

DEPARTMENT OF ECOLOGY

July 9, 1996

TO: Bob Duffy, SWRO

FROM: Art Johnson, EILS

SUBJECT: Results of Monitoring Metals in Chambers/Clover Creek Drainage
(WA-12-1110, WA-12-1115)

Summary of Findings

The ten metals addressed in the state's surface water quality standards were analyzed by low-level methods in water collected from the mouths of Chambers Creek, Clover Creek, and Leach Creek in south Tacoma. Sampling was done on two occasions during summer low flow and once each during two fall runoff events in August - October, 1995. Zinc, copper, lead, and arsenic were routinely detectable, while nickel, cadmium, chromium, and mercury were almost exclusively detected during wet weather. The remaining metals, silver, and selenium, were never detected.

Metals concentrations did not differ greatly among the three creeks and were generally low. Results were well within aquatic life criteria, except for lead and mercury which were at or above chronic criteria in wet weather samples from Clover and Leach Creeks. However, the analytical uncertainty at the low lead and mercury concentrations being measured makes this finding subject to question.

Leach Creek, a tributary to lower Chambers Creek, had very high levels of total suspended solids and turbidity during runoff events and was having a severe adverse effect on the clarity of Chambers Creek. The highest concentrations of most metals were found in the runoff event samples from Leach Creek

Recommendations

1. Add metals to the other parameters currently being analyzed at Ecology ambient monitoring station #12A110, "Clover Creek above Steilacoom Lake" (the ambient routine metals analysis includes zinc, copper, lead, cadmium, and mercury).
2. Investigate the source(s) of erosion and associated metals to Leach Creek.

Background

Based on land-use concerns, the Chambers/Clover Creek Watershed Action Plan identified metals as a possible water quality problem in Clover Creek (Pierce County Public Works and Utilities, 1994). Following completion of the 1994 Needs Assessment for the South Puget Sound management area (Emmett, 1995), the Department of Ecology, Southwest Regional Office (SWRO) requested that Environmental Investigations & Laboratory Services Program (EILS) survey metals concentrations in the drainage.

The survey was conducted during August - October, 1995. Sampling was done on two occasions during summer low flow (August 4 and September 1) and once each during two fall runoff events (September 27 and October 10). These periods were selected to be representative of the range of metals concentrations likely to occur in the drainage. Due to budget constraints, only one or two samples per site could be analyzed for each collection period, precluding statistical comparisons between sampling sites or season.

Water samples were collected at the three locations shown in Figure 1. The Chambers Creek near Steilacoom and Clover Creek above Steilacoom Lake sites are historical Ecology ambient monitoring stations, #12A070 and #12A110, respectively. Based on a draft report from a 1991-92 USGS study (McCarthy, in press), a third sampling site was tentatively selected on the north fork of Clover Creek. This was later changed to the mouth of Leach Creek because the north fork was dry during August and September, and because Leach Creek appeared to be severely degraded during rain storms.

The metals analyzed were zinc, copper, lead, nickel, cadmium, silver, arsenic, chromium, mercury, and selenium. These are the ten metals addressed in the Washington State Surface Water Quality Standards (Chapter 173-201 WAC). Metals were analyzed using low-level methods, either as dissolved or total recoverable depending on the form specified in the standards. Ancillary data were also obtained on flow, temperature, conductivity, pH, total suspended solids (TSS), turbidity, and hardness.

Methods of Sampling and Analysis

Metals samples were simple grabs collected by hand in 1-liter teflon bottles. Samples were preserved with sub-boiled, purified nitric acid to pH < 2. The acid was carried in small teflon vials, one per sample. Water samples for dissolved metals were filtered through a 0.45µm cellulose-nitrate filter unit (Nalgene #450-0045, type S) before being acidified. Each sample was placed in a polyethylene bag and held on ice for transport to the Ecology Manchester Laboratory.

