WASHINGTON STATE DEPARTMENT OF ECOLOGY

Chehalis Best Management Practices Evaluation Project

Report on the Black River Project Area

Abstract

This report describes surface water monitoring results for best management practices (BMP) implementation at the Black River Ranch, located in southwestern Thurston County. Sampling was done from river mile (RM) 11.8 to 13.2. Implementation of BMPs occurred from 1991 to 1995, including installation of a waste management system with a solids separator and over-winter storage pond; application of waste at agronomic rates; herd-size reduction; and water conservation practices. The overall study design includes dry season pre\post monitoring and dry and wet season upstream\downstream water quality monitoring. In comparing 1994 dry season results to data collected in 1991 and 1992, the downstream deep water station showed continued improvements in water quality over 1991 conditions, confirming improvements seen in 1992. Dry season levels of conductivity, turbidity, ammonia, total persulfate nitrogen, and total phosphorus have dramatically declined since 1991. The 1994-95 wet season sampling showed higher levels of ammonia, turbidity, and conductivity at a tributary draining the Black River Ranch, in comparison to the two Black River stations. All three sites did not meet fecal coliform criteria. Additional post-BMP monitoring is recommended after BMPs have been implemented long enough to be effective, and on-site soils have recovered.

Introduction

The purpose of this study is to document improvements in surface water quality associated with best management practices (BMPs) installed at the Black River Ranch, a dairy operation located in western Thurston County. This study also provides follow-up to the Black River Dry Season Total Maximum Daily Load (TMDL) Study.

The Black River basin is a sub-basin of the Chehalis River watershed. In the Chehalis and Black River basins, poor water quality has been identified as a threat to the fishery resource and other beneficial uses. In the Black River low dissolved oxygen and high temperatures are a critical problem for the fishery resource during the dry season low flow period. During the wet season, high fecal coliform levels are the major water quality problem.

To protect beneficial uses, the TMDL process is being implemented by Ecology for the Black River basin. Total Maximum Daily Load Studies by Pickett (1994) and Coots (1994) found that nonpoint source pollution is the predominant source of poor water quality. Successful implementation of the Black River Basin TMDL includes establishing BMPs to control nonpoint pollution.

by Debby Sargeant
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Study Area

The Black River, located in Thurston and Grays Harbor Counties, drains about 128 square miles of land, and is roughly 24 miles long with over 84 miles of tributaries. Figure 1 shows the study area. The Black River is classified as a Class A waterbody, according to Washington Administrative Code Chapter 173-201A.

The Black River Ranch is located in Thurston County in Sections 20 and 21, Township 16 N, Range 4 W. The ranch is bordered on the west by Mima Creek and on the south by the Black River between RM 11.8 and 13.2. Twenty-five to 100 meters of wooded wetlands border this section of the Black River. The ranch includes 700 acres on mostly Spanaway-Nisqually soils. Soils are deep and somewhat excessively drained. Liquid and solid manure have been applied to the soils on the site year round since 1972. Over-application of waste has modified the soils over time. The normally porous soils have become somewhat impervious (Swotek, 1995).

History

In August 1989 there was a fish kill on the Black River in the vicinity of RM 7.1 at the Moon Road Bridge. The fish kill involved a variety of fish species and the total number of fish was in the thousands. In October 1990, Thurston County and a citizen's monitoring group found high fecal coliform levels from approximately RM 9.5 upstream to 150 yards above the mouth of Mima Creek (TCEH, 1991). In November 1990 Ecology's Southwest Regional Office (SWRO) sampled five sites on the Black River between RM 7.0 and RM 19.0. A significant increase in fecal coliform levels was documented at RM 7.1 and RM 9.5 as compared to sites above RM 15.0 (Harvester, 1992). No probable source was found.

As a result of the fish kill and historical water quality problems, the Black River was included in the Chehalis River TMDL study. Both dry and wet season TMDL studies were done on the Black River. As a part of the dry season TMDL study, water quality monitoring was conducted from July to October 1991 and 1992. A memorandum summarized water quality data from 1991, finding that evidence pointed to a possible discharge of pollutant to the Black River originating at RM 12.2 (Pickett, 1991). The memo states that a dairy farm north of the river is the most prominent land use in the study area and the dairy could possibly be a source of wastes.

In January of 1991 Ecology's SWRO responded to an agricultural animal waste complaint at the Black River Ranch. The inspection revealed serious problems with their waste management practices including no winter storage, over-application of animal waste to fields, and animal waste piped into ditches that drained to nearby surface water. In January of 1991 Ecology formally initiated the Agricultural Compliance Memorandum of Agreement which gave the Black River Ranch 24 months to develop and implement a farm plan, including a waste management plan.

Methods

Implementation of Best Management Practices

Thurston Conservation District (TCD) and the local Natural Resource Conservation Service (NRCS) provided information on the types of BMPs installed and information about soils. The manager of the Black River Ranch provided details on when BMPs were installed.

