WATER QUALITY STATUS REPORT

WILLOW CREEK

1980

Department of Health & Welfare
Division of Environment
Boise, Idaho

1981

Report No. WQ-47

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INTRODUCTION

The Idaho Agricultural Abatement Plan (1979) identified stream segments in which farmland runoff was impacting water quality. Willow Creek was identified as having severe pollution due to dryland farming erosion. The Soil Conservation Service has accumulated little information on the Willow Creek watershed and its water quality problems. The Idaho Department of Health and Welfare, Division of Environment, began a survey on water quality in April 1980 in order to provide some baseline information on the watershed.

Willow Creek is a tributary of the South Fork of the Snake River. Its waters are impounded by Ririe Dam approximately six miles above the town of Ririe, Idaho, and are substantially diverted for agricultural irrigation. The upper stream segments of Willow Creek are a high priority for abatement of sediment from dryland farming. It originates in steep rolling mountains of 6500-7000 feet elevation. Substantial snow accumulation and the steep topography contribute to a large spring runoff. This runoff and dryland farming practices in Upper Willow Creek result in severe erosion rates with much of this sediment entering Ririe Reservoir.

MATERIALS AND METHODS

Site Locations and Sampling Dates

Fifteen (15) stations (Figure 1) were selected on Willow Creek and its tributaries by a combination of map analysis and field surveillance. They

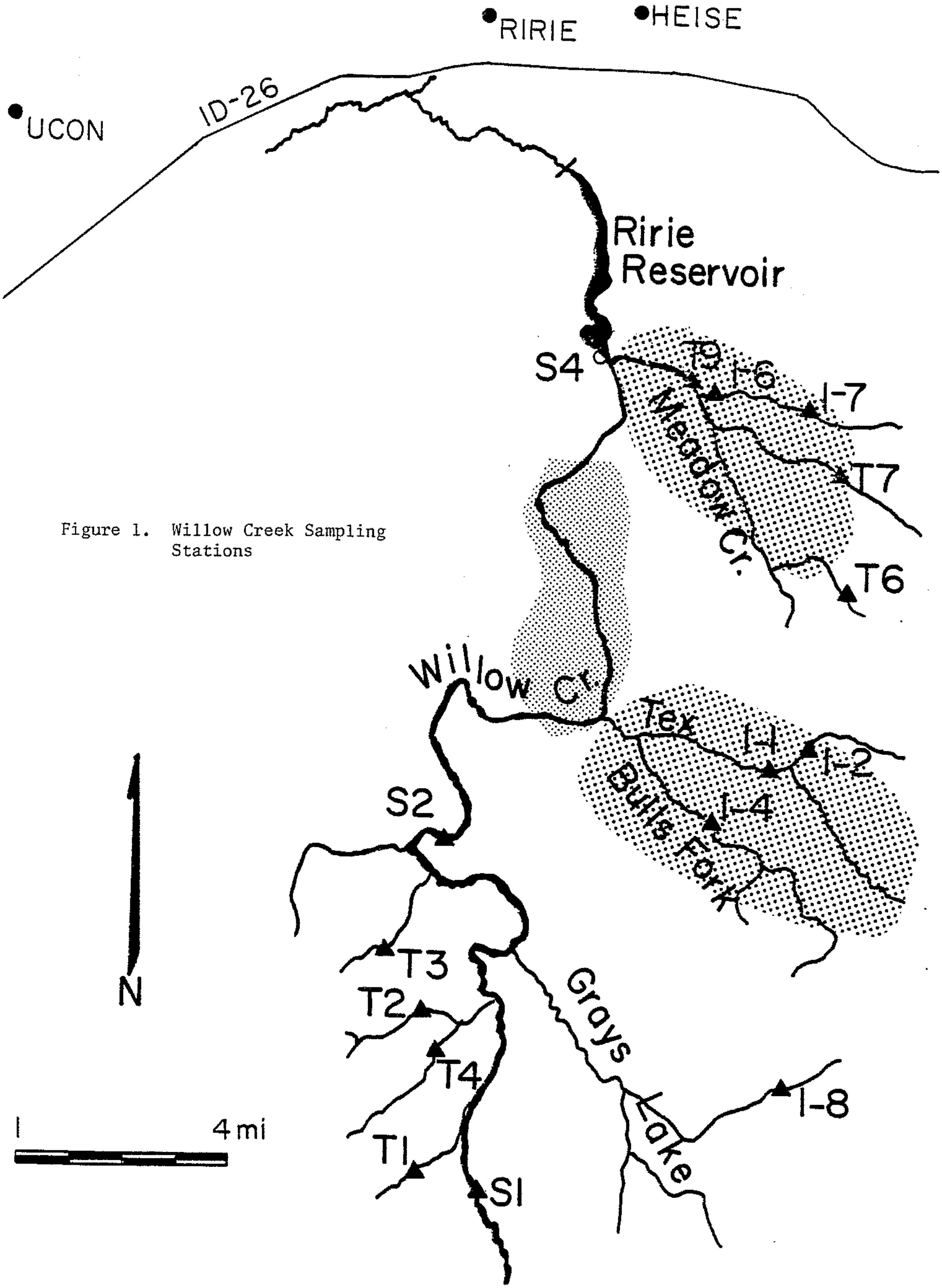

Figure 1. Willow Creek Sampling Stations

were chosen to examine the potential effects of dryland farming practices on Willow Creek. The sampling regime lasted from April 1980 - April 1981, although some stations were sampled prior to April 1980.

Two tributaries were ephemeral and were eliminated from the study as it progressed (Table 1). As initial results were obtained, it became apparent that other stations were of minor importance to potential water quality degradation in Willow Creek. These tributaries were either not impacted by land use practices, or their watershed size and consequent water discharge were small. These secondary stations are also shown in Table 1. In general, they were sampled through August 1980. Those stations on Willow Creek and those tributaries determined most likely to impact Willow Creek were sampled through April 1981 and were designated as primary stations.

Occasional road inaccessibility in winter and spring prevented sampling all sites each time. There are no roads near the mouth of Willow Creek; this section was not sampled until Spring 1981 when funds were made available for helicopter use.

Parameters

All samples were analyzed for the following chemical, physical, and bacteriological parameters: Total residue, suspended solids (SS), chemical oxygen demand (COD), total ammonia (NH_3-N); total nitrite + nitrate (NO_2+NO_3-N), total Kjeldahl nitrogen (TKN), total phosphorus (T-P), ortho-phosphorus (O'-PO_4; dissolved), specific conductance, hardness, chloride, fluoride, sulphate, silica, total coliform, fecal coliform, and fecal streptococcus. The primary stations which were sampled in 1981 were only analyzed for total residue, suspended solids and the above forms of nitrogen and phosphorus.

