



Prepared in cooperation with the
Alaska Department of Environmental Conservation

Concentrations of Fecal Coliform Bacteria in Creeks, Anchorage, Alaska, August and September 1998

Open-File Report 99-236

**U.S. Department of the Interior
U.S. Geological Survey**

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By Joseph M. Dorava and Andra Love

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS, WATER-QUALITY UNITS, AND VERTICAL DATUM

	Multiply	by	To obtain
	inch (in.)	25.4	millimeter
	foot (ft)	0.3048	meter
	mile (mi)	1.609	kilometer
	cubic feet per second (ft ³ /s)	0.02832	cubic meter per second

In this report, water temperature is reported in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: °F = 1.8 (°C) + 32

WATER-QUALITY UNITS

mL, milliliter

col/100 mL, fecal coliform colonies per 100 milliliters of water

mg/L, milligrams per liter

µs/cm, microsiemens per centimeter at 25 degrees Celsius

VERTICAL DATUM

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929—A geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

Water samples were collected from five creeks in undeveloped, semi-developed, and developed areas of Anchorage, Alaska, during August and September 1998 to determine concentrations of fecal coliform bacteria. In undeveloped areas of Ship, Chester, and Campbell Creeks, and the semi-developed area of Rabbit Creek, concentrations of fecal coliform bacteria ranged from less than 1 to 16 colonies per 100 milliliters of water. In the semi-developed area of Little Rabbit Creek, concentrations ranged from 30 to 860 colonies per 100 milliliters of water. In developed areas of the creeks, concentrations of fecal coliform bacteria ranged from 6 to 80 colonies per 100 milliliters of water.

INTRODUCTION

Federal, State, and municipal agencies use fecal indicator bacteria to assess potential human health risks from waterborne diseases. Fecal indicator bacteria live in warm-blooded animals, and are typically introduced to surface water with animal and human wastes. Although they are not disease causing, the presence of fecal indicator bacteria in a water sample is correlated to the presence of several waterborne disease-causing organisms (pathogens). Because fecal indicator bacteria survive longer, occur in greater numbers, and are easier to test for than pathogenic bacteria, they are typically used as an acceptable measure of a water body's suitability for specific uses. The most widely used fecal indicator bacteria for the assessment of water bodies are fecal coliform.

Although fecal indicator bacteria commonly come from the intestines of warm-blooded animals including man, they may also be associated with soils, vegetation, and insects. Because of the possibility of nonanimal sources, the occurrence of fecal coliform does not conclusively indicate fecal contamination.

From 1988 to 1992, the Municipality of Anchorage collected data on fecal coliform from numerous creeks (Municipality of Anchorage, unpublished data, 1999). On the basis of the data collected, five creeks (Ship, Chester, Campbell, Rabbit, and Little Rabbit Creeks) were included on the 303(d) "List of Water Quality-Limited Waterbodies" publication (Alaska Department of Environmental Conservation, 1992), and have remained on this list through 1998 (ADEC, 1998). The unpublished data from the Municipality of Anchorage and several previous studies of creeks in Anchorage indicate that fecal coliform concentrations frequently exceeded ADEC standards and were highest during snowmelt and storm runoff periods (Brabets and Wittenberg, 1983; Brabets, 1987; James M. Montgomery Consulting Engineers Inc., 1990). There are, however, few comparable sets of data for undeveloped reaches of these creeks.

To address this lack of data, the U.S. Geological Survey (USGS), in cooperation with the ADEC, collected data to determine the fecal coliform concentration from undeveloped or semi-developed areas in the upper watersheds of five creeks in Anchorage. During an approximate 30-day period from August through September 1998, two to five samples were collected from undeveloped areas in the upper watersheds of each creek. One "check sample"

was collected from a developed site in the lower watershed of each of these five creeks. The purpose of the check samples was to evaluate whether samples collected during August and September 1998 were significantly different from historical samples from the lower reaches. This report presents the results of the 1998 data-collection activity

