WATER QUALITY STATUS REPORT • REPORT NO. 81

DEEP CREEK AND MUD CREEK
Twin Falls County, Idaho
1986

Idaho Department of Health and Welfare
Division of Environmental Quality
Water Quality Bureau
Boise, Idaho

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ABSTRACT

Deep Creek and Mud Creek are located in Twin Falls County near Buhl, Idaho. From April through October, these two creeks convey irrigation drainage water from the western part of the Twin Falls irrigation tract to the Snake River. During 1986, water quality surveys were conducted on both creeks to assess water quality conditions and beneficial use impairments due to agricultural pollutants. In addition, data were collected to identify subbasins within each watershed for agricultural best management practices treatment under the Idaho Agricultural Pollution Abatement Program.

During the 1986 irrigation season, Deep Creek and Mud Creek contributed an estimated 5,150 tons and 3,660 tons, respectively, of sediment to the Snake River. Inorganic nitrogen and total phosphorus levels in both creeks exceeded recommended limits to prevent nuisance plant growth. Organic nitrogen and total phosphorus levels were elevated prior to the irrigation season and may reflect a continual input of animal wastes to these creeks.

Fecal coliform bacteria densities in both creeks exceeded the secondary contact recreation standard (200 bacteria/100 ml) at most stations throughout the irrigation season. Ratios of fecal coliform bacteria to fecal streptococcus bacteria indicate that the predominant source of these bacteria was livestock. Ratios also indicated an intermittent contamination of the creeks with human wastes.

Macroinvertebrate collections from Deep Creek and Mud Creek also indicate degraded water quality conditions exist in both creeks. Substantial portions of the invertebrate communities present in each creek were composed of pollution tolerant species. Irrigation season water quality impacts were integrated by invertebrate communities throughout the summer and reflected by reductions in taxa richness, densities, and number of "clean water" species in fall samples.

The data indicate that beneficial uses are being impaired or threatened in both creeks due to agricultural pollutants. Levels of agricultural pollutants could be reduced through application of agricultural best management practices to eroding farmland and confined animal feeding operations. Critical subbasins within each drainage were identified for agricultural best management practices treatment. These include the Low Line Canal and Upper Deep Creek subbasin in the Deep Creek drainage, and the Silo Creek and Upper Mud Creek subbasins in the Mud Creek drainage. Any sediment retention practices applied to farmland in these subbasins

would help prevent sediment, nutrients, and bacteria from entering the creeks and ultimately the Snake River. Best management practices directed at managing animal waste and dairy wastewaters should also receive high priority to reduce nutrient and bacteria loading of these creeks, and to protect public health.

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INTRODUCTION

Runoff from agricultural lands is a major source of pollutants to surface waters of Idaho, particularly in the irrigated south central portion of the state. Pollutants commonly present in irrigation tailwater and dairy or feedlot runoff include suspended sediment, nutrients, and bacteria. These pollutants adversely impact the quality of receiving waters and threaten designated beneficial uses.

The Idaho Agricultural Pollution Abatement Plan (IDHW-DOE, ISCC, and U.S. EPA 1983) was developed and implemented to solve water quality problems arising from agricultural activities. This plan focuses on reducing non-point source agricultural pollution impacts on surface waters through implementation of best management practices (e.g., sedimentation ponds, filter strips, minimum tillage, livestock waste management systems, etc.) in critical drainage basins. As part of this plan, Soil Conservation Districts (SCDs) were asked to help identify streams impacted by agricultural activities. Information obtained from SCDs, Idaho Department of Fish and Game, and the IDHW-Division of Environmental Quality was reviewed and impacted streams were prioritized for treatment under the plan.

The Balanced Rock SCD identified Deep Creek and Mud Creek as streams impacted by agricultural pollutants, and both were categorized as first priority stream segments in 1982. This designation implies degraded water quality conditions exist in both creeks which can be improved through implementation of agricultural best management practices (BMPs).

According to the Idaho Water Quality Standards and Wastewater Treatment Requirements (Idaho Department of Health and Welfare 1985) Deep Creek and Mud Creek should be managed to provide a diversity of beneficial uses. These uses include: agricultural water supply, cold water biota, salmonid spawning, and secondary contact recreation.

PAST WATER QUALITY STUDIES

In 1980 the IDHW-Division of Environmental Quality conducted a water quality study on Deep Creek and Mud Creek to assess existing conditions. Parameters monitored monthly from March through August at several creek and tributary drain stations included suspended sediment, bacteria, nutrients, and metals. The data indicated degraded water quality conditions existed and that beneficial uses were likely being impacted. The poor water quality was considered a result of agricultural activities in these drainages-primarily from eroding cropland and numerous dairy and feedlot operations.

Because it was apparent that agricultural activities were degrading water quality, the Balanced Rock SCD applied for and received a State Agricultural Planning Grant for the Deep Creek/Mud Creek watersheds in 1985. This planning grant was to provide the necessary information and basis for pursuing a BMP-Implementation Grant for a local water and soil conservation resource management program under the State Agricultural Pollution Abatement Plan. In conjunction with the work performed by the Balanced Rock SCD and the Soil Conservation Service (SCS), the IDHW-Division of Environmental Quality conducted an intensive water quality survey in 1986 on Deep Creek and Mud Creek.

OBJECTIVES

The objectives of this intensive water quality survey on Deep Creek and Mud Creek were as follows:

a) Assess existing water quality conditions and impacts from agricultural activities in these watersheds during the 1986 irrigation season.

b) Expand the existing water quality data base on both creeks to include a complete water year to assess pre- and post-irrigation season water quality.

c) Identify priority subbasins within each drainage for application of BMP's.

d) Provide baseline data for comparison of water quality conditions after a BMP implementation project.

DRAINAGE BASIN DESCRIPTION

Deep Creek and Mud Creek are located in the western portion of Twin Falls County (Figure 1). The Deep Creek drainage consists of approximately 36,075 acres and begins southeast of Castleford and includes the area west of Buhl and east of the Salmon Falls Creek drainage. Deep Creek generally flows northward to its confluence with the Snake River in Melon Valley. Mud Creek lies northwest of Buhl and east of the Deep Creek drainage. Mud Creek drains about 23,920 acres as it flows north through the center of Melon Valley to its confluence with the Snake River.

The SCS has estimated that about 80% of both watersheds are surface irrigated through ridge and furrow systems. Principal crops include dry beans, corn, alfalfa, wheat, barley, potatoes, and peas. There are also 60 to 70 dairy and feedlot operations located in the Deep Creek and Mud Creek drainages. It is estimated that 3,500 and 2,500 acres are utilized in the Deep Creek and Mud Creek drainages, respectively, for livestock grazing.

Soils in these watersheds may be characterized as predominantly fine sandy loams and silty clay loams with moderate to high erosion potentials. Evidence of past erosion exists in the form of areas of limy materials that are exposed on many irrigated fields. In the lower ends of both drainages, bank mass wasting becomes significant. In these areas the stream channels are deeply incised and vertical exposed banks are common. During high water these banks erode and slump into the creeks.

The climate of the Buhl-Castleford area and the Melon Valley is considered semi-arid, with the valley receiving about 20 cm of precipitation annually. Higher elevations generally receive greater amounts of precipitation with most of this falling as snow in winter.

MONITORING STATIONS

This study was conducted throughout 1986 to assess water quality conditions during a complete water year. The study was initiated in April to document pre-irrigation and early irrigation impacts, and continued through November to assess post-irrigation water quality.

Five sampling stations were established along Deep Creek from east of Castleford to about 1 mile above its mouth. These stations are summarized in Table 1 and identified in Figure 2. In addition, sampling stations were established on five major tributaries and/or irrigation drains to the creek to assess loadings and to identify critical subbasins. Similarly, three monitoring stations were established on Mud Creek and three on major tributaries of the creek (Table 1, Figure 3). Because little farming occurs in the East Fork of Mud Creek subbasin, this tributary was not monitored during this study.

MATERIALS AND METHODS

Field parameters were analyzed with portable meters which were calibrated prior to each survey. Dissolved oxygen and temperature were measured with a YSI Model 54A meter. Specific conductance was measured with a YSI Model 33 SCT meter. The pH was determined with an Accumet Mini pH meter, Model 640A (Fisher Scientific Co.). Flow measurements were taken with a Marsh-McBirney Model 201D current meter and used to calculate discharge (Q, in cubic feet per second).

A churn splitter was used to collect cross-composited water samples from well-mixed locations at each station. Water samples for chemical analysis were collected in 1 liter cubitainers. Samples for nutrient analysis were preserved with 2 ml H_2SO_4. Water samples for dissolved ortho-phosphate analysis were field filtered using 0.45μ Micron Sep Magna Nylon 66 Membrane Filters (Fisher Scientific Co.). This was done with polypropylene syringes and Gelman Delrin syringe-type membrane filter holders; filtrate was collected in Corning 10 ml polystyrene disposable culture tubes. Samples were placed on ice and cooled to 4°C. Chemical analyses were conducted by the Idaho Department of Health and Welfare, Bureau of Laboratories, Boise, following Standard Methods (American Public Health Association 1985).

Bacterial grab samples were collected in sterile 250 ml Nalgene polyethylene bottles. These samples were cooled to 4°C and delivered to the Twin Falls Branch of the IDHW-Bureau of Laboratories. Analysis of bacterial samples followed Standard Methods (American Public Health Association 1985).

Macroinvertebrates were collected at various Deep Creek and Mud Creek stations in March and September, 1986, with a modified Hess sampler ($0.10m^2$). Three replicate samples were collected from riffle areas at each station. Samples were preserved in the field with 70% isopropyl alcohol and processed by the IDHW-Bureau of Laboratories, Boise.

QUALITY ASSURANCE

Duplicate (split) and spiked water samples were collected at various stations on different dates to assess the accuracy and precision of the data collected. This quality assurance (QA) component of the field work follows Bauer (1986) and Bauer et al. (1986a, 1986b) guidelines.

Duplicate samples were collected to assess precision. At a given station, these QA samples were collected from the same composite collected for routine water chemistry samples. Duplicate bacteria samples were collected as close together in the stream as possible.

Four sets of spiked samples were collected during the study from various Deep Creek and Mud Creek stations to assess accuracy. Chemical spikes were prepared by the IDHW-Bureau of Laboratories, Boise, and sealed in Kimble 10 ml glass ampules. Spikes were prepared for ammonia, nitrate, ortho-phosphate, total phosphorus, and total Kjeldahl nitrogen. Celite was used for suspended solids spiking and was pre-weighed into plastic vials.

In the field, ampules or vials were opened and their contents mixed with 900 ml of sample water in 1 liter cubitainers. All QA samples were then stored on ice at 4°C and shipped to the IDHW-Bureau of Laboratories in Boise for analysis following Standard Methods (American Public Health Association 1985). Percent recovery for spikes was determined by subtracting background concentrations (as determined from duplicate or routine samples) from known spike values.

RESULTS AND DISCUSSION

This section of the report is divided into two parts. The first part discusses Deep Creek water quality and also includes general comments concerning the significance of each water quality parameter. The second part discusses Mud Creek water quality.

DEEP CREEK

STREAM FLOW

Deep Creek is a regulated stream with flows greatly modified by irrigation water management. From its confluence with the High Line Canal of the Twin Falls Canal system to its mouth, Deep Creek is considered a collection and conveyance structure for irrigation water (IDHW 1985).

Mean stream flow during this study ranged from 26.6 cfs at S-4 near Castleford to 158.1 cfs at S-3A (Table 2). Downstream of S-3A a substantial portion of Deep Creek flow is diverted at the L-10 diversion; therefore, mean flows are lower downstream than at S-3A.

Base flow occurs in February and March at around 20 cfs (Table 3). During this period, creek flow originates as several large springs in the vicinity of S-3; the streambed is dry from this point upstream until irrigation begins. Irrigation water is turned into the canals and enters Deep Creek in mid-April. Snake River water enters Deep Creek from branches of the High Line and Low Line canals of the Twin Falls Canal Company.

Peak flows occur in early April as the canal system is flushed, and in September when irrigation water is only being used for some late grain and pastures. Flows during these periods are typically around 150 cfs and may exceed 200 cfs. Although natural stream flows are likely less than 50 cfs in Deep Creek in the fall, irrigation water may maintain stream flows at around 200 cfs into early November to provide water to hydroelectric facilities on adjacent canals.

SUSPENDED SEDIMENT

The suspended sediment load of a river consists of particles (mineral or organic) that require little energy to transport once they are entrained in the water column (Morisawa 1968). Suspended sediment adversely impacts aquatic ecosystems by reducing light penetration and primary production, and by physically damaging sensitive tissues of aquatic organisms (e.g., gill tissues). As this material is deposited on the streambed, it smothers fish eggs, juvenile fish , and fish-food organisms. Stream bottoms once diverse in terms of available habitat for aquatic organisms, become uniform, physically unstable substrates.

Mean suspended sediment concentrations during the study ranged from 35.8 mg/l at S-4 to 96.7 mg/l at S-2 (Table 2). Suspended sediment concentrations were around 2 mg/l throughout Deep Creek prior to the irrigation season. During the irrigation season, this parameter approached or exceeded 200 mg/l at stations S-1A and S-2.

Turbidity, which is positively correlated with suspended sediment (e.g., $r^2 = 0.93$ at S-1A), may be used to assess seasonal variability in suspended sediment levels. In March, stream turbidity was generally less than 1 NTU. During the irrigation season, turbidity fluctuated widely in response to flow and suspended sediment load of Deep Creek, which are both related to water usage and crop management. Turbidity data indicate three discrete periods of elevated suspended sediment levels during the study (Figure 4).

The first period occurred shortly after the canals were filled and represents turbidity due to sediment eroded from canals and Deep Creek as the creek approached bank-full conditions when the canals were flushed. Sediment was also contributed from pre-irrigation of row crops such as beans. A second peak occurred in mid-July. During this period flows increased from minimum values measured in June. This peak likely represents a period of time when the second cutting of hay was occurring and row crops were again being irrigated.

A third peak in turbidity occurred in early September. At this time the third cutting of hay was occurring, and water was probably only being used to irrigate late grain and pastures. Therefore flows increased and some of the sediment accrued by the channel during the summer was being flushed out of the system. This is evident from declining turbidities throughout October although flows remained high. For example, turbidity declined throughout September and October at S-1A although flows were consistently in excess of 200 cfs during the same period.

As expected, except for D-3, mean suspended sediment concentrations in the drains exceed values calculated for the creek. Excluding D-3, which is a perennial tributary that receives no irrigation tailwater, mean concentrations ranged from 68.6 mg/l at D-2A to 297.3 mg/l at D-1 (Table 4). Highest concentrations (around 300 mg/l) were measured during the irrigation season at D-4 and D-5. A concentration of 2,540 mg/l was measured at D-1 on one date when the drain was being chained by the canal company to physically remove excessive growths of aquatic plants and algae. The potential impact of chaining events on the creek is discussed later in this section of the report.

An estimate of suspended sediment loading to Deep Creek by the five monitored drains may be calculated using flow and concentration data. For these calculations, the irrigation season was defined as April 15 to October 31, and flow and concentration data for a given date were used to calculate the total load for a given time period. Depending upon sampling frequency, interval length ranged from 13 to 29 days. Pre-irrigation water quality data were assumed to be representative of ambient water quality conditions and loads. The calculated loadings are rough estimates because of a number of factors such as sampling frequency, time of day when samples were collected, etc., which affect the accurracy of interval loading figures. Also, because of limited data, baseline suspended sediment loads are also approximate. An estimate of the agricultural contribution to these loadings was calculated by subtracting estimated baseline loads from total loads during the irrigation season.

The five drains monitored in this study transported about 8,305 tons of sediment to Deep Creek during the irrigation season (Table 5). Most of this load may be attributed to agricultural inputs. Of this amount, about 5,150 tons (or 62%) were exported to the Snake River (Figure 2) and 3,155 tons were stored in Deep Creek. Apparently about 1,300 tons of sediment were trapped behind the L-10 diversion during the irrigation season.

About 90% of the suspended sediment load entering Deep Creek arises from two sources: Low Line Canal or D-2A (63%) and D-5 (27%) (Table 5). Although sediment concentrations at D-2A were typically lower than those at the other drain stations (Table 5) the greater flows of the Low Line Canal resulted in a large sediment loading of Deep Creek. Implementation of best management practices to reduce soil erosion on critical acres within subbasins drained by these two canals would be expected to substantially reduce sediment loadings to Deep Creek and the resulting water quality impacts. Sediment loading of Deep Creek should be measured after BMP implementation and compared to the above figure to assess the effectiveness of the project.

NUTRIENTS

Nitrogen (N) and phosphorus (P) are essential nutrients for plant growth. These nutrients frequently limit plant growth due to a limited supply in contrast to a large demand (particularly during the summer). When these nutrients are abundant, productivity is enhanced and plant biomass increases. Dense plant growth may adversely impact aquatic life during periods of dieback when decomposing plants reduce dissolved oxygen levels in the water. Also, in slack-water areas where reaeration is minimal, nighttime dissolved oxygen concentrations may reach critically low levels due to plant respiration.

Inorganic Nitrogen

A concentration of 0.3 mg/l total inorganic nitrogen (NH_3, NO_2, and NO_3) is usually considered the limit for preventing nuisance growths of aquatic plants and algae (IDHW 1980). Usually ammonia and nitrite are quickly oxidized to nitrate, and nitrate is therefore the major form considered when comparisons to this limit are made.

Agricultural return flows and Deep Creek usually exceeded the 0.3 mg/l criteria (Tables 2 and 4). Although some nitrate undoubtedly enters Deep Creek with irrigation tailwater, the predominant source of nitrate to the creek is groundwater. Samples from seeps in the lower Deep Creek drainage indicated groundwater nitrate nitrogen concentrations to be in the range of 4 to 6 mg/l. Creek nitrate concentrations are generally at their peak during base flow conditions before the irrigation season. For example, in March, 1986 at S-1A and S-3A, instream nitrate nitrogen concentrations were 4.2 and 5.2 mg/l, respectively. As irrigation began, nitrate concentrations declined as Snake River water diluted the base flows of Deep Creek (Figure 5).

Generally, maximum instream nitrate concentrations during the irrigation season were observed when agricultural return flows to Deep Creek were at a minimum. Note however, that nitrate concentrations still exceeded the eutrophication limit even during peak irrigation flows of greater than 200 cfs at S-1A. Although some of the groundwater nitrate likely arises from leaching of nitrogen fertilizers applied to farmland, a significant portion of this nitrate may be attributed to leguminous crops in the Deep Creek drainage. In the nearby Rock Creek watershed, the major source of inorganic nitrogen (nitrate) is considered to be alfalfa and other leguminous crop plowout (Clark 1986). This is probably true for the Deep Creek watershed as well.

Nitrate concentrations at S-4 were well below those measured at the other stream stations. The annual mean nitrate nitrogen concentration at S-4 was only 0.03 mg/l (Figure 6) This reflects the fact that all flow at S-4 is Snake River water. Nitrate concentrations increase downstream as groundwater feeds the creek.

Organic Nitrogen

The major sources of organic nitrogen (total Kjeldahl nitrogen) in the Deep Creek drainage are animal waste runoff and organic debris associated with suspended sediment. Mean annual organic nitrogen concentrations generally increased with downstream progression (Figure 6), reflecting generally higher suspended sediment concentrations in downstream areas (Table 2). Organic nitrogen concentrations prior to irrigation were 0.4 to 0.6 mg/l and increased to maximum values of about 1.2 to 1.4 mg/l during the irrigation season. Pre-irrigation concentrations probably reflect a continual input of animal waste to the drainage. Clark (1986) has shown animal waste runoff to contain considerable amounts of inorganic and organic nitrogen. Peaks in mean organic nitrogen concentrations at S-3 and S-2 (Figure 6) probably reflect farm pond discharges and pasture runoff, respectively, in these areas.

As in other agricultural water quality studies (e.g., Clark 1985, 1986; Lathum 1986), the data indicate that a large portion of the organic nitrogen in transport was associated with suspended sediment. A positive correlation was found to exist between organic nitrogen and suspended sediment (e.g., $r^2 = 0.87$ at S-1A, see Figure 7). Once instream, these nitrogenous compounds are eventually oxidized to nitrates to further support primary production.

Phosphorus

Phosphorus is frequently the nutrient that limits primary production of aquatic systems. Uncontaminated surface waters typically have total phosphorus concentrations of 0.01 to 0.05 mg/l with ionic orthophosphate representing usually less than 5 percent of the total (Tarapchak et al. 1982; Prepas and Rigler 1982).

To control primary productivity and prevent nuisance aquatic plant and algae growth, a limit of 0.1 mg/l total phosphorus is usually applied (Mackenthum 1973). Where streams discharge into the stagnant waters of an impoundment, a more restrictive limit of 0.05 mg/l is recommended (U.S. EPA 1977).

Mean annual total phosphorus concentrations in Deep Creek exceeded the 0.1 mg/l limit at all stations (Table 2). Mean concentrations calculated for the drain stations also exceed this value except for drain D-3, which did not receive irrigation tailwater (Table 4).

Total phosphorus concentrations were generally positively correlated with suspended sediment concentrations at all stations indicating that most phosphorus in Deep Creek was associated with particulate organics or adsorbed to sediment (e.g., r^2= 0.89 and 0.95 at S-1A and S-2, respectively, see Figures 8 and 9). Background instream levels were around 0.1 mg/l indicating ample phosphorus is present year-round to support algae growth. Some of this phosphorus likely enters the creek during precipitation events with runoff from dairy and feedlot operations. During periods of peak instream turbidity, total phosphorus values were as high as 0.3 to 0.4 mg/l. Drain concentrations of total phosphorus ranged from 0.06 mg/l to 2.5 mg/l with maximum concentrations occurring during periods of maximum turbidity. Highest concentrations were measured at drain stations D-1, D-4, and D-5.

Instream dissolved orthophosphate levels increased during the irrigation season from background levels of less than 0.005 mg/l to around 0.1 mg/l. Highest instream dissolved orthophosphate concentrations were measured at S-4 (Table 2). The data generally support the conclusion that irrigation water leaches this nutrient from fertilized fields. Generally, elevated dissolved orthophosphate concentrations reflected periods of fertilizer application, and decreased to approach background levels near the end of the irrigation season even though flow increased substantially (Figure 10).

Drain mean dissolved orthophosphate concentrations ranged from 0.03 mg/l to 0.089 mg/l (Table 4). Highest concentrations were measured in drains D-1, D-4, and D-5. Background values in spring-fed drains (i.e., D-1 and D-3) were around 0.004 and 0.025 mg/l, respectively. During the irrigation season, concentrations in D-1 increased as much at 70 fold to as high as 0.29 mg/l. In drain D-3, which receives little if any irrigation tailwater, concentrations increased to only 0.04 mg/l during the summer.

Nutrient Loadings

As with suspended sediment, nutrient loads were calculated using flow and concentration data. During the irrigation season, the five monitored drains contributed 70.2 tons of organic nitrogen and 76.4 tons of nitrate nitrogen to Deep Creek, with about 97% and 77% of these loads, respectively, due to agricultural contributions (Tables 6 and 7; Figures 11 and 12). About 82% of the total organic nitrogen load entering Deep Creek may be attributed to drains D-2A (58.3%) and D-5 (23.7%). Of the total loading from these drains, about 30% is stored in the stream channel during the irrigation season. This material is available for export during the remainder of the year, or for oxidation to nitrate and incorporation into algal biomass. A large portion of this material is apparently deposited in the slack waters of the L-10 diversion (Figure 11).

Most of the nitrate nitrogen entering Deep Creek (about 98% of the total) is from drains D-1, D-2A, and D-3 (Table 7). Drains D-1 and D-3 are primary sources because they are spring-fed perennial tributaries with high background nitrate levels (e.g., D-3 had a mean nitrate nitrogen concentration of 4.85 mg/l). Drain D-2A contributes a significant load because of its high flows. The remaining drains, D-4 and D-5, contribute substantially less nitrate because of the lower nitrate level in Snake River water.

Deep Creek exports more nitrate to the Snake River than it receives from tributaries; about 68.9 tons during the irrigation season. Primary sources of this additional nitrate include springs and dairy and feedlot runoff downstream of S-2. Agricultural inputs represent only about 44% of the total nitrate load for the irrigation season at the mouth of Deep Creek (Figure 12).

In terms of total phosphorus (Table 8), about 17 tons of phosphorus were transported to Deep Creek by the monitored drains during the irrigation season. Of this amount, 59% and 25% may be attributed to drains D-2A and D-5, respectively. About 40% of the total load imported to Deep Creek remains stored in the channel; a large portion of this (about 30%) was probably deposited at the L-10 diversion (Figure 13). The stored material is likely particulate phosphorus and dissolved orthophosphate that has been converted chemically or biologically instream to a particulate (Hem 1985). Once in the sediment, this phosphorus can support abundant macrophyte growth.

The drains also contributed about 2.4 tons of dissolved orthophosphate to Deep Creek during the irrigation season (Table 9). As with total phosphorus, the primary sources of dissolved orthophosphate were D-2A (34.3% of total input) and D-5 (31.8%). Apparently Deep Creek exported less dissolved orthophosphate to the Snake River than it accrued from the drains (Figure 14). Because the chemistry of phosphorus favors precipitation (Hem 1985), it is likely that some dissolved orthophosphate was retained in the sediments or as a particulate in the form of plant biomass.

Although most phosphorus entering Deep Creek and transported by the creek was associated with particulates, a substantial portion was as dissolved orthophosphate. Meybeck (1982) noted that particulate phosphate forms comprise about 95% of the total phosphorus in rivers. In Deep Creek, dissolved orthophosphate represented 17% to 22% of total phosphorus and in the drains dissolved orthophosphate accounted for 8% to 42% of the total. In agricultural watersheds there may be more dissolved orthophosphate present due to leaching of this nutrient from fertilized fields.

BACTERIA

Fecal contamination of water is indicated by the presence of coliform bacteria (i.e., gram negative, lactose fermenting, enteric rods). If fecal coliforms are present, the water is contaminated by fecal material of warm-blooded animals, and it is possible that pathogenic microorganisms are present as well. An additional bacteriological indicator of fecal contamination used in the United States are strains of *Streptococcus faecalis*. These organisms do not survive in water as long as coliforms, so their presence indicates a recent pollution event (Atlas 1984).

The ratio of fecal coliform bacteria to fecal streptococci (FC/FS ratio) is often used to assess the origin of fecal contamination in stream water pollution studies. If this ratio is less than 0.7 animal wastes are indicated; a ratio greater than 4 is indicative of contamination by human wastes (Clausen *et al.* 1977).

Secondary contact recreation (or wading) is a designated beneficial use for Deep Creek. To support this beneficial use, water quality standards state that the geometric mean for fecal coliforms shall not exceed 200 organisms/100 ml (IDHW 1985).

Sources of coliform bacteria to Deep Creek are numerous. Sources include irrigation return flows, runoff from confined animal feeding operations, areas where livestock have direct access to the creek or its tributaries, and human wastes.

Annual instream geometric mean fecal coliform densities ranged from 292/100 ml at S-4 to 727/100 ml at S-3, and therefore the State standard was exceeded at all stations (Table 10, Figure 15). The data indicate that this standard was exceeded at all stream stations from about early May through September (Figures 16-20). Fecal coliform densities were as high as 22,000/100 ml and 24,000/100 ml at S-3 and S-4, respectively, during the irrigation season. Concentrations of both fecal coliforms and fecal streptococcus bacteria varied considerably between stream stations and sampling dates (Table 10). Generally, elevated bacteria levels were associated with high flows and increased turbidities, indicating these organisms were associated with organic or sediment particles in irrigation tailwater.

Bacteria densities at the drain stations generally exceeded those measured instream (Table 10). Annual geometric mean fecal coliform densities ranged from 388/100 ml at D-2A to 2,293/100 ml at D-4. Highest fecal coliform densities were measured in drains D-4 (44,000/100 ml) and D-5 (99,000/100 ml). Densities of fecal coliform and fecal strep bacteria were highly variable between stations and sampling dates; (Figures 21-25); highest densities were often associated with elevated flows and turbidities. As discussed below, at various stations on certain dates other activities on these drains may have affected bacteria densities.

Fecal coliform to fecal streptococcus ratios calculated for the period of study were similar for stream and drain stations (Table 10). This ratio ranges from around .5 to .9, which indicates a predominance of livestock waste.

On several dates ratios calculated at certain drain stations ranged from 3.5 to 4.5, indicative of pollution derived from human sources. For example, the ratio calculated for samples collected on July 7 at D-5 was 4.3. On this date, turbidity and flow in the drain were not exceptionally high.

WATER QUALITY IMPACTS FROM DRAIN CHAINING EVENTS

During the irrigation season, artificial conveyances and tributaries used to transport nutrient-rich irrigation tailwater became clogged with algae and macrophytes. This requires that these conveyances be periodically cleaned. Where drains do not discharge to surface waters, volatile algicides such as Acrolene or Xylene are often used. Where conveyances discharge directly to surface waters, aquatic plants are mechanically removed or dislodged by large chains pulled through a channel by tractors. The dislodged plants and other materials are then transported to the perennial creek downstream.

A chaining event was observed at D-1 on August 28, 1986. Drain flow increased dramatically after the chaining event as would be expected (Table 11). In addition, suspended sediment levels and all parameters associated with the sediment (e.g., turbidity, total Kjeldahl nitrogen, total phosphorus, etc.) increased as this material was resuspended. Loadings of sediment, nutrients, and bacteria to Deep Creek increased substantially during this brief period. For example, mean suspended sediment concentration and daily loading for D-1 during the 1986 irrigation season were 146.2 mg/l and 4,526.6 lbs/day, respectively. During this brief chaining period, these values increased to levels of 2,540 mg/l and 158,992 lbs/day, respectively. If this chaining event occurred over a 30 minute period, about 3,300 pounds of sediment would have been transported to Deep Creek. This 30 minute loading exceeds the mean daily loading of 3,082 pounds calculated for this station. Therefore, channel cleaning events, although required to maintain water delivery, do result in a large pulse of sediment, nutrients, and bacteria being transported to downstream reaches. The dislodged plant biomass transported downstream also represents a considerable nutrient input not assayed in this study.

MACROINVERTEBRATES

Macroinvertebrates are well suited for assessing environmental conditions because a) they are not very mobile and therefore reflect water quality conditions near the point of collection, b) most species have life cycles of a year or less so their presence reflects recent stream conditions, and c) their presence reflects an integration of stream conditions through time not assessable by discrete physical/chemical "grab" sampling programs (Platts et al. 1983; Rosenberg et al. 1986). Sensitive species and life stages respond quickly to environmental stress while overall communities generally respond more slowly. A typical stream benthic community is composed primarily of insects (Hynes 1970; Minshall 1969), although other groups such as annelids, crustaceans, molluscs, and flatworms are frequently present.

A number of approaches have been utilized in the literature to interpret benthic data. Invertebrate densities, species composition, and species diversity have been used. In general, clean water would be expected to support a diverse benthic community dominated by pollution-intolerant species. Recent work has focused attention on assessing functional feeding groups to examine community trophic structure, and on biotic indexes which incorporate a measure of species tolerance to pollution.

The EPT value or index is one tool that is used frequently in benthic community analysis. This value is the sum of the taxa richness for the groups Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These groups of macroinvertebrates are generally considered sensitive to pollutants. The EPT value has been found to be consistently related to water quality; a higher value indicates better water quality while a lower value indicates poorer water quality.

Another index that incorporates species tolerance to pollution is the Biotic Condition Index (BCI) developed by Winget and Mangum (1979). This model predicts a community tolerance quotient (CTQp) based upon percent slope, alkalinity, sulfate concentration, and sediment composition measured at a given location. Calculated values range from 50 to 108; high values predict the presence of a benthic community comprised of relatively pollution-tolerant organisms.

Following Winget and Mangum (1979) tolerance quotients are assigned to each species present in a benthic community (values range from 2 to 108), and a mean actual community tolerance quotient is calculated (CTQa). The Biotic Condition Index is equal to CTQp/CTQa x 100. A BCI greater than 100 indicates a community better than predicted (i.e., composed of less tolerant organisms), while a BCI of less than 100 indicates a community comprised of more pollution-tolerant species than expected and therefore indicative of degraded water quality.

Community Structure and Invertebrate Abundance

Invertebrates collected on each sampling date are summarized in Tables 12 and 13; a total of 32 taxa were represented (Table 14). In terms of species richness, Trichoptera, Molluscs, and Diptera were best represented with 7, 6, and 4 taxa, respectively. However, many of the taxa were not identified to species, and Chironomidae alone probably includes many species.

In terms of densities, the data indicate a benthos that is dominated by generally pollution-tolerant taxa such as Hydropsyche sp., Hydroptilla sp., Baetis tricaudatus, Chironomidae, and Molluscs. For example, at station S-3A in March, 1986, Baetis tricaudatus and Molluscs accounted for about 73% and 16%, respectively, of the individuals present (Table 12). At station S-3 in September, 1986, about 87% of the organisms collected were Molluscs (Table 13).

Although most organisms collected were pollution-tolerant species, two Plecopteran taxa were collected in March, 1986, which are indicative of good water quality. Isoperla sp. and Hesperoperla pacifica were collected at Station S-1A. These taxa were not found at any other station in March, and were absent at S-1A after the irrigation season.

Invertebrate data indicate a general improvement in water quality downstream. For example, a comparison of stations S-3 and S-1A in March indicates that although fewer species were collected at S-1A, that a greater percentage of these were pollution-intolerant forms such as Plecoptera (Table 12). In September after the irrigation season, a greater portion of taxa collected at all stations were pollution-tolerant forms (Table 13). Although more taxa were collected at most of the stations after the irrigation season, EPT values decreased at all stations indicating that the additional species collected were not "clean water" taxa (Tables 12 and 13). Except at S-1A, invertebrate densities decreased considerably after the irrigation season. For example, at S-3, densities decreased from about 5,150/m^2 in March to about 180/m^2 in September. That this station is severely impacted during the irrigation season is also evident by a reduction in species richness from 20 to 6 taxa.

Lists of taxa collected only in March or September are summarized in Table 16. Seven species with a mean TQ of 33.4 that were collected in March samples were not collected in September. Five new taxa with a mean TQ of 76.8 were collected in the September post-irrigation season samples. Although some differences in the taxa collected on each sampling date may be due to life cycle variability and/or sampling procedures, generally after irrigation fewer species were present and a greater percentage of these tended to be pollution-tolerant forms. Overall the number of species collected from Deep Creek declined from 27 to 25, the mean TQ increased from 83.3 to 87.4, and the EPT value decreased from 7 to 5 taxa (Table 14). One pollution-tolerant taxon that is indicative of poor water quality, Tubifex sp., was collected at S-4 in September. These oligochaetes are typically found in polluted streams where dissolved oxygen concentrations are low (Cole 1983). In late summer when algae production was at its peak, anoxic conditions probably existed during the night at S-4 when respiring algae and slack water conditions contributed to a dissolved oxygen sag.

Biotic Condition Index

The CTQa calculated for each station (Table 15) indicate that the benthos of Deep Creek is composed primarily of tolerant species. In March CTQa's ranged from 75 at S-1A to 93.7 at S-3A. In September after irrigation, the communities present were comprised of an increasing number of tolerant species and CTQa's ranged from 89.6 at S-1A to 108 at S-3.

Calculated BCI values are all less than 100 (Table 15) and indicate that a more tolerant benthic community is present than expected due to degraded water quality. BCI values were lower in March than in September. In March, values range from 56 to 71 while in September they range from 81.5 to 96.2. Therefore, although water quality conditions improve during the non-irrigation season (e.g., mean CTQp decreases from 85.2 in September to 55.2 in March), the benthic community composed primarily of tolerant species reflects and integrates long-term water quality conditions including irrigation season impacts. Hence, in March there is a greater discrepancy between CTQp and CTQa and the BCI is low. Since water quality conditions were good in March, the degraded water quality indicated by a low BCI occurred during some other time period. The most obvious impact is irrigation return flow during the agricultural season.