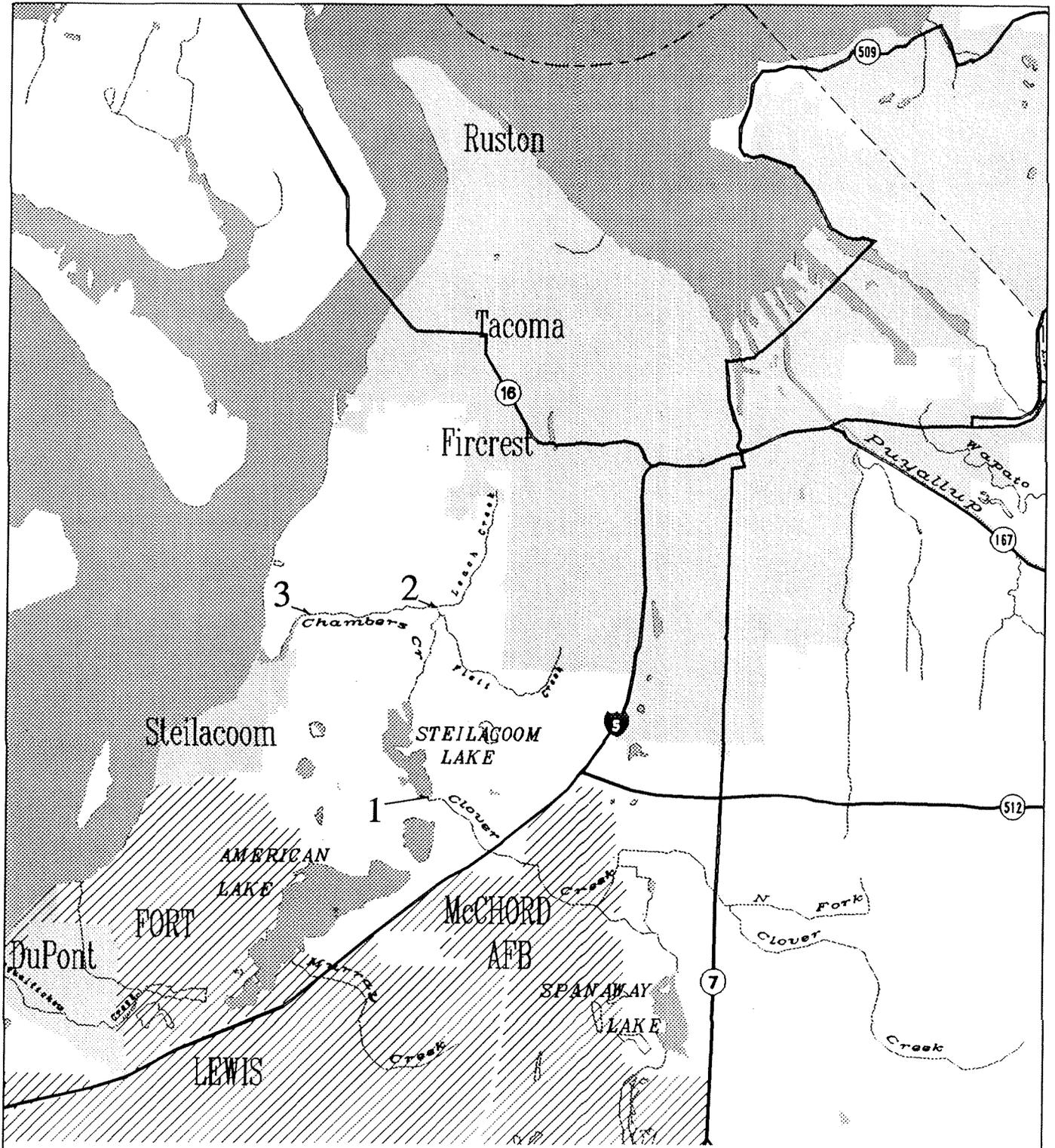


Figure 1. Sampling Sites for Metals in Chambers/Clover Creek Drainage, 1995

Sampling Sites:

1. Clover Creek above Steilacoom Lake
2. Leach Creek
3. Chambers Creek near Steilacoom

Source:

Sampling sites by lat/long - A Johnson Ecology/ESLS
 Roads and Hydrology - WOFM 1990 HGR

▲ Map Area

Scale 1:140,000

Miles



EIS GIS 12/95

Cleaning protocols for metals sampling are described in Kammin et al. (1995). Analysis of bottle and filter blanks prepared as part of this survey showed no evidence of metals contamination arising from sample containers, acid preservative, or the filtering process.