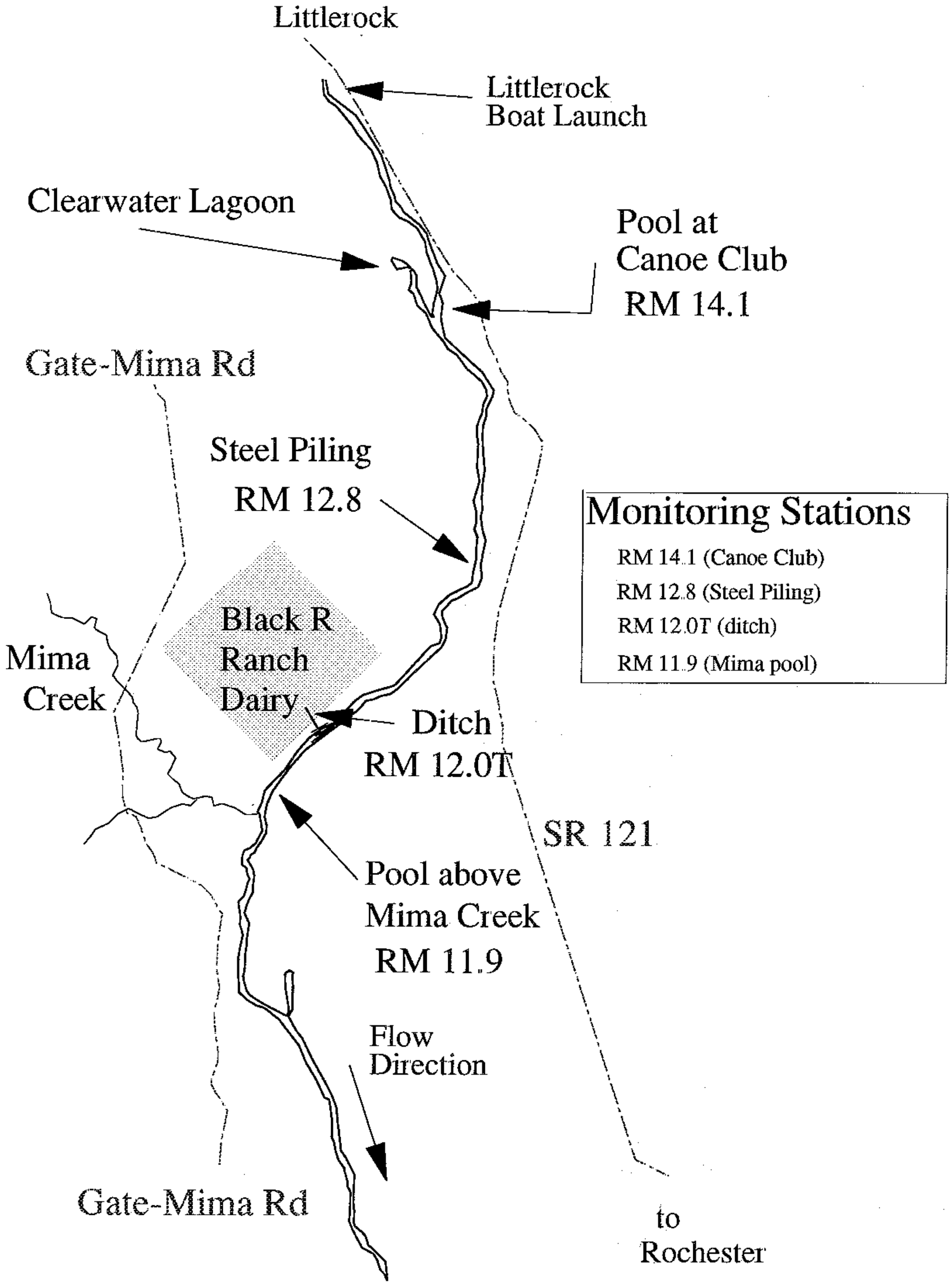


Figure 1. Black River and tributary sampling sites

Sampling Design

A Quality Assurance Project Plan (QAPP) was developed for this project (Sargeant, 1994). The QAPP describes monitoring activities for the period July 1994 through June 1995. Figure 1 shows the locations of summer and winter sampling sites.

Summer monitoring locations were based on a pre\post and upstream\downstream monitoring design. Summer sampling included two sites on the mainstem of the Black River: RM 11.9, in a pool just upstream of Mima Creek; and RM 14.1, in a pool just upstream of the Canoe Club boat launch. Sampling occurred on August 30 and September 13, 1994. Both sites were monitored at two depths: the surface mixed layer and the deep hypoxic layer. For both sampling events there was no rainfall within the previous 72 hours.

Wet season monitoring locations were only based on an upstream/downstream design, since no comparable historical data were available for pre\post comparison. Winter sampling included three sites: two sites on the mainstem Black River, at RM 11.9 and at RM 12.8 (just downstream of the steel piling); and one tributary site at RM 12.0T. The tributary drains areas of the Black River Ranch. Winter sampling occurred on the following dates: November 16 and 29, 1994; January 23 and 31, 1995; and March 5, 1995.

For four out of the five winter sampling events, 0.25 inch or more of rainfall had fallen in the previous 24 hours. The sampling event on January 23, 1994, was during a dry period.

Field measurements for temperature, pH, and conductivity were made during all surveys as described in the QAPP. Dissolved oxygen measurements were taken during the summer surveys.

During summer sampling events, discrete water samples were collected at 20% and 80% of total depth. Field measurements were taken at 1-meter intervals. Laboratory samples were collected at all sites for turbidity, total organic carbon, nitrite\nitrate, ammonia, total persulfate nitrogen, and total phosphorus.

For winter sampling events samples were collected from flowing water by subsurface grab from the center channel (3 to 12 inches depth). Laboratory samples were collected at all sites for turbidity, nitrite\nitrate, ammonia, total persulfate nitrogen, and fecal coliform.

Immediately following collection, samples were placed in the dark on ice, and shipped to Ecology's Manchester Environmental Laboratory (MEL) within 24 hours after sample collection. Samples were analyzed in accordance with the QAPP.

Analysis of Data

Summer data were compared to historical data collected in 1991 and 1992 at the same sites and depths (Pickett, 1994). In 1991 the sampling occurred on three consecutive days, to assure that sample independence for statistical analysis data from this time period was averaged. Summer season is defined as the period of time when the middle Black River stratifies into two layers as determined by field measurements. Upstream and downstream data were also compared, clustering the data into shallow and deeper water as was done in historical analysis of the data (Pickett, 1991). Winter data were also analyzed using an upstream and downstream comparison.

A statistical test for the significance of variations between sites upstream and downstream (spatial) and past and present (temporal) 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. Where a statistically significant difference was noted for multiple sites, a non-parametric Tukey-type multiple comparison test (Zar, 1984) was used to determine which sites were different.

Results

Data quality assurance results can be found in Appendix A. A summary of the dry and wet season monitoring data from the project area can be found in Appendices B and C, respectively. A summary of the results of the Kruskal-Wallis statistical analysis of the wet season data can be found in Appendix D. For the dry season historical comparison no statistically significant difference ($P \leq 0.10$) was found, probably due to the low pre-BMP sample size (for 1991, $n=1$).

Best Management Practices

Since 1991 major improvements have occurred at the Black River Ranch. From June to October 1991 herd size was reduced from 3,450 to 1,250 animal units (one animal unit is equivalent to 1,000 pounds of animal, or about one cow). Construction of a 17.3 million gallon waste pond began in May 1994. The waste storage system includes a solids separator and a two-cell waste storage pond. As of 1994, there had been a reduction of flush water from approximately 30 to 14.8 gallons per head per day. This resulted in water savings of about 2 million gallons per month at the farm.

Construction of the waste pond was completed in October 1994. Use of the pond did not begin until January 1995 due to additions of piping and the separator. Some waste application may have occurred during November 1994 (Swotek, 1995). In October 1995, a revised waste application schedule was completed allowing application of liquid manure from March through September, timing of manure application based on soil moisture content.

Precipitation

Precipitation for the wet season sampling period, November 1994 through March 1995, was 37.78 " measured at the Olympia Airport NOAA Weather Station. This is slightly higher than the normal average of 35.39" (Perrich, 1992) expected for November through March. Preceding 24 hour rainfall for each sampling day is shown in Table 1.

For all summer sampling events there was no rainfall within the previous 72 hours.

