WASHINGTON STATE DEPARTMENT OF ECOLOGY

Chehalis River Best Management Practices Evaluation Project--

1995-96 Water Quality Data Report for Bunker/Deep Creek Project Area

Abstract

This interim report describes water quality monitoring results for the second year of a six-year project to evaluate the effectiveness of best management practices (BMPs). Pre- and post-BMP monitoring was done on Deep Creek and a site at the mouth of Bunker Creek. The 1995-96 dry season pre- and post-monitoring results showed water quality improvement in fecal coliform levels at a site on Deep Creek where fencing was installed to exclude livestock from the creek. The dissolved oxygen (D.O.) criterion was not met at any of the sites, with lower D.O. levels seen in August and September. During the 1995-96 wet season, monitoring continued to show high turbidity and high levels of total suspended solids. Turbidity standards were exceeded at two sites on Deep Creek during the wet season.

Introduction

This report presents the results for the 1995-96 dry and wet season monitoring of Bunker and Deep Creeks. This project is funded in part by the U.S. Fish & Wildlife Service (USFWS) Chehalis Fisheries Restoration Program (CFRP). The purpose of the monitoring is to gather pre- and post-BMP data on several sites in the Deep Creek basin and the mouth of Bunker Creek, and to follow up on the Upper Chehalis River Dry Season Total Maximum Daily Load (TMDL) Study (Pickett, 1994). Monitoring sites are shown in Figure 1.

Methods

Sampling was conducted as described by the Quality Assurance Project Plan (QAPP) and addendum (Sargeant, 1994; 1995). In 1995, two dry season monitoring events were conducted as planned. A third sampling event on September 13, 1995, was added because high fecal coliform levels were found at DCM 2.4. To isolate the source of bacteria, three sites were sampled: the downstream Deep Creek site (DCM 2.4); a Deep Creek site just upstream of the future BMP site (DCM 2.7); and at the mouth of a tributary just upstream of this site (DCM 2.7T). In 1996, three dry season monitoring events were conducted at the usual sites. During the 1995-96 wet season ten winter sampling events were conducted. Tables 1 and 2 show the sampling dates.

During the dry season, laboratory samples were collected for fecal coliform, nitrite/nitrate nitrogen, ammonia nitrogen, total persulfate nitrogen, and dissolved oxygen. At Bunker Creek, samples for 5-day biochemical oxygen demand (BOD5) were also collected. In 1996, samples were also collected at all sites for total phosphorus. During the wet season, laboratory

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samples for turbidity and total suspended solids were collected at all sites. During the wet season an additional upstream site was sampled. Field measurements for temperature, pH, discharge, and conductivity were made during all surveys as described in the QAPP, except on September 13, 1995, when only laboratory samples for fecal coliform were collected.

Flows were obtained using a velocity meter and top-set wading rod, or estimated using a flow curve developed from calibrating flows to gauges placed at the beginning of the wet season.

Samples were collected from flowing water by subsurface grab from the center channel. Immediately following collection, samples were placed in the dark, on ice, and shipped to Ecology's Manchester Environmental Laboratory within 24 hours after collection. Samples were analyzed in accordance with the QAPP. Dissolved oxygen samples were preserved on site and were analyzed within 24 hours at the Ecology headquarters' laboratory.

Analysis of Data

In order to compare 1995-96 dry season results between sites and between years a statistical test for the significance of variations was done using SYSTAT (1991) statistical software. Comparisons were made for each parameter using a non-parametric test, the Kruskal-Wallis one-way analysis of variance. A statistical significance level of $P \leq 0.05$ was used.

Results

Best Management Practices

In 1994 and 1995 erosion control practices were installed in the upper reaches of Deep Creek. Between the 1995 and 1996 summer sampling, the Lewis Conservation District installed a number of BMPs at several sites in the lower reaches of Deep Creek. As of January 1997 the Conservation District, in cooperation with landowners, will have fenced most of creek side area where cattle or horses are kept (Brummer, 1996). The BMPs installed were funded in part by USFWS CFRP funds.

The following is a summary of BMPs installed as of June 1996 and their relation to the water quality monitoring stations:

Downstream of DCM 2.4

On a site with 2 horses and 10-12 cattle, 2,650 feet of fencing was installed on both sides of the creek. There are two animal crossings at the sites.

Upstream of DCM 2.4 and downstream of DCM 3.6

One landowner keeps animals between these two stations. They had 20 cattle and a few horses in 1995; in early summer of 1996 the herd size was reduced to 12 cattle and a few horses. At this site 4,552 feet of fencing was installed along 3,000 feet of the creek, on both sides. Three pasture pumps were installed and there is one animal access point.

A large culvert on Deep Creek washed out during the flooding on February 6, 1996. This culvert had been identified as a cause of bank erosion immediately downstream of the culvert. The culvert was replaced in April of 1996.

