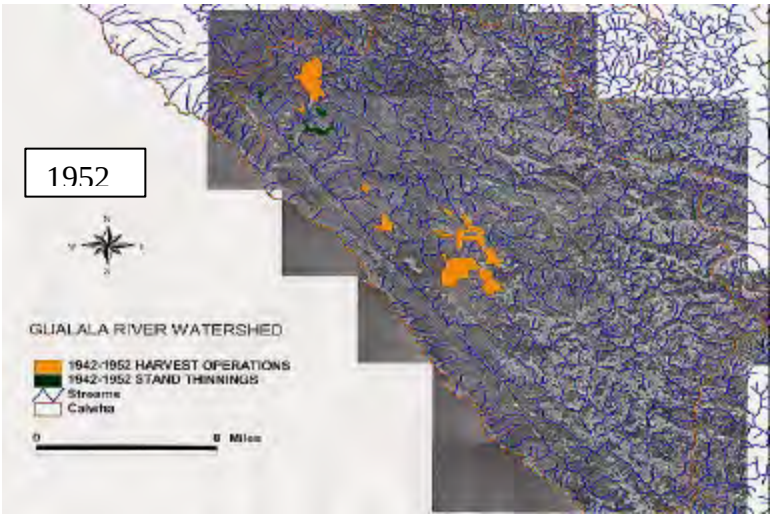
General Watershed Findings

1. Most current riparian overstory conditions reflect shade canopy in-growth of young conifer/ hardwood regeneration from riparian zones entirely cleared of all vegetation between 1952 and 1968. However, a full rotationary time period will be needed within WLPZs to fully reinstate overstory canopy strand structure of late seral trees to coincide with post Depression 1936-1942 era overstory canopy cover. In 30 to 40 year old conifer plantations in higher reaches of the watershed, entire bank to bank shade canopy cover has been reinstated over smaller streams. After initial land clearing and forest removal, prolonged pasture grazing spanning decades in the northeast and east areas of the watershed prevented timely reestablishment of canopy cover over watercourses. With the decline of ranching in recent years, young sapling sized conifers/ hardwoods have reestablished in riparian areas

FIGURE 3: 1961 aerial photo, Post World War II

Pre-Forest Practice Rules logging in the Buckeye Creek Subbasin. Franchini Ck. and a new streamside road are in upper right





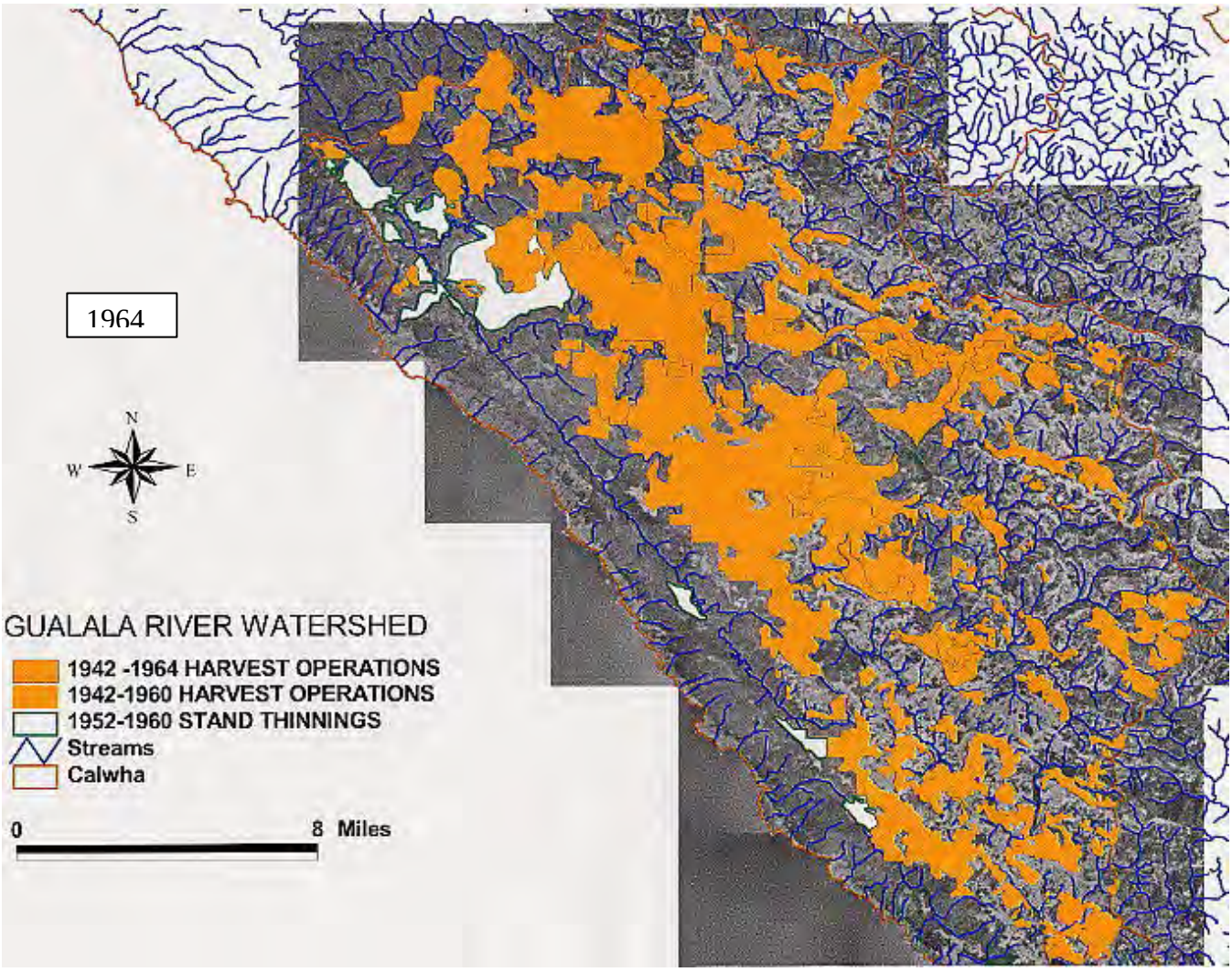


FIGURE 4. Harvest Operations 1942-1960

In a period of only twelve years between 1952 (top) and 1964 (below), heavy tractors eliminated most of the conifer dominated timberstand in the watershed. The 1964 flood rained down on vast areas of recently exposed ground with no erosion controls installed. Streamside roads and landings were built in or adjacent to most major watercourses in these areas.

2. The 1964 storm event rained down on large sub basin-wide timber harvest block areas. These areas were tractor yarded regardless of sideslope condition with no erosion control facilities installed or proper disposal of sidecast effected. This caused massive erosion, slides, and washing of soil and debris into watercourses. Sedimentation, pool infill, and stream widening have been documented at the point of discharge immediately after the 1964 flood. In steeper terrain, for example in the N.F/ SF. Fuller Creek and higher reaches of the North Fork and Rockpile sub-basins, sedimentation debris has washed downstream to low lying alluvial basins, per 1984 and 1999 photos and field observations, re-exposing a rocky substrate upstream to varying degrees. This substantiates more detailed studies of post 1964 sediment transport studies on Redwood Creek, which shows that sediment was dispersed downstream over time and deposited in lower energy environments on the flood plains and in the stream channels.

3. A shallow pool structure generally predominates in moderate gradient tributary streams. In these lower energy gradient environments, low stream pool frequency and shallow pool depth coincide with contemporary fisheries studies showing predominantly young of the year steelhead populations and absence of coho. This contrasts with the earliest fisheries studies dating back to the early 1960s showing deeper and more frequent pool structure with consistent coho observations, and older steelhead found in these many of these same areas. This is particularly noted adjacent to late 1950s/ early 1960s tractor areas that continue to discharge debris into watercourse during large storm events, i.e. Buckeye and Wheatfield Basins. The extent to which that recovery is slowed by current land use practices, interacted with more recent storm events, is unknown. However it is apparent that instream conditions noted in these areas are not fully supportive of anadromous salmonids today.

GENERAL RECOMMENDATIONS

1. Decommission or upgrade roads to minimize the potential for additional debris and sediment inputs to watercourses. This assessment finds that streamside roads and landings built 40 to 50 years ago are heavily concentrated in the watershed, and are a high priority need for stabilization. The Logging Impacts Map shows specific locations The large-scale stabilization program carried out in Fuller Creek is exemplary in promoting the recovery of the aggraded stream channel conditions in an area identified with the worst of the logging related damage in the watershed. Recommendations for road abandonment and improvements are:

2. Properly size all road watercourse crossings based on the 100 year return period standard recently implemented, and install bridge crossings over all Class I watercourses to reduce the potential for failure and washout.

3. Increase size and density of trees and promote replanting in the riparian corridors in the entire Gualala River watershed, especially in the eastern areas predominated by oak woodland and chaparral, and the Wheatfield Fork subbasin

Vegetation

Prior to European settlement, coniferous forest extended throughout approximately two thirds of the watershed. Dense old growth redwood forests occupied the northwestern portion of the watershed, particularly the alluvial North Fork sub-basin. Old growth redwood also lined the long and narrow South Fork valley basin. Douglas fir predominated in central and mid slope locations more distant from the coast.

Further inland in the eastern portion of the watershed, the natural distribution of Douglas fir becomes increasingly fragmented. Here, the long summer drought limits Douglas fir to north facing slopes. The oak-woodland predominates as a more continuous distribution on higher, inland terrain the more distant from the coastal marine

influence. Large areas of prairie grassland occupy the driest sites along ridge and upslope locations. These occupy larger continuous areas on the highest and easternmost areas of the watershed.

Fluvial Geomorphology

In response to the 1964 storm, sediment accumulated in many of the upper reaches –the transport reaches. Prior land use, such as in-stream landings and roads, elevated sediment loads. Some of the sediment blocked active channels; the rest become stored outside of the active channel. Subsequently, the accumulated sediment in the active transport channels generally has been dispersed downstream, where its fate is unknown. The rest has been variably vegetated and stabilized but may remain available for remobilization during sufficiently high flows.

Although other recorded peak discharge flood events have exceeded the 1965 water year, data are not readily available for evaluating the relative impact of these individual events on the watershed. An indication of the recent general changes in channel character is being provided in the final DMG report through comparison of reconnaissance mapping from aerial photos taken in the springs of 1984, 1999 and 2000. These maps show that in much of the watershed the length of general channel characteristics indicative of excess sediment (multi-thread channels, numerous lateral bars, eroding banks, etc.) has decreased over the most recent 15 year period.

The Gualala River fluvial system is unique in many ways. In many areas during high flows, tributaries back up and drop sediment at their mouths, which is later incised as flows diminish. This backwater effect was noted in several of the main tributaries and has formed a sediment mound in the active channel. During low flows, stream water percolates though the mound rather than flowing over it. It is unpredictable, at this time, whether future flows will reduce or build these mounds. m

The river persists in transporting and storing sediment even at elevated loads. The residence time of excess sediment accumulated in transport reaches is relatively short (in a geologic sense) and some recovery is apparent over decades. However, excess sediment accumulated in lower depositional reaches is hard to quantify and may remain much longer with only vague evidence of recovery. The Gualala River Watershed was similarly affected by 1964 flood and antecedent logging, and was studied well beyond the scope of this assessment. There, long term channel surveys show sediment delivered during the 1964 flood are still stored in the middle and lower reaches (Oazki and Jones, 1998 and 1999).

Thalweg Surveys

The vertical complexity of the stream channel was measured using thalweg surveys at the GRI GRWC monitoring reaches. GRWC protocols were followed, recoding elevation and distance at every significant change in the streambed through a 1000 foot reach. Elevation was measured with an engineer's level and distance with a 200' tape. Benchmarks and fixed starting and ending points were used to assure that the surveys are comparable from year to year. Area under the thalweg to an arbitrary zero level was calculated to allow accurate comparisons of thalweg elevation between years. Thalweg aggradation or degradation is reported in feet relative to the elevation of the channel in the first year of measurement.

Following a large sediment event, a significant aggradation of the channel (>1') is expected, followed by a slow degradation over the next several years (Madej, 1999). A stable channel is expected to fluctuate a little (< ± 0.5') each year. We have re-measured six thalweg surveys since 1998. No measurement has exceeded ± 0.5' from the original measurement. The thalwegs are fluctuating up and down by a few inches per year. There was a significant event on New Years Day 1997. If it had resulted in lasting channel aggradation, it would be expected that the repeat surveys would show a steady degradation. This has not been the case. Although it has only been four years with no significant stressing events, what has been measured would be consistent with the behavior of a stable channel.

While there are no significant changes in bed elevation at these sites on a year-to-year basis, scouring and redeposition during storm events has not been measured. Such events within any one year can be catastrophic for salmonid embryo survival, destroying or capping redds.

Madej, (1999) suggests using the variation index as a way of quantifying the roughness of a stream and hence its suitability for fish. The variation index is defined as [(standard deviation of residual water depths/bankfull depth) * 100]. A flat wide streambed with sediment filled pools would have a low variation index. A stream with many deep pools interspersed with riffles would have a high variation index. As the streams in the Madej study cleared of flood deposits after major events, the variation index approached or exceeded 20. The extent to which these indices are directly comparable to Gualala River's geology, fluvial network and processes, and hyrdology is not specifically known. However, when the variation index was calculated for the GRI GRWC thalweg survey data using the maximum bankfull depth measured in the DFG 2001 habitat surveys in the Gualala, most of the variation indexes were well above 20.

TABLE 2: VARIATION INDEX

Variation Index of Thalweg Profiles

Watershed Cooperative Monitoring Program

(1998 - 2000)

Watershed	Site Number	Watershed* Size (acres)	Variation Index 1998	1999	2000	2001
North Fork Subbasin						
North Fork	473	30,600				36.8
North Fork	204	25,433		43.6		49.6
Little North Fork	404**	4,217				46.8
Little North Fork	203**	1,963	23.1	20.9	20.9	20.2
Robinson	207	1,068		18.2		
Dry Creek	211	4,104	63.3	57.6	58.8	55.6
Dry Creek	212**	3,756			43.8	
Rockpile Subbasin						
Rockpile Creek	221	22,373	19.0	11.9		
Buckeye Subbasin						
Buckeye Creek	223	25,588			46.4	
Buckeye Creek	231	21,198	53.4			
South Fork Subbasin						
South Fork	217**	157,415	39.1		36.5	33.9
South Fork	402**	31,081		21.0		
Pepperwood Creek	218**	1,825	19.5	17.5		

*Watershed size is calculated as the area above the monitoring site.

**Maximum Bankfull depth estimated from cross-section surveys

Water Quality

The water quality analysis included comparison of available data to water quality objectives from the Basin Plan, Total Maximum Daily Load suggested targets, and EMDS dependency relationships (thresholds) and other ranges and thresholds derived from the literature (Table 1). With the exception of the Basin Plan objectives, these ranges and thresholds are not legal regulatory numbers. Rather, they are based on information available at the time and are expected to change as new data and analyses become available.

The D_{50} ranges are based on a study by Knopp (1993) who measured a variety of instream parameters on a number of North Coast streams. He presented results for a group of 18 watersheds judged to have had no human disturbance history or little disturbance within the last 40 years. The mean D_{50} value of this data set was 69 mm. The minimum measured value was 37 mm, and the maximum was 183 mm. The intent in the analyses in this assessment is to evaluate the available data against Knopp's distribution. It is not the intent to suggest 37 mm as a minimum value independent of other information about the distribution of the data.

The temperature range for "fully suitable conditions" of 50-60 F (10-15.6 C) was developed as an average of the needs of several cold water fish species, including coho salmon and steelhead trout. As such, the range does not represent fully suitable conditions for the most sensitive cold water species (usually considered to be coho).

The lethal maximum temperature of 75 F (23.9 C) was derived from literature reviews presented in RWQCB (2000). Peak temperatures are important to consider as they may reflect short-term thermal extremes that, unless salmonids are able to escape to cool water refugia, may be lethal to fish stocks. The literature supports a critical peak lethal temperature threshold of 75 F, above which death is usually imminent for many Pacific Coast salmonid species (Brett, 1952; Brungs and Jones, 1977; RWQCB, 2000; Sullivan, et al., 2000).

TABLE 3: In-channel criteria used in the assessment of water quality data.

Water Quality Parameter	Range or Threshold	Source of Range or Threshold
PH	6.5-8.5	Basin Plan, p 3-3.00
Dissolved Oxygen	7.0 mg/L	Basin Plan, p 3-3.00
Temperature	No alteration that affects BUs [1]	Basin Plan, p 3-3.00
	No increase above natural > 5 F	Basin Plan, p 3-4.00
	50-60 F MWAT [2] – proposed fully suitable	EMDS proposed Fully Suitable Range [3]
	75 F daily max (lethal)	Cold water fish rearing, RWQCB (2000), p. 37
Sediment Settleable matter	Not to cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00
Suspended load	Not to cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00, 3-3.00
Turbidity	no more than 20 percent increase above natural occurring background levels	Basin Plan, p 3-3.00
Percent fines <0.85 mm	<14% in fish-bearing streams [4]	Gualala TSD, CRWQCB (2001)
Percent fines <6.4 mm	<30% in fish-bearing streams	Gualala TSD, CRWQCB (2001)
V* in 3rd order streams with slopes 1-4 % [5]	≤0.15 (mean) <0.45 (max)	Gualala TSD, CRWQCB (2001)
Median particle size (d_{50}) in 3rd order streams of slopes 1-4 %	>69mm (mean) >37mm (min)	Knopp (1993)

[1] BUs = Basin Plan beneficial uses
[2] MWAT=maximum average weekly temperature, to be compared to a 7-day moving average of daily average temperature
[3] EMDS = Ecological Management Decision Support model used as a tool in the fisheries limiting factors analysis. These ranges and thresholds were derived from the literature and agreed upon by a panel of NCWAP experts.

[4] fish-bearing streams=streams with cold water fish species
[6] CDFG=Calif. Department of Fish and Game habitat threshold

The data we compared to these ranges and thresholds from a water quality perspective were:

- Continuous water temperature data from data loggers
- Percent fines < 0.85 mm from McNeil samples
- D_{50} from pebble counts
- Dissolved oxygen, pH, conductance (dissolved solids), nutrients (nitrogen, phosphorus)

Turbidity and suspended solids data were not available for this assessment, and represent a limitation in the water quality part of the assessment. The data and summary plots are included in Appendix 9.

USEPA data from April of 1974 to June of 1988 indicate a moderately hard water oligotrophic stream with pH slightly above neutral, high dissolved oxygen, low dissolved solids, and low nutrients (nitrogen and phosphorus). RWQCB results from 2001 do not differ. There were no large differences among the stations, though South Fork pH and hardness values were somewhat higher than in the rest of the Gualala.

Water temperature is a limiting factor for most of the mainstem areas, and some tributaries. Water temperatures are expressed as the highest of the floating weekly average for the summer (MWAT). Those values were within the proposed "fully suitable" range of 50-60 F in many tributaries in the North Fork subbasin, and in some other small tributaries in other subbasins. Mainstem water temperatures for the larger streams (North Fork, Rockpile, Buckeye, Wheatfield Fork, and South Fork/Main Gualala) were above that range. More relationships by subbasin are provided in subsequent sections of this report.

Streambed substrate size is likely a limiting factor for salmonids. While streambed particle sizes (D_{50}) from 1997-2000 data provided by GRI and GRWC showed some improvements over time in some tributaries, D_{50} values were small in the remaining locations. It is well documented that small streambed particle sizes (gravel and lower) make for a more mobile streambed. Mobile streambeds can reduce salmonid embryo survival by destroying and/or capping the redds (Nawa et al., 1990). Smaller particles can smother salmonid embryos, especially those 6.5 mm and less in diameter (Bjornn, et al 1976).

Aquatic/Riparian Condition

Historic conditions for aquatic habitat in the Gualala River can only be inferred from fragmentary information in CDFG stream surveys from the 1960s and from historic aerial photo reconnaissance of canopy conditions. The stream surveys which are most useful are those that immediately followed World War II, and they revealed comparatively higher pool frequency and depth, and longer reaches of suitable spawning gravels. Post 1950s and 1960s era logging surveys documented a shallow pool structure, reduced pool frequency and water quality problems related to logging debris deposited into streams. Current habitat inventories showed shallower pool structure and reduced frequency on most of the tributaries surveyed throughout the watershed.

Canopy cover was complete in most tributaries as of 1942 indicating advanced regeneration from original old growth logging. Streams in the eastern portion of the Gualala basin had a naturally more open canopy even in 1942 photos. Aerial photos from 1961, 1965, and 1981 showed canopy closure substantially reduced. As of 2001, canopy cover measurements taken during habitat typing surveys show improving canopy closure. Aerial photos from 1999 substantiate these findings. Large wood is deficient in many areas of the Gualala River basin as a result of past timber harvest operations and large wood removal projects aimed at improving fish passage.

Stream buffers are important to the protection of fish habitat for several reasons. With respect to stream temperature, dense trees immediately along a stream provide shade from direct sunshine on the stream surface. Stream buffers with dense canopy also help to reduce air temperature, thus reducing convective heat inputs to streams; however, scientific investigations are still uncertain as to how wide and dense buffers need to be to adequately provide for this microclimate effect.

TABLE 4: Gualala Tributaries Surveyed 2001

Tributary Name	DFG Surveyed length (miles)	Length (Miles)	
		Permanent	Intermittent
Buckeye Creek	18.9	16.0	2.8
Danfield Creek	2.3	4.3	0.0
Doty Creek	1.2	2.7	0.0
Dry Creek	2.1	0.9	0.6
Dry Creek Trib. #1	0.5	0.0	2.9
Haupt Creek	0.4	4.8	0.9
House Creek	10.4	11.8	1.5
Little N. Fork Gualala	3.9	4.1	0.0
Little N. Fork Gualala Trib. 2	1.0	0.0	1.3
Log Cabin Creek	0.3	1.3	0.0
Marshall Creek	4.1	8.3	0.0
McGann Gulch	0.4	0.0	2.0
North Fork Gualala	11.3	13.6	0.0
Palmer Creek	0.1	0.0	1.3
Pepperwood Creek	3.4	3.7	1.1
Robinson Creek	1.5	0.8	1.6
Rockpile Creek	8.5	21.3	0.9
South Fork Gualala	1.6	35.7	0.6
Tombs Creek	7.1	8.5	0.0
Wheatfield Fork Gualala	22.1	28.8	2.6
TOTALS	**101.2**	**166.6**	**20.1**

ADD GIS-based HABITAT FIGURES HERE

Fish Habitat Relationship

Coho and steelhead utilize an anadromous life history strategy. The term anadromous refers fish that spawn in freshwater and migrate to the ocean to grow and mature before returning to freshwater streams to spawn. Anadromous salmonids have diverse life history strategies in order to reduce competition between species and also to increases the odds for survival of species encountering a wide range of environmental conditions in both the freshwater and marine environments. A summary of the life history strategies, and historic and

current status the anadromous salmonid population of Gualala River is provided below. Further details are provided in each subbasin discussion. A detailed account of coho salmon and steelhead and life histories is presented in Appendix X.

The Gualala River historically has been an important stream for its runs of coho (silver) salmon and steelhead. Historical records document large coho and steelhead populations. A 1970's U.S. Bureau of Reclamation study of northern California estimated that 75 miles of habitat was available to coho salmon in the Gualala Basin and that 4,000 adults returned annually (U.S. BOR, 1974). The CDFG reported 16,000 steelhead, 4,000 coho and zero Chinook (California Department of Fish and Game, 1965). However, according to anecdotal information provided by anglers, "stray" chinook salmon inhabited low gradient reaches of the mainstem and larger tributaries

Coho were known to spawn and rear in 14 tributaries, but began to decline by the late 1960's and few were observed in the 1970's stream surveys. Cox (1994) reported that coho were known to have spawned and reared in the North Fork, Buckeye, Wheatfield Fork and South Fork subbasins, including the following areas: lower to middle reaches of the North Fork and Little North Fork, the middle reaches of Buckeye Creek, including Franchini Creek, the middle reaches of Wheatfield Fork, the larger Wheatfield Fork tributaries including Haupt, House, and Fuller Creeks, and Marshall and Sproule Creeks in the South Fork. Steelhead were found to be the most abundant species in a fish community composed of coho, roach, stickleback, sculpins and lampreys. DFG stocked the North Fork subbasin several times to increase coho spawning stock. The last recorded coho young-of the-year was in Dry Creek in 1998.

Surveys from the 1960's and 1970's found salmonids in considerably higher numbers and in a larger geographic area in the watershed. Due to a lack of quantitative information, historical population estimates of anadromous salmonids are unknown. However, based on anecdotal information, amount of historical and current suitable habitat, qualitative assessments, and comparisons with other north coast streams, it is highly probable that populations have declined compared to historical numbers throughout the watershed.

The 2001 electrofishing surveys showed that coho salmon were not observed in their historic tributaries and steelhead one year and older may have decreased in some tributaries in the watershed. Overall the watershed appears to be dominated by roach and steelhead young-of-the-year, with steelhead one year and older present, but in smaller numbers.

ADD FIGURES: BASIN HISTORIC AND CURRENT DISTRIBUTION

In 2001, the following tributaries were electrofished to identify species composition: North Fork; Little North Fork; Doty; Franchini; Wheatfield; House; Haupt; Pepperwood; and Tombs Creeks. Data indicated that differences in fish community structure exist between subbasins. The North Fork Basin was dominated by sculpin, roach and steelhead young of the year. Fish data was unavailable for the Rockpile subbasin. The Buckeye subbasin showed that Franchini Creek was dominated by steelhead one year and older in the middle and upper reaches with steelhead young-of the-year present. The Wheatfield subbasin was dominated by roach with few steelhead one year and older present. Very little of the South Fork was available to survey due to the lack of landowner access. Steelhead young of the year were dominant in the two reaches that were sampled. Further research and improved sampling strategies would greatly benefit stock assessment efforts.

ADD FIGURES: BASIN HISTORIC AND CURRENT DISTRIBUTION FROM EFISHING

TABLE 5: Fishery Resources of Gualala River

COMMON NAME	SCIENTIFIC NAME
ANADROMOUS	
Coho Salmon	*Oncorhynchus kisutch*
Steelhead Trout	*Oncorhynchus mykiss*
Pacific Lamprey	*Lampetra tridentata*
FRESHWATER	
Coastrange Sculpin	*Cottus aluticus*
Prickly Sculpin	*Cottus asper*
Threespine Stickleback	*Gasterosteus aculeatus*
MARINE OR ESTUARINEDEPENDENT	
Surf Smelt	*Hypomesus pretiosus*
Shiner Surfperch	*Cymatogaster aggregate*
Staghorn Sculpin	*Leptocottus armatus*
Starry Flounder	*Platicthys stellatus*
AMPHIBIANS	
Pacific giant salamander	*Dicamptodon tenebrosus*
Tailed Frog	*Ascaphus truei*
Red-Legged Frog	*Rana aurora*
Foothill Yellow-legged Frog	*Rana boylei*

Anadromous Salmonid Natural History

Steelhead

Steelhead trout are an anadromous strain of rainbow trout that migrate to sea and return to inland rivers as adults to spawn. In contrast to all Pacific salmon, not all steelhead die after spawning. U.S Fish and Wildlife service stated that a run of approximately 10,000 steelhead occurred in Gualala River in 1960 (USFW 1960). This is an uncertain estimate, for it was contrived from data relating to other streams of similar size and characteristics which were then applied to Gualala River. It is unknown if the Gualala River support different stocks of steelhead. Local fishermen remember three different stocks: winter run, “bluebacks” or “half-pounders”.

Generally, throughout their range in California, steelhead that are successful in surviving to adulthood spend at least (the most successful young steelhead spend from) two years in fresh water before emigrating downstream. In the Gualala River, steelhead generally migrate as 2-year old smolts during spring and early summer months. Emigration appears to be more closely associated with size than age, 6-8 inches being the size of most downstream migrants. Downstream migration in unregulated streams has been correlated with spring freshets.

In the Gualala River watershed, steelhead were the only species of salmonids observed in 2001 electrofishing surveys. All streams surveyed in the watershed contained steelhead populations of various concentrations (Brown 1988; DFG surveys 2001). Young of the year steelhead were the dominant age class found.

Steelhead numbers have diminished from historic numbers, whereas coho were not observed anywhere in the subbasin. The ability of steelhead to persist may be attributed to their ability to inhabit stream conditions that are available in many of the tributaries of Gualala River. These tributaries have steep gradients, migration barriers, lack of channel complexity, and exhibit higher water temperatures that limit production of coho salmon. Steelhead have displayed more adaptability to these conditions.

Coho Salmon

California coho salmon (*Oncorhynchus kisutch)*, also known as silver salmon, are listed as threatened under the Federal Endangered Species Act (ESA; NMFS 1995). This listing has come as a response to the declining numbers throughout their southern range. A 1995 estimate stated that less than 5,000 wild coho salmon (no hatchery influence) spawned in California each year (Moyle et. al 1995). This is a drastic decline from statewide estimates in the 1940's, which assumed there was anywhere from 200,000 to one million adult coho in California (Calif. Advisory Committee on Salmon and Steelhead Trout 1988). Essentially, coho populations are less than 6% of what they were in the 1940's.

Coho salmon exhibit a three-year life cycle and do not appear to have the genetically distinct and spatially separated runs that other salmon and steelhead trout have displayed. After spending two years in the ocean, coho return to spawn in late fall and early winter following seasonally significant rains. As with other species of salmon, coho die after spawning. Unlike other salmon species, coho salmon redds can be situated in substrates composed up to 10% fines (Emmett, et al, 1991), but typically spawning success and fry survival are favored by very clean gravel consisting of less then 5% fines (CDFG 1991).

Juvenile coho typically spend one year in the freshwater streams before migrating out to the ocean. Consequently, adequate cover, cool water, high canopy density, and sufficient food to sustain them through their fry and juvenile stages become critical habitat components. Specifically, secondary channel habitats, such as cool, backwater pools with a large woody debris cover, are highly preferred habitat conditions for developing juvenile coho salmonids (CDFG 1991).

The Gualala River watershed, like other systems in California, have suffered declines or absent populations of coho. Coho were estimated to have a run of _____ spawners in 1960 (U.S. Fish and Wildlife 1960).

Fish History and Status

Fishing Interests, Constituents

In progress

Fish Restrictions, Acts, Protections

In progress

Fish Restoration Programs

In progress

Special Status Species

In progress

Ecological Management Decision Support (EMDS)

Introduction

This report is intended to be useful to landowners, watershed groups, and individuals to help guide land use and management decisions. As noted above, the assessment operates on multiple scales ranging from the detailed and specific stream reach level to the very general basin level scale. In the Gualala, for example, there is a general problem with elevated amounts of fine-grained sediment in lower gradient stream channels. These are reaches used by coho salmon and steelhead trout. This sediment is generally harmful to salmonid habitat as discussed above, and developed in the following discussion about the EMDS model.

This condition is not uncommon throughout most of the overall NCWAP coastal region. To improve that condition, and therefore salmonid habitat, will require long periods of time even with reduced levels of erosion brought about by careful watershed stewardship. A goal of this program is to help guide, and therefore accelerate that recovery, by focusing, stewardship and improvement activities where they will be most effective. Scaling down through finer levels guided by the recommendations should help accomplish this focus.

To do so, the report is constructed to help provide that focus of energy and other resources. A user can focus down from the general basin finding and recommendation concerning high sediment levels to the various subbasin sections, or the summary subbasin recommendation table to see if the general recommendation is applicable to a subbasin of interest. From there, if that is the case, the next step is to determine which streams in the subbasin may be affected by sediment. There is a list of surveyed streams in each subbasin section. In the general recommendation section, there is a tributary finding and recommendation summary table that indicates the findings and recommendations for the surveyed streams within the subbasin. From there, if indicated, field investigations at the stream reach or project site can be conducted to make an informed decision on a project, or design improvement activities.

For example in the Gualala Wheatfield fork Subbasin, sediment is an issue in the findings and recommendations. From the list of tributaries in the subbasin section the tributary table can be referred. House Creek is a Wheatfield fork Subbasin stream on that list that has both streambank and road sourced erosion as issues for treatment related to land use projects or improvement activities.

During the past two years, numerous landowners gave permission for erosion control surveys to be conducted on their lands in cooperation with the Gualala River Watershed Council and the DFG Restoration Grants Program based upon the recommendation in this DFG Stream Report. NCWAP, through its EMDS tool and resultant spatial presentation of its findings will provide the opportunity to conduct better coordinated stewardship and restoration work like this at the much broader, basin scale.

A NCWAP Tool for Data Synthesis

As part of the watershed assessment, the NCWAP team is using computer models called knowledge base or expert systems. These are tools that help scientists define how a complicated ecosystem, such as a watershed, functions. The software allows scientists to combine data of different environmental factors, such as stream temperature and substrate composition, to produce a synthesis of watershed conditions for native salmonids. The tools provide a consistent and repeatable approach to evaluating conditions across numerous watersheds in the region. The knowledge base modeling software requires scientists to identify and evaluate specific environmental factors or attributes which contribute to the formation of anadromous salmonid habitats.

For this purpose, the NCWAP will employ a linked set of software: NetWeaver, Ecological Management Decision Support (EMDS) and ArcView™. NetWeaver (Saunders and Miller (no date)), developed at Pennsylvania State University, helps scientists build graphics of networks that specify how the various environmental factors are incorporated into an overall stream or watershed assessment. These networks resemble branching tree-like flow charts, and graphically show the logic and assumptions used in the synthesis.

EMDS (Reynolds 1999), was developed by Dr. Keith Reynolds at the USDA-Forest Service, Pacific Northwest Research Station. It uses the networks created with NetWeaver in conjunction with environmental data stored in a geographic information system (ArcView™) to perform the assessments and facilitate rendering the results into maps. This combination of NetWeaver/EMDS/ArcView software is currently being used for watershed assessment within the federal lands included in the Northwest Forest Plan.

The Knowledge Base Network

For California's north coastal watersheds, the NCWAP scientists built two knowledge base networks using the best available scientific studies and information on how various environmental factors combine to affect anadromous fish on the north coast. The first, called the Stream Reach model, addresses conditions for salmon on individual stream reaches. The second, the Watershed Condition model, serves as a framework for synthesis by watershed of a number of environmental factors. In creating both of these networks, the NCWAP scientists have used what is termed a 'top-down' approach.

This is perhaps best explained by way of example. The NCWAP scientists start from the proposition that the overall condition of a given watershed is suitable for maintaining healthy populations of native salmon and trout, and through the design of the knowledge base (the network) seek to evaluate the 'truth' of that assertion. They then constructed a knowledge base network is to specify the types of information needed to test the proposition, and how each will be used.

The 'ingredients', or data, needed for the assessment are broken down into categories. To evaluate watershed conditions for salmonids, the scientists specified that data are required on several general environmental factors. The knowledge base network (figure 1) shows that information on upland condition, roads, passage barriers, and stream condition factors are all needed in the watershed assessment. The 'AND' decision node (where the factors are combined) means that each of the four general factors must be suitable for the fish for the 'watershed is suitable for native salmonids' proposition to be evaluated as completely 'true'.

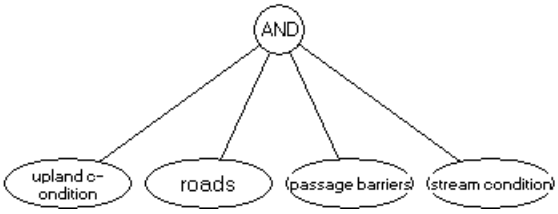


FIGURE 5

The Knowledge Base is for Assessing Watershed Conditions for Native Salmonids. Each of the Elliptical Boxes Shows a Factor Used in the Assessment and Lines Indicate How They are Linked to the "AND" Node Where They are Compared.

In a similar manner, each of the four main environmental factor is actually made up of smaller constituent components. For example, in the NCWAP Watershed Condition model the 'upland condition' factor consists of a sub-network of more detailed data on land use, land cover (vegetation) and slope stability that determine it (not shown in the above figure). Information in the sub-network that determines land use includes data on developed area, cultivated area, grazed area and area of timber harvests. In knowledge bases, this pattern of logic networks can be expanded up or down as much as desired, until there is a full picture of all factors affecting salmonid conditions in the watershed. The beginning boxes (end branches) in a knowledge base network are where the data is entered.

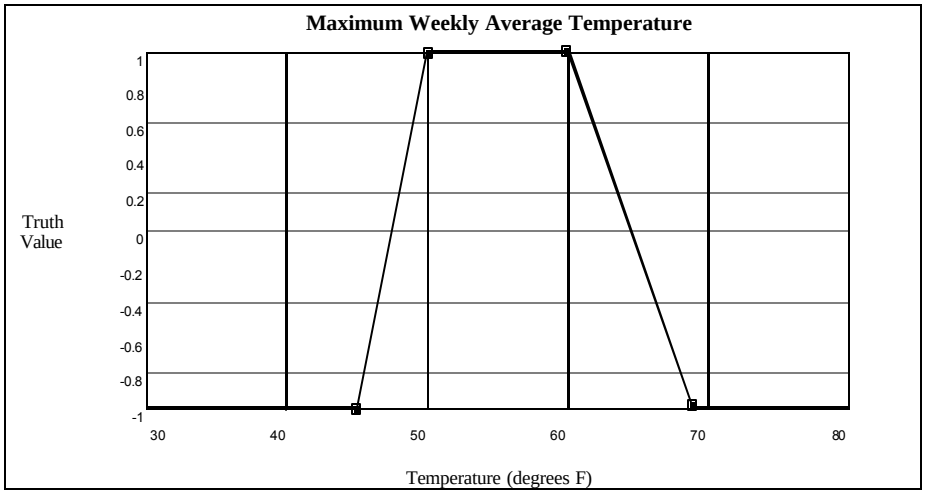


FIGURE 6: Relationship between Water Temperature and Suitability for Salmon

EMDS Uses this Type of Function in Conjunction with Data to Evaluate a Proposition, in this Case that "Water Temperature is Suitable for Native Salmon and Trout."

Wherever there is a proposition in the network, scientists use simple graphs that determine its degree of truth, according to the data and its implications for salmon. Figure 2 shows an example, where the proposition is "the stream temperature is suitable for salmon". The horizontal axis shows temperature in degrees Fahrenheit, while the vertical is labeled 'Truth Value' and ranges from –1 to +1. The line shows what are completely unsuitable temperatures (-1), completely suitable temperatures (+1) and those that are in-between (> -1 and <+1). In this way, similar graphic relations are created for all propositions in the EMDS evaluation.

For all evaluated propositions in the network, the results are a number between –1 and +1. The number shows the degree to which the data support or refute the 'conditions are suitable' proposition. In all cases a value of +1 means that the proposition is 'completely true', and –1 implies that it is 'completely false', with in-between values indicate 'degrees of truth' (i.e. values approaching +1 being closer to true and those approaching –1 converging on completely untrue). A zero value means that the proposition cannot be evaluated based upon the data available. Breakpoints (where slope of function changes) in the figure 2 example occur at 45, 50, 60 and 68 degrees F. The NCWAP fisheries biologists determined these temperatures by a search of the scientific literature.

In EMDS, the data that is fed to the knowledge base network comes from GIS layers stored and displayed in ArcView. Thus many of the GIS data layers developed for the program will be used directly in the watershed condition syntheses.

Advantages Offered By Netweaver/EMDS/ArcView Software

The NetWeaver/EMDS/ArcView software offers a number of advantages for use in the NCWAP. At this time no other widely available package allows a knowledge base network to be linked directly with a geographic information system such as ArcView. This link is vital to the production of maps and other graphics reporting the watershed assessments.

The graphs and NetWeaver-based flow diagrams required that the NCWAP scientists be forthright and explicit in how they have defined suitable conditions for salmonids needed for the completion of their lifecycle. The process was thus formalized and quantified, and is now repeatable systematically throughout the assessments of all watersheds. Equally important, the nature of the networks assists open communication to the general public through simple graphics and easily understood flow diagrams.

Another feature of the system is the ease of running alternative scenarios. Scientists and others can test the sensitivity of the assessments (i.e. perform 'sensitivity analyses') to different assumptions about the environmental factors and how they interact, through changing the knowledge-based network and breakpoints. 'What-if' scenarios can be run by changing the shapes of curves (e.g. figure 2) at the base level, or by changing the way the data are combined and synthesized in the network.

NetWeaver/EMDS/ArcView tools can be applied to any scale of analysis, from reach specific to entire watersheds. The spatial scale can be set according to the spatial domain of the data selected for use and issue(s) of concern. Alternatively, through additional network development, smaller scale analyses (i.e. subwatersheds) can be aggregated into a large hydrologic unit. With sufficient sampling and data, analyses can even be done upon single or multiple stream reaches.

NetWeaver ranks the environmental factors (given the logic and environmental factors <-> conditions relationships) by their influence on the overall habitat indicator values derived. They also show which factors, with more complete and comprehensive data, would improve the quality of the analysis in the most cost-effective manner.

EMDS and NetWeaver are public domain software (NetWeaver on a trial basis), available to anyone at no cost over the Internet. Although the NCWAP will employ EMDS and NetWeaver for watershed synthesis, this is not meant to preclude the use of other knowledge base expert systems, approaches, or models for further exploration of fish-environment relationships.

Management applications of watershed synthesis results

While EMDS-based syntheses are important tools for watershed assessment, they do not by themselves yield a course of action for management. EMDS results will require interpretation, and how they are employed depends upon other important issues, such as social and economic concerns. In addition to the accuracy of the expert opinion and knowledge base system constructed, the currency and completeness of the data available for a stream or watershed will strongly influence the degree of confidence in the results.

The output from EMDS Watershed and Stream Reach models will be used to support several levels of planning. At the regional level, the State anticipates the NCWAP analyses to be incorporated into coho, chinook, and steelhead recovery plans being developed by National Marine Fisheries Service (NMFS). It will provide a finer level of detail than factors identified at the Evolutionary Significant Unit (ESU) or domain level. This can assist recovery plan development, to focus on appropriate conditions and potential corrective actions by landowners and others. The results of the synthesis will also aid watershed level planning by watershed groups and others. It can provide direction for developing a strategy and sequence for fixing habitat “bottlenecks” to salmonid production or health.

EMDS syntheses can be used at the basin scale, to show current watershed status. Maps depicting those factors that may be the largest impediments, as well as those areas where conditions are very good, can help guide protection and restoration strategies. The EMDS model can also help to assess the cost-effectiveness of different restoration strategies. By running sensitivity analyses on the effects of changing different habitat conditions, it can help decision makers determine how much effort is needed to significantly improve a given factor in a watershed and whether the investment is cost-effective.

At the project planning level, the model results can help landowners, watershed groups and others select the appropriate types of restoration projects and places (i.e., planning watersheds or larger) that can best contribute to recovery. Agencies will also use the information when reviewing projects on a watershed basis.

The main strength of using NetWeaver/EMDS/ArcView knowledge base software in performing LFAs is its flexibility, and that through explicit logic, easily communicated graphics and repeatable results, it can provide insights as to the relative importance of the constraints limiting salmonids in North Coast watersheds. In the NCWAP, the analyses will be used not only for assessing conditions for fish in the watersheds and to help prioritize restoration efforts, but also to facilitate an improved understanding of the complex relationships between environmental factors, human activities, and overall habitat quality for native salmon and trout.

EMDS in the Gualala River Assessment

Note to the reader: The final EMDS model was analyzed for the Northfork subasin. The other subbasins will be addressed in the next version of the synthesis report. The results are contained in the appendix.

Analyses and Results by Subbasin

Gualala Basins: Estuary, Northfork, Rockpile, Buckeye, Wheatfield, Main/Southfork

Introduction

For the purpose of the NCWAP study of Gualala River watershed, the basin is divided into five subbasins. The five subbasins conform with Calwater 2.2 Planning Watershed boundaries. Data analysis and subsequent synthesis was by subbasin, providing detail on a smaller scale. More detailed information is included in Appendices. Table 6 provides a subbasin summary table.

TABLE 6: Gualala Subbasin Summary.

Subbasin	Northfork	Rockpile	Buckeye	Wheatfield Ffork	Mainstem Southfork	Total
Square Miles	47.86	34.98		40.26	47.86	
Acreage, Total						
Private Acres	99%	100%	99%	99%	100%	
Federal Acres	0	0	0	0	0	
State Acres	0	0	0	0	0	
Principal Communities	Gualala	Gualala	Gualala	Annapolis	Cazadero	
Predominant Land Use	Timber Grazing Subdivision	Timber Grazing	Timber Grazing Agriculture	Timber Grazing Agriculture	Timber Grazing Agriculture	
Predominant Vegetation Type	Coniferous Deciduous					
Miles of Blue Line Stream						
Low Elevation						
High Elevation						

Gualala Estuary

Introduction

The Gualala River estuary/lagoon is located approximately 0.5 miles south of the town of Gualala. Estuaries are links between freshwater and marine environments where mixing of sea water and freshwater creates environmental conditions that are well suited for the anadromous life history life strategy used by salmon, steelhead, and cutthroat trout. These fish pass through the estuary during seaward migrations as

juveniles and as adults, gain access though the estuary to the freshwater during spawning migrations. The brackish water of the estuary provides an important area where salmonids can acclimate to changes in salinity as they move between the freshwater and marine environments. In addition, the mixing of seawater and freshwater that occurs in the estuary helps create a very productive environment for fish. Because of their high productivity and isolation from predators, estuaries are considered important nursery areas for juvenile fish including salmon, steelhead, and coast cutthroat trout. During summer months, a sand bar typically forms across the mouth of the estuary that blocks the flow of tidewater and creates a coastal lagoon.

The Sotoyome Resource Conservation District, in partnership with the Gualala River Watershed Council, has been awarded a $150,000 grant by the California Coastal Conservancy to perform a Gualala estuary assessment and to develop an estuary enhancement plan. The goal of the assessment is to thoroughly assess the physical and biological conditions of the estuary and lower river, ascertain the estuary's importance to the life history pattern of salmonids, and determine how existing conditions may be impairing ecological productivity in the project area. The key questions to be answered are: *What is the role of the Gualala River Estuary with respect to salmonid abundance and distribution, as habitat for steelhead and coho salmon?* And second, *What factors may be limiting salmon and steelhead production in the estuary?*

Following this assessment, and based upon the findings of the assessment, an enhancement plan will be developed which will provide specific recommendations for the enhancement of the lower Gualala River and estuary.

Geology

In progress.

Vegetation

The riparian was probably alder with a redwood over story along the upper estuary (above the bridge). But most photos of the lower estuary are after the mill (on the flat area north and ocean side of the bridge) was built so we can't tell if that area was cleared or naturally scrub. Wetlands are primarily on the lower south side of the estuary.

Land Use

Early Land Use

Native Americans made extensive use of the Gualala River. Pomo villages and seasonal campsites were located throughout all of the Gualala River sub basins. Areas most frequently settled were "alongside river or creek banks, in sunny meadow clearings (Park, 1980). The forests contained abundant wildlife and salmon were available seasonally. Fire was used by the native americans as a land management tool. Forests were routinely burned to reduce the fuel loading as an aid to hunting and to urge new vegetation growth.

The Kashia Pomo occupied about 30 miles of the coast of northwest Sonoma County and extended inland for 13-15 miles (Bean and Theodoratus, 1978). This territory encompassed the Wheatfield Fork sub basin and the South Fork sub basin from its headwaters to the Wheatfield Fork. Bordering the Kashia to the north were the Yokiya of Rockpile. The Yokiya inhabited a " rough strip of land about eight miles in width along the coast, and possibly 18 miles inland" (Park, 1980). The Yokiya region appears to include both the Buckeye and Rockpile sub basins.

A third group of Native Americans that inhabited the watershed were the Bokeya Pomo. Lands of the Bokeya extended from the Gualala River to just north of the Navarro River. The Bokeya occupied the North Fork sub basin with villages and campsites at the headwaters of the North Fork and settlements at the coast near the mouth of the Gualala River.

Fish History and Status

The Gualala estuary/lagoon provides critical habitat in the life cycle of anadromous salmonids and many other valuable fishery resources. Estuaries are the nexus between freshwater and marine environments which anadromous salmonids pass through as juveniles during seaward migrations and where adults gain access to their natal rivers during spawning migrations. Estuaries are recognized as valuable salmonid nursery areas because they

provide abundant food supplies, they offer protection from predators, and are diverse habitat areas. Several fish species, have adopted an estuarine residency, particularly for reproduction and early stages of their life cycle. Some species deposit eggs or give live birth directly in estuaries, while others have evolved mechanisms which help the delivery of their young into estuaries by ocean tides or riverine currents. Fish including salmonids that utilize estuaries for an important part of their life cycle are referred to as estuarine-dependant. The estuarine rearing is a strategy that adds diversity to juvenile salmonid life history patterns and likely increases the odds for survival of a species encountering a wide range of environmental conditions in both the freshwater and marine environments. An extended estuarine residency may be especially beneficial for salmonids from rivers where low summer flows or warm water temperatures severely limit summer rearing habitat. An Account of the Fishes Caught in the Lower Gualala River, California, 1984 through 1986 – Charles Brown Bay Delta Fisheries Project:

Subbasin	Northfork	Rockpile	Buckeye	Wheatfield Ffork	Mainstem Southfork	Total
Current Fish Species	steelhead pacific lamprey prickly sculpin coastrange sculpin roach 3 spine stickleback	steelhead roach pacific lamprey prickly sculpin coastrange sculpin 3 spine stickleback	steelhead roach pacific lamprey coastrange sculpin	steelhead roach pacific lamprey	steelhead roach pacific lamprey	steelhead roach pacific lamprey prickly sculpin coastrange sculpin 3 spine stickleback

Sampling occurred at seven stations, two upstream of the Highway 1 bridge. “We caught seven species of fishes in the Gualala Estuary and lower river. Steelhead were caught at all stations. Roach, coastrange and prickly sculpin were caught at lower river and upper estuary stations. Starry flounder and Pacific staghorn sculpin were only caught in the lower estuary near the ocean. Threespine stickleback were caught in the lower river and upper to mid-estuary”. “Steelhead were larger in the fall than in the spring at mid-estuary stations, but larger in the spring at lower estuary stations”.

Currently, the Gualala River Watershed Council has a grant for a two year study. The main stem tidal influence ending point is being identified and the study site includes up to the confluence of the NF.

The bar at the bridge appears to be increasing along with increased island formations around the old mill pier structures. Mendocino county has been doing cross-sections surveys at the bridge and Gualala Aggregates has cross-sections installed upstream of the bridge.

Fish Habitat Relationship

The present condition of the Gualala estuary/lagoon has limited the biological function and therefore production of salmonids. Over the past 100 years, the construction and operation of a mill in the 1860s to the early 1900s, railroad and road development within the flood plane, a Highway Bridge and artificial breeching of the bar have modified the physical structure of the estuary. The need for artificial breeching may have been due to both changes in the ocean currents and weather patterns and excessive sediment accumulations from naturally occurring geology and land use activities. Excessive sediment accumulation has probably reduced the size of the estuary and wetland areas, reduced the tidal prism, and altered drainage patterns all which impair the physical function and the ability of the estuary/lagoon to fully support salmonids.

Subbasin Issues

The term 'issues" is used here in a generic sense to denote any topic of interest, concern, import, or relevance to the watershed assessment. As such, issues can be direct limitations on salmonid suitability, potential factors for consideration, concerns regarding potential practices, suggestions, or observations of the data that are particularly relevant to the development of hypotheses and recommendations.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***The present state of estuarine habitat is limiting the production of salmonids in Gualala River.***

Supporting Findings:

In progress.

Contrary Findings:

None noted.

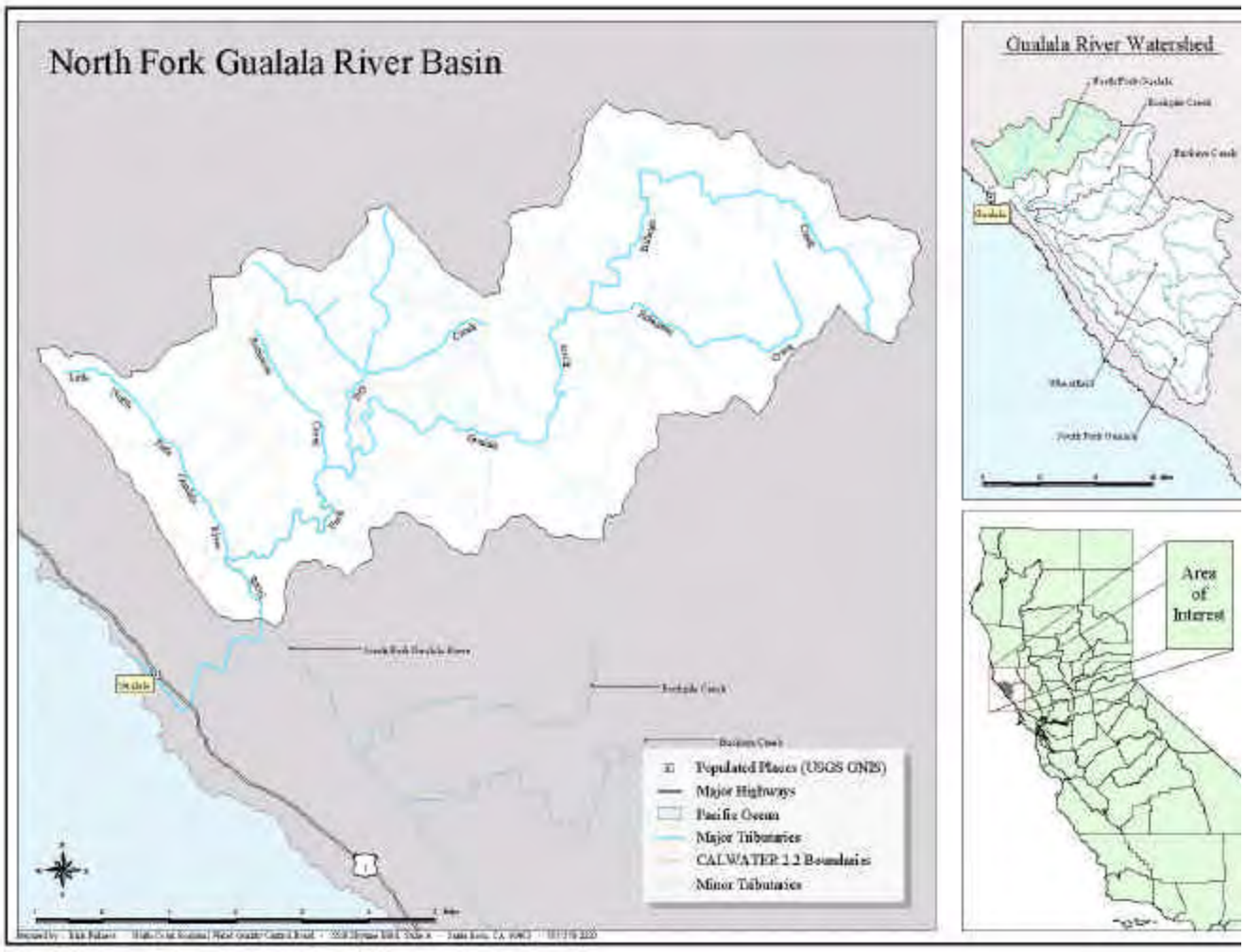
Recommendations:

- Encourage present estuary assessment program and provide technical assistance when necessary.
- Develop long term temperature monitoring program.
- Continue and/or expand monitoring anadromous salmonid population efforts.
- Work with responsible agencies, the Gualala River Watershed Council and landowners to improve physical structure and biologic function of the estuary.
- Continue efforts such as road improvements and decommissioning throughout the basin to reduce sediment delivery to Gualala River and its tributaries.
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Gualala River and its tributaries. Where current canopy is inadequate and site conditions are appropriate, use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy.

Introduction

The North fork subbasin is under management by the Pioneer Ltd., Mendocino Redwood Co., Gualala Redwoods Inc., and other smaller private landowners. The land is primarily used for timber production, grazing, small vineyards and rural 40 acre and larger subdivisions.

FIGURE 7: North Fork Gualala River Basin



Geology

The steepest topography and broadest tributary valleys are found in the North Fork basin (Plate 1). The area is characterized by rectilinear, low ordered drainages underlain by the Coastal Belt of the Franciscan Formation. Preliminary interpretations suggest that this part of the Gualala watershed was uplifted more recently than the remainder. A series of NW trending strike-slip faults have offset drainages in a uniform manner. Although the formation of this region created steep slopes, the area is relatively more stable and coherent compared to the rest of the watershed. Steep, V-shaped, narrow, rectilinear, fault controlled valleys characterize the upper reaches of the basin. A parallel network of faults creates a stream network with a simple zigzag pattern consisting of a high density of short, closely spaced drainages. Rosgen classes range from A++ to B types. Type A channels are characterized by “inherent channel sternness, high sediment transport potential, and relatively low in channel sediment storage capacity”. In eastern half of the NF basin, Central Belt mélange underlies prairies. Large areas of active earthflows and other forms of landsliding are abundant and contribute sediment to watercourse. The

steep drainage gradients in the upper reaches can be generally characterized as supply (>12%) or transport (4-12%) reach categories.

In lower reaches of the basin, streams generally meander through alluviated valleys that range from a couple hundred feet to almost one thousand feet across within steep, U-shaped valleys. Streams in this area are characterized by "C" type Rosgen with "sinuous, low level relief, well developed flood plains built by the river, and characteristic point bars within the active channel". Continual sediment deposition and storage in these reaches probably dates back millennia or more. The valley floors broaden downstream toward the San Andreas Fault.

There is an abrupt steepening of stream grade where the river enters the San Andreas Fault Zone. An anomalous mound of sediment has formed immediately upstream of the confluence with the Little North Fork as is common in many areas. This sediment accumulation may be related to deposition caused by the slowing of the North Fork as it merges with flows of the Little North Fork. This frequently observed situation is informally known as a "back water effect". The active channel of the North Fork has incised into the mound of sediment, leaving much of the sediment stored on the flood plain.

Vegetation and Land Use

The North Fork subbasin has the longest span of past land use practices in the watershed. The redwood dominated alluvial flats were clear-cut around the turn of the century. During the logging of the 50s and 60s, these areas were considered pre-merchantable young growth. In the purchase discussions for GRI in 1948, the second growth redwood was given zero value. These stands have mostly been selectively cut two times since the original turn of the century clear-cut. Aerial photos from 1936 show these areas area forested with predominantly mid-sized second growth redwood with no active road network. The 1936 shade canopy cover map (Figure 6 below) shows bank to bank exposure limited to the lower basins alluvial floodplains. At this time, the channel was naturally aggraded and wide, preventing dense wooded conifer growth adjacent to the stream channel. Upstream of the confluence with Dry Creek, topography is narrowly incised with conifer canopy entirely covering the main stem North Fork until one reaches the melange, which is largely non-coniferous and lacking in canopy. There was entire bank to bank cover over all tributary watercourses in the middle and lower North Fork basin, including Stewart Creek, Dry Creek, Robinson Creek, and Doty Creek.

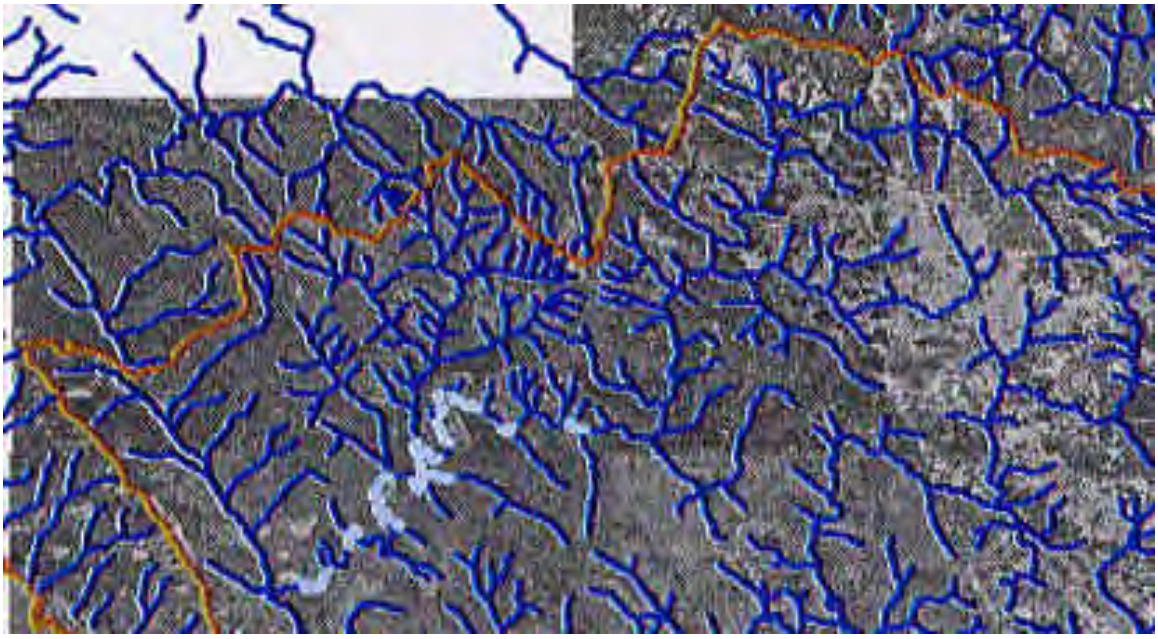


FIGURE 8: 1936 Bank to Bank stream shade canopy exposure (light blue)

Logging operations accelerated during the mid-1950s in inland Douglas fir dominated areas in the middle to upper reaches of the basin. Road construction was built running adjacent to the main stream channel of all primary tributary watercourses (See Figure 9).

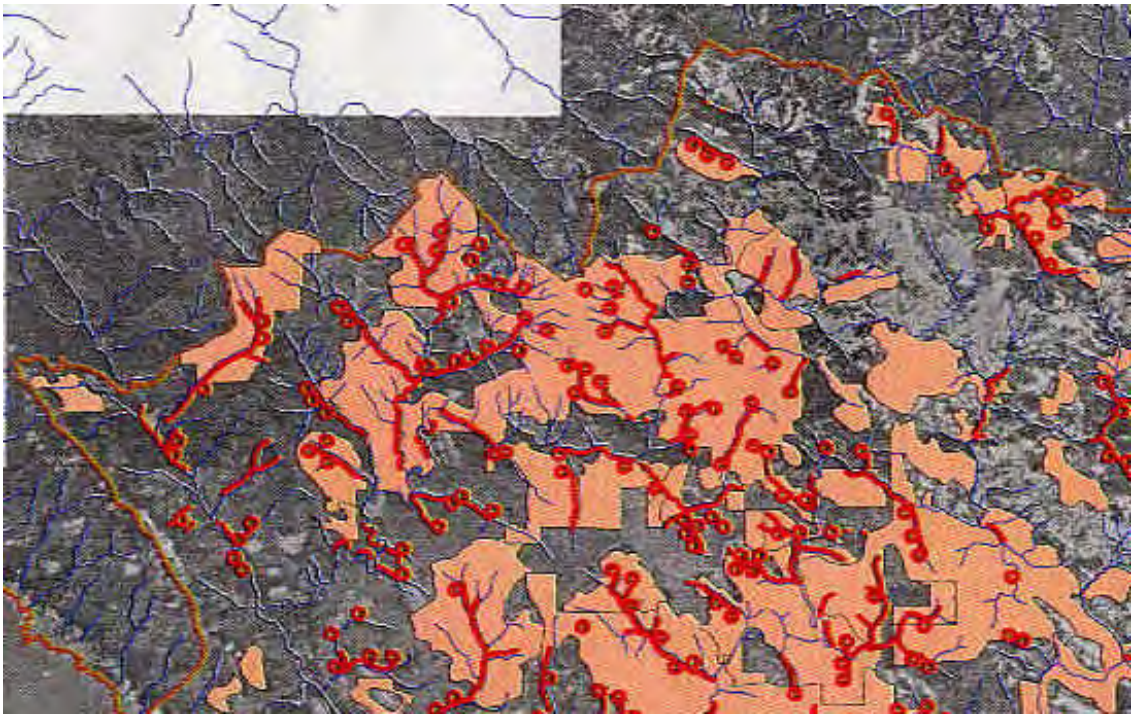


FIGURE 9: Harvest operations 1952-1964 & streamside roads/landings1952-1968

All red lines show where road fill has been pushed into the creek burying the streambank..

Roadfill sidecast to the stream channel was undermined during peak flows creating numerous debris slides and road fill failures discharging into watercourses. This upper area of the basin was affected by the 1964 flood although actual impacts that can be attributed directly to the flood were not documented with this assessment due to lack of 1965 air photo coverage in Mendocino Co. Most of the lower areas of the basin, including the Little North Fork, were logged between 1965 and 1968. Lateral road construction continued to follow the streambank channel to one side, removing riparian canopy.

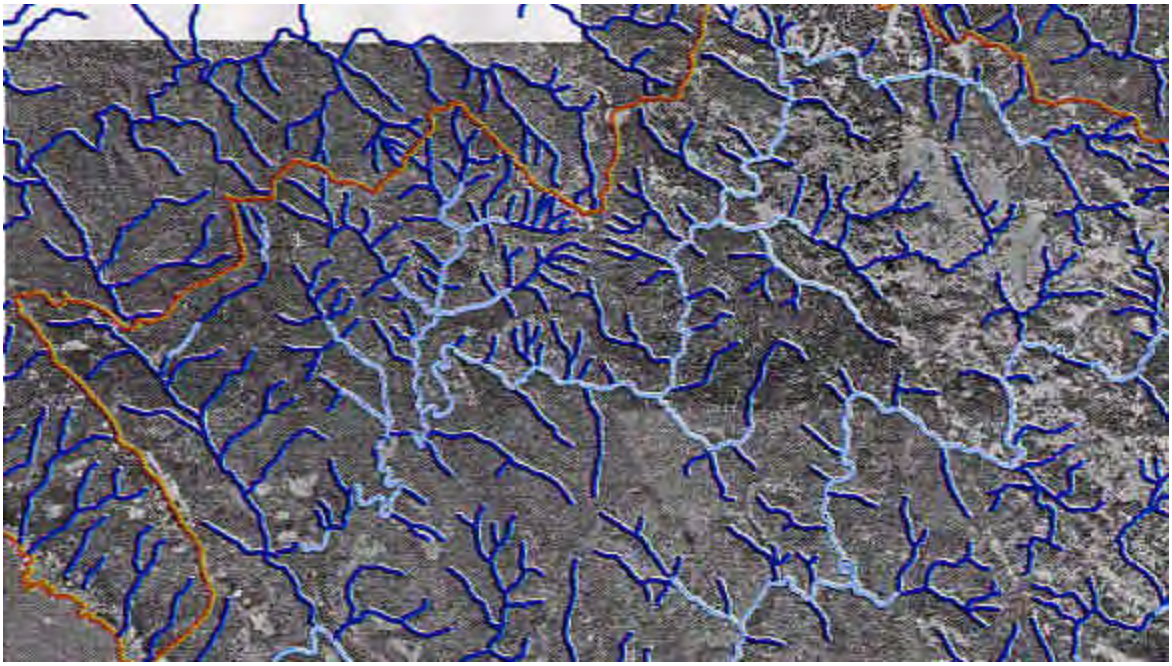


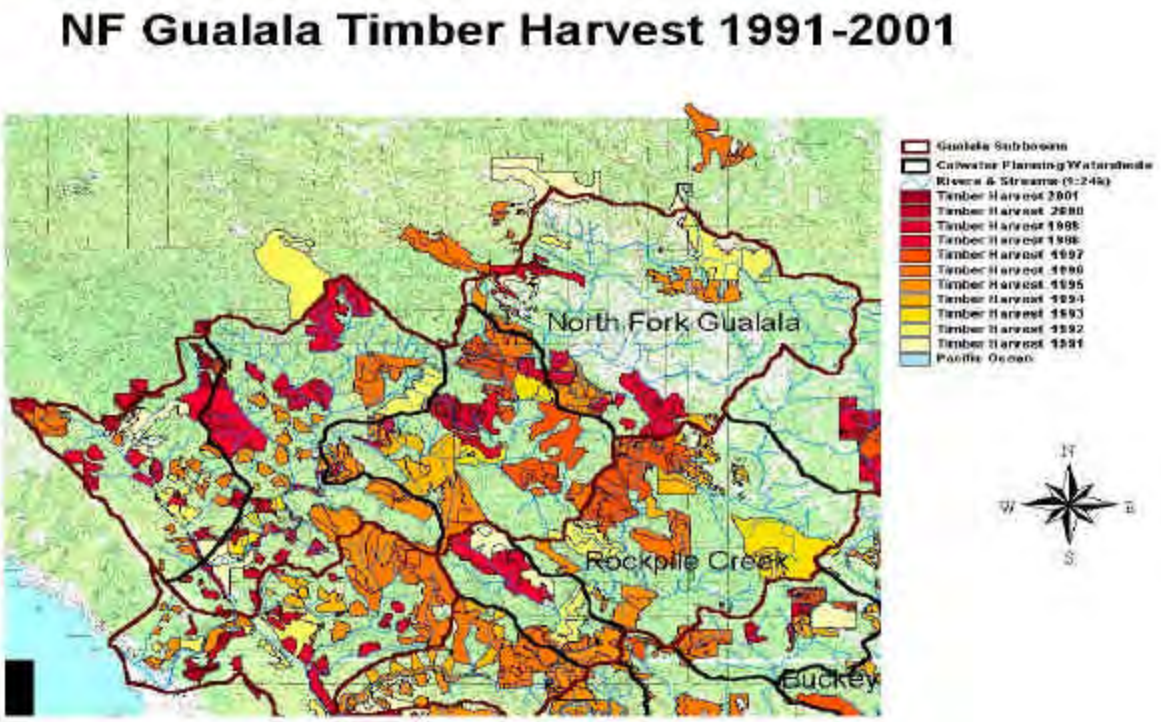
FIGURE 10: Bank to bank shade canopy exposure (white).

Blue shows partial to entire shade canopy cover.

This practice left bank to bank watercourse exposure throughout the main stem of the North Fork, and all major tributary watercourses including Stewart Creek, Dry Creek, Robinson Creek and Doty Creek (See 1981 Bank to Bank Shade Canopy Exposure Map, Figure 8 above). The bank-to-bank overstory shade canopy cover for 2000 shows improvement compared to 1981. DFG habitat typing data for 2001 shows average canopy density improving with 77% density for the North Fork mainstem and 84% for the North Fork basin tributaries. The habitat typing results are consistent with canopy measurements surveyed by the cooperative monitoring program between the Gualala River Watershed Council and Gualala Redwoods, Inc. The canopy condition is also consistent with the results of the Hillslope Monitoring Group Study (1998). The riparian protections provided by the Forest Practices Act over the last 25 years have resulted in a significant improvement of the riparian canopy over post WWII logging conditions. However, to achieve and maintain desired riparian conditions in the entire watershed, protections need to be implemented and adhered to.

1968 to 1990 was a period of relative inactivity compared to previous eras. Logging operations were slow during the recessions of 1970 and 1973. During the later 1970s, partial stand entries and commercial thinnings were the dominant stand treatments. Active harvest operations resumed from 1990 to present (see Figure 10). The clearcut method becomes predominant. Areas that had once been understocked and therefore avoided during the 1960s had become mature and were subject to harvest.

FIGURE 11: NF Gualala Timber Harvest 1991-2001



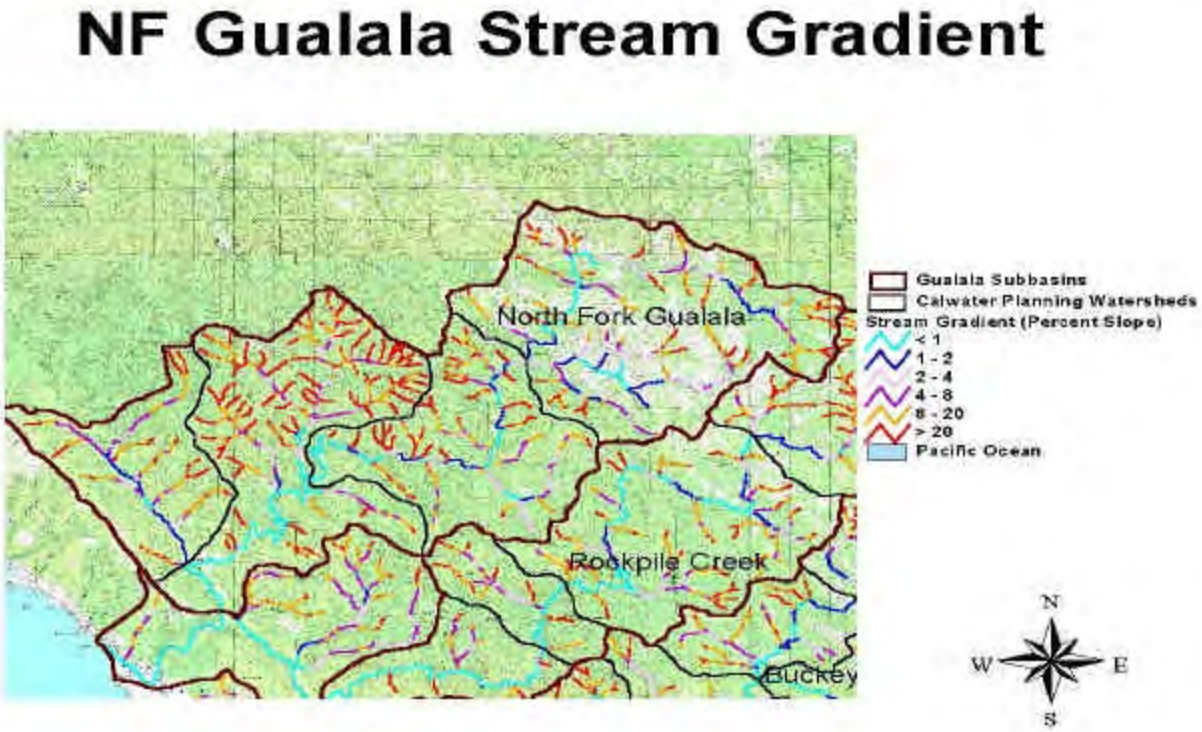


FIGURE 12: NF Gualala Stream Gradients

DISCUSSION

North Fork post WW II timber operations were the most dispersed compared to the other basins. Second growth redwood stands in the 1950s and 1960s in the lower and middle reaches had zero value, and were either thinned of other conifer species, or avoided altogether. The 1952 photos show that the first operational blocks in the watershed were in the North Fork. The last phase of the Post WWII logging boom was also in the middle reaches of the North Fork between 1964 and 1968. This contrasts with the Rockpile and Buckeye basins where most of the timbered areas were entirely removed in more narrow timeframes.

Comparative 20 year stream channel width measurements between 1936 and 1999 were inconclusive. However, the Rockpile, Buckeye, and Wheatfield Fk. basins did show channel width widening responses to more concentrated harvest operations upstream. In addition, the sharper contrast between steeper gradients in the upper NF reaches, and near level gradients along lower NF reaches compared to the other basins (see Gradient Map above) tended to wash fines downstream. This probably accounts for the suitable pool development generally observed by DFG in many of the stream reaches of the middle basin reaches. Streambed particle sizes (d_{50}) from 1997-2000 data provided by GRI and GRWC in the tributaries came out larger but more d50 sampling is needed in the tributaries to confirm this. These sites also showed some improvement over time (see Figure below). d_{50} values were small in many to most locations elsewhere. The smaller d50 values found in the lower reaches of the main stem can be attributed to high rates of sedimentation transport. Small streambed particle sizes (gravel and lower) create a more mobile streambed. Similarly, average embeddedness in the North Fork basin ranged from 26-50% (2001 data), less than optimum, and varied by major tributary watercourse. This still compares better than the other basins. The combinations of (1) high stream gradients, and (2) comparatively dispersed post WW II harvests, probably accounts for the McNiel sampling data falling within the higher range of U.S. EPA standards, but not exceeding them. TMDL threshold standards are set lower.

Roads

Successive aerial photo overlays show a shift in current road locations to ridgelines and mid slope benches. This coincides with general field observations that the older streamside roads are now mostly vegetated and wooded. In addition, the EMDS model shows the North Fork basin with the highest road density in the watershed, reflecting active timber harvesting during the 1990s. This can indicate a need to evaluate and upgrade road drainage facilities to current sizing standards in the North Fork, and to actively monitor the road network during the winter period to assure functional dispersal of drainage. Landowners within the North Fork basin have implemented road-upgrading programs. Many programs are developed in conjunction with the Gualala River Watershed Council, government agencies and/or Resource Conservation Districts. For example, Gualala Redwoods, Inc. in partnership with the Watershed Council and the Sotoyome Resource Conservation District (Sonoma County) has assessed and produced an implementation plan for the entire Little North Fork watershed. When the work is completed approximately 45 miles will be upgraded and an estimated 57,993 cubic yards of sediment will be prevented from entering the watercourses As part of Gualala Redwoods, Inc. road management program, an additional 32 miles of roads (26%) has been upgraded in the North Fork basin in the last three years reducing sediment delivery to streams by an estimated 8,606 cubic yards.

Fluvial Geomorphology

Doty Creek Planning Watershed

Aerial photo interpretation of the Doty Creek planning watershed found overall minor levels of channel disturbance in the 1984 photos. Most channel disturbance in this planning watershed was concentrated along Doty Creek where approximately 30 percent of the channel appeared disturbed and in an un-named tributary (S.11, T.11N., R.15W.) where approximately 50 percent of the channel appears disturbed. Overall there was a total of 27 small landslides in the 1984 imagery that appeared to deliver sediment into the channels. Eleven of those slides were adjacent to Doty Creek and 5 on the un-named tributary. Eleven more slides were scattered through the planning watershed.

Aerial photo interpretation of the Doty Creek planning watershed found overall conditions of the channels improved in the 1999/2000 photos. No major channel disturbances are visible on these recent photos and four landslides were mapped as delivering sediment to the channels. Three slides are along the upper reaches of Fleming Creek and one on Doty Creek are observed in 1984 photos.

Robinson Creek Planning Watershed

Aerial photo interpretation of the Robinson Creek planning watershed found overall levels of channel disturbance greater in the 1984 photos (WAC-84-C, 4-21-84) than the 1999/2000 photos (WAC–C-99CA, 4-13-99; WAC-00-CA, 4-2-00). In the 1984 images, approximately 75 percent of the North Fork Gualala River within the Robinson Creek planning watershed appeared disturbed with enlarged and numerous bars and lack of riparian vegetation. Seven landslides are mapped as delivering to the lower reach of main channel or to adjacent minor tributaries. By 1999/2000, the North Fork Gualala channel appears to have improved with disturbance between 50 and 75 percent, but channel bars appear smaller. Six delivering landslides are mapped in the lower reach, four at locations mapped in 1984.

Approximately 75 percent of the lower portion of Robinson Creek appeared disturbed in the 1984 photos with numerous longitudinal bars and cutoff chutes. Three landsides were mapped as delivering sediment into the channel. In 1999/2000, Robinson Creek improved having approximately 30 percent of the channel showing signs of disturbance, but the number of delivering landslide increased to 7, most were at location different from 1984.

Dry Creek had at least 80 percent of the channel disturbed in the 1984 images upstream from the junction with the North Fork Gualala to the confluence of Johnny Woodin and Fisher ridges (S. 6, T.11N., R.14W.). The upper reach of Dry Creek above this point is also disturbed at least 80 percent with 13 landslides mapped as delivering to the channel. On the north side of Fisher Ridge approximately 50 percent of the channel is disturbed and seven channel delivering landslides are mapped. Between Johnny Woodin and Brandt ridges an un-named tributary has approximately 30 percent channel disturbance with 11 landslides mapped as delivering to the channel. In the 1999/2000 images, the upper reach of Dry Creek improved to approximately 50 percent of the channel showing disturbance with 13 landslides, 5 of which are mapped in 1984. The lower reach also improved to approximately 50 percent of the channel showing disturbance and 8 delivering landslides. The un-named tributary between Johnny Woodin and Brandt ridges has less than 25 percent disturbance with 6 delivering landslides.

Aerial photo interpretation of McGann Gulch 1984 images found greater than 80 percent of the main channel disturbed with 9 delivering landslides. By 1999/2000, channel disturbance is less than 50 percent with most occurring in the lower reach. Four landslides deliver to McGann Gulch, all were also delivering in 1984.

Stewart Creek Planning Watershed

In the 1984 images, at least 80 percent of the North Fork Gualala River within the Stewart Creek planning watershed appeared disturbed with enlarged and numerous bars, cutoff chutes and a lack of riparian vegetation. Thirty-two landslides are mapped as delivering to the North Fork Gualala main channel or to adjacent minor tributaries. By 1999/2000, the North Fork Gualala channel appears to have improved to where 50 to 70 percent of the main channel appears disturbed. Thirty-four delivering landslides are mapped, 14 of which are at location mapped in 1984 images.

Stewart Creek appears to have at least 90 percent of the channel disturbed in 1984 images with 6 landslides delivering to the channel. By 1999/2000, the stream improved to where approximately only one-third of the upper reach appeared disturbed. Six delivering landslides were mapped in 1999/2000.

Billings Creek Planning Watershed

In the 1984 images, approximately 25 percent of the lower and 75 percent of the upper reaches of Billings Creek appeared disturbed with enlarged bars, multi-thread channels, bank erosion and lack of riparian vegetation. By 1999/2000, in the lowermost reach approximately 10 percent appeared disturbed. In the middle reach, 50 percent of the channel appeared disturbed with 7 delivering landslides. The upper reach appeared to improve with less than 50 percent of the reach disturbed and 6 delivering landslides.

Robinson Creek (a second creek) appeared to have approximately 70 percent channel disturbance in the 1984 images. Some improvement occurred by 1999/2000 with approximately 50 percent disturbance. Palmer Creek had minor sections of disturbance with 6 delivering landslides mapped on the adjacent slopes.

Water Quality

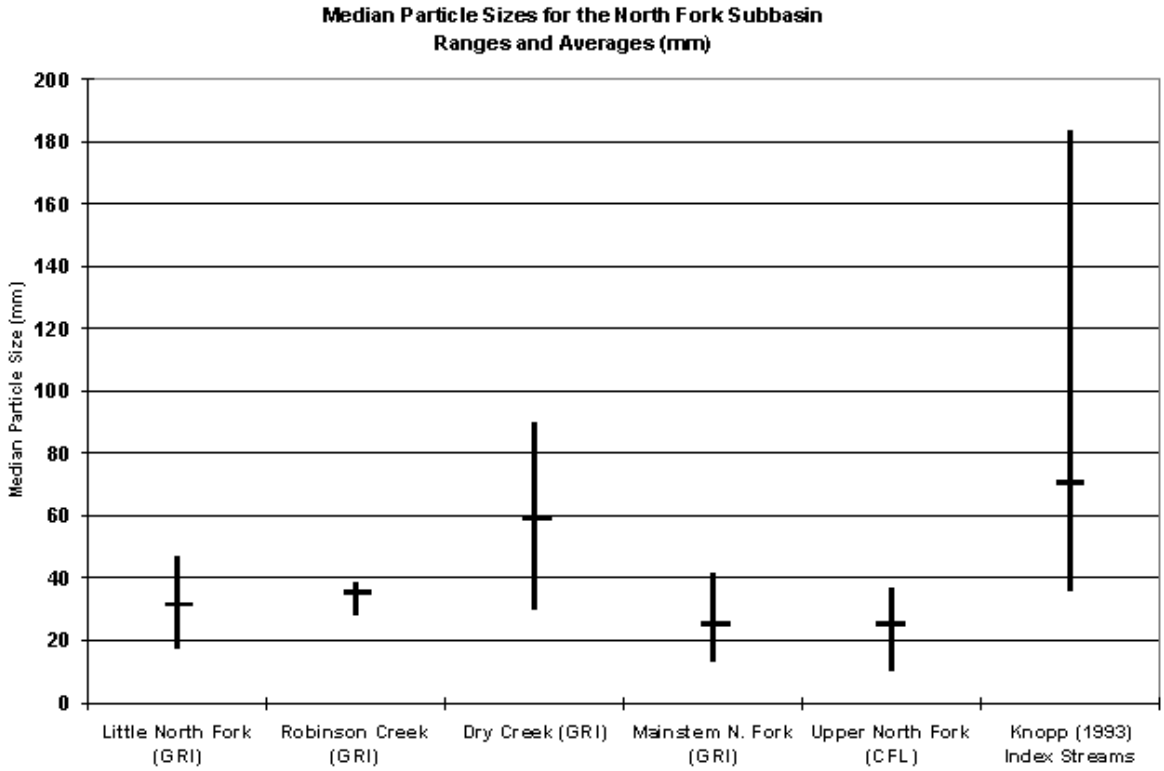
In-Stream Sediment

Pebble count data are available from GRI for a total of 12 sites (Figure 13) for the period of 1997-2001. Data from CFL are available for three sites for the period of 1995-1997. We compared those data to Knopp (1993), who collected instream substrate data from 18 north coast index streams judged to have had no human disturbance history or little disturbance within the last 40 years. He averaged d50 values for three riffles per reach, and found a minimum d50 value of 37 mm, an average of 69 mm, and a maximum d50 value of 183 mm. Knopp also presented the data with 80 and 95 percent confidence limits. We believe the GRI data to be comparable, and used the average of individual d50 values for the GRI riffles (3 riffles per site). The CFL d50 data were presented in a figure and the values estimated from the graph with a ruler. The analysis also would be improved by calculating the 80 and 95 percent confidence limits for both data sets as well. Once we determine that the data are comparable, we will perform that additional analysis. The minimum, average, and maximumfor the GRI and CFL data are compared to the same statistic from Knopp (1993) in the following table:

TABLE 7: Stream samples

Stream Name	Years	No. of Sites	No. of Samples *	Minimum (mm)	Mean (mm)	Maximum (mm)
Little North Fork (GRI)	97-01	3	8	18	30	46
Robinson Creek (GRI)	97, 99	2	3	29	34	38
Dry Creek (GRI)	97 98-01 one site	3	7	31	59	89
Mainstem N. Fork (GRI)	97 99, 01 one site	4	5	14	24	41
North Fork (CFL)	95-97	3	9	11	24	36
Knopp (1993) Index Streams	1992	18	18	37	69	183
* no. of samples = number of averages included in the comparison						

FIGURE 13: Median Particle Sizes for North Fork Subbasin



The significance of these data lie in the mobility of the sediments and the resultant impacts to salmonid embryo survival. Small particles are mobilized by smaller and more frequent flow events. Increased bedload mobility can directly impact salmonid spawning success due to redd destruction and capping (Nawa et al., 1990). Destruction of redds during incubation affects survival of the embryos from that spawning event, potentially affecting the timing of runs. Cedarholm (1983) found that a decrease in particle size distribution on the Clearwater River in Washington favored a later run timing in adult steelhead from January to March in response to bedload movement. Shifting bedload in northern California could have a greater impact on coho salmon, because they have not been documented spawning later than February in California coastal streams (Allen and Hassler, 1986).

Some temporal trends were observed in the lower Dry Creek site (DRY# 211)(Robinson Creek Planning Watershed). Of the three transects, one experienced a steady increase in D_{50} from 32 mm in 1997 to 64 mm in 2001. The other two transects increased in D_{50} from 31 and 30 mm in 1997 to 70 mm and 86 mm in 1999, then decreased to 54 mm and 45 mm in 2001.

In addition to bedload mobility, the median particle sizes observed in these areas are mostly at the low end of observed spawning use for steelhead and coho. Reiser and Bjornn (1979) present from literature, substrate sizes where various salmonids were observed spawning: 6-102 mm diameter for steelhead, and 13-102 mm for coho. In the same paper they caution that particles less than 6.4 mm hinder the emergence of chinook and steelhead embryos.

Although McNeil data can be quite variable across a riffle area, percent fines <0.85 mm from McNeil cores of riffles at four sites in the mainstem Little North Fork, one site in Doty Creek, and one site in McGann Gulch (sites dot 256, mcg 209, lnf 255, lnf 201, lnf 202, lnf 203), often exceeded the Gualala proposed TMDL target of 14% (Figure 12). Dry Creek site 211 was closer to the target, but exceeding in three of four years.

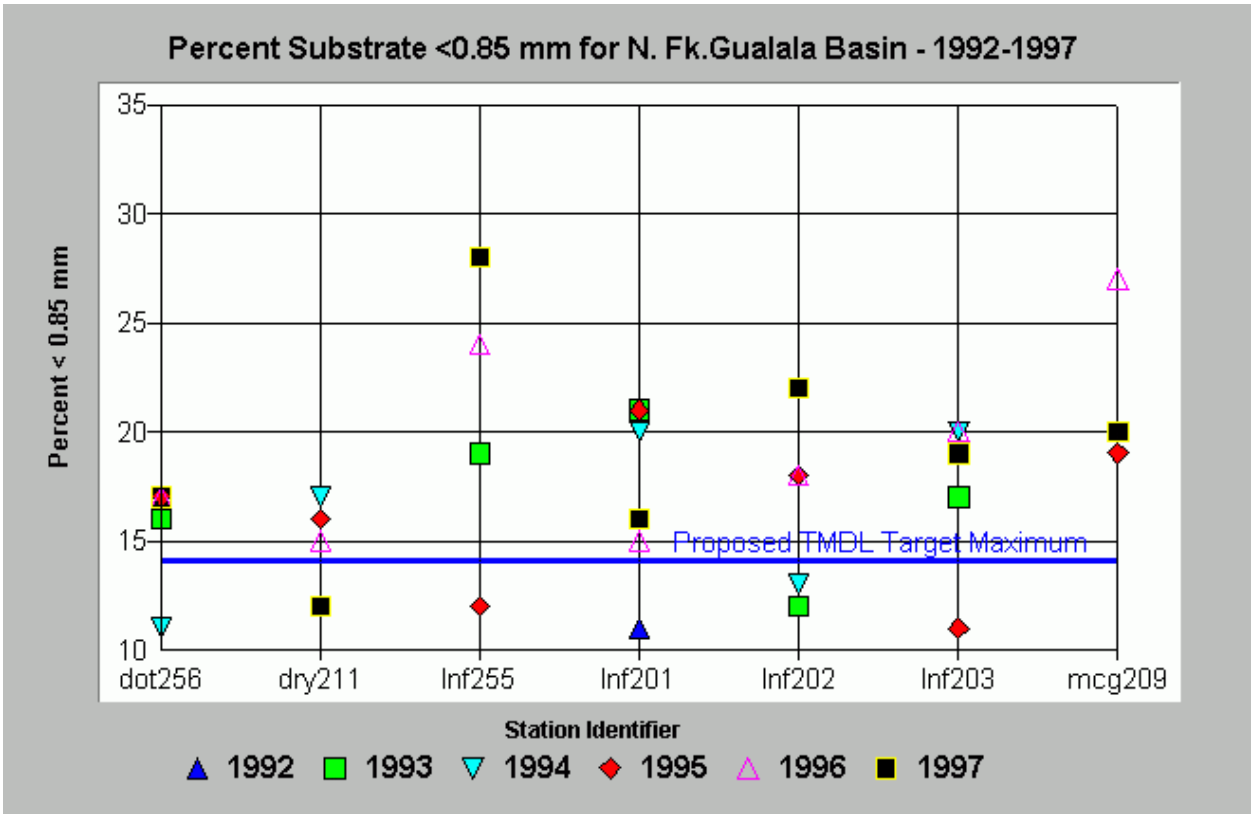


FIGURE 14: Percent substrate for North Fork Gualala Basin 1992-1997

Data are averages of eight McNeil core samples per site, wet sieved and volumetrically determined.

The Gualala Technical Support Document for the TMDL (CWQCB 2001) (Gualala TSD) lists the current top eight sediment sources as: road mass wasting, bank erosion, natural sources, surficial road erosion, timber harvest, road gullies, road crossing failures, and skid trails. Figure presents data used by Regional Board staff to prepare the Gualala TSD for the Total Maximum Daily Load for Sediment (CRWQCB, 2001). Figure 13 presents estimates of sediment delivery from mass wasting features greater than 10,000 ft^2 in plan area observed in the 1999/2000 photos, but not observed in the 1988 photos. The estimate also includes enlargement of previously existing features. Only features greater than 10,000 ft^2 in plan area were estimated. Estimates of sediment delivery are presented by geographic association with management activity, regardless of cause. Rates of sediment delivery were estimated based on feature area, average depth of failure of 56 measured features, proximity to watercourses, and a conversion factor of 1.48 $tons/yd^3$.

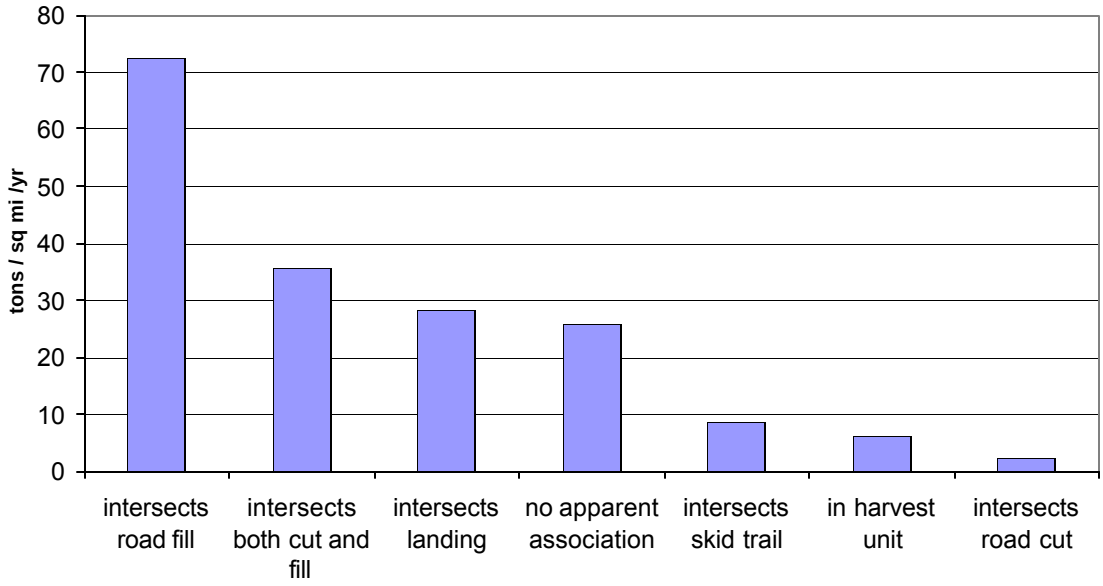


FIGURE 15: Results of Gualala TMDL Aerial Photo Inventory

Recently Active Mass Wasting Features (occurring between 1988 and 1999/2000 photo sets) with Management Associations (Plan Area > 10000 sq ft) - Total Estimated Sediment Delivery (ton/mi2/yr)

Major sediment sources still exist in this basin. For example, in McGann Gulch, a large in stream landing complex built in the late 1960s more recently failed. The upper reaches have scoured out leaving the sediment to settle out in the lower reaches. Due to the loading, McGann Gulch now flows underneath the gravel at the base of the Gulch during low flows, upstream of the North Fork, or dries up, stranding young of the year steelhead trout. In-stream landings and streamside roads from the 1960s are densely concentrated in Dry and Robinson Creeks. Some of these have been noted to continue to discharge during peak flows.

Water Temperature

Stream temperatures are limiting suitability for salmonids in specific areas of the North Fork subbasin. Water temperature data are available from GRI and GRWC for a total of 27 sites for the period of 1994-2001. In general, the MWATs from continuous monitors placed by GRI and GRWC in the smaller tributaries are within or near the 50-60 F range proposed as "fully supportive" of salmonids for all the North Fork tributaries. However, temperatures are above the fully suitable range in the North Fork mainstem. Water temperatures are high coming from the non-forested mélange in the northeastern portion of the subbasin. Water temperatures cool as the cooler tributaries provide inflow (Figure 16).

Maximum seasonal temperatures for the same sites in the North Fork subbasin were largely below the 75 F lethal maximum with four sites in the mainstem North Fork (sites nf258, nf214, nf216, nf272) exceeding the lethal maximum.

These temperature metrics represent conditions for the mainstem North Fork that are not fully suitable for salmonids. Canopy appears to be a factor in the higher temperature streams coming off the northeastern portion of the basin. A Landsat vegetation theme with maximum MWATs for the period of record shows the response of stream temperatures to low canopy and higher air temperatures in the open oak woodland in the eastern melange areas, and the influence of cooler tributaries (Figure 17). Tributary streams are cooler and have a cooling influence on the mainstem of the North Fork. Maintenance of dense coniferous riparian zones in the tributaries and reestablishment where possible in the mainstem North Fork and upper tributaries may improve stream temperatures in the moderately sized watersheds. These data and discussions support a finding of temperature as a

limiting factor for salmonids in the North Fork subbasin. This conclusion is reflected in the Subbasin Issues and Hypotheses sections that appear at the end of this subbasin section.

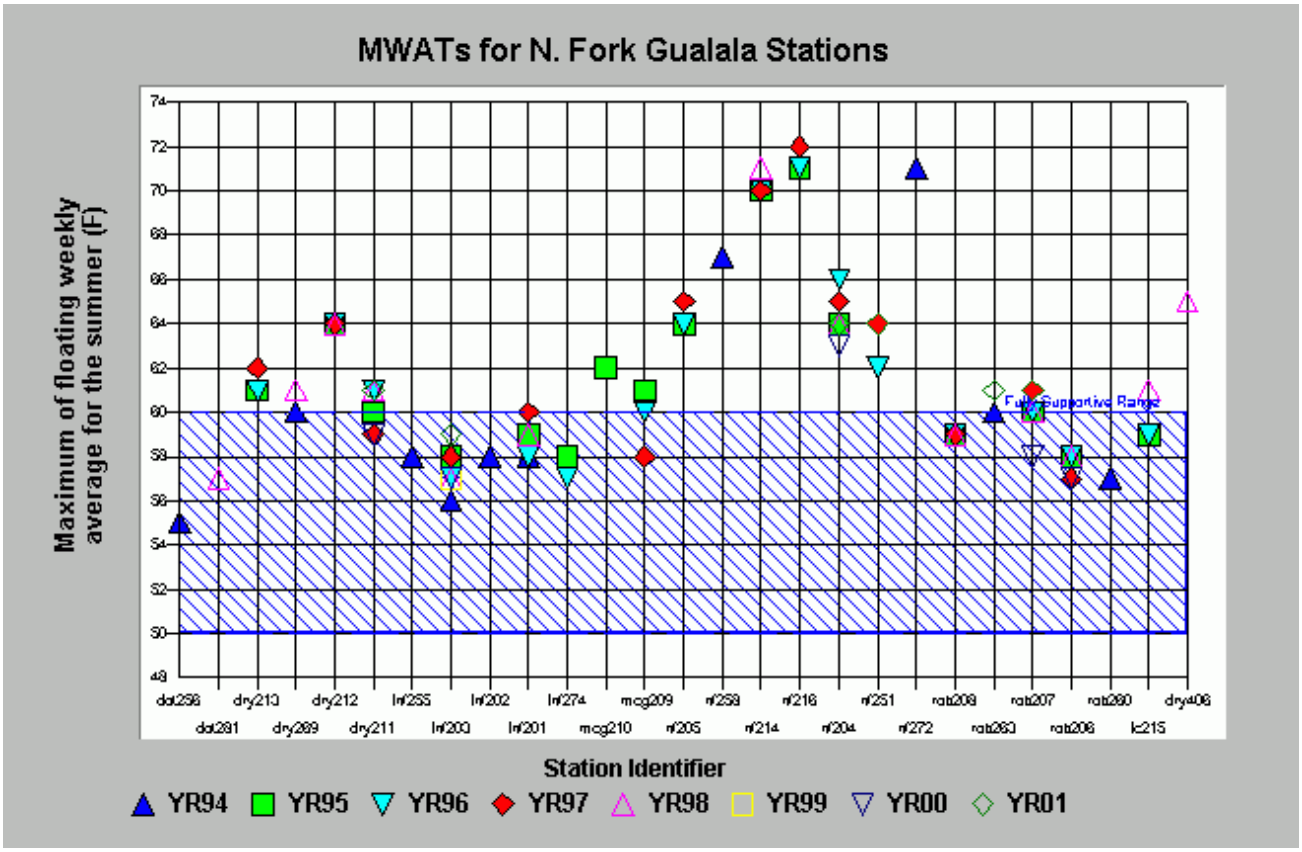


FIGURE 16: Maximum Weekly Temperatures 1994-2001

Data are from GRI and GRWC continuous monitoring devices.
Site locations are provided in Appendix 9.

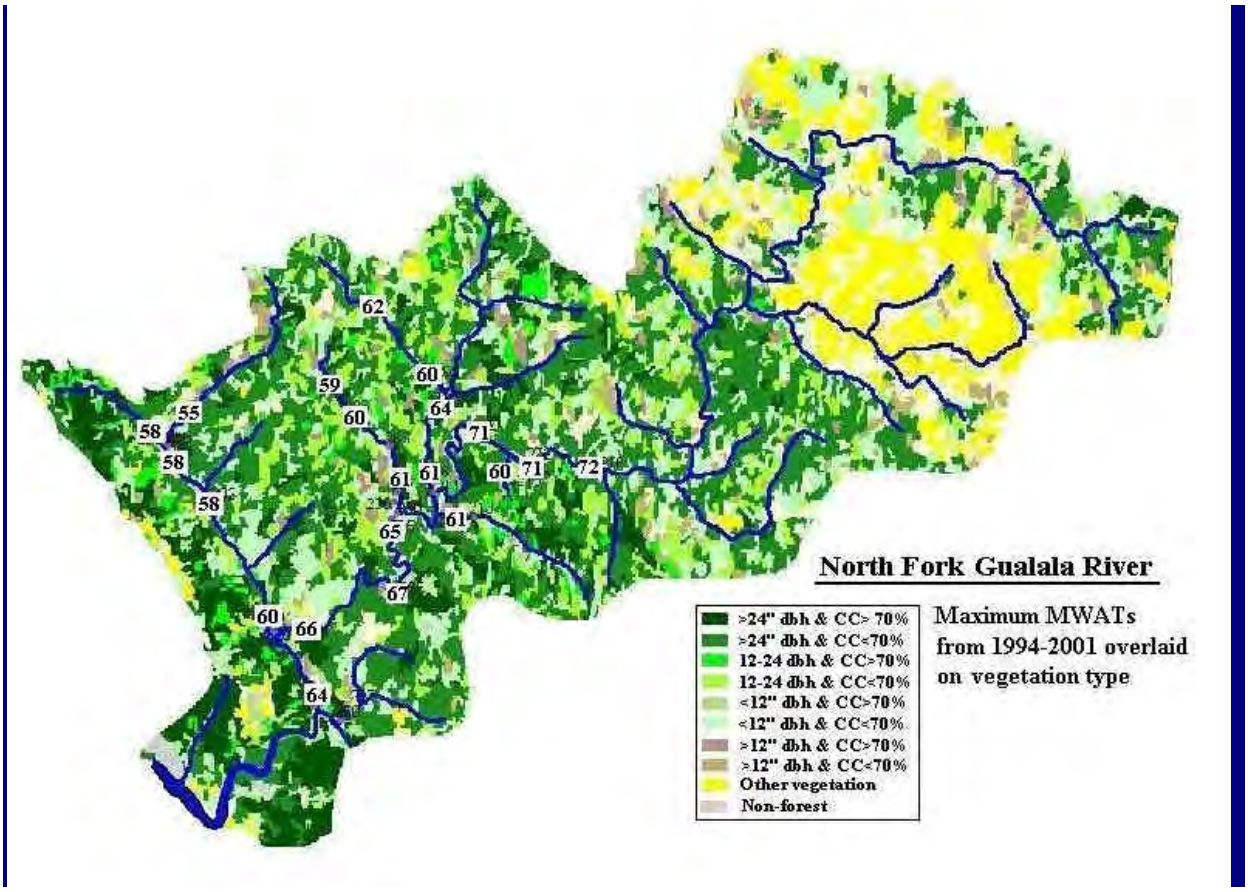


FIGURE 17: Maximum MWATs 1994-2001

1994 Landsat vegetation theme for the North Fork Gualala River Subbasin. The predominantly yellow and green are in the upper, northeastern portion of the watershed is the Franciscan mélange.

Aquatic/Riparian Conditions

Both the Gualala River Watershed Council and Gualala Redwoods, Inc. describe moderate to suitable pool formation for the upper tributaries. Habitat inventory surveys indicated good pool development along the main stem North Fork between Dry and Stewart Creeks in 2001 and along portions of the Little North Fork & Dry Creek. These surveys showed that pools comprised 43% of the habitat for the North Fork main stem and 50% and 42% for the Little North Fork and Dry Creek respectively.

In 1964, substrate in the upper reaches was characterized by DFG as boulder and cobble (60% boulder, 20% cobble, 20% gravel), and in the lower reaches as gravel and cobble (80% gravel, 20% cobble, 10% sand). In 2001, GWRC/GRI describes similar conditions. The upper reaches are dominated by boulder, cobble, gravel and the lower reaches by gravel. In the areas with small particle sizes, predominantly in the lower reaches, the lack of deep pools and predominance of small streambed particles indicate more sediment in the channel than can be transported and likely, a shifting streambed (smaller particles being more mobile). Lack of deep pool habitat for salmonids and a shifting bed where redds can be covered or destroyed reduce suitability for salmonids. In the Little North Fork there are few pools over three feet in depth, the large wood was yarded out of the stream, and the streambed is composed of gravel. In the North Fork mainstem, the DFG 2001 habitat surveys found pools comprised 43% of the habitat with a maximum pool depth of 11.2 feet, compared to 50% pools with a maximum depth of 10 ft in 1964. Adding large wood to the streams would assist in pool development and ordering of the stream substrate.

Habitat inventory surveys showed average canopy density improving with 77% density for the North Fork mainstem and 84% for the North Fork basin tributaries. These results are consistent with canopy measurements surveyed by the cooperative monitoring program between the Gualala River Watershed Council and Gualala

Redwoods, Inc. The canopy condition is also consistent with the results of the Hillslope Monitoring Group Study (1998).

Tables 8 and 9 show recent canopy density measurements within the North Fork Basin. Table 8 density and canopy composition are measured at the thalweg. Density is measured by using a spherical densiometer and the surveyor estimates canopy composition. Table 8 density is measured from the center of channel using a spherical densiometer. The canopy composition is measured by identifying and counting tree species in riparian plots that extend from bank full 100 feet inland on both sides of the channel.

TABLE 8: DF & G Habitat typing data

North Fork Subbasin
DF&G Habitat Typing Data
(June-August, 2001)

Tributary	Canopy Density	Canopy Composition	
		Coniferous	Hard wood
North Fork	77%	38%	62%
Dry Creek	73%	45%	55%
Dry Creek Tributary (1)	60%	52%	48%
Little North Fork	92%	46%	54%
McGann	80%	38%	63%
Doty Creek	94%	49%	51%
Log Cabin	93%	45%	55%
Robinson Creek	66%	39%	61%
Little North Fork Tributary (1)	100%	69%	31%

TABLE 9: Canopy Density

Canopy Density
North Fork Subbasin
Watershed Cooperative Monitoring Program
(1997-2001)

Tributary	Canopy Density	Riparian Composition	
		Coniferous	Hardwood
North Fork	65%	26%	74%
Dry Creek	69%	86%	14%
Dry Creek Tributary (1)	n/a	n/a	n/a
Little North Fork	93%	77%	22%
McGann	n/a	n/a	n/a
Doty Creek	n/a	n/a	n/a
Log Cabin	n/a	n/a	n/a
Robinson Creek	74%	80%	20%
Little North Fork Tributary (1)	n/a	n/a	n/a

Most large wood was yarded out of the streams during the 1950s, 1960s and 1970s. Recently, large wood surveys have been conducted in Robinson Creek, Dry Creek, the Little North Fork, and the lower section of the North Fork main stem as part of the Watershed Cooperative Monitoring Program. The literature suggests (Beechie and Sibley, 1997 and Martin, 1999) that about 130 pieces > 8” per 1,000 feet of large wood is an appropriate level. On average, the monitoring surveys demonstrate that large wood is deficient in most areas of the basin. However, as shown in Table 11, both Dry Creek and the Little North Fork have the highest wood volume and pieces per 1000 ft of stream reach for the basin. The high pool ratios in both tributaries could be a reflection of the large wood numbers.

To augment the natural recruitment process of LWD, an ongoing cooperative large wood placement project in the watershed has placed an additional 9,100 cubic feet of LWD in the Little North Fork and Robinson Creek tributaries. Approximately 64 pieces of LWD with an average diameter of 32 inches have been added to the Little North Fork at 8 sites along the stream reach. The placement of wood is not included in Table 11.

TABLE 10: DFG Habitat Typing Data (June-Aug 2001)

North Fork Subbasin

Tributary	Pool Frequency *	Pool Depth Maximum (Feet)	Pool Depth Mean (Feet)	Dominant Substrate	Substrate Embeddedness
North Fork	43%	11.6	1.0	Sand & Gravel	0-25%
Dry Creek	42%	2.9	0.7	Gravel	26-50%
Dry Creek Tributary (1)	44%	2.0	0.6	Boulders, Gravel & Cobble	51-76%
Little North Fork	50%	3.9	0.9	Gravel	0-25%
McGann	20%	1.8	0.5	Gravel & Cobble	51-76%
Doty Creek	35%	3.3	0.7	Gravel	51-76%
Log Cabin	29%	1.3		Gravel	0-25%
Robinson Creek	36%	4.8	0.8	Gravel	0-25%
Little North Fork Tributary (1)	33%	1.3	0.6	Silt & Clay	26-50%

* By habitat occurrence

TABLE 11: Summary of large woody debris

North Fork Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2000)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
North Fork	473	30,600	1,567	33
North Fork	204	25,433	1,958	35
Little North Fork	404	4,217	5,099	50
Little North Fork	203	1,963	3,843	77
Robinson	207	1,068	1,592	39
Dry Creek	211	4,104	5,168	69
Dry Creek	212	3,756	2,470	27

*Watershed size is calculated as the area above the monitoring site.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at three reach sites in the North Fork basin in 2000 (Jon Lee) can be characterized as average when compared to similar north coast watersheds (Table 12).

TABLE 12: Summary of Macroinvertabrate Sampling

North Fork Subbasin
Gualala Redwoods, Inc.
(2000)

Tributary	Site Number	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Little North Fork	203	31	0.85	4.5%	5,340	30%
Dry Creek	211	32	0.79	4.4%	1,857	40%
Dry Creek	212	41	0.92	4.5%	1,528	19%

Fish History and Status

Salmonid populations in the North Fork basin reflect a variety of factors, a major one being instream habitat, both physical structure and water temperatures. Larger and older age steelhead and coho require deep pools with sufficient shelter for rearing. Steelhead were observed in most of the basin. However, according to historical documentation steelhead one year and older have declined. GRI snorkel surveys conducted yearly in the Little North Fork since 1998 show a steelhead population dominated by young of the year but with one year and older age classes present. DFG electrofishing surveys in the Little North Fork show similar results. Coho have been observed in the basin historically, with the last documented observation of coho in the North Fork basin in 1998. Coho were not observed during the electrofishing surveys at sites on the Little North Fork and along the North Fork mainstem conducted in 2001.

Subbasin Issues

The term 'issues" is used here in a generic sense to denote any topic of interest, concern, import, or relevance to the watershed assessment. As such, issues can be direct limitations on salmonid suitability, potential factors for consideration, concerns regarding potential practices, suggestions, or observations of the data that are particularly relevant to the development of hypotheses and recommendations.

- Fish density – Based on limited sampling in the upper North Fork drainage, coho have not been found. Four years of electrofishing in three streams show stable population of juvenile steelhead.

- Fish population information is poor due to access issues for surveys. Considering the paucity of information on salmonid distribution and abundance, the possibility of training local landowners to survey their own streams and conduct fish population surveys would be advisable.

- Steelhead rescue project exists on Doty Creek.

- In-stream habitat diversity and complexity, based on surveys available, appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.

- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Past land use practices have limited large woody debris recruitment potential.

- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.

- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.

- Sub-division construction, grazing, feral pigs, and landuse conversions are issues in the upper Northfork subbasin..

- Water chemistry – No data are available on pH, dissolved oxygen, nutrients.

- Water temperatures during summer months do exceed optimal conditions for salmon throughout some of this planning basin, particularly in larger order streams.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediment levels are not fully suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species.

The term "working hypotheses" presented below is used in a general sense, not in a rigorous scientific sense. What we refer to as hypotheses generally involve drawing cause and effect relationships between limiting factors and the natural or anthropogenic causes. We refer to them as "working" hypotheses because, in general, we are not "proving" them in a rigorous, scientific or statistical sense, but are proposing them because of relationships we see in the data we have evaluated. As such, they are not surprises, rather logical outgrowths of the data already presented, and they are often tied closely to the subbasin issues.

"Findings" generally refers to specific facts, which may also be connected with a reasonably well established scientific conclusion.

The "limitations" are issues of data, analysis, scientific understanding, etc., that limit our certainty about our findings or the supportability of the hypothesis.

The "recommendations" are actions we believe should be taken to address the limiting factor and causal mechanism identified in the hypothesis, where we conclude that the hypothesis is supportable; steps that should be taken to increase our understanding of the basis for rejecting or not rejecting the hypothesis

This section is a work in progress. That is, not all of the hypotheses have been developed by the Gualala Assessment Team. The hypotheses, findings, etc. offered below are not completely explained, but are given as examples that we will further develop. As we evaluate the results of the EMDS model runs more relationships will no doubt become apparent, and will be added as working hypotheses.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***Water temperatures in the mainstem North Fork Subasin are not fully suitable for anadromous salmonids. Depleted overstory shade canopy cover along the North Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:

MWATs exceeded the fully suitable range of 50-60 F at all eight North Fork mainstem sites for the period of record (1994-1998, 2000-2001), ranging from 62-72 F (Figure xx).

Seasonal maxima exceeded the 75 F lethal maximum 40% of the time during the same period of record, ranging from 66-80 F.

The highest MWATs for the period of record presented on a LandSat vegetation layer (Figure xx) point out: Water temperatures are higher in the upstream areas draining the northeastern portion. Vegetation in the area upstream of those high temperatures (Franciscan melange) is open oak grasslands with poor canopy

Two historical timber harvest eras eliminated riparian shade canopy throughout the lower and middle reaches of the North Fork: 1860 to 1900, and 1952 to 1968, elevating stream temperatures as measured today in the latter, and presumed in the former.

There is partial riparian cover in the oak woodland melange in the upper basin reaches.

Contrary Findings:

Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Limitations:

Data from Gualala Redwoods Inc.'s eight mainstem sites in about the lower 9 miles were evaluated. The North Fork mainstem is about 10 miles long, with headwater tributaries extending about another 11 miles. Data represents about 50% of total blue line length.

The extent of the thermal reaches for the sites is unknown.

Three sites had only one year's data (NF 258, NF 272, NF 406)

Raw data were not evaluated for inconsistencies, thus assumptions were made that GRI and GRWC performed quality assurance and quality control.

Individual canopy measurements for the entire watershed were not available, Landsat 1994 layers from the US Forest Service were used instead

Conclusions:

The hypothesis is supported, given the limitations.

Recommendations:

Investigate the availability and quality of other data for the northeastern area. Include and reevaluate the hypothesis.

More temperature, monitoring and canopy ground-truthing on the northeastern area would assist in further describing the relationship.

Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the North Fork and its tributaries.

Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.

Working Hypothesis: ***Stream reach conditions in the Northfork subbasin are limiting the suitability for sustaining healthy populations of native anadromous salmonids in specific areas.***

Supporting Findings:

The EMDS reach model results indicate the following:

- Pool Shelter Complexity is low in Doty Creek and the Little North Fork upstream of Log Cabin Creek; very low in the Dry Creek tributary and in the Little North Fork from (and including) Log Cabin Creek downstream to the confluence with the North Fork; extremely low in Dry Creek downstream of the three tributary confluence and in the mainstem North Fork for the entire survey area from upstream of Dry Creek downstream to the confluence with the South Fork Gualala.

- Pool Quality rating is low in Robsinson Creek; very low in Dry Creek tributary, the little North Fork, Doty Creek; extremely low in Dry Creek below the three tributary confluence.
- Pool depth was rated extremely low in the Little North Fork watershed, Robinson Creek Dry Creek, and McGann Gulch.
- In-channel conditions were rated low in all watersheds within the subbasin, with the exception of the Mainstem North Fork.
- Embeddedness was high in the surveyed section of Robinson Creek, and very high in the surveyed section of Doty Creek.
    - Canopy Density is: Low in Dry Creek downstream of the three tributary confluence and in the surveyed section of Robinson Creek.Very low in the upper two-thirds of the surveyed section of the Dry Creek tributary.

Contrary Findings:

The EMDS reach model results indicate the following:

- Pool Shelter Complexity was rated barely suitable in the surveyed section of Robinson Creek.
- Pool Quality is somewhat suitable in the surveyed section of the mainsteam North Fork.
- Pool Depth is fully suitable in the surveyed section of the mainsteam North Fork.
- In-channel conditions are somewhat suitable in the surveyed section of the mainsteam North Fork.
- Embeddedness was low to very low in the subbasin, with the exception of Robinson Creek, Doty Creek, and McGann Gulch.
- Canopy Density is mostly suitable in the surveyed section of the mainsteam North Fork, and fully suitable in the Little North Fork subwatershed.

Limitations: Not all tributaries in the subbasin were surveyed.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

Restoration activities should focus on areas needing improved pool quality, and on improving canopy density in Robinson and Dry Creeks.

Working Hypothesis: ***A lack of in-stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools)***

Supporting Findings:

Heavy tractors which built roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed large woody debris in the basin.

Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, reducing the available recruitment supply of large woody debris.

Although stream buffers are regenerating under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as large woody debris in channel formation processes have not yet been reestablished.

Cleaning of streams to remove “fish barriers” made of large woody debris occurred throughout the subbasin.

Contrary Findings: None noted.

Limitations: None noted.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

Gualala River Watershed Council and Gualala Redwoods Inc. are encouraged to do more large woody debris placement work throughout the N.F. basin. .

Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Working Hypothesis: ***Due to the steep topography of the NF basin, many roads are located in erosion-prone areas; such as, adjacent to stream channels or across debris slide slopes.***

Supporting Findings:

Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

Road density and stream density in the upper NF basin is the highest in the Gualala watershed [EMDS results]. This combination results in a high number of stream crossings. The steep topography and high stream density result in intense, flashy runoff, and frequent debris flows that challenge poorly engineered stream crossings.

Mapping and aerial photo analysis shows that legacy roads preferentially followed streams up the narrow valleys resulting in stream side canopy removal and in-stream and near-stream grading. [Appendix XX: CDF Map of In-stream Roads and Landings and Map of Vegetation Changes]

The fast runoff of storm water produces high peak flows along major tributaries that challenge in-stream and near-stream road related structures. [Appendix XX: DWR Hydrology Report of the Gualala Watershed]

The 1981 photos show a high density of road and landing failures along streamside roads throughout the steep, deeply incised terrain in the Stewart Ck. Planning watershed.

The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records in Dry , Robinson, Stewart Creeks, and McCann Gulch. These sites are confirmed on ground by CDF and DMG field inspectors.

Contrary Findings:

None noted.

Limitations:

None noted.

Conclusions:

Hypotheses are supported given the stated limitations.

In this steep, erosion-prone area, careful road sitting, design, and maintenance are necessary to avoid increased sedimentation of streams. Poorly sited or engineered roads will likely produce sediment impacts to streams.

Recommendations:

Evaluate the feasibility of abandoning streamside roads.

Culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.

Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.

Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Doty, Dry, Robinson, Stewart, and McCann Gulch.

Working Hypothesis: ***Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habitat.***

Supporting Findings:

Comparison of historic stream survey and electrofishing show a decline in salmon populations. [Appendix XX: DFG Catch Statistics]

Comparison of historic stream surveys and current habitat inventory survey showed that pools of some tributaries have become shallower and some streambeds have become embedded with fine sediment over the last several decades. Both are limiting factors to salmonids [Appendix XX: DFG Stream and Habitat Inventory Survey Reports]

Both historic and modern aerial photos show that numerous debris flows and slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

Contrary Findings:

Embeddeness is suitable on the Northfork, Little Northfork and Log Cabin creeks.

Embeddeness may be suitable on additional tributaries which have not been surveyed.

Limitations:

None noted.

Conclusions:

Hypotheses are supported given the stated limitations.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravel. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations:

Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

Rockpile Subbasin

Introduction

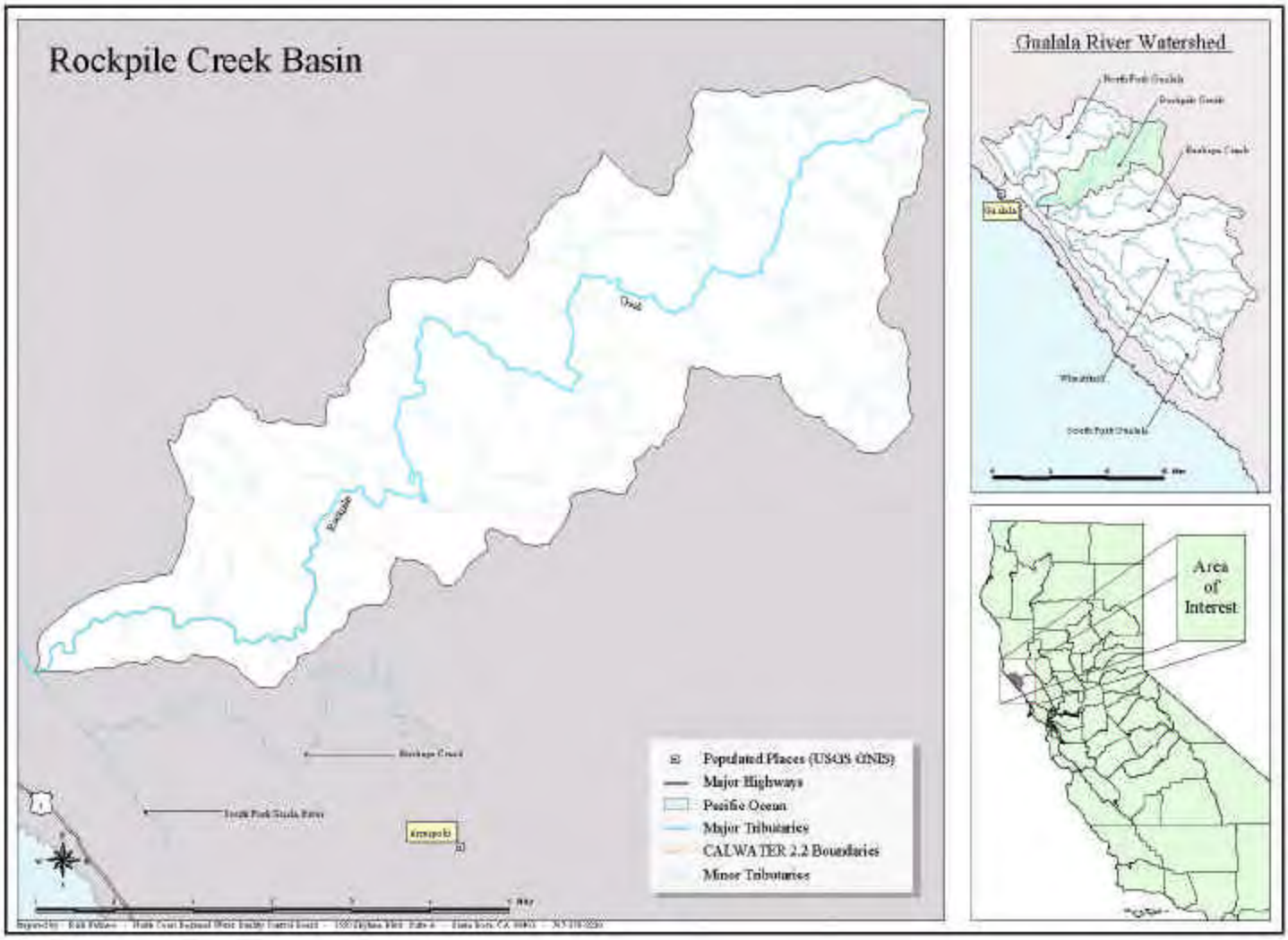


FIGURE 18: Rockpile Creek subbasin

Geology

Geologic conditions of the Rockpile Basin (12% of watershed) are very similar to the North Fork, except that topography is less steep and the main channel is narrower (Plate 1). A series of NW trending strike-slip faults have offset drainages in the middle and upper Rockpile basin. This created a zigzag pattern with abrupt turns in the stream network. The valleys in these areas are steep, narrow, and V-shaped. Horsethief canyon especially characterizes this topography. Drainage gradients in the higher reaches of the basin are characterized by Rosgen classes ranging from A++ to B types, with the upper B-type more predominant. (DMG NCWP) In the lower basin, a longer response reach of less than 4% gradient parallels Stanly Ridge

Vegetation

The narrow Rockpile basin contains high site timber ground downstream from Rockpile Peak. Upstream areas contain mixed conifer hardwood forests with grassland on ridgelines and south facing slopes. In the lower and middle reaches, the 1942 photos show dense mature coniferous shade canopy cover over all primary streams. Only the lowest reaches near the confluence point with the South Fork is Rockpile Creek wide enough to create bank to bank exposure in an alluvial flood basin (See Figure 19, below).

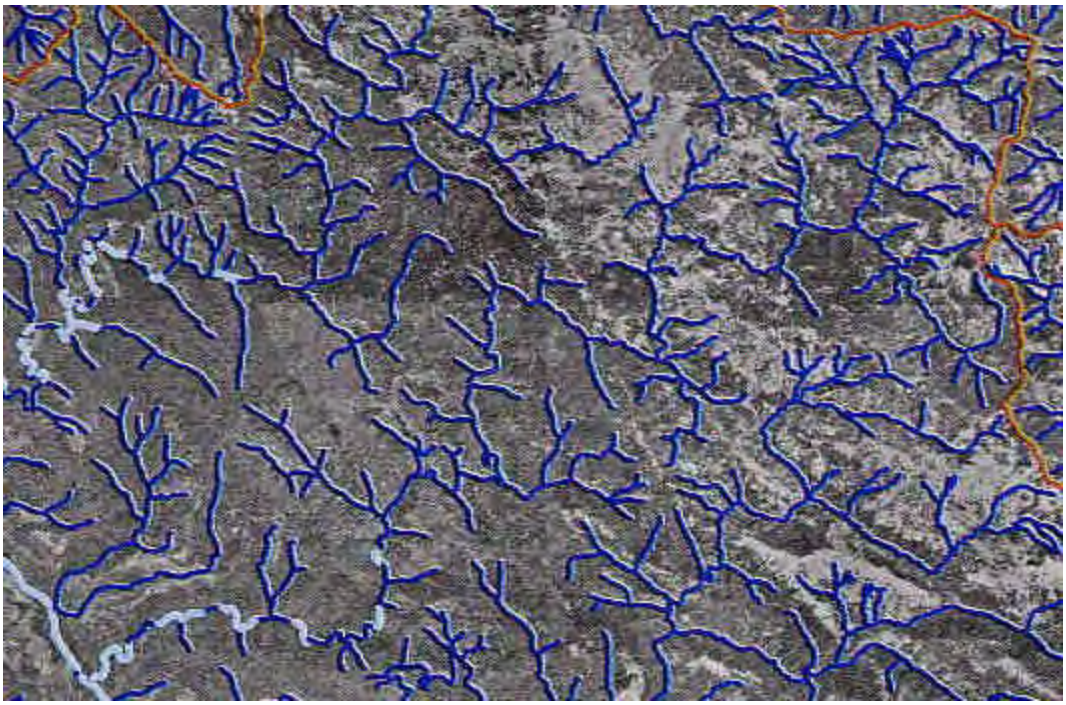


FIGURE 19: 1941 Rockpile Creek overstory canopy exposure

942 Bank to bank overstory shade canopy expose (white), lower left, on Rockpile Ck. Blue lines show partial to entire canopy cover.

Land Use

Logging operations resumed after the depression era lull in the Rockpile drainage in the mid 1950s. The middle reaches of Rockpile Creek downstream from Horsethief Canyon formed the central area of a large multi-basin operations unit stretching down from the upper North Fork southeast through Franchini Creek to the main stem Buckeye Creek. By 1960, rectangular block harvest areas following straight parcel lines appear in the middle to upper reaches. By 1964, each of these had enlarged to merge into one continuous harvest area Due to the steep, deeply incised terrain, haul roads and landings were densely concentrated along Class I watercourses

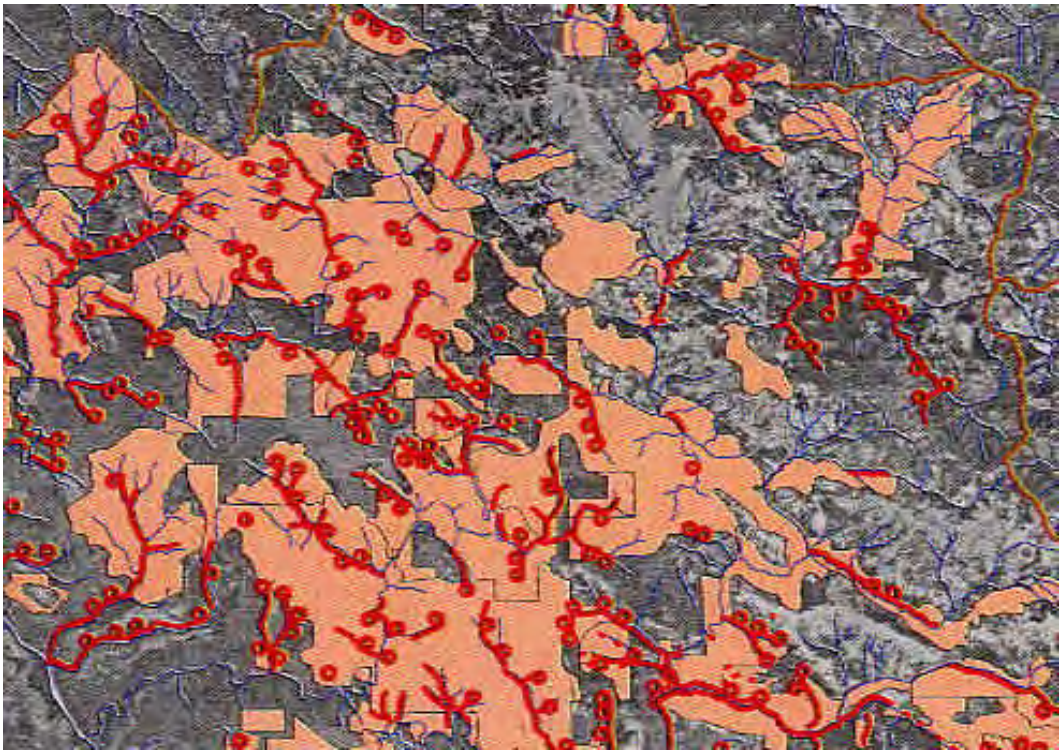


FIGURE 20: Tractor Harvest Operations 1952-1964

Also shown streamside roads and landings (red). Red lines show where tractors have pushed dirt fill into the watercourse to make the road , covering the streambank.

The central reaches of Rockpile had one of the largest continuous areas in the watershed logged between 1960 and 1964. This occurred in steep terrain with no erosion control structures installed just prior to the 1964 storms. Numerous road washouts and stream aggradations are referenced in the THP record attributable to this time period (See tributary descriptions below) Logging operations removed all riparian canopy cover leaving bank to bank watercourse exposure throughout the entire main stem of Rockpile Creek extending from the South Fork upstream to the Upper Rockpile Planning Watershed (see 1981 Shade Canopy Exposure Map, Figure 18 below).

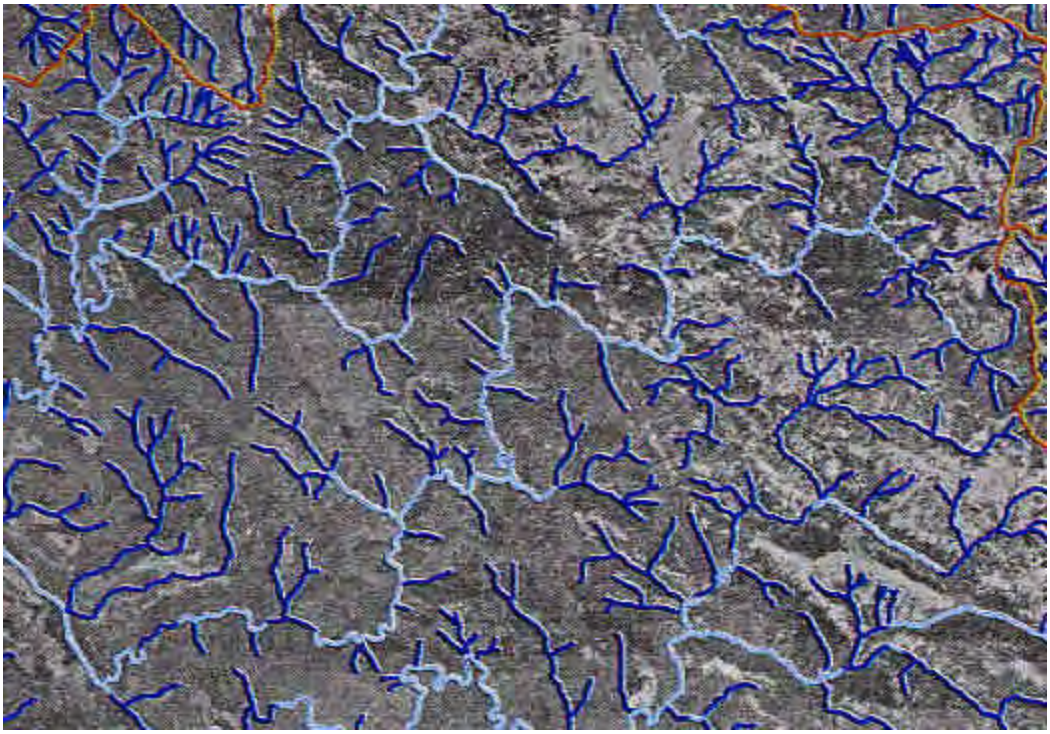


FIGURE 21: 1981 Bank to Bank shade canopy exposure

1981 Bank to Bank shade canopy exposure (white), Rockpile Ck.
Dark blue lines show partial to entrie canopy cover.

The bank-to-bank overstory shade canopy cover for 2000 shows improvement compared to 1981, reflecting riparian in-growth since the late 1960s. Coast Forestlands reported reinstatement of overstory shade canopy in numerous upper reach tributary watercourses (CFL SYP, 1997). CFL no harvest WLPZs are routinely stipulated for all THPs along Rockpile Creek and Class II tributaries to mitigate temperature impairment throughout the basin. Canopy cover is lacking in most areas along the main stem Rockpile Creek, mid to higher reaches (CFL THP 1-97-475).

The Gualala Technical Support Document (CWQCB 2001) identified roads as one of the major current sediment sources in the Rockpile Creek subbasin. Road densities range from a low of 2.8 miles per square mile (mi/sq mi) in the Upper Rockpile Calwater to a high of 7.5 mi/sq mi in the Red Rock Calwater, with Lower and Middle Rockpile both with about 6 mi/sq mi.

Central Rockpile Ck.

- By the early 1960s, the main haul road followed directly along the central reaches of Rockpile Ck. Remnants of road and landings in Rockpile Ck. continue to contribute sediment during peak flows. Shade limited along Rockpile Ck due to large amounts of road segments and landings directly in or adjacent to upper reaches of Rockpile Ck (THP 97-510 CFL) from 30 yrs ago.
- Skidding and hauling in watercourses during 1950s, 60s, were noted in central and upper reaches of Rockpile watershed. High sedimentation and accumulation of debris found in channel. Downcutting and subsequent downstream aggregations noted. Conditions described in a stage of recovery as stream flow continues to flush sediment and organic material downstream (CFL 97-341, 97-345). In very steep areas, Class II and III watercourses were not used as skid trails.

Red Rock Ck.

- Logged in 1959-1960. The main haul road was built along Red Rock Ck. for nearly the entire length of the Class I watercourse. Numerous in stream landings lined Red Rock Creek (CDF NCWP).
- In the mid 1990s, extensive streambank rehabilitation work was carried out by J. Monchke.

Upper Rockpile Ck.

- Seven seed tree overstory removal/ dispersed harvest THPs dated 1997-98 exceeded 60% of the 2700 acre Brandt tract within the Upper Rockpile Ck. WAA. These plans directed road repair work throughout the road network area wide. This included (1) repair of two watercourse diversions (CFL 97-371), (2) removal of a long section of seasonal road across Rockpile Ck. (legacy road), and (3) repair of two other watercourse diversions, (CFL 98-091). These THPs stipulated temporary watercourse road crossing specifications as the dominant use among seasonal road laterals. This requires abandonment of road crossing structures with road approaches bladed back to reestablish original streambank configuration and exposed soils treated with grass seed and mulch.

Fluvial Geomorphology

Rockpile Super Planning Watershed

Aerial photo interpretation of the Lower Rockpile Creek planning watershed found overall levels of channel disturbance greater in the 1984 photos (WAC-84-C, 4-21-84) than the 1999/2000 photos (WAC–C-99CA, 4-13-99; WAC-00-CA, 4-2-00).

Lower Rockpile Creek Planning Watershed

In the 1984 images, at least 80 percent of the lower reach of Rockpile Creek within the planning watershed appeared disturbed with enlarged and numerous bars, braided reaches, and a lack of riparian vegetation. Thirteen landslides were mapped along the reach as delivering sediment to the channel in 1984. By 1999/2000 there is some improvement in the channel conditions as 50 percent of the channel reach appears disturbed in the imagery. Three delivering landslides are mapped along the main reach and 12 slides are mapped in an un-named tributary located in Section 28, Township 11 North, Range 14 West.

Redrock Planning Watershed

Rockpile Creek in the Redrock planning watershed is also characterized by a high percentage, greater than 80 percent, of apparent channel disturbance in the 1984 imagery. Five delivering landslides are mapped along the main channel. An un-named tributary (S.22, T.11N., R.14W.) also has approximately 25 percent channel disturbance with 3 adjacent landslides likely delivering sediment to the channels.

By 1999/2000 there was some improvement in the channel disturbance characteristic in Rockpile Creek, resulting in 50 to 75 percent apparent disturbance. Four delivering landslides are mapped. The un-named tributary of section 22 showed an increase in disturbance indicators with approximately 50 percent of the channel disturbed and an increase to 13 delivering landslides.

Middle Rockpile Creek Planning Watershed

Approximately 75 percent of the middle reach of Rockpile Creek appeared disturbed in the 1984 imagery with bank erosion common, particularly in Section 12, Township 11 North, Range 14 West. Fourteen landslides were

mapped as delivering sediment to the channel and adjacent tributaries. Two other un-named tributaries along the southeastern flank of McGuire Ridge showed signs of significant channel disturbance in Sections 14 and 15, Township 11 North, Range 14 West. These un-named tributaries appear to have at least 80 percent of the reach disturbed with 7 adjacent landslides delivering sediment.

By 1999/2000 disturbance in the middle reach of Rockpile Creek is reduced to approximately 50 percent with 10 delivering landslides. The two un-named tributaries in section 14 and 15 have also improved with disturbance approximately 25 percent of the reach and 2 delivering landslides.

Approximately 75 percent of the channels in Horsethief Canyon appear disturbed in the 1984 imagery with one delivering landslide. By 1999/2000, the upper reach improved and only 25 percent appears disturbed, most in the lower portion of the reach. However, 3 delivering landslides are mapped adjacent to the main channel or tributaries.

Upper Rockpile Creek Planning Watershed

Approximately 50 percent of upper Rockpile Creek channel shows characteristics of channel disturbance in the 1984 imagery. Twenty-seven landslides are mapped as delivering sediment to the channel. By 1999/2000 the overall disturbance is still approximately 50 percent, but the upper reach of the is less disturbed and the number of delivering landslide has decreased to 15.

Water Quality

In-stream Sediment

Small particle sizes observed from pebble counts provided by GRI, GRWC, and CFL indicate an unstable and mobile streambed potentially limiting suitability for salmonids in the lower and middle reaches of the Rockpile mainstem (Figure xx). Six sites were sampled in the lower three miles from 1997-1999 (GRI/GRWC) and the middle seven to 10 miles in 1995-1997 (CFL) (Figure 23). To compare the data to Knopp (1993), the individual D50 values for the sites (3 transects per site) were averaged. The minima, maxima, and averages for those averages were considerably lower than the same statistics from Knopp (1993):

TABLE 13: Sediment particle size sampling

Stream Name	Years	No. of Sites	No. of Samples	Minimum (mm)	Average (mm)	Maximum (mm)
Lower Rockpile Creek (GRI)	97 one for 97-99	3	5	25	28	32
Middle Rockpile Creek (GRI)	97, 99	3	9	16	25	38
Knopp (1993) Index Streams	1992	6	18	37	69	183

*no of samples = number of averages included in this comparison

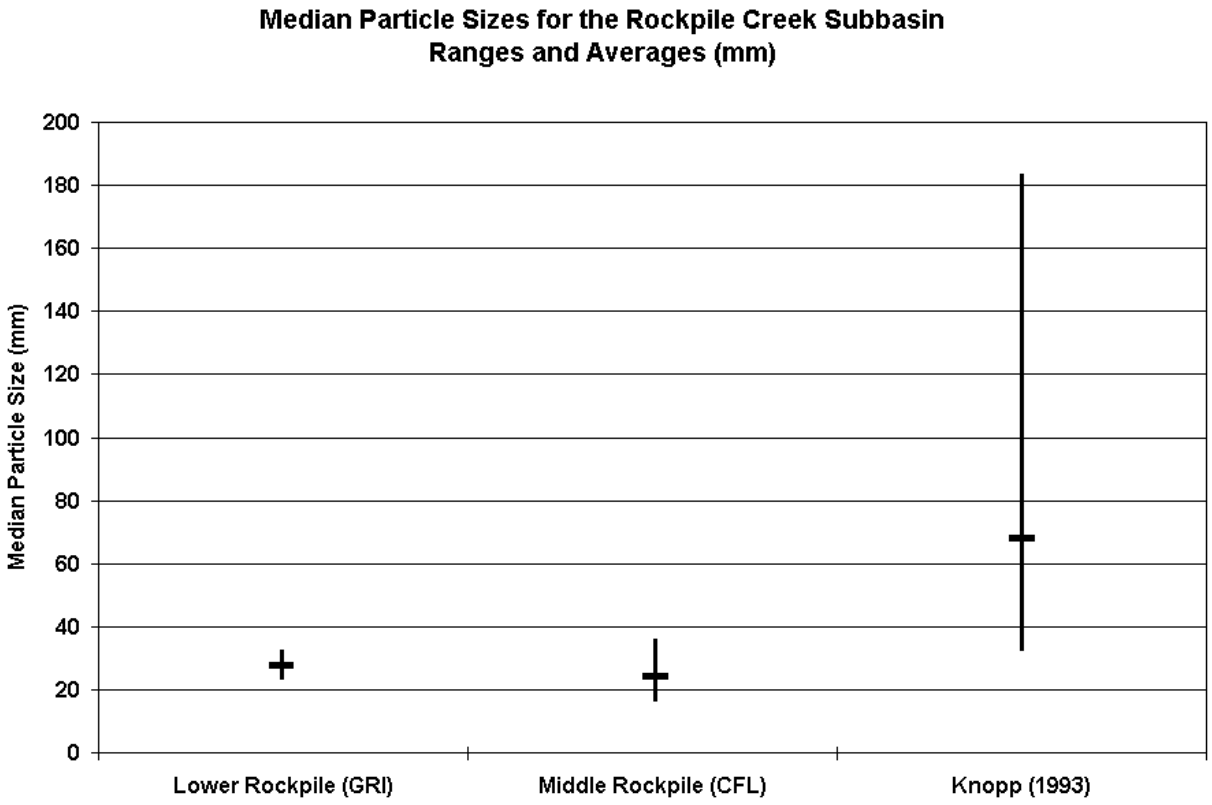


FIGURE 22: Median particle size sampling - Rockpile Creek

One transect of three at the lowest site in the subbasin (RP#221) had an increase in D_{50} from the 1997/98 median of 28 mm to 1999's D_{50} of 55 mm.

Small average particle sizes found at these sample locations result in increased bedload mobility. Finer grained beds are more easily mobilized by flows, resulting in shifting riffles and pools. One potential causal factor is sediment delivery from roads and associated erosional features. The Gualala Technical Support Document (CWQCB 2001) identified roads as one of the major current sediment sources in the Rockpile Creek subbasin. Road densities range from a low of 2.8 miles per square mile (mi/sq mi) in the Upper Rockpile CalWater to a high of 7.5 mi/sq mi in the Red Rock CalWater, with Lower and Middle Rockpile both with about 6 mi/sq mi.

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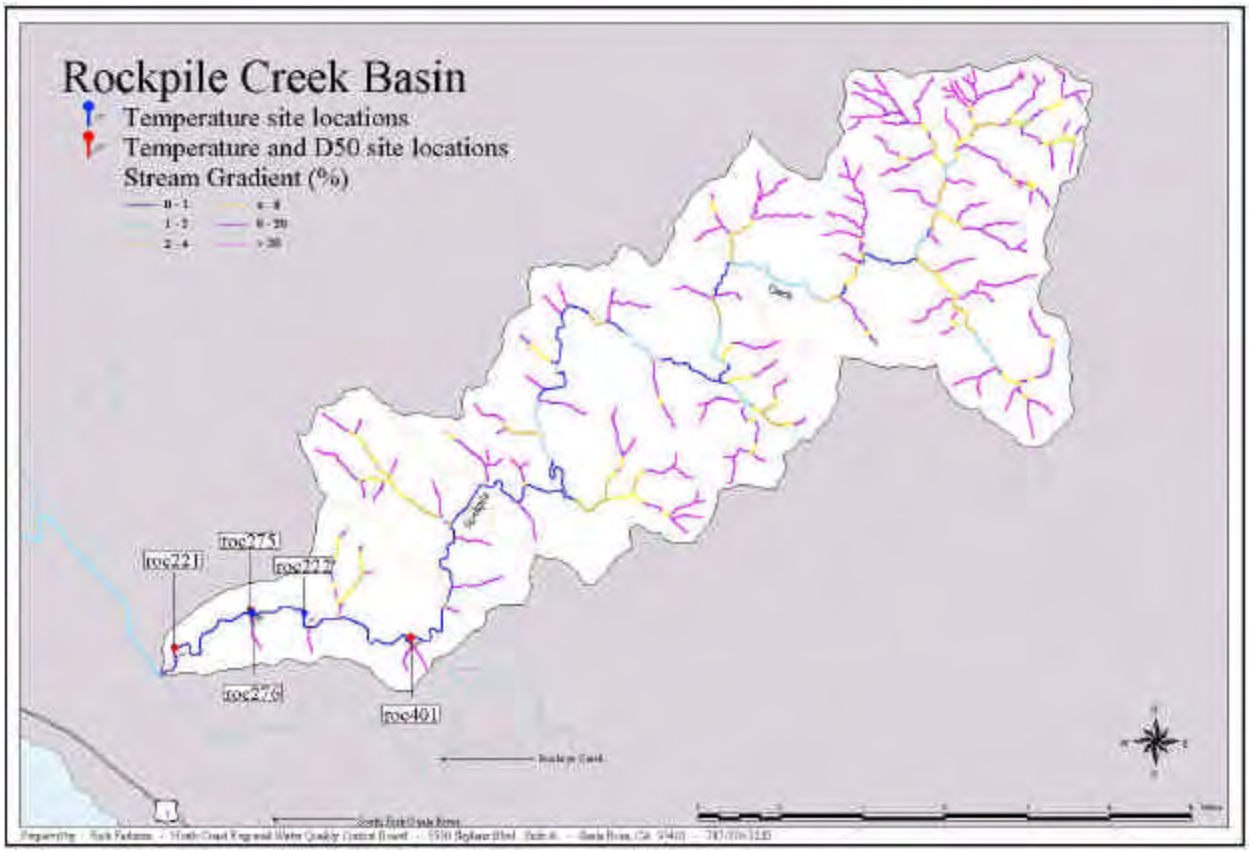


FIGURE 23: Rockpile Creek Temperature & D50 sites

Water Temperatures

Water temperature data were available from GRI for three mainstem and one tributary site in the lower three miles for 1994-98 and 2000-01 (Figure 23). Water temperatures expressed as the MWAT for the tributary (roc 276) were 57 F in 1997 and 1998 (the only years sampled), within the suitable range of 50-60 degrees F. The seasonal maximum for that tributary station was 59 F both years, well below the 75 F lethal maximum (Figure 24).

MWATs for the four sites in the lower three miles of mainstem Rockpile Creek exceeded the suitability range in the years sampled. Seasonal maximum temperatures for those four sites in the mainstem ranged from 71-75 F, just below the lethal maximum.

There was no apparent spatial or temporal trend to the mainstem water temperature data when compared to a LandSat derived vegetation theme. The stations are miles downstream of the open oak woodland, in a forested portion of the lower watershed. Rockpile Creek flows off the melange terrain and may be naturally warm in the Upper Rockpile CalWater, but open canopy along the main stem as it flows into the marine climatic influence probably contributes to high water temperatures lower in the subbasin or maintains the higher temperatures.

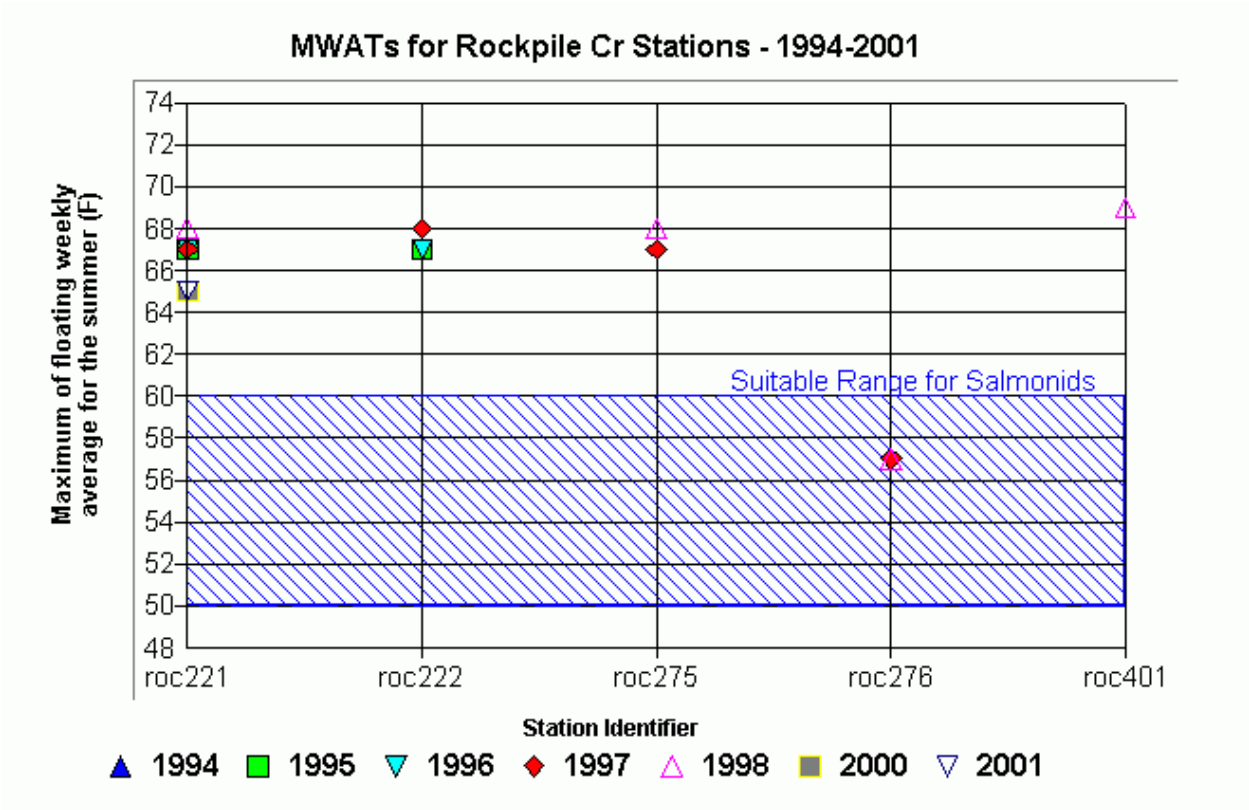


FIGURE 24: Maximum Weekly Avg. temperatures

Maximum weekly average temperatures for sites in the lower three miles of Rockpile Creek.

Roc 276 is a small tributary.

Aquatic/Riparian Conditions

High embeddedness levels found by habitat inventory surveys, along with gravel as the dominant substrate indicate unsuitable habitat for salmonids. In this low gradient environment, the high average range of embeddedness of 51 to 75% was measured from the South Fork confluence to approximately one eighth mile below Red Rock Creek. The survey describes this section of Rockpile as dominated by flatwater and lateral scour pools. Pool frequency by length was 36% and mean pool depth was 1.4 feet.

Large woody debris surveys from the Rockpile Creek subbasin "Watershed Cooperative Monitoring Program"1n 1998 and 1999 at a site in lower Rockpile (# 221) found 18 and 33 pieces per 1000 feet of stream channel with a volume of 1,291 and 2,520 cubic feet, respectively.

To augment the natural recruitment process of LWD, an ongoing cooperative large wood placement project in the watershed has placed an additional 2,909 cubic feet (18 pieces) of LWD in Rockpile Creek. The placement of wood is not included in Table 14.

TABLE 14: Summary of large woody debris surveys

Rockpile Subbasin Watershed Cooperative Monitoring Program (1998 - 2001)				
Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Rockpile Creek	221	22,373	2,412	23

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

Gradient is suitable for coho salmon in the mainstem of lower Rockpile up through the Middle Rockpile CalWater, although tributaries to lower Rockpile are mainly too steep for the species. A 1974 fisheries survey reported coho juveniles. Electrofishing surveys in the 1990s conducted by CDFG and Coastal Forest Lands (CFL) along segments of Rockpile Creek have not detected coho juveniles. Since the Rockpile "stream system likely had coho in the past", the National Marine Fisheries Service has listed the entire ESU, not just streams which presently have coho populations. The high water temperatures in Rockpile Creek and restricted pool depth are likely limiting coho salmon and steelhead production.

Fish Habitat Relationship

Any redds built in these finer grained beds would be at a greater risk during flows that move the bed.

Subbasin Issues

- Fish density – No current data exists.
- In-stream habitat diversity and complexity, based on surveys available, appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.
- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.
- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.
- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.
- Sub-division construction are not an issue at this time. However, Pioneer Ltd owns a larger portion of the upper subbasin and is for sale. Grazing are possible issue as in the upper subbasin.
- Water chemistry – No data is available on pH, DO, nutrients.
- Water temperatures data suggests that summer high temperatures exceed optimal conditions for salmon throughout much of this planning basin.
- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.
- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species.

Subbasin Issues and Recommendations

Working Hypothesis: The Rockpile subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.

Supporting Findings:

Sources of upstream sediment include highly erodible earth materials, mass wasting, seismic activity, and land use.

Water temperatures in the estuary, as a result of warming effects upstream, may exceed a level that is fully suitable of salmonids.

Contrary Findings:

Improving canopy

Limitations:

Conclusion:

Recommendations:

Working Hypothesis: *Many roads, in the lower Rockpile Creek basin, are located in erosion-prone areas; such as, adjacent to stream channels or across debris slide slopes. In the upper basin, active earthflow complexes are so abundant that they are unavoidably crossed by many roads.*

Supporting Findings:

Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

The large portions of the upper basin are underlain with the mélange of the Central Belt of the Franciscan Assemblage and vegetated with prairie and sparse oaks. Runoff from the prairie is rapid creating potentially high peak flows. Landsliding is especially abundant in the mélange. These high flows and landsliding challenge poorly engineered stream crossings.

Contrary Findings:

None at this time.

Limitations:

These conditions are well constrained within the scope of work performed thus far.

Conclusions:

In the erosion-prone Rockpile Creek basin, careful road siting, design, and maintenance is necessary to avoid increased sedimentation of streams. Poorly sited or engineered roads will likely produce sediment impacts to streams.

Recommendations:

Evaluate the feasibility of abandoning streamside roads.

In steep terrain, culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.

Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.

Working Hypothesis: *Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.*

Supporting Findings:

Comparison of modern and historic stream surveys show a decline in salmon populations.

Comparison of modern and historic stream surveys show that some pools have become shallower and streambeds have become embedded with fine sediment over the last several decades. Both conditions are deleterious to salmon.

Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

Contrary Findings:

None at this time.

Limitations:

These conditions are well constrained within the scope of work performed thus far.

Conclusions:

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations:

Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and presesnt Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

[Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

- Most of the roads in the basin were built strictly to support logging operations.

- Most of the middle reaches of the Rockpile basin were clear-cut between 1952 and 1968 buillding roads in or along the major tributaries streams and main stem Rockpile. Timber operations were particularly pronounced immediately prior to the 1964 flood. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground on steep slopes.

- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the Middle Rockpile Planing Watershed.

- Comparative 20 year stream channel width measurements between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.

- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:

None at this time.

Limitations

These conditions are well constrained within the scope of work performed thus far.

Conclusions

Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.

- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Red Rock Creek, Horsethief Canyon, and larger tributary watercourses in the middle reaches of the basin flanked by McGuire Ridge between Rockpile Peak and Robinson Ridge, downstream of Burnt Ridge Creek

Working Hypothesis: ***Depleted overstory shade canopy cover along Rockpile Ck. and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Rockpile Creek and tributaries. There was near entire canopy elimination in the Middle Rockpile Planning Watershed, with operations especially pronounced during the late 1950s to 1964.

Contrary Findings:

- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Recommendations:

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Rockpile Ck. and its tributaries.

- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.

- Increase continuous temperature monitoring efforts.

Working Hypothesis: ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.

- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.

- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:

None noted.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Recommendations:

- Artificial LWD installation projects vastly speed up in channel diversity development

- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Buckeye Subbasin

Introduction

Of the three northern sub-basins of roughly equal size, the Buckeye basin (14% of watershed) contains the most moderate terrain compared to the North Fork and Rockpile

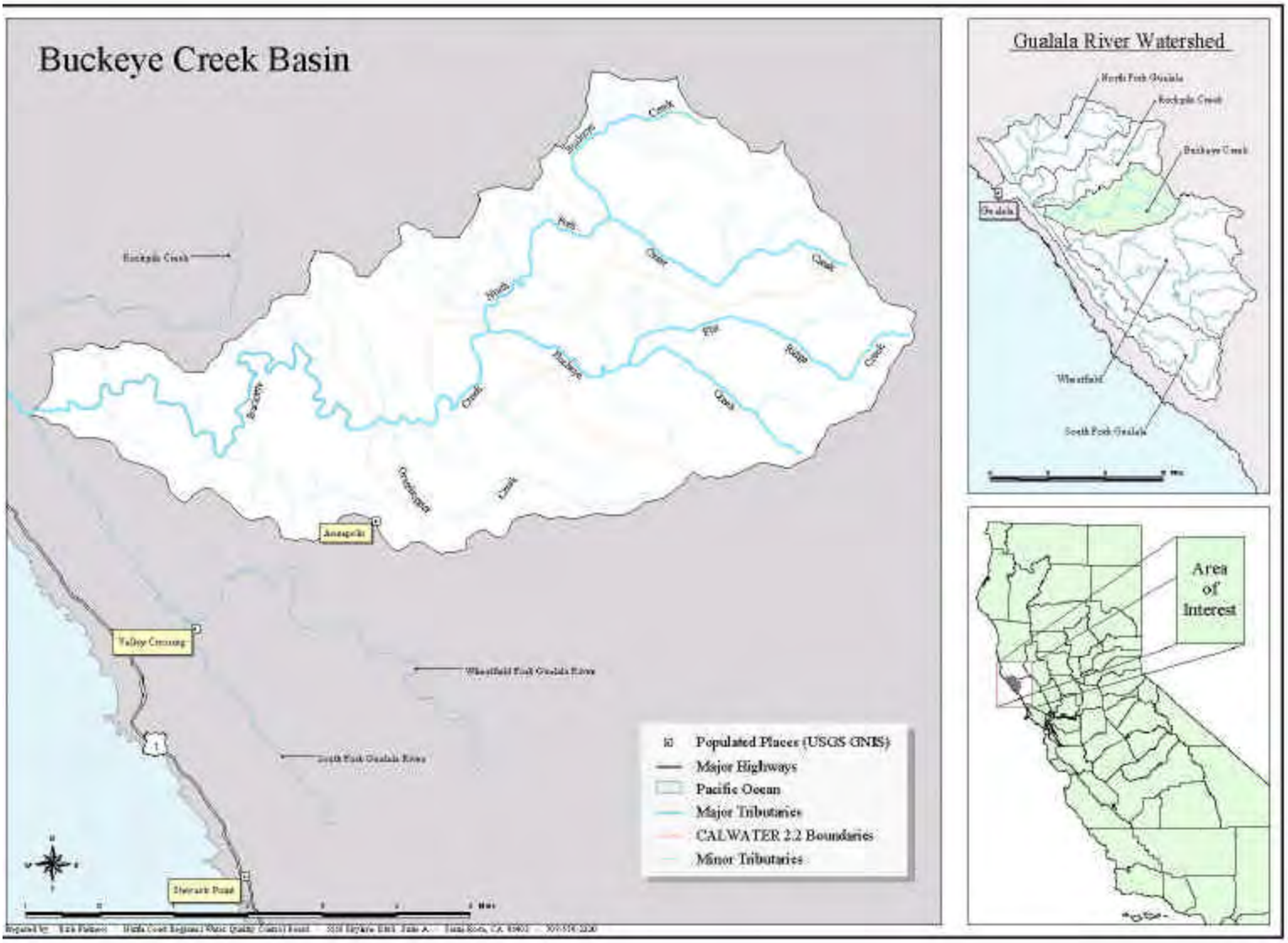


FIGURE 25: Buckeye Creek Basin

Geology

In the mid to upper reaches of Buckeye, stream channels cross and deflect along strike-slip faults creating abrupt zigzags. Osser and Flat Ridge Creeks are two examples. While the mainstem of Buckeye Creek maintains a mild gradient for most of its length, tributaries are steeper having headwaters in supply (>12%) or transport (4-12%) reach categories. Exceptions are Grasshopper, Osser and Roy Creeks, which have long response reaches of

channels less than 4% gradient. CDF mapping found abundant landslides in the Buckeye basin following the 1964 storm as well as subsequent major storms. DMG mapping shows numerous historically active streamside failures occur all along its course. Many of these involve poorly maintained older roads. (Plate 1)

Vegetation

The wider Buckeye basin contains high site redwood ground in the lowest reaches. Further inland, Douglas fir and then mixed conifer-hardwood predominates. Oak and prairie grassland is the dominant vegetation type east of Osser and Flat Ridge Creeks. As in Rockpile Creek, the 1942 photos show mature coniferous shade canopy cover over all primary streams. Only the lowest reaches near the confluence with the South Fork is the main channel of Buckeye Creek wide enough to result in bank to bank exposure (see Figure 26 below).

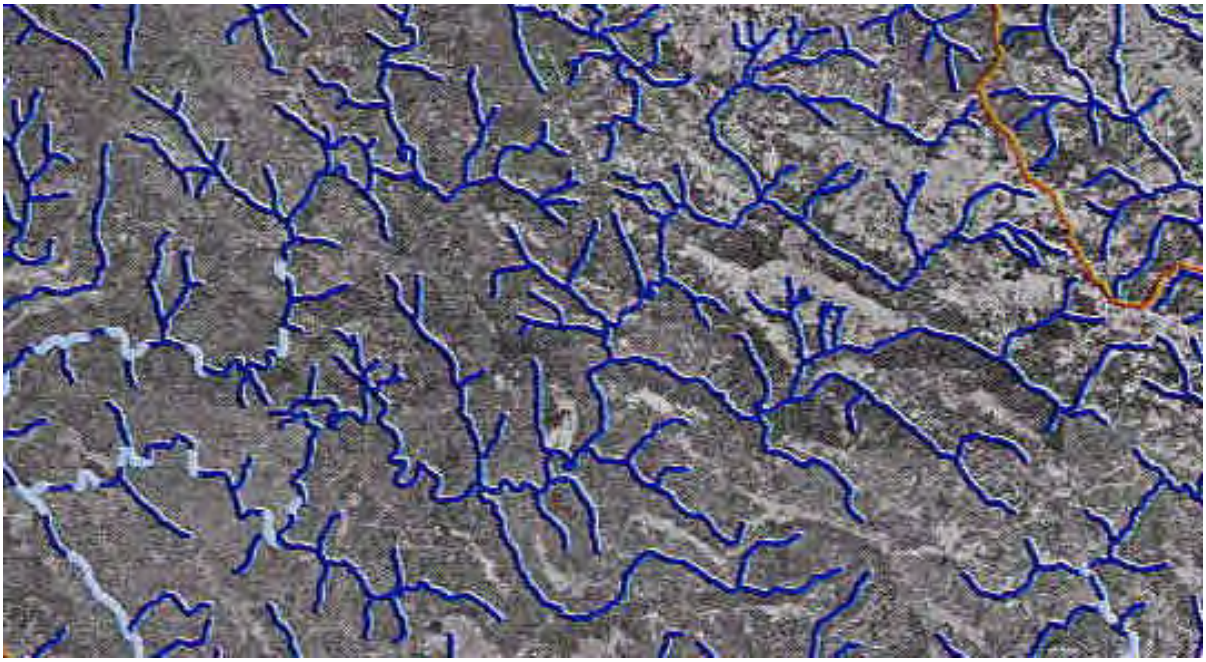


FIGURE 26: 1942 Bank to bank shade Canopy Exposure

Bank to bank shade canopy exposure (white) and partial to entire cover (blue).

Land Use

In the late 1950s, the Franchini Creek basin and surrounding area formed the south portion of the large multi basin harvest complex area bounded by the upper North Fork and the main stem Buckeye Creek. This unit followed a large mid 50s operation that extended south from the main stem Buckeye through the lower Wheatfield basin to lower Fuller Creek. In the middle 1950s, downslope Douglas fir trees lining a narrow riparian corridor were removed from both Roy and Osser Creeks. The Grasshopper Creek sub-basin was logged by 1964. Downslope areas of Douglas fir were logged throughout Soda Springs and Flatridge Creeks by 1964. Streamside roads and landings are particularly concentrated throughout (1) Francini Creek, (2) Grasshopper Creek, and (3) the North Fork Buckeye including Osser Creek. (See Figure 27 below).

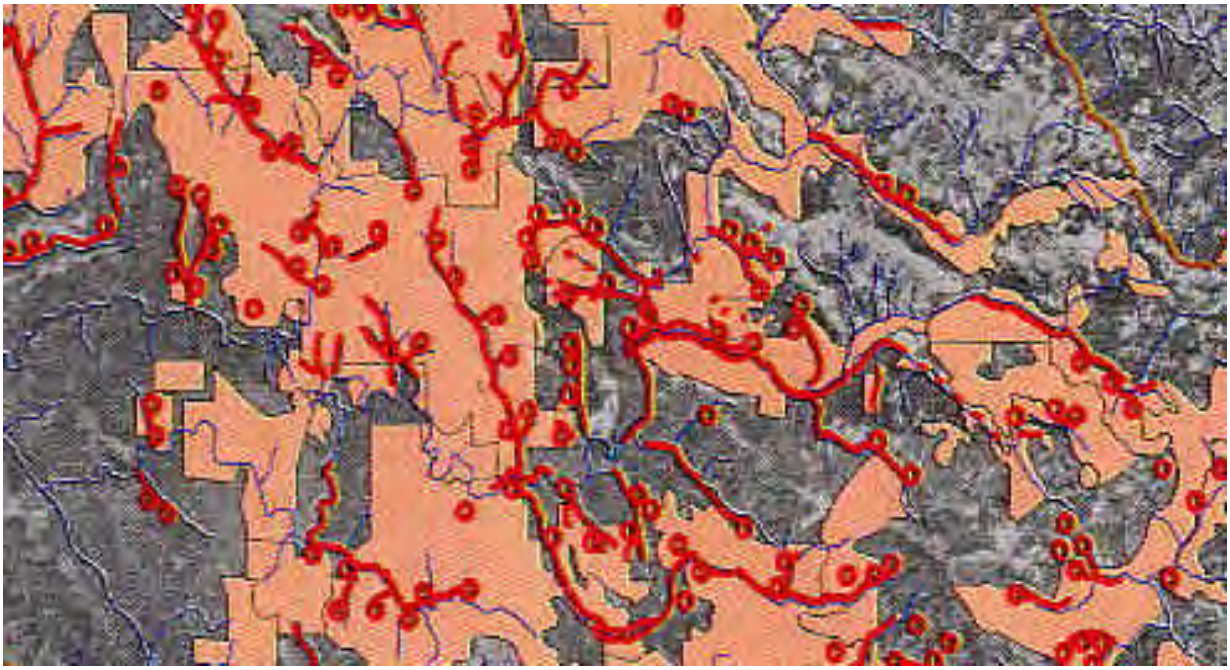


FIGURE 27: Buckeye Basin - Harvest Operations 1952-1964

Also shown above streamside roads and landings 1952 to 1968. Red lines show where road fill has been pushed into the creek

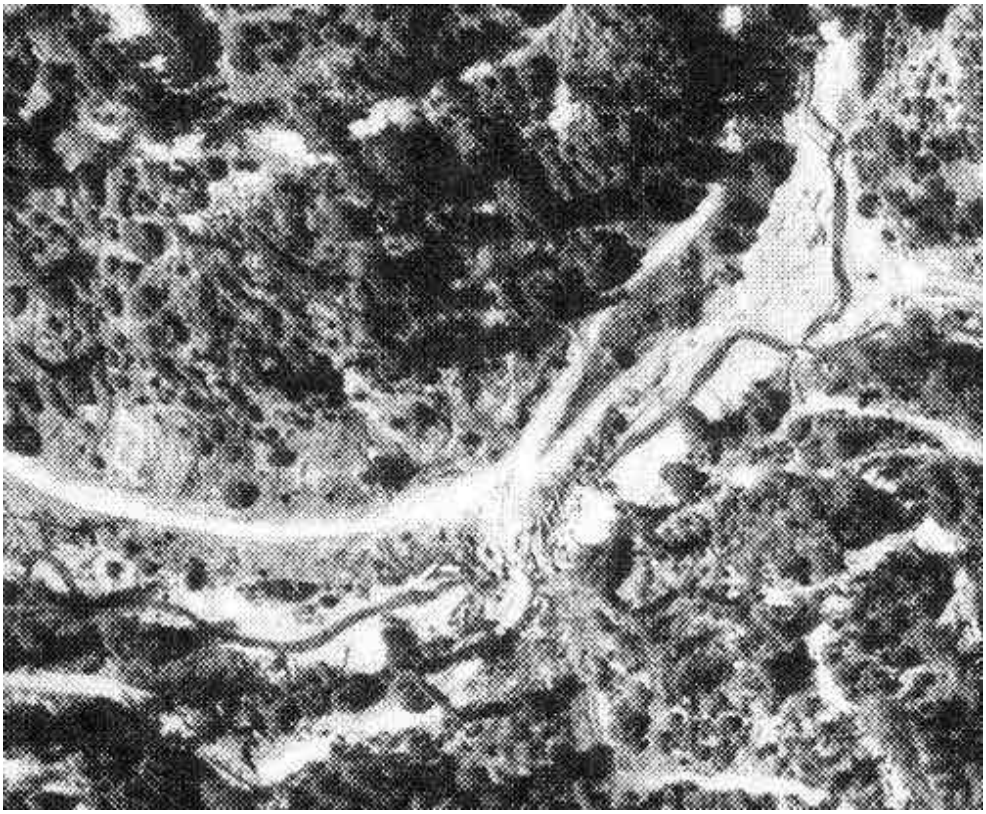


FIGURE 28: Grasshopper Creek

Tractor yarding was active in the Grasshopper Ck. basin in the mid 60s, leaving logs and wood debris piled over the stream channel. During the 1964 flood, this debris floated down to a low road crossing of Grasshopper Ck (left), creating a jam. The resulting dam breached at the south road approach, diverting onto the west road. approach, which collapsed into the Creek. Sinuous channel movement is evident through silt and sand depositions (left). Grasshopper Ck still has higher sediment loads today as a lower gradient watercourse.

Major sediment inputs from tractor logging areas by the 1964 flood and subsequent storms are well documented. Timing of pool infill and development

Over the streambank of a shallow pool structure coincides with declining fisheries and habitat conditions. See Fisheries Section for progression of declining stream stucture and fisheries distributions over time.

Twenty year interval stream channel width measurements from 1942 to 1999 show a response widening of the lower Buckeye storage reach between 1961 and 1981 from the mouth to Franchini Ck. This coincides with concentrated harvest activites between the late 1950s to 1968 when most of the timbered areas in the basin had been liquidated by tractors over a narrower time frame compared to the North Fork at this time, which did not show a response. 1942 channel widths can be considered baseline as most of the basin at this time consisted of undisturbed Douglas-fir timberlands.

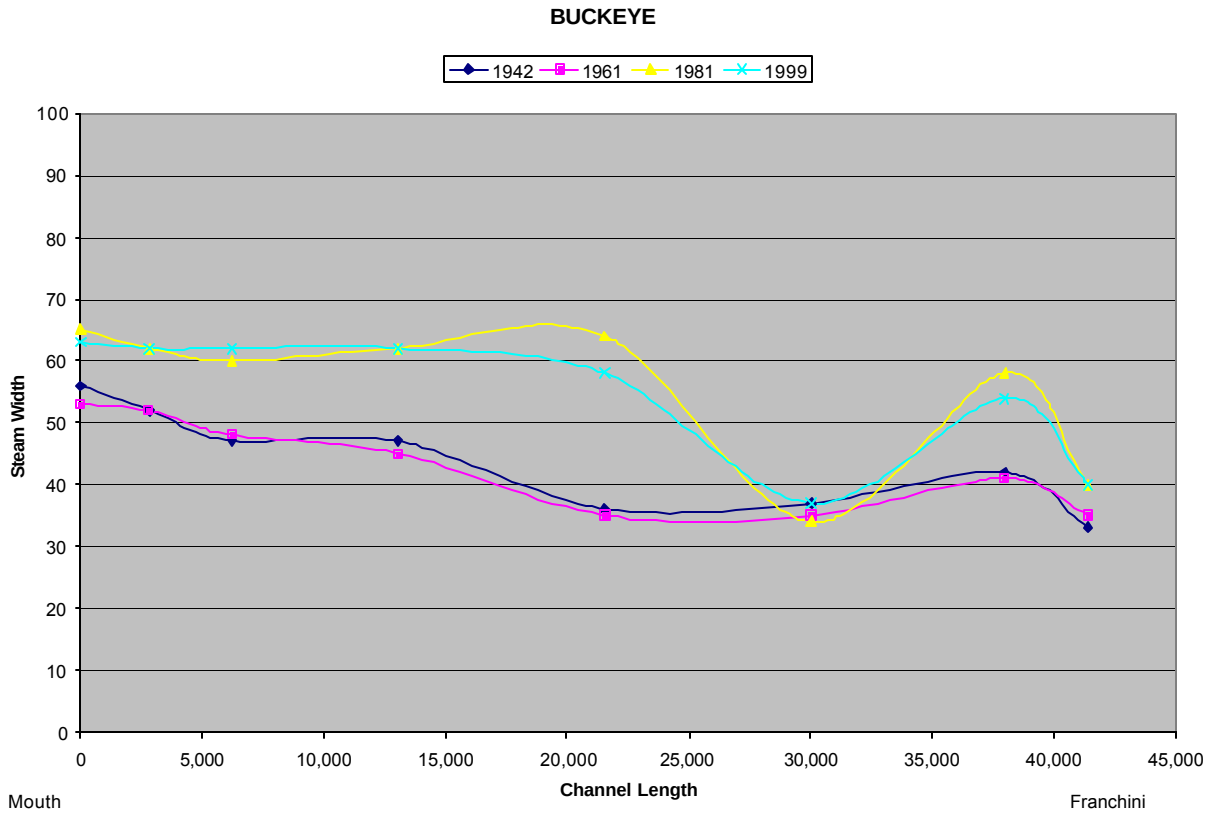


FIGURE 29: 20 yr. intervalstream channel

1942 to 1999, lower Buckeye reach.

The interval between 1942 and 1961 shows similar widths at the time when the Francini Creek basin was just finished, and tractors were moving northeast towards Grasshopper Ck. No recovery or narrowing is indicated by 1999 compared to 1981.

During THP review, Senior DMG Geologist T. Spittler described "The Buckeye Creek watershed has been severely impacted by tractor logging between WWII and 1973. Skid trails were constructed in streams and draws, watercourses were filled, and surface flows were concentrated and diverted. As a result, Buckeye Creek is severely aggraded, filling most pools" (Geological Review 89-091 SON, T. Spittler). Past damage is still contributing significant quantities of sediment to streams. Large amounts of stored sediments are still present in these watercourses. During storm events, this material moves downstream filling pools, scouring channels, and silting spawning beds. Old woody debris pushed into the channel now rots out losing support strength among the soil matrix. This causes more stream channel failures and entry of soils and fine sediment into watercourses (CFL THP 1-95-114).

A no-harvest provision within the Class I (in the middle reaches on CFL lands and vicinity) follows a four year standard of added protection for Buckeye Creek. "The landowners and agencies agree that Buckeye Creek has a temperature problem and needs additional time to develop the shade and pools to improve fish habitat. The pre-1973 practice to build roads and landings in or near streams was widespread and led to massive degradation of the stream system. They were choked with sediment and large woody debris. Stream side vegetation was eliminated and shade canopy was greatly reduced." (S Smith, CDF Field Inspector).

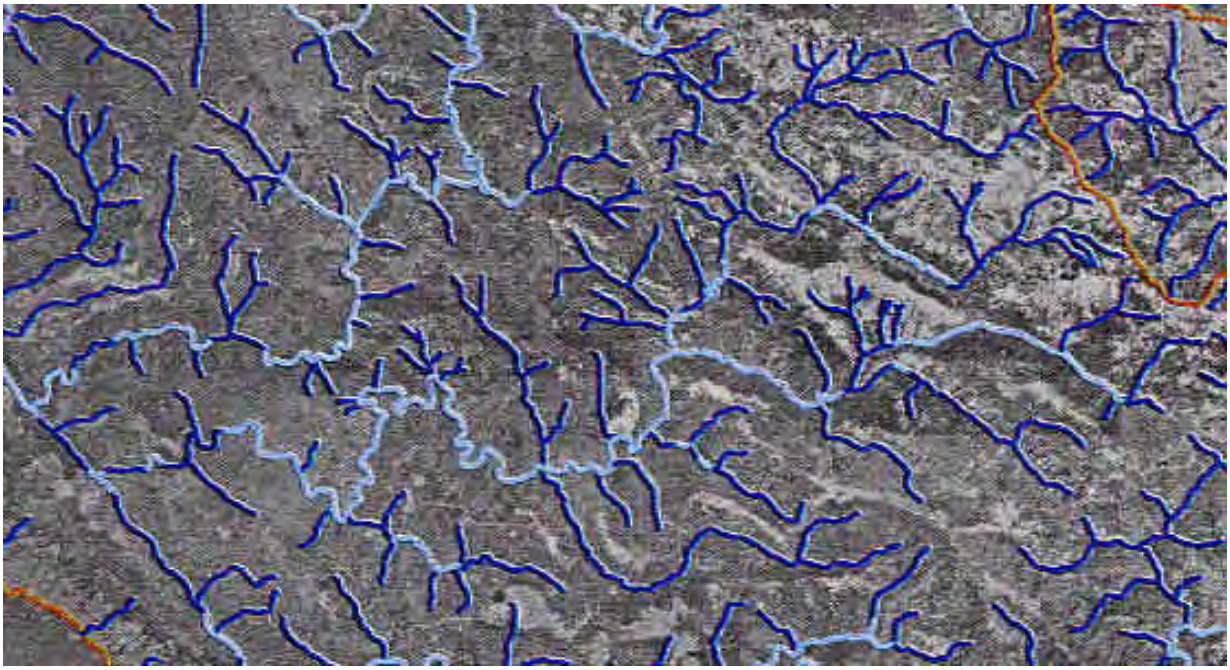


FIGURE 30: 1981 - Bank to bank shade canopy exposure

1981 Bank to bank shade canopy exposure (white) and partial to entire canopy cover (blue)

DOCUMENTATION OF LAND USE IMPACTS BY MAJOR TRIBUTARY

Little Creek

- The Little Ck. basin was logged during the late 1950s. The main haul road followed the stream channel throughout the entire Class I portion of Little Ck. Numerous in stream landings were concentrated in this tributary watershed.
- Lower to Mid Reaches Buckeye, CFL, the main seasonal road followed along the streambed or adjacent to Buckeye Ck. (See Logging Impacts Map , CDF NCWP). This road undercut steep ground between Stanly and Brushy Ridges causing landslides into Buckeye Ck. This road section has been abandoned by a rock slide and numerous washouts. Little River tributary also similarly tractor logged. Tractor logging occurred on slopes in excess of 65% (97-036, CFL).

Franchini Creek.

- The entire tributary basin was logged 1959-1960. The main seasonal road followed in and adjacent to the stream channel. Numerous debris slide failures have been noted along the main WLPZ road in 1961 and 1965 photos, as Francini Ck. undermined the road
- WQ stream surveys of Francini Ck find fine sediment almost completely burying cobble (WQ TMDL, 2001).
- The Francini Ck. watershed was burned through during the 1950s. Subsequent salvage logging used in WLPZ roads and in stream landings (97-034, CFL).

Grasshopper Creek.

- The main haul road, now abandoned, followed the stream channel of Grasshopper Ck. leading west to the Buckeye Ck. Rd. No culverts were used and the road was abandoned with no stabilization measures applied. Logs were skidded downhill, often directly in watercourses. No waterbars were built or stream crossings ditched out. Stream channels now contain large amounts of stored sediment behind jams of large woody debris. The channel continues to downcut to pre-logging level. (93-328)
- Fine sedimentation in pools relative to volume of fine sediment and water (V*) shows 59% pool volume filled with fine sediment, rating comparatively high (Knopp, 1992).
- Grasshopper Creek enters a steep, narrow canyon before its confluence with Buckeye Creek. The canyon walls are mapped as debris slide slopes; although, no landslides were found in the photos

examined. In fact landsliding is somewhat rare in the Grasshopper Creek basin (DMG NCWP)..

Middle Reaches Buckeye Creek.

- Subject to harvest removals and conversion to pastureland, including burning, during the 1950s, 1960s. High sedimentation and accumulation of debris were found in channel. Downcutting and subsequent downstream aggregations were noted. Uncontrolled installation of fills, failure to remove fills, and lack of erosion control facilities has caused several landslides and locally severe erosion. Soda Springs Cks. are also Class I watercourses. PHI describes LWD as common in smaller streams. Existing haul road leads in and out of Buckeye Ck. There were major road repairs to correct on site sediment sources (97-070 and 442, CFL).

- Water T, 16 to 19C, east and west tributaries Buckeye Ck. exceed optimum for Coho south of Bear ridge, Kelly Rd (Flat Ridge Ck. Planning Watershed). Much of the streams are forested with sapling sized conifers/ hardwoods. Extensive grassland areas with more open riparian zones from older intent to conversion, now abandoned. Watercourse areas were heavily cut out during late 1950s tractor operations. Stream diversion repairs noted. New road construction to relocate road segments to ridgeline (CFL 97-227).

- Stream diversion realignments of Class II watercourses specified to repair deep gully erosion down roads and skid trails. This was required on an 800 acre plan upslope of Buckeye Ck as a Class I watercourse. A no-harvest provision within the Class I follows a four year landowner agreement standard of added protection for Buckeye Ck.

North Fork Buckeye

- Steelhead and Coho reported in North Fork Buckeye in 1964. A 1982 survey found pools at 25-40%. Steelhead comprised 40% of fish, among high temps, algae blooms, and lack of cover. A 1995 survey showed 20% pools.

- No harvest WLPZ measures implemented to mitigate streamshade deficiencies from pre 1973 era. Historically, area occupied by Douglas-fir. The area was tractor logged during the 1950s. Some areas entered lightly due to terrain and poor quality of the timber stand. Uncontrolled installation of fills, failure to remove fills, and lack of erosion control facilities has caused several landslides and locally severe erosion. Correction of on-site sediment sources with THPs. Watercourse diversion repairs were noted under THP 1-97-084. Historical intent to permanent conversion to grazing lands with the Howlett Ranch. The older haul road was located adjacent to NF Buckeye Ck. A diverted Class II watercourse triggered a large translational/ rotational slide and “massive erosion” (DMG Report, M. Manson CFL 97-084). The plan required redirection of the watercourse to natural channel by excavator work. Class II watercourse tractor crossings left in place from the 1950s have washed through leaving vertical cuts over 6 ft. down.

<u>Roy Creek (higher Buckeye watershed)</u>

- Most areas were tractor logged during late 1950s to 1960s. Logging was accompanied by attempted conversion to rangeland. Site recon. during several PHIs documents tractor skidding down all slopes irregardless of steepness, to roads and landings located in or adjacent to watercourses. The lack of erosion control caused deep gullying down skid trails discharging into watercourses. Large quantities of soil and debris was placed or washed into watercourses. Debris slides above and below roads are common and frequent. Maintenance of a passable road surface involves clearing of slide debris from the roads and installing infrequent ditch relief culverts. Recent timber harvest activity since 1973 repaired and improved drainage conditions where operations occurred. (M. Jameson, CDF Audit Forester, 1995).

