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WATER QUALITY OF THREE SMALL WATERSHEDS IN NORTHERN UTAH

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ABSTRACT

The chemical, physical, and bacteriological characteristics of streamflow from three small adjacent drainages in the Wasatch mountains of northern Utah are tabulated and discussed. These watersheds are sufficiently undisturbed so their chemical water quality essentially reflects their natural characteristics. Though man's presence here is minimal and livestock are excluded, the bacterial load of these streams indicates some pollution by warmblooded animals. Suspended sediment is negligible.

This report summarizes the chemical, physical, and bacteriological characteristics of streamflow from three small watersheds within the Davis County Experimental Watershed of northern Utah (fig. 1). Although this portion of the Wasatch Mountains was severely abused in the past, it has been protected since 1930 from fire, domestic livestock grazing, and timber cutting. These 45 years of protection have returned this area to near pristine conditions. The reported data can be considered as benchmark measures of streamflow quality from drainages with limited recent impact by man.

The three watersheds occupy adjacent south-facing slopes that drain into Farmington Creek and lie within the 6,000- to 9,000-foot elevation zone. The Halfway Creek, Corduroy Creek, and Whipple Creek catchments occupy 464, 140, and 359 acres, respectively. The Corduroy watershed has been essentially undisturbed since 1930; Whipple has a two-lane gravel road parallel to the upper border; and the upper 15 percent of Halfway was contour trenched in 1964. A comparison of streamflow measurements before and after this trenching showed no significant change in water yields (Doty 1971).

All three streams have steep (30 to 40 percent) gradients and "V"-shaped channels which eroded to bedrock prior to the mid-1930's. These channels are now becoming stabilized.

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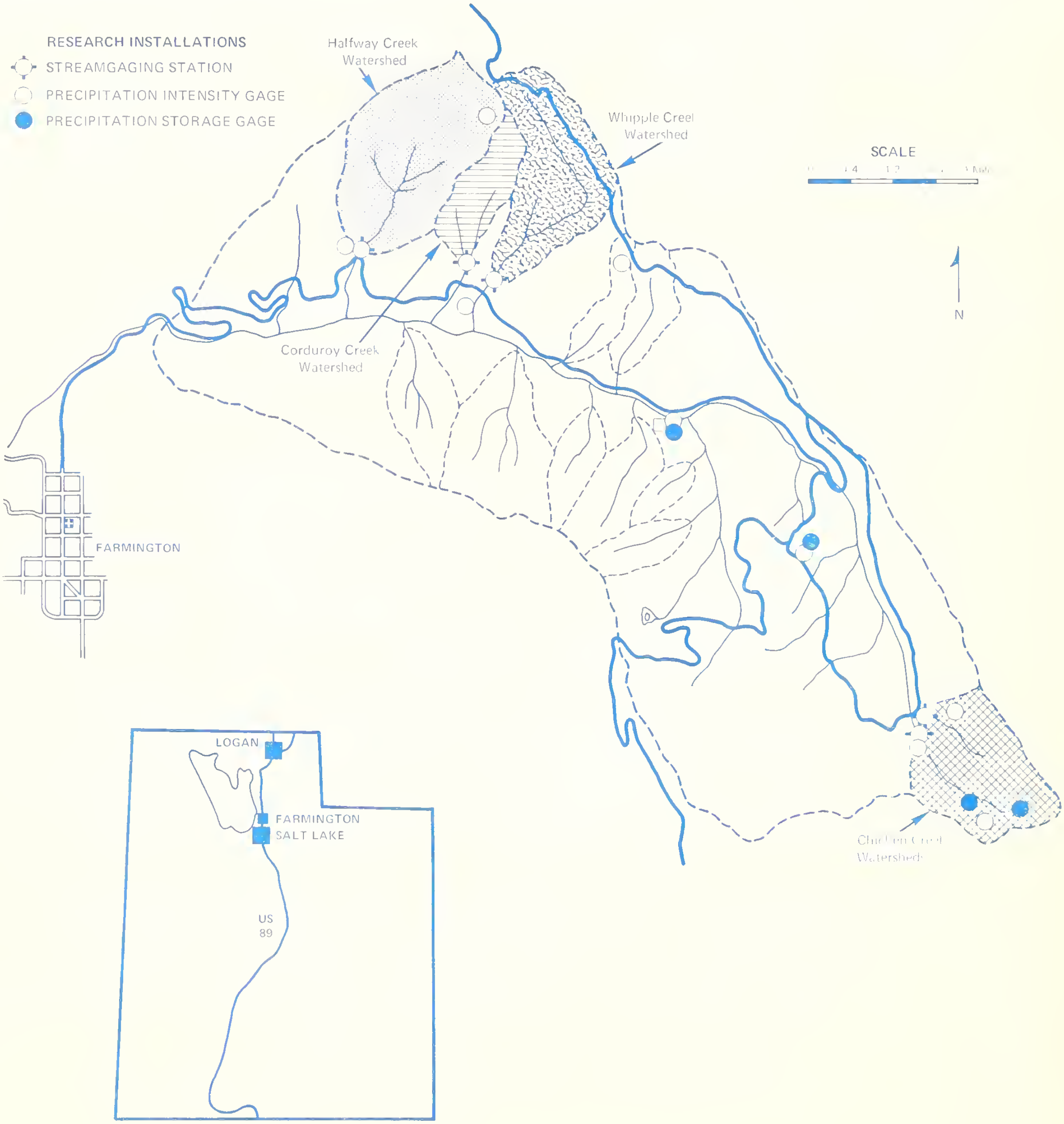