Functional Feeding Group Analysis

The invertebrates collected were placed into functional feeding groups following Cummins (1973), Merritt and Cummins (1984), and Pennak (1978) (Tables 12 and 13). This classification scheme is based upon morphological/behavioral adaptations for food aquisition and not necessarily the type of food eaten (e.g., detritus, algae, etc.). The particular type of food eaten by a given species may vary with season, food availability, and life stage. Such a classification, while only an approximation due to complex feeding relationships, helps to assess the trophic structure of a benthic invertebrate community.

Generally, the predominant functional feeding groups observed in Deep Creek were scrapers, collector-gatherers, and collector-filterers (Table 17, Figures 26 and 27). For example, about 94% of the organisms collected at S-3A in March could be classified as scrapers (Figure 26). Similarly, about 80% of the invertebrates collected at S-3 in September were scrapers (Figure 27). With elevated instream nutrient concentrations and high nutrient loadings from tributary drains, algae and aquatic plants are abundant. Scrapers are primarily herbivorous and would graze on the abundant algal growth in the riffle areas that were sampled.

MUD CREEK

STREAM FLOW

As with Deep Creek, Mud Creek flows are modified by irrigation water management. Numerous laterals from the Low Line Canal feed the headwaters of Mud Creek near Buhl, and water is diverted from the creek at several locations for irrigation and other purposes.

During this study mean flow ranged from 28.5 cfs near the Buhl airport (Station M-3) to 136.0 cfs at M-1 near the mouth of Mud Creek (Figure 3; Table 18). Base flows of about 60 to 70 cfs occur near the mouth of Mud Creek during February and March (Table 19). Flows increase during April as Snake River water is turned into the Twin Falls Canal System and eventually reaches Mud Creek. Creek flows fluctuate throughout the summer months primarily in response to irrigation water management. Peak flows occur in September as irrigation water is used only for some late grain and pastures and as the canal system is flushed (Figure 28).

SUSPENDED SEDIMENT

Suspended sediment concentrations were between 8 to 20 mg/l in Mud Creek prior to the irrigation season. During the summer, concentrations as high as 180 mg/l and 130 mg/l were measured at stations M-3 and M-1, respectively. Mean concentrations for the study period ranged from 51.4 mg/l at M-3 to 15.8 mg/l at M-2 (Table 18). Generally, the highest concentrations were measured at M-3, and then levels decreased substantially in the mid-reaches of the creek at M-2 due to several major diversions upstream which act as sediment traps (Figure 29). For example, on July 8, 1986 suspended sediment concentrations were 180 mg/l and 24 mg/l at M-3 and M-2, respectively.

Turbidity levels, which reflect suspended sediment concentrations, fluctuated considerably during the study (Figure 30). As with Deep Creek, turbidity data for Mud Creek generally indicate three periods of increased sediment loads and degraded water quality. With similar cropping patterns and management in both watersheds, these three peaks reflect water quality conditions integrating the same crop management practices as discussed under the Deep Creek section of this report. The only deviation from this pattern is the elevated turbidity at M-1 on September 8, 1986. This measurement reflects crop management activities in the Silo Creek subbasin (i.e., upstream of MD-1). During this period, most crop irrigation was complete and the third cutting of hay was occurring. This resulted in high tributary flow and scouring of stored sediment deposits.

Highest tributary suspended sediment concentrations were measured in the MD-1 tributary (Table 20). Mean values for the three tributaries ranged from 15.4 mg/l for MD-2 to 66.4 mg/l for MD-1. The three tributaries monitored during this study transported about 2,600 tons of sediment to Mud Creek during the irrigation season (Table 21). Load calculations for M-1 indicate that Mud Creek exported about 3,660 tons of sediment to the Snake River during the same period, or about 1000 tons in excess of calculated tributary input (Figure 3). This material may arise from bank mass wasting, instream sediment storage, or unknown tributary drains. That the Mud Creek reach above M-2 is a sediment trap is evident from these data as well. A significant suspended sediment load entered the Mud Creek system from the headwaters upstream of M-3 and drain MD-3 (about 965 tons). However, only about 44% of this load (or 434 tons) was transported past M-2.

Over 94% of the calculated suspended sediment load entering Mud Creek from tributaries arises from the Silo Creek (or MD-1) subbasin (Table 21). This tributary of Mud Creek had the highest mean suspended sediment concentration and flow of the three tributaries that were monitored. Implementation of agricultural BMPs within this subbasin would be expected to substantially reduce sediment loading of lower Mud Creek and the Snake River. A second area that should be considered for BMP implementation is the area upstream of M-3. The data indicate that a significant sediment load enters the headwaters of the Mud Creek drainage from branches of the Low Line Canal. At this location in the canal system, many irrigation return flows have entered the Low Line Canal and contributed to its suspended sediment load. Fortunately for the creek, much of this material is trapped by downstream diversions so that suspended sediment levels in the mid-reaches of the creek are substantially reduced.

NUTRIENTS

Inorganic Nitrogen

The 0.3 mg/l total inorganic nitrogen limit to prevent nuisance plant growth was exceeded in Mud Creek and agricultural return flows to Mud Creek (Tables 18 and 20). As with Deep Creek, the predominant source of nitrate to the creek is probably groundwater. Highest instream nitrate values were observed prior to the irrigation season. For example, in March the nitrate nitrogen concentration measured at M-3 was 5.5 mg/l. In May, as discharge increased due to agricultural return flows, this concentration decreased to about 2 mg/l (Figure 31).

Tributary nitrate nitrogen concentrations were usually highest in tributaries MD-1 and MD-3. Both of these tributaries receive wastewater from fish hatcheries. Hatchery wastewater is typically high in ammonia and organic nitrogen (Litke 1986), both of which may be oxidized instream to nitrate.

Organic Nitrogen

As in the Deep Creek watershed, the major sources of organic nitrogen (total Kjeldahl nitrogen) in the Mud Creek drainage are dairy and feedlot runoff, fish hatcheries, and organic compounds adsorbed to eroded soils. Mean annual organic nitrogen concentrations were positively correlated with suspended sediment (Table 18). Generally, concentrations were highest at M-3 and decreased in the mid-reaches of the creek where diversions acted as sediment traps (Figure 32). Highest instream organic nitrogen and nitrate nitrogen levels were observed at station M-3. This not only reflects the elevated suspended sediment levels observed at this station but also indicates nutrient loading from upstream pastures and farm ponds.

Organic nitrogen concentrations prior to the irrigation season ranged from 0.6 to 0.7 mg/l, and increased to maximum values of between 0.8 to 1.3 mg/l during the irrigation season. Groundwater in the Mud Creek watershed typically has an organic nitrogen level of about 0.2 mg/l.

Concentrations in excess of this during the non-irrigation season likely reflects an organic nitrogen loading from dairies, feedlots, fish facilities, and precipitation runoff from cropland.

Phosphorus

Mean annual total phosphorus concentrations in Mud Creek exceeded the 0.1 mg/l limit to prevent excessive aquatic plant growth at all stations (Table 18). Pre-irrigation instream levels were 0.1 mg/l at all stations, and therefore ample phosphorus enters the creek from other sources to support plant growth. These values increased to 0.2 to 0.3 mg/l during the irrigation season. Mean concentrations calculated for the tributary stations also exceed the 0.1 mg/l criterion (Table 20). Highest tributary total phosphorus levels were observed at MD-1 (mean of 0.21 mg/l) in the Silo Creek subbasin.

The data generally indicate a positive correlation between total phosphorus and suspended sediment (e.g., r^2= 0.77 and 0.81 at M-1 and M-2, respectively, see Figures 33 to 35), which suggests that a substantial portion of the phosphorus in transport was adsorbed to sediment particles. Lowest mean total phosphorus levels and suspended sediment levels were observed at M-2, which would reflect a trapping of sediment and particulate phosphorus forms behind instream diversions.

The correlation between total phosphorus and suspended sediment, although generally recognized in agricultural pollution impact studies (e.g., Clark 1986, Latham 1986) does not hold for certain locations and time periods in Mud Creek. These periods include the post-irrigation season canal flushing in early October (Figures 33 to 35) and the middle of the irrigation season at M-2 (Figure 34). These sediment peaks without total phosphorus peaks may reflect some sort of phosphorus metabolism and uptake mechanism while the sediment is stored behind instream diversions or in canals. When the sediments are then disturbed an increase in suspended sediments is observed without a concomitant increase in total phosphorus.

Mean instream dissolved orthophosphate concentration was about 0.05 mg/l at all stations. Levels increased during the irrigation season to 0.07 to 0.09 mg/l from pre-irrigation levels of between 0.005 to 0.03 mg/l (Table 18).

Mean tributary dissolved orthophosphate concentrations were similar to instream values and ranged from 0.05 to 0.06 mg/l. Highest concentrations were observed in tributary MD-1 (Table 20).

Nutrient Loadings

During the irrigation season, the three monitored tributaries contributed 35.2 tons of organic nitrogen and 107.6 tons of nitrate nitrogen to Mud Creek (Tables 22 and 23). Of the total organic nitrogen load, only 65.3% can be attributed to agricultural sources (Table 22). Other sources contributing to this load include hatcheries on Silo Creek (MD-1) and on drain MD-3. About 84% of the total organic nitrogen load transported from the monitored tributaries to Mud Creek originates in the Silo Creek (MD-1) subbasin (Table 22). Mud Creek delivered about 58 tons of organic nitrogen to the Snake River during the irrigation season. Since the tributaries contributed about 61% of this load, other unmonitored sources must also be contributing organic nitrogen to the creek. If instream loads are accounted for (i.e., load at M-2 and MD-1) then approximately 13.8 tons of organic nitrogen entered the creek between M-2 and M-1 which are not accounted for by these data (see Figure 36). Other sources may include the East Fork of Mud Creek, small irrigation drains, farm pond discharges, and runoff and/or discharges from dairies and feedlots in this reach.

About 107 tons of nitrate nitrogen were transported to Mud Creek during the agricultural season by the three monitored tributaries. Only about 28% of this total load may be attributed to agricultural sources; the remainder likely arose from groundwater inputs, dairies, feedlots, and hatcheries. Of the total load, about 85% may be attributed to the Silo Creek (MD-1) subbasin (Table 23). If upstream contributions are added to this load (see Figure 37) , then approximately 50 tons of nitrate nitrogen entered the creek between M-2 and M-1 which are not accounted for by these data. Possible sources are listed above. Regardless of source, ample nitrate was present in Mud Creek to support plant growth.

The tributaries contributed about 8 tons of total phosphorus to Mud Creek during the irrigation season. Of this amount, about 87% may be attributed to tributary MD-1 (Table 24). In addition to irrigation tailwater, other sources might include fish hatchery effluent and feedlot runoff. Total phosphorus export to the Snake River at M-1 (15.8 tons) exceeds total phosphorus loading of the creek by the drains and upstream areas by about 7 tons (Figure 38). As with organic nitrogen, this phosphorus probably originates from similar sources between M-2 and M-1.

The three monitored tributaries contributed about 2 tons of dissolved orthophosphate to Mud Creek during the agricultural season. The Silo Creek subbasin (MD-1) accounted for about 75% of this load (Table 25). As with total phosphorus, more dissolved orthophosphate was exported to the Snake River during the irrigation season than could be accounted for by instream and tributary loading figures (Figure 39). Additional sources must supply more of this nutrient to the reach between M-2 and M-1.

As noted for Deep Creek, a substantial portion of total phosphorus was dissolved orthophosphate in Mud Creek. Dissolved orthophosphate represented about 27% to 44% of total phosphorus instream, and in the tributaries dissolved orthophosphate accounted for 25% to 52% of the total. Again, dissolved orthophosphate may account for a greater portion of total phosphorus in agricultural impacted streams where this nutrient is leached from fertilized cropland.

In terms of nutrient loadings, the Silo Creek subbasin (MD-1) accounts for the majority of nitrogen and phosphorus entering Mud Creek and eventually the Snake River. However, it should be noted, as with suspended sediment, that a significant source of nutrients to Mud Creek is the watershed area upstream of M-3. BMP implementation projects in both areas would reduce suspended sediment loading of Mud Creek as well as reduce loadings of nutrient forms adsorbed to sediment particles.

BACTERIA

As with Deep Creek, secondary contact recreation is a designated beneficial use for Mud Creek. In order to support this use, state water quality standards require a geometric mean fecal coliform density of less than 200 organisms/100 ml (IDHW 1985). This standard was exceeded at all stream stations with annual instream geometric mean fecal coliform densities ranging from 480/100 ml at M-2 to 2014/100 ml at M-3 (Table 26, Figure 40). Instream bacteria densities were highly variable throughout the study with most measurements exceeding the secondary contact recreation standard (Figures 41 to 43). Densities appeared to be correlated with elevated flows, turbidities, and suspended sediment concentrations which indicates that most of the bacteria were associated with organic or inorganic particles in transport. Highest densities were generally observed at station M-3 which is just downstream of a pasture, and lowest concentrations were typically measured at M-2 which is downstream of diversions which act as sediment traps. Fecal coliform densities reached values as high as 15,000/100 ml and 29,000/100 ml at stations M-3 and M-1, respectively, during the irrigation season. In contrast, the maximum fecal coliform density observed at M-2 during the same period was 2,300/100 ml (Table 26).

Fecal coliform densities at the tributary stations were generally similar to or less than those measured instream (Table 26). This suggests that other sources such as dairies, feedlots, unmonitored drains, pasture runoff, and wildlife contributed bacteria to the creek during the study. Annual geometric mean fecal coliform densities ranged from 393/100 ml at MD-2 to 989/100 ml at MD-1 (Table 26). Highest fecal coliform densities were measured in drains MD-1 (203,000/100 ml) and MD-3 (6,800/100 ml). As noted instream, bacteria densities in the tributaries were also correlated with turbidity and flow and fluctuated considerably (Figures 44 to 46). The notable peak bacteria density on August 13, 1986 at MD-1 may be the result of a discharge from an upstream feedlot, cleaning of irrigation drains, or discharge of septage to Silo Creek (see below).

Fecal coliform to fecal streptococcus ratios (FC/FS) calculated for the study period were similar for tributary and stream stations (Table 26). Mean values for all stations ranged from 0.37 to 0.52, and generally indicate the source of bacteria to be primarily livestock in mixed pollution. That other sources are present is indicated by calculated ratios of 3.0 to 4.0 at different stations on various dates, which would indicate the bacteria were derived primarily from human sources on these dates. The FC/FS ratio calculated for the peak density in August at MD-1 was 4.7.

MACROINVERTEBRATES

Community Structure and Invertebrate Abundance

Twenty four (24) invertebrate taxa were collected from Mud Creek during the study (Table 27). Invertebrate groups best represented include the Trichoptera (6 taxa) and Molluscs (5 taxa). In terms of densities, the data indicate that the benthos of Mud Creek is dominated by taxa such as Brachycentrus sp., Hydropsyche sp., Oligoplectrum sp., Baetis tricaudatus, and Optioservus sp. For example, in March at Station M-1, Hydropsyche and Baetis tricaudatus accounted for about 62% and 12%, respectively, of the invertebrates collected (Table 28). Similarly, over 85% of the invertebrates collected at M-2 in September were <u>Brachycentrus</u> larvae (Table 29).

Generally the data indicate that the benthic community is impacted by the degraded water quality of the irrigation season. After the irrigation season taxa richness decreased, the EPT index decreased, the CTQa increased indicating fewer "clean water" species were present, and densities decreased (Table 31). For example, at station M-1 densities declined from 1950 individuals/m^2 to 476/m^2 and taxa richness declined from 14 to 9 taxa. Overall, the total number of taxa collected from Mud Creek declined after irrigation from 21 to 17 taxa, as did the EPT value (8 to 5 taxa).

A summary of taxa collected only in the March or September samples is given in Table 31. Five species with an average TQ of 57 that were collected in March were not collected in September. Three new taxa were collected in September, after the irrigation season, all with a TQ of 108. For all of the taxa collected during the study, the mean community tolerance increased from 80 in March to 91.4 in September. Therefore, after the irrigation season fewer individuals were collected representing fewer taxa, and the taxa that were collected were generally pollution tolerant forms. With CTQa's of greater than 80 at each station regardless of season, the management strategy for Mud Creek based upon these biological data should be towards habitat and water quality improvements (Winget and Mangum 1979).

<u>Biotic Condition Index</u>

Calculated BCI values are all less than 100 and indicate that a more pollution tolerant invertebrate community is present in Mud Creek than expected (Table 30). BCI values were considerably lower in March than in September indicating that although water quality conditions improve during the non-irrigation season (i.e., CTQp decreases), that the invertebrate community still exhibits the result of this stress and is composed primarily of pollution tolerant taxa (i.e., CTQa does not decrease a corresponding amount). Therefore, the stress imposed on the benthic community during the irrigation season is integrated by the community and is evident in community structure during the non-irrigation season as well.

Functional Feeding Group Analysis

The predominant functional feeding groups observed in Mud Creek were collector-filterers, scrapers, and collector-gatherers (Table 32, and Figures 47 and 48). For example, in March at M-1, 77.6% of the invertebrates collected could be classified as collector-filterers. Similarly, in September at M-2 and M-3 this functional feeding group accounted for over 90% of the individuals collected. These organisms collect algae, detritus, and dead invertebrates from the water column. With the abundant nutrients available to Mud Creek to support primary production, a substantial portion of the food resources of this functional feeding group is likely algae.

QUALITY ASSURANCE

Quality assurance samples (duplicates and spikes) were collected at various stations on both creeks throughout this study to evaluate data quality. These samples were used to assess if reported values were equivalent to environmental values at the time of collection. Precision and accuracy (or bias) estimates may be utilized as a measure of how close these two values are for a given data set.

Precision

Precision is a measure of the agreement between duplicate measurements of the same parameter under the same set of environmental conditions (Bauer 1986). When duplicate samples are collected, the average relative range is used to describe precision. Precision was generally good for suspended sediment, nitrate, total Kjeldahl nitrogen, total phosphorus, and dissolved orthophosphate (Table 33). Precision was not as good for ammonia, and poor for fecal coliform bacteria.

Poor agreement between duplicate fecal coliform samples has been noted in other surveys (e.g., Clark 1986, Bauer 1986). This low precision has been attributed to the difficulty in collecting homogeneous duplicate field samples and also the difficulty in obtaining representative subsamples for plating in the lab (Bauer 1986).

Accuracy

Accuracy is a measure of the agreement between a measurement and the true value for a given parameter. Accuracy is estimated from spiked quality assurance samples by percent recovery. Percent recovery is calculated as the ratio of a spiked sample value to the true value. If a number of spiked quality assurance samples are collected for a given parameter, then average percent recoveries are calculated for comparison.

Generally, mean percent recovery was excellent for suspended sediment (99.0% ± 6.7%) and nitrate (106.8% ± 10.8%) (Table 34). Recovery was good for total Kjeldahl nitrogen (117.8% ± 11.8%), total phosphorus (106.5% ± 5.2%), and dissolved orthophosphate (110.2% ± 8.1%). Recovery for ammonia was poor with an average percent recovery of 145.7% (± 38.2%). The variability in ammonia recovery is difficult to explain. A portion of this variability is inherent in the method used for ammonia analysis. Also, some error may be introduced based upon the way samples were handled (i.e., preservation, storage times, etc.). It is also possible that a portion of the organic nitrogen spike (urea), which is in the same spike prepared for ammonia, partially hydrolyzes to ammonia upon acidification or during sample storage. The exact reason for such high percent recoveries for ammonia remains to be determined.

CONCLUSIONS

Deep Creek and Mud Creek water quality is being impaired by agricultural non-point sources and designated beneficial uses are threatened. Primary contaminants include suspended sediment, nutrients, and bacteria. Pollutant sources include irrigated cropland and animal waste runoff or discharges from confined animal feeding operations.

In both creeks suspended sediment levels increased substantially during the irrigation season. Fluctuations in suspended sediment levels and stream flow could be traced to irrigation practices and crop management. Soil erosion in these two watersheds results primarily from furrow irrigation of crops such as beans or corn from April through September. Stream bank erosion also probably contributes to the sediment load of each creek. The excess sediment in Deep Creek and Mud Creek results in loss of habitat for fish spawning and impacts the streambed invertebrate community which represents the food of resident fish populations.

Nutrient levels (nitrogen and phosphorus) in both creeks were at or near levels which stimulate nuisance plant growths prior to the irrigation season. Elevated nitrate levels could be attributed to groundwater inputs to the creeks. A major source of inorganic nitrogen to groundwater may be alfalfa and other leguminous crop plow out.

Organic nitrogen (total Kjeldahl nitrogen) and total phosphorus levels were also elevated prior to irrigation and may reflect a continuous input of animal wastes to these creeks. Sources of these nutrients would include feedlots, dairies, and fish hatcheries. During the irrigation season, organic nitrogen and total phosphorus levels were positively correlated with turbidity and suspended sediment levels. Agricultural BMP implementation projects in both watersheds to reduce soil erosion and to manage animal wastes would therefore also be expected to help reduce instream levels of these nutrients. Nutrients associated with solids in fish hatchery discharges could be reduced by better operation and maintenance practices at these facilities. Orthophosphate levels generally increased during the irrigation season and reflect leaching of this nutrient from fertilized fields.

Generally, concentrations of most nutrient parameters increased during the irrigation season to levels well in excess of criteria established to prevent nuisance plant growth. Aquatic plants and algae responded to these nutrients with a large increase in biomass. Many sampling stations were covered with thick mats of macrophytes or algae by mid-summer. Although these plants produce oxygen via photosynthesis during the day, they also consume considerable quantities of oxygen at night via respiration. With the large plant biomass present in both creeks, it is likely that in quiescent areas (e.g., S-4, S-3 in Deep Creek) dissolved oxygen levels could have been lowered during the night to below critical levels stressing fish populations.

Fecal coliform bacteria densities in both creeks exceeded the secondary contact standard at most stations throughout the irrigation season. Fecal coliform to fecal streptococcus ratios calculated for the survey stations indicated the source of most of these bacteria to be livestock. These bacteria would enter Deep Creek and Mud Creek in runoff or discharges from feedlots or dairies. Fecal coliform to fecal streptococcus ratios as high as 4.5 were calculated for various stations on certain dates and indicate discharges of human wastes to these creeks during these periods.

Macroinvertebrate collections from both creeks indicated degraded water quality conditions as a substantial portion of the invertebrate fauna in both creeks was composed of pollution tolerant species. That the irrigation season had a deleterious impact on invertebrate communities was evident by reductions in taxa richness, densities, and number of "clean water" species in samples collected in September. This negative impact on the invertebrate communities in both creeks is also evident during non-irrigation periods. During these periods, although water quality conditions improve, benthic communities remain composed primarily of pollution-tolerant taxa and reflect stresses imposed on the communities during other times of the year. Biologic indexes used to examine the invertebrate data collected indicate that both creeks have communities composed of a greater number of pollution tolerant taxa than expected based upon physical characteristics. Biological data indicate that both creeks should be managed to improve instream habitat and water quality (Winget and Mangum 1979).

RECOMMENDATIONS

The data indicate that degraded water quality conditions existed in both Deep Creek and Mud Creek during the irrigation season. In addition, wastes from confined animal feeding operations impact these creeks throughout the year. At present, several designated beneficial uses for both creeks are impaired or threatened.

To improve water quality and assure full protection of benefical uses, it is recommended that the Balanced Rock SCD submit a proposal for funding to implement an agricultural BMP project in both watersheds. This project should focus on BMPs to reduce soil erosion and also BMPs to control animal wastes and dairy wastewater. BMPs implemented to reduce soil erosion would reduce suspended sediment levels, nutrient levels, and bacteria levels in both creeks and ultimately the Snake River. Similarly, BMPs directed at properly managing animal wastes in these watersheds would reduce nutrient and bacteria loading of these creeks and reduce the probability of public health problems. In addition, stream bank areas prone to mass-wasting should be identified and stabilized.

Because of funding restrictions, BMP treatment should be centered upon those subbasins in each watershed which contribute the largest loads of agricultural pollutants to Deep Creek, Mud Creek, and ultimately the Snake

River. Loading data from this survey indicate these priorities should be the subbasins drained by the following:

A) Deep Creek Watershed

1) Drain D-2A; branch of the Low Line Canal.

2) Drain D-5; Upper Deep Creek subbasin.

B) Mud Creek Watershed

1) MD-1; Silo Creek subbasin.

2) M-3; Upper Mud Creek subbasin.

In the Deep Creek watershed, water quality problems due to the Low Line Canal should be addressed through a cooperative effort with the Twin Falls SCD. Agricultural return flows entering the Low Line Canal need to be examined, and significant sources should be mangaged through BMP treatment to reduce sediment, nutrient, and bacteria loading of the canal. Improving Low Line Canal water quality would ultimately improve water quality in the lower Deep Creek drainage as well as in the headwaters of Mud Creek. Similar efforts on the High Line Canal system would help improve water quality in the upper Deep Creek drainage above S-4. The Balanced Rock SCD should focus its BMP treatment activities in the upper Deep Creek subbasin.

In the Mud Creek watershed, BMP implementation in the Silo Creek subbasin and in headwater areas fed by branches of the Low Line Canal should improve instream water quality.

Implementation of agricultural BMP cost-share projects in both drainages should help to control sediment, nutrient, and bacteria loading of these creeks. Through time, water quality would be expected to improve and designated beneficial uses again be fully protected. Water quality data and estimated irrigation season loadings presented in this report should be used as a standard for comparison of water quality conditions following BMP implementation projects.

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Table 1. Summary of Deep Creek and Mud Creek survey stations, 1986.

Station	Description	Latitude	Longitude	River Mile	Elevation (Feet)	STORET #
S1-A	Deep Creek above mouth Section 10	42 39 30	114 48 33	324.3/592.0/.4	2920	2060249
S-2	Deep Creek at USGS gage near Buhl	42 37 08	114 50 33	324.3/592.0/5.5	3480	2060086
S-3A	Deep Creek at 4000 North Road	42 34 14	114 50 26	324.3/592.0/8.7	3650	2060248
S-3	Deep Creek at 3800 North Road	42 32 57	114 49 54	324.3/592.0/11.2	3760	2060087
S-4	Deep Creek East of Castleford (at 1000 East Road)	42 43 52	114 50 53	324.3/592.0/14.0	3850	2060088
D-1	Drain between Sections 31 and 32, T9S/R14E	42 35 43	114 50 59	324.3/592.0/8.0/.2	3620	2060092
D-2A	Low Line Canal at 1100 East Road	42 33 22	114 49 41	324.3/592.0/9.7/.7	3740	2060250
D-3	Drain between Sections 17 and 16, T10S/R14E (at 1100 East Road)	42 33 24	114 49 45	324.3/592.0/10.7/.3	3740	2060094
D-4	Drain between Sections 20 and 21, T10S/R14E	42 33 00	114 49 41	324.3/592.0/11.3/.2	3760	2060095
D-5	Drain between Sections 28 29, T10S/R14E	42 44 10	114 49 44	324.3/592.0/12.8/.2	3820	2060096

Table 1. Summary of Deep Creek and Mud Creek survey stations, 1986 (continued).

Station	Description	Latitude	Longitude	River Mile	Elevation (feet)	STORET *
M-1	Mud Creek 1 mile above mouth	42 38 15	114 47 15	324.3/592.3/1.0	3260	2060114
M-2	Mud Creek above Clear Creek	42 37 39	114 48 35	324.3/592.3/4.0	2970	2060055
M-3	Mud Creek west of National Guard Armory	42 35 17	114 48 35	324.3/592.3/7.9	3580	2060112
MD-1	J-3 Drain at mouth (Silo Creek)	42 49 24	114 47 09	324.3/592.3/1.4	2960	2060113
MD-2	Clear Creek at mouth	42 37 40	114 47 34	324.3/592.3/3.9/.1	3260	2060115
MD-3	Mud Creek - 2 mi w, 1 mi N, 1/4 mi E, 1/4 mi N (section 22)	42 37 55	114 48 20	324.3/592.3/.4	3280	2060116

Table 2. Water quality data for the Deep Creek stream survey stations, 1986. Values listed are annual means (and ranges).

PARAMETER	S-1A	S-2	S-3A	S-3	S-4
Temperature (°c)	13.6 (8.0-21.2)	13.1 (8.0-19.1)	14.7 (9.1-20.5)	15.7 (11.0-22.0)	17.8 (10.4-28.0)
Stream Flows (cfs)	122.6 (36.1-260.0)	92.7 (5.8-203.9)	158.1 (24.8-279.0)	52.8 (10.5-175.0)	26.56 (7.4-104.0)
Turbidity (NTU's)	14.6 (.6-36.0)	19.6 (1.5-44.0)	13.4 (0.6-32.0)	10.8 (0.6-36.5)	12.4 (4.0-24.0)
Conductivity (umhos)	811.5 (648-1055)	680.7 (555-1125)	576.9 (458-1006)	614.0 (372-915)	388.0 (294-432)
Dissolved Oxygen (mg/l)	7.16 (3.8-10.3)	7.49 (3.5-13.0)	7.08 (3.2-11.9)	6.7 (2.8-8.9)	6.9 (3.6-9.3)
Dissolved Oxygen (% sat)	67.9 (34.2-88.8)	70.2 (36.0-112.1)	68.1 (34.0-102.6)	66.5 (29.8-89.1)	72.9 (36.0-112.6)
pH	8.5 (7.7-9.0)	8.5 (8.1-9.12)	8.6 (8.0-9.3)	8.5 (7.8-9.1)	8.9 (8.34-9.62)
TKN (mg/l)	0.71 (0.4-1.4)	0.74 (0.4-1.2)	0.65 (0.4-1.05)	0.70 (0.4-1.03)	0.56 (0.38-0.78)
NO2 + NO3 -N (mg/l)	2.5 (1.6-4.9)	2.4 (1.06-10.2)	1.70 (0.56-5.22)	1.86 (0.15-5.04)	0.03 (0.006-0.07)
Ortho -PO4 (mg/l)	0.03 (.001-.072)	0.03 (.013-.06)	0.018 (.008-.032)	0.05 (.009-.11)	0.03 (0.003-0.15)
Total P (mg/l)	0.15 (.069-0.32)	0.19 (0.01-0.4)	0.13 (0.05-0.3)	0.16 (0.04-0.3)	0.13 (0.02-0.2)
Volatile Residue (mg/l)	8.8 (2.0-16.0)	7.3 (2.0-22.0)	6.4 (2.0-18.0)	5.7 (0.8-18.0)	5.8 (2.0-14.0)
Suspended Sediment (mg/l)	63.8 (2.0-174.0)	96.7 (2.0-206.0)	54.4 (2.0-142.0)	38.1 (2.0-136.0)	35.8 (2.0-72.0)
Fecal Coliform (#/100 ml)	663 (7-15000)	717 (23-6300)	460 (35-7000)	727 (20-22000)	292.3 (20-24000)
Fecal Strep (#/100 ml)	2092 (197-14000)	1829 (52-9850)	1098 (48-32000)	2521 (180-14000)	2186 (250-9000)
F/C Ratio	0.6 (.03-3.1)	0.55 (.05-1.35)	0.98 (.15-8.3)	0.72 (.04-3.8)	0.45 (.004-3.2)

Table 3. USGS flow record for the Deep Creek monitoring station near Buhl, Idaho (#13095050) for the October 1985 - September 1986 water year.

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - BOISE 03/04/88

STATION NUMBER 13095050 DEEP CREEK AT MOUTH NR BUHL IDAHO SPRING SOURCE AGENCY USGS
LATITUDE 423930 LONGITUDE 1144830 GEOLOGIC UNIT DATUM STATE 16 COUNTY 083

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	279	246	33	29	43	22	21	73	71	40	70	110
2	234	221	35	28	32	21	28	62	78	33	67	122
3	211	170	36	29	29	20	89	54	78	33	59	130
4	265	153	34	28	27	20	123	66	81	38	66	134
5	281	161	32	29	30	20	45	81	124	60	58	121
6	240	175	31	29	29	21	76	61	108	60	58	137
7	231	151	33	29	23	21	63	73	156	63	52	146
8	269	123	33	29	22	22	59	84	186	55	44	162
9	249	106	32	30	22	21	60	76	142	69	41	195
10	220	105	31	30	22	21	108	67	140	77	41	209
11	195	91	30	30	22	20	162	79	125	74	43	206
12	203	93	29	29	23	20	165	66	114	86	60	197
13	218	98	29	29	28	20	176	62	86	96	72	188
14	229	102	29	30	25	20	189	59	92	96	57	185
15	210	92	29	29	27	20	143	54	107	55	47	205
16	198	95	29	30	27	21	125	54	104	47	45	215
17	195	50	28	33	43	20	127	49	85	48	46	233
18	190	50	29	42	59	19	108	46	59	48	47	219
19	190	37	28	41	38	19	111	44	56	41	49	191
20	192	37	29	85	34	19	115	45	54	42	57	219
21	199	35	30	48	32	19	117	55	53	48	63	200
22	220	35	29	26	33	20	46	64	55	43	58	188
23	244	36	30	33	42	19	37	70	53	51	61	208
24	220	37	29	32	68	18	41	65	52	73	70	211
25	190	36	29	31	62	18	58	96	48	90	79	223
26	194	35	29	30	75	18	49	89	50	97	73	248
27	200	35	28	30	62	17	77	59	38	86	70	264
28	197	36	28	30	32	20	100	67	34	88	77	224
29	211	35	28	30	---	21	57	75	46	89	83	212
30	193	34	28	43	---	20	69	73	52	89	87	217
31	225	---	27	91	---	21	---	66	---	86	92	---
TOTAL	6792	2710	934	1092	1011	618	2744	2034	2527	2001	1892	5719
MEAN	219	90.3	30.1	35.2	36.1	19.9	91.5	65.6	84.2	64.5	61.0	191
MAX	281	246	36	91	75	22	189	96	186	97	92	264
MIN	190	34	27	26	22	17	21	44	34	33	41	110
MED	211	92	29	30	31	20	83	66	78	60	59	203
AC-FT	13470	5380	1850	2170	2010	1230	5440	4030	5010	3970	3750	11340

CAL YR 1985 TOTAL 16945 MEAN 111 MAX 281 MIN 27 MED 69 AC-FT 33610
WTR YR 1986 TOTAL 30074 MEAN 82.4 MAX 281 MIN 17 MED 58 AC-FT 59650

Table 4. Water quality data for the Deep Creek drain survey stations, 1986. Values listed are annual means (and ranges).