Upstream of DCM 3.6 and downstream of DCM 3.9

Three pieces of property received BMP treatments in this stretch of creek. The site just upstream of DCM 3.6 received 1,300 feet of fencing along the South side of the creek, with no animal access points. This piece of property includes Rundoph Creek. Fencing of Rundoph will be completed by January 1997. Approximately 11 cow/calf pairs and one steer are kept at this site.

Just upstream, 750 feet of fencing was installed along both sides of the creek. As of June 1996, there were no animals kept at this site.

Just downstream of the DCM 3.9 site, 1,040 feet of fencing was installed along both sides of the creek. One pasture pump was installed, and there is no animal access to the creek at this site. The landowner keeps 15-18 cattle at this site.

Upstream of DCM 3.9

The landowner immediately upstream of DCM 3.9 keeps a herd of cattle. The property alongside the creek has been fenced for a number of years. Upstream of this site there is no known domestic animal access.

Upstream of DCM 4.5

In 1994 and 1995 in the upper reaches of Deep Creek, the CFRP and Department of Natural Resources funded BMPs to target erosion control treatment, including: 38 miles of abandoned trail and road restoration; 6 miles of drainage upgrade; erosion control treatments such as culvert replacement and sedimentation traps; and stream bank revegetation (Ireland, 1995).

Precipitation

The preceding 24 and 48 hour rainfall as measured at the Olympia Airport NOAA Weather Station for each dry season sampling day is shown in Table 1. For all dry season events the previous 48 hour rainfall was less than 0.10".

The preceding 24 and 48 hour rainfall as measured at the Olympia Airport NOAA Weather Station for each wet season sampling day is shown in Table 2. The average previous 48 hour rainfall for sampling in 1995-96 was 0.89" as compared to 0.80" for 1994-95 wet season sampling.

Data Quality

Standard laboratory quality assurance (QA) procedures were followed for all samples, including calibration standards, spikes, and laboratory duplicates. All meters used in the survey were calibrated and used in accordance with user manuals. Field QA procedures are described in the QAPP (Sargeant, 1994)

To estimate the precision of field sampling the percent relative standard deviation (%RSD) was calculated for each replicate pair for the 1995-96 Bunker/Deep Creek sampling season. Replicates are two samples collected at the same site as close as possible in time. The mean %RSD for the laboratory parameters and D.O. is shown in Table 3. The replicates for D.O. represent a comparison of wet chemistry analysis.

The mean %RSD fell within 15 % or less for all parameters, which meets the data quality objectives specified in the QAPP.

Data qualifiers were reported with some data as indicated in Tables 4 and 5. In Table 4 a "J" qualifier was used for the fecal coliform sample obtained on July 12, 1995, at station DCM 2.4. The "J" qualifier is an estimated count in that it signifies greater than 150 fecal colonies on the plate. There could be two or more bacteria landing in the same place during filtration, so the "true" result could be greater than or equal to the reported result. The "J' qualifier was taken into consideration during analysis of the fecal coliform data. All data are considered usable, subject to the qualification provided.

Water Quality Characterization

Dry Season

Table 4 presents the dry season field and laboratory results for Bunker and Deep Creeks. During all dry season sampling events, temperature, pH, and ammonia met water quality standards for all sites.

During the dry season none of the sites fully met the D.O. criterion of 8.0 mg/L for Class A waters. The Deep Creek sites were above 8.0 mg/L in July but not in August and September. Dissolved oxygen levels were the lowest at the Bunker Creek site, ranging from 4.8 to 7.5 mg/L. Although D.O. was low, BOD5 samples collected in Bunker Creek were below detection limits.

Figure 2 presents nitrogen levels for Bunker and Deep Creeks. At the mouth of Bunker Creek ammonia levels averaged 0.079 mg/L in 1995 and 0.039 mg/L in 1996. While ammonia levels at all sites met water quality standards, they did not meet the Bunker Creek dry season ammonia target of <0.010 mg/L, as recommended in the Upper Chehalis River Dry Season Total Maximum Daily Load Study (Pickett, 1994) The elevated ammonia levels may be partially responsible for low D.O. at these sites.

In 1996 total phosphorus levels were measured, and all sites were below 0.10 mg/L. Phosphorus concentrations above 0.10 mg/L in flowing waters may stimulate algal growth (EPA, 1986).

Figure 3 presents fecal coliform levels for Bunker and Deep Creeks. In 1995 fecal coliform standards were not met at two stations, DCM 3.6 and DCM 2.4. In 1995 a great increase in bacteria levels was seen between DCM 3.6 and DCM 2.4. Geometric mean fecal coliform values were 220 cfu/100 mL at DCM 3.6 and 2,000 cfu/100 mL at DCM 2.4. In 1996 all stations met the fecal coliform standard, with dramatic improvements in bacteria levels at DCM 2.4. In 1996 the GM fecal coliform was 89 cfu/100 mL at DCM 3.6 and 69 cfu/100 mL at DCM 2.4.

