A Rapid Assessment of Sediment Delivery from Clearcut Timber Harvest Activities in the Battle Creek Watershed, Shasta and Tehama Counties, California

Appendix A

November, 2011

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to

A Rapid Assessment of Sediment Delivery from Clearcut Timber Harvest Activities in the Battle Creek Watershed, Shasta and Tehama Counties, California

November, 2011

Report prepared at the request of

The California Resources Agency

by staff from

The California Department of Forestry and Fire Protection (CAL FIRE)

The California Department of Fish and Game (DFG)

The Central Valley Regional Water Resource Control Board (CV RWQCB)

and

The California Geological Survey (CGS)

Appendices

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- A.2 - October 3, 2011 CVRWQCB response to receipt of turbidity data
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Appendix A

Battle Creek Turbidity Data

A.1 - Battle Creek Turbidity Data Distributed September 20, 2011

A.2 – October 3, 2011 CVRWQCB response to receipt of turbidity data

A.3 – October 3, 2011 CVRWQCB review of turbidity data

Appendix A.1

Battle Creek Turbidity Data Distributed September 20, 2011

Wopat, Michael

From: jodifredi@aol.com
Sent: Tuesday, September 20, 2011 2:42 PM
To: pcreedon@waterboards.ca.gov
Cc: rcrandall@waterboards.ca.gov; awilson@waterboards.ca.gov; klandau@waterboards.ca.gov; wwyels@waterboards.ca.gov; choppin@waterboards.ca.gov; fweber@waterboards.ca.gov; tdoduc@waterboards.ca.gov; THoward@waterboards.ca.gov; MYounghein@Calepa.ca.gov; dcoupe@waterboards.ca.gov
Subject: Water Quality Monitoring of Battle Creek
Attachments: Battle_Creek__CVRWQCB_Sign-on_Letter(3)log.pdf; Battle_Creek_WQ_Assessment.pdf; Attachment_1_Data_Set.xls; Attachment_2_Area_Map.pdf

Dear Ms. Creedon,

Please find the attached letter regarding water quality monitoring of Battle Creek signed by seventeen organizations. You will also find three additional attachments: 1) A letter (dated 8/19/11) from the California Sportfishing Protection Alliance to the Battle Creek Alliance, and 2 support documents to that letter: a) Battle Creek Monitoring Data Set, and b) Area Map.

Please do not hesitate to contact us with any questions.

Regards,
Jodi Frediani

Jodi Frediani
Forestry Consultant
Santa Cruz Group
Ventana Chapter, Sierra Club
ph/fax 831-426-1697
JodiFredi@aol.com

Jodi Frediani
Director
Central Coast Forest Watch
ph/fax 831-426-1697
JodiFredi@aol.com

Pamela Creedon, Executive Officer
Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive, Suite 200
Rancho Cordova, CA 95670-6144
Fax: (916) 341-5199

VIA: Electronic Submission
Hardcopy if requested

September 20, 2011

Subject: Battle Creek Water Quality Monitoring

Dear Ms. Creedon,

The undersigned organizations are requesting that the Central Valley Regional Water Quality Control Board (Regional Board), in the absence of comprehensive water quality sampling data in the Battle Creek Watershed, take immediate action to conduct a thorough investigation and direct Sierra Pacific Industries (SPI) to implement a responsible water-quality monitoring program throughout the watershed. We believe such monitoring must include instream turbidity and herbicide sampling, utilizing approved standard operating procedures (SOPs) with proper quality assurance and quality control (QA/QC). Both compliance monitoring and assessment and trend monitoring, must be conducted for Battle Creek.

State and federal agencies are spending $128 million to bring endangered salmon back to 48 miles of the Battle Creek watershed which has been blocked by dams for nearly a century.

> *The Restoration Project spans Tehama and Shasta Counties …and ….proposes to facilitate the safe passage for, and the growth and recovery of, naturally-produced anadromous fish populations, including three federally-listed runs: the Central Valley spring-run chinook salmon, the Central Valley steelhead trout, and the Sacramento River winter-run Chinook salmon*.[1]

With the possible exception of efforts to restore spring-run salmon on the San Joaquin, the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project) is the most ambitious and important salmon habitat restoration opportunity in the Central Valley. It is the largest such project in the nation. Yet, while this ambitious and costly project moves forward, thousands of acres are being clear cut upstream, potentially jeopardizing the whole restoration effort.

None of the multiple timber harvest plans approved by Cal Fire and under the silviculture waiver of the Central Valley Regional Water Quality Control Board (Regional Board) have been required to do any water quality sample monitoring, either for turbidity or herbicides. The Regional Board provided assurances during development of the waiver and during subsequent litigation on the inadequacy of the waiver, that a requirement for instream water quality monitoring was unnecessary, because clear cutting does not create a water quality problem. New evidence brings that assertion into question.

The California Sportfishing Protection Alliance (CSPA) recently conducted a review of water quality sampling data gathered over a 20-month period by the Battle Creek Alliance (BCA), a community volunteer organization, in four tributaries of Battle Creek. CSPA reviewed the data from BCA's monitoring program and found evidence of adverse changes in water quality conditions attributable to clear-cutting activities. Numerous and continuous exceedances of the turbidity Water Quality Standards in the Regional Water Quality Control Plan (Basin Plan) were observed. (August 19, 2011 CSPA letter attached)

The report also compared the BCA data to earlier published data from the U.S. Fish and Wildlife Service (FWS), data collected daily during an 18-month period at the Coleman fish hatchery on Battle Creek. The FWS data showed less than 7% of the data exceeding 5 NTUs. The BCA post-clear-cut data on average exceeds 5 NTUs 37% of the time. In one example, "*Canyon Creek has a mean average turbidity of more than 11 NTUs and on average, exceeds 5*

[1] http://www.battle-creek.net/restoration.html

NTUs 76% of the time. Canyon Creek….. station is in the heart of the clear-cut area." (August 19, 2011 CSPA letter)

On August 30, 2011, CSPA submitted a Public Records Act request to the Regional Board for access to all records pertaining to, "*water quality and water quality monitoring in the Battle Creek watershed including any data from monitoring conducted by Sierra Pacific Industries (SPI), any Regional Board staff evaluation of monitoring data collected from the Battle Creek watershed and any correspondence between the Regional Board and SPI related to water quality in the Battle Creek watershed*."

CSPA has since been advised that the Regional Board is not in possession of any instream data collected by SPI, and that the Board is negotiating with SPI to have data they have collected in Bailey Creek analyzed by a third party. However, Bailey Creek is only one of a number of creeks in the area and, over the last few years, major timber harvesting has occurred in Canyon and Rock Creek sub-watersheds. Such limited data cannot be deemed to be representative and is insufficient to adequately assess the potential threats from the large-scale logging currently being conducted throughout the Battle Creek Watershed. Nearly 20,000 contiguous acres have been/are in the process of being logged in the watershed since 1998. 78% of that, or over 15,000 acres, will have been clearcut. Cumulatively, they have the potential to jeopardize the downstream Restoration Project.

Given the importance of this watershed to salmon, without water quality monitoring data, the validity of the general timber wavier and the credibility of the timber harvest process are called into question.

SPI asserts they have herbicide data. They have included text in the Battle Creek Blue Ridge THP (THP 2-10-067 TEH), pg 117, referencing a monitoring and effectiveness program they conducted from 2000- 2008 related to their use of herbicides. They state they collected 3,730 samples that were tested for five herbicides as well as seven other potential water quality chemical contaminants. All samples were reportedly sent to a California Environmental Laboratory Accreditation Program for analysis. While the sampling was not conducted in the Battle Creek watershed, it may still provide useful information, although it is not an acceptable surrogate for actually monitoring widely applied chemicals in the Battle Creek watershed.

The Battle Creek Salmon and Steelhead Restoration Project is a multi-agency, multi-year effort undertaken at great public expense in a heroic effort to save dying populations of California's iconic salmon. All measures must be undertaken to insure its success. As long as the various agencies do not have any assessment of instream impacts from the extensive and continuous upstream logging operations, the whole effort may be a lost cause. While stream access is essential for spawning salmonids, that access must be to clean and healthy habitat. Even small levels of sediment, turbidity and herbicide can adversely affect fish viability and reproductive success. And previous studies indicate that spawning and rearing habitat in the restoration watershed have been adversely impacted.

With that in mind, we again ask that you take immediate action to conduct a thorough investigation, obtain all available water quality monitoring data from SPI, make the raw data available to the public, and direct SPI to implement a responsible water-quality monitoring program in the Battle Creek Watershed.

We also ask for a written response to this letter outlining the actions that will be undertaken by the Regional Board.

Respectfully,

Jodi Frediani
Director
Central Coast Forest Watch

Luke Breit
Forests Forever

Justin Augustine
Staff Attorney
Center for Biological Diversity

Marily Woodhouse
Director
Battle Creek Alliance

Zeke Grader
Executive Director
Pacific Coast Federation of
Fisherman's Association

Bill Jennings
Executive Director
California Sportfishing Protection Alliance

Jack Ellwanger
Pelican Network

Mauro Oliveira
Stop Clearcutting California

Michael Endicott
Resource Sustainability Advocate
Sierra Club California

Susan Robinson
Board Member
Ebbetts Pass Forest Watch

Craig Thomas
Director
Sierra Forest Legacy

Laureen Clair
CFO
SOL Communications, Inc.

Karen Schambach
President
Center for Sierra Nevada Conservation

Kyle Haines
Klamath Forest Alliance

Douglas Bevington
Forest Program Director
Environment Now

Chris Wright
Executive Director
Foothill Conservancy

Andrew
Executive Director
Environmental Protection Information Center

Attachments:
8/19/11 CSPA letter: Attachment 1-Battle Creek Monitoring Data Set; Attachment 2-Area Map

California Sportfishing Protection Alliance

"An Advocate for Fisheries, Habitat and Water Quality"

3536 Rainier Avenue, Stockton, CA 95204

T: 209-464-5067, F: 209-464-1028, E: deltakeep@me.com, W: www.calsport.org

19 August 2011

Ms. Marily Woodhouse, Director
The Battle Creek Alliance
Marily Woodhouse <marily-lobo@hotmail.com>

VIA: Electronic Submission
Hardcopy if Requested

Dear Marily,

The California Sportfishing Protection Alliance (CSPA) received your letter and data requesting technical assistance in reviewing in stream sampling data assessing the potential impacts of forest clear-cutting operations and the maze of logging roads within the Battle Creek watershed.

In response to your request we assigned Mr. Steven Bond and Mr. Richard McHenry to review the data and assess the potential water quality impacts. Mr. Bond is a Professional Geologist, and Certified Hydro-geologist and Engineering Geologist with more than 30 years of experience in pollutant fate and transport in groundwater and surface water. He has worked for the U.S. Geological Survey, U.S. Army Corps of Engineers, Central Valley Regional Water Quality Control Board and as a private consultant. Mr. McHenry is a Professional Civil Engineer with 25 years of experience. He was Senior Supervisor of the Central Valley Regional Water Quality Control Board's NPDES permitting unit for the Sacramento Valley for over a decade and retired as the Senior Engineer in the State Water Board's Office of Enforcement.

CSPA has reviewed the data from the Battle Creek Alliance monitoring program (Four-Creeks) and find evidence of adverse changes in water quality conditions attributable to clear-cutting activities, and numerous and continuous exceedances of the turbidity Water Quality Standards in the Regional Water Quality Control Plan (Basin Plan). See Attachment 1.