Discharge

Two United States Geological Survey (USGS) stations on the Chehalis River were used to determine flows in the Black River during dry season sampling. The station at Grand Mound (12027500) is upstream of the Black River at Chehalis RM 59.9 and the station at Porter (12031000) is downstream of the Black River at Chehalis RM 33.3. The mouth of the Black

River is at Chehalis RM 47.0. Pickett (1994) developed an equation to calculate summer flow in the Black River using flow measurements at Grand Mound and Porter. This calculation can be applied during dry weather conditions of low flow and little or no rainfall during the previous few days. Rainfall for the three days preceding sampling in summer 1994 was a trace or less as measured by the Olympia Airport NOAA Weather Station. Table 2 presents discharge for stations at Porter and Grand Mound, and the calculated flow for the mouth of the Black River for 1991, 1992, and 1994 dry season sampling dates.

Table 1. Weather For Black River Sampling Events.

Date	**Preceding 24 hour rainfall**	**Sample day weather**
November 16, 1994	0.25"	Little rain while sampling
November 23, 1995	0.45"	Heavy rain while sampling
January 23, 1995	0.0 "	No rain while sampling
January 31, 1995	1.41"	Heavy rain while sampling
March 5, 1995	0.28"	No rain while sampling

Table 2. Prediction of Black River Flows Based on USGS Flows in the Chehalis River.

Date	Porter (cfs)	Grand Mound (cfs)	Porter-Grand Mound (cfs)	Estimated flows Black River (cfs)
8/21/91	357	214	143	72
9/10/91	426	291	135	66
9/11/91	408	277	131	63
9/12/91	402	277	125	59
6/23/92	417	273	144	73
7/23/92	315	191	124	58
8/05/92	246	145	101	45
8/31/92	182	117	65	30
8/30/94	285	215	70	32
9/13/94	442	363	79	35

Flows in the Black River were described by Pickett (1994) as being somewhat less than average for the 1991 low flow period, and critically low in 1992. Flows during sampling events for 1994 were even lower than 1992. The 7-day low flow with an average return time of 10 years (7Q10) is a standard measure of critical low flow and is specified in the water quality standards as the flow to be considered in the analysis of standards compliance. Pickett (1994) estimated the 7Q10 critical low flow for the Black River to be 30 cfs. During both sampling events in summer 1994, the river was near critical low flow, which was similar to 1992 conditions.

Water Quality Characterization

Temperature

During both dry season sampling events the water was stratified, with a layer of cooler water near the bottom. Temperature gradients of 4.9 and 2.2°C were observed between surface and bottom on August 30 and September 13, 1994, respectively. Temperatures at all sites met the water quality standard of 18°C, except for the August 30, 1994, shallow water sampling at RM 11.9.

Conductivity

Conductivity is a measure of how easily electricity can pass through water. It is an indirect measure of the amount of dissolved ions present. Conductivity can often be used to predict total dissolved solids (TDS). Conductivity was used in this study to evaluate dissolved materials at each site in order to identify suspected pollutant sources that exhibit higher concentrations of TDS. There are no water quality standards for conductivity.

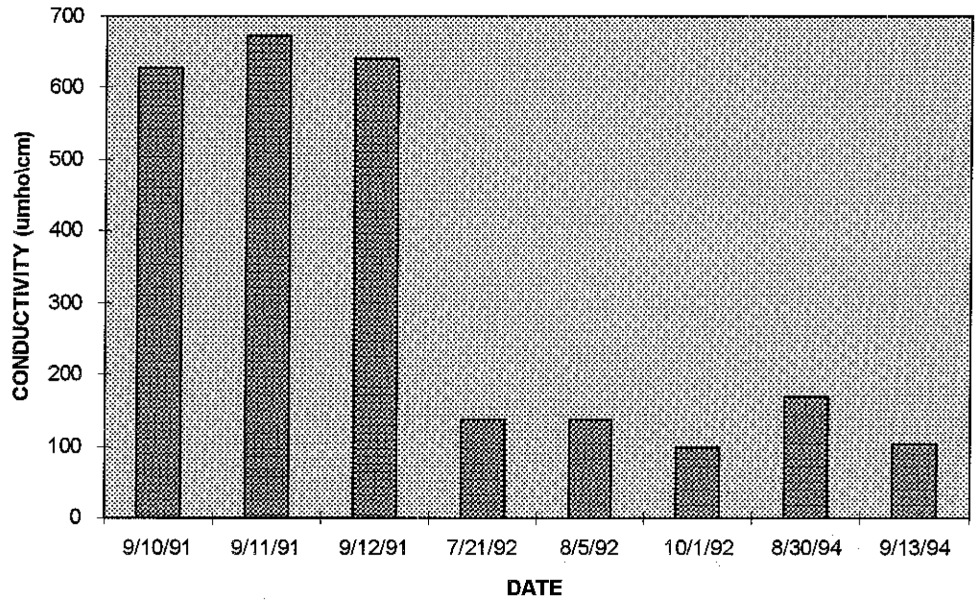
Dry Season -- Conductivity at RM 11.9 ranged from 100 to 168 μmho/cm. At RM 14.1 conductivity ranged from 100 to 161 μmho/cm. At both sites conductivity generally increased with depth. Conductivity from deep and surface samples did not vary significantly upstream to downstream. In comparing historical data there is a pattern of decreasing conductivity over time at the deeper station at RM 11.9 (Figure 2).

Wet Season -- Conductivity levels ranged from 59 to 108 μmho/cm at RM 11.9, from 86 to 409 μmho/cm for the tributary at RM 12.0T, and from 55 to 100 μmho/cm at RM 13.1. A statistical difference in conductivity was noted between the three stations using the Kruskal-Wallis test ($P=0.02$). To determine which sites were different, a non-parametric Tukey-type test was done. A significant difference ($P \leq 0.05$) in conductivity levels was found between the river stations and the tributary at RM 12.0T, with the highest conductivity levels being in the tributary.

pH

The pH for all sites fell within the water quality standard of 6.5 to 8.5, except for the August 30, 1994 deep water sampling at RM 14.1, where the pH at 4 and 5 meters was 6.4. As noted in Pickett (1994), it is likely that decomposition of organic material in the sediment near the bottom reduces pH.