Statistical testing showed significantly higher levels of fecal coliform in 1995 at DCM 2.4 as compared to DCM 3.6. No significant difference was noted in 1996. Statistically significant improvements in fecal coliform levels were noted for DCM 2.4 between 1995 and 1996. No other statistically significant differences were noted between years or sites.

Wet Season

Table 5 presents the wet season field and laboratory results for Bunker and Deep Creeks. During all wet season sampling events temperature and pH met water quality standards for all sites. Figures 4 and 5 present turbidity and total suspended solids (TSS) data for each site during the wet season.

To determine compliance with the water quality standards for turbidity, standards were applied to each reach in the study by using the station immediately upstream as background. Turbidity standards were not met at DCM 2.4 during three sample events, and during one event on February 6, 1996, at DCM 3.9. During February 6, 1996, flows were extremely high. Sampling occurred just prior to flood conditions that washed out a culvert under a road between DCM 3.9 and 2.4. The culvert was replaced after the 1995-96 wet season sampling had concluded. No turbidity violations occurred, using the upstream station as background, for the rest of the sampling year after February 6, 1996. This suggests that the loss of the erosive culvert may have contributed to improved turbidity.

Total suspended solids values correlate strongly with turbidity, with a coefficient of determination (r2) of 0.97. (The coefficient of determination ranges from 0 to 1- the stronger the relationship between x and y, in this case TSS and turbidity, the higher the r2.) Turbidity and discharge correlate moderately with an r2 of 0.67. Correlation with previous 24, 48, and 72 hour rainfall is weak, with a relatively better correlation between turbidity and 72 hour rainfall (r2= 0.30). Correlations were done using 1995-96 wet season sampling data from all sites, with 50 data pairs serving as the basis for correlation.

Conclusions

During the dry season at DCM 2.4 dramatic improvement in bacteria levels was seen between 1995-96. The most likely cause of improvement is the fencing done to exclude livestock from the creek and a decrease in herd size.

Dissolved oxygen levels did not meet standards especially during late summer, and ammonia levels at the mouth of Bunker Creek were higher than the TMDL level of <0.010 mg/L.

Turbidity and TSS levels were high during the wet season sampling especially during higher flows. During the first five sample events turbidity increased between DCM 3.6 and 2.4. During the 1994-95 wet season sampling, turbidity increased between DCM 3.6 and 2.4 during 9 out of 10 sample events (Sargeant, 1996). Improvements in turbidity levels during moderate flows were seen between DCM 3.6 and 2.4 after an erosive culvert washed out between the two sites.

Recommendations

- Continue dry season monitoring to determine BMP effectiveness on Deep Creek, especially for fecal coliform and nitrogen.
- Continue wet season monitoring for turbidity and TSS to determine BMP effectiveness on Deep Creek, especially at sites DCM 3.6 and 2.4.