- Roy Ck., in the lower 2 miles above the confluence with Osser Ck., is described in poor condition. High bedloads of sediment line the channel, partially filling pools. Size of pools is reduced by sediment. LWD is not abundant. Upper tributary of N.F.Buckeye Ck. is wide and shallow with low amounts of LWD. Most of the large hardwood and conifers that once lined the streambanks have been cut and the area converted to grass, creating high stream temperatures. (M. Jameson, 95-114). A pool at 2:00 P.M. 8/19/94 measured 75F, a second at 72F. With the recent elimination of grazing activity, conifers have begun to reinvade pastured areas

- The lower kilometer of Roy Creek crosses the Tombs Creek Fault Zone and is impacted by a large active earthflow complex that makes up the NW hillside above the creek. The earthflow formed in the Central Belt Formation which is on the NE side of the Tombs Creek Fault Zone. (the earthflow is a grassy area, probably never offered LWD

Osser Creek (higher Buckeye watershed)

- Logged by late 1950s. Many areas in Osser Ck. subwatershed were first harvested by a diameter limit cut. Tractor operations used some creek channels as skid trails, building landings in or near watercourses. Sediment pushed into creeks from historical operations is still present, and slowly flushing during peak flow events (CFL 99-145).

- Field recon during several PHIs describes Osser Ck subject to heavy deposits of soil and debris (CFL 97-070 and CFL 95-114). Size of pools reduced substantially by filling with fine sediments. An active earthflow impinges on the creek in areas probably contributing fines but on-site evaluation is needed to verify. Most channel overstory cover removed by historical logging and conversion to pastureland. Current shade on Osser Ck. is estimated at 80% in upper reaches, and increasingly lower in downstream reaches. Current condition is described in a stage of recovery, requiring many decades for fine materials to flush downstream during high flow events. Background levels of sedimentation are generally high but not specifically known and should be considered in evaluating recovery from land use disturbance. Streamside shading will similarly require several decades to recover with conifer ingrowth after cessation of grazing and conversion to pastureland. (M. Jameson, 95-114).

Fluvial Geomorphology

Aerial photo interpretation of the North Fork Gualala planning watershed found overall levels of channel disturbance greater in the 1984 photos (WAC-84-C, 4-21-84) than the 1999/2000 photos (WAC–C-99CA, 4-13-99; WAC-00-CA, 4-2-00).

Little Creek Planning Watershed

Buckeye Creek in the Little Creek planning watershed is characterized by approximately 80 percent apparent channel disturbance in the 1984 imagery. Bank erosion is common in the reach upstream of Little Creek. Seventeen delivering landslides are mapped. Little Creek has approximately 80 percent apparent channel disturbance in the 1984 imagery with some areas of bank erosion and 14 delivering landslides.

By 1999/2000, Buckeye Creek has recovered some with approximately 50 to 75 percent channel disturbance and 12 delivering landslides. Bank erosion continues upstream of the junction with Little Creek. Little Creek has recovered more with approximately 25 percent of the channel having disturbance characteristics and 6 delivering landslides mapped.

Grasshopper Creek Planning Watershed

The 1984 imagery of Grasshopper Creek planning watershed shows that Buckeye Creek between Grasshopper and Soda Springs creeks is approximately 25 percent disturbed with some areas of bank erosion and two delivering landslides. By 1999/2000 the area increase in apparent disturbance to less than 50 percent, continued bank erosion and seven landslides delivering sediment to the channel.

In Francini Creek, the 1984 imagery shows at least 90 percent channel disturbance with 17 delivering landslides. In the 1999/2000 imagery some improvement is evident with approximately 50 percent of the reach apparently disturbed reach with 2 delivering landslides.

The lower reach of Grasshopper Creek is approximately 50 to 75 percent disturbed in the 1984 imagery with 3 delivering landslides. By 1999/2000 signs of apparent channel disturbance are less than 25 percent of the reach, mostly in the upper portion. Four delivering landslides are mapped from the 1999/2000 images.

Soda Springs Creek shows approximately 25 percent apparent channel disturbance and 2 delivering landslides in 1984 imagery. In the 1999/2000 images, disturbance characteristics are seen on less than 10 percent of the reach, but 4 delivering landslides are mapped.

Harpo Reach Planning Watershed

In the 1984 imagery, the North Fork of Harpo Reach planning watershed shows approximately 10 percent apparent disturbance most within a mile upstream of the junction with Buckeye Creek. Some additional disturbance is mapped along an un-named tributaries in Sections 29 and 30, of Township 11 North, Range 13 West. Ten delivering landslides are mapped across this planning watershed.

By 1999/2000 the un-named tributaries in Section 29 continue to show disturbance while the section of North Fork above Buckeye Creek appears to have recovered. A new portion of Buckeye Creek for approximately one mile below the North Fork Osser planning watershed boundary now has signs of channel disturbance. Other areas of the watershed show general improvement in channel conditions.

Flat Ridge Creek Planning Watershed

The lower reach of Buckeye Creek below Flat Ridge Creek is generally disturbed up to 75 percent of the reach in the 1984 imagery and 4 delivering landslides are mapped. Above the junction with Flat Ridge Creek, the 1984 imagery shows less disturbance in Buckeye Creek with up to 50 percent impacted and 8 deliverin landslides.

By 1999/2000 the portion of Buckeye downstream of Flat Ridge Creek has improved with approximately 20 percent disturbed and 7 delivering landslides. Above Flat Ridge Creek, Buckeye Creek continues to have approximately 50 percent disturbed reach, but the disturbed areas are a higher percentage in the downstream portion.

Flat Ridge Creek shows approximately 70 percent disturbance in the 1984 imagery and 10 delivering landslides. By 1999/2000 the reach has generally recovered from the disturbance.

North Fork Osser Creek Planning Watershed

In the 1984 imagery, Roy Creek shows less than 10 percent of the channel disturbed with 2 delivering landslides near the junction with Osser Creek. In the 1999/2000 images, channel disturbance appears to increase to less than 25 percent. Osser Creek has approximately 10 percent disturbance and 4 delivering landslides in the 1999/2000 images.

Water Quality

In-stream Sediment

Streambed particle sizes are small compared to Knopp (1993), and may be a limiting factor for salmonid suitability in parts of the Buckeye Creek subbasin. Median particle size (D_{50}) measurements were provided by GRI for three sites in about the lower three miles of the Buckeye mainstem (Little Creek Planning Watershed). Data from three sites in the middle section, from 3.5 to 13 miles upstream (Little Creek, Grasshopper Creek, and Flat Ridge Creek Planning Watersheds), were provided by CFL (Figure 31).

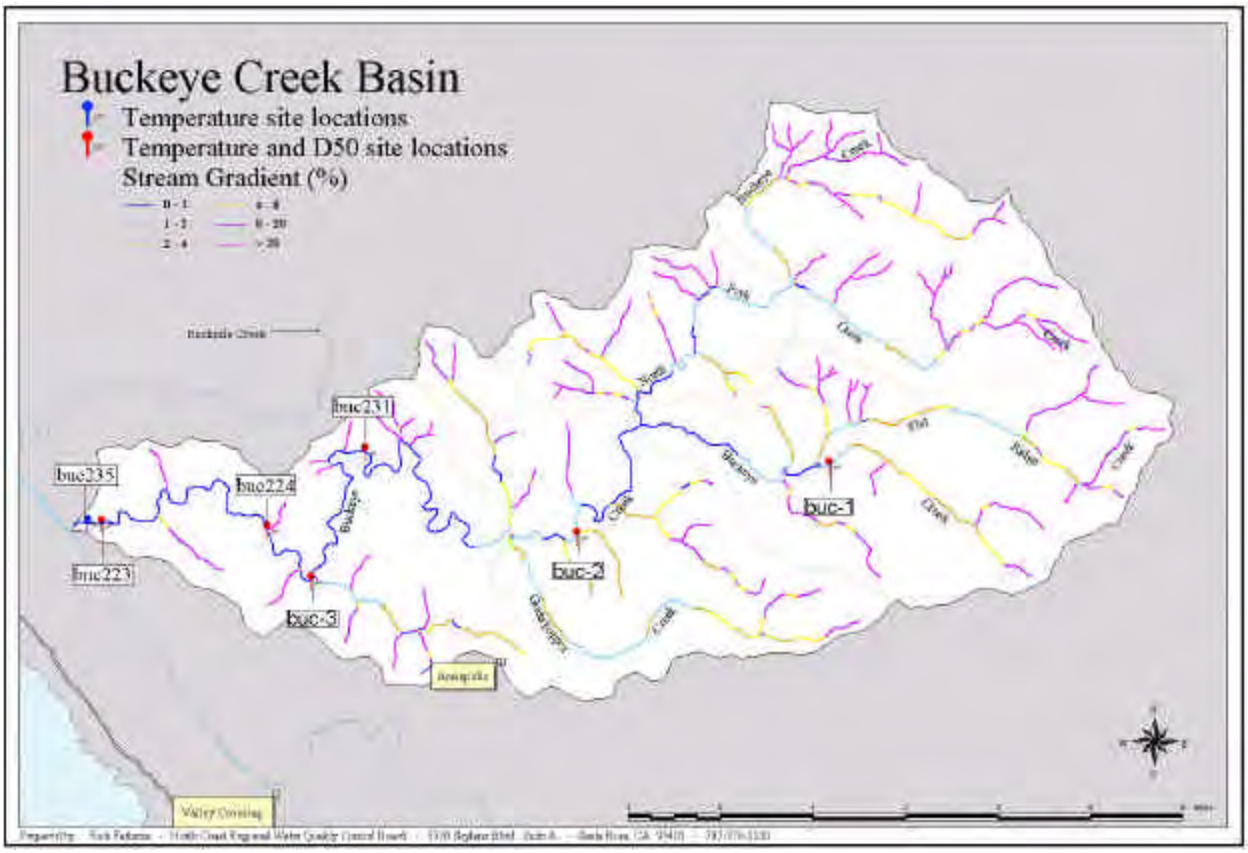


FIGURE 31: Buckeye Creek sampling sites

(***buc-1, buc-2, and buc-3 are CFL sites)***

GRI measured D_{50} at three transects per site in 1997, the upper site in 1998, and the lower site in 2000. CFL measurements are for the 1995-1997 period. The lowest site in the basin (BC#223) showed some improvement over time, two transects of three showing an increase in D_{50} from the 1997 medians of 16 and 30 mm to D_{50} values of 35 and 47 mm in year 2000.

The CFL data showed a decrease in particle size from their upper site to the lower site, a span of about 9 miles. The upper site D50 was 24 mm, the middle site was 18 mm, and the lower site was 9 mm.

To compare the data to Knopp (1993), the individual D_{50} values for the sites (3 transects per site) were averaged. The minima, maxima, and averages were considerably lower than the same statistic from Knopp (1993): following table and figure.

Stream Name	Years	No. of Sites	No. of Samples *	Minimum (mm)	Average (mm)	Maximum (mm)
Lower Buckeye Creek (GRI)	97 one for 97-99	3	5	25	28	32
Middle Buckeye Creek (GRI)	97, 99	3	9	16	25	38
Knopp (1993) Index Streams	1992	6	18	37	69	183
* no. of samples = number of averages included in the comparison						

TABLE 15: Median Particle size (D50) sampling efforts

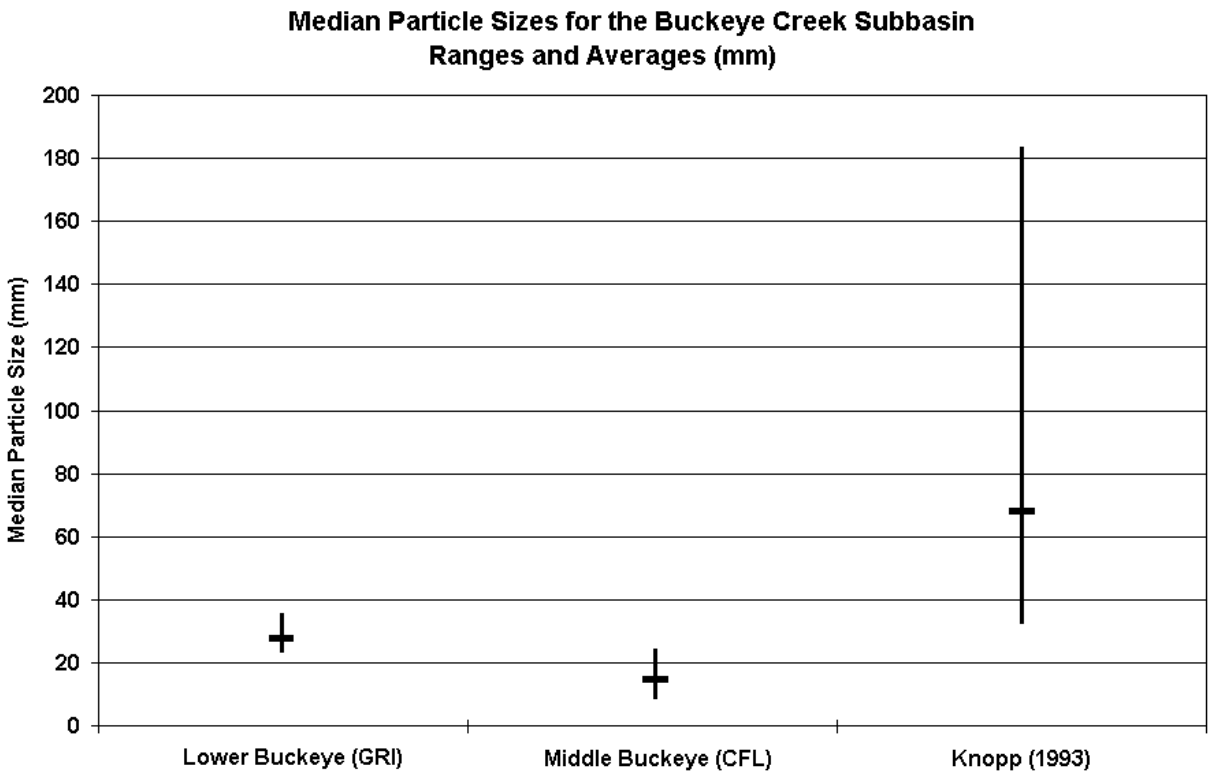


FIGURE 32: Median particle sizes in Buckeye Creek Subbasin

The lowest site in the basin (BC#223) showed some improvement over time, two transects of three showing an increase in D_{50} from the 1997 medians of 16 and 30 mm to D_{50} values of 35 and 47 mm in year 2000.

Water Temperature

Water temperatures for the mainstem Buckeye Creek in the lower three miles are probably limiting suitability for salmonids. Continuous temperature monitoring data were available from GRI for four sites in the same area as the sediment data (lower three miles of the mainstem), for a total of 15 seasonal points in the period of 1994-1977 and 1999-2001 (Figure 31, above).

Seasonal maximum temperatures for the mainstem ranged from 70-76 F, close to the lethal maximum. MWAT values were above the proposed "fully suitable range" of 50-60 degrees F at all sites in all years, with an apparent downstream cooling (Figure 33).

The LandSat-derived vegetation theme for the Buckeye Creek subbasin shows more open stream canopy than for Rockpile as Buckeye flows into the marine influence, probably contributing to high water temperatures low in the subbasin to a greater extent.

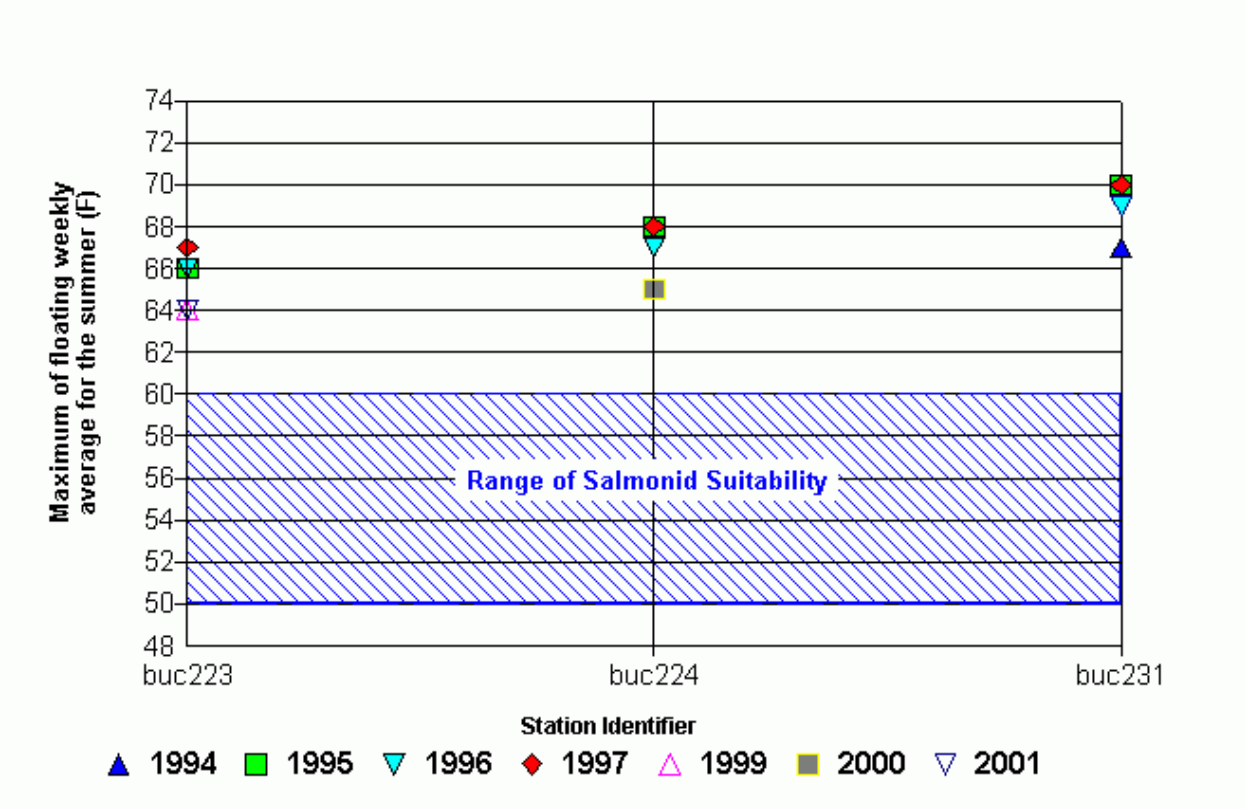


FIGURE 33: MWAT - lower three miles - 1994-2001

Maximum weekly average temperatures (MWAT) for the lower three miles of the Buckeye Creek subbasin, 1994-2001.

Aquatic/Riparian Conditions

Habitat inventory surveys conducted in 2001 showed the dominant substrate as gravel. Average embeddedness from DFG surveys in 2001 was higher than optimal, ranging from 26-50% along the main stem to Flatridge Creek.

TABLE 16: Instream Data

Buckeye Subbasin

DF&G Habitat Typing Data

(June-August, 2001)

Tributary	Pool Frequency *	Pool Depth Maximum (Feet)	Pool Depth Mean (Feet)	Dominant Substrate	Substrate Embeddedness
Buckeye Creek	41%	3.5	1.2	Gravel	26-50%

* By habitat occurrence

TABLE 17: Summary of Large Woody Debris

Buckeye Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2000)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Buckeye Creek	223	25,588	2,946	49
Buckeye Creek	231	21,198	0,228	7

*Watershed size is calculated as the area above the monitoring site.

The Cooperative Monitoring Program surveys show both Buckeye Creek sites lacking in volume and pieces of LWD (Table 17). Buckeye is slated to be part of phase two of the LWD cooperative placement project in the watershed.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at one reach site in the Buckeye subbasin in 2000 by Jon Lee can be characterized as average when compared to similar north coast watersheds (Table 18).

TABLE 18: Summary of Macroinvertabrate Sampling

Gualala Redwoods, Inc.
Buckeye Subbasin
(2000)

Tributary	Site Number	Watershed* Size (acres)	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Buckeye	223	25,588	32	0.88	4.0%	5,713	26%

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

Buckeye Creek spawning areas were noted to be an average of 25-50% embedded, which is over the optimal range for salmonid spawning substrate in 1998. Electrofishing of Franchini Creek in 2001 observed steelhead, and no coho were found.

A second 1995 survey showed that Buckeye Creek had a fish community dominated by less than one year old steelhead with a few sculpin also present. Yearling and two year old steelhead were present but in low numbers.

Kimsey (1953) reported steelhead young-of-the-year were concentrated in the upper reaches. One year and older congregated in the lower reaches during the summer. Cox (1994) stated that coho had once existed in Buckeye Creek and Franchini Creek. Fox and Quinn (1964) reported incidental occurrence of coho and steelhead upstream in the North Fork Buckeye below Osser and Roy creeks, although roach predominated the sample.

The summer 1964 survey showed 50% pools among boulders occupied by steelhead at 250/ 100 ft. 1-8 inches long. One stream temp of 72 F was measured during the September 1964 survey.

Fish Habitat Relationship

Habitat inventories were conducted on the entire 53,653 feet of mainstem Buckeye Creek in 2001. The pool frequency was 44% by percent occurrence. Maximum pool depth was 3.5 feet and mean pool depth was 1.2 feet.). Survey reaches were co-dominated by mid-channel pools and flatwater with a substrate consisting of gravel. Canopy closure averaged 53% with conifers contributing 35% and deciduous tree the remainder.

A 1970 survey reported 30% pools, and substrate from predominantly gravels to 50% silt and 30% sand, after logging and 1964 flows. A 1980 survey found steelhead, fine sediment and lack of shade documented (99-445). Stream aggradation is indicated as a result of past forest practices as evidenced by numerous alluvial flats and general absence of deep pools. A 1995 survey found 20% pools, majority in 3 to 4 foot depth range and deeper. Limited watercourse shade canopy overstory cover was reported in higher (east) portions of the Buckeye Creek watershed.

Subbasin Issues

- Fish density – No current data exists.
- In-stream habitat diversity and complexity, based on surveys available, appears to be insufficiently diverse. Inadequate pool depth and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.
- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.
- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.
- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.
- Sub-division construction are not an issue at this time. However, Pioneer Ltd owns a larger portion of the upper subbasin and is for sale. Grazing are possible issue as in the upper subbasin
- Water chemistry – No data is available on pH, DO, nutrients.

- Water temperatures data suggests that summer high temperatures exceed optimal conditions for salmon throughout much of this planning basin.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***The Buckeye subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- EMDS results and temperature data are still being analyzed.

Contrary Findings:

Improving canopy

Potential Recommendations:

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

- Most of the roads in the basin were built strictly to support logging operations.

- Most of the middle reaches of the Buckeye basin were clear-cut between 1952 and 1968 building roads in or along the major tributaries streams and main stem Buckeye. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground.

- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the middle reaches Buckeye basin.

- Comparative 20 year stream channel width measurements between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.

- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:
None at this time.

Limitations

These conditions are well constrained within the scope of work performed thus far.

Conclusions

Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Potential Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources:
  - Franchini, Grasshopper, and Osser Creeks.

Working Hypothesis: ***Depleted overstory shade canopy cover along Buckeye Ck. and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Buckeye Creek and tributaries. There was near entire canopy elimination in the middle reaches and upper reaches of the Buckeye basin, with operations especially pronounced during the late 1950s to 1964.

Contrary Findings:
- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Recommendations:
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the Buckeye Creek and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.

Working Hypothesis: ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.
- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.
- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:
None noted.

Limitations*:* Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Potential Recommendations:

- Artificial LWD installation projects vastly speed up in channel diversity development

- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

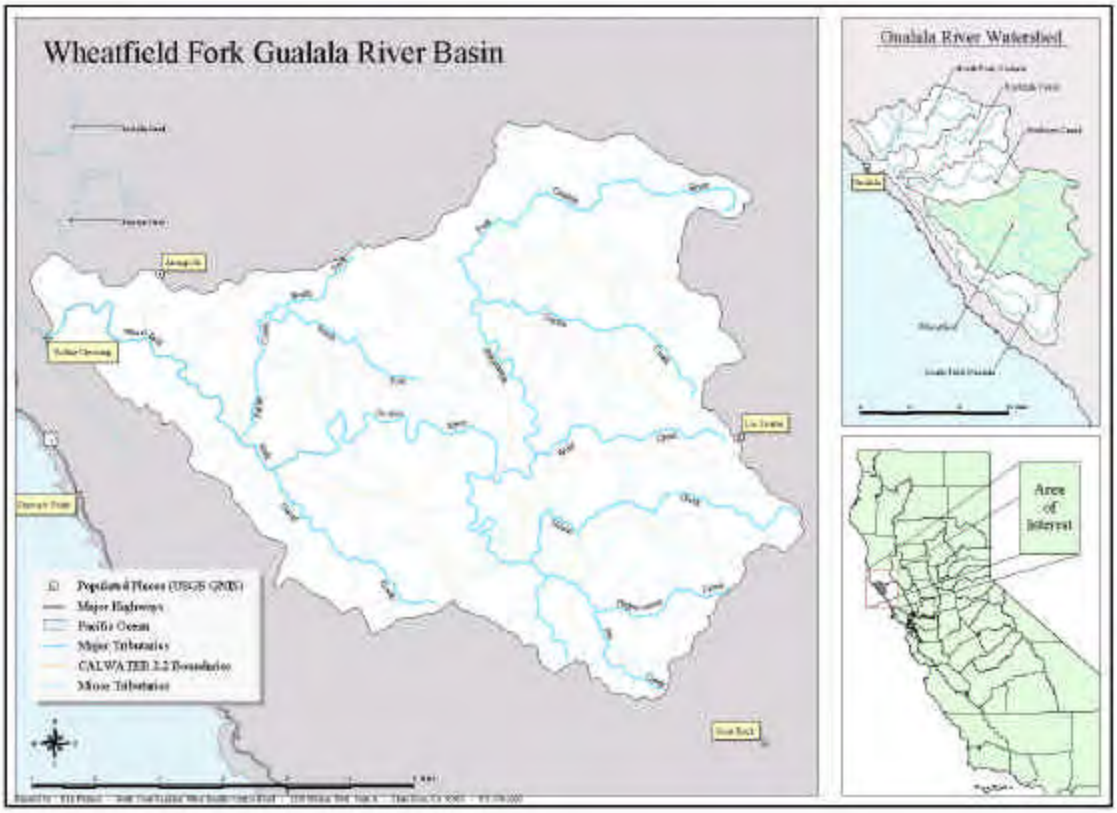


FIGURE 34: Wheatfield Fork Subbasin

Geology

The Coastal Belt of the Franciscan Formation is bounded on the east and west by major strike-slip faults, the Tombs Creek Fault and the San Andreas Fault, respectively. These and several strike-slip faults cut the bedrock in this basin. Multiple generations of lateral movement along these strike-slip faults have progressively disrupted and rearranged drainage and created vertical changes in the topography. The winding path of the Wheatfield Fork is 56 km wide long, compared to a total lineal distance of 24 km. This is due to two parallel, NW oriented shutter ridges that form obstacles around which the river flows. The shutter ridges probably slid progressively NW and/or uplifted into position along the San Andreas and Tombs Creek, and ancillary faults. The ridges shunt Wheatfield Fork drainage along their NW trending, east facing range fronts. More complex patterns of stream disruption due to faulting are evident in the eastern portion of the subbasin and are described in the geology report in the Appendix. The headwaters of the Wheatfield lie on the east side of the Tombs Creek Fault Zone within the Central Belt of the Franciscan Formation. Large earthflow complexes are abundant in this area. Large complexes of rockslides flank the ridges along the Tombs Creek and San Andreas Faults. The Ohlson Ranch Formation is poorly consolidated and is subject to landsliding along the edges of terraces or along incised drainages.

VEGETATION

The 1942 photos show dense mature Douglas-fir redwood timber bordering both sides of the lower reaches of the Wheatfield Fork mainstem. However, in 1942, the river frequently shifted back and forth to the opposite stream bank throughout an aggraded channel basin. Despite the large standing timber flanking the streambank, the channel is wide enough to still create longer sections of bank to bank canopy exposure from the South Fork upstream to the confluence with Tombs Creek allowing for long term warming. The main tributary watercourses were largely covered. There was dense coniferous canopy cover over Fuller, Tobacco, and Haupt Creeks. There was partial to entire canopy cover over the more inland locations including NF Wheatfield, Tombs and House Creeks. These was consistent partial to entire oak-woodland cover along riparian channels in the dense melange soil type

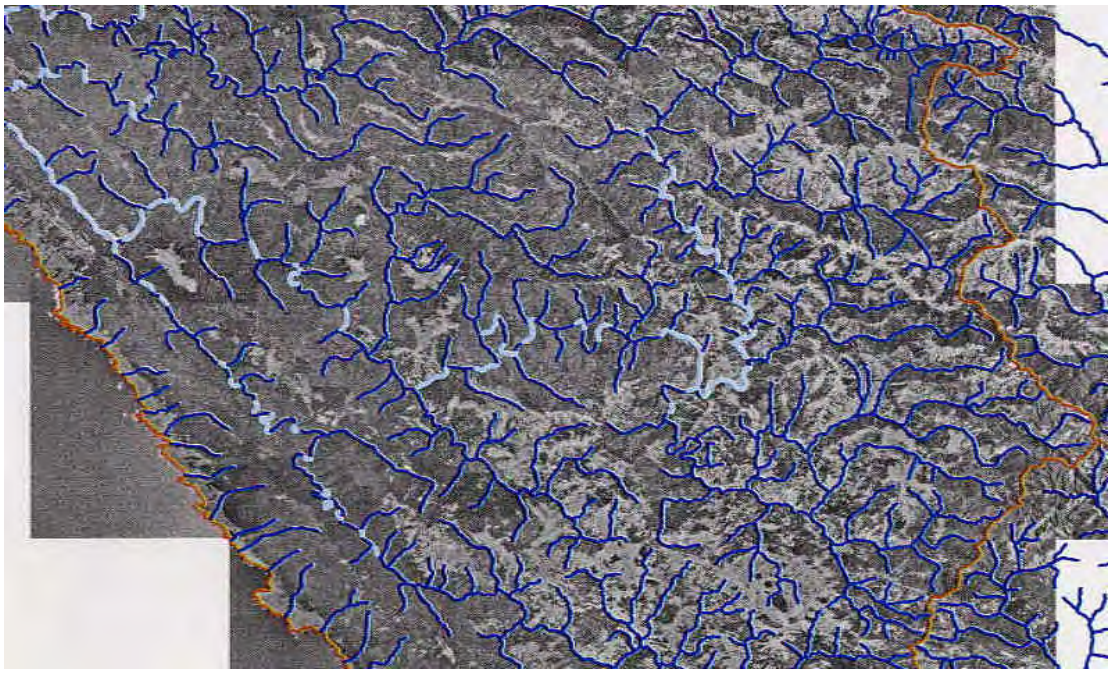


FIGURE 35: 1942 Bank to bank streamside canopy cover

1942 Bank to Bank streamside shade canopy cover (white). Blue shows partial to entire shade canopy cover.

LAND USE

Timberland use and ranching have been the dominant land use practices. The highest timber site ground is in the lower reaches within the coastal fog influence. After WW II, these areas were logged first in the early 1950s, south of Knob Hill and flanked by Burnt Knoll Ridge to the east. During the middle to later 1950s, proximity to coastal transportation routes confined logging operations to the lower reaches of Fuller, Tombs, and House Creeks. Logging operations then spread east and north when road networks were built inland. The late 1950s, and early 1960s were the most active harvests in the North Fork of the Wheatfield, Tombs, and House Creeks. Timber clearance, road building followed by prolonged pastureland use was the dominant practice in this portion of the sub-basin, most evident in the Pepperwood Creek tributary to House Creek

Throughout all of these areas during this time period, inner riparian areas were the central locations of road building. tractor yarding, and timber removal. In the steep, deeply incised Sullivan and Fuller Creek canyons, the entire logging road network was built along the creek at the base of steep ravines. Streamside roads and landings are particularly concentrated along Tobacco Creek, lower House Creek, central North Fork Wheatfield, and central to higher Tombs Creeks.

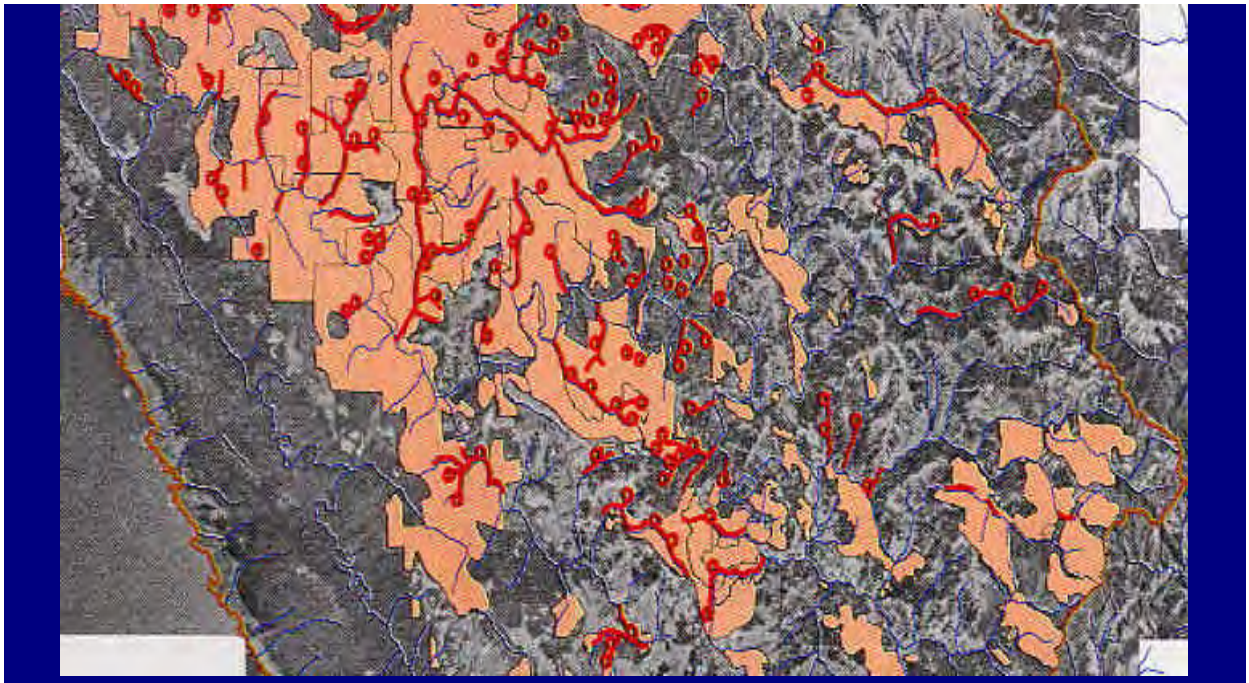
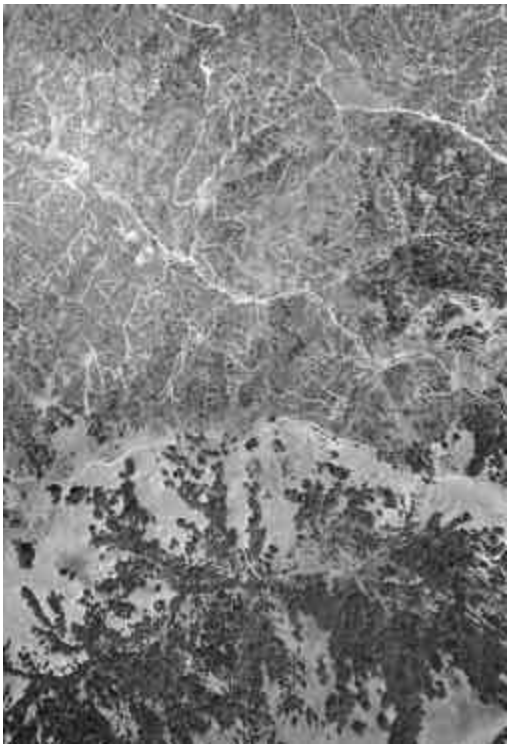


Figure 36: TIMBER HARVEST OPERATIONS 1952-1964

Streamside roads and landings (red). As a result, the 1964 flood event incised the in-stream landings and undercut streamside roads collapsing sections into the creek. The non-existent road drainage concentrated runoff triggering debris slides accessing watercourses.



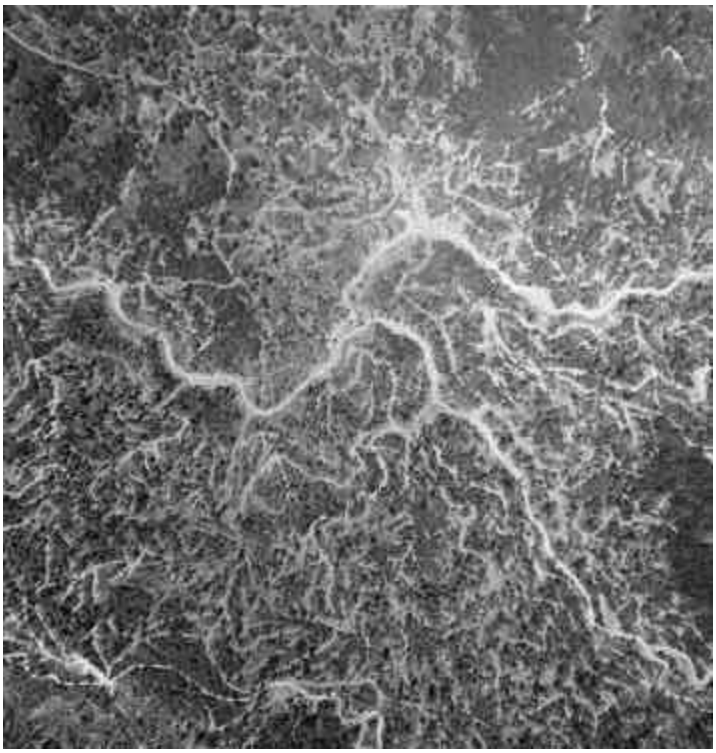


Figure 37: Conifer Block removal exposing Tobacco Ck.
Streamside roads along N.F. Fuller (right) June, 1965 CalTrans 1200 scale

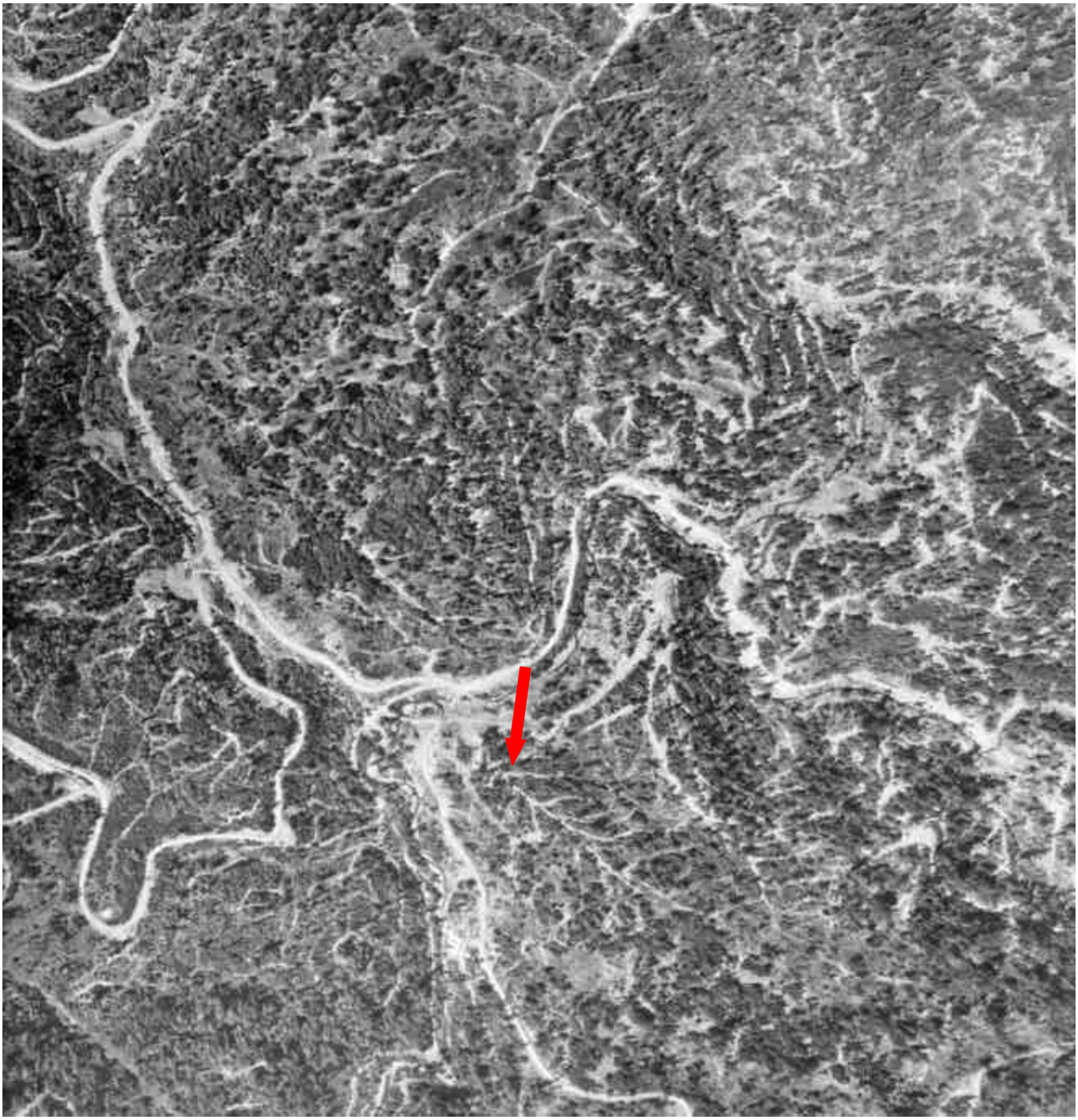


FIGURE 38: Central Landing Complex - Main Stem Fuller Ck.

The 1964 winter storm surge incised the landing complex (lower left) and destroyed the lower NF Fork Road (upper right). Note meandering stream flow patterns over filled substrate (red arrow). By 1984, most of this debris had washed downstream, and Fuller Creek, flowed straight through the original V-shaped stream channel bordering the landing. The 1996 storms washed remaining debris out to expose the graveled substrate seen today.

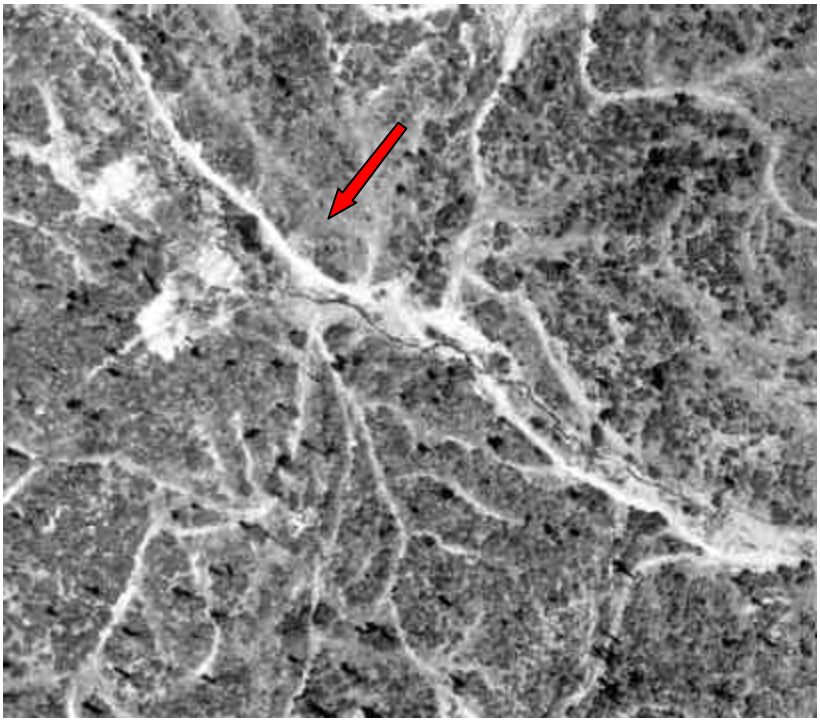
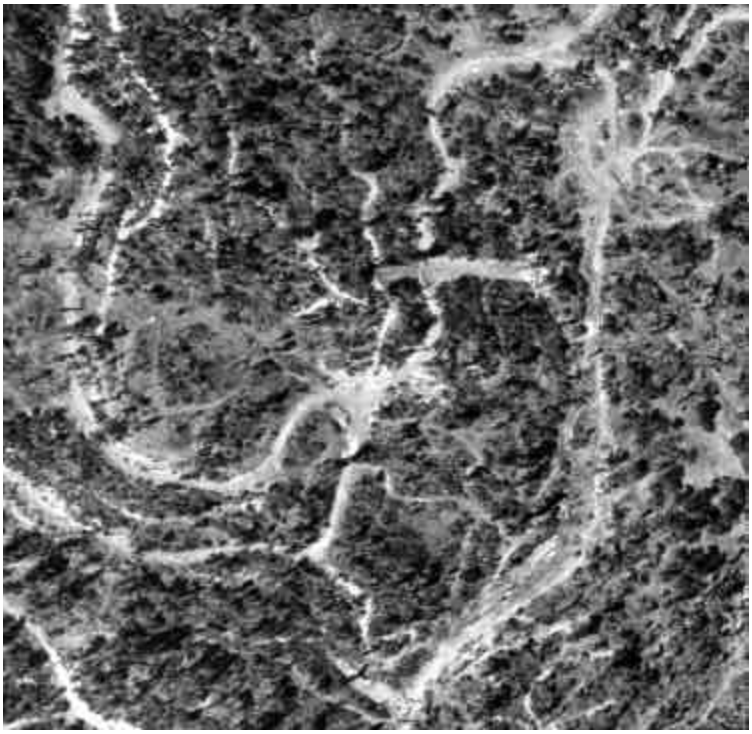


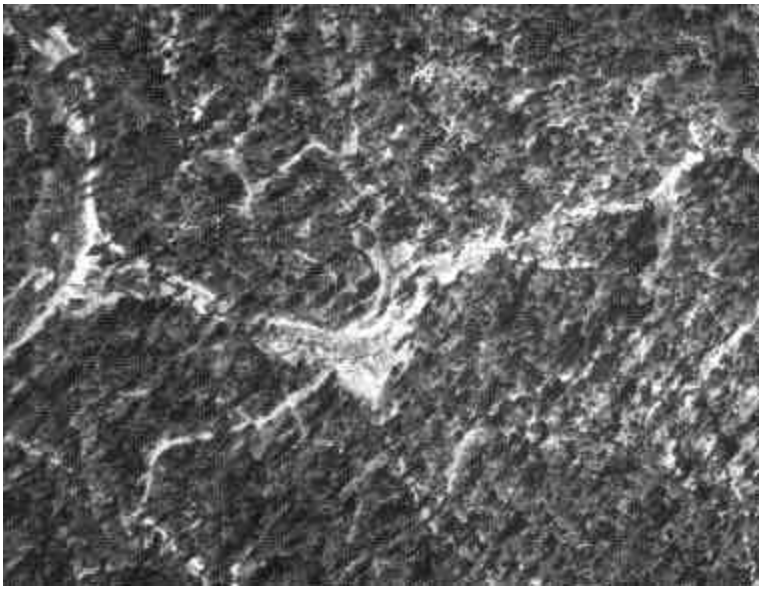
FIGURE 39: Tobacco Ck. 1964



Tobacco Ck. incised the in-stream landing (upper left) during the 1964 winter storm surge, creating a canyon on the discharge side (red arrow).

Debris slides slice through several road contours, discharging onto a tributary watercourse to Wheatfield Fork, at Annapolis Fire Station, 1965 (lower left). Note complete absence of any erosion control measures, including road cross ditches, and dipped road watercourse crossings.

FIGURE 40: Wheatfield Fork - Annapolis Fire Station



Sullivan Creek meanders over buried stream pools, June 1965. Sullivan Creek follows a fault that separates the Coastal and highly erodible Central Belts of the Franciscan Formation and crosses the poorly consolidated Ohlson Ranch Formation As a deeply incised canyon, the haul road was built along the creek. By 1984, this debris had washed downstream. Sullivan Ck returned to a linear drainage. Much of this debris is probably still deposited on the aggregated substrate of Wheatfield Fork, one quarter mile downstream .

FIGURE 41: Sullivan Creek, 1965

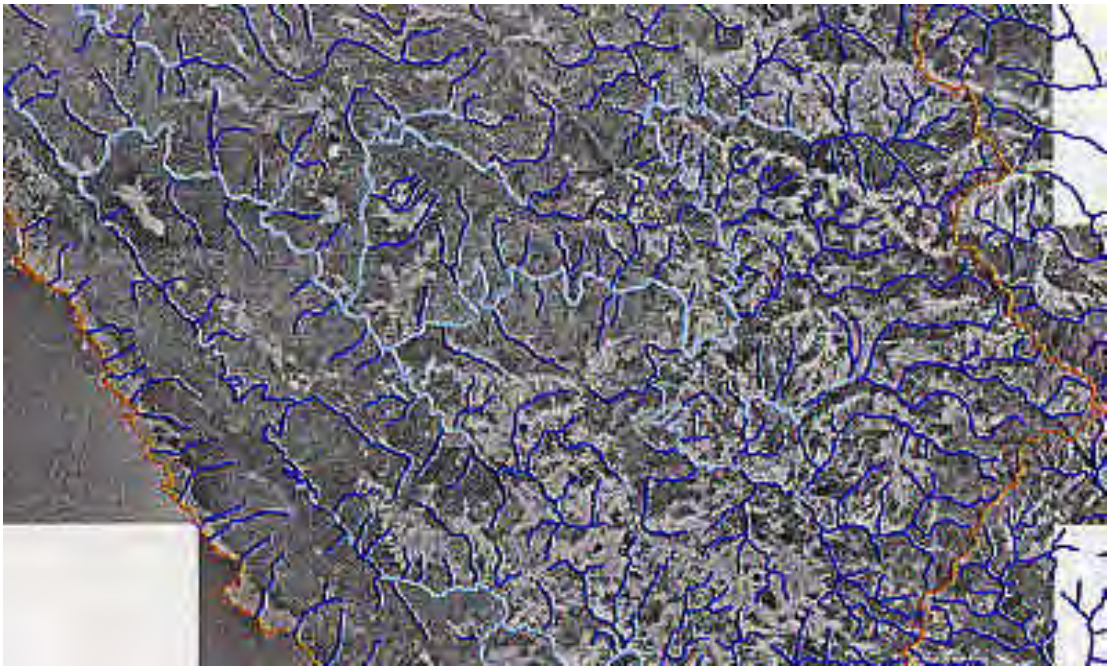


FIGURE 42: Bank to bank shade canopy exposure 1981

1981 Bank to bank shade canopy exposure (white) and partial to entire shade canopy cover (blue).

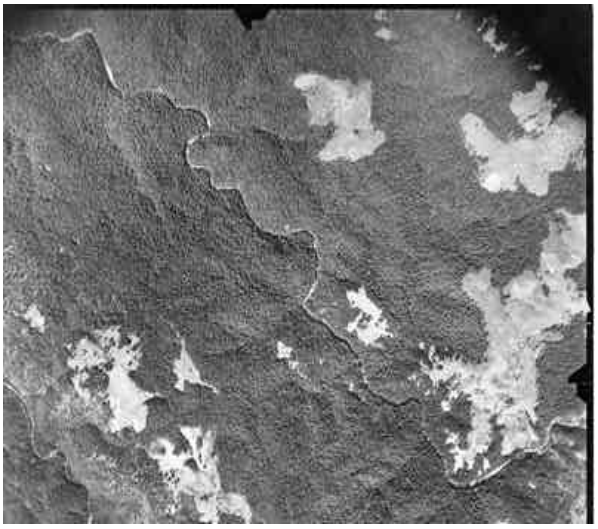


FIGURE 43: Lower Wheatfield Fork 1942

1942, lower Wheatfield Fork, Fuller Ck. (right). The Gualala study used 1936 and 1942 photos to show baseline conditions of riparian cover. Old growth logging was basically finished by the turn of the century. The watershed was inactive during the Great Depression. Large tracts of original Douglas-fir stands dominated the middle reaches of Rockpile, Buckeye, and Wheatfield basins by 1942. Baseline stream channel widths were measured, progressing upstream to House Ck. from the confluence with the South Fork

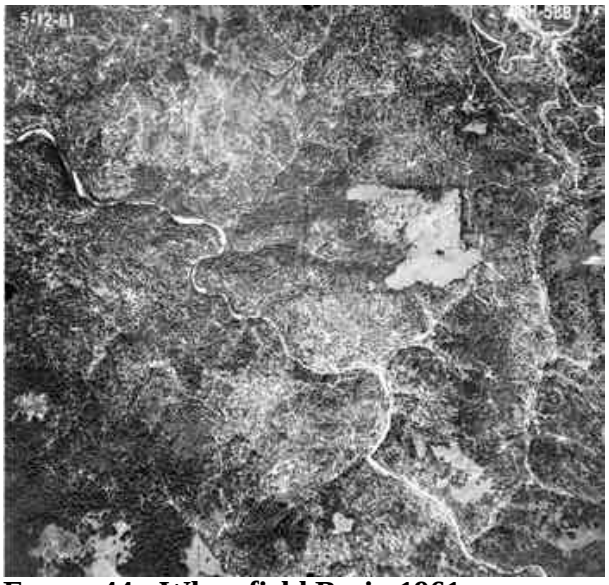


FIGURE 44: Wheatfield Basin 1961

1961. Starting during the mid 1950s, early versions of the D-8 and D-10 tractors block cleared the entire lower Wheatfield basin. Tractors roamed up and down smaller creeks, and built roads and landings in or along larger streams. The lack of any erosion control measures in these areas made large parts of watershed vulnerable to large storm events. Stream channel widths did show a widening response, see Figure
below. Tractors eliminated riparian canopy cover and in stream Large Woody Debris.

There were still consistent Coho salmon and larger steelhead counts during this time period.

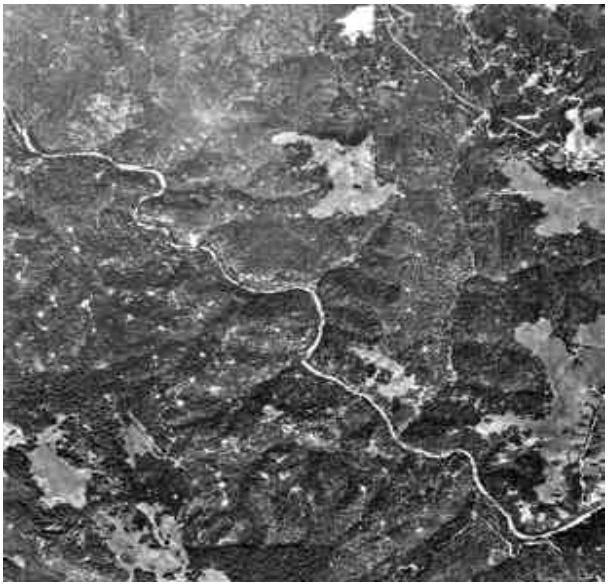


FIGURE 45: 1984 photo

1984. Young conifer in-growth reestablished vegetative cover, although storm run-off continues to concentrate along streamside legacy roads and skid trails. Pool infill, shallow pool structure, stream simplification, and increasing embeddednes, impair anadromous fisheries viability. DMG mapped stream channel disturbances in addition to landslide densities using the 1984 aerial photos. Stream surveys show declines of anadromous fisheries.

1999. The area is now more fully vegetated. Streamside legacy roads and landings have increasingly stabilized. Deep road and skid trail gullies may have incised down to rock or hard clay. DMG generally found fewer stream channel disturbances compared to 1984. Road related debris slides generally diminish. The Gualala Watershed Restoration Council has removed many of the old log chunk, dirt fill road stream crossings in Fuller Creek (right). Lower Wheatfield Fork. continues to show a widened channel width compared to 1942.

FIGURE 46: Fuller Creek 1999

Twenty year interval stream channel width measurements from 1942 to 1999 show a response widening of the lower Wheatfield Fork between 1942 and 1961 from the mouth to Haupt Ck, but possibly narrowing back down to 1942 widths at House Ck. This coincides with concentrated harvest activites between 1952s and 1960 when most of the timbered areas in this part of the basin had been operated by tractors over a narrow time frame. 1961 to 1981 continues to show a response widening compared to 1942. 1942 channel widths can be considered baseline as most of the basin at this time consisted of undisturbed Douglas-fir timberlands (see 1942 photo above)

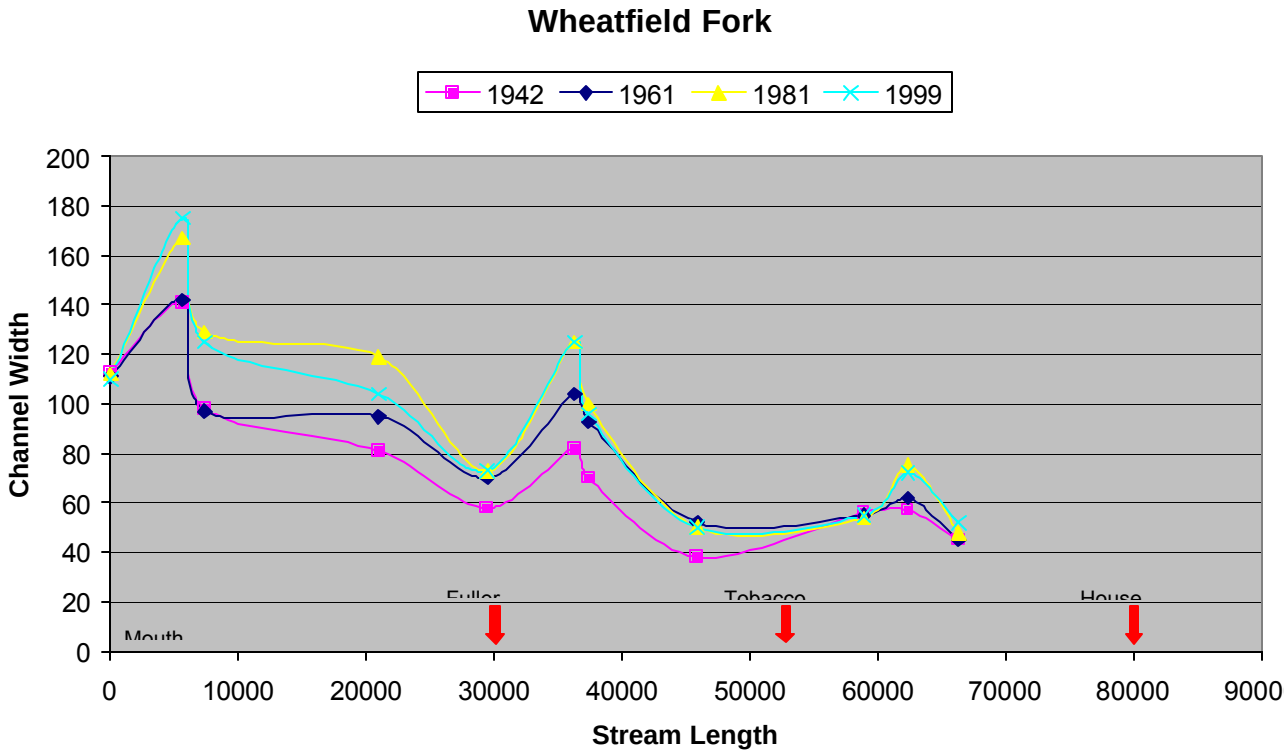


FIGURE 47: Stream channel measurements-Wheatfield Fork

Land Use Impacts Documentation

Fuller Creek

The Fuller Ck. sub-basin consis ts of steep, deeply incised terrain. Upper reaches are characterized by inner gorge ravines. In the lower reaches, there has been deep downcutting by Fuller Ck. between plateau areas of moderate to near level terrain upslope. The upper sub-basin including North and South Forks were mostly logged by between 1960 and 1964. The Lower reaches south of Fuller Mt. were logged during the mid to late 1950s (See Logging History Maps). Main haul roads were all built along the creek channel at the base of steep terrain. Large in stream landing complexes were built by filling the channel with wood debris chunks and topped with dirt. Skid trails were constructed in streams and draws, and surface flows were concentrated and diverted. The 1964 flood event caused massive erosion downcutting, slides, and washing of soil and debris into watercourses. Numerous stream surveys spanning 1964 to present correlate declining fisheries populations with shallow pool structure and declining pool frequency. More recently, there has been concentrated restoration work to stabilize sediment sources.

- Four large debris flows are apparent in the 1965 photos. These slides originate from areas that were severely disturbed by logging. By 1984 these slides are obscured by revegetation. Active landsliding is most abundant along the SF of Fuller. An unmaintained logging road parallels the creek on the north side. The road is generally 20-30' above the creek. The slopes are steep, large debris slides are very common. The road has been obliterated by debris slides. 1961 photos show minimal active slide movement prior to harvesting. The 1942 photos show dense mature wooded cover with few visibly apparent active slides. Similarly, the South Fork contained dense mature conifer cover, which was logged by 1964. To this day, sideslopes along the S.F. continue to discharge a variety of sediment in the creek. The roadbed is actually intercepting large volumes of sediment. Field inspection of two of the delivering debris slides revealed that the one consisted mainly of coarse gravel and the consisted mainly of crumbly shale that would readily decompose into fines. The streambed below these slides consisted of coarse gravel and cobbles and did not seem excessively sediment impacted (DMG NCWP).
- By 1968, a massive debris slide breached two road spans contouring steep terrain in the South Fork. Starting from the Fuller Mt. Ridge, the slide mass rammed down onto the South Fork, creating a lake. This later breached, leaving a water-fall appearance in the channel (CDF NCWP).
- The earliest documented fisheries survey in Fuller Ck. dates to summer, 1964. At this time, Rowell and Fox found the main stem Fuller Ck. (up to NF/SF) still supporting salmon and steelhead. Pools constituted 70% of the stream reach with a maximum pool depth of six ft. Fine sediment comprised 20% of the stream substrate. By 1971, Parke and Klamt found pools reduced to 40% of the reach, maximum pool depth at 4 ft., and silt and sand at 35%. Of total stream substrate.
- In 1964, Rowell found the North Fork still supporting salmon and steelhead but in rapid decline due to logging, reporting pools at 30% total reach, and 40% substrate consisting of sand and silt, deepest pools at 3 ft, and overstory canopy depletion by removal of riparian conifers. By 1971, Parke and Klamt found pools reduced to 25% of the stream reach of the NF, and maximum pool depth at 2 ft.
- In 1964, Rowell and Fox reported in the South Fork heavy sand deposits at 50% of the substrate among dense concentrations of jams, logging slash and debris. Pools had completely filled in with a maximum depth of 2 ft. and average depth of six inches. By 1971, Parke and Klamt reported some recovery in the SF to 15-20% favorable habitat by reach, maximum pool depth 2.5 ft., silt and sand comprising 50% of total substrate, but a water temperature of 78F. The 1964 flood may have flushed some of the logging debris downstream by 1971 since coho and steelhead counted at 100/100 ft. reach.
- By 1996, Sotoyome reported the Main Stem Fuller comprised of 61% riffles and 39% pools, similar to the 1971 survey. In the NF, Sotoyome found pool frequency at 36% and maximum pool depth at 3 ft., and 68% shade canopy cover, indicating recovery from logging damage. In the SF, Sotoyome found pools had increased to 35% reach and maximum depth at 4 ft. Only 37% of pools were greater than 2 ft. depth. Shade canopy cover measured at 59%. Cox (1989) found densities of steelhead juveniles at 53/100 ft. reach but a 1995 survey reported half this density (Cox, 1995). These factors indicate recovery, but slower compared to the NF (P. Higgins, 2001).
- The 1995 Sotoyome survey describes Sullivan Ck. in mid-recovery at 23% pools but 16% of the streambed was dry from aggregation. Average depth of pools was 2 ft. but 38% of pools were greater than 3 ft. deep. Canopy had recovered to 89%.

Tobacco Creek

- Main road built along Tobacco Ck. with series of landings in or adjacent to the main creek. The 1964 flood event incised each of these landings cutting deep vertical gorges and creating canyons on the discharge side (See Figure above)
- By 1964, harvest operations advanced east of the Tobacco Ck. area to the higher reaches of an adjacent larger order stream flowing down a ravine to Wheatfield Fk. The 1964 flood event triggered a long torrent slide all the way down the creek through a mature timbered tract discharging into Wheatfield Fk. By the late 1960s, a haul road was built over the torrent slide following the creek
- Three large dormant landslides line the creek.

Haupt Creek

- First logged in the late 1800s to early 1900s with steam donkeys. Ben May logging Co. Lumber Co. was the first major landowner The lower portion of Haupt Ck. was logged during the late 1950s. (98-281, MRC). Most remaining areas upstream were logged by 1970.
- The creek runs through the Coastal Belt Franciscan and forms a steep inner gorge with debris slide slopes In 1964, Klamt and Pool described the headwaters and lower reaches of Haupt Ck. "so aggraded from the previous logging that the stream flowed underground in places" Pools comprised 80% reach length, with maximum pool depth at 5 ft. Coho and steelhead equally abundant but at densities of 25/100 ft. Roach found at 200 per 100 ft. In 1970, Park and Klamt found that pools had declined to 60% stream reach, and maximum depth reduced to 3 ft. Coho salmon still noted in 1970 at densities of 25/ 100 ft., but only in the lower reaches. Steelhead had increased substantially to 500/ 100 ft in the lowest reach and 100/100 ft. further upstream. Steelhead compete well in altered stream habitats (Higgins, 1995). The aggregation point causing subsurface stream flow in lower Haupt, had washed downstream by 1970.
- Coho was not observed in the middle reach during electrofishing conducted in October, 2001. The lower reach was dominated by steelhead young-of-the-year and roach, with sculpins, stickleback, steelhead 1+ and newts present (DFG, 2001). As noted in a 1964 stream report: Haupt Creek is polluted from siltation and slash from past logging operations (DFG NCWP).
- Currently, the LP SYP describes the main channel of Haupt Ck. having relatively low structural diversity with long shallow stretches and only occasional pools. Heavy aggregation is not indicated. Historically active landsliding has been limited to small (< 100' greatest dimension) events. Best ratings for spawning conditions of all tributaries to Wheatfield Ck (98-281, LP SYP). Currently, Coho are not found. Steelhead only (T. Wooster, DF&G). Haupt Ck. is highly responsive to rainfall probably because of its steep narrow inner gorge (98-281 MRC). Major tributary Class II in lower south bank of Haupt, used as a skid trail prior to 1970, downslope of Tin Barn Rd.

North Fork Wheatfield (upstream from Tombs Creek)

- Downslope areas along the Main Stem N.F. Wheatfield, flanked by Bear and Gibson ridges, were tractor logged during the late 1950s. This reach cuts a steep valley across Central Belt terrain and is flanked on both sides by earthflows.(DMG NCWAP) Upslope areas were logged by 1964. Tractor skid trails were excavated throughout deeply incised terrain along the N.F. No active slide areas are apparent in 1942 photos. The 1964 photos show numerous steep inner channel debris slides along the N.F. among recently logged areas. During the 1964 flood, one watercourse diverted onto the haul road, discharging at the headwall of one the larger slides Another major watercourse diversion onto roads is noted in this area An earthflow and rock slides are notable along the stream. In the steep canyon shallow debris sliding is common, mapped as debris slide slopes.
- Northeast corner of Wheatfield watershed logged 1991 thru 1997, most heavily roaded area. Remaining portion of this part of the watershed helicopter logged due to steep terrain . Ridge tops converted to orchards or vineyards.
- The upper part of the reach (above Tombs Creek) was heavily dominated by roach (26), Elk Creek
- Elk Creek, tributary to the higher reaches of N.F. Wheatfield, was used historically for livestock grazing known as the Tabor Ranch. Mixed conifer/ hardwood stand developed in response to clearing and burning operations with intent to convert to pastureland. Elk Ck. was heavily impacted by tractor operations in 1950s, 1960s. Upper segments of Elk Ck. were used as skid trails with instream landings at truck road crossings. Logging debris and soil placed in stream beds. Flushing of this material continues with peak flow events. Existing road adjacent to Class II abandoned with new road relocated to the ridgeline (93-436 CFL. Five steam diversions onto truckroads repaired (92-382). Streambank rehabilitation work directed by J. Monchke.

Tombs Creek

- The sub-basin in underlain by the Central Belt of the Franciscan Formation, containing a high concentration of landslides, many active
- Upper Wheatfield, Tombs Creek, timber harvested to convert to grazing land in larger areas of the subwatershed. Sedimentation and accumulation of organic debris in channels during original tractor logging during the late 1950s and 1960s (CFL 97-158). Conversions to pastureland have been the dominant form of historical use. Tractor skidding down watercourses removed overstory canopy cover with intent to maintain permanent conversion for grazing use.
- One channel type of B4 was electrofished and showed that roach dominated (134) with steelhead 1+ (25), steelhead young-of-the-year (18), stickleback (5), newt (5), and steelhead 2+ (2) present. A roach dominated community indicates impaired conditions (DFG NCWP, 2001).

House Creek

- Coho were known to spawn and rear in House Creek (Cox, 1994). A 1965 survey found steelhead ranging from 75 to 125/ 100 ft. among near equal number of roach and stickleback along three sample reaches. No coho were reported in this 1965 survey. Pollution-Use by horses, cattle and sheep (DFG, 1965). A 1970 survey reported Coho at 25/ 100 ft. in the lowest sample reach. Steelhead –500+/100 ft. in lower sections and 100/100 ft. in upper section. Sheep in upper one mile of stream (DFG, 1970).
- The gate on a 4-5' high dam on house creek on Soper Wheeler property has been opened because the reservoir has been completely filled with bedload from upstream. Downstream of the dam the channel is incised to bedrock, probably due to the depletion of bed and suspended loads. In a few areas along House Creek, remnant bedrock terraces –capped with cobble sized alluvium- are found above the channel (as much as 1-5-20' in one area)
- Downstream of the dam, House Creek, the bed changes dramatically from a shallow flat bottomed, fines-dominated condition to a bedrock terrace covered with cobbles coarse sands, and gravels. A large portion of the alluvium is out of the active channel. This terrace occurs approximately at the toe of a large active landslide. Some of the coarse material may have derived from the slide. The bedrock terrace may represent a localized uplift or tilting, perhaps due to deep-seated forcing of the landslide against the bank. For example some slides move by rotational about a horizontal axis. So, in rotational slides, the toe area may become somewhat elevated. However; no attempt has been made to test these hypotheses Continued use by cattle has trampled the banks in some areas and may adversely contribute to the nutrient load –algae was noted to be common in pools in House Creek
- In the lowest reaches of House Ck. near Wheatfield Fork, roads were built up several Class I tributary watercourses during the late 1950s throughout a larger timbered tract flanked by Skyline Ridge. Peak flows during the 1964 flood removed several sections of the road
- In the highest reaches of the House Ck. basin, upstream of the confluence with both Brink and Cedar Cks., Douglas-fir tracts on north facing slopes were entirely removed during the mid 1950s. Long sections of riparian areas were entirely cleared of all overstory canopy cover with intent for conversion to pastureland. Lack of erosion control facilities created gully erosion noted in 1965 photos

Pepperwood Ck. (Tributary to House Ck.)

- In the headwaters of Pepperwood (Oak Mountain) landsliding is especially abundant, active, and complex. Downstream in map sections 15 and 16 the stream cuts into a broad alluvial terrace that is almost 900 feet wide at the confluence with Jim Creek. Much of terrace material is outside of the active channel. This terrace and those along House Creek seem to be isolated remnants of former drainage patterns and may even be related to isolated fluvial deposits along the crest of Kings Ridge about a mile to the south and elsewhere in the uplift. And so it is uncertain whether the coarse and locally abundant alluvial deposits and bedload result solely from sediment transport within the current stream network from the abundant landslides in the headwaters or from a former system that has been deranged by faulting and uplift and no longer operates.
- Other abandoned areas have regenerated with young conifer/ hardwood overstory. Numerous active earthflows occur along large portions of channels, even more abundant are dormant earthflows that potentially could be reactivated. In each of these landslide-impacted reaches, the channels widen.
- Vegetation has been shaped by repeated fires. Area entirely burned over in 1955, with other subsequent fires to present. Conversions to pastureland have been the dominant form of historical use. Tractor skidding down watercourses removed overstory canopy cover with intent to maintain permanent conversion for grazing use. In many areas, soil compaction by heavy cattle access has prevented timely reestablishment of overstory canopy cover of watercourses with recent abandonment of agricultural use.

Fluvial Geomorphology

Wheatfield Fork-Lower Wheatfield Fork Super Planning Watershed

Annapolis Planning Watershed

In the 1984 imagery at least 80 percent of Wheatfield Fork of Gualala River appears disturbed with large lateral bars common, bank erosion in several areas, and 25 delivering landslides. By 1999/2000 there is some reduction in the size of the bars in the middle reach, less bank erosion, and 9 landslides, three are in the same location as in the 1984 imagery.

Flat Ridge Creek Planning Watershed

In the 1984 imagery, Fuller Creek below the North Fork/South Fork junction has less than 80 percent disturbed with several areas of multithread channel, 5 delivering landslides are mapped. Sullivan Creek appears disturbed for approximately one-half mile upstream of Fuller Creek. In the 1999/2000 imagery less than 30 percent of the lower portion of Fuller Creek is disturbed, but 13 delivering landslides are mapped.

The North Fork of Fuller Creek appears to be less than 50 percent disturbed in the 1984 imagery, mostly in the upper reaches, six delivering landslides are mapped. By 1999/2000 less than 25 percent of the upper reach is disturbed and 9 landslides are mapped.

The South Fork of Fuller Creek is at least 80 percent disturbed in the 1984 imagery with braided channels common, and 39 delivering landslides. By 1999/2000 less than 50 percent of the channel appears disturbed, some bank erosion associated with a near channel road and 30 delivering landslides are mapped.

Tobacco Creek Planning Watershed

In the 1984 imagery, Wheatfield Fork in the Tobacco Creek planning watershed is at least 75 percent disturbed with bank erosion along the outside bends common, and 37 delivering landslides. By 1999/2000 less than 50 percent of the channel appears disturbed. Bank erosion on the outside of bends continues, 29 delivering landsides are mapped, 15 at locations mapped from the 1984 images.

Tobacco Creek has approximately 30 percent channel disturbance in the 1984 imagery with braided and incised channels common. An un-named tributary in Sections 22 and 27, Township 10 North, Range 13 West has approximately 50 percent disturbance and 5 delivering landslides in 1984 imagery. By 1999/2000, less than 20 percent of Tobacco Creek appears disturbed, most in the lower reach, and 3 delivering landslides are mapped in the upper reach area.

Haupt Creek Planning Watershed

In the 1984 imagery, approximately 30 percent of Haupt Creek appears disturbed mostly in Sections 9 and 12 of Township 9 North, Range 13 West, and 4 delivering landslides are mapped. By 1999/2000, less than 30 percent is disturbed with the disturbance shifting downstream to the lower half of the channel, mostly in Sections 4, 9 and 10, Township 9 North, Range 13 West. Twenty-one delivering landslides are mapped from the 1999/2000 imagery.

Wheatfield Fork-Hedgepeth Lake Super Planning Watershed

House Creek Planning Watershed

In the 1984 imagery, channel disturbance ranged from 25 to 50 percent with 2 delivering landslides mapped along House Creek. By 1999/2000, less than 25 percent of House Creek appears disturbed.

Pepperwood Creek Planning Watershed

Pepperwood Creek appears to have approximately 50 percent channel disturbance in the 1984 imagery and 25 to 50 percent in the 1999/2000 imagery. Two delivering landslide are mapped from the 1999/2000 imagery.

Danfield Creek has approximately 50 percent channel disturbance in the 1984 imagery and 5 delivering landslides. In the 1999/2000 imagery, approximately 30 percent of the channel is disturbed.

Britain Creek Planning Watershed

The upper reach of House Creek above Pepperwood Creek and Pepperwood Creek in Sections 3, 4 and 5, Township 9 North, Range 12 West, both appear to have 50 percent disturbance in the 1984 imagery. The amount of channel disturbance in 1999/2000 imagery is similar to 1984 with addition of 2 delivering landslides.

Wheatfield Fork-Walters Ridge Super Planning Watershed

Wolf Creek Planning Watershed Planning Watershed

In the Wolf Creek planning watershed, Wheatfield Fork channel disturbance ranges from 25 to 50 percent in the 1984 imagery with 18 delivering landslides mapped. In the 1999/2000 imagery less than 25 percent of Wheatfield Fork within Wolf Creek planning watershed appears disturbed and 10 delivering landslides are mapped, 8 upstream of the confluence with Tombs Creek.

In the 1984 imagery, less than 25 percent of Wolf Creek appears disturbed, mostly in the upper reach, and 4 delivering landsides are mapped. By 1999/2000 less than ten percent of the channel is disturbed with 3 delivering landslides.

Approximately 50 percent of Spanish Creek appears disturbed in the 1984 imagery mostly upstream of the confluence with Buzzard Creek, 3 delivering landslides are mapped. By 1999/2000 less than 25 percent of Spanish Creek is disturbed above the junction with Buzzard Creek.

Tombs Creek Planning Watershed Planning Watershed

Fifty to seventy-five percent of the Tomb Creek appears disturbed in the 1984 imagery with 10 delivering landslides. In the 1999/2000 imagery less than 25 percent of the channel is disturbed, mostly in Section 17, Township 10 North, Range 12 West, and 4 delivering landslides are mapped.

Buck Mountain Planning Watershed Planning Watershed

In the 1984 imagery, the Wheatfield Fork in Buck Mountain planning watershed has less than 75 percent disturbed channel, mostly in the lower reach, and eleven delivering landslides. By 1999/2000 the channel disturbance is less than 30 percent and seven delivering landslides are mapped.

Tobacco Creek Planning Watershed

In the 1984 imagery, Wheatfield Fork in the Tobacco Creek planning watershed is at least 75 percent disturbed with bank erosion along the outside bends common, and 37 delivering landslides. By 1999/2000 less than 50 percent of the channel appears disturbed. Bank erosion on the outside of bends continues, 29 delivering landsides are mapped, 15 at locations mapped from the 1984 images.

Tobacco Creek has approximately 30 percent channel disturbance in the 1984 imagery with braided and incised channels common. An un-named tributary in Sections 22 and 27, Township 10 North, Range 13 West has approximately 50 percent disturbance and 5 delivering landslides in 1984 imagery. By 1999/2000, less than 20 percent of Tobacco Creek appears disturbed, most in the lower reach, and 3 delivering landslides are mapped in the upper reach area.

Haupt Creek Planning Watershed

In the 1984 imagery, approximately 30 percent of Haupt Creek appears disturbed mostly in Sections 9 and 12 of Township 9 North, Range 13 West, and 4 delivering landslides are mapped. By 1999/2000, less than 30 percent is disturbed with the disturbance shifting downstream to the lower half of the channel, mostly in Sections 4, 9 and 10, Township 9 North, Range 13 West. Twenty-one delivering landslides are mapped from the 1999/2000 imagery.

Wheatfield Fork-Hedgepeth Lake Super Planning Watershed

House Creek Planning Watershed

In the 1984 imagery, channel disturbance ranged from 25 to 50 percent with 2 delivering landslides mapped along House Creek. By 1999/2000, less than 25 percent of House Creek appears disturbed.

Pepperwood Creek Planning Watershed

Pepperwood Creek appears to have approximately 50 percent channel disturbance in the 1984 imagery and 25 to 50 percent in the 1999/2000 imagery. Two delivering landslide are mapped from the 1999/2000 imagery.

Danfield Creek has approximately 50 percent channel disturbance in the 1984 imagery and 5 delivering landslides. In the 1999/2000 imagery, approximately 30 percent of the channel is disturbed.

Britain Creek Planning Watershed

The upper reach of House Creek above Pepperwood Creek and Pepperwood Creek in Sections 3, 4 and 5, Township 9 North, Range 12 West, both appear to have 50 percent disturbance in the 1984 imagery. The amount of channel disturbance in 1999/2000 imagery is similar to 1984 with addition of 2 delivering landslides.

Wheatfield Fork-Walters Ridge Super Planning Watershed

Wolf Creek Planning Watershed Planning Watershed

In the Wolf Creek planning watershed, Wheatfield Fork channel disturbance ranges from 25 to 50 percent in the 1984 imagery with 18 delivering landslides mapped. In the 1999/2000 imagery less than 25 percent of Wheatfield Fork within Wolf Creek planning watershed appears disturbed and 10 delivering landslides are mapped, 8 upstream of the confluence with Tombs Creek.

In the 1984 imagery, less than 25 percent of Wolf Creek appears disturbed, mostly in the upper reach, and 4 delivering landsides are mapped. By 1999/2000 less than ten percent of the channel is disturbed with 3 delivering landslides.

Approximately 50 percent of Spanish Creek appears disturbed in the 1984 imagery mostly upstream of the confluence with Buzzard Creek, 3 delivering landslides are mapped. By 1999/2000 less than 25 percent of Spanish Creek is disturbed above the junction with Buzzard Creek.

Tombs Creek Planning Watershed Planning Watershed

Fifty to seventy-five percent of the Tomb Creek appears disturbed in the 1984 imagery with 10 delivering landslides. In the 1999/2000 imagery less than 25 percent of the channel is disturbed, mostly in Section 17, Township 10 North, Range 12 West, and 4 delivering landslides are mapped.

Buck Mountain Planning Watershed Planning Watershed

In the 1984 imagery, the Wheatfield Fork in Buck Mountain planning watershed has less than 75 percent disturbed channel, mostly in the lower reach, and eleven delivering landslides. By 1999/2000 the channel disturbance is less than 30 percent and seven delivering landslides are mapped.

Water Quality

In-stream Sediment

The NCRWQCB evaluated median particle size (D_{50}) measurements provided by GRI for two sites in 1997 WF#227 and WF#403) and one site (WF#226) in 1997 and 2000 from the lower three miles of the Wheatfield Fork mainstem (Annapolis Planning Watershed) (Figure 40). To compare the data to Knopp (1993), the individual D_{50} values for the sites (3 transects per site) were averaged. Then the minimum, maximum, and average for those averages were compared to the same statistic from Knopp (1993) in the following table.

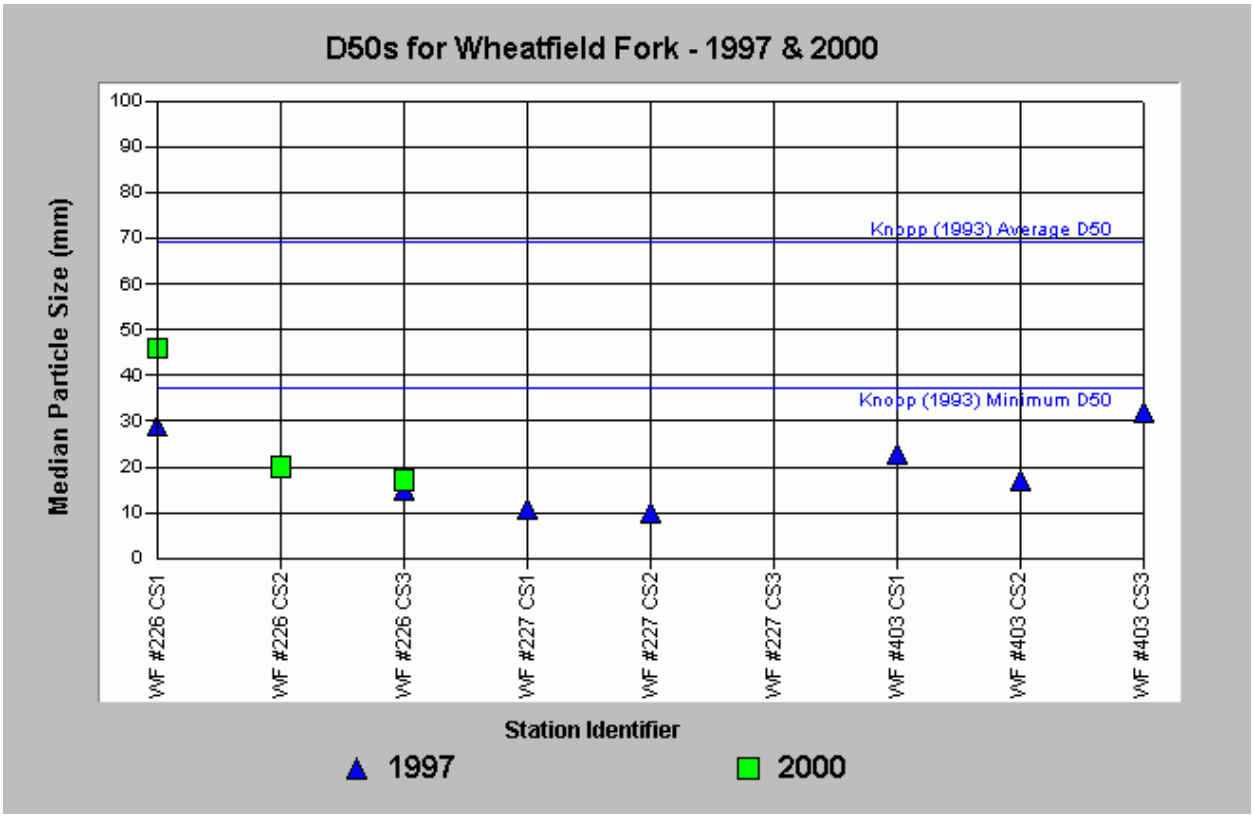


FIGURE 48: Median particle sizes - Wheatfield Fork 1997/2000

While the lowest site in the subbasin showed an increase in D_{50} in one transect of three from the 1997 value of 29 mm to the year 2000 value of 49 mm, median particle sizes at the sites measured in the subbasin are small. DFG embeddedness values for the subbasin overall averaged in the 26-75% range, outside of optimum and into ranges not suitable for salmonid spawning. Both those parameters indicate that sediment particle size and the amount of fine sediment are limiting factors for salmonids. Having maps of landslide activity, roads and other human landscape disturbances, and embeddedness and dominant

Aggradation is indicated by the 1964 survey observation of a large rock outcrop extending 12 feet over the water near the confluence of the Wheatfield with the South Fork. Here, the depth of the Wheatfield Fork was estimated at 10 to 15 ft. in depth. Subsequent aggradation is indicated by a 1995 watercourse survey reporting only the tip of this same rock outcrop. This indicates aggradation of 20-25 ft. between 1950 and 1995 where the elevation is 80 ft (Cox, 1997).

Water Temperature

The NCRWQCB evaluated water temperature data for the subbasin provided by GRI and GRWC from continuous monitors for the periods 1995-1998 and 2000-2001 at 13 sites (total of 25 measurements for the period). The highest MWATs for the period of record from Wheatfield Fork mainstem stations going from upstream of Haupt Creek downstream to near the confluence from the South Fork ranged from 69-73 F, all above the proposed "fully supportive" range of 50-60 F (Figure 49). The seasonal maxima for those same stations ranged from 74-82 F, near or above the lethal maximum of 75 F.

Some evidence of mainstem cooling by tributaries was seen in the 2001 data, with an MWAT in the mainstem above Fuller Creek (wf 617) at 72 F and in the mainstem downstream (wf 600) at 70 F (Figure 49). Water temperatures were lower in one small tributary (wf 228) sampled from 1995-1998 with MWATs ranging from 56-58 F and seasonal maxima ranging from 57-59 F, all within proposed "fully supportive" ranges. Water temperatures in the Fuller Creek watershed (fc 901, fc 618, fc 619, fc 608, fc 606) were on the high side, with MWATs ranging from 59-66 F at five stations in 2000 and 2001.

Water quality data from StoRet for 1988 and from NCRWQCB sampling in 2001 indicate a relatively soft water oligotrophic system. All parameters measured were within the Basin Plan limits and nutrient levels (nitrogen and phosphorus) were below detection limits (Appendix 9).

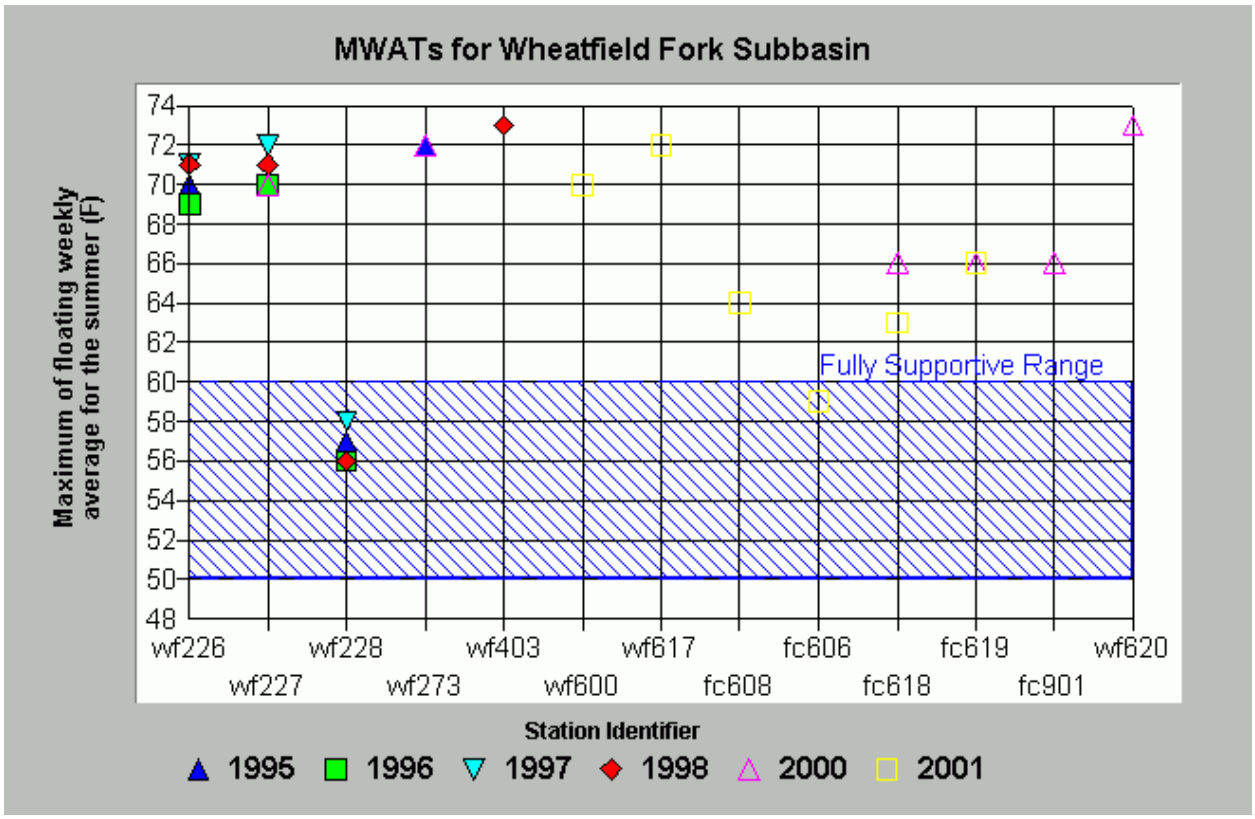


FIGURE 49: MWAT - Wheatfield Fork 1995-2001

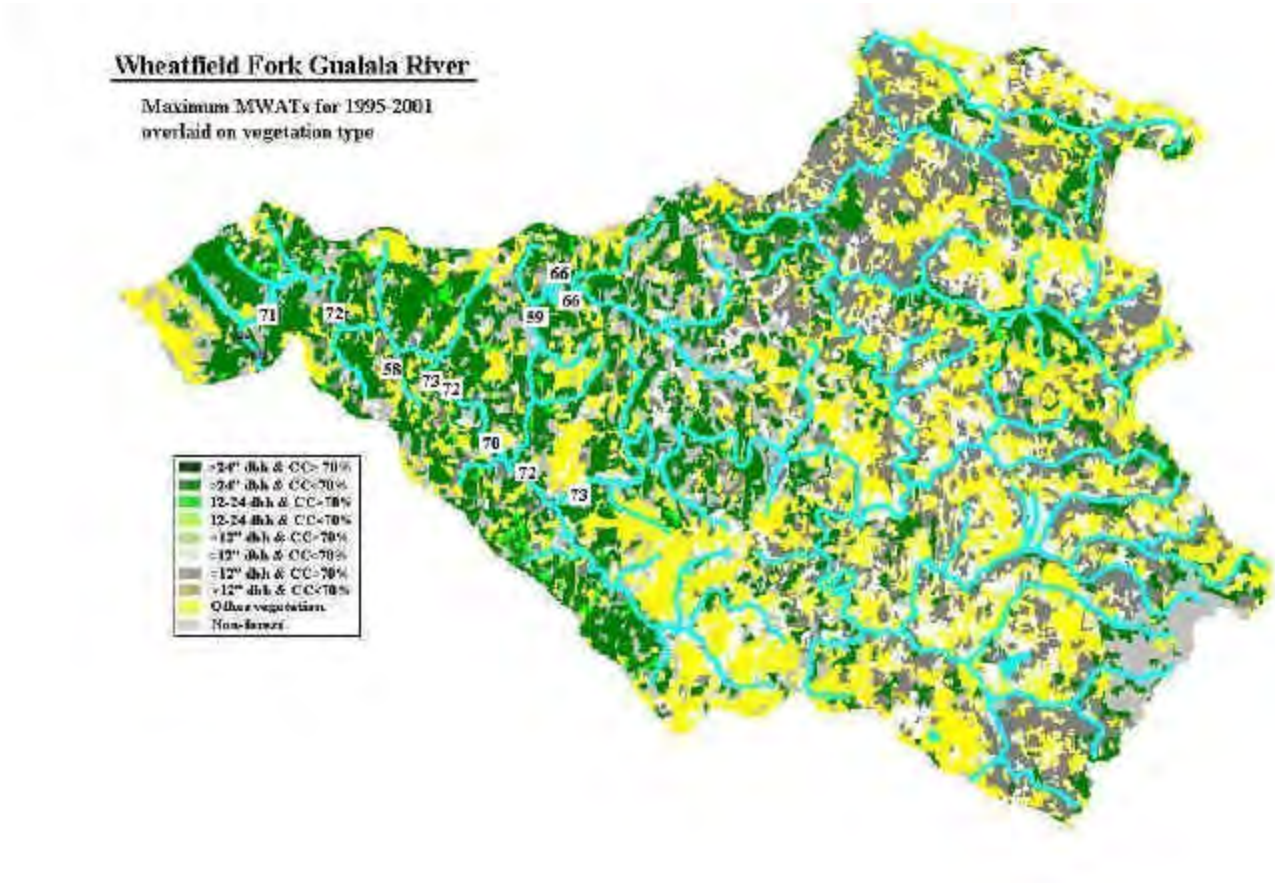


FIGURE 50: Wheatfield Fork Subbasin

Aquatic/Riparian Conditions

The 2001 DF&G surveys describe fish habitat along the Wheatfield Fork dominated by flatwater and riffles with substrates consisting of cobble/ gravel, silt/ clay and bedrock. The mean pool depth in areas sampled is less than 0.50 ft with an average embeddedness of 26-70%. A mostly deciduous canopy covers less than 50% on average sub-basin wide.

TABLE 19: Instream Data - Wheatfield Fork Subbasin

Wheatfield Fork Subbasin

DF&G Habitat Typing Data

(1996 - 2001)

Tributary	Pool Frequency*	Pool Depth Maximum (Feet)	Pool Depth Mean (Feet)	Dominant Substrate	Substrate Embeddedness
Wheatfield Fork	35%	9.3	1.0	Gravel	26-50%
Tombs Creek	45%	3.9	1.0	Gravel	26-50%
Pepperwood Creek	27%	1.5	1.3	Gravel	0-25%
Danfield Creek	22%	5.8	1.5	Cobble	51-75%
Haupt Creek	33%	1.6**	1.6**	Sand	76-100%
Fuller Creek Mainstem	41%	6.0	1.1	Gravel	76-100%
NF Fuller Creek	51%	1.0	1.0	Gravel	51-75%
SF Fuller CreeK	50%	30/4.5	0.9	Gravel	51-75%
Sullivan CreeK	36%	3.4	1.0	n/a	51-75%

* By habitat occurrence **Partial survey

The Louisiana-Pacific Corporation's (formerly, MRC) Sustained Yield Plan shows low (0-39%) watercourse shade canopy cover for most higher (east) portions of the Wheatfield Fork watershed. Smaller sections show moderate cover (40-70%). The LP SYP notes no spawning gravel along a survey strip along Wheatfield Fork. The SYP describes spawning habitat as fair, summer rearing habitat as poor, and overwintering habitat as fair. LWD is described as not abundant in any of the survey reaches.

Tables 20 and 21 show recent canopy density measurements within the Wheatfield Basin. Table 20 density and canopy composition are measured at the thalweg. Density is measured by using a spherical densiometer and the surveyor estimates canopy composition. Table 21 density is measured from the center of channel using a spherical densiometer. The canopy composition is measured by identifying and counting tree species in riparian plots that extend from bank full 100-ft. inland on both sides of the channel.

Table 20: Canopy Density - Wheatfield Subbasin

DF&G Habitat Typing Data

(1996- 2001)

Tributary	Canopy Density	Canopy Composition	
		Coniferous	Hardwood
Wheatfield Fork	44%	48%	52%
Tombs Creek	65%	70%	30%
Pepperwood Creek	9%	95%	5%
Danfield Creek	49%	100%	0%
Haupt Creek*	81%	47%	53%
Fuller Creek Mainstem	67%	44%	56%
NF Fuller Creek	68%	59%	39%
SF Fuller Creek	59%	54%	45%
Sullivan Creek	89%	58%	42%

*Partial survey

Table 21: Watershed Coop. Monitoring prog.

\Watershed Cooperative Monitoring Program

(1996-2001)

Tributary	Canopy Density	RiparianComposition	
		Coniferous	Hardwood
Wheatfield Fork*	40%	90%	10%
Tombs Creek	n/a	n/a	n/a
Pepperwood Creek	n/a	n/a	n/a
Danfield Creek	n/a	n/a	n/a
Haupt Creek	n/a	n/a	n/a
Fuller Creek Mainstem	n/a	n/a	n/a
NF Fuller Creek	n/a	n/a	n/a
SF Fuller CreeK	n/a	n/a	n/a
Sullivan CreeK	n/a	n/a	n/a

*Only one reach site surveyed on lower Wheatfield

TABLE 22: Summary of Large Woody Debris surveys

Wheatfield Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2001)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Wheatfield Fork	226	71,409	1,531	15

*Watershed size is calculated as the area above the monitoring site.

The Cooperative Monitoring Program surveys show the lower Wheatfield lacks volume and pieces of LWD.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at one reach site in the Wheatfield basin in 2000 by Jon Lee can be characterized as average when compared to similar north coast watersheds (Table 23).

TABLE 23: Summary of Macroinvertebrate Sampling

Wheatfield Subbasin
Gualala Redwoods, Inc.
(2000)

Tributary	Site Number	Watershed* Size (acres)	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Wheatfield Fork	226	71,409	32	0.85	4.3%	7,312	32%

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

Historically, the sub-basin was dominated by steelhead rainbow trout with a small number of roach. Steelhead and coho spawned in the tributaries. The earliest fisheries surveys date back to 1964. A summer 1964 stream survey of Wheatfield Fork from the headwaters to Redwood Creek found 50% gravel and 5% fine sediment, conductive to steelhead habitat with juvenile densities averaging 200 per100 feet of watercourse reach. A 1964 survey found the main stem Fuller Creek still supporting salmon and steelhead. Pools constituted 70% of the stream reach with a maximum pool depth of six feet. Fine sediment comprised 20% of the stream substrate. In 1970, coho salmon were found in the lower reaches of Haupt Creek at densities of 25 per100 feet. Steelhead had increased substantially from 1964 to 500 per100 feet in the lowest reach and were lower at 100 per 100 feet further upstream. A 1970 survey in House Creek estimated coho at 25 per100 feet in the lower section, and steelhead at 500+per100 feet in lower sections and 100 per100 feet in the upper section.

Since 1970, Coho have not been observed in the Wheatfield subbasin. Steelhead one year and older have declined or were not observed in the tributaries during 2001 surveys where current and previous data exist and can be compared.

Currently, the fish community appears to be dominated by roach, stickleback, and sculpin, with smaller, less than one-year-old steelhead. Older one and two year steelhead are present only in low numbers. The numbers of steelhead are notably lower than observed in the 1970 surveys. Specifically, the lowest reach survey was dominated by roach (228), with sculpin (9), stickleback (6), steelhead young-of-the-year (2) and steelhead 1+ (2) present. The middle part of the reach was heavily dominated by roach (58), with sculpin (2) and stickleback (2) present. Steelhead young-of-the-year and steelhead 1+ or older were not observed. The upper part of the reach (above Tombs Creek) was heavily dominated by roach (26), with sculpin (2), stickleback (3), steelhead young-of-the-year (1) and steelhead 1+ (1) and 3+ (1) present. Two steelhead (2) were observed, but not netted.

Subbasin Issues

- Fish density –

- In-stream habitat diversity and complexity, based on very limited surveys appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.

- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.

- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.

- Vineyards are very prevalent, grazing and sub-division development are also issues at thitime. Feral pigs also impact the land.

- Water chemistry – No data is available on pH, DO, nutrients.

- Water temperatures data is very limited throughout the subbasin. Data on the Southfork showed temperatures above the fully suitable range for salmonids. Summer high temperatures probably exceed optimal conditions for salmon throughout much of this planning basin. This may be due to natural existing conditions in some areas.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species. Pampas grass is observed.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***The Wheatfield fork subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- Sources of upstream sediment include highly erodible earth materials, mass wasting, seismic activity, and land use.

- Water temperatures in the estuary, as a result of warming effects upstream, may exceed a level that is fully suitable of salmonids.

Contrary Findings:

Recommendations:

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

- Most of the lower and middle reaches of the Wheatfield Fork basin were clear-cut between 1952 and 1961 building roads in or along the major tributaries streams and main stem Buckeye. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground.

- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s are noted in timber harvest plan records, particularly the lower reaches of the Wheatfield Fork basin.
- Comparative 20 year stream channel width measurements between 1942 and 1961, and 1981 show channel width widening responses to concentrated harvests upstream.

- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:
None at this time.

Limitations
These conditions are well constrained within the scope of work performed thus far.

Conclusion
Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.

- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources:

- Lower reaches of House Creek, Haupt Creek, Tobacco Creek, North Fork Wheatfield Fork

Working Hypothesis: ***Depleted overstory shade canopy cover along Wheatfield Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Wheatfield Fork and tributaries. There was near

entire canopy elimination along the lower main stem and main tributaries, especially pronounced during the mid to late 1950s.

Contrary Findings:

- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Recommendations:

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Wheatfield Fork and its tributaries.

- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.

- Increase continuous temperature monitoring efforts.

Working Hypothesis: ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.

- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.

- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:

None noted.

Limitations:

Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Recommendations:

- Artificial LWD installation projects vastly speed up in channel diversity development.
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Mainstem/South fork Subbasin

Geology

Most of the SF is an alluvial stream that mostly flows within the linear valley formed by San Andreas Fault (Figure 39). However the upper reaches are incised to bedrock and occupy a parallel valley east of the San Andreas Fault. Large active earthflows are common along most the length of South Fork (Plate 1). Small (< 100 feet greatest dimension) historically active slides that delivered into SF are especially abundant from Russian Trough Spring and northward. From our limited observations the sediment production along the roughly parallel lengths of

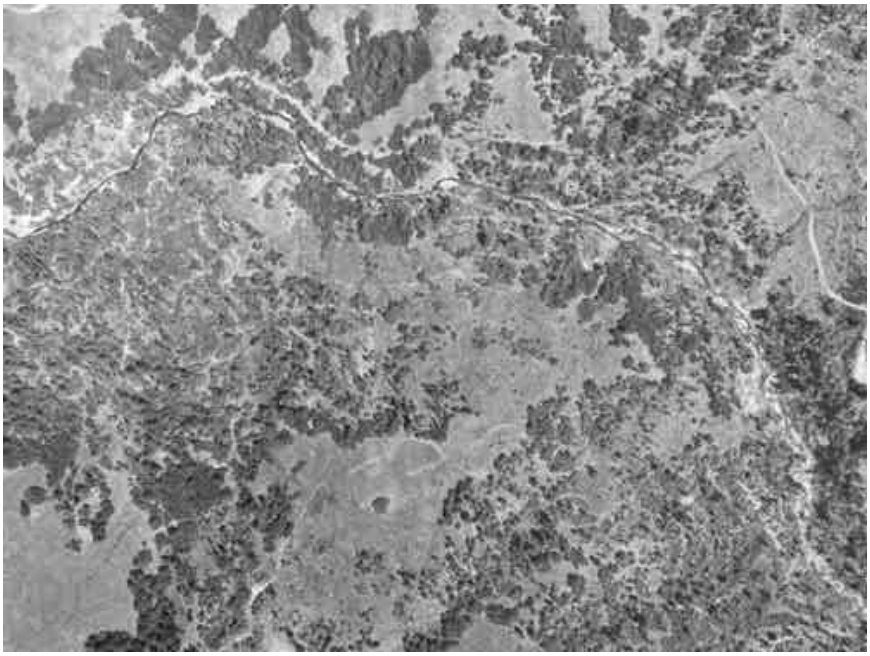
Marshall Creek and SF is similar. But unlike the Marshall Creek, the majority of the historically active, small landslides occur within the generally more stable Coastal Belt Franciscan rocks. These rocks presumably have been severely weakened by shearing within the San Andreas Fault Zone

VEGETATION

The 1942 photos show the South Fork upstream of the Wheatfield, bordered by a variety of timber types as a result of an area-wide fire in the early 1900s. There was partial to entire canopy cover throughout most reaches along the main stem Upper South Fork, Marshall Creek, and tributaries. McKenzie Creek had dense mature Redwood Douglas fir cover. There was consistent oak-woodland cover along upland riparian channels in the dense melange soil type. This prairie grassland-oak woodland is the dominant vegetative cover in upslope areas

LAND USE

Timber use and ranching have been the dominant landuse activities. Tractor logging operations began early in the basin due to the proximity of the coast and available road networks. Timbered areas along the lower to central reaches of the main stem Marshall Creek were logged during the mid 1950s. This removed overstory shade canopy from north facing slopes where conifered areas were confined. During the mid to late 1950s, all downslope conifered areas throughout Wild Cattle and Palmer Canyons were removed during an area wide conversion. Logging operations used stream channels for skid trails, truck roads, and landing sites. Harvest operations removed overstory canopy cover with intent to maintain permanent conversion for grazing use Two large fires burned through the area. The first was in 1955. The Creighton Ridge Fire burned through the area during the early 1980s.



Overstory shade canopy elimination,

FIGURE 51: Upper South Fork, June 1965

At the turn of the century, the railroad was built along the South Fork Gualala to transport old growth logs to the Clipper Mill. The local area was initially harvested during the turn of the century. Remnants of turn-of the-century era logging systems are still evident in portions of the watercourse channel. Old growth cutover areas were then used as grazing land. The current second growth stand in the South Fork is the result of regeneration following a severe fire in the early 1900s. The area was reentered during the 1950s for removal of scattered larger sized timber. Recently, vineyard development along the uppermost ridgelines has been the dominant activity with a decline in ranching.

Conversion project removing conifers over the creek, leaving hardwoods upslope.

FIGURE 52: Conversion Project

Marshall Ck.

- Marshall Creek drains an area where the Central and Coastal Belts of the Franciscan Formation have been complexly faulted and shuffled. Large active earthflows within the Central Belt rocks are common along most the length of Marshall. Small (< 100 feet in greatest dimension) historically active slides that delivered into Marshall Creek are especially abundant in the lower reaches where the stream crosses the weak rocks of the Central Belt Franciscan Formation
- Conversions to pastureland have been the dominant form of historical use. Major portions of riparian areas were converted to pastureland A loop conversion project removed all downslope conifered areas eliminating the riparian zone throughout Wild Cattle Canyon, extending east in an arc connecting Palmer Canyon, during the later 1950s. Sheep were noted grazing in riparian zone in Palmer Canyon during a 1981 survey.

McKenzie Creeks.

- The McKenzie drains Kings Ridge, which is a small portion of a 4kmx8km area that was uplifted no later than the last 5 million years as a result of compression along the San Andreas Fault. See the geology report for explanation. Within this uplift, the upper two forks of McKenzie flow through parallel steep canyons flanked by debris slide slopes where the channels widen. The lower McKenzie narrows and flows southward across the uplift and joins Marshall
- Numerous active earthflows occur along large portions of channels, even more abundant are dormant earthflows that potentially could be reactivated. In each of these landslide-impacted reaches, the channels widen
- A continuous wide belt of mature Douglas-fir occupied the lower and central reaches of McKenzie Ck. extending from the confluence with Marshall Ck. to Devils Rib Ridge. Parker and Pool (1964) surveyed this tributary to Marshall Ck. finding optimal steelhead habitat. Fine sediment only comprised 10% substrate with pools at 60% habitat by reach. Steelhead densities were estimated at 50/ 100 ft. length, and ratio of steelhead to roach were estimated at 95:5 (P. Higgins Gualala Compilation, 2001). The Upper McKenzie was then logged after the 1964 fisheries survey. The main haul road followed the stream channel. Numerous in stream landings are located throughout the basin. The riparian zone was cleared of all overstory vegetation.
- A 1999 stream survey found 43% pools by reach and 1.2 ft. depth, 23% riffles, and 29% flatwater. Substrate consisted of 47% cobble/ gravel, 30% boulders, and 12% silt and sand. Substantial post logging damage noted.
- The McKenzie Ck. sub-basin has been a high priority area with the Gualala Watershed Restoration Council. Numerous restoration projects have been completed.
- Wild Hog Canyon Creek and Carson Creek Both creeks were logged during the late 1950s. The haul road and landing sites lined the main channel. Overstory riparian canopy was removed.

Fluvial Geomorphology

Marshall Creek Super Planning Watershed

Middle South Fork Gualala River Planning Watershed

In the 1984 imagery, channel disturbance in the South Fork Gualala River ranged from 50 to 75 percent with 26 delivering landslides. By 1999/2000, the length of channel disturbance had not changed significantly and 41 delivering landslides are mapped. Wide lateral bars and bank erosion are common.

Upper South Fork Gualala River Planning Watershed

Channel disturbance in the 1984 imagery ranges from 25 to 50 percent with 16 delivering landslides. In the 1999/2000 imagery approximately 25 percent of the channel is disturbed and 19 delivering landslides are mapped.

Lower Marshall Creek Planning Watershed

In the 1984 imagery, the lower reach of Marshall Creek has 50 to 75 percent channel disturbance. In 1999/2000 imagery, approximately 50 percent of the channel is disturbed downstream of McKenzie Creek and 10 delivering landslides are mapped.

Upper Marshall Creek Planning Watershed

McKenzie Creek is greater than 50 percent disturbed in the 1984 imagery with three delivering landslides. In the 1999/2000 imagery, less than 25 percent appears disturbed with 2 delivering landslides.

Lower South Fork Gualala River Super Planning Watershed

Big Pepperwood Creek Planning Watershed

In the 1984 imagery, less than 25 percent of Big Pepperwood Creek and tributaries appear disturbed with 16 delivering landslide mapped. South Fork Gualala commonly has large lateral bars with less than fifty percent of the channel appearing disturbed. By 1999/2000 Big Pepperwood Creek has less than 25 percent disturbed channel with 12 delivering landslides. The South Fork Gualala channel bars near Big Pepperwood Creek appear to be reduced in size.

Mouth of Gualala River Planning Watershed

In the 1984 imagery approximately 50 percent of the South Fork of the Gualala River in the Mouth of Gualala River planning watershed appears to have large lateral and mid-channel bars, especially at tributary with Wheatfield Fork. By 1999/2000 the size of the bars appears smaller in the imagery, more vegetation on bars, but the Wheatfield Fork confluence still appears impacted. Excess bars appear at the mouths of Wheatfield, Buckeye and Rockpile creeks. Field reconnaissance found that sediment build up at the mouth of the major channels causes surface water to flow subsurface for several hundreds feet upstream from Gualala River.

Water Quality

In-stream Sediment

Substrate particle sizes were measured by GRI at four sites in the lower South Fork subbasin, two in the mainstem (GUAL # 402, GUAL # 225) and two in Big Pepperwood Creek (PW #218, PW #219). To compare the data to Knopp (1993), the individual D_{50} values for the sites (3 transects per site) were averaged. Then the minimum, maximum, and average for those averages were compared to the same statistic from Knopp (1993) in the following table.

Stream Name	Years	No. of Sites	No. of Samples *	Minimum (mm)	Mean (mm)	Maximum (mm)
Upper South Fork	97-99	1	2	13	16	20
Lower South Fork	98, 00	2	3	20	23	25
Big Pepperwood	97, 98, 99	2	4	31	35	40
Knopp (1993) Index Streams	1992	18	18	37	69	183
* no. of samples = number of averages included in the comparison						

TABLE 24: Median particle sizes - South Fork subbasin

Median particle sizes from five sites sampled by GRI in 1997-2001 in the South Fork subbasin.

Streambed particle sizes at site SFG #402 sampled by GRI in 1997 and 1999 are small, and indicate sediment in this area, at least, as limiting (Figure XX). To compare the data to Knopp (1993), the individual D_{50} values for the site (3 transects) were averaged. Then the minimum, maximum, and average for those averages were compared to the same statistic from Knopp (1993) in the following table:

Stream Temperature

Water temperature data were available for 15 sites in the South Fork/Main Gualala subbasin for the period of 1994-2001. Seven sites were located in the mainstem, four sites in the Pepperwood Creek watershed, two sites in Groshong Gulch, and two sites in McKenzie Creek watershed (Figure 53).

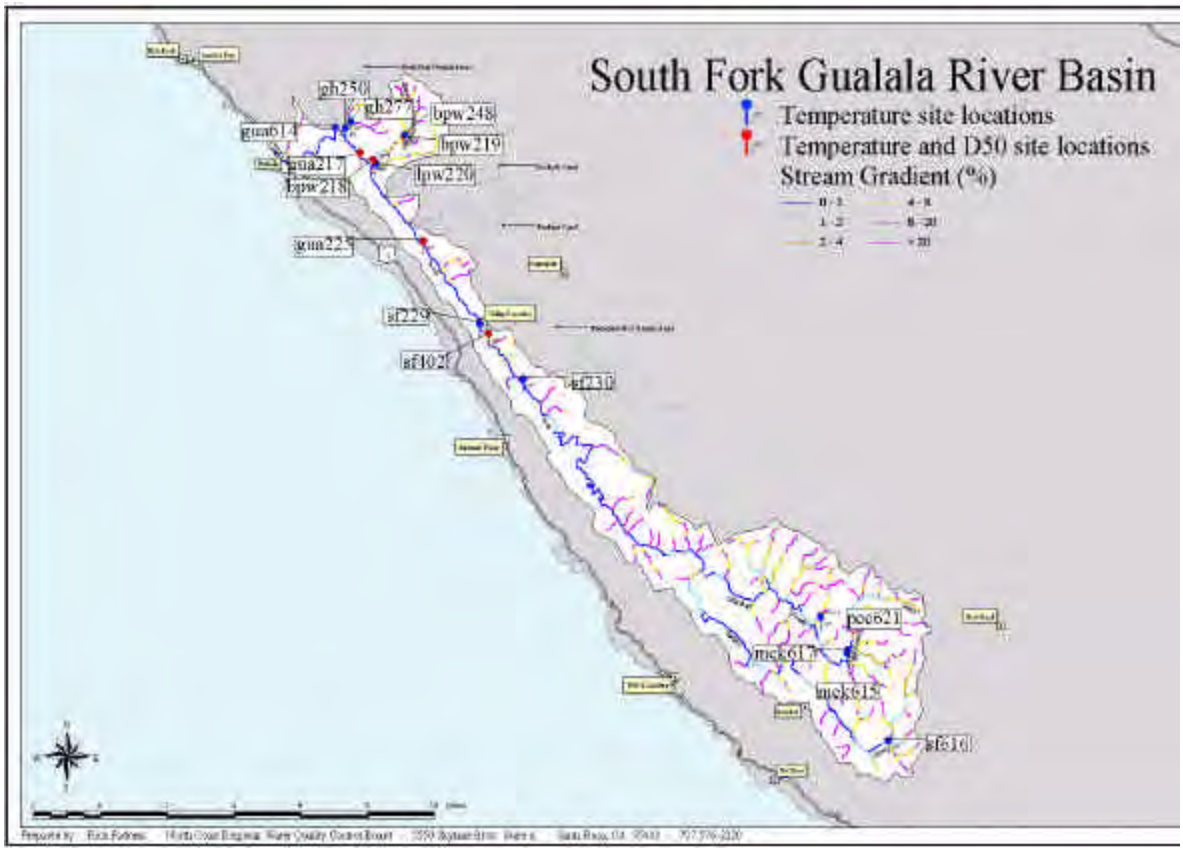


FIGURE 53: South Fork Gualala River Basin

Water temperature and sediment sampling sites in the South Fork/Main Gualala subbasin.

Water temperatures at the mainstem sites were above the suitable range for salmonids, while the lower tributaries were much cooler. MWATs at the seven mainstem stations (gua 614, gua 217, gua 225, sf 229, sf 402, sf 230, sf616) ranged from 64-72 F, all above the proposed suitable range for salmonids (Figure 54). Seasonal maxima ranged from 66-78 F, the lowest occurring at the farthest upstream site (sf616).

Tributaries to the lower mainstem generally exhibited lower MWATs. Water temperature observations for two sites in Groshong Gulch (gh250, gh 277) from 1996, 1999, and 2000 provided an MWAT range of 56-58 F, within the proposed "fully supportive" range. Seasonal maxima ranged from 57-64 F, under the lethal maximum limit (Figure 39, above). Sites in the Pepperwood creek watershed (lpw 220, bpw 218, bpw 219, bpw 248) had MWATs slighty below the upper level of the suitable range, with the Little Pepperwood Creek site (lpw220) MWATs hovering around the upper level.

While the lower tributaries exhibited lower MWATs than the mainstem sites, this was not the case for the McKenzie Creek sites (mck615, mck 617). Data for the two years of record (2000, 2001) produced MWATs ranging from 61-68 F, above the suitable range (Figure 54). Seasonal maxima for those two sites ranged from 61-75 F, below and close to the lethal limit of 75 F. Vegetation in the upper reaches of the watershed, especially McKenzie Creek tend towards non-forested types with lower canopy in the riparian zone (Figure 55).

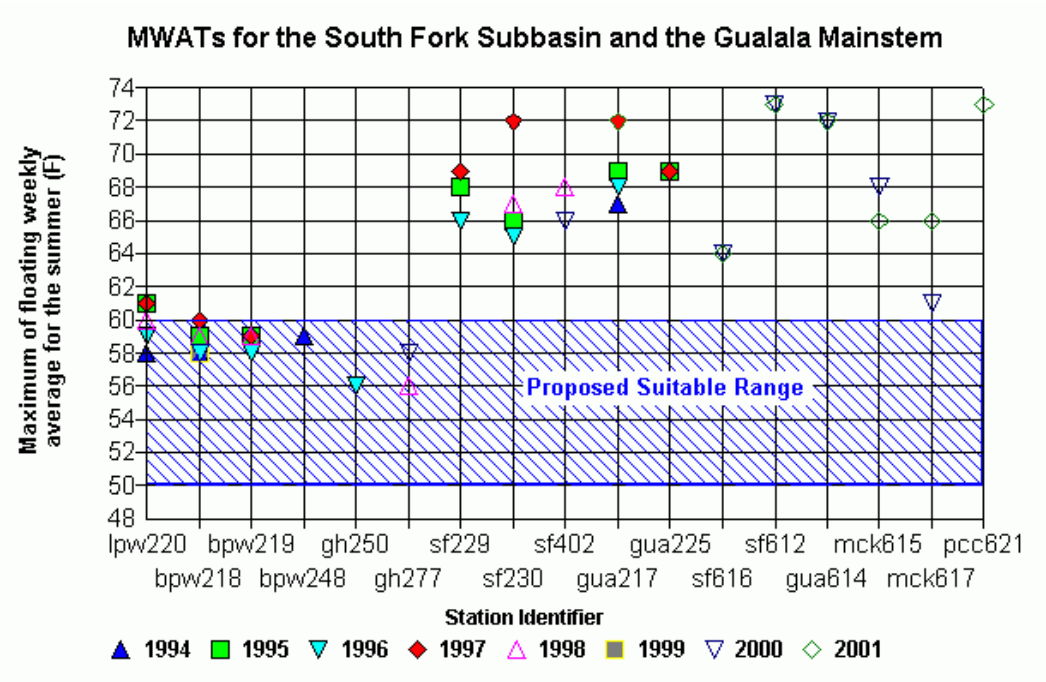


FIGURE 54: MWAT - South Fork Subbasin/Gualala Mainstream

Maximum weekly average temperatures for the South Fork/Main Gualala subbasin, 1994-2001. Data are from continuous temperature monitors placed by GRI and GRWC.

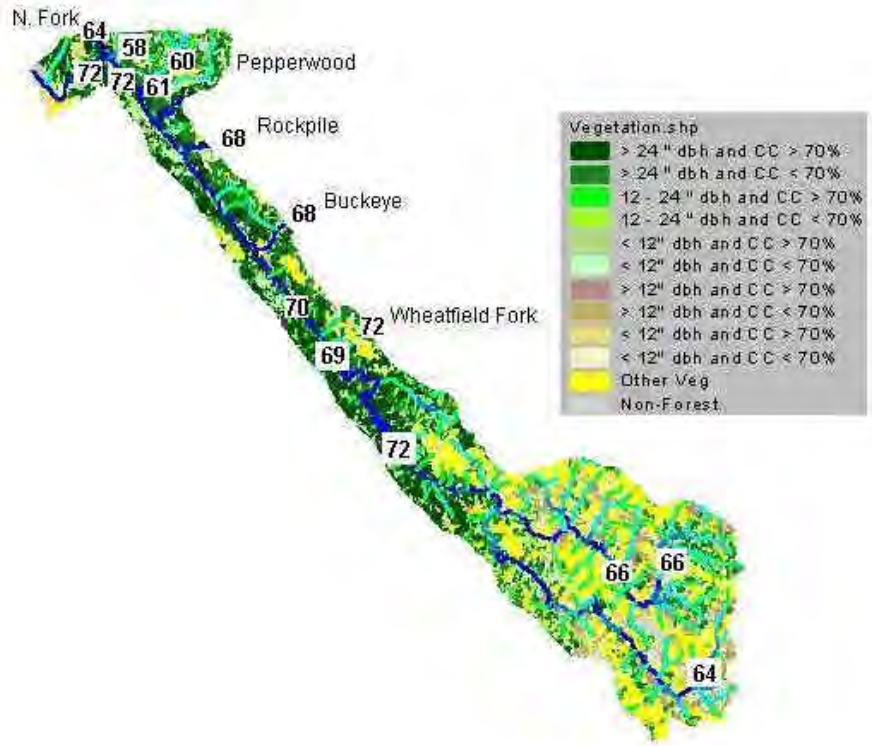


FIGURE 55: MWAT - 1994-2001

Highest MWATS for the period of record of 1994-2001 on a 1994 LandSat vegetations theme for the South Fork//Main Gualal aubbasin. The predominantly yellow and light green areas in the upper watershed (southern portion) indicate oak woodland and grasslands on the Franciscan melange.

Aquatic/Riparian Conditions

TABLE 25: Instream Data - Upper South Fork Subbasin

DF&G Habitat Typing Data

(1999 - 2001)

McKenzie Creek	43%	8.8	1.2	Gravel	26-50%
Carson Creek	49%	4.6	1.0	Gravel	51-75%
Camper Creek	30%	2.6	0.9	Gravel	26-50%
Wild Hog Creek	35%	3.1	0.6	Gravel	26-50%
Marshall Creek					
Palmer					

Tables 26 shows recent canopy density measurements within the Upper South Fork Basin measured at the thalweg. Density is measured by using a spherical densiometer and the surveyor estimates canopy composition. No Watershed Cooperative Monitoring Program data were available.

TABLE 26: Canopy Density - Gualala Mainstream & South Fork Subbasins

DF&G Habitat Typing Data (1999 - 2001)

	1999	2000	2001
McKenzie Creek	69%	44%	56%
Carson Creek	84%	44%	56%
Camper Creek	87%	49%	51%
Wild Hog Creek	73%	24%	76%
Marshall Creek			
Palmer			

TABLE 27: Summary of Large Woody Debris Surveys

Gualala Mainstem & Lower South Fork Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2001)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Pepperwood Creek	218	1,825	2,275	61
Gualala South Fork	217	157,415	1,207	23
Gualala South Fork	402	31,081	1,390	23

*Watershed size is calculated as the area above the monitoring site.

The Cooperative Monitoring Program surveys show the lower South Fork and Pepperwood Creek lack volume and pieces of LWD.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at one reach site in the Lower South Fork basin and one reach site in Pepperwood Creek in 2000 by Jon Lee can be characterized as average when compared to similar north coast watersheds (Table 28).

TABLE 28: Summary of Macroinvertebrate Sampling

Gualala Mainstem & South Fork Subbasin
Gualala Redwoods, Inc.
(2000)

Tributary	Site Number	Watershed* Size (acres)	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Pepperwood Creek	218	1,825	32	0.79	4.7%	4,961	39%
South Fork Gualala	217	157,415	28	0.87	4.4%	7,112	28%

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

The Upper South Fork was historically dominated by steelhead/ rainbow trout with a small number of roach. Suitable anadromous spawning and rearing habitat existed in the tributaries. The higher 6 mile reach was optimal steelhead habitat with abundant steelhead spawning gravel. The middle reach contained stagnant areas with some dry areas. No coho salmon were found during this survey. However, coho salmon were found in another 1964 survey in Marshall Creek at 30 per 100 feet. Along the main stem Upper South Fork, steelhead densities were 100 per 100 feet in the upper survey reach, 25 per 100feet in the middle reach, and 10 per 100 feet in the lowest reach. The lowest 15 miles downstream of Marshall Creek was not surveyed (Higgins 1997).

Two reaches of the upper South Fork were electrofished in November, 2001. Only young of the year (less than one year old) are dominant. One and two year age classes were present.

Coho are currently not known to exist in the South Fork Gualala Watershed. Barraco and Boccione (1977) surveyed the lower South Fork finding pools to comprise 70% stream reach habitat

Fish Habitat Relationship

Subbasin Issues

- Fish density – Little current data exists. Electrofishing of the Upper Southfork observed multi-age class composition of steelhead, but no coho.

- In-stream habitat diversity and complexity, based on very limited surveys appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.

- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.

- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.

- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.

- Sub-division construction is an issue at this time. Timber harvest, grazing and vineyards are prevalent. Feral pigs also impact the land.

- Water chemistry – No data is available on pH, DO, nutrients.

- Water temperatures data is very limited throughout the subbasin. Data on the Southfork showed temperatures above the fully suitable range for salmonids. Summer high temperatures probably exceed optimal conditions for salmon throughout much of this planning basin. This may be due to natural existing conditions in some areas.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species. Pampas grass is observed.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***The South Fork subbasin provides somewhat suitable and unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- Sources of upstream sediment include highly erodible earth materials, mass wasting, seismic activity, and land use.

- Water temperatures in the estuary, as a result of warming effects upstream, may exceed a level that is fully suitable of salmonids.

Contrary Findings:

None noted.

Recommendations:

- Survey ability was severely limited by landowner access. Agency Biologists and the Gualala River Watershed Council should consider training landowners to conduct habitat inventory and fisheries surveys.

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

- Conifer block removal, followed by permanent conversion to pastureland, was the dominant historical land use practice in the basin.. Prolonged cattle encroachment into streams prevented timely riparian canopy reestablishment, reducing vegetational barriers to erosion.

- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:
None at this time.

Limitations

These conditions are well constrained within the scope of work performed thus far.

Conclusions

Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

- Building fences along creeks is now highly encouraged by Resource Conservation Districts, and now more widely implemented on private ranches.
- Continue to decommission streamside roads and landings. The following tributary contain the highest density of these still active sediment sources:
- McKenzie Creek.

Working Hypothesis: ***Depleted overstory shade canopy cover along the higher reaches of the Upper South Fork, and Marshall Creek and tributaries from legacy harvests, followed by conversion to grazing land, continues to contribute to elevated water temperatures.***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of the Upper South Fork, Marshall Creek and tributaries. There was near entire canopy elimination in many areas.
- Vineyard development in recent times can encroach into riparian zones.

Contrary Findings: None

Recommendations:

- Encourage livestock exclusionary measures along streams.
- Exclude vineyard development from riparian areas.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.
-

Working Hypothesis: ***Depleted overstory shade canopy cover along the South Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of South Fork and tributaries. There was near entire canopy elimination in the middle reaches and upper reaches of the South Fork basin, with operations especially pronounced during the late 1950s to 1964.

Contrary Findings:

- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Recommendations:

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the South Fork and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.

Working Hypothesis: ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.

- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.

- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:
None noted.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Recommendations:
- Artificial LWD installation projects vastly speed up in channel diversity development.
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Limitations of the Assessment

This assessment provides useful and valuable information represented a considerable effort of the involved agencies, contractors, and public. It was limited in duration, scope, detail, and analysis level due to constraints in budget, time, access, and overall resources. Where data are limited, working hypotheses are offered along with recommendations to test or improve the knowledge base. Specific limitations are presented below to put the assessment in context.

- Point or more local data, e.g., individual stream reaches, were described in relation to those small geographical areas. As descriptions and inferences are drawn from those data to a more regional, watershed scale the certainty associated with those conclusions and inferences is reduced. In those cases, the NCWAP team offered working hypotheses with suggestions for testing or improving the level of certainty. This is due to lacking historical and current data compared to the Mattole and Redwood River watersheds coupled with the unique geology of the Gualala watershed make subbasin comparisons difficult. Hence, this draft hopes to describe sound hypotheses based upon the most current information available to reduce speculation.
- DFG conducted over 100 miles of habitat inventory on streams throughout the entire watershed from June – November, 2001. Approximately 15 miles of habitat inventory data existed prior to this assessment, collected by the Sotyomy RCD (1995) and DFG (1999). This immense amount of data collect in 2001 has undergone and continues to undergo QA/QC processing, however, without this extensive fieldwork, current instream conditions would have remained unknown and the EMDS model could not have been used on the Gualala. DFG conducted electro fishing surveys in all subbasins except Rockpile through November, 2001 for this assessment. Data are still being compared to past existing data.
- DMG's landslide and geomorphic analyses were limited to aerial photo interpretation from two sets of photos: 1984 and1999-2000, and limited field verification. Limited aerial photo coverage does not bracket temporal distribution of important watershed events, which may not be evident in photos taken years after the fact. Field checking of interpretations was extremely limited.
- The geologic analysis did not identify erosion sources beyond mass wasting and gullying, such as surface erosion or erosion induced by human activities.
- At the analysis scale of 1:24,000, the detection of geologic features smaller than 100 feet in greatest diameter is poor.
- Detailed site level mapping of landslides and sediment delivery were conducted by outside parties in various portions of the watershed. However, time and staffing constraints prevented evaluation of those data.
- DMG has not reviewed all geologic references from other sources used in this report. Geologic conclusions cited by others do not necessarily reflect the views of DMG.
- DMG's assessment of fluvial and hillslope conditions has not been completed; findings may change when relative potential maps are completed.
- Existing geologic mapping of the Rockpile Creek subbasin is limited to the CDMG 2-degree sheet. The presence and location of geologic features in this area were inferred from surrounding areas where more detailed mapping was available.
- CDF's land use analysis used aerial photos exclusively. Sediment sources found in earlier photo sets were not field reviewed to ascribe current comparative condition.
- Localized point source channel aggradations and meandering flows observed shortly after the 1964 storms were not systematically compared sequentially through time to detail evolving stream channel morphology. Only spot point comparisons with 84, 88, and 1999 photos were done depending on where 1964 flood damage was observed.
- There was only time to compare the broadest contrasts between 1950s/ 1960 era impacts with declining habitat conditions. More subtle habitat changes to properly characterize recent land use activities requires a far larger and detailed data base to make significant conclusions.
- NCRWQCB's water chemistry analysis was limited to available USEPA StoRet data for the period April of 1974 to June of 1988 at three locations, and three samples obtained by NCRWQCB at five locations in 2001. The sampling frequency and small number of locations did not allow for any detailed temporal analysis.
- Pesticide data were not available from StoRet, nor collected in the NCRWQCB sampling of 2001.
- Collection of additional water quality data on daily dissolved oxygen, pH, conductance, and temperature at locations near the confluences of several major tributaries did not occur due to access limitations.
- NCRWQCB analyzed water temperature and in-channel data supplied by the GRWC and GRI for the period from 1992 to 2001. Not all locations received sampling throughout that period, limiting the ability to compare across years and among sites.
- The temperature range used for "proposed fully suitable" of 50-60 F was developed as an average of the needs of several cold water fish species, including coho salmon and steelhead trout. As such, the range does not

represent fully suitable conditions for the most sensitive cold water species (usually considered to be coho).

- In-channel data and some temperature data were provided as summary statistics (medians, means, and maximums), limiting the ability to factor variability into the analysis, and not allowing for independent checks on the data quality. As such, the analyses and subsequent assessment are limited in scope.
- Temperature data analysis did not include probability of exceedence from cumulative distribution plots, or hours of exceedance of a threshold. This analysis was limited by not having raw data for all sites, obtaining raw data late in the analysis, and data interface problems.
- NCRWQCB did not have turbidity nor suspended solids data, though considers them critical to watershed analysis. The absence of those data and any analysis of suspended loads and turbidity are limitations in this assessment.
- Analysis of temperature information is without knowledge of the extent of a thermal reach upstream of the continuous data logger.

References Cited

These references were specifically cited in the body of the report. A complete listing of the data and literature sources used in the watershed assessment is presented in Appendix 4.

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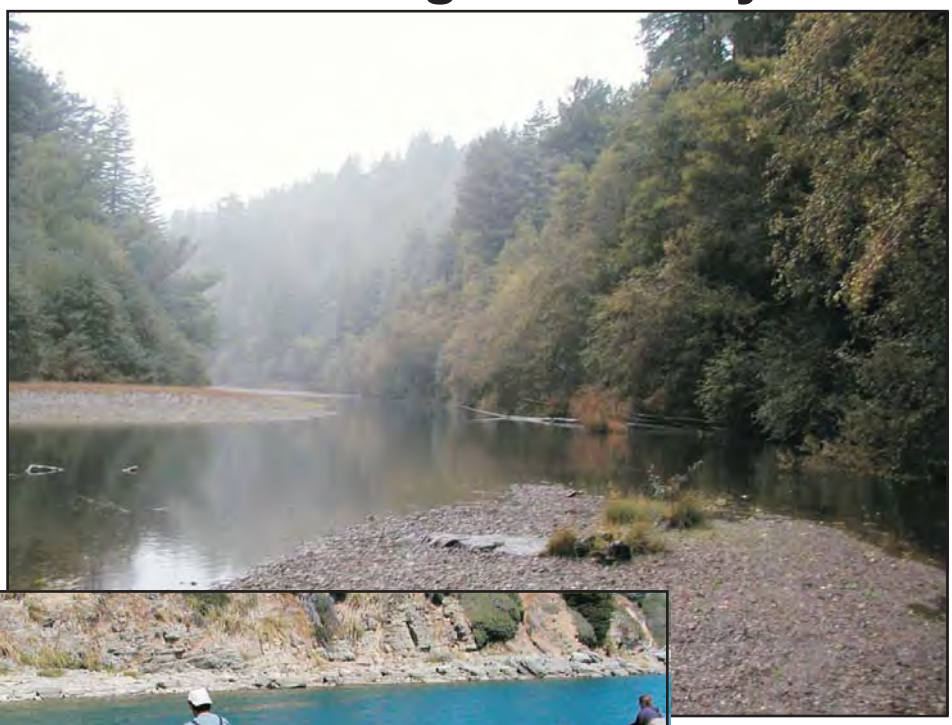
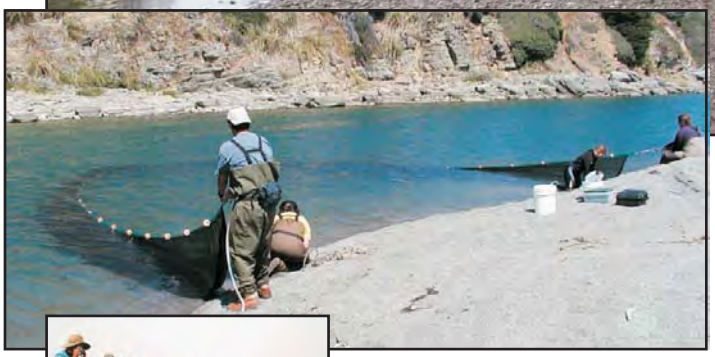
Gualala Estuary and Lower River Enhancement Plan: Results of 2002 and 2003 Physical and Biological Surveys





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Gualala Estuary and Lower River Assessment and Enhancement Plan: Results of 2002 and 2003 Physical and Biological Surveys

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CHAPTER 1.0 INTRODUCTION

The Gualala River estuary is located on the northern coast of California, about 37 miles north of the town of Jenner. Although the Gualala River has historically been an important system for steelhead and coho salmon fisheries, knowledge of the dynamics of anadromous salmonid fisheries has been limited to anecdotal information, with little focused study. The State Coastal Conservancy (SCC) has been involved with studies on the lower Gualala River since 1995, beginning with a grant for a literature search of existing data associated with the ecological integrity of the Gualala River watershed. Information provided from that work effort demonstrated that there were significant gaps in the literature relative to the lower river and estuary. Since then, the California Department of Fish and Game issued the final report of the North Coast Watershed Assessment Program (NCWAP) Gualala Watershed studies (Klamt et al., 2003).

Acknowledging the importance of coastal estuaries to the overall health of coastal watersheds and the existing lack of data on the lower Gualala River, the Sotoyome Resources Conservation District (SRCD), the SCC, and the Gualala River Watershed Council(GRWC)) resolved to broaden the scientific understanding of the Gualala watershed, particularly the lower river and estuary. As a result, ECORP Consulting, Inc. (ECORP) and Kamman Hydrology & Engineering (KHE) were contracted by the SRCD to assess the lower river and estuary in 2002 and 2003, and develop recommendations for an enhancement plan for the Gualala River Watershed including the Estuary and Lower River Project. This estuary study is intended to complement and expand on the NCWAP study.

1.1 Goals

The overall goals of the Gualala Estuary and Lower River Project were to:

- Collect baseline data on steelhead to develop population estimates,
- Determine possible impairing factors on ecological productivity,

- Identify further research needs, and
- Develop recommendations for an Enhancement Plan

To address these goals, ECORP and KHE conducted an assessment of the existing physical, water quality, and biological habitat conditions, including use of the estuary by juvenile salmonids during open and closed estuary conditions. The enhancement plan provides specific recommendations for the protection of the Gualala estuary and Lower River and its natural resources.

1.2 Objectives

The objectives for the Gualala Estuary and Lower River Project are outlined below for each of the project components.

1.2.1 Hydrologic and Geomorphic Analyses Objectives

The general objectives of the Hydrologic and Geomorphic study component were to describe historic and seasonal hydrologic, hydraulic, and geomorphic characteristics and processes in the estuary, and evaluate these issues relative to habitat quality for anadromous salmonids.

Specifically, these objectives were to:

- Describe the existing and historic morphology of the estuary and lower river,
- Characterize the magnitude and variability of freshwater inflow to the estuary (especially summer base-flows),
- Attempt to identify changes in river base flow rates as a result of upstream diversions,
- Characterize physical processes controlling the opening and closing of the estuary inlet,
- Evaluate sediment transport characteristics of the lower river and estuary, and

- Describe temporal variation and linkages between inlet morphology, freshwater inflow, and water quality in the estuary.

1.2.2 Water Quality Objectives

The objective of the Water Quality Study Component was to:

- Provide seasonal water quality profiles throughout the Gualala Estuary, including temperature, dissolved oxygen, pH, conductivity and/or salinity..

1.2.3 Aquatic Ecology Objectives

The objectives of the Aquatic Ecology Study Component were to:

- Determine distribution and abundance of salmonids in the Gualala Estuary,
- Describe seasonal habitat conditions in the Gualala Estuary,
- Describe seasonal habitat availability in the Gualala Estuary,
- Develop a species list and relative abundance of all observed fish, birds and mammals, and if possible given budget considerations,
- Determine adult steelhead use and timing of migration through the Gualala Estuary.

1.2.4 Terrestrial and Marsh Ecology Objectives

The objectives of the Terrestrial and Marsh Ecology Component were to:

- Delineate wetland areas,
- Develop a list of plant species in and around the lower estuary floodplain area,
- Map plant species, communities, and species distribution,
- Describe use of the lower estuary floodplain area by wildlife, and
- Develop a list of species observed in the wetland/floodplain area during the assessment period.

It became apparent as the study progressed that the objectives of the terrestrial and marsh ecology component could not be addressed, due mainly to budgetary considerations. This issue was addressed before the Steering Committee and the Technical Advisory Committee (see below), and the decision was made to focus our studies on the aquatic ecology, hydrology, and geomorphic components of the study. The reader is directed to the Gualala River Watershed Assessment Report (Klamt et al., 2003) that contains recent information on the Gualala River watershed, including both aquatic and terrestrial components. That report was a product of the North Coast Watershed Assessment Program (NCWAP). Through the limited observation of the terrestrial and marsh conditions present, it appears that restoration opportunities that fortify native dune and dune scrub vegetation at the lower study area, and enhance the quality of native riparian tree and shrub species in the middle reach of the study area, will reinforce the native plant communities of the area. As is the case of many north coast habitats, disturbed soils in the Gualala River estuary area show rapid encroachment of invasive and non-native species that include, but are not limited to pampass grass (*Cortaderia selloana*), scotch broom (*Cytisus spp*), and various thistle species. This report does not purport to deliver expertise on the composition of invasive species or approach to manage these threats to the ecological balance, but suggests further attention and action to enhance native riparian and terrestrial/marsh species.

1.3 Study Participants

1.3.1 Steering Committee

The SCC and the grantee formed a Steering Committee (Steering Committee) to oversee the implementation of the work plan, track the budget, and ensure project completion consistent with the requirements of the contract between the grantee and the SCC.

1.3.2 Estuary Technical Advisory Committee

A Technical Advisory Committee (TAC) was established to assist the Steering Committee in developing a work plan that would meet the defined goals and objectives of the project. The TAC included agency personnel with expertise in the fields of fisheries biology, geomorphology, hydrology, water quality, and coastal processes. The primary responsibility of the TAC was to ensure that: work-plan tasks were conducted consistent with the contractual requirements, protocols and sampling methodologies were scientifically sound, and that study results were provided to the Steering Committee in a timely manner.

1.3.3 Public Participation

Outreach to GRWC and the general public took place annually. ECORP and KHE provided a mid-study report and updates to the Steering Committee and TAC, describing project status and results of various study components. This flow of information provided opportunities for adaptive management of the project during the assessment and enhancement plan development phases. ECORP and KHE provided additional volunteer time to educate the public about the study when requested by local stakeholder groups.

The outreach efforts included a critique and review of the contents of this final report by stakeholder groups and private individuals. It is important that the community outreach, similar to that provided through this study, continue as a follow up in order to ultimately accomplish any recommendations expressed within this report. For this reason, community education and outreach about the report recommendations and general needs for the ecological integrity of the Gualala River Estuary and Lower river should be a priority component for future project based activities, management plans, and implementation strategies that result from this report.

1.4 Project Management

Project Management efforts were conducted by the SRCD. The SRCD worked closely with ECORP, KHE, and the SCC to ensure that the scope of work was implemented in an efficient and effective manner. The Project Assistant to the Council and the administrative support team at the SRCD conducted daily administrative project oversight, and in particular:

- coordinated with subcontractors, field agents, SRCD staff, volunteers and other groups/individuals involved with the implementation effort,
- addressed project issues as they occurred and developed adaptive management strategies to rectify and document these issues, and
- provided mechanisms and coordination for public outreach and public involvement.

This document has been prepared to address each of the objectives by project study component. Chapter 2.0 (prepared by KHE) addresses hydrology and geomorphology study components. Chapter 3.0 (prepared by ECORP) addresses water quality and aquatic ecology study components. Chapter 4.0 (prepared by KHE, ECORP, and SRCD) presents the summary of findings, and Chapter 5.0 (prepared by KHE, ECORP, and SRCD) presents the summary of findings, and enhancement planning recommendations.

1.5 Acknowledgements

Significant contributions were made to this study from the following individuals and entities: Elmer Dudik and Robert Klamt with the North Coast Regional Water Control Board coordinated and supervised a significant water quality monitoring program in the estuary during the study period. Their data and findings were integral to developing an understanding of estuary and lower river water quality conditions. Elmer Dudik also provided additional insight into characterizing the linkage between summer water quality and algal blooms (see Section 3.3.4 of this report). Volunteers who provided hours to tireless assistance in the implementation of study field tasks included Jamie Hall (photo-

point monitoring, fishery seining, surveying, and more), Don Kemp, and Steve May of Surf Market (Photo-Point Monitors); and Ron Rolleri, Robert Keeble, Dan Munton, Adam Crook, and Tegner Weiseth (fishery seine net volunteers). In addition, Gualala Redwoods Inc. was generous in providing the study team with available information, data, and access to/through their property.

1.6 References

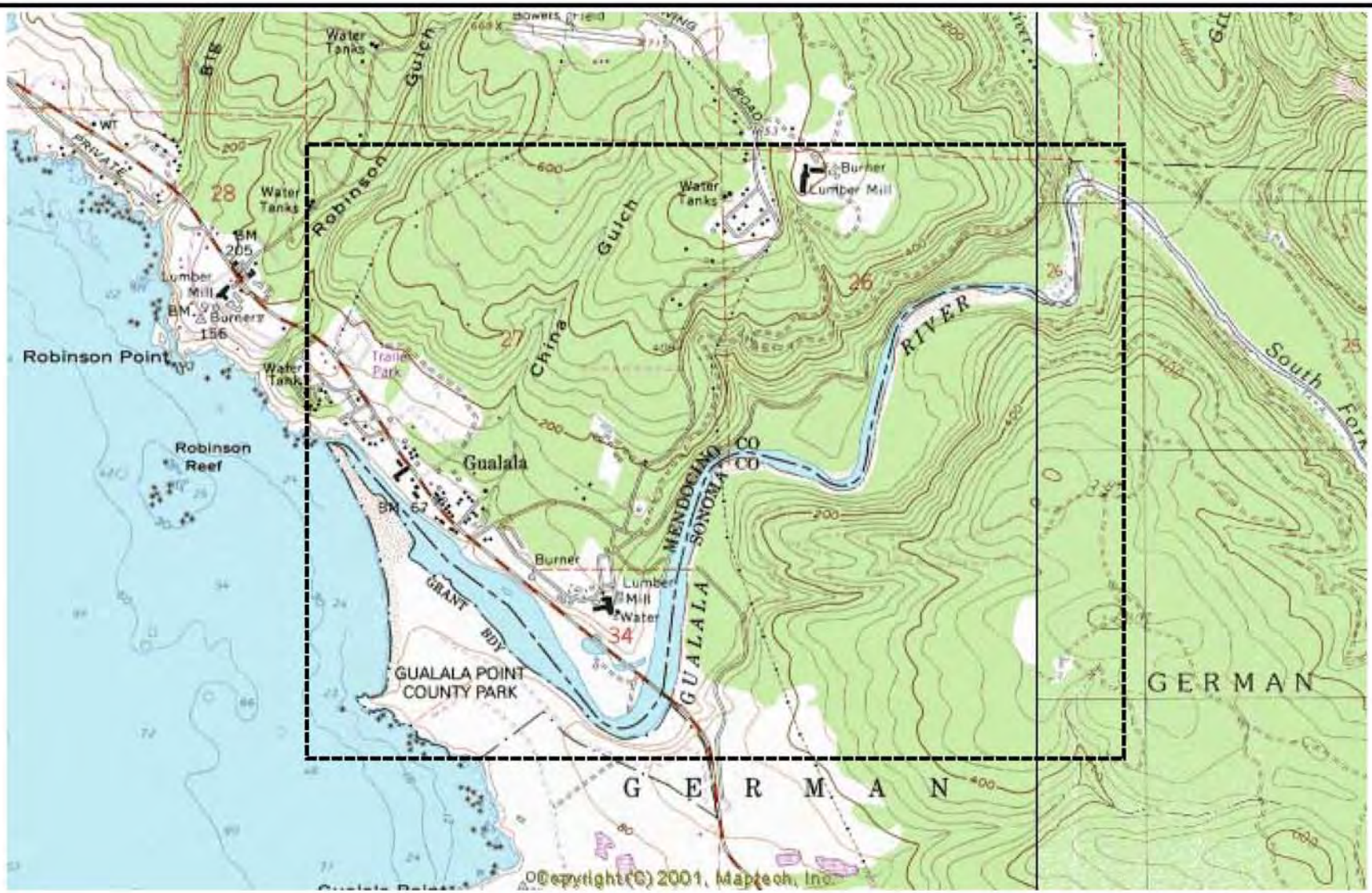
Klamt, R.R., LeDoux-Bloom, C., Clements, J., Fuller, M., Morse, D., and Scruggs, M.,2003, Gualala River watershed assessment report, North Coast Watershed Assessment Program. California Resources Agency and California Environmental Protection Agency, Sacramento, CA, 367p. (plus Appendices).

CHAPTER 2.0 HYDROLOGY AND GEOMORPHOLOGY INVESTIGATIONS

2.1 Introduction: Study Objectives and Approach

The lower Gualala River and its coastal estuary comprise a highly dynamic system. The study area is indicated in Figure 2-1 and consists of the lower Gualala River between the confluence with the North Fork Gualala River and Pacific Ocean. Seasonally, the Gualala river mouth varies between an estuary, with open connection to the ocean (typically winter) and closed, to semi-closed estuary behind a beach barrier (typically during summer). Given the shallow, fresh-water dominated, and closed-off nature of the Gualala River coastal water body, it can also be referred to as a "coastal lagoon" (Sorensen et al., 1993). It will be, however, referred to as an estuary or coastal estuary for reader convenience throughout this report. The duration and extent of these end-member states is controlled by the dominance of a variety of physical processes that control the construction or breaching of the barrier beach.

The goal of this investigation is to identify and describe the dominant physical characteristics and processes controlling aquatic and riparian habitats of the Gualala River coastal estuary with emphasis on salmonid fishery habitat. Kamman Hydrology & Engineering, Inc. (KHE) developed and implemented the study based on a conceptual morphological and process model for California coastal river mouth systems. This model assumes that a river mouth inlet is controlled by various complementary and competing forces that breach or reconstruct barrier beaches. Typically, California coastal estuaries go through a seasonal progression of morphological change. In winter, the estuary inlet commonly breaches and remains open due to storm flows. Once the inlet is open, tidal action aids in the inlet scour process. This also floods the estuary with high salinity waters. As winter storm flows subside, waves build up the barrier beach using sand, migrating along the shoreline (littoral drift), forming a sand-spit between the ocean and estuary. After estuary inlet closure, the main source of water to the estuary is fresh water



Source: USGS 7.5-Minute Gualala Quadrangle

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Project Study Area

FIGURE 2.1

inflow. Periodic wave over-wash also significantly impacts barrier beach morphology and estuary water quality.

This study focused on monitoring and/or characterizing a suite of hydrologic, geomorphic, and coastal conditions and processes to better understand the linkage and/or trends between estuary physical and biological systems. Between August of 2002 and December 2003, specific monitoring activities and analyses completed as part of this study included:

1) Continuous estuary water level monitoring,
2) Estimation of daily freshwater inflow to the estuary,
3) Completion of a series of baseflow measurements on primary tributary channels to the South Fork Gualala River between the Pacific Ocean and Valley Crossing (Twin Bridges) to develop estuary freshwater inflow estimates,
4) Development of a detailed water budget for the estuary to estimate seepage rates and net transfers of water between estuary and ocean,
5) Completion of annual cross-sectional profiles of the estuary and estuary inlet,
6) Assistance in the coordination and implementation of a photo-monitoring program of the barrier beach and estuary inlet conditions,
7) Completion of a review of historical aerial photographs and maps to identify historical changes in estuary and lower river morphology,
8) Assessment of the local tide and wave climate acting on the estuary barrier beach using available tide, wave and wind data from nearby NOAA tide gages and offshore buoys,
9) Assistance in the monitoring of general water quality parameters (emphasis on salinity) throughout the estuary,
10) Qualitative assessment of sediment transport through the lower river and estuary during the study period using survey results, field observations, and grain size information from repeat pebble counts at selected bars within the lower river and estuary reaches; and

11) Coordination and contract management for the preparation of an aerial photogrammetric image of the project area.

As indicated in Section 1.0, this study was designed to further elaborate and expand on the North Coast Watershed Assessment Plan (NCWAP) salmonid habitat investigation of the lower river and estuary. As such, it was originally intended that the results of this study and associated resource management and enhancement recommendations would serve as a companion document to the final Gualala NCWAP report. Therefore, this Section of the report builds on the physical science data and information presented in the NCWAP report and appendices (Klamt et al., 2003). This report does not attempt to duplicate or summarize the hydrologic and geomorphic information presented in the NCWAP report, except as needed.

2.2 Physical Setting

The existing and historic meteorologic and hydrologic characteristics of the Gualala River Watershed are presented in detail in the 2003 Final NCWAP report. This section of the report provides a more detailed description of on-shore and offshore hydrologic and hydrodynamic conditions experienced during and leading up to the study period. Where appropriate, study period conditions are compared to long-term average or median conditions.

2.2.1 Precipitation

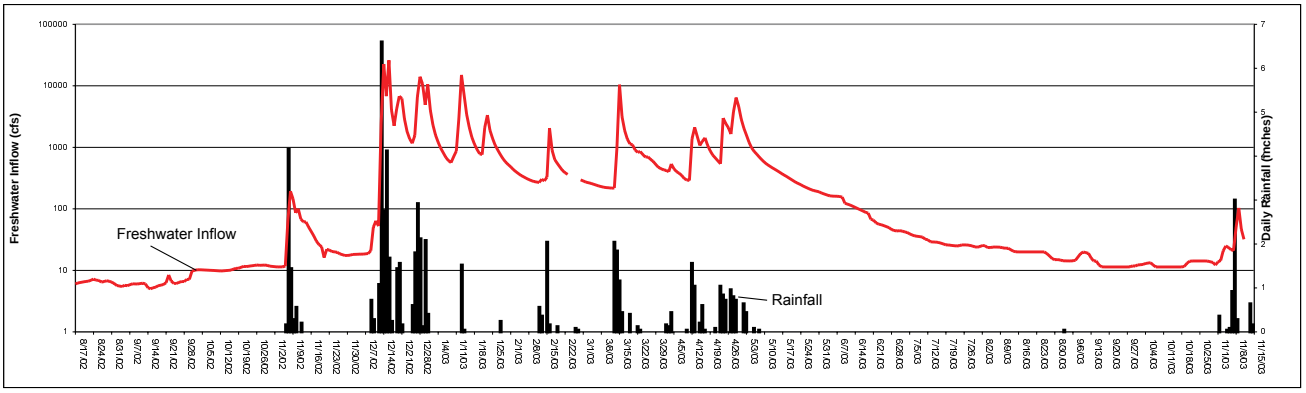
Based on analysis of long-term records, precipitation in the study area is distinctly seasonal, with up to 90-percent of total rain falling during the 5 months of November through March. Most precipitation comes with the passage of multiple low-pressure fronts associated with storms lasting several days in duration. With the exception of the last two months, the study period (August 2002 through November 2003) falls within

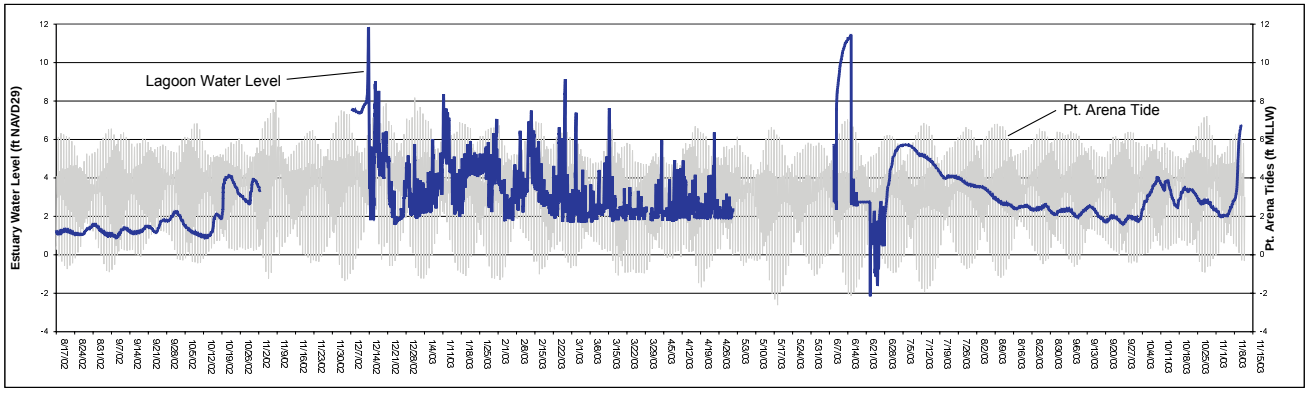
water years[1] WY2002 and WY2003. Based on analysis of long-term rainfall records for area gages, the rainfall totals for the study period are comprised of near average (92-percent of average for WY2002) to below average (83-percent of average for WY 2003) year types. Daily precipitation totals at the Venado rain gage for the study period are presented in the top panel of Figure 2.2. Daily values for the Venado gage, located in the Russian River drainage, are presented here because there are no readily available daily rainfall totals from the Gualala River watershed for the study period. The peak daily rainfall total was 6.6-inches on December 13, 2002, with other notable (>3-inch) daily rainfall totals occurring on November 7, 2002, December 27, 2002, and November 8, 2003. Early season barrier breaches occurred during each of these storms. The seasonal and daily rainfall distribution for the study period reflects the general meteorological characteristics described above. However, April 2003 was an exceptionally wet month compared to long-term monthly averages. April 2003 rainfall totals for the Fort Ross rain gage were 6.39-inches compared to the long-term (1905 to 2003) April average of 2.79-inches. These late season rains sustained high inflow to the estuary, which was the primary cause for the late season breach on June 15, 2003.

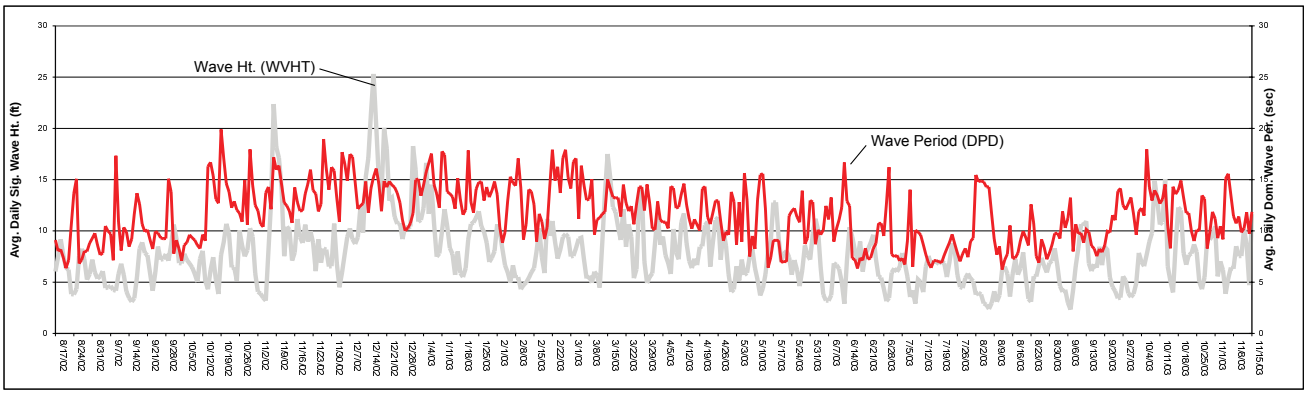
2.2.2 Estuary Freshwater Inflow

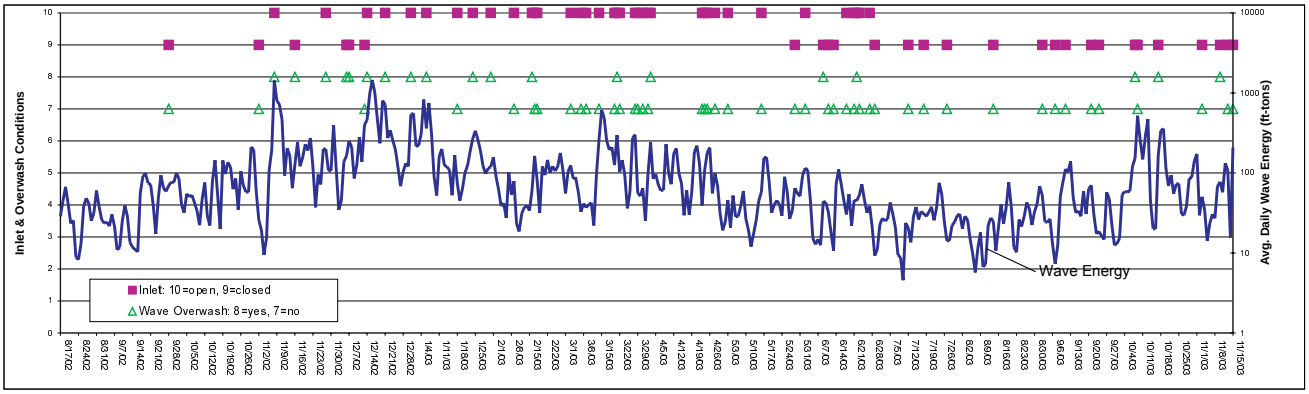
For the study period, freshwater inflow to the estuary was estimated using a variety of data sources and technical methods. In general, unit runoff estimates and regression equations were developed for segments of the Gualala River using: a) available data for Gualala River Watershed stream flow gages maintained by the U.S. Geological Survey and California Department of Water Resources over the study period, and b) late season base flow measurements completed by KHE on major tributaries to the South Fork Gualala River. A more detailed summary of the methods and data used to develop the inflow record are presented in Appendix A.

[1] A " water year" is defined as the 12-month period, October 1 through September 30 and is designated by the calendar year in which it ends.









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Hydrologic Monitoring Results

FIGURE

2.2

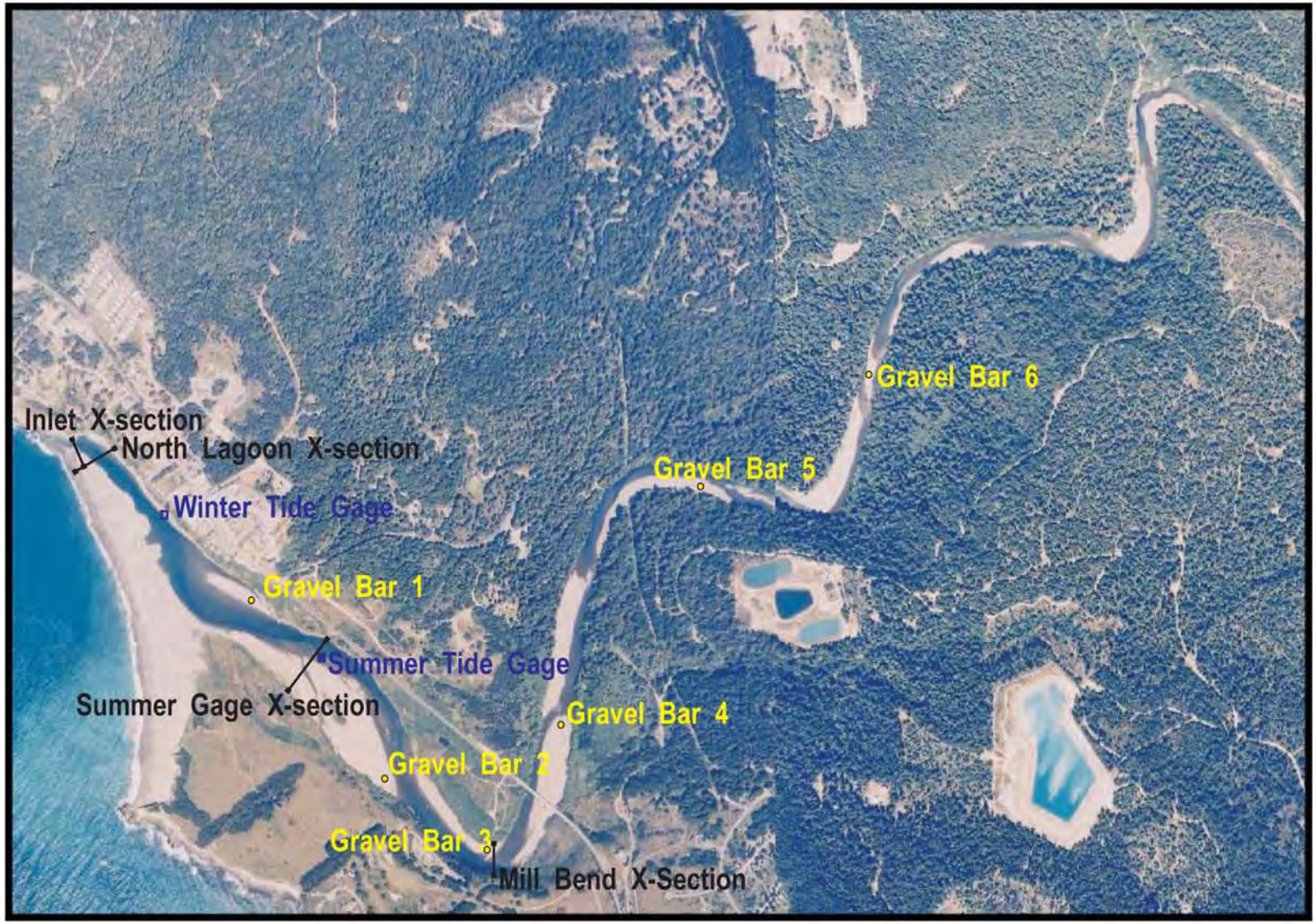
Estimated freshwater inflow to the estuary over the study period is presented in the top panel of Figure 2.2 along with daily rainfall totals. Inflow responses to storms and the rise and post-winter recession in the baseflow rates are clearly evident. Although the on-setof winter storms is not out of the ordinary during the study period, the combination of continued storm pulses and sustained elevated baseflows to the estuary through June of 2003 are notable differences to long-term average conditions. As a result, the persistence of elevated estuary inflow delayed the full closure of the barrier beach and also promoted the complete fresh water filling of the estuary by early June of 2003, leading to overtopping and breaching of the barrier beach.

2.2.3 Estuary Water Levels

Estuary water levels were monitored on a 15-minute time interval over the study period. A Global Water-brand XL-14 water level logger (deployed in a 10-foot long, 2-inch diameter PVC stilling well) was secured to the riprap filled log-crib in the middle portion of the estuary on August 16, 2002. In anticipation of damage or loss of the instrument during high winter flows, the gage was relocated to the east bank of the estuary (lower portion), adjacent to the Surf Market in early November 2002. The logger and stilling well were secured to an existing iron pipe, cemented into boulders at the base of the cliff. This gage is referred to as the winter gage location while the subsequent site is referred to as the summer gage location. Both gage locations are indicated on Figure 2.3.

Monitored estuary water levels are illustrated on the second panel (from top) of Figure 2.2. Coverage of the full range of estuary water levels was not achieved at either gauging location. As a result, the water levels are truncated over the lower range. Periods of missing records also exist for the periods of November/December 2002 and May/June 2003. Missing monitoring data resulted from logger maintenance problems.

The seasonal changes in estuary water levels are captured in the water level record. In August through early November 2002, the barrier beach remained intact. Daily diurnal



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Tide Gage, Cross-Section, and Pebble Count Locations

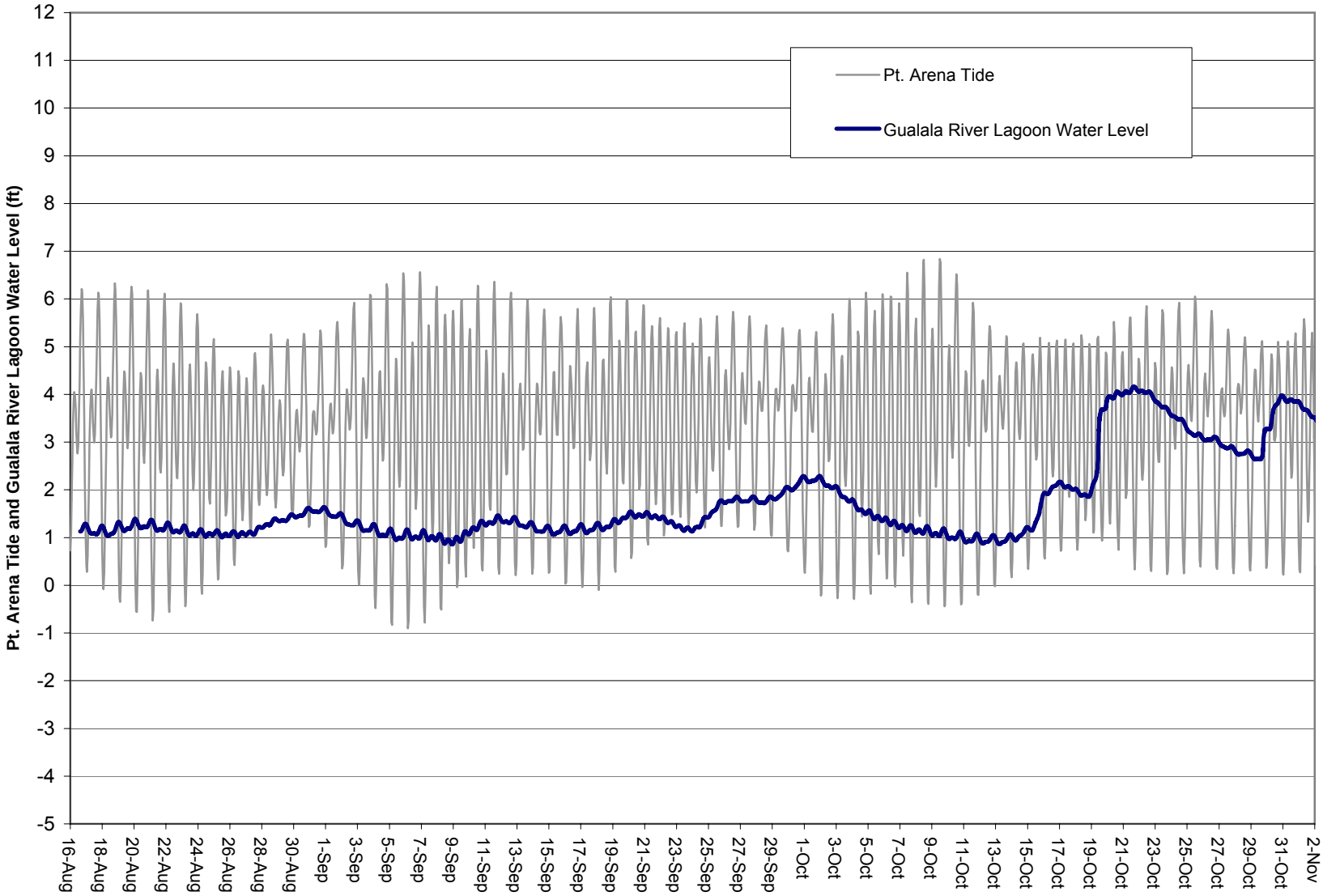
FIGURE

2.3

fluctuations in water level up to a few tenths of a foot are present, resulting from a weak connection to ocean tides - likely a pressure response through the barrier beach sand (Figure 2.4). Water level fluctuations of 0.5- to 1.0-foot over this period result from waves overtopping the barrier beach (wave over-wash).

The water level record in early December 2002 captures the second barrier breach of the season on December 13, 2002 (the first breach occurred during the storm of November 6-7, 2002, but no water level data is available for this event). Over 10-feet of water level drop was recorded during the December 2003 break, but the change in water level was likely several feet greater as the outlet through the barrier beach eroded down to the daily MLLW tide level – an elevation well below the tide gage monitoring range. Subsequent recorded water levels through December 2002 and into May 2003 fluctuate broadly due to varying degrees of freshwater inflow and tidal exchange through the breach. Repeat cycles of breach infilling (barrier reconstruction) and subsequent erosion are seen by the vertical migration of daily minimum water levels.

The June 15, 2003 breach also resulted in a drop in estuary water levels by at least 9 feet as seen in Figure 2.2. Again, the drop in water level was likely greater than indicated (by at lease several feet) when compared to the MLLW-levels recorded at the Pt. Arena tide gage. The estuary water level record indicates a rapid reconstruction of the barrier beach over the two-week period following the breach event with estuary water levels again rising in response to relatively high inflow rates. Inflow and the seepage rate through the barrier beach "stabilize" in early July 2003, as estuary water levels level off and begin to fall in response to receding inflow rates (see Figure 2.2). The small amplitude (tenths of a foot) tidal signature returns to the water level record upon complete closure by early July 2003 with higher amplitude increases resulting from wave over-wash occurring in the late fall-early winter of 2003. As seen in the rise in estuary water levels by up to 2-feet, wave over-wash contributed a significant volume of water to the estuary in the late fall period of 2003. With the advent of the first storm of the winter season on November 10, 2003, estuary water levels rise more sharply until the barrier



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Lower Gualala River and Coastal Lagoon Assessment and Enhancement Plan

Lagoon Water Level vs. Pt. Arena Tide (August 15 - November 2, 2002)

FIGURE 2.4

GRE tide gage.xls,Figure 2-4

beach is overtopped, followed by a precipitous drop in water levels of over 8-feet as waters quickly scour and erode a deep outlet, draining the estuary.

2.2.4 Ocean Tides

Ocean tides for Point Arena Cove reported by NOAA are plotted against estuary water levels in Figure 2.2. These tides are representative of ocean water level conditions adjacent to the Gualala River coastal estuary. The diurnal and semidiurnal components of the tides at Arena Cove are mixed, resulting in a daily tidal regime with two high waters and two low waters with the levels in each set displaying different magnitudes. Based on mean tidal statistics for the Arena Cove gage, the observed range between MHHW and MLLW is almost 5.9-feet. During estuary inlet formation, the maximum scour depth through the barrier breach is controlled by the minimum (MLLW) tide range over the inlet formation period. Exchange of tidal waters between ocean and estuary also work to keep the inlet open. Thus, the magnitude of tidal range plays an important role in scouring and maintaining an open inlet in two ways. First, the tidal range will control the total volume (tidal prism) exchanged through the inlet. The greater the tidal prism, the greater scour potential to maintain an open inlet. Secondly, it appears from a plot of Arena Cove tides that the daily higher-high water normally precedes the lower-low water, creating a maximum seaward gradient through the inlet during the larger of the semidiurnal ebb tide events. Velocities and scour potential are greatest during this period and, if acting with no external influences that reconstruct the inlet, the net tidally induced scour could, theoretically, keep the inlet open indefinitely.

2.2.5 Wave Climate

For purposes of this report, the wave climate acting on the Gualala River coastal estuary barrier beach refers predominantly to wave height and frequency. The waves most important to barrier-beach formation and destruction are generated by winds blowing for sufficient duration and over a long-enough distance (fetch) to create wind waves. The

wave climate off the Northern California coast is influenced primarily by atmospheric-ocean interactions over the North Pacific Ocean (Ambrose and Orme, 2000)

The wave climate acting on the Gualala River estuary barrier beach over the study period is best characterized by a series of wave variables measured at the NOAA buoy located approximately 19-miles offshore from Point Arena. These variables include:

- Significant wave height (WVHT), calculated as the average of the highest one-third of all wave heights during a 20-minute monitoring period; and
- Dominant wave period (DPD), calculated as the period with the maximum wave energy.

These values were used to estimate corresponding deep-water wave energy (WVE) approaching the coastline and acting on the Gualala River Mouth. WVE was calculated as the product of the wavelength and the square of the WVHT, as follows:

$$WVE = (w*L*WVHT^2)/8$$

Where WVE is expressed in ft-tons, w is the weight of a cubic foot of water (64 lbs) and L is wavelength in feet. The wavelength (L) is calculated pursuant to Bascom (1980), as follows (assuming deep-water waves):

$$L = 5.12*DPD^2$$

Plots of WVHT, DPD, and WVE over the study period are presented in Figure 2.2. Noise in the data is attributable to interference of two or more sets of wind-waves originating from different sources/locations. It's also worth noting that the wave climate is unrelated to the tidal regime. Some generalities about the wave climate data presented on Figure 2.2 include:

- There is a general seasonal cycle of higher wave energy in winter and lower wave energy in summer expressed by the sinusoidal shape to the annual plot of wave energy;
- Periods of maximum WVHT and WVE and short DPD have the greatest destructive effect on the barrier beach;
- Maximum WVHT and WVE that typically accompany storms combine with high estuary inflow to breach the barrier beach; and
- Periods of long DPD (swell) and low to modest WVHT typically dominate in summer and result in barrier beach construction/buildup.

2.2.6 Barrier Beach-Estuary-Lower River Morphology

The following section summarizes the results of an investigation into historical changes in estuary morphology. This discussion is followed by further description of the study results that describe the changes and processes observed to be controlling barrier-beach formation, destruction and estuary morphology during the study period.

Historic Conditions

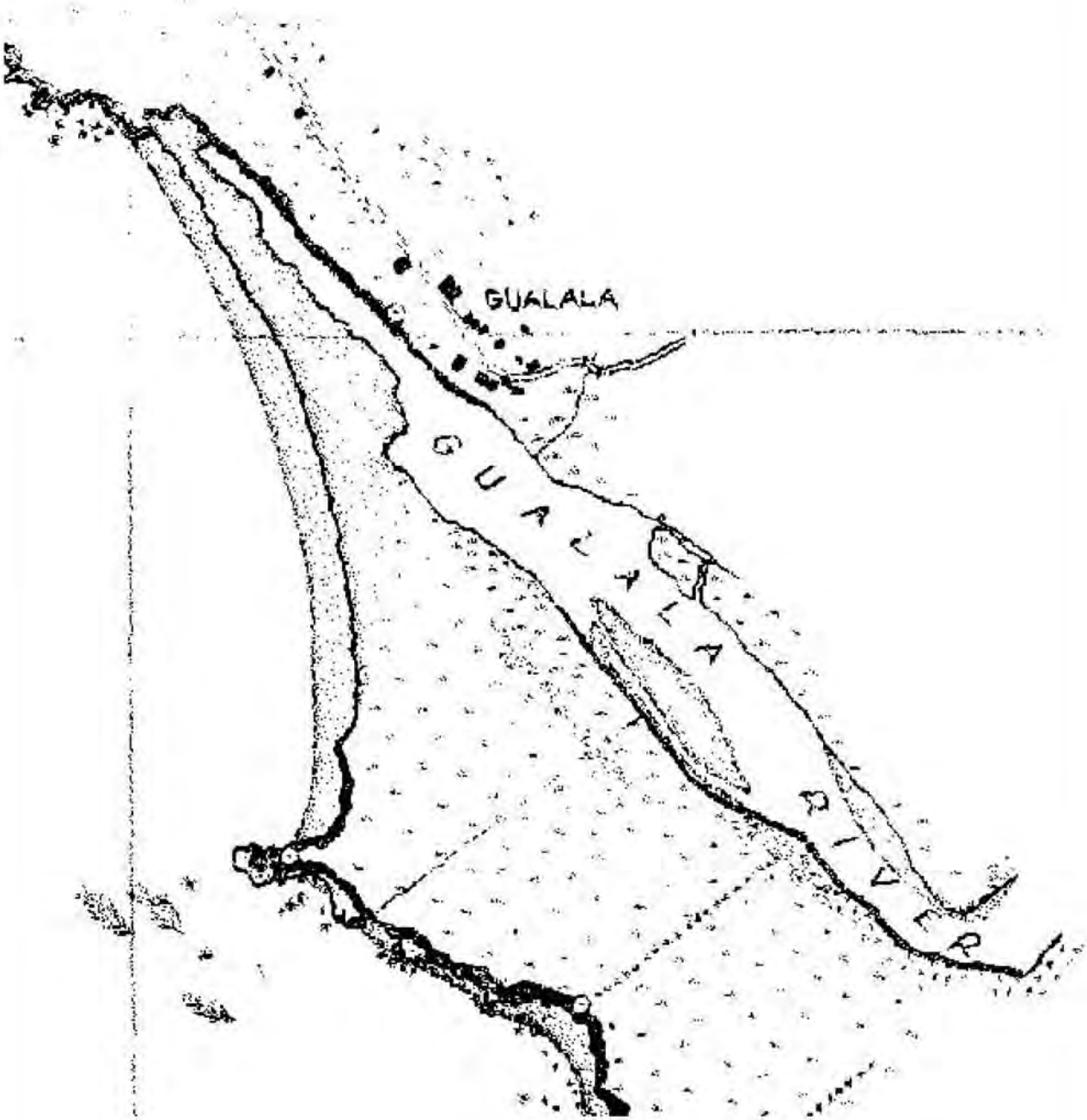
Numerous aerial photographs of the lower Gualala River and estuary were obtained and reviewed as part of this analysis. Sources of photographs included the California Department of Forestry and Fire Protection, WAC Corporation of Eugene, Oregon, and Pacific Aerial Surveys of Oakland, California. In addition, historic USGS topographic maps and a 1929 U.S. Coast and Geodetic Survey map of the coastline were reviewed. The following aerial photographs were reviewed.

1. 1936 (month/day unknown)
2. 5/12/1961
3. 2/20/1967
4. 5/04/1980

5. 6/16/1981
6. 4/21/1984
7. 8/01/1989
8. 6/17/1992
9. 3/25/1996
10. 5/19/1996
11. 4/13/1999
12. 5/19/1999
13. 4/02/2000
14. 4/22/2002
15. 7/02/2003

As discussed in greater detail below, there are notable and large-scale seasonal changes in the estuary-barrier beach system during any given year. A review of aerial photographs indicated no notable changes in the physical setting and character of the estuary beyond those that likely fall within the natural seasonal variability. For example, no significant repositioning or erosion of various bar forms within the lower river or estuary was observed. Interestingly, the large bar located on the west side of the summer tide gage appears to be the same size and in the same location in all photographs and on the 1929 geodetic survey map (Figure 2.5). Determining changes in the size of longitudinal and point bars on aerial photographs, in an attempt to qualitatively identify changes in sediment deposition patterns, was not possible due to highly varying river flow and estuary water level conditions between aerial images. Thus, no definitive conclusions were reached with respect to whether estuary bathymetry has changed over time.

The inlet breach also appears to occur at the north end of the barrier beach in all photographs, either immediately adjacent to or within several hundred feet of the bedrock cliff marking the north end of the estuary. There are anecdotal accounts of the breach occurring closer to the south end of the beach during extreme flood events during an El Niño period. However, these types of breaches start out as overtopping along the entire



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1929 U.S. Coast and Geodetic Survey Map

FIGURE

2.5

barrier length. Because of the coastline geometry, net coastal wave climate, and littoral sand transport patterns, it appears that the south end of the barrier beach is consistently higher in elevation than the north end, suggesting that most barrier breaching will set up at the north end of the beach except during extreme, overwhelming flood events.

Changes Over Study Period

A program of near-weekly photo-point monitoring of the Gualala River estuary/barrier beach was very helpful in capturing and documenting the variability in the seasonal cycles of system evolution. A summary of photo-point observations is presented in Table 2.1. The following information and observations are included in the Table:

- Whether the inlet (barrier beach breach) is open or closed;
- Occurrence of active wave over-wash;
- Evidence for previous wave over-wash;
- Estimated estuary water level;
- Presence and estimate of high water erosion lines;
- Water color in terms of the presence of significant sediment inflow to the estuary (brown color) or presence of salt-water in estuary (turquoise color); and
- Presence of flood debris or kelp in/on the estuary and beach.

Photo point observations provided the most definitive chronology of barrier beach breaching and reconstruction over the study period. Illegal breaches from human activity, which can significantly affect the natural cycle of open and closed inlets and result in decreased survival of juvenile salmonids rearing in the estuary, were not observed during the study period, although natural breaches did occur. Observations of whether the inlet was open or closed and periods of active wave over-wash are also presented graphically on the lower pane of Figure 2.2.