Monitoring Program

The Four Creeks monitoring program is a 20-month effort by a community volunteer organization to sample and record the water quality of four tributaries of the North Fork of Battle Creek between December 2009 and July 2011. The region is an area of 85 square miles located southeast of Redding, California, between 3000 feet and 5000 feet elevation on the western slopes of Mount Lassen. The program includes 11 monitoring stations on Bailey Creek, Rock Creek, Canyon Creek, and Digger Creek. There is an additional station on the south fork of Battle Creek. The objective of the program is to establish a record of water quality in order to assess the potential impacts from the recent forest clear-cutting activities in the region of the four creeks.

Photo Imagery Assessment

Historical aerial photo imagery reveal that 35% of the region's 85 square miles (29 square miles) have been clear-cut within the past 9 -12 years. The photo imagery shows that these relatively recent logging/clear-cutting operations are the dominant activities in the region. The potential for water quality impacts from these clear-cutting operations is the subject of the Four-Creeks Monitoring Program.

Data Analysis

For this review CSPA looked for comparable data from unaffected streams and we looked for comparable turbidity data from the same watershed. We found no published data for these four creeks at any time. We did find published data and references to miscellaneous data for the period 1955 through 2002 for Battle Creek and some other tributaries. Most of the historical data is collected more than 10 miles downstream of the Four-Creek project. A single, 18 month daily record of turbidity was data collected and published by U.S Fish and Wildlife Service (FWS)[1] at the Coleman fish hatchery on Battle Creek (see Attachment 2). The FWS covers the period from September 1999 to February 2001. While the two data sets represent the same approximate duration (≈ 1.5 years) the FWS data set consists of daily measurements in contrast to the Four-Creek data set that consists a 10% sampling of the time span.

Pre-Clear-Cut vs. Post-Clear-Cut data

The FWS, pre-clear-cutting data set shows typical low turbidity with a mean average of four NTU's with less than 7% of the data exceeding 5 NTU's. In contrast, the four-creek monitoring data shows that the upstream, post-clear-cut mean average is 5 NTU's and on average exceeds 5 NTU's 37% of the time. The difference is that the post-clear-cut, Four-Creek data shows greater increases in turbidity compared to the pre-clear-cut FWS data.

- Canyon Creek has a mean average turbidity of more than 11 NTU's and on average, exceeds 5 NTU's 76% of the time. Canyon Creek, represented by CCC, this station is in the heart of the clear-cut area. Canyon Creek is tributary to Rock Creek.
- Rock Creek is represented by RC, and RCP, has a mean average turbidity of more than 5 NTU's and on average, exceeds 5 NTU's 43% of the time.
- Digger Creek, which is south of Rock Creek, is represented by DC, FMC, and DCH. It has a mean average turbidity of 3 NTU's and on average, exceeds 5 NTU's 16% of the time.
- Bailey Creek, which is north of Rock Creek, is represented by BCT and BCP. It has a mean average turbidity of less than 3 NTU's and on average, exceeds 5 NTU's 18% of the time.
- NFB: Below the confluence of Bailey Creek, Rock Creek with the north fork of Battle Creek is station NFB. NFB has a mean average turbidity of less than 4 NTU's and on average, exceeds 5 NTU's 29% of the time.
- SFB: The South Fork Battle Creek station, SFB, has a mean average turbidity of a little less than 5 NTU's and on average, exceeds 5 NTU's 26% of the time.

Although the before and after conditions can only be inferred from the differences in the

[1] http://www.fws.gov/redbluff/PDF/Battle%20Creek%20Juvenile%20Salmonid%20Monitoring%2002-03.pdf

locations of the data and the periods of time represented (i.e., downstream pre-clear-cut daily data, and upstream post-clear-cut 10% sampling), we can make certain conclusions from the information in the preceding paragraph. Typically, upstream reaches are characterized by turbulent flows, steep gradients, cold water temperatures, coarse substrates, and well-oxygenated water, whereas lowland reaches are typically characterized by warmer water temperatures, gentle gradients, turbidity, sediment deposition, fine substrates, and smaller concentrations of dissolved oxygen. If we use this general characterization, we can infer that given equal conditions, the Four-Creeks water quality should have lower turbidity than the downstream data. But, the data shows the opposite, strongly suggesting changed conditions for the upstream environment. This points directly at the likely impacts from the clear-cutting in the Four-Creeks watershed.

Basin Plan Turbidity Water Quality Standard Exceedances

We also reviewed the Four-Creeks data in terms of turbidity changes within occurring on the same day. For that, we compared the following pairs of stations: BCT > BCP, CCC > CC2, CC2 > CC, RC > RCP, DC > FMC, FMC > DCH. Certain pairs where omitted because they represented water quality changes owing to different water sources. For example: BCP to NFP compares the water from Bailey Creek to the North Fork of Battle Creek mixed with Bailey Creek, and CC to RC compares Canyon Creek to Rock Creek and its tributaries mixed with Canyon Creek.

- Bailey Creek (BCT > BCP), turbidity increased in 56% of the sampling events and 20% of the sampling events registered (8) exceedances of the Basin Plan water Quality Standard for turbidity.
- Canyon Creek (CCC > CC2) turbidity increased in 40% of the sampling events and 37% of the sampling events registered (13) exceedances of Basin Plan Turbidity Water Quality Standard. Also on Canyon Creek (CC2 > CC) turbidity increased in 85% of the sampling events and 76% of the sampling events registered (39) exceedances of Basin Plan Water Quality Standard.
- Rock Creek (RC > RCP) turbidity increased in 83% of the sampling events and 61% of the sampling events registered (30) exceedances of Basin Plan Water Quality Standard.
- Digger Creek (DC > FMC) turbidity increased in 20% of the sampling events and 20% of the sampling events registered (2) exceedances of Basin Plan Water Quality standard. Also on Digger Creek (FMC > DCH) turbidity increased in 75% of the sampling events and 40% of the sampling events registered (8) exceedances of Basin Plan Water Quality Standard.

Based on our review of the submitted data and sampling procedures, we can reasonably conclude that it is unlikely that the grab sampling activities would have captured peak turbidity flows within the watershed. Ideally, instream sampling devices would have been installed with frequent interval sampling that could have captured a more comprehensive assessment of turbidity increases related to stormwater events. The limited resources of the Battle Creek Alliance volunteer organization likely prohibit this level of sampling. A more robust sampling program is highly recommended to further quantify the water quality impacts of forest clear-cutting operations and the maze of logging roads within the Battle Creek watershed

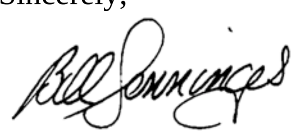
However, the Battle Creek Alliance’s Four-Creeks monitoring program documents at least 100 exceedances of the Basin Plan Water Quality Standard for turbidity. While some of the preceding station pairs used for this determination are widely spaced, all, with the exception of NFB and DCH, are within the 85 square mile region of clear-cutting activities. And, because clear-cutting operations are or appear to be the dominant influence on turbidity within the region, the changes in turbidity can likely be attributed to variations in the clear-cutting effects from different areas. Consequently, we may reasonably conclude that the exceedances of the Basin Plan Water Quality Standard owing to increases in turbidity are attributable to the timber harvest activities in the watersheds.

Summary

- Historical aerial photo imagery that in the last 10 years 35%, 29 square miles of forested land has been clear-cut by timber harvesting operations.
- The timber harvest activities of the past decade are the dominant activity in the watersheds with pollution producing potential.
- The Four-Creeks post-clear-cut water quality has higher turbidity than the downstream FWS pre-clear-cut water quality data, indicating changed conditions in the upstream environment.
- Canyon Creek and Rock Creek are the most impacted streams and show the greatest occurrence of high turbidity registering 81 exceedances of the Basin Plan Water Quality Standard for turbidity.
- The Four Creeks monitoring program has registered at least 100 exceedances of the Basin Plan Water Quality Standard for turbidity.
- Based on our review of the submitted data we feel confident that it is reasonable to conclude that the turbidity exceedances of the Basin Plan water Quality Standard are attributable to the timber harvest activities in the Battle Creek watershed(s).

We hope that CSPA's evaluation of the data is of value to you and the Battle Creek Alliance. Please contact me at (209) 464-5067 if we can be of further assistance or answer any questions regarding our review and assessment of the data.

Sincerely,



Bill Jennings, Executive Director
California Sportfishing Protection Alliance

Attachment 1: Battle Creek Monitoring Data Set.
Attachment 2: Area Map.