PARAMETER	D-1	D-2A	D-3	D-4	D-5
Temperature (°c)	13.4 (7.0-19.1)	16.1 (10.0-21.2)	13.9 (10.1-21.0)	16.3 (10.5-24.0)	17.5 (10.9-28.0)
Flow (cfs)	7.5 (1.1-17.8)	114.0 (6.4-171.2)	21.0 (4.9-33.3)	4.4 (1.02-9.6)	32.0 (0.15-58.0)
Turbidity (NTU's)	42.2 (2.0-250.0)	16.3 (0.7-44.0)	3.4 (0.7-16.0)	26.8 (7.0-80.0)	20.5 (1.2-54.0)
Conductivity (umhos)	829.1 (570-1042)	455.4 (335-900)	928.5 (620-1080)	402.3 (335-438)	415.8 (310-663)
Dissolved Oxygen (mg/l)	7.38 (4.0-10.3)	6.94 (4.3-9.2)	8.32 (4.7-11.2)	7.29 (5.5-8.7)	6.84 (3.4-9.6)
Dissolved Oxygen (% sat)	69.3 (42.5-85.8)	69.3 (43.0-85.2)	80.2 (44.3-103.7)	73.6 (56.6-88.2)	69.8 (39.1-93.7)
pH	8.5 (7.9-9.1)	8.8 (8.1-9.4)	8.4 (7.8-9.0)	8.7 (8.2-9.3)	8.8 (7.9-9.7)
TKN (mg/l)	1.42 (0.35-6.08)	0.60 (0.38-0.87)	0.59 (0.50-0.74)	0.83 (0.38-1.47)	0.89 (0.37-1.99)
NO2 + NO3 -N (mg/l)	3.1 (1.22-5.15)	0.95 (0.004-5.8)	4.85 (2.5-5.9)	0.13 (0.006-0.8)	0.10 (0.004-0.86)
Ortho-PO4 (mg/l)	0.089 (0.004-0.29)	0.014 (0.003-0.042)	0.03 (0.02-0.04)	0.06 (0.01-0.27)	0.04 (0.003-0.08)
Total P (mg/l)	0.46 (0.1-2.5)	0.15 (0.07-0.3)	0.09 (0.08-0.10)	0.25 (0.06-0.5)	0.23 (0.06-0.6)
Volatile Residue (mg/l)	19.4 (0.2-122.0)	5.8 (2.0-24.0)	3.4 (2.0-8.0)	13.0 (2.0-36.0)	7.6 (2.0-24.0)
Suspended Sediment (mg/l)	297.3 (2-2540)	68.6 (2-210)	8.9 (2-26)	95.9 (20-328)	115.2 (6-332)
Fecal Coliform (#/100 ml)	1174 (2-33000)	388 (20-4700)	446 (7-9800)	2294 (120-44000)	1756 (30-99000)
Fecal Strep (#/100 ml)	6042 (95-59000)	1000 (200-5600)	1322 (134-5900)	5400 (510-38500)	4822 (220-150000)
F/C Ratio	0.51 (0.02-1.94)	0.78 (0.04-4.32)	0.92 (0.01-4.19)	0.85 (0.08-3.38)	0.76 (0.04-4.30)

Table 5. Estimated 1986 irrigation season suspended sediment loadings of the Deep Creek drains. Percentage of total load due to agricultural inputs, mean flows, and mean suspended sediment levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean Susp. Sed. (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
D-1	8.2	146.2**	530.0	99.9	6.4
D-2A	123.7	79.5	5243.0	100.0	63.1
D-3	21.2	9.1	97.7	94.2	1.2
D-4	4.4	95.9	178.7	100.0	2.1
D-5	34.7	124.3	2255.9	100.0	27.2
Total Load			**8305.3**		

*Sum may not equal 100% due to rounding.
**Peak suspended sediment concentration of 2540 mg/l on 8/28/86 due to drain chaining event was not included in mean calculation.

Table 6. Estimated 1986 irrigation season total Kjeldahl nitrogen (TKN) loadings of the Deep Creek drains. Percentage of total load due to agricultural inputs, mean flows, and mean TKN levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean TKN Conc. (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
D-1	8.2	1.32**	4.65	95	6.6
D-2A	123.7	0.63	40.95	100	58.3
D-3	21.2	0.6	6.42	78	9.1
D-4	4.4	0.83	1.5	100	2.1
D-5	34.7	0.93	16.65	100	23.7
Total Load			**70.2**		

*Sum may not equal 100% due to rounding.

**Peak TKN concentration of 4.57 mg/l on 8/28/86 due to drain chaining event was not included in mean calculation.

Table 7. Estimated 1986 irrigation season nitrate nitrogen loadings of the Deep Creek drains. Percentage of total load due to agricultural inputs, mean flows, and mean NO2+NO3-N levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean NO2+NO3-N (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
D-1	8.2	3.02**	12.82	87.3	16.8
D-2A	123.7	0.17	11.49	100.0	15.0
D-3	21.2	4.75	51.1	68.1	66.8
D-4	4.4	0.13	0.28	100.0	0.4
D-5	34.7	0.04	0.74	100.0	0.9
Total Load			**76.4**		

*Sum may not equal 100% due to rounding.
**NO2+NO3-N concentration of 3.01 mg/l on 8/28/86 during drain chaining event was not included in mean calculation.

Table 8. Estimated 1986 irrigation season total phosphorus loadings of the Deep Creek drains. Percentage of total load due to agricultural inputs, mean flows, and mean total phosphorus levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean Total P (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
D-1	8.2	0.35**	1.22	95.1	6.9
D-2A	123.7	0.16	10.44	100.0	59.4
D-3	21.2	0.1	1.05	73.3	5.9
D-4	4.4	0.25	0.46	100.0	2.6
D-5	34.7	0.24	4.4	100.0	25.0
Total Load			**17.6**		

*Sum may not equal 100% due to rounding.
**Peak total phosphorus concentration of 2.5 mg/l on 8/28/86 due to drain chaining event was not included in mean calculation.

Table 9. Estimated 1986 irrigation season dissolved orthophosphate (PO4-P) loadings of the Deep Creek drains. Percentage of total load due to agricultural inputs, mean flows, and mean dissolved orthophosphate levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean PO4-P (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
D-1	8.2	0.09**	0.32	98.6	13.5
D-2A	123.7	0.014	0.82	100.0	34.3
D-3	21.2	0.03	0.37	88.3	15.6
D-4	4.4	0.07	0.11	100.0	4.6
D-5	34.7	0.04	0.76	100.0	31.8
Total Load			**2.38**		

*Sum may not equal 100% due to rounding.
**Peak dissolved orthophosphate concentration of 0.15 mg/l on 8/28/86 due to drain chaining event was not included in mean calculation.

Table 10. Fecal coliform and fecal streptococcus bacteria densities (number/100 ml) in Deep Creek and monitored drains, 1986. Means listed are annual geometric means.

Station	n	Fecal Coliform Minimum	Fecal Coliform Maximum	Fecal Coliform Mean	Fecal Strep Minimum	Fecal Strep Maximum	Fecal Strep Mean	FC/FS ratio
S-1A	14	7	15000	663.6	197	14000	2092.3	0.6
S-2	15	23	6300	717.9	52	9850	1829	0.55
S-3A	14	35	7000	460.4	48	32000	1098.9	0.98
S-3	13	20	22000	727.1	180	14000	2521.3	0.72
S-4	13	20	24000	292.3	250	9000	2186.1	0.45
D-1	14	2	33000	1174	95	59000	6042.7	0.51
D-2A	13	20	4700	388.1	200	5600	1000.6	0.78
D-3	14	7	9800	445.8	134	5900	1321.8	0.92
D-4	11	120	44000	2293.8	510	38500	5399.7	0.85
D-5	13	30	99000	1756.5	220	150000	4821.7	0.76

Table 11. Overview of water quality impacts as a result of chaining drain D-1 on August 28, 1986, to remove algae and aquatic macrophytes.

Date	Flow (cfs)	Turbidity (NTU)	TKN (mg/l)	NO2+NO3-N (mg/l)	PO4-P (mg/l)	Total P (mg/l)	Susp. Sed. (mg/l)	Fecal Coliforms (#/100 ml)	Fecal Strep (#/100 ml)
8/14/86	5.2	34	1.21	4.38	0.094	0.4	258	33000	17000
8/28/86	11.6	250	4.57	3.01	0.15	2.5	2540	26000	49000
9/9/86	11.4	18	0.64	3.68	0.096	0.2	62	420	1900

Date	TKN	Loadings (lbs/d)* NO2+NO3-N	Total P	PO4-P	Susp. Sed.
8/14/86	33.9	122.8	11.2	2.6	7236.3
8/28/86	285.9	188.3	156.4	9.7	158922
9/9/86	39.3	226.3	12.3	5.9	3812.3

*Values not corrected
for background levels.

Table 12. Mean densities (number/m2), tolerance quotients (TQ), functional feeding groups (FFG), and EPT values of macroinvertebrates collected in Deep Creek, March 21, 1986. Tolerance quotients are from Winget and Mangum (1979).

TAXON	S-1A	S-2	S-3A	S-3	TQ	FFG
Plecoptera						
Isoperla sp.	26.70				48	PR
Hesperoperla pacifica	20.00				18	PR
Trichoptera						
Brachycentrus sp.	3.30			16.70	24	C-F,SC
Helicopsyche borealis			20.00	26.70	18	SC
Hydropsyche sp.	30.00	730.00	6.70	29.70	108	C-F
Hydroptilla sp.		20.00	13.30	1967.00	108	P-H,SC
Rhyacophila sp.	3.30	25.00			18	PR
Ephemeroptera						
Baetis tricaudatus	370.00	1400.00	2113.00	170.00	72	SC
Ephemerella inermis		173.00	270.00	26.70	48	SC,C-G
Tricorythodes minutus				16.70	108	C-G
Diptera						
Chironomidae	40.00	190.00	83.30	2413.30	108	C-G,PR
Simulium sp.	23.30		23.30	40.00	108	C-F
Antocha sp.		15.00			24	C-G
Lepidoptera						
Paragyractis sp.	280.00	40.00			72	SC
Coleoptera						
Optioservus sp.	46.70	110.00	36.70	13.30	108	SC,C-G
Odonata						
Ischnura sp.				3.30	72	PR
Crustacea						
Amphipoda						
Hyalella azteca		115.00	3.30	26.70	108	C-G
Isopoda						
Ascellus sp.				116.70	108	C-G
Hirudinea				83.30	108	PA/PR
Nematoda	3.30				108	PA/P-H
Bivalvia						
Piscidium sp.			10.00	40.00	108	C-F
Sphaerium sp.			40.00	16.70	108	C-F
Gastropoda						
Fluminicola virens		220.00	263.30	26.70	108	SC
Fontelilicella sp.				26.70	108	SC
Gyraulus sp.				43.30	108	SC
Physa sp.			23.30	53.30	108	SC
Turbellaria						
Planariidae	3.30				108	PR/C-G
Total #/meter2	849.90	3038.00	2906.20	5156.80		
Total number of taxa	12	11	13	20		
EPT Value	6	5	5	7		

Key:
SC = Scraper
C-G =Collector/Gatherer
C-F =Collector/Filterer
P-H =Piercer/Herbivore
PR =Predator
PA/PR =Parasite/Predator

Table 13. Mean densities (number/m2), tolerance quotients (TQ), functional feeding groups (FFG), and EPT values of macroinvertebrates collected in Deep Creek, September 5, 1986. Tolerance quotients are from Winget and Mangum (1979).

TAXON	S-1A	S-2	S-3A	S-3	S-4	TQ	FFG
Trichoptera							
Amiocentrus sp.	3.3	10				24	C-G
Brachycentrus sp.	3.3					24	C-F,SC
Hydropsyche sp.	243	3.3	130	10		108	C-F
Hydroptila sp.			5			108	P-H,SC
Leucotrichia sp.			10			108	C-G
Ephemeroptera							
Baetis tricaudatus	20		145		67	72	SC
Ephemerella inermis		16.7			6.7	48	SC,C-G
Tricorythodes minutus	6.7				10	108	C-G
Diptera							
Chironomidae	13.3	140	15		16.7	108	C-G,PR
Simulium sp.	6.7		10			108	C-F
Hexatoma sp.					3.3	36	PR
Lepidoptera							
Paragyractis sp.	370	36.7	55			72	SC
Coleoptera							
Optioservus sp.	63	13.3	55			108	SC,C-G
Odonata							
Ischnura sp.	3.3	3.3	10		6.7	72	PR
Ophiogomphus sp.	6.6					108	PR
Crustacea							
Amphipoda							
Hyalella azteca	6.7					108	C-G
Hirudinea		26.7	5	13.3	80	108	PA/PR
Bivalvia							
Piscidium sp.		10	15		3.3	108	C-F
Sphaerium sp.	3.3	70	140	13.3		108	C-F
Gastropoda							
Fluminicola virens	30	320	300	80		108	SC
Fonticellicella sp.		10		20	143	108	SC
Gyraulus sp.			10			108	SC
Physa sp.	3.3	60	15	43	100	108	SC
Turbellaria							
Planariidae		6.7				108	PR,C-G
Oligochaeta							
Tubifex sp.					6.7	108	C-G
Total #/meter2	782.5	726.7	920	179.6	443.4		
Total number of taxa	15	14	15	6	11		
EPT Value	5	3	4	1	3		

Key:
SC = Scraper
C-G =Collector/Gatherer
C-F =Collector/Filterer
P-H =Piercer/Herbivore
PR =Predator
PA/PR =Parasite/Predator

Table 14. Species list of invertebrates collected in Deep Creek, 1986. Taxa richness, mean tolerance values, and EPT values for the two sampling dates are listed for comparison.

	21-Mar	5-Sep
Plecoptera		
Isoperla sp.	X	
Hesperoperla pacifica	X	
Trichoptera		
Amiocentrus sp.		X
Brachycentrus sp.	X	X
Helicopsyche borealis	X	
Hydropsyche sp.	X	X
Hydroptila sp.	X	X
Leucotrichia sp.		X
Rhyacophila sp.	X	
Ephemeroptera		
Baetis tricaudatus	X	X
Ephemerella inermis	X	X
Tricorythodes minutus	X	X
Diptera		
Antocha sp.	X	
Chironomidae	X	X
Hexatoma sp.		X
Simulium sp.	X	X
Lepidoptera		
Paragyractis sp.	X	X
Coleoptera		
Optioservus sp.	X	X
Odonata		
Ischnura sp.	X	X
Ophiogomphus sp.		X
Crustacea		
Amphipoda		
Hyalella azteca	X	X
Isopoda		
Asellus sp.	X	
Hirudinea	X	X
Nematoda	X	
Bivalvia		
Pisidium sp.	X	X
Sphaerium sp.	X	X
Gastropoda		
Fluminicola virens	X	X
Fontelicella sp.	X	X
Gyraulus sp.	X	X
Physa sp.	X	X
Turbellaria		
Planariidae	X	X
Oligochaeta		
Tubifex sp		X
Total number of taxa	27	25
Mean tolerance quotient	83.3	87.4
EPT Value	7	5

Table 15. Density (number/m2), number of species of macroinvertebrates collected, community tolerance quotients (CTQa), Biotic Condition Index, and EPT values for the Deep Creek stations on the dates indicated.

	S-1A	S-2	S-3A	S-3	S-4
			21-Mar-86		
Density (*/m2)	849.9	3038	2906.2	5156.8	--*
Number of taxa	12	11	13	20	--
Number of taxa with TQ=108	6	6	10	15	--
% of taxa with TQ=108	50%	54%	77%	75%	--
CTQp	50	53	53	66	--
CTQa	75	80.2	93.7	92.7	--
Biotic Condition Index	67	66	56	71	--
EPT value	6	5	5	7	--
			5-Sep-86		
Density (*/m2)	782.5	726.7	920	179.6	443.4
Number of taxa	15	14	15	6	11
Number of taxa with TQ=108	10	10	12	6	7
% of taxa with TQ=108	67%	71%	80%	100%	64%
CTQp	80	86	86	88	86
CTQa	89.6	92.6	100.8	108	89.4
Biotic Condition Index	89.3	92.8	85.3	81.5	96.2
EPT value	5	3	4	1	3

*--Channel was dry, no samples collected.

Table 16. Invertebrate taxa collected from Deep Creek that were restricted to one of the sampling periods, March or September, 1986.

Taxon	Tolerance quotient
March 21, 1986 only	
Isoperla sp.	48
Hesperoperla sp.	18
Helicopsyche borealis	18
Rhyacophila sp.	18
Antocha sp.	24
Ascellus sp.	108
Nematoda	108
Mean TQ	33.4
September 3, 1986 only	
Amiocentrus sp.	24
Leucotrichia sp.	108
Hexatoma sp.	36
Omphiogomphus sp.	108
Tubifex sp.	108
Mean TQ	76.8

Table 17 Functional feeding groups of macroinvertebrates collected at the Deep Creek stations on the dates listed, 1986. Values listed are individuals/m2.

	S-1A	S-2	S-3A	S-3	S-4
			21-Mar-86		
Scraper	696.7	1943	2726.3	386.7	--*
Collector/gatherer	40	320	86.6	2573.4	--
Collector/filterer	56.6	730	80	143.1	--
Piercer/herbivore	0	20	13.3	1967	--
Predator	53.3	25	0	3.3	--
Parasite/predator	3.3	0	0	83.3	--
			5-Sep-86		
Scraper	486.3	456.7	580	143	316.7
Collector/gatherer	30	150	25	0	33.4
Collector/filterer	256.3	83.3	295	23.3	3.3
Piercer/herbivore	0	0	5	0	0
Predator	9.9	10	10	0	10
Parasite/predator	0	26.7	5	13.3	80

*-- Channel was dry, no samples collected.

Table 18. Water quality data for the Mud Creek stream survey stations, 1986. Values listed are annual means (and ranges).

PARAMETER	M-1	M-2	M-3
Temperature (°c)	14.9 (8.0-20.5)	15.1 (9.0-21.0)	16.8 (9.0-23.5)
Flow (cfs)	136.0 (66.6-188.3)	43.4 (15.9-65.6)	28.5 (6.3-42.7)
Turbidity (NTU's)	10.1 (1.8-25.0)	6.4 (1.3-34.0)	11.7 (1.0-30.0)
Conductivity (umhos)	914.0 (786-1065)	887.0 (819-1000)	733.5 (110-976)
Dissolved Oxygen (mg/l)	7.2 (4.6-9.8)	7.2 (2.7-9.6)	7.8 (3.6-12.0)
Dissolved Oxygen (% sat)	70.8 (48.9-90.7)	70.6 (28.7-87.8)	79.0 (40.0-115.4)
pH	8.5 (7.5-9.05)	8.5 (8.2-9.1)	8.6 (8.1-9.12)
TKN (mg/l)	0.77 (0.51-1.15)	0.61 (0.5-0.76)	0.82 (0.44-1.27)
NO2 + NO3 -N (mg/l)	2.94 (2.08-5.0)	2.92 (2.18-4.66)	3.15 (1.86-5.48)
Ortho -PO4 (mg/l)	0.05 (0.018-0.069)	0.05 (0.03-0.07)	0.06 (0.005-0.09)
Total P (mg/l)	0.19 (0.08-0.30)	0.12 (0.09-0.20)	0.19 (0.07-0.30)
Volatile Residue (mg/l)	5.9 (2.0-20.0)	4.8 (2.0-12.0)	5.8 (2.0-18.0)
Suspended Sediment (mg/l)	44.4 (4.0-130.0)	15.8 (2.0-48.0)	51.4 (4.0-180.0)
Fecal Coliform (#/100 ml)	823.6 (30-29000)	480 (34-2300)	2014 (220-15000)
Fecal Strep (#/100 ml)	3538.5 (125-11000)	2330 (500-16000)	6082 (720-29000)
F/C Ratio	0.52 (0.02-2.96)	0.48 (0.008-1.72)	0.51 (0.04-1.67)

Table 19. USGS flow record for the Mud Creek monitoring station near Buhl, Idaho (#13094700) for the October 1985 - September 1986 water year.

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - BOISE 03/04/88

STATION NUMBER 13094700 MUD CREEK NR BUHL ID STREAM SOURCE AGENCY USGS
LATITUDE 423934 LONGITUDE 1144716 DRAINAGE AREA DATUM 2950.00 STATE 16 COUNTY 083

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	152	101	79	65	81	76	55	68	88	76	98	140
2	150	97	86	68	77	75	54	65	91	79	102	140
3	145	98	89	68	77	72	58	62	93	79	102	137
4	143	97	81	65	73	73	58	69	95	85	99	145
5	142	95	79	67	74	71	53	81	113	93	100	139
6	143	93	77	67	72	71	54	88	102	90	98	139
7	160	93	79	64	70	74	57	98	126	90	93	145
8	146	93	81	63	68	80	61	93	134	83	93	156
9	141	96	78	65	68	76	59	96	122	86	94	165
10	138	96	76	64	67	76	62	102	116	89	97	157
11	138	93	73	64	67	74	65	100	117	92	96	147
12	134	87	71	64	72	73	67	95	114	96	85	150
13	139	83	71	63	112	74	69	93	106	91	82	149
14	144	79	69	64	83	71	70	89	100	86	93	155
15	140	82	70	65	80	71	63	86	95	84	96	156
16	137	89	69	71	75	73	65	79	92	92	97	148
17	132	87	67	84	108	69	68	73	83	97	97	145
18	128	84	66	85	120	66	66	75	76	102	96	146
19	128	85	65	79	93	64	60	77	75	100	102	148
20	129	87	64	79	85	64	59	80	73	98	107	150
21	128	86	64	72	81	64	54	90	74	99	105	147
22	126	85	65	67	84	64	53	95	79	95	108	145
23	129	83	65	77	86	63	60	98	79	97	120	146
24	124	86	65	72	80	62	69	96	75	100	126	155
25	122	86	64	67	78	60	71	99	73	108	121	153
26	119	81	63	65	76	60	76	98	77	108	122	161
27	119	81	63	65	75	58	80	90	72	107	119	156
28	113	85	63	65	76	55	73	90	70	109	121	147
29	110	87	62	76	---	56	65	87	74	106	132	142
30	113	82	63	106	---	56	69	88	77	101	134	149
31	112	---	63	99	---	52	---	86	---	104	136	---
TOTAL	4124	2657	2190	2205	2258	2093	1893	2685	2761	2922	3271	4458
MEAN	133	88.6	70.6	71.1	80.6	67.5	63.1	86.6	92.0	94.3	106	149
MAX	160	101	89	106	120	80	80	102	134	109	136	165
MIN	110	79	62	63	67	52	53	62	70	76	82	137
AC-FT	8180	5270	4340	4370	4480	4150	3750	5330	5480	5800	6490	8840

CAL YR 1985 TOTAL 23679 MEAN 91.4 MAX 217 MIN 37 AC-FT 46970
WTR YR 1986 TOTAL 33517 MEAN 91.8 MAX 165 MIN 52 AC-FT 66480

Table 20. Water quality data for the Mud Creek tributary survey stations, 1986. Values listed are annual means (and ranges).

PARAMETER	MD-1	MD-2	MD-3
Temperature (°c)	14.9 (8.0-21.0)	15.9 (9.0-22.0)	15.3 (7.0-21.5)
Flow (cfs)	54.1 (24.7-85.5)	4.17 (1.15-9.2)	11.8 (4.6-17.4)
Turbidity (NTU's)	13.2 (1.4-33.0)	2.2 (1.0-6.0)	3.6 (2.5-6.0)
Conductivity (umhos)	908.3 (791-1097)	953.0 (851-1019)	855.0 (792-984)
Dissolved Oxygen (mg/l)	7.0 (3.8-9.8)	6.4 (3.4-8.5)	6.8 (3.2-9.6)
Dissolved Oxygen (% sat)	68.2 (38.0-90.7)	63.6 (34.0-77.9)	67.3 (32.0-84.9)
pH	8.4 (8.0-8.9)	8.4 (7.9-8.9)	8.6 (8.2-9.1)
TKN (mg/l)	0.94 (0.59-1.4)	0.53 (0.32-0.82)	0.66 (0.47-0.78)
NO2 + NO3 -N (mg/l)	3.2 (2.4-5.2)	1.05 (0.47-3.10)	2.31 (1.75-3.79)
Ortho -PO4 (mg/l)	0.05 (0.018-0.11)	0.05 (0.016-0.08)	0.06 (0.014-0.10)
Total P (mg/l)	0.21 (0.10-0.40)	0.11 (0.10-0.20)	0.12 (0.10-0.20)
Volatile Residue (mg/l)	6.4 (2.0-16.0)	4.0 (2.0-10.0)	5.3 (2.0-16.0)
Suspended Sediment (mg/l)	66.4 (2.0-156.0)	15.4 (2.0-40.0)	16.1 (2.0-38.0)
Fecal Coliform (#/100 ml)	989.9 (10-203000)	393.7 (100-1100)	558.5 (10-6800)
Fecal Strep (#/100 ml)	5240.2 (215-43000)	1733.9 (89-6700)	3642.6 (85-57500)
F/C Ratio	0.66 (0.008-4.72)	0.37 (0.03-1.3)	0.51 (0.006-1.60)

Table 21. Estimated 1986 irrigation season suspended sediment loadings of the Mud Creek tributaries. Percentage of total load due to agricultural inputs, mean flows, and mean suspended sediment levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean Susp. Sed. (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
MD-1	58.3	76.3	2458.0	98.9	94.1
MD-2	4.2	14.9	40.1	42.3	1.5
MD-3	12.5	16.5	113.7	69.5	4.3
Total Load			**2611.8**		

*Sum may not equal 100% due to rounding.

Table 22. Estimated 1986 irrigation season total Kjeldahl nitrogen (TKN) loadings of the Mud Creek tributaries. Percentage of total load due to agricultural inputs, mean flows, and mean TKN levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean TKN Conc. (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
MD-1	58.3	0.97	29.74	68.2	84.4
MD-2	4.2	0.51	1.19	16.8	3.4
MD-3	12.5	0.67	4.31	58.0	12.2
Total Load			**35.2**		

*Sum may not equal 100% due to rounding.

Table 23. Estimated 1986 irrigation season nitrate nitrogen loadings of the Mud Creek tributaries. Percentage of total load due to agricultural inputs, mean flows, and mean NO2+NO3-N levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	NO2+NO3-N (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
MD-1	58.3	2.96	91.3	24.7	84.8
MD-2	4.2	0.76	1.8	<5	1.7
MD-3	12.5	2.18	14.5	49.5	13.52
Total Load			**107.6**		

*Sum may not equal 100%
due to rounding.

Table 24. Estimated 1986 irrigation season total phosphorus loadings of the Mud Creek tributaries. Percentage of total load due to agricultural inputs, mean flows, and mean total phosphorus levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean Total P (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
MD-1	58.3	0.235	7.33	81.8	87.4
MD-2	4.2	0.117	0.28	53.9	3.3
MD-3	12.5	0.121	0.77	68.4	9.2
Total Load			**8.4**		

*Sum may not equal 100% due to rounding.

Table 25 Estimated 1986 irrigation season dissolved orthophosphate (PO4-P) loadings of the Mud Creek tributaries. Percentage of total load due to agricultural inputs, mean flows, and mean dissolved orthophosphate levels for this period are presented for comparison.

Drain	Mean Flow (cfs)	Mean PO4-P (mg/l)	Irrigation season load - tons	% Agricultural Contribution	% of total load*
MD-1	58.3	0.056	1.72	86.0	75.7
MD-2	4.2	0.056	0.12	80.4	5.5
MD-3	12.5	0.066	0.43	91.9	18.8
Total Load			**2.27**		

*Sum may not équal 100% due to rounding.

Table 26. Fecal coliform and fecal streptococcus bacteria densities (number/100 ml) in Mud Creek and monitored tributaries, 1986. Means listed are annual geometric means.

Station	n	Fecal Coliform Minimum	Fecal Coliform Maximum	Fecal Coliform Mean	Fecal Strep Minimum	Fecal Strep Maximum	Fecal Strep Mean	FC/FS ratio
M-1	15	30	29000	823	125	11000	3538	0.52
M-2	14	34	2300	480	500	16000	2330	0.48
M-3	15	220	15000	2014	720	29000	6082	0.51
MD-1	14	10	203000	989	215	43000	5240	0.66
MD-2	14	100	1100	393	89	6700	1733	0.37
MD-3	14	10	6800	558	85	57500	3642	0.51

Table 27. Species list of invertebrates collected in Mud Creek, 1986. Taxa richness, mean tolerance values, and EPT values for the two sampling dates are listed for comparison.

	21-Mar	3-Sep
Trichoptera		
Amiocentrus sp.	X	X
Brachycentrus sp.	X	X
Helicopsyche borealis	X	
Hydropsyche sp.	X	X
Hydroptila sp.	X	
Oligoplectrum sp.	X	
Ephemeroptera		
Baetis tricaudatus	X	X
Ephemerella inermis	X	
Tricorythodes minutus		X
Diptera		
Chironomidae	X	X
Hexatoma sp.	X	
Simulium sp.	X	X
Lepidoptera		
Paragyractis sp.	X	X
Coleoptera		
Optioservus sp.	X	X
Odonata		
Ischnura sp.	X	X
Crustacea		
Amphipoda		
Hyalella azteca	X	X
Hirudinea	X	X
Nematoda	X	
Bivalvia		
Piscidium sp.	X	X
Gastropoda		
Fluminicola virens		X
Fontelicella sp.	X	X
Gyraulus sp.	X	
Physa sp.	X	X
Oligochaeta		
Tubifex sp.		X
Total number of taxa	21	17
Mean tolerance quotient	80	91.4
EPT Value	8	5

Table 28. Mean densities (number/m2), tolerance quotients (TQ), functional feeding groups (FFG), and EPT values of macroinvertebrates collected in Mud Creek, March 21, 1986. Tolerance quotients are from Winget and Mangum (1979).

TAXON	M-1	M-2	M-3	TQ	FFG
Trichoptera					
Amiocentrus sp.			13.3	24	C-G
Brachycentrus sp.	63.3	413.3	80	24	C-F,SC
Helicopsyche borealis		33.3		18	SC
Hydropsyche sp.	1206.7	240	343.3	108	C-F
Hydroptilla sp.	6.7		13.3	108	P-H,SC
Oligoplectrum sp.	220	120		24	C-F
Ephemeroptera					
Baetis tricaudatus	236.7	186.7	38.7	72	SC
Ephemerella inermis	6.7	63.3	56.7	48	SC,C-G
Diptera					
Chironomidae	56.7	83.3	80	108	C-G,PR
Simulium sp.	10	6.7	113.3	108	C-F
Hexatoma sp.		3.3		36	PR
Lepidoptera					
Paragyractis sp.	60			72	SC
Coleoptera					
Optioservus sp.	46.7	133.3	133.3	108	SC,C-G
Odonata					
Ischnura sp.	3.3			72	PR
Crustacea					
Amphipoda					
Hyalella azteca	16.7	73.3	3.3	108	C-G
Hirudinea		3.3	130	108	PA/PR
Nematoda	3.3	10		108	PA/P-H
Bivalvia					
Pisciduim sp.	13.3	13.3	10	108	C-F
Gastropoda					
Fontelicella sp.		20		108	SC
Gyraulus sp.			6.7	108	SC
Physa sp.		20	3.3	108	SC
Total #/meter2	1950.1	1423.1	1025.2		
Total number of taxa	14	16	14		
EPT Value	6	6	6		

Key:
SC = Scraper
C-G =Collector/Gatherer
C-F =Collector/Filterer
P-H =Piercer/Herbivore
PR =Predator
PA/PR =Parasite/Predator

Table 29. Mean densities (number/m2), tolerance quotients (TQ), functional feeding groups (FFG), and EPT values of macroinvertebrates collected in Mud Creek, September 3, 1986. Tolerance quotients are from Winget and Mangum (1979).

TAXON	M-1	M-2	M-3	TQ	FFG
Trichoptera					
Amiocentrus sp.	93.3			24	C-G
Brachycentrus sp.	63.3	2280	250	24	C-F,SC
Hydropsyche sp.	246.7	175	433.3	108	C-F
Ephemeroptera					
Baetis tricaudatus	10	30	3.3	72	SC
Tricorythodes minutus			3.3	108	C-G
Diptera					
Chironomidae	10	10		108	C-G,PR
Simulium sp.		5	3.3	108	C-F
Lepidoptera					
Paragyractis sp.	30			72	SC
Coleoptera					
Optioservus sp.		35	6.7	108	SC,C-G
Odonata					
Ischnura sp.			3.3	72	PR
Crustacea					
Amphipoda					
Hyalella azteca		5		108	C-G
Hirudinea			20	108	PA/PR
Bivalvia					
Piscidium sp.		5		108	C-F
Gastropoda					
Fluminicola virens	10		3.3	108	SC
Fontelicella sp.		45	13.3	108	SC
Physa sp.	3.3	20	13.3	108	SC
Oligochaeta					
Tubifex sp.	10			108	C-G
Total #/meter2	476.6	2610	753.1		
Total number of taxa	9	10	11		
EPT Value	4	3	4		

Key:
SC = Scraper
C-G = Collector/Gatherer
C-F = Collector/Filterer
P-H = Piercer/Herbivore
PR = Predator
PA/PR = Parasite/Predator

Table 30. Density (number/m2), number of species of macroinvertebrates collected, community tolerance quotients (CTQ), Biotic Condition Index, and EPT values for the Mud Creek stations on the dates indicated.

	M-1	M-2	M-3
		21-Mar-86	
Density (#/m2)	1950.1	1423.1	1025.2
Number of taxa	14	16	14
Number of taxa with TQ=108	8	10	10
% of taxa with TQ=108	57%	63%	71%
CTQp	50	51	53
CTQa	84	81.4	89.1
Biotic Condition Index	59.5	62.6	59.4
EPT value	6	6	6
		3-Sep-86	
Density (#/m2)	476.6	2610	753.1
Number of taxa	9	10	11
Number of taxa with TQ=108	5	8	8
% of taxa with TQ=108	56%	80%	73%
CTQp	80	71	86
CTQa	81.3	96	93.8
Biotic Condition Index	98.4	73.9	91.6
EPT value	4	3	4

Table 31. Invertebrate taxa collected from Mud Creek that were restricted to one of the sampling periods, March or September, 1986.

Taxon	Tolerance quotient
March 21, 1986 only	
Helicopsyche borealis	18
Hydroptila sp.	108
Oligoplectrum sp.	24
Ephemerella inermis	48
Hexatoma sp.	36
Nematoda	108
Mean TQ	57
September 3, 1986 only	
Tricorythodes minutus	108
Fluminicola virens	108
Tubifex sp.	108
Mean TQ	108

Table 32. Functional feeding groups of macroinvertebrates collected at the Mud Creek stations in March and September, 1986. Values listed are densities (individuals/m2).

	M-1	M-2	M-3
		21-Mar-86	
Scraper	350.1	456.6	238.7
Collector/gatherer	73.4	156.6	96.6
Collector/filterer	1513.3	793.3	546.6
Piercer/herbivore	6.7	0	13.3
Predator	3.3	3.3	0
Parasite/predator	3.3	13.3	130
		3-Sep-86	
Scraper	53.3	130	39.9
Collector/gatherer	113.3	15	3.3
Collector/filterer	310	2465	686.6
Predator	0	0	3.3
Parasite/predator	0	0	20

Table 33. Precision of duplicate samples from Deep Creek and Mud Creek, 1986.

STORET #	Parameter	n	Average Relative Range (%)
80154	Suspended sediment	13	11.5
00610	NH3-N	13	21.6
00630	NO2+NO3-N	13	10.2
00625	Total Kjeldahl nitrogen	13	9.5
00665	Total phosphorus	13	7.4
00671	Dissolved PO4-P	13	15.8
00095	Specific conductance	13	3.5
00076	Turbidity	13	18.2
31616	Fecal Coliforms	12	48.2
31679	Fecal Strep	12	19.4

Table 34. Average percent recovery for spiked samples from Deep Creek and Mud Creek, 1986.