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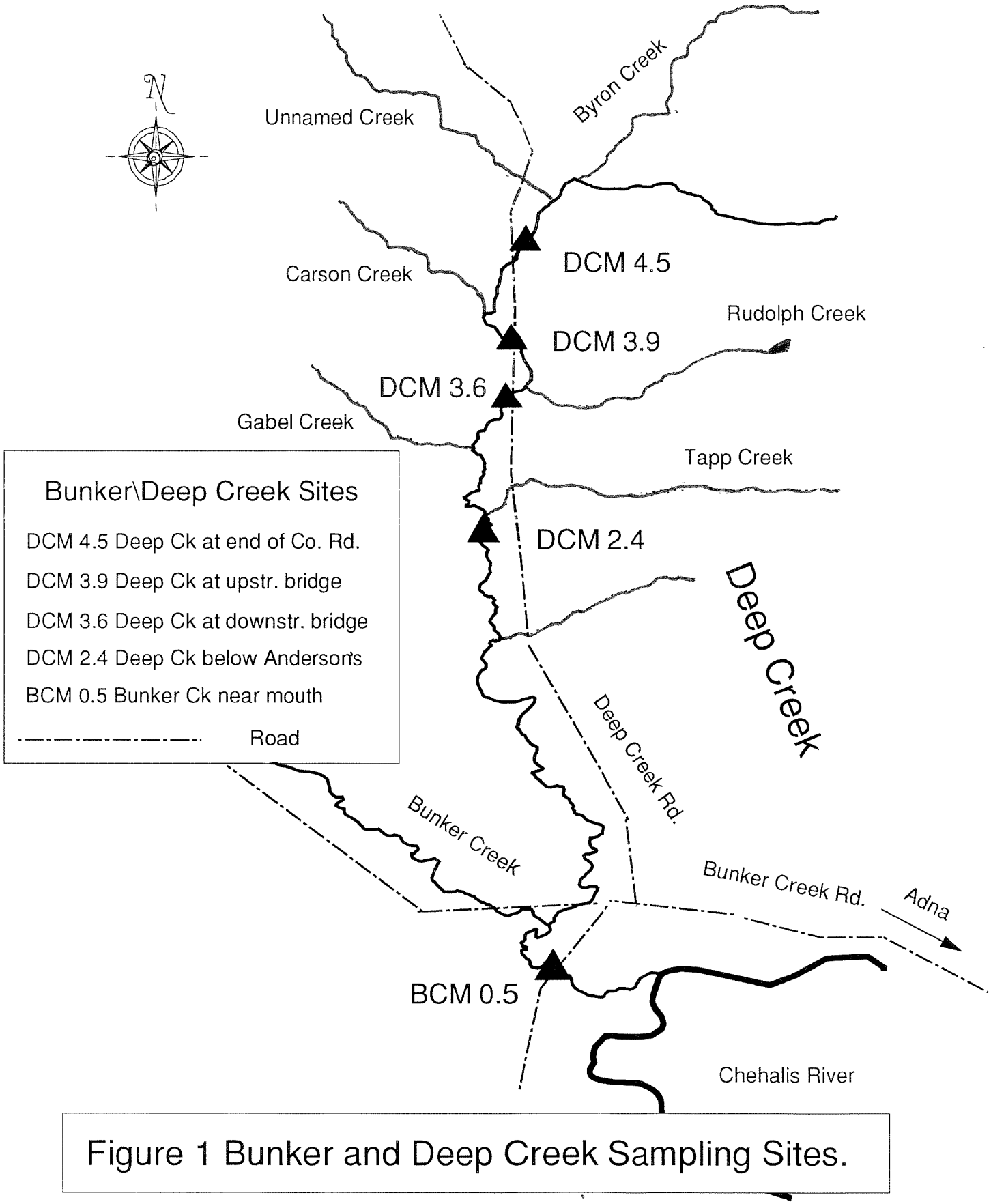

Figure 1 Bunker and Deep Creek Sampling Sites.

