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Water Quality Assessment in the Burley and Minter Creek Watersheds Kitsap and Pierce Counties, Washington

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Water Quality Assessment in the Burley and Minter Creek Watersheds Kitsap and Pierce Counties, Washington

by

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Abstract

Water quality was monitored in the major freshwater tributaries of Burley Lagoon and Minter Bay from December 1992 through March 1993. The objective was to evaluate water quality in the Burley and Minter Creek watersheds after 10 years of remedial action implementation. Elevated levels of fecal coliform bacteria (FC) continue to result in Class AA water quality violations throughout the watersheds. The mean FC levels at the mouths of Purdy and Minter Creeks were significantly higher in 1992-93 than baseline conditions in 1983. Mean FC levels at the mouth of Burley Creek and in the upper Minter watershed were twice as high in 1992-93, but the increase was not significant. Baseline (1988-89) FC levels in upper Purdy Creek were low, however, this was the only location where a statistically significant decrease in FC concentrations was identified. It appears that although Burley and Minter watersheds have a large percentage of rural acreage treated with best management practices, bacterial water quality has continued to decline in these freshwater systems. In October 1993, Burley Lagoon was upgraded for shellfish harvesting based on marine water quality data collected by the Department of Health.

Introduction

Background

Burley Lagoon and Minter Bay are located at the northern end of Henderson Bay in Carr Inlet, about ten miles northwest of Tacoma (Figure 1). Historically, both estuaries were productive commercial shellfish growing areas. In 1981, the commercial oyster beds in Burley Lagoon were reclassified from Approved to Restricted. In 1982, Minter Bay was reclassified from Approved to Prohibited. The reclassifications were based on water quality surveys performed by the Washington Department of Health (DOH) and United States Food and Drug Administration. The data documented levels of fecal coliform bacteria (FC) which exceeded the National Shellfish Sanitation Program standards for Approved commercial shellfish areas (DOH, 1993). Nonpoint pollution is thought to be the leading cause of water quality deterioration leading to shellfish harvest restrictions (Recreational Shellfish Committee, 1993).

In 1983 the Department of Ecology (Ecology) performed a comprehensive water quality monitoring study in both Burley and Minter Creek watersheds (Determan *et al.*, 1985). Determan identified freshwater tributaries as the primary source of the FC entering the estuaries. The sources of bacterial contamination were identified as failing on-site sewage systems, livestock sources from scattered small farms, and stormwater runoff.

After five years of watershed management and restoration efforts, the Bremerton-Kitsap County Health Department conducted a water quality survey in both watersheds based on Determan's sampling design (Struck 1990). Struck found that overall water quality in the project area had not improved significantly since 1983. However, a statistically significant improvement was found in the Bear Creek watershed. According to Struck, the improvement in this watershed was likely the result of intensive implementation of livestock best management practices (BMPs) and on-site septic system repairs. Population increases, changes of location and magnitude of contaminant sources, and failure to focus on priority areas were listed as possible causes for the lack of significant improvement in overall water quality.

Burley and Minter watersheds have received the most state funding for remedial actions of all the shellfish projects in Washington. As of August 1989, the watersheds also contained the greatest percentage (15%) of rural acreage treated with BMPs (Determan, 1993). Encouraged by the concentration of efforts in this watershed, Ecology's Southwest Regional Office of Water Quality and the Shorelands Program Planning Section requested that the Watershed Assessments Section evaluate current water quality in the Burley and Minter watersheds. The primary objectives for this evaluation were to: 1) monitor fecal coliform bacteria and total suspended solids (TSS) in freshwater tributaries to Burley Lagoon and Minter Bay; 2) compare these data to wet season data collected by Determan and Struck and; 3) evaluate whether remedial actions performed since the early 1980's have resulted in improved water quality in the watersheds.

Watershed Description

Both Burley Lagoon and Minter Bay are classified as AA marine water (WAC 173-201-085). The rearing, spawning and harvesting of clams, oysters, and mussels are included as beneficial uses to be protected by this classification. Burley and Minter Creeks, as well as their tributaries, are classed as AA waters by the fact that they are tributaries to Class AA marine waters (WAC 173-201-070). This classification provides the highest level of protection in the state water quality standards.

Each watershed covers approximately 10,000 acres, primarily in South Kitsap County (Figure 1). Small farms and residential tracts are scattered over a rural landscape with forested uplands. Much of the ongoing residential and recreational/non-commercial farm development is along the main tributaries. Growth continues to advance into the upland areas (Determan *et al.*, 1985; Struck, 1990).

Population growth and land development continue to affect both Burley and Minter watersheds. South Kitsap County and human population grew approximately 72% between 1970 -1980, and 28% between 1980 and 1990. Continued population growth in the South Kitsap area is expected, with an increase of 49% anticipated between 1990 and 2010 (KCDCD, 1993). Specifically, it is estimated that the Burley and Minter watersheds are experiencing a population growth of 2-3% per year (Parametrix, 1991).

Watershed soils are not well suited for conventional on-site sewage treatment and disposal systems (SCS, 1980). Unsuitable soils cover about 50 percent of the Minter watershed and 75 percent of the Burley/Purdy watershed. In general, these soils consist of a shallow upper layer of moderately permeable topsoil underlain by impermeable layers of cemented glacial till and/or clay. This results in seasonal perched water tables and saturated soil conditions throughout much of the period between December and April (Determan *et al.*, 1985).

For the last ten years, the Kitsap County Conservation District has been working with small farm owners to implement BMPs in the Burley and Minter watersheds. The most common BMPs in the watershed have been stream fencing, installation of gutters and downspouts, riparian restoration, reseeding and replanting, animal waste management, maintenance of BMPs, and education. Recent remedial efforts have been concentrated in the upper Burley Creek watershed (Garitone, 1993). At least 80

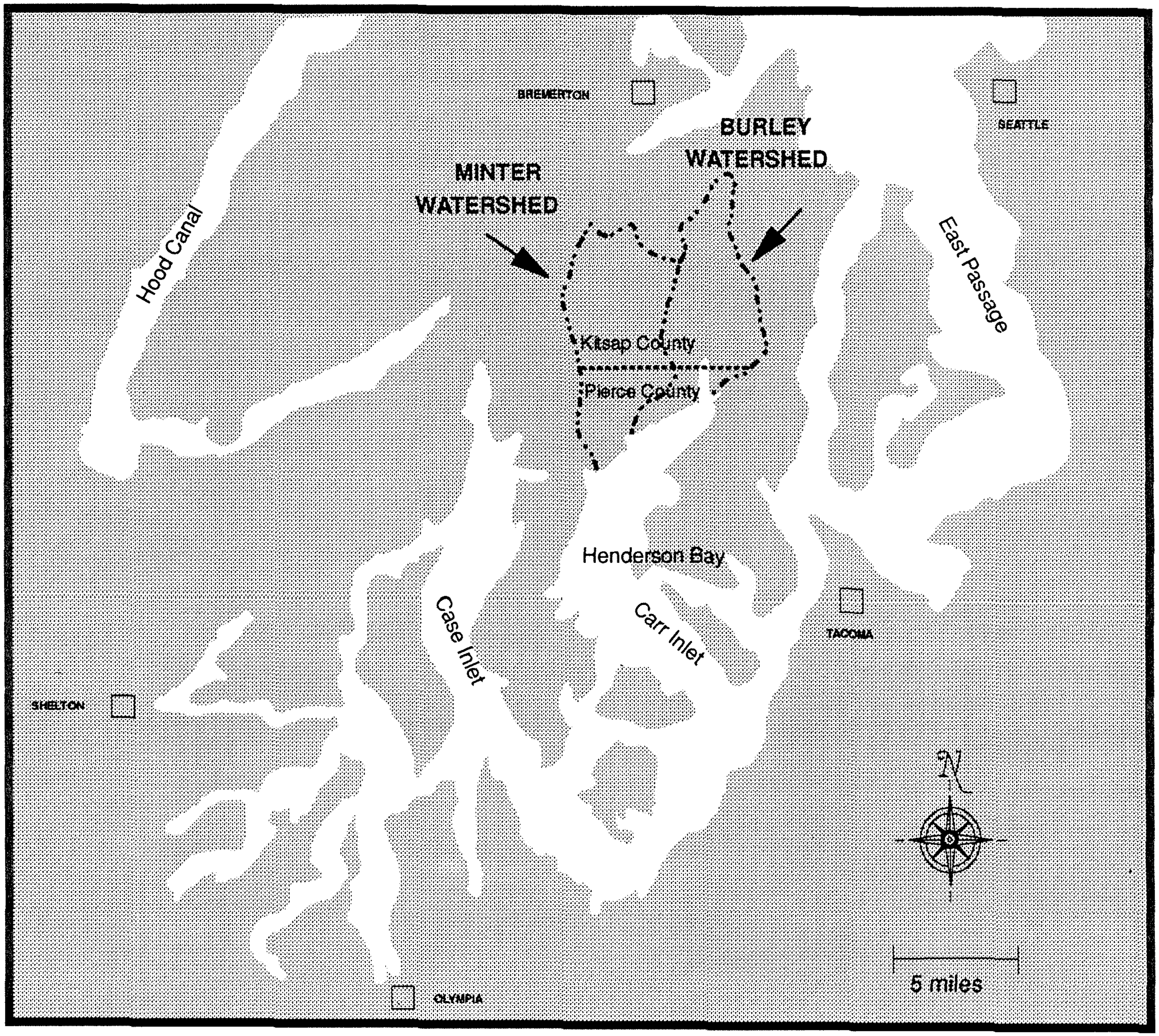

Figure 1. Southern Puget Sound showing Burley and Minter Watersheds.

BMPs were installed in the Burley Lagoon watershed during the 1991-1992 grant period. Efforts were also focused in completing corrections associated with the sewer line at the Purdy Shopping Center (DOH, 1993).

Methods

Site Selection

Twenty one freshwater stations were monitored from December 1992 through March 1993 in the Burley and Minter watersheds (Figures 2 and 3). Monitoring locations were selected based on historic water quality sites (Determan *et al.*, 1985; Struck 1990). Site names are representative of location, where letters designate the sub-watershed and numbers represent location relative to the mouth of the creek. For example, site B1 is located at the mouth of Burley Creek and B2 is the next upstream site.

Sampling Methods

It was not possible to sample 21 stations in one day. Therefore, the tributary mouth "core" sites in both watersheds were sampled weekly and the tributary segment stations were sampled every other week. This schedule allowed each entire watershed to be sampled twice a month. Sampling at sites M1 and P1 was scheduled to avoid tidal influence.

When possible, stream flow was measured at each site using a Marsh McBirney current meter. Additionally, stage height was recorded at staff gauges installed by Ecology at sites B2, BR1, P1, and M2. Stage height was also recorded at the Kitsap County staff gage located at site B1 and at the USGS gage at site H1.

Mid-channel grab samples were collected for FC and TSS. FC samples were collected in 250 mL sterilized glass bottles. TSS samples were collected in laboratory-cleaned 1,000 mL polypropylene bottles. Samples were immediately put in coolers containing ice and delivered within 24 hours to the EPA/Ecology Laboratory in Manchester, Washington.

Sample processing and analysis conformed to procedures described by Huntamer (1986). Bacteria samples were analyzed using the membrane filter technique (APHA method #922D); TSS were filtered and weighed following APHA method #254OD. All analyses were performed within established holding times.