STORET #	Parameter	Average Percent Recovery	95% Confidence Interval
80154	Suspended sediment	99.0	6.7
00610	NH3-N	145.7	38.2
00630	NO2+NO3-N	106.8	10.8
00625	Total Kjeldahl nitrogen	117.8	11.8
00665	Total phosphorus	106.5	5.2
00671	Dissolved PO4-P	110.2	8.1

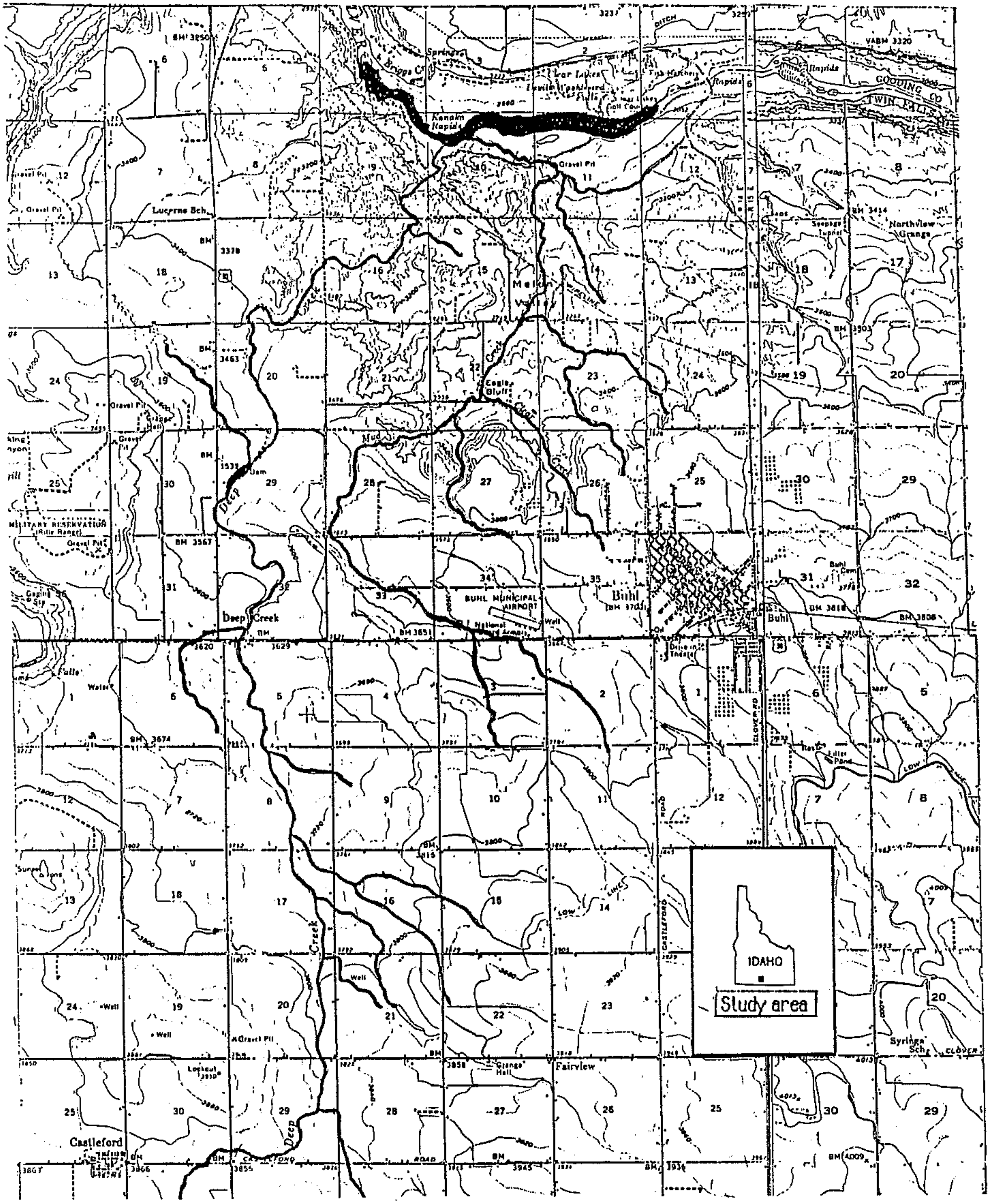

Figure 1. Locations of Deep Creek and Mud Creek watersheds, Twin Falls County, Idaho. Map source U.S.G.S. Buhl Quadrangle, 1:62,5000 scale.

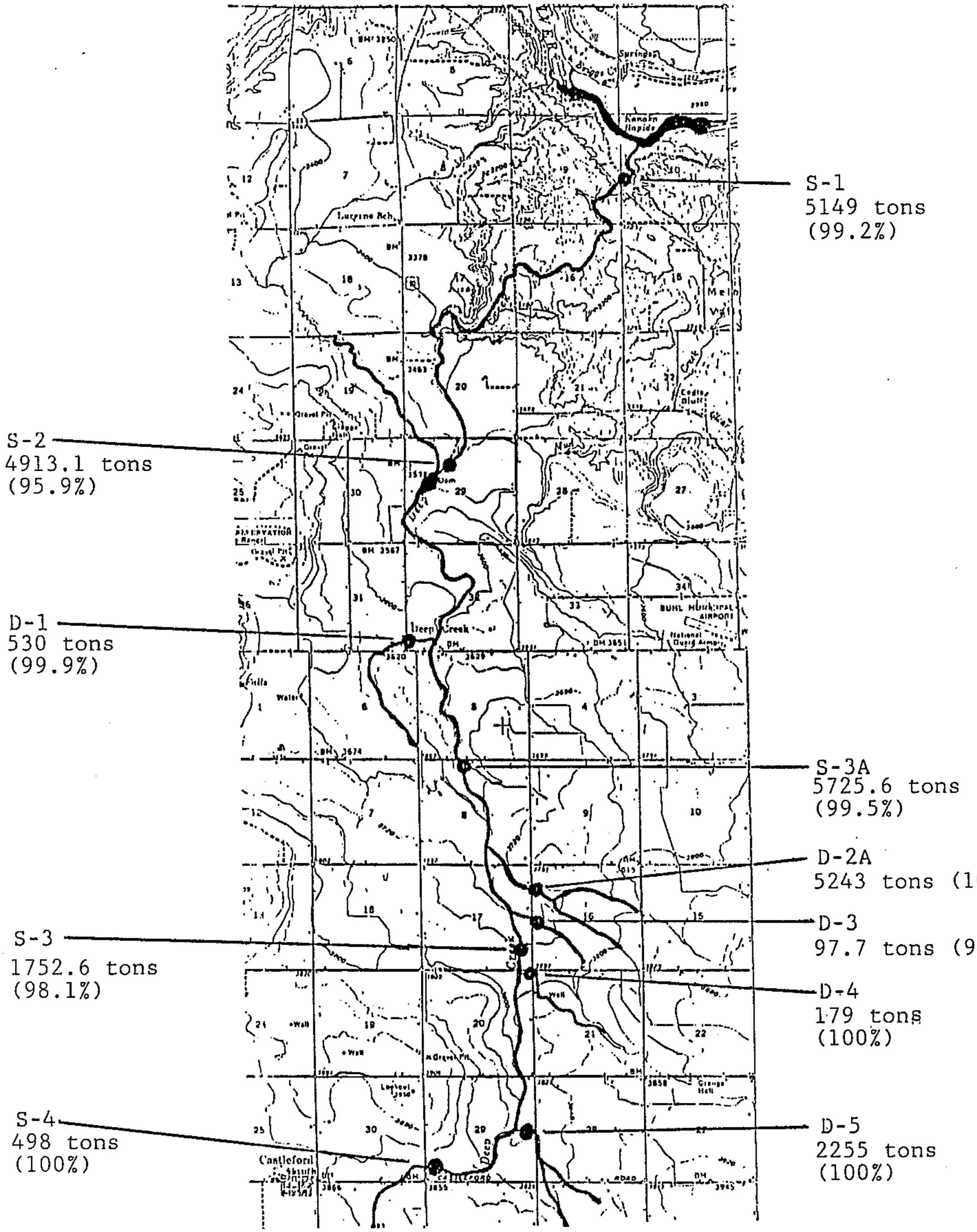

Figure 2. Locations of the Deep Creek monitoring stations, and estimated irrigation season suspended sediment loadings. Percentage of loadings due to agricultural inputs are given in parentheses.

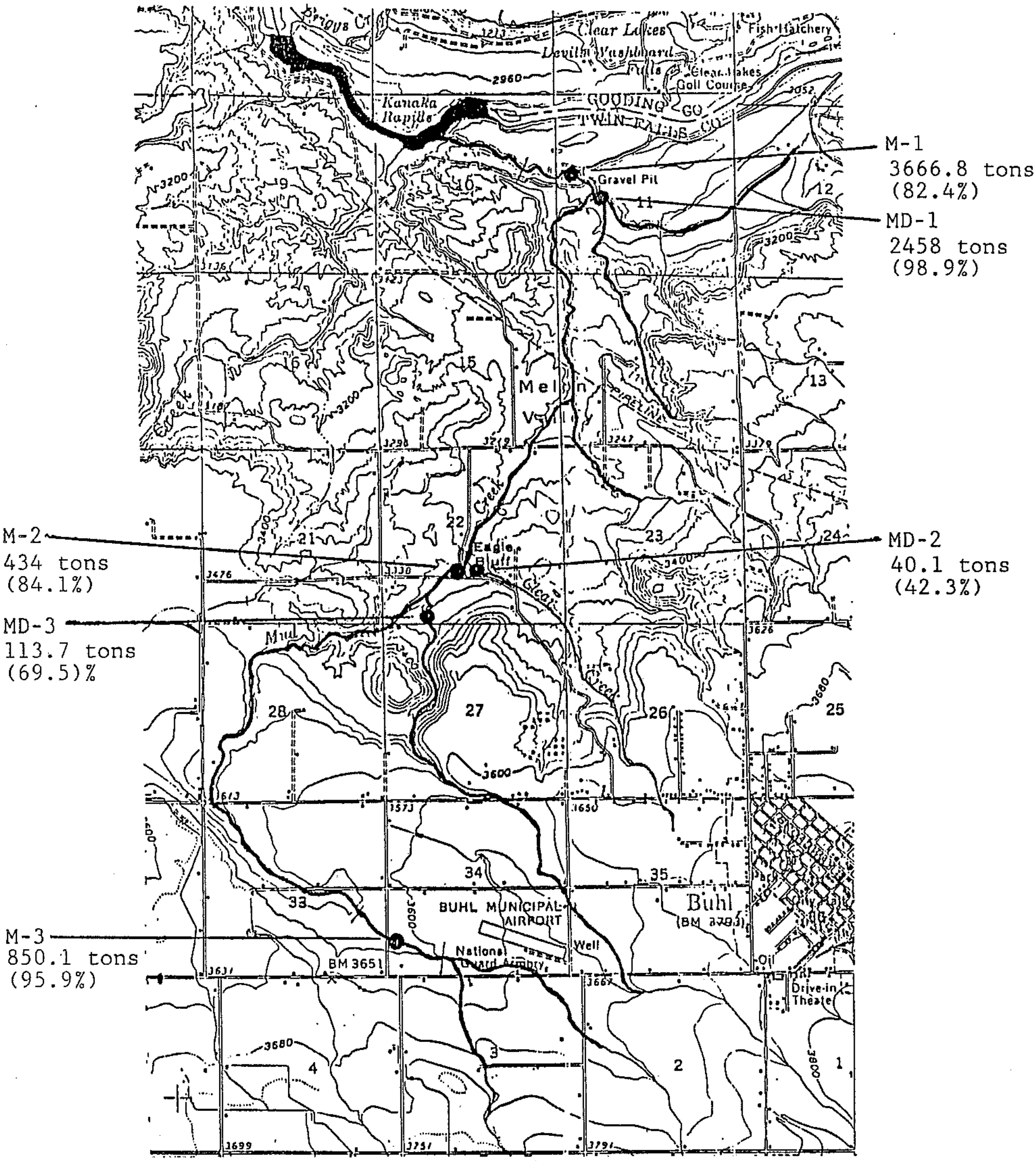

Figure 3. Locations of the Mud Creek monitoring stations, and estimated irrigation season suspended sediment loadings. Percentage of loadings due to agricultural inputs are given in parentheses.

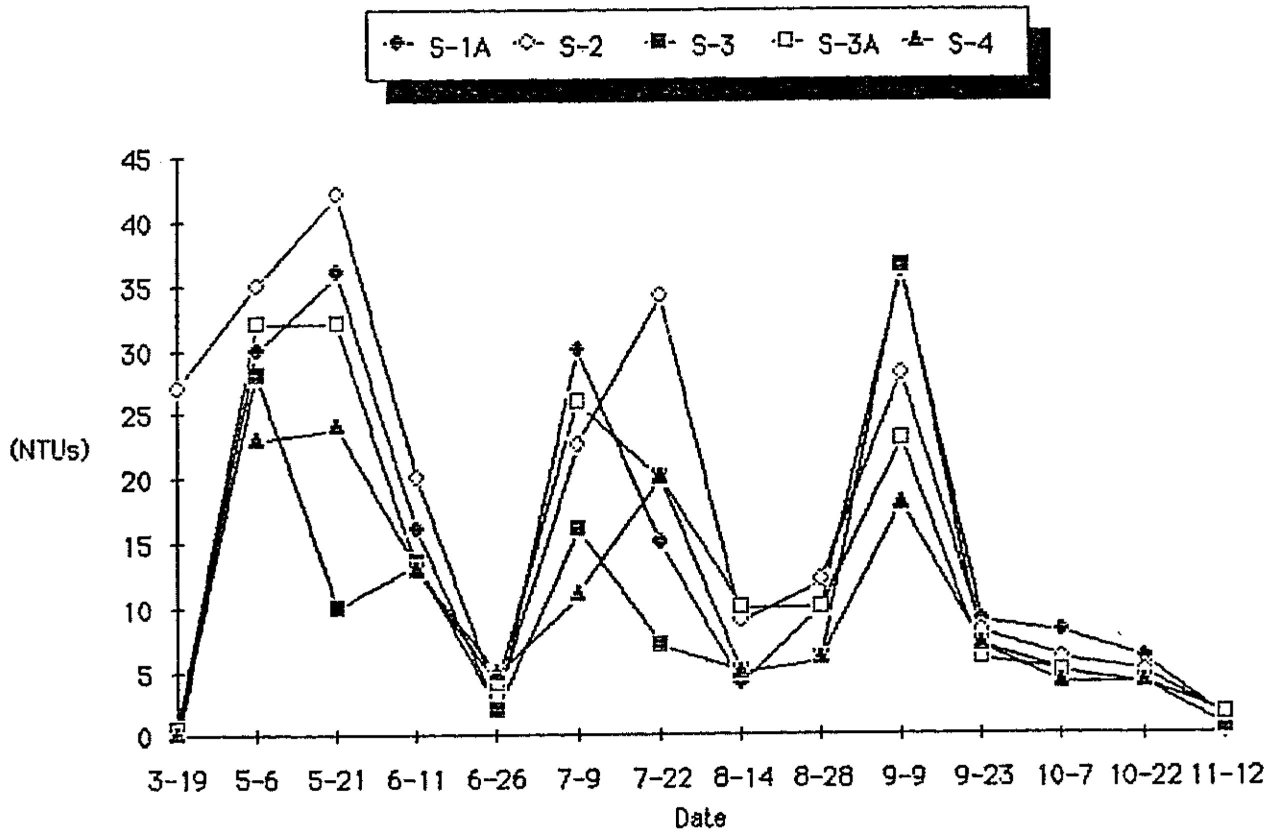

Figure 4. Turbidity (in NTUs) at the Deep Creek monitoring stations, 1986.

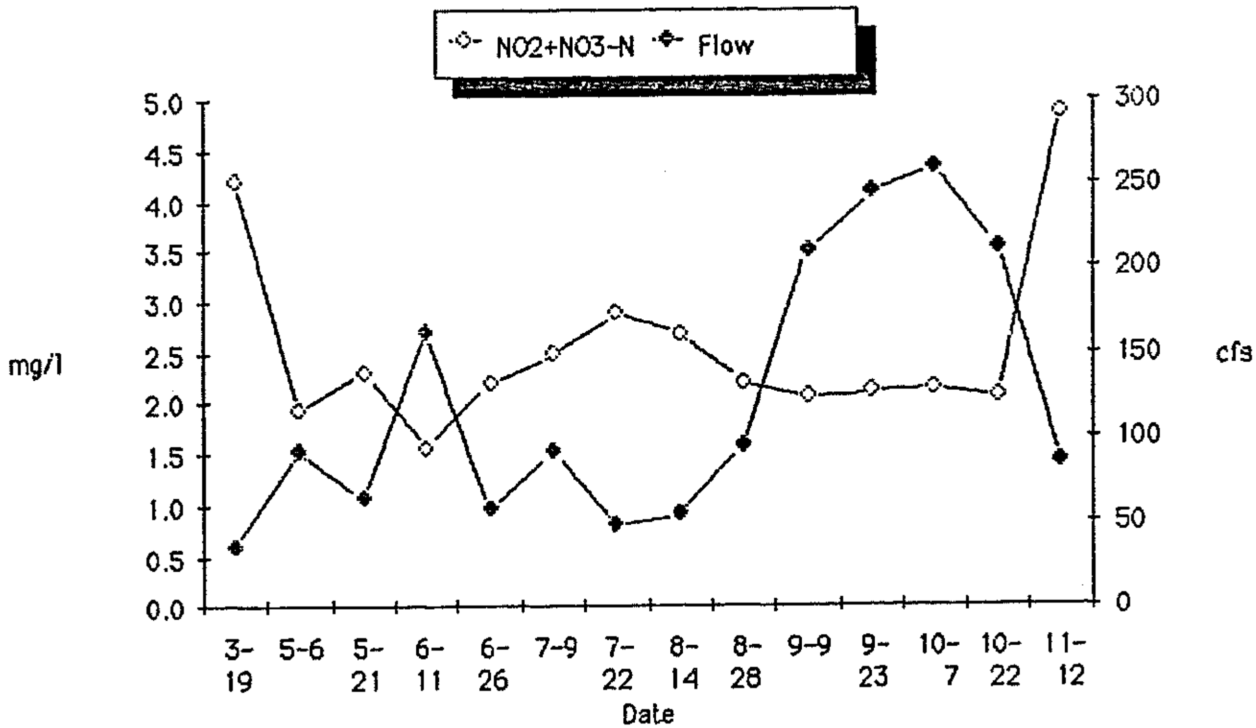

Figure 5. Flow (in cubic feet per second - cfs) and NO2+NO3-N concentrations (in mg/l) at Deep Creek station S-1A during 1986.

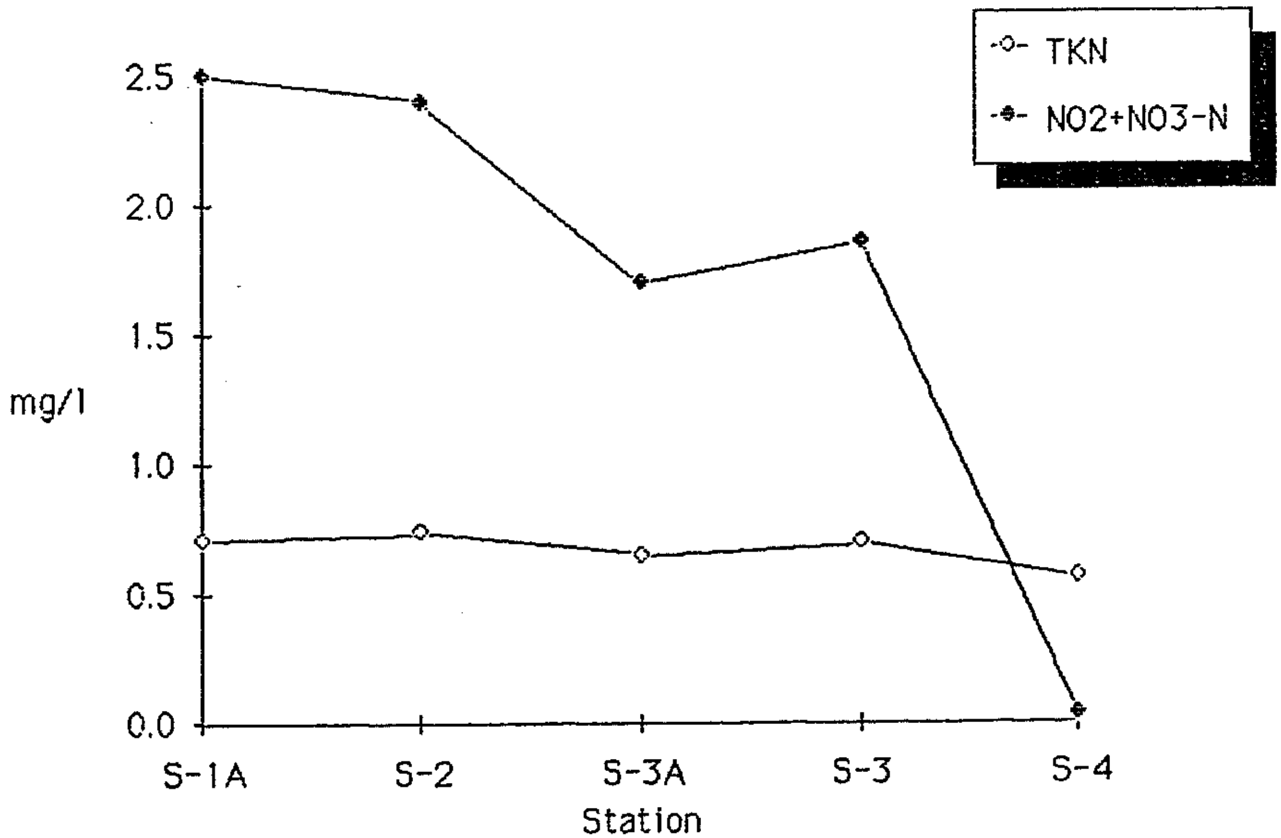

Figure 6. Mean annual NO2+NO3-N and total Kjeldahl nitrogen (TKN) concentrations at the Deep Creek survey stations, 1986.

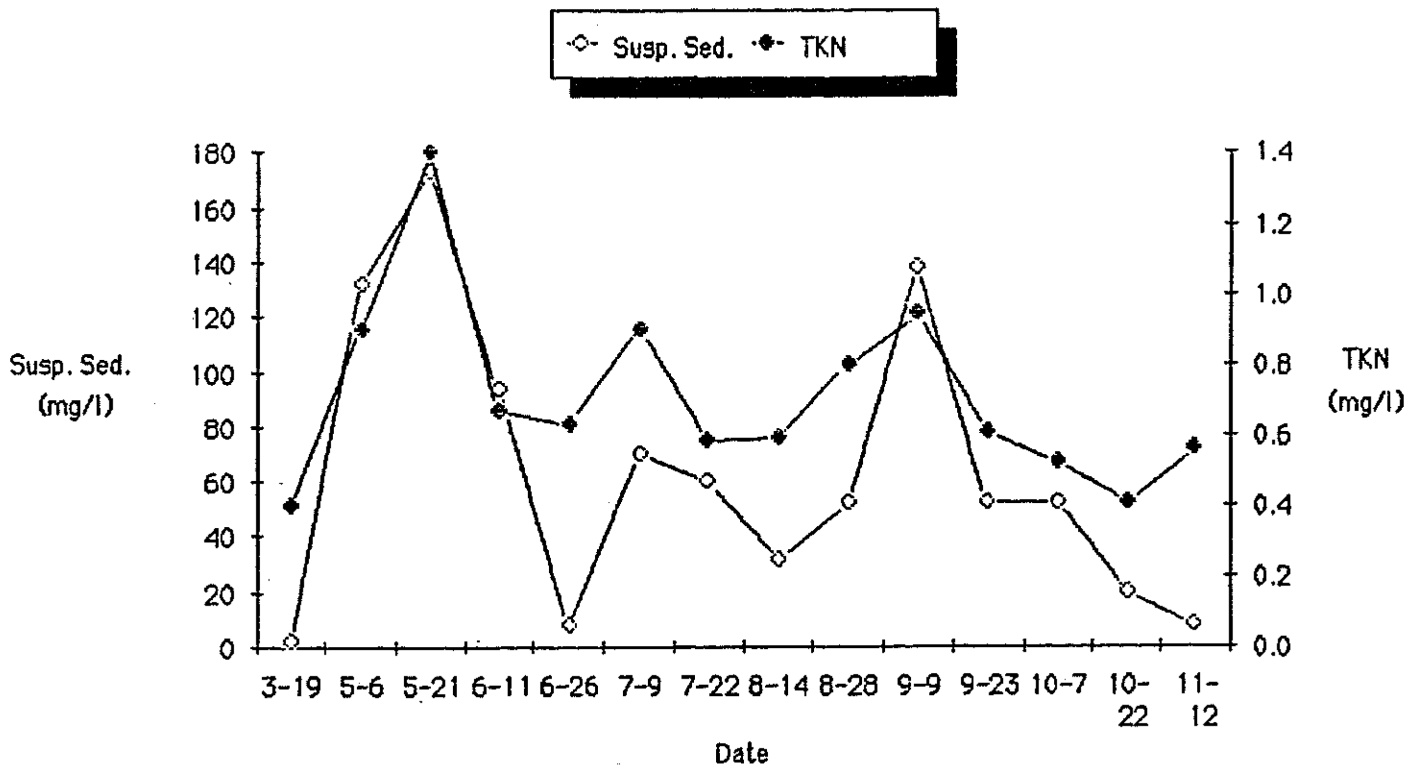

Figure 7. Suspended sediment and total Kjeldahl nitrogen concentrations (in mg/l) at Deep Creek station S-1A during 1986.

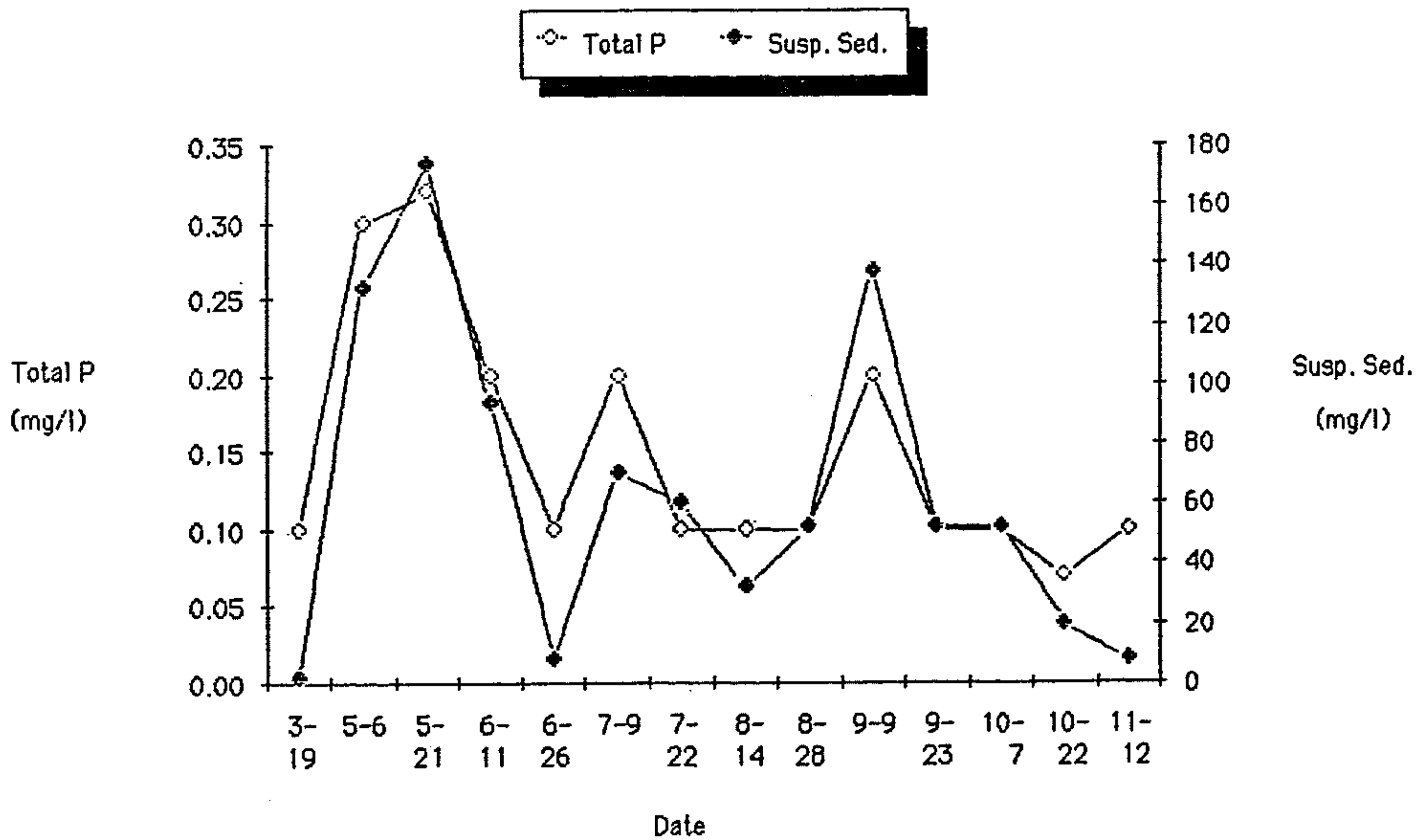

Figure 8. Total phosphorus and suspended sediment concentrations at Deep Creek station S-1A during 1986.

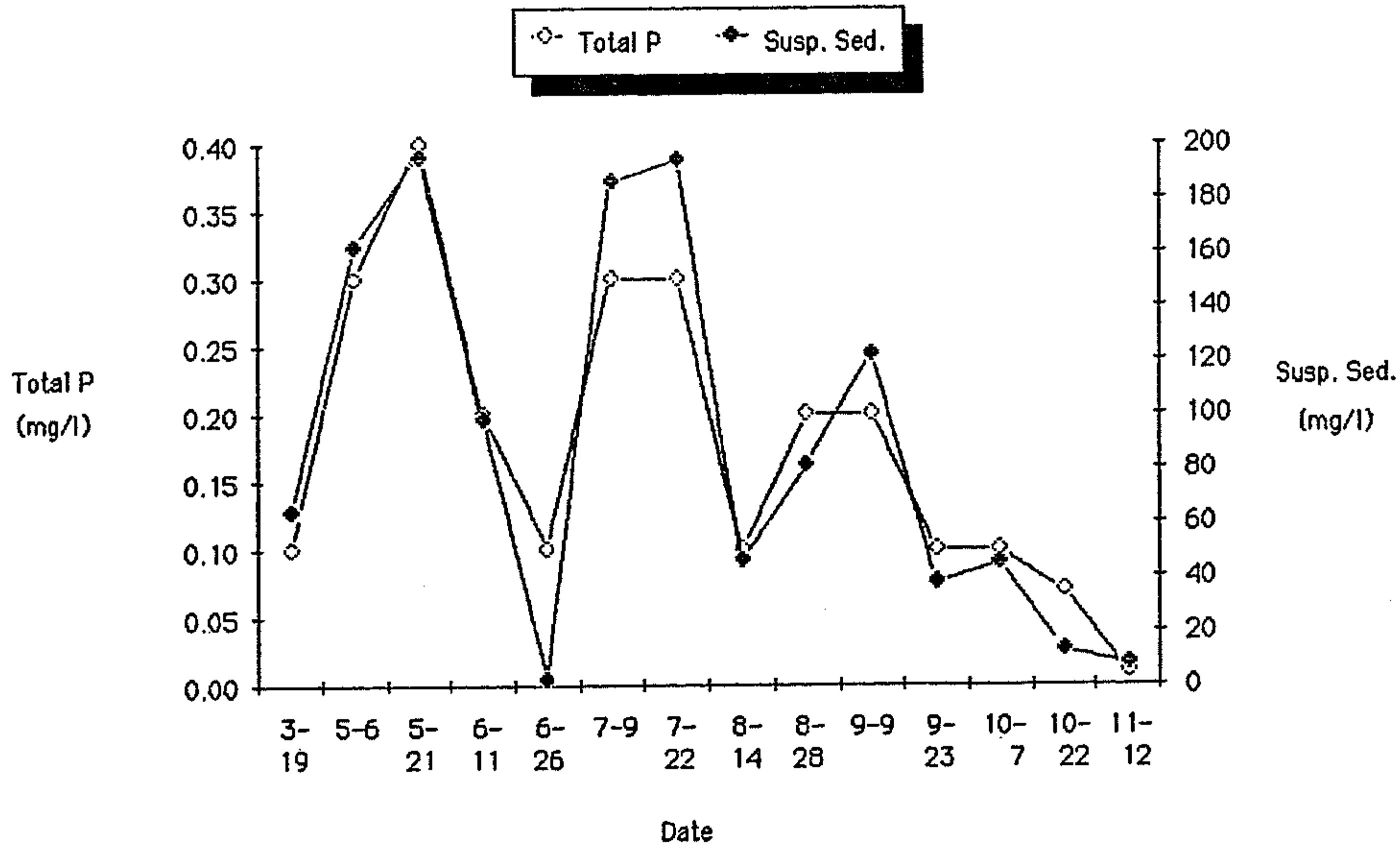

Figure 9. Total phosphorus and suspended sediment concentrations at Deep Creek station S-2 during 1986.

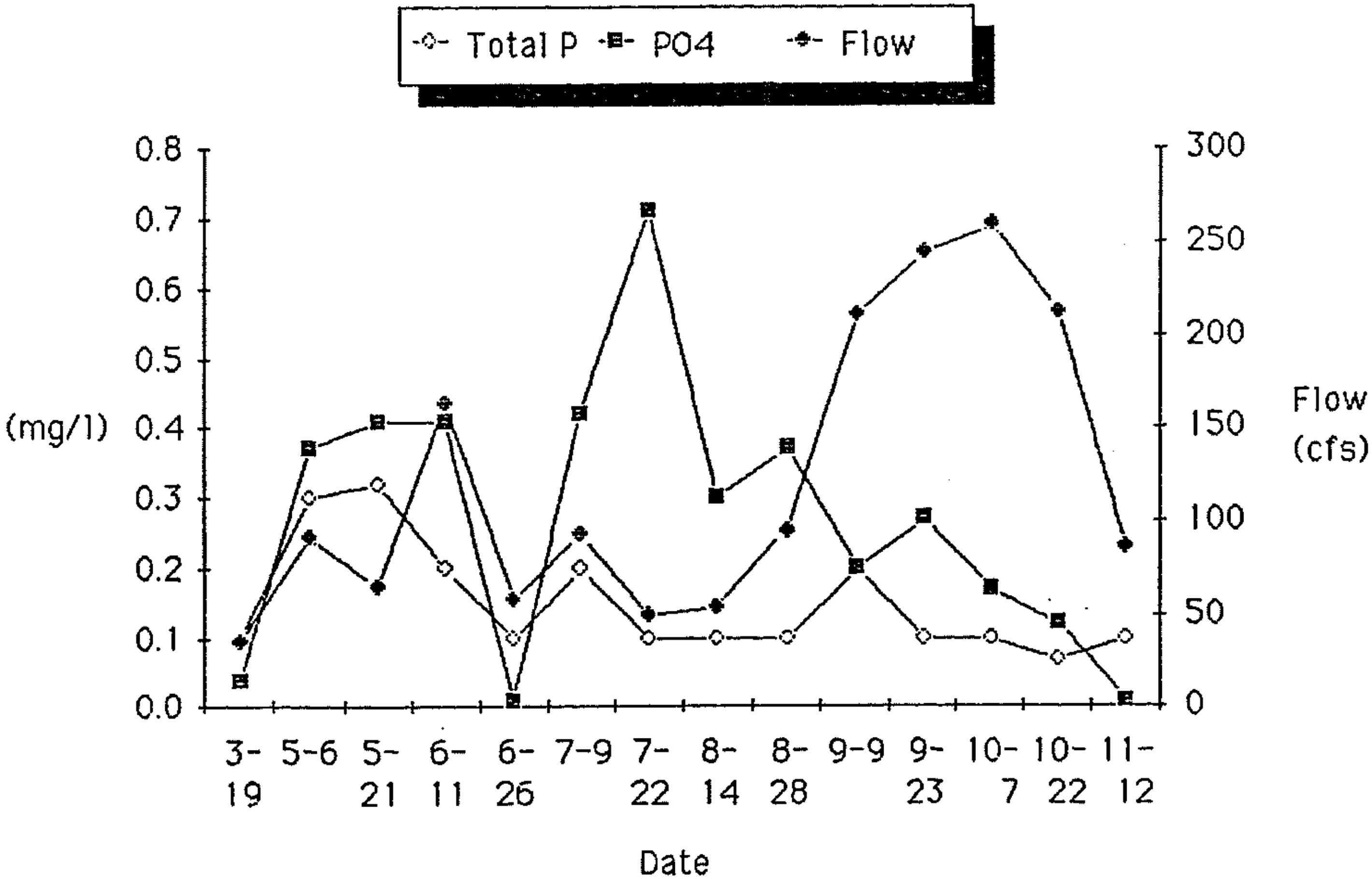

Figure 10. Dissolved orthophosphate (X 10) and total phosphorus concentrations (in mg/l), and flow (in cubic feet per second - cfs), at Deep Creek station S-1A during 1986.