Temperature was measured with a precision thermometer. pH was determined with an Orion model 250A meter. Flows were gaged with a Swoeffler meter and top-setting rod. Sample containers and preservation for other water quality parameters are described in Huntamer and Hyre (1991).

Chemical analysis was done at Manchester Laboratory. Mercury was determined by Cold Vapor Atomic Fluorescence Spectrometry using EPA Method 245.7. The other metals were analyzed by Inductively Coupled Plasma/Mass Spectrometry following EPA Method 200.8. Conductivity, TSS, turbidity, and hardness were analyzed by EPA Methods 120.1, 160.2, 180.1, and 130.2, respectively.

Quality of the Metals Data

Manchester Laboratory prepared written quality assurance reviews of the metals data. These assessed adherence to sample holding times, instrument calibration, results on procedural blanks, spike recoveries, and laboratory control sample analyses. With the exception of low spike recoveries (52 - 59%) for the September 27 mercury samples, no significant problems were identified with the data. The quality assurance reviews are in Appendix A.

The precision of the metals data reported for Chambers/Clover Creek drainage can be assessed from results on four sets of duplicate (split) and replicate (separately collected) field samples (summarized in Appendix B). The duplicates provide an estimate of analytical precision. Total variability (analytical + field) is indicated from results of replicate sampling.

In most cases agreement between duplicate sample analysis was 10% or better. This within-sample variability was on the same order as the between-sample variability seen in replicate samples, suggesting short-term variations in metals concentrations were not significant. The mercury analysis however was less precise; results on some samples differed by factors of 2 to 4. The means of the duplicate/replicate analyses are used in the remainder of this report.

Results and Discussion

Based on NOAA (1995) weather station records for Tacoma, precipitation for August - October 1995 was normal. Only trace amounts of rain fell in the week preceding the low flow sample collections on August 14 and September 1.

Precipitation during September and October and timing of wet weather sampling events are shown in Figure 2. A dry period of more than 2 weeks preceded the first runoff event samples collected September 27 when the maximum precipitation for that month was recorded, 0.81 inches. Sampling for the second and largest of the rain events during September-October, 1.25 inches, took place October 10.

General water quality conditions encountered in Chambers/Clover Creek drainage are shown in Table 1. Low flows measured in Chambers and Clover in August and September were 40 cfs and 4 - 6 cfs, respectively. Chambers Creek increased by 10 cfs during the first runoff event sampled in late September. An increase in flow was not observed in Clover Creek, although TSS and turbidity were substantially elevated over low flow conditions.

During the larger runoff event in October, flows increased by a factor of 3 in Chambers Creek (to 137 cfs) and a factor of 5 in Clover Creek (to 20 cfs), compared to low flow. Higher flows were associated with reduced pH and hardness as well as higher TSS and turbidity.

Wet weather samples from Leach Creek showed very high levels of TSS (80 and 235 mg/L) and turbidity (38 and 81 NTU). As Leach Creek was contributing 25 - 40% of the flow in Chambers Creek, the adverse impact on the clarity of Chambers Creek was readily apparent immediately downstream of their confluence. (TSS and turbidity in a sample collected September 27 from Chambers Creek immediately above Leach Creek were only 3 mg/L and 1.4 NTU; similar samples were not collected in October.)