STANDARDS FOR FECAL COLIFORM BACTERIA

Concentrations of fecal coliform bacteria in this report are expressed as the geometric mean of several samples and are reported as number of colonies per 100 milliliters of water (col/100 mL). For all potable waters, the detection of 1 col/100 mL may be cause for concern for public health (Myers and Wilde, 1997). In Alaska, the ADEC water-quality standards for a drinking-water supply state that in a 30-day period, the geometric mean of samples may not exceed 20 col/100 mL, and not more than 10 percent of the samples may exceed 40 col/100 mL (ADEC, 1999, p. 7). For water-contact recreation, the ADEC standards indicate that the geometric mean of samples collected during a 30-day period may not exceed 100 col/100 mL and not more than one sample, or more than 10 percent of the samples if there are more than 10 samples, may exceed 200 col/100 mL (ADEC, 1999, p. 7). The U.S. Environmental Protection Agency (1977) considers 200 col/100 mL an acceptable threshold for water contact recreation.

DESCRIPTION OF STUDY SITES

Ship, Chester, Campbell, Rabbit, and Little Rabbit Creeks were selected for sampling. All five originate at about 3,000 ft altitude in the Chugach Mountains and flow through the Anchorage lowlands to Cook Inlet. Each of these creeks has had elevated concentrations of

fecal coliform bacteria (ADEC, 1992, 1998). The sampling sites in the upper parts of the Ship, Chester, and Campbell Creek watersheds (fig. 1) were considered to be in undeveloped areas for this study because there was little human impact upstream from the sites. The sampling sites in the upper parts of the Rabbit and Little Rabbit Creek watersheds were considered to be in semi-developed areas for this study because only single-family homes separated by large lots were upstream from the selected sampling sites. The sampling sites on the lower parts of the watersheds of all creeks were considered to be in developed areas for this study because the areas upstream consisted of high-density housing and commercial development. The lower sites were selected as closely as possible to the sites previously sampled by the Municipality of Anchorage, and reported in reports by Brabets and Witterberg (1983), Brabets (1987), and James M. Montgomery Consulting Engineers Inc. (1990).

Ship Creek: The sampling site for the upper watershed of Ship Creek (fig.1) is approximately 7 mi upstream from the Glenn Highway and 9 mi upstream from urbanized areas. The upper site (not shown on figure 1) is accessed by a hiking trail that starts just before Arctic Valley Road terminates at Alpenglou Ski Area. The trail crosses Ship Creek, and four samples were collected about 10 ft upstream from this trail crossing. About 0.5 mi downstream from this site, two more samples were collected from a tributary to Ship Creek, about 10 ft upstream from the trail. For this study, both these sites were considered as representing undeveloped areas of upper Ship Creek. The sampling site in the developed, lower watershed of Ship Creek is on the upstream side of a bridge where the creek crosses Reeve Boulevard (fig. 1).

Chester Creek: The sampling site in the upper part of Chester Creek (fig. 1) is on Fort Richardson about 3 mi upstream from Muldoon