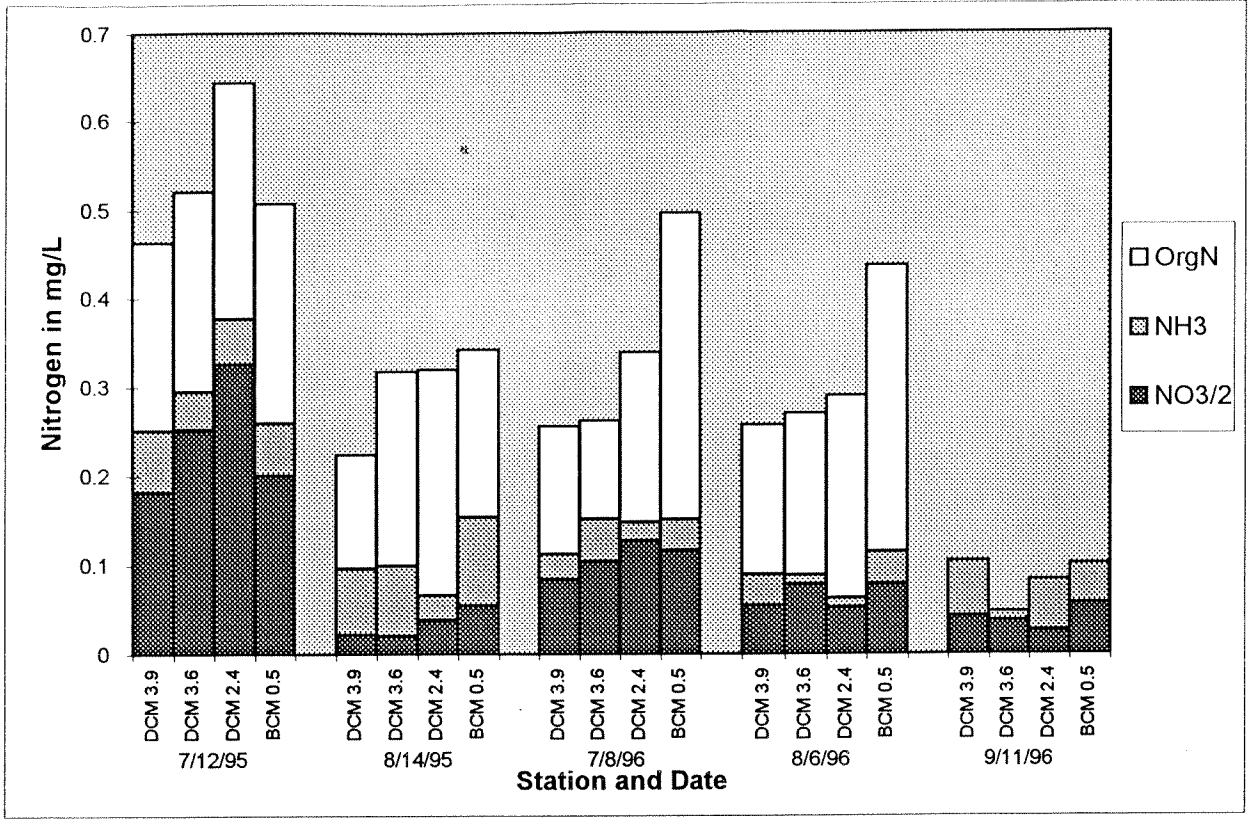

Figure 2. Nitrogen Levels at Bunker and Deep Creeks.

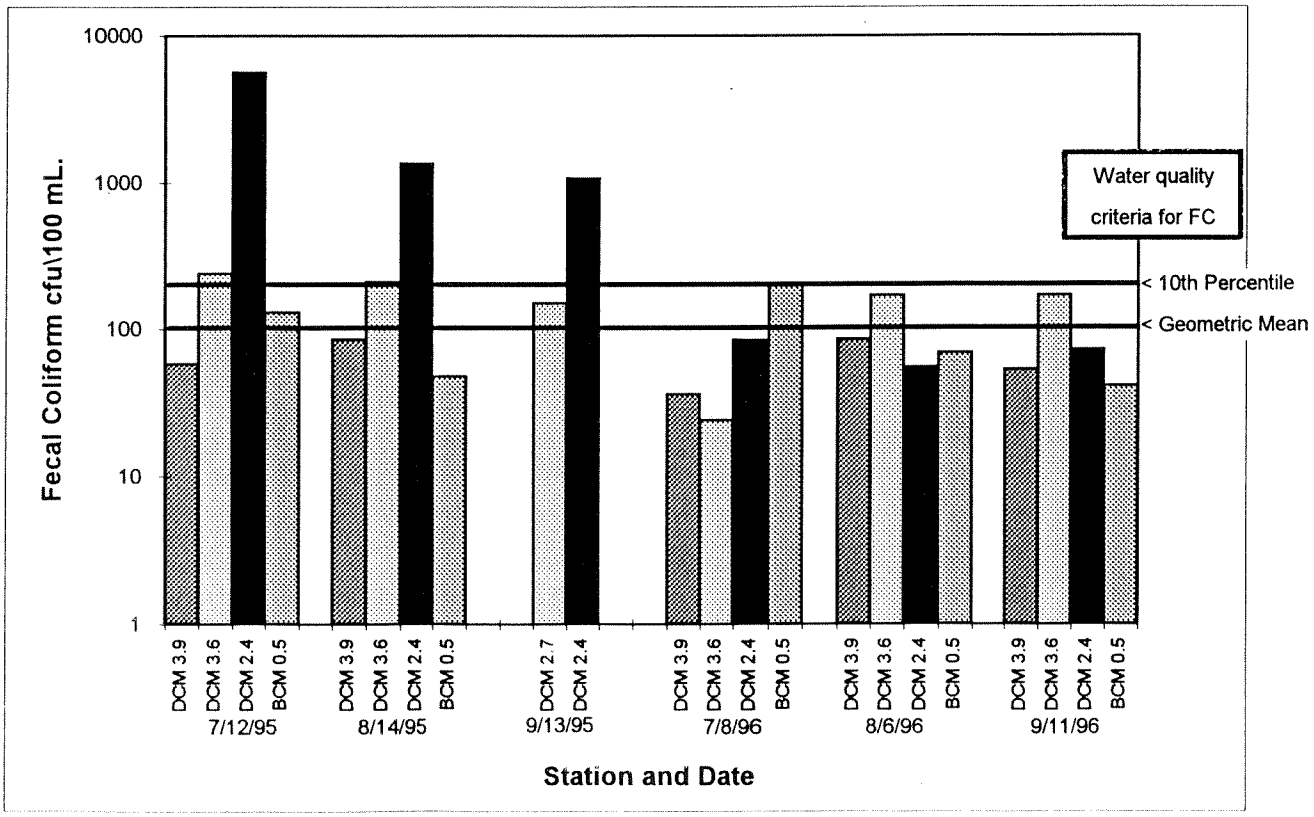

Figure 3. Fecal Coliform Levels at Bunker and Deep Creeks.