Table 1. SURVEY STATIONS

Station Number		Latitude/ Longitude	River Mile	Elevation	STORET #
S1	Willow Cr. at High Bridge Rd. T1S, R40E, Sec. 28	43°18'20"/ 111°46'20"	796.5/52.5	5950'	2080300
S2	Willow Cr. at Kepps Crossing Rd. T1N, R40E, Sec. 20	43°24'30"/ 111°47'10"	796.5/41.8	5420'	2080301
S4	Willow Cr. (Tailwaters of Ririe Reservoir)	43°30'35"/ 112°02'30"	796.5/.1	5060'	2080303
T1*	Canyon Cr. at Bone T1S, R40E, Sec. 20	43°23'45"/ 111°47'30"	796.5/51.4/1.3	6100'	2080306
T2*	Squaw Cr. at Grays Lake Rd. T1S, R40E, Sec. 5	43°21'20"/ 111°47'20"	796.5/48.1/2.0	5760'	2080307
T3**	Rock Cr. at Grays Lake Rd. T1N, R40E, Sec. 36	43°22'30"/ 111°48'20"	796.5/43.1/2.0	5750'	2080308
T4*	Birch Cr. at Road T1S, R40E, Sec. 8	43°22'00"/ 111°48'40"	796.5/48.1/2.0/1.5	6160'	2080309
T6*	Meadow Cr. at Trail Cr. T2N, R41E, Sec. 28	43°28'20"/ 111°38'20"	796.5/25.1/7.3	5850'	2080311
T7*	Deep Cr. at Deep Cr. Rd. T2N, R41E, Sec, 16	43°30'20"/ 111°38'35"	796.5/25.1/2.4/3.0	5920'	2080312
T9	Meadow Creek at Mouth T2N, R40E, Sec. 2	43°32'20"/ 111°43'25"	796.5/26.7/.1	5060'	2080302
I1	Tex Cr. Below Indian Fork T1N, R41E, Sec. 8	43°25'30"/ 111°39'40"	796.5/37.0/3.1	5650'	2080333
I2*	Indian Fork at Mouth T1N, R41E, Sec. 8	43°25'35"/ 111°39'30"	796.5/37.0/3.2/.1	5650'	2080334
I4	Bulls Fork at Road, T1N, R40E, Sec. 14	43°24'45"/ 111°41'00"	796.5/37.0/.9/2.3	5600'	2080335
I6*	Mud Spring Cr. at Mouth T2N, R40E, Sec. 2	43°32'20"/ 111°43'25"	796.5/26.6/2.0/.1	5060'	2080336
I7**	Mud Spring Cr. (Midway) T2N, R41E, Sec. 8	43°31'30"/ 111°39'15"	796.5/26.6/2.0/1.7	5800'	2080337
I8*	Hell Cr. at Brockman Rd. T1S, R41E, Sec. 16	43°20'15"/ 111°39'40"	796.5/46.6/4.3/3.5	5918'	2080338

*Secondary
**Ephemeral

Dissolved oxygen, water temperature, and pH were analyzed onsite. Flow was determined when possible.

Methods

Field parameters (discharge, dissolved oxygen, temperature, and pH) were measured according to Idaho Department of Health and Welfare, Division of Environment, Technical Procedures Manual. Other parameters were analyzed according to Standard Methods for Examination of Water and Wastewater or EPA's Methods for Chemical Analysis of Water and Wastes.

RESULTS

Stream Flow

The discharge record for the primary stations is incomplete (Table 2). Where flow records on Willow Creek are unavailable, the ratio of station discharges on Willow Creek was utilized. Only those data for 1980 are included in the estimate of mean discharge. Inclusion of 1981 spring data would bias the annual estimate of discharge since spring 1980 data were also utilized.

The Willow Creek watershed exhibits a pattern of runoff which is typical of the high cool deserts of southeastern Idaho. Minimum flows are found in late summer and early fall. Autumn rains slightly increase stream discharge. Winter precipitation is primarily in the form of snow. Cold temperatures and minimal melting result in winter base flow equal to, or less than, late summer flow. Late winter and spring thaws and rains create the major runoff which results in severe erosion and delivery of sediments to stream segments.

Table 2. DISCHARGE RECORD FOR WILLOW CREEK WATERSHED (cfs)

	Station					
Date	S1	S2	S4	I1	I4	T9
3/26/80	21*	31.1	39*	--	--	--
4/2/80	28*	40.5	51*	20	4	5.8
5/2/80	--	--	--	--	6.4	5.4
8/18/80	--	--	--	2.6	1.9	2.8
8/29/80	34.2	44.6	56*	1.0	1.3	0.8
1980 Mean	27.8	38.7	48.6	7.9	3.4	3.7
4/25/81	136*	198	248	3.4	0.8	5.0

*Estimated from Known Station Relationships

Table 3. PRIMARY STATIONS

Parameter	Mean Mineral Concentrations (mg/l)				
	S1	S2	I1	I4	T9
Sp. Cond.	330	400	737	794	699
Hardness ($CaCO_3$)	170	177	319	394	334
T. Alk ($CaCO_3$)	154	167	273	264	260
Ca	48	50	86	87	93
Mg	11.7	14.0	28.0	29.7	25.3
Na	7.4	14.0	37.2	29.6	23.8
K	1.4	2.3	4.1	4.8	4.5
Cl	8.6	16.0	64.6	74.6	55.4
Fl	0.2	0.2	0.3	0.3	0.2
SO_4	8.0	17.0	47.0	36.0	42.0
SiO_2	17.0	16.0	15.5	24.4	20.8
			Mean Demand (mg/l)		
COD	7.2	15.3	21.5	30.0	56.0

Table 4. SECONDARY STATIONS

Mean Mineral Concentrations (mg/l)									
Parameter	T1	T4	T2	T6	T7	I7	I6	I8	C.V. (%)
Sp. Cond.	528	606	500	639	629	678	626	526	11
Hardness ($CaCO_3$)	271	300	251	310	303	296	253	254	9
T. Alk ($CaCO_3$)	231	266	235	249	261	264	228	233	6
Ca	84	88	75	86	86	98	63	69	14
Mg	16.0	20.0	15.0	23.0	20.6	19.8	21.6	18.4	14
Na	9.3	24.0	12.9	14.0	12.8	20.2	18.7	12.4	32
K	1.5	4.9	3.8	2.9	2.3	3.1	4.4	2.5	36
Cl	21.0	25.0	18.8	30.0	28.3	53.4	39.8	26.7	37
Fl	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0
SO_4	15.0	45.0	14.0	48.0	17.0	34.0	28.0	18.0	50
SiO_2	15.0	36.0	26.0	15.8	16.6	19.8	37.8	10.4	45
Mean Demand (mg/l)									
COD	8.4	10.6	14.4	12.2	14.0	17.0	14.7	11.4	21

Total Residue and Suspended Solids

Total residue and suspended solids concentrations for the primary stations are shown in Figure 2. Total residue concentrations at High Bridge were nearly equal for all sample dates. Some suspended solids were entrained during spring runoff periods. Willow Creek at Kepps Crossing showed total residue concentration nearly equivalent to High Bridge (S1). Suspended solids concentrations were greater than at S1, but again, were evident only in spring.

Total residue concentration for the tributaries were nearly equivalent to each other and approximately twice those of the Willow Creek stations. Suspended solids concentrations were substantially greater at most times of the year in these tributaries than in Willow Creek, ranging from 20-7000 mg/l.

The Environmental Protection Agency and Idaho Water Quality Bureau use a maximum of 25-80 mg/l of suspended solids as a guideline for concentrations which may be harmful to aquatic life. The primary stations showed that suspended sediments concentrations during periods of high runoff were always greater than this benchmark.