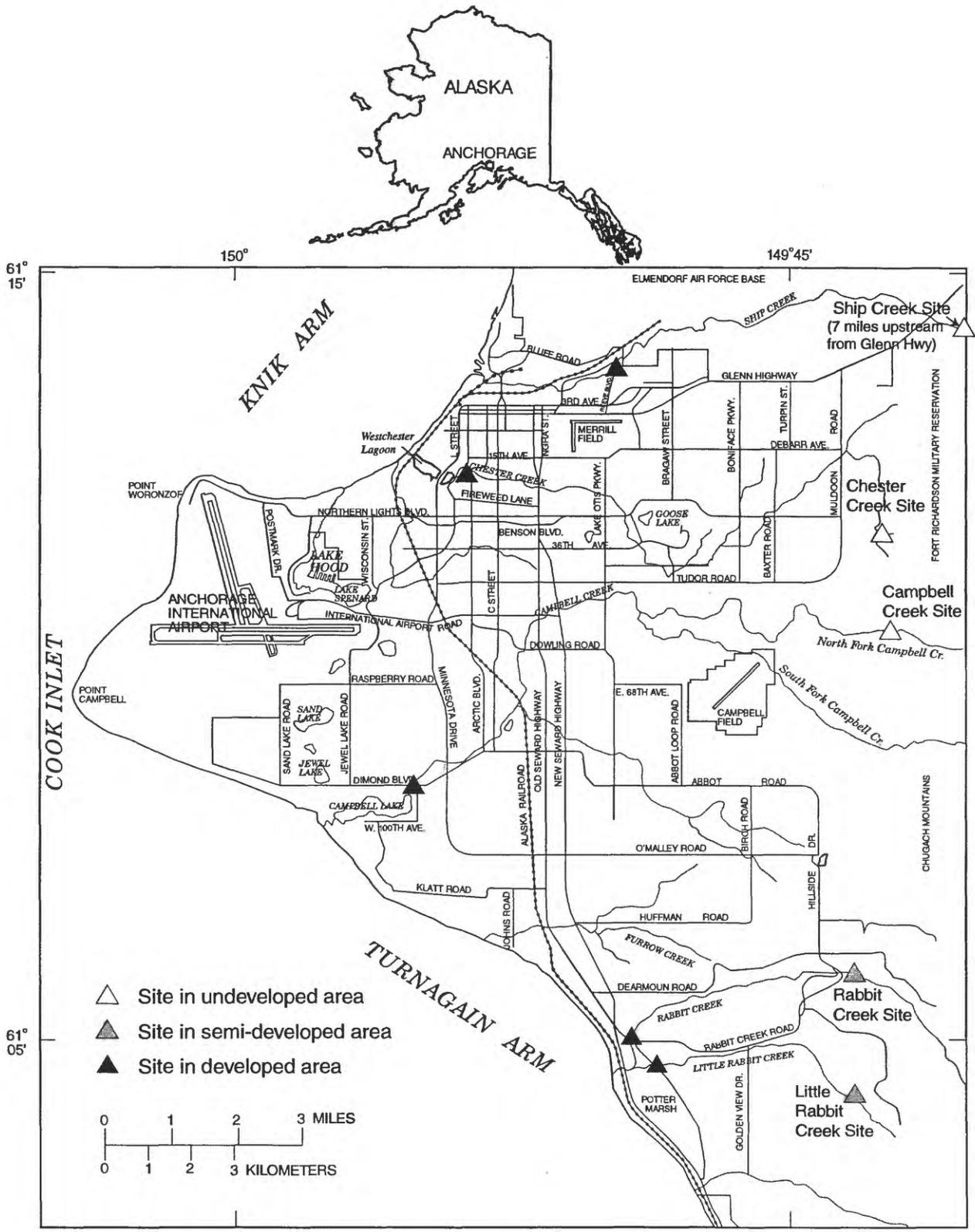


Figure 1. Fecal indicator bacteria sampling sites in local creeks in Anchorage, Alaska.

Road. Only three samples were collected at this site because access was delayed by military permitting. The sampling site in the developed, lower part of Chester Creek is about 100 ft downstream from the culvert where the creek crosses Arctic Boulevard (fig. 1).

Campbell Creek: The sampling site in the upper part of Campbell Creek is on the North Fork (fig. 1). Access to this sampling site is from Basher Road, which is east of Campbell Airstrip Road (not labeled on figure 1). At the end of Basher Road, a steep trail leads directly down to the creek. Water samples were collected at a site about 5 ft upstream from this trail crossing. The sampling site in the developed, lower part of Campbell Creek is upstream from where the creek crosses Dimond Boulevard (fig. 1).

Rabbit Creek: The sampling site in the upper semi-developed part of Rabbit Creek is approximately 25 ft upstream from where the creek crosses Hillside Drive (fig. 1). Although considerable recent development was evident upstream from the sampling site, it was selected for this study because access to sites farther upstream was limited, and data had been collected at this site in previous years. The sampling site in the developed, lower part of Rabbit Creek is upstream from where the creek crosses the Old Seward Highway (fig. 1).

Little Rabbit Creek: The sampling site in the upper, semi-developed part of Little Rabbit Creek (fig. 1) was about 50 ft east of George Road, near the intersection of George Road and Nickleen Drive (not labeled on figure 1). Recent development also was evident upstream from this sampling site, but it too was selected for this study because access to sites farther upstream was limited, and data had been collected at this site in previous years. The sampling site in the developed, lower part of Little Rabbit Creek is at the Old Seward Highway (fig. 1).