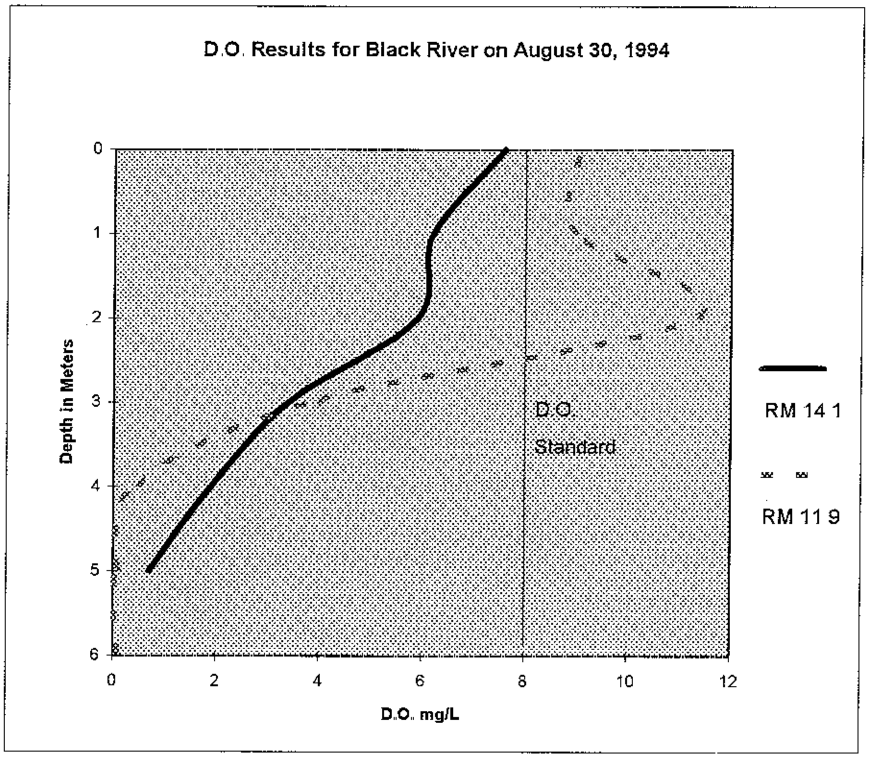
Figure 2. Historical Dry Season Comparison of Conductivity for RM 11.9 at Depth.



Dissolved Oxygen
The water quality criterion for dissolved oxygen (D.O.) in the Black River states that D.O. shall exceed 8.0 mg/L. Dissolved oxygen measurements were done during the dry season sampling only. The site at RM 14.1 did not meet D.O. criteria for any depth, including surface samples, and the site at RM 11.9 met D.O. criteria in the upper 2 meters of water (Figure 3). Measurements at both sites ranged from anoxic at lower depths to 69-119% saturation nearer the surface.

Turbidity
The water quality standard for turbidity in the Black River requires that turbidity levels not exceed 5 NTU above background turbidity when background is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

Dry season -- Mainstem station turbidity levels ranged from 1.4 to 14 NTU. Turbidity levels at the two stations were within 5 NTU of each other for both sampling events, except on August 30, 1994, when deep water turbidity was 13 NTU at RM 11.9 and 5 NTU at RM 14.1. In comparing historical data, there is a pattern toward decreasing turbidity over time at the deeper station at RM 11.9 (Figure 4).



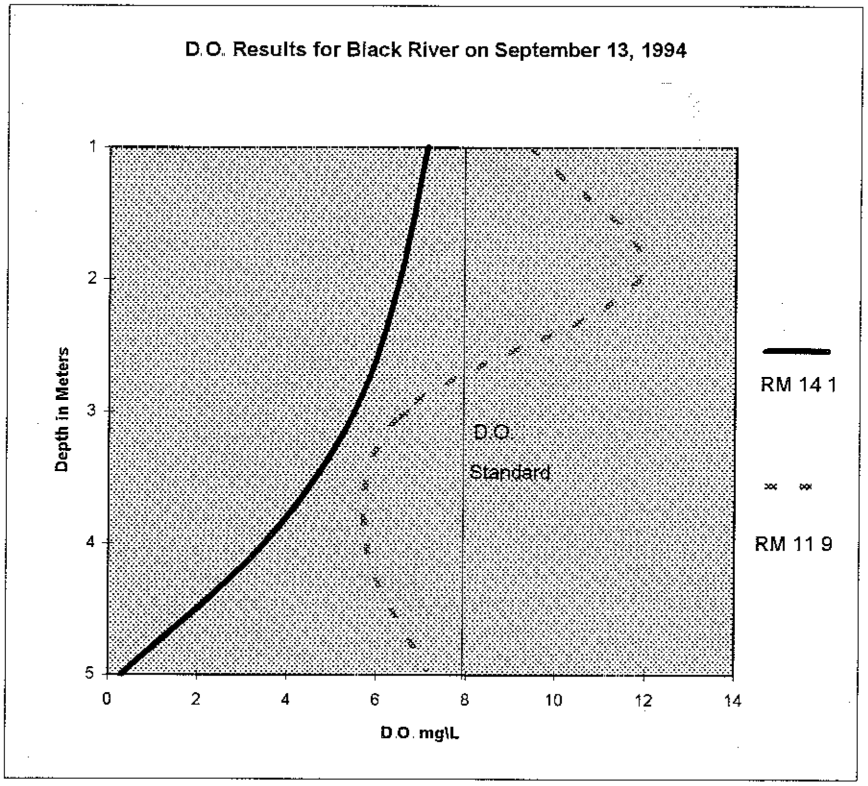
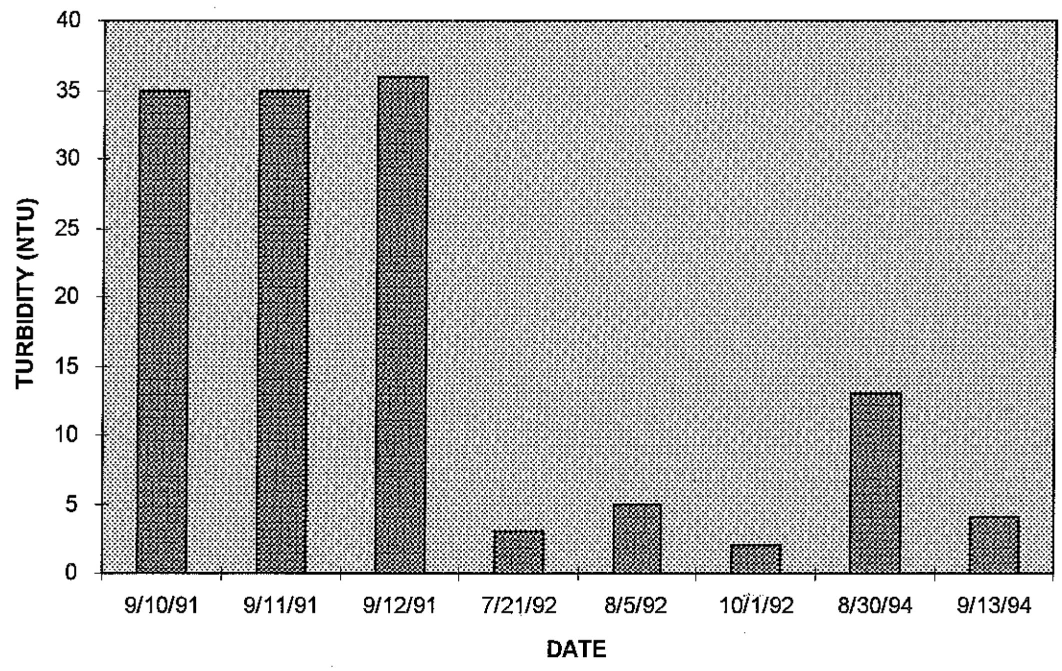


Figure 3. 1994 Dry Season D.O. Levels by Depth for Black River Sampling Stations.