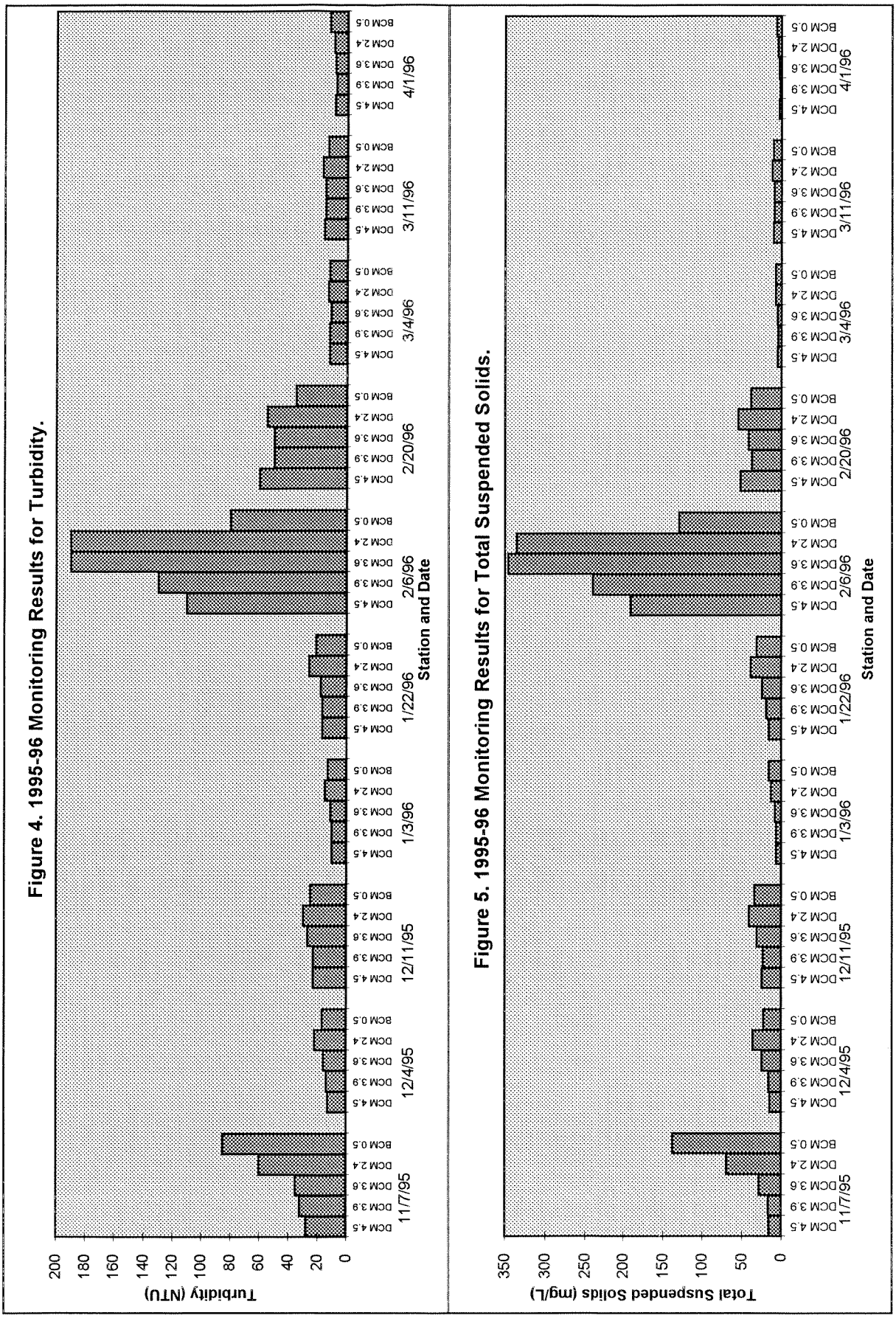
Figure 4. 1995-96 Monitoring Results for Turbidity.
Turbidity (NTU)
0
20
40
60
80
100
120
140
160
180
200
Station and Date
11/7/95
12/4/95
12/11/95
1/3/96
1/22/96
2/6/96
2/20/96
3/4/96
3/11/96
4/1/96
DCM 4.5
DCM 3.9
DCM 3.6
DCM 2.4
BCM 0.5
Figure 5. 1995-96 Monitoring Results for Total Suspended Solids.
Total Suspended Solids (mg/L)
0
50
100
150
200
250
300
350
Station and Date
11/7/95
12/4/95
12/11/95
1/3/96
1/22/96
2/6/96
2/20/96
3/4/96
3/11/96
4/1/96
DCM 4.5
DCM 3.9
DCM 3.6
DCM 2.4
BCM 0.5

Table 1. Previous rainfall for Dry Season Sampling Trips.

Date	Preceding 24 hour rainfall (inches)	Preceding 48 hour rainfall (inches)
July 12, 1995	0.00	0.00
August 14, 1995	0.00	0.02
September 13, 1995	0.00	0.00
July 8, 1996	0.00	0.00
August 6, 1996	0.03	0.09
September 11, 1996	0.00	0.00

Table 2. Previous rainfall for Wet Season Sampling Trips.