As shown in Table 1, the adverse effects of Leach Creek were less evident 1.5 miles downstream at the sampling site on the mouth of Chambers Creek. Peach Creek (not shown in Figure 1) enters Chambers Creek below the Leach Creek confluence and was flowing clear during both wet weather sampling events (no samples were taken). Flett Creek, the third Chambers tributary, located upstream of Leach Creek (Figure 1), was not seen flowing during the present survey (as observed from Bridgeport Way, approximately 1 mile above Chambers Creek).

The metals data are in Table 2. Zinc, copper, lead, and arsenic were detectable at all sampling sites and in all or almost all samples. Concentration of these metals did not differ greatly between dry and wet weather. Nickel, cadmium, chromium, and mercury were only detected during wet weather sampling, except for one instance of mercury in Clover Creek. Silver and selenium were never detected.

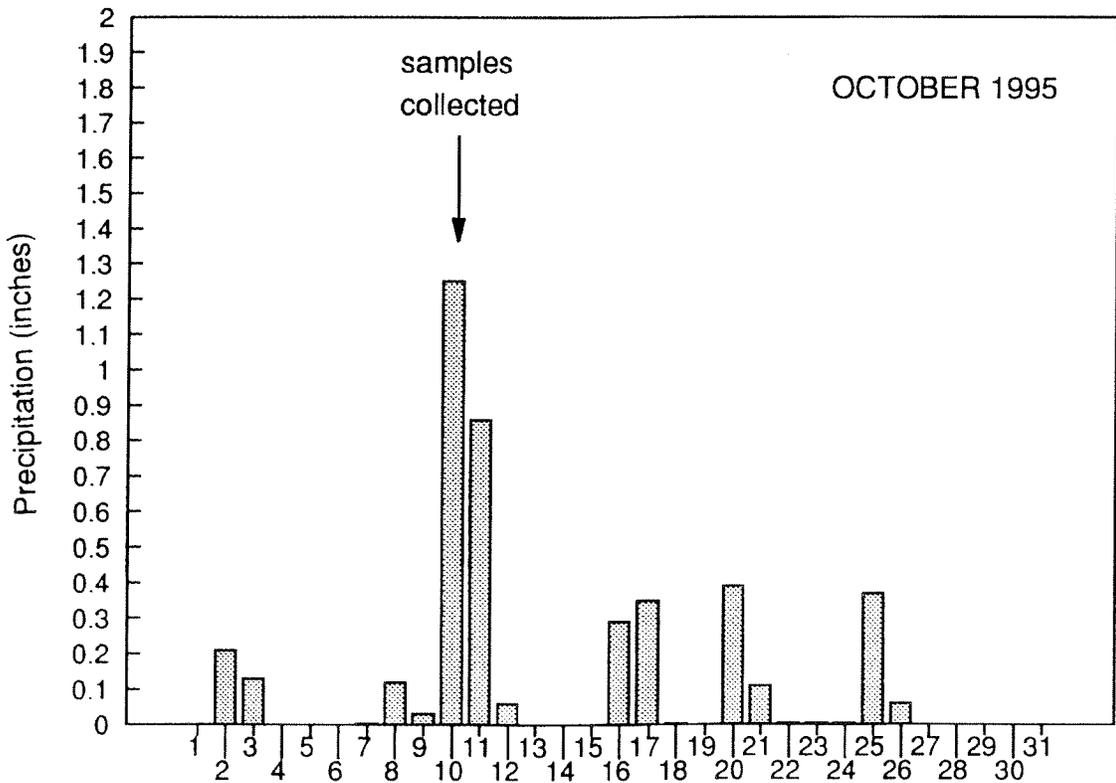
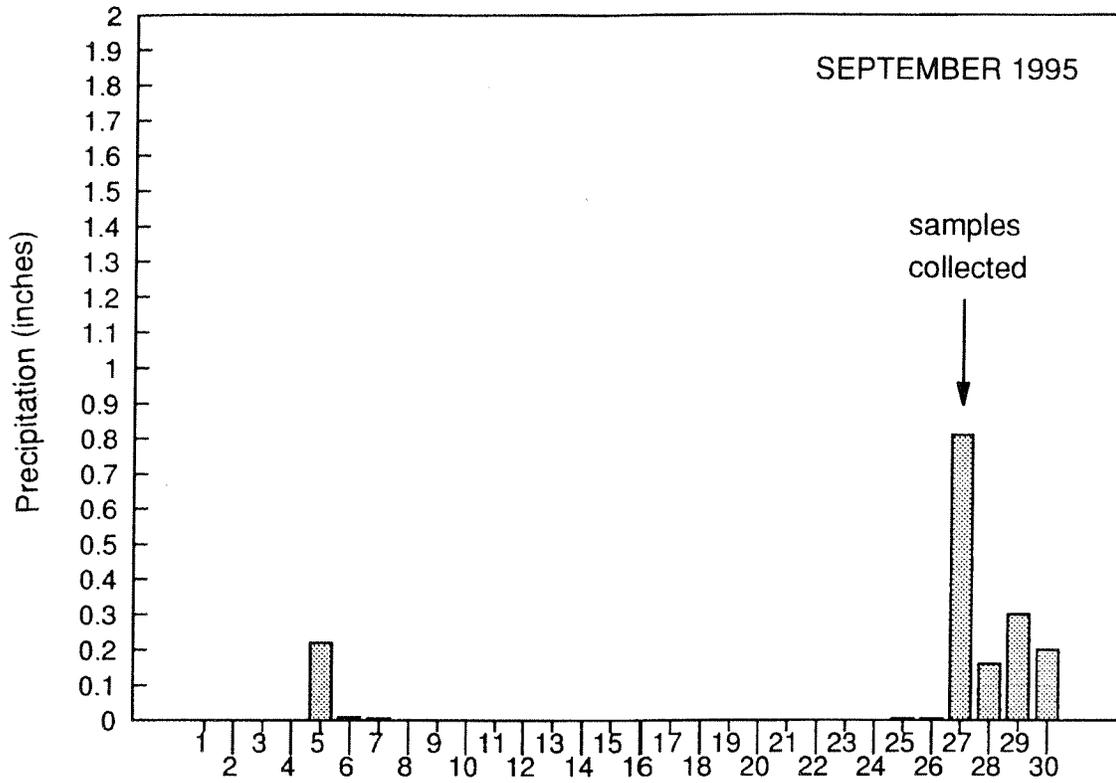