Figure 4. Historical Comparison of Dry Season Turbidity Levels for RM 11.9 at Depth.



Wet season -- During all five sampling events the mainstem Black River stations were within 5 NTU of each other, and met water quality criteria. Turbidity levels on the Black River ranged from 1.5 to 3.7 NTU. The tributary site at RM 12.0T had turbidity levels ranging from 1.9 to 12 NTU. Turbidity levels were higher for the station at RM 12.0T than at the Black River sites during four out of five sampling events; the differences were significant (P=0.07).

Total Organic Carbon

Total organic carbon (TOC) measures the organic carbon concentration in the water column, which usually derives from biological sources. Since some portion of the TOC in the water may contribute to carbonaceous biochemical oxygen demand (CBOD), TOC can be an indirect measure of CBOD and an indicator of pollutant sources. Some elevation of TOC may also occur from natural sources such as from wetlands or autumn leaf fall.

Total organic carbon samples were collected only during the dry season. Surface water TOC at both sites ranged from 1.8 to 2.5 mg/L. Deeper water values at RM 14.1 were 1.8 and 2.0 mg/L, while at RM 11.9 values were 9.6 and 3.3 mg/L.

Nitrogen
Total persulfate nitrogen, nitrite/nitrate, and ammonia were collected at all stations during both the dry and wet season sampling. There are no surface water quality criteria for total persulfate nitrogen or nitrite/nitrate. The water quality standards provide a calculation that factors in the fisheries resource, temperature, and pH to determine chronic and acute criteria for ammonia.

Since total persulfate nitrogen measures total organic and inorganic nitrogen, subtracting the inorganic portions (ammonia, nitrite, and nitrate) will give a measure of the organic nitrogen available. Organic nitrogen is found in soil organic matter, animal manure, crops, sewage sludge, and compost.

Dry Season -- All stations met water quality standards for ammonia. In almost all samples, most of the nitrogen was present as nitrite\nitrate, except the August 30, 1994, deep water sample at RM 11.9. For this sample, ammonia levels were 1.47 mg/L, nitrite\nitrate levels were below detection limits, and D.O. was 0.1 mg\L. The very low D.O. indicates a lack of nitrification, or possibly even a denitrifying environment.

In comparing this year's data to historical data, data from 1991 show very high levels of ammonia and total persulfate nitrogen at the RM 11.9 deep station relative to 1992 and 1994 (Figure 5 and Figure 6).

Figure 5. Historical Comparison of Dry Season Ammonia Levels for RM 11.9 at Depth.

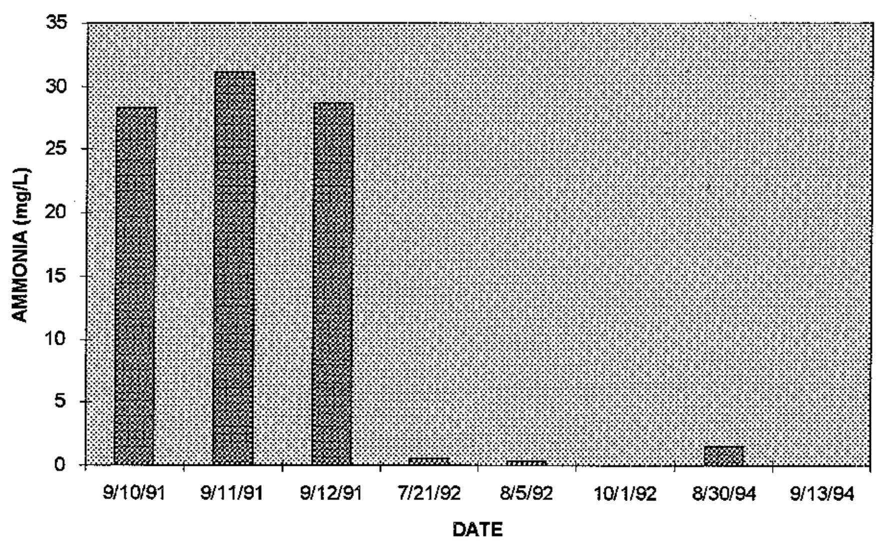
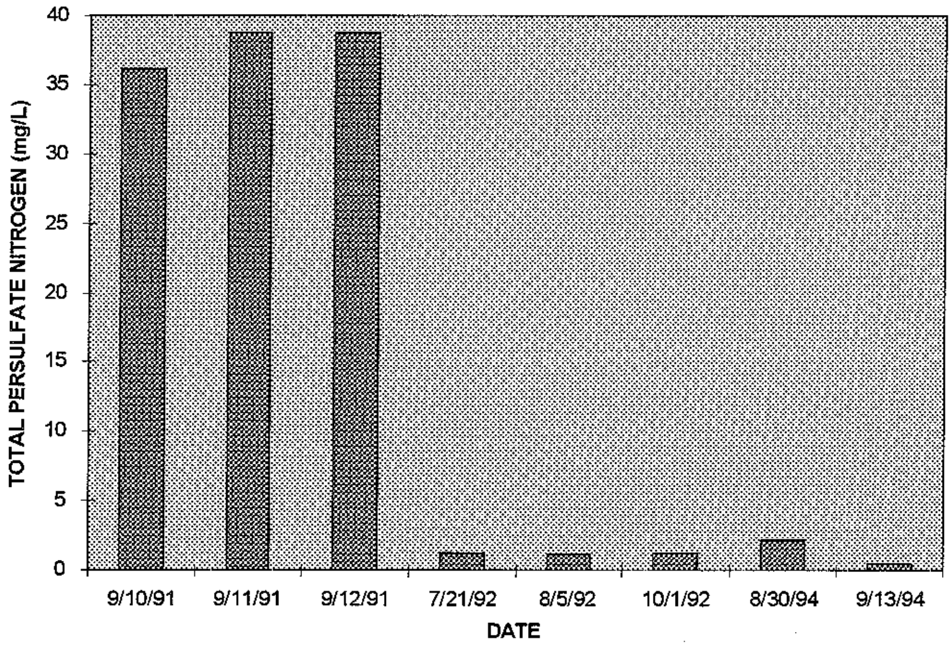


Figure 6. Historical Comparison of Dry Season Total Nitrogen Levels for RM 11.9 at Depth.