Figure 1.--The Halfway, Corduroy, and Whipple Creek watersheds in the Farmington Canyon drainage. Interpretive data were obtained from the Chicken Creek watersheds.

Soils are coarse textured, immature, rocky, and shallow (Doty 1971). The parent material is a complex of Precambrian metamorphic rocks (Bell 1952), referred to as the Farmington Canyon Complex by Eardley and Hatch (1940). These rocks are divided into four facies and subfacies from green schists to granulite.

Dense oakbrush (*Quercus gambelii* Nutt.) occupies the lower elevations. Intermediate elevations have extensive brush fields, mostly of *Ceanothus velutinus* Dougl. Two species of sagebrush (*Artemisia tridentata* Nutt. and *A. scopulorum* A. Gray) with a ground cover of grasses and forbs grow on drier midslopes and the upper ridges.

Two-thirds of the annual streamflow volume results from snowmelt during the March through June period (Doty 1971). Streamflow during the remainder of the year is almost exclusively from deep seepage and interflow. Most summer storms are light; less than 2 percent of summer precipitation results in direct runoff (Croft and Marston 1950); but the runoff from intense storms is flashy and often erosive. The remainder is lost through evapotranspiration. Consequently, the low streamflow period reflects the drainage characteristics of each watershed during the time when the influence of concurrent precipitation is negligible (Hall 1968).

METHODS

Several hundred water samples were collected at the mouths of the three watersheds and analyzed over a 3-year period (1970-1972). Most analyses were restricted to chemical and physical characteristics following the techniques described in "Standard Methods" (American Public Health Association 1971). Samples were collected weekly from April through November, and semimonthly during the remainder of the year. Bacterial analyses were made on fewer samples gathered less frequently. Polyethylene containers were used to collect streamflow and precipitation samples for chemical and physical analyses. Sterile, nontoxic, plastic bags were used to sample for bacterial analyses.

Nonfiltered water samples were analyzed for pH, specific conductance, and total alkalinity. Filtered samples were analyzed for calcium, magnesium, sodium, potassium, ortho-phosphate, and nitrate. Dissolved solids were calculated as a product of specific conductance times 0.78, an empirical formula. Suspended sediment was measured gravimetrically.