		Bailey > North Fork Battle Crk					Canyon Crk > Rock Crk > North Fork Battle Crk								Digger Creek				
		BCT	BCP	NTU change	NFB	NTU change	CCC	CC2	NTU change	CC	NTU change	RC	RCP	NTU change	DC	FMC	NTU change	DCH	NTU change
Elevation	ft msl	3990	2580		1920		3660	3410		3160		3090	2590		3440	≈ 2880		≈ 2120	
		9. Bailey top (BCT) (el 3990)	6. Bailey Creek Ponderosa (BCP) (el 2580)	BCT to BCP	1. NF Battle Creek (NFB)(el 1920)	BCP to NFB	Canyon Crk Culvert (CCC) (el 3660)	5.2 Canyon Creek 2 (CC2) (el 3410)	CCC to CC2	5.1 Canyon Creek 1(CC (el 3160)	CC2 to CC	4.Rock Creek (RC) (el 3090)	2. Rock Creek, Ponderosa (RCP) (el 2590)	RC to RCP	3. Digger, Forward Mill (DC) (el 3440)	Forward Mill Culvert (FMC)	DC to FMC	7. Digger Ponderosa (DCH)	FMC to DCH
Date	Weather	NTU	NTU		NTU		NTU	NTU		NTU		NTU	NTU		NTU	FMC		NTU	
12/30/2009	cloudy-- .08" rain prev day		0.66		0.78	0.12				5,02		2.11	1.26	-0.85	3.2			1.64	
12/31/2009	cloudy																		
1/2/2010	partly cloudy, .26 rain 1/1				1.03					6.65		1.43	2.06	0.63					
1/10/2010	cloudy	0.81			0.85					4.06		1.28	1.3	0.02	0.85			0.56	
1/12/2010	.98" rain	2.91	1.78	-1.13	1.98	0.2		6.17		15.1	8.93	2.03	5.94	3.91	6.43			5.11	
1/13/2010	.65" rain																		
1/15/2010	cloudy																	0.84	
1/18/2010					3.59														
1/19/2010																			
1/20/2010	rain 'til 2:00				4.87			28.8		33.6	4.8	13.6			10.4			7.25	
1/21/2010	cloudy																		
1/26/2010		3.74	6.62	2.88	11.4	4.78		16.9		29.9	13	9.7	18.6	8.9	6.61			5.63	
1/30/2010	cloudy																		
1/31/2010	sunny	1.97	2.78	0.81	6.65	3.87		18.2		22.8	5.9	6.13	12.4	6.27	3			6.04	
2/3/2010	cloudy									18.2		6.87							
2/7/2010	sunny	3.11	2.34	-0.77	5.65	3.31		16.3		24.6	8.3	9.13	13.9	4.77	4.77			5.76	
2/12/2010	cloudy	0.99	1.27	0.28	3.18	1.91	8.26	10	1.74	16.1	6.1	6.8	8.93	2.13	2.28	1.59	-0.69	1.49	-0.1
2/19/2010	sunny	1.11	0.62	-0.49	2.2	1.58	5.8	6.88	1.08	14.8	7.92	8.81	5.25	-3.56	2.16	1.07	-1.09	1.18	0.11
2/27/2010	p.sunny/ rain 2/26	3.35	1.63	-1.72	4.3	2.67	7.37	10.7	3.33	17.9	7.2	4.2	7.33	3.13	3.06	0.83	-2.23	3.42	2.59
3/4/2010	p.sunny/WSRCD				2.7		5.43	7.93	2.5	15.3	7.37	4.1			1.94	0.73	-1.21		-0.73
3/15/2010	sunny	0.78	1.14	0.36	3.33	2.19	5.34	6.41	1.07	13.7	7.29	4.12	6.12	2	2.22	0.74	-1.48	1.38	0.64
4/3/2010	cloudy	0.82	0.84	0.02	2.4	1.56	4.27	4.24	-0.03	12.3	8.06	2.45	4.24	1.79	1.44	0.6	-0.84	0.96	0.36
4/12/2010	rain a.m.	1.08	0.68	-0.4	2.38	1.7	4.86	4.53	-0.33	13.3	8.77	2.87	4.39	1.52	1.77	0.9	-0.87	1.49	0.59
4/21/2010	rain a.m.	1.29	3.06	1.77	5.83	2.77	7.02	11.1	4.08	21.3	10.2	4.1	10.7	6.6	2.36	0.85	-1.51		-0.85
4/30/2010	sunny	2.08	1.31	-0.77	2.68	1.37	5.5	4.65	-0.85	11.9	7.25	3.48	5.97	2.49	1.81	0.62	-1.19	1.85	1.23
5/11/2010	sunny	1.17	0.69	-0.48	2.65	1.96	4.25	4.09	-0.16	10.3	6.21	1.92	3.59	1.67	1.15	0.66	-0.49	1.44	0.78
5/20/2010	sunny	2.84	1.91	-0.93	2.16	0.25	4.31	2.92	-1.39	9.77	6.85	1.5	3.34	1.84	1.57	Dry		1.81	
5/30/2010	sunny	0.97	1.27	0.3	1.67	0.4	6.91	2.72	-4.19	8.45	5.73	1.39	3.53	2.14	1.23	Dry		1.03	
6/4/2010																			
6/6/2010		8.78	9.6	0.73	8.16	-1.44	5.72	3.7	-2.02	9.27	5.57	1.71	3.27	1.56	2.7	Dry		3.37	
6/23/2010	sunny	2.17	2.78	0.61	2.82	0.04	8.22	3.86	-4.36	8.41	4.55	3.13	3.87	0.74	2.55	Dry			
7/3/2010	sunny	1.97	2.14	0.17	2.21	0.07	5.34	2.88	-2.46	6.79	3.91	1.47	2.53	1.06	1.56	Dry			
7/15,16/ 2010	hot	4.44	2.42	-2.02	3.18	0.76	9.86	4.36	-5.5	7.41	3.05	1.62	3.71	2.09	2.81	Dry		1.53	
7/28, 29/ 2010	hot	1.93	1.55	-0.38	1.4	-0.15	8.46	2.31	-6.15	4.11	1.8	1.07	1.76	0.69	1.58	Dry		0.8	
8/9/2010	sunny	0.92	0.61	-0.31	1.29	0.68	dry	3.01		3.56	0.55	1.68	1.56	-0.12	0.76	Dry		0.83	
8/23,24/ 2010	sunny	1.05	0.65	-0.4	0.68	0.03	dry	4.75		3.97	-0.78	1.28	1.71	0.43	1.14	dry		0.71	
8/31,9/1/ 2010	hot	0.61	1.62	1.01	0.84	-0.78		2.84		2.79	-0.05	1.2	1.45	0.25	1.49			1.61	
9/14/2010	sunny	0.79	1.71	0.92	0.67	-1.04		4.13		2.57	-1.56	0.89	1.62	0.73	1.69			1.09	
9/29/2010	hot	0.81	0.94	0.13	0.82	-0.12		2.87		2.49	-0.38	1.53	1.78	0.25	1.83			1.7	
10/6/2010		0.88	1.55	0.67	1.14	-0.41		3.54		2.58	-0.96	1.61	1.35	-0.26	2.17			2.01	
10/15/2010	Partly cloudy	0.93	1.58	0.65	0.97	-0.61		3.82		2.77	-1.05	1.32	1.58	0.26	3.16			1.49	
10/22/2010	cloudy	0.58	0.46	-0.12	0.82	0.36		2.95		1.83	-1.12	0.76	1.6	0.84	1.03			1.84	
10/29/2010	partly cloudy	1.48	1.29	-0.19	1.48	0.19		2.72		6.03	3.31	2.54	3.19	0.65	2.68			4.43	
11/7/2010	rain	2.21			2.67			15.2		24.3	9.1	2.98							

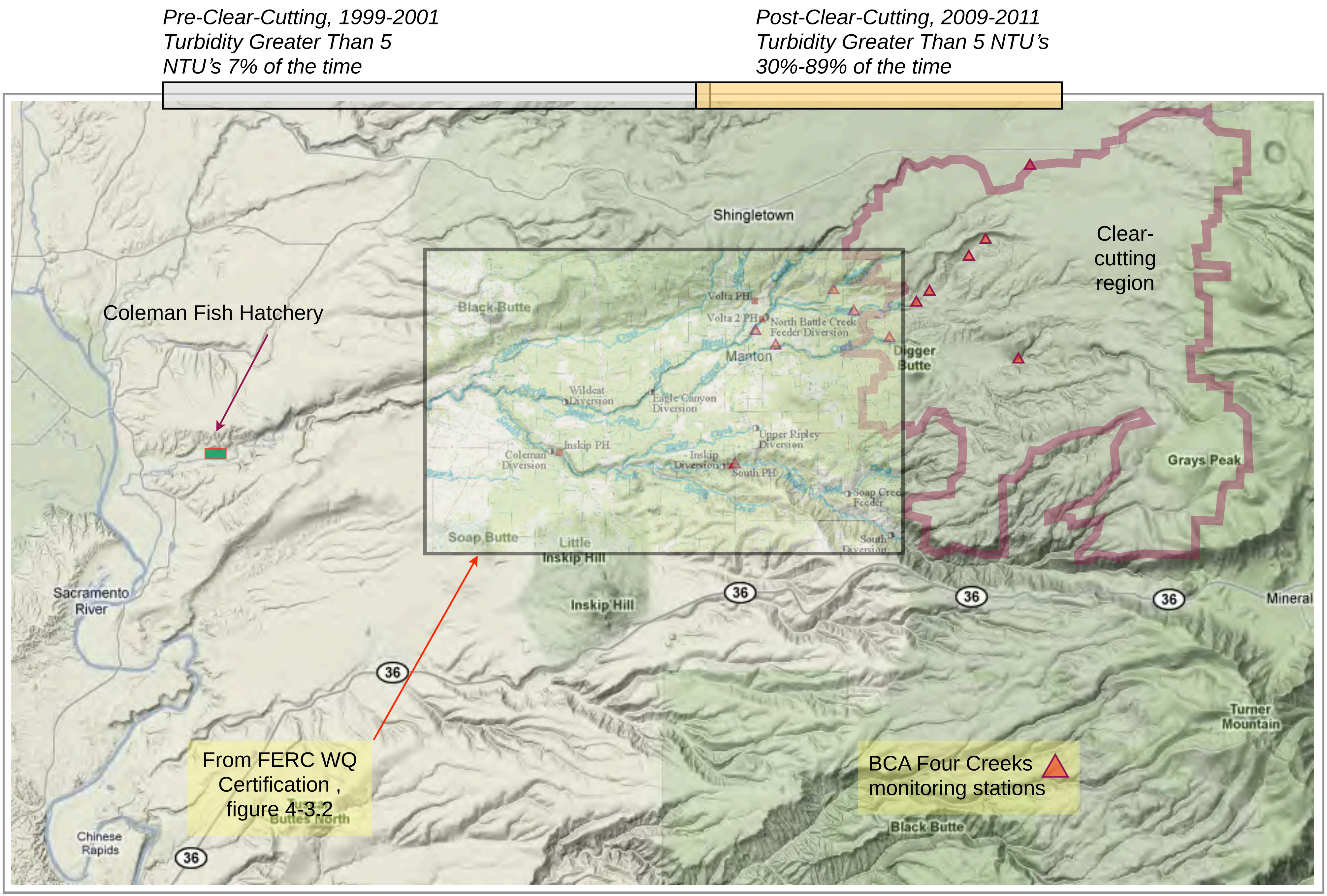
		Bailey > North Fork Battle Crk					Canyon Crk > Rock Crk > North Fork Battle Crk								Digger Creek				
		BCT	BCP	NTU change	NFB	NTU change	CCC	CC2	NTU change	CC	NTU change	RC	RCP	NTU change	DC	FMC	NTU change	DCH	NTU change
Elevation	ft msl	3990	2580		1920		3660	3410		3160		3090	2590		3440	≈ 2880		≈ 2120	
		9. Bailey top (BCT) (el 3990)	6. Bailey Creek Ponderosa (BCP) (el 2580)	BCT to BCP	1. NF Battle Creek (NFB)(el 1920)	BCP to NFB	Canyon Crk Culvert (CCC) (el 3660)	5.2 Canyon Creek 2 (CC2) (el 3410)	CCC to CC2	5.1 Canyon Creek 1(CC (el 3160)	CC2 to CC	4.Rock Creek (RC) (el 3090)	2. Rock Creek, Ponderosa (RCP) (el 2590)	RC to RCP	3. Digger, Forward Mill (DC) (el 3440)	Forward Mill Culvert (FMC)	DC to FMC	7. Digger Ponderosa (DCH)	FMC to DCH
Date	Weather	NTU	NTU		NTU		NTU	NTU		NTU		NTU	NTU		NTU	FMC		NTU	
11/8/2010	sunny				1.5										0.74			1.91	
11/16/2010	sunny	2.15	0.97	*-1.18*	1.14	*-2.11*		2.91		1.92	*-0.99*	1.92	1.43	*-0.49*	1.32			1.54	
12/1/2010	cloudy				0.81														
12/5/2010	sun/cloud				2.05			8.75		11.6	**2.85**	3.51	5.78	**2.27**				2.31	
12/9/2010	cloudy				41 .0					22.6		8.94			5.57				
12/15/2010	sunny	6.89			7.33		19.3	20.7	1.4	31.4	**10.7**	15.8	13.7	*-2.1*	2.43			6.61	
12/26/2010	cloudy/ rain	1.05	3.83	**2.78**	6.37	**2.54**	15	15.5	0.5	20.1	**4.6**	10.3	15.3	**5**	4.26	4.57	0.31	5.33	0.76
1/13/2011	rain on snow	6.22			5.92		8.17	22	**13.83**	40	**18**	5.54			1.54	4.25	**2.71**		*-4.25*
1/30 2011	cloudy, rain prev. pm after 2 wks dry	1.98	2.39	0.41	2.91	0.52	5.81	8.53	**2.72**	23.9	**15.37**	7.77	7.26	*-0.51*	2.93	1-3.33		3.22	
2/10/2011	sunny, dry	5.07	1.41	*-3.66*	2	0.59	7.78	6.49	-1.29	17.3	**10.81**	3.43	5.06	**1.63**	2.84	dry		2.8	
3/5/2011	cloudy	1.06								16.4		7.17							
3/6/2011	rain	7.58			32.5		30.2	69.6	**39.4**	81.4	**11.8**	15.5				6.4			
3/18/2011	rain/snow				7.75					22.8		9.77				4.02			
3/23/2011	rain/snow				7.78					17.1		8.82			4.63	5.7	**1.07**		
4/3/2011	sunny	2.19			4.45		10.1	17.5	**7.4**	18.5		7.83	11.1	**3.27**	3.8	3.94	0.14	4.66	0.72
4/9/2011	sunny	1.32			4.24		9.37	6.42	*-2.95*	12.1	**5.68**	6.06	7.84	**1.78**	6.7	2.31	*-4.39*	4.99	**2.68**
4/18/2011	rain				13.3		10.7			28.2		5.75				2.72			
4/19/2011	sunny				5.37														
5/5/2011	sunny	2.13			3.23		13.1	12.1	**6.29**	18.1	**6**	3.98	5.44	**3.28**	4.66	1.48	*-3.18*	2.61	**1.13**
5/12-14/2011	sunny	2.33			3.19		8.23									1.02		2.88	**1.86**
5/18/2011	sun/cloud	5.27	8.84	**3.57**	7.36	*-1.48*	16.6	21.6	**5**	28.4	**6.8**	4.64	18.3	**13.66**	5.46	1.21	*-4.25*	6.22	**5.01**
5/26/2011	sun/cloud	2.27	3.74	**1.47**	3.16	*-0.58*	8.05	7.51	*-0.54*	13.6	**6.09**	5.81	8.61	**2.8**	4.92	1.05	*-3.87*		*-1.05*
6/2/2011		2.43	3.95	**1.52**	4.75	0.8	11.1	8.96	*-2.14*	15.2	**6.24**	4.5	10.4	**5.9**	5.01	1.2	*-3.81*	3.69	**2.49**
6/11/2011	cloudy	5.26			5.42		12.1	9.89	*-2.21*	13	**3.11**	5.5	6.68	**1.18**	4.7	1.13	*-3.57*	4.81	**3.68**
6/19/2011	sunny	13.4	5.89	-7.51	5.42	*-0.47*	16.7	8.59	*-8.11*	11.6	**3.01**	4.33	8.18	**3.85**	10.6	dry		7.1	
6/26/2011	sun/hot	6.51	11.9	**5.39**	5.54	*-6.36*	8.44	11	**2.56**	13.5	**2.5**	6.65	4.78	*-1.87*	8.14	dry		5.57	
7/4/2011	hot	3.31	7.86	**4.55**	6.12	*-1.74*	7.85	7.36	*-0.49*	13.4	**6.04**	4.72	6.22	**1.5**	4.53	dry		4.61	
7/12/2011	sunny; car issue,didn't finish						14.2			9.78		2.64			3.38				
7/19/2011	sunny	6.21	6.59	0.38	3.11	*-3.48*	8.94	4.89	*-1.61*	12.2	**7.31**	2.89	4.71	**1.82**	5.42	dry			
7/30/2011	hot	2.85			4.51		8.77	7.33	*-1.44*	7.46	0.13	2.86			3.96	dry			