Wet Season -- The ammonia criterion for chronic toxicity was exceeded once at tributary site RM 12.0T on November 16, 1994. The chronic criterion for ammonia nitrogen on this date was calculated as 2.27 mg/L based on EPA (1986; 1992), compared to an ammonia level at the tributary of 4.62 mg/L. A statistical difference in ammonia was found between the three stations using the Kruskal-Wallis test. A non-parametric Tukey-type test showed the significant difference ($p \leq 0.05$) occurred between stations RM 11.9 and RM 12.0T, with higher ammonia levels in the tributary.

Nitrite/nitrate levels for RM 12.8 ranged from 0.580 to 0.879 mg/L, the tributary at RM 12.0T ranged from 0.064 to 0.753 mg/L, and RM 11.9 ranged from 0.627 to 1.19 mg/L. A statistical difference in nitrite\nitrate was found between the three stations using the Kruskal-Wallis test. A non-parametric Tukey-type test showed a significant difference ($P \leq 0.05$) in nitrite\nitrate levels between the river stations and RM 12.0T, with lower nitrite\nitrate levels at RM 12.0T.

Organic nitrogen at RM 12.8 ranged from 0.09 to 0.29 mg/L, with a mean of 0.19 mg/L. For the tributary at RM 12.0T, values ranged from 0.21 to 3.62 mg/L with a mean of 1.71 mg/L. At RM 12.8, values ranged from 0.14 to 0.34 mg/L, with a mean of 0.22 mg/L.

The tributary at RM 12.0T had high levels of organic nitrogen and ammonia, and lower levels of nitrite\nitrate relative to the other sites. This indicates loading of an organic nitrogen source and likely a lack of nitrification that would convert ammonia to nitrate. The lack of nitrification could be due to low dissolved oxygen, cold water, absence of nitrifying bacteria, or close proximity to the source.

Phosphorus

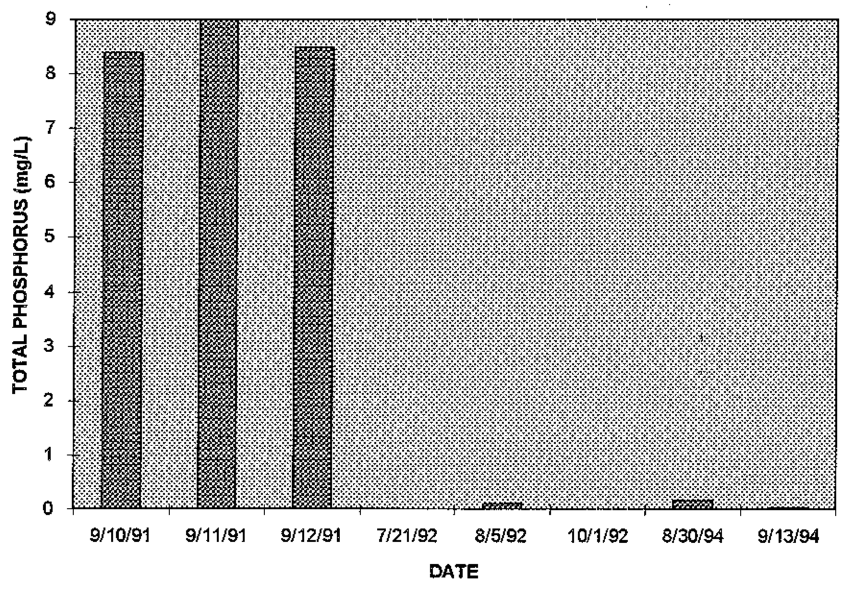
Total phosphorus samples were collected only during the dry season. Shallow water values ranged from 0.03 to 0.04 mg/L. These values meet the TMDL target of 0.05 mg/L for the upper 2 meters of water (Pickett, 1994). Deeper water values ranged from 0.03 to 0.16 mg\L.

In comparing 1994 results with historical data, deeper water total phosphorus levels at RM 11.9 showed a dramatic improvement since 1991 (Figure 7). The 1991 phosphorus data are qualified due to use of a different method. The qualifier states that the analyte was detected at the reported result; actual values may be higher.

Fecal Coliform

The water quality standard for fecal coliform in the Black River system is <u>both</u> not to exceed a geometric mean value of 100 cfu/100 mL, and not to have more than 10 percent of all samples obtained for calculating the geometric mean value exceed 200 cfu/100 mL. Fecal coliform samples were collected only during the wet season.

Figure 7. Historical Comparison of Dry Season Total Phosphorus Levels for RM 11.9 at Depth.



Exceedences of the fecal coliform standard are described in Table 3. It is important to note that a single value above 200 cfu/100 mL would constitute a violation of the second part of the fecal coliform standard. All stations exceeded criteria for fecal coliform. The Black River station at RM 11.9 exceeded both parts of the standard, and the other two stations exceeded one part of the standard.

However, no statistically significant difference was noted in fecal coliform levels between stations. The lack of significant statistical difference between sites could be due to upstream sources of fecal coliform, high winter flows (dilution), low sample size, or improvements in water quality due to BMP implementation at the Black River Ranch.

Table 3. Fecal Coliform Results for Black River Project - Wet Season.

STATION	Geometric mean below 100 cfu/100 mL?	10 % or less of all samples for calculating GM exceed 200 colonies/100 mL?
Mainstem, RM 11.9	**NO (GM=110)**	**NO (1 of 5 samples exceed 200)**
Tributary RM 12.0T	Yes (GM=98)	**NO (2 of 5 samples exceed 200)**
Mainstem RM 12.8	Yes (GM=60)	**NO (2 of 5 samples exceed 200)**

In the Black River Wet Season Nonpoint Source TMDL Study (Coots, 1994), a target fecal coliform load allocation of 50 cfu/100 mL was recommended for all segments of the Black River. Both mainstem stations, RM 11.9 and RM 12.8, exceeded the recommended load allocation.

Conclusions

- During the dry season, the deep water station at RM 11.9 continued to show improvement in water quality over 1991 conditions, confirming improvements seen in 1992. Water quality parameters showing improvement include: conductivity, turbidity, ammonia, total persulfate nitrogen, and total phosphorus.