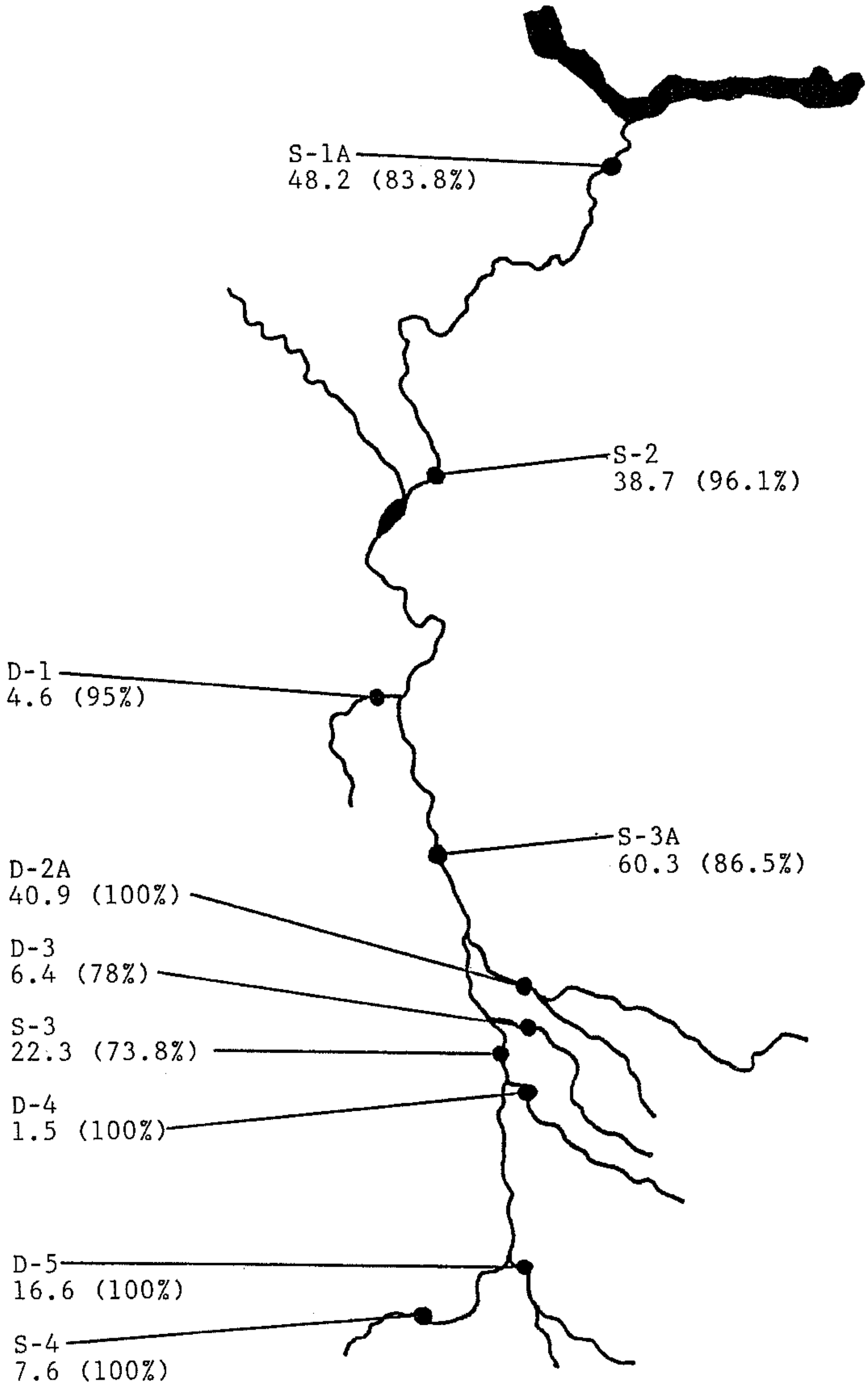

Figure 11. Irrigation season total Kjeldahl nitrogen loadings for the Deep Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

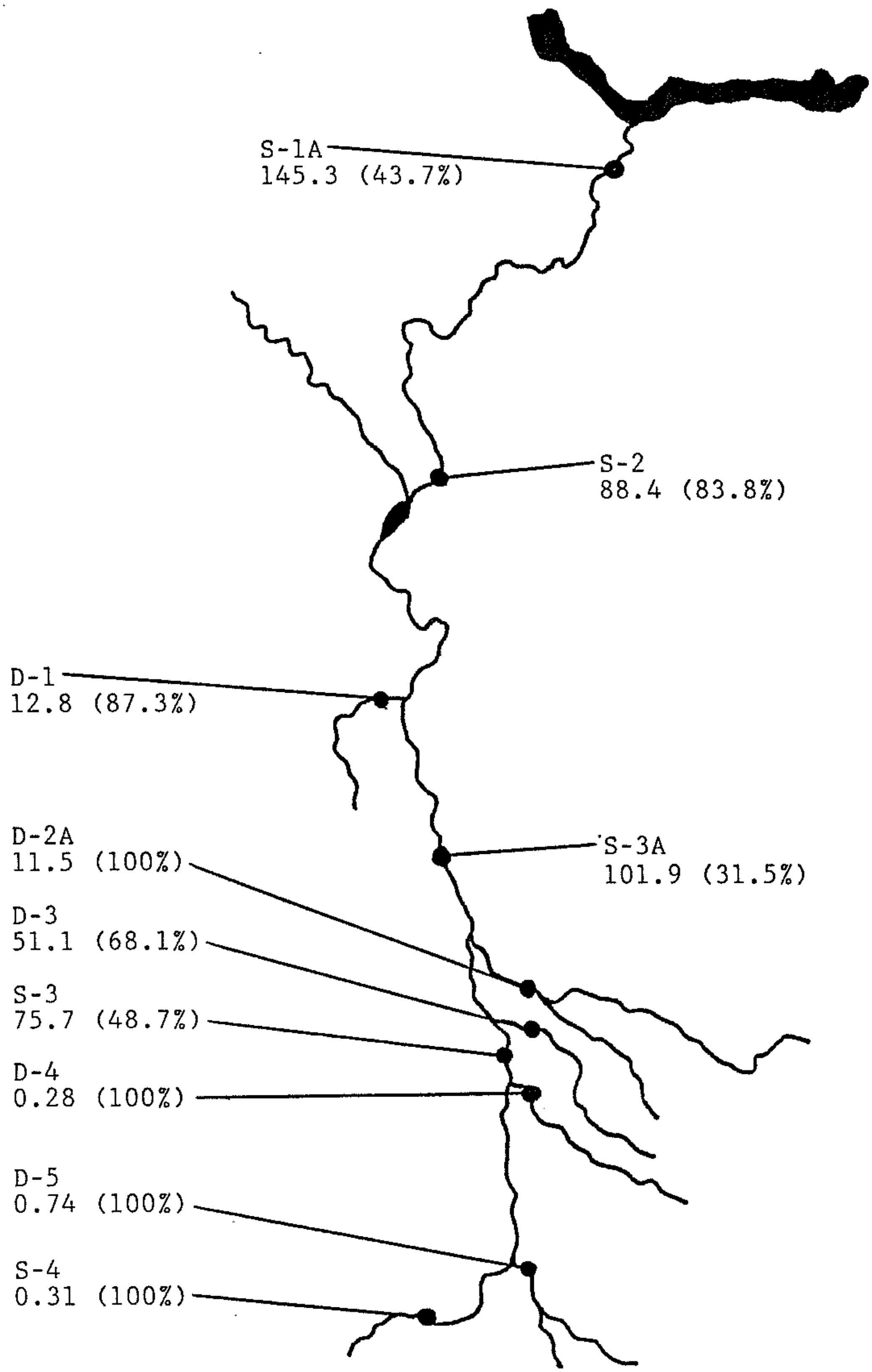

Figure 12. Irrigation season NO_2+NO_3-N loadings for the Deep Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

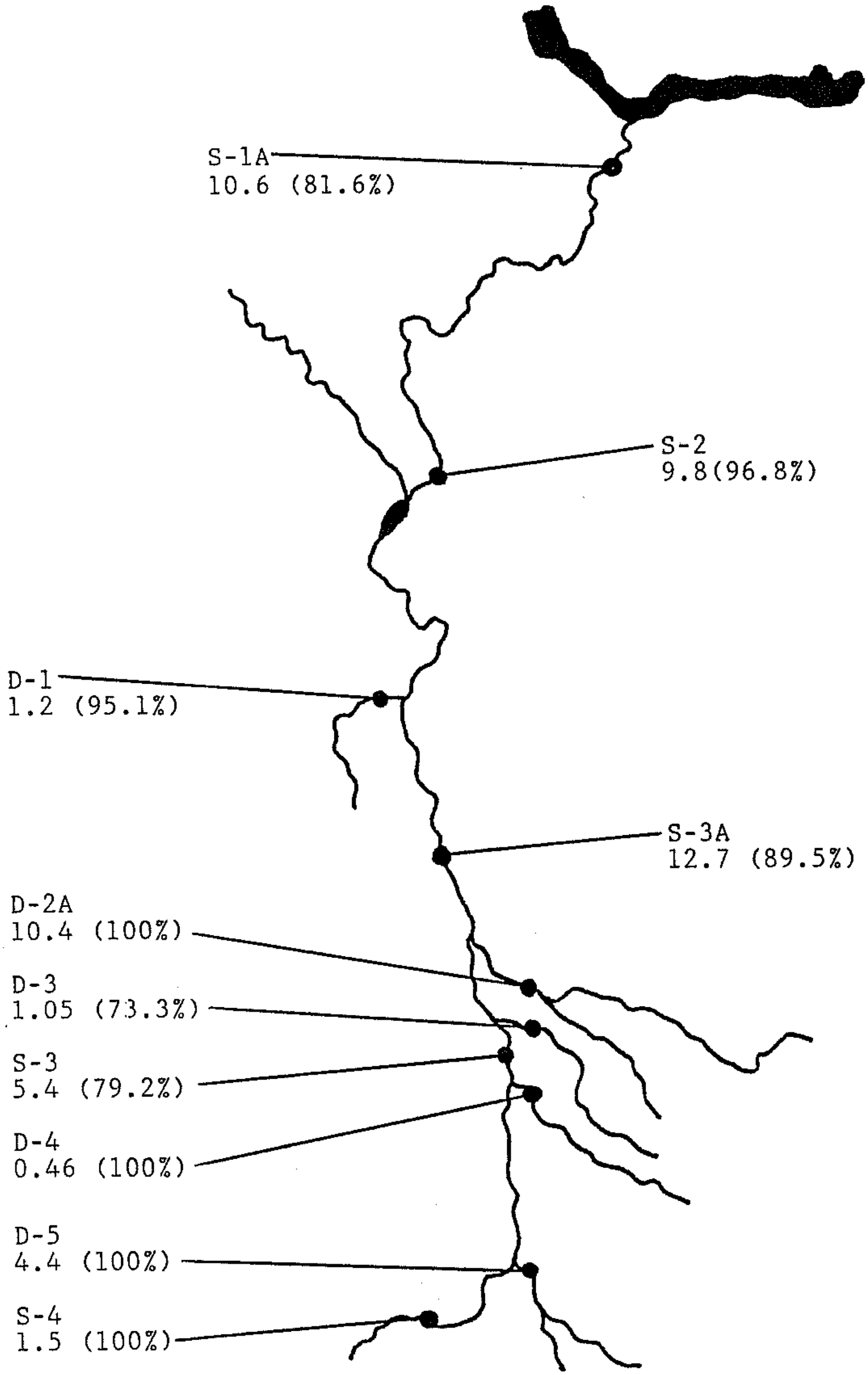

Figure 13. Irrigation season total phosphorus loadings for the Deep Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

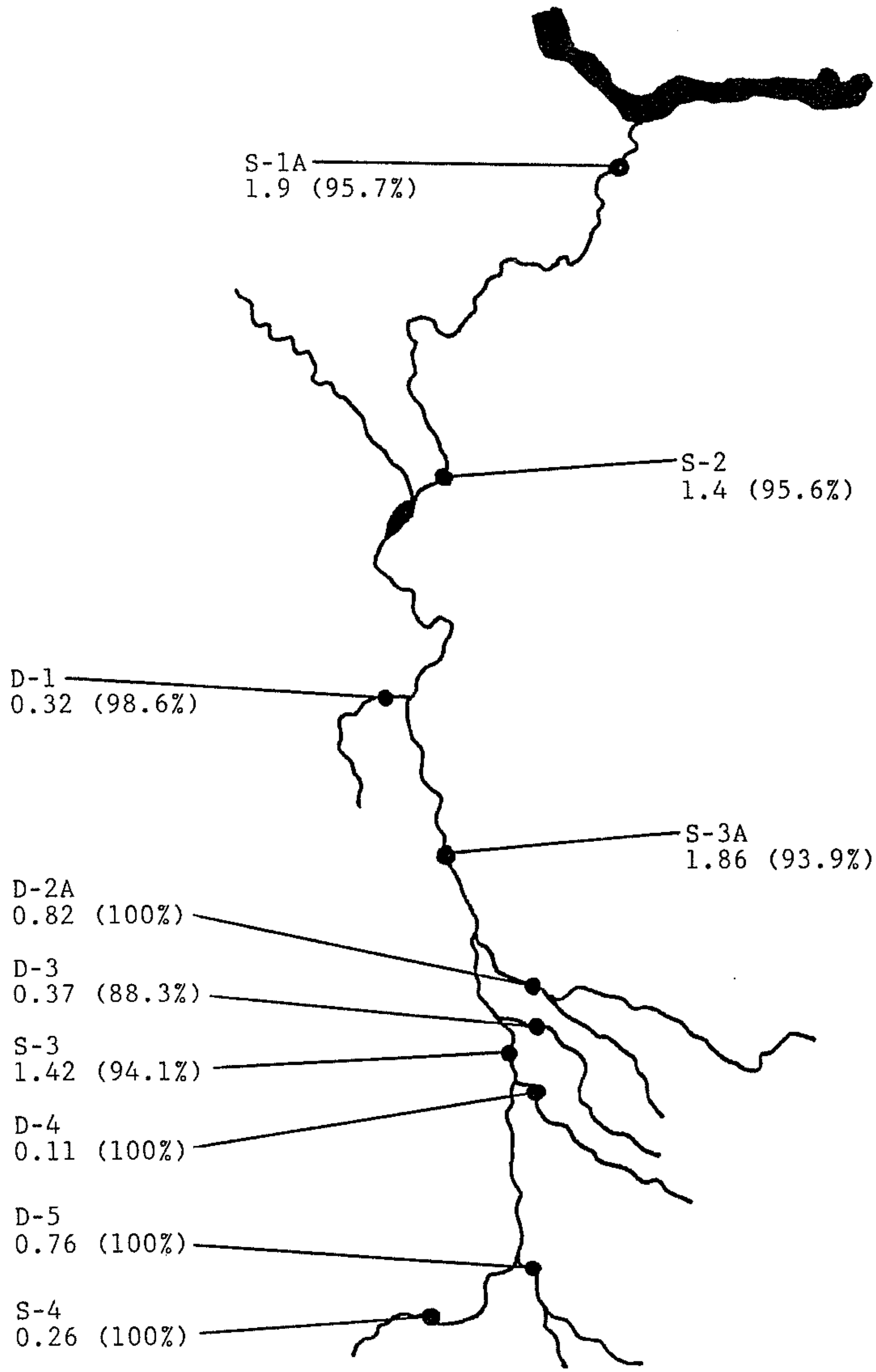

Figure 14. Irrigation season dissolved orthophosphate loadings for the Deep Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

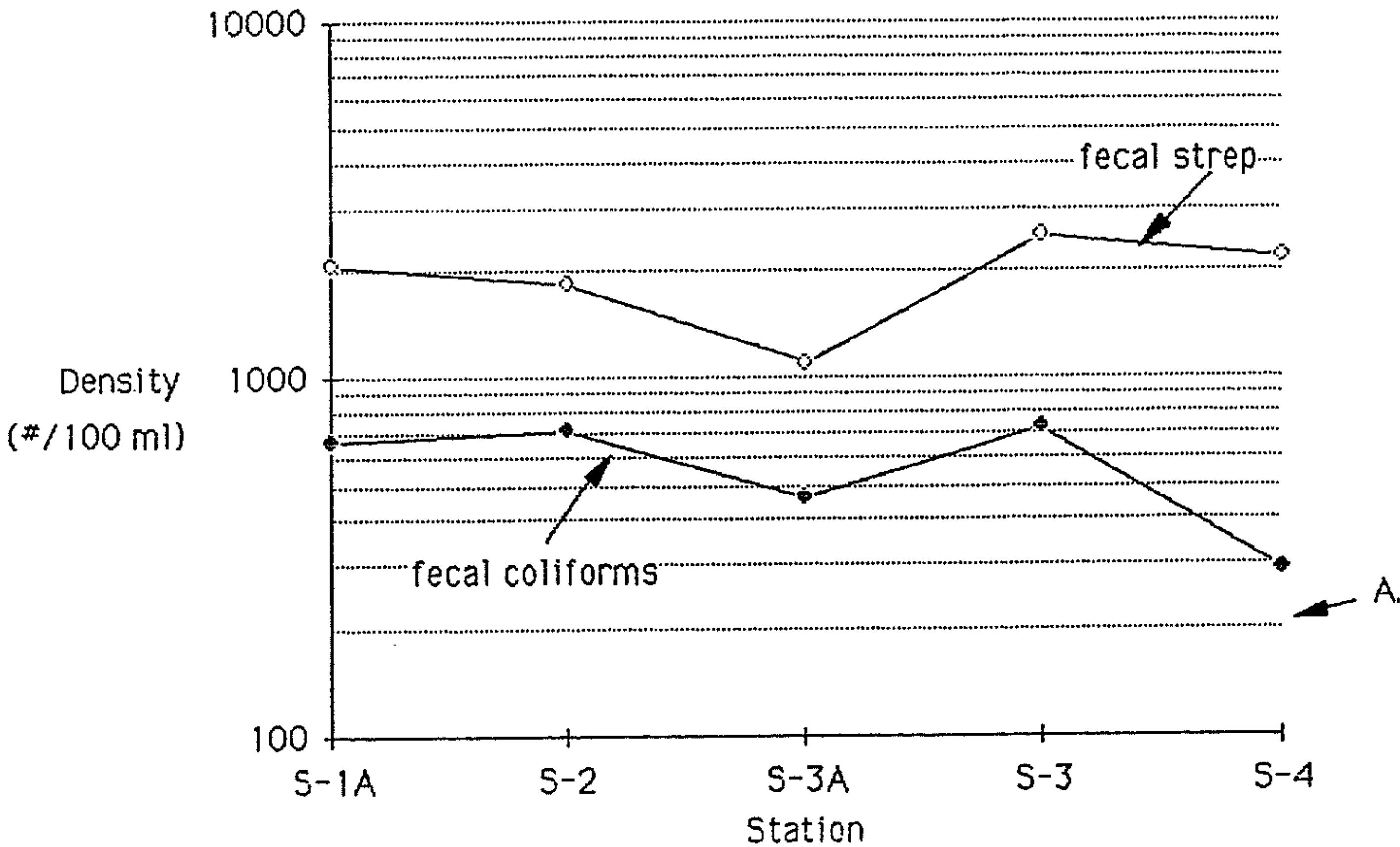

Figure 15. Annual geometric mean densities of fecal coliform and fecal streptococcus bacteria at the Deep Creek stream stations, 1986. A - secondary contact recreation standard.

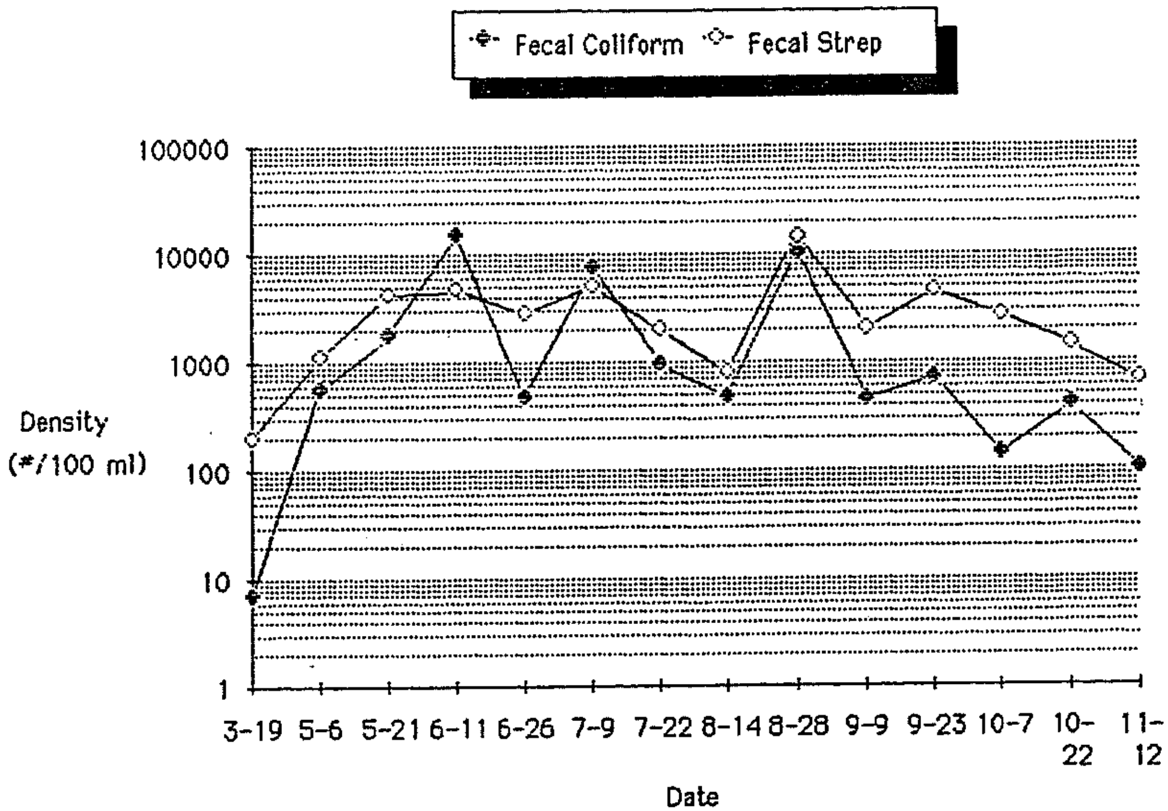

Figure 16. Bacteria densities in Deep Creek at station S-1A, 1986.

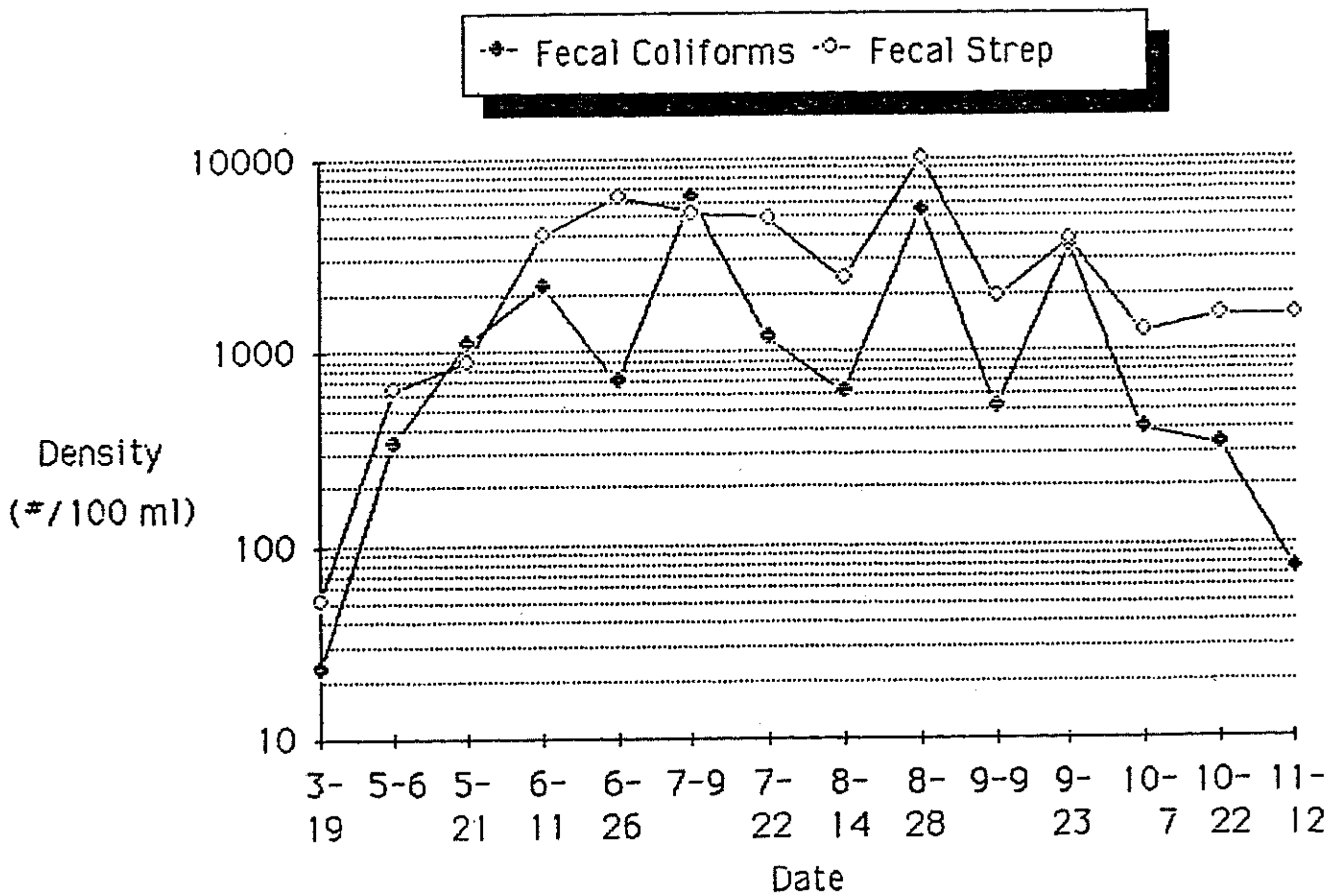

Figure 17. Bacteria densities in Deep Creek at station S-2, 1986.

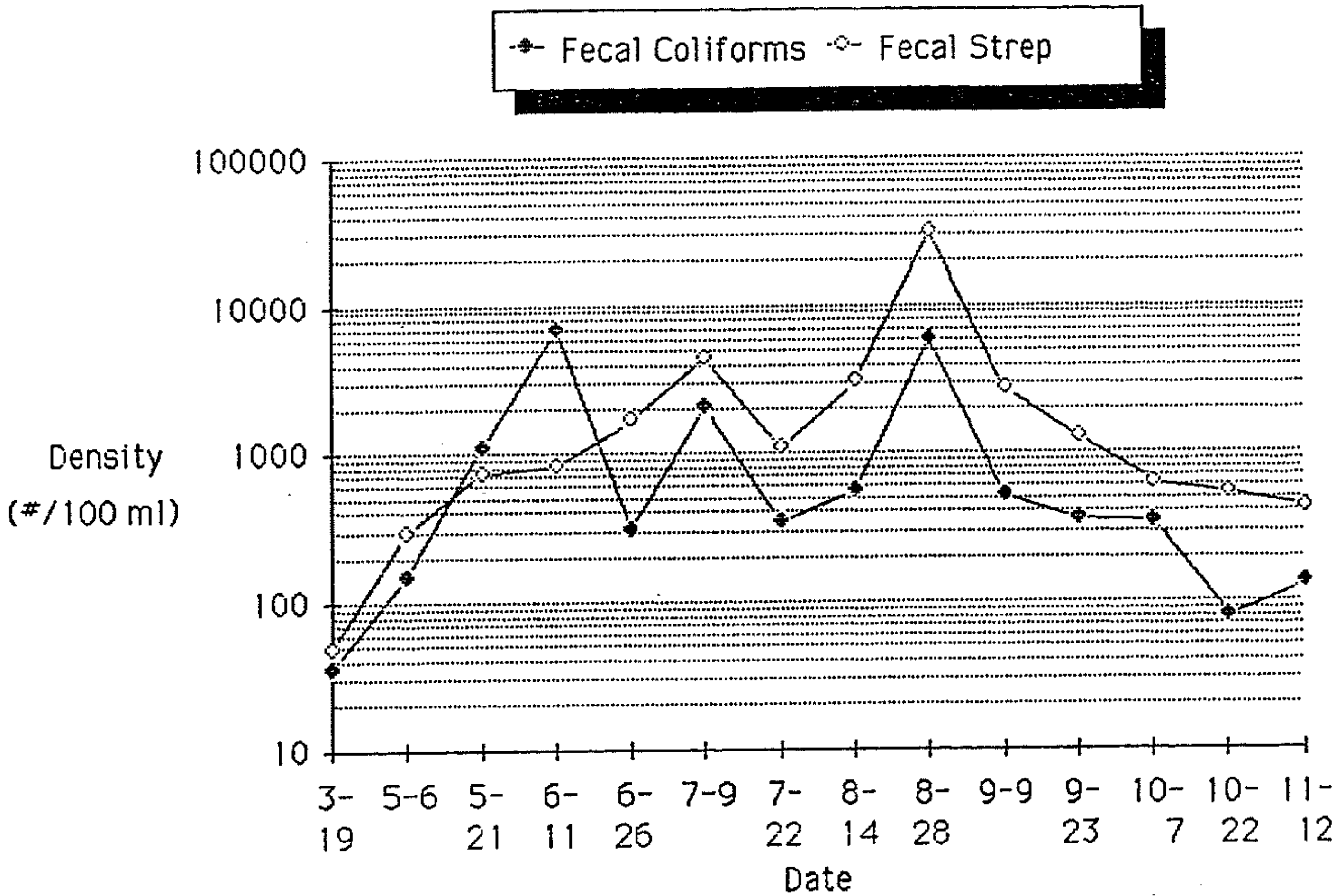

Figure 18. Bacteria densities in Deep Creek at station S-3A, 1986.

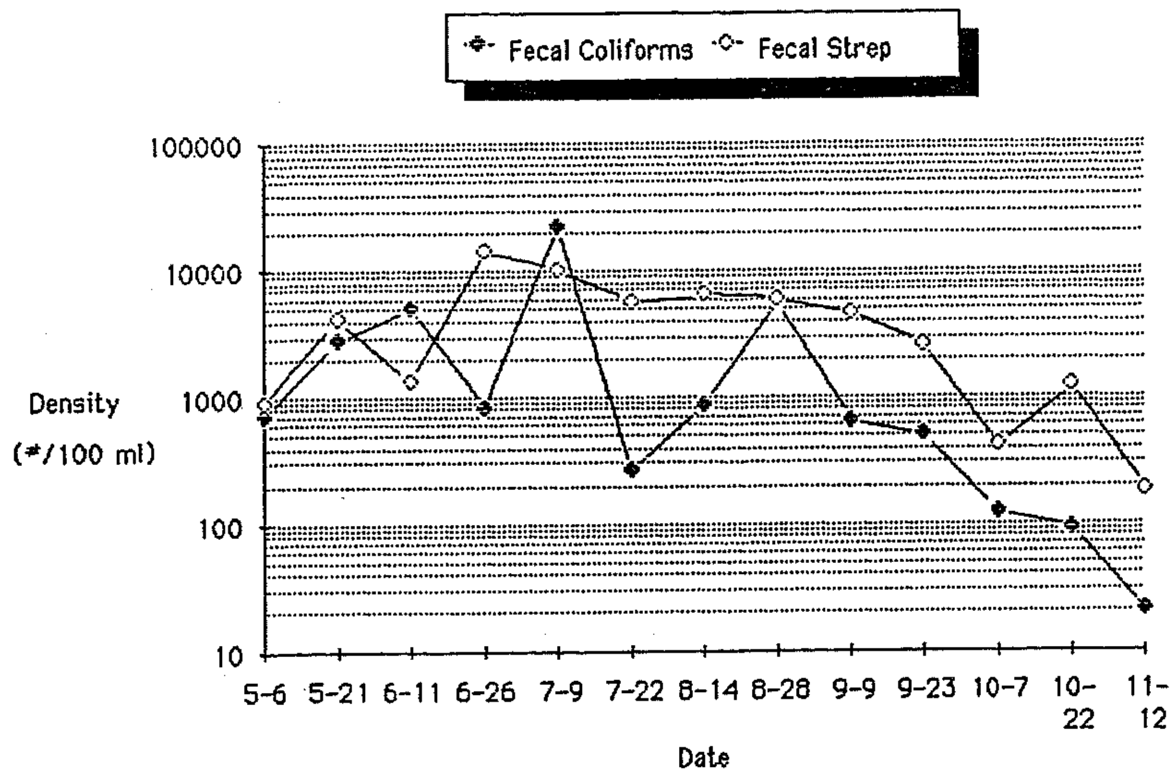

Figure 19. Bacteria densities in Deep Creek at station S-3, 1986.

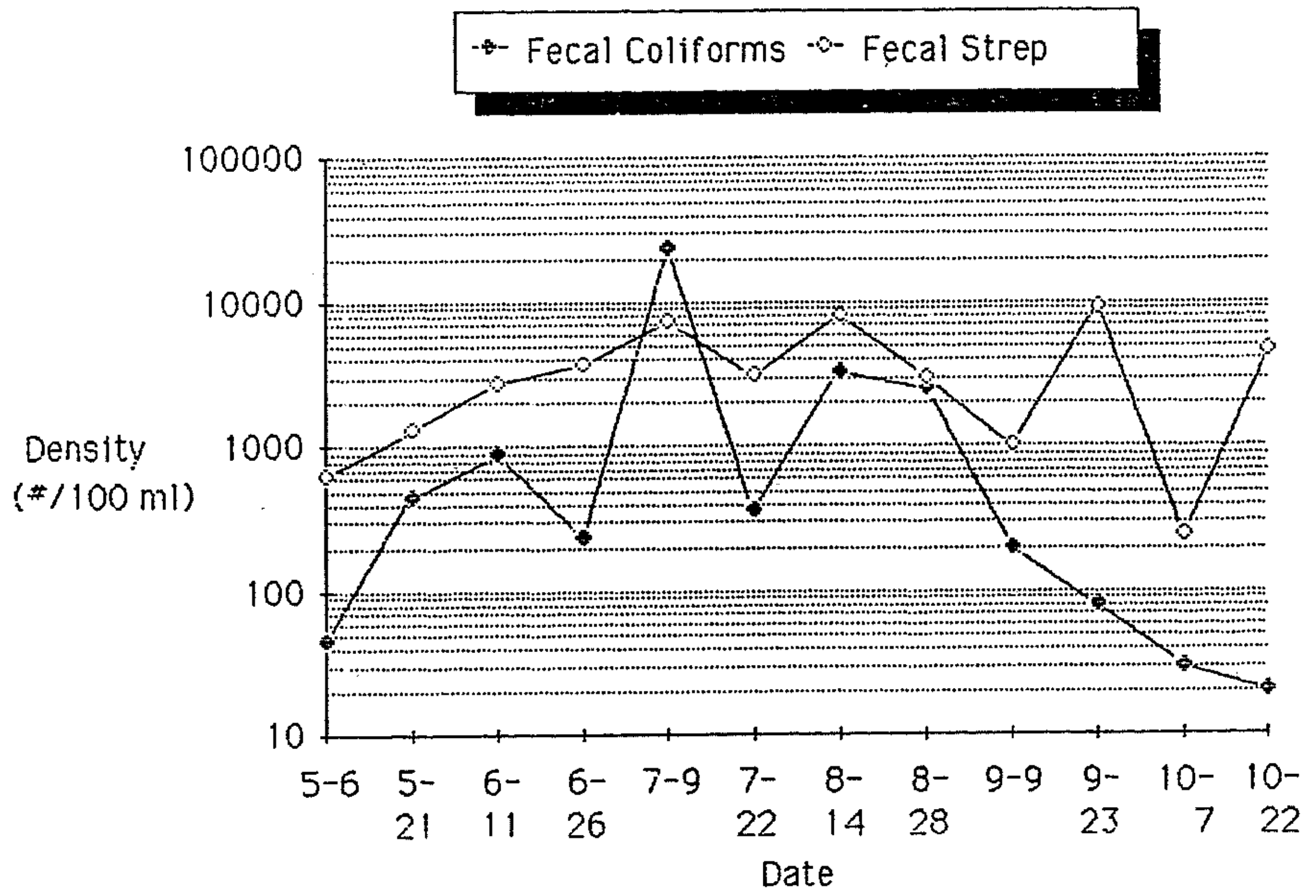

Figure 20. Bacteria densities in Deep Creek at station S-4, 1986.