STUDY METHODS

Sample Collection Procedures

Routine samples were taken according to methods prescribed by the American Public Health Association and others (1992). Sterile 100-mL sample bottles were obtained and remained closed until the sample was taken. At a point equidistant from both banks, the bottle was placed top downward in the water approximately 6–12 in. from the surface, and then turned until the top pointed slightly upward in the direction of the streamflow. The cap was then removed and a water sample was collected. The cap was replaced and the bottle was removed from the water. Bottles were labeled with collector's name, date, time, site name, and bottle code. At each site, a single 100-mL sample was collected and kept chilled until delivered to a commercial laboratory in Anchorage.

A duplicate sample of water was also collected once at each undeveloped site. This duplicate sample of about 500 mL of water was collected using two sterile 250-mL bottles and methods similar to those described above. Additionally, stream discharge, water temperature, specific conductance, pH, and dissolved-oxygen concentrations were determined at each site during duplicate water sampling.

Sampling times were selected to systematically collect samples during an approximate 30-day-long period without concern for documenting specific flow regimes such as peak or low flows. Samples were collected once a week from early August through the first week in September. The duplicate sample was collected at each site during the last site visit.

Sample Processing

Routine samples were processed by the Anchorage laboratory of Columbia Analytical Services, Inc. (CASI); duplicate samples were processed by USGS personnel. The time span from routine sample collection to delivery at

the CASI laboratory did not exceed 24 hours. Holding times (the time span from collection to the beginning of incubation) for duplicate samples processed at the USGS laboratory did not exceed 6 hours. Holding times for routine samples processed at the CASI laboratory did not exceed 24 hours (Kim Tiplady, CASI analyst, oral commun., 1999).

Both CASI and USGS used in-house quality control/assurance procedures such as running a beginning blank and an ending blank, and using sterile buffered water for each sample. Fecal coliform concentrations were determined as the geometric mean using various sample volumes for duplicate samples. CASI also reported fecal concentrations as geometric means per 100 mL for the routine samples (Kim Tiplady, CASI analyst, oral commun., 1999).

All fecal coliform concentrations for this study were determined with the membrane-filter method (Myers and Wilde, 1997; American Public Health Association and others, 1992). In general, the water sample or a diluted sample of the water is filtered through a membrane filter using a low-pressure vacuum pump. The membrane filter is then placed in a petri dish filled with a nutrient-rich incubation medium. The bacteria in the water sample that are retained on the filter develop into visible colonies after incubation under specific conditions. For fecal coliform, these conditions include 24 ± 2 hours of growth at a temperature of 44.5 ± 0.2 °C (Myers and Wilde, 1997). The visible colonies are then counted to provide a quantitative value of bacteria present in the sample volume tested. The concentration value reported is the geometric mean value per 100 mL of water, which is based on several sub-sample volumes with various colony counts for each sample. Under the best or "ideal" analytical conditions, counts would range from 20 to 60 colonies for each sample tested. For duplicate samples analyzed during this study, sample results were identified in those instances where non-ideal counting conditions existed (see table 2 later in this report). Geometric means can only be calcu-

lated if all values are non-zero. For this report, all reported values of zero and of "less than 1" were converted to 1 before the geometric mean was calculated. The geometric means were then rounded using standard engineering practice and reported to the nearest whole colony.

FECAL COLIFORM CONCENTRATIONS

Ship Creek: The Municipality of Anchorage has numerous studies and data that provide historical information on fecal coliform concentrations in Ship Creek. For this report, a published subset (Montgomery-Watson Engineers, 1993) of these data was used. This subset consisted of 27 samples having a geometric mean concentration of 16 col/100 mL (table 1). The samples were collected from three sites (Glenn Highway, Reeve Boulevard, and Post Road) during 1988-92. The geometric mean of six samples collected between August 6 and September 4, 1998, from the upper, undeveloped area was 2 col/100 mL (table 2). No individual samples had concentrations that were greater than the ADEC threshold of 40 col/100 mL. These concentrations were all within the ADEC threshold for water contact recreation.