- During the wet season, the tributary at RM 12.0T remains a problem because of violations of water quality criteria for ammonia and fecal coliform, and significantly higher levels of conductivity, turbidity, and ammonia as compared to the river. This could either be because the storage pond was still not being used during the 1994 sampling events, or as a residual effect from the previous practice of year-round application of manure (Swoteck, 1995).

- It may be premature to conclude post-BMP monitoring because soils at the Black River Ranch need rehabilitation to promote mineralization of manure. However, further post-BMP monitoring should be delayed until BMPs are fully implemented and properly functioning, and soils are rehabilitated.

Recommendations

- Postpone further post-BMP monitoring of the Black River Ranch site until BMPs have been fully implemented; the timing should be decided in consultation with TCD. Before more post-BMP monitoring occurs, Ecology's project manager should verify with TCD that BMPs have been properly functioning and maintained, and that rehabilitation of the soils (natural or otherwise) has occurred. Dry season follow-up monitoring of the same sites, depths, and parameters is recommended. For wet season post-BMP monitoring, the tributary at RM 12.0T should be monitored, as well as the upstream and downstream stations.

- Continue implementation of the TMDL.

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Appendix A. Quality Assurance

Quality Assurance Procedures

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).

Quality Assurance Results

To estimate the precision of field sampling the percent standard deviation or coefficient of variation (CV) was calculated for each replicate pair for the entire 1994\95 Chehalis BMP Evaluation Study. Replicates are two samples collected at the same site as close as possible in time.

The CV is calculated by dividing the standard deviation by the mean. This value is then multiplied by 100 so the CV can be expressed as a percentage. To evaluate the central tendency of CV values, the mean was calculated rather than the root mean squared value (RMS), because values near the detection limit tend to skew the RMS value. Also, Coots (1994) used a mean CV to determine precision for fecal coliform data, and for the sake of comparability it was used here as well.

The mean CV for all fecal coliform replicates is shown in Table A-1. When bacteria densities are low (nearer the detection limit), a higher CV is expected (e.g., the CV for replicate samples with values of 1 and 2 is 47%, whereas the CV for 100 and 101 is 0.7%). The data in Table A-1 show mean CVs that are similar or lower that the means reported by Coots (1994) for the Black River Wet Season TMDL Study. The fecal coliform replicate variability is considered acceptable.

The mean CVs were also calculated for NH3, NO2/3, TPN, turbidity, TOC, total phosphorus, and dissolved oxygen (Table A-1). The replicates for D.O. represent a comparison of field meter readings and wet chemistry analysis.

The mean for all parameters except ammonia and TOC fell within reasonable limits, 10 percent or less. For ammonia, three values at or near the detection limit tended to skew the mean. For values above the detection limit (beginning at 0.06 mg/L) the mean CV for ammonia was calculated as 5.7% (n=7), indicating a reasonable level of precision. For TOC, only one replicate sample pair was available for comparison; more replicates are necessary to make an accurate determination of precision.

Data qualifiers were reported with some data from the Black River project area, as indicated in Appendices B and C.

Table A-1. Precision as Mean and Median CV.

PARAMETER	MEAN CV	number of replicates
Fecal Coliform (FC)	15.5%	n=54
FC ≤ 100 cfu/100 mL	20.7%	n=34
FC > 100cfu/100 mL	8.0%	n=20
Ammonia	23.4%	n=12
Nitrite/nitrate	2.4%	n=15
Total persulfate nitrogen	7.2%	n=16
Turbidity	1.5%	n=13
TOC	21.1%	n=1
Total Phosphorus	7.6%	n=2
Dissolved Oxygen	3.3%	n=7

In Appendix B a "J" qualifier was used for nutrient samples taken on August 30, 1994. During storage of the samples at the Manchester Laboratory the refrigeration unit failed over a weekend. The samples were found at 32°C the following Tuesday morning, September 6, 1994. The specific length of time the samples were stored at elevated temperature is not known.

The Manchester Laboratory does not have data about sample storage at elevated temperatures, but the addition of acid to the samples should prevent changes in nutrient concentrations. The samples were "J" flagged because of the strict storage requirements called for in the EPA methods. The "J" qualifier was taken into consideration during analysis of the nutrient data.

In Appendix C, a "J" qualifier was used for fecal coliform samples collected on January 31, 1995, because a dilution was missed during the laboratory procedure. The results reported are likely an underestimate of the actual value. The "J" qualifier was taken into consideration during analysis of the fecal coliform data.

All data are considered usable, subject to the qualification provided.

APPENDIX B

BLACK RIVER DRY SEASON FIELD AND LABORATORY DATA

Paired results are replicate samples.

				FIELD DATA					LABORATORY DATA																
Station	Date	Time	Depth meters	Temp ° C	pH	COND µmho /cm	Dissolved Oxygen mg/L meter	Dissolved Oxygen mg/L Winkler	Turbidity NTU		Total Organic Carbon mg/L		NH3 mg/L			NO2/3 mg/L			Org. N	TPN mg/L			Total Phosphorus mg/L		
RM 11.9	8/30/94	14:00	0	19.3	7.0		9.1																		
RM 11.9	8/30/94	14:00	1	18.4	7.0	110	9.0		1.4		1.8		J<	0.01		J	0.77		0.12	J	0.90		J	0.03	
RM 11.9	8/30/94	14:00	2	16.0	6.9		11.4																		
RM 11.9	8/30/94	14:00	3	15.3	6.8		4.0																		
RM 11.9	8/30/94	14:00	4	15.0	6.6		0.5																		
RM 11.9	8/30/94	14:00	5	14.9	6.5	168	0.1		14	12	9.6	7.1	J	1.47		J<	0.01		0.65	J	2.13		J	0.16	
RM 11.9	8/30/94	14:00	6	14.4	6.6		0.1																		
RM 11.9	9/13/94	11:45	1	15.9	6.9	103	9.4		2.3		2.5			0.03			0.91		0.22		1.17			0.04	
RM 11.9	9/13/94	11:45	2	15.2	6.8	107	11.9																		
RM 11.9	9/13/94	11:45	3	14.4	6.7	120	6.7																		
RM 11.9	9/13/94	11:45	4	14.1	6.7	103	5.8		4.1		3.3		<	0.01			0.31		0.15		0.47			0.03	
RM 11.9	9/13/94	11:45	5	13.7	6.8	100	7.2	7.7																	
RM 14.1	8/30/94	12:40	0	16.8	6.9		7.6																		
RM 14.1	8/30/94	12:40	1	15.3	6.7	102	6.2		1.9		1.8		J	0.02		J	0.39		0.12	J	0.52		J	0.03	
RM 14.1	8/30/94	12:40	2	13.9	6.6		5.9																		
RM 14.1	8/30/94	12:40	3	11.4	6.5		3.4																		
RM 14.1	8/30/94	12:40	4	11.1	6.4	160	1.9	1.8	5.0		1.8		J	0.02		J	2.95		0.22	J	3.19		J	0.05	
RM 14.1	8/30/94	12:40	5	11.0	6.4		0.7																		
RM 14.1	9/13/94	10:52	1	14.8	6.9	100	7.1	6.8	2.1		2.2		<	0.01	0.02		0.29	0.31	0.11		0.41	0.41		0.03	0.03
RM 14.1	9/13/94	10:52	2	14.4	6.8	101	6.5																		
RM 14.1	9/13/94	10:52	3	14.0	6.8	101	5.5																		
RM 14.1	9/13/94	10:52	4	13.3	6.7	113	3.5		4.7		2.0			0.14			2.64		0.67		3.45			0.07	
RM 14.1	9/13/94	10:52	5	11.2	6.5	161	0.3																		