A pair of estuary/barrier-beach surveys was completed over the study period in order to capture and quantify changes in cross-sectional estuary profiles between September 28,

TABLE 2.1

Photo-Point Monitoring Observations
Gualala Lower River and Coastal Lagoon Assessment and Enhancement Plan

DATE	TIME	Weather	INLET			Wave Overwash (active)		Wave Overwash (previous)		Water Level			Flood Debris		High Water Erosion lines (Active)			Erosion lines (Previous)		Water Color (Sedimentation)			Water Color (Salt Water Exchange)			Kelp in Estuary	
			Open	U	Closed	Yes	No	Yes	U	No	Low	Med	High	Yes	No	yes		No	Yes		Yes	U	No	Yes	U	No	Yes	No
5/29/2002	U	clear			Closed	9	No	7		No*	6		High		No			No	Yes				No	Yes				No
8/16/2002	U	cloudy			Closed	9	No	7		U*	6		High		No			No	Yes*				No			No		No
9/28/2002	U	clear			Closed	9	No	7		No	5		Med		No			No		No			No			No		No
11/2/2002	U	clear			Closed	9	No	7	Yes		6		Med		No			No		No			No		U*			No
11/8/2002	U	cloudy	Open			10	Yes	8	Yes		6		High	Yes				No		No	Yes			Yes				No
11/11/2002																												
11/16/2002	U	partly cloudy			Closed	9	Yes	8	Yes		6		High	Yes		yes				No	Yes			Yes			Yes	
11/28/2002	U	cloudy	Open			10	Yes	8	Yes		6		High	Yes		yes				No	Yes				U*		Yes	
12/6/2002	U	cloudy			Closed	9	Yes	8	Yes		6		High		No			No		No			No	Yes			Yes	
12/7/2002	U	clear			Closed	9	Yes	8	Yes		6		High		No			No		No			No	Yes			Yes	
12/13/2002	11:30	Rain			Closed	9	No	7	Yes		6		High		No			No		No			No	Yes			Yes	
12/14/2002	11:30	Rain	Open			10	Yes*	8	Yes		6		High		No	yes				No	Yes					No		No
12/21/2002	U	clear	Open			10	Yes*	8	Yes		6		High		No	yes			Yes		Yes					No		No
12/31/2002	U	partly cloudy	Open			10	Yes	8	Yes		6		High		No					No	Yes					No		No
1/6/2003	15:45	clear	Open			10	Yes	8		No	5		High		No					No	Yes					No		No
1/18/2003	12:25	clear	Open			10	No	7	Yes		6		High		No	yes			Yes		Yes			Yes*				No
1/24/2003	15:00	overcast	Open			10	Yes	8	Yes		6		High		No	yes			Yes				No	Yes*				No
1/31/2003	U	clear	Open			10	Yes	8	Yes		6		High		No			No	Yes				No	Yes*				No
2/9/2003	U	clear	Open			10	No	7	Yes		6		High		No	yes			Yes				No	Yes*				No
2/16/2003						10		8			6																	
2/17/2003	17:00	clear	Open			10	No	7	Yes		6		High		No			No	Yes				No	Yes*				No
2/18/2003	U	clear	Open			10	No	7	Yes		6		Med		No	Yes			Yes				No	Yes*				No
3/3/2003	U	clear	Open			10	No	7	Yes		6		Med		No	Yes			Yes				No	Yes*				No
3/7/2003	U	clear	Open			10	No	7	Yes		6		Med		No			No	Yes				No	Yes*				No
3/9/2003	U	clear	Open			10	No	7	Yes		6		Med		No			No	Yes				No			No		No
3/14/2003	U	cloudy	Open			10	No	7	Yes		6		High		No	Yes			Yes		Yes					No		No
3/20/2003	U	cloudy	Open			10	No	7	Yes		6		High		No	Yes			Yes		Yes			Yes				No
3/21/2003	U	clear	Open			10	Yes	8	Yes		6		High		No			No	Yes				No	Yes*				No
3/22/2003	U	clear	Open			10	No	7	Yes		6		High		No			No	Yes				No	Yes*				No
3/28/2003	U	clear		U*		10	No	7	Yes		6		High		No			No	Yes				No	Yes				No
3/29/2003	U	clear		U*		10	No	7	Yes		6		High		No			No	Yes				No	Yes				No
3/31/2003	U	clear	Open			10	No	7	Yes		6		High		No			No	Yes		Yes					No		No
4/2/2003	16:40	overcast	Open			10	No	7	Yes		6		High		No	Yes			Yes				No	Yes				
4/3/2003	*					10		8			6																	
4/23/2003	U	cloudy		U*		10	No	7	Yes		6		High		No			No	Yes				No	Yes**				No
4/24/2003	U	cloudy		U*		10	No	7	Yes		6		High		No			No	Yes				No	Yes**				No
4/25/2003	U	Partly cloudy	Open			10	No	7	Yes		6		High		No	Yes*			Yes		Yes					No		No
4/28/2003	11:40	rain	Open			10	No	7	Yes		6		High		No	Yes*			Yes		Yes					No		No
5/3/2003	13:40	clear	Open			10	No	7	Yes		6		High		No	Yes			Yes		Yes			Yes				No
5/16/2003	11:00	clear	Open*			10	No	7	Yes		6		High		No	Yes			Yes				No	Yes**				No
5/29/2003	U	clear			Closed	9	No	7	Yes		6		High		No			No	Yes				No	Yes*				No
6/2/2003	U	clear	Open			10	No	7	Yes		6		High		No			No	Yes				No	Yes*				No

TABLE 2.1

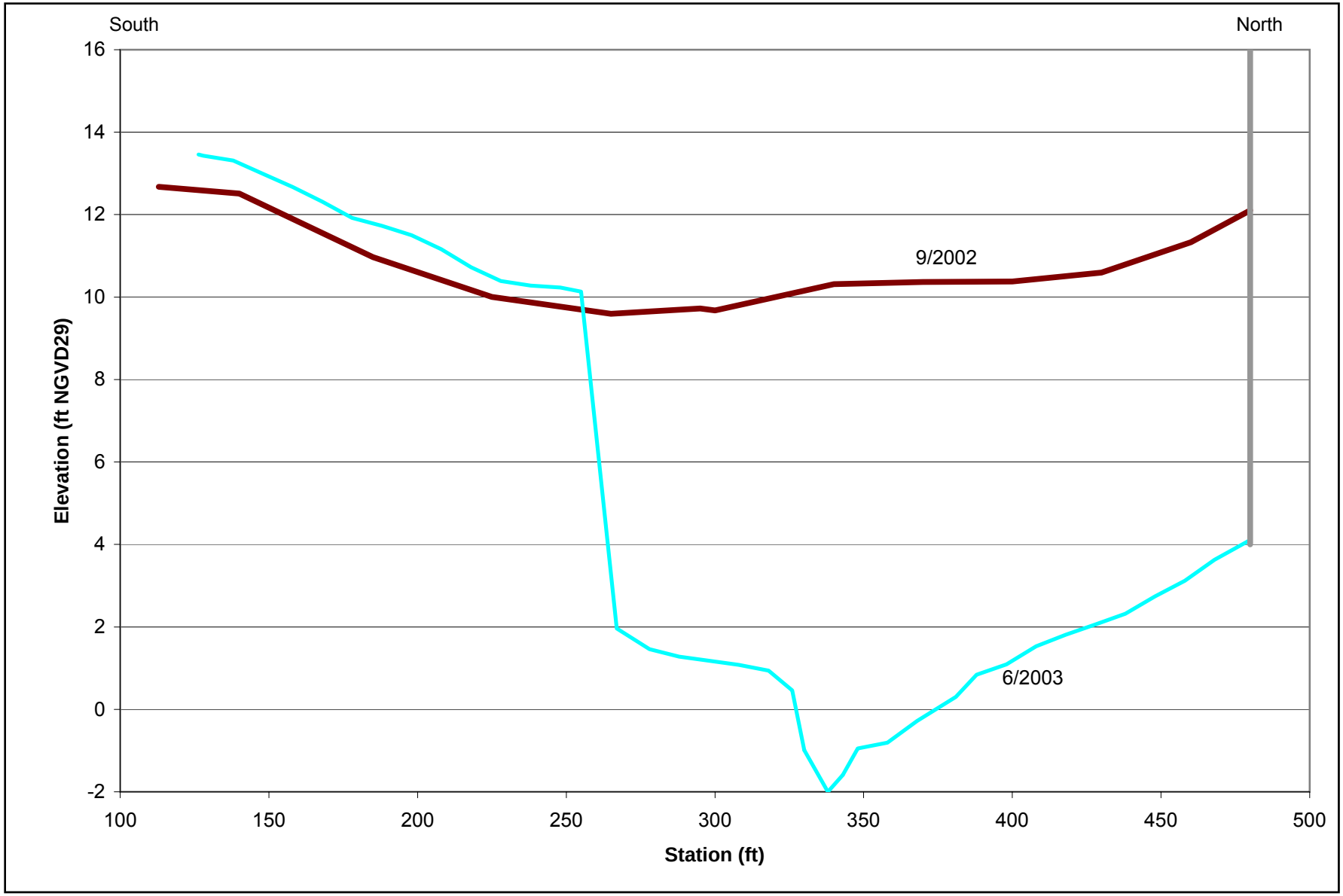
Photo-Point Monitoring Observations
Gualala Lower River and Coastal Lagoon Assessment and Enhancement Plan

DATE	TIME	Weather	INLET			Wave Overwash (active)		Wave Overwash (previous)			Water Level			Flood Debris		High Water Erosion lines (Active)		(Previous)		Water Color (Sedimentation)			Water Color (Salt Water Exchange)			Kelp in Estuary	
			Open	U	Closed	Yes	No	Yes	U	No	Low	Med	High	Yes	No	yes	No	Yes	No	Yes	U	No	Yes	U	No	Yes	No
6/6/2003																											
6/9/2003	U	overcast			Closed	Yes*		Yes*					High		No	Yes**	No					No	Yes***				No
6/11/2003	U	clear			Closed		No	Yes					High		No		No		No			No	Yes*				No
6/13/2003	10:40	clear			Closed		No	Yes					High		No		No		No			No			No		No
6/18/2003	12:30	clear	Open				No			No		Med			No	Yes		Yes				No			No		No
6/21/2003	U	clear	Open				No			No		Med			No		No	Yes				No			No		No
6/22/2003	*																										
6/23/2003	14:40	clear	Open				No	Yes				Med			No	Yes		Yes				No			No		No
6/27/2003	U	clear	Open				No	yes*					High		No		No	Yes				No	Yes**				No
6/29/2003	14:15	clear			Closed		No	yes*					High		No		No	Yes				No	Yes**				No
7/12/2003	12:00	clear			Closed		No			No			High		No		No		No			No			No		No
7/18/2003	14:48	clear			Closed		No			No			High		No		No	Yes*				No			No		No
7/27/2003	12:52	Foggy			Closed		No			No			High		No		No	Yes*				No			No		No
8/14/2003	12:45	overcast			Closed		No			No			High		No		No	Yes*				No			No		No
9/2/2003	U	overcast			Closed		No			No			High		No		No	Yes*				No			No		No
9/7/2003	U	cloudy			Closed		No			No			High		No		No	Yes*				No			No		No
9/11/2003	10:10	clear			Closed		No			No			High		No		No	Yes*				No			No		No
9/21/2003	16:40	clear			Closed		No			No			High		No		No	Yes*				No			No		No
9/24/2003	9:40	overcast			Closed		No			No			High		No			Yes*				No			No		No
10/8/2003	U	clear			Closed	Yes				No			High		No		No		No			No		U*			No
10/9/2003	U	clear			Closed		No	Yes					High		No		No		No			No	Yes*				No
10/17/2003	13:50	clear			Closed	Yes		Yes					High		No		No	Yes				No	Yes		No		No
11/3/2003	11:16	clear			Closed		No	Yes				Med			No			Yes				No			No		No
11/10/2003	10:30	clear			Closed	Yes		Yes					High		No		No		No			No	Yes				No
11/13/2003	10:34	overcast			Closed		No	Yes					High		No		No		No			No		U*			No
11/15/2003	U	overcast			Closed		No	Yes					High		No		No		No			No		U*			No
11/19/2003	15:20	overcast			Closed		No	Yes					High		No		No		No			No		U*			No
11/30/2003	U																										
12/2/2003	10:30	overcast			Closed		No	Yes					High		No		No		No			No			No		No
12/3/2003	11:12	clear	Open				No	Yes				Med			No	Yes		Yes		Yes					No		No
12/7/2003	U	cloudy	Open				No	Yes				Med			No	Yes		Yes		Yes					No		No
12/15/2003	U	clear	Open			Yes		Yes				Med			No	Yes		Yes		Yes			Yes				No
12/16/2003	U	cloudy	Open			Yes		Yes					High		No	Yes		Yes		Yes			Yes				No
12/28/2003	14:37	cloudy	Open			Yes*		Yes					High		No	Yes		Yes		Yes			Yes				No

2002 and June 22, 2003. Cross-sectional survey locations are indicated on Figure 2.3 while profiles are presented on Figure 2.6 through Figure 2.9. The September 2002 and June 2003 profiles are presented together on each location-specific graphic. The September 2002 surveys reflect closed inlet conditions during the late summer of 2002 while the 2003 surveys capture the post-late season breach of June 15, 2003. Although the inlet was open to tidal exchange in late June 2003, the survey occurred during a period of barrier beach reconstruction and inlet infilling. Figure 2.6, a profile completed in a N-S direction and parallel to the north end of the barrier beach, illustrates the difference in closed versus breached beach conditions. Note that the breach of June 2003 was over 200-feet wide and over 8-feet deep at the time of the survey.

Figure 2.7 presents east-west cross-sectional profiles through the north end of the estuary. The west end of this section is located in the barrier beach while the east end is located at the base of the cliff-face (see Figure 2.3). The substrate encountered in this section consisted entirely of barrier beach sand along the western part of the transect and bedrock along the eastern portion. The difference in barrier beach morphology between surveys is striking in this section as the beach in September 2002 encroaches much further into the estuary (east) than in June 2003. This contrast illustrates the phenomenon of landward migration of the barrier beach during the summer beach reconstruction phase in the form of wave over-wash lobes. The net effect is the migration of sediment from the beach face and crest to the landward side of the barrier, resulting in landward (eastern) migration of the barrier beach into the estuary.

Further to the south, upstream of the barrier beach, changes in the cross-sectional profile of the estuary are not as dramatic. At the summer gage profile location, there appears to be some infilling of the small channel on the west side of the gage and minor scour of the channel to the east (see Figure 2.8). Apart from these changes, survey results indicate there was little change in the size and shape of the large central bar and far western



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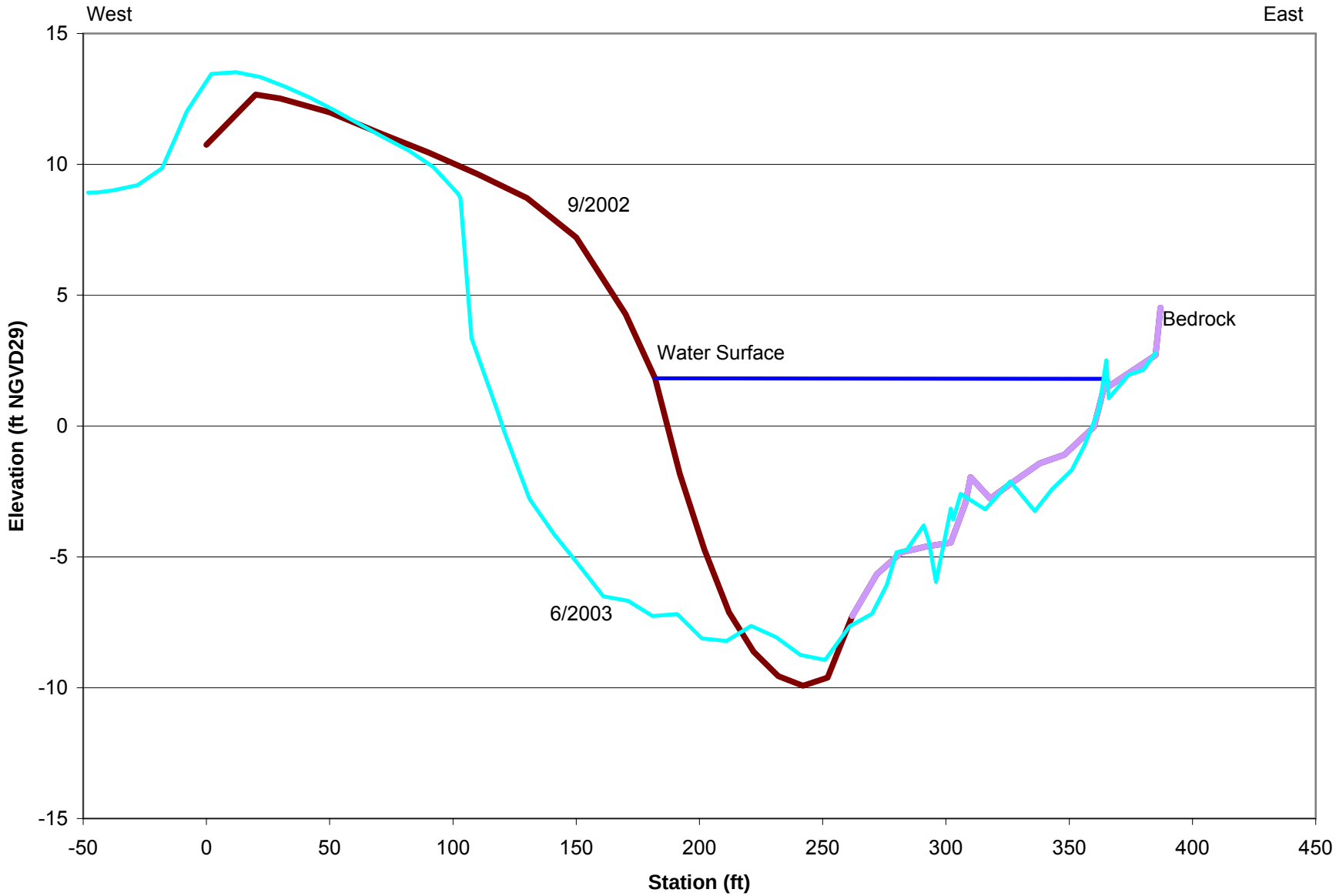
Lower Gualala River and Coastal Lagoon Assessment and Enhancement Plan

Cross-Sectional Profiles of Lagoon Inlet - 9/28/02 and 6/22/03

FIGURE 2.6

Cross Sections.xls,Figure 2-6



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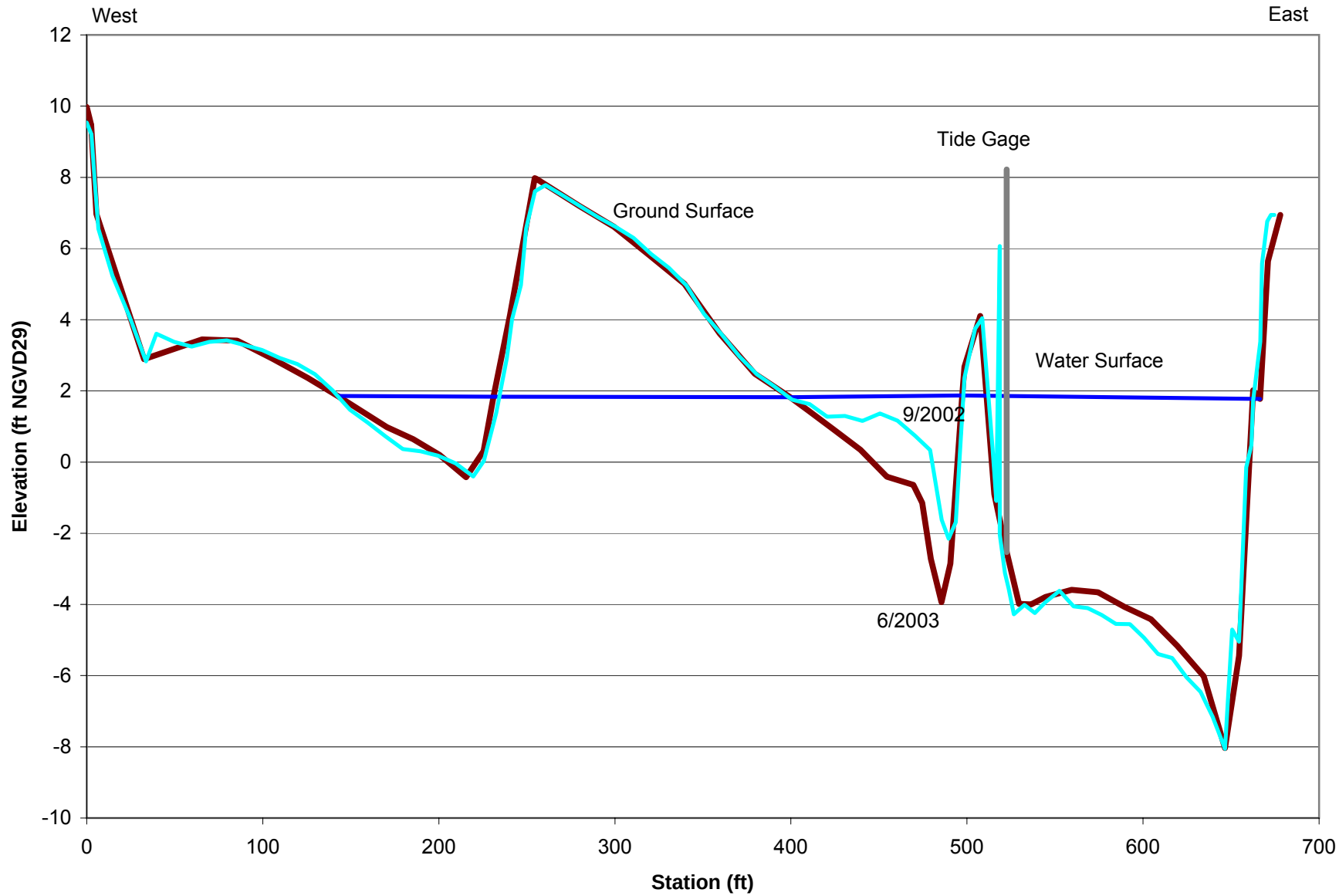
Lower Gualala River and Coastal Lagoon Assessment and Enhancement Plan

Cross-Sectional Profiles at **North** End of Lagoon - 9/28/02 and 6/22/03

FIGURE 2.7

Cross Sections.xls,Figure 2-7



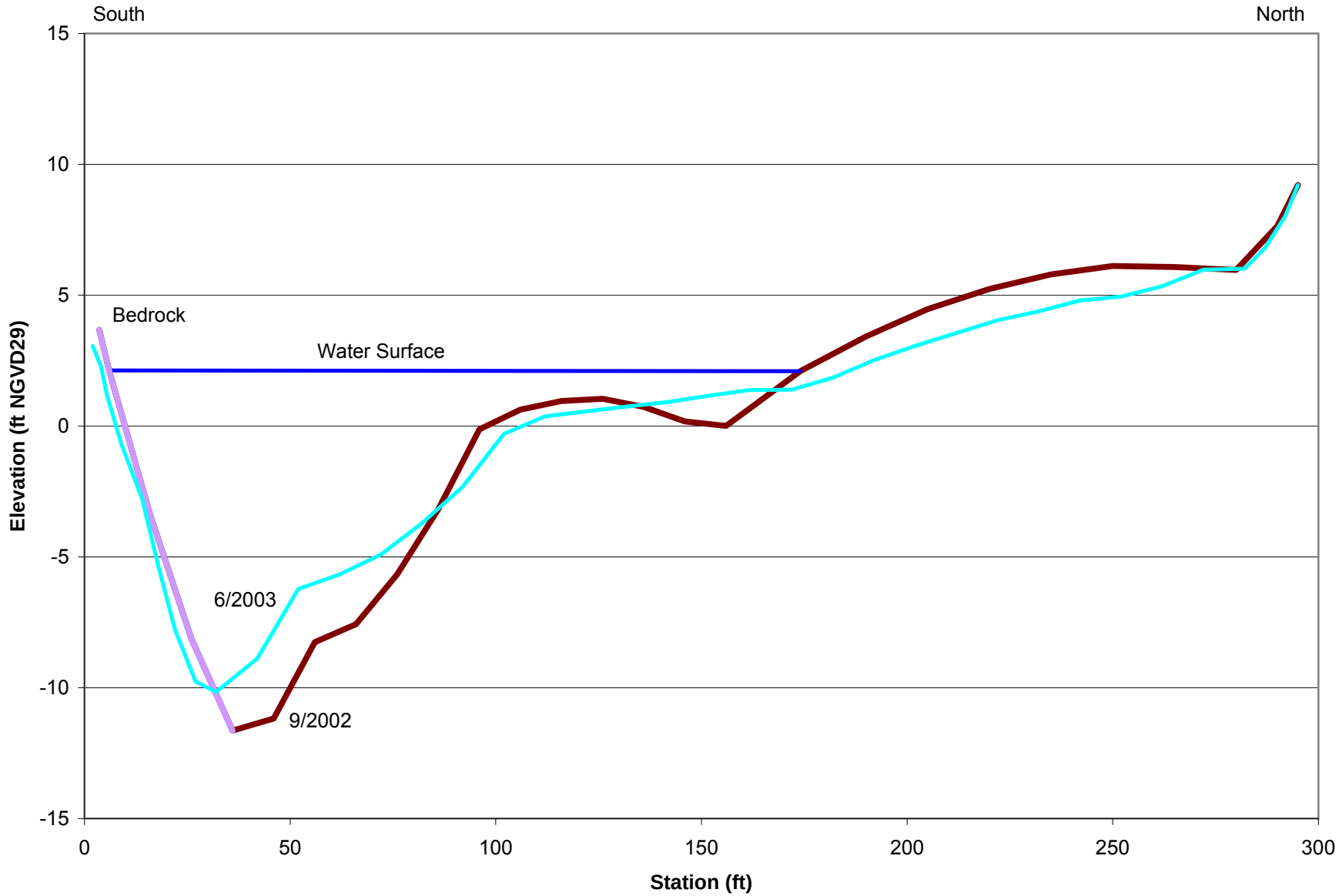
Kamman Hydrology & Engineering, Inc.

Lower Gualala River and Coastal Lagoon Assessment and Enhancement Plan

Cross-Sectional Profiles at Summer Tide Gage - 9/28/02 and 6/22/03

FIGURE 2.8

Cross Sections.xls,Figure 2-8



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Lower Gualala River and Coastal Lagoon Assessment and Enhancement Plan

Cross-Sectional Profiles at Mill Bend - 9/28/02 and 6/22/03

FIGURE 2.9

Cross Sections.xls,Figure 2-9

channel over the study period, even in response to the high flow events of December 2002. It is worth noting that with the exception of bedrock on the east bank and the rip-raped filled crib island that serves as the summer tide gage location, the entire bed along this section consists of river derived sand, gravel and cobbles. It is unclear, based solely on a visual inspection of Figure 2.8, if the summer gage cross-section experienced net aggradation or degradation between survey events.

Cross-sectional survey results at Mill Bend display a change in bar morphology between September 2002 and June 2003 (see Figure 2.9). With the exception of the bedrock that comprises the left (south) bank, the majority of material that makes up the point bar is river sand, gravel and cobble. Again, visual comparison of cross-sectional profiles at Mill Bend does not provide a clear indication of whether there was net aggradation or degradation of the point bar at Mill Bend between survey dates.

Monitoring of point bar grain size also indicates the redistribution and/or turnover of gravel in lower river bars over the study period. Pebble counts were completed on a total of six gravel bars within the upper estuary and Lower River on 9/13/02 and 9/24/03. Gravel bar sample locations are indicated on Figure 2.3. The grain size distribution graphs for each sampling event are provided in Appendix A along with a comparison between 2002 and 2003 sample events. The significant results of this analysis were: 1) grain size distributions varied widely among bars during the 2002 sample period with the mean grain size (D50) varying between 10mm and 50mm; 2) grain size distribution varied significantly less between bars sampled in 2003, with D50's ranging from approximately 14mm to 23mm; 3) no pattern of down-stream fining in grain-size was observed during either sampling event; and 4) grain size distributions varied noticeably between sample dates at all six point bars, suggesting sediment turn-over along the entire sampled reach during the winter of 2002/03.

2.3 Estuary Morphodynamics

Combining all of the data and observations collected over the study period (photo-point monitoring, estuary cross-sectional surveys, estuary water level recordings, grain-size sampling, freshwater inflow, and wave climate data) provides a detailed description of the cause and effect relationships that control the Gualala River coastal estuary morphology. This section of the report attempts to describe these changes in terms of dominant physical processes and consequences to estuary habitats.

In general, the Gualala River mouth follows a seasonal pattern where the barrier beach breaches during the first major floods of the winter rainy season. The typical wave climate (lower wave energy) and low freshwater inflows of summer allow for infilling of the inlet and reconstruction of the beach barrier. As was observed over the study period, there are several cycles of barrier breaching and partial reconstruction throughout the seasonal transitions between end member states. However, the highly variable climate of Northern California may lead to similarly unpredictable estuary conditions. For example, barrier beach formation may be delayed during wet years due to prolonged high inflow and destructive wave energy. Closure of the beach during moderate inflow may allow for high water levels to develop in the estuary that overtop and incise through the barrier beach.

The cycle of Gualala River coastal estuary barrier-beach breaching and reconstruction can be described in terms of beach/estuary morphology and dominant physical processes controlling that form. A chronological description of these evolving morphodynamic states follows. It is important to realize that the timing, resultant form, and duration of these phases are not “set in stone,” and this synthesis simply reflects the conditions that existed over the study period.

During the summer months of July through September, the barrier could be described as stationary, implying a beach in equilibrium with environmental forces. Characteristics

and typical conditions that give rise to this form include: low wave energy with waves dominated by low amplitude swells, neap tidal conditions, prolonged absence of freshwater inflow, and absence of storm waves. This is typically a period of beach face construction. The beach face also displays the lowest gradient normal to the shoreline during this state**.**

With an increase in wave energy (high magnitude, long period waves) into late fall (October and November), a state of onshore barrier beach migration develops. Notable characteristics of this stage include, continued minimal freshwater inflows, onshore sediment transport and a lower gradient beach face slope, and most notably, wave over-wash. The wave over-wash pushes sand off the crest of the beach, creating over-wash lobes that build off the barrier backslope, extending for significant distance into the estuary. These prominent features account for the significant change observed in barrier beach morphology captured in the cross-sectional surveys described above and illustrated in Figure 2.7. These features also give rise to steep back barrier beach slopes both above and below the estuary water surface.

As wave energy increases with the advent of winter storms, beach-face erosion overtakes beach replenishment due to a net increase in destructive, high magnitude, low period waves, especially at higher tide stages. These processes also lead to a characteristically steeper winter beach face. Partial to whole-scale breaching occurs as a result of high estuary water levels associated with increased freshwater inflows. As seen throughout the winter of 2002/03, the resultant estuary inlet will remain open after breaching as long as there is sufficient freshwater inflow to the estuary combined with tidal prism to counter constructive wave activity at the beach face. This is typically a punctuated process whereby the magnitude of constructive and destructive forces changes on a daily basis with the inlet morphology following suite. For example, the initial breaches in early November of both 2002 and 2003 did not occur until the onset of the first storms and relatively high freshwater inflow. In both cases, inlets quickly filled with sand and the barrier beach reformed due to a rapid recession of inflow rates back to relatively low

late-fall magnitudes. Conversely, barrier breaches that occur later in the winter season (e.g., December of 2002) remain open primarily due to sustained high magnitude freshwater inflow rates in combination with tidal exchange.

The breaching event of June 15, 2003 was unique in that it was not triggered by a single storm inflow pulse, but resulted from a gradual estuary filling from relatively high seasonal base flows sustained by the above average April 2003 rainfall contributions to the watershed. Breaching in this instance occurred as a result of the estuary over spilling the barrier beach. In the evening of June 15, 2003, there was an extreme difference in water surface elevation between estuary and ocean water surfaces, as the breach occurred during the lower-low water stage of a spring tide cycle. As a result, an estimated 564-acre-feet of water drained from the estuary over a span of 24 hours. Based on a post-breach cross-sectional survey (see Figure 2.6) and recorded estuary water levels, it is estimated that the erosive energy from this event resulted in an approximately 250-foot wide breach of over 10-feet deep.

Barrier beach reconstruction after the June 15, 2003 breach was relatively rapid and freshwater inflows began refilling the estuary (see Figure 2.2). By early July 2003, outflows from the estuary (as evaporation and seepage through the barrier beach) exceeded inflow and estuary water levels began to decline. Equilibrium between estuary inflow and outflow was again reached by mid-August of 2003, resulting in relatively static estuary water levels and barrier beach morphology until the onset of wave over-wash events in early October 2003.

2.4 Estuary Water Quality and Habitat Relations

The majority of water quality monitoring for this study was completed by ECORP Consulting, Inc. (presented in Chapter 3.0 of this report) and North Coast Regional Water Quality Control Board staff (RWQCB) (Dudik, 2003). KHE completed supplemental water quality monitoring on several occasions throughout the study period. This section

of the report provides a summary of project water quality-monitoring results as they relate to the morphodynamic stages of estuary and barrier beach development.

The short-term cycles of barrier beach/inlet breaching and reconstruction over the winter season result in sharp changes in estuary salinity. The RWQCB monitoring results for the period February 19-24, 2003 indicate that during periods when the majority of the inlet is partially closed and experiencing limited tidal exchange during high tide periods (i.e., estuary water level fluctuations up to only 2-feet) the estuary becomes a freshwater system, except for the deeper portions of pools along Mill Bend. With the advent of higher wave energy, wave overwash and barrier breaching, like that seen on February 24, 2003, high salinity waters quickly invade the estuary during flood tide, raising estuary salinities to 20 parts per thousand (ppt) near the summer tide gage and up to17 ppt at Mill Bend. These same monitoring results indicate that salinities quickly fall back to the freshwater range later in the day as the estuary drains during the ebb tide and high freshwater inflow essentially flush the system.

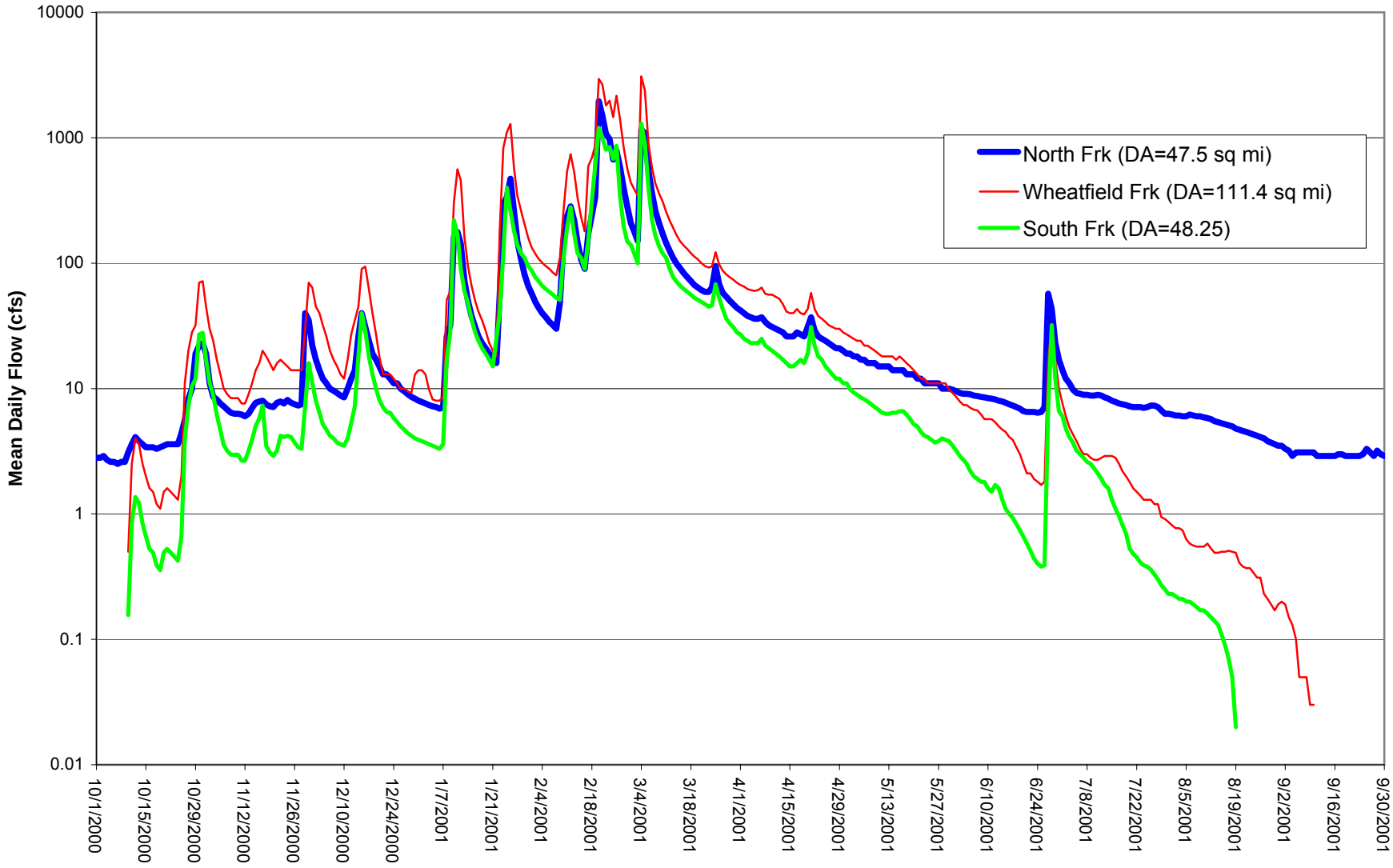
RWQCB water quality monitoring results for the period May 30-June 2, 2003 indicate that the inlet is still open but the effects of salinity intrusion do not appear to encroach up to Mill Bend even though estuary water levels fluctuate by up to 5-feet in response to daily tidal cycles. Over this monitoring period, salinity concentrations range between 0.0 and 17 ppt at the summer tide gage site, but remain entirely within the freshwater range in the shallow portions of Mill Bend. Where seen, shallow water salinity concentrations rise and fall in concert with tidally induced changes in estuary water levels and concentrations quickly return to the freshwater range during ebb tidal periods due to relatively high freshwater inflow rates.

Monitoring of estuary water quality on June 26, 2003 was completed during the inlet/beach reconstruction phase following the late season breach of June 15, 2003. The RWQCB reports that the inlet was essentially closed at this time as also indicated by the estuary water level record. Water level and photo-point monitoring data indicate open

inlet conditions bracket this event during the days leading up to and preceding the sampling event. Water quality monitoring during this event consisted of completing a series of 12 evenly spaced vertical profiles from the inlet mouth to upstream of the Highway 1 Bridge. Results of water quality monitoring indicate stratified conditions from the Ocean up to the Highway 1 Bridge, consisting of a 2.5- to 3.0-layer of freshwater overlying saline water. The boundary between fresh and saline water was sharp and laterally continuous. A repeat of this same water quality monitoring approach on July 30, 2003, one month after final barrier beach construction, revealed the estuary consisted entirely of freshwater with the exception of remnant saline pockets in the deepest parts of the Mill Bend pool.

Water quality monitoring in the mid-summer to early fall (July through September) during the static stage reveals the estuary is a freshwater body with the exception of the stagnant saline pocket trapped at depths (greater than 8-feet) in the Mill Bend pool. The October 23, 2003 water quality monitoring, completed by the RWQCB, occurred during a phase of periodic wave overwash. As a result of the overwash, estuary salinities were elevated to varying degrees (concentrations ranging from 0.43 to 9.16 ppt) between the former inlet location and the Highway 1 Bridge. Well-developed stratified conditions did not exist, although higher salinities were detected in deeper pools.

Based on results of hydrologic monitoring and investigations, the North Fork Gualala River is an important source of baseflows to the lower Gualala River during the late season periods when the estuary is prone to high salinity conditions. Figure 2.10 presents a comparison of daily flows at the USGS gages on the North Fork, South Fork, and Wheatfield Fork during WY2001. Although there are flows contributing to the lower river from the South Fork the geologic and land-use conditions in the North Fork simply allow it to contribute a greater runoff per unit area than the other major tributaries feeding the lower river.



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Lower Gualala River and Coastal Lagoon Assessment and Enhancement Plan

Daily Flow Rates - North Fork, South Fork, and Wheatfield Fork (WY2001)

FIGURE 2.10

2001 Flow Analysis.xls,Figure 2-9

Although the Gualala River coastal estuary adjusts in a predictable manner to natural conditions and processes, it is important to realize that the changes are controlled by subtle shifts in the balance of physical forces. The hydrologic and water quality characteristics within the coastal estuary throughout the year control the extent and quality of aquatic habitat for resident species. *Thus, any change to the timing or magnitude of any given characteristic or physical process brought about by human activity may have significant adverse affects on the estuary ecology*. Wave climate and tidal conditions are not likely to change over the long term. However, changes in freshwater inflow and sediment delivery rates may introduce instability and adverse impacts to estuary habitat quality. There are numerous examples of how changes in water delivery and mechanical barrier breaches have adversely impacted aquatic habitats in other California coastal river systems including Redwood Creek in Humboldt County, Santa Clara River in Ventura County, Malibu Creek in Los Angeles County, and Pescadero, San Gregorio, Waddell, and Pomponio Creeks in San Mateo County (Redwood National Park, 1983; Environmental Science Associates 2003; Ambrose & Orme, 200; Smith, 1990 & 1987; and Swanson et al, 1990).

Based on the monitoring completed over the study period, it appears that the Gualala Coastal estuary functioned in a natural and healthy manner during the "normal" and "below average" water year-type conditions and was dominated by fresh-water conditions. High salinity conditions were quickly flushed by freshwater inflows during ebb tidal cycles when the inlet was open or diluted during closed inlet conditions.

2.5 References

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CHAPTER 3.0 AQUATIC ECOLOGY

3.1 Introduction

The aquatic monitoring tasks were the responsibility of ECORP, including fish and benthic macroinvertebrate monitoring, and water quality monitoring.

The objective of the Water Quality Study Component was to:

- provide seasonal water quality profiles throughout the Gualala Estuary, including temperature, dissolved oxygen, pH, conductivity and/or salinity.

The objectives of the Aquatic Ecology Study Component were to:

- determine distribution and abundance of salmonids in the Gualala Estuary,
- describe seasonal habitat conditions in the Gualala Estuary,
- describe seasonal habitat availability in the Gualala Estuary,
- develop a species list and relative abundance of all observed fish, birds and mammals, and if possible given budget considerations,
- determine adult steelhead use and timing of migration through the Gualala Estuary.

Adult steelhead use and timing of migration was not addressed in this report due to budget considerations. In addition, outmigration (including timing of outmigration) of juvenile steelhead was not directly studied.

3.2 Methods

3.2.1 Water Quality

To evaluate potential water quality affects on salmonids present in the estuary, especially during low flow conditions, water quality profiles (i.e., parameter measurements with

depth) were obtained concurrently with all fish sampling efforts. Water quality profiles consisted of a series of measurements recorded at prescribed intervals, from the surface to the bottom of the water column. Profile data parameters included temperature, dissolved oxygen, conductivity, salinity, and pH. Additionally, continuous recording temperature units were used to record water temperatures 0.5 meters below the surface and 0.5 meters off the bottom at selected locations.

All water quality data were tabulated and graphed by site location and date. An analysis of water quality conditions at varying estuary water surface levels, as well as open versus closed estuarine conditions, was conducted.

3.2.2 Aquatic Ecology

To adequately sample and evaluate aquatic habitats and species in the estuary, the estuary was divided into three sections: lower estuary section, middle or transitional section, and upper or riverine section (Figure 3.1). These divisions were based primarily on habitat characteristics, substrate types, and flow conditions within the estuary. The lower estuary section extends from the mouth of the river [River Mile (RM) 0.0] upstream to a point where the coastal vegetation community becomes established along the south bank at RM 0.4. The middle estuary (i.e., transitional section) extends from the upstream end of the lower estuarine section to just upstream of Mill Bend, or the "GRI (Gualala Redwoods, Inc.) Beach" located just downstream of the Highway 1 Bridge) RM 0.4 to RM 1.2. The upper estuary (i.e., riverine section) extends from the Highway 1 Bridge at RM 1.2, upstream to the confluence with the North Fork Gualala River at RM 3.4.

Aquatic Habitat Types

Aquatic habitat types within the Gualala River estuary were measured using standard techniques developed by the CDFG and utilized in North Coast Watershed Assessment

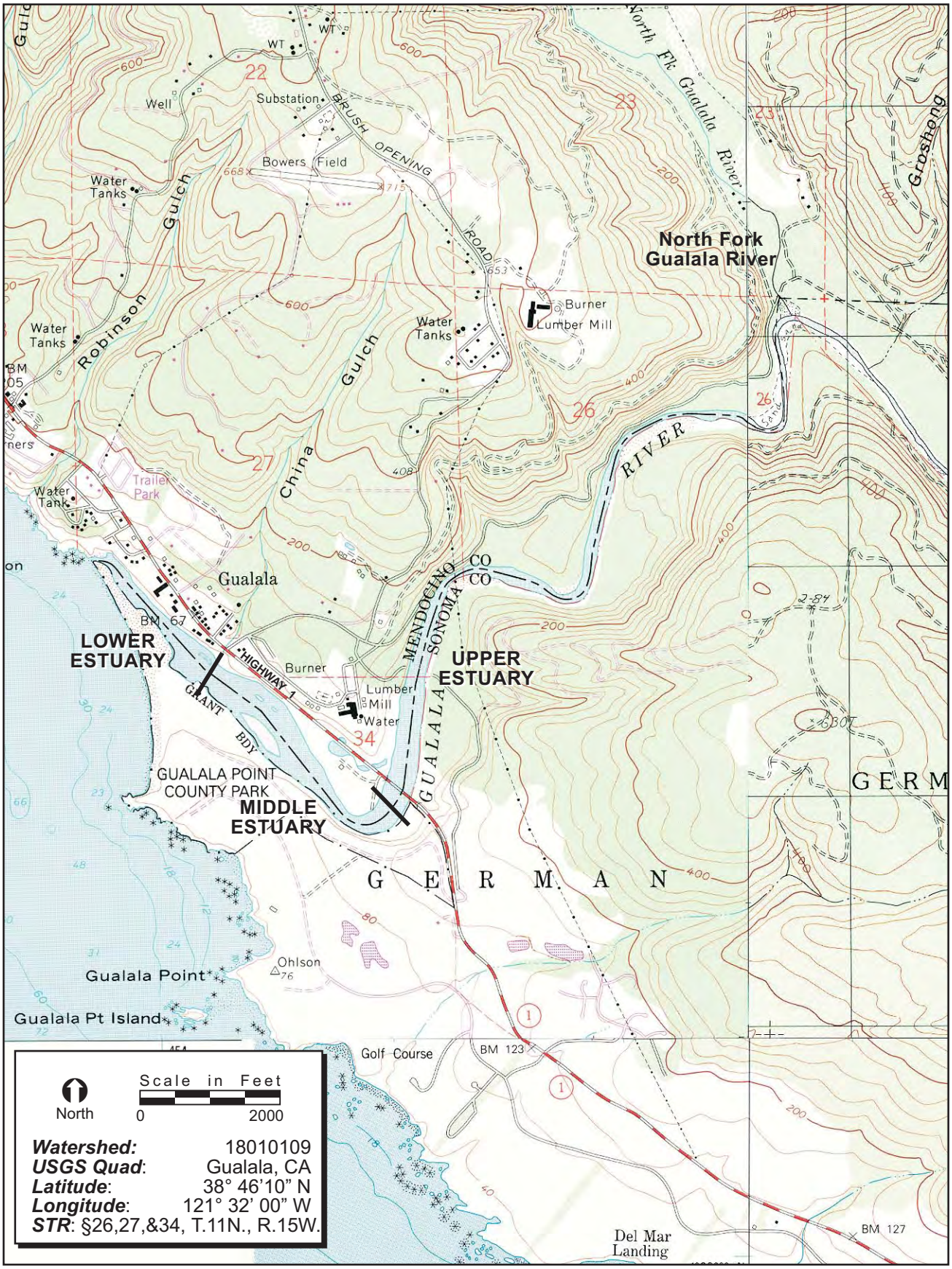

FIGURE 3.1 Project Site and Vicinity Map

2002-105 Gualala River

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Program (NCWAP) studies. Habitat types were based primarily on the combined affects of differences in salinity, depth, and substrate parameters within the estuary.

In general, four distinct habitat subsystems are present in the Gualala estuary:

1) marine,
2) brackish,
3) freshwater estuary, and
4) riverine.

A marine subsystem is present only during short transitional periods, with limited distribution in the lower estuary, when the mouth of the estuary has breached. Significant amounts of marine water can also enter the estuary during heavy surf conditions.

The brackish water subsystem is an extension of the marine subsystem, and is also transitional in nature in the Gualala estuary. Brackish water conditions can extend upstream farther than marine conditions, and for slightly longer time periods. However, the tendency of the Gualala estuary is toward a closed, freshwater state.

The freshwater estuary subsystem is by far the most common habitat type in the Gualala estuary. Even after breaches, or inputs of marine water from heavy surf conditions, the Gualala estuary generally returns to freshwater conditions within a short time period (days to weeks).

The riverine subsystem often consists of a narrow, subtidal river channel that may be seasonally influenced by salt water, or may contain freshwater throughout the year.

3.2.2.1 Fisheries

This study was designed to collect fisheries data throughout the Gualala estuary to develop population estimates for juvenile steelhead residing in the estuary, and to

describe fish species composition and abundance. Sampling within the estuary was focused on summer through fall months to obtain fish population data during summer and fall low-flow conditions. During this time period, habitat for juvenile steelhead in other portions of the basin can become limiting due to both natural and human-induced factors. Such limiting factors include streamflow volume (which affects the amount of available fish habitat), water temperature, habitat quality, and stream sedimentation due to past logging practices, road building, and other land use practices. These and other watershed-specific issues have been addressed in the 2003 NCWAP report (Klamt *et. al*. 2003).

2002 Season

Field sampling was initiated in June 2002 and was conducted every three weeks through November 2002. A total of 6 monthly sampling events were completed (June through November). Fish sampling was conducted using a 100-foot bagged beach seine (1/8 inch delta mesh). Samples were collected within the three estuary sections (upper, middle, and lower) to obtain sufficient data to describe fish and macroinvertebrate distribution patterns relative to different water quality and substrate conditions present within the three estuary sections. Approximately 20 hauls were completed within the estuary during each sampling event. Beach seining was complemented by quantitative assessments of habitat quality, substrate evaluation, and water quality measurements.

Originally, the fisheries sampling design was conducted every three weeks beginning in late spring and extending through the fall, to provide sufficient data to characterize the steelhead population structure and to calculate population estimates for the estuary. However, during the 2002 August sampling event, riverine sampling upstream of the Highway 1 bridge became difficult due to dense blooms of filamentous algae. Because of the extreme difficulty associated with sampling in areas with large accumulations of filamentous algal, a decision was made to decrease sampling in the upper section. In general, filamentous algae is pervasive throughout the lower river and in some areas of the estuary from mid-summer through late-fall. These blooms did not appear to adversely

impact steelhead juveniles during the 2002 or 2003 sampling seasons; in fact, steelhead fry were often observed using filamentous algae as cover. During the mid-summer to late fall period, the lower river is very shallow. The channel in this part of the river is wide and without significant riparian or other shaded cover (except along the channel edges) that would reduce or limit solar radiation input, a major factor conducive to algal and/or other macrophytic plant growth. Increased stream temperatures during the mid-summer and fall months reflect the increases in solar radiation and often exceed 20 ºC. In combination, the elevated water temperatures and increases in solar radiation would favor the growth of macroalgae and other aquatic plants providing sufficient nutrients are available. Nutrient loading can and may occur in the Gualala River watershed from anthropomorphic sources, such as agricultural runoff, campgrounds, and septic systems. However, these factors are outside the scope of this study.

During the initial October sampling, an additional sampling day was added following the normal mark/recapture sampling event to independently estimate the steelhead population at that time. Also, the fall 2002 sampling effort was extended into November to take advantage of the fact that the estuary remained closed and to gain further understanding of steelhead use of the estuary in late fall.

2003 Season

From further discussions at the TAC meeting after the first year of sampling had been completed, two general issues arose:

- that upstream migration of juvenile steelhead from the lower estuary into the upper estuary or river may occur during the onset of late-fall wave overwash and increased estuary salinity, and

- that based on observations reported by CDFG biologists during summer snorkel surveys in the North Fork Gualala River, Coho salmon may still be present in the estuary[2].

To address the above issues, field sampling in 2003 began in February to evaluate the presence/absence of Coho salmon in the estuary, since Coho salmon are known to utilize estuarine habitats elsewhere along the California coastline early in the year (Cannata, 1998). Also, the sampling effort was increased in the riverine section of the estuary to obtain additional data for evaluating the potential for upstream migration of juvenile steelhead during late fall. The increase in the number of upstream hauls likely had an affect on abundance estimates for some species (in particular, three-spine stickleback) for 2003, as compared to the 2002.After the February sampling event, sampling was resumed in May, and then continued monthly through October 2003. A total of 7 monthly sample events were completed during the 2003 season (February and May through October).

Sampling Protocols

Seining was the primary method for fish sampling throughout the estuary. In most cases, the seine was deployed parallel to the shoreline, at a distance of about 75 feet from the shoreline, from an inflatable boat. At least a four-person crew then pulled the seine into shore. However, in the riverine section near the confluence with the North Fork, the seine was set along one side of the river channel and pulled across to the other side of the river. Also, in some backwater areas, a two-person 10-meter seine was used to sample in and around submerged and emerged vegetation. Fish caught in the beach seine were identified to species, then measured to fork length (to the nearest mm) and weighed (to the nearest 0.1 gram). All specimens were immediately returned to the water, except for steelhead 80 mm or greater in length, which were fin-clipped and marked with a freeze brand to identify the catch from each sampling event. Additionally, during each

[2] Juvenile Coho salmon were reported (but not confirmed) to NOAA fisheries personnel to have been stranded immediately after the early summer breach event on June 15, 2003.

sampling event, lengths were recorded for a representative number of fish species other than salmonids (i.e., the first 30 recorded of each species).

Population Analysis

Marking and subsequent recapture of steelhead allowed for calculation of population estimates within the estuary for each sampling event. Steelhead population estimates were made using two different estimators; a modified Petersen (Schnabel and Schumacher, (Ricker, 1975) mark/recapture strategy, and the Jolly-Seber estimator. The modified Petersen estimator assumes a closed system with no recruitment or mortality. The Jolly-Seber method assumes an open system and allows a calculation of survival for each sampling event. Each estimator functions independently of the other, which provides two different approaches to estimating population size. Individual steelhead lengths and weights were also used to assess fitness of Gualala River juvenile steelhead in the estuary throughout the summer and fall.

Data collected during the two sampling years were tabulated by date and estuary section to document the temporal and spatial distribution patterns of steelhead within the estuary. These data were also compared against physical habitat characteristics and water quality parameters, using non-parametric statistics to analyze potential limiting factors in estuary productivity. Standard analytical techniques were incorporated, including calculation of condition factor, development of length-frequency histograms, and the calculation of tri-weekly population estimates from mark-recapture sampling.

Steelhead Stomach Analysis

Steelhead stomach analyses were completed on all steelhead mortalities associated with field sampling. Steelhead mortalities were placed into labeled jars with 10% buffered formalin, and transported to the ECORP Consulting, Inc. laboratory facilities in Roseville for later analysis. A few specimens were analyzed together due to mixing of stomach

contents when specimens were prepared for fixation. Each fish was dissected and the entire digestive system examined. Organisms were identified to lowest taxonomic level depending on the condition of the specimen.

3.2.2.2 Benthic Macroinvertebrate Surveys

Benthic macroinvertebrate (BMI) sampling in the Gualala estuary was conducted in three reaches: lower reach - RM 0.4 to RM 1.1; middle reach - RM 1.6 to RM 2.0; and upper reach - RM 2.5 to RM 3.2. In 2002, three sites per reach were sampled during the July fish-sampling event under closed estuary conditions. A second set of samples was collected in 2003 in the middle estuary (RM 0.8) during the May sampling effort, while the estuary was breached and the river was flowing to the ocean. During breach conditions, riffle habitat becomes more abundant and is similar to that found in the upstream riverine reach.

Sampling was conducted with a kick-net according to the CDFG California Stream Bioassessment Procedure (CSBP) protocols for streams and rivers. Three 1 ft x 2 ft areas along each transect were sampled using a D-framed kick net with standard mesh (0.5 mm). The three samples were placed into a bucket, elutriated using a standard sieve (0.5 mm mesh; #35 sieve), and processed to remove excess fine sediment and debris. The remaining sample was placed into a container with 95% ethanol and then stained with Rose Bengal dye.

A modified sampling method was used to collect benthic macroinvertebrates in the lower (non-flowing) part of the estuary. In this lower section, three distinct areas were chosen to collect samples: one in an area of widgeon grass, one in a gravel area, and one along the Mill Bend area. During sampling, a five to six foot area was agitated and multiple sweeps with the kick-net were performed to collect the sample. The samples were then placed into a 0.5 mm sieve, and large pieces of course particulate organic matter (CPOM) were inspected for clinging organisms and then discarded.

In the laboratory, each sample was placed into a grid-lined sub-sampling pan (5-cm square cells). A random number table was used to choose random grids and all material (detritus and invertebrates) was removed from the pan. The sub-sample was sorted using stereo dissecting microscopes at 10X magnification. A total of 300 organisms were removed from each sample for identification. Any remaining macroinvertebrates were removed from the subsample, enumerated, and placed into a separate labeled vial (i.e., sample ID, date collected, amount of subsample and number of macroinvertebrates) containing 70% ethanol. The taxonomic identification of organisms was conducted according to the CSBP Level III protocols (genus and species).

3.3 Results

3.3.1 Water Quality

Water quality data were collected from June through November 2002, and from February through October 2003. Sampling was conducted during both closed (2002) and open (2003) conditions. During most sampling events, water quality profile data were collected in association with fish sampling efforts. Water quality profiles consisted of a series of measurements recorded at equal intervals from the water surface to the bottom of the water column. Profile measurements included; temperature, dissolved oxygen (D.O.), conductivity, salinity, pH, and turbidity as total dissolve solids (T.D.S.). Water temperatures were also recorded at 0.5 meters below the surface and at 0.5 meters above the bottom. All water quality data was tabulated and graphed by site location and date. These data were also grouped for analysis of open vs. closed estuarine conditions.

In addition to collecting water quality data at fish sampling sites, profiles were also taken at specific locations throughout the estuary during each sampling event. These additional water quality stations were located in the following areas:

- mouth of estuary,
- near the tide gage,

- near China Gulch,
- Mill Bend, and
- 100 m above Highway 1 Bridge

The locations of all water quality profile sampling stations are provided in Figure 3.2. Raw water quality profile data are provided in Appendix B, by sampling year, month, and estuary location.

Water Quality Depth Profiles

Water quality depth profiles were collected at selected locations within the estuary in conjunction with most fish sampling events in 2002 and 2003. The following section describes the general water quality conditions present within the estuary during these sampling periods.

Summer Period (June through August)

June:
In June 2002, water quality profiles obtained in the lower and middle estuary up to Mill Bend, showed well-mixed conditions for all parameters during this closed lagoon period (Appendix B-1 through B-4). Water temperatures ranged from about 18.0 – 19.0 °C, salinity readings were slightly above zero (freshwater dominated), and D.O. varied from about 7.0 – 9.0 mg/L. The water quality profile at the long pool at Mill Bend showed that salinity stratification (from 0 to 27 ppt) had occurred between 9.0 and 10.0 ft deep (see Appendix B-4). Water temperatures remained relatively constant with depth ranging from about 17.0 – 18.0°C; however, D.O. levels decreased substantially from about 8 to 9 mg/L in the surface layer, to about 3 mg/L at a depth of 12 ft. Below 12 ft. depth, D.O. continued to drop to a minimum value of about 2 mg/L on the bottom (20 ft deep).

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Figure 3.2: Gualala Estuary Sampling Site Locations

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As expected, water quality profiles obtained in June 2003 under open estuary conditions (after June 15, 2003 breach) were substantially different than water quality profiles obtained during closed estuary conditions that were present in 2002. At the mouth of the estuary, marine conditions dominated the water column with salinities and associated T.D.S values ranging from about 30.5 ppt on the surface to 33.5 ppt on the bottom (at 6 ft deep) (Appendix B-27). Water temperature, D.O., and pH values were relatively consistent with depth: averaging 11.0°C, 10.0 mg/L, and 7.8, respectively.

Moving upstream from the mouth, profiles collected at the tide gage and at China Gulch indicated more brackish conditions (7-17 ppt) on the surface (upper 2 ft of the water column) (Appendix B-28 and B-29), below which, salinity returned to about 33 ppt. As before, the T.D.S. profile mimicked the salinity curve. Water temperatures decreased from a range of 15.0 to 17.0°C on the surface, to about 11.0°C at a depth of 3 ft. Values obtained for both D.O. and pH were relatively constant throughout the water column, with values averaging about 10.0 mg/L and 8.0, respectively.

The profile obtained at Mill Bend (Appendix B-30) also showed the increased presence of freshwater, but also showed salinity stratification from less than 0.5 ppt in the surface layer, to about 24 ppt between the depths of 7 and 8 ft. The water temperature profile showed a substantial drop in temperature at and below the stratification layer (from 20.0°C to about 13.0°C), with no associated decrease in D.O. Both D.O. and pH values were relatively stable throughout the water column, with values ranging between 10.0 and 11.0 mg/L and 7.0 to 8.0, respectively. Water quality data collected at the shallow (4 ft deep) site 100 m above the Highway 1 Bridge showed the same general profile and parameter values as that described above for the upper 7-ft of the water column at Mill Bend (Appendix B-31).

July:

During the July 2002 sampling effort at Mill Bend, salinity stratification (from 0 to 25 ppt) occurred at the surface between 0 and 1-foot of water (Appendix B-5). Water

temperatures in the stratification layer increased substantially (~22.5 – 26.5°C), then decreased below the salinity wedge to a minimum temperature of about 21.0°C, and then gradually increased again to a maximum temperature of about 27.0°C at the bottom (~15 ft deep). Dissolved oxygen levels fluctuated slightly with increasing depth, but values were generally between 7.0 to 8.0 mg/L. Well-mixed freshwater conditions were observed above the Highway 1 Bridge (Appendix B-6).

Water quality data collected during the July 2003 sampling effort showed a change in the estuary from primarily marine conditions to a freshwater environment. Profiles obtained in the lower and middle estuary up to Mill Bend documented well-mixed conditions with salinities <0.5 ppt (Appendix B-32 and B-33). Water temperatures throughout the water column were warm, ranging from 21.5°C at the mouth of the estuary to slightly over 22.0°C at China Gulch. Dissolved oxygen values were relatively consistent with depth, ranging between 9.0 and 10.0 mg/L; and a stable pH of 8.5. As noted earlier, T.D.S. values paralleled the salinity readings.

At the Mill Bend station, stratified conditions were still present, ranging from 0 on the surface to about 21 ppt on the bottom (Appendix B-34). Water temperature increased from 20.5°C in the surface layer to about 24.0°C below the stratified layer. Total dissolved solids increased proportionately with increasing salinity. Dissolved oxygen levels in the upper 11.0 ft of the water column averaged about 9.0 mg/L. However, D.O. levels within and below the stratification layer showed a substantial increase in concentration, which must be considered an anomalous response to increased salinity and temperature. As noted in June, values for pH were relatively stable with depth, ranging from 7.0 to 8.0.

At the shallow site 100 m above the Highway 1 Bridge, water quality data showed the same general profile and parameter values, except for D.O., which was slightly lower in July at about 8.0 to 8.5 mg/L (Appendix B-35).

August:

Two water quality profiles were obtained at Mill Bend in August 2002. On August 2, salinity stratification (from 0 to about 25 ppt) was still present at the site, but had moved from the surface into deeper water between 10.0 and 11.0 ft deep (Appendix B-7). The water column above the stratification layer was well mixed, with water temperatures averaging about 18.0°C, and D.O. values around 8.0 mg/L. Within and below the stratification layer, water temperatures increased sharply to about 25.0°C at a depth of about 15 ft., and D.O. levels dropped to about 6.5 mg/L. On August 13, a second profile was obtained at Mill Bend that generally showed deteriorating water quality conditions at the site (Appendix B-8). The stratified layer (from 0 to about 22 ppt) had expanded into shallower water, and was now located between 5.0 and 11.0 ft deep. Surface waters had remained about the same (18.0°C), and temperatures at and below the stratification layer were still warm, averaging about 23.0°C. Below the stratified layer, D.O. levels continued to drop, ranging between 4.5 and 6.0 mg/L between 10 ft deep and the bottom (15 ft deep).

In August 2003, water quality profiles were obtained at the mouth of the estuary, and at Mill Bend. At the mouth, water column conditions showed well-mixed conditions reflecting a freshwater environment (Appendix B-36). Water temperatures throughout the water column were still warm, ranging from 21.1 to 25.0°C. Dissolved oxygen levels fluctuated slightly with depth, but were generally between 10.0 and 11.0 mg/L. Values for pH (about 8.8) were stable with depth.

At Mill Bend, salinity stratification (0 to about 22 ppt) had moved slightly deeper, occurring between 12.0 and 13.0 ft deep (Appendix B-37). In the water column above the stratification layer, water quality parameters were generally similar (except surface water temperature which dropped to an average of about 19.5°C) to the values obtained at the mouth of the estuary. At and below the stratification layer, water temperatures increased to a maximum of about 23.0°C, D.O. decreased rapidly to just above zero from 13 ft deep to the bottom (16 ft deep), and pH decreased slightly to about 7.0.

Fall Period (September through November)

September:

In late September 2002, the water quality profile at the long pool at Mill Bend showed that salinity stratification (from 0 to 25 ppt) had occurred between about 6 and 10 ft deep (Appendix B-9). Surface water temperatures were about 17 °C, but increased rapidly to about 21.0°C below the stratified layer. Dissolved oxygen levels decreased substantially in the saline layer from about 7.5 mg/L at about 6 ft deep, to <1.0 mg/L at 10 ft deep. Below 10 ft deep, D.O. increased rapidly again and at 13 ft deep, was back to surface concentrations.

Profiles obtained in late September 2003 showed relatively well mixed conditions from the summer tide gage upstream to the Highway 1 Bridge (Appendix B-39 through B-42), as observed during the summer months (see Appendix B-31, B-35, and B-42). At the mouth, the profile indicated some influence of ocean wave-wash, with slightly increased salinity below 10 ft deep (Appendix B-38). Salinities throughout the estuary were <0.5 ppt., and surface water temperatures were generally warm (between 20.5 and 21.5°C); however, water temperatures decreased with depth. In the lower estuary (from the mouth to China Gulch), water temperatures below a depth of about 2 ft were generally 2.0 to 3.0°C cooler than on the surface. The greatest decrease in temperature occurred at the stations located at Mill Bend and 100 m above the Highway 1 Bridge where water temperatures below a depth of about 4 ft were >3.0°C cooler than surface temperatures. The substantial decrease in temperature observed at the station above the Highway 1 Bridge is unusual considering the shallow depth. D.O. levels fluctuated with depth at most sites, but were generally in the range of 9.0 to 11.0 mg/L; and pH values averaged between 8.0 and 9.0.

October:

The water quality profile at Mill Bend (2002) showed that the salinity stratification had weakened slightly (relative to September) to a maximum salinity of 17 ppt, within a

depth range of about 6 ft (Appendix B-10). Surface waters had cooled slightly from September to about 15.0°C, and decreased further to about 13.5°C below the salinity wedge. Dissolved oxygen concentrations on the surface were low (about 6.0 mg/L) and decreased to about 4.0 mg/L within and below the stratification layer.

Water quality profiles collected in late October 2003 showed the effects of increased salinity concentrations due to wave overwash extending throughout the lower and middle estuary, up to and including Mill Bend (Appendix B-43 through B-45). Upstream of Mill Bend (station located 100 m above the Highway 1 Bridge), the estuary was still well mixed, with a salinity of < 0.5 ppt, water temperatures between 13.5 to 15.0°C, D.O. levels between 7.5 and 8.5 mg/L, and a pH of around 8.2 (Appendix B-46).

Below Mill Bend, salinity stratification began at a depth of about 3 ft and gradually increased with depth to a maximum of 12 ppt on the bottom. As expected, profiles for conductivity and T.D.S. mimicked the increasing salinity gradient. Water quality profiles for D.O., pH, and temperature showed little change with depth during this period, regardless of location in the lower or middle estuary. In general, D.O. levels ranged from about 7.5 to 10.0 mg/L, pH levels were between 8 and 8.5, and temperatures ranged from about 15.0 °C on the bottom to 17.0 °C in the middle and upper water column.

At Mill Bend in October (2002), salinity stratification began at about 5 ft deep, and gradually increased to around 9 ppt on the bottom (15 ft deep) (Appendix B-45). As in the lower estuary, conductivity and T.D.S. values generally paralleled the salinity gradient. Dissolved oxygen levels decreased slightly from the surface to 5 ft deep (12 to 10 mg/L), then dropped rapidly below that point to about 2 mg/L at 10 ft deep. Below a depth of about 8.5 ft, D.O. levels were low (< 5 mg/L). Water temperatures varied according to depth and salinity concentration. Surface water temperatures to a depth of 5 ft averaged about 14.0 °C, then increased steadily to a depth of 9 ft and stabilized at around 17 °C. Values for pH were generally similar (7 to 8) throughout the water column.

November:

November water quality profiles were only obtained in 2002. Two sampling efforts were conducted during this month (November 8 and 23); however, only Mill Bend profiles were collected on November 23. Profiles collected on November 8 in the lower and middle estuary showed that surface waters were more saline than during the October sampling period (Appendix B-11 through B-13). As noted in Chapter 2.0, the estuary was partially breached during the storm of November 6-7. Surface water salinity was greatest at the mouth (12 ppt), and then decreased steadily moving up the estuary, to about 3 ppt at Mill Bend. Salinity stratification at the lower and middle estuary stations generally increased linearly from the surface to a maximum salinity of about 25 ppt on the bottom (10 ft deep). Temperature and D.O. values in the lower and middle estuary remained relatively consistent with depth and between stations. Water temperatures during this period ranged from about 13.0 to 14.0 °C, and D.O. levels varied between 8.0 and 9.0 mg/L.

At Mill Bend, the salinity gradient was stronger and more pronounced than in the lower portions of the estuary (see Appendix B-13). Salinity increased steadily from the surface (~3 ppt) to about 27 ppt at a depth of about 6 ft, and then slowly increased to a maximum salinity of about 30 ppt on the bottom (20 ft). In contrast to conditions present during the October sampling period, water temperatures did not increase and D.O. levels did not decrease below the stratification layer. Water temperature values remained relatively constant with depth (13.0 to 14.0 °C), as were D.O. levels (8 to 9 mg/L).

By the November 23 sampling event, surface salinities at the mouth and at upstream locations showed a substantial decrease from the earlier November 8 sampling effort (Appendix B-14 through B-16). At the mouth of the estuary, a slight increase in salinity occurred below 3 ft deep, likely a result of tidal influences and/or wave overwash. The water quality profile obtained at Mill Bend on November 23 (see Appendix B-16) was more similar to the profile collected in October (see Appendix B-10) at Mill Bend than to the profile obtained on November 8 (see Appendix B-13). On November 23, salinity

stratification occurred between the 7 and 10 ft deep, with a corresponding increase in salinity from 0 to about 25 mg/L (see Appendix B-16). Water temperature increased from about 11.5 °C on the surface to about 14 °C below the stratified layer. Dissolved oxygen levels showed the same substantial decline within and below the stratification layer, from about 9 mg/L on the surface to about 2 mg/L at a depth of 13 ft.
Salinity stratification was also present at China Gulch located below Mill Bend (see Appendix B-15). Stratification began at a depth of about 4 ft, and gradually increased with depth to a maximum of 15 ppt on the bottom. Temperature showed little change with depth; however, D.O. decreased with depth below about 7 ft deep to a minimum value of about 6.5 mg/L.

Late Winter/Spring 2003 (February through May)

Field sampling in 2002 began in June, and as a result winter/spring data is not available. However, water quality data were collected in the late winter and spring of 2003, during February, April, and May. During the latter part of this period, the barrier beach was breached and the Gualala River flowed directly to the ocean.

February/April:
Freshwater conditions dominated the estuary for the three-month period. Water quality profiles obtained at various locations within the estuary showed well-mixed conditions in the estuary (Appendix B-17 through B-21). During each of the three sampling events conducted during the winter/spring period, measured values for temperature, salinity/conductivity, pH, total dissolved solids, and generally for dissolved oxygen, were similar (and at levels appropriate for juvenile steelhead survival) throughout the water column regardless of location within the estuary. During February and April sampling events, water temperatures averaged 10.0 to 11.4°C, with DO ranging from 9.5 to 12.7 mg/L.

May:

In May, salinity stratification (0 to 21 ppt) was evident at the Tide Gage (Appendix B-23) at depths below 5.0 ft, but conditions appeared to be well-mixed near the mouth (Appendix B-22). As would be expected, TDS levels mimicked the salinity curve. Above the stratified layer, water quality parameters were similar throughout the estuary: water temperatures averaged about 14.0°C, D.O. levels were between 11.0 and 12.0 mg/L, and pH values were around 7.5. Below the stratified layer, water temperatures decreased to about 12.0°C, D.O. levels fluctuated from about 10.0 to 12.5 mg/L, and pH decreased slightly to an average of about 7.0. Well-mixed freshwater conditions dominated the estuary from China Gulch upstream (Appendix B-24 through B-26).

Continuous Temperature Recorders

In 2002, Hobo continuous recording temperature recorders were placed in the estuary to monitor water temperatures during the summer period at selected locations within the Gualala estuary. During the study period, some of the temperature recorders were lost or stolen (high recreational use area), and others were lost due to burial by sand. In July and August 2002, water temperatures in the upper estuary exceeded 25 ºC (thermal maximum for steelhead) on 11 days (Appendix B-47). On the 11 days that the temperature exceeded 25 ºC, the duration of the exceedance ranged from one to six hours. Hourly maximum temperature readings ranged from 25.2 to 26.7 ºC on those days. During the same time period, bottom and surface water temperatures recorded in the middle estuary did not reach 25 ºC (Appendix B-48).

In 2003, none of the continuous temperature data recorders for the month of July were recovered from the estuary. Consequently, new recorders were deployed in August 2003. Continuous temperature data for August and September showed that water temperatures exceeded 25 ºC on only two days in August 2003 (Appendix B-49 and B-50). On the two days that the temperature exceeded 25 ºC, the duration was only one-hour each day. Hourly maximum temperature readings did not exceed 25.6 ºC on the two days.

Salinity Patterns in the Estuary

Salinity patterns within the estuary are graphically presented for each site visit for both 2002 and 2003 (Appendix B-51). The graphs include all available salinity data obtained from both profile data and spot measurements made at individual haul locations. Surface and bottom salinities are presented by river mile, from the mouth to the upper estuary.

The estuary was closed throughout all sampling events in 2002, except for the last sampling effort on November 23. With the exception of the deep hole at Mill Bend (RM 1.1), the estuary was predominantly freshwater in 2002. Ocean wave-wash began to increase bottom salinities at the mouth of the estuary by late September 2002, and continued to increase through the October and November sampling events. By the early November sampling event, surface waters began to show increased salinities ranging from 11 ppt near the mouth to about 3 ppt at Mill Bend (mile 1.2). However, the estuary breached between the November 8 and the November 26 and 27 sampling events, flushing the saline water from the bottom of the pool at Mill Bend. Following this breach event, the entire estuary was freshwater (see Appendix B-51) and remained fresh through the February 2003 sampling period.

The estuary was open during the May and June 2003 sampling events. In May, salinities of about 22 ppt were recorded on the bottom at RM 0.4. By June, salinities (ranging from 25-33 ppt) were recorded on the bottom upstream as far as the Highway 1 Bridge (mile 1.2); surface waters showed salinities ranging from 30 ppt near the mouth to about 5 ppt in the lower-middle estuary (RM 0.41) (Appendix B-51). As in 2002, the deep hole at Mill Bend contained saline water throughout the 2003 summer and fall sampling periods. As observed in 2002, ocean wave-wash in late September and October 2003 increased bottom salinities in the lower estuary.

In both 2002 and 2003, the Gualala River estuary was primarily for most of the year, except when the estuary was open and when ocean wave-wash contributed saline water to the estuary.

3.3.2 Aquatic Ecology

3.3.2.1 Fisheries

Sampling Effort

Survey efforts were similar between the two years, with a mean number of 19 hauls per month in 2002, and 21 hauls per month in 2003 (Table 3.1). However, in 2002, 90 percent of the sampling effort was concentrated in the middle and lower estuary sections, whereas in 2003, 75 percent of the sampling effort occurred in these lower two sections. In the upper (riverine) section, the number of hauls increased from 10 percent in 2002, to 25 percent in 2003, as requested by the TAC. The location and river mile of all fish sampling efforts is provided in Figure 3.2.

Species Composition and Abundance

Species composition and abundance data for all sampling events in 2002 and 2003 are provided in Table 3.2 and are summarized below.

2002 Sampling Results

A total of eight fish species were collected in the Gualala River and estuary during surveys in 2002. Ninety percent of the catch consisted of steelhead, threespine stickleback, and Pacific staghorn sculpin. Steelhead comprised the majority of the catch at 46.1%, followed by threespine stickleback at 30.1% (Figure 3.3). The remaining nine percent of the catch consisted primarily of coastrange sculpin and Gualala roach, along with a few surf smelt and Pacific herring. Table 3.3 provides a numerical breakdown of all species captured in 2002 by month and reach (upper, middle, and lower). In general, estuarine species (Pacific staghorn sculpin and starry flounder) were more abundant in 2002 (comprising 17% of the catch) than in 2003 (<0.6% of the catch).

Table 3.1 Total number of hauls per month and estuary section for 2002 and 2003 at the Gualala estuary.

2002 Sampling Events	Number of Hauls			
	Lower Estuary	**Middle Estuary**	**Upper Estuary**	**Total**
June	10	7	2	19
July	12	3	2	17
August	25	8	2	35
September	28	7	1	36
October	31	7	2	40
November	12	10	8	30
Total	**118**	**42**	**17**	**177**

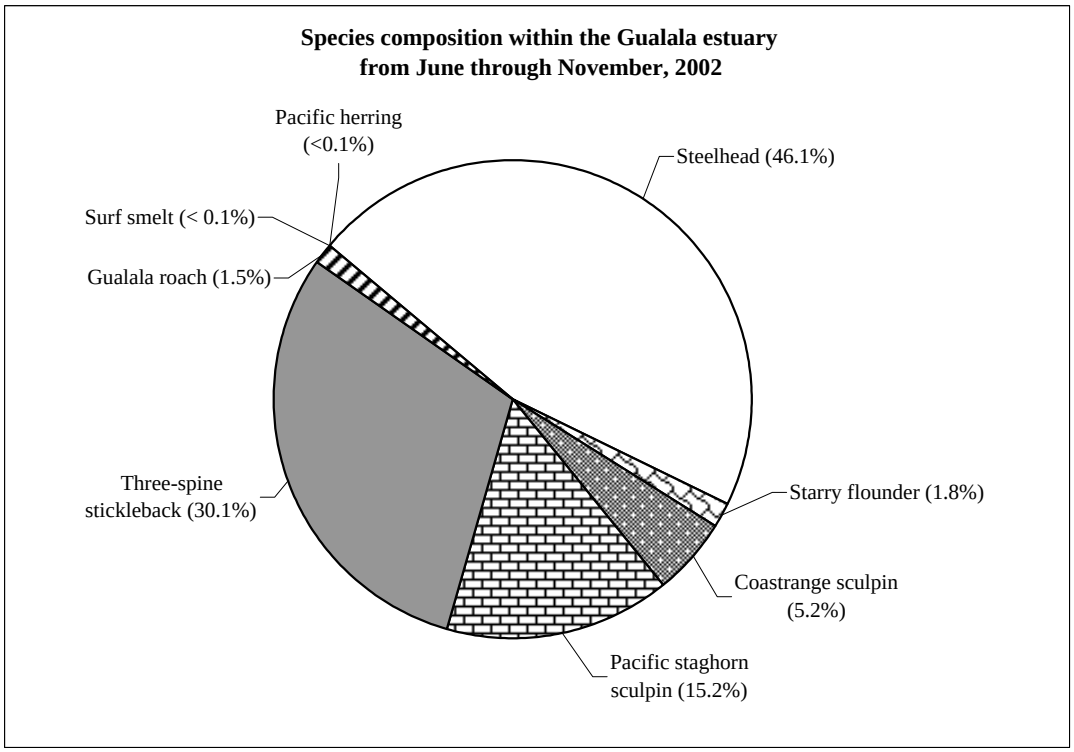
2003 Sampling Events	Number of Hauls			
	Lower Estuary	**Middle Estuary**	**Upper Estuary**	**Total**
February	10	7	4	21
May	9	2	1	12
June	8	2	15	25
July	7	6	3	16
August	15	2	6	23
September	18	6	5	29
October	30	8	10	48
Total	**97**	**33**	**44**	**174**

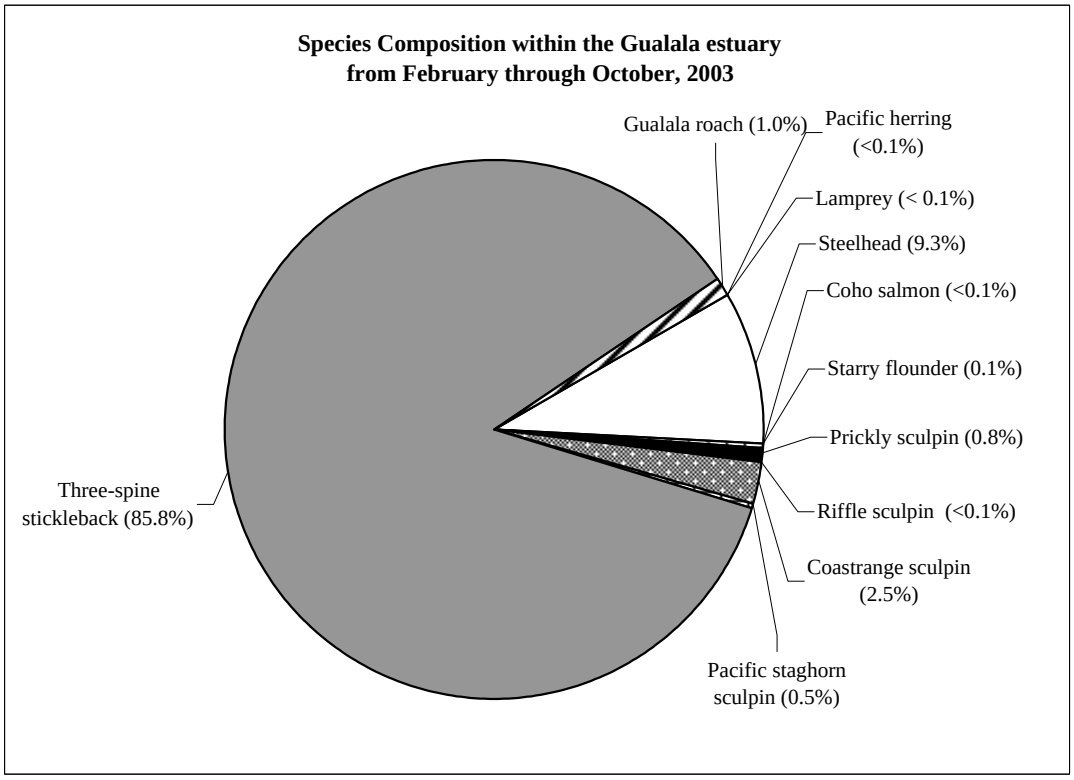
Table 3.2 Summary of fish abundance in the Gualala estuary by species and sampling event from June through November 2002, and from February through October 2003.

2002 Sampling Events	Event Number	Steelhead	Coho Salmon	Starry flounder	Prickly sculpin	Riffle sculpin	Coastrange sculpin	Pacific staghorn sculpin	Three-spine stickleback	Gualala roach	Pacific herring	Surf smelt	Lamprey	Total
June 19-20	1	159	0	13	0	0	39	23	41	82	3	2	0	**362**
July 10-12	2	696	0	99	0	0	3	295	199	18	0	0	0	**1,310**
August 1-2	3	820	0	13	0	0	124	106	95	0	0	0	0	**1,158**
August 12-13	4	833	0	28	0	0	0	509	457	11	0	0	0	**1,838**
September 4-6	5	1,135	0	22	0	0	189	407	591	1	0	0	0	**2,345**
September 25-27	6	825	0	19	0	0	229	214	1044	12	0	0	0	**2,343**
October 21-22	7	275	0	1	0	0	0	64	757	40	0	0	0	**1,137**
October 24	8	372	0	0	0	0	0	1	0	0	0	0	0	**373**
November 26-27	9	11	0	2	0	0	0	73	161	0	0	0	0	**247**
Total		**5,126**	**0**	**197**	**0**	**0**	**584**	**1,692**	**3,345**	**164**	**3**	**2**	**0**	**11,113**

2003 Sampling Events	Event Number	Steelhead	Coho Salmon	Starry flounder	Prickly sculpin	Riffle sculpin	Coastrange sculpin	Pacific staghorn sculpin	Three-spine stickleback	Gualala roach	Pacific herring	Surf smelt	Lamprey	Total
February 18-19	10	84	0	9	0	0	89	1	34	0	0	0	1	**218**
May 19-20	11	233	1	1	0	3	92	41	164	0	0	0	0	**535**
June 17-18	12	342	0	3	1	1	5	145	905	68	1	0	0	**1,471**
July 22-23	13	620	0	1	18	0	0	69	200	180	0	0	0	**1,088**
August 22-23	14	520	0	16	14	0	439	5	10,152	5	0	0	0	**11,151**
September 23-24	15	940	0	9	4	0	170	1	14,969	134	0	0	0	**16,227**
October 27-28	16	1108	0	2	305	1	104	0	8,485	93	0	0	0	**10,098**
October 30	17	621	0	6	40	0	286	0	6,425	1	0	0	0	**7,379**
Total		**4,468**	**1**	**47**	**382**	**5**	**1,185**	**262**	**41,334**	**481**	**1**	**0**	**1**	**48,167**

Figure 3.3 Species composition within the Gualala estuary during the 2002 and 2003 sampling seasons.





Because of the large number of steelhead captured in 2002, the primary focus of the sampling effort was rapid processing of steelhead to prevent mortality, with less emphasis on non-salmonid species. Steelhead was the most likely species to suffer stress related mortality during thermal highs, which occurred in July and August. To prevent steelhead mortality, only visual estimates of stickleback abundance were made, especially YOY. Substantial blooms of filamentous algae severely hindered sampling in the upper section from July through the end of summer. As a result, sampling frequency in the upper estuary in 2002 was reduced.

2003 Sampling Results

A total of eleven fish species were collected during the 2003 surveys. The majority of the catch (95 percent) consisted of threespine stickleback and steelhead. However, in contrast to 2002, threespine stickleback dominated the catch at 86%, with steelhead comprising only 9% of the catch (see Figure 3.3). The remaining five percent consisted primarily of coastrange sculpin and Gualala roach, with lower numbers of prickly sculpin and Pacific staghorn sculpin. Additionally, a few Pacific lamprey ammocoete, starry flounder, riffle sculpin, Pacific herring, and one juvenile coho salmon were captured in 2003. A single juvenile Coho salmon (102 mm in length) was collected in the lower estuary during the May sampling event. No other Coho salmon were collected during the study. Anecdotal information obtained from CDFG snorkel surveys and local residents indicated the possible presence of juvenile Coho salmon in the upper watershed. It is therefore likely that this individual was an outmigrant. Table 3.4 provides a numerical breakdown of all species captured in 2003 by month and section (upper, middle, and lower). Overall, conditions in the estuary in 2003 appeared to favor freshwater species.

In 2003, steelhead were generally not as abundant in most hauls, especially from May through July. Therefore, hauls could be processed quickly. Consequently, there was additional time available to process the large number of threespine stickleback in the

Table 3.3 Fish species, and numbers of individuals captured in the Gualala estuary in 2002 by sampling month and estuary section.

2002 Sampling Events	Estuary Section	Species									
		Steelhead	Coho Salmon	Starry flounder	Coastrange sculpin	Pacific staghorn sculpin	Threespine stickleback	Gualala roach	Pacific herring	Surf smelt	Total Number
June	Lower Estuary	81	0	13	21	23	4		3	2	147
	Middle Estuary	54	0		6		11	73			144
	Upper Estuary	24	0		12		26	9			71
	Total	**159**	**0**	**13**	**39**	**23**	**41**	**82**	**3**	**2**	**362**
July	Lower Estuary	104	0	57		233	55				449
	Middle Estuary	426	0	42		62	102	18			650
	Upper Estuary	166	0		3		42				211
	Total	**696**	**0**	**99**	**3**	**295**	**199**	**18**			**1,310**
August	Lower Estuary	1,486	0	39	10	191	335	9			2,070
	Middle Estuary	67	0	1	80	358	135	1			642
	Upper Estuary	100	0	1	34	66	82	1			284
	Total	**1,653**	**0**	**41**	**124**	**615**	**552**	**11**			**2,996**
September	Lower Estuary	1,813	0	41	392	439	1,001	1			3,687
	Middle Estuary	140	0		26	175	632	12			985
	Upper Estuary	7	0			7	2				16
	Total	**1,960**	**0**	**41**	**418**	**621**	**1,635**	**13**			**4,688**
October & November	Lower Estuary	487	0	1		15	620	40			1,163
	Middle Estuary	161	0	1		57	78				297
	Upper Estuary	10	0	1		66	220				297
	Total	658	0	3		138	918	40			1,757
	Overall Total	**5,126**	**0**	**197**	**584**	**1,692**	**3,345**	**164**	**3**	**2**	**11,113**

Table 3.4 Fish species, and numbers of individuals captured in the Gualala estuary in 2003 by sampling month and estuary section.

2003 Sampling Events	Estuary Section	Species											Total Number
		Steelhead trout	Coho Salmon	Starry flounder	Prickly sculpin	Riffle sculpin	Coastrange sculpin	Pacific staghorn sculpin	Threespine stickleback	Gualala roach	Pacific herring	Lamprey	
February	Lower Estuary	45		7			16	1	32			1	102
	Middle Estuary	30		2			65		1				98
	Upper Estuary	9					8		1				18
	Total	**84**		**9**			**89**	**1**	**34**			**1**	**218**
May	Lower Estuary	229	1	1		3	69	41	158				502
	Middle Estuary	3					23		6				32
	Upper Estuary	1											1
	Total	**233**	**1**	**1**		**3**	**92**	**41**	**164**				**535**
June	Lower Estuary	210		3				72	876		1		1,162
	Middle Estuary	23						3	3	23			52
	Upper Estuary	109			1	1	5	70	26	45			257
	Total	**342**		**3**	**1**	**1**	**5**	**145**	**905**	**68**	**1**		**1,471**
July	Lower Estuary	202		1				64	18				285
	Middle Estuary	317			12			5	82				416
	Upper Estuary	101			6				100	180			387
	Total	**620**		**1**	**18**			**69**	**200**	**180**			**1,088**
August	Lower Estuary	182		16	1		418	5	9,535	2			10,159
	Middle Estuary	72					5		9				86
	Upper Estuary	266			13		16		608	3			906
	Total	**520**		**16**	**14**		**439**	**5**	**10,152**	**5**			**11,151**
September	Lower Estuary	387		8	2		130	1	8,353	24			8,905
	Middle Estuary	52		1			16		2,909				2,978
	Upper Estuary	501			2		24		3,707	110			4,344
	Total	**940**		**9**	**4**		**170**	**1**	**14,969**	**134**			**16,227**
October	Lower Estuary	1,076		2	2	1	344		8,060	1			9,486
	Middle Estuary	496		4			26		1,000	1			1,527
	Upper Estuary	157		2	343		20		5,850	92			6,464
	Total	1,729		8	345	1	390		14,910	94			17,477
	Overall Total	**4,468**	**1**	**47**	**382**	**5**	**1,185**	**262**	**41,334**	**481**	**1**		**48,167**

associated filamentous algae that was abundant in the catch. In addition, more hauls were completed in the upper section in 2003, than in 2002, which also increased the threespine stickleback catch over that from 2002.

Non-Salmonid Fish Species, 2002-2003 Overall Results

The following section presents a brief analysis of selected fish population data of the more abundant species collected in the estuary in 2002 and 2003.

Threespine stickleback (*Gasterosteus aculeatus*)

Threespine stickleback were abundant throughout the estuary, especially in areas with submerged vegetation and filamentous algae. This species was substantially more abundant in the catch in 2003 than in 2002, likely a result of increased sampling in riverine habitat in 2003 (see Tables 3.3 and 3.4). However, during both years, stickleback occurred in the greatest numbers in the lower estuary. In general, stickleback abundance was greatest from August through October. Length-frequency analyses show that adults and juveniles were found together throughout the estuary during this time period in both 2002 and 2003 (Appendix C-1).

In both 2002 and 2003, young-of-the-year (YOY) stickleback began appearing in the catch as early as July, with continued breeding through October. YOY stickleback were also present in the catch during the February 2003 sampling effort in the lower estuary, indicating a possible bi-modal breeding pattern in the estuary.

Pacific staghorn sculpin (*Leptocottus armatus*)

Pacific staghorn sculpin were substantially more abundant in the estuary in 2002 than in 2003 (see Tables 3.3 and 3.4). Length-frequency analyses for both sampling years indicate that all Pacific staghorn sculpin captured were juveniles, with the majority

ranging in size from about 25 to 65 mm (fork length) (Appendix C-2). This species was captured throughout the estuary during most sampling events, but were most abundant in the lower and middle estuary. Young-of-the-year Pacific staghorn sculpin began to appear in the catch in June of both years. In 2003, sampling conducted after estuary closure (July through October) yielded increasingly lower numbers of fish.

Starry flounder (*Platichthys stellatus*)

As with Pacific staghorn sculpin, starry flounder were substantially more abundant in the estuary in 2002 than in 2003 (see Tables 3.3 and 3.4). Starry flounder were captured during most sampling events in both years, with the greatest numbers occurring in the lower and middle estuary. The greatest numbers of flounder were collected in July 2002, with lower numbers of individuals captured through the remainder of the season. In 2003, starry flounder comprised a small percentage of the catch, with the highest numbers occurring in the August hauls. Length-frequency analyses for sampling years indicate that the majority of the fish captured were juveniles (generally less than 160 mm in length) (Appendix C-3). Small numbers of young-of-the-year flounder began to appear in the catch during the June sampling event in both years.

Coastrange sculpin *(Cottus aleuticus)*

Coastrange sculpin were more abundant in the estuary in 2003 than in 2002 (see Tables 3.3 and 3.4). This species was captured throughout the estuary in both years and during most sampling events, but were most abundant in the lower and middle estuary. Length-frequency analyses for the two sampling years indicate that the majority of the fish captured were juveniles (Appendix C-4). The highest numbers of coast range sculpin were captured during the August and September sampling events in 2002, and during the August through October sampling events in 2003.

Gualala roach *(Lavinia symmetricus parvipinnis)*

Gualala roach is a subspecies of the California roach and is found primarily in the Gualala River system. Gualala roach were more abundant in the catch in 2003 than in 2002 (see Tables 3.3 and 3.4), at least partially due to increased sampling effort in riverine habitat. This species was captured during most sampling events throughout the estuary; however, the highest numbers consistently occurred in the middle and upper estuary, especially in areas with aquatic and riparian vegetation. Gualala roach were conspicuously absent from the catch during the February and May, 2003 sampling events. Young-of-the-year roach first appeared during the July sampling event in 2003, but were not present during 2002 sampling events. Length-frequency analysis indicates that multiple year classes were present in the estuary (Appendix C-5).

3.3.2.2 Steelhead Population Estimates

Distribution and Abundance

The total number of steelhead captured during each year was relatively similar; 5,126 fish in 2002, and 4,468 fish in 2003 (Table 3.5). Steelhead comprised 46.1% of the catch in 2002, and only 9.3% of the catch in 2003 (see Figure 3.3). The low percentage of steelhead to total catch in 2003 was due to the extremely large numbers of stickleback collected in that year. Steelhead were captured within all three-estuary sections throughout both sampling years. During most sampling events in both years, the majority of steelhead were collected in the lower and middle estuary sections (see Tables 3.3 and 3.4).

Annual differences in steelhead catch reflect annual (and seasonal) variation in several biological and physical factors. Other than biological variation (e.g., numbers of adult spawners, spawner-recruitment functions, age class specific mortality), the amount and quality of physical habitat directly affects the number of steelhead that are available to

Table 3.5 Steelhead number, length range, and percent by age class for each sampling event in the Gualala estuary from June through November 2002, and from February through October 2003.

2002 Sampling Events	Date(s)	Age 0+ Length Range (mm)	Age 0+ Number Caught	Age 0+ Percent Caught	Age 1+ and Older Length Range (mm)	Age 1+ and Older Number Caught	Age 1+ and Older Percent Caught	Total No.
1	June 19-20	29 - 79	118	74.2	81 - 182	41	25.8	159
2	July 10-12	41 - 84	475	68.2	85 - 188	221	31.8	696
3	August 1-2	37 - 84	145	17.7	85 - 206	675	82.3	820
4	August 12-13	49 - 89	191	22.9	90 - 194	642	77.1	833
5	September 4-6	51 - 89	150	13.2	90 - 198	985	86.8	1,135
6	September 26-27	71 - 99	76	9.2	100 - 234	749	90.8	825
7	October 21-22	77 - 104	33	12.0	107 - 214	242	88.0	275
8	October 24	77 - 104	54	14.5	105 - 208	318	85.5	372
9	November 26	0 - 104	0	0.0	139 - 212	11	100.0	11
	Total		**1,242**			**3,884**		**5,126**

2003 Sampling Events	Date(s)	Age 0+ Length Range (mm)	Age 0+ Number Caught	Age 0+ Percent Caught	Age 1+ and Older Length Range (mm)	Age 1+ and Older Number Caught	Age 1+ and Older Percent Caught	Total No.
10	February 18-19	51 - 104	33	39.3	107 - 230	51	60.7	84
11	May 19-20	32 - 79	62	26.6	80 - 137	171	73.4	233
12	June 17-18	26 - 84	272	79.5	85 - 138	70	20.5	342
13	July 22-23	51 - 84	142	22.9	85 - 161	478	77.1	620
14	August 21-23	67 - 89	60	11.5	90 - 198	460	88.5	520
15	September 23-24	73 - 99	201	21.4	100 - 203	739	78.6	940
16	October 27-28	82 - 104	44	4.0	105 - 221	1,064	96.0	1,108
17	October 30	86 - 104	27	4.3	105 - 238	594	95.7	621
	Total		**841**			**3,627**		**4,468**

rear in the estuary. The condition of the estuary (i.e., open vs. closed) during the late spring/early summer outmigration period can have a major impact on the estuarine population. If given the opportunity (i.e., open estuary conditions), smolt steelhead will voluntarily outmigrate from the estuary to the ocean. This is in contrast to large breach events, as occurred in 2003, when the estuary at bankfull level breached, causing a drop in surface water elevation of close to 10 feet. A breach of this magnitude likely causes many juvenile steelhead, as well as other fish species and aquatic organisms, which may not be fully ready to enter seawater to be flushed from their refugia.

Age and Growth

Length-frequency histograms bimodal peaks indicate the presence of age 0+ and age 1+ and older steelhead age classes in 2002. The 2003 data do not have a distinctive bimodal trend; however, the length ranges indicate that multiple year classes of steelhead were also collected throughout 2003. Length-frequency histograms are provided separately by month and year for each of the three estuary sections (Appendix C-6). With the exception of June and July 2002, and June 2003, age 1+ and older fish dominated the catch (see Table 3.5). The data also indicate that the majority of steelhead captured in the lower and middle estuary were age 1+ and older, while age 0+ fish were collected in similar numbers in all three-estuary sections, though in greater abundance in the upper estuary during spring (Table 3.6). Young-of-the-year (YOY) steelhead first appeared in the catch during the June sampling event in 2002, and during the May sampling effort in 2003. Growth of juvenile steelhead in the estuary is illustrated by the monthly length-frequency histographs for each sampling year.

Table 3.6. Distribution of age 0+ and age 1+ and older steelhead by estuary section for 2002 and 2003.

Estuary Section	Year		Number of Steelhead		Total No.
			Age 0+	Age 1+ and older	
Lower Estuary	2002		387	3584	3971
	2003		303	2028	2331
		Total	**690**	**5612**	**6302**
Middle Estuary	2002		570	278	848
	2003		161	832	993
		Total	**731**	**1110**	**1841**
Upper Estuary	2002		285	22	307
	2003		377	767	1144
		Total	**662**	**789**	**1451**

General Condition of Steelhead in the Gualala Estuary

Steelhead condition factor was determined for all fish collected during each sampling event in 2002 (Table 3.7) and 2003 (Table 3.8). The condition factor of each fish was calculated using the following formula:

$$\textit{Condition Factor} = \frac{\textit{Length}^3}{\textit{Weight} \times 100{,}000}$$

where length is measured in mm, weight is measured in grams, 100,000 is a unit conversion factor, and condition factor is dimensionless. In general, the closer the ratio is to 1.0, the healthier the fish. The mean condition factor for all fish collected in both 2002 and 2003, regardless of capture location or age class, was about 1.1. However, the range of condition factor values was generally greater during each sampling event in 2002, than in 2003. This may suggest slightly more stressful conditions during transient periods in 2002 (i.e., short periods of warm water temperature), than were observed in 2003.

Table 3.7 Steelhead mean condition factor by month and estuary section for age 1+ and older fish captured in 2002.

2002 Sampling Events	Estuary Section	Mean Condition Factor	Number Caught	Condition Factor Range Minimum	Condition Factor Range Maximum
June, 2002	Lower Estuary	1.1	38	0.9	1.4
	Middle Estuary	1.1	3	1.1	1.2
	Upper Estuary	a	0	–	–
July, 2002	Lower Estuary	1.2	98	0.7	1.5
	Middle Estuary	1.1	122	0.6	1.7
	Upper Estuary	1.4	1	1.4	1.4
August, 2002	Lower Estuary	1.1	1306	0.7	1.9
	Middle Estuary	1.0	3	0.9	1.1
	Upper Estuary	1.1	8	0.7	1.2
September, 2002	Lower Estuary	1.1	1672	0.6	2.2
	Middle Estuary	1.2	56	0.9	1.5
	Upper Estuary	1.2	6	1.0	1.3
October, 2002	Lower Estuary	1.1	468	0.9	1.3
	Middle Estuary	1.2	85	1.1	1.8
	Upper Estuary	1.2	7	1.1	1.3
November, 2002	Lower Estuary	1.0	2	1.0	1.1
	Middle Estuary	1.1	9	0.9	1.3
	Upper Estuary	a	0	–	–

[a] = No age 1+ or older fish were collected from this estuary section during this sampling event

Table 3.8 Steelhead mean condition factor by sampling event and estuary section for age 1+ and older fish captured in 2003.

2003 Sampling Events	Estuary Section	Mean Condition Factor	Number Caught	Condition Factor Range Minimum	Condition Factor Range Maximum
February, 2003	Lower Estuary	1.0	44	0.9	1.1
	Middle Estuary	1.0	5	0.9	1.1
	Upper Estuary	1.0	2	1.0	1.0
May, 2003	Lower Estuary	1.1	168	0.8	1.3
	Middle Estuary	0.8	2	0.7	0.9
	Upper Estuary	1.1	1	1.1	1.1
June, 2003	Lower Estuary	1.1	67	0.9	1.5
	Middle Estuary	a	0	–	–
	Upper Estuary	1.0	3	1	1.1
July, 2003	Lower Estuary	1.1	166	0.8	1.2
	Middle Estuary	1.1	260	0.7	1.5
	Upper Estuary	1.1	52	1.0	1.3
August, 2003	Lower Estuary	1.1	178	0.9	1.3
	Middle Estuary	1.1	57	0.7	1.3
	Upper Estuary	1.0	225	0.7	1.4
September, 2003	Lower Estuary	1.0	353	0.8	1.4
	Middle Estuary	1.1	47	1.0	1.3
	Upper Estuary	1.1	339	0.7	1.4
October, 2003	Lower Estuary	1.1	1052	0.5	1.5
	Middle Estuary	1.1	461	0.8	1.4
	Upper Estuary	1.0	145	1.0	1.3

[a] = No age 1+ or older fish were collected from this estuary section during this sampling event

Population Estimates

Two different population estimators, Peterson-Schnabel and Jolly-Seber, were used to estimate the steelhead population in the Gualala estuary in 2002 and 2003. The Peterson-Schnabel method assumes that the estuary is closed during the sampling period, while the Jolly-Seber method assumes an open system during the sampling period and includes all marked fish that are re-captured on subsequent sampling events. Population estimates for each method were calculated following the last sampling event of the year.

The Petersen-Schnabel method uses fish re-capture data in conjunction with the overall sampling results to estimate population size. All steelhead 80 mm or larger (age 1+ and older) were marked with a freeze brand or fin clipped each sampling event to allow for identification of re-captured fish in subsequent sampling efforts. A summary of the number of age 1+ steelhead captured and marked, and the numbers of fish re-captured during each sampling event is provided in Table 3.9.

The estuary remained closed throughout the 2002 sampling period; however, in 2003 the estuary was open during the first three sampling events. Consequently, the February, May, and June sampling data were not included in the 2003 population estimate. The resulting Petersen-Schnabel overall population estimates for steelhead in the Gualala estuary during 2002 and 2003 are provided in Appendix C. Petersen-Schnabel population estimates for age 1+ and older steelhead generally ranged from 9,704 to 11,731 in 2002, and from 39,652 to 42,702 in 2003 (Table 3.10).

Differences between 2002 and 2003 in the apparent annual steelhead population estimates are most likely due to the violation of the assumption of a closed estuarine system in 2003. Although large numbers of juveniles were collected during the sample events in spring 2003, very few were subsequent recaptured, likely due to their emigration from the estuary (open estuary conditions were present through July). This

Table 3.9 Summary of age 1+ steelhead collected, branded, and recaptured per sampling event within the Gualala estuary from June through November 2002, and from February through October 2003.

				Recaptured from Sampling Event								
2002 Sampling Events	**Event Number**	**No. of Age 1+ and Older Steelhead Collected**	**No. of Age 1+ and Older Steelhead Given a Traceable Mark**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
June 19-20	1	41	41	–								
July 10-12	2	221	213	8	0							
August 1-2	3	675	664	3	4	4						
August 12-13	4	642	554	10	18	54	6					
September 4-6	5	985	803	5	24	65	76	8				
September 25-27	6	749	543	0	11	43	58	80	13			
October 21-22	7	242	169	2	5	14	19	16	16	1		
October 24	8	318	0	0	2	7	29	30	24	34	0	
November 26-27	9	11	0	0	0	1	0	0	0	0	0	0
Total		**3,884**	**2,987**	**28**	**64**	**188**	**188**	**134**	**53**	**35**	**0**	**0**

				Recaptured from Sampling Event							
2003 Sampling Events	**Event Number**	**No. of Age 1+ and Older Steelhead Collected**	**No. of Age 1+ and Older Steelhead Given a Traceable Mark**	**10[a]**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
February 18-19	10	51	46	4[b]							
May 19-20	11	171	171	0	0						
June 17-18	12	70	70	0	0	0					
July 22-23	13	478	476	0	0	0	2[b]				
August 21-23	14	460	457	0	0	0	1	0			
September 23-24	15	739	727	0	0	0	0	7	2[b]		
October 27-28	16	1,064	994	0	5	7	2	2	40	11[b]	
October 30	17	594	0	0	4	1	0	0	9	28	na
Total		**3,627**	**2,941**	**4**	**9**	**8**	**5**	**9**	**51**	**39**	**na**

[a] sample event 10 recaptures were minimal due to estuary breach event (i.e., breach occurred after week 10)

[b] recaptured from same sampling event

na - not applicable (no traceable marks given during sampling event 17)

Table 3.10 Age 1+ and older steelhead population estimates for the Gualala estuary for 2002 and 2003, using the Petersen-Schnabel Method.

2002 Sampling Events	Sampling Event	Captured	M_t (Marked fish at large)	R	C_tM_t	M_tR_t	$C_tM^2_t$	$R^2_tC_t$	N	s^2	s	95% CI
June 19-20	1	159.0										
July 10-11	2	696.0	41.0	8.0	2.9E+04	3.3E+02	1.2E+06	4.5E+04	**3170.7**	44543.9	211.1	**2.4**
August 1-2	3	820.0	280.0	7.0	2.3E+05	2.0E+03	6.4E+07	4.0E+04	**28700.0**	20090.0	141.7	**69.3**
August 12-13	4	833.0	965.0	82.0	8.0E+05	7.9E+04	7.8E+08	5.6E+06	**9684.9**	1867028.0	1366.4	**3.0**
September 4-6	5	1135.0	1607.0	170.0	1.8E+06	2.7E+05	2.9E+09	3.3E+07	**10666.3**	8200368.6	2863.6	**1.7**
September 25-27	6	825.0	2510.0	192.0	2.1E+06	4.8E+05	5.2E+09	3.0E+07	**10729.3**	6082551.1	2466.3	**2.2**
October 21-22	7	275.0	3114.0	72.0	8.6E+05	2.2E+05	2.7E+09	1.4E+06	**11730.8**	237596.9	487.4	**12.4**
October 24	8	372.0	3313.0	126.0	1.2E+06	4.2E+05	4.1E+09	5.9E+06	**9704.2**	843689.9	918.5	**5.6**
November 26-27	9	11.0	3313.0	1.0	3.6E+04	3.3E+03	1.2E+08	1.1E+01	**18221.5**	1.4	1.2	**8234.3**

2003 Sampling Events	Sampling Event	Captured	M_t (Marked fish at large)	R	C_tM_t	M_tR_t	$C_tM^2_t$	$R^2_tC_t$	N	s^2	s	95% CI
July 22-23	13	478.0										
August 21-23	14	460.0	478.0	1.0	2.2E+05	4.8E+02	1.1E+08	4.6E+02	**109940.0**	460.0	21.4	**811.8**
September 23-24	15	739.0	938.0	7.0	6.9E+05	6.6E+03	6.5E+08	3.6E+04	**86647.8**	36210.9	190.3	**72.1**
October 27-28	16	1064.0	1677.0	44.0	1.8E+06	7.4E+04	3.0E+09	2.1E+06	**39651.7**	2059902.2	1435.2	**4.4**
October 30	17	592.0	2741.0	37.0	1.6E+06	1.0E+05	4.4E+09	8.1E+05	**42701.9**	810445.7	900.2	**7.5**

M_t = total # fish marked @ large

C_t= total sample taken day t

R_t = recaptures for day t

N = Pop Est.

s = standard deviation

s^2 = sample variance

results in a biased, elevated population estimate. In addition, there are several factors affecting estuarine population estimates that we cannot address because of the lack of available data, including the annual adult escapement, size of the annual spawning population, annual spawning success, success of hatch, age class specific survival, other watershed-wide movement patterns, and other population dynamics. These "upper watershed" factors were not the focus or objective of the current study.

All sampling data collected in 2002 and 2003 were used in calculating the Jolly-Seber annual population estimates. The Jolly-Seber overall population estimate of steelhead in the Gualala estuary is provided in Appendix C. Population estimates for age 1+ and older steelhead ranged from 2,389 to 9,496 in 2002, and from 9,994 to 28,814 in 2003 (Table 3.11). Reasons for the differences in Jolly-Seber population estimates are similar to those given above for the Petersen-Schnabel estimator, although a closed system is not an assumption for the Jolly-Seber estimator. For this reason, it is likely that the true population estimates are more likely reflected in the ranges given by the Jolly-Seber estimates.

Carrying Capacity

It is uncertain whether the estuary is at its full carrying capacity with regards to rearing. Bathymetry appears unchanged since the early part of the twentieth century, and so it is doubtful that estuarine conditions have worsened substantially since that point in time. However, in relation to the overall population of salmonids in the Gualala river system, it is clear that the estuary is not the limiting factor to production. It is more likely that degraded habitat conditions upstream are limiting production of steelhead, and thus the numbers of young steelhead that are available to utilize the estuary. This is at least partially supported by the relatively high proportion of young of the year (YOY) steelhead present in the estuary. Normally, the majority of YOY (other than the initial downstream dispersal of fry) will remain in their natal tributaries, at least until fall freshets, which tend to initiate outmigration. In the absence of high quality rearing

Table 3.11 Age 1+ and older steelhead population estimates for the Gualala estuary for 2002 and 2003, using the Jolly-Seber Method.

2002 Sampling Events	**Sampling Event (t)**	**Captured**	**m_t**	**u_t**	**n_t**	**s_t**	**R_t**	**Z_t**	**α**	**Mt**	**Nt**	**ϕ_t**	**λ_t**
June 19-20	1	41	0	41	41	41	28	na	0.02	0.0	**na**	1.9	na
July 10-11	2	221	8	213	221	221	64	20	0.04	76	**1,882.3**	1.0	12.987869
August 1-2	3	675	7	668	675	675	184	77	0.01	288	**24,366.6**	0.7	0.3040607
August 12-13	4	642	82	560	642	642	182	179	0.13	711	**5,507.7**	1.3	1.3305726
September 4-6	5	985	170	815	985	981	126	191	0.17	1647	**9,496.0**	1.0	1.0062504
September 25-27	6	749	192	557	749	748	40	125	0.26	2476	**9,620.0**	0.2	1.0491029
October 21-22	7	242	72	170	242	242	34	93	0.30	718	**2,389.0**	0.5	0.9333155
October 24	8	318	126	192	318	318	0	1	0.40	445	**1,117.8**	na	na
November 26-27	9	11	1	10	11	11	na	na	na	na	**na**	na	na

2003 Sampling Events	**Sampling Event (t)**	**Captured**	**m_t**	**u_t**	**n_t**	**s_t**	**R_t**	**Z_t**	**α**	**Mt**	**Nt**	**ϕ_t**	**λ_t**
July 22-23	13	478	0	478	478	476	3	17	0.002	2,027	**971,052.8**	0.35	0.59
August 22-23	14	460	1	459	460	455	9	19	0.004	867	**199,935.7**	0.24	0.61
September 23-24	15	739	7	732	739	724	49	21	0.011	312	**28,813.8**	0.52	0.67
October 27-28	16	1,064	56	1,008	1,064	991	28	14	0.054	535	**9,994.1**	na	na
October 30	17	594	42	552	594	0	*na*	*na*	*na*	*na*	**na**	na	na

m_t = # of marked fish caught in sample t

u_t = # of unmarked fish caught in sample t

n_t = total # of fish caught in sample t ($n_t = m_t + u_t$)

s_t = # of fish released after sample t (n_t - # of accidental deaths)

R_t = # of s_t fish released at sample t and caught again in some later sample (refer to "Method Table B" below for calculation)

Z_t = # of fish marked before sample t, not caught in sample t, but caught in some sample after t (refer to "Method Table B" below for calculation)

conditions within those natal tributaries, the remaining rearing habitat is limited primarily to the estuary. The fact that the Gualala estuary is typically a closed, freshwater system - unlike many other north coast estuaries, including the Noyo, Little, Navarro, and Garcia Rivers - makes the Gualala estuary a suitable place for YOY to rear. Survival of outmigrants is a function of their size at outmigration. Survival of age 1+ and older outmigrant steelhead (to adult stage) is much greater than that for YOY outmigrants, except when YOY have had a chance to rear in the highly productive conditions present in the Gualala estuary.

3.3.2.3 Steelhead Abundance By Age Class

For analytical purposes, steelhead catch data was separated according to age class: YOY versus age 1+ and older fish. The following section discusses the results of fish sampling efforts by year and age class during the spring (May-June), summer (July-August), and fall (September-October). Total number of steelhead captured and mean number of steelhead captured per haul, are provided relative to distribution (by river mile) within the estuary. Due to differences in water year type and associated water quality parameters within the estuary in 2002 and 2003 (closed versus open estuary, respectively), sampling results are also discussed in relation to changes in seasonal habitat conditions. The two years of sampling occurred in two very different water year types, with the estuary being closed prior to sampling in 2002, and remaining open in 2003 through mid-July.

Total Number of Steelhead Captured by Year

Age 0+ steelhead

During the spring 2002 sampling events, YOY steelhead were captured in relatively low numbers throughout the estuary (see Figure 3.4). In 2003 (open estuary), YOY were also distributed throughout the estuary; however, the highest numbers of YOY steelhead were captured in the lower portion of the middle estuary (see Figure 3.4).The increased

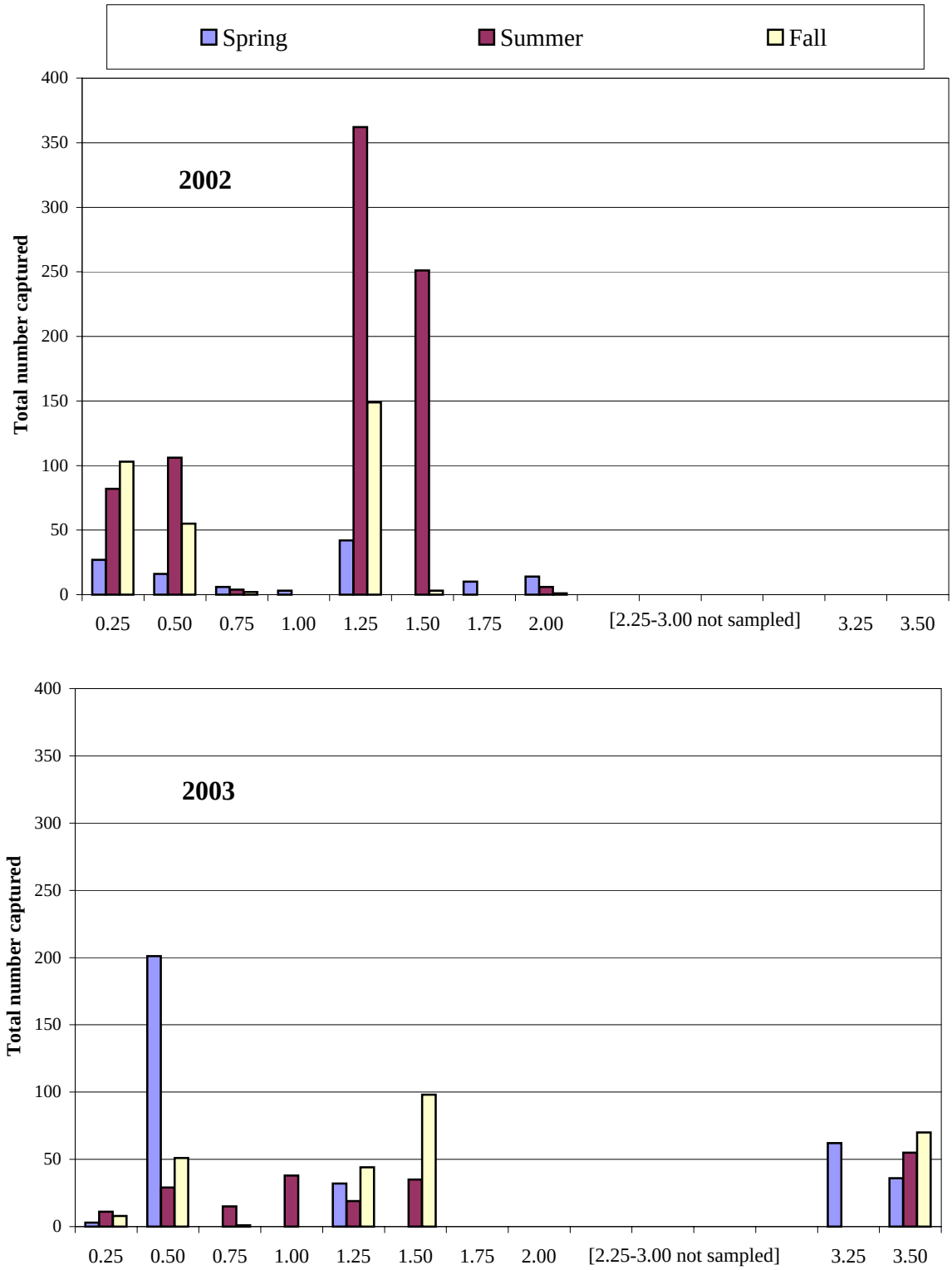


Figure 3.4 Total number of YOY steelhead captured by season from all hauls within each distance category, Gualala estuary.

number of steelhead in the lower part of the estuary is likely associated with the higher outflows in spring 2003, which tended to push fish lower in the estuary.

In the summer of 2002, the highest number of YOY were captured in the upper estuary, with smaller numbers occurring in the lower to middle estuary. The high numbers of YOY in the upper estuary was likely due to the seasonal reduction of rearing habitat in smaller tributary streams. In contrast, YOY steelhead that were concentrated in the lower middle estuary in the spring of 2003, had dispersed and by the summer sampling were distributed in similar abundance throughout the estuary. The dispersal was likely a result of the estuary closing in early July, which created similar water quality and associated habitat conditions throughout the entire estuary.

During the fall sampling events for both 2002 and 2003, YOY steelhead were captured throughout the estuary, again with the highest numbers occurring in the upper estuary. Riverine conditions in the upper estuary favor the presence of YOY pre-smolt steelhead relative to the more saline conditions present in the lower estuary. YOY steelhead in the upper estuary were observed to be brightly colored, retaining parr marks and native rainbow trout coloration typical of resident (stream dwelling) rainbow trout. In contrast, most fish collected from the lower estuary were in the process of smoltification, and were generally bright silver in color. Smoltification is the physiological process by which juvenile anadromous salmonids (including steelhead and coho salmon) prepare to enter the salt-water environment after spending their early life history in freshwater. Factors that may affect the onset of smoltification include changes in water chemistry, water temperature, and photoperiod (day length).

Age 1+ and older steelhead

During the spring of 2002, age 1+ and older steelhead were captured (albeit in low abundance) throughout the lower to middle estuary (see Figure 3.5). This is likely a result of the closed estuary conditions, which precluded outmigration from the estuary.

In contrast, the open estuary conditions in the spring of 2003 allowed for passage of smolt steelhead out of the estuary over an extended period of time. As a result, fish were actively migrating out of the system and were not captured in large numbers at any location. The highest numbers of fish were collected in the lower middle estuary (see Figure 3.5).

The steelhead smoltification process is driven by a number of factors, sometimes competing, including water temperature, photoperiod, streamflow, and any number of "stressor" variables (e.g., loss of habitat, exposure to adverse water quality conditions, exposure to toxic substances). In the current context, many of the steelhead that were captured in the lower and middle estuary were observed to be undergoing smoltification, as evidenced by their silvery color and deciduous scales. When the opportunity arises (breached estuary), they actively outmigrate to the ocean.

In the summer of 2002, the highest number of age 1+ and older steelhead were captured in the lower to lower-middle estuary. Few fish age 1+ and older were captured at other locations within the estuary. Steelhead were concentrated in the lower estuary where conditions were appropriate for smoltification to occur. In summer 2003, age 1+ and older steelhead, which were concentrated in the lower estuary in the spring, had become more abundant throughout the estuary. This re-distribution was likely a result of the estuary closing in early July, which created similar water quality and associated habitat conditions throughout the entire estuary.

During the fall sampling events for both 2002 and 2003, age 1+ and older steelhead were captured throughout the estuary, with the highest numbers occurring in the lower to lower-middle estuary. In 2002, few fish were captured in the upper estuary. However, in 2003, steelhead were also captured in relatively high numbers in the upper estuary, likely due to the improved water quality conditions present in 2003 relative to water quality parameters in 2002.

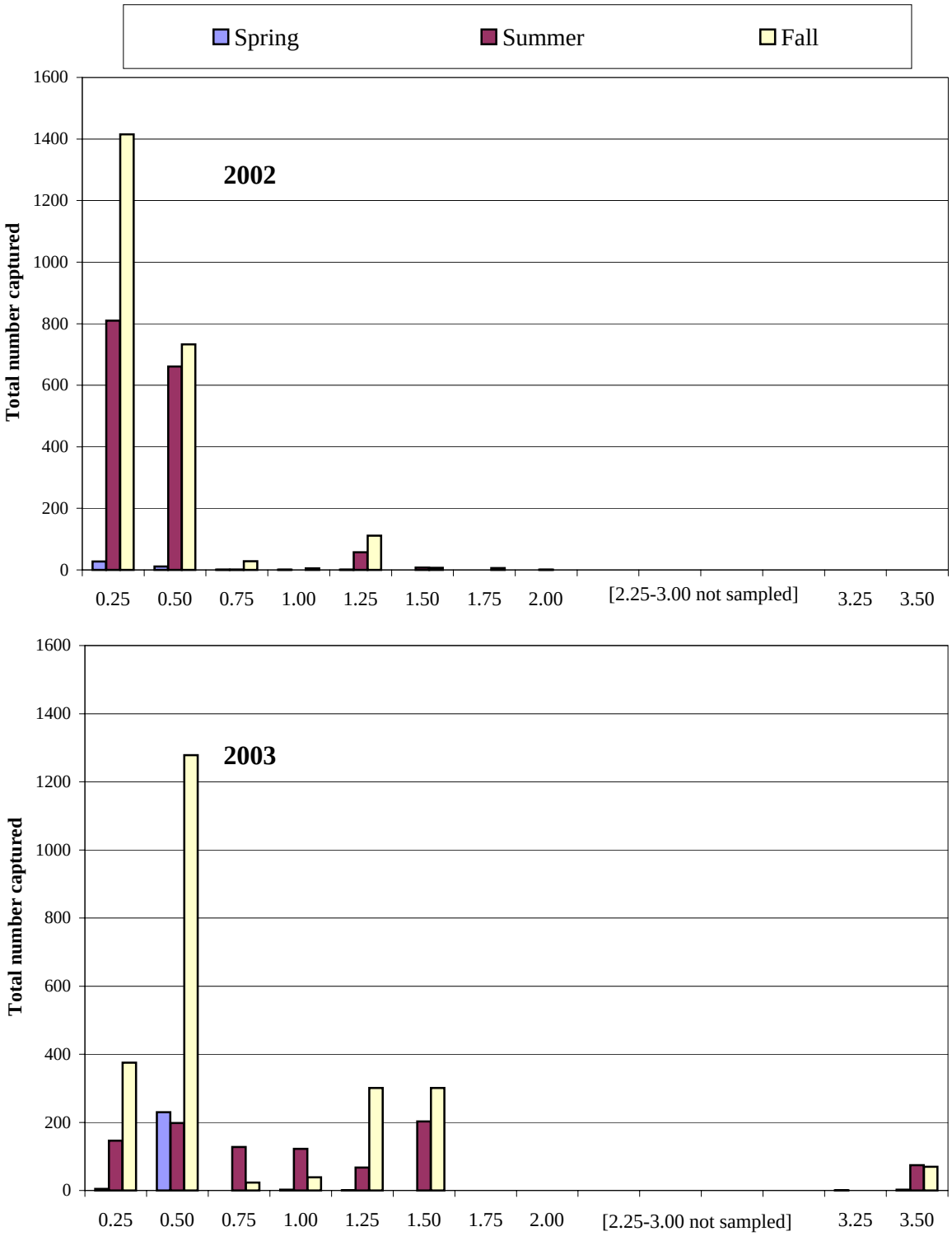


Figure 3.5 Total number of one year and older steelhead captured by season from all hauls within each distance category, Gualala estuary.

Mean Number of Steelhead Captured per Haul

Age 0+ steelhead

In 2002 during closed estuary conditions, YOY steelhead were generally concentrated in the upper estuary. The mean number of YOY steelhead captured per haul was highest in the upper estuary during all sampling periods, with the highest number of fish captured during the summer sampling events (Figure 3.6).

In 2003, the distribution of YOY steelhead varied relative to water quality conditions associated with both open and closed estuary environments. During the spring sampling period when the estuary was open, the mean number of YOY steelhead captured per haul was highest in the lower and upper sections of the estuary. At the beginning of the summer sampling period the estuary closed (early July). During this time period, YOY fish were most abundant in the middle and upper estuary; with the highest mean number of steelhead captured per haul occurring in the upper estuary. By the fall sampling period, virtually all of the YOY fish were captured in the upper estuary (Figure 3.7). During the single sampling event conducted in February, YOY steelhead were captured in both the middle and upper estuary, with the highest mean number of fish per haul occurring in the upper estuary.

Age 1+ and older steelhead

Throughout the 2002 sampling season, the mean number of age 1+ and older steelhead per haul was highest in the lower and middle estuary sections. In the spring, only a small number of fish were captured per haul. During the summer and fall sampling events, the mean number of fish captured per haul increased substantially, with the highest number occurring in the lower estuary (Figure 3.8).

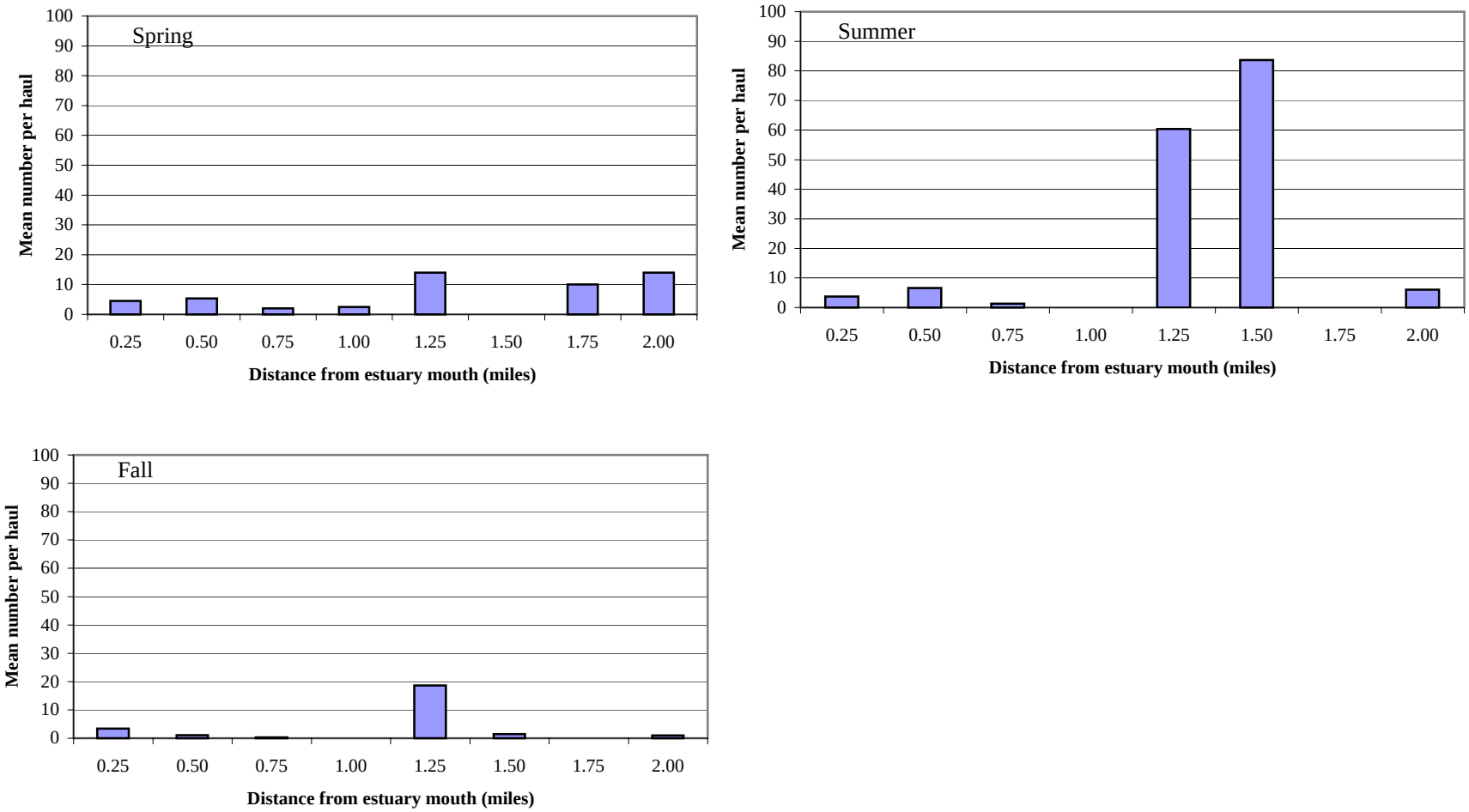


Figure 3.6 Mean number of YOY steelhead captured per haul during spring, summer, and fall 2002, Gualala estuary.

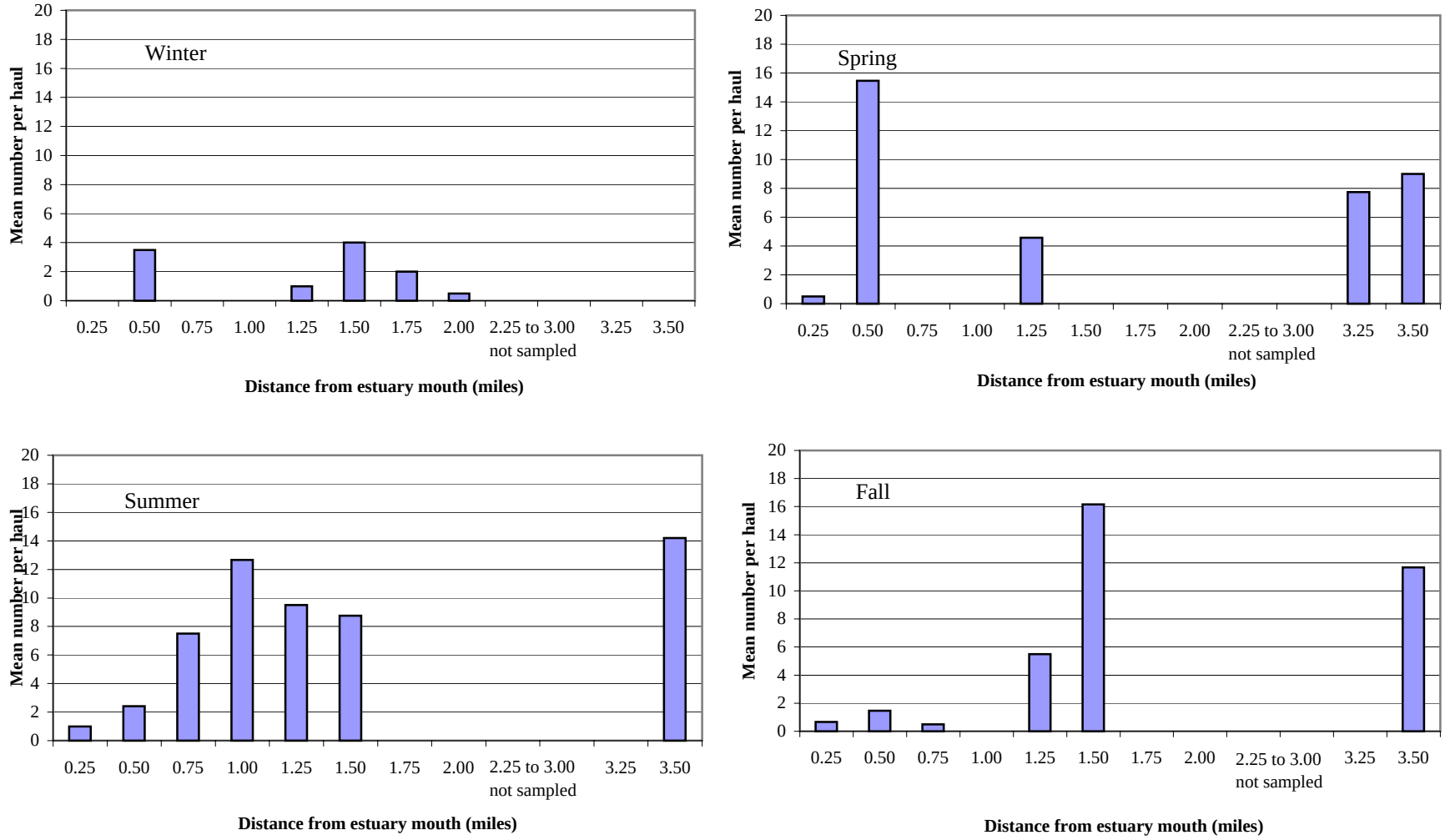


Figure 3.7 Mean number of YOY steelhead captured per haul during 2003, Gualala estuary.

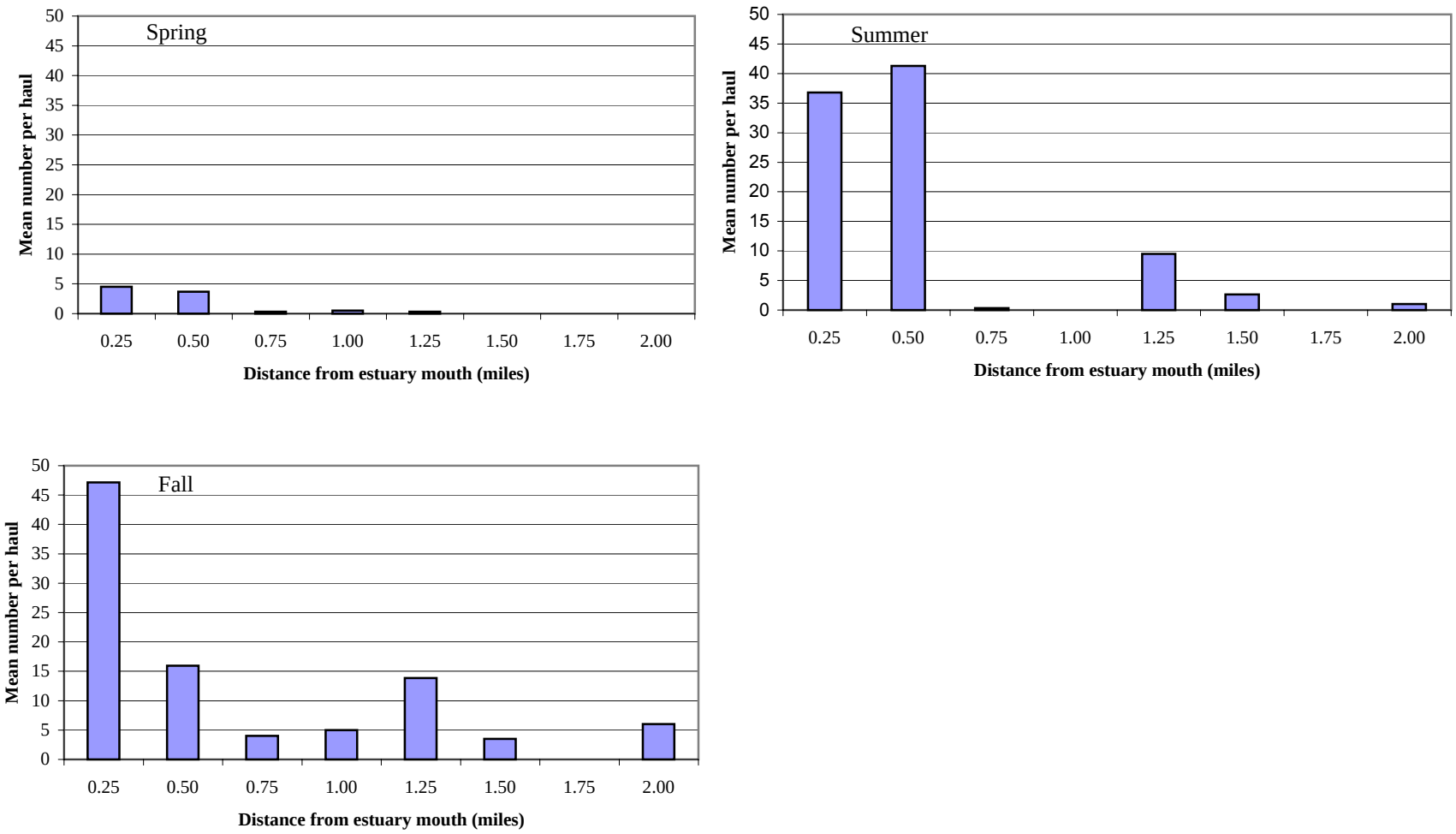


Figure 3.8 Mean number per haul of one year & older steelhead captured during 2002, Gualala estuary.

In the spring of 2003 (open estuary), the majority of the age 1+ and older steelhead were captured in the middle estuary, with the highest mean number of fish per haul occurring in the lower portion of the middle estuary. During the summer and fall, age 1+ and older steelhead were distributed throughout the estuary (Figure 3.9). During the summer sampling period (closed estuary), age 1+ and older fish were most abundant in the middle and upper estuary; with the highest mean number of steelhead captured per haul occurring in the middle estuary. By the fall sampling period, the highest mean number of age 1+ and older fish captured per haul occurred in the upper estuary, followed by slightly lower numbers in the lower and lower middle estuary. During the single sampling event conducted in February, age 1+ and older steelhead were distributed throughout much of the estuary. However, as during the spring sampling events, the highest mean number of fish captured per haul occurred in the lower portion of the middle estuary.

Low numbers of age 1+ and older fish were captured during spring sampling in both years (see Figures 3.8 and 3.9), however, the majority of this age-class was collected in the lower estuary.

Mean Length of Steelhead Captured per Haul

Age 0+ steelhead

Young-of-the-year (age 0+) steelhead were distributed throughout the estuary, during all 2002 sampling events, under closed estuary conditions. During the spring sampling period, the mean lengths of YOY captured per haul generally ranged from about 60 to 67 mm mean length (Figure 3.10), with the largest fish captured in the lower and lower-middle estuary, and in the upper portion of the upper estuary. This same general pattern continued into the summer sampling period. The largest fish (now 70 to 77 mm mean length) remained in the lower and lower-middle estuary, and in the upper portion of the upper estuary (mile 2.00). Between these two areas, the mean lengths of YOY steelhead

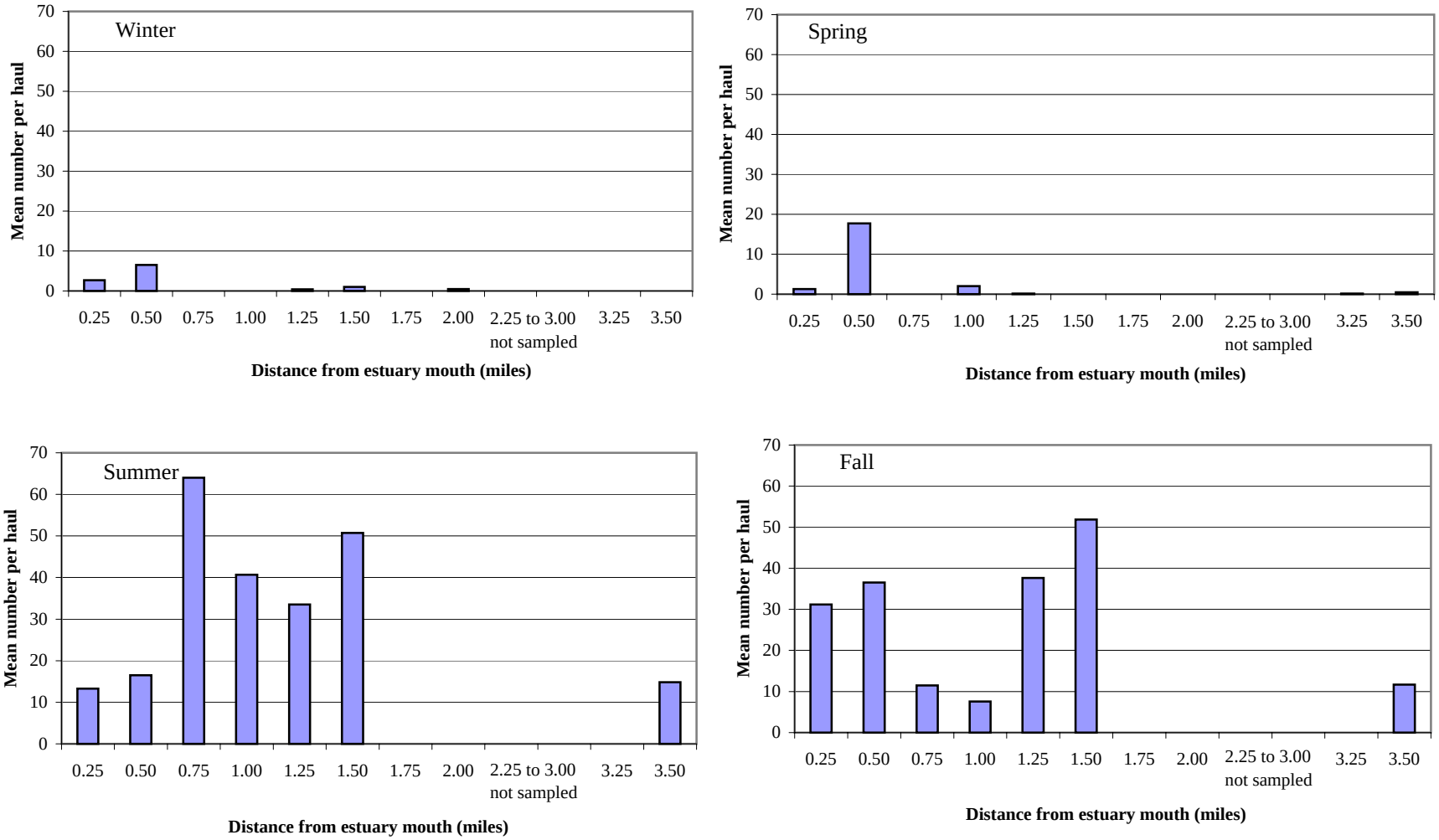


Figure 3.9 Mean number per haul of one year & older steelhead captured during 2003, Gualala estuary.

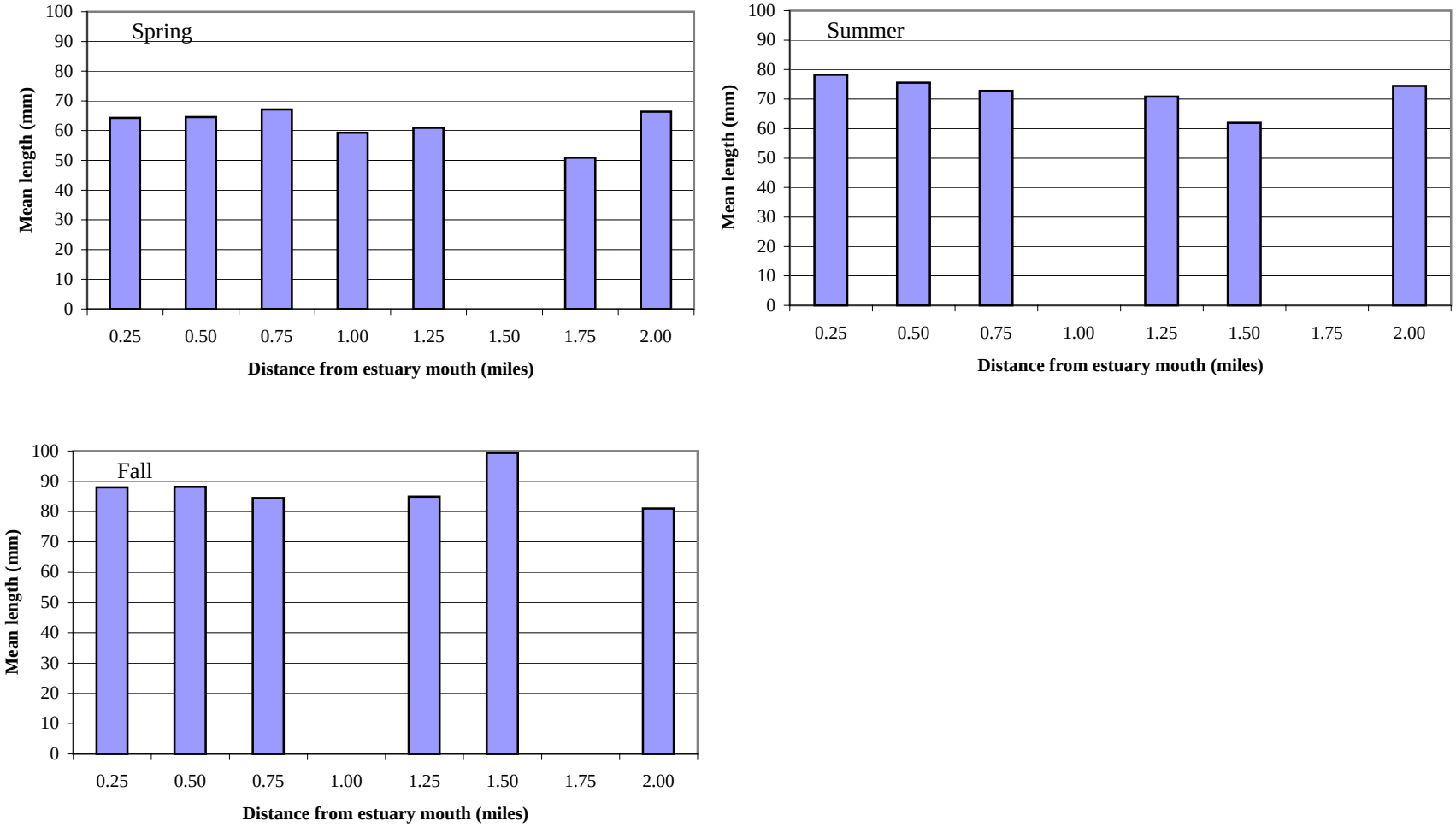


Figure 3.10 Mean length of YOY steelhead captured by distance category during spring, summer, and fall 2002, Gualala estuary.

decreased steadily moving upstream through the estuary to a minimum mean length of 62 mm at mile 1.50 in the upper estuary. By the fall sampling period, all of the largest YOY fish (now 100 mm mean length) were captured in the upper estuary at mile 1.50, where the smallest mean length fish were captured during the summer sampling events. The mean length of YOY steelhead captured at other locations in the estuary generally ranged from 80 to 88 mm mean length. In 2002, the highest mean number of YOY captured per haul occurred in the upper estuary during all three sampling periods.

As in 2002, YOY steelhead were distributed throughout the estuary during all sampling periods in 2003. During the spring sampling period when the estuary was open, the mean length of YOY steelhead was highest in the lower estuary (about 75 mm) (Figure 3.11). Mean lengths of YOY fish captured per haul were lower (ranging from about 60 to 67 mm) at other stations within the estuary. After the estuary had closed in early July, summer sampling efforts showed that the largest fish (81 to 84 mm mean length) were distributed throughout the estuary. Smaller fish (about 72 mm mean length), moving downstream from upstream spawning locations, were captured at stations higher in the estuary (mile 3.50). During the fall sampling events, the largest fish (100 mm mean length) were captured in the lower estuary. Sampling conducted upstream of the lower estuary, showed that mean lengths of fish captured steadily decreased with increasing distance from the mouth.

During the single event sampling effort conducted in February, steelhead were captured throughout the estuary, with the largest fish (about 87 mm mean length) occurring in the lower estuary. Fish captured elsewhere in the estuary ranged in size from 58 to 72 mm mean length). These fish were part of the 2002 cohort, and their small size was likely due to slower growth rates in cooler upstream habitats and/or late spawning efforts.

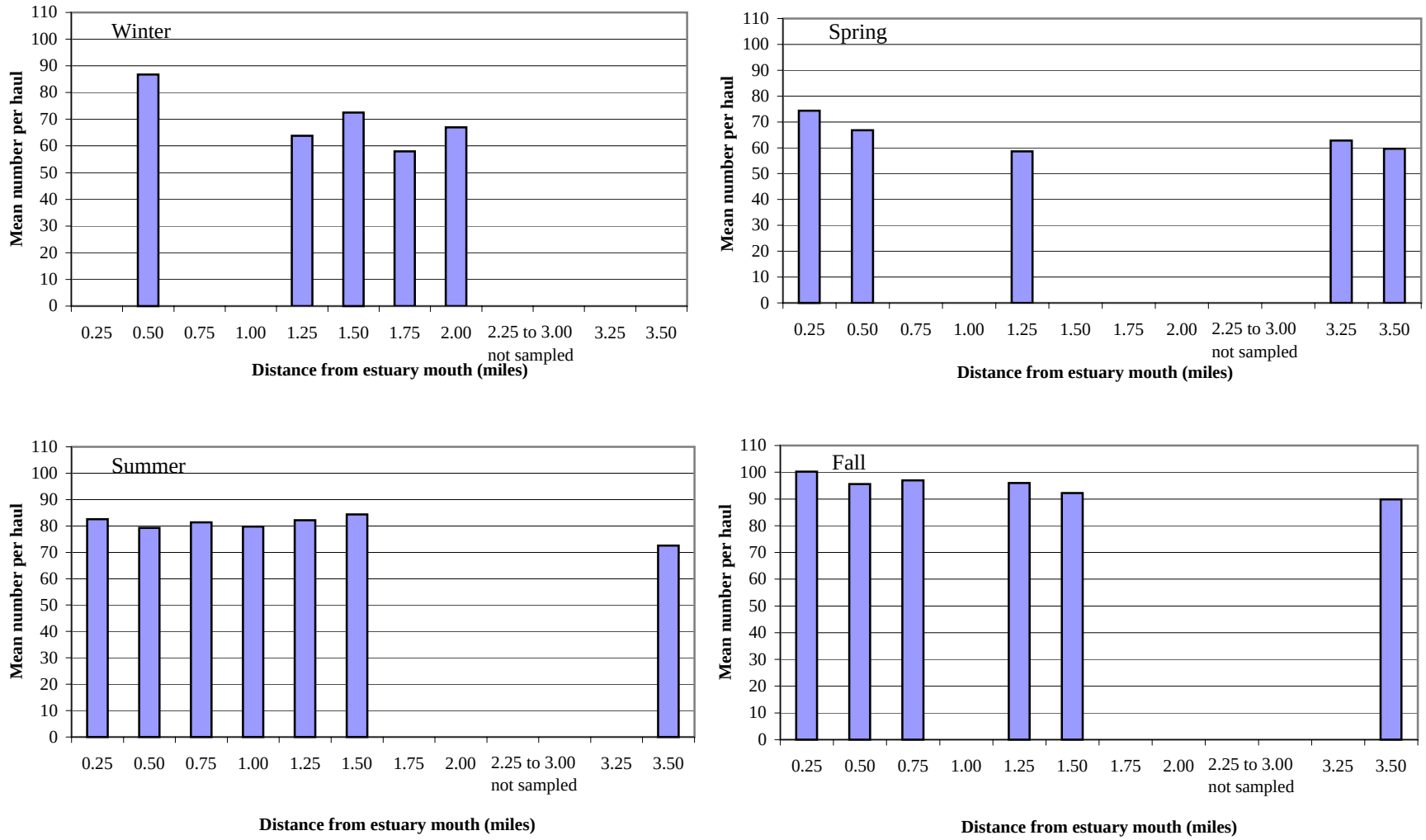


Figure 3.11 Mean length of YOY steelhead captured by distance category during spring, summer, and fall 2003, Gualala estuary.

Age 1+ and older steelhead

One-year and older steelhead were distributed throughout the estuary, during all 2002 sampling events under open estuary conditions. During the spring sampling period, the mean lengths of age 1+ and older fish captured per haul generally ranged from about 92 to 103 mm mean length (Figure 3.12), with the largest fish captured in the lower estuary. As expected, the smallest fish were captured high in the upper estuary (mile 3.50). During the summer sampling period (following the estuary closure in early July), larger fish (105 to 110 mm mean length) were relatively evenly distributed throughout the estuary; however, the largest fish were still in the lower and lower-middle estuary. By the fall sampling period, the largest fish (141 to 146 mm mean length) had moved upstream to the area around Mill Bend. The smallest fish were again captured in the upper estuary.

During the single event sampling effort conducted in February 2003, steelhead were captured throughout the estuary (Figure 3.13), with the largest fish (about 210 mm mean length) occurring in the upper estuary at mile 1.50. Slightly smaller fish were captured throughout the lower and middle estuary, with the smallest fish (about 110 mm mean length) occurring at higher locations in the upper estuary. These smaller fish were likely part of the 2002 cohort, and their small size was likely due to slower growth rates in cooler upstream habitats and/or late spawning efforts.

In 2003, the highest mean number of age 1+ and older fish captured per haul generally occurred in the lower estuary during all four sampling periods.

Stomach Analyses

Despite careful handling procedures, some steelhead mortalities occurred as a result of processing and fish marking efforts. Stomach analyses were conducted on all steelhead mortalities to obtain baseline information on the types of prey items being consumed.

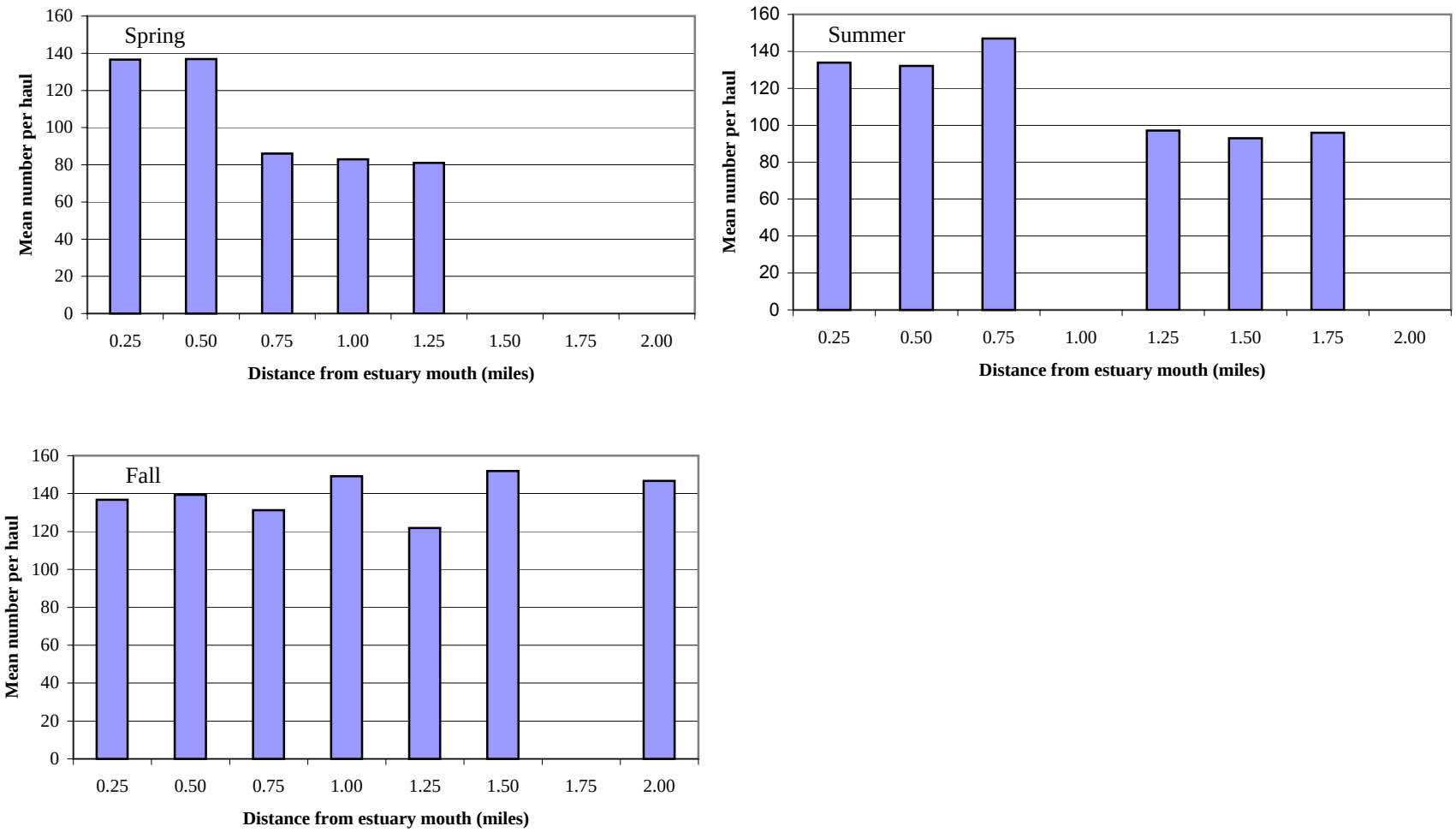


Figure 3.12 Mean length per haul of one year & older steelhead captured during 2002, Gualala estuary.

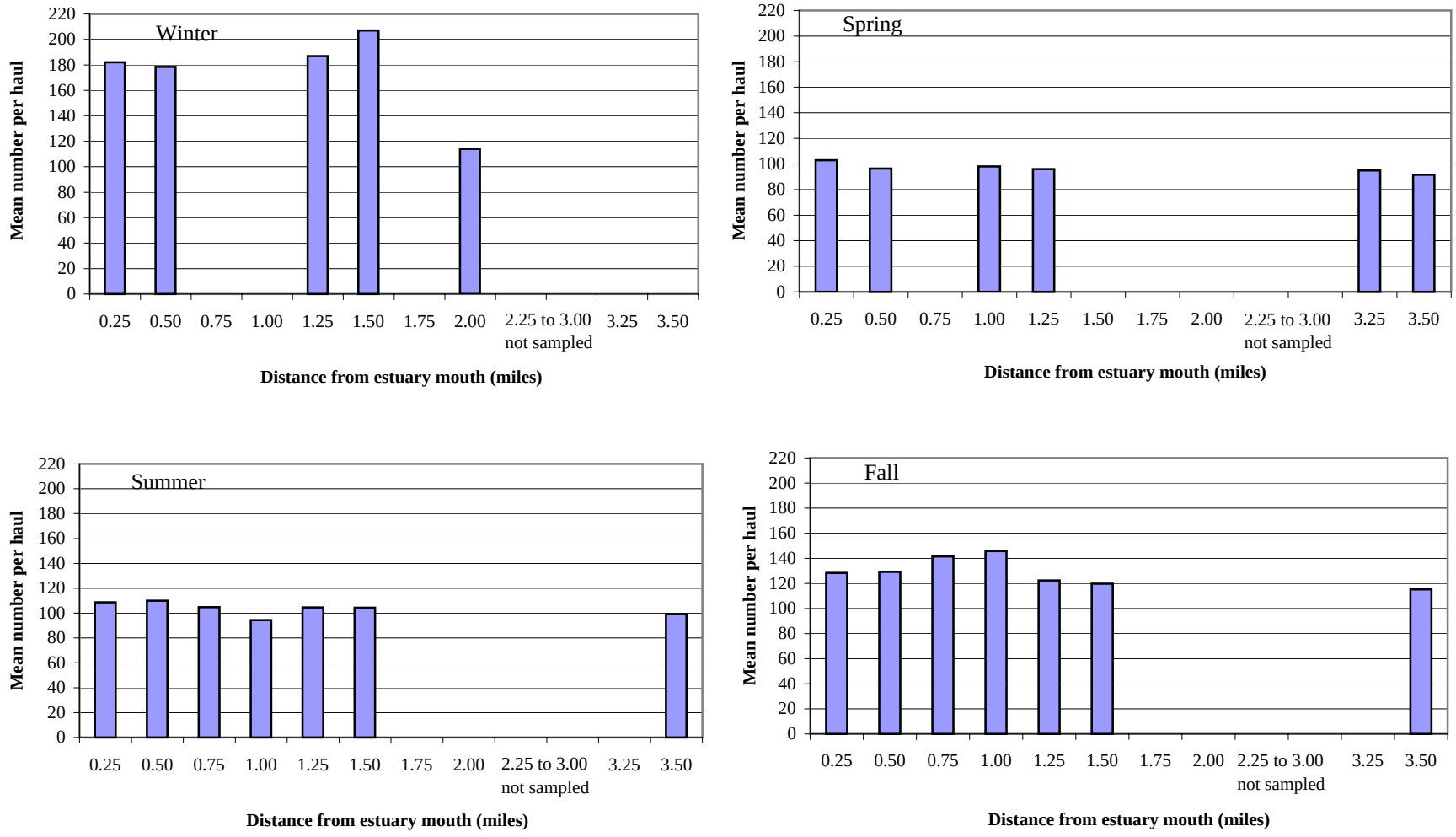


Figure 3.13 Mean length of of one year & older steelhead captured by distance category during spring, summer, and fall 2003, Gualala estuary.

When possible, prey species were also categorized by age class. The taxa were divided into three groups: insect (including terrestrial or aquatic adults), zooplankton (Amphipoda and Isopoda), and non-insect taxa (mites, mollusks, nematodes, and Oligochaetes).

Fish mortalities were not separated according to the estuary section in which they were collected; however, prey species identified in the stomach contents of individual steelhead often provided anecdotal information on feeding location within the estuary. A summary of the dietary components (by percent) of age 0+, 1+, and 2+ and older steelhead is provided in Table 3.12. Zooplankton (*Gnorimosphaeroma* sp., C*orophium* sp., and *Ramellogammarus* sp.) was one of the most abundant prey items found in the stomachs of age 0+ and age 1+ steelhead. Many of the steelhead contained both insect and zooplankton taxa. Non-insect taxa (e.g, neomysis) were the least abundant prey items in age 0+ and age 1+ fish, but become the most important dietary component for older (age 2+) age classes. Most of the insect taxa were associated with riverine (flowing water) conditions in the upper estuary; however, feeding observations (during sampling events) and stomach analyses show that steelhead were also actively feeding on midge adults and emerging pupa in the middle and lower estuary. Insect taxa consisted of adult ants, all life stages of midges, corixids, and thrips (Order: Thysanoptera). It is likely that steelhead in the estuary feed opportunistically on a variety of prey items depending on seasonal availability and abundance. In 2002, one steelhead collected in the lower estuary regurgitated sand lances when captured.

Table 3.12. Summary of the primary dietary components of steelhead captured in the Gualala estuary in 2002 and 2003

	Age 0+	**Age 1+**	**Age 2+ and older**
Percent Insect	25.5	31.3	0.0
Percent Non-Insect	6.1	4.3	100.0
Percent Zooplankton	68.4	64.4	0.0
N	14	19	2

3.3.3 Benthic Macroinvertebrate Surveys

The following section provides a brief summery of the general habitat conditions recorded for each of the three sections, including; riparian vegetation present, substrate composition, Substrate Complexity score, and Physical Habitat Quality score. Additional site information and water quality data for each section is presented in Table 3.13.

Substrate complexity was determined based on the combination of two habitat parameters, epifaunal substrate/available cover, and embeddedness. The substrate complexity score (SC Score) is the sum of these two parameters determined during field analysis. The range for substrate complexity is 0 to 40 with the following categories:

Category	SC Score
• Optimal	40 to 32
• Sub-optimal	31 to 22
• Marginal	21 to 12
• Poor	11 to 0

Microhabitat data were collected using the CDFG California Stream Bioassessment Procedure (CSBP) Physical/Habitat Quality form that rates a sample reach for 10 habitat categories. Each category has a rating scale from 0 to 20, and ratings are summed to provide the total Physical Habitat Quality Score (PHQ Score). The CSBP PHQ Score is similar to the EPA's Physical Habitat Quality Score, which is used throughout the U.S.

Category	PHQ Score
• Optimal	200 to 150
• Sub-optimal	149 to 100
• Marginal	99 to 50
• Poor	49 to 0

Site Descriptions

Lower Reach - RM 0.4 to 1.1

The lower reach extended from RM 0.4 to RM 1.1. Riparian vegetation consists primarily of California bay, willow, ash, and alder. Horsetail and nutsedge were also present along the banks. The dominant substrates were fines (41.7%) and gravel (40.0%). This section received a Substrate Complexity score 31 (sub-optimal), and a Physical Habitat Quality score of 140 (sub-optimal).

In May 2003, BMI sampling was conducted at RM 0.8 while the estuary was breached. The samples were collected in riffle habitat, which had formed near the upstream end of the island as a result of the breach. This site received a Substrate Complexity of 35 (sub-optimal) and a Physical Habitat Quality score of 136 (sub-optimal). The dominant substrates were gravel (50.0%) and fines (40.0%).

Middle Reach - RM 1.6 to 2.0

This 850 meter reach extended upstream of the Highway 1 Bridge to RM 2.0 (near campground). Riparian vegetation consisted of California bay, coast redwood, Douglas fir, willow, alder, ash, cedar, blackberry and nutsedge. The substrate was dominated by fines (41.7%) and gravel (40%). This reach received a Substrate Below the stratified layer Complexity score 31 (sub-optimal) and a Physical Habitat Quality score of 140 (sub-optimal).

Upper Reach - RM 2.4 to 3.2

This 967-meter reach began at the campground and extended upstream near the confluence with the north fork. Riparian vegetation consists primarily of redwood,

Table 3.13 Physical habitat and water quality data collected during benthic macroinvertebrate surveys in the lower Gualala River and Estuary, July 2002 and May 2003.

	Upper Reach: RM 2.4 to RM* 3.2				**Middle Reach : RM 1.6 to RM 2.0**				**Lower Reach: RM 0.4 to RM 1.14**				**Lower Reach: RM 0.8, May 2003**			
	1	2	3	**Mean**	1	2	3	**Mean**	1	2	3	**Mean**	1	2	3	**Mean**
Sampling information																
Sampling notes:									Three 5-m sweeps in widgeon grass bed	Gravel kick appx 6 sq. ft. followed by three sweeps	Vegetation sweep and grab @ Mill Bend					
Date Sampled				**7/11/2002**				**7/11/2002**				**7/12/2002**				**5/20/2003**
Time Sampled				**9:00**												**14:45**
GPS	10S0456646	10S0456633	10S0456149		10S0455802	10S0455478	10S0455478		N/A	N/A	N/A					
UTM	4292282	4292043	4291853		4291219	42921138	4290892		N/A	N/A	N/A					
Site characteristics																
Canopy cover (%)	0	35	95	**43.3**	15	0	2	5.7	N/A	N/A	N/A		0	0	0	**0**
Gradient (%)	<1	<1	1	**<1**	<1	<1	<1	<1	N/A	N/A	N/A		<1	<1	<1	**<1**
Transect Location (m)	31	15.0	12.0		25	20	18		N/A	N/A	N/A		25	29.5	37.5	
Elevation (ft)				**53**				**13**								
Reach Length (m)				**967**				**850**								**75**
Physical characteristics																
Riffle Length (m)	60.0	25.0	15.0	**33.3**	43.0	34.0	22.0	**33.0**	N/A	N/A	N/A					**71.6**
Avg. Riffle Width (m)	9.0	13.5	9.4	**10.6**	17.0	12.3	25.0	**18.1**	N/A	N/A	N/A		37.5	36.6	37	**37.0**
Avg. Riffle Depth (ft)	0.28	0.27	0.3	**0.3**	0.52	0.55	0.72	**0.6**	N/A	N/A	N/A		1.69	1.39	1.50	**1.5**
Riffle Velocity (ft/s)	1.9	1.1	2.6	**1.9**	0.6	0.5	0	**0.4**	N/A	N/A	N/A		2.4	3.00	2.91	**2.8**
Substrate Complexity	31	31	31	**31.0**	31	31	31	**31.0**	N/A	N/A	N/A		35	35	35	**35.0**
Embeddedness (%)	5	5	10	**6.7**	10	25	35	**23.3**	N/A	N/A	N/A		5	5	5	**5.0**
Substrate Consolidation	Low	Low	Low	**Low**	Low	Med	Med	**Med-Low**					Low	Low	Low	**Low**
Specific Conductance (μs/cm)				**180**				**260**				**301**				**0.1**
Dissolved Oxygen (mg/l)				**7.3**				**7.8**				**7.0**				**8.8**
Dissolved Oxygen (%)				**74.4**				**92.1**				**79.9**				**104.7**
Water Temp (C°)				**17.3**				**23.2**				**21.5**				**24.6**
Total Dissolved Solids (g/l)				**0.138**				**0.175**				**0.209**				**0.0**
Salinity (ppt)				**0.10**				**0.13**				**0.15**				**0.0**
Physical Habitat Quality Score				**121**				**140**				**N/A**				**136**
Substrate Composition																
Fines (<0.1")	25	25	50	**33.3**	50	35	40	**41.7**	100	20	25	**48.3**	40	40	40	**40.0**
Gravel (0.1-2")	70	72.5	49	**63.8**	30	40	50	**40.0**	0	60	0	**20.0**	50	50	50	**50.0**
Cobble (2-10")	5	2.5	1	**2.8**	20	25	10	**18.3**	0	20	0	**6.7**	10	10	10	**10.0**
Boulder (>10")	0	0	0	**0.0**	0	0	0	**0.0**	0	0	75	**25.0**	0	0	0	**0.0**
Bedrock (solid)	0	0	0	**0.0**	0	0	0	**0.0**	0	0	0	**0.0**	0	0	0	**0.0**
Riparian Vegetation	willow, bunchgrass, redwood, Douglas fir, ash, alder				bay laurel, willow, alder, ash, cedar, horsetail, nutsedge				N/A				Riparian area located approximately 15 meters or greater from waters edge.			

Additional Notes:

* River Mile (RM) calculated from estuary mouth.

N/A = data not taken as collection technique and site selection did not conform to CSBP type sampling in lower estuary site i July 2002.

Douglas fir, ash, and alder. Bunchgrass was also present along the banks. The dominant substrates were gravel (63.8%) and fines (33.3%). This section received a Substrate Complexity score of 31 (sub-optimal), and a Physical Habitat Quality score of 121 (sub-optimal).

CSBP Metrics

Benthic macroinvertebrate sampling was conducted in all three estuary reaches in July 2002, to characterize the benthic macroinvertebrate community relative to food availability for juvenile steelhead. Based on the results, species composition and associated biological metrics for each of the estuary sections reflected changes from a riverine environment in the upper estuary to a more estuarine environment in the middle and lower estuary. In May 2003, while the estuary was breached, a second set of BMI samples were collected in the middle estuary where a riffle had formed at the top of the island to access if the benthic taxa had shifted toward a more riverine fauna. The riffle was sampled using CSBP protocols.

Table 3.14 provides a summary of the metrics specified by the CSBP for each of the reaches in the Gualala estuary. However, due to the lack of CSBP defined tolerance values and Functional Feeding Group (FFG) designations for the dominant taxa (*Gnorimosphaeroma* sp.) in the estuary, Tolerance metrics (TV, Percent Tolerant Organisms, and Percent Intolerant Organisms) and the FFG metrics are not relevant. A FFG designation of collector was assigned for this taxon.

The estimated abundance of benthic macroinvertebrates was highest in the transitional section and lowest in the riverine area (Figure 3.14). Taxa richness, Shannon Diversity Index and the EPT Indices were highest in the upper estuary (riverine habitat) and declined downstream in the estuarine environment (Figures 3.15 through 3.17). The percentage of non-insect taxa is presented in Figure 3.18. This metric shows the change in the BMI community that occurs between the upper reach, which is dominated by insect

Table 3.14 Summary of the benthic macroinvertebrate metrics for the lower Gualala River and Estuary, July 2002 and May 2003.

	Upper Reach - RM 2.4 to RM 3.2* (2002)			**Middle Reach - RM 1.6 to RM 2.0**			**Lower Reach - RM 0.4 to RM 1.1 (2002)**			**Lower Reach - RM 0.8**		
	Mean	CV	Total	Mean	CV	Total	Mean	CV	Total	Mean	CV	Total
Estimated Abundance	1391.4	52.1	4174.2	3601.1	62.7	10803.2	1778.5	47.5	5335.6	1853.9	43.1	5561.6
Taxa Richness	38.0	14.7	69.0	16.3	12.7	34.0	10.0	148.0	19.0	9.3	16.4	15.0
Percent Dominant Taxon	23.1	29.7	13.3	85.0	10.3	85.0	69.0	13.1	55.8	64.8	13.7	65.1
EPT Taxa	14.0	31.1	27.0	4.0	86.6	10.0	0.3	1732.1	1.0	0.3	173.2	1.0
EPT Index (%)	33.3	33.1	33.2	5.1	64.7	5.1	0.3	897.4	0.3	0.2	173.2	0.2
Sensitive EPT Index	14.0	53.8	13.9	0.9	173.2	0.9	0.0	0.0	0.0	0.2	173.2	0.2
Ephemeroptera Taxa	6.0	16.7	9.0	3.0	57.7	7.0	0.3	1212.4	1.0	0.0	NA	0.0
Plecoptera Taxa	3.7	31.5	7.0	0.3	173.2	1.0	0.0	0.0	0.0	0.0	NA	0.0
Trichoptera Taxa	4.3	70.5	11.0	0.7	173.2	2.0	0.0	0.0	0.0	0.3	173.2	1.0
Dipteran Taxa	9.3	16.4	17.0	4.0	66.1	8.0	1.3	312.2	3.0	1.7	34.6	2.0
Percent Dipteran	22.9	68.5	22.6	4.6	73.5	4.6	1.5	162.3	1.4	1.1	36.7	1.1
Non-Insect Taxa	9.3	6.2	17.0	6.0	28.9	10.0	7.0	21.8	11.0	5.0	0.0	7.0
Percent Non-Insect	26.5	42.3	26.9	89.3	6.9	89.3	97.2	6.1	97.3	98.0	1.4	97.9
Percent Chironomidae	19.5	68.4	19.1	4.5	71.6	4.5	1.5	158.4	1.4	0.0	NA	0.0
Percent Hydropsychidae	0.3	173.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.0
Percent Baetidae	13.7	13.9	13.7	0.6	51.5	0.6	0.3	109.9	0.3	0.0	NA	0.0
Shannon Diversity	2.8	9.7	3.2	0.8	46.6	0.8	1.1	21.6	1.4	0.8	7.3	0.9
Tolerance Value	4.1	18.5	4.0	0.7	59.3	0.7	2.6	11.4	2.5	2.7	28.4	2.7
Percent Intolerant	13.4	45.3	13.4	0.6	129.9	0.6	0.0	0.0	0.0	0.0	NA	0.0
Percent Tolerant	2.8	25.5	2.8	0.4	114.7	0.4	20.0	1.1	18.6	31.4	31.8	31.1
Percent Collectors	48.4	27.4	48.4	95.4	0.8	95.4	95.2	4.4	95.2	97.7	1.5	97.6
Percent Filterers	3.5	78.5	3.5	0.0	NA	0.0	0.5	173.2	0.5	0.0	NA	0.0
Percent Grazers	25.7	36.9	25.8	1.3	91.7	1.3	0.0	0.0	0.0	0.9	81.5	0.9
Percent Predators	18.1	16.4	18.0	2.6	49.4	2.6	4.3	81.0	4.3	0.6	79.5	1.0
Percent Shredders	1.8	103.4	1.8	0.3	173.2	0.3	0.0	0.0	0.0	0.2	173.2	0.2

CV = Coefficent of Variation

* River Mile (RM) calculated from the estuary mouth.

Figure 3.14. Estimated Abundance of Benthic Macroinvertebrates in the Lower Gualala River and Estuary, July 2002 and May 2003

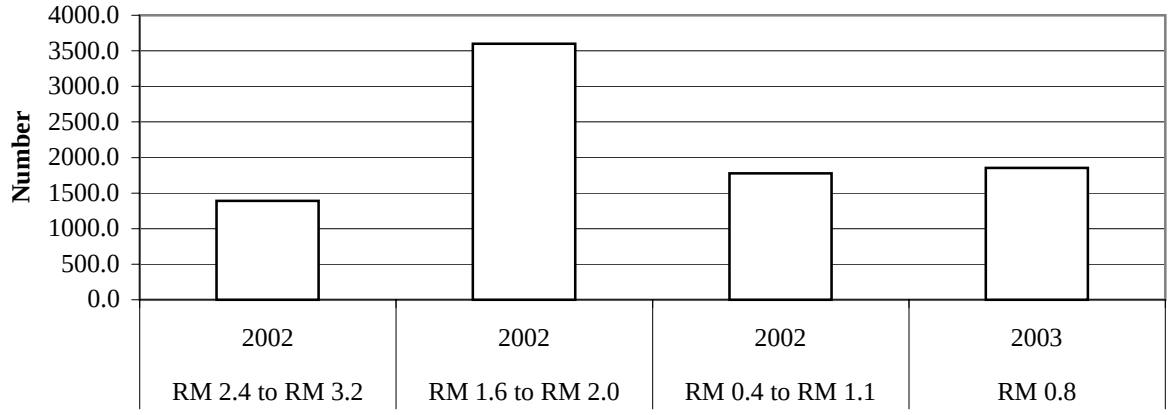


Figure 3.15. Taxa Richness for Benthic Macroinvertebrates in the Lower Gualala River and Estuary, July 2002 and May 2003

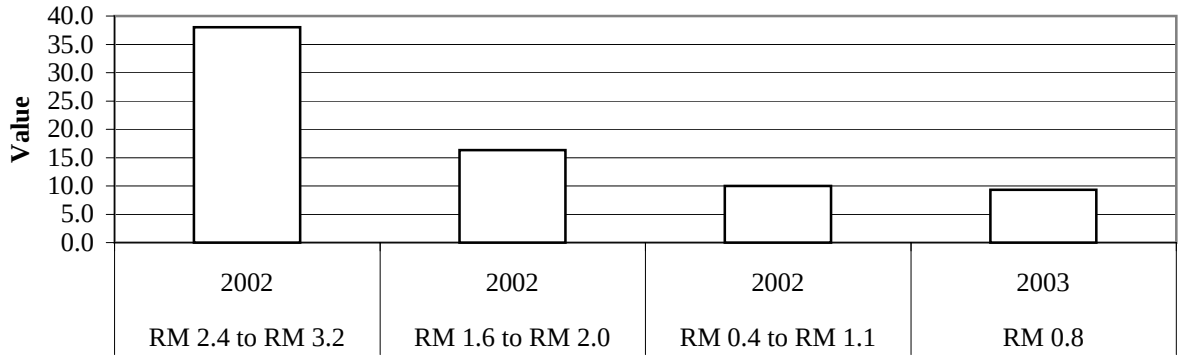
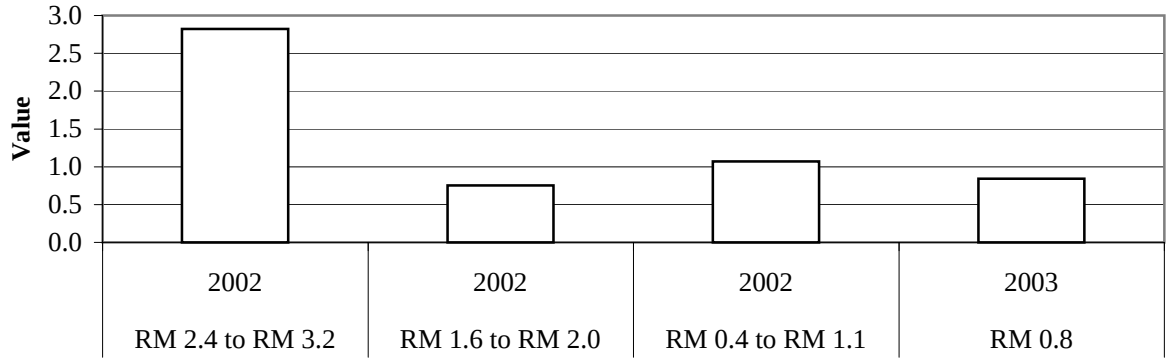


Figure 3.16. Shannon Diversity Indices for Benthic Macroinvertebrates in the Lower Gualala River and Estuary, July 2002 and May 2003



taxa, and the lower reaches, which are dominated by zooplankton taxa. The dominant taxa metric in the upper reach was split among the three samples; a midge tribe (Tanytarsini), a mayfly (*Baetis* sp.) and an isopod (*Gnorimosphaeroma* sp.), while zooplankton taxa; isopod (*Gnorimosphaeroma* sp.) and amphipods (*Corophium* sp. and *Gammarus* sp. in the 2002 grab samples, *Hyalella azteca* in the 2003 sample) were dominant taxa in the middle and lower reaches (Figure 3.19). The benthic macroinvertebrate community begins to shift toward a community dominated by estuarine organisms in the upper reach (RM 2.4) as indicated by the isopod (Gnorimosphaeroma sp.) was 27% of the sample.

3.3.4 Seasonal Algae and Macrophytic Plant Growth/Decay

The following section provides a description of algae and macrophytic plant growth and decay observed in the Gualala Estuary in the summer during both years of the monitoring period. Most of the accounts presented below are based on the field observations and interpretation of Elmer Dudik, North Coast Regional Water Quality Control Board.

Lower Estuary

During both summers of the estuary study, large mats of algae were observed forming in the lower river and estuary. Based solely on field observations, algal mat growths appear to consist of *Cladophora*, *Spirogyra*, *Hydrodictyon*, or *Rhizoclonium*, but are dominated by *Cladophora*, *Rhizoclonium*, or *Spirogyra*. Extensive growths of *Spirogyra* were ruled out because growths did not display the growth-associated characteristics - typically large, usually slippery-slimy, mats that age yellow-brown. *Hydrodictyon* typically requires actively flowing water and conditions in the lower estuary were more stagnant with diffuse flow during the summer field monitoring events. In contrast, algal blooms are usually associated with massive increases in planktonic, typically unicellular to short stranded microalgae that discolor the water. Algal blooms that were observed in the estuary may have been promoted by longer summer days providing increased solar input.

Extensive populations of Widgeon grass (*Ruppia maritima*), an aquatic, seed bearing flowering plant were also observed during the summer periods. Both algae and widgeon grass consume dissolved oxygen (DO) during the day and produce carbon dioxide at night. Flows were also reduced to the lower estuary from upstream resulting in a reduced input of more oxygen rich freshwater. During the RWQCB's September sampling event, the algal mats and large portions of the Widgeon grass were undergoing senescence and beginning to bacterially decompose. This led to increased oxygen consumption via respiration by the bacteria, reflected in the sample results for September having the lowest DO levels when compared to the other sampling periods. The algae and Widgeon grass mats were probably the largest source of nutrients to the bacteria. The October 23, 2003 RWQCB sampling showed that DO levels rebounded to as high as 19 mg/L, likely a result of wave-wash over the barrier beach, as evidenced by sand deltas and erosional channels observed leading from the ocean to the estuary that day. Dissolved oxygen concentrations remained low in the lower water column at the Mill Bend site, as before.