The blue colored cells represent an in turbidity from station to station.

The blue cells with bold red numerals represent a measured violation of the Regional Board's Basin Plan Water Quality Criteria for Turbidity.

The italic text in pink colored cells represent a decline in turbidity from station to station.

Figure 2


Pre-Clear-Cutting, 1999-2001
Turbidity Greater Than 5
NTU's 7% of the time
Post-Clear-Cutting, 2009-2011
Turbidity Greater Than 5 NTU's
30%-89% of the time
Coleman Fish Hatchery
Clear-
cutting
region
Shingletown
Black Butte
Volta PH
Volta 2 PH
North Battle Creek
Feeder Diversion
Manton
Digger
Butte
Wildcat
Diversion
Eagle Canyon
Diversion
Coleman
Diversion
Inskip PH
Upper Ripley
Diversion
Inskip
Diversion
South PH
Soap Butte
Little
Inskip Hill
Inskip Hill
Grays Peak
36
Mineral
Sacramento
River
Turner
Mountain
From FERC WQ
Certification ,
figure 4-3.2
BCA Four Creeks
monitoring stations
Black Butte
Chinese
Rapids

Appendix A.2

October 3, 2011 CVRWQCB response to receipt of turbidity data

3 October 2011

Jodi Frediani, et al.
Forestry Consultant
Santa Cruz group
Centana Chapter, Sierra Club
JodiFredi@aol.com

Via electronic mail

RESPONSE TO EMAIL COMMUNICATION DATED 20 SEPTEMBER 2011 REGARDING CONCERNS ABOUT IMPACTS FROM LOGGING IN THE BATTLE CREEK WATERSHED

The Central Valley Regional Water Quality Control Board (Central Valley Water Board) received your emailed letter of concern and supporting documents dated 20 September 2011. In your letter you outlined concerns regarding Sierra Pacific Industries' (SPI) timber harvest activities in the Battle Creek watershed and their potential for impacts on the downstream salmonid restoration efforts.

The Central Valley Water Board shares your concerns regarding the protection of aquatic habitat for salmonids within the larger scope of the Battle Creek Restoration Project. We have been actively permitting and conducting inspections on a variety of projects within the Battle Creek watershed for decades, including the timber harvest operations in the upper reaches of the watershed that you mention.

You requested that the Central Valley Water Board take immediate action to conduct a thorough investigation in the Battle Creek watershed. In addition to the normal review, permitting and inspection processes within our Non-Point Source, Stormwater/401 Certification and Timber Harvest Regulatory programs, staff has increased our investigatory and multi-agency efforts within the Battle Creek watershed. The Battle Creek watershed is, like many foothill communities in the Sierras and Cascades, subject to multiple uses such as; grazing, farming, vineyard conversion, timber harvesting, recreation, illegal marijuana plantations, county roads, rural residential, etc. This makes tracking impacts to water quality from one single activity a challenge. We are inspecting a wide-variety of activities in the watershed and putting together a plan for immediate and future actions. However, the Battle Creek watershed exceeds 237,000 acres and the effort necessary to conduct such an assessment is extensive and not completed as yet.

SPI Data – Bailey Creek
You requested that we obtain all available water quality monitoring data from SPI. We are currently working with SPI to have an appropriate analysis of their Bailey Creek data

conducted and submitted to us using a professional experienced in the field of instream turbidity data interpretation to validate the analysis. Such an analysis, of more than 16 million data points, is not feasible to complete in a short amount of time. We are communicating with SPI and a potential third party expert in order to determine what can be reasonably expected in such an analysis within a fairly short time frame.

SPI In-stream Monitoring

At the request of SPI staff, we are assisting in the search for locations on SPI-owned lands that may provide opportunities for in-stream monitoring station installation. As you know, not every stream reach is appropriate for long-term installation of monitoring equipment. In the upper tributaries of Battle Creek, stream configuration is not always conducive to long-term, continuous monitoring station installation. Limitations on station installation include: unconfined channels that do not have consistent flow, sufficient depth or mixing for year-round monitoring; monitoring locations easily accessible to the public are thus frequently subject to vandalism; stream elevation and flow conditions that limit the ability to gather data during times of low flow or freezing of entire stream segments. We also recognize that there are multiple in-holdings of ranches, homes, vineyards, and other land uses that must be taken into consideration when designing a monitoring program.

Clearly, this investigation is not going to be short and we must acknowledge the need for long-term continuous inspections, regulatory and outreach efforts within the Battle Creek watershed.

Interagency Efforts

We have dedicated two field staff personnel to an interagency inspection effort that includes staff from the California Department of Forestry and Fire Protection (Cal Fire), California Geologic Survey and the California Department of Fish and Game. This field assessment aims to determine if sediment impacts are being generated by timber harvest activities conducted under the Board of Forestry's Forest Practice Rules in the upper watersheds. We anticipate a final report will be produced by the teams in mid-November 2011. In addition, presentations to the public will be scheduled as soon as feasibly possible after completion of the final report. Likely venues for public presentations include: the Board of Forestry, Central Valley Water Board, Fish and Game Commission, and the Battle Creek Working Group.

Internal Efforts

Staff from our Non-Point Source program is conducting inspections on various activities in the upper tributary sub-watersheds, including the restoration project itself, grazing activities, recreational activities, vineyards, etc.

We are also reviewing all of the stream condition data that has been gathered from a wide variety of sources over the past several decades, including those data required by our NPDES permits.

Staff participates in the paper and field review of timber harvest plans proposed on private lands. Central Valley Water Board staff has participated in 9 of 10 pre-harvest inspections conducted in the larger Battle Creek watershed on private lands over the last ten years. Additionally, we have conducted or participated in an additional 18 inspections in the watershed since mid-2006.

CSPA

Staff reviewed the CSPA data analysis of Ms. Woodhouse's data and we wish to advise caution in relying on the data to prove that a single land use is creating water quality impacts in the Battle Creek watershed. However, the data is certainly useful for providing a basis for trend monitoring, and does provide some direction for prioritizing and directing our field inspections, as noted above.

Clearly, the data provided by Ms. Woodhouse is not conclusive. Nor, as your letter states, will the analysis of data collected by SPI on Bailey Creek be conclusive. You rightly acknowledge the limitations of data collected in one sub-watershed being applicable to all the other sub-watersheds within the larger Battle Creek watershed.

Ms. Woodhouses' data indicates that several sampling locations are potentially being subject to increased turbidity. Our field inspections confirm that sediment is being transported from a variety of sources, most of which are related to roads, both private and county-owned.

During timber harvest plan review and field inspections, we specifically analyze roads and watercourse crossings as roads are the most common and dominant sources of sediment related to timber harvest activities. Whenever a road is located too close to a watercourse, or the opportunities for drainage placement to control discharge to a watercourse are limited, management measures are put in place to remove or re-route those roads or otherwise address the sediment transport issue. Over the past ten years our records indicate that over 18 miles of roads on SPI lands, many of which presented a threat to water quality, have been removed from the network. In many cases, new roads with modern design standards were built in more appropriate areas within the landscape to better protect water quality but still provide access for landowner management and fire suppression efforts. Further efforts to improve roads on private timber lands may be needed, once our assessment of the situation is completed.

The road network in the larger Battle Creek watershed is comprised of a combination of legacy and new roads, owned by the federal government, the counties (Tehama and Shasta) and private landowners. The Central Valley Water Board will be communicating with the Lassen National Forest and both Tehama and Shasta Counties, regarding the need to improve the road networks in the larger Battle Creek watershed.

Board of Forestry Rules
Staff is directly involved in the drafting, review and providing suggested revisions on the Board of Forestry's rules that apply to activities with potential to impact threatened or endangered salmonid species. Our participation in rule development and revision has been continuous since the first version of the Threatened and Impaired rules were drafted in the late 1990's, through the newest anadromous salmonid protection (ASP) rules recently adopted by the Board of Forestry.

Central Valley Water Board staff is also involved in the efforts to re-organize, revise and improve the Board of Forestry's Forest Practice Rules associated with roads and crossings. Staffs' field experience validates the scientific literature which shows that roads are, by an order of magnitude, the greater contributor of sediment to streams vs. harvest units. This leads us to conclude that efforts to improve implementation of road and watercourse crossing best management practices will be the most effective path for ensuring water quality protection in Battle Creek and in all of our forested watersheds.

We appreciate your concern and assure you that we are taking measures to ensure the protection of beneficial uses of water quality in the Battle Creek watershed. Further questions can be directed to our Timber Program Manager, Angela K. Wilson at (530) 224-4856.