BURLEY WATERSHED

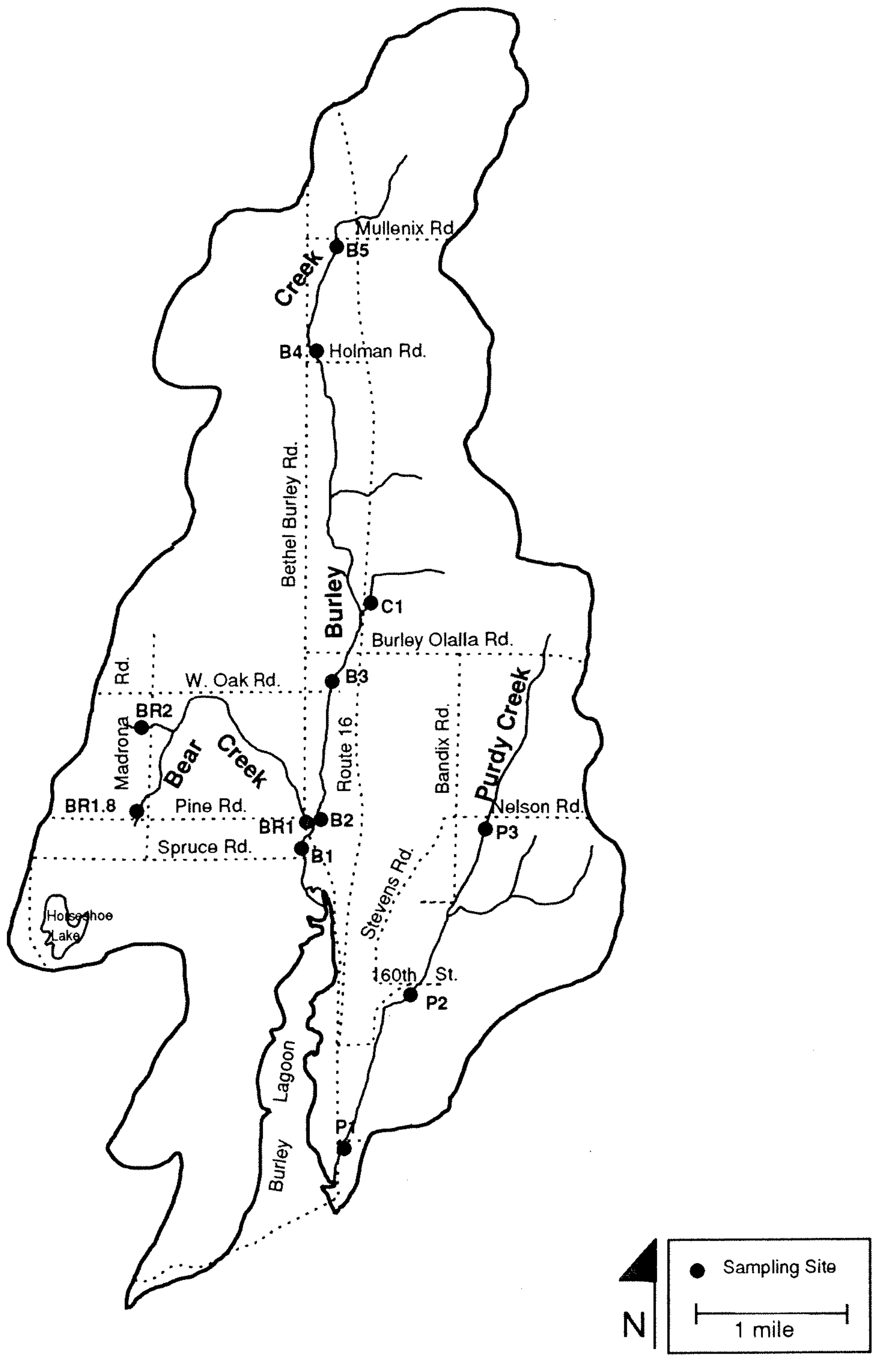

Figure 2. Station locations for the water quality monitoring study in Burley Watershed 1992-93.

MINTER WATERSHED

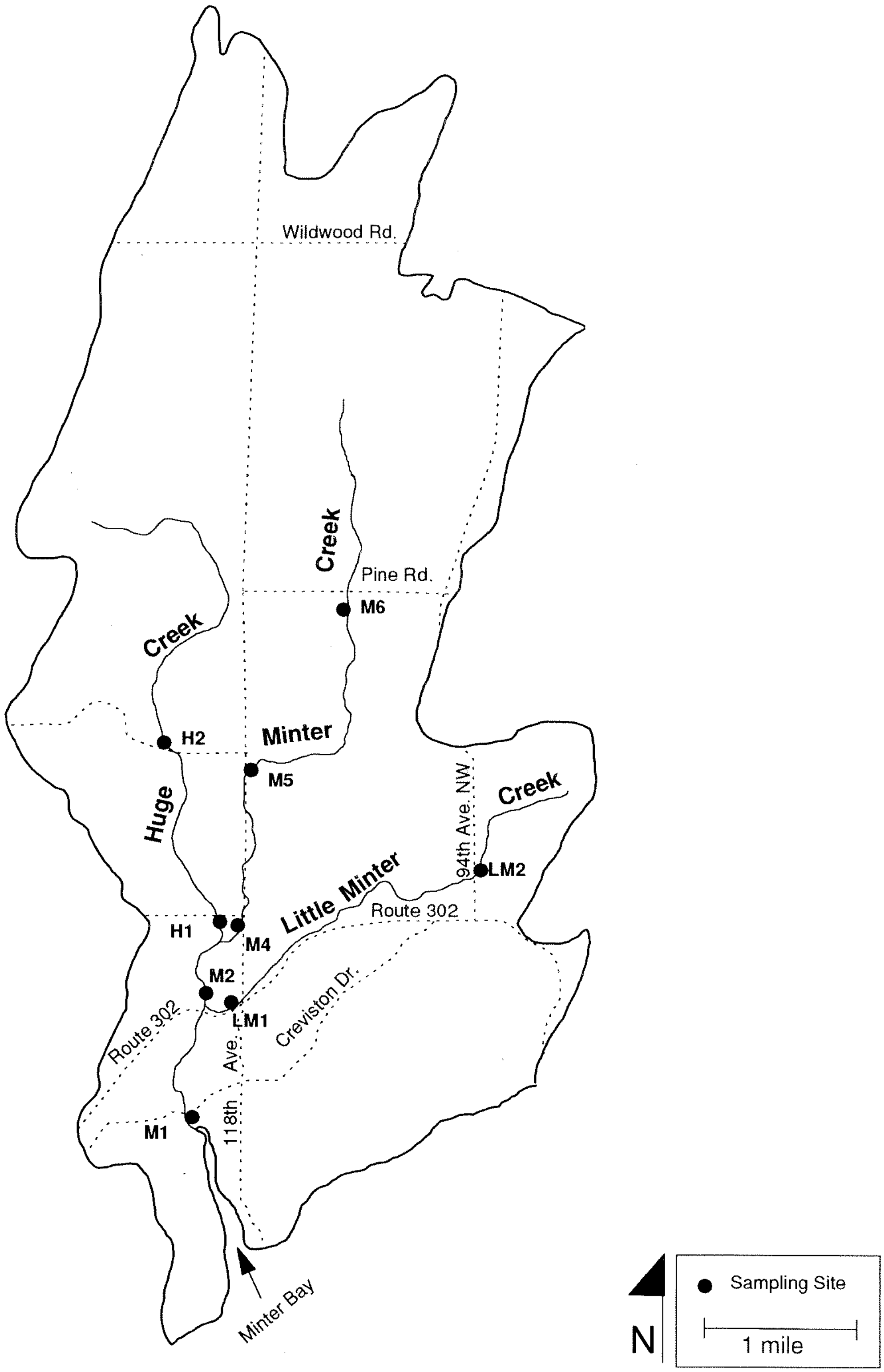

Figure 3. Station locations for the water quality monitoring study in Minter Watershed 1992-93.

A storm event was monitored on December 7-9, 1992. On December 7, the entire Burley watershed and the core Minter stations were sampled. Sampling on the following two days was limited to the Burley watershed. Monitoring was performed in coordination with DOH sampling of Burley Lagoon.

Replicate samples and flow measurements were taken at 10 percent of the sites to assess both field and laboratory variability. The sites were selected randomly each week.

A relatively unimpacted site (C1) was monitored as a control for water quality comparison. This is the same control site used in Determan's 1983 survey. The site is located on State School Land in a small Burley Creek sub-watershed. The forested upper watershed was harvested 5 years ago and has since regrown. There are only a few scattered houses in the upper watershed (Garitone, 1993).

Site BR2 was originally selected as an upstream site on Bear Creek. However, in February 1993 Determan assisted in field work and recognized that the site was improperly placed. Sampling at BR1.8, the correct upstream location, began in March 1993.

Precipitation data for 1992-93 were obtained from Washington State Department of Fish and Wildlife personnel at the Minter Creek Salmon Hatchery. Rainfall is measured at the hatchery with established National Oceanographic and Atmospheric Administration (NOAA) station equipment. NOAA rain data for 1983, 1988, and 1989 were obtained through Earth Info, Inc (1992).

Considerations in Data Analysis

Data Analysis 1992-93

Data collected on consecutive days were considered to be autocorrelated. Therefore, only data collected on the first day of a series were used for further analyses.

When flow was not measured in the field, discharge estimates were calculated using rating curves or by establishing correlations between discharge at paired sites. The estimated values were used in calculations. These values are flagged in Appendix A with an "E" qualifier.

Flow at site B1 was difficult to measure accurately due to deep and irregular channel morphology. Therefore, discharge data from Kitsap County were used for this site (LeCuyer, 1993).

All data were reviewed and accepted with associated lab qualifiers. Replicate values were averaged and the resulting values used in subsequent calculations; geometric means were reported for fecal coliform bacteria. Relative percent difference (RPD), the difference between two replicates expressed as a percentage of their mean, was used to compare replicate values. Results are illustrated in Appendix B using a box plot. High variability was seen with the December 21 replicate pair for bacteria at site B2 (600 coliform forming units [cfu]/100mL and 150 cfu/100mL). These data were accepted under the assumption that the high RPD was due to environmental variability. Other replicates had artificially high RPDs which resulted when individual values approached one, e.g., replicate FC values of 1 cfu/100 mL and 7 cfu/100 mL result in an RPD of 150.

The Minter Hatchery rain gauge was read daily at 8:00 AM and represents 24 hour precipitation from 8:00 AM the previous day. This is different than rain data for most other NOAA stations which report the 24 hour rainfall from midnight to midnight of the given date. Additionally, hourly rain data were not available. Forty-eight hour rain data were used for analysis in this report, i.e. 48 hour rain is precipitation that fell on the sampling day, plus the rain that fell the previous day. We felt that this measure best characterized the hydrologic characteristics of the watersheds.

Violation of the FC Class AA water quality standard was used as the primary criterion to characterize 1992-93 water quality within each watershed. The Class AA standard for FC in freshwater states that "fecal coliform organism levels shall both not exceed a geometric mean value of 50 colonies/100 mL and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL." The emphasis on both in the criterion signifies that either a geometric mean exceedance or 10% frequency exceedance yields a violation of the water quality standards.

Historical Data Analysis

For comparison of our data to historical data only wet season data were used from the earlier studies; the wet season was defined as November through April. Data from our study were collected bimonthly between December 1992 and March 1993 (Appendix A). Determan's data include monthly to twice monthly samples collected from January-April 1983 and November-December 1983 (Appendix C). Struck's data include monthly to twice monthly samples taken from January through March of both 1988 and 1989 (Appendix D).

Fecal coliform, discharge, and TSS data from 1992-93 were compared to the earliest baseline data set (*i.e.*, either 1983 or 1988-89 data). Appendix E identifies which sites were compared from each data set. Log transformed FC and discharge data were normally distributed (Systat, 1990), therefore, log transformed data and parametric statistics were used for analysis. TSS data were not normally distributed;

the non-parametric Kruskall-Wallis test was used when analyzing these data. Samples for TSS were not collected in 1988-89.

Discharge was significantly lower in 1992-93 at 50 percent of the monitoring sites when compared to baseline data (independent T-test, $p <= 0.05$). To remove the influence of discharge, an Analysis of Covariance (ANACOVA) was used to compare FC between the years. Preliminary data analysis was performed to determine whether appropriate assumptions were met (Appendix F) before applying this test (Kleinbaum, Kupper, and Miller, 1988). Sites P1, M1, and M4 were the only sites that met all necessary assumptions. An independent T-test was used to compare FC data for the remaining sites. Significance was determined at $p <= 0.05$.

Results and Discussion

Precipitation

Wet Season 1992-93

The data collected during the 1992-93 study did not represent typical wet season conditions. Precipitation in the Burley and Minter watersheds was 41% below the 30-year average for December 1992 through March 1993 (Appendix G). Routine sampling events occasionally coincided with "rain events," however, as a result of our sampling design, data were not collected at all sites during any given rain event.

Historical Comparison

Precipitation varied within and between study periods (Appendix G). The wet season rainfall during the Determan study was 32% greater than the 30-year monthly average whereas the rainfall during the 1988-89 and 1992-93 wet seasons were 26% and 41% lower than the 30-year monthly average, respectively. It was not surprising that discharge was often significantly lower in 1992-93 when compared to baseline data (Table 1).

Water Quality

Burley Watershed 1992-93

Violations of the FC Class AA standard were identified throughout the Burley Creek watershed (Table 2). Of particular note is the lower reach of Burley Creek (sites B1 and B2), where both parts of the standard were exceeded (Table 2; Figure 4). Poor water quality in the lower Burley Creek watershed could be due to the transition into poorer soils, lack of focused BMPs, and increased proximity to the town of Burley where septic failures may be a problem. Sources affecting water quality appear to be

Table 1. Discharge summary statistics for Burley and Minter Watersheds. Data from the 1992-93 water quality monitoring study are compared to baseline data.