Most of the estuary during the mid- to late summer low flow period is shallow, and without riparian or other shaded cover that would reduce or limit solar radiation inputs, another factor conducive to algal and/or other macrophytic plant growth. Stream temperatures during the mid- to late summer months reflect increase solar radiation and hovered around 20 ºC. In October, water temperatures dropped to 15 - 16 ºC at all locations. In combination, the elevated water temperatures and increased in solar radiation favors the growth of macroalgae and other aquatic plants, provided sufficient nutrients are available.

The observations and measurements described above suggest that during the mid- to late summer period, there is enough phosphorous from natural inputs to promote the extensive algal and plant growth. In turn, the primary nutrient sources to the lower estuary that could contribute to any form of eutrophication are the algal mats and, perhaps, the Widgeon grass during senescence. However, under existing conditions, it is speculated that end-point eutrophication, as experienced in many closed systems like

lakes and ponds, probably does not have a chance to occur in the Gualala Estuary because of the relatively high freshwater inflow, and occasional wave wash under high surf conditions. The estuary alignment with prevailing summer winds also allow for regular mixing of the water column in the lower estuary. The above-mentioned factors in the Gualala Estuary tend to prevent a "closed system" from forming where bacterial decomposition could proceed to produce truly hypoxic or anaerobic conditions.

Upper Estuary

The upper estuary from the Hwy 1 bridge was completely freshwater during the June and October Regional Board's 2003 sampling events. Populations of algae on the bottom along with "streamers" and surface accumulations in the water column were observed over this period. There was noticeable flow in the lower river that provided a source of dissolved oxygen. Two locations sampled upstream of the bridge in October had DO concentrations of 9.6 and 10.3 mg/L. Plant matter present during the late summer probably undergoes bacterial decomposition, releasing more nutrients into the cycle, but not to the point of eutrophy because freshwater inflow prevents the lower river from stagnating. Water temperatures also increased in an upstream direction during the June sample period, but decreased during October due to the arrival of mostly overcast, late summer fog sampling. Thus, it appears that increases in temperature, along with increases in sunlight, helped to stimulate the growth of macroalgae and other aquatic plants, but not planktonic algae.

A natural seasonal cycle of primary productivity by algae and other aquatic plants is evident in the Gualala River estuary. This is followed by the seasonal senescence and eventual bacterial decomposition of the aquatic plants, lowering DO levels during the late summer, particularly when flows from upstream are reduced and wave-wash over the sandbar is nonexistent. The relatively small size of the estuary and perennial freshwater inflow are important variables in maintaining a freshwater dominated, health estuary.

3.4 Discussion

During the two years of sampling conducted in the lower Gualala River and estuary by ECORP, water quality and habitat conditions varied in response to river flow. During 2002, the estuary remained closed until the first November storm event. The fact that the estuary remained closed throughout spring and summer, and into fall resulted in generally favorable rearing conditions (predominantly freshwater). In addition, water temperatures were generally suitable, with the exception of a few days of increased water temperatures (see 2002). In 2003, the estuary remained open into May, breached again for a short period in the middle of June, and breached again during the first storm event in November. This pattern of repeated breaching resulted in increase salinity values during summer, a time when young of the year and older juvenile steelhead are migrating to the estuary to continue freshwater rearing. The importance of this estuarine rearing stage is to rapidly increase their size (in particular, weight) prior to entering the Pacific Ocean. Survival of outmigrating smolt steelhead increases with size (i.e., weight), presumably because they are better able to withstand stress associated with the transition from fresh to salt water conditions. In addition, the amount of available habitat is increased over that found in the stream. The areal extent of habitat is increased in the estuary when conditions are otherwise suitable (i.e., water quality). Under freshwater conditions, prey items are more abundant and the juvenile steelhead are more able to rapidly increase weight.

In 2002, the estuary was predominantly freshwater throughout the summer and early fall, except for the pocket of saline water in the deep pool at Mill Bend. However, water quality conditions in 2003 were highly variable associated with high spring runoff and an open estuary into mid July. As a result, the estuary/estuary fluctuated between primarily freshwater and brackish to marine conditions.

Figure 3.17. EPT Indices for Benthic Macroinvertebrates in the Lower Gualala River and Estuary, July 2002 and May 2003

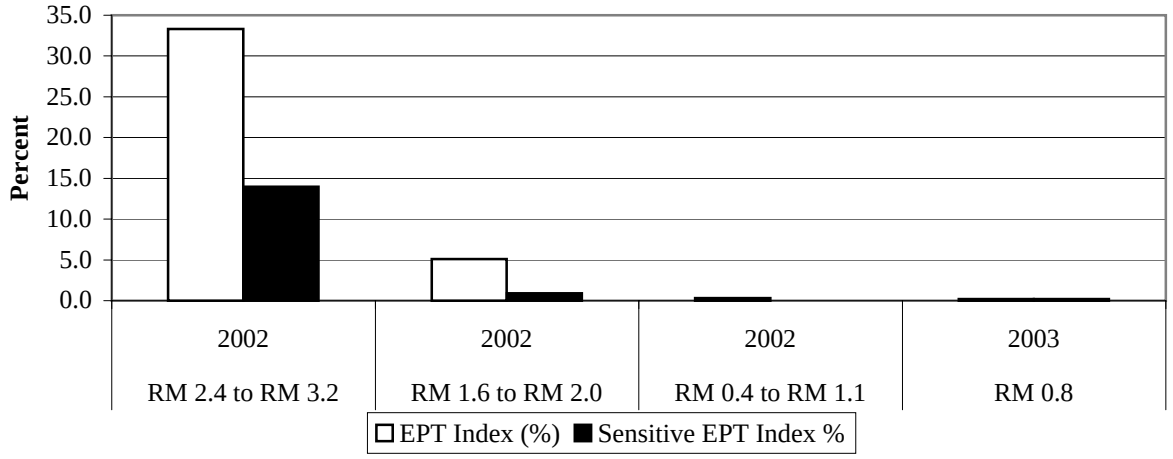


Figure 3.18. Percentage of Non-Insect Taxa Metric for Benthic Macroinvertebrates in the Lower Gualala River and Estuary, July 2002 and May 2003

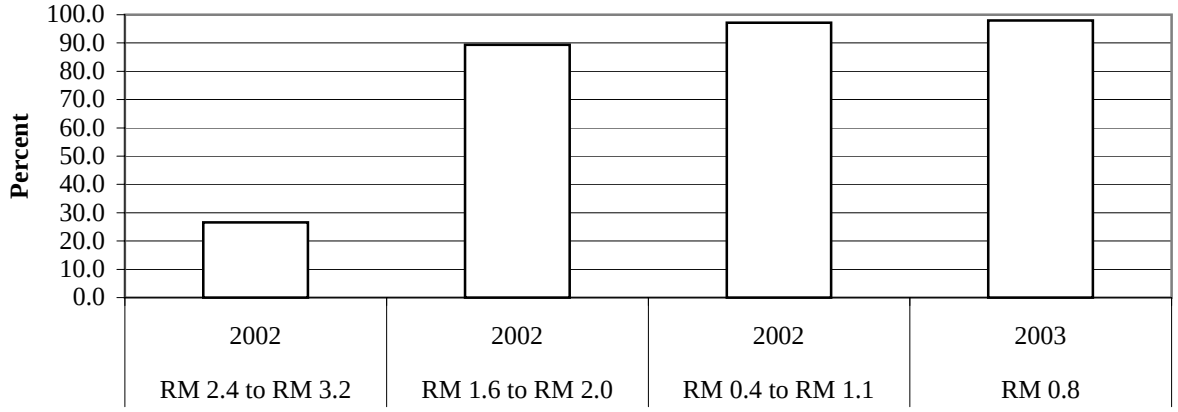
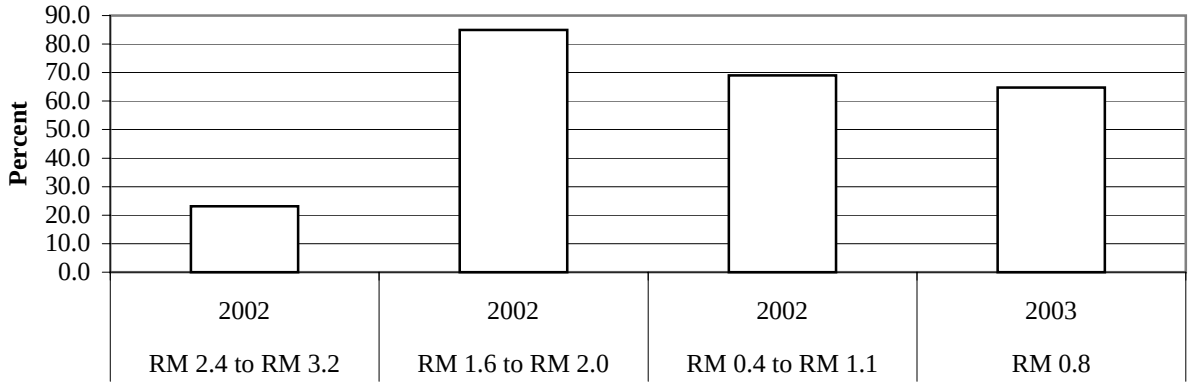


Figure 3.19. Dominant Taxa Metric for Benthic Macroinvertebrates in the Lower Gualala River and Estuary, July 2002 and May 2003



2002

Young-of-the-year steelhead were relatively abundant in the catch from June through early September, with decreased numbers recorded for the remainder of the sampling season. During the spring, YOY steelhead were captured in highest numbers in the lower and middle estuary up to the Highway 1 Bridge. In summer, YOY were substantially more abundant in the catch from Mill Bend upstream to mile 1.50, but were also captured in higher numbers in the lower estuary. By fall, total numbers of YOY had decreased above Mill Bend, with similar numbers recorded for the lower estuary.

Age 1+ and older fish were captured in low numbers throughout the estuary in the spring, likely due to emigration prior to estuary closure. However, by the summer period there was a substantial increase in the number of age 1+ and older fish, which were most abundant in the lower estuary, but were also captured in increasing numbers in the vicinity of the Highway 1 Bridge. In the fall, even higher numbers of steelhead were captured in the lower and lower-middle estuary, and in the vicinity of the Highway 1 Bridge. During this period, age 1+ and older steelhead were captured in highest numbers in the lower estuary. Sampling conducted in November after the estuary had breached showed that few age 1+ and older fish were still present in the lower and lower-middle estuary, likely due to emigration following the estuary breach. During the spring and summer periods, the largest age 1+ and older steelhead were captured in the lower and lower-middle estuary.

Water quality conditions were generally favorable for steelhead throughout the summer and fall, except in the deep pool at Mill Bend, where salinity stratification often created poor water quality conditions with warm water temperatures and very low dissolved oxygen levels. In the fall, ocean wave-overwash created saline conditions on the bottom in the lower and lower-middle estuary. As the fall progressed, continued wave-overwash steadily increased surface and bottom salinities in the lower and middle estuary, until the estuary breached in November. Based on the 2002 sampling data, the distribution of YOY steelhead did not appear to be affected by the increased salinities in the lower and middle estuary.

In general, water temperatures were adequate for steelhead rearing throughout the estuary. During eleven days in July and early August, temperatures generally exceeded the thermal maximum for steelhead, however areas of lowered water temperature (thermal refugia) were sometimes present in deep water. There is some discrepancy among investigators as to the thermal maximum for steelhead; Raleigh *et al*. (1984) reported 25 ºC, other investigators (Jobling, 1981 and Lee and Rinne, 1980) report 26 ºC, and Moyle (2002) found that temperatures of 24–27 ºC are lethal to steelhead, except for very short exposures of a few hours. Based on continuous temperature data collected within the estuary, surface water temperatures exceeded 25 ºC for up to 6 hours per day over the eleven days. Based on this analysis, it appears that water temperatures throughout the estuary were generally favorable for steelhead rearing in the estuary in 2002, except for short periods (maximum 6 hours) during late July/early August. A portion of the catch during the early August sampling event appeared to be stressed (lethargic behavior) from warm water and air temperatures

<u>2003</u>

Steelhead were less abundant in the catch in 2003 than in 2002, likely due to greater emigration during the spring 2003 when the estuary was open. Young-of-the-year steelhead were captured in relatively low numbers during February and May when the estuary was open. However, the numbers of YOY fish substantially increased during the June sampling event, which was likely associated with the estuary closing in late May. Variable numbers of YOY steelhead were captured from July through September, with a significant drop in numbers occurring during the October sampling events. During the spring, YOY steelhead were captured in highest numbers in the lower-middle estuary, with reduced numbers of fish in the upper estuary. In summer, YOY were captured in similar numbers throughout the estuary. By fall, total numbers of YOY were highest in the upper estuary above the Highway 1 Bridge; however, fish were also captured in slightly lower numbers in the middle estuary. In the winter and spring, the largest YOY

were captured within the lower and lower-middle estuary. During the summer and fall, the largest YOY were distributed throughout the estuary, as noted in 2002.

Except for the lower estuary, one-year and older fish were captured in very low numbers throughout the estuary during the spring sampling event. This is likely due to emigration prior to estuary closure in late May. By the summer period, these fish were relatively evenly distributed throughout the estuary. In the fall, the highest numbers of age 1+ and older fish were captured in the lower and lower-middle estuary as observed in 2002, with lower numbers present from Mill Bend upstream into the upper estuary. During the winter, spring and summer periods, the largest age 1+ and older steelhead were evenly distributed throughout the estuary.

As in 2002, water quality conditions were generally favorable for steelhead throughout the summer and fall, except in the deep pool at Mill Bend, where salinity stratification often created poor water quality conditions with warm water temperatures and very low dissolved oxygen levels. Similar to 2002, ocean wave-wash in the fall created saline conditions on the bottom in the lower and lower-middle estuary. As the fall progressed, continued wave-wash steadily increased surface and bottom salinities in the lower and middle estuary, until the estuary breached in November. Based on the 2003 sampling data, the distribution of YOY steelhead appeared to be affected by the increased salinities in the lower and middle estuary during the summer and fall. As salinities increased in the lower and middle estuary, YOY steelhead appeared to migrate upstream into fresher water.

In general, water temperatures in the estuary were adequate for steelhead rearing throughout most of the year, except for two days in July when temperatures exceeded the thermal maximum for steelhead. Based on continuous temperature data collected within the estuary, the longest period of time that surface water temperatures exceeded 25 ºC over the two days in July was for 1-hour.

The numbers of steelhead present within the estuary may be affected by predation, especially river otter and various avian species, including white pelican, osprey, mergansers, gulls, and cormorants. During sampling events in both years, these predators were observed actively feeding on steelhead throughout the estuary. During closed estuary conditions in 2002 when surface waters were calm, conditions may have favored those predators that rely on eyesight (e.g., otters, osprey, and other avian predators) to locate prey. However, the total affect of these predators on juvenile steelhead population numbers within the estuary is unknown.

3.4.1 Benthic Macroinvertebrates

Benthic community sampling, although limited, was conducted to examine the food resources for the fish community. The 2002 NCWAP report on the Gualala Watershed (Klamt *et. al*., 2002) describes the upper watershed as having a good biotic rating based upon an IBI community evaluation approach. Based on the results of the current study effort, including assessments of water quality, fish populations, and the benthic community, the lower river and estuary also appear to provide suitable habitat and food resources for maintaining steelhead and other fish aquatic species.

Based on the limited benthic sampling conducted in 2002 and 2003, two discrete benthic communities were identified within the Gualala River estuary. Sampling indicated that the benthic community begins to transition from a riverine or insect dominated community to an estuarine or non-insect dominated community at mile 2.4 in the upper reach. An isopod (*Gnorimosphaeroma* sp.), was the dominant taxa found in the samples from the mouth to the transition area. Based on a sample size of 35 fish, stomach analyses showed that this organism (which was the most abundant organism in the samples) was the dominant food item in most fish examined. This observation is consistent with most salmonid species, which are known to be opportunistic feeders on the most abundant food items present in the environment (Raleigh et.al. 1984).

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CHAPTER 4.0 SUMMARY OF CONCLUSIONS

4.1 Introduction

This section summarizes the key findings and conclusions regarding overall condition and aquatic health of the Gualala River coastal estuary determined from each the hydrology and geomorphic, water quality, and aquatic ecology investigations. These conclusions/hypotheses are based predominantly on data and observations collected during the 2002 and 2003-study period. Adult steelhead escapement and juvenile outmigration study components were not part of the scope of this coastal estuary and lower river study.

4.2 Summary

Overall General Observation:

- The estuary appears to be in good biotic condition based upon hydrology, water quality, fish population and benthic invertebrate community conditions.

Hydrology and Water Quality Observations:

- Seasonal changes to the Gualala River coastal estuary geomorphology and water quality occur throughout the year in a fairly predictable manner, and are controlled by subtle shifts in the balance of natural processes, most notably freshwater inflow and wave energy.

- The hydrologic and water quality characteristics of the coastal estuary control the extent and quality of aquatic habitat. Any significant change in the magnitude or timing of a physical condition or process (e.g., climate, water diversions that decrease freshwater inflow, degraded water quality conditions from land use practices) will likely have a significant adverse effect on estuary ecology.

- In order to maintain healthy conditions for steelhead rearing in the estuary, an ample supply of good quality inflow needs to be maintained and protected. This can be assessed quantitatively through additional study (e.g., PHABSIM analysis), however it is also assessed by the ability of the estuary to maintain freshwater conditions during closure.

Fisheries Specific – Summary Points:

- Anecdotal information obtained from local residents and CDFG snorkel surveys, as well as the capture of one juvenile Coho salmon in the estuary indicate that a remnant coho salmon population may be present in the Gualala River Watershed.

- Adverse physical, biologic, or water quality conditions in the estuary were not identified as a limiting factor to Coho salmon populations in the Gualala River estuary. An exception to this would be unseasonably warm estuarine water temperatures, most notably in the shallow lower river and upper estuary, often associated with low inflow conditions. The factors limiting Coho in the basin appear to be associated with degraded habitat conditions in the upstream portions of the watershed.

- Surface water temperatures exceeded 25-degrees C for several hours per day for short durations during the summer in 2002. Although it appears that areas of thermal refugia do exist in the estuary, unseasonably warm water temperatures may sometimes be a limiting factor on steelhead rearing in the coastal estuary.

- Steelhead rearing capacity in the coastal estuary is generally good for pre-smolt and smolt steelhead under existing conditions. However, additional deep pool habitat, and increased cool water inflow would increase summer thermal refugia.

- Habitat conditions within the estuary appear to be adequate to accommodate steelhead rearing, even with the high degree of inter- and intra-annual variability in the hydrology and water quality of the coastal estuary.

- The estuary is generally dominated by freshwater conditions throughout the rearing season. During periods of barrier breaches and wave overwash, saline water enters the estuary, affecting water quality upstream as far as Mill Bend. As long as there is a good supply of inflow, salinity stratification maintains shallow freshwater lenses. When the barrier beach reforms, the estuary quickly returns to generally freshwater conditions.

- Salinity increases in the lower to middle estuary due to late-fall wave overwash caused juvenile steelhead in these sections to seek freshwater conditions in the upper estuary. As expected, there was evidence of juvenile steelhead out-migration during breeching.

- The benthic invertebrate communities transition from riverine (insect) to estuarine dominated species well above the Highway 1 Bridge in the upper reach of the estuary. The dominant juvenile steelhead food source in the estuary is an isopod (zooplankton), *Gnorimosphaeroma sp.*.

- The low number of juveniles found in the estuary during the spring and early summer of 2003 likely resulted from emigration associated with the late-season breach that drained the estuary on June 15, 2003.

- Young-of-the-year (YOY) steelhead were typically more abundant in the upper estuary, especially during periods of low flow and lower estuary stratification. During this time, the upper estuary provides preferred riverine conditions for YOY. When

the entire estuary was dominated by freshwater conditions, YOY and older juveniles tended to be distributed evenly throughout the estuary.

- Scores for "Substrate Complexity" and "Physical Habitat Quality" indicated the presence of good habitat conditions for both juvenile steelhead rearing and prey items throughout the estuary.

Other limiting factor considerations:

- Field observations suggest that predation on aquatic species by mammals and birds are high throughout the late spring through summer period. The affect of this predation on juvenile steelhead population within the estuary is unknown.

Mid-summer through late-fall filamentous algal blooms are pervasive throughout the lower river and estuary. These blooms appear to occur naturally in north coast streams and result from increasing water temperature and photoperiod, as well as a supply of both natural and human-induced nutrients. The presence of these filamentous algal blooms did not appear to adversely impact steelhead juveniles during the 2002 and 2003 sampling seasons, however dense accumulations could displace fish from otherwise useable habitat.

- As to some specific limiting factors that can be caused by anthropogenic behaviors, no unnatural-illegal breaches were observed to occur during the study period. Artificial estuary breaches can have a significant negative effect on the survivability of anadromous species. Additionally, while illegal off road vehicle use is known to occur in the lower river, no data were collected that would indicate whether this activity results in significant adverse affects to juvenile salmonids. General community education that addresses these types of human behaviors is important components to the continued stewardship of the ecological resources found in the Gualala River Watershed.

- Land use and impact was not analyzed in this study. In general, the available reports such as the NCWAP report (Klamt et al., 2003), and the analysis set forth in the TMDL- sediment document (December 2001) characterize the origin, land use history, and future recommendations for land use relative to improvement of watershed conditions.

- Through the limited hydrologic analysis of sediment movement conducted through this study, sediment transport through the estuary and lower river did not appear to be a limiting factor for fisheries populations within the estuary. Very high suspended sediment values are known to adversely affect rearing salmonids. However, no suspended sediment sampling or monitoring was completed as part of this study.

- Land use practices related to timber harvest, forest conversion, and agricultural development (vineyards) were not critiqued as a portion of this study. For those practices, the authors note that successful compliance with the Forest Practices Act, and all applicable county, state, and federal regulations, as well as community stewardship of the land, are the best safeguards to ameliorate negative impacts to the watershed. The authors note that the Gualala has a developing tradition of effective landowner- stakeholder group forums to address these matters in a constructive manner.

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CHAPTER 5.0 ENHANCEMENT PLAN AND RECOMMENDATIONS

5.1 Introduction

This section describes management and enhancement opportunities that will meet the goal of sustaining and improving natural resources within the lower Gualala River and coastal estuary. This section also identifies and describes constraints on resource management efforts based on the hydrologic and biologic assessments described in the previous sections. Although the geographic focus of this section is on the lower river and estuary, successful implementation of strategies will require a watershed-based approach towards protection and enhancement. It is intended that this information serve as a planning and operational guide to assist landowners and interested parties in conserving, managing, and enhancing natural resources.

It is encouraging to note that during the timeframe of the study, the estuary and lower river appeared to be healthy and productive and estuary condition was not a limiting factor to coho and steelhead rearing. In contrast, it is important to acknowledge that the Gualala River Watershed, upstream of the estuary, remains designated as an impaired water body for sediment and temperature, and will require substantial and long-term efforts to improve overall conditions. The inhabitants of the Gualala River Watershed are in a unique position to implement watershed recovery strategies and actions: the watershed has an active and sophisticated citizenry interested in its future recovery; there has been an analysis of upper watershed conditions provided by the North Coast Watershed Assessment Program project (Klamt, 2003); there have been updates to the fisheries work conducted in response to issues raised in the NCWAP report (Gualala River Implementation Summary, 2003); preliminary TMDL analyses for both sediment (2001) and temperature (2002) have been completed; and several projects for upland restoration including retirement of old roads, instream large woody debris enhancement, and comprehensive trend monitoring for water temperature, channel morphology, and upland habitat monitoring (e.g., riparian inventories) have all been funded and completed. It should also be noted that the voluntary and proactive compliance of landowners in the

Gualala River Watershed is promising, and should be further encouraged to ensure long-term protection and enhancement of the watershed.

5.2 Existing Resource Management Activities and Regulatory Compliance

The main resource management and restoration guidance documents for the Gualala River watershed is the 2003 NCWAP report, follow up Implementation Summary reports, and TMDL studies and documents. The NCWAP program and follow up Implementation Summary reports provide important summaries and status about the watershed (estuary and lower river excluded) and specific areas of concern for restoration in each sub-basin. The NCWAP report recommendations point to the need to repair and retire as necessary the vast road network in the watershed, put more large woody debris in the streams to improve habitat complexity and provide refugia, and most importantly ensure that land management practices adequately provide for the protection and enhancement of instream habitat.

In a more limited way, the TMDL sediment document also summarizes conditions that deserve further attention in different sub-basins. While the North Coast Regional Water Quality Control Board TMDL implementation plan is still some years short of its required implementation (2007 for sediment, 2011 for temperature), each year landowners in the watershed have continued to “treat” significant portions of road in specific sub-basins. For example, 80% of the roads have received sediment reduction treatments in the Fuller Creek sub-basin, through voluntary projects, primarily funded by State and federal funds, that did not come about from mitigation or other forced action.

With the exception of the 195-acre Gualala Point Regional Park, which is managed by the Sonoma County Regional Parks Department and a combined 219 acres of State and Federal lands in the Wheatfield and main-stem South Fork watersheds, the vast majority of the watershed (190,773-acres) is privately owned (Klamt et al., 2003). Apart from several general resource management plan (RMP) objectives applicable to all Sonoma

County Regional Parks, actions that may impact natural and biological resources activities in the watershed, including restoration efforts, fall under the purview of mandatory federal and state environmental statutes. These statutes include, but are not limited to: the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA), federal Clean Water Act and state Porter-Cologne Water Quality Act, Federal Endangered Species Act (FESA) and California Endangered Species Act (CESA), and State Forest Practice Act. The Gualala River has also been designated an impaired water body (for sediment) by the U. S. Environmental Protection Agency (USEPA) and North Coast Regional Water Quality Control Board (who must set total maximum daily loads (TMDLs) for the constituents that are causing the impairment).

A number of actions identified in this section would require CEQA and/or NEPA review if they were to be implemented. Most of the proposed management recommendations can be performed under a negative declaration or a mitigated negative declaration. Management recommendations that involve Federal or state-listed wildlife species may require consultation under FESA and CESA. When considering implementation of management recommendations that may affect sensitive plants and animals, responsible parties should also anticipate in coordinating with state and federal resource agencies, including the California Department of Fish and Game and U.S. Fish and Wildlife Service.

5.3 Management Goals and Objectives

The overall goal of this enhancement plan is to sustain and improve the natural vitality and biodiversity of natural resources within the lower Gualala River and coastal estuary, much of which is dependant upon resource protection and recovery actions in the upper watershed. This goal includes the need to ensure that natural resources are not diminished, and when possible, to improve the unique and diverse aquatic and surrounding riparian, wetland, and upland habitats and the natural physical processes that sustain these habitats. To achieve this qualitative goal, objectives were developed to

identify specific and measurable desired outcomes resulting from implementing a specific management action. Thus, each management and enhancement plan objective listed below includes a brief discussion of: a) the specific implementation and/or management activities (opportunities) proposed to achieve the objective; b) the desired outcome of the objective; and c) known constraints associated with implementation of an activity. Primary protection and restoration efforts focus on: protecting freshwater inflow to the estuary; reducing sediment production from the upper watershed; enhancing aquatic habitats throughout the watershed; reducing human-derived nutrient loads to the estuary; and fostering voluntary participation of landowners in resource protection and restoration efforts. No priority or level of importance is implied by the order in which objectives are presented below.

OBJECTIVE 1: To protect the current supplies, and enhance, if necessary, freshwater inflow to the coastal estuary.

Desired Outcome: To protect water quality and aquatic habitats by maintaining the natural seasonal cycle of coastal estuary and barrier beach morphology..

Implementation Activities:

- Discourage the development of any surface water diversions in the watershed that independently or cumulatively have a significant impact on reducing the inflow to the coastal estuary, especially during summer and fall months.
- Discourage development of surface-water influenced wells that have impart similar significant adverse impact on summer base flows or recharge to the local groundwater system impacts to those stated above.
- Ensure that future residential and agricultural development projects do not adversely impact summer base flows or recharge to local groundwater systems.
- Encourage the implementation of water conservation measures throughout the watershed to reduce existing cumulative impacts.
- Restore a program of monitoring summer base flows in major tributary channels.

- Establish minimum flows in watershed tributaries, where necessary and where heavily impacted by diversion, to protect salmonid rearing habitat.
- Land acquisition or creation of conservation easements with willing partners.
- Seek to establish partnerships that provide for working landscapes consistent with the protection and enhancement of Gualala River ecological resources.
- Identify restoration planning needs and projects in watershed tributaries referenced by existing studies such as the NCWAP report.

Constraints:

- Existing legal and illegal water diversions.
- Natural variability in climate and stream flows.
- Data gaps for implementation of restoration goals.

OBJECTIVE 2: To eliminate any potential for unnatural breaching of the barrier beach.

Desired Outcome: To maintain the seasonal cycle of coastal estuary and barrier beach morphology and protect aquatic habitats.

Implementation Activities:

- Develop an educational and public awareness program to alert local residents of impacts to estuary ecology due to artificial breaching.
- Post sign at kiosk at County Park informing public about beneficial attributes of a coastal estuary system and ecological risks of artificial breaching.

Constraints: Funding availability for educational outreach has been scant for watershed groups in the recent past.

OBJECTIVE 3: To assess and minimize possible input of toxics or excessive nutrient loads to the estuary.

Desired Outcomes:

- Improved aquatic habitat for avian and other wildlife species that rely on aquatic habitats for food.
- Protect estuary from eutrophication.
- Reduce algae growth in lower river and estuary.

Implementation Activities:

- Assess and reduce the use of toxic herbicides, pesticides and other agricultural chemicals in the watershed.
- Investigate cumulative impacts of septic system and water treatment discharges, if any.
- Ameliorate dysfunctional septic systems, if present.
- Educate and reduce the potential for illegal or irresponsible dumping.

Encourage Best Management Practices in both developed/urban areas and upper watershed, using existing programs and documents such as the SRCD House and Garden Audit, Farm Planning and Backyard Stewardship Programs.

Constraints:

- Identify funding sources.
- Landowner participation.

OBJECTIVE 4: To reduce excessive sediment supplies to lower river and estuary.

Desired Outcome: Protect and enhance aquatic habitat for resident fish and organisms as well as for avian and other wildlife species that rely on aquatic habitats for food not only in the lower river and estuary, but also throughout the entire watershed.

Implementation Activities:

- Expand on NCWAP report ranking charts at sub-basin priority levels for fisheries, instream, and upland restoration work. The natural sequence is to continue this work with the following steps:
    a. Identify highest priority sub-basins for restoration; identify and rank priority projects in the top sub-basins
    b. Integrate restoration rankings with NCWAP series maps that address these factors and prioritize projects in each sub-basin
    c. Cross-reference and chart multiple target restoration goals from agency and group sources (SCC, DFG, SWRCB, GRWC, etc) and identify benchmarks to satisfy the goals. This tool is useful for cross-agency communication.
    d. Address data gaps and provide funding to complete data collection where landowner permission is gained
- Continue to encourage more environmentally friendly logging and land development practices, (including BMPs). Ensure consistency with Forest Practice Rules.
- Develop an educational and public awareness program to alert local residents of the impact of off-road vehicles in streambeds and associated upland areas, and other related topics.
- Conduct sediment source analysis for priority roads and related features identified in the NCWAP report maps as potential contributors of fine sediment.
- Repair and Retire logging roads, and treat other upslope sediment sources identified in the NCWAP report maps and identified through field reconnaissance.
- Land conversion and acquisition.
- Pursue property acquisitions or easements that provide for working landscapes consistent with the protection of the Gualala's ecological resources
- Long-term monitoring of estuary profiles to track changes in morphology.
- Evaluate potential effects of instream gravel mining relative to degradation or creation (through pool construction or channel modification) of instream habitat.

Constraints:

- Identify funding sources.
- Landowner participation.

OBJECTIVE 5: Implement public outreach efforts for landowner sediment reduction and instream habitat improvement project development once sub-basin priorities are met and supporting data available.

Desired Outcome: Improve habitats for aquatic species and reduce the threat of adverse impacts to the estuary from sediment and water quality impairments.

Implementation Activities:

- Develop a series of parcel map databases to guide outreach process appropriate to sub-basin priority needs.
- Develop and document outreach.
- Identify and fund prioritized enhancement projects.
- Conduct necessary pre-project inquiries such as sediment source investigations, planting designs, and specific permitting requirements.
- Conduct pre and post monitoring of project effectiveness and relate monitoring to existing trend monitoring underway for the larger watershed.
- Provide watershed wide education and networking about watershed project accomplishments and restoration project developments.

Constraints:

- Identify funding sources.
- Landowner participation.

OBJECTIVE 6: To increase public awareness of the importance of dune and dune scrub vegetation.

Desired Outcome: Improve habitats for sensitive native plants and nesting birds.Encourage public awareness of sensitive plants and nesting birds.

Implementation Activities:

- Education and stewardship programs through community and County Park.
- Reduced/improved trail access and signage through/from County Park.
- Removal of non-native (competing) plant species.

Constraints:

- Heavy public access through County Park.
- Presence and competition from exotic species.

OBJECTIVE 7: To further develop and facilitate consensus of watershed resource management plan goals, objectives, and implementation strategies and prepare a watershed resource management and restoration implementation plan.

Desired Outcome: Buy-in of local landowners, resource/regulatory agencies, and other local stakeholders.

Implementation Activities:

- Utilize the GIS developments already provided to the watershed such as the sophisticated road routing layer that can identify and track both road related restoration features (down to specific culvert replacements), and stream related restoration as well.
- Develop a large wood inventory budget on a watershed wide basis that predicts natural woody deposition rates into streams.

- Develop a water budget that addresses flow rate and quantity issues needed to provide a healthy ecosystem to offset impairment conditions.
- Provide the capacity for data development, management, quality control, and data entry that updates NCWAP digital databases, report addendums, map development, etc.
- Coordinate/meet with local landowners and agency staff to revise and approve the resource management and restoration plan.
- Work with stakeholders to develop an implementation strategy for proposed management actions.
- Develop public education and stewardship programs.

Constraints: Interest and financing.

OBJECTIVE 8: Evaluate the condition of terrestrial, riparian and wetland habitats bordering the lower river and estuary with the aim at developing management and restoration strategies to protect improve them.

Desired Outcome: To delineate riparian and wetland areas; develop a comprehensive list of plants and wildlife residing along the lower river and estuary; identify endangered and sensitive plant and animal species residing and/or utilizing the lower river and estuary; develop a map of plant species, communities, habitat zones, and species distribution; describe the use and dependence of bird and wildlife species on the lower river and estuary aquatic system; and identify opportunities to preserve and improve habitat for plant and animal species and the healthy linkage to the adjacent aquatic ecosystems.

Implementation Activities:

- Conduct the specific biologic, botanical and ecologic surveys and studies necessary to address the specific outcomes listed above.

Constraints:

- Competition from non-native and exotic species.
- Majority of surrounding property is under private ownership.
- Heavy public access through the County Park.

OBJECTIVE 9: To protect and enhance steelhead and Coho salmon habitat.

Desired Outcome: Improve habitats for spawning and rearing steelhead and Coho salmon.

Implementation Activities:

- Implementation of any or all of the Objectives (1 through 8) listed above.

Constraints:

- Interest and financing.

5.4 Summary of Recommendations

In an effort to assist local resource management entities with implementation of the estuary protection and enhancement strategies outlined above, the following list of data collection and analysis tasks are proposed. A brief description of the rational and need for these items and how they will contribute to protection and enhancement of the coastal estuary is also provided.

1. Identify and quantify the volume of existing and proposed surface water diversions and groundwater extractions in the river basin in terms of percent of estimated annual flow at selected locations. The objective of this investigation is to determine the degree of reduction in freshwater inflow to the coastal estuary and attempt to identify the minimal seasonal inflow needs to maintain healthy conditions. This study should also assess potential impacts to changes in North Fork Gualala River summer

baseflow, the main summer/fall source of surface inflow to the lower river and estuary.

2. Continue river flow monitoring at existing USGS gauges. These data are necessary to accurately and reasonably quantify freshwater inflow to the estuary. Again, these data along with concomitant estuary water level and water quality monitoring will assist in identifying minimum freshwater inflow requirements to maintain healthy juvenile steelhead rearing conditions.

3. Complete a detailed water budget of the estuary to quantify the magnitude and importance of groundwater inflow and barrier beach seepage (outflow) in maintaining favorable freshwater conditions in the estuary during the summer and fall periods.

4. Perform an impact assessment of mammal and bird predation on juvenile steelhead populations in the coastal estuary. The objective of this analysis is to determine the relative significance/stress predation has on juvenile steelhead populations in the estuary.

5. Complete biologic and botanical assessments to map wetlands, inventory riparian and upland wildlife species (esp. endangered and sensitive species), and identify and map native and exotic plant species in and around the study area, with emphasis on dune and scrub vegetation and marsh ecology in the lower and middle reaches corresponding to the county parks and private landowner parcels. Prepare an exotic removal and planting plan to address future restoration and management efforts.

6. Continue a hydrologic/geomorphic monitoring program including: weekly photo-monitoring; continuous estuary water level monitoring; seasonal estuary morphology surveys; gravel bar pebble counts; and bimonthly or event-driven water quality monitoring of the coastal estuary. The objectives of this work are consistent with those outlined in the Hydrology Section of the report. Collecting this information

during a wider variety of water year types will be necessary to: 1) understand the effects of reduced freshwater inflow; 2) identify periods and conditions associated with poor rearing habitat (not observed during the 2002 and 2003 sampling seasons); and 3) assist in quantifying the minimum freshwater inflow rate to maintain healthy aquatic ecological conditions.

7. Implement a nutrient, toxic chemical, and general water quality parameter monitoring program to determine: 1) the source of nutrients fueling algal blooms in the lower river and estuary and threat of eutrophication from instream, near-stream, and upstream (upslope) sources; 2) collect and identify the algae and aquatic plants of concern; 3) collect chlorophyll and nutrient samples and conduct sediment oxygen demand sampling and analyses; 4) identify and evaluate the relative importance of other hydrologic and water quality factors contributing to algal blooms; 5) evaluate if any chemical applications within the watershed are impacting the lower river and coastal estuary; and 6) identify and quantify historic, existing and future potential nutrient sources including septic systems, agricultural operations, and other potential sources. It cannot be overstated that, together with decreased freshwater inflow rates, increased nutrient loads pose the greatest threat to long-term health of aquatic habitat in the estuary.

8. Continue fish sampling pursuant to the methods and approach followed as part of this investigation. The objective of this continued sampling is to evaluate population and habitat conditions over a broader range of water year-type conditions and to test population estimators over a broad range of conditions.

9. Conduct fish escapement surveys to better understand affects of spawning stock on extent of production and recruitment.

10. Better investigate the use of the lower river and North Fork as summer/fall refugia during periods of increased salinity in the estuary associated with wave overwash.

11. Expand on the results and interpretations of this study with previously published work on the north coast for purposes of regional watershed recovery planning. Integrate the findings from this narrow scope of work into the broader watershed perspective.

LIST OF APPENDICES

Appendix A. Hydrology

Appendix B. Water Quality

Appendix C. Fish Species Length Frequency Histograms

Appendix D. Benthic Macroinvertebrate Data

APPENDIX A

Hydrology

APPENDIX A.1

Methodology for Estimating Freshwater Inflow to Gualala River Coastal Lagoon

Kamman Hydrology & Engineering, Inc.

The primary objective of this analysis is to develop a daily freshwater inflow record for the Gualala River Coastal Lagoon; the study period for the analysis ranges from 10/1/00-1/31/04. The following is a brief description of the methodologies used in constructing the inflow record.

The contributing watershed was broken into 7 tributaries: Wheatfield Fork, South Fork, North Fork, Rockpile, Buckeye, Pepperwood, and the Remaining South Fork. The average daily flow for each tributary was calculated, or estimated, for each day of the period of analysis (10/1/00 – 1/31/04), and the sum of the daily flow values was used to estimate the daily freshwater input to the Estuary.

DAILY TRIBUTARY INFLOW: Wheatfield Fork, South Fork, and North Fork

Wheatfield Fork (WF)

- Data was obtained from the California Department of Water Resources (DWR) or the United States Geological Survey (USGS) for the following parameters and dates:
  - FLOW: 10/1/00-9/30/02; 6/10/03-11/29/03; 12/3/03-1/31/04
  - STAGE: 10/1/01-2/23/03; 2/28/03-1/31/04
- Missing daily flow values for 10/1/02-2/23/03; 2/28/03-6/9/03; and 11/30/03-12/2/03 were calculated from a derived stage-flow equation/relationship (i.e., a rating curve) for WY 2002.
- WF Rating Curve: Upon analysis of the rating curve, it was separated into 3 parts and 3 different equations (see Figures 1 and 2).
  - For stage <= 3.69 ft: (WF Q) = $4x10^{-32}(h)^{57.146}$ [R^2 = 0.9817]
  - For stage <= 3.78 ft: (WF Q) = 75(h) – 266.5 [R^2 = 1.0]
  - For stage > 3.78 ft: (WF Q) = $81.83(h)^2 – 589.58(h) + 1076.6$ [R^2 = 0.9973]
  - *Q = flow (cfs); h = stage (ft)*

South Fork (SF)

- Data was obtained from the California Department of Water Resources (DWR) or the United States Geological Survey (USGS) for the following parameters and dates:
  - FLOW: 11/18/00-9/30/02
  - STAGE: 10/1/01-9/30/02; 12/23/03; 12/26/03; 12/29/03
- A rating curve was developed for the SF for WY 2002. However, only 3 mean daily stage values (above) exist outside the range of dates that have reported flow values. Thus, the rating curve is presently not useful for predicting flows.

Missing daily flow values for 10/1/00-11/17/00; and 10/1/02-1/31/04 were calculated via a regression analysis with the WF.

- Flow-Regression (WF vs. SF): SF flows were predicted using the following regression equation (see Figure 3):
  - (SF Q) = $0.3265(\text{WF Q})^{1.0835}$ [$R^2 = 0.9694$]
  - *note*: SF flows <= 0.1 were omitted from the regression

North Fork (NF)

- Data was obtained from the California Department of Water Resources (DWR) or the United States Geological Survey (USGS) for the following parameters and dates:
  - FLOW: 10/1/00-9/30/02
  - STAGE: 10/1/01-9/30/02; 12/11/02-2/23/03; 2/26/03-1/31/04
- A rating curve was developed for the NF for WY 2002. However, the rating curve predicted unusually high summer/base flows for the NF (WY 2003) compared to the USGS WF flow data for that same time period. It was noticed that the stage values for the NF in the summer of 2003 were consistently about 1-foot higher than the stage values in the summer of 2002. Thus, a change in channel geometry likely occurred between these two periods and may account for the pronounced discrepancies in the predicted base flow values. For higher flows (ca. above 200 cfs), the rating curved predicted reasonable NF flow values, but it cannot be determined at this point what effect a potential change in channel geometry has on these predicted NF flow values as well. For these reasons, the rating curve is not being used at this time.

  Missing NF daily flow values for 10/1/02-1/31/04 were calculated via a regression analysis with the SF. An initial regression was done for both SF vs. NF and WF vs. NF for WY 2001-2002, and the R^2 value was slightly better for the overall SF vs. NF regression. Because of distinctly different relationships (particularly for the lower flows), or trends (i.e., an obvious shift in the regression line and data), for WY 2001 vs. 2002, only WY 2002 was used for the final regression equations.

- Flow-Regression (SF vs. NF): Upon analysis of the data, the regression curve was separated into 2 parts and 2 different equations. NF flows were predicted using the following regression equations:
  - For SF stage <= 4.7 ft: (NF Q) = 1.8361(SF Q) + 7.7646 [$R^2 = 0.9615$]
  - For SF stage > 4.7 ft: (NF Q) = $3.2334(\text{SF Q})^{0.8142}$ [$R^2 = 0.9533$]
  - *note*: SF flows <= 0.1 were omitted from the regression
  - *note*: 10/31/01 was omitted from the regression (outlier)

Daily unit runoff values (cfs/mi^2) were then calculated for the above 3 tributaries

DAILY TRIBUTARY INFLOW: Rockpile, Buckeye, Pepperwood Creeks and remaining drainage area.

Unit runoff values (cfs/mi^2) were calculated for all 7 tributaries based on field data collected by Kamman Hydrology & Engineering, Inc. (KHE) on 9/4/2002, 9/27/2002, and 11/1/2002 (see Table A-1-1). All flow measurements were completed using standard flow measurements to the procedures and protocols outlined in:

Rantz, S.E., 1982, Measurement and computation of streamflow, Volume 1. Measurement of stage and discharge. U.S. Geological Survey Water Supply Paper 2175, 284p.

All flow measurements were completed near the confluence with the main-stem Gualala River. Based upon similarities among unit runoff values for the various tributaries, the daily unit runoff values calculated for the 3 tributaries above were used as surrogates in order to derive complete flow records (daily time step) throughout the period of analysis for the 4 remaining tributaries (*below*).

Rockpile (RP)
(RP Q) = (SF q)(RP da)
where: *q = unit runoff (cfs/mi^2)*
da = drainage area (mi^2)

Buckeye (BU)
(BU Q) = (WF q)(BU da)

Pepperwood (PW)
(PW Q) = (NF q)(PW da)

Remaining South Fork (remSF)
(remSF Q) = (SF q)(remSF da)

TABLE A.1.1
Base Flow Measurements on Select Gualala River Tributaries

Location		Q (cfs)	Temp (C)	Temp (F)	Cond. (uS)
South Fork at Switchville	8/16/2002	11.73	19.90	67.82	209.20
	9/4/2002	8.44	20.90	69.62	212.00
	9/27/2002	7.35	16.40	61.52	218.00
	11/1/2002	8.08	12.7	54.86	216.00
North Fork USGS gage location	9/4/2002	3.87	16.30	61.34	189.00
	9/27/2002	3.01	15.60	60.08	188.00
	11/1/2002	3.31	11.30	52.34	190.00
North Fork at North Gualala Water Company Well 5	9/4/2002	2.15	16.40	61.52	185.90
	9/27/2002	1.92	15.70	60.26	182.00
	11/1/2002	1.77	12.40	54.32	182.50
North Fork at Confluence wth Little North Fork	9/4/2002	3.38	15.70	60.26	194.90
	9/27/2002	3.21	15.10	59.18	193.00
	11/1/2002	2.55	12.50	54.50	194.00
Pepperwood Creek Near mouth	9/4/2002	0.17	13.20	55.76	211.50
	9/27/2002	0.21	13.20	55.76	211.50
	11/1/2002	0.17	8.40	47.12	207.10
Rockpile Creek.	9/4/2002	0			
	9/27/2002	0			
	11/1/2002	0			
Buckeye Creek	9/4/2002	0.59	16.90	62.42	253.80
	9/27/2002	0.64	15.00	59.00	256.00
	11/1/2002	0.98	10.20	50.36	247.90
Sourth Fork at Sea Ranch well	9/4/2002	1.04	20.20	68.36	265.70
	9/27/2002	1.24	16.80	62.24	253.00
	11/1/2002	1.61	15.00	59.00	263.50
Sourth Fork at USGS gage location	9/4/2002	0			
	9/27/2002	0			
	11/1/2002	0			
Wheatfield Fork at USGS gage location	9/4/2002	0.63	20.20	68.36	265.70
	9/27/2002	0			
	11/1/2002	0			

APPENDIX A.2

Results of Pebble Count Analysis

Kamman Hydrology & Engineering, Inc.

Pebble counts and grain-size distribution analyses followed the methods outlined in the following documents:

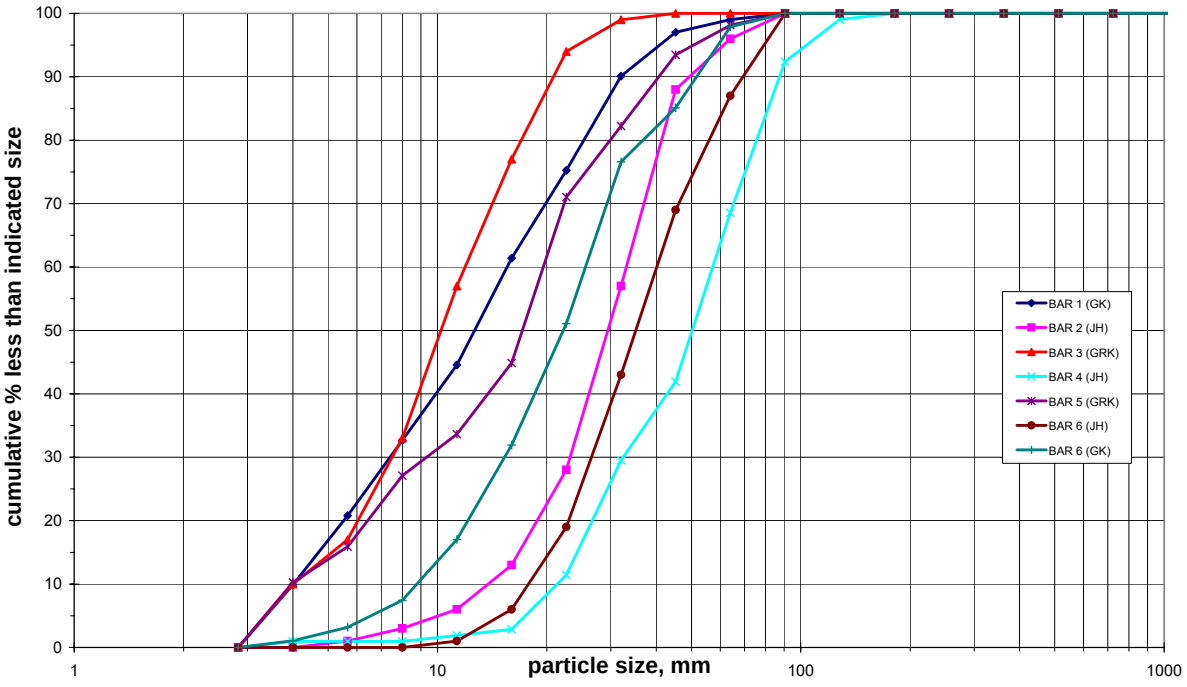
Bunte, K. and Abt, S.R., 2001, Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analyses in sediment transport, hydraulics, and streambed monitoring. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-74, May.

Kondolf, G.M., 1997, Application of the pebble count: noteson purpose, method, and variants. Journal of the American Water Resources Association, vol. 33, no.1, February, pp. 79-87.

Grain size distributions are presented on the following graphics. See report text for sample dates and locations.

FIGURE A.2.1
Pebble Count Grain-Size Distributions
Gualala Lower RIver and Coastal Lagoon Assessment and Enhancement Plan

Results from September 2002 Sampling



Results from June 2003 Sampling

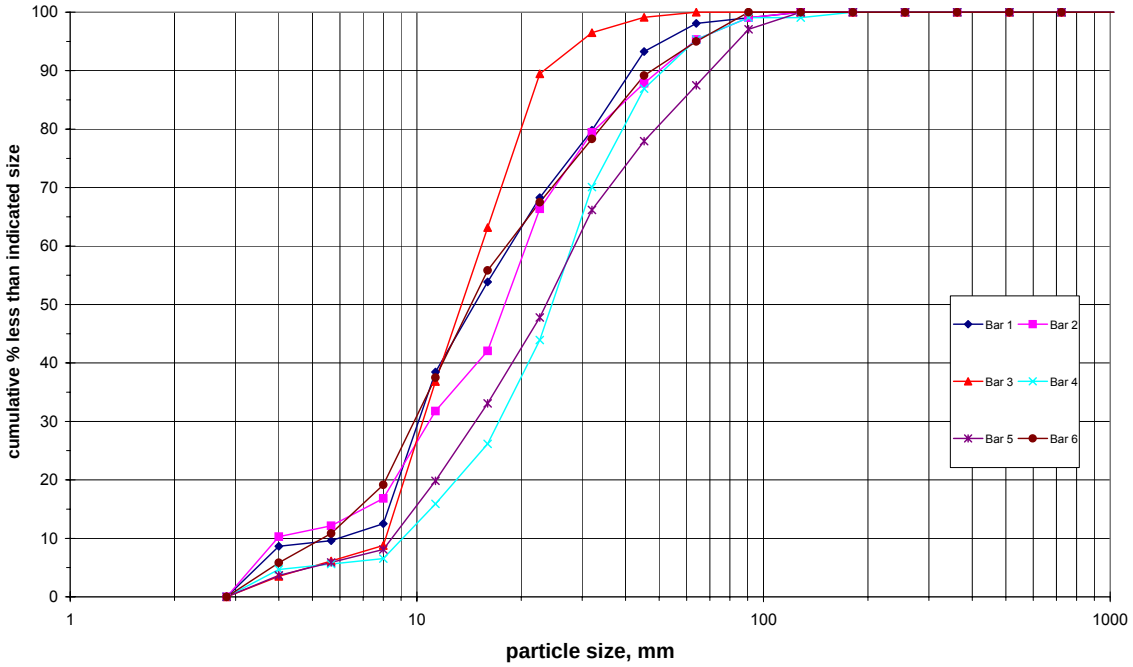
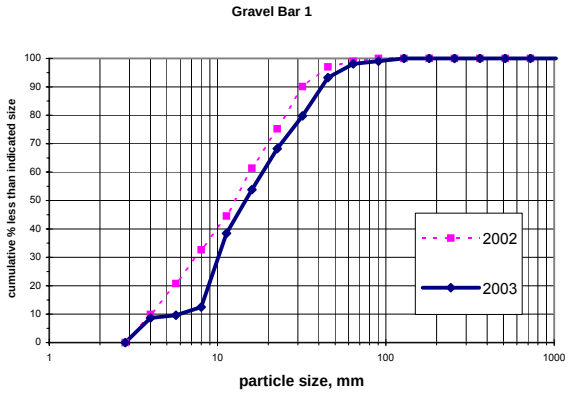
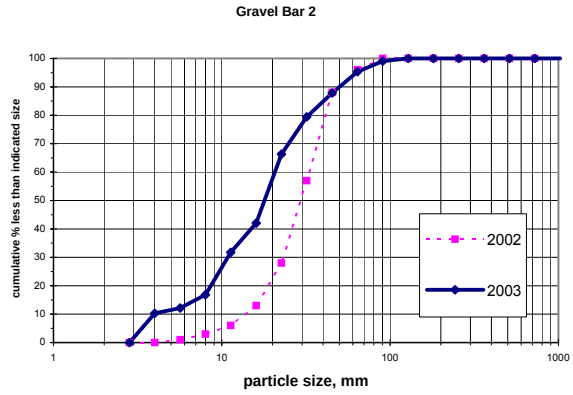
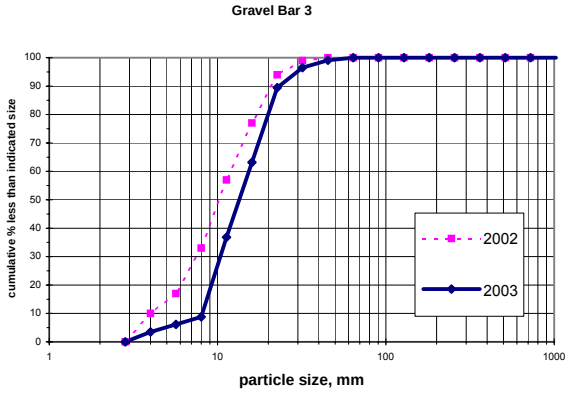
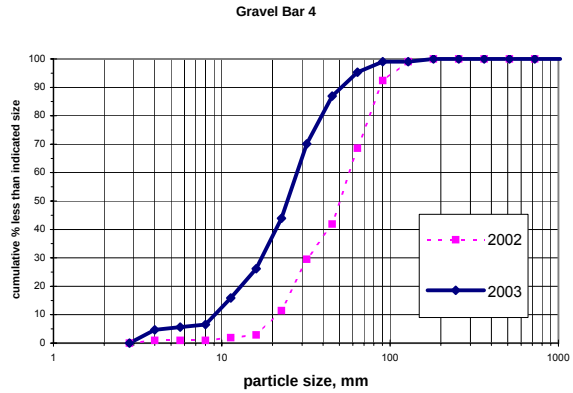


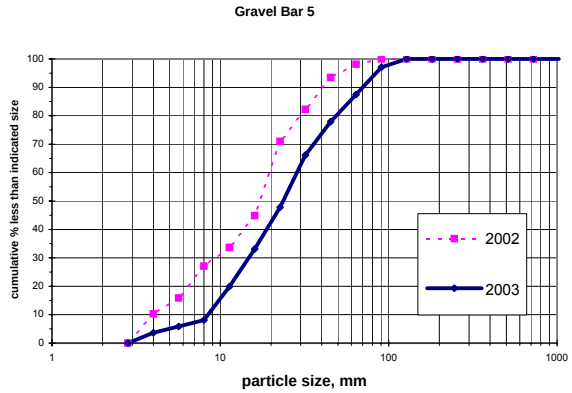
FIGURE A.2.2
Pebble Count Grain-Size Distributions
Gualala Lower RIver and Coastal Lagoon Assessment and Enhancement Plan

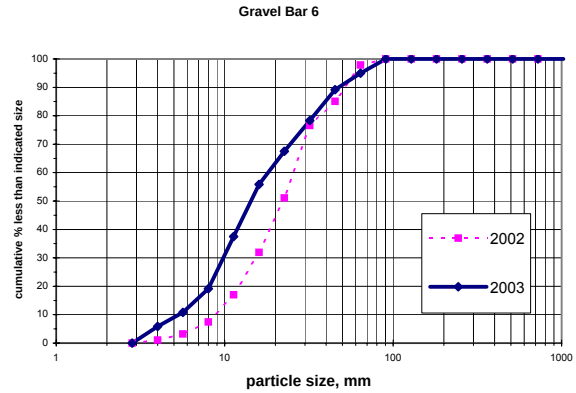








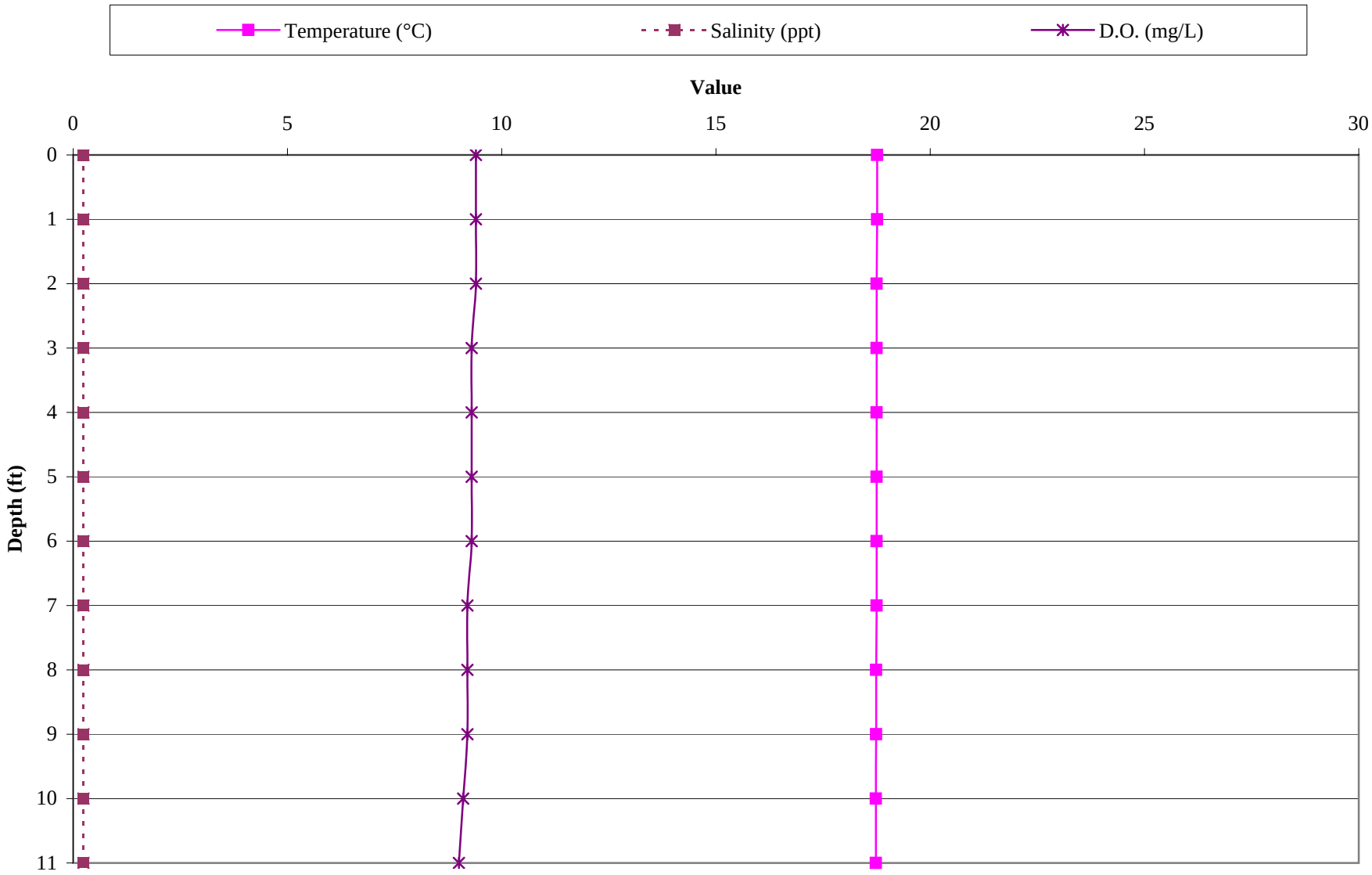




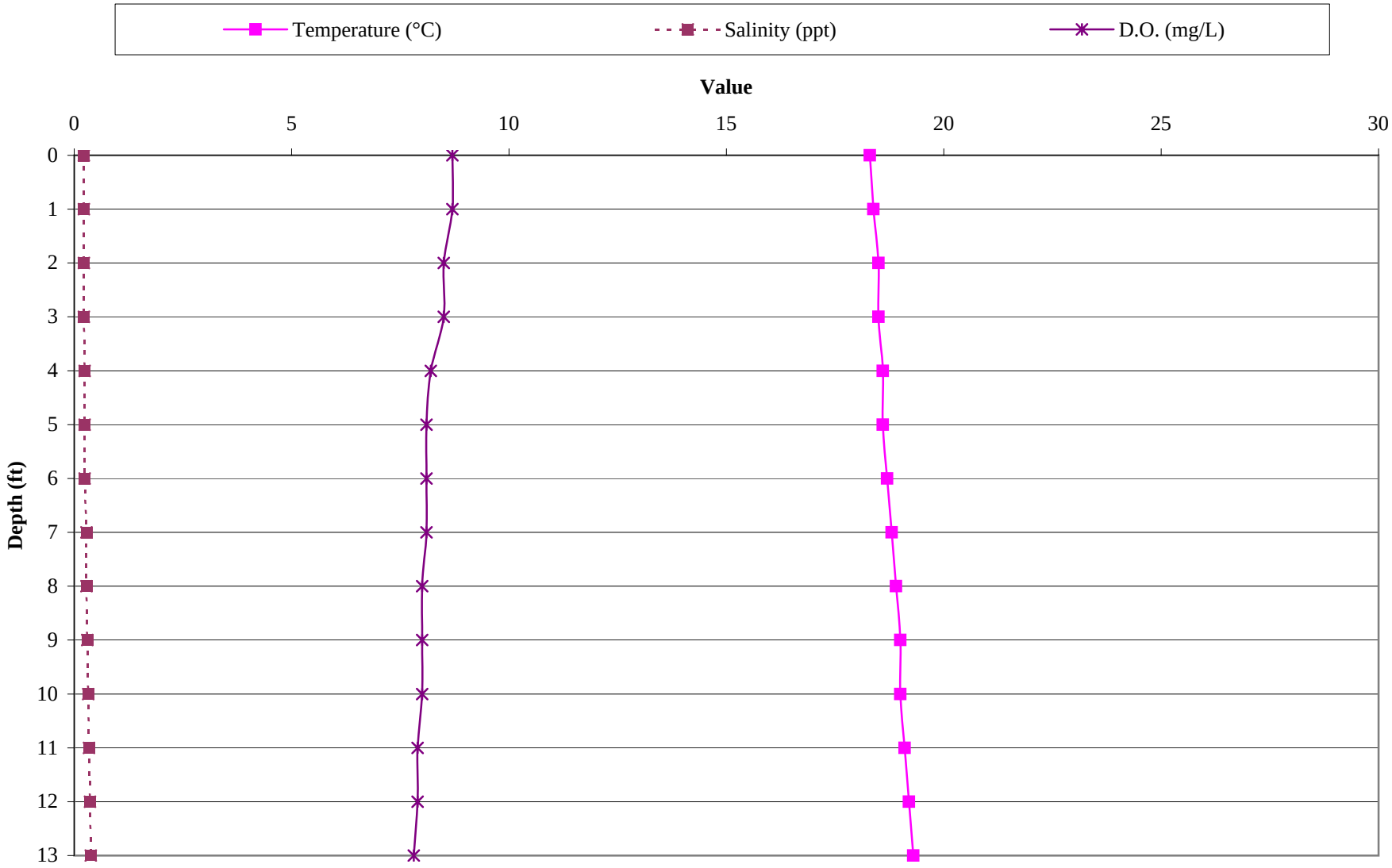
APPENDIX B

Water Quality

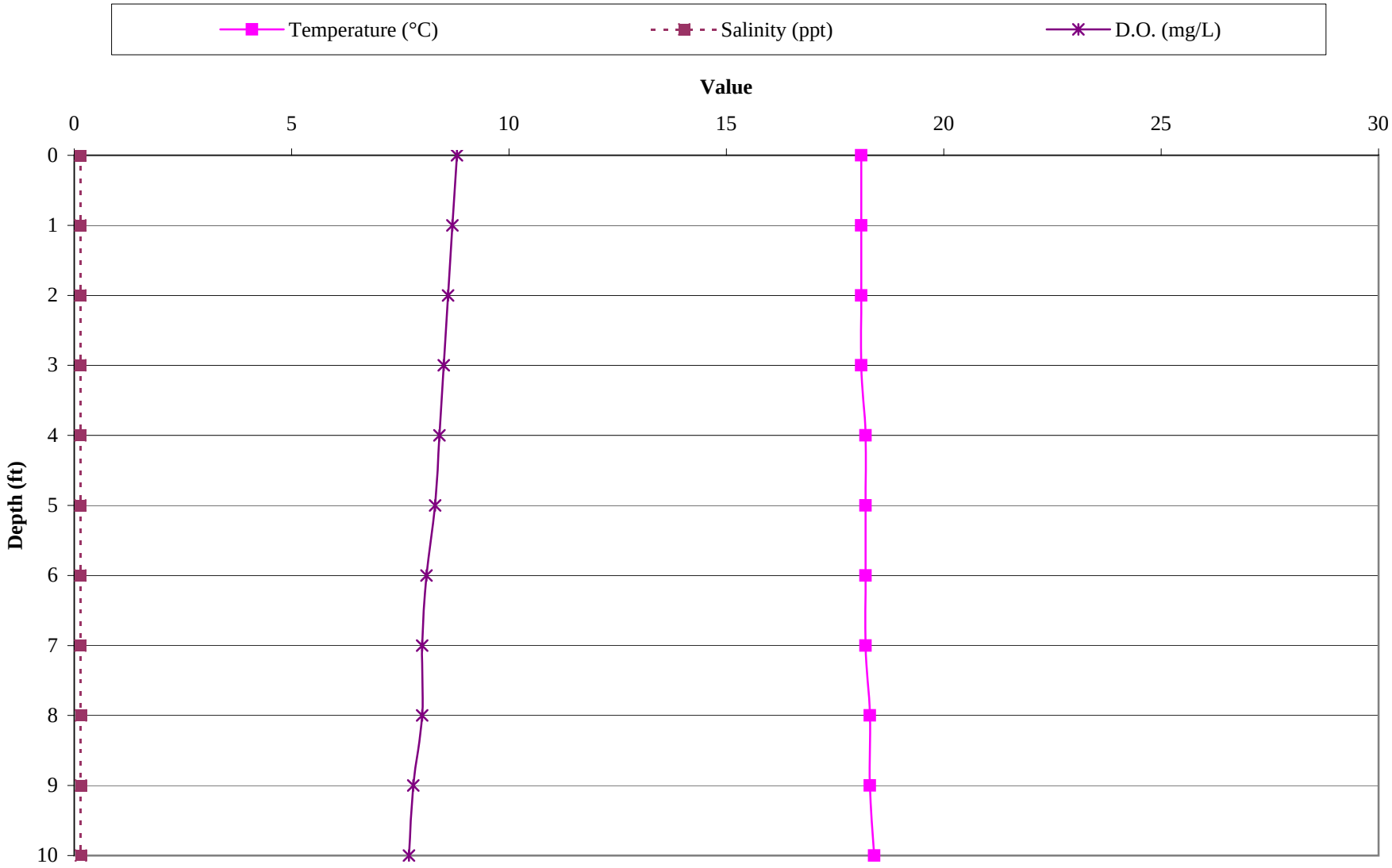
Appendix B-1. Gualala Water Quality Depth Profile - Mouth of the Estuary - 6/12/02.



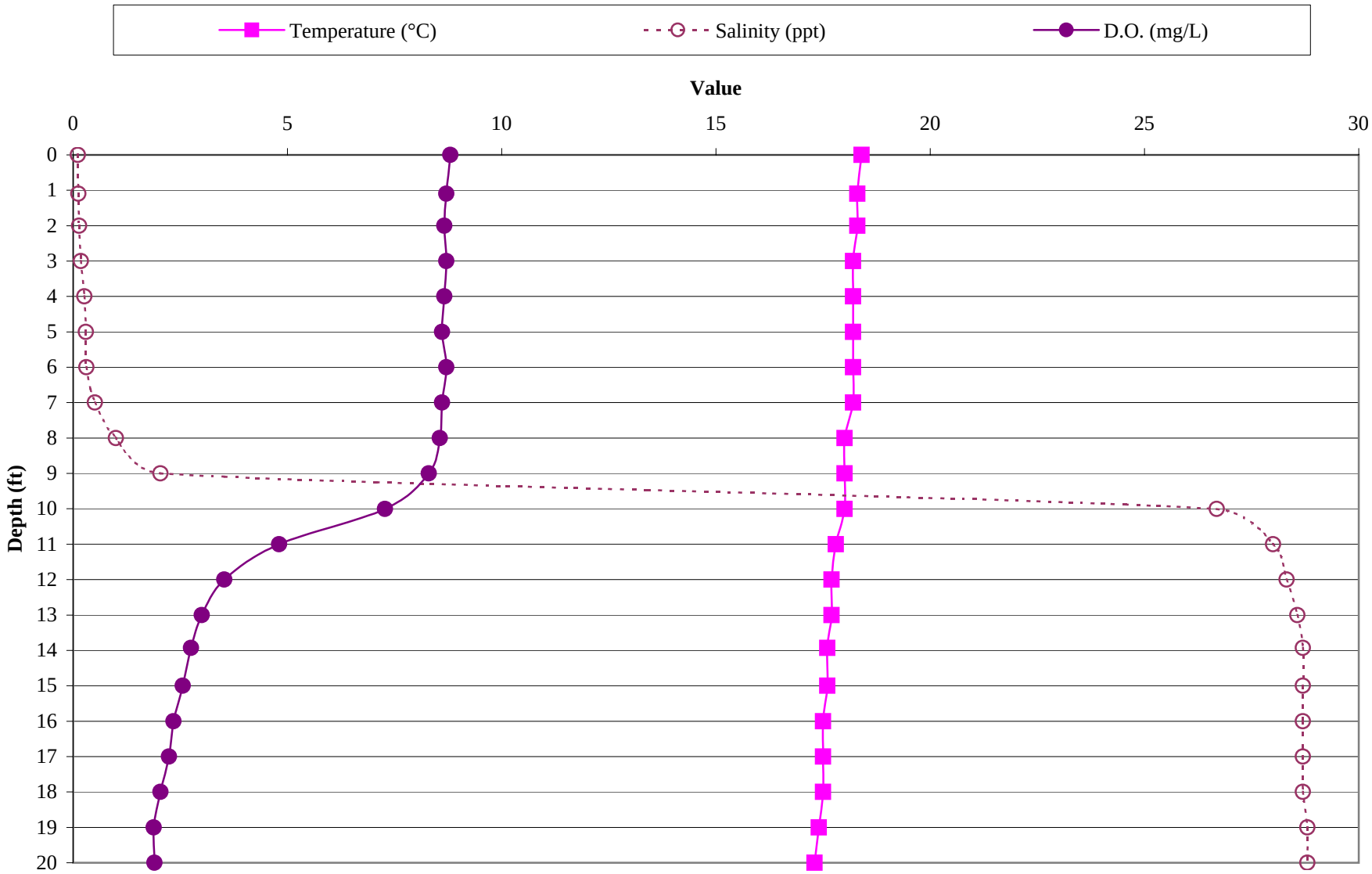
Appendix B-2. Gualala Water Quality Depth Profile - Tide Guage -6/12/02.



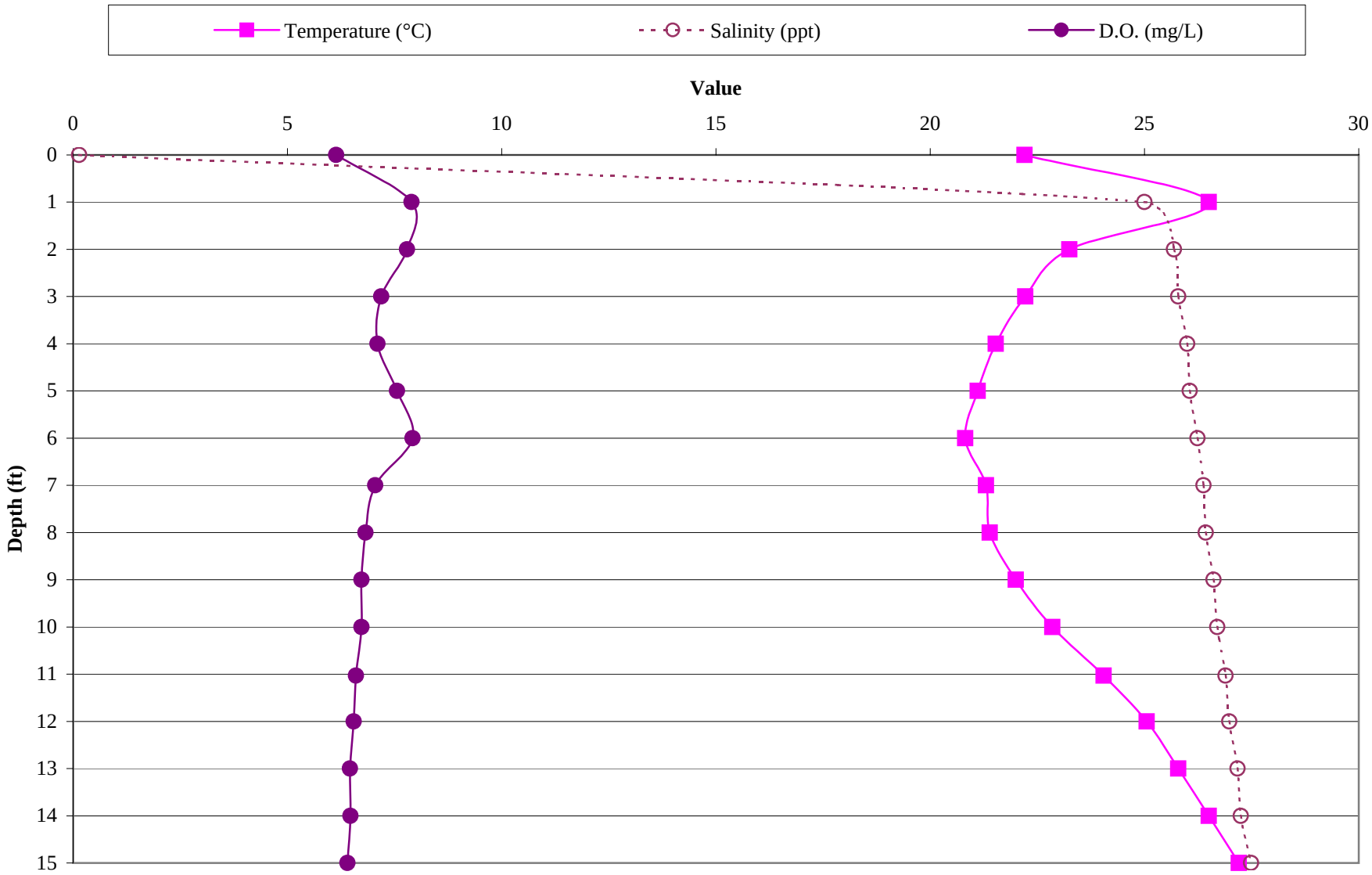
Appendix B-3. Gualala Water Quality Depth Profile - China Gulch - 6/12/02.



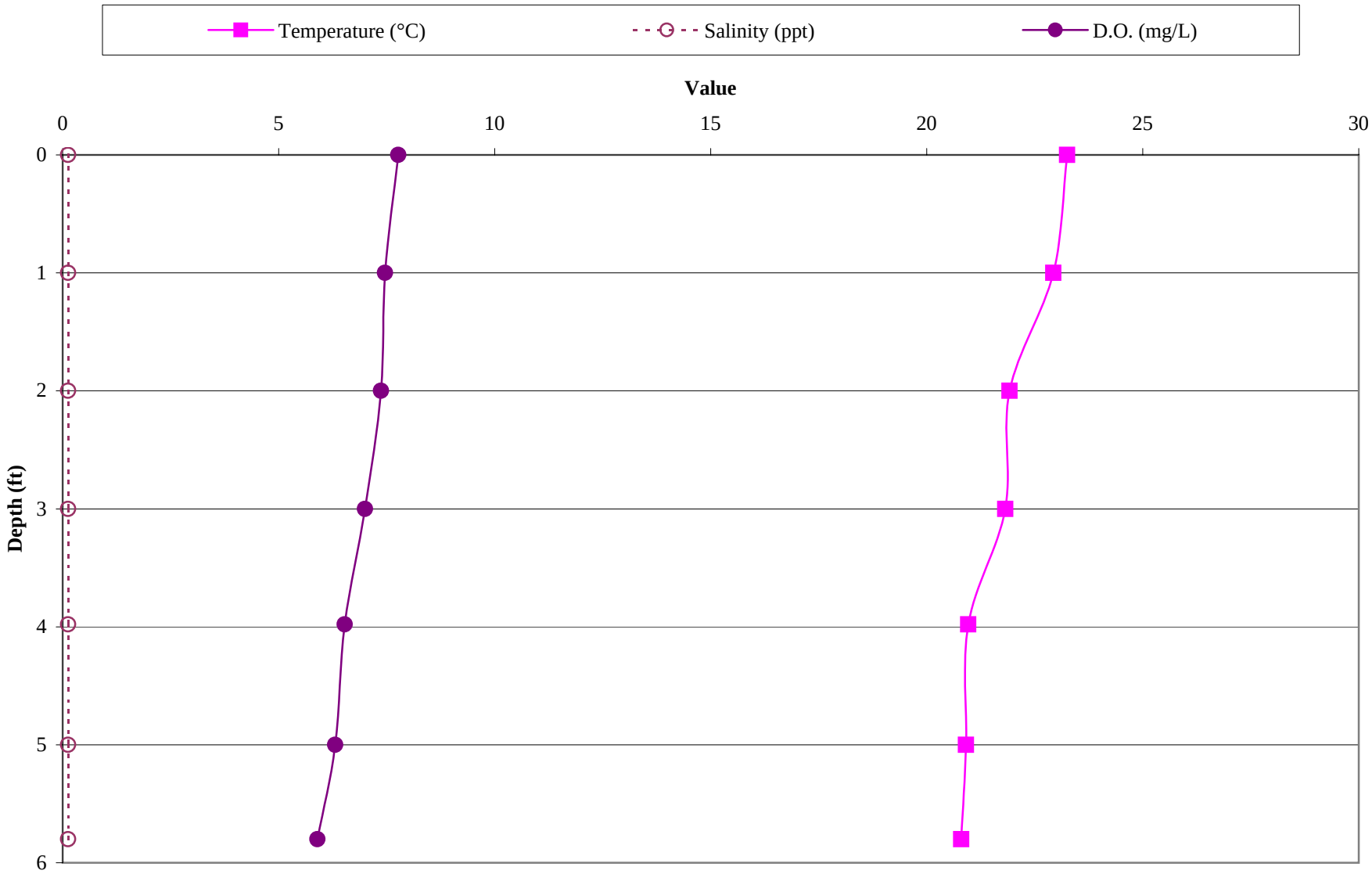
Appendix B-4. Gualala Water Quality Depth Profile - Mill Bend - 6/12/02.



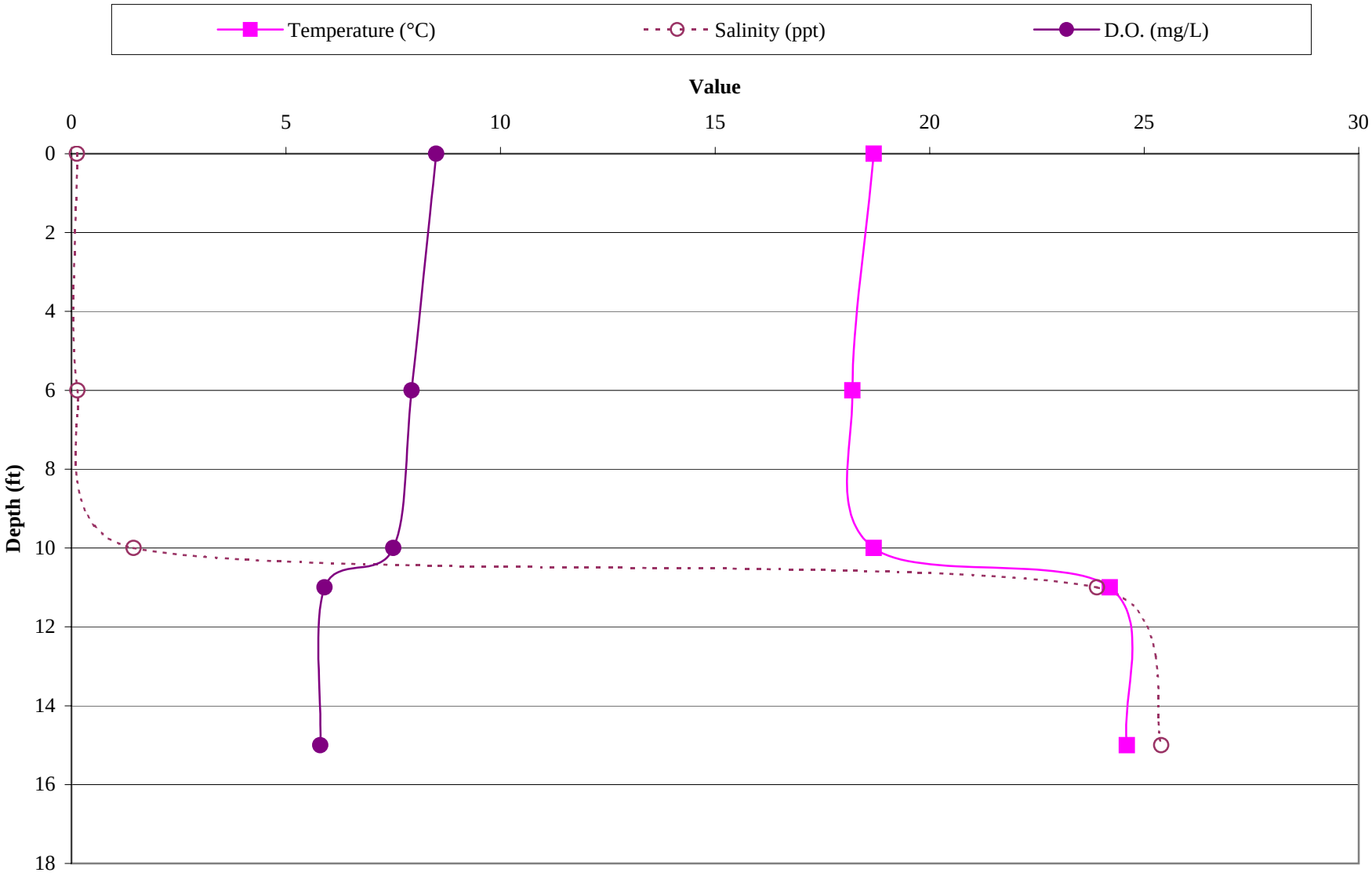
Appendix B-5. Gualala Water Quality Depth Profile - Mill Bend - 7/11/02.



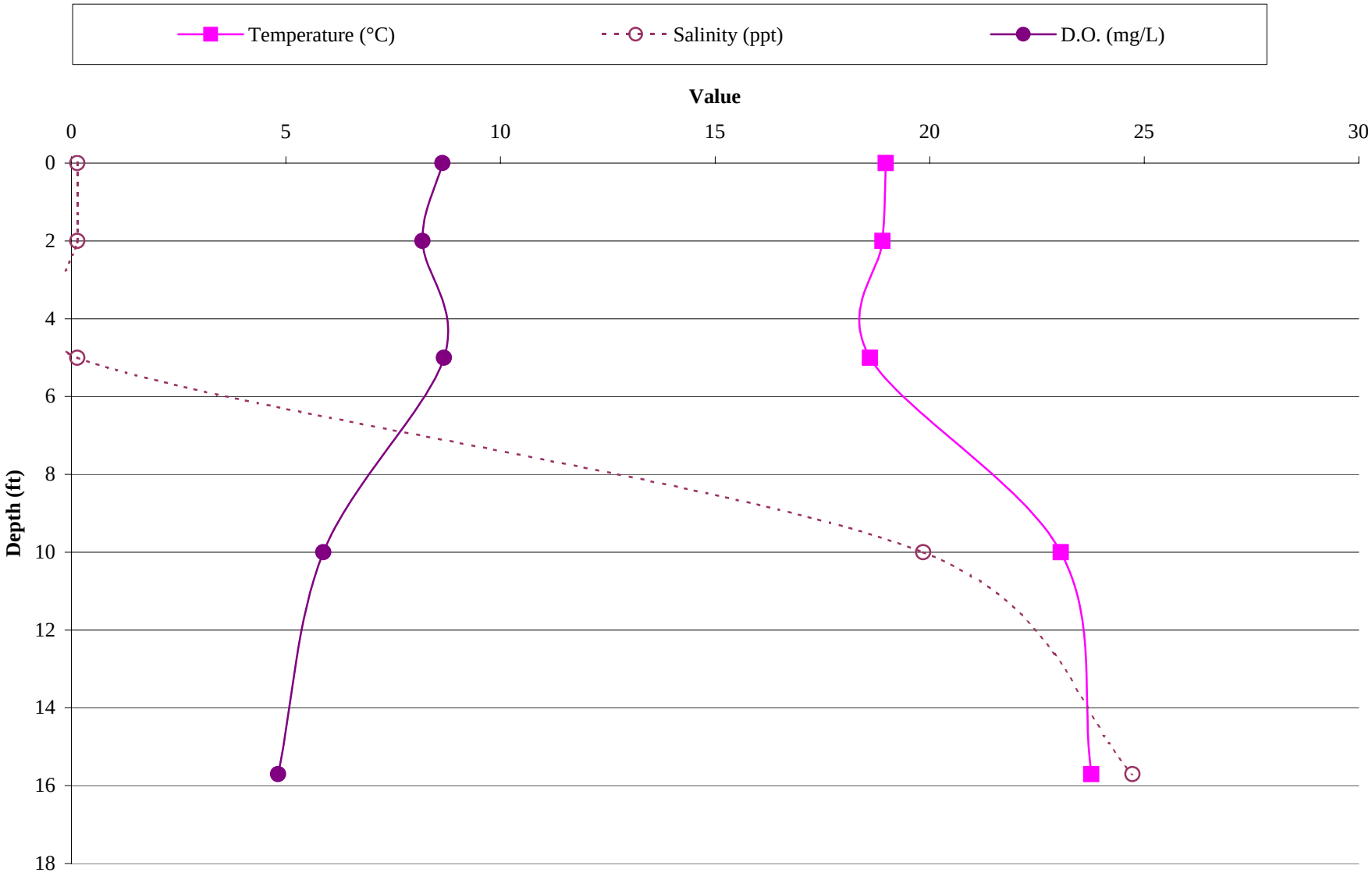
Appendix B-6 Gualala Water Quality Depth Profile - Above Highway 1 Bridge - 7/11/02.



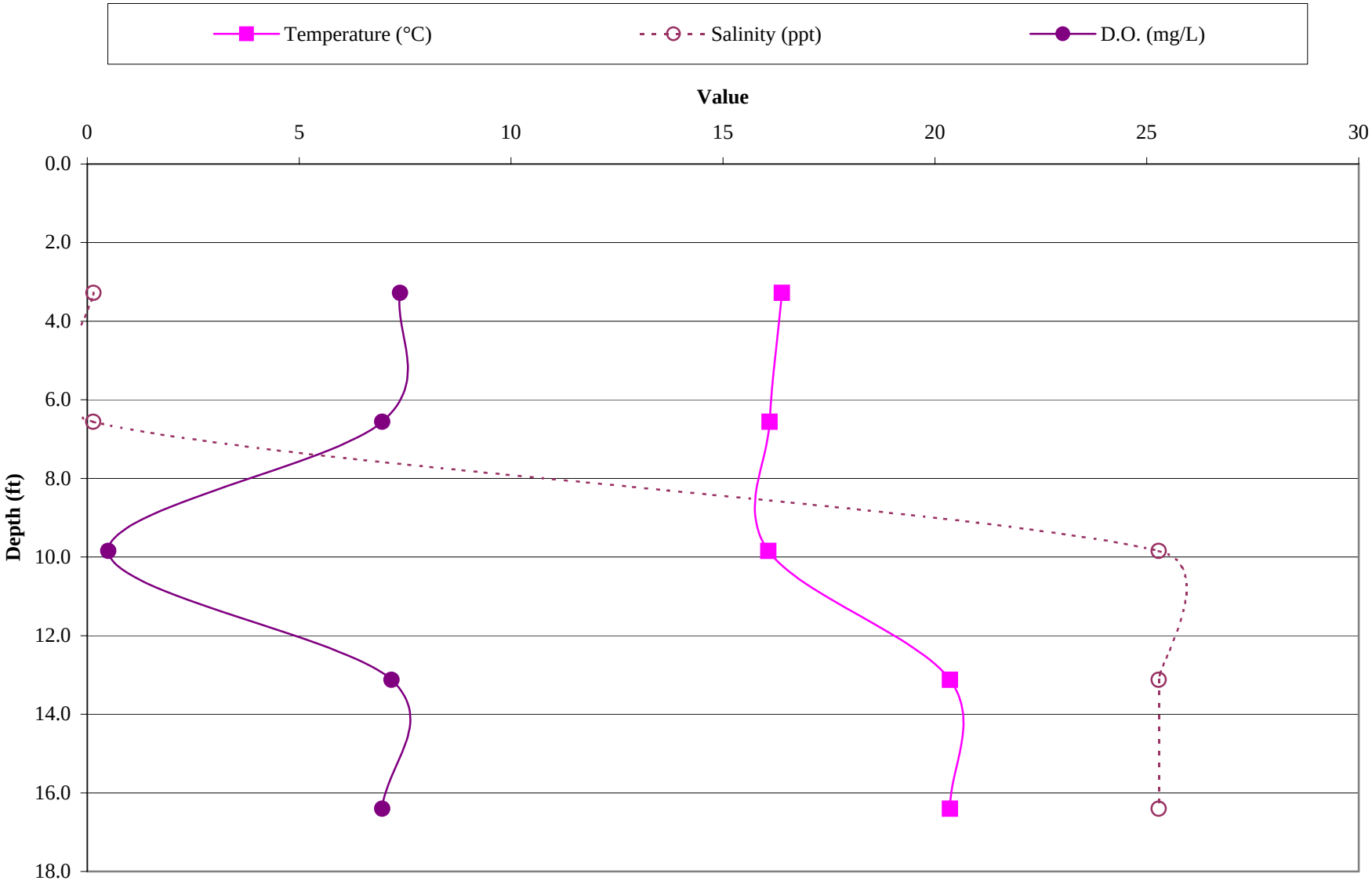
Appendix B-7. Gualala Water Quality Depth Profile - Mill Bend - 8/2/02



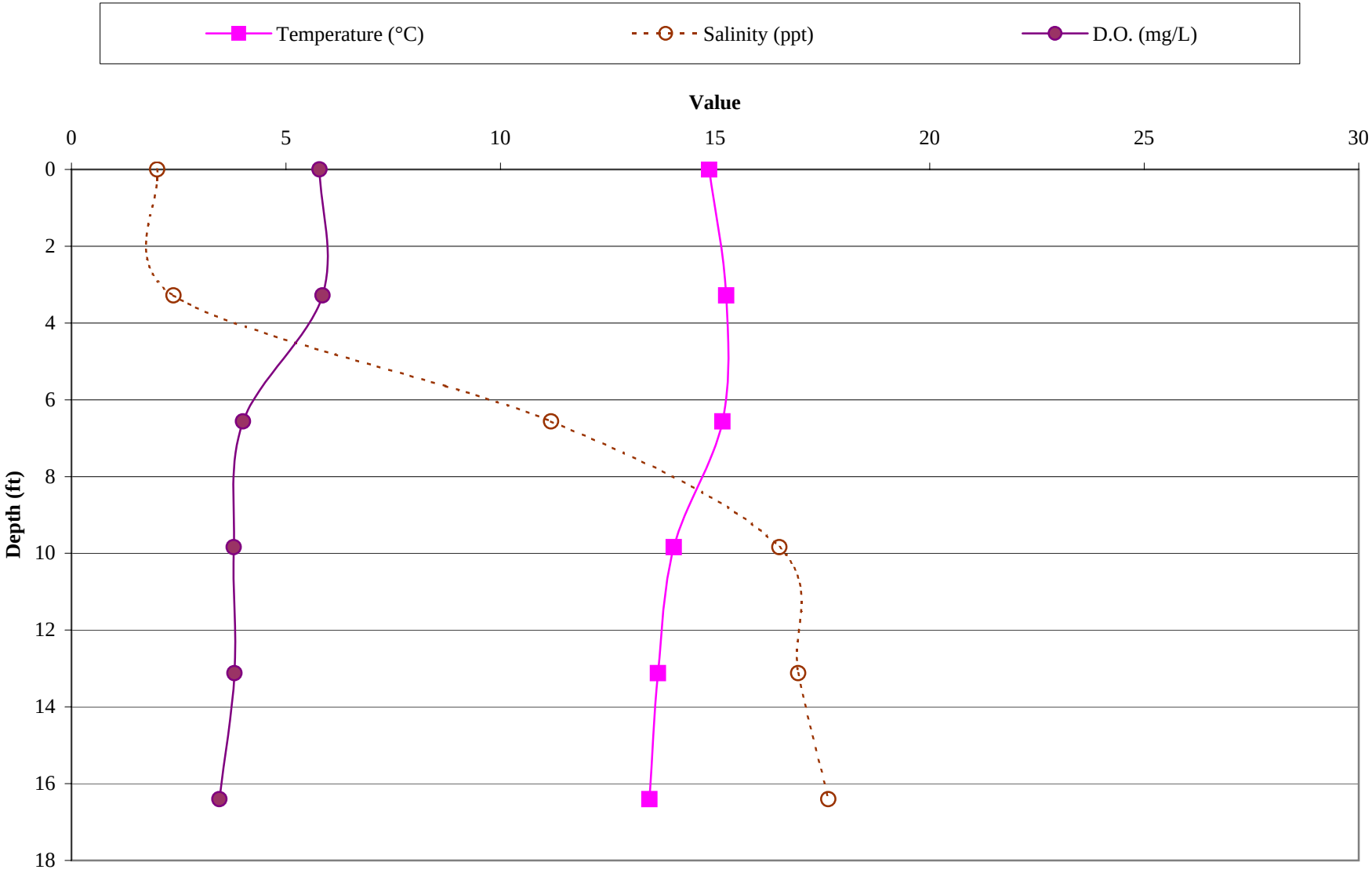
Appendix B-8. Gualala Water Quality Depth Profile - Mill Bend - 8/13/02



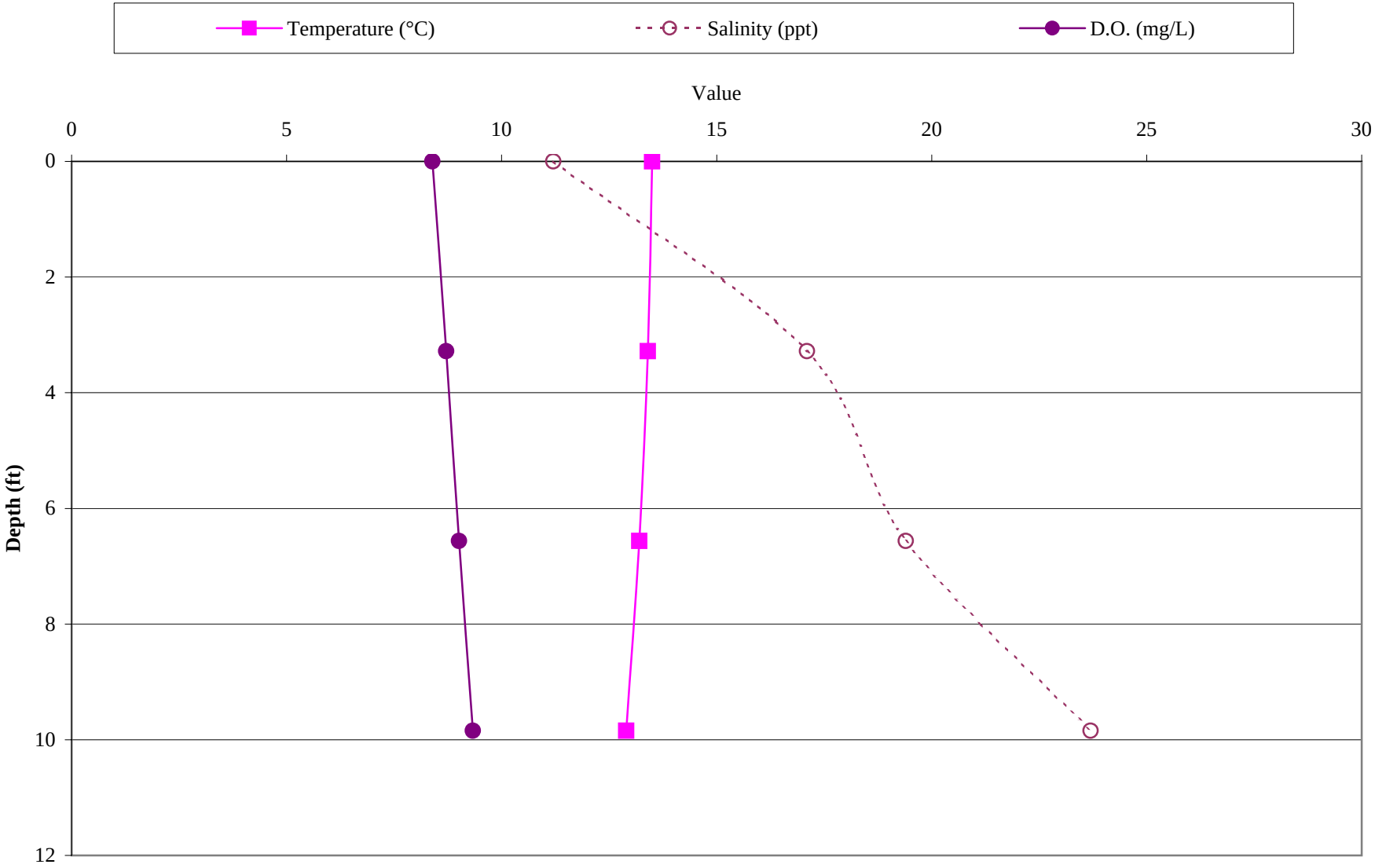
Appendix B-9. Gualala Water Quality Depth Profile - Mill Bend - 9/27/02



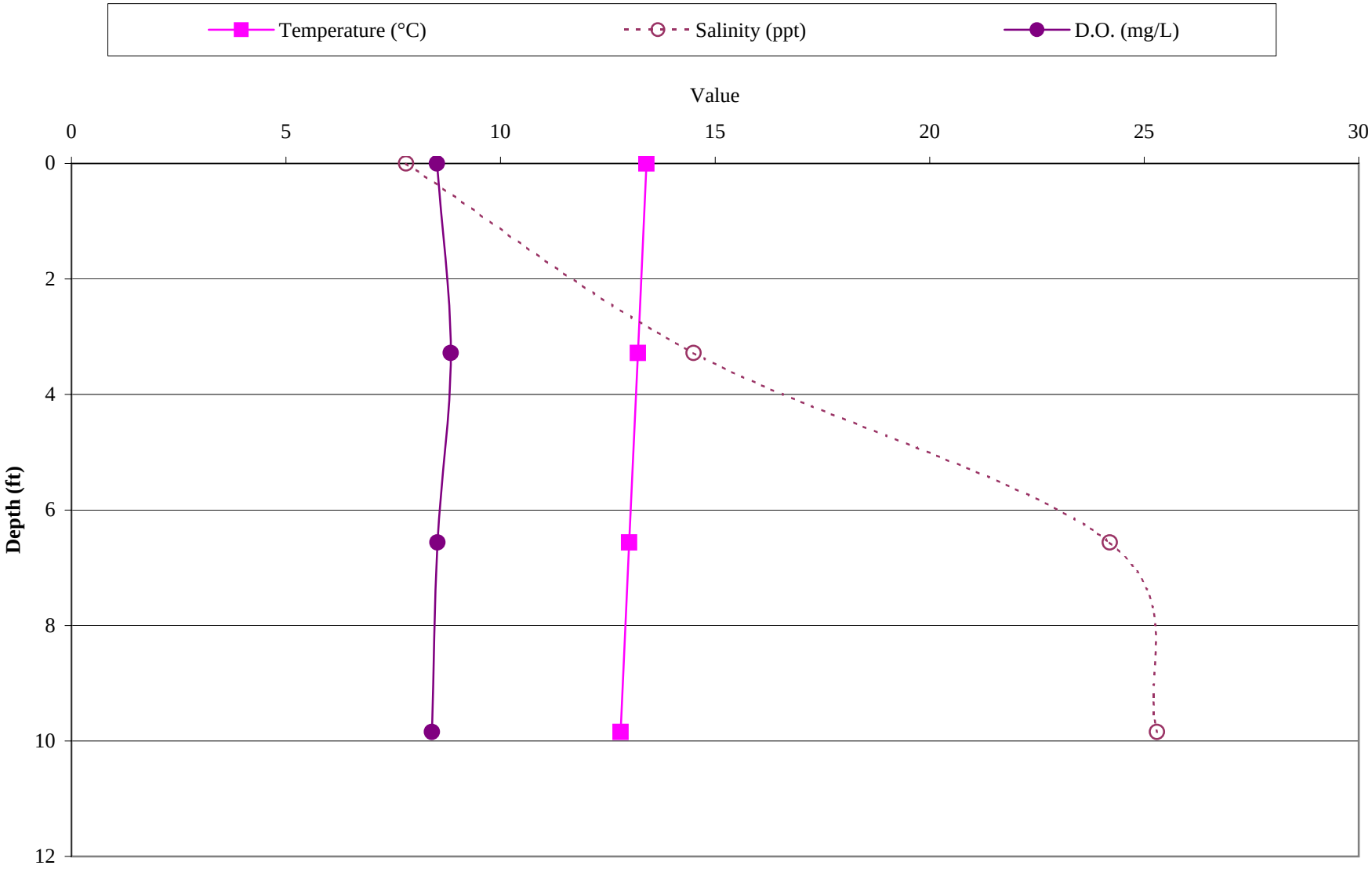
Appendix B-10. Gualala Water Quality Depth Profile - Mill Bend - 10/24/02



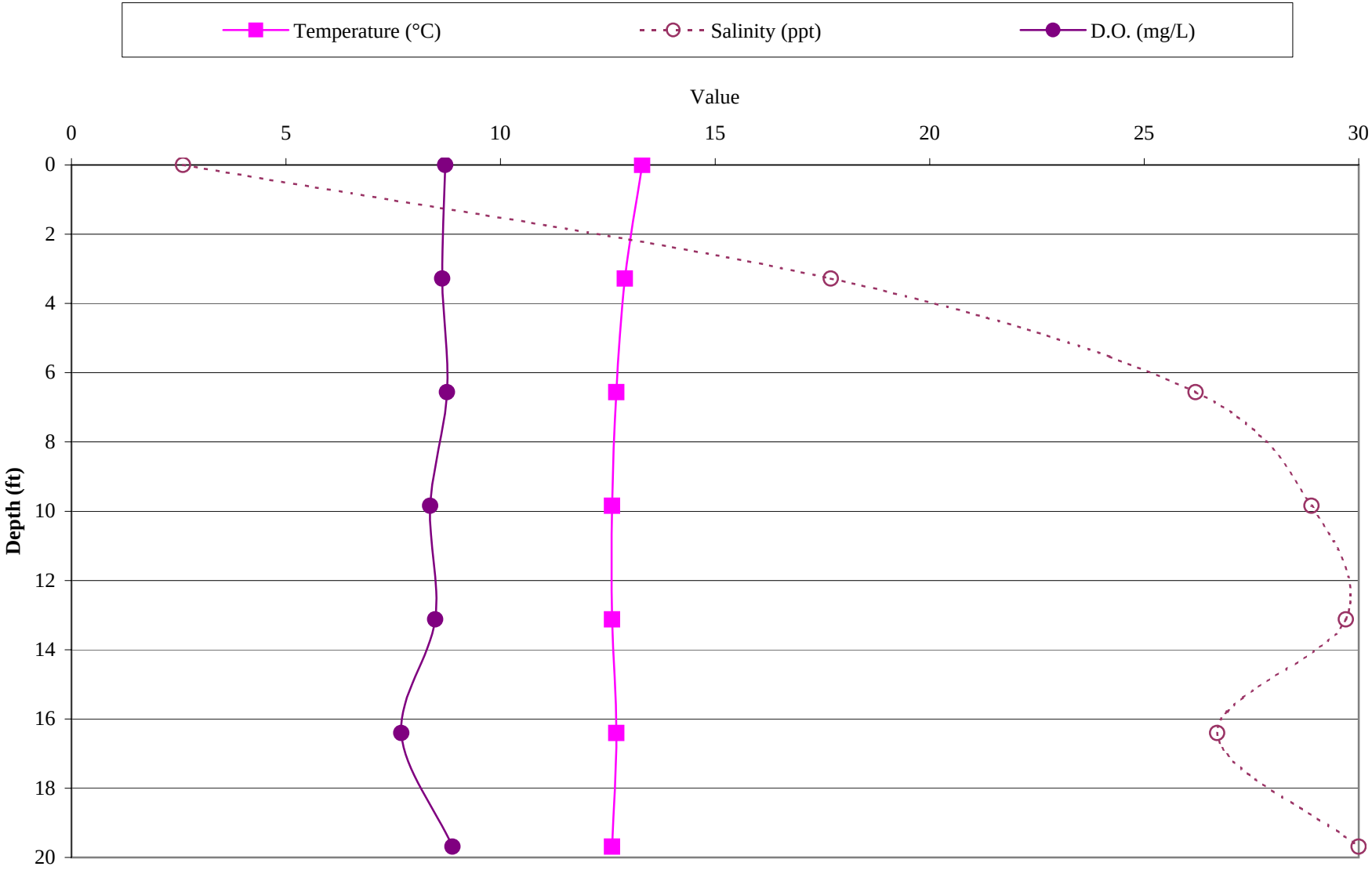
Appendix B-11. Gualala Water Quality Depth Profile - Mouth of the Estuary - 11/8/02



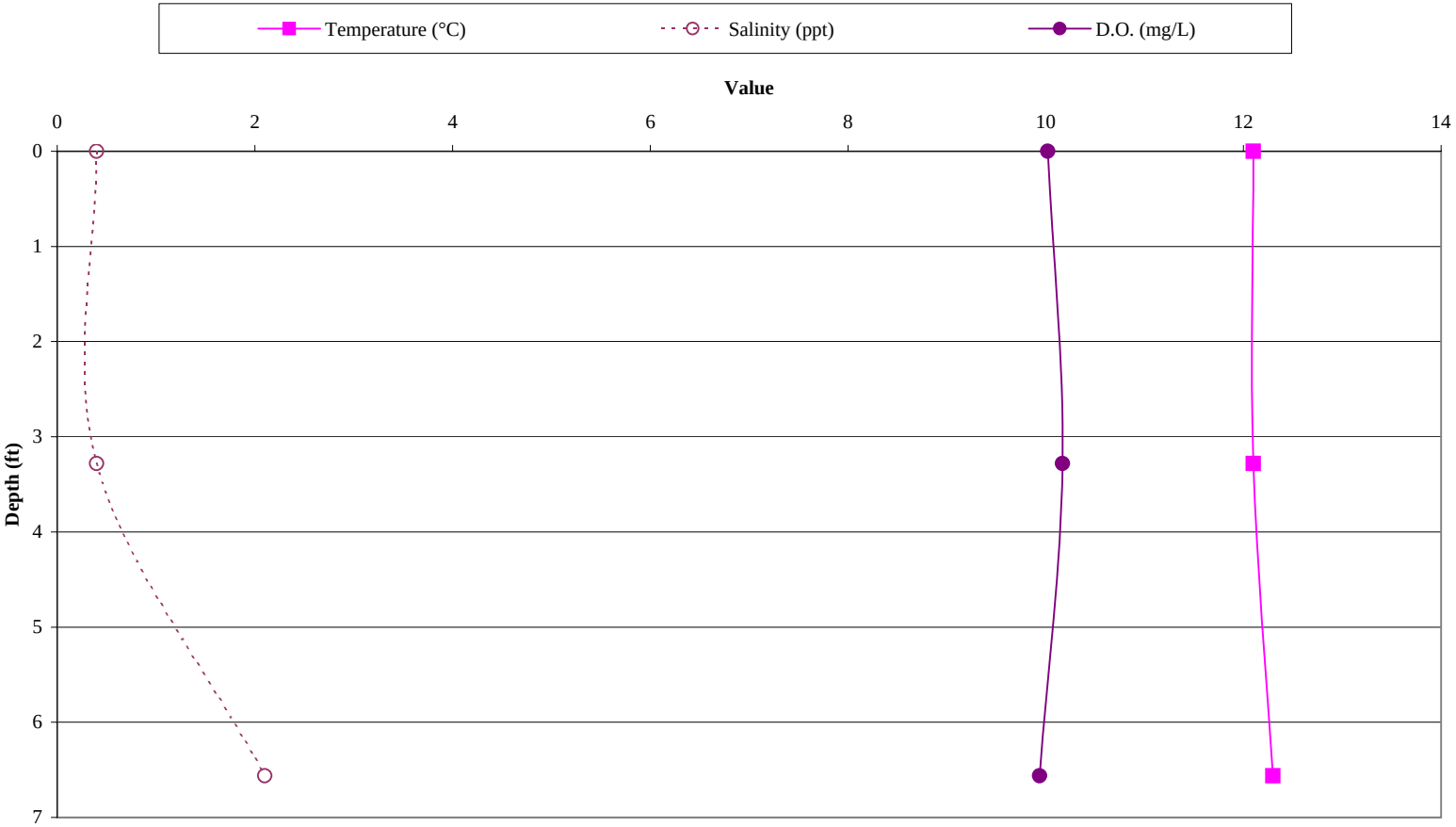
Appendix B-12. Gualala Water Quality Depth Profile - China Gulch - 11/8/02



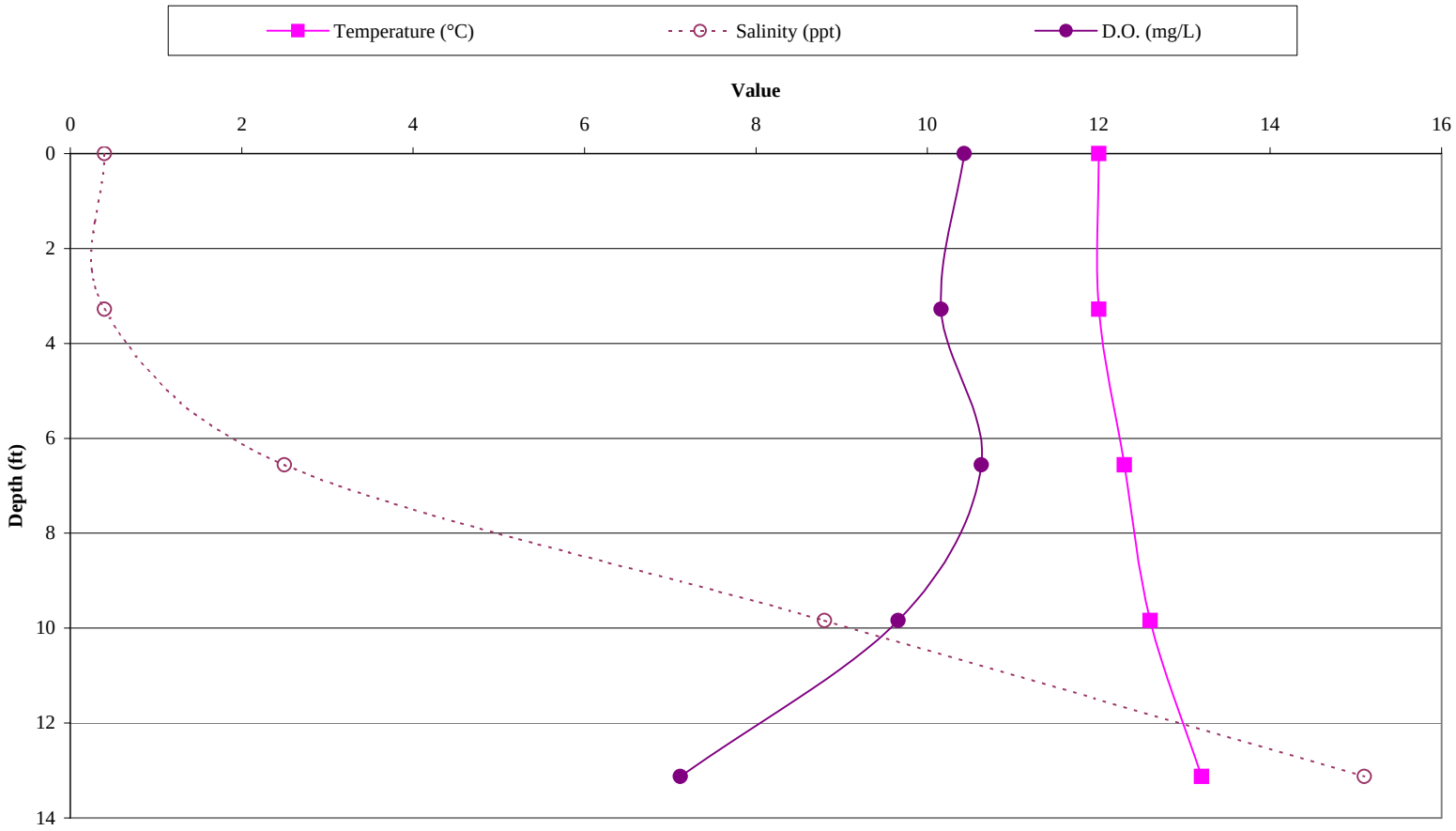
Appendix B-13. Gualala Water Quality Depth Profile - Mill Bend - 11/8/02



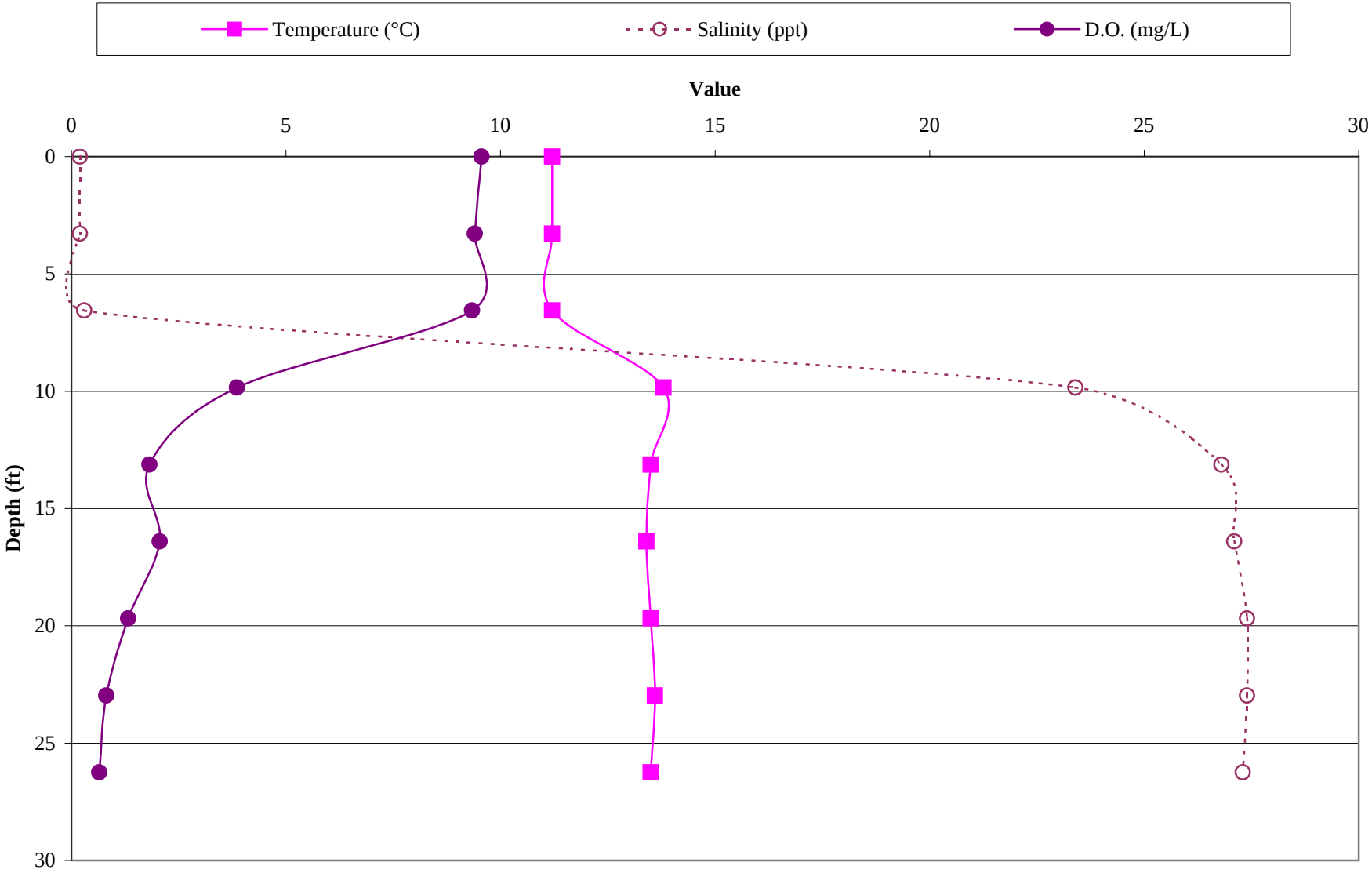
Appendix B-14. Gualala Water Quality Depth Profile - Mouth of Estuary - 11/23/02



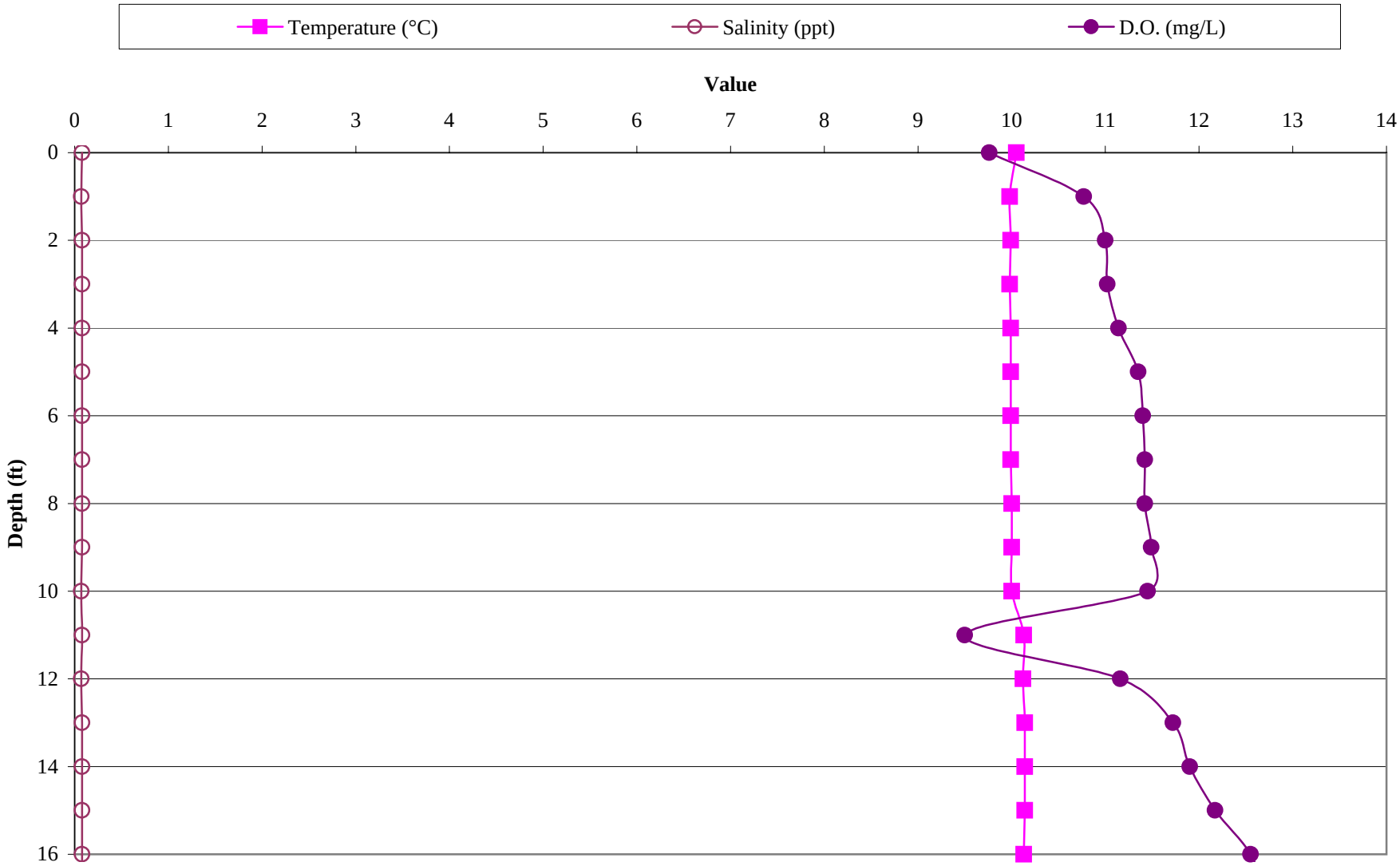
Appendix B-15. Gualala Water Quality Depth Profile - China Gulch - 11/23/02



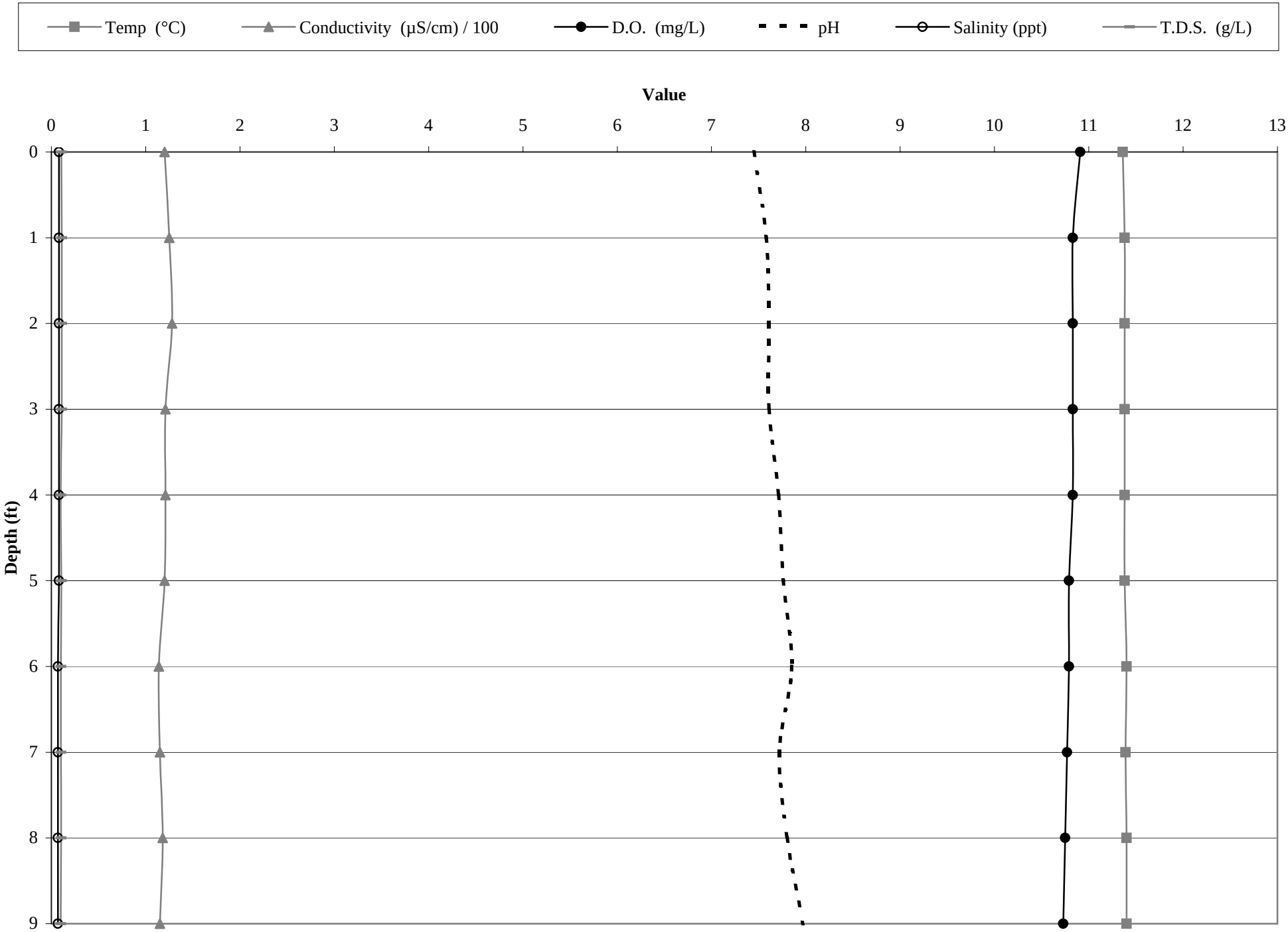
Appendix B-16. Gualala Water Quality Depth Profile - Mill Bend - 11/23/02



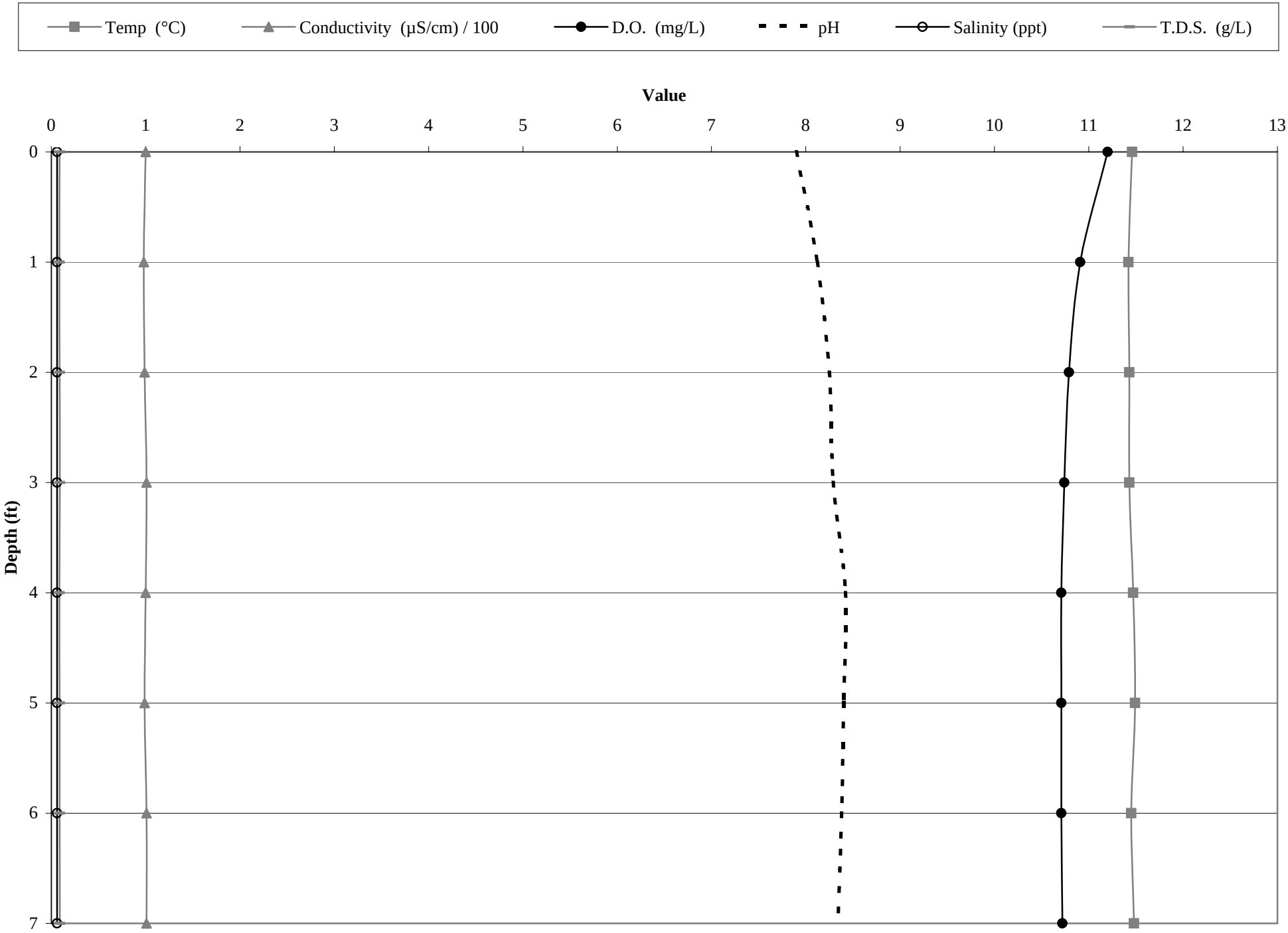
Appendix B-17. Gualala Water Quality Depth Profile - Mill Bend - 2/18/03



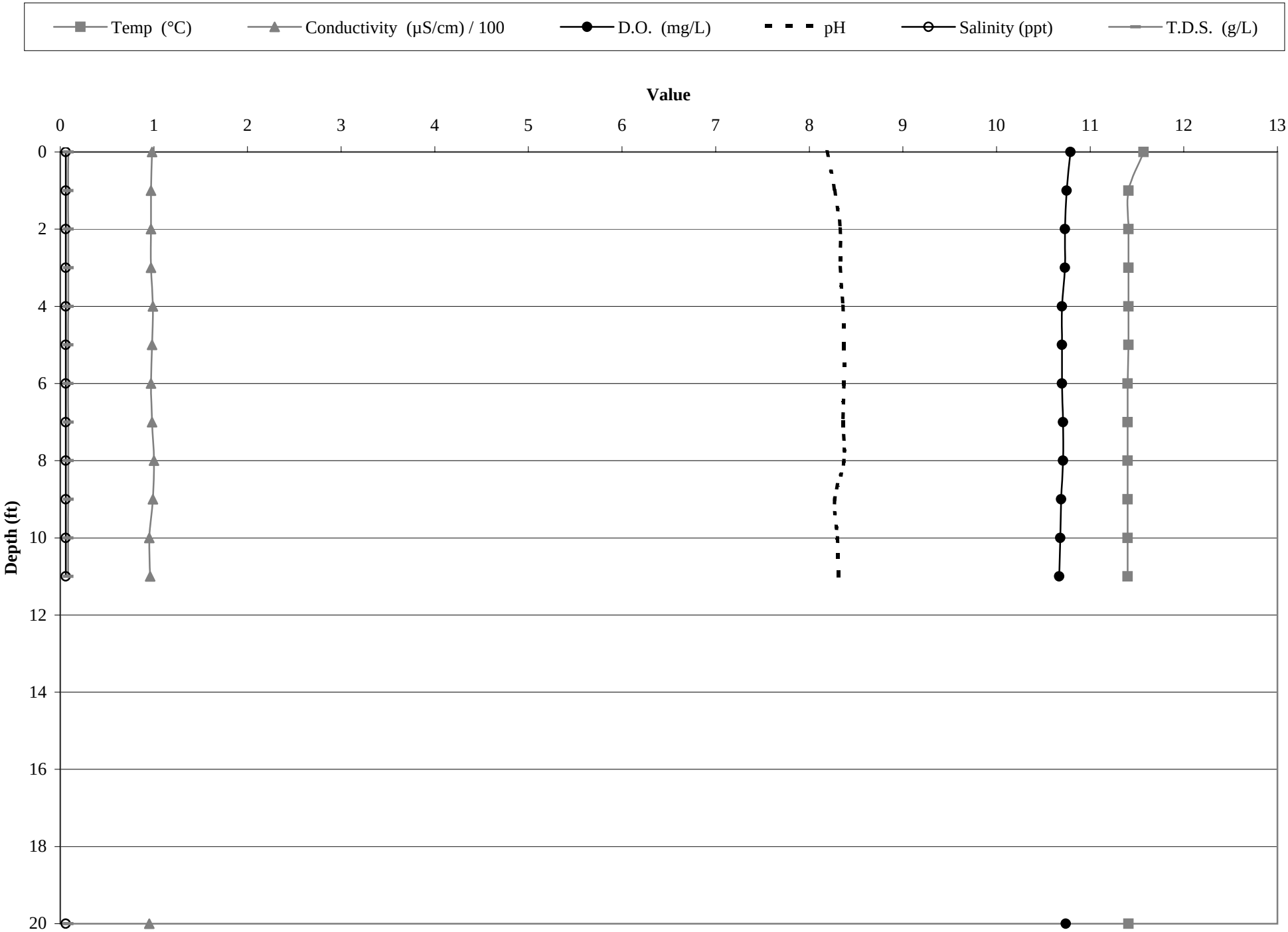
Appendix B-18. Gualala Water Quality Depth Profile - Mouth of Estuary - (4/28/03)



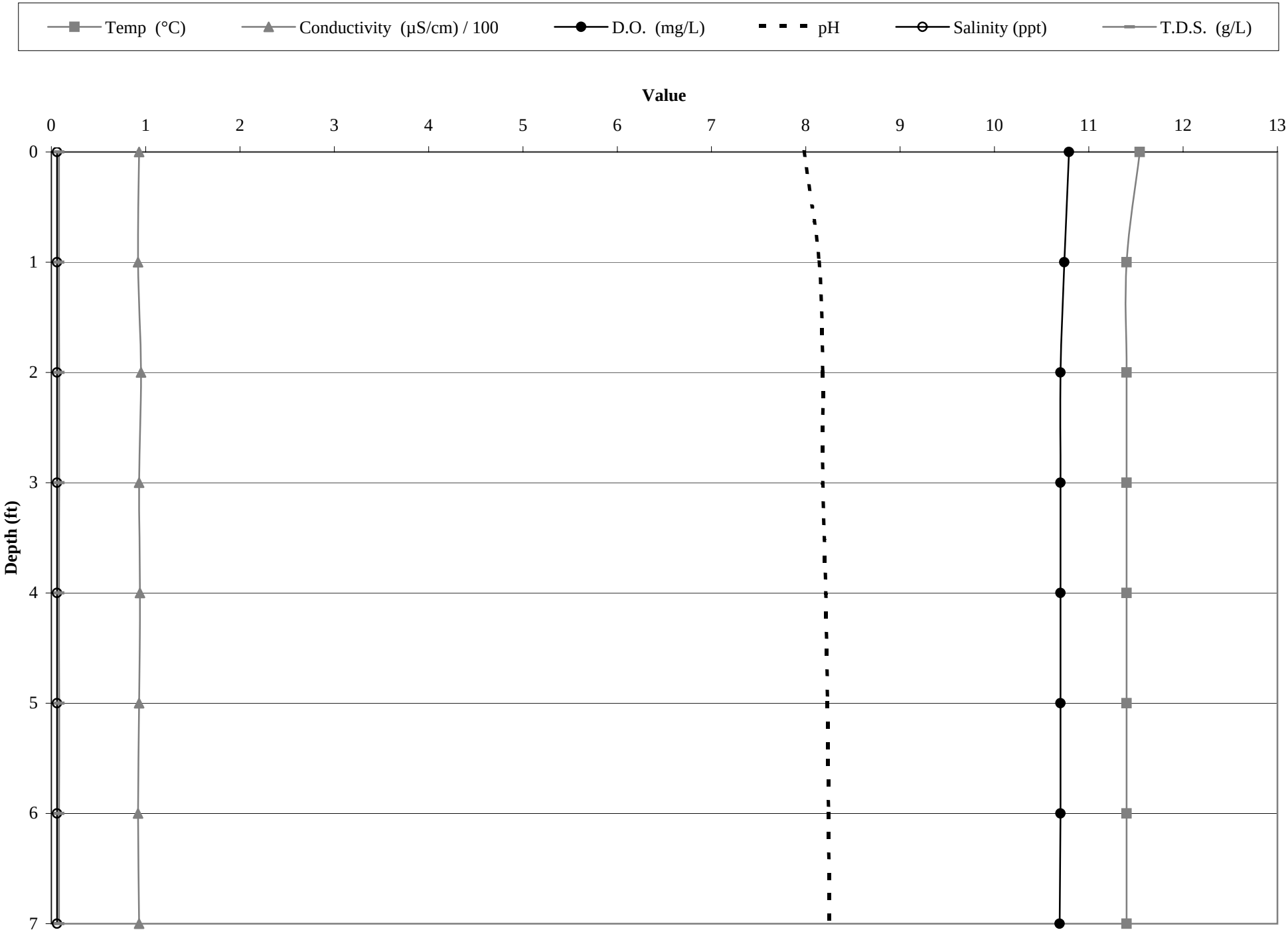
Appendix B-19. Gualala Water Quality Depth Profile - China Gulch - (4/28/03)



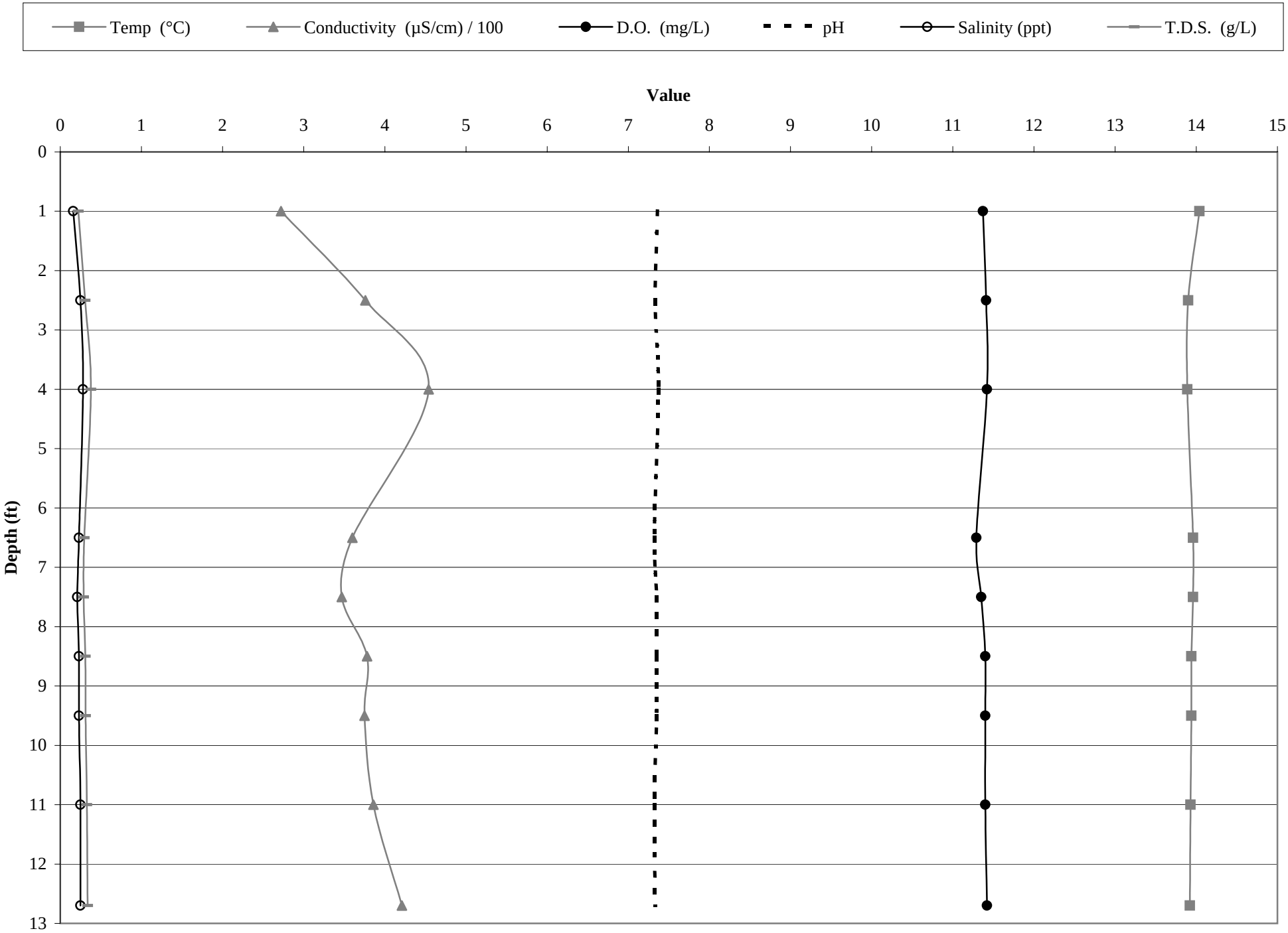
Appendix B-20. Gualala Water Quality Depth Profile - Mill Bend - (4/28/03)



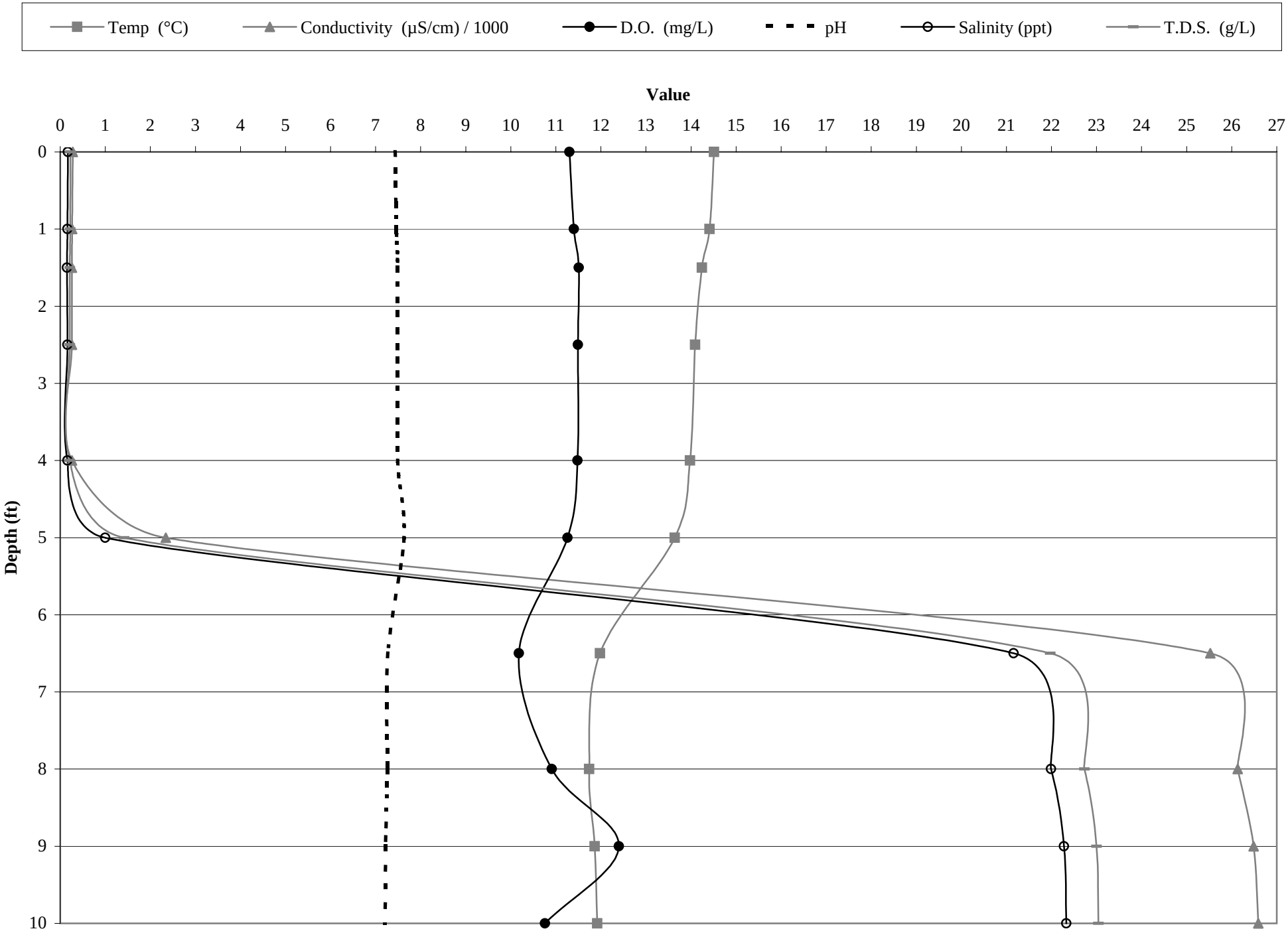
Appendix B-21. Gualala Water Quality Depth Profile - Above Highway 1 Bridge - (4/28/03)



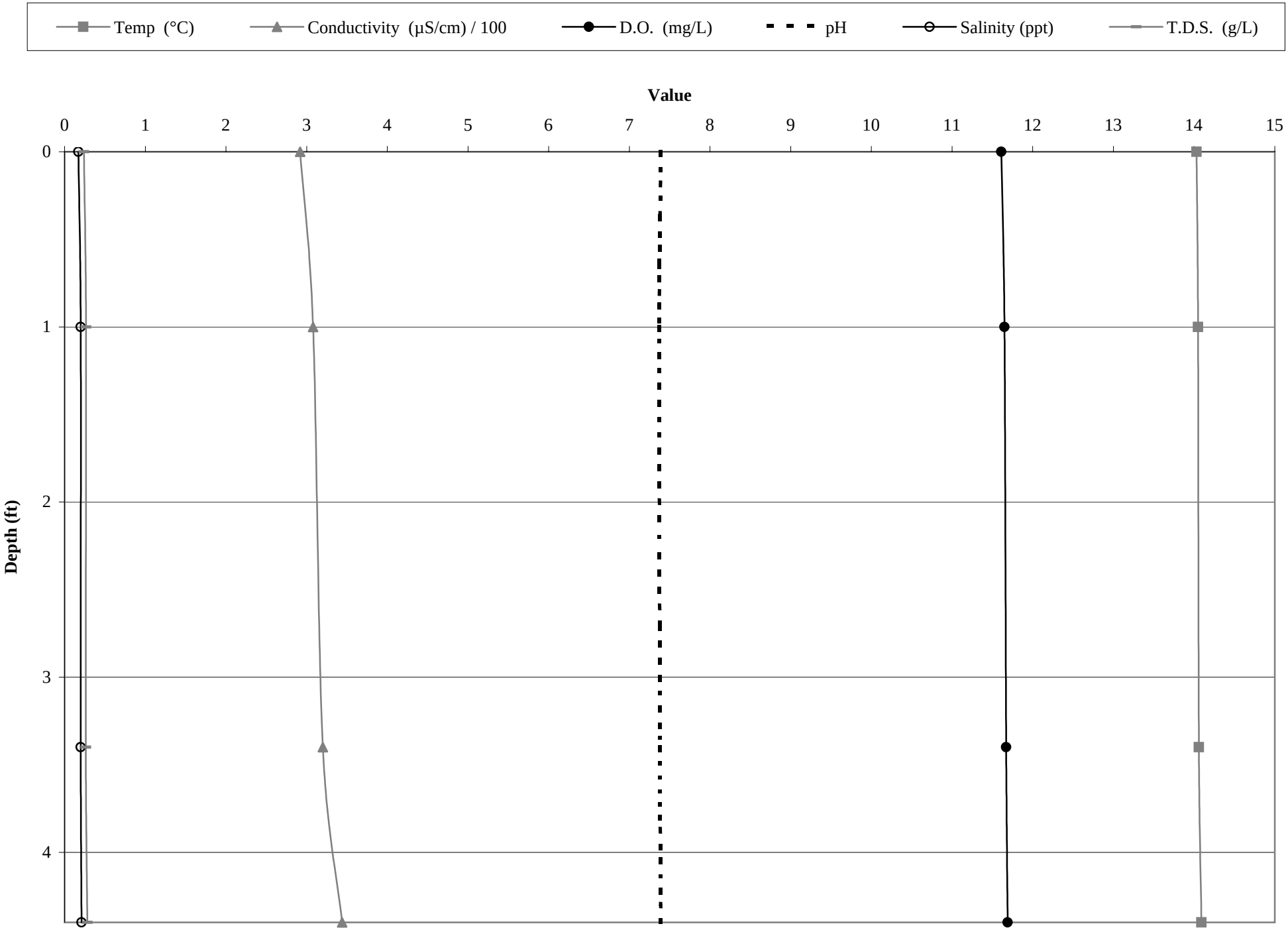
Appendix B-22. Gualala Water Quality Depth Profile - Mouth of Estuary- (5/19/03)



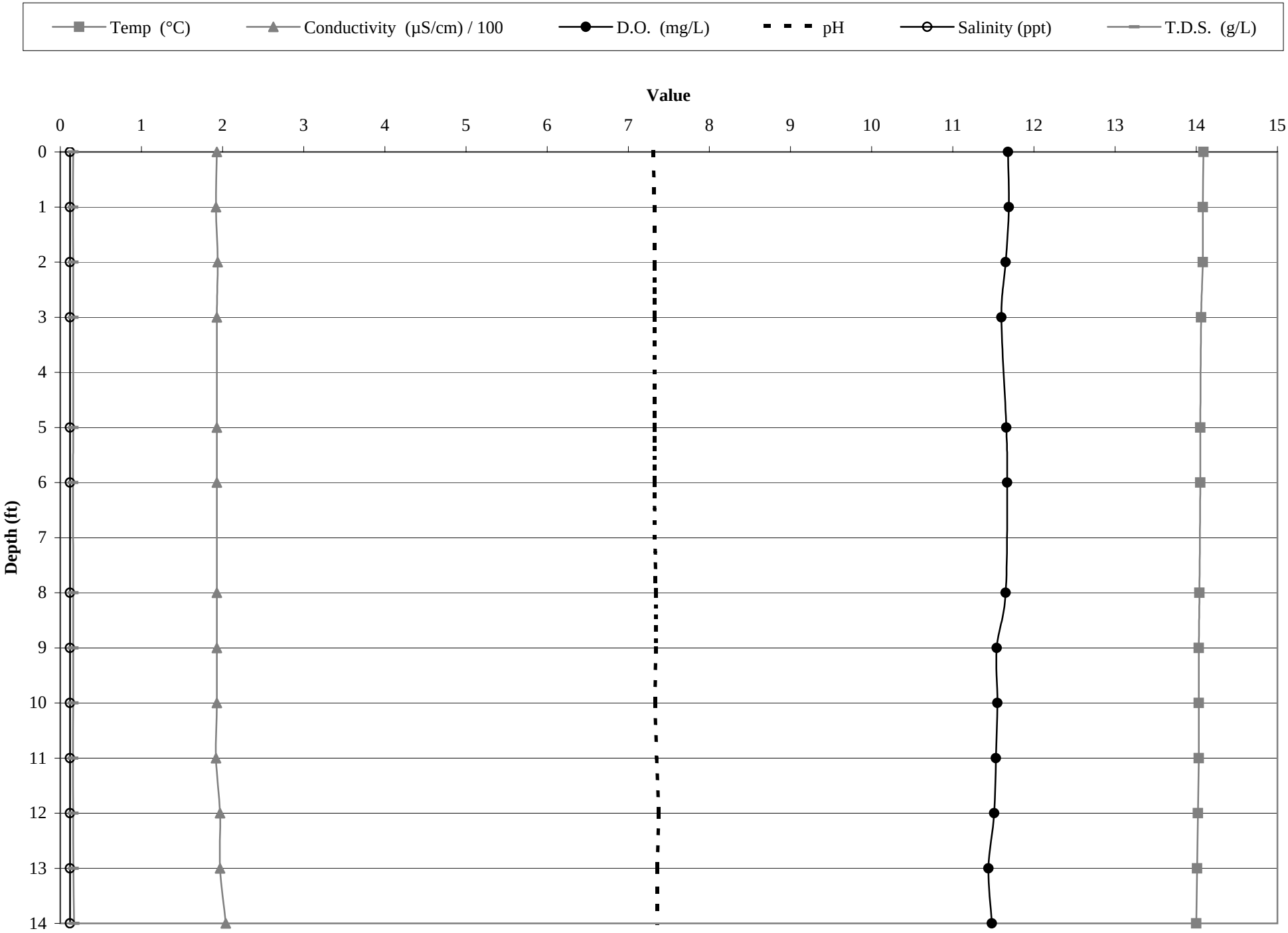
Appendix B-23. Gualala Water Quality Depth Profile - Tide Gage - (5/19/03)



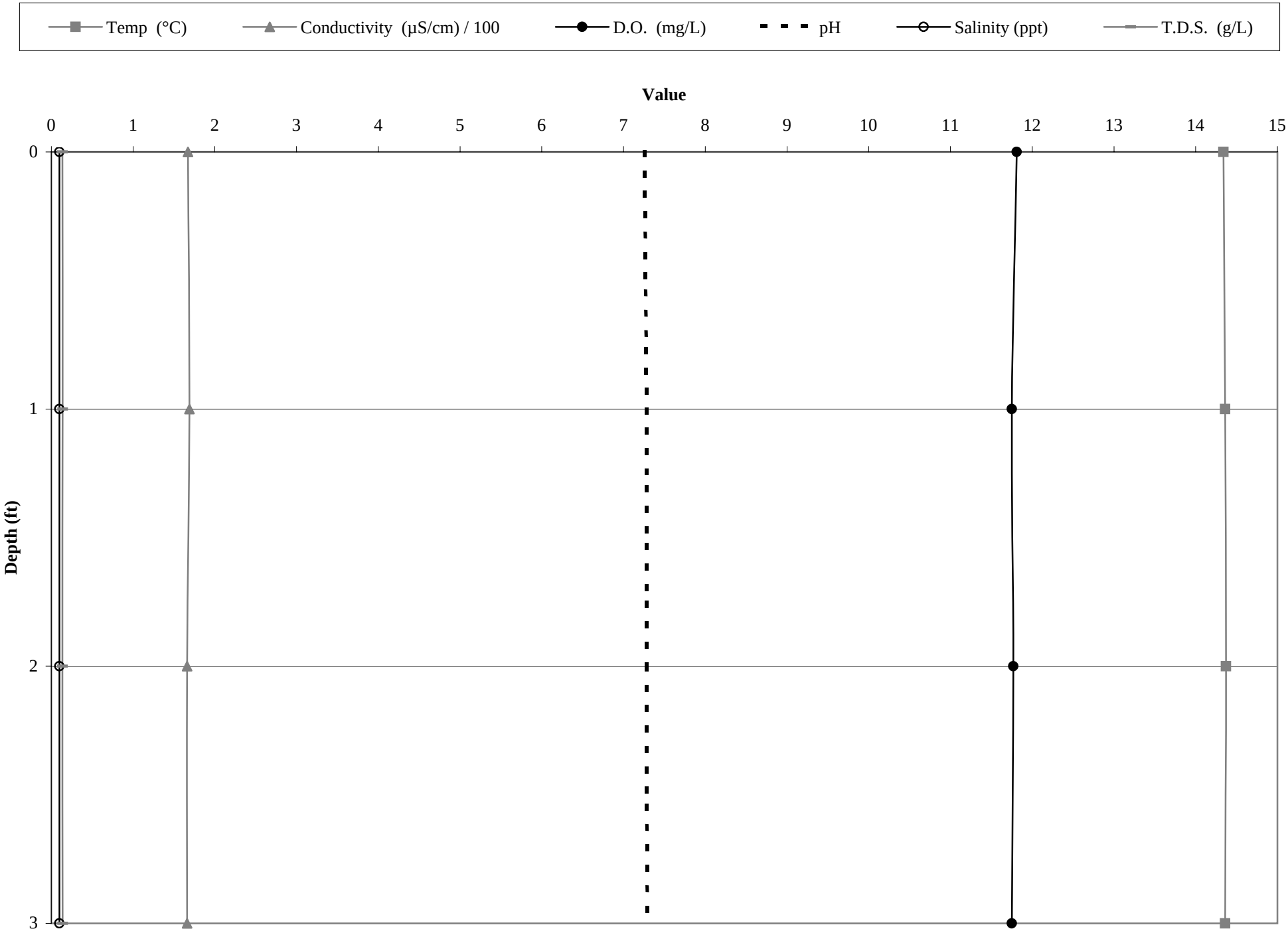
Appendix B-24. Gualala Water Quality Depth Profile - China Gulch - (5/19/03)



Appendix B-25. Gualala Water Quality Depth Profile - Mill Bend - (5/19/03)

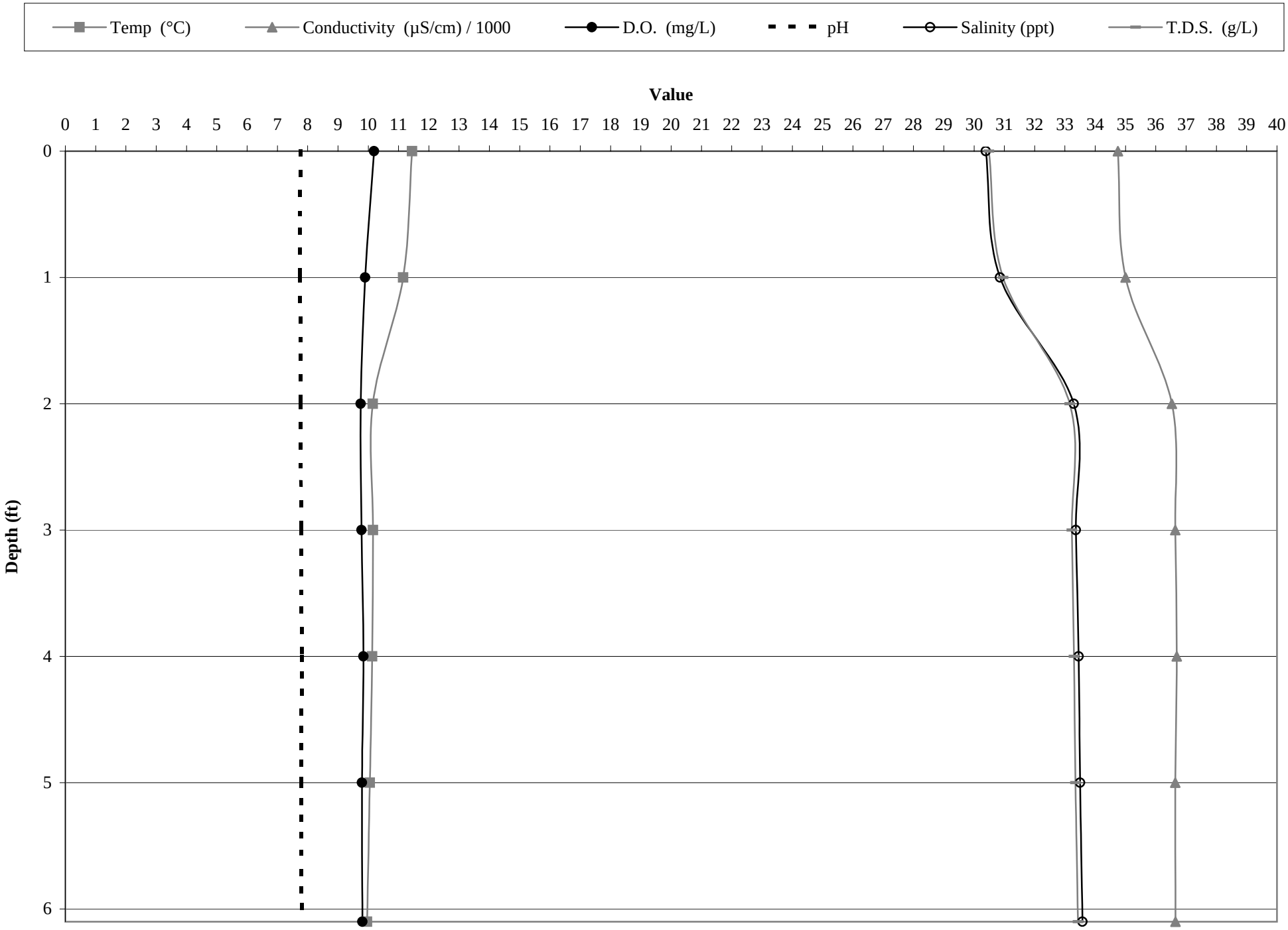


Appendix B-26. Gualala Water Quality Depth Profile - Above Highway 1 Bridge - (5/19/03)



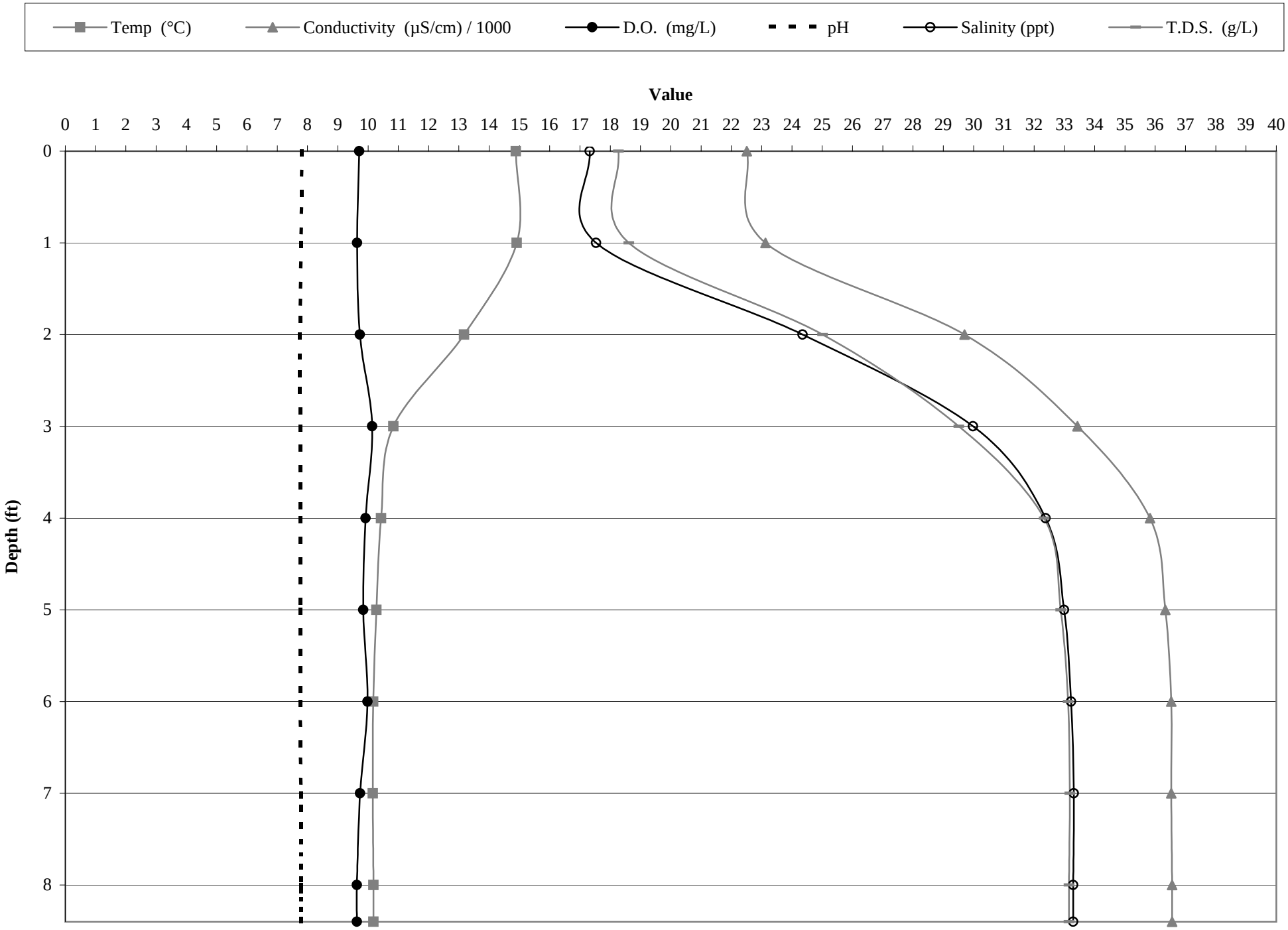
Time: 1330

Appendix B-27. Gualala Water Quality Depth Profile - Mouth of Estuary- (06/17/03)



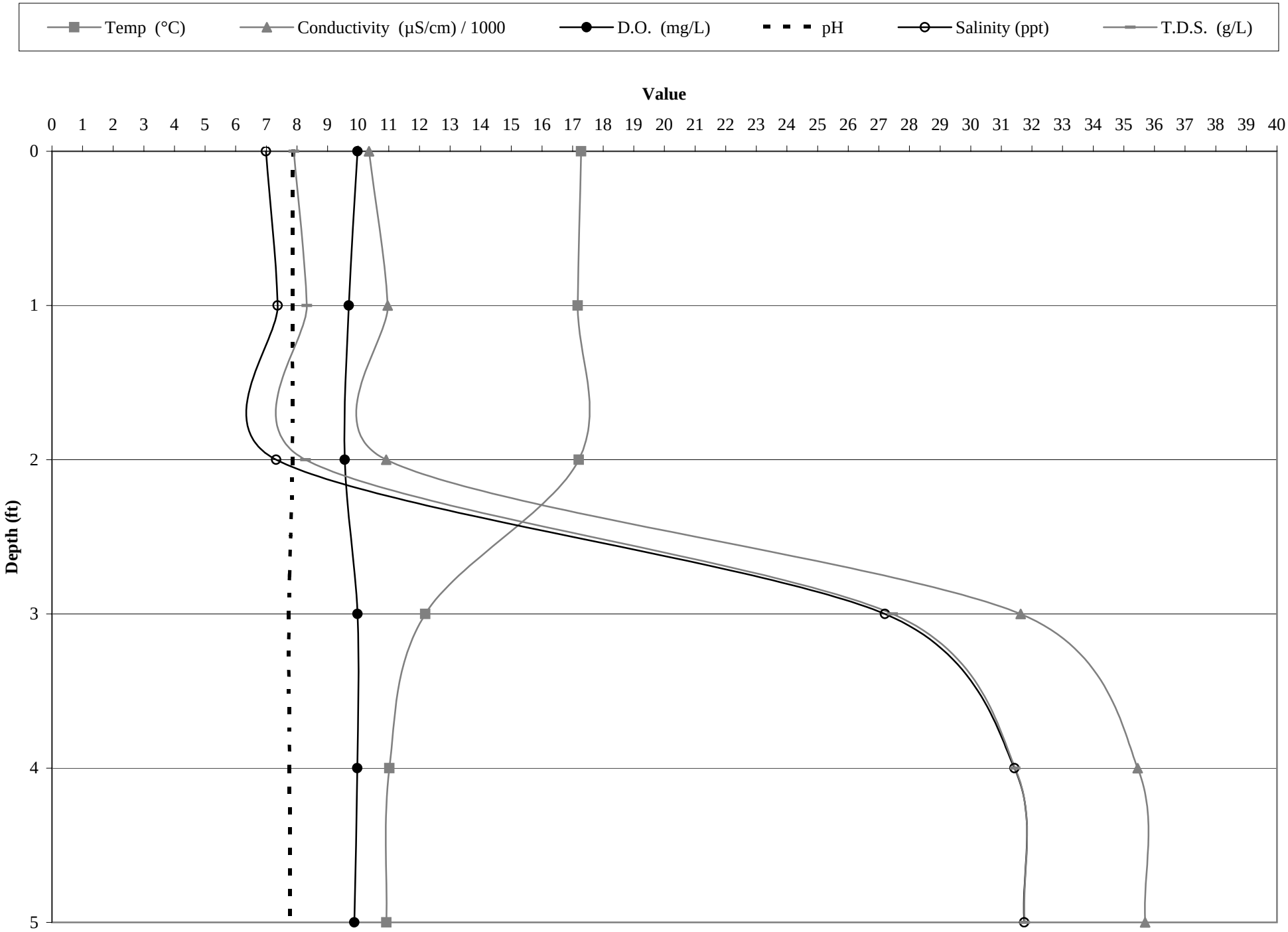
Time: 1400

Appendix B-28. Gualala Water Quality Depth Profile - Tide Gauge- (06/17/03)



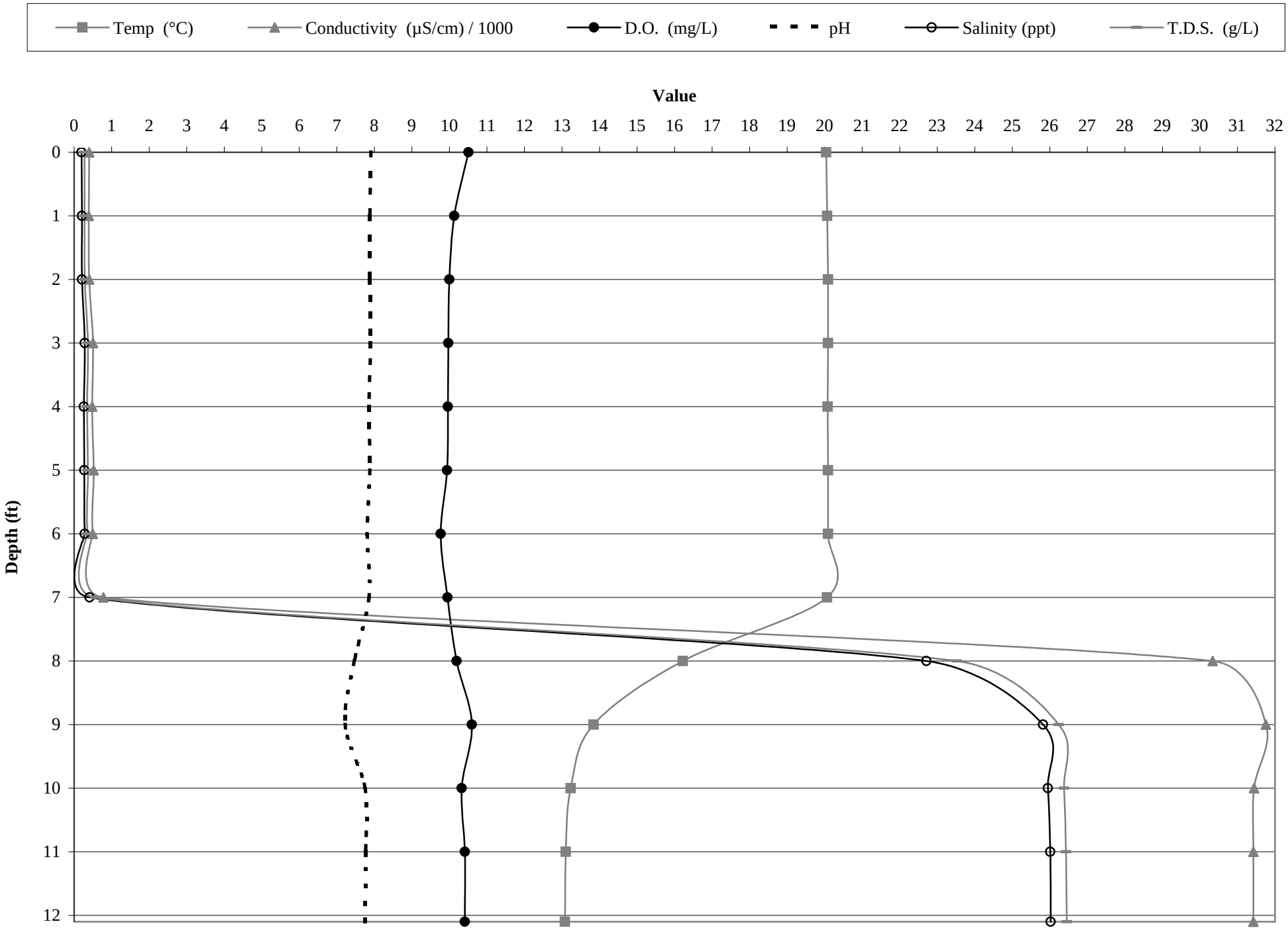
Appendix B-29. Gualala Water Quality Depth Profile - China Gulch - (06/17/03)

Time: 1430



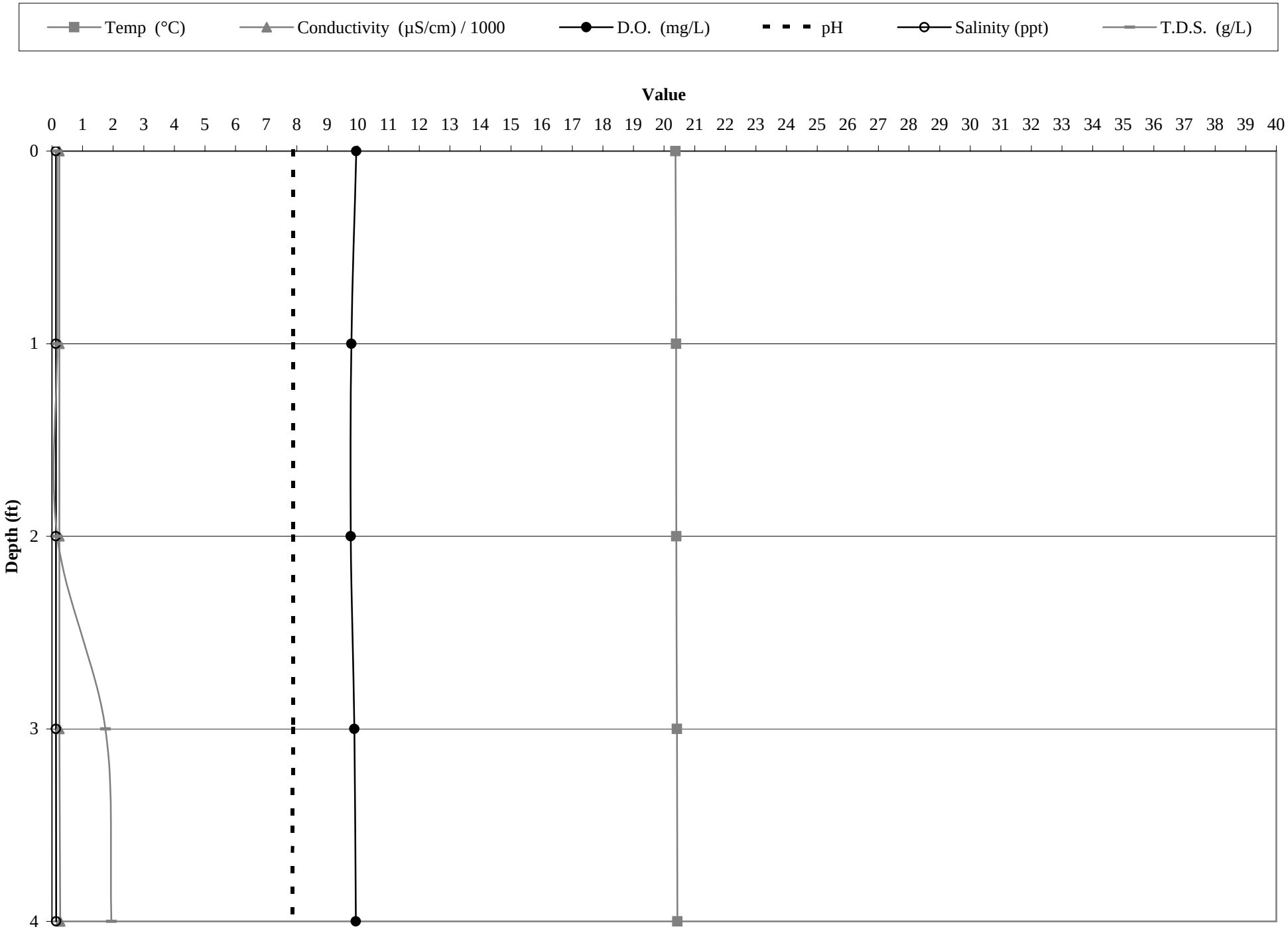
Appendix B-30. Gualala Water Quality Depth Profile - Mill Bend - (06/17/03)

Time: 1545

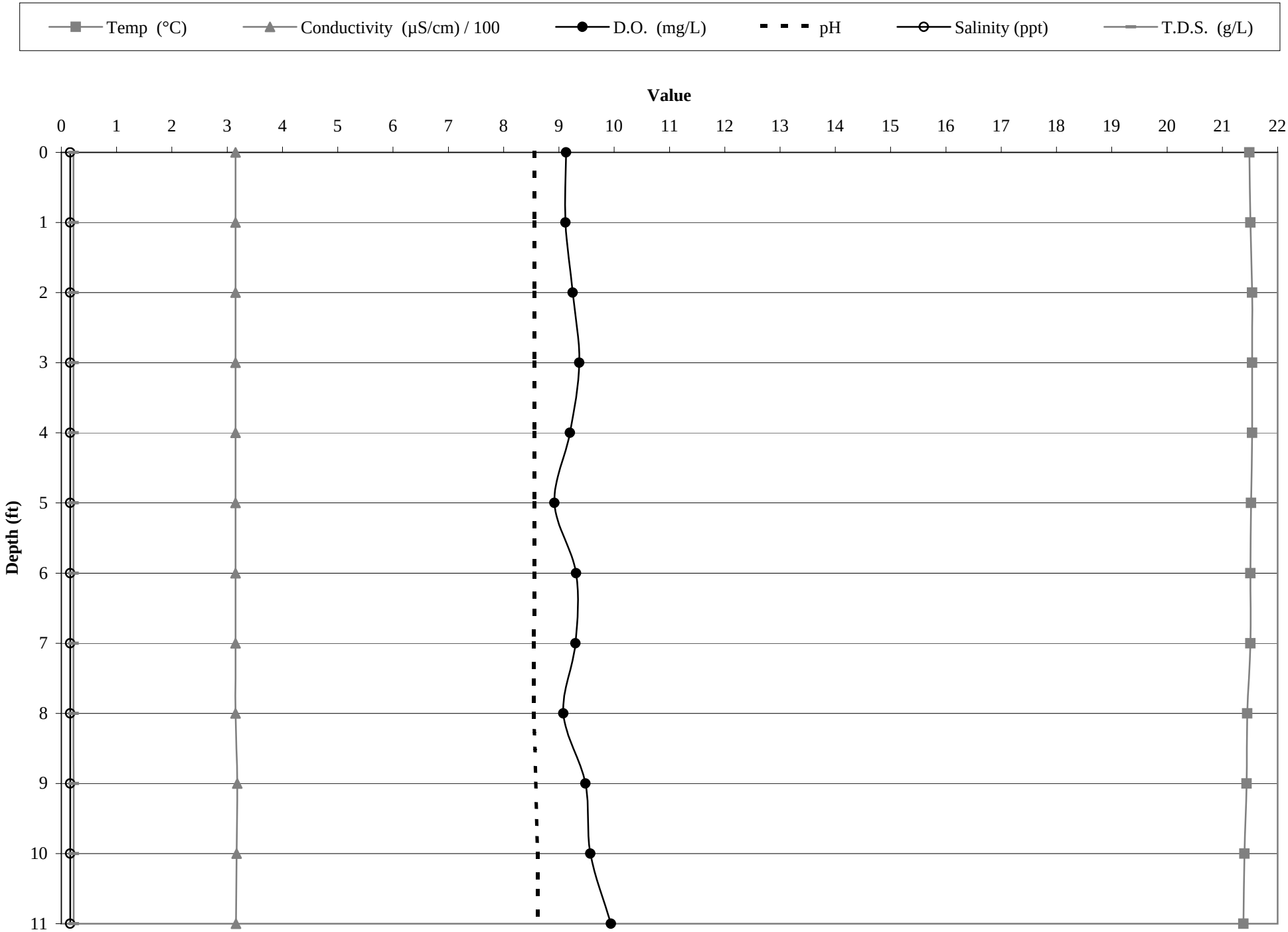


Appendix B-31. Gualala Water Quality Depth Profile - Above Highway 1 Bridge - (06/17/03)

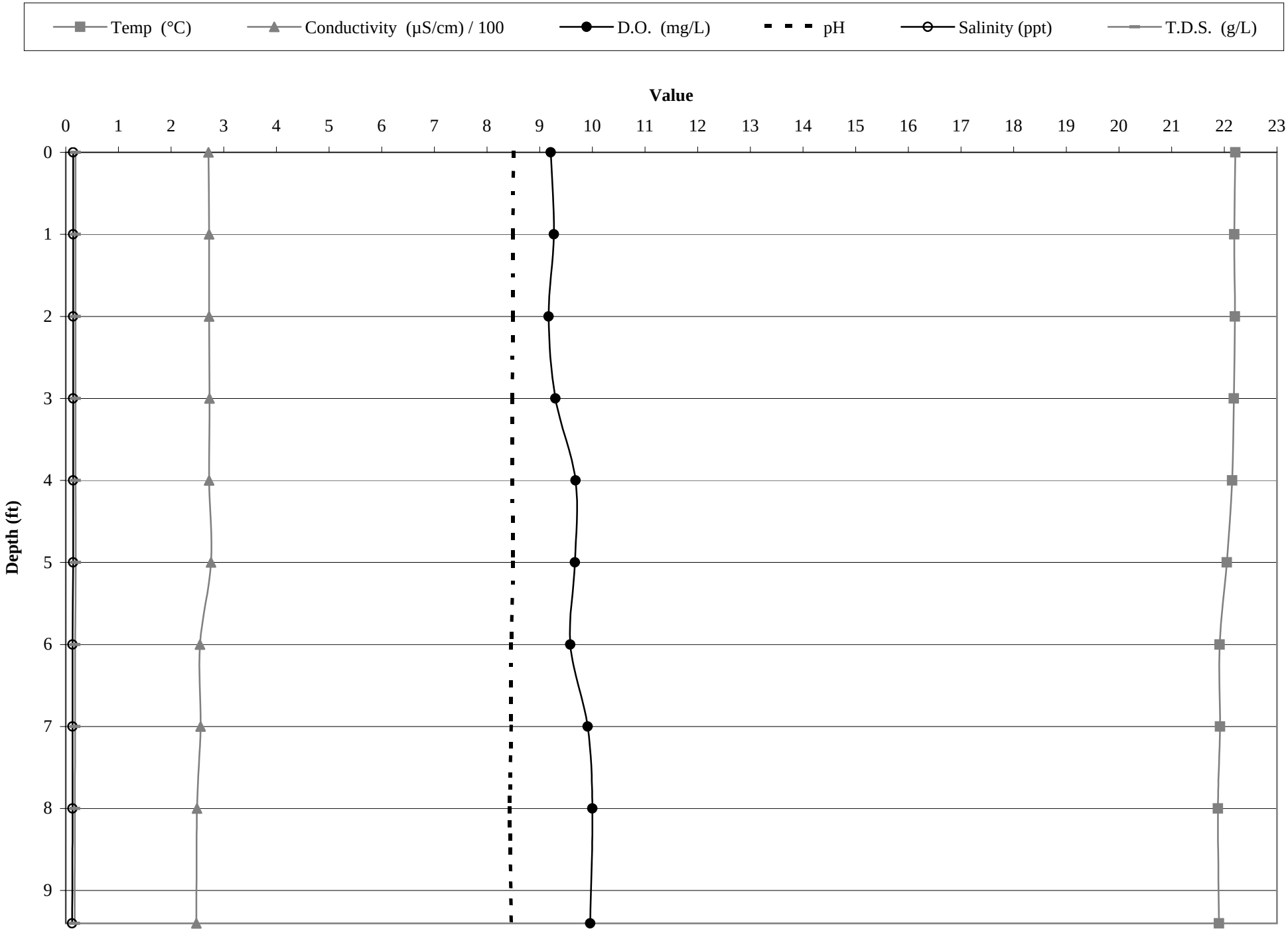
Time: 1600



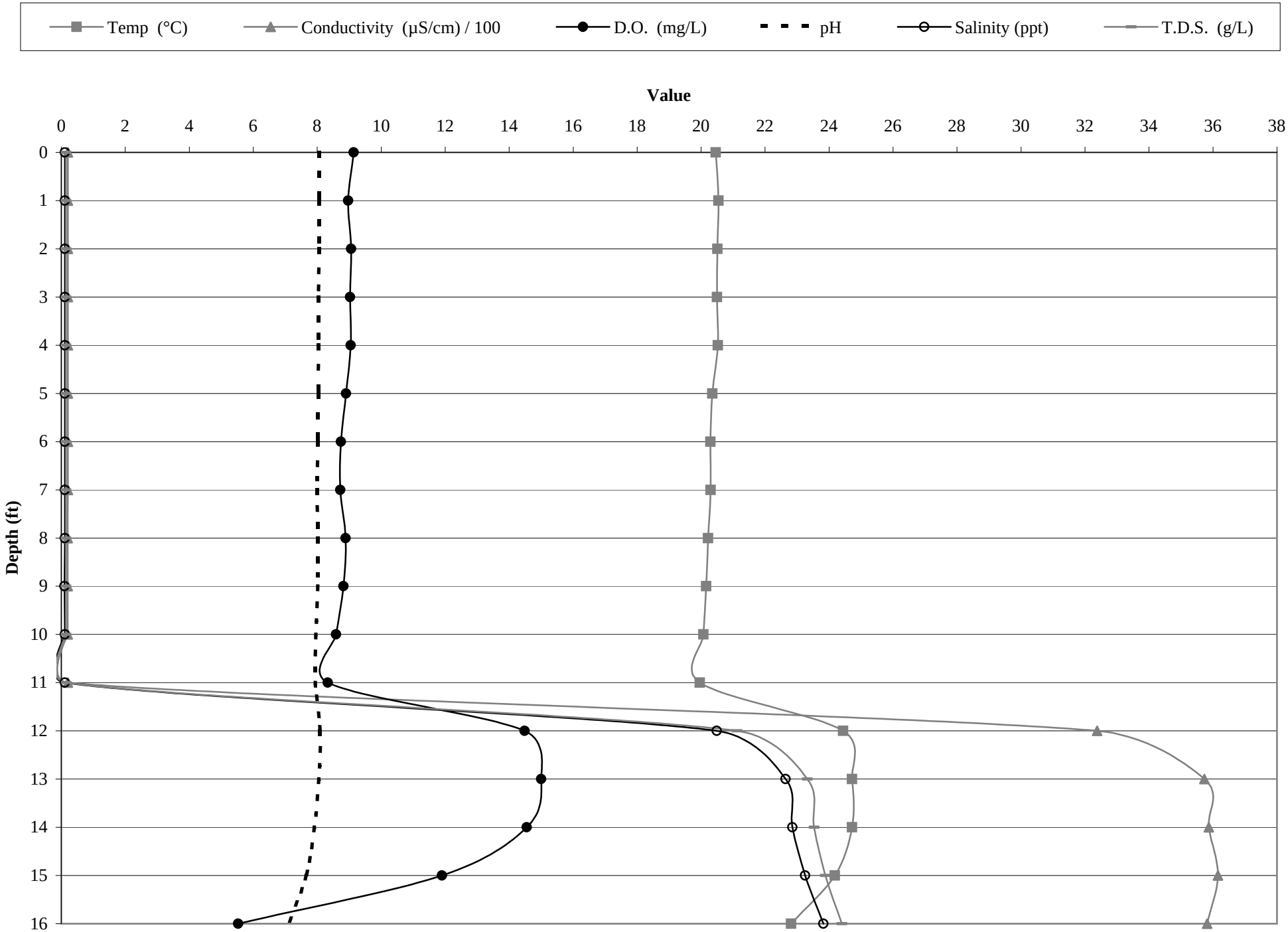
Appendix B-32. Gualala Water Quality Depth Profile - Mouth of Estuary- (07/22/03)