Original signed by Robert Crandall

(for) Pamela C. Creedon
Executive Officer

AW: jmtm

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cc: See attached list

DISTRIBUTION LIST

Jodi Frediani, Director, Central Coast Forest Watch, Santa Cruz
Luke Breit, Forests Forever, Sacramento
Justin Augustine, Staff Attorney, Center for Biological Diversity, San Francisco
Marily Woodhouse, Director, Battle Creek Alliance, Montgomery Creek
Zeke Grader, Executive Director, Pacific Coast Federation of Fisherman's Associations, San Francisco
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Laureen Clair, CFO, SOL Communications, Inc.
Karen Schambach, President, Center for Sierra Nevada Conservation
Kyle Haines, Klamath Forest Alliance
Douglas Bevington, Forest Program Director, Environment Now, Santa Monica
Chris Wright, Executive Director, Foothill Conservancy, Pine Grove
Andrew Orahoske, Executive Director, Environmental Protection Information Center, Arcata

Appendix A.3

October 3, 2011 CVRWQCB review of turbidity data

California Regional Water Quality Control Board
Central Valley Region
Katherine Hart, Chair

Acting Secretary for
Environmental Protection

415 Knollcrest Drive, Suite 100, Redding, California 96002
(530) 224-4845 • FAX (530) 224-4857
http://www.waterboards.ca.gov/centralvalley

Edmund G. Brown Jr.
Governor

TO: Pamela Creedon, EO
Robert Crandall, AEO

AUTHOR: Drew Coe, Engineering Geologist

SIGNATURE:_*original signed*___

REVIEWED BY: Angela K. Wilson, PG 8157

DATE: 3 October 2011

SIGNATURE:_*original signed*___

SUBJECT: RESPONSE TO THE CALIFORNIA SPORTFISHING PROTECTION ALLIANCE'S ANALYSIS OF STREAM SAMPLING DATA IN THE BATTLE CREEK WATERSHED.

Central Valley Regional Water Quality Control Board (Central Valley Water Board) staff has had a chance to review the dataset and subsequent analyses performed by the California Sportfishing Protection Alliance (CSPA) on turbidity data collected by the Battle Creek Alliance (Four Creeks data). The analyses are summarized in a letter dated 19 August, 2011, sent to Ms. Marily Woodhouse, director of the Battle Creek Alliance. In general, Central Valley Water Board staff found many of the assertions regarding timber harvest-induced turbidity violations made by CSPA are not supported by the available data. Furthermore, staff has extensive field experience within the Battle Creek Watershed, and found that the assumptions of the CSPA analyses did not reflect the types of physical processes operating in the Battle Creek Watershed. General issues related to the analyses are briefly summarized as the following:

- No consideration given for minimum detectable effects;
- No information provided regarding potential measurement errors;
- No control for spatial variability in turbidity in the analyses;
- No control for temporal variability in turbidity in the analyses;
- Analyses assumptions did not reflect the types of watershed processes governing turbidity patterns in Battle Creek drainage;
- No linkage of monitoring results to beneficial use impairment.

The following document details each of these issues. Staff also discusses: 1) How the Four Creeks dataset can be utilized for determining the status of water quality in the watershed; 2) How the dataset can be utilized it can be used for water quality improvement; and 3) Recommendations for improving water quality monitoring in the Battle Creek Watershed.

Minimum Detectable Effects

The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) states minimum levels of changes for numeric Water Quality Objectives.

Exceeding the level of change stated in the Basin Plan is considered a violation of Water Quality Objectives. This minimum level of change can also be viewed as a minimum detectable effect (MDE) expected by the Central Valley Water Board for proving the exceedance of Water Quality Objectives.

A MDE is the "smallest change in the average value of a given water quality variable that would be considered statistically significant" (Loftis et al., 2001). High spatial and temporal variability, along with the potential for measurement error, increases the MDE for the water quality constituent of interest (i.e., turbidity). For example, high natural variability and high measurement error makes the detection of small changes very difficult.

To explore the concept of MDEs and how they apply to turbidity in the Central Valley Region, we must look at the Basin Plan Water Quality Objective for turbidity. The Fourth Edition of the Basin Plan has the following standards for turbidity:

- Where natural turbidity is less than 1 Nephelometric Turbidity Unit (NTU), controllable factors shall not cause downstream turbidity to exceed 2;
- Where natural turbidity is between 1 and 5 NTUs, increases shall not exceed 1 NTU;
- Where natural turbidity is between 5 and 50 NTUs, increases shall not exceed 20 percent;
- Where natural turbidity is between 50 and 100 NTUS, increases shall not exceed 10 NTUs; and
- Where natural turbidity is greater than 100 NTUs, increases shall not exceed 10 percent.

From these standards we can see that the Basin Plan only allows for relatively small changes in turbidity (i.e., 1 to 10 NTUs) when the turbidity of the receiving water is low to moderate (i.e., 0 to 50 NTUs). It should also be acknowledged that exceedances of these magnitudes are very difficult to detect in a statistically rigorous manner given the naturally high spatial and temporal variability in turbidity in undisturbed forested watersheds (MacDonald et al., 1991; MacDonald, 1992). As such, monitoring studies must be designed appropriately if these standards are to be used to document violations. The study design was not provided, nor addressed within the CSPA analyses.

<u>No Information Regarding Measurement Errors</u>

No information is presented on the make, model, or year of turbidimeter used for data collection. This information is important given the small absolute changes in turbidity reported as Basin Plan violations. It is important to consider that the average and median turbidity values for the entire Four Creeks dataset are 6.0 NTUs and 3.8 NTUs, respectively. The average change in turbidity constituting a Basin Plan violation is 4.9 NTU (n=74), with a median change of 2.8 NTUs. Approximately 32% of the alleged violations are less than or equal to 2 NTUs (i.e., an error associated with some turbidimeters), and 68% of the violations are less than or equal to 5 NTUs. These magnitudes of change are generally imperceptible to the human eye. Knowing the accuracy of the turbidimeter is important, and will allow us to determine the percentage of alleged violations that might be due to measurement error.

The type of turbidimeter will also dictate the quality assurance and sampling protocol used (i.e., QA/QC). Concerns related to QA/QC include:

- Turbidimeter must be calibrated regularly to prevent measurement drift;
- The turbidimeter optical sensor must be cleaned to prevent fouling;
- Grab sample containers must be appropriately cleaned; and
- Instream sampling must be conducted so as to not disturb channel bottom sediments;

Given the small absolute changes in turbidity reported as Basin Plan violations, this information is critical for assessing the potential for measurement and sampling error, and how these errors might affect the results of the analyses.

The comparison between the Four Creeks dataset and turbidity grab samples taken at the Coleman Fish Hatchery are also problematic given that measurements were likely taken using two separate types of turbidimeters. Turbidity comparisons between two different turbidimeters are not recommended for documenting relatively small exceedances because the error associated in the comparison can greatly exceed the minimum turbidity standard in the Basin Plan (Lewis et al., 2007 http://www.fire.ca.gov/cdfbofdb/PDFS/Tprobe_final_report.pdf).

<u>Control for Spatial Variability in Turbidity</u>

The CSPA analyses uses above-and-below comparisons of Four Creeks data to document Basin Plan violations, and to compare turbidity between the upper watershed (Four Creeks area) and the lower watershed (Battle Creek at Coleman Fish Hatchery) (Map 1). The proper way to document Basin Plan exeedances is to follow a rigorous above-and-below sampling procedure. Using this method, water quality samples are taken immediately above a known discharge (e.g., sediment plume emanating from clearcut; turbid road drainage), and far enough below the discharge to allow for complete mixing. These samples should be taken as close in time as possible (Figure 1). This approach controls for spatial and temporal variability, as well as treatment (i.e., land use disturbance) effects. Hence, you can clearly tie Basin Plan exceedances to a discrete source of pollution from land use activities.

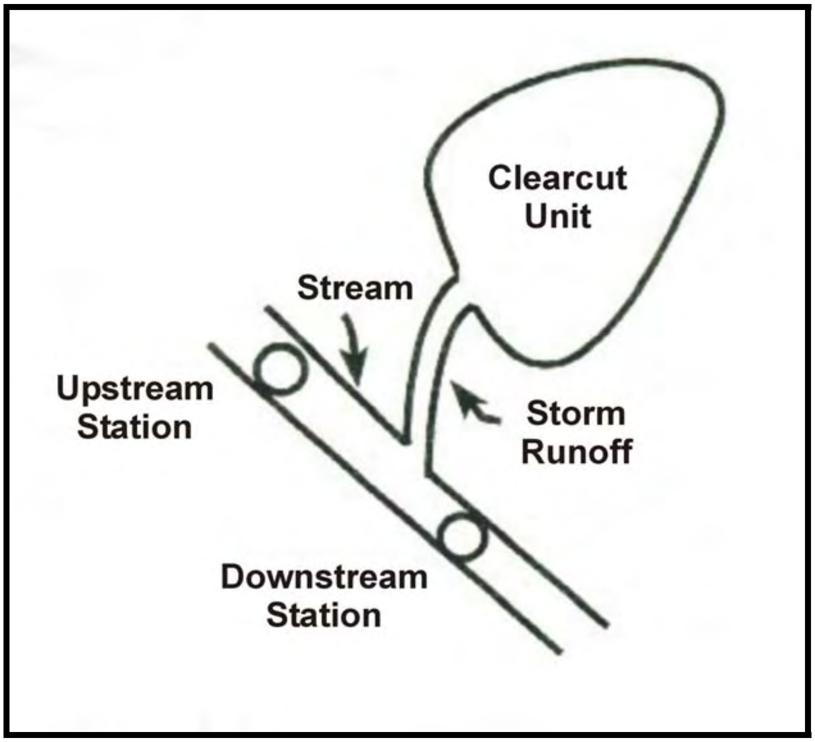

Figure 1. A schematic of an appropriate above-and-below sampling design utilized for monitoring timber harvest activities. Monitoring staff should sample immediately above a discrete discharge point (e.g., sediment plume) emerging from the timber harvest unit or road segment, and far enough below the discharge site to allow for complete mixing (adapted from Caux and Moore, 1997). Distance between sampling points should be hundreds of feet rather than miles apart.

In contrast, above-and-below comparisons of Four Creeks data are done between monitoring stations a minimum of 1.2 miles apart, with a maximum distance of 6.7 miles between stations (Table 1; Map 1 and 2). To control variability, above-and-below stations should be hundreds of feet apart, not miles apart for comparison purposes (MacDonald et al., 1991; MacDonald, 1992). Also, the difference in watershed area between compared stations ranges from 0.9 to 104.3 mi^2 (Table 1), with some monitoring stations having two orders of magnitude difference in watershed area (i.e., FMC to DCH; see Map 2b). Large longitudinal distances and large differences in watershed areas between above-and-below sampling points introduces too much uncontrolled variability, in addition to an increasing number of potentially confounding land uses, to discern significant changes in turbidity due to timber harvest. Potential turbidity increases from clearcutting are only one of many different natural and anthropogenic sediment sources (e.g., bank erosion; channel incision; grazing; county roads) in the watershed. Spatial variability in controlling processes between sites (e.g., sediment transport capacity; sediment supply) can easily account for the differences in turbidity between monitoring stations (Gomi et al., 2005; Markman, 1990).

Furthermore, the comparison between the FMC and DC sites, FMC and DCH sites, and CCC and CC2 sites are inappropriate in that they are each comparisons between two entirely different streams, rather than above-and-below comparisons of the same stream (Figure 2; Map 2a and Map 2b;). Turbidity comparisons are also made between the Four Creeks dataset and turbidity grab samples made at the Coleman Fish Hatchery, despite the fact that the Coleman Fish Hatchery is 19.3 miles downstream (Map 1), and has a watershed area 300% (i.e., 350 mi^2 versus 136.8 mi^2) larger than the Four Creeks area. Again, there is no consideration for the spatial variability in the controlling processes that influence turbidity, and how these might affect the turbidity differences between monitoring stations.

Table 1. Elevational difference, longitudinal distance, and watershed area comparisons between sampling stations for the Four Creeks dataset, Battle Creek.