Date	Preceding 24 hour rainfall (inches)	Preceding 48 hour rainfall (inches)
November 7, 1995	1.51	1.98
December 4, 1995	0.37	0.45
December 11, 1995	0.76	1.39
January 3, 1996	0.41	0.46
January 22, 1996	0.01	0.88
February 6, 1996	1.32	1.39
February 20, 1996	0.30	0.77
March 4, 1996	0.47	0.87
March 11, 1996	0.17	0.51
April 1, 1996	0.24	0.24
Average	**0.56**	**0.89**

Table 3. Field Precision as % Relative Standard Deviation.

Parameter	% Relative Standard Deviation	Number of Replicates
Fecal Coliform (FC)	14.5 %	n=10
Nitrite/nitrate Nitrogen	2.0 %	n=4
Ammonia Nitrogen	5.5 %	n=5
Total Persulfate Nitrogen	11.3 %	n=3
Total Phosphorus	8.3 %	n=2
Turbidity	2.9 %	n=7
Total Suspended Solids	6.3 %	n=5
Dissolved Oxygen	0.4 %	n=11
BOD5	*	n=3

* All replicates were below detection limits

Table 4.
Bunker\Deep Creek Dry Season Field and Laboratory Data

(paired values are field replicates)

Site Location	Date	Time	Temp. ° C	pH	Conductivity umho/cm*	Discharge cfs	Dissolved Oxygen mg\L**		Dissolved Oxygen % Saturation	BOD5 mg/L		Nitrite\nitrate nitrogen mg/L		Ammonia Nitrogen mg/L		Total Persulfat Nitrogen mg/L		Total Phosphorus mg/L		Fecal Coliform cfu/100 mL	
DCM 3.9	7/12/95	12:55	14.2	6.6	103	0.3	8.1	8.2	79%			0.182		0.069		0.463				55	61
DCM 3.9	8/14/95	10:40	12.5	7.4	114	0.1	6.6	6.7	62%			0.022		0.074		0.224				85	
DCM 3.9	7/8/96	12:00	15.0	7.5	60	0.3	7.7	7.8	77%			0.084		0.028		0.256		0.022		36	
DCM 3.9	8/6/96	10:30	14.4	7.2	&	0.8	5.7		56%			0.054		0.035		0.257		0.063		90	79
DCM 3.9	9/11/96	12:22	12.7	7.3	110	0.1	5.8		55%			0.042		0.062				0.090		48	57
DCM 3.6	7/12/95	12:20	13.8	6.7	110	0.3	9.1	9.1	88%			0.250	0.254	0.038	0.047	0.577	0.464			220	260
DCM 3.6	8/14/95	11:30	12.4	7.7	117	0.1	7.5	7.5	70%			0.020		0.079		0.317				210	
DCM 3.6	7/8/96	12:45	15.1	7.5	61	0.7	8.8		87%			0.104		0.048		0.262		0.026		22	26
DCM 3.6	8/6/96	11:00	14.4	7.4	&	0.5	7.7	7.7	75%			0.078		< 0.010		0.270		0.054		170	
DCM 3.6	9/11/96	12:56	13.0	7.2	123	0.0	6.0	5.9	56%			0.037		< 0.010				0.069		170	
DCM 2.7T	9/13/95	11:00																		200	220
DCM 2.7	9/13/95	11:00																		150	
DCM 2.4	7/12/95	11:45	13.7	6.8	118	0.8	9.1	9.2	88%			0.326		0.051		0.644				J 5600	
DCM 2.4	8/14/95	12:15	13.1	7.7	141	0.1	7.2	7.2	67%			0.039	0.037	0.028	0.027	0.306	0.332			1200	1500
DCM 2.4	9/13/95	10:20				0.2														930	1200
DCM 2.4	7/8/96	13:25	15.6	7.5	73	0.6	8.6		86%			0.125	0.128	0.020	0.021	0.370	0.309	0.031	0.037	84	
DCM 2.4	8/6/96	9:55	14.5	7.2	&	0.8	6.8		67%			0.052		< 0.010		0.290		0.053		55	
DCM 2.4	9/11/96	13:15	13.4	7.3	155	0.1	6.4		61%			0.026		0.057				0.079		72	
BCM 0.5	7/12/95	10:45	14.8	6.6	115	2.9	7.5	7.5	74%	< 3	< 3	0.201		0.058		0.507				130	
BCM 0.5	8/14/95	9:15	14.8	7.3	118	0.7	5.2	5.2	51%	< 3	< 3	0.054		0.102	0.097	0.342				57	39
BCM 0.5	7/8/96	11:40	15.9	7.5	85	2.8	7.4		75%	< 3		0.116		0.035		0.496		0.031		200	
BCM 0.5	8/6/96	9:00	15.8	6.8	&	2.3	5.5		55%	< 3	< 3	0.078		0.036		0.436		0.052		69	
BCM 0.5	9/11/96	13:35	15.4	7.3	110	0.5	4.8		48%	< 3		0.055	0.056	0.046	0.044			0.083	0.088	33	48

* Specific conductance at 25° C

** D.O. determined by using the azide-modified Winkler titration method.

& Conductivity meter not functioning

J An estimated count, signifies greater than 150 fecal colonies on the plate. The "true" results could be greater than or equal to the reported result.