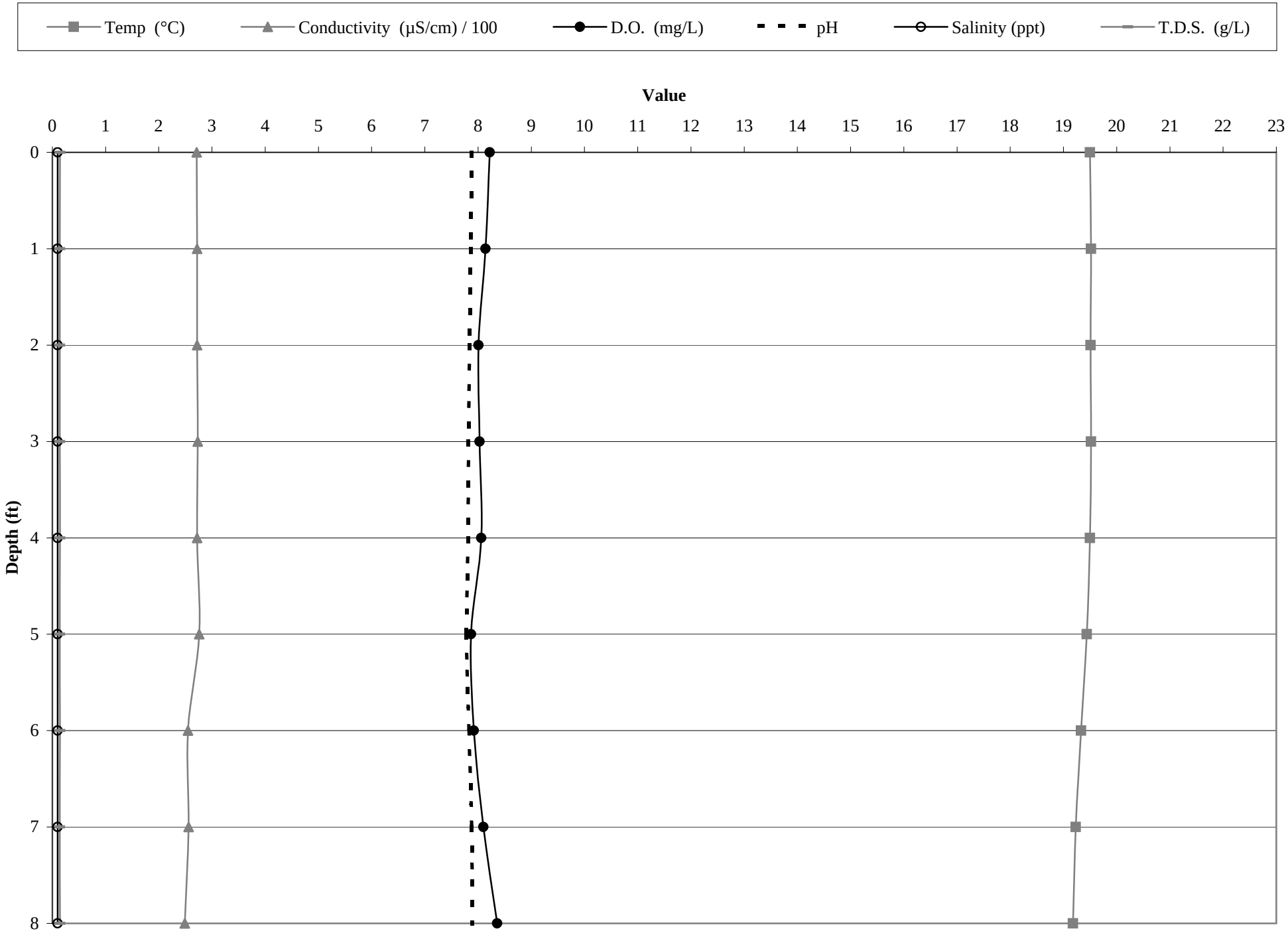
Appendix B-33. Gualala Water Quality Depth Profile - China Gulch - (07/22/03)



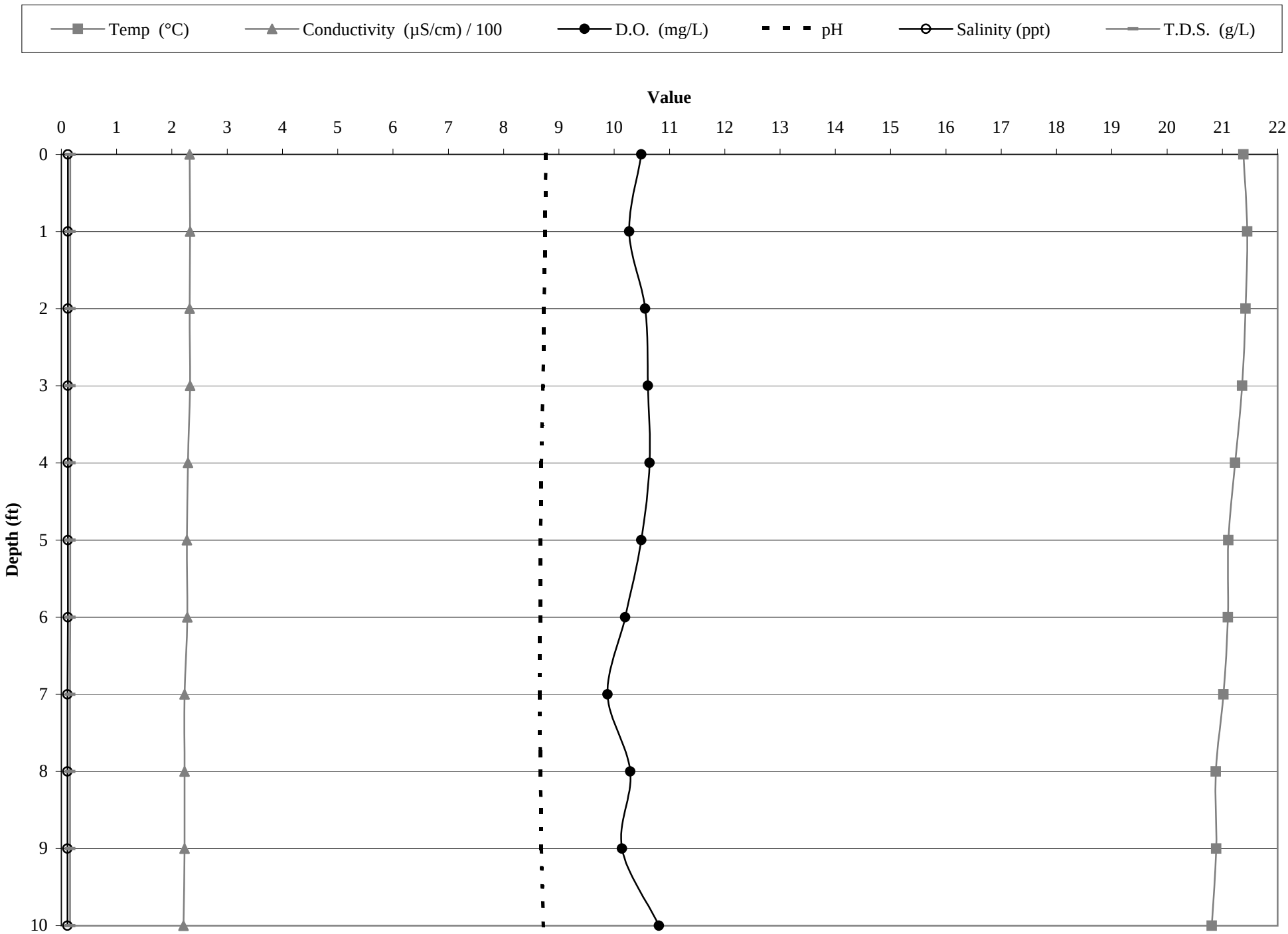
Appendix B-34. Gualala Water Quality Depth Profile - Mill Bend - (07/22/03)



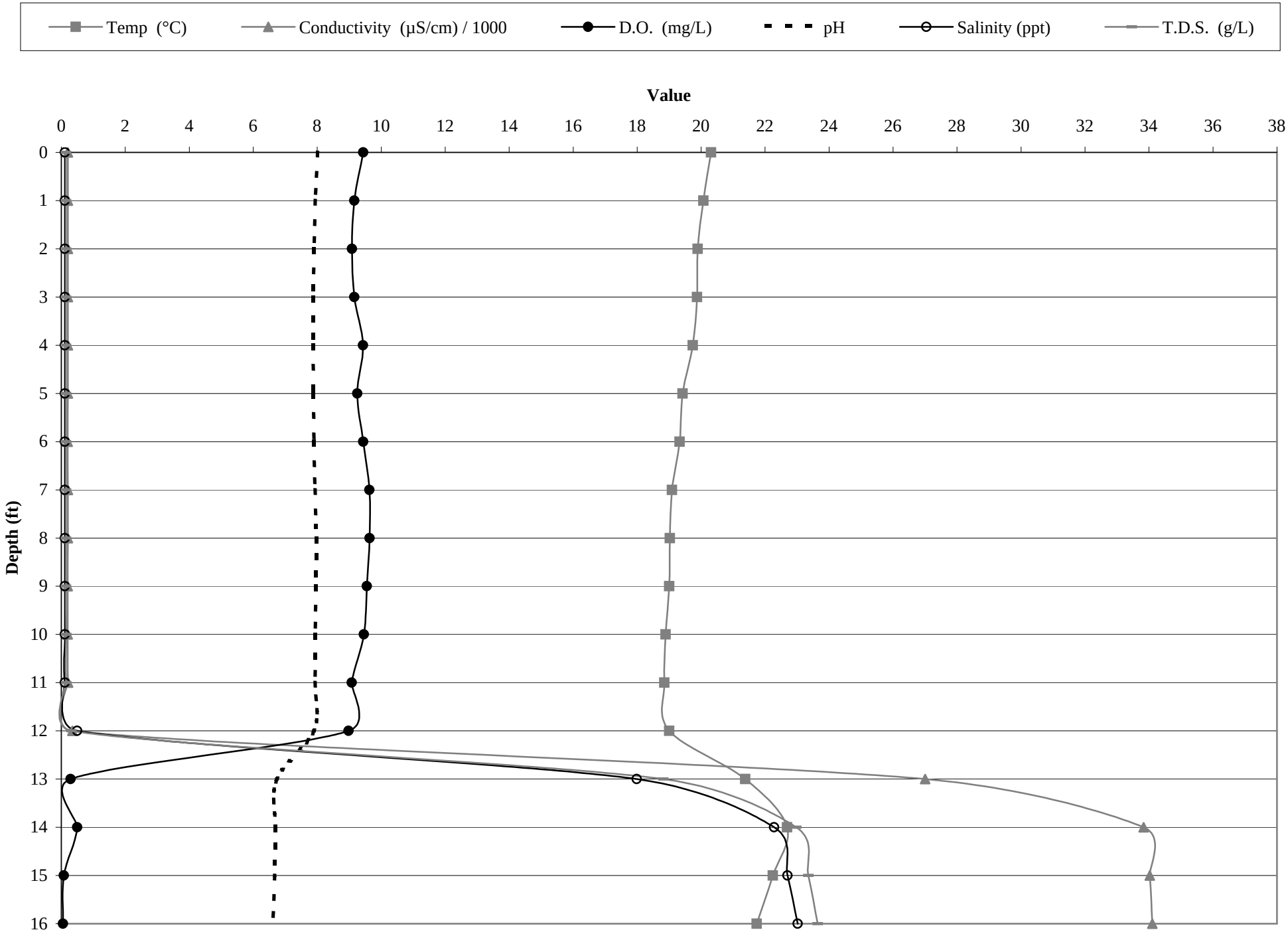
Appendix B-35. Gualala Water Quality Depth Profile - Above Highway 1 Bridge - (07/22/03)



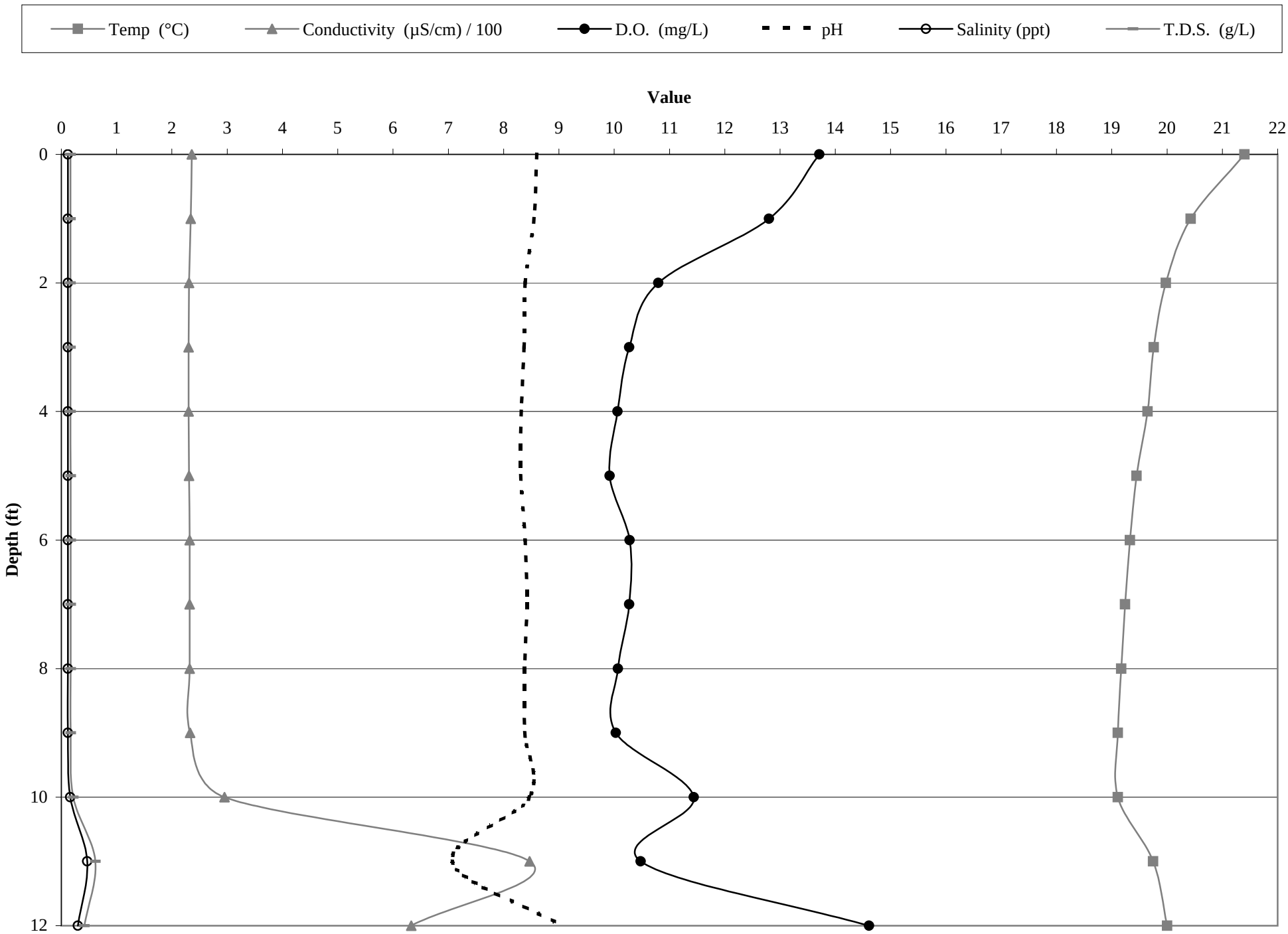
Appendix B-36. Gualala Water Quality Depth Profile - Mouth of Estuary - (08/23/03)



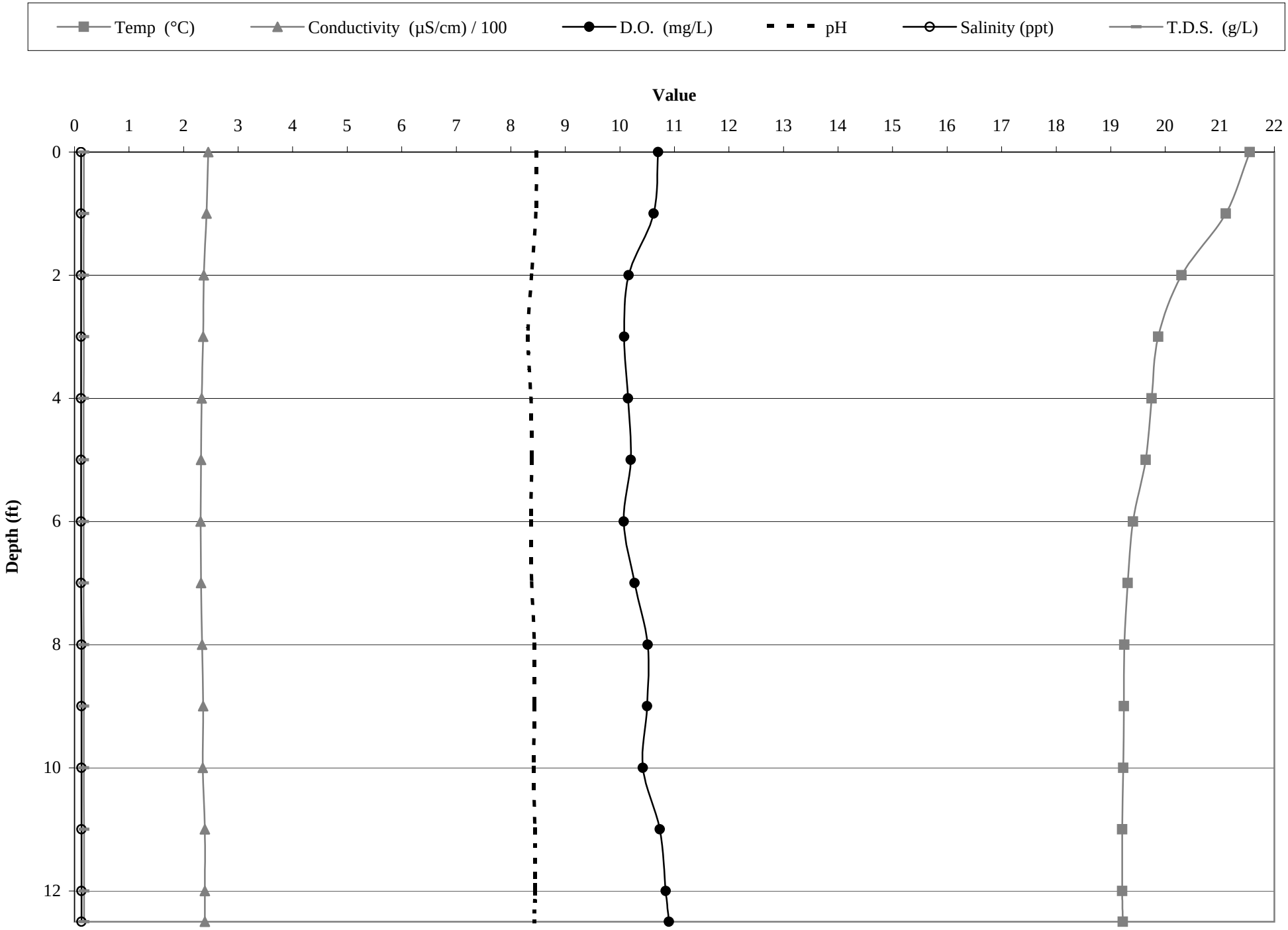
Appendix B-37. Gualala Water Quality Depth Profile - Mill Bend - (08/23/03)



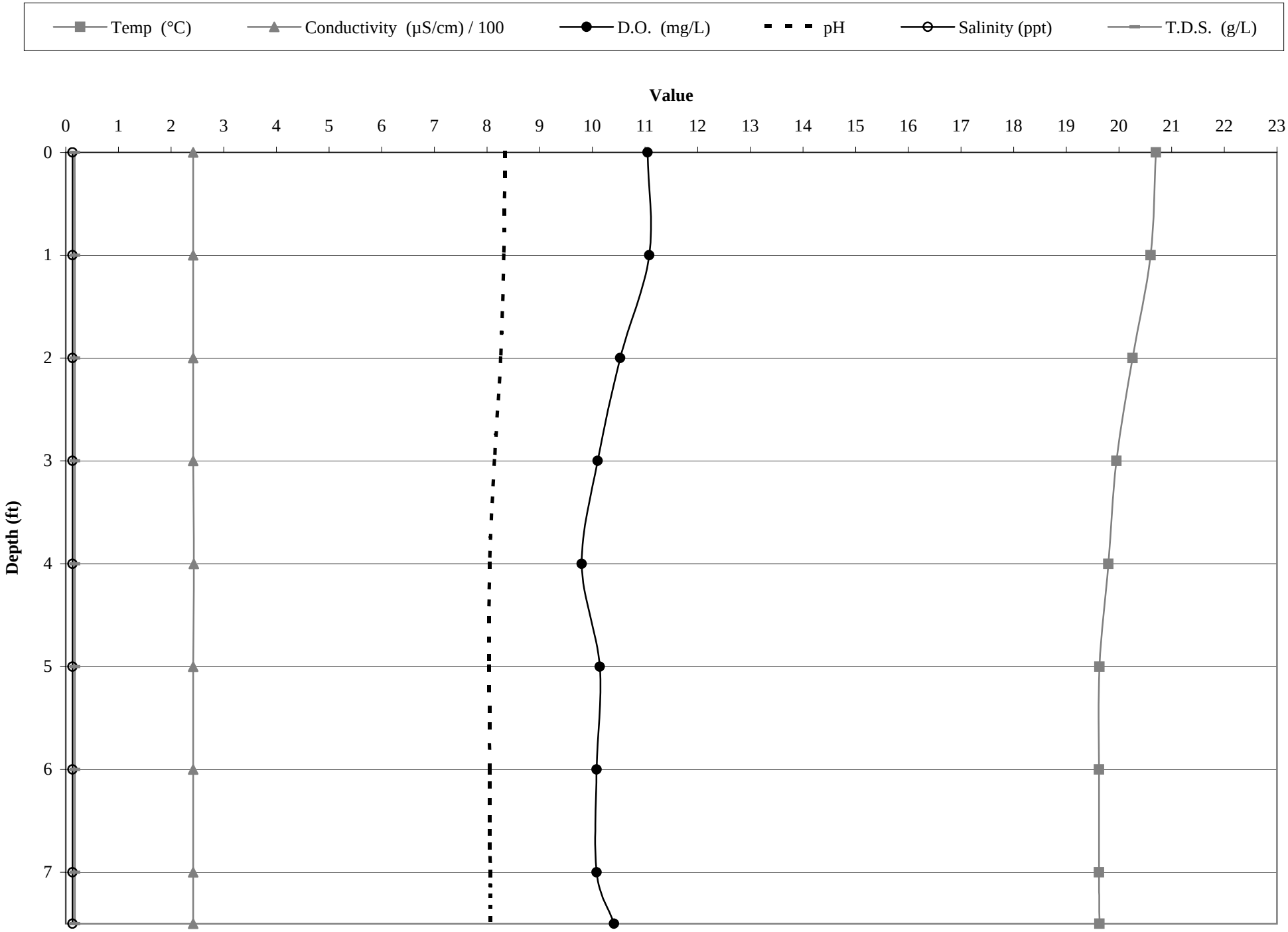
Appendix B-38. Gualala Water Quality Depth Profile - Mouth of Estuary- (9/22/03)



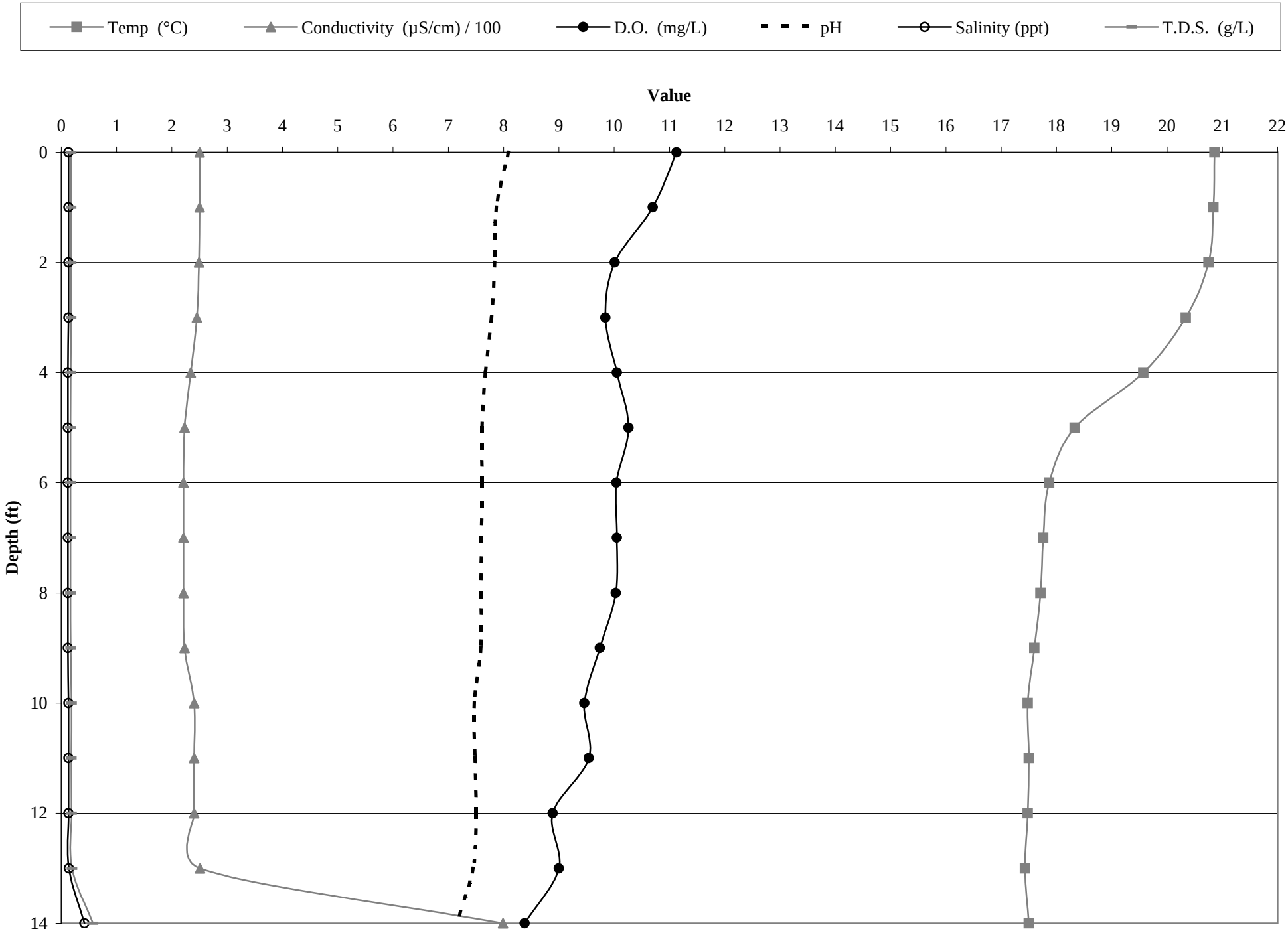
Appendix B-39. Gualala Water Quality Depth Profile - Tide Guage - (9/22/03)



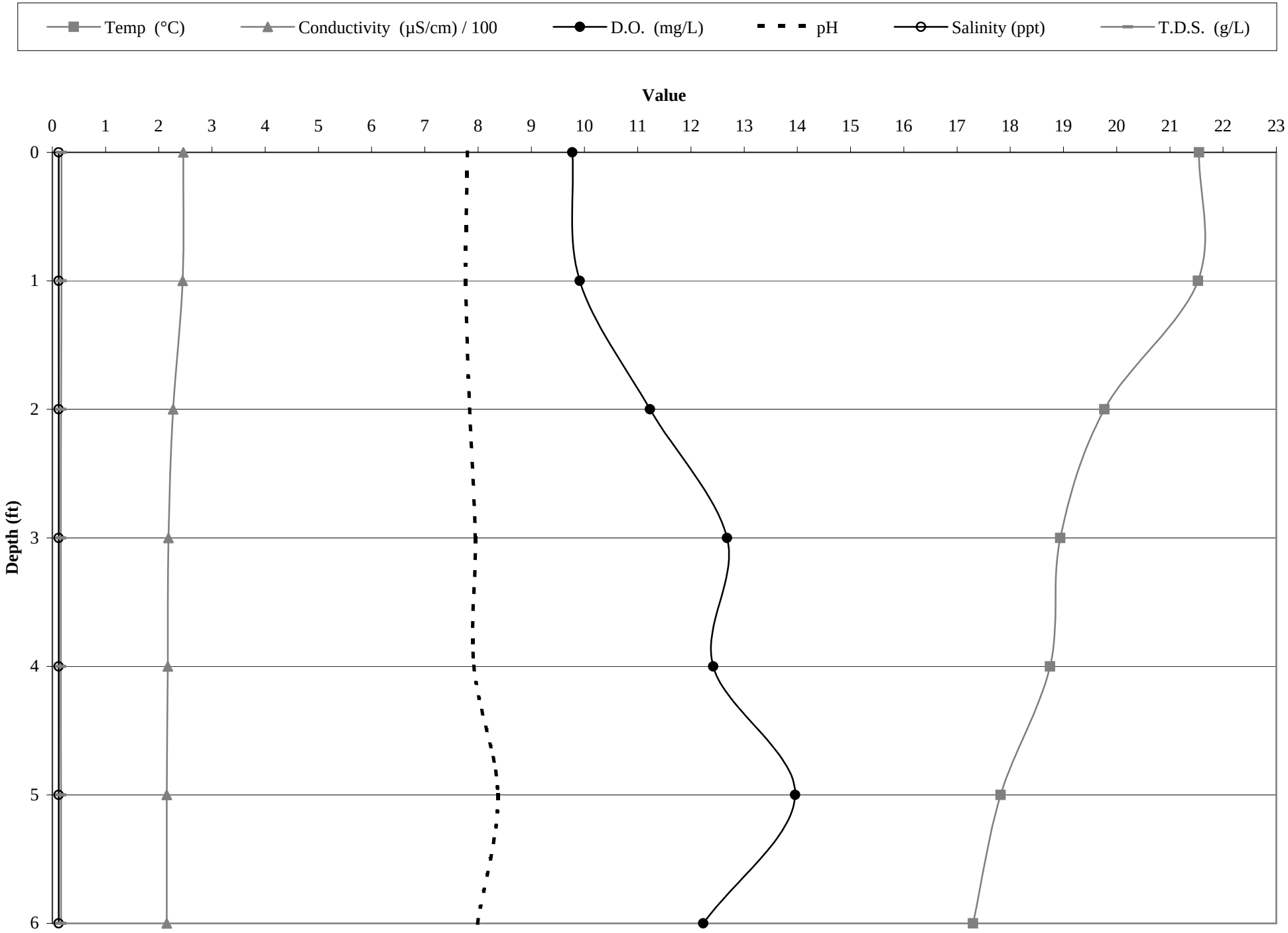
Appendix B-40. Gualala Water Quality Depth Profile - China Gulch - (09/22/03)



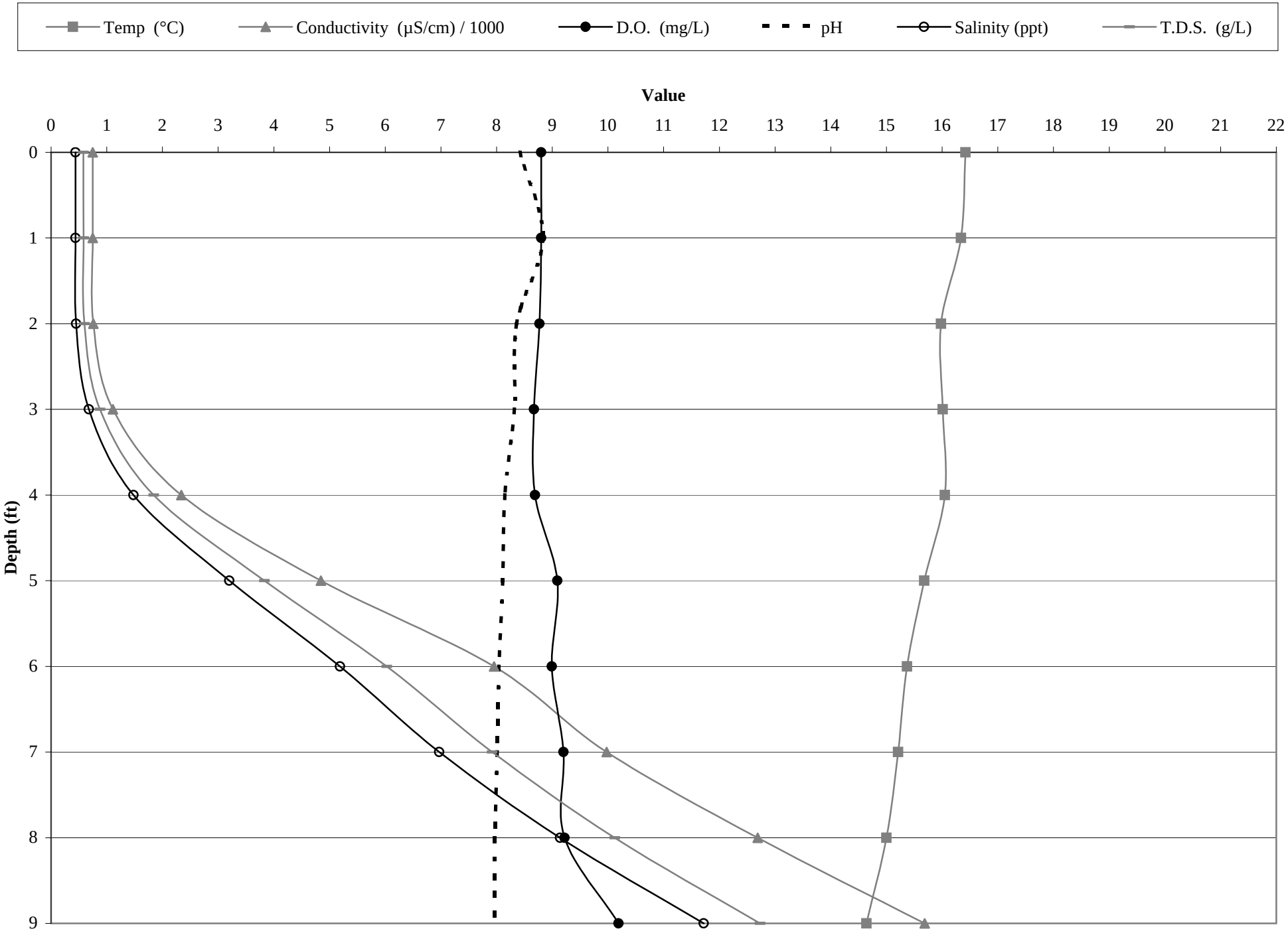
Appendix B-41. Gualala Water Quality Depth Profile - Mill Bend - (9/22/03)



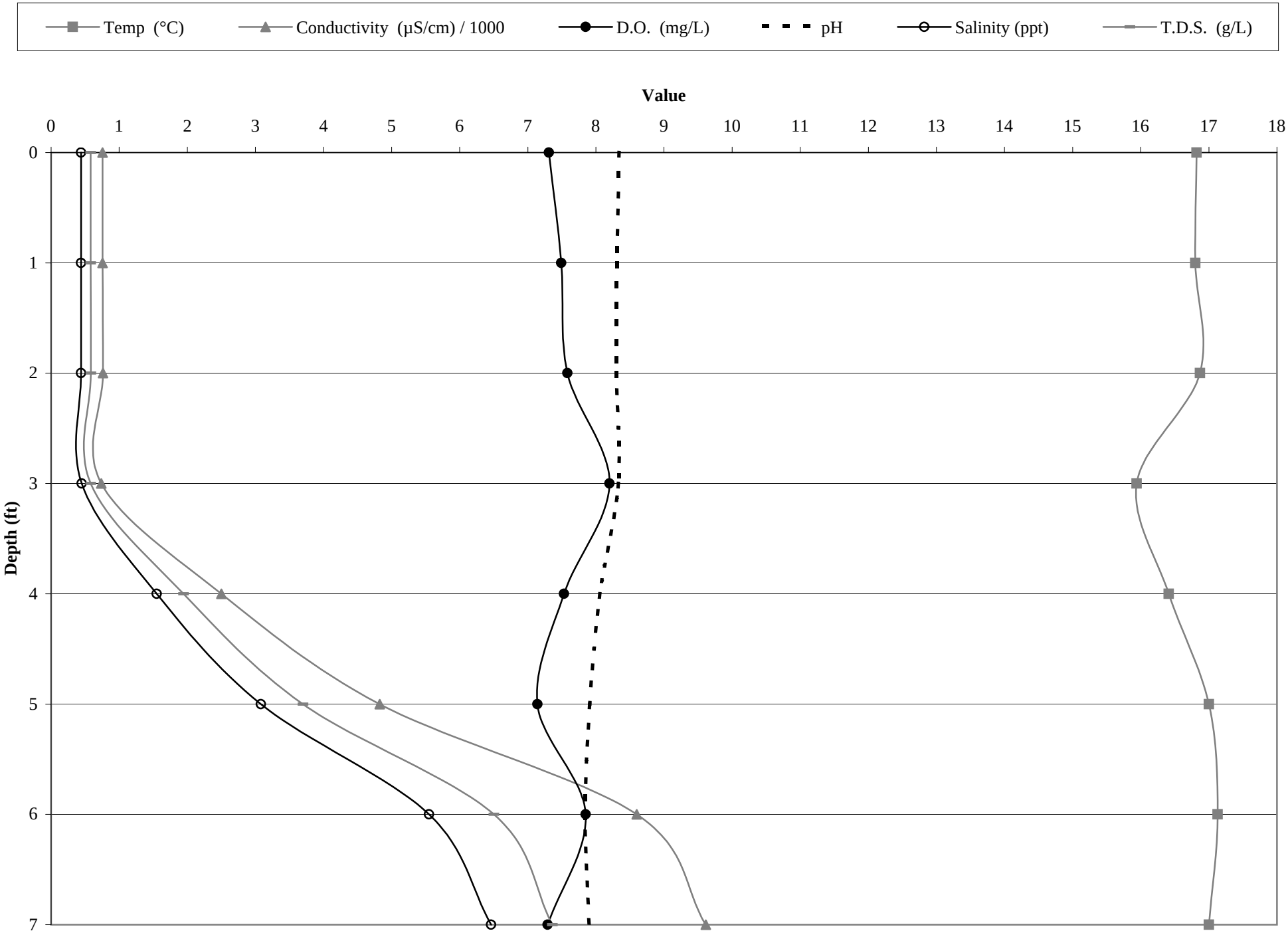
Appendix B-42. Gualala Water Quality Depth Profile - Above Highway 1 Bridge - (09/22/03)



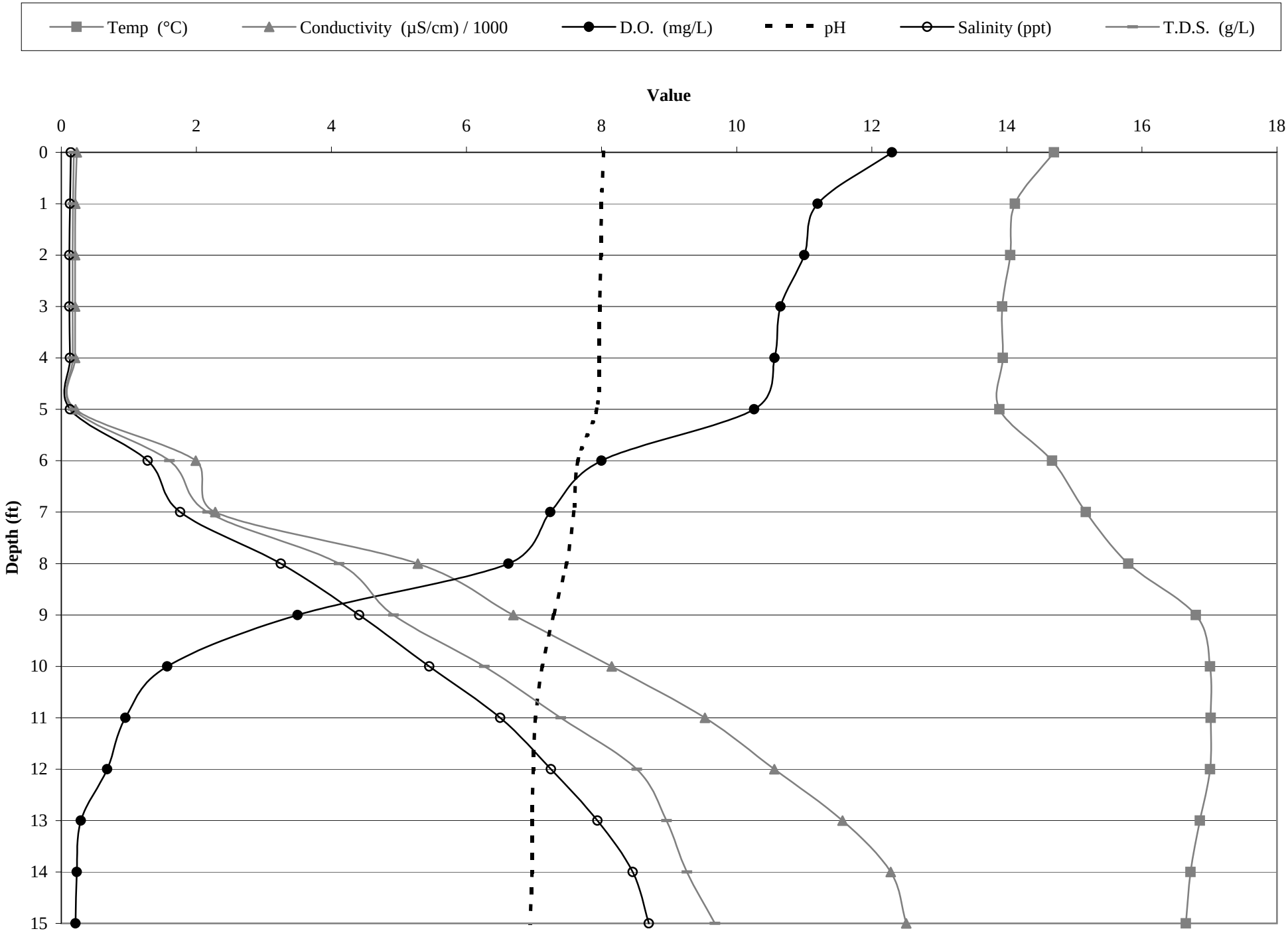
Appendix B-43. Gualala Water Quality Depth Profile - Mouth of Estuary- (10/27/03)



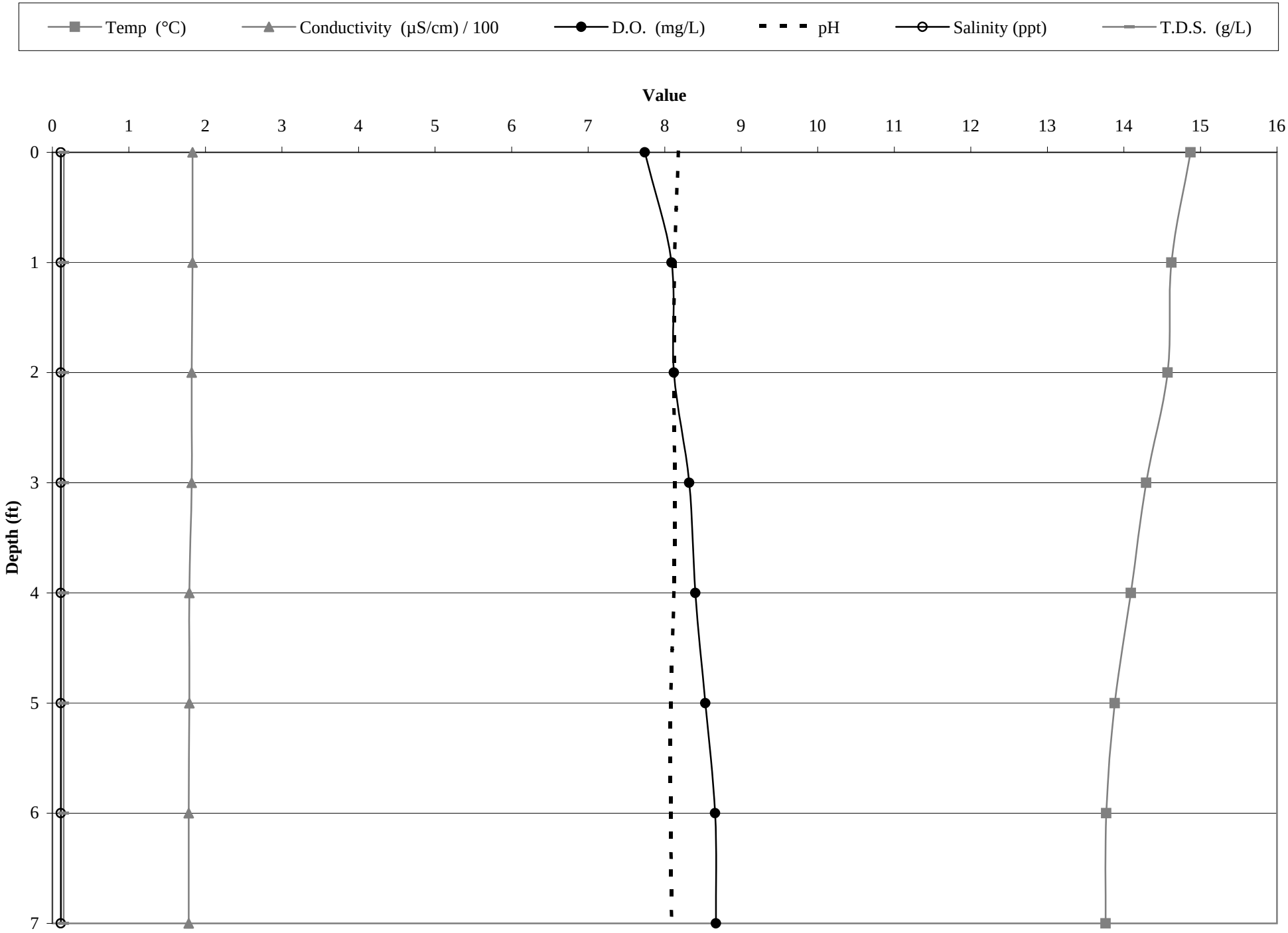
Appendix B-44. Gualala Water Quality Depth Profile - China Gulch - (10/28/03)



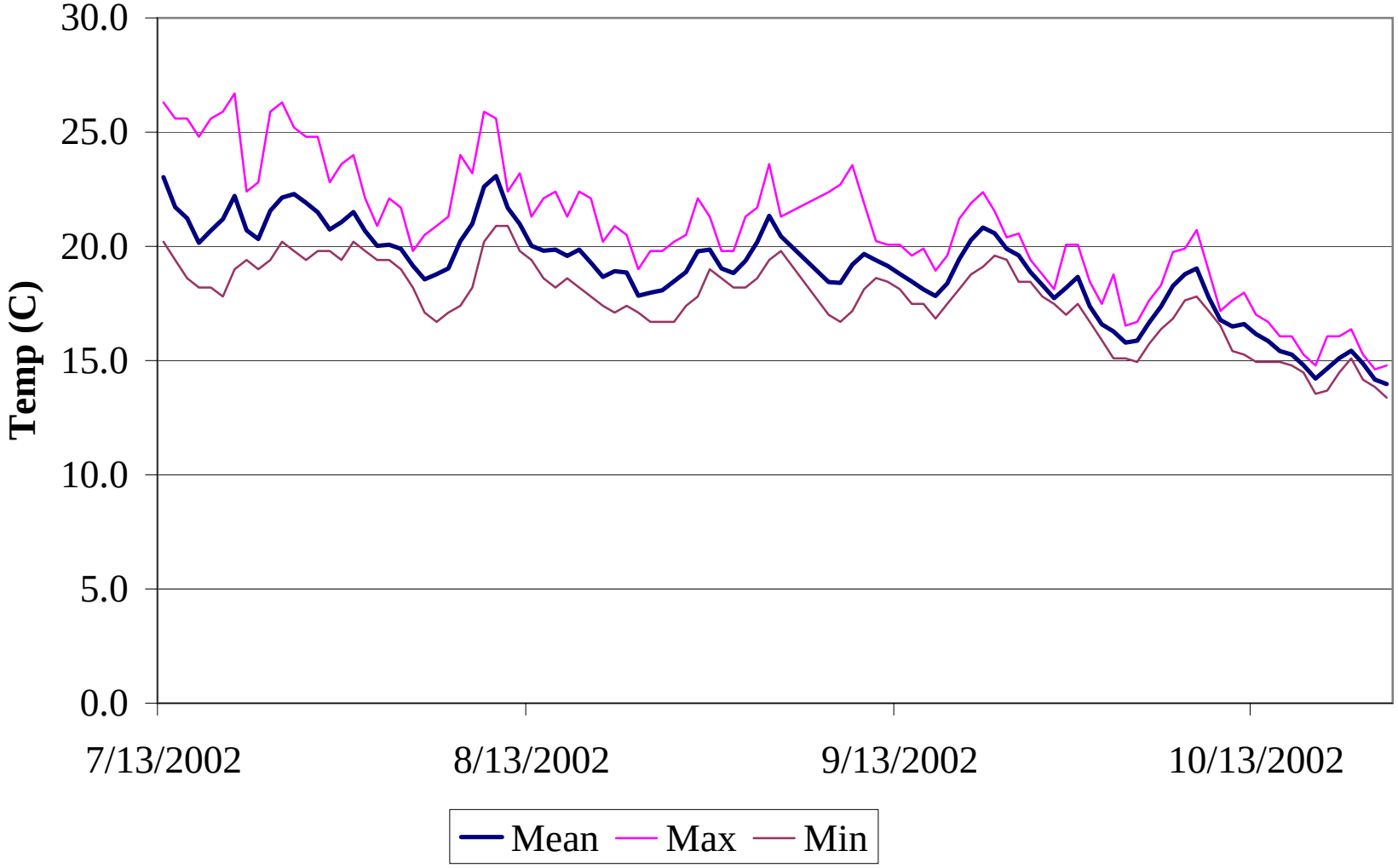
Appendix B-45. Gualala Water Quality Depth Profile - Mill Bend - (10/28/03)



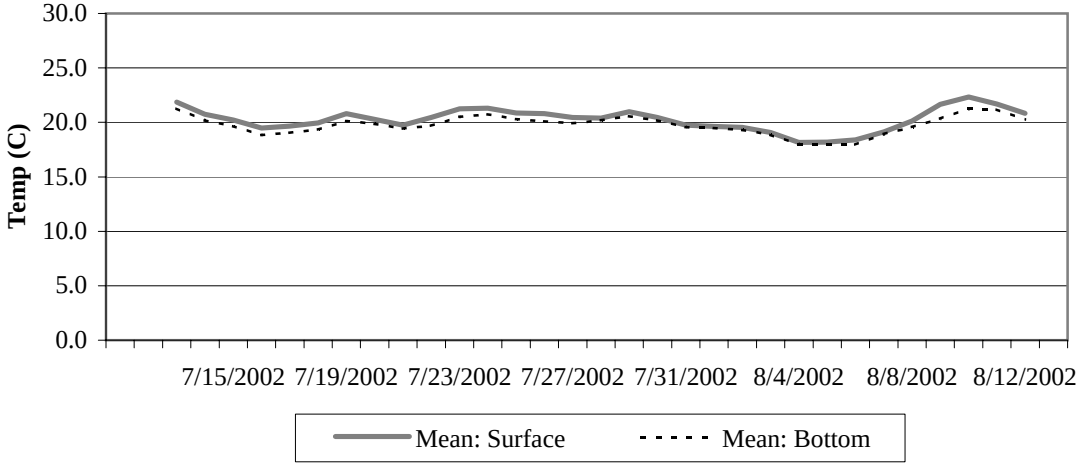
Appendix B-46. Gualala Water Quality Depth Profile - Above Highway 1 Bridge - (10/28/03)

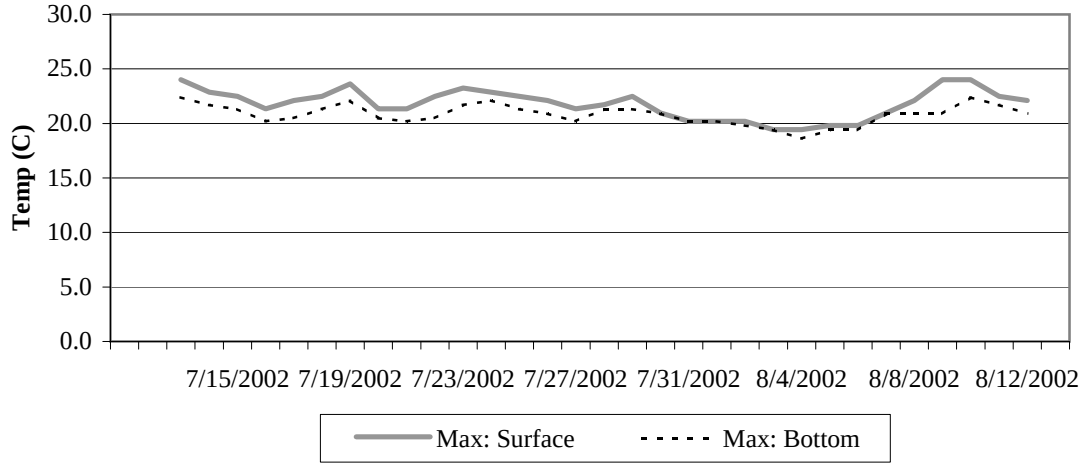


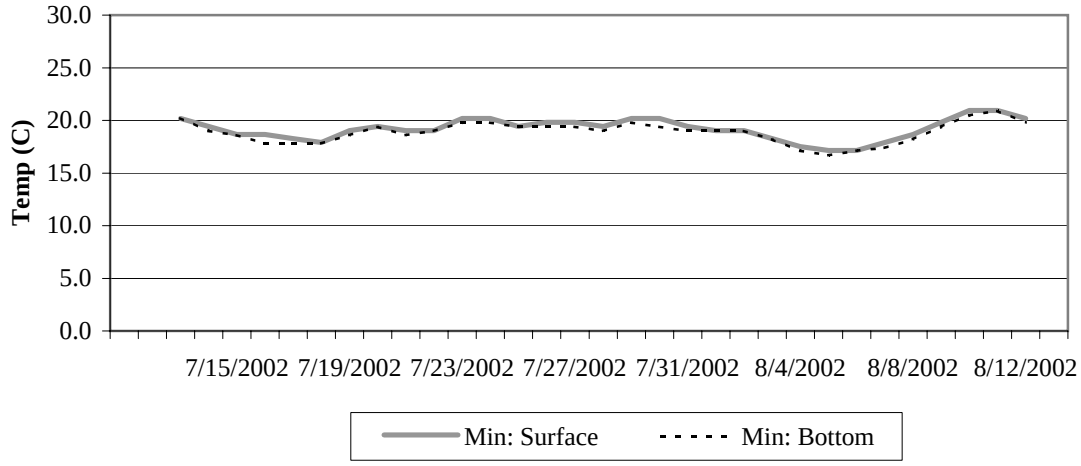
Appendix B - 47. 2002 Gualala Upper Estuary Daily Mean, Maximum and Minimum Temperature for July 13 through October 24, 2002.



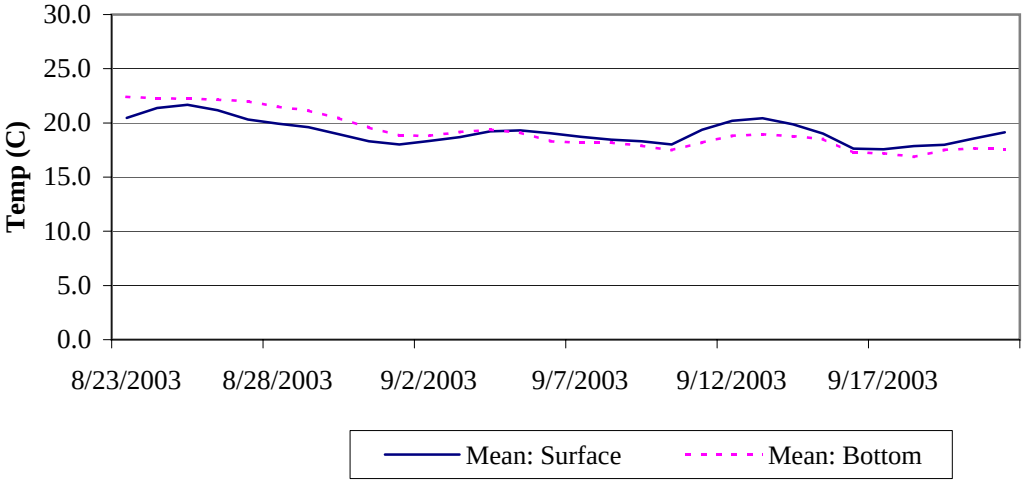
Appendix B - 48. 2002 Gualala River Middle Estuary Daily Mean, Maximum and Minimum Temperatures for July 13 through August 12, 2002

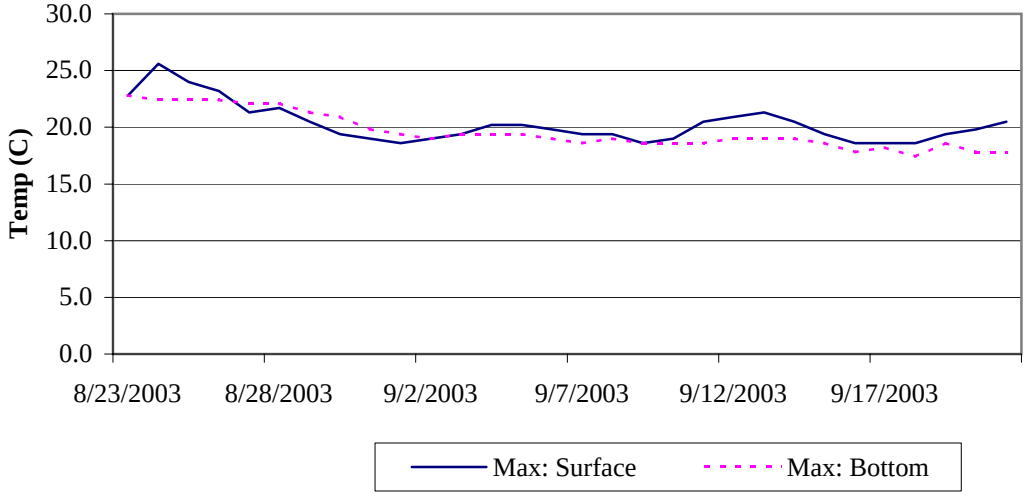


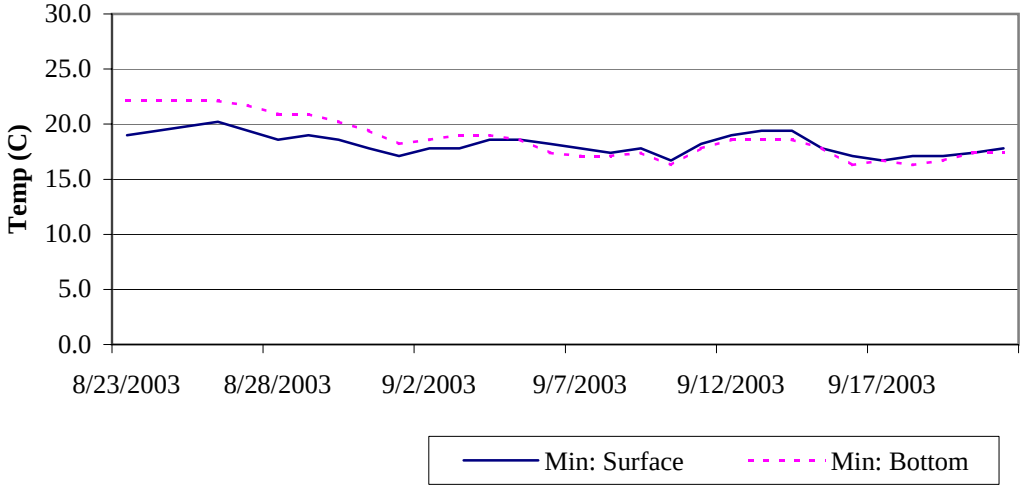




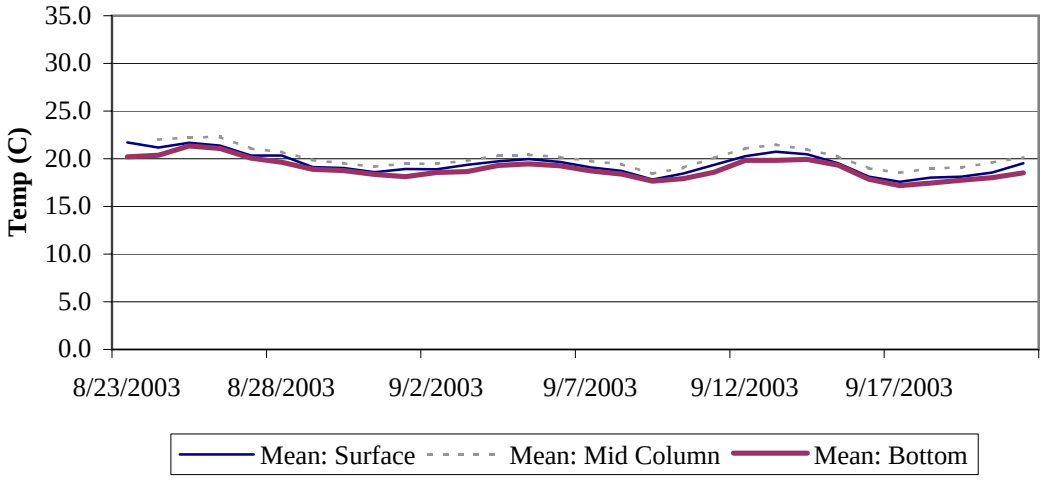
Appendix B - 49. Gualala River Estuary Mill Bend Daily Mean, Maximum and Minimum Temperatures for August 23 through September 21, 2003

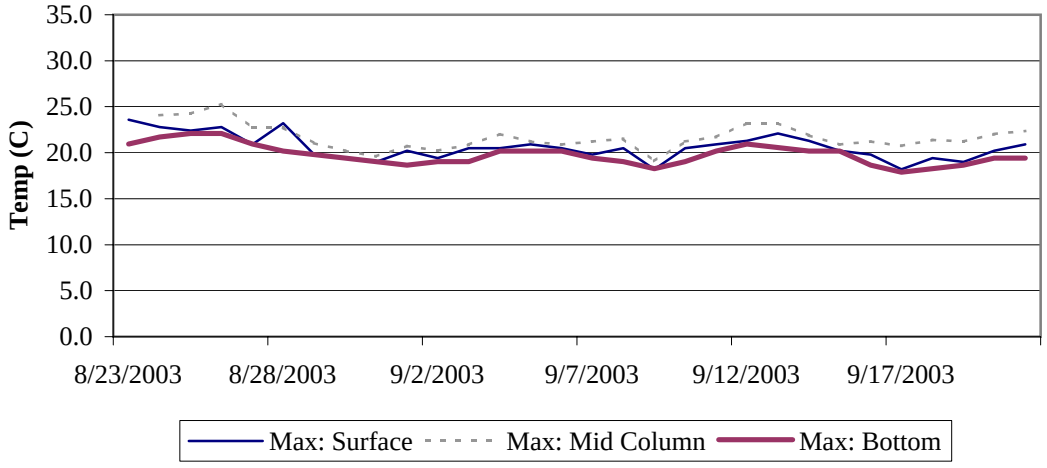


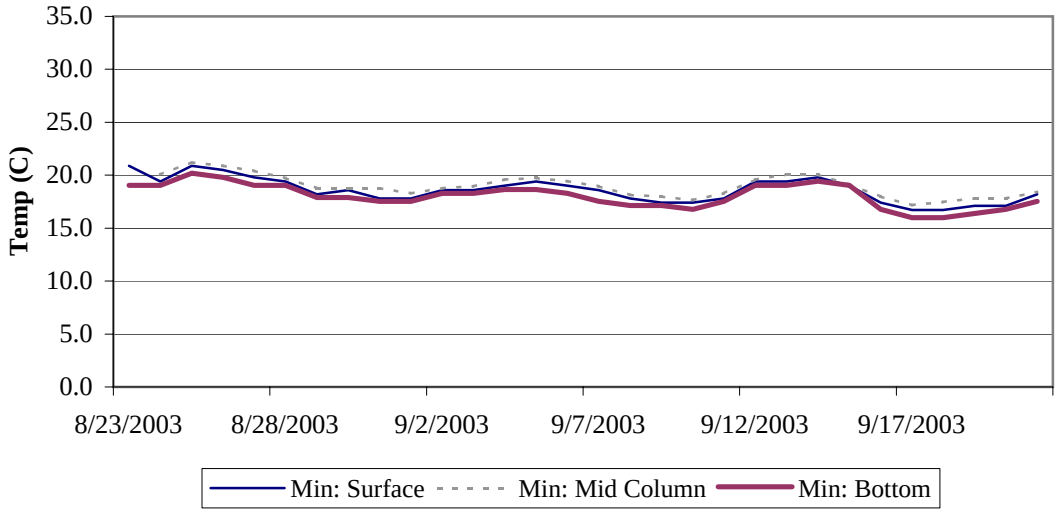




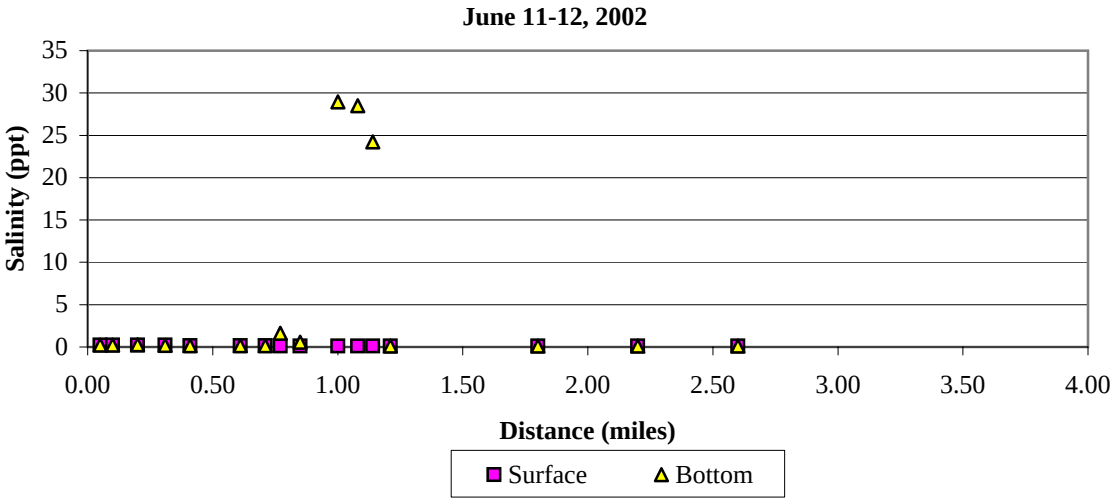
Appendix B - 50. Gualala Middle Estuary Daily Mean, Maximum and Minimum Temperatures from August 23 through September 21, 2003.

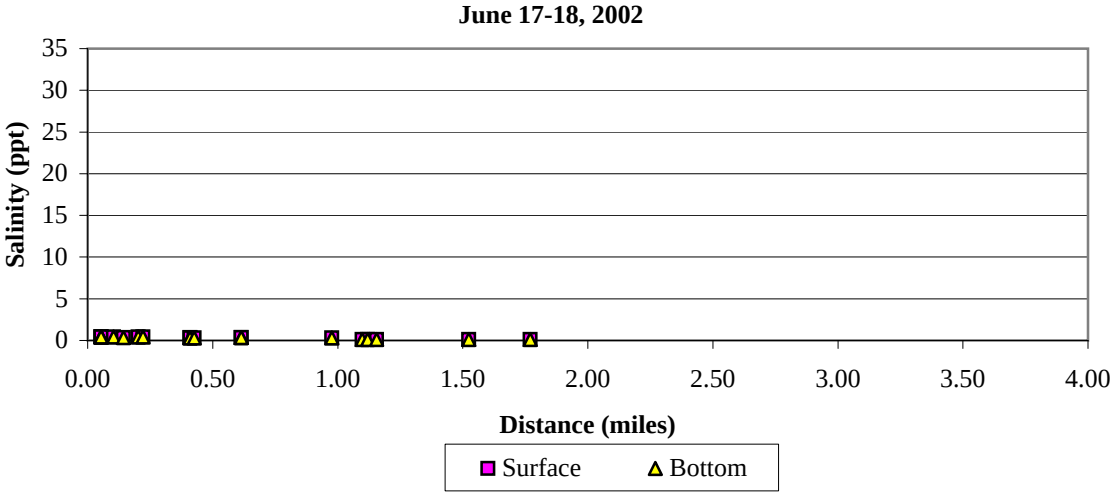


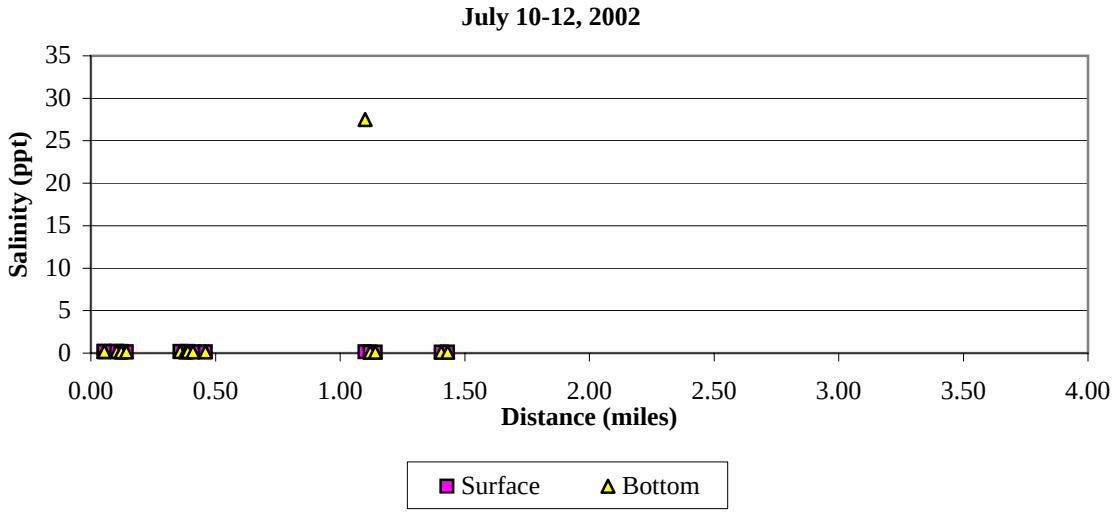




Appendix B-51. Salinity vs. Distance in the Gualala River Estuary, 2002-2003.

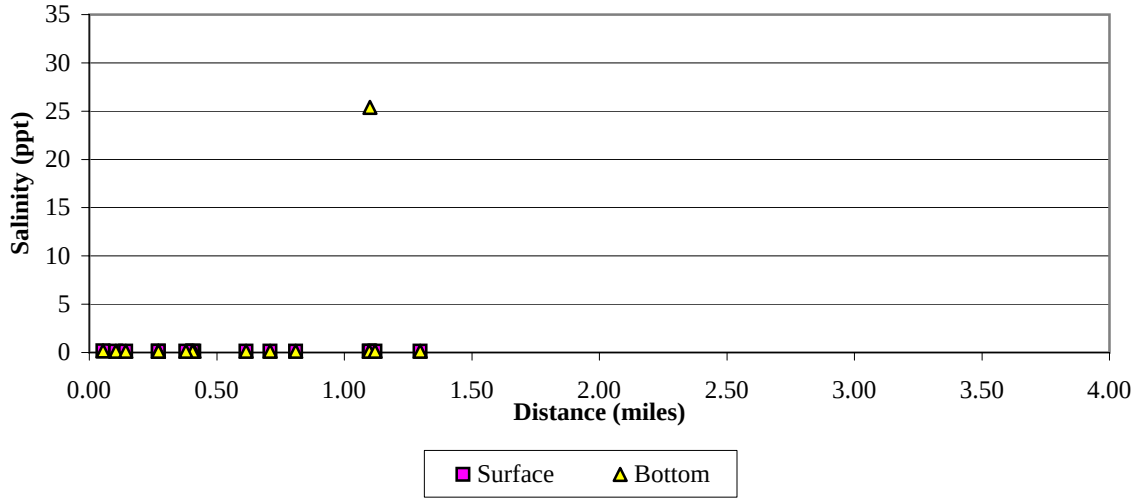




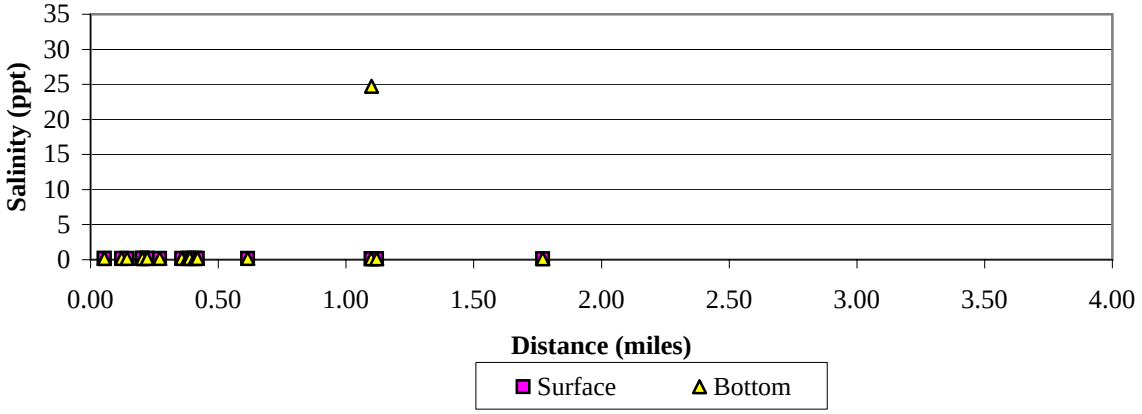


Appendix B-51. (Cont.) Salinity vs. Distance in the Gualala River Estuary, 2002-2003.

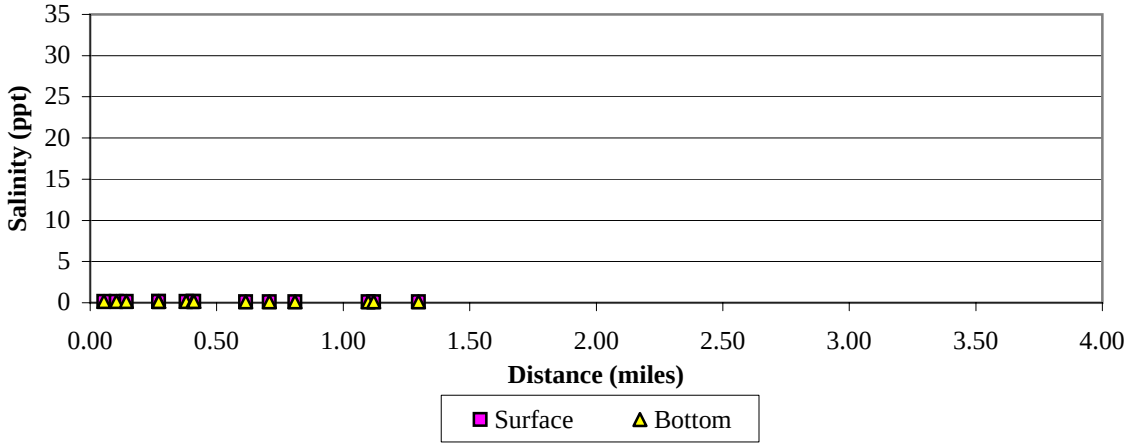
August 2, 2002



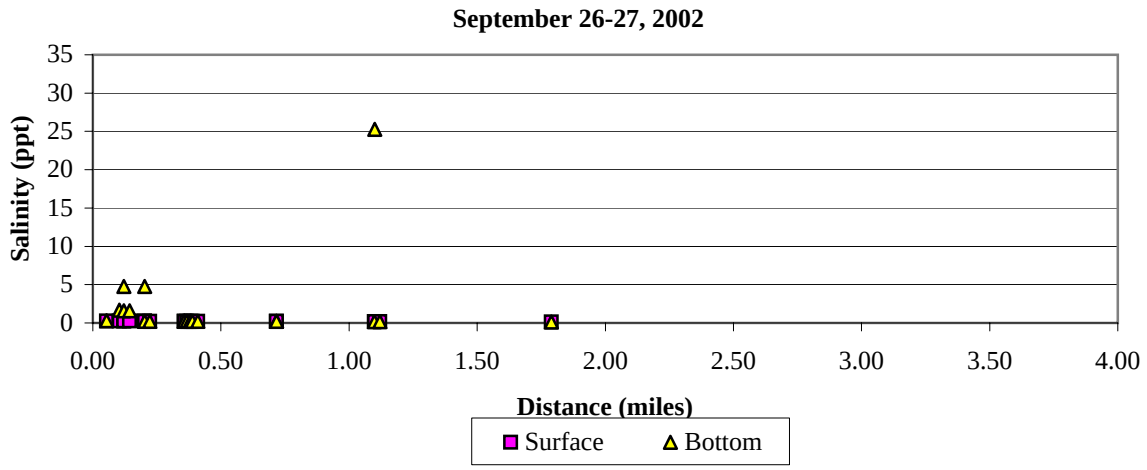
August 12-13, 2002

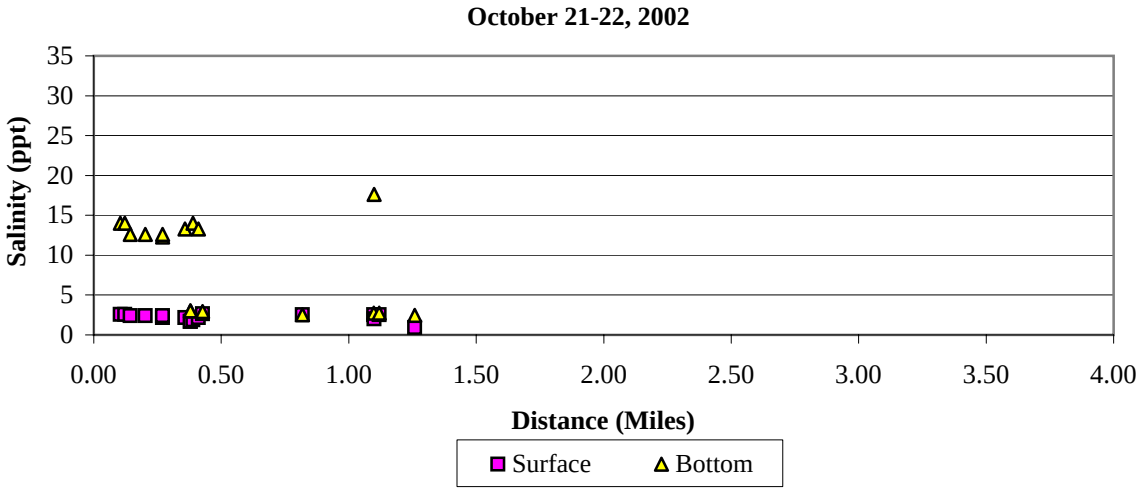


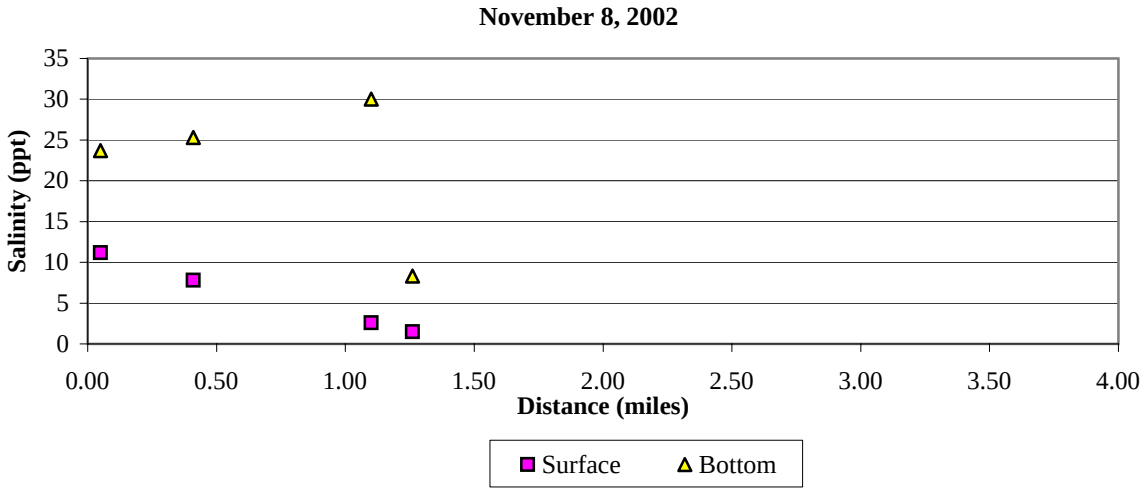
September 1-2, 2002



Appendix B-51. (Cont.) Salinity vs. Distance in the Gualala River Estuary, 2002-2003.

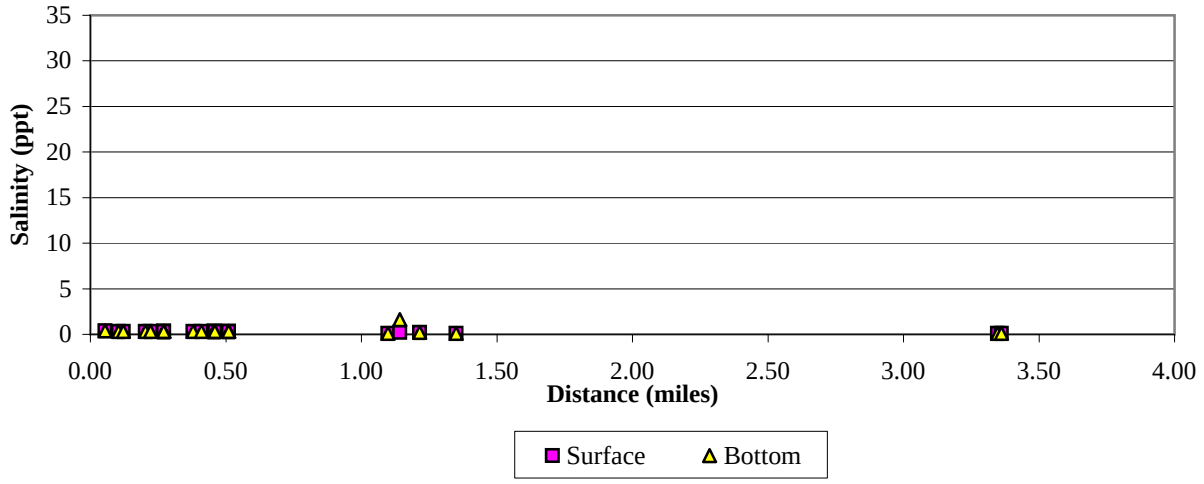




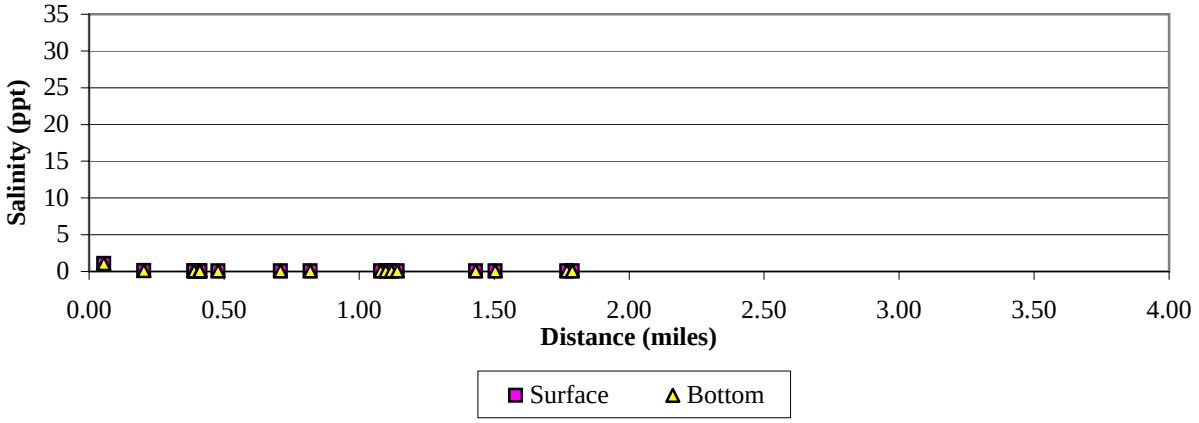


Appendix B-51. (Cont.) Salinity vs. Distance in the Gualala River Estuary, 2002-2003.

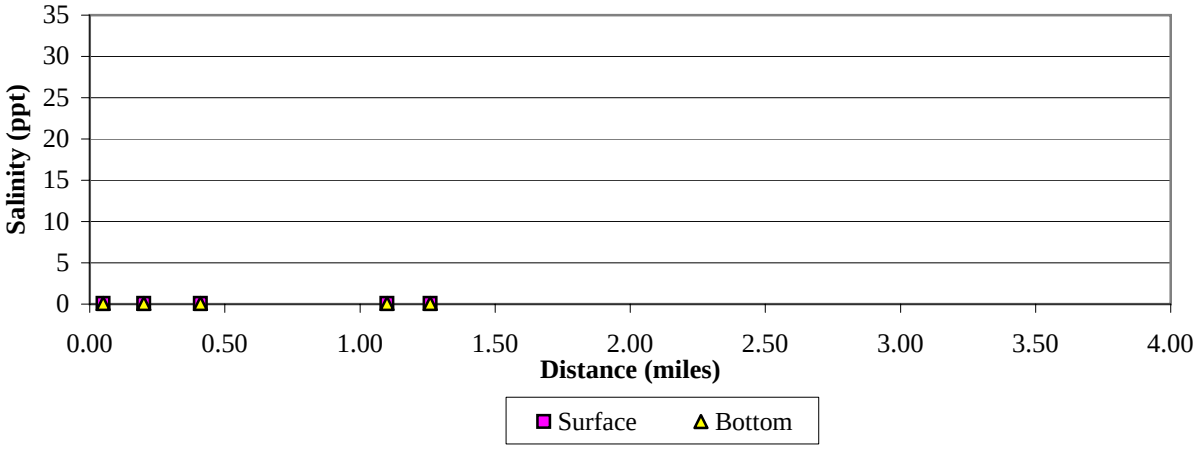
November 26-27, 2002



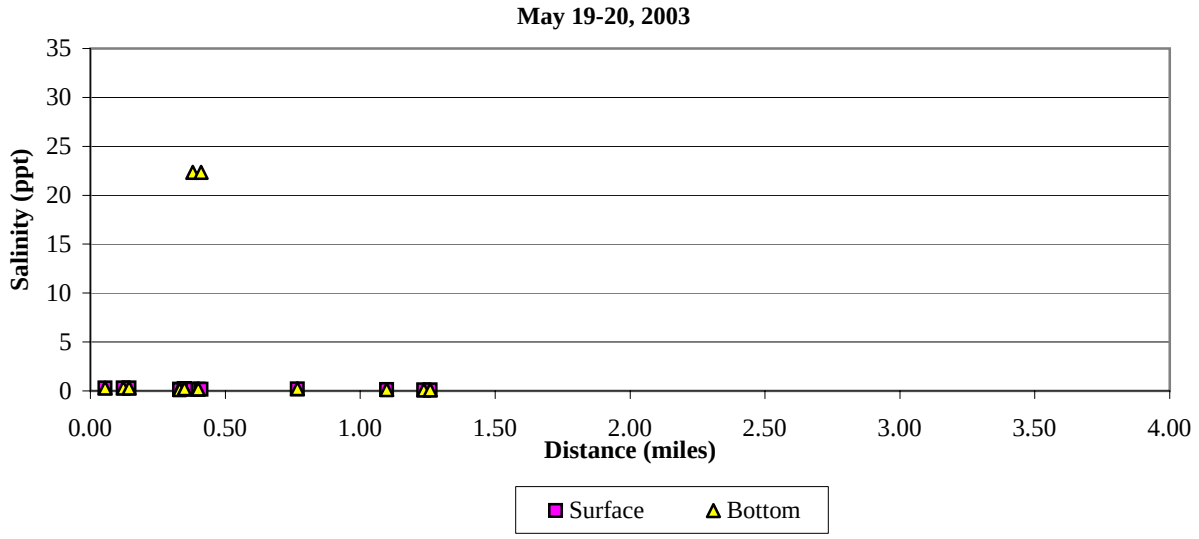
February 18-19, 2003

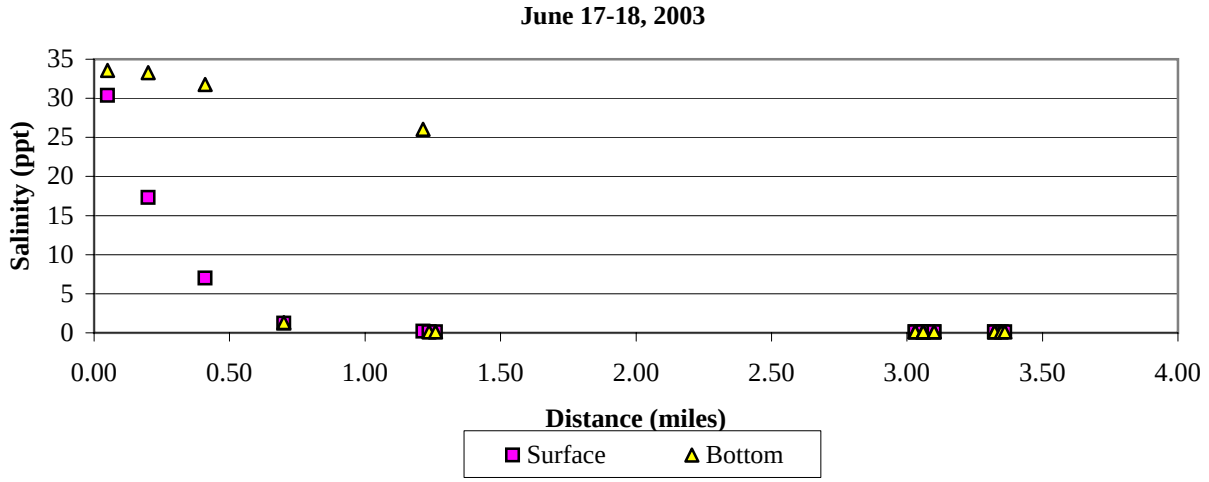


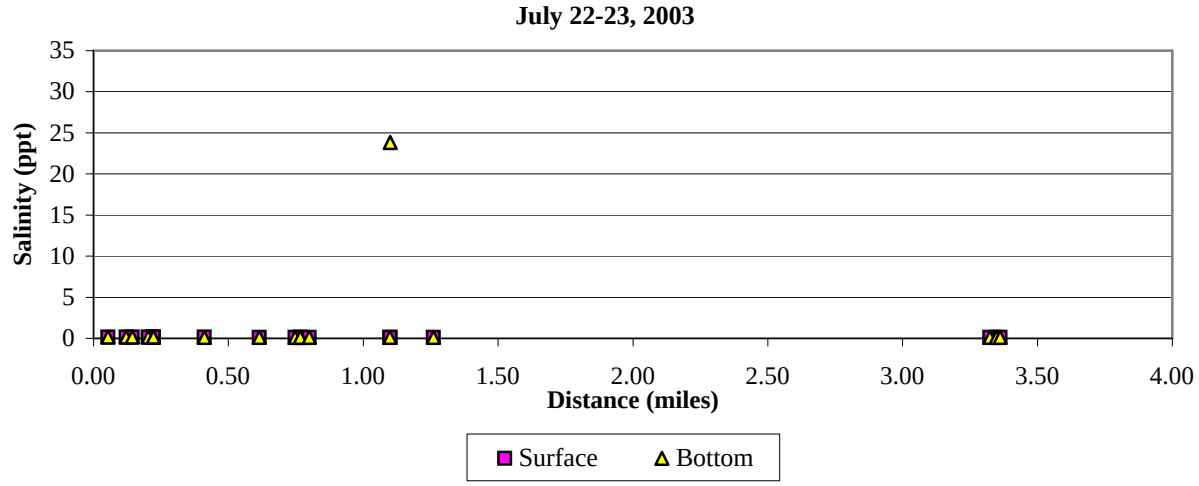
April 28, 2003



Appendix B-51. (Cont.) Salinity vs. Distance in the Gualala River Estuary, 2002-2003.

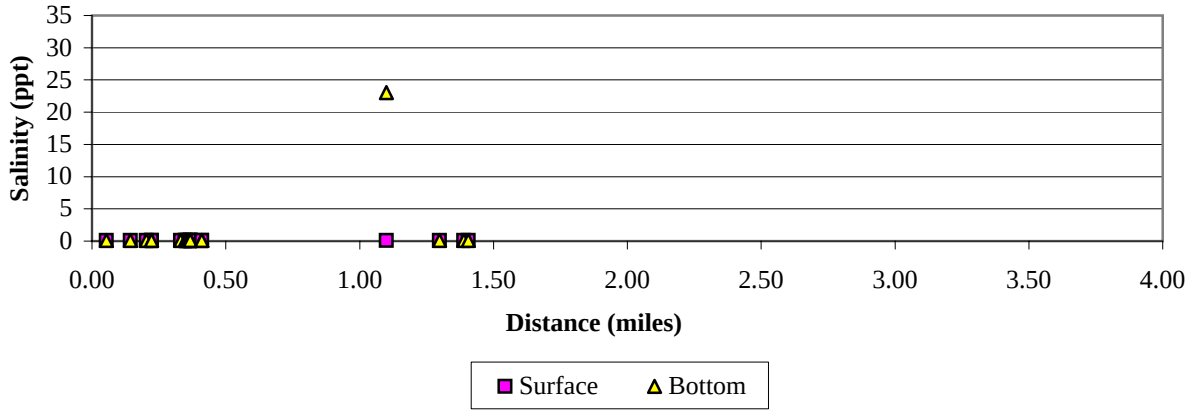




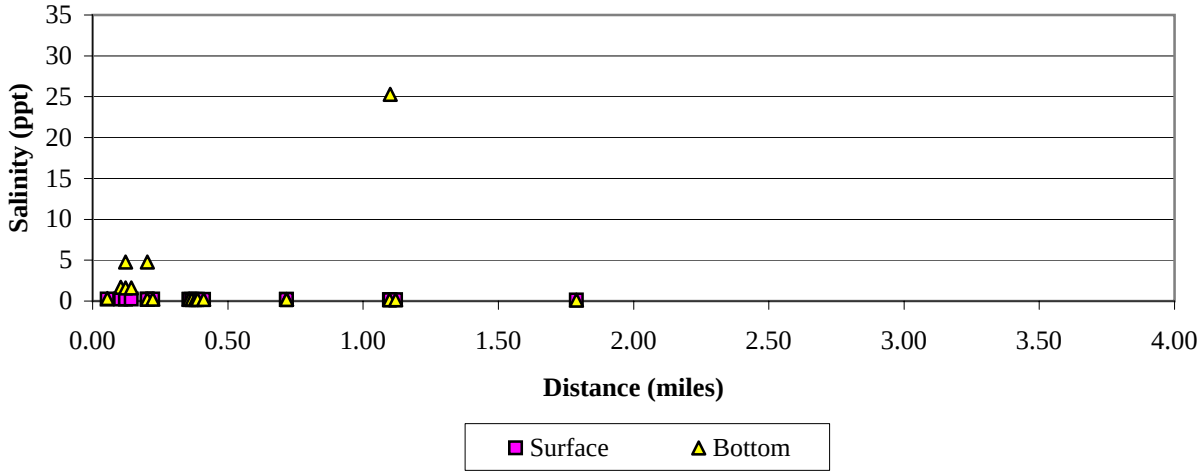


Appendix B-51. (Cont.) Salinity vs. Distance in the Gualala River Estuary, 2002-2003.

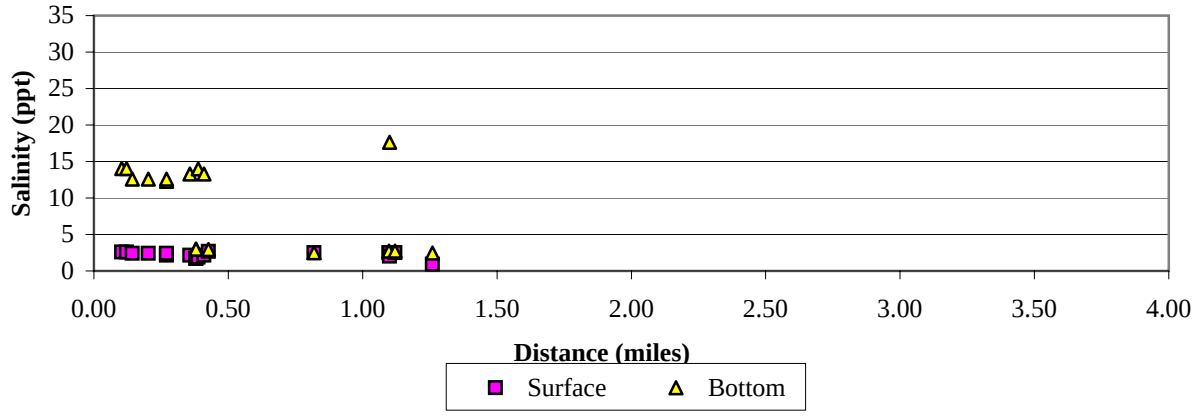
August 21-23, 2003



September 23-24, 2003



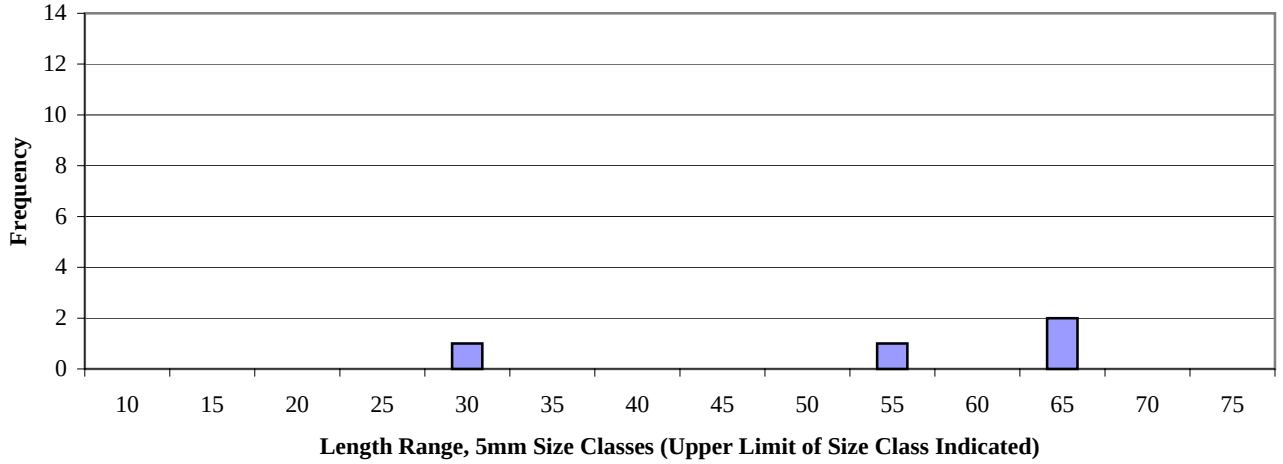
October 27-28, 2003.



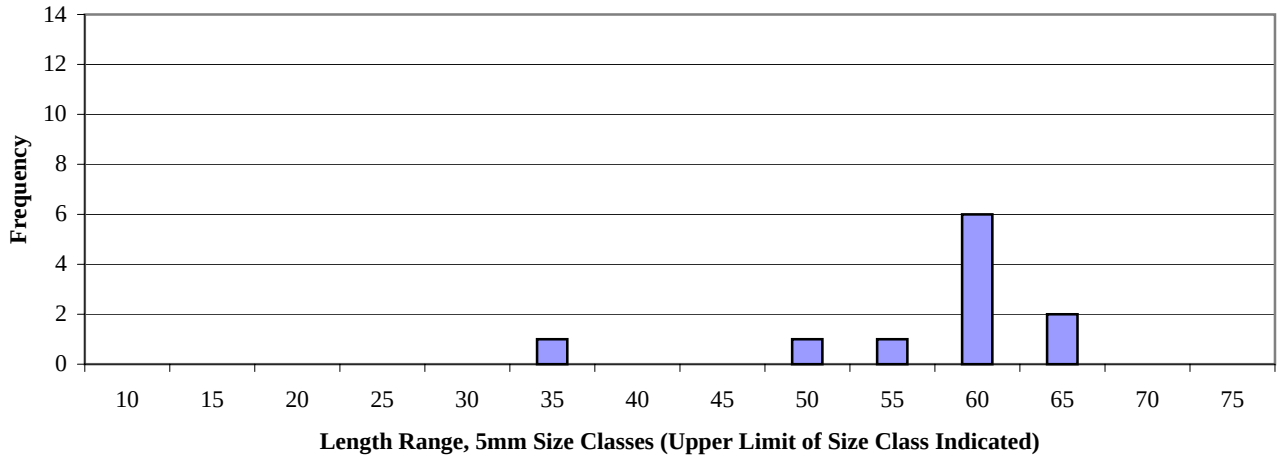
APPENDIX C

Fish Species Length Frequency Histograms

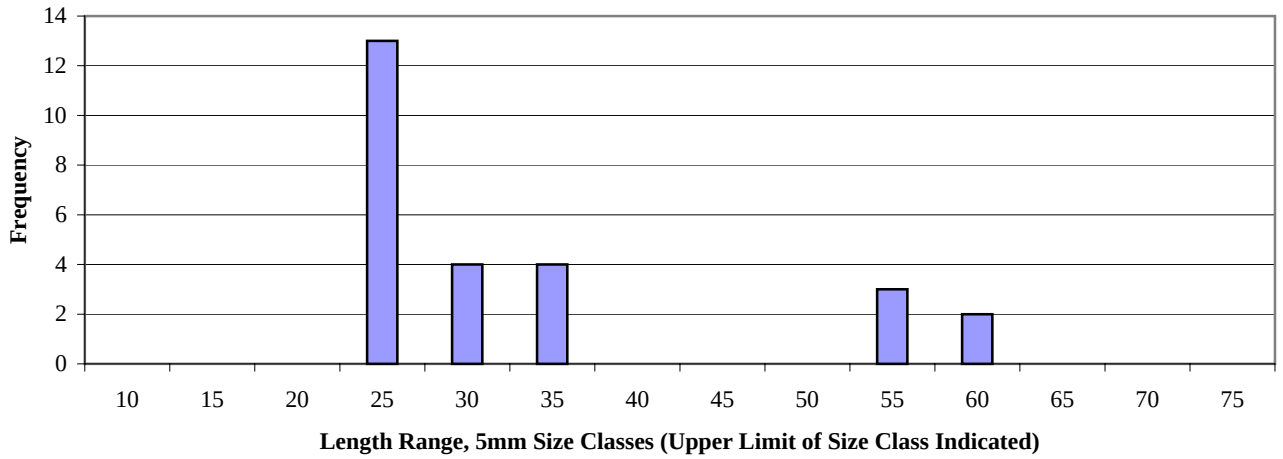
Appendix C-1.1. Three-Spine Stickleback Length Frequency during June 2002 Sampling Event for the Lower Gualala Estuary.



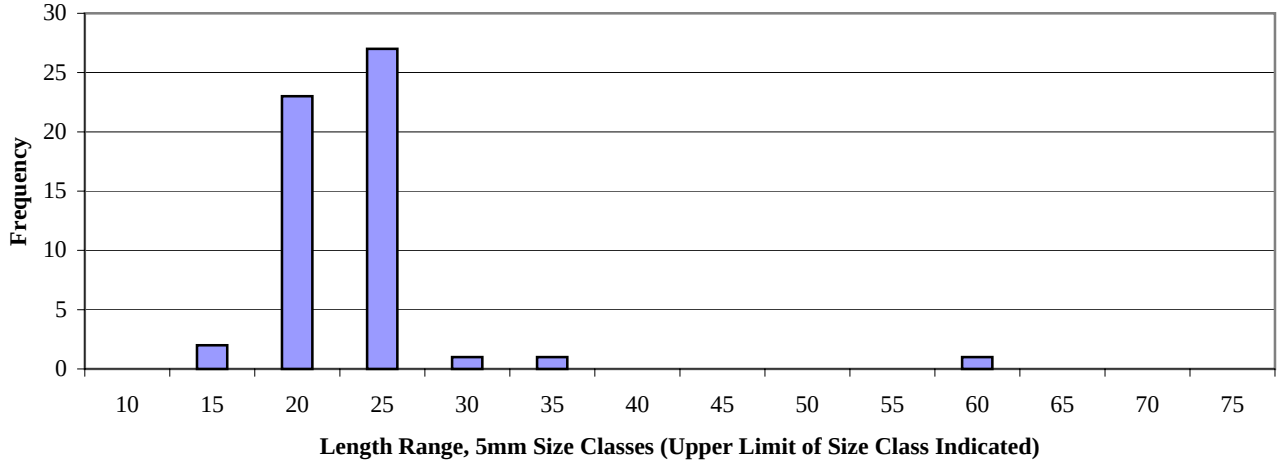
Appendix C-1.2. Three-Spine Stickleback Length Frequency during June 2002 Sampling Event for the Middle Gualala Estuary.



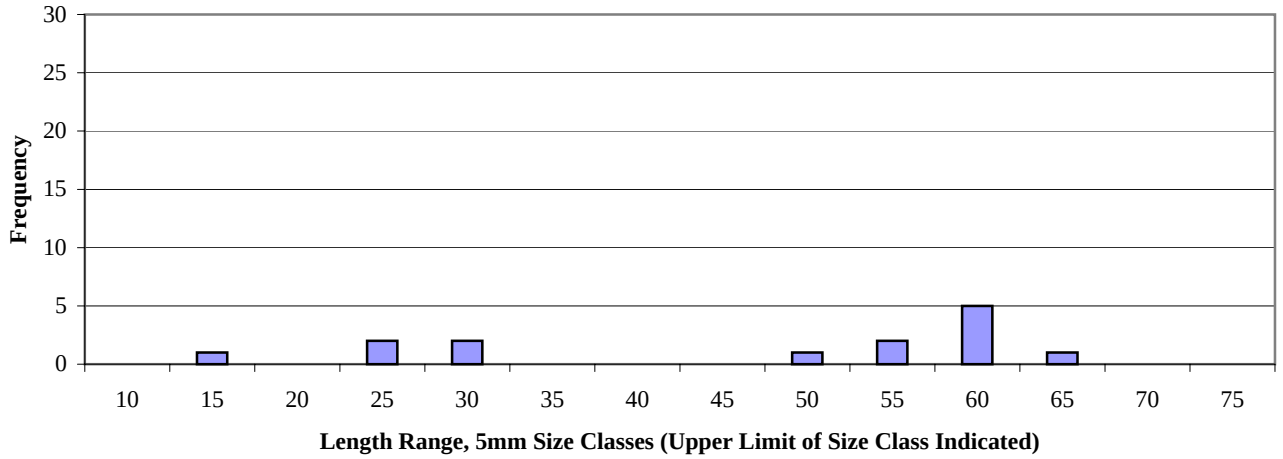
Appendix C-1.3. Three-Spine Stickleback Length Frequency during June 2002 Sampling Event for the Upper Gualala Estuary.



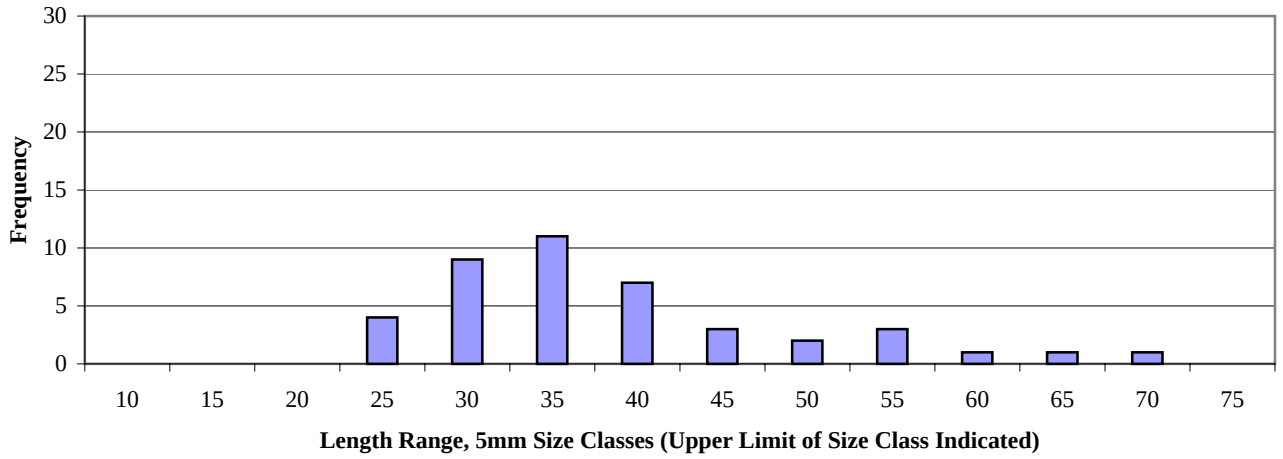
Appendix C-1.4. Three-Spine Stickleback Length Frequency during July 2002 Sampling Event for the Lower Gualala Estuary.



Appendix C-1.5. Three-Spine Stickleback Length Frequency during July 2002 Sampling Event for the Middle Gualala Estuary.



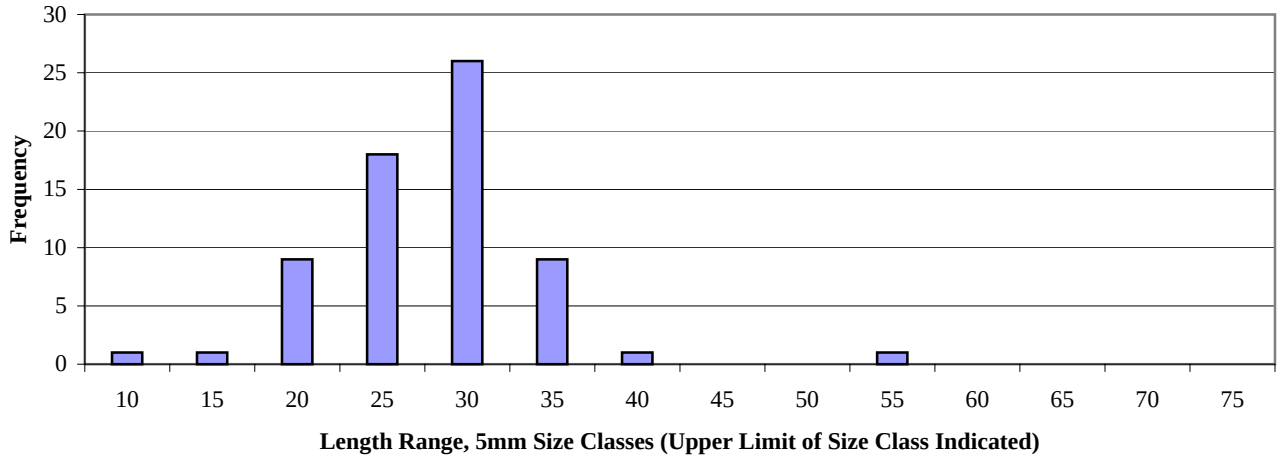
Appendix C-1.6. Three-Spine Stickleback Length Frequency during July 2002 Sampling Event for the Upper Gualala Estuary.



APPENDIX C-1

Appendix C-1.7. Three-Spine Stickleback Length Frequency during August 2002 Sampling Events for the Lower Gualala Estuary.

Appendix C-1.8. Three-Spine Stickleback Length Frequency during August 2002 Sampling Events for the Middle Gualala Estuary.

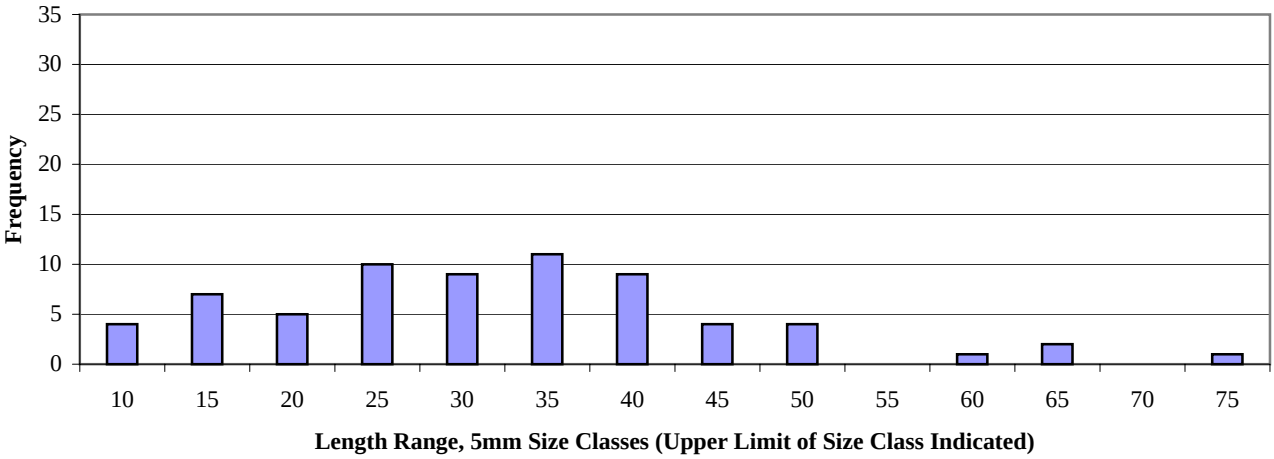


Appendix C-1.9. Three-Spine Stickleback Length Frequency during August 2002 Sampling Events for the Upper Gualala Estuary.

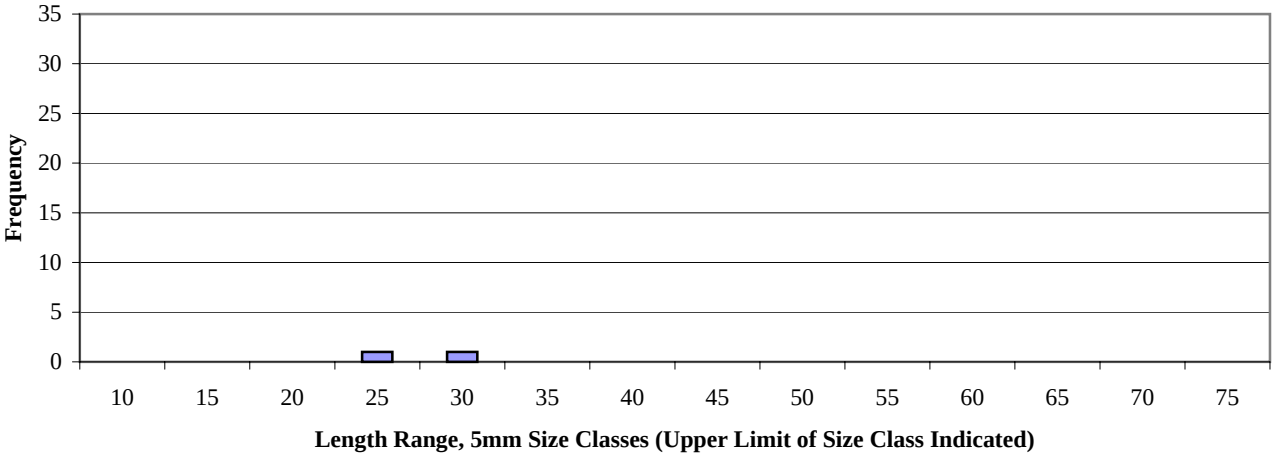
APPENDIX C-1

Appendix C-1.10. Three-Spine Stickleback Length Frequency during September 2002 Sampling Events for the Lower Gualala Estuary.

Appendix C-1.11. Three-Spine Stickleback Length Frequency during September 2002 Sampling Events for the Middle Gualala Estuary.

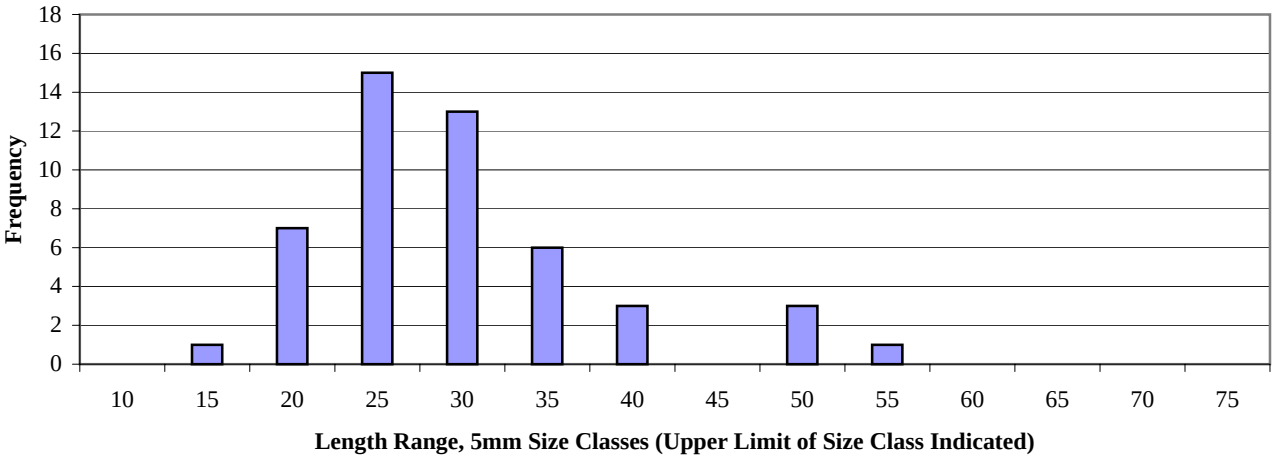


Appendix C-1.12. Three-Spine Stickleback Length Frequency during September 2002 Sampling Events for the Upper Gualala Estuary.

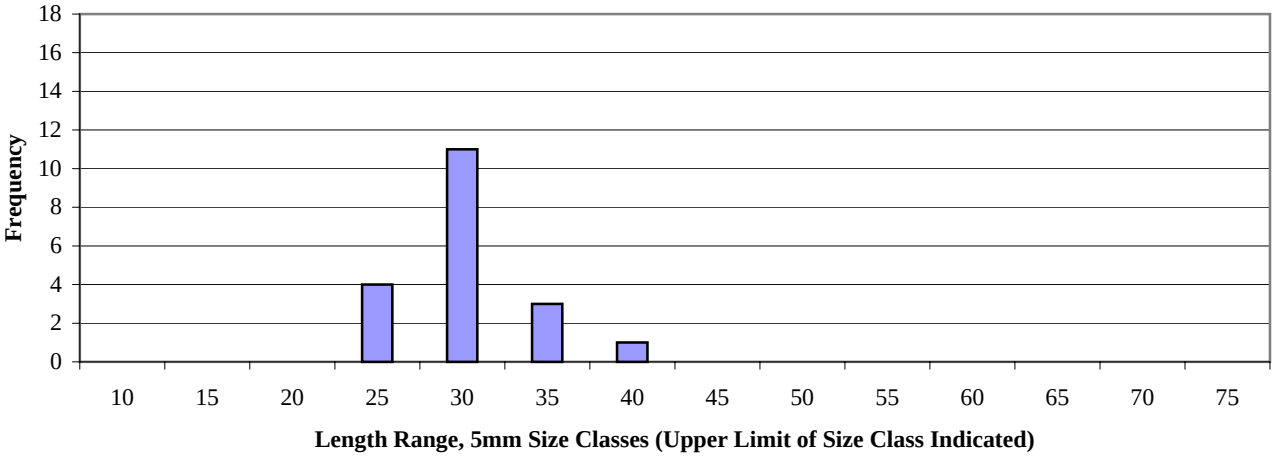


Appendix C-1.13. Three-Spine Stickleback Length Frequency during October-November 2002 Sampling Events for the Lower Gualala Estuary.

Appendix C-1.14. Three-Spine Stickleback Length Frequency during October-November 2002 Sampling Events for the Middle Gualala Estuary.



Appendix C-1.15. Three-Spine Stickleback Length Frequency during October-November 2002 Sampling Events for the Upper Gualala Estuary.

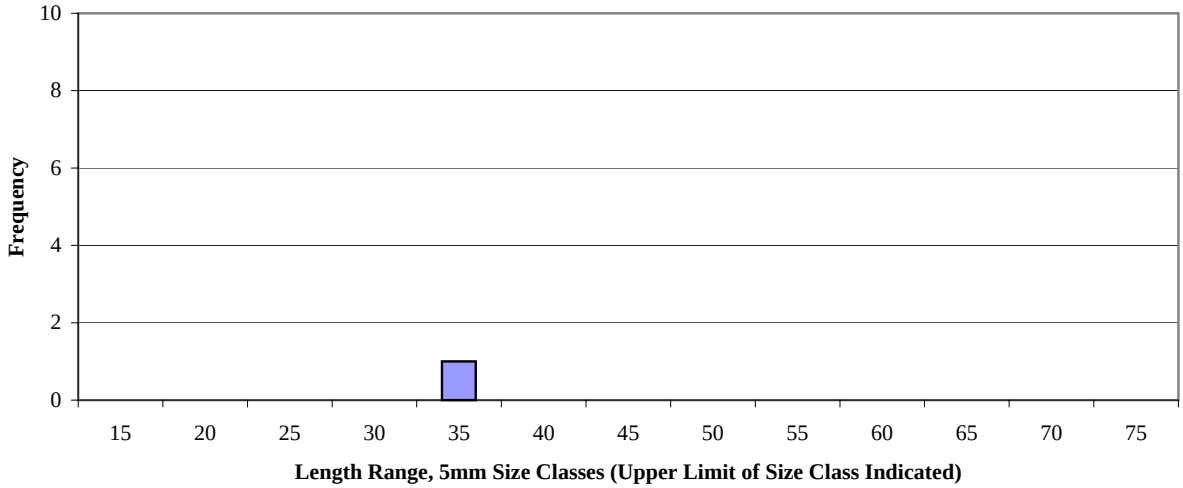


APPENDIX C-1

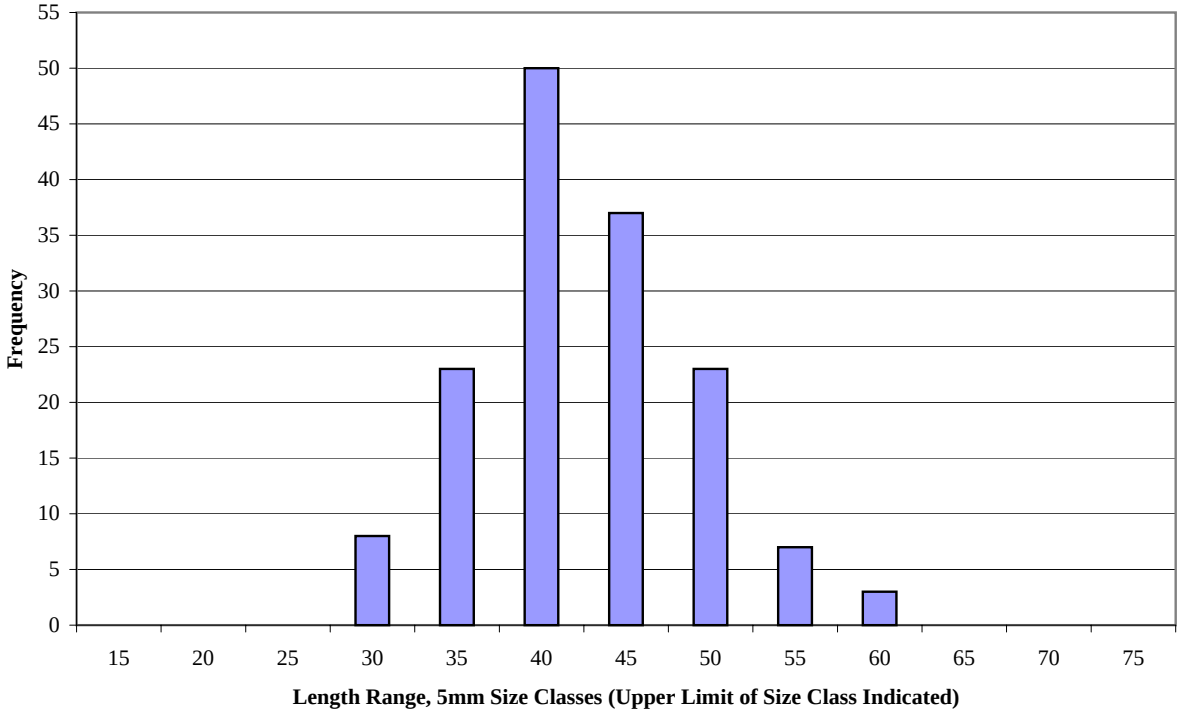
Appendix C-1.16. Three-Spine Stickleback Length Frequency during February 2003 Sampling Event for the Lower Gualala Estuary.

Appendix C-1.17. Three-Spine Stickleback Length Frequency during February 2003 Sampling Event for the Middle Gualala Estuary.

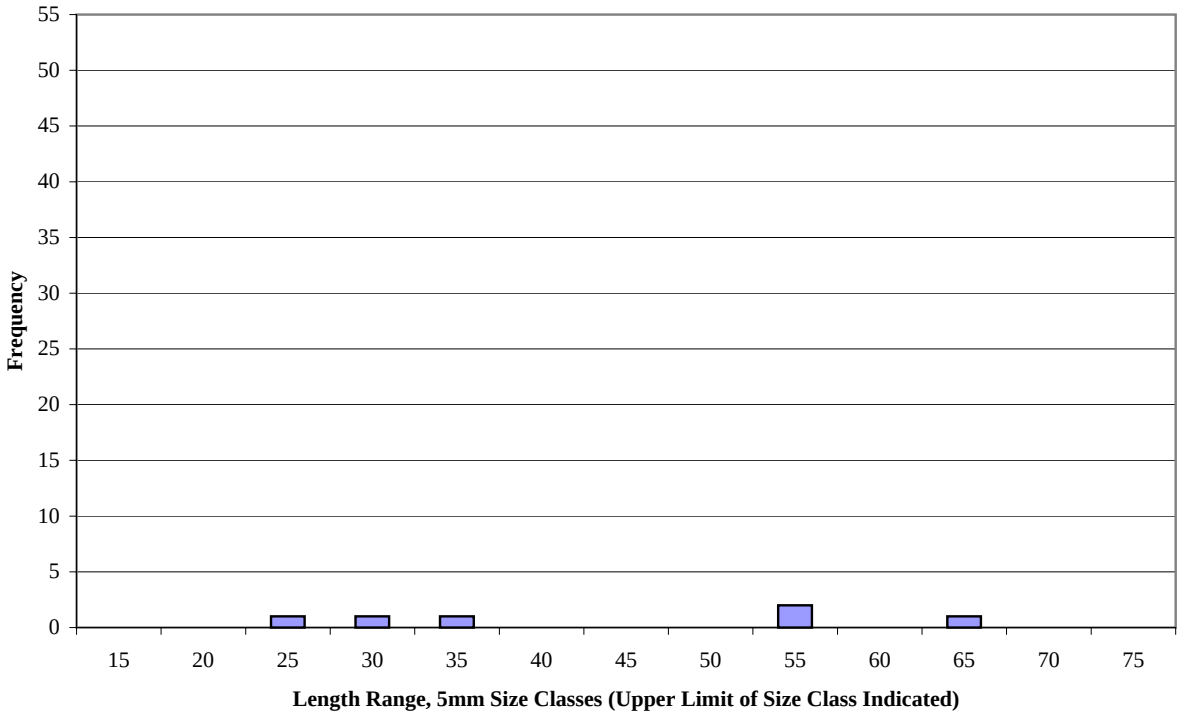
Appendix C-1.18. Three-Spine Stickleback Length Frequency during February 2003 Sampling Event for the Upper Gualala Estuary.



Appendix C-1.19. Three-Spine Stickleback Length Frequency during May 2003 Sampling Event for the Lower Gualala Estuary.



Appendix C-1.20. Three-Spine Stickleback Length Frequency during May 2003 Sampling Event for the Middle Gualala Estuary.

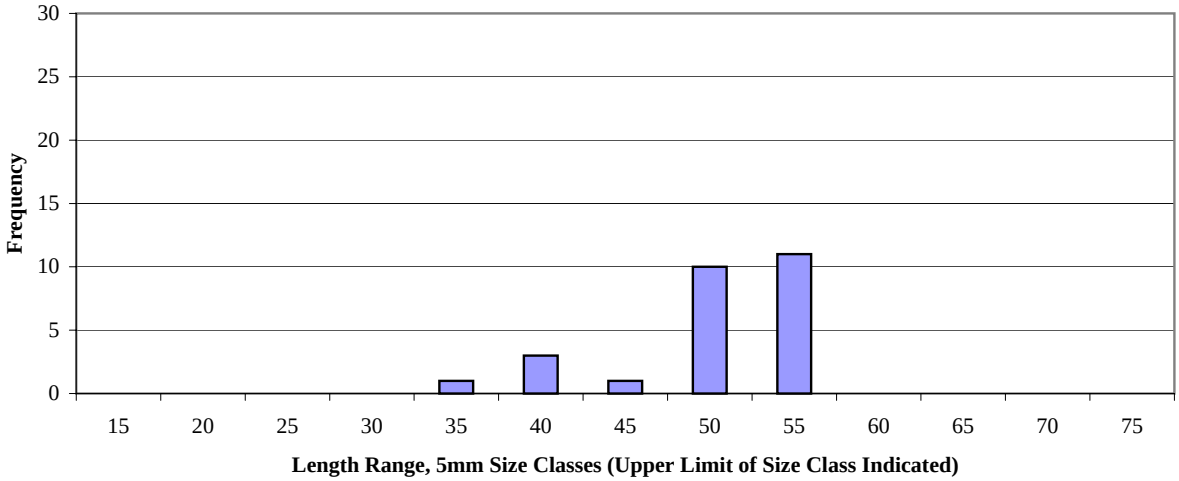


APPENDIX C-1

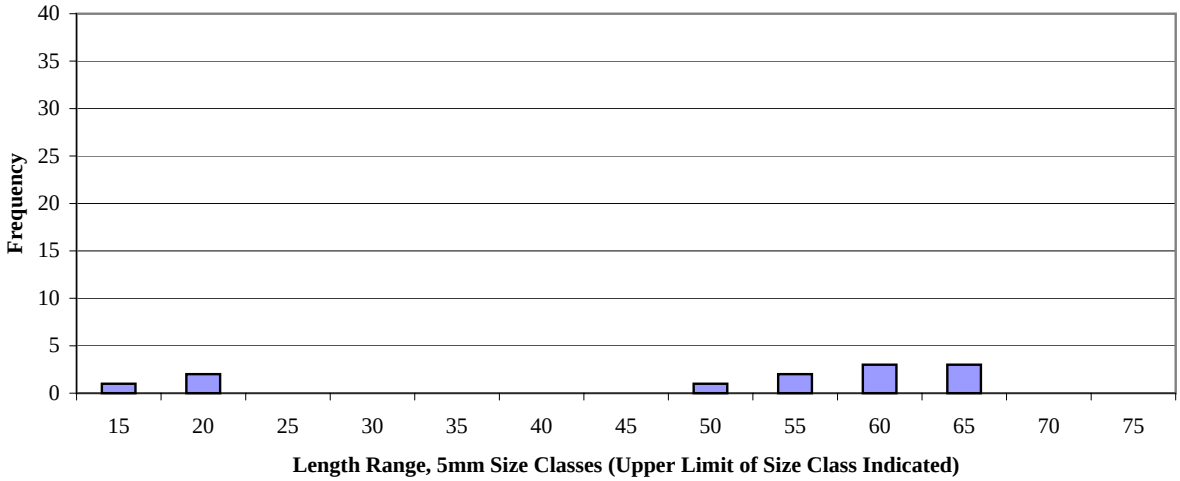
Appendix C-1.21. Three-Spine Stickleback Length Frequency during June 2003 Sampling Event for the Lower Gualala Estuary.

Appendix C-1.22. Three-Spine Stickleback Length Frequency during June 2003 Sampling Event for the Middle Gualala Estuary.

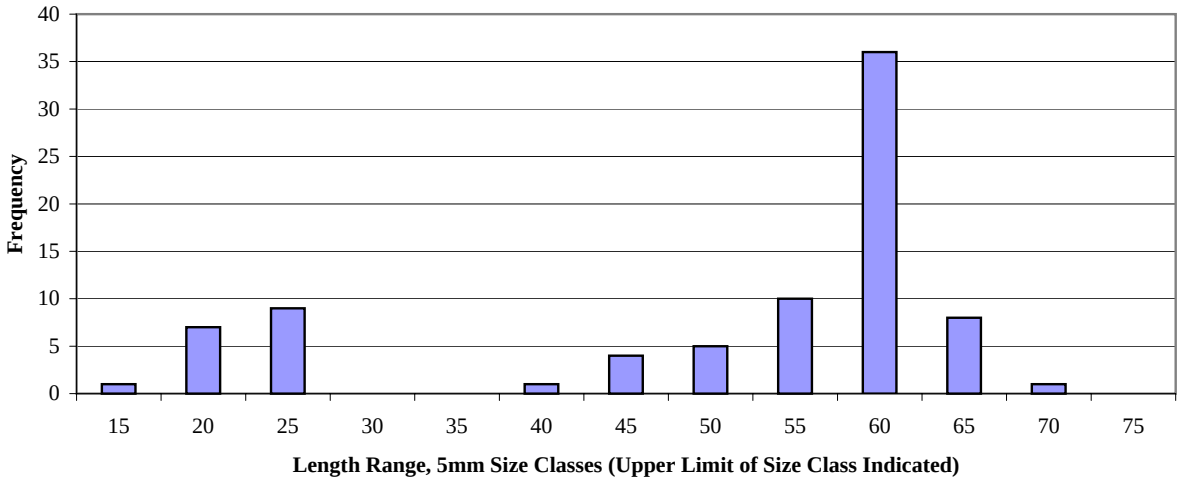
Appendix C-1.23. Three-Spine Stickleback Length Frequency during June 2003 Sampling Event for the Upper Gualala Estuary.



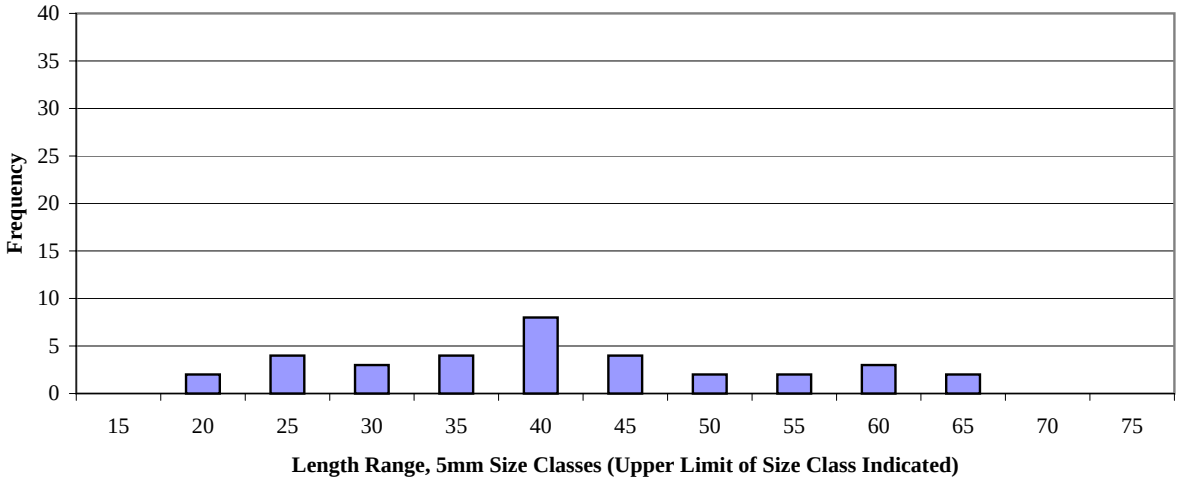
Appendix C-1.24. Three-Spine Stickleback Length Frequency during July 2003 Sampling Event for the Lower Gualala Estuary.



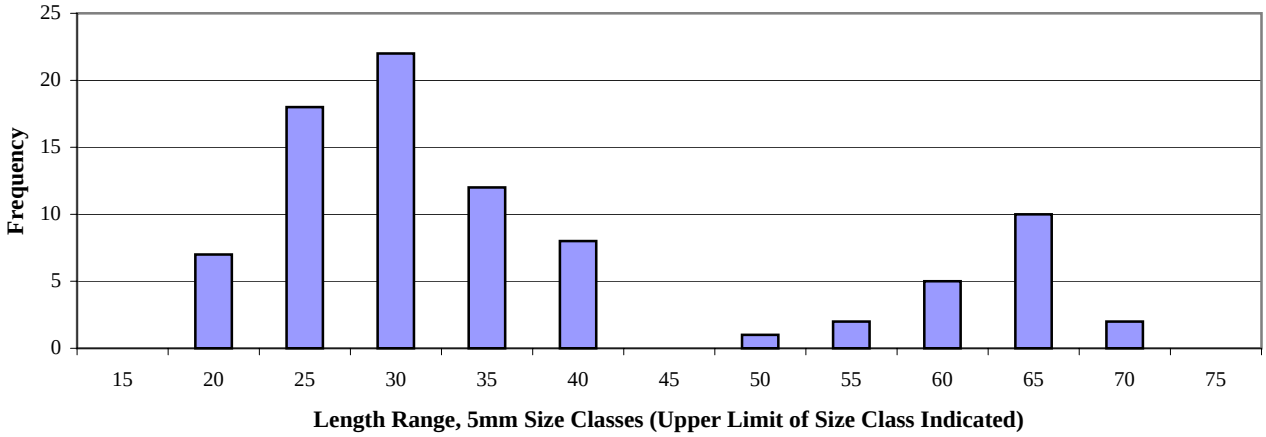
Appendix C-1.25. Three-Spine Stickleback Length Frequency during July 2003 Sampling Event for the Middle Gualala Estuary.



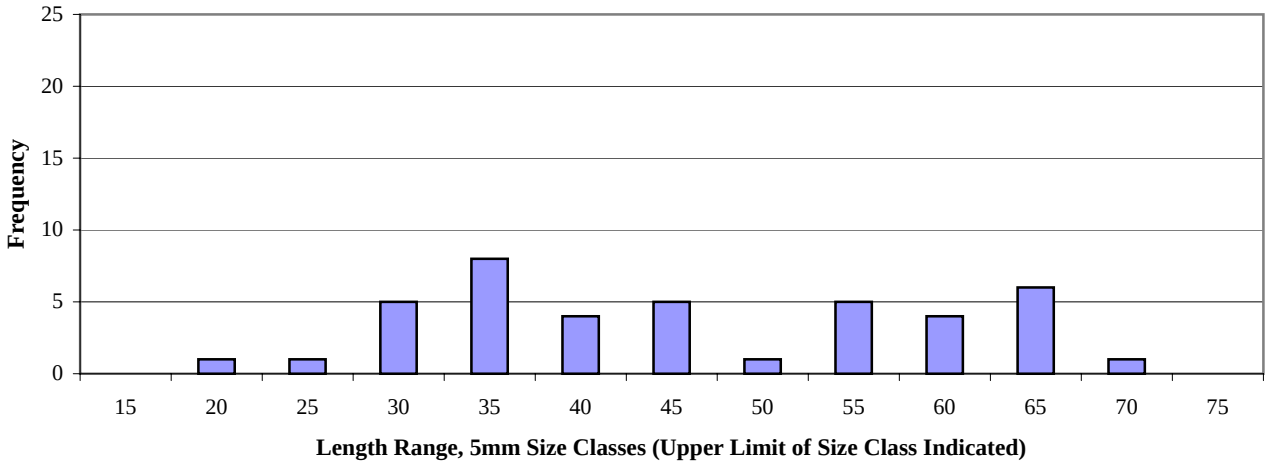
Appendix C-1.26. Three-Spine Stickleback Length Frequency during July 2003 Sampling Event for the Upper Gualala Estuary.



Appendix C-1.27. Three-Spine Stickleback Length Frequency during August 2003 Sampling Event for the Lower Gualala Estuary.

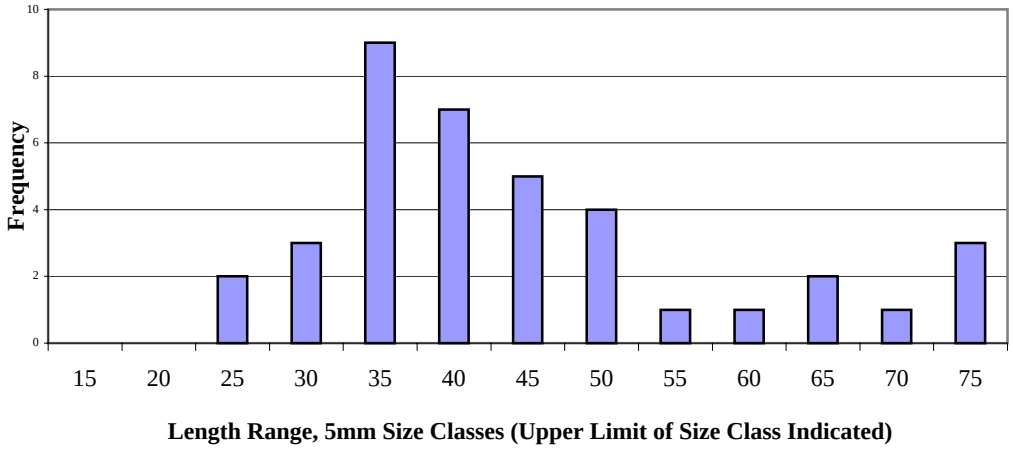


Appendix C-1.28. Three-Spine Stickleback Length Frequency during August 2003 Sampling Event for the Upper Gualala Estuary.



Appendix C-1.29. Three-Spine Stickleback Length Frequency during September 2003 Sampling Event for the Lower Gualala Estuary.

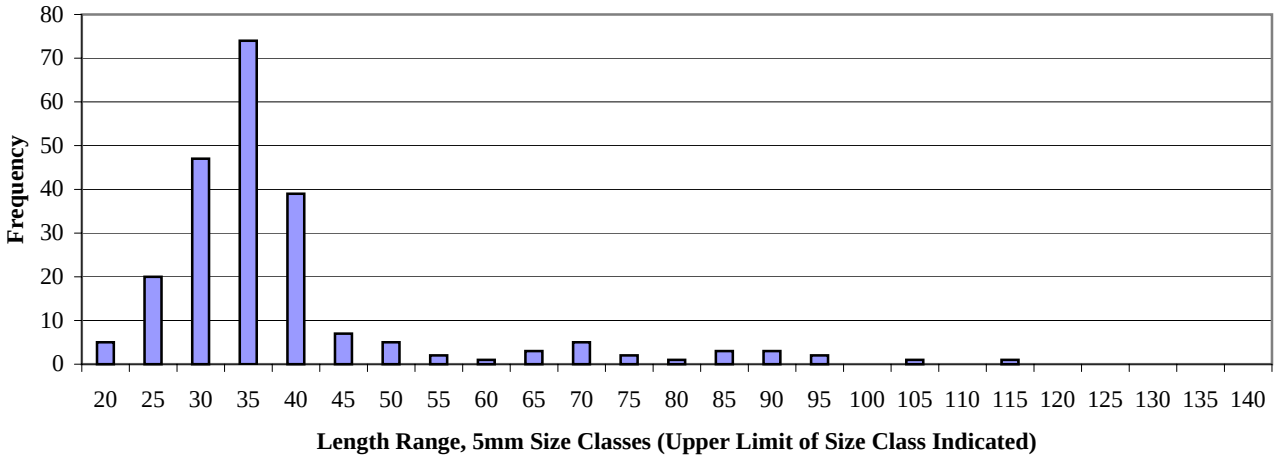
Appendix C-1.30. Three-Spine Stickleback Length Frequency during October 2003 Sampling Event for the Lower Gualala Estuary.



APPENDIX C-2

Appendix C-2.1. Pacific Staghorn Sculpin Length Frequency during June 2002 Sampling Event for the Lower Gualala Estuary.

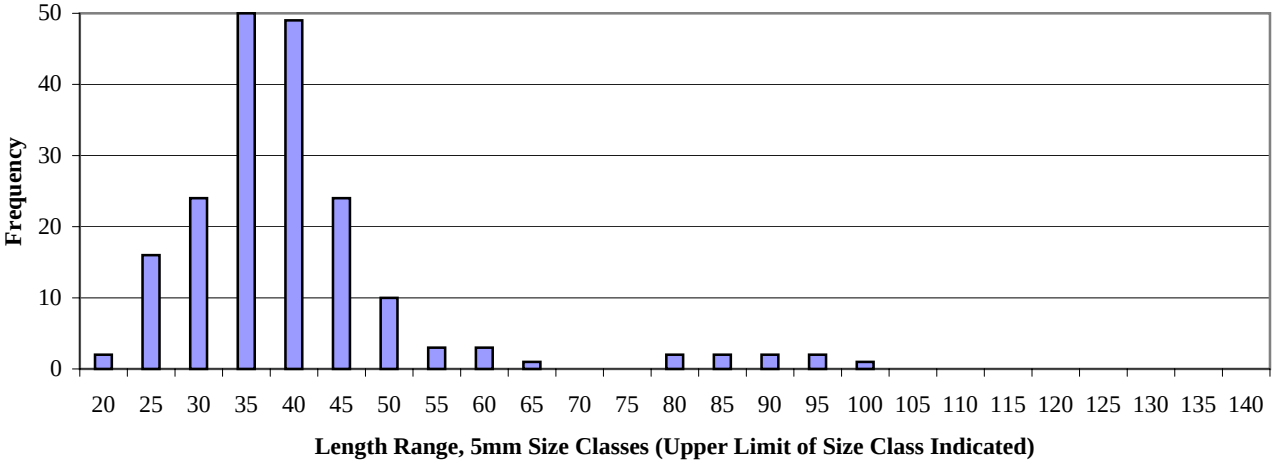
Appendix C-2.2. Pacific Staghorn Sculpin Length Frequency during July 2002 Sampling Event for the Lower Gualala Estuary.



Appendix C-2.3 Pacific Staghorn Sculpin Length Frequency during July 2002 Sampling Event for the Middle Gualala Estuary.

APPENDIX C-2

Appendix C-2.4. Pacific Staghorn Sculpin Length Frequency during August 2002 Sampling Events for the Lower Gualala Estuary.

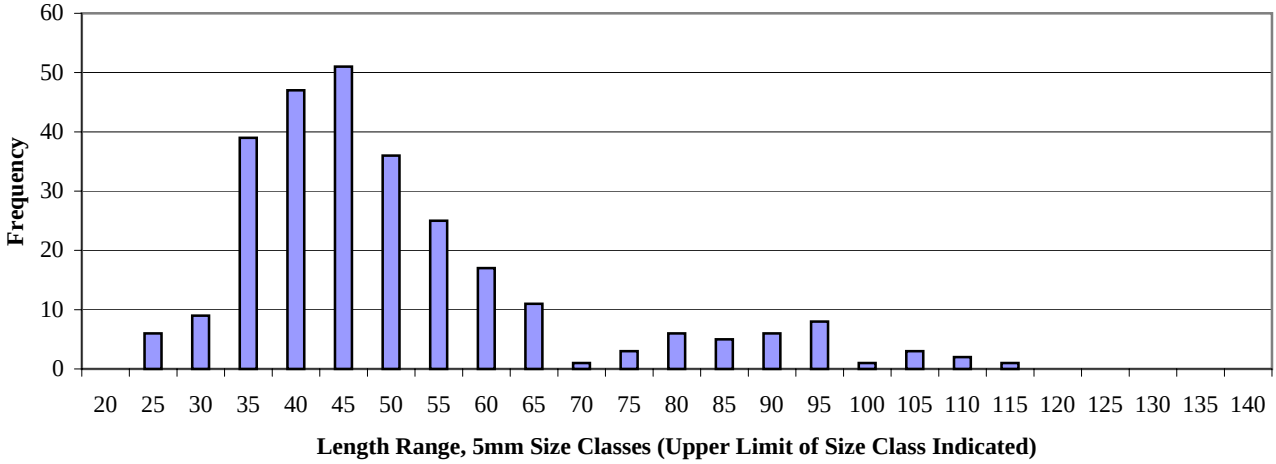


Appendix C-2.5. Pacific Staghorn Sculpin Length Frequency during August 2002 Sampling Events for the Middle Gualala Estuary.

Appendix C-2.6. Pacific Staghorn Sculpin Length Frequency during August 2002 Sampling Events for the Upper Gualala Estuary.

APPENDIX C-2

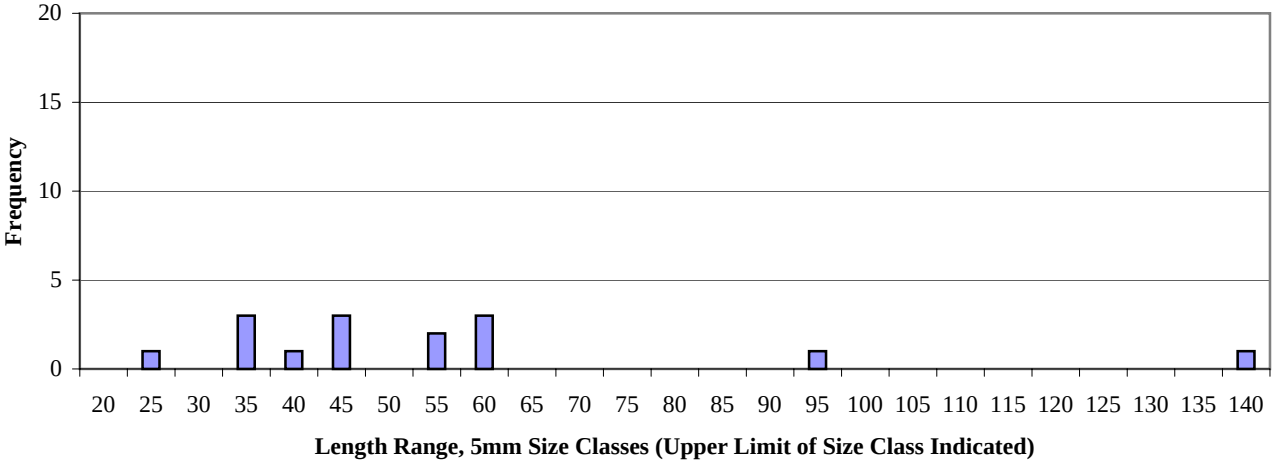
Appendix C-2.7. Pacific Staghorn Sculpin Length Frequency during September 2002 Sampling Events for the Lower Gualala Estuary.



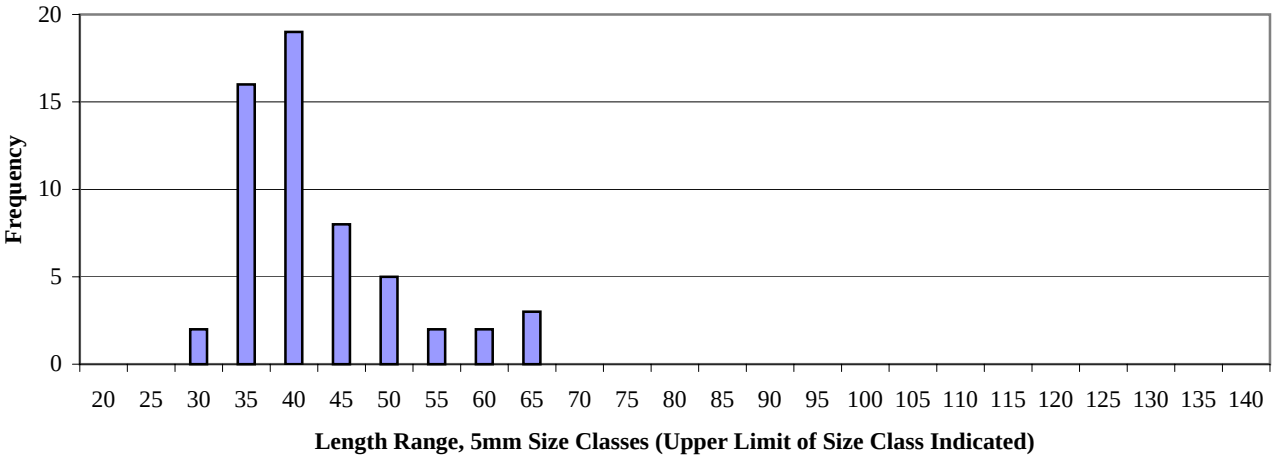
Appendix C-2.8. Pacific Staghorn Sculpin Length Frequency during September 2002 Sampling Events for the Middle Gualala Estuary.

Appendix C-2.9. Pacific Staghorn Sculpin Length Frequency during September 2002 Sampling Events for the Upper Gualala Estuary.

Appendix C-2.10. Pacific Staghorn Sculpin Length Frequency during October-November 2002 Sampling Events for the Lower Gualala Estuary.



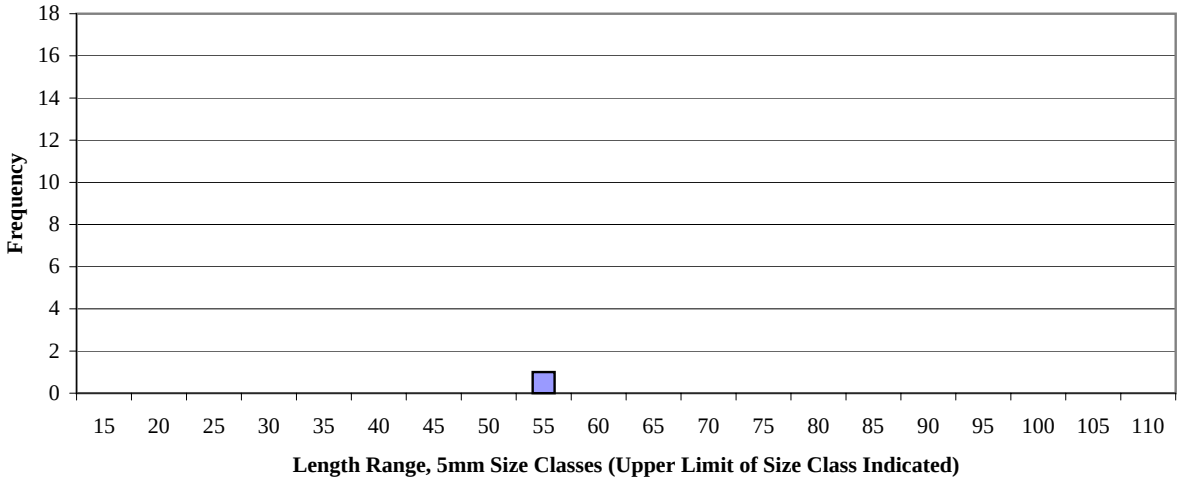
Appendix C-2.11. Pacific Staghorn Sculpin Length Frequency during October-November 2002 Sampling Events for the Middle Gualala Estuary.



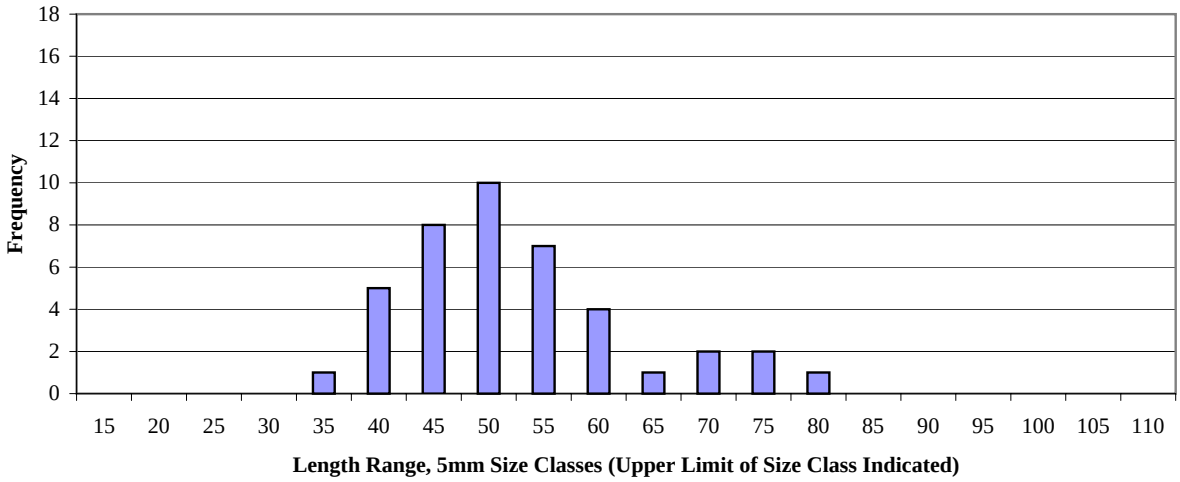
Appendix C-2.12. Pacific Staghorn Sculpin Length Frequency during October-November 2002 Sampling Events for the Upper Gualala Estuary.

APPENDIX C-2

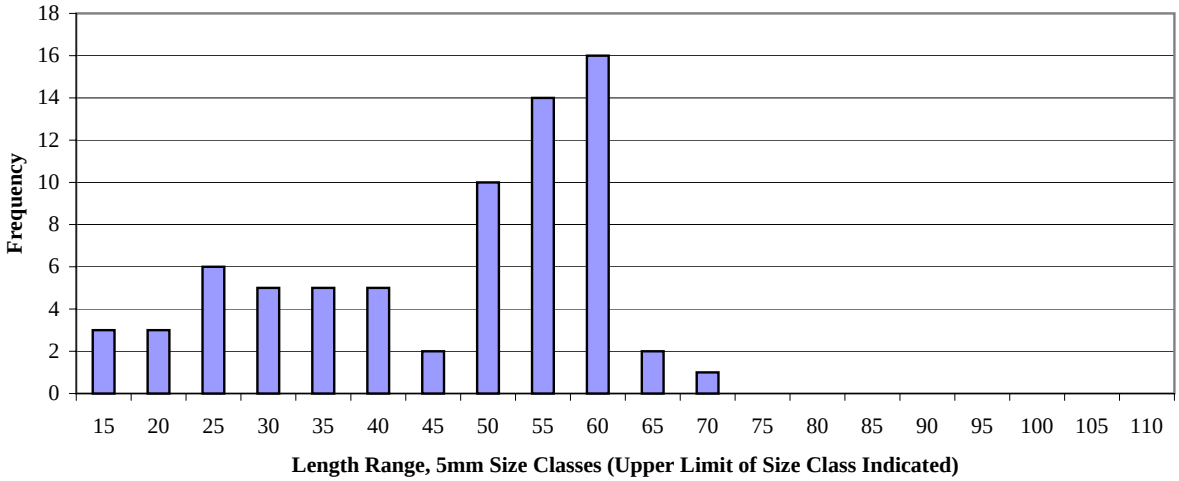
Appendix C-2.13. Pacific Staghorn Sculpin Length Frequency during February 2003 Sampling Event for the Lower Gualala Estuary.



Appendix C-2.14. Pacific Staghorn Sculpin Length Frequency during May 2003 Sampling Event for the Lower Gualala Estuary.

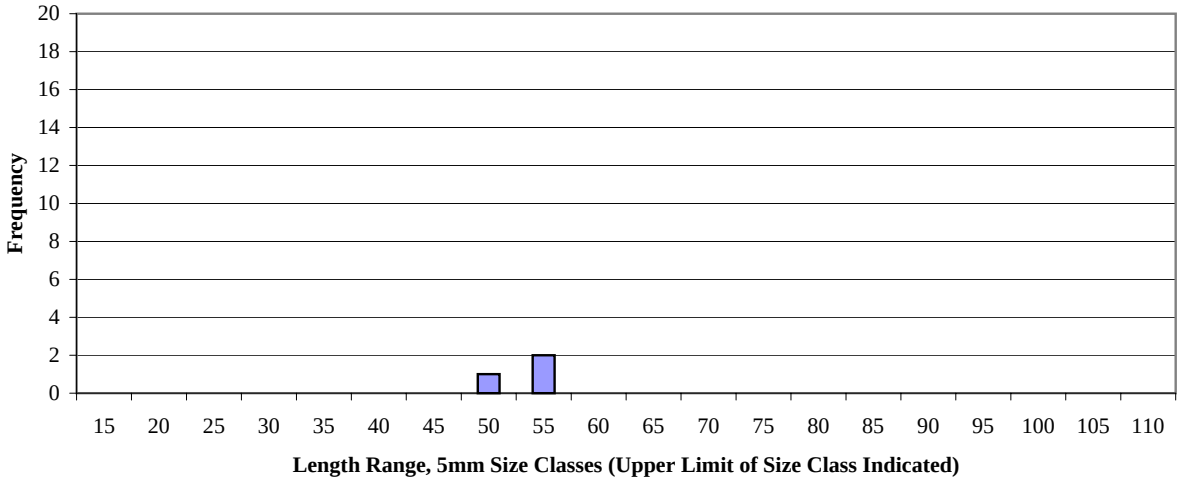


Appendix C-2.15. Pacific Staghorn Sculpin Length Frequency during June 2003 Sampling Event for the Lower Gualala Estuary.

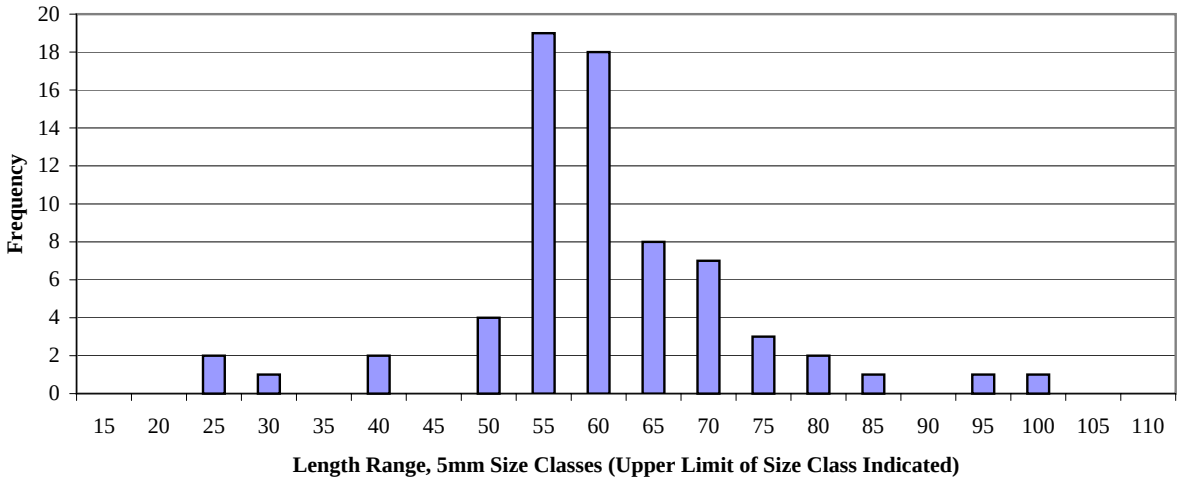


APPENDIX C-2

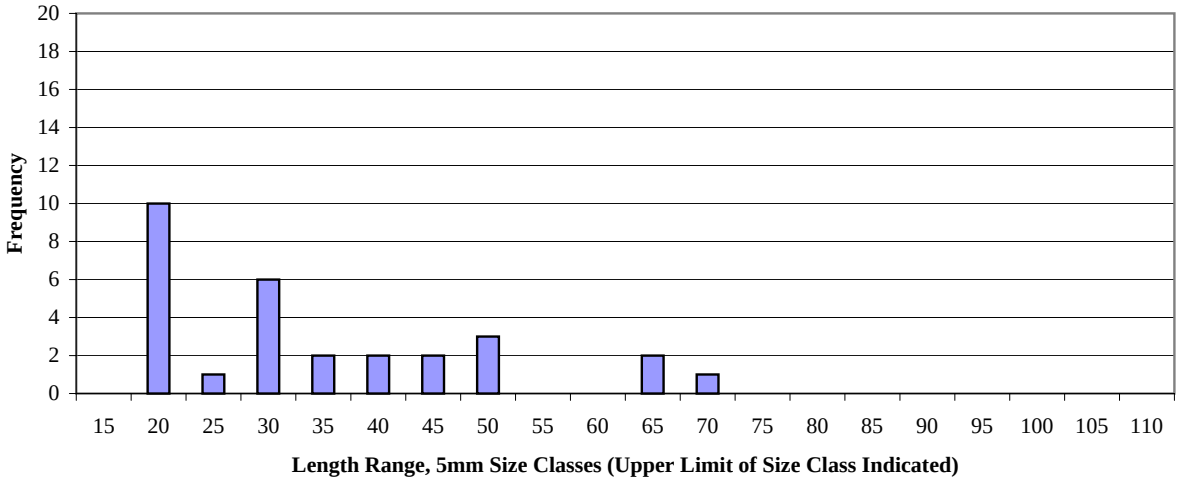
Appendix C-2.16. Pacific Staghorn Sculpin Length Frequency during June 2003 Sampling Event for the Middle Gualala Estuary.



Appendix C-2.17. Pacific Staghorn Sculpin Length Frequency during June 2003 Sampling Event for the Upper Gualala Estuary.

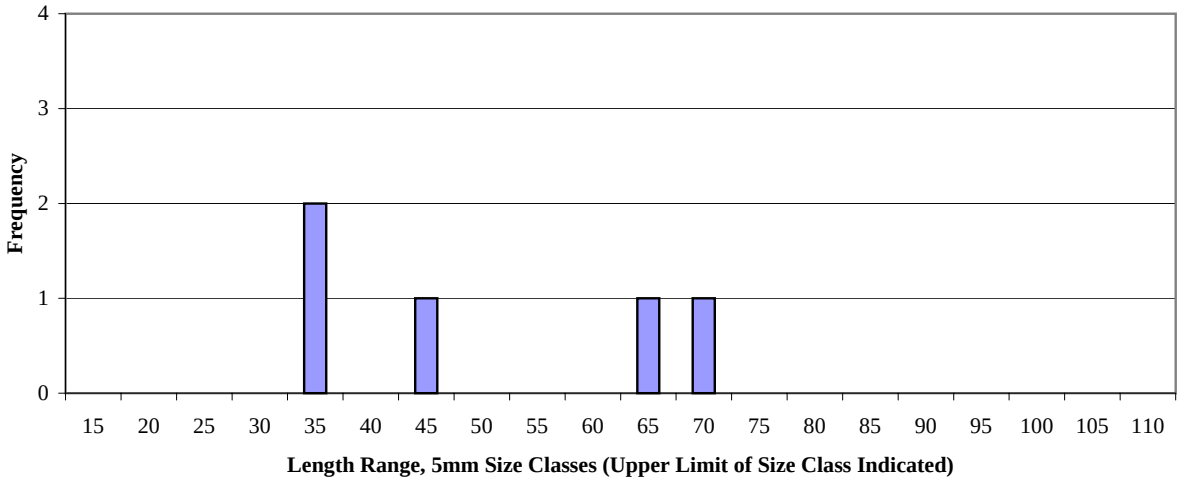


Appendix C-2.18. Pacific Staghorn Sculpin Length Frequency during July 2003 Sampling Event for the Lower Gualala Estuary.

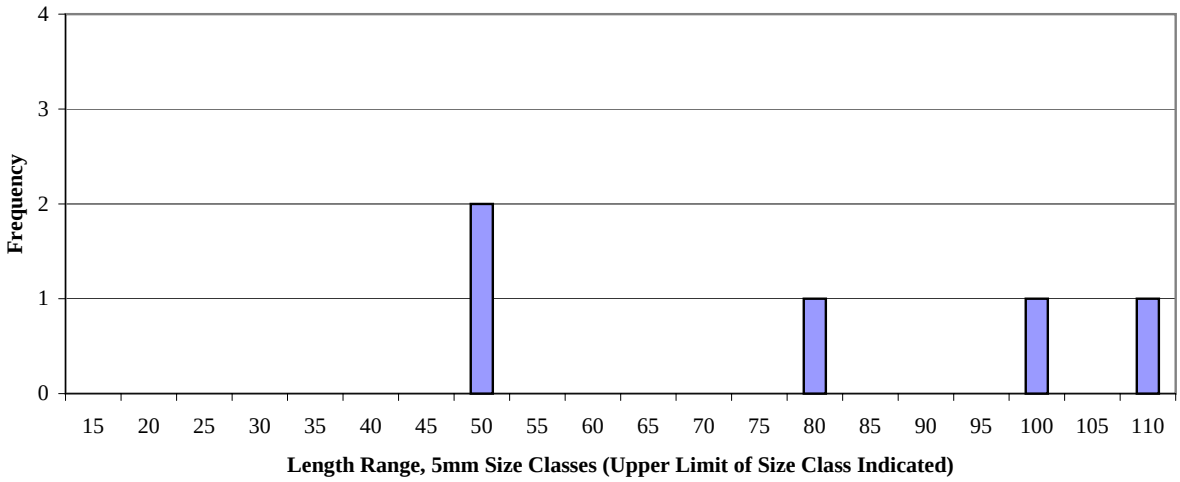


APPENDIX C-2

Appendix C-2.19. Pacific Staghorn Sculpin Length Frequency during July 2003 Sampling Event for the Middle Gualala Estuary.



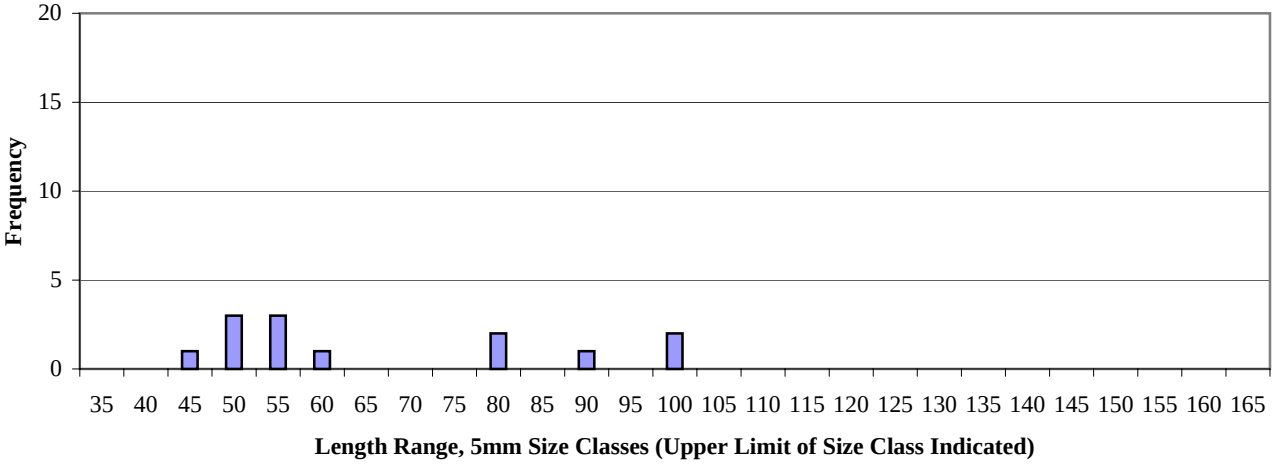
Appendix C-2.20. Pacific Staghorn Sculpin Length Frequency during August 2003 Sampling Event for the Lower Gualala Estuary.



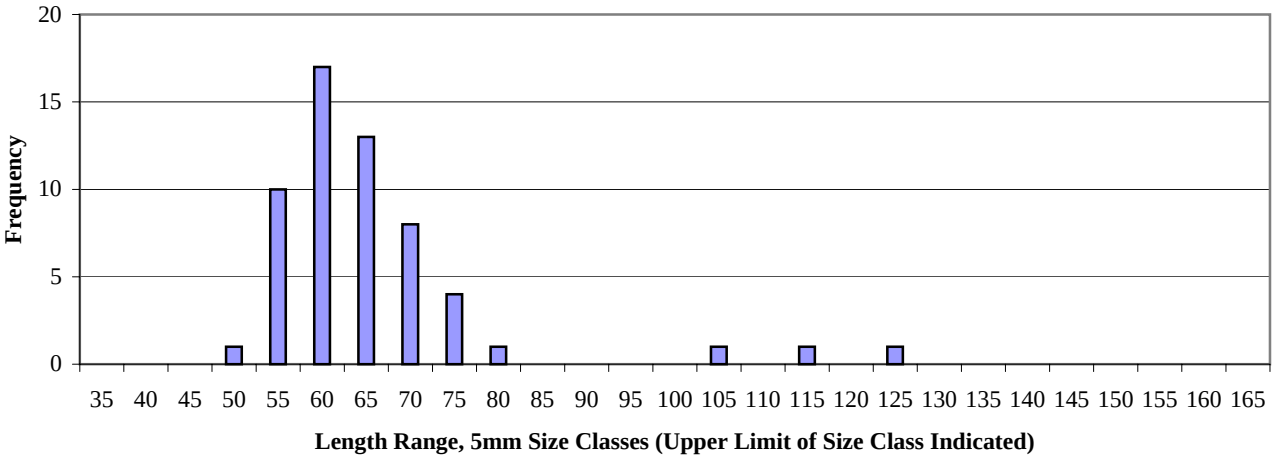
Appendix C-2.21. Pacific Staghorn Sculpin Length Frequency during September 2003 Sampling Event for the Lower Gualala Estuary.

APPENDIX C-3

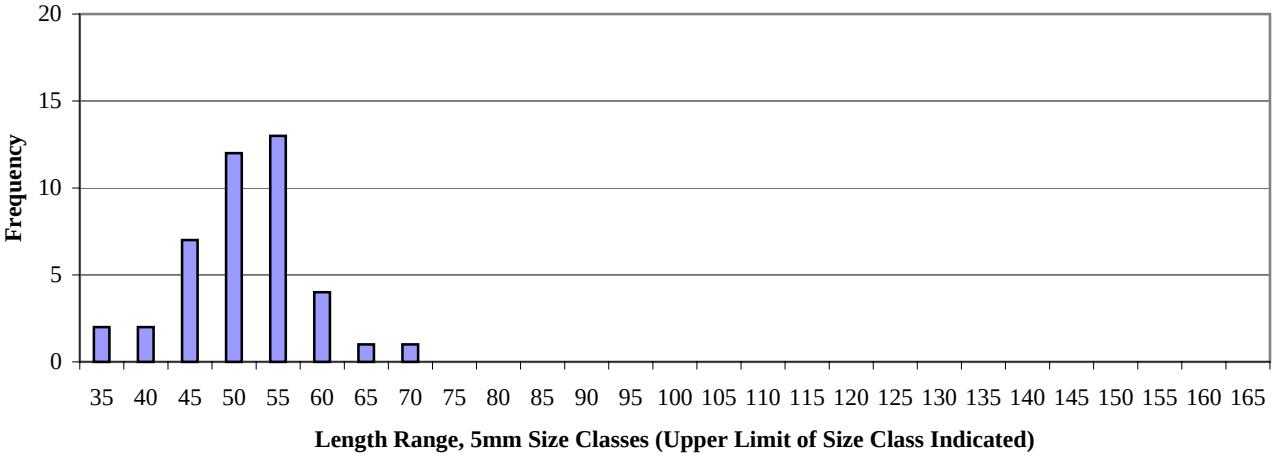
Appendix C-3.1. Starry Flounder Length Frequency during June 2002 Sampling Event for the Lower Gualala Estuary.



Appendix C-3.2. Starry Flounder Length Frequency during July 2002 Sampling Event for the Lower Gualala Estuary.

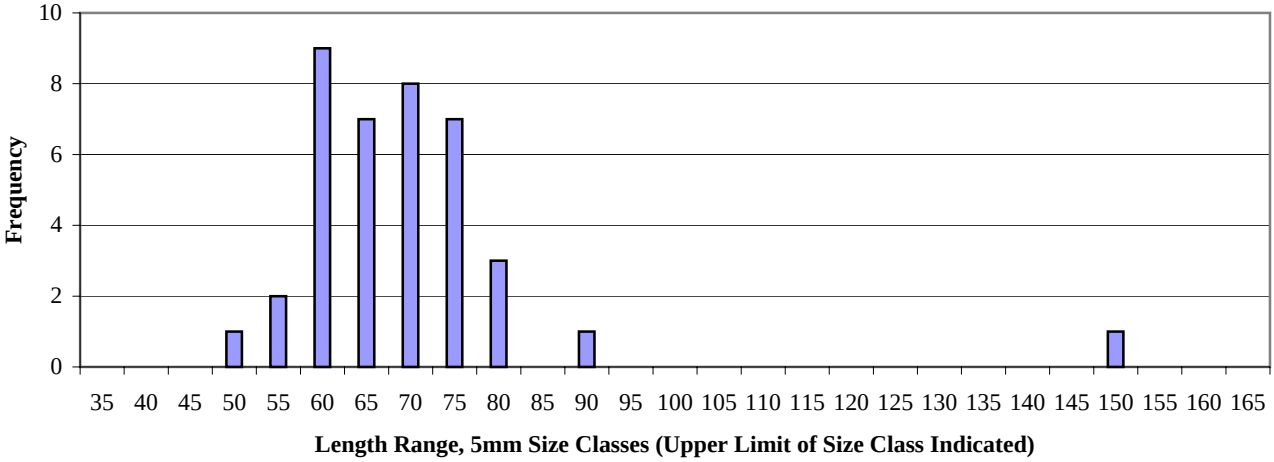


Appendix C-3.3. Starry Flounder Length Frequency during July 2002 Sampling Event for the Middle Gualala Estuary.



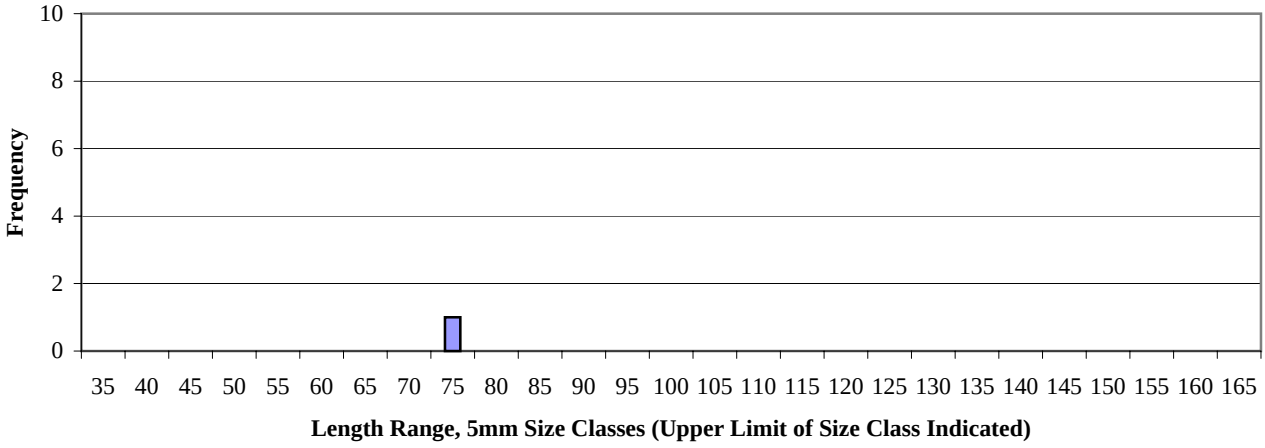
APPENDIX C-3

Appendix C-3.4. Starry Flounder Length Frequency during August 2002 Sampling Events for the Lower Gualala Estuary.

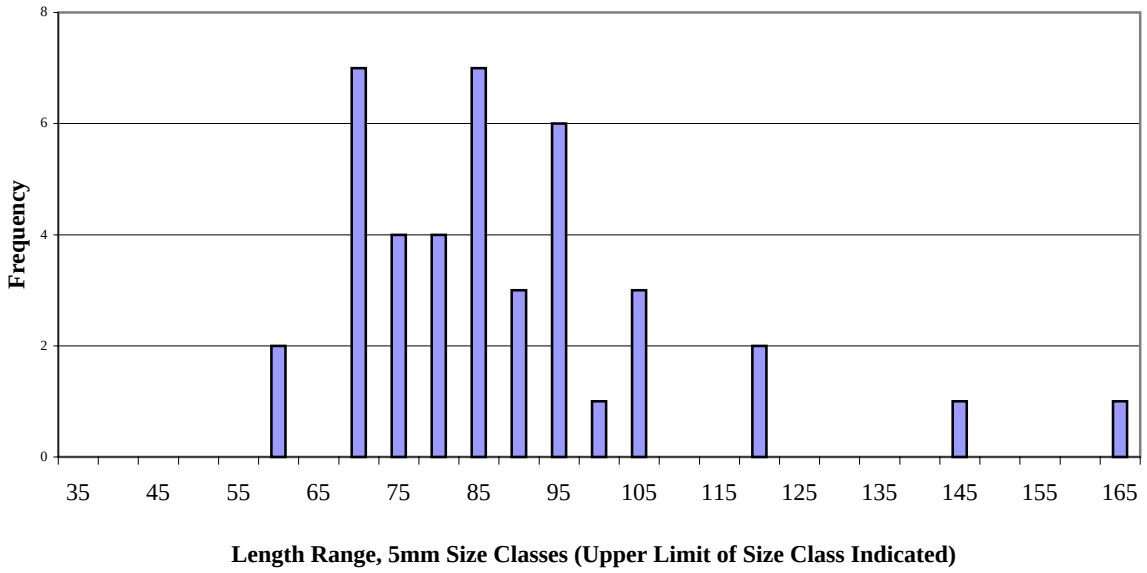


Appendix C-3.5. Starry Flounder Length Frequency during August 2002 Sampling Events for the Middle Gualala Estuary.