Stations	Elevation Difference Between Stations (feet)	Distance Between Stations (miles)	Comparison of Watershed Area (mi^2)
BCT to BCP	1410	6.7	18.6 vs. 32.4
BCP to NFB	660	2.7	32.4 vs. 136.8
CCC to CC2	250	1.2	0.5 vs. 1.4
CC2 to CC	250	1.6	1.4 vs. 3.0
RC to RCP	500	2.2	18.0 vs. 22.3
DC to FMC	560	3.0	21.1 vs. 0.4
FMC to DCH	760	3.7	0.4 to 38.5

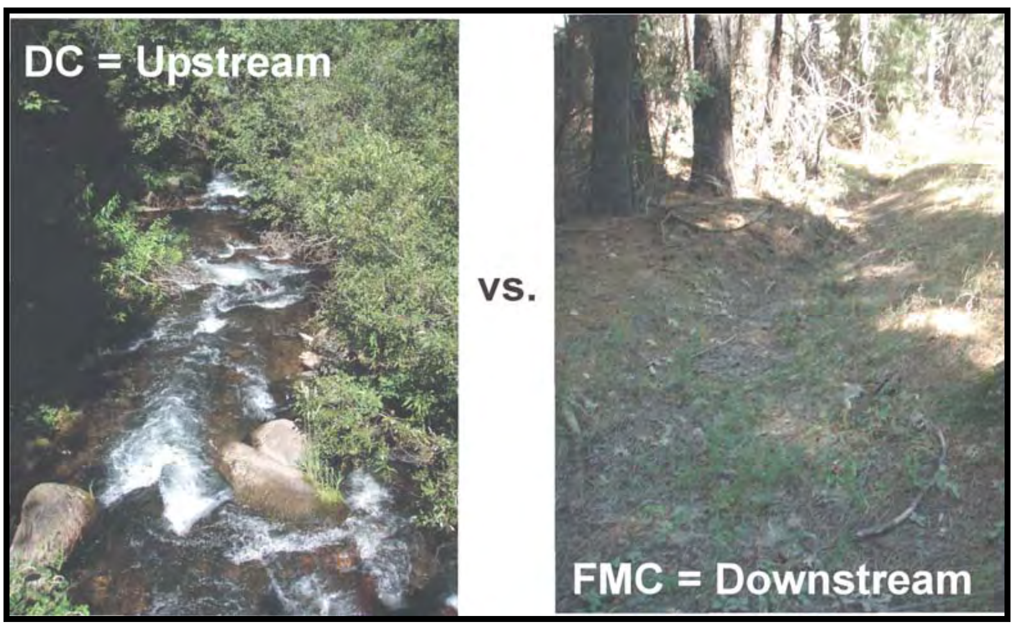

Figure 2. A visual comparison between the DC and FMC monitoring stations. DC was used as the "upstream" site and FMC was used as the "downstream" site. Comparisons were made between the two monitoring stations, despite the fact they were on two different streams with obvious differences in the physical processes controlling turbidity (i.e., sediment transport capacity, sediment supply, etc.). Similar comparisons between two entirely different streams exist for FMC and DCH, and CCC and CC2.

Control for Temporal Variability in Turbidity

The CSPA analyses details Basin Plan violations by comparing 1999-2001 Coleman Fish Hatchery turbidity data to the turbidity data in the Four Creeks area collected from 2009-2011. Central Valley Water Board staff attempted to find the 1999-2001 data collected by the United States Fish and Wildlife Service at the Coleman Fish Hatchery on Battle Creek (see linked document in CSPA letter[1]). While staff did not find data conforming to this time span, staff did find graphed turbidity data for the Coleman Fish Hatchery from October of 2002 through September of 2003 (see Figure 3). These data indicate a maximum turbidity value of approximately 13 NTU, with the majority of data falling within a range of 1 to 6 NTU – generally imperceptible by the naked eye. In the absence of the 1999-2001 tabular data, we can not compare the distributions of turbidity data from the Coleman Fish Hatchery with the Battle Creek Alliance data (i.e., Four Creeks data). However, we can make general statements regarding the appropriateness of watershed-scale data comparisons from samples taken during different years.

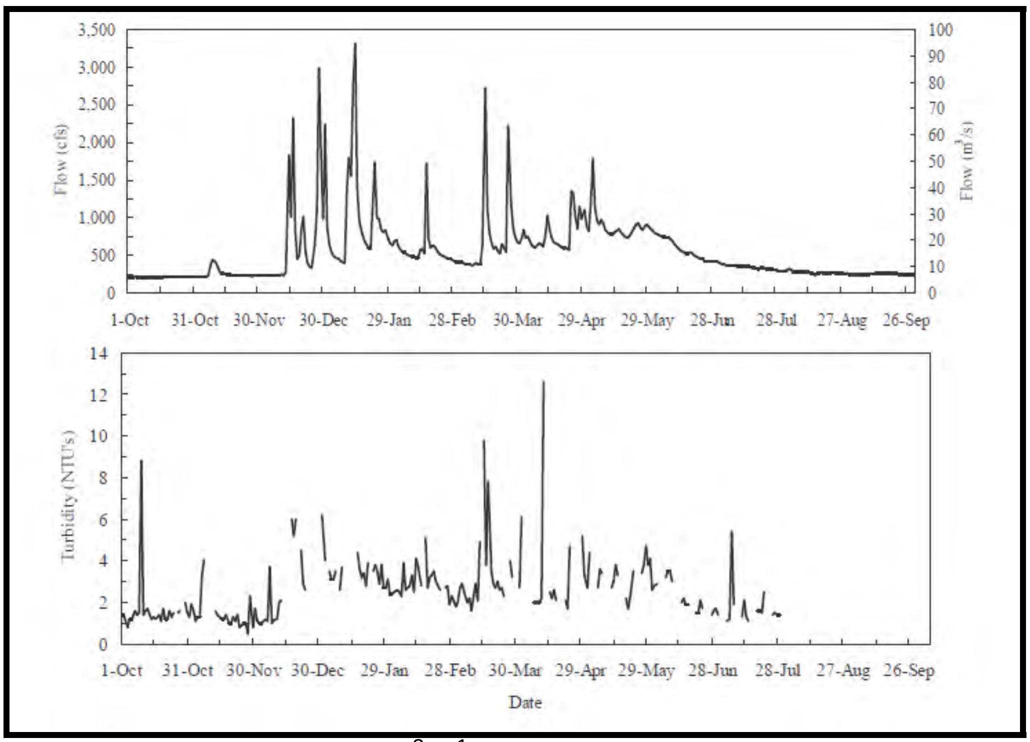

Figure 3. Mean daily flow ($ft^3\ s^{-1}$) and turbidity (NTUs) at the Lower Battle Creek rotary screw trap from October 1, 2002 through September 30, 2003 (taken from Whitton et al., 2007).

Turbidity is often used as a surrogate for suspended sediment concentration (Lewis, 1996). Hence, much of our knowledge regarding the temporal variability of suspended sediment also applies to turbidity. Not only can turbidity vary highly during a storm event, but also between events and years due to temporal fluctuations in transport capacity (i.e., variations in flow

[1]http://www.fws.gov/redbluff/PDF/Battle%20Creek%20Juvenile%20Salmonid%20Monitoring%2002-03.pdf

magnitude, duration, and frequency), sediment supply (i.e., variations in the supply of hillslope and in-channel sediment sources) and their interactions (Bunte and MacDonald, 1996, Gomi et al., 2005). These intra-event variations are often so large that it is difficult to detect changes from anthropogenic disturbances (Bunte and MacDonald, 1996). Due to these variations it is usually necessary to have pre-treatment and post-treatment data, as well as untreated (i.e., unharvested) controls to detect the effects of timber harvest at the watershed scale (Gomi et al., 2005). Turbidity can vary strongly with discharge, and stream flow is often used as a covariate in analysis because it increases the statistical power of finding a treatment effect. Given that there is no statistical rigor in the monitoring design to account for these sources of temporal variability and no information on stream flow, it is inappropriate to compare turbidity values collected over different time spans to determine the potential effects of clearcutting in the basin. Added to the fact that the comparisons were made between two vastly different locations in the watershed (Map 1), and with different turbidimeters, the comparison essentially becomes meaningless.

Analyses Assumptions and Physical Processes in the Battle Creek Watershed

The erroneous above-and-below comparisons and comparisons between separate decades underlie a larger issue in the analyses – a lack of understanding regarding the physical processes that operate in the Battle Creek watershed. This is evidenced directly by the following statement made in the CSPA analyses when comparing the Four Creeks dataset to data collected downstream at the Coleman Fish Hatchery:

> Typically, upstream reaches are characterized by turbulent flows, steep gradients, cold water temperatures, coarse substrates, and well-oxygenated water, whereas lowland reaches are typically characterized by warmer water temperature, gentle gradients, turbidity, sediment deposition, fine substrates, and smaller concentrations of dissolved oxygen. If we use this general characterization, we can infer that given equal conditions, the Four-Creeks water quality should have lower turbidity than the downstream data. But, the data shows the opposite, strongly suggesting changed conditions for the upstream environment. This points directly at the likely impacts from the clear-cutting in the Four-Creeks watershed.

Upland streams are closely coupled to spatially and temporally variable hillslope sediment sources, and can receive episodic and chronic sediment from both natural and anthropogenic sources of sediment (e.g., mass wasting, raveling, bank erosion, soil creep, etc) (MacDonald and Coe, 2007). Hence, inputs of sediment can result in increased turbidity and these turbidity plumes readily move in the downstream direction. As the turbidity plume moves downstream it is subject to dilution from potentially clear water tributaries, and the larger sediment size fractions in the turbidity plume are subject to storage in the lee of roughness elements (e.g., large boulders) and in large woody debris dams. As a result, suspended sediment/turbidity plumes are often attenuated in the downstream direction, with a resultant decrease in turbidity (Sullivan, 1995; MacDonald, 1992; MacDonald and Coe, 2007). CSPA's assumptions regarding increases in turbidity in the downstream direction might apply to comparisons between Battle Creek and the lower reaches of the Sacramento River, but their assumptions regarding watershed processes (e.g. downstream fining) does not apply to comparisons between the upper and lower reaches of Battle Creek.

Linkage to Beneficial Uses

The CSPA analyses failed to draw the link between turbidity increases and the beneficial uses of water. The Basin Plan states that "waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses." The beneficial uses of water for the Battle Creek watershed are defined in the Basin Plan as follows:

- Agricultural supply – irrigation and stock watering;
- Hydropower generation;
- Water contact recreation (REC-1);
- Non-contact water recreation (REC-2);
- Warm and cold freshwater habitat;
- Cold freshwater migration of aquatic organisms;
- Warm and cold freshwater spawning, reproduction, and/or early development; and
- Wildlife habitat.

CSPA contends that the turbidity exceedances pose a threat to the ongoing salmonid restoration project in the watershed. As such, it is important to compare the Four Creeks dataset with known turbidity exposure-response relationships for salmonids.