Bacterial examinations included total coliform, fecal coliform, and fecal streptococci counts. A ratio of fecal coliform to fecal streptococci counts (FC/FS) was used to indicate possible sources of any contamination.[2]

A stream-gaging station on Halfway Creek and recording precipitation gages at the head and mouth of Halfway Creek watershed provided data supplementary to this study. Further interpretive information was available from other precipitation gages in Farmington Canyon, streamflow quality data from Chicken Creeks (5 miles southeast of the three studied watersheds), and the chemical characteristics of precipitation samples collected in the Chicken Creek watersheds.

RESULTS AND DISCUSSION

The bacteriological quality of the three streams was measured in 14 to 17 samples from each watershed. The physical and chemical data came from 29 to 110 samples from each stream (table 1).

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[2]The cooperation of Utah State University, particularly George Coltharp and Les Darling, is acknowledged for the bacterial analyses.

Table 1.--*Water quality of Halfway, Corduroy, and Whipple Creeks (1970-1972)*

Parameter	Units	No. of samples	Minimum	Maximum	Average
HALFWAY CREEK					
pH	units	110	6.10	7.80	7.13
Conductivity	μmhos	110	83.00	265.00	105.48
Dissolved solids	mg/1	35	25.20	94.30	70.54
Total alkalinity	mg/1	67	20.00	72.00	32.65
Calcium	mg/1	108	4.17	31.25	9.61
Magnesium	mg/1	104	.41	6.75	3.23
Sodium	mg/1	103	.76	16.25	7.38
Potassium	mg/1	59	.05	6.00	.95
Phosphorus	mg/1	53	.00	.52	.06
Nitrate	mg/1	31	.12	.65	.34
Sodium adsorption ratio	ratio	103			.54
Suspended sediment	mg/1	106	.10	29.70	7.50
Total coliform	counts/100 ml	17	1	500	61
Fecal coliform	counts/100 ml	17	0	183	12
Fecal streptococcus	counts/100 ml	17	0	500	51
CORDUROY CREEK					
pH	units	70	5.50	7.80	6.98
Conductivity	μmhos	70	82.00	420.00	109.03
Dissolved solids	mg/1	35	53.30	83.30	68.75
Total alkalinity	mg/1	62	22.00	69.00	31.56
Calcium	mg/1	69	.25	23.50	7.72
Magnesium	mg/1	70	2.04	5.70	3.49
Sodium	mg/1	69	1.55	13.00	6.78
Potassium	mg/1	50	.05	6.00	1.05
Phosphorus	mg/1	53	.00	.63	.07
Nitrate	mg/1	30	.25	.70	.37
Sodium adsorption ratio	ratio	74			.49
Suspended sediment	mg/1	69	.30	16.40	5.55
Total coliform	counts/100 ml	17	2	240	42
Fecal coliform	counts/100 ml	17	0	36	2
Fecal streptococcus	counts/100 ml	16	0	230	31
WHIPPLE CREEK					
pH	units	94	5.70	8.00	7.11
Conductivity	μmhos	94	53.00	695.00	130.79
Dissolved solids	mg/1	29	44.50	119.00	80.95
Total alkalinity	mg/1	66	22.00	60.00	38.97
Calcium	mg/1	93	1.77	24.00	9.56
Magnesium	mg/1	93	.87	9.00	4.37
Sodium	mg/1	93	.60	13.80	8.11
Potassium	mg/1	55	.05	4.70	1.15
Phosphorus	mg/1	47	.00	.55	.07
Nitrate	mg/1	31	.07	.52	.34
Sodium adsorption ratio	ratio	92			.56
Suspended sediment	mg/1	84	.10	247.80	9.86
Total coliform	counts/100 ml	14	2	570	72
Fecal coliform	counts/100 ml	15	0	158	13
Fecal streptococcus	counts/100 ml	14	0	345	60

Chemical Quality

Most mineral-bearing waters are known to have pH values in a narrow range of pH 6 to 9 and to remain very constant. These streams are no exception: the mean value for all three was pH 7.1 and it fluctuated little throughout the year. Total alkalinity, mainly bicarbonate, contributed about half of the total dissolved solids load. This accounts for the neutral pH.