Appendix C-3.6. Starry Flounder Length Frequency during August 2002 Sampling Events for the Upper Gualala Estuary.

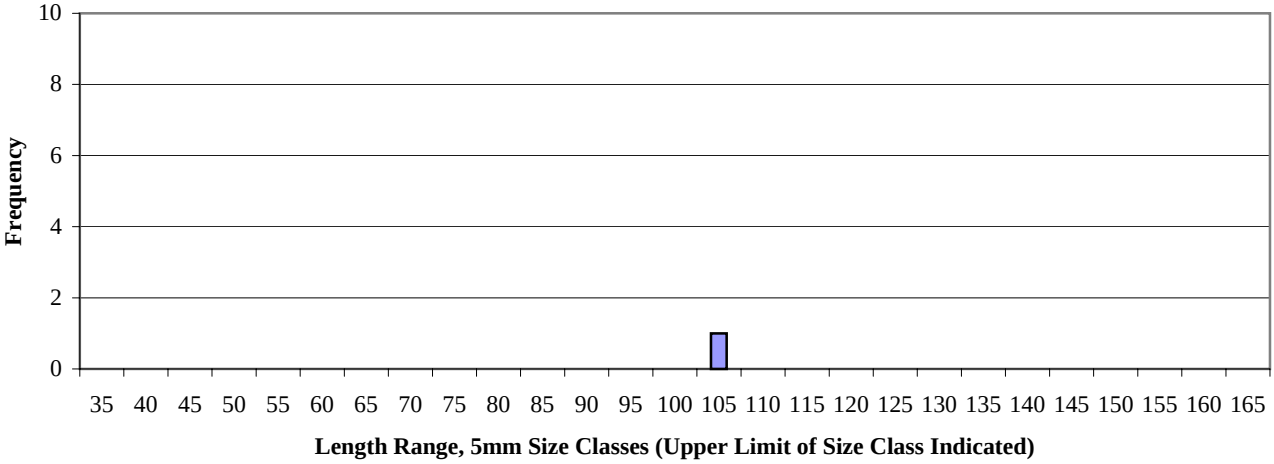


Appendix C-3.7. Starry Flounder Length Frequency during September 2002 Sampling Events for the Lower Gualala Estuary.

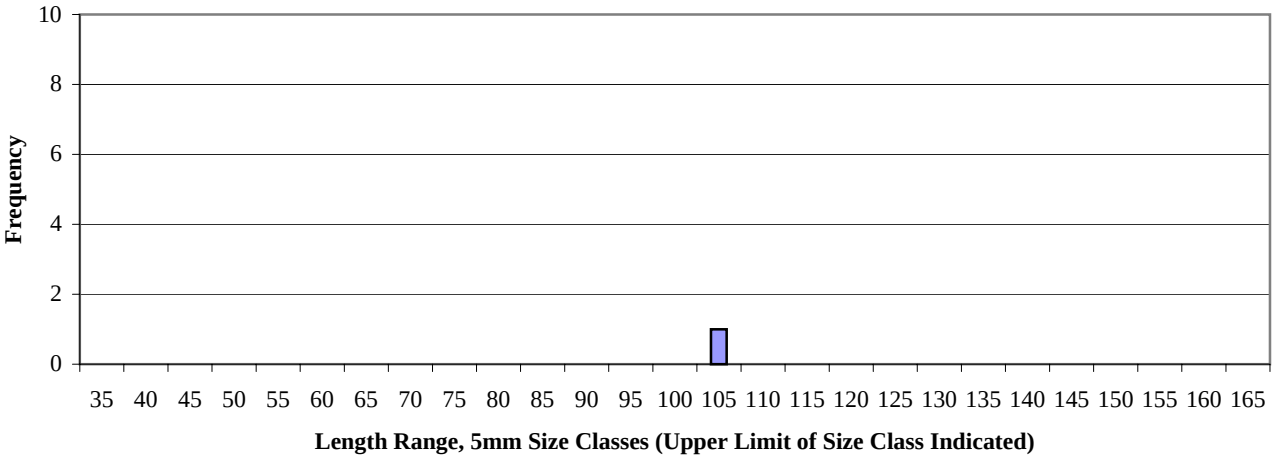


APPENDIX C-3

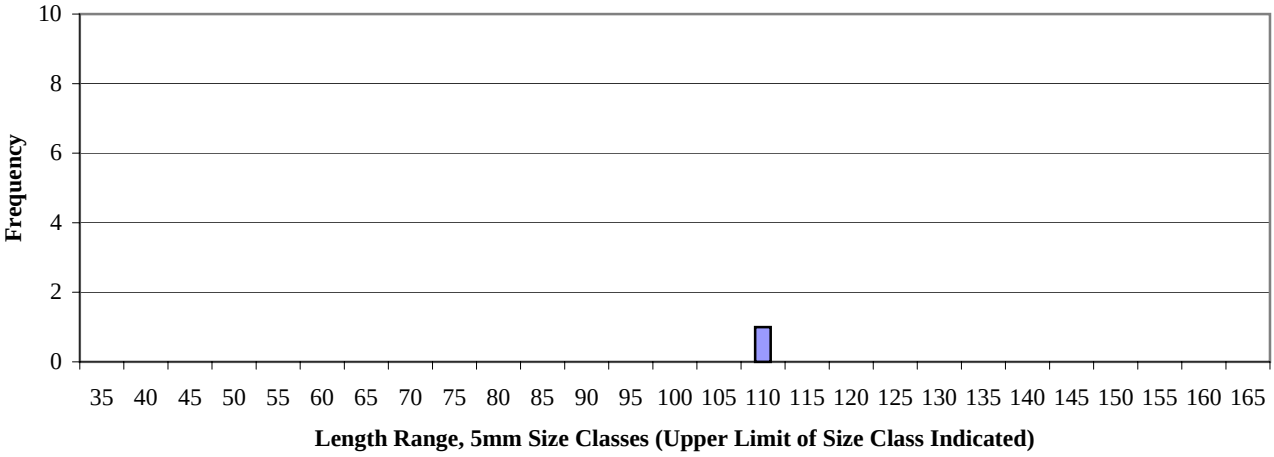
Appeindix C-3.8. Starry Flounder Length Frequency during October-November 2002 Sampling Events for the Lower Gualala Estuary.



Appendix C-3.9. Starry Flounder Length Frequency during October-November 2002 Sampling Events for the Middle Gualala Estuary.

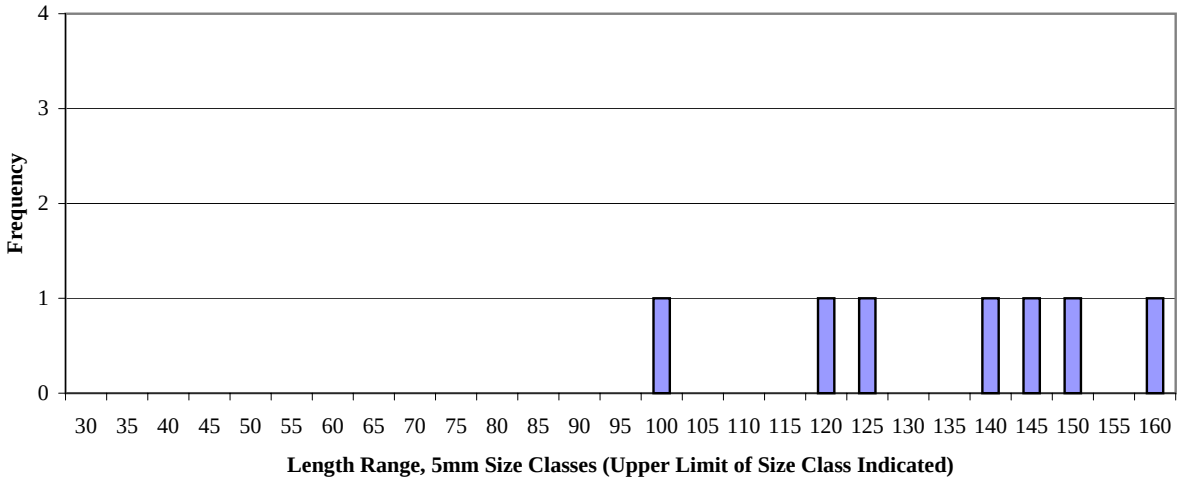


Appendix C-3.10. Starry Flounder Length Frequency during October-November 2002 Sampling Events for the Upper Gualala Estuary.



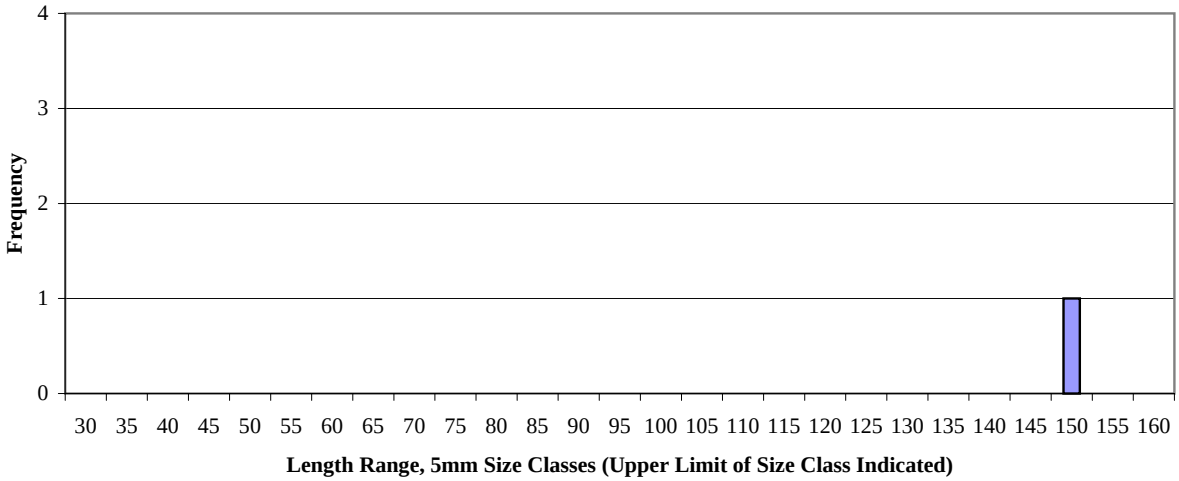
APPENDIX C-3

Appendix C-3.11. Starry Flounder Length Frequency during February 2003 Sampling Event for the Lower Gualala Estuary.



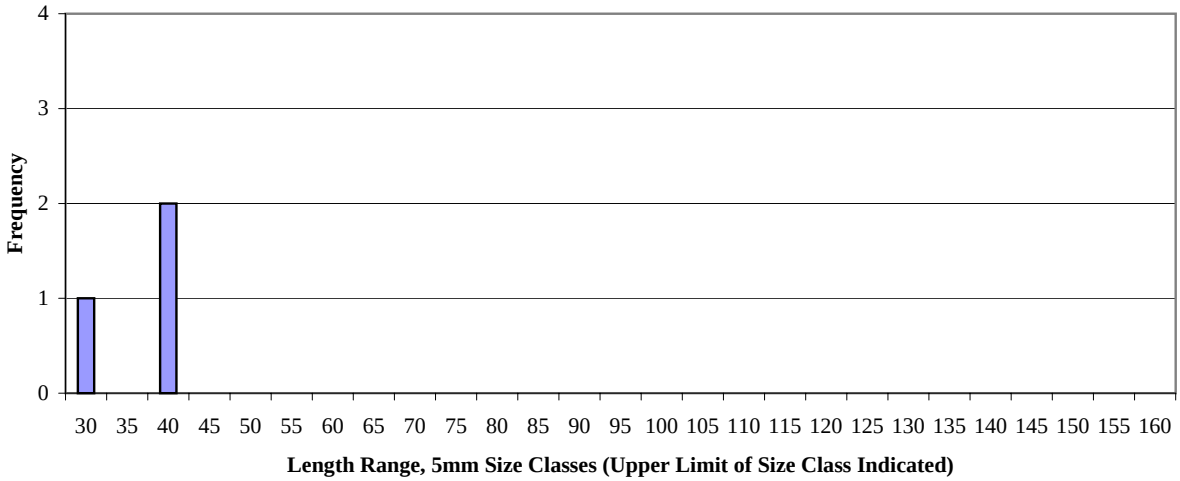
Appendix C-3.12. Starry Flounder Length Frequency during February 2003 Sampling Event for the Middle Gualala Estuary.

Appendix C-3.13. Starry Flounder Length Frequency during May 2003 Sampling Event for the Lower Gualala Estuary.

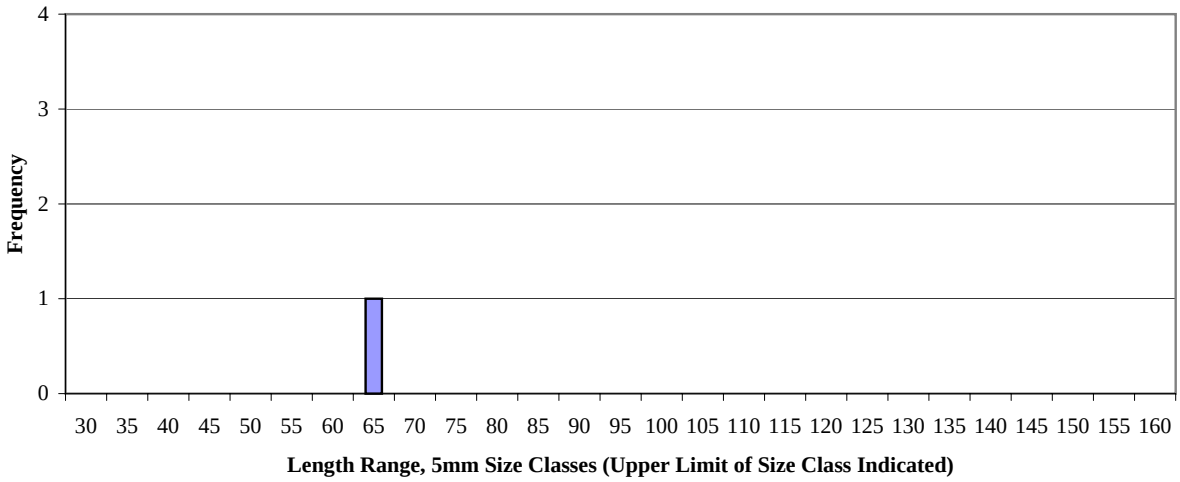


APPENDIX C-3

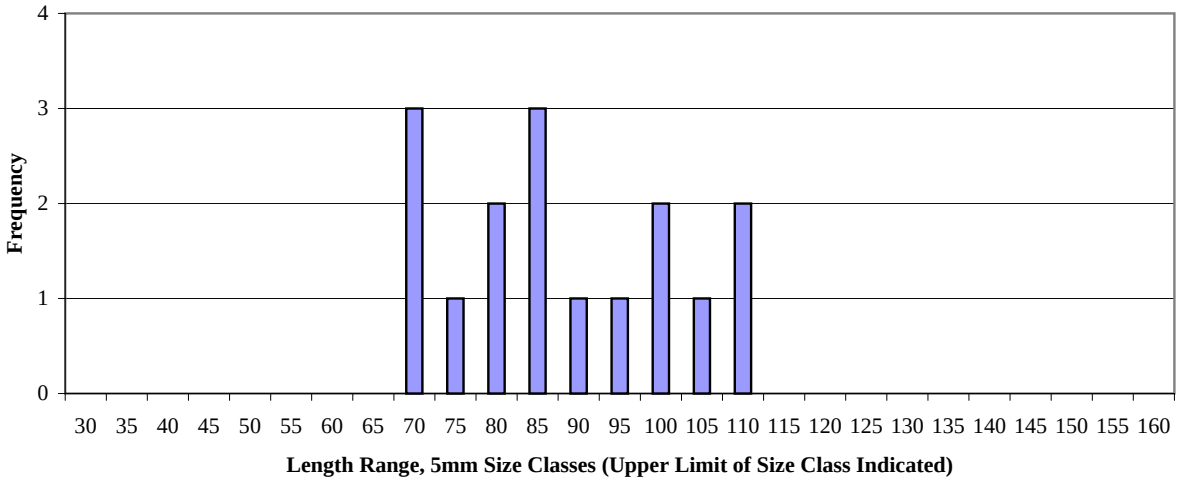
Appendix C-3.14. Starry Flounder Length Frequency during June 2003 Sampling Event for the Lower Gualala Estuary.



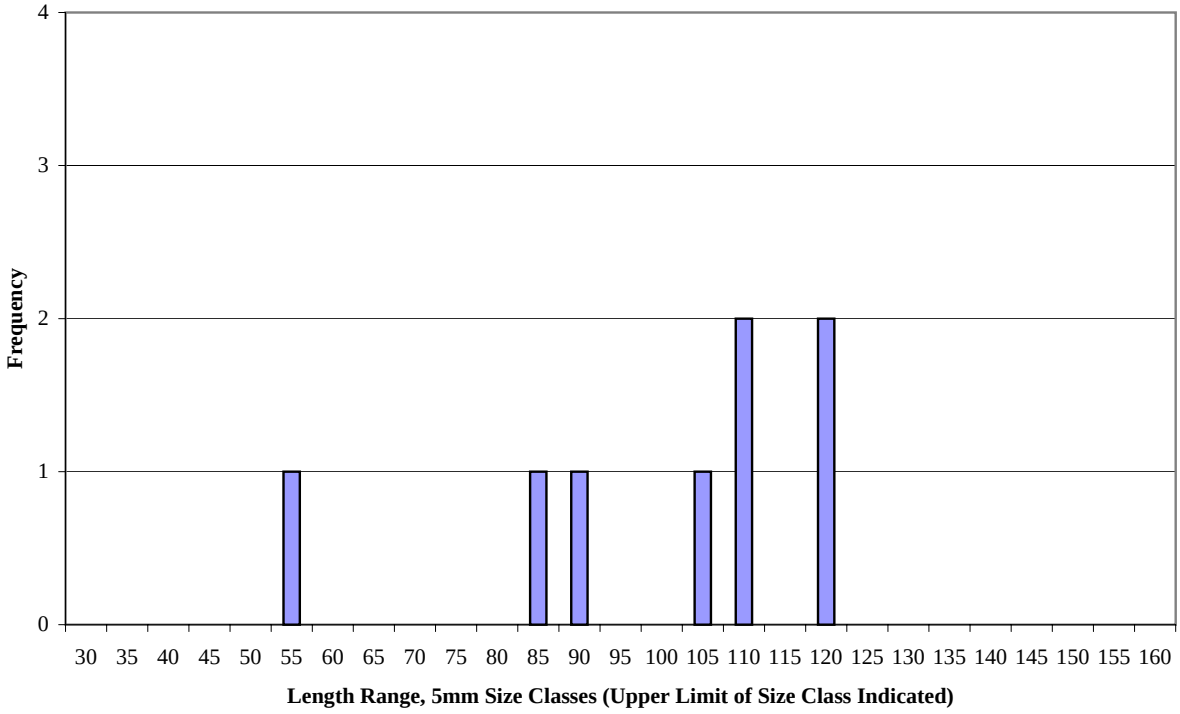
Appendix C-3.15. Starry Flounder Length Frequency during July 2003 Sampling Event for the Lower Gualala Estuary.



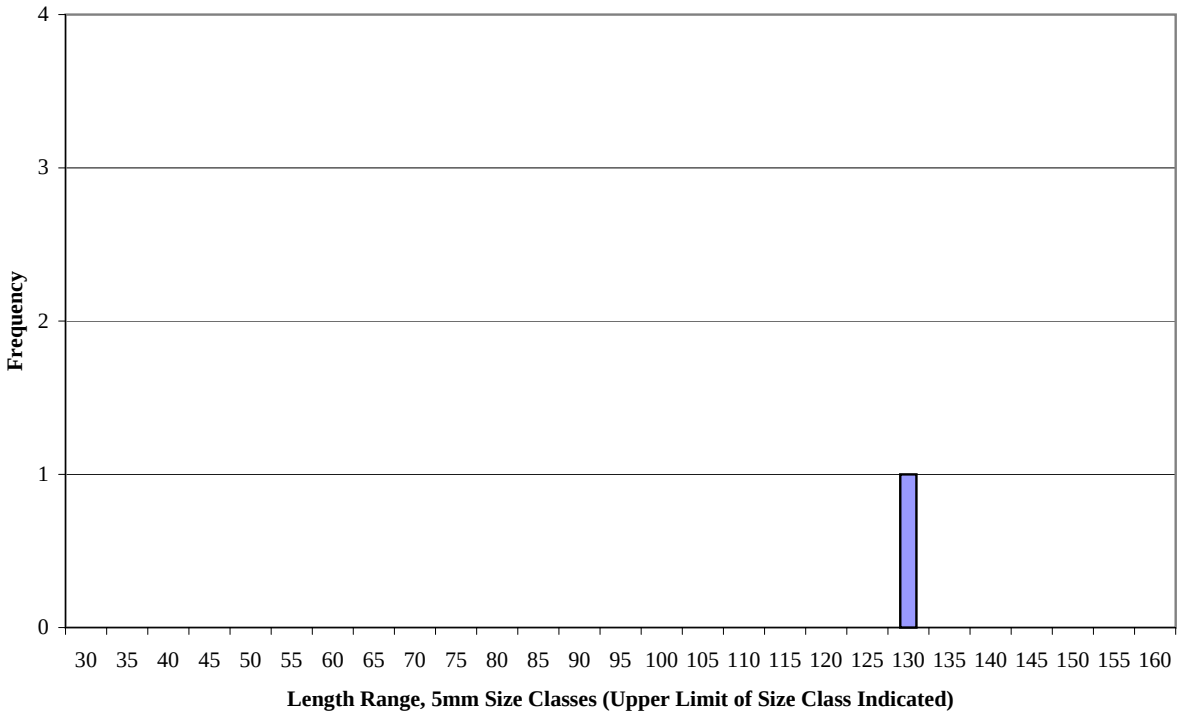
Appendix C-3.16. Starry Flounder Length Frequency during August 2003 Sampling Event for the Lower Gualala Estuary.



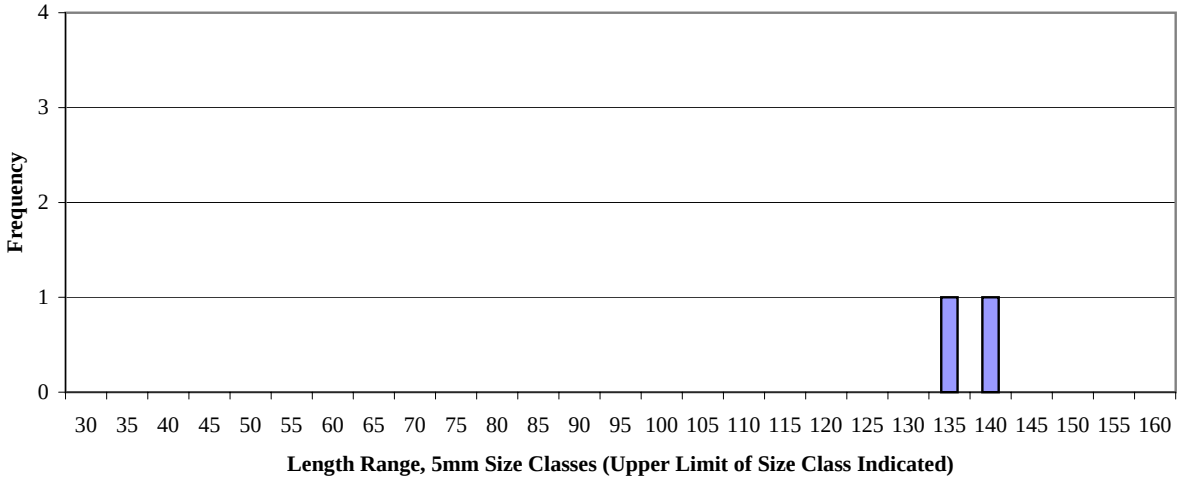
Appendix C-3.17. Starry Flounder Length Frequency during September 2003 Sampling Event for the Lower Gualala Estuary.



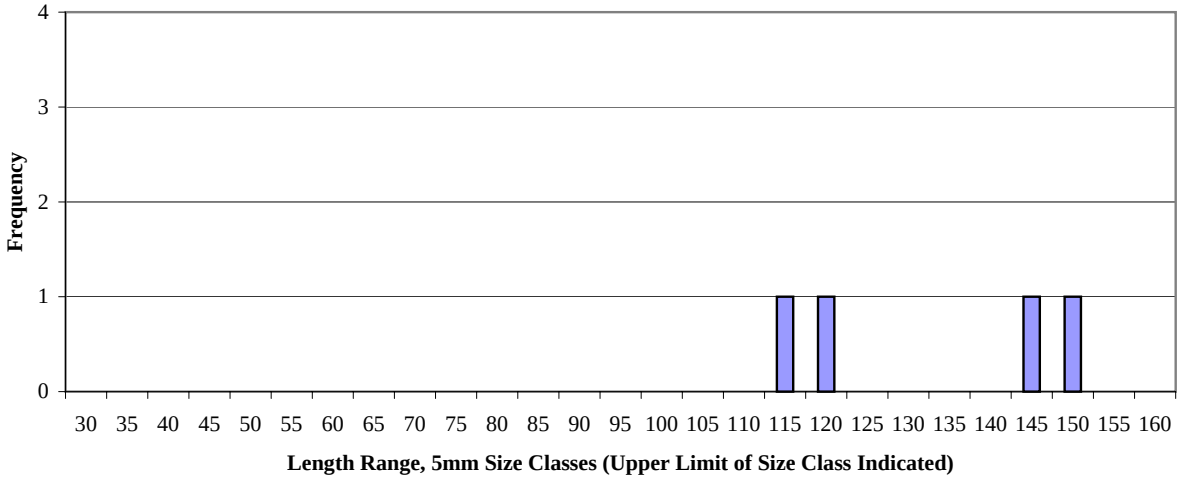
Appendix C-3.18. Starry Flounder Length Frequency during September 2003 Sampling Event for the Middle Gualala Estuary.



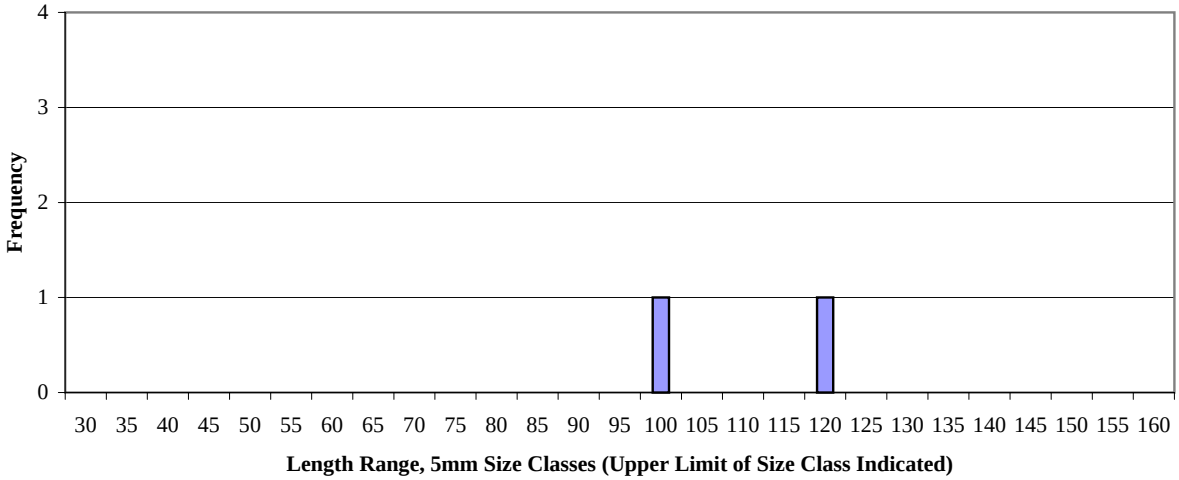
Appendix C-3.19. Starry Flounder Length Frequency during October 2003 Sampling Event for the Lower Gualala Estuary.



Appendix C-3.20. Starry Flounder Length Frequency during October 2003 Sampling Event for the Middle Gualala Estuary.

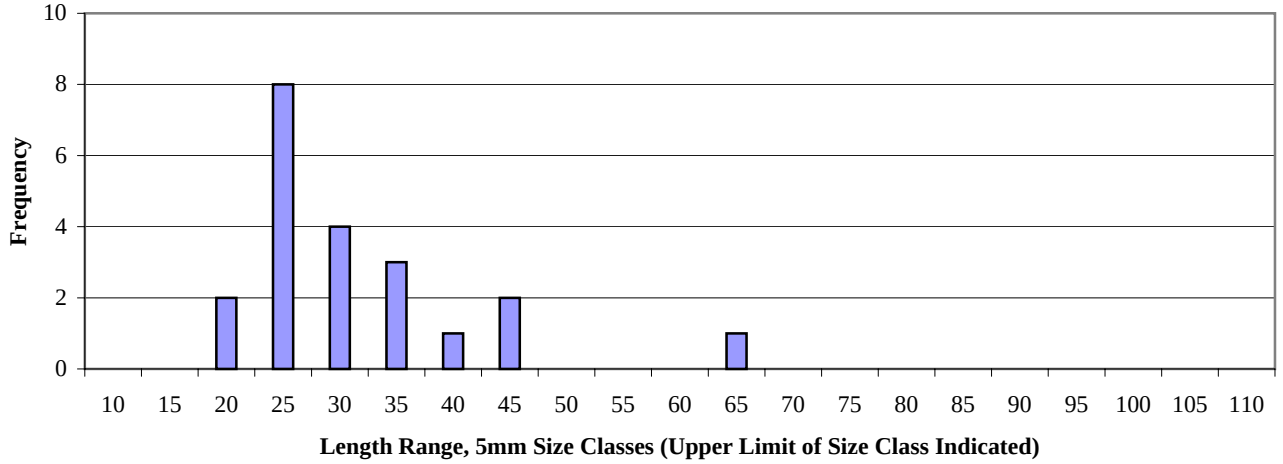


Appendix C-3.21. Starry Flounder Length Frequency during October 2003 Sampling Event for the Upper Gualala Estuary.



APPENDIX C-4

Appendix C-4.1. Coastrange Sculpin Length Frequency during June 2002 Sampling Event for the Lower Gualala Estuary.



Appendix C-4.2. Coastrange Sculpin Length Frequency during June 2002 Sampling Event for the Middle Gualala Estuary.

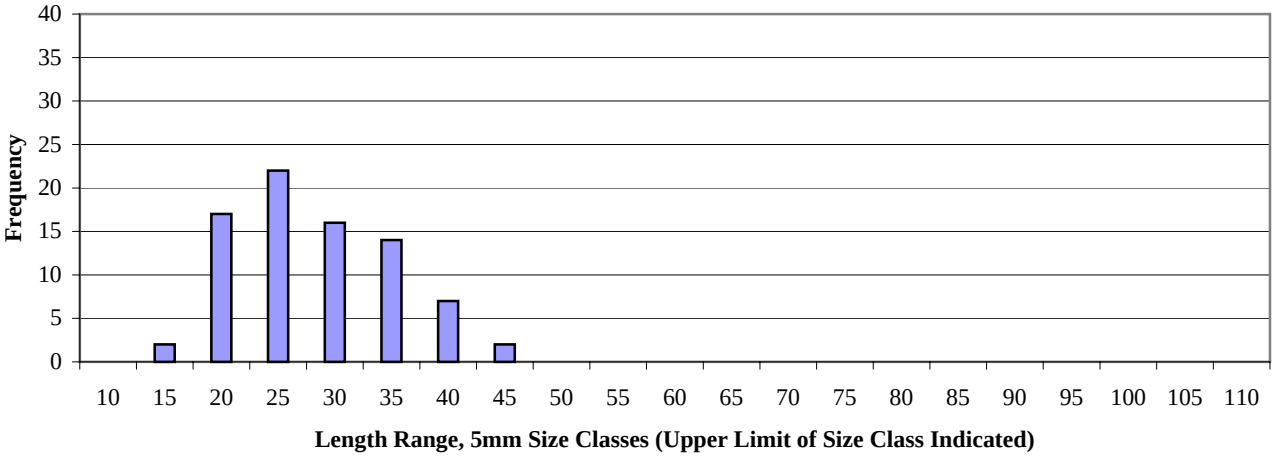
Appendix C-4.3. Coastrange Sculpin Length Frequency during June 2002 Sampling Event for the Upper Gualala Estuary.

APPENDIX C-4

Appendix C-4.4. Coastrange Sculpin Length Frequency during July 2002 Sampling Event for the Upper Gualala Estuary.

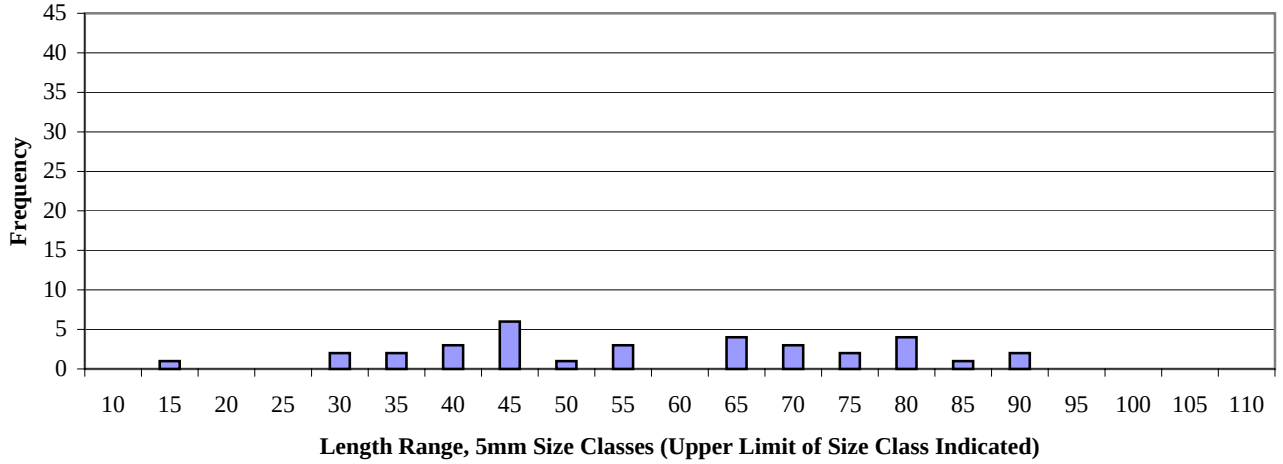
Appendix C-4.5. Coastrange Sculpin Length Frequency during August 2002 Sampling Events for the Lower Gualala Estuary.

Appendix C-4.6. Coastrange Sculpin Length Frequency during August 2002 Sampling Events for the Middle Gualala Estuary.



APPENDIX C-4

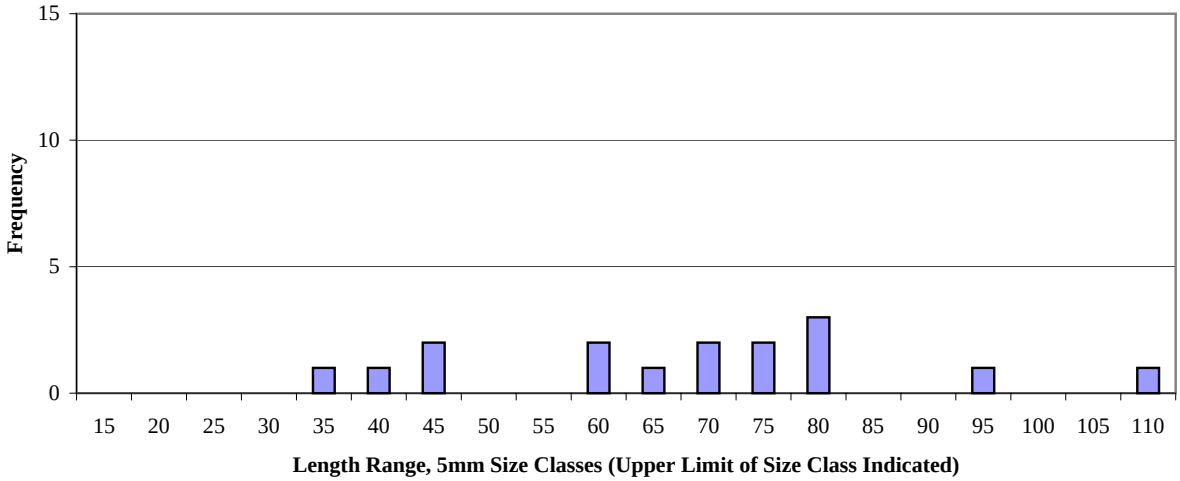
Appendix C-4.7. Coastrange Sculpin Length Frequency during August 2002 Sampling Events for the Upper Gualala Estuary.



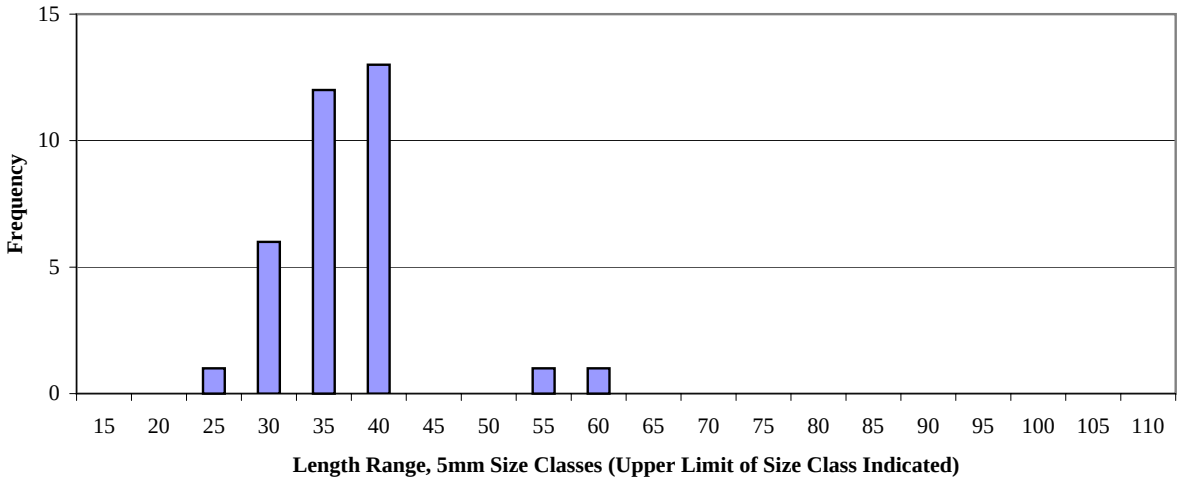
Appendix C-4.8. Coastrange Sculpin Length Frequency during September 2002 Sampling Events for the Lower Gualala Estuary.

Appendix C-4.9. Coastrange Sculpin Length Frequency during September 2002 Sampling Events for the Middle Gualala Estuary.

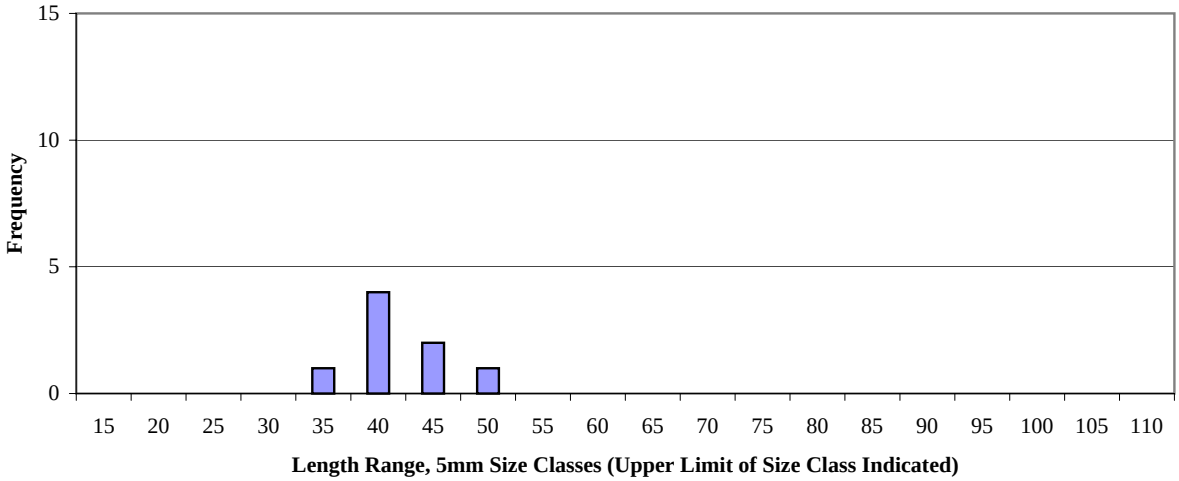
Appendix C-4.10. Coastrange Sculpin Length Frequency during February 2003 Sampling Event for the Lower Gualala Estuary.



Appendix C-4.11. Coastrange Sculpin Length Frequency during February 2003 Sampling Event for the Middle Gualala Estuary.

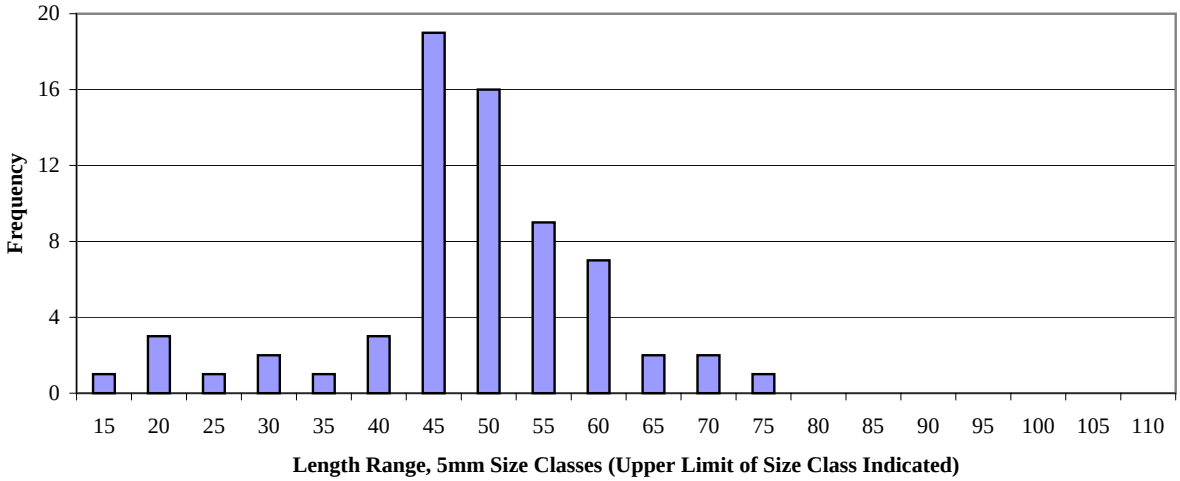


Appendix C-4.12. Coastrange Sculpin Length Frequency during February 2003 Sampling Event for the Upper Gualala Estuary.

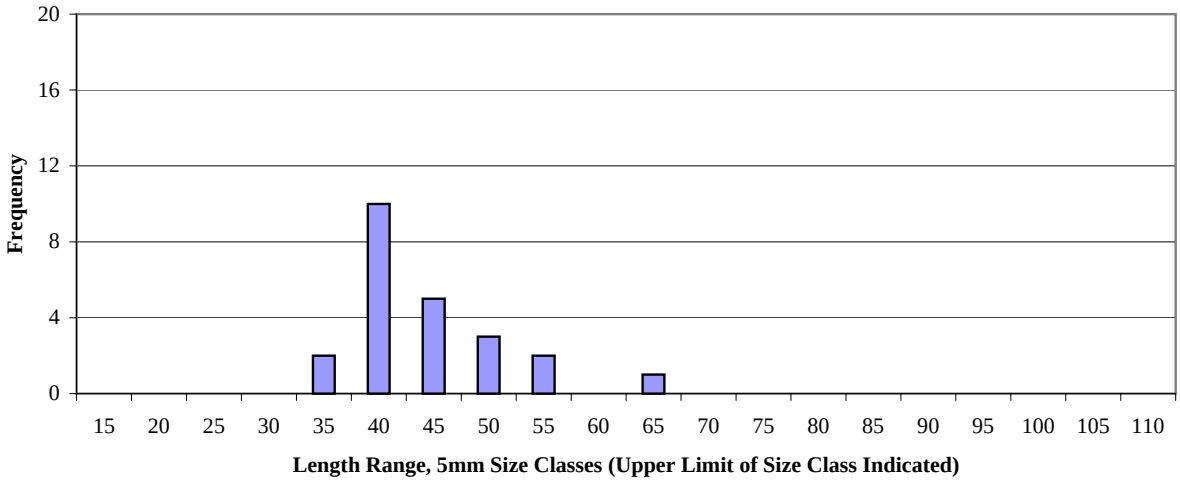


APPENDIX C-4

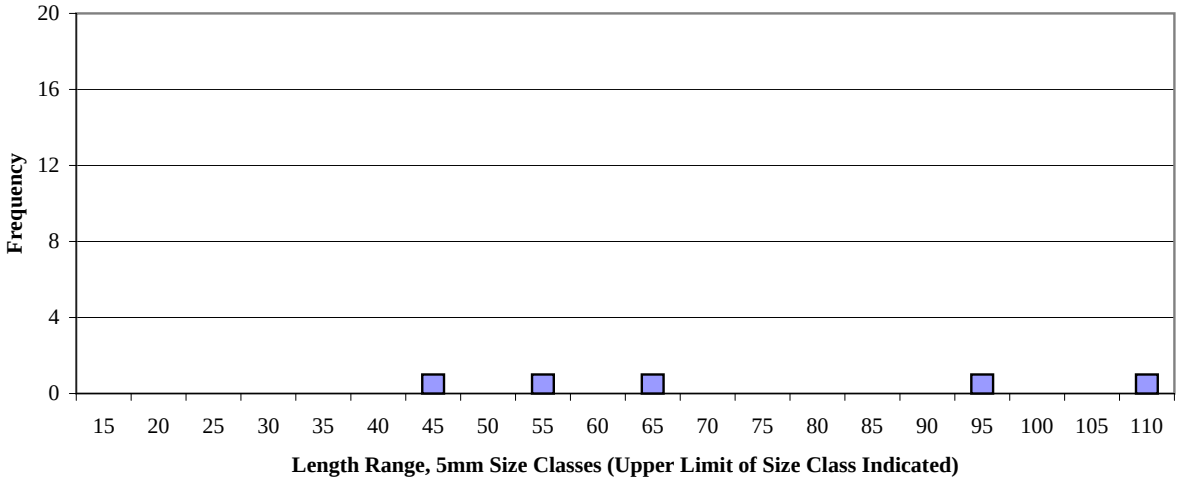
Appendix C-4.13. Coastrange Sculpin Length Frequency during May 2003 Sampling Event for the Lower Gualala Estuary.



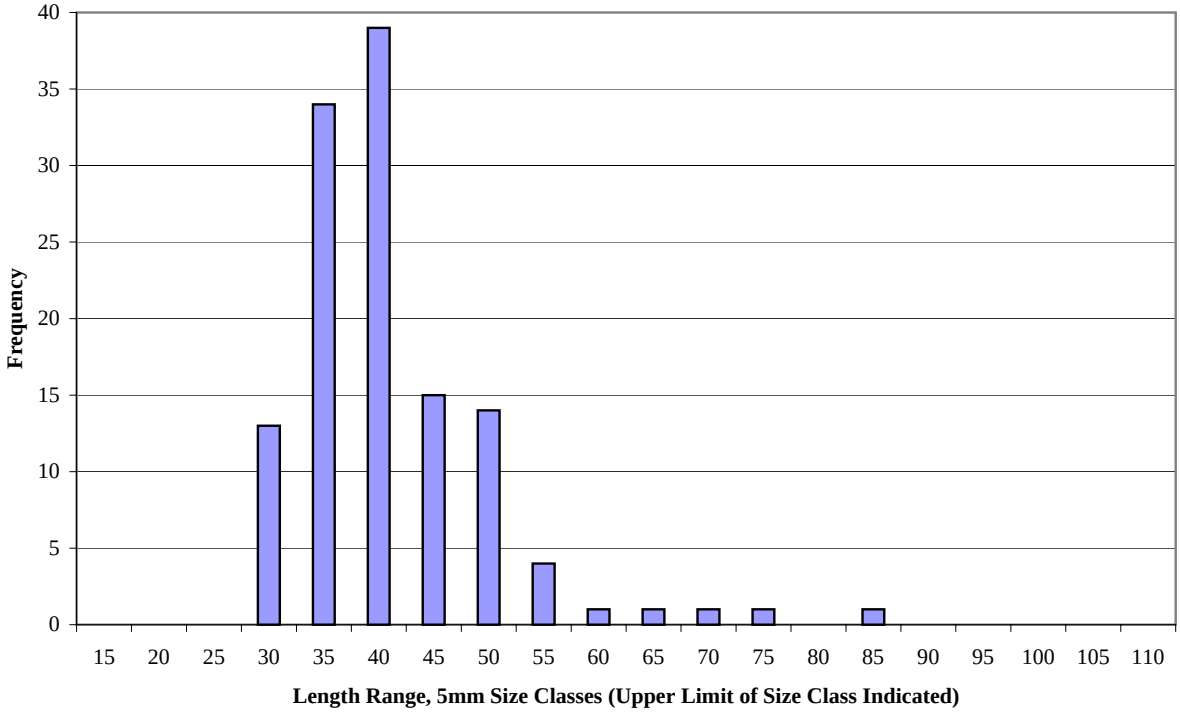
Appendix C-4.14. Coastrange Sculpin Length Frequency during May 2003 Sampling Event for the Middle Gualala Estuary.



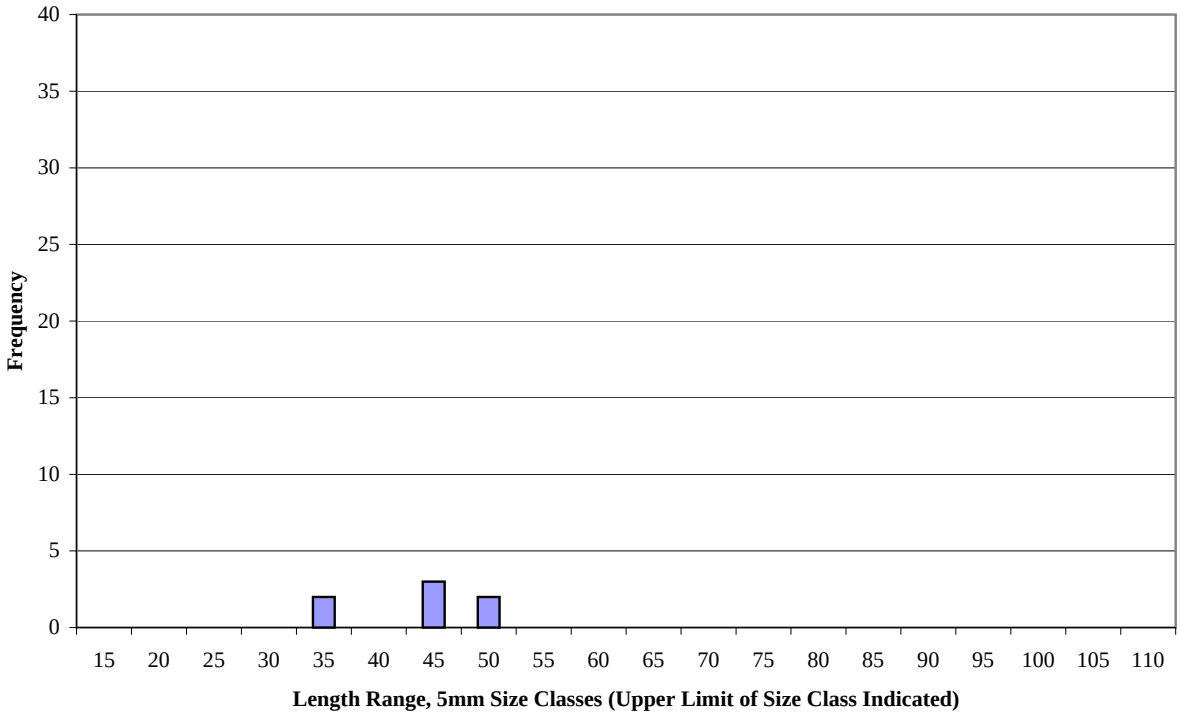
Appendix C-4.15. Coastrange Sculpin Length Frequency during June 2003 Sampling Event for the Upper Gualala Estuary.



Appendix C-4.16. Coastrange Sculpin Length Frequency during August 2003 Sampling Event for the Lower Gualala Estuary.

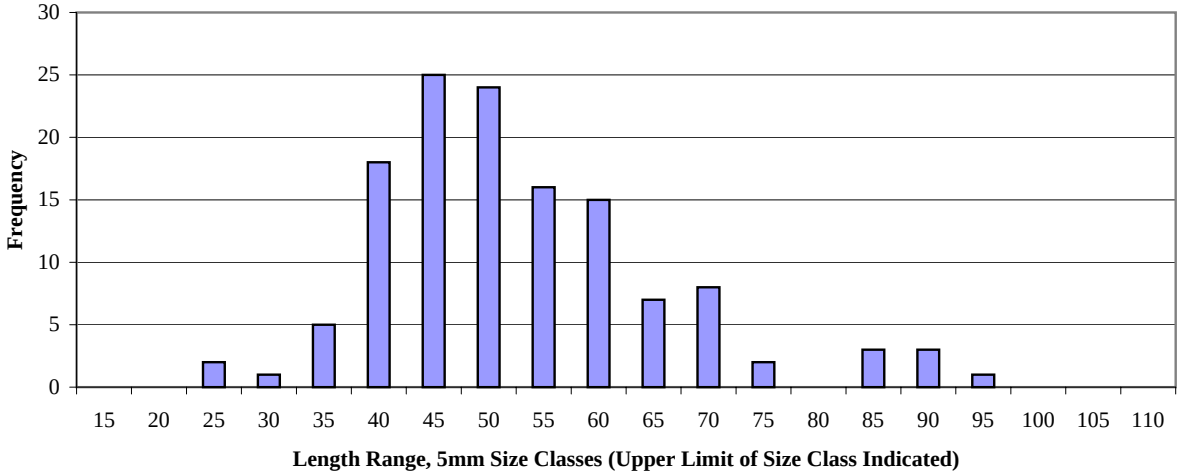


Appendix C-4.17. Coastrange Sculpin Length Frequency during August 2003 Sampling Event for the Upper Gualala Estuary.

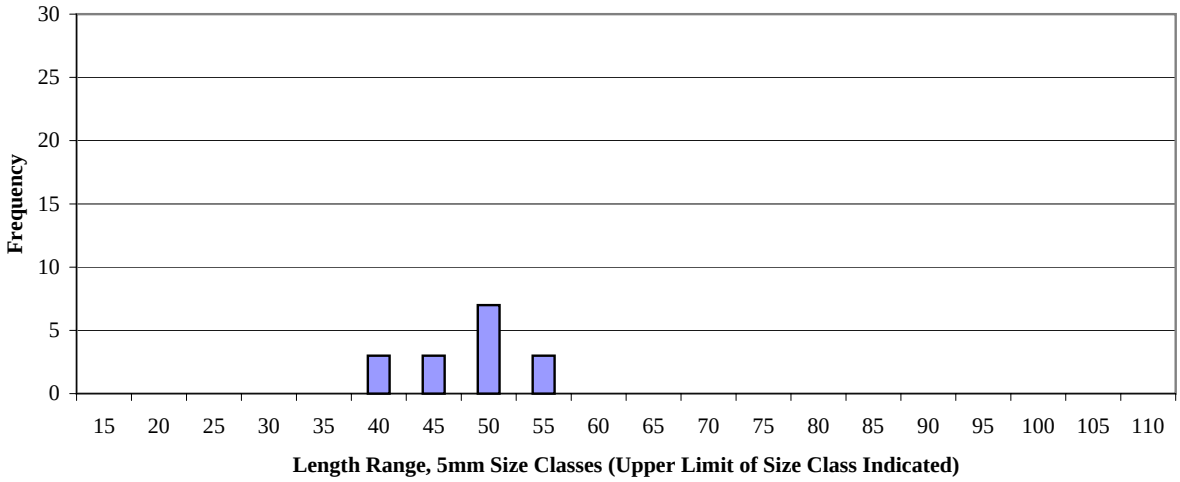


APPENDIX C-4

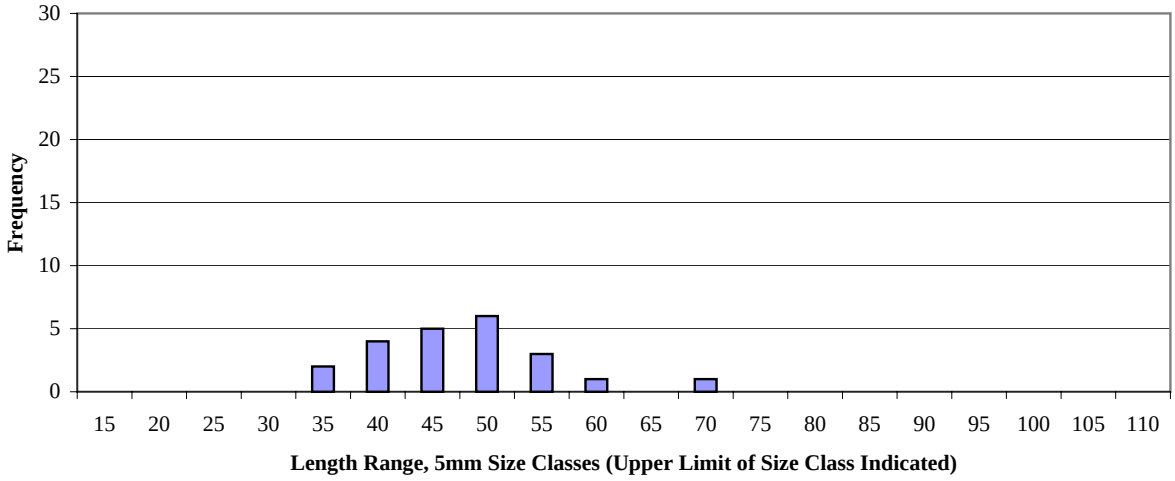
Appendix C-4.18. Coastrange Sculpin Length Frequency during September 2003 Sampling Event for the Lower Gualala Estuary.



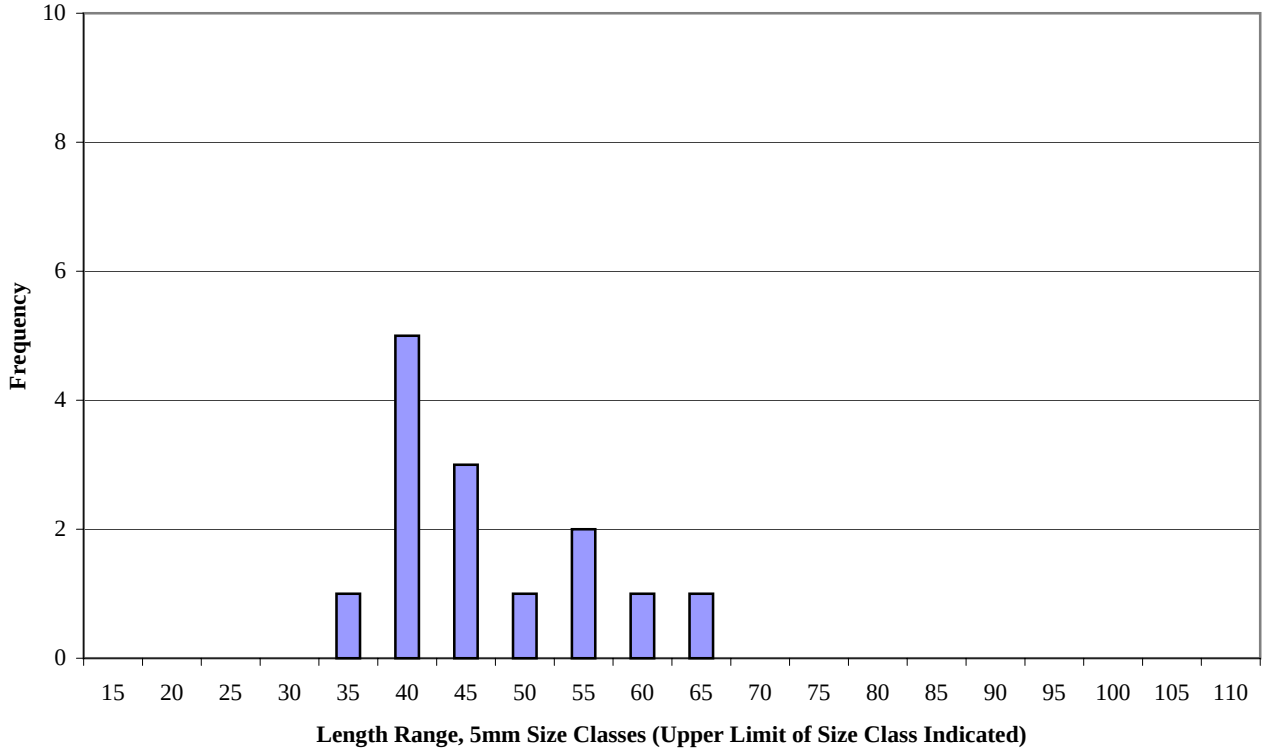
Appendix C-4.19. Coastrange Sculpin Length Frequency during September 2003 Sampling Event for the Middle Gualala Estuary.



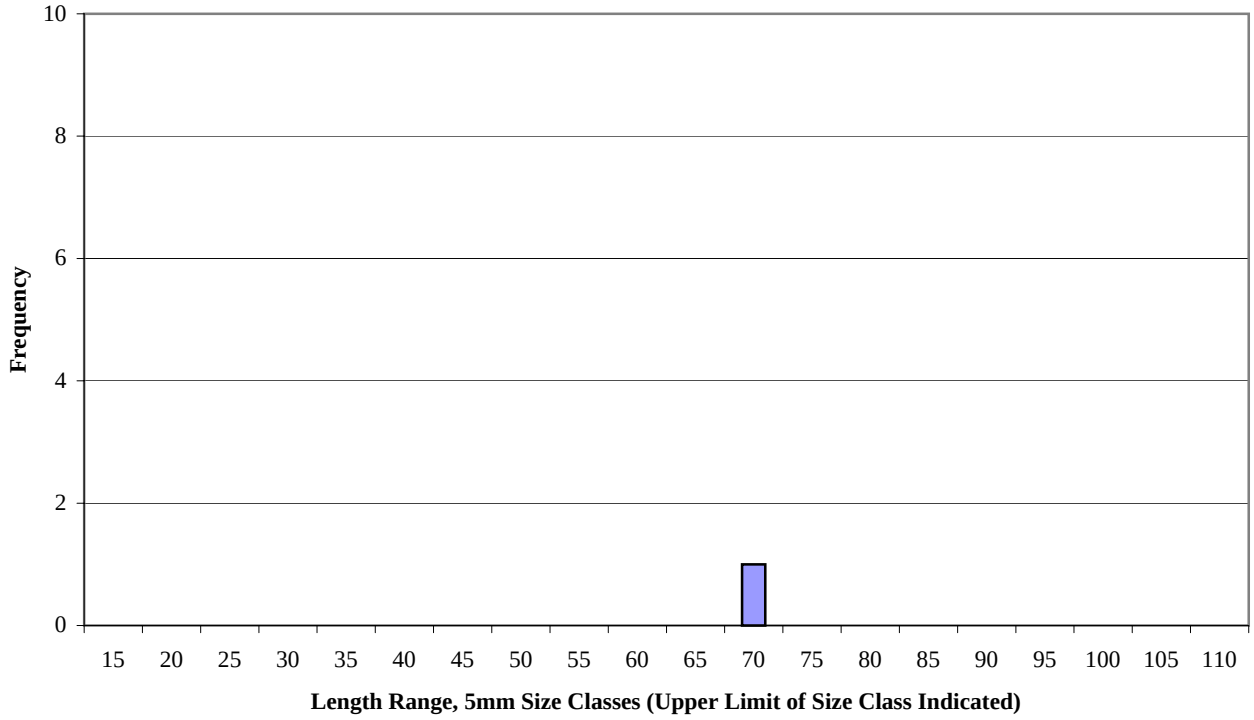
Appendix C-4.20. Coastrange Sculpin Length Frequency during September 2003 Sampling Event for the Upper Gualala Estuary.



Appendix C-4.21. Coastrange Sculpin Length Frequency during October 2003 Sampling Event for the Lower Gualala Estuary.



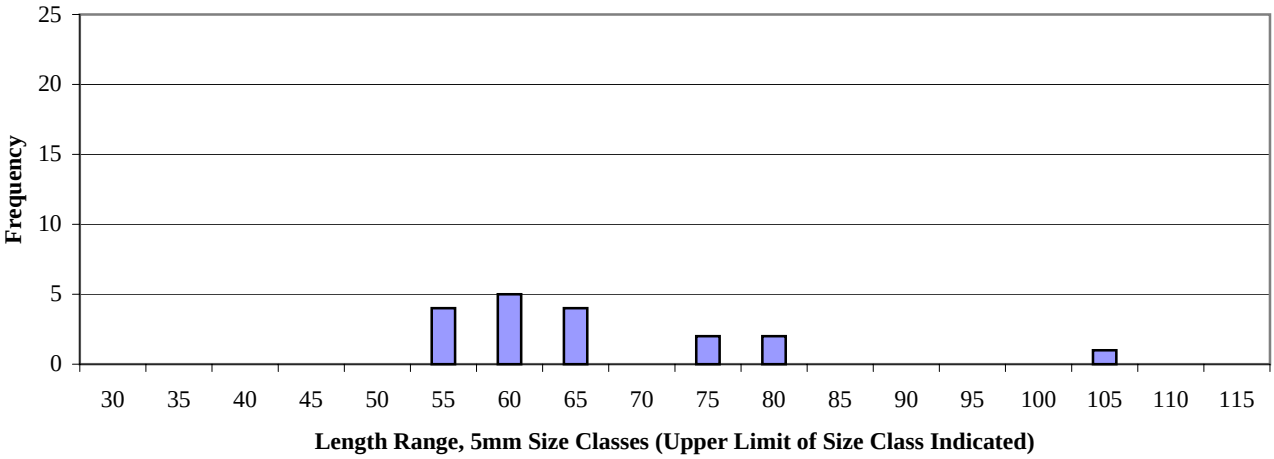
Appendix C-4.22. Coastrange Sculpin Length Frequency during October 2003 Sampling Event for the Middle Gualala Estuary.



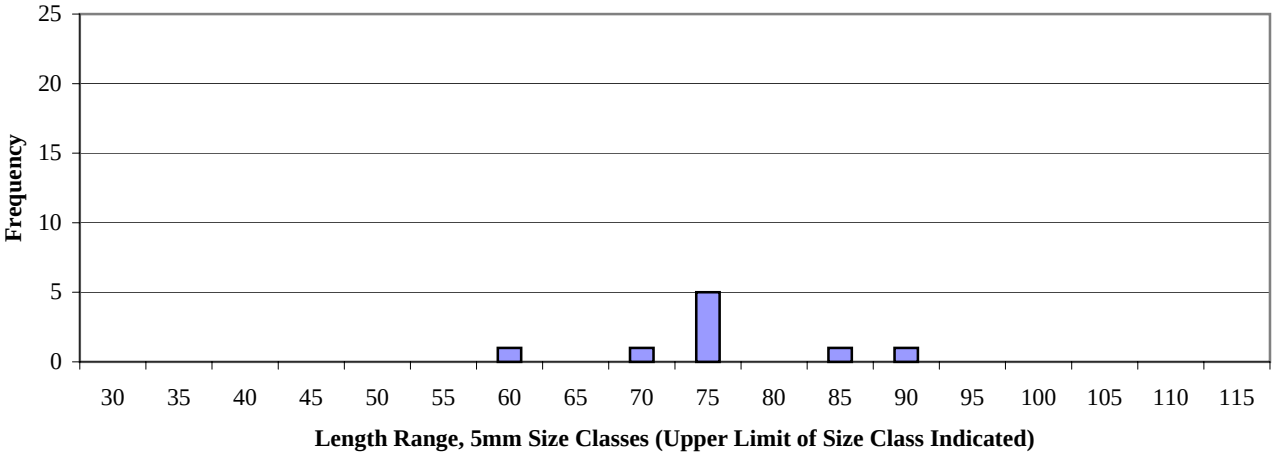
APPENDIX C-5

Appendix C-5.1. Gualala Roach Length Frequency during June 2002 Sampling Event for the Middle Gualala Estuary.

Appendix C-5.2. Gualala Roach Length Frequency during July 2002 Sampling Event for the Middle Gualala Estuary.

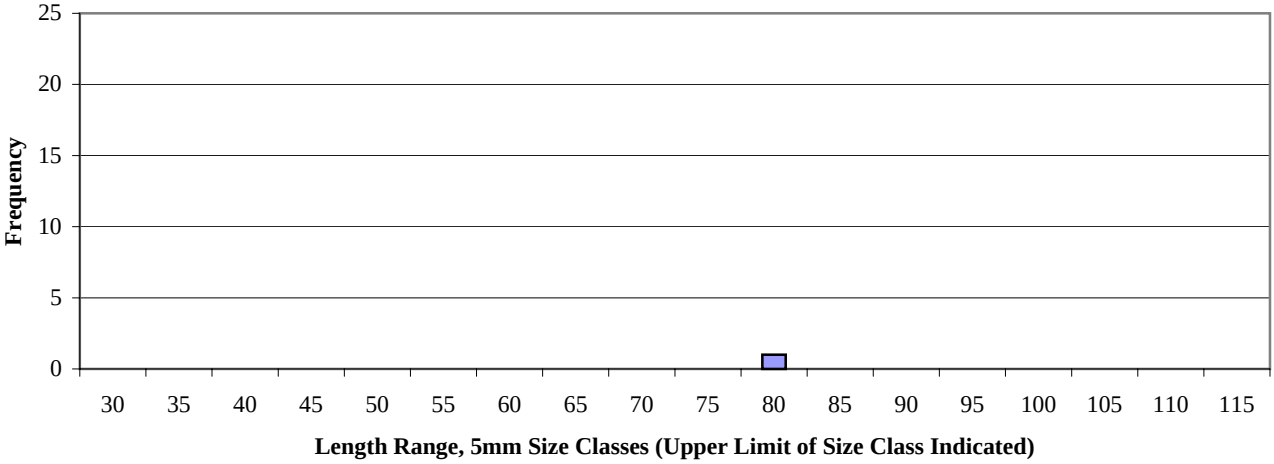


Appendix C-5.3. Gualala Roach Length Frequency during August 2002 Sampling Events for the Lower Gualala Estuary.

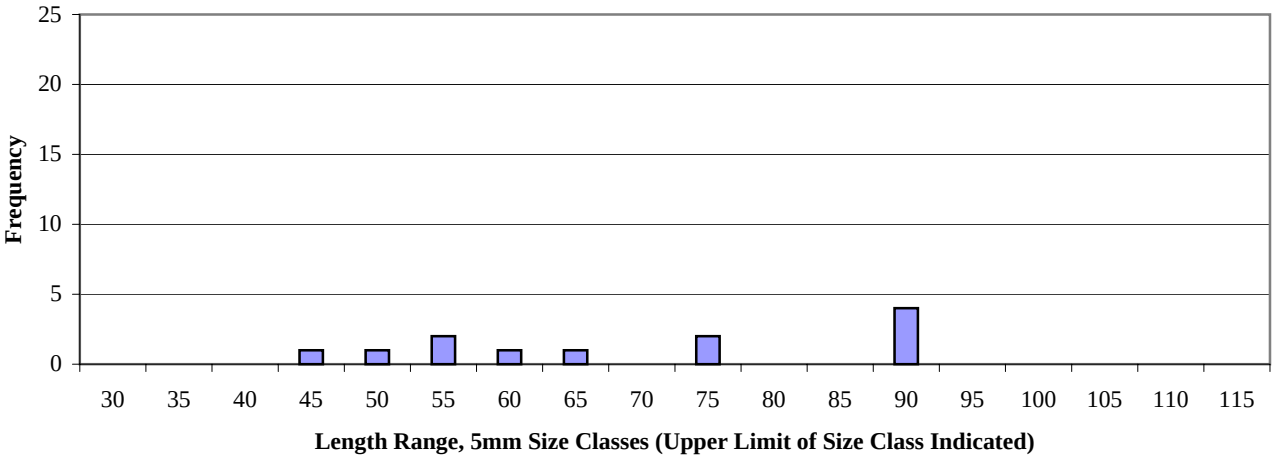


APPENDIX C-5

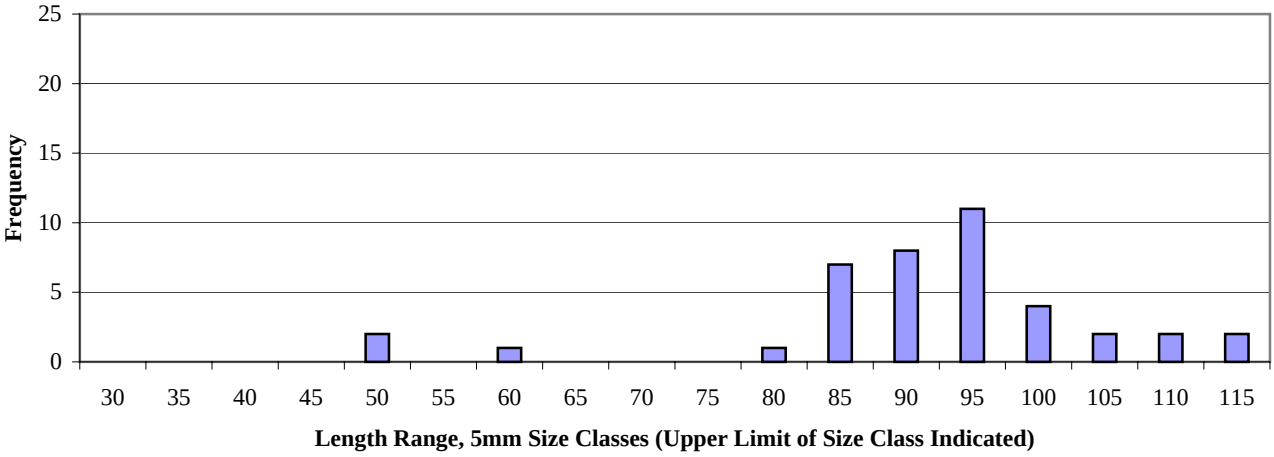
Appendix C-5.4. Gualala Roach Length Frequency during September 2002 Sampling Events for the Lower Gualala Estuary.



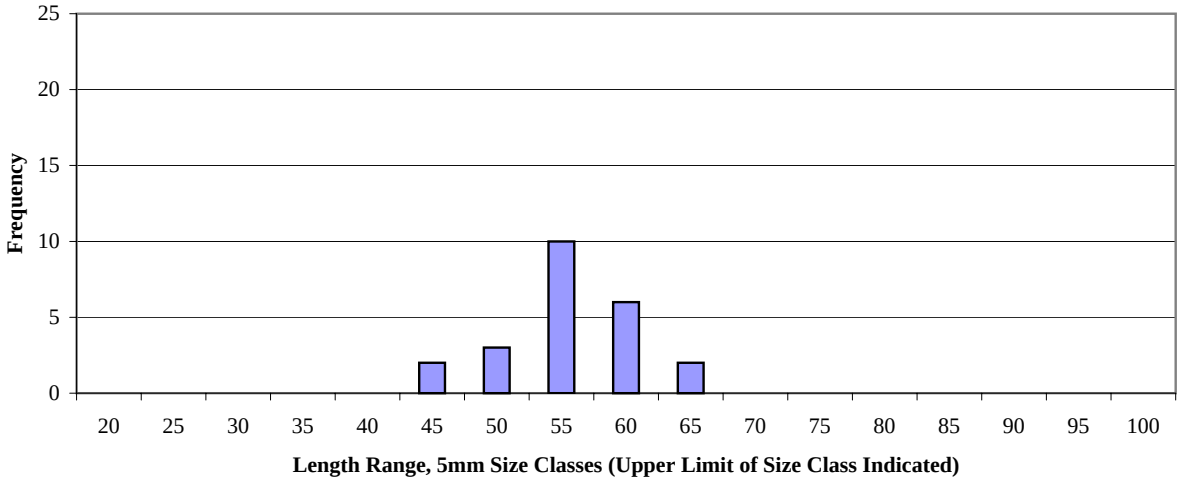
Appendix C-5.5. Gualala Roach Length Frequency during September 2002 Sampling Events for the Middle Gualala Estuary.



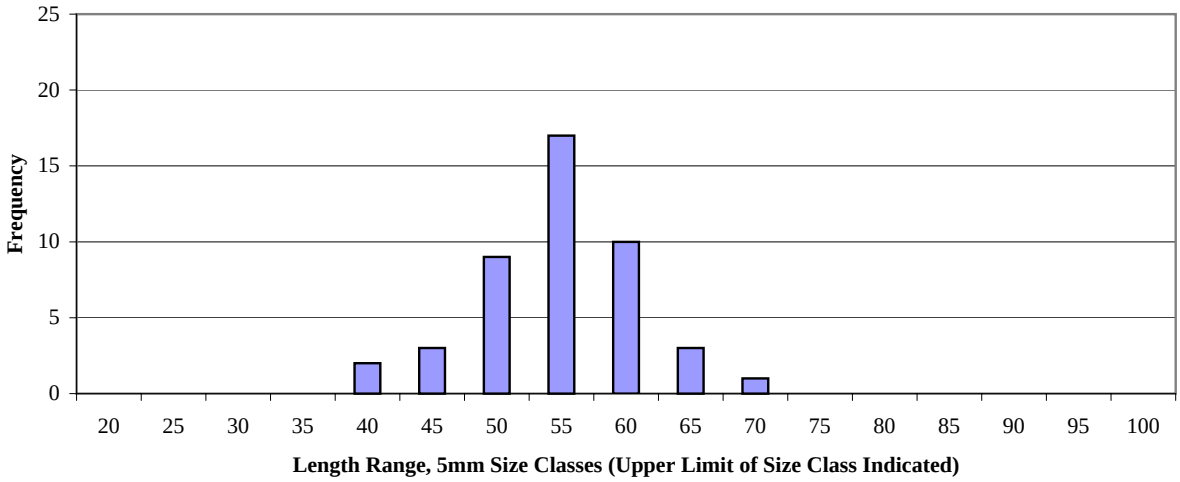
Appendix C-5.6. Gualala Roach Length Frequency during October-November 2002 Sampling Events for the Lower Gualala Estuary.



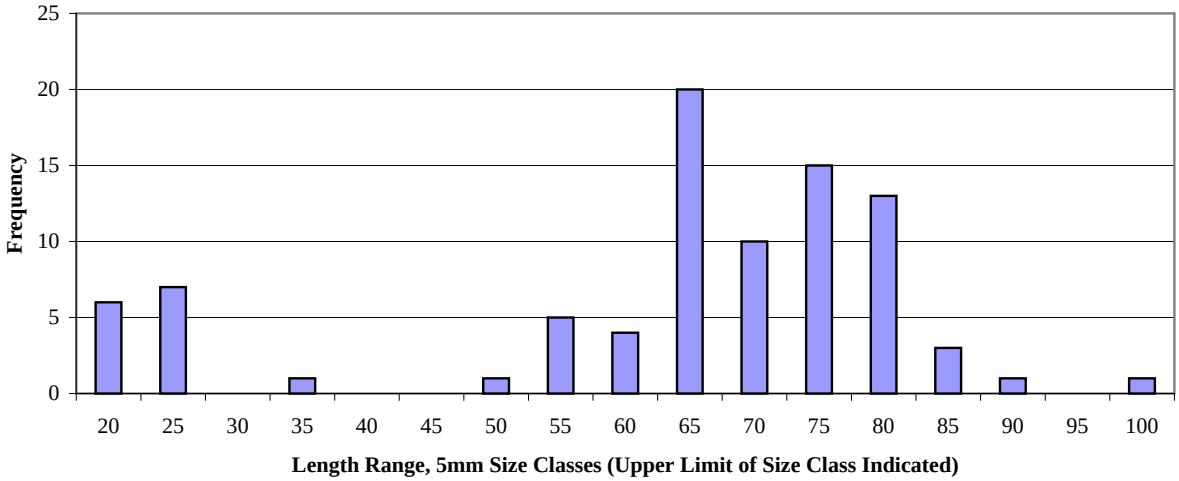
Appendix C-5.7. Gualala Roach Length Frequency during June 2003 Sampling Event for the Middle Gualala Estuary.



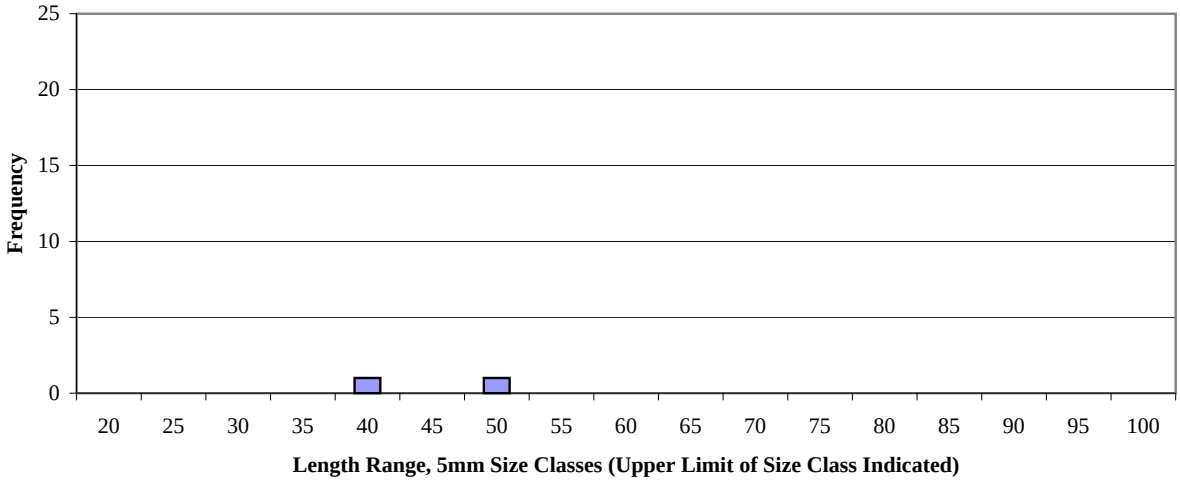
Appendix C-5.8. Gualala Roach Length Frequency during June 2003 Sampling Event for the Upper Gualala Estuary.



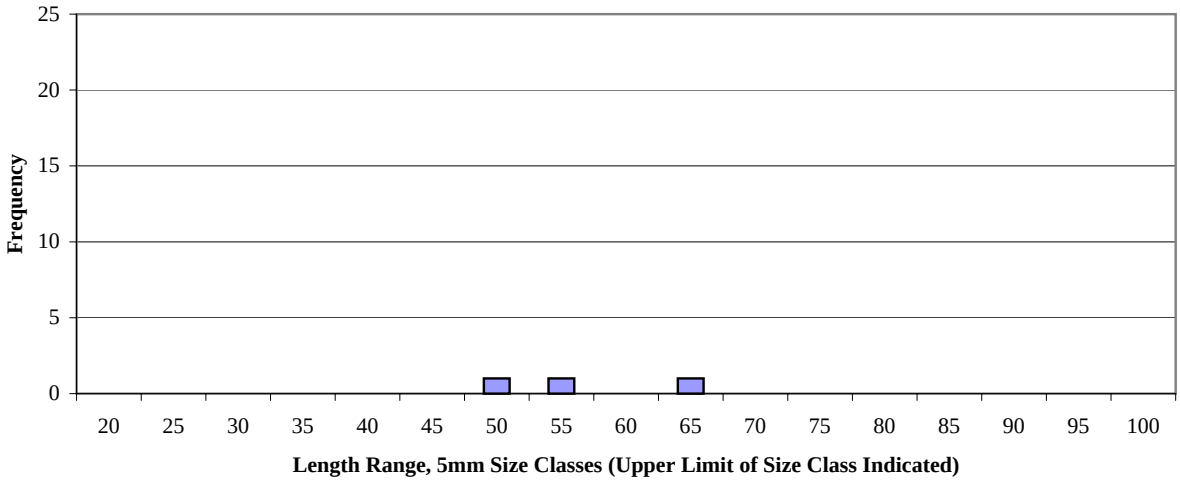
Appendix C-5.9. Gualala Roach Length Frequency during July 2003 Sampling Event for the Upper Gualala Estuary.



Appendix C-5.10. Gualala Roach Length Frequency during August 2003 Sampling Event for the Lower Gualala Estuary.

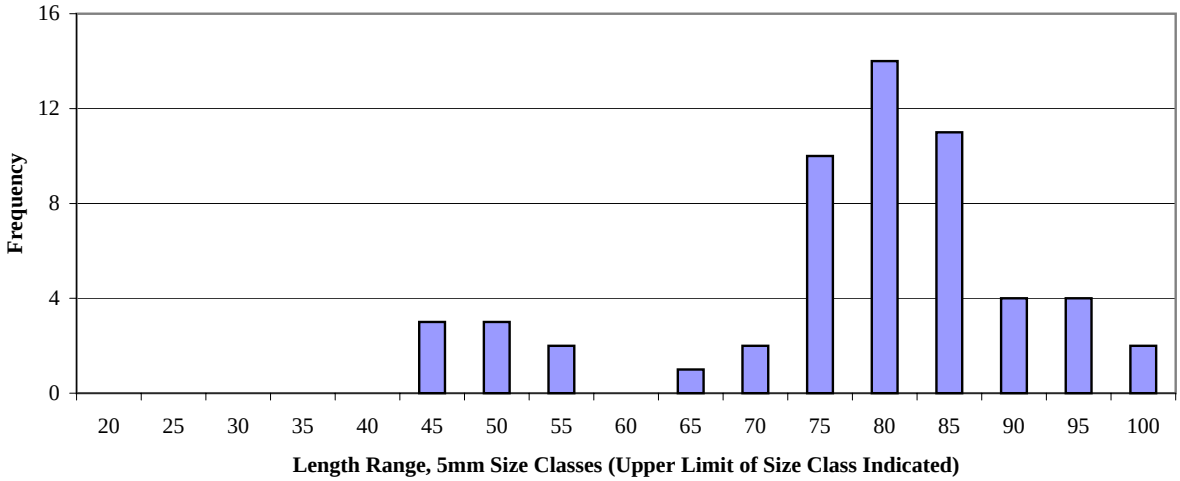


Appendix C-5.11. Gualala Roach Length Frequency during August 2003 Sampling Event for the Upper Gualala Estuary.

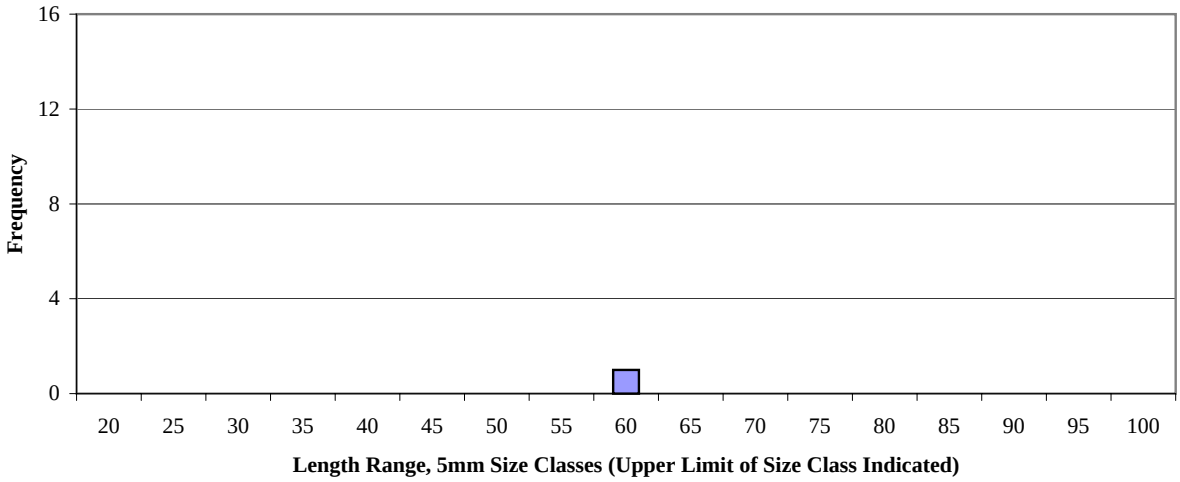


Appendix C-5.12. Gualala Roach Length Frequency during September 2003 Sampling Event for the Lower Gualala Estuary.

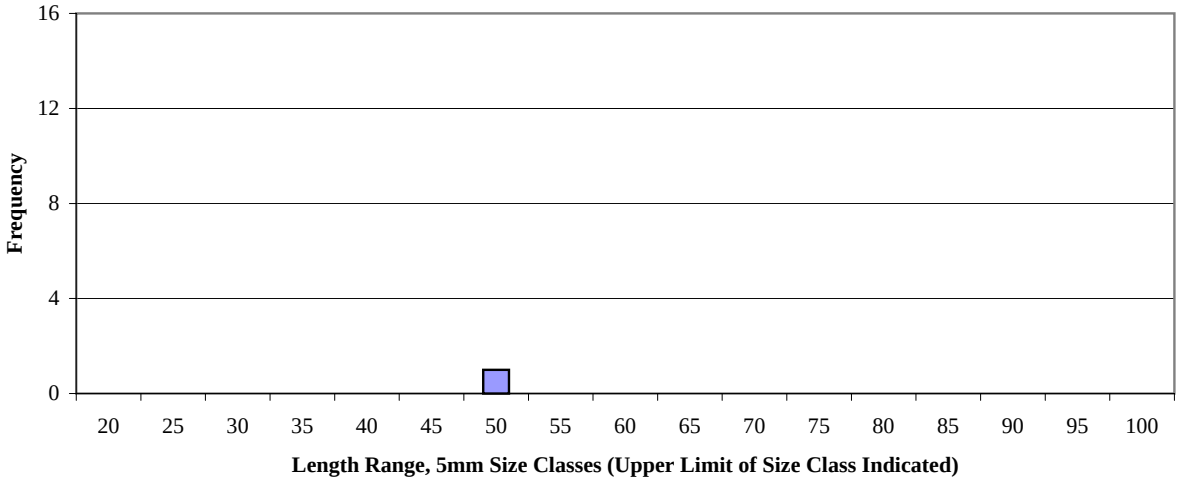
Appendix C-5.13. Gualala Roach Length Frequency during September 2003 Sampling Event for the Upper Gualala Estuary.



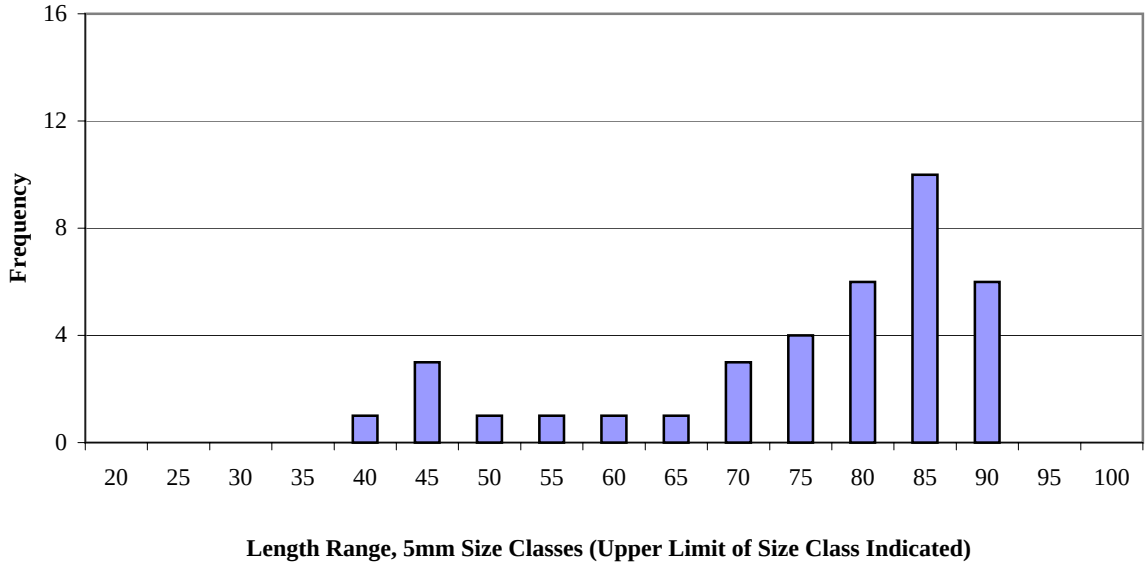
Appendix C-5.14. Gualala Roach Length Frequency during October 2003 Sampling Events for the Lower Gualala Estuary.



Appendix C-5.15. Gualala Roach Length Frequency during October 2003 Sampling Events for the Middle Gualala Estuary.

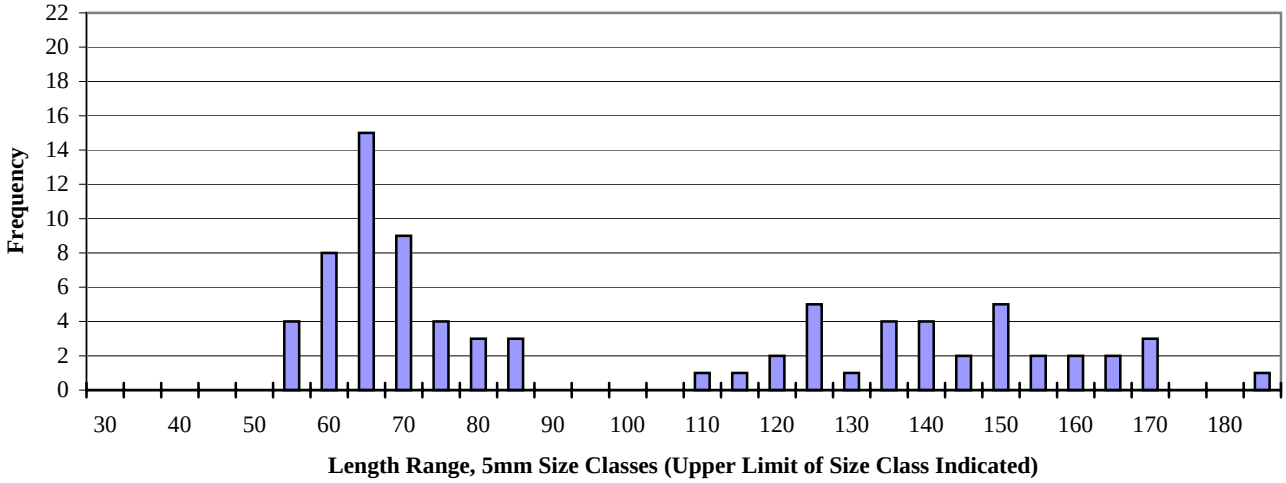


Appendix C-5.16. Gualala Roach Length Frequency during October 2003 Sampling Event for the Upper Gualala Estuary.

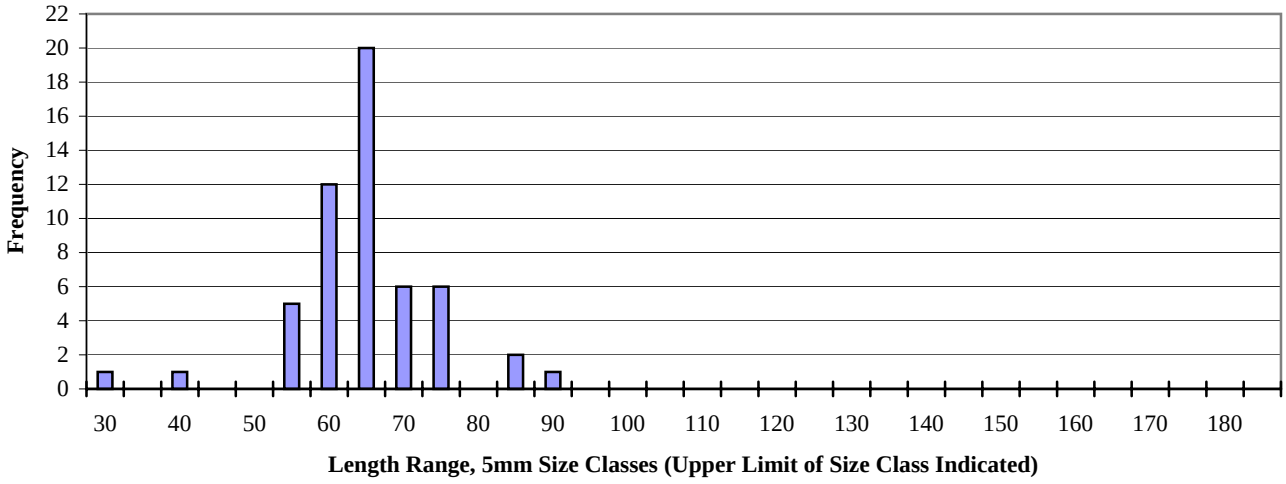


APPENDIX C-6

Appendix C-6.1. Steelhead Length Frequency during June 2002 Sampling Event for the Lower Gualala Estuary.



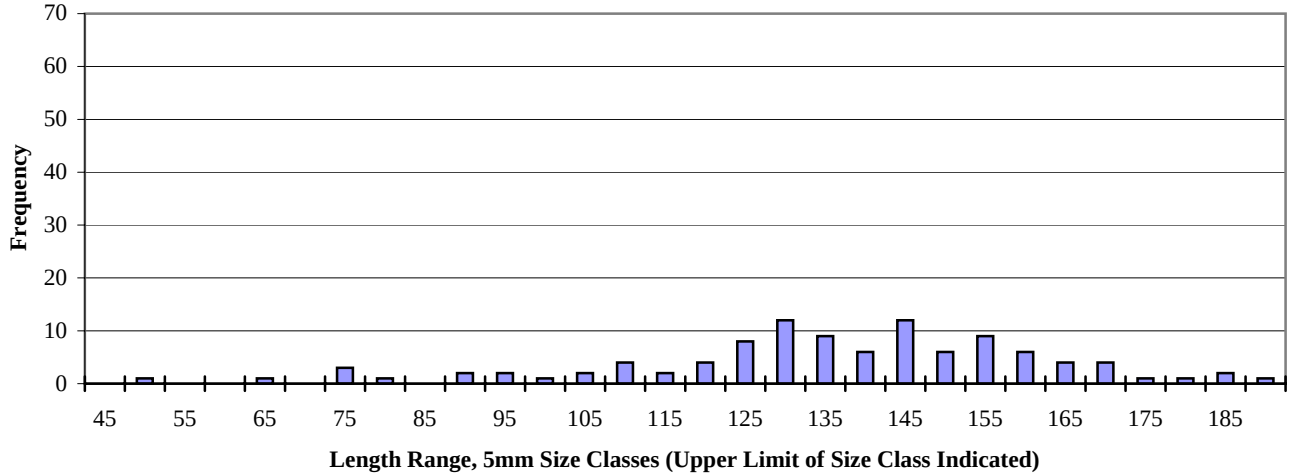
Appendix C-6.2. Steelhead Length Frequency during June 2002 Sampling Event for the Middle Gualala Estuary.



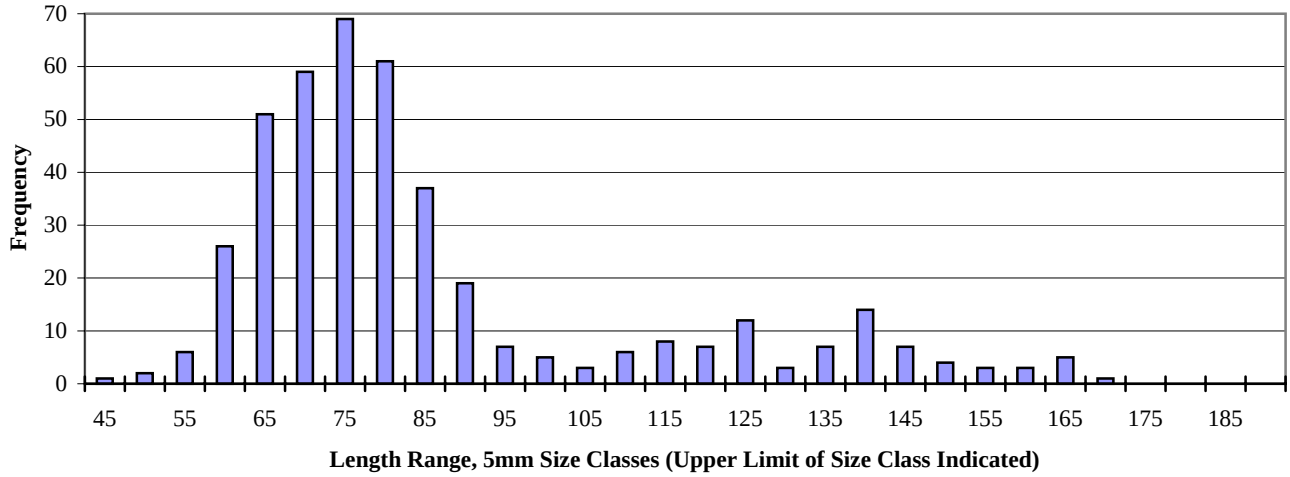
Appendix C-6.3. Steelhead Length Frequency during June 2002 Sampling Event for the Upper Gualala Estuary.

APPENDIX C-6

Appendix C-6.4. Steelhead Length Frequency during July 2002 Sampling Event for the Lower Gualala Estuary.



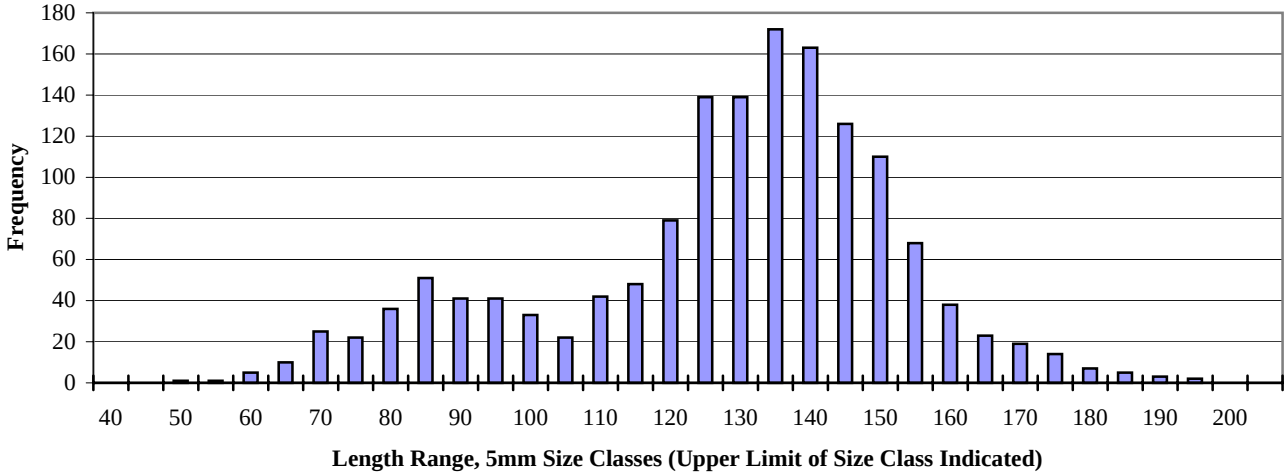
Appendix C-6.5. Steelhead Length Frequency during July 2002 Sampling Event for the Middle Gualala Estuary.



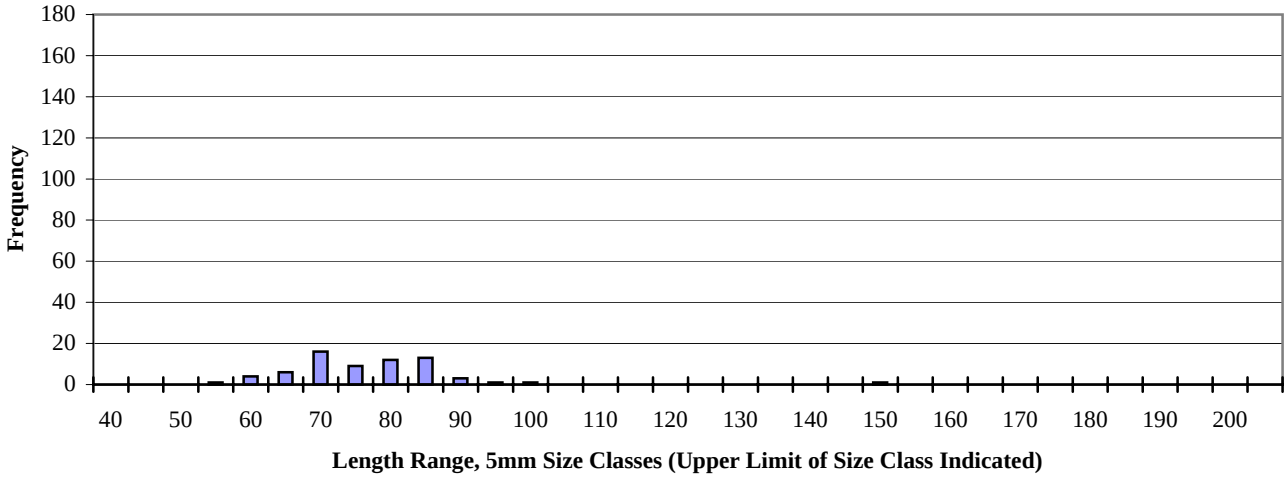
Appendix C-6.6. Steelhead Length Frequency during July 2002 Sampling Event for the Upper Gualala Estuary.

APPENDIX C-6

Appendix C-6.7. Steelhead Length Frequency during August 2002 Sampling Events for the Lower Gualala Estuary.



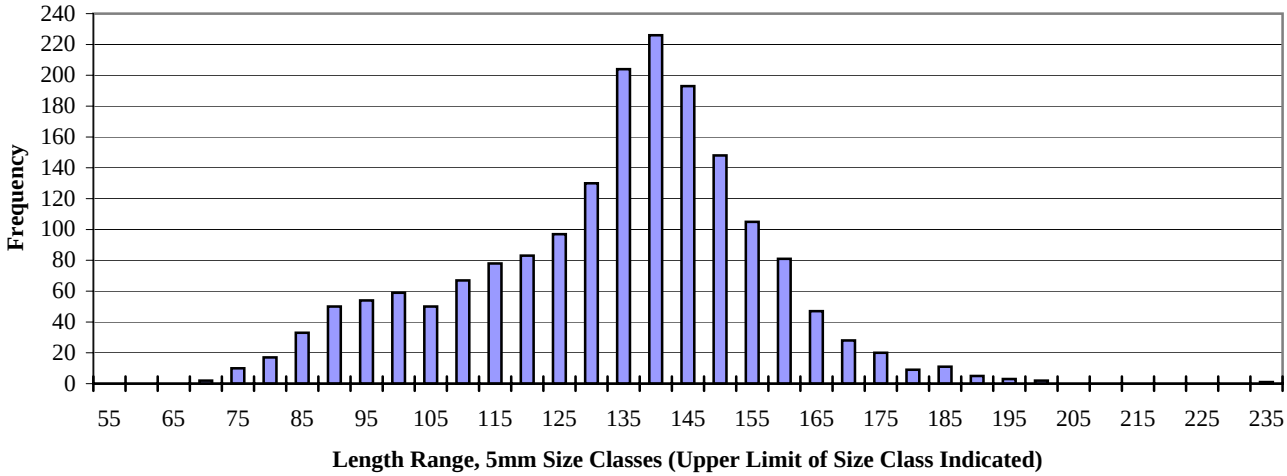
Appendix C-6.8. Steelhead Length Frequency during August 2002 Sampling Events for the Middle Gualala Estuary.



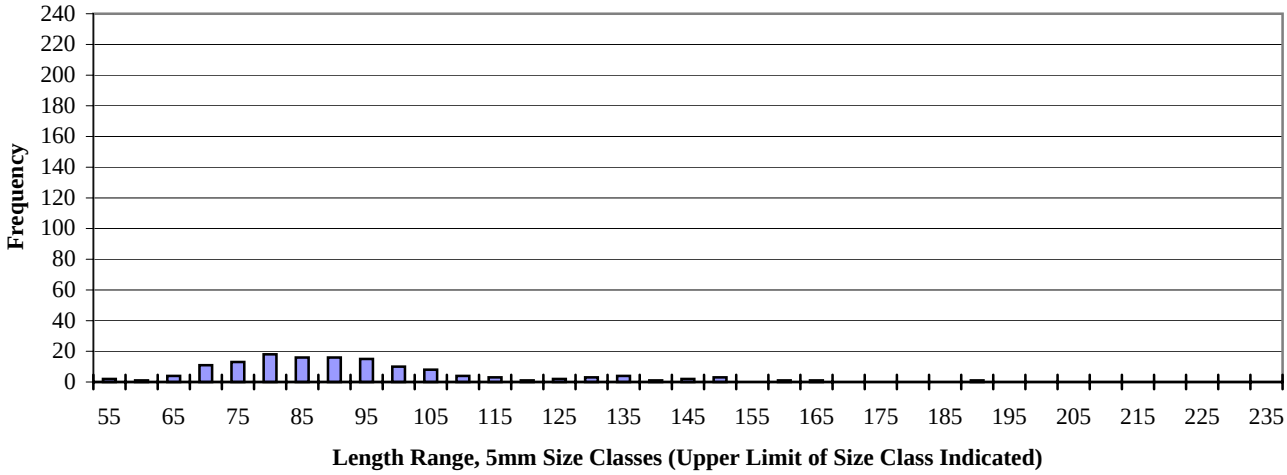
Appendix C-6.9. Steelhead Length Frequency during August 2002 Sampling Events for the Upper Gualala Estuary.

APPENDIX C-6

Appendix C-6.10. Steelhead Length Frequency during September 2002 Sampling Events for the Lower Gualala Estuary.



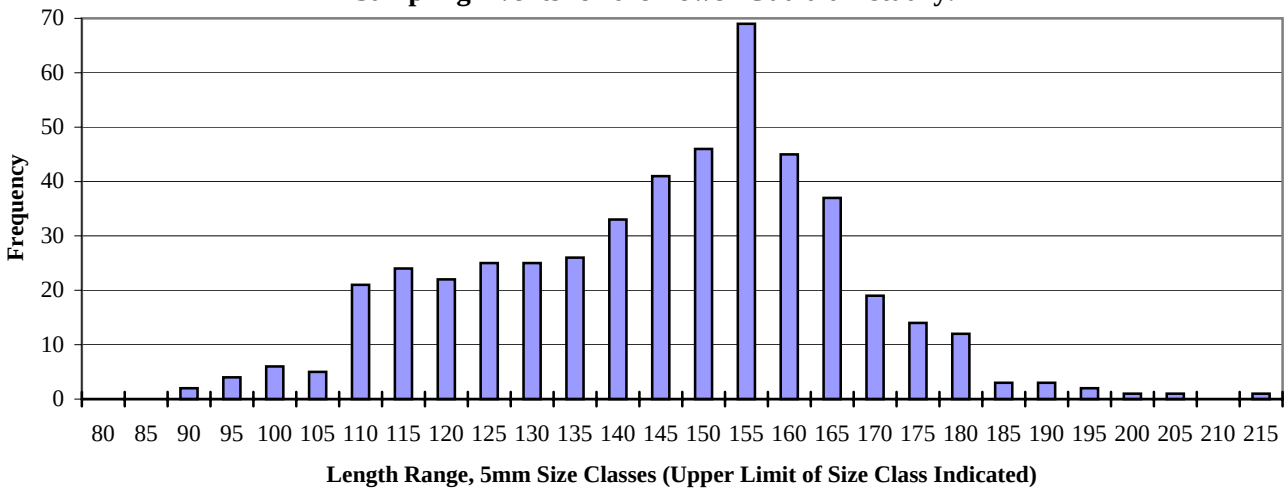
Appendix C-6.11. Steelhead Length Frequency during September 2002 Sampling Events for the Middle Gualala Estuary.



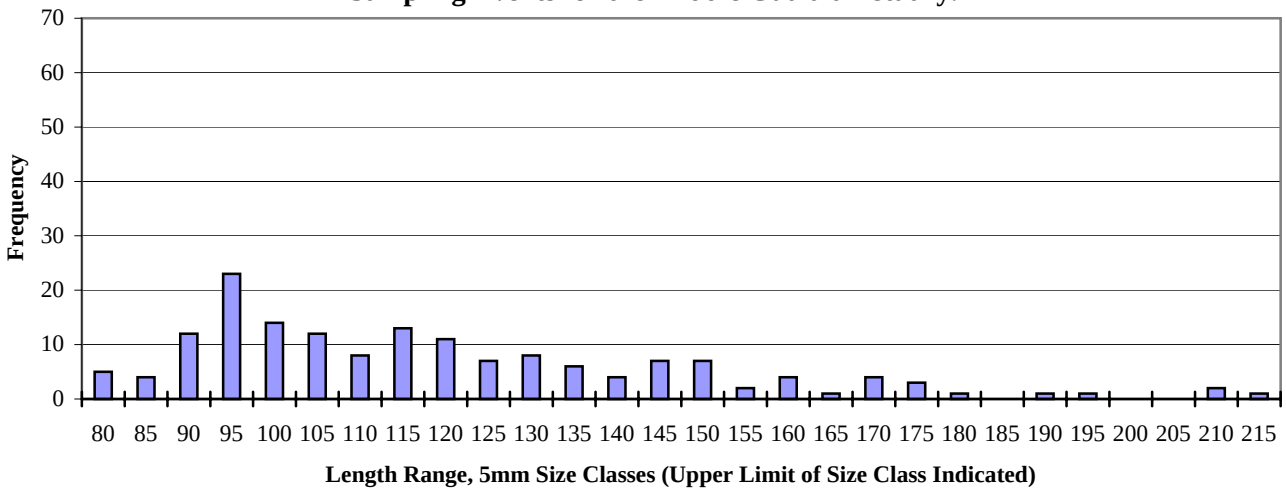
Appendix C-6.12. Steelhead Length Frequency during September 2002 Sampling Events for the Upper Gualala Estuary.

APPENDIX C-6

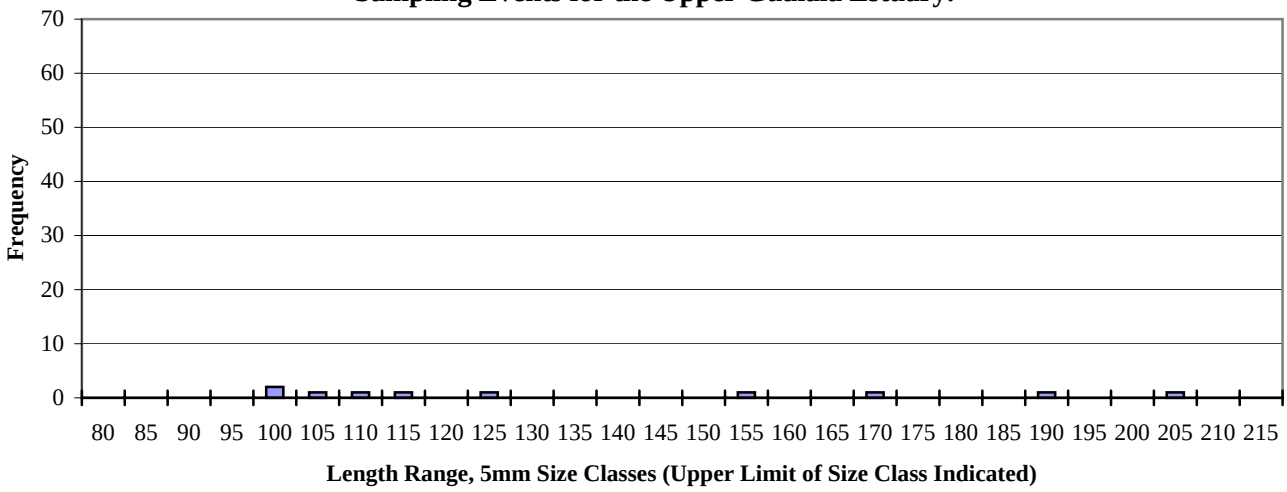
Appendix C-6.13. Steelhead Length Frequency during October-November 2002 Sampling Events for the Lower Gualala Estuary.



Appendix C-6.14. Steelhead Length Frequency during October-November 2002 Sampling Events for the Middle Gualala Estuary.



Appendix C-6.15. Steelhead Length Frequency during October-November 2002 Sampling Events for the Upper Gualala Estuary.



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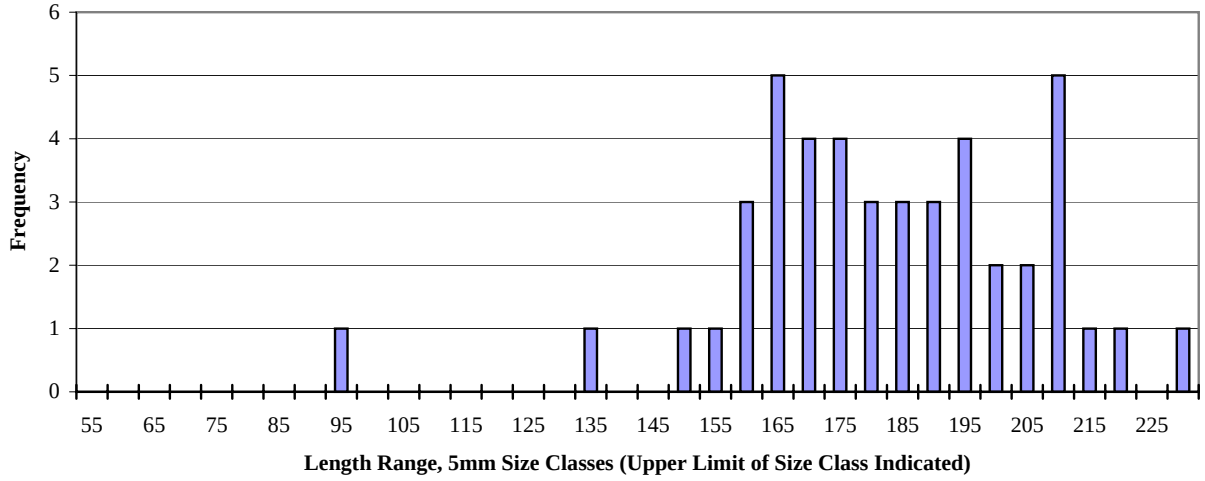
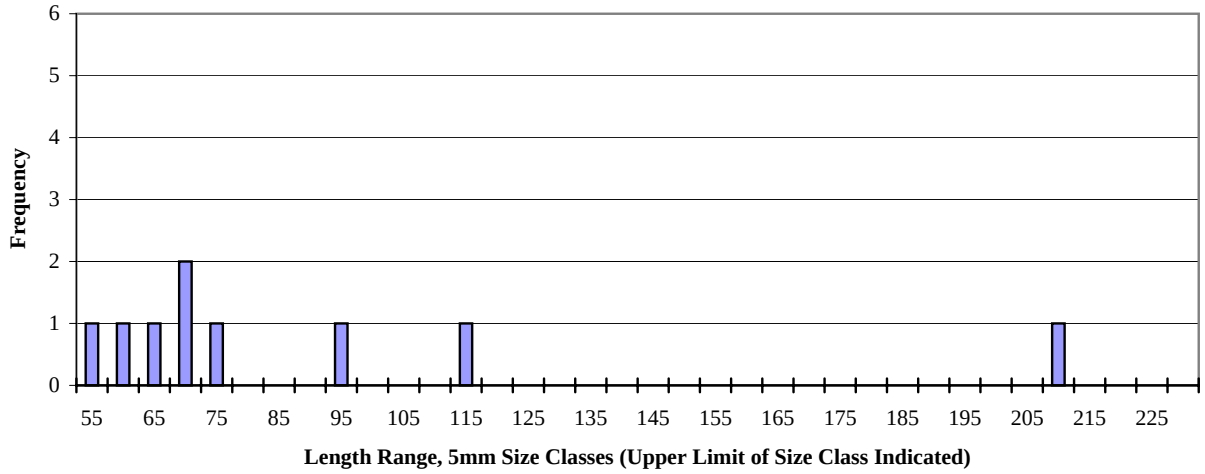
Appendix C-6.16. Steelhead Length Frequency during February 2003 Sampling Event for the Lower Gualala Estuary.



Appendix C-6.17. Steelhead Length Frequency during February 2003 Sampling Event for the Middle Gualala Estuary.

Appendix C-6.18. Steelhead Length Frequency during February 2003 Sampling Event for the Upper Gualala Estuary.



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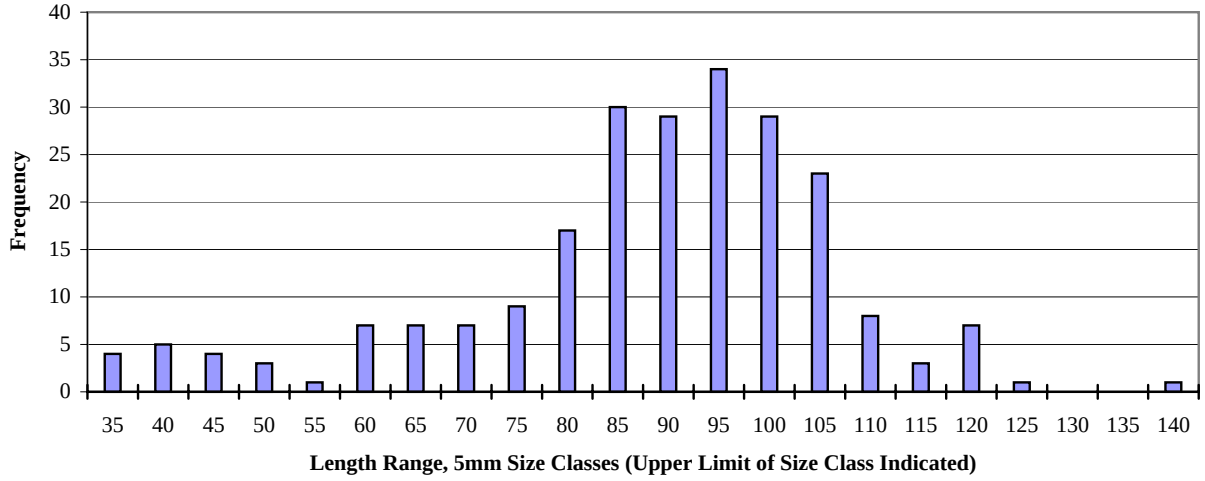
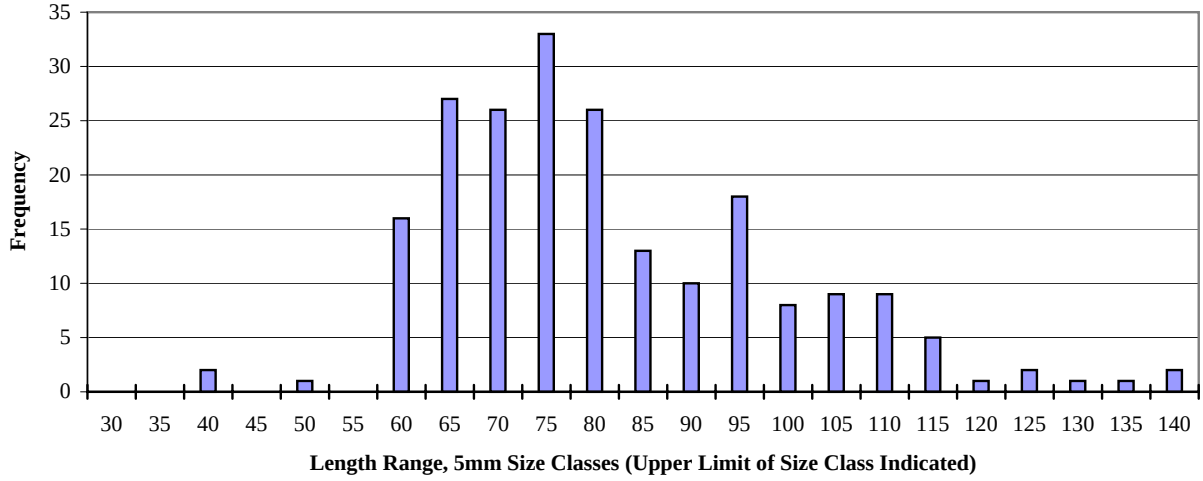
Appendix C-6.19. Steelhead Length Frequency during May 2003 Sampling Event for the Lower Gualala Estuary.



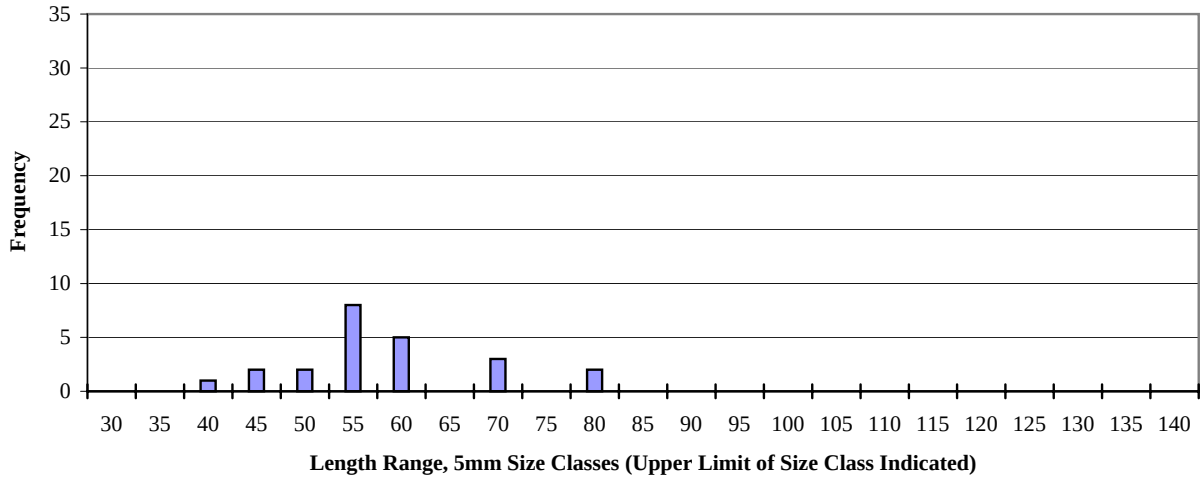
Appendix C-6.20. Steelhead Length Frequency during May 2003 Sampling Event for the Middle Gualala Estuary.

Appendix C-6.21. Steelhead Length Frequency during May 2003 Sampling Event for the Upper Gualala Estuary.

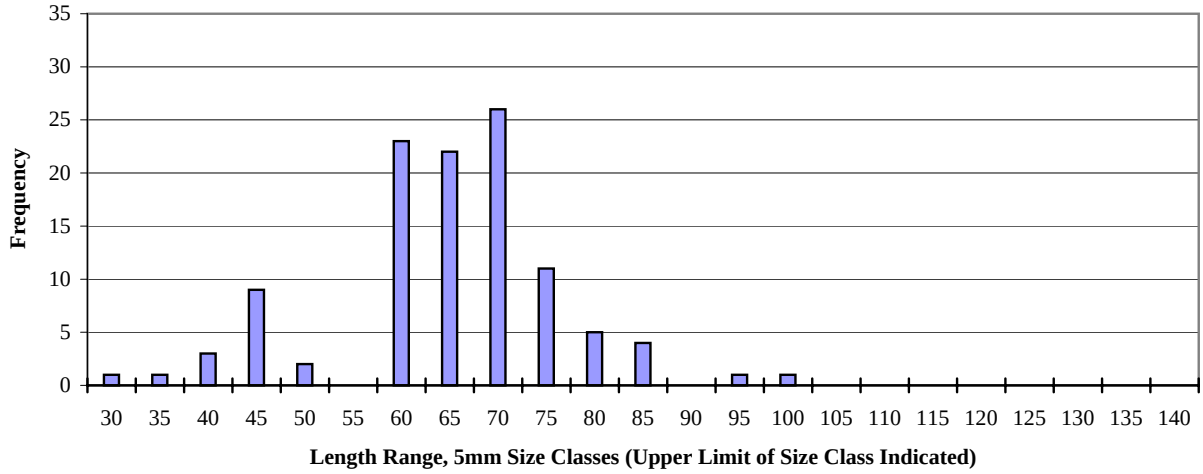
Appendix C-6.22. Steelhead Length Frequency during June 2003 Sampling Event for the Lower Gualala Estuary.



Appendix C-6.23. Steelhead Length Frequency during June 2003 Sampling Event for the Middle Gualala Estuary.



Appendix C-6.24. Steelhead Length Frequency during June 2003 Sampling Event for the Upper Gualala Estuary.



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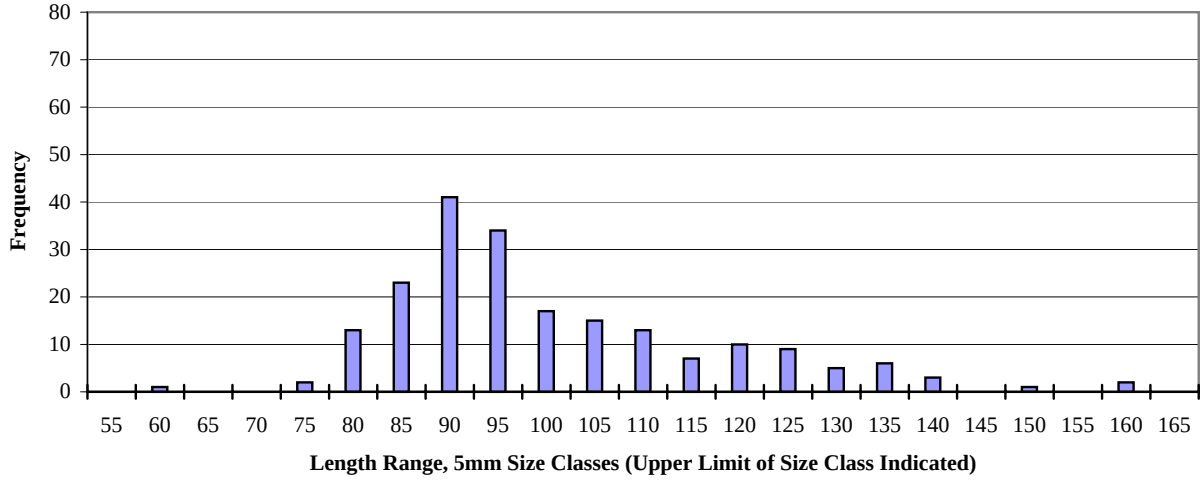
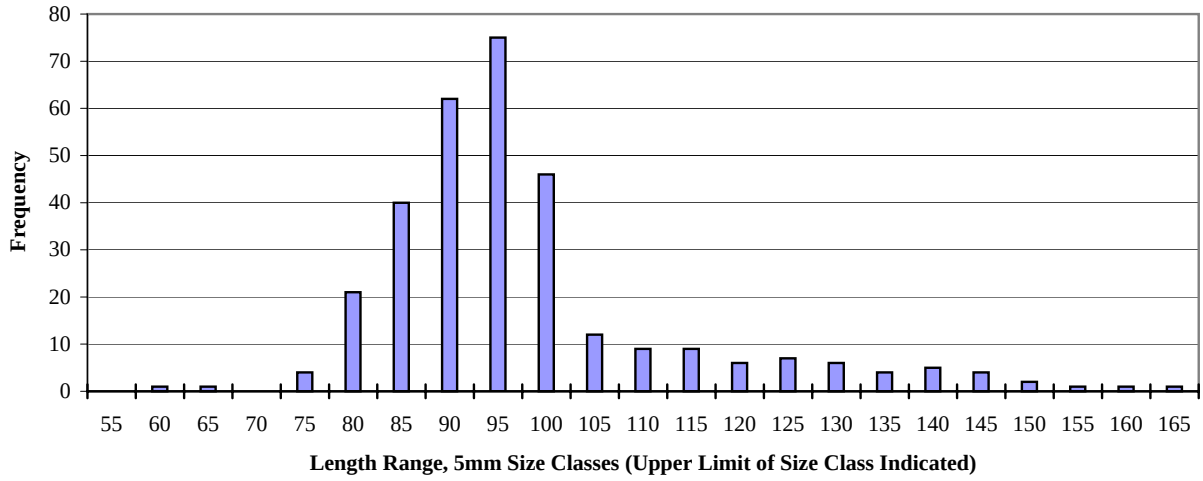
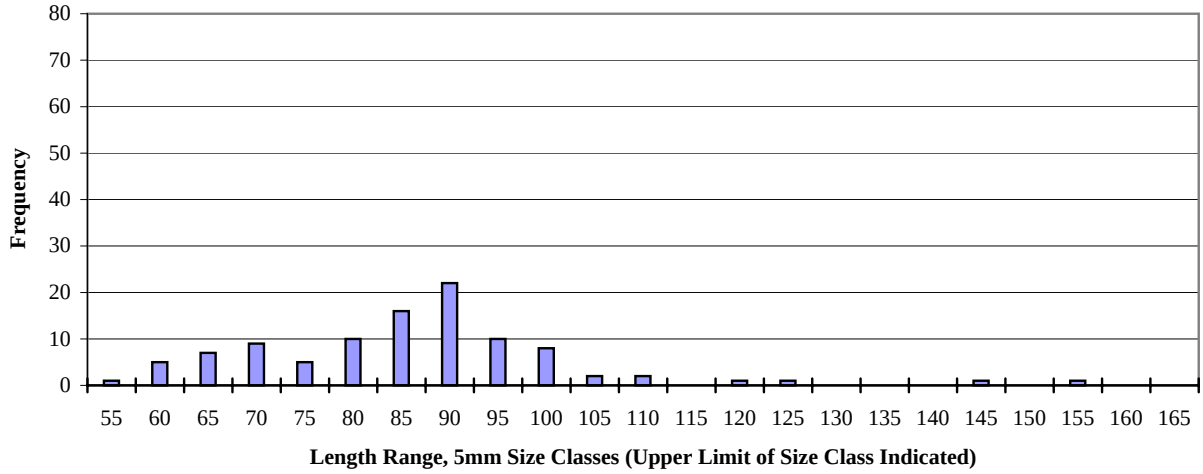
Appendix C-6.25. Steelhead Length Frequency during July 2003 Sampling Event for the Lower Gualala Estuary.



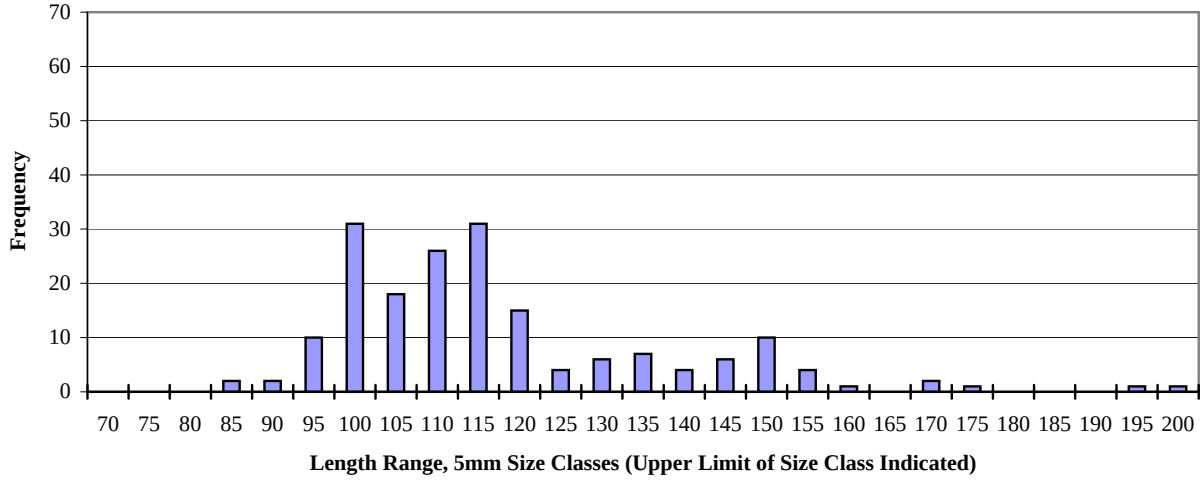
Appendix C-6.26. Steelhead Length Frequency during July 2003 Sampling Event for the Middle Gualala Estuary.



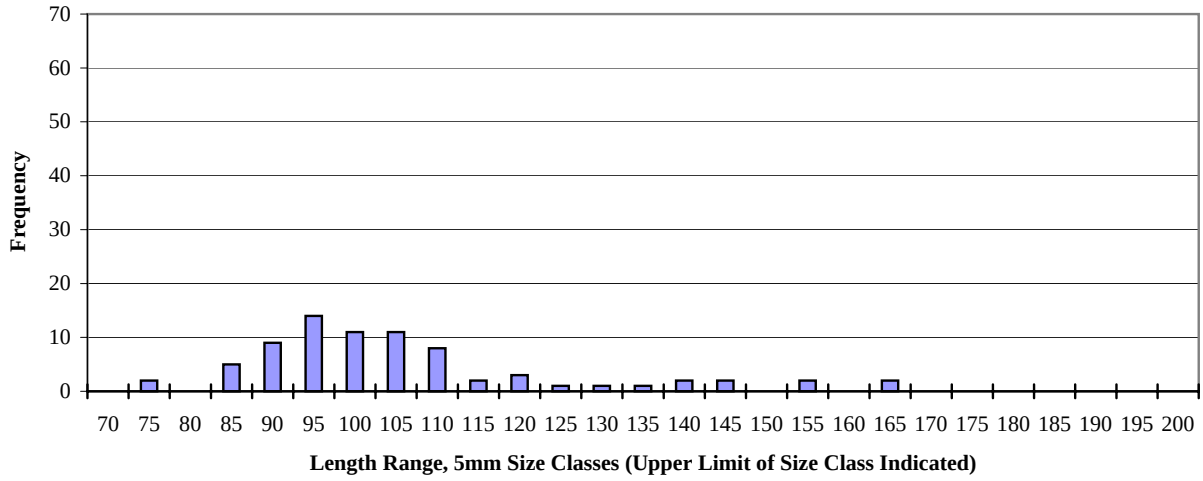
Appendix C-6.27. Steelhead Length Frequency during July 2003 Sampling Event for the Upper Gualala Estuary.



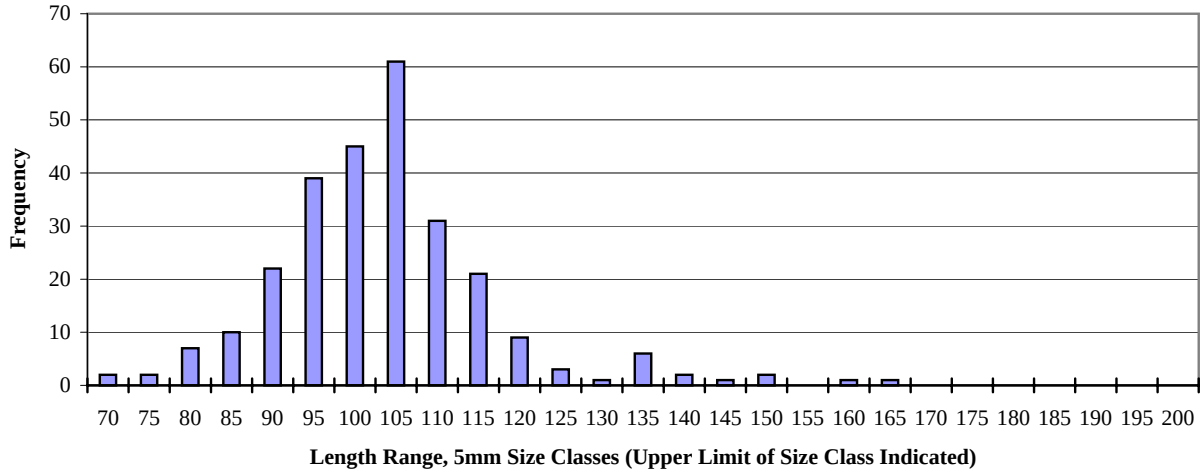
Appendix C-6.28. Steelhead Length Frequency during August 2003 Sampling Event for the Lower Gualala Estuary.



Appendix C-6.29. Steelhead Length Frequency during August 2003 Sampling Event for the Middle Gualala Estuary.



Appendix C-6.30. Steelhead Length Frequency during August 2003 Sampling Event for the Upper Gualala Estuary.



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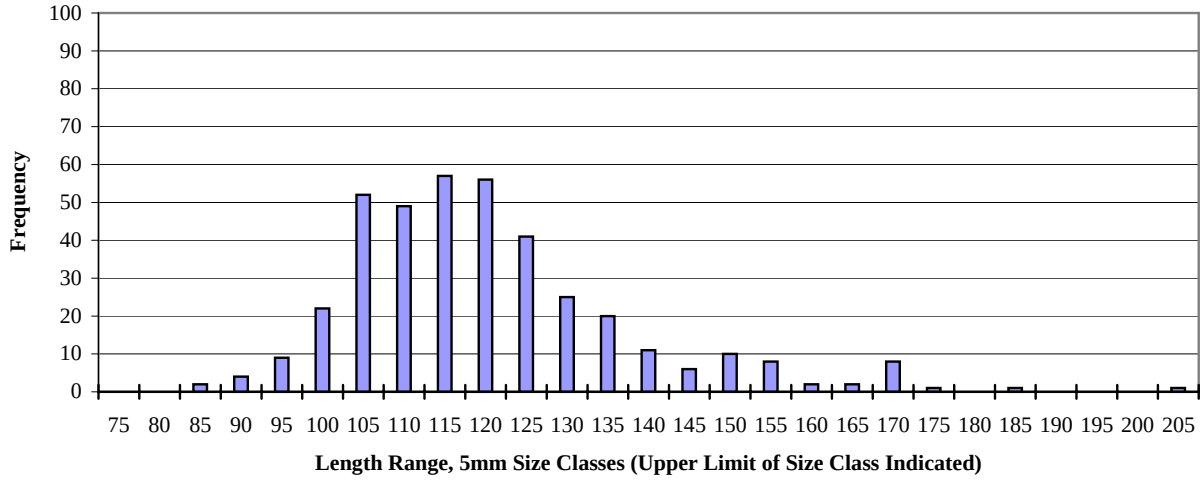
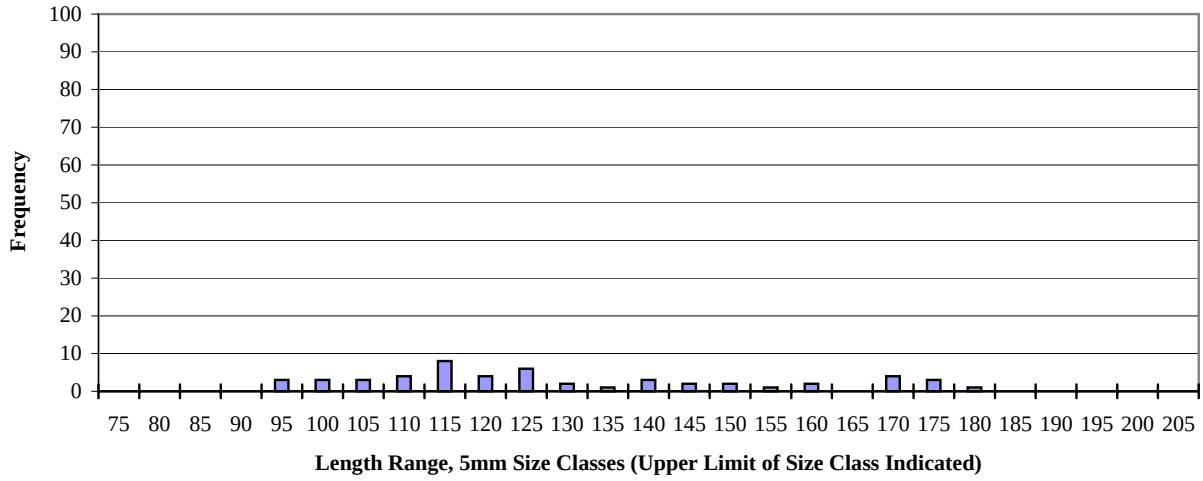
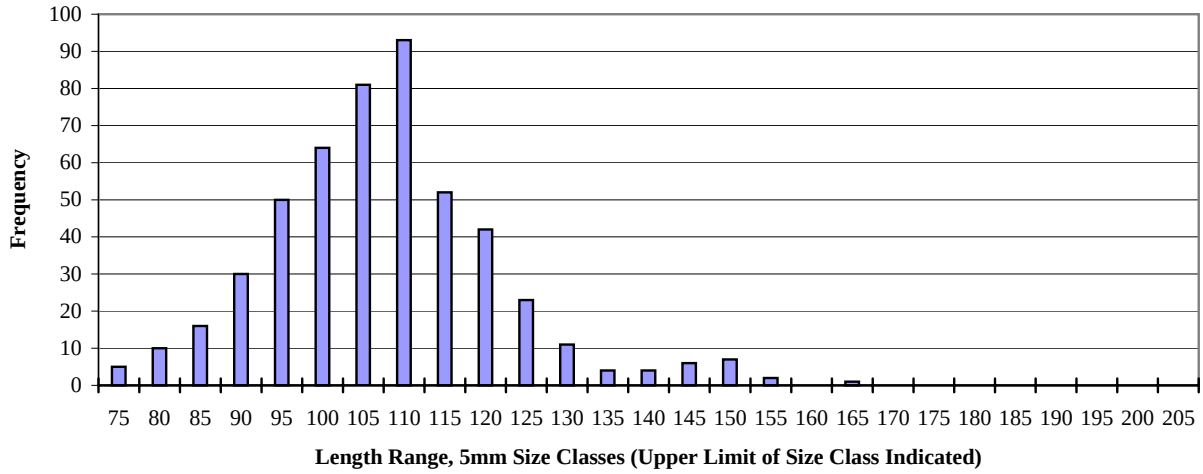
Appendix C-6.31. Steelhead Length Frequency during September 2003 Sampling Event for the Lower Gualala Estuary.



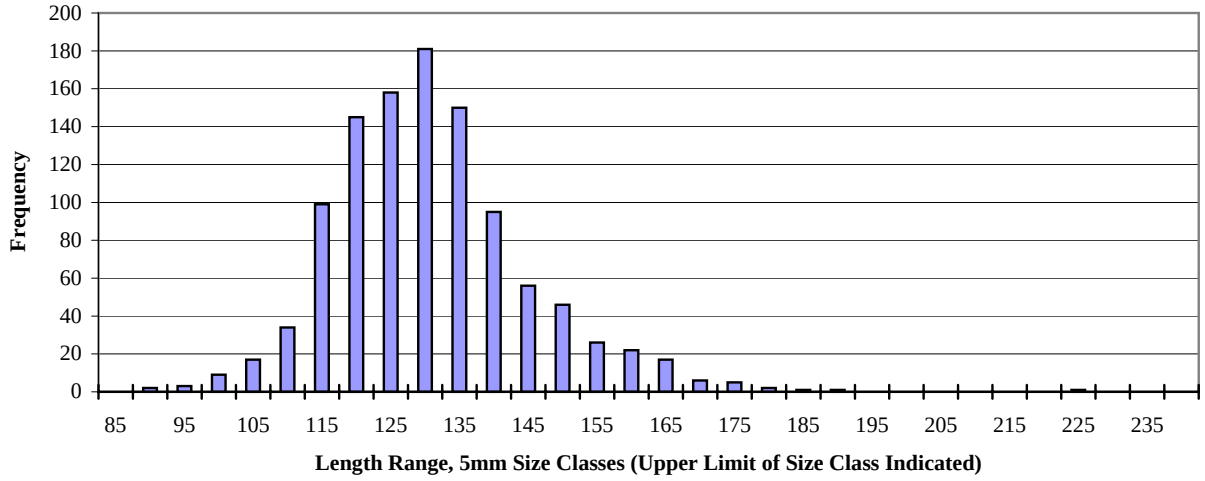
Appendix C-6.32. Steelhead Length Frequency during September 2003 Sampling Event for the Middle Gualala Estuary.



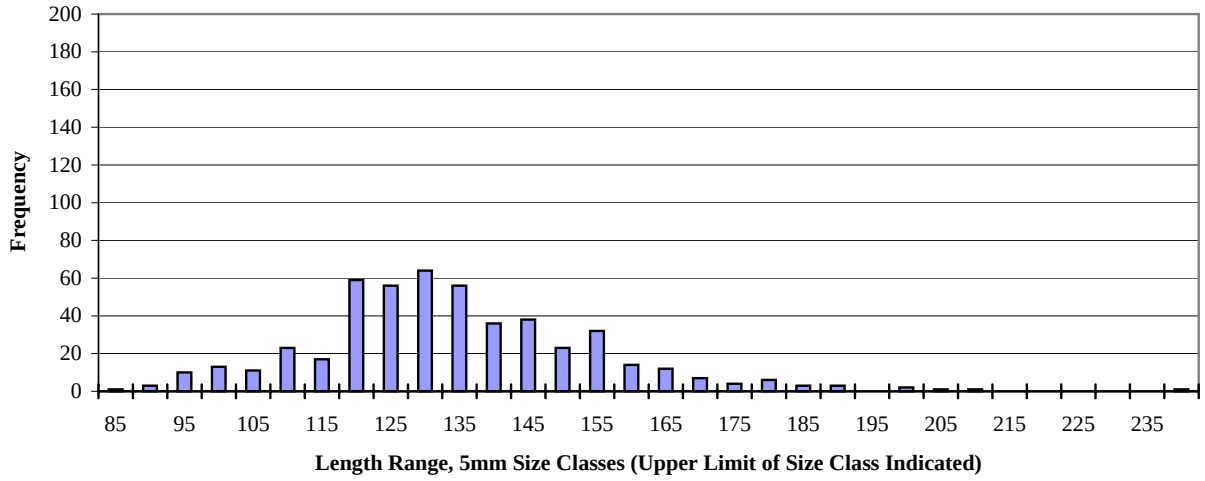
Appendix C-6.33. Steelhead Length Frequency during September 2003 Sampling Event for the Upper Gualala Estuary.



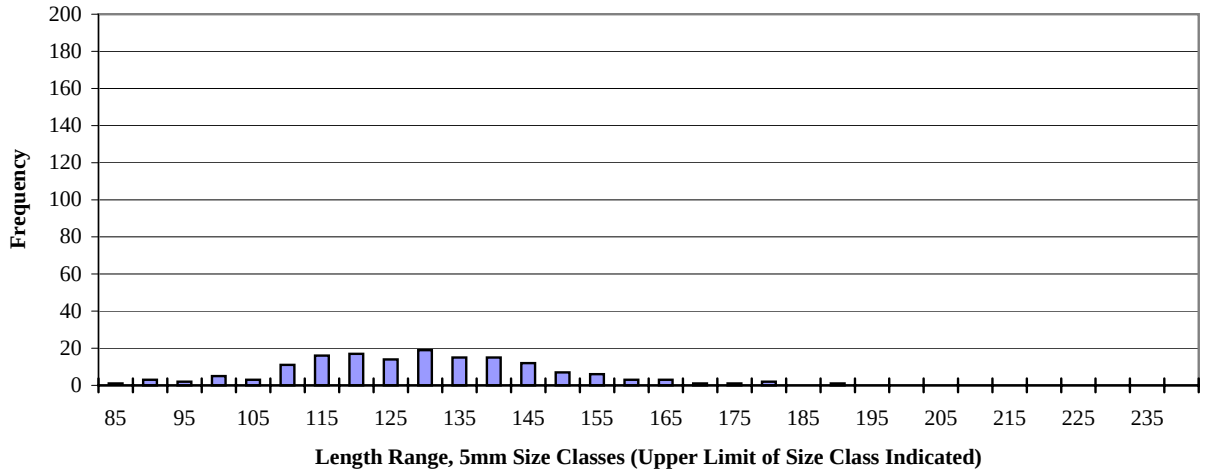
Appendix C-6.34. Steelhead Length Frequency during October 2003 Sampling Events for the Lower Gualala Estuary.



Appendix C-6.35. Steelhead Length Frequency during October 2003 Sampling Events for the Middle Gualala Estuary.



Appendix C-6.36. Steelhead Length Frequency during October 2003 Sampling Events for the Upper Gualala Estuary.



Appendix C-7.1. Gualala Estuary Project: Age 1+ Steelhead Population Estimates using Jolly-Seber Method, 1st Season.

Date	Sampling Event (t)	Captured	m_t	u_t	n_t	s_t	R_t	Z_t	α	Mt	Nt	ϕ_t	λ_t
June 19-20, 2002	1	41	0	41	41	41	28	na	0.02	0.0	**na**	1.9	na
July 10-11, 2002	2	221	8	213	221	221	64	20	0.04	76	**1,882.3**	1.0	12.987869
August 1-2, 2002	3	675	7	668	675	675	184	77	0.01	288	**24,366.6**	0.7	0.3040607
August 12-13, 2002	4	642	82	560	642	642	182	179	0.13	711	**5,507.7**	1.3	1.3305726
September 4-6, 2002	5	985	170	815	985	981	126	191	0.17	1647	**9,496.0**	1.0	1.0062504
September 25-27, 2002	6	749	192	557	749	748	40	125	0.26	2476	**9,620.0**	0.2	1.0491029
October 21-22, 2002	7	242	72	170	242	242	34	93	0.30	718	**2,389.0**	0.5	0.9333155
October 24, 2002	8	318	126	192	318	318	0	1	0.40	445	**1,117.8**	na	na
November 26-27, 2002	9	11	1	10	11	11	na	na	na	na	**na**	na	na

m_t = # of marked fish caught in sample t

u_t = # of unmarked fish caught in sample t

n_t = total # of fish caught in sample t ($n_t = m_t + u_t$)

s_t = # of fish released after sample t (n_t - # of accidental deaths)

R_t = # of s_t fish released at sample t and caught again in some later sample (refer to "Method Table B" below for calculation)

Z_t = # of fish marked before sample t, not caught in sample t, but caught in some sample after t (refer to "Method Table B" below for calculation)

a_t = proportion of animals marked:

α_t = proporiton of animals marked:

$$\alpha_t = \frac{m_t + 1}{n_t + 1}$$

M_t = # of marked fish in the population:

$$M_t = \frac{(s_t + 1)Z_t}{R_t + 1} + m_t$$

N_t = estimated population size before time t:

$$N_t = \frac{M_t}{\alpha_t}$$

Method Table B:

	Time of Capture (t) (t = sample event #)								
	1	2	3	4	5	6	7	8	9
Time of Last Capture (event #)									
1	-	8	3	10	5	0	2	0	0
2		0	4	18	24	11	5	2	0
3			4	54	65	43	14	7	1
4				6	76	58	19	29	0
5					8	80	16	30	0
6						13	16	24	0
7							1	34	0
8								0	0
Total Marked, m_t	0	8	7	82	170	192	72	126	1
Total Unmarked, u_t	41	213	668	560	815	557	170	192	10
Total Caught, n_t	41	221	675	642	985	749	242	318	11
Total Released, s_t	41	221	675	642	981	748	242	318	11

= do not use same week recaptures

Example of how to compute R_t and Z_t (for t = 4):

sum of area

$R_4 = 182$

$Z_4 = 179$

ϕ_t = probability of survival (ration of number of marked fish at the start of sample t+1 to the number of fish at the end of sample t :

$$\phi_t = \frac{M_{t+1}}{M_t + (s_t - m_t)}$$

λ_t = dilution rate; an estimate of the number of fish to the population through birth and immigration :

$$\lambda_t = \frac{N_{t+1}}{\phi_t[N_t - (n_t - s_t)]}$$

Appendix C-7.2. Gualala Estuary Project - 2nd Season: Age 1+ Steelhead Population Estimates using Jolly-Seber Method.

Date	Sampling Event (t)	Captured	m_t	u_t	n_t	s_t	R_t	Z_t	α	Mt	Nt	ϕ_t	λ_t
July 22-23, 2003	13	478	0	478	478	476	3	na	0.002	0	**na**	0.19	na
August 22-23, 2003	14	460	1	459	460	455	9	2	0.004	92	**21,252.1**	0.12	2.38
September 23-24, 2003	15	739	7	732	739	724	49	4	0.011	65	**6,012.5**	0.45	3.09
October 27-28, 2003	16	1,064	44	1,020	1,064	991	28	9	0.042	352	**8,327.4**	na	na
October 30, 2003	17	594	37	557	594	*na*	*na*	*na*	*na*	*na*	**na**	na	na

m_t = # of marked fish caught in sample t

u_t = # of unmarked fish caught in sample t

n_t = total # of fish caught in sample t ($n_t = m_t + u_t$)

s_t = # of fish released after sample t (n_t - # of accidental deaths)

R_t = # of s_t fish released at sample t and caught again in some later sample (refer to "Method Table B" below for calculation)

Z_t = # of fish marked before sample t, not caught in sample t, but caught in some sample after t (refer to "Method Table B" below for calculation)

a_t = proportion of animals marked:

α_τ = proporiton of animals marked:

$$\alpha_t = \frac{m_t + 1}{n_t + 1}$$

M_t = # of marked fish in the population:

$$M_t = \frac{(s_t + 1)Z_t}{R_t + 1} + m_t$$

N_t = estimated population size before time t:

$$N_t = \frac{M_t}{\alpha_t}$$

Method Table B:					
	Time of Capture (t)			**(t = event #)**	
	13	14	15	16	17
Time of Last Capture (event #)					
13	2[a]	1	0	2	0
14		0	7	2	0
15			2[a]	40	9
16				11[a]	28
Total Marked, m_t	0	1	7	44	37
Total Unmarked, u_t	478	459	732	1,020	557
Total Caught, n_t	478	460	739	1,064	594
Total Released, s_t	476	455	724	991	0

[a] = recaptured from same sampling event

= do not use same week recaptures

Example of how to compute R_t and Z_t (for t = 15):

	sum of area
R_{15} = 49	
Z_{15} = 4	

ϕ_t = probability of survival (ration of number of marked fish at the start of sample t+1 to the number of fish at the end of sample t :

$$\phi_\tau = \frac{M_{t+1}}{M_t + (s_t - m_t)}$$

λ_t = dilution rate; an estimate of the number of fish to the population through birth and immigration :

$$\lambda_t = \frac{N_{t+1}}{\phi_t[N_t - (n_t - s_t)]}$$

APPENDIX D

Benthic Macroinvertebrate Data

Appendix D. Lower Gualala River and Estuary Benthic Macroinvertebrate Survey Results, July 2002 and May 2003 .

			Upper Reach: RM 2.4 to RM 3.2				Middle Reach : RM 1.6 to RM 2.0			
	TV	FFG	EC-510	EC-511	EC-512	Total	EC-513	EC-514	EC-515	Total
PHYLUM ARTHROPODA										
Class Insecta										
Coleoptera (adults)										
Dytiscidae	5	p		1		1				
Uvarus subtilis	5	p								
Elmidae	4	c	3			3				
Narpus sp.	4	c	1		1	2				
Optioservus sp.	4	g	29	25	69	123	1			1
Rhizelmis nigra	2	g								
Zaitzevia sp.	4	c	7		3	10				
Coleoptera (Larvae)										
Dytiscidae	5	p								
Oreodytes sp.	5	p								
Elmidae	4	c								
Optioservus sp.	4	g	8	15	3	26	2	1		3
Zaitzevia sp.	4	c	3	2	1	6				
Psephenidae										
Eubrianax edwardsi	4	g								
Diptera										
Ceratopogonidae	6	p								
Ceratopogonidae pupa	6	p	3			3				
Atrichopogon sp.	6	c								
Bezzia sp./ Palpomyia sp.	6	p	7		2	9			1	1
Probezzia sp.	6	p								
Chironomidae	6									
Chironominae	6	c								
Chironominae pupa	6	nf		1		1	1			1
Chironomini	6	c	2	2		4				
Tanytarsini	6	c	86	20	26	132	3	10	14	27
Orthocladiinae	5	c	18	3	6	27			6	6
Orthocladiinae pupa	5	nf			6	6			1	1
Krenosmittia sp.	1	c							1	1
Podonominae	6	c	3	1		4				
Tanypodinae	7	p	1	9	6	16		4	1	5
Tanypodinae pupa	7	nf						1	1	2
Dolichopodidae	4	p		1		1				
Empididae	6	p								
Chelifera sp.	6	p	3			3				
Dolicocephala sp.	6	p								
Hemerodromia sp.	6	p	2		1	3				
Simuliidae	6	f								
Prosimulium sp.	3	f								
Simulium sp.	6	f			8	8				
Tanyderidae	1									
Protanyderus sp.	1				1	1				
Tipulidae	3	s	2			2				
Antocha sp.	3	c	2			2				
Hexatoma sp.	2	p		1	1	2				
Hemiptera										
Corixidae	8	p								
Sigara sp.	8	p							2	2
Naucoridae	5	p								
Ambrysus sp.	5	p						1		1
Sialidae	4	p								
Sialis sp.	4	p						1		1
Odonata										
Gomphidae	4	p								
Ophiogomphus sp.	4	p		1		1	1			1
Ephemeroptera										
Baetidae	4	g								
Baetis sp.	5	c	16	1	16	33	1			1
Diphetor hageni	5	c	21	50	32	103		2		2
Fallceon quilleri	4	c							3	3
Ephemerellidae	1	c		2		2		2		2
Attenella sp.	2	c	2		7	9				
Serratella sp.	2	c	8	21		29				
Heptageniidae	4	g	7	20	11	38	3	2		5
Leucrocuta/Nixe sp.	3	g		7		7		2		2
Isonychiidae	2	c								
Isonychia velma	2	c	2		3	5				
Leptophlebidae	2	c								
Paraleptophlebia sp.	4	c		3		3		10	19	29

Appendix D. Lower Gualala River and Estuary Benthic Macroinvertebrate Survey Results, July 2002 and May 2003 .

			Upper Reach: RM 2.4 to RM 3.2				Middle Reach : RM 1.6 to RM 2.0			
	TV	FFG	EC-510	EC-511	EC-512	Total	EC-513	EC-514	EC-515	Total
Plecoptera										
Chloroperlidae	1	p	15		11	26		2		2
Paraperla sp.	0	p	1			1				
Suwallia sp.	1	p		6		6				
Nemouridae	2	s								
Malenka sp.	2	s	1	2	1	4				
Perlidae	1	p	2			2				
Calineuria californica	2	p		1	6	7				
Pteronarcyidae	0	s								
Pteronarcys sp.	0	s	1			1				
Trichoptera										
Glossosomatidae	0	g								
Glossosomatidae pupa	0	nf		11		11				
Glossosoma sp.	0	g		1		1				
Protoptila sp.	1	g	2	12	1	15				
Hydropsychidae	4	f		2		2				
Cheumatopsyche sp.	5	f		1		1				
Hydropsyche sp.	4	f	5			5				
Hydroptilidae	4	g								
Hydroptilidae pupa	4	nf	5			5				
Hydroptila sp.	6	g	2			2				
Lepidostomatidae	1	s								
Lepidostoma sp.	1	s		10		10		1		1
Rhyacophilidae	0	p								
Rhyacophila sp.	0	p	1			1				
Sericostomatidae	3	g								
Gumaga sp.	3	s		1		1		2		2
Subphylum Chelicerata										
Class Arachnoidea										
Acari										
Hydrodromidae	5	p								
Hydrodromia sp.	5	p		4	2	6				
Hygrobatidae	5	p								
Atractides sp.	8	p	1	4	2	7				
Corticacarus sp.	8	p								
Hygrobates sp.	8	p			1	1				
Lebertiidae	8	p								
Lebertia sp.	8	p	6	5	3	14	1		1	2
Scutolebertia sp.	8	p								
Limnessidae	5	p								
Limnesia sp.	5	p							4	4
Pionidae	5	p								
Tiphys sp.	5	p							2	2
Sperchontidae	8	p								
Sperchon sp.	8	p			1	1				
Sperchonopsis verrucosa	8	p	3			3				
Torrenticolidae	5	p								
Torrenticola sp.	5	p	19	20	20	59	1	1	1	3
Unioncolidae	5	p								
Unionicola sp.	5	p								
Undetermined	5	p	3			3				
Subphylum Crustacea										
Class Malacostraca										
Amphipoda										
Corophiidae										
Corophium sp.	4	c	1	2	1	4	2	7	8	17
Gammaridae	4	c								
Gammarus sp.	4	c	4			4		2	8	10
Talitridae										
Hyalella azteca	8	c								
Isopoda										
Sphaeromatidae										
Gnorimosphaeroma sp.		c	1		94	95	291	282	236	809
Mysidacea										
Mysis sp.		f		19		19				
Class Ostracoda										
Ostracoda	8	c								
PHYLUM COELENTERATA										
Class Hydrozoa										
Hydroida										
Hyridae										
Hydra sp.	5	p								

Appendix D. Lower Gualala River and Estuary Benthic Macroinvertebrate Survey Results, July 2002 and May 2003 .

			Upper Reach: RM 2.4 to RM 3.2				Middle Reach : RM 1.6 to RM 2.0			
	TV	FFG	EC-510	EC-511	EC-512	Total	EC-513	EC-514	EC-515	Total
PHYLUM MOLLUSCA										
Class Gastropoda										
Prosobranchia										
Pleuroceridae	6	g								
Juga sp.	7	g	6	38		44	1			1
PHYLUM NEMATODA	5	p	1			1				
PHYLUM PLATYHELMINTHES										
Class Turbellaria										
Tricladida										
Planariidae	4	p		2		2	1			1
Polycelis coronata	1	om								
PHYLUM ANNELIDA										
Class Oligochaeta	5	c			2	2	1			1
Class Polychaeta										
Neredidae										
Nereis sp.		c								
PHYLUM NEMERTEA										
Class Enopla										
Tertastemmatidae										
Prostoma sp.	8	c		2		2				
Total			316	329	348	993	310	333	309	952
Abundance Calculation										
Extra BMIs			0	4	0		0	0	0	
Grids Picked			4	4	5		1	5	1	
Total Grids			12	12	32		20	32	8	
Estimated Abundance			948.0	999.0	2227.2	4174.2	6200.0	2131.2	2472.0	10803.2
CSBP Metric Calculation										
Taxa Richness			43.0	39.0	32.0	69.0	14.0	18.0	17.0	34.0
Percent Dominant Taxon			27.2	15.2	27.0	13.3	93.9	84.7	76.4	85.0
EPT Taxa			16.0	17.0	9.0	27.0	2.0	8.0	2.0	10.0
EPT Index (%)			28.8	45.9	25.3	33.2	1.3	6.9	7.1	5.1
Sensitive EPT Index			11.1	22.5	8.3	13.9	0.0	2.7	0.0	0.9
Ephemeroptera Taxa			6.0	7.0	5.0	9.0	2.0	5.0	2.0	7.0
Plecoptera Taxa			5.0	3.0	3.0	7.0	0.0	1.0	0.0	1.0
Trichoptera Taxa			5.0	7.0	1.0	11.0	0.0	2.0	0.0	2.0
Dipteran Taxa			11.0	8.0	9.0	17.0	2.0	3.0	7.0	8.0
Percent Dipteran			40.8	11.6	16.4	22.6	1.3	4.5	8.1	4.6
Non-Insect Taxa			10.0	9.0	9.0	17.0	7.0	4.0	7.0	10.0
Percent Non-Insect			14.2	29.2	36.2	26.9	96.1	87.7	84.1	89.3
Percent Chironomidae			34.8	10.9	12.6	19.1	1.3	4.5	7.8	4.5
Percent Hydropsychidae			0.0	0.9	0.0	0.3	0.0	0.0	0.0	0.0
Percent Baetidae			11.7	15.5	13.8	13.7	0.3	0.6	1.0	0.6
Shannon Diversity			2.9	3.0	2.5	3.2	0.4	0.8	1.1	0.8
Tolerance Value			4.8	4.1	3.3	4.0	0.3	0.7	1.1	0.7
Percent Intolerant (0-2)			11.1	20.4	8.9	13.4	0.0	1.5	0.3	0.6
Percent Tolerant (8-10)			3.2	3.3	2.0	2.8	0.3	0.0	1.0	0.4
Percent Collectors			57.0	33.1	55.2	48.4	96.1	94.6	95.5	95.4
Percent Filterers			1.6	6.7	2.3	3.5	0.0	0.0	0.0	0.0
Percent Grazers			17.1	35.9	24.1	25.8	2.3	1.5	0.0	1.3
Percent Predators			21.5	16.7	16.1	18.0	1.3	2.7	3.9	2.6
Percent Shredders			1.3	4.0	0.3	1.8	0.0	0.9	0.0	0.3
Total Percentages			98.4	96.4	98.0	97.6	99.7	99.7	99.4	99.6

Appendix D. Lower Gualala River and Estuary Benthic Macroinvertebrate Survey Results, July 2002 and May 2003 .

			Lower Reach: RM 0.4 to RM 1.14				Lower Reach: RM 0.8, May 2003			
	TV	FFG	EC-516	EC-517	EC-518	Total	EC-110	EC-111	EC-112	Total
PHYLUM ARTHROPODA										
Class Insecta										
Coleoptera (adults)										
Dytiscidae	5	p								
Uvarus subtilis	5	p			4	4				4
Elmidae	4	c								
Narpus sp.	4	c								
Optioservus sp.	4	g								
Rhizelmis nigra	2	g								
Zaitzevia sp.	4	c								
Coleoptera (Larvae)										
Dytiscidae	5	p								
Oreodytes sp.	5	p			1	1				
Elmidae	4	c								
Optioservus sp.	4	g					1	5		6
Zaitzevia sp.	4	c								
Psephenidae										
Eubrianax edwardsi	4	g					1	1	1	3
Diptera										
Ceratopogonidae	6	p								
Ceratopogonidae pupa	6	p								
Atrichopogon sp.	6	c								
Bezzia sp./ Palpomyia sp.	6	p								
Probezzia sp.	6	p					1	1		2
Chironomidae	6						4	2	3	9
Chironominae	6	c	2			2				
Chironominae pupa	6	nf								
Chironomini	6	c								
Tanytarsini	6	c	1		2	3				
Orthocladiinae	5	c			9	9				
Orthocladiinae pupa	5	nf								
Krenosmittia sp.	1	c								
Podonominae	6	c								
Tanypodinae	7	p								
Tanypodinae pupa	7	nf								
Dolichopodidae	4	p								
Empididae	6	p								
Chelifera sp.	6	p								
Dolicocephala sp.	6	p								
Hemerodromia sp.	6	p								
Simuliidae	6	f								
Prosimulium sp.	3	f								
Simulium sp.	6	f								
Tanyderidae	1									
Protanyderus sp.	1									
Tipulidae	3	s								
Antocha sp.	3	c								
Hexatoma sp.	2	p								
Hemiptera										
Corixidae	8	p								
Sigara sp.	8	p			3	3				
Naucoridae	5	p								
Ambrysus sp.	5	p			1	1				
Sialidae	4	p								
Sialis sp.	4	p								
Odonata										
Gomphidae	4	p								
Ophiogomphus sp.	4	p						1		1
									1	1
Ephemeroptera										
Baetidae	4	g								
Baetis sp.	5	c								
Diphetor hageni	5	c								
Fallceon quilleri	4	c			3	3				
Ephemerellidae	1	c								
Attenella sp.	2	c								
Serratella sp.	2	c								
Heptageniidae	4	g								
Leucrocuta/Nixe sp.	3	g								
Isonychiidae	2	c								
Isonychia velma	2	c								
Leptophlebidae	2	c								
Paraleptophlebia sp.	4	c								

Appendix D. Lower Gualala River and Estuary Benthic Macroinvertebrate Survey Results, July 2002 and May 2003 .

			Lower Reach: RM 0.4 to RM 1.14				Lower Reach: RM 0.8, May 2003			
	TV	FFG	EC-516	EC-517	EC-518	Total	EC-110	EC-111	EC-112	Total
Plecoptera										
Chloroperlidae	1	p								
Paraperla sp.	0	p								
Suwallia sp.	1	p								
Nemouridae	2	s								
Malenka sp.	2	s								
Perlidae	1	p								
Calineuria californica	2	p								
Pteronarcyidae	0	s								
Pteronarcys sp.	0	s								
Trichoptera										
Glossosomatidae	0	g								
Glossosomatidae pupa	0	nf								
Glossosoma sp.	0	g								
Protoptila sp.	1	g								
Hydropsychidae	4	f								
Cheumatopsyche sp.	5	f								
Hydropsyche sp.	4	f								
Hydroptilidae	4	g								
Hydroptilidae pupa	4	nf								
Hydroptila sp.	6	g								
Lepidostomatidae	1	s								
Lepidostoma sp.	1	s								
Rhyacophilidae	0	p								
Rhyacophila sp.	0	p								
Sericostomatidae	3	g								
Gumaga sp.	3	s						2		2
Subphylum Chelicerata										
Class Arachnoidea										
Acari										
Hydrodromidae	5	p								
Hydrodromia sp.	5	p								
Hygrobatidae	5	p								
Atractides sp.	8	p								
Corticacarus sp.	8	p								
Hygrobates sp.	8	p								
Lebertiidae	8	p								
Lebertia sp.	8	p		1		1		1	1	2
Scutolebertia sp.	8	p								
Limnessidae	5	p								
Limnesia sp.	5	p	2		3	5				
Pionidae	5	p								
Tiphys sp.	5	p								
Sperchontidae	8	p								
Sperchon sp.	8	p								
Sperchonopsis verrucosa	8	p								
Torrenticolidae	5	p								
Torrenticola sp.	5	p						1		1
Unioncolidae	5	p								
Unionicola sp.	5	p	22	1	3	26				
Undetermined	5	p								
Subphylum Crustacea										
Class Malacostraca										
Amphipoda										
Corophiidae										
Corophium sp.	4	c	50	19	31	100	4		1	5
Gammaridae	4	c								
Gammarus sp.	4	c	20	42	20	82				
Talitridae										
Hyalella azteca	8	c					98	78	135	311
Isopoda										
Sphaeromatidae										
Gnorimosphaeroma sp.		c	228	271	45	544	203	269	184	656
Mysidacea										
Mysis sp.		f	5			5				
Class Ostracoda										
Ostracoda	8	c			177	177				
PHYLUM COELENTERATA										
Class Hydrozoa										
Hydroida										
Hyridae										
Hydra sp.	5	p	1			1				

Appendix D. Lower Gualala River and Estuary Benthic Macroinvertebrate Survey Results, July 2002 and May 2003 .

			Lower Reach: RM 0.4 to RM 1.14				Lower Reach: RM 0.8, May 2003			
	TV	FFG	EC-516	EC-517	EC-518	Total	EC-110	EC-111	EC-112	Total
PHYLUM MOLLUSCA										
Class Gastropoda										
Prosobranchia										
Pleuroceridae	6	g								
Juga sp.	7	g								
PHYLUM NEMATODA	5	p								
PHYLUM PLATYHELMINTHES										
Class Turbellaria										
Tricladida										
Planariidae	4	p								
Polycelis coronata	1	om								
PHYLUM ANNELIDA										
Class Oligochaeta	5	c		1		1	4			4
Class Polychaeta										
Neredidae										
Nereis sp.		c	6	1		7	2	2	3	7
PHYLUM NEMERTEA										
Class Enopla										
Tertastemmatidae										
Prostoma sp.	8	c								
Total			337	336	302	975	318	363	326	1007
Abundance Calculation										
Extra BMIs			7	7	0					
Grids Picked			5	9	7		5	3	1	
Total Grids			12	64	48		16	16	8	
Estimated Abundance			825.6	2439.1	2070.9	5335.6	1017.6	1936.0	2608.0	5561.6
CSBP Metric Calculation										
Taxa Richness			10.0	7.0	13.0	19.0	9.0	11.0	8.0	15.0
Percent Dominant Taxon			67.7	80.7	58.6	55.8	63.8	74.1	56.4	65.1
EPT Taxa			0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
EPT Index (%)			0.0	0.0	1.0	0.3	0.0	0.6	0.0	0.2
Sensitive EPT Index			0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.2
Ephemeroptera Taxa			0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
Plecoptera Taxa			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trichoptera Taxa			0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
Dipteran Taxa			2.0	0.0	2.0	3.0	2.0	2.0	1.0	2.0
Percent Dipteran			0.9	0.0	3.6	1.4	1.6	0.8	0.9	1.1
Non-Insect Taxa			8.0	7.0	6.0	11.0	5.0	5.0	5.0	7.0
Percent Non-Insect			99.1	100.0	92.4	97.3	97.8	96.7	99.4	97.9
Percent Chironomidae			0.9	0.0	3.6	1.4	0.0	0.0	0.0	0.0
Percent Hydropsychidae			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Baetidae			0.0	0.0	1.0	0.3	0.0	0.0	0.0	0.0
Shannon Diversity			1.1	0.7	1.4	1.4	0.9	0.8	0.8	0.9
Tolerance Value			1.3	0.8	5.9	2.5	2.7	1.9	3.4	2.7
Percent Intolerant (0-2)			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Tolerant (8-10)			0.0	0.3	59.6	18.6	30.8	21.8	41.7	31.1
Percent Collectors			91.1	99.4	95.0	95.2	97.8	96.1	99.1	97.6
Percent Filterers			1.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Percent Grazers			0.0	0.0	0.0	0.0	0.6	1.7	0.3	0.9
Percent Predators			7.4	0.6	5.0	4.3	0.3	1.1	0.3	1.0
Percent Shredders			0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.2
Total Percentages			100.0	100.0	100.0	100.0	98.7	99.4	99.7	99.7

GUALALA RIVER WATERSHED COUNCIL

Strategic Plan

2010 - 2015

Prepared By:

The Gualala River Watershed Council

Originally adopted: 2001
Revised: February, 2010

Watershed Background

The Gualala River Watershed, located in both Mendocino and Sonoma Counties, drains 685 miles of fish bearing streams of the northern California Coastal Ranges. The Gualala River enters the Pacific Ocean at the town of Gualala, 114 miles north of San Francisco and 17 miles south of Point Arena. At 212,563 acres (342 mi^2) it is the largest watershed in the Mendocino Coast Hydrological Unit.

The Gualala River Watershed Council Strategic Plan

Is designed to be adaptive and updated regularly for the purpose of understanding, protecting, maintaining and restoring the natural balance of the watershed

while incorporating environmental, social and economic needs.

The watershed has a rural population of 3,419 centered near four unincorporated communities; Gualala, Sea Ranch, Annapolis and Stewarts Point. The economic viability of the area has long depended on timber and agriculture as a main source of employment with 80% of all the watershed lands zoned for timber production. However, employment in service industries that support tourism and recreation has increased over the past two decades.

A long history of movement along the San Andreas and Tombs Creek faults has been a dominant force in shaping the basin.

In 1993, the USEPA listed the Gualala River on its federal Clean Water Act §303(d) list of impaired water bodies due to declines in diadromous salmonids from excessive sedimentation. The listing was updated in 2003 and water temperatures in the basin are now considered impaired as well. *A Technical Support Document (TSD) for the Total Maximum Daily Load for the Gualala* was completed by the North Coast Regional Water Quality Control Board (NCRWQCB) in 2003. The Gualala River TSD estimates that 85% of the anthropogenic sediment sources impacting the river today are derived from poorly constructed timber and ranch roads.

The Gualala River lies within the Central California Coast Coho Salmon Evolutionary Significant Unit (ESU), which is listed as endangered under the Endangered Species Act (NMFS 2005). Critical habitat includes all river reaches and estuarine areas accessible to Coho salmon within the ESU's geographic area (NMFS 1999). Winter run steelhead in the Gualala river basin are part of the Northern California Steelhead Distinct Population Segment (DPS) and are listed as threatened under the Federal ESA (NMFS 2006).

GRWC Ground Rules

1. Give the same priority to solving the concerns of others, including the publics' concerns, as you will your own.
2. Make a commitment to listen carefully: ask questions to understand others and make statements that explain or educate.
3. Make a commitment to search for opportunities to make the process work.
4. Members should state their own needs, problems, and opportunities, not rigid or inflexible positions. Work on positive approaches to concerns raised.
5. Commit to achieving consensus.
6. Commit to be an advocate for the agreed upon strategy and implementation activities.
7. Attempt to protect each other and the GRWC process from disruptive influence.
8. Weapons of war and any previous disagreements are to be left at the door.
9. Anyone may leave the GRWC process and the above ground rules. But only after telling the group why and allowing the GRWC the chance to solve the problem.
10. Everyone will be mindful of the impacts that their public and private statements will have on the perceptions of the GRWC.
11. No GRWC member will attribute suggestions, comments or ideas of another member to the news media or to non-participants.
12. GRWC members are encouraged to seek the best advice from people who are outside the GRWC process.
13. GRWC members accept the responsibility to keep their friends and associates informed of the progress of the GRWC.

Overview of the Gualala River Watershed Council (GRWC)

In the 1980s declines in salmonid populations motivated local citizens to work to restore populations to self-sustaining levels.

In the 1990s a local coalition of restoration organizations, environmental groups, stakeholders and State & Federal Agencies was created in response to the Clean Water Act §303(d) listing of the Gualala.

This coalition formally became the Gualala River Watershed Council in 1996.

The GRWC is governed by the Gualala River Watershed, Inc. a 501c(3) non-profit and a voluntary Board of Directors comprising nine members who represent landowners, the community at large and community organizations.

Mission Statement

The mission of the Gualala River Watershed Council is to provide an environment for landowners, resource managers, agencies, community organizations and interested citizens to work towards restoring the natural balance of the Gualala River Watershed.

GOALS

The GRWC will work towards attaining our goals by implementing solutions on a prioritized basis using sound science and common sense to reach a cooperative, collaborative agreement that maximizes the common goals of all the parties.

To, understand, restore and protect the ecosystem of the Gualala River Watershed.

- Understand and monitor the health of the watershed by implementing programs that use sound scientific methods.
- Improve water Quality and Quantity and work towards the attainment goals of the TMDL.
- Provide information to landowners, agencies and the community to raise critical thought and analysis on issues that impact the watershed.
- Encourage stewardship of the natural resources and promote educational opportunities that focus on Best Management Practices, Watershed restoration, and Watershed health.
- Build the capacity of the Gualala River Watershed Council to enable long-term stability, sustainability and success.

OBJECTIVES

GOAL: UNDERSTAND AND MONITOR THE HEALTH OF THE WATERSHED BY IMPLEMENTING PROGRAMS THAT USE SOUND SCIENTIFIC METHODS.

Objective: Continue and expand GRWC Monitoring Program Plan to assess and monitor Water Quality and Quantity.

Task 1: Expand new reach sites by a minimum of three (3) a year and continue annual surveys of reference and rotational reaches and temperature monitoring. Yearly implementation of monitoring must be in accordance with Monitoring Program Plan.

Task 2: Collect baseline and project effectiveness data in all planning watersheds where restoration projects are proposed.

Task 3: Continue USGS Cooperative Gauge Program for the South Fork. Assist if possible, with funding for the North Fork gauge and expand program to include Wheatfield Fork Gauge.

Task 4: Work with NCRWQB to expand SWAMP program for annual water quality monitoring at existing SWAMP sites.

Task 5: Annually update the GRWC Monitoring Program database, Monitoring Program Plan Report and GRWEMP based on current monitoring data and analysis.

Task 6: Provide input, monitoring data and analysis to landowners, partners and public agencies for planning purposes. Specifically provide information to NMFS for their watershed based planning efforts for Coho salmon and Steelhead trout populations.

Task 7: Develop Memorandum of Understandings with landowners participating in the GRWC Monitoring Program.

Task 8: Coordinate Technical Advisory Committee (TAC) for Monitoring Program oversight.

Objective: Continue to develop and implement scientific studies and research working in cooperation and collaboration with public agencies (specifically SWRCB, NCRWQCB, CDF&G and NOAA) and landowners.

Task 1: Fund and implement salmonid population studies.

Task 2: Fund and implement Preliminary Hydrologic Investigation, Wheatfield Fork Gualala River Study and expand to other basins starting with the North Fork SPWS.

Task 3: Fund and implement Rainfall and Flow relationship study to understand historic correlations between estuary bar openings and closures and Coho salmon spawning capabilities.

Task 4: Collaborate with TAC to understand and prioritize additional study gaps.

Task 5: Make available GRWC data and analysis for inclusion in independent studies.

Objective: Develop Funding Strategies for Gualala River Watershed Council Monitoring Program.

Task 1: Increase annual grant submittals.

Task 2: Fully develop and expand "fee for services" program for monitoring to develop baseline monitoring funding.

Task 3: Work with partners to continue to fund or provide matching funds to implement scientific studies.

Objective: Increase and formalize the Community Monitoring Program by developing specific sustainable monitoring projects for volunteers.

Task 1: Continue and expand the Summer Student Internship Program with local high schools and colleges.

Task 2: Work with the CDF&G and develop and train a volunteer group for conducting winter spawning surveys.

Task 3: Develop a volunteer group to build and place brush racks for salmonid pool shelter.

Task 4: Plan an annual day for community snorkel surveys in the estuary.

GOAL: IMPROVE WATER QUALITY AND QUANTITY AND WORK TOWARDS THE ATTAINMENT GOALS OF THE TMDL.

Objective: Implement NPS sediment reduction projects using priorities outlined in the GRWEMP.