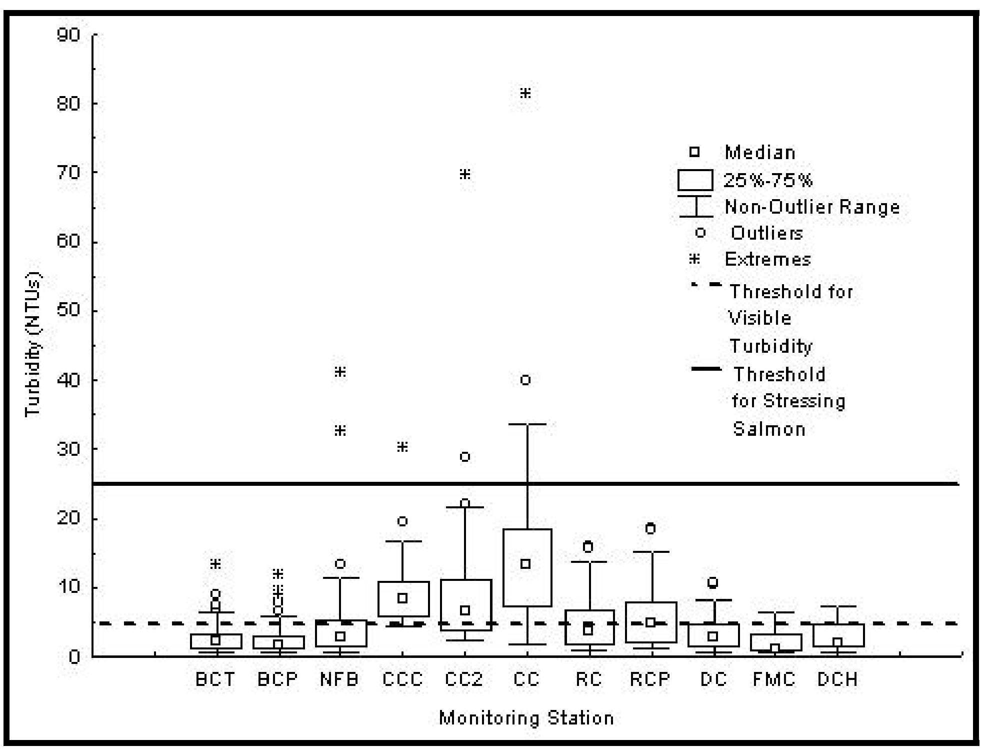

Figure 4. Turbidity values by monitoring station for the Four Creeks dataset (n=549). The solid horizontal line represents the 25 NTU threshold for stressing salmonids (Sigler et al., 1984). The dashed line represents the turbidity threshold visible by the human eye.

A frequently used exposure-response relationship is the one documented by Sigler et al. (1984). This is also frequently cited as one of the lowest thresholds for salmonid response. Their laboratory study showed that as little as 25 NTUs of turbidity over a 14-day duration caused a reduction in steelhead and coho salmon growth. Figure 4 shows how the Four Creeks data relates to this turbidity threshold, and cumulative frequency analysis indicates that 97.6% of the 549 samples fall below the 25 NTU threshold. In fact, 60% percent of the data was below 5 NTU – the level of turbidity imperceptible by the human eye.

The Basin Plan states "that achievement of the [water quality] objectives depends on applying them to controllable water quality factors." The turbidity differences in the CSPA analyses are likely to be reflections of the spatial, temporal, and measurement-related sources of variability inherent with monitoring turbidity. Staff finds natural variability to be an uncontrollable, rather than controllable, factor.

Uses of the Four Creeks Dataset

The Central Valley Water Board staff sees value in the data collected by the Battle Creek Alliance in that it offers a limited view of the status of turbidity in the Battle Creek watershed. For example, of the 549 samples collected, 97.6% percent of the samples were below the lower turbidity threshold for stressing salmonids commonly used in the literature (i.e., 25 NTUs) (Sigler et al., 1984). Overall, the mean and median turbidity of the Four Creeks dataset was 6.0 and 3.8 NTUs, respectively. These levels are generally imperceptible to the human eye. As such, the dataset indicates a relatively low exposure of salmonids to stressing levels of turbidity, and relatively low turbidity overall (Figure 5).

The Four Creeks dataset does provide some spatially explicit information into potential water quality problems in the watershed. For example, the Four Creeks dataset indicates that the Canyon Creek monitoring stations (i.e., CC, CC2, and CCC) have elevated turbidity levels relative to the other monitoring stations. Field inspection of the Canyon Creek watershed indicates significant sediment delivery from the county maintained Rock Creek Road, which parallels Canyon Creek for much of its length (Figure 6a and b). All the Canyon Creek monitoring stations showed direct evidence of fine-grained sediment delivery from the Rock Creek Road, which likely accounts for the elevated turbidity at all three stations. A private in-holding within the Canyon Creek watershed also allows grazing, with evidence of livestock grazing in the channels (Figure 6c). No sediment plumes or erosion features were observed coming directly off the nearby clearcuts. These observations indicate that sediment sources other than clearcuts might be resulting in the elevated turbidity at the Canyon Creek monitoring stations.

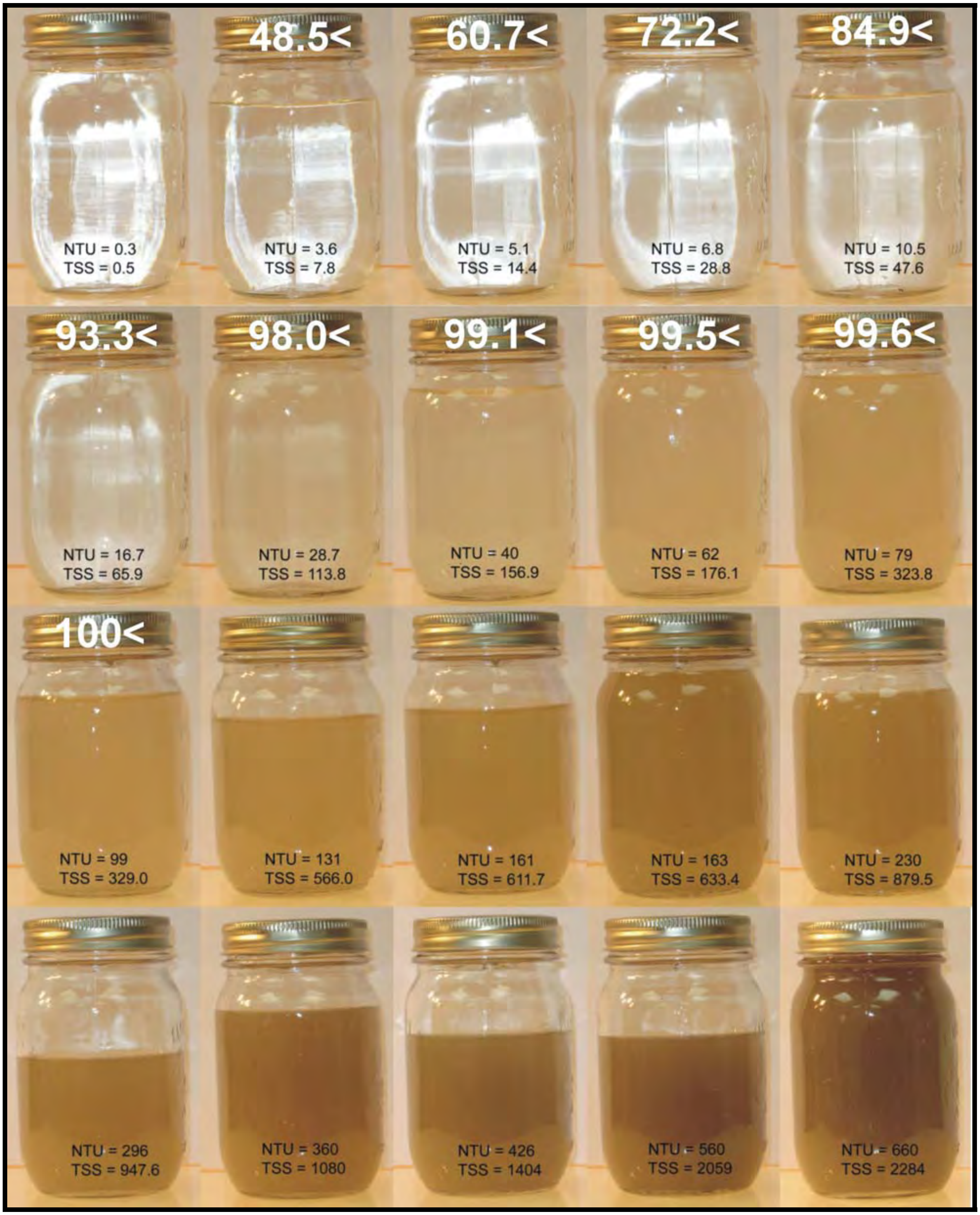

Figure 5. Water samples displaying different values of turbidity (NTUs) and total suspended solids (TSS). White numbers indicate the percentage (%) of the Four Creeks samples (n=549) less than the turbidity value displayed on the jar.

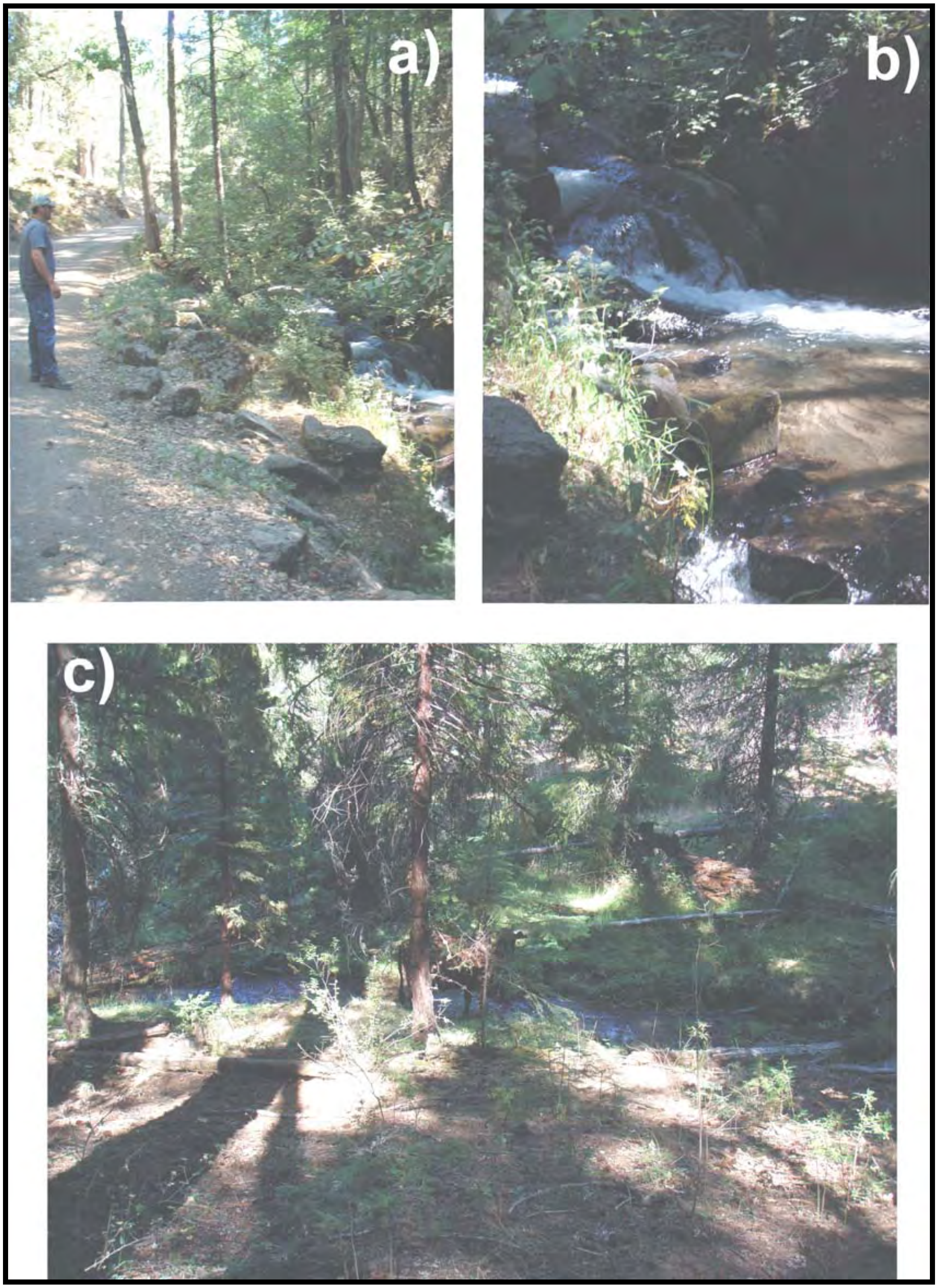

Figure 6. Pictures showing other potential sediment sources in the Canyon Creek watershed. **a)** Stream adjacent county road at CC monitoring station; **b)** Fine sediment in pool at CC monitoring station. Sediment in the pool matches the particle size and color seen on the county road; **c)** Cattle grazing in the stream between monitoring stations CCC and CC2.