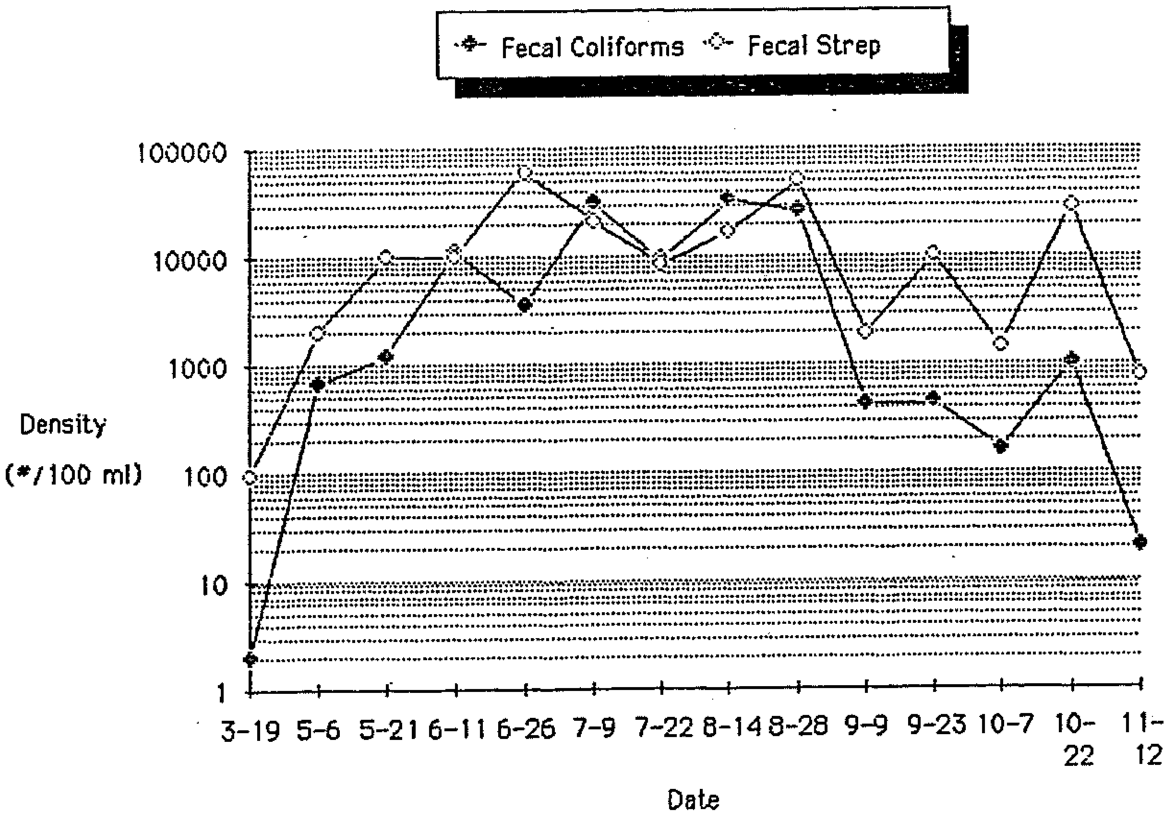

Figure 21. Density of bacteria at drain station D-1 during 1986.

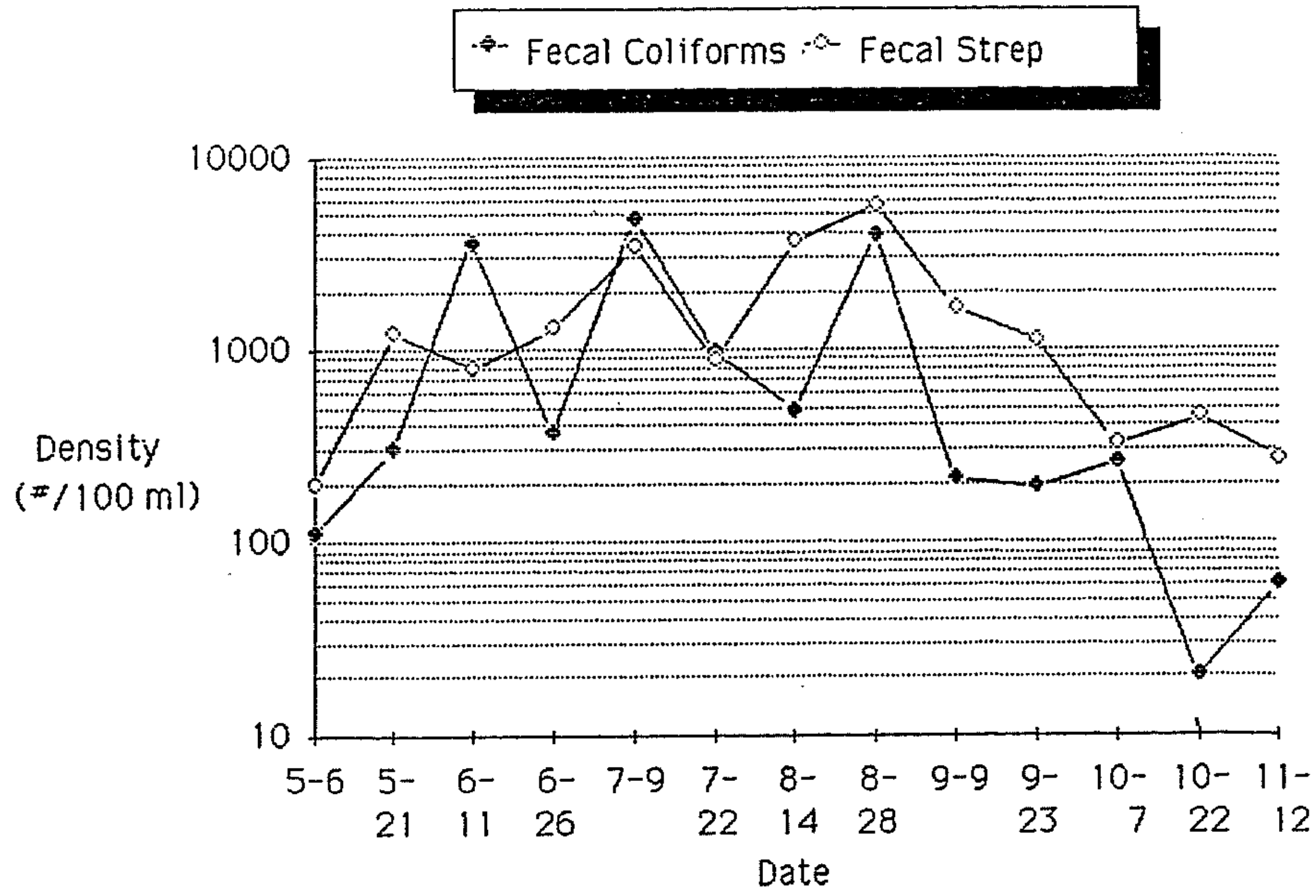

Figure 22. Bacteria densities at drain station D-2A during 1986.

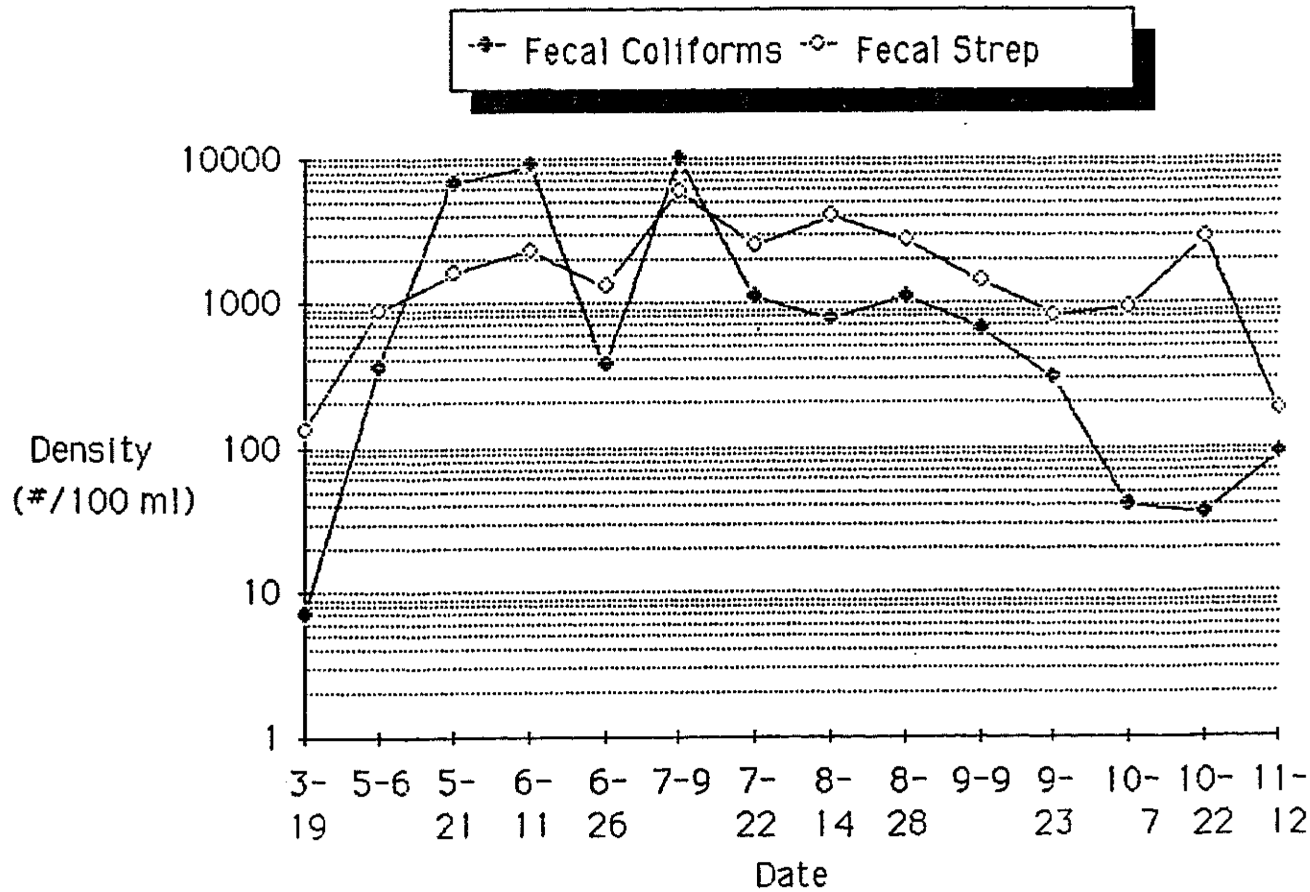

Figure 23. Bacteria densities at drain station D-3 during 1986.

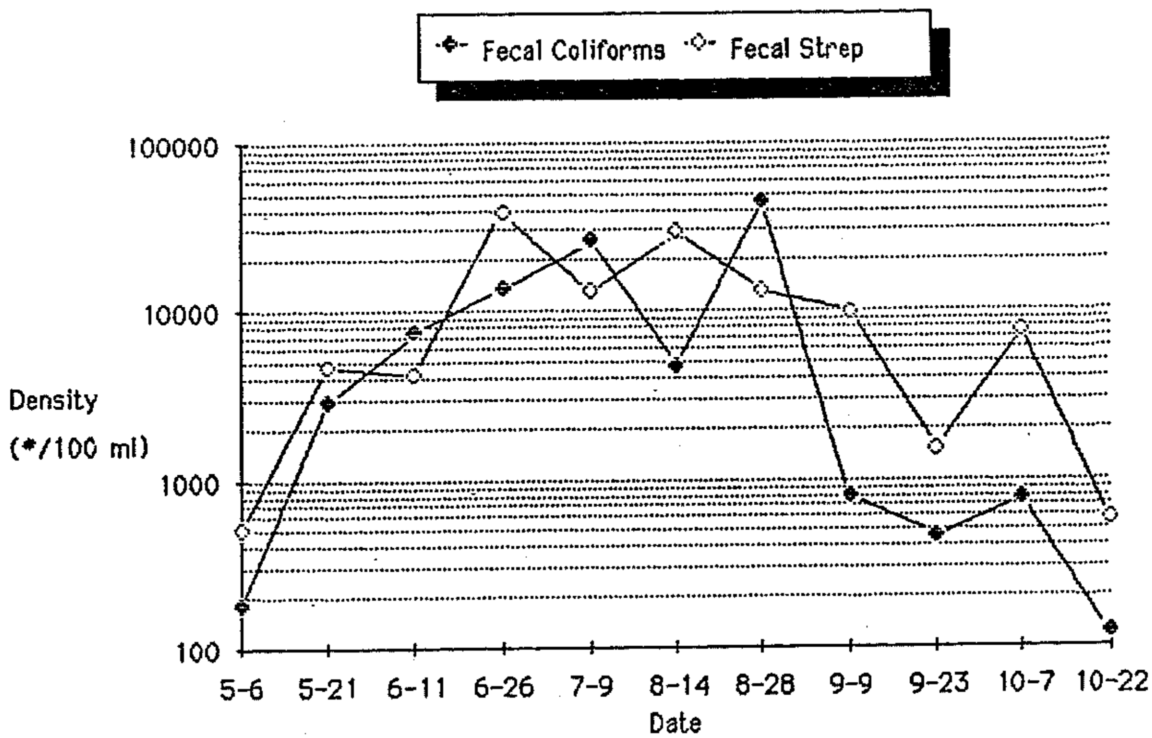

Figure 24. Bacteria densities at drain station D-4 during 1986.

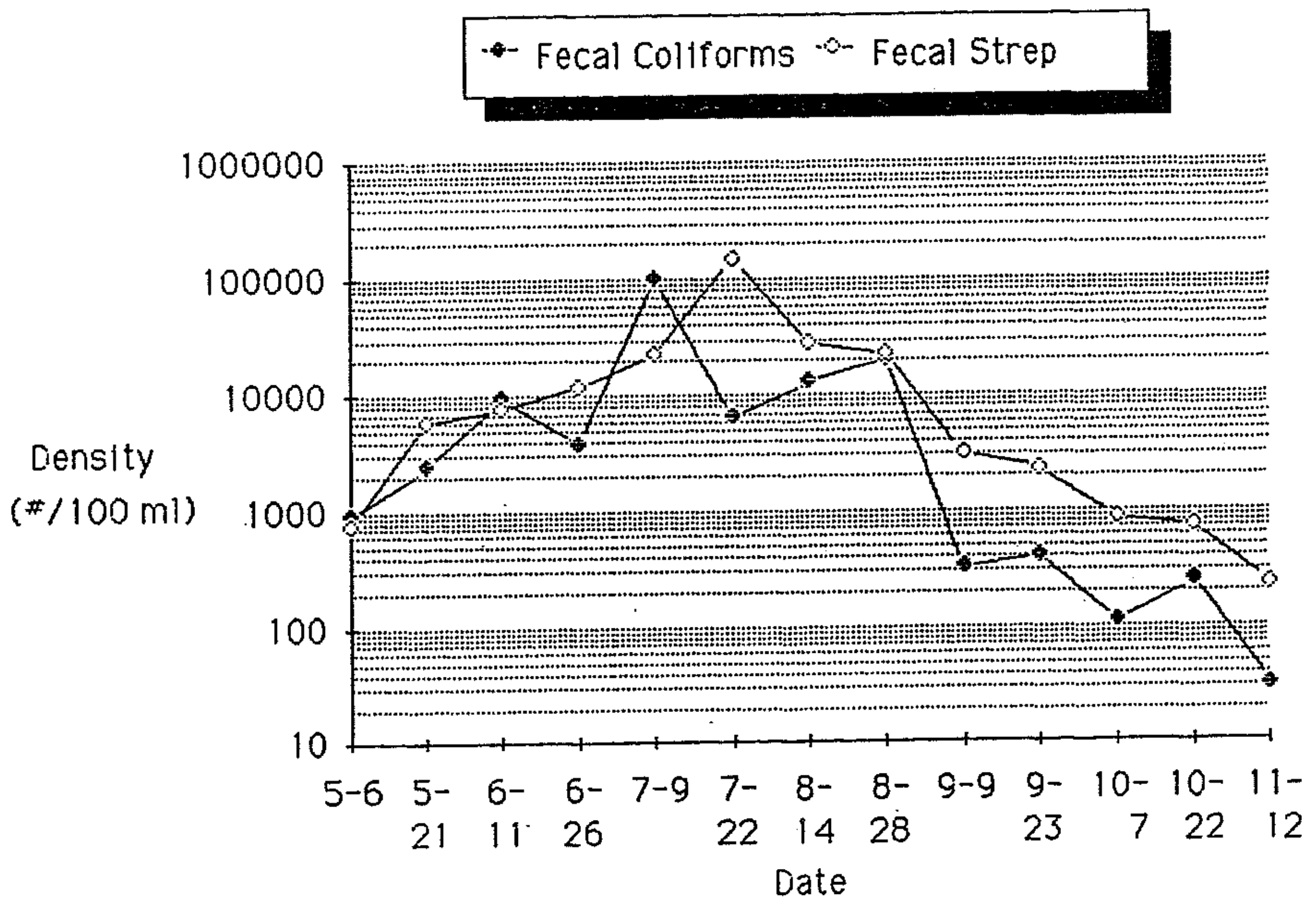

Figure 25. Bacteria densities at drain station D-5 during 1986.

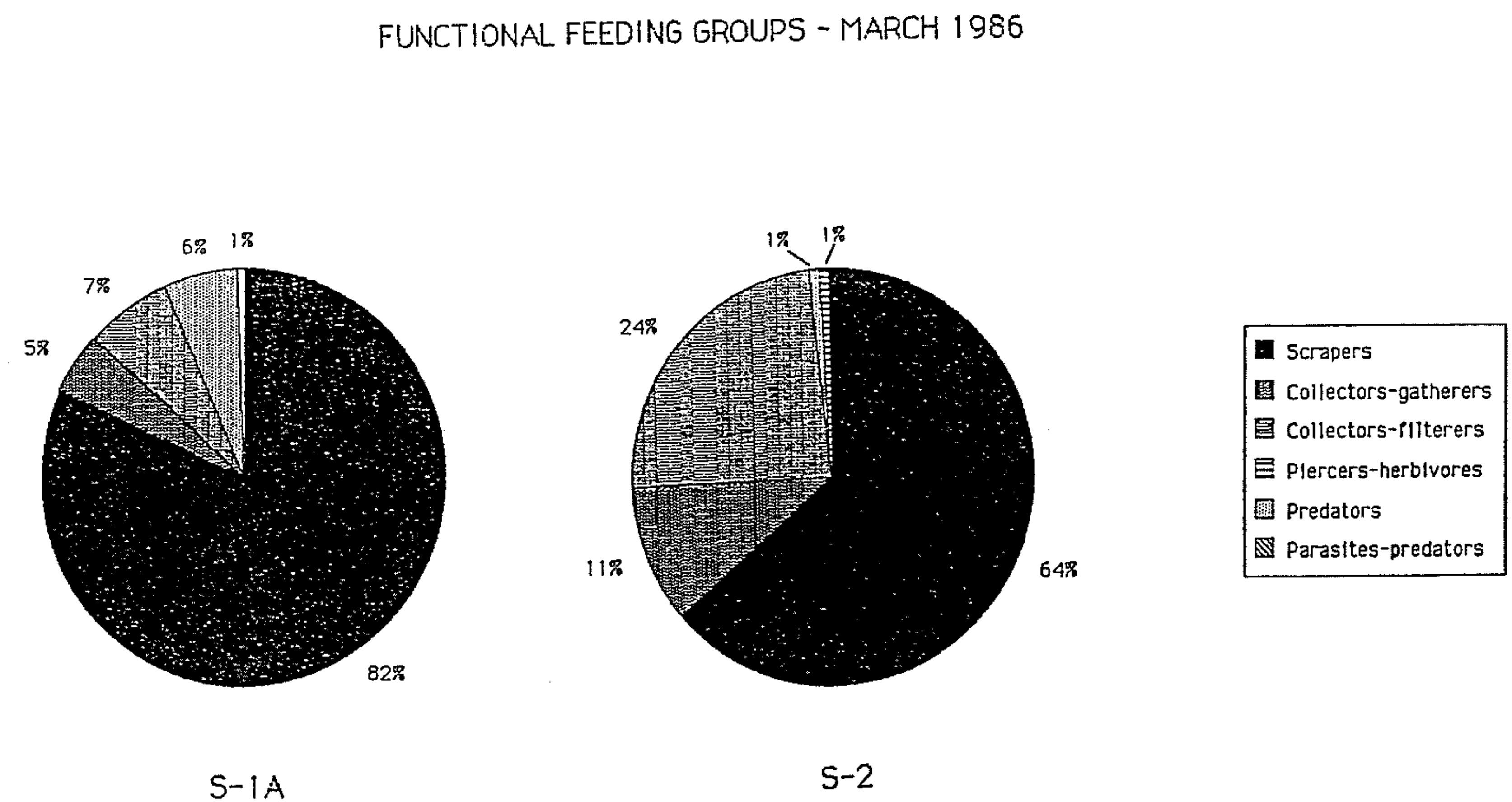

Figure 26. Functional feeding groups of macroinvertebrates collected (% occurrence by numbers of individuals) at the Deep Creek stations indicated, March 21, 1986.

FUNCTIONAL FEEDING GROUPS - MARCH 1986

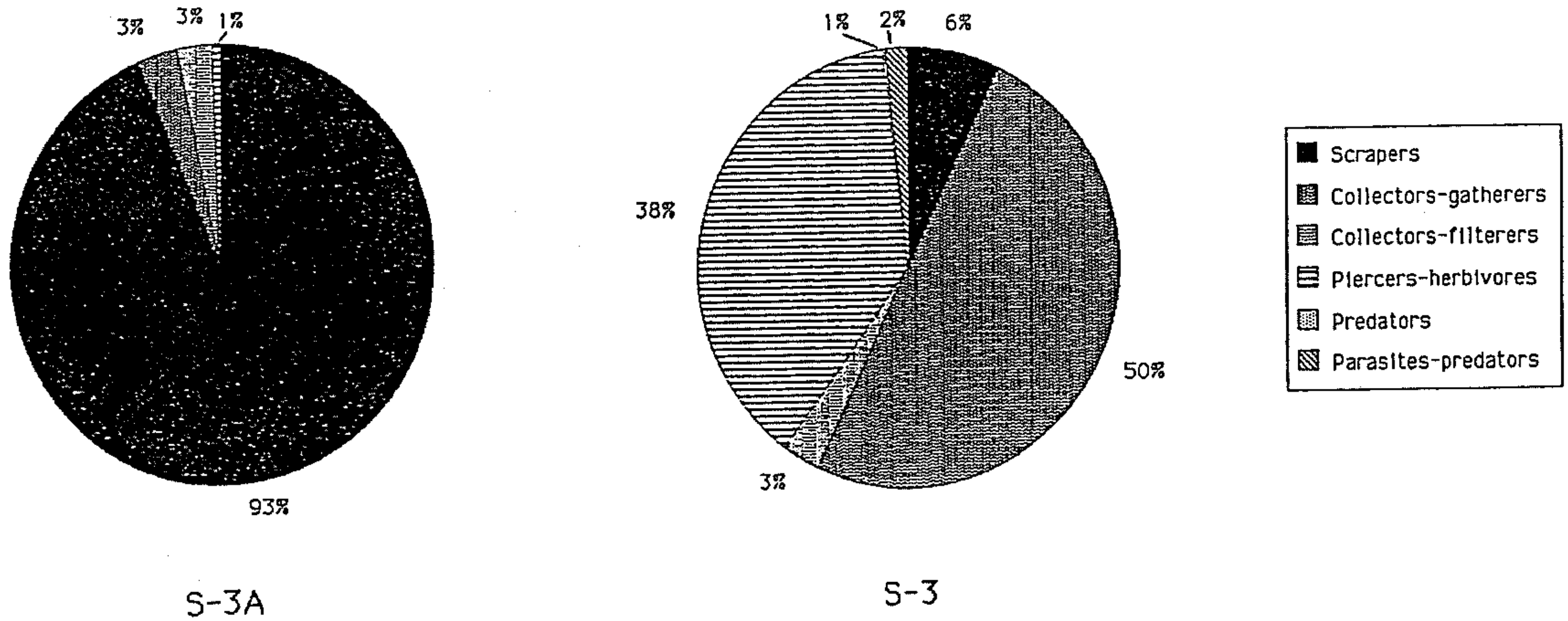

Figure 26. Continued.

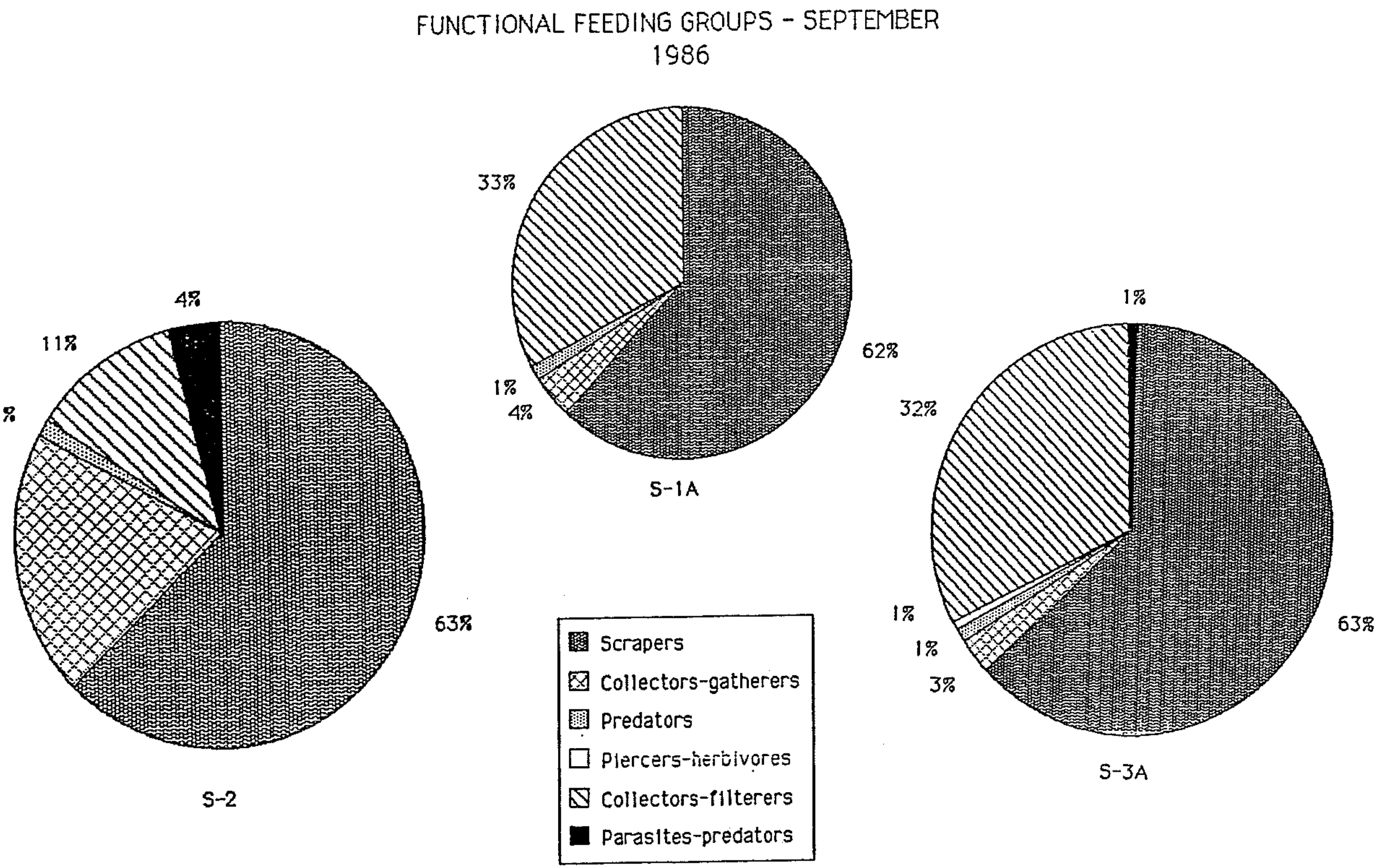

Figure 27. Functional feeding groups of macroinvertebrates collected (% occurrence by numbers of individuals) at the Deep Creek stations indicated, September 5, 1986.

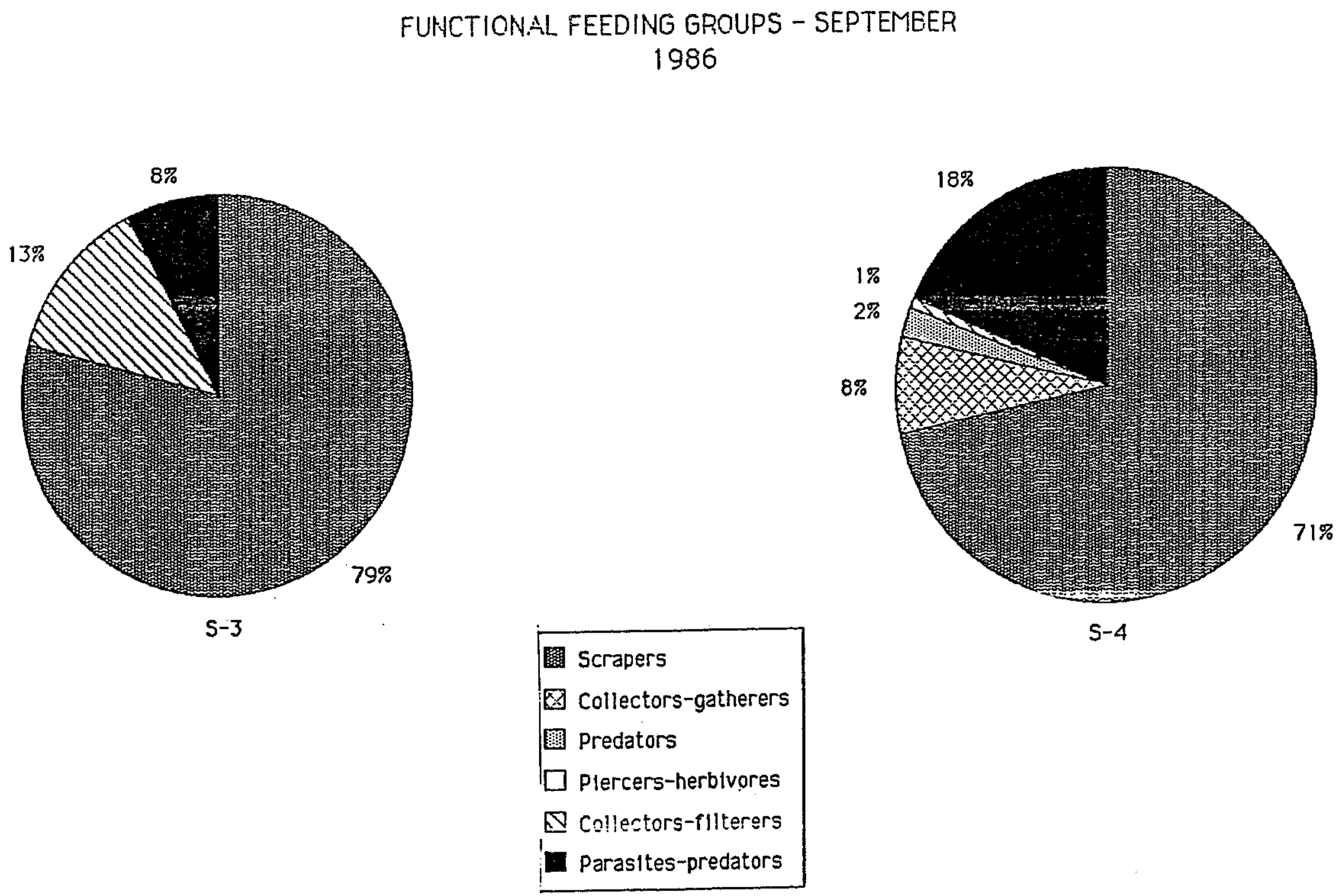

Figure 27. Continued.

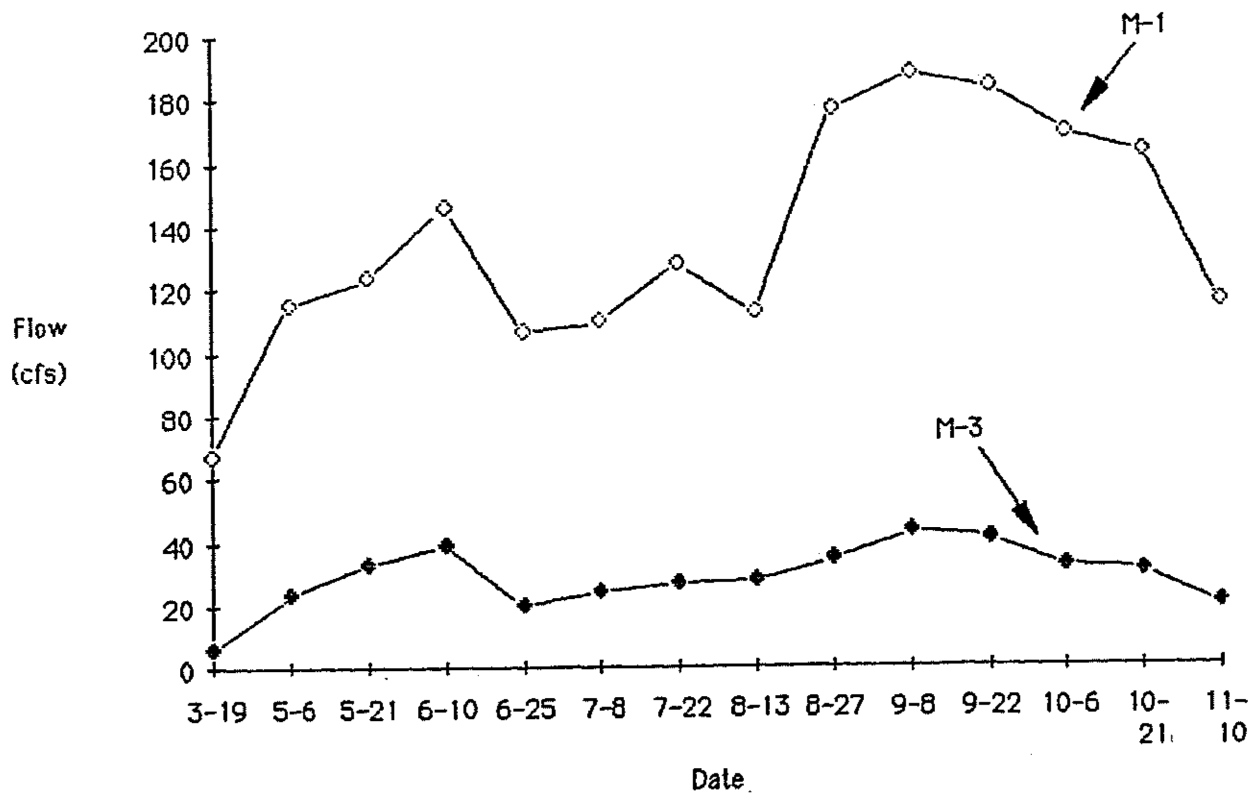

Figure 28. Flow (in cubic feet per second - cfs) at Mud Creek stations M-1 and M-3 on the dates indicated, 1986.