Solids loading of the stations was determined based upon mean sediment concentration and the mean discharge for 1980. Spring 1981 values were not included in the calculations so as not to bias the loading estimates (through the use of two spring periods).

Nearly 45 tons of sediment per day were transported past Willow Creek at Kepps (Crossing (S2), compared to the upstream station of 15 tons/day (Figure 3). Approximately half of these sediments were in the suspended state. Meadow Creek transported nearly all of its 20 tons/day as suspended. Tex Creek and Bulls Fork contribute nearly 20 & 15 tons/day, respectively.

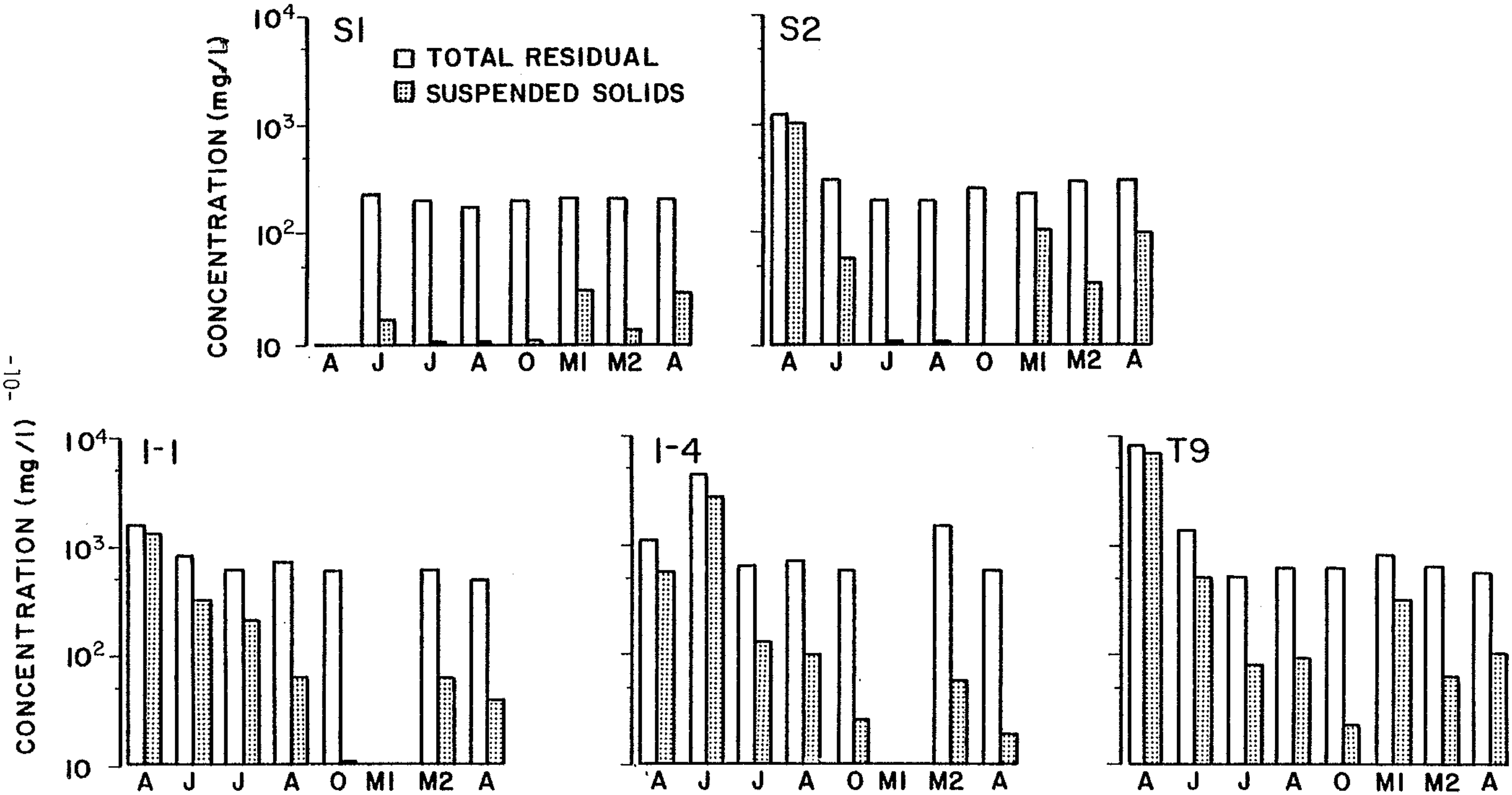

Figure 2. Sediment Concentrations for Primary Stations
(M1 & M2 are 2 Days in March 1981).