Burley Watershed

Site	Year	Discharge (cfs) sample size	min	max	G. Mean	
B1	1983	10	12.2	48.2	25.6	
	1993	16	18.1	111.2	26.1	
B2	1983	8	27.0	58.1	40.6	
	1993	17	12.5	58.2	18.0	*
B3	1988-89	5	13.7	33.1	20.2	
	1993	9	11.2	38.3	12.6	
B4	1988-89	5	5.1	10.4	6.8	
	1993	9	3.9	13.4	5.0	
B5	1988-89	2	2.8	9.4	5.1	
	1993	9	1.2	7.3	1.9	
P1	1983	10	7.3	21.1	13.1	
	1993	17	2.5	39.5	5.5	*
P2	1988-89	3	4.1	9.7	6.0	
	1993	11	0.5	11.1	2.3	*
P3	1988-89	1	2.0	2.0	2.0	
	1993	12	0.6	4.9	1.0	
BR1	1983	8	4.8	14.3	9.1	
	1993	17	1.5	17.0	4.3	*
BR1.	1983	6	0.2	1.5	1.5	
	1993	4	0.2	3.0	2.7	
BR2	1993	9	0.1	0.9	0.2	
C1	1983	8	0.5	1.7	0.9	
	1993	9	0.2	1.0	0.6	

Minter Watershed

Site	Year	Discharge (cfs) sample size	min	max	G. Mean	
M1	1983	10	28.9	168.6	57.8	
	1993	14	17.3	103.3	28.1	*
M2	1988-89	2	27.2	47.5	36.0	
	1993	17	16.7	94.9	24.6	
M4	1983	10	15.7	66.1	28.8	
	1993	8	6.5	41.4	13.2	*
M5	1988-89	4	9.5	25.3	12.8	
	1993	8	4.4	39.2	10.2	
M6	1988-89	4	4.1	24.5	8.9	
	1993	8	2.2	29.8	5.5	
LM1	1983	10	2.1	20.0	4.6	
	1993	17	0.4	12.7	1.3	*
LM2	1983	10	0.6	11.5	2.6	
	1993	8	0.4	6.3	0.9	*
H1	1983	10	10.8	82.0	23.9	
	1993	16	4.2	28.9	6.6	*
H2	1988-89	2	9.3	14.3	11.5	
	1993	8	2.6	12.7	4.5	*

* = Statistically different geometric means (independent T-test, $p <= 0.05$)

Table 2. Mean fecal coliform bacteria levels in Burley Creek Watershed as compared to the Class AA water quality criterion.

Site	Sample Size	FECAL COLIFORM BACTERIA (cfu/100 mL) Geometric Mean	#Samples >100	%Samples >100
Burley Creek				
B1	16	170 *	10	63 **
B2	16	120 *	8	50 **
B3	9	27	1	11 **
B4	9	24	1	11 **
B5	9	10	1	11 **
Purdy Creek				
P1	16	24	2	13 **
P2	11	12	2	18 **
P3	10	6	1	10
Bear Creek				
BR1	16	47	3	19 **
BR1.8	4	14	1	25 **
BR2 (tributary)	9	5	0	0
Control Creek				
C1	9	2	0	0

* Exceeds the first part of the Class AA criterion
** Exceeds the second part of the Class AA criterion

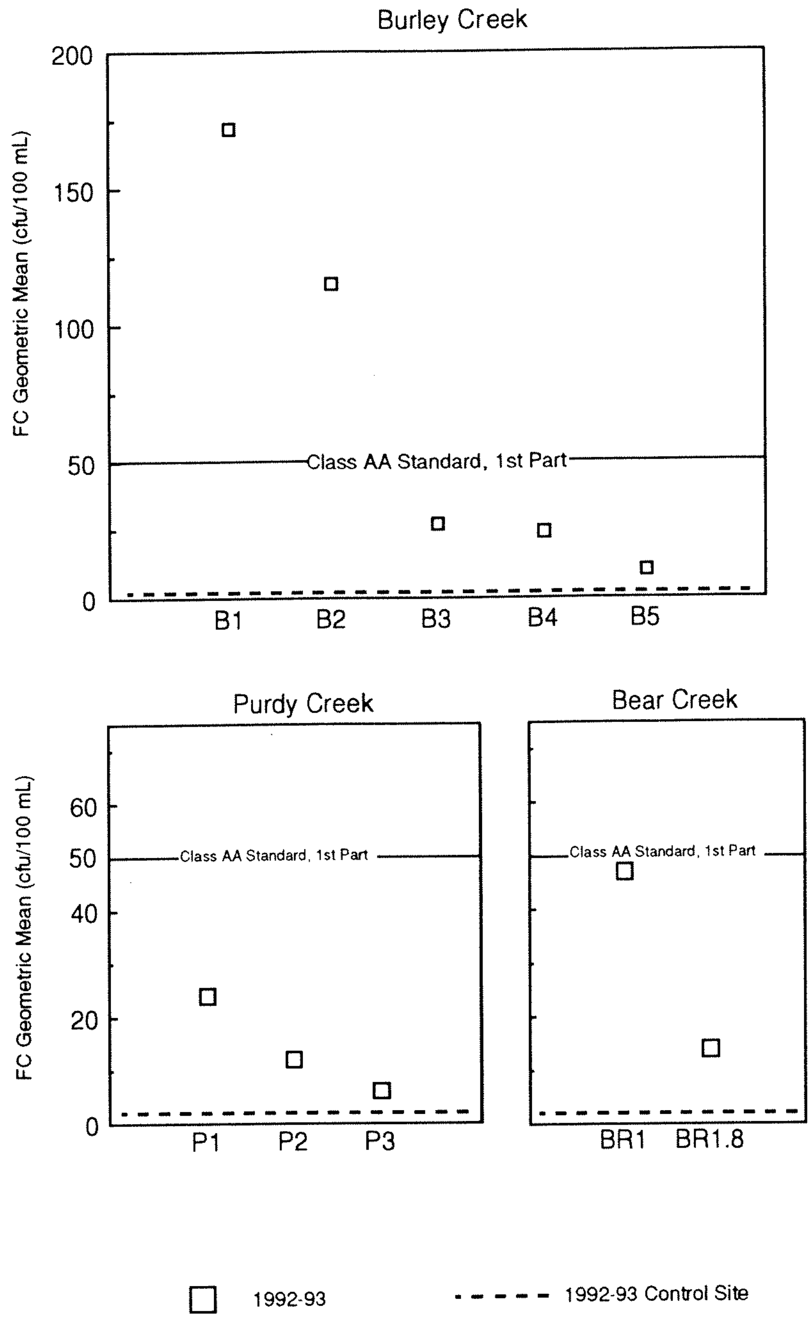

Figure 4. Comparison of geometric mean fecal coliform bacteria (FC) levels in the Burley Watershed during the 1992-93 water quality monitoring study.

located primarily below site B3. In general, the upper watershed (sites B3, B4, and B5) had low FC levels except during rain events, when the watershed responded with FC peaks exceeding 100 cfu/100 mL (Appendix A). This resulted in violations of the second part of the water quality standard.

Fecal coliform levels were relatively low in Purdy Creek except during rain events when high peak values led to excursions of the second part of the standard at sites P1 and P2. The upper reach site (P3) did not exceed the standard, however FC levels increased during rain events on December 8 (71 cfu/100 mL) and January 20 (200 cfu/100 mL) (Appendix A). Total suspended solids were comparatively high in upper Purdy Creek even during low rain fall. The source for this is unclear, however, tree thinning operations have been occurring in the upper watershed (Garitone, 1993).

The water quality standard for FC was exceeded on the mainstem of Bear Creek, with more than 10 percent of the samples exceeding 100 cfu/100 mL. The small tributary sampled on Bear Creek (BR2) did not exceed the water quality standard for FC. On February 9, 1993, while performing routine sampling at the mouth of Bear Creek (BR1), the water turned opaque brown with sediment. Road maintenance activity was the source (Dickes, 1993). Kitsap County was performing routine dredging of roadside ditches in the area. The ditch along Bethel-Burley Road was draining into Bear Creek, resulting in a mean TSS concentration of 160 mg/L. The NWRO contacted Kitsap County to express concern regarding ditch dredging during the wet season (Wright, 1993). A TSS concentration of similar magnitude was also found on March 22, 1993, during a rain event. This most likely resulted from the resuspension of sediment deposited during earlier dredging activities.

Low FC levels found in the control creek resulted in a mean FC value of 2 mg/L. Upstream sites in Burley, Purdy, and Bear Creeks also had low mean FC values (Figure 4). However, the maximum FC level in the control creek (24 cfu/100 mL, collected during a rain event) was only half the maximum value found at these other upstream locations.

In general, both FC and TSS concentrations increased during rain events. This was particularly obvious at downstream sampling locations. For example, at site B1 at the mouth of Burley Creek, FC concentrations increased from 48 cfu/100 mL on January 11 (0 inches of rain) to approximately 1,000 cfu/100 mL on January 20 (1.95 inches of rain); corresponding TSS concentrations increased from 4 mg/L to 64 mg/L (Appendix A). These elevated concentrations are likely due to direct runoff, bank erosion, and sediment resuspension.

A three-day storm event was monitored in the Burley Creek watershed on December 7-9, 1992. The three consecutive days featured 0.25, 0.75, and 0.35 inches of rain, respectively. Elevated FC and TSS levels were seen primarily on the second day, with increased precipitation and discharge. Levels decreased on the following day as rain subsided. Again, increased FC and TSS concentrations were likely the result of increased runoff into the creeks, eroding stream banks, and resuspension of bottom sediment.

While the data from this study were being analyzed, DOH upgraded Burley Lagoon to Conditionally Approved. The upgrade was based on data collected from sanitary shoreline surveys in the Lagoon as well as samples taken from Burley and Purdy Creek mouth sites (DOH, 1993). Their data suggested that declines in water quality were linked to rain. The upgrade will allow commercial harvesting in Burley Lagoon except during a period of 5 days following a 24-hour rainfall of 0.5 inch or greater (DOH, 1993).

Minter Watershed 1992-93

Violations of the Class AA standard were also identified throughout the Minter Creek watershed (Table 3; Figure 5). Concentrations were particularly high during rain events. Water quality declined in upper Minter Creek in the reach between sites M5 and M6. Both parts of the water quality standard were exceeded at sites M4 and M5. According to the Kitsap County Conservation District (Garitone, 1993), BMPs have been focused along Minter Creek between sites M4 and M5 and may be the cause for the lower concentrations at the downstream site (M4). However, problem areas identified between sites M5 and M6 have not yet been addressed by the Conservation District (Garitone, 1993).

More than 10% of the samples collected at both sites in Little Minter Creek were greater than 100 cfu/100 mL. Again, elevated levels occurred during rain events. The highest FC count (5,600 cfu/100 mL) found in both Burley and Minter Creek watersheds during our study was collected at the upper Little Minter Creek site (LM2) during the rain event on March 22, 1993. Mean bacteria levels were higher in the upper watershed than in the lower watershed, unlike other creeks in the study. This pattern on Little Minter Creek has also been documented in other studies, with the source identified as poor stock management (Determan *et al.*, 1985; Struck, 1990; TPCHD, 1990).

FC levels were low in Huge Creek except during rain events. Elevated FC levels in the upper watershed on March 22, 1993, resulted in a FC standard violation.

Historical Data Comparison for Burley Watershed

The mean fecal coliform bacteria level at the mouth of Burley Creek (site B1) was greater in 1992-93 than in 1983, though not significantly ($p=0.06$, see Table 4). The decline in water quality in the lower reaches of Burley Creek may reflect the lack of

Table 3. Mean fecal coliform bacteria levels in Minter Creek Watershed as compared to the Class AA water quality criterion.

Site	Sample Size	FECAL COLIFORM BACTERIA (cfu/100 mL) Geometric Mean	#Samples >100	%Samples >100
Minter Creek				
M1	14	28	3	21 **
M2	16	33	3	19 **
M4	8	60 *	2	25 **
M5	8	99 *	3	38 **
M6	8	12	1	12 **
Little Minter				
LM1	16	20	2	12 **
LM2	8	41	2	25 **
Huge Creek				
H1	16	11	1	6
H2	8	7	1	12 **

* Exceeds the first part of the Class AA criterion

** Exceeds the second part of the Class AA criterion

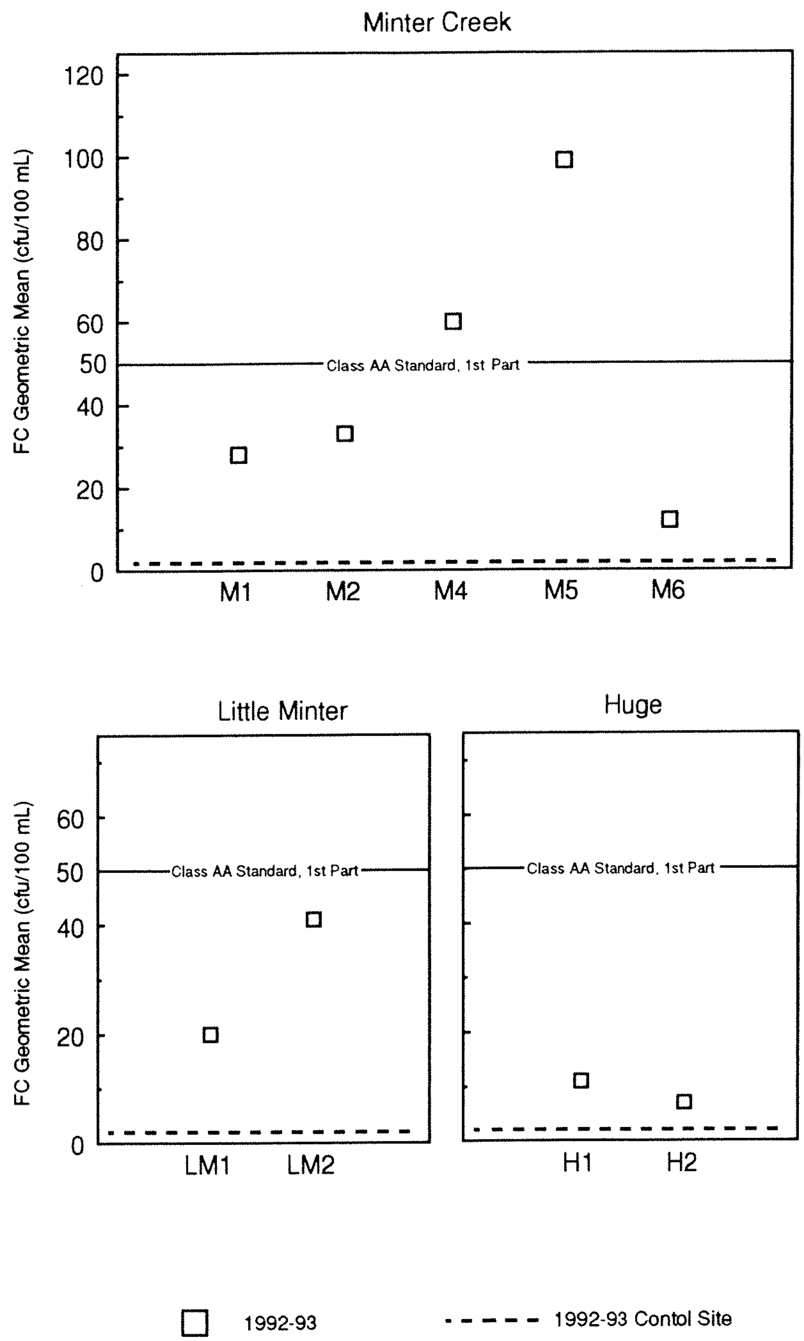

Figure 5. Comparison of geometric mean fecal coliform bacteria (FC) levels in the Minter Watershed during the 1992-93 water quality monitoring study.