< Less than the reported result.

J Analyte was positively identified. The associated numerical result is an estimate (see Appendix A).

APPENDIX C

BLACK RIVER WET SEASON FIELD AND LABORATORY DATA

Paired results are replicate samples.

			FIELD DATA			LABORATORY DATA												
Station	Date	Time	Temp ° C	pH	COND µmho /cm	Turbidity NTU		NH3 mg/L		NO2/3 mg/L		TPN mg/L		ORG N mg/L	Fecal Coliform cfu/100 mL			
RM 11.9	11/16/94	9:30	7.4	6.8	108	1.6		0.058		0.864		1.26		0.34		20		
RM 11.9	11/29/94	10:15	5.4	7.2	78	1.7	2.0	0.035		0.743		0.92		0.14		110	S	120
RM 11.9	1/23/95	11:35	4.8	7.3	74	1.5		0.011		1.160		1.35		0.18		23		
RM 11.9	1/31/95	12:20	8.7	7.7	59	3.7		0.045		0.627		0.85		0.18	J	2400	J	2000
RM 11.9	3/5/95	11:25	6.7	7.1	71	1.7		0.010		1.190		1.47		0.27		150		
RM 12.0T	11/16/94	9:40	6.0	6.9	409	12		4.62		0.064		8.30		3.62	S	220	S	250
RM 12.0T	11/29/94	10:30	5.1	7.0	200	1.9		0.050		0.753		1.01		0.21		150		
RM 12.0T	1/23/95	11:50	3.7	6.8	154	3.9		0.688		0.197		2.59		1.71		29		17
RM 12.0T	1/31/95	12:30	9.5	7.4	86	2.8		0.145		0.427		1.10		0.53		820		
RM 12.0T	3/5/95	11:35	5.3	6.9	153	3.6		0.199		0.106	0.146	2.90	2.68	2.50		11		16
RM 12.8	11/16/94	9:15	7.5	6.9	100	1.5		0.041	0.047	0.701	0.704	1.04	1.02	0.29		14		9
RM 12.8	11/29/94	10:05	5.7	7.3	74	1.9		0.088		0.654		0.83		0.09		43		
RM 12.8	1/23/95	11:15	4.4	6.7	65	1.5		0.010		0.871		1.08		0.20		7		
RM 12.8	1/31/95	12:05	8.6	7.7	55	3.5		0.051		0.580		0.79		0.16	J	890	J	1000
RM 12.8	3/5/95	11:15	6.2	7.3	68	2.0		0.010		0.879		1.12		0.23	S	270		

< Less than the reported result.
S Spreader colony present; number reported is likely underestimated.
J Analyte was positively identified. The associated numerical result is an estimate (see Appendix A).

APPENDIX D: Results of Kruskal-Wallis Analysis of Data

Probability that no difference exists
Significance at alpha $\leq$ 0.05 shown in bold, for alpha $\leq$ 0.10 the ranking is shown.

DRY SEASON 1991, 1992, 1994 HISTORICAL COMPARISON AT RM 11.9 **

	Surface Layer		**Deep Layer**	
	alpha	ranking	alpha	ranking
Temperature	0.343		0.377	
pH	0.759		0.444	
Conductivity	0.885		0.304	
D.O	0.304		0.953	
Turbidity	0.298		0.213	
NH3	0.261		0.343	
NO2/3	0.807		0.501	
TPN	0.901		0.343	
T.Phos.	0.643		0.343	
TOC	1.000 †		0.564 †	

† TOCs were done in 1992 and 1994 at this site

DRY SEASON 1991, 1992, 1994 HISTORICAL COMPARISON AT RM 14.1 **

	Surface Layer		**Deep Layer**	
	alpha	ranking	alpha	ranking
Temperature	0.165		0.741	
pH	0.331		0.150	
Conductivity	0.165		0.729	
D.O	0.741		0.223	
Turbidity	1.000		0.221	
NH3	0.150		0.741	
NO2/3	0.223		0.368	
TPN	0.223		0.165	
T.Phos.	0.135		0.223	
TOC	0.301 ††			

†† TOCs done for this site in 1992 and 1994 for the shallow layer, 1994 only for the deep layer.

** In 1991 sampling occurred on three consecutive days, to assure sample independence for statistical analysis, data from this time period was averaged.

DRY SEASON 1994 Upstream (U) vs Downstream (D)

	Surface Layer alpha	**Deep Layer** alpha
Temperature	0.121	0.121
pH	0.121	0.439
Conductivity	0.121	1.000
D.O	0.121	1.000
Turbidity	1.000	1.000
NH3	1.000	1.000
NO2/3	0.121	0.121
TPN	0.121	0.121
T.Phos.	0.317	1.000
TOC	0.683	0.121

WET SEASON 1994\95 Upstream (U) vs Downstream (D)

	alpha	ranking
Temperature	0.691	
pH	0.716	
Conductivity	**0.016**	**RM 12.0T > RM 11.9 > RM 12.8 ***
Turbidity	0.074	RM 12.0T > RM 12.8 > RM 11.9
NH3	**0.026**	**RM 12.0T > RM 12.8 > RM 11.9 ***
NO2/3	**0.039**	**RM 11.9 > RM 12.8 > RM 12.0T ***
TPN	0.105	
FC	0.887	

* For conductivity, NH3, and NO2/3 a non-parametric Tukey-type multiple comparison test was done to determine which sites had the statistically significant (alpha = 0.05) difference in water quality. The results were as follows: significant difference in conductivity between RM 12.8 and RM 12.0T; in NH3 between RM 11.9 and RM 12.0T; and in NO2/3 between RM 11.9 and RM 12.0T.