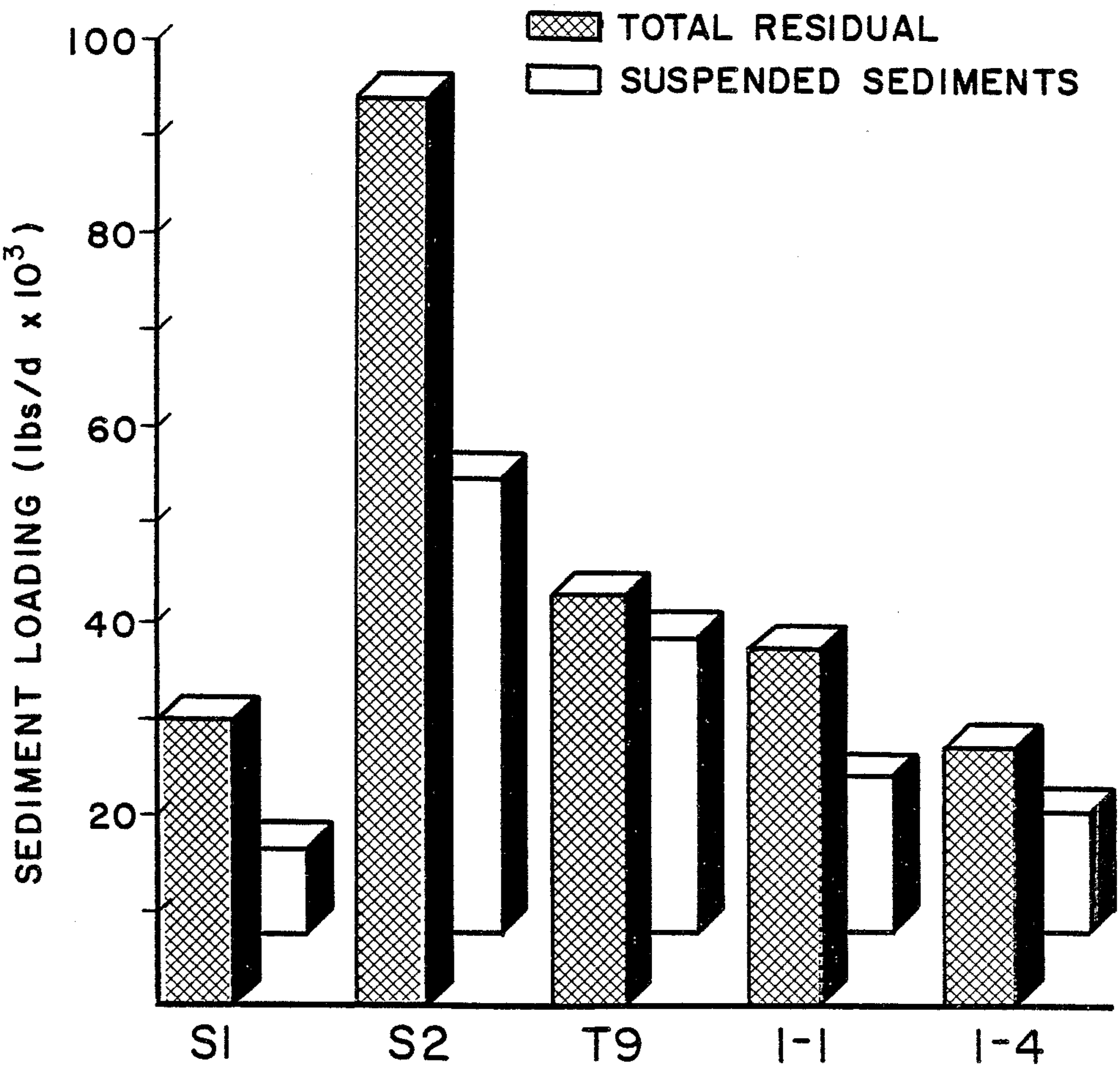

Figure 3. Sediment loading of primary stations (based upon 1980 mean discharge and sediment concentrations).

Nutrients

Various forms of phosphorus and nitrogen may create nuisance conditions in water. High nutrient loading may result in algal or plant "blooms", odors, and fish kills.

Phosphorus

Total phosphorus and ortho-phosphate concentrations were nearly similar at S1 & S2 (Figure 4). As with sediment concentrations, the tributary concentrations of phosphorus were much greater than the main stem. Much of the phosphorus at those stations was in the dissolved state.

However, total phosphorus (phosphorus contained in and on soil particles suspended in the water column plus that dissolved in the water) was very closely correlated with suspended sediments. The coefficient of determination (r^2) between these two parameters was 0.99; a coefficient of ± 1 indicates perfect correlation; thus, during high flows, large amounts of phosphorus are lost into the stream column with the sediments.

On an annual basis, over 60 pounds of phosphorus per day were transported past S2 compared with less that 10 lb/day at S1 (Figure 5). Of this, approximately 12.5 lb/day and 2.5 lb/day of ortho-phosphate were transported past S2 and S1, respectively. The tributaries delivered between 2.5 and 5 lb/day of phosphorus in the dissolved form.

Nitrogen

The forms of nitrogen of greatest interest are nitrate, nitrite, ammonia, and organic nitrogen. These forms are all biochemically interconvertible; thus, in order to assess nitrogen pollution in surface or groundwaters, all of the various types should be determined.

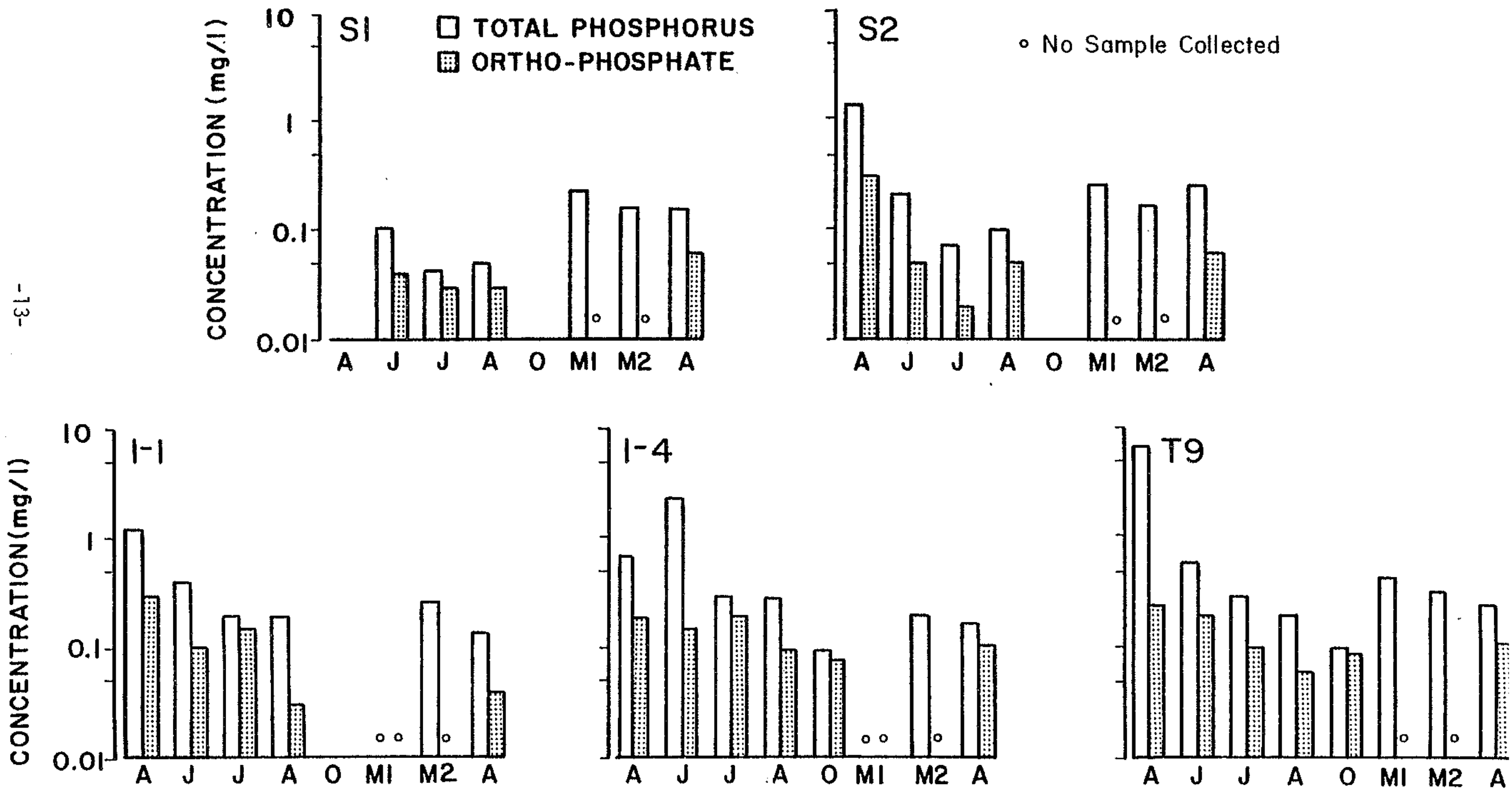

Figure 4. Phosphorus concentrations for primary stations.