Table 4. Geometric mean values for fecal coliform bacteria at sites where there was a significant difference between 1992-93 and baseline data. Geometric mean values are flow-adjusted at sites which were statistically tested by ANACOVA. Sample size is in parenthesis.

FECAL COLIFORM BACTERIA
(geometric mean cfu/100mL)

Site	1992-93		Baseline 1983		Baseline 1988-89		Statistical Test	Significance Level
Burley Creek								
B1	170	(16)	76	(10)	-	-	t-test	0.06 *
Purdy Creek								
P1	41	(16)	16	(11)	-	-	ANACOVA	0.04
P3	6	(10)	-	-	22	(4)	t-test	0.03
Minter Creek								
M1	45	(14)	13	(10)	-	-	ANACOVA	0.01
M4	110	(8)	18	(10)	-	-	ANACOVA	< 0.01
M5	99	(8)	-	-	38	(5)	t-test	0.06 *

* These sites are not significant at p<=0.05, however, due to the proximity to the significance level they warrant attention. All other sites which were not p<=0.05 had p> 0.20.

focused source controls, compounded by poor soils. It was not possible to adjust the FC data for flow using ANACOVA due to violations of test assumptions.

Table 5 shows that mean FC concentrations at site B2 were almost twice as high in 1992-93 as compared to 1983, but this difference was not statistically significant (p=0.28). Stream discharge was significantly lower in 1992-93 then in 1983, which would have led us to expect lower fecal coliform concentrations resulting from reduced runoff. However, it was not possible to adjust the FC data for flow using ANACOVA due to violations of test assumptions.

Upper Burley Creek watershed (sites B3, B4, B5) had lower or similar mean bacteria levels in 1992-93 when compared to baseline (Table 5). However, these apparent improvements in FC counts were not statistically significant. Recent remedial efforts have been concentrated in the upper Burley Creek watershed (Garitone, 1993).

Mean FC levels in lower Purdy Creek (sites P1 and P2) appear to be similar between the years (Table 5). However, discharge was found to be significantly lower in 1992-93 at both sites. An ANACOVA was performed for site P1 to adjust for the effects of discharge. Flow-adjusted FC means at this site were in fact significantly higher in 1992-93 (Table 4).

Mean FC values at site P3 in the upper Purdy watershed decreased from 22 cfu/100 mL in 1988-89 to 6 cfu/100 mL in 1992-93 (Table 5). Although the baseline value was relatively low, this was a statistically significant decrease. Reasons for the decrease may be due to natural variation: there have not been any concentrated efforts to reduce FC sources in this area (Garitone, 1993). Discharge could not be evaluated due to lack of baseline data.

There were no significant differences in TSS data between 1993 and 1983 at any of the sites in Burley Creek watershed (Table 6).

Historical Data Comparison for Minter Watershed

Mean FC levels in Minter Creek were significantly higher in 1992-93 when compared to baseline data at both the mouth site (M1) and an upper watershed site (M4). Fecal coliform bacteria levels at site M5 were twice as high in 1992-93 when compared to 1988-89 baseline data, however, the increase was not significant (p=0.06). Statistical test results are summarized in Table 4. Mean FC levels at the mouth of Minter Creek appear to be similar during 1992-93 and 1983 (Table 5). However, discharge was found to be significantly lower in 1992-93. An ANACOVA was used to adjust mean FC results for discharge at sites M1 and M4. Flow-adjusted means at both sites were significantly higher in 1992-93 compared to 1983.

Table 5. Fecal coliform summary statistics for Burley and Minter Watersheds. Data from the 1992-93 water quality monitoring study are compared to baseline data.

Burley Watershed

Site	Year	Fecal coliform (cfu/100 mL)			
		sample size	min	max	G. Mean
B1	1983	10	18	380	76
	1993	16	40	1900	172
B2	1983	8	17	380	66
	1993	16	29	1500	115
B3	1988-89	5	34	180	62
	1993	9	6	1000	27
B4	1988-89	5	3	130	24
	1993	9	5	210	24
B5	1988-89	5	6	170	20
	1993	9	1	300	10
P1	1983	11	6	230	32
	1993	16	6	1500	24
P2	1988-89	5	2	82	15
	1993	11	2	290	12
P3	1988-89	4	7	84	22
	1993	10	1	200	6
BR1	1983	8	7	870	76
	1993	16	4	1400	47
BR1.	1983	7	2	51	9
	1993	4	1	290	14
BR2	1993	9	1	67	5
C1	1983	8	< 1	13	2
	1993	9	1	24	2

Minter Watershed

Site	Year	Fecal coliform (cfu/100 mL)			
		sample size	min	max	G. Mean
M1	1983	10	4	120	24
	1993	14	4	240	28
M2	1988-89	2	5	71	19
	1993	16	9	200	33
M4	1983	10	4	100	29
	1993	8	23	400	60
M5	1988-89	5	13	110	38
	1993	8	49	270	99
M6	1988-89	5	4	60	17
	1993	8	1	294	12
LM1	1983	10	3	140	31
	1993	16	4	600	20
LM2	1983	10	2	140	19
	1993	8	5	5600	41
H1	1983	10	6	70	16
	1993	16	1	660	11
H2	1988-89	3	2	51	14
	1993	8	1	290	7

Table 6. TSS summary statistics for Burley and Minter Watersheds. Data from the 1993 water quality monitoring study are compared to baseline data. TSS data were not collected in 1988-89.

Burley Watershed

Site	Year	TSS (mg/L) sample size	min	max	median
B1	1983	10	2	20	7
	1993	16	3	150	6
B2	1983	8	1	18	7
	1993	16	4	150	6
B3	1993	9	1	30	5
B4	1993	9	1	19	4
B5	1993	9	1	10	2
P1	1983	11	1	8	3
	1993	16	1	71	2
P2	1993	11	1	16	2
P3	1993	10	1	22	11
BR1	1983	8	3	34	9
	1993	16	2	160	5
BR1.	1983	7	1	3	1
	1993	4	1	7	2
BR2	1993	9	1	11	3
C1	1983	8	2	11	5
	1993	9	2	10	4

Minter Watershed

Site	Year	TSS (mg/L) sample size	min	max	median
M1	1983	10	1	18	7
	1993	14	1	67	5
M2	1993	16	1	54	4
M4	1983	10	1	17	6
	1993	8	3	100	5
M5	1993	8	1	65	5
M6	1993	8	1	43	2
LM1	1983	10	2	12	7
	1993	16	1	52	2
LM2	1983	10	1	3	2
	1993	8	1	9	2
H1	1983	10	1	11	3
	1993	16	1	45	1
H2	1993	8	1	35	2

Fecal coliform bacteria levels were not significantly different in 1992-93 when compared to baseline data in either Huge Creek or Little Minter Creek. However, all of the sites monitored on these creeks had significantly lower discharge in 1992-93. Unfortunately, the data did not meet the assumptions for ANACOVA, so statistical comparisons of flow-adjusted means could not be performed.

Like the Burley Creek watershed, Minter Creek watershed showed no significant differences in TSS data between 1992-93 and 1983 at any of the sites.

Conclusions

- The primary objectives of the water quality study conducted in Burley and Minter watersheds were to monitor FC and TSS levels during the 1992-93 wet season and compare results to wet season baseline data collected in 1983 or 1988-89. However, due to low precipitation in 1992-93, these data do not reflect typical runoff conditions. Data collected in 1992-93 most likely under represent potential bacterial load.

- Violations of the Class AA water quality standard for FC were found throughout the Burley and Minter watersheds in 1992-93. Elevated concentrations occurred primarily during rain events. Conditions were particularly poor in the lower reaches of Burley Creek and Purdy Creek and in the upper reaches of Minter Creek. The mean FC levels in the lower reaches of Purdy and Minter Creeks were significantly greater in 1992-93 when compared to baseline wet season data.

- Upper Purdy Creek was the only location where a significant decrease in FC levels was detected relative to earlier years. The reason for the decrease is unclear since nonpoint source control efforts have not been focused in this area.

- Little Minter Creek was the only tributary with higher concentrations in the upper watershed. This same situation has been identified in past water quality studies.

- Significant increases in mean FC levels may have been detected at other locations in the Burley and Minter watersheds if discharge had been similar between the study years.

- There has been a concentrated effort to implement agricultural BMPs in the Burley and Minter Creek watersheds over the last 10-year period. This study did not document significant improvements in water quality. It appears that remedial efforts in the watershed are only slowing the degradation rate in the face of continued bacterial pollution sources, growth, and development in the watersheds.

- There were no marine water samples taken during the 1992-93 Ecology study and therefore no conclusions can be directly made regarding improvements to either Burley Lagoon or Minter Bay. Improvements from the correction of the on-site septic system at the Purdy Shopping Center also could not be deduced from this study.

Recommendations

- Point source controls have been focused in the Burley and Minter Creek watersheds, however, water quality continues to decline, particularly during rain events. Water quality protection will require additional controls on growth and development, and nonpoint sources in the watersheds.

- The 1992-93 water quality investigation was not designed to identify the effectiveness of specific BMPs or the effect of BMPs at individual locations. Regular monitoring of FC levels and TSS concentrations performed upstream/downstream and before/after BMP implementation should be a priority. This would provide important data regarding the effectiveness of site-specific BMPs and may assist in identifying new bacterial sources to the system.

- Future wet season monitoring of nonpoint pollution should specifically target rain events. This would provide a better representation of FC and TSS loading into surface waters.

- Continue to implement and maintain agricultural BMPs in both Burley and Minter Creek watersheds. Funding for BMP implementation and maintenance should be a priority.

- On-site sewage system surveys and repairs, as well as a regular maintenance program, should be a priority in the Burley and Minter Creek watersheds. Funding for alternative on-site sewage systems which offer more advanced treatment may be necessary due to poor soil conditions.

- Agricultural BMP implementation and sewage system surveys should be focused in the lower reaches of Burley Creek between sites B1 and B3, and upper Minter Creek between sites M4 and M6. Source identification, correction, and maintenance should be a priority in these areas.

- Sources for fecal coliform bacteria contamination should be investigated and appropriate source controls implemented and maintained in upper Little Minter Creek.

- Reduce sediment delivery to ditches. Limit dredging of ditches to dry weather.

- Funding for public education should also be a priority. Education will enhance remedial efforts toward continued water quality improvements.

- The Department of Health should be contacted to discuss the findings of this study.

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Appendices

Appendix A. Data for the Burley and Minter Watersheds, December 1992-March 1993.