< Less than the reported result

TABLE 5.
Bunker\Deep Creek Wet Season Field and Laboratory Data
(paired values are field replicates)

Site Location	Date	Temperature ° C	pH	Conductivity umho/cm*	Discharge cfs	Turbidity NTU		Total Suspended Solids mg/L	
DCM 4.5	11/7/95	8.3	6.8	72	23	28		16	
DCM 4.5	12/4/95	8.0	6.6	57	34	13	12	14	15
DCM 4.5	12/11/95	8.5	6.5	56	45	23		24	
DCM 4.5	1/3/96	8.4	7.5	64	24	10		6	
DCM 4.5	1/22/96	6.8	7.8	57	53	17		16	
DCM 4.5	2/6/96	5.8	7.5	49	80	110		191	
DCM 4.5	2/20/96	7.6	7.6	55	33	60		52	
DCM 4.5	3/4/96	6.5	6.6	60	8	12		5	
DCM 4.5	3/11/96	8.8	6.7	58	13	16		10	
DCM 4.5	4/1/96	7.4	6.7	65	5	8.3		3	
DCM 3.9	11/7/95	8.2	6.8	70	31	32	32	17	
DCM 3.9	12/4/95	8.2	6.5	56	48	14		16	
DCM 3.9	12/11/95	8.5	6.9	56	59	23		23	
DCM 3.9	1/3/96	8.4	7.4	63	28	10		6	
DCM 3.9	1/22/96	6.7	7.8	58	71	17		18	19
DCM 3.9	2/6/96	5.9	7.6	51	117	130		240	
DCM 3.9	2/20/96	7.4	7.7	55	41	50		38	
DCM 3.9	3/4/96	6.8	6.6	56	E 6	12	11	4	
DCM 3.9	3/11/96	8.9	6.7	62	15	15		9	
DCM 3.9	4/1/96	7.6	6.8	62	5	7.4		2	
DCM 3.6	11/7/95	8.2	6.8	71	34	35		28	
DCM 3.6	12/4/95	8.2	6.4	56	51	16		24	
DCM 3.6	12/11/95	8.5	6.7	65	60	27		31	
DCM 3.6	1/3/96	8.4	7.4	64	28	11	11	8	
DCM 3.6	1/22/96	6.8	7.9	62	77	18		24	
DCM 3.6	2/6/96	6.0	7.7	50	E 142	190		360	332
DCM 3.6	2/20/96	7.5	7.8	55	42	50		42	
DCM 3.6	3/4/96	6.8	6.6	60	10	11		5	
DCM 3.6	3/11/96	9.2	6.7	60	17	15		9	
DCM 3.6	4/1/96	7.8	6.8	65	6	8.0		3	
DCM 2.4	11/7/95	8.2	6.8	73	56	60		69	
DCM 2.4	12/4/95	8.1	6.7	59	60	22		36	
DCM 2.4	12/11/95	8.6	6.9	79	82	30		41	
DCM 2.4	1/3/96	8.4	7.3	63	39	15		14	11
DCM 2.4	1/22/96	6.8	8.1	59	97	26		39	
DCM 2.4	2/6/96	6.0	7.7	51	E 170	190		335	
DCM 2.4	2/20/96	7.5	7.6	58	59	55		55	
DCM 2.4	3/4/96	6.8	6.6	60	16	13		7	
DCM 2.4	3/11/96	9.2	6.8	66	23	16	17	12	
DCM 2.4	4/1/96	7.9	6.9	70	7	9.1		4	
BCM 0.5	11/7/95	7.7	7.0	60	~	85		138	
BCM 0.5	12/4/95	7.9	7.0	51	~	16	17	22	
BCM 0.5	12/11/95	8.4	6.8	72	~	25		34	
BCM 0.5	1/3/96	8.5	6.8	76	~	13		16	
BCM 0.5	1/22/96	6.4	7.9	52	~	21		32	
BCM 0.5	2/6/96	5.4	7.7	46	~	80		130	
BCM 0.5	2/20/96	7.3	7.7	60	~	35		39	
BCM 0.5	3/4/96	6.8	6.6	54	~	12	12	7	
BCM 0.5	3/11/96	9.4	6.8	55	~	13		10	
BCM 0.5	4/1/96	8.2	7.1	63	~	12		6	6

* Specific conductance at 25° C
E Field estimate\gauge reading.
~ Wet season flows were not obtained at BCM 0.5