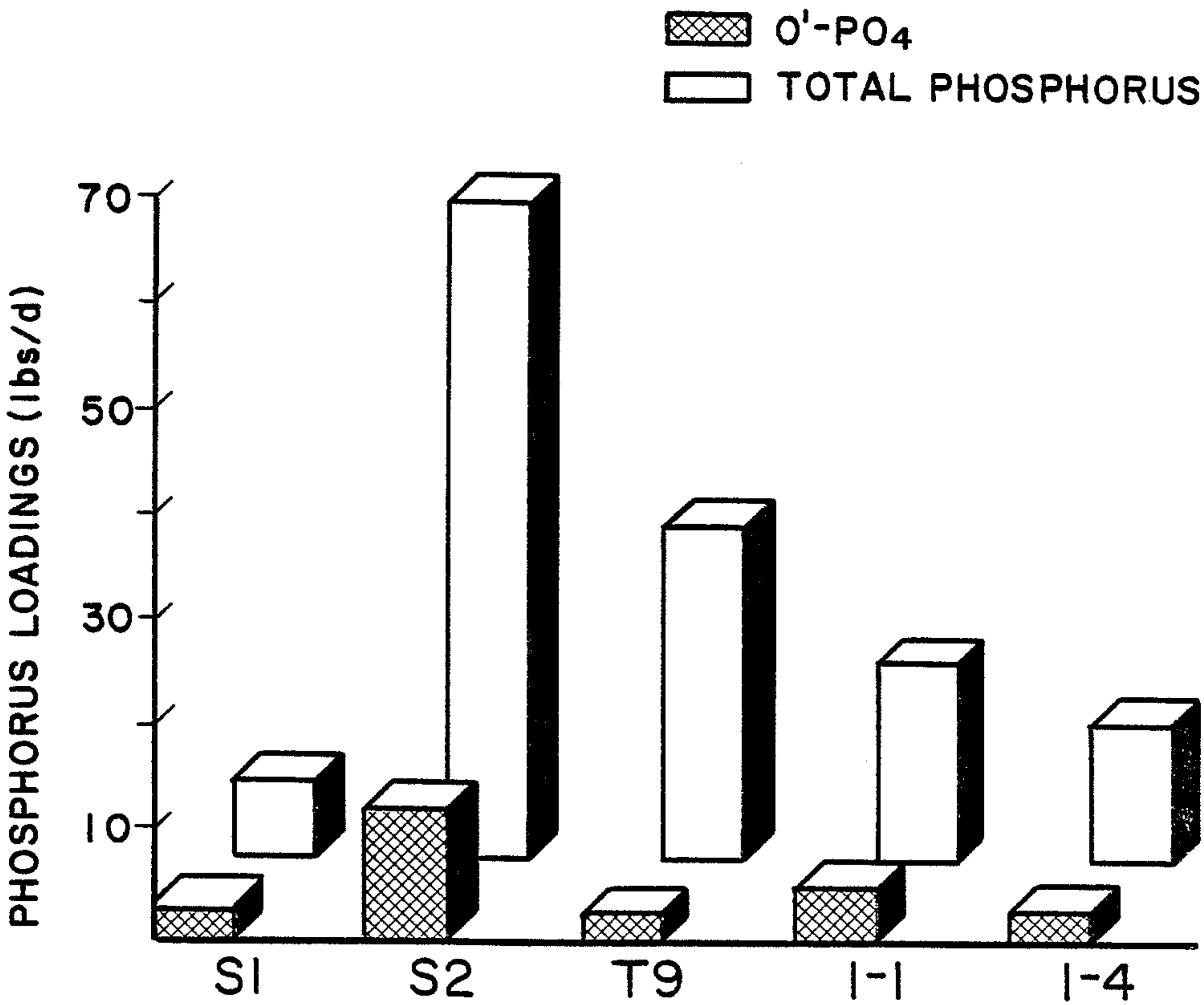

Figure 5. Phosphorus loadings of primary stations (based upon 1980 mean discharges of phosphorus concentrations).

Winter wheat is usually fertilized with ammonia, which is rapidly converted to nitrate in the soil; thus, its concentrations in water should be fairly low unless major precipitation closely follows an application of fertilizer. Ammonia concentrations were fairly consistent at S1, ranging between 0.04 and 0.07 mg/l; they were only slightly greater at S2 (Figure 6). The tributaries showed concentrations of NH_3 ranging from 0.03 to 0.16 mg/l.

Nitrates and nitrites in concentrations greater than 0.3 mg/l are generally accepted as stimulating excessive plant growth. Nitrogen in the combined forms of nitrate and nitrite were evident at S1 (Figure 6). Samples from 1980 did not show these forms of nitrogen at S1. NO_2+ NO_3 concentrations were highest at S2 in spring samples, ranging up to 0.34 mg/l. The primary station tributary samples showed high amounts of NO_2+NO_3. Meadow Creek (T9) concentrations ranged from 0.2 to 0.9 mg/l, while Tex Creek (I1) concentrations ranged from 0.37 - 2.1 mg/l and Bulls Fork (I4) ranged from 0.15 - 1.8 mg/l.

Total Kjeldahl nitrogen (TKN; sum of organic nitrogen and ammonia nitrogen) includes naturally-occurring proteins and urea, and numerous synthetic organic materials. Total Kjeldahl nigrogen concentrations were approximately 1.0 mg/l for all dates except October at S1 and S2 (Figure 6). The tributaries also showed fairly consistent although slightly higher concentrations of TKN.

NO_2+NO_3 loadings for the study period at S2, based upon mean concentration and mean discharge, was nearly seven times that of S1 (Figure 7). The primary tributary loadings ranged between 6 and 35 lbs/day with Tex Creek showing the greatest. TKN loadings for all primary stations ranged between 35 and 320 lbs/day. TKN loading at S2 was over twice that of S1.