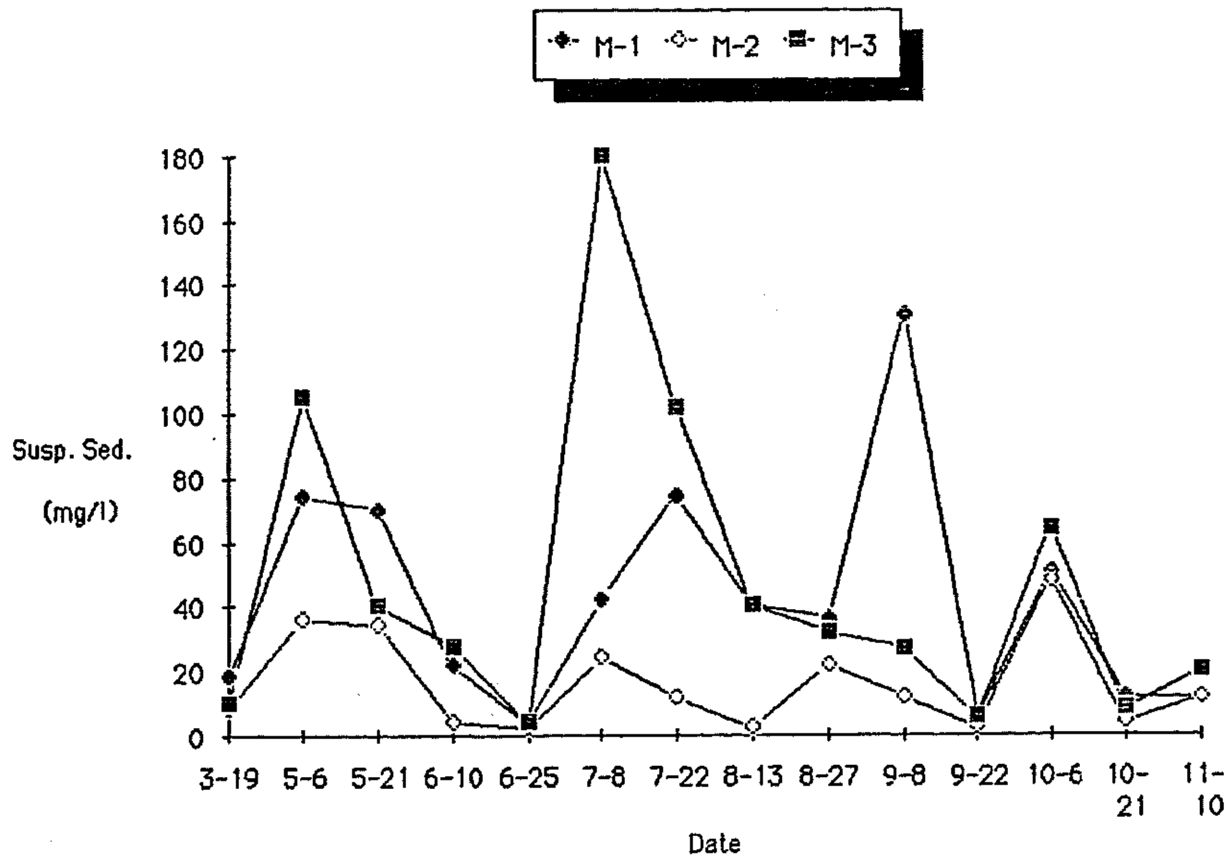

Figure 29. Suspended sediment concentrations (in mg/l) at the Mud Creek stream stations on the dates indicated, 1986.

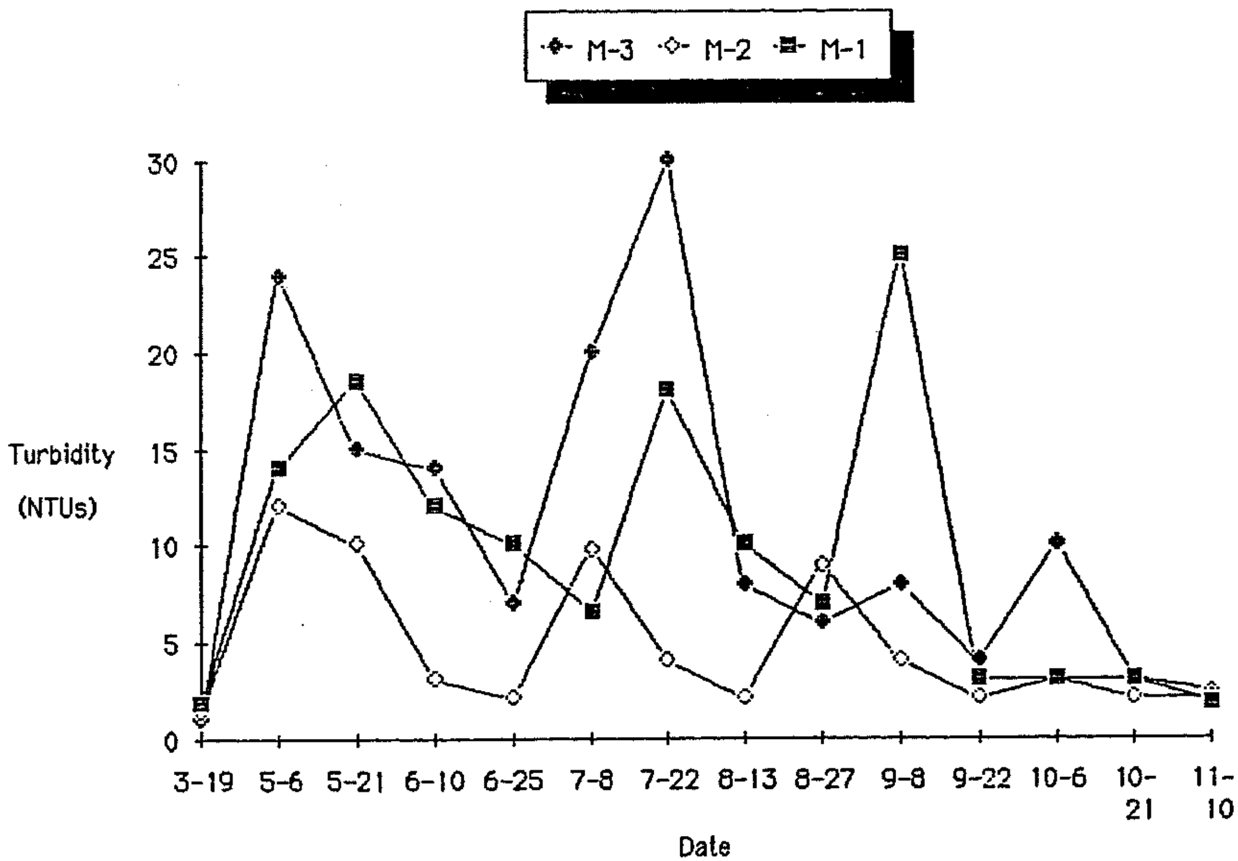

Figure 30. Turbidity levels (in NTUs) at the Mud Creek stations on the dates indicated, 1986.

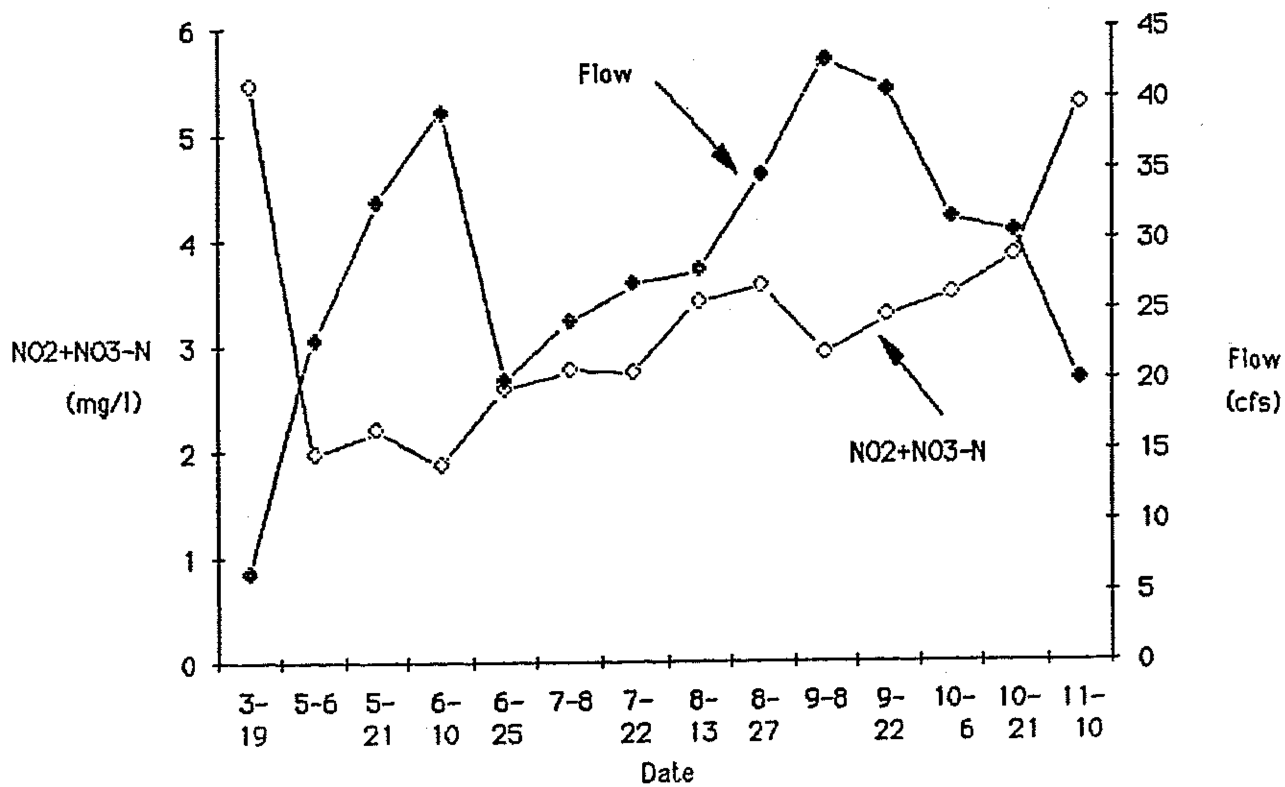

Figure 31. Flow (in cubic feet per second - cfs) and NO2+NO3-N concentrations (in mg/l) at Mud Creek station M-3 during 1986.

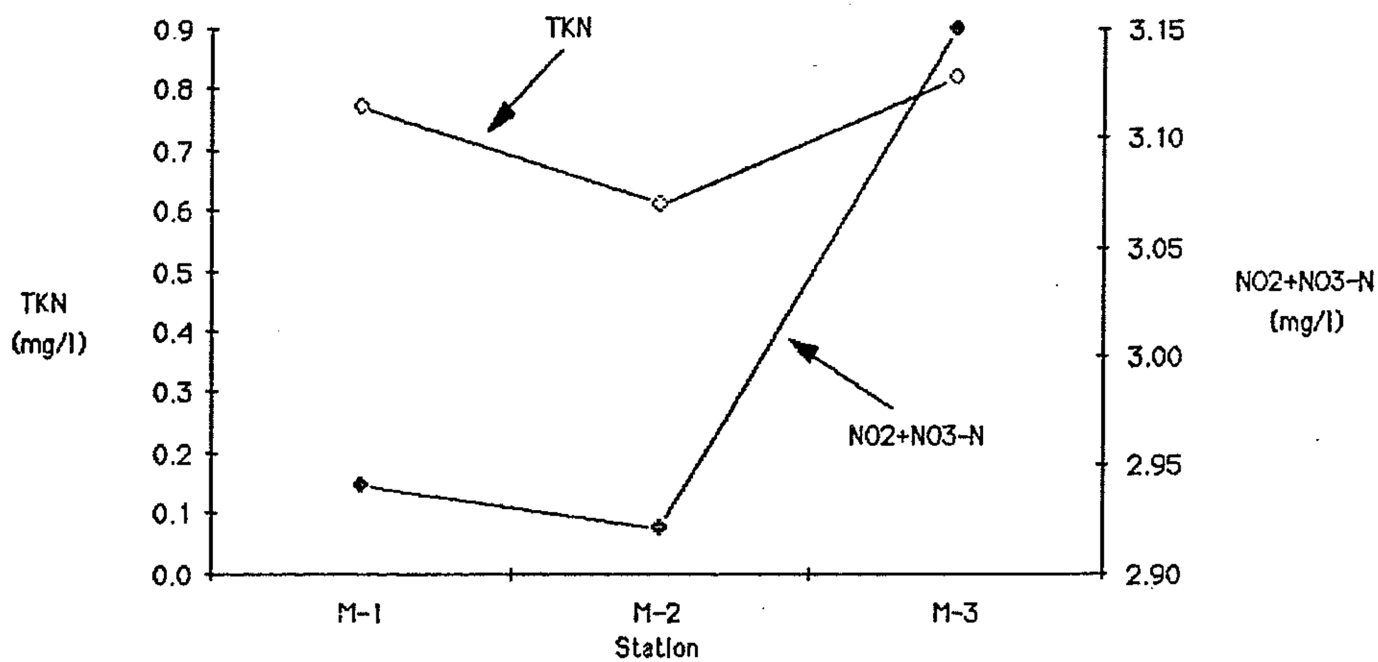

Figure 32. Mean annual total Kjeldahl nitrogen (TKN) and NO2+NO3-N concentrations at the Mud Creek survey stations, 1986.

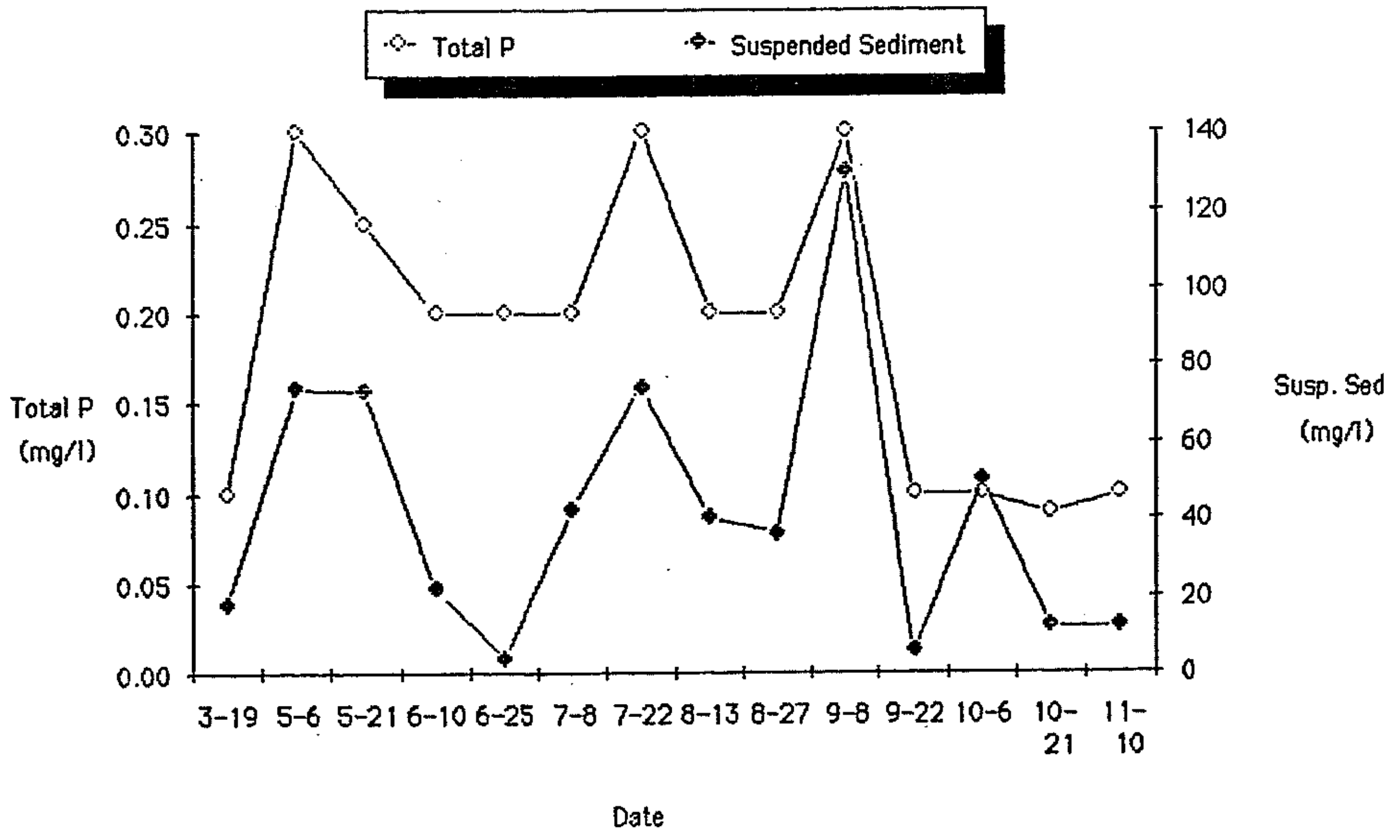

Figure 33. Suspended sediment and total phosphorus concentrations (in mg/l) at Mud Creek station M-1 on the dates indicated, 1986.

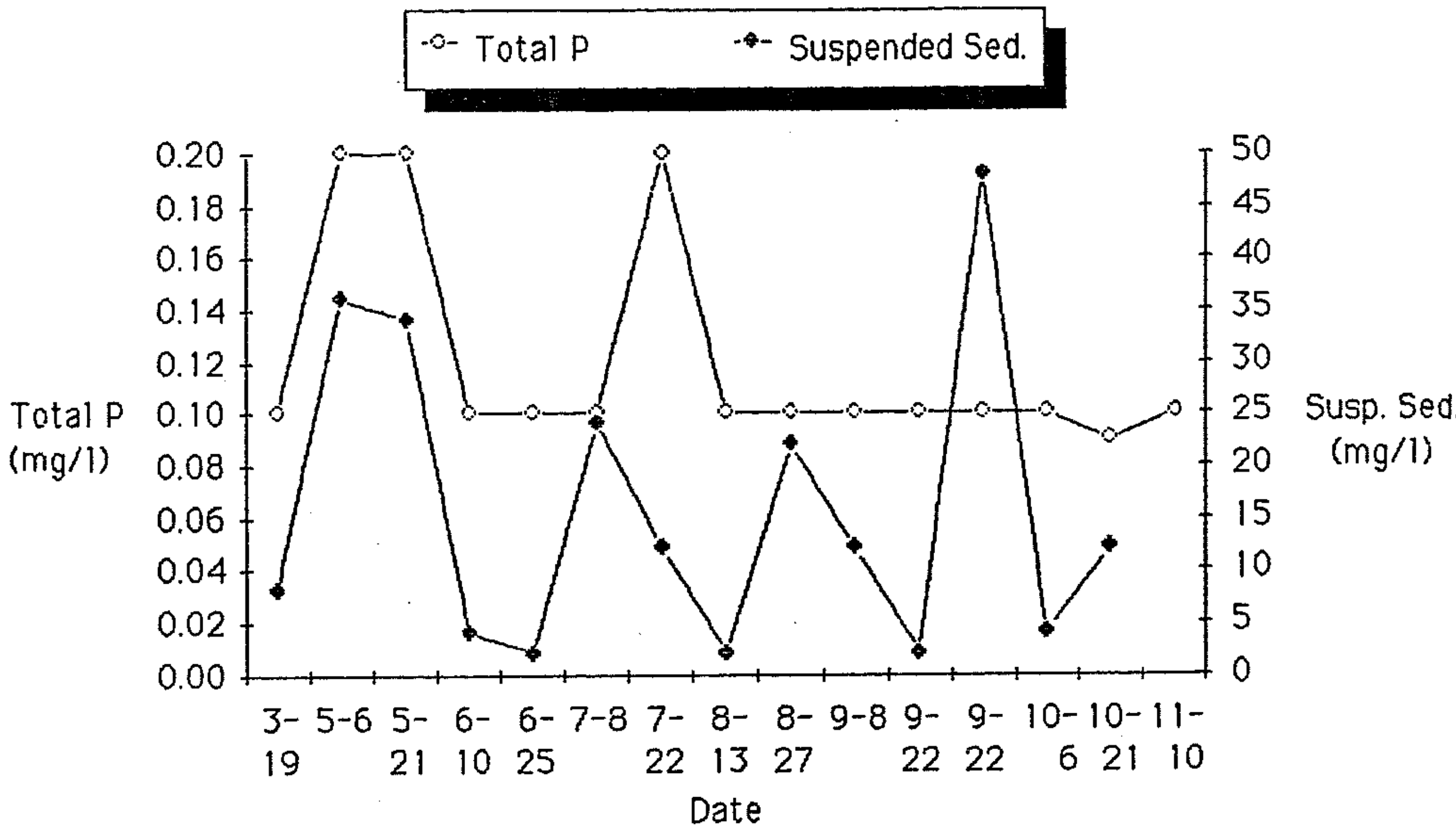

Figure 34. Suspended sediment and total phosphorus concentrations (in mg/l) at Mud Creek station M-2 on the dates indicated, 1986.

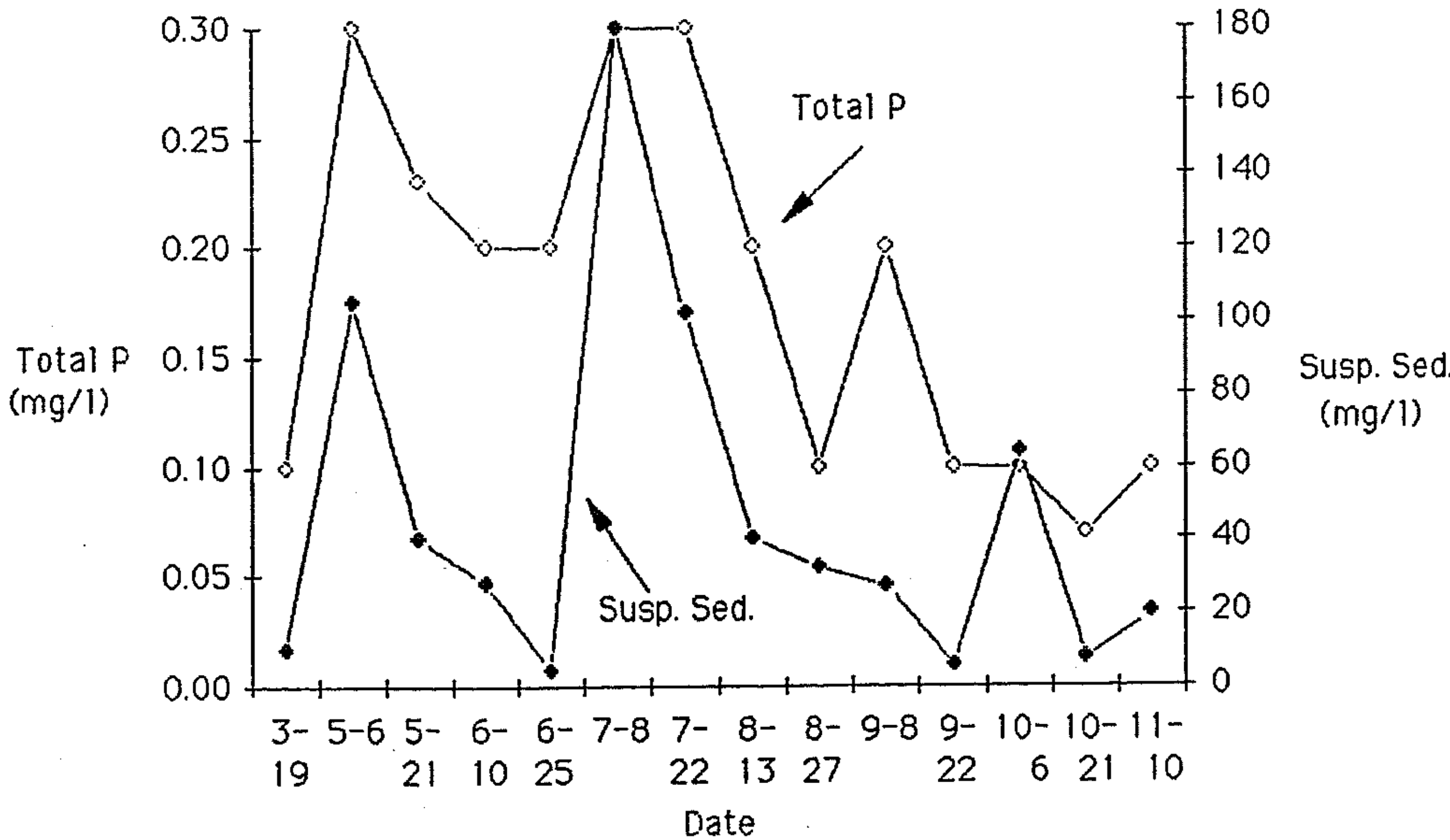

Figure 35. Suspended sediment and total phosphorus concentrations (in mg/1) at Mud Creek station M-3 on the dates indicated, 1986.

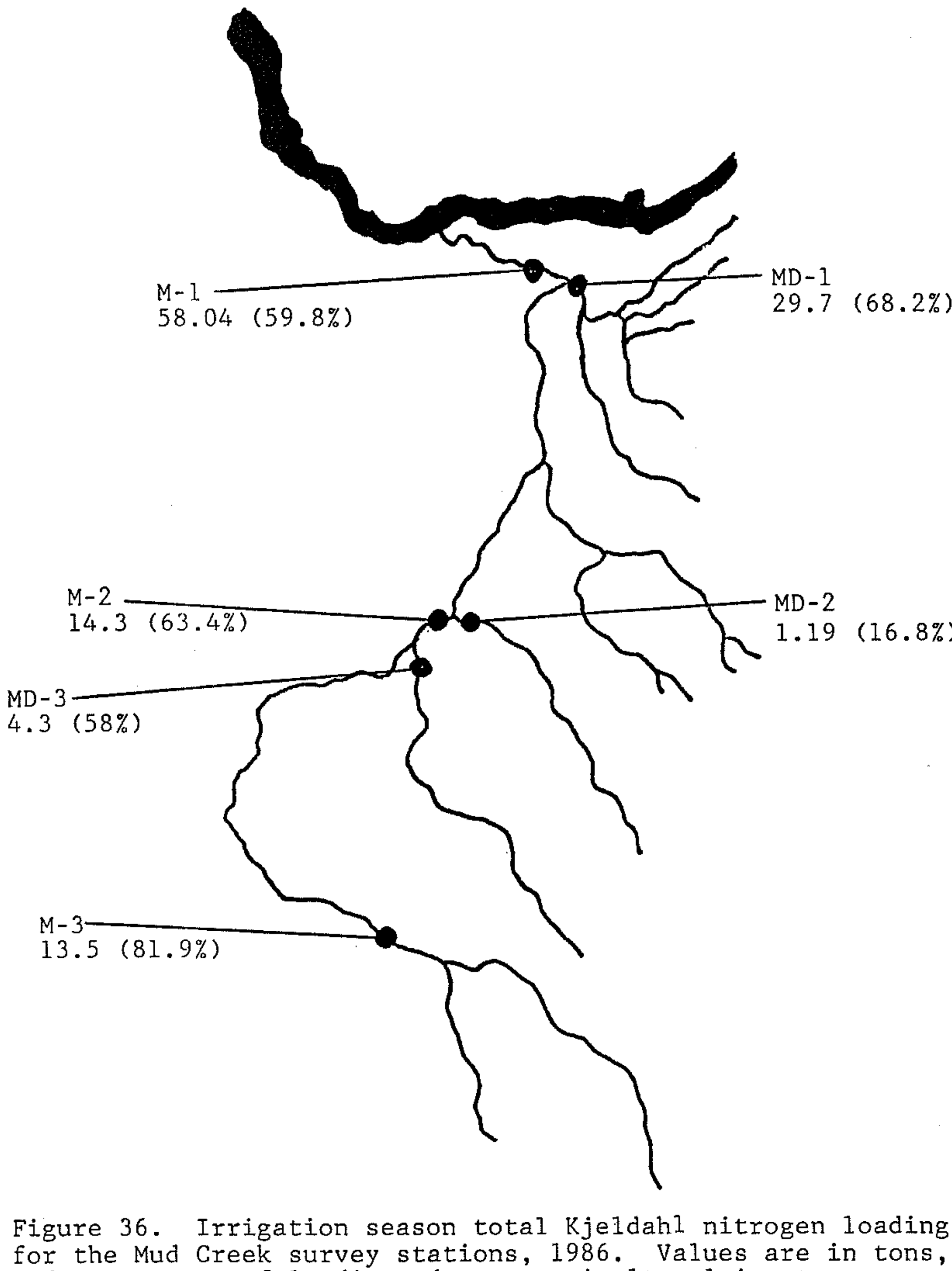

Figure 36. Irrigation season total Kjeldahl nitrogen loadings for the Mud Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

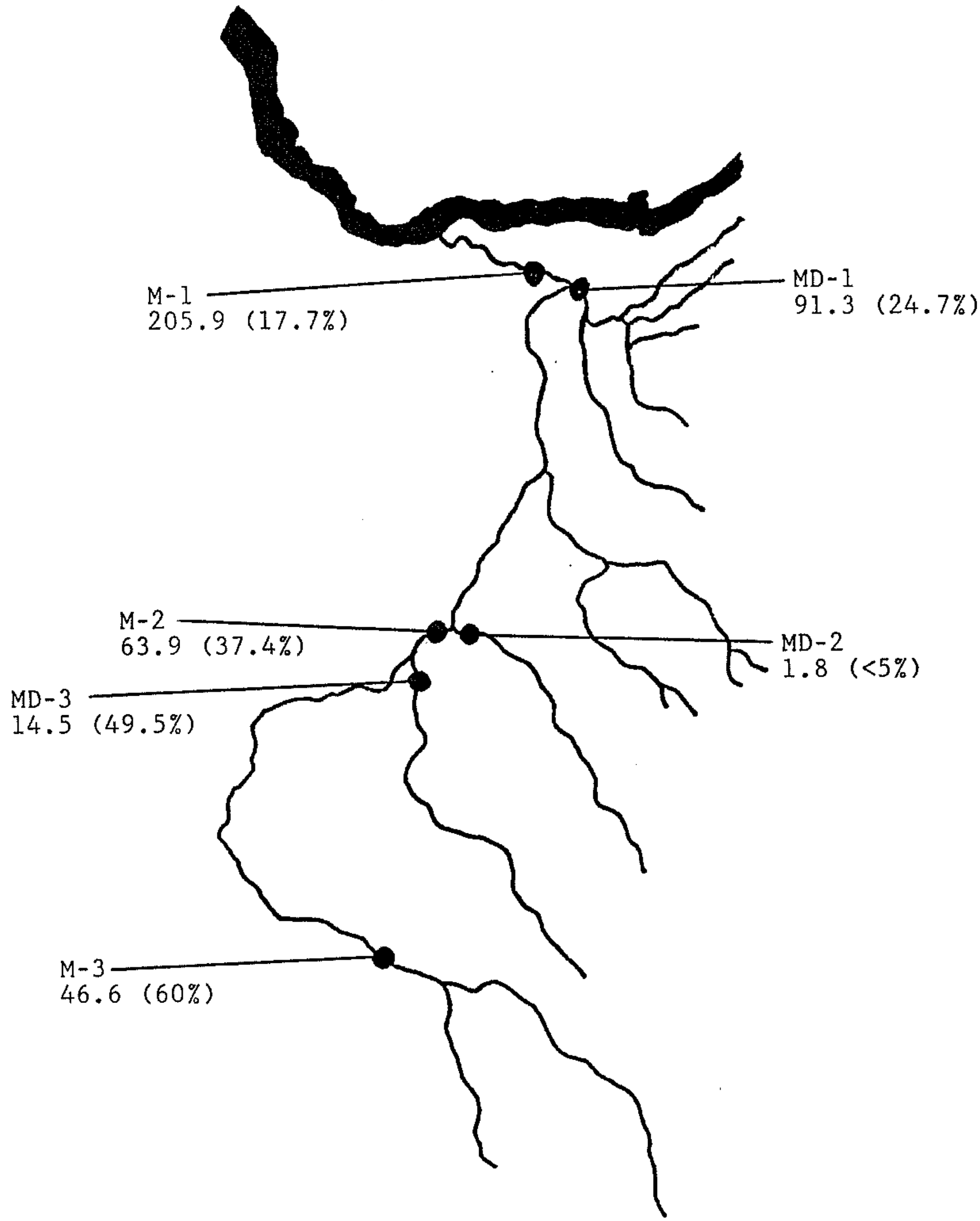

Figure 37. Irrigation season NO_2+NO_3-N loadings for the Mud Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

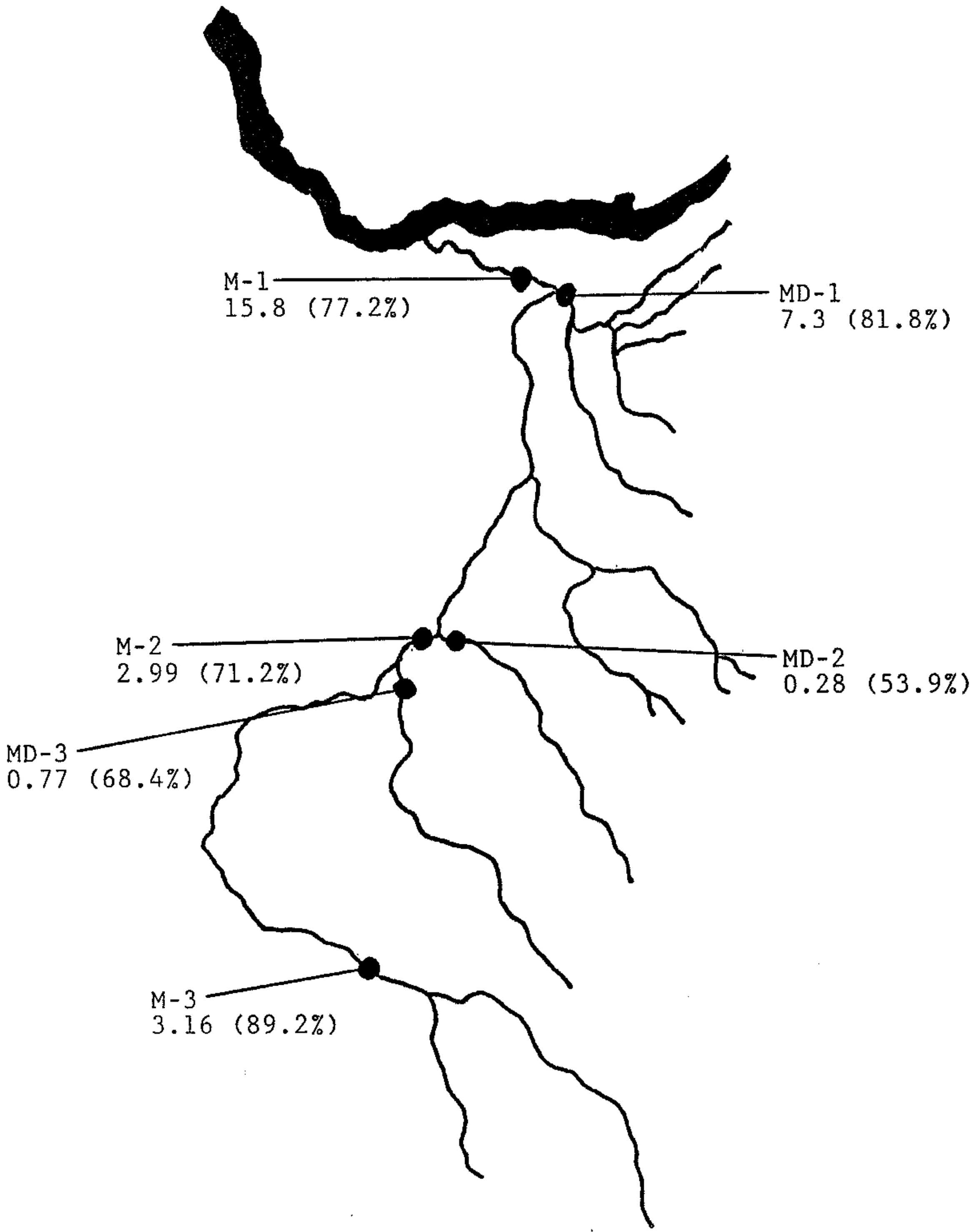

Figure 38. Irrigation season total phosphorus loadings for the Mud Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

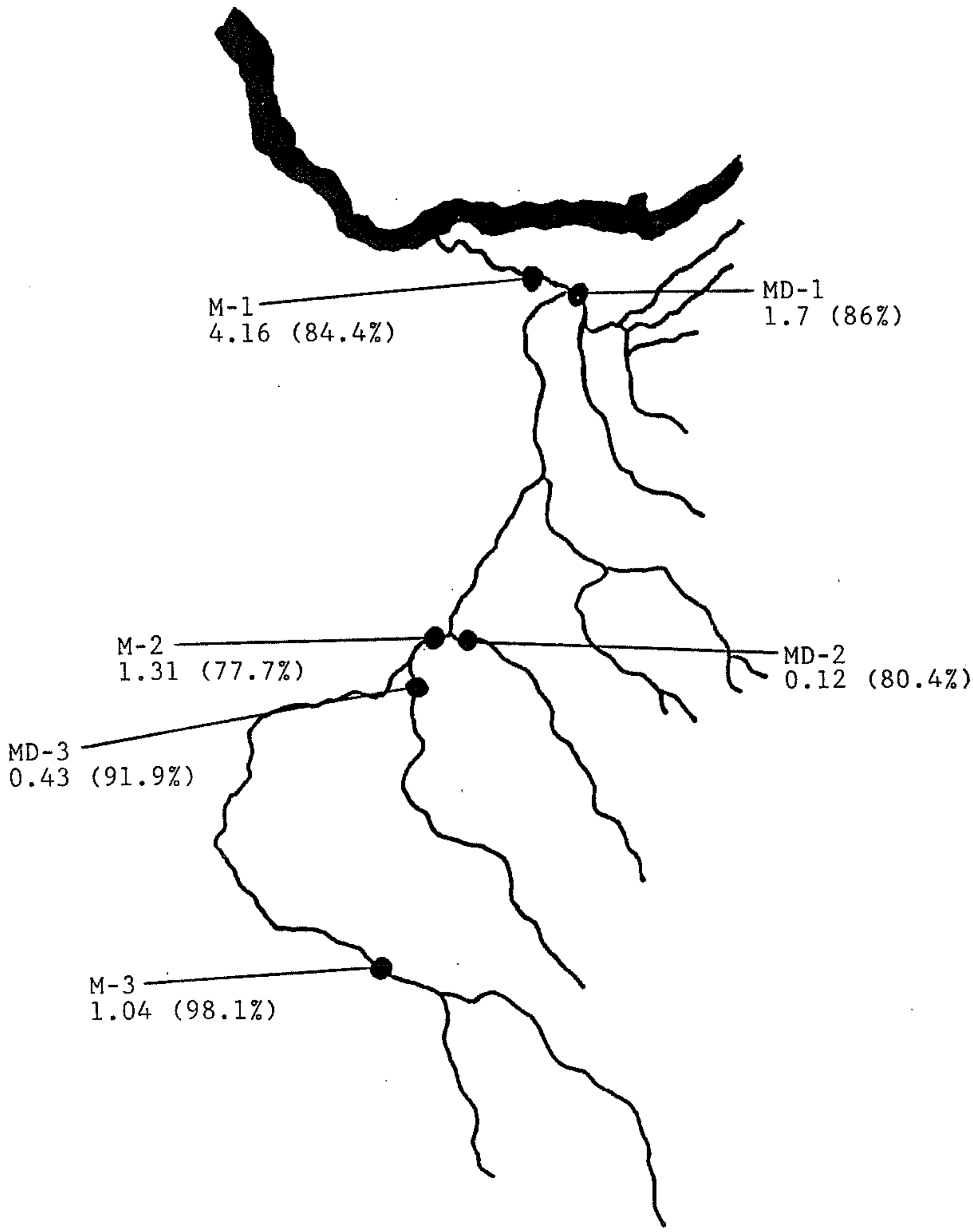

Figure 39. Irrigation season dissolved orthophosphate loadings for the Mud Creek survey stations, 1986. Values are in tons, and percentage of loadings due to agricultural inputs are given in parentheses.