DATE	LAB #	TIME	SITE		DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
Burley Watershed Data									
07-Dec-92	508501	915	B1		19.6	0.73	240	5	0.36
08-Dec-92	508518	940	B1		30.4	1.05	220	37	1.00
09-Dec-92	508529	1023	B1		29.6	1.03	50 J	9	1.09
14-Dec-92	508552	1305	B1		24.8	0.90	57 X	8	0.07
21-Dec-92	528083	1233	B1	R	24.8	0.90	84	4	0.17
21-Dec-92	528094	1233	B1	R	24.8	0.90	100	5	0.17
28-Dec-92	18092	1234	B1		25.8	0.93	160	8	0.34
04-Jan-93	28133	1026	B1		22.8	0.84	53	5	0.25
11-Jan-93	38092	1525	B1		18.3	0.68	48	4	0.00
20-Jan-93	48135	920	B1		80.1	1.76	1000 >	64	1.95
25-Jan-93	58140	1350	B1		111	2.00	450 X	50	2.80
08-Feb-93	78135	850	B1		20.7	0.77	320	4	0.11
09-Feb-93	78157	1135	B1		18.8	0.70	29	5	0.45
16-Feb-93	88130	1030	B1		18.1	0.67	64	6	0.00
22-Feb-93	98140	1320	B1		19.4	0.72	240	6	0.21
02-Mar-93	108135	1005	B1		18.3	0.68	120	3	0.40
08-Mar-93	118139	1310	B1		18.8	0.70	40	4	0.00
15-Mar-93	128135	1105	B1		19.9	0.74	180	6	0.26
22-Mar-93	138140	1250	B1		64.4	1.60	1900	152	2.34
30-Mar-93	148135	1040	B1		19.9	0.74	330	8	0.15
03-Dec-92	--	1155	B2		13.7	0.42	--		0.00
07-Dec-92	508502	928	B2		13.2 E	0.44	84	5	0.36
08-Dec-92	508519	1008	B2		28.6	0.70	220	27	1.00
09-Dec-92	508530	1032	B2		15.3	0.62	110	6	1.09
14-Dec-92	508554	1230	B2		22.6	0.60	61 X	7	0.07
21-Dec-92	528095	1248	B2	R	--	--	600	5	0.17
21-Dec-92	528084	1248	B2	R	20.5	0.58	150	5	0.17
28-Dec-92	18090	1316	B2		22.3	0.60	130	8	0.34
04-Jan-93	28134	1112	B2		19.3	0.52	37 S	5	0.25
11-Jan-93	38091	1555	B2		12.8	0.41	110	5	0.00
20-Jan-93	48136	1240	B2		50.9	1.16	1500 S	37	1.95
25-Jan-93	58141	1420	B2		58.2	1.42	490 X	43	2.80
08-Feb-93	78145	920	B2	R	14.4	0.46	160	5	0.11
08-Feb-93	78136	920	B2	R	14.1	0.46	100	5	0.11
09-Feb-93	78158	1150	B2		14.6	0.46	29	5	0.45
16-Feb-93	88146	1100	B2	R	12.8	0.44	43	6	0.00
16-Feb-93	88131	1100	B2	R	12.2	0.44	52	6	0.00
22-Feb-93	98141	1340	B2		14.5	0.48	36	4	0.21
02-Mar-93	108136	1025	B2	R	13.2	0.45	39	4	0.40
02-Mar-93	108146	1025	B2	R	13.7	0.45	33	4	0.40
08-Mar-93	118140	1325	B2		14.2	0.48	29	6	0.00
15-Mar-93	128136	1120	B2		15.3	0.48	52	5	0.26
22-Mar-93	138141	1315	B2	R	--	--	1200	150	2.34
22-Mar-93	138144	1320	B2	R	51.6	1.28	1100	158	2.34
30-Mar-93	148136	1055	B2		15.8	0.50	110	6	0.15
07-Dec-92	508503	--	B3		11.2 E	--	7	1	0.36
08-Dec-92	508522	1109	B3		19.9	--	320	26	1.00
09-Dec-92	508533	1135	B3		10.6	--	70 J	5	1.09
21-Dec-92	528086	1323	B3		16.0	--	29	6	0.17
04-Jan-93	28137	1445	B3		12.8	--	43 S	5	0.25

Appendix A. Continued.

DATE	LAB #	TIME	SITE		DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
20-Jan-93	48141	1430	B3		38.3	--	1000 >	30	1.95
08-Feb-93	78141	1100	B3		11.5	--	14	3	0.11
16-Feb-93	88132	1245	B3		11.9	--	21	3	0.00
02-Mar-93	108141	1210	B3		11.5	--	14	5	0.40
15-Mar-93	128142	1250	B3		12.6	--	6	6	0.26
30-Mar-93	148142	1355	B3		17.6	--	41	8	0.15
07-Dec-92	508504	--	B4		4.1	--	20 S	1	0.36
08-Dec-92	508524	1210	B4		6.6	--	230	27	1.00
09-Dec-92	508535	1233	B4		4.4	--	80 J	10	1.09
21-Dec-92	528087	1407	B4		5.4	--	12	4	0.17
04-Jan-93	28145	1605	B4	R	--	--	20	4	0.25
04-Jan-93	28139	1605	B4	R	5.6	--	18	4	0.25
20-Jan-93	48143	1530	B4		13.4	--	210	19	1.95
08-Feb-93	78143	1125	B4		4.1	--	57	4	0.11
16-Feb-93	88133	1345	B4		3.9	--	15	4	0.00
02-Mar-93	108143	1255	B4		4.0	--	7	3	0.40
15-Mar-93	128144	1345	B4		4.0	--	5	3	0.26
30-Mar-93	148144	1445	B4		4.8	--	100	7	0.15
07-Dec-92	508505	--	B5		1.2	--	11	1 U	0.36
08-Dec-92	508525	1159	B5		2.9	--	300	14	1.00
09-Dec-92	508536	1214	B5		2.0	--	70 J	3	1.09
21-Dec-92	528088	1357	B5		2.3 E	--	15	2	0.17
04-Jan-93	28140	1535	B5		2.2	--	17	6	0.25
20-Jan-93	48144	1550	B5		7.3	--	300	10	1.95
08-Feb-93	78144	1145	B5		1.2	--	3 U	1	0.11
16-Feb-93	88134	1400	B5		1.2	--	1	1	0.00
02-Mar-93	108144	1315	B5		1.5	--	2	3	0.40
15-Mar-93	128145	1405	B5		1.7	--	13	2	0.26
30-Mar-93	148145	1500	B5		2.0	--	13	7	0.15
03-Dec-92	--	1145	BR1		3.0	1.10	--	--	0.00
07-Dec-92	508510		BR1		1.5	--	61	3	0.36
08-Dec-92	508520	1010	BR1		6.2	1.23	280	34	1.00
09-Dec-92	508531	1054	BR1		7.0	1.16	80 J	7	1.09
14-Dec-92	508553	1253	BR1		4.8	1.12	17	5	0.07
21-Dec-92	528085	1303	BR1		4.4	1.12	36	5	0.17
28-Dec-92	18091	1248	BR1		4.2	1.12	86	5	0.34
04-Jan-93	28135	1227	BR1		4.3	1.09	43	2	0.25
11-Jan-93	38090	1610	BR1		3.0	1.04	28	2	0.00
20-Jan-93	48137	1250	BR1		11.5	1.38	550 S	32	1.95
25-Jan-93	58142	1440	BR1		14.5	1.43	230	55	2.80
08-Feb-93	78137	935	BR1		3.3	1.04	24	3	0.11
09-Feb-93	78159	1205	BR1	R	--	--	15	171	0.45
09-Feb-93	78161	1205	BR1	R	3.8	1.05	18	155	0.45
16-Feb-93	88135	1115	BR1		3.0	1.04	4	2	0.00
22-Feb-93	98142	1400	BR1		3.3	1.05	18	11	0.21
02-Mar-93	108137	1045	BR1		3.2	1.04	17	2	0.40
08-Mar-93	118141	1340	BR1		3.7	1.06	15	4	0.00
15-Mar-93	128137	1140	BR1	R	3.5	1.06	41	3	0.26
15-Mar-93	128146	1140	BR1	R	3.6	1.06	28	3	0.26
22-Mar-93	138142	1335	BR1		17.0	1.46	1400	160	2.34
30-Mar-93	148137	1105	BR1		3.5	1.04	63 X	5	0.15

Appendix A. Continued.

DATE	LAB #	TIME	SITE	DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
08-Mar-93	118145	1350	BR1.8	0.2	--	1 U	1	0.00
15-Mar-93	128138	1220	BR1.8	0.2	--	20	2	0.26
22-Mar-93	138143	1405	BR1.8	3.0	--	290	7	2.34
30-Mar-93	148139	1115	BR1.8	0.2	--	7	2	0.15
07-Dec-92	508511	--	BR2	0.1	--	1	1 U	0.36
08-Dec-92	508521	1038	BR2	0.7	--	36	10	1.00
09-Dec-92	508532	1115	BR2	0.2	--	7	1	1.09
11-Jan-93	30894	1635	BR2	0.1	--	1 U	2	0.00
20-Jan-93	48146		BR2 R	0.9	--	54	13	1.95
20-Jan-93	48138	--	BR2 R	--	--	84	9	1.95
25-Jan-93	58145	1505	BR2	0.4	--	34	6	2.80
08-Feb-93	78138	950	BR2	0.2	--	3	2	0.11
16-Feb-93	88136	1130	BR2	0.1	--	1 U	2	0.00
02-Mar-93	108138	1100	BR2	0.1	--	1 U	3	0.40
15-Mar-93	128139	1200	BR2	0.1	--	4	3	0.26
30-Mar-93	148138	1135	BR2	0.1	--	40	8	0.15
07-Dec-92	508506	--	C1	0.2	--	1 U	2	0.36
08-Dec-92	508523	1130	C1	0.9	--	3	8	1.00
09-Dec-92	508534	1158	C1 R	--	--	1	2	1.09
09-Dec-92	508539	1158	C1 R	0.5	--	4	3	1.09
21-Dec-92	528089	1345	C1	0.8	--	1 U	3	0.17
04-Jan-93	28138	1510	C1	0.6	--	1 U	3	0.25
20-Jan-93	48142	1455	C1	1.0	--	24 J	10	1.95
08-Feb-93	78142	1115	C1	0.7	--	1 U	4	0.11
16-Feb-93	88145	1325	C1 R	0.6	--	1 U	2	0.00
16-Feb-93	88140	1325	C1 R	0.6	--	2	3	0.00
02-Mar-93	108142	1240	C1	0.7	--	1	4	0.40
15-Mar-93	128143	1315	C1	0.7	--	1	6	0.26
30-Mar-93	148147	1420	C1 R	0.7	--	2	6	0.15
30-Mar-93	148143	1420	C1 R	0.7	--	2	6	0.15
03-Dec-92	--	1445	P1	2.7	0.43	--	--	0.00
07-Dec-92	508507	955	P1 R	2.5	0.45	27	1 U	0.36
07-Dec-92	508516	--	P1 R	--	--	33	1	0.36
08-Dec-92	508517	900	P1	7.7	0.60	180	14	1.00
09-Dec-92	508528	958	P1	10.5	0.61	52	3	1.09
14-Dec-92	508551	1400	P1	5.4	0.54	18	1	0.07
21-Dec-92	528080	945	P1	6.6	0.57	27	2	0.17
28-Dec-92	18093	1507	P1 R	5.9	0.56	57	4	0.34
28-Dec-92	18080	1507	P1 R	--	--	43	4	0.34
04-Jan-93	28130	1635	P1	4.3	0.49	14	1 U	0.25
11-Jan-93	30893	1445	P1	2.7	0.43	8	2	0.00
20-Jan-93	48145	--	P1 R	--	--	310	31	1.95
20-Jan-93	48130	950	P1 R	21.5	0.86	480	27	1.95
25-Jan-93	58130	1235	P1	39.5	1.26	92	19	2.80
08-Feb-93	78130	1205	P1	3.9	0.46	9	2	0.11
09-Feb-93	78147	1320	P1	4.2	0.48	5	2	0.45
16-Feb-93	88137	1455	P1	3.1	0.45	6	1	0.00
22-Feb-93	98144	1300	P1 R	3.8	0.48	7	1	0.21
22-Feb-93	98139	1300	P1 R	3.8	0.48	9	1	0.21
02-Mar-93	108130	1405	P1	3.1	0.46	9	2	0.40

Appendix A. Continued.