Staff Recommendations

Staff recommendations are as follows:

1) Identify and remedy controllable sources of sediment to Battle Creek.
2) Assist the Battle Creek Alliance in developing a scientifically sound, statistically valid sampling scheme for determining sources of water quality impacts in the Battle Creek Watershed;
3) Encourage the development of a network of continuous turbidity monitoring stations in the Battle Creek Watershed.

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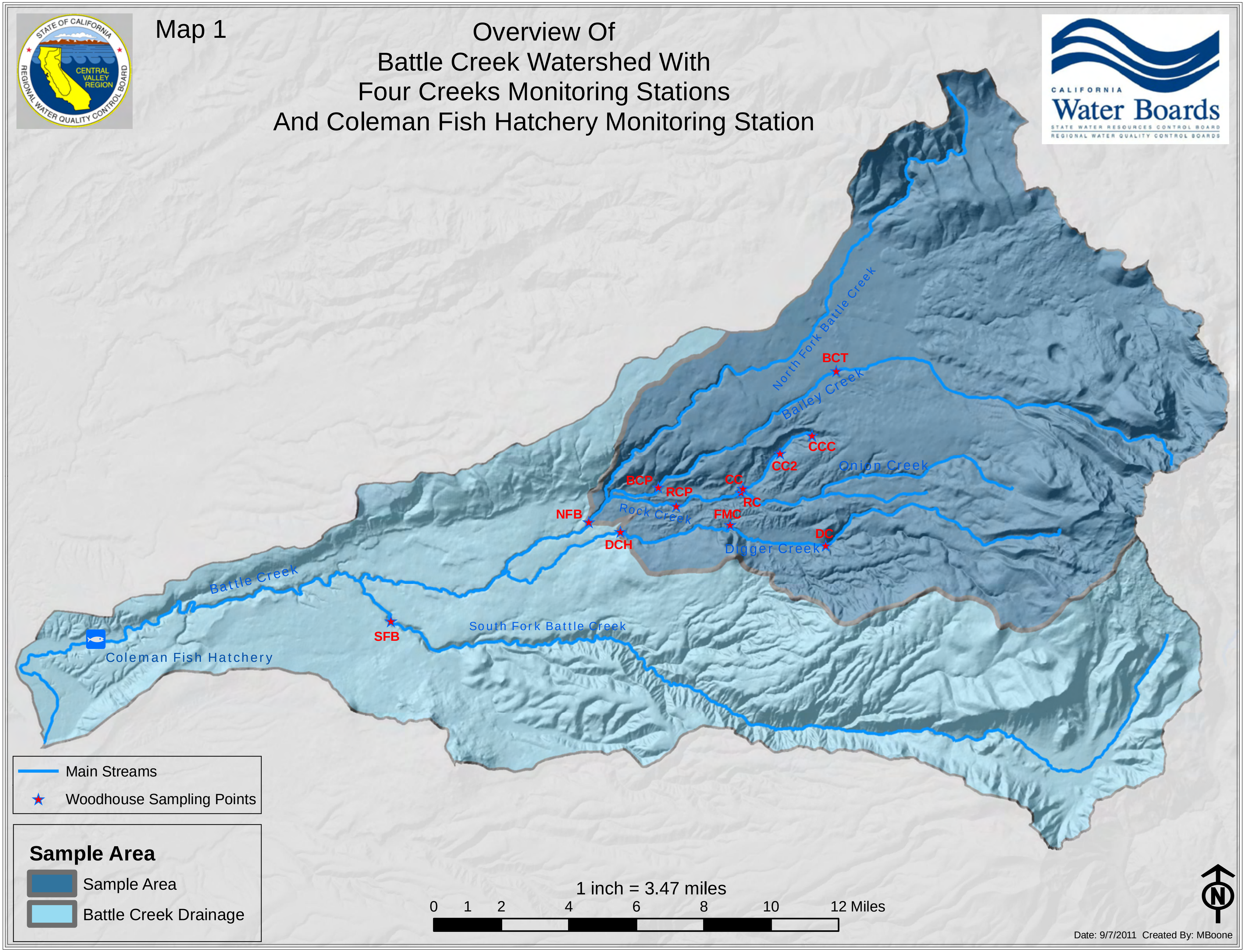
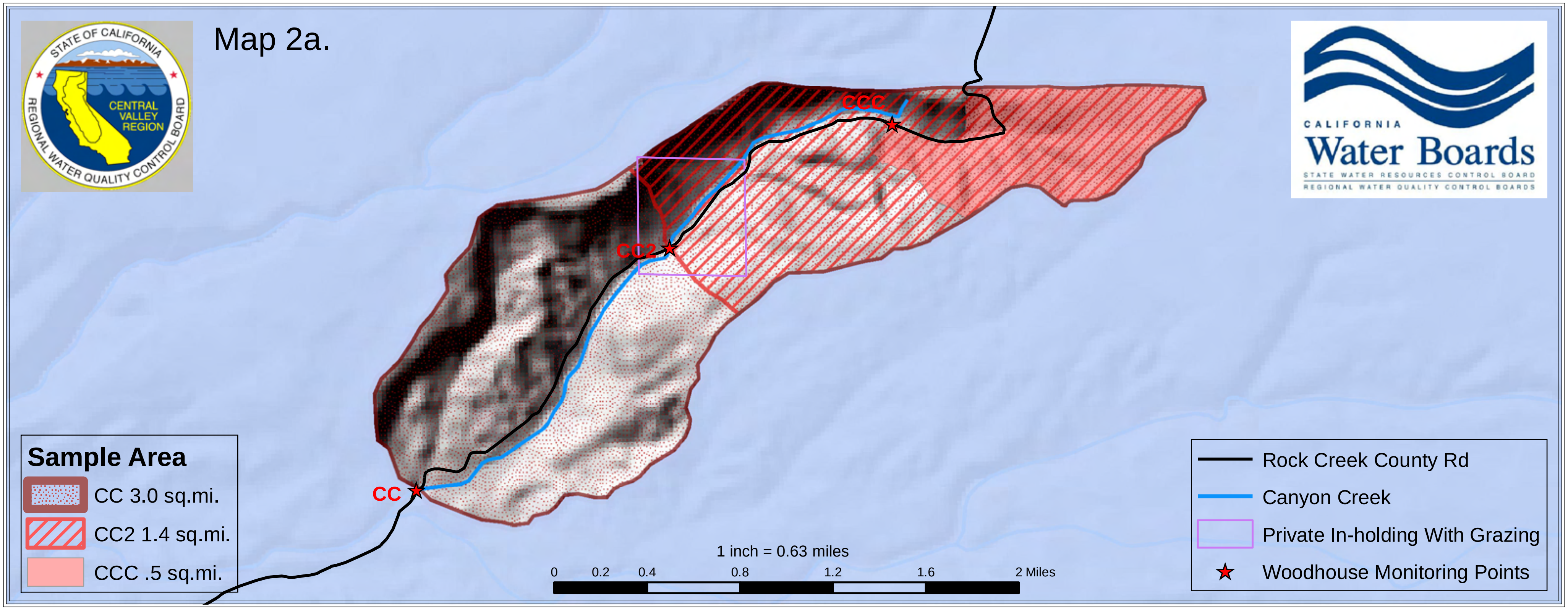
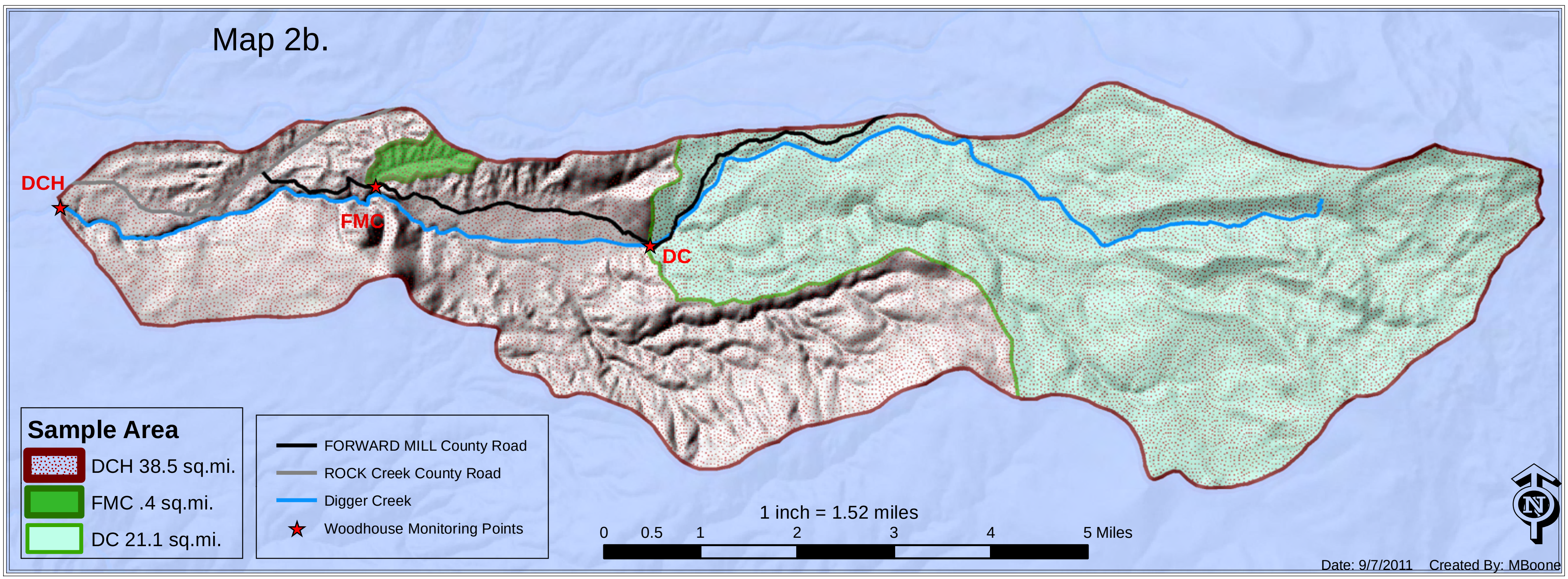
Map 1

Overview Of Battle Creek Watershed With Four Creeks Monitoring Stations And Coleman Fish Hatchery Monitoring Station




Map 2a.
STATE OF CALIFORNIA
CENTRAL VALLEY REGION
REGIONAL WATER QUALITY CONTROL BOARD
CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS
CCC
CC2
CC
Sample Area
CC 3.0 sq.mi.
CC2 1.4 sq.mi.
CCC .5 sq.mi.
1 inch = 0.63 miles
0 0.2 0.4 0.8 1.2 1.6 2 Miles
Rock Creek County Rd
Canyon Creek
Private In-holding With Grazing
Woodhouse Monitoring Points


Map 2b.
DCH
FMC
DC
Sample Area
DCH 38.5 sq.mi.
FMC .4 sq.mi.
DC 21.1 sq.mi.
FORWARD MILL County Road
ROCK Creek County Road
Digger Creek
Woodhouse Monitoring Points
1 inch = 1.52 miles
0 0.5 1 2 3 4 5 Miles
N
Date: 9/7/2011 Created By: MBoone