Figure 2. Rainfall for Runoff Event Samples

Table 1. General Water Quality Conditions in Chambers/Clover Creek Drainage

Location:	DRY WEATHER SAMPLES					
	Clover Creek		Chambers Creek		Leach Creek	
	14 Aug.	1 Sept.	14 Aug.	1 Sept.	14 Aug.	1 Sept.
Date (1995):						
Sample No.:	33-8041	36-8061	33-8040	36-8060	--	--
Flow (cfs)	6	4	40	40		
Temperature (C)	14.1	13.7	13.8	13.9		
Conduct. (umhos/cm)	142	145	185	186		
pH (s.u.)	--	7.5	--	7.6	(no samples)	
TSS (mg/L)	4	4	2	2		
Turbidity (NTU)	1.6	1.6	0.7	2.1		
Hardness (mg/L)	49	52	71	72		

Location:	WET WEATHER SAMPLES					
	Clover Creek		Chambers Creek		Leach Creek	
	27 Sept.	10 Oct.	27 Sept.	10 Oct.	27 Sept.	10 Oct.
Date (1995):						
Sample No.:	39-8073/4	41-8107/10	39-8070	41-8105	39-8075	41-8108/9
Flow (cfs)	3	20	50	137	19	35
Temperature (C)	14.8	13.8	13.3	13.9	13.9	13.1
Conduct. (umhos/cm)	149	50	192	137	164	77
pH (s.u.)	7.2	7.0	7.4	7.2	7.5	7.0
TSS (mg/L)	14	26	< 1	6	80	235
Turbidity (NTU)	7.7	13	0.6	6.2	38	81
Hardness (mg/L)	53	19	75	53	71	36

Overall, differences in metals concentrations between the three creeks were not large. Slightly higher levels of zinc, copper, lead, cadmium, and mercury were observed in Clover Creek than in Chambers Creek. Arsenic concentrations were consistently higher in Chambers than Clover Creek. As shown in Table 2, this could have been due to inputs from Leach Creek.