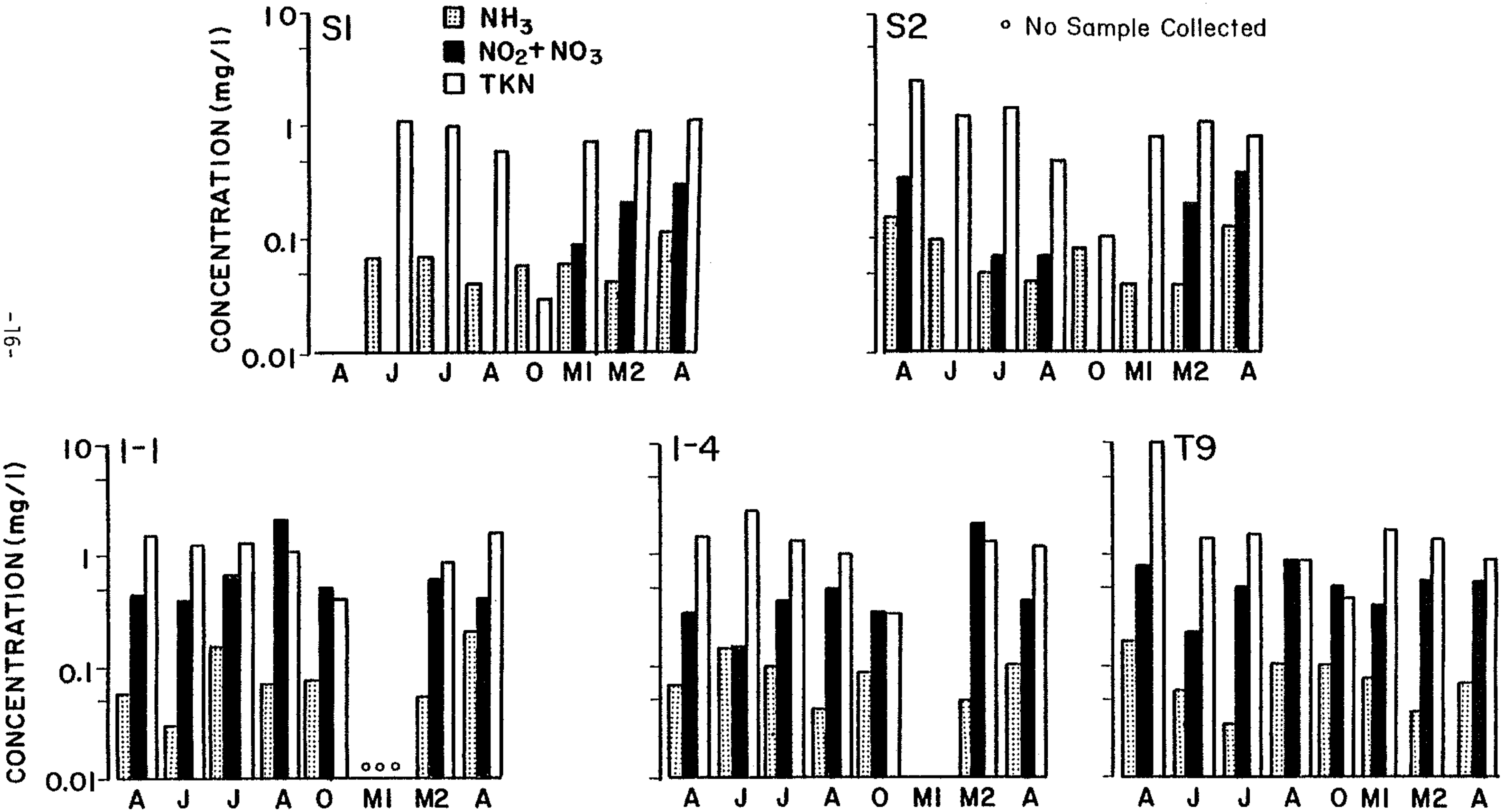

Figure 6. Nitrogen concentrations at primary stations.

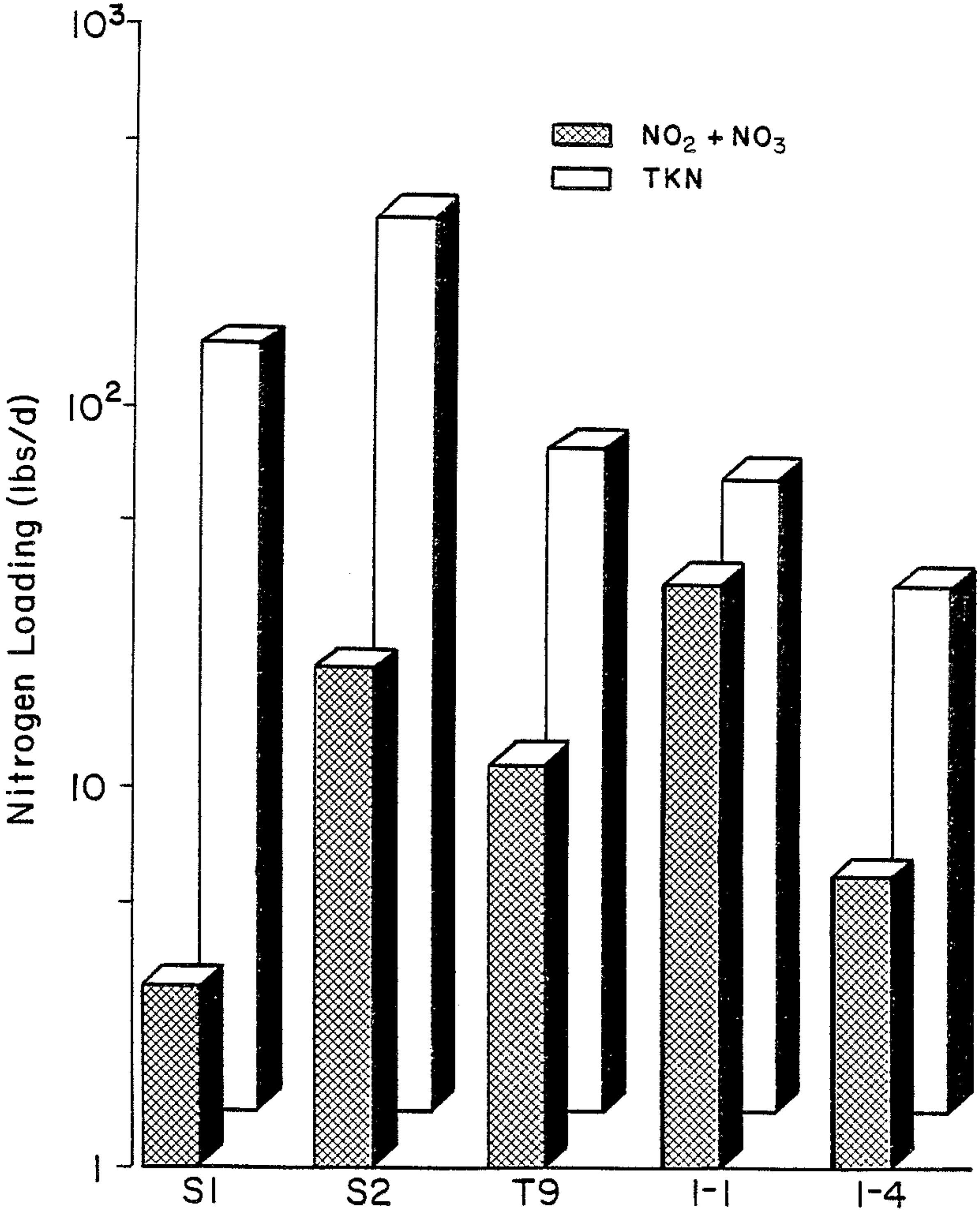

Figure 7. Nitrogen loadings at primary stations (based upon 1980 mean discharges and nitrogen concentrations).