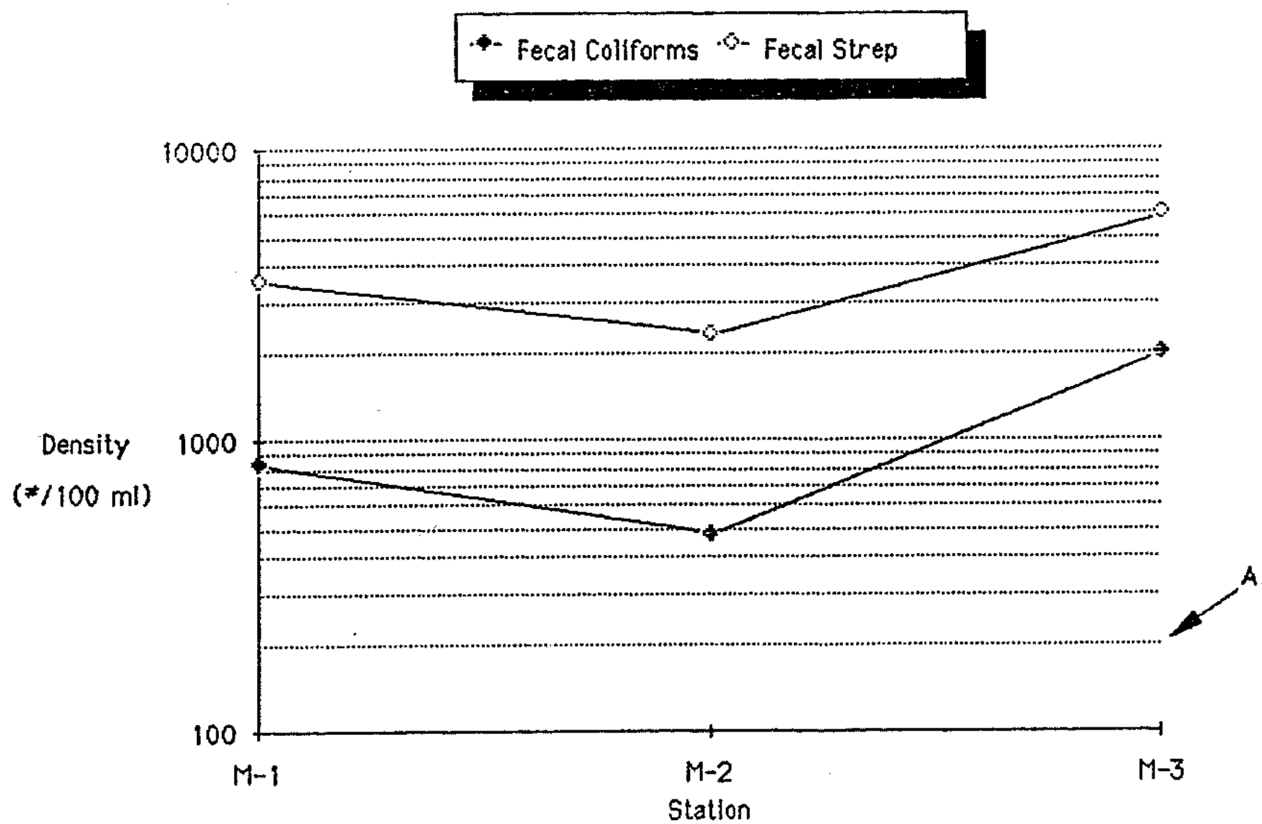

Figure 40. Annual geometric mean densities of fecal coliform and fecal streptococcus bacteria at the Mud Creek stream stations, 1986. A – secondary contact recreation standard.

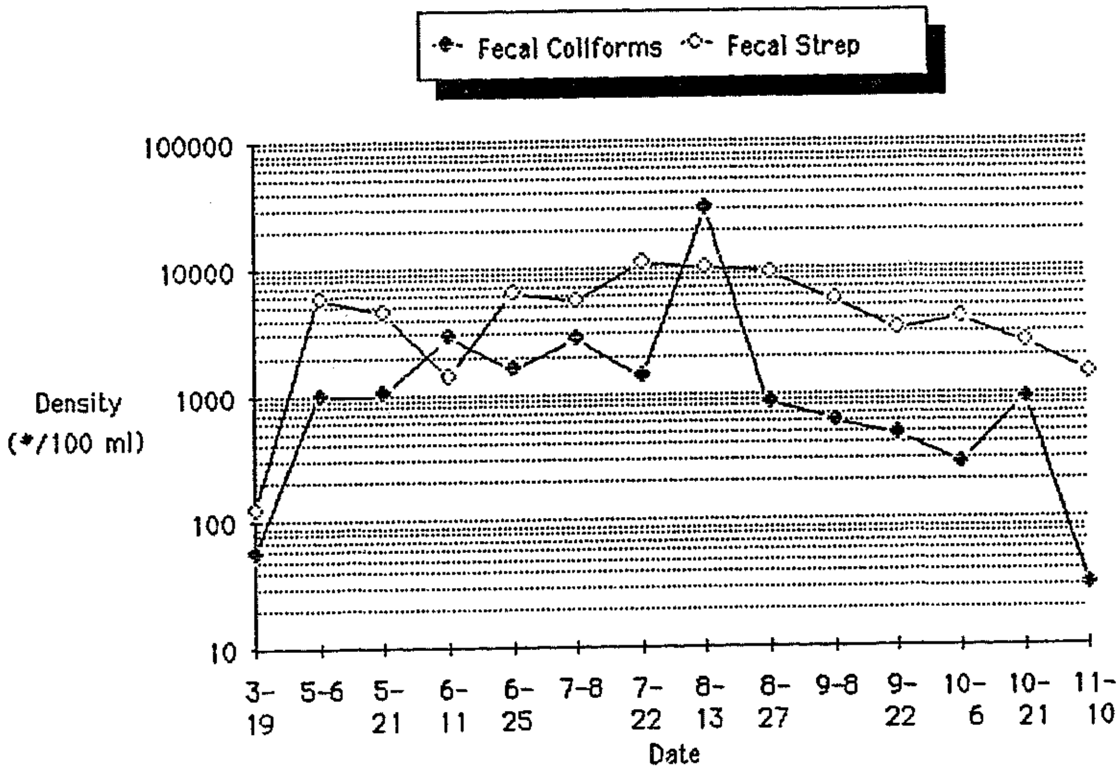

Figure 41. Bacteria densities at Mud Creek station M-1 during 1986.

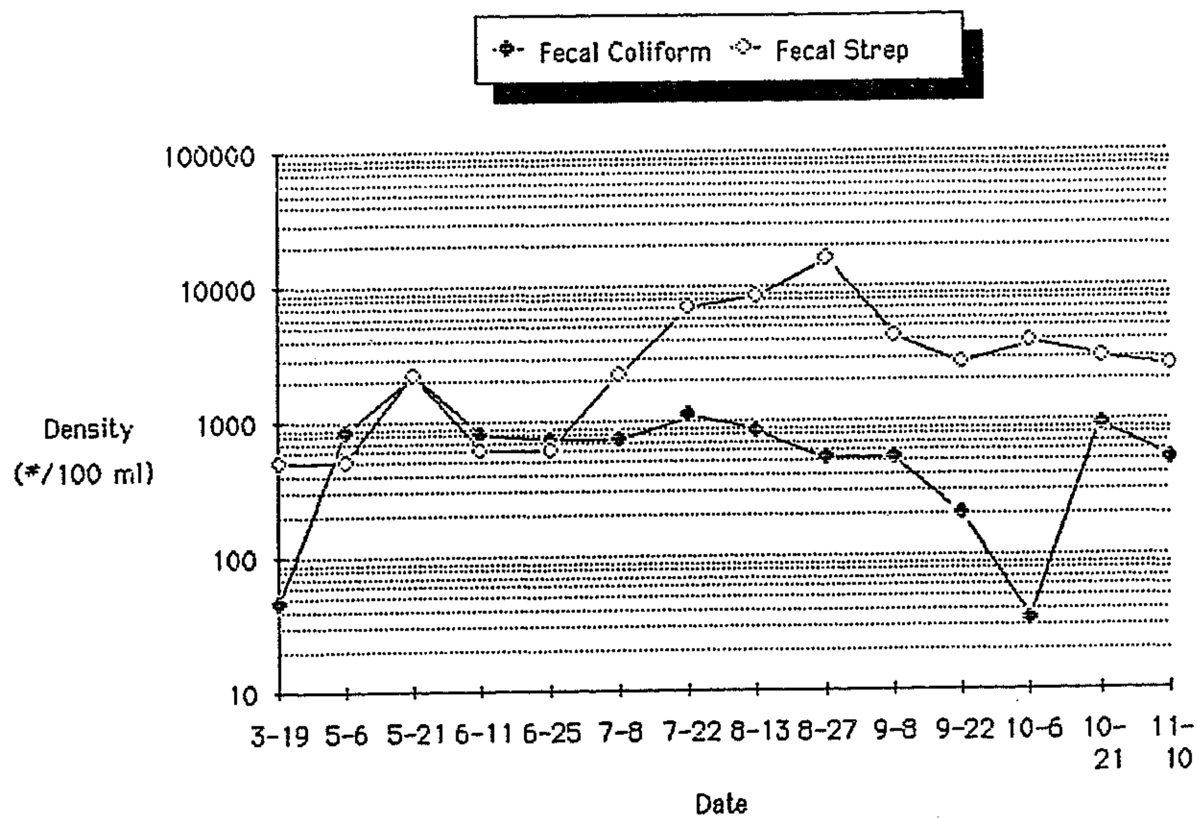

Figure 42. Bacteria densities at Mud Creek station M-2 during 1986.

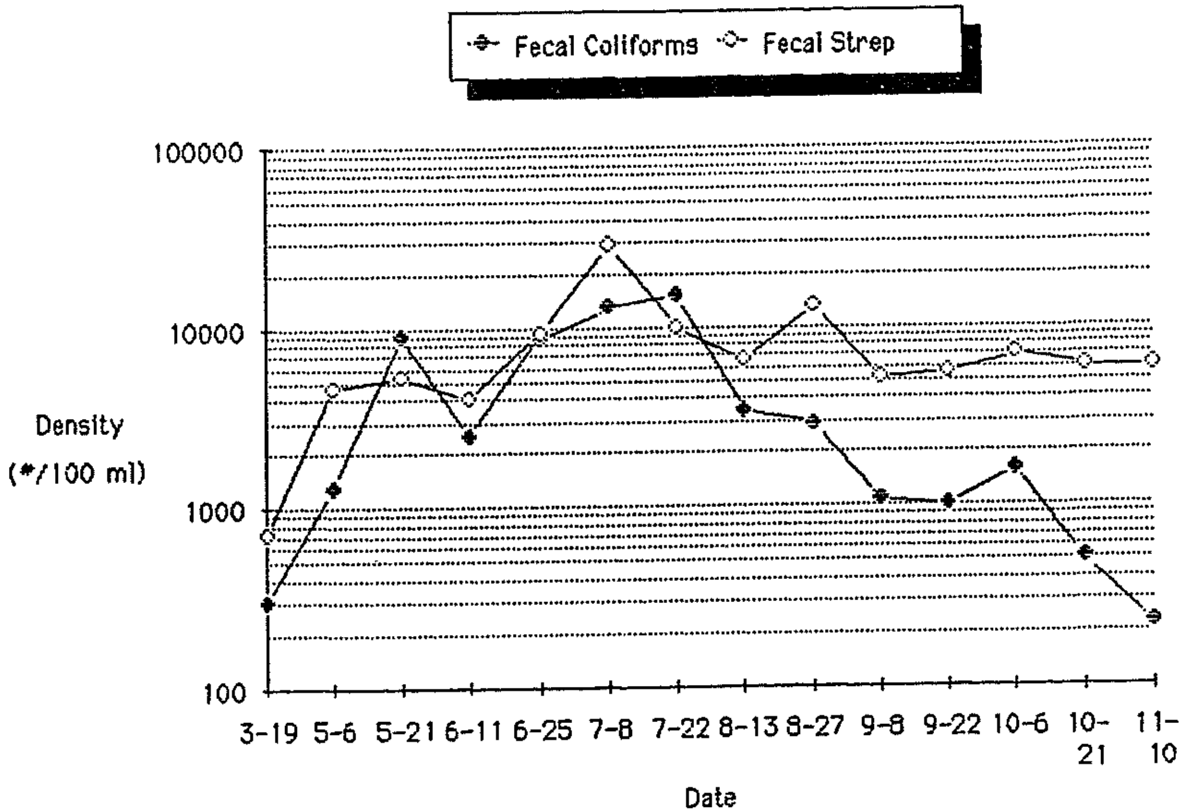

Figure 43. Bacteria densities at Mud Creek station M-3 during 1986.

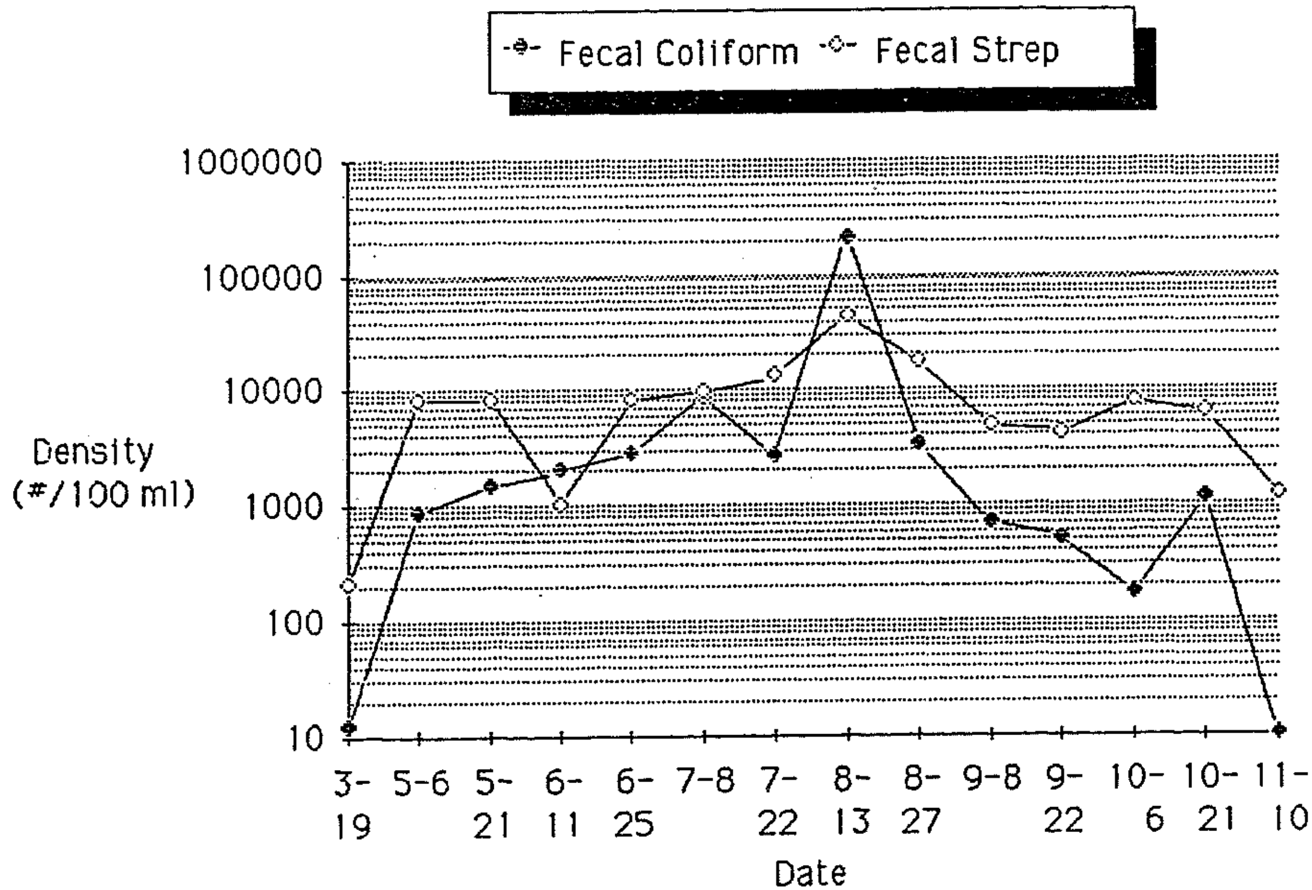

Figure 44. Bacteria densities at Mud Creek tributary station MD-1 during 1986.

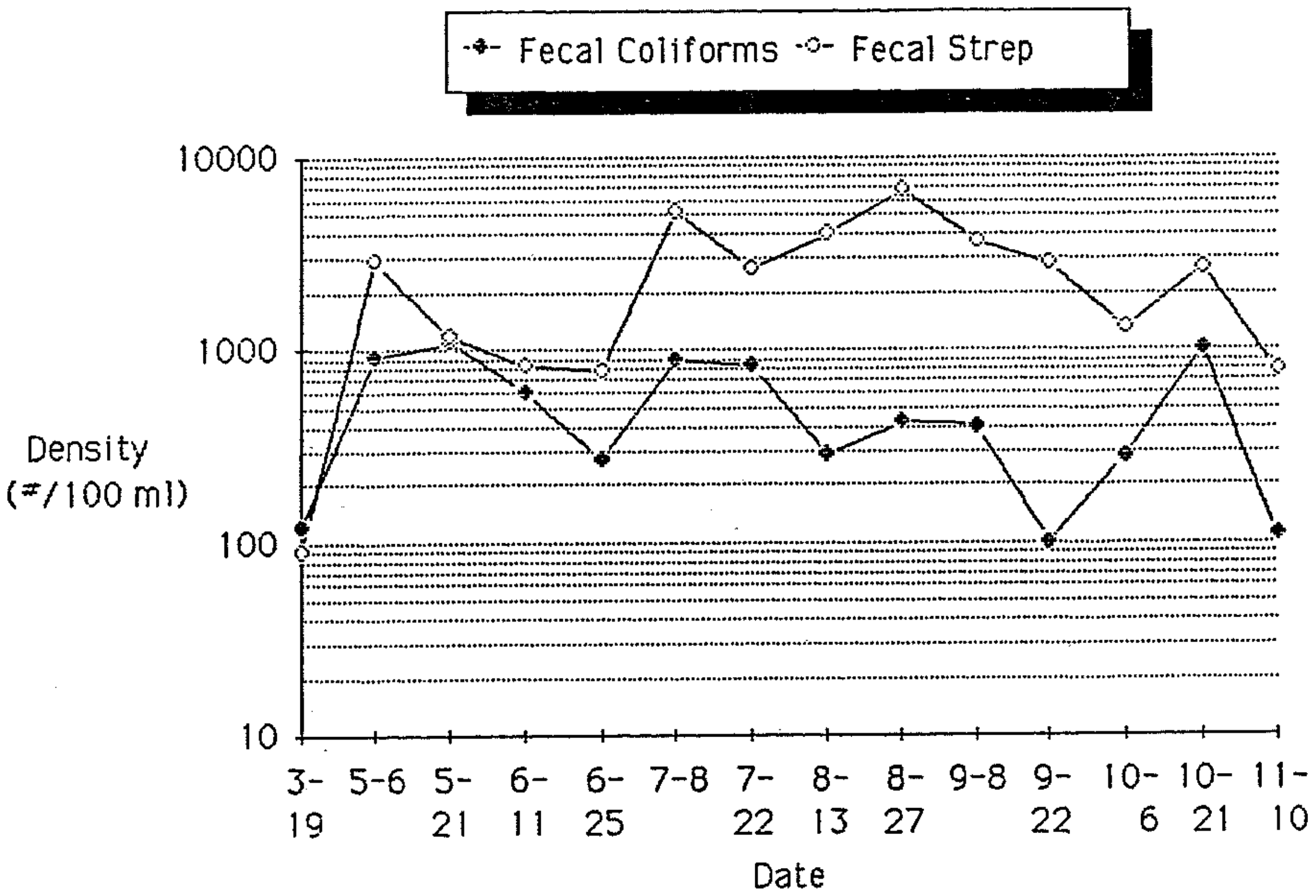

Figure 45. Bacteria densities at Mud Creek tributary station MD-2 during 1986.

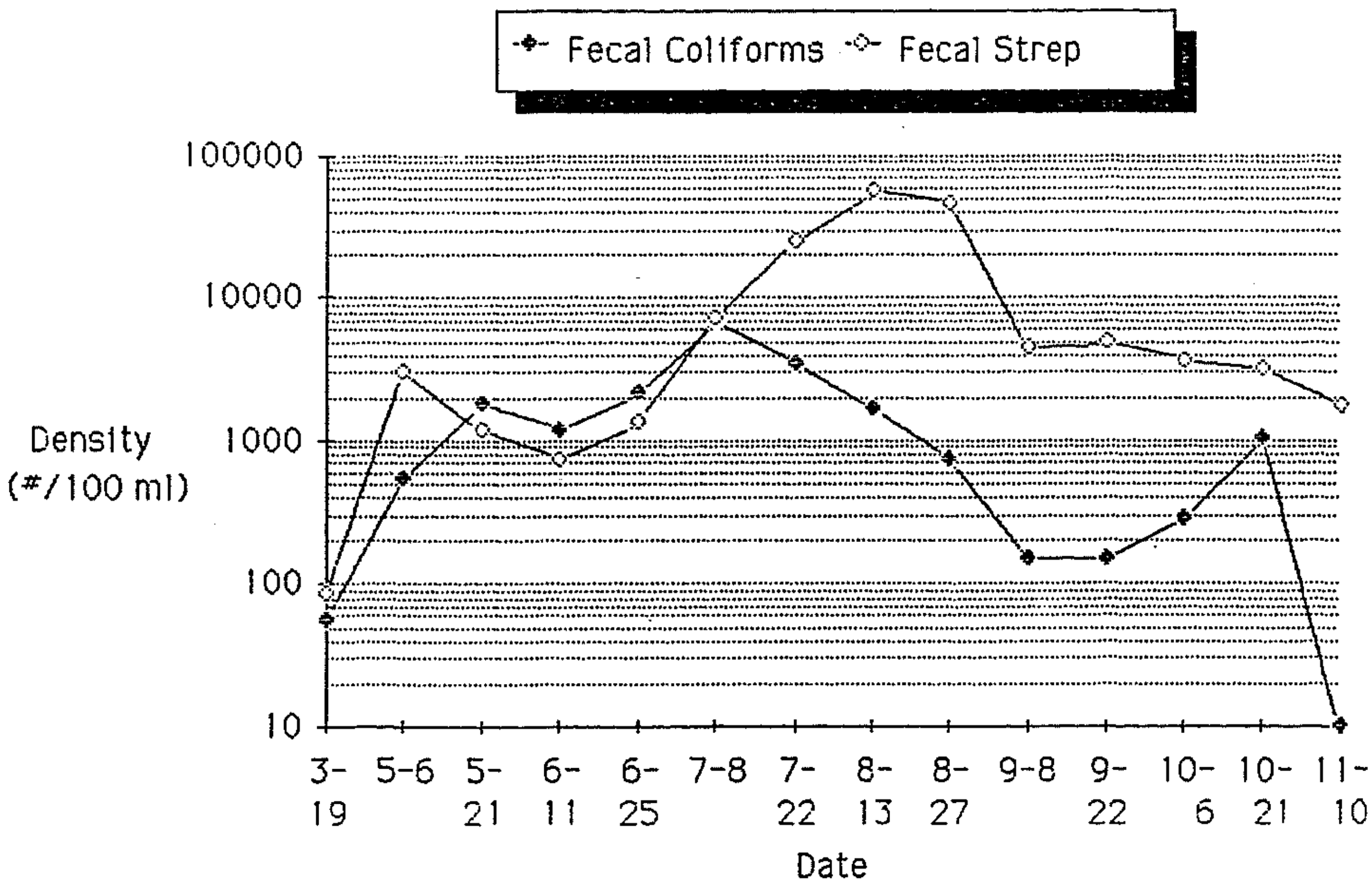

Figure 46. Bacteria densities at Mud Creek tributary station MD-3 during 1986.

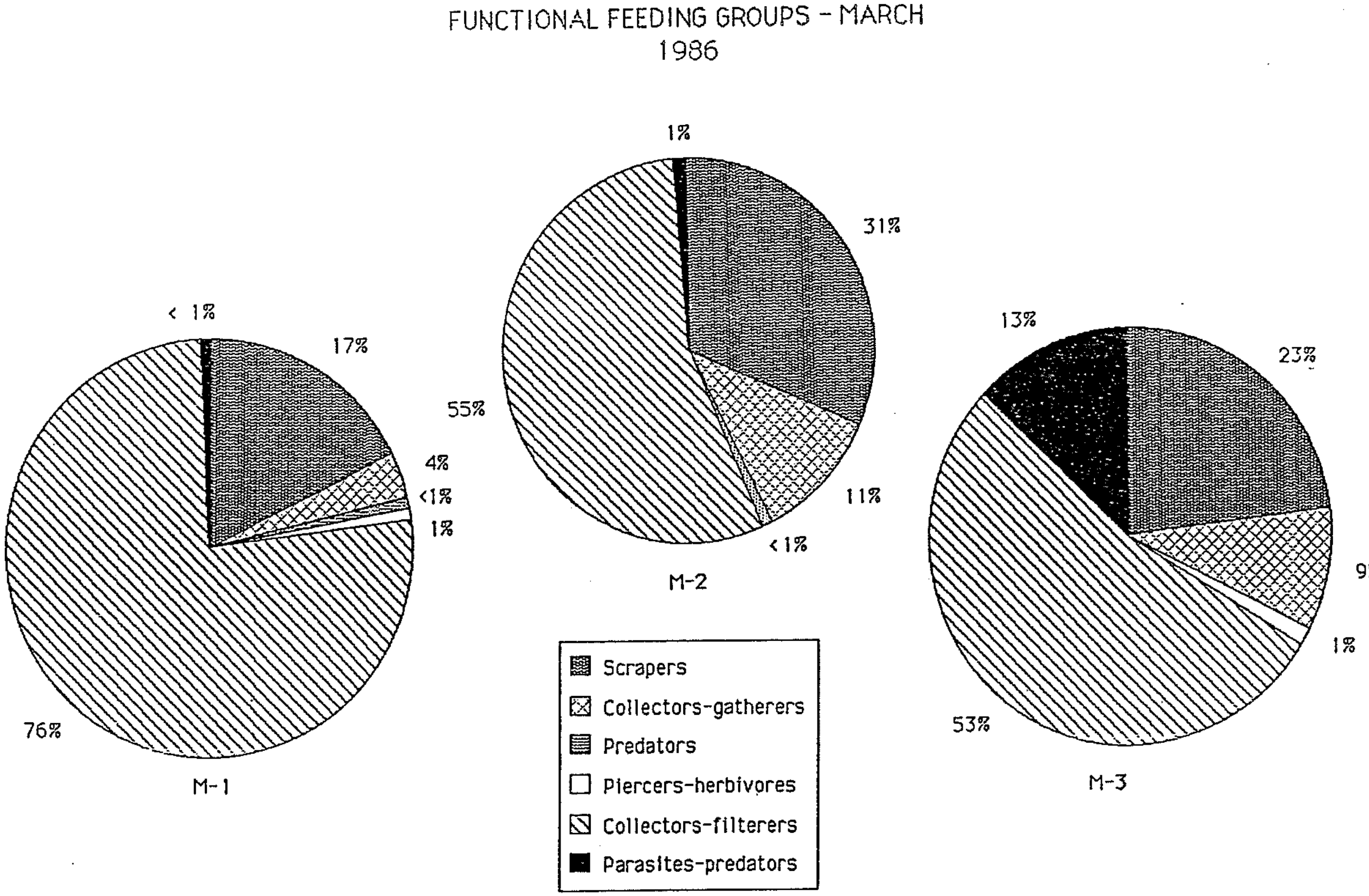

Figure 47. Functional feeding groups of macroinvertebrates collected (% occurrence by number of individuals) at the Mud Creek stations indicated, March 21, 1986.

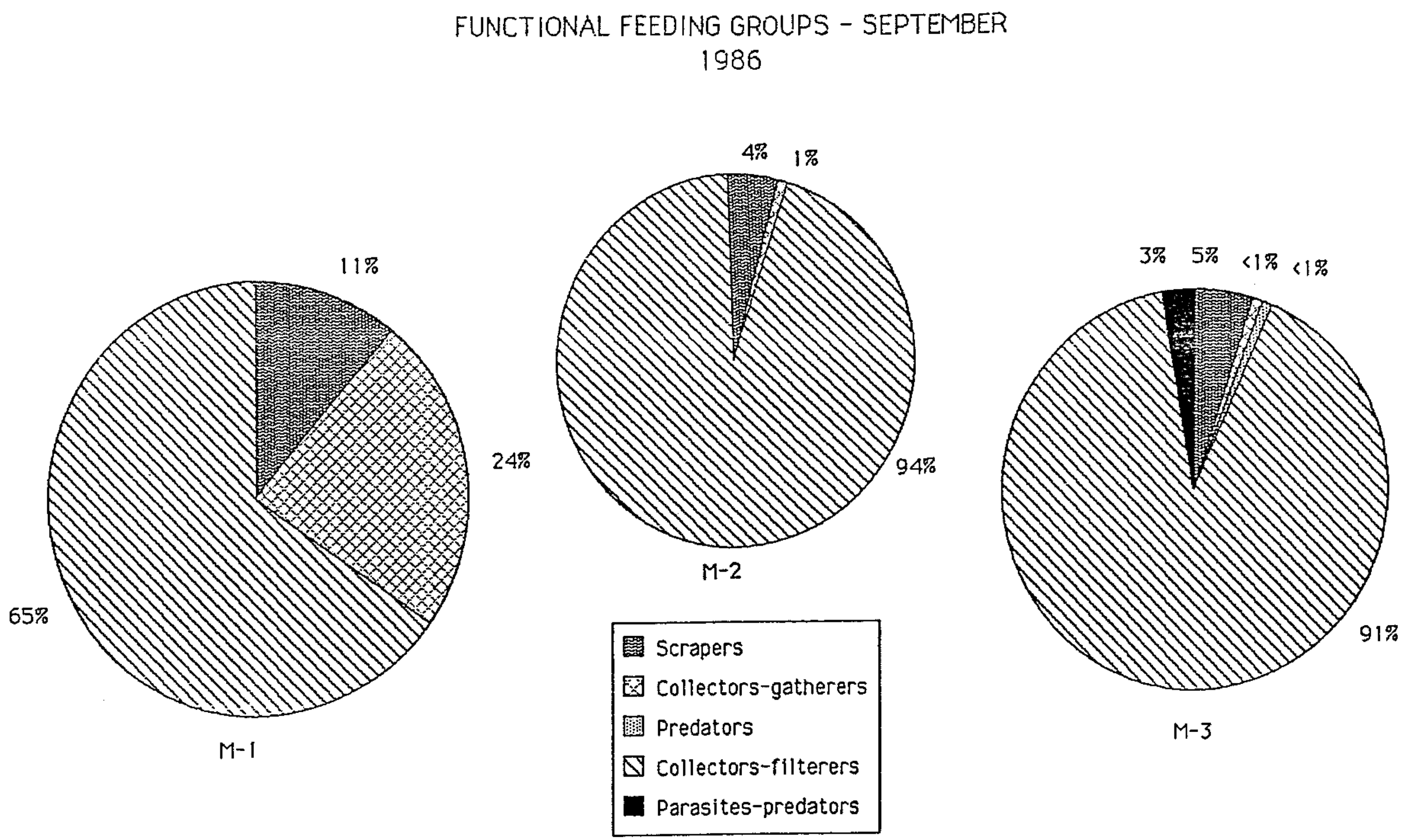

Figure 48. Functional feeding groups of macroinvertebrates collected (% occurrence by number of individuals) at the Mud Creek stations indicated, September 3, 1986.