Task 1: Work with landowners and partners to help plan and fund voluntary implementation of the Gualala River TMDL through upslope and in-stream restoration projects.

Task 2: Work with landowners, partners and NCRWQCB to assist in the development of WDRs for large landowners.

Objective: Provide landowners, partners and agencies with tools and resources for developing land use, restoration and conservation strategies that ensure consistency throughout the watershed. Use, when possible, existing efforts that support sound resource management.

Task 1: Complete road inventory database by outreach to landowners currently not included.

Task 2: Finalize draft and continue to plan and implement projects based on priorities outlined in the Gualala River Watershed Enhancement and Management Plan.

Task 3: Work with NMFS and CDF&G to develop programmatic permitting for road restoration and the Large Wood Program.

Task 4: Work with landowners and partners to implement conservation plans that incorporate TMDL strategies for small to medium landholdings.

Task 5: Develop landowner based water use planning program to address water use issues.

Task 6: Encourage and provide assistance to landowners and partners to participate in GRWC Programs or use GRWC protocols for trend and effectiveness monitoring, database management and restoration.

Task 7: Expand and disseminate existing resource database for information sharing among landowners, contractors, agencies and the public.

Objective: Develop Funding Strategies for Gualala River Watershed Council Restoration Program.

Task 1: Increase annual grant submittals.

Task 2: Work with landowners and partners to explore alternative funding sources for NPS implementation on lands managed under NTMPs.

Task 3: Fully develop and expand “fee for services” program for restoration implementation.

Task 4: Investigate developing a mitigation banking program to implement restoration projects.

Task 5: Work with landowners and partners to continue to fund or provide matching funds to implement restoration projects.

GOAL: Provide information to landowners, agencies and the community to raise critical thought and analysis on issues that impact the watershed.

Objective: Provide information in objective, fact based formats using multiple methods to ensure broad and comprehensive understanding.

Task 1: Ensure all information distributed is based on sound, objective science.

Task 2: Continue to update and expand the GRWC website so that it remains a highly functioning resource and research tool.

Task 3: Re-launch the GRWC Quarterly Newsletter "Downstream."

Task 4: Continue to provide multimedia presentations to local organizations and the scientific community.

Task 5: Create workshops and study groups wherein experts provide topical information to engage the community in understanding complex scientific, legislative, and regulatory matters.

Task 6: Work in partnership with the State and County Parks Department, Redwood Coast Land Conservancy and Save the Redwoods League to develop interpretive themes and designs for public access areas within the watershed.

GOAL: Encourage stewardship of the natural resources and promote educational opportunities that focus on Best Management Practices, Watershed restoration, and Watershed health.

Objective: Provide educational forums for partners and landowners to learn about conservation and restoration programs, techniques, and cost sharing opportunities.

Task 1: Assemble a landowner orientation package containing resources developed through the Working Tools for Working Lands Program and other GRWC Programs

Task 2: Engage landowners to attend and participate in workshops by introducing an overview of the concepts, values and goals of Conservation Planning and Best Management Practices.

Task 3: Coordinate field trips in the watershed to review implementation methods and assess project effectiveness.

Objective: Provide information to landowners, agencies and the community to raise critical thought and analysis on issues that impact the watershed.

Task 1: Provide information in objective, fact based formats using multiple methods to ensure broad and comprehensive understanding.

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Task 5: Continue to provide multimedia presentations to local organizations and the scientific community.

Task 6: Create workshops and study groups wherein experts provide topical information to engage the community in understanding complex scientific, legislative, and regulatory matters related to restoration of the watershed.

Task 7: Work in partnership with the State and County Parks Department, Redwood Coast Land Conservancy and Save the Redwoods League to develop interpretive themes and designs for public access areas within the watershed

GOAL: BUILD THE CAPACITY OF THE GUALALA RIVER WATERSHED COUNCIL TO ENABLE LONG-TERM STABILITY, SUSTAINABILITY AND SUCCESS.

Objective: Develop local community funding sources.

Task 1: Continue to coordinate and expand USGS Gauge Funding Program.

Task 2: Expand "fee for service" model to include non-participating landowners throughout the watershed.

Task 3: Include a PayPal donation vehicle within the website.

Task 4: Design a donation program that includes innovative concepts (i.e. Adopt a Log, Name a Road, Install a Reach).

Objective: Increase grant funding base.

Task 1: Increase the number of annual grant submittals to public agencies.

Task 2: Expand grant submittals to include private foundation donation and grant programs.

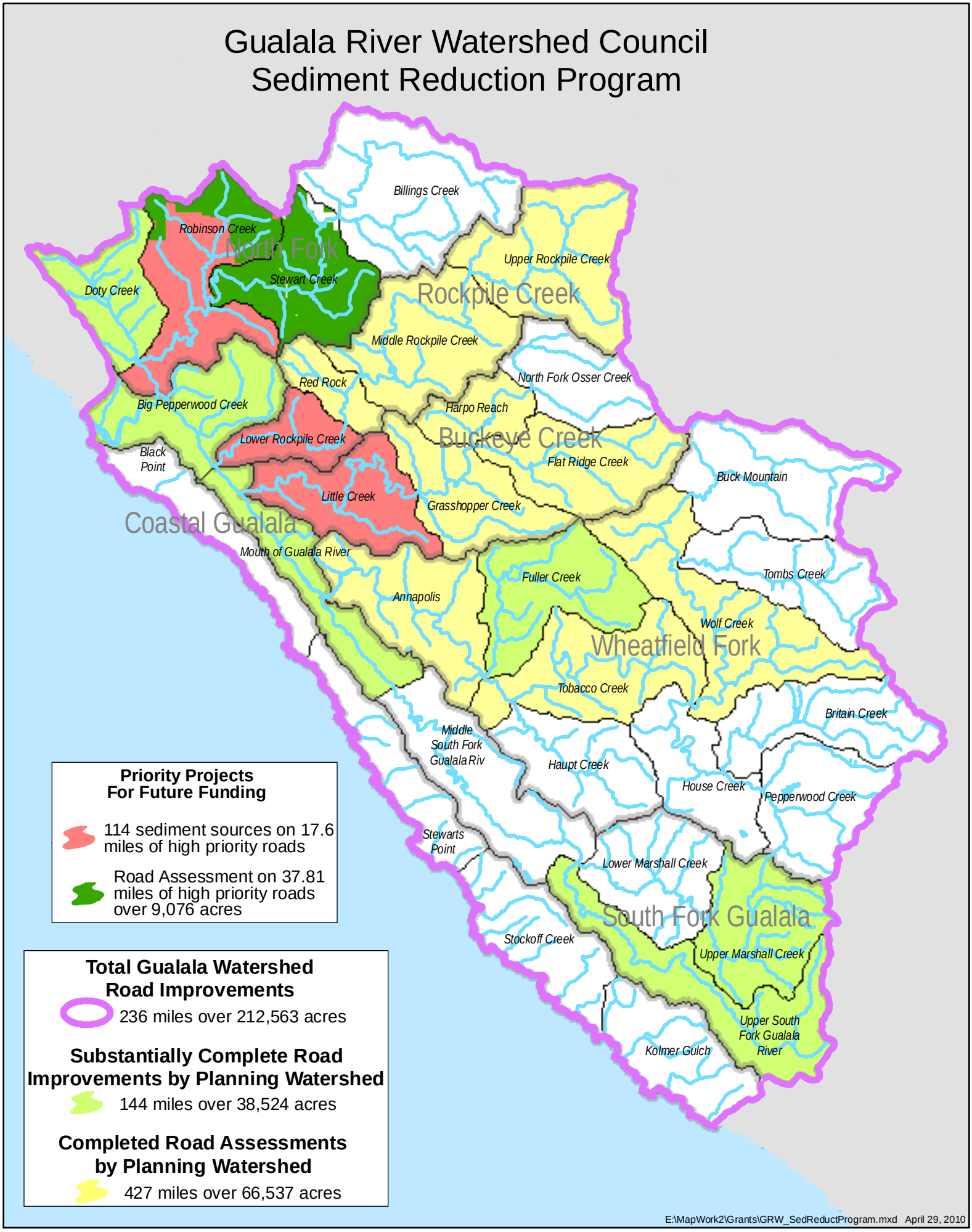
Objective: Maintain adequate GRWC paid professional staff to implement GRWC Goals and Objectives and provide leadership and oversight to maximize efficient use of volunteers.

Task 1: Annually reevaluate the number of paid staff needed to run an efficient organization.

Task 2: Evaluate staff performance in accordance with performance measures.

Task 3: Expand the volunteer base to assist with program development.

Gualala River Watershed Council
Sediment Reduction Program



Plans and Programs

Within the GRWC a wide variety of groups are working in concert toward understanding, protecting and restoring the Gualala River watershed. Cooperating partners include 80% of the landowners within this 342 mi^2 coastal watershed along with State and Federal Resource Agencies, local land conservancies, local non-profits and local businesses. To implement the objectives of the GRWC goals a Draft Watershed Enhancement and Management Plan with three Program modules is under development.

In addition to the Total Maximum Daily Load TSD, (NCRWQCB, 2003) many studies have been conducted on the Gualala River Watershed documenting the adverse conditions limiting salmonid populations. Two notable assessment plans have been completed for the watershed and are the basis for the Gualala River Watershed Council's adaptive *Gualala River Watershed Enhancement and Management Plan*.

First, the *Gualala River Watershed Assessment Report* (Klamt, *et al*., 2003) was conducted by a multi-agency task force, the North coast Watershed Assessment Program (NCWAP)now known as the Coastal Watershed Planning and Assessment Program (CWPAP). The report states that pool depth and shelter are major limiting factors to salmonids throughout the watershed and the top restoration priority for all the sub-basins is to increase in-stream habitat complexity. Key recommendations to achieve this goal are "Continue efforts such as road assessments, storm proofing, improvements, and decommissioning throughout the watershed to reduce sediment delivery to the Gualala River and its tributaries."

Second, the *Gualala Estuary and Lower River Enhancement Plan* (ECORP Consulting, Inc. *et al*., 2005) was a result of a partnership with Gualala River Watershed Council and the Sotoyome Resource Conservation District, funded by the California State Coastal Conservancy. In the estuary study the factors limiting Coho populations in the watershed were attributed to "degraded habitat conditions in the upstream portions of the watershed" and a key recommendation is to "repair and retire logging roads and treat upslope sediment sources."

Education & Outreach Program

Since 1997 the GRWC has hosted workshops and presentations that provide stakeholders with the opportunity to gain awareness of watershed issues.

The GRWC takes the approach of providing information to the community with the goal of raising critical thought and analysis on issues that impact the watershed.

This "study group" focus allows landowners and stakeholders easy access to information, from which all members of the community can draw conclusions on complex scientific, legislative, and regulatory matters. While landowners, stakeholders and community members may draw different conclusions

from the information presented, the engagement of the community in the process is the core of the GRWC mission.

Monitoring Program

The GRWC is a leader in the growth and development of programs for watershed assessment and monitoring. Our monitoring program is designed to understand watershed conditions through collaboration between private landowners, community groups and public agencies.

The GRWC collects information on the physical condition of the watershed using protocols developed by the GRWC and approved by the California EPA and the North Coast Regional Water Quality Control Board. The program is specifically designed to evaluate ecological events, watershed trends, the effects of Best Management Practices (BMPs), and the effectiveness of restoration Projects.

To date, thirty-five (35) monitoring reaches have been installed within the watershed. Surveys of thalweg elevations, cross-sections, riparian vegetation, canopy density, substrate, temperature, and large wood inventories have been conducted eighty-four (84) times at these established sites over the past 12 years.

Restoration Programs

Tip and Dip to save the fish!

Implementation of sediment non-point source restoration projects throughout the watershed has yielded substantial accomplishments in the recovery of beneficial habitat in salmonid bearing streams.

The GRWC has participated in the reduction of anthropogenic sediment sources entering watercourses by assisting landowners with funding and the implementation of BMPs to upgrade timber, rural subdivision, and ranch roads.

Road networks are assessed at the planning watershed scale and are continually re-prioritized based on completed road sediment source implementation, sediment source analysis, road densities, roads proximate to streams, quality of in-stream habitat and land use.

Over 236 miles of road have been upgraded, abandoned or decommissioned preventing *56,000 dump truck* loads of sediment from entering the watercourses.

Five CalWater Planning watersheds are completed and all high and moderate priority roads within the watershed boundaries are upgraded and hydrologically disconnected from the stream channels comprising 38,524 acres or 18% of the watershed.

The GRWC is working with and have support from landowners in an additional 12 CalWater Planning watersheds to implement road improvements through future funding sources.

Working Tools for Working Lands

Developing straight forward tools for landowners to use in the field increases participation in Best Management Practices and watershed restoration. The GRWC offers a number of tools and resources for landowner to use for property assessment and planning.

For example, to assist landowners in the watershed, the GRWC in collaboration with Gualala Redwoods, Inc. developed integrated working maps and databases for the assessment of monitoring road systems within the watershed. The grid module is used to evaluate sub-watershed size then uses a hydrologic model to color streams based on the culvert size needed to withstand a 100 year flood.

Maps can then be tailored in a number of different ways designating individual parcels, planning watersheds, or USGS 7.5" Quadrangles.

Wood In the Stream Program

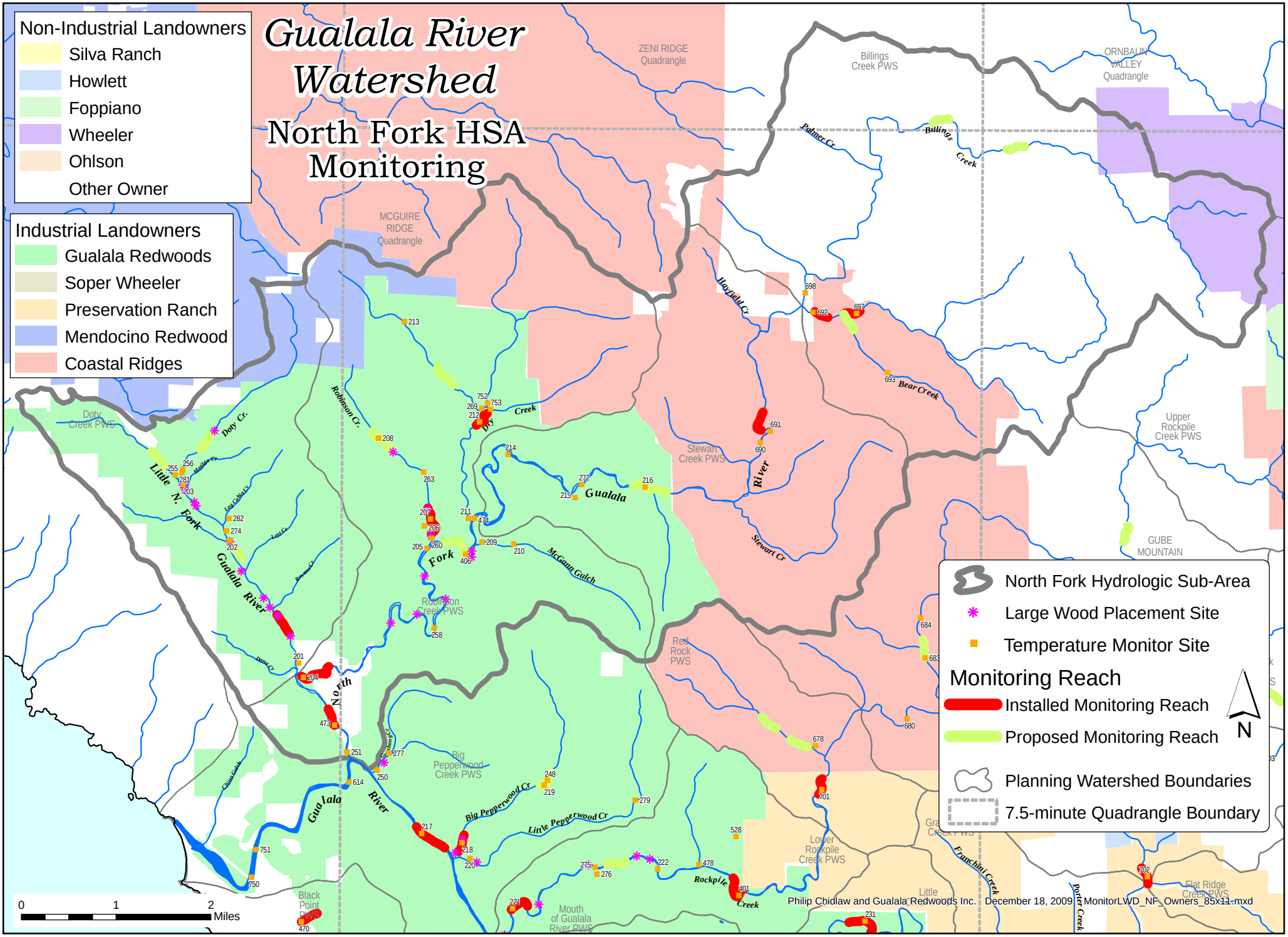
In 2000 the GRWC and Gualala Redwoods, Inc., a large landowner within the watershed, started a cooperative effort to address in-stream limiting factors facing salmonid populations in the watershed.

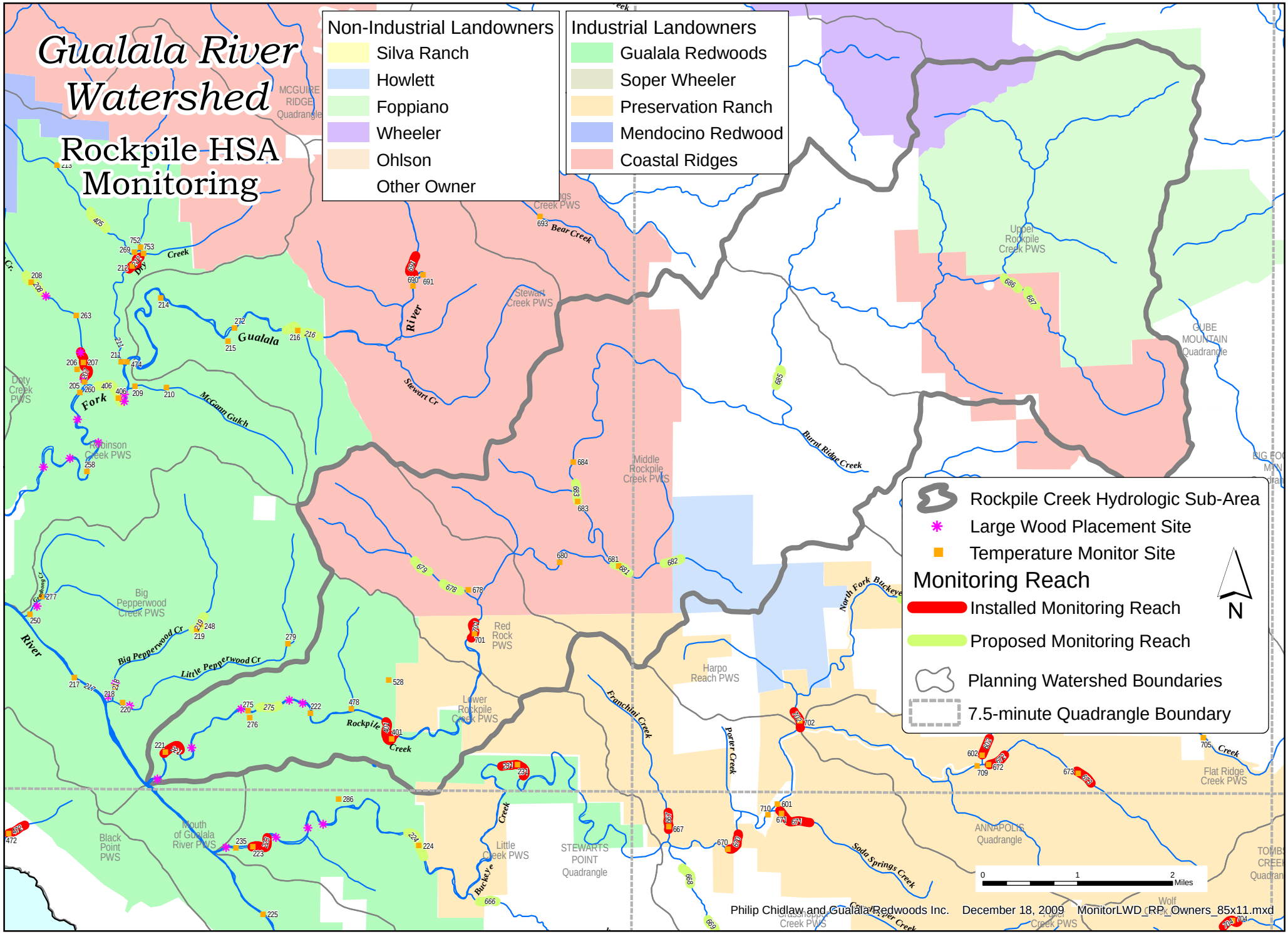
To restore salmonid habitat large wood is placed in stream reaches to increase the frequency, depth and size of cold water pools, increase sediment sorting and provide both shelter from high velocity flows and predators.

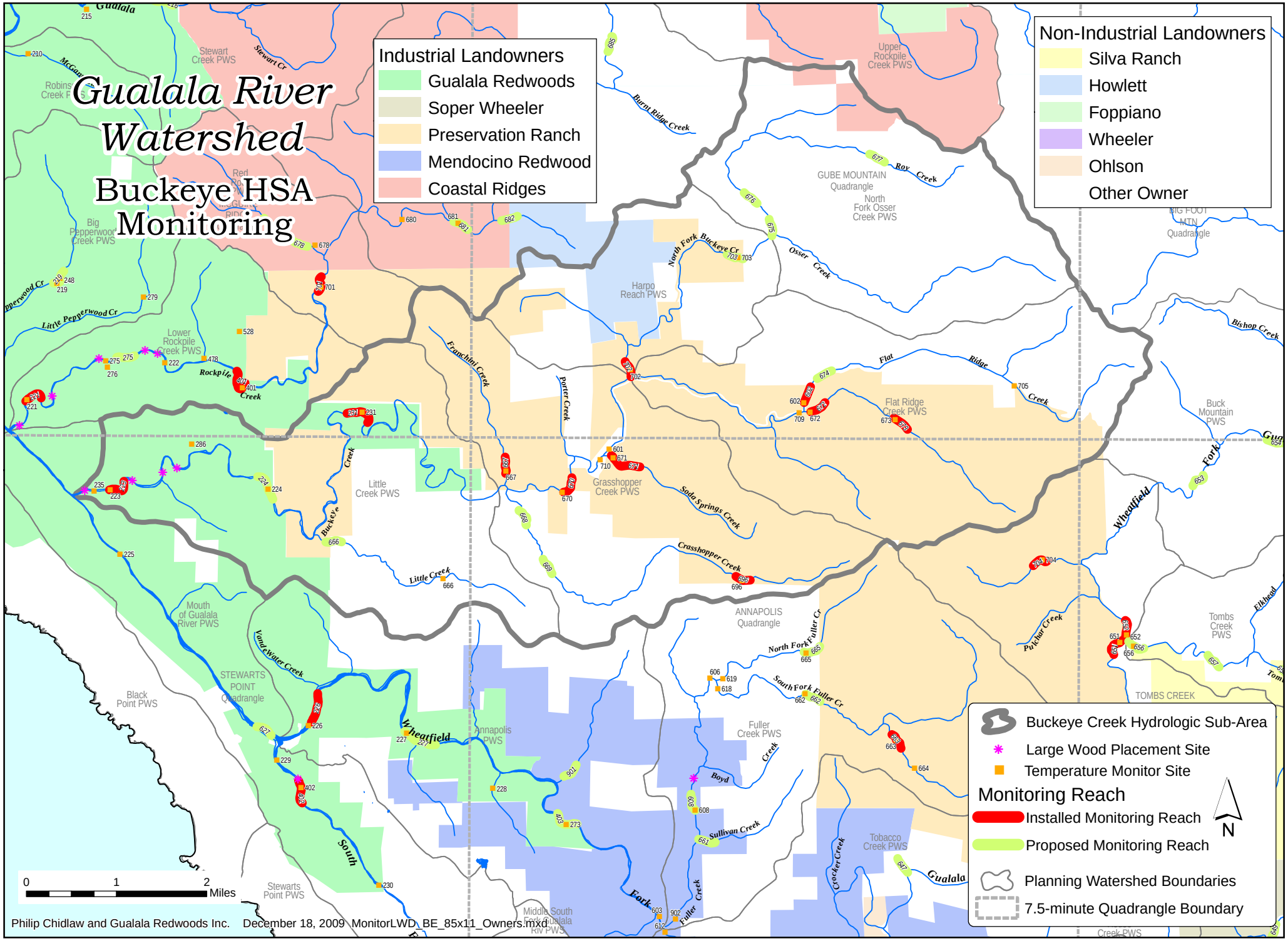
This project has greatly enhanced summer and winter rearing habitat for Coho salmon and Steelhead trout thus increasing the potential recovery of salmonid fisheries within the Gualala.

Since the program's inception 502 logs, 71 logging truck loads have been placed in 9 tributaries (8 miles of blue line stream) within the watershed. Cost analysis of the program has shown the project to be very efficient at $250.00 per log placed. Expectation is that the log cost will continue to decrease as the program matures and becomes more efficient. Project log retention, defined as logs that have remained in the tributaries where they were placed is 84%.

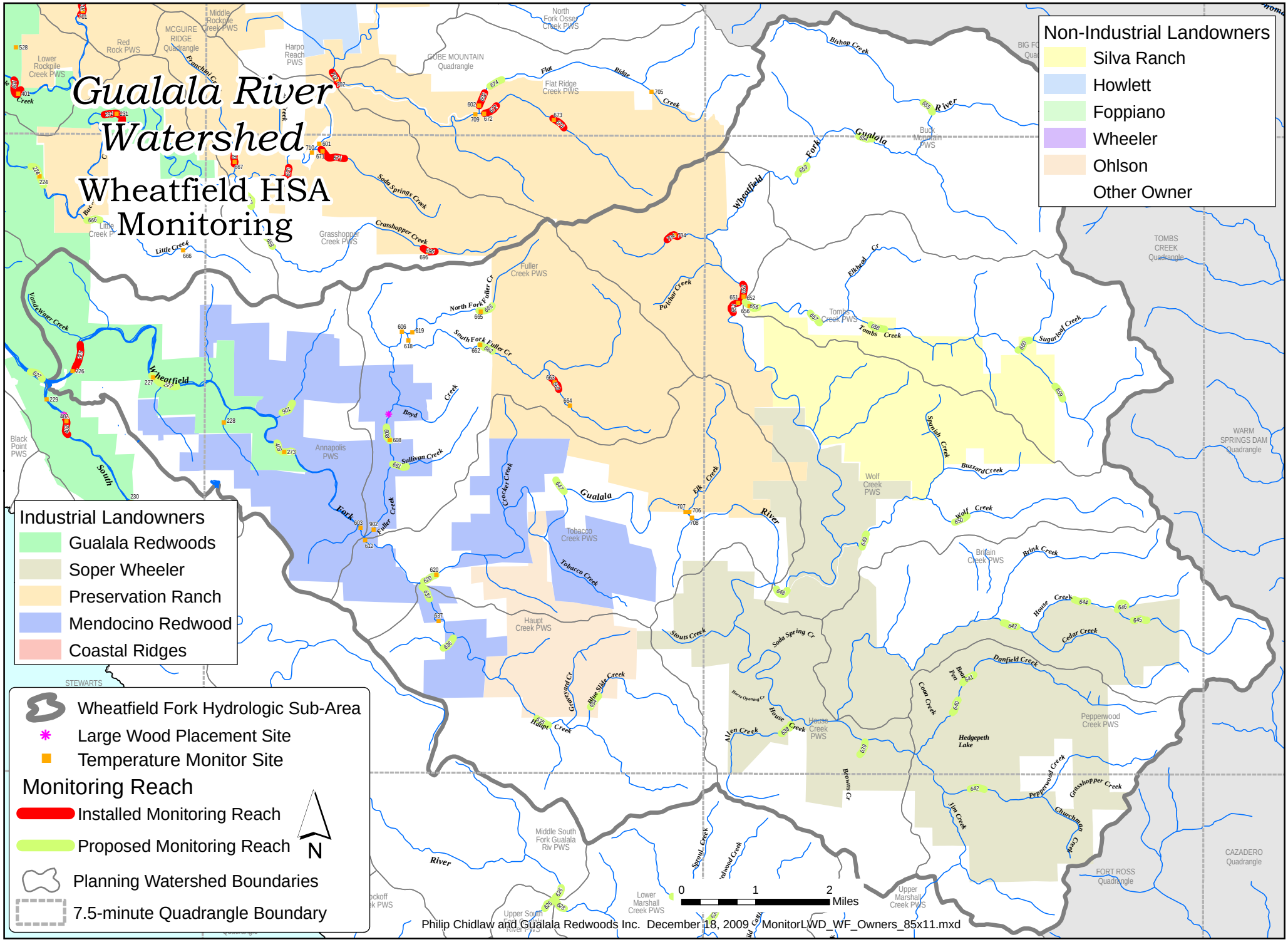
Pre and post project effectiveness monitoring clearly show an increase in pool frequency, pool depth, and pool area in streams loaded with large wood through this program.

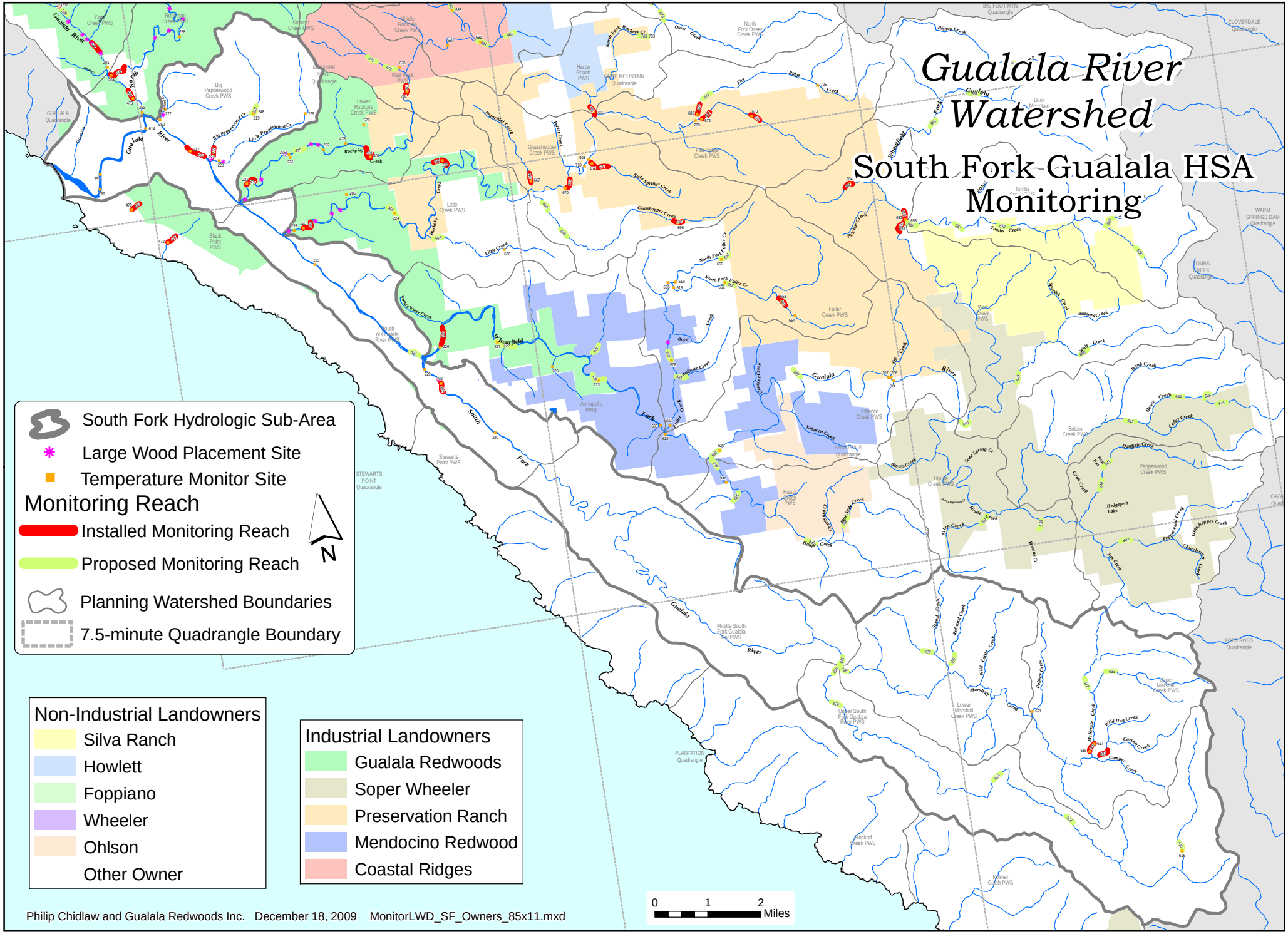

Gualala River Watershed
North Fork HSA Monitoring
Non-Industrial Landowners
Silva Ranch
Howlett
Foppiano
Wheeler
Ohlson
Other Owner
Industrial Landowners
Gualala Redwoods
Soper Wheeler
Preservation Ranch
Mendocino Redwood
Coastal Ridges
North Fork Hydrologic Sub-Area
Large Wood Placement Site
Temperature Monitor Site
Monitoring Reach
Installed Monitoring Reach
Proposed Monitoring Reach
Planning Watershed Boundaries
7.5-minute Quadrangle Boundary
N
0 1 2 Miles
Philip Chidlaw and Gualala Redwoods Inc. December 18, 2009 MonitorLWD_NF_Owners_85x11.mxd
ZENI RIDGE Quadrangle
MCGUIRE RIDGE Quadrangle
ORNBALIN VALLEY Quadrangle
GUBE MOUNTAIN
Billings Creek PWS
Doty Creek PWS
Stewart Creek PWS
Robinson Creek PWS
Big Pepperwood Creek PWS
Red Rock PWS
Lower Rockpile Creek PWS
Upper Rockpile Creek PWS
Black Point PWS
Mouth of Gualala River PWS
Little Gra Creek PWS
Flat Ridge Creek PWS
Gualala River
Little N. Fork
North Fork
Doty Creek
Robinson Cr.
Doty Cr.
Muller Cr.
Log Cabin Cr.
Log Cr.
Beaver Cr.
Dana Cr.
Chris Gulch
Gualala River
McGann Gulch
Big Pepperwood Cr
Little Pepperwood Cr
Rockpile Creek
Stewart Cr
Hayfield Cr
Palmer Cr
Billings Creek
Bear Creek
Franchini Creek
Porter Creek


Gualala River Watershed
Rockpile HSA Monitoring
Non-Industrial Landowners
Silva Ranch
Howlett
Foppiano
Wheeler
Ohlson
Other Owner
Industrial Landowners
Gualala Redwoods
Soper Wheeler
Preservation Ranch
Mendocino Redwood
Coastal Ridges
Rockpile Creek Hydrologic Sub-Area
Large Wood Placement Site
Temperature Monitor Site
Monitoring Reach
Installed Monitoring Reach
Proposed Monitoring Reach
Planning Watershed Boundaries
7.5-minute Quadrangle Boundary
N
0
1
2
Miles
Gualala
River
Fork
Dry
Creek
Bear Creek
Stewart Cr
McGann Gulch
Big Pepperwood Cr
Little Pepperwood Cr
Rockpile
Creek
Franchini Creek
Porter Creek
Burnt Ridge Creek
North Fork Buckeye
Buckeye
Soda Springs Creek
Flat Ridge Creek PWS
Upper Rockpile Creek PWS
Middle Rockpile Creek PWS
Lower Rockpile Creek PWS
Stewart Creek PWS
Red Rock PWS
Harpo Reach PWS
Little Creek PWS
Big Pepperwood Creek PWS
Black Point PWS
Mouth of Gualala River PWS
Doty Creek PWS
Robinson Creek PWS
MCGUIRE RIDGE Quadrangle
GUBE MOUNTAIN Quadrangle
ANNAPOLIS Quadrangle
STEWARTS POINT Quadrangle
Philip Chidlaw and Gualala Redwoods Inc. December 18, 2009 MonitorLWD_RP_Owners_85x11.mxd



Philip Chidlaw and Gualala Redwoods Inc. December 18, 2009 MonitorLWD_BE_85x11_Owners.mxd


Gualala River Watershed
Wheatfield HSA Monitoring
Non-Industrial Landowners
Silva Ranch
Howlett
Foppiano
Wheeler
Ohlson
Other Owner
Industrial Landowners
Gualala Redwoods
Soper Wheeler
Preservation Ranch
Mendocino Redwood
Coastal Ridges
Wheatfield Fork Hydrologic Sub-Area
Large Wood Placement Site
Temperature Monitor Site
Monitoring Reach
Installed Monitoring Reach
Proposed Monitoring Reach
Planning Watershed Boundaries
7.5-minute Quadrangle Boundary
N
0 1 2 Miles
Philip Chidlaw and Gualala Redwoods Inc. December 18, 2009 MonitorLWD_WF_Owners_85x11.mxd


Gualala River Watershed
South Fork Gualala HSA Monitoring
South Fork Hydrologic Sub-Area
Large Wood Placement Site
Temperature Monitor Site
Monitoring Reach
Installed Monitoring Reach
Proposed Monitoring Reach
Planning Watershed Boundaries
7.5-minute Quadrangle Boundary
N
Non-Industrial Landowners
Silva Ranch
Howlett
Foppiano
Wheeler
Ohlson
Other Owner
Industrial Landowners
Gualala Redwoods
Soper Wheeler
Preservation Ranch
Mendocino Redwood
Coastal Ridges
0 1 2 Miles
Philip Chidlaw and Gualala Redwoods Inc. December 18, 2009 MonitorLWD_SF_Owners_85x11.mxd

Gualala River

Location	•Mendocino County
Watershed Area	•298.0 Square Miles
Potential Habitat	•266.6 Stream Miles
Vegetation	•52% Coniferous, 31% Montane Hardwood, 16% Grassland
Erodability	•Low (29%) to High (71%)
Ownership Patterns	•99% Private
Dominant Land Uses	•Timber, Agriculture, Gravel Mining
Housing Density	•Moderate
TMDL Pollutants	•Sediment, Temperature

Gualala River estuary. *Photo by Bob Coey, NMFS.*

Gualala River Coho Salmon: Persistent – Low Abundance

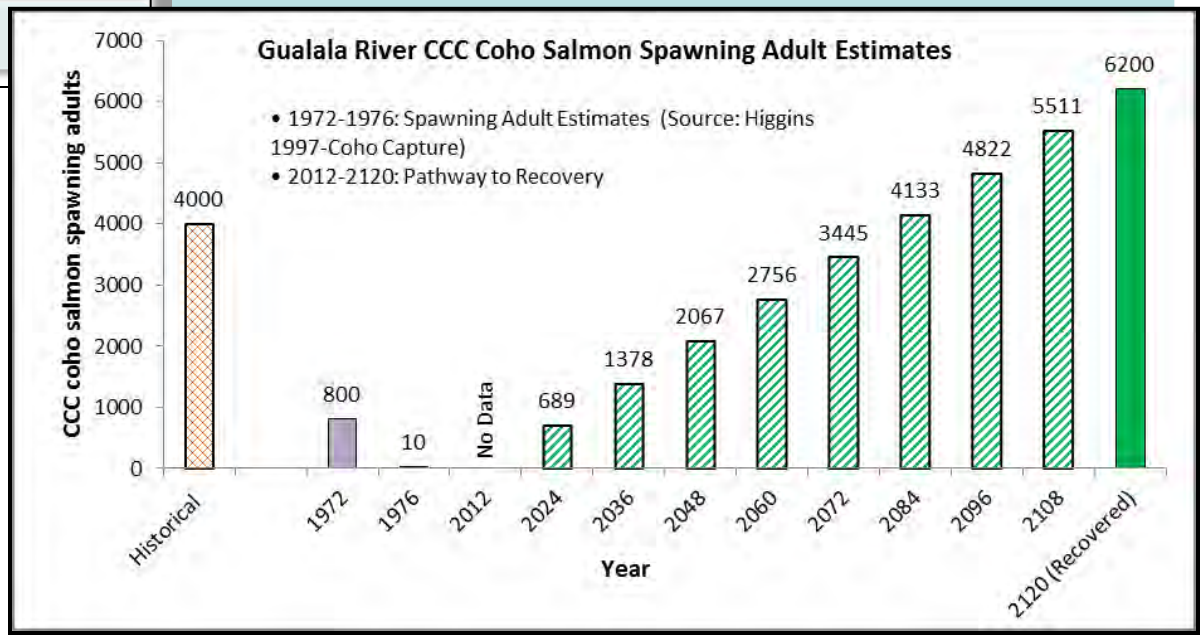
Recovery Goals

✓ Conduct monitoring to track population response to recovery action implementation

Gualala River Adult Spawner Targets

Downlisting to Threatened 3,100

Recovery 6,200



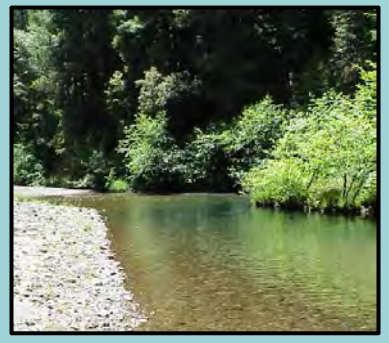
STEELHEAD: YES
CHINOOK SALMON: NO

Gualala River

Potential Habitat: 266.6 miles
Recovery Target: 6,200 Spawning Adult Coho Salmon

Current Instream, Watershed and Population Conditions

Estuary/Lagoon	Habitat Complexity	Hydrology	Passage & Migration	Riparian Vegetation	Sediment	Stream Temperature	Velocity Refuge	Water Quality	Viability	Landscape Patterns
FAIR	POOR	FAIR	GOOD	FAIR	FAIR	FAIR	FAIR	FAIR	POOR	GOOD



Preventing Extinction & Improving Conditions

Priority 1: Immediate Restoration Actions

- Treat high priority slides and landings
- Develop critical flow values that are the basis for minimum bypass flow requirements to support summer rearing

Priority 2 & 3: Long-Term Restoration Actions

- Monitor water quality in the Gualala estuary during the summer months
- Investigate the hydrodynamics of freshwater inflow and estuary water quality conditions
- Monitor, identify problems, and prioritize needed changes to permitted water diversions
- Upgrade water rights information system and promote off channel storage
- Increase frequency of LWD and other complex habitat structures in seasonal habitat and migratory reaches
- Improve passage conditions

SOTOYOME RESOURCE CONSERVATION DISTRICT

Recovery Partners

Gualala River Watershed Council, Gualala Redwood Company

RESOURCES AGENCY CALIFORNIA DEPARTMENT FISH & GAME

Photo courtesy from left to right: Campbell Timberland, Campbell Timberland, KRIS Information System, City of Santa Rosa and Morgan Bond, SWFSC

Gualala River

Potential Habitat: 266.6 miles
Recovery Target: 6,200 Spawning Adult Coho Salmon

Future Threats

Agriculture	Channel Modification	Disease & Predation	Fire & Fuel Management	Fishing & Collecting	Hatcheries & Aquaculture	Livestock & Ranching	Logging	Mining	Recreation	Urban Development	Roads & Railroads	Severe Weather	Diversions & Impoundment
HIGH	MEDIUM	LOW	LOW	MEDIUM	NA	MEDIUM	HIGH	MEDIUM	LOW	LOW	HIGH	MEDIUM	HIGH

Reducing Future Threats

Priority 1: Immediate Threat Abatement Actions

- Discourage forest-to-vineyard land conversions
- Decommission or upgrade roads
- Reduce road density by 10 percent of the next 10 years
- Ensure current and future water diversions do not impair summer rearing

Priority 2 & 3: Long-Term Threat Abatement Actions

- Maintain functional riparian stream buffers that provide desirable stream canopy cover adjacent to agricultural land
- Identify and eliminate depletion of summer base flows
- Evaluate and avoid impacts to off channel habitat in timber harvest
- Retain the largest trees in all riparian zones (including intermittent and ephemeral streams) for bank stability and long-term wood recruitment
- Conserve and manage forestlands for older forest stages
- Conduct inspections and correct conditions of all roads prior to winter
- Ensure all future road or bridge repairs at stream crossings provide unimpaired fish passage for all salmonid life stages

Wide and shallow riffle in the Gualala River
Photo provided by KRIS Information System, and is used with permission

Conservation Highlights

- The Gualala River Watershed Council (GRWC) has worked with landowners to conduct sediment reduction projects that have prevented more than 15,000 dump truck loads of sediment from polluting streams.
- GRWC has installed 70 stream temperature monitoring stations throughout the watershed. They conduct annual surveys of fish and aquatic and riparian habitat, and completed the first scientific study of the Gualala River Estuary.
- Gualala Redwood Company has installed many instream LWD structures on the North Fork Gualala River

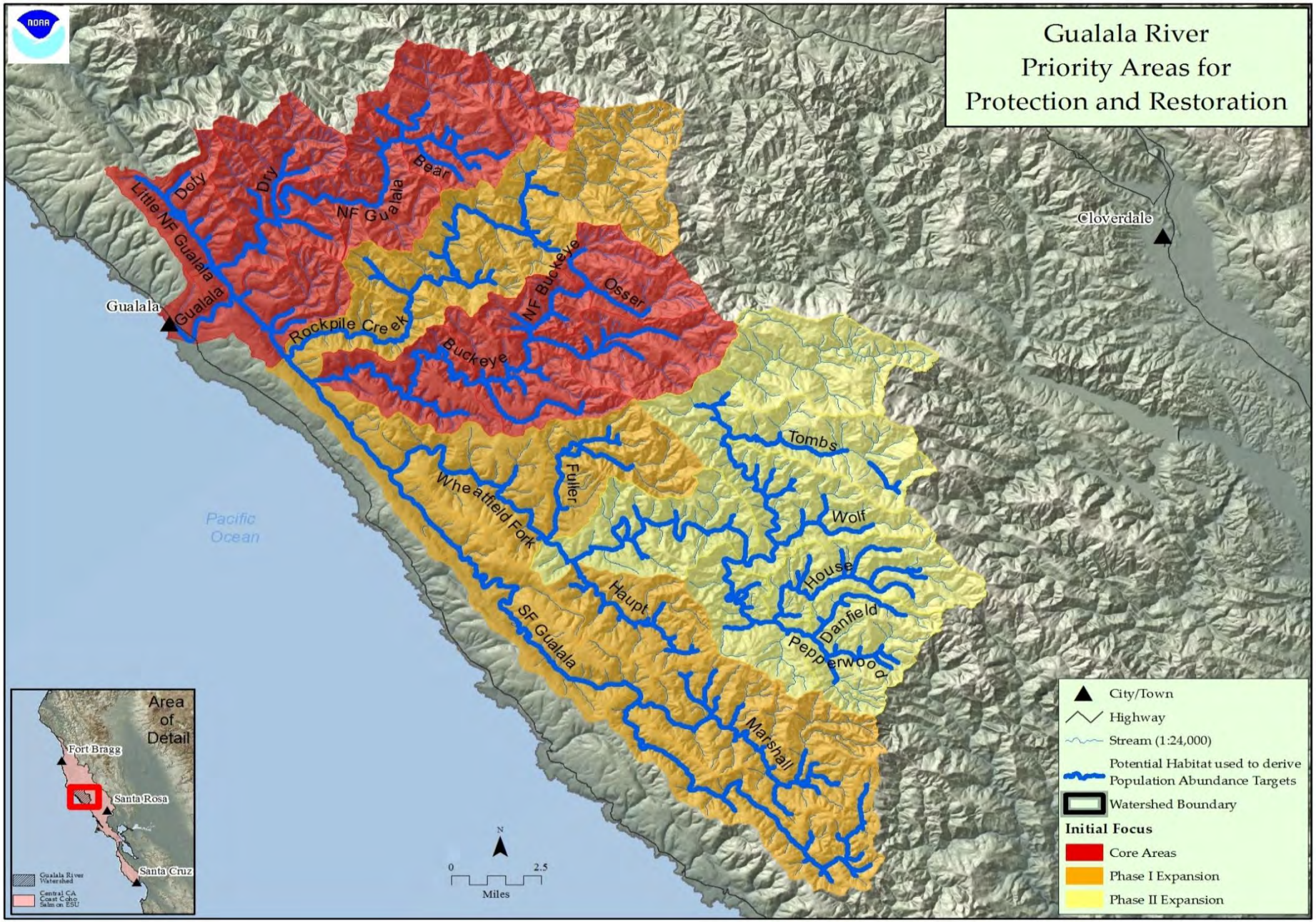


Figure 1: Map of Gualala River

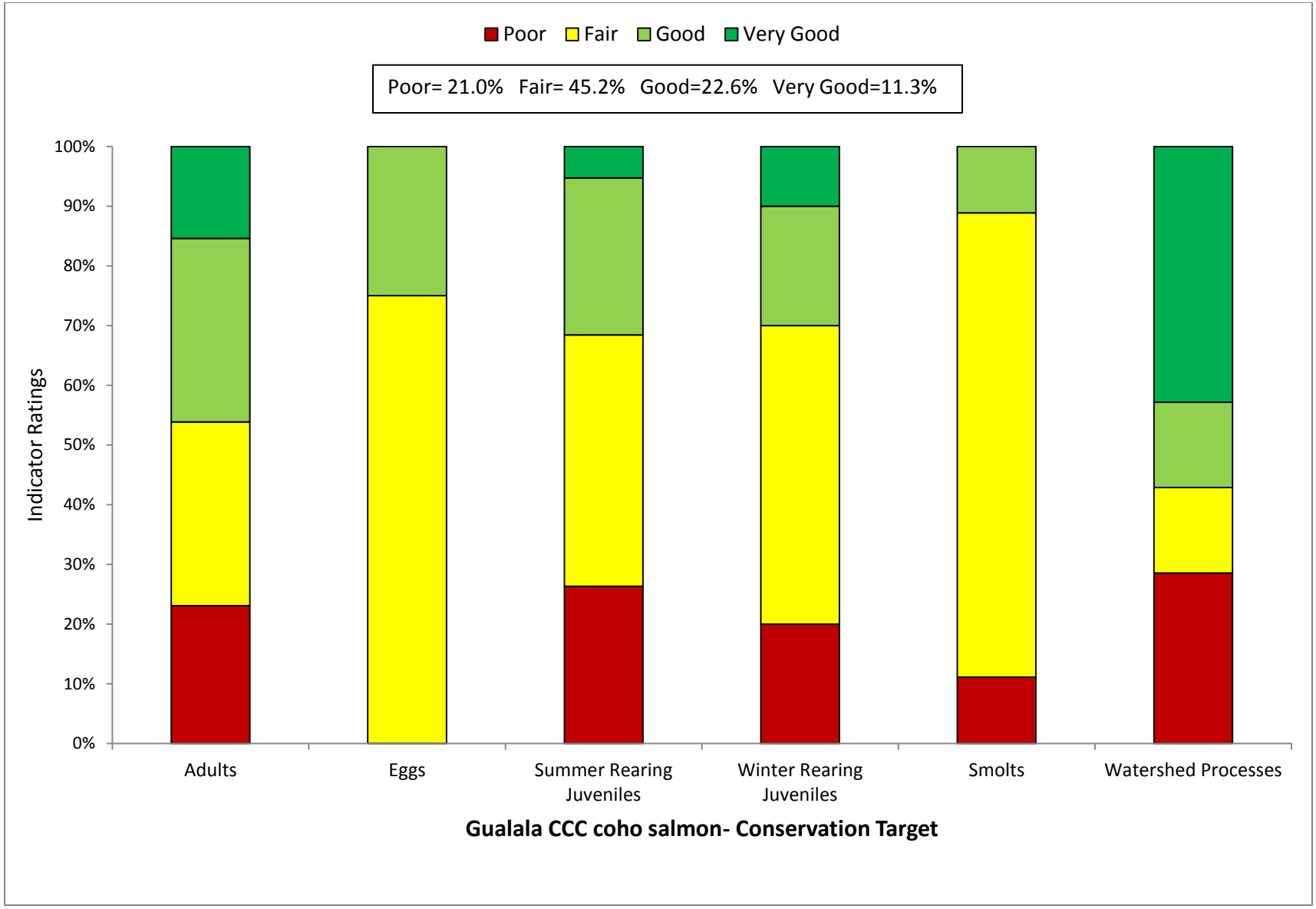


Figure 2: Viability Results by Lifestage

Table 1: CAP Viability Results ~ Gualala River

Target	Attribute	Indicator	Result	Rating	Method	Desired Criteria
Adults	Habitat Complexity	Large Wood Frequency (BFW 0-10 meters)	**9.25 Key Pieces/100m**	Good	NMFS Expert Estuary/Lagoon Panel	6 to 11 key pcs/100m
Adults	Habitat Complexity	Large Wood Frequency (BFW 10-100 meters)	**2.15 Key Pieces/100m**	Good	NMFS Expert Estuary/Lagoon Panel	1.3 to 4 Key Pieces/100 meters
Adults	Habitat Complexity	Pool/Riffle/Flatwater Ratio	**48% streams 37% IP-km (>30% Pools; >20% Riffles)**	Poor	SEC Analysis/CDFG Data	75% to 90% of streams/ IP-Km (>30% Pools; >20% Riffles)
Adults	Habitat Complexity	Shelter Rating	**8% streams 2% IP-km (>80 stream average)**	Poor	SEC Analysis/CDFG Data	75% to 90% of streams/ IP-Km (>80 stream average)
Adults	Hydrology	Passage Flows	**Risk Factor Score =58**	Fair	SEC Analysis/CDFG Data	NMFS Flow Protocol: Risk Factor Score 35-50
Adults	Passage/Migration	Passage at Mouth or Confluence	**75% of IP-km to 90% of IP-km accessible**	Good	SEC Analysis/CDFG Data	75% of IP-Km to 90% of IP-km
Adults	Passage/Migration	Physical Barriers	**100% of IP-km accessible**	Very Good	SEC Analysis/CDFG Data	75% of IP-Km to 90% of IP-km
Adults	Riparian Vegetation	Tree Diameter (North of SF Bay)	**40 - 54% Class 5 & 6 across IP-km**	Fair	SEC Analysis/CDFG Data	55 - 69% Class 5 & 6 across IP-km
Adults	Riparian Vegetation	Tree Diameter (South of SF Bay)	**0**	0	SEC Analysis/CDFG Data	≥80% Density rating "D" across IP-km
Adults	Sediment	Quantity & Distribution of Spawning Gravels	**>90% of IP-km accessible**	Very Good	SEC Analysis/CDFG Data	75% of IP-Km to 90% of IP-km
Adults	Velocity Refuge	Floodplain Connectivity	**50-80% Response Reach Connectivity**	Fair	SEC Analysis/CDFG Data	>80% Response Reach Connectivity
Adults	Water Quality	Toxicity	**Sublethal or Chronic**	Fair	SEC Analysis/CDFG Data	No Acute or Chronic
Adults	Water Quality	Turbidity	**75% to 90% of streams/ IP-km maintains severity score of 3 or lower**	Good	SEC Analysis/CDFG Data	75% to 90% of streams/ IP-Km maintains severity score of 3 or lower
Adults	Viability	Density	**<1 spawner per IP-km**	Poor	SEC Analysis/CDFG Data	low risk spawner density per Spence (2008)
Eggs	Hydrology	Flow Conditions (Instantaneous Condition)	**Risk Factor Score =67**	Fair	SEC Analysis/CDFG Data	NMFS Flow Protocol: Risk Factor Score 35-50
Eggs	Hydrology	Redd Scour	**Risk Factor Score =75**	Fair	SEC Analysis/CDFG Data	NMFS Flow Protocol: Risk Factor Score 35-50

Eggs	Sediment	Gravel Quality (Bulk)	**12-14% (0.85mm) and <30% (6.4mm)**	Good	NMFS Instream Flow Analysis	12-14% (0.85mm) and <30% (6.4mm)
Eggs	Sediment	Gravel Quality (Embeddedness)	**66% streams 69% IP-km (>50% stream average scores of 1 & 2)**	Fair	NMFS Instream Flow Analysis	75% to 90% of streams/ IP-Km (>50% stream average scores of 1 & 2)
Summer Rearing Juveniles	Estuary/Lagoon	Quality & Extent	**Impaired but functioning**	Fair	NMFS Instream Flow Analysis	Properly Functioning Condition
Summer Rearing Juveniles	Habitat Complexity	Large Wood Frequency (Bankfull Width 0-10 meters)	**9.25 Key Pieces/100m**	Good	NMFS Instream Flow Analysis	6 to 11 key pcs/100m
Summer Rearing Juveniles	Habitat Complexity	Large Wood Frequency (Bankfull Width 10-100 meters)	**2.15 Key Pieces/100m**	Good	NMFS Instream Flow Analysis	1.3 to 4 Key Pieces/100 meters
Summer Rearing Juveniles	Habitat Complexity	Percent Primary Pools	**24% streams 29% IP-km (>49% of pools are primary pools)**	Poor	NMFS Instream Flow Analysis	75% to 89% of streams/ IP-Km (>49% of pools are primary pools)
Summer Rearing Juveniles	Habitat Complexity	Pool/Riffle/Flatwater Ratio	**45% streams 33% IP-km (>30% Pools; >20% Riffles)**	Poor	NMFS Instream Flow Analysis	75% to 90% of streams/ IP-Km (>30% Pools; >20% Riffles)
Summer Rearing Juveniles	Habitat Complexity	Shelter Rating	**8% streams 3% IP-km (>80 stream average)**	Poor	NMFS Instream Flow Analysis	75% to 90% of streams/ IP-Km (>80 stream average)
Summer Rearing Juveniles	Hydrology	Flow Conditions (Baseflow)	**Risk Factor Score =75**	Poor	NMFS Instream Flow Analysis	NMFS Flow Protocol: Risk Factor Score 35-50
Summer Rearing Juveniles	Hydrology	Flow Conditions (Instantaneous Condition)	**Risk Factor Score = 51-75**	Fair	NMFS Watershed Characterization	NMFS Flow Protocol: Risk Factor Score 35-50
Summer Rearing Juveniles	Hydrology	Number, Condition and/or Magnitude of Diversions	**0.15 Diversions/10 IP-km**	Good	NMFS Watershed Characterization	0.01 - 1 Diversions/10 IP km
Summer Rearing Juveniles	Passage/Migration	Passage at Mouth or Confluence	**50% of IP-km to 74% of IP-km accessible**	Fair	NMFS Watershed Characterization	75% of IP-Km to 90% of IP-km
Summer Rearing Juveniles	Passage/Migration	Physical Barriers	**100% of IP-km accessible**	Very Good	Population Profile/BPJ	75% of IP-Km to 90% of IP-km
Summer Rearing Juveniles	Riparian Vegetation	Canopy Cover	**50% streams 14% IP-km (>85% average stream canopy)**	Fair	SEC or PAD/CDFG Data	75% to 90% of streams/ IP-Km (>85% average stream canopy)
Summer Rearing Juveniles	Riparian Vegetation	Tree Diameter (North of SF Bay)	**40 - 54% Class 5 & 6 across IP-km**	Fair	Population Profile/BPJ	55 - 69% Class 5 & 6 across IP-km
Summer Rearing Juveniles	Riparian Vegetation	Tree Diameter (South of SF Bay)	**0**	0	SEC or PAD/CDFG Data	≥80% Density rating "D" across IP-km
Summer Rearing Juveniles	Sediment (Food Productivity)	Gravel Quality (Embeddedness)	**63% streams 70% IP-km (>50% stream average scores of 1 & 2)**	Fair	SEC or PAD/CDFG Data	75% to 90% of streams/ IP-Km (>50% stream average scores of 1 & 2)

Summer Rearing Juveniles	Water Quality	Temperature (MWMT)	**50 to 74% IP-km (<20 C MWMT; <16 C MWMT where coho IP overlaps)**	Fair	Population Profile/BPJ	75 to 89% IP km (<16 C MWMT)
Summer Rearing Juveniles	Water Quality	Toxicity	**Sublethal or Chronic**	Fair	NMFS Watershed Characterization/CWHR	No Acute or Chronic
Summer Rearing Juveniles	Water Quality	Turbidity	**75% to 90% of streams/ IP-km maintains severity score of 3 or lower**	Good	NMFS Watershed Characterization/CWHR	75% to 90% of streams/ IP-Km maintains severity score of 3 or lower
Summer Rearing Juveniles	Viability	Density	**<0.2 fish/meter^2**	Poor	SEC Analysis/CDFG Data	0.5 - 1.0 fish/meter^2
Summer Rearing Juveniles	Viability	Spatial Structure	**75-90% of Historical Range**	Good	NMFS Watershed Characterization/CWHR	75-90% of Historical Range
Winter Rearing Juveniles	Habitat Complexity	Large Wood Frequency (Bankfull Width 0-10 meters)	**9.25 Key Pieces/100m**	Good	NMFS Watershed Characterization/CWHR	6 to 11 key pcs/100m
Winter Rearing Juveniles	Habitat Complexity	Large Wood Frequency (Bankfull Width 10-100 meters)	**2.15 Key Pieces/100m**	Good	NMFS Watershed Characterization/CWHR	1.3 to 4 Key Pieces/100 meters
Winter Rearing Juveniles	Habitat Complexity	Pool/Riffle/Flatwater Ratio	**48% streams 37% IP-km (>30% Pools; >20% Riffles)**	Poor	NMFS Watershed Characterization/CWHR	75% to 90% of streams/ IP-Km (>30% Pools; >20% Riffles)
Winter Rearing Juveniles	Habitat Complexity	Shelter Rating	**8% streams 2% IP-km (>80 stream average)**	Poor	CDF Vegetation Maps/BPJ	75% to 90% of streams/ IP-Km (>80 stream average)
Winter Rearing Juveniles	Passage/Migration	Physical Barriers	**100% of IP-km accessible**	Very Good	Population Profile/BPJ	75% of IP-Km to 90% of IP-km
Winter Rearing Juveniles	Riparian Vegetation	Tree Diameter (North of SF Bay)	**40 - 54% Class 5 & 6 across IP-km**	Fair	Population Profile/BPJ	55 - 69% Class 5 & 6 across IP-km
Winter Rearing Juveniles	Riparian Vegetation	Tree Diameter (South of SF Bay)	**0**	0	SEC Analysis/CDFG Data	≥80% Density rating "D" across IP-km
Winter Rearing Juveniles	Sediment (Food Productivity)	Gravel Quality (Embeddedness)	**63% streams 70% IP-km (>50% stream average scores of 1 & 2)**	Fair	SEC Analysis/CDFG Data	75% to 90% of streams/ IP-Km (>50% stream average scores of 1 & 2)
Winter Rearing Juveniles	Velocity Refuge	Floodplain Connectivity	**50-80% Response Reach Connectivity**	Fair	SEC Analysis/CDFG Data	>80% Response Reach Connectivity
Winter Rearing Juveniles	Water Quality	Toxicity	**Sublethal or Chronic**	Fair	NMFS Watershed Characterization	No Acute or Chronic
Winter Rearing Juveniles	Water Quality	Turbidity	**50% to 74% of streams/ IP-km maintains severity score of 3 or lower**	Fair	NMFS Watershed Characterization	75% to 90% of streams/ IP-Km maintains severity score of 3 or lower

Smolts	Estuary/Lagoon	Quality & Extent	**Impaired but functioning**	Fair	SEC Analysis/CDFG Data	Properly Functioning Condition
Smolts	Habitat Complexity	Shelter Rating	**8% streams 2% IP-km (>80 stream average)**	Poor	Population Profile	75% to 90% of streams/ IP-Km (>80 stream average)
Smolts	Hydrology	Number, Condition and/or Magnitude of Diversions	**0.24 Diversions/10 IP-km**	Good	Population Profile	0.01 - 1 Diversions/10 IP km
Smolts	Hydrology	Passage Flows	**Risk Factor Score =51-75**	Fair	TRT Spence (2008)	NMFS Flow Protocol: Risk Factor Score 35-50
Smolts	Passage/Migration	Passage at Mouth or Confluence	**50% of IP-km to 74% of IP-km accessible**	Fair	TRT Spence (2008)	75% of IP-Km to 90% of IP-km
Smolts	Smoltification	Temperature	**50-74% IP-km (>6 and <14 C)**	Fair	TRT Spence (2008)	75-90% IP-Km (>6 and <16 C)
Smolts	Water Quality	Toxicity	**Sublethal or Chronic**	Fair	TRT Spence (2008)	No Acute or Chronic
Smolts	Water Quality	Turbidity	**50% to 74% of streams/ IP-km maintains severity score of 3 or lower**	Fair	EPA/RWQCB/NMFS Criteria	75% to 90% of streams/ IP-Km maintains severity score of 3 or lower
Smolts	Viability	Abundance	**Smolt abundance which produces moderate risk spawner density**	Fair	Newcombe and Jensen 2003	Smolt abundance to produce low risk spawner density per Spence (2008)
Watershed Processes	Hydrology	Impervious Surfaces	**0.101% of Watershed in Impervious Surfaces**	Very Good	SEC Analysis	3-6% of Watershed in Impervious Surfaces
Watershed Processes	Landscape Patterns	Agriculture	**0.548% of Watershed in Agriculture**	Very Good	EPA/RWQCB/NMFS Criteria	10-19% of Watershed in Agriculture
Watershed Processes	Landscape Patterns	Timber Harvest	**26-35% of Watershed in Timber Harvest**	Fair	Newcombe and Jensen 2003	25-15% of Watershed in Timber Harvest
Watershed Processes	Landscape Patterns	Urbanization	**2% of watershed >1 unit/20 acres**	Very Good	EPA/RWQCB/NMFS Criteria	8-11% of watershed >1 unit/20 acres
Watershed Processes	Riparian Vegetation	Species Composition	**51-74% Historical Species Composition**	Good	Newcombe and Jensen 2003	51-74% Intact Historical Species Composition
Watershed Processes	Sediment Transport	Road Density	**4.8 Miles/Square Mile**	Poor	EPA/RWQCB/NMFS Criteria	1.6 to 2.4 Miles/Square Mile
Watershed Processes	Sediment Transport	Streamside Road Density (100 m)	**4.1 Miles/Square Mile**	Poor	Newcombe and Jensen 2003	0.1 to 0.4 Miles/Square Mile

Table 2: CAP Threats Results ~ Gualala River

	Threats Across Targets	Adults	Eggs	Summer Rearing Juveniles	Winter Rearing Juveniles	Smolts	Watershed Processes	Overall Threat Rank
	Project-specific threats	1	2	3	4	5	6	
1	Agriculture	Medium	Medium	High	Medium	Medium	Medium	High
2	Channel Modification	Medium	Low	Medium	Low	Low	Low	Medium
3	Disease, Predation and Competition	Low	-	Medium	Low	Low	Low	Low
4	Fire, Fuel Management and Fire Suppression	Low	Low	Medium	Low	Low	Low	Low
5	Fishing and Collecting	High	-	Low	-	Medium	-	Medium
6	Hatcheries and Aquaculture	-	-	-	-	-	-	-
7	Livestock Farming and Ranching	Medium	Low	Medium	Low	Medium	Low	Medium
8	Logging and Wood Harvesting	Medium	High	High	High	High	High	High
9	Mining	Medium	Low	Medium	Medium	Medium	Medium	Medium
10	Recreational Areas and Activities	Low	Low	Medium	Low	Low	Low	Low
11	Residential and Commercial Development	Low	Low	Medium	Low	Low	Low	Low
12	Roads and Railroads	Medium	High	Medium	High	Medium	High	High
13	Severe Weather Patterns	Medium	Medium	Medium	Low	Medium	Low	Medium
14	Water Diversion and Impoundments	Medium	Medium	High	Medium	High	Medium	High
	Threat Status for Targets and Project	High	High	High	High	High	High	High

Central CA Coast Coho Salmon ~ Gualala River

ACTIONS FOR RESTORING HABITATS

1. Restoration- Estuary

1.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

1.1.1. **Recovery Action:** Increase the physical extent of estuarine habitat

1.1.1.1. **Action Step:** Investigate the extent of sedimentation within the estuary/lagoon associated with watershed legacy impacts (logging). Evaluate sediment transport within the estuary and determine if the estuary is "filling" with sediment or "flushing" sediment (recovering).

1.1.1.2. **Action Step:** Identify past mechanical fill sites (inside of Mill Bend (?)) and develop strategies targeting the re-establishment of wetland marsh habitat (if feasible).

1.1.1.3. **Action Step:** Develop and implement rehabilitation projects designed to increase the physical extent of high quality habitat for rearing juvenile salmonids within the Gualala River estuary.

1.1.2. **Recovery Action:** Increase and enhance estuarine habitat complexity features

1.1.2.1. **Action Step:** Increase the percentage of area containing high value habitat complexity elements and features (SAV, LWD, boulders, marshes, vegetation, pools > 2 meters).

1.1.2.2. **Action Step:** Identify strategic locations to install LWD structures designed to increased pool depth and habitat conditions within the Gualala River estuary.

1.1.3. **Recovery Action:** Improve the quality of freshwater lagoon habitat

1.1.3.1. **Action Step:** Install continuous water quality monitoring stations in the Gualala estuary during the summer months. Monitor at a minimum temperature, dissolved oxygen, and salinity.

1.1.4. **Recovery Action:** Improve freshwater inflow

1.1.4.1. **Action Step:** Install a stream gauge immediately upstream of the estuary/lagoon to monitor inflow conditions during the dry season.

1.1.4.2. **Action Step:** Investigate the hydrodynamics of freshwater inflow and estuary water quality conditions relative to juvenile salmonid estuarine summer rearing (osmo-regulating and non-osmoregulating).

1.1.4.3. **Action Step:** Identify and implement minimum freshwater inflow thresholds to ensure optimal estuary health and function.

2. Restoration- Floodplain Connectivity

No species-specific actions were developed.

3. Restoration- Habitat Complexity

3.1. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range.

3.1.1. **Recovery Action:** Increase large wood frequency (BFW 0-10 meters)

3.1.1.1. **Action Step:** Increase wood frequency in salmonid spawning and rearing areas to the extent that a minimum of 6 key LWD pieces exists every 100 meters in 0-10 meter BFW streams.

3.1.1.2. **Action Step:** Design and install LWD structures in McKenzie and Wild Hog creeks, and the SF sub-basin to the extent that optimal LWD frequency is achieved at strategic locations.

3.1.2. **Recovery Action:** Increase large wood frequency (BFW 10-100 meters)

3.1.2.1. **Action Step:** Increase wood frequency in seasonal habitat and migratory reaches to the extent that a minimum of 1.3 to 4 key LWD pieces exists every 100 meters in 10-100 meter BFW streams.

3.1.2.2. **Action Step:** Design and implement a SF Gualala mainstem migration project. Focus should include a higher frequency of significantly large wood structures to enhance staging pool development.

3.1.2.3. **Action Step:** Evaluate, design, and implement salmonid habitat improvement structures as appropriate to the stream channel type and hydrologic conditions within the Rockpile Sub-basin

3.1.2.4. **Action Step:** Evaluate, design, and implement salmonid habitat improvement structures as appropriate to the stream channel type and hydrologic conditions within the Buckeye Sub-basin.

3.1.3. **Recovery Action:** Improve pool shelter rating

3.1.3.1. **Action Step:** Evaluate, design, and implement strategies to improve shelter pools ratings within the Rockpile and Buckeye sub-basins and the following tributaries: Boyd, Buckeye, Camper, Carson, Danfield, Doty, Dry, Franchini, Fuller, Grasshopper, Groshong Gulch, House, Little NF GR, Log Cabin, Marshall, McGann, McKenzie, NF Fuller, Lower NF GR, Palmer Canyon, Pepperwood, Rockpile, SF Fuller, Sullivan, Tombs, Wheatfield Fork, and Wild Hog creeks.

3.1.4. **Recovery Action:** Increase primary pools frequency

3.1.4.1. **Action Step:** Evaluate, develop, and implement strategies to increase primary pool frequency in high priority reaches within the following tributaries: Boyd, Doty, Dry, Fuller, Little NF GR, Log Cabin, Marshall, McGann, McKenzie, Palmer, Robinson, Tombs, and West Fork Fuller.

3.1.4.2. **Action Step:** Identify historic CCC coho salmon habitats lacking in channel complexity and implement restoration projects designed to create or restore complex habitat features that provide for localized pool scour, velocity refuge, and cover. Prioritize Core areas first followed by Phase I areas.

3.1.4.3. **Action Step:** Encourage coordination of LWD placement in streams as part of logging operations and road upgrades to maximize size, quality, and efficiency of effort (CDFG 2004).

3.1.4.4. **Action Step:** Encourage landowners to implement restoration projects as part of their ongoing operations in stream reaches where large woody debris is lacking.

3.1.4.5. **Action Step:** Maintain current LWD, boulders, and other structure-providing features to maintain current stream complexity, pool frequency, and depth (CDFG 2004).

3.1.5. **Recovery Action:** Improve pool/riffle/flatwater ratios (hydraulic diversity)

3.1.5.1. **Action Step:** Increase the frequencies to 75% of the streams within the watershed

4. Restoration- Hydrology

4.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

4.1.1. **Recovery Action:** Improve flow conditions (baseflow conditions)

4.1.1.1. **Action Step:** Continue to work with the North Gualala Water Company on water right Permit 14853. Ensure that the Site-specific Study Plan prepared for the NGWC by Stillwater Sciences (11 October 2011) is completed within the next 3-yrs. Implement recommendations within the next 5-years. Ensure salmonid life history requirements targeted in the proposal are evaluate under a range of water year types (dry - wet). Evaluate potential impacts to dry season estuary water quality conditions associated with Permit 14853.

4.1.1.2. **Action Step:** Map all water diversions and upgrade the existing water rights information system so that water allocations can be readily quantified by watershed.

4.1.1.3. **Action Step:** Monitor, identify problems, and prioritize needed changes to permitted water diversions on current or potential coho salmon streams.

4.1.1.4. **Action Step:** Install and maintain a gauging station immediately upstream of the estuary to monitor freshwater inflow during the dry season.

4.1.1.5. **Action Step:** Develop critical flow values that are the basis for minimum bypass flow requirements to support juvenile rearing habitat conditions during the dry season. Focus on core coho salmon areas initially.

4.1.1.6. **Action Step:** Install and maintain a stream gauge at an appropriate location near the base of Rockpile Creek.

4.1.1.7. **Action Step:** Install and maintain a stream gauge at an appropriate location near the base of Buckeye Creek.

4.1.1.8. **Action Step:** Install and maintain a stream gauge at an appropriate location immediately downstream of the SF Gualala and Wheatfield Fork confluence.

4.1.1.9. **Action Step:** Evaluate and implement off-channel storage facilities to reduce impacts of water diversion (storage tanks for rural residential users). Focus efforts in the NF Gualala and Wheatfield sub-watersheds.

5. Restoration- Landscape Patterns

5.1. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

5.1.1. **Recovery Action:** Prevent increased landscape disturbance

5.1.1.1. **Action Step:** Consider developing and/or identifying Salmonid Preserves. Consider the Gualala River watershed as a Salmonid Preserve.

5.1.1.2. **Action Step:** Should large tracts of forestlands within the Gualala River watershed become available for purchase, the State of California and/or the Federal Government should consider purchasing the area as a Demonstration Forest, State Park, or Salmonid Preserve.

5.2. **Objective:** Address the inadequacy of existing regulatory mechanisms

5.2.1. **Recovery Action:** Prevent increased landscape disturbance

5.2.1.1. **Action Step:** Discourage counties from rezoning forestlands to rural residential or other land uses (e.g., vineyards).

5.2.1.2. **Action Step:** Discourage any forestland to agricultural and/or rural/urban development.

6. Restoration- Passage

6.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

6.1.1. **Recovery Action:** Modify or remove physical passage barriers

6.1.1.1. **Action Step:** Evaluate, design, and implement appropriate fish passage at South Beach Road Crossing on Fuller Creek (Wheatfield Fork sub-basin; See CALFISH: PAD_ID 736904; Passage ID 13268)

6.1.1.2. **Action Step:** Evaluate, design, and implement appropriate fish passage designs in Palmer Canyon and McKenzie creeks (Wheatfield Fork sub-basin; Klamt et al. 2003).

7. Restoration- Pool Habitat

No species-specific actions were developed. See Habitat Complexity.

8. Restoration- Riparian

8.1. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

8.1.1. **Recovery Action:** Improve tree diameter

8.1.1.1. **Action Step:** Increase tree diameter to a minimum of 80% CWHR density rating "D" across all current and potential spawning and juvenile rearing areas.

8.1.1.2. **Action Step:** Prioritize large tree retention along the SF Gualala River.

8.1.1.3. **Action Step:** Conduct conifer release to promote growth of larger diameter trees where appropriate.

8.1.2. **Recovery Action:** Improve canopy cover

8.1.2.1. **Action Step:** Increase the average stream canopy cover within potential spawning and rearing reaches to a minimum of 80%.

8.1.2.2. **Action Step:** Evaluate buffers width and/or timber harvest in terms of light penetration and potential changes to micro-climate conditions along the SF Gualala River.

8.1.2.3. **Action Step:** Identify and implement riparian enhancement projects where current canopy density and diversity are inadequate and site conditions are appropriate to: initiate tree planting, thinning, and other vegetation management to encourage the development of a denser more extensive riparian canopy in the following reaches and tributaries of the NF Gualala sub-basin: upper reaches of Dry Creek, Robinson Creek, the central and higher reaches of the mainstem, and the lower reaches of Bear and Stewart Creeks (Klamt et al. 2003).

8.1.2.4. **Action Step:** Identify and implement riparian enhancement projects where current canopy density and diversity are inadequate and site conditions are appropriate to: initiate tree planting, thinning, and other vegetation management to encourage the development of a denser more extensive riparian canopy in the following reaches and tributaries of the Rockpile sub-basin: mainstem Rockpile Creek, Red Rock Creek, and Horsetheif (Klamt et al. 2003).

8.1.2.5. **Action Step:** Identify and implement riparian enhancement projects where current canopy density and diversity are inadequate and site conditions are appropriate to: initiate tree planting, thinning, and other vegetation management to encourage the development of a denser more extensive riparian canopy in the following reaches and tributaries of the Buckeye sub-basin: upper reaches of Buckeye Creek, Franchini, Grasshopper, and Soda Springs creeks (Klamt et al. 2003).

9. Restoration- Sediment

9.1. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

9.1.1. **Recovery Action:** Improve instream gravel quality

9.1.1.1. **Action Step:** Treat high priority slides and landings identified in credible landowner assessments.

9.1.1.2. **Action Step:** Continue efforts such as erosion proofing, improvements, and decommissioning, through the Rockpile sub-basin to reduce sediment delivery to central Rockpile Creeks and Rockpile tributaries.

10. Restoration- Viability

10.1. **Objective:** Address other natural or manmade factors affecting the species continued existence

10.1.1. **Recovery Action:** Increase spawner density

10.1.1.1. **Action Step:** Determine if there is a need for a conservation hatchery/supplementation/augmentation program. Assess the following prior to supplementation (Action Steps 2-7):

10.1.1.2. **Action Step:** Determine the biological or DPS significance of the Gualala coho salmon population.

10.1.1.3. **Action Step:** Investigate the population dynamics and viability status of coho salmon in the Gualala River watershed.

10.1.1.4. **Action Step:** Determine if the coho salmon population within the Gualala River watershed is at a short-term or immediate risk of extinction.

10.1.1.5. **Action Step:** Identify population viability goals and the expectations of a conservation hatchery/supplementation/augmentation program.

10.1.1.6. **Action Step:** Investigate the genetic diversity of coho salmon in the Gualala River.

10.1.1.7. **Action Step:** If determine necessary, identify a source population (in or out of basin stock) that could be used to start a population augmentation/supplementation/ broodstock program.

10.1.2. **Recovery Action:** Increase spatial structure and diversity

10.1.2.1. **Action Step:** Continue and expand upon biological monitoring activities to determine salmonid population and productivity trends at the watershed and sub-watershed scales. Information regarding spawner escapement and smolt production are the highest priorities.

11. Restoration- Water Quality

11.1. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

11.1.1. **Recovery Action:** Improve stream temperature conditions

11.1.1.1. **Action Step:** Expand continuous temperature monitoring efforts into the upper sub-basins and tributaries that provide summer rearing for salmonids. Investigate canopy composition and monitoring air temperature to examine the relationship between canopy, temperature, and other micro-climate effects on water temperature (Klamt et al. 2003).

11.1.1.2. **Action Step:** Evaluate the current adequacy of buffer zones in recently logged areas and ensure stream temperatures have not increased due to these activities.

11.1.1.3. **Action Step:** Implement actions to maintain and restore water temperatures to meet habitat requirements for CCC coho salmon in specific streams (CDFG 2004).

THREAT ABATEMENT ACTIONS

12. Threat- Agricultural Practices

12.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

12.1.1. **Recovery Action:** Prevent impairment to instream habitat complexity (altered pool complexity and/or pool riffle ratio)

12.1.1.1. **Action Step:** Discourage forest-to-vineyard land conversions or other agricultural activities that may impact natural stream channel morphology.

12.1.2. **Recovery Action:** Prevent impairment to instream substrate/food productivity (gravel quality and quantity)

12.1.2.1. **Action Step:** Address sources from agricultural activities that deliver sediment and runoff to stream channels.

12.1.2.2. **Action Step:** Work with vineyard owners to assess the effectiveness of erosion control measures throughout the winter period.

12.1.2.3. **Action Step:** Encourage and assist the NRCS and RCD to increase the number of landowners participating in sediment reduction planning and implementation.

12.1.2.4. **Action Step:** Establish appropriately sized and properly functioning riparian buffers adjacent to watercourses that have a potential to deliver sediment to spawning and rearing habitat.

12.1.3. **Recovery Action:** Prevent impairment to water quality (instream water temperature)

12.1.3.1. **Action Step:** Maintain functional riparian stream buffers that provide desirable stream canopy cover adjacent to agricultural land activities.

12.1.4. **Recovery Action:** Prevent impairment to watershed hydrology

12.1.4.1. **Action Step:** Promote off-channel storage facilities (e.g. winter diversion ponds) in efforts to reduce in-stream flow impacts associated with agricultural water use.

12.1.5. **Recovery Action:** Prevent increased landscape disturbance

12.1.5.1. **Action Step:** Work within the agricultural community to educate landowners and enhance practices that provide for functional watershed processes.

12.1.5.2. **Action Step:** Improve education and awareness to agencies, landowners, and the general public regarding salmonid recovery and habitat requirements.

12.2. **Objective:** Address the inadequacy of existing regulatory mechanisms

12.2.1. **Recovery Action:** Prevent increased landscape disturbance

12.2.1.1. **Action Step:** Coordinate with regulatory agencies authorizing/permitting forestland-to-agriculture conversions to ensure consistency with salmonid recovery goals.

12.2.1.2. **Action Step:** Streamline permit processing where landowners are conducting actions aligned with recovery priorities.

12.2.1.3. **Action Step:** Technical support to counties by NMFS staff should be conducted to encourage county general plan updates that include measures to conserve and protect salmonids and their habitats.

12.2.2. **Recovery Action:** Prevent impairment to watershed hydrology

12.2.2.1. **Action Step:** Identify and eliminate depletion of summer base flows from unauthorized water users.

12.2.2.2. **Action Step:** Develop legislation to fund county planning for environmentally sound agricultural growth and water supply.

13. **Threat- Channel Modification**

No species-specific actions were developed.

14. **Threat- Disease/Predation/Competition**

No species-specific actions were developed.

15. **Threat- Fire/Fuel Management**

No species-specific actions were developed.

16. **Threat- Fishing/Collecting**

16.1. **Objective:** Address the inadequacy of existing regulatory mechanisms

16.1.1. **Recovery Action:** Prevent reduced density, abundance, and diversity

16.1.1.1. **Action Step:** Work with CDFG to modify Section 8.00(b)(1) low flow minimum flow closure for Mendocino, Sonoma, and Marin counties. Discontinue using the Russian River at Guerneville gauging station for angling closures and use the Navarro River USGS gauging station (11468000) which better reflects hydrologic conditions in smaller unregulated coastal Sonoma/Mendocino streams.

17. **Threat- Hatcheries**

No species-specific actions were developed.

18. **Threat- Livestock**

18.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

18.1.1. **Recovery Action:** Prevent adverse alterations to riparian species composition and structure

18.1.1.1. **Action Step:** Reduce livestock and feral pig access to the riparian zone to encourage bank stabilization and re-vegetation of riparian areas within the following sub-basins: Gualala Main stem/ SF Garcia, Wheatfield Fork, Rockpile (Klamt et al. 2003).

19. **Threat- Logging**

19.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

19.1.1. **Recovery Action:** Prevent impairment to floodplain connectivity (quality & extent)

19.1.1.1. **Action Step:** Timber harvest planning should evaluate and avoid impacts to off channel habitat, floodplains, ponds, and oxbows.

19.1.2. **Recovery Action:** Prevent impairment to instream habitat complexity (reduced large wood and/or shelter)

19.1.2.1. **Action Step:** Encourage coordination of LWD placement projects in streams (as necessary) as part of logging operations.

19.1.2.2. **Action Step:** Retain the largest trees in all riparian zones (including intermittent and ephemeral streams) for bank stability and long-term wood recruitment.

19.1.3. **Recovery Action:** Prevent impairment to instream substrate/food productivity (gravel quality and quantity)

19.1.3.1. **Action Step:** Encourage all permanent and year-round access roads beyond the THP parcel be surfaced after harvest completion with base rock and road gravel, asphalt, or chipseal, as appropriate.

19.1.3.2. **Action Step:** Map unstable soils and use that information to guide land use decisions, road design, THPs, and other activities that can promote erosion.

19.1.3.3. **Action Step:** Establish equipment limitation zones on headwater streams and swales.

19.1.3.4. **Action Step:** Decommissioning legacy roads, upgrading road networks, and other rehabilitation work targeting reductions in fine sediment inputs to stream networks.

19.1.4. **Recovery Action:** Prevent impairment to water quality (instream water temperature)

19.1.4.1. **Action Step:** Encourage wider riparian buffer zones in areas where stream temperatures or riparian canopy are found limiting.

19.1.4.2. **Action Step:** Protect current riparian zones in all summer salmonid rearing areas to the extent that they are able to mature, provide, and maintain a minimum of 80% canopy cover.

19.1.5. **Recovery Action:** Prevent adverse alterations to riparian species composition and structure

19.1.5.1. **Action Step:** Conserve and manage forestlands for older forest stages.

19.1.5.2. **Action Step:** Manage riparian areas for their site potential composition and structure.

19.1.6. **Recovery Action:** Prevent increased landscape disturbance

19.1.6.1. **Action Step:** Consider the development of a Watershed Database (similar to the CDFG Northern Spotted Owl database) for salmonids that provides watershed data and information in a consistent fashion to all foresters for consideration in their harvest plans.

19.1.6.2. **Action Step:** Acquire key large tracts of forestlands identified as a priority by Federal, State, local government, and non-governmental organizations

19.1.6.3. **Action Step:** Provide for properly functioning watershed processes (e.g., cycles of wood, water and sediment) by promoting long term sustainable forestry practices that support coho salmon habitats.

19.1.6.4. **Action Step:** Should large tracts of forestlands within the Gualala River watershed identified as a Core or Phase I in this recovery plan become available for purchase, the State of California or other entities should consider purchasing the area as a Demonstration Forest or State Park.

19.1.6.5. **Action Step:** Forestlands supporting Core, Phase I and Phase II priority areas should be considered for purchase (if feasible within the next 5 years).

19.1.6.6. **Action Step:** Discourage home building or other incompatible land use in areas identified as timber production zones (TPZ).

19.1.6.7. **Action Step:** Maintain and expand California's working forestlands and forestlands held by the State, and prevent future conversion of forestlands to agriculture or other land uses.

19.2. **Objective:** Address the inadequacy of existing regulatory mechanisms

19.2.1. **Recovery Action:** Prevent increased landscape disturbance

19.2.1.1. **Action Step:** Work with Sonoma county planning staff to minimize rezoning forestlands to rural residential or other land uses (e.g., vineyards).

19.2.1.2. **Action Step:** Coordinate with regulatory agencies to minimize conversions in key watersheds and discourage forestland conversions.

19.2.1.3. **Action Step:** Establish greater oversight and post-harvest monitoring by the permitting agency for operations within Core, Phase I and Phase II CCC coho salmon areas.

19.2.1.4. **Action Step:** Assign NMFS staff to conduct THP reviews of the highest priority areas using revised "Guidelines for NMFS Staff when Reviewing Timber Operations: Avoiding Take and Harm of Salmon and Steelhead" (NMFS 2004).

19.2.1.5. **Action Step:** Require tree retention on the axis of headwall swales Any deviations should be reviewed and receive written approval by a licensed engineering geologist.

19.2.1.6. **Action Step:** Extend the monitoring period and upgrade THP road maintenance after harvest.

19.2.1.7. **Action Step:** Investigate opportunities to programmatically permit the forest certification program to authorize incidental take for landowners through Section 10(a)(1)(B).

20. Threat- Mining

No species-specific actions were developed.

21. Threat- Recreation

No species-specific actions were developed.

22. Threat- Residential/Commercial Development

No species-specific actions were developed.

23. Threat- Roads/Railroads

23.1. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

23.1.1. **Recovery Action:** Prevent impairment to instream substrate/food productivity (gravel quality and quantity)

23.1.1.1. **Action Step:** Decommission riparian road systems and/or upgrade roads (and skid trails on forestlands) that deliver sediment into adjacent watercourses (CDFG 2004).

23.1.1.2. **Action Step:** Use available best management practices for road construction, maintenance, management and decommissioning (e.g. Weaver and Hagans, 1994; Sommarstrom et al., 2002; Oregon Department of Transportation, 1999).

23.1.1.3. **Action Step:** Conduct road and sediment reduction assessments to identify sediment-related and runoff-related problems and determine level of hydrologic connectivity.

23.1.1.4. **Action Step:** Conduct annual inspections of all roads prior to winter. Correct conditions that are likely to deliver sediment to streams. Hydrologically disconnect roads.

23.1.1.5. **Action Step:** Encourage, when necessary and appropriate, restricted access to unpaved roads in winter to reduce road degradation and sediment release. Where restricted access is not feasible, encourage measures such as rocking to prevent sediment from reaching streams with coho salmon (CDFG 2004).

23.1.1.6. **Action Step:** Evaluate, develop, and implement strategies to address decommissioning old roads, maintaining existing roads, and constructing new roads in the following Gualala mainstem/ SF Gualala Subbasin tributaries: McKenzie Creek, Marchall Creek, Palmer Canyon Creek, Wild Hog Creek, South Fork, and Marshall Creek.

23.1.1.7. **Action Step:** Evaluate, develop, and implement strategies to address decommissioning old roads, maintaining existing roads, and constructing new roads in the following Wheatfield Fork sub-basin tributary reaches: Lower reaches of Haupt and Tabacco Creeks; Lower to middle reaches of Tombs, Wolf, and Elk creeks, and unnamed trib to the mainstem Wheatfield Fork upstream from Tombs Creek, to Elk Creek, and flanked by Bear and Gibson ridges; larger watercourses to the lower reaches of House Creek; middle to higher reaches of House, Pepperwood, Danfield, and Cedar creeks (Klamt et al. 2003).

23.1.1.8. **Action Step:** Evaluate, develop, and implement strategies to address decommissioning old roads, maintaining existing roads, and constructing new roads in the following North Fork sub-basin tributaries: Stewart, Dry, Upper Billings, upper Robinson, Doty, Log Cabin creeks, and McGann Gulch (Klamt et al. 2003).

23.1.1.9. **Action Step:** Use appropriately sized culverts in steep terrain to accommodate flashy, debris-laden flows and maintain trash racks to prevent culvert plugging and subsequent road failure in the Buckeye sub-basin (GRWA 2003).

23.1.2. **Recovery Action:** Prevent impairment to passage and migration

23.1.2.1. **Action Step:** Prevent future barriers on newly constructed roads utilizing NMFS Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001a)

23.1.2.2. **Action Step:** Ensure that all future road or bridge repairs at stream crossing provide unimpaired fish passage for all salmonid life stages.

23.1.3. **Recovery Action:** Prevent impairment to water quality (increased turbidity, suspended sediment, and/or toxicity)

23.1.3.1. **Action Step:** Design new roads that avoid riparian areas and are hydrologically disconnected from the stream network.

23.1.4. **Recovery Action:** Prevent increased landscape disturbance

23.1.4.1. **Action Step:** Reduce road densities by 10 percent over the next 10 years, prioritizing high risk areas in historical habitats or Core CCC coho salmon watersheds.

23.1.4.2. **Action Step:** Develop a Road Sediment Reduction Plan that prioritizes sites and outlines implementation and a timeline of necessary actions.

23.1.4.3. **Action Step:** Conduct outreach and education regarding the adverse effects of roads, and the types of best management practices protective of salmonids.

23.1.4.4. **Action Step:** Develop a Salmon Certification Program for road maintenance staff.

24. Threat- Severe Weather Patterns

24.1. **Objective:** Address the inadequacy of existing regulatory mechanisms

24.1.1. **Recovery Action:** Prevent impairment to stream hydrology (stream flow)

24.1.1.1. **Action Step:** Use the emergency drought operations center (EDOC) or other similar group to oversee implementation of water conservation measures and alternatives.

24.1.1.2. **Action Step:** Work with CDFG, Counties, other agencies, and knowledgeable biologists to develop emergency rules and adopt implementation agreements.

24.1.1.3. **Action Step:** Impose mandatory conservation measures to maintain instream flow needs of CCC coho salmon.

25. Threat- Water Diversion/Impoundment

25.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

25.1.1. **Recovery Action:** Prevent impairment to stream hydrology (stream flow)

25.1.1.1. **Action Step:** Ensure that current and future water diversions (surface or groundwater) do not impair water quality conditions in summer rearing reaches.

25.1.1.2. **Action Step:** Ensure water supply demands can be met without impacting flow either directly or indirectly through groundwater withdrawals and aquifer depletion.

25.1.1.3. **Action Step:** Provide incentives to water rights holders willing to convert some or all of their water rights to instream use via petition change of use and §1707 (CDFG 2004).

25.1.2. **Recovery Action:** Prevent impairment to passage and migration

25.1.2.1. **Action Step:** Establish flow related adult and smolt migration thresholds for prior to authorizing future water diversions.

25.1.3. **Recovery Action:** Prevent impairment to the estuary (quality and extent)

25.1.3.1. **Action Step:** Discourage the development of any surface water diversions in the watershed that independently or cumulatively have significant impact on reducing inflow to the estuary during spring/summer/fall months (ECORP and Kamman Hydrology & Engineering 2005).

25.1.3.2. **Action Step:** Develop and implement Estuary Inflow Protection and Enhancement Guidelines to maintain estuary function and provide information for estuary restoration.

25.1.4. **Recovery Action:** Prevent impairment to water quality (instream temperature)

25.1.4.1. **Action Step:** Ensure future water diversions do not impair instream water temperatures during the dry season.

25.2. **Objective:** Address the inadequacy of existing regulatory mechanisms

25.2.1. **Recovery Action:** Prevent impairment to stream hydrology (stream flow)

25.2.1.1. **Action Step:** Ensure all water diversions and impoundments are complaint with AB2121 or other appropriate protective measures.

25.2.1.2. **Action Step:** Identify and work with the SWRCB to eliminate depletion of summer base flows from unauthorized water uses. Coordinated efforts by Federal and State, and County law enforcement agencies to remove illegal diversions from streams.

25.2.1.3. **Action Step:** Improve coordination between agencies and others to address season of diversion, off-stream reservoirs, bypass flows protective of coho salmon and their habitats, and avoidance of adverse impacts caused by water diversion (CDFG 2004).

26. Threat- Watershed Process

No species-specific actions were developed.

Table 3: Implementation Schedule ~ Gualala River

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-1.1	**Objective**	**Estuary**	**Address the present or threatened destruction, modification or curtailment of the species habitat or range**										
GuaR-CCC-1.1.1	Recovery Action	Estuary	Increase the physical extent of estuarine habitat										
GuaR-CCC-1.1.1.1	Action Step	Estuary	Investigate the extent of sedimentation within the estuary/lagoon associated with watershed legacy impacts (logging). Evaluate sediment transport within the estuary and determine if the estuary is "filling" with sediment or "flushing" sediment (recovering).	3	10	CDFG, NMFS HCD, NOAA RC, NRCS, RCD, RWQCB	117.00	117.00				234	Cost based on sediment assessment estimated at $12.22/acre. Assume 10% of total watershed acres.
GuaR-CCC-1.1.1.2	Action Step	Estuary	Identify past mechanical fill sites (inside of Mill Bend (?)) and develop strategies targeting the re-establishment of wetland marsh habitat (if feasible).	3	10	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD						TBD	Cost accounted for in other action steps. Feasibility of re-establishing wetland marsh habitat should be identified in estuary monitoring.
GuaR-CCC-1.1.1.3	Action Step	Estuary	Develop and implement rehabilitation projects designed to increase the physical extent of high quality habitat for rearing juvenile salmonids within the Gualala River estuary.	3	10	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners	680	680				1,360	Cost based on treating 5 acres (assume 5% of total estuarine habitat) at a rate of $272,120/acre.
GuaR-CCC-1.1.2	Recovery Action	Estuary	Increase and enhance estuarine habitat complexity features										
GuaR-CCC-1.1.2.1	Action Step	Estuary	Increase the percentage of area containing high value habitat complexity elements and features (SAV, LWD, boulders, marshes, vegetation, pools > 2 meters).	2								101,000	Cost based on stream complexity recovery action at $101,120/mile from estuary mouth to Highway 1 bridge.
GuaR-CCC-1.1.2.2	Action Step	Estuary	Identify strategic locations to install LWD structures designed to increased pool depth and habitat conditions within the Gualala River estuary.	2	10								Costs associated with installation of LWD would be encompassed by increasing the percentage of area high value habitat.
GuaR-CCC-1.1.3	Recovery Action	Estuary	Improve the quality of freshwater lagoon habitat										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-1.1.3.1	Action Step	Estuary	Install continuous water quality monitoring stations in the Gualala estuary during the summer months. Monitor at a minimum temperature, dissolved oxygen, and salinity.	2	5	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, RCD, RWQCB	15.00					15	Cost based on continuous monitoring gauges estimated at $5,000/unit. Assume a minimum of 3 for lagoon. Cost does not account for maintenance or data management.
GuaR-CCC-1.1.4	Recovery Action	Estuary	Improve freshwater inflow										
GuaR-CCC-1.1.4.1	Action Step	Estuary	Install a stream gauge immediately upstream of the estuary/lagoon to monitor inflow conditions during the dry season.	2	5	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, Public, RWQCB	1.00					1	Cost based on stream gauges estimated at $1,000/gauge. Cost does not account for maintenance or data management.
GuaR-CCC-1.1.4.2	Action Step	Estuary	Investigate the hydrodynamics of freshwater inflow and estuary water quality conditions relative to juvenile salmonid estuarine summer rearing (osmo-regulating and non-osmoregulating).	2	10	CDFG, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Consultants, Private Landowners, RCD, RWQCB, SWRCB	136.61	136.61				273	Cost based estuary use estimated at $273,217/project.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-1.1.4.3	Action Step	Estuary	Identify and implement minimum freshwater inflow thresholds to ensure optimal estuary health and function.	2	5	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Consultants, RWQCB, SWRCB	63.01					63	Cost based on stream flow model estimated at $63,005/project.
GuaR-CCC-3.1	**Objective**	**Habitat Complexity**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range.**										
GuaR-CCC-3.1.1	Recovery Action	Habitat Complexity	Increase large wood frequency (BFW 0-10 meters)										
GuaR-CCC-3.1.1.1	Action Step	Habitat Complexity	Increase wood frequency in salmonid spawning and rearing areas to the extent that a minimum of 6 key LWD pieces exists every 100 meters in 0-10 meter BFW streams.	2	10	Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, Public, RCD	350.00	350.00				700	Cost based on treating 28 miles (assume 1 project/mile in 50% High IP) at a rate of $25,000/mile.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-3.1.1.2	Action Step	Habitat Complexity	Design and install LWD structures in McKenzie and Wild Hog creeks, and the SF sub-basin to the extent that optimal LWD frequency is achieved at strategic locations.	2	20	Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, Public, RWQCB							Cost accounted for in above.
GuaR-CCC-3.1.2	Recovery Action	Habitat Complexity	Increase large wood frequency (BFW 10-100 meters)										
GuaR-CCC-3.1.2.1	Action Step	Habitat Complexity	Increase wood frequency in seasonal habitat and migratory reaches to the extent that a minimum of 1.3 to 4 key LWD pieces exists every 100 meters in 10-100 meter BFW streams.	2	10	CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, Public, RCD, RWQCB	125.00	125.00				250	Cost based on treating 10 miles (assume 1 project/mile in 50% High IP) at a rate of $25,000/mile.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-3.1.2.2	Action Step	Habitat Complexity	Design and implement a SF Gualala mainstem migration project. Focus should include a higher frequency of significantly large wood structures to enhance staging pool development.	2		CDFG, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, Public, RCD							
GuaR-CCC-3.1.2.3	Action Step	Habitat Complexity	Evaluate, design, and implement salmonid habitat improvement structures as appropriate to the stream channel type and hydrologic conditions within the Rockpile Sub-basin	2		Conservation Fund, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, Public, RCD, The Nature Conservancy							
GuaR-CCC-3.1.2.4	Action Step	Habitat Complexity	Evaluate, design, and implement salmonid habitat improvement structures as appropriate to the stream channel type and hydrologic conditions within the Buckeye Sub-basin.	2		CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, Private Landowners, Public, RCD, RWQCB							
GuaR-CCC-3.1.3	Recovery Action	Habitat Complexity	Improve pool shelter rating										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-3.1.3.1	Action Step	Habitat Complexity	Evaluate, design, and implement strategies to improve shelter pools ratings within the Rockpile and Buckeye sub-basins and the following tributaries: Boyd, Buckeye, Camper, Carson, Danfield, Doty, Dry, Franchini, Fuller, Grasshopper, Groshong Gulch, House, Little NF GR, Log Cabin, Marshall, McGann, McKenzie, NF Fuller, Lower NF GR, Palmer Canyon, Pepperwood, Rockpile, SF Fuller, Sullivan, Tombs, Wheatfield Fork, and Wild Hog creeks.	2	20	CDFG, Conservation Fund, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, Public, RCD, The Nature Conservancy	175.00	175.00	175.00	175.00		700	Cost based on treating 28 miles (assume 1 project/mile in 50% High IP) at a rate of $25,000/mile. This action step should be in concert with increasing LWD frequency and therefore cost could be lower.
GuaR-CCC-3.1.4	Recovery Action	Habitat Complexity	Increase primary pools frequency										
GuaR-CCC-3.1.4.1	Action Step	Habitat Complexity	Evaluate, develop, and implement strategies to increase primary pool frequency in high priority reaches within the following tributaries: Boyd, Doty, Dry, Fuller, Little NF GR, Log Cabin, Marshall, McGann, McKenzie, Palmer, Robinson, Tombs, and West Fork Fuller.	2	20	CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, Public, RCD							Cost accounted for in other action steps.
GuaR-CCC-3.1.4.2	Action Step	Habitat Complexity	Identify historic CCC coho salmon habitats lacking in channel complexity and implement restoration projects designed to create or restore complex habitat features that provide for localized pool scour, velocity refuge, and cover. Prioritize Core areas first followed by Phase I areas.	2	20	CDFG, NOAA RC, Private Landowners						TBD	Continue current restoration projects in progress.
GuaR-CCC-3.1.4.3	Action Step	Habitat Complexity	Encourage coordination of LWD placement in streams as part of logging operations and road upgrades to maximize size, quality, and efficiency of effort (CDFG 2004).	2	20	CalFire, CDFG, NOAA RC, Private Landowners						In-Kind	Cost to coordinate projects is expected to be low.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-3.1.4.4	Action Step	Habitat Complexity	Encourage landowners to implement restoration projects as part of their ongoing operations in stream reaches where large woody debris is lacking.	2	60	CDFG, NOAA RC, Private Landowners						In-Kind	Minimal cost expected.
GuaR-CCC-3.1.4.5	Action Step	Habitat Complexity	Maintain current LWD, boulders, and other structure-providing features to maintain current stream complexity, pool frequency, and depth (CDFG 2004).	2	60	CDFG, NMFS, NRCS, Private Landowners						In-Kind	Cost to maintain LWD is expected to be minimal.
GuaR-CCC-3.1.5	Recovery Action	Habitat Complexity	Improve pool/riffle/flatwater ratios (hydraulic diversity)										
GuaR-CCC-3.1.5.1	Action Step	Habitat Complexity	Increase the frequencies to 75% of the streams within the watershed	2	20							TBD	Cost should be accounted for in increase LWD frequency and primary pools.
GuaR-CCC-4.1	**Objective**	**Hydrology**	**Address the present or threatened destruction, modification or curtailment of the species habitat or range**										
GuaR-CCC-4.1.1	Recovery Action	Hydrology	Improve flow conditions (baseflow conditions)										
GuaR-CCC-4.1.1.1	Action Step	Hydrology	Continue to work with the North Gualala Water Company on water right Permit 14853. Ensure that the Site-specific Study Plan prepared for the NGWC by Stillwater Sciences (11 October 2011) is completed within the next 3-yrs. Implement recommendations within the next 5-years. Ensure salmonid life history requirements targeted in the proposal are evaluate under a range of water year types (dry - wet). Evaluate potential impacts to dry season estuary water quality conditions associated with Permit 14853.	2	20	CDFG, CDFG Law Enforcement, Gualala Watershed Council, NMFS HCD, NMFS OLE, NMFS PRD, North Gualala Water Company, SWRCB						In-Kind	
GuaR-CCC-4.1.1.2	Action Step	Hydrology	Map all water diversions and upgrade the existing water rights information system so that water allocations can be readily quantified by watershed.	2	60	CDFG, NMFS, North Gualala Water Company, Private Landowners, Sea Ranch, SWRCB						TBD	Costs may be minimal due to the low number of diverters in this basin.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-4.1.1.3	Action Step	Hydrology	Monitor, identify problems, and prioritize needed changes to permitted water diversions on current or potential coho salmon streams.	2	10	BLM, CDFG, NMFS, North Gualala Water Company, Private Landowners, Sea Ranch, SWRCB						TBD	Problems should be identified through mapping diversion and developing stream flow model.
GuaR-CCC-4.1.1.4	Action Step	Hydrology	Install and maintain a gauging station immediately upstream of the estuary to monitor freshwater inflow during the dry season.	2	10	CDFG, NMFS, USGS	0.50	0.50				1	Provide consistent funding for the North Fork Gualala River and possible funding for the Wheatfield Forks of the Gualala River. Cost of installing stream gage is $1000/unit. Cost does not account for maintenance or data management.
GuaR-CCC-4.1.1.5	Action Step	Hydrology	Develop critical flow values that are the basis for minimum bypass flow requirements to support juvenile rearing habitat conditions during the dry season. Focus on core coho salmon areas initially.	1	5	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, RCD, RWQCB, Sea Ranch, SWRCB							Cost accounted for in stream flow model.
GuaR-CCC-4.1.1.6	Action Step	Hydrology	Install and maintain a stream gauge at an appropriate location near the base of Rockpile Creek.	3	10	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, RWQCB, SWRCB	0.50	0.50				1	Cost based on stream gauge estimated at $1,000/gauge. Cost does not account for maintenance or data management.
GuaR-CCC-4.1.1.7	Action Step	Hydrology	Install and maintain a stream gauge at an appropriate location near the base of Buckeye Creek.	3	indefinitely	CDFG, NMFS HCD, NMFS PRD, NRCS, Private Landowners, RCD, SWRCB							

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-4.1.1.8	Action Step	Hydrology	Install and maintain a stream gauge at an appropriate location immediately downstream of the SF Gualala and Wheatfield Fork confluence.	3	10	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, NRCS, Private Landowners, RCD, Sea Ranch, SWRCB	0.50	0.50				1	Cost based on stream flow gauge estimated at $1,000/gauge. Cost does not account for maintenance or data management.
GuaR-CCC-4.1.1.9	Action Step	Hydrology	Evaluate and implement off-channel storage facilities to reduce impacts of water diversion (storage tanks for rural residential users). Focus efforts in the NF Gualala and Wheatfield sub-watersheds.	2	20	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, North Gualala Water Company, NRCS, SWRCB						TBD	Cost difficult to estimated because of participation of landowners and feasibility of off-channel storage facilities.
GuaR-CCC-5.1	**Objective**	**Landscape Patterns**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range**										
GuaR-CCC-5.1.1	Recovery Action	Landscape Patterns	Prevent increased landscape disturbance										
GuaR-CCC-5.1.1.1	Action Step	Landscape Patterns	Consider developing and/or identifying Salmonid Preserves. Consider the Gualala River watershed as a Salmonid Preserve.	2	100	CDFG, NMFS, NMFS HCD, NMFS PRD, NOAA RC							
GuaR-CCC-5.1.1.2	Action Step	Landscape Patterns	Should large tracts of forestlands within the Gualala River watershed become available for purchase, the State of California and/or the Federal Government should consider purchasing the area as a Demonstration Forest, State Park, or Salmonid Preserve.	2	50	CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD, NOAA RC						TBD	Cost difficult to estimate because of fair market value and land use turnover.
GuaR-CCC-5.2	**Objective**	**Landscape Patterns**	**Address the inadequacy of existing regulatory mechanisms**										
GuaR-CCC-5.2.1	Recovery Action	Landscape Patterns	Prevent increased landscape disturbance										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-5.2.1.1	Action Step	Landscape Patterns	Discourage counties from rezoning forestlands to rural residential or other land uses (e.g., vineyards).	1	100	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, North Gualala Water Company, NRCS, RCD, Sea Ranch, Sonoma County, SWRCB						In-Kind	
GuaR-CCC-5.2.1.2	Action Step	Landscape Patterns	Discourage any forestland to agricultural and/or rural/urban development.	1	100	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, Gualala Watershed Council, NMFS, NMFS HCD, NMFS PRD, North Gualala Water Company, NRCS, Private Landowners, Public, RCD, Sea Ranch, Sonoma County, SWRCB						In-Kind	
GuaR-CCC-6.1	**Objective**	**Passage**	**Address the present or threatened destruction, modification or curtailment of the species habitat or range**										
GuaR-CCC-6.1.1	Recovery Action	Passage	Modify or remove physical passage barriers										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-6.1.1.1	Action Step	Passage	Evaluate, design, and implement appropriate fish passage at South Beach Road Crossing on Fuller Creek (Wheatfield Fork sub-basin; See CALFISH: PAD_ID 736904; Passage ID 13268)	2	10	CDFG, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD	31.50	31.50				63	Cost based on stream crossing at $63,000/unit.
GuaR-CCC-6.1.1.2	Action Step	Passage	Evaluate, design, and implement appropriate fish passage designs in Palmer Canyon and McKenzie creeks (Wheatfield Fork sub-basin; Klamt et al. 2003).	2	10	CDFG, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD	950	950				1,900	Cost based on implementing two fish passage facilities at a rate of $961,000/unit.
GuaR-CCC-8.1	**Objective**	**Riparian**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range**										
GuaR-CCC-8.1.1	Recovery Action	Riparian	Improve tree diameter										
GuaR-CCC-8.1.1.1	Action Step	Riparian	Increase tree diameter to a minimum of 80% CWHR density rating "D" across all current and potential spawning and juvenile rearing areas.	2	20	Board of Forestry, CalFire, CDFG, Conservation Fund, Gualala Redwood Company, NMFS HCD, NMFS PRD, The Nature Conservancy	1,205	1,205	1,205	1,205		4,820	Cost based on treating 3 miles (assume 80 acres/mile in 5% High IP) at a rate of $20,057/acre.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-8.1.1.2	Action Step	Riparian	Prioritize large tree retention along the SF Gualala River.	2	50	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD						In-Kind	
GuaR-CCC-8.1.1.3	Action Step	Riparian	Conduct conifer release to promote growth of larger diameter trees where appropriate.	2	10	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD, NRCS, RCD	550	550				1,100	Cost based on treating 9 miles (assume 80 acres/mile in 15% High IP) at a rate of $1,422/acre.
GuaR-CCC-8.1.2	Recovery Action	Riparian	Improve canopy cover										
GuaR-CCC-8.1.2.1	Action Step	Riparian	Increase the average stream canopy cover within potential spawning and rearing reaches to a minimum of 80%.	2	20	Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, The Nature Conservancy	1,205	1,205	1,205	1,205		4,820	Cost based on treating 3 miles (assume 80 acres/mile in 5% High IP) at a rate of $20,057/acre. This action step should be in concert with increasing tree diameter to a minimum of 80% CWHR.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-8.1.2.2	Action Step	Riparian	Evaluate buffers width and/or timber harvest in terms of light penetration and potential changes to micro-climate conditions along the SF Gualala River.	2	50	Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD						In-Kind	
GuaR-CCC-8.1.2.3	Action Step	Riparian	Identify and implement riparian enhancement projects where current canopy density and diversity are inadequate and site conditions are appropriate to: initiate tree planting, thinning, and other vegetation management to encourage the development of a denser more extensive riparian canopy in the following reaches and tributaries of the NF Gualala sub-basin: upper reaches of Dry Creek, Robinson Creek, the central and higher reaches of the mainstem, and the lower reaches of Bear and Stewart Creeks (Klamt et al. 2003).	2	20	Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, RCD						TBD	Cost likely accounted for in above action steps.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-8.1.2.4	Action Step	Riparian	Identify and implement riparian enhancement projects where current canopy density and diversity are inadequate and site conditions are appropriate to: initiate tree planting, thinning, and other vegetation management to encourage the development of a denser more extensive riparian canopy in the following reaches and tributaries of the Rockpile sub-basin: mainstem Rockpile Creek, Red Rock Creek, and Horsetheif (Klamt et al. 2003).	2	20	Board of Forestry, CalFire, CDFG, Conservation Fund, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, RCD, The Nature Conservancy						TBD	Cost likely accounted for in above action steps.
GuaR-CCC-8.1.2.5	Action Step	Riparian	Identify and implement riparian enhancement projects where current canopy density and diversity are inadequate and site conditions are appropriate to: initiate tree planting, thinning, and other vegetation management to encourage the development of a denser more extensive riparian canopy in the following reaches and tributaries of the Buckeye sub-basin: upper reaches of Buckeye Creek, Franchini, Grasshopper, and Soda Springs creeks (Klamt et al. 2003).	2	20	Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, RCD						TBD	Cost likely accounted for in above action steps.
GuaR-CCC-9.1	**Objective**	**Sediment**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range**										
GuaR-CCC-9.1.1	Recovery Action	Sediment	Improve instream gravel quality										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-9.1.1.1	Action Step	Sediment	Treat high priority slides and landings identified in credible landowner assessments.	1	20	CDFG, NOAA RC, Private Landowners						TBD	Site specific information needed for a accurate cost estimate.
GuaR-CCC-9.1.1.2	Action Step	Sediment	Continue efforts such as erosion proofing, improvements, and decommissioning, through the Rockpile sub-basin to reduce sediment delivery to central Rockpile Creeks and Rockpile tributaries.	2	10	Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD	30.00	30.00				60	Cost based on decommissioning 5 miles of road network at a rate of $12,000/mile.
GuaR-CCC-10.1	**Objective**	**Viability**	**Address other natural or manmade factors affecting the species continued existence**										
GuaR-CCC-10.1.1	Recovery Action	Viability	Increase spawner density										
GuaR-CCC-10.1.1.1	Action Step	Viability	Determine if there is a need for a conservation hatchery/supplementation/augmentation program. Assess the following prior to supplementation (Action Steps 2-7):	1	12	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NOAA SWFSC						In-Kind	This recommendation will determine cost for action steps below
GuaR-CCC-10.1.1.2	Action Step	Viability	Determine the biological or DPS significance of the Gualala coho salmon population.	1	20	CDFG, NMFS, NMFS HCD, NMFS PRD, NOAA RC, NOAA SWFSC						In-Kind	
GuaR-CCC-10.1.1.3	Action Step	Viability	Investigate the population dynamics and viability status of coho salmon in the Gualala River watershed.	1	10	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NOAA SWFSC	65.00	65.00				130	Cost based on abundance and distribution monitoring estimated at $129,391/project.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-10.1.1.4	Action Step	Viability	Determine if the coho salmon population within the Gualala River watershed is at a short-term or immediate risk of extinction.	1	20	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NOAA SWFSC						In-Kind	
GuaR-CCC-10.1.1.5	Action Step	Viability	Identify population viability goals and the expectations of a conservation hatchery/supplementation/augmentation program.	1	20	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NOAA SWFSC						In-Kind	
GuaR-CCC-10.1.1.6	Action Step	Viability	Investigate the genetic diversity of coho salmon in the Gualala River.	1	20	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NOAA SWFSC						In-Kind	
GuaR-CCC-10.1.1.7	Action Step	Viability	If determine necessary, identify a source population (in or out of basin stock) that could be used to start a population augmentation/supplementation/ broodstock program.	1	20	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NOAA SWFSC						In-Kind	
GuaR-CCC-10.1.2	Recovery Action	Viability	Increase spatial structure and diversity										
GuaR-CCC-10.1.2.1	Action Step	Viability	Continue and expand upon biological monitoring activities to determine salmonid population and productivity trends at the watershed and sub-watershed scales. Information regarding spawner escapement and smolt production are the highest priorities.	2	10	CDFG, NMFS, Private Landowners, RCD	115.00	115.00				230	Cost based on annual spawner ground estimated at $64,040/year and smolt outmigration surveys $50,030/year for Central Coastal diversity stratum.
GuaR-CCC-11.1	**Objective**	**Water Quality**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range**										
GuaR-CCC-11.1.1	Recovery Action	Water Quality	Improve stream temperature conditions										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-11.1.1.1	Action Step	Water Quality	Expand continuous temperature monitoring efforts into the upper sub-basins and tributaries that provide summer rearing for salmonids. Investigate canopy composition and monitoring air temperature to examine the relationship between canopy, temperature, and other micro-climate effects on water temperature (Klamt et al. 2003).	2		CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC							
GuaR-CCC-11.1.1.2	Action Step	Water Quality	Evaluate the current adequacy of buffer zones in recently logged areas and ensure stream temperatures have not increased due to these activities.	2		Board of Forestry, CalFire, CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, Private Landowners, RCD							
GuaR-CCC-11.1.1.3	Action Step	Water Quality	Implement actions to maintain and restore water temperatures to meet habitat requirements for CCC coho salmon in specific streams (CDFG 2004).	2		CDFG, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NRCS, Private Landowners							
GuaR-CCC-12.1	**Objective**	**Agricultural Practices**	**Address the present or threatened destruction, modification or curtailment of the species habitat or range**										
GuaR-CCC-12.1.1	Recovery Action	Agricultural Practices	Prevent impairment to instream habitat complexity (altered pool complexity and/or pool riffle ratio)										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-12.1.1.1	Action Step	Agricultural Practices	Discourage forest-to-vineyard land conversions or other agricultural activities that may impact natural stream channel morphology.	1	30	Board of Forestry, CalFire, CDFG, NMFS, Sonoma County						In-Kind	This action is considered part of doing business with regulatory agencies and stakeholders.
GuaR-CCC-12.1.2	Recovery Action	Agricultural Practices	Prevent impairment to instream substrate/food productivity (gravel quality and quantity)										
GuaR-CCC-12.1.2.1	Action Step	Agricultural Practices	Address sources from agricultural activities that deliver sediment and runoff to stream channels.	3		CA Coastal Commission, CDFG, DWR, NOAA RC, NRCS, Private Landowners, RCD							
GuaR-CCC-12.1.2.2	Action Step	Agricultural Practices	Work with vineyard owners to assess the effectiveness of erosion control measures throughout the winter period.	3	5	CalFire, CDFG, NMFS, RWQCB, Sonoma County	50.00					50	Cost estimate for field work by agency or other staff.
GuaR-CCC-12.1.2.3	Action Step	Agricultural Practices	Encourage and assist the NRCS and RCD to increase the number of landowners participating in sediment reduction planning and implementation.	3		CDFG, NMFS, NOAA RC, Private Landowners							
GuaR-CCC-12.1.2.4	Action Step	Agricultural Practices	Establish appropriately sized and properly functioning riparian buffers adjacent to watercourses that have a potential to deliver sediment to spawning and rearing habitat.	3		NRCS, Private Landowners, RCD							
GuaR-CCC-12.1.3	Recovery Action	Agricultural Practices	Prevent impairment to water quality (instream water temperature)										
GuaR-CCC-12.1.3.1	Action Step	Agricultural Practices	Maintain functional riparian stream buffers that provide desirable stream canopy cover adjacent to agricultural land activities.	2	20	FishNet 4C, NOAA RC, Private Landowners, Sonoma County						TBD	Additional information needed on the size and scope of projects in order to estimate cost.
GuaR-CCC-12.1.4	Recovery Action	Agricultural Practices	Prevent impairment to watershed hydrology										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-12.1.4.1	Action Step	Agricultural Practices	Promote off-channel storage facilities (e.g. winter diversion ponds) in efforts to reduce in-stream flow impacts associated with agricultural water use.	2	10	CalFire, CDFG, NMFS, NMFS OLE, Private Landowners, Sonoma County, SWRCB						TBD	Low cost to promote. Implementation likely 1-2 million based on recent Russian River costs to develop off-channel storage.
GuaR-CCC-12.1.5	Recovery Action	Agricultural Practices	Prevent increased landscape disturbance										
GuaR-CCC-12.1.5.1	Action Step	Agricultural Practices	Work within the agricultural community to educate landowners and enhance practices that provide for functional watershed processes.	3	20	Farm Bureau, FishNet 4C, Private Landowners, Sonoma County						0	Relatively low cost is expected to work with agricultural community.
GuaR-CCC-12.1.5.2	Action Step	Agricultural Practices	Improve education and awareness to agencies, landowners, and the general public regarding salmonid recovery and habitat requirements.	3		NMFS, NOAA RC, NRCS, Private Landowners, Public, RCD							
GuaR-CCC-12.2	**Objective**	**Agricultural Practices**	**Address the inadequacy of existing regulatory mechanisms**										
GuaR-CCC-12.2.1	Recovery Action	Agricultural Practices	Prevent increased landscape disturbance										
GuaR-CCC-12.2.1.1	Action Step	Agricultural Practices	Coordinate with regulatory agencies authorizing/permitting forestland-to-agriculture conversions to ensure consistency with salmonid recovery goals.	1		CalFire, CDFG, NMFS HCD, NMFS PRD, Sonoma County							
GuaR-CCC-12.2.1.2	Action Step	Agricultural Practices	Streamline permit processing where landowners are conducting actions aligned with recovery priorities.	2		CDFG, NMFS HCD, NMFS PRD, NOAA RC, Private Landowners, RCD							

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-12.2.1.3	Action Step	Agricultural Practices	Technical support to counties by NMFS staff should be conducted to encourage county general plan updates that include measures to conserve and protect salmonids and their habitats.	3		NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, Public Works, RCD, Sonoma County							
GuaR-CCC-12.2.2	Recovery Action	Agricultural Practices	Prevent impairment to watershed hydrology										
GuaR-CCC-12.2.2.1	Action Step	Agricultural Practices	Identify and eliminate depletion of summer base flows from unauthorized water users.	2	20	CDFG, NMFS HCD, NMFS OLE, NMFS PRD, NOAA RC, North Gualala Water Company, SWRCB						TBD	Development of stream flow model will identify summer base flow levels.
GuaR-CCC-12.2.2.2	Action Step	Agricultural Practices	Develop legislation to fund county planning for environmentally sound agricultural growth and water supply.	2	30	CDFG, NMFS HCD, NMFS PRD, Sonoma County, SWRCB						In-Kind	
GuaR-CCC-16.1	**Objective**	**Fishing/Collecting**	**Address the inadequacy of existing regulatory mechanisms**										
GuaR-CCC-16.1.1	Recovery Action	Fishing/Collecting	Prevent reduced density, abundance, and diversity										
GuaR-CCC-16.1.1.1	Action Step	Fishing/Collecting	Work with CDFG to modify Section 8.00(b)(1) low flow minimum flow closure for Mendocino, Sonoma, and Marin counties. Discontinue using the Russian River at Guerneville gauging station for angling closures and use the Navarro River USGS gauging station (11468000) which better reflects hydrologic conditions in smaller unregulated coastal Sonoma/Mendocino streams.	2	100	CDFG, NMFS						In-Kind	
GuaR-CCC-18.1	**Objective**	**Livestock**	**Address the present or threatened destruction, modification or curtailment of the species habitat or range**										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-18.1.1	Recovery Action	Livestock	Prevent adverse alterations to riparian species composition and structure										
GuaR-CCC-18.1.1.1	Action Step	Livestock	Reduce livestock and feral pig access to the riparian zone to encourage bank stabilization and re-vegetation of riparian areas within the following sub-basins: Gualala Main stem/ SF Garcia, Wheatfield Fork, Rockpile (Klamt et al. 2003).	3		CDFG, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD							
GuaR-CCC-19.1	**Objective**	**Logging**	**Address the present or threatened destruction, modification or curtailment of the species habitat or range**										
GuaR-CCC-19.1.1	Recovery Action	Logging	Prevent impairment to floodplain connectivity (quality & extent)										
GuaR-CCC-19.1.1.1	Action Step	Logging	Timber harvest planning should evaluate and avoid impacts to off channel habitat, floodplains, ponds, and oxbows.	2	50	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD, NRCS, RCD						In-Kind	
GuaR-CCC-19.1.2	Recovery Action	Logging	Prevent impairment to instream habitat complexity (reduced large wood and/or shelter)										
GuaR-CCC-19.1.2.1	Action Step	Logging	Encourage coordination of LWD placement projects in streams (as necessary) as part of logging operations.	3	30	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD, NOAA RC, RCD						In-Kind	This recommendation should be considered standard practice.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-19.1.2.2	Action Step	Logging	Retain the largest trees in all riparian zones (including intermittent and ephemeral streams) for bank stability and long-term wood recruitment.	2	100	Board of Forestry, CalFire, Gualala Redwood Company, NMFS HCD, NMFS PRD, NRCS, RCD						In-Kind	
GuaR-CCC-19.1.3	Recovery Action	Logging	Prevent impairment to instream substrate/food productivity (gravel quality and quantity)										
GuaR-CCC-19.1.3.1	Action Step	Logging	Encourage all permanent and year-round access roads beyond the THP parcel be surfaced after harvest completion with base rock and road gravel, asphalt, or chipseal, as appropriate.	3	60	CalFire, Private Landowners						TBD	See Roads section.
GuaR-CCC-19.1.3.2	Action Step	Logging	Map unstable soils and use that information to guide land use decisions, road design, THPs, and other activities that can promote erosion.	3	20	CalFire, California Geological Survey, Private Consultants, Private Landowners, RWQCB						TBD	Cost expected to be low because much of this mapping has been completed.
GuaR-CCC-19.1.3.3	Action Step	Logging	Establish equipment limitation zones on headwater streams and swales.	3	50	Board of Forestry, CalFire, CDFG, NMFS HCD, NMFS PRD, NRCS, RCD						In-Kind	

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-19.1.3.4	Action Step	Logging	Decommissioning legacy roads, upgrading road networks, and other rehabilitation work targeting reductions in fine sediment inputs to stream networks.	2	20	Board of Forestry, CalFire, CDFG, Conservation Fund, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, Private Landowners, RCD	137.50	137.50	137.50	137.50		550	Cost to decommission 40 miles (assume 10% of road network) at a rate of $12,000/mile.
GuaR-CCC-19.1.4	Recovery Action	Logging	Prevent impairment to water quality (instream water temperature)										
GuaR-CCC-19.1.4.1	Action Step	Logging	Encourage wider riparian buffer zones in areas where stream temperatures or riparian canopy are found limiting.	2	30	Board of Forestry, CalFire, Friends of the Gualala River Watershed, Gualala Redwood Company, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD						In-Kind	
GuaR-CCC-19.1.4.2	Action Step	Logging	Protect current riparian zones in all summer salmonid rearing areas to the extent that they are able to mature, provide, and maintain a minimum of 80% canopy cover.	2	100	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD, Private Landowners, RCD						In-Kind	
GuaR-CCC-19.1.5	Recovery Action	Logging	Prevent adverse alterations to riparian species composition and structure										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-19.1.5.1	Action Step	Logging	Conserve and manage forestlands for older forest stages.	2	100	Board of Forestry, CalFire, CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD						In-Kind	
GuaR-CCC-19.1.5.2	Action Step	Logging	Manage riparian areas for their site potential composition and structure.	2	60	Board of Forestry, CalFire, CDFG, NMFS						TBD	Cost of reducing timber available in riparian areas needs to be calculated for estimating cost of this action.
GuaR-CCC-19.1.6	Recovery Action	Logging	Prevent increased landscape disturbance										
GuaR-CCC-19.1.6.1	Action Step	Logging	Consider the development of a Watershed Database (similar to the CDFG Northern Spotted Owl database) for salmonids that provides watershed data and information in a consistent fashion to all foresters for consideration in their harvest plans.	3	20	Board of Forestry, CDFG, NMFS HCD, NMFS PRD						TBD	
GuaR-CCC-19.1.6.2	Action Step	Logging	Acquire key large tracts of forestlands identified as a priority by Federal, State, local government, and non-governmental organizations	2	30	CDFG, NMFS, NMFS HCD, NMFS PRD, NOAA RC						TBD	Cost are difficult to estimate because of fair market value and rate of turnover.
GuaR-CCC-19.1.6.3	Action Step	Logging	Provide for properly functioning watershed processes (e.g., cycles of wood, water and sediment) by promoting long term sustainable forestry practices that support coho salmon habitats.	2	100	Board of Forestry, CalFire, CDFG, NMFS HCD, NMFS PRD, RWQCB						In-Kind	
GuaR-CCC-19.1.6.4	Action Step	Logging	Should large tracts of forestlands within the Gualala River watershed identified as a Core or Phase I in this recovery plan become available for purchase, the State of California or other entities should consider purchasing the area as a Demonstration Forest or State Park.	2	20	BLM, CalFire, California Coastal Conservancy, CDFG, Conservation Fund, NMFS, Private Landowners, Sonoma County, State Parks, The Nature Conservancy						TBD	Not able to estimate cost at this time.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-19.1.6.5	Action Step	Logging	Forestlands supporting Core, Phase I and Phase II priority areas should be considered for purchase (if feasible within the next 5 years).	2	50	CDFG, NMFS HCD, NMFS PRD, NOAA RC							
GuaR-CCC-19.1.6.6	Action Step	Logging	Discourage home building or other incompatible land use in areas identified as timber production zones (TPZ).	3	60	CalFire, CDFG, NMFS, Private Landowners, Sonoma County						TBD	Costs may be low if conducted with existing federal, state and county staff.
GuaR-CCC-19.1.6.7	Action Step	Logging	Maintain and expand California's working forestlands and forestlands held by the State, and prevent future conversion of forestlands to agriculture or other land uses.	2	50	Board of Forestry, CalFire, CDFG, NMFS						In-Kind	
GuaR-CCC-19.2	**Objective**	**Logging**	**Address the inadequacy of existing regulatory mechanisms**										
GuaR-CCC-19.2.1	Recovery Action	Logging	Prevent increased landscape disturbance										
GuaR-CCC-19.2.1.1	Action Step	Logging	Work with Sonoma county planning staff to minimize rezoning forestlands to rural residential or other land uses (e.g., vineyards).	1	60	CalFire, NMFS HCD, Sonoma County						0	Cost low if conducted with current regulatory and County staff.
GuaR-CCC-19.2.1.2	Action Step	Logging	Coordinate with regulatory agencies to minimize conversions in key watersheds and discourage forestland conversions.	1		Board of Forestry, CalFire, CDFG, NMFS HCD, NMFS PRD							
GuaR-CCC-19.2.1.3	Action Step	Logging	Establish greater oversight and post-harvest monitoring by the permitting agency for operations within Core, Phase I and Phase II CCC coho salmon areas.	2		Board of Forestry, CalFire, CDFG, NMFS HCD, NMFS PRD, RWQCB							
GuaR-CCC-19.2.1.4	Action Step	Logging	Assign NMFS staff to conduct THP reviews of the highest priority areas using revised "Guidelines for NMFS Staff when Reviewing Timber Operations: Avoiding Take and Harm of Salmon and Steelhead" (NMFS 2004).	1	10	CalFire, NMFS							The recovery action is considered in-kind and part of conducting business.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-19.2.1.5	Action Step	Logging	Require tree retention on the axis of headwall swales Any deviations should be reviewed and receive written approval by a licensed engineering geologist.	2	60	CalFire, California Geological Survey, CDFG, NMFS PRD, Private Consultants, Private Landowners, RWQCB						TBD	Cost can not be determined without information on the number of acres and cost of merchantable timber retention.
GuaR-CCC-19.2.1.6	Action Step	Logging	Extend the monitoring period and upgrade THP road maintenance after harvest.	2	10	CalFire, CDFG, NMFS PRD, Private Landowners, RWQCB							
GuaR-CCC-19.2.1.7	Action Step	Logging	Investigate opportunities to programmatically permit the forest certification program to authorize incidental take for landowners through Section 10(a)(1)(B).	3		Board of Forestry, CalFire, CDFG, NMFS PRD							
GuaR-CCC-23.1	**Objective**	**Roads/Railroads**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range**										
GuaR-CCC-23.1.1	Recovery Action	Roads/Railroads	Prevent impairment to instream substrate/food productivity (gravel quality and quantity)										
GuaR-CCC-23.1.1.1	Action Step	Roads/Railroads	Decommission riparian road systems and/or upgrade roads (and skid trails on forestlands) that deliver sediment into adjacent watercourses (CDFG 2004).	1	10	CDFG, NOAA RC, Private Landowners, RCD, Sonoma County	300.00	300.00				600	Based on remaining number of miles of roads that have not been upgraded (500 miles) in Core and Phase I recovery areas. Cost to decommission roads based on $12,000/mile for 500 miles. If roads were upgraded, costs would be $21,000/mile for an estimated total of $1,050,000.
GuaR-CCC-23.1.1.2	Action Step	Roads/Railroads	Use available best management practices for road construction, maintenance, management and decommissioning (e.g. Weaver and Hagans, 1994; Sommarstrom et al., 2002; Oregon Department of Transportation, 1999).	1	60	Private Landowners, RCD, Sonoma County						TBD	Cost of maintaining upgraded roads will depend on severity of previous winter.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-23.1.1.3	Action Step	Roads/Railroads	Conduct road and sediment reduction assessments to identify sediment-related and runoff-related problems and determine level of hydrologic connectivity.	2	5	NRCS, Private Consultants, Private Landowners, RCD						TBD	Cost expected to be low because most areas have been surveyed.
GuaR-CCC-23.1.1.4	Action Step	Roads/Railroads	Conduct annual inspections of all roads prior to winter. Correct conditions that are likely to deliver sediment to streams. Hydrologically disconnect roads.	2	5	CDFG, Private Consultants, Private Landowners, RWQCB						TBD	Five years may be sufficient to determine problem segments that would be strormproofed.
GuaR-CCC-23.1.1.5	Action Step	Roads/Railroads	Encourage, when necessary and appropriate, restricted access to unpaved roads in winter to reduce road degradation and sediment release. Where restricted access is not feasible, encourage measures such as rocking to prevent sediment from reaching streams with coho salmon (CDFG 2004).	2	20	Private Landowners						TBD	Twenty years is suggested to institutionalize these practices.
GuaR-CCC-23.1.1.6	Action Step	Roads/Railroads	Evaluate, develop, and implement strategies to address decommissioning old roads, maintaining existing roads, and constructing new roads in the following Gualala mainstem/ SF Gualala Subbasin tributaries: McKenzie Creek, Marchall Creek, Palmer Canyon Creek, Wild Hog Creek, South Fork, and Marshall Creek.	2	20	CDFG, Gualala Redwood Company, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, RCD, RWQCB						TBD	Cost likely accounted for in other action steps.
GuaR-CCC-23.1.1.7	Action Step	Roads/Railroads	Evaluate, develop, and implement strategies to address decommissioning old roads, maintaining existing roads, and constructing new roads in the following Wheatfield Fork sub-basin tributary reaches: Lower reaches of Haupt and Tabacco Creeks; Lower to middle reaches of Tombs, Wolf, and Elk creeks, and unnamed trib to the mainstem Wheatfield Fork upstream from Tombs Creek, to Elk Creek, and flanked by Bear and Gibson ridges; larger watercourses to the lower reaches of House Creek; middle to higher reaches of House, Pepperwood, Danfield, and Cedar creeks (Klamt et al. 2003).	2	20	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD, RWQCB						TBD	Cost likely accounted for in other action steps.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-23.1.1.8	Action Step	Roads/Railroads	Evaluate, develop, and implement strategies to address decommissioning old roads, maintaining existing roads, and constructing new roads in the following North Fork sub-basin tributaries: Stewart, Dry, Upper Billings, upper Robinson, Doty, Log Cabin creeks, and McGann Gulch (Klamt et al. 2003).	2	20	CDFG, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD, RWQCB						TBD	Cost likely accounted for in other action steps.
GuaR-CCC-23.1.1.9	Action Step	Roads/Railroads	Use appropriately sized culverts in steep terrain to accommodate flashy, debris-laden flows and maintain trash racks to prevent culvert plugging and subsequent road failure in the Buckeye sub-basin (GRWA 2003).	2	50	CDFG, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD, RWQCB						In-Kind	This recommendation should be considered standard practice.
GuaR-CCC-23.1.2	Recovery Action	Roads/Railroads	Prevent impairment to passage and migration										
GuaR-CCC-23.1.2.1	Action Step	Roads/Railroads	Prevent future barriers on newly constructed roads utilizing NMFS Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001a)	2	20	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NRCS, Private Landowners, RCD, RWQCB						In-Kind	
GuaR-CCC-23.1.2.2	Action Step	Roads/Railroads	Ensure that all future road or bridge repairs at stream crossing provide unimpaired fish passage for all salmonid life stages.	2	20	CDFG, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD, RWQCB						In-Kind	
GuaR-CCC-23.1.3	Recovery Action	Roads/Railroads	Prevent impairment to water quality (increased turbidity, suspended sediment, and/or toxicity)										
GuaR-CCC-23.1.3.1	Action Step	Roads/Railroads	Design new roads that avoid riparian areas and are hydrologically disconnected from the stream network.	2	60	Private Consultants, Private Landowners, Sonoma County						In-Kind	This recommendation should be considered standard practice.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-23.1.4	Recovery Action	Roads/Railroads	Prevent increased landscape disturbance										
GuaR-CCC-23.1.4.1	Action Step	Roads/Railroads	Reduce road densities by 10 percent over the next 10 years, prioritizing high risk areas in historical habitats or Core CCC coho salmon watersheds.	1	10	FishNet 4C, Private Landowners, RCD	1,100	1,100				2,200	Cost based on decommissioning 176 miles of road at a cost of $12,000/mile. Recovery action related to prevent impairment to instream substrate by decommissioning riparian roads.
GuaR-CCC-23.1.4.2	Action Step	Roads/Railroads	Develop a Road Sediment Reduction Plan that prioritizes sites and outlines implementation and a timeline of necessary actions.	3	5	Board of Forestry, CDFG, NMFS HCD, NMFS PRD, NRCS, RCD, RWQCB							
GuaR-CCC-23.1.4.3	Action Step	Roads/Railroads	Conduct outreach and education regarding the adverse effects of roads, and the types of best management practices protective of salmonids.	3	30	Board of Forestry, CDFG, NMFS HCD, NMFS PRD, NOAA RC, NRCS, RCD, RWQCB						In-Kind	
GuaR-CCC-23.1.4.4	Action Step	Roads/Railroads	Develop a Salmon Certification Program for road maintenance staff.	2	10							In-Kind	
GuaR-CCC-24.1	**Objective**	**Severe Weather Patterns**	**Address the inadequacy of existing regulatory mechanisms**										
GuaR-CCC-24.1.1	Recovery Action	Severe Weather Patterns	Prevent impairment to stream hydrology (stream flow)										
GuaR-CCC-24.1.1.1	Action Step	Severe Weather Patterns	Use the emergency drought operations center (EDOC) or other similar group to oversee implementation of water conservation measures and alternatives.	2	60	CDFG, CDFG Law Enforcement, NMFS OLE, North Gualala Water Company, Private Landowners, Public, Sea Ranch, Sonoma County						TBD	Need additional analysis to estimate cost which will vary with drought frequency.

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-24.1.1.2	Action Step	Severe Weather Patterns	Work with CDFG, Counties, other agencies, and knowledgeable biologists to develop emergency rules and adopt implementation agreements.	2	10	CDFG, NMFS HCD, North Gualala Water Company, Sea Ranch, Sonoma County Water Agency, SWRCB						0	Cost expected to be low if conducted by existing agency staff.
GuaR-CCC-24.1.1.3	Action Step	Severe Weather Patterns	Impose mandatory conservation measures to maintain instream flow needs of CCC coho salmon.	3	10	CDFG, NMFS						0	Prioritizing existing funding mechanisms is not expected to add additional cost to the process.
GuaR-CCC-25.1	**Objective**	**Water Diversion/Impoundment**	**Address the present or threatened destruction, modification or curtailment of the species habitat or range**										
GuaR-CCC-25.1.1	Recovery Action	Water Diversion/Impoundment	Prevent impairment to stream hydrology (stream flow)										
GuaR-CCC-25.1.1.1	Action Step	Water Diversion/Impoundment	Ensure that current and future water diversions (surface or groundwater) do not impair water quality conditions in summer rearing reaches.	1		CDFG, CDFG Law Enforcement, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS HCD, NMFS OLE, NMFS PRD, NOAA RC, SWRCB							
GuaR-CCC-25.1.1.2	Action Step	Water Diversion/Impoundment	Ensure water supply demands can be met without impacting flow either directly or indirectly through groundwater withdrawals and aquifer depletion.	1		CDFG, CDFG Law Enforcement, NMFS HCD, NMFS PRD, SWRCB							
GuaR-CCC-25.1.1.3	Action Step	Water Diversion/Impoundment	Provide incentives to water rights holders willing to convert some or all of their water rights to instream use via petition change of use and §1707 (CDFG 2004).	2		CDFG, NMFS HCD, NMFS PRD, SWRCB							

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-25.1.2	Recovery Action	Water Diversion/Impoundment	Prevent impairment to passage and migration										
GuaR-CCC-25.1.2.1	Action Step	Water Diversion/Impoundment	Establish flow related adult and smolt migration thresholds for prior to authorizing future water diversions.	1	5	CDFG, NMFS HCD, NMFS PRD, North Gualala Water Company, SWRCB							
GuaR-CCC-25.1.3	Recovery Action	Water Diversion/Impoundment	Prevent impairment to the estuary (quality and extent)										
GuaR-CCC-25.1.3.1	Action Step	Water Diversion/Impoundment	Discourage the development of any surface water diversions in the watershed that independently or cumulatively have significant impact on reducing inflow to the estuary during spring/summer/fall months (ECORP and Kamman Hydrology & Engineering 2005).	1	5	CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, North Gualala Water Company, SWRCB							
GuaR-CCC-25.1.3.2	Action Step	Water Diversion/Impoundment	Develop and implement Estuary Inflow Protection and Enhancement Guidelines to maintain estuary function and provide information for estuary restoration.	1		CDFG, NMFS HCD, NMFS PRD, SWRCB							
GuaR-CCC-25.1.4	Recovery Action	Water Diversion/Impoundment	Prevent impairment to water quality (instream temperature)										
GuaR-CCC-25.1.4.1	Action Step	Water Diversion/Impoundment	Ensure future water diversions do not impair instream water temperatures during the dry season.	1		CDFG, Gualala Watershed Council, NMFS HCD, NMFS PRD, North Gualala Water Company, NRCS, RCD, Sea Ranch, SWRCB							
GuaR-CCC-25.2	**Objective**	**Water Diversion/Impoundment**	**Address the inadequacy of existing regulatory mechanisms**										

Recovery Strategy Number	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs ($K)						Comments
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuaR-CCC-25.2.1	Recovery Action	Water Diversion/Impoundment	Prevent impairment to stream hydrology (stream flow)										
GuaR-CCC-25.2.1.1	Action Step	Water Diversion/Impoundment	Ensure all water diversions and impoundments are complaint with AB2121 or other appropriate protective measures.	1		CDFG, CDFG Law Enforcement, NMFS HCD, NMFS OLE, NMFS PRD, SWRCB							
GuaR-CCC-25.2.1.2	Action Step	Water Diversion/Impoundment	Identify and work with the SWRCB to eliminate depletion of summer base flows from unauthorized water uses. Coordinated efforts by Federal and State, and County law enforcement agencies to remove illegal diversions from streams.	1		CDFG, CDFG Law Enforcement, NMFS HCD, NMFS OLE, NMFS PRD, SWRCB							
GuaR-CCC-25.2.1.3	Action Step	Water Diversion/Impoundment	Improve coordination between agencies and others to address season of diversion, off-stream reservoirs, bypass flows protective of coho salmon and their habitats, and avoidance of adverse impacts caused by water diversion (CDFG 2004).	2		CDFG, CDFG Law Enforcement, NMFS HCD, NMFS OLE, NMFS PRD, SWRCB							

GUALALA RIVER WATERSHED COUNCIL

Quality Assurance Project Plan
For
Monitoring Sediment Reduction

Revised Version for Proposition 50

QUALITY ASSURANCE PROJECT PLAN FOR MONITORING SEDIMENT REDUCTION IN THE GUALALA RIVER WATERSHED

Prepared for:
California State Water Resources Control Board
and
California North Coast Regional Water Quality Control Board

By
Kerry Williams, Sotoyome Resource Conservation District
Kathleen Morgan, Gualala River Watershed Council
December 2002

A. PROJECT MANAGEMENT

1. Title Page and Approvals

QUALITY ASSURANCE PLAN FOR MONITORING SEDIMENT REDUCTION IN THE GUALALA RIVER WATERSHED

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Approvals:

North Coast Regional Water Quality Control Board

By: Peter Otis Date: December 4, 2002
Environmental Planner
Quality Assurance Manager

AA. Revisions Page and Approvals

I. Table 7.1: Total Suspended Solids has been revised 4/1/08 to the following:

Parameter	Method/range	Units	Detection Limit	Sensitivity	Precision	Accuracy	Completeness
Total Suspended Solids (TSS)	Residue, Non-Filterable (EPA Method 160.2)	mg/l	4	NA	Standard Reference Materials (SRM, CRM, PT) within 95% CI stated by provider of material. If not available then with 80% to 120% of true value	Laboratory duplicate, Blind Field duplicate, or MS/MSD 25% RPD Laboratory duplicate minimum.	80%

II. Section 5, page 21, paragraph 5 has been revised 4/1/08 to the following:

If data do not meet the project's specifications (see Table 7.2 –error tolerance), the following actions will be taken. First, the technical advisors will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. If the problem cannot be corrected by re-training, revision of techniques, or replacement of supplies/equipment, then the technical advisors and the TAC will review the DQOs and determine if the DQOs are feasible. If the specific DQOs are not achievable, the parameter should be eliminated from the monitoring program.

Approval:

_____ 4/1/08
Kathleen Morgan Date
GRWC CQAO
GRWC Contract Manager

_____ _____ _____ _____
SWRCB QAO Date SWRCB Contract Manager Date

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3. Distribution List

Primary distribution list for the Gualala River Watershed Monitoring Program Quality Assurance Plan:

NAME	AGENCY/ORGANIZATION
Lauren Clyde	North Coast Regional Water Quality Control Board
Bill Cox & Doug Albin	California Department of Fish & Game
Matt O'Connor	O'Connor Environmental, Inc.
Steering Committee	Gualala River Watershed Council
Technical Advisory Committee	Gualala River Watershed Council
Field Team Leaders	Gualala River Watershed Council

Once approved, this Quality Assurance Project Plan (QAPP) will be available to any interested party by requesting a copy from the Sotoyome Resource Conservation District (SRCD) (see address on title page).

4. Project/Task Organization

The members of the Gualala River Watershed Council (GRWC) in partnership with the SRCD are implementing the Gualala River Watershed Monitoring Program. The GRWC is an association of stakeholders in the Gualala River watershed. These stakeholders include any persons and/or entities that live within, own property within, use water from, operate commercial businesses within or are affected by land uses within the Gualala River Watershed. There is also consistent participation by representatives of local, state and federal agencies.

Formation of the GRWC in 1997 was facilitated by the North Coast Regional Water Quality Control Board (NCRWQCB), the California Department of Forestry (CDF), the Redwood Coast Land Conservancy (RCLC) and with ongoing support from the SRCD.

The development of a Gualala River Watershed Monitoring Program with a QAPP is part of the ongoing development of a watershed enhancement plan for the Gualala River watershed. This program is currently being funded by grants from the State Water Resource Control Board (State WRCB) 319(h) program and the California Department of Fish and Game (CDFG) SB271 program.

The GRWC monitoring program is managed by the SRCD with program over site and coordination by the GRWC Steering Committee, and Matt O'Connor, O'Connor Environmental, Inc.

The following personnel and subcontractors will perform sample collection and analysis:

- Trained GRWC citizen volunteers
- Trained GRWC supervising staff

- O'Connor Environmental, Inc.
- Forest Science Project
- Macroinvertebrate Lab

The Sediment Reduction in the Gualala River Watershed Monitoring 319(h) Project is a multi-organization project. Consultants and volunteer citizen monitors and staff from Gualala Redwoods, Inc. (GRI) will work together to monitor and assess natural streams in the Gualala River watershed at monitoring sites selected as outlined in the scope of work for the project. The results of this monitoring shall be reviewed during periodic technical advisory committee (TAC) meetings. In addition, any problems, concerns, and/or proposed amendments to this QAPP will also be reviewed and discussed by the TAC.

The following is a list of key personnel and their project responsibilities.

TASK	**KEY PERSONNEL**
Contract Manager	Lauren Clyde, North Coast RWQCB
Project Director	Kerry Williams, Sotoyome RCD
Coordinator for Field Teams & TAC	Kathleen Morgan, GRWC
Equipment Supply, Calibration	Nola Craig, DFG Staff, SRCD Staff, GRI Staff, Kathleen Morgan, Matt O'Connor, GRWC volunteers
Field Data Collection	Nola Craig, DFG Staff, SRCD Staff, GRI Staff, Kathleen Morgan, Matt O'Connor, GRWC volunteers
Data Management	Matt O'Connor, Kathleen Morgan, Kerry Williams, SRCD Staff, GRI staff
Quality Assurance/Quality Control	Matt O'Connor, GRWC Team Leaders
Technical Advisors	Matt O'Connor, agency members of TAC

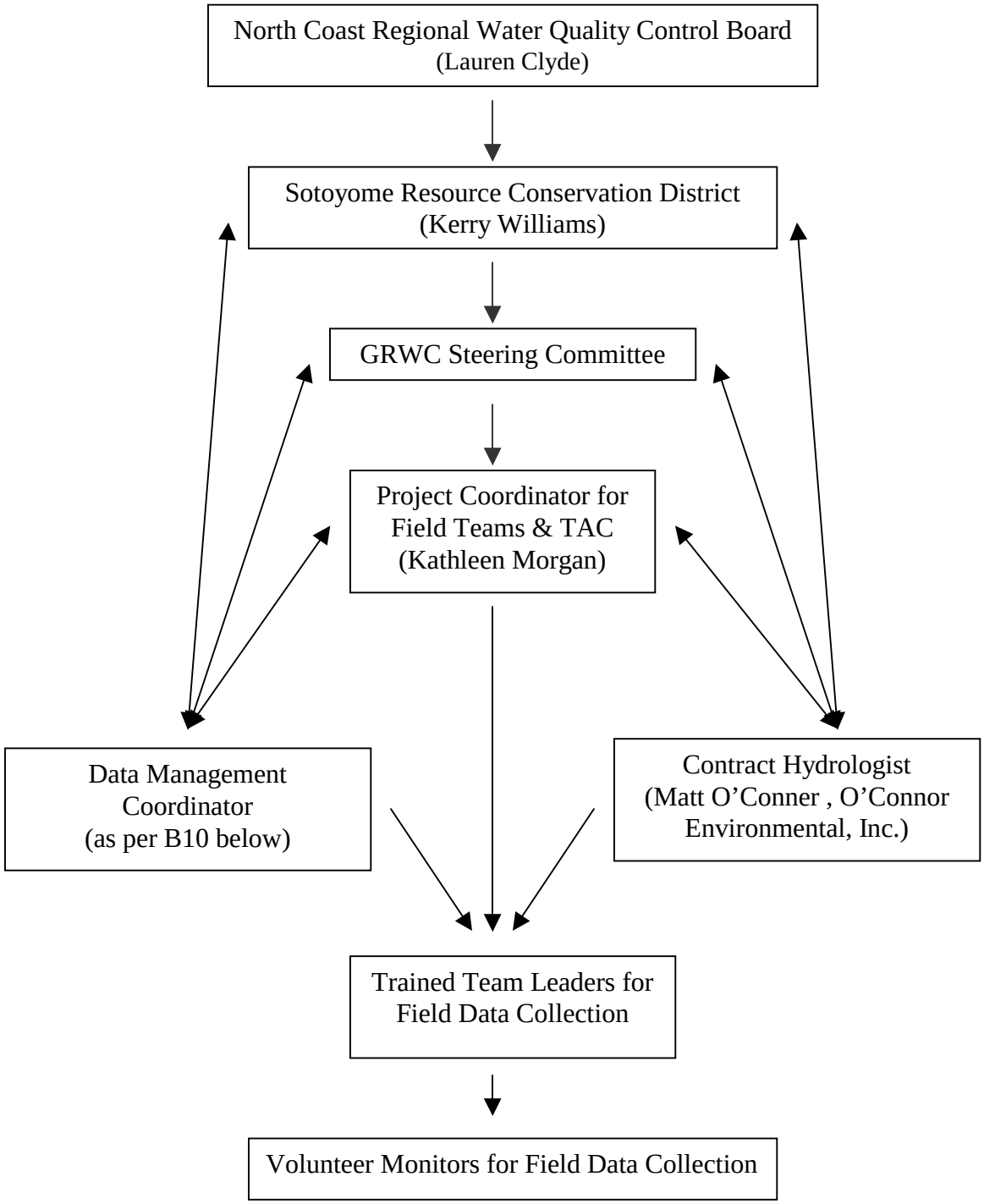
The organizational structure of the GRWC monitoring program is illustrated in Figure A-1.

5. Problem Definition/Background

Land use practices, combined with erosive landscape characteristics have accelerated the rate of erosion and mass wasting, and contributed to sedimentation in the Gualala River and its tributaries. Sedimentation is a result of a variety of natural and anthropogenic factors, including mass wasting, roads, and surface erosion. Sedimentation is believed to be a major contributing factor to the decline of historic runs of salmon and steelhead..

There is insufficient information to adequately assess the status of aquatic resources in the Gualala River watershed. The GRWC was formed in order to address watershed conditions and activities, including water quality concerns within the watershed. There are also small citizen monitoring groups forming to conduct monitoring in the various areas of the watershed and some private landowners have been conducting monitoring for several years. If quality assurance is adequate, valuable information will be provided for watershed management. One of the primary tasks of the GRWC is to design and implement a monitoring program for the watershed. A TAC has been formed to advise on this task.

Figure A-1 Organizational structure of the GRWC monitoring program.



6. Project/Task Description

This project will supplement existing agency information by monitoring streams in the Gualala River watershed. The focus of the project is on physical aquatic habitat and physical and biological water quality measures that will assist in identifying the status of these aquatic resources. Analysis, for the most part, will be conducted in the field with test kits and field instruments.

The objective of this project is to improve water quality through collaboration between public agencies, community groups, and private landowners. The project involves a three-year incremental process to implement non-point source controls, emphasizing on road improvements and to develop a mechanism for further assessments and implementation for reducing sedimentation in the watershed. The assessment and implementation will be aimed at improving water quality by reducing up-slope erosion impacts to the aquatic resources, improving the riparian zone, and enhancing anadromous salmonid habitat in the tributaries and main stem of the Gualala River watershed.

A map of the Gualala River watershed is attached as Appendix A.

The GRWC monitoring groups will be monitoring water quality in Gualala River watershed. Physical and biological parameters are measured; however, not all groups are measuring all parameters. Table 6.1 identifies the type and frequency of the monitoring parameters.

This QAPP addresses data quality objectives for the following parameters:

- Temperature
- Longitudinal Profiles & Benchmarks
- Cross-section Measurements
- Pebble Counts
- Large Woody Debris
- Canopy and Riparian Measurements
- Benthic Macroinvertebrate
- Streamflow, Turbidity and Total Suspended Solids

Table 6.1 Type and Frequency of Monitoring in the Sediment Reduction in the Gualala River Watershed Monitoring Program

Parameter	Maximum Frequency	Time of Year
Temperature	A	Summer
Longitudinal Profiles & Benchmarks	B	Summer
Cross-sections	B	Summer
Pebble Counts	B	Summer
Large Wood Debris	B	Summer
Canopy & Riparian Measurements	B	6/1-8/31
Benthic Macroinvertebrates	B	Fall
Stream Flow, Turbidity & Total Suspended Solids (Optional monitoring element)	C	Winter/Spring

Frequency: A: Annual B: Annual or less frequently depending on objectives C: Seasonal, frequency depending on objectives and flow conditions

7. Quality Objectives and Criteria

Table 7.1 Data Quality Objectives for Conventional Water Quality Parameters

Parameter	Method/range	Units	Detection Limit	Sensitivity	Precision	Accuracy	Completeness
Temperature	Thermometer (-5 to 50)	^{o}C	-5	0.5 ^{o}C	± 10%	± 10%	80%
Turbidity	Tubes (5 -)	JTUs	< 5	5 JTUs	± 5 JTUs	NA	80%
Total Suspended Solids (TSS)	Refer to page ia for revisions						

NA: not applicable

Table 7.2 Data Quality Objectives for Physical Aquatic Habitat Parameters

Parameter	Time scale	Spatial scale	Endpoints/units	Tolerated error	Supporting documentation	Prep by professionals
Large woody debris survey	1 year maximum and after major events.	Stream reaches of 1000 ft or 20 bankfull widths, whichever is more.	All LWD > 6 in. diameter and > 4 ft length within the bankfull channel; locate position of LWD in the long-profile.	Length +/- 1 ft per 5 ft, Diameter +/- 2 in. per 6 in., Root wad dimensions +/- 1 ft per 2 ft of size. Distance from start point (long profile survey) +/- 3 ft to center point of log.	Notes on how to locate beginning and ending points of reach, associated long-profile data, associated cross-section data.	Measurement techniques, how to handle odd LWD shapes, how to estimate jam volumes when all pieces are not visible.
Longitudinal channel profile	1 year maximum and after major events.	Stream reaches of 1000 ft or 20 bankfull widths, which ever is more. Thalweg elevation minimum of 10 ft intervals.	The most important features to measure are: riffle crests, breaks in slope and deep points of pools. Measure elevation (± 0.02 ft) whenever the channel bed changes slope and at least every 15 ft where the slope is relatively uniform (e.g. a long run, riffle or pool).	Elevation +/- 0.02 ft; distance (± 3 ft) from start point and left right offset (± 4ft). Elevation closure within 0.01 ft for each benchmark, each turning point, and each 500 linear feet of distance.	Notes on how to locate beginning and end points of reach, associated cross-section data, pebble count data, photo-documentation of stream channel and benchmarks.	Surveying techniques, site selection.
Cross-sections	1 year maximum and after major events.	3 per 1000 ft reach are conventional; sites initially selected are likely spawning sites defined as riffles located at pool tails.	Elevation observations at inflections points with at least one intervening point between breaks in slope. The most important features to measure are: breaks in slope, bankfull, wetted width and thalweg. Average spacing between observations equivalent to < 5% of bankfull width.	Elevation closure within 0.01 ft for each benchmark, each turning point, and each 500 linear feet of distance.	Notes on how to locate beginning and ending points of cross-section, associated long-profile data, pebble count data, and photo-documentation of stream channel.	Surveying techniques, site selection.

Table 7.2 continued…

Parameter	Time scale	Spatial scale	Endpoints/units	Tolerated error	Supporting documentation	Prep by professionals
Pebble count (Wolman 1954) (as specified for GRWC) Refer to Appendix F	1 year maximum and after major events.	4 per 1000 ft reach are conventional; sites initially selected are likely spawning sites defined as riffles located at pool tails.	100 measurements in a random walk on the riffle surface from upstream to downstream, collecting a pebble diameter at 3 ft intervals (about one stride by the observer). Lateral extent of observation area defined by active bed deposits lacking significant vegetation or leaf litter.	Individual pebbles to +/- 1mm	Location within long profile and associated cross-section stations and reach end point.	Measurement techniques and data recording.
Riparian Canopy Closure	1 year at time of installation of the temperature data logger.	Thermal reaches of a 1000 to 2000 feet above data logger installation site.	Using a spherical densiometer adapted to the Strickler method (1959). From center of channel take measurements at 100 ft. intervals along the thermal reach.	+/- 2 intersections in the field of view	Notes on how to locate beginning and ending points of a thermal reach and center of channel, associated Forest Science protocols.	Measurement technique and data recording.
Riparian Canopy Density	1 year maximum and after major events.	In stream channel and riparian forest stand plots located at 200 ft intervals along monitoring reach.	Using a spherical densiometer, measure the percentage of overhead canopy density at 5 locations along a transect perpendicular to the stream channel: center of channel, at the left and right edge of the bankfull channel, and at 50ft beyond the bankfull channel edge in the riparian zone.	+/- 2 squares in the field of view i.e. +/- < 10%	Notes on how to locate beginning and ending points of reach, associated long-profile data, reference to associated riparian stand inventory plots.	Measurement technique, sampling rules regarding non-standard situations (e.g. what is done if the 50 ft distance ends on a road, or a very steep slope that cannot be negotiated?).

Table 7.2 continued…

Parameter	Time scale	Spatial scale	Endpoints/units	Tolerated error	Supporting documentation	Prep by professionals
Riparian forest stand inventory	1 year maximum and after major events.	Sample of trees and downed logs within a 100 ft long, 21.8 ft wide (20th acre) rectangular plot and understory in a 100th acre sub-plot in riparian forest stands located at 200 ft intervals along monitoring reach.	Measure height and live crown % and distance of the first 3 conifer trees > 5.6 in DBH from the origin of the plot centerline. Estimate DBH and measure distance of all remaining tree species >5.6 in DBH. The diameter of all down logs that intersect the 100 ft centerline of the plot is also measured. A 100th acre lesser vegetation sub-plot is established 15 ft from bankfull. The plot is established and monumented with rebar at the edge of the bankfull channel and the 100 ft end point.	Length/Height +/- 1 ft. Diameter +/- 1 in. Distance from plot start point +/- 1 ft	Notes on how to locate beginning and ending points of plot, adjust 100 ft measurement for slope, associated long-profile data, reference to associated riparian canopy data.	Measurement techniques and sampling rules for non-standard situations (e.g. what is done if the 100 ft distance ends on a road? or a very steep slope that cannot be negotiated?).
Turbidity	Instantaneous during periods of storm runoff	Designated cross-section locations within larger monitoring sites	NTU's, see Table 7.1	See Table 1, +/- 10%	Manufacturer's instruction manuals.	Training of monitoring team leaders; QA/QC on data and instrument logs
Stream Discharge	Instantaneous during periods of storm runoff	Designated cross-section locations within larger monitoring sites	cubic feet per second (cfs)	+/- 10%	US Geologicial Survey WRI Report 00-4036, ver. 1.1 (CD-ROM interactive training manual)	Training of monitoring team leaders; QA/QC on data and instrument logs

Table 7.2 continued…

Parameter	Time scale	Spatial scale	Endpoints/units	Tolerated error	Supporting documentation	Prep by professionals
Total Suspended Solids	Instantaneous during periods of storm runoff	Designated cross-section locations within larger monitoring sites	Sample collected using a depth-integrated sampler; sample represents verticle spatial average concentration of solids in the water column; optimal sample is in or near channel thalweg as flow conditions permit; number of samples likely to be limited by funds available for lab processing; intended for correlation with turbidity data and stream discharge collected at the same site and time	See Table 1, +/- 10%	Manufacturer's instruction manual for use of depth integrated sampler (equivalent to USGS DH-48 sampler)	Training of monitoring team leaders; QA/QC on data and instrument logs

Benchmarks for each parameter are addressed separately

Table 7.3 Data Quality Objectives for Biological Parameters

Parameter	Method/range	Units	Detection Limit	Sensitivity*	Precision	Accuracy	Completeness
Benthic Macro-invertebrates	Calif. Stream Bioassessment Protocol (CDFG)	N/A	Family level	N/A	$\leq$ 5% difference	$\leq$ 5% difference	80%

8. Special Training/Certification

The Gualala River Watershed Coordinator, members of the GRWC, employees of SRCD, employees of Gualala Redwoods, Inc. and volunteers from the community will collect data at selected sites in the watershed and will receive training in techniques used to evaluate general watershed condition. All protocols and example data collection sheets are attached in the Appendices and source documentation is identified in the protocols themselves.

The data will be made available to the public to use for educational and informational purposes. It is hoped that information gained from the ongoing volunteer monitoring program will lead to land management decisions that consider the health of the watershed.

All citizen-monitoring leaders must participate in three hands-on training sessions related to water quality and channel monitoring conducted by either GRWC or a comparable entity and approved by the SRCD and RWCQB. Training sessions will be held in the Gualala River watershed. Certificates of completion will be provided once all training as been completed. The following topics will be covered under this training:

- General hydrology
- Ecology
- Health and Safety
- Quality Assurance and Quality Control (QA/QC) Measures
- Sampling Procedures
- Field Analytical Techniques
- Data recording

The trainer will ensure that volunteer citizen monitoring leaders are reading instruments and recording results correctly. Individual trainees are evaluated by their performance of analytical and sampling techniques, by comparing their results to known values, and to results obtained by trainers and other trainees. Sampling and safety techniques will also be evaluated. The trainer will discuss corrective action measures with the volunteers, and the date by which the action will be taken. The citizen-monitoring leader is responsible for reporting back if any corrective action is taken. Certificates of completion will be provided once all training has been completed.

To be certified for macroinvertebrate bioassessment citizen monitoring leaders must also participate in a three-day training course provided by the CDFG, the Sustainable Lands Stewardship Institute, the American Fisheries Society, or the State WRCB.

9. Documents and Records

All field results will be recorded at the time of completion in the field, using the data sheets (data sheets are included with each individual protocol in the appendices B through H) and field logbooks. Each monitoring group will also keep and record information in the instrument maintenance logs.

Data sheets will be reviewed for outliers and omissions before leaving the sample site at the completion of each data collection. Data sheets will be signed after review by a team-monitoring leader. Data sheets will be turned in to data headquarters within one week of actual data collection. Data headquarters will be either the SRCD office or.(we need to choose another alternate location in Gualala area)The monitoring coordinator's house. Copies of all data sheets will be made immediately upon receipt at data headquarters. Original copies will be stored in an "original binder" and copies will be put into a "working binder." Copies of all information in the field logbooks will be made and inserted into the working copy binder. Entry of all data will be made into a computer database within three months of data collection. computer backup copies will be made on a quarterly basis and will be made and held at data headquarters. All data entry and other tasks involving data sheets will utilize the working binder. The original binder shall be used as a reference only. Field sheets are archived for three years from the time they were collected.

Instrument maintenance logs will also be kept by each citizen-monitoring group for each instrument in use. These include HOBO temperature units. The instrument logs detail the dates of equipment inspection and calibrations, as well as the dates reagents are replaced. The logs will be returned to the team-monitoring leader following each monitoring event, in case a review is necessary. Instrument logs will be turned in with data sheets and photocopies will be placed in the working binder.

A field site log pertaining to the location, including maps, specific directions to locating sample sites in the field, photographs, and site characteristics (including site selection criteria particular to each site) will be maintained at headquarters and updated annually. Within one week after each site visit, copies of the field log will be made and inserted in the working binder. Once field logs are full, the original will be kept at data headquarters along with other original documentation.

The Monitoring Program Coordinator and scientific members of the Technical Advisory Committee will complete an annual audit of data sheets and instrument logs.

B. DATA GENERATION AND AQUISITION

1. Sampling Process Design

Up to 30 sampling sites will be selected as part of this program with the GRWC and TAC participation. The following criteria will be evaluated when choosing sampling locations:

- sample can be taken in main river current or where homogeneous mixing of water occurs (pertains to temperature and turbidity measurements);
- sample is representative of the part of the river of interest which may include sampling related to implementation projects;
- location complements or supplements historical data;
- location represents a stream reach that possesses typical representative value for fish and wildlife or recreational use.

Additional criteria that will help determine the location of sampling sites includes:

- access (convenience in terms of time and effort);
- safety (access and specific site conditions anticipated during periods of field data collection);
- permission to cross private property (access agreement).

The monitoring program, as outlined in task 4 of the 319h contract, requires reference sites to assess the effectiveness of implementation projects. These locations will be chosen upstream and downstream of any potential impact, and upstream and downstream of any secondary discharge or disturbance.

Prior to final site selection, permission to access the stream is obtained from all property owners. If access to the site is a problem, the citizen-monitoring leader will select an alternate site. Safety issues will be included in the Gualala River Watershed Monitoring Manual.

The group leader will review sample sites. Relevant site characteristics will be observed and recorded on the field data forms and logs.

Data pertaining to date and time of sampling and weather conditions will be transcribed to the field data log (described in A9 above). A catalog of site photographs will be maintained as part of the field data log. See tables 6.1, 7.1, 7.2, 7.3.

2. Sampling Methods

Field Observations

Sampling Site Observations

Site condition observations will include pertinent detail about the location of the site, access, special considerations, photos obtained, and sampling point location(s), as well as climatic and hydrologic variables. These observations will be documented in a waterproof field data log as well as on data collection sheets (referred to in A9) to maintain standardization of information, and ensure all variables are recorded. All forms for data collection will be included in the appendices for each individual protocol. The field data pertaining to site conditions will be transcribed to the field data log (see A9).

Automated Sample Collection

Data loggers are effective in collecting physical-chemical measurements on short time intervals over many days without constant staff oversight. Data are stored on internal memory chips and downloaded to a computer in the field or office for further data analysis. The only protocol utilizing automated sample collection in this QAPP is temperature.

Temperature

Temperature loggers manufactured by Onset® Corp., will be programmed to sample at least every 96-minutes. With 8K of internal memory, a full summer of data can be collected. Additionally, the 96-minute sampling interval is the minimum specified in the cooperative effort developed by the Forest Science Project (FSP 1998) to detect daily maxima (Appendix B).

Basic considerations for site selection are presented in the modified protocol. The primary use of the data at this point is for characterizing a stream reach, so placement is in a well-mixed, flowing section of the stream that is representative of a reach.

A thermal reach is a reach with similar (relatively homogenous) riparian and channel conditions for a sufficient distance to allow the stream to reach equilibrium with those conditions. The length of reach required to reach equilibrium will depend on stream size (especially water depth) and morphology (TFW, 1993). A deep, slow moving stream responds more slowly to heat inputs and requires a longer thermal reach, while a shallow, faster moving stream will generally respond faster to changing riparian conditions, indicating a shorter thermal reach. Generally, it takes about 1000 feet of similar riparian and channel conditions to establish equilibrium with those conditions in fish-bearing streams.

Data sheets for calibration, deployment, and site conditions accompany the data for each deployment and are provided in Appendix B. Raw field data is delivered to the Forest Science Project (FSP) for processing and analysis according to FSP protocols. The processed temperature data is then returned to the GRWC in both raw and analyzed form.

Channel Measurements

Stream channels form and are maintained by the interaction of streamflow and sediment regimes in a process that yields consistent average channel shape and size (Dunne and Leopold 1978). A reach is a section of a stream at least 20 times longer than its average channel width (Flosi and Reynolds, 1994) that maintains relatively homogenous channel morphology, flow, and physical, chemical, and biological characteristics.

The width and depth of a channel reflects the discharge and sediment load the channel receives, and must convey, from its drainage area. Channels are formed during peak flow events, and channel dimensions typically reflect hydraulic conditions during bankfull (channel-forming) flows.

Channel form and composition is monitored at low water. The monitoring is done within a section of a stream called a study reach. All locations for study reaches will be selected, reconnoitered with respect to reach criteria described above, and flagged by GRWC Technical Committee Members (TAC) and/or Technical Advisors before the sites are assigned to be surveyed. During reach reconnaissance, locations where cross-sections and bed composition protocols will be implemented are flagged. The study reach will be re-visited on a seasonal schedule consistent with the monitoring objectives. The study reach procedure for channel form monitoring is outlined below and specific information regarding basic surveying techniques is available in Appendix C.

- The study reach is first laid out on the ground
- Bankfull indicators are identified and bankfull width is determined
- Three benchmarks are established
- Three cross-sections are then located and staked
- A longitudinal survey is performed
- Cross-sections are surveyed
- Bed composition protocols are performed
- Large woody debris is surveyed
- Riparian measurements and Canopy Density are recorded
- Water quality tests are run

The following descriptions are summaries of the measurements with reference to specific literature. Specific methods and the actual references for these metrics are presented in the appendices.

Longitudinal (Thalweg) Profiles & Benchmarks

The amount of variability in thalweg along a longitudinal axis in the stream is a good measure of complexity of the wetted stream channel. Pools, logs, boulders, riffles, etc. add complexity to the channel that affect sediment transport, channel form, and fish habitat. Changes in the thalweg profile reflect overall changes in the channel complexity, which are a result of channel-forming forces in the stream. Reduction of complexity occurs with excessive sediment introduction. Increased complexity indicates a recovery from such a condition. Thalweg profiles provide information on existing conditions, but are useful in trend analysis over the long term.

Strictly implemented, a thalweg profile or survey, as mentioned above, measures the streambed elevation along the thalweg of the stream, taking particular care to measure all breaks-in-slope, riffle crests, maximum pool depths, and pool tail-outs. Concurrently, while the tapes, levels, etc., are set up for measuring thalweg profiles, the locations of transects for cross-sections are also usually documented and measured (Madej, and Ozaki, 1996; Ramos, 1996). Since it is impossible to uniformly arrange the longitudinal tape exactly over the thalweg, measurements should be perpendicularly referenced to the centerline tape, and read to within one foot. Ramos suggests that as thalweg measurements intersect the point of a designated cross-section, the thalweg should be measured at the intersection first, and then the cross-section is surveyed before

proceeding upstream. In addition to the thalweg elevations, other variables, such as water surface, bar height, substrate size, high water marks, and comments on local channel features such as pools, riffles, runs, and the presence or absence of large woody debris can be recorded. Subsequent analysis of the profile allows the detection of changes in the vertical dimensions of channel features. Depending on the data obtained from the thalweg survey, standard parametric and non-parametric statistical methods can be applied to more fully interpret survey results.

Depending on the study's intent, the reach length surveyed in a thalweg profile may vary from 20 to 50 channel widths. Rather than channel widths, surveys can also be modeled around a specific number of meander segments, generally three to four, within a reach (Madej, and Ozaki, 1996; Trush, 1997; Rosgen, 1996). The important consideration in selecting a specific length for a reach to conduct thalweg profiles is the ability of the study design to answer any questions or hypotheses proposed, whether it is to detect changes over time in channel aggradation or degradation, or to inventory available pool and riffle habitat for salmonids and other insteam biota.

Specific methods and the actual references for Longitudinal Profile surveys are presented in Appendix E.

Cross-sections

Channel cross-section measurements provide valuable information on the shape and dimension of a stream channel and its relationship to the flood plain. Coupled with other measurements, cross-sections measured repeatedly over a period of years provide valuable information on the transport and storage of sediment in the stream channel and inter-annual variation of stream channel geometry. Common parameters can include width/depth ratio, bankfull depth, entrenchment, and flood-prone area. For utility and ease of reference, other parameters, such as scour chain and bank-pin placement (for monitoring bed scour and fill and bank erosion and accretion, respectively), pebble counts, riparian canopy measurements, etc., can also be combined and conducted at cross-section locations.

Monitoring the long-term changes in cross-sectional data can provide insights into channel bed and bank stability, and relationships between sediment transport and discharge (Beschta and Platts 1986). , For example, stream aggradation may be manifested by changes in channel geometry such as decreasing thalweg depth, increasing channel width, and increasing mean bed elevations. Channel incision (i.e. downcutting) may be indicative of a return to more "natural" conditions from previous management and/or impacts of major storms and floods (McDonald, et al., 1991).

A typical study design can have as few as three, or as many as 15-20 cross-sections located in a study reach. A reach has been variously defined as 20-50 bankfull flow widths (Kondolf and Micheli), one thousand meters (Knopp, 1993), or a predetermined length based on the geomorphic characteristics of the watercourse under study. For example, Madej and Ozaki, defined a study area as 26 kilometers long in Redwood Creek from its confluence with the

Pacific Ocean to a slope-determined end point. Within the study area the 26 km stream segment was divided into three interconnected reaches, an upper, middle, and lower reach. A total of 58 cross-sections were nested within the three reaches. The end points of each reach were determined by major breaks in stream gradient.

A cross-sectional profile is developed by measuring points along a tape measure stretched across the stream and recording the distance, and surveying streambed elevations at each specific point along the tape. Streambed characteristics, such as changes in bottom elevations, the position of the field estimated bankfull height, wetted width, breaks in slope, and the deepest points in the particular channel feature being measured are recorded. The end points of the cross-section should extend at least above the estimated bankfull stage and preferably beyond the current floodplain.

Specific methods and the actual references for Longitudinal Profile surveys are presented in Appendix E.

Pebble Counts

One of the most widely used methods of sampling grain size from a streambed is the pebble count technique (Wolman, 1954). It can be used as a simple and rapid stream assessment method that may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams (Potyondy and Hardy, 1994). Pebble counts are routinely used by geomorphologists, hydrologists and others to characterize bed material particle size distributions of wadable, gravel bedded streams. The procedures have been adapted in fisheries studies as a preferred alternative to visually characterizing surface particle sizes commonly used during instream flow studies (Kondolf and Li, 1992). The methodology is best applied in gravel and cobble streams with a single channel and are not applicable to lower gradient, sand-bed dominated channels. A recent, comprehensive review of [Bunte, 2001 #641] measurement of streambed sediment in wadable, gravel bedded streams describes the advantages and constraints of a wide variety of sampling designs.

Pebble counts are conducted by randomly collecting, counting and measuring the intermediate diameter (b-axis) of 100, and up to 200 (Kappesser, 1993) particles from the surface of a given streambed. Bunte and Abt (2001) suggest that accurate characterization of the size distribution of sediment for a given reach requires a sample of 400 measurements. Riffles deemed suitable for spawning salmonids are the preferred location for sampling efforts (Schuett-Hames, et al., 1999). Pebbles are collected along transects at measured points following a predetermined grid pattern, or by walking the streambed and picking up individual pebbles at the toe of a boot along a toe-to-heel, zigzag pattern. Whether the structured grid pattern or the toe-to-heel method is used, all transects should traverse the stream channel from the estimated bankfull to bankfull stage.

After at least 100 pebbles are sampled cumulative size distribution curves can be developed for the D50, median particle size, the diameter at which 50% of the particles are finer, and the D16

and D84, the diameters at which 16% and 84% of the particles are finer. Other analyses that may be applied are the geometric mean diameter: $dg = [(D84)(D16)]^{0.5}$ and the geometric sorting coefficient: $sg = (D84/D16)^{0.5}$ (Kondolf and Li, 1992). As mentioned, it has been shown that shifts toward the lower end of the pebble count cumulative frequency curves may be indicative of significant increases in streambed fines from accelerated natural and or land-use disturbances. Conversely, a progressive coarsening of streambed surface particles may indicate improving conditions from past upstream and/or upslope disturbances.

Specific methods and the actual references for pebble count procedures are presented in Appendix F.

Large Woody Debris

Large Woody Debris (LWD) is known to be an important structural element of stream channels. It improves juvenile Coho salmon and steelhead trout summer rearing habitat by increasing the numbers and depths of pools. Large amounts of LWD also increase winter cover that is critical for salmonid protection from predation and the reduction of water velocity.

Beechie and Sibley (1997) concluded that when the number of LWD pieces (>8 inches in diameter) reached about 122 pieces /1,000 Ft., pool formation is less sensitive to further increases in LWD loading. Similarly, Martin (1999) found that the effectiveness of LWD for forming pools in alluvial channels was diminished when the LWD load exceeded a threshold of approximately 137 pieces. LWD loading (m^3 of LWD per 100 m of channel length) in surveyed stream reaches in northern California have been compiled and may provide another useful basis for assessment of LWD abundance [O'Connor Environmental, 2000 #687].www.fire.ca.gov/bof/pdfs/garcia_LWD_final.pdf

To monitor large woody debris we use an inventory method developed in partnership by GRI and the GRWC after reviewing other accepted techniques. It is designed to allow sorting and recompiling of data to answer different questions over time. A measurement is made of every piece that breaks the plane of the bankfull line and is at least 6” in diameter on the small end and 4’ long.

Specific methods and references for monitoring LWD are presented in Appendix G.

Riparian Measurements and Canopy

Riparian, or streamside forest, provides habitat for many types of wildlife, shades the creek keeping water temperatures cool for salmon and trout, and protects creek banks. When a tree is undercut and falls into the creek it becomes the large wood, and essential element for fish habitat. There are several features of riparian forest that indicate its value as habitat and as part of the stream system. The density and diversity of plant species, the width of the riparian corridor beyond the edge of the creek scour channel, the size of the trees in the corridor and the occurrence of dead trees, vines, downed wood and other features, all describe the habitat value of the forest for birds, mammals, reptiles, amphibians and salmonids.

The density of the streamside tree canopy creating shade over the creek, and the availability of large trees along the banks to become wood in the stream are features of the riparian forest, which relate to salmon and trout habitat in the creek channel. The extent of creeks in the watershed with dense riparian corridor indicates where water temperatures are likely to be low. By assessing the riparian area the current conditions of the riparian areas will be documented and these current conditions can be compared throughout the watershed. The objective of the riparian assessment is to understand and identify areas in need of restoration and enhancement. In addition, monitoring over time will provide the opportunity to investigate the relationship between riparian stand conditions and LWD recruitment to stream channels and effect on aquatic habitat.

The riparian surveys use the Forest Projection System (FPS) developed by Dr. Jim Arney of Forest Biometrics. Riparian forest stands will be inventoried by identifying a sample of trees by species within 20th acre plots at 200 ft intervals along the established monitoring reaches. The 20th acre fixed plots are run up-hill from bank-full to 100 feet and are 21.8' wide. Measurements of live trees, snags, down-logs and understory vegetation are documented.

Canopy density is measured using a spherical densiometer to record the riparian vegetation shading the creek. The measurements are taken in conjunction with the riparian surveys. Measurements are taken at five points at the established riparian plot sites: center of channel, bank-full (right & left), and 50 ft. inland from the bankfull point. Four readings per location are made first facing upstream, left bank, downstream, and right bank then the results are averaged to provide an estimate of canopy cover for that point.

Specific methods and the actual references for canopy and riparian monitoring procedures are presented in Appendix H.

Biological Sample Collection

Freshwater benthic macro invertebrates include worms, snails, clams, crustaceans, aquatic beetles, the nymph form of mayflies, stoneflies, dragonflies and damselflies and larval form of caddisflies and true flies. They are a minimum of 0.5 mm in length and live primarily on instream boulder, cobble or gravel substrate. They are most easily categorized into feeding guilds, species that obtain a common food source in a similar manner. The most common feeding guilds are shredders, filter-collectors, collect-gatherers, scrapers-grazers, and predators.

The physical structure of rivers and streams are measured by stream order, which is related to watershed size. Stream order influences the assemblage of benthic macro invertebrates. The Gualala River mainstem is a fourth order stream, all other tributaries within the basin are of smaller order. The predominant feeding guilds in fourth order streams are scrapers, which consume the algal growth associated with a more open canopy cover and collectors utilizing the high amount of fine particulate organic matter, which has drifted downstream. Shredders, which

process leaf litter and other forest debris, and collectors, which further process shredder excrement, usually dominate first and second order streams.

Macroinvertebrate samples will be obtained using the methodology outlined in the *California Stream Bioassessment Procedure* (CDFG 1999). Sampling sites will be selected according to guidance provided in those protocols as well as knowledge of the watershed and land uses upstream of the site.

Other interesting, descriptive, or unusual biota will be noted in the field log at the time of sampling to provide additional qualitative information on the relative health of the water body.

Stream Discharge, Turbidity, and Total Suspended Solids

The measurements and data analysis presented below describe a limited monitoring program utilizing field observations and measurements collected by monitoring personnel that could be used to quantitatively characterize the magnitude of the measured parameters. Although the protocol provides for the collection of quantitative data, the interpretation of the data is limited by high sample variance and small sample size. A statistically robust data set that could potentially be used to assess trends or cause-effect relationships between water quality and land management would require at minimum a continuous data record that could be produced only by automated samplers, supplemented by a field monitoring program comparable to that presented here. It would be possible for committed field personnel to produce a valuable data set using this monitoring protocol, however, the investment of time and effort would be high.

Simultaneous measurements of stream discharge (instantaneous rate of flow in units of cubic feet per second), water turbidity, and total suspended solids in the water column form a discrete component of the monitoring program that can be conducted during periods of storm runoff from October through the end of the rainy season. Monitoring sites will require installation of a monumented cross-section, a staff plate allowing observation of water surface elevation surveyed in the cross-section, and must be relatively accessible and safe for sampling during periods of runoff.