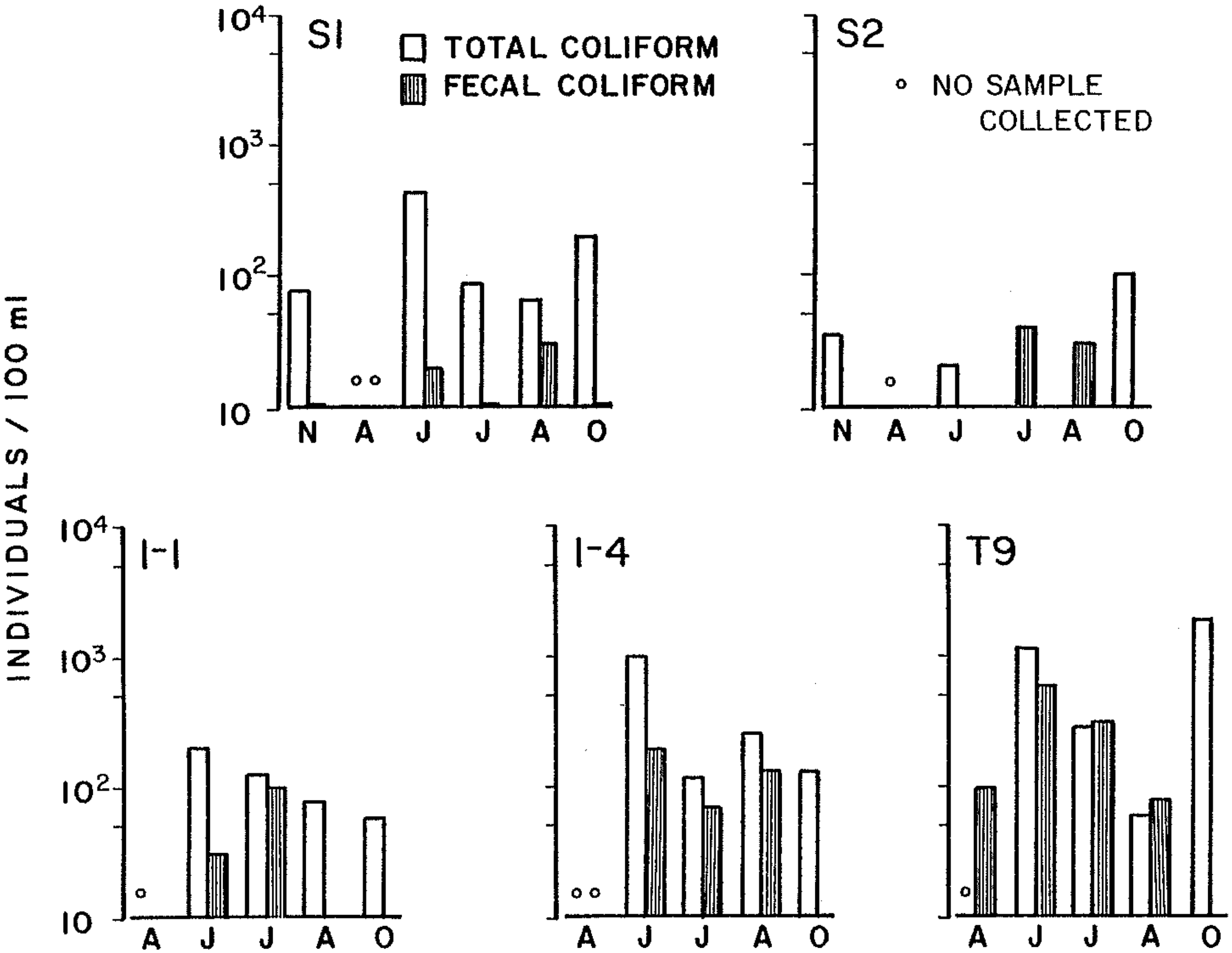

Figure 8. Coliform densities at primary stations.

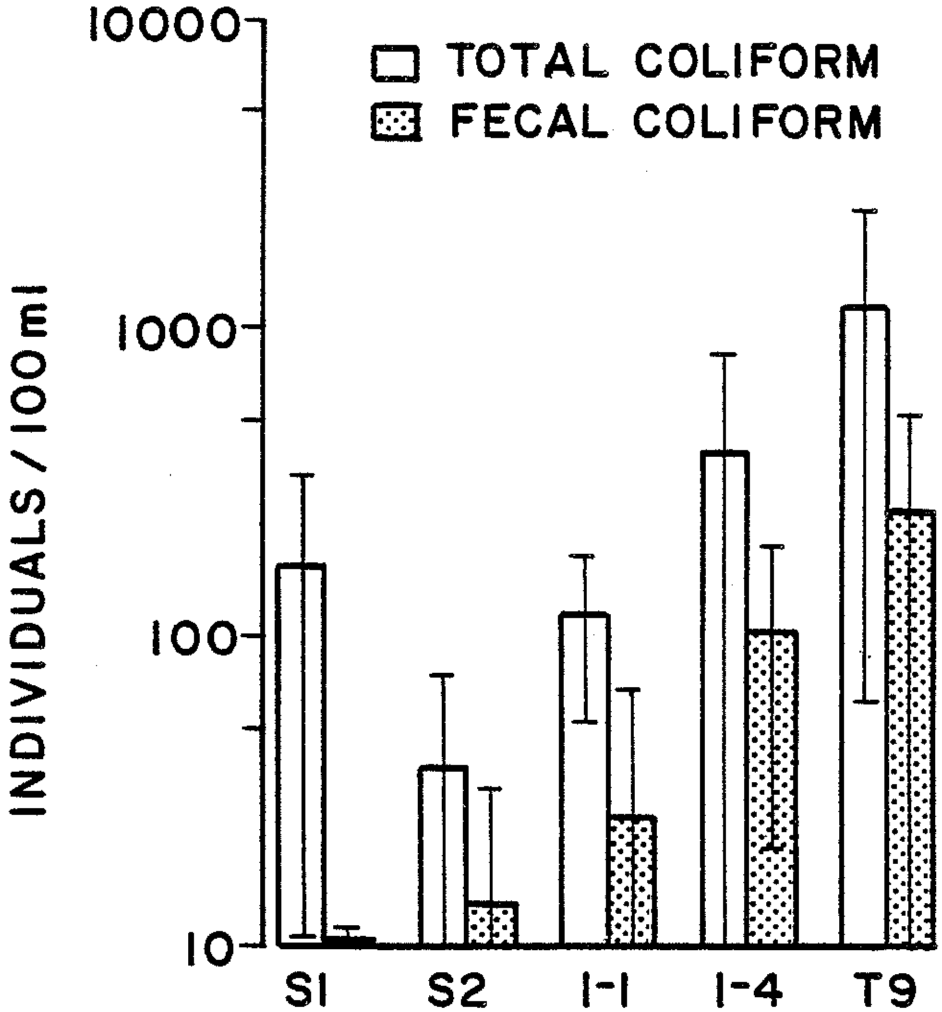

Figure 9. Coliform densities at primary stations (mean ± standard deviation).