DATE	LAB #	TIME	SITE		DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
08-Mar-93	118142	1055	P1	R	4.1	0.47	7	2	0.00
08-Mar-93	118143	1055	P1	R	4.1	0.47	8	2	0.00
15-Mar-93	128130	1430	P1		4.4	0.48	8	2	0.26
22-Mar-93	138139	1200	P1		22.4	0.94	1500 J	71	2.34
30-Mar-93	148130	1240	P1		4.6	0.52	16	3	0.15
07-Dec-92	508508	--	P2		0.5	--	17	1 U	0.36
08-Dec-92	508527	1322	P2		4.1 E	--	100	7	1.00
09-Dec-92	508538	1343	P2		5.5 E	--	16	7	1.09
21-Dec-92	528081	1129	P2		3.5 E	--	13	3	0.17
04-Jan-93	28131	1355	P2		2.4 E	--	5	4	0.25
20-Jan-93	48139	1335	P2		11.1 E	--	290	16	1.95
08-Feb-93	78139	1010	P2		2.1	--	9	1	0.11
16-Feb-93	88138	1155	P2		1.7	--	2	1	0.00
22-Feb-93	98145	1420	P2		2.2	--	3	4	0.21
02-Mar-93	108139	1125	P2		1.8	--	5	2	0.40
08-Mar-93	118146	1415	P2		2.3	--	2	2	0.00
15-Mar-93	128140	1455	P2		2.3	--	120	2	0.26
30-Mar-93	148140	1310	P2	R	2.6	--	27	3	0.15
30-Mar-93	148146	1310	P2	R	2.6	--	35	3	0.15
07-Dec-92	508509	--	P3		0.6	--	1	1 U	0.36
08-Dec-92	508526	1340	P3		1.4	--	71	14	1.00
09-Dec-92	508537	1354	P3		1.9 E	--	21	2	1.09
21-Dec-92	528082	1139	P3		1.8	--	19	1	0.17
28-Dec-92	--	--	P3		1.1	--	--	--	0.34
04-Jan-93	28132	1420	P3		0.9 E	--	6	3	0.25
20-Jan-93	48140	1400	P3		4.9	--	200	12	1.95
08-Feb-93	78146	1030	P3	R	0.9	--	11	22	0.11
08-Feb-93	78140	1030	P3	R	0.9	--	3	21	0.11
16-Feb-93	88139	1215	P3		0.7	--	10	11	0.00
22-Feb-93	98146	1440	P3		0.8	--	1 U	18	0.21
02-Mar-93	108140	1140	P3		0.7	--	1	10	0.40
08-Mar-93	118147	1430	P3		0.8	--	--	--	0.00
15-Mar-93	128147	1515	P3	R	0.9	--	3	2	0.26
15-Mar-93	128141	1515	P3	R	0.8	--	5	1	0.26
30-Mar-93	148141	1330	P3		1.0	--	13	10	0.15

Minter Watershed Data

DATE	LAB #	TIME	SITE		DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
07-Dec-92	508512	1523	H1	R	4.4 E	1.04	8	1 U	0.36
07-Dec-92	508515	1523	H1	R	--	--	1	1	0.36
14-Dec-92	508543	1110	H1		5.1 E	1.11	8	7	0.07
21-Dec-92	528093	1109	H1		6.4 E	1.18	29	4	0.17
28-Dec-92	18085	1057	H1		5.7	1.12	13	1	0.34
04-Jan-93	28144	1200	H1		5.1	1.10	4	1	0.25
11-Jan-93	38083	1120	H1		4.2	1.04	36	1	0.00
20-Jan-93	48134	1150	H1		12.7	1.43	84	10	1.95
25-Jan-93	58135	1035	H1		28.9	1.90	71	20	2.80
08-Feb-93	78134	1400	H1		5.2	1.12	1 U	1	0.11
09-Feb-93	78152	940	H1		5.5	1.13	1	1	0.16
16-Feb-93	88144	1000	H1		4.7	1.09	7	1 U	0.00
22-Feb-93	98137	1000	H1		5.2	1.11	3	1	0.21
02-Mar-93	108134	940	H1		4.7	1.06	3	1	0.40

Appendix A. Continued.

DATE	LAB #	TIME	SITE		DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
08-Mar-93	118137	1125	H1		5.8	1.07	3	1	0.00
15-Mar-93	128134	1035	H1		4.8	1.10	29	1	0.26
22-Mar-93	138137	1400	H1		18.0	1.60	660 J	45	2.34
30-Mar-93	148134	1015	H1		6.0	1.17	2	4	0.15
14-Dec-92	508546	1148	H2		3.8	--	14	1 U	0.07
28-Dec-92	18088	1155	H2		3.6	--	8	1	0.34
11-Jan-93	38086	1235	H2		2.6	--	1	1 K	0.00
25-Jan-93	--	--	H2	R	9.7	--	--	--	2.80
25-Jan-93	58138	1130	H2	R	9.6	--	14	19	2.80
09-Feb-93	78160	1035	H2	R	3.7	--	13	1	0.16
09-Feb-93	78155	1035	H2	R	3.6	--	10	2	0.16
22-Feb-93	98138	1100	H2		3.5	--	1	3	0.21
08-Mar-93	118138	1225	H2		3.3	--	1	1	0.00
22-Mar-93	138138	1505	H2		12.7	--	290	35	2.34
03-Dec-92	-	1325	LM1		0.5	--	--	--	0.00
07-Dec-92	508514	--	LM1		0.7	--	5	1	0.36
14-Dec-92	508550	1035	LM1	R	--	--	6	14	0.07
14-Dec-92	508542	1030	LM1	R	1.5	--	4	13	0.07
21-Dec-92	528092	1049	LM1		2.2	--	18	5	0.17
28-Dec-92	18084	1034	LM1		1.3	--	79	2	0.34
04-Jan-93	28143	1250	LM1		1.1	--	11	1	0.25
11-Jan-93	38082	1100	LM1		0.4	--	12	2	0.00
20-Jan-93	48133	1120	LM1		4.6	--	600	38	1.95
25-Jan-93	58132	940	LM1		12.7	--	420	52	2.80
08-Feb-93	78133	1340	LM1		1.1	--	40	1	0.11
09-Feb-93	78149	920	LM1		1.2	--	20	2	0.16
16-Feb-93	88143	940	LM1		0.9	--	16	1 U	0.00
22-Feb-93	98135	940	LM1		0.8	--	16	1	0.21
02-Mar-93	108133	845	LM1		0.6	--	4	2	0.40
08-Mar-93	118130	1020	LM1		1.0	--	16	2	0.00
15-Mar-93	128133	1015	LM1		1.1	--	7	1	0.26
22-Mar-93	138135	1045	LM1		2.6	--	55 S	37	2.34
30-Mar-93	148133	950	LM1		1.3	--	5	3	0.15
14-Dec-92	508549	1325	LM2		0.8	--	24 X	1 U	0.07
28-Dec-92	18081	945	LM2		0.8	--	24	1	0.34
11-Jan-93	38080	1000	LM2	R	0.4	--	4	1	0.00
11-Jan-93	38088	--	LM2	R	--	--	6	2	0.00
25-Jan-93	58134	1012	LM2	R	6.3	--	370	5	2.80
25-Jan-93	58144	--	LM2	R	--	--	370 X	4	2.80
09-Feb-93	78151	850	LM2		0.6	--	8	1 U	0.16
22-Feb-93	98136	910	LM2		0.6	--	8	3	0.21
08-Mar-93	118131	920	LM2		0.7	--	22	2	0.00
22-Mar-93	138136	1005	LM2		1.3	--	5600 J	9	2.34
14-Dec-92	508540	1340	M1		25.3 E	--	17	20	0.07
21-Dec-92	528090	1015	M1		32.5 E	--	32	12	0.17
28-Dec-92	18082	1425	M1		26.4 E	--	24	7	0.34
11-Jan-93	38095	1415	M1		17.3	--	29	4	0.00
20-Jan-93	48131	1030	M1		48.8	--	200 S	67	1.95
25-Jan-93	58131	1300	M1		103.3	--	150	47	2.80
08-Feb-93	78131	1235	M1		22.5	--	14	2	0.11

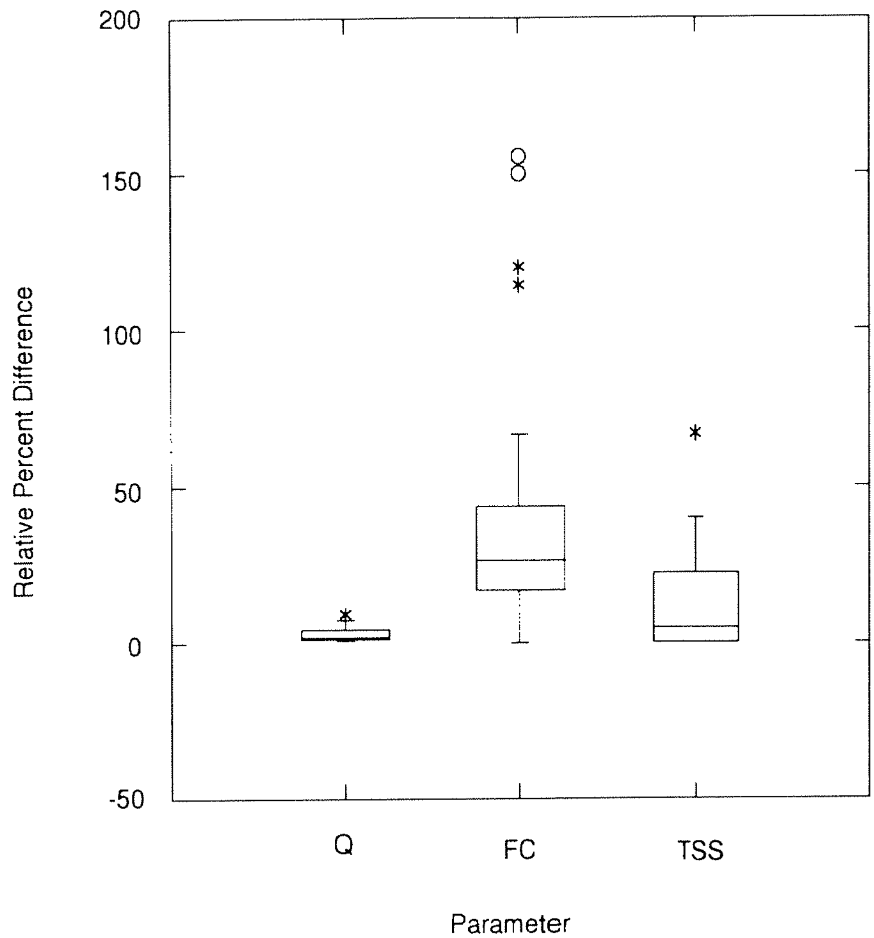
Appendix A. Continued.

DATE	LAB #	TIME	SITE		DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
09-Feb-93	78148	1350	M1		24.5	--	11	4	0.16
16-Feb-93	88141	1520	M1		19.9	--	14	4	0.00
22-Feb-93	98130	1220	M1		24.0	--	27	3	0.21
02-Mar-93	108131	1345	M1		20.6	--	4	1	0.40
08-Mar-93	118132	945	M1		23.6	--	21	3	0.00
15-Mar-93	128131	1550	M1		20.8	--	6	2	0.26
22-Mar-93	138130	1115	M1		36.6	--	240	23	2.34
30-Mar-93	148131	1215	M1		22.7	--	33	6	0.15
03-Dec-92	--	1300	M2		18.9	0.40	--	--	0.00
07-Dec-92	508513	1437	M2		16.7	--	20	1	0.36
14-Dec-92	508548	1020	M2	R	--	--	26	6	0.07
14-Dec-92	508541	1008	M2	R	22.6	0.49	27	7	0.07
21-Dec-92	528091	1031	M2		27.2	--	31	4	0.17
28-Dec-92	18083	1030	M2		23.6	0.46	25	5	0.34
04-Jan-93	28142	1220	M2		22.9	0.45	24 X	2	0.25
11-Jan-93	38089	--	M2	R	--	--	20	3	0.00
11-Jan-93	38081	1045	M2	R	18.2	0.38	13	3	0.00
20-Jan-93	48132	1105	M2		45.2	0.74	140	49	1.95
25-Jan-93	58143	--	M2	R	--	--	130	54	2.80
25-Jan-93	58133	900	M2	R	94.9	1.50	120	55	2.80
08-Feb-93	78132	1340	M2		19.4	0.72	26	3	0.11
09-Feb-93	78150	925	M2		22.3	0.71	41	2	0.16
16-Feb-93	88142	940	M2		19.7	0.68	29	1	0.00
22-Feb-93	98131	940	M2		21.4	0.70	18	2	0.21
02-Mar-93	108145	840	M2	R	19.0	0.68	14	8	0.40
02-Mar-93	108132	840	M2	R	18.8	0.68	19	4	0.40
08-Mar-93	118133	1025	M2		21.8	0.67	28	3	0.00
15-Mar-93	128132	1010	M2		21.9	0.69	9	3	0.26
22-Mar-93	138131	1050	M2		29.3	0.78	200	32	2.34
30-Mar-93	148132	955	M2		22.1	0.72	41	4	0.15
14-Dec-92	508544	1120	M4		10.7	--	36	5	0.07
28-Dec-92	81086	1128	M4		11.9	--	27	4	0.34
11-Jan-93	38084	1140	M4		6.5	--	23	5	0.00
25-Jan-93	58136	1055	M4		41.4	--	150	53	2.80
09-Feb-93	78153	955	M4		9.6	--	28 X	4	0.16
22-Feb-93	98132	1020	M4		9.7	--	47	3	0.21
08-Mar-93	118134	1140	M4		9.5	--	96	4	0.00
22-Mar-93	138132	1415	M4		31.1	--	400	100	2.34
14-Dec-92	508545	1140	M5		8.9 E	--	80	1 U	0.07
28-Dec-92	18087	1217	M5		8.8 E	--	49	3	0.34
11-Jan-93	38085	1215	M5		4.4	--	84 X	6	0.00
25-Jan-93	58137	1115	M5		39.2	--	140	17	2.80
09-Feb-93	78154	1010	M5		6.8	--	72	5	0.16
22-Feb-93	98133	1040	M5		7.9	--	100	3	0.21
08-Mar-93	118135	1150	M5	R	6.7	--	92	4	0.00
08-Mar-93	118144	1150	M5	R	6.8	--	120	6	0.00
22-Mar-93	138133	1530	M5		23.7	--	270	65	2.34
14-Dec-92	508547	1205	M6		4.6	--	11	2	0.07
28-Dec-92	18089	1232	M6		4.6	--	19	2	0.34
11-Jan-93	38087	1310	M6		2.2	--	11	1	0.00

Appendix A. Continued.