The field protocol includes observations of time and stream stage, collection of a depth integrated water sample for subsequent lab analysis of suspended solids, collection of a surface grab sample for field measurement of turbidity, and measurement of stream discharge (requires at least 0.5 hours of wading and measurement of stream velocity with a current meter). Supplemental data on flow velocity at the water surface will be collected using a float test. The relationship between stream discharge and surface velocity will be used to improve the accuracy of estimated stream discharge during periods when in-stream measurements are not possible or unsafe. Following the discharge measurement, a second set of stage and water samples are collected. Observations of stage, turbidity, and suspended solids immediately before and following discharge measurements are intended to account for variability of conditions in the short-term, including potentially rapid changes in stream stage and discharge.

The surface grab sample for field measured turbidity should be taken as near the channel thalweg as possible, and must be collected from a location where flow is well-mixed. The same criteria apply to the depth integrated sample. Samples for turbidity will be processed immediately in the field. Samples for suspended solids will be labeled and refrigerated and will be transported to a contract laboratory as soon as possible, normally within 72 hours. Chain of custody forms will be maintained for these samples.

Stream discharge measurements typically require measurement of stream velocity at a minimum of 10 points, and preferable 20, in the cross-section. These measurements necessarily include periods of storm runoff. Safety considerations are paramount, and it is anticipated that there will be periods of flow when field personnel will determine that in-stream measurements are not sufficiently safe. In recognition of this reality of field work in streams, supplemental observations of surface velocity are included in the monitoring protocol.

Specific methods and the actual references for canopy and riparian monitoring procedures are presented in Appendix I.

Photo Documentation

Photos of the downstream end of the reach are taken to document location of benchmarks used to relocate and resurvey the reach. In addition, instream photo monitoring using photos taken both upstream and downstream from station zero, at each cross-section station, and at end of the reach is conducted to record general channel conditions and assist in interpretation of channel change over time. No formal analysis of photos is conducted. Specific methods are included in the monitoring procedure where photo documentation is part of the methodology (i.e. longitudinal profiles, cross-sections).

3. Sample Handling and Custody

Field teams will collect data with a team leader supervising. All data sheets and instrument logs will be turned into the team leader who will check the data for quality and completeness. As noted above, chain of custody will be documented for water samples collected for laboratory processing, withshipment to laboratory based on the protocols for the individual metrics. Chain of custody (COC) forms will be maintained for all samples.

4. Analytical Methods

The parameters being measured as part of this QAPP are physical in nature and do not involve analytical methods, with the exception of turbidity and total suspended solids. Turbidity measurements will be collected using a field instrument approved for this purpose by the California Regional Water Quality Control Board, North Coast region (RWQCB). Total suspended solids would be determined using EPA Method 160.2. Additional information regarding these methods is provided in Appendix I.

5. Quality Control Requirements

Each of the parameters being used in this QAPP has an associated Quality Control, which is addressed in the Appendices.

Field data sheets will be checked and signed in the field by the monitoring leader. For laboratory samples the monitoring team leader will discard any results where holding times have been exceeded, sample identification information is incorrect, samples were inappropriately handled, or calibration information (recorded in the instrument logs) is missing or inadequate. Following each event, the team leader will collect the field notebooks and data sheets. All notebooks and data sheets will then be copied and stored in a site-specific binder. The binder and the original data will be stored in a specied location.

Independent laboratories will report their results to the monitoring leader. The leader will verify sample identification information, review the chain-of-custody forms, and identify the data appropriately in the database.

Data sheets and data files will be reviewed quarterly by the technical advisors to determine if the data meet the Quality Assurance Project Plan objectives. They will identify outliers, spurious results or omissions to the citizen-monitoring leader. They will also evaluate compliance with the data quality objectives. They will suggest corrective action that will be implemented by the citizen-monitoring leader. Problems with data quality and corrective action will be reported in final reports.

If data do not meet the project's specifications (see Table 7.2 –error tolerance), the following actions will be taken. First, the technical advisors will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. If the problem cannot be corrected by re-training, revision of techniques, or replacement of supplies/equipment, then the technical advisors and the TAC will review the DQOs and determine if the DQOs are feasible. If the specific DQOs are not achievable, the parameter should be eliminated from the monitoring program.

6. Instrument/Equipment Testing, Inspection and Acceptance Maintenance

All sampling equipment will be inspected for broken or missing parts, and will be tested to ensure proper operation. Inspection of equipment will occur as a pre-sampling check prior to use or as indicated by an exceeded QC limit. Maintenance will be performed in accordance with manufacturers recommendations or more frequently if problems are identified by QC checks.

Testing, inspection, and calibration for each specific piece of equipment are addressed in the Appendices. The following is a list of equipment that will be needed for the parameters being measured in this QAPP:

- ✓ Onset Hobo Temperature Data Loggers
- ✓ Non-Mercury Thermometers (NIST certified)
- ✓ Engineers Level, tripod, Stadia rod, 8” carpenter level
- ✓ Compass
- ✓ Clinometer
- ✓ Densiometer
- ✓ Calculator
- ✓ Camera
- ✓ 200’ Fiberglass 2-sided tape, 150” Fiberglass tape, Spenser tape, 25’steel tapes, clear metric rulers
- ✓ (optional) Turbidometer, field unit (issued by RWQCB to GRWC)

Additional equipment that will be used but will not require any testing, QA/QC related inspection or maintenance will include:

- ✓ Fence Posts
- ✓ D-shaped kick net (0.5 mesh)
- ✓ Lag Bolts & Driver
- ✓ 3’ Rebar
- ✓ Flagging
- ✓ Rudd Paint
- ✓ Aluminum & Code Tags
- ✓ Sledge Hammer
- ✓ Fence Post Pounder
- ✓ Clippers & Machete

7. Instrument/Equipment Calibration and Frequency

The equipment calibration and frequency is addressed for each protocol where equipment needs to be calibrated. This includes the calibration of the data loggers discussed in the temperature protocol (Appendix B) and the calibration of the turbidometer used in the optional water quality protocol (Appendix I).

8. Inspection/Acceptance of Supplies and Consumables

The inspection of supplies and consumables for the macroinvertebrate sampling are outlined in California Stream Bioassessment Procedure. Inspection of equipment will occur as a pre-sampling check prior to use or as indicated by an exceeded QC limit. Maintenance will be performed in accordance with manufacturers recommendations or more frequently if problems are identified by QC checks.

9. Non-direct Measurements

N/A to project

10. Data Management

Refer to A9 above for discussion regarding handling of data sheets and instrument logs. The designated data management coordinator will review the field sheets and enter the data deemed acceptable by the citizen monitoring leader(s) and the technical advisors. Data will be entered into a spreadsheet or a database using a format that is approved by the RWQCB. The data coordinator will review electronic data, compare to the original data sheets and correct entry errors. After performing data checks, and ensuring that data quality objectives have been met, data analysis will be performed. Summary statistics will be generated annually.

Raw Data

Raw data will be provided to the State WRCB and RWQCB in electronic form at least once every year so that it can be included in the 305(b) report and referenced for other watershed improvement projects and/or studies. Appropriate quality assurance information can be provided upon request. This should occur when the data files are updated and backed up (see A9 above). Refer to B2, B3 and B5 for additional discussion regarding data quality control processes.

Analysis

Temperature

Raw temperature data will be processed according to the methods outlined in the FSP protocols. A core set of metrics will be calculated from the data on a seasonal basis. These will include:

- daily minimum
- daily maximum
- daily average
- seven-day moving average of the daily mean
- seven-day moving average of the daily maximum

Yearly summary statistics calculated from the daily and weekly data will be produced for each site for each year. Yearly site-specific statistics of the seasonal maximum for the Maximum Weekly Average Temperature (MWAT) and the seasonal Maximum (Max) will be produced in chart form for each Super Planning Watershed (NCWAP Synthesis Report, 2002).

Longitudinal (Thalweg) Profiles & Benchmarks

Subsequent analysis of the channel profile may reveal subtle changes in channel morphology resulting from small scale shifts in bed sediment associated with low-magnitude annual floods and will document major changes in the stream bed that may result from high-magnitude floods that occur relatively infrequently. A core set of metrics will be calculated from the thalweg elevation data on an annual basis. These will include:

- channel slope

- a plot of the thalweg profile and associated summary data used to evaluate:
    - local changes in bed conditions, including location and depth of pools
    - changes in channel elevation relative to base year elevation
- Variation Index (Madej, 1999), a metric developed in northern California to evaluate channel response to and recovery from bed aggradation.

Summary statistics for slope, the thalweg profile and channel elevation are calculated by using an Excel database developed for Gualala Redwoods, Inc. The Variation Index is a means to quantifying variability in a longitudinal channel profile and is calculated by using the Longpro database developed by the USGS and Redwood National Park.

Cross-sections

Analysis of the cross-sectional profile may reveal changes in streambed elevation, bank stability, bankfull width/depth ratio, and channel scour and/or fill (aggradation/degradation). A core set of metrics will be calculated on an annual basis. These will include:

- bankfull width/depth ratio
- a cross-sectional profile plot to evaluate changes in streambed elevation and bank stability.
- changes in channel elevation relative to base year elevation
- channel scour and/or fill (Madej, 1999)

Summary statistics for bank-full width/depth ratio are calculated by using the CDF&G protocol. The cross-sectional profile plot and the channel elevation change are calculated by using an Excel database developed by Gualala Redwoods, Inc. Channel scour and/or fill is calculated by using the Winscour database developed by the USGS and Redwood National Park

Pebble Counts

It has been shown that shifts toward the lower end of the pebble count cumulative frequency curves may be indicative of significant increases in streambed fines from accelerated natural and or land-use disturbances. Conversely, a progressive coarsening of streambed surface particles may indicate improving conditions from past upstream and/or upslope disturbances. A core set of metrics will be calculated on an annual basis. These will include:

- d50, median particle size, the diameter at which 50% of the particles are finer
- d16, the diameter at which 16% of the particles are finer
- d84, the diameter at which 84% of the particles are finer

Summary statistics for the particle size diameters will be provided for individual sites and averaged by study reach. Other analyses that may be applied on a site-specific basis are the geometric mean diameter, $dg = [(D84)(D16)]^{0.5}$, and the geometric sorting coefficient, $sg = (D84/D16)^{0.5}$ (Kondolf and Li, 1992).

Large Woody Debris

Beechie and Sibley (1997) concluded that when the number of LWD pieces (>8 inches in diameter) reached about 122 pieces /1,000 Ft., pool formation is less sensitive to further increases in LWD loading. Similarly, Martin (1999) found that the effectiveness of LWD for forming pools in alluvial channels was diminished when the LWD load exceeded a threshold of approximately 137 pieces.

Calculating the size, position and number of LWD pieces within a survey reach will allow monitoring of natural LWD recruitment and assist in planning and monitoring future LWD restoration plans. A core set of metrics will be calculated from the data on an annual basis. These will include:

- cubic feet of LWD per 1,000 feet (also determined in units of m^3/100 m)
- number of LWD pieces per 1,000 feet

Yearly summary statistics are reported by monitoring study reach. A comparison of LWD load in each sample reach to the frequency distribution for regional values may be provided.

Riparian Measurements and Canopy

Subsequent analysis of riparian data allows the calculation of the riparian habitat within the study reaches. A core set of metrics will be calculated from the riparian surveys and canopy data on an annual basis. These will include:

- canopy density at center of channel, bank-full and 50' into the riparian zone
- riparian composition
- basal area
- tree height

Summary statistics for canopy density, riparian composition and basal area are averages for the study reach sites. Tree height is calculated by averaging the height of the 100 tallest trees per acre.

Turbidity

If and when turbidity data are collected, simultaneous measurement of stream discharge must occur. The turbidity data would be summarized in tabular format, including collection time and date, location of sample site, and stream discharge. In addition, for each sample station, a scatter plot showing turbidity as a function of stream discharge will be presented, and a linear regression analysis will be performed using stream discharge as the independent variable and turbidity as the dependent variable. If a relatively large data set is collected, it is expected that turbidity will be correlated with discharge.

Stream Discharge

In addition to the data report above, stream discharge observations will also be computed in terms of discharge per unit watershed area for comparison to continuous gauge data collected at

the North Fork, Wheatfield, and South Fork gauges. If a relatively large data set is collected, it is expected that discharge will be correlated with one of the continuous gauges, and that a predictive relationship using linear regression can be developed whereby the continuous gauge data can be used to estimate discharge in smaller tributary watersheds based on drainage area.

Total Suspended Solids

These data are collected to determine the extent to which turbidity is correlated with suspended sediment transport. To the extent that these parameters are correlated at a monitoring site, turbidity data can be interpreted as an estimator for sediment load. Where available, total suspended solids will be reported in the summary table along with turbidity and discharge data. In addition, for each sample station, a scatter plot showing total suspended solids as a function of turbidity will be presented, and a linear regression analysis will be performed using turbidity as the independent variable and total suspended solids as the dependent variable. If a relatively large data set is collected, it is expected that total suspended solids will be correlated with turbidity. For individual sampling stations, a predictive relationship will be developed using linear regression which relates total suspended solids to turbidity. It is anticipated that the number and frequency of collection of samples for analysis of total suspended solids will decrease over time, once the predictive relationship is established.

Biological Sample Collection

Benthic macro invertebrate biotic condition is commonly measured by species richness, species composition, and tolerance/intolerance metrics. Species richness and composition tend to decrease in response to habitat disturbance. Harrington (2000) developed the Russian River Index of Biological Integrity, which includes six metrics:

- taxa richness
- percent dominant taxa
- EPT taxa
- modified EPT taxa
- Shannon diversity
- tolerance value

These six metrics will be integrated into a single score, which is compared to determine biotic condition categories: excellent (30-24), good (23-18), fair (17-12), and poor (11-6).

C. ASSESSMENT AND OVERSIGHT ELEMENTS

1. Assessment and Response Actions

Review of all field and data activities is the responsibility of the monitoring leader, with the assistance of the TAC. The monitoring leader, or a technical advisor will accompany volunteers on the 1st and 2nd sampling trips. If possible, volunteers in need of performance improvement will be retrained. All volunteers must attend a refresher course offered annually by the GRWC,

SRCD or other recognized agency or entity. If errors in sampling technique are consistently identified, retraining may be scheduled more frequently.

Within the first three months of the monitoring project, State WRCB staff, or its designee, will evaluate field and laboratory performance and provide a report to the citizen-monitoring group. All field and laboratory activities, and records may be reviewed by state and EPA quality assurance officers as requested. If corrective action is required, State WRCB and the Regional WQCB staff will work with the SRCD and monitoring group to implement improvements.

2. Reports

The technical advisors will review draft reports to ensure the accuracy of data analysis and data interpretation. Raw data will be made available to data users per their request. The individual citizen monitoring organizations will report their data to their constituents after quality assurance has been reviewed and approved by their technical advisors. Every effort will be made to submit data and/or a report to the State and/or Regional Board staff in a fashion timely for their data uses, e.g. 305(b) report or special watershed reports.

D. DATA VALIDATION AND USABILITY ELEMENTS

1. Data Review, Validation and Verification

Data sheets will be reviewed quarterly by the technical advisors to determine if the data meet the Quality Assurance Project Plan objectives. They will identify outliers, spurious results or omissions to the monitoring team leaders. They will also evaluate compliance with the data quality objectives. They will suggest corrective action that will be implemented by the citizen-monitoring leader. Problems with the data quality and corrective action will be reported in final reports.

2. Validation and Verification Methods

As part of the standard field protocols, any sample readings out of the expected range will be reported to the monitoring team leader. A second sample will be taken as soon as possible to verify the condition. It is the responsibility of the team monitoring leader to re-train volunteers until performance is acceptable.

3. Reconciliation with User Requirements

All references are contained in the appendices.

Appendix

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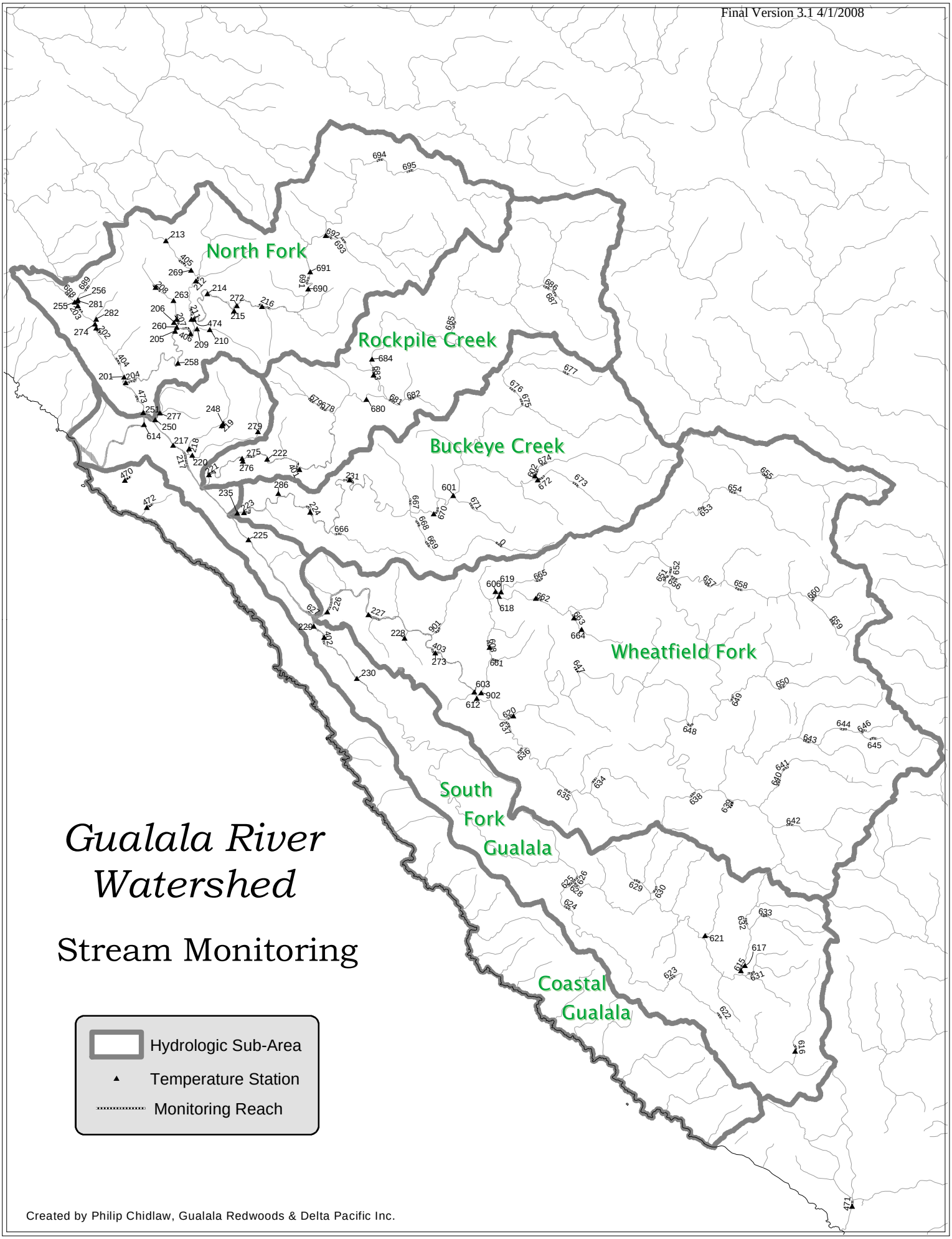

Created by Philip Chidlaw, Gualala Redwoods & Delta Pacific Inc.

Appendix B
Water Temperature Monitoring

Introduction

Background
This protocol has been adapted in large part from the Forest Science Project's Protocol (FSP 1998). Stream temperature is one of the most important environmental factors affecting aquatic ecosystems. The vast majority of aquatic organisms are poikilothermic--their body temperatures and hence their metabolic demands are determined by temperature. Temperature has a significant effect on cold-water fish, both from a physiological and behavioral standpoint. Below is a brief list of the physiological and behavioral processes affected by temperature (Spence et al., 1996):

- Metabolism
- Food requirements, appetite, and digestion rates
- Growth rates
- Developmental rates of embryos and alevins
- Timing of life-history events, including adult migrations, fry emergence, and smoltification
- Competitor and predator-prey interactions
- Disease-host and parasite-host relationships

This protocol sets forth a sampling approach that will provide consistent data that can be used to address stream temperature issues at broad regional scales, i.e., watershed, basins, and regions.

Scope and Application
The field methods described in this protocol are for obtaining representative stream temperatures from perennial streams for regional monitoring. The field methods are specifically applicable for the deployment of continuous monitoring temperature sensors (e.g., Hobo Temps, Temp Mentors, Stowaways, etc.) for the purpose of identifying diurnal changes in temperature, seasonal changes in thermal regime as well as seasonal changes. Possible interferences in the accurate and precise measurement of stream temperature include: 1) exposure of the sensor to ambient air, 2) improper calibration procedures, including date and time settings, 3) improper placement of the sensor in the stream, 4) low battery, 5) inherent malfunctions in the sensor or data logger, and 6) vandalism.

Summary of Method
All continuous stream temperature monitoring sensors should be calibrated against a National Institute of Standards and Technology (NIST) traceable thermometer. Sensors not meeting precision and accuracy data quality objectives should not be used. Sensors should be placed in a well-mixed zone, e.g., at the end of a riffle or cascade. Monitoring location should represent average conditions — not pockets of cold water refugia or isolated hot spots. Location of sampling points should either avoid or account for confounding factors that influence stream temperatures such as:

- confluence of tributaries
- groundwater inflows
- channel morphology (particularly conditions that create isolated pools or segments)
- springs, wetlands, water withdrawals, effluent discharges, and other hydrologic factors
- beaver ponds and other impoundments

The sensor should be placed toward the thread or thalweg of the channel. Keep in mind that flow will decrease throughout the summer resulting in an exposed sensor. The thermistor portion of the device should not be in contact with the bottom substrate or other substrate that may serve as a heat sink (e.g., bridge abutment or boulder). Secure the sensor unit to the bottom of the channel with aircraft cable, surgical tubing, rebar, or diver's weights. The sensor should be set to record temperatures at sampling intervals that should not exceed 1.6 hours (96 minutes).

Equipment and Supplies

Calibration and Standardization
Prior to deployment of sensors, calibration of each sensor must be performed. The following is a list of equipment and supplies for calibration:

- NIST traceable thermometer - resolution of 0.2ºC or better, an accuracy of ±0.2ºC or better.
- controlled-temperature water bath, or water-filled thermos
- ice chest
- laboratory notebook
- ice

Field Measurements
There are several useful materials and pieces of equipment that should be taken to the field to install or service temperature sensors. These include:

- securing material such as zip ties, bailing wire, aircraft cable, surgical rubber tubing, locks, rebar, cinder blocks, large rocks with drilled holes, diver's weights
- GPS w/extra batteries
- surveyors marking tape or flagging
- sledge hammer (e.g., two-pound)
- wire cutters and/or pocket knife

- thermistor equipment items (silicone rings, submersible cases, silicone grease, silica packets)
- portable computer or interface for data downloading and launching
- backup batteries and thermistors
- timepiece/watch
- Rite-in-the-Rain field book w/ extra field sheets
- NIST-traceable auditing thermometer
- waders
- camera and film
- brush removal equipment (e.g., safety axe)
- maps and aerial photos
- first aid kit
- spray paint, rags and clean up cloths
- metal stakes or spikes, rebar

Pre- and Post-Deployment Calibration and Standardization

A. A NIST-traceable thermometer must be used to test the accuracy and precision of the temperature sensors. The NIST-traceable thermometer should be calibrated annually, with at least two calibration points between 10ºC (50ºF) and 25ºC (77ºF). Calibrations should be performed using a thermally stable mass of water, such as a controlled-temperature water bath, or water-filled thermos or ice chest. The stable temperature of the insulated water mass allows direct comparison of the unit's readout with that of the NIST-traceable thermometer. Accuracy of the NIST-traceable thermometer must be within ±0.5ºC.

B. Prior to use, all continuous monitoring devices should be calibrated at room temperature (~25ºC, 77ºF) and in an ice water bath to insure that they are operating within the accuracy over the manufacture's specified temperature range. Calibrate all continuous monitoring devices with a NIST-traceable laboratory thermometer at two temperatures, room temperature (i.e., ~77ºF, 25ºC) and near the freezing point of water as follows:

   When calibrating and prior to deployment, set all units to the same current date and synchronize all devices using an accurate watch/clock that will be used to time the recording intervals of the reference thermometer. Call for the correct time.

   Set the record interval of each thermograph to a short period, six to 30 seconds.
   Record the date, sensor serial number, data logger serial number, and analyst's name in a laboratory notebook. Table 1 is an example of a format that can be used for data collection. The same sensor and same data logger should be deployed in the field as they were paired together during calibration.

   Place the reference thermometer and the continuous monitoring devices in a five-gallon pail filled with about three gallons of water that has reached room temperature overnight or in a controlled-temperature water bath that has reached room temperature (~77ºF, 25ºC). Make

sure the casings of all continuous monitoring devices are completely submerged. Stir the water, just prior to, and during the calibration period to prevent any thermal stratification.

After allowing 10 to 20 minutes for the continuous monitoring devices to stabilize, begin recording data for a 10-minute interval. Record the time, the reference thermometer temperature, and the continuous monitoring device temperatures measured at the predetermined sampling frequency (e.g., 6 second, 10 second) used during the 10-minute interval. After all readings are completed, calculate the difference between the reference thermometer and each of the continuous monitoring devices for each reading and calculate the mean difference. Record the data using a format similar to that shown in Table 1.

Table 1. Example of Calibration Data Collection Table

4/12/98	**Sensor Serial Number = 10043 Data logger S.N. = 2S256S**	**Analyst: Joe Celsius**	**Reference Thermometer No. 412**
Time (sec)	**NIST Thermometer Reading (ºC)**	**Device Reading (ºC)**	**Difference (ºC)**
0	25.0	24.8	-0.2
10	25.1	25.0	-0.1
20	25.0	24.9	-0.1
30	25.2	25.0	-0.2
40	25.0	24.6	-0.4
Etc.			
		Mean = 24.9 S.D. = 0.16	Mean Diff. = -0.16

C. Any continuous monitoring devices not operating within their specified accuracy range should be thoroughly scrutinized. If a particular device returns readings that are outside of the manufacturer's accuracy limits, but is still precise, then a correction factor (addition and/or multiplication) can be applied to the data. Precision should be within 0.2 standard deviations (S.D.) of the mean. Acceptable precision should be observed over the range of temperatures that will be experienced in the field. The correction factor, when applied over the calibration range, should give temperature values that are within the accuracy limits of the device. If units are inaccurate and imprecise they should not be used.

D. Using the same water bath, add enough ice to nearly fill the bucket and bring the temperature down to nearly freezing. Stir the ice bath to achieve and maintain a constant water temperature. Place the reference thermometer and the continuous monitoring devices in the water bath or five gallon pail. Again, make sure that the casings are completely submerged.

E. Repeat steps 2B-D with ice water bath.

F. Also confirm that thermograph batteries have sufficient charges for the entire monitoring period (will the length of the upcoming field season fit into the life expectancy of the unit's lithium batteries?).

G. Calibration (post-deployment calibration) should also be repeated when sensors are retrieved at the end of the sampling season. Repeat steps 2A-F.

Quality Assurance and Quality Control

Laboratory
Precision and accuracy should be 0.2 SD and ±0.5ºC, respectively for each continuous monitoring device.

Monitoring equipment with detachable sensors must be marked in order to match the sensor with the data logger. This allows instrument and sensor to be calibrated and tested prior to deployment, and also makes malfunctions easier to diagnose and correct. A logbook must be kept that documents each unit's serial number, calibration date, test results, and the reference thermometer used (Table 1).

Field
In addition to laboratory quality control checks, temperature monitoring equipment should be audited during the field season if possible. A field audit is a comparison between the field sensor and a hand-held NIST-traceable reference thermometer. The purpose of a field audit is to ensure the accuracy of the data and provide an occasion for corrective action, if needed. A minimum of two field temperature audits should be taken during the sampling period — one after deployment when the instrument has reached thermal equilibrium with the environment, and ideally one prior to recovery of the device from the field. Reference thermometers used for field audits must meet the same specifications as those used for laboratory calibrations: accuracy of ±0.5ºC, resolution of 0.1ºC. Exercise caution with mercury thermometers in the field.

A field audit is performed as follows:

Place the reference thermometer in close proximity to the continuous monitoring device.

Record the reference thermometer temperature and the sensor temperature in a field notebook. A stable reading is usually obtained within 10 thermal response units or time constants. For example, a reference thermometer with a ten-second time constant should give a stable reading in 100 seconds.

Post-processing audit accuracy must be within ±0.5ºC .

> Response time (time constant) is the time required by a sensor to reach 63.2% of a step change in temperature under a specific set of conditions. Response time values should be provided by the manufacturer. Five time constants are required for the sensor to stabilize at 100% of the step change value. Ten time constants are recommended to ensure that the reference thermometer has reached equilibrium with the stream temperature.

Data loggers typically set date and time based on the set-up computer's clock. It is important that field personnel synchronize their watches to the computer clock's time. Prior to the field audit, the computer clock should be set to the correct date and time by calling for the correct Pacific time.

Procedures

Water temperatures vary through time and space. The temporal and spatial aspects of deploying stream temperature monitoring devices is discussed in the following sections.

Temporal Considerations of Sensor Deployment

Sampling Window
Launch sensors to capture the hottest period of the field season, which will vary with watershed location. Coastal streams in Humboldt and Del Norte Counties require deployment at least during July, August, and September; whereas Mendocino County and more inland streams may require longer recording periods (June-October) (FFFC, 1996). For consistency it is recommended that the sampling window be from June 1 to October 1. This sampling window will ensure that the highest temperatures during the summer will be captured in the data set.

Sampling Frequency
The time interval between successive temperature readings can be adjusted from every few seconds, to every few hours, to every few days, for most continuous monitoring devices. Table 2 shows some of the typical sampling frequencies and the number of days the device can be left in the field prior to data downloading. In most monitoring activities, the primary objective is to determine the highest temperatures attained during the year. Thus, one of the deciding factors in setting the sampling frequency on a device will be to ensure that the daily maximum temperature is not missed.

The more frequent the monitoring, the more precisely the duration of daily maximum temperature can be characterized. The disadvantage of frequent data collection is reduced number of days of data storage and increased number of data points to be analyzed. Some agencies and other groups have found that an 80-minute sampling interval still captures the daily maximum stream temperatures for sites (OCSRI, 1996). If a less frequent sampling interval is desired, then a pilot study must be performed with monitoring at 30-minute intervals over a one to two week period during the hottest time of the year to determine how rapidly stream temperatures change. Pilot study information can provide information on the time interval most appropriate for capturing the daily maximum.

Table 2. Typical Sampling Frequencies and Storage Capacity of a Hobo® Data Logger Used for Stream Temperature Monitoring

2K Memory / 1,800 Meas.	8K Memory / 7,944 Meas.	32K Memory / 32,520 Meas.	Sample Frequency
37.5 days	165 days	677 days	30 min
45 days	198 days	813 days	36 min
60 days	264 days	1084 days	48 min
75 days	331 days	1355 days	1 Hr
90 days	397 days	1626 days	1.2 Hr
120 days	529 days	2165 days	1.6 Hr
150 days	662 days	2710 days	2 Hr
180 days	799 days	3270 days	2.4 Hr
240 days	1050 days	4300 days	3.2 Hr
360 days	1590 days	6540 days	4.8 Hr

Note: BoxCar and LogBook software's launch menu allows the user to choose from 42 intervals ranging from 0.5 seconds to 4.8 hours. The table shows the most likely settings that may be used for stream temperature monitoring. Mention of trade names does not denote endorsement by the Fish, Farm, and Forests Community Forum, the Forest Science Project, or any of their cooperators.

Selection of appropriate sites for monitoring is dependent upon the purpose and monitoring questions being asked. There are two scales of consideration for the appropriate monitoring site: selection of a sample point or location in the stream which provides representative data and the broader strategy of selecting sites that can provide useful information to answer the questions being asked.

Data Downloading

It is preferable to have the data cover the entire monitoring without interruptions. However, if data must be downloaded during the monitoring period due to insufficient data logger memory, record the date and time the sensor was removed from the stream and the date and time when it was returned to the stream. Some models may allow for downloading of data without interruption or removal of the sensor from the stream. Be sure to return the sensor to the same approximate location and depth after downloading. During a field visit for data downloading or auditing, record in the field notebook whether the sensor was exposed to the air due to low flow, discontinued flow, or vandalism. This information will be valuable for verification and validation of the data in the office.

Mid-Season Field Audit/Calibration Check

If data downloading is performed in mid-season, an opportunity for a mid-season field audit and calibration check presents itself. See Field Section for mid-season field audit and calibration procedures.

Spatial Considerations of Sensor Deployment

Stream Sample Point Location
The simplest and most specific scale is a sampling point on a stream. Here, the focus is on sample collection methods that will reduce variability and maximize representativeness.

Monitoring must record daily maxima at locations which represent average conditions - - not pockets of cold water refugia or isolated hot spots. Measurements should be made using a sampling protocol appropriate to indicate impact to beneficial uses (OCSRI, 1996). Thus, location of sampling locations should be done in a manner that is representative of the waterbody or stream segment of interest. In order to collect representative temperature data, sampling site selection must minimize the influence of confounding factors, unless the factor is a variable of interest. Some confounding factors include:

- confluence of tributaries
- groundwater inflows
- channel morphology (particularly conditions that create isolated pools or segments)
- springs, wetlands, water withdrawals, effluent discharges, and other hydrologic factors
- beaver ponds and other impoundments

Site Installation
Unless study design dictates differently, all sensors should be placed in the thalweg of riffles to insure a complete mixing of the water and to maintain sufficient water depth for the duration of the sampling window. Alternatively, if riffles are too shallow place the sensor in a pool or glide that exhibits well-mixed conditions. Do not place the sensor in a deep pool that may stratify during the summer, unless this is the objective of your study. This measure insures that sensors are not selectively placed in cooler areas such as stratified pools, springs, or seeps or in warm, stagnant locations (hot spots) that would misrepresent a stream reach's temperature signature. A hand-held thermometer can be used to document sufficient mixing by making frequent measurements horizontally and vertically across the stream cross-section. If stream temperatures are relatively homogenous (±1-2 C) throughout the cross-section during summer low-flow conditions, then sufficient mixing exists.

Monitoring devices should be installed such that the temperature sensor is completely submerged, but not in contact with the bottom. Place the sensor near the bottom of the stream by attaching it to a rock, large piece of woody debris, or a stake. Use zip ties, surgical tubing, or aircraft cable to attach the sensor to the bottom substrate. Rebar or diver's weights can be used if no suitable fastening substrate is available. For non-wadeable streams, the sensor should be placed one meter below the surface, but not in contact with a large thermal mass, such as a bridge abutment or boulder (ODF, 1994). If the monitoring site is not in a heavily visited area, mark the location of the sensor by attaching flagging marked with the gauge number or site ID number to nearby vegetation.

Precautions against vandalism, theft, and accidental disturbance should be considered when installing equipment. In areas frequented by the public, it is advisable to secure or camouflage equipment. Visible tethers are not recommended because they attract attention. When equipment

cannot be protected from disturbance, an alternative monitoring site should be considered. For external data loggers that are not waterproof, place them above the mean high water line to prevent loss during a freshet. Some data loggers must be housed in a waterproof metal or plastic box that should be locked and chained to a tree. Data logger boxes and cables should be covered with rocks, moss, and wood to hide equipment.

Install the sensor in a shaded location; shade can be provided by canopy cover or some other feature such as large woody debris. If no shaded locations are available, then it may be necessary to construct a shade cover for the sensor (e.g., using a section of large diameter plastic pipe.) The intention for this measure is to avoid direct solar warming of the sensor. The intent is not to suggest that sensors should be placed only in shaded thermal reaches.

Sensors should be located at the downstream end of a thermal reach, so as to characterize the entire thermal reach, as opposed to local conditions. Protocols for characterizing thermal refugia can be found in FFFC (1996).

The number of thermograph units deployed will vary with 1) drainage area of the watershed, 2) numbers and sizes of inflow tributaries or other transitions in riparian condition, 3) changes in elevation, and 4) proximity to coastal fog zone. In all circumstances, a continuous monitoring device should be located as far downstream as surface water flows during the summer. In watersheds with multiple sensors locate them in a lower/upper or lower/middle/upper distribution.

Mark all monitoring site locations on a USGS 1:24,000 topographic map, aerial photo, or GIS map. Clearly show the location of the site with respect to other tributaries entering the stream, e.g., above or below the confluence. Record measured distance to a uniquely distinguishable map feature (i.e., road crossing, specific tributary, etc.) Draw a diagram of the monitoring area. Include details such as: harvest unit boundaries, sensor location and thermal reach length, tributaries with summer flow, description of riparian stand characteristics for each bank, areas where portions of the stream flow become subsurface, beaver pond complexes, roads near the stream, other disturbances to the channel or riparian vegetation (heavy grazing, gold dredging, gravel mining, water withdrawals).

Record the serial number of each sensor/data logger combination at each monitoring site. Make an effort to deploy the same sensor/data logger combination at the same site each year.

Once a sensor/data logger combination has been deployed at a site, do not move the equipment to another location. Adjustments in sensor location may be necessary if the initial location ran dry, and the sensor must be moved to the active, flowing channel. This will necessitate a unique site_id for spatial statistical analysis. Make notes of such relocations in the field notebook.

If sensors are used to collect long-term baseline or trend data in specific watersheds, establish fixed-location monitoring stations so that data sets will be comparable.

Site-Specific Data Collection
Other site-specific data should be collected at the time of sensor deployment or retrieval. These additional attributes will greatly assist in post-stratification and interpretation of status and trends in stream temperatures.

Length of Thermal Reach or Stream Segment
The thermal reach extends 300-600 meters above the site, depending on stream size (TFW, 1993). With a hip chain or measuring tape, measure the length of thermal reach or stream segment (in feet). If the stream has more than one channel, measure along the channel that carries most of the summer flow.

Canopy Closure
Use a spherical densiometer at evenly spaced intervals to determine average canopy closure for the thermal reach above the monitoring site. Take canopy closure measurements at 50-meter intervals along the thermal reach. If the percent canopy cover varies by more than 20% between measurements, then take additional measurements at 25-meter intervals to more accurately determine the average percent canopy closure for the reach. In order to save time, it may be advantageous to determine canopy closure at 25-meter intervals from the start, thus avoiding the need to back-track in cases where the variability exceeds 20%. In addition to calculating the average canopy closure, keep a record in a field notebook of the percent canopy closure at each sampling interval and note the locations on a map or sketch of the reach to document how the shade level varies through the reach. At each 25- or 50-meter interval, stand in the center of the channel and measure canopy closure four times: facing upstream, downstream, right bank, and left bank. Average these four values to obtain canopy closure for the location.

Elevation
Determine the elevation at the midpoint of the thermal reach from a USGS topographic map, or altimeter and record on data sheet to nearest feet.

Average Bankfull Width and Depth
Bankfull width and depth refer to the width and average depth at bankfull flow. These dimensions are related to discharge at the channel-forming flow, and can be used to characterize the relative size of the stream channel. This characterization will be useful for later post-stratification and assessment of stream temperature data. In addition, the ratio of bankfull width to depth (width:depth ratio) of a stream channel provides information on channel morphology. Width:depth ratio is related to bankfull discharge, sediment load, and resistance to bank erosion (Richards, 1982). For example, channels with large amounts of bedload and sandy, cohesionless banks are typically wide and shallow, while channels with suspended sediment loads and silty erosion-resistant banks are usually deep and narrow. Changes in width:depth ratio indicate morphologic adjustments in response to alteration of one of the controlling factors (Schumm, 1977).

Refer to Channel Form Monitoring Appendix E for step-by-step procedures for estimating bankfull width and depth.

Average Wetted Width
Measure the wetted channel width at the location where the sensor is placed. This measurement should be collected at the time of deployment and at the time of retrieval. Change in wetted width over the field season will provide information on the change in flow during the monitoring period. Follow the method outlined in Flosi (1998).

Habitat Type
Record the habitat type in which the sensor was placed. Use the following codes for the habitat types:

Riffle	Shallow reaches with swiftly flowing, turbulent water
run	Relatively uniform flowing reaches with little surface agitation
spool	Shallow pools less than 2 feet in depth with good flow (no thermal strata)
mpool	Mid-sized pools 2 to 4 feet in depth with good flow (no thermal strata)
dpool	Deep pools greater than 4 feet in depth or pools suspected of maintaining thermal strata (possible thermal strata)

Stream Class
Record the stream classification as defined by the California Forest Practice Rules.

1 - *Class I Watercourse:* Domestic supplies, including springs, on site and/or within 100 feet downstream of the operations area and/or 2) Fish always or seasonally present onsite, includes habitat to sustain fish migration and spawning.

2 - *Class II Watercourse:* a) Fish always or seasonally present offsite within 1000 feet downstream and/or 2) Aquatic habitat for nonfish aquatic species. 3) Excludes Class III waters that are tributary to Class I waters.

3 - *Class III Watercourse:* No aquatic life present, watercourse showing evidence of being capable of sediment transport to Class I and II waters under normal high water flow conditions after completion of timber operations.

4 - *Class IV Watercourse:* Man-made watercourses, usually downstream, established domestic, agricultural, hydroelectric supply or other beneficial use.

For Class I watercourses make a concerted effort to collect fish presence/absence and/or abundance data in the same thermal reaches or stream segments where stream temperature data is being gathered. Conduct fish surveys during the period when stream temperatures are highest (July-August).

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Data Field Form

To assist in the collection and organization the site-specific information a field data form has been adapted from the Forest Science Project form. The form can be found below. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

GRWC Stream Temperature Field Data Form

Station ID:	**File Name:**
Stream Name:	
X Coordinate:	**Y Coordinate:**
Projection (UTM Zone 10 NAD 27 preferred):	
Basin Name:	**USGS Quadrangle:**
Describe Placement:	
Surveyor:	**Organization:**
Device ID (serial #):	**Device Type:**
Calibration Date:	
Installation:	***Removal:***
Date Launched:	**Date Retrieved:**
Time:	**Time:**
Air Temperature ©:	**Air Temperature ©:**
Water Temperature ©:	**Water Temperature ©:**
Depth at Instument:	**Depth at Instrument:**
Depth of Instrument:	**Depth of Instrument:**
Maximum Depth:	**Maximum Depth:**
Wetted Width:	**Wetted Width:**
Wetted Length:	**Wetted Length:**

Habitat Type (circle one):	
Riffle	shallow reaches with swiftly flowing, turbulent water
Run	relatively uniform flowing reaches with little surface agitation
Spool	shallow pool less than 2 feet in depth with good water flow
Mpool	mid-sized pool 2 to 4 feet in depth with good water flow
Dpool	deep pools greater than 4 feet in depth or pools suspect of maintaining thermal strata
Mpool	mid-sized pool 2 to 4 feet in depth with good water flow

Thermal Reach Information:	Diagram or Photo
Bankfull Width:	
Bankfull Depth:	
Reach Length:	
Mean Canopy Closure:	
Average Channel Gradient:	
Average Channel Aspect:	
Channel Type (Flossi et al., 1998):	
Stream Class (I,II, etc.):	
Elevation:	
Drainage area:	
Comments:	

Appendix C
SURVEYING BASICS

Introduction

Topographic surveying is an essential tool in watershed monitoring. A basic field survey establishes the horizontal and/or vertical location of a series of points in relation to a starting point (called a benchmark). Repeated surveys of the stream channel, in each study reach, are used to document changes over time in the shape of the streambed. Changes in the sediment supply affect the shape of the streambed. The shape of the streambed, in turn, affects the amount of bedload material that the stream can carry.

Sediment levels are an important factor in determining the quality of salmon habitat. Salmon spawn on gravel beds in the stream. High levels of sediment prevent the circulation of oxygen and inhibit the ability of salmon eggs to develop into fry.

Figure 1. Automatic Level

Protocol Summary

The objectives of the survey include measuring the bankfull width of the stream, the slope of the streambed and the size of bed material. By making annual survey measurements, over a number of years, it is possible to assess changes in the amount of material stored in the bed of the stream, this information will indicate trend in the amount of bedload that is being delivered to the study reach.

The cross-section survey, in conjunction with identifying bankfull indicators, allows the direct measurement of the bankfull width. The longitudinal survey measures the channel slope. The longitudinal survey also shows the shape of the streambed along the direction of flow.

A survey of the stream channel is accomplished by using a surveying tool called an *automatic level* (see Figure 1). The automatic level is carefully set up to establish a horizontal reference plane. The horizontal reference plane allows the relative elevation of different features on the streambed to be measured. Distances from the horizontal reference plane are measured down to the surface of the ground using the *survey rod*. The Survey Protocol (*page 2*) describes, in detail, the steps to be followed in setting up the tripod and the automatic level. It describes how to use the automatic level (Figure 1) and the survey rod to measure elevation.

Surveying requires at least two people. The *Instrument Person* operates the automatic level and records the measurements in the level logbook. The *Rod Person*, selects sites and holds

the survey rod at the site while the Instrument Person is reading it. The protocol explains how to calibrate the instrument using a point of known elevation called a *benchmark*.
The general procedure for surveying is to first set up the instrument. Once the instrument is level, the rod is placed on a point with a known elevation called a benchmark. The instrument person looks through the telescope on the level and reads the number on the rod. The reading (backsight) is added to the elevation of the benchmark to give the elevation of the instrument crosshairs. The rod is then placed on a point whose elevation is to be determined. The reading (foresight) is subtracted from the elevation of the instrument to get the elevation of the new point.
Distances between points are measured with a tape measure or are measured optically with the level and the rod. Careful notes, including sketch maps, are taken to help interpret the survey information.

Surveying Protocols

Directions for Instrument Person

- Step 1: Setting Up the Tripod.
  1. Extend the legs of the tripod until the top of the tripod is level with your chin.
  2. Push one of the legs firmly into the ground. Spread the tripod legs 3' to 4' apart. Push the other two legs into the ground.
  3. Level the top of the tripod by raising or lowering the legs.
     Note: Leveling the instrument will be easier if the tripod head is on a nearly horizontal plane.
  4. After the head is level check that the leg adjusting screws are tight and the legs are firmly set in the ground.

- Step 2: Setting Up the Level.
  1. Place the instrument on the tripod.
  2. Screw the level snugly (finger-tight) to the head of the tripod.
     Note: Do not over-tighten the screw.
  3. Move the level screws in pairs to bring the bubble into the target circle on the level vial.
  4. Rotate the scope 90^0 degrees and re-level.
  5. Repeat until the bubble stays in the target circle throughout a 360^0-degree rotation. This procedure brings the instrument into the range where the self-leveling pendulum prism can operate.
  6. Turn the telescope to bring the rod into the field of vision.

- Step 3: Reading the Rod

The numbers on the face of the rod show the distance measured from the ground in feet. The scale can be read to the one hundredths of a foot. Whole numbers of feet are marked off on the scale on the left of the rod by the longer line with an angled end. For example, see the number 3.00 in Figure 2. The number of feet is read at the top of this line and is indicated by the large red numbers. Tenths-of-feet are also marked by a line with an angled end. For example, see the number 2.90 in Figure 2. The black numbers indicates the number of tenths-of-feet.

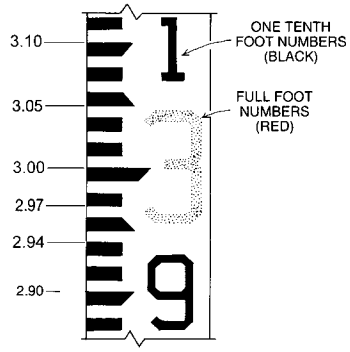

Figure 2. Face of the survey rod

Each black line and each white space on the scale is exactly one hundredths of a foot. The top of each black line, between the angled tenth-of-a-foot lines, mark off 2/100th's of a foot. Even number hundredths of a foot can be read at the top of the lines. Odd number hundredths of a foot are read at the bottom.

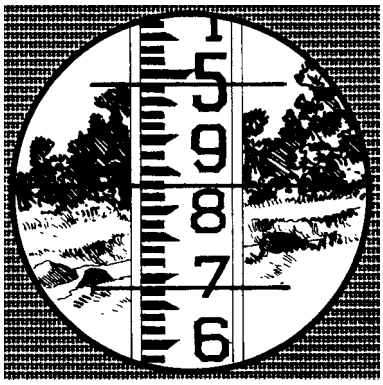

Figure 3. Reading the rod. The elevation is read at the middle line. The upper and lower lines are called stadia.

Point the telescope towards the rod. The center crosshairs should cross the face of the rod (Figure 3). Turn the focus knob until the rod can be clearly seen. Adjust the eyepiece to darken or lighten the cross hairs. I f the rod is leaning to the side, ask the rod person to move the top of the rod until it is vertical. The rod person should try to keep the rod vertical along your line-of-sight. The center crosshair gives the elevation. Do not use the upper or lower lines for elevation. The upper and lower lines are called stadia. Using the stadia lines to measure distance will be described later.

Directions for the Rod Person

The rod person decides where to set the rod, which is the most vital part of the survey.

The level is attached to the back of the rod. Use the bubble on the level to adjust and maintain the rod so that it is vertical. Stand behind the rod so that the rod can be held vertical and the level can be read. Holding the rod vertical is essential. If the rod leans forward or backwards the reading will be larger than the true value, see Figure 4.

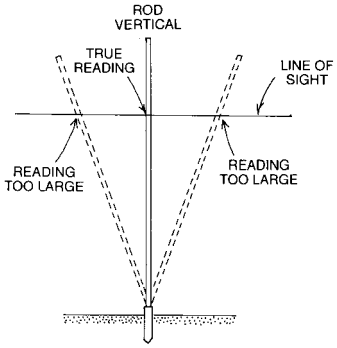

Figure 4. Keep the rod vertical.

When changing the length of the rod it is essential that each section be fully extended and properly secured. When a section of the rod is fully extended a locking button should pop into place.

Measuring Distance

Measuring with Tape

- Tapes marked in feet that can be read to the hundredth of a foot can be used to measure distance. Always make sure that the tape for the horizontal distance is the same standard as your stadia rod.
- When measuring horizontal distance stretch the tape tight before making the reading.
- Do not use a tape to measure the horizontal distance if the tape cannot be stretched out on a horizontal line between the points.

Measuring distance with surveying level

Use the level and the survey rod to estimate distances where stretching a tape would be difficult. To do this read the *stadia,* the short crosshairs above and below the central crosshair on the survey rod.

- Set up the level at one end of the distance to be measured. Place the Survey Rod at the other point.
- Read the rod at the upper and the lower stadia line.
- Subtract the lower stadia reading from the upper stadia reading
- Multiply the difference by 100 to get the distance from the instrument to the rod.

Differential Level Survey

A differential level survey is used to measure the relative elevation of points that are quite far apart. For example, a differential level survey can be used to determine the true elevation of your benchmark if a point of known true elevation is several hundred feet from your site. It consists of making a series of instrument setups along a route that ends back where it began. The route of the survey is called a *traverse*. From each instrument setup, the rod is taken to a point of known elevation to establish the *instrument height*. The instrument height is used to calculate the elevation of new points after the rod is read on the new point. Temporary reference points, called *turning points*, are

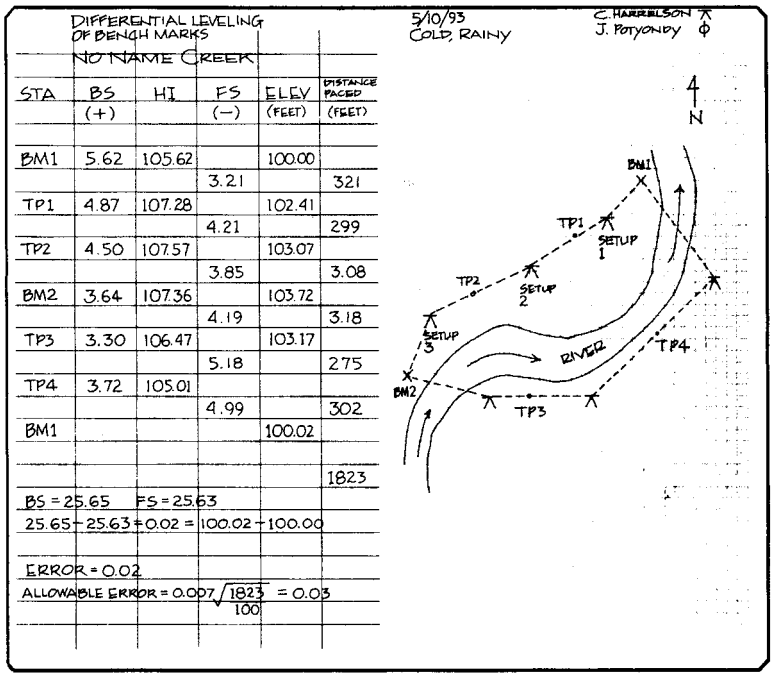

Figure 5. Field notes from a differential survey. The purpose of the survey is to find the elevation of BM-2 relative to BM-1. The traverse starts at BM-1. Returning to BM-1 closes the survey.

established before the instrument is moved to a new location. The details of the process are described below.

- The first reading (a reading is also called a *shot*) is to the benchmark. In Figure 5, the benchmark is BM-1. The elevation of the benchmark is known or assumed, see Figure 6. If the elevation of the benchmark is assumed it is strongly recommended that you survey from your benchmark to a benchmark with known elevation.
- Place the rod on the benchmark.
- Get the rod vertical.
- Read the scale where the crosshair crosses the rod face.
- Record the reading in the field book as a *backsight*. In the notes, *backsight* is abbreviated as BS.

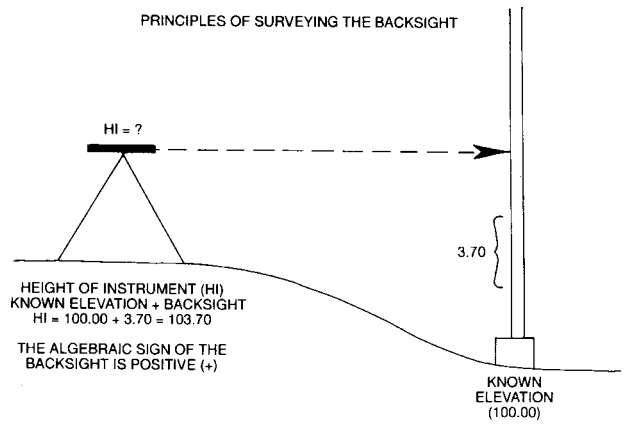

Figure 6. Shooting the backsight to find the instrument height.

- The shot to the benchmark is called a backsight. The backsight reading is added to the elevation of the benchmark to calculate the *instrument height*, see Figure 6. The instrument height is the elevation of the instrument crosshair.
- The notes shown in Figure 5 give an example of a differential survey. The elevation of BM-1 is given as 100.00 feet. The backsight to BM-1 is 5.62 feet. Thus, the height of the instrument, for the first setup, is 105.62 feet.
- Use a tape, the stadia method, or pacing to measure the distance from the instrument to the benchmark. Record the distance in the field book. The total distance covered by the survey is used to calculate the allowable error of the survey. This will be explained below.
- In Figure 5, the distance was determined by pacing. The distance between BM-1 and TP-1 is shown as 321 feet.
- The rod person should drive a stake in the ground as a temporary reference known as a turning point, TP. The TP should be in the direction of the survey and about the same distance from the instrument as the benchmark. The stake should be solidly in the ground so that it does not shift.
- The rod is then placed on the TP and the instrument person reads the elevation and records it as a foresight, see Figure 7.
- For example, in Figure 5, the foresight, FS, of TP-1 is 3.21.
- The foresight of TP-1 is subtracted from the instrument height to determine the elevation of TP-1.

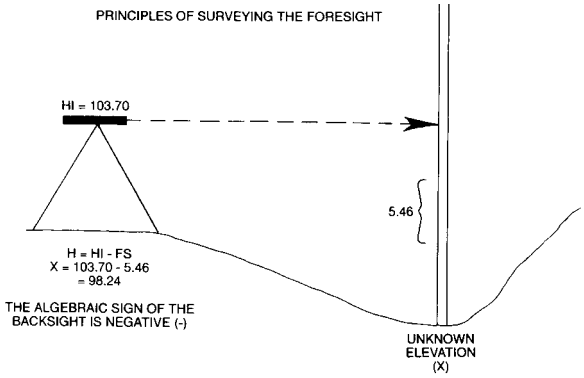

Figure 7. Shooting a foresight. The instrument height is already known.

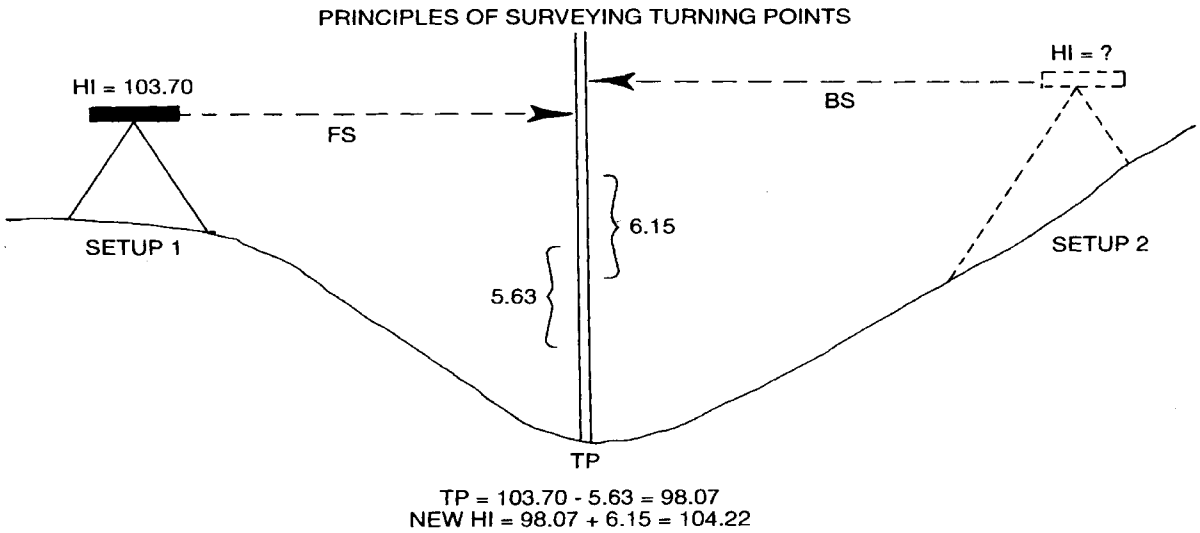

Figure 8. Using *turning points* to move the instrument.

- For example, in Figure 5, the foresight of TP-1 (3.21) is subtracted from the instrument height (105.62) to calculate the elevation of TP-1 (102.41).
- The instrument is then moved to the other side of TP-1.
- The rod is then placed on TP-1 and the rod is read as a backsight, after the instrument has been setup and leveled. The backsight is added to the elevation of TP-1 to calculate the instrument height. For example, the backsight to TP-1 from setup 2 is 4.87 feet. The backsight (4.87) is added to the elevation of TP-1 (102.41) to calculate the instrument height (107.28) at setup 2.
- The process outlined in steps 1-8 is repeated until the traverse is closed by shooting the original benchmark as a foresight. See the map in Figure 5.
- After you have closed the survey, the elevation of the benchmark at the end of the survey is compared to its original value. This process is known as closing the survey. The difference between the calculated elevation of the benchmark and its original value is the error.

  The acceptable amount of error depends on the total distance of the differential level survey. One equation to estimate the acceptable error is:

$$Acceptable\ \ Error \leq 0.007\sqrt{(total\ \text{distance})/100}$$

Where the *total distance* is the sum of the distances between the instrument stations in the differential level survey loop. For example, in Figure 7, the total distance of the differential level survey is 1,823 feet and the acceptable error is 0.03 feet.

A differential level survey can be performed as part of a longitudinal survey or cross-section survey. These types of surveys are described in other protocols. The purpose of the longitudinal and cross-section surveys is to gather elevation and distance data for selected points along the stream channel.

References

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Appendix D
Field Equipment

Introduction

There are a variety of different types of equipment and instrumentation available to help take field measurements. Below is a description of the equipment we will be using for in-stream monitoring program. Please carefully read the instructions describing the use of each. For quality and measurement control each surveying team will have to fill out the attached instrument form.

Tapes

We have two types of tapes: lineal tapes that measure distance, and Spenser diameter tapes for measuring tree diameter.

Lineal Tapes

We have several lengths of tapes. The longest tapes are 200 ft. tapes, fiberglass and marked in tenths of feet. These tapes are used for the longitudinal profiles and cross-sections. The tapes that are marked in inches (usually reel tapes) are used for the riparian plots.

Spenser diameter tapes

Spenser tapes are two sided tapes. One side is calibrated so that when the tape is wrapped around the circumference of a tree, the tape is actually showing the diameter of the tree [so it is adjusted by a factor of π because C (circumference) $= \pi$ (diameter)]. This side of the tape is printed in red ink. The other side is a lineal tape. A common error is to read the lineal side of the tape instead of the diameter side. Be sure to check your reading of the tape to make sure the number you have called out for diameter actually makes sense.

Diameter is almost always measured at breast height (DBH). DBH is the point on the tree trunk that is 4.5 feet from the ground. An easy way to measure DBH in the field is to pre-measure where 4.5 ft. is located on your body, then you will be able to easily estimate this height.

Pacing

In many field situations, pacing (or counting your steps) is the preferred method of measuring distance, where very precise distance measurements are not necessary. With practice, pacing can be quite accurate. However, it is usually not so accurate in the mountains of the Pacific Northwest, where slopes are steep, slipping is common, and large logs often interfere with straight-line travel. Nevertheless, pacing is a standard method used for rough separations of distance.

Start with a lineal tape and lay out a straight-line course of at least 300 feet. A pace is defined as two steps, so if you start walking with your right foot, the spot where your left foot lands is equivalent to one pace. Pace to the end of the calibrated line and total the number of paces you took. Repeat the process several times. The average number of paces, divided into the length of the line, is your pace length. Some people find that pace length in meters is preferable, others like the English units of feet (which are a little more precise as the unit is smaller). Pick your favorite, but know the conversion factor between them (feet X 3.3 = meters, meters/3.3 = feet).

Once you know your pace, you can follow simple compass courses on flat ground with relative ease.

Clinometers

A clinometer is a handy device for determining slope (in percent) and for measuring tree height. The standard Suunto brand will be employed. It has a dial containing two scales: percent on the left, and degrees on the right. As one sights the clinometer with one eye and leaves the other eye open, objects are lined up with the horizontal line in the dial, and a degree or percent then can be read off the dial. In case there is confusion about the dial, turn the clinometer up vertically and the scales are defined on the left and right side of the dial. We employ the percent scale to denote slope steepness, and the angle scale for an estimate of tree height.

Slope Determinations

In order to determine slope steepness, sight the clinometer directly upslope or downslope on an object that is at eye height in either direction. The reading on the clinometer is the percent slope (left scale) or slope angle (right scale). In the upslope direction, the reading will be (+), while in a downslope direction it will read (-). Often, an upslope and downslope measurement will be averaged to determine average slope steepness, but the direction of the reading (+ or -) is not included.

Tree Height Determinations

The determination of tree height uses the angle scale on the clinometer.

You must be a known distance of 66 ft away from the tree. Sight the clinometer at the base of the tree and then the top of the tree. On flat ground, you are generally sighting from zero to the top of the tree, but "zero" is really eye height, so your eye level must be added to the height.

If you have to take readings on slopes. Try to move laterally (across slope) for tree height measurements - your horizontal distance will be more accurately measured.

On a slope you will generally be either below or above the base of the tree. Generally the position above the tree is more accurate than being below the tree. If above the tree base but below the top, you must add both sightings together. If below the tree base, you must take a sighting to the top of the tree, and subtract from it the sighting to the bottom of the

tree: (for example, 100 to top, 30 to bottom = 70 ft. reading). If above both the tree base and the top of the tree, usually you'll have to move your position.

Spherical Densiometers

The spherical densiometer can be used as a hand held instrument to estimate relative vegetative canopy closure or canopy density caused by vegetation. Vegetation canopy closure is the area of the sky over the selected stream channel that is bracketed by vegetation (regardless of density). Canopy density is the amount of the sky blocked within the closure by vegetation. Canopy closure can be constant throughout the season if fast growing vegetation is not dominant, but density can change drastically if canopy vegetation is deciduous.

Canopy density is measured in conjunction with the riparian plot surveys and canopy closure is measured when installing temperature data loggers.

Operation of the Spherical Densiometer to Estimate Canopy Density

The spherical densiometer should be held 12-18 inches in front of your body and at elbow height, so that the operator's head is not visible in the mirror (and will not be counted as canopy cover!). Make sure the level bubble is level. In each square of the grid, assume that there are four dots, representing the center of quarter-square subdivisions of each of the grids. In the following instructions, it is assumed that you are under a forest canopy where openings are less common than canopy. Systematically count the number of dots NOT occupied by canopy (where you can see sky at that dot). Multiply the total count by 1.04 to obtain the percent of overhead area not occupied by canopy, as there are only 96 dots to count. The difference between this and 100 is the canopy cover in percent. Make four readings per location – start by facing upstream then turn in a clockwise fashion taking a reading every 90 degrees – and average them to provide an estimate of canopy cover from that point.

Obviously, this instrument is not useful for measuring understory tree, shrub, or herb cover.

Operation of the Spherical Densiometer to Estimate Canopy Closure

These instructions are for using a convex spherical densiometer that has adapted to the modifications developed by Strickler (1959). Strickler uses only 17 of the line intersects as observation points by taping a right angle on the mirror surface (Figure D-1).

Stand in the middle of the stream channel facing upstream. The densiometer is held in the hand, in front of the body at waist level, with the arm from the hand to the elbow parallel to the water surface. The convex densiometer is held away from the observer's body with the apex of the V pointed towards the observer. The observer's eye reflection should be seen along the margin of the original grid (Figure D-1). Level the densiometer using the bubble indicator and maintain the level and standard eye positions while recording. The grid between the V formed by the tape encloses 17 observation points. Each point has a value of 1.5 percent when four different readings are made. The number of points <u>surrounded by vegetation</u> are counted when measuring canopy closure.

Measurements are taken in four quadrants while standing on the same point (facing upstream, right bank, downstream, left bank).

The points counted for each reading are totaled and multiplied by 1.5 to obtain the percentage of canopy closure.

If all possible observation points are counted, the total value will be 102 percent (68 x 1.5 = 102). Although this error is small and not considered important for comparisons of relative values, the following correction factor can be applied to determine the correct percentile:

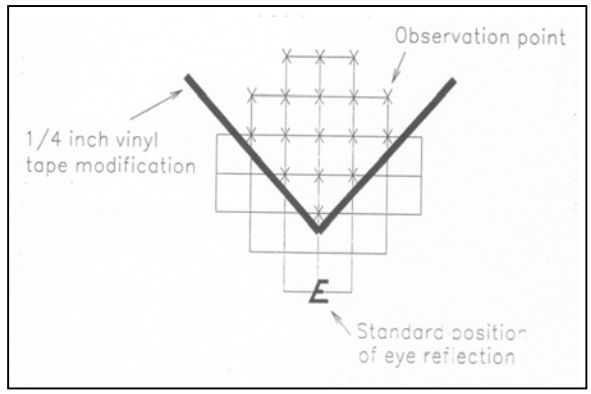


Figure D-1: Modified grid of spherical densiometer.

Calculated Value	Subtract from Calculated Value
Less than 30	0
30 to 60	-1
Over 60	-2

Example: (8+11+7+12)(1.5) = 57% subtract 1% = 56% closure

The Compass

Compasses come in many types. The examples below use the Silva Ranger Type 15 compass. This may or may not be the type of compass you have in the field. The Silva Ranger has some adjustments not seen in other compasses. While the principles of compass use are standard, their application to a particular compass type may be unique. This compass is graduated in 2 degree (^{o}) increments of azimuth from 0° to 360°. North is 0°, east is 90°, south is 180°, west is 270° and north again is 360° (0°). The compass has three basic parts. The Magnetic Needle is attracted by the magnetic North Pole of the earth. The red end points north and the white end south. The Graduated Dial turns and can be set to any desired bearing. The bearing is set to read in degrees. The Base Plate with Sighting Mirror is the housing of the compass and serves to point out the line of travel.

Beware of iron or steel objects if they are close to the compass. They will throw off the readings of the compass.

Map and Field Bearings

If you are working from a bearing on a map, it is referenced to true north and is called a true bearing. This is not the same as working from uncorrected bearings in the field, such as the location of a mountaintop in the distance that you take a compass bearing on. Sections A, B, C, D, and E below are based on working from “map to terrain” and deal with true bearings. Sections F and G are uncorrected bearings and are based on working from terrain to map.

Section A. How to use the compass to point out desired directions

First, the dial must be set to the desired degree reading. If this is known, simply turn the dial so that the correct reading appears at the index pointer. Second, without changing the dial setting, the entire compass must be positioned so that the orienting arrow lines up with the magnetic needle and the red end of the needle lies within the two orienting points. When these two conditions are fulfilled, the desired direction is indicated by the sighting line. Always keep the compass level so that the needle can move freely.

Section B. Using the compass without the sight.

When the dial is set as described in Section A, you can use the compass either with or without the aid of the sight. In situations where fast action is important, open the cover wide and make sure the orienting arrow and magnetic needle are lined up. The sighting line extends straight from the index pointer across the sight. Fix your sight on a distant object and head for it.

Section C. Using the compass with the sight.

For situations where accuracy counts, use the sight. The dial is set as in Section A. Hold the compass at eye level and adjust the cover to slightly less than a 90° opening, so the mirror reflects a top view of the compass dial. While looking in the mirror, move your sighting eye sideways until you see the sighting line intersect one of the two luminous points. Without changing the relationship between compass and eye, pivot yourself and compass together until you see in the mirror that the orienting arrow is lined up with the magnetic needle and the red end of the needle is between the orienting points. Your direction or objective will now lie straight beyond the sight on the upper edge of the cover.

Section D. How to obtain your bearing from a map.

In Section A, one of the two basic conditions for using the compass is to set the dial at the desired degree setting. If this degree, or bearing, is not known, it can be easily determined from a map. First, lay the compass on the map so either the inch scale or millimeter scale is exactly on (or parallel with) the line on the map you wish to travel, AND the hinged cover points in the direction you wish to travel. Then, while holding the compass in position on the map, turn the dial so the meridian lines of the compass are exactly parallel with any meridian (north-south) line on the map, AND the letter “N” on the top of the dial is toward North on the map (not turned down toward South). You may now remove the compass from the map. In these two steps your compass was set for the degree reading to your destinations and this reading may now be used as the index pointer. In fact, while performing these two steps you automatically fulfilled the first basic condition mentioned in Section A, and you may directly proceed to use the compass as per Section B or C.

Section E. How to Take a Bearing.

A "bearing" means the direction or the degree reading from one object to another. One of those objects is usually YOU. To "take" a bearing means to determine the direction from one object to another.

A. From a map, bearings are taken as described in Section D. The "bearing" is the degree reading indicated at the index pointer.

B. Out in the terrain, bearings can be taken by reversing the steps described in Sections B and C. For example, if you are using the compass without the sight, open the cover wide and hold it level and waist high in front of you. The sight and sighting line should be pointing directly ahead of you. The sighting line acts as a pointer. Pivot yourself and your compass around together until the sighting line points straight to the object on which you are taking the bearing. Without changing the position of the compass, carefully turn the dial until the orienting arrow and the magnetic needle are lined up and with the red end of the needle lying between the two orienting points. The "bearing" to your objects is now the degree reading indicated at the index pointer.

C. In a similar manner, bearings can be taken by using the sight. In this case, hold the compass at eye level and adjust the cover so the top of the dial is seen in the mirror. Face toward your object and sight across the compass sight. Look in the mirror and adjust the position of the compass so that the sighting line intersects one of the luminous points. While you simultaneously see your object across the sight, and the sighting line across one of the luminous points, turn the dial so that the orienting arrow is line up with the needle, red end being between the orienting points. The "bearing" to your object is now the degree reading indicated at the index pointer.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

State of California Resources Agency, Department of Fish and Game (1998), *California Salmonid Stream Habitat Restoration Manual*, Third Edition.

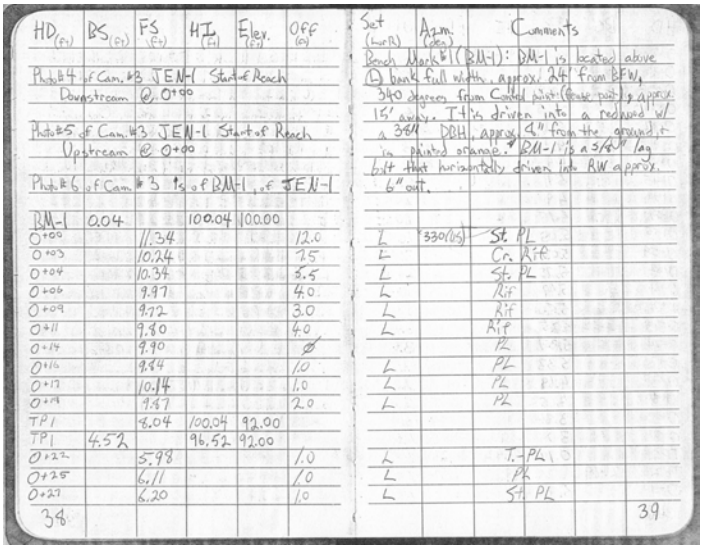
Appendix E
CHANNEL FORM MONITORING

Getting started

Before the fieldwork starts surveyors need to organize their notebooks, forms and equipment. Verify with the GRWC that all the property owners along the study reach have given permission for the monitoring. In addition, make sure that proper notice is given to the property owners before starting the fieldwork.

Directions for Organizing the Level Notebook

Set up the level notebook for the site. Use a *Rite-in-the-Rain* (or equivalent brand) All-Weather Level Notebook. These books are about 5”x 7” and each page has six columns. Laid flat, they photocopy onto 8-1/2” x 11” sheet for standard filling.



HD (Ft)	BS (Ft)	FS (Ft)	HI (Ft)	Elev. (Ft)	Off (Ft)	Set (Left/R)	Azm. (deg)	Comments
Photo #4 of Cam. #3 JEN-1 Start of Reach Downstream @ 0+00								
Photo #5 of Cam. #3 JEN-1 Start of Reach Upstream @ 0+00								
Photo #6 of Cam. #3 ↑s of BM-1, of JEN-1								
BM-1	0.04		100.04	100.00				
0+00		11.34			12.0	L	330(1/5)	St. PL
0+03		10.24			25	L		Cr. Rif
0+04		10.34			8.5	L		St. PL
0+06		9.97			4.0	L		Rif
0+09		9.72			3.0	L		Rif
0+11		9.80			4.0	L		Rif
0+14		9.90			Ø			PL
0+16		9.84			1.0	L		PL
0+17		10.14			1.0	L		PL
0+19		9.87			2.0	L		PL
TP1		8.04	100.04	92.00				
TP1	4.52		96.52	92.00				
0+22		5.98			1.0	L		T. PL
0+25		6.11			1.0	L		PL
0+27		6.20			1.0	L		St. PL

Bench Mark #1 (BM-1): BM-1 is located above (1) bank full width, approx. 2ft from BFW, 340 degrees from Control point (base point) approx. 15' away. It is driven into a redwood w/ a 36" DBH, approx. 4" from the ground it is painted orange. BM-1 is a 3/4" lag bolt that horizontally driven into RW approx. 6" out.

Figure 9: Sample page from Level Notebook

- Step 1: Number all the pages in your notebook.
  Note: Leave the first page blank for the Table of Contents, which will be filled in after the survey is finished.
- Step 2: Introductory page. Go to the second page and prepare an introductory page with the site name and number, project description, date and weather, names and tasks of crew.
  Note: This information will be repeated in a new introductory page each day before you start surveying.
- Step 3: Label the notebook columns, see Figure 2.
  - The first column is labeled **HD** for *Horizontal Distance*.
    The HD is the distance along the thalweg where the elevation readings are taken.
  - The second column is labeled **BS** for *Backsight*.
    The BS is the actual vertical distance from the point of known elevation to a horizontal line projected by the instrument. There is only one BS for each setup of the instrument and it will always be your first reading after setup.
  - The third column is labeled **FS** for *Foresight.*
    The FS is a rod reading taken on any point to determine its elevation.

- The fourth column is labeled **HI** for *Height of the Instrument.*
  The HI is computed by adding the backsight reading to the benchmark elevation or the elevation on which the backsight was taken. HI=Elev +BS
- The fifth column is labeled **Elev**ation.
  The point at which elevations are known or determined are either benchmarks or turning points. To determine the elevation of all other points use Elev=HI-FS.
- The sixth & seventh column is labeled **Offset** for the *horizontal distance offset*.
  The offset is the distance from the HD tape to the actual rod placement site in the thalweg. It is rounded to the nearest foot. Which side of the tape the offset is on is also noted by listing left or right bank.
- The eighth column is labeled **AZM** for the *azimuth* of the *horizontal distance* tape.
  The azimuth of the horizontal distance tape is taken looking upstream and always when there is a change in the direction of the tape.
- The last four columns are labeled **Comment**.
  This is where the surveyors record the type of habitat being surveyed (i.e. pool, riffle, run). In addition, surveyors should record other factors such as fish or amphibian presence, types of vegetation or unusual features.

Be neat and orderly so that the data you record can be easily read. Note all pertinent details in your descriptions. Over the years, the field book will be used to re-locate the benchmark and various survey stakes or markers. The field book will also be the source of data used to analyze the changes in stream shape with time.

Figure 10: Surveying Equipment

Directions for Organizing the Supplemental Forms

Set up a binder or covered clipboard that contains the following documents and supplemental data forms copied onto *Rite-in-the-Rain* paper:

- ❑ A topographical map
- ❑ Copies of old field notes and data forms
- ❑ Copies of all the landowner access agreements
- ❑ Equipment Form
- ❑ Pebble Count Forms (2 sheets)
- ❑ Large Woody Debris Forms (5)
- ❑ Canopy Forms (1)
- ❑ Riparian Plot Forms (12 sheets)

Directions for Organizing the Equipment

Make sure all your equipment has been properly calibrated and is in good working order, see Figure 10. Fill out the Equipment List Form (page 12) making sure you include all the serial numbers. Check your equipment against the following list:

- ❑ Engineer's Level
- ❑ Tripod
- ❑ Stadia Rod
- ❑ Bullet Level
- ❑ Compass
- ❑ Calculator
- ❑ 11 Fence Posts
- ❑ 10 Lag Bolts & Driver

- ❑ 200’ Fiberglass Tape
- ❑ 150’ Fiberglass Tape
- ❑ Spencer Tape
- ❑ 25’ Steel Tape
- ❑ Clear Metric Ruler
- ❑ Clinometer
- ❑ Densiometer
- ❑ 24 pieces of 3’ Rebar
- ❑ Flagging
- ❑ Rudd paint
- ❑ Aluminum & Code Tags
- ❑ Sledge Hammer
- ❑ Fence Post Pounder
- ❑ Clippers & Machete

Identifying Bankfull

A stream is said to be at bankfull when the water is at the top of the bank and just about to overflow, see Figure 4. The flow at bankfull (bankfull discharge) is the flow that, over time, shapes the channel. The bankfull width is measured by locating indicators of the bankfull level on opposite banks of the channel and measuring the horizontal distance between the points.

Bankfull Indicators (Leopold, 1994).

1. The point bar is the sloping surface that extends into the channel from the bank on the inside bend of a curve in the channel. The top of the point bar is usually at the level of the floodplain. Floodplains generally result from the extension of point bars as the river moves laterally by erosion and deposition through time. The top of a point bar is the lowest possible level of bankfull.
2. The bankfull level is usually marked by a change in vegetation. For example, the change from bare gravel bar to forbs, herbs and grass. Willows can occur well below bankfull. Usually large mature alders do not occur below bankfull. The type of lichens or moss may change at the bankfull level.
3. A topographic break usually occurs at bankfull. The ground may change from a slope bar to a near vertical bank. The change in topography may be subtle.
4. The bankfull level is often marked by a change in size of material on the bed. The change can be from fine to coarse or from coarse to fine.
5. Deposits of flood debris are unreliable and should be used only as a confirmation of other indicators. Debris deposits often indicate the level of the last large flood and may not indicate the bankfull level. Debris in willow branches may have been deposited when the branches were bent over by the force of the floodwater.

Directions for Locating Bankfull Indicators

Use the following procedure to flag bankfull indicators on both sides of the stream. The most consistent indicators on both sides of the channel will indicate the bankfull level. Designate one color of flagging for bankfull indicators. An easy method to flag the bankfull indicators is to put a nail through a piece of flagging and push the nail into the ground

- Step 1: Flag the top of any point bars in the marked reach.
- Step 2: Look for the lower limit of perennial vegetation or a change in vegetation type or density. Flag several of these points on both banks.

  Note: Remember that after extended periods of drought, perennial plants may invade the channel.
- Step 3: Flag the lower limit of moss or lichens on the banks or rocks.

- Step 4: Flag the lowest mature alders on both sides of the channel.
- Step 5: Look for and flag changes in the slope of the bank.

  Note: A change from a near vertical to a horizontal surface is the best indicator of the floodplain and bankfull level. Many streambanks have multiple changes in slope so be careful. A slope break may also indicate a terrace. A terrace is an old floodplain that has been abandoned by a downcutting stream. A terrace usually has perennial vegetation and definite soil structure.

- Step 6: Flag changes in bank materials.

  Note: Typically, a change from coarse to fine material on the surface of the bank indicates the bankfull level. However, the change can also be from fine to coarse. Changes in bank slope are often associated with a change in the size of the bank material.

- Step 7: Look for undercut banks covered by dense root mat from perennial vegetation. Feel up beneath the root mat and estimate the upper extent of the undercut. A spike or pin-flag may be inserted horizontally through the root mass and located by touch at the upper extent of the undercut. This will probably be slightly lower than bankfull.

  Note: Undercut banks are often the best indicators in steep or confined streams that lack a floodplain.

- Step 8: Note any inundation water lines. These may be marked by sediment or lichen. Stain lines are often left by frequent low flows so bankfull is at or above the *highest* stain line.
- Step 9: Wade to the center of channel to view bankfull on both banks. Note features such as bars, boulders, root wads that may effect the water surface elevation or direct the current.
- Step 10: Discuss the significance of individual indicators. Assess the indicators and determine bankfull.
- Step 11: Remove flagging that does not designate bankfull.

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the flagging used to mark the bed-material regions. Pick up any trash you may have dropped.

Establish the Benchmarks

When the study reach is established a primary benchmark is selected and its location documented. The survey level is set up where the benchmark and the stream channel are visible. The elevation of the benchmark is shot and recorded. In subsequent years, the benchmark is used as the vertical (elevation) reference for the survey.
A benchmark is a permanent mark near the area to be surveyed that can be located every year. The benchmark serves as the vertical or elevation reference point for the study reach. The elevation may be assumed (100 ft. is normally used) or tied into a project datum or mean sea level.

- For long-term permanent sites three benchmarks are established near the beginning of the study reach. Each cross-section associated with a longitudinal profile must have a benchmark installed on the left and right bank.
- The benchmarks are located outside of the channel, above bankfull and if possible above the floodplain but within line of sight of the reach start point.
- One of the benchmarks should be located on the opposite bank from the other two. This will allow recovery in case of a bank failure.
- The two recommended methods for establishing benchmarks are:
  1. Lag bolt monument – screw a 6-inch lag bolt into the base of a large, healthy tree so the stadia rod can be set on its head and be visible and leveled (no over-hanging branches, etc.). Select a healthy tree (typically a conifer) 14'' in diameter or larger, with roots that are protected from stream erosion, and not subject to windthrow.
  2. Fence post monument – drive an 8' fence post vertically to within 2' of the ground surface. Fence posts need to be installed above bank-full.

Before starting to survey always review the material in the Surveying Basics, Appendix C.

Directions for Installing Benchmarks

- Step 1: Install the access marker for the study reach.
  Install a fence post marker at the nearest road access point. Tag with station ID (stream name & site #).
- Step 2: Install the benchmarks.
  Install 3 benchmarks using lag bolts screwed into the base of trees or fence posts. Number the benchmarks and tag (use aluminum tags) with station ID (stream name and site #), and benchmark #.

  Note: All benchmarks need to be installed outside of bankfull, in stable ground. At least one benchmark should be installed on the opposite bank. All benchmarks need to have a clear line of sight to the reach start point. Benchmark #1 should be the primary benchmark with the most secure location and the best line of sight to the study reach start point.
- Step 3: Document the primary benchmark position.
  Stand at the access marker and with your compass find the azimuth and estimate the distance from the access marker to the primary benchmark (benchmark #1). Record the azimuth in your level notebook.
- Step 4: Document the secondary benchmarks positions.

Stand at the primary benchmark (benchmark #1), find the azimuth and estimate the distance to both secondary benchmarks (benchmarks #2 and #3), record in your level notebook under site description.

- Step 5: Photo Documentation.
  From the access marker take a photo of the primary benchmark (benchmark #1).
  From the primary benchmark take photos of the secondary benchmarks (benchmarks #2 & #3). Log the photo numbers with a description of the photos (i.e. Photo #1 = BM1 taken from access marker) in your level notebook.
- Step 6: Mapping.
  In your level notebook describe in detail the location of your benchmarks, access marker and study reach start. Draw a site map of the area.

Reviewing the Study Reach

After finding bank-full at the start of the study reach, installing or finding the existing access markers and benchmarks, your next step is to walk the study reach from beginning to end. As you walk up the reach, observe the following:

- Location of benchmarks
- Bankfull and the active channel
- Location of all cross-sections
- Location of logjams
- Location of the reach end points
- Roads and topographic features

Documents from past surveys will help you identify the beginning and end of the reach and cross-section benchmarks. If the study reach has not been previously surveyed then you need to look for flagging that delineates the reach segments. Also note access points to the nearest road. As you work your way up the study reach you may find it helpful to find new access points along the way.

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

Longitudinal (Thalweg) Profiles

Repeated longitudinal profile surveys of the stream channel are done to document changes in channel form and hydraulic variables. After the benchmark elevation is calculated, the rod person moves to the downstream end of the study reach and the thalweg is profiled. Riffles, runs and pools are defined and the elevations measured.

The survey is conducted in conjunction with the benchmarks, the cross-sections, the pebble counts and the Large Woody Debris surveys. All five surveys are linked by either elevation or horizontal distance.

Before starting to survey always review the material in the Surveying Basics, Appendix C.

Directions for Laying out the Horizontal Distance

- Step 1: Monument the start of the study reach.
  Install fence posts outside of bankfull on the left and right banks in a line, which is perpendicular to the flow. Starting at left bank lay a tape between the fence posts.
- Step 2: Find the starting point for the horizontal distance (HD).
  Find the center of the channel in the lay line between the two fence posts marking the start of the study reach. *This is your starting point for the HD*. Stake by using a temporary piece of rebar.
  > *Note: This is your starting point for the longitudinal profile. You will attach the zero (0+00) end of your thalweg tape to this stake.*
- Step 3: Document the HD starting point.
  Record the distance from the left bank fence post to the HD starting point.
  Then stand at the primary benchmark. Take a bearing to the HD starting point, record.
  Measure and record the distance from the primary benchmark to the HD starting point.
  > *Note: Record all distances and azimuths in your level notebook under the description of the site. The measurements will assist future surveyors to find the exact starting point of your survey.*
- Step 4: Laying the horizontal distance tape.
  Attach the zero ft end of a 200' fiberglass tape to the HD starting point stake. Walk up-stream near the thalweg and lay the tape in as straight a line as possible. Stake any curves in the tape. Stake the 200 ft end.
  > *Note: The tape may be layed up to 20' from the thalweg. Any curve in the tape needs to be staked to an angle.*
- Step 5: Flagging for riparian plots.
  Flag left and right bankfull at the HD starting point for the riparian plot surveys. You will continue to flag bankfull every 200' when you start a new segment.
  > *Note: <u>Always</u> record on flagging: stream name, site #, distance, date, purpose, crew.*
- Step 6: Photo documentation.
  Stand in middle of channel at the HD starting point. Take photos of the stream channel; first looking downstream then upstream. Record photo numbers in your level notebook.
  > *Note: Photo documentation is repeated at all cross-sections and the end point (1000')*

Directions for Performing the Longitudinal Profile Survey

- Step 1: Setup the engineer's level.
  Setup the level at a location where both the benchmark and the downstream end of the study reach are visible. The line-of-sight of the level must be higher than the benchmark.
  Note: To set up the level follow the instructions in Surveying Basics in Appendix C. Choose the location to minimize the number of times the level will have to be moved. Moving the level adds time and potential error to the survey.
- Step 2: Surveying the benchmarks.
  1. Turn the telescope to view the primary benchmark. The rod person places the rod on top of the benchmark. The rod is held vertically by using a level.
     Note: Stand so that you can control the rod and see the level.
  2. The instrument person reads the elevation on the rod and records it as a backsight. After recording the backsight elevation, re-check the rod reading.
     Note: The elevation of the primary benchmark will be set at 100'. See Figure 6 in the Surveying Basics section.
  3. Calculate the instrument height by adding the elevation of the benchmark to the backsight (HI=Elev + BS).
  4. Turn the telescope to the secondary benchmarks and repeat the process.
     Note: Elevations of the secondary benchmarks are not recorded in the BS column but in the site description area.
- Step 3: Surveying the thalweg.
  1. The rod person stands at the HD starting point looking up-stream. Take the azimuth and distance (in this case the distance would be 0+00) of the first straight section of the HD tape. The instrument person records the azimuth in the AZM column at the distance the azimuth is taken.
     Note: The distance and the azimuth of the HD tape are always recorded at each angle change throughout the longitudinal profile.
  2. The rod person moves to the thalweg at the HD starting point, tells the instrument person the horizontal distance (in this case it would be 0+00) and then levels the rod.
  3. The instrument person always waits until the rod person says "level" then reads the elevation and records it as a foresight.
  4. The rod person then tells the instrument person the offset of the stadia rod from the tape.
     Note: The offset is rounded to the nearest foot and needs to be recorded as to which side of the HD tape; left or right bank.
  5. Calculate the elevation of the thalweg at the start point by subtracting the foresight from the instrument height (Elev=HI-FS).
  6. The rod person moves upstream to the next survey point in the thalweg.
     - First take the azimuth if the HD tape has changed angles.
     - Second take the horizontal distance
     - Third place and level the rod in the thalweg
     - Fourth take the elevation
     - Fifth take the offset

     Note: The most important thalweg features to measure are; riffle crests, breaks in slope, and the deep points of pools.
     Always measure the beginning, middle and end of any feature.

Measure the elevation whenever the channel bed changes slope. Where the slope is relatively uniform (e.g. a long run, riffle or pool) measurements can be farther apart but not more than 15'.

- Step 4: Follow the above procedure until the instrument person can no longer see the stadia rod. The line of sight may be blocked by vegetation or the stream may curve.
  Note: Vegetation can be moved by using bungee cords to tie it back.

Directions for Moving the Instrument (Turning Points)

- Step 1: Finding a stable foresight elevation.
  Pick a point for a foresight that is stable.
  Note: A boulder, a nail hammered into a piece of large wood or a stake are all good choices.
- Step 2: Recording a Turning Point (TP) foresight.
  In the HD column write TP1 instead of the horizontal distance. Record the elevation in the foresight (FS) column.
  Note: For accuracy, repeat the turning point foresight by removing the rod and then replace it in the same spot, verify elevation.
- Step 3: Moving the engineer's level.
  Setup the level at a location where both the TP and the thalweg of the study reach are visible. The line-of-sight of the level must be higher than the TP.
  Note: To set up the level follow the instructions in Surveying Basics in Appendix C. Choose the location to minimize the number of times the level will have to be moved. Moving the level adds time and potential error to the survey.
- Step 4: Recording a Turning Point (TP) backsight
  Place the rod in the exact spot the TP1 foresight was taken. In the HD column write TP1 instead of the horizontal distance. Record the elevation in the backsight (BS) column.
  Note: For accuracy, repeat the turning point backsight by removing the rod and then replace it in the same spot, verify elevation.
- Step 5: Continue surveying the thalweg along the horizontal distance tape.
  Note: Follow the above steps every time the engineer's level is moved.

Directions for Closing the Survey

- Step 1: Ending the thalweg survey.
  Always end the survey at the designated ending point. Continue surveying up to the end of the designated reach if your last tape lay was short of the ending point.
- Step 2: Differential Survey.
  After you have reached the end of the horizontal distance for the longitudinal survey, you must run a differential survey back to the benchmark. The elevation of the benchmark at the end of the survey is compared to its original value. This process is known as closing the survey. Closing the survey is accomplished by executing a number of turning points from the end of the longitudinal survey back to the primary benchmark. The difference between the calculated elevation of the benchmark and its original value is the error.
  Note: To close the survey you want to use the shortest way back to the beginning (primary benchmark). It is sometimes easiest to use a road or trail that parallels the stream.

For more information consult the Differential Level Survey section in Surveying Basics, Appendix C.

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

Cross-section Survey

Permanent cross-sections are essential for monitoring the stream channel. Additionally, the cross-sections sites provide established locations for pebble counts and photo surveys.
Each of our study reaches has three monumented cross-sections and they are surveyed in conjunction with the longitudinal survey. The cross-sections are placed at pool tail crests to document salmonid spawning habitat. Stakes are placed on opposite streambanks to mark each end of the cross-section. The line connecting the stakes should be at right angles to the stream flow. Distance along the cross-section is referenced to the stake on the left bank (facing downstream).

The rod is read on top of the left bank stake. The rod is then placed on the ground next to the stake and read. The rod person then places the rod on a series of points across the channel. The distance is recorded and the rod is read at every *break in slope*. A break in slope is the point where the angle of the ground surface changes (for example, at the top of a bank there is a distinct change in the slope of the ground surface).

The rod and distance should also be read at every significant channel feature such as the top of bank, bankfull indicators, bottom of the bank, edge of water and the thalweg (deepest point in channel).

Before starting to survey always review the material in Surveying Basics, Appendix C.

Directions for Performing a Cross-section Survey

- Step 1: Monument the cross-section.
  Install fence posts outside of bankfull on the left and right banks in a line that is perpendicular to the flow.
- Step 2: Delineate the cross-section data.
  In your level notebook draw a line below your last entry for the thalweg survey. Note that this is the start of a cross-section and the cross-section number.
- Step 3: Measuring the cross-section.
  Starting at left bank lay a tape between the fence posts. Stretch the tape from the left bank stake to the right bank stake. Read and record the horizontal distance between the stakes.
  Note: Leave the tape stretched to guide the rod person as she/he moves from point to point along the cross-section.
- Step 4: Surveying the cross-section.
  1. Start the survey at the left bank stake. Place the rod on top of the left bank stake and record the elevation as a foresight. The HD will be zero and under comments you will note that this elevation is at the top of the left bank stake.

2. Place the rod vertically on the ground next to the stake. Read the rod and record the value as a foresight. The cross-section distance of this elevation is also zero. Note in the comment section that this elevation is the base of the left bank stake.
   Note: All elevations for the cross-section will be foresights unless you need to move the instrument.
3. Then proceed to the next break in slope or the next channel feature, such as the bankfull stage or wetted width.
   Note: The elevations of all breaks in slope, bankfull stage, wetted width and the thalweg need to documented by identifying those elevations in the comment section.
   The maximum spacing between elevations cannot be greater than 5% of bankfull width.

- Step 5: Ending the cross-section survey.
  Continue shooting the elevation and recording the distance at each point along the cross-section. Finish the cross-section by taking the elevation at the base of the right bank stake and then on top of the right bank stake.
  Note: If the tape is too high for the rod person to read the instrument person can read the distance from the instrument to the rod using the stadia lines (see the Basic Surveying protocol). If the distance between the rod and the instrument is measured, make sure that it is recorded as such. It will be necessary to convert the distance from, "the distance from the instrument" to, "the distance from the left bank stake".
  Occasionally you will have to move the instrument to complete the cross-section survey. This may happen if an obstacle such as a large tree limb is blocking your line of sight. Do your turning points before and after you move the instrument. Follow the instructions in Surveying Basics, Appendix C.
- Step 6: Photo documentation.
  Stand in middle of channel at cross-section. Take photos of the stream channel; first looking downstream then upstream. Record photo numbers in your level notebook.
  Note: Photo documentation is repeated at all cross-sections and the start point (0+00') and end point (10+00')

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

Jackson, Dennis, Marcus, Laurel (1999) *Creating a Watershed Atlas and Monitoring Program, Watershed Stewardship Workbook.*

Leopold, Luna B., ***A View of the River***, 1994, Harvard University Press, Cambridge, MA.

GRWC Monitoring Equipment List

Station: _____ Date: _____

Crew: _____

Equipment	Serial Number
Surveying Book	
200' Fiberglass Tape	
150' Fiberglass Tape	
Carpenters 25' Steel Tape	
Spencer Tape	
Metric Ruler	
Engineers Level	
Tripod for Engineer Level	
Bullet Level	
Stadia Rod	
Stadia Rod Level	
Compass	
Densiometer	
Clinometer	
Camera	
Fence Post Hammer	
Maul	
Electric Drill	
Ratchet	
Machete and/or Clippers	
Other:	

Appendix F
Pebble Counts

Introduction

The composition of the streambed (substrate) is an important factor in how streams behave. Observations tell us that steep mountain streams with beds of boulders and cobbles act differently from low gradient streams with beds of sand or silt. This difference can be documented with a quantitative description of bed material.

The most efficient basic technique is the Wolman Pebble Count (1954). Pebble counts can be made using grids, transects, or random step-toe procedure. We use a step-toe procedure here. Pebble counts are conducted at the three cross-sections in the study reach.

Starting at bankfull, the riffle is traversed and every three feet the surveyor randomly selects a pebble. The pebble is measured at the intermediate axis. It is important for the surveyor to avert their eyes and pick up the first particle touched by their index finger at the toe of your wader. This continues in a zigzag pattern transecting the stream until 100 pebbles are measured.

Pebble counts are easier if you have two surveyors. One to act as the observer who will wade the stream and measure the pebbles and the other as data recorder who remains on the bank.

Directions for Performing a Pebble Count

- Step 1: Start the transect.
  1. Select the closest riffle downstream from the cross-section.
  2. Record the Horizontal Distances (HD) of the downstream and upstream ends of the riffle.
  3. Select a random starting point (perhaps by tossing a pebble) at one of the bankfull elevations.
  4. Averting your gaze, pick up the first particle touched by the tip of your index finger at the toe of your wader.
- Step 2: Measure the intermediate axis (Figure F-1).
  Measure (with the metric ruler) the intermediate axis (neither the longest nor the shortest of the three mutually perpendicular sides of each particle picked up)
  Note: To measure embedded particles or those too large to be moved in place, measure the smaller of the two exposed axis.
- Step 3: Call out the measurement.

To make sure the recorder has heard the correct measurement have the note taker repeat back the information for confirmation.

- Step 4: Take one step across the channel in the direction of the opposite bank and repeat the process.
- Step 5: Traverse across the stream perpendicular to flow. Continue your traverse of the cross-section until you reach an indicator of bank-full stage on the opposite bank so that all areas between bank-full elevations are representatively sampled. Move up and down the stream in a zigzag fashion.
- Step 5: Continue to pick up particles until you have 100 measurements.

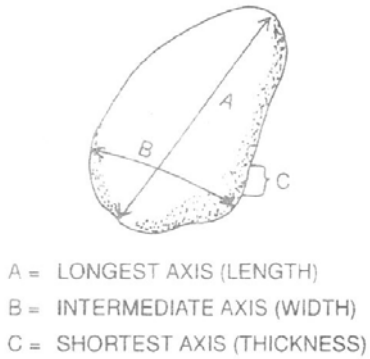


Figure F-1: Pebble Axis

Equipment and Forms List for 1,000 ft. Reach

- ❑ Clear plastic metric ruler (meters)
- ❑ 2 sheets of Pebble Count Forms (4 forms)
- ❑ Clipboard
- ❑ Pencils

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

Jackson, Dennis, Marcus, Laurel (1999) *Creating a Watershed Atlas and Monitoring Program, Watershed Stewardship Workbook.*

Leopold, Luna B., *A View of the River*, 1994, Harvard University Press, Cambridge, MA.

Data Field Form

To assist in the collection and organization of site-specific information, a field data form can be found below. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

Station: _____ Date: _____ Crew: _____

Distance: _____ Cross-section number: _____

Pebble Count

1	26	51	76
2	27	52	77
3	28	53	78
4	29	54	79
5	30	55	80
6	31	56	81
7	32	57	82
8	33	58	83
9	34	59	84
10	35	60	85
11	36	61	86
12	37	62	87
13	38	63	88
14	39	64	89
15	40	65	90
16	41	66	91
17	42	67	92
18	43	68	93
19	44	69	94
20	45	70	95
21	46	71	96
22	47	72	97
23	48	73	98
24	49	74	99
25	50	75	100

Station: _____ Date: _____ Crew: _____

Distance: _____ Cross-section number: _____

Pebble Count

1	26	51	76
2	27	52	77
3	28	53	78
4	29	54	79
5	30	55	80
6	31	56	81
7	32	57	82
8	33	58	83
9	34	59	84
10	35	60	85
11	36	61	86
12	37	62	87
13	38	63	88
14	39	64	89
15	40	65	90
16	41	66	91
17	42	67	92
18	43	68	93
19	44	69	94
20	45	70	95
21	46	71	96
22	47	72	97
23	48	73	98
24	49	74	99
25	50	75	100

Appendix G
Large Woody Debris Survey

Introduction

Large Woody Debris (LWD) is known to be an important structural element of stream channels. It improves juvenile Coho salmon and steelhead trout summer rearing habitat by increasing the numbers and depths of pools. Large amounts of LWD also increase winter cover that is critical for salmonid protection from predation and high water velocity.

All wood pieces greater that 6" in diameter and 4' long that are within the stream channel or the pith breaks the bankfull plane are included in the survey. The thalweg tape layed for the longitudinal survey is used to record the horizontal distance of the pieces. As the team walks up the channel each piece is numbered and tagged for tracking purposes and the horizontal distances are recorded. The type of piece is determined as log or root wad and species is recorded. Total length and the length within bank-full are measured. Using a Spenser tape the team measures a number of different diameters including diameter at bankfull LWD must always be measured with a Spenser tape.

The LWD survey will always be conducted in 200' segments after each tape lay of the longitudinal survey has been completed. It is important to work as a team. One surveyor is the recorder and their duties consist of reading the horizontal distance, recording the measurement information and helping to take the physical measurements. The other surveyor is the LWD tagger and the primary measurement taker.

In small streams bankfull and the LWD is fairly evident from mid-channel so you can inventory both banks as you walk up the steam segment. In larger streams it may be necessary to survey the left and right banks separately.

Directions for Performing the LWD Survey

- Step 1: LWD form.
  Fill out the LWD form with all location, date and crew information.
- Step 2: Horizontal distance.
  Start at the beginning of your tape, which will be the downstream position of your segment.
  Note: If it is the start of the study reach then your starting point is 0+00'.
- Step 3: LWD size assessment.
  1. Determine if the piece is 6 inches in diameter for a length of 4 feet. If not, the piece is too small to include in the survey and is not considered to be LWD.

2. Next determine if the piece is in the bankfull channel. LWD that is partially within bankfull is included if the pith breaks the bankfull plane of the bankfull line.

- Step 4: LWD Horizontal Distance.
  If the piece is considered to be LWD then first determine and record the horizontal distance. The horizontal distance is always taken at the LWD downstream point of contact.
- Step 5: LWD Number.
  Tag and number the piece. Record the number on the form. Plastic tags with pre-determined numbers will be provided. In addition, with the landowner's permission, spray paint the number so it is visible from the survey channel.

  Note: Staple guns will be used to secure the tags. Try to attach tags in cavities or areas that are protected. Painting large numbers on the LWD will assist future survey crews.
- Step 6: LWD Species and Location.
  Determine the LWD Species and record the wood Location. If the pith of the LWD breaks the bankfull plane then the wood is not considered to be in bankfull but on the left or right bank.

  Note: Left and right bank are always determined by looking downstream.
- Step 7: LWD Quality.
  First decide if the piece is part or a logjam or possibly perched above the stream. If not, then decide if the piece is keyed in or mobile. Always envision the piece reacting to bankfull stage to make this determination.
- Step 8: LWD Source.
  To determine the source of the LWD first look to see if the wood is part of a restoration project. Wood that has been manually placed in the streams is usually marked. If you can't see markings you can sometimes see cables or bolts. If the wood does not appear to be part of a restoration project then try to determine how the piece entered the stream. Most pieces will be simply "unknown" which means the origin cannot be determined.
- Step 9: LWD Total Measurements.
  a. Length: If the LWD is a log measure the total length. If the LWD is a log with a root wad attached, measure only to 1 ft. above assumed ground level of the tree if it was upright.

     Note: The rootwad will be measured separately. Measurements for length are taken to the original LWD size parameter of 6" in diameter. Always stop your length measurement when the diameter of the LWD goes below 6".

  b. Diameters: First measure the large end of the log this is the D1. If the log has a root wad attached then measure the diameter at 1 ft. above assumed ground level. Second measure the small end this is the D2.

     Note: For diameter measurements make sure you use the appropriate side of the Spenser tape (the numbers are red). Remember, the small end diameter will never be less than 6".
- Step 10: LWD Bankfull measurements.

  Note: You will always measure the portion of the log that is within bankfull as if it is a separate log.

a. Length: If the LWD is a log measure the length of the log within bankfull. This means measure from the instream end of the log to where it breaks the bankfull line or plane. If the LWD is a log with a root wad attached, remember to measure only to 1 ft. above assumed ground level of the tree if it was upright. If the whole log is within bankfull then the Bankfull length is equal to the Total length.

   Note: The rootwad will be measured separately. Measurements for length are taken to the original LWD size parameter of 6" in diameter. Always stop your length measurement when the diameter of the LWD goes below 6".

b. Diameters: First measure the large end of the log this is the D1. Depending how the log is situated this measurement could be either the instream end of the log or the diameter of the log where it breaks the bankfull line or plane. If the whole log is within bankfull then the Bankfull diameters are equal to the Total diameters. If not, then measure the length of the log within bank-full and record as bankfull length. Second measure the small end this is the D2.

   Note: *For diameter measurements make sure you use the appropriate side of the Spenser tape (the numbers are red). Remember, the small end diameter will never be less than 6" and if the log has a root wad attached then measure the diameter at 1 ft. above assumed ground level.*

- Step 11: LWD Rootwad Measurements.
  Root wads are measured by first measuring the height of the wad. This is the distance from the roots to 1 ft. above ground level point. Next measure the width and then the depth.

Equipment & Forms List for 1,000 ft. Reach

- ❑ Installed Horizontal Distance Tape (200 ft.)
- ❑ Spenser Tape
- ❑ Large Wood Forms (5)
- ❑ Clipboard
- ❑ Pencils
- ❑ Paint
- ❑ Plastic Numbered Tags
- ❑ Aluminum Tags and Nails
- ❑ Hammer and Staple Gun

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

Data Field Form

To assist in the collection and organization of site-specific information, a field data form can be found attached. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

Jackson, Dennis, Marcus, Laurel (1999) *Creating a Watershed Atlas and Monitoring Program, Watershed Stewardship Workbook.*

Leopold, Luna B., *A View of the River*, 1994, Harvard University Press, Cambridge, MA.

State of California Resources Agency, Department of Fish and Game (1998), *California Salmonid Stream Habitat Restoration Manual*, Third Edition.

Large Woody Debris Inventory Form

Modified on 03/10/03

Station ID: _____

Date: _____

Crew: _____

Reach Length: _____

Species	Code	**Location**	Code	**Quality**	Code	**Source**	Code
Redwood	1	In Bankfull	2	Keyed	1.0	Unknown	1.0
Douglas Fir	2	Left bank*	3	Digger wedged	1.2	Green Unknown	1.4
Pine	3	Right bank*	4	Digger cabled	1.3	Windthrow	5.0
White Wood	4	Bank to bank	5	Buried	1.4	Green Windthrow	5.4
Tanoak	5			Mobile	2.0	Undercut Bank	6.0
Alder	6			Log Jam	5.0	Green UC Bank	6.4
Maple	7			Perched	6.0	Landslide	7.0
Willow	8					Green Landslide	7.4
Other HW	9					Project	9.0

Note: *To qualify as LWD a piece of wood must be at least 6" in diameter for 4' in length.*

Distance	LWD#	Sp.	Loca-	Quality	Source	Log Total			Log Bankfull			Root Wad Size (Feet)		
From 0' (Feet)			tion			Length	D1 *Large End*	D2 *Small End*	Length	D1 *Large End*	D2 *Small End*	A Axis Height	B Axis Width	C Axis Width

* Left bank and right bank determined by looking down stream.

Appendix H
Riparian Surveys

Introduction

Riparian surveys use a fixed 20th acre plot every 200' starting at the zero point along the steam monitoring reaches. The plots run perpendicular to the stream channel, are 21.8' wide and extend from a permanent point at bankfull to a permanent point 100' inland (adjusted for slope). All trees larger than 5.6" in diameter at breast height (DBH) are recorded as to size, species and placement within the plot. A sampling method for tree height allows for a statistical projection of tree height per acre. A smaller 100th acre lesser vegetation plot is established 15' inland from the bankfull point. The lesser vegetation survey records the number and the species of trees and brush less than 5.6" DBH plus the vegetation type and percent of ground cover.

Canopy density is measured by using a spherical densiometer. Measurements are taken in conjunction with the riparian surveys every 200 ft. starting at the zero point of the survey reach. The density is measured at center of channel, left and right bank and 50 ft. inland from bankfull.

The Riparian surveys need to be conducted by a survey team (2 or more) and are completed after the longitudinal profile and LWD surveys are finished. The start or zero points of the riparian plots are always the left and right bankfull sites that were flagged during the longitudinal survey.

Riparian surveys are not conducted where the slope is greater than 75%.

Before starting the riparian survey review the material in Field Equipment, Appendix D.

Directions for Performing the Riparian Survey

- Step 1: Riparian survey form.
  Fill out the top box of the riparian survey form. Include station (reach name & number), date, the form number in relationship to the total number of riparian forms for the study reach and crew names. For plot location always use the HD of the plot along the study reach. Make sure you designate left or right bank (i.e. 0+00RB).
  Note: Left and right bank are designated when looking downstream.
- Step 2: Laying out the riparian plot.
  1. Always start with the left bank plot. Place rebar at the bankfull point, paint for easier identification.
  2. Using your compass, stand perpendicular to the stream then sight on a feature approximately 100 ft. inland and record the azimuth on your plot form. Keep the bearing on your compass because this will be the lay line for your tape.

Note: The reciprocal bearing is the tape lay line for the right bank plot.

3. Attach the riparian plot lineal tape to the rebar. This will be your start point (zero).
   Note: This tape will be in feet and inches.
4. One team member stays at bankfull, the second team member starts to lay the tape 100 ft. inland using a compass and following the plot bearing.
5. As the second team member lays the tape they flag both the 15 ft. point and the 50 ft. point. This will be the center of the 100th acre lesser vegetation plot (15 ft.) and where canopy density (50 ft.) is measured.

- Step 3: Determining slope.
  The horizontal distance of the plot is always adjusted to compensate for slope. A clinometer and the slope adjustment table are used to develop a specific horizontal distance for each riparian plot.
  1. Using a clinometer, the team member at bankfull sights on the team member at 100 ft.
     Note: To determine slope the person using the clinometer always sights on an object at eye level.
  2. Record the slope percent and using the slope adjustment chart (Table 2) determine and then record the true horizontal distance.
  3. The team member now adjusts the tape to the true horizontal distance and places and paints a piece of rebar. Flag above the rebar for easy identification.
- Step 4: Measuring tree diameters.
  Record the location and measure the diameter of all trees that are larger than 5.6" diameter at breast height (DBH) within 10', 10.7" of either side of the tape. In addition, record the distance and measure the diameter of any downed log at the point the tape transects the log.
  1. First determine if the tree is within the plot. If it is larger than 5.6" DBH and located within 10' 10.7" of either side of the tape then fill in the location number.
     Note: The location number is the distance the tree is from bankfull on the horizontal distance tape.
  2. Using the code tables attached to your Riparian Form fill in the codes for Tree Species (Table 2) and Group (Table 4).
  3. Using a Spenser tape measure the diameter and record.
  4. If a log transects the tape, is larger than 4 inches in diameter for 6 ft in length then record Location, Species and Group and measure the diameter at the point the log transects the horizontal distance tape.
     Note: Downed logs are only measured if they transect the horizontal distance tape.
  5. Continue until all trees are measured and recorded.
- Step 5: Measuring tree height.
  Measure the diameter, height and crown ratio of the first 3 conifers from bankfull in the riparian plot.
  1. After recording the Location, Species and Group of the first conifer from bankfull attach a Spenser tape to the tree. Walk 66 feet to an area where you can see the base and the top of the tree.
     Note: Although it is not always possible, the reading will be more accurate if you try to stay at the same elevation as the tree you're measuring.

2. Using a clinometer first site on the base of the tree, record. Make sure you record whether the number is negative or positive. Next site on the top of the tree, record reading in the Top column. Using the formula, add negative numbers and subtract positive numbers, record tree height in the Total column.
3. Next estimate the percent of live crown.
4. Measure the diameter, height and crown ratio of the next two conifers, for a total of 3 conifers.

- Step 6: 100th Acre Lesser Vegetation Plot.
  Lesser vegetation plots are fixed radius plots measured 11.78' from a point 15' inland from the bankfull rebar. Trees less than 5.6" DBH are recorded along with the percent of lesser vegetation ground cover.
  1. Stand at the 15' point along the horizontal distance tape. This will be the center of the fixed radius plot. Extend a tape out 11.78".
  2. Rotate the tape 360 degrees and record all trees less than 5.6" DBH as to Species, Group and Diameter that are within the circle.
     Note: Lesser vegetation trees may be grouped into size categories by species.
  3. Next within the same plot area, record the lesser vegetation using the codes listed in Table 3. Estimate the percent of area covered for each lesser vegetation species within the plot area and record in the % Cover column.
     Note: The total of the % Cover column for the lesser vegetation may be larger than 100% because of vegetation layers.
- Step 7: Canopy density.
  In the study reach canopy density is always surveyed in conjunction with the riparian plots. Density is measured using a spherical densiometer at the center of channel, left and right bank at bankfull and left and right at the 50' point in the riparian plots.
  1. Fill out canopy form with station (reach name & number), date and crew initials.
  2. Next fill out the plot location. This will be the horizontal distance of the riparian plot along the study reach.
  3. Measure the bankfull width by stretching a tape from the left bankfull rebar to the right bankfull rebar, record.
  4. Stand in the center of channel between the bankfull rebar facing upstream. Hold the densiometer 12-18 inches in front of your body and at elbow height, so that your head is not visible in the mirror. Make sure the level bubble is level.
  5. In each square of the grid, assume that there are four dots, representing the center of quarter-square subdivisions of each of the grids. Systematically count the number of dots NOT occupied by canopy.
  6. Multiply the total count by 1.04 to obtain the percent of overhead area not occupied by canopy,
  7. The difference between this and 100 is the canopy cover in percent. Record this number in Column 1. Make four readings per location – start by facing upstream then turn in a clockwise fashion taking a reading every 90 degrees – and average them to provide an estimate of canopy cover from that point.
  8. Repeat the above instructions at all canopy measurement sites.

Clean-Up

Wind up all of the tapes. Pick up any trash you may have dropped.

Equipment List for 1,000 ft. Reach

- ❑ Compass
- ❑ Clinometer
- ❑ Spherical Densiometer
- ❑ Calculator
- ❑ 200 ft. tape (tenths) for Bankfull Width
- ❑ 150 ft. tape (inches) for Riparian Plots
- ❑ Spenser tape
- ❑ 24 pieces of rebar
- ❑ Hammer
- ❑ Paint
- ❑ Flagging

Forms List for 1,000 ft. Reach

- ❑ 12 sheets of Riparian Survey Forms (24 forms)
- ❑ 1 Set of Riparian Tables (Tables 1-4)
- ❑ 1 Canopy Density Form
- ❑ Clipboard
- ❑ Pencils
- ❑ Permanent Marker (black)
- ❑ Study Reach Level Notebook

References

Dr. James D. Arney, Forest Biometrics, Forest Projection and Planning System (FPS)

State of California Resources Agency, Department of Fish and Game (1998), *California Salmonid Stream Habitat Restoration Manual,* Third Edition.

Riparian Survey Form

Station ID: _____ **Date:** _____ **Page:** _____ **Of:** ____

Plot **Fixed** **Minimum** **Vegetation**

Location: _____ **Plot:** 20th acre **DBH:** 5.6" **Plot:** 100th Acre

Slope: _____ **Azimuth:** _____ **Offset from HD tape:** 10', 10.7"

20th Acre Plot								100th Acre Plot			
				Tree Height & % Crown							%
Location	Species	Group	DBH	Base	Top	Total	Crown	Species	Group	DBH	Cover

Riparian Survey Form

Station ID: _____ **Date:** _____ **Page:** _____ **Of:** ____

Plot **Fixed** **Minimum** **Vegetation**

Location: _____ **Plot:** 20th acre **DBH:** 5.6" **Plot:** 100th Acre

Slope: _____ **Azimuth:** _____ **Offset from HD tape:** 10', 10.7"

20th Acre Plot								100th Acre Plot			
				Tree Height & % Crown							%
Location	Species	Group	DBH	Base	Top	Total	Crown	Species	Group	DBH	Cover

Riparian Survey Tables

Table 1
Slope Adjustment Table

% Of Slope	Horizontal Distance (feet)
0	100'
5	100.12'
10	100.15'
15	101.12'
20	101.98'
25	103.08'
30	104.4'
35	105.95'
40	107.7'
45	109.66'
50	111.8'
55	114.13'
60	116.62'
65	119.27'
70	122.07'
75	125'

Table 2
Tree Species

Survey Code	Species
BM	Big-leaf Maple
BP	Bishop Pine
BO	California Black Oak
LO	Canyon Live Oak
DF	Douglas Fir
GC	Golden Chinquapin
GF	Grand Fir
PM	Madrone
CX	Misc. Conifers
HX	Misc. Hardwoods
BL	Pepperwood (Bay)
PP	Ponderosa Pine
RA	Red Alder
RW	Redwood
SP	Sugar Pine
TO	Tanoak
MY	Wax Myrtle
WH	Western Hemlock
WI	Willows

Table 3
Lesser Vegetation

Survey Code	Species
AZ	Azalea
BE	Berry, Sp.
BB	Blue Blossom
CE	Ceanothus, Sp.
CO	Coffee Berry
CB	Coyote Brush
OG	Dwarf Oregon Grape
EH	Evergreen Huckleberry
EQ	Equisetum Sp.
FN	Ferns Sp.
FW	Fireweed
FO	Forbes
GR	Grass
LU	Lupine
AR	Manzanita
PG	Pampas Grass
PO	Poison Oak
RH	Red Huckleberry
RD	Rhodendron
RO	Roses
SA	Salal
SB	Scotch Broom
TH	Thistle, Sp.

Table 4
Group

Survey Code	Description
..	Green Trees
.D	Snag
DD	Down Log
LV	Lesser Vegetation
.P	Planted Tree
.C	Fresh Stump

Canopy Density Form

Station ID: _____ Date: _____ Crew: _____

			1	2	3	4	Avg.
Plot							
Location:	_____	Channel center					
		Bank full left					
BF Width:	_____	50' left					
		Bank full right					
		50' right					
Plot			1	2	3	4	Avg.
Location:	_____	Channel center					
		Bank full left					
BF Width:	_____	50' left					
		Bank full right					
		50' right					
Plot			1	2	3	4	Avg.
Location:	_____	Channel center					
		Bank full left					
BF Width:	_____	50' left					
		Bank full right					
		50' right					
Plot			1	2	3	4	Avg.
Location:	_____	Channel center					
		Bank full left					
BF Width:	_____	50' left					
		Bank full right					
		50' right					
Plot			1	2	3	4	Avg.
Location:	_____	Channel center					
		Bank full left					
BF Width:	_____	50' left					
		Bank full right					
		50' right					
Plot			1	2	3	4	Avg.
Location:	_____	Channel center					
		Bank full left					
BF Width:	_____	50' left					
		Bank full right					
		50' right					

Appendix I
Stream Discharge, Turbidity, and Total Suspended Solids

Monitoring Objectives

1. Collect streamflow and water quality data during the rainy season at selected monitoring stations to establish baseline water quality conditions.
2. Monitor water quality and streamflow over several winters and attempt to establish trends in water quality conditions.
3. Develop a data set for water quality and streamflow in a Gualala River sub-watershed for future comparisons to other locations.

Monitoring Overview

Please refer to Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245 for the specific procedures for measuring and monitoring stream discharge.

Establish Monitoring Stations

1. Install staff plate
2. Survey cross-section and staff plate elevation
3. Establish the "course" for observations of surface float velocity

Data Collection

1. Upon arrival at monitoring station, record the following
    a. Sample location (monitoring station name)
    b. Date and time
    c. Description of weather conditions and flow conditions
    d. Gage height of water surface
    e. Repeat gage height observation
2. Water quality sample collection
    a. Turbidity sample (grab sample from surface as near center of channel as possible for immediate processing using field turbidity meter)
    b. Suspended sediment sample (depth integrated using DH- 48 for laboratory analysis for Total Suspended Solids; remove a sample aliquot for turbidity measurement using field meter)
    c. Note approximate location of sample location in relation to staff plate and centerline of channel (e.g. "5 ft downstream of staff plate from surface 4 ft from left edge channel")

3. Discharge measurement using the current meter **AND/OR** float velocity observations (minimum of 6)
4. Repeat 2 above
5. Repeat 1-4 above at each sampling station
6. Perform turbidity measurements on samples immediately following completion of sampling circuit (process all samples at the same time, noting the time of sample processing)
7. Complete sample storage and chain of custody forms; shipment to laboratory to be arranged.
8. Photocopy data sheets and instrument logs; notify data coordinator regarding data collected.

Monitoring Procedures

- Step 1: Site Information.
  1. Fill in the appropriate station at which observations and samples are collected.
  2. Record initials of the individuals collecting observations and samples.
  3. Date and time of arrival at site.
- Step 2: Current weather.
  Circle one of the five choices that best describes the weather conditions at time of arrival at the site. If conditions change significantly, this can be noted in #7.
- Step 3: Flow conditions.
  This provides two descriptions of stream flow conditions described below.
  1. Circle one of the three choices that best describe the appearance of the water in the stream.
  2. Circle one of the four choices that best describe stream flow conditions regarding whether the stream is at or near a steady and low base flow, whether the stream is rising, falling or at or near a steady peak discharge.
  3. Water temperature measured in the field; circle F if Fahrenheit or C if Centigrade degrees (see Appendix B)
- Step 4: Previous weather.
  This provides two types of descriptions of recent weather affecting streamflow; it is possible that choices from 6a and 6b may apply. Note that this will be used as a supplemental description of rainfall records from rain gages in the watershed.
  1. Circle one of the two choices pertaining to preceding dry weather.
  2. Circle all of the four choices that apply pertaining to preceding rainy weather.
- Step 5: Comments.
  Note any additional information, problems or issues that may affect the data reported. If stream flow is very high and wading the stream is not safe, note that here.
- Step 6: Water surface elevation.
  Data collected pertain to the elevation of the stream observed at the staff plate (stream gage). Observations are made twice as described below.
  1. Time and elevation (staff plate reading) <u>before</u> discharge measurement (or float velocity).
  2. Time and elevation <u>after</u> discharge measurement (or float velocity).
- Step 7: Crest gage reading.

These measurements pertain to previous high water elevation recorded at the crest gage by water dissolving toothpaste smeared on a cedar grapestake fitted inside the PVC tube near the staff plate.

1. Measure and record the distance from the top of the grapestake to the end of the toothpaste remaining on the grapestake,
2. The adjustment factor needed to convert 9a to the equivalent water surface elevation on the staff plate; a value will be established for each station based on cross-section survey data.
3. Adjusted peak water surface elevation at the gage (staff plate).

- Step 8: Water quality samples.
  Three samples are collected: two grab samples and one depth-integrated sample using a DH-48 suspended load sampler (refer to DH-48 manufacturer's instructions or USGS Field Methods for additional details of sampling procedure). Grab samples are collected from the surface in a bottle as near to the thalweg (location of highest stream velocity) and are analyzed for turbidity at the end of the day. The DH-48 sample is sent to a contract laboratory for analysis of Total Suspended Solids (TSS); a small portion of this sample is used for turbidity analysis.
  1. Grab sample #1 is collected prior to discharge measurement.
  2. DH-48 depth integrated sample is collected in the thalweg (if possible) after the discharge measurement is completed.
  3. Grab sample #2 is collected immediately after the DH-48 sample.
  4. Date & time turbidity analysis is conducted, results of analysis, and the initials of the individual conducting the analysis.
  5. Remarks regarding any special circumstances or conditions affecting the timing, location or quality of water samples.
  6. Chain of custody information: Storage conditions for sample #2 for subsequent delivery to laboratory for analysis. Include location (address/residence), date & time, and storage conditions (ice chest, refrigerator, etc.)
- Step 9: Discharge measurement field observations.
  Refer to USGS instructional materials for detailed instructions at background on the technique. <u>Not to be performed by a novice.</u>
  1. Position on discharge measurement cross section measured with zero located on the left bank (facing downstream). This position defines the center of each discharge sub-cell for which a velocity measurement is obtained. LEW is the horizontal position of the left edge of water; REW is the horizontal position of the right edge of water facing downstream.
  2. Water depth at the velocity measurement position corresponding to location (a) above.
  3. Velocity measurement depth-point where velocity meter is positioned on the top set rod. The top set rod is designed to allow rapid positioning of velocity meter at above the bed equivalent to 0.4 times the water depth; this is equivalent to the position 0.6 times the depth below the water surface.
  4. Record the number of revolutions of the current meter as expressed by the number of audible "clicks" in the time interval selected (minimum 20 seconds or as specified by USGS guidance). For relatively low velocity flows, the sensor wire should be positioned to graze the single-revolution cam on the current meter axle. For high

velocity flows, the wire should be positioned to graze the five-revolution cam on the current meter axle. The selected cam for the discharge measurement is set at the beginning of the measurement and should not be changed after measurements begin.

5. Length of velocity measurement interval in seconds. This can vary for different locations in the cross-section, but should not be less than 20 seconds.
6. Mean water velocity computed from current meter rating table. This column is left blank in the field. Qualified personnel perform computations in the office.
7. Discharge of flow cell. This column is left blank in the field. Qualified personnel perform computations in the office. Discharge of the cell is calculated as the product of the width of the cell (horizontal distance between adjacent flow cells entered in column a), flow depth at the center of the cell (entered in column b), and the mean velocity of the cell (column g).
8. Total measured discharge. This column is left blank in the field. Qualified personnel perform computations in the office. Calculated as the sum of discharge cells (column g).
9. Name of operator of current meter.
10. Name of individual who computes discharge and date computed.

- Step 10: Float Velocity Data.
  These stream velocity data supplement current meter measurements and need not be collected in all cases. These data are most useful during periods of high stream discharge and should be collected after discharge measurements are completed at the same location. In some cases, stream discharge may be too high to safely measure by wading with the current meter, and the discharge is estimated from the velocity of surface floats. Over the course of the first sampling season, we would like to obtain paired data from current meter measurements and float velocity measurements to develop an adjustment factor between mean velocity (11f) and mean surface velocity. In the absence of site-specific data, the relationship is mean velocity = 0.85 x surface velocity. Refer to the appendix in the QAPP for technique of float measurements. Dried orange peels are an ideal float.
  1. Record the length of stream channel over which velocity is measured with floats.
  2. Location of float test in cross-section (left, center or right of channel surface); two float observation are required for each third of the channel width.
  3. Time in seconds for each float to travel the test length of stream surface.
  4. Raw float velocity (course distance divided by time of travel (12a divided by 12c). Computed in the office or in the field-may be left blank in the field.
  5. Adjusted float velocity (raw velocity x 0.85 <u>or</u> a site specific adjustment factor determined by qualified personnel)-may be left blank in the field.
  6. Measure mean channel width.

Equipment & Forms List

- ❑ Current meter
- ❑ Wading rod
- ❑ DH 48 suspended sediment sampler
- ❑ Sample bottles for DH 48
- ❑ Flexible nylon measuring tape (165 ft)
- ❑ Stop watch
- ❑ Steel tape measure (pocket size)
- ❑ Toothpaste (for crest gages)
- ❑ Thermometer
- ❑ Floats (dry orange peels)

Clean-Up

- Disassemble, dry and lubricate current meter
- Dry and secure turbidometer

Data Field Form

To assist in the collection and organization of site-specific information, a field data form can be found attached. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245

Edwards, Thomas K. and Glysson, G. Douglas (no date), Field Methods for Measurement of Fluvial Sediment. U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter C2

Instructions for Sampling with a US DH-48 Depth-Integrating Suspended Sediment Sampler (manufacturer's product)

Gualala River Watershed Council-Hydrologic and Water Quality Monitoring Form-Fuller Creek (3/2002)

1. Station: North Fork South Fork Mainstem Sullivan **2. Observers:**

3. Date:_____ **Time:** _____ am pm **4. Current Weather:** Clear Cloudy Showers Rain Heavy Rn.

5. Flow Conditions: **5a.** Clear / Turbid / Muddy

5b. Base Flow / Rising Flow / Peak Flow / Falling Flow **5c.** Water Temp. _____ F / C

6. Previous Weather: **6a**. Dry: 1-3 days / 3+days **6b.** Rain: Overnight / Yesterday / Past 2 days / 3+days

7. Comments on 1-6:_____

_____

_____

8. Water Surface Elevation: **8a.** Time_____ Elev. _____ ft **8b.** Time_____ Elev. _____ ft

9. Crest Gage Reading: **9a.** High Water Mark (Distance From Top of Wood Insert) _____ ft

9b. Adjustment to Gage Datum _____ft **9c.** Crest Peak (Gage Equivalent) _____ft

10. Water Quality Samples: ***Sample Labels Include Station, Date, and Sample #***

10a. Sample #1-Surface grab Location Time_____

10b. Sample #2-Depth integrated (DH-48) Location Interval Time Time_____

10c. Sample #3-Surface grab Location Time_____

10d. Turbidity Analytic Results Sample Turbidity Sample Processing by:_____

Sample #	Date Processed	Time Processed	NTU's
1			
2			
3			

10e. Comments on samples: _____

_____

_____

10f. Chain of Custody:

Sample for Laboratory Analysis (Sample #2) Stored At_____

Date _____Time _____ Storage Conditions <

---

11. Discharge Measurement: ***Conduct "spin test" on current meter. Note wire on Cam 1x or 5x. Items f, g and h are <u>not</u> completed in the field.***

11a. Station (ft)	*11b. Depth (ft)*	*11c. Sample Depth (0.4 D) (ft)*	*11d. # of Revolutions*	*11e. Sample Duration (sec)*	*11f. Velocity (ft/s)*	*11g. Discharge (cfs)*
LEW						
REW						

				11h. Total Discharge=	

11i. Current meter operator:_____

11j. Discharge computations by: _____Date_____

12. Float Velocity *(if performed)* 12a. **Float Course Distance (feet)**

12b. Observation # & Location	1-	2-	3-	4-	5-	6-
12c. Time for Float (seconds)						
12d. Raw Velocity (ft/s)						
12e. Adjusted Velocity (ft/s)						

12f. Mean Width of Water Surface (feet)

Discharge Measurement Notes & Comments:

Announcement Regarding Permit Streamlining Drought Response for Domestic Storage
From: Wildlife CDFWNews
Sent: Thursday, March 13, 2014 2:55 PM
To: Wildlife CDFWNews
Subject: State Streamlines Domestic Water Tank Storage Process In Response to Drought

(This e-mail is being sent to all CDFW employees.)

California Department of Fish and Wildlife News Release
March 13, 2014
Media Contact:
Jordan Traverso, CDFW Communications, (916) 654-9937
George Kostyrko, State Water Board Communications, (916) 341-7365

State Streamlines Domestic Water Tank Storage Process In Response to Drought

As the unprecedented drought continues in California, a number of the state's coastal rivers and streams are in danger of reaching critically low stages later this summer, threatening rural drinking water supplies. But plans are now in place to assist landowners that store water for use later in the season through a state program.
The California Department of Fish and Wildlife (CDFW) and the State Water Resources Control Board (State Water Board) announced today that they will expedite approval for the installation of storage tanks by landowners who currently divert water from these important rivers and streams. The action comes under the State Water Board's Small Domestic Use (SDU) registration program.

Installing tanks to divert and store water when flows are higher will help improve rural water supply reliability and fire safety while also relieving pressure for in-stream diversions during the drier months when fish need it most.
The State Water Board has an existing statewide registration program for domestic use of water, allowing home water uses such as drinking and fire protection. These small domestic registrations must comply with general conditions from the State Water Board and typically receive project specific conditions from CDFW.
Landowners eligible for the SDU program currently can request approval to divert to storage. However, this can be a lengthy process requiring site-specific evaluations that address in-stream and habitat needs.

With today's action, CDFW has essentially "pre-approved" the installation of storage tanks that meet the general criteria. The State Water Board has agreed to incorporate these criteria as conditions of approval, and to expedite the issuance of the registrations. This action will result in the collection of water during any upcoming precipitation events, taking advantage of higher flows, and using the stored water later in the season when there may be little to no water available.

Some of these water tanks can provide months of storage to meet domestic water supply needs.
"We have been working in these coastal communities for many years, and have good reason to believe that these emergency changes are going to be welcomed," said Charlton H. Bonham, Director of CDFW. "Many landowners who have wanted to take these steps can do so now more quickly with greater regulatory certainty from our department."

This action is designed to capture water when it is raining and right after rain events. It is not designed to expand any applicant's existing water right or amount of diversion. Capturing rain when it falls from the sky and storing it for use later can also help reduce the impacts to fish and wildlife from diverting water from streams during the driest times of the summer. Today's action was the direct result of suggestions made by local communities and fish conservation organizations such as Trout Unlimited, Mattole River Sanctuary Forest and the Salmonid Restoration Federation.

"The drought is going to be really hard for fish and wildlife as well as agriculture and people," said State Water Board Executive Officer Tom Howard. "CDFW and the State Water Board are open to any solution from any corner of the state on how to make it through these tough times together."

Expedited permitting is available to applicants that meet all of the criteria set forth in the program. SDU program eligibility can be found at
http://www.waterboards.ca.gov/waterrights/water_issues/programs/registrations/.

Eligible parties are those that are already diverting from a stream under a riparian basis of right in CDFW Regions 1 or 3. The party should be diverting for domestic and fire protection use only, and has or will install a rigid style water storage tank. The storage tank should be big enough in size to store at least 60 days of water supply for the house.

Parties who are eligible will need to accept the general CDFW conditions, most importantly that they will use the stored water as a substitute for withdrawing additional water during the summer when flows are lowest. The State Water Board will expedite processing of registration forms where the party meets the CDFW eligibility criteria.
This will help protect fish during periods of low stream flow, especially this year with the drought conditions.

With California facing one of the most severe droughts on record, Governor Brown declared a drought State of Emergency and directed state officials to take all necessary actions to prepare for water shortages. The Governor signed legislation to immediately help communities deal with the devastating dry conditions affecting our state and to provide funding to increase local water supplies after it was passed with bipartisan support in the legislature.

Governor Brown met with President Obama about crucial federal support during the ongoing drought, and the state continues to work with federal partners to ensure coordinated drought monitoring and response. Governor Brown and the administration have also expressed support for federal legislation introduced by Senators Feinstein and Boxer and Representatives Jim Costa, Tony Cárdenas and Sam Farr.

Across state government, action is being taken. The Department of General Services is leading water conservation efforts at state facilities, and the California State Architect has asked California school districts and Community Colleges to act on the Governor's call to reduce water usage. The Department of Transportation is cutting water usage along California's roadways by 50 percent. Caltrans has also launched a public awareness campaign, putting a water conservation message on their more than 700 electronic highway signs.

In January, the state took action to conserve water in numerous Northern California reservoirs to meet minimum needs for operations impacting the environment and the economy, and recently the

Department of Water Resources and U.S. Bureau of Reclamation announced they would seek the authority to make water exchanges to deliver water to those who need it most. The State Water Resources Control Board announced it would work with hydropower generators and the Federal Energy Regulatory Commission to preserve water in California reservoirs, and the California Department of Fish and Wildlife and the California Fish and Game Commission restricted fishing on some waterways due to low water flows worsened by the drought.

The state is working to protect local communities from the dangers of extreme drought. The California Department of Public Health identified and offered assistance to communities at risk of severe drinking water shortages and is working with other state and local agencies to develop solutions for vulnerable communities. CAL FIRE hired additional firefighters and is continuously adjusting staffing throughout the state to help address the increased fire threat due to drought conditions. The California Department of Food and Agriculture launched a drought website to help farmers, ranchers and farmworkers find resources and assistance programs that may be available to them during the drought.

Even as the state deals with the immediate impacts of the drought, it's also planning for the future. In 2013, the California Natural Resources Agency, the California Environmental Protection Agency and CDFA released the California Water Action Plan, which will guide state efforts to enhance water supply reliability, restore damaged and destroyed ecosystems and improve the resilience of our infrastructure.

Governor Brown has called on all Californians to voluntarily reduce their water usage by 20 percent, and the Save Our Water campaign launched four public service announcements encouraging residents to conserve and has resources available in Spanish. Last December, the Governor formed a Drought Task Force to review expected water allocations and California's preparedness for water scarcity. In May 2013, Governor Brown issued an Executive Order to direct state water officials to expedite the review and processing of voluntary transfers of water.

###

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When you file your California income tax return, please consider making a voluntary contribution to the California Sea Otter Fund (line 410) or the Rare and Endangered Species Fund (line 403). Thank you!

Persons with disabilities needing reasonable accommodation to participate in public meetings or other CDFW activities are invited to contact the Department's Reasonable Accommodation Coordinator Melissa Carlin at (916) 651-1214 or Melissa.Carlin@wildlife.ca.gov. Reasonable Accommodation requests for facility and/or meeting accessibility should be received at least 21 days prior to the event. Requests for American Sign Language Interpreters should be submitted at least two weeks prior to the event, and requests for Real-Time Captioning at least four weeks prior to the event. These timeframes are to help ensure that the requested accommodation is met. If a request for an accommodation has

been submitted but due to circumstances is no longer needed, please contact the Reasonable Accommodation Coordinator immediately.

Sanctuary Forest
PO Box 166
Whitethorn
California 95589

Steven E. Walters and Cheryl Lisin
14400 Briceland Thorn Road
Box 443
Whitethorn CA 95589

2/20/14

Notice regarding end of 2013-14 no-pumping season:

Dear Steve and Cheryl,

Pursuant to sections I and IX of Exhibit B of your *Agreement for Seasonal Forbearance of Diversion of Water* with Sanctuary Forest, this letter provides notice that the no- pumping period for pumping or diversions from the Mattole or its springs and tributaries have ended as of 2/12/14. Please note that the pumping rate restrictions for Green Creek are 10 gpm throughout the entire year.

According to the Forbearance agreement you can start pumping from Green Creek when it is over .25 cfs or MS6 is over 25cfs. Doing the lazy armchair method, we estimate MS6 is at 25 cfs when the Ettersburg Gauge is at 90cfs. We have been looking at the prediction for the flow at Ettersburg, and it looks like it will be over 360cfs tomorrow, February 12th, 2014.
You are in the safe zone to pump on Green Creek as of 2/12/14.

Please record your current water meter reading on your water use log for calculation of your total water use during the restricted season. There is no obligation to continue tracking your water use during the unrestricted season. We will be contacting you soon to schedule a monitoring phone call.
The monitoring will include a review your water use log and discussion of how your water management system worked for you. Your feedback will be used to improve the Mattole Flow Program and if needed make adjustments to your system.

Thank you for participating in this important program to help improve Mattole streamflows and salmonids survival. The program and all of you who participate are making a difference!

Sincerely,

Tasha McKee McCorkle

Tasha McKee McCorkle
Executive Director

	Name	APN Number	Summer use in gallons	Winter use in gallons	Residence (sq. ft.)	Barn (sq. ft.)	Other (sq. ft.)	size of the garden, landscaped area, orchard	irrigation system
Gualala/ NGWC	Mark Clark	145-9-3-7	15,000	5,000	1,000			300	no
	Gualala Arts	145-290-09-00					5,000	100,000	Yes
	David and Harmony Susella	144-20-0-35			800			400	no
	Rebecca Willhoit	145-021-05-00	5,300	3,000	1,500	100		100	no
	Gualala Building Supply	145-166-07	750	300			8,000	500	yes
	Arff	145-166-07	100	0			1,200	100	no
	Anthoni "Chuckie" Sorensen	145-9-2-10	2,000	800	1		200	176	yes
	John and Peggy Bower	144-21-00300	8,000	5,000	2,500		1,500	53,800	yes
	Julie and Dave Bower	145-191-12-00	2,200	1,875	2,500		800	500	no
	Spencer Brooks	144-20-0-15	1,200	400	1,300		400	3,000	yes
	Robert Shimon	142-152-03	22,000	16,000	2,300	640		11,000	Yes
	Ken Spacek	123-040-010	9,000	750	1,900	1,622		21,050	No
	Chris and Stacy Aitchison	123-030-026	3,500	1,000	3,500	800		300	Yes
Buckeye	Matt Nelson and April	121-280-015-000	30,000	10,000	1,250			5,000	Yes
	Cliff Putnam-Commercial	123-100-009	22,000	0	Vineyard/forebearance			523,000	yes
	Cliff Putnam-Residential	123-060-023	40,000	0			10,000	871,200	yes
	Randal Sinclair	122-080-034	40,000	5,000	625	600	400	40,000	yes
	Gordon and Zoe Smith	123-010-025	400	0	1,000	800		2,500	yes
Wheatfield	Silva Family LLC (Dale Silva)	138-010-05, 138-	24,000	10,000	1,200	3,600	2,200	1,000	No
	Soper-Wheeler Co	200-006, 123-220-	70,000	0			Forbearar	4,700	yes
	(18) Kashia Band of Pomo Indians	123-160-003	54,847	0	27,000		2,750		no
	Cliff Putnam-Commercial	123-100-009	22,000	0			Forbearar	523,000	yes
	Cliff Putnam-Residential	123-060-023	40,000	0			10,000	871,200	yes
	Peter Fels	107-110-028-000	18,000	2,250	3,915	800		3,915	
	Christopher Fohner	107-150-026	8,000	2,000	1,500	300		44,000	yes
	Sustainable Futures (Sunali and B	109-340-054	240,000	104,000	450	1640	250	523,000	yes
	James Entriken and Blossom Liev	109-470-009	12,000	3,000	1000	500		300	no
	Layana and Jeffry Berman	107-150-018	10,000	5,000	1900	400		800	no
	Tim Schmidt	109-350-017	20,000	5,000	2750	900		60000	Yes
	John Lievore-Caerleon Safford	107-130-022	90,000	45,000	1056			50000	Yes
	Jim Finn	107-130-014	75,000	6,000	1850			12000	yes
outh Fork	Peter Cooper	107-160-010	17,000	6,000	2176	800		150000	some
	Miriam Simos		13,500	2,250	1900		500	130000	yes
	Lake Perry and Lawrence Hunter	107-160-005	120,000	0	1600			4000	yes

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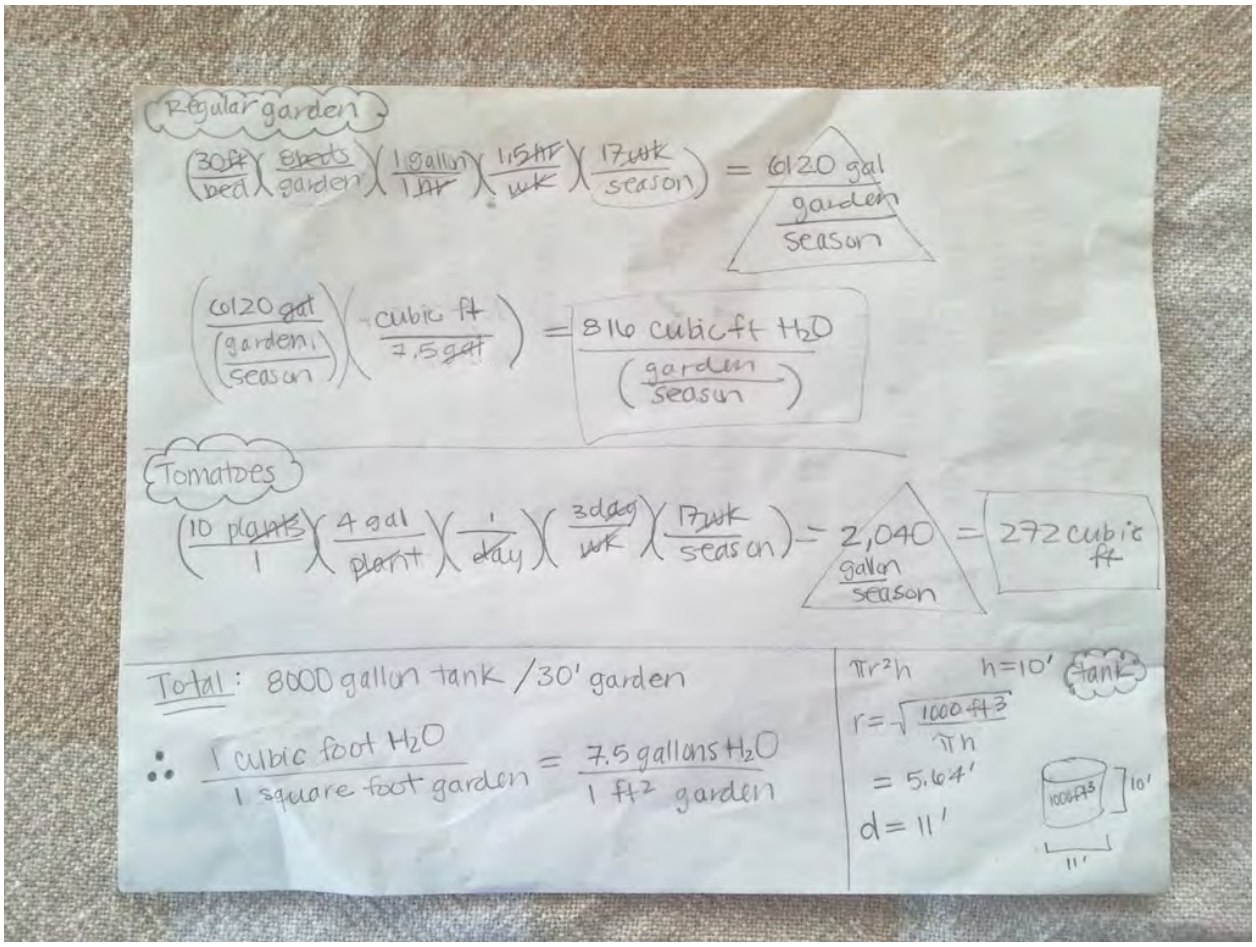
Name	APN Number	Summer use in gallons	Winter use in gallons	Residence (sq. ft.)	Barn (sq. ft.)	Other (sq. ft.)	size of the garden, landscaped area, orchard	irrigation system
John Garber	107-150-17	70,000	20,000	1600	1800	30	3000	yes
Charles Hope	107-180-015	10,000	10,000	1250	640	1280	2000	no
Ft Ross Volunteer Fire Department (One 55,000 gallon tank for fire prevention)								
Denis O'Leary	107-320-010	3,000	2,000	1,200	120		2,400	yes
Drue Banister	107-32-12	11876	6626	3500	700	700	76000	yes

The Flow Bank –DRAFT Program Plan

Protecting Stream Flows in The Gualala River



Prepared by: The Gualala River Watershed Council, June 2014

THE FLOW BANK-PROTECTING STREAM FLOW IN THE GUALALA RIVER

Gualala River Watershed Overview

Located in both Mendocino and Sonoma Counties, the Gualala River drains 685 miles of streams in the northern California Coastal Ranges. The river enters the Pacific Ocean south of the town of Gualala, 114 miles north of San Francisco and 17 miles south of Point Arena. At 212,563 acres (332 mi^2) it is one of the largest watersheds in the Mendocino Coast Hydrological Unit. The watershed is over 32 miles long north-south, with an average width of 14 miles. The entire basin lies within 20 miles of the Pacific Ocean. Elevations vary from sea level to 2,602 feet at Gube Mountain and terrain is most mountainous in the northern and western parts of the basin.

The watershed has a rural population of 3,419 centered near four unincorporated communities; Gualala, Sea Ranch, Annapolis and Stewarts Point. The economic viability of the area has long depended on timber and agriculture as a main source of employment with 80% of all the watershed lands zoned for timber production.

The climate is influenced by fog near the coast with seasonal temperatures ranging between 40°F to 60°F, with the interior basin ranging from below freezing to over 90 (F) degrees seasonally. Generally rain events occur between November and April. Rainfall also varies by location within the basin with 33 inches falling on average near the town of Gualala and totals reaching over 63 inches in some areas within the interior.

The Gualala River lies within the Central California Coast Coho salmon Evolutionary Significant Unit (ESU), which is listed as endangered under the Endangered Species Act (NMFS 2005). Critical habitat includes all river reaches and estuarine areas accessible to Coho salmon within the ESU's geographic area (NMFS, 1999). Winter run steelhead in the Gualala river basin are part of the Northern California Steelhead Distinct Population Segment (DPS) and are listed as threatened under the Federal ESA (NMFS, 2006).

In 1993, the USEPA listed the Gualala River on its federal Clean Water Act §303(d) list of impaired water bodies due to declines in anadromous salmonids from excessive sedimentation. The listing was updated in 2003 and water temperatures in the basin are now considered impaired as well.

Coho naturally inhabited the streams flowing from coniferous forest but were likely sub-dominant to steelhead in interior basin areas draining the mélange due to the more open nature of the channels, less suitable habitat, and naturally warmer stream temperatures.

The Flow Bank Program

The GRWC developed The Flow Bank Program to address the growing crisis of severe seasonal water shortage within the watershed. The program is designed to increase surface flow during the critical summer low flow period to protect aquatic wildlife and provide a secure and reliable water supply to the human community.

During summer months, when stream flows and groundwater supplies are lowest, human demand is highest and endangered fish populations are under extreme stress due to lack of flows, cool water temperatures and high oxygen levels. Increasing flows by developing alternative sources will reduce all these impacts to salmonid populations.

A pattern of low flows in the Gualala has caused areas of both main-stem and tributary reaches to dry up, leaving disconnected channels and poor water quality in the remaining reaches. Since the onset of the current drought, surface flow in creeks are being severely impacted and are not meeting winter and

summer minimum bypass flow requirements impairing the environment along with the local agricultural and residential community.

The focus of Flow Bank program is to assist the agricultural and residential community to reduce the use of water diversions and increase off-stream storage capacity in exchange for a commitment to decrease water extraction from direct diversion, springs and wells during low flow periods (see attached Forbearance Agreement).

The project objectives are to promote and implement rainwater catchment systems as an alternative water supply to enhance stream-flow during the critical summer low flow period; monitor the effectiveness of the catchment systems; increase the local community's awareness about issues facing the watershed; develop strategic partnerships to address the impact of drought conditions in the watershed and identify best management practices to maximize benefits to people and ecosystems.

A pattern of low flows in the Gualala has caused areas of both main-stem and tributary reaches to dry up, leaving disconnected channels and poor water quality in the remaining reaches. Since the onset of the drought, surface flow in creeks are being severely impacted and are not meeting winter and summer minimum bypass flow requirements impairing the environment along with the local agricultural and residential community.

To alleviate these impacts the GRWC is proposing to install 5,000 gallon residential and 55,000 gallon agricultural systems, providing winter water collection for use during dry periods. This project will save 660,000 gallons of water a year, close to 20 million gallons of water over the life of the tanks, which would normally be pumped from diversions, surface springs and shallow wells.

The program will be implemented building upon GRWC partnerships and maximizing the outcomes and costs associated with attainment of Gualala River TMDL and Basin Plan goals. Failing to implement solutions to manage and minimize the low-flow crisis may have devastating impacts on the already threatened native salmonid populations and the local community will continue to be beset by tensions and conflicts over water consumption and supply.

Program Goals and Objectives

Protect critical surface flows and in-stream cool water infusion from springs to enhance rearing salmonid habitat

- Install rainwater catchment systems in the watershed to reduce the demand for water diversions during critical low flow periods.
- Continue ongoing efforts to address the conflict of sharing water equitably between humans and watershed ecosystems

Provide the watershed community with the knowledge and tools for adapting to an increasing unstable water future.

- Increase public awareness about changing weather patterns and the benefits that can be achieved by implementing appropriate climate change adaptation strategies.
- Restore and maintain healthy watershed conditions by utilizing the rainwater catchment program as a tool to effectively engage our diverse communities and encourage communication within and between these groups to gain community support and motivate them to take cooperative actions.

- Provide educational materials to the watershed community to raise awareness about changing climate conditions and threats to water.
- Promote rainwater harvesting as a response to drought conditions and an alternative water source that can help promote long-range water conservation.

Improve economic vitality in the Gualala River Watershed.

- Contract with local vendors and service providers for the installation of water storage tanks.
- Conserve and protect the natural environment to support recreational activities and working landscapes in the Gualala River Watershed.

Program Policy

Climate change, leading to prolonged drought, has affected water quantity and quality within watershed. Storm events begin later and overall rainfall has been below average for the last three seasons (USGS, 2011-2014) lowering flow, delaying salmonid migration (NOAA, 2012) and forcing adults to spawn in main-stem channels (GRWC, 2012). During summer months, when stream flows and groundwater supplies are lowest, human demand is highest and endangered fish populations are under extreme stress. Additionally, climate change forecasts indicate that greater seasonal variations in rainfall could affect water security. Recent study findings show that the climate-related choices we make today and in coming years can have a profound impact on future conditions (California Energy Commission Reports on the Third Assessment). It is therefore urgent that we act now to protect our natural resources, public health, agricultural resources, and public amenities.

Focus Areas

Summer stream withdrawals cumulatively impact both environmental flows and downstream users (Grantham et al. 2010). As demand for water grows, and climate change increases rainfall variability, we must identify management scenarios that maximize benefits to people and ecosystems. Three major direct water diversions for households occur in the watershed; North Gualala Water Company (North Fork basin), Sea Ranch Water Company (South Fork basin), and Stewarts Point Rancheria (Wheatfield Fork basin).

The Sea Ranch Water Company has developed sufficient off-site storage (reservoir) to prevent water extraction during low flow periods. The program should assist the Company with water conservation techniques. Kashia and the North Gualala Water Company have direct diversions and limited off-site storage. The program should assist the two Companies with water conservation techniques and the installation of alternative water supplies and storage.

Gualala

The North Gualala Water Company services approximately 1,000 residents and commercial properties in the towns of Gualala and Anchor Bay. The main source of water is flood plain wells on the North Fork Gualala River. Since 2010, the North Gualala Water Company increasingly has not met daily minimum by pass flows requirements cumulating in a total of 247 days in 2013 when the company was not in compliance with its existing permit. A moratorium is currently in place for new water service within the district.

Annapolis

Annapolis is an unincorporated area straddling a ridge between the Wheatfield Fork and Buckeye Creek of the Gualala River. Most residents within the area rely on direct diversions, springs or shallow wells. During low-flow periods a residents have limited water supplies, necessitating the purchase of water.

Kashia

The Stewarts Point Rancheria's water supply relies on a direct diversion from the Wheatfield Fork directly below the confluence with Haupt Creek. The Rancheria has insufficient storage to prevent water extraction during low flow periods. Currently, the Rancheria has eighteen potential rain water harvesting sites, including the Kashia Grammar School.

Rural Residential Subdivisions

- MendoSonoma 1&2,
- Brushy Loop,
- Gualala Ranch,
- Seaview,
- Navarro Ranch,
- Wickersham

Agriculture

In the Gualala, most medium sized landowners (1,000 to 5,000 acres) practice multi-use land use. Water use includes irrigation for livestock and small agricultural (i.e. orchards and vineyards) ventures. Water supplies are from direct diversions, springs and shallow wells.

Rain Water Harvesting System Installation Priorities

Due to limited funding availability the installation of rain water harvesting systems, project proponents will be prioritized based on the following criteria:

- Focus Areas
- Type of diversion
    - Direct stream diversions
    - Springs
    - Wells
- Amount and type of water use

Program Monitoring

Pre-project monitoring and post-project effectiveness monitoring is an essential component to the program. In addition to monitoring water usage through water bills, baseline data for flow and temperature is available through ten years of thalweg surveys. Two flow gauges are currently USGS certified and on-line in the Gualala; the South Fork gauge on the South Fork below the confluence of the Wheatfield Fork and the North Fork Gauge on the North Fork below the Little North Fork confluence. These gauges provide useful information relating to water diversions, water quality and monitoring, and floodplain mapping. Current climate conditions have made it challenging for GRWC, as well as its partner organizations, to establish reliable baseline data.

These monitoring efforts will provide us with valuable data regarding in-stream flows within the watershed and will allow GRWC to continue the process of long-term trends monitoring and determine

the effectiveness of its water conservation projects. Three components are included in the monitoring plan for the the Flow Bank Program:

- Surveying reaches above and below water diversions to determine habitat conditions.
- Monitoring flow during the low season
- Obtaining water bills or well-elevation measurements at the beginning and the end of the summer season (April and October). Without metered water these measurements will help determine the effects of water conservation efforts.

Summary

Collaborative efforts to restore stream flow on North Coast streams reflect a trend in water management. Several RCDs and organizations have developed successful programs enabling residents in their watersheds to collect and store rainfall for use during the summer months when flows are at critically low levels. GRWC is in a unique position in our community, with the ability and resources to build on these existing efforts and implement a storage and forbearance program in the Gualala River Watershed. Goldridge RCD's *Save Our Salmon* project, the water conservation efforts of the Occidental Arts and Ecology Center Water Institute, and SPAWN's *10,000 Rain Gardens*, served as models for this program. Building strategic partnerships with these organizations, governmental and non-governmental organizations, and Gualala River Watershed landowners is a key to a long-term sustainable program.

The Flow Bank - Protecting Stream Flow in the Gualala River

The Flow Bank – Protecting Stream Flow in the Gualala River

The Gualala River Watershed Council and the Coast Ridge Community Forest have developed a water conservation program for the Gualala.

To conserve water we have developed a rainwater catchment program intended to provide landowners and residents with an alternative source of water for outdoor, non-potable purposes (gardens, landscaping, livestock, etc.) and potable drinking water.

To determine if there is an interest in this program we would appreciate your help by filling out this questionnaire and return to: Judy Rosales, jrosales@mcn.org and copy Kirsten Sequoia, ksequoia.grwc@mcn.org.

Name: _____

Address: _____

Mailing Address: _____

APN Number _____

Email: _____ Phone: _____

1. How would you describe your site *(check all that apply):*

   ☐ Residence ☐ Commercial ☐ Agriculture

   ☐ Other _____

2. How many people live at your residence? _____

3. What is your source of water, and what portion of your water use comes from each source?

   ☐ Well ☐ Spring

   ☐ Riparian/stream ☐ Other

4. What is your average monthly water use?
   See the attached guide for estimated water use.

   Summer use in gallons _____ Winter use in gallons_____

5. What is the collection area of your buildings *(*please list all*)*?
   To calculate the collection area of a structure's roof, measure the horizontal length and width of your roof line (not the sloped roof) and multiply the two measurements.

   Residence_____ sq. ft. Barn_____ sq. ft. Other_____sq. ft.

6. Please describe the garden or landscape at this site:

   What is the approximate size of the garden, landscaped area, orchard?

   _____Square Feet

7. Is there an irrigation system at this site?

   ☐ Yes ☐ No

8. Did you purchase water in 2013/2014? If so, how many gallons? _____
   Is this an increase from previous years? If so, how many gallons did you purchase between 2010-2012?

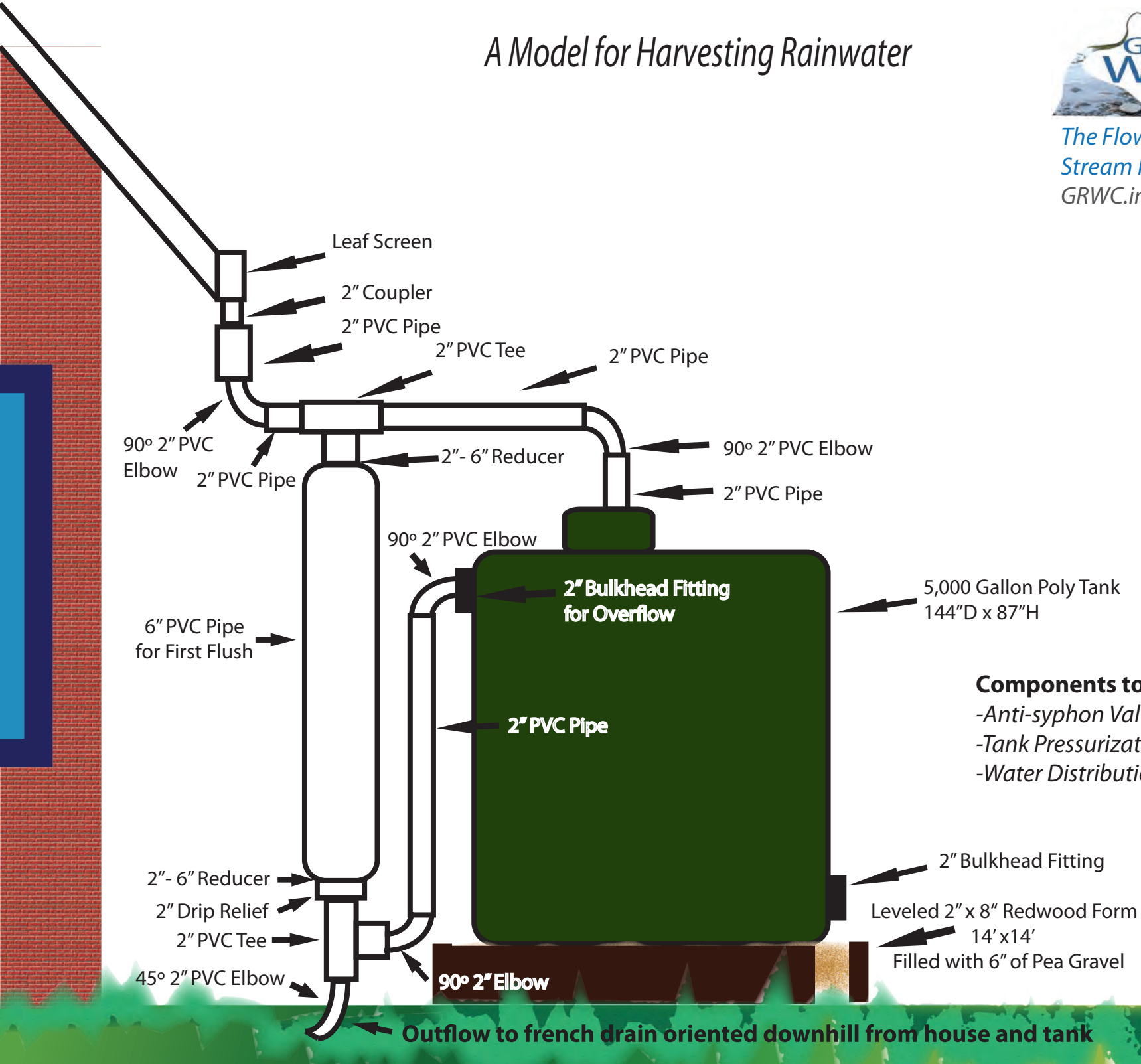
   2010_____ 2011 _____ 2012 _____

A Model for Harvesting Rainwater

Gualala River Watershed Council

The Flow Bank - Protecting Stream Flow in the Gualala River

GRWC.info (707) 884-9166



Components to Consider:

-Anti-syphon Valve and Inspection

-Tank Pressurization (if needed)

-Water Distribution Supplies

Draft Landowner Contract Example

LANDOWNER AUTHORIZATION AGREEMENT
GRWC Drought Assistance and Monitoring Program (DAMP) – Phase I
California Department of Fish and Wildlife Grant Agreement XXXX

This Agreement ("Agreement") is made and effective DATE, ("Effective Date") by and between NAME ("Landowner") and the Gualala River Watershed Council ("GRWC"), a a non-profit organization exempt under section 501 (c) (3).

RECITALS

A. GRWC has established the Drought Assistance and Monitoring Program (DAMP) with grant funding received from grant agreement #XXX from the CDFW Fisheries Restoration Grant Program ("FRGP Grant").

B. The purpose of the Program ("Program Purpose") is to restore salmonid habitat by reducing the amount of water withdrawn from the North Fork and Buckeye Creek watersheds during critical low-flow periods. To facilitate the Program Purpose, landowners selected for participation in the Program will be provided with rainwater catchment systems for non-potable water, including one or more holding tanks, which will be filled with rainwater during the wet weather months and used as non-potable water supply during the time period of use ("Use Period") as specified in Section 3b of the Operation and Maintenance Plan described in Exhibit C attached hereto and incorporated herein ("Operation and Maintenance Plan").

C. Landowner is the fee owner, or has the indefeasible right of possession for no less than the Term described in Section 1 below, of that real property located in the Gualala River Watershed, Sonoma County, California, described as follows:

   The real property described in Sonoma County Records as Assessor's Parcel #xxx-xxx-xxx (the "Property").

   Street address:

D. The Project is being funded, in part, by funds from CDFW Fisheries Restoration Grant Program Agreement XXXXXXXX. Additional funding in the form of matching funds may consist of, without limitation, (a) state or local grants GRWC receives, or (b) an agreed-upon cost share paid directly by the Landowner.

E. The cost of the Project on this parcel is estimated to be $XXX, not including project oversight and administrative costs.

F. Landowner and GRWC now desire to enter into this Agreement for the purpose of setting forth the terms and conditions for the implementation of the Project on Landowner's Property, as well for the purpose of setting forth the rights and obligations of Landowner and GRWC with respect to the ongoing monitoring, maintenance and use of the Project.

AGREEMENT

FOR THE CONSIDERATION STATED IN THIS AGREEMENT AND OTHER VALUABLE CONSIDERATION, THE PARTIES AGREE AS FOLLOWS:

1. Term of Agreement

The term of this Agreement is fifteen (15) years from the Effective Date ("Term").

2. Construction of the Catchment System

The Catchment System shall be constructed and implemented on the Property as set forth in this section and Exhibits.

a. GRWC will contract with a licensed and qualified general contractor to undertake the construction and installation of the Catchment System and shall administer any such contract.

b. The construction of the Catchment System may begin immediately after the Effective Date, and shall be completed in accordance with the Project Construction Plan in Exhibit B attached hereto and incorporated herein. Barring delays, construction of the Catchment System is expected to be completed no later than DATE ("Completion Date"). The parties agree that the Completion Date may be extended upon the request of the GRWC, and that Landowner shall agree to extend the Completion Date for reasonable periods in the event that the construction of the Catchment System cannot be completed by the Completion Date due to circumstances beyond GRWC's reasonable control.

c. The Catchment System shall be constructed on the Property substantially in accordance with the descriptions set forth on Exhibits A and B and any attachments thereto, all of which are incorporated into this Agreement by this reference.

3. Rights and Obligations of the Landowner

a. Water Conservation and Catchment System Maintenance

(i) During the Term, the Landowner agrees to carry out the activities defined in the Operation and Maintenance Plan (Exhibit C).

(ii) Throughout the Term, the Landowner shall not engage in any practice nor undertake any acts that impair the Program Purpose or damage or reduce the effectiveness of the Project. Landowner shall prevent any such acts by any person acting for, on behalf of, or under right or permission granted by the Landowner. Further, during the period of use throughout the Term of this Agreement, Landowner shall not utilize water extracted, directly or indirectly, from XXXXXXX Creek for non-potable, outdoor uses. Landowner may utilize XXXXXXX-supplied water for emergency purposes in the event of fire or other imminent threat to life or property.

(iii) Upon completion of the installation of the Catchment System, Landowner shall be responsible for maintaining the Catchment System for the Term. Landowner is not required to replace the Catchment System if it is damaged or destroyed by acts of God, intentional acts of third parties, or negligence of third parties.

(iv) GRWC shall monitor Landowner's water use from the Catchment System during the Use Period (as defined in Exhibit C) and shall, at least annually, provide a report of such usage to GRWC in a form developed and distributed by GRWC.

b. Financial Rights and Obligations

(i) Any duty of Landowner hereunder to pay any part of the cost of the Catchment System may be waived by GRWC on a showing by Landowner of financial hardship. Application for such waiver shall be in a form, including such information, as is reasonably required by GRWC to assure fairness and privacy.

(ii) Any obligation by Landowner hereunder to pay any part of the cost of the Catchment System may, at GRWC's option, be satisfied by the Landowner providing "in kind" of labor or materials. Landowner agrees to pay $XX, or 10% of the costs of the Catchment System as matching funds (the "Contribution"). Landowner and GRWC shall mutually agree in writing on the terms of payment of the Contribution.

c. Other Rights and Obligations

(i) Landowner, at Landowner's sole expense, shall be responsible for connecting the Catchment System to any plumbing or other water delivery system used by Landowner to make use of the water from the Catchment System.

(ii) Landowner, at Landowner's sole expense, shall provide electrical service to the Catchment System as necessary.

(iii) The Landowner is responsible for infrastructure installation necessary to make Catchment System functional (i.e. gutters.) The Landowner has 30 days to complete these installations.

4. <u>Grant of Permission</u>

Landowner hereby authorizes GRWC and its subcontractors to implement the Project on the Property, as provided in this Agreement.

The Landowner authorizes GRWC staff and its subcontractors to enter the Property, upon reasonable advance notice, for the purposes of:

a. Constructing or evaluating construction of the Catchment System commencing on the effective date of this Agreement and continuing throughout the period of construction and Project implementation.

b. Monitoring the Project, maintaining or repairing the Catchment System, throughout the Term. GRWC shall have the right, but not the obligation, to monitor the Project, and/or maintain or repair the Catchment System.

c. GRWC monitoring of tank water levels and meters.

d. Landowner authorizes CDFW staff to enter the Property, upon reasonable advance notice, for the purpose of project implementation and effectiveness monitoring throughout the first three years following construction.

5. Notification

a. GRWC shall notify the Landowner before entering the Property. GRWC may, at its option, provide such notification by written notice sent to the Landowner at the address shown below, by telephone call to the Landowner at the phone number shown below, or by email to the Landowner at the email address shown below.

b. Any other notification under this Agreement shall be made in writing and (a) mailed by first class mail, return receipt requested, to the address(es) shown below, (b) sent via email to the address(es) indicated below; or (c) sent via fax to the fax numbers shown below.

c. Any notification under this agreement shall be provided to the parties at the following mailing addresses, telephone and/or fax numbers, or email addresses.

GRWC	**LANDOWNER**
Gualala River Watershed Council	NAME
P.O. Box 1269	ADDRESS 1
Gualala, California 95445	ADDRESS 2
Tel: 707.884.9166	TELEPHONE
Fax: 707.884.3461	FAX
email: grwc@mcn.org	EMAIL

The notification addresses, phone or fax numbers, and email addresses for any party may be changed by written notice to the other party given in accordance with this Section 5c.

6. Termination of Agreement

This Agreement may only be terminated by GRWC and may be terminated by GRWC without GRWC incurring liability for breach of the Agreement, upon the occurrence of one or more of the following conditions:

a. The mutual written agreement of the GRWC and the Landowner.

b. GRWC's determination that:

(i) compliance with the Agreement will result in the violation of a federal, state or local statute or regulation; or

(ii) termination of the Agreement would be in the public interest, or;

(iii) grant funding provided to GRWC for the Project is terminated, delayed or reduced.

c. If the Landowner defaults in the performance of any of the terms and conditions of this Agreement, or materially breaches any of its provisions or warranties, and fails to cure the default or breach within 21 business days after service on Landowner of written notice of such default or breach.

7. Enforcement and Dispute Resolution

a. In addition to any right to terminate this Agreement in the event of default or breach by Landowner, GRWC shall have any other rights available in law or equity to remedy or recover for any injury or damages it suffers as a result of such breach or default.

b. Notwithstanding its rights pursuant to Section 7, it is the intention of GRWC to strive to amicably resolve any dispute which might arise with Landowner or Landowner's successors in interest concerning this Agreement. GRWC agrees that prior to taking any other action GRWC will communicate any concerns relating to Landowner's performance under this Agreement to Landowner and shall provide a reasonable opportunity, including through mediation, for Landowner to fully present and address Landowner's views and concerns with regard to the dispute or;

8. Reimbursement upon Termination

In the event of termination of this Agreement by mutual agreement, the Landowner shall reimburse GRWC for all costs paid or incurred by GRWC for the Project under this Agreement (including those costs paid by grant monies), including, but not limited to, all construction, implementation, monitoring, maintenance, and repair activities. If the termination occurs after the Project has been installed, the reimbursement amount shall be prorated by the number of years (or portion thereof) out of the 15 years of the Term that the Project has been in service and maintained by the Landowner as required.

9. Landowner Rights

a. GRWC shall not disturb the Property, except as necessary for the construction, maintenance, or monitoring of the Project.

b. GRWC shall not engage in any nuisance activities on the Property. Reasonable activities associated with construction, maintenance or monitoring shall not be considered nuisance activities.

c. GRWC shall not interfere with privileges or rights that the Landowner has or may grant to others, except to the extent that such privileges or rights are modified by this Agreement and by the grant of authorization to GRWC to construct or monitor the Project.

10. <u>Laws and Regulations</u>

GRWC and Landowner shall comply with all federal, state and local laws and regulations applicable to the construction of the Project.

11. <u>Landowner's Title to the Property, Authority</u>

a. GRWC's exercise of the rights and permission granted herein shall never give rise to any claim of title to the Property on the part of GRWC or parties claiming through or under it.

b. Landowner warrants and represents that Landowner has the actual authority to enter into this Agreement and to authorize the implementation of the Project on the Property and warrants that all other owners of the property to Landowner have also signed this Agreement.

c. Landowner warrants that, as of the Effective Date of this Agreement, Landowner has not granted privileges or rights to others that may interfere with the activities that GRWC is authorized to undertake pursuant to this Agreement. Landowner further agrees that Landowner shall not, after the Effective Date of this Agreement, grant any other person or entity rights or privileges that may interfere with the activities that GRWC is authorized to undertake pursuant to this Agreement or with the obligations of Landowner under this Agreement.

12. <u>Indemnification</u>

a. Landowner will defend, indemnify and hold the GRWC and its agents, employees, contractors or subcontractors, their agents, employees, and funding agencies harmless from any all claims, demands, or liability arising out of the Project to the extent such claims, demands, or liability arise from, or are related to, the acts or omissions of Landowner or Landowner's agents, employees, invitees, contractors, or persons acting under any of them. Such duty of defense and indemnification shall extend to claims, demands, or liability for injuries

occurring before, during or after completion of the Project. As discussed above in Recital B, the water stored by the Project will be suitable for non-potable outdoor uses only; Landowner's indemnification obligations under this Section 13 include indemnification for any all claims, demands, or liability arising out of the use of the stored water for any purpose other than non-potable outdoor uses.

b. GRWC will defend, indemnify and hold the Landowner, their agents employees, contractors or subcontractors, their agents, or employees harmless from all claims, demands, or liability arising out of the Project to the extent such claims, demands, or liability arise from, or are related to, the acts or omissions of GRWC or its agents, employees, invitees, contractors, or persons acting under any of them. Such duty of defense and indemnification shall extend to claims, demands, or liability for injuries occurring before, during or after completion of the Project.

13. Covenants Run with the Land

For its Term, the obligations of this Agreement are agreed to be covenants running with the land within the meaning of California Civil Code §1468. The covenants shall run with the Property and be binding upon and to the benefit of the Landowner and GRWC, and their assigns and successors in interest.

A Memorandum of this Agreement in a form substantially as set forth on Exhibit D shall be recorded with the Sonoma County Recorder by GRWC.

14. Miscellaneous Provisions

a. Governing Law: The interpretation and performance of this Agreement shall be governed by the laws of the State of California.

b. Severability: If any provision of this Agreement is found to be void, invalid or unenforceable, it will be reformed to comply with applicable law or stricken if not so conformable, so as not to affect the validity and/or enforceability of the remainder of this Agreement.

c. Landowner covenants to give actual notice of this Agreement and its terms to any party or entity to whom Landowner intends to convey, devise or transfer any interest (including a security interest) in the Property prior to such conveyance, devise or transfer.

d. No joint venture or partnership is created by this Agreement as between GRWC and any other party hereto.

Signatures follow on the next page.

LANDOWNER(S):

Date: _____

_____
Signature

_____
Print Name

GUALALA RIVER WATERSHED COUNCIL:

Date: _____

By: _____
Executive Director

Exhibit A
Rainwater Catchment System Components, Plan and Specifications

System summary

The rainwater harvesting system consists of 3 basic parts:

1. The collection system. This part of the system includes the roof collection areas, rain gutters, downspouts, screening and first flush devices, and the conveyance pipes that carry water to the storage tanks. The conveyance pipes are "dry lines" running overhead, and are empty when it is not raining.
2. 5,000-gallon HDPE storage tanks, measuring 102" in diameter by 146" in height.
3. The water distribution system, which consists of a pump and pressure tank fed by the combined outlets of the two storage tanks. For purposes of reporting to the grant funding agency, a water meter is located at the pump and will be read monthly during the use period. The size and rating has yet to be decided, but will be agreed by Landowner and GRWC.

See attached plans.

Exhibit B
Project Construction Plan

1. Project Planning

The Landowner has reviewed and accepted the Catchment System designs and specifications attached as Exhibit A. GRWC shall notify Landowner of any proposed modifications to the Catchment System specifications and provide Landowner with a description of those modifications for review and approval. The Landowner shall not unreasonably withhold approval.

The Landowner shall be given notice in time to attend, and may be present for all Project layouts.

2. Construction activities and scheduling

Landowner agrees to:

- Work cooperatively with GRWC and our contractors and subcontractors in scheduling the work necessary for Catchment System construction.
- Provide approximate locations of underground utilities, including septic, gas, electric and water.
- Keep spaces agreed for installation of Catchment System components clear of personal possessions, other items and debris at all times during system construction.
- Provide ready access to the installation area during the period of construction.

GRWC agrees to:

- Cooperate in the scheduling of construction of the Catchment System and implementation of the Project.
- Meet and confer with the Landowner for layout of any Catchment System component affecting the landowner's normal activities.
- Confirm that all contractors retained by GRWC are properly licensed and insured, including, but not limited to workers compensation and general liability insurance.
- Provide management assistance to the Landowner for pre-construction layout, designs and specifications.
- Provide Landowner no less than 24-hour notice by telephone to gain access for layout, construction, inspections and similar activities.
- Provide the Landowner with at least 15 days advance notice of the commencement date of construction activities on the property and the anticipated time needed for the construction activities.
- Abide by a schedule as agreed to between Landowner and GRWC that provides for the completion of all phases of construction by the Completion Date.

Exhibit C

Exhibit C

Operation and Maintenance Plan
for LANDOWNER NAME
DATE

1. Introduction

This Operation and Maintenance Plan has been prepared to help Landowner comply with the terms of this Agreement by providing information for the operation and maintenance of the Catchment System. The goal of the Project is to increase the amount of water in the North Fork and Buckeye watersheds during the dry summer/fall months while providing the landowner with a secure supply of water for outdoor, non-potable needs.

2. Catchment System Operation

a. Rainwater harvesting

The rainwater harvesting system consists of three main components: the collection area (your roof), piping to convey collected water to the storage tank (including a "first flush" device), and the storage tank. A total of 0.6 gallons of water will be generated by each square foot of roof space for each inch of rain that falls. Depending on the size of your roof, it is likely that in an average winter, the tank will fill before the rainy season ends. Once the tank is full, water will flow through an overflow pipe to be dispersed on the ground.

b. Time period for stored water use

The system has been sized for use during the months of May through October of each year ("Use Period"). Landowner should monitor the water level in the tank(s) during the period of use, and adjust water use if necessary to ensure that stored water will last through the month of October. If the stored water is used completely before the end of the use period, landowner is responsible for purchasing water to refill the tank.

c. Inspection and monitoring

Landowner will be responsible for inspecting and maintaining the rainwater harvesting system, including the storage tank. Inspection and maintenance procedures are detailed below.

Monitoring of system use is required by the funder, and will be accomplished using two methods: by periodic checks on the tank water level and installed meters during the May through October period, and through analysis of monthly water use data provided by the GRWC.

3. Catchment System maintenance and repair

a. Collection and conveyance system maintenance

(i) The roof collection area, gutters and screening devices must be inspected before the start of the rainy season, and any leaves, duff or other debris should be removed. This will help to prevent debris from clogging gutters or downspouts. If your roof is located in an area where leaves and duff accumulate, roof and gutter inspection and cleaning should occur a minimum of one additional time during the wet season.

(ii) The first flush systems will allow any fine sediment, bird droppings or other small debris to be washed off the roof and diverted before collected water begins flowing to the storage tank. To a large extent, the first flush devices are designed to be self-maintaining – diverted water will drain out of each first flush device slowly, leaving it empty and ready to divert a first flush during the next rain. However, each first flush device should be cleaned out before the start of the rainy season to ensure that any accumulated sediment or other debris does not reduce its capacity.

(iii) Conveyance pipes: If the debris screens and first flush devices are maintained and functioning properly, conveyance pipes should remain clear of debris and all but the finest grains of sediment. The conveyance pipes will be installed at a slope that will ensure that flowing water will keep fine sediments entrained. The system is designed to be drained during the dry season to eliminate standing water in the pipes.

b. Tank maintenance: Landowner shall inspect the tank and manifold on a regular basis, a minimum of once every three months, including an inspection at the beginning and the end of the period of use each year. If components should fail during the first two years after system installation, Landowner shall notify GRWC for repair or replacement. Thereafter, landowner shall be responsible for arranging repair or replacement of warranty or non-warranty components. Landowner acknowledges that GRWC has provided Landowner with all relevant system warranty and maintenance information.

(i) Tank base: The tank will be placed on a pad composed of compacted gravel. The base of the tank should be inspected to ensure that no settling is occurring. If settling of the pad or deformation of the tank is noted, landowner should contact GRWC immediately so that the problem can be remedied by the installation contractor.

(ii) Leaks: Some leaks are very obvious, with water visibly seeping from the tank or pipes. Other leaks are more subtle, and can be detected by the presence of wet spots that don't go away during dry weather, thriving vegetation in the area around the tank or pipes, etc. Landowner will

contact the manufacturer regarding repairs or replacement of items under warranty, but will notify GRWC.

(iii) Proper tank security: Landowner agrees to keep tank opening securely covered, except when necessary to gain access for tank cleaning and maintenance. If the cover is not secured, rodents, birds and other animals could gain entry and contaminate the stored water. Insects such as mosquitoes can also enter the tank if the cover is not kept securely in place. If light is allowed to enter the tank, it will encourage algae growth and the tank will need to be cleaned more frequently.

(iv) Draining and cleaning the tank: With proper care, the tank should need cleaning infrequently. Should the tank need to be drained, a drain fitting has been included on the manifold at the tank outlet.

Landowner will monitor the interior of the tank to ensure that excess sediment is not building up. When cleaning or draining the tank, the following procedures should be followed:

A. The tank should be cleaned at the beginning of the winter rainy season, when minimal water is stored in it.
B. Sediment build-up or algae. For sediment build-up, the bottom of the tank should be flushed through the drain fitting. A small amount of additional water may be needed to remove the sediment. For algae, soap and water should be used to scrub the inside of the tank with a brush. Bleach should not be used.
C. Tank should be flushed to a location away from the creek or any channel or water body that might deliver to the creek. If possible, water flushed from the tank should be dispersed to avoid erosion.

c. Plumbing system and pump maintenance
Technical support, and maintenance and warranty information for the pump will be attached to this agreement once a pump contractor and pump specs have been determined.

Exhibit D
Memorandum of Recording

Recording Requested By
and When Recorded Return to:

Gualala River Watershed Council
P.O. Box 1269
Gualala, California 95445

[Space Above This Line for Recorder's Use]

MEMORANDUM OF **LANDOWNER AUTHORIZATION AGREEMENT**

This Memorandum of Landowner Authorization Agreement ("Memorandum") is made and entered into between XX ("Landowner") and the Gualala River Watershed Inc. ("GRWC"), a non-profit organization exempt under section 501 (c) (3), to witness that:

Landowner has entered into a Landowner Authorization Agreement ("Agreement") with GRWC and effective as of DATE, and terminating on END DATE the terms of which Agreement are made a part hereof as though fully set forth herein. The Agreement includes provisions which are agreed to be covenants running with the land and which affect the real property described as follows:

The real property described by the grant deed recorded in Sonoma County Recorder's as Assessor's Parcel #XXX-XXX-XXX ("Property).

Street address: XXX.

[SIGNATURES FOLLOW ON NEXT PAGE]

The undersigned have executed this Memorandum on the date indicated adjacent to their signature:

LANDOWNER(S):

Date: _____

_____
Signature

_____
Print Name

Date: _____

_____
Signature

_____
Print Name

GUALALA RIVER WATERSHED COUNCIL:

Date: _____

By: _____
Executive Director