The combined mineral concentration of calcium, magnesium, sodium, and potassium made up 30 percent of the dissolved solids. Even the maximum contents of all ions measured were well within permissible limits for drinking water (Todd 1970).

The nitrate content of runoff from these watersheds is reasonably constant and quite low. Mean nitrate levels of each of these streams were almost equal, averaging 0.35 mg/l. Again, even the maximum concentrations were 60 times lower than the recommended maximum limits for drinking water (Todd 1970).

Interesting relations concerning nitrate-nitrogen and local stream conditions can be shown with supplementary data. The rapid flowing, "bubbling brook" type stream, represented by Halfway, Corduroy, and Whipple Creeks was six-fold higher in nitrate concentration than the slow and placid Chicken Creeks. Chicken Creeks lost nitrate from their sources to their mouths; it apparently was removed by aquatic plants growing in beaver ponds. Nitrate concentration in precipitation falling on the Chicken Creek watersheds usually was greater than that found in the streams.

Ortho-phosphorus phosphate concentration was generally less than 0.10 mg/l. Most natural waters contain relatively low levels of phosphorus in the soluble state.

The quality of these waters for irrigation uses is indicated by the sodium adsorption ratio (SAR) and specific conductance values. Mean SAR values were less than 1.0 milliequivalent per liter for all streams. Conductance was only one-fifth the maximum level recommended for irrigation water. Utilizing both criteria, these streams are in the excellent class, having both low salinity and low sodium hazard (Thorne and Thorne 1951).

Physical Quality

Generally, suspended sediment contents were extremely low. Large quantities are frequently produced by summer storms flushing out the stream channels; but these stormflows comprise a negligible part of the annual water yield. Suspended sediment also increases with the spring runoff, but drops off sharply when this flow recedes. Again, this is apparently a flushing action, removing an accumulation of material from the stream banks. Organic material is prevalent in the suspended sediment, accounting for about 10 percent of the total. The greater suspended sediment load in Whipple Creek, especially during high flows, possibly can be attributed to erosion from the road at the upper border of this watershed.

Bacteriological Quality

Several factors appear to affect the number of bacteria in the streams. These, in turn, resulted in a wide range of values (0 to 500 counts per 100 ml) in the samples. The counts were usually low, approximately 50 counts per 100 ml, and these declined to nearly zero during the winter and spring seasons when the watersheds were completely covered with snow.

A single storm (3.16 inches rainfall in 8 hours) in August 1971 produced high streamflow with very high bacterial counts. In this stormflow the fecal streptococci counts were 500, 230, and 345 per 100 ml from Halfway, Corduroy, and Whipple Creeks, respectively. Fecal coliform counts also were very high. Before and after this storm the fecal coliform counts were at or near zero. Accumulated bacteria-laden material was apparently flushed down the streams. Because fecal coliforms, generally, do not multiply outside the intestines of warmblooded animals, and therefore have short life spans, the high densities of fecal coliforms are indicative of relatively recent pollution. The FC/FS ratios for each stream during this stormflow were less than one, indicating a nonhuman source.

CONCLUSIONS

Water quality from these relatively undisturbed watersheds is extremely good. It is excellent for irrigation. However, the presence of fecal bacteria during much of the year would make it necessary to treat this water to make it potable. Minimal chlorination probably would suffice.

The chemical and physical qualities of these streams, especially the contents of dissolved substances, are related to the climatic and geologic characteristics of the area and indicate possible minimum levels that can be expected for such streams. Nitrate and bacteria contents reflect localized stream conditions that could be important in proper watershed management.

All parameters measured, except suspended solids, appear to reflect similar conditions on all three watersheds. The contour trenching and the road appear to have some influence on suspended solids, with the road through the Whipple Creek drainage possibly increasing sediment production the most. It is just as likely, however, that natural erosion rates are higher in the Whipple Creek than in the Corduroy Creek watershed.

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