The metals results are compared to criteria for protection of aquatic life in Table 3. The criteria shown are the state standards updated to include the recent EPA revisions announced in the Federal Register (1995).

Table 2. Metals Concentrations in Chambers/Clover Creek Drainage (ug/L)

DRY WEATHER SAMPLES						
Location:	Clover Creek		Chambers Creek		Leach Creek	
Date (1995):	14 Aug.	1 Sept.	14 Aug.	1 Sept.	14 Aug.	1 Sept.
Sample No.:	33-8041	36-8061	33-8040	36-8060	--	--
<u>Dissolved</u>						
Zinc	1.3	2.0	1 U	1 U		
Copper	0.68	0.58	0.55	0.56		
Lead	0.63	0.27	0.03 U	0.04	(no samples)	
Nickel	1 U	1 U	1 U	1 U		
Cadmium	0.04 U	0.04 U	0.04 U	0.04 U		
Silver	0.03 U	0.03 U	0.03 U	0.03 U		
<u>Total Recoverable</u>						
Arsenic	1.0 P	1.2 P	1.9 P	1.9 P		
Chromium	1 U	1 U	1 U	1 U	(no samples)	
Mercury	0.001 U	0.002	0.001 U	0.001 U		
Selenium	1 U	1 U	1 U	1 U		
WET WEATHER SAMPLES						
Location:	Clover Creek		Chambers Creek		Leach Creek	
Date (1995):	27 Sept.	10 Oct.	27 Sept.	10 Oct.	27 Sept.	10 Oct.
Sample No.:	39-8073/4	41-8107/10	39-8070	41-8105	39-8075	41-8108/9
<u>Dissolved</u>						
Zinc	5.0	4.1	1 U	2.1	5.6	7.3
Copper	1.2	1.0	0.47	1.6	3.8	2.9
Lead	0.66	0.43	0.06	0.29	0.45	0.61
Nickel	1 U	1 U	1 U	1 U	1.1	1 U
Cadmium	0.14	0.048	0.04 U	0.04 U	0.04 U	0.046
Silver	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U
<u>Total Recoverable</u>						
Arsenic	1 U	1 U	1.7	2.2	6.1	5.1
Chromium	1 U	1.1	1 U	1 U	2.6	4.8
Mercury	0.006 J	0.066	0.001 P	0.006	0.018 N	0.034
Selenium	1 U	1 U	1 U	1 U	1 U	1 U

Note: detected concentrations in **bold**

U = not detected at or above reported value

P = below minimum quantitation limit

N = spike recovery outside control limits

Table 3. Metals Concentrations in Chambers/Clover Creek Drainage Compared to Criteria for Protection of Aquatic Life (ug/L)

Metal	Range of Concentrations	Aquatic Life*	
		Chronic	Acute
<u>Dissolved</u>			
Zinc	1 U - 7.3	58	64
Copper	0.47 - 3.8	6.3	8.9
Lead	0.04 - 0.68	1.0	30
Nickel	1 U - 1.1	87	787
Cadmium	0.04 U - 0.46 P	0.62	1.8
Silver	0.03 U (all samples)	--	1.0
<u>Total Recoverable</u>			
Arsenic	1 U - 6.1	190	360
Chromium	1 U - 4.8	101	311
Mercury	0.001 U - 0.066	0.012	2.1
Selenium	1 U (all samples)	5	20

* dissolved metals and chromium criteria are for 50 mg/L hardness

U = not detected at or above reported value

P = below minimum quantitation limit

Aquatic life criteria for dissolved metals and total recoverable chromium are a function of hardness, with metals toxicity decreasing with increasing values of hardness. Except for the October samples collected in Clover and Leach Creeks, the lower end of the hardness range observed in the drainage was 50 mg/L. As shown in Table 3, no dissolved metal or chromium concentrations exceeded criteria under conditions of 50 mg/L hardness.