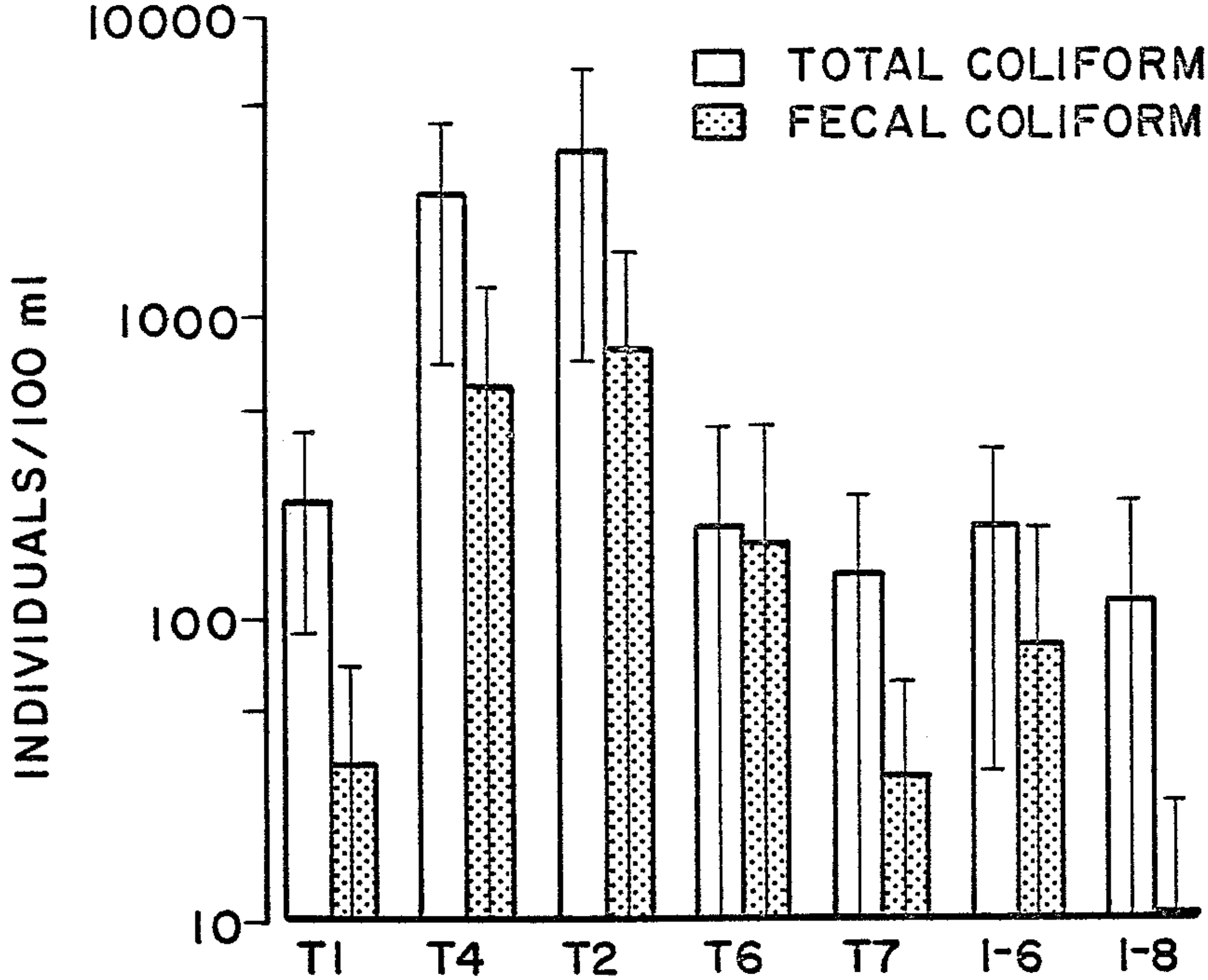

Figure 10. Coliform densities at secondary stations (mean ± standard deviation).

BACTERIA

Coliform bacteria are widely distributed in nature. Many are native to the gut of warm-blooded animals including man, while others may enter the gut by ingestion of vegetable matter or untreated water. Coliform bacteria leave the gut by means of fecal discharge; they may then enter water directly or indirectly by overland runoff. In general, coliforms are considered harmless; however, fecal coliforms, which specifically indicate fecal contamination by warm-blooded animals, may denote the presence of pathogenic bacteria.

Significant fecal coliform densities (Figure 8) were noted at both S1 and S2 during summer months (presumably from grazing cattle). Total coliform concentrations were greater at S1 than at S2. Primary tributary samples showed high fecal and total coliform densities, although they were probably classifiable for primary contact recreation, as designated by the Idaho Water Quality Standards and Wastewater Treatment Requirements.

Mean coliform concentration showed a wide variation for the primary stations (Figure 9). Both fecal and total coliform densities were greatest at T9. As expected, the secondary stations also showed wide variance (Figure 10). Squaw Creek (T2) and Birch Creek (T4) coliform densities were of sufficient magnitude to exceed maximum allowable concentration for primary contact recreation.

MINERALS

Mean mineral concentrations for the primary stations show close similarity between tributaries to Willow Creek (I1, I4, T9) (Table 3). The most upstream station on Willow Creek (High Bridge - S1) had lower concentrations of all minerals, except silica, than any other station. The midway station on Willow Creek (Kepps Crossing - S2) exhibited concentrations between those of S1 and the three tributaries.

The mean mineral concentrations of the secondary stations are also very similar among stations (Table 4). Coefficients of variation range from 0 to 50%; Canyon Creek (T1) concentrations for all parameters were, in general, lower than other tributaries. The similarity of these tributaries for all parameters led to their status as secondary.

OTHER WATER QUALITY PARAMETERS

pH

Measurements of pH ranged between 7.2 and 9.0 and, therefore, within the Idaho water quality standard range of 6.5 - 9.0.

Dissolved Oxygen

The minimum dissolved oxygen concentration measured was 6.5; thus, all samples were above the recommended minimum of 6.0 mg/l for dissolved oxygen.

SUMMARY

1) Willow Creek watershed exhibits a typical runoff pattern for southeastern Idaho streams with minimum flows in late summer and midwinter, and maximum flows in spring.
2) Suspended sediment concentrations were greatest during periods of high stream flows, ranging up to 7000 mg/l in disturbed portions of the watershed. Nearly 45 tons of sediment per day were transported in Willow Creek at the most downstream station. This is an increase of 200% over the upstream station and, presumably, attributable to dryland farming practices.
3) Total phosphorus concentration was well correlated with stream flow, indicating a large loss of this nutrient during periods of high flow. Annually, over six times the phosphorus is lost at the downstream Willow Creek station compared to the upstream control.
4) Ammonia concentrations were consistently low when compared to nitrates and nitrites; these latter two forms showed highest concentrations during periods of high stream flow, ranging up to seven times the accepted standards. On an annual basis, at least six times the nitrogen in form of nitrate and nitrite is lost at the most downstream Willow Creek station compared to the upper station.
5) Fecal coliform bacteria are indicators of fecal contamination, and were generally within Idaho water quality standards for primary contact recreation at the main stations of this study.
6) In general, mineral concentrations were not notably different between upstream and downstream stations on Willow Creek. Mean mineral concentrations for most Willow Creek watershed tributaries varied only slightly.
7) Dissolved oxygen and pH were within water quality standards.

8) Tex Creek, Bulls Fork, and Meadow Creek were tentatively identified as primary contributors to water quality problems of Willow Creek. These stations exhibited either large fluctuations as in mineral or residue concentration, or continually elevated concentrations.

Meadow Creek watershed should probably be given primary consideration in any management plan for Willow Creek. It has deep easily-eroded topsoils and some severe slopes, both farmed and undisturbed. The proximity of Meadow Creek to Ririe Reservoir is such that all nutrients and sediments which enter Meadow Creek are nearly certain to end up in the reservoir. This high nutrient loading may result in nuisance algal blooms, odors, fish kills and, of course, sedimentary fill-in.

9) Further study on the sub-basins indicated by this study is warranted. Correlation of these data with a well-established discharge record is fundamental. Data on land use practices and implementation of best management practices are important and may be instituted on small basins as demonstration projects.

Willow Creek at the mouth should be included in any future study. Information on rate of sediment input to Ririe Reservoir is also important. Additional sampling should be done in autumn and winter to establish further baseline data.