The geometric mean of 2 col/100 mL of the six samples from the undeveloped reach is much less than both the 16 col/100 mL for the historical subset and 26 col/100 mL for the August—September historical subset (table 1). The single check sample from the developed area during the current study, however, was 7 col/100 mL (table 2), which is also well below the geometric means of the historical values.

Chester Creek: Unpublished data from the files of the Municipality of Anchorage indicate that the mean concentration, based on 62 samples, in the developed lower reach of Chester Creek was 442 col/100 mL (table 1). The check sample collected from the lower reach on September 4 was 80 col/100 mL (table 2). The

Table 1. Fecal coliform concentrations in Anchorage creeks, 1988-92 and 1998
 [Concentration in colonies per 100 milliliters of water]

Creek	1988-92 Municipality of Anchorage unpublished data				1998 USGS data	
	Geometric mean concentration	No. of samples	August/September geometric mean concentration	No. of samples	August/September geometric mean concentration	No. of samples
Ship Creek	16	27	26	6	3	6
Chester Creek	442	62	695	18	6	3
Campbell Creek	55	370	47	68	3	6
Rabbit Creek	25	56	53	18	8	6
Little Rabbit Creek	111	249	257	67	270	6

geometric mean of three samples collected between August 19 and September 4 from the upper, undeveloped reach was 5 col/100 mL, and no sample exceeded 40 col/100 mL. Although the 80 col/100 mL in the check sample is well below the historical average of 442 col/100 mL, both the check sample and the historical data indicate a large difference in fecal coliform concentrations between the developed and undeveloped reaches.

Campbell Creek: Unpublished data from the Municipality of Anchorage indicate that 370 samples collected for the lower, developed reach have yielded an average of 55 col/100 mL (table 1). The check sample collected on September 5 from the developed reach was 68 col/100 mL (table 2), which is near this historical average. Five samples collected from the upper, undeveloped reach between August 5 and September 5, however, averaged only 2 col/100 mL. A very significant difference in concentrations of fecal coliform bacteria seems to exist between the developed and undeveloped areas.

Rabbit Creek: According to Municipal files, 56 samples from the lower, developed part of the creek averaged 25 col/100 mL (table 1). The check sample collected on September 5 contained 12 col/100 mL (table 2). The five samples collected from the semi-developed area between August 5 and September 5 had a geometric mean of 6 col/100 mL. Although 6 col/100 mL for the semi-developed area appears to be significantly less than the long-term mean for the lower watershed, 25 col/100 mL, this conclusion is not valid. The check sample for the developed area during the 1998 field season was 12 col/100 mL, which was within the range of values for the semi-developed area and significantly lower than the historical values. The observed differences may be caused by geographic, temporal, or other factors.

Little Rabbit Creek: Municipal files indicate that 249 samples have been collected from the developed part of the creek. These samples averaged 111 col/100 mL (table 1). The check sample collected from this same reach on September 5 contained 68 col/100 mL

Table 2. Fecal coliform concentrations in Anchorage creeks, August and September 1998

[col/100 mL, colonies per 100 milliliters of water]

Date	Fecal coliform concentration (col/100 mL)		Date	Fecal coliform concentration (col/100 mL)	
	Undeveloped site	Developed site		Semi-developed site	Developed site
Ship Creek			Rabbit Creek		
August 6	6		August 5	<1	
August 11	<1		August 10	6	
August 17	2		August 17	8	
August 27	2		August 28	^a 6	
September 4	^a 2	^a 8	August 28	14	
September 4	2	6	September 5	16	12
<i>Geometric mean</i>	2	7	<i>Geometric mean</i>	6	
Chester Creek			Little Rabbit Creek		
August 19	2		August 5	30	
September 4	^a 7		August 10	350	
September 4	10	80	August 17	860	
<i>Geometric mean</i>	5		August 28	^a 160	
Campbell Creek			August 28	100	
August 5	6		September 5	120	68
August 11	6		<i>Geometric mean</i>	161	
August 17	2				
August 28	^a <1				
August 28	<1				
September 5	2	68			
<i>Geometric mean</i>	2				