At the low hardness of 19 mg/L measured in Clover Creek during October the dissolved lead concentration of 0.43 µg/L slightly exceeded the 0.30 µg/L chronic criterion but the difference in the two values is within the analytical variability in the lead data (Appendix B). The lead concentration in Leach Creek during October, 0.61 µg/L, was at the chronic criterion of 0.69 µg/L, for a hardness of 36 mg/L.

Standards for total recoverable arsenic, mercury, and selenium are independent hardness. Arsenic, mercury, and selenium concentrations were within water quality criteria except for mercury concentrations in Clover and Leach Creeks. The chronic mercury criterion of 0.012 µg/L was exceeded during wet weather in one Clover Creek sample at 0.066 µg/L and in both the Leach Creek samples at 0.018 and 0.034 µg/L. However, as with lead, analytical variability makes these findings subject to question.

The only other recent metals data that could be located on this drainage are from the previously mentioned 1991-92 USGS study of Clover Creek. As this report has not yet been released the author has requested the data not be used. For the most part, the USGS data corroborate findings of the present survey that metal concentrations in Clover Creek are generally moderate-to-low.

References

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- Huntamer, D. and J. Hyre. 1991. Manchester Environmental Laboratory, Laboratory Users Manual. Washington State Dept. of Ecology, Manchester, WA.
- Kammin, W.R., S. Cull, R. Knox, J. Ross, M. McIntosh, and D. Thompson. 1995. Labware Cleaning Protocols for the Determination of Low-Level Metals by ICP-MS. American Environmental Laboratory 7(9).
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- NOAA. 1995. Climatological Data: Washington. August through September data for station Tacoma 1 @ Tacoma Public Works (index no. 8278). Vol. 099, No. 8 - 10. National Climatic Data Center, Ashville, NC.
- Pierce County Public Works and Utilities. 1994. Chambers-Clover Creek Watershed Management Committee: Preliminary Draft Watershed Characterization. Water Resources Division, Tacoma, WA.

Appendix A

Samples Collected in Chambers/Clover Creek Drainage during August - October, 1995

Sample No.	Date	Time	Location	Remarks
33-8040	14-Aug	1000	Chambers Creek	
33-8041	14-Aug	1045	Clover Creek	
36-8060	1-Sep	1100	Chambers Creek	
36-8061	1-Sep	0945	Clover Creek	Analyzed in duplicate
39-8070	27-Sep	0915	Chambers Creek	
39-8071	27-Sep	0930	Chambers Creek	Filter blank
39-8072	--	--	--	Bottle Blank
39-8073	27-Sep	1045	Clover Creek	Analyzed in duplicate
39-8074	27-Sep	1045	Clover Creek	Replicate of sample 39-8073
39-8075	27-Sep	0950	Leach Creek	
41-8105	10-Oct	1225	Chambers Creek	
41-8107	10-Oct	1305	Clover Creek	
41-8108	10-Oct	1130	Leach Creek	Analyzed in duplicate
41-8109	10-Oct	1130	Leach Creek	Replicate of sample 41-8108
41-8110	10-Oct	1305	Clover Creek	Replicate of sample 41-8107



STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (360) 871-8860 • FAX (360) 871-8850

September 26, 1995

To: Art Johnson, Project Officer

From: Myrna McIntosh, Metals Chemist *mm*

Subject: Chambers - Clover Creek Metals

QUALITY ASSURANCE SUMMARY

Data quality for this project is generally good. No significant quality assurance issues are noted with the data.

SAMPLE INFORMATION

The samples from the Chambers - Clover Creek project were received by the Manchester Laboratory on 9/5/95 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSIS

Spiked and duplicate spiked sample analysis were performed on this data set. All spike recoveries are within the CLP acceptance limits of +/- 25 %.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSIS

LCS analysis are within the windows established for each parameter. The selenium recovery of NIST 1643c is somewhat low at 65 % recovery but the rest of the laboratory control samples are OK. Data was not qualified.