DATE	LAB #	TIME	SITE		DISCHARGE (CFS)	GAGE (units)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
25-Jan-93	58139	1205	M6		29.8	--	80	15	2.80
09-Feb-93	78156	1100	M6		3.2	--	1 U	2	0.16
22-Feb-93	98143	1135	M6	R	3.5	--	1	1	0.21
22-Feb-93	98134	1135	M6	R	3.4	--	7	1	0.21
08-Mar-93	118136	1240	M6		3.4	--	3	1	0.00
22-Mar-93	138134	1435	M6	R	15.7	--	270	42	2.34
22-Mar-93	138145	1435	M6	R	15.9	--	320	44	2.34

R = Replicate sample.
E = Estimate.
U = The analyte was not detected at or above the reported result.
X = High background count.
S = Spreader (colonies possibly masked by other bacteria).
J = The analyte was positively identified. The associated numerical result is an estimate.



Appendix B. Relative percent differences for replicate samples for the Burley and Minter water quality monitoring study, 1992-93.

Appendix C. Wet season data for the Burley and Minter Watersheds, January 1983-December 1983 (Determan et al 1985).

DATE	SITE	1983 SITE NAME	DISCHARGE (CFS)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
Burley Watershed Data						
11-Jan-83	B1	BUO.3	29.7	36	8	0.02
17-Jan-83	B1	BUO.3	14.2	64	8	0.30
07-Feb-83	B1	BU0.3	12.2	89	6	0.09
21-Feb-83	B1	BU0.3	48.2	184	10	0.48
21-Mar-83	B1	BU0.3	29.7	25	6	0.16
04-Apr-83	B1	BU0.3	16.4	205	6	0.00
18-Apr-83	B1	BU0.3	30.4	69	4	0.00
14-Nov-83	B1	BU0.3	42.3	384	20	1.90
29-Nov-83	B1	BU0.3	16.6	18 J	2	0.00
13-Dec-83	B1	BU0.3	47.0	68	10	0.93
21-Feb-83	B2	BU0.6	37.2	378 J	8	0.48
07-Mar-83	B2	BU0.6	58.1	100	18	1.28
08-Mar-83	B2	BU0.6	94.8	550	64	2.45
09-Mar-83	B2	BU0.6	132.5	426	36	1.88
10-Mar-83	B2	BU0.6	67.7	85 J	14	0.43
21-Mar-83	B2	BU0.6	35.6	17 J	3	0.16
04-Apr-83	B2	BU0.6	39.4	46	5	0.00
18-Apr-83	B2	BU0.6	28.2	58	4	0.00
14-Nov-83	B2	BU0.6	56.3	198	12	1.90
29-Nov-83	B2	BU0.6	27.0	19	1	0.00
13-Dec-83	B2	BU0.6	56.8	58	8	0.93
21-Feb-83	BR1	BR0.0	14.3	55	9	0.48
07-Mar-83	BR1	BR0.0	9.3	631	34	1.28
08-Mar-83	BR1	BR0.0	27.4	776	89	2.45
09-Mar-83	BR1	BR0.0	30.4	741	51	1.88
10-Mar-83	BR1	BR0.0	17.2	870	15	0.43
21-Mar-83	BR1	BR0.0	7.9	40	13	0.16
04-Apr-83	BR1	BR0.0	9.0	76 J	6	0.00
18-Apr-83	BR1	BR0.0	6.2	7 J	4	0.00
14-Nov-83	BR1	BR0.0	12.4	866	14	1.90
29-Nov-83	BR1	BR0.0	4.8	12 J	3	0.00
13-Dec-83	BR1	BR0.0	13.0	150	8	0.93
21-Feb-83	BR1.8	BR1.8	1.5	4 J	3	0.48
21-Mar-83	BR1.8	BR1.8	1.5	2 J	2	0.16
04-Apr-83	BR1.8	BR1.8	1.3	4 J	1	0.00
18-Apr-83	BR1.8	BR1.8	0.4	50	1	0.00
14-Nov-83	BR1.8	BR1.8	0.2	51	1	1.90
28-Nov-83	BR1.8	BR1.8	0.0	6 J	1 K	0.05
13-Dec-83	BR1.8	BR1.8	0.4	14	1	0.93
21-Feb-83	C1	X0.2	0.5	1 J	4	0.48
07-Mar-83	C1	X0.2	1.5	13 J	11	1.28
08-Mar-83	C1	X0.2	2.0	4 J	31	2.45
09-Mar-83	C1	X0.2	2.4	1 J	16	1.88
10-Mar-83	C1	X0.2	1.6	2 J	6	0.43
21-Mar-83	C1	X0.2	0.9	1 K	5	0.16
04-Apr-83	C1	X0.2	1.1	2 J	2	0.00
18-Apr-83	C1	X0.2	0.8	1 K	8	0.00

Appendix C. Continued.

DATE	SITE	1983 SITE NAME	DISCHARGE (CFS)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
Burley Watershed Data						
11-Jan-83	B1	BUO.3	29.7	36	8	0.02
17-Jan-83	B1	BUO.3	14.2	64	8	0.30
07-Feb-83	B1	BU0.3	12.2	89	6	0.09
21-Feb-83	B1	BU0.3	48.2	184	10	0.48
21-Mar-83	B1	BU0.3	29.7	25	6	0.16
04-Apr-83	B1	BU0.3	16.4	205	6	0.00
18-Apr-83	B1	BU0.3	30.4	69	4	0.00
14-Nov-83	B1	BU0.3	42.3	384	20	1.90
29-Nov-83	B1	BU0.3	16.6	18 J	2	0.00
13-Dec-83	B1	BU0.3	47.0	68	10	0.93
21-Feb-83	B2	BU0.6	37.2	378 J	8	0.48
07-Mar-83	B2	BU0.6	58.1	100	18	1.28
08-Mar-83	B2	BU0.6	94.8	550	64	2.45
09-Mar-83	B2	BU0.6	132.5	426	36	1.88
10-Mar-83	B2	BU0.6	67.7	85 J	14	0.43
21-Mar-83	B2	BU0.6	35.6	17 J	3	0.16
04-Apr-83	B2	BU0.6	39.4	46	5	0.00
18-Apr-83	B2	BU0.6	28.2	58	4	0.00
14-Nov-83	B2	BU0.6	56.3	198	12	1.90
29-Nov-83	B2	BU0.6	27.0	19	1	0.00
13-Dec-83	B2	BU0.6	56.8	58	8	0.93
21-Feb-83	BR1	BR0.0	14.3	55	9	0.48
07-Mar-83	BR1	BR0.0	9.3	631	34	1.28
08-Mar-83	BR1	BR0.0	27.4	776	89	2.45
09-Mar-83	BR1	BR0.0	30.4	741	51	1.88
10-Mar-83	BR1	BR0.0	17.2	870	15	0.43
21-Mar-83	BR1	BR0.0	7.9	40	13	0.16
04-Apr-83	BR1	BR0.0	9.0	76 J	6	0.00
18-Apr-83	BR1	BR0.0	6.2	7 J	4	0.00
14-Nov-83	BR1	BR0.0	12.4	866	14	1.90
29-Nov-83	BR1	BR0.0	4.8	12 J	3	0.00
13-Dec-83	BR1	BR0.0	13.0	150	8	0.93
21-Feb-83	BR1.8	BR1.8	1.5	4 J	3	0.48
21-Mar-83	BR1.8	BR1.8	1.5	2 J	2	0.16
04-Apr-83	BR1.8	BR1.8	1.3	4 J	1	0.00
18-Apr-83	BR1.8	BR1.8	0.4	50	1	0.00
14-Nov-83	BR1.8	BR1.8	0.2	51	1	1.90
28-Nov-83	BR1.8	BR1.8	0.0	6 J	1 K	0.05
13-Dec-83	BR1.8	BR1.8	0.4	14	1	0.93
21-Feb-83	C1	X0.2	0.5	1 J	4	0.48
07-Mar-83	C1	X0.2	1.5	13 J	11	1.28
08-Mar-83	C1	X0.2	2.0	4 J	31	2.45
09-Mar-83	C1	X0.2	2.4	1 J	16	1.88
10-Mar-83	C1	X0.2	1.6	2 J	6	0.43
21-Mar-83	C1	X0.2	0.9	1 K	5	0.16
04-Apr-83	C1	X0.2	1.1	2 J	2	0.00
18-Apr-83	C1	X0.2	0.8	1 K	8	0.00

Appendix C. Continued.

DATE	SITE	1983 SITE NAME	DISCHARGE (CFS)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
14-Nov-83	C1	X0.2	1.7	1	3	1.90
28-Nov-83	C1	X0.2	0.8	1 K	2	0.05
12-Dec-83	C1	X0.2	0.5	8 J	8	0.94
11-Jan-83	P1	P0.1	19.5	122	5	0.02
17-Jan-83	P1	P0.1	10.6	14 J	4	0.30
07-Feb-83	P1	P0.1	8.1	6	1	0.09
21-Feb-83	P1	P0.1	15.0	225 J	4	0.48
07-Mar-83	P1	P0.1	20.1	105	8	1.28
08-Mar-83	P1	P0.1	39.1	115	16	2.45
09-Mar-83	P1 R	P0.1	45.0	78	11	1.88
09-Mar-83	P1 R	P0.1	37.9	55	11	1.88
10-Mar-83	P1	P0.1	27.4	47 J	8	0.43
21-Mar-83	P1	P0.1	9.6	6 J	1	0.16
04-Apr-83	P1	P0.1	11.5	49 J	2	0.00
18-Apr-83	P1	P0.1	--	9 J	3	0.00
14-Nov-83	P1	P0.1	16.8	85	5	1.90
28-Nov-83	P1	P0.1	7.3	31	1	0.05
13-Dec-83	P1	P0.1	21.1	25	3	0.93
Minter Watershed Data						
10-Jan-83	H1	H0.1	82.0	14 J	11	1.64
18-Jan-83	H1	H0.1	19.0	25	3	0.73
08-Feb-83	H1	H0.1	12.0	9 J	2	1.17
09-Feb-83	H1	H0.1	34.0	345	11	1.64
10-Feb-83	H1	H0.1	31.0	39	6	1.34
22-Feb-83	H1	H0.1	38.2	16 J	3	1.42
22-Mar-83	H1	H0.1	17.4	6 J	1	0.16
05-Apr-83	H1	H0.1	18.8	16 J	2	0.00
20-Apr-83	H1	H0.1	10.8	8 J	3	0.00
15-Nov-83	H1	H0.1	25.7	70	8	2.22
29-Nov-83	H1	H0.1	18.1	9	1	0.00
13-Dec-83	H1	H0.1	51.4	41	7	0.93
10-Jan-83	LM1	UN0.0	20.0	78	12	1.64
18-Jan-83	LM1	UN0.0	4.3	15 J	4	0.73
08-Feb-83	LM1	UN0.0	2.2	6 J	5	1.17
09-Feb-83	LM1	UN0.0	11.3	629	35	1.64
10-Feb-83	LM1	UN0.0	7.0	73	12	1.34
22-Feb-83	LM1	UN0.0	6.7	7 J	10	1.42
22-Mar-83	LM1	UN0.0	4.2	3 K	6	0.16
05-Apr-83	LM1	UN0.0	3.4	60	4	0.00
20-Apr-83	LM1	UN0.0	2.4	63	8	0.00
15-Nov-83	LM1	UN0.0	5.4	144	10	2.22
29-Nov-83	LM1	UN0.0	2.1	99	2	0.00
13-Dec-83	LM1	UN0.0	9.5	120	8	0.93
10-Jan-83	LM2	UN2.0	11.5	114	2	1.64
18-Jan-83	LM2	UN2.0	4.2	16 J	1	0.73
08-Feb-83	LM2	UN2.0	0.6	3 J	1	1.17
22-Feb-83	LM2	UN2.0	4.1	29	2	1.42
22-Mar-83	LM2	UN2.0	2.3	2 K	2	0.16
05-Apr-83	LM2	UN2.0	2.4	4 J	1	0.00

Appendix C. Continued.

DATE	SITE	1983 SITE NAME	DISCHARGE (CFS)	FC (cfu/100mL)	TSS (mg/L)	48HR RAIN (inches)
20-Apr-83	LM2	UN2.0	1.3	52	3	0.00
15-Nov-83	LM2	UN2.0	4.4	141	2	2.22
28-Nov-83	LM2	UN2.0	1.5	14	2	0.05
12-Dec-83	LM2	UN2.0	2.5	51	1 K	0.94
10-Jan-83	M1	M0.0	168.6	48	18	1.64
18-Jan-83	M1	M0.0	52.0	42	6	0.73
08-Feb-83	M1	M0.0	34.0	12 J	8	1.17
09-Feb-83	M1	M0.0	107.2	234	25	1.64
10-Feb-83	M1	M0.0	81.0	69	8	1.34
22-Feb-83	M1	M0.0	49.7	24	14	1.42
22-Mar-83	M1	M0.0	28.9	24	5	0.16
05-Apr-83	M1	M0.0	57.6	16 J	4	0.00
20-Apr-83	M1	M0.0	44.4	12	4	0.00
14-Nov-83	M1	M0.0	86.7	120	10	1.90
29-Nov-83	M1	M0.0	41.1	4 J	1	0.00
13-Dec-83	M1	M0.0	107.3	53	8	0.93
10-Jan-83	M4	M1.3	66.1	88	17	1.64
18-Jan-83	M4	M1.3	29.0	21 J	4	0.73
08-Feb-83	M4	M1.3	18.2	16 J	4	1.17
09-Feb-83	M4	M1.3	46.9	389	17	1.64
10-Feb-83	M4	M1.3	32.6	61	5	1.34
22-Feb-83	M4	M1.3	31.8	40	7	1.42
22-Mar-83	M4	M1.3	20.4	54	5	0.16
05-Apr-83	M4	M1.3	30.6	12 J	1	0.00
20-Apr-83	M4	M1.3	18.7	23	6	0.00
15-Nov-83	M4	M1.3	40.9	100	11	2.22
29-Nov-83	M4	M1.3	15.7	4 J	1 K	0.00
13-Dec-83	M4	M1.3	46.4	53	6	0.93

R = Replicate sample.
J = The analyte was positively identified. The associated numerical result is an estimate.
K= Less than.

Appendix D. Wet season data for the Burley and Minter Watersheds, January - March in 1988 and 1989 (Struck, 1990)

DATE	SITE		1988/89 SITE NAME	DISCHARGE (CFS)	FC (cfu/100mL)	48HR RAIN (inches)
Burley Watershed Data						
20-Jan-88	B3	R	BO3	13.7	50	0.13
20-Jan-88	B3	R	BO3	13.7	23	0.13
23-Mar-88	B3		BO3	26.8	49	0.69
16-Jan-89	B3	R	BO3	33.1	170	1.07
16-Jan-89	B3	R	BO3	33.1	200	1.07
23-Feb-89	B3		BO3	19.7	43	0.40
01-Mar-89	B3		BO3	14.2	68	0.50
20-Jan-88	B4	R	BO5	5.1	3	0.13
20-Jan-88	B4	R	BO5	5.1	2	0.13
23-Mar-88	B4		BO5	7.7	35	0.69
16-Jan-89	B4		BO5	10.4	127	1.07
23-Feb-89	B4		BO5	6.1	43	0.40
01-Mar-89	B4		BO5	5.9	13	0.50
20-Jan-88	B5		BO6	--	6	0.13
23-Mar-88	B5		BO6	--	39	0.69
16-Jan-89	B5		BO6	9.4 E	171	1.07
23-Feb-89	B5		BO6	2.8	9	0.40
01-Mar-89	B5		BO6	--	10	0.50
20-Jan-88	P2		PO2	--	11	0.13
23-Mar-88	P2		PO2	4.1	61	0.69
16-Jan-89	P2		PO2	9.7	82	1.07
23-Feb-89	P2		PO2	5.3	7	0.40
01-Mar-89	P2		PO2	--	2	0.50
20-Jan-88	P3		PO3	2.0	7	0.13
23-Mar-88	P3		PO3	--	58	0.69
16-Jan-89	P3		PO3	--	84	1.07
01-Mar-89	P3		PO3	--	7	0.50
Minter Watershed Data						
19-Apr-88	H2		H02	--	2	0.00
16-Jan-89	H2		H02	14.3	26	1.07
01-Mar-89	H2		H02	9.3	51	0.50
16-Jan-89	M2		M03	47.5	71	1.07
01-Mar-89	M2		M03	27.2	5	0.50
20-Jan-88	M5	R	M05	9.5	23	0.13
20-Jan-88	M5	R	M05	9.5	32	0.13
23-Mar-88	M5		M05	9.8	33	0.69
19-Apr-88	M5		M05	--	13	0.00
25-Oct-88	M5		M05	7	16	0.00
16-Jan-89	M5		M05	11.4 E	66	1.07
05-Apr-89	M5		M05	25.3	110	1.23
20-Jan-88	M6		M06	--	10	0.13
23-Mar-88	M6		M06	4.1	19	0.69

Appendix D. Continued.

DATE	SITE	1988/89 SITE NAME	DISCHARGE (CFS)	FC (cfu/100mL)	48HR RAIN (inches)
16-Jan-89	M6	M06	12	60	1.07
01-Mar-89	M6	M06	5.1	4	0.50
05-Apr-89	M6	M06	24.5	30	1.23

R = Replicate sample.
E = Estimate.

Appendix E. Site names for the 1992-93 Burley and Minter Watershed study with the associated site name and baseline data year used for statistical comparison.

BURLEY WATERSHED

1992-93	1983 (1)	1988-89 (2)
Burley Creek		
B1	BU0.3	-
B2	BU0.6	-
B3	-	B03
B4	-	B05
B5	-	B06
Purdy Creek		
P1	P0.1	-
P2	-	P02
P3	-	P03
Bear Creek		
BR1	BR0.0	
BR1.8	BR1.8	-
BR2	-	-
C1	X0.2	-

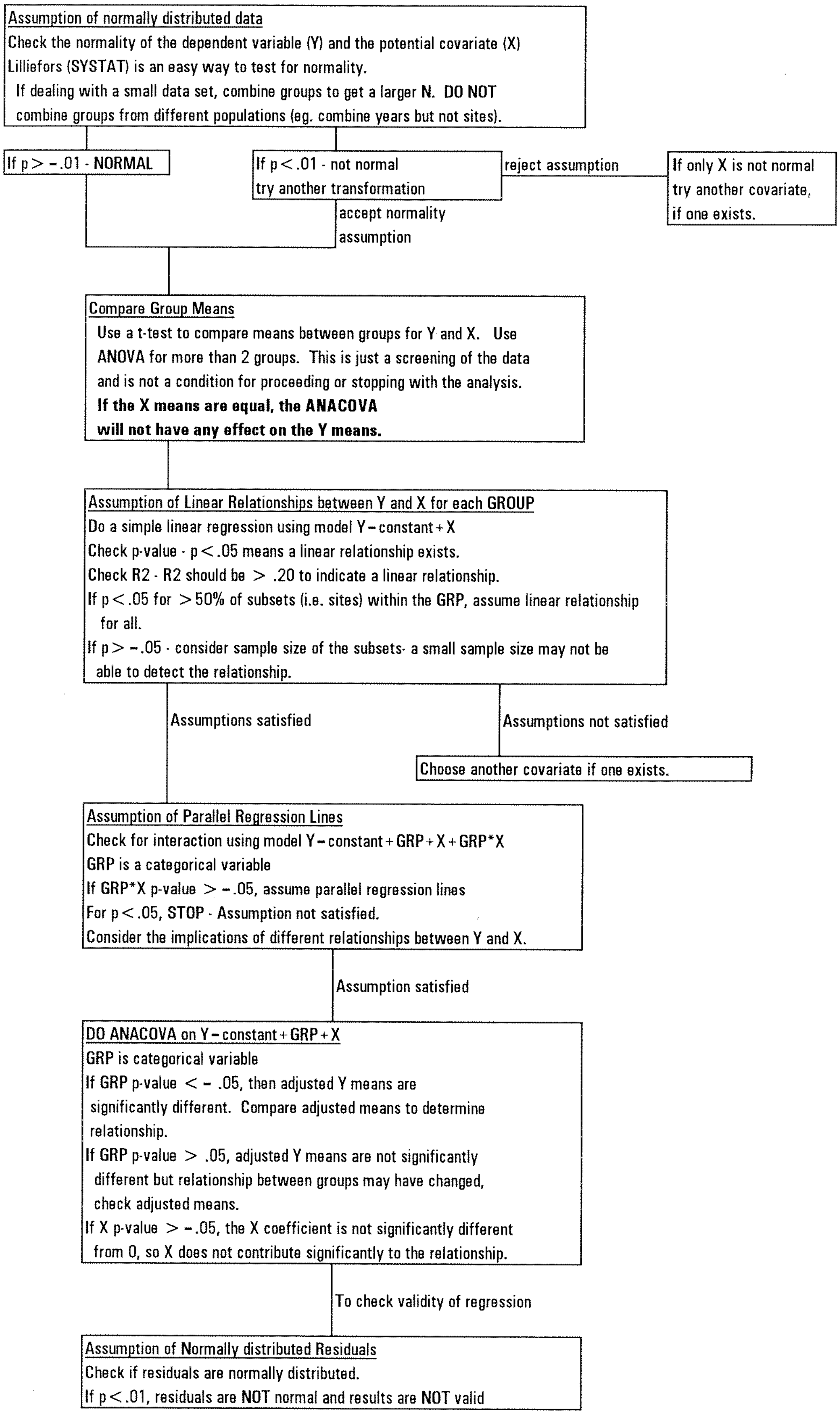
MINTER WATERSHED

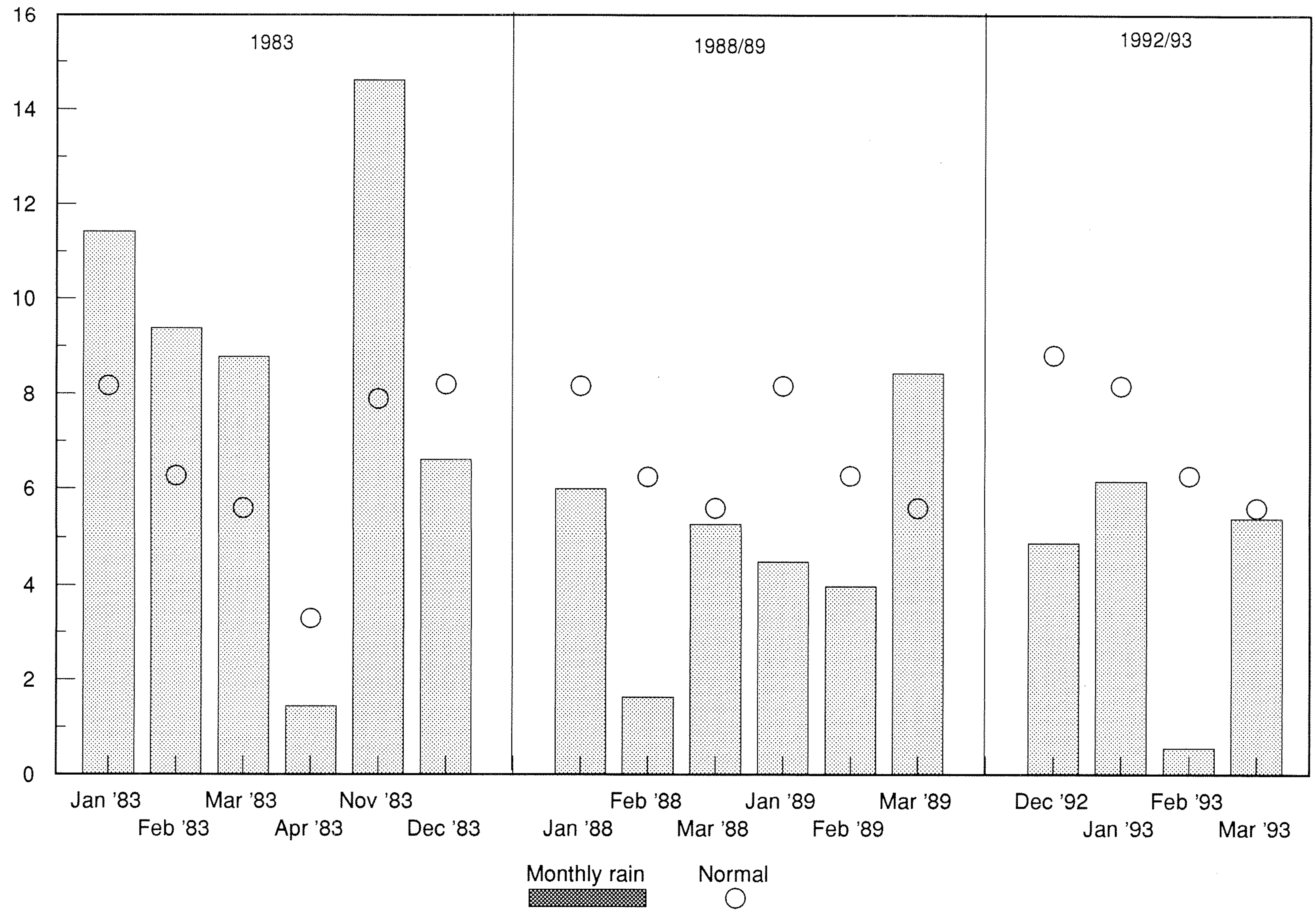
1992-93	1983 (1)	1988-89 (2)
Minter Creek		
M1	M0.0	-
M2	-	M03
M4	M1.3	-
M5	-	M05
M6	-	M06
Little Minter Creek		
LM1	UN0.0	-
LM2	UN2.0	-
Huge Creek		
H1	H0.1	-
H2	-	H02

1 Determan, et al., 1983
2 Struck, 1990

Appendix F. Analysis of Covariance (ANACOVA) flowchart performed on data sets to determine whether appropriate assumptions were met.

ANACOVA is a parametric test that adjusts for factors that may be influencing the variable of interest. By removing the influence of the factor (the covariate), the variable of interest (the dependent variable) can be compared between groups (years, sites, etc.)





Appendix G. Monthly rainfall during study months compared to normal rainfall.