^aQuality assurance/quality control duplicate; non-ideal counts

(table 2). Five samples collected from the semi-developed reach during August 5 to September 5 had a geometric mean of 161 col/100 mL. The mean of 161 col/100 mL is biased by two very high values on August 10 and 17, during which time there were no comparable values for the developed reach. The August 10 and 17 values

may represent a temporal change that may also have occurred but was undetected in the lower reach. The apparent conclusion that the mean concentration in the upper watershed (161 col/100 mL) is greater than the mean concentration in the lower watershed (111 col/100 mL) is tenuous (table 1).

SUMMARY AND DISCUSSION

In four of the five Anchorage creeks (Ship, Chester, Campbell, Rabbit) tested during this study, the concentration of fecal coliform was less than the State's threshold for drinking-water supply (20 col/100 mL). In Little Rabbit Creek, however, the concentration of fecal coliform exceeded the threshold for drinking water in every sample and exceeded the threshold for water-contact recreation (200 col/100 mL) in two samples.

The expected result of fecal coliform bacteria sampling along each creek was that concentrations would be substantially higher at the developed sites than at the undeveloped and semi-developed sites. Fecal coliform bacteria concentrations were higher at the developed sites than at the undeveloped sites for same-day samples on Ship Creek, Chester Creek, and Campbell Creek. In contrast, the concentration of fecal coliform bacteria was lower at the developed sites than at the semi-developed sites for same-day samples on Rabbit Creek and Little Rabbit Creek.

For Ship, Chester, and Campbell Creeks, concentrations of fecal coliform on September

4 and 5 were lower at the undeveloped sites than they were at the developed sites. For Rabbit and Little Rabbit Creeks, however, concentrations of fecal coliform on September 5 were higher at the semi-developed site than they were at the developed site (table 2).

At the developed sampling sites, Ship Creek and Rabbit Creek had mean concentrations of fecal coliform less than the 20 col/100 mL water-quality standard for drinking-water supply. However, the concentration of fecal coliform at the developed sampling sites on Chester, Campbell, and Little Rabbit Creeks (80, 68, and 68 col/100 mL, respectively; table 2) each exceeded the 20 col/100 mL water-quality standard for drinking-water supply. All samples collected had mean concentrations of fecal coliform that were lower than the ADEC standard for water-contact recreation.

In addition to the measurements of fecal coliform bacteria, selected water-quality properties and stream discharge were measured (table 3) during the duplicate sampling trips, to give a general indication of water conditions during sample collection.

Table 3. Water-quality properties and stream discharge measured in Anchorage creeks during duplicate sampling, 1998

[°C, degree Celsius; $\mu\text{S}/\text{cm}$, microsiemen per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; ft^3/s , cubic feet per second]

Site	Date	Water-quality properties				
		Temperature (°C)	pH	Specific conductance ($\mu\text{S}/\text{cm}$)	Dissolved oxygen (mg/L)	Discharge (ft^3/s)
Ship Creek	September 4	8.9	8.1	169	13.5	
Chester Creek	September 4	6.6	8.1	129	12.8	4.1
Campbell Creek	August 28	4.0	7.5	136	12.8	20
Rabbit Creek	August 28	3.5	6.9	64	12.7	22
Little Rabbit Creek	August 28	3.5	7.7	100	12.9	5.3

Generally, fecal coliform concentrations determined from duplicate samples were similar to those in the routine samples (table 2). For example, duplicate samples collected at Chester Creek and Rabbit Creek differed by only a few colonies, and at Ship Creek and Campbell Creek they were exactly the same.

Municipality of Anchorage data from 1988-92 show that fecal coliform concentrations were generally higher during the months of August and September than annual concentration values (table 1). With the exception of Little Rabbit Creek, concentrations measured in the 1998 study were much lower than those reported in prior years (tables 1 and 2). The temporal variability at most sites, however, is 1 to 2 orders of magnitude. Larger data sets over longer periods of time are necessary to define long-term trends at the sites described in this report.

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