Please call Bill Kammin at SCAN 360-871-8801 to further discuss this project.

MMM:mmm



STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (360) 871-8860 • FAX (360) 871-8850
November 13, 1995

To: Art Johnson, Project Officer

From: Myrna McIntosh, Metals Chemist

Subject: Chambers - Clover Creek Metals, Weeks 39 & 41 *MM*

QUALITY ASSURANCE SUMMARY

Data quality for this project is very good. One batch of mercuries is qualified due to low spike recoveries.

SAMPLE INFORMATION

The samples from the Chambers - Clover Creek project were received by the Manchester Laboratory on 9/28/95 & 10/11/95 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSIS

Spiked and duplicate spiked sample analysis were performed on this data set. All spike recoveries, with the exception of one batch of mercuries are within the CLP acceptance limits of +/- 25%.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSIS

LCS analysis are within the windows established for each parameter.

Please call Bill Kammin at SCAN 360-871-8801 to further discuss this project.

MMM:mmm

Appendix B

Appendix B. Within- and Between-Sample Variability, Chambers/Clover Creek Drainage (ug/L)

Metal	Split (duplicate) Samples			Separate (replicate) Samples		
	#1	#2	RPD*	#1**	#2	RPD
<u>Dissolved:</u>						
Zinc	2.3	1.7	30	2.0	na	--
	4.1	na	--	4.1	4.1	0
	4.4	5.8	27	5.1	4.9	4
	6.9	7.7	12	7.3	7.3	0.4
Copper	0.6	0.56	6	0.58	na	--
	1.0	na	--	1.0	1.0	3
	1.3	1.4	0.7	1.3	1.1	16
	2.9	2.8	3	2.8	2.9	2
Lead	0.43	na	--	0.43	0.43	2.1
	0.30	0.24	23	0.27	na	--
	0.59	0.61	2	0.60	0.62	4
	0.59	0.62	4	0.61	0.71	16
Nickel	1 U	1 U	--	1 U	na	--
	1 U	na	--	1 U	1 U	--
	1 U	1 U	--	1 U	1 U	--
	1 U	1 U	--	1 U	1 U	--
Cadmium	0.04 U	0.04 U	--	0.04 U	na	--
	0.04 U	0.04 U	--	0.04 U	0.051	--
	0.047	na	--	0.047	0.048	2
	0.1	0.1	0	0.1	0.18	57
Silver	0.03 U	na	--	0.03 U	0.03 U	--
	0.03 U	0.03 U	--	0.03 U	na	--
	0.03 U	0.03 U	--	0.03 U	0.03 U	--
	0.03 U	0.03 U	--	0.03 U	0.03 U	--

Appendix B. (continued)

Metal	Split (duplicate) Samples			Separate (replicate) Samples		
	#1	#2	RPD*	#1**	#2	RPD
<u>Total Recoverable:</u>						
Arsenic	1 U	na	--	1 U	1 U	--
	1 U	1 U	--	1 U	1 U	--
	1.2	1.1	9	1.2	na	--
	4.9	5.3	8	5.1	5.1	0.6
Chromium	1 U	1 U	--	1 U	na	--
	1 U	1 U	--	1 U	1 U	--
	1.2	na	--	1.2	1 U	--
	4.3	5.4	22	4.8	4.8	0
Mercury	0.004	0.001	115	0.002	na	--
	0.004	0.007	56	0.006	0.006	0
	0.089	na	--	0.089	0.043	71
	0.032	0.038	17	0.035	0.034	3
Selenium	1 U	na	--	1U	1 U	--
	1 U	1 U	--	1 U	na	--
	1 U	1 U	--	1U	1 U	--
	1 U	1 U	--	1 U	1 U	--

* RPD = relative percent difference ((range of values/mean) x 100)

** mean of split sample results

U = not detected at or above reported